Near-Miss Reporting to Enhance Safety in the Steel Industry

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

Authors

Ibukun Awolusi
Department of Civil, Construction and Environmental Engineering, University of Alabama, Tuscaloosa, Ala., USA
igawolusi@crimson.ua.edu

Eric Marks
Department of Civil, Construction and Environmental Engineering, University of Alabama, Tuscaloosa, Ala., USA
eric.marks@eng.ua.edu

Contact

Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

Don B. Daily SAFETY GRANT
To Promote Steel Industry Safety and Health

This article is the first in a series of Safety First articles featuring the reports from the recipients of the 2014–2015 Don B. Daily Safety Grant.

Accident statistics of the steel industry indicate that steel manufacturing continues to be a dangerous work environment when compared to other industrial sectors within the United States. Steel manufacturing is one of the most hazardous industries because of its complex sociotechnical system. The steel manufacturing process involves the use of high technology and physical labor, making safety management a complicated task.[1] Past safety performance has been largely measured and driven by lagging indicators (including injuries, illnesses and fatalities), but improvements and enhancements of safety performance can be experienced through implementing safety leading indicators (including reporting near misses) to measure worker safety performance.

Leading indicators are measurements of processes, activities, and conditions that define performance and can predict future results.[2] A leading indicator is the result of periodic measurements of a specific safety performance. Leading indicators provide opportunities for safety managers to identify areas of safety performance that need improvement before injuries or fatalities occur.[3] Near misses are categorized as a type of safety leading indicator. Because near misses require a meaningful or actionable metric, they are further categorized as an active safety leading indicator and must be quantifiable.[2] Typically near-miss incidents are not reported in terms of hours or worker exposure, but rather as single events or instances. By recording near misses, steel manufacturing workers can be educated on strategies to prevent future accidents.

Different strategies have been attempted in an effort to prevent injuries. One of these strategies is an incident reporting system, which is becoming more common in conventional manufacturing plants.[4] An effective means should be adopted for reporting accidents and near misses to increase personnel participation, explaining that reporting is not used to judge persons for their errors, but to analyze events and learn from them, avoiding their repetition.[5] The basis of analyzing accidents is collecting the facts, classifying, and reporting them precisely and in a timely manner.

Therefore, different organizations, according to their needs and requirements, should design and use definite incident reporting forms that will make the information-gathering process and incident reporting easy.[6]

In this article, a review of injury statistics in the steel manufacturing industry is presented and followed by comprehensive discussions on the meaning of leading indicators and near misses. Industry findings of near-miss data collection and reporting methods, including literature associated with non-steel manufacturing applications of near-miss reporting, are also reviewed. A near-miss reporting program is developed and the methodology for near-miss data collection and analysis is described in detail. Best practices for implementation of the near-miss reporting program are also recommended. The ultimate accomplishment of this research is the development of a functional near-miss information management program for identifying and investigating near misses to disseminate knowledge that can be used to forestall the occurrence of major accidents in the steel industry.

Literature Review

Steel manufacturing environments are often characterized by dangerous situations and conditions. The following review covers current injury and fatality incidents in the steel manufacturing environment, as well as research in near-miss reporting for this industry. A research needs statement is derived from findings of the review.

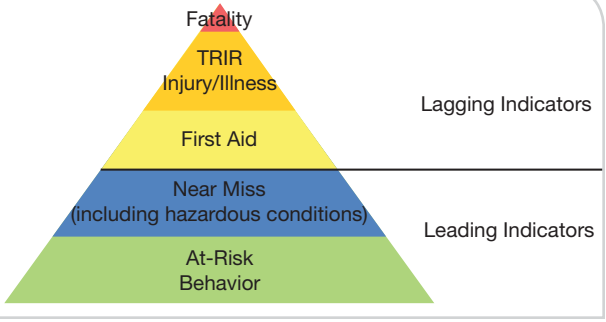
Injury Statistics in the Steel Manufacturing Industry — The manufacturing industry continues to be one of the most dangerous for workers when compared to other industries in the United States. Table 1 shows the number of fatalities for the metal manufacturing industry for the past 10 years. Although the number of occupational fatalities in metal manufacturing has been on the decline, the average per year continues to remain above 70.

Table 1

Occupational Fatalities for the Metal Manufacturing Industry[7]

Year(s)	Fatalities per year
2004–2010	77 per year
2011	63
2012	67
2013	64

Figure 1



Heinrich's Safety Pyramid.[14]

Leading Indicators — Safety performance indicators can be divided into leading and lagging indicators. Lagging indicators are unable to reflect if a hazard has been mitigated, the severity of an event or the event causation.[8,9] Safety leading indicators are measurements of processes, activities, and conditions that evaluate safety performance and can predict future results.[3,10,11] Companies that track leading indicators will be able to maintain a more accurate assessment of the effectiveness of the safety program.[12] Leading indicators can detect and provide guidance on where corrective measures can be implemented to break the chain of events that might lead to a fatal accident.[13] Leading indicators can also evaluate specific aspects of safety performance over a period of time. These leading indicators enable the safety managers in a steel manufacturing plant to recognize areas of workers' safety performance that need to be improved to forestall the occurrence of injuries or fatalities.

Heinrich's Safety Pyramid (shown in Figure 1) provides a motivation to reduce the number of actual accidents by identifying, recording and mitigating accidents that had a potential to occur. The Safety Pyramid illustrates that a multitude of minor incidents are required for one major incident to occur, and even more near misses should occur for some minor incidents.[14] By identifying, reporting and mitigating near misses, safety lagging indicators, including first aids, injuries, illnesses and fatalities, can be avoided.

The Linear Causation Models, which submit that accidents are the end result of a sequence of events (e.g., the Domino Theory and the Loss Causation Models), are derived from the Safety Pyramid.[13] The existing Safety Pyramid has been revised and expanded in several other research investigations to include "incidents without damage or loss" and "unsafe hazards and conditions."[15] The theories of the Safety Pyramid also support previous research findings

that all serious injury to workers can be successfully prevented.[16–19]

Non-injury or near-miss incidents should be systematically identified and investigated to mitigate the probabilities of the occurrence of major accidents. Near misses meet the requirements of defining an actionable leading metric, including:

1. Data must be numeric.
2. Data must be easily understood.
3. Data must be perceived as credible.
4. Data must signal the need for action.
5. Data must be related to other indicators.
6. Data must not generate unintended consequences.[2]

In the past, near misses were reported as single events or instances rather than hours or worker exposure.[20] Lessons learned from near-miss reporting can be used to educate and train steel workers on how to prevent future accidents.

It is important for all safety leading indicators to follow a consistent measurement process to ensure that the data recorded and analyzed are resourceful to the final users. The process should be undertaken by knowledgeable and well-trained personnel who will follow a definite data collection order and schedule. A functional tool for a reliable and uniform collection of data and information should also be maintained to create a good database.

Near Misses — The U.S. Department of Labor defines a near miss as an incident where no property damage and no personal injury were sustained, but where, given a slight shift in time or position, damage and injury easily could have occurred.[7] Neither the U.S. Department of Labor nor the Occupational Safety and Health Administration (OSHA) currently require private companies to report near-miss data.[22]

A number of different companies interested in taking advantage of the benefits of near misses implement near-miss reporting programs within their organizations. For instance, The University of Texas health care system implemented a "close-call reporting system," which allows users to anonymously submit reports so as not to be identified by their supervisor.[23] Close calls (i.e., near misses) reported in this system are categorized based on human factor principles. The collected data is used to identify and mitigate areas of vulnerability. This system, like many others, allows for online entry into a database to ensure prompt analysis and dissemination of results.[24]

Several attempts have been made to improve safety in steel manufacturing through innovation and research. Patterns of incidents in steel manufacturing plants have been identified and studied.[1] One case study evaluated a similar incident reporting system in steel manufacturing and found that safety performance was improved after implementing and maintaining an incident reporting system that included near-miss reporting.[4]

Near-Miss Reporting Methods in Other Industries — Many U.S. industrial sectors have experienced improved safety performance through near-miss reporting. For example, the offshore drilling sector experienced statistically significant lost-time injury rates (60% reduction of lost-time injuries) through near-miss reporting. In the offshore drilling industrial sector, a rate of 0.5 near-miss reports per worker was correlated with a 75% decrease in lost-time injuries.[25]

The medical field in the U.S. experiences a large number of patient deaths as a result of medical errors.[26] Near misses reported for transfusion medicine identified the following root causes: (1) samples collected from the wrong patient, (2) mislabeled samples and (3) requests from the wrong patient.[27] Near-miss reporting was similarly implemented into nursing homes to identify causes of error.[28]

One study of the chemical process industry identified seven stages to reporting and analyzing near-miss information:[29] (1) identification, (2) disclosure, (3) distribution, (4) direct and root-cause analysis, (5) solution determination, (6) dissemination and (7) resolution. This study also found that employees may be reluctant to report near misses due to fear of retaliation.

The U.S. Nuclear Regulatory Commission (NRC) requires inspectors to review a reactor when a near-miss event is reported. More than 200 reviews by inspectors were conducted by the NRC in 2010.[30] Most reported incidents were low risk, but high-severity near-miss reports resulted in further investigation.

The transportation services industry also benefits from reporting near misses.[31] The Civil Aviation Authority (CAA), which regulates the United Kingdom's aviation industry, uses near-miss reporting to record and assess potential safety incidents. The CAA maintains a near-miss reporting database to contribute to the improvement of air safety by identifying and mitigating hazardous conditions and situations.[32]

In comparison to other industrial sectors, the steel manufacturing industry has been slower to implement near-miss reporting practices. The research team reviewed existing work and visited a steel manufacturing mill to inquire about its safety program as it relates to near misses. The feasibility of implementing and maintaining a near-miss reporting program with a steel manufacturing company and environment was also assessed. By reporting, analyzing and

disseminating near-miss information, hazardous situations and conditions can be identified and mitigated before a lagging indicator occurs.

Nature of Hazards in the Steel Industry — In order to properly determine the best approach toward managing safety in any industry, it is important to understand the nature of the injuries and hazards common to the industry. This will help to cultivate a broader knowledge on how the proposed technique will be implemented in managing the hazards. The choice and the implementation of specific measures for preventing workplace injury and illness in the iron and steel industry depend on the recognition of the principal hazards and the anticipated injuries and diseases, ill health and incidents.[33]

According to the International Labour Organization (ILO) code of practice on safety and health in the iron and steel industry, the most common causes of injury and illness in the iron and steel industry are:

1. Slips, trips and falls on the same level.
2. Falls from height.
3. Unguarded machinery.
4. Falling objects.
5. Engulfment.
6. Working in confined spaces.
7. Moving machinery, on-site transport, forklifts and cranes.
8. Exposure to controlled and uncontrolled energy sources.
9. Exposure to asbestos.
10. Exposure to mineral wools and fires.[33]

Injuries or accidents resulting from these hazards are usually caused by an unsafe act, unsafe condition or a near miss. Consequently, a near-miss reporting program can be used to provide a strategy for investigating the root cause of the incidents to prevent potential accidents.

Objective and Methodology

The purpose of this research is to create a near-miss reporting program and an implementation strategy. The near-miss reporting program will include recommended best practices for identifying, reporting and mitigating near misses in steel manufacturing. The research will develop an actionable definition of a near-miss or non-injury event, show how reporting can be a positive experience, describe how near-miss data can be effectively collected, analyzed and managed, and show how near-miss data can be used to improve the safety process.

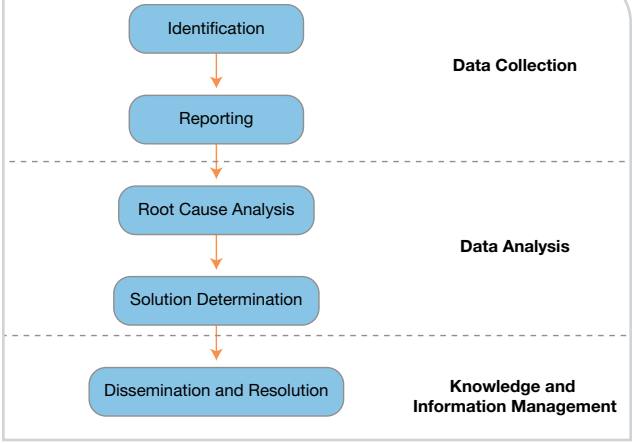
This research reviewed existing academic literature and industry findings of near-miss data collection and reporting methods associated with non-steel manufacturing applications, such as aviation, energy production and the medical field,[25–32] to elicit benefits in the management of safety. This literature review identified best practices of near-miss reporting in these industrial sectors. Where applicable, these best practices were included in the created near-miss reporting program.

An investigation on the current use of near-miss reporting in the steel industry was also carried out and culminated with a visit to a steel manufacturing mill to inquire about its existing near-miss reporting program. Two expert safety managers conducted an interview with the research team and shared their experiences with near-miss reporting, including benefits and limitations of the system. The managers also shared their current methodology for reporting, collecting, analyzing and disseminating near-miss information. Based on the results of the literature review and expert interview, the research team created the following near-miss reporting program.

Proposed Near-Miss Data Collection and Analysis Program

The proposed near-miss data collection and analysis program is structured for effectively collecting and analyzing near-miss events. The program provides a methodology for safety managers and other management personnel in the steel manufacturing plant environment to transform collected near-miss data into usable safety information. The near-miss reporting

Figure 2



Stages in near miss-data collection and analysis system.

program involves three broad phases of information flow, which are fragmented into five distinct steps. The three phases and their corresponding steps are presented in Figure 2. This program implements an information management system for near misses by processing and converting near-miss data to useful information and ultimately for knowledge dissemination to the employees.

Step 1: Identification — This is the step at which a worker recognizes an unsafe event or set of conditions in a workplace as a near miss. All employees in the manufacturing plant must undergo training on how to identify near misses and differentiate them from lagging indicators, such as injuries or illnesses. This step empowers employees to act as key participants in correctly identifying and reporting near misses that occur during the workday. If the near miss is of high severity or poses an imminent danger, the worker should execute the "stop work" order and mitigate any hazards without delay.

Step 2: Reporting — At this stage, identified near misses are reported by the workers to their immediate supervisor through a variety of reporting strategies. Depending on workplace environmental constraints, the reporting procedure can be either electronic or paper-based. If paper-based is selected, the data would be later entered into an electronic database by safety management personnel. Both reporting options must be accompanied with database capabilities to create a reliable repository of the reported near-miss data. This database should possess the following functional abilities:

- Store, retrieve and display raw and analyzed data.
- Perform statistical analysis of incidents reported.
- Navigate through incident forms, reports and other applications.
- Provide various categories of information to the user.
- Enable customization capabilities.
- Support commonly used programming languages for modification.

Step 3: Root-Cause Analysis — Based on reported near-miss information from Step 2, an investigation team will review each individual report. The investigation team should include safety managers, supervisors and the employee who reported the near miss. If a large number of near misses are submitted, the safety manager may prioritize the near-miss reports based on the level of severity for immediate review (i.e., higher-severity reports are reviewed first). A severity value should be assigned to each near-miss report according to the injury potential to humans or damage to property. Part of this review process involves identifying one or more root causes that resulted in the reported near miss. Another function of the investigative team would be classifying the near miss. For the categorization of the root causes of the near-miss incidents, the Eindhoven Classification Model (ECM) is modified and applied to the steel industry in this case.[34] The categories of the Eindhoven Classification Model for Human Errors in Steel Manufacturing are shown in Table 2.

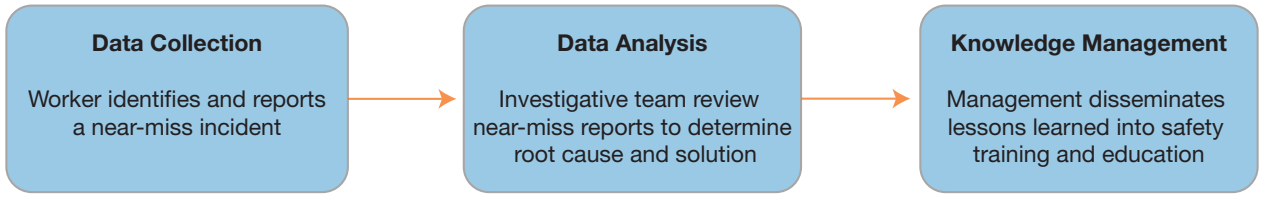
Step 4: Solution Determination — After a root cause has been determined and the near miss has been categorized, the investigative team will determine the appropriate correction measures which should be established to mitigate the hazardous situation or set of conditions reported. The solutions proffered for the near-miss event should be reviewed and approved by all members of the investigative team. Once a consensus is reached, the solution should be

Table 2

Eindhoven Classification Model for Human Errors in Steel Manufacturing[34]

Factor	Category	Definition
Skill-based	Slips and tripping	Failures in performance of highly developed skills or failures in whole body movement
Rule-based	Qualifications, coordination, verification, identification, monitoring, compliance and protocol	Failures due to application of bad rules or incorrect application of good rules
Knowledge-based	Knowledge	The inability of an individual to apply his or her existing knowledge to a new situation
Other	Mechanical, cultural and external	Failures due to mechanical issues, failures resulting from collective approach, failures beyond the control and responsibility of the investigating organization

Figure 3



Flow of near-miss information.

implemented and monitored by the safety manager and investigative team.

Step 5: Dissemination and Resolution — This step is critical to the success of the entire near-miss reporting program. A broader audience involving all employees in the steel manufacturing environment should be informed of the reported near miss and the implemented corrective actions. The near-miss information should also be shared with other active steel manufacturing plants to bring about synergy among steel manufacturing companies. Safety managers will integrate lessons learned from the reported near miss into existing safety training. This step allows for the worker who reported the near miss to receive feedback on how the situation would be corrected to decrease the potential detrimental consequences. By educating steel manufacturing workers in different plants on lessons learned from near-miss data collection and analysis, safety performance of workers can be greatly improved. Figure 3 depicts the flow of information for a single reported near miss.

Conclusion

Prevailing records indicate that every one job in the American steel industry supports nearly seven jobs in the U.S. economy, reflecting its ripple effect on employment.[35] This further underpins the need to deploy safety best practices to ensure that high safety and health standards are maintained in all steel manufacturing environments. The ability to collect, analyze and disseminate safety information using a large amount of useful data from leading indicators can allow for hazardous events and conditions to be efficiently mitigated and controlled before a lagging indicator occurs.

Best practices for a near-miss reporting program, including implementation strategies, were recommended. These included several research deliverables for educating workers on how to identify near misses, database resources to collect and analyze near-miss data, and near-miss information flowcharts. This research endeavor is a first step that must be succeeded by the effective development and implementation of the proposed near-miss reporting system in the steel manufacturing industry. It also provides a solid foundation for future research in near-miss reporting in the steel manufacturing industry as well as other industrial sectors.

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