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SIX SIGMA - A BREAKTHROUGH IMPROVEMENT STRATEGY FOR BUSINESS IMPROVEMENT- AN OVERVIEW

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ABSTRACT

In the present era of globalization, where the competition to survive in market gets tougher, the organizations need to become more productive and efficient. Manufacturing including service organizations need to improve quality, while reducing cost and enhancing quality & productivity with limited resources. Brilliant and innovative approaches and ideas are replacing the conventional techniques to survive in the global competitive market. Six Sigma quality management approach can directly fulfill these requirements, if implemented properly. Six Sigma improvement drive is the latest and most effective technique in the quality engineering and management spectrum.

It is a highly disciplined process that helps to focus on developing and delivering quality products & services. It is the most effective breakthrough strategy ever devised. Many organizations have earlier tried Downsizing, Outsourcing, Activity based costing, Business process reengineering, Just in time, Kaizen & TQM for improving quality and business results. While all these quality improvement drives are useful in their own ways, they often fail to make breakthrough improvements in bottom line and quality.

The Six Sigma concept gains more and more importance because of its successful implementation in the companies. Six Sigma is a powerful business strategy that employs a disciplined approach to tackle process variability using the application of statistical and non-statistical tools and techniques in a rigorous manner. Six Sigma is a methodology that improves quality and productivity by analyzing data with analytical and statistical tools to find root cause of production problems and to implement controls .It is a business strategy that focuses on improving customer requirement understanding, business system productivity and financial performance.

This paper is an attempt to introduce Six Sigma as a breakthrough improvement strategy for industries. An attempt is made to make some critical examinations relating to Six Sigma. The purpose is basically to capture the varied perspectives of Six Sigma and to provide a direction for integrating them into the planning, design and implementation framework to enhance the effectiveness of Six Sigma.

KEY WORDS

Breakthrough Improvement, Six Sigma, Six Sigma Quality, Six Sigma Roadmap.

INTRODUCTION

Quality Management

During the last decades, quality management has been put forward by a numbers of its promoters as a new management theory. Quality management can be described as a management revolution, a revolutionary philosophy of management, a new way of thinking about the management of organizations, a paradigm shift, a comprehensive way to improve total organizational performance, an alternative to management by control or as a framework for competitive management (Foley, 2004). Despite the high aims of promoters of quality management, the failures of organizations trying to implement a successful quality management programme have been well documented (Brown et al. 1994; Eskildson (1994), Harari 1997; Cao et al. 2000; Nwabueze 2001.

Quality Management Concepts

Concepts that have been presented and promoted are, for instance, Total Quality Management (TQM), Lean Manufacturing, Just-in-Time (JIT) Management, Kaizen, Business Process Reengineering (BPR), Business Excellence, Six Sigma etc.

Most of the quality management approaches fall into three major categories:

(A) Management systems – based on a set of consensus or regulatory requirements such as ISO 9000 & ISO 14000.

(B) Business process improvement strategies – emphasizing analytical, statistical and managerial tools to improve and control product, process and service quality, such as TQM, Lean management, SPC, JIT manufacturing, TPM, BPR, MBO, Quality Circles, Zero Defects, Six Sigma and so on.

(C) Performance excellence models – involving a regional or national set of award criteria used to evaluate a quality management system and the resulting business performance, Malcolm Baldrige National Quality Inter Award, European Quality Award, the Deming Prizes, The Golden Peacock National Quality Award, Rajiv Gandhi National Quality Award, European Quality Award, Korean National Quality Grand Prize etc. are few examples.

Organizations must determine which of these approaches will best fit their business model & provide the greatest return on investment.

Six Sigma

Recent developments have included increased organizational and academic interest in the Six Sigma approach to business improvement. Six Sigma was born approximately two decades ago as a process improvement philosophy to help improve business financial performance. It was developed in industry and spread largely by professional consultants. Since its introduction it has found its way into most sectors of today's business society. Inspired leaders, such as Jack Welch and Larry Bossidy, have incorporated Six Sigma into the fabric of their businesses and achieved results beyond the predictions of the most enthusiastic Six Sigma advocate. Six Sigma has also been expanded from merely improving existing processes to the design of new products and processes.

Six Sigma has now evolved from a quality improvement program to an overall business strategy executive system and business-results-oriented program, which seems more *total* than total quality management (TQM).

Six Sigma has acquired a strong perspective stance with practices often being advocated as universally applicable. Since its inception more than a decade ago, Six Sigma as a quality improvement framework has been gaining increasing attention & acceptance in industry. The performance in both manufacturing & service operations can now be calibrated in terms of "Sigma level", and companies eager to impress customers have begun to label themselves as "Six Sigma organizations". The Six-Sigma approach combines statistical methods with improvement processes to create a new methodology. This knowledge is then applied to improvement projects in an attempt to increase bottom line financials and customer satisfaction.

EVOLUTION OF SIX SIGMA

Over the past half-century various industries focused their attention to the quality of products. A large number of system/methods have been developed in an attempt to improve the product quality in industrial & service sectors. The Six Sigma approach to quality is said to have begun

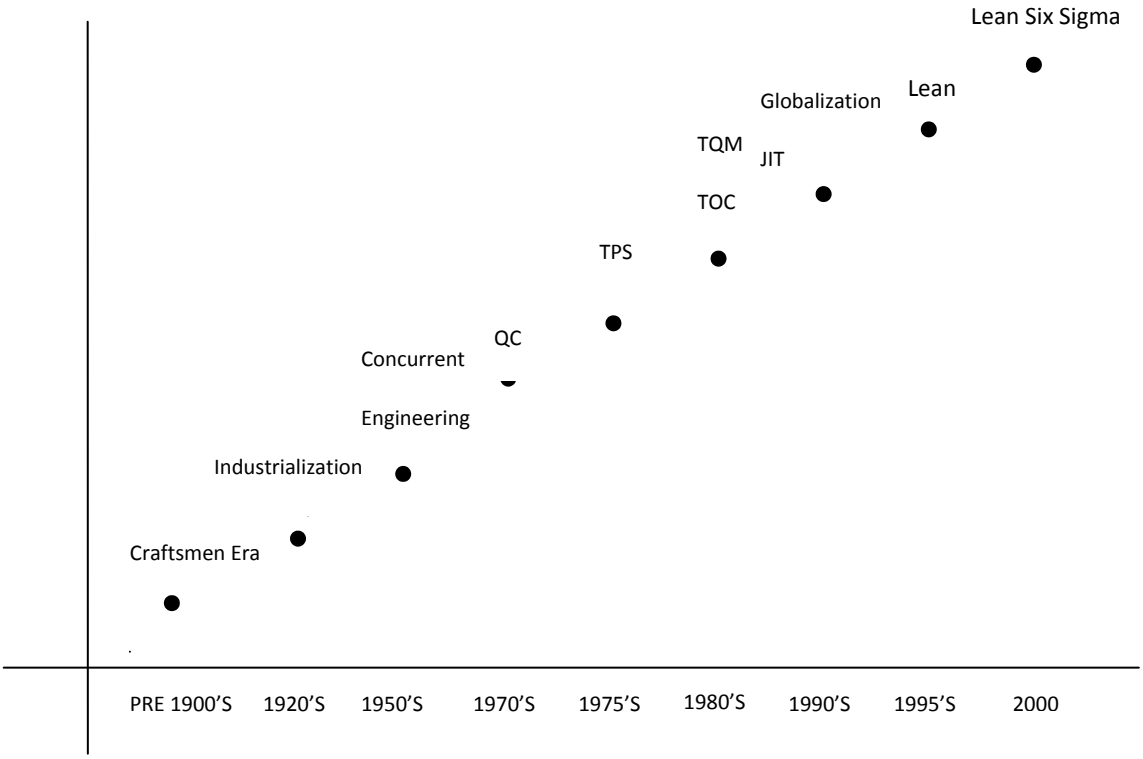

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Fig 1: Initiative Time Line

with Bill Smith, a reliability engineer at Motorola, in 1987 (Evans and Lindsay, 2005). Many measurement standards (Cpk, zero Defects etc.) later came into practice, but credit for coining the term "Six Sigma" goes to Bill Smith, an engineer at Motorola company . However, Six Sigma took off as a significant quality movement in the mid 1990s when Jack Welch, CEO of General Electric, " . . . went nuts about Six Sigma and launched it," calling it the most ambitious task the company had ever taken on. (Welch, 2001). "Six Sigma has taken the corporate world by storm and represents the thrusts of numerous efforts in manufacturing and service organizations to improve products, services, and processes." (Evans and Lindsay, 2005). "Evidence of the power of the Six Sigma way is already visible in the huge gains tallied by some very high-profile companies and some not-so-high profile ones, . . . " (Pande et al., 2000).

Six Sigma is regarded as a fresh quality management strategy which can replace SQC, TQC, TQM and others. There are many success stories of Six Sigma application in well known world-class companies. Six Sigma was pioneered by Motorola and launched as a strategic initiative in 1987. Since then, and particularly from 1995, an exponentially growing number of prestigious global firms have launched a Six Sigma program. Motorola, General Electric, Allied Signal (Merged with Honeywell), Boeing, Caterpillar, IBM, Dell, Xerox, Citibank, DHL, 3M, Raytheon, U.S. Air Combat Command , Microsoft, DEC,NASA, Texas Instruments, Sony, Kodak, Nokia, The McGraw- Hill Companies, Intel, Philips Electronics etc. have been quite successful in Six Sigma. In Korea, the Samsung, LG, Hyundai groups and Korea Heavy Industries & Construction Company etc. have been quite successful with Six Sigma. Manufacturing and Service organizations in India also adopted the concept of Six Sigma as an approach, these are L&T, Essar, Reliance , Tata Motors, TELCO, TISCO, Mahindra & Mahindra, Tata Honeywell Ltd., VIP Industries, TVS Suzuki Ltd., Jhonson & Jhonson, Grasim Industries, Apollo Tyres, HEG Ltd., Pidilite Industries, IPCL, Wipro, Cummins, Tata Consultancy Services, Godrej, Hindalco Ltd., Jindal Stainless Steel, Reliance Energy, Ultra Tech Cement Ltd.,Vodaphone, SKF, Airtel, Cognizant Technology Solutions, ICICI Prudential, ITC,Mumbai's Dabbawala etc.

WHY SIX SIGMA?

Six Sigma provides flexibility in the new millennium of 3Cs, which are:

- Change : changing society
- Customer : Power is shifted to customer and customer demand is high
- Competition : Competition in quality and productivity

The pace of change in last decade has been unprecented, and the speed of change in this new millennium is perhaps faster than ever before. Most notably, the power has shifted from producer to customer. The producer-oriented industrial society is no more in existence, and the customer-oriented information society exists. The customer has all the rights to order, select and buy goods and services. Competition in quality and productivity has been ever-increasing. Six Sigma is a methodology that provides businesses with tools to improve the capability of their processes by decreasing variation, which leads to a reduction in defects and an improvement in profits, employee morale and quality of products and services. Six Sigma is a disciplined, data-driven approach to process improvement aimed at the near-elimination of defects from every product, process and transaction. It can be used to improve every facet of business, from production, to human resources, to order entry, to technical support. Six Sigma can be used for any activity that is concerned with cost, timeliness and quality of results.

It solves business problems and quality problems in order to promote profitability and growth. Marketplace requirements are wed into business outputs in an aggressive program designed to transform the enterprise into a highly aligned profit making organization. Below the enterprise level, Six Sigma methods reduce variation, improve product quality, shorten the product development cycle, accelerate business transactions and improve overall service. The types of "business success" an organization may achieve are broad because the proven benefits of the Six Sigma "system" are diverse, including:

Improvement of the bottom line
Improvement of significant process
Alignment of participants and their activities with overall corporate goals
Provision of suite of systematic approaches to improvement, problem-solving and sustainment
Management of projects
Enhancement of staff capabilities
Emphasis on measurement and results
Improvements to corporate marketing
Enhancements in the use of statistical analysis
Development of focused products
Improvement of market share
Improvement of customer retention
Cost reduction
Productivity improvement
Market-share growth
Cycle-time reduction
Defect reduction
Culture change
Product/service development
And many more.

Improvements in these areas usually represent dramatic cost savings to businesses, as well as opportunities to retain customers, capture new markets, and build a reputation for top performing products and services. Six Sigma is about making every area of the organization better able to meet the changing needs of customers, markets, and technologies—with benefits for employees, customers, and shareholders.

The successful implementation of Six Sigma can result in benefits in the areas of cost reduction, increased profit, increased market share and enhanced business competitiveness, mainly by the reduction of the cost of poor quality (COPQ).COPQ usually includes appraisal costs, internal failure costs, and external failure costs. In manufacturing industries, COPQ sometimes reaches 15% of total sales. In service industries, the situation is even more serious. COPQ may account for as much as 50% of total costs. However, these COPQ could be saved with the use of Six Sigma. Indeed, thousands of companies around the world have enjoyed the breakthrough benefits of Six Sigma.

Six Sigma activities and achievements, seen mainly in large manufacturing operations, are also becoming more prevalent in small businesses, transactional business processes (e.g., HR and purchasing), and in the service sector (Gnibus & Krull, 2003; Goh, 2002; Hammer & Goding, 2001; Harry, 1998; Smith, 2003). Smaller companies have had similar financial success compared to larger companies but on a smaller scale (Brue, 2002; Gnibus & Krull, 2003; Harry, 1998). Both small and big organizations profited from implementing their own Six Sigma methodologies even though the Six Sigma method was originating from big companies. From at least a financial perspective, it appears that Six Sigma has had a considerable impact on numerous organizations across a variety of industries.

WHAT IS SIGMA?

'σ' pronounced as 'Sigma' is a letter in the Greek alphabet. It is used to designate the distribution or spread (variation) about the mean of a process i.e. where the process is centered around. Generally as we have seen in our example most of the values will cluster around the mean value. Values away from the central value will occur with lesser frequency. 'σ' is called standard deviation. For a stable process i.e. when process is under statistical control or within the chance cause variation only, predictions about process can be made from a knowledge of 'σ'.

WHAT IS SIX SIGMA?

Sigma *(σ)* is a letter that has become the statistical symbol and metric of process variation. The sigma scale of measure is perfectly correlated to such characteristics as defects-per-unit, parts-per-million defectives, and the probability of a failure. Six is the number of sigma measured in a process, when the variation around the target is such that only 3.4 outputs out of one million are defects under the assumption that the process average may drift over the long term by as much as 1.5 standard deviations.

In business and manufacturing organizations, variations in a process almost always result in defects, rework and scrap. If one can reduce the variation in a process, one can reduce the defects in the process (Harry, 1998). Six Sigma focuses all functions in "process". A process is a set of interrelated or interacting activities which transform inputs into outputs. Every process / procedure has an expected outcome / measurement called a "mean". Every outcome/measurement has some variability. The measure of that variability is called sigma (σ). Thus, the focus of Six Sigma methodology in manufacturing / business is to reduce variability and defects of processes.

A company's performance level is measured by the sigma level of their business processes. To increase the performance, the variation has to decrease. Fig 2. indicates how continual reduction of process variation can lead to higher quality, improved productivity and reduced cost (Desai, T. and Shrivastava, R., 2008).

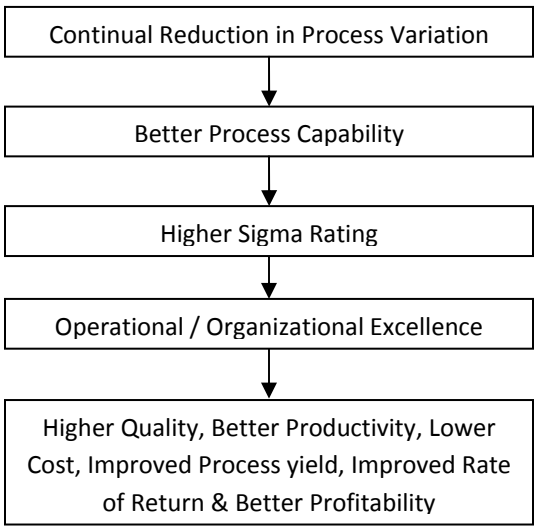
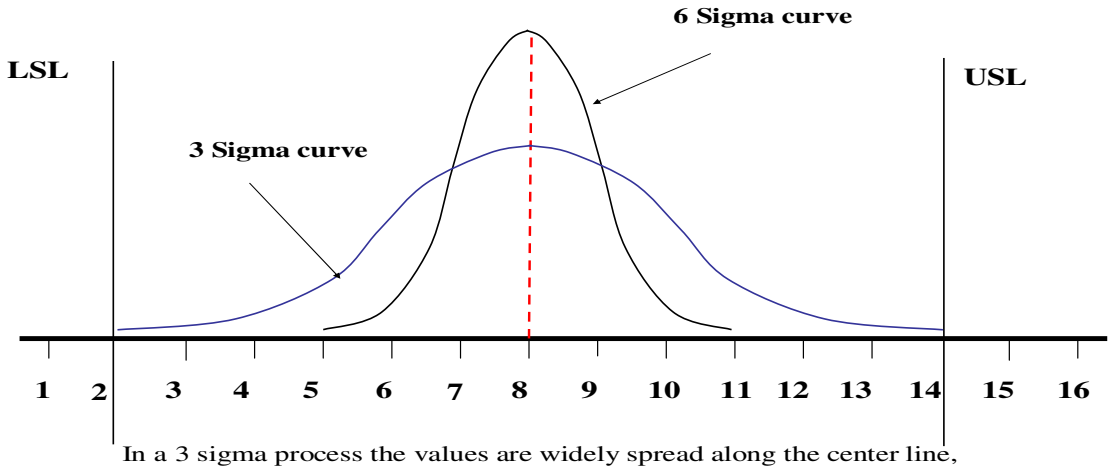


Fig 2. Process variation and higher quality

The goal of Six Sigma program is to reduce the variation in every process to such an extent that the spread of 12 Sigmas i.e. 6 Sigmas on either side of the mean fits within the process specifications. Figure 3 explains this concept. This figure also depicts the difference between 3-Sigma and 6-Sigma process. Six Sigma approach helps to ensure that the inherent variability in a process or service, the entire output is kept within the permissible or acceptable level i.e. it is an effort to keep the defects level at less than 3.4 parts per million. It is as good as zero. Higher the sigma level, lower is the DPMO number. This is evident from the Table 1 [Harry, 1998]. This table indicates how the industries are categorized based on the Sigma Level and Defects per Million Opportunity (DPMO).



In a 3 sigma process the values are widely spread along the center line, showing the higher variation of the process. Whereas in a 6 Sigma process, the values are closer to the center line showing less variation in the process.

Fig 3: Six Sigma Concept

Table 1 Sigma level and DPMO defining class of industry

Sigma level	Defects per million opportunities(DPMO)	Cost of poor quality(COPQ)	Industry class
6	3.4	< 10% sales	**World class**
5	230	10 to 15% of sales	
4	6,200	15 to 20% of sales	**Average**
3	67,000	20 to 30% of sales	
2	3,10,000	30 to 40% of sales	**Non-competitive**
1	7,00,000	>40% of sales	

Assuming that the process output is represented by a normal distribution, about 99.73% of the output is contained within bounds that are 3 standard deviations (3σ) from the mean. In this case the proportion of nonconforming product is about 0.27%, which is approximately 2700 parts per million (ppm). On the surface, this appears to be very satisfactory, but in reality it can be misleading. For example, if a product contains 10,000 parts or 10,000 operations, an average of 27 defects per product unit is expected. The product / process quality could be improved and it must be designed to tolerance limits that are significantly more than $\pm$ 3σ from the mean. In other words the product / process quality could be improved by reducing the value of 'σ' and limits could be set at 6σ, that is the process variability must be so small that the specification limits are 6 (Six) standard deviations from the mean, fig.4. If the process distribution is stable-that is, it remains centered between the specification limits – the proportion of nonconforming product should be only 0.001 ppm on each tail.

In real – world situations, the process distribution will not always be centered between the specification limits, process shifts to the right or left are common. Even if the process mean shifts by as much as 1.5 standard deviations from the center, the proportion of nonconforming product will be about 3.4 ppm. Comparing this to a three-sigma capability of 2700 ppm, this shows significant improvement in the expected level of quality from the process.

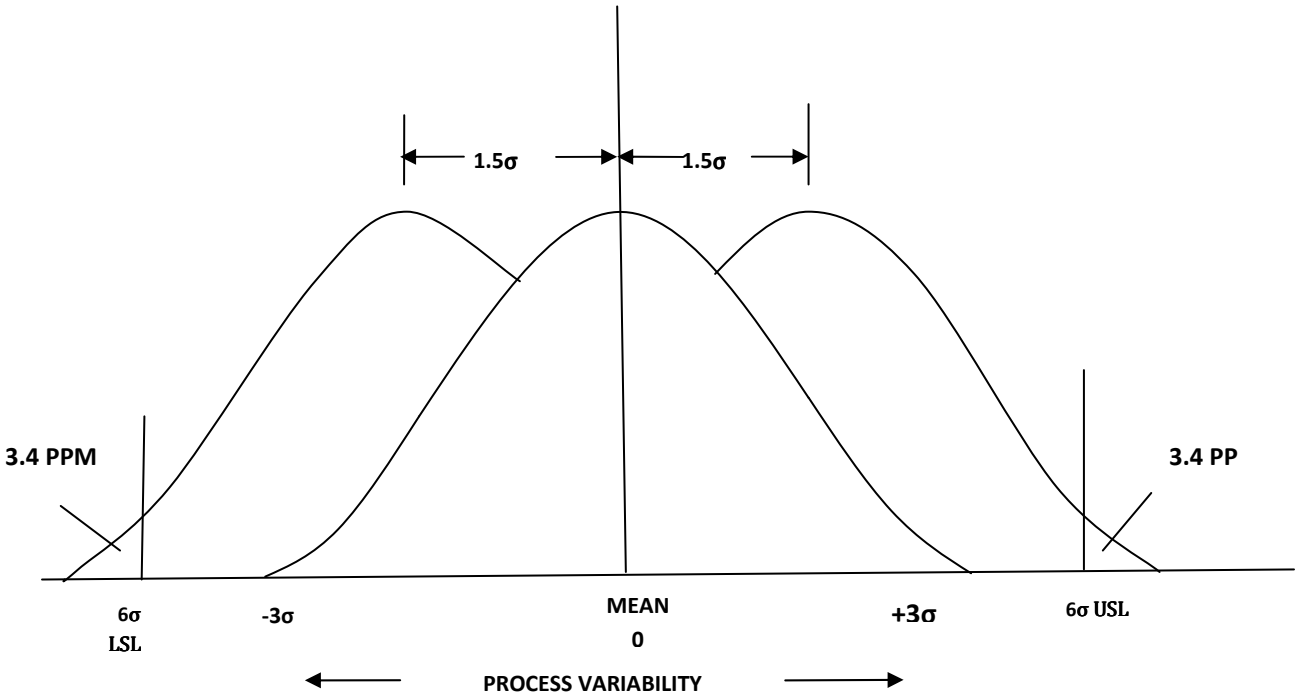


Fig 4: Six Sigma Capability

Six Sigma is a rigorous, focused and highly effective implementation of proven quality principles and techniques. Incorporating elements from the work of many quality pioneers, Six Sigma aims for virtually error free business performance. A company's performance is measured by the sigma level of their business processes. Traditionally companies accepted three or four sigma performance levels as the norm, despite the fact that these processes created between 6,200 and 67,000 problems per million opportunities! The Six Sigma standard of 3.4 problems per million opportunities is a response to the increasing expectations of customers and the increased complexity of modern products and processes.

The Six Sigma initiative focuses on continually improving the efficiency and effectiveness of all processes, tasks and transactions within any organization. This is achieved mainly on a project-by-project basis by a critical mass of members, trained in performance-enhancement methods, within a receptive and company culture and perpetuating infrastructure.

Six Sigma is both a business improvement strategy and a methodology to measure process performance. It is used to increase profits by eliminating defects, waste, and variability and to find the causes of mistakes in products, processes and services to increase yields. In Six Sigma, focus on the customer is the top priority. Performance standards are based on actual customer input, so that process effectiveness can be measured and customer satisfaction can be predicted. Variation signals fluctuation in the process output and is often a major source of poor quality; hence variation reduction is the key in terms of business process improvement. Variation is present in all processes and every aspect of work. Unintended variation reduces process performance and decreases customer satisfaction. Producing high quality products and services in the modern industrial environment is a tough task because of the existence of variation. Therefore, Six Sigma aims particularly at reducing variation. The word *sigma* or the symbol "*σ*" is used in statistical notation to represent the standard deviation in a population. The standard deviation is also used as a general measure of variation in any kind of product or process. With six standard deviations between the process mean and the customer's specification limit, we arrive at 3.4 defects per million opportunities (DPMO); that is, a 99.9997 percent yield. Before the Six Sigma technique was introduced, a three-sigma level of variation was regarded as being fairly good quality performance. Three sigma may be acceptable for a product or process having only a single or a few stages. It is not good enough for many products that are the result of hundreds of thousands of stages, such as automobiles and computers.

5.0 SIX SIGMA IMPLEMENTATION AND MANAGEMENT

Six Sigma is not about quality in the traditional sense. Quality, defined traditionally as conformance to internal requirements, has little to do with Six Sigma. Six Sigma is about helping the organization make more money by improving customer value, efficiency and productivity. To link this objective of Six Sigma with quality requires a new definition of quality. For Six Sigma purposes we define quality as the value added by a productive endeavor. Quality comes in two flavors: potential quality and actual quality. Potential quality is the known maximum possible value added per unit of input. Actual quality is the current value added per unit of input. The difference between potential and actual quality is waste. Six Sigma focuses on improving quality (i.e., reducing waste) by helping organizations produce products and services better, faster and cheaper. There is a direct correlation between quality levels and ''sigma levels'' of performance. For example, a typical company operating at roughly four sigma will produce roughly 6,210 failures per million transactions. Six Sigma focuses on customer requirements, defect prevention, cycle time reduction, and cost savings. Thus, the benefits from Six Sigma go straight to the bottom line.

For non-Six Sigma companies, these costs are often extremely high. Companies operating at three or four sigma typically spend between 20 and 30 percent of their revenues fixing problems. This is known as the cost of quality, or more accurately the cost of poor quality. Companies

operating at Six Sigma typically spend less than 5 percent of their revenues fixing problems **(**Figure 5) (Pyzdek, T., 2003). The reason for direct relationship of costs to sigma levels is that sigma levels are a measure of error rates, and it costs money to correct errors. Figure 6 (Pyzdek, T., 2003) shows the relationship between errors and sigma levels. As the sigma level goes up, the error rate drops exponentially, and that this correlates well to the empirical cost data shown in Figure 5. Also note that the errors are shown as errors per million opportunities, not as percentages. This is another convention introduced by Six Sigma. In the past we could tolerate percentage error rates (errors per hundred opportunities), today we cannot.

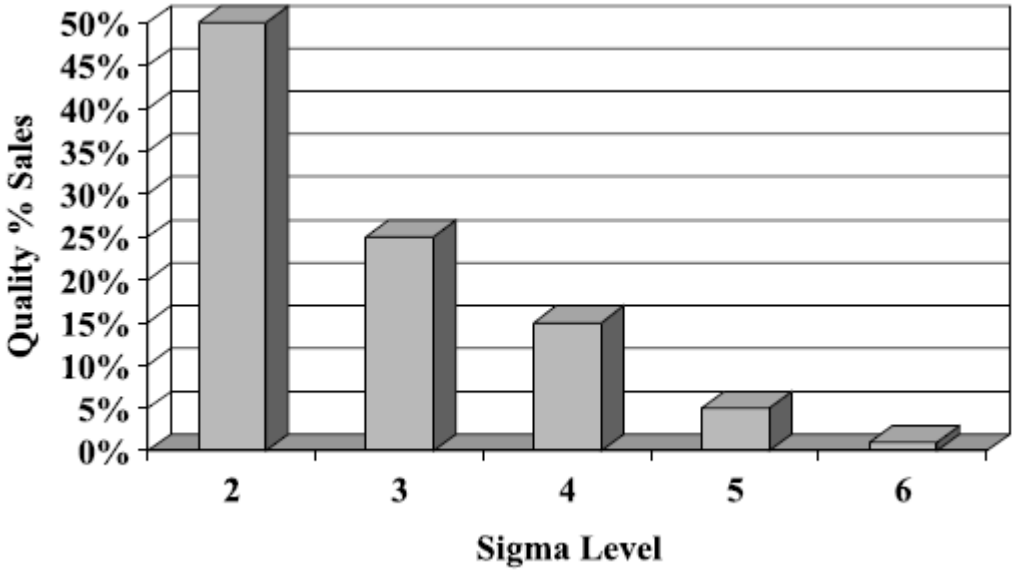


Fig. 5 Cost of poor quality versus sigma level (Pyzdek, T., 2003)

Six-sigma is a high performance, data driven method for improving quality by removing defects and their causes in business process activities. Six-sigma's target is to achieve less than 3.4 defects or errors per million opportunities hence the name. Higher the number of Sigmas, the more consistent is the process output or smaller is the variation. It is particularly powerful when measuring the performance of a process with a high volume of outputs.

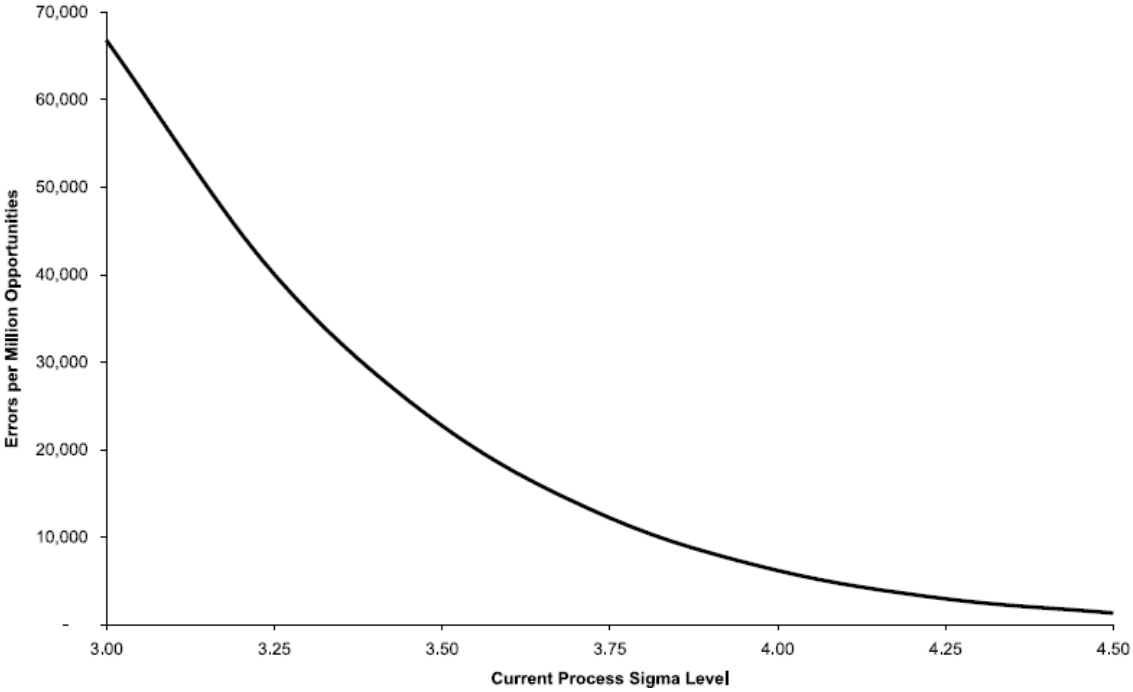


Fig 6. Error rate versus sigma level (Pyzdek, T., 2003).

Six-Sigma is a business improvement approach that seeks to find and eliminate causes of mistakes or defects in business processes by focusing on process outputs that are of critical importance to customers. Six-Sigma projects also often focus on improving productivity, process yields, production rates and process downtime. As a result, process performance is enhanced, customer satisfaction is improved, and the bottom-line is impacted through savings and increased revenue. Six-Sigma is a strategic approach that works across all processes, products and industries.

SIX SIGMA IS DEFINED

Six Sigma has been defined in the practitioner literature in a variety of ways. Quality Progress called Six Sigma a ''high-performance, data-driven approach to analyzing the root causes of business problems and solving them'' (Blakeslee, 1999., Harry and Schroeder, 2000), in their popular book on Six Sigma, described it as a ''business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction''. Hahn et al. (2000) described Six Sigma as a disciplined and statistically based approach for improving product and process quality. On the other hand, Sanders and Hild (2000) called it a management strategy that requires a culture change in the organization.

Six Sigma fundamentally focuses on reduction in variability. This technique is a simple common sense concept for those who understand statistical principles of targeting the mean to the required nominal value and controlling variance around the mean. But it is much more than just a statistical approach to problem solving. It is a company-wide initiative to improve both top line and bottom line through sustained customer satisfaction. The entire movement is driven by the voice of the external customer and concentrates on what is really important for the customer (Seth and Rastogi, 2004). It involves designing, improving, and monitoring business activities to minimize or eliminate waste while optimizing customer satisfaction and increasing financial stability (Pande et al., 2000). Six Sigma is customer focused and has the potential to achieve exponential quality improvement through the reduction of variation in system processes.

SIX SIGMA

Six Sigma is a comprehensive, flexible and holistic system; an organization wide approach driven by close understanding of customer needs, disciplined use of facts and data, and statistical analysis, for managing and improving business processes (by eliminating variations in processes) having goal of less than 3.4 defects per million opportunities(DPMO) for every process for achieving, sustaining and maximising business success.

BASICS OF SIX SIGMA

Six Sigma offers a measure of goodness, a methodology for improving performance, a measurement system that drives dramatic results, and a new paradigm that requires a passionate commitment from leadership to set high expectations. Figure 6 demonstrates the relationship between defect rate, sigma level, and cost reduction opportunities.

Six Sigma has been labeled as a metric, a methodology, and now, a management system.

SIX SIGMA AS A METRIC

Sigma is the measurement used to assess process performance and the results of improvement efforts - a way to measure quality. Businesses use sigma to measure quality because it is a standard that reflects the degree of control over any process to meet the standard of performance established for that process.

Sigma is a universal scale. The sigma scale allows us to compare very different business processes in terms of the capability of the process to stay within the quality limits established for that process. The Sigma scale measures Defects Per Million Opportunities (DPMO). When used as a metric, Six Sigma technically means having no more than 3.4 defects per million opportunities, in any process, product or service.

A process that operates at 4.6 Sigma is operating at 99.9% quality level.

That means:

- 4000 wrong medical prescriptions each year
- More than 3000 newborns being dropped by doctors/nurses each year
- 2 long or short landings at American airports each day
- 400 lost letters per hour

A process that operates at the 6 Sigma level is operating at 99.9997% quality level. At 6 Sigma, these same processes would produce:

- 13 wrong drug prescriptions per year
- 10 newborns dropped by doctors/nurses each year
- 2 long or short landings at U.S. airports each year
- 1 lost letter per hour

With sigma as the scale, measures of as-is process quality and standards for should-be process targets for quality improvement can be set and understood for any business process.

SIX SIGMA AS A METHODOLOGY

As a methodology, it is used to evaluate the capability of a process to perform defect-free, where a defect is defined as anything that results in customer dissatisfaction. Six Sigma's breakthrough strategy combines improved metrics and a new management philosophy to significantly reduce defects thereby strengthening a firm's market position and improving the profit line (Harry and Schroeder, 2000). The Six Sigma methodology builds on the Six Sigma metric. Six Sigma practitioners measure and assess process performance using DPMO and sigma. They apply the rigorous DMAIC (Define, Measure, Analyze, Improve, and Control) methodology to analyze processes in order to root out sources of unacceptable variation, and develop alternatives to eliminate or reduce errors and variation. Once improvements are implemented, controls are put in place to ensure sustained results. The organizations achieved significant improvements in product and service quality and profitability over the last several years using this DMAIC methodology. Depending on the state of the process, product, or service addressed by the project, a different methodology is sometimes used. For instance, for products or processes that are being designed or redesigned, the Define, Measure, Analyze, Design, Verify (DMADV) or the Identify, Design, Optimize, Validate (IDOV) framework is often used. These structures form the basis of Design for Six Sigma (DFSS).

Six Sigma as a Management System

Six Sigma as a best practice is more than a set of metric-based problem solving and process improvement tools. At the highest level, Six Sigma has been developed into a practical management system for continuous business improvement that focuses management and the organization on four key areas:

- Understanding and managing customer requirements
- Aligning key processes to achieve those requirements
- Utilizing rigorous data analysis to understand and minimize variation in key processes
- Driving rapid and sustainable improvement to the business processes.

As such, the Six Sigma Management System encompasses both the Six Sigma metric and the Six Sigma methodology. When Six Sigma is implemented as a management system, the organizations derive the greatest impact.

Six Sigma focuses on establishing world-class business-performance benchmarks and on providing an organizational structure and road-map by which these can be realized. This is achieved mainly on a project-by-project team basis, using a workforce trained in performance-enhancement methodology, within an organization culture and infrastructure. Six Sigma is particularly relevant to the enhancing of value of products and services from a customer perspective, but it is also directly applicable to improving the efficiency and effectiveness of all processes, tasks and transactions within any organization. Projects are thus chosen and driven on the basis of their relevance to increased customer satisfaction and their effect on business-performance enhancement through gap analysis, namely, prior quantitative measurement of existing performance and comparison with that desired.

Success in Six Sigma is dependent on active senior management leadership and mentoring, an established infrastructure of black and green belts, a continuing project focus on 'bottom line' opportunities and results, with established teams trained in using a structured approach and methodology to achieve the desired results.

SIX SIGMA PROCESS-IMPROVEMENT MANAGEMENT

The Six Sigma improvement process refers to the mechanism of breakthrough to world-class standards of performance across the whole enterprise .It is focused on 'adding value'; one in which organizations seek out opportunities to improve efficiency and effectiveness with a view to enhancing profit margins, competitiveness and customer satisfaction:

- It achieves results through a highly focused system of problem-solving and process-improvement projects;
- An infrastructure is created to make it work and keep on working;
- It is implemented through a standard road-map for each project undertaken;
- It is an initiative that aims at channeling and unifying the efforts of everyone in the organization towards the Six Sigma goal;
- It is based on scientific method utilizing practical and directed statistical thinking and methodology.,
- It is equally applicable to all processes in an organization and to any organization.

SIX SIGMA QUALITY

The Six Sigma philosophy was created to improve on some of the drawbacks of TQM. Kuei and Madu (2003) define Six Sigma as:

Six Sigma quality = meeting the very specific goal provided by the 6σ metric and

Management = enhancing process capabilities for Six Sigma quality.

Six Sigma is a disciplined, data-driven approach aimed at eliminating defects (driving towards six standard deviations between the mean and the nearest specification limit) in any process (George, 2002). The term "Six Sigma," borrowed from statistics, describes how a process is performing. To achieve the "Six Sigma" level, a process must not produce more than 3.4 defects per million opportunities. A "Six Sigma opportunity" is the total quantity of chances for a defect.

Six-Sigma is also a measure of process performance. The methodology utilizes 'process sigma' as a measure of process capability with a 6-sigma process having a defect level of 3.4 parts-per-million opportunities (ppm) and a 3-sigma process having a defect level of 66,807 ppm (Harry, 1998). In many instances a 6-sigma process is considered world class. The performance of most processes today is in the 3 to 4-sigma range. The Six-Sigma measure of process capability assumes that the process average may shift over the long-term by as much as 1.5 sigma (standard deviations) despite our best efforts to control it. In the case of the 6-sigma process, 3.4ppm is obtained by assuming that the specification limits are six standard deviations away from the process target value and that the process may shift by as much as 1.5 sigma. The 3.4 ppm value is the area under the normal curve beyond 6 – 1.5 = 4.5 sigma. Similarly, the 66807 ppm for the 3-sigma process is the area beyond 3 – 1.5 = 1.5 sigma.

The ability to produce products and services with only 3.4 defects per million opportunities yields a Six-Sigma process. Such a level of performance is considered to be

World-class for many processes. Six-Sigma level of performance should not be the goal for all processes. Some processes require a higher level of performance (e.g., airline safety). A lower level of performance may be acceptable for other processes. The appropriate level of performance is a business decision trading off the cost of attaining the higher level of performance versus the benefits of a higher performing process. The appropriate process sigma level may change over time as customer needs and competitive pressures change.

SIX SIGMA- THE ESSENCE

A symbol of excellence- a level of performance (3.4 defects par million) that reflects significantly reduced defects in products and services.

The sigma and part per million (ppm) are correlated as indicated in Table 2.

Table 2 Sigma & PPM

Sigma	Defects per million (PPM)
2	3,08,537
3	66,807

4	6,210
5	233
6	3.4

A statistical metric that describes how well processes meet requirements in terms of process capability as well as a benchmark for comparison and improvement.
A strategic tool which aims at eliminating defective output by bringing down the cost of quality to zero.
A data and fact driven management approach with focus on the customer. A set of statistical tools and techniques to help measure, analyze, improve and control processes and products.
A rigorous, analytical, process-oriented methodology for solving problems.
A mechanism which allows companies to drastically improve their bottom line and top line.
The focus of Six Sigma is on the following areas:
Root cause of any problem & its elimination / prevention.
Focus is on the inputs to the process & not on the output.
Focus is on the problem & not on the symptom.
Focus is on controlling the problem or the deviation & not on monitoring.

SIX SIGMA -THE ROLE

1. Six sigma attacks variation (variance) which is more effective than target value, by improving capability of processes.
2. It reduces quality costs viz. inspection costs, defects and defective costs, rework and rectification costs, costs related to product recall, customer goodwill etc.
3. It is a methodology which measures and controls costs which directly affects the bottom line, rather than talking about intangible saving.
4. It significantly improves yields of the process.
5. It improves the return on investment (ROI) and thereby profitability of a company.
6. It attacks and reduces random or natural causes of process variation also. Conventional SQC attacks on non-random or assignable causes of variation only and tolerates (or lives) with neutral (random) variations of the process.

INFRASTRUCTURE

Creation of an infrastructure to assure that performance improvement activities have the necessary resources is a very powerful feature of Six Sigma. Failure to provide this infrastructure is one of the reasons for failure of TQM implementations in the past. TQM presented general principles and left it to each organization to decide how to put the principles into practice. Sigma provides a quasi-standardized set of guidelines for deployment. Hence Six Sigma enjoys a much higher success rate than TQM. Of course, there are still those companies that put together half-hearted efforts and call it Six Sigma. They will fail just as those companies who deploy half-baked TQM programs. Six Sigma full-time change agents are the catalyst that institutionalizes change**.** Figure 7 illustrates the infrastructure required by Six Sigma. General functions at different level are mentioned below.

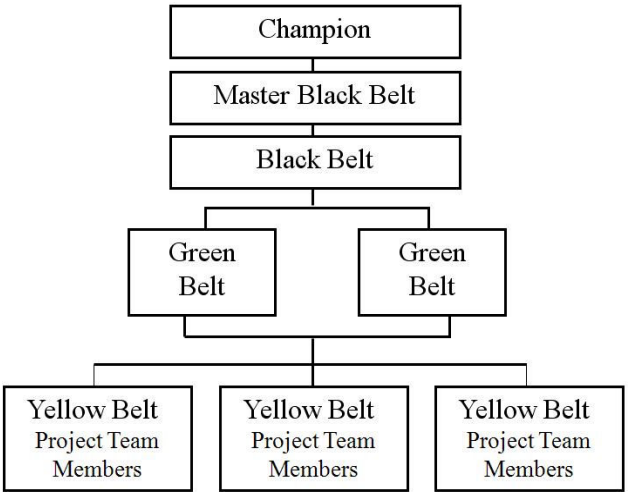


Fig. 7 A typical Structure in Six Sigma Organization

A Six Sigma deployment effort typically starts with the following infrastructure:

- A senior executive, often a president or chief executive officer, provides the necessary impetus and alignment by assuming a leadership role.
- An executive committee, working operationally at a level similar to that of the senior executive, oversees the Six Sigma deployment.
- A champion sponsors an individual project. This individual is usually a member of the executive committee and has enough influence to allocate resources and remove obstacles without having to appeal to a more senior individual.
- A process owner has the authority and responsibility to make improvements to operations.
- A black belt supports project teams, taking a leadership role in this effort. This individual is a full-time change agent who is allocated to several projects. A black belt is usually a quality professional, but is often not an expert on the operational processes within the scope of the project.

- A green belt works part-time on a project or perhaps leads a smaller-scope project.
- A master black belt mentors the Six Sigma community (black belts and green belts), often provides training, and advises the executive committee. A master black belt must have a proven track record of effecting change and be a known and trusted individual. This track record is established by having successfully completed and led numerous Six Sigma projects within the same organization.

SIX SIGMA: THE PROJECT-BY-PROJECT APPROACH

There are many possible different approaches to the project-by-project approach to improvement in organizations. The standard Six Sigma project road-map proposed here is a generic one. It consists of eight steps:

1. Identify the project.
2. Define the project.
3. Measure current process performance.
4. Analyze the current process.
5. Develop the improvements; pilot and verify.
6. Implement the changes; achieve breakthrough in performance.
7. Control at new level; institutionalize to hold the gains.
8. Communicate new knowledge gained; transfer solution to similar areas.

IMPLEMENTING SIX SIGMA

The steps required to successfully implement Six Sigma are described below:

1. Successful performance improvement must begin with senior leadership. Start by providing senior leadership with training in the philosophy, principles, and tools they need to prepare their organization for success. Using their newly acquired knowledge, senior leaders direct the development of a management infrastructure to support Six Sigma. Simultaneously, steps are taken to ''soft-wire'' the organization and to cultivate an environment where innovation and creativity can flourish. This involves reducing levels of organizational hierarchy, removing procedural barriers to experimentation and change, and a variety of other changes designed to make it easier to try new things without fear of reprisal.
2. Systems are developed for establishing close communication with customers, employees, and suppliers. This includes developing rigorous methods of obtaining and evaluating customer, owner, employee, and supplier input. Base line studies are conducted to determine the starting point and to identify cultural, policy, and procedural obstacles to success.
3. Training needs are rigorously assessed. Remedial basic skills education is provided to assure that adequate levels of literacy and numeracy are possessed by all employees. Training is imparted to all employees in systems improvement tools, techniques, and philosophies.
4. A framework for continuous process improvement is developed, along with a system of performance indicators for monitoring progress and success. Six Sigma metrics focus on the organization's strategic goals, drivers, and key business processes.
5. Business processes to be improved are chosen by management, and by people with intimate process knowledge at all levels of the organization.
6. Six Sigma projects are conducted to improve business performance linked to measurable financial results. This requires knowledge of the organization's constraints.
7. Six Sigma projects are conducted by individual employees and teams comprising of Green Belts, Black Belts, Master Black Belts and Champions. The approach is simple, but it is by no means easy. Research has shown that organizations that successfully implement Six Sigma perform better in virtually every business category, including return on sales, return on investment, employment growth, and share price increase.

CONCLUSION

In this paper the varied perspectives of Six Sigma are described and a direction is provided for integrating them into the planning, design and implementation framework to enhance the effectiveness of Six Sigma. Six Sigma improvement drive is the latest and most effective technique in the quality engineering and management spectrum. Six Sigma has been widely accepted as a business strategy to improve business profitability and achieve operational excellence through the effective application of both statistical and non statistical tools. The program is applicable to not only manufacturing processes but also to processes related with administrative and office works, technical education systems, etc. Six Sigma as a powerful business strategy has been well recognized as an imperative for achieving and sustaining operational (process) effectiveness, producing significant savings to the bottom line and thereby achieving organizational excellence. Six Sigma is a methodology that links various established management and statistical tools in a structured manner for demonstrable quality improvement. The methodology requires the organization's overall support: Support for Six Sigma means making sure that top management drives the effort that sufficient resources are allocated to make it succeed, that the culture is supportive of change, and that employees develop the skills and behaviors necessary to reinforce Six Sigma efforts at the level of individual jobs and work processes.

The improvement drives such as Total Quality Management, Business Process Reengineering, Kaizen, Just in Time etc. are useful in their own ways, but they often fail to make breakthrough improvements in bottom line (profitability, return on investment etc.). If implemented properly with total commitment & focus, Six Sigma can put industries at the forefront of the global competition. It has proven to be one of the most emerging strategies of the 21st century for accelerating innovations and continuous improvement activities in achieving operational and business excellence. Six Sigma will continue to grow and evolve to match the needs of the modern business in the 21st century.

ABBREVIATIONS

TQM – Total Quality Management, JIT – Just in Time, BPR – Business Process Reengineering, SPC – Statistical Process Control, , TPM – Total Productive Maintenance, , MBO – Management by Objectives, QC – Quality Control, TPS – Toyota Production System, TOC – Theory of Constraints, QFD – Quality Function Deployment, FMS – Flexible Manufacturing System, SQC – Statistical Quality Control, TQC – Total Quality Control, COPQ – Cost of Poor Quality, DPMO – Defects per Million Opportunities, , DMAIC – Define Measure Analyze Improve & Control, DMADV – Measure Analyze Develop Verify, DFSS –Design for Six Sigma, ROI – Return on Investment

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