six Σ =?

what is six sigma?

six Σ =?

With businesses striving to focus on the customer and achieve competitiveness through consistently reliable products and services, it should be no surprise that the issue of six sigma quality is now attracting increasing attention from manufacturers and service providers in the UK and beyond. Professor Tony Bendell , of the University of Leicester and Services Ltd who is working with Smallpeice Enterprises Ltd, describes why six sigma is something we are going to hear a lot more about

In the past few years, major US corporations have made public the benefits attributed to their six sigma programmes. AlliedSignals saved $175 million in 1995, and nearly double that in 1996. In 1997, General Electric announced that it would save $500 million that year because of six sigma and by 1998 the programme savings had risen to $1.2 billion. The bottom line is that corporations moving toward six sigma levels of performance have saved billions of dollars and boosted their stock values.

However, while dollar signs do help to highlight the potential of this quality approach, they do little to resolve the confusion that often surrounds all such 'quality movements' or explain how the benefits of six sigma are achieved.

The moment of conception

It was Motorola which conceptualised six sigma as a quality goal in the mid 1980s and first recognised that modern technology was so complex that old ideas about acceptable quality levels were no longer applicable. But the term, and the company's innovative six sigma programme, only came to real prominence in 1989 when Motorola announced it would achieve a defect rate of not-more-than 3.4 parts per million within five years. This claim effectively changed the focus of quality within the US, from one where quality levels were measured in percentages (parts per hundred) to a discussion of parts per million or even parts per billion. It was not long before many of the US giants - Xerox, Boeing, GE, Kodak - were following Motorola's lead.

While few dispute this history, one area of confusion is the interpretation of the term six sigma. The original industrial terminology is based on the established statistical approach which uses a sigma measurement scale (ranging from two to six) to define how much of a product or process normal distribution is contained within the specification. Essentially, the higher the sigma value the less likely it is for a defect to occur, because more of the process distribution is contained within the specification.

Sliding scales

As the sigma scale describes defects in parts per million, the desire to achieve six sigma either side of the nominal target inside the specification relates to very tight production characteristics or equivalently a very low incidence of cases outside the specification, 'defects'. In fact, under the assumption of normality, a product or process operating at six sigma quality would have a 99.999998 per cent yield, or defects at 0.002 parts per million (two parts per billion). At the more typical three sigma quality level, the yield will be 99.73 per cent or 2,700 defects per million opportunities.

By taking into account the fact that the product or process mean might vary from the nominal target by up to 1.5 sigma, this translates into a yield at six sigma, of 99.99966 per cent or 3.4 defects per million - the target declared by Motorola and now regarded as 'six sigma' quality by industry in general. By applying the same 'worst case scenario' (a 1.5 sigma deviation) to the typical levels of three and four sigma achieved by many manufacturing companies, the gulf between the world-class goal and average performance is dramatically illustrated. At three sigma the yield falls steeply to only 93.32 per cent

‘While six sigma programme implementation need not require any significant capital expenditure, it does warrant a long-term vision, management commitment and commensurate attention and resources.’

or 66,810 defects per million opportunities. Even at four sigma, the number of defects is 6,210 per million.

The six sigma philosophy

The other area where there is significant scope for misunderstanding is in the application of six sigma. Some companies simply see it as a measure of quality that should just be used to strictly control the delivery of defect-free product. However this is not the view held by those organisations, such as Motorola, that have driven forward the six sigma approach, and have gained the major benefits from it. Rather than a random application of a quality measure, these leading companies see six sigma as the basis of a best-in-class philosophy, and a long-term business strategy. As such, six sigma becomes an evolutionary phase of a company’s quality strategy, serving to further enhance the results of existing programs. For example, while six sigma relates to all of the criteria of the EFQM excellence model, its primary impact is on the processes criterion.

The fundamental objective of this approach to six sigma is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction, often through the application of improvement projects. In this way, waste and cost are driven out of the organisation as quality improves, and customer satisfaction is increased through the continuous improvement in quality. Moreover, while efforts have concentrated on Design for six sigma or project-based manufacturing improvements, there is a growing realisation that six sigma is effectively applicable in every process and transaction within a company. Using the common measurement index of ‘defects per unit’, where a unit can be virtually anything including a line of code or an administrative form, companies have started to utilise the approach to reduce defects in non-manufacturing operations.

Aiming for excellence

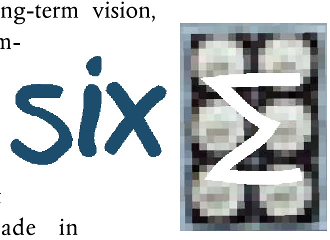
Crucially, because a six sigma programme in essence means overall excellence, implementation requires more than simply explaining what six sigma means and expecting everyone to begin doing it immediately. Now often referred to as six sigma programmes, this generic business encompassing approach contains a number of key features (see box 1).

One established framework for this is Motorola’s ‘six steps towards six sigma’. There are actually various versions of the six steps, which primarily change depending on the process being improved, but all are aimed at ensuring that improvement activities maintain the link between customer quality requirements, ‘parts’ and processes. In general terms the steps are:

- identify requirements of end product
- determine the characteristics of the product components that are key to meeting the end product requirements (applicable techniques include: cause and effect diagrams, failure mode effects and criticality analysis (FMECA), quality function deployment (QFD), Taguchi methodology/design of experiments)
- determine for each key characteristic, the process step that effects or controls it
- identify target value for each characteristic that minimises the impact of variation upon the end product, and determine the maximum allowable range or tolerance of that characteristic. (Robust design, QFD, FMECA)
- identify actual or expected variation in each characteristic and determine capability of relevant process step for that characteristic
- ensure that process steps are in statistical control and centred around the targets to be achieved

Respect for the masters

While six sigma programme implementation need not require any significant capital expenditure (other than for training), it does warrant a long-term vision, management commitment and commensurate attention and resources. It is also essential that investment is made in training designated staff in the appropriate methods, tools and techniques, and then enabling them to manage the programme and guide improvement projects. These people, particularly those now commonly referred to as master black belts, black belts and green belts, are the core of the six sigma programme.

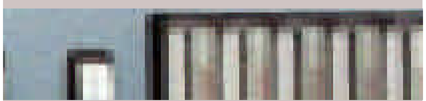


Typically, a black belt will have undertaken a training programme consisting of a minimum of 20-25 days training, and carried out an improvement project over a three to six month training period. A green belt will perhaps have undertaken around 10 to15 days training. When fully trained a black belt will work full time on improvement projects, while a green belt is likely to spend at least 20 per cent of their time on projects. Master black belts are site experts and trainers of black and green belts. Experiences from US organisations suggest that companies might train and maintain ten black belts per 1,000 employees, and one master black belt per 1,000 employees.

Achieving six sigma is a challenge to any company and not all implementations succeed. Failure results from weak leadership, slack goal setting, poor project management, and inadequate resources and training. Establishing six sigma fully throughout an organisation is a long-term programme - essentially it is an ongoing process of continuous improvement where even the most dedicated company may set goals for achieving six sigma quality over six to ten years. However, if properly introduced, companies should experience financial benefits shortly after they begin. US companies have reported that a typical black belt is expected to carry out four to six projects per year, and when deployed on high leverage projects can achieve cost reductions of $200,000 per project.

Through ongoing deployment, a six sigma company generates and substantially saves money by focusing on key customer critical issues and functioning on a higher level of efficiency. Reduced defects, scrap and re-work lead to immediate bottom-line benefits, and as production line waste drops off the company can make more efficient use of all resources. Improved design processes lead to better quality and more reliable products with reduced lead times, and better transactional processes reduce errors and increase productivity. As a result new customers begin purchasing from a company known for its high quality goods, and so revenues increase.

Smallpeice



Professor Tony Bendell is programme leader within a major new UK-based six sigma programme developed by specialist trainers for industry, Smallpeice Enterprises Ltd.

The Smallpeice six sigma programme provides a route to achieving black belt or senior green belt certification via an intensive three-month training schedule combined with assessed in-company project work. The flexible training programme includes modules on Taguchi Methodology, SPC, FMEA, project management, quality function deployment, Poka Yoke (mistake proofing), problem solving and leadership skills, and is supplemented by options from Smallpeice's portfolio of specialist courses in design engineering, lean manufacturing, project management, and management development.

This programme launch provides a unique alternative for UK manufacturers who have previously been restricted to adopting courses imported from the US and delivered by US consultants. The Smallpeice programme has been developed specifically for UK manufacturers, and successful participants will receive a certificate of recognition from the University of Leicester Management Centre, following external assessment of final project reports.

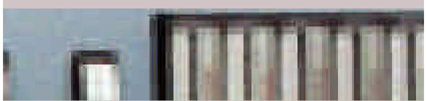
The first black belt and senior green belt public programmes commence in March 2000. Further details on the Smallpeice six sigma programme go to: www.smallpeice.co.uk.

Practice makes perfect

To compete in a world market, companies have to move toward a six sigma level of performance, and it is not just the US giants who have recognised this. There are an increasing number of UK businesses which are now following suit.

One UK operation that has fully adopted the six sigma philosophy, and endorses it unreservedly, is General Domestic Appliances' (GDA) Refrigeration Factory in Peterborough. The six sigma approach was introduced into the company in 1996 through its US co-owner GE. As the company's manufacturing director, Jon Harper, readily admits, the UK managers were initially sceptical that this was just another six month fad. But it only took a few projects to demonstrate to both the management team and engineering staff that adopting the six sigma approach could make a major difference. The company found it was able to solve problems that had been long running issues, and were able to get into sub-1,000 parts per million problems and tackle them effectively.

Implementing six sigma



Companies implementing six sigma may:

- adopt a systematic approach.
- define and establish roles and responsibilities within design, manufacturing and throughout the organisation
- identify, introduce and establish methods and techniques for the defining of processes and customer requirements, and the identification of critical steps and key measures
- introduce practices for benchmarking performance and processes for prioritising improvement opportunities
- use a standard to identify, reduce and control the sources of variation, allowing allowing individuals or project teams to focus on reducing the standard deviation within the process, rather than obsessing over method. This also helps ensure the correct application of the powerful tools - such as statistical analysis, experimental design and project management - that speed up the execution of improvement activities

Having adopted the six sigma philosophy, the underlying structured methodology and accompanying techniques - including FMEA, Ishikawa diagrams, design of experiments - are now used throughout the company to solve a wide variety of problems and, most importantly, improve customer satisfaction. For example, one project has solved the problems caused by the companies shop floor data collection system, which in some cases had lead to the wrong products being delivered to customers. A full assessment and analysis of the issues resulted in both changes to the system, including the introduction of more tracking and verification stations, and the introduction of better labelling which helps operators identify the product more easily. Financially, this project saved the operation £47,000 (with such savings recurring each year) and more importantly reduced the potential for customer dissatisfaction.

As GDA has recognised, six sigma is about more than just good engineering. It is about tackling problems using a structured methodology, the right tools, within a team environment. According to Jon Harper the team element of six sigma is a big part of its success. This is because operators have a great deal more to offer than they are traditionally asked for, and by employing truly multi-disciplined project teams, the six sigma methodology provides a way to unlock that potential.

As well as using multi-disciplined teams, there are some other key elements to

'Within four months, the results of the project had reduced the service call rate for poor sealing doors from 1.13 per cent to 0.6 per cent, which equated to a cost saving of £15,000 per annum, and immeasurable benefits in improved customer satisfaction.'

GDA's six sigma methodology. All projects are championed by a senior member of staff, and led by a green or black belt whose task it is to form and guide the project team. Depending on the project this team could include design engineers, manufacturing engineers, production operators, service staff, supplier representatives etc. Also regular reviews are essential, and these are attended by the project champion and leader and a master black belt. Moreover, all projects follow a six step process:

- define problem phase
- measurement phase
- analysis phase
- improve phase
- control phase
- transfer phase

A frost free example

An example of what happens in the above six sigma stages is provided by a recent project to improve door sealing on the company's frost-free range of appliances.

With the overall aim of establishing the cause of this problem and tackling it at source, the define phase of the six sigma project at GDA set about establishing the boundary of the problem. A brief analysis showed that the problems could be due to a range of contributing factors - the seal itself, the body panel designs and manufacture, the final product assembly, or the distribution process. Therefore to help assess all the possibilities, the multi-disciplined project team included representatives from design, service, production - including operators - and the seal supplier. For the next step, the measurement phase, the team introduced some new internal measures to more accurately check the seal fit prior to dispatch. Soon after the monitoring was started it became apparent through simple Pareto analysis that a large majority of poor fit problems were centred around just three measurement points. It was then a case of using further measurement approaches - such as tolerance analysis of components in those areas, and paired comparisons - to pinpoint the defect cause. As a result the main issue was traced to the design of the bottom hinge. Without having undertaken the structured analysis and measurement tasks prescribed by the six sigma approach, there would have been little chance of finding this problem.

Within the analysis phase, the team assessed - through FMEA - all the findings, and as well as the hinge itself, the team discovered some additional factors that were outside the areas normally considered, which could also contribute to sealing problems. It also became obvious, due to the fact that there were representatives from the seal suppliers on the team, that not only did the suppliers not fully understand GDA's requirements for the seal, but that the company's designers did not understand the supplier's processes. As a result of this analysis, it was possible to instigate a number of changes during the projects improve phase. As well as employing design of experiments to determine the optimum dimensions for a new bottom bracket that would ensure good sealing, changes were also made to the suppliers systems and product packaging to better suit GDA's assembly processes.

The team then monitored these changes during the control phase, to ensure that the changes did bring the process under control, and that the number of poor fitting seals were radically reduced. This stage was also crucial for gaining the buy-in of the workforce to the implemented changes, and for establishing those operators who were directly involved in the project team as 'champions' who will ensure that the new controls are maintained. In the final transfer phase, the findings of the project were assessed for relevance to other projects. In the case of this door-sealing project, which had concentrated on the company's range of frost-free appliances, much of the data and insight gained was also applicable to the company's larger volume static refrigeration products.

It is a money spinner

Within four months, the results of the project had reduced the service call rate for poor sealing doors from 1.13 per cent to 0.6 per cent, which equated to a cost saving of £15,000 per annum, and immeasurable benefits in improved customer satisfaction. This is just one of the many similar projects undertaken by the factory, and since last year the operation's six sigma programme has generated savings of well over one million pounds.

Apart from such financial benefits, as an overall result of implementing six sigma, GDA has also seen the manner in which engineers and operators approach improvement projects change significantly over the past few years, and the confidence with which people propose solutions has grown enormously. Now, using its experience, the company has more recently begun work on design for six sigma - moving from problem solving into problem prevention. It has also refocused the effort from cost reduction onto improving customer satisfaction and a key question for all projects is now: will the customer feel the difference? Q

Professor Tony Bendell is the Rolls-Royce funded professor of quality and reliability management at the University of Leicester. His post is held jointly between the Engineering Department and the Management Centre. He is also managing director of Services Ltd, a quality and productivity training and consultancy organisation he set up in 1983. As well as his extensive work on six sigma, statistical tools of quality, the revisions to ISO 9000 etc, Bendell is founding chairman and now president of the East Midlands Quality Club and he is author of numerous books, including books on statistical quality methods, The Sunday Times book on *Quality Measuring and Monitoring*, and two Financial Times books on benchmarking.