IMPROVE SAFETY, HEALTH, AND ENVIRONMENTAL PROTECTION THROUGH THE INTRODUCTION OF SIX SIGMA

By

Thomas L. Kaliher

A Research Paper

Submitted in Partial Fulfillment of the
Requirement for the
Master of Science Degree
With a Major in

Risk Control

Approved: 3 Semester Credits

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Investigation Advisor

The Graduate School
University of Wisconsin-Stout
May 2003

The Graduate School

University of Wisconsin Stout

Menomonie, WI 54871

ABSTRACT

Kaliher Thomas L
(Last Name) (First Name) (Initial)

Improve Safety, Health, and Environmental Protection Through the Introduction of Six Sigma
(Title of Thesis)

Risk Control
(Graduate Major)

Dr. Elbert Sorrell May/2003 61
(Research Advisor) (Date) (No. of Pages)

American Psychological Association, 5th Ed.
(Manual Style)

The primary objective of this study was to evaluate the impact of implementation of a Six Sigma program on a company's safety, health, and environmental protection performance. The review of literature included the evolution of safety health, and environmental protection; the evolution of management; the background of Six Sigma; the Six Sigma problem solving process; and the application of Six Sigma to safety health, and environmental protection. An interview guide was used to collect data related to the effects of the integration of Six Sigma on the safety, health, and environmental protection of the company. The findings resulting from the interview questions imply that Six Sigma can be effective in improving a company's safety, health, and environmental

protection. Finally, the paper offers some conclusions and recommendations concerning the connection we can make between Six Sigma and safety, health, and environmental protection. There is a connection we can make between Safety and Six Sigma. Six Sigma is a team-based approach to problem solving. Today's safety professional should move beyond the standard reactive measurements of safety performance. Six Sigma provides the process for the development of a safety, health, and environmental protection performance measurement program by establishing well-defined performance measures, identifying all areas of performance, and documenting procedures for implementing the program.

ACKNOWLEDGEMENTS

I would like to thank my friends, especially Mike Sorensen, for their support during my pursuit of this degree. I would also like to thank the Risk Control staff, especially Mary Fandry, her assistance and upbeat attitude have been an inspiration. In addition, I would like to give a special thanks to my advisor, Dr. Elbert Sorrell, whose assistance has been invaluable.

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CHAPTER ONE

STATEMENT OF THE PROBLEM

Introduction

As a result of changes in management philosophies brought on by introduction of concepts such as "Management by Doing, Management by Directing, and Management by Results" (Joiner, 1994, p. 8 – 9), management changed its relationship with the workforce. No longer did workers react to orders from management. The workforce became an active participant in decision-making. As a result of these concepts, many changes took place in organizations. Some turned to Total Quality Management (TQM).

The programs that institutionalize the drive for continuous improvement included both TQM and Six Sigma. According to Cole (1999), TQM was conceived not as a specific technique or tool, but as a framework within which one can place an evolving set of tools. Mahoney and Thor (1994) believed TQM was a comprehensive management improvement philosophy. Jordan and Michel (2000) suggested continuous improvement was the same as improving quality. Breyfogle, Cupello, and Meadows (2001) defined Six Sigma as , "…a team-based approach to problem solving and process improvement." (p.225)

While these process improvement techniques were designed for quality, through process reviews, management realized that safety, health, and environmental protection were an integral part of the management system. Breyfogle et al. (2001) believed the mindsets management adopted represented an awareness that was evident in successful businesses.

The many principles and techniques that concerned managing for high quality with low waste have now begun to gel into a management framework that Joiner (1994) called "4th Generation Management" (p. 7). According to Breyfogle et al. (2001), fourth generation managers care about results, but know that better results can reliably be obtained only through fundamental improvement. They manage the organization as a system, developing process thinking, base decisions on data, and understand process variation. Contributors to this new consciousness include Peter Drucker (1992), Dan Petersen (2001) and Joseph M. Juran and Gryna (1976).

The potential financial devastation caused by the costs associated with accidents necessitates the adoption of process improvements in the areas of safety, health, and environmental protection. Integration of safety, health, and environmental protection into the company's management improvement process can result in continuous improvement in processes that will reduce human losses, financial losses, and material losses.

Purpose Statement

The purpose of the study was to evaluate if the implementation of Six Sigma at company X improved their safety, health, and environmental protection performance.

Research Questions

This study provided answers to the following questions:

1. How does the Six Sigma program affect the safety, health, and environmental protection performance of organizations?

2. What criterion was used to evaluate the safety, health, and environmental protection performance of the organization interviewed for this study?

3. How were safety, health, and environmental integrated into Six Sigma programs?

Background and Significance

According to the October 7, 2002 press release from the National Safety Council, "there were 5,300 workplace fatalities due to unintentional injuries and 3.9 million disabling injuries last year" (p. 1). When the average cost of wages and productivity losses, medical expenses, and administrative expenses as determined by the National Safety Council (2002) are considered, workplace fatalities cost 5.4 billion dollars and disabling injuries cost 113 billion dollars. Companies must consider these costs.

The costs related to accidents can potentially devastate a company. The potential financial devastation caused by the costs associated with accidents necessitates the adoption of process improvements in the areas of safety, health, and environmental protection. Integration of safety, health, and environmental protection into the company's management improvement process can result in continuous improvement in processes that will reduce human losses, financial losses, and material losses.

Definition of Terms

The following definitions were used in this study:

- Benchmarking is the "world's best" standards against which managers and their organizations are to be judged across all activities" (Hilmer & Donaldson, 1996, p. 107).
- Control chart is used to help analyze, sustain, and monitor the current levels of performance stability or predictability of a process and to identify key issues for problem solving or root cause analysis. Control charts have three main elements:

a center line, usually the average of all of the data points; an upper control limit UCL), and a lower control limit (LCL) calculated from the data" (Arthur, 2001)

- Paradigm is the model of thinking that represents the ideas considered to be true and best, the theories and knowledge that direct policies and actions. (Adams, 1995)
- Pareto chart is the graphical technique used to quantify problems so that effort can be expended in fixing the "vital few" causes, as opposed to the "trivial many" (Breyfogle, Cupello, & Meadows, 2001, p. 249).
- Safety metrics is a system of tools and techniques that allows safety managers to measure safety performance with the same quantitative precision as other indicators of an organization's productivity. (Janicak, 2003, p. xvii)
- Sigma: The Greek letter sigma, σ, is used to express the standard deviation of a process. Standard deviation measures the variation or amount of spread about the process average. Sigma quality level is sometimes used to describe the output of a process (Breyfogle, Cupello, & Meadows, 2001, p. 6)
- Six Sigma: "A term coined by Motorola that emphasizes process improvement by reducing variability and making general improvements…A Six Sigma quality level is said to equate to 3.4 parts per mission outside specification limits" (Breyfogle et al., 2001, p. 250).

Assumptions

The following assumptions were made in the study:

1. The people interviewed have an in depth knowledge of Six Sigma process improvement.

2. The perceptions of the people interviewed are representative of the organization.

Limitations

This study is limited by the following:

1. Determining the effectiveness of a management program can be subjective.

2. A small sample (one company interviewed) may not be representative of all companies that employ Six Sigma.

CHAPTER TWO

LITERATURE REVIEW

Introduction

The purpose of this literature review was to survey literature relevant to this study. In particular, the review covered the evolution of safety, health and environmental protection; evolution of management, Six Sigma, and application of Six Sigma to safety.

Evolution of Safety, Health and Environmental Protection

This portion of the review examines the evolution of safety, health and environmental protection. Grimaldi and Simonds (1984) reminded us that one of the major hurdles to safety progress has been the inclination to rely on common opinions about it. As humanity progressed, people reasoned that whoever caused an injury should suffer an equal harm. Through the sixteenth – nineteenth century (Adams, 1995) the basic law for governing employer liability for worker injuries rested in common law. Three doctrines that were highly beneficial to the employer: fellow servant rule – the employer was not liable for employee injuries caused by the negligence of a fellow employee; contributory negligence – the employer was not liable for accidents due to an employee's negligence; assumption of the risk – the employer was not liable because the employee was aware of all the job risks.

Early History

Grimaldi and Simonds (1984) identified the first legislation to prevent industrial injury as the 1802, Health and Morals of Apprentices Act. Although directed to the safety and health of children, it was the first legislation on behalf of safety. At the same time, punitive compensation for preventable injuries caused by unguarded mining

equipment was provided in England. As a result of the inadequacies in the common law approach to paying injured workers, workers' compensation laws began in Germany in 1885 and in Great Britain in 1897.

Compulsory worker's compensation was established as a no-fault insurance system. It made the employer liable for work-related deaths and injuries, regardless of whether there had been employee negligence. In return for the right to these incontestable benefits, the employees and their families gave up the right to bring suit for damages under the common law. In 1908 (Heinrich, 1959), Congress passed a workers' compensation act providing benefits to federal employees. New Jersey passed the first workers' compensation law in 1911. In 1912 the first estimates of total industrial deaths were prepared. "The estimate was 35,000" (Heinrich, 1959, p. 431). Carriers of workers' compensation insurance, anxious to keep accidents at a minimum, initiated safety inspection services (Adams, 1995).

The role of the American government in the protection movement was exemplified by the number and variety of regulations and laws that have shaped the course of safety, health, and environmental protection concepts. Since 1887, the federal government, through the Interstate Commerce Commission, has exercised regulatory powers over the transportation of passengers as well as hazardous materials.

According to Adams (1995), "the failure of safety professionals to gain universal acceptance of the role of accident prevention in traditional management practices has, finally, resulted in an evolving system of safety by government regulation" (p. 7). In 1970, Congress passed the Williams-Steiger Act more popularly known as the Occupational Safety and Health Act (OSHA). According to Grimaldi and Simonds

(1984), this act authorized the federal government to set and enforce the safety and health standards for all places of employment affecting interstate commerce and to enforce the standards with criminal and civil penalties for violations. This law provided an additional impetus for management, (Adams, 1995, p. 9), "maintaining compliance and thereby avoiding citations, fines, and even possible imprisonment."

Heinrich

According to Adams (1995), H. Waldo Heinrich is the "godfather" of the safety profession (p. 4). After reviewing seventy-five thousand industrial accident records from insurance companies and plant owners, Heinrich (1959) concluded that 88% of all injuries were caused by unsafe acts. In 1955, Heinrich (1959) analyzed accident cases reported by the State of Pennsylvania, analysis showed unsafe acts for "82.6 % of the cases and mechanical causes for 89 % of all accidents" (p. 21).

Heinrich's (1959) basic philosophy of accident prevention was based on 10 axioms. They were as follows:

1. The occurrence of an injury invariably results from a completed sequence of factors-the last one of these being the accident itself. The accident in turn is invariably caused or permitted directly by the unsafe act of a person and/or a mechanical or physical hazard.
2. The unsafe acts of persons are responsible for a majority of accidents.
3. The person who suffers a disabling injury caused by an unsafe act, in the average case has had over 300 narrow escapes from serious injury as a result of committing the very same unsafe act. Likewise, persons are exposed to mechanical hazards hundreds of times before they suffer injury.

4. The severity of an injury is largely fortuitous-the occurrence of the accident that results in injury is largely preventable.

5. The four basic motives or reasons for the occurrence of unsafe acts provide a guide to the selection of appropriate corrective measures.

6. Four basic methods are available for preventing accidents-engineering revisions, persuasion and appeal, personnel adjustment, and discipline.

7. Methods of most value in accident prevention are analogous with the methods required for the control of the quality, cost, and quantity of production.

8. Management has the best opportunity and ability to initiate the work of prevention; therefore it should assume the responsibility.

9. The supervisor or foreman is the key person in industrial accident prevention. His application of the art of supervision to the control of worker performance is the factor of greatest influence in successful accident prevention. It can be expressed and taught as a simple four-step formula.

10. The humanitarian incentive for preventing accidental injury is supplemented by two powerful economic factors: (1) the safe establishment is efficient productively and the unsafe establishment is inefficient; (2) the direct employer cost of industrial injuries for compensation claims and for medical treatment is but one-fifty of the total cost which the employer must pay. (p. 13 – 14)

Heinrich (1959) considered the occurrence of an injury to be the result of a series of events. Several factors in the "accident-occurrence sequence is given in chronological order in the following list: ancestry and social environment, fault of person, unsafe act and/or physical hazard, accident, and injury." (p. 15) Goetsch (1993) believed the theory

has two major points: “Injuries are caused by the action of preceding factors; and removal of the central factor (unsafe act/hazardous condition) negates the action of the preceding factors and in so doing, prevents accidents and injuries” (p. 35). Adams (1995) described Heinrich’s 1st Axiom as the “theory of accident causation” (p. 15).

In 1959, H.W. Heinrich in *Industrial accident prevention* wrote that management was responsible for the “safe mechanical and physical conditions in the workplace” (p. 45). However, it was a “moral obligation of the employer, to his employee, and to society requires that a reasonably safe working environment be maintained” (p. 45). Heinrich felt that it was “a most difficult task to be practical and fair in any attempt by law to achieve wholly safe employee working conditions” (p. 43).

Petersen (2001), in *Safety management: A human approach,* described the development of safety as a series of eras. In chronological order they include, “inspection…unsafe act and condition…industrial hygiene…noise…safety management…OSHA…accountability…behavior based… and human.” (p. 3 – 7) Heinrich’s publication of *Industrial accident prevention* in 1931 ushered in the unsafe act and condition era. Petersen (1989) updated Heinrich’s Axioms and called them “new principles of safety management. (p. 15)

Petersen’s principles are:

1. An unsafe act, an unsafe condition: all these are symptoms of something wrong in the management system.
2. Certain sets of circumstances can be predicted to produce severe injuries. These circumstances can be identified and controlled: unusual and routine; high-energy sources, nonproductive activities, and certain construction situations.

3. Safety should be managed like any other company function. Management should direct the safety effect by setting achievable goals, by planning, organizing, and controlling to achieve them.

4. The key to effective line safety performance is management procedures that fix accountability.

5. The function of safety is to locate and define the operational errors that allow accidents to occur. This function can be carried out in two ways: (1) by asking why searching for root causes of accidents, and (2) by asking whether certain known, effective controls are being utilized.

6. The causes of unsafe behavior can be identified and classified. Some of the classifications are overload (improper matching of a person's capacity with the load), traps, and the worker's decision to err. Each cause is one which can be controlled.

7. In most cases, unsafe behavior is normal human behavior; it is the result of normal people reacting to their environment. Management's job is to change the environment that leads to the unsafe behavior.

8. There are three major subsystems that must be dealt with in building an effective safety system; the physical, the managerial, and the behavioral.

9. The safety system should fit the culture of the organization.

10. There is no one right way to achieve safety in an organization; however, for a safety system to be effective, it must meet certain criteria. The system must:

1. Force supervisory performance
2. Involve middle management

3. Have top management visibly showing their commitment.
4. Have employee participation
5. Be flexible
6. Be perceived as positive. (p. 15)

According to Adams (1995), Shewart's control chart revealed that 85% or more of the variations in an operating system have their origins in the characteristics of the system. In addition, Dr. Juran (Breyfogle et al., 2001) found that 80% of problems were attributable to defects in the work processes.

After reviewing the development of safety theory, it can be concluded of the importance that management plays in the attainment of a successful safety program. Grimaldi and Simmonds (1984) make the following point: that while everyone has a role, "Safety is an acknowledged management responsibility" (p. 6). Heinrich (1959) agrees, **"**the initiative and the chief burden of activity in accident prevention rest upon the employer; however, the practical field of effort for prevention through psychology is directed largely to the employee, but through management and supervision" (p. 73).

Evolution of Management

Transition to the 90's

Joiner (1994, pp. 8 - 9) described the methods of getting things done as a series of generations. The first generation is described as; "Management by Doing," In this style the person does the job without assistance. In the second generation, "Management by Directing," the communication is in one direction. A leader tells subordinated what to do. In the third generation, "Management by Results" people are told what to do, with the caveat that they will be rewarded or punished based on their results. In the fourth

generation, "managers care greatly about results but know that better results can reliably be obtained only through fundamental improvement (p. 10).

The essence of the fourth generation management is referred to as the "Joiner Triangle" (Joiner, 1994, p. 11). The corners of the "Joiner Triangle are "quality, all one team, and scientific approach" (p. 11). Joiner described the corners of the triangle as follows:

> Quality-Understanding that quality is defined by the customer; developing an obsession for delighting customers-not being satisfied with merely getting rid of what annoys them but going beyond to understand their current and future needs deeply…
>
> All One Team-Believing in people; treating everyone in the organization with dignity, trust, and respect…
>
> Scientific Approach-Learning to manage the organizations as a system, developing process thinking, basing decisions on data, and understanding variation. (p. 12)

Total Quality Management

According to Nonaka (1995), as more requirements were identified as necessary for achieving world class quality. To simplify discussion, a shorter label was given. The most popular label was the term, "total quality management, or TQM" (p. 596). In the opinion of Nonaka (1995), the list prepared by the National Institute of Standards and Technology to evaluate applications for the Malcolm Baldrige National Quality Award was the best available definition of TQM. A CEO Issue Sheet (Summer 2002) identified the criteria for the Baldrige as, "focus on performance excellence for the entire

organization in an overall management framework…identify and track all-important organizational results: customer, product/service, financial, human resource, and organizational effectiveness" (p.1).

While traditional management focuses on producing results. According to Adams (1955), "Total quality management focuses on managing the processes that produce the results" (p.3). Colle (1999) wrote, "TQM is conceived not as a specific technique or tool but as a framework within which one can place an evolving set of tools" (p.143). The objective is continuous improvement of the process, not solving a problem, or carrying out a project. Mahoney and Thor (1994) believe, "total quality management (TQM) provides the best current example of a comprehensive management improvement philosophy" (p. 204). According to Harry (1997), "Six Sigma is a means to realize the philosophy and values associated with Total Quality Management" (p. 2.31).

Six Sigma

Background

According to Breyfogle, et al. (2001), the term "Six Sigma" originated at Motorola, where the Six Sigma methodology was developed and refined. Eventually the approach was adopted and refined by other organizations. Terms were coined at Motorola and elsewhere to describe various roles within the Six Sigma process. To avoid any controversy or conflict over the use of some of these historical terms, a number of organizations have chosen to refer to their Six Sigma activities using different names. For example, AlliedSignal refers to Six Sigma as "operational excellence" (p. 12).

In GE's 1997 Annual Report (GE, 1997), CEO Jack Welch proudly stated that Six Sigma "focuses on moving every process that touches our customers-every product and

service (emphasis added)-toward near-perfect quality." Welch (GE chairman and CEO) made Six Sigma training mandatory for any employee who wanted to be considered for promotion, including senior executives, and forcefully reiterated GE's mission of becoming a Six Sigma company within 5 years (Miles, 1991, pp. 27 – 34).

Breyfogle et al. (2001) found that the strength behind Six Sigma business strategy was that it focused on objectives that were vitally important to the needs of the organization. According to Breyfogle et al. (2001), organizations can sometimes get so involved in how to count and report defects that they lose sight of the real value of Six Sigma, "orchestrating process improvement and reengineering in such a way that they achieve significant bottom-line benefits through the implementation of statistical techniques" (p. xi).

According to Ogranovitch (2002), implementing a Six Sigma improvement program can pay off in other ways:

> Customer specifications become much clearer
>
> Actual ability to meet such specifications also becomes clear and can be used to improve marketing focus, product pricing or cost assignment.
>
> Other decisions are better supported with the data and facts that teams can bring to the decision.
>
> The rigorous teamwork skills are transferable to other operations.
>
> Products can be made better, less costly and easier to guarantee. (p. 76)

What is Six Sigma?

Six Sigma, according to Harry (1997), is many things. "

> Six Sigma is a statistical measurement…It tells us how good our products, services, and processes are." (p. 2.3)
>
> Six Sigma is a business strategy…It can greatly help us gain a competitive edge. (p. 2.4)
>
> Six Sigma is a philosophy. It is an outlook, a way that we perceive and work within the business world. (p. 2.4)
>
> Six Sigma is a means to link values with actions which, in turn, sets improvement in motion. (p. 2.28)

According to Breyfogle et al. (2001), "Six Sigma is a team-based approach to problem solving and process improvement" (p. 225). While, according to Breyfogle & Cuppello (2001) some people view Six Sigma quality as merely a rigorous application of statistical tools. Others view Six Sigma as merely a sophisticated version of Total Quality Management (TQM).

According to Pande and Holpp (2002), Six Sigma can be refined into six themes. They are:

> Theme One: Genuine Focus on the Customer...In Six Sigma, customer focus becomes top priority...
>
> Theme Two: Data- and Fact-Driven Management...Six Sigma discipline begins by clarifying what measures are key to gauging business performance and then gathers data and analyzes key variables...
>
> Theme Three: Processes Are Where the Action Is...Whether focused on designing products and services, measuring performance, improving efficiency and

> customer satisfaction, or even running the business, Six Sigma positions the process as the key vehicle of success...
>
> Theme Four: Proactive Management...Six Sigma...encompasses tools and practices that replace reactive habits with a dynamic, responsive, proactive style of management.
>
> Theme Five: Boundaryless Collaboration...The opportunities available through improved collaboration within companies and with vendors and customers are huge...
>
> Theme Six: Drive for Perfection; Tolerate Failure...any company that makes Six Sigma its goal will have to keep pushing to be ever more perfect while being willing to accept-and manage-occasional setbacks. (pp. 14-16)

Benchmarking

Sigma can be calculated using actual measurement or defect data. "By knowing the defect rate of any characteristic, we can use a benchmarking chart to determine the correspondingly sigma level of capability (Harry, 1997 p. vii). According to Nonaka (1995), "The concept of benchmarking grew out of the need to establish quality goals based on factual analysis rather than empirical judgment" (p. 592). It is a means of identifying best practices. However, there can be a downside to benchmarking. According to Hilmer and Donaldson (1996),

> Benchmarking**,** put simply, has all the advantages and disadvantages of copying…
>
> Put another way, against whom does the leading runner pace himself or herself, and how does the runner know whether or not it is possible to do even better, by a wide margin? (p. 106)

Hilmer and Donaldson (1996) go on to write

> By erecting "the world's best" standards against which managers and their organizations are to be judged across all activities, benchmarking guarantees that almost everyone can feel like a failure! Since scale and other factors put the world's best performance beyond the control of most managers, benchmarking raises expectations without providing the means to close the gaps identified. (p. 107)

Roles for managers and employees

According to Breyfogle et al. (2001), the success of Six Sigma depends on the existence of a solid infrastructure and executive leadership that supports the organizations vision. Leaders need to take personal responsibility for driving Six Sigma efforts. True leaders are able to articulate the vision that then becomes believable to their employees. "True leaders show their employees the future and, through their own actions, motivate them to achieve goals" (p. 35).

According to Breyfogle et al. (2001), special titles are given to people within an organization who have Six Sigma roles. A few of the names for these roles are Process Owner or Sponsor, Champion, Master Black Belt, Black Belt, and Green Belt.

According to Harry (1997), the Six Sigma Champion has the managerial and technical knowledge to facilitate the leadership, implementation, and deployment of Six Sigma. The Champion is familiar with Six Sigma strategies, tactics, and tools necessary for achieving breakthrough in key product designs, manufacturing processes, services, and administrative processes. The responsibilities of the Champion are to:

- Ensure that projects stay aligned with overall business goals and provide direction when they don't
- Keep other members of the leadership team informed on the progress of projects…
- Negotiate conflicts, overlaps, and linkages with other Six Sigma projects. (Pande and Holpp, 2002, p. 24)

The Black Belt is the full-time person dedicated to the Six Sigma process. According to Pande and Holpp (2002), "the Black Belt leads, inspires, manages delegates, coaches, and "baby-sits" colleagues and becomes almost expert in tools for assessing problems and fixing or designing processes and products" (p. 22). According to Harry (1997),

> Black Belts are a cadre of individual contributors from various discipline areas which, when adequately trained and technically supported, can serve as change agents, internal consultants. …They stimulate management thinking by posing new ways of doing things, challenge conventional wisdom by demonstrating successful application of new methodologies, seek out and pilot new tools, create innovative strategies, and develop others to follow in their footsteps. (p. 23.5)

A Black Belt works as a member of a team assigned to a Six Sigma project. The Black Belt is responsible for (Pande and Holpp, 2002) organizing the team, participating in training, and keeping projects moving to completion.

According to Pande and Holpp (2002),

> the Master Black Belt (MBB) serves as a coach and mentor or consultant to Black Belts working on a variety of projects…The MBB may also become a part-time

> Six Sigma trainer for Black Belts and other groups. Finally, the MBB may get involved in special Six Sigma-related projects: for example, investigating customer requirements or developing measures for key processes. (p. 22)

The Green Belt is someone trained in Six Sigma skills. However, Six Sigma (either as a team member or assistant team leader) is an additional duty for the Green Belt. The role of the Green Belt is, "to bring the new concepts and tools of Six Sigma right to the day-to-day activities of the business" (Pande and Holpp, 2002, p. 23).

Six Sigma Problem Solving Process

According to Pande and Holpp (2002),"improvement, problem-solving, and process-design teams" (p. 27) are the most visible of a Six Sigma effort. These teams, led by Black Belts or Green Belts are formed to solve problems and/or improve processes. Pande and Holpp (2002) described the life cycle of this process in terms of six phases: "Phase 1: Identifying and Selecting the Project(s), Phase 2: Forming the Team, Phase 3: Developing the Charter, Phase 4: Training the Team, Phase 5: Doing DMAIC (Define, Measure, Analyze, Improve, and Control) and Implement Solutions, and Phase 6: Handing off the Solution" (pp. 28-30). Detailed descriptions of the phases of the life cycle are:

> Phase 1: Identifying and Selecting the Project(s) - In this phase the organization identifies potential projects that meet the criteria established by the organization. A management team then selects the project(s) that are the most promising.
>
> Phase 2: Forming the Team – Management selects either a Black or Green Belt and additional team members. People are selected based on their knowledge of the situation and their potential to contribute to the solution…

> Phase 3: Developing the Charter – The Charter includes the reasons for pursuing the project, the goal, a basic project plan, scope and other considerations, and a review of roles and responsibilities…
>
> Phase 4: Training the Team – While the focus is on the DMAIC process and tools…Up to four weeks of training is spread out over the life of the project. The preponderance of training takes place during the initial phases of the process.
>
> Phase 5: Doing DMAIC and Implement Solution –Teams must develop project plans, training, pilots, and procedures for their solution and are responsible for both putting them in place and ensuring that they work-by measuring and monitoring results-for a meaningful period of time…
>
> Phase 6: Handing OFF the Solution –The official owner of the solutions accepts the responsibility to sustain the gains achieved by the team. (pp. 29 - 30)

According to Pande and Holpp (2002), the common problem solving process for Six Sigma teams is the "DMAIC process: Define, Measure, Analyze, Improve, and Control." (p. 27) The DMAIC process can be defined as a series of steps. They are:

> Step 1: Define the Problem – The team must grapple with an array of questions: What are we working on? Why are we working on this particular problem? Who is the customer? What are the customer requirements?...Once these questions are answered-at least in draft form-the DMAIC Charter can be developed.
>
> Step2: Measure – The Measure step has two main objectives: Gather data to validate and to quantify the problem/opportunity and begin teasing out facts and numbers that offer clues about the causes of the problem.

Step 3: Analyze – The team uses the Analyze step to find out the 'root cause." One of the principles of good DMAIC problem solving is to consider many types of causes, so as not to let biases or past experience cloud the team's judgment…Some of the common cause categories to be explored are

- Methods: the procedures or techniques used in doing the work
- Machines: the technology, such as computers, copiers, or manufacturing equipment, used in a work process
- Materials: the data, instructions, numbers or facts, forms, and files that, if flawed, will have a negative impact on the output.
- Measures: faulty data resulting from measuring a process or changing people's actions on the basis of what's measured and how
- Mother Nature: environmental elements, from weather to economic conditions, that impact how a process or a business performs
- People: a key variable in how all these other elements combine to produce business results.

Step 4: Improve – Once new ideas are developed, they have to be tested, refined, and implemented…The "final" solution or series of changes must always be approved by the Champion and often by the entire leadership team…New changes have to be "sold" to organization members whose participation is critical. Data must be gathered to track and to verify the impact (and unintended consequences) of the solution.

Step 5: Control – Specific Control tasks that DMAIC Black Belts and teams must complete include:

- Developing a monitoring process to keep track of the changes that have set out
- Creating a response plan for dealing with problems that may arise
- Helping focus management's attention on a few critical measures that give them current information on the outcomes of the project (the Y) and key process measures, too (the Xs)

From the people standpoint, the team must

- "Sell" the project through presentations and demonstrations
- Hand off project responsibilities to those who do the day-to-day work
- Ensure support from management for the long-term goals of the project. (pp. 31 -40)

Pande and Holpp (2002) suggested three different approaches to implementing the "Six Sigma change process."

On-Ramp 1: The "Business Transformation...For those organizations with the need, vision, and drive to launch Six Sigma as a full-scale change initiative...Some of the companies that have adopted the business transformation approach to Six Sigma are General Electric, Ford, Starwood Hotels, Bombardier, and 3M...

On-Ramp 2: Strategic Improvement...effort can be limited to one or two critical business needs and training aimed at addressing major opportunities or weaknesses.

On-Ramp 3: Problem Solving...This approach targets nagging and persistent problems-often ones that have been the focus of earlier but unsuccessful

> improvement efforts-with people trained in the comprehensive Six Sigma tool set...The benefit of this approach is in focusing on meaningful issues and addressing their root causes, using data and effective analysis rather than plain old gut feeling. (pp. 17-20)

Application of Six Sigma to Safety, Health and Environmental Protection

According to Breyfogle et al. (2001), the Model of Managing for Outstanding Safety, "begins with management commitment, flowing from fundamental beliefs and driven by a vision of excellence…Management commitment, line ownership, and workforce involvement are the fundamental "drivers" of safety" (pp. 7 -8). Breyfogle et al. (2001) suggest, "The key to major improvement in safety is to develop understanding, commitment, and will in corporate leaders, CEOs in particular. They must be convinced that excellent safety will not cost more in the long run and will deliver valuable results" (p. 23).

According to Jordan and Michel (2000),

> …a company must view safety as having intrinsic value-certainly; the safety of the customer and for the workforce is valuable. Safety is an essential part of your company's business systems…A safe product is one that meets the customers' explicit and implicit expectations on usability without doing them harm. The customer may have radically different expectations for product use than you do, so you must be alert for both expected and unexpected safety hazards… Safety is also a major factor on the factory floor and in processes. Workforce safety is a mandatory requirement when you are laying out your facilities and designing your processes. No company can afford the disruption caused by a series of safety

> incidents. No company can afford the immediate impact on the workforce, the long-term burdens of workers' compensation, the potential for even great liability, or the delays as processes are redesigned for improved safety standards. (pp. 147 - 148)

The priority given to safety must be visible in all the actions of the company, particularly in the behavior of management. According to Breyfogle et al. (2001),

> Giving overriding priority to safety does not imply that costs, quality, customer service, production volume, and other business parameters are not critically important. They are the lifeblood of successful companies. Rather, this belief means than in any case of conflict between safety and other objectives, safety is given overriding priority. (p. 63)

According to Breyfogle et al. (2001), the main barriers (for leaders intent on making a step change in their company's safety performance) are:

1. There are a few good techniques to "measure" the state of safety management, in particular to measure the intangibles such as management commitment. Thus assessment of safety is usually observational and anecdotal rather than quantitative.
2. Although there are descriptions of how the safest companies manage safety, because of the lack of measurement tools, there are few quantitative benchmark data. There is poor understanding of what constitutes "World Class Safety."
3. Partly because of the inadequacy of the assessment tools and the lack of benchmark data, management is often reluctant to undertake the fundamental

> changes required to reform safety. Better ways are needed to help convince them that a step change can be managed through orderly processes. (p. xi)

Janicak (2003) used Six Sigma techniques to "measure" the state of safety management. According to Janicak (2003), the quantification of safety performance should be done through the following systematic approach: "define the standardized units of measure; develop instruments and methods that are capable of measuring in terms of the units of measure; use the instruments or methods to measure performance" (p. 2). Janicak goes on to write, "safety performance is now measured with the same tools and techniques common to quality measures of other aspects in the organization" (p. 3.).

> A safety performance measurement system based upon Six Sigma requires the manager responsible for health, safety, and environmental protection have management program in place. "This program framework, at a minimum, consists of defining acceptable levels of performance, collecting data, comparing performance against the acceptable levels, and finally, taking corrective action to improve performance levels." (Janicak, 2003, p. 7)

According to Janicak (2003),

> The basic concept of performance measurement involves (a) planning and meeting established operating goals/standards, (b) detecting deviations from planned levels of performance, and (c) restoring performance to the planned levels of achieving new levels of performance. The first requirement of a safety performance measure is a team approach to developing and implementing the program because safety and its improvement is not the responsibility of one department or one person but of everyone in the organization. …A collaborative

> approach makes it easier to assess safety performance using safety metrics from various departments. For example, to measure safety performance with regard to back injuries, an organization can use a safety metric of recordable injuries from the personnel department, records of near miss incidents from the production department, and the number of visits to the plant emergency room from the medical department. In this situation, three departments have three different methods of measuring back injuries. (pp. 8 -10)

The performance measurement process can be separated into 11 discrete steps (Training Resources and Data Exchange (TRADE) (1995) pp. 1-9 – 1-10). This framework describes the process generically. Janicak (2003) gave the following example of a bottling company that has been experiencing an increased frequency of back injuries and wishes to implement a safety performance measurement process.

1. Identify the process flow.

First, the process is analyzed and broken down into it various job tasks. Workers are required to lift filled 5-gallon water bottles off of a conveyor, carry them, and place the bottles on pallets.

2. Identify Critical Activities to Measured

In this step, identify those aspects of the job tasks that can be measured in terms of safety performance. Examples of critical activity related to potential back injuries could be the lifting of the water bottles, moving filled pallets, etc. Example of measurable outcomes related to back injury prevention include the number of bottle lifting using proper lifting techniques, the number of pallets

moved using appropriate material handling devices, attendance at back injury prevention training programs, etc.

3. Establish Performance Goals or Standards.

An example of a performance goal may be the reduction of recordable back injuries by 80 percent in a three-month period. The performance goals and standards should include the measurable activity, the level to which acceptability is met, and the time period by which the goal should be attained.

4. Establish Performance Measurement.

Individual performance measures should be defined that are indicative of the established performance goals. For example, with a goal of reducing back injuries, activities that can be measured include use of proper lifting techniques, providing and attending safety training related to back injury prevention, etc. The key is to establish measures that are tied to the performance goals and standards.

5. Identify Responsible Parties.

Determine who will be responsible for implementing the safety performance program and establish methods of accountability.

6. Collect Data.

Data needs should be identified, as well as the procedures for collection. The data requirements are identified through the established performance measures. Examples of data can include accident reports, job observations, training records, etc.

7. Data Analysis.

The performance measure data requires analysis. The analysis techniques are tied to the performance measures and the performance goals. The format of the performance measures indicates the types of data analysis techniques that can or cannot be used. The performance goals are also tied to the analysis techniques. If the performance goal is the reduction of back injuries over a period of time, the analysis technique used should be capable of identifying such a decrease, if it does exist.

8. Compare Actual Performance to Goals.

With the data collected and analyzed, a comparison is made between the performance and the established goals. The safety manager ascertains differences between the obtained performance and the desired performance as defined by the performance goals.

9. Corrective Action.

A decision is made at this point as to whether corrective action is necessary. If the performance levels fall short of the desired performance goals, further analysis as to the reasons for the results is necessary.

10. Make Changes to Meet the Goals.

One option available to the safety professional is to modify current practices to bring the safety performance in line with the goals and standards. This may require the implementation of new programs, the modification or enforcement of current programs, or the selection of more appropriate performance measures that are indicative of the true levels of safety performance.

11. New or Modified Goals.

Depending upon the results, the safety measure may have to reevaluate the safety performance goals to ensure they meet the organization's needs. Changes in production and job tasks may necessitate a change in the performance goals. With continual improvement as an underlying goal of safety performance, once a level of safety performance is met, improvement in the desired performance standards may be another reason for reevaluating the performance goals and standards. (pp. 1-9 – 1-10)

Summary

Safety, health, and environmental protection has evolved over the centuries. As humanity progressed, people reasoned that whoever caused an injury should suffer equal harm. Through the sixteenth – nineteenth century, the basic law governing employer liability favored the employer. In 1802 the first legislation to prevent industrial injury was passed. With the approach of the twentieth century worker's compensation laws began in Germany.

Between 1908 and 1970 there were legislative actions and other related activities that affected safety, health, and environmental protection in the United States,. The most significant action affecting safety was the Williams-Steiger Act more popularly known as the Occupational Safety and Health Act (OSHA). This act authorized the federal government to set and enforce the safety and health standards for all places of employment affecting interstate commerce and to enforce the standards with criminal and civil penalties for violations. This law provided an additional impetus for management to maintain compliance.

The management evolution has been described as a series of generations. In the first generation, the person does the job without assistance; in the last generation (fourth), management realizes that the best results can only be attained through system improvement. These system improvement techniques include total quality management and Six Sigma.

The key to major improvement in safety is a commitment from management. Before management is willing to make changes to reform safety, health and environmental protection; adequate assessment tools and benchmark data are required.

Six Sigma provides the process for the development of a safety performance measurement program by establishing well-defined performance measures, identifying all areas of safety performance, and documenting procedures for implementing the program. Control charts, run charts, and Pareto diagrams can be used to track and monitor safety performance, establish trends, and evaluate program performance against accepted tolerances. These assessment tools and benchmark data overcome management's reluctance to reform safety, health, and environmental protection.

CHAPTER THREE

METHODOLOGY

Introduction

This chapter describes the methods and procedures used to carry out this field study.

Unstructured interviews were used in this study. The primary objective of this study was to evaluate the impact of implementation of a Six Sigma program on a company X's safety, health, and environmental protection performance.

Subject Selection and Description

Safety professionals from a Fortune 100 company were selected to participate in this study. This company participates in the Six Sigma program. The population consisted of two safety professionals. The researcher has professional contacts with one of the safety professionals. The other safety professional is a professional acquaintance of the researcher's advisor.

Instrumentation

The survey consisted of an on-site personal and telephonic taped interview. The instrument was a personal interview guide (see Appendix B, "Interview Guide"). The interview guide was provided to respondents one week before the scheduled interview. The literature review formed the basis for developing the instrument that answered the research questions. Specifically, questions were developed to address both the effectiveness of Six Sigma in the area of safety, health and environmental performance and how safety, health and environmental protection are integrated into Six Sigma programs.

A privacy statement was read prior to recording any interviews. Since the interview questions were constructed specifically for this study, there are no measures of validity or reliability.

Data Collection

Two safety professionals (known by researcher and/or research advisor) were emailed the intent of the study and requested to participate. The participants were asked to mail or fax back their completed consent forms. The researcher interviewed one person telephonically and the other in person. Both interviews were taped. No names were used in the thesis. The company was described as X. The transcription of the interviews did not include either the name of the company or the name of the individual.

Data Analysis

The primary objective of this study was to identify the effectiveness of the Six Sigma program and to determine how safety, health, and environmental protection is integrated into Six Sigma programs. Each question was analyzed in the following manner.

<u>Research question 1: Safety, Health, and Environmental Protection</u>

How does management view Safety, Health, and Environmental protection in your organization?

This question was analyzed using the "Six Steps of Analysis" as described by Kvale (1996).

The first step is when subjects describe their lived world during the interview.

> A second step would be that subjects themselves discover new relationships during the interview…
>
> In a third step, the interviewer, during the interview, condenses and interprets the meaning of what the interviewee describes, and "sends" the meaning back.
>
> In a fourth step, the transcribed interview is interpreted by the interviewer…
>
> A fifth step would be a re-interview.
>
> A possible sixth step would be to extend the continuum of description and interpretation to include action, in that subjects begin to act from new insights they have gained during the interview. (pp. 189 – 190)

Research question 2: Criterion Used to Evaluate Safety, Health, and Environmental Protection Performance

What were the safety, health, and environmental protection performance of the organization?

No analysis was necessary for this question. The response provided measures that will be used to compare results from question three.

Research question 3: Integration of Safety, Health, and Environmental Protection into Six Sigma Programs

To what extent in Safety, Health, and Environmental Protection integrated into Six Sigma programs?

This question was analyzed the same as question one.

Limitations

One limitation of the instrument was that it has no measures of validity or reliability. Since only one company participated in this study, any results should be used cautiously to infer to other companies.

Summary

This study was carried out using both telephonic and on-site personal interviews. The data analysis included the "Six Steps of Analysis" for some questions and in other questions comparisons were made against benchmarks provided by the interviewee.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The purpose of this study was to evaluate if the implementation of Six Sigma at company X improved their safety, health, and environmental protection performance.

The following research questions served as the basis for the study:

1. How does the Six Sigma program affect the safety, health, and environmental protection performance of organizations?

2. What criterion was used to evaluate the safety, health, and environmental protection performance of the organization interviewed for this study?

3. How were safety, health, and environmental protection integrated into Six Sigma programs at the organization interviewed for this study?

This chapter included all results of the research, demographics resulting from the research, and discussion of the research questions under investigation. This chapter concluded with discussion regarding the finding of this study on the effect of Six Sigma on safety, health, and environmental protection performance; and compared and contrasted the author's findings with those found in the literature review of Chapter II.

Demographic Information

The subjects selected for this study consisted of two EHS (Environmental, Health, and Safety) professionals from a Fortune 100 company that has implement a Six Sigma. Both were trained as Six Sigma greenbelts. The telephonic interview lasted 80 minutes and the personal interview lasted 90 minutes. Both interviews were recorded.

Interview Analysis

The interview questions along with item analysis are presented as follows:

Research Question #1 - How does the Six Sigma program affect the safety, health, and environmental protection in your organization?

The 1990-2001 Environmental Progress included the following:

a. 91% reduction in volatile organic air emissions

b. 84 % reduction in manufacturing release to water

c. 12 % reduction in solid waste

d. 35% reduction in our rate of waste generation

e. 88% reduction in US EPA Toxic Release Inventory (TRI) releases.

At one of Company X's sites, the results of Six Sigma were too early (started 9 months ago) to tell. They have a number of ongoing Six Sigma projects in the field of environmental health and safety. One project was in training systems. This project's goal was to have 100% compliance with training requirements. In the past when people moved, their training records were not available to the new area/department. Expected results include a potential for savings in productivity and cost avoidance (duplicating training), and compliance. Additional projects included: increasing participation in BBS (Behavior Based Safety); reducing solvent emission; and looking at reducing wastes that go to landfills.

Research Question #2 - What criterion was used to evaluate the safety, health, and environmental performance of your organization? While incident and frequency rate were measured, Company X now look at such things as audits of the environmental health and safety. (Five different areas are looked at; and more areas are being added each year)

Each facility/division audits not only the environmental health and safety plan but also the Global Safety and Health Plan. The Global Safety and Health Plan was developed to promote a safe and healthy workplace for employees. The Plan consisted of 34 elements designed to prevent injuries and illnesses; unplanned events, such as fires and explosions; and to promote 24-hour safety and health.) The plans were evaluated (through audits) and then rated using a color coding system: green (>90%), yellow (>80%) and red (<80%). This score card was integrated into each person's annual efficiency report.

Research Question #3 - How are safety, health, and environmental integrated into Six Sigma programs at your organization (unit)? Environmental health and safety was integrated into the culture of Company X. The Chief Executive Officer (CEO) directed that Company X will use Six Sigma. Six Sigma is integrated into all facets of the business. At Company X, Six Sigma is a business improvement methodology. Six Sigma created a common language and provided measurement tools to reduce variation and deliver consistent results. Through Six Sigma initiatives, safety, health, and environmental protection are totally integrated into the management function. In 2001, the company launched a new Environmental, Health and Safety (EHS) Management System to help address changing societal needs and expectations. Two major improvements are an integration of corporate environmental health and safety planning and goal setting with business unit planning and goal setting; and the introduction of Life Cycle Management. Life Cycle Management placeec additional focus on both processes and products to control environmental health and safety effects throughout a product's life cycle.

Discussion

The primary objective of this study was to evaluate if the implementation of a Six Sigma program could improve a company's safety, health, and environmental protection performance. The review of literature included the evolution of safety health, and environmental protection; the evolution of management; the background of Six Sigma; the Six Sigma problem solving process; and the application of Six Sigma to safety, health, and environmental protection.

The literature revealed the key to major improvement in safety, health, and environmental protection was a commitment from management. However, before management was willing to make changes to reform safety, health and environmental protection; adequate assessment tools and benchmark data were required. The assessment tools and benchmark data needed to overcome management's reluctance to reform safety, health, and environmental protection were provided by Six Sigma tools such as Control charts, run charts, and Pareto diagrams. These tools were used to track and monitor safety performance, establish trends, and evaluate program performance against accepted tolerances. The literature provided a description of the Six Sigma process for the development of a safety performance measurement program by establishing well-defined performance measures, identifying all areas of safety performance, and documenting procedures for implementing the program.

The study confirmed that management support was critical to the implementation of Six Sigma. This support provided the impetus to integrate Six Sigma into all processes. Personnel knew that decisions would not be based on hunches but rather on

Six Sigma Methodology. Proactive audits indicated that Six Sigma was having a positive impact on company X's safety, health, and environmental protection performance.

Summary

This chapter reviewed the purpose and demographic data of the study. The data from this chapter, along with other sources molded the recommendations that will be given in chapter five.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The primary purpose of this study was to evaluate if the integration of safety, health, and environmental protection into a company's management improvement process could result in continuous improvement in processes that will reduce human losses, financial losses, and material losses. The management improvement system was Six Sigma.

Data was gathered using a personal interview guide as a survey instrument. A review of relevant literature served as the basis for the development of the personal interview guide. The guide was used to collect data related to the effectiveness of Six Sigma in the area of safety, health, and environmental performance; and how safety, health, and environmental protection are integrated into Six Sigma programs.

The findings of the study indicated the key to major improvement in safety was a commitment from management. However, before management was willing to make changes to reform safety, health and environmental protection; adequate assessment tools and benchmark data were required. These assessment tools and benchmark data needed to overcome management's reluctance to reform safety, health, and environmental protection were provided by Six Sigma tools such as control charts, run charts, and Pareto diagrams.

Management support provided the impetus to integrate Six Sigma into all processes.

Management requires that decisions will be based on data derived from Six Sigma methodology not on hunches.

Proactive audits indicated that Six Sigma are having a positive impact on company X's safety, health, and environmental protection performance.

Conclusions

As a conclusion of this study, the author believes the integration of safety, health, and environmental protection into the company's Six Sigma process can result in continuous improvement in processes that will reduce human losses, financial losses, and material losses. It appears ongoing Six Sigma projects at company X will result in improved compliance, savings in productivity, and substantial cost avoidance. The Six Sigma approach to problem solving and process improvement has resulted in the initiation of projects that are projected to save substantial amounts of money in reducing landfill wastes, reducing solvents emissions, and increasing participation in Behavior Based Safety. While incident and frequency rates are still used to evaluate safety, health, and environmental protection, it appears greater emphasis is now being placed on proactive audits as a means to identify areas that require management control. It appeared Six Sigma was fully integrated into the fabric of company X. Decisions were based on Six Sigma generated data, not hunches. It can be concluded, that Six Sigma has created a common language and measurement tools to reduce variation in processes and deliver improvements in the areas of safety, health, and environmental protection.

Recommendations

Recommendations Related to This Study

1. Consider implementing Six Sigma for improving organizational processes. After management has made the decision to support Six Sigma, integrate safety, health, and environmental protection into process improvement initiatives.
1. Once a project is selected for Six Sigma analysis, consider tracking its benefits beyond the life of the project.
2. If management does not support company-wide implementation of Six Sigma, as a minimum, utilize Six Sigma tools to analyze selected processes. These tools will provide management with the performance data and assessment tool need to justify the changes required to reform safety, health, and environmental protection. The improvements in safety, health, and environmental protection will provide management with the impetus to further support company-wide implementation of Six Sigma to their company.
3. Develop an effective audit system to ensure progress in safety, health, and environmental protection.

Recommendations for Further Study

Additional research should be conducted to determine:

1. If Six Sigma is the long term solution to improving the safety, health, and environmental protection of a company.
1. The best design of audits to determine the performance of a company's safety, health, and environmental protection performance.

2. If safety, health, and environmental protection initiatives can be translated into top- and bottom-line results.
3. If safety, health, and environmental protection professionals can align the processes and systems that influence behavior with their goals and those of senior management.
4. If a mathematical correlation between safety, health, and environmental protection and expense reduction or revenue growth.

Advancements can be made in terms of a company's safety, health, and environmental protection performance. The results of this study support this conclusion. Companies must recognize management support is required for implementation of any process improvement system, including Six Sigma.

REFERENCES

Adams, E.E. (1995). *Total quality safety management.* Des Plaines, IL: American Society of Safety Engineers.

Arthur, J. (2001). *Six sigma simplified: quantum improvement made easy* (2nd ed.). Denver: Life Star.

Breyfogle III, F. W., Cuppello, J. M., & Meadows, B. (2001). *Managing six sigma: A practical guide to understanding, assessing, and implementing the strategy that yields bottom-line success.* New York: John Wiley & Sons.

Brown, M.G., Hitchcock, D.E., & Willard, M.L. (1994). *Why tqm fails and what to do about it*. New York: Irwin Professional Publishing.

Cole, R. C. (1999). *Managing quality fads: How american business learned to play the quality game* New York: Oxford University Press.

Crosby, P.B. (1992). *Completeness*. New York: New American Library/Dutton.

Deming, E. (1994). *The new economics for industry, government, and education* (2nd ed.). Cambridge, MA: Massachusetts Institute of Technology Center for Advanced Educational Services.

Drucker, P. F. (1992). *Managing for the future: The 1990s and beyond*. New York: Truman Talley Books.

Estimating the costs of unintentional injuries, 2001. Retrieved November 4, 2002 from: http://www.nsc.org/lrs/statinfo/estcost2001.html.

Goetsch, D. L. (1993). *Occupational safety and health in the age of high technology for technologists, engineers, and managers* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

Grimaldi, J.V., & Simonds, R.H. (1984). *Safety management* (4th ed.). Homewood, Il: Richard D. Irwin, Inc.

Harry, M. J. (1997). *The vision of six sigma: A roadmap for breakthrough* (5th ed., Vol. I). Phoenix: Tri Star Publishing.

Harry, M. J. (1997b). *The vision of six sigma: A roadmap for breakthrough* (5th ed., Vol. II). Phoenix: Tri Star Publishing.

Heinrich, H.W. (1959). *Industrial accident prevention* (4th ed.). New York: McGraw-Hill.

Hilmer, F.G., & Donaldson, L., (1996). *Management redeemed: Debunking the fads that undermine our corporations.* New York: The Free Press.

Hutchins, D. (1995). The history of managing for quality in the united kingdom. In J.M. Juran (Ed.), *History of managing for quality: The evolution, trends, and future directions of managing for quality* (pp. 433 – 474). Milwaukee, WI: ASQC Quality Press.

Janicak, C. A. (2003). *Safety metrics: tools and techniques for measuring safety performance*. Rockville, MD: ABS Consulting/Government Industries.

Joiner, B. L. (1994). *Fourth generation management: The new business consciousness.* New York: McGraw-Hill.

Jordan, J. J. Jr., & Michel, F.J. (2000). *Next generation manufacturing: Methods and techniques.* New York: John Wiley & Sons.

Juran, J.M., & Gryna, F.M. (1976). *Quality planning & analysis* (3rd ed.). New York: McGraw-Hill.

Kvale, S. (1996). *Interviews: An introduction to qualitative research interviewing.*

London: SAGE Publications.

Lerner, F. (1995). The history of quality assurance in germany. In J. M. Juran (Ed.), *History of managing for quality: The evolution, trends, and future directions of managing for quality* (pp. 209 – 258). Milwaukee, WI: ASQC Quality Press.

Mahoney, F.X., & Thor, C.G. (1994). *The tqm trilogy: Using iso 9000, the deming prize, and the baldrige award to establish a system for total quality management.* New York: AMACOM.

Miles, M., (1991, October). Cowboy quality, *Quality Progress*, 32(10), 27 – 34.

National Institute of Standards and Technology. (2002). *Baldrige, six sigma, & iso: Understanding your options.* Author.

National safety council introduces new safety management system. (2002, October 7). Retrieved November 11, 2002 from: http://www.nsc.org/news/nr1000702bp.html.

Nonaka, I. (1995). The recent history of managing for quality in Japan. In J. M. Juran, (Ed.), *History of managing for quality: The evolution, trends, and future directions of managing for quality* (pp. 517 – 552). Milwaukee, WI, ASQC Quality Press.

Odiorne, G. (1972). *Training by objectives*. New York: Addison-Wesley Publishing.

Ogranovitch S. (2002). Understanding management infrastructure options. *Professional Builder*, 67(10), 72-76.

Pande, P., & Holpp, L. (2002). *What is six sigma?* New York: McGraw-Hill.

Petersen, D. (2001). *Safety management: A human approach* (3rd ed.). Des Plaines,

Illinois: The American Society of Safety Engineers.

Roughton, J. E., & Mercurio, J.J. (2002). *Developing an effective safety culture: A leadership approach*. Boston: Butterworth-Heinemann.

Stewart, J. M. (2002). *Managing for world class safety.* New York: John Wiley & Sons.

Training Resources and Data Exchange Performance-Based Management Special Interest Group (1995). *How to measure performance-a handbook of techniques and tools*

Webster's new world college dictionary (3rd ed.). (1997). New York: Simon & Schuster Macmillan.

APPENDIX A

AGREEMENT TO PARTICIPATE AS A RESEARCH SUBJECT

Agreement To Participate As A Research Subject

Application: Individual volunteering to allow researcher to interview them concerning the integration of safety, health, and environmental protection into their company's process improvement program.

Thomas Kaliher, the researcher, at the University of Wisconsin-Stout is conducting a research project called, *Improved Safety, Health, and Environmental Protection Through Six Sigma.* It is not anticipated that this study will present any risk to you. I would appreciate your participation in this study.

The purpose of the study is to evaluate if the implementation of Six Sigma at company X and Y has improved their safety, health, and environmental performance. The collection of data will allow the researcher to decipher the effects of Six Sigma on safety, health and environmental performance. The information gathered will be kept in the sole custody of and viewed only by the researcher and the subject.

Your participation in this project is completely voluntary. If at any time you wish to stop participating in this research, you may do so, just inform the researcher Thomas Kaliher. Upon completion of the study, the researcher will destroy all tapes of conversation and all information collected from the subject. The analyzed findings will be available for your viewing.

Note: Questions or concerns about the research study should be addressed to *Thomas Kaliher*, the researcher, at 715.235.2363 or email at kalihert@uwstout.edu, or Dr, Elbert Sorrell, at 715.232.2630 or email at sorrelle@uwstout.edu. Questions about the rights of research subjects can be addressed to:

Sue Foxwell
Human Protections Administrator
UW-Stout Institutional Review Board for the Protection of Human Subjects in Research
11 Harvey Hall
Menomonie, WI 54751
Phone Number: 715.232.1126

APPENDIX B

CONSENT FORM

CONSENT FORM

I understand that my participation in this study is strictly voluntary and I may discontinue my participation at any time without prejudice.

I understand that the purpose of this study is to evaluate how the implementation of Six Sigma at company X and Y has improved their safety, health, and environmental performance. The research project is titled, *Improved Safety, Health and Environmental Protection Through Six Sigma*.

I further understand that any information that is collected from me during this study will be held in the strictest confidence and will not be part of any permanent record. I understand that upon completion of the study, the researcher (Thomas Kaliher) will destroy all tapes of conversation. However, the analyzed findings will be available for my viewing. I am aware that I have not and am not waiving any legal or human rights by agreeing to this participation.

By signing below I verify that I am 18 years of age or older, in good mental and physical condition, and that I agree to and understand the conditions listed above.

Signature_____ Date_____

Please fax or mail completed form to:

Masters Program in Risk Control
Attn: Thomas Kaliher
125 Science Wing
Menomonie, WI 54751

Fax: 715-232-5236

APPENDIX C

INTERVIEW GUIDE

INTERVIEW GUIDE

I want to understand your world. Help me to understand it.

1. How does the Six Sigma program affect the safety, health, and environmental protection in your organization?

- How do you and your company (unit) view the relationship between the management of safety, health, and environmental protection and the management of other parameters?
- Do you think that striving for excellence in safety affects the ability of your company (unit) to be excellent in other areas-quality, costs, and profits? Help or hinder?
- To what extent are you personally satisfied with the safety performance of your organization?
- What makes Six Sigma different from other programs?
- Your company (unit) has a fine safety record. What are the main reasons?
- How satisfied are you with your company's (unit's) safety performance?
- What will prevent your company from achieving success with Six Sigma in the field of safety, health, and environmental protection?
- Have you had any Six Sigma program in the safety, health, and environmental protection area? If yes, what were the results?

2. What criterion was used to evaluate the safety, health, and environmental performance of your organization?

- How does Six Sigma affect the safety, health, and environmental performance of your organization?
- What safety information (data) do you rely on to tell you how the company (unit) is doing?
- What are the benchmarks for safety, health, and environmental protection performance?

3. How are safety, health, and environmental integrated into Six Sigma programs at your organization (unit)?

- How is safety represented in the DMAIC process?
- How effective are your project teams?
- Are there any safety Greenbelts or Blackbelts?
- How involved is the workforce in general in Six Sigma safety, health, and environmental protection activities?