

Preventing Major Losses

Changing OSH Paradigms & Practices

By James M. Keane

Over time, industry as a whole has done a tremendous job improving its recordable injury rates, lost-time incidence rates and injury severity rates. These efforts are significant and worthy of recognition. However, many business leaders and employees still subscribe to the belief that by reducing recordable injury rates or lost-time incidence rates, they are also reducing the chances that a fatality or other major loss will occur. This belief, or normalcy bias, is not supported by the loss facts from industry (Table 1). As Petersen (2001) says, "Circumstances that produce the severe accident are different than those that produce the minor accident." Manuele (2005, 2008) and others have urged business leaders and OSH professionals to recognize that reducing the frequency of minor incidents will not equivalently reduce the occurrence of major loss incidents.

OSHA's Voluntary Protection Programs (VPP) application challenges this normalcy bias with this statement (found in the definitions included with the application):

Safety and health management system. For the purposes of VPP, a method of preventing employee fatalities (emphasis added), injuries and illnesses through the ongoing planning, implementation, integration and control of four interdependent elements: management leadership and employee involvement; work site analysis; hazard prevention and control; and safety and health training.

Many industries and businesses have robust systems and tools to identify and mitigate hazards that may contribute to major losses. However, an organization that celebrates yearly declines in recordable injury rates and large numbers of work hours without a lost-time injury while also continuing to experience workplace fatalities, permanently disabling injuries/illnesses or major monetary losses of property and materials should consider this statement: "Our current safety systems are designed to deliver exactly what we are getting. If we want a different result, a better result, we must change the process."

To achieve such change, the first step is to alter how and what people think about major losses (e.g., fatalities, permanently disabling injuries/illnesses, major monetary losses of materials, equipment or property). The OSH profession needs to develop a tool set that focuses on low-probability/high-severity events. These tools must extend beyond typical physical conditions to work practices and process safety aspects.

The Real Problems

The jobs of leaders and OSH professionals would be much easier if there were simple answers and a simple solution to the sources and causes of major losses in the workplace. But, there are not. The causes, precursors and variables that contribute to a major loss are complex. They may have existed since the facility and its equipment were designed, or were built and installed. They may be deeply rooted within an organization's culture. They also may be inadvertently reinforced by invalid assumptions, paradigms and practices held by employees, business leaders and even OSH professionals.

When asked what safety metrics they measure, most OSH professionals will indicate one or more of the following:

- total recordable incident rate (TRIR);
- days away from work or restricted time (DART);
- lost-time incident rate (LTIR);
- process safety incident severity rate;
- severity rate.

IN BRIEF

• Personal, business leadership and industry paradigms and practices contribute to the continued loss of life and permanently disabling injuries and illnesses being experienced in the U.S. and other industrialized nations.

• To improve these results, OSH professionals must challenge current safety paradigms and practices, change long-held beliefs and do things differently. Initiating a concerted effort to prevent major losses is one step in that process.

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These are all trailing or lagging indicators that reflect an organization's safety history, up to a point. Many safety practitioners have noted flaws of these types of indicators and are challenging the validity of relying solely on such measures. Although some businesses and site locations track leading indicators such as action item completion percentage, management of change checks or inspections completed, they may not be measuring those that could signal that a major loss is looming.

Bureau of Labor Statistics (BLS) reports that 4,383 workers died in 2012 from occupational injuries. This is the lowest annual total since the census was first conducted in 1992. That is equivalent to a rate of 3.2 fatalities per 100,000 workers in the U.S. In the U.K. and in Australia, the fatality rates are significantly lower, 0.5 and 1.9, respectively (BLS, 2012; Australia Safety and Compensation Council, 2012; HSE, 2013) (Table 1). Why is this the case? Although each country tallies its statistics differently, these global counterparts have a greater focus on hazard recognition and identification, and require risk assessment in workplaces. Statistics related to fatal illnesses and permanently disabling injuries are another stark reminder that more must be done (Table 2).

Let's consider an example. One company's historical fatality rate is 3.3 per 100,000 and its annual rate for permanently disabling injuries is 9.9 per 100,000. Both measures are close to industry average. However, this organization has operations in numerous locations worldwide. In total, the company's average rates are actually better than the aggregate averages of the countries in which it operates. Are those results good enough? Within this company, the odds are that 1 of about 30,000 employees will die on the job within the next 12 months, and 1 in 10,000 will suffer a total and permanently disabling injury in that same time period. When it comes to losing a life, a limb or livelihood, those are poor odds.

An organization must answer two questions:

1) Will current safety management system and safety processes prevent a fatality, disabling injury or major property loss?

2) Have safety processes and tools identified all workplace hazards?

Many business leaders will quickly respond "yes" and cite their lagging indicators as proof that their systems, processes and tools are doing the job. Most safety professionals will respond "no." Why are the answers different? It is a matter of what each group believes about safety status and processes. Even then,

most safety professionals recognize that no single method or set of methods can likely identify 100% of hazards. Hazard identification is a continual and ongoing search.

Changing the Process

"Current safety systems are designed to deliver exactly what we are getting." This statement is akin to the famous quote (often attributed to Albert Einstein), "Insanity is doing the same thing over and

Table 1

Comparison of National Level Worker Fatality Rates

Country (time frame)	Workplace fatalities	Fatalities per 100,000 workers
U.K. (2012/2013, provisional)	148	0.5
Australia (2012)	198	1.7
U.S. (2012, preliminary) All private sector - private industry, construction and agriculture	4,383	3.2
Canada (2012)	977	5.0
Mexico (2004)	---	9.0
China (2009)	83,196	10.4
South Korea (2012)	1,134	12.0

Note. Total number of fatalities in Mexico for 2004 not available. Fatalities related to injuries. Illness related fatalities are excluded. Data adapted from various sources including Health and Safety Executive, U.S. Bureau of Labor Statistics, Australia Safety and Compensation Council, and International Labor Organization.

Table 2

Comparison of National Level Worker Illness Fatality & Disabling Injury Rates

Country	Illness fatality rates (estimated)	Permanently disabling injury rates (estimated)
U.K.	93.4 times the fatal injury rate ≈ 47 per 100,000	cannot be determined
Australia	29.8 times the fatal injury rate ≈ 51 per 100,000	≈ 4.0 per 100,000 workers (with a rising trend)
U.S.	12.2 times the fatal injury rate ≈ 39 per 100,000	≈ 7.7 per 100,000 workers (permanent and total disability) ≈ 38.2 per 100,000 workers (permanent partial disability)

Note. Data adapted from various sources including Health and Safety Executive, U.S. Bureau of Labor Statistics, Australia Safety and Compensation Council, International Labor Organization, National Council on Compensation Insurance and "Global Trend According to Estimated Number of Occupational Accidents and Fatal Work-Related Diseases at Region and Country Level," by P. Hämäläinen, K.L. Saarela and J. Takala, 2008, Journal of Safety Research 40, pp. 2125-2139.



OSH professionals must present credible, convincing evidence that some beliefs about safety are based on incomplete information, speculation, fads, unrepeatability research, and false perceptions and information.

over again, and expecting different results." Or, as Mark Twain said, "If you do what you've always done, you'll get what you always got." The OSH profession must look beyond current methods and processes, and embrace change.

How can safety systems and processes be made more robust and more comprehensive? How can the knowledge level within a business team be broadened to prevent major losses? The first step is to educate business leaders and team members on the true nature of the organization's major hazards and risks. Without a change in core beliefs, different results cannot occur.

Therefore, OSH professionals must present credible, convincing evidence that some beliefs about safety are based on incomplete information, speculation, fads, unrepeatability research, and false perceptions and information. OSH professionals must recognize that the nonsafety-trained personnel only know what they have primarily experienced or read with respect to safety—their so-called *experience basket*. Each experience basket is unique based on one's background, training, social network and more. A structured effort to prevent major losses is a true opportunity to educate and engage nonsafety personnel, and provide them with safety risk management skills and additional life skills.

Preventing Major Losses

A preventing-major-losses (PML) process enables an active approach to understanding how to assess hazards using descriptive language, and it can provide direction for allocating limited resources. Let's discuss the key elements for an effective PML process.

Identify Major Hazards

Major hazards, the scenarios that can and will occur leading to a major loss, may not necessarily have warning signs. These hazards may have existed since the site was opened or they may have been designed into the process, machinery or site itself. To identify them, one must use basic loss causation models such as PEME (people, equipment, machinery, environment) and understand the intersecting relationship among these factors. This step should also include basic fire and explosion models such as the fire triangle, dust explosion pentagon and failure causation examples for pressure and fired vessels.

Examine Human Error

An organization must also review human error. The OSH profession has perpetuated Heinrich's (1941) research that 88% of losses are caused by human failure, and as a result it is instilled into most safety processes. But one must ask, What is human error, and what are its causes? Manuele (2003, 2008) considers human errors to be system failures, and Reason and Hobbs (2003) call them consequences, not just causes.

Dekker (2006) also offers insight into understanding human error, particularly the need to

look deeper at systems and processes and to search beyond human error for loss causation. To achieve this, OSH professionals can apply Clemens's (2000) approach of clearly stating the source, mechanism and outcome for each hazard scenario identified. When the most credible outcome for a hazard scenario is a fatality or other major loss, one is departing from traditional hazard identification models that are typified by a broad, general list of things that may cause harm.

Understand Why Losses Occur

If an organization does not understand why losses occur, how can it prevent them? Many can recall Reason's (1990) swiss cheese model that illustrates why protective barriers, or safeguards, are not perfect (Figure 1).

Within the PML process, team members must predict what can allow or cause deficiencies in safeguards to emerge or line up. Observations and findings should not be based on what should be in place or how a task or activity should be completed, but on actual operating conditions and practices. Safety team members must think outside current safety inspection paradigms to see the possibilities.

Safety culture is another consideration. Many point toward culture as a source of losses, so team members should review the safety culture continuum, its levels and characteristics. One effective model is the Energy Institute's (1999) Hearts and Minds Program, which is based on research on safety and behavior at several U.K. universities. This culture continuum ladder contains five distinct levels of OSH cultural development that may exist within a plant site or a business unit or an entire enterprise:

- Pathological: "Who cares as long as we are not caught?"
- Reactive: "Safety is important; we do a lot every time we have an incident."
- Calculative: "We have systems in place to manage all hazards."
- Proactive: "Safety leadership and values drive continuous improvement."
- Generative: "OSH is how we do business around here."

Therefore, the safety team must ask, "Which of these five statements best reflects our culture?"

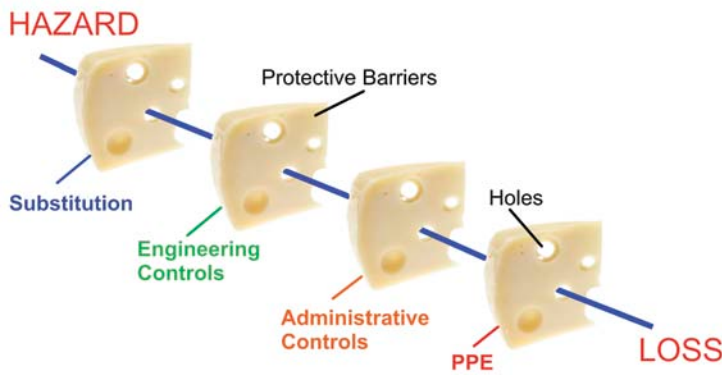
Apply the Hierarchy of Controls

Unlike safety professionals, most business leaders and nonsafety personnel are not familiar with the hierarchy of controls or its application. In a PML process, team members define a range for the effectiveness for each level of control. For example, a team might reference the ranges developed by WorkSafe ACT (2014) to reinforce why engineering/physical controls are more effective than administrative/behavioral controls, especially when faced with hazard scenarios that could take a life or limb.

WorkSafe ACT: Hierarchy of Controls & PML

Elimination of the hazard. Examples include the proper disposal of surplus or retired equip-

Figure 1
Swiss Cheese Model



ment that contains substances such as asbestos, and removal of excess quantities of chemicals accumulated over time in a facility. The elimination of hazards is 100% effective.

•**Substitution of the hazard.** Examples include the replacement of solvent-based printing inks with water-based inks, of asbestos insulation or fire-proof materials with synthetic fibers, and the use of titanium dioxide white pigment instead of lead white. The effectiveness of substitution is wholly dependent on the replacement selected.

•**Engineering controls.** Examples include installing machine guards at hazardous locations, adding local exhaust ventilation over a process area that releases noxious fumes, and fitting a muffler on a noisy exhaust. The effectiveness of engineering solutions ranges from 70% to 90%.

•**Administrative controls.** Examples include training and education, job rotation, planning, scheduling certain jobs outside normal working hours to reduce general exposure, early reporting of signs and symptoms, and instructions and warnings. The effectiveness of administrative controls ranges from 10% to 50%. (Also, to maintain their effectiveness, administrative controls typically require significant resources over long periods of time.)

•**PPE.** Examples include safety glasses and goggles, earmuffs and earplugs, hard hats, steel-toe footwear, gloves, respiratory protection and aprons. The effectiveness of PPE in realistic work situations does not exceed 20%.

While there is no set scale or measure for control effectiveness, these suggestions represent a reasonable range. Of course, a site can implement short-term solutions that combine several controls while longer-term engineering solutions are developed and implemented to mitigate the risk to an as low as reasonably practicable (ALARP) level.

Identify Sources of Major Loss

Major hazards may be surrounded by guarding, isolating techniques, layers of administrative controls and possibly PPE. In some cases, however, a major hazard may go unrecognized by workers

who are directly exposed to it (e.g., entrapment in equipment, falls).

Identifying these hazards can seem a daunting challenge, but a PML strategy offers a specific, focused and disciplined process. It emphasizes triggers that research has identified as the sources and precursors of actual major losses at that site and within that industry. A trained and engaged team can then focus strictly on exposures that can credibly lead to a fatality, permanently disabling injury/illness, or significant monetary loss of materials, equipment or property. This disciplined approach helps the team avoid being overwhelmed by the number of hazards present, and enables them to concentrate on separating the significant few from the trivial with respect to major loss sources and their precursors.

For general industry applications, the PML process entails identifying 11 trigger groups, each of which contains multiple other triggers.

1) Travel/mobile equipment. Actions and interaction of workers and assets with moving mobile equipment and transportation elements.

2) Work at heights.

3) Exposure to uncontrolled energy sources. Worker and asset exposure to a specific set of energy sources.

4) Work arrangements. Isolated workplaces, exposure to various work sites and work in high-noise environments.

5) Confined space operations. Confined space entry, rescue and associated operations.

6) Hazardous materials. Egress, reactivity and exposure to various classes of materials.

7) Process modifications. Process control norms, process safety devices and management of change.

8) Equipment control modifications. Equipment controls (electrical, pneumatic and other sources) and management of change.

9) New equipment. Recognizing the lack of operating experience, inadequacies of training and the lack of hazard identification associated with any new installation.

10) Psychosocial. Recognizing that stress, working conditions, workplace violence, substance abuse and similar factors affect workers.

11) Environment. Recognizing the power of nature and proactively identifying and preparing protections for workers and property.

As an example, the travel/mobile equipment trigger group could include:

- 1.a. Operation of and interaction between pedestrians and vehicles
 - 1.a.i. Powered industrial trucks (inside and outside facility)

- 1.a.ii. Vehicular traffic (auto, truck) on facility grounds
- 1.b. Vehicle loading and unloading (trucks, rail-cars)
 - 1.b.i. Loading docks
 - 1.b.ii. Rail sidings
 - 1.b.iii. Bulk storage loading/unloading sites
- 1.c. Transport of unsecured loads
- 1.d. Business-required travel using commercial vehicles (K-C vehicle, plane, train, taxi, bus)
- 1.e. Business-required travel using noncommercial vehicle (personal vehicle, powered land vehicle, helicopter, boat)
- 1.f. Operation of specialized mobile equipment (log loaders or other transport vehicle less than 5 tons)
- 1.g. Commercial traffic near facility

With 11 groups and multiple triggers within each, the team could easily identify more than 100 individual triggers. To facilitate the process, the trigger groups can be summarized and provided to the team as a one-page list, a spreadsheet or similar for easy access and reference.

As noted, this is a departure from the typical hazard identification process. If teams try to identify and assess anything and everything that could cause harm or a loss, they will be quickly overwhelmed and the process may fail. Instead, when trained to look specifically for the sources of major losses, team members consciously ignore lower-level hazards.

Risk Assessment

Once a major loss hazard scenario is identified, a risk assessment is performed. Many risk assessment tools, methods and processes are available, but the selected approach should follow a validated or recognized method while meeting company needs. The process must be trainable and it must provide consistent results within a site location and relatively consistent measures between different sites.

A graphical approach such as that suggested in ANSI/ASSE Z10-2012 is recommended even though it may be easier at times to convince leadership of the magnitude of a risk by using a quantitative approach. In adapting the Z10 model for a PML effort, note that the focus on major hazards and their potential higher-order severity will use only the left half of the matrix (Figure 2) for initial PML risk assessment.

The scope of the PML risk analysis is limited to major losses with credible high severity. The risk assessment matrix has two dimensions, severity and likelihood of occurrence or exposure, with descriptive words such as fatality, disability, likely, probable, sometime, etc., as the keywords to choose from. But before these can be used, all involved must understand what these descriptions mean and how to correctly select from these words. Otherwise, the risk assessment process can become biased or produce skewed and possibly inconsistent results.

For example, most people will assess a hazard scenario's severity based on their personal experience and knowledge from reading loss reports or other literature. However, as noted, each person's experience basket is unique. Therefore, to provide some consistency, it is important to determine the most credible severity (outcome) for the hazard scenarios, not the worst conceivable.

To assist in this process, OSH professionals can reference the Abbreviated Injury Scale (AIS; Association for the Advancement of Automotive Medicine, 2008). Knowing the types of injuries that are truly considered life threatening and those that are deemed untreatable/unsurvivable or disabling can help team members improve the quality and consistency of decisions regarding outcomes. Table 3 highlights a few injuries that are considered unsurvivable according to AIS. Other resources include the TNO (1992) *Green Book*, which provides methods for determining the possible damage to people and objects that result from releases of hazardous materials.

This same approach may also be used for the other dimension of likelihood of occurrence or exposure. Some consider this to be the Achilles heel of any risk assessment because the level chosen is considered a guess at best. Therefore, in addition to various references in the lit-

Figure 2
Risk Assessment Matrix for PML

Hierarchy of controls Potential effect on likelihood of occurrence or exposure (general tendencies, not absolutes)	Likelihood of OCCURRENCE or EXPOSURE for selected unit of time or activity	Severity of injury or illness consequence and remedial action			
		CATASTROPHIC Employee fatalities, general public fatalities or serious injuries, loss of materials/property in excess of USD \$2 million, environmental damage recovery greater than 2 years, government agency involvement	CRITICAL Employee amputations, partial/total loss of sight or hearing, general public injuries requiring physician treatment, loss of materials/property from USD \$500,000 to \$2 million, environmental damage recovery from 1 to 2 years, national media attention	MARGINAL Minor injury, lost workday incident	NEGLECTIBLE First aid or minor medical treatment
No controls	Frequent Likely to occur repeatedly, probability greater than 90%	HIGH Operation not permissible	HIGH Operation not permissible	SERIOUS High priority remedial action	MEDIUM Take remedial action at appropriate time
Use of PPE or administrative controls and their combinations	Probable Likely to occur several times, probability range 60% to 90%	HIGH Operation not permissible	HIGH Operation not permissible	SERIOUS High priority remedial action	MEDIUM Take remedial action at appropriate time
	Occasional Likely to occur sometime, probability range 15% to 60%	HIGH Operation not permissible	SERIOUS High priority remedial action	MEDIUM Take remedial action at appropriate time	LOW Risk acceptable: remedial action discretionary
Control combinations	Remote Not likely to occur, probability range 1% to 15%	SERIOUS High priority remedial action	MEDIUM Take remedial action at appropriate time	MEDIUM Take remedial action at appropriate time	LOW Risk acceptable: remedial action discretionary
Engineering controls/solutions	Improbable Very unlikely, less than a 1% probability	MEDIUM Take remedial action at appropriate time	LOW Risk acceptable: remedial action discretionary	LOW Risk acceptable: remedial action discretionary	LOW Risk acceptable: remedial action discretionary

erature, the hierarchy of controls itself is used to better define and address the levels in this dimension. The results are incorporated into the matrix in Figure 2.

Within the PML risk assessment process, the team should also address instances of exposure to multiple hazards for the same group of workers or property. Many risk assessment tools are effective for evaluating individual hazard exposures, but today's work environments are rarely so simple.

Taking Action

No process is complete unless action is taken. As Winston Churchill said:

To look is one thing. To see what you look at is another. To understand what you see is another. To learn from what you understand is something else. But to act on what you learn is all that really matters.

This means doing more than conducting an inspection or preparing recommendations for upper management. The key is to take the correct actions in the correct order to best reduce the risk levels to ALARP. The selected actions and solutions also must be balanced against the costs of attaining that lower risk level. In some cases, the cost to achieve ALARP may be disproportionate to the benefits attained.

The PML process should define specific cutoff points for risk levels and required action planning, as well as implementation time frames for each level. For example, Figure 2 contains clear guidance about when a facility should stop operations due to an unacceptable risk level. This element can also provide guidance on different mitigation techniques and approaches to affect each term on the risk level matrix.

Practical Application of a PML Process

The first step for installing PML into an organization is recognizing that the process can be an effective countermeasure to the problem of major losses in the workplace. Second, the leadership team must fully support the approach and be engaged in it.

The third step is education and training. Team members must understand the key concepts and thought process behind them. They must also know how to use the concepts in the work environment. The initial training session should include the hosting site's leadership team, engineers, safety team members and informal shop floor leaders. This training should comply with ANSI Z490.1-2009, Criteria for Accepted Practices in Safety, Health and Environmental Training, to ensure that it is effective. Class time should include interactive group exercises during which participants can practice

Table 3

Unsurvivable Injuries, Partial List

AIS score (listed in injury severity score assignment format)	6: Currently untreatable, unsurvivable
Head and neck (including C1 to C7)	Brain stem (hypothalamus, medulla, midbrain, pons) Laceration, massive destruction (crush type injury), penetrating injury, transection pFCI = 1
	Carotid artery, internal Bilateral laceration pFCI = 1
	Cervical spine cord, C-3 and above Contusion or laceration with complete cord syndrome (quadriplegia or paraplegia with no sensation or motor function), not further specified, with/without fracture, dislocation or both pFCI = 1
External	Body second-degree or third-degree burn Partial or full thickness, including incineration \geq 90% total body surface area
	Whole body (explosion type injury) Massive, multiple organ injury to brain, thorax and/or abdomen with loss of one or more limbs and/or decapitation

Note. Adapted from Abbreviated Injury Scale 2005 Update 2008, by Association for the Advancement of Automotive Medicine, 2008, Barrington, IL: Author.

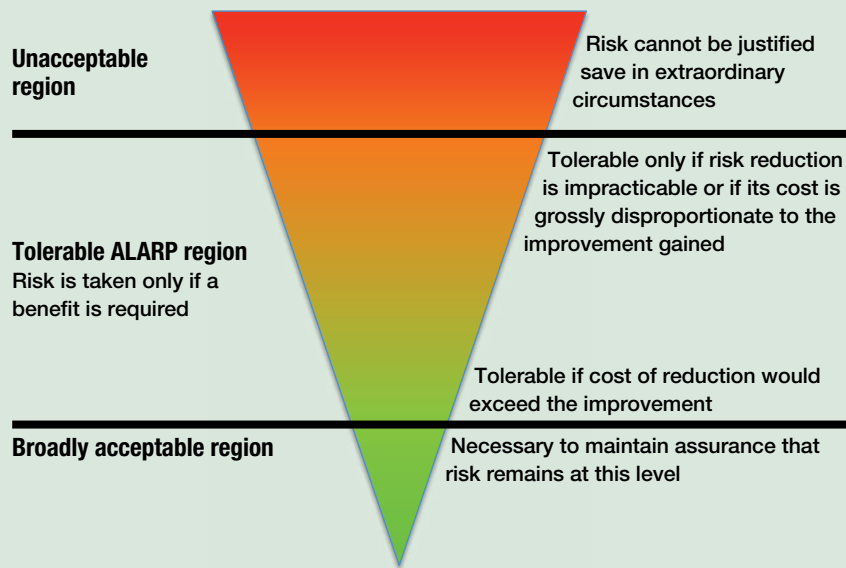
the new concepts and truths. One exercise should be an actual limited scope practice PML inspection.

Once a core team has been trained, a site can implement the process in several ways. Any implementation plan will be dictated by the operation's size, its management system, employee knowledge and safety education level, and various other factors. Following is a brief example of how one business unit within a Fortune 500 company has implemented PML.

The business unit has multiple manufacturing locations across North America and Europe. Its safety leadership team recognized that a PML process offered a systematic approach to identifying hazards that could result in major losses. To gain support, leaders received an executive summary that explained the PML process, its benefits and its resource requirements.

Next, a PML training session was held at one location in Europe and another in the U.S. for the initial core teams. Safety leaders and other business and site resources came together for an interactive, thought-provoking training session. Each session included practical examples, hands-on application of the new concepts and a competency check. Individuals who successfully completed the

Figure 3 ALARP Model



session and received an acceptable score on the competency examination were certified to lead and participate in the PML process.

Currently, the unit's safety leadership supports PML rollout at all manufacturing facilities on a schedule that is advantageous for each location. To date, feedback has been positive, particularly with regard to the identification of hazards that had not been documented using other methods.

Conclusion

To achieve needed changes in safety management, OSH professionals must alter how and what people think about major losses (e.g. fatalities, permanently disabling injuries/illnesses, major monetary losses of materials, equipment or property). A structured effort to prevent major losses is a true opportunity to educate and engage non-safety personnel, and provide them with safety risk management skills and additional life skills. **PS**

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