THE
BENDIX
CORPORATION

GUIDANCE SYSTEMS
DIVISION
DENVER OPERATIONS

# HAZARD ANALYSIS OF UNDERGROUND COAL MINE HAULAGE SYSTEMS

CONTRACT NO. HO242046

FINAL REPORT

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# Hazard Analysis of Underground Coal Mine Haulage Systems

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## FOREWORD

This report was prepared by The Bendix Corporation, Guidance Systems Division, Denver, Colorado under USBM Contract Number HO242046. The contract was initiated under the Coal Mine Health and Safety Program. It was administered under the technical direction of the Pittsburgh Mining and Safety Research Center with Mr. William Wiehagen acting as the Technical Project Officer. Mr. R. J. Simonich was the Contract Administrator for the Bureau of Mines.

This report is a summary of the work completed under the contract; the work was done during the period July 1974 to June 1975.

The principal investigators were Herman Ankenbruck, Sanford Blackman, Hanns Billmayer, William Hargreaves, and Michael Perlman. Mr. George Judy of George L. Judy Associates, acting as consultant, provided specific expertise in mining practices, equipment, and procedures. Valuable recommendations and accident statistical data were provided by the Mining Enforcement and Safety Administration, Safety Analysis Center. Significant contributions were made by the management, miners, and safety personnel of the mines visited.

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# 1. SUMMARY

Analyses of statistical data indicate that haulage accidents are one of the largest sources of injuries and fatalities in underground coal mines, and that the rate of accidents in transportation has been increasing during the past few years. These previous analyses were performed by correlating accident or fatality data at a rather high level of miner activity. In this present investigation, underground surveys were made by observing conditions and activities in some detail at a rather low level of activity in an attempt to understand factors contributing to hazards in the specific situations observed. The aim of the current study was to derive preventive measures that might obviate the hazardous conditions and unsafe acts observed; and, following this, to provide recommendations for additional research and development to reduce accident potential in underground transportation.

The major project tasks are diagrammed together with the task outputs in figure 1-1. Initially, a preliminary study of all underground haulage operations was performed in order to establish the kinds of data needed and to provide the rationale leading to the data requirement. At the same time, the various types of haulage equipment used for each operation were defined. A preliminary analysis of each type of haulage operation was performed in order to establish the sequence of tasks required to operate haulage equipment. These tasks were transferred directly onto observation forms, and were used in developing interview forms. In parallel with the task analysis, a review was made of accidents and hazards that might occur during each type of operation.

In-mine surveys were made in 35 underground coal mines in 10 different coal seams that were believed to be representative of U.S. mines. Operations were observed in all areas of underground transportation, including about 90 sections. At each mine, interviews were held with mine personnel in order to obtain basic data and to provide information on operations that were difficult to observe.

The survey data were analyzed and correlated from mine to mine in order to establish which hazards were prevalent in the 35 mines surveyed. Following this, actual 1974 accident reports for those same mines were perused in order to establish correlation with the hazard observations. The results of this correlation are summarized in table 1-1, which lists those observed factors that may have contributed to the reported accidents in those mines. Following an analysis of the manner in which each observed hazard may contribute to each type of accident, preventive measures that might alleviate each hazard were conceived. A summary of these recommended preventive measures is presented in table 1-2.

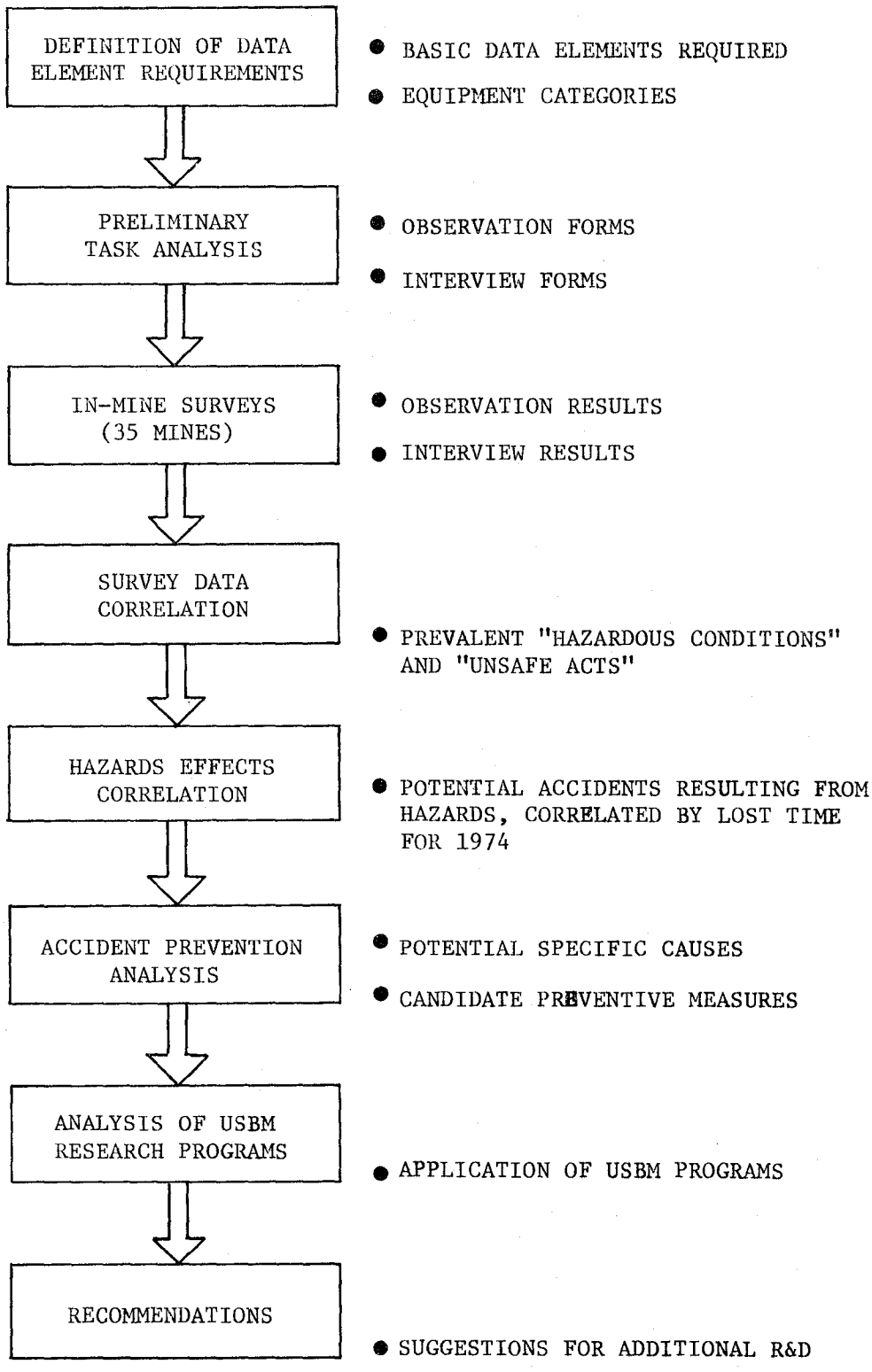



Figure 1-1. Project Summary

# Table 1-1. Prevalent Observed Factors Apparently Contributing to Serious Accidents During 1974 in the 35 Mines Surveyed

| FAULT CLASSIFICATION | FACTORS CONTRIBUTING TO HAZARDS | HAULAGE CATEGORY | $I_n$ |
|---|---|---|---|
| ENVIRONMENTAL | Restricted Overhead Clearance | Trackless | 15/106 |
| | Abrupt Change of Overhead Clearance | Track | 15/72 |
| | Hanging Roof Bolts | Track | 26/70 |
| | Uneven Sidling Wet Floor | Trackless | 35/106 |
| | Insufficient Illumination | Trackless | 1/92 |
| | Insufficient Illumination at Transfer Points | Track | 18/72 |
| | Lack of Illumination at Transfer Points | Belt | 23/54 |
| | Noise Resulting in Poor Communications | Trackless | 53/95 |
| PLANNING | Lack of Side Clearance | Belt | 13/71 |
| | Poor Maintenance of Track Gauge, Alignment, Ballast, and Roadway Drainage | Track | 28/73 |
| | View Obstructed by Brattice | Trackless | 58/101 |
| | Lack of Traffic Control | Track | 10/27 |
| | Communication Media Poor | Track | 28/43 |
| | Defective Equipment (Maintenance) - Brakes, Lights, Bell, Steering, Tramming Control | Trackless | 68/160 |
| | Defective Equipment (Maintenance) - Brakes, Lights, Bell, Controller, Sander, Skids, etc. | Track | 22/73 |
| | Defective/Misaligned Switch or Position Indicator | Track | 14/71 |
| EQUIPMENT | Poor Design or Location of Controls | Track | 5/66 |
| | | Trackless | 38/165 |
| | Lack of Adequate Emergency Stop Devices - Entire Length of Mantrip | Belt | 9/40 |
| | Lack of Warning Signs/Safety Interlocks to Prevent "Turn-On" While Working on Belt | Belt | 60/65 |
| | Lack of "Start" Warning Devices | Belt | 66/66 |
| | Lack of Warning Device Where Hazard to Personnel Exists at Mine Car Loading Points | Transfer Point | 30/37 |
| | Inadequate or No Panic Bars | Trackless | 94/132 |
| | Lack of Adequate Guards at Drive Pulleys | Belt | 3/63 |
| | Poor Driver Visibility | Trackless | 64/159 |
| | Lack of, or Poor Design of, Canopies | Trackless | 91/169 |
| | Insufficient Lighting on Vehicles | Trackless | 20/147 |
| | No Windshield or Cab on Locomotive | Track | 51/68 |
| | Lack of/Defective Automatic Couplers | Track | 8/54 |
| | Inadequate Decouplers/Going Between Cars | Track | 20/54 |
| UNSAFE ACTS | Failure to Give Warning Before Spotting Mine Car | Track | 30/37 |
| | Working On or Too Close to Moving Belt or Unguarded Pulley | Belt | 11/64 |
| | Failure to Wear Eye Protection | Belt | 16/49 |
| | | Track | 27/70 |
| | Items Protruding From Equipment | Trackless | 8/148 |
| | Does Not Use Lever, Steps Between Cars to Couple/Uncouple | Track | 12/45 |
| | Not Remaining Seated (Standing to Replace Trolley Pole) | Track | 20/70 |
| | Excessive Speed for Circumstances | Track | 6/74 |
| | | Trackless | 16/144 |
| | Not Using Proper Rerailing Device | Track | 8/40 |
| | Not Facing Direction of Travel | Trackless | 13/120 |
| | Inexperienced or Unfamiliar Operator | Trackless | 18/148 |
| | Riding In Unsafe Position, Standing | Trackless | 35/143 |
| | Not Sounding Bell at Start, Before Curtains, or Before Turning | Trackless | 134/146 |
| | Headlights Not on While Tramming | Trackless | 17/142 |
| | Not Shutting Down, Setting Brakes, Blocking a Parked Vehicle | Trackless | 7/112 |
| | Not Checking Equipment (Pre-Shift) | Trackless | 14/124 |
| | Not Observing Caution Passing Thru Brattice | Trackless | 20/119 |
| | Poor Cable Control | Trackless | 10/106 |
| | Loading Coal Too High - Visibility | Trackless | 37/131 |
| | Getting On or Off Moving Conveyors | Belt | 5/11 |

NOTES: $I_n$ = Normalized Incidence Rate = Incidence of Observed Hazardous Conditions or Unsafe Acts ÷ Total Number of Unit Observations.

## Table 1-2. Summary of Recommended Preventive Measures

OPERATOR COMPARTMENT AND CONTROLS

Standardize and optimize operator's compartment (human engineering) (TRACKLESS, TRACK).

Proportional tramming control (TRACKLESS).

Attenuation of steering torque feedback (e.g., modified power steering) (TRACKLESS).

Adjustable seat (TRACKLESS).

Slow-rise shock absorbers on vehicle seats (TRACKLESS).

Automatic speed limiting devices (that apply emergency brake above set speed) (TRACK).

Provide convenient on-off switch location that can be actuated from riding position on belt (BELT-MANTRIP).

Key-locking switch to prevent energizing belt drives during maintenance (BELT).

Closed circuit TV monitoring for closer supervision (BELT).

Electromagnetic obstacle detector (TRACKLESS, TRACK).

REMOTE/AUTOMATIC CONTROLS

Automatic control of track vehicles (TRACK).

Central remote control of track vehicles (TRACK).

In mines employing a dispatcher, switch-position indicators on dispatcher display (TRACK).

In mines employing a dispatcher, install dispatcher displays of vehicle velocity and locations (TRACK).

Automatic or remote control decoupling (i.e., operated from motor) (TRACK).

Automatic couplers with self-centering devices (TRACK).

More positive decoupling device that holds coupler open until car separation (e.g., detent) (TRACK).

CONTINUOUS HAULAGE

Substitute continuous conveyor haulage for shuttle cars (TRACKLESS).

BRAKES AND PANIC BARS

Automatic, fail-safe emergency/parking brake (sets when vehicle power is removed from tram motor, when actuated by panic bar, or when any component of service brake fails) (TRACKLESS, TRACK).

"Dead man" controls tied to automatic brakes (TRACKLESS, TRACK).

Positive, mechanical parking brake separate from service brake (TRACKLESS, TRACK).

Interlock drive motors with brake line pressure to prevent operation with "low" brakes (TRACKLESS, TRACK).

BRAKES AND PANIC BARS (Continued)

Improved parking brake indicator (e.g., via brake surface forces) to give positive indication of FULL-ON condition (TRACKLESS, TRACK).

Panic bar design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles (TRACKLESS).

PROTECTIVE CANOPIES

Design (or redesign) canopies for optimal visibility and/or egress (TRACKLESS).

Design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles (TRACKLESS).

Canopies or full cab enclosures to restrict body projection (TRACK).

Design and installation guidelines for cabs and windshields on operational track equipment for use by manufacturers and mine shops in retrofitting vehicles (TRACK).

ILLUMINATION AND VISION AIDS

Diffused area illumination of haulageways to improve driver cues and reduce hazard reaction times (TRACKLESS).

High intensity diffused headlamps (new lens design) (TRACKLESS).

Two reliable headlamps and side lights or reflectors on each end of vehicle (TRACKLESS).

Interlock headlights with tramming direction control (TRACKLESS).

Lights that may be dimmed but turned off only when machine power is removed (TRACKLESS).

Keep headlamps clean (TRACKLESS).

Portable task lights and area lights (TRACK, TRACKLESS).

Standard color marker lights for use on parked vehicles (TRACKLESS).

Provide parked trips with end reflectors (TRACK).

Reflective paint and/or tape with colors for different functions (GENERAL).

Reflective clothing for all mine personnel (GENERAL).

Reflective paint on low roof and obstructions (TRACKLESS).

Reflective paint for temporary marking of hanging bolts until bolt removed/replaced (TRACKLESS, TRACK).

Flexible warning sign hanging at same height as obstructions (TRACK).

## Table 1-2. Summary of Recommended Preventive Measures (Concluded)

ILLUMINATION AND VISION AIDS (Continued)

Adequate means of marking roof to indicate shuttle car route with best clearance (TRACKLESS).

Designate entries/crosscuts being used for shuttle cars run by operator placement of portable markers, (e.g., reflective cones) (TRACKLESS).

Substitute lower profile machine (TRACKLESS).

Locate operator near boom end of shuttle car (TRACKLESS).

Control loading height of coal to improve operator's opposite side view (TRACKLESS).

Fold down sideboards (TRACKLESS).

Double-split ventilation to reduce number of curtains in haulageways (TRACKLESS).

Transparent brattice to improve visibility (TRACKLESS).

NOISE CONTROL

Reduce machine noise (through isolation, insulation, and redesign) (GENERAL).

Discriminating electronic ear muffs (GENERAL).

COMMUNICATIONS

Area-wide communication between vehicles and all miners in same area (GENERAL).

Short range line-of-sight transceivers between foreman, loader/continuous miner operator, and shuttle car drivers (GENERAL).

Reduce noise in trolley phone system by conventional noise reduction design techniques (TRACK).

Reliable voice communication between brakeman and motorman (TRACK).

Additional communication along belt (BELT).

"Hands-free" type of communication system (TRACK).

MAINTENANCE

Built-in test equipment for improved machine preshift checks (i.e., hydraulic pressure, cable faults) and trouble diagnosis (possibly programmed) (TRACKLESS).

Variable cable tension or feedback devices to minimize whip and tension (SHUTTLE CAR).

Quick disconnect trailing cable connectors with safety interlocks (TRACKLESS).

Improved roadway maintenance, leveling, and drainage (TRACKLESS).

Drag-bar on rear of shuttle car to aid in road leveling and filling (TRACKLESS).

Greater use of dewatering wells, sump holes and/or drainage ditches (TRACK).

MAINTENANCE (Continued)

Preshift machine check list signed and submitted to foreman (TRACKLESS, TRACK).

Scheduled preventive maintenance and improved overall maintenance prrocedures with strict user written feedback (GENERAL).

Separate standards of rail and track bed quality for coal and non-coal usages, and methods of testing to standards (TRACK).

WARNING

Automatic warning devices interlocked with tram levers and seats on shuttle cars.

Relocate warning sound sources to reduce annoyance to operator (TRACKLESS).

Time-delay actuator in porta-feeder to give audible warning before equipment moves (TRACK).

Signs or warning devices of environmental hazards (flashing lights, reflectors, etc.) (TRACK).

Time-delay circuit and warning in belt drive switch (BELT).

MISCELLANEOUS

Improved material handling procedures and techniques (TRACKLESS, TRACK, BELT).

More intensive safety education and job training programs (including multi-job training) (GENERAL).

More effective enforcement of regulations and/or closer supervision (GENERAL).

Alternative tire designs to improve traction under differing bottom conditions (TRACKLESS).

Substitute battery or diesel vehicles (TRACKLESS).

Modify roof control locally, where belt side clearance is limited, to allow wider entries (arches, bolts) (BELT).

Keep work areas free of debris (GENERAL).

Use proven/proper tools (GENERAL).

Optimal design for safety glasses or flip-up shield to provide protection and allow for use of corrective prescription (GENERAL).

Mobile (and fixed) equipment specifically designed for lifting and moving heavy components in the limited space of coal mines (GENERAL).

Remotely controlled trolley pole placement (TRACK).

Replace trolley pole with pantograph design having wide capture span and limited pole freedom, to obviate pole direction reversing, and reduce hand manipulation (TRACK).

More positive switch-position sensors (TRACK).

The postulated preventive measures were related to known USBM programs containing developments pertinent to reduction of haulage hazards. The application of these programs was noted; and a summary was prepared outlining some of the suggestions for additional research and development that might be undertaken or continued. This summary is presented as table 1-3.

## Table 1-3. Summary of Suggestions for Additional Research and Development

OPERATOR COMPARTMENT AND CONTROLS

Develop and demonstrate standardized operator compartments and controls for various track and trackless vehicles.

Develop and demonstrate a system for interlocking drive motors with brake line pressure on trackless vehicles to prevent operation with low brakes.

Develop and demonstrate a retrofit installation of an adjustable seat for trackless face vehicles used in moderately low coal.

Design and evaluate the use of an optimized shuttle car seat equipped with slow-rise shock absorbers.

Develop and demonstrate the use of a key-locking switch to prevent energizing belt drives during maintenance.

AUTOMATIC PILOTS

Continue development of electromagnetic obstacle detectors for use where visibility is limited.

REMOTE/AUTOMATIC CONTROLS

Develop and demonstrate an instrumentation system that will display track vehicle locations and speeds to a dispatcher.

Continue design and development of automatic and remote control concepts for tracked vehicles.

Continue development of remote controls for coupling, decoupling, and parking of mine cars.

Design and demonstrate a simple mechanism for holding automatic couplers open until mine cars separate.

CONTINUOUS HAULAGE

Develop and demonstrate instrumentation systems for automatically controlling continuous face haulage conveyors.

BRAKES AND PANIC BARS

Continue design and development of automatic brakes and "dead-man" controls for trackless and track vehicles.

Develop and demonstrate an improved parking brake indicator that will give a positive indication of FULL-ON condition for both track and trackless vehicles.

PROTECTIVE CANOPIES

Continue development of canopy concepts for low coal haulage machines, perhaps exploring alternatives to complete overhead coverage.

Consider an analytical-design study to determine if full cab enclosures offer a viable alternative to canopies in view of the need for two routes of egress.

Provide simple design and installation guidelines for each model of trackless and track equipment, for use by mine shops in retrofitting vehicles.

ILLUMINATION AND VISION AIDS

Provide for new headlight lens designs for trackless face haulage vehicles. Design should provide diffuse light up and to the side.

Investigate a configuration of headlights and low intensity side lights that will make face haulage vehicles more visible to other miners in the vicinity.

Demonstrate a system that would automatically switch headlights when tram control direction is changed.

Table 1-3. Summary of Suggestions for Additional Research and Development (Concluded)

NOISE CONTROL

Continue current efforts to reduce machine noise.

Improve electronic ear muffs to provide a better fit and eliminate sound distortion.

COMMUNICATIONS

Define the potential gains from using short-range line-of-sight communications between personnel in a working section.

Develop methods of reducing noise in trolley phones.

MAINTENANCE

Develop and demonstrate the use of built-in test equipment to display hydraulic system and electrical system faults on a shuttle car.

Develop rail and track bed design standards for light rails used for mantrips and supply, separate from main line coal haulage standards.

Analyze and evaluate haulage equipment maintenance procedures used in current coal mines. Develop a sample generalized scheduled/preventive system to aid operators and to be used in conjunction with MESA training.

WARNING

Develop and demonstrate automatic warning devices interlocked with tram levers and seats on a shuttle car.

Develop and demonstrate time delay/warning actuators for porta-feeders and belts.

MISCELLANEOUS

Fault-tree analysis of haulage mining functions to highlight hazards of each activity, in conjunction with development of MESA training courses.

Tire and tread designs specifically for underground coal mine haulage vehicles.

Human factors study to establish optimal configurations for safety glasses or flip-up shields.

Develop methods of remotely controlling trolley poles from the operator's normal position. An attractive alternative would be the development of a pantograph concept with a wide wire-capture span that would not have to be reversed for direction changes.

Demonstrate the utility of proximity switches to indicate track switch position.

## 2. INTRODUCTION

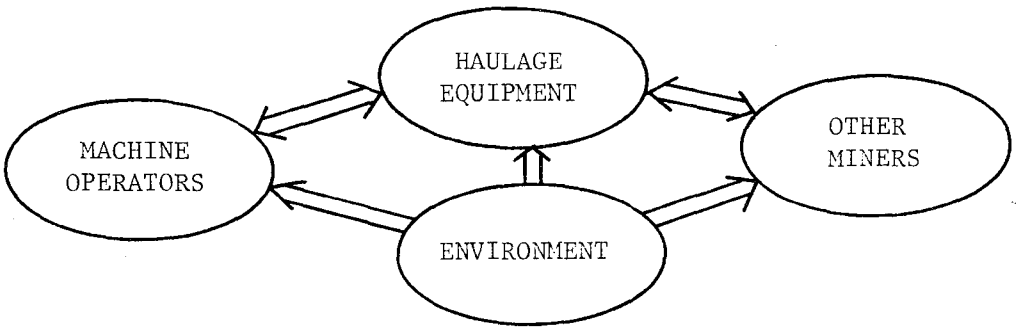
Coal mining productivity in terms of coal mined per man-day increased by 80 percent between 1956 and 1966. During that time span the fatality frequency rate in terms of tons of coal produced declined appreciably. The frequency rate in terms of man-hours of exposure decreased, but to a lesser extent. The trend of the transportation fatality rate, rather than showing a decrease, persisted, and actually showed a slight increase based on man-hours of exposure. The specific causes of this rising trend had not been determined through analyses correlation and interpretation of existing accident data records. Many of the interrelations and distributions had been analyzed, but the hazards associated with each task and element of the various haulage systems had not been identified.

It was believed that an in-depth investigation and analysis of underground haulage hazards, based on an underground survey of a sufficiently large sample of mines, mine sections, and coal seams, would provide a representative and complete model of haulage systems, equipment, and processes currently being used. It was intended that the survey and analysis would result in recommendations for equipment changes, procedural changes, and additional education and training programs.

As suggested in figure 2-1, the objective of this effort was to point the way to reducing accident potential in underground transportation by improving the interfaces between machine operators, other miners, haulage equipment, and the environment. To this end, two major tasks were undertaken:

a. Determine the cause of the rising trend in accidents related to underground transportation. In-mine surveys were made by direct observation in 35 underground coal mines, about one-half of which were under 50-inch seam height. In these surveys, approximately 1 week was spent in each mine observing all kinds of transportation and interviewing mine personnel. In the context of the present study, haulage includes any equipment or system that moves coal, supplies, or men between the face area to the surface. It does not include removal of coal from the seam nor surface operations. The general concept was to rely mainly on personal observation, and to obtain from interviews only information that was difficult or impossible to observe first hand during the visit. Past experience and statistics for each mine were used to guide the survey teams toward observation of the most critical operations.

REDUCE ACCIDENT POTENTIAL BY IMPROVING INTERFACES




A. DETERMINE CAUSE OF RISING TREND IN ACCIDENTS RELATED TO UNDERGROUND TRANSPORTATION:

OBSERVATION

HAZARDOUS CONDITIONS
UNSAFE ACTS

INTERVIEW

OFFICIALS
WORKERS
VICTIMS/WITNESSES

B. RECOMMEND METHODS OF REDUCING ACCIDENTS BY CHANGES IN:

EQUIPMENT

SYSTEM
COMPONENT

MINE

ENVIRONMENT
SYSTEM
PROCEDURES

Figure 2-1. Hazard Analysis of Underground Coal Mine Haulage Systems

b. Recommend methods of reducing accidents by changes in equipment, and, to a lesser extent, by more fundamental changes in the overall mine operations, increased training and motivation, and perhaps propose changes in regulations. Again, the concept was mainly to evaluate solutions of problems where the survey team had first-hand knowledge of a real situation, even if this meant missing some less obvious factors. Thus it was hoped that specific solutions to problems could be identified, rather than provide generalities or speculation about situations not actually seen by the research team. It is to be noted, however, that this was not a detailed design study, but an analysis of the more critical problems of a broad range of transportation operations and equipment types.

The study took place between July 1974 and May 1975, and consisted of four phases. In phase I, the data requirements were defined. This included establishing the data elements requirements and the rationale for their selection, haulage task analysis, selection of candidate mines, and in-mine demonstration of the survey techniques to be used. Phase II included underground observations of all kinds of transportation and interviews with mine personnel. In phase III, the survey results were analyzed along with a review of current USBM research programs that might have been applicable to solving observed problems. In phase IV, recommendations were made for improving the operational interfaces as outlined in the paragraphs ahead. A brief discussion of each of these phases is contained in following sections in this report.

The personnel selected for this investigation had varied experience in system analysis, industrial engineering, electrical and mechanical engineering, mining, and psychology. In order to gain the most from the experience of each researcher, the same personnel took part in all phases of the project.

The Technical Project Officer for this investigation was William Wiehagen of the U.S. Bureau of Mines, Pittsburgh Mining and Safety Research Center, who provided valuable guidance throughout. Personnel of the Mining Enforcement and Safety Administration, Safety Analysis Center, also contributed considerable assistance in commenting on the study approach, providing accident statistics, and evaluating recommendations. Mr. George Judy of George L. Judy Associates, acting as consultant, provided specific expertise in mining practices, equipment, and procedures. Special thanks are due the management, miners, and safety personnel of some 35 mines, without whose excellent cooperation the study would not have been possible. We trust that this and similar investigations will return dividends on their investment.

## 3. PRELIMINARY ANALYSIS

In order to lay a foundation for the survey and subsequent analysis, it was necessary to define the kinds of data needed and to conceive the underground haulage operations in some detail. The preliminary analysis briefly encompassed the total scope of the project with emphasis on preparing forms for observations and interviews.

3.1 Data Requirements - A summary of the basic data required from the survey is listed in table 3-1 together with a brief statement of the rationale leading to the requirement. It was believed that if the researchers could obtain even reliable qualitative information on all of the "requirements" in table 3-1, an adequate basis would be laid for the subsequent analysis. (As it turned out during the surveys, information on regulations, procedures, maintenance, and training effectiveness was difficult to obtain and evaluate, often because formal records were not available in summary form, and sometimes (e.g., training) the subject was too complex to cover adequately in the time available.)

Some of the data desired was available from published information on the mines selected and was updated during interviews with mine personnel. (A list of the types of questions asked of mine personnel is given in table 3-2.) In order to provide a vehicle for obtaining consistent data from all mines, structured interview forms were prepared.

3.2 Preliminary Task Analysis - In preparation for the survey and to obtain a preview of each type of haulage equipment and the operation, a task analysis to a moderate level of detail was made. Table 3-3 contains a list of the basic equipment categories considered. The analysis and subsequent survey included underground haulage and transportation operations from the outby loader interface to the mine portal. It did not consider removal of coal from the seam nor operations aboveground, except where these were integral with underground haulage. Although the emphasis was on coal haulage, the transportation of personnel, supplies, and equipment was included. A simplified diagram of a typical haulage operation is sketched in figure 3-1. The task analyses were transformed directly onto observation forms, one page of which is shown in figure 3-2. In parallel with the operation task analysis, a review was made of all accidents that might occur during each type of operation. Figure 3-3 contains a suggestion of this kind of preparation, but at a high level of activity. This concept was carried down to the detailed task level, listing potential "hazardous conditions" and "unsafe acts" that might occur in conjunction with each task. Thus the surveyors were prepared ahead of time to observe those activities that were most conducive to accidents, and also knew what kind of problems to look for. During interviews with mine safety officials, these preconceptions were reviewed for each particular mine before observation began.

Table 3-1. Data Element Requirements

| |
|---|
| MINE NUMBER, LOCATION, SEAM, AND DISTRICT: Fundamental data. |
| HAULAGE TYPES FOR COAL, SUPPLIES, PERSONNEL: Fundamental to study. |
| TASK BREAKDOWN: Provided a preview and detailed understanding of activities in each haulage operation. Provided a format for observation. Updated during survey. |
| HAZARD-CRITICAL POINTS: These were the places in the operation where accidents were deemed likely to happen. Provided a guide for observers to take data meaningful to the study. |
| OBSERVED HAZARDOUS CONDITIONS: These were the actual conditions of equipment, mine, or environment observed by the surveyors while underground or obtained during interviews. Basic survey outputs. |
| OBSERVED UNSAFE ACTS: These were actual acts observed that were judged to be unsafe, whether or not they were a clear violation of the Code of Federal Regulations, Title 30, Part 75. Basic survey outputs. |
| RECENT ACCIDENT STATISTICS: Recent accident types, severity, and causes (if available) of all lost-time accidents for each mine visited. Possible correlation parameters. |
| VICTIM AND WITNESS BACKGROUND AND COMMENTS: First-hand accounts of the most recent lost-time accidents in each mine not possible for researchers to observe. |
| PLACE DIMENSIONS: Affect accident potential directly or indirectly. Affect maneuvering spaces, parking space, safety zones, visibility, head room, safe speed, etc. |
| GENERAL RIB CONDITIONS: Modify place dimension information. May contribute indirectly to haulage related hazards. |
| GENERAL BOTTOM CONDITIONS: Affect accident potential, ability to control machines, electrical hazards, safe speed, traction, footing, etc. |
| GENERAL TOP CONDITIONS: May contribute indirectly to haulage related accidents. |

Table 3-1. Data Element Requirements (Concluded)

SPECIAL SAFETY FEATURES ON EQUIPMENT: May affect hazardous conditions; part of basic survey output.

MINE PLAN AND VENTILATION SYSTEM: Fundamental mine characteristics that may influence haulage type, routing, and operations.

MINING METHOD: May affect haulage operation, interfaces, number of activities, routes, etc.

PRODUCTION RATES: Indication of mine size and overall efficiency of operation. Possible correlation parameter.

SAFETY REGULATIONS AND PROCEDURES: Degree of formality and compliance may affect incidence of unsafe acts.

JOB PROCEDURES: Degree of formality in training, verifying and updating procedures may give a general indication of management control and motivation to improve all phases of mine operation, including safety.

TRAINING: The depth and types of training for equipment operation and safety may find correlation with unsafe acts, and hazardous conditions to a lesser degree.

MAINTENANCE SCHEDULES BY TYPE: The degree of formality may affect data on hazardous conditions.

AVERAGE DOWN TIME FOR HAULAGE EQUIPMENT: Indication of maintenance efficiency.

EXPERIENCE LEVEL OF MINERS AND FOREMEN: May affect data on unsafe acts. Possible correlation parameter.

Table 3-2. Interview Questions

| INFORMATION \ PERSONNEL | MANAGEMENT | SAFETY OFFICIAL | UNION REPRESENTATIVES | WITNESSES | VICTIMS | SUPERVISORS | MINERS |
|---|---|---|---|---|---|---|---|
| General Mine Data and Communication, Lighting, Instrumentation, Controls, etc. | X | X | | | | | |
| Major Safety Problems | | X | X | | | | X |
| Environmental Problems | | X | | | | X | |
| Accident Statistics | | X | | | | | |
| Accident Specifics (last 4 months) | | | | X | X | | |
| Inspection/Maintenance Procedures and Breakdown Data | X | X | | | | X | |
| Safety Regulations and Procedures | | X | | | | | |
| Conformance to Safety Regulations | | X | | | | X | X |
| Safety Motivation - Enforcement and Rewards | X | | | | | | |
| Experience Level - Supervision and Miners | X | | | | | X | X |
| Training - Job Procedures Formalized and Verified | X | X | | | | X | X |
| Safety Classes | | X | | | | | |
| Haulage System and Operational Details | | | | | | X | X |

Table 3-3. Basic Equipment Categories

| TRANSPORTATION GROUP | EQUIPMENT TYPE EXAMPLES |
|---|---|
| Trackless | Shuttle Cars, Tractor-Trailer, Tractor Scoop, Low Boy, etc. (Cable-Elec, Battery, or Diesel) |
| Mine Gauge Railroad | Coal Cars, Man Cars, Equip Cars, Jeeps, etc. (Drag-Cable, Cable-Elec, Trolley, Diesel, or Diesel-Elec) |
| Conveyor | Belt, Chain, Feeders, Self-Advancing, etc. |
| Hoist | Cage, Skip, Koepe, etc. (Vertical or Slope) |
| Transfer | Bins, Rotary Dump, Drop-Bottom Dump, Centrifugal Dump, Car Spotter, etc. |

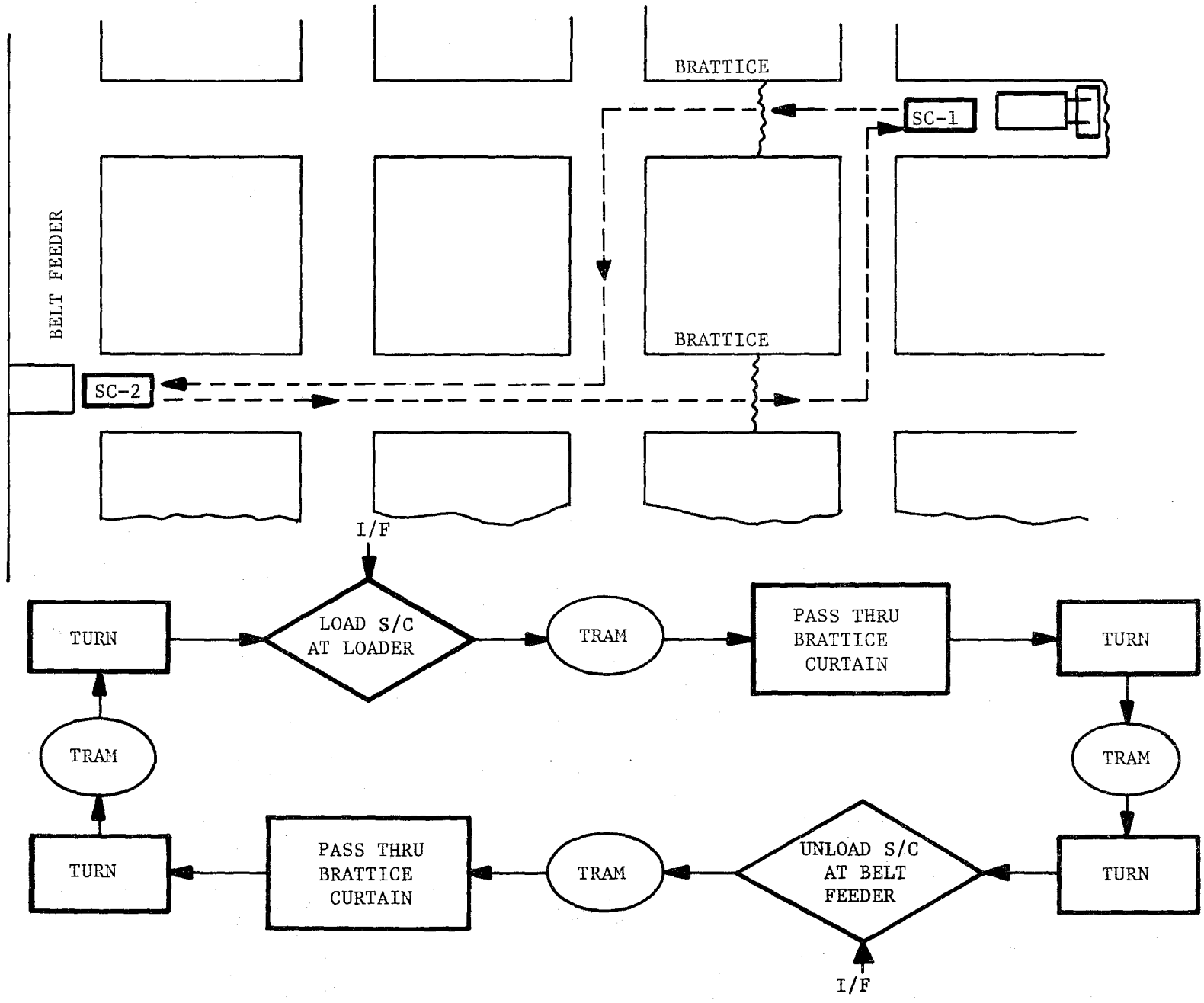



Figure 3-1. Simplified Diagram of Shuttle Car Operation

FORM A | HAULAGE TASK ANALYSIS | MINE: 4/17/74 SEAM: Pittsburg DISTRICT: 2

TRANSPORTATION GROUP: Trackless TYPE: S/C PLACE IN MINE: FACE X SEC MAIN CYCLES/SHIFT 20

EQUIPMENT MFR: JOY MODEL: 10SC22B PRODUCT HAULED: COAL X PERS SUPPL.

| FUNCTION | FREQ | TIME | OPERATOR TASK | REMARKS | HAZARD COND | UNSAFE ACT |
|---|---|---|---|---|---|---|
| 2. Tram | 60 | 5.0 | Note position of trailing cable. | | Cable buried by coal spillage | |
| | | | o Change seats to face direction of travel. | | | |
| | | | o Reset headlights. | | Left front light out | |
| | | | * Sound warning bell and ascertain that all personnel are clear before starting. | | | Sounder Bell after starting |
| | | | o Drive speed suitable for conditions. | | | |

RR GRADE: _____ SECT. VENT: 2 in, 2 E-L, Neutcomer

SIGNALLING: _____ PHONE: _____

SWITCHING: _____ ELECT: _____

Figure 3-2. Sample Observation Form

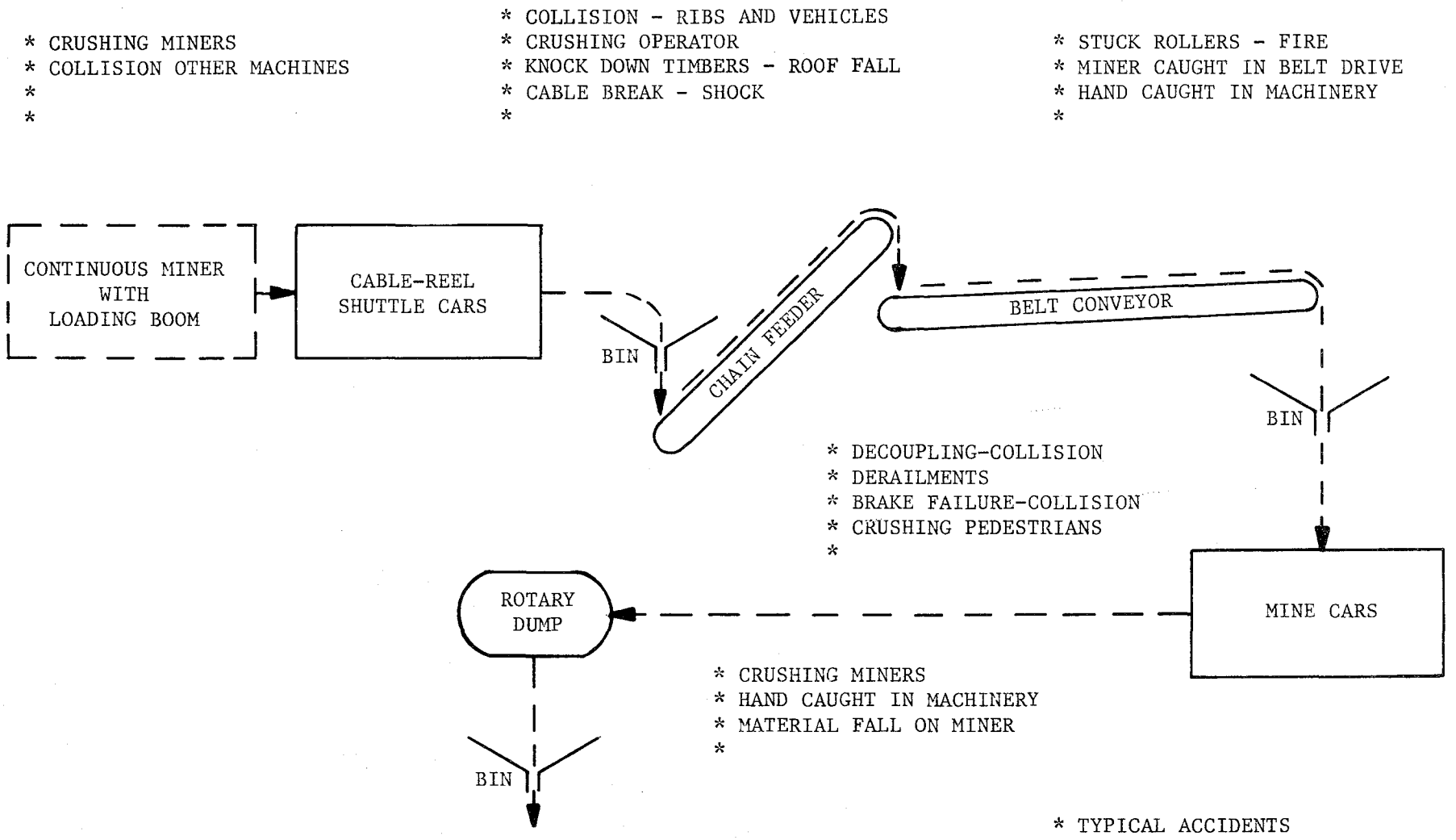



Figure 3-3. Hypothetical Underground Coal Mine Haulage System

# 4. IN-MINE SURVEYS

4.1 Seams and MESA Districts Visited - Table 4-1 contains a summary of the MESA districts and coal seams visited. A total of 35 mines were included in the survey. It may be noted that about one-half of the survey was conducted in mines with heights of 50 inches or less. In general, it is believed that these mines represent a fairly good cross section of coal mines in the U.S. in terms of mine plans, mine systems, and environmental conditions. While most of the sections visited used room-and-pillar mining, three used the shortwall mining method.

4.2 Equipment Categories Observed - In making the selection of the specific mines to include in the survey, an attempt was made to observe all of the types of haulage currently being used in the U.S. Table 4-2 contains a list of the kinds of haulage equipment used for transporting coal, men, supplies, and equipment.

4.3 Survey Approach - The survey at each mine consisted of approximately 1 week, divided into three major parts: initial meeting with key personnel, observations of haulage operations, and interviews with mine personnel. The initial meeting served three purposes: 1) to explain and coordinate our visit, 2) to gain familiarity with the mine, and 3) to choose the "hazard-critical" points for observation. During these interviews with management and safety personnel, an attempt was made to obtain data on mine accident history for the previous 2 or 3 years, whether the accidents resulted in lost time or not. In a few cases, convenient summary data were available, but for the most part only qualitative information was obtained.

During the underground observations, the task analyses were completed and updated to reflect the actual activities that took place. Observed "hazardous conditions" or "unsafe acts" were noted in the appropriate columns on the forms. Usually, each operation was observed several times, often from different observer locations. The intent was to spend sufficient time observing each "hazard critical" operation so as to understand the problems of the operator and to assess those factors that might contribute to accidents. In addition, interviews were held with most haulage equipment operators to obtain their views on the problems and factors contributing to accidents, some of which, of course, were not observable. Where possible and permitted, the observer would ride with the trip. Most of these were on main haulage runs and man trips. In some cases it was possible only to watch the

Table 4-1. Survey Mines and Seams

| MESA DISTRICT | SEAMS | NO. OF MINES | SEAM HEIGHT (INCHES) |
|---|---|---|---|
| 2 | Lower Kittanning | 3 | 42-54 |
| | Pittsburgh | 3 | 68-78 |
| | Lower Freeport (D) | 2 | 40-42 |
| 3 | Pittsburgh | 2 | 72-76 |
| | Sewell | 4 | 27-42 |
| 4 | Pocahontas No. 3 | 3 | 37-72 |
| | Pocahontas No. 6 | 1 | 60 |
| 5 | Taggert No. 5 | 4 | 42-50 |
| 6 | Middle Coalburg | 1 | 84 |
| | Elkhorn No. 3 | 1 | 42-44 |
| | Elkhorn No. 9 | 1 | 60 |
| 8 | Herrin No. 6 | 5 | 72-80 |
| | Illinois No. 5 | 2 | 50-54 |
| 9 | Lower Sunnyside | 1 | 60 |
| | Upper Sunnyside | 1 | 50 |
| | Colorado (B) | 1 | 84 |

Table 4-2. Equipment Categories Observed

| HAULAGE CATEGORY | APPROXIMATE NUMBER OF UNIT OPERATIONS OBSERVED |
|---|---|
| TRACKLESS | |
| Shuttle Car (Cable) | 132 |
| Teletram (Diesel) | 4 |
| Tractor-Trailer (Battery) | 5 |
| Tractor-Scoop (Battery) | 9 |
| Tractor-Scoop (Diesel) | 2 |
| Personnel/Supply (Battery) | 26 |
| Personnel/Supply (Diesel) | 2 |
| TRACK | |
| Main Line (Trolley) | 13 |
| Secondary (Trolley) | 10 |
| Secondary (Battery) | 6 |
| Supply (Trolley) | 12 |
| Supply (Battery) | 9 |
| Personnel (Trolley) | 41 |
| Personnel (Battery) | 12 |
| CONVEYORS | |
| Main and Secondary (Belt) | 61 |
| Feeders (Chain) | 28 |
| Continuous Face (Belt) | 4 |
| Continuous Face (Flex Belt) | 2 |
| Continuous Face (Chain) | 3 |
| Used for Personnel/Supplies | 14 |
| TRANSFER | |
| Rotary Dump | 10 |
| Drop-Bottom Dump | 1 |
| Side Dump | 1 |
| Car Spotters | 37 |
| Transfer Bins | 44 |
| HOIST | |
| Elevators | 18 |
| Cages | 10 |
| Slope | 13 |
| Skip | 4 |

start and end of an operation or to observe activities only at discrete points. For example, long conveyors were observed at the loading points, transfer points where one conveyor loads onto another or unloads, at drives, and at control stations. When possible, low level maintenance activities also were observed.

## 5. DATA CORRELATION AND ANALYSIS

5.1 Summary of Survey Results - Table 5-1 contains a quantitative summary of all "hazardous conditions" and "unsafe acts" observed in the mines surveyed. In each box, the denominator is the total number of observations of an activity or separate unit of equipment in operation. The numerator is the number of times the specific hazardous condition was observed or the number of operations where the unsafe act was committed. In regard to a few factors (general mine illumination, vehicle lighting, noise, canopy configuration, and control design) inadequate ratings were given only where conditions were seriously worse than the average, although these factors were considered to be less than optimal in nearly all cases, as noted in the "remarks" column.

The normalized incidence rate ($I_n$) was computed to provide a numerical indication of the prevalence of the "fault" in the 35 mines surveyed, and was used as an input into subsequent analysis. The reader will note that this factor not only gives an indication of how bad things were in the sample mines, but also how good things were in regard to a great number of factors. It is to be noted that the observers got the impression that most of these mines had, or were developing, positive safety action programs that have promise of reducing hazards. It is hoped that this subject analysis will provide some useful suggestions to them for inclusion in these programs.

5.2 Hazard Effects - Correlation With Accident Statistics - In order to provide a basis for helping to establish the importance of the observed factors in contributing to accidents, a compilation was made of haulage-related accidents that have occurred during 1974 in the 35 mines surveyed. These data were obtained by perusal of about 600 accident reports in the files of the Mine Enforcement and Safety Administration Health and Safety Analysis Center. It is to be noted that these haulage-related accidents included accidents classified in categories other than "haulage" in the MESA files. Because of this and because the accident data sample is rather small, the correlation between this sample and all mines in the U.S. is not very good. (See, for example, the data in references 1 and 2.) Many of the accidents were eliminated because they resulted from unique situations or were not directly related to haulage. The list was further reduced to include only those accidents in which more than 40 man-days were lost during 1974 in the 35 mines surveyed. The remaining accidents were then classified into the 18 significant types given in table 5-2.

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts

HAULAGE CATEGORY: Trackless

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| HAZARDOUS CONDITIONS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Environment | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Insufficient or obstructed side clearance (36 inches minimum; 75.1403-10h). | 6 | 1 | 5 | 5 | 3 | 3 | 4 | 5 | 5 | 8 | 3 | 3 | 3 | 6 | 3 | 4 | 4 | 2 | 1/1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1/2 | 2 | 2 | 2 | 1 | 2/106 | |
| Irregular ribs, brows, and ledges. | 1/6 | 1 | 5 | 5 | 3 | 3 | 4 | 5 | 1/5 | 8/8 | 3 | 3 | 3 | 6 | 3 | 4 | 4 | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 2/2 | 2/2 | 2 | 2 | 2 | 2/2 | 2/2 | 2 | 2/2 | 2 | 1 | 20/106 | |
| Abrupt change of overhead clearance. | 6 | 1 | 5 | 1/5 | 3 | 3 | 4 | 5 | 5 | 8 | 3 | 1/3 | 1/3 | 6 | 3 | 4 | 4 | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1/2 | 1/2 | 2 | 2 | 2 | 2 | 1 | 5/106 | |
| Restricted overhead clearance. | 6 | 1 | 3/5 | 1/5 | 2/3 | 3 | 4 | 5 | 5 | 8 | 3 | 3 | 3 | 6 | 3 | 4 | 4 | 2 | 1 | 2/2 | 2/2 | 2/3 | 2 | 2/2 | 2 | 2 | 2 | 2 | 2 | 1/2 | 2 | 2 | 2 | 2 | 1 | 15/106 | |
| Lack of signs warning of restricted overhead clearance (75.1403-10c). | 6 | | | | 1/1 | | | | | 8 | | | 1/3 | 6 | | | | | | 2 | 2 | | | 2 | 2 | 2 | | | | | 2 | 2 | 2 | | | 2/40 | Observations are in mines that use trackless haulage to surface or for supplies. |
| Uneven, sidling, wet, or muddy floor (75.1403-10i). | 1/6 | 1 | 2/5 | 5/5 | 1/3 | 3/3 | 2/4 | 3/5 | 2/5 | 1/8 | 1/3 | 3 | 3 | 6 | 3 | 1/4 | 4 | 2/2 | 1/1 | 1/2 | 1/2 | 1/3 | 1/2 | 2 | 2/2 | 2/2 | 2 | 2 | 2 | 2 | 2/2 | 2 | 2 | 2 | 1 | 35/106 | |
| Poor footing, including clearance area along ribs (e.g., rounded rib-bottom intersection). | 6 | 1 | 5 | 5 | 1/3 | 3 | 4 | 1/5 | 1/5 | 8 | 1/3 | 3 | 3 | 6 | 3 | 4 | 4 | 2 | 1 | 2 | 1/2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1/2 | 2 | 2 | 2 | 2 | 1 | 6/106 | Illumination in all mines visited was less than desirable, but it is considered OK by the miners. Bendix believes that general safety would be improved by more light properly diffused. |
| Roof supports that may be dislodged by vehicle. | 6 | 1 | 5/5 | 5 | 3 | 3 | 4 | 2/5 | 5 | 8 | 3 | 3 | 3 | 6 | 3 | 2/4 | 1/4 | 2 | 1/1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 11/106 | |
| View obstructed by brattice. | | 1 | 10/10 | 5/5 | 3/3 | 3 | 4 | 2/5 | 2/5 | 6/6 | 1/3 | 2/2 | 2/2 | 4/4 | 3 | 2/4 | 3/4 | 1/2 | 1 | 2/2 | 2 | 1/3 | 2 | 2 | 1/4 | 2/4 | 1/2 | 1/2 | 2/2 | 2 | 2/2 | | 2/2 | 1/2 | 1 | 58/101 | |
| Excessive debris or spillage on roadway. | 6 | 1 | 5/5 | 3/5 | 3 | 3 | 2/4 | 2/5 | | 8 | 3 | 3 | 3 | 6 | 3 | 4 | 4 | 2 | 1 | 2 | 2 | 1/3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1/2 | 1/2 | 2 | 1/2 | 2 | 1 | 16/101 | |
| Insufficient illumination. | 6 | 1 | 5 | 1/5 | 3 | 3 | 4 | | | 6 | 3 | 3 | 3 | 4 | 5 | 4 | 4 | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | 2 | 2 | 1 | 1/92 | Noise appeared to be a problem near the face and at rail loading points in all mines, even though miners did not complain. |
| Excessive dust, resulting in poor visibility. | 6 | 1 | 5/5 | 5 | 3 | 3 | 4 | 1/5 | | 6 | 1/3 | 2 | 2 | 4 | 1/3 | 4 | 4 | 1/2 | 1 | 2 | 2 | 2/3 | 2 | 2 | 2 | 1/2 | 1/2 | 2 | 2 | 2 | 1/2 | 2 | 2 | 2 | 1 | 14/95 | |
| Noise resulting in poor communication. | 6 | 1/1 | 5/5 | 1/2 | 3/3 | 3/3 | 4/4 | 5/5 | 5/5 | 6 | 3 | 2 | 2 | 4 | 3 | 4/4 | 4/4 | 2 | 1 | 1 | 2 | 3/3 | 2/2 | 2 | 2/2 | 2/2 | 1 | 2 | 2/2 | 2/2 | 2/2 | 2 | 2/2 | 1/2 | 1 | 53/95 | |

NOTES: 1. $I_n$ = Normalized Incidence Rate = Incidence of Observed Hazardous Conditions or Unsafe Acts ÷ Total Number of Unit Observations.

2. Blank Space Indicates an Item or a Condition Not Observed.

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Trackless

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Equipment | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Poor driver visibility. | 12 | 2 | 8/10 | 2/10 | 3/6 | 6 | 8 | 4/10 | 2/10 | 6 | 2/6 | 4/4 | 4/4 | 4 | 2/4 | 6/8 | 6/8 | 2 | 1/1 | 2/2 | 2/2 | 2/6 | 4 | 1 | | 2/4 | | | 2/4 | 3/4 | 3/4 | | 3/4 | 1/2 | 1 | 64/159 | |
| Defective equipment (maintenance): brakes, lights, steering, audible warning device, tramming control. | 8/12 | 2 | 4/10 | 3/5 | 2/6 | 4/6 | 2/4 | 3/10 | 4/10 | 4/8 | 2/4 | 4 | 3/3 | 3/6 | 2/3 | 8 | 2/8 | 1/2 | 1 | 1/2 | 2/2 | 2/6 | 1/4 | | 2/4 | 2/4 | 1/3 | 3 | 2/4 | 3/4 | 3/4 | | 2/5 | 2 | 1 | 68/160 | |
| Lack of, or poor design of, canopies. | 12 | 2 | 4/10 | 10/10 | 6/6 | 2/6 | 8 | 5/10 | 8/10 | 6 | 6/6 | 4/4 | 4 | 4/4 | 2/4 | 4/8 | 4/8 | 2/2 | 1/1 | 2/2 | 2/2 | 6/6 | 4/4 | 1 | 4 | 4 | 2/2 | 3/3 | 4 | 4/4 | 4/4 | | 2/5 | 2 | 1 | 91/169 | No canopy designs were considered optimal although some were adequate. |
| Square corners on equipment (should be rounded). | 12 | 2 | 10 | | | 6 | 8 | | | 8 | 6 | 4 | 5 | 6 | 4 | 8 | 8 | 2 | 1 | 2 | 2 | | | 1 | 4 | 4 | 2 | 3 | | | | 5 | 2 | 1 | 0/116 | |
| Items protruding from equipment. | 12 | 2 | 10 | 5 | 6 | 6 | 8 | 5 | 5 | 2 | 6 | 4 | 5 | 2 | 4 | 8 | 4/8 | 2 | 1 | 2 | 2 | 6 | 4 | 1 | 2/4 | 2/4 | 2 | 3 | 4 | 4 | 4 | | 5 | 2 | | 8/148 | Vehicle lighting was not considered optimal on any vehicles. |
| Lack of visible means of disconnecting power from trailing cables. | 12 | 2 | 10 | | | 6 | 8 | | | 6 | | | | 4 | | 8 | 8 | | | 2 | 2 | | | 1 | 4 | 4 | | | | | | 5 | 2 | 1 | 0/85 | Mines 26, 33, and 34 have cages or gates therefore no need for panic bars. Many machines had panic bars which interfered with the operation of equipment controls. |
| Insufficient lighting on vehicles. | 12 | 2 | 10 | 2/6 | 6 | 6 | 4 | 1/5 | 2/6 | 8 | 6 | 1/4 | 5 | 6 | 1/3 | 2/8 | 2/8 | 1/2 | 1/1 | | | 1/6 | | | 1/4 | 4 | 2 | 1/3 | 2/4 | 4 | 2/4 | | 5 | 2 | 1 | 20/147 | |
| Inadequate or no panic bars. | 12/12 | 2 | 6/10 | 2/4 | 6/6 | 6/6 | 8/8 | | | 8/8 | 6/6 | 4/4 | 4/4 | 6/6 | 4/4 | 2/8 | 2/8 | 2/2 | 1/1 | 2/2 | 2/2 | 2/6 | 4 | 1 | 4/4 | | 2/2 | 3 | 3/4 | | 4 | | | | 1 | 94/132 | |
| Use of improper circuit breakers or splicing on trailing cables. | 12 | 2 | 10 | 10 | 6 | 6 | 8 | 6 | 4 | 6 | | | | 4 | | 8 | 8 | | | 2 | 2 | 6 | 4 | 1 | | 4 | | | 1/4 | 4 | 4 | | 4 | | 1 | 1/126 | Includes instances where miners complained about equipment on safety belt catching on controls. No controls appeared to be optimal although miners complained in only a few cases, e.g., foot controls crossed. |
| Poor design or location of controls. | 12 | 2 | 6/10 | 6 | 4/6 | 6 | 4/8 | 5/10 | 5/10 | 6 | 6 | 1/4 | 1/4 | 4 | 4 | 2/8 | 8 | 1/2 | 1 | 2/2 | 2 | 6 | 1/4 | 1 | 1/4 | 1/4 | 2 | 3 | 1/4 | 4 | 1/4 | | 2/5 | 2 | 1 | 38/165 | |
| No dimmer switch on shuttle car. | 12 | 2 | 10 | | 6 | 1/6 | 8 | | | 6 | | 1/2 | | 4 | | 8 | 8 | | | 2 | 2 | | | 1 | 4 | 1/4 | 2 | 2 | | | | | 4 | | 1 | 3/94 | |
| Operation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Two shuttle cars using same road. | 6 | 2 | 2/10 | 3 | 3 | 6 | 2/8 | 1/5 | | 6 | 3 | 2 | 2 | 4 | 2 | 2/8 | 2/8 | | 1 | 2 | 2 | 2/3 | 2/2 | | 4 | 4 | 1 | 1 | 1/2 | 2 | 2/4 | | 5 | 2 | 1 | 16/114 | |
| Excessive back-spooling. | 12 | 2 | 2/10 | 1/2 | 1/3 | 2/6 | 8 | 5 | | 3/6 | 3 | 2 | 2 | 4 | 2 | 8 | 8 | 2 | 2 | 2 | 2 | 3 | 1/2 | 1 | | 4 | | 3 | 1/2 | | 1/4 | | 4 | 2 | 1 | 12/117 | |

Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Trackless

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| UNSAFE ACTS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Excessive speed. | 2/12 | 2 | 10 | 4 | 1/4 | 6 | 8 | 2/5 | 5 | 8 | 2/6 | 4 | 5 | 2/4 | 4 | 3/8 | 3/8 | 2 | 1 | 2 | 2 | 3 | 1/2 | 1 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | | 5 | 2 | 1 | 16/144 | |
| Failure to face direction of travel (75.1403-10j). | 1/12 | 2 | 2/10 | 4 | 4 | | | | | 8 | 1/6 | 2/4 | 5 | 4 | 4 | 8 | 8 | 2 | 1 | 2/2 | 2/2 | 3 | 1/2 | 1 | 2/4 | 4 | 3 | 3 | 2 | 2 | 2 | | 5 | 2 | 1 | 13/120 | |
| Handling of equipment by inexperienced or unfamiliar operators. | 2/12 | 2 | 2/10 | 1/4 | 3/6 | 6 | 8 | 2/5 | 2/5 | 1/8 | 6 | 4 | 5 | 4 | 4 | 8 | 8 | 2 | 1 | 2 | 2 | 2/3 | 2 | 1 | 4 | 4 | 3 | 3 | 1/2 | 1/2 | 1/2 | 2 | 5 | 2 | 1 | 18/148 | |
| Riding in an unsafe position, operators standing while car is moving, riding inside shuttle car when conveyor chain is not locked. | 4/12 | 2/2 | 5/10 | 1/1 | 2/4 | 1/6 | 1/8 | 1/5 | 2/5 | 8 | 2/6 | 2/4 | 5 | 6 | 4 | 2/8 | 4/8 | 2 | 1/1 | 2 | 2 | 1/3 | 2 | 1 | 2/4 | 2/4 | 3 | 3 | 2 | 2 | 2 | | 5 | 2 | 1 | 35/143 | |
| Changing seats while car is in motion. | 12 | 2 | 10 | 4 | 1/4 | 6 | 8 | 5 | 1/5 | 8 | 6 | 4 | 5 | 6 | 4 | 8 | 8 | 2 | 1 | 2 | 2 | 3 | 2 | 1 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | | 4 | | 1 | 2/143 | |
| Failure to sound audible warning before starting, and at approach to curtains, turns, or any place where persons are likely to be (75.1403-10f). | 12/12 | 2/2 | 10/10 | 4/4 | 4/4 | 6/6 | 8/8 | 3/5 | 3/5 | 6/6 | 5/6 | 2/4 | 2/4 | 3/4 | 4/4 | 8/8 | 8/8 | 4/4 | 2/2 | 2/2 | 2/2 | 3/3 | 2/2 | 1/1 | 4/4 | 4/4 | 4/4 | 3/4 | 2/2 | 1/2 | 2/2 | | 5/5 | 2/2 | 1/1 | 134/146 | |
| Failure to dim headlights. | 1/12 | 2 | 6/10 | | | 6 | 8 | | | 2/8 | 6 | 4 | 5 | 6 | 4 | 8 | 8 | 2 | 1 | 2 | 2 | | | 1 | 4 | 4 | 3 | 3 | | | | | 4 | 2 | 1 | 9/116 | |
| Failure to have headlights on while tramming. | 1/12 | 1/2 | 10 | 1/3 | 4 | 6 | 8 | 1/5 | 1/5 | 2/6 | 6 | 4 | 1/5 | 6 | 4 | 2/8 | 8 | 1/2 | 1 | 2 | 1/2 | 3 | 2 | 1 | 2/4 | 2/4 | 3 | 3 | 2 | 2 | 2 | | 1/4 | 2 | 1 | 17/142 | |
| Parking equipment in dangerous locations, such as near curtains or track. | 12 | 2 | 2/10 | 3 | 4 | 6 | 8 | | 1/3 | 1/8 | 6 | 4 | 5 | 4 | 4 | 8 | 8 | 2 | 1 | 2 | 2 | 3 | 2 | | 4 | 4 | 2 | 1/3 | 2 | 2 | 2 | | 1/5 | 2 | 1 | 6/134 | |
| Failure to shut controls off, set brakes, and secure or block wheels to prevent rolling, on unattended equipment. | 12 | 2 | 10 | | 2 | 6 | 2/8 | 2/5 | 5 | 2/8 | | | 1 | 4 | | 8 | 8 | | | 2 | 2 | 3 | 2 | | 4 | 4 | | | 2 | 2 | 2 | | 1/5 | 4 | 1 | 7/112 | |
| Failure to set brake when changing seats. | 2/12 | 2/10 | 10/10 | 3 | 4 | 6/6 | 8/8 | 5 | 5 | 3/6 | 6 | 4 | 4 | 2/4 | 1/4 | 8/8 | 8/8 | 2 | 1 | | 2 | 3 | 2 | | 4/4 | 4/4 | | 3 | 2 | 2 | 2 | | 5/5 | | 1/1 | 64/140 | |

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Trackless

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Getting on or off moving equipment. | 1/12 | 1/2 | 1/10 | 1/4 | 1/4 | 1/6 | 1/8 | 1/5 | 1/5 | 1/8 | 1/6 | 1/4 | 1/5 | 1/6 | 1/4 | 1/8 | 1/8 | 1/2 | 1/1 | 1/2 | 1/2 | 1/3 | 1/2 | | 1/4 | 1/4 | 1/3 | 1/3 | 1/2 | 1/2 | 1/2 | | 1/5 | 1/2 | 1/1 | 1/145 | |
| Failure to check equipment (brakes, lights, etc.) and familiarize with roadway at start of each shift. | 1/12 | 1/2 | 1/10 | 3/4 | 1/5 | 1/6 | 2/8 | 1/5 | 1/5 | 1/3 | 1/2 | 1/2 | 1/2 | 1/2 | 1/3 | 2/8 | 1/8 | 1/2 | 1/1 | 1/2 | | 2/3 | 1/2 | | 1/4 | 1/4 | 1/3 | 1/3 | 1/2 | 1/2 | 1/2 | | 2/4 | 1/2 | 1/1 | 14/124 | |
| Following other cars too closely. | | 1/2 | 1/10 | 1/1 | 1/4 | 1/6 | 1/8 | 1/5 | 1/5 | 1/2 | 1/6 | 1/4 | 1/5 | 1/2 | 1/4 | 1/8 | 1/8 | | 1/2 | 1/2 | | 1/3 | 1/2 | | 1/4 | 1/4 | 1/3 | 1/1 | 1/2 | 1/2 | 1/2 | | 1/5 | 1/2 | 1/1 | 2/115 | |
| Failure to deenergize equipment while being repaired. | 1/12 | | 2/10 | | | | | | | 1/8 | | | | 1/1 | | | | | | 1/2 | 1/2 | | | | | | | | | | | | | | | 4/35 | |
| Failure to keep area of operating controls clear of obstructions. | 1/12 | 1/2 | 1/10 | | 1/4 | 1/6 | 1/8 | 1/2 | 1/5 | 1/8 | 1/6 | 1/4 | 1/5 | 1/6 | 1/4 | 1/8 | 1/8 | 1/2 | 1/2 | 1/2 | 1/2 | 1/3 | 1/2 | | 1/4 | 1/4 | 1/3 | 1/3 | 1/2 | 1/2 | 1/2 | 1/2 | 1/5 | 1/2 | 1/1 | 5/141 | |
| Loading coal too high - no visibility. | 1/12 | 2/2 | 8/10 | 1/4 | 1/4 | 3/3 | 4/4 | 1/5 | 1/5 | 2/6 | 1/6 | 1/4 | 1/4 | 2/4 | 1/4 | 3/8 | 3/8 | 1/2 | 1/2 | 2/2 | 2/2 | 1/3 | 1/2 | 1/1 | 1/4 | 2/4 | 1/2 | 1/3 | 1/2 | 1/2 | 1/2 | | 1/4 | | 1/1 | 37/131 | |
| Raising boom while tramming - blocking visibility. | 2/12 | 1/2 | 1/10 | 1/4 | 1/4 | 1/6 | 1/8 | 1/5 | 1/5 | 1/6 | 1/6 | 1/4 | 1/4 | 1/4 | 1/4 | 2/8 | 3/8 | 1/2 | 1/2 | 1/2 | 1/2 | 1/3 | 1/2 | 1/1 | | 1/4 | | 1/3 | 1/2 | 1/2 | 1/2 | | 2/4 | | 1/1 | 12/132 | Mine 4 must raise boom before final stop at dump to clear belt. |
| Failure to observe caution when passing thru brattice. | 1/12 | 1/2 | 4/10 | 4/4 | 2/4 | 1/6 | 1/8 | 1/1 | 1/2 | 1/6 | 1/2 | 1/4 | 1/4 | 1/4 | 1/1 | 2/8 | 1/8 | 1/1 | | 1/2 | | 1/3 | 1/2 | | 1/4 | 1/4 | 1/1 | 1/2 | 1/2 | 1/2 | 2/2 | | 1/5 | 1/2 | 1/1 | 20/119 | |
| Poor cable control. | 1/12 | 1/2 | 1/10 | 1/4 | 1/3 | 1/6 | 1/8 | 1/5 | 1/5 | 1/6 | | | | 1/4 | | 2/8 | 3/8 | | | 1/2 | 1/2 | 1/3 | 1/2 | 1/1 | | 1/4 | | | 1/2 | 1/2 | 1/2 | | 1/4 | | 1/1 | 10/106 | |
| Moving supplies and men on same trip. | | 1/2 | 1/10 | 1/4 | 1/3 | 1/6 | 1/8 | 1/5 | 1/5 | 1/2 | | | | 1/1 | | 1/8 | 1/8 | | | 1/2 | | 1/3 | 1/2 | | 1/4 | 1/4 | | | 1/2 | 1/2 | 1/2 | | 1/5 | 1/2 | 1/1 | 1/91 | |

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Track

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| HAZARDOUS CONDITIONS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Environment | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Insufficient or obstructed side clearance (24 inches minimum one side; CFR 75.1403-8). | $\frac{\overline{6}}{}$ | $\frac{\overline{1}}{}$ | $\frac{2}{5}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{5}}{}$ | $\frac{\overline{6}}{}$ | $\frac{\overline{3}}{}$ | $\frac{\overline{3}}{}$ | | | | | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{5}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{2}{72}$ | |
| Lack of warning sign where clearance crosses over. | $\frac{\overline{6}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{5}}{}$ | | | $\frac{\overline{5}}{}$ | $\frac{\overline{6}}{}$ | | | | | | | $\frac{\overline{2}}{}$ | | $\frac{\overline{4}}{}$ | $\frac{\overline{5}}{}$ | | | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | | | | | | $\frac{\overline{4}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{0}{48}$ | |
| Abrupt change of overhead clearance. | $\frac{\overline{6}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{5}}{}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{\overline{5}}{}$ | $\frac{\overline{6}}{}$ | $\frac{2}{3}$ | $\frac{2}{3}$ | | | | | $\frac{\overline{2}}{}$ | $\frac{2}{2}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{5}}{}$ | $\frac{2}{2}$ | $\frac{1}{1}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{1}{2}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{15}{72}$ | |
| Lack of signs warning of change of or restricted overhead clearance. | $\frac{\overline{6}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{5}}{}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{\overline{5}}{}$ | $\frac{\overline{6}}{}$ | $\frac{1}{3}$ | $\frac{1}{3}$ | | | | | $\frac{\overline{2}}{}$ | $\frac{1}{2}$ | $\frac{2}{4}$ | $\frac{\overline{5}}{}$ | | | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{1}{2}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | | $\frac{1}{2}$ | $\frac{1}{2}$ | | $\frac{\overline{1}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{10}{67}$ | |
| Irregular ribs and brows. | $\frac{\overline{6}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{5}}{}$ | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{\overline{5}}{}$ | $\frac{\overline{6}}{}$ | $\frac{\overline{3}}{}$ | $\frac{3}{3}$ | | | | | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{5}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | $\frac{\overline{2}}{}$ | $\frac{2}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{2}{4}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{10}{72}$ | |
| Hanging roof bolts. | $\frac{\overline{6}}{}$ | $\frac{1}{1}$ | $\frac{2}{5}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{2}{5}$ | $\frac{3}{6}$ | $\frac{1}{3}$ | $\frac{2}{3}$ | | | | | $\frac{1}{2}$ | $\frac{\overline{2}}{}$ | $\frac{2}{4}$ | $\frac{2}{5}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{1}{2}$ | | $\frac{1}{1}$ | | $\frac{1}{4}$ | | $\frac{\overline{2}}{}$ | $\frac{2}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{1}{1}$ | $\frac{2}{4}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{26}{70}$ | |
| Poor condition of ballast around ties. | $\frac{1}{6}$ | $\frac{\overline{1}}{}$ | $\frac{3}{5}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{1}{5}$ | $\frac{2}{6}$ | $\frac{1}{3}$ | $\frac{\overline{3}}{}$ | | | | | $\frac{1}{2}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{4}}{}$ | $\frac{1}{5}$ | $\frac{1}{2}$ | $\frac{1}{1}$ | $\frac{1}{2}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | $\frac{\overline{2}}{}$ | $\frac{2}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{19}{72}$ | |
| Poor drainage of track roadway. | $\frac{1}{6}$ | $\frac{\overline{1}}{}$ | $\frac{2}{5}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{\overline{5}}{}$ | $\frac{\overline{6}}{}$ | $\frac{\overline{3}}{}$ | $\frac{\overline{3}}{}$ | | | | | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | $\frac{2}{4}$ | $\frac{2}{5}$ | $\frac{1}{2}$ | $\frac{1}{1}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{1}{2}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | $\frac{\overline{2}}{}$ | $\frac{1}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{15}{72}$ | |
| Poor maintenance of track gauge and alignment. | $\frac{1}{6}$ | $\frac{\overline{1}}{}$ | $\frac{3}{5}$ | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{1}{6}$ | $\frac{1}{5}$ | $\frac{1}{3}$ | $\frac{\overline{3}}{}$ | | | | | $\frac{1}{2}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{4}}{}$ | $\frac{1}{5}$ | $\frac{\overline{2}}{}$ | $\frac{1}{1}$ | $\frac{1}{2}$ | $\frac{\overline{1}}{}$ | $\frac{1}{2}$ | | $\frac{\overline{1}}{}$ | | $\frac{1}{4}$ | | $\frac{1}{2}$ | $\frac{2}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{2}{4}$ | $\frac{1}{1}$ | $\frac{\overline{1}}{}$ | $\frac{22}{72}$ | |
| Uneven joints. | $\frac{1}{6}$ | $\frac{\overline{1}}{}$ | $\frac{3}{5}$ | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{\overline{6}}{}$ | $\frac{\overline{5}}{}$ | $\frac{\overline{3}}{}$ | $\frac{1}{3}$ | | | | | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{4}}{}$ | $\frac{1}{5}$ | $\frac{1}{2}$ | $\frac{1}{1}$ | $\frac{1}{2}$ | $\frac{\overline{1}}{}$ | $\frac{1}{2}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | $\frac{\overline{2}}{}$ | $\frac{2}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{1}{4}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{16}{72}$ | |
| Insufficient illumination at transfer points. | $\frac{1}{6}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{5}}{}$ | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{3}{5}$ | $\frac{\overline{6}}{}$ | $\frac{2}{3}$ | $\frac{3}{3}$ | | | | | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | $\frac{1}{4}$ | $\frac{1}{5}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{2}{2}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{4}}{}$ | | $\frac{\overline{2}}{}$ | $\frac{2}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{1}}{}$ | $\frac{18}{72}$ | |
| Spillage or foreign articles on tracks. | $\frac{1}{6}$ | $\frac{\overline{1}}{}$ | $\frac{5}{5}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{\overline{3}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{3}}{}$ | $\frac{1}{3}$ | | | | | $\frac{1}{2}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{4}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | | $\frac{\overline{2}}{}$ | | $\frac{\overline{2}}{}$ | $\frac{1}{2}$ | $\frac{\overline{2}}{}$ | | $\frac{\overline{1}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{2}}{}$ | $\frac{\overline{1}}{}$ | $\frac{11}{64}$ | |

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Track

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Lack of, or obstructed, shelter holes (75.1403-9). | 6 | 1 | 5 | 2 | 2 | 5 | 6 | 1/3 | 1/3 | | | | | 2 | 2 | 4 | 5 | 2 | 1 | 2 | 1 | 2 | | 1 | | 4 | | 2 | 2 | 2 | | 1 | 2/4 | 1/1 | 1 | 5/72 | |
| Trolley wires not properly supported or guarded where men work or pass under wires, around doors, and at mantrip stations. | 6 | 1 | 3/5 | 2 | 2 | 5 | 6 | 1/3 | 1/3 | | | | | 1/2 | 2 | 4 | 5 | 2 | 1 | 2 | 1 | 2 | | 1 | | 4 | | 2 | 1/2 | 2 | | 1 | 4 | 1 | 1 | 7/72 | |
| Excessive wear or kinking of trolley wire. | 6 | 1 | 2/5 | | 2 | 5 | 6 | 3 | 1/3 | | | | | 2 | 2 | 4 | 5 | 2 | 1 | 2 | 1 | 2 | | 1 | | 4 | | 2 | 1/2 | 2 | | 1 | 3/4 | 1 | 1 | 7/70 | |
| Planning | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Many mines run only mantrips and supplies on rail. Do not have dispatchers or central traffic control. |
| Lack of traffic control. | 1 | 1/1 | 1/1 | 1/1 | | 1 | 1 | | 3 | | | | | 1 | 1/1 | 1/1 | 1/1 | 1/1 | 1/1 | 1 | 1/1 | | | 1 | | 1 | | | 2 | 2 | | 1 | 1/1 | 1 | 1 | 10/27 | |
| Haulage during mantrip time. | 2 | 1 | 5 | 1 | | 5 | 6 | | 3 | | | | | | 1 | 4 | 5 | 2 | 1 | 2 | | | | | | 4 | | | 2 | | | | 4 | 1 | 1 | 0/50 | |
| Lack of runarounds and side tracks conducive to "flying switches" and pushing trips on mainline. | 1 | | | 1/1 | | 5 | 6 | | 3 | | | | | | | | | | | | | | | 1 | | 4 | | | 2 | 1/2 | | 1 | 4 | 1 | | 2/31 | |
| Lack of telephone near mantrip station. | 6 | 1 | 5 | 2 | 2 | 5 | 6 | 3 | 3 | | | | | 2 | 2 | 4 | 5 | | | 2 | 1 | 2 | | 1 | | 4 | | | 2 | 2 | | 1 | 4 | 1 | 1 | 0/67 | |
| Communication media poor. | 6/7 | 1 | 1/1 | 1/2 | 2/2 | 1/1 | 1/1 | 3/3 | 2/3 | | | | | 2 | 1/1 | 1/1 | 1/1 | 1/1 | 1/1 | 2 | | 2 | | 1 | | 1/1 | | 1 | 1/2 | 2/2 | | 1 | 1/1 | 1/1 | 1 | 28/43 | |
| Lack of adequate crossovers where men must cross at loading points. | | 1 | 5 | 2 | | 1/5 | 6 | 3 | 3 | | | | | | | 4 | 5 | | | | | 2 | | | | 4 | | | 1/2 | | | | 2/4 | 1 | 1 | 4/48 | |
| Equipment | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Poor design of controls. | 3 | 1 | 5 | 2 | | 1/5 | 6 | 3 | 1/3 | | | | | 2 | 2 | 4 | 5 | 3 | 1 | 2 | 1 | | | 1 | | 4 | | 2 | 1/2 | 2 | | 1 | 2/4 | 1 | 1 | 5/66 | Few controls appeared to be optimal. |
| Defective equipment or missing safety devices (maintenance): lights, reflectors, audible warning device, brakes, controllers, sanding devices, jack, rerailer, fire extinguisher, skids. | 6/9 | 1 | 5 | 1/1 | | 2/5 | 6 | 1/3 | 1/3 | | | | | 2 | 2 | 3/4 | 5 | 3 | 1/1 | 2 | 1/1 | 1/2 | | 1 | | 4 | | 2 | 1/2 | 2 | | 1 | 3/4 | 1/1 | 1 | 22/73 | |

Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Track

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Excessive sparking from trolley wire. | $\frac{}{6}$ | $\frac{}{1}$ | $\frac{5}{5}$ | $\frac{}{2}$ | | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{3}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{1}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{6}{72}$ | |
| No windshield and cab on locomotive. | $\frac{12}{12}$ | $\frac{1}{1}$ | $\frac{5}{5}$ | | | $\frac{5}{5}$ | $\frac{6}{6}$ | | $\frac{2}{2}$ | | | | | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{3}{3}$ | $\frac{1}{1}$ | $\frac{2}{2}$ | $\frac{1}{1}$ | | | $\frac{}{1}$ | | $\frac{4}{4}$ | | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{1}{2}$ | | | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{51}{68}$ | |
| Couple/Decouple | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lack of or defective automatic couplers. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{}{2}$ | | $\frac{}{5}$ | $\frac{}{6}$ | | $\frac{}{3}$ | | | | | | | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{1}$ | | | $\frac{2}{2}$ | | | | | $\frac{2}{4}$ | | $\frac{1}{2}$ | $\frac{}{2}$ | | | | $\frac{2}{4}$ | $\frac{1}{1}$ | | $\frac{8}{54}$ | |
| Inadequate decoupling devices necessitating going between cars to decouple. | $\frac{1}{7}$ | $\frac{1}{1}$ | $\frac{5}{5}$ | $\frac{1}{2}$ | | $\frac{}{5}$ | $\frac{2}{6}$ | | $\frac{2}{3}$ | | | | | $\frac{}{2}$ | | $\frac{1}{4}$ | $\frac{}{5}$ | $\frac{}{1}$ | | | | | | | | $\frac{2}{4}$ | | $\frac{1}{2}$ | $\frac{1}{2}$ | | | | $\frac{2}{4}$ | $\frac{1}{1}$ | | $\frac{20}{54}$ | |
| Switch/Reset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Missing or inoperative switch position indicator. | $\frac{}{7}$ | | $\frac{2}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{1}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{}{2}$ | | $\frac{1}{4}$ | $\frac{1}{5}$ | | | $\frac{}{2}$ | $\frac{1}{1}$ | | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | | $\frac{6}{64}$ | |
| Foreign matter or debris in switch. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{2}{5}$ | | $\frac{1}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{2}{3}$ | $\frac{1}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{1}{1}$ | $\frac{}{2}$ | $\frac{1}{1}$ | | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{1}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | | $\frac{9}{69}$ | |
| Defective switch. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{2}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{2}{3}$ | $\frac{2}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{1}{1}$ | | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{1}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | | $\frac{8}{71}$ | |
| Misaligned switch. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{1}{5}$ | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{1}{3}$ | $\frac{1}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{1}{1}$ | | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{1}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{1}{4}$ | $\frac{}{1}$ | | $\frac{7}{71}$ | |
| Mantrips | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Boarding and discharge points not posted. | $\frac{}{6}$ | | $\frac{5}{5}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{5}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{4}{4}$ | $\frac{5}{5}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{}{2}$ | | $\frac{}{3}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{1}{2}$ | $\frac{1}{2}$ | | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{30}{70}$ | |
| Lack of safety items (75.1403-6): audible warning device, headlight on each end, reflectors on ends and sides, two independent braking systems, sanding devices. | $\frac{}{6}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{5}$ | $\frac{1}{6}$ | $\frac{1}{3}$ | $\frac{1}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{3}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{1}$ | $\frac{}{2}$ | | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{6}{68}$ | |

Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Track

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Supply and waiting areas located so men must cross under trolley wire to board or leave mantrip or get supplies. | $\frac{}{6}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{1}{2}$ | $\frac{1}{1}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{1}{3}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{1}$ | $\frac{1}{2}$ | $\frac{}{1}$ | | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{8}{68}$ | |
| Mantrip car design forces miners to exit/enter on trolley side. | $\frac{}{6}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{2}{2}$ | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{}{3}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{1}$ | $\frac{}{2}$ | | | $\frac{4}{4}$ | $\frac{1}{1}$ | $\frac{}{1}$ | $\frac{7}{67}$ | |

## Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Track

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| UNSAFE ACTS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Failure to check equipment at start of shift: brakes, lights, warning devices, sanding devices, wiring, controller, trolley phone, trolley pole, fire extinguisher, rerailers, jacks, etc. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Never at the motor barn to observe this activity. According to interviews these items are always checked. |
| Failure to use an empty car between locomotive and car hauling pipe, rail, timber, etc. | 1/6 | 1 | 5 | | | 5 | 6 | | | | | | | | | 1/4 | 5 | | | | | | | | | 4 | | | | | | | 4 | 1 | | 2/41 | |
| Failure to respond to warning signals. | 6 | 1 | 5 | 1/2 | | 5 | 6 | 3 | 3 | | | | | 2/2 | | 4 | 5 | | | 2 | | 2 | | 1 | | 4 | | | 2 | 1 | | | 4 | 1 | | 3/59 | |
| Walking under trolley wire. | | 1 | 5 | 2/2 | 2/2 | 5 | 6 | 1/3 | 1/3 | | | | | | 2 | 1/4 | 2/5 | 3 | 1 | | | 1/2 | | | | 2/4 | | 2 | 1/2 | 1/2 | | | 1/4 | 1/1 | | 16/59 | |
| Failure to use proper rerailing devices. | | 1 | 3/5 | | | 5 | 6 | | 1/1 | | | | | | | 1/4 | 5 | | 1/1 | | | | | | | 4 | | 1/1 | 2 | | | | 1/4 | 1 | | 8/40 | |
| Push Trip | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pushing trips on main haulage roads (except from side track to loading points or at shaft and slope bottoms). | 1 | | | | | 5 | 6 | | 2 | | | | | | | | | 1 | | | | | | | | 4 | | 1 | 2 | 2 | | | 1/4 | 1 | | 1/29 | |
| Riding between cars, on loaded cars, front bumper, or lead car of a pushed trip, operators standing in their decks. | 7 | 1 | 5 | 2/2 | | 2/5 | 6 | 3 | 3 | | | | | 2 | 1 | 4 | 4 | 3 | 1 | | | | | | | 4 | | 1 | 2 | 2 | | | 2/4 | 1 | | 6/61 | |
| Getting on or off moving equipment. | 2/6 | 1 | 5 | | 2 | 5 | 6 | | | | | | | 2 | 2 | 4 | 5 | 1/3 | 1 | 2 | | 2 | | 1 | | 4 | | 2 | 2 | 2 | | 1 | 4 | 1 | | 3/63 | |
| Failure to stay in the clear of moving equipment, running ahead, walking or working alongside, failure to seek refuge in shelter holes. | 6 | 1 | 5 | 2 | 2 | 5 | 6 | 3 | 3 | | | | | 2 | 2 | 4 | 1/5 | 3 | 1 | | | 2 | | | | 1/4 | | 2 | 2 | 2 | | | 1/4 | 1 | | 3/67 | |

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Track

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Any work on moving or running equipment. | $\frac{}{1}$ | | | $\frac{}{2}$ | $\frac{}{2}$ | | | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{}{1}$ | | | | | | | | $\frac{}{2}$ | | | | | | | $\frac{}{2}$ | | | | | | $\frac{0}{16}$ | |
| Failure to communicate by visible and audible signals, telephone, trolley phone, paging system, messages, notification of concerned when working on equipment. | | | | $\frac{1}{1}$ | | | | $\frac{}{1}$ | $\frac{}{1}$ | | | | | | $\frac{}{2}$ | | | $\frac{2}{3}$ | $\frac{1}{1}$ | | $\frac{}{1}$ | $\frac{}{1}$ | | | | | | $\frac{}{2}$ | $\frac{}{2}$ | | | | | | $\frac{4}{15}$ | |
| Excessive speed for circumstances. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{3}{5}$ | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{2}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{6}{74}$ | |
| Failure to follow at a safe distance (300 feet minimum; 75.1403-10g). | $\frac{1}{7}$ | $\frac{}{1}$ | $\frac{2}{5}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{1}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{1}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{1}{2}$ | | $\frac{}{1}$ | | $\frac{2}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{11}{72}$ | |
| Failure to use trip lights. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{}{2}$ | | $\frac{}{5}$ | $\frac{}{6}$ | | $\frac{}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{0}{69}$ | |
| Failure to face or watch direction of travel. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{0}{74}$ | |
| Operation of equipment by inexperienced and unfamiliar operators. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{2}$ | $\frac{}{2}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{1}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{1}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{2}{72}$ | |
| Failure to familiarize with the road environment. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{2}$ | | | | | | | $\frac{}{4}$ | $\frac{}{5}$ | | | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | | | $\frac{}{2}$ | | | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{0}{60}$ | |
| Failure to move only under the direction of a dispatcher where a dispatcher is employed. | $\frac{}{7}$ | | | | | $\frac{}{5}$ | $\frac{}{6}$ | | $\frac{}{3}$ | | | | | $\frac{}{2}$ | | | | | | $\frac{}{2}$ | $\frac{}{1}$ | | | $\frac{}{1}$ | | $\frac{}{4}$ | | | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{3}{4}$ | $\frac{}{1}$ | | $\frac{3}{41}$ | |
| Switch/Reset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Flying switches. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{}{5}$ | | $\frac{1}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{1}{3}$ | $\frac{2}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{2}$ | | | $\frac{1}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{1}$ | | $\frac{5}{69}$ | |
| Failure to reset switch for mainline. | $\frac{1}{6}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{1}{3}$ | | | | | | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{1}{2}$ | | | $\frac{}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{1}{2}$ | | | | $\frac{}{1}$ | $\frac{1}{4}$ | $\frac{}{1}$ | | $\frac{5}{64}$ | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Track

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Having more than one locomotive in a signal block except for trailing locomotive. | $\frac{}{1}$ | | | | | | | | $\frac{}{2}$ | | | | | | | | | | | | | | | | | | | | $\frac{}{2}$ | | | | | | | $\frac{0}{5}$ | Was not observed, but few mines used a block signal system. |
| Failure to shut controller off when placing pole on wire. | $\frac{1}{7}$ | $\frac{1}{2}$ | $\frac{2}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{1}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{6}{75}$ | |
| Having more than 1 car between wreck and locomotive when re-railing. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Never observed a wreck being re-railed. |
| Riding in cars with supplies and tools. | | $\frac{}{1}$ | $\frac{2}{5}$ | $\frac{1}{2}$ | $\frac{2}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{3}$ | | | | | $\frac{}{2}$ | $\frac{1}{1}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{1}{2}$ | | $\frac{1}{1}$ | | | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{8}{62}$ | |
| Backpoling if not necessary. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{1}{3}$ | | | | | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | | | | $\frac{}{4}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | | $\frac{}{4}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{2}{69}$ | |
| Failure to shut off controls, to set brakes tightly, to secure the brake wheel, and to take off the pole (on locomotive) on standing or parked equipment. | $\frac{}{7}$ | $\frac{}{1}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{6}$ | $\frac{}{3}$ | $\frac{}{2}$ | | | | | | $\frac{}{1}$ | $\frac{}{4}$ | $\frac{}{5}$ | | | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{}{1}$ | | $\frac{}{4}$ | | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | $\frac{2}{4}$ | $\frac{}{1}$ | | $\frac{2}{64}$ | |
| Parking equipment in dangerous locations, for example, beyond safety zone on curved part of turnout. | $\frac{}{7}$ | | | $\frac{}{2}$ | $\frac{}{2}$ | | | $\frac{1}{3}$ | $\frac{}{2}$ | | | | | | $\frac{}{2}$ | | | $\frac{}{3}$ | $\frac{}{1}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{2}$ | | $\frac{}{1}$ | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{}{1}$ | | | $\frac{}{1}$ | $\frac{1}{36}$ | |
| Couple/Decouple | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Coupling or decoupling of moving equipment. | $\frac{}{3}$ | | | | | | | | $\frac{}{3}$ | | | | | | | | | $\frac{}{1}$ | | | | | | | | | | $\frac{}{2}$ | $\frac{}{2}$ | | | | | | | $\frac{0}{11}$ | |
| Coupling inside curves. | $\frac{}{3}$ | | | | | | | | $\frac{}{3}$ | | | | | | | | | $\frac{}{1}$ | | | | | | | | | | $\frac{}{2}$ | $\frac{}{2}$ | | | | | | | $\frac{0}{11}$ | |
| Does not use lever, steps between cars. | $\frac{1}{6}$ | $\frac{}{1}$ | $\frac{}{5}$ | | | $\frac{1}{5}$ | $\frac{2}{6}$ | | | | | | | | | $\frac{1}{4}$ | $\frac{}{5}$ | | | | | | | $\frac{1}{2}$ | | $\frac{2}{4}$ | | $\frac{1}{2}$ | | | | $\frac{2}{4}$ | $\frac{1}{1}$ | | $\frac{12}{45}$ | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

## Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Track

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Mantrips | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Boarding or leaving cars on the side toward the trolley wire. | 1/6 | 1/1 | 3/5 | 2/2 | 1/2 | 2/5 | 6/6 | 3/3 | 2/2 | | | | | 1/2 | 1/1 | 4/4 | 5/5 | 2/2 | 1/1 | 2/2 | 1/1 | 2/2 | | 1/1 | | 4/4 | | 2/2 | 1/2 | 1/2 | | 1/1 | 2/4 | 1/1 | 1/1 | 14/70 | |
| Riding on the side toward the trolley wire, on open mantrip cars. | 1/6 | 1/1 | 3/5 | 2/2 | 2/2 | 2/5 | 6/6 | 1/3 | 2/2 | | | | | 1/2 | 1/1 | 4/4 | 5/5 | 1/2 | 1/1 | 2/2 | 1/1 | 1/2 | | 1/1 | | 2/4 | | 1/1 | 1/2 | 2/2 | | 1/1 | 4/4 | 1/1 | 1/1 | 20/69 | |
| Riding between cars. | 6/6 | | | 2/2 | | | | | 2/2 | | | | | 2/2 | | | 1/1 | | | | | 1/1 | | | | | | 2/2 | 2/2 | 2/2 | | | | | | 0/20 | |
| Failure to wear safety goggles while riding on open mantrips. | 6/6 | 1/1 | 5/5 | 1/2 | 2/2 | 5/5 | 6/6 | 1/3 | 3/3 | | | | | 2/2 | 1/1 | 2/4 | 3/5 | 2/2 | 1/1 | 1/2 | 1/1 | 1/1 | | 1/1 | | 1/4 | | 2/2 | 1/2 | 2/2 | | 1/1 | 4/4 | 1/1 | 1/1 | 27/70 | |
| Failure to ride mantrip cars. | 3/3 | | | | | | | | | | | | | 2/2 | 1/1 | | | 2/2 | | 1/1 | 1/1 | | | | | | | 2/2 | | | | | | | | 0/12 | |
| Overcrowding of mantrip cars. | 3/3 | 1/1 | 5/5 | | 1/2 | 5/5 | 6/6 | 2/2 | 2/2 | | | | | 2/2 | 1/1 | 4/4 | 5/5 | 1/2 | | 1/1 | 1/1 | 2/2 | | | | 4/4 | | 2/2 | 2/2 | | | | 4/4 | 1/1 | | 4/57 | |
| Failure to use an empty car between locomotive and open mantrip car. | | | | | | | | | | | | | | | 1/1 | 1/4 | 1/5 | 1/1 | | | | | | | | | | | | | | | | | | 3/11 | |
| Boarding or leaving moving mantrip cars. | 3/3 | 1/1 | 5/5 | 2/2 | 2/2 | 5/5 | 6/6 | 3/3 | 2/2 | | | | | 2/2 | 1/1 | 4/4 | 5/5 | 2/2 | 1/1 | 1/1 | 1/1 | 2/2 | | | | 4/4 | | 2/2 | 2/2 | 2/2 | | | 4/4 | 1/1 | 1/1 | 0/64 | |
| Failure to board or leave in an orderly manner. | 3/3 | 1/1 | 5/5 | | | 5/5 | 6/6 | 2/2 | 2/2 | | | | | 2/2 | 1/1 | 4/4 | 5/5 | 2/2 | 1/1 | 1/1 | | 2/2 | | | | 4/4 | | 2/2 | 2/2 | | | | 4/4 | 1/1 | 1/1 | 0/56 | |
| Failure to remain seated when car is in motion (standing to replace trolley). | 2/6 | 1/1 | 3/5 | 1/2 | 2/2 | 1/5 | 2/6 | 1/3 | 1/3 | | | | | 1/2 | 1/1 | 1/4 | 1/5 | 2/2 | 1/1 | 1/1 | 1/1 | 2/2 | | 1/1 | | 2/4 | | 2/2 | 1/2 | 2/2 | | 1/1 | 2/4 | 1/1 | 1/1 | 20/70 | |
| Mixing mantrip and loaded cars. | 3/3 | 1/1 | 5/5 | | | 5/5 | 6/6 | | 3/3 | | | | | | 1/1 | 4/4 | 5/5 | 2/2 | | | | | | | | 4/4 | | 2/2 | 2/2 | | | | 4/4 | 1/1 | 1/1 | 0/49 | |

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Conveyor

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $T_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| HAZARDOUS CONDITIONS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lack of adequate guards at conveyor drive, head, belt tension, and tail pulleys. | | $\frac{-}{1}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | $\frac{1}{3}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{5}$ | $\frac{-}{2}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{1}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{1}{2}$ | $\frac{-}{1}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | | | | | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{1}$ | $\frac{3}{63}$ | |
| Lack of adequate crossovers where necessary for men to cross conveyor. | | $\frac{-}{1}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | $\frac{1}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{5}$ | $\frac{-}{2}$ | $\frac{-}{3}$ | | | | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | | | $\frac{-}{2}$ | $\frac{2}{2}$ | $\frac{-}{2}$ | $\frac{2}{2}$ | $\frac{-}{1}$ | | $\frac{-}{2}$ | | | | | | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{1}{2}$ | $\frac{-}{2}$ | | $\frac{6}{53}$ | |
| Lack of adequate clearance alongside belts. | | $\frac{-}{1}$ | $\frac{1}{3}$ | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{3}{5}$ | $\frac{-}{2}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{1}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{-}{1}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | | | | | $\frac{1}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{1}$ | $\frac{13}{71}$ | |
| Lack of fire protection on conveyor line (75.1100-2b). | | $\frac{-}{1}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{1}{5}$ | $\frac{1}{2}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{1}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{1}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | | | | | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{1}$ | $\frac{7}{71}$ | |
| Excessive dust in atmosphere. | | $\frac{-}{1}$ | $\frac{3}{3}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{1}{2}$ | $\frac{-}{2}$ | $\frac{2}{5}$ | $\frac{-}{2}$ | $\frac{2}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{2}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | $\frac{2}{2}$ | $\frac{-}{2}$ | $\frac{1}{2}$ | $\frac{-}{2}$ | $\frac{-}{1}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | | | | | $\frac{1}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{1}$ | $\frac{14}{71}$ | |
| Excess coal and lubricant spillage (fire hazard). | | $\frac{-}{1}$ | $\frac{2}{3}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{1}{5}$ | $\frac{-}{2}$ | $\frac{-}{3}$ | $\frac{1}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{2}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{1}$ | $\frac{-}{3}$ | $\frac{1}{2}$ | | | | | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{2}$ | $\frac{-}{1}$ | $\frac{7}{71}$ | |
| Lack of adequate or inoperative emergency stop devices (continuous pull cord along entire length for mantrip). | | | | $\frac{1}{2}$ | $\frac{1}{2}$ | | | $\frac{1}{5}$ | $\frac{-}{2}$ | | $\frac{1}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | | $\frac{1}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{3}$ | $\frac{-}{2}$ | | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | | | | | | | | | | | | $\frac{9}{40}$ | |
| Lack of warning signs and safety interlocks to prevent turning on conveyor when it is being worked on. | | $\frac{1}{1}$ | $\frac{3}{3}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{-}{5}$ | $\frac{2}{2}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{2}{3}$ | $\frac{2}{3}$ | $\frac{3}{3}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{3}{3}$ | $\frac{2}{2}$ | | | | | $\frac{2}{2}$ | | $\frac{2}{2}$ | $\frac{2}{2}$ | | $\frac{60}{65}$ | |
| Lack of starting warning device. | | $\frac{1}{1}$ | $\frac{3}{3}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{5}{5}$ | $\frac{2}{2}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{1}{1}$ | $\frac{3}{3}$ | $\frac{2}{2}$ | | | | | | | $\frac{2}{2}$ | $\frac{1}{2}$ | $\frac{1}{1}$ | $\frac{66}{66}$ | |
| Lack of tools to facilitate splicing belts, moving heavy components. | | | | | | | | $\frac{3}{5}$ | | | | | | | | | | | | | | | $\frac{1}{2}$ | | | | | | | | | | | | | $\frac{4}{7}$ | |

Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Conveyor

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| Mantrips | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Belt speed too fast for carrying men. | | | | | | | | | | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{1}$ | | | $\frac{}{2}$ | | $\frac{}{2}$ | | | | | | | | | | | | | $\frac{0}{11}$ | |
| Inadequate clearance above and on sides of conveyor (18 inches above, 36 inches on sides, where men board or leave). | | | | | | | | | | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{1}$ | | | $\frac{}{2}$ | | $\frac{}{2}$ | | | | | | | | | | | | | $\frac{0}{11}$ | |
| Transporting men and supplies together. | | | | | | | | | | | | | | | | $\frac{}{3}$ | $\frac{1}{3}$ | $\frac{}{1}$ | | | $\frac{1}{2}$ | | $\frac{}{2}$ | | | | | | | | | | | | | $\frac{2}{11}$ | |
| Lack of adequate illumination (including colored lights or reflective signs) at loading and unloading stations. | | | | | | | | | | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{1}$ | | | $\frac{}{2}$ | | $\frac{1}{2}$ | | | | | | | | | | | | | $\frac{1}{11}$ | |
| Lack of telephone near loading and unloading points. | | | | | | | | | | | | | | | | $\frac{}{3}$ | $\frac{1}{3}$ | $\frac{}{2}$ | | | $\frac{}{2}$ | | $\frac{1}{2}$ | | | | | | | | | $\frac{}{2}$ | | | | $\frac{2}{14}$ | |

Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Conveyor

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| UNSAFE ACTS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Crossing conveyors at other than designated crossover points. | | $\frac{}{1}$ | $\frac{}{3}$ | $\frac{}{2}$ | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{1}{2}$ | $\frac{}{2}$ | | $\frac{}{3}$ | $\frac{1}{2}$ | | | | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{4}{70}$ | |
| Reaching behind guards while conveyor is moving. | | | | $\frac{}{2}$ | $\frac{}{2}$ | | | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{3}$ | | | | $\frac{}{2}$ | | | | | | | $\frac{}{2}$ | $\frac{}{2}$ | | | | | | | | | $\frac{}{2}$ | | | | | $\frac{0}{22}$ | |
| Working too close to moving conveyor (cleanup). | | $\frac{}{1}$ | $\frac{1}{3}$ | | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{5}$ | $\frac{1}{2}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{2}$ | $\frac{}{3}$ | $\frac{1}{3}$ | $\frac{1}{3}$ | $\frac{}{3}$ | $\frac{}{2}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{1}{2}$ | | $\frac{}{3}$ | $\frac{}{2}$ | | | | | $\frac{}{2}$ | | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{8}{63}$ | |
| Working on moving conveyor (lubricating, etc.). | | | | $\frac{}{2}$ | $\frac{}{2}$ | | | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{2}$ | $\frac{1}{3}$ | | | $\frac{}{3}$ | $\frac{}{2}$ | | | $\frac{}{2}$ | $\frac{1}{2}$ | | | | | | | | $\frac{2}{2}$ | | | | | $\frac{4}{38}$ | |
| Working near unguarded pulleys. | | | | $\frac{}{2}$ | $\frac{1}{2}$ | | | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{2}$ | $\frac{}{3}$ | | | $\frac{}{3}$ | $\frac{}{2}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | | | | | | | $\frac{}{2}$ | | | | | $\frac{1}{41}$ | |
| Failure to wear eye protection. | | $\frac{}{1}$ | $\frac{2}{3}$ | $\frac{}{2}$ | $\frac{1}{2}$ | | | $\frac{2}{5}$ | $\frac{}{2}$ | $\frac{2}{3}$ | | | | $\frac{2}{3}$ | | $\frac{}{3}$ | $\frac{1}{3}$ | $\frac{1}{3}$ | | $\frac{}{2}$ | $\frac{2}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | | $\frac{1}{3}$ | $\frac{1}{2}$ | | | | $\frac{1}{2}$ | | $\frac{1}{2}$ | $\frac{}{2}$ | | $\frac{17}{49}$ | |
| Removing supplies from moving belts. | | | | | | | | | | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{1}{1}$ | | $\frac{1}{1}$ | $\frac{2}{2}$ | | $\frac{2}{2}$ | | | | | | | | $\frac{}{2}$ | | | | | $\frac{6}{14}$ | |
| Getting on or off of moving conveyors. | | | | | | | | | | | | | | | | $\frac{}{3}$ | $\frac{1}{3}$ | $\frac{}{1}$ | | | $\frac{2}{2}$ | | $\frac{2}{2}$ | | | | | | | | | | | | | $\frac{5}{11}$ | |
| Riding conveyors not designed specifically for mantrips. | | | | | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{3}$ | | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{1}{3}$ | $\frac{}{1}$ | | | $\frac{}{2}$ | | $\frac{1}{2}$ | | | | | | | | | | | | | $\frac{2}{24}$ | |

Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Coal Transfer Points

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| HAZARDOUS CONDITIONS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lack of stopblocks or other protective devices on ramps to prevent overtravel and overturning. | $\frac{\overline{6}}{6}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{3}}{3}$ | $\frac{5}{5}$ | $\frac{2}{3}$ | $\frac{\overline{4}}{4}$ | $\frac{\overline{3}}{3}$ | $\frac{1}{5}$ | $\frac{1}{2}$ | $\frac{6}{6}$ | | | | $\frac{\overline{3}}{3}$ | | $\frac{2}{4}$ | $\frac{2}{5}$ | | | $\frac{\overline{1}}{1}$ | $\frac{2}{2}$ | | $\frac{\overline{2}}{2}$ | | $\frac{\overline{3}}{3}$ | $\frac{\overline{3}}{3}$ | | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{2}{2}$ | $\frac{1}{2}$ | | $\frac{\overline{4}}{4}$ | | $\frac{\overline{1}}{1}$ | $\frac{28}{74}$ | |
| Narrow, or poorly constructed ramps. | $\frac{\overline{6}}{6}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{5}}{5}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{4}}{4}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{5}}{5}$ | $\frac{\overline{2}}{2}$ | $\frac{1}{6}$ | | | | $\frac{\overline{3}}{3}$ | | $\frac{\overline{4}}{4}$ | $\frac{\overline{5}}{5}$ | | | $\frac{1}{1}$ | $\frac{2}{2}$ | | $\frac{\overline{2}}{2}$ | $\frac{\overline{1}}{1}$ | | | $\frac{\overline{1}}{1}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{2}}{2}$ | | $\frac{\overline{4}}{4}$ | | $\frac{\overline{1}}{1}$ | $\frac{4}{70}$ | |
| Lack of adequate clearance and headroom at ramps and dumps. | $\frac{\overline{6}}{6}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{3}}{3}$ | $\frac{3}{5}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{4}}{4}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{5}}{5}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{6}}{6}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{3}}{3}$ | $\frac{3}{4}$ | $\frac{3}{5}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{1}}{1}$ | $\frac{1}{1}$ | $\frac{\overline{2}}{2}$ | | $\frac{\overline{2}}{2}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{2}}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{\overline{2}}{2}$ | | $\frac{\overline{4}}{4}$ | | $\frac{\overline{1}}{1}$ | $\frac{12}{89}$ | |
| Excess spillage on ramps. | $\frac{\overline{6}}{6}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{3}}{3}$ | $\frac{3}{5}$ | $\frac{2}{3}$ | $\frac{\overline{4}}{4}$ | $\frac{\overline{3}}{3}$ | $\frac{2}{5}$ | $\frac{1}{2}$ | $\frac{1}{6}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{3}}{3}$ | $\frac{3}{4}$ | $\frac{3}{5}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{1}}{1}$ | $\frac{1}{1}$ | $\frac{2}{2}$ | | $\frac{\overline{2}}{2}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{2}}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | | $\frac{1}{4}$ | | $\frac{\overline{1}}{1}$ | $\frac{22}{89}$ | |
| Lack of adequate warning devices where a hazard to personnel may exist at mine car loading point. | $\frac{6}{6}$ | $\frac{1}{2}$ | | $\frac{1}{2}$ | $\frac{3}{3}$ | | | $\frac{2}{5}$ | $\frac{2}{2}$ | | | | | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{2}{2}$ | $\frac{1}{1}$ | $\frac{2}{2}$ | $\frac{1}{1}$ | | | | | $\frac{\overline{1}}{1}$ | | | | | $\frac{1}{2}$ | $\frac{2}{2}$ | | | | | | $\frac{30}{37}$ | |
| Lack of adequate bins at loading points. | | $\frac{\overline{1}}{1}$ | $\frac{\overline{3}}{3}$ | $\frac{5}{5}$ | $\frac{2}{3}$ | $\frac{\overline{4}}{4}$ | $\frac{\overline{3}}{3}$ | $\frac{1}{5}$ | $\frac{1}{2}$ | $\frac{1}{6}$ | $\frac{2}{3}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{3}}{3}$ | $\frac{2}{4}$ | $\frac{2}{5}$ | $\frac{\overline{2}}{2}$ | $\frac{\overline{1}}{1}$ | $\frac{1}{1}$ | $\frac{2}{2}$ | | $\frac{2}{2}$ | $\frac{\overline{1}}{1}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{3}}{3}$ | $\frac{\overline{1}}{1}$ | | | $\frac{\overline{2}}{2}$ | $\frac{1}{2}$ | | $\frac{\overline{4}}{4}$ | | $\frac{\overline{1}}{1}$ | $\frac{22}{76}$ | |
| Lack of illumination at belt heads. | | $\frac{1}{1}$ | $\frac{3}{3}$ | $\frac{2}{5}$ | $\frac{1}{3}$ | $\frac{4}{4}$ | $\frac{1}{3}$ | $\frac{\overline{5}}{5}$ | | | | | | | | $\frac{2}{4}$ | $\frac{2}{4}$ | | | | | $\frac{2}{2}$ | $\frac{\overline{2}}{2}$ | | $\frac{\overline{3}}{3}$ | $\frac{1}{3}$ | | | | $\frac{\overline{2}}{2}$ | $\frac{2}{2}$ | | $\frac{1}{4}$ | $\frac{1}{3}$ | $\frac{\overline{1}}{1}$ | $\frac{23}{54}$ | |
| Lack of telephone at belt heads. | | | | $\frac{\overline{5}}{5}$ | | | | | | | | | | | | | | | | | | $\frac{2}{2}$ | | | | | | | | $\frac{\overline{2}}{2}$ | | | | | | $\frac{2}{9}$ | |

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Coal Transfer Points

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $I_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| UNSAFE ACTS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Failure to give warning signals and to check the loading points before spotting mine cars. | $\frac{6}{6}$ | $\frac{1}{2}$ | | $\frac{1}{2}$ | $\frac{3}{3}$ | | | $\frac{2}{5}$ | $\frac{2}{2}$ | | | | | $\frac{3}{3}$ | $\frac{3}{3}$ | $\frac{2}{2}$ | $\frac{1}{1}$ | $\frac{2}{2}$ | $\frac{1}{1}$ | | | | | $\frac{}{1}$ | | | | $\frac{1}{2}$ | $\frac{2}{2}$ | | | | | | $\frac{30}{37}$ | |
| Leaving shuttle cars, etc., parked on ramp. | $\frac{}{12}$ | $\frac{1}{2}$ | $\frac{2}{10}$ | $\frac{}{5}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{2}{8}$ | $\frac{}{5}$ | $\frac{}{2}$ | $\frac{}{6}$ | | | | $\frac{}{4}$ | | $\frac{}{4}$ | $\frac{}{4}$ | | | $\frac{}{1}$ | | $\frac{}{3}$ | $\frac{}{2}$ | | $\frac{}{2}$ | $\frac{2}{4}$ | | $\frac{}{4}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{1}{4}$ | | $\frac{}{1}$ | $\frac{8}{95}$ | |
| Attempting to loosen chute hangups without exercising extreme caution. | | $\frac{}{1}$ | $\frac{}{3}$ | $\frac{}{2}$ | | $\frac{}{4}$ | $\frac{}{3}$ | $\frac{}{2}$ | $\frac{}{2}$ | | | | | | | $\frac{}{4}$ | $\frac{1}{5}$ | | | | | $\frac{}{3}$ | | | $\frac{}{3}$ | $\frac{}{3}$ | | | | | | | $\frac{1}{4}$ | $\frac{}{3}$ | | $\frac{2}{42}$ | |
| Men working or standing too close to chutes. | | $\frac{}{1}$ | $\frac{}{3}$ | $\frac{}{2}$ | | $\frac{}{4}$ | $\frac{}{3}$ | $\frac{1}{2}$ | $\frac{}{2}$ | $\frac{}{6}$ | | | | $\frac{}{4}$ | | $\frac{}{4}$ | $\frac{}{5}$ | | | | | $\frac{}{3}$ | | | $\frac{}{3}$ | $\frac{}{3}$ | | | | | | | $\frac{}{4}$ | $\frac{}{3}$ | | $\frac{1}{52}$ | |
| Failure to adequately block mine cars or take other precautions to prevent cars on slopes from drifting toward dump. | $\frac{}{6}$ | | | $\frac{}{1}$ | | $\frac{}{4}$ | $\frac{}{3}$ | | $\frac{1}{2}$ | | | | | | | | | | | | | | | | | $\frac{}{3}$ | | | $\frac{1}{1}$ | | | | $\frac{1}{4}$ | $\frac{}{3}$ | | $\frac{3}{27}$ | |

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Continued)

HAULAGE CATEGORY: Hoisting

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $r_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| HAZARDOUS CONDITIONS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lack of, or inoperative, safety interlocks on doors. | $\frac{}{1}$ | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | | $\frac{}{1}$ | $\frac{1}{2}$ | $\frac{1}{1}$ | $\frac{1}{1}$ | | | | | | | | | | | $\frac{}{1}$ | | | | | | | | | | | | $\frac{3}{13}$ | |
| Lack of high sides and gates, safety chains, etc., on ends, and overhead protection on cages hoisting men. | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | | $\frac{1}{1}$ | $\frac{}{1}$ | $\frac{1}{1}$ | $\frac{}{1}$ | | $\frac{1}{1}$ | | | | | | | | | | | | | | | | $\frac{}{1}$ | | | | | $\frac{3}{12}$ | |
| Lack of locking device to prevent tilting of self-dumping cages, platforms, etc., when used to transport men. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lack of safety devices to prevent overspeed and overtravel of hoists and to provide additional safety limits for mantrips. | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | | | | | | | | | $\frac{}{1}$ | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | | | | $\frac{0}{15}$ | |
| Failure of position indicator. | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{1}$ | | | | | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{0}{10}$ | |
| Lack of proper inspection and maintenance. | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | | | | | | | | | | | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{0}{12}$ | |
| Lack of adequate signalling systems (two required, one a telephone or speaking tube) one of which the hoisting engineer can hear at all times while men are underground. | | | | | | | $\frac{}{3}$ | $\frac{}{3}$ | | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | | | $\frac{}{1}$ | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{0}{19}$ | |
| Failure to have hoisting signals posted. | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{1}{2}$ | | | $\frac{1}{1}$ | | | | | | | | | | | | | | | | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{2}{12}$ | |
| Lack of adequate warning-delay system before energizing. | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | | | $\frac{1}{1}$ | | | | | | | | | | | | $\frac{1}{1}$ | $\frac{1}{1}$ | | $\frac{2}{2}$ | $\frac{2}{2}$ | | $\frac{7}{13}$ | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# Table 5-1. Summary of Observed Hazardous Conditions and Unsafe Acts (Concluded)

HAULAGE CATEGORY: Hoisting

| FACTORS CONTRIBUTING TO POTENTIAL ACCIDENTS | MINE NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $r_n$ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | | |
| UNSAFE ACTS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Overcrowding of mantrips. | $\frac{}{6}$ | | | | | | $\frac{}{1}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | | | | | | | | | | | | | | | | $\frac{}{2}$ | $\frac{}{1}$ | | $\frac{0}{29}$ | |
| Hoisting men and equipment together, unless men are required to handle the equipment. | $\frac{}{6}$ | | | | | | $\frac{}{1}$ | $\frac{}{3}$ | $\frac{}{3}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | | | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | | | | $\frac{0}{28}$ | |
| Entering or leaving conveyance in motion or after a signal to move the conveyance has been given to the hoistman. | | | | | | | $\frac{}{1}$ | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{1}{1}$ | | | | | | $\frac{}{2}$ | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{2}{2}$ | $\frac{1}{1}$ | | $\frac{4}{22}$ | |
| Running hoist too fast. | | | | | | | $\frac{}{1}$ | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{1}$ | | $\frac{0}{20}$ | |
| Having brakes and clutch disengaged at the same time on a free drum. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | $\frac{}{2}$ | $\frac{}{1}$ | | $\frac{0}{3}$ | |
| Starting hoist in wrong direction when at, or near, limit of travel. | | | | | | | | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | | | $\frac{}{1}$ | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{1}$ | | $\frac{0}{13}$ | |
| Failure to commence retarding at a sufficient distance from the end of travel and to continue retarding at proper rate. | | | | | | | | | | | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | | | $\frac{}{1}$ | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{1}$ | | $\frac{0}{13}$ | |
| Failure to properly observe marks on indicator cutting off power at an intermediate position and not setting the brake. | | | | | | | | | | | | | | $\frac{}{2}$ | | | | | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{1}$ | | $\frac{0}{7}$ | |
| Hoist being operated by unexperienced or unauthorized person. | | | | | | | | | | $\frac{}{2}$ | | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{2}$ | $\frac{}{1}$ | | | | | | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | | $\frac{}{2}$ | $\frac{}{1}$ | | $\frac{0}{14}$ | Mines 18, 33, and 34 employed a miner on a slope hoist that jumped off to operate a switch. |
| Getting on and off moving equipment. | | | | | | | | | | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | $\frac{}{1}$ | | | | $\frac{1}{2}$ | $\frac{}{2}$ | | | | | $\frac{}{2}$ | | | | | | $\frac{}{2}$ | $\frac{}{2}$ | | $\frac{2}{2}$ | $\frac{1}{1}$ | | $\frac{4}{18}$ | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

## Table 5-2. Significant Types of Accidents

| | SIGNIFICANT TYPES OF ACCIDENTS (WHERE MORE THAN 40 MAN-DAYS WERE LOST) | HAULAGE CATEGORY | NO. OF SERIOUS ACCIDENTS (>40 MAN-DAYS) | TOTAL NO. OF ACCIDENTS | TOTAL LOST TIME (MAN-DAYS) |
|---|---|---|---|---|---|
| A | Personnel Struck or Run Over By Vehicle | Trackless | 6 | 6 | 2,884 |
| B | | Track | 2 | 5 | 235 |
| C | Collision Between Vehicles | Track | 2 | 5 | 146 |
| D | Collision or Contact Between Vehicle and Fixed Obstacles or Equipment | Trackless | 4 | 17 | 429 |
| E | Riding Personnel Struck Parts of Body on Top or Side Obstruction | Trackless | 1 | 11 | 227 |
| F | | Track | 3 | 5 | 320 |
| G | Riding Personnel Struck, Run Over, or Squeezed While Getting On or Off Moving Equipment | Track | 1 | 3 | 68 |
| H | | Belt | 1 | 5 | 117 |
| I | Riding Personnel Injured Because of Rough Ride or Sudden Stops and Starts | Trackless | 2 | 8 | 116 |
| J | | Track | 1 | 2 | 80 |
| K | Personnel Injured During Derail, Rerailing or Because of Faulty Switch | Track | 2 | 10 | 205 |
| L | Personnel Squeezed or Run Over When Uncoupling or Coupling | Track | 4 | 12 | 792 |
| M | Riding Personnel Caught Between Moving Parts of Vehicle | Trackless | 2 | 2 | 186 |
| N | | Track | 1 | 1 | 48 |
| O | Personnel Struck or Squeezed When Caught By Trailing Cable | Trackless | 2 | 7 | 6,187 |
| P | Personnel Injured By Shock, Burn, or Explosion of Trailing Cable | Trackless | 1 | 7 | 126 |
| Q | Personnel Working Close Caught In Unprotected Belt Components | Belt | 2 | 3 | 12,023 |
| R | Personnel Riding Belt Carried Into Transfer Point | Belt | 1 | 1 | 108 |
| S | Personnel Struck By Equipment or Tools That Came Loose (Excluding Rerailing' | Track | 1 | 4 | 78 |
| T | | Belt | 2 | 4 | 259 |
| U | | Transfer | - | 2 | 49 |
| V | | Hoist | 1 | 1 | 42 |
| W | Riding Personnel Struck By Loose Trolley Pole | Track | 1 | 5 | 68 |
| X | Falling Material Struck Miner | Trackless | 3 | 3 | 233 |
| Y | Small Object Struck Miner's Eye | Various | 1 | 2 | 137 |
| Z | Miscellaneous - Strained Muscles, Slip and Fall, Bumped Self, Etc. | Various | 2 | 17 | 324 |

For each of the 18 accident types, the potential contributing factors from the observation results (table 5-1) were correlated for application in the following manner. The item was deemed to be a probable contributing factor for the 35 mines surveyed if it passed two tests:

a. The hazardous condition or unsafe act could indeed lead to the accident type.

b. The hazardous condition or unsafe act was prevalent in the 35 mines surveyed, i.e., the normalized incidence rate was greater than about 0.2.

The results of this correlation are summarized in table 5-3 by classifying each of the prevalent factors and noting the haulage category and the accident types to which the factor may contribute.

There are four classifications of "faults" that might lead to a hazard or accident: environmental irregularities, planning or software faults, equipment or design faults, and unsafe acts or human faults. For the purposes of the present analysis, the definition of each classification is as follows:

a. Environmental Irregularities - Physical conditions in the mine that may affect safety directly or indirectly.

b. Planning or Software Faults - Problem areas that are related to overall mine systems.

c. Equipment or Design Faults - Problems related to the design or choice of specific haulage equipment.

d. Unsafe Acts or Human Faults - Errors in judgement, negligence, or breaches of common sense committed by individual miners.

This correlation of accident types and contributing factors amounts to a highly restricted form of fault-tree analysis, except that here actual observations were used to replace a purely analytical listing of potential hazards and faults. By restricting the analysis to the statistical accident experience and observations of prevalent hazardous conditions and unsafe acts in the 35 mines, the analysis contains discussions only of those situations where the survey team had direct experience. Note that a more comprehensive and rigorous fault-tree analysis of each system would have considered many more contingencies, some of which may be quite important to the overall safety of miners working in or near haulage operations.

# Table 5-3. Correlation of Accident Types and Contributing Factors

| FAULT CLASSIFICATION | FACTORS CONTRIBUTING TO HAZARDS | HAULAGE CATEGORY | $I_n$ [1] | RELATED SIGNIFICANT TYPES OF ACCIDENTS [2] A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | NUMBER OF ACCIDENTS | NUMBER OF SERIOUS ACCIDENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EN VI RO NM EN TA L | Restricted Overhead Clearance | Trackless | 15/106 | | | | x | x | | | | | | | | | | | | | | | | | | | | | | 28 | 5 |
| | Abrupt Change of Overhead Clearance | Track | 15/72 | | | | | | x | | | | | | | | | | | | | | | | | | | | | 5 | 3 |
| | Hanging Roof Bolts | Track | 26/70 | | | | | | x | | | | | | | | | | | | | | | | | | | | | 5 | 3 |
| | Uneven Sidling Wet Floor | Trackless | 35/106 | x | | | x | x | | | | x | | | | | | x | | | | | | | | | | | | 49 | 15 |
| | Insufficient Illumination | Trackless | 1/92 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | Insufficient Illumination at Transfer Points | Track | 18/72 | | x | x | | | | x | | | | | | | | | | | | | | | | | | | | 13 | 5 |
| | Lack of Illumination at Transfer Points | Belt | 23/54 | | | | | | | | | | | | | | | | | x | x | | | | | | | | x | 3 | 2 |
| | Noise Resulting in Poor Communications | Trackless | 53/95 | x | | | | | | | | | | | | | | | | | | | | | | | | | | 6 | 6 |
| PL AN NI NG | Lack of Side Clearance | Belt | 13/71 | | | | | | | | x | | | | | | | | | x | | x | | | | | | | | 12 | 5 |
| | Poor Maintenance of Track Gauge, Alignment, Ballast, and Roadway Drainage | Track | 28/73 | | x | x | | | | | | | x | x | | | | | | | | | | | | | | | | 22 | 7 |
| | View Obstructed by Brattice | Trackless | 58/101 | x | | | x | x | | | | | | | | | | | | | | | | | | | | | | 34 | 11 |
| | Lack of Traffic Control | Track | 10/27 | | | x | | | | | | | | | | | | | | | | | | | | | | | | 5 | 2 |
| | Communication Media Poor | Track | 28/43 | | | x | | | | | | | | | x | | | | | | | | | | | | | | | 17 | 6 |
| | Defective Equipment (Maintenance) - Brakes, Lights, Bell, Steering, Tramming Control | Trackless | 68/160 | x | | | x | x | | | | x | | | | | | x | | | | | | | | | | | | 49 | 15 |
| | Defective Equipment (Maintenance) - Brakes, Lights, Bell, Controller, Sander, Skids, etc. | Track | 22/73 | | x | x | | | | x | | | | x | x | | | | | | | | | | | | | | | 25 | 8 |
| | Defective/Misaligned Switch or Position Indicator | Track | 14/71 | | x | x | | | | | | | | x | x | | | | | | | | | | | | | | | | 22 | 7 |
| EQ UI PM EN T | Poor Design or Location of Controls | Track | 5/66 | | x | x | | | | | | | x | | | | | | | | | | | | | | | | | 12 | 5 |
| | | Trackless | 38/165 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | Lack of Adequate Emergency Stop Devices - Entire Length of Mantrip | Belt | 9/40 | | | | | | | x | | | | | | | | | | | x | | | | | | | | | 6 | 2 |
| | Lack of Warning Signs/Safety Interlocks to Prevent "Turn-On" While Working on Belt | Belt | 60/65 | | | | | | | | | | | | | | | | | x | | | | | | | | | | 3 | 2 |
| | Lack of "Start" Warning Devices | Belt | 66/66 | | | | | | | | | | | | | | | | | x | | | | | | | | | | 3 | 2 |
| | Lack of Warning Device Where Hazard to Personnel Exists at Mine Car Loading Points | Transfer Point | 30/37 | | x | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 2 |
| | Inadequate or No Panic Bars | Trackless | 94/132 | | | | x | x | | | | | | | | | | | | | | | | | | | | | | 28 | 5 |
| | Lack of Adequate Guards at Drive Pulleys | Belt | 3/63 | | | | | | | | | | | | | | | | | x | | x | | | | | | | | 7 | 4 |
| | Poor Driver Visibility | Trackless | 64/159 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | Lack of, or Poor Design of, Canopies | Trackless | 91/169 | | | | | x | | | | | | | | | | | | | | | | | | | | x | | 14 | 4 |
| | Insufficient Lighting on Vehicles | Trackless | 20/147 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | No Windshield or Cab on Locomotive | Track | 51/68 | | | | | | x | | | | | | | | | | | | | | | | | | x | | x | 12 | 4 |
| | Lack of/Defective Automatic Couplers | Track | 8/54 | | x | x | | | | | | | | | x | | | | | | | | | | | | | | | 22 | 8 |
| | Inadequate Decouplers/Going Between Cars | Track | 20/54 | | | | | | | | | | | | x | | | | | | | | | | | | | | | 12 | 4 |
| UN SA FE TA CT S | Failure to Give Warning Before Spotting Mine Car | Track | 30/37 | | x | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 2 |
| | Working On or Too Close to Moving Belt or Unguarded Pulley | Belt | 11/64 | | | | | | | | | | | | | | | | | x | | x | | | | | | | | 7 | 4 |
| | Failure to Wear Eye Protection | Belt | 16/49 | | | | | | | | | | | | | | | | | | | | | | | | | | x | 2 | 1 |
| | | Track | 27/70 | | | | | | | | | | | | | | | | | | | | | | | | | | x | 2 | 1 |
| | Items Protruding From Equipment | Trackless | 8/148 | x | | | x | | | | | | | | | | | | | | | | | | | | | | | 23 | 10 |
| | Does Not Use Lever, Steps Between Cars to Couple/Uncouple | Track | 12/45 | | | | | | | | | | | | x | | | | | | | | | | | | | | | 12 | 4 |
| | Not Remaining Seated (Standing to Replace Trolley Pole) | Track | 20/70 | | | | | | x | | | | x | | | | x | | | | | | | | | | x | | | 13 | 5 |
| | Excessive Speed for Circumstances | Track | 6/74 | | x | x | | | x | x | | | x | | | | | | | | | | | | | | | | | 25 | 9 |
| | | Trackless | 16/144 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | Not Using Proper Rerailing Device | Track | 8/40 | | | | | | | | | | | x | | | | | | | | | | | | | | | | 10 | 2 |
| | Not Facing Direction of Travel | Trackless | 13/120 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | Inexperienced or Unfamiliar Operator | Trackless | 18/148 | x | | | x | x | | | | x | | | | | | x | x | | | | | | | | | | | 56 | 15 |
| | Riding In Unsafe Position, Standing | Trackless | 35/143 | | | | | x | | | | x | | | | x | | | | | | | | | | | | | | 21 | 5 |
| | Not Sounding Bell at Start, Before Curtains, or Before Turning | Trackless | 134/146 | x | | | | | | | | | | | | | | | | | | | | | | | | | | 6 | 6 |
| | Headlights Not on While Tramming | Trackless | 17/142 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | Not Shutting Down, Setting Brakes, Blocking a Parked Vehicle | Trackless | 7/112 | x | | | | | | | | | | | | x | | | | | | | | | | | | | | 8 | 8 |
| | Not Checking Equipment (Pre-Shift) | Trackless | 14/124 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | Not Observing Caution Passing Thru Brattice | Trackless | 20/119 | x | | | x | x | | | | x | | | | | | | | | | | | | | | | | | 42 | 13 |
| | Poor Cable Control | Trackless | 10/106 | | | | | | | | | | | | | | | x | x | | | | | | | | | | | 14 | 2 |
| | Loading Coal Too High - Visibility | Trackless | 37/131 | x | | | x | | | | | x | | | | | | | | | | | | | | | | x | | 34 | 15 |
| | Getting On or Off Moving Conveyors | Belt | 5/11 | | | | | | | | x | | | | | | | | | | | | | | | | | | | 5 | 1 |

NOTES: 1. $I_n$ = Normalized Incidence Rate = Incidence of Observed Hazardous Conditions or Unsafe Acts ÷ Total Number of Unit Observations.

2. See table 5-2, 1974 Accident Statistics For 35 Mines Surveyed.

One might be tempted to try some numerical analyses with the observation and accident results obtained. The reader, however, is warned that such analyses should take into account several factors that may tend to bias the results: for the most part, observations only recorded existence or nonexistence of a condition or event, not the degree of quality of it. Next, the observers believe their own presence sometimes may have influenced the miners to safer practices. Time was a factor, and whereas a "hazardous condition" might be observed as a static thing, "unsafe acts" may have been missed because of the relatively short period of observation. Also, some of the factors listed in table 5-1 are more important than others. Last, in regard to the accident data correlation in table 5-3, a considerable amount of judgment was used in correlating the "contributing factors" to the accident types.

Notwithstanding the caveats above, the results of tables 5-1 and 5-3 appear to suggest that "hazardous conditions" are perhaps more prevalent than "unsafe acts." However, one might speculate further that many hazardous conditions are the indirect result of activities (or inactivities) of miners. On the other hand, attitudes of miners might well reflect the posture of management and supervision, and perhaps of the unions. It also appears that equipment and planning "faults" are more prevalent than environmental faults. Indeed, uncorrectable environmental hazards appear to be far less common than correctable hazards (including some environmental conditions). Based on the 1974 accident record for the samples of mines surveyed (table 5-2), one might guess that the chances of having a serious accident in trackless and track haulage in a mine are about equal (about one every 16 months); but that the chances of having a lost-time accident in conveyor haulage, coal transfer, and hoisting are lower (about one every 5 years for conveyors, and much less for coal transfer and hoisting). Carrying this speculation further, it is noted that hoisting, coal transfer, and belt haulage have less men directly involved. This might lead to the conclusion that the safety could be improved by using haulage systems amenable to automation and remote control. The fact that two out of the three fatalities in the particular data sample contained in table 5-2 occurred in belt haulage is believed to be an anomaly, and should probably not be given too much weight.

5.3 Accident Prevention Analysis - Preventive measures that might be suggested to reduce accidents will provide one or both of the following beneficial effects:

a. Improve system interfaces between any combination of man-machine-mine-man; thereby reducing the probability of the miners making mistakes. Most of the preventive measures considered fall into this category.

b. Reduce exposure to accidents by removing personnel from dangerous areas, reducing the number of personnel in dangerous areas, or limiting the time a miner might spend in critical situations.

These preventive measures fall into one of the groupings outlined in table 5-4 in the form of EQUIPMENT/SYSTEM CHANGES or OPERATION/PROCEDURES CHANGES. In table 5-5, the significant accident types are listed along with the probable causes as observed. In parallel with each kind of hazardous condition or unsafe act, there is noted one or more candidate preventive measure, identified according to the groupings in table 5-4. All preventive measure options conceived are included in table 5-4 in order to provide a rather complete list of candidates that occurred to the researchers. Some of the options would require major changes and incur large expenditures, and others are relatively minor. Many of these are not very innovative, but are already in use in a large number of mines.

In preparing this list, cost was not a consideration. Also, even though the germ of a cure is noted, in most cases the choice and application of preventive measures will require trade-offs and designs to a far greater level than allowed during this investigation. Indeed some of the candidates listed will even be impractical in a large number of mine situations.

It is to be noted that a problem in the area of, for example, human error does not have to be cured by a "human" change, but it might be cured by a preventive measure in the "design" or "software" classification. Unfortunately, it is seldom possible to put a finger on one fault and match that fault with a single cure. In some cases the adaption of only one preventive measure might mitigate a particular hazard; whereas in other situations two or more preventive measures may be required to attain significant improvements. Usually, a complex set of factors contribute to any accident. The physical environment is often a factor; certain procedures, mining methods, and equipment that are in wide use in the U.S. today may be inherently conducive to some kinds of accidents. The job itself is sometimes demanding and at other times boring, which makes it difficult for the miner to stay "psyched up" at the proper level so he can react to stimuli with correct responses.

Table 5-4. Preventive Measure Grouping

I. EQUIPMENT/SYSTEM CHANGES

1. General Mine System Change.
2. Major Machine Substitution.
3. Major Machine Modification.
4. Minor Equipment Modification.

II. OPERATION/PROCEDURES CHANGES

1. Reroute or reschedule major haulage activities.
2. Minor changes to low-level activities or processes.
3. Changes in frequency or level of inspection and maintenance.
4. More intensive safety education and job training programs.
5. More effective enforcement of regulations and/or closer supervision.
6. Change and/or modification of regulations.

# Table 5-5. Candidate Preventive Measures

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| A. Personnel struck or run over by vehicle | Trackless | Uneven, sidling, wet floor | I4 - Drag-bar on rear of shuttle cars to aid in road leveling and filling.<br>I4 - Slow-rise shock absorbers on vehicle seats.<br>I4 - Alternative tire designs to improve traction under differing bottom conditions.<br>II3- Improved roadway maintenance, leveling, filling, and drainage. |
| | | Insufficient illumination | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction times.<br>I1 - Designate entries/crosscuts being used for shuttle cars run by operator placement of portable markers (e.g., reflective cones).<br>I4 - Reflective clothing on all mine personnel. |
| | | Noise, resulting in poor communications | I1 - Area-wide communication between vehicles and all miners in same area.<br>I1 - Short range line-of-sight transceivers between foreman, loader/continuous miner operator, and shuttle car drivers.<br>I3 - Reduce machine noise (through isolation, insulation, and redesign).<br>I4 - Discriminating electronic car muffs. |
| | | View obstructed by brattice | I1 - Double-split ventilation to reduce number of curtains in haulageway.<br>I1 - Transparent brattice. |
| | | Defective equipment (maintenance): brakes, lights, bells, steering, tramming controls | I3 - Automatic, fail-safe emergency brake (sets when vehicle power is removed from tram motor, when actuated by panic bar, or when any component of service brake fails).<br>I3 - Built-in test equipment for improved preshift checks (i.e., hydraulic pressure, cable conductor/insulation faults) and trouble diagnosis (possibly programmed).<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Poor design, or location, of controls | I3 - Standardize and optimize operator compartments (human engineering).<br>I3 - Proportional tramming control.<br>I3 - Attenuation of steering-torque feedback (e.g., modified power steering).<br>I3 - Interlock tram motors with brake line pressure to prevent operation with "low" brakes.<br>I3 - Positive, mechanical parking brake separate from service brake.<br>I3 - "Dead man" control tied to automatic emergency brake. |
| | | Poor driver visibility | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I1 - Designate entries/crosscuts being used for shuttle cars run by operator placement of portable markers (e.g., reflective cones).<br>I2 - Substitute lower profile machine.<br>I3 - Locate operator near boom end of shuttle car.<br>I4 - Redesign canopies for optimal visibility.<br>I4 - Adjustable seat.<br>I4 - Electromagnetic obstacle detector.<br>I4 - Reflective clothing for all mine personnel.<br>I2 - Control loading height of coal to improve operator's opposite side view.<br>I4 - Folddown sideboards. |
| | | Insufficient lighting on vehicle | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I4 - High intensity diffused headlamps (new lens design).<br>I4 - Lights that may be dimmed but turned off only when machine power is removed.<br>I4 - Two reliable headlamps and side lights or reflectors on each end of vehicle.<br>I4 - Reflective paint and/or tape with colors for different functions.<br>II2- Keep headlamps clean. |
| | | Items protruding from equipment | I1 - Improved material handling procedures and techniques.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Excessive speed for circumstances | I3 - Proportional tramming control.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Not facing direction of travel | I3 - Seat interlock with audible warning after limited backward travel.<br>I3 - Swing-around rotational cab.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| Personnel struck or run over by vehicle (concluded) | Trackless | Inexperienced or unfamiliar operator | I3 - Standardize and optimize operator compartments (human engineering).<br>II4- More intensive training and job safety programs, including multi-job training.<br>II5- Closer supervision. |
| | | Not sounding bell at start, before curtains, or before turning | I4 - Automatic, short audible or visible signal when tramming direction changes.<br>I4 - Relocate warning sound source to reduce annoyance to operator.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| | | Headlights not on while tramming | I3 - Interlock tram motors with headlight circuit.<br>I4 - High intensity diffused headlamps (new lens design).<br>I4 - Lights that may be dimmed but turned off only when machine power is removed.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| | | Not shutting down, setting brakes, blocking a parked vehicle | I3 - Automatic fail-safe parking brake; sets whenever vehicle power is removed from tram motors.<br>I3 - Improved parking brake setting indicators (e.g., brake surface forces) that positively indicate FULL-ON setting.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| | | Not making preshift check of equipment | I3 - Built-in test equipment for improved preshift checks (i.e., hydraulic pressure, trailing cable conductor/insulation faults, etc.) and trouble diagnosis (possibly programmed).<br>II3- Checklist signed and submitted to foreman.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of mine regulations and/or closer supervision. |
| | | Not observing caution when passing through brattice | I1 - Double-split ventilation.<br>I1 - Transparent brattice.<br>I3 - Proportional tramming control.<br>I3 - Integrated brake and tramming control.<br>II4- More intensive safety education and job training programs. |
| | | Loading coal too high - restricting visibility | I2 - Substitute lower profile machine.<br>I3 - Locate operator near boom end of shuttle car.<br>I4 - Redesign canopies for optimal visibility.<br>I4 - Adjustable seat.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Various | I2 - Substitute continuous conveyor haulage for shuttle cars. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| B. Personnel struck or run over by vehicle | Track | Insufficient illumination at transfer points | I1 - Directed and shaded illumination at switches and transfer points.<br>I4 - Reflective clothing for all miners. |
| | | Poor maintenance of track guage, alignment, ballast, and roadway drainage | I1 - Improved roadway maintenance, leveling, filling, and drainage.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures.<br>II3- Separate standards of rail and track bed quality for coal and non-coal usages, and methods of testing to standards. |
| | | Defective equipment (maintenance): brakes, lights, bells, controllers, sanders, skids, etc. | I3 - Automatic, fail-safe emergency brakes.<br>I3 - Built-in test equipment for preshift checks (i.e., hydraulic/pneumatic pressure, conductor/insulation faults, etc.) and trouble diagnosis (possibly programmed).<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Defective misaligned switch or position indicator | I1 - In mines employing a dispatcher, switch-position indicators on dispatcher's display.<br>I4 - More positive switch-position sensors.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict written feedback. |
| | | Poor design, or location, of controls | I3 - Standardize and optimize operator compartments (human engineering).<br>I3 - Interlock drive motors with brake line pressure to prevent operation with inadequate brakes.<br>I4 - Self-centering controller and "dead man" control tied to brakes.<br>I4 - "Hands-free" type of communication system. |
| | | Lack of warning devices where hazards to personnel exist at mine car loading points | I3 - Time-delay actuator feeding device that emits audible warning before equipment moves. |
| | | Lack of, or defective, automatic couplers | I4 - Automatic couplers with self-centering devices (e.g., springs).<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Failure to give warning before spotting mine car | I3 - Time-delay actuator feeding device that emits audible warning before equipment moves. |
| | | Excessive speed for circumstances | I1 - Automatic speed limiting devices (that apply emergency brake above set speed).<br>I1 - In mines employing dispatcher, install dispatcher displays of vehicle velocity and locations.<br>I1 - Centralized remote control or fully automatic operation of tracked vehicles.<br>I1 - Signs or warning devices of environmental hazards (flashing lights, reflectors, etc.).<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| C. Collision between vehicles | Track | Insufficient illumination at transfer points | I1 - Directed and shaded illumination at switches and transfer points.<br>I4 - Provide parked trips with end reflectors.<br>I4 - Electromagnetic obstacle detectors. |
| | | Poor maintenance of track guage, alignment, ballast, and roadway drainage | I1 - Improved roadway maintenance, leveling, filling, and drainage.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with written user feedback.<br>II3- Separate standards of rail and track bed quality for coal and non-coal usages, and methods of testing to standards. |
| | | Lack of traffic control | I1 - Block signal system (provided it's justified by volume of traffic).<br>I1 - Upgrade dispatcher's capability to display vehicle location.<br>I1 - Central remote control of track vehicles.<br>I1 - Automatic control of track vehicles. |
| | | Communication media poor | I1 - Reduce noise in trolley phone system by conventional noise-reduction design techniques. |
| | | Defective equipment (maintenance): brakes, lights, bells, controllers, sanders, skids, etc. | I3 - Built-in test equipment for preshift checks (i.e., hydraulic/pneumatic pressure, conductor/insulation faults, etc.) and trouble diagnosis (possibly programmed).<br>I3 - Automatic, fail-safe emergency brakes.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Defective, misaligned switch or position indicator | I1 - In mines employing a dispatcher, switch-position indicators on dispatcher's display.<br>I4 - More positive switch-position sensors.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict written feedback.. |
| | | Poor design, or location, of controls | I3 - Standardize and optimize operator compartments (human engineering).<br>I3 - Interlock drive motors with brake line pressure to prevent operation with inadequate brakes.<br>I4 - Self-centering controller and "dead man" control tied to brakes.<br>I4 - "Hands-free" type of communication system. |
| | | Lack of, or defective, automatic couplers | I4 - Automatic couplers with self-centering devices (e.g., springs).<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Excessive speed for circumstances | I1 - Automatic speed limiting devices (that apply emergency brake above set speed).<br>I1 - In mines employing dispatcher, install dispatcher displays of vehicle velocities and locations.<br>I1 - Centralized remote control or fully automatic operation of tracked vehicles.<br>I1 - Signs or warning devices of environmental hazards (flashing lights, reflectors, etc.).<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| D. Collision, or contact, between vehicle and fixed obstacles or equipment | Trackless | Restricted overhead clearance | I1 - Diffused area illumination.<br>I1 - Adequate means of marking roof to indicate route with best clearance.<br>I4 - Slow-rise shock absorbers on vehicle seats.<br>I4 - Drag-bar on rear of shuttle car to aid in road leveling and filling.<br>II2- Improved roadway maintenance, leveling, filling, and drainage. |
| | | Uneven, sidling, wet floor | I4 - Canopies (or full cab enclosures) designed for maximum visibility and egress.<br>I4 - Alternative tire designs to improve traction with differing bottom conditions.<br>I4 - Slow-rise shock absorbers on vehicle seats.<br>I4 - Drag-bar on rear of shuttle car to aid in road leveling and filling.<br>II3- Improved roadway maintenance, leveling, filling, and drainage. |
| | | Insufficient illumination | I1 - Diffused area illumination of haulageway to improve driver cues, and reduce hazard reaction times.<br>I1 - Designate entries/crosscuts being used for shuttle cars run by operator placement of portable markers (e.g., reflective cones).<br>I4 - Standard color marker lights for use on parked vehicles. |
| | | View obstructed by brattice | I1 - Double-split ventilation.<br>I1 - Transparent brattice. |
| | | Defective equipment (maintenance): brakes, lights, bells, steering, tramming control | I3 - Built-in test equipment for improved preshift checks (i.e., hydraulic pressure, cable conductor/insulation faults) and trouble diagnosis (possibly programmed).<br>I3 - Automatic, fail-safe emergency brake (sets when vehicle power is removed from tram motors, when actuated by panic bar, or when any component of service brake fails).<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Poor design, or location, of controls | I3 - Standardize and optimize operator compartments (human engineering).<br>I3 - Proportional tramming controls.<br>I3 - Attenuation of steering torque feedback (e.g., modified power steering).<br>I3 - Interlock tram motors with brake line pressure to prevent operation with "low" brakes.<br>I3 - Positive, mechanical parking brake separate from service brake.<br>I3 - "Dead man" control tied to automatic emergency brake. |
| | | Inadequate, or no, panic bars | I4 - Canopy with full cab enclosure or with gate (as alternative to panic bar).<br>I4 - Design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles. |
| | | Poor driver visibility | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I1 - Designate entries/crosscuts being used for shuttle cars run by operator placement of portable markers (e.g., reflective cones).<br>I2 - Substitute lower profile machine.<br>I3 - Automatic shuttle car guidance system.<br>I3 - Locate operator near boom end of shuttle car.<br>I4 - Redesign canopies for optimal visibility and egress.<br>I4 - Adjustable seat.<br>I4 - Electromagnetic obstacle detector.<br>II2- Control loading height of coal to improve operator's opposite side view.<br>I4 - Folddown sideboards. |
| | | Insufficient lighting on vehicle | I4 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I4 - High intensity diffused headlamps (new lens design).<br>I4 - Lights that may be dimmed but turned off only when machine power is removed.<br>I4 - Two reliable headlamps, and side lights or reflectors on each end of vehicle.<br>I4 - Reflective paint and/or tape with colors for different functions.<br>II2- Keep headlamps clean. |
| | | Items protruding from equipment | I1 - Improved material handling procedures and techniques.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| Collision, or contact, between vehicles and fixed obstacles or equipment (concluded) | Trackless | Excessive speed for circumstances | I3 - Proportional tramming control.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Not facing direction of travel | I3 - Seat interlock with audible warning after limited backward travel.<br>I3 - Swing-around rotational cab.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and closer supervision. |
| | | Inexperienced or unfamiliar operator | I3 - Standardize and optimize operator compartments (human engineering).<br>II4- More intensive safety education and job training programs (multi-job training).<br>II5- Closer supervision. |
| | | Headlights not on while tramming | I3 - Interlock motors with headlight circuit<br>I4 - High intensity diffused headlamps (new lens design).<br>I4 - Lights that may be dimmed but turned off only when machine power is removed.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and closer supervision. |
| | | Not making preshift check of equipment | I3 - Built-in test equipment for improved preshift checks (i.e., hydraulic pressure, trailing cable, conductor/insulation faults, etc.) and trouble diagnosis (possibly programmed).<br>II3- Check list signed and submitted to foreman.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| | | Not observing caution when passing through brattice | I1 - Double-split ventilation.<br>I1 - Transparent brattice.<br>I3 - Proportional tramming control.<br>I3 - Integrated brake and tramming control.<br>II4- More intensive safety education and job training programs. |
| | | Loading coal too high, restricting visibility | I2 - Substitute lower profile machine.<br>I3 - Locate operator near boom end of shuttle car.<br>I4 - Redesign canopies for optimal visibility and egress.<br>I4 - Adjustable seat.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| E. Riding personnel struck parts of body on top or side obstruction | Trackless | Restricted overhead clearance | I1 - Diffused area illumination.<br>I1 - Adequate means of marking roof to indicate route with best clearance.<br>I4 - Slow-rise shock absorbers on vehicle seats.<br>I4 - Drag-bar on rear of shuttle car to aid in road leveling and filling.<br>I4 - High intensity diffused headlamps (new lens design).<br>II2- Improved roadway maintenance, leveling, filling, and drainage. |
| | | Uneven, sidling, wet floor | I4 - Canopies or full cab enclosures designed for maximum visibility and egress.<br>I4 - Alternative tire designs to improve traction with differing bottom conditions.<br>I4 - Slow-rise shock absorbers on vehicle seats.<br>I4 - Drag-bar on rear of shuttle car to aid in road leveling and filling.<br>II3- Improved roadway maintenance, leveling, filling, and drainage. |
| | | Insufficient illumination | I1 - Diffused area illumination of haulageway to improve driver cues, and reduce hazard reaction time.<br>I4 - Reflective paint on low roof and obstructions. |
| | | Lack of, or poor design of, canopies | I4 - Canopies or full cab enclosures designed for maximum visibility and egress.<br>I4 - Design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles. |
| | | View obstructed by brattice | I1 - Double-split ventilation.<br>I1 - Transparent brattice. |
| | | Defective equipment (maintenance): brakes, lights, bells, steering, tramming controls | I3 - Built-in test equipment for improved preshift checks (i.e., hydraulic pressure) and trouble diagnosis (possibly programmed).<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Poor design, or location, of controls | I3 - Standardize and optimize operator compartments (human engineering).<br>I3 - Proportional tramming control.<br>I3 - Attenuation of steering torque feedback (e.g., modified power steering).<br>I3 - Interlock tram motors with brake line pressure to prevent operation with "low" brakes. |
| | | Inadequate, or no, panic bars | I4 - Design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles.<br>I4 - Canopy with full cab enclosure or with gate (as alternatives to panic bar). |
| | | Poor driver visibility | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I2 - Substitute lower profile machine.<br>I3 - Locate operator near boom end of shuttle car.<br>I4 - Redesign canopies for optimal visibility.<br>I4 - Adjustable seat.<br>II2- Control loading height of coal to improve operator's opposite side view.<br>I4 - Folddown sideboards. |
| | | Insufficient lighting on vehicles | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I4 - High intensity diffused headlamps (new lens design).<br>I4 - Lights that may be dimmed but turned off only when machine power is removed.<br>I4 - Two reliable headlamps and side lights or reflectors on each end of vehicle.<br>I4 - Reflective tape and/or paint with colors for different functions.<br>II2- Keep headlamps clean. |
| | | Excessive speed for circumstances | I3 - Proportional tramming control.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Not facing direction of travel | I3 - Seat interlocks with audible warning after limited backward travel.<br>I3 - Swing-around rotational cabs.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| Riding personnel struck parts of body on top or side obstruction (concluded) | Trackless | Inexperienced or unfamiliar operator | I3 - Standardize and optimize operator compartments (human engineering).<br>II4- More intensive safety education and job training programs (multi-job training).<br>II5- Closer supervision. |
| | | Riding in unsafe position, standing | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I2 - Substitute lower profile machine.<br>I3 - Locate operator near boom end of shuttle car.<br>I4 - Adjustable seat.<br>I4 - Redesign canopies for optimal visibility and egress.<br>I4 - Folddown sideboards.<br>II2- Control loading height of coal to improve operator's opposite side view. |
| | | Headlights not on while tramming | I3 - Interlock tram motors with headlight circuit.<br>I4 - High intensity diffused headlamps (new lens design).<br>I4 - Lights that may be dimmed but turned off only when machine power is removed.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of mine regulations and/or closer supervision. |
| | | Not making preshift check of equipment | I3 - Built-in test equipment for improved preshift checks and trouble diagnosis (possibly programmed or automatic).<br>II3- Check list signed and submitted to foreman.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Not observing caution when passing through brattice | I1 - Double-split ventilation.<br>I1 - Transparent brattice.<br>I3 - Proportional tramming controls.<br>I3 - Integrated brake-tramming control.<br>II4- More intensive safety education and job training programs. |
| | | Various | I2 - Substitute continuous conveyor haulage for shuttle cars. |
| F. Riding personnel struck parts of body on top or side obstruction | Track | Abrupt change of overhead clearance | I1 - Flexible warning sign hung at same height as obstruction.<br>I4 - Canopies or full cab enclosures to restrict body projection.<br>I4 - Reflective tape or paint on projections. |
| | | Hanging roof bolts | I4 - Canopies or full cab enclosures designed for maximum visibility and egress.<br>II2- Reflective paint for temporary marking until bolt removed/replaced.<br>II3- Scheduled preventive maintenance and improved maintenance procedures with strict written feedback. |
| | | No windshield or cab on locomotive | I4 - Design and installation guidelines for cabs and windshields on operational track equipment for use by manufacturers and mine shops in retrofitting vehicles. |
| | | Not remaining seated (standing to replace trolley pole) | I3 - Remotely controlled trolley pole placement.<br>I3 - Replace trolley pole with pantograph design having wide wire-capture span and limit pole freedom, obviate direction reversing, and reduce hand manipulation.<br>II3- Scheduled preventive maintenance (trolley wires and tracks) and improved maintenance procedures with strict written feedback.<br>II4- More intensive safety education and job training programs. |
| | | Excessive speed for circumstances | I1 - Automatic speed limiting devices.<br>I1 - Central remote control or automatic control of track vehicles.<br>I1 - Signs or other devices to warn of environmental hazards. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| G. Riding personnel struck, run over, or squeezed while getting on or off moving equipment | Track | Insufficient illumination at transfer points | I1 - Directed and shaded illumination at transfer points. |
| | | Defective equipment (maintenance): brakes, lights, bells, controllers, sanders, skids, etc. | I3 - Built-in test equipment for preshift checks (i.e., hydraulic/pneumatic pressure, conductor/insulation faults, etc.) and trouble diagnosis (possibly programmed).<br>I3 - Automatic, fail-safe emergency brakes.<br>II3- Scheduled preventive maintenance and improve overall maintenance procedures with strict user feedback. |
| | | Excessive speed for circumstances | I1 - Automatic speed limiting devices.<br>I1 - Central remote control or automatic control of track vehicles.<br>I1 - Signs or other devices to warn of environmental hazards.<br>II4- More intensive safety education and job training programs. |
| | | Getting on and off moving vehicles | II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| H. Riding personnel struck, run over, or squeezed while getting on or off moving equipment | Belt | Lack of side clearance | I1 - Modify roof control locally to allow wider entries (arches, belts).<br>II3- Scheduled preventive maintenance (clean up) and improved maintenance procedures with strict written feedback. |
| | | Lack of adequate emergency stop devices, entire length of mantrip | II3- Scheduled preventive maintenance and improved maintenance procedures with strict written feedback. |
| | | Getting on or off moving conveyors | I4 - Provide convenient switch location that can be actuated from position on belt.<br>I4 - Provide switch with delay circuit.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| I. Riding personnel injured because of rough ride or sudden starts or stops | Trackless | Uneven, sidling, wet floor | I3 - Improved roadway maintenance, leveling, filling, and drainage.<br>I4 - Drag-bar on rear of shuttle cars to aid in leveling and filling.<br>I4 - Alternative tire designs to improve traction under differing bottom conditions. |
| | | Insufficient illumination | I1 - Diffused area illumination of haulageways to improve driver cues and reduce hazard reaction time.<br>I4 - Standard color marker light for use on parked equipment. |
| | | Defective equipment (maintenance): brakes, lights, bells, steering, tramming controls | I3 - Built-in test equipment for improved preshift checks (i.e., hydraulic pressure, cable conductor/insulation faults) and trouble diagnosis (possibly programmed).<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Poor design, or location, of controls | I3 - Standardize and optimize operator compartments (human engineering).<br>I3 - Proportional tram control.<br>I3 - Attenuation of steering-torque feedback (e.g., modified power steering). |
| | | Poor driver visibility | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I3 - Locate operator near boom end of machine.<br>I3 - Automatic shuttle car guidance system.<br>I4 - Redesign canopy for optimal visibility.<br>I4 - Adjustable seat.<br>I4 - Electromagnetic obstacle detector. |
| | | Insufficient lighting on vehicles | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I4 - High intensity diffused headlamps (new lens design).<br>I4 - Lights that may be dimmed but turned off only when machine power is removed.<br>I4 - Two reliable headlamps, and side lights on each end of vehicle.<br>II2- Keep headlamps clean. |
| | | Excessive speed for circumstances | I3 - Proportional tramming control.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| Riding personnel injured because of rough ride or sudden starts or stops (concluded) | Trackless | Not facing direction of travel | I3 - Seat interlock with audible warning after limited backward travel.<br>I3 - Swing-around rotational cab.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| | | Inexperienced or unfamiliar operator | I3 - Standardize and optimize operator compartments (human engineering).<br>II4- More intensive safety education and job safety programs (multi-job training).<br>II5- Closer supervision. |
| | | Riding in unsafe position, standing | I1 - Diffused area illumination of haulageway to improve driver cues.<br>I1 - Adequate means of marking roof to indicate route with best clearance.<br>I2 - Substitute lower profile machine.<br>I3 - Automatic shuttle car guidance system.<br>I3 - Locate operator near boom end of shuttle car.<br>I4 - Electromagnetic obstacle detector.<br>I4 - Adjustable seat.<br>II2- Control loading height of coal to improve operator's view of opposite side. |
| | | Headlights not on while tramming | I3 - Interlock tram motors with headlight circuit.<br>I4 - Lights that may be dimmed but turned off only when machine power is removed.<br>I4 - High intensity diffused headlamps (new lens design). |
| | | Not making preshift equipment check | I3 - Built-in test equipment for improved preshift checks (i.e., hydraulic pressure, cable conductor/insulation faults) and trouble diagnosis (possibly programmed).<br>II3- Check list signed and submitted to foreman.<br>II4- More intensive safety education and job safety programs.<br>II5- Closer supervision. |
| | | Not observing caution when passing through brattice | I1 - Double-split ventilation.<br>I1 - Transparent brattice material.<br>I3 - Proportional tramming controls.<br>I3 - Integrated brake and tramming control.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Loading coal too high, restricting visibility | I1 - Diffused area illumination of haulageway to improve driver cues and reduce hazard reaction time.<br>I1 - Designate entries/crosscuts being used for shuttle cars run by operator placement of portable markers (e.g., reflective cones).<br>I2 - Substitute lower profile machine.<br>I3 - Locate operator near boom end of shuttle car.<br>I4 - Redesign canopies for optimal visibility.<br>I4 - Adjustable seat.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| J. Riding personnel injured because of rough ride or sudden starts or stops | Track | Poor maintenance of track gauge, alignment, ballast, roadway drainage | I1 - Improved roadway maintenance, leveling, filling.<br>I1 - Greater use of dewatering wells, sump holes and/or drainage ditches.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict written feedback.<br>II3- Separate standards of rail and track bed quality for coal and non-coal usages, and methods of testing to standards. |
| | | Defective equipment (maintenance): brakes, lights, bells, controllers, sanders, skids, etc. | I3 - Built-in test equipment for improved preshift checks (e.g., pneumatic pressure, conductor/insulation faults, etc.) and trouble diagnosis (possibly programmed).<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Defective, misaligned switch or position indicator | I1 - In mines employing dispatcher, switch position indicators on dispatcher display.<br>I4 - More positive switch position sensors.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict written feedback. |
| | | Poor design, or location, of controls | I3 - Standardize and optimize operator compartments (human engineering).<br>I3 - Interlock drive motors with brake line pressure to prevent operation with inadequate brakes.<br>I4 - Self-centering controller and "dead man" control tied to brakes.<br>I4 - "Hands-free" type of communication system. |
| | | Not remaining seated (e.g., standing to replace trolley pole) | I3 - Remotely controlled trolley pole placement.<br>I3 - Replace trolley pole with pantographic design having wide wire-capture span and limit pole freedom, obviate direction reversing, and reduce hand manipulation.<br>II3- Scheduled preventive maintenance (trolley wire and track) and improved overall maintenance procedures with strict written feedback.<br>II4- More intensive safety education and job training programs. |
| | | Excessive speed for circumstances | I1 - Automatic speed limiting devices (apply emergency brakes above set speed).<br>I1 - Centralized remote control or fully automatic operation of tracked vehicles.<br>I1 - Signs or other devices to warn of environmental hazards (flashing lights, reflectors, etc.).<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| K. Personnel injured during derail, rerailing, or because of faulty switch | Track | Poor maintenance of track gauge, alignment, ballast, and roadway drainage | I1 - Greater use of dewatering wells, sump holes, and/or drainage ditches.<br>I1 - Improved roadway maintenance, leveling, filling.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict written feedback.<br>II3- Separate standards of rail and track bed quality for coal and non-coal usages, and methods of testing to standards. |
| | | Defective equipment (maintenance): brakes, lights, bells, controllers, sanders, skids, etc. | I3 - Built-in test equipment for improved preshift checks (e.g., pneumatic pressure, conductor/insulation faults, etc.) and trouble diagnosis (possibly programmed).<br>I3 - Automatic, fail-safe emergency brakes.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Not using proper rerailing device | II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Defective, misaligned switch or position indicator | I1 - More positive switch position sensors.<br>I1 - In mines employing a dispatcher, switch position indicators on dispatcher display.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict written feedback. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| L. Personnel squeezed or run over when coupling or uncoupling | Track | Communication media poor | I1 - Reduce noise in trolley phone system by conventional noise reduction design techniques. |
| | | Lack of, or defective, automatic couplers | I4 - Automatic couplers with self-centering devices.<br>II2- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Inadequate decouplers - going between cars | I1 - Reliable voice communication between brakeman and motorman.<br>I3 - Automatic or remote control decoupling (i.e., operated from motor).<br>I4 - More positive decoupling device that holds coupler open until car separation (e.g., detent).<br>II2- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback. |
| | | Does not use lever - steps between cars to couple, uncouple | I1 - Reliable voice communication between brakeman and motorman.<br>I3 - Automatic or remote control decoupling (i.e., operated from motor).<br>I4 - More positive decoupling device that holds coupler open until car separation (e.g., detent).<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| M. Riding personnel caught between moving parts of vehicle | Trackless | Riding in unsafe position | I1 - Diffused area illumination of haulageway to improve driver cues.<br>I1 - Adequate means of marking roof to indicate route with best clearance.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| | | Not shutting down, setting brakes, blocking a parked vehicle | I3 - Automatic fail-safe parking brake; acts whenever vehicle power is removed from tram motors.<br>I3 - Improved parking brake setting indicators (e.g., via brake surface pressure) that positively indicate FULL-ON setting.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| N. Riding personnel caught between moving parts of vehicle | Track | Not remaining seated (e.g., standing to replace trolley pole) | I3 - Remotely controlled trolley pole placement.<br>I3 - Replace trolley pole with pantograph design having wide wire-capture span and limit pole freedom, obviate direction reversing, and reduce hand manipulation.<br>II3- Scheduled preventive maintenance (trolley wires and track) and improved maintenance procedures with strict written feedback.<br>II4- More intensive safety education and job training programs. |
| O. Personnel struck or squeezed when caught by trailing cable | Trackless | Uneven, sidling, wet floor | I1 - Improved roadway maintenance, leveling, filling, and drainage.<br>I4 - Drag-bar on rear of shuttle car to aid in road leveling and filling. |
| | | Defective equipment (maintenance): cable reel | I3 - Built-in test equipment for improved preshift checks (i.e., cable forces or torque in reel) or trouble diagnosis.<br>II3- Scheduled preventive maintenance and improved maintenance procedures with strict user written feedback. |
| | | Inexperienced or unfamiliar operator | I3 - Standardize and optimize operator compartments (human engineering).<br>II4- More intensive safety education and job training programs (multi-job training).<br>II5- Closer supervision. |
| | | Poor cable control | I2 - Substitute battery or diesel vehicles.<br>I2 - Substitute continuous conveyor face haulage.<br>I4 - Variable cable tension or feedback device to minimize whip and tension.<br>II4- More effective job training programs.<br>II5- Closer supervision. |

## Table 5-5. Candidate Preventive Measures (Continued)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| P. Personnel injured by shock, burn, or explosion of trailing cable | Trackless | Inexperienced or unfamiliar personnel | I3 - Built-in test equipment to provide conductor/insulation fault analysis.<br>II3- Preventive scheduled maintenance and improved maintenance procedures with strict written feedback.<br>II4- More effective safety education and job training programs (multi-job training).<br>II5- Closer supervision. |
| | | Poor cable control | I2 - Substitute battery or diesel vehicles.<br>I2 - Substitute continuous conveyor face haulage.<br>I4 - Variable cable tension or feedback device to minimize whip and tension.<br>II4- More effective safety education and job training programs.<br>II5- Closer supervision. |
| | | Various | I4 - Quick disconnect trailing cable connectors with safety interlock. |
| Q. Personnel working close caught in unprotected belt components | Belt | Lack of illumination at transfer points | I1 - Directed and shaded illumination at transfer points.<br>I4 - Reflective tape or paint with colors for different functions.<br>II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict written feedback. |
| | | Lack of side clearance | I1 - Modify roof control locally to allow wider entries (arches, belts).<br>II2- Scheduled preventive maintenance (clean up) and improved overall maintenance procedures with strict written feedback. |
| | | Lack of warning signs/safety interlocks to prevent "turn-on" while working on belt | I1 - Additional communication along belt.<br>I4 - Switch locking key to prevent energizing belt drives during maintenance. |
| | | Lack of "start" warning devices | I3 - Time delay circuit and warning in belt drive switch. |
| | | Lack of adequate guards at drive pulleys | II5- More effective enforcement of regulations and/or closer supervision. |
| | | Working on or too close to moving belt or unguarded pulley | I1 - Modify roof control locally to allow wider entries (arches, belts).<br>I1 - Closed circuit TV monitoring for closer supervision.<br>II2- Scheduled preventive maintenance (clean up) and improved maintenance procedures with strict written feedback. |
| R. Personnel riding belt carried into transfer point | Belt | Lack of illumination at transfer points | I1 - Directed and shaded illumination at transfer points. |
| | | Lack of adequate emergency stop devices - entire length of mantrip | II2- Scheduled preventive maintenance and improved overall maintenance procedures with strict written feedback. |
| T. Personnel struck by equipment or tools that came loose | Belt | Lack of side clearance | I1 - Modify roof control locally to allow wider entries (arches, belts).<br>II3- Scheduled preventive maintenance (clean up) and improved overall maintenance procedures with strict written feedback. |
| | | Lack of adequate guards at drive pulleys | II5- More effective enforcement of regulations and/or closer supervision. |
| | | Working on or too close to moving belt or unguarded pulley | I1 - Modify roof control locally to allow wider entries (arches, belts).<br>I1 - Closed circuit TV monitoring for closer supervision.<br>II2- Scheduled preventive maintenance (clean up) and improved maintenance procedures with strict written feedback. |

## Table 5-5. Candidate Preventive Measures (Concluded)

| SIGNIFICANT TYPES OF ACCIDENTS | HAULAGE CATEGORY | RELATED CONTRIBUTING FACTORS | CANDIDATE PREVENTIVE MEASURES |
|---|---|---|---|
| W. Riding personnel struck by loose trolley pole | Track | No windshield or cab on locomotive | I4 - Design and installation guidelines for cabs and windshields on operational track equipment for use by manufacturers and mine shops in retrofitting vehicles. |
| | | Not remaining seated (e.g., standing to replace trolley pole) | I3 - Remotely controlled trolley pole placement.<br>I3 - Replace trolley pole with pantograph design having wide wire-capture span and limit pole freedom, obviate direction reversing, and reduce hand manipulation.<br>II3- Scheduled preventive maintenance (trolley wire and track) and improved overall maintenance procedures with strict written feedback.<br>II4- More intensive safety education and job training programs. |
| | | Excessive speed for circumstances | I1 - Automatic speed limiting devices.<br>I1 - Centralized remote control or fully automatic operation of tracked vehicle.<br>I1 - Signs or other devices to warn of environmental hazards (flashing lights, reflectors, etc.).<br>II4- More intensive safety education and job training programs. |
| X. Falling material struck miner | Trackless | Lack of, or poor design of, canopies | I4 - Redesign canopies or full cab enclosures for optimal visibility and egress.<br>I4 - Design and installation guidelines for each model of equipment now in use for use by mine shops in retrofitting vehicles. |
| | | Loading coal too high | I3 - Locate operator near boom end of shuttle car.<br>I4 - Redesign canopies or full cab enclosures for optimal visibility and egress. |
| Y. Small object struck miner's eye | Various | No windshield or cab on locomotive | I4 - Design and installation guidelines for placing cabs or windshields on rail equipment for use by manufacturers and mine shops in retrofitting operational vehicles. |
| | | Failure to wear eye protection | I4 - Optimal design for safety glasses or flip-up shield to provide protection and allow for use of corrective prescription.<br>II4- More intensive safety education and job training programs.<br>II5- More effective enforcement of regulations and/or closer supervision. |
| Z. Miscellaneous - strained muscles, slip and fall, bumped self, etc. | Various | Lack of illumination at transfer points | I1 - Directed and shaded illumination at switches and transfer points.<br>I4 - Portable task lights.<br>I4 - Portable area lights.<br>I4 - Reflective paint and/or tape with colors for different functions.<br>II2- Keep work areas free of debris.<br>II2- Use proven/proper tools.<br>II4- More intensive safety education and job training programs.<br>II5- Closer supervision. |
| | | Various | I2 - Provide mobile and fixed equipment specifically designed for lifting and moving heavy components in the limited space of coal mines. |

In this study, an attempt was made to include these realities as existing conditions, and to provide relatively short-term solutions that might be applied to a cross section of present U.S. underground coal mines as they are operated today. Here, and in the trade-off analysis and recommendations to follow, the concept was to attack each problem at the system level, taking into account the complex interrelationships of men, methods, equipment, and environment. An attempt was made to establish the most probable or significant faults, and then match up preventive measures that were believed to hold the greatest promise of improvement in the overall operation. Initially, a search was made for causes other than human faults or environmental irregularity faults in line with the definitions given ahead. This was done in order to force discovery of preventive measures in the areas of: first, design, and second, procedures. Those problems not amenable to design or procedures cure, then, must be attacked via other means such as improved training and changes in regulations.

The foregoing may appear to put an inordinate burden on mine management and equipment suppliers to save the miner from injury. However, the purpose of the analysis was to point the way toward development of equipment and mine systems that would do just that: make it difficult for the miner to do the wrong thing, or conversely, make it easier for him to do the right thing.

The candidate preventive measures were rearranged somewhat by functional category to facilitate the trade-off analysis and for later correlation with recent USBM research and development programs. The trade-off parameters used are:

a. Effectiveness in alleviating observed hazards.

b. Commonality, i.e., the degree of which a single concept might mitigate more than one hazard.

c. Minimum time schedule to develop and implement the preventive measure operationally in a significant fraction of U.S. coal mines.

d. Complexity of the system required to meet the preventive measure requirements.

e. Probable total cost to implement the concept in a significant fraction of U.S. coal mines.

f. System or hardware reliability in the underground coal mine environment.

g. Ease of maintainability of the operational system including resupply.

h. Consideration of significant additional electrical power requirements.

i. Form factor, i.e., consideration of shape, size and location requirements, especially where additional hardware may interfere with othermachine functions.

j. The degree to which the preventive measure may improve or inhibit operational flexibility.

k. Technical risk in bringing the concept to operational utility.

l. The potential that adaption of the concept may introduce new safety problems in adjacent areas.

m. Factors other thanthe above that may bear on the feasibility of implementation or general utilization of the concept in many mines.

These parameters are contained in table 5-6. The numerical ratings for each parameter indicate as follows:

3 - Very Good
2 - Good
1 - Marginal
? - Could Not Evaluate

In the right-hand column is a summary comment symbol providing an opinion about the schedule and feasibility of the preventive measure concept, where:

S - Potential Significant Short-Term Gains
L - Potential Significant Long-Term Gains
? - Overall Feasibility of Concept Not Certain

In applying the ratings, each preventive measure concept was considered independently of the others. For example, effectiveness means only the effectiveness of that concept in relation to the particular hazard(s) it is designed to reduce. Therefore the overall value of one concept can not always be compared directly with another. The ratings given in table 5-6 were based mainly on the judgment of the project personnel, including the mining consultant, Mr. George Judy. It is conceivable that developments unknown to the project team may suggest different ratings than those chosen here. Readers are therefore encouraged to supply their own evaluations.

## Table 5-6. Trade-Off Analysis

| CANDIDATE PREVENTIVE MEASURES | Effectiveness | Commonality | Schedule | Complexity | Cost | Reliability | Maintainability | Power Req'ts | Form Factor | Opn'l Flexibility | Tech Risk | New Problems | Utilization | Summary Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPERATOR COMPARTMENT AND CONTROLS | | | | | | | | | | | | | | |
| Standardize and optimize operator's compartment (human engineering) (TRACKLESS, TRACK). | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | | L |
| Proportional tramming control (TRACKLESS). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | | L |
| Attenuation of steering torque feedback (e.g., modified power steering) (TRACKLESS). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | | ? |
| Adjustable seat (TRACKLESS). | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Slow-rise shock absorbers on vehicle seats (TRACKLESS). | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Integrated brake and tramming control (TRACKLESS). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | L | | L |
| Block signal system (provided it's justified by volume of traffic) (TRACK). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | L |
| Automatic speed limiting devices (that apply emergency brake above set speed) (TRACK). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | L |
| Provide convenient on-off switch location that can be actuated from riding position on belt (BELT-MANTRIP). | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | | S |
| Key-locking switch to prevent energizing belt drives during maintenance (BELT). | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Closed circuit TV monitoring for closer supervision (BELT). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | L |
| AUTOMATIC PILOTS | | | | | | | | | | | | | | |
| Automatic shuttle car guidance system (TRACKLESS). | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | ? |
| Electromagnetic obstacle detector (TRACKLESS, TRACK). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | | L |
| REMOTE/AUTOMATIC CONTROLS | | | | | | | | | | | | | | |
| Automatic control of track vehicles (TRACK). | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | L |
| Central remote control of track vehicles (TRACK). | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | L |
| In mines employing a dispatcher, switch-position indicators on dispatcher display (TRACK). | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| In mines employing a dispatcher, install dispatcher displays of vehicle velocity and locations (TRACK). | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | L |
| Automatic or remote control decoupling (i.e., operated from motor) (TRACK). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | L |
| Automatic couplers with self-centering devices (TRACK). | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| More positive decoupling device that holds coupler open until car separation (e.g., detent) (TRACK). | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | S |

Table 5-6. Trade-Off Analysis (Continued)

| CANDIDATE PREVENTIVE MEASURES | Effectiveness | Commonality | Schedule | Complexity | Cost | Reliability | Maintainability | Power Req'ts | Form Factor | Opn'l Flexibility | Tech Risk | New Problems | Utilization | Summary Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTINUOUS HAULAGE | | | | | | | | | | | | | | |
| Substitute continuous conveyor haulage for shuttle cars (TRACKLESS). | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | L |
| BRAKES AND PANIC BARS | | | | | | | | | | | | | | |
| Automatic, fail-safe emergency/parking brake (sets when vehicle power is removed from tram motor, when actuated by panic bar, or when any component of service brake fails) (TRACKLESS, TRACK). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | | L |
| "Dead man" controls tied to automatic brakes (TRACKLESS, TRACK). | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | | S |
| Positive, mechanical parking brake separate from service brake (TRACKLESS, TRACK). | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | | S |
| Interlock drive motors with brake line pressure to prevent operation with "low" brakes (TRACKLESS, TRACK). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | | L |
| Improved parking brake indicator (e.g., via brake surface forces) to give positive indication of FULL-ON condition (TRACKLESS, TRACK). | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| Panic bar design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles (TRACKLESS). | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| PROTECTIVE CANOPIES | | | | | | | | | | | | | | |
| Design (or redesign) canopies for optimal visibility and/or egress (TRACKLESS). | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | L |
| Canopy with full cab enclosure or with gate (as alternative to panic bar) (TRACKLESS). | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 3 | 1 | | L |
| Design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles (TRACKLESS). | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| Canopies or full cab enclosures to restrict body projection (TRACK). | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| Design and installation guidelines for cabs and windshields on operational track equipment for use by manufacturers and mine shops in retrofitting vehicles (TRACK). | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| Swingaround rotational cabs (TRACKLESS). | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | | L |
| ILLUMINATION AND VISION AIDS | | | | | | | | | | | | | | |
| Diffused area illumination of haulageways to improve driver cues and reduce hazard reaction times (TRACKLESS). | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 3 | 2 | | S |

Table 5-6. Trade-Off Analysis (Continued)

| CANDIDATE PREVENTIVE MEASURES | Effectiveness | Commonality | Schedule | Complexity | Cost | Reliability | Maintainability | Power Req'ts | Form Factor | Opn'l Flexibility | Tech Risk | New Problems | Utilization | Summary Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High intensity diffused headlamps (new lens design) (TRACKLESS). | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | L |
| Two reliable headlamps and side lights or reflectors on each end of vehicle (TRACKLESS). | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | | L |
| Interlock headlights with tramming direction control (TRACKLESS). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | L |
| Lights that may be dimmed but turned off only when machine power is removed (TRACKLESS). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | L |
| Keep headlamps clean (TRACKLESS). | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Directed and shaded illumination at transfer points (TRACK). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | L |
| Portable task lights and area lights (TRACK, TRACKLESS). | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | | S |
| Standard color marker lights for use on parked vehicles (TRACKLESS). | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Provide parked trips with end reflectors (TRACK). | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Reflective paint and/or tape with colors for different functions (GENERAL). | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Reflective clothing for all mine personnel (GENERAL). | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Reflective paint on low roof and obstructions (TRACKLESS). | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Reflective paint for temporary marking of hanging bolts until bolt removed/replaced (TRACKLESS, TRACK). | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Flexible warning sign hanging at same height as obstructions (TRACK). | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Adequate means of marking roof to indicate shuttle car route with best clearance (TRACKLESS). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | S |
| Designate entries/crosscuts being used for shuttle cars run by operator placement of portable markers, (e.g., reflective cones) (TRACKLESS). | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Substitute lower profile machine (TRACKLESS). | 2 | 2 | 1 | 3 | 1 | 2 | 2 | 2 | 2 | 1 | 3 | 1 | 1 | L |
| Locate operator near boom end of shuttle car (TRACKLESS). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | | L |
| Control loading height of coal to improve operator's opposite side view (TRACKLESS). | 2 | 2 | 3 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | | S |
| Folddown sideboards (TRACKLESS). | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | | S |

Table 5-6. Trade-Off Analysis (Continued)

| CANDIDATE PREVENTIVE MEASURES | Effectiveness | Commonality | Schedule | Complexity | Cost | Reliability | Maintainability | Power Req'ts | Form Factor | Opn'l Flexibility | Tech Risk | New Problems | Utilization | Summary Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Double-split ventilation to reduce number of curtains in haulageways (TRACKLESS). | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 1 | L |
| Transparent brattice to improve visibility (TRACKLESS). | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| NOISE CONTROL | | | | | | | | | | | | | | |
| Reduce machine noise (through isolation, insulation, and redesign) (GENERAL). | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | | L |
| Discriminating electronic ear muffs (GENERAL). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| COMMUNICATIONS | | | | | | | | | | | | | | |
| Area-wide communication between vehicles and all miners in same area (GENERAL). | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 1 | L |
| Short range line-of-sight transceivers between foreman, loader/continuous miner operator, and shuttle car drivers (GENERAL). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Reduce noise in trolley phone system by conventional noise reduction design techniques (TRACK). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | | L |
| Reliable voice communication between brakeman and motorman (TRACK). | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | | L |
| Additional communication along belt (BELT). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| "Hands-free" type of communication system (TRACK). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| MAINTENANCE | | | | | | | | | | | | | | |
| Built-in test equipment for improved machine preshift checks (i.e., hydraulic pressure, cable faults) and trouble diagnosis (possibly programmed) (TRACKLESS). | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | | L |
| Variable cable tension or feedback devices to minimize whip and tension (SHUTTLE CAR). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | L |
| Quick disconnect trailing cable connectors with safety interlocks (TRACKLESS). | 2 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | | S |
| Improved roadway maintenance, leveling, and drainage (TRACKLESS). | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Drag-bar on rear of shuttle car to aid in road leveling and filling (TRACKLESS). | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 3 | 2 | | S |
| Greater use of dewatering wells, sump holes and/or drainage ditches (TRACK). | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Preshift machine check list signed and submitted to foreman (TRACKLESS, TRACK). | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | | S |

Table 5-6. Trade-Off Analysis (Continued)

| CANDIDATE PREVENTIVE MEASURES | Effectiveness | Commonality | Schedule | Complexity | Cost | Reliability | Maintainability | Power Req'ts | Form Factor | Opn'l Flexibility | Tech Risk | New Problems | Utilization | Summary Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback (GENERAL). | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | | S |
| Separate design standards of rail and track bed quality for coal and non-coal usages (TRACK). | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | | S |
| WARNING | | | | | | | | | | | | | | |
| Seat interlock with audible warning after limited backward travel (TRACKLESS). | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | 3 | 1 | | S |
| Automatic, short audible or visible signal when tramming lever is engaged (TRACKLESS). | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| Relocate warning sound sources to reduce annoyance to operator (TRACKLESS). | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |
| Time-delay actuator in porta-feeder to give audible warning before equipment moves (TRACK). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| Signs or warning devices of environmental hazards (flashing lights, reflectors, etc.) (TRACK). | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| Time-delay circuit and warning in belt drive switch (BELT). | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | | S |
| MISCELLANEOUS | | | | | | | | | | | | | | |
| Improved material handling procedures and techniques (TRACKLESS, TRACK, BELT). | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | | L |
| More intensive safety education and job training programs (including multi-job training) (GENERAL). | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | | L |
| More effective enforcement of regulations and/or closer supervision (GENERAL). | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | | S |
| Alternative tire designs to improve traction under differing bottom conditions (TRACKLESS). | ? | 3 | 2 | 2 | 2 | 2 | 2 | 2 | ? | 3 | 2 | 3 | | L |
| Substitute battery or diesel vehicles (TRACKLESS). | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | | L |
| Modify roof control locally, where belt side clearance is limited, to allow wider entries (arches, bolts) (BELT). | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | | S |
| Keep work areas free of debris (GENERAL). | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | | S |
| Use proven/proper tools (GENERAL). | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | | L |
| Optimal design for safety glasses or flip-up shield to provide protection and allow for use of corrective prescription (GENERAL). | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | | S |

Table 5-6. Trade-Off Analysis (Concluded)

| CANDIDATE PREVENTIVE MEASURES | Effectiveness | Commonality | Schedule | Complexity | Cost | Reliability | Maintainability | Power Req'ts | Form Factor | Opn'l Flexibility | Tech Risk | New Problems | Utilization | Summary Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mobile (and fixed) equipment specifically designed for lifting and moving heavy components in the limited space of coal mines (GENERAL). | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | | | L |
| Remotely controlled trolley pole placement (TRACK). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | ? | | | L |
| Replace trolley pole with pantograph design having wide capture span and limited pole freedom, to obviate pole direction reversing, and reduce hand manipulation (TRACK). | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | ? | | | L |
| More positive switch-position sensors (TRACK). | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | | S |

5.4 Application of Recent USBM Programs - A list of known USBM research programs containing developments pertinent to reduction of haulage hazards in underground coal mines is presented in table 5-7. The objectives and outputs of these programs, as understood by the project personnel, are compared with the alternative preventive measures conceived in table 5-8, by noting the degree of application of the R&D program and suggesting additional work that might lead to implementation of the preventive measure. Where the preventive measure appeared to be outside the area of competence of the project personnel and perhaps outside the province of current USBM responsibility, the notes may merely point out that some work has been done on the subject and perhaps recognizing that more is needed. Tracing the suggestion back to table 5-5, the reader may gain insight into the situation and hazard, if these are not already well known. In general, recommendations in the area of design have been given the most attention, and of these, more emphasis has been placed on those that might be implemented in a short time span. Because of the many variables involved in different mines and situations, the project personnel did not feel sufficiently confident to provide overall priorities for the various preventive measure concepts. Also, to reach some objectives, it may be prudent to pursue both short- and long-term developments toward the same goal. For example, consider the problem of decoupling and coupling mine cars. H0346042 is pursuing a development of remote coupling operated from the locomotive, thereby eliminating the need for a "snapper" for this function. The authors believe that this development will indeed be worth the investment, and should be pursued. The cost and schedule to implement this concept operationally in a large fraction of the coal mines, however, suggest that an interim short-term fix may be considered, even if only partially effective in reaching the total objectives of H0346042.

In general, the authors feel that with the exception of training and motivation, possibly the largest payoffs for improved safety are in better maintenance of all kinds of equipment and systems. It is therefore suggested that the USBM give serious consideration to providing more assistance to the industry in developing improved methods in this aspect of coal mining.

Table 5-7. Applicable USBM Research and Development Programs

| | |
|---|---|
| **Standardization of Controls** | |
| H0230021 | Standardization of Controls for Underground Electric Face Equipment |
| H0242033 | Optimized Operator Compartment |
| **Automatic Pilots for Shuttle Cars** | |
| H0111194 | Automatic or Remote Control on Coal Mining Machines |
| **Remote/Automatic Control** | |
| H0242011 | Feasibility of Automated Rail-Haulage Systems in Underground Coal Mines |
| H0346042 | Automatic Coupler for Mine Cars |
| **Continuous Haulage** | |
| H0133037 | Feasibility of Hydraulic Transportation in Underground Coal Mines |
| H0242025 | Study of Continuous Face Haulage Systems |
| **Panic Bars and Automatic Brakes** | |
| H0110896 | Automatic Brakes for Mine Track Transportation Systems |
| H0111670 | Inherently Safe Mining Systems in Conventional and Continuous Coal Mines |
| H0133031 | Design Criteria for Panic Bars on Continuous Miners, Auger Miners and Battery Mine Tractors |
| H0230021 | Standardization of Controls for Underground Electric Face Equipment |
| H0242033 | Optimized Operator Compartment |
| **Protective Canopies** | |
| H0111670 | Inherently Safe Mining Systems in Conventional and Continuous Coal Mines |
| H0220031 | Protective Canopies for Underground Low-Coal Electrical Face Equipment Including Shuttle Cars |
| H0242020 | Survey on Protective Canopy Design |
| H0242028 | Design and Development of Protective Canopies for a Shuttle Car, Loader, and Roof Drill |
| H0242065 | Protective Canopies for Shuttle Cars, Loaders, and Cutters |
| H0346102 | Low Coal Canopy Study |
| H0357091 | Development of Protective Canopy Concepts for Underground Rail Haulage Equipment |
| H0357090 | Fabrication and Evaluation of Protective Canopies for 3-Foot Coal Seams |

Table 5-7. Applicable USBM Research and Development Programs (Concluded)

| | |
|---|---|
| **Illumination** | |
| H0111670 | Inherently Safe Mining Systems in Conventional and Continuous Coal Mines |
| H0220065 | Exploration of Illumination Concepts for Underground Coal Mines |
| H0230026 | Machine Lighting System for Low Seam Coal |
| H0242021 | Portable Task Luminaire |
| H0242023 | Development of Fluorescent Cap Lamp System |
| H0242048 | Development of Illumination for Low Coal Mines |
| H0242049 | Develop and Evaluate Fluorescent Lighting Systems for Underground Mines |
| H0242050 | Additional Fluorescent Luminaire Hardware and Assistance in Field Evaluation |
| **Noise Control** | |
| H0122054 | Noise Abatement in Mining Machinery |
| H0220048 | Mechanical Noise Control for Pneumatic Drill |
| G0133026 | Study of Roof Warning Signals and Use of Personal Hearing Protection in Underground Coal Mines |
| H0144078 | Alternate Conveyor Designs for Mine Machinery |
| H0346046 | Noise Control of Underground Diesel-Powered Mining Equipment |
| **Communications** | |
| H0111670 | Inherently Safe Mining Systems in Conventional and Continuous Coal Mining |
| G0101702 | Mine Communications and Monitoring |
| H0133038 | Development of Mine Communication Standards |
| H0133005 | EM Noise Measurement in Coal Mines |
| S0133035 | Mine Communication - Engineering and Administrative Services |
| H0232056 | Coal Mine Communications System (Follow-On of S0122076) |
| H0230034 | Develop Induction Radio System for Evaluation, Deep Shaft Metal Mines |
| S0144082 | Guidelines for Underground Telephone Systems |
| H0242010 | Waveform Generator--Package and Receiver |
| H0346045 | Technical Services for Mine Communications |
| H0346067 | Mine Wireless Communication System |
| S0346089 | Provide Communication Systems, Manuals and Technical Support |
| **Miscellaneous** | |
| H0346138 | Cable Fault Location at Elevated Voltage Level |
| H0122011 | Protection and Trouble Shooting of Coal Mine Electrical Cables |
| H0110423 | Quick Disconnect Couplers for Trailing Cables |
| G0133077 | Mine Electrical Systems Evaluation |
| G0155003 | Evaluation of Coal Mine Electrical System Safety |
| H0242015 | System for Handling Underground Mine Supplies and Materials |
| H0242037 | Mine Machinery Trainer Development and Fabrication |
| H0364079 | Lincoln Lab Model LTS-3S, Training System |
| S0144010 | Review and Evaluation of Current Training Programs Found in Various Mining Environments |

# Table 5-8. Application of USBM Programs

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| Operator Compartment and Controls | | |
| I3 - Standardize and optimize operator's compartment (human engineering) (TRACKLESS, TRACK). | | USBM contracts HO230021 and HO242033 were directed toward development of general design criteria as well as preliminary standard controls and control configurations for the most commonly found functional requirements (both trackless and track equipment). In addition USBM contract HO252048, entitled "Fabrication and Evaluation of Optimized Operator Compartments," demonstrates and evaluates these standards on specific equipment models for a shuttle car and a battery scoop. This appears to meet most but not all the needs.<br>ADDITIONAL R&D SUGGESTED<br>a) Demonstration and evaluation of standardization applied to additional equipment models of more equipment types until the majority of present day new equipment needs are covered. Drawings describing the modifications would be a desirable output of this effort since they could also be used to determine which standardization needs could be accomplished economically and practically in field modifications of existing equipment. |
| | 1-2 years | |
| | 6 months | b) A feasibility study of adding a regulation to the Mandatory Health and Safety Standards requiring standardization of equipment controls through certification of compliance of new equipment at time of delivery would be desirable. Safety improvements in the future probably require recognition that operator inexperience and greater needs for multi-job training are prevalent factors in coal mine accident statistics today and probably will increase in the future. |
| I3 - Proportional tramming control (TRACKLESS). | | The technology for adding this feature is currently available for use in mines where it is operationally and economically feasible. Improved traction when accelerating over wet bottoms through smoothness of control and better battery mileage on battery tractors-scoops appear to be secondary benefits to consider along with safety. Equipment is available today if specified on orders for new equipment and might possibly be considered for retrofit on existing equipment. |
| I3 - Attenuation of steering torque feedback (e.g., modified power steering) (TRACKLESS). | 6 months - 1 year | ADDITIONAL R&D SUGGESTED<br>This preventive measure is applicable to certain small battery powered vehicles presently without power steering to attenuate road shocks, in particular, "golf cart" types transporting miners. A USBM design concept study for methods of adding shock and feedback attenuation modifications to these vehicle types might be desirable. |
| I4 - Adjustable seat (TRACKLESS). | 6 months - 1 year | ADDITIONAL R&D SUGGESTED<br>A demonstration and evaluation of an adjustable seat installed on several models of shuttle cars and tractor-scoops could be included as part of the USBM contract HO252048, "Fabrication and Evaluation of Optimized Operator Compartments." Drawings and/or guidelines describing the installation on each equipment model in major present day use are desirable to implement field modifications and retrofit wherever the needs for improved operator visibility and safer seating positions are justified. |
| I4 - Slow-rise shock absorbers on vehicle seats (TRACKLESS). | 6 months | ADDITIONAL R&D SUGGESTED<br>A demonstration and evaluation of slow-rise shock absorbers that raise the seat slowly but lower rapidly when vehicle pitching motions reduce clearance between operator's head and canopy top or mine roof might be desirable as part of USBM contract HO252048. These devices are currently available for construction machinery but drawings describing installation on each shuttle car equipment model in major present day use are desirable to implement retrofits when desired. |
| I3 - Integrated brake and tramming control (TRACKLESS). | | USBM contracts HO230021 and HO242033 were directed toward the development of standard control configurations and the optimization of the operator compartment. Their recommendations were separate brake and tram controls in standardized arrangements and coordinated through the separate actions of right and left legs. This approach probably meets all the present coordination needs for manually controlling tram speed and braking. |
| I1 - Block signal system (provided it's justified by volume of traffic) (TRACK). | 6 months - 1 year | USBM contract HO242011 studied a completely automatic system of rail haulage traffic control and therefore would eliminate needs for block signals.<br>ADDITIONAL R&D SUGGESTED<br>Since the operational implementation of this automatic system will be a rather long term effort and may never be justified in some smaller mines, it would appear desirable to study the safety impacts of adding block signal systems to various mine haulage plans with differing traffic volumes, possibly utilizing fault tree analysis as the basic assessment tool. No new technology or development appears necessary other than possibly that necessary to prove the reliability of the present sensors or tripping contactors operating the block. |
| I1 - Automatic speed limiting devices (that apply emergency brake above set speed) (TRACK). | | USBM contract HO110896 included development work and demonstration test of speed limit controls installed on the locomotive and would appear to meet all the needs of this preventive measure provided that it is coordinated with the installation of automatic brake equipment. |

## Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| I4 - Provide convenient on-off switch location that can be actuated from riding position on belt (BELT-MANTRIP).<br>I4 - Key-locking switch to prevent energizing belt drives during maintenance (BELT). | 6 months | ADDITIONAL R&D SUGGESTED<br>Acceptance of these control techniques for improving safety would be most effective probably if USBM designed a model belt control scheme that could be adopted for use in many different mine plans and wrote a requirements standard for belt control that included a description of the model. |
| I1 - Closed circuit TV monitoring for closer supervision (BELT). | 6 months - 1 year | ADDITIONAL R&D SUGGESTED<br>Acceptance of this supervision technique would probably be best implemented by USBM designing some examples of application situations requiring continuous supervision and possibly arranging a mobile rig to test and demonstrate its use in situ. All technology is available (except permissibility requirements) and at least one mine to our knowledge has extensive operating experience with the technique. |
| Automatic Pilots<br>I3 - Automatic shuttle car guidance system (TRACKLESS). | | USBM contract H0111194 studied and found feasible some concepts of completely automatic and partially automatic shuttle car systems that either eliminated or reduced the usage of riding operators. Currently this project is testing in underground conditions sensors that apparently have all the data capability required for steering guidance and obstacle detection but does not remove the needs for a riding operator to accelerate, brake, operate conveyor, and take over all control at loading and unloading points. The same may be said of a USBM work statement for "Automation of Cableless Haulage" currently released for proposals. It would appear that this work will improve the shortcomings in driver visibility that were apparent in this survey and therefore contribute to future safety even without strict automation of functions. |
| | 2-4 years | ADDITIONAL R&D SUGGESTED<br>a) Longer term objective of removing rider operator completely from shuttle car should be pursued with further automation design and demonstration studies as justified by proven progress in sensor capabilities.<br>b) Requirements standards should be written to guide future automatic shuttle car designs in steps by manufacturers when USBM feels technical and economic feasibility has been demonstrated. |
| I4 - Electromagnetic obstacle detector (TRACKLESS, TRACK). | | USBM contract H0111194 is directed toward development of sensors and control devices, including obstacle detectors, for various face equipment but does not appear to consider the use of an obstacle detector on track haulage equipment. |
| | 6 months - 1 year | ADDITIONAL R&D SUGGESTED<br>If obstacle detector capability is satisfactorily demonstrated on shuttle cars or other trackless vehicles, a demonstration test of its suitability when installed on track vehicles might be considered and lead the way to a possible requirements standard for equipment designers. |

# Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| Remote/Automatic Controls | | |
| I1 - In mines employing a dispatcher, switch-position indicators on dispather display (TRACK). | | Technology presently exists for implementing remote switch position indicators by individually wiring switches to indicators or by using multiplexing techniques. |
| I1 - In mines employing a dispatcher, install dispatcher displays of vehicle velocity and locations (TRACK). | 1-2 years | USBM contract HO242011 studied automation of rail haulage and defined requirements for vehicle location detectors and vehicle velocity sensors.<br>ADDITIONAL R&D SUGGESTED<br>Further effort should be expended toward developing and demonstrating a system that will display vehicle locations and speeds to a dispatcher. Development of this system will be required for the automated rail haulage system and could provide increased safety in a shorter time period than will be required for development of the automated system. |
| I1 - Automatic control of track vehicles (TRACK). | | USBM contract HO242011 studied automation of rail haulage and defined a feasible automated system relying on the dispatcher for central control of the system. In addition, it defined the additional requirements for automating most of the dispatcher functions. This effort should be continued. |
| I1 - Central remote control of track vehicles (TRACK). | 2-3 years | USBM contract HO346042 is presently studying designs for an automatic remote control coupler which would be needed for an automated rail haulage system.<br>ADDITIONAL R&D SUGGESTED<br>Work should be continued toward development of an automated rail haulage system. Initial emphasis should be on those elements of the system that can be implemented independently and which will eliminate existing hazards. These interim developments might include the automatic remote control coupler and the vehicle location and velocity displays. |
| I3 - Automatic or remote control decoupling (i.e., operated from motor) (TRACK). | 1 year | USBM contract HO346042 is currently studying designs that remotely control decoupling from the motor cab and appears to satisfy all the requirements for eliminating the hazards of manual decoupling.<br>ADDITIONAL R&D SUGGESTED<br>As the operational implementation of this coupler design under contract HO346042 in a large number of mines may be a rather long term effort, (i.e., requiring replacement of most couplers presently in use) it appears that a retrofitting design applicable to the Willison type coupler might provide an interim means of eliminating manual decoupling. |
| I4 - Automatic couplers with self-centering devices (TRACK). | 6 months - 1 year | USBM contract HO346042 is directed toward a coupler design which meets this requirement completely (i.e., truck-mounted coupler with self-centering springs to prevent bypassing).<br>ADDITIONAL R&D SUGGESTED<br>As the operational implementation of this coupler design in a large number of mines may be a rather long term effort (i.e., replacement and remounting of most couplers presently in use) it appears desirable to study the possibility of an interim retrofitting design that might simply add self-centering springs to the existing wide capture range Willison couplers to materially reduce the possibility of bypassing couplers. |
| I4 - More positive decoupling device that holds coupler open until car separation (e.g., detent) (TRACK). | 1 year | USBM contract HO346042 is studying designs for automatic couplers that obviously eliminate this need completely. (No hazard to personnel due to insufficient action of the decoupling latch exists without a manual decoupling operation.)<br>ADDITIONAL R&D SUGGESTED<br>As the operational implementation of this coupler design in a large number of mines may be a rather long term effort, it would appear desirable to design a practical retrofit to existing mine couplers that provides positive decoupling latch clearances (i.e., detent) until car separation is completed. |
| Continuous Haulage | | |
| I2 - Substitute continuous conveyor haulage for shuttle cars (TRACKLESS). | 2 years | Continuous face haulage systems are presently in production and are in use in several mines. USBM contract HO242025 is a study and evaluation of the various concepts used for continuous face haulage systems.<br>ADDITIONAL R&D SUGGESTED<br>Safety and cost factors might be improved if all manual functions of the continuous haulage systems were automated. Ancillary developments that will be needed to realize the full potential of continuous haulage include: 1) automatic roof drill/bolter, 2) face ventilation integral with the continuous miner, 3) remote or automatic control of the continuous miner, 4) remote reading methane monitors, 5) roof and bottom sensors, and 6) automatic integral rock duster, perhaps combined with automatic fire suppression. |

# Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| Brakes and Panic Bars | | |
| I3 - Automatic, fail-safe emergency/parking brake (sets when vehicle power is removed from tram motor, when actuated by panic bar, or when any component of service brake fails) (TRACKLESS, TRACK). | 1-2 years | USBM contract H0110896 provided designs and a requirements standard for separate emergency and parking brakes that are automatic and fail-safe. It pertains to small size haulage equipment but appears to adequately demonstrate the practicality of automatic brakes in track haulage.<br>ADDITIONAL R&D SUGGESTED<br>a) A design study and demonstration test of automatic emergency/parking brakes for several popular models of shuttle car vehicles is recommended. A requirements standard is desirable as a guideline for future designs. |
| I3 - "Dead man" controls tied to automatic brakes (TRACKLESS, TRACK). | 1 year | b) Demonstration testing a practical "dead man" control for both track and trackless vehicles appears in order to avoid complaints of inconvenience such as encountered in contract H0110896 with track locomotives. |
| I3 - Positive, mechanical parking brake separate from service brake (TRACKLESS, TRACK). | 1 year | c) Demonstrating the feasibility of interlocking drive motor operation with brake line pressure would probably offer mines an interim alternative to completely automatic brakes. |
| I3 - Interlock drive motors with brake line pressure to prevent operation with "low" brakes (TRACKLESS, TRACK). | 2 years | d) Since USBM contract H0346042 currently studies automatic couplers with provisions for electrical power on each mine car for brake purposes, instead of pneumatics, consideration might be given to retrofitting the demonstration locomotive and mine cars with the necessary changes to utilize electrical power and possibly also the automatic coupler designs that result from contract H0346042. |
| I3 - Improved parking brake indicator (e.g., via brake surface forces) to give positive indication of FULL-ON condition (TRACKLESS, TRACK). | 6 months - 1 year | ADDITIONAL R&D SUGGESTED<br>A study of retrofit measures that could be used to increase the reliability of parking brake settings in commonly found models of trackless vehicles and also track utility vehicles is suggested. |
| I4 - Panic bar design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles (TRACKLESS). | | USBM contract H0133031 provides all the required information to suitably install panic bars. If material in the final report is distributed to mine shop personnel, no additional effort should be necessary. |
| Protective Canopies | | |
| I4 - Design (or redesign) canopies for optimal visibility and/or egress (TRACKLESS). | 1 year | USBM contracts H0220031, H0242028, H0242065 and H0346102 all contribute to the design of canopies with optimal visibility.<br>ADDITIONAL R&D SUGGESTED<br>It appears that low coal canopies (36 inches and below) present a major visibility problem and possible alternatives should be studied. These alternatives could be partial protective devices such as protective bars which would bridge roof falls. |
| I4 - Canopy with full cab enclosure or with gate (as alternative to panic bar) (TRACKLESS). | 1 year | Joy Manufacturing Company has developed a shuttle car canopy which consists of a complete enclosure with a gate.<br>ADDITIONAL R&D SUGGESTED<br>The problem that exists with the full enclosures is the lack of emergency exits. Better designs, which will permit the escape of the operator in case the machine stalls in a position where the door or gate can not be opened, must be conceived before complete enclosures can be accepted. |
| I4 - Design and installation guidelines for each model of equipment, for use by mine shops in retrofitting vehicles (TRACKLESS). | 1 year | The effort in this area is not adequate as yet.<br>ADDITIONAL R&D SUGGESTED<br>Guidelines which describe canopy designs for each type of equipment should be made available to each mine operator. In order for mines to install the optimal canopy designs, they must have data available which will give them the necessary knowledge required to retrofit their equipment. |
| I4 - Canopies or full cab enclosures to restrict body projection (TRACK). | | Most manufacturers of track vehicles have done an adequate job on vehicles such as portal busses. Recently initiated contract H0357091 is aimed at development of preliminary cab concepts for locomotives and utility vehicles. |
| I4 - Design and installation guidelines for cabs and windshields on operational track equipment for use by manufacturers and mine shops in retrofitting vehicles (TRACK). | 1 year | The effort in this area is not adequate as yet.<br>ADDITIONAL R&D SUGGESTED<br>Following contract H0357091 guidelines that describe cab and windshield designs for each type of equipment should be made available to each mine operator. In order for mines to retrofit their equipment with optimal cabs and windshields they must have data available which will give them the necessary knowledge required and can be used by their shop personnel for retrofitting. |
| I3 - Swingaround rotational cabs (TRACKLESS). | | USBM contract H0111670 probably meets all the requirements for swingaround rotational cabs needed at this time. |

# Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| Illumination and Vision Aids | | |
| I1 - Diffused area illumination of haulageways to improve driver cues and reduce hazard reaction times (TRACKLESS). | | USBM contracts HO111670, HO220065, HO230026, HO242048 and HO242049 adequately meet requirements of diffused area illumination of haulageways. |
| I4 - High intensity diffused headlamps (new lens design) (TRACKLESS). | 1 year | There appears to be no attempt at present to work this area.<br>ADDITIONAL R&D SUGGESTED<br>A lens design which would direct headlight beams in a more advantageous direction (i.e., roof, rib, etc.). Present headlight designs permit the light beam only in a direct forward direction. An improved lens design might also be useful in reducing the blinding effect of personnel looking at the oncoming vehicles. |
| I4 - Two reliable headlamps and side lights or reflectors on each end of vehicle (TRACKLESS). | 1 year | Efforts in this direction are nonexistent.<br>ADDITIONAL R&D SUGGESTED<br>A need exists to provide better visibility for machine operators, and for vehicles to be more easily visible from all directions. Dual headlights and side and rear lights or reflectors would be one way of improving a visibility problem. Protection from damage will, of course, be required, especially for any side lights. |
| I3 - Interlock headlights with tramming direction control (TRACKLESS). | | In order to prevent operation of a vehicle without the headlights on, an interlock between the tramming direction control and the corresponding headlights would eliminate the problem. |
| I4 - Lights that may be dimmed but turned off only when machine power is removed (TRACKLESS). | | No new technology is required; although the USBM might demonstrate the concept. |
| II2- Keep headlamps clean (TRACKLESS). | | In situations where extremely muddy conditions continually cover up the headlights some type of lamp cleaning systems might be installed. This could be in the form of a circular windshield wiper or a high pressure water spray. |
| I1 - Directed and shaded illumination at transfer points (TRACK). | | No new technology is required. |
| I4 - Portable task lights and area lights (TRACK, TRACKLESS). | | USBM contracts HO242021, HO242048 and HO242049 adequately meet the requirements to develop portable task lights and area lights. |
| I4 - Standard color marker lights for use on parked vehicles (TRACKLESS). | | No new technology is required. |
| I4 - Provide parked trips with end reflectors (TRACK). | | No new technology is required. |
| I4 - Reflective paint and/or tape with colors for different functions (GENERAL). | | Reflective paint or tape could be used as an interim solution to the more costly illumination installation. Different colors could be used to differentiate between moving parts and fixed parts, and might be especially useful if dangerous components were identified. |
| I4 - Reflective clothing for all mine personnel (GENERAL). | | Another alternative or complement to the in-mine illumination can be the use of reflective clothing worn by all personnel. This may be a rather costly solution to the visibility problem and miner acceptance is questionable. |
| I4 - Reflective paint on low roof and obstructions (TRACKLESS). | | No new technology is required. |
| I4 - Reflective paint for temporary marking of hanging bolts until bolt removed/replaced (TRACKLESS, TRACK). | | No new technology is required. |
| I4 - Flexible warning sign hanging at same height as obstructions (TRACK). | | Flexible warning signs, hung along track routes at the same height above the track as an obstruction such as a low spot in the roof, would prevent riders of track vehicles from striking the obstruction. These signs would have to hang some distance from the low spot or obstruction. In case a rider were to strike the sign, indicating he was sitting too high, he would have sufficient time to lower himself. |

Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| I1 - Adequate means of marking roof to indicate shuttle car route with best clearance (TRACKLESS). | | Existing materials such as reflectors or reflective paint can be used to accomplish this. |
| I1 - Designate entries/crosscuts being used for shuttle cars run by operator placement of portable markers (e.g., reflective cones) (TRACKLESS). | | No new technology is required. |
| I2 - Substitute lower profile machine (TRACKLESS). | | Wherever possible machinery used should be low enough to give the operator enough clearance to have unrestricted visibility. This option may not be economical, especially in very low mines where the lowest machines are already being used. |
| I3 - Locate operator near boom end of shuttle car (TRACKLESS). | | This location would improve the operator's vision particularly during the loaded segment of the shuttle car run. |
| I2 - Control loading height of coal to improve operator's opposite side view (TRACKLESS). | | No new technology is required for this solution. This can be accomplished by closer supervision during the loading operation. |
| I4 - Folddown sideboards (TRACKLESS). | | Sideboards that fold down easily when the conveyor is empty will improve operator vision significantly on shuttle cars with high sideboards. |
| I1 - Double-split ventilation to reduce number of curtains in haulageways (TRACKLESS). | | No new technology is required. However, this option is generally available only to mines yet to be opened. |
| I1 - Transparent brattice to improve visibility (TRACKLESS). | | Present technology makes transparent brattices readily available. Most of these, however, are rather stiff and tend to leak air. As progress is being made by manufacturers of brattice cloth, no USBM development is recommended. |
| Noise Control | | |
| I3 - Reduce machine noise (through isolation, insulation, and redesign) (GENERAL). | | USBM contracts HO122054, HO220048, HO144078, HO346046 and HO133027 appear to be directed toward solving the mine machine noise problem. Additional work completed in this field can be found in RI7998 and RI7876. Should be continued. |
| I4 - Discriminating electronic ear muffs (GENERAL). | 1-2 years | The discriminating ear muff was developed in-house by the USBM/PMSRC. It provides ear protection which allows normal hearing at low noise levels yet protects the wearer from high noise levels.<br>ADDITIONAL R&D SUGGESTED<br>Because ear muffs are somewhat uncomfortable, some research should be performed to possibly build the system into the miner's cap. Some modification is needed to accommodate personnel wearing safety glasses. To be effective the ear muffs must fit snugly. The stems of safety glasses keep the ear muffs from providing a good fit. In the aforementioned development, some sound distortion was noted which could be corrected by improved electronics. Recommend this effort be continued to alleviate the problems mentioned above. |

# Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| Communications | | |
| I1 - Area-wide communication between vehicles and all miners in same area (GENERAL). | | USBM contracts H0111670, H0232056, S0122076, H0346067, S0133035 and H0396045 are directed toward defining specifications for communications systems and developing communication hardware. The results of these programs are applicable to implementing the recommended communications. |
| I1 - Short range line-of-sight transceivers between foreman, loader/continuous miner operator, and shuttle car drivers (GENERAL). | 1 year | ADDITIONAL R&D SUGGESTED<br>A study might be conducted to determine the potential safety benefits which would result from additional communications on sections, along haulageways, and throughout the mine. |
| I1 - Reduce noise in trolley phone system by conventional noise reduction design techniques (TRACK). | 1-2 years | USBM contract H0230034 developed a frequency diversity communication system to overcome nulls due to standing waves on the hoist rope of deep shaft mines. This system could be used to overcome nulls on trolley phone systems in coal mines.<br>ADDITIONAL R&D SUGGESTED<br>A study similar to that conducted for pager phone systems under contract S0144082 should be conducted for trolley phone systems. This study should include an investigation of the causes of poor voice reception, including electrical noise, acoustical noise and environmental factors such as high humidity, corrosive atmosphere and dust as they affect the operation of trolley phone equipment and voice intelligibility. Guidelines and criteria should be formulated for the development of improved systems and for the installation and maintenance of these and existing systems. |
| I1 - Reliable voice communication between brakeman and motorman (TRACK). | | The Engineering Division of Consolidation Coal Company has developed a two-way communication system which will enable a motorman and brakeman to communicate with each other in a track loop loading area. |
| I1 - Additional communication along belt (BELT). | | The PMSRC in-house developed belt-box pager phone allows communication with roving miners anywhere within the near vicinity of the mine pager phone lines, which normally run along the belt entries. This system requires the miner to attach a set of clip leads into the phone lines in order to communicate.<br><br>Lee Engineering has developed a two-way walkie-talkie communication system which uses the phone lines as the transmitting and receiving antenna and does not require any physical connection of the walkie-talkie to the phone lines. This system was demonstrated along a longwall face but could be used along belt lines where phone lines are strung. |
| I4 - "Hands-free" type of communication system (TRACK). | | A special microphone and speaker that readily fits into a miner's helmet was developed as part of the belt-box pager phone referred to above. This helmet system could be used with other communications systems to provide "hands-free" communication for all miners. |

# Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| Maintenance | | |
| I3 - Built-in test equipment for improved pre-shift machine checks (i.e., hydraulic pressure, cable faults) and trouble diagnosis (possibly programmed) (TRACKLESS). | 1-2 years | USBM contracts H0346138 and H0122011 are directed toward the development and fabrication of equipment to check faults in trailing cables either while in use in the mine or in the shop. This is a portable type of equipment that would be used by a mechanic or a repairman.<br>ADDITIONAL R&D SUGGESTED<br>This program could be taken one step further with the development of Built-In Test Equipment (BITE). It might be a press-to-test panel mounted in some convenient place in the operator's compartment. It should be relatively simple to operate and made to be included in the operator's preshift equipment test; and might include a sequential type switch which would check opens and shorts in the trailing cable and other predetermined critical electrical circuits. A second panel mounted in the same place might display data to check out hydraulic pressures. |
| I4 - Variable cable tension or feedback devices to minimize whip and tension (SHUTTLE CAR). | | USBM contract H0122011 - Besides the development of a simple but effective means of checking faults in the trailing cable, this program is also looking into methods of reducing or eliminating cable whip. It calls for development of a technique for a torque adjustment on cable reels maintaining constant pressure during both payout and retrieval. This contract appears to be directed toward meeting all the requirements of this preventive measure. |
| I4 - Quick disconnect trailing cable connectors with safety interlocks (TRACKLESS). | | USBM contract H0110423 addressed this problem and has been completed. The basic technology is currently available for use in mines where feasible. Several manufacturers now make this type of hardware. The relevance of the development of this hardware is important as it provides a method of replacing a trailing cable more rapidly. This in turn facilitates compliance with the law requiring a temporary splice to be replaced within 24 hours. |
| II3- Improved roadway maintenance, leveling, and drainage (TRACKLESS).<br>I4 - Drag-bar on rear of shuttle car to aid in road leveling and filling (TRACKLESS). | | There is currently no known USBM contract addressing these roadway maintenance problems. These areas are checked out by company safety officials, foremen and MESA inspectors. One method of aiding in maintaining a shuttle car roadway is to attach a drag-bar under the boom end of the vehicle. It is hung by chain so that it scrapes along the roadway surface, smoothing it as the machine goes to and from the face. Many mines are currently using this technique which can be implemented without any appreciable machine downtime and at a reasonable cost. |
| I1 - Greater use of dewatering wells, sump holes and/or drainage ditches (TRACK).<br>II3- Separate standards of rail and track bed quality for coal and non-coal usages (TRACK). | 1 year | There are no known standards specifically for rail bed quality for track used only for personnel and supply transportation.<br>ADDITIONAL R&D SUGGESTED<br>It would be helpful if the USBM were to develop design standards for rail including track joints, switches, bonding, etc., and also for track bed quality including ties, ballast, grades, etc. The lack of standards may have created hazardous situations leading to both personnel injuries and costly equipment damage. |
| II3- Scheduled preventive maintenance and improved overall maintenance procedures with strict user written feedback (GENERAL). | 2 years | A good scheduled preventive maintenance program will offer the following advantages:<br>a) Increased reliability and availability.<br>b) Fewer unscheduled large scale repairs.<br>c) Lower repair costs, therefore lower total costs.<br>d) Better quality product because of properly adjusted equipment.<br>e) Conservation of assets, increased life expectancy.<br>f) Less need for backup equipment.<br>g) Identification of high cost items.<br>h) Greater safety for the worker.<br>Presently many of the mines surveyed do not have this type of program. The largest portion of their maintenance is done on a breakdown basis; when the equipment fails, it is repaired. This can also be very costly, for if a major component goes out, the equipment could be lost for a shift or longer, thus hindering production. A good preventive maintenance program will consume some time but in the long run will cost less.<br>ADDITIONAL R&D SUGGESTED<br>Possibly the USBM could analyze and evaluate the maintenance procedures used by some of the more successful coal mines and those of companies in similar industries. A generalized system, including course material could be developed and distributed to underground coal mines. This material might be used by MESA also to update or develop specific training courses for maintenance people. With the help of equipment manufacturers, training manuals and maintenance procedures could be developed for specific pieces of equipment. |

# Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| II3- Preshift machine check list signed and submitted to foreman (TRACKLESS, TRACK). | | A standard check list for each piece of operating equipment should be made available so that each operator on that machine will make the same daily checks. Each shift, the foreman notes any problem areas and turns in a repair request to maintenance. The next time the operator checks his equipment, those problem areas should be repaired. If not his check list will so indicate and the foreman will then check back with maintenance, closing the loop.<br>ADDITIONAL R&D SUGGESTED<br>This check list could be developed along with the maintenance procedure suggested in the previous preventive measure. |
| Warning<br>I3 - Seat interlock with audible warning after limited backward travel (TRACKLESS). | 6 months - 1 year | The truck and automotive industry is using similar technology that requires vehicle operators to use their seat restraints. That same type of interlock could be modified so that if an operator is not sitting in the seat that faces the direction of travel an audible warning would sound after limited movement in the wrong direction. This would be a relatively simple retrofit for units already in service and an easy fix for the manufacturer to incorporate into new units. As with automobiles, there may be some objection to the noise.<br>ADDITIONAL R&D SUGGESTED<br>Retrofit program for a shuttle car to install this device. Demonstrate and evaluate the equipment under normal working conditions underground. |
| I4 - Automatic, short audible or visible signal when tramming lever is engaged (TRACKLESS). | 6 months - 1 year | Similar technology is being used by manufacturers of surface equipment. These vehicles sound an audible signal anytime they are put into reverse. This recommendation is for an audible signal each time the tramming lever is engaged. It should not be a continuous signal but one of short duration, to alert persons around the equipment that it is about to move.<br>ADDITIONAL R&D SUGGESTED<br>Retrofit program for a shuttle car to install this device. Demonstrate and evaluate the equipment under normal working conditions underground. |
| I4 - Relocate warning sound sources to reduce annoyance to operator (TRACKLESS). | | Presently the operating procedures for trackless vehicles direct the operators to give an audible signal when they start up, pass through brattice curtain and before rounding corners. It was discovered during our interviews or by inspection that the warning devices (hand operated air horns or bells) were located in awkward positions so that the operator could not easily operate them or they were too close to his ear and annoying when operated. In some cases the device was clogged with coal and inoperable. The warning device should be located so that it does not blare in the operator's ear, is easily accessible and in a place that protects it from being cluttered with debris. |
| I3 - Time-delay actuator in porta-feeder to give audible warning before equipment moves (TRACK). | 6 months - 1 year | Presently when the porta-feeder switch is activated the equipment surges into motion. The actuation switch should have a time-delay built in, that would give an audible warning to anyone near the equipment which is about to move. This is a simple, inexpensive fix that could be retrofitted in the mine.<br>ADDITIONAL R&D SUGGESTED<br>Develop the relay circuit and signal; and retrofit a porta-feeder actuation switch. Demonstrate and evaluate at an underground transfer point. |
| I1 - Signs or warning devices of environmental hazards (flashing lights, reflectors, etc.) (TRACK). | | Many construction companies and other industries are currently using similar devices, a barricade, scotchlite signs (reflective surface), electric blinker lights or any combination of these items. These would be used in places where a hazard occurs frequently but is not usual condition such as low spots that collect water, an area along the track that had a recent rib roll, low spots in the roof or hanging objects, etc. These items are readily available from manufacturers, conveniently portable and easy to set up. |
| I3 - Time-delay circuit and warning in belt drive switch (BELT). | 6 months - 1 year | Hardware to accommodate this preventive measure is available and can be simply implemented. It would provide a short delay and an audible signal anytime the belt drive is actuated. Many times men are working near or loading material on the belt when someone inadvertently turns it on, resulting in minor and sometimes major injuries. This retrofit can be made onsite and will prevent a lot of carelessly caused lost time.<br>ADDITIONAL R&D SUGGESTED<br>Retrofit a belt drive switch with a time-delayed circuit and audible signal. Demonstrate and evaluate under normal working conditions underground. |

# Table 5-8. Application of USBM Programs (Continued)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| Miscellaneous | | |
| I1 - Improved material handling procedures and techniques (TRACKLESS, TRACK, BELT). | | USBM contract H0242015 is directed toward researching the problem areas of material handling in underground coal mines. Another phase of the same contract is to develop mechanical systems and tools which augment and/or replace the tasks of manually handling supplies and materials in these mines. This program appears to be well directed toward meeting all the requirements of this preventive measure. |
| II4- More intensive safety education and job training programs (including multi-job training) (GENERAL). | | MESA is launching a major effort in training that appears to be well directed. Also, under USBM contract H0242037, the contractor is developing a mine machinery trainer system to teach routine job procedures, machine control and safety attitudes for underground mining. As an example of industry programs, Consolidation Coal Company has instituted a safety action training program for all their employees (union and non-union). It is tailor-made to instruct each employee in the safe way to accomplish specific mining tasks. In essence, miners go back to the classroom to learn how to do their jobs more safely. This program is new and not fully instituted. The next phase of this program will have supervisory personnel concentrating on studying individual work habits to pin-point unsafe practices and to develop new policies and programs as deterents to accidents.<br><br>Work in the education and training area is being done in other agencies outside of industry and government. The University of West Virginia's Mining Extension Service, for example, realizing the need for better teaching programs and instructional material, has set up teaching locations right in the coal producing regions of the state. The educational material and training aides used by these centers are continually revised and updated.<br><br>USBM contract S0144010 is currently reviewing existing training programs in the mining industry as related to safety and the reduction of accidents. It will also recommend new programs and determine if any programs should be discontinued.<br>1 year ADDITIONAL R&D SUGGESTED<br>Fault tree analysis of all mining functions might be performed to support MESA training activities. This type of analysis would highlight the particular hazards associated with each task and aid in organizing task-hazard relationships, and thus aid in presentation of training materials. |
| II5- More effective enforcement of regulations and/or closer supervision (GENERAL). | | MESA personnel currently make regular inspections to all the mines in each district. In some districts mines with injury rates substantially above the coal industry's overall average, have full time safety inspectors. For the most part, however, the responsibility rests with mine management, supervisors and the miners themselves. |
| I4 - Alternative tire designs to improve traction under differing bottom conditions (TRACKLESS). | 1 year | At the present time it is not known if any research has been done in the area of tire and tread design specifically for underground coal mines. In reviewing equipment manufacturer's literature, tire suppliers (Goodyear, Firestone, Goodrich and General) only offer one and sometimes two different types of tires.<br>ADDITIONAL R&D SUGGESTED<br>A USBM study of present environmental conditions and what type of tires are available for use in the mines might result in safer designs as well as provide optimal operation under all conditions. |
| I2 - Substitute battery or diesel vehicles (TRACKLESS). | | Many mines are using battery vehicles and one visited is using diesel. The plus in the minds of those using them is the fact that the equipment is cableless. In so many mines today equipment is down due to a nicked cable and precious production time is lost waiting for a splice or more serious repair. The cables are also a hazard to personnel working around them. When a shuttle car starts up the cable whips as pressure is put on cable drum and it in turn puts tension in the cable. Cableless vehicles also permit longer runs from the face to the unloading point, and consequently the tail piece or rail does not have to be moved as often. |
| I1 - Modify roof control locally, where belt side clearance is limited, to allow wider entries (arches, belts) (BELT). | | In many mines roof control along belt entries is done with timber and cribs. This type of roof control reduces side clearance. One method of improving these conditions would be to use steel arches or bolts to widen the entry in important work areas. |
| II2- Keep work areas free of debris (GENERAL). | | This preventive measure is mainly a matter of enforcement by responsible supervisor. |
| II2- Use proven/proper tools (GENERAL). | | In many cases the proper tool is made available for the miners to use, but they find a short cut or different method of correcting the problem. This often results in additional damage to other equipment, such as using a wooden block and a switch to rerail a derailed car. This again becomes a matter of strict and proper supervision, conscientiousness on the part of the miner, and having the proper tools made available. |

# Table 5-8. Application of USBM Programs (Concluded)

| RECOMMENDED PREVENTIVE MEASURES | DEVELOPMENT SCHEDULE | CURRENT DEVELOPMENT STATUS |
|---|---|---|
| I4 - Optimal design for safety glasses or flip-up shield to provide protection and allow for use of corrective prescription (GENERAL). | 1 year | Safety glasses and flip-up shields are available, but the design of both items could be refined. Some safety glasses with either plain or prescription lenses have side shields made of opaque plastic material restricting peripheral vision. The glasses could be made to have some transparent material permiting side vision. Flip-up shields are presently straight pieces of clear plastic affording no side protection when in protective position. The shields could be molded to provide side protection and possibly the bottom edge curved to the face to prevent foreign objects from entering.<br>ADDITIONAL R&D SUGGESTED<br>The USBM might consider a human factors study aimed at establishing optimal configurations for eye protection specifically for underground miners. The study would have to consider a broad spectrum of miner activities as well as the environment. |
| I2 - Mobile (and fixed) equipment specifically designed for lifting and moving heavy components in the limited space of coal mines (GENERAL). | | USBM contract H0242015 is directed toward researching the problem areas of material handling in underground coal mines. Another phase of the same contract is to develop mechanical systems and tools which augment and/or replace the tasks of manually handling supplies and materials in these mines. This program appears to be well directed toward meeting all the requirements of this preventive measure. |
| I3 - Remotely controlled trolley pole placement. (TRACK). | 1 year | Some mines and other industries are currently using equipment that has hydraulically operated retractors or snatch cords which remove trolley pole from wire and secure it to vehicle. Presently there is nothing available that will remotely replace the pole back on the trolley wire. Frequent loss of pole contact occurs because of kinky trolley wires. The operator has to stand up to replace the pole, which puts him in jeopardy from the roof, off balance, or from arcing. A recent USBM contract H0357091 is developing protective canopies for underground rail haulage equipment which will make it more difficult to manually place a pole on wire from operator's compartment.<br>ADDITIONAL R&D SUGGESTED<br>The USBM might develop a method of remotely placing the trolley pole on the wire without requiring the operator to stand up from under a protective canopy. |
| I3 - Replace trolley pole with pantograph design having wide capture span and limited pole freedom, to obviate pole direction reversing, and reduce hand manipulation (TRACK). | 1 year | Currently, many surface electric train systems use a pantograph device to maintain contact with the overhead trolley wire. A similar device could be adapted to underground equipment. It would probably require a harp with a wide capture span and a shorter trolley pole.<br>ADDITIONAL R&D SUGGESTED<br>The USBM could initiate a study to adapt this surface-type concept to an underground locomotive for demonstration and evaluation. The concept should include the requirement that the pole not have to be reversed when direction is changed. |
| I1 - More positive switch-position sensors (TRACK). | 6 months - 1 year | The technology to implement this preventive measure is currently available in industry. The use of proximity switches placed close to the tapered ends of each switch point would give a more positive indication than the present methods used.<br>ADDITIONAL R&D SUGGESTED<br>Demonstrate and evaluate this method to prove or disprove its reliability over present methods. |

## 6. REFERENCES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