Incident Records

Understanding the Past to Prevent Future Hazardous Energy Incidents

By Neil McManus and Assed N. Haddad

IN BRIEF
- Incident summaries are the primary source of information about injury-producing events involving contact with sources of hazardous energy. This article describes a disciplined process for extracting information from these summaries and discusses the implications of such information for incident reconstruction.
- The article identifies sources of historic information; discusses processes for extracting information from incident summaries; discusses current practices; advocates for coherence, organization, comprehensiveness and completeness information to be collected and stored in future; and suggests actions needed to achieve this goal.

Written records are the primary resource for information about incidents involving contact with sources of hazardous energy. The incident reconstruction process begins with the extraction of factual information, including location, date, time, occupation, age and gender of the victim, and progresses to asking focused questions to gather qualitative and inferential information. Extracting inferential information involves application of broad-spectrum knowledge about the circumstances of work. When this inquiry is performed with care, the information can help the researcher identify trends in these events and reveal areas that require attention. Work on statistical and stochastic data is an important means of transforming data into information, information into knowledge and knowledge into action.

Matrixes Provide Guidance

The historic record is a precious source of information about human activity. Written records that capture information from witnesses and follow-up investigation provide the highest possible level of information for future study and inquiry. This contrasts with other explorations of the past in which the historic record is but a small fragment of the total of what is needed for thorough study. In these instances, investigators are forced to infer big-picture meaning from little information.

When structuring records for future inquiry, it is important to determine the nature of what to capture. Haddon's (1972; 1983) matrix is a starting point when seeking to collect data on hazardous energy incidents. Haddon proposed partitioning events that constitute incidents into three phases: preevent, event and postevent. Within each phase, human factors, equipment factors and environmental factors influence an event's progression and outcome. These factors form the framework

Neil McManus, CSP, CIH, ROH, is a practicing industrial hygienist with more than 30 years' experience. He is chair of ANSI Z9.9 and a member of ANSI Z9 and ANSI Z117.1. McManus is an AIHA Fellow and an international member of ASSE. McManus holds an M.Sc. in Radiation Biology and an M.Eng. in Occupational Health and Safety Engineering.

Assed N. Haddad, Ph.D., is an associate professor at the Polytechnic School of Federal University of Rio de Janeiro (Escola Politécnica da UFRJ). He is also a civil, safety, and quality and reliability engineer. Haddad holds a Ph.D. in Production Engineering from UFRJ and an M.Sc. in Civil Engineering from Universidade Federal Fluminense.

of a matrix for recording detail about the event including causes and interactions.

Another consideration is Rumsfeld's (2002) matrix (Table 1). Rumsfeld outlined the framework of the matrix in reply to a question about the nature of information pertaining to events that have not occurred. He states:

> As we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns—the ones we don't know we don't know. And if one looks throughout the history of our country and other free countries, it is the latter category that tends to be the difficult one.

Table 1

Rumsfeld Matrix

Class of information	Status of information
Known	Known
Known	Unknown
Unknown	Known
Unknown	Unknown

Written records that capture information from witnesses and follow-up investigation provide the highest possible level of information for future study and inquiry.

This statement captures the essence of the dilemma about what to capture in historic records for use by future investigators. The coherence, organization, comprehensiveness and completeness of historical information is key. Paraphrasing Rumsfeld (2002), OSH professionals know from previous experience what information should be captured. It is also known that some information may be needed in the future that has no importance in the present and might not be captured.

Therefore, the profession needs to explore the information derivable from these records and ponder how to ensure the best selection of content from a rare and precious resource, namely serious and fatal events. Records such as workers' compensation claims submitted by employers, investigative reports produced by regulators, and in-depth reports created by dedicated investigation teams are the primary source of much of what is known about these incidents.

A useful strategy for structuring records to capture information from past events for future use is to apply the concepts Rumsfeld (2002) describes. This means capturing essentials (primary level) known to be absolutely necessary for future investigation; information peripheral to the essentials (secondary level) identifiable as "should have" for deriving additional factual information beyond that captured directly; and information described as "nice to have" (tertiary and quaternary level) whose utility at this time is not known. Information at this level is useful for deriving further factual information and inferences from primary- and secondary-level information. An investigator knowledgeable in the industry of focus can then create as comprehensive a picture as possible of a specific event with a manageable amount of information.

Historic reports often present findings that are open to interpretation. Sometimes an interpretation is correct, other times partially correct and sometimes completely incorrect, as demonstrated over the passage of time and based on the discovery of additional information and reanalysis of existing data. Providing sufficient information of the right type in the historic record is the best way to minimize this issue.

This requires careful design of incident records and careful selection of the type and quantity of information to capture and retain for future use. The challenge is to gain the maximum possible information from the existing written records and incident summaries. It is crucial that future records capture the maximum amount of quantitative information in a repeatable manner from records that originate from different sources while minimizing to the extent possible qualitative and especially inferential information.

Obtaining Historic Information

Following are some examples of the process of obtaining information from historic records:

- Date (quantitative); weather records (qualitative); surface slipperiness (inferential).
- Date (quantitative) + time (qualitative); light level (qualitative); surface visibility (inferential).
- Occupation (quantitative); training (qualitative); knowledge (inferential).
- Task (qualitative); equipment (qualitative); function (inferential).
- Procedure (qualitative); action (inferential); motive (inferential).

The inquiry progresses from identifying and capturing data readily obtainable from event summaries (e.g., date, time, victim age) to information that is increasingly difficult to acquire (e.g., weather conditions, lighting, occupation, work activity, familiarity with the work). At the same time, the process progresses from quantitative to qualitative to inferential elements. Quantitative elements (e.g., date, victim age) are factual and verifiable. Qualitative elements are less reliable. The reliability of inferable elements depends on quantitative and qualitative elements.

As information quality degrades, confidence decreases. The envelope formed by the outer limit of information retrievable by deconstructing the event defines the extent of what is derivable from the information contained in and beyond the incident summaries. The quality and thoroughness of inquiry reflected in the questions posed define the limits of what is retrievable.

The Historic Record of Hazardous Energy Incidents

Hazardous energy is the level of energy capable of interacting with biological tissue needed to produce immediate and serious injury (McManus, 2012). The amount of energy needed to produce immediate and serious energy depends on the target. Targets include DNA in the nucleus of cells, tissues and or-

Table 2

Summary Statistics for Fatal Occupational Incidents, 1992-2002

Event or exposure	% within category	Total for category
Transportation		**41**
Roadway incidents	23	
Other	18	
Contact with objects and equipment		**15**
Strike by	10	
Caught in	3	
Struck, caught, or crushed in collapsing structure, equipment or material	2	
Violence and other injuries by persons and animals		**17**
Homicide	10	
Other	7	
Falls		**14**
Falls to lower level	12	
Other falls	2	
Harmful substances or environments		**9**
Electrocution	4	
Temperature extremes	1	
Inhalation of harmful substance	1	
Other harmful substance	2	
Fires and explosions		**3**

gans, and the whole body. Quantities of energy that cause immediate and serious injury to DNA cause no detectable impact on larger body parts.

An important starting point for this discussion is information provided by Bureau of Labor Statistics (BLS, 2013). BLS provides detailed summary statistics of industrial experience. Table 2 provides the average for the years 1992 to 2002 (11 years) for each type of event or exposure. As shown, interaction with hazardous levels of energy is responsible for the vast majority of fatal occupational injuries.

BLS data shift slightly from year to year based on various factors, including the state of economic activity and regulatory emphasis on a particular causative element. Obtaining more-detailed trends about incidents involving hazardous levels of energy is a difficult task. This has led to several government-sponsored reports as well as some independent reports. Despite the age of some of the documents, the data and underlying lessons that they contain are relevant and valuable today.

The most useful reports provide summaries from individual events. These reports present incidents by task, industry sector or causative agent. These summaries enable independent review of the situation surrounding the event. Preserving these summaries for future investigation is vital, as shown in other areas where future research and inquiry regarding different questions have revealed previously unrecognized information.

Table 3 summarizes the main reports that are readily available to researchers. Some documents contain summaries of individual events that are suitable for further review, while others contain summaries performed by the source. It should also be noted that the direction of inquiry reflects the researcher's interest. The varying interest and focus between researchers is one reason the ongoing availability of historic records is essential.

To illustrate, regulators are interested in actions and decision making that reflect management system deficiency. Regulators use this information to assess, create or increase regulatory requirements. Practitioners in the field where harm actually occurs are likely to be more interested in the type and development of hazardous conditions and workers' response to them.

Sources of Incident Information

Report incompleteness is a common concern as is the small number of records available compared to the actual number of incidents that have likely occurred (OSHA, 1982a; 1982b; 1983; 1985; 1988; 1990). In the absence of reports and sufficient detail, an investigator is forced to read between the lines (NIOSH, 1983a). This is often the case because an employer's incident reports are created primarily to process workers' compensation claims, meaning they focus on the nature of the injury and not the incident itself. Incompleteness always leaves open the question about bias in the selection of summaries for analysis. The small number of summaries hinders the statistical analysis needed to identify factors that contribute to these incidents (NIOSH, 1983a).

One key source of information is the reports generated by NIOSH's Fatality Assessment and Control Evaluation (FACE) program. FACE has since performed 500 on-site fatality investigations; the results are posted on the NIOSH (2013) website (**www.cdc.gov/niosh/face**). FACE aims to identify factors that increase the risk of work-related fatalities, particularly those that involve confined spaces, electrocutions, machine-related injury and falls from elevation (NIOSH, 1994).

Rather than rely solely on written reports or forms submitted by employers for information, FACE personnel conduct site visits. The investigators perform firsthand observation and investigation, and conduct witness interviews. Using the team approach provides continuity and consistency from one investigation to another and enables investigators to reconstruct incidents in a repeatable manner (NIOSH, 1994). Several states also operate FACE programs. These agencies conduct surveillance, targeted investigations and prevention activities using the FACE model. In addition to the NIOSH targets, states investigate fatalities based on state-level concerns.

Another source is a CSB (2006) report on combustible dust. Investigators reviewed general industry dust fires and explosions that occurred from 1980 to 2005. This report lists 281 major incidents involving combustible dust that killed 119 workers, injured 718 others and destroyed many of the industrial facilities involved. Specifically, CSB concluded that dust collectors are the equipment most often involved in these incidents. Similarly, Zalosh, Grossel, Kahn, et al. (2005), report that dust collectors are involved in more than 40% of all dust explosions. Grinders, silos, hoppers and mixers were also involved in many of the reported incidents.

For many years, the agricultural safety and health establishment has operated in parallel to and somewhat isolated from mainstream OSH (Riedel & Field, 2011). The Agricultural Safety and Health Program at Purdue University has documented grain entrapments for many years. In 1978, this group created the National Grain Entrapment

Table 3

Information Sources on Occupational Fatalities Involving Hazardous Energy

Activity/focus	Source	Comments
Fires, explosions involving liquids and gases	OSHA, 1982a	Individual summaries of 50 fatal incidents
Maintenance, servicing of machinery	OSHA, 1982b	Individual summaries of 83 fatal incidents
Maintenance, servicing of machinery	NIOSH, 1983a	Very brief individual summaries of 59 fatal incidents
Welding, cutting	OSHA, 1988	217 fatal incidents reviewed, individual summaries of 164 fatal incidents
Electrocution	NIOSH, 2000	Individual incident summaries for 224 fatal incidents
Shipbuilding, ship repair	OSHA, 1990	Individual summaries of 151 fatal incidents
Confined spaces	OSHA, 1985	Individual summaries of 122 incidents, some involved sources of hazardous energy
Confined spaces	NIOSH, 1994	Individual summaries of 70 incidents, some involved sources of hazardous energy
Confined spaces	Meyer, 2004a	Summary of causative factors by year from 1992 to 2001; some incidents involved sources of hazardous energy
Confined spaces	Meyer, 2004b	Summary of causative factors by year from 1997 to 2001; some incidents involved sources of hazardous energy
Mining	MSHA, 1988	Individual summaries of 38 fatal incidents
Grain handling	USDA, 1980	250 fatal incidents listed
Grain handling	USDA, 1982	434 fatal incidents listed
Grain handling	OSHA, 1983	Individual summaries of 105 fatal incidents
Grain elevators, feed mills	NIOSH, 1983b	Literature review involving 187 fatal incidents
Grain storage and handling	Riedel & Field, 2011	Review of 800 entrapments and suffocations in the U.S. between 1970 and 2010
Chemical processing	Duguid, 2001	Review of 562 incidents, summary information
Chemical processing	Mannan, et al., 2001	Review of incidents contained in five databases
Ionizing radiation	González, 1999	Review of 134 major incidents world-wide involving reactors and criticality, radioactive sources, and radiation-producing machines
Ionizing radiation	Vargo, 1999	Review of criticality incidents in the former Soviet Union and Russia
Ionizing radiation	LANL, 2000	Review of 38 criticality incidents in the U.S.
Ionizing radiation	Ortiz, et al., 2000	Review of incidents involving sources of ionizing radiation
Ionizing radiation	Yusko, 2001	Review of 60 incidents involving 'orphan' radioisotope sources
Ionizing radiation	IAEA, 1996	Review of incidents in industrial irradiation facilities
Ionizing radiation	IAEA, 1998	Review of incidents involving industrial radiography
Ionizing radiation	IAEA, 2000	Review of incidents related to radiotherapy
Dust fires and explosions	CSB, 2006	Review of 281 major incidents
Agriculture	CAIR, 2011	Agricultural incidents in Canada from 1990 to 2008

Some documents contain summaries of individual events that are suitable for further review, while others contain summaries created by the source.

Database, with cases dating back to 1964, and the Purdue Agricultural Confined Space Database, which contains records for incidents that occurred in 18 U.S. states and one Canadian province.

Such long-term dedication to this task is vital for establishing consistency, trends and continuity in the information gathered and processed. For example, Riedel and Field (2011) summarized more than 800 fatal engulfments and suffocations that occurred in the U.S. between 1970 and 2010. One factor accelerating on-farm fatality rates was the adoption of postharvest processing and storage in the mid-1960s. These activities included the field shelling of corn, high-volume grain handling and artificial

The incident summary is the primary source of information. Within each level, the information can be quantitative, qualitative or intuitive. Links between parameters contained in the same level or between levels form the basis for deriving more information.

Figure 1

Hierarchy-Based System for Extracting Information From Incident Summaries

Primary level			**Secondary level**			**Tertiary level**		
Quantitative	***Qualitative***	***Inferential***	***Quantitative***	***Qualitative***	***Inferential***	***Quantitative***	***Qualitative***	***Inferential***
Date			Month					Possible weather
			Day					Workers on site
Time				Shift				Workers on site
								Visibility
			Incident/hour					Severity of hazard
			Victims/ incident					Severity of hazard
Age					Knowledge base			
Type of incident								
Energy source								
Technical cause								
Incident					Agent or condition			
Onset				Pre-exist or work activity				Mechanism of action
				Rate of onset				Severity of hazard
Initiator								
Operation				Process			Substance and other hazards	
				Volume				Confinement
Structure				Process			Substance and other hazards	
				Volume				Confinement
Volume								Confinement
Contents							Substance	
	Visual condition				Presence of hazard			
	Olfactory condition				Presence of hazard			
Reason for work								
Nature of activity					Routine versus unusual			
Task				Substance and other hazards				Loss of control
								Procedural flaw
				Process			Substance and other hazards	
Occupation of worker				Process			Substance and other hazards	
		Worker qualified for task						
		Knowing						
		Helpless						
		Violation						
Prepare					None, correct or incorrect			
Test					None, correct or incorrect			
PPE					None, correct or incorrect			
Equipment failure								
		Faulty task design						

drying of corn. Widespread decentralization that accompanied conversion of low-tech farms into high-tech grain processing operations has considerably increased the risk of injury and death to farmers.

Many farms are nano- or pico-sized enterprises. They lack knowledge about incident prevention as a result, and they lack preventive engineering measures and PPE due to limited resources. In this environment, farmers are forced to employ all available individuals, including spouses and children (CAIR, 2011). Spouses and children know less about the risks of this work and have less direct experience in addressing adverse situations.

The Canadian Agricultural Injury Reporting (CAIR) collects and analyzes information on agricultural injuries from across the country based on fatality and hospitalization data. In 2011, CAIR reported on agricultural fatalities in Canada for the 19 calendar years from 1990 to 2008. These data indicate that the injury-producing events are not random or isolated. Many recurrent patterns are evident. From 1990 to 2008, 1,975 people died in agricultural incidents in Canada. About 70% of those cases involved machines and machinery. The top five causes of death were run-overs (20%), rollovers (18%), entanglements (8%), traffic collisions (7%) and entrapment from being pinned or struck by a machine (7%) (CAIR, 2011). This is not surprising since these workplaces are heavily mechanized.

The Internet has created an opportunity to revolutionize provision of information about hazardous energy incidents. For example, OSHA (2014) hosts an online database that contains incident summaries current to 1 year prior to the date of the inquiry. OSHA (2014) Form 170 is used to record information about fatal events. The content provided on this form controls the content available for future research. OSHA CPL 2.77 provides guidance for completing the form.

Organizing the Information

Figure 1 provides a means of organizing research. It contains three levels of inquiry: primary, secondary and tertiary; a quaternary level is also possible. The incident summary is the primary source of information. Within each level, the information can be quantitative, qualitative or intuitive. Links between parameters contained in the same level or between levels form the basis for deriving more information.

Quantitative information found in these resources can give rise during incident deconstruction to quantitative, qualitative or intuitive information on the next lower level. Qualitative information can give rise to qualitative or intuitive information on the next lower level. Information creation at the

Information derived from incident summaries and reports in the historic record typically focuses on organizational function and depends on the analyst's interest and focus.

Table 4

Summary of Analysis of Occupational Fatalities Involving Hazardous Energy From Different Sources

Level/category	Deficiency
Organization and administration of work	
Policy	Absence of, poorly elucidated, or otherwise ineffective organizational policy
Management Effectiveness	•Absent or ineffective oversight of operational activity •Absence of accountability in supervision •Failure to apply experience to improve conditions of work •Failure to implement change in comprehensive manner
Training	•Absent, inappropriate, insufficient, or ineffective training in performance of work and emergency response •Failure to upgrade skills and knowledge during change of process or equipment •Absence of technical training about the potential hazard posed by the condition
Procedural	Absent, inappropriate or ineffective procedure for routine and unusual activity
Logistical	•Absence of, inappropriate, insufficient, or ineffective planning for routine and unusual work activities and emergency response •Absence of, inappropriate, or insufficient quantity of equipment appropriate to the task •Failure to inspect equipment to identify faulty operation •Absence of or inappropriate maintenance of equipment identified as faulty
Performance of work	
Supervisory	•Failure to exercise skills necessary for effective supervision •Ineffective oversight of activity on multiple work sites •Equipment not calibrated or serviced •Absence of, inappropriate, insufficient, or ineffective preparation for routine and emergency situations
Worker	•Failure to inspect and to remove faulty equipment prior to use •Absence of, inappropriate, or ineffective testing to determine conditions •Failure to test at appropriate moment(s) during the work cycle •Failure to follow procedure correctly or completely •Refusal to follow procedure •Defeat of safety devices •Impulsive decision-making during unexpected situation •Miscommunication during execution of procedure

Table 5

Task vs. Conditions as a Factor in Fatal Incidents Involving Hazardous Energy From Different Sources

	Number of fatal incidents									
	Electrocution		*Engulfment*		*Entanglement*		*Fire/explosion*		*Process*	
	Total	Avoid[a]	Total	Avoid[a]	Total	Avoid[a]	Total	Avoid[a]	Total	Avoid[a]
Condition	252	179	67	67	81	13	61	61	43	16
Low voltage	95	50								
High voltage	157	129								
Electrical workers	61	45								
Nonelectrical workers	96	84								

Note. [a]*Avoidance of contact with the energy source was a possible factor in the incident.*

The potential conflict between task and conditions with regard to sources of hazardous energy is observable in all types of incidents.

qualitative and especially the intuitive level depends on the researcher's knowledge and experience, which limit the extent of the outer boundary achievable in exploring incident summaries.

To start, one documents the quantitative and qualitative information provided in the incident summaries. The easiest data to capture are date and time, and victim's age, gender, job title and occupation. Date enables the researcher to ascertain additional quantitative information including day of the week and season of the year, and weather conditions (e.g., temperature, rain, snow). Time allows one to infer potential issues with visibility (daylight vs. darkness) and work shift (day, evening, night, weekend). In addition, the narrative may include quantitative information about structures, processes, and machines and equipment involved. Such information provides the basis for determining volume, content/contaminants and internal structure.

Work activity described in the narrative provides a cross-check against job title and occupation. This information also helps the researcher determine hierarchical and social relationships involving victims and survivors. In addition, the narrative describes the nature of the situation and flow of events preceding the incident and sometimes after it.

Results & Discussion

Incident deconstruction is the critical and fundamental first step in gaining an understanding of the human behavior that leads to nonfatal and fatal events involving contact with hazardous energy. It is a difficult exercise that requires considerable knowledge and interpretive and inferential skills. Incident summaries often provide minimal information, which complicates the ability to extract useful details.

Using the system illustrated in Figure 1, incident deconstruction was applied in the review of hundreds of fatal incidents (McManus, 1999; 2012). This process showed it is possible to extract considerable information beyond what is reported in the summaries. In this case, such information played a prominent role in understanding the dynamics of the events. This again highlights the importance of information quality and quantity.

Information derived from incident summaries and reports in the historic record typically focuses on organizational function and depends on the analyst's interest and focus (Table 4, p. 39). Comments in Table 4 readily apply across the spectrum of human activity regardless of the industry and apply directly to reports referenced in Table 3.

Considerably more information is readily available in the incident summaries. To illustrate, the reports referenced in Table 3 cover the range of automation from none to low to high. Automation or its absence is a potential factor in incidents involving contact with hazardous energy. The injury prevention issues are the same regardless of an operation's sophistication.

The summaries contained in the reference documents reflect both production- and maintenance-oriented activity. Production versus maintenance is a key factor in hazardous energy incidents. Activity described in the reports reviewed reflects a considerably wider spectrum of automation than exists today. This is because automation is an ongoing, progressive process. Automation has deemphasized activity related to production of goods and heightened emphasis on equipment maintenance.

In a highly automated industry, the operator is a spectator to outcomes programmed into the memory of programmable logic controllers. As Duguid (2001) reports, people involved in process industry incidents act remotely from the point of contact with sources of hazardous energy, except during maintenance. The consequences of such automation are most evident in situations in which a worker deliberately overrides the automated system or under circumstances that were not predicted during programming arise.

The airline industry provides excellent examples of this situation. Pilots provide oversight to the actions of the autopilot. In circumstances of deliberate override, the pilot assumes control of the aircraft, a situation that has had both positive and negative outcomes.

For example, positive outcomes have occurred when large passenger aircraft have run out of fuel and landed safely thanks to the pilots' intervention (Deveau, 2013). Another example is the U.S. Airways aircraft that lost power to both engines after striking a flock of birds. In these cases, the pilots were forced to operate the aircraft without power (Stetzer, 2014). Overreliance on automated systems to the point of losing skill is a hypothesis being discussed regarding the crash of an aircraft in San Francisco, CA (Jolivet, 2013). If pilots are to remain active participants in flying aircraft, they must actively practice this skill under all conditions, foreseeable and otherwise.

The organization of Table 4 reflects the outlook of different interests on the information derivable from the incident summaries. For example, organization and administration of work reflects the interest of regulators because management is accountable by law for safety at work. Regulators are interested in assessing the effectiveness of existing regulations. The outcome from the review might include new or improved mandates.

Full appreciation of the dynamics of work that preceded an incident is necessary to respond appropriately. Additional essential information (e.g., routine vs. nonroutine, production vs. maintenance, suitability of training, and worker knowledge and experience) provides insight about the work being performed when the incident occurred. A comprehensive summary can provide this information. Other factors include temporal development of the hazardous condition (preceding or resulting from the start of work), distractions affecting the work, knowledge about hazardous conditions in the work area, influence over conditions and compliance with work procedures. A comprehensive incident summary can provide this information.

To illustrate the importance of a thorough understanding of the nature of the situation as described in an event summary, consider the conflict between attending to one's task and attending to the conditions under which it is performed. This conflict arises because the brain cannot simultaneously focus information-processing capability on more than one input at any time (NSC, 2010). Where this situation becomes deadly is the simultaneous occurrence of two conditions: a life-threatening hazard that is avoidable and a work task.

McManus (2012) analyzed hazard summaries from fatal incidents published by NIOSH (2000) and OSHA (1982a; 1982b; 1983; 1985; 1988; 1990). Results suggest that tasks and the conditions of work under which they are performed are parallel, independent, mutually exclusive realities in workplaces and work spaces. The existence of these realities and the absence of interaction between them are crucial to understanding this aspect in incident causation and occurrence. One cannot focus simultaneously on task and conditions during the performance of work. Rather, one can focus on one or the other of these realities at any point in time, not both at the same time.

Table 5, which contains data from McManus (2012), provides an example to illustrate this concept. Table 5 summarizes the potential conflict between task and conditions with regard to sources of hazardous energy. The data suggest that this conflict is observable in all types of incidents for which individual summaries are available. The results suggest that avoidance was the chosen or only means of protection against contact with the source of hazardous energy in many of these situations.

Incident summaries can also provide information on the role of knowledge. A global review of incident summaries (Table 4) indicates that lack of knowledge is a major theme in causation of incidents involving hazardous energy. This is consistent with comments provided in Table 3.

Table 6, which also contains data from McManus (2012), illustrates this concept. In the events summarized in the table, the victim had no training in control of the hazard, perceived the ability to perform the task without undue risk, or perceived the lack of protective measures (e.g., shutdown of the energy source, shielding between the source and the person, PPE).

Long-term employment in a facility provides the greatest potential for an employee to anticipate and recognize hazardous conditions and the risks posed by situations in which they are present. Short-duration permanent and temporary employees and employees of contractors might recognize the hazard, but are much less likely to be able to judge correctly the magnitude of the risk of harm.

Such analyses reveal another factor: the ability to influence or control the progression or outcome of situations. This refers to the level of personal influence afforded to workers as well as visitors to a site. Influence or control applies to a task in context of the conditions in which it is performed. Some cases reviewed highlight *knowledgeable helplessness,* which means that the victim recognized the presence of the hazard but performed the task regardless of the consequence. This is particularly the case with electrical contact incidents.

In many cases, persons outside of the situation or who had little reason to experience exposure to the hazardous condition were unable to exercise influence or control over the event. The data suggest that this situation can occur even when the victim worked in the affected work space.

Employees of the owner/host employer may

Incident summaries can also provide information on the role of knowledge.

Table 6

Personal Conditions as Factors in Fatal Incidents Involving Hazardous Energy From Different Sources

	Number of fatal incidents involving pre-existing, workplace hazardous conditions									
	Electrocution		*Engulfment*		*Entanglement*		*Fire/explosion*		*Process*	
	Total		**Total**		**Total**		**Total**		**Total**	
Condition	252		67		81		61		43	
Unknowing		69		9		-		1		6
Helpless		105		1		4		-		2
Violation		60		1		35		3		17

Effort is needed upfront to standardize reporting to ensure completeness and thoroughness. This will produce considerable future benefit toward understanding these events.

find it difficult to exercise the right to refuse unsafe work. Despite legal protection afforded by regulatory statutes, anyone who challenges supervision or management by raising a concern about working conditions faces the risk of subsequent repercussion or sanction. Long-term employees understand organizational politics. Such knowledge is critical because internal politics can influence the decision about whether and how to exercise the right to refuse work perceived as dangerous.

Contract employees hold an almost untenable position regarding expression of the right to refuse unsafe work on the property of another employer. Workers for entities that perform downscale work tend to be poorly educated and poorly paid, and they may be unfamiliar with the right to safe work conditions. These individuals need the job. As a result, the ability to anticipate and recognize dangerous situations is a major challenge.

Other incidents involving mechanical equipment (shown in Table 6 as entanglement) highlight knowledgeable control. In these situations, the victim or associated others exercised incomplete or unreliable control, or reactivated the equipment or machine in an unintended or accidental manner.

Regulations often mandate the creation of formal, written work procedures. The summaries contained in the reports listed in Table 3 and summarized in Table 6 (where possible to infer this information) suggest that failure to follow procedures was a recognizable characteristic in some cases. However, compliance with procedures was insufficient to prevent some of the incidents. In this context, violation is a neutral term that includes all types of failure to follow formal and informal workplace procedures.

Employees of the owner/host employer learn about site procedures through training and education, and occasionally as a result of being disciplined. Knowledge of acceptable work practices is an outcome of duration of service. Long-service employees should have learned expectations and how to achieve them as an outcome of the experience gained during their employment.

During site orientation, contract employees are introduced to many rules concerning expectations of behavior. Presenting many rules at one time is counterproductive because a person can absorb and apply only so much information. The outcome is that essential information is lost among information presented solely to prove that coverage occurred. Because of this information overload, contractors run the risk of unknowingly and unintentionally breaking rules of conduct, especially essential rules.

Some incidents reflect the theme of knowledge, control and violation. In these cases, the victim attempted to perform the task without adherence to procedures or without protective measures, despite having full knowledge of the hazardous condition(s). This was especially the case in incidents involving electrical energy and mechanical equipment.

All of these examples draw attention to the unknown unknowns (Rumsfeld, 2002) and the ability to extract information beyond that normally reported in incident summaries (McManus, 2012). Capturing the unknown unknowns in incident summaries for future use is an important goal. The challenge is to anticipate future information needs in order to develop capture protocols that minimize subsequent unknown unknowns.

Optimizing Information Quality

The critical requirements for records created today for future use are coherence, organization, comprehensiveness, and completeness in information selection, collection and presentation. Typical incident summaries are highly variable in content. Effort is needed upfront to standardize reporting to ensure completeness and thoroughness. This will produce considerable future benefit toward understanding these events and addressing the issues they reveal.

The Internet makes available large quantities of information. The availability of information that will form the historic record into the future brings with it the need to establish quality assurance standards. Quality assurance is an underlying concept of ANSI/ASSE Z10-2012. Application of principles outlined in Z10 and similar documents to data selection, collection and preservation by various contributors is one way to establish common management practices. Bringing together agencies that create and provide this information to establish a common format for reporting seems to be an essential first step in this process. Garber, Betit, Watters, et al. (2014), further illustrate the importance of organization in providing information in an easily accessible manner and the process for achieving this goal.

Conclusion

The OSH profession has a critical need to establish and preserve a comprehensive historical record of incidents that involve contact with sources of hazardous energy. To be most useful for future study, incident summaries must capture extensive and readily accessible detail. The choice of what to record is critical to future use and research. **PS**

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