Continuous Improvement

Six Sigma

Problem-solving techniques create safer, healthier worksites

By Jack B. ReVelle

THIS ARTICLE BRINGS TOGETHER two important topics: safety and six sigma. While most readers understand many aspects of environmental health and safety, few are equally conversant and comfortable with six sigma as an organizational philosophy, problem-solving methodology and breakthrough strategy. This article defines six sigma; explains how it is used as a performance measure to assess levels of quality and safety; discusses its application to create safer, healthier worksites; identifies key six sigma tools; reviews special skills needed by "black belts" to achieve six sigma and the roles they play in making the process work; details the personal commitment needed from SH&E managers; and suggests what needs to be done to accelerate the culture change necessary to ensure six sigma success with respect to the SH&E function. The article concludes with success stories detailing how some well-known organizations have converted six sigma from its original focus on manufacturing processes to include considerable emphasis on employee, customer and supplier safety and health.

When integrated as a breakthrough strategy initiative, six sigma will do more than just support significant improvement in manufacturing and transactional processes; it will also provide a managerial methodology that delivers vastly improved safety- and health-related processes. Like every organizational process, SH&E has undiscovered opportunities for improvement. In fact, issues relative to the safety and health of employees, customers and vendors are paramount in addressing process improvement.

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Process improvement (PI) is a disciplined methodology for understanding, analyzing and continually improving business processes, capabilities and procedures; the objective is to meet or exceed customer desires while minimizing safety and health hazards to which employees, customers and vendors are exposed. The sidebar on pg. 39 ("Process Improvement Definitions") offers some key PI definitions [ReVelle(b); Brassard, et al].

PI uses structured, graphical techniques for data collection, analysis, measurement and management support to achieve better solutions, such as increased return on investment (ROI), reduced accidents, fewer health hazards and increased employee satisfaction. The sidebar on pg. 39 ("Levels of Data Analysis") introduces a range of levels for process data analysis. Readers are encouraged to locate their organization (large or small) within this range. For those not pleased with the conclusion, this article provides some guidance regarding what needs to be done.

What Is Six Sigma?

For more than 20 years, a growing number of organizations—both for-profit and not-for-profit—have been adopting six sigma as their primary PI initiative [Breyfogle; Harry and Schroeder; Pande, et al(a); (b)]. The philosophy of six sigma is to employ a financially focused, highly structured approach to PI decision making using current, valid performance metrics. The sidebar on pg. 40 ("The Many Facets of Six Sigma") lists its many facets, while Figure 1 (pg. 40) graphically depicts the differences between low-sigma and high-sigma processes. In this context, USL and LSL represent the upper- and lower-specification limits, respectively.

Many organizations benchmark to compare their own processes to similar processes of other successful organizations. Six sigma benchmarking begins with process baselining to create a starting point for improvement. Ultimately, achieving a six sigma capability yields a maximum process accident rate of about 3.4 occurrences per million accident opportunities. Table 1 (pg. 41) depicts how sigma levels relate to parts per million (ppm) levels. As the table shows, a two sigma process (left-hand column) is equivalent to 308,538 ppm (right-hand column). On the other end of the spectrum, six sigma equates to a mere 3.4 ppm. With respect to safety, SH&E professionals must strive to prevent all incidents that lead to injuries and illnesses. Using six sigma tools is an effective way to move more rapidly toward that goal [Brassard, et al; Breyfogle; Harry and Schroeder; Pande, et al(a); (b); ReVelle(b)].

A breakthrough strategy is a thoroughly researched, well-planned series of interrelated steps designed to guide an organization to a much higher level of achievement. The six sigma strategy is a totally defined, carefully executed methodology for characterizing, then optimizing any transactional (business) or industrial process (Figure 2, pg. 41) [Breyfogle; Harry and Schroeder; Pande, et al(a); (b)].

Six Sigma: A Perspective

Six sigma can be viewed as a drill-down from an organization's statements of its mission, vision and values to a methodical strategy that achieves quantified, organizational goals and objectives according to a preplanned schedule. Six sigma focuses on achieving documented increases in return on investment) by:

- improving employee satisfaction;
- reducing cycle time and variation;
- improving workplace safety and health;
- targeting six-sigma-level quality;
- improving process capability and yields;
- measuring accurately and constantly;
- improving processes continuously;
- defeating the competition;
- gaining marketshare;
- improving operating income.

Six sigma objectives are directly and quantifiably connected to the objectives of every organization, large or small [Breyfogle; Harry and Schroeder; Pande, et al(a); (b)].

The drill-down sequence begins with one primary objective of every for-profit organization—to make money. Organizations that have begun PI initiatives recognize the importance of focusing on continuous improvement of all critical processes. This decision leads to the use of the six sigma problem-solving methodology: define, measure, analyze, improve and control (commonly known as DMAIC, pronounced de-may-ik) (Table 2, pg. 42). Once the statistical analysis is complete, results are easily converted to a "sigma level" statement that is used to assess the state of the process with respect to SH&E opportunities [Breyfogle; Brassard, et al; Harry and Schroeder; Pande, et al(a); (b); ReVelle(b)].

For example, suppose a particular process is identified as being critical using organization-specific criteria. Review of the company's OSHA Form 300 reveals that during 2003, a total of three recordable accidents were associated with this process. Since the process is worked by three employees for two eight-hour shifts five days a week for 50 weeks a year, this amounts to 3 x 2 x 8 x 5 x 50 = 12,000 work-hours per year. The following calculation would be used to determine the OSHA accident rate per 200,000 workhours:

$$\textbf{Accident Rate} = \frac{3}{12{,}000} = \frac{x}{200{,}000}$$

However, to determine the sigma level for the same accident rate, a similar calculation would be performed, based on 1 million workhours (i.e., accident opportunities) as follows:

$$\textbf{Accident Rate} = \frac{3}{12{,}000} = \frac{x}{1{,}000{,}000}$$

As Table 1 indicates, 250 accidents (parts) per million (ppm) opportunities (also known as defects per million defect opportunities, or DPMO) is a sigma level of about five—where six is considered to be world-class performance. The sidebar on pg. 42 ("Why 99") futher clarifies this concept.

Applying Six Sigma to Create Safer, Healthier Worksites

How can this problem-solving methodology be used to identify where attention should be focused in order to create safer worksites (Figure 3, pg. 43)? Using process maps, select critical process points, (i.e., where and/or when a significant potential for accidents and/or health hazards are known to exist), yet have never been sufficiently addressed to eliminate or significantly reduce them. Based on OSHA Form 300 records, determine the ratio of the frequency of actual accident/hazard exposure occurrences to the number of potential accident/hazard exposure opportunities for each critical point on the process maps [ReVelle(c)].

In the next step, convert all critical process point ratios to accidents (parts) per million opportunities and use a sigma conversion table to transform the ppms to sigma levels (as previously discussed). Next, rank order the critical process points from the least value of sigma to the greatest value. Using a "worst first" approach, process improvement is initiated at the critical process points with the least values of sigma (Figure 4, pg. 45).

Six Sigma Tools

A large number of six sigma tools are available, and a major subset of these are especially important because of their frequent use. These tools are used by the process improvement teams (PITs) to achieve their objectives. They can be classified as being either diagnostic (used to find and clarify process-related problems) or prescriptive (used to fix or improve such problems). The sidebar on

Process Improvement Definitions

- A process is a series of sequential, repeatable steps/tasks that have both a beginning and an end, and which results in either a product or a service.
- An accident is an error of omission or commission that occurs just before, during or just after an employee's process involvement.
- An accident opportunity exists whenever or wherever an accident can occur.
- A performance metric is a ratio of the number of accidents reported to the number of possible accident opportunities.
- Metrics can be expressed either as attribute/discrete data (generated by counting) or as variable/continuous data (generated by measuring).
- A process improvement team (PIT) is a trained group of process stakeholders using its project charter as its guide and led either by a six sigma black belt or green belt.

Levels of Data Analysis

Data are derived from counts and measurements. They are used to classify, describe, improve and control elements of processes. Data analysis falls into these levels:

1) The company only uses experience, not data.
2) The company collects data, but only looks at the numbers.
3) The company groups data so as to form charts and graphs.
4) The company uses sample data with descriptive statistics.
5) The company uses sample data with inferential statistics.
6) The company uses six sigma to better understand and significantly improve safety-and health-related processes.

The Many Facets of Six Sigma

- Six sigma is a statistical measurement for process improvement.
- Sigma is used to identify the spread/dispersion of observations around the average/mean of a process.
- Sigma value indicates how often (frequency) accidents* or health hazards are likely to occur.
- Sigma value is a performance metric that indicates how well a specific process is performing. The higher the sigma value, the better the process performance.
- Sigma measures process capability to produce accident-free (zero accidents) and health-hazard-free work.
- Sigma values increase as accident/health hazard rates are reduced. As a result, workers' compensation costs decline, productivity increases and employee satisfaction levels improve.

**An accident is any event that results in harm to an employee, e.g., any temporary or permanent body part damage or loss, any critical-to-quality equipment or machinery failure resulting in its inability to perform its intended function, or any error of omission or commission in job training or instruction.*

pg. 43 ("DMAIC Phases") presents selected tools and their relationships to the five phases of six sigma breakthrough strategy. The "Six Sigma Tools" sidebar (pg. 44) offers brief descriptions for some frequently used tools [Brassard, et al; ReVelle(b); (c); ReVelle and Harrington; ReVelle and Stephenson; Walters)].

Early on, six sigma participants learn that the output of one tool frequently becomes the input to another. For example, when examining attribute (discrete) data, the tallest column in a Pareto diagram (a type of bar chart) is identified as one of the "critical or vital few" and, subsequently, becomes the problem box, i.e., the effect in a cause-and-effect diagram (used for root-cause analysis). The multiple causes identified by the PIT during the cause-and-effect analysis are then rank ordered using multivoting by team members (subject-matter experts). The PIT brainstorms, then multivotes on a brief list of potential interventions. The top two or three vote-getters are quantitatively evaluated using force field analysis (a graphical technique augmented with prioritization) to highlight each intervention's positives and negatives. This results in a rank ordering of the interventions for review by the PIT, which then reaches a conclusion as to its recommended action [Brassard, et al; ReVelle(b)].

Six sigma tools can also be used independently of each other to achieve specific objectives. For example, scatter analysis (also known as regression analysis) is most frequently used to determine the presence and type (positive or negative) of a mathematical relationship between two variables such as human height (an independent variable) and weight (a dependent variable, i.e., weight is dependent on height, not vice versa) [Brassard, et al; ReVelle(b)].

Figure 4 (pg. 45) introduces an unusual application of scatter analysis. In this example, some measure of productivity (an independent variable) such as the number of parts produced per million workhours (PPM) is plotted on the horizontal (x) axis of an L-shaped matrix (the scatter diagram) and some measure of safety (a dependent variable), such as the number of accidents per million workhours (also PPM), is plotted on the vertical (y) axis of the same matrix.

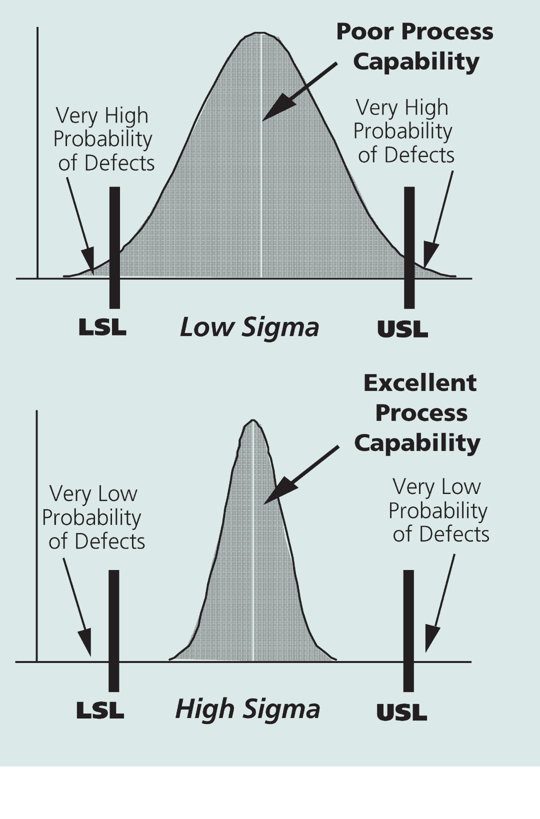
When bivariate data (a pairing of "x" and "y" values) for a single group of employees or a collection of departments is plotted on the scatter diagram just described, each data point will be located in one—and only one—of the five-segment template. Suppose two points are located in segment 5. The persons or departments represented by this point are well-above-average because they have unusually high productivity and extremely low accident rates. The opposite is true for any points in segment 1. Between these two extremes, segments 2, 3 and 4 receive the other persons or departments depending on the magnitude of their "x" and "y" values. Thus, the development of an objective comparison of safety performance is relatively straightforward using this tool.

How to Develop & Apply Six Sigma Skills

Those most involved in the technical leadership of a six sigma initiative are known as black belts. Depending on the source of their technical training, black belts may receive anywhere from one to four weeks of training from certified master black belts. During and following their technical training, black belts must lead major PI initiatives that are expected to yield exceptional results measured in terms of reduced accident and/or health hazard exposure rates, workers' compensation rates, process cycle time duration, process cycle time variation, and/or increased return on investment, return on net assets (RONA) or other established financial measure [Brassard, et al; Breyfogle; Harry and Schroeder; Pande, et al(a); (b)].

Figure 1

Sigma: A Measure of Dispersion



Black belts are highly knowledgeable, seasoned employees who possess detailed understanding of a breadth of critical skills gained through years of experience and training. These skills are threefold; black belts must have personal skills (open-minded, eager to learn new ideas, desire to drive change, self starter and motivated, track record of results); statistical skills (conversant with basic and advanced statistical/probabilistic concepts, regression analysis, root-cause analysis, experimental design, quality function deployment, measurement systems); as well as organizational skills (product and process knowledge, respected, strong interpersonal communications, aware of organizational relationships, team player).

Roles of a Black Belt

By virtue of his/her many process improvement-related responsibilities, the roles of a six sigma black belt are extensive and include the following:

•**Mentor.** Cultivate a network of six-sigma-trained personnel at the local organizational level or site. This will likely include green belts whose training and experience with six sigma is considerably less than that of black belts.

•**Teach.** Provide formal training of local personnel in six sigma breakthrough strategies, methodologies and tools.

•**Coach.** Provide one-on-one support to local trainees and green belts.

•**Transfer.** Share new strategies, methodologies and tools via training, workshops, case studies and local symposia.

•**Discover.** Find application opportunities for six sigma strategies, methodologies and tools, both internal and external (e.g., suppliers and customers).

•**Identify.** Surface business opportunities through company-to-company partnerships.

•**Influence.** "Sell" the organization on the use of six sigma strategies, methodologies and tools [Brassard, et al; Breyfogle; Pande, et al(a); (b)].

The Six Sigma Commitment

Subscribing to the six sigma philosophy requires a four-way commitment:

1) To the organization: Commit to using six sigma to identify what needs to be done and assess ongoing performance.

2) To black belts:

•Provide full-time training effort. The organization must commit to maximize this new process improvement resource, then send the "best of the best" for training.

•Ensure that every division/department participates in the process and trains black belts.

•Provide developmental plans and incentives. Make being a black belt a great career move.

3) To establish a business unit "champion":

•Make sure s/he occupies a key business unit leadership position.

•This individual is responsible for removing barriers and ensures local ownership of PI projects.

Table 1

Sigma Level: PPM Transformation

σ Level	Process Centered	Process Shift = ±1.5s
0.5	617,075 ppm	841,345 ppm
1.0	317,311	691,462
1.5	133,614	500,000
2.0	45,500	308,538
2.5	12,419	158,655
3.0	2,700	66,807
3.5	465	22,750
4.0	63	6,210
4.5	7	1,350
5.0	57 ppb	233
5.5	38	32
6.0	2	3.4
6.5	0.1	0.3
7.0	0.001	0.02

Figure 2

Breakthrough Strategy for Sustained Process Improvement

Define & Measure
What is the baseline safety process capability?

Analyze
When, where and how often do accidents occur?

Improve
How can a safety process capability reach a six sigma level? What are the vital few factors?

Control
What controls will be established to maintain the gain?

Table 2

Six Sigma 12-Step Process

Phase	Step
Define and measure	1) Select product or process critical to quality characteristics.
	2) Define performance standard.
	3) Validate measurement system.
	4) Establish process capability.
Analyze	5) Define improvement objectives.
	6) Identify variation sources.
	7) Screen potential causes for change and identify the vital few.
Improve	8) Discover variable relationships between vital few.
	9) Establish operating tolerances on vital few.
	10) Validate measurement system for vital few.
Control	11) Determine ability to control vital few.
	12) Implement process control system on vital few.

Why 99 Percent Good Isn't Good Enough

When things are reduced to numbers, the focus is made clear. A practical meaning of "99.9 percent good" equates to the following:

- 18,000 lost articles of mail every hour
- 15 minutes each day of unsafe drinking water
- 5,000 incorrect surgical procedures per week
- 2 or more accidents per day at major airports
- 20,000 wrong drug prescriptions each year
- 7 hours each month without electricity

3 Sigma Capability

- 93.32 percent (historical standard)

4 Sigma Capability

99.38 percent (historical standard)

6 Sigma Capability

99.99966 percent (world-class)

4) To provide leadership that demonstrates commitment in every way:

- Use the six sigma problem-solving process as a strategic weapon to delight internal and external customers.
- Keep enthusiasm at a high pitch.
- Provide resources.
- Motivate, reward and celebrate successes.

Accelerate the Change Process

A leader within an organization can take various steps to accelerate the change process.

- Get involved. Work with black belts to mobilize commitment across the entire organization. Make the changes a permanent part of the organization's culture.
- Identify and remove barriers to the change process.
- Ensure that only top personnel are nominated for black belt training.
- Ensure full support is present during all phases of six sigma (DMAIC).
- Ask black belts many questions to ensure they are focused on the right things.
- Encourage follow-up and monitoring of activities.
- Carefully select high-impact projects.
- Be proactive. Motivate and ensure that the change process is real.
- Be familiar with and involved in every project as much as is appropriate.
- Make six sigma reviews a regular part of the management process.
- Celebrate successes and recognize accomplishments [Breyfogle; Harry and Schroeder; Pande, et al(a); (b)].

Six Sigma Implementation

The following hypothetical Q&A examines key details for those relatively new to the six sigma process [ReVelle(d)].

Question: It sounds as though six sigma is geared to large organizations. Can small businesses benefit from six sigma?

Answer: Any organization, regardless of size, can benefit from six sigma. The process will improve programs designed to manage SH&E, quality, customer satisfaction, finances and more. The keys are commitment and follow through.

Question: What if senior management does not use or subscribe to six sigma?

Answer: The entire organization is not needed to kick off a PI initiative. In fact, some organizations have found that it is better to engage just one or two departments as prototypes to prove the value and "fit" of the initiative. This requires fewer resources and takes less time.

Question: What resources—time, people and money—are required to develop a lasting commitment to six sigma?

Answer: Once six sigma has been accepted as a philosophy, a problem-solving methodology and a breakthrough strategy, enlightened management will recognize and accept it as an investment in its future, not just another expense. Most organizations that implement six sigma achieve most goals and objectives within two to three years. They realize breakeven on their personnel and financial investments, as well as reduced accident rates and workers' compensation rates. Yes, larger organizations invest more than smaller organizations, but their returns are proportionately greater.

An Example

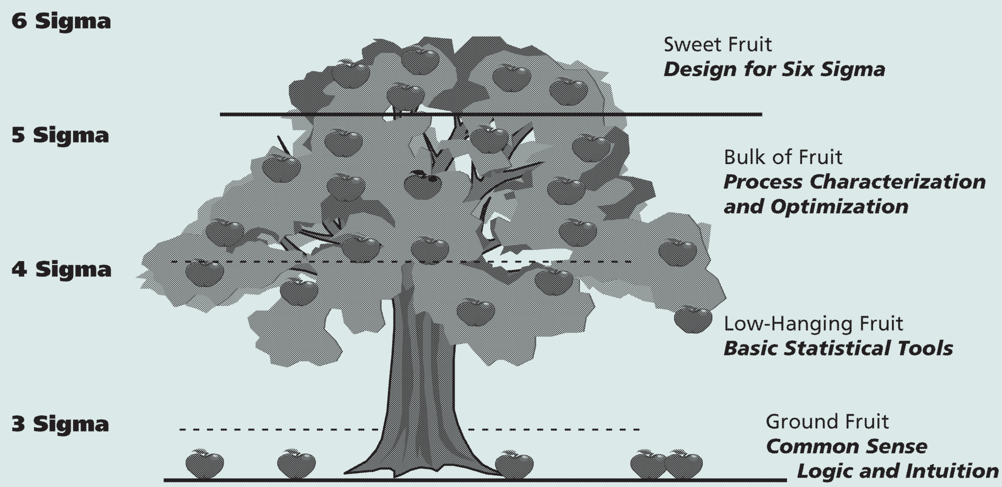
Working with an existing client in early 2004, the author provided technical assistance to the client's

Trade Accident Prevention-Process Improvement Team (TAP-PIT). The client (a regional homebuilder) requested that the author demonstrate how to effectively apply six sigma tools to substantially reduce their subcontractors' (trades') reportable accidents. In response, the author introduced a team of the client's executives, some of whom were already familiar with the tools noted to Figure 5 (pg. 45).

Figure 5 is a process flowchart that presents 16 numbered steps. Except for five steps (1, 4, 14, 15 and 16), each includes the particular tool most appropriate to effectively and efficiently complete that step. With respect to the first step, the client was advised to invite sufficient subcontractors to ensure that they represented at least one-half to two-thirds of the TAP-PIT membership. Recall the five phases of six sigma: Define (D), Measure (M), Analyze (A), Improve (I) and Control (C). The letters noted in each step in Figure 5 identify to which of the five DMAIC phases each step contributes.

Figure 3

Six Sigma Rewards



We don't know what we don't know.
We can't act on what we don't know.
We won't know until we search.
We won't search for what we don't question.
We don't question what we don't measure.
Hence, we measure or we just don't know.

Success Stories

Many companies—including Honeywell, Dow Chemical, DuPont, General Electric (Health and Safety as well as Transportation Systems) and Bechtel Jacobs—have adopted six sigma as a primary focus in their efforts to reduce safety and health hazards. The facts regarding these case studies are widely available on the Internet, and relevant websites are cited (in the references) for each company for those interested in learning more.

Honeywell International

At Honeywell International's corporate headquarters, a safety improvement team used Pareto analysis to identify 25 worksites with the greatest potential for reducing medically reportable safety cases and lost workdays (Honeywell). "Pareto analysis is a sorting process whereby you look for and sort by various trends and attributes," says Danny Reese, corporate director, safety and industrial hygiene. "It helps you understand where your various problems might be." Other six sigma tools were used to identify causes and effects of injuries at each site. As a result, the team reduced reportable cases at the sites by 43 percent and lost workday cases by 50 percent in 1999.

The safety team also created an intranet-based tool kit that can be used by teams at every Honeywell location. The team's initiatives resulted in a 33-percent improvement in global safety performance and $1.4 million in productivity improvements in 1999. Honeywell's safety strategy involves a disciplined, multistep process that helps to answer several questions:

1) How effective are current safety processes?

2) How can those processes be improved?

3) What are the barriers to making these changes?

4) Which of the initiatives will have the greatest impact?

5) How will gains be achieved and maintained?

Dow Chemical

Beyond manufacturing applications, organizations use six sigma to optimize nonmanufacturing

DMAIC Phases & Relevant Tools

Define
Brainstorming, affinity analysis, multivoting and process mapping.

Measure
Tally sheet, Pareto analysis, histogram, scatter analysis and statistical control charts.

Analyze
Cause-and-effect analysis, force field analysis and prioritization matrix.

Improve
Design of experiments, probability distributions and simulation.

Control
Assignments matrix plus all of the above.

processes such as accounts receivable and sales, as well as safety and health. For example, Harvard Business School's Working Knowledge reports that Dow Chemical estimates the application of six sigma to its environmental health and safety services has saved the company $130 million in a recent two-year span (Dow; Nielsen and Orshal).

In its annual Dow Global Public Report, the corporation announced that "a significant percentage of our six sigma projects are directed at delivering improved performance in environmental health and safety, including personal safety and waste reduction."

According to JMP, a producer of statistical software used to support six sigma projects, one of Dow's great successes occurred in the automotive industry. A six-sigma-designed experiment was used to develop a statistical model that enabled automobile manufacturers and their first-tier suppliers to make automobiles safer (JMP).

DuPont

At DuPont, many of the 4,000 completed or current six sigma projects have resulted in reduced environmental impact or increased safety. For example, at a U.S. plant, a six sigma project is credited with saving 50 billion British Thermal Units (BTUs) by reducing the amount of purchased steam unnecessarily condensed and lost to drainage. At a site in the People's Republic of China, a project helped reduce electricity consumption and, therefore, carbon dioxide emissions. Another major project focused on ways to reduce soft-tissue injuries and illnesses companywide (DuPont; Holliday).

General Electric

General Electric's global focus on improving SH&E programs has shown great results in recent years with injuries decreasing more than 60 percent since 1996. "That means almost 5,000 fewer employees have suffered an injury or illness at work since 1997," says Kurt Krueger, GE's health and safety manager and a team leader for Corporate Environmental Programs [GE(a)].

Under the GE Health and Safety Framework Scorecard program, 21 specific elements are measured and systematically improved using the six sigma methodology, including job safety analysis, accident reporting and contractor health and safety, as well as employee involvement.

Another GE organization, GE Transportation Systems, recently improved its entire SH&E program in Contagem, Brazil, and was able to achieve a 25-percent reduction in its recordable injury rate [GE(c)]. The program's success is attributed to the use of six sigma. "What we've been able to achieve is just incredible," says Robiana Gomes, an EHS leader and a six sigma green belt at GE Transportation Systems. "Nine

Six Sigma Tools

Benchmarking. Search for best practices that lead to superior performance by an organization.

Cause-and-effect diagram. Structured form of brainstorming that graphically shows the relationship of causes and subcauses to an identified effect (problem).

Control chart. Chart showing sequential or time-related performance of a process that is used to determine when the process is operating in or out of statistical control, using control limits defined on the chart.

Force field analysis. List identifying promoting and inhibiting forces that must be overcome before opportunity/problem lists can be built or effective solutions can be implemented.

Histogram. Specific type of bar chart that illustrates the frequency distribution of a series of measurements of continuous (variable) data.

Multivoting. Structured series of votes by a team that reduces a list containing a large number of items to a manageable few.

Pareto diagram. Type of bar chart prioritized in descending order from left to right, distinguished by a cumulative percentage line that identifies the vital few opportunities for improvement.

Process flowchart/map. Chart symbolically shows the input from suppliers, the sequential work activities and the customer output. Map also shows handoffs of products/services from one function or person to another.

Prioritization matrix. Designed to guide a team through a logical reduction of available options to identify the one "best" choice. Reduction process is based on a set of weighted criteria pre-established by the team. Uses an L-shaped, two-dimensional matrix format.

Randomization. Procedure used to minimize risk associated with biases due to undetected or uncontrollable causes within inspections and experiments.

Sampling. Taking a random sample of units, portions of material or observations from a larger population of the same provides a valid basis for making decisions concerning the larger quantity.

Scatter analysis. L-shaped, two-dimensional graph used to determine the extent to which two types of data may be related as well as the orientation of the relationship.

Tally sheet/data table. Data collection form designed to ensure a consistent, effective and economical way to gather, organize, analyze and display data. User-friendly tally sheets are key to successful data gathering.

Trend/Run chart. Line graph for the study of data over some specified period of time. After observations have been made and the associated data have been recorded, data points are plotted and connected to locate possible trends.

months ago, we didn't have a consistent environmental, health and safety program. So, we implemented 21 projects to support this initiative. The projects involved teams in manufacturing and engineering as well as health and safety—and brought direct benefits to customers, the environment, contractors and our employees."

GE Medical Systems' (GEMS) Healthcare Services division helps healthcare facilities implement six sigma projects in an effort to significantly reduce errors, promote efficiency and provide better patient care. Three examples are GEMS' agreements with the Yale-New Haven Hospital in New Haven, CT; North Shore-Long Island Jewish Health System in Bay Shore, NY; and Virtua Health, a community hospital healthcare system in Mount Holly, NJ [GE(b); Van Kooy, et al).

Bechtel Jacobs

Bechtel Jacobs Co. LLC, the management and integration

Figure 4

Safety Performance Assessment Using Scatter Analysis Technique

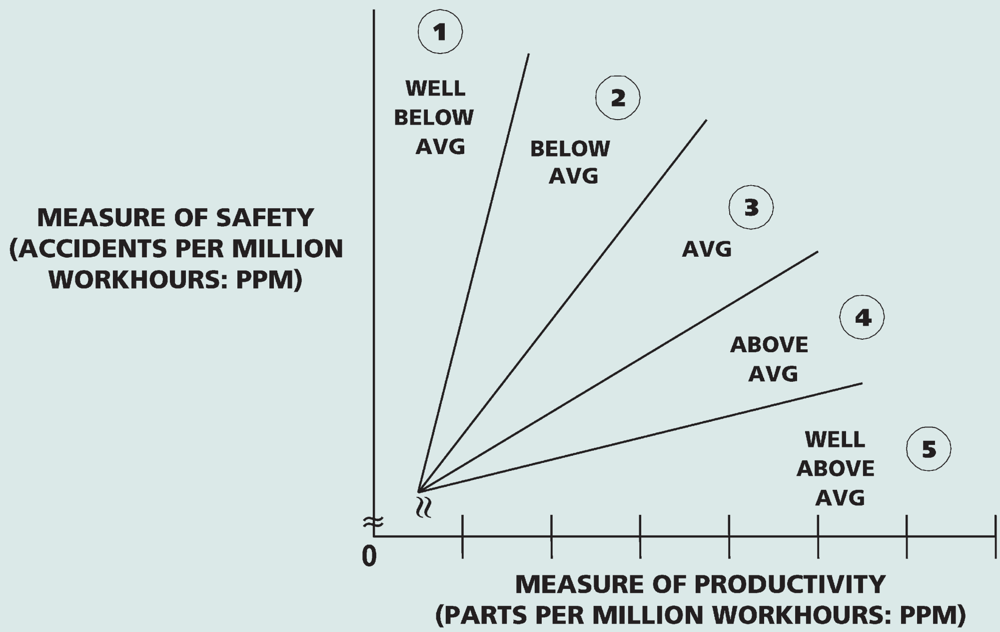
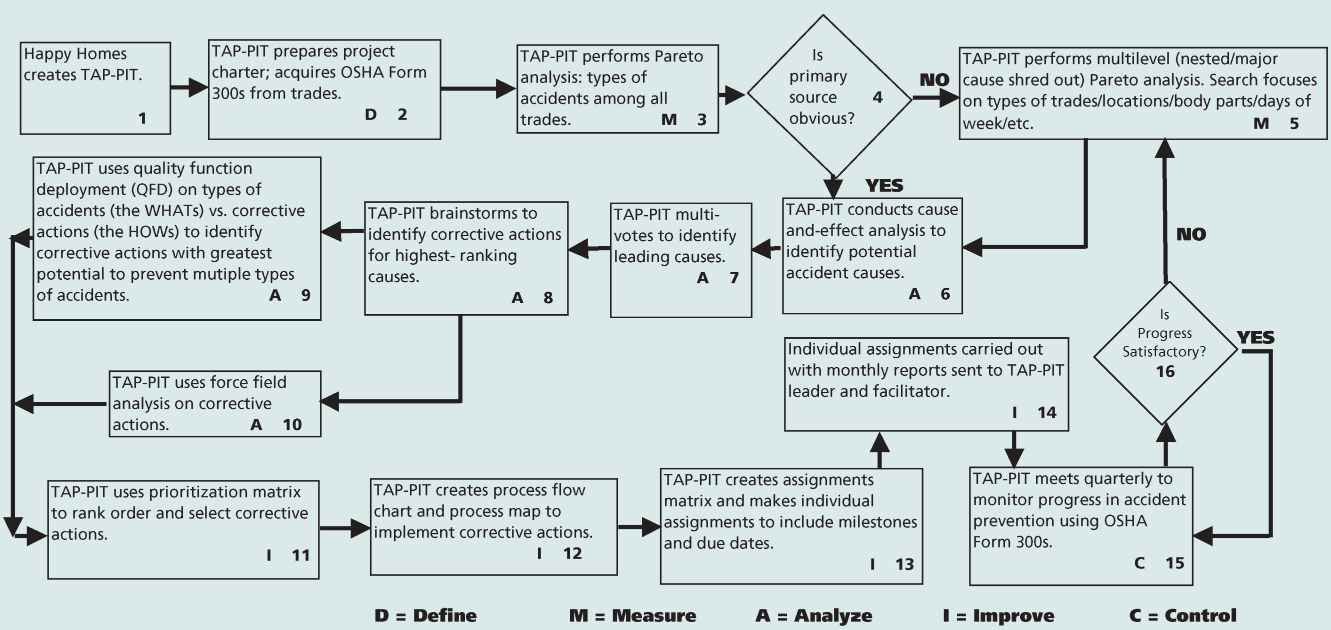


Figure 5

Happy Homes Trade Accident Prevention/ Process Improvement Team (TAP-PIT)



contractor for the Dept. of Energy's (DOE) Oak Ridge Operations Environmental Management program, used six sigma methodology to address an undesirable trend in industrial safety performance. The improvement team selected the DOE cost index value as the metric to indicate overall industrial safety performance. As a direct result of applying the DMAIC problem-solving methodology, a savings of some $297,000 was achieved from June to November 2001, with an expectation of further savings of $764,000 in FY2002. Costs for identifying problem areas as well as developing and installing improvements was $50,000, but other implementing sites did not incur all of these costs since the overall framework and required training materials used in some improvements had already been developed (Allen and Stevenson).

Texas A&M University

Educational institutions have recognized the value to applying Six Sigma to achieving OSHA's Process Safety Management (PSM) standard. Three members of the Process Safety Center, a part of the Chemical Engineering Dept. at Texas A&M University have written a 16-page document that thoroughly describes the important relationship between PSM and six sigma (Keren, et al).

Conclusion

Six sigma, with its 20-year history of successful problem solving and data analysis in business and industry, has tremendous potential for helping occupational safety and health professionals reduce accident rates and health hazards. The onus is on SH&E professionals to learn about this strategy in order to ensure that its potential for improving workplace safety and health is maximized. This article is just the beginning of an important journey. Based on results experienced to date, applying six sigma within the SH&E function will lead to fewer accidents and health hazards—both inside and outside an organization. ■

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