



Construction Industry Institute®

# Measuring Safety Performance with Active Safety Leading Indicators

## Construction Industry Institute

|                                             |                                           |
|---------------------------------------------|-------------------------------------------|
| Abbott                                      | AMEC                                      |
| Air Products and Chemicals                  | AZCO                                      |
| Ameren Corporation                          | Alstom Power                              |
| American Transmission Company               | Audubon Engineering Company               |
| Anheuser-Busch InBev                        | Aveng Group                               |
| Aramco Services Company                     | BIS Industrial Services                   |
| ArcelorMittal                               | Baker Concrete Construction               |
| Architect of the Capitol                    | Barton Malow Company                      |
| BP America                                  | Bechtel Group                             |
| Barrick Gold Corporation                    | Bentley Systems                           |
| Bristol-Myers Squibb Company                | Black & Veatch                            |
| CITGO Petroleum Corporation                 | Burns & McDonnell                         |
| Cameco Corporation                          | CB&I                                      |
| Cargill                                     | CCC Group                                 |
| Chevron                                     | CDI Engineering Solutions                 |
| ConocoPhillips                              | CH2M HILL                                 |
| DTE Energy                                  | CSA Group                                 |
| The Dow Chemical Company                    | Coreworx                                  |
| DuPont                                      | Day & Zimmermann                          |
| Eastman Chemical Company                    | Dresser-Rand Company                      |
| Ecopetrol                                   | eProject Management, LLC                  |
| Eskom Holdings                              | Emerson Process Management                |
| ExxonMobil Corporation                      | Faithful+Gould                            |
| General Electric Company                    | Flad & Associates                         |
| General Motors Corporation                  | Flint Energy Services                     |
| GlaxoSmithKline                             | Fluor Corporation                         |
| Global Infrastructure Partners              | Foster Wheeler USA Corporation            |
| Huntsman Corporation                        | GS Engineering & Construction Corporation |
| International Paper                         | Gross Mechanical Contractors              |
| Irving Oil Limited                          | Hargrove Engineers + Constructors         |
| Kaiser Permanente                           | Hatch                                     |
| Koch Industries                             | Hilti Corporation                         |
| Eli Lilly and Company                       | IHS                                       |
| Linde North America                         | Industrial Contractors Skanska            |
| LyondellBasell                              | Innovative Design Engineering Associates  |
| Marathon Petroleum Corporation              | JMJ Associates                            |
| National Aeronautics & Space Administration | JV Driver Projects                        |
| NOVA Chemicals Corporation                  | Jacobs                                    |
| Occidental Petroleum Corporation            | KBR                                       |
| Ontario Power Generation                    | Kiewit Corporation                        |
| Petroleo Brasileiro S/A - Petrobras         | Kvaerner North American Construction      |
| Petroleos Mexicanos                         | Lauren Engineers & Constructors           |
| Petroliaam Nasional Berhad                  | Matrix Service Company                    |
| Phillips 66                                 | McCarthy Building Companies               |
| Praxair                                     | McDermott International                   |
| The Procter & Gamble Company                | Midwest Steel                             |
| Reliance Industries Limited (RIL)           | M. A. Mortenson Company                   |
| SABIC - Saudi Basic Industries Corporation  | Parsons                                   |
| Sasol Technology                            | Pathfinder                                |
| Shell Global Solutions US                   | Quality Execution                         |
| Smithsonian Institution                     | The Robins & Morton Group                 |
| Southern Company                            | S&B Engineers and Constructors            |
| Statoil ASA                                 | SAIC Constructors                         |
| Teck Resources Limited                      | SKEC USA                                  |
| Tennessee Valley Authority                  | SNC-Lavalin                               |
| TransCanada Corporation                     | The Shaw Group                            |
| U.S. Army Corps of Engineers                | Siemens Energy                            |
| U.S. Department of Commerce/NIST/           | Technip                                   |
| Engineering Laboratory                      | Tenova                                    |
| U.S. Department of Defense/                 | TOYO-SETAL Engenharia                     |
| Tricare Management Activity                 | URS Corporation                           |
| U.S. Department of Energy                   | Victaulic Company                         |
| U.S. Department of Health & Human Services  | Walbridge                                 |
| U.S. Department of State                    | Wanzek Construction                       |
| U.S. Department of Veterans Affairs         | Wood Group Mustang                        |
| Vale                                        | WorleyParsons                             |
|                                             | Yates Construction                        |
|                                             | Zachry Holdings                           |
|                                             | Zurich                                    |



**Documents**

Document Sharing Hub

# **Measuring Safety Performance with Active Safety Leading Indicators**

**Prepared by  
Construction Industry Institute  
Research Team 284, Leading Indicators for Safety**

**Research Summary 284-1  
Version 1.1  
October 2012**

© 2012 Construction Industry Institute™

The University of Texas at Austin

CII members may reproduce and distribute this work internally in any medium at no cost to internal recipients. CII members are permitted to revise and adapt this work for their internal use, provided an informational copy is furnished to CII.

Available to non-members by purchase; however, no copies may be made or distributed, and no modifications may be made without prior written permission from CII. Contact CII at <http://construction-institute.org/catalog.htm> to purchase copies. Volume discounts may be available.

All CII members, current students, and faculty at a college or university are eligible to purchase CII products at member prices. Faculty and students at a college or university may reproduce and distribute this work without modification for educational use.

Printed in the United States of America.

Version 1.0 (July 2012)

Version 1.1 (October 2012) – Minor text edits throughout

# Contents

| <i>Chapter</i>                                                                                | <i>Page</i> |
|-----------------------------------------------------------------------------------------------|-------------|
| Executive Summary                                                                             | v           |
| 1. Introduction                                                                               | 1           |
| 2. Background                                                                                 | 3           |
| 3. Research Methods                                                                           | 7           |
| 4. Findings                                                                                   | 15          |
| 5. Implementation Resource                                                                    | 23          |
| 6. Conclusions and Recommendations                                                            | 25          |
| References                                                                                    | 27          |
| Glossary                                                                                      | 29          |
| Appendix A: Passive Leading Indicators Implemented<br>on at Least 80 Percent of the Projects  | 31          |
| Appendix B: Passive Leading Indicators Implemented<br>on Less than 80 Percent of the Projects | 35          |
| Appendix C: Samples of Active Leading Indicators                                              | 37          |



## Executive Summary

Despite reductions in injury rates in the past few decades, many firms with world-class safety records have, in recent years, been frustrated by the inability to make step-change improvements in safety. Efforts to reduce injury rates by simply monitoring classic measures such as the Occupational Safety and Health Administration (OSHA) Total Recordable Injury Rate (TRIR) and the Experience Modification Rate (EMR) have not achieved the desired step-change improvement. Many safety professionals believe that the careful selection, measurement, and response to leading indicators of safety performance will yield significant improvements. CII established Research Team (RT) 284, Leading Indicators for Safety, to investigate the potential of these critical project metrics.

Leading indicators are *measures of attitudes, behaviors, practices, or conditions that influence construction safety performance*. RT 284 divides leading indicators into two groups, namely passive and active. **Passive leading indicators** are the *safety strategies that should be implemented before the construction phase begins to set the project up for success*. Typically, these practices (e.g., contractual language and staffing) are not adjusted once the project begins, but serve as predictors of safety performance during construction. Alternatively, **active leading indicators** are *safety-related practices or observations that can be measured during the construction phase, and that can trigger positive responses*. Active leading indicators can be measured and adjusted as the project progresses to dynamically monitor and improve safety performance. RT 284 considers this difference between passive and active leading indicators—a distinction it made during the planning phase of the research process—an important contribution to industry safety. *The research team believes that implementation of active safety leading indicators opens a whole new approach to measuring project safety performance.*

In order to independently examine both passive and active leading indicators, the research team divided the research effort into two phases. In the first phase, the team identified and defined over 100 safety strategies as potential passive leading indicators. To evaluate which of these passive leading indicators best predicted safety performance, the team conducted interviews with management and safety professionals who had familiarity with 57 ongoing or recently completed major projects. Responses to the interview questions related to a project's use of the identified passive leading indicators were statistically compared to the project TRIR. From this comparison, 10 significant passive leading indicators showed a strong negative correlation with injury and illness rates. That is, the injury rates declined as more passive leading indicator practices were implemented. In fact, a statistical analysis of these data indicates that, in general, project recordable injuries were reduced by 0.85 per 200,000 worker hours for every two of the passive leading indicators that were implemented.

The second phase of the research focused on identifying active leading indicators that were extracted from three data sources. First, the research team established three subcommittees to identify, define, and evaluate active leading indicators specific to owners, contractors, and vendors, based on the experience and expertise of the team members. Second, the team conducted detailed case studies at 19 ongoing construction sites in an attempt to identify active leading indicators that were already being employed. These case studies involved data collection through site visits and project management interviews. Finally, the research included a detailed review of the safety performance of 14 award-winning projects identified from CII member organizations. The research activities in the second phase yielded 22 high-potential active leading indicators that have proven to be successful on past projects completed by industry leaders.

To help organizations implement active leading indicators, the research team created Implementation Resource (IR) 284-2, *Implementing Active Leading Indicators*. This resource explains that, when organizations select leading indicators for implementation, they should evaluate

their current safety program, select leading indicators that complement existing strategies, and carefully add new leading indicators that integrate well into the organizational culture. It is important to recognize that leading indicator data collection must be built upon a comprehensive safety management program, which must begin with the full adoption of the CII Zero Accidents Techniques, including aggressive and visible senior management leadership that fosters employee involvement and ownership.



## Introduction

Historically, the frequency and severity of injuries in the construction industry have been greater than in other industries. In addition to worker pain and suffering, the direct costs associated with workplace injuries can significantly reduce project revenues. Furthermore, injuries can have indirect costs in the form of elevated insurance premiums, increased regulatory intervention, project delays, declines in employee morale, increased worker turnover, and other adverse impacts. For decades, researchers have been studying different organizational strategies with the ultimate goal of decreasing injuries, illnesses, and fatalities. The passage of the Occupational Safety and Health Act (OSHA) of 1970 accelerated safety improvement. In fact, the fatality rate in the construction industry decreased by more than 50 percent in the first twenty years after the passage of OSHA. The injury and fatality rates have continued to show improvement, but in recent years, the rate of improvement has slowed. These trends have been documented by the National Safety Council and the Bureau of Labor Statistics.

Construction firms typically rely on safety strategies that were developed and implemented over the past twenty years to form their safety programs. Most firms continue to measure performance on the basis of several commonly used lagging indicators of safety success: the Total Recordable Injury Rate (TRIR); Days Away from Work, Restricted Work or Transfer rates (DART); and the Experience Modification Rates (EMR). In order to advance safety, some industry professionals have started to measure and track leading indicators of safety performance. Leading indicators are measures of the implementation of specific safety processes and may be used as predictors of safety performance.

As mentioned in the executive summary, leading indicators are *measures of attitudes, behaviors, practices, or conditions that influence construction safety performance*. RT 284 has divided leading indicators into two groups: passive and active. **Passive leading indicators** are the

*safety strategies that may be implemented before the construction phase begins to set the project up for success. Once project construction begins, these practices (e.g., contractual language, staffing, the designer's role in safety, and training protocols) typically cannot be easily adjusted. They may, however, serve as predictors of construction safety performance. Alternatively, **active leading indicators** are safety-related practices or observations that can be measured during the construction phase, and that can trigger positive responses. Active leading indicators are measures of practices that can be easily adjusted as the project progresses to dynamically improve safety performance. This study focused on evaluating the effectiveness of passive leading indicators of construction safety performance through the use of interviews. The research team's further detailed study of active leading indicators included case studies conducted with selected construction projects in the United States.*

## Background

Over the past 20 years, construction organizations have dedicated significant funding to the development and implementation of safety strategies, with the goal of increasing compliance and reducing injuries, illnesses, and fatalities. Rajendran and Gambatese (2009) found that there are over 300 injury-prevention strategies in the construction industry. Examples include job hazard analyses, written safety plans, safety audits, emergency response plans, personal protective equipment, and many others. According to CII Research Summary 160-1, *Safety Plus: Making Zero Accidents a Reality*, an effective foundation for safety management includes the following nine strategies: 1) demonstrated management commitment; 2) staffing for safety; 3) pre-project and pre-task planning; 4) safety education and training; 5) employee involvement; 6) safety recognition and rewards; 7) accident/incident investigations; 8) drug testing; and 9) subcontractor management. These nine strategies, as well as design for safety, which was investigated by CII RT 101, are only discussed briefly here; the team's assumption is that these CII Zero Accidents techniques have been implemented within organizations and serve as a basic foundation for safety management. Organizations without such program elements should first build the basic structure of a safety program before employing leading indicators.

### Demonstrated management commitment

Every safety strategy or program implemented in an organization should be supported by top management. Safety performance is exceptionally good when top management is visibly involved in safety (CII RT 160). The time that upper management spends with field safety representatives correlates positively with safety performance. Hallowell and Gambatese (2009) found that experts believe that active upper management support and commitment is one of the important factors for the reduction of injury rates.

## **Staffing for safety**

To ensure that the safety needs of large projects are satisfied, resources should be allocated to fund full-time safety staff. As the number of workers on a project increases, it is important to proportionally increase the number of dedicated safety managers. Safety managers should be intimately involved with the development and execution of safety programs on site, including but not limited to the following: pre-task plans, safety audits, safety training, and incident investigations.

## **Planning: pre-project and pre-task planning**

For many years, research has shown that safety planning activities are essential to safety success. This begins with pre-project planning, the phase during which hazards are identified and addressed before construction work begins. At the crew level, pre-task planning helps to ensure that the workers have thought through the work process and that the workers are fully prepared to perform the work safely. It is essential to ensure that pre-task planning meetings occur at the location at which the work will be conducted. It is also crucial that pre-task planning be incorporated into the daily work routine, and that supervisors be engaged in this planning process.

## **Safety education: orientation and specialized training**

Injuries in the workplace are caused by a combination of hazardous exposures and unsafe worker actions. The inability of workers to identify hazards and respond appropriately is a principal cause of safety risk. To respond to these potential shortcomings, employers are encouraged to implement hazard recognition programs, provide site orientations, and offer other specialized training.

## **Worker involvement**

The inclusion of workers in all aspects of safety planning and execution is an important aspect of proper safety management. In fact, this is one of the top strategies by which safety performance can be improved. Worker

involvement is known to be effective because it encourages positive perceptions of safety policies and because workers adhere more readily to policies that they help create. Thus, any changes that are implemented to encourage safe work behavior should directly involve the workers to ensure their support or buy-in.

### **Evaluation, recognition, and rewards**

Positive reinforcement in the form of verbal praise or public recognition is an effective means by which to reward workers for good safety performance. Workers will then be inclined to repeat those actions that resulted in the positive reinforcement. These are not lavish programs and merely require that supervisors and managers fully understand how to effectively reward workers who perform their work tasks in a safe manner.

### **Incident investigations**

To identify root causes and positively react to injuries, a well-established protocol for incident investigation should be developed. Investigations should focus on identifying root causes and developing controls to prevent future incidents. Near misses should be included in investigations because they can serve as learning opportunities without injury occurrence.

### **Drug and alcohol testing**

After pre-employment screening, drug and alcohol testing is a vital aspect of safety management and should be conducted randomly and in response to any OSHA recordable incident. In addition to this testing, the organization should have consistent and clearly communicated policies regarding employees who fail a test. The policies may include rehabilitation efforts, which are generally directed toward first-time offenders.

## **Subcontract management**

The general contractor must ensure that the safety plan and activities extend to subcontractors. Because worksites typically involve many employers who influence project safety culture, it is important that the general contractor include subcontractors in orientation and training sessions, pre-task planning activities, drug and alcohol testing, and other safety activities.

## **Safety in design**

Designing for safety is “the incorporation of construction knowledge in the design effort and consideration of safety early on and throughout the project” (Hecker et al. 2005). Researchers found that 42 percent of construction fatalities and 22 percent of injuries are linked to decisions made during design. To facilitate designing for safety, Gambatese et al. (1997) created Implementation Resource 101-2, *Design for Safety Toolbox*, which packaged hundreds of design suggestions into a software tool that made the design suggestions available to designers during the design phase. This software was updated in 2009 as a user-friendly software module, Implementation Resource 101-2, *Design for Construction Safety Toolbox*, Version 2.0 (Hinze and Marini 2008).

## Research Methods

This project involved two distinct data collection efforts. The objectives of the first phase were the following:

- identify potential passive leading indicators of construction safety performance
- reduce the dataset to those indicators that differentiate strong safety performance from average or poor performance
- measure the relative effectiveness of these indicators.

The objectives of the second phase were the following:

- identify potential active leading indicators of safety performance
- evaluate their effectiveness based on ease of implementation
- identify metrics
- quantify threshold values
- devise action plans.

Although these were two distinct phases, they were completed concurrently and drew from similar data sources. The following discussion provides details on the data sources and collection procedures.

### Phase 1: Passive Leading Indicators

In order to achieve the research objectives, the team divided the data collection process into two distinct phases. After the research team identified and defined passive leading indicators, team members conducted interviews with project representatives from 57 ongoing or recently-completed construction projects throughout the U.S. This gave the team empirical data that it statistically analyzed to determine which of the leading indicators could best serve as predictive measures of safety performance.

### *Phase 1a: Identifying potential passive leading indicators*

The literature review revealed nearly 100 safety strategies that may serve as passive leading indicators of safety performance. The team identified most of these strategies by reviewing the results of prior CII safety research efforts. After having developed an initial list of potential passive leading indicators, the team members took up the task of supplementing and refining it to include additional initiatives currently implemented in their respective organizations. The result was a list of 104 potential passive leading indicators, with associated operational definitions based on a common understanding of the strategies. These were incorporated into a six-page questionnaire that included questions about the following project characteristics and concerns:

- type of contract
- criteria for contract award
- schedule status
- budget status
- hours worked
- work hour restrictions
- owner involvement in safety
- orientation and training
- subcontractor management
- drug testing
- addressing safety during the design phase
- heavy equipment practices
- personal protective equipment (PPE) policies
- programs to involve workers in safety
- worker recognition
- incident investigations.