Catching Near Hits

By STEPHEN J. WALLACE

Industry efforts to improve safety in recent years have resulted in fewer accidents. According to the Bureau of Labor Statistics (BLS), the total number of recordable injury/illness cases in manufacturing has steadily decreased—dropping from 13.2 in 1990 to 9.7 in 1998 (per 100 full-time employees) (Figure 1). Although this decrease in the number of injuries/illnesses that require medical treatment is a positive trend, the resulting improved performance, coupled with corporate downsizing which limits the time that individuals have for additional activities, has led to fewer incidents being thoroughly investigated.

To continue this downward trend in injuries and use resources wisely, efforts must focus on capturing and investigating less-serious accidents—so-called near hits (which are referred to as near misses in some literature)—that may have resulted in only minor (or no) injuries. This objective is also consistent with requirements in OSHA's Process Safety Management Standard and EPA's Risk Management Program that state any incident "which could reasonably have resulted in a catastrophic release" should be investigated. This article outlines one method to successfully accomplish this task.

STRATEGIES OF INVESTIGATION

Documentation

Investigation and documentation strategy is a crucial aspect of a near-hit investigation. Some sites use a two-tiered approach, depending on the actual or potential impact of circumstances. The first level includes near-hit reporting; depending on the severity of the issue, a second, more-formal review may be required.

All personnel should be able to report near hits; however, the responsibility for investigation and documentation at the first tier of reporting often belongs to the first-line supervisor, with input from other knowledgeable personnel. To make safety near-hit reporting successful, it can be incorporated into existing management systems (e.g., an International Organization for Standardization system for ensuring product quality). This approach may help operations and maintenance personnel who are familiar with the existing quality and production system use that same system to capture safety incidents. As a result, reporting should increase. Figure 2 shows an example of a form that can be used to facilitate reporting.

Defining a Near Hit

To ensure success, the term "near hit" must be clearly defined. Ambiguity may lead to incomplete information and analysis. Historically, industry has been able to recognize obvious near hits. For example, a large hydrocarbon release that did not contact an ignition source has been recognized for its potential impact. This same logic can be applied to events that are not so obvious.

Care must be taken to ensure that a near hit incident is not defined too narrowly or too broadly. In Z16.5-1998, American National Standards Institute (ANSI) defines a near hit as an occurrence in the work process (including an employee act or behavior) that has an injury, illness or death potential where the injury, illness or death did not occur. Occurrences (or incidents) generally have two components: an act and a condition. Often, the act or condition is a given—it must occur. In such cases, it is imperative that the opposite act or condition never occur.

For example, a car needs gasoline to function. However, striking a match at the gas tank inlet during fill up may result in an explosion. Thus, if an individual lights a match near the tank inlet, yet it does not ignite, an incident has still occurred. A near hit can thus be further defined as an event in which the system is only one act or condition away from an event with serious, measurable consequences.

Consider a classic occupational situation encountered every day in chemical and petrochemical facilities. Workers need specific tools and equipment to perform necessary maintenance. Often, the work must be performed on elevated structures. In some cases, other workers may need to pass underneath the structure (e.g., to take readings on process equipment) when work is being performed.

If a tool falls from the structure, yet does not impact anyone at the time, this situation is a near hit. Only one condition is missing—a worker was not present

under the structure when the tool fell or was not standing where it fell. Had this condition been present, it is highly likely an injury would have occured. Likewise, if personnel are present in a barricaded area where equipment is routinely being lifted and lowered overhead, only one act (e.g., dropping equipment) stands in the way of a serious injury.

Other events that should be regarded as near-hit incidents include process parameter excursions (such as temperature, pressure and level deviations) within 10 percent of design limits; emergency shutdowns that occur safely; activation of relief valves or safety protection systems; and utility hoses blowing out, even if no one is impacted. Table 1 provides a more-extensive list.

TABLE 1
What Can Be Considered a Near Hit?

- Process leaks and fires.
- Operational errors that are revised or changed to safe situations without incident.
- Hose blowing out, even if hose contents do not contact personnel.
- Personnel performing work with improper or inadequate permits.
- Employees working without PPE.
- Failing to follow procedures that could have credibly been involved in a safety incident.
- Injuries, even those not requiring first aid, as they likely resulted from an unsafe condition or behavior.
- Improper vehicle entry into process areas.
- Emergency shutdowns and activation of relief valves, deluge system or other safety systems.
- Objects dropped from upper levels, even if they do not contact personnel.
- Process parameter excursions (such as pressure, temperature and level) beyond critical limits (within 10 percent of design limits).
- Entrapment of persons.
- Situations resulting in neighbor complaints such as noise and odors.
- Other serious equipment failures or situations that a supervisor feels could have resulted in an undesirable safety situation.

Addressing Causes

A primary objective of any investigation, including one involving a near hit, is to determine the failure mechanism(s) and take corrective action. Most incidents consist of controllable actions and/or conditions. The key is to determine the causes as well as the effects so appropriate action may be taken to prevent recurrence.

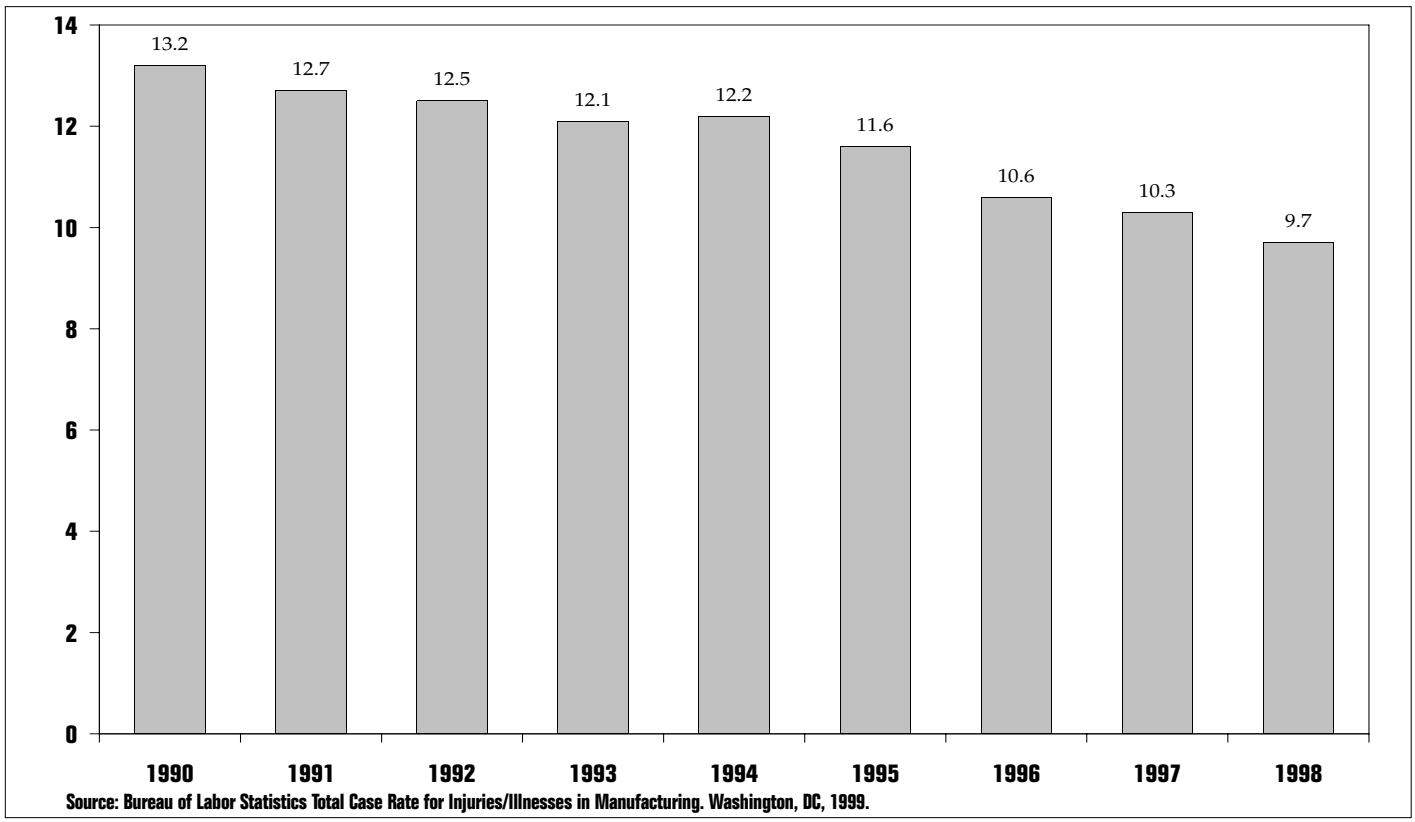
Some companies categorize causes to determine patterns in management systems; these data are best presented in a pie chart. Categorization is not meant to be an endpoint, but it helps determine the allocation of resources. For example, if several investigations indicate that a primary causal factor is training, then efforts could be made to more clearly define training objectives, methods and evaluation criteria. Table 2 lists several categories of causes that could be used to determine common patterns, along with potential action items.

Developing Recommendations

Follow up is another vital element of any investigation. All recommendations should be written in such a manner that they are "doable" and address the identified incident causes. Recommendations should be written with the end result in mind. In some cases, those responsible for implementing recommendations were not involved in the investigation; therefore, items should be written so that someone external to the investigation process can immediately understand their intent.

However, care must be taken to avoid deluging the reviewer with so much information that the original point is lost. The best recommendations address the broad issues associated with incidents, and specific issues as appropriate. Action items

FIGURE 1
Injury/Illness Trends in Manufacturing



Source: Bureau of Labor Statistics Total Case Rate for Injuries/Illnesses in Manufacturing. Washington, DC, 1999.

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should be assigned to an individual, who must also be given an appropriate target date for completion. All action items must be tracked to completion as well.

GOALS FOR IMPLEMENTATION

Quantity and quality of reports are two primary goals when implementing a near-hit reporting strategy.

Expectations for Quantity of Reports

Along with investigation quality, the number of reports generated is another key consideration. Since the premise of near-hit reporting is to document as much information as possible before issues actually become injuries, one must gauge the completeness and accuracy of the reporting system. Management must resist the temptation to interpret a higher number of reports as a signal of more problems. Rather, higher reporting indicates that issues are being identified and concerns are being addressed *before* they become more serious. In other words:

- What is not reported cannot be thoroughly investigated.
- What is not thoroughly investigated cannot be changed.
- What is not changed cannot be improved (CCPS).

To gauge the number of near hits a facility can expect, an evaluation can be based on the number of serious injuries that occur. For this exercise, one can refer to the studies conducted by Heinrich, which suggest that the ratio of major lost-time injuries to near hits is approximately 300 to 1 for accidents involving the same person; other evaluations place the ratio closer to 175 to 1 (Fletcher).

Although these studies are limited (and, in cases such as Heinrich, have not been statistically validated), their conclusions support the commonly held notion that serious injuries are often preceded by an even greater number of near hits. Therefore, when the accident pyramid for a company is not truly a pyramid (with a considerably large base=near hits), the area of incident reporting could use more focus.

Management must stress to the workforce that near hits should be reported. One way to achieve this is to track the number of near hits reported per department per month; then, during periodic safety meetings, the reasons that the number of reports fluctuate can be discussed. Targets can be set for the number of reports that should be submitted, and rewards given when targets are met. However, care must be taken to ensure that the focus is on actual near hits and that personnel are not merely submitting reports to meet predetermined quotas.

Improving Quality Standards

Along with the drive to ensure that an appropriate number of reports are generated, emphasis must be placed on the quality of information received. Some organizations have found success by focusing on three key areas: management commitment and emphasis, employee training and consequences.

The first step is to have genuine commitment from management that is demonstrated at every opportunity. Whether in staff meetings, postings or direct conversations, management must take visible steps to ensure that all employees understand that high-quality investigations, appropriate documentation and follow-through on recommendations are top priorities.

In addition, all personnel who will generate, investigate, review or follow up on recommended actions must receive appropriate training. During this training, management must communicate its expectations regarding items that should be reported; cause-and-effect analysis and cause categorization; and documentation/follow up. Practical workshops that focus on writing reports are also valuable. Case studies can be presented to help participants determine whether a scenario is a near hit and learn how it should be documented.

Several benefits can be realized by providing positive consequences for submitting near-hit reports. Awards may be given to personnel who submit reports that meet minimum standards for quality, including the development of recommendations that address incident causes rather than the response to the incident itself. Departments that increase near-hit reporting may also be rewarded.

CASE STUDIES

The following case studies describe incidents in which timely investigation and early action could have prevented the noted consequences. They involve issues such as design, permitting, maintenance, changes and construction. This exercise is not meant to second-guess actions that were taken nor to be an exhaustive discussion of all incident causes/solutions. Rather, the goal is to present a basic review of situations that existed when an actual incident occurred in order to illustrate the positive effect of early hazard recognition and investigation.

Case 1

Maintenance was being performed on a reactor. The work required that a leg of the reactor be opened to the atmosphere. During a break, the technician left the job area and did not communicate that the work was not complete. All sources of energy were not isolated.

Potential consequences. This scenario may demonstrate a weakness in this facility's permitting process. If a review of lockout/tagout were conducted, it would be discovered that the reactor was not appropriately isolated. As a result, an operator might have inadvertently started flow to the reactor, resulting in a release of flammable material and subsequent explosion.

Case 2

A tank was being used to store a material that reacted violently with water. Prior to this, the tank had been used to store materials that were compatible with water. Tank fittings were still compatible with fittings on water hoses used at the plant, and a connecting pipe between the tank and an empty water tank was still in place. Multiple valves existed in the line that was closed. The area was monitored occasionally, but not frequently.

Potential consequences. This scenario may indicate a design flaw. For example, an employee could inadvertently (or deliberately) attach a water hose to the tank or misalign valves in the common pipe. If the pressure-relief device on the tank was inoperable, or had not been designed for this use, then the result could be an exothermic reaction that could overpressure the tank. Had the connecting pipe been removed or had tank fittings been made incompatible with the water hose (and other fittings for utility hoses), then the probability of tank overpressure would be minimized.

Case 3

Two relief valves, identical in appearance but with different setpoints, were removed from a plant during a shutdown and sent out for overhaul. One valve was set to operate at a gauge pressure of 15 psi, the other at 30 psi. These pressures were stamped on the flanges but the valves were not uniquely identified in any other way;

TABLE 2
Cause Categories & Control Measures

Cause Category	Definition	Items to Consider
Inadequate training	Personnel did not know proper action to take.	• Determine patterns to focus efforts. • Reorganize training to present clear objectives.
Failure to audit prior to work	Failure to assess work conditions and identify hazards prior to work.	• Training in behavioral issues. • Ensure employees understand company philosophy regarding shortcuts. • Implement mandatory *wait-and-observe* periods prior to hazardous work.
Inadequate design	Design of equipment is flawed and either creates or exacerbates a hazard.	• Issue design standards. • Ensure compliance with design standards. • Provide training for engineers and draftspersons.
Inadequate inspection and test program	Failure to test or inspect critical equipment, which may result in a failure or degrade an existing safeguard.	• Ensure the competency and credentials of inspectors. • Ensure appropriate resources are available for inspections and tests. • Evaluate adequacy of procedures and training.
Inadequate procedure	Procedures/practices did not address situation (specify maintenance or operations).	• Revise procedures to include noted situations. • Ensure that employees who write procedure have access to information regarding industrial incidents.
Failure to follow procedures	Employee knew and understood requirements, but did not follow them.	• Interview employees to determine underlying issues. • Ensure employees understand company philosophy regarding shortcuts. • Review the adequacy and effectiveness of disciplinary policy.
Equipment defect	Failure of equipment, instruments or seals that is the result of a defect and not a procedural or training issue.	• Ensure adequacy of quality control program for incoming materials.
External	Weather events or issues that were outside the span of control of all personnel.	• Provide protection against the elements (e.g., lightening protection).
Unknown	An incident in which the cause cannot be determined.	• Initiate further investigation with a larger team.

no additional precautions were taken when the valves were removed for service.

Potential consequences. This scenario appears to indicate a maintenance procedural issue. The chances for interchanging valves are greater when no unique number is assigned to a valve. The installation of the 30-psi valve on a vessel that is only rated for 15 psi diminishes the margin necessary for safe operation. One action item resulting from this near-hit report may be to attach a numbered tag to the relief valve when it is removed and another tag with the same number to the flange.

Case 4

A crane operator at a construction site is lifting pipe to an elevated level. The area below is not routinely traversed, but personnel do occasionally walk through it. The rigging breaks and the piping falls. Fortunately, no one is walking through the area at the time.

Potential consequences. Although no one was impacted at the time, this scenario indicates that a problem exists, and the situation could be repeated. The only additional condition that would need to exist for an injury to occur is the presence of personnel below. To eliminate this problem, the area could be barricaded during lifts. In addition, the site should assess the effectiveness of its operator training program and implement a stringent critical lift plan that involves scrutinizing the integrity of rigging.

Case 5

The water supply line for a sprinkler system was being repainted for identification and to prevent corrosion. The painting contractors were not familiar with the system and inadvertently painted over the fusible links of the sprinkler heads.

Potential consequences. A coat of paint elevates the sprinkler head's melting temperature; consequently, it will not function properly during an actual fire. This scenario highlights hazards that can accompany routine and well-intentioned changes; it also illustrates potential problems that can arise in communication with contractors.

Case 6

A permit was issued for work to be performed on an acid line. The permit stated that goggles must be worn, yet the employee performing the job did not wear goggles.

Potential consequences. Even if the line has been drained, trapped pressure may cause acid to be splashed into the employee's eyes. Initially, the injured person would appear to be solely at fault for this situation. However, a thorough in-

FIGURE 2
Sample Near-Hit Report Form

Consequence Category
❑ **Safety**_____ ❑ **Raw Material** _____ ❑ **Other**_____
❑ **Environmental** _____ ❑ **Product** _____

Plant/Department: _____

Incident Date: _____ **Time:** _____ **Duration:** _____
Event:

Problem Description:

Root and Contributing Cause(s):

Corrective Action:

Action Items	Responsibility	Target Completion	Actual Completion

Cost of Non-Conformance:
(Estimated)

Prepared by: _____
(If a safety or environmental incident, list all personnel involved in the initial investigation.)

Approved by: _____
Dept. Manager

vestigation of the permitting process might be in order. For example, do all permits issued mandate that goggles be worn, without regard to actual hazards? If so, this protocol could cause a maintenance worker to ignore the instruction when an actual hazard exists.

Certainly, in some examples presented, no incident actually occurred (based on the classic definition of incident). However, in many cases, a critical safeguard may have been compromised. With this weakening of the lines of defense, an incident could occur with the introduction of only one action or condition (Sanders; Kletz).

HIGH-LEVEL INVESTIGATIONS

When an incident goes beyond the near-hit stage, a more-formal, team-oriented investigation may be warranted. Many companies have set criteria (e.g., recordable injuries, large fires, significant equipment damage) used to decide whether to assemble a team for a comprehensive investigation. The techniques described for near-hit assessments can also be applied to these investigations; the key difference will be the number of people involved.

CONCLUSION

To continue the downward trend in injuries and comply with OSHA and EPA expectations, facilities must implement a comprehensive approach to investigating near-hit conditions and actions. By emphasizing expectations regarding quality and quantity of near-hit reports, facilities can ensure that they are pursuing an appropriate approach.

To recap, the critical elements of a near-hit reporting program can be summarized in four steps: 1) Define what constitutes a near hit. 2) Determine the incident cause(s). 3) Develop recommendations to respond to the incident and prevent recurrence. 4) Track those recommendations to completion. This strategy ensures that an appropriate level of investigation is performed and complete, accurate documentation is created. ■

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