

Incident Investigation

Our Methods Are Flawed

By Fred A. Manuele

It would be a rare exception if an outline for a safety management system did not include a requirement for incidents to be investigated and analyzed. And that is appropriate; incident investigation is a vital element within a safety management system. The comments in section E6.2 of ANSI/AIHA/ASSE Z10-2012, Standard for Occupational Health and Safety Management Systems (OHSMS) (ANSI/AIHA/ASSE, 2012, p. 25), describe the benefits that can be obtained from incident investigations:

IN BRIEF

- An earlier review of incident investigation reports revealed an enormous gap between established reporting procedures and actual practice.
- Supervisors are commonly assigned responsibility for incident investigation. However, most supervisors are not qualified to offer recommendations for improving operating systems because they lack sufficient knowledge of hazard identification and analysis, and risk assessment.
- This article presents a sociotechnical model for hazards-related incidents. Such a system stresses an interdependent relationship between humans and machines, and accommodates the needs of both the system's output goal and workers' needs.

incident investigations:

- Incidents should be viewed as possible symptoms of problems in the OHSMS.
- Incident investigations should be used for root-cause analysis to identify system or other deficiencies for developing and implementing corrective action plans so as to avoid future incidents.
- Lessons learned from investigations are to be fed back into the planning and corrective action processes.

As Z10 proposes, organizations should learn from past experience to correct deficiencies in management systems and make modifications to avoid future incidents.

Research Results

The author has reviewed more than 1,800 incident investigation reports to assess their

quality, with an emphasis on causal factors identification and corrective actions taken (Manuele, 2013, p. 316). This revealed that an enormous gap can exist between issued investigation procedures and actual practice. On a 10-point scale, with 10 being best, an average score of 5.7 would be the best that could be given, and that could be a bit of a stretch.

These reviews confirmed that people who completed investigation reports were often biased in favor of selecting an employee's unsafe act as the causal factor and thereby did not proceed further into the investigation.

The author then conducted a five-why analysis to determine why this gap exists between issued procedures and actual practice. As the analysis proceeded, it became apparent that our model is flawed on several counts. The author's observations follow. These observations are made *a priori*, that is, relating to or derived by reasoning from self-evident proposition.


Why Incident Investigations May Not Identify Causal Factors

When supervisors are required to complete incident investigation reports, they are asked to write performance reviews of themselves and of those to whom they report, all the way up to the board of directors. Managers who participate in incident investigations are similarly tasked to evaluate their own performance and the results of decisions made at levels above theirs.

It is understandable that supervisors will avoid expounding on their own shortcomings in incident investigation reports. The probability is close to zero that a supervisor will write: "This incident

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An enormous gap can exist between issued investigation procedures and actual practice.

occurred in my area of supervision and I take full responsibility for it. I overlooked X. I should have done Y. My boss did not forward the work order for repairs I sent him 3 months ago.”

Self-preservation dominates, logically. This also applies to all management levels above the line supervisor. All such personnel will be averse to declaring their own shortcomings. Similarly, it is not surprising that supervisors and managers are reluctant to report deficiencies in the management systems that are the responsibility of their superiors.

With respect to operators (first-line employees) and incident causation, Reason (1990) writes:

Rather than being the main instigator of an accident, operators tend to be the inheritors of system defects created by poor design, incorrect installation, faulty maintenance and bad management decisions. Their part is usually that of adding the final garnish to a lethal brew whose ingredients have already been long in the cooking. (p. 173)

Supervisors, one step above line employees, also work in a “lethal brew whose ingredients have already been long in the cooking.” Supervisors have little or no input to the original design of operations and work systems, and are hampered with regard to making major changes to those systems. The author’s practical on-site experience has shown that most supervisors do not have sufficient knowledge of hazard identification and analysis, and risk assessment to qualify them to offer recommendations for improving operating systems.

History

In safety management systems, first-line supervisors are often responsible for initiating an incident investigation report. In relatively few organizations, this responsibility is assigned to a team or an operating executive.

It is presumed that supervisors are closest to the work and that they know more about the details of what has occurred. The history on which such assignments are based can be found in three editions of Heinrich’s *Industrial Accident Prevention*. Heinrich’s influence continues to this day. Heinrich

(1941, 1950, 1959) comments on incident investigation methods in the second, third and fourth editions of his book.

The person who should be best qualified to find the direct and proximate facts of individual accident occurrence is the person, usually the supervisor or foreman, who is in direct charge of the injured person. The supervisor is not only best qualified but has the best opportunity as well. Moreover, he should be personally interested in events that result in the injury of workers under his control.


In addition, he is the man upon whom management must rely to interpret and enforce such corrective measures as are devised to prevent other similar accidents. The supervisor or foreman, therefore, from every point of view, is the person who should find and record the major facts (proximate causes and subcauses) of accident occurrence.

In addition, he and the safety engineer should cooperate in finding the proximate causes and subcauses of potential injury producing accidents. (1941, p. 111; 1950, p. 123; 1959, p. 84)

Heinrich’s premise that the supervisor is best qualified to make incident investigations continues to be influential to this day, as evidenced by the following example from NSC (2009).

Depending on the nature of the incident and other conditions, the investigation is usually made by the supervisor. This person can be assisted by a fellow worker familiar with the process, a safety professional or inspector, or an employee health professional, the joint safety and health committee, the general safety committee or a consultant from the insurance company. If the incident involves unusual or special features, consultation with a state labor department, or a federal agency, a union representative or an outside expert may be warranted. If a contractor’s personnel are involved in the incident, then a contractor’s representative should also be involved in the investigation.

The supervisor should make an immediate report of every injury requiring medical treatment and other incidents he or she may be directed to



In a sense, the manager is required to write a performance appraisal on him/herself and on the people in the reporting structure above his/her level.

investigate. The supervisor is on the scene and probably knows more about the incident than anyone else. It is up to this individual, in most cases, to put into effect whatever measures can be adopted to prevent similar incidents. (p. 285)

Ferry (1981) also writes that the supervisor is closest to the action and most often is expected to initiate incident investigations. But he was one of the first writers to introduce the idea that supervisors may have disadvantages when doing so.

The supervisor/foreman is closest to the action. The mishap takes place in his domain. As a result, he most often investigates the mishap. If it is the supervisor's duty to investigate, he has every right to expect management to prepare him for the task.

Yet the same reasons for having the supervisor/foreman make the investigation are also reasons he should not be involved. His reputation is on the line. There are bound to be causes uncovered that will reflect in some way on his method of operation.

His closeness to the situation may preclude an open and unbiased approach to the supervisor-caused elements that exist. The more thorough the investigation, the more likely he is to be implicated as contributing to the event. (p. 9)

Ferry (2009) makes similar comments about line managers and staff managers (e.g., personnel directors, purchasing agents).

A thorough investigation often will find their functions contributed to the mishap as causal factors. When a causal factor points to their function they immediately have a point in common with the investigator. (p. 11)

In one organization whose safety director provided input for this article, the location manager leads investigations of all OSHA recordable incidents. That is terrific; senior management is involved. Many of the constraints applicable to the people who report to the manager can be overcome. But, in a sense, the manager is required to

write a performance appraisal on him/herself and on the people in the reporting structure above his/her level. If contributing factors result from decisions the manager made or his/her bosses made, details about them may not be precisely recorded.

Investigation Teams

Discussions with several corporate safety professionals indicate that their organizations use a team to investigate certain incidents. Assume the team consists of supervisors who report to the same individual as the supervisor for the area in which the incident occurred. The team is expected to write a performance appraisal on the involved supervisor as well as on the person to whom all of them report, and that person's bosses.

A priori, it is not difficult to understand that supervisors would be averse to criticizing a peer and management personnel to whom they also report. The supervisor whose performance is reviewed because of an incident may someday be part of a team appraising other supervisors' performance.

At all management levels above line supervisor, it would also be normal for personnel to avoid being self-critical. Self-preservation dominates at all levels.

Safety professionals should realize that constraints similar to those applicable to a supervisor also apply, in varying degrees, to all personnel who lead or are members of investigation teams.

Nevertheless, the author found that incident investigation reports completed by teams were superior. Ferry (1981, p. 12) says, "Special investigation committees are often appointed for serious mishaps" and "their findings may also receive better acceptance when the investigation results are made public."

To the extent feasible, investigation team leaders should have good managerial and technical skills and not be associated with the area in which the incident occurred.

Chapter 7 of *Guidelines for Investigating Chemical Process Incidents* (CCPS, 2003) is titled "Building and Leading an Investigation Team." Although the word *chemical* appears in the book's title, the text is largely generic. The opening paragraph of Chapter 7 says:

A thorough and accurate incident investigation depends upon the capabilities of the assigned team. Each member's technical skills, expertise and communication skills are valuable considerations when building an investigation team. This chapter describes ways to select skilled personnel to participate on incident investigation teams and recommends methods to develop their capabilities and manage the teams' resources. (p. 97)

This book is recommended as a thorough dissertation on all aspects of incident investigation. Throughout the book, competence, objectivity, capability and training are emphasized.

Training for Personnel on Incident Investigation

If personnel are to perform a function they should be given the training needed to acquire the nec-

essary skill. Others make similar or relative comments. Ferry (1981) says, "If it is the supervisor's duty to investigate, he has every right to expect management to prepare him for the task" (p. 9).

The following citation is from *Guidelines for Investigating Chemical Process Incidents*: "High quality training for potential team members and supporting personnel helps ensure success. Three different audiences will benefit from training: site management personnel, investigation support personnel and designated investigation team members including team leaders" (CCPS, 2003, p. 105).

For each organization, several questions should be asked; the answers may differ greatly.

- How much training on hazards, risks and investigation techniques do supervisors and investigation team members receive?

- Does the training make them knowledgeable and technically qualified?

- How often is training provided?

Consideration also must be given to the time lapse between when supervisors and others attend a training session and when they complete an incident investigation report. It is generally accepted that knowledge obtained in training will not be retained without frequent use. It is unusual for team members to participate in two or three incident investigations in a year. Inadequate training may be a major problem.

What Is Being Taught: Causation Models

Dekker (2006) makes the following astute observation, worthy of consideration by all who are involved in incident investigations.

Where you look for causes depends on how you believe accidents happen. Whether you know it or not, you apply an *accident model* to your analysis and understanding of failure. An accident model is a mutually agreed, and often unspoken, understanding of how accidents occur. (p. 81)

Safety professionals must understand that how they search for causal or contributing factors relates to what they have learned and their beliefs with respect to incident causation. There are many causation models in safety-related literature. Dekker (2006) describes three kinds of accident models. His models, abbreviated, are cited as examples of the many models that have been developed.

- The sequence-of-events model. This model sees accidents as a chain of events that leads up to a failure. It is also called the domino model, as one domino trips the next. **[Author's note: The domino sequence was a Heirlichean creation.]**

- The epidemiological model. This model sees accidents as related to latent failures that hide in everything from management decisions to procedures to equipment design.

- The systemic model. This model sees accidents as merging interactions between system components and processes, rather than failures within them. (p. 81)

Dekker (2006) strongly supports a systems approach to incident investigation, taking into con-

sideration all of the relative management systems as a whole. He says:

The systems approach focuses on the whole, not the parts. The interesting properties of systems (the ones that give rise to system accidents) can only be studied and understood when you treat them in their entirety. (p. 91)

Dekker is right: Whether persons at all levels are aware of it, they apply their own model and their understanding of how incidents occur when investigations are made. Thus, two questions need consideration:

- What have safety professionals been taught about incident causation?

- What have safety professionals been teaching people in the organizations they advise?

Answers to those questions greatly affect the quality of incident investigations. Based on the author's research (Manuele, 2011), the myths that should be dislodged from the practice of safety are:

- 1) Unsafe acts of workers are the principal causes of occupational incidents.

- 2) Reducing incident frequency will achieve an equivalent reduction in injury severity.

These myths arise from the work of Heinrich and can be found in the four editions of *Industrial Accident Prevention* (1931, 1941, 1950, 1959). Analytical evidence developed by the author indicates that these premises are not soundly based, supportable or valid.

Heinrich professed that among the direct and proximate causes of industrial incidents:

88% are unsafe acts of persons; 10% are unsafe mechanical or physical conditions; and 2% are unpreventable. (1931, p. 43; 1941, p. 22; 1950, p. 19; 1959, p. 22)

Heinrich advocated identifying the first proximate and most easily prevented cause in the selection of remedies for the prevention of incidents. He says:

Selection of remedies is based on practical cause-analysis that stops at the selection of the first proximate and most easily prevented cause (such procedure is advocated in this book) and considers psychology when results are not produced by simpler analysis. (1931, p. 128; 1941, p. 269; 1950, p. 326; 1959, p. 174)

Note that the first proximate and most easily prevented cause is to be selected (88% of the time, a human error). That concept permeates Heinrich's work. It does not encompass what has been learned subsequently about the complexity of incident causation or that other causal factors may be more significant than the first proximate cause.

Many safety practitioners still operate on the belief that the 88-10-2 ratios are soundly based. As a result, they focus on correcting a worker's unsafe act as the singular causal factor for an incident rather than addressing the multiple causal factors that contribute to most incidents.

A recent example of incident causation complexity appears in the following excerpt from the report prepared by BP (2010) following the April 20, 2010, *Deepwater Horizon* explosion in the Gulf of Mexico.

Practitioners who are not informed on current thinking with respect to incident causation are not qualified to identify causal and contributing factors.



The team did not identify any single action or inaction that caused this incident. Rather, a complex and interlinked series of mechanical failures, human judgments, engineering design, operational implementation and team interfaces came together to allow the initiation and escalation of the accident. (p. 31)

During an incident investigation, a professional search to identify causal factors such as through the five-why analysis system will likely find that the causal factors built into work systems are of greater importance than an employee's unsafe act.

The author's previous work (Manuele, 2011) covered topics such as moving the focus of preventive efforts from employee performance to improving the work system; the significance of work system and methods design; the complexity of causation; and recognizing human errors that occur at organizational levels above the worker.

Although response to that article was favorable, some communications received contained a disturbing tone. It became apparent that Heinrich's premise that 88% of occupational incidents are caused by the unsafe acts of workers is deeply embedded in the minds of some safety practitioners and those they advise. This is a huge problem. This premise was taught to students in safety science degree programs for many years and is still taught. The author received a call from one professor who said that the 2011 article gave him the leverage he needed to convince other professors that some of Heinrich's premises are not valid and should not be taught.

How big is the problem? Paraphrasing an April 2014 e-mail from the corporate safety director of one of the largest companies in the world, "We are thinking about how far to go to push Heinrich thinking out of our system. We still have some traditional safety thinkers who would squirm and voice concerns if we did that."

In May 2014, the author spoke at a session arranged by ORCHSE, a consulting organization

whose members represent Fortune 500 companies. When the more than 85 attendees were asked by show of hands whether Heinrich concepts dominated their incident investigation systems, more than 60% responded affirmatively. This author believes that many of those who did not respond positively were embarrassed to do so.

At an August 2014 meeting of 121 safety personnel employed by a large manufacturing company, participants were asked: About what percentage of the incident reports at your location identify unsafe acts as the primary cause? The results follow:

% of reports	Participant responses
100%	3%
75%	33%
50%	37%
25%	12%
< 25%	15%

A total of 73% of participants indicated that for 50% to 100% of incident reports, workers' unsafe acts are identified as the primary cause. To quote the colleague who conducted this survey, "We've got work to do."

Also, note the following comments that are significant with respect to how big the problem is. For more than 35 years, E. Scott Geller has been a prominent practitioner in behavior-based safety. His current thinking is relative to the reality of causal factors and their origins. Excerpts from a recent article follow (Geller, 2014).

A person who believes that most injuries are caused by employee behavior can be viewed as a safety bully. This belief could influence a focus on the worker rather than the culture or management systems, or many other contributing factors. As Deming warns, "Don't blame people for problems caused by the system."

When safety programs are promoted on a premise such as "95% of all workplace accidents are caused by behavior," one can understand why union leaders object vehemently and justifiably to such. Claiming that behaviors cause workplace injuries and property damage places blame on the employee and dismisses management responsibility. Most worker behavior is an outcome of the work culture, the system.

It is wrong to presume that behavior is a cause of an injury or property damage. Rather, behavior is one of several contributing factors, along with environmental and engineering factors, management factors, cultural factors and person-states. (pp. 41-42)

This author concludes that supervisors, management personnel above the supervisory level, investigation team members and safety practitioners who are not informed on current thinking with respect to incident causation are not qualified to identify causal and contributing factors, particularly those that derive from inadequacies in an organization's culture, operating systems and technical aspects applications, and from errors made at upper management levels. This presents a challenge for safety professionals, as well as an opportunity.

Multifactorial Aspects of Incident Causation

Most hazards-related incidents, even those that seem to be the least complex, have multiple causal factors that derive from *less than adequate* workplace and work methods design, operations management and personnel performance.

The author's reviews of incident investigation reports, mostly on serious injuries and fatalities, showed that:

- Many incidents resulting in serious injury or fatality are unique and singular events, having multiple and complex causal factors that may have organizational, technical, operational systems or cultural origins.

- Causal factors for low probability/serious consequence events are seldom represented in the analytical data on incidents that occur frequently. (Some ergonomics-related incidents are the exception.)

Those studies also showed that a significantly large share of incidents resulting in serious injuries and fatalities occurred:

- when unusual and nonroutine work is being performed;
- in nonproduction activities;
- in at-plant modification or construction operations (replacing a motor weighing 800 lb to be installed on a platform 15 ft above the floor);
- during shutdowns for repair and maintenance, and startups;
- where sources of high energy are present (electrical, steam, pneumatic, chemical);
- where upsets occur (situations going from normal to abnormal).

In every report reviewed, multiple causal factors were identified; there was an initiating event followed by a cascade of contributing factors that developed in sequence or in parallel. They related directly to deficiencies in operational management systems that should be subjects of concern when investigations are made.

Johnson (1980) writes succinctly about the multifactorial aspect of incident causation:

Accidents are usually multifactorial and develop through relatively lengthy sequences of changes and errors. Even in a relatively well-controlled work environment, the most serious events involve numerous error and change sequences, in series and parallel. (p. 74)

Human Errors: Management Decision Making

Particular attention is given here to *Guidelines for Preventing Human Error in Process Safety* (CCPS, 1994). Although the term *process safety* appears in the book's title, the first two chapters provide an easily read primer on human error reduction.

Safety professionals should view the following highlights as generic and broadly applicable. They advise on where human errors occur, who commits them and at what level, the influence of organizational culture and where attention is needed to reduce the occurrence of human errors.

It is readily acknowledged that human errors at the operational level are a primary contributor to

the failure of systems. It is often not recognized, however, that these errors frequently arise from failures at the management, design or technical expert levels of the company. (p. xiii)

A systems perspective is taken that views error as a natural consequence of a mismatch between human capabilities and demands, and an inappropriate organizational culture. From this perspective, the factors that directly influence error are ultimately controllable by management. (p. 3)

Almost all major accident investigations in recent years have shown that human error was a significant causal factor at the level of design, operations, maintenance or the management process. (p. 5)

One central principle presented in this book is the need to consider the organizational factors that create the preconditions for errors, as well as the immediate causes. (p. 5)

Since "failures at the management, design or technical expert levels of the company" affect the design of the workplace and the work methods (i.e., the operating system), it is logical to suggest that safety professionals encourage that incident investigations focus on improving the operating system to achieve and maintain acceptable risk levels.

Dekker's (2006) premises are pertinent to this subject. Several excerpts follow:

Human error is not a cause of failure. Human error is the effect, or symptom, of deeper trouble. Human error is systematically connected to features of people's tools, tasks and operating systems. Human error is not the conclusion of an investigation. It is the starting point. (p. 15)

Sources of error are structural, not personal. If you want to understand human error, you have to dig into the system in which people work. (p. 17)

Error has its roots in the system surrounding it; connecting systematically to mechanical, programmed, paper-based, procedural, organizational and other aspects to such an extent that the contributions from system and human error begin to blur. (p. 74)

The view that accidents really are the result of long-standing deficiencies that finally get activated has turned people's attention to upstream factors, away from frontline operator "errors." The aim is to find out how those "errors," too, are a systematic product of managerial actions and organizational conditions. (p. 88)

The Systemic Accident Model . . . focuses on the whole [system], not [just] the parts. It does not help you much to just focus on human errors, for example, or an equipment failure, without taking into account the sociotechnical system that helped shape the conditions for people's performance and the design, testing and fielding of that equipment. (p. 90)

Reason's (1997) book, *Managing the Risks of Organizational Accidents*, is a must-read for safety professionals who want to learn about human error reduction. Reason writes about how the effects

of decisions accumulate over time and become the causal factors for incidents resulting in serious injuries or substantial damage when all the circumstances necessary for the occurrence of a major event fit together. He stresses the need to focus on decision making above the worker level to prevent major incidents:

Latent conditions, such as poor design, gaps in supervision, undetected manufacturing defects or maintenance failures, unworkable procedures, clumsy automation, shortfalls in training, less than adequate tools and equipment, may be present for many years before they combine with local circumstances and active failures to penetrate the system's layers of defenses.

They arise from strategic and other top level decisions made by governments, regulators, manufacturers, designers and organizational managers. The impact of these decisions spreads throughout the organization, shaping a distinctive corporate culture and creating error-producing factors within the individual workplaces. (p. 10)

If the decisions made by management and others have a negative effect on an organization's culture and create error-producing factors in the workplace, focusing on reducing human errors at the worker level—the unsafe acts—will not solve the problems. Thus, the emphasis in incident investigations should be on the management system deficiencies that result in creating a negative "culture" and "error-producing factors in the workplace."

A Causation Model

Safety professionals are obligated to give advice based on a sound and studied thought process that considers the reality of the sources of hazards. The author proposes that a causation model must encompass the following premises.

- An organization's culture is the primary determinant with respect to the avoidance, elimination, reduction or control of hazards and whether acceptable risk levels are achieved and maintained.
- Management commitment or noncommitment to operational risk management is an extension of the organization's culture.
- Causal factors may derive from decisions made at the management level when policies, standards, procedures, provision of resources and the accountability system are less than adequate.
- A large majority of the problems in any operation are systemic. They derive from management decisions that establish the operating sociotechnical system—the workplace, work methods and governing social atmosphere-environment.
- A sound causation model for hazards-related incidents must consider the entirety of the sociotechnical system, applying a holistic approach to both the technical and social aspects of operations. It must be understood that those aspects are interdependent and mutually inclusive.

The sociotechnical system in an organization is a derivation of its culture. The following definition of a sociotechnical system is a composite of several definitions and the author's views, based on experience.

A sociotechnical system stresses the holistic, interdependent, integrated and inseparable interrelationship between humans and machines. It fosters the shaping of both the technical and social conditions of work in such a way that both the system's output goal and the workers' needs are accommodated.

This article presents a sociotechnical model for hazards-related incidents (Figure 1). It is the author's composite and is influenced by his research and experience.

Cultural Implications That Encourage Good Incident Investigations

In one company in which management personnel are fact-based and sincere when they say that they want to know about the contributing factors for incidents, regardless of where the responsibility lies, a special investigation procedure is in place for serious injuries and fatalities.

That company's management recognized that it was difficult for leaders at all levels to complete factual investigation reports that may be self-critical. Thus, an independent facilitator serves as the investigation and discussion team leader. At least five knowledgeable people serve on the team. All team members know that a factual report is expected.

It is known that the CEO reads the reports, asks questions to ensure that the reports are complete, and sees that leaders resolve all of the recommendations made to a proper conclusion. Thus, the CEO's actions demonstrate that the organization's culture requires fact determination and continual improvement. The culture dominates and governs.

Cultural Implications That May Impede Incident Investigations

Guidelines for Preventing Human Error in Process Safety (CCPS, 1994) contains a relative and all-too-truthful paragraph related to an organization's culture:

A company's culture can make or break even a well-designed data collection system. Essential requirements are minimal use of blame, freedom from fear of reprisals and feedback which indicates that the information being generated is being used to make changes that will be beneficial to everybody.

All three factors are vital for the success of a data collection system and are all, to a certain extent, under the control of management. (p. 259)

In relation to the foregoing, the title of Whittingham's (2004) book, *The Blame Machine: Why Human Error Causes Accidents*, is particularly appropriate. According to Whittingham, his research shows that, in some organizations, a blame culture has evolved whereby the focus of investigations is on individual human error and the corrective action stops at that level. That avoids seeking data on and improving the management systems that may have enabled the human error.

What Whittingham describes is indicative of an inadequate safety culture. As an example of an aspect of a negative safety culture, consider the fol-

lowing real-world scenario with which this author became familiar that represents a culture of fear:

An electrocution occurred. As required in that organization, the corporate safety director visited the location to expand on the investigation. During discussion with the deceased employee's immediate supervisor, it became apparent that the supervisor knew of the design shortcomings in the lockout/tagout system, of which there were many at the location.

When asked why the design shortcomings were not recorded as causal factors in the investigation report, the supervisor responded, "Are you crazy? I would get fired if I did that. Correcting all these lockout/tagout problems will cost money and my boss doesn't want to hear about things like that."

This culture of fear arose from the system of expected performance that management created. The supervisor completed the investigation report in accord with what he believed management expected. He recorded the causal factor as "employee failed to follow the lockout/tagout procedure" and the investigation stopped there.

In such situations, corrective actions taken usually involve retraining and giving additional emphasis to the published standard operating procedure. Design shortcomings are untouched. Overcoming such a culture of fear in the process of improving incident investigation processes will require careful analysis and much persuasive diplomacy.

A Course of Action

If incident investigations are thorough and unbiased, the reality of the technical, organizational methods of operation and cultural causal factors will be revealed. If appropriate action is taken on those causal factors, significant risk reduction can be achieved. To improve incident investigation quality, safety professionals should do the necessary research and develop a plan of action.

- Safety professionals must base their practice on sound principles. They must understand the importance of and the serious need for their guidance on incident investigation to all levels of management and for investigation teams. Thus, it is suggested that safety professionals review the causation model on which their advice is based.

- A sociotechnical causation model for hazards-related incidents (Figure 1) emphasizes the influence of an organization's culture and the shortcomings that may exist in controls when safety policies, standards, procedures and the accountability system are inadequate with respect to the design processes and operations risk management. A causation model should relate to such inadequacy of controls.

- Improving the quality of incident investigations in most organizations will require significant changes in their culture and safety professionals must understand the enormity of the task. In such an initiative, knowledge of management of change methods is necessary (Manuele, 2014).

- Valid data on the quality of incident investigations should be developed. So, an evaluation should

Figure 1

Sociotechnical Causation Model for Hazards-Related Incidents

An organization's culture is established by the board of directors and senior management.

Management commitment or noncommitment to providing the controls necessary to achieve and maintain acceptable risk levels is an expression of the culture.

Causal factors may derive from shortcomings in controls when safety policies, standards, procedures, the accountability system or their implementation are

Inadequate with respect to

The design processes and operational risk management and the inadequacies impact negatively on:

- Providing resources
- Risk assessments
- Competency and adequacy of staff
- Maintenance for system integrity
- Management of change/prejob planning
- Procurement, safety specifications
- Risk-related systems
 - Organization of work
 - Training, motivation
 - Employee participation
 - Information, communication
 - Permits
 - Inspections
 - Incident investigation and analysis
 - Providing PPE
- Third-party services
- Emergency planning and management
- Conformance/compliance assurance
- Performance measures
- Management reviews for continual improvement

Multiple causal factors derive from inadequate controls.

The incident process begins with an initiating event. There are unwanted energy flows or exposures to harmful substances.

Multiple interacting events occur sequentially or in parallel.

Harm or damage results, or could have resulted in slightly different circumstances.

be made of a sampling of completed investigation reports. In studies made by the author, the identification entries in incident investigation forms (e.g., name, department, location of the incident, shift, time, occupation, age, time in the job) received relatively high scores for thoroughness of completion.

Thus, it is suggested that the evaluation concentrate on incident descriptions, causal and contributing factor determination, and corrective actions taken. If the number of entries in an available data bank presents a manageable unit, all incident descriptions can be reviewed. As the data bank increases in size, decisions must be made about the number of incidents that practicably should be reviewed. Where the data bank is large, a safety professional may want to evaluate only incidents that result in serious injury or

The five-why analysis and problem-solving technique is easy to learn and effective; the training time and administrative requirements are not extensive.

illness, perhaps those valued in workers' compensation claims data at \$25,000 or more.

This level was selected pragmatically while working with larger companies. Safety directors decided to have the incident review process pertain to perhaps two or three or 5,000 incidents. For example, in a company in which about 5,000 workers' compensation claims are reported annually, the computer run at a \$25,000 selection level provided data on 375 cases, about 7.5% of total cases. They represented more than 70% of total claims values.

- An assessment should follow of the reality of the culture in place with respect to incident investigations. This is vital. Safety professionals must understand that the culture will not be changed without support from senior management and that they must adopt a major role to achieve the necessary change.

- Other evaluations should be made to determine what is being taught about incident investigation; whether the guidance given in procedure manuals is appropriate and adequate; and whether the investigation report form assists or hinders thorough investigations.

- From the foregoing, the safety professional should draft an action plan to convince management of the value of making changes in the expected level of performance on incident investigation. One item in the action plan should propose adopting a problem-solving technique, an incident investigation technique.

The Five-Why Analysis System

The five-why analysis and problem-solving technique is easy to learn and effective; the training time and administrative requirements are not extensive. Before applying this technique, training should cover the fundamentals of hazard and risk identification and analysis. The author promotes adoption of the five-why technique rather strongly. For most organizations, achieving competence in applying the technique to investigations will be a major step forward.

The five-why concept is based on an uncomplicated premise, so it can be easily adopted in an incident investigation process, as some safety professionals have done. For the occasional complex incident, starting with the five-why system may lead to the use of event trees, fishbone diagrams or more sophisticated investigation systems.

Other incident investigation techniques exist. Highly skilled investigators may say that the five-why process is inadequate because it does not promote identification of causal factors resulting from decisions made at a senior management level. That is not so. Usually, when inquiry gets to the fourth "why," considerations are at the management levels above the supervisor and may consider decisions made by the board of directors.

Given an incident description, the investigator or the investigation team would ask "why" five times to get to the contributing causal factors and outline the necessary corrective actions. A colleague who has adopted the five-why system says that he has taught incident investigators to occasionally interject a "how could that happen?" into the dis-

ussion—an interesting innovation. A not-overly complex example of a five-why application follows.

The written incident description says that a tool-carrying wheeled cart tipped over onto an employee while she was trying to move it. She was seriously injured.

1) Why did the cart tip over? The diameter of the casters is too small and the carts are tippy.

2) Why is the diameter of the casters too small? They were made that way in the fabrication shop.

3) Why did the fabrication shop make carts with casters that are too small? It followed the dimensions provided by engineering.

4) Why did engineering provide fabrication dimensions for casters that have been proven to be too small? Engineering did not consider the hazards and risks that would result from using small casters.

5) Why did engineering not consider those hazards and risks? It never occurred to the designer that use of the small casters would create hazardous situations. The designer had not performed risk assessments.

Conclusion: I [the department manager] have made engineering aware of the design problem. In that process, an educational discussion took place with respect to the need to focus on hazards and risks in the design process. Also, engineering was asked to study the matter and has given new design parameters to fabrication: The caster diameter is to be tripled. On a high-priority basis, fabrication is to replace all casters on similar carts. A 30-day completion date for that work was set.

I have also alerted supervisors to the problem in areas where carts of that design are used. They have been advised to gather all personnel who use the carts and inform them that larger casters are being placed on carts, and instruct them that until then, moving the carts is to be a two-person effort. I have asked our safety director to alert her associates at other locations of this situation and how we are handling it.

Sometimes, asking "why" as few as three times gets to the root of a problem; on other occasions, six times may be necessary. Having analyzed incident reports in which the five-why system was used, the author offers several cautions:

- Management commitment to identifying the reality of causal factors is necessary for success.

- Ensure that the first "why" is really a "why" and not a "what" or a diversionary symptom.

- Expect that repetition of five-why exercises will be necessary to get the idea across. Doing so in group meetings at several levels, but particularly at the management level, is a good idea.

- Be sure that management is prepared to act on the systemic causal factors identified as skill is developed in applying the five-why process.

A safety director who contributed material for this article says the following about his application of the five-why system.

I have trained supervisors, shift managers, department managers and facility managers in the use of the five-why system for accident investigations. I taught them the difference between

fact finding and fault finding. They understand that documenting a failure on their part does not necessarily mean that they are lousy supervisors and will help us identify system problems that we must correct. I review every investigation report. Anytime I feel they have stopped asking “why” too soon, I assist them with additional investigation to ensure that the root cause(s) are identified and appropriate corrective actions are developed and implemented.

The literature on the five-why system is not extensive because it is not complex. Two Internet resources are listed in the references for this article.

Conclusion

If incident investigations are objective and thorough, the symptoms relating to technical, organizational, methods of operation and cultural causal factors will be revealed. If appropriate action is taken on those causal factors, significant risk reduction can be achieved. But, as is established in this article, incident investigations are most often not thorough and factual.

That presents significant challenges and opportunities for safety professionals. It is incumbent on them to be well informed about incident causation. As Dekker (2006) says, “Where you look for causes depends on how you believe accidents happen. Whether you know it or not, you apply an *accident model* to your analysis and understanding of failure,” (p. 81).

It is apparent that the magnitude of the need as safety professionals give advice on incident investigation and causal factor determination is huge. In most organizations, a major culture change will be necessary to significantly improve the quality of incident investigations, a change that can be achieved only with management support over time.

Assume that a safety professional decides to take action to improve the quality of incident investigation. It is proposed that the following comments about incident investigation, as excerpted from the Report of the *Columbia* Accident Investigation Board (NASA, 2003), be kept in mind as a base for reflection throughout the endeavor.

Many accident investigations do not go far enough. They identify the technical cause of the accident, and then connect it to a variant of “operator error.” But this is seldom the entire issue.

When the determinations of the causal chain are limited to the technical flaw and individual failure, typically the actions taken to prevent a similar event in the future are also limited: fix the technical problem and replace or retrain the individual responsible. Putting these corrections in place leads to another mistake—the belief that the problem is solved.

Too often, accident investigations blame a failure only on the last step in a complex process, when a more comprehensive understanding of that process could reveal that earlier steps might be equally or even more culpable. In this Board’s opinion, unless the technical, organizational, and cultural recommendations made in this report are implemented, little will have been accom-

plished to lessen the chance that another accident will follow. (p. 177)

Paraphrasing, for emphasis: If the cultural, technical, organizational and methods of operation causal factors are not identified, analyzed and resolved, little will be done to prevent recurrence of similar incidents. **PS**

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