Serious Injuries & Fatalities

A call for a new focus on their prevention

By Fred A. Manuele

OVER THE PAST FEW DECADES, serious injuries and workplace fatalities have been significantly reduced. However, statistical trends in the more recent past indicate that additional research and knowledge are needed about causation and preventive measures so that safety professionals can give counsel on how these injuries and fatalities can be further reduced. To achieve this, SH&E professionals must adopt a new mindset that gives serious injury prevention a higher priority.

This will require several actions. The safety professional must address the phenomenon that seems to have developed in companies which continue to report serious injuries and fatalities despite otherwise stellar performance. In addition, the myth that preventing incidents that occur frequently will equivalently encompass severity reduction must be debunked. Other factors, such as organizational safety culture with respect to preventing serious injuries and the effect of the current economic climate, must be considered as well.

To help SH&E professionals in these endeavors, a mechanism for an internal study of severity potential is provided and the need for improved incident investigation is emphasized. In addition, an outline is presented for conducting a gap analysis that would compare existing safety management systems to the provisions of ANSI/AIHA Z10.

The Safety Performance Phenomenon

In early 2007, the Alcoa Foundation awarded a grant to Indiana University of Pennsylvania (IUP) to support a national forum on fatality prevention in the workplace. In a news release (Alcoa, 2007) announcing the grant, Lon Ferguson, chair of IUP's Safety Sciences Department, said:

> The reliance on traditional approaches to fatality prevention has not always proven effective. This fact has been demonstrated by many companies, including some thought to be top performers in worker safety and health, as they continue to experience fatalities while at the same time achieving benchmark performance in reducing less serious injuries and occupational illnesses.

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The author's analyses, made over the past several years, support Ferguson's statement. Traditional safety management systems may not adequately address severe injury and fatality potentials. Others have also recognized the phenomenon. For example, the membership of ORC Worldwide (formerly Organization Resource Counselors) consists of about 140 Fortune 500 companies. Many of those companies have outstanding safety cultures and commendable safety management systems in place.

However, because some of those companies continue to experience fatalities and serious injuries, ORC is creating a special system to gather data on the specifics of their occurrence. It is expected that the system will include fatalities, serious injuries that had fatality potential and near-hits that under other circumstances may have resulted in serious consequences. The data will be analyzed with the hope that the outcomes will provide more information than is now available for their prevention.

Collectively, SH&E professionals should ask whether there is adequate in-depth knowledge of the causal factors for low-probability/serious-consequence incidents. The author's research on incident investigations (see p. 34) suggests that there is not.

Statistical Indicators: Fatalities

The reduction in both the number of serious injuries and fatalities and their rates in recent years must be recognized, as they are an indication that those involved in the practice of safety are doing many things right. The fatality rate data in Tables 1 and 2 are based on excerpts from National Safety Council's *Accident Facts* (now *Injury Facts*) and the Bureau of Labor Statistics' (BLS) annual census of fatal occupational injuries. The fatality rate is the number of fatalities per 100,000 workers.

Years ending in 1 were chosen as a focal point for this review so that an observation could be made of results since OSHA took effect in 1971. While employment increased more than 280% from 1941 to 2001, the number of fatalities dropped more than 67%—and the fatality rate dropped more than 88%. This record is highly favorable and complimentary to all involved.

One also cannot ignore the emergence of OSHA in 1971 and the greater concentration on workplace safety that followed. Using 1971 data as a base, the fatality rate was reduced about 75% by 2001. Table 2 picks up from Table 1 and provides data on fatalities and fatality rates since 2001.

According to the 2001 data, 5,900 fatalities occurred and the fatality rate was 4.3. However, consider the data for 2002 through 2006. The number of fatalities increased 3.2% and the fatality rate remained the same. Fatality rates over a 6-year period have not varied substantially.

Why did the number of fatalities increase? Has there been a reversal of the downward trend experienced in previous years? Why did the fatality rate not continue the remarkable reductions seen in the years from 1941 through 2001? Safety professionals have a responsibility to promote the causal factor research needed to answer those questions.

Statistical Indicators: Serious Injury Trending

Data on the characteristics of serious injuries and workers' compensation claims frequency have been extracted from two sources: National Council on Compensation Insurance (NCCI) and BLS.

National Council on Compensation Insurance

In 2006, NCCI issued a video, *The Remarkable Story of Declining Frequency—Down 30% in the Past Decade.* This 12-minute video reports that workers' compensation claim frequency is down considerably, not only in the U.S. but also in several industrialized countries.

However, a 2005 NCCI research brief titled "Workers' Compensation Claim Frequency Down Again," states that "there has been a larger decline in the frequency of smaller lost-time claims than in the frequency of larger lost-time claims."

Consider the trend numbers presented in Table 3 (p. 34), taken from NCCI's *State of the Line* report (Mealy, 2005). These data show reductions in selected categories of claim values for the years 1999 and 2003, expressed in 2003 hard dollars. While the frequency of workers' compensation cases is down, the greatest reductions are in lower cost claims. The reduction in cases valued from $10,000 to $50,000 is about one-third of that for cases valued at less than $2,000. For cases valued over $50,000, the reduction is about one-fifth of that for the less costly injuries. Thus, costly claims—those for serious injuries and fatalities—loom larger within the spectrum of all claims reported.

Bureau of Labor Statistics

For many years, BLS has issued reports titled *Lost Work-Time Injuries and Illnesses: Characteristics and Resulting Time Away From Work* and *Workplace Injuries and Illnesses.* The data in Table 4 (p. 35), taken from those reports, indicate that the total number of cases resulting in lost work-time and the DART rate (which includes cases with days away from work, job transfer or restriction) have reduced substantially. From 2000 to 2006, the number of lost work-time cases dropped by 480,518 (28.9%), while the DART dropped 23.3%. Those reductions are commendable.

BLS data on lost work-time injuries and illnesses tracks well with NCCI reports with respect to the lost workday categories in which the reductions occurred. Data in Table 5 (p. 35) are from the BLS's *Lost Work-Time Injuries and Illnesses: Characteristics and Resulting Time Away From Work* reports for the years 1995 and 2006. Table 10 in those reports is titled "Percent distribution of nonfatal occupational injuries and illnesses involving days away from work." It shows the percentages of select days-away-from-work categories as each category relates to the total number of days-away-from-work cases reported in a given year.

The decreases (the trends) in the percentages for the first four days-away-from-work categories are noteworthy. The frequency of incidents resulting in lesser injury is down. For the 11-to-20-days-away category, the increase of 1.8% only begins to show an upward trend. The 9.6% increase for the 21-to-30-days-away category deserves attention, as does the increase of 35.3% for the 31 or more days-away category. Given this, it is recommended that safety professionals determine whether increases in the 21-to 30 and the 31-or-more days-away categories have occurred in their organizations' operations.

In 2002, OSHA revised the rules on how days away from work are counted, so the trend data in Table 5 need a closer look. Using the base data from the BLS reports for the years 1995 through 2001, and assuming the rules had not changed, Alan Hoskin, a statistician formerly with National Safety Council, statistically projected numbers for the years 2002 and 2003. He found that the differences are small—1.2% and 1.7%—and do not greatly affect the trend data.

One cannot conclude from the BLS data that the number of incidents resulting in severity of 21 to 30

Table 1

All Fatalities, All Occupations: 1941-2001

Year	No. of fatalities	Fatality rate	No. of workers (1,000s)
1941	18,000	37	48,100
1951	16,000	28	57,450
1961	13,500	21	64,500
1971	13,700	17	78,500
1981	12,500	13	99,800
1991	9,800	8	116,400
2001	5,900	4.3	136,000

Note. *Data based on excerpts from* Accident Facts, *by National Safety Council, 1995, Itasca, IL: Author, and "Census of Fatal Occupational Injuries, 1997-2006," by Bureau of Labor Statistics, 2007, Washington, DC: U.S. Department of Labor, Author. The fatality rate is the number of fatalities per 100,000 workers. Years ending in 1 were chosen as a focal point for this review so that an observation could be made of results since OSHA took effect in 1971.*

Abstract: *Worker injuries have been dramatically reduced, but much of that reduction has been in the less severe injury categories. Serious injuries have not been reduced equivalently. This article examines types of activities in which serious injuries occur, presents an instrument for studying injury severity and calls for SH&E professionals to conduct a gap analysis of their organizations' existing safety management systems.*

Table 2

All Fatalities, All Occupations: 2001-2006

Year	No. of fatalities	Fatality rate
2001	5,900	4.3
2002	5,524	4.0
2003	5,559	4.0
2004	5,703	4.1
2005	5,702	4.0
2006	5,703	3.9

Note. *Data based on excerpts from "Census of Fatal Occupational Injuries, 1997-2006," by Bureau of Labor Statistics, 2007, Washington, DC: U.S. Department of Labor, Author. The fatality rate is the number of fatalities per 100,000 workers.*

Table 3

Categories of Injury Reductions

Value of claim	Declines in frequency
Less than $2,000	34%
$2,000 to $10,000	21%
$10,000 to $50,000	11%
More than $50,000	7%

or 31 or more days away from work has increased. The data in Table 4 show that the number of lost work-time cases has been significantly reduced. The data in Table 5 indicate that incidents resulting in severity are a larger segment of all days-away-from-work cases reported and that serious injuries have not been reduced at the same rate as less severe injuries.

Debunking the Myth

To further reduce serious injuries and fatalities, safety professionals must address a long-held and still applied belief that reducing incident frequency will equivalently reduce incidents that result in severity. The data in this article convincingly show that this premise is unsustainable.

Others have raised the issue as well. At the 2003 Behavioral Safety Now Conference, James Johnson, a managing director at Liberty Mutual Insurance Co., said:

> I'm sure that many of us have said at one time or another that frequency reduction will result in severity reduction. This popularly held belief is not necessarily true. If we do nothing different than we are doing today, these types of trends will continue.

In 2004, DNV Consulting issued an invitation to the process industry titled "Leading Indicators for Major Accident Hazards: An Invitation to Industry Partners." The goal was to get the industry to finance research into the causal factors for major accidents—a goal that was not achieved. In part, this invitation stated:

> Much has been said about the classical loss control pyramid, which indicates the ratio between no loss incidents, minor incidents and major incidents, and it has often been argued that if you look after the small incidents, the major loss incidents will improve also. The major reality, however, is somewhat different. If you manage the small accidents effectively, the small accident improves, but the major accident rate stays the same, or even slightly increases.

To recognize that the premises on which the pyramids, the triangles or the specific ratios (e.g., the 300-29-1 ratios) were built are not valid requires a major concept change—and the data show this is necessary.

Consider, also, the symmetry between what Johnson said in 2003 and a philosophical statement of Yogi Berra: "If you keep doing what you did, you will keep getting what you got." Listen to these voices and those of DNV and this author. It is obvious that frequency reduction does not necessarily produce equivalent severity reduction. If safety professionals propose nothing different with respect to safety management systems than they have proposed in the past, serious injury potential will not be significantly reduced. The data require that safety professionals adopt a new mindset—one that results in a targeted focus on preventing low-probability/serious-consequence events.

Characteristics of Incidents Resulting in Severe Injuries & Fatalities

As safety professionals study the characteristics of incidents that result in serious injuries and fatalities to select predictive indicators from those data, they should consider the following general observations based on the author's analyses of more than 1,200 incident investigation reports.

1) A large proportion of incidents resulting in serious injuries and fatalities occur:

a) when unusual and nonroutine work is being performed;

b) when upsets occur—meaning normal operations become abnormal;

c) in nonproduction activities;

d) where sources of high energy are present;

e) in what can be called at-plant construction operations (e.g., a motor that weighs 800 lb and sits on a platform 15 ft above the floor needs to be replaced, and the work will be performed by in-house personnel).

2) Many incidents resulting in serious injuries and fatalities are unique and singular events, having multiple and complex causal factors that may have organizational, technical, operational systems or cultural origins.

3) Causal factors for low-probability/high-consequence events are not represented in the analytical data on incidents that occur frequently and result in minor injury. However, such incidents, occurring in routine work, may be predictors of severity potential if a high energy source was present (e.g., operation of powered mobile equipment, electrical contacts). Also, certain ergonomics-related incidents are exceptions.

4) The quality of the incident investigation reports reviewed was, on average, abysmal. A large percentage of the investigations stopped when human error—the so-called unsafe act—was identi-

fied and the corrective action focused on modifying worker behavior. The investigations seldom proceeded upward into the decision making that may have influenced what the worker did.

Guidelines for Preventing Human Error in Process Safety, published by the Center for Chemical Process Safety (1994), contains two chapters that provide a primer on human error reduction. Excerpts from that text follow.

> 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.
>
> One of the central principles in this book is the need to consider the organizational factors that create the preconditions for errors, as well as the immediate causes.

Specifics From Certain Studies

Supporting the foregoing general observations, the following specifics were noted in the experience of individual companies when analyses were made of serious injuries and fatalities.

•Thirty-five percent of serious injuries and fatalities were triggered by a deviation from normal operations (upsets).

•Over a 10-year period, 51% of fatalities occurred to contractor employees.

•In three companies with a combined total of 230,000 employees, each having low OSHA incidence rates, composite data indicated that 74% of lost workday cases with days away from work involved ancillary and support personnel.

•For companies with incidence rates higher than their industry's average, and in companies where the work involves heavy materials handling or is highly repetitive, the percentage of severe injuries occurring to production personnel was higher than for those to support personnel.

•About 50% of major accidents involved the operation of powered mobile equipment (e.g., forklifts, cranes).

•Reviews of serious injuries and fatalities involving exposure to electric current indicate that while lockout/tagout systems may have met OSHA and National Electrical Code requirements, the design of the systems produced error-inducing situations (e.g., lockout stations were not conveniently located).

•Hazards and risks were not adequately addressed during the design process, and inadequate design features often appeared as causal factors in incident investigation reports.

•Having effective management of change procedures in place would have greatly reduced major accident potential.

Petersen (1998) also subscribed to the view that serious injury and fatality potential need special attention.

> If we study any mass data, we can readily see that the types of accidents that result in temporary total disabilities are different from the types of accidents resulting in permanent partial disabilities or in permanent total disabilities or fatalities. The causes are different. There are different sets of circumstances surrounding severity. Thus if we want to control serious injuries, we should try to predict where they will happen.

Since studies have established that the causal factors and the circumstances surrounding incidents which result in serious injuries are different, safety professionals should try to predict where serious injuries and fatalities may occur, and recommend improvements necessary in the relative safety management systems so as to avoid their occurrence.

Table 4

Trends for Lost-Worktime Cases

Year	Total cases	DART rates
2000	1,664,018	3.0
2001	1,537,567	2.9
2002	1,436,200	2.8
2003	1,315,920	2.6
2004	1,259,320	2.5
2005	1,234,680	2.4
2006	1,183,500	2.3

Note. *Data from "Lost Worktime Injuries and Illnesses: Characteristics and Resulting Time Away From Work, 1995-2006," by Bureau of Labor Statistics, 2007. Washington, DC: U.S. Department of Labor, Author. DART rate includes cases with days away from work, job transfer or restriction.*

Table 5

DAFW Cases by Duration: 1995-2006

	Percent of days away from work cases by number of days						
	1	**2**	**3-5**	**6-10**	**11-20**	**21-30**	**31 or more**
1995	16.9	13.4	20.9	13.4	11.3	6.2	17.9
2006	14.3	11.6	18.5	12.9	11.5	6.8	24.3
% change from 1996	-15.4	-13.4	-11.5	-3.8	+1.8	+9.6	+35.8

Note. *Data from "Lost Worktime Injuries and Illnesses: Characteristics and Resulting Time Away From Work, 1995-2006," by Bureau of Labor Statistics, 2007. Washington, DC: U.S. Department of Labor, Author. DAFW = days away from work.*

Significance of Organizational Culture

Since causal factors for incidents resulting in serious injuries and fatalities are largely systemic and a reflection of the organization's safety culture, that subject must be explored. Comments from the *Report of the Columbia Accident Investigation Board* (NASA, 2003) are pertinent.

> The physical cause of the loss of *Columbia* and its crew was a breach in the thermal protection system on the leading edge of the left wing. In our view, the NASA organizational culture had as much to do with this accident as the foam.

In every organization, its culture—values, norms, beliefs, myths and practices—is translated into a system of expected behavior. That expected behavior positively or negatively impacts decisions made with respect to management systems, design and engineering, operating methods, work methods and prescribed task performance.

For many workplace incidents that result in serious consequences there has been, over time, a continuum of less-than-adequate safety decisions that created a system of expected behavior which condoned considerable risk taking. Management decisions shape the corporate culture and create error-producing factors.

Reason (1997) also discusses the accumulation of systemic causal factors.

> 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* (emphasis added).

The Current Business Climate: Effect on Organizational Culture & Decision Making

Both a literature review and discussions with safety professionals require that consideration be given to the current economic climate and its possible effect on an organization's safety culture. Consider the following statements from the *Report of the OECD Workshop on Lessons Learned from Chemical Accidents and Incidents.* (OECD is the Organization for Economic Cooperation and Development, an international group.)

> The concept of "drift" as defined by [Jens] Rasmussen was generally agreed upon as being far too common in the current business environment. Rasmussen defined "drift" as the systematic organizational performance deteriorating under competitive pressure, resulting in operation outside the design envelope where preconditions for safe operation are being systematically violated (OECD, 2005).

The OECD report also includes comments attributed to Norika Hama, a professor of international economics at Doshisha University Business School:

> In their bid to make profit under deflationary pressures, [Japanese] companies have been restructuring their operations and trying to cut costs, and are compelled to continue using facilities and equipment that normally would have been replaced and renewed years ago, thereby raising the risk of accidents. Also because of job cuts, the firms do not have sufficient numbers of workers who can repair and keep the old equipment in proper condition.
>
> The operation of Japan's manufacturing industries was once looked upon as a global standard, but the fact that major companies that are supposed to symbolize that standard have been hit by serious accidents shows deflation has damaged the nation's industrial base.

Also consider what Rasmussen (1997) says about risk management:

> Companies today live in a very aggressive and competitive environment which will focus the incentives of decision makers on short-term financial and survival criteria rather than long-term criteria concerning welfare, safety and the environment. Studies of several accidents revealed that they were the effects of a systematic migration of organizational behavior toward accident under the influence of pressure toward cost-effectiveness in an aggressive, competitive environment.

Comments from the U.S. Chemical Safety and Hazard Investigation Board (CSB) report on the 2005 BP Texas City, TX, explosion that resulted in 15 deaths and 180 injuries are also pertinent.

> The Texas City disaster was caused by organizational and safety deficiencies at all levels of the BP Corp. Warning signs of a possible disaster were present for several years, but company officials did not intervene effectively to prevent it. Cost cutting and failure to invest left the Texas City refinery vulnerable to a catastrophe. BP targeted budgeted cuts of 25% in 1999 and another 25% in 2005, even though much of the refinery's infrastructure and process equipment were in disrepair.

In a March 20, 2007, CSB news release, then chair Carolyn Merritt said, "The combination of cost-cutting, production pressures and failure to invest caused a progressive deterioration of safety at the refinery." The impact of economics on decisions that may have a negative effect on the safety culture must be taken seriously.

Assume that an organization's senior executives want to know about the economics-related predictors for serious injury potential that may exist in their operations and that safety professionals want to conduct a study to identify them. Such a study can be built on the following outline.

1) In the current business climate, does the incentive system for decision makers result in focusing on short-term financial goals, resulting in drift—the systematic organizational performance deteriorating under competitive pressure?

2) Has the gap widened between issued policy and procedure, and what actually takes place at the company's locations?

3) Does the organization continue using facilities and equipment that normally would have been replaced years ago, thereby raising the risk of serious injuries and fatalities?

4) Has there been a high turnover of location managers, the result being considerable variation in the emphasis on safety management?

5) Is staffing at all levels sufficient—both as to number and qualifications—to maintain a superior level of safety performance?

6) Because of staff cuts, does the firm have insufficient numbers of qualified workers who can repair and keep equipment in proper condition?

7) Has complacency developed at the site due to presumed superior performance, as measured by OSHA statistics?

8) Do safety audits lack the depth needed to identify continuing deterioration in management systems that results in greater risk?

Every element in this list relates to concerns expressed by safety professionals about deterioration in safety management systems as they comment on trends in their organizations.

Avoiding Self-Delusion

With respect to the Texas City incident, CSB (2005) also says that "a very low personal injury rate at Texas City gave BP a misleading indicator of process safety performance." Others have similarly become aware that low injury incidence rates have little predictive value for severity potential. In a speech at the International Association of Oil and Gas Producers Offshore Safety Forum, Volkert Zijlker (2005), chair of the Oil and Gas Producers Safety Committee, said:

> We need to differentiate our focus on recurring safety incidents commensurate to the escalation potential. We concluded that TRIR/LTIF have little predictive value toward the potential escalation to single and multiple fatalities. They also tell us little about major accident risk.

Neither safety professionals nor executive management should delude themselves into believing that achieving low OSHA incidence rates ensures that serious injuries will not occur.

Actions to Reduce Serious Injury Potential

With a concentrated focus on further preventing serious injuries, safety professionals should consider the following initiatives:

1) Propose a study of serious injuries and fatalities in the entities to which they give counsel.

2) Significantly improve the quality of incident investigations.

3) Conduct a gap analysis, emphasizing the prevention through design provisions in ANSI/AIHA Z10-2005.

4) Initiate a system such as the critical incident technique (NSC, 2001a; Infopolis 2 Consortium) to gather information on near-hits.

Propose a Study of Serious Injuries & Fatalities

To produce information that relates directly to the entities to which safety professionals give counsel, it is proposed that serious injuries and fatalities which have occurred in those entities be studied. Such studies will not be time-consuming since the data to be collected and analyzed should already exist or be easily obtained. A model instrument that can be used in this study is shown in Figure 1 (p. 38); it should be modified to suit an organization's structure, culture, inherent risks, operations specifics and incident experience.

The study should seek predictive indicators, represented by shortcomings in safety management systems, so that improvement can be proposed. Item 8 in the survey instrument pertains to causal factors and would address those pertinent to the operations being studied.

Improve Incident Investigations

While the reality of the design and engineering, operational systems and cultural causal factors should be identified and analyzed in the proposed study, safety professionals should not be surprised to find that the incident investigation reports lack in-depth causal factors determination. As noted, the author's studies of 1,200 reports have found that incident investigations seldom reveal the core causal factors.

Comments by the Columbia Accident Investigation Board (NASA, 2003) match the conclusions drawn by this author through his research. While reading the following excerpts from that group's report, safety professionals should think about how they relate to the quality of the incident investigation systems in their organizations.

> 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,

To produce information that relates directly to the entities to which safety professionals give counsel, serious injuries and fatalities which have occurred in those entities should be studied.

Figure 1

Serious Injury & Fatality Review Instrument

1. Enter incident descriptive data____

2. Enter NAICS code__________	Job title(s)______________________	
3. Type of event	Serious Injury	3-A____
	Fatality	3-B____
	Near hit—life threatening	3-C____
4. Type of work code	Main operation/principle business	4-A____
	Operation support/ancillary personnel	4-B____
	Motor vehicle, other than sales	4-C____
	Construction/renovation	4-D____
	Sales	4-E____
	Office	4-F____
5. Work/task performed	Often/continuously/routine	5-A____
	Only occasionally	5-B____
	Seldom/quarterly or less	5-C____
6. Enter	Employee	6-A____
	Contractor	6-B____
7. Injury type	Fall	7-A____
	Struck by/against	7-B____
	Electrocution	7-C____
	Caught in/between	7-D____
	Motor vehicle (auto/truck)	7-E____
	Other mobile equipment	7-F____
	Exposure to chemical substance	7-G____
	Other	7-H____

8. Identify and enter the causal factors (design and engineering, operational, system, cultural, organizational, etc.) ____

organizational and cultural recommendations made in this report are implemented, little will have been accomplished to lessen the chance that another accident will follow.

As noted, many incidents resulting in serious injuries are unique and singular events, having multiple and complex causal factors that may have organizational, technical, operational systems or cultural origins. Substantial reductions in serious injuries are unlikely if incident investigation systems are not improved to address the reality of their causal factors.

The 5 Why System

One way to improve an incident investigation system is to use the 5 why technique. Highly skilled incident investigators may say that this technique is inadequate because it does not promote the identification of root causal factors that result from decisions made at a senior executive level. Nevertheless, achieving competence in applying this concept will be a major step forward in many organizations.

The origin of the 5 why process is attributed to Taiichi Ohno. While he was at Toyota, Ohno developed and promoted a practice of asking why five times to determine what caused a problem so that root causal factors can be identified and effective countermeasures implemented. The process is applied in a large number of settings for a wide range of problems.

Since the premise on which the 5 why concept is based is uncomplicated, it can be (and has been) easily incorporated into the incident investigation process. For more complex incident situations, starting with the 5 why strategy may lead to the use of event trees or fishbone diagrams or more sophisticated investigation systems (iSixSigma).

Conduct a Gap Analysis

Approval of ANSI/AIHA Z10-2005 was a major development. Provisions in Z10 are state of the art. To identify shortcomings in safety management systems that relate particularly to serious injury prevention, it is suggested that safety professionals conduct a gap analysis to compare existing safety management systems to the provisions in Z10.

While this analysis should include all provisions in the standard, the focus here is on prevention through design processes since most companies will find shortcomings in their safety management systems concerning them (Manuele, 2008). Improvements in these processes should reduce serious injury potential.

- **Design reviews.** Z10 requires that processes be in place to conduct safety-related design reviews so as to avoid bringing hazards and risks into the workplace.
- **Risk assessments.** Hazards are to be identified and analyzed, and risks are to be assessed and prioritized.
- **Hierarchy of controls.** An organization must implement and maintain a process for achieving feasible risk reduction based on a prescribed hierarchy of controls.
- **Management of change.** The objective of a management of change system is to prevent introducing hazards and risks into the work environment when operational changes are made. Given the author's studies of incident experience—in which it was noted that many incidents resulting in serious injuries occur when unusual work is done (e.g., as when changes are made)—safety professionals should strongly consider proposing the adoption of such a system.
- **Procurement.** Z10 requires that safety specifications be included in purchasing and acquisition processes to avoid bringing hazards and risks into the workplace.

As the gap analysis proceeds, the system shortcomings identified should be evaluated with respect to their being predictive of the probability that major incidents may occur.

Encourage Use of a Variation of the Critical Incident Technique

The proposed survey instrument (Figure 1) contains provisions to enter data on life-threatening near-hits. Safety professionals should consider adopting a system—such as the critical incident technique (NSC, 2001; Infopolis 2 Consortium)—to collect data on near-hits and out-of-the-norm situations to capture the predictive value such data provide. The purpose of applying the technique is to identify and address hazards that have serious injury potential.

A system requiring interviews, form completion or computer entry is created whereby employees are asked for their input on serious injury potential, including near-hit hazardous situations. For the process to succeed, one must recognize that workers are a valuable resource in identifying hazards and risks because of their extensive knowledge of how the work gets done.

With respect to incident recall, Johnson (1980) says:

> Such [incident recall] studies, whether by interview or questionnaire, have a proven capacity to generate a greater quantity of relevant, useful reports than other monitoring techniques, so much so as to suggest that their presence is an indispensable criterion of an excellent safety program.

A system that seeks to identify causal factors before their potentials are realized would serve well in attempts to avoid low-probability/serious-consequence events.

Conclusion

To reduce the potential for major accidents, management must embed that purpose within its culture. This will ensure that avoiding the causal factors for severe injuries is considered in the application of every element in the safety management system.

Achieving this requires a new mindset—in every aspect of safety management, from the design process to dismantling and disposition—and giving serious injury prevention a higher priority. The intent would be to achieve an understanding that personnel at all levels have a particular responsibility to:

- anticipate, predict and take corrective action on hazards and risks that may have serious injury or fatality potential;
- ensure that root causal factors for incidents which result in severe injuries are reviewed in depth;
- identify predictive indicators, including knowledge obtained from studies of near-hits;
- address organizational, operational, technical and cultural causal factors.

As safety professionals study serious injury causal factors and identify the improvements needed in safety management systems, they may find that a culture change is necessary. This would require them to take a significant leadership role. ■

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