MEASURING COST OF QUALITY

A CASE STUDY

by

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List of Abbreviations

AC	Appraisal cost
ASQC	American Society for Quality Control
BS	British Standards
BTB	Back To Basics
CAR	Corrective Action Request
COC	Cost of Conformance
COC Report	Certification of Conformance Report
CONC	Cost of Non Conformance
COQ	Cost of Quality
FC	Failure cost
HRDF	Human Resources Development Fund
ISO	International Standards Organisation
ISS	Inspection Specification Sheet
JIT	Just In Time
MDS	Mould Data Sheet
MIS	Manufacturing Instruction Sheet
NPDL	Non Productive Direct Labour
PC	Prevention cost
PDL	Productive Direct Labour
PMD	Predetermined Methods Data
PPM	Parts Per Million
QCC	Quality Control Circles

QLF	Quality Loss Function
TQM	Total Quality Management

PENGUKURAN KOS KUALITI: SATU KAJIAN KES

Abstrak

Kaedah pengukuran kos kualiti sudah berada sekian lama di industri. Walaubagaimanapun, disebabkan sumber pengetahuan dan kemahiran yang terbatas di kalangan ahli industri, ia tidak banyak dilaksanakan.

Kajian ini merupakan penyiasatan ke atas amalan pengukuran kos kualiti di Syarikat ABC, Pulau Pinang. Syarikat ini telah mula mengumpul data kos kualiti sejak awal tahun 90-han. Kajian ini memeriksa data dari tahun 1992 hingga 1996. Unsur-unsur Sistem Kos Kualiti dikaji dengan mendalam. Pelaksanaan unsur-unsur ini juga dianalisis. Kos kualiti keseluruhan dibandingkan dengan data dari kajian-kajian lain serta standard kos kualiti yang terdapat pada masa kini. Adalah didapati bahawa terdapat beberapa unsur kos kualiti yang tidak diambilkira dalam sistem pengukuran yang digunakan di Syarikat ABC. Beberapa unsur seperti data ponteng, keefisenen, kalibrasi, dan pusing ganti buruh tidak diambilkira. Unsur-unsur ini sebenarnya amat penting memandangkan keadaan ekonomi dan kekurangan tenaga buruh yang dihadapi di negara ini. Unsur-unsur ini, serta beberapa lagi unsur lain disenaraikan dan dihuraikan dengan mendalam di dalam tesis ini.

Satu cadangan baru sistem pengukuran kos kualiti dibangunkan dengan elemen tambahan dan satu kajian perbandingan dijalankan antara amalan kini dengan yang dicadangkan. Cadangan sistem baru pengukuran kos kualiti dibandingkan dengan penyelidikan-penyelidikan lain, dan dipersembahkan dalam format jadual dan dibincangkan. Kos kualiti syarikat ABC adalah 9.22% dari peratusan penjualan. Kos itu tidak jauh berbeza dari angka yang didapati di dalam kajian-kajian lain.

Abstract

The measurement of Cost of Quality (COQ) has been around for a long time. Its use has not been widely spread due to limited resources on knowledge and application skills.

This study is an investigation on the quality cost measurement practice at Company ABC, Penang. Company ABC has been measuring COQ from the early nineties. This study reviewed data from 1992 to 1996. The elements used in its Quality Cost System were reviewed and the application of the elements were analysed. The overall COQ was then compared to present-day standards and studies. It was found that there were several elements of COQ that were not measured in Company ABC's quality cost system. Some elements, for example absenteeism, calibration, labour inefficiencies and labour turnover are not included in the calculation of quality cost. These elements should have been included, given the present day economic and labour shortage in the country. These elements, together with several others are listed and discussed in some detail in this thesis.

A proposed COQ measurement system was developed with additional elements and a comparison study was carried out between the proposed and present practices. The proposed COQ measurement system was compared to other studies in a tabular format and discussed. The COQ at Company ABC was 9.22% as a percentage of sales and was found to be in line with other studies.

CHAPTER 1 - INTRODUCTION

1.1 Definition

Cost of quality (COQ) carries a number of meanings. Juran and Gryna (1988) reported that to some, 'quality cost' is equated to 'the cost of attaining quality', while to others, COQ is the cost that is required to run the Quality Department of an organisation. However, the interpretation of the quality specialists is that it is simply the cost of poor quality, namely, the costs associated in finding and correcting defective work. Juran and Gryna (1988) further stated that the trend has been to adopt the interpretation of the quality specialists.

According to Crosby (1990), the COQ for many organisations is very high, and that the reason is unknown. The typical COQ for the average organisation is in the range of 40% to 50% of sales for organisations in the manufacturing and service industry. Crosby indicated that from his experiences the ideal value for COQ would be approximately 2.5% of sales.

Over the years since it was first used in the 1950's, several studies have been conducted by various researchers. For instance, studies conducted by Plunkett *et al* (1987), Schmidt & Jackson (1982), Crosby (1990) and Plunkett & Dale (1987) have shown that the manufacturing and service industries have COQ of between 40% to 50% of sales. Other writers report slightly different ranges. Werner (1977) reported a much lower range, which is 15% to 20% of sales for the manufacturing industry,

and 25% to 45% for the service sector. Although these numbers and ranges differ, what they have in common is that there is a tremendous potential of cost savings if controls on COQ could be successfully implemented. If COQ could be reduced, this translates to increased profits to the organisation. This eventually results in cheaper products for the consumers.

1.2 Research Motivation

This study has been carried out in a toy manufacturing company in Penang. In this thesis, the company is referred to as 'Company ABC'. This company is a subsidiary plant of Company ABC Corporation, headquartered in the United States of America. Since it was first measured, the COQ has been averaging approximately 5.22% of sales in a five-year period. This amounted to RM8.4 million annually. Any amount saved from the RM8.4 million would add to the bottom line or profitability of the company. It was within this realisation that this project was undertaken.

The COQ measurement system was first established by Company ABC's corporate office in the 1980's. This was followed and practised in the many subsidiary manufacturing plants located in the United States. When the manufacturing facilities were later transferred to Asian countries, these COQ measurements were not practised. This was because the implementation of the COQ measurement system was not imposed upon the overseas plants by the corporate office. In addition, there were other forms of measurements that were used to gauge the performance of the

companies, such as, manufacturing rate, inventory turns and various other financial measurements.

Company ABC started operations in Malaysia in 1981. The COQ measurements were started in mid 1991, following the preparation towards implementation of a quality management system based on the internationally renowned ISO 9000. Having been in operation for more than ten years now, many of the practices have undergone extensive improvements. Hence, when the COQ was first measured in 1992, it was found that the figure was approximately 5% of sales. However, it is believed that when operations started and in the 1980's, the COQ for Company ABC must have been much higher.

1.3 Review of the Current COQ

Since COQ's inception in 1992, five years worth of COQ data was tabulated and reviewed in the most comprehensive manner ever performed at Company ABC. The review identified some deficiencies in the present system, and proposes an improved measurement system accordingly. For example, calibration as an element of prevention cost is not included in the COQ measurements even though Stolber (1990), as well as the relevant standards, the ASQC (1967) and the BS 6143 (1992), call for its inclusion. As a result of this study, this element has been included in the proposed system. Another example is that of the measurement of failure cost. The 100% component inspection is considered as a rework element in the present system, and hence it falls under the failure cost category. In actual fact, according to

the available standards, the ASQC (1967) and the BS 6143 (1992), as well as the literature, a major portion of this element belongs to the appraisal category. This is because the process constitutes an inspection on each component first, before a decision could be made on whether or not to rework the component. In Company ABC, out of all the components, only 20% are reworked. This indicates a flaw in the design of the present system of measurement. As a result of this study, this element is proposed to be re-categorised from failure cost into appraisal cost

In addition to re-categorising this element, several new elements have also been proposed to be included into failure cost, namely .

- Operational efficiency,
- Labour turnover,
- Absenteeism, and
- Calibration.

The inclusion of these elements was necessary, as they constitute a major part of failure cost. Literature and standards, such as BS 6143 (1992), Collins (1995) and Jacobsen (1997) had included these elements as part of COQ. These elements were used in a different industry. This will be elaborated in subsequent chapters of this study.

Since 1992, no comprehensive study of this kind had been conducted to verify the practicality of the COQ system used at Company ABC. Considering the importance of the information it carries, this study was timely indeed. It served to strengthen the COQ system and minimise the inherent weaknesses. The proposed

system, if applied, could enhance the decision-making process for the management of Company ABC, particularly on matters pertaining to cost reduction and savings, which will ultimately result in improved profitability.

As stated earlier, Company ABC has been measuring COQ since 1992. Based on the last five years data, the COQ as a percentage of sales has been averaging at 5.22% per year. The range had been 4.91% to 5.65% from 1992 to 1996, with the lowest at 4.91% in 1993 and the highest at 5.65% in 1995. The data denotes a small variation. This shows that the cost of quality has been rather stable in Company ABC over the period.

1.3.1 Monitoring COQ

The COQ data are reviewed on a weekly and on a monthly basis. The weekly review is a brief review meeting that includes the sharing of information and performance of the company amongst the staff. This meeting has a large audience, comprising of managers, foremen and supervisors. The discussion is normally focused on the previous week's performance. For example, during these meetings, the items that contribute to the scrap cost are discussed at length. In this manner, management would be able to focus on the highlighted items to minimise defects and costs of manufacturing in the coming weeks. The other elements that are discussed at this meeting are quality performance, efficiency, material shrinkage and quarantines.

On the other hand, the monthly review meetings also discuss similar items but it is attended by top management only, namely the Managing Director and Directors of Company ABC. However, during the monthly meetings, the data is consolidated on a monthly basis. As such, these meeting enable top management to have a bird's eye view of the company's performance, as indicated by the COQ.

Following the numerous discussions held in these meetings, decisions are then made to enhance performance and profitability of the company. For example, if the COQ for a certain process is found to be very high, then, management will decide on a corrective action plan. The corrective action will then be monitored to ensure that the COQ for the process could be minimised.

Hence, it is obvious that the COQ data is being used to the fullest in the company. It becomes the basis for many decisions that will ultimately affect the overall performance of the company. This includes items not just relating to operational and procedural matters, but those involving strategic and policy-related matters as well. Since the data is used for such important purposes, it has to be accurate and reliable. The elements of the COQ measurement system have to be consistent with the available standards like the ASQC (1967) developed by the American Standards for Quality Control (ASQC), and other common industry practices. The system should also include all the necessary and relevant elements that enable an accurate portrayal of the COQ in the company.

At Company ABC, the COQ system calls for the measurement of quality cost similar to the standards laid down by the ASQC. The procedure was first written

in 1991. and marked as 'Revision A'. Since then, there have been several revisions. The revisions to 'Revision A' have mainly been simplifications and clarifications of the procedure, and hence were merely peripheral, and not fundamental in nature. The changes have improved the comprehension and understanding of the procedure for all its users. For example, changes were made on the reporting format as well as some working definitions. However, as stated earlier, no fundamental change to the way COQ measurements were conducted was made.

The objective of this study is to review the present mode of measurement, to improve on the current methodology of COQ determination and to study the current company policy, business practises and working environment.

1.4 Aims and Objectives of the Research

The overall aim of this research is to investigate the effectiveness of the existing system that is used to compute the COQ at Company ABC. Once this is carried out, the system can then be improved. Hence, the objectives of this study are:

- To study the existing COQ measurement system,
- To gauge the effectiveness of the existing system,
- To identify the strengths and weaknesses inherent in the system, and
- To recommend an improved version of the system.

An improved version of the measurement system will provide an accurate picture, which in turn will assist management to reduce the cost of operation. This system of measurement should be available for use on a daily, weekly, and monthly basis in order to assist in the improvement of processes, as well as managing the business to be cost effective and profitable. This will result in Company ABC having the competitive advantage over its competitors by being cost effective, as well as having satisfied shareholders and happy customers.

1.5 Scope of Study and Choice of Methodology.

The scope of the study and the choice of methodology used had been the function of available resources, mainly data availability. Even amongst Company ABC's sister organisations world-wide, exchange of COQ information has been very limited. It is due not only to the fact that some of the organisations do not have the data at hand, but also that some organisations regard this information as confidential. This is also true in the literature. Apart from a few studies done by writers such as Plunkett & Dale (1987), Brown (1978), Werner (1977) and Stolber (1990), there is a dearth of information on the exact COQ incurred by companies. Whilst much have been written on the subject, many of the writings focus on the do's and don't's of the COQ measurement system, rather than the numerical values of the costs.

Thus, it was finally decided that the study would focus on COQ at Company ABC only. This investigation hence becomes that of the case study approach. Being an ideal methodology when a holistic, in-depth investigation is needed, according to

Feagin *et. al* (1991), the case study approach has received much attention from its users, including Yin (1993, 1994), Stake (1995) and Tellis (1997). These users, who have wide experience in this methodology, have developed robust procedures in this area. If a researcher follows the set procedures, then the researcher follows methods that are well developed and tested as any in the scientific field. Case studies are made to bring out the details from the viewpoint of the participants by using multiple sources of data Tellis (1997).

Galliers (1992) defined case study as an attempt at describing relationships, which exist in reality, usually within a single organisation or organisational groupings. The COQ data of company ABC are real values measured per the defined COQ procedures, which are similar to the ASQC standards. Hence the COQ data are consistent per the procedure.

Garman and Clayton (1997) gave a similar definition of a case study. They described case study as "an in-depth investigation of a discrete entity (which maybe a single setting, subject, collection or event) on the assumption that it is possible to derive knowledge of the wider phenomenon from intensive investigation of a specific instance or case".

Reliability is always an issue in research. Essentially, reliability concerns the extent to which a research will yield the same or similar outcome if the research is repeated. As in the case of Company ABC, the procedures are defined and COQ data was collected by independent accounts personnel (finance department) and they have been adhering to the prescribed COQ procedure that was established in 1991. As

such, all associated cost to the relevant COQ element will remain intact and consistent until the COQ procedure has been amended and approved by the heads of department of Company ABC.

The validity of this case study can be relied on as the proposed method of COQ measurement does not differ very much from the studies conducted by various researches. COQ measurements ranged from 15% to 50% as reported by several researchers and Werner (1977) had reported that COQ for the manufacturing industries ranged from 15% to 20%. The ideal value of COQ as reported by Crosby (1990) was 2.5%. In Company ABC, the COQ was found to be 9.22% in the proposed study and the company has been in operation since 1981. As such the value of COQ at Company ABC is within the range of COQ data found from the other reported studies.

All the above comparisons were done from the perspective of looking at the total cost picture, as well as that of looking from the perspective of each individual cost element.

1.6 Benefits of the research

The study on COQ of Company ABC would verify the reliability of the present system. However, an improved version would assist management in the decision making process for productivity improvement. Management would also be able to focus on cost impacts and work on reducing them. This would add to the bottom line profits of the company. The system would also enable Company ABC to

benchmark against itself on a daily, weekly, monthly and yearly basis. This in turn would allow Company ABC to track its performance on a timely and consistent manner.

With an improved version of the measurement system, and if this system could be implemented at other similar industries, it would allow bench marking against each other, thus creating competitiveness for improvement. However, this may not be possible with competitor industries since the information would be considered confidential. Nevertheless, it could still be used for comparison purposes with other affiliate companies if and when the need arises.

CHAPTER 2 - LITERATURE REVIEW

COQ measurement has its origin from the early 1950s. Feigenbaum (1956) classified COQ into three categories -- namely, prevention, appraisal and failure, commonly known as the PAF-model. This model is almost universally accepted, as reported by Plunkett and Dale (1987). Moen (1997) indicated that there are several shortcomings in this traditional approach. According to him, this traditional model was mainly internally focused and reactive in nature. Improvement activities are prioritised according to easily identifiable measures like failures, rework and negative feedback from the customer *after* problems have occurred. Customer requirements, needs and expectations are not used proactively to direct quality improvements. In addition, increased customer satisfaction and loyalty is not captured in this kind of reporting system.

Another researcher, Diallo *et. al* (1995) reported that because a certain percentage of reject is considered necessary in a production process, and as long as these figures do not exceed a certain threshold value, actual failure costs are sometimes not recorded. The threshold value is determined by defect rates, which in turn is based on specification limits. These limits are often based on internal company opinions and the performance of production equipment. Under this system, the exact failure cost will never be known as it will always be hidden behind the values of specification limits and perceived equipment performance. Oblivious to management, this kind of system can increase the overall product cost.

A review of the literature indicates that there are several models that can be used to measure COQ. The main models are the process cost model, as described in BS6143 Part1 (1992), and the PAF model, as described in BS6143 Part 2 (1990). Apart from this, the American Society for Quality Control (ASQC) series of related publications describe models of cost of quality, which are combinations of the two models stated above.

In addition, as Kehoe (1996) indicated, the Taguchi Loss Function also serves as an alternative method to measure the COQ. This method seems to be a more holistic approach at looking at COQ. There are also a number of studies conducted in the United Kingdom on this subject which are discussed later in this chapter. All the cost of quality models are discussed, and their applications and shortcomings are presented in some detail.

There have been numerous criticisms - both positive as well as negative - regarding the need to measure cost of quality. For example, Campanella (1999) stated that:

"The language of money is essential. For a successful quality effort, the single most important element is leadership by upper management. To gain that leadership, we can propose some concepts or tools. That is the wrong approach. Instead, we should first convince management that a problem exist that requires their attention and action, i.e., excessive cost due to poor quality."

On the other hand, Campanella (1999) had indicated that some authors worry that the collection and analysis of quality cost will cause management to feel

that these activities alone are sufficient to deal with whatever quality problem at hand. He also wrote, "Quality cost measurements and publications do not solve quality problems. We must also identify improvement projects, establish clear responsibilities, provide resources to diagnose and remove causes of problems, and take other essential steps."

Whichever model the organisation has decided to choose, the involvement of management is crucial. The initial need is to gain management interest and support. The magnitude of cost of quality is likely to gain their interest. However, their support can be achieved by selling a good action programme whereby money savings appear promising. The programme should contain sufficient detail to show the planning activity and the results expected showing money savings and tangible quality improvements.

2.1 Process Cost Model

The process cost model is described in great detail in the BS 6143 Part 1 (1992). Crosby (1979, 1996, 1999) discussed it at length in several of his books. Basically, this approach of measuring COQ differentiates between cost of conformance (COC) and that of non-conformance (CONC). It is applicable both in the service as well as manufacturing sector.

The BS 6143 Part 1 (1992) defines cost of conformance as the intrinsic cost of providing products and services, which adhere to customer-defined

specifications. All related genuine costs that are used in producing the product are considered as cost of conformance. These costs consist of the raw material used, the labour utilised, and the tests that the product go through. In contrast, cost of non-conformance is defined as the cost of wasted time, materials and capacity associated with a process in the receipt, production, despatch and correction of unsatisfactory goods and services. The total process cost would be the summation of cost of conformance and cost of non-conformance for a particular process.

The BS 6143 Part 1 (1992), describes the process cost model in a simplified manner and can easily be comprehended by the process users. Reading and understanding it would be the first step before gathering information on quality and productivity of a particular process of interest. The standard also states that every employee in an organisation contributes and also operates within a process. As such, because the work performed is value adding in nature, the labour cost of each employee associated to a particular process will be computed under the cost of conformance. However, should the employee work on a non value added activity such as rework, this will be classified as a cost of non-conformance.

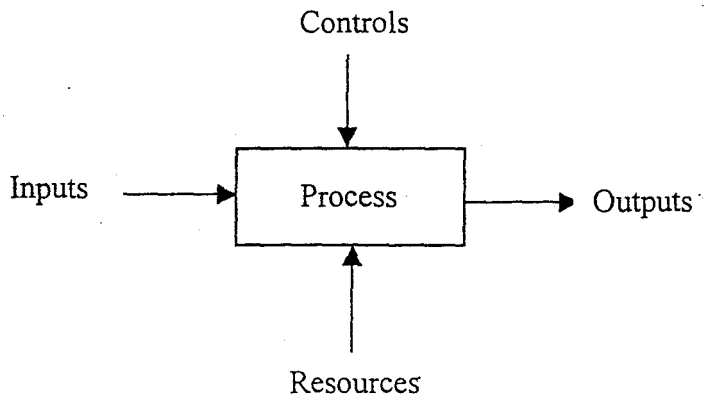

Figure 2.1 Typical block diagram of a basic process model.

Figure 2.1 shows a typical block diagram of a basic process. As can be seen, a generic process constitutes input, output, the resources needed, and the control elements. Input comprises of raw materials and tools, whereas output would be the finished product. Resources include labour and energy, and the controls are the environmental impact, process and the product specifications.

In order to calculate the cost of conformance and cost of non-conformance, a process is identified and all activities relating to the process are listed. The next step would be to identify the cost elements associated to the process. They are to be recorded under one of the following categories:

a) People,

b) Equipment,

c) Materials, and

d) Environment.

Each individual cost element is identified as a cost. This can either be a cost of conformance and/or a cost of non-conformance. For example, the material used in the finished product as an output will be classified as a cost of conformance, while the material wasted in this process will be classified as a cost of non-conformance.

In summary, the cost of conformance would be the cost of operating the process at the optimum level. This would be the minimum cost of operating the process. On the other hand, the cost of non-conformance is the cost incurred due to

inefficiencies within the specified process. An example of this would be using more labour versus what has been originally specified, or producing products that do not meet specifications and thus become rejects.

2.2 The Prevention, Appraisal and Failure (PAF) Model

In this model, there are three categories of the cost - namely, prevention, appraisal, and failure. In 1964, sixteen experienced members of the ASQC got together to address the issue on how to measure cost of quality. It was estimated at that time that cumulatively, the COQ in the US manufacturing industry exceeded thirty five billion US dollars. The quality cost committee of ASQC published a booklet in 1967 entitled "Quality Cost – What & How". This booklet became the main reference of many quality practitioners when they wanted to start a COQ measuring system in their organisations. The PAF model is the traditional method of measuring cost of quality.

The report, ASQC (1967) also noted that quality cost information is of very great importance to the top management of organisations. The information would guide them in lowering the cost of the product as well as for improving product quality. By knowing the magnitude of these cost, it can open up many opportunity areas. In most businesses, management has no idea of the large amount of money that makes up quality cost.

According to some studies, for example, Gryna (1988), cost data collected and presented in accordance to the PAF model has been difficult to analyse and interpret. Many controversies have also arisen. For example, the inclusion of overhead on top of direct labour and direct material cost of scrap and rework is arguable. This is because the overhead cost can be considered as a part of normal operating expenses and therefore should not be included. Another example is that of unavoidable manufacturing waste. In Company ABC, 'manufacturing waste' is mainly non-defective parts, but trimmed out material removed from a die-cast part. It can be argued that this is a normal part of operating a process. These arguments about inclusion or non-inclusion of certain costs, according to Gryna (1988), can result in the downfall of the total cost of quality measurement initiative. This is because there could be a controversy on the motive of the data collector in inflating the actual cost of quality. In addition, because of the uncertainties mentioned above, the PAF model also does not provide a good structure upon which cost saving opportunities can be identified.

Apart from Gyrna (1988), Campanella (1999) also criticised this cost model. He wrote that the scope of this model should be expanded because however important the cost of non-conformance is, the cost of inefficient processes need to be determined. The PAF model only emphasises on the cost of non-conformances, whereas the cost of running the process inefficiently is not measured. The inefficiency is the labour wasted and the under utilisation of the machinery and equipment.

In addition to a description of the PAF elements, the ASQC and British Standards also describe that investment in prevention activities can substantially

reduce internal and external failure cost. The reduction of external complaints (which is categorised under 'external failure cost') is important not only to reduce cost but also to maintain purchaser goodwill and employee morale.

It is also observed that cost of quality patterns and the cost of quality elements used in the measuring system differ from company to company, as well as from industry to industry. Thus, it is almost impossible to make comparisons of the data between organisations. It is also important for management to decide which cost elements are to be selected for use in a cost of quality measurement system in the organisation.

The ASQC standard defines cost of quality as follows:

1. Prevention Cost

Prevention cost consists of the costs of any action taken to investigate, prevent or reduce the risk of nonconformity or defect. Examples include preventive maintenance, calibration, product qualification, and system performance audit. The costs associated with the personnel engaged in designing, implementing and maintaining the quality system also contribute to prevention cost.

2. Appraisal Cost

Appraisal costs include the cost of evaluating the conformance to specified quality requirements. This includes the cost of verification and control, which are performed at any stage of the manufacturing quality loop such as product inspection, receiving inspection and product audit. In addition, product qualification, which

includes prototype inspection, design evaluation tests, and qualification tests also contribute to appraisal cost.

3. Internal Failure Cost

Internal failure cost is the cost arising due to nonconformity or defects at any stage of the production loop such as costs of scrap, rework, retest, re inspection and redesign. All the costs associated to internal failure cost are localised within the organisation. In other words, the failures are captured prior to shipment to the customers.

4. External Failure Cost

External failure costs include the cost arising after the product has been delivered to the customer or user. This category of cost includes the cost of claims against warranty, replacement and consequential losses, and evaluation of penalties incurred. This cost is generated because the customer has found the product to be defective or does not meet the product specification.

2.3 Budgeting Quality Cost

The ASQC module also includes a description of how cost of quality can be budgeted appropriately. It discusses that cost of quality budgeting should consider the four categories (prevention, appraisal, internal failure, and external failure) and the general trend of the data, rather than budgeting the individual elements in the categories.

The traditional approach of performing cost budgeting was to budget for the individual elements, such as the amount of inspection, test and quality control personnel. Then management would try to cut the budget, element by element, each year whether or not the overall job was performed satisfactorily as reported by Kumar and Britain (1995).

The ASQC approach is a newer one, which establishes budgets for total cost of quality reduction. In this approach, management looks at the COQ as a total category, rather than looking at individual elements. In other words, the focus is not on the micro element, rather, on the value of the cost in each category. Hence, a comparison between the data in each category can be done. This would encourage investments in the prevention and the supporting appraisal categories to accomplish an overall reduction. The basic principle in looking at the four-category relationship is to allow investment in prevention and appraisal to make substantial reductions in internal and external failure costs. Savings in internal failures will be in the form of lower scrap and defects. This would translate into customer acceptance and goodwill.

2.4 Activity Based Costing

Cost of quality can be identified and collected with most of the financial accounting system. One of the accounting systems that is compatible with cost of quality methodology and objectives is the Activity Based Costing. The aim of the Activity Based Costing system is to improve overall cost effectiveness by focusing on key cost elements. Quality related costs are assigned to specific activities, products, processes, or department, such that these cost can be targeted for cost reduction.

Webster (1995) had outlined a five-step approach for using Activity Based Costing to identify the costs of poor quality. The steps are as follows:

1. Identify all activities for prevention and appraisal, and results of internal and external failures.
2. Determine the activity costs associated with prevention and appraisal tasks, and with internal and external failures.
3. Identify the activities that benefit from prevention and appraisal categories and what causes internal and external failures.
4. Assign the Activity Based Cost of quality, for prevention, appraisal and failure (internal and external) activities.
5. Adjust the calculated costs for products and services to reflect these additional costs of quality.

Campanella (1999) stated that the conventional accounting practices are often inadequate for cost of quality analysis and insufficient for continuous improvement applications. Hence forth, the Activity Based Costing system is better suited to the calculation of COQ because of its more detailed cost database. The conventional accounting usually has the cost of quality buried in the standard cost. Campanella (1999) further elaborated with an example. According to him, a standard cost for a product may be based on a historical 90 percent yield, which means approximately 10 percent of the standard cost represents scrap. A 10 percent scrap level is planned, which translates into the cost of scrap showing up in the accounting ledger only if it exceeded the planned 10 percent. In this case, it would appear as a 'cost overrun'.

The Activity Based Costing system in conjunction with COQ analysis offers several advantages. Overhead cost can be accurately broken down and assigned to the activity that is responsible for these costs. Computerization of Activity Based Costing system will help in providing information on a timely and consistent basis. With the ability to calculate cost of poor quality, identification of unproductive activities become easier, which assist management to make decisions. Changes in COQ can be realistically gauged over a period of time. Non-value added activities can be identified and eliminated, leading to improvements to cycle time, quality and cost.

2.5 Taguchi Loss Function

Genichi Taguchi, a Japanese engineer, has defined another relationship between performance of cost and quality as described by Kehoe (1996). Taguchi *et. al* (1989) defined quality as; "the loss a product causes to society after being shipped." This offers an alternative way of showing how quality and cost are related. The ASQC and the BS6143 standards measure cost just in terms of money. Products and services should conform only to specified tolerances and thus, the value of the cost of non-conformance captured in this calculation would be minimum. Only where the product or service is out of the specified tolerance limits, then the cost of non-conformance would be higher.

On the other hand, Taguchi defines optimum quality as taking place when the product or component meets the nominal specification. Any deviation from the nominal specification will amount to the occurrence of cost of non-conformance even

though this cost is not borne by the manufacturer of the product. In other words, cost is incurred when the product is not at its nominal value even though it is still within tolerance. This cost is most likely to be borne by society.

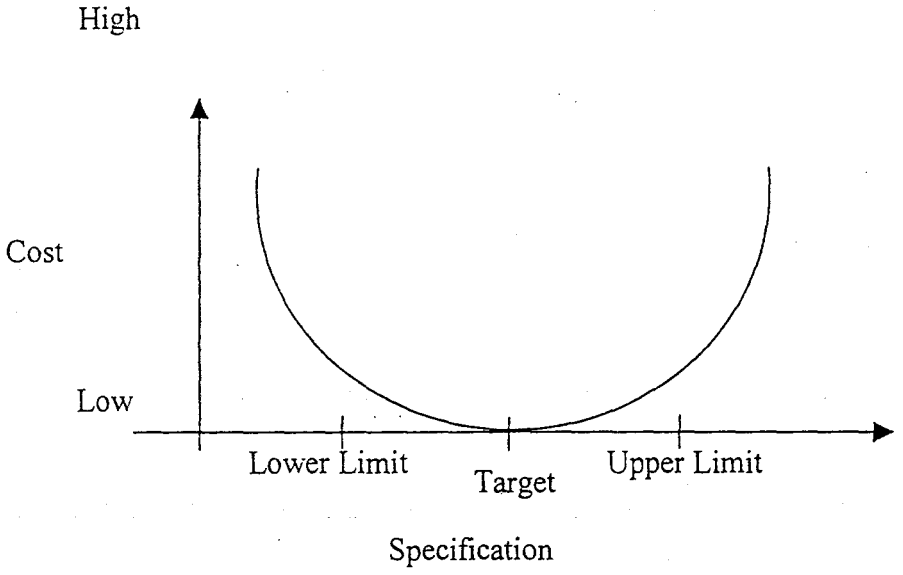

Figure 2.2 Taguchi Loss Function – according to Taguchi (1989)

The Taguchi Loss Function graph as described by Kehoe (1996), in Figure 2.2 shows the relationship between cost and the parameter specification of a product. From the graph it can be deduced that cost of non-conformance starts as soon as the product or service deviates from the target or nominal value. The graph shows that the Taguchi model is a more severe form of measurement. It places emphasis on providing products or services, which are as close as possible to the target value, and not just simply within the engineering specifications of the product or services.

The Taguchi loss function form of measurement is more appropriate for complex products and operations like the assembly of a motorcar, television set or airlines time tabling. According to Kehoe (1996), the Taguchi loss function enables