USING FAULT TREE ANALYSIS TO FOCUS MINE SAFETY RESEARCH

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ABSTRACT

Fault tree analysis is a systematic safety analysis tool that proceeds deductively from the occurrence of an undesired event (accident) to the identification of the root causes of that event. One recurring mine safety problem—a dozer falling into a void over a drawpoint on a coal surge pile—was analyzed using available, inexpensive fault tree programs on a personal computer. The analysis identified basic and intermediate events that led to the burial of the dozer and graphically depicted the interrelationship between these various subordinate events as well as the various chain of events leading up to the primary event. A sensitivity analysis on these probabilities showed which events had the greatest influence on dozer burial in a coal surge pile.

INTRODUCTION

Researchers at the Spokane Research Laboratory of the National Institute for Occupational Safety and Health (NIOSH) are investigating the use of fault tree analysis to find root causes of mining accidents and fatalities. This paper describes the development of a fault tree as applied to one mining system, that of the high number of injuries and fatalities that occur when a dozer falls into a void in a coal surge pile. Current research is focused on detecting voids, studying the dynamics of void formation inside the coal pile, and developing a better way of guiding the dozer operator on the pile. Fault tree analysis applied to a surge pile system (or any other mining system) may suggest root causes and refine the focus of safety research.

Fault tree analysis (see Lambert, 1973) is one of many systematic safety analysis methods developed in the last 40 years to promote the safety of highly complex technical systems. Bell Telephone Laboratories first used fault tree analysis in 1962 to study the safety of the launch control system for Minuteman missiles. Since that time, fault tree analysis has been used by the Boeing Company to enhance the safety of airplanes and by the nuclear industry to improve the safety and reliability of nuclear reactors.

Fault tree analysis is a systematic deductive procedure used to identify the basic causes of a fault event. The method is deductive because it starts from a single fault at the top of a flow chart and expands out and downward to identify the many contributing causes to that single top fault. Thus, the method proceeds from one event to many events. If the system were to be studied inductively, the starting point would be at the bottom. Many fault conditions would be identified and then these conditions would be evaluated to find how they might connect to generate an undesired event. This is a tedious and perhaps impossible task.

Fault tree analysis starts with a top fault event and proceeds deductively by asking "How can this event have happened?" Immediate contributing causes to this top fault event are identified and then listed as part of the next lower level of analysis (subfaults). These subfault events are then connected as influencing inputs to the upper-level event by means of either "and" gates or "or" gates. An "and" gate requires that all subfault events are necessary for an upper-level event to occur. An " or" gate says that each of the input subfaults in and of itself is sufficient to generate the upper-level event. Inputs to an "and" gate are necessary conditions for the upper-level event, and if these inputs are all present, then the upper-level event must of necessity occur. It also means that if one or more of the “and” inputs are missing, then the top fault event will not occur. Inputs to the "or" gate are sufficient conditions for the occurrence of the upper-level event. This means that if any one event occurs, then the upper-level fault event will occur.

This same deductive procedure is applied to each of the identified subfaults of the top fault event. Answers are linked to each of the upper-level events by means of the "and" or "or" gates. This procedure then continues from level to level to create an upside-down tree; that is, a tree with the narrowest end at the top (containing the top fault event) with branches outward and downward. Branching continues until a state of resolution is reached that identifies the root causes and admits no further analysis. The analyst may choose to terminate the study in one or more branches of the fault tree if he or she thinks that the analysis will not result in any more meaningful information or if that branch has already been satisfactorily resolved in another branch. The ultimate result is a qualitative fault tree terminating in a set of basic faults and undeveloped events. This fault tree in and of itself is revealing in terms of identifying contributing factors to the undesired top fault event and in showing how they are interrelated.

The analysis, however, can be carried further by establishing or assigning probabilities of occurrence for each of the basic faults and undeveloped events. This results in a *quantitative* fault tree. Such a quantitative fault tree allows the analyst to calculate the probability of occurrence of the top fault event given the probabilities of occurrence of each of the root causes and undeveloped events.

Interesting measures, such as importance and sensitivity, can then be calculated. These measures indicate how much each basic fault and undeveloped event influence the probability of occurrence of the top fault event. In a sensitivity analysis, one can vary the probability of each basic fault and undeveloped event to see how this change influences the probability of occurrence of the top fault event. This procedure allows the analyst to detect how sensitive the top fault event is to changes in the magnitude and variability of probabilities of occurrence of each basic fault or undeveloped event.

Both qualitative and quantitative analyses result in a set of critical paths, sometimes called “cut sets” or “min sets.” These are sets of components that, when they occur, will cause a top fault event. A minimal cut set is a set of events that, if any event were removed from that set, would not generate a top fault event. Cut sets show the various paths to the top fault event. Identification of cut sets is important for directing efforts to prevent a top fault event.

Fault tree analysis has been traditionally used for deterministic systems, such as aircraft and nuclear reactors. However, there is no inherent reason why a fault tree analysis cannot be applied, perhaps with lesser expectations, to nondeterministic systems. In this paper, all possible modes of occurrence of an undesirable event—a dozer burial in a coal surge pile—are identified in a systematic fashion so that a clear and demonstrable record of the process is provided. The paper also provides a baseline for evaluating possible changes to procedures for using dozers on coal surge piles. More detailed instructions for constructing fault trees can be found in references listed in the bibliography section of this paper.

SYSTEM DESCRIPTION

A coal surge pile may be used at either a surface or an underground mine. The surge pile may be used to stockpile mine-run raw coal or clean coal from the washing plant. Raw coal may have been crushed before stockpiling and may contain some noncoal refuse material. Clean coal has been sized and washed, and waste material (refuse) separated and removed. Generally, raw coal contains larger particles than does clean coal.

The need for surge piles is based on the disjunction between mining schedules and washing plant feed schedules. In addition, the dispatch of coal to customers does not necessarily match the continuous output from the washing plant. Mines with large, clean coal stockpiles can better meet coal sale orders without requiring that their customers have facilities for coal storage. Thus, a surge pile or some other type of storage is required to stockpile the coal.

Surge piles at four coal mines—three in West Virginia and one in Illinois—were visited. These surge pile sites are typical of what is used throughout the United States. All four sites had common components and varied only in lateral dimensions and height. These basic components are an overhead conveyor, a stacker tube, a conical pile of coal, an underlying tunnel with a conveyor and multiple feeders, and dozers to push coal on the surface of the pile.

The overhead conveyor is used to move the coal to the top of the stacker tube. The first portion of the conveyor may be inclined to attain stacker height while the remainder of the conveyor is horizontal from the surge pile perimeter to the stacker tube. The stacker tube is a concrete hollow cylinder with windows strategically placed throughout its height. When coal falls into the stacker tube from the conveyor, the tube fills to the height of the external pile and spills out the windows. The stacker tube acts as a support for the conveyor and controls flow onto the pile via gravity through the windows. The capacity of the surge pile is limited by the height of the stacker tube and the angle of repose of the cone of coal. Furthermore, because of the spacing of the underlying feeders, live capacity is less.

Dozers are used to push coal away from the stacker cone area, creating an extended bench that ultimately increases the capacity of the pile and is limited only by available area and the feasibility of pushing coal long distances. When coal is taken from a surge pile, dozers are used to push coal back to the feeders within the stacker cone area. Not all feeders operate at once when discharging, but feeders are chosen selectively in conjunction with the dozing operation. One or more dozers may be used to push

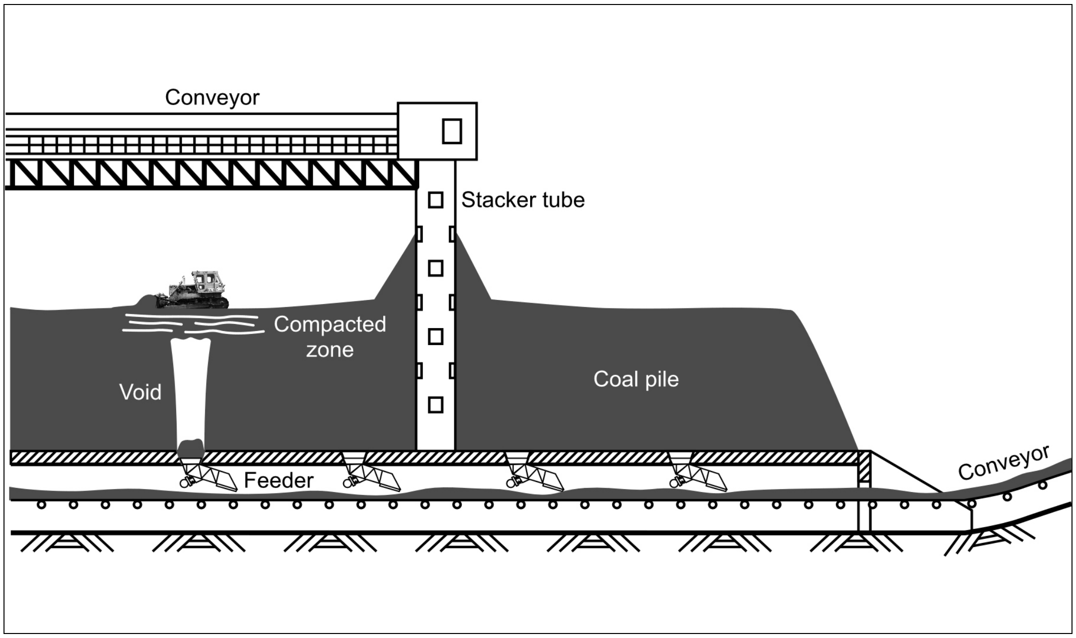

Figure 1. Surge pile showing overhead conveyor, stacker tube, feeders, and conveyor tunnel

coal to the active feeders. Figure 1 illustrates the components of a surge pile.

MSHA has published a safety manual (MSHA, 1993) for stockpiling that includes a section on proper dozer operation. MSHA recommends keeping the dozer a safe distance from the feeder. When coal is pushed to the feeder draw hole, one load should be brought close to the hole, then that load should be bumped into the feeder with a second load.

Fatal Surge Pile Accidents

Fatal accidents have occurred on surge piles when a dozer was driven over a hidden void and fell into it, burying and suffocating the operator. MSHA has reported 17 fatalities directly related to a collapsed void that occurred from 1980 through 1998 (MSHA, 2000). Of these, 10 were dozer operators, one a tractor operator, and six were persons on foot. One dozer-related surge pile fatality occurred in 1999.

The three most recent coal surge pile fatality reports were reviewed for the current work. These three fatalities occurred in 1995, 1998, and 1999. Circumstances of each accident were slightly different, but in all three accidents, a dozer was operating directly over or near the feeder, the stacker tube was feeding onto the pile, the pile heights were all equal to or greater than 40 ft, and all dozers were apparently pushing coal away from the stacker tube. Differences in feeder operation at the time of the accidents were (1) the feeders were on, (2) gravity allowed the coal to be fed to an operating belt from a nonenergized vibratory feeder, and (3) the sliding gate gravity feeder and belt were turned off. Overhead feeder markers were used at two of the three mines. Two of the three surge piles were clean coal; the third was raw coal. In two of the three fatalities, the dozer orientation was blade-up in the void, while in the third, the dozer was oriented sideways.

Communication between dozer operator(s) and the control room operating the belts and feeders is important. Lack of communication may have been the cause for two of these accidents. The third accident, however, resulted even though the underlying belt and feeders were off. The void had formed 10 days earlier, but had been undetected. Figure 1 shows a scenario in which the dozer operator is positioned directly over an unsuspected void.

Currently, MSHA, NIOSH, and industry are focusing on reducing or eliminating coal surge piles accidents and fatalities. MSHA has tested strengthened glass to prevent the dozer cab from filling with coal in the event the dozer fell into a collapsed void, and West Virginia has recently passed a law requiring the use of strengthened glass in dozers operating on coal surge piles. According to MSHA, two mines are investigating the use of remote-controlled dozers to remove operators from the hazardous area (Fredland, personal communication, 1999). One remote-controlled dozer is currently operational. NIOSH is supporting research in the detection of voids in coal surge piles using geophysical methods. NIOSH is also developing a global positioning system (GPS) with an onboard visual display to track and monitor dozer position with respect to feeder locations, which would provide real-time positioning information to a dozer operator.

FAULT TREE ANALYSIS OF DOZER BURIAL IN COAL SURGE PILES

The fault tree is constructed by first identifying the top fault event, which, in this case, is a dozer falling into a void on a coal surge pile. A secondary event (A) that contributes directly to the top fault event occurs when the dozer operator positions the dozer directly over the hazardous feeder zone. The only other secondary event (B) required to trigger the top fault event is the formation of a void within the coal pile between the feeder and the surface. These two secondary events are further broken down to determine the root causes. Figure 2 shows the completed fault tree for a dozer falling into a void on a coal surge pile.

In secondary event A, where the dozer is driven directly over or near the feeder, the question arises as to why the operator put him- or herself in this hazardous position. Either the operator has unintentionally driven over the feeder or feels confident that no void exists at the feeder. For the former, six reasons were proposed: poor visibility, inexperience, inadequate training, fatigue, distractions, and inadequate feeder markers. In this fault tree, only the poor visibility event was further explored. Six reasons were then developed for the poor visibility response: that the dozer was being driven at night, the cab windows were dirty, the sun caused a glare on the windows, the cab structure obstructed vision, weather conditions (such as rain, snow, or blowing dust) were poor, and steam was rising from the pile.

If the operator had intentionally positioned the dozer over the feeder, confident that no void existed but putting him- or herself at risk, the only feasible reason was to save time by taking a more direct route during dozing. Three types of actions that favor a direct route are driving over or backing up to the hazardous feeder zone while pushing coal away from the feeder area when expanding the pile, pushing coal to an active feeder but passing over an adjacent feeder or backing up to the hazardous zone, and passing over a feeder when relocating and moving onto or off the pile.

In secondary event (B), a void is formed over a feeder when there is subsurface flow at the same time there is no surface flow. Subsurface flow or flow from the feeder happens normally when the conveyor is on and the feeder allows flow. If the feeder is energized and the belt is on, flow will occur. Flow may also occur when the feeder is turned off if there are changes in coal properties, such as the angle of repose of the coal. (A safety gate may be installed to prevent such flow. However, an additional condition may be set up if a safety gate is installed but is open.)

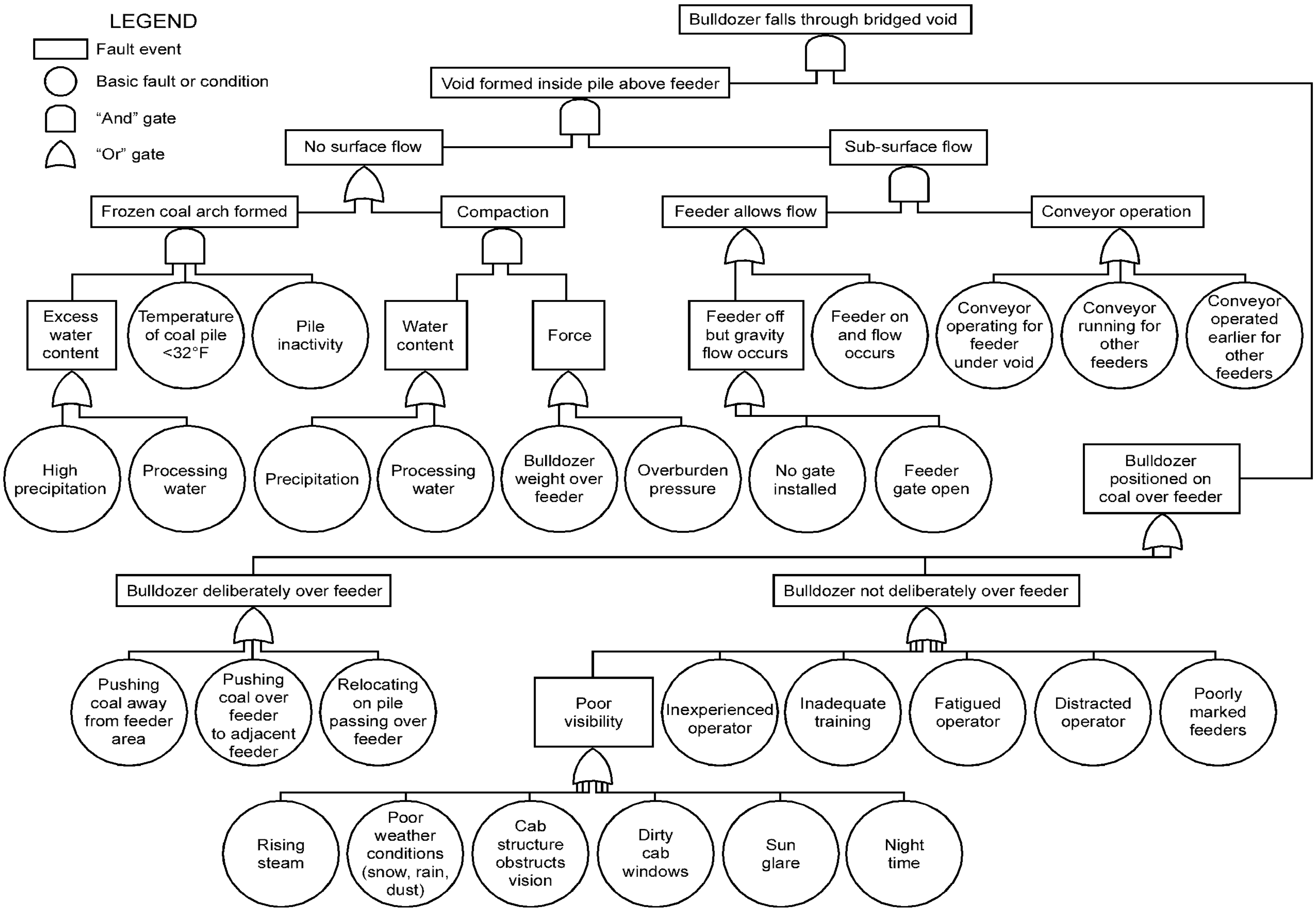

Figure 2. Fault tree analysis

A contradiction is faced in the question "How can surface flow not occur when subsurface flow occurs?" A basic understanding of flow in a surge pile is important for understanding why surface flow does not take place even when there is subsurface flow. The "funnel flow" concept (Jenike et al. 1959) describes the condition in a pile when coal is drawn from an underlying feeder. A typical opening dimension of 5 by 5 ft at the base of a pile will only allow vertical movement in a column of coal having the same dimensions. As the flow column reaches the surface, a void or hole will form. The upper sides of the hole will fail at the angle of repose as the column is drawn down. However, if the upper layer of coal is held together by a cohesive force acting between coal particles, then the strength of this layer may prevent surface flow, and a void will form below the surface to a depth comparable to the amount of coal drawn from the feeder.

In the fault tree analysis, two cohesive conditions were proposed: simple compaction and binding of coal particles by freezing water. In order for freezing water to bind the coal together, a water source is needed. Because a coal surge pile is open to the elements, rain and/or snow will provide that source. In clean coal piles, moisture will also be left over from the cleaning operation. During fall, winter, and spring, low temperatures may result in freezing water binding the coal particles so no surface flow can take place, even though above-freezing temperatures are present in the coal below the surface. Time is also a factor, and an inactive pile will be more prone to surface freezing.

Compaction of coal near the surface of the pile can also prevent surface flow. Compaction requires that a force be applied over an area of the coal. The degree of compaction will vary depending on water content. If no moisture is present, then the likelihood of cohesive strength and therefore compaction diminishes. As discussed above, moisture may come from rain or snow or from the cleaning plant. The force applied to the coal at the surface over the feeder is most likely the result of the weight and vibration of the dozer. A less likely source is coal overburden pressure. According to the MSHA accident report for the fatality in November of 1998, compacted layers were observed overhanging less-compacted layers below in the void (Harding, 1998). Here again, the dozer must be positioned over the feeder to compact the coal.

Quantification of the Fault Tree

The qualitative construction of the fault tree shows the interdependence of events. It does not, however, depict the amount of influence the basic events have on the top fault event. A quantified fault tree does show the influence of a basic event on the top fault event and ranks the basic events in terms of this influence. The practicality of a fault tree approach becomes apparent in such a construction. A quantified fault tree is a strategy, a plan of action, for it shows which events have the most influence on the occurrence of the top fault event and therefore which events should be addressed first in any type of efficient and effective remedial action. A quantified fault tree analysis can show where to act first to generate the most results for the least amount of work.

The first step in quantifying a fault tree is to assign initial probabilities to the basic events. This step was taken by gathering information from a focus group familiar with coal surge piles. The group was given the graphic of the fault tree and then asked to assign qualitative ratings for the probabilities of occurrence of the basic events using their experience and best judgment. Table 1 was used as a guide for collecting this qualitative evaluation.

Once the focus group agreed on the qualitative evaluation of the probability of a basic event (for example, a "low" probability), the corresponding numerical value of 10^{-4} from Table 1 was assigned to "low" in the fault tree. This approach was chosen over a detailed questionnaire given to plant operators because there was little time to construct, send out, and evaluate a comprehensive survey. What is important here is not the *absolute* probability values, but the *relative* values. If a consistency in the assignment of values can be maintained, then all that is needed to evaluate the fault tree was to identify the events that have the most influence on the occurrence of the top fault event relative to the other events in the fault tree.

Table 1. Classes for probability of occurrence (Kirsten 1999)

Qualitative evaluation	Quantitative evaluation	
Certain	Every time	1.0
Very high	1 in ten	10^{-1}
High	1 in a hundred	10^{-2}
Moderate	1 in a thousand	10^{-3}
Low	1 in ten thousand	10^{-4}
Very low	1 in a hundred thousand	10^{-5}
Extremely low	1 in a million	10^{-6}
Practically zero	1 in ten million	10^{-7}

These initial probabilities were mathematically propagated through the fault tree. For comparison, two fault tree analysis computer programs, SAPHIRE (Russel, 1997) and Faltrese (Wilcox, 1996), were each used to generate the probabilities for each cut set and the top fault event. Mathematical measures of importance and sensitivity for basic events, probability, and importance for cut sets were also computed.

The importance measure was computed for both basic events and for cut sets. The importance of an event E is the ratio of the sum of the probabilities of the cut sets containing E to the probability of the top fault event T. Intuitively, this means how much influence the event has in affecting the occurrence of the top fault event. The formula is—

Importance of event E = (∑ probability of cut sets containing event E)/Probability of top fault event T).

The measure of importance for cut sets is the ratio of the probability of occurrence of the cut set to the probability of occurrence of the top fault event. The formula is—

Importance of cut set C = (Probability of cut set C)/(Probability of top fault event T).

The sensitivity measure is used for only initial events and measures the amount of change in the top fault event given a set amount of change in the basic event. This measure is the percentage of change in the top fault event divided by a given percentage of change in the basic event of interest. In these computations, a change in the assigned probability of 10% to the basic probability was used. Whatever number is used, however, is arbitrary, since the results are relative comparisons. The formula is—

$$S_E = (\triangle(P_T) / P_T) / (\triangle(P_E) / P_E),$$

where S_E = sensitivity of event E,
P_E = probability of event E,
and P_T = probability of top fault event T.

Table 2 lists the 28 identified basic events along with their assigned probabilities of occurrence, their computed importance, and their computed sensitivity measures. Table 3 lists the top 36 cut sets ordered according to their probability of occurrence, the percentage of their contribution to the top fault event, and cumulative percentage. Four-hundred-eighty cut sets were determined from the fault tree. Of these cuts sets, 408 composed five basic events, and 72 composed six basic events. The overall probability of the main event was 4.0E-08 or a practically zero chance of happening at one surge pile over a period of 1 year If the number of surge piles (337) in the United States is considered and a sum of probabilities is produced for all surge piles, the value is 1.3E-05, or very low.

COMPARISON OF FAULT TREE ANALYSIS TO CURRENT RESEARCH

The applicability of using fault tree analysis can be determined further by comparing current research on surge piles to results from the fault tree analysis. Solutions to the surge pile problem are being worked on by NIOSH, MSHA, and industry, as mentioned earlier. Although most of the important cut sets determined by fault tree analysis are not being investigated, the use of GPS is one exception. GPS fits well into fault tree analysis and is being studied as a means of preventing operators from positioning dozers over a potential void. Using GPS positions with respect to feeders provides warnings in real time, as well as position data for safety analysis and training. Other topics that might be investigated using fault tree analysis are improved feeder markers, prevention of coal compaction, and dozer operating procedures when pushing coal.

CONCLUSIONS

Fault tree analysis is a useful technique to define root causes of a fault event such as a dozer falling into a void on a coal surge pile. The quantitative analysis made possible the determination of the most influential root causes of this event. Even though the assigned probabilities for each root cause may be somewhat subjective, the outcome provides insight into which cut sets or combination of events are more likely to cause the top fault event. Comparison of current research to the results of a fault tree analysis indicates new topics for research that are of high importance.

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Table 2. Identified basic events listed by computed importance along with assigned probabilities of occurrence and computed sensitivity measures.

Basic event	Computed importance	Assigned probability	Qualitative probability	Computed sensitivity
Dozer weight over feeder	1.16859E+00	1.00E-03	Moderate	9.98990E-01
Feeder on and flow occurs	1.15808E+00	1.00E-01	Very high	9.89990E-01
Processing water	5.84890E-01	1.00E-01	Very high	4.73117E-06
Processing water 2	5.84890E-01	1.00E-01	Very high	4.73680E-01
Precipitation	5.84880E-01	1.00E-01	Very high	4.73680E-01
Conveyor operated earlier for other feeders	3.89920E-01	1.00E-01	Very high	2.98890E-01
Conveyor operating for feeder under void	3.89920E-01	1.00E-01	Very high	2.98890E-01
Conveyor running for other feeders	3.89920E-01	1.00E-01	Very high	2.98890E-01
Cab structure obstructs vision	1.76700E-01	1.00E-03	Moderate	1.50640E-01
Dirty cab windows	1.76700E-01	1.00E-03	Moderate	1.50640E-01
Night time	1.76700E-01	1.00E-03	Moderate	1.50640E-01
Poor weather conditions	1.76700E-01	1.00E-03	Moderate	1.50640E-01
Rising steam	1.76700E-01	1.00E-03	Moderate	1.50640E-01
Sun glare	1.76700E-01	1.00E-03	Moderate	1.50640E-01
Inadequate training	1.76703E-02	1.00E-04	Low	1.50504E-02
Pushing coal away from feeder area	1.76703E-02	1.00E-04	Low	2.98890E-01
Pushing coal over feeder to adjacent feeder	1.76703E-02	1.00E-04	Low	1.50504E-02
Relocating on pile passing over feeder	1.76703E-02	1.00E-04	Low	1.50504E-02
No gate installed	1.15808E-02	1.00E-03	Moderate	8.91884E-03
Distracted operator	1.76703E-03	1.00E-05	Very low	1.50490E-03
Tired operator	1.76703E-03	1.00E-05	Very low	1.50490E-03
Overburden pressure	1.16859E-03	1.00E-06	Practically zero	9.97993E-04
Fatigued operator	1.76703E-03	1.00E-05	Very low	1.50490E-03
Feeder gate open	1.15808E-04	1.00E-05	Very low	8.91001E-05
Feeder gate open	1.15808E-04	1.00E-05	Very low	8.91001E-05
Pile inactivity	1.16859E-05	1.00E-05	Very low	9.98802E-06
Temperature of coal pile <32°	1.16859E-05	1.00E-03	Moderate	9.98802E-06
High precipitation	4.99496E-06	1.00E-01	Very high	4.73117E-06

Table 3. Thirty-six of the highest probability (1.0E-09) cut sets and their cumulative percentages. Percentage of individual cut sets is 2.5%.

Cut no.	Cumulative percentage	Cut sets
1	2.5	Conveyor running feeder, dozer over feeder, feeder on and flow occurs, precipitation2, rising steam
2	5.0	Conveyor running for other, dozer over feeder, feeder on and flow occurs, precipitation2, rising steam
3	7.5	Conveyor running feeder, dozer over feeder, feeder on and flow occurs, processing water2, rising steam
4	10.0	Conveyor operated earlier, dozer over feeder, feeder on and flow occurs, precipitation2, rising steam
5	12.5	Conveyor running for other, dozer over feeder, feeder on and flow occurs, processing water2, rising steam
6	15.0	Conveyor running feeder, dozer over feeder, feeder on and flow occurs, night time, precipitation2
7	17.5	Conveyor operated earlier, dozer over feeder, feeder on and flow occurs, processing water2, rising steam
8	20.0	Conveyor running feeder, dozer over feeder, feeder on and flow occurs, precipitation2, sun glare
9	22.5	Conveyor running for other, dozer over feeder, feeder on and flow occurs, night time, precipitation2
10	25.0	Conveyor running feeder, dirty cab windows, dozer over feeder, feeder on and flow occurs
11	27.4	Cab obstructs vision, conveyor running feeder, dozer over feeder, feeder on and flow occurs
12	29.9	Conveyor running for other, dozer over feeder, feeder on and flow occurs, precipitation2, sun glare
13	32.4	Conveyor running feeder, dozer over feeder, feeder on and flow occurs, night time, processing water2
14	34.9	Conveyor operated earlier, dozer over feeder, feeder on and flow occurs, night time, precipitation2
15	37.4	Conveyor running for other, dirty cab windows, dozer over feeder, feeder on and flow occurs
16	39.9	Cab obstructs vision, conveyor running for other, dozer over feeder, feeder on and flow occurs
17	42.4	Conveyor running feeder, dozer over feeder, feeder on & flow occurs, precipitation2, weather
18	44.9	Conveyor running feeder, dozer over feeder, feeder on & flow occurs, processing water2, sun glare
19	47.4	Conveyor operated earlier, dozer over feeder, feeder on & flow occurs, precipitation2, sun glare
20	49.9	Conveyor running for other, dozer over feeder, feeder on & flow occurs, night time, processing water2
21	52.4	Conveyor running feeder, dirty cab windows, dozer over feeder, feeder on and flow occurs
22	54.9	Cab obstructs vision, conveyor running feeder, dozer over feeder, feeder on and flow occurs
23	57.4	Conveyor operated earlier, dirty cab windows, dozer over feeder, feeder on and flow occurs
24	59.9	Cab obstructs vision, conveyor operated earlier, dozer over feeder, feeder on and flow occurs
25	62.4	Conveyor running for other, dozer over feeder, feeder on and flow occurs, precipitation2, weather
26	64.9	Conveyor running for other, dozer over feeder, feeder on and flow occurs, processing water2, sun glare
27	67.4	Conveyor operated earlier, dozer over feeder, feeder on and flow occurs, night time, processing water2
28	69.9	Conveyor running for other, dirty cab windows, dozer over feeder, feeder on and flow occurs
29	72.4	Cab obstructs vision, conveyor running for other, dozer over feeder, feeder on and flow occurs
30	74.9	Conveyor running feeder, dozer over feeder, feeder on and flow occurs, processing water2, weather
31	77.3	Conveyor operated earlier, dozer over feeder, feeder on and flow occurs, precipitation2, weather
32	79.8	Conveyor operated earlier, dozer over feeder, feeder on and flow occurs, processing water, sun glare
33	82.3	Conveyor operated earlier, dirty cab windows, dozer over feeder, feeder on and flow occurs, processing water2
34	84.8	Cab obstructs vision, conveyor operated earlier, dozer over feeder, feeder on and flow occurs, processing water2
35	87.3	Conveyor running for other, dozer over feeder, feeder on and flow occurs, processing water2, weather
36	89.8	Conveyor operated earlier, dozer over feeder, feeder on and flow occurs, precipitation2, weather

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