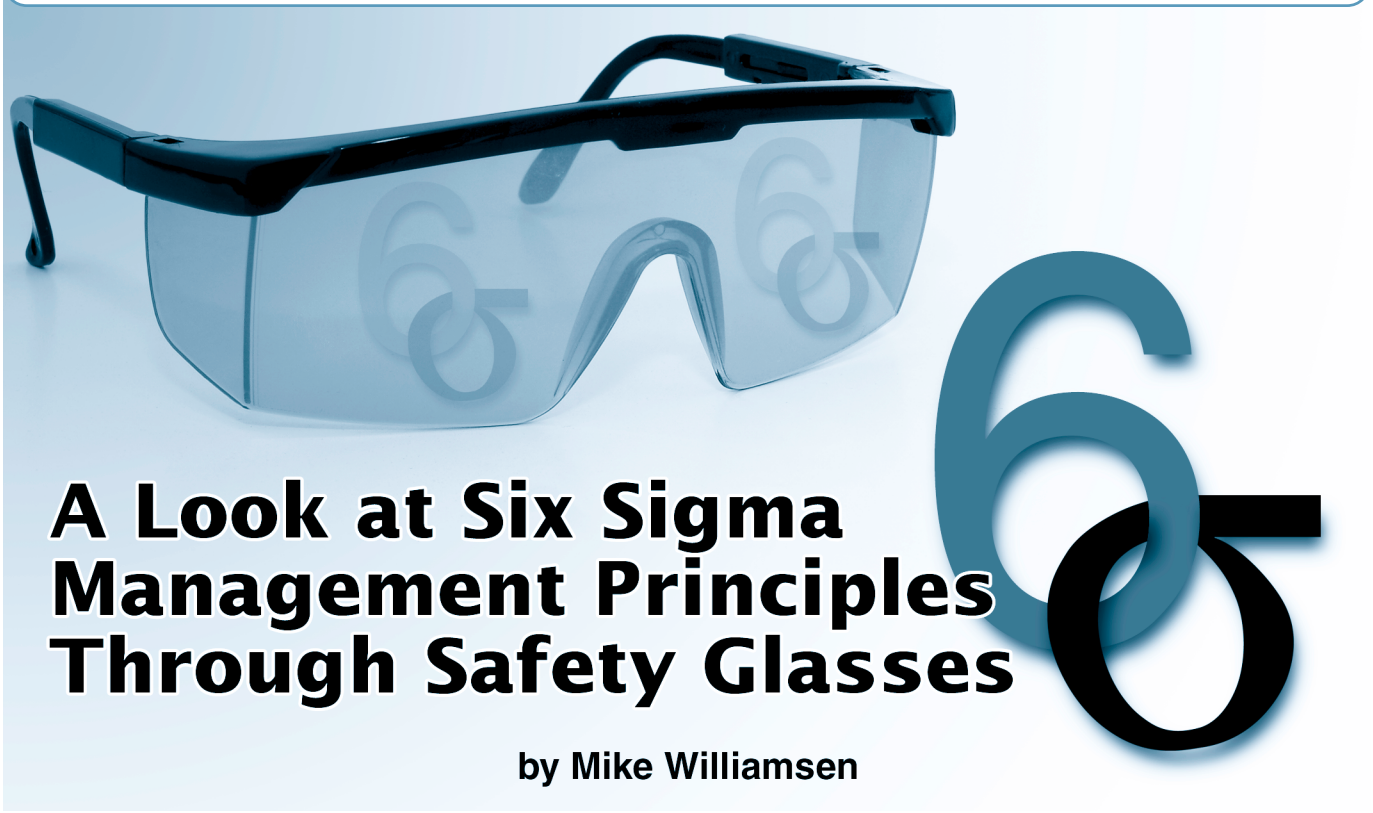
This article is condensed from a longer article, "Six Sigma Safety—Applying Quality Management Principles to Foster a Zero-Injury Safety Culture," which was first published in the June 2005 issue of *Professional Safety*, a publication of the American Society of Safety Engineers; www.asse.org. It is reprinted here with permission.



A Look at Six Sigma Management Principles Through Safety Glasses

by Mike Williamsen

Is safety given the same commitment as product quality? Are employees accountable for their own safety? Is safety excellence embedded into the company psyche? These are the fundamental questions that are driving today's safety revolution.

In much the same way total quality management made significant strides during the 1980s, industrial safety is poised for its own transformation. This article provides an actionable approach to how a zero-injury culture can be driven by adopting the same tools and tactics of product quality's Six Sigma methodology.

Six Sigma tools are nonproprietary, with a growing number of documented references to their statistical origin.[1] This article documents their practical application to safety and their resulting injury breakthroughs.

SAFETY PERFORMANCE CULTURE

Like all good innovations, Six Sigma emerged from an evolution of ideas. Although the concept originated with a group of engineers at Motorola Inc. during the mid-1980s, Six Sigma incorporates the theory and logic of quality pioneers such as W.E. Deming, Joseph Juran, and Philip Crosby to address the age-old question: "Is the effort to achieve quality dependent on detecting and fixing defects? Or can quality be achieved by preventing defects through manufacturing controls and product design?"

What Six Sigma did for quality is about to occur in industrial safety.

At its core, this approach is about improving effectiveness and efficiency. Its primary pursuit is perfection—a never-ending dissatisfaction with current performance. What separates Six Sigma from conventional quality concepts is its focus on communicating measurable error ratios. By incorporating customer-focused objectives and metrics to drive continuous improvement—and by establishing processes that are so robust that defects rarely occur—Six Sigma quality objectives aspire to reach a three-parts-per-million error ratio at a 99.9996% incidence. Statistically, Six Sigma variations are the standard deviation around the mean, represented by the Greek symbol sigma (σ).

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Today's Six Sigma quality community includes certification that incorporates formal instruction, performance standards, and applying a wide range of analytical problem-solving tools, such as Pareto charts (i.e., pie charts and bar graphs), process maps, and fishbone diagrams (see Figure 1). Its mastery borrows from the martial arts vernacular (e.g., green belt, black belt, sensei) to define levels of understanding and performance.

SIX SIGMA CONTROL LEVELS

What Six Sigma did for quality is about to occur in industrial safety. The same desire to eliminate production mistakes is at work to reduce injury rates. In this parallel journey there are six levels, or Six Sigma in safety. Each "sigma control" builds on the previous level until the sixth sigma—a zero-injury culture—is attained.

One Sigma Control: 'Reacting'

One sigma is set in the era of the three E's of safety: engineer, educate, and enforce. The tools for these rudimentary safety mechanics include work orders, safety rules, injury investigations, and compliance programs. While barely touching the surface of why injuries occur, one sigma tools nonetheless lay the foundation in establishing a safe workplace. As with one sigma in quality, the performance—conceptually, at least—is 68.5% error-free. This first level represents the ability to sustain the essentials in worker safety.

Two Sigma Control: 'What We See'

The tools for two-sigma control include observation programs, job safety analyses, and near-miss reporting. At this level, awareness and analysis tools are applied to reach a two-sigma level or injury-free rate of approximately 98.5%. Research indicates that a 10% error level requires roughly 3000 observations to detect and act on mistakes.[2-4] As errors decrease, more observations are needed to detect the incorrect activities, which means a 1% error level requires approximately 10,000 observations to be statistically valid.[5] It's a benchmark that underscores just how challenging it is for companies to move beyond two-sigma control without adding to its traditional safety repertoire of observation programs and "rearview mirror" reporting. Two sigma control is focused on "what we see" in the workplace.

Three Sigma Control: 'What We Do'

Three-sigma product quality requires well-defined responsibilities and accountabilities to provide predictable results on a regular basis. The same is true for three-sigma safety. Without safety accountability at all levels, the possibility for companies to attain this level is next to impossible. Organizations that have been able to move from two to three sigma have generally attributed their success to the introduction of individual accountabilities into their safety programs. Embracing the conventions of accountability and personal responsibility is a critical factor in achieving a workplace that

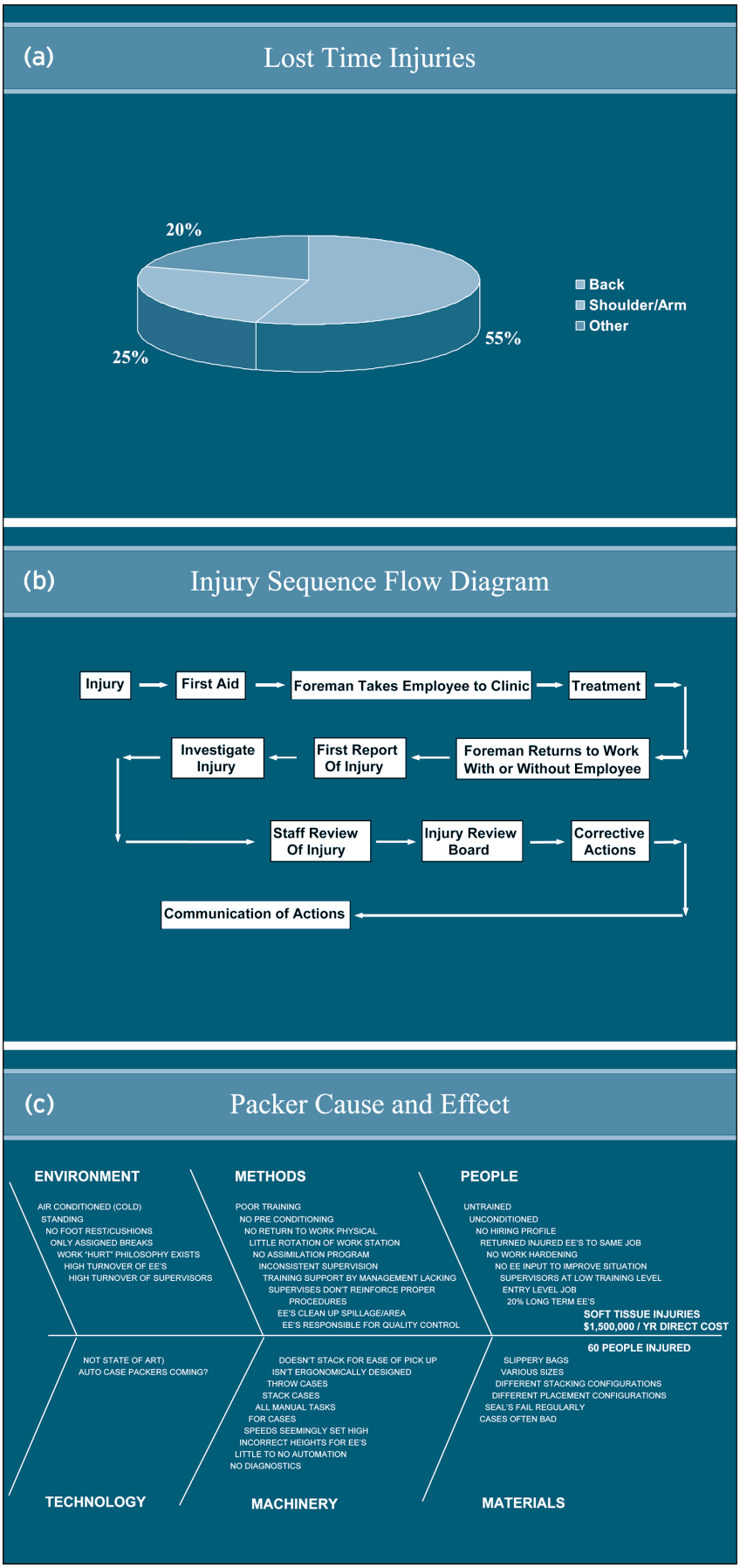

Figure 1. Examples of Six Sigma analytical problem-solving tools: (a) Pareto (pie) chart, (b) process map, and (c) fishbone diagram.

is 99.7% injury-free. While three sigma is commendable, companies are still incurring lost-time injuries at a rate of 3 per 1000 employees. Three-sigma control addresses "what we do" in the workplace.

Four Sigma Control: 'What We Believe'

Beginning in 1979, Dan Petersen teamed up with Charles Bailey to develop a comprehensive and statistically validated safety perception survey on behalf of the U.S. rail industry.[6-8] Today, the survey system is used to audit an organization's safety culture and identify perception gaps across 20 categories, cross-tabulated by management, supervisors, and front-line employees. The self-administered questionnaire includes 73 questions and provides companies with a statistically reliable method to answer the questions, "Where do our people believe we are weak?" and "Where do they agree and disagree?" Today's safety perception survey results can be compared with a database that combines more than two million respondents. It's a tool that provides statistically valid data for industry-wide comparison analyses.

The survey system breakthrough added an important dimension to pinpoint opportunities. Not only does it identify safety shortcomings, its implementation is recognized as an invaluable "buy-in" mechanism to set the stage for continuous improvement work teams—a necessary component to reach four-sigma control: 99.97% injury-free. Four-sigma control concentrates on the nonobservable "what we believe" in workplace safety.

Five and Six Sigma Control: 'How We Engage and How We Lead'

The next challenge is to utilize the data in the previous four levels of safety:

- The fundamentals: injury and work order data
- Observable processes
- Accountabilities of what we do
- Information on what we believe from a safety perception survey

The material from these four safety databases needs to be applied in a rapid, accurate, and functional way. Once a company is nearing four sigma, the major barriers to effective cross-functional continuous improvement are eliminated. A roadmap can be developed to an unprecedented five-sigma (99.997%) and six-sigma (3 injuries per 1 million employees) safety performance. At this point, an organization can approach a virtual zero-injury workplace.

Action Item Matrix

Item Number	Task to be Accomplished	The Team	The Date	Comments
Each item on the list is numbered. As items are completed, they are moved to the bottom of the list. This provides a record of what the team has completed, as well as what still needs to be accomplished.	This is a simple, succinct statement of the issue. Each task or action item is a small, manageable portion of the larger project scope.	The list of volunteers who have agreed to accomplish this action item. Each item may have one or more volunteers—or in some cases none, if the assignment is not ready to be worked on.	This indicates the next report date for the task team on this action item. It may be a completion date, a progress report date or other target date.	This field holds information pertinent to the action item (e.g., "awaiting vendor quote").

As in a Six Sigma quality program, all the foundational mechanics—engineer–educate–enforce, observe, investigate, accountability principles, and thought patterns—are necessities to establish an authentic Six Sigma safety culture. The challenge is to create a sustainable safety culture where heightened safety decisions occur without any thought. It's a process that begins by addressing the milestones to continuously improve.

Good data are necessary. However, to achieve four-sigma performance and beyond, safety professionals need to implement a similar approach to what zero-error quality cultures use in manufacturing. That's why the next two critical success factors to establish a zero-injury safety culture require continuous improvement teams to "own" and implement the following:

- A regular, sanctioned meeting system with actionable rules and mechanisms and trained leaders to manage the continuous improvement process in safety; and
- Six Sigma analytical techniques/tools with safety issues and projectible data.

Once these critical success factors are in place, a zero-error safety culture can be a recognized strength alongside the traditional business necessities of customer service, quality assurance, and manufacturing efficiencies. The resulting savings in both cost and hardship can be dramatic.

SIX SIGMA TOOLS IN THE WORKPLACE

Five- and six-sigma injury control requires statistical process control tools, a dedicated continuous improvement (CI) team, and active participation from all levels of employees. This latter component emphasizes the importance of effective meetings. Organizing effective "subteams" to execute tasks is essential. Furthermore, because many of the subteams combine cross-functional employees from disparate groups, it is critical to delineate proven principles to create a meeting structure that ensures efficiency, participation, action, and high performance.

Effective Meetings for Continuous Improvement

To achieve results from safety meetings, the person who calls the meeting must focus on its purpose and desired outcomes. By deploying the POP model—purpose, outcomes, process—the group can remain focused and on task.

Task: Define Machine Operator Role

Definition

The key safety accountabilities of the operator are to use safe work practices, use all safety equipment when required, and promote safety with coworkers.

Responsibilities

1) Before each shift, inspect/check the work area to identify any unsafe issues and correct or initiate corrective action as needed.
2) Perform daily housekeeping duties to keep/maintain work area in a safe and clutter-free condition.
3) Attend and participate in all shift supervisor safety meetings.
4) Team with the supervisor to present/discuss topics in the supervisor safety meeting (two to four per year).
5) Initiate and follow up on safety work orders.
6) Provide appropriate safety and health training to new/transferred personnel.
7) Review and improve job hazard analyses regularly.
8) Be familiar with all documents in work area.
9) Pay attention to coworkers and outside personnel working in the area. If they are not following proper practices or procedures, talk with them immediately about correcting their activities.
10) Inspect containers to ensure that they are labeled correctly. If not, relabel them immediately.

Measures of Performance

1) Appraisal by supervisor of individual task achievement.
2) Observations by supervisor.

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Purpose

The purpose is a mini-mission statement. Why is the group meeting? If the purpose is unclear, start with an open-ended question, "What is our purpose for this meeting?" If necessary, record responses on a flipchart until agreement is reached. Subsequent meetings of this same group need to restate the purpose and make sure it remains on target. If the meeting starts to wander or branch into a tangent, ask whether the current topic is "on purpose." A typical safety purpose may resemble a statement such as, "Develop safety accountabilities for all levels of the organization that will help eliminate injuries."

Outcomes

What will be accomplished when the stated purpose is achieved? This is a brainstormed list of the issues that the meeting is designed to address. It is also the metric for whether those tasks have been accomplished. The whole team or group participates in setting these outcomes and, therefore, seeks complete agreement as to definitions of success. Not only will this eliminate future differences, it also helps eliminate discussions that stray from the desired outcome. A typical set of outcomes for a safety team might be: accountabilities that make a difference in safety for every job in the facility; a tracking system to follow accomplishment of these accountabilities; a reward system that reinforces these activities; and reduced injury frequency as a result of doing this work well.

Process

How will the purpose and outcomes be accomplished? What typically follows is a description of how the team will work. Often, it is divided into small problem-solving groups that include volunteers to accomplish small tasks. Why volunteers? When people get to place themselves in performance zones where they are comfortable, they are more likely to succeed. Conversely, quick delegation can lead to having the wrong people assigned to the wrong task. If there are not enough volunteers to perform all the work in the time allotted, time or resources (or both) may need to be increased. One distinction must be remembered throughout: This is not a crisis team; it is an improvement team that fosters the continuous improvement process.

Action Item Matrix

In many cases, a significant number of tasks need to be completed by various people in varying time frames. To effectively manage this wide spectrum, it is best to use an action item matrix (AIM), which is a simple five-column spreadsheet (see "Action Item Matrix" sidebar on page 9).

At this point, the team has its assignments, the POP statement and its progress-tracking mechanism, and the AIM. How often should the team meet? The whole team meets every two weeks, with the task or subteams meeting more frequently as they are problem-solving units. More-frequent whole team meetings do not allow the subteams enough time to complete their tasks and are an inefficient use of time. Less-frequent meetings do not create the needed sense of urgency.

Using an actual case study as an example, an entire safety program was developed in less than nine months using this meeting process.[9,10] Hourly and salaried employees applied these guidelines for all 20 safety perception survey categories. Although the impact cannot be entirely attributed to the team initiatives, the number of serious injuries dropped by more than 80% over the course of two years.

EFFECTIVE TASK FORCES

How are task forces created? How are tasks ranked? The answers are summarized in the following process:

- Start with an AIM.
- Supervisors trained in CI techniques can generally lead up to two CI teams of three to 10 people while still performing their normal work tasks.
- Attempt to enlist only volunteers so people assign themselves to tasks they want to pursue and are willing to make the time to complete.
- Implement only short-term, 90-day teams that have effective facilitation, leadership, and closure.
- If those three characteristics are not achievable, then the teams should not be initiated. The shortsighted approach of trying to "do everything for everybody right now" will only lead to frustration.
- Have teams meet every two weeks to reconnect on a regular basis. The time between meetings can be increased to three weeks, but the groups should not meet more often than every two weeks. Subteams should meet as necessary to test, discuss, and resolve problems. The "Task" sidebar on page 9 provides an example of hourly employee safety accountabilities developed through this process. This process can be used in each of the 20 safety perception survey categories.

CASE STUDY

The case study that follows shows how Six Sigma continuous improvement tools were used to turn around a munitions manufacturing site faced with recurring environmental challenges. Learn how simple process control approaches helped the company transform its culture by giving equal emphasis to production, profits, and vigilance for environmental safety. **em**