LRC ITEM DETAILS FORM

Acquisitions
Ctrl n° used:

Class n° in 082 field:

Subject Library
LRC class n°: 658.1552
(if different from above)

Feature headings:

Added class n^{os}: 660.0681

Loan statuses: PTSL PTWK REF

SHL STD WEEK

Subject Index:

Other remarks:

Database services
Ctrl n°:
(if different from above)

Other remarks:

EVALUATION OF THE PROCESS COST MODEL AT TRICO LIMITED PONTYPOOL

IAN RIGGS

THESIS SUBMITTED FOR THE DEGREE OF MASTER OF PHILOSOPHY

JULY 1998

UNIVERSITY OF GLAMORGAN
SCHOOL OF DESIGN & ADVANCED TECHNOLOGY

ABSTRACT

This thesis evaluates the use of the Process Cost Model to identify, categorise and analyse Quality related costs, as defined within the British Standard BS6143 Part 1: 1992. It compares and contrasts this approach against the traditional Prevention-Appraisal-Failure (P-A-F) model used in most manufacturing environments.

The evaluation was accomplished by conducting a pilot study in a manufacturing area and an administration area over a three month period during 1998. A cross-functional team was established in each area to carry out the study and evaluate the results.

The results demonstrate that the Process Cost Model was able to identify a wide range of costs that would not normally be included in a traditional quality cost analysis. The detail provided on both costs of conformance and non-conformance proved to be an ideal mechanism to control the section's budgeted costs and to identify key areas for improvement. However, because of the amount of detail, it proved difficult to summarise at company level.

It was also found that when applying the Process Model to non-manufacturing areas it was necessary to develop local mechanisms to identify the cost elements, as the finance system did not capture the required information. The manufacturing area on the other hand already had in place detailed financial recording systems that allowed easy data capture.

The use of the Process Cost model will be developed further in each section and department to provide ownership to those responsible for the process. These cost reports will provide information on the total operation cost and help to prioritise improvement actions.

DEDICATION

This thesis is dedicated to my wife, Katherine, and to my sons, Thomas and Alexander, who over the past three years have given me the inspiration and support necessary to complete this work.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Mr Tony Smith and Mr Mike Board of the University of Glamorgan, who provided me with advice, support and constructive criticism throughout the research and implementation of this work.

I must also thank the following individuals who in various ways have contributed towards this research project:

My colleagues in the pilot study teams who gave their time generously to try out these new ideas and who provided valuable input and insight into the research.

Mr Emrys Thomas, Managing Director, Collin Williams, Manufacturing Director and Terry Morgan, Finance Director of Trico Limited who allowed me to use their resources to conduct the pilot studies.

My parents, Gwyn and Jean Riggs, who have always provided me with the support and encouragement to learn new things.

CHAPTER ONE - TRICO OVERVIEW

Trico was founded in 1916 by John R. Oshei in Buffalo, New York State. The idea of a windscreen wiping system came as a result of Mr Oshei causing a minor accident by striking a cyclist on a stormy night along Delaware Avenue, in Buffalo. The cyclist sustained only minor injuries but Mr Oshei spoke of the accident as a "harrowing experience which implanted in my mind the definite need for maintaining vision while driving in the rain."

The car he was driving at the time was a National Roadster, the type that had won the Indianapolis race in 1914. The windshield fitted at this time was made of a pyralin curtain. The day after the accident Mr Oshei cut a circular hole through the windshield in the line of vision. The roadster, with its snug fitting top and side curtains provided sufficient air pressure to keep the rain and snow from entering the car. This was the first application of the basic law of pressures and vacuums that was to become Trico's business foundation.

A short time later pyralin curtains were replaced by glass windshields which came in two sections with a slit between the top and the bottom. Mr Oshei was made aware of a hand operated squeegee device used for cleaning windshields. The inventor was John N. Jepson, a retired electrical engineer from Gould Coupier Works. Mr Oshei persuaded Jepson to allow him to establish a sales company for his device which they called the 'Rain Rubber.' The device slid manually in the horizontal space between the upper and lower halves of the windshield and was normally carried in the toolbox for mounting in case of rain. It's slogan was "It slides in the slot" (Figure 1.1).

Mr Oshei formed a partnership with Dr Peter Cornell and William Haines as stockholders and established a manufacturing plant on Main Street, Buffalo and were soon selling the 'Rain Rubber' nationally.

When the Rain Rubber market extended to Europe and Australia the company became known as the 'Tri-Continental Corporation.' The telegraph and cable code was 'Trico' which was later adopted as the company's corporate name.

Figure 1.1 - Trico Advertisement, circa 1920

Windshield wiper production was discontinued during the final years of World War One due to car production disruption. Instead the 35 employees of Trico produced locks and hinges for ammunition boxes.

In 1918, after the signing of the armistice, production of the Rain Rubber continued. Mr Jepson sold his interest in Trico and moved to Florida.

As the success of the Rain Rubber continued Trico purchased a five story stock house on Elliot Street to expand the manufacturing capacity to meet the production demand. During this time Trico perfected other types of screen cleaning device and its 'Crescent Cleaner' eventually became standard equipment on virtually all automobiles. The Crescent Cleaner was also a hand operated device that was mounted in a hole above the windshield. It swung in an arc pattern with its spring loaded wiper arm.

Trico's first automatic windshield wipers were produced in 1921 and by 1922 Cadillac were fitting them as standard equipment. At their peak, before the depression, Trico employed more than 1500 workers and supplied 70% of all American cars produced.

In 1928 Trico established a manufacturing plant in London, England to support Ford's new factory in Dagenham, East London. At this time Trico also took ownership of its main competitor, the Folberth Auto Speciality Company of Cleveland.

Also in 1928 Trico patented the '5 Ply' wiper blade that comprised of a series of independently flexible edges between which the water was squeezed from the windshield and removed from the line of vision. It was an outstanding success and at one point was used on nearly 100% of all motor vehicles manufactured.

During World War Two Trico was again used to manufacture military equipment and munitions.

In 1951 Trico completed its 5 year expansion program that added a further 1,000,000 square feet of manufacturing space and employment rose from the original 35 in 1916 to 2067 in 1945, 3945 in 1948, and 4595 in 1950. At its peak in 1962 Trico had 2,200,000 square feet and 5,000 employees world wide.

During the early 1960s Trico established a licensee in Japan called Nippon Wiper Blade (NWB) which held a license agreement to manufacture Trico designed wiper arms and blades until 1989. By the end of the agreement NWB had become the second largest supplier of screen wiping products in the world, second only to Trico (see Figure 1.2).

Also during this period Trico established a joint venture with Champion in South Africa to create a licensee to manufacture automotive products for the

South African automotive industry. This company became known as TriChamp, an abbreviation of the Trico-Champion parent companies.

In response to the emerging Indian Car Market, Trico also established a licensee agreement with the West India Power Equipment (W.I.P.E) to support Ford and General Motor's new Indian manufacturing facilities.

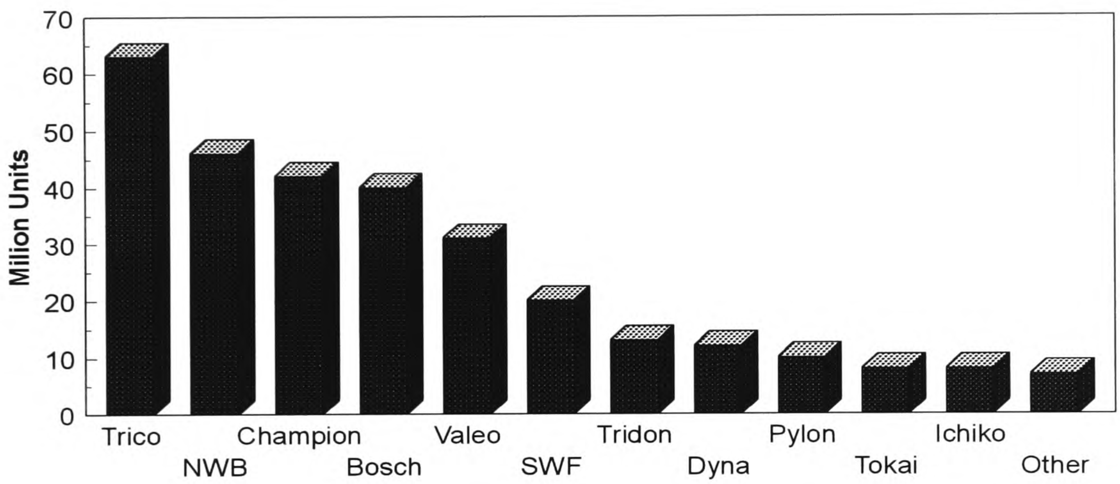


Figure 1.2 - World Wiper Blade Manufacture 1997 (Million units)

In 1994 Trico became part of the Stant Corporation of America, a group of companies supplying automotive components to the North American Original Equipment (O.E) and aftermarket. Stant itself was founded in 1898 and supplied the fledgling car industry with name badges. It now produces a range of products including thermostats, radiator caps, hose clamps, fuel caps and speciality automotive tools. The acquisition of Trico doubled Stant's turnover to around $700 million.

Trico Limited

Established in North West London in 1928 as Trico-Folberth Limited the company supplied Ford Motor Company with the 'Crescent Cleaner.' Due to the rapidly growing automobile industry in the U.K Trico moved in 1931 to

Brentford in West London on the then new Great West Road to increase its capacity.

During the war years of 1939 - 1945 Trico produced shell fuses and headlamp masks as well as wiper blades for military vehicles.

It was during this period that car manufacturers were developing curved windscreens. Trico Limited had the challenge of designing a wiper blade that could meet the demand of the 'wrap round' screen. As a result the 'Rainbow' blade was produced which comprised of a flexible baking strip and a triple yoke pressure distributing mechanism. This was the forerunner of today's wiper blades.

By 1959 Trico had no fewer than 8 production plants and offices scattered around their neighbouring districts. Operating in such a decentralised manner created many problems for the company and therefore in 1962 they developed a large factory on adjacent land in Brentford to bring all the operations 'under one roof.'

By 1975 the company also opened a manufacturing plant in Northampton to support the British car manufacturers based in the Midlands.

In 1976 Trico became involved in the longest industrial dispute in its history when its workers went on strike for nearly 6 months. This action resulted in a major loss of business and credibility in the marketplace.

In the late 1980s Trico employed 960 employees and had a total working area of 36,000 square meters. Over 400 vehicle models world wide were fitted with Trico brand original equipment.

The automotive industry at this time was one of the most demanding. Suppliers to the large car companies were expected to reduce costs of up to 5% per annum and improve Quality rejects to less than 50 parts per million. To achieve this they promoted continuous improvement and defect prevention techniques through Quality Standards such as Ford's Q-101 and GM's Targets for Excellence program.

Also many car companies had introduced a purchasing policy to reduce the number of suppliers for each commodity to at most two, and in many cases only one. This was based upon the Japanese principle of long term supplier relationships. This had the effect of making the automotive component supplier market yet more competitive.

In order to meet these new challenges a strategic plan was developed to relocate Trico's operations away from Brentford. The company at this time employed a relatively old, unionised workforce that operated under a piecework incentive scheme with a very traditional hierarchical management in a factory that had become very outdated.

The plant also had many people issues ;

- Multi union, the two largest being the Amalgamated Engineering Union (AEU), and the Manufacturing, Scientific and Financial (MSF)
- Restrictive practices
- Individual piecework incentive based upon quantity with no reference to quality
- 90 job titles
- Works/staff/manager/executive canteens

This led to a culture based upon an 'us and them' attitude. As a result it had a full time convenor and numerous shop stewards.

In 1992, because of these issues, the company decided to move its location away from Brentford to Pontypool, South Wales with all the advantages of a green field site and a purpose built factory.

Trico took the opportunity to introduce a modern culture into the company and made the company single status. It removed all piece work incentives and encouraged a team work philosophy at all levels within the organisation

Rather than the traditional production line system Trico introduced a production cell layout ran by operator teams who are responsible for the complete manufacture, testing and shipping of the product.

The results enabled Trico to continue the level of activity from its pre-Pontypool days, with half the employees, and under half the working floor space.

Current Operations

At the end of 1997 Trico Limited had a turnover of approximately £33 Million and employs over 500 employees. It operates in 16,000 square metres. Daily production rates total 80,000 wiper blades and 15,000 arm assemblies per day.

European Market

Trico Limited supplies both Original Equipment and Aftermarket product throughout Europe. Market research shows that the wiper blade market in particular has potential to grow, and could easily double if motorists followed manufacturers recommendations and replaced wiper blades every 12 months.

Research has shown that German and French drivers tend to change their wiper blades as a matter of habit every 12 months whilst only 35% of U.K drivers do so.

Table 1.1 shows the Western European wiper blades sales for 1991 to 1995 and also the projected sales until the year 2000.

Table 1.1 - Western Europe Wiper Blade Sales

Western Europe wiper blade sales, 1991 - 1995 (Million units)					
	1991	1992	1993	1994	1995
Original Equipment	27	27	22.9	23.8	24.6
Replacement	107.7	110.6	113.5	116.4	119.6
Total	134.7	137.6	136.4	140.2	144.2
Western Europe forecast wiper blade sales, 1996 - 2000 (Million units)					
	1996	1997	1998	1999	2000
Original Equipment	25.8	25.7	25.3	25.1	25.1
Replacement	122.2	125.8	129	132.2	135.4
Total	148	151.5	154.3	157.3	160.5
Source : The Economist Intelligence Unit Limited 1996					

Competitors

Although Trico is the largest supplier of wiper blades world wide, in Europe they are only the fifth largest supplier of wiper systems. The market share of the main five competitors is shown in Table 1.2.

Table 1.2 - Western Europe : Wiper Blade Market Share (%) 1996

Bosch	32
Valeo	18
Champion	15
SWF (ITT)	14
Trico	9
Others	12
Total	100
Source : EIU forecasts	

Trico and SWF are regarded as wiper blade specialists whilst Bosch and Valeo are two of Europe's largest automotive component suppliers manufacturing a wide range of components including head lamps, heating systems, electronics etc.

Included in the "Other" category is the anglo-italian manufacturer Fister (now part of Tridon, a Canadian wiper manufacturer) as well as imports from Far Eastern manufacturers.

Customers

Trico's customer base can be grouped into four categories;

1. Original Equipment.

This accounts for 40% of the total sales of Trico UK product. The main customers include ;

- Alfa Romeo
- Aston Martin
- Daewoo
- DAF
- Ford
- Honda
- Jaguar
- Lancia
- LandRover
- Leyland Truck
- Lotus
- Maserati
- Opel
- Porsche
- Rolls Royce
- Rover Group
- Saab
- Vauxhall
- Volkswagen Group
- Volvo

2. Original Equipment Spares (OES)

The OES market accounts for approximately 12% of total sales per year. The main OES customers are ;

- Ford (Motorcraft)
- Rover (Unipart)
- Honda
- Mazda
- Nissan
- Mitsubishi
- Volvo
- Suzuki

3. Aftermarket

The aftermarket comprises of many different customers and in total represents approximately 30% of total sales per year. Key accounts are ;

- NGK
- Partco
- OK Petrol Stations (Sweden)
- Trico Own Brand
- Macorex

4. Inter-Company

Trico also supplies other parts of the Trico group with its products notably North America with approximately £5 million of product per year (18% of total sales).

Accreditations

Since its relocation in 1992 Trico Limited has developed its Quality System to meet the requirements of its major customers. Notably these include ;

- Volkswagen VDA-6.2 - November 1994
- ISO9001:1994 - January 1995
- Ford Q1 - January 1995
- Porsche VDA-6.2 - April 1995
- QS9000 - March 1996

QS9000 is the new automotive standard developed by Ford, GM and Chrysler and has been adopted as a global automotive standard by the major car manufacturers. Trico Limited achieved third party registration in March 1996, which at the time made Trico only the 12th company in Europe and only the 100th in the World to do so.

Over the past two years the automotive industry has also been keen to promote the use of environmental management systems amongst its manufacturing plants and throughout its supply base. In response to this challenge and also to manage its own environmental performance Trico established an environmental management system to meet the requirements of ISO14001 and the European Eco-Management and Audit Scheme (EMAS). In February 1997 Trico became the first automotive component supplier to achieve EMAS in the UK.

CHAPTER TWO - DEVELOPMENT OF TOTAL QUALITY MANAGEMENT

Total Quality Management (TQM) is a title that has been used since the latter half of the 1980s. It describes the Western approach of the deployment of Quality 'thinking' within all levels of the organisation. However, the application of Quality principles has been with us since the earliest civilisations.

Primitive man was a gatherer of useful materials such as food, hunting tools, shelter, etc. His survival was dependant upon his knowledge of what plants were safe to eat, which ones were poisonous, which wood made the most effective weapons, etc. This was the age of Usufacture where the person who made the tool also used it and the quality of his work directly affected his existence. (Juran, 1990)

As the level of technology grew people began to divide work into specialist areas such as farmers, carpenters, mason; etc. In this environment a sellers' success was dependant upon his craftsmanship and hence reputation.

> "Attaining an undoubted quality reputation was of the utmost importance to a seller. The seller's income, family security, and status in the community as a 'reliable' craftsman all were directly affected by the quality of his product" (Juran, 1990)

As societies developed trade was now such that the seller and buyer no longer met face to face. Merchants took goods from place to place acting as intermediaries. The buyer could no longer rely on reputation of the seller. The market place rule was *caveat emptor* - let the buyer beware.

In the Middle Ages these craftsmen grouped together in major cities and towns and formed Guilds. The Guilds were designed to protect its members by providing a livelihood and security. The Guilds established standards, specifications and defined test requirements for their products.

> "The authority invested in the Guilds was a powerful ally of quality, many of the regulations being aimed at the maintenance

> of value and conformance to standards. The wardens of the Goldsmiths Company were empowered "utterly to condemn and seize and break all defective work and force good work to be stamped with the Company's mark." (Juran, 1995)

In the reign of Edward III, Wardens were appointed for each craft by royal charter. Their role was to "see that the work be good and right and to reform what defects they shall find therein, and thereupon inflict due punishment upon the offenders." (Drew, 1972)

These Guilds established a method of traceability to identify the producer of the work by 'Marks' or 'Seals' on the product. These marks were also used to provide product information such as the type and quantity of ingredients used as well as to show that the product had been independently inspected and was of a good standard. (Juran, 1995)

In the middle of the 18th century the Industrial Revolution transformed industry as the world new it.

> "The Industrial Revolution opened the way for the growth of the modern corporation with its great capacity to produce and distribute goods and services. Corporations have created specialised departments to carry out certain functions (design, manufacture, inspection and test) which are essential to launching any new or changed product" (Juran, 1990)

In the early twentieth century the next revolution in the manufacturing industry came with the introduction of mass flow production at Henry Ford's Detroit motor works. (BBC, 1994)

Automobile manufacture before this time was carried out by craftsmen, a carry over from the coach building tradition.

> "In 1894, the Honourable Evelyn Henry Ellis, a wealthy member of the English Parliament, set out to buy a car. He didn't go to a

> car dealer - there weren't any. Nor did he contact an English automobile manufacturer - there weren't any of those either.
>
> Instead he visited the noted Paris machine tool company of Panhard et Levassor and commissioned an automobile. P&L's workforce was overwhelmingly composed of skilled craftspeople who carefully hand-built cars in small numbers." (J. P Womack, D.T Jones & D. Roos, 1990)

In 1908 Henry Ford implemented the Mass Production Flow Line process. This process involved breaking the assembly of the automobile into small repetitive operations that could be carried out by cheaper, unskilled labour.

In order for this Mass Production system to function effectively Ford relied on the ability for parts to be totally interchangeable. Ford insisted that every component used in the Model T must have been produced using the same gauging system. Before this component manufacturers used their own gauging which undoubtedly meant that a high proportion of the assembly time and cost was spent modifying parts so that they would fit. This was the case for Panhard & Levassors craftsmen.

> "When the parts eventually arrived at P&L's final assembly hall, their specifications could be described as approximate. The job of the skilled fitters in the hall was to take the first two parts and file them down until they fit together perfectly." (J. P Womack, D.T Jones & D. Roos, 1990)

At Ford's Assembly Hall in Detroit, Quality would have been tested for by a team of inspectors, sorting out the good from the bad.

> "This step peaked in the large inspection organisations of the 1920s and 1930s, separately organised from production and big enough to be headed by superintendents." (A.V Feigenbaum, 1986)

For the first time quality was separated from production and the battle between the production departments and the inspectors began. The result was that production saw the requirements of the inspectors as too rigid and in many cases irrelevant to the product intended use. The inspectors were motivated by finding as many defects as possible which only served to de-motivate and alienate the production departments. Hence it first appeared that production output and quality was not compatible.

During the 1920's Walter A. Shewhart developed the first control charts for use with manufactured product at Bell Telephone Laboratories. This was intended to make the inspectors role more efficient by reducing the need to inspect 100% of the product. Instead samples could be taken from a production run and used to create confidence that the batch was 'in specification.' (Grant & Leavenworth, 1988)

Between 1924 and 1938 these initial statistical techniques were further developed by, among others, W. Edwards Deming and Eugene L. Grant. However commercial manufacturing companies were not convinced of their benefits and largely ignored such techniques. Only the military, because of the sensitivity of the product, investigated their use as part of a defect prevention philosophy.

With the outbreak of the Second World War in 1939 the industrial scene in America and Europe changed rapidly to cope with the new demands placed on them by the military.

> "A massive conversion of manufacturing plants from civilian, commercial productions to military production, was launched. The automobile companies and their suppliers readily changed from car engines to aircraft engines, from cars and trucks to tanks, military trucks and planes, from auto parts to small arms and ammunitions. The car companies and major suppliers found themselves under increasing constraints to adhere to established military standards and practices, among them the use of specified sampling plans and control charts" (Lightstone, M et al ASQC 1993 Congress)

For most companies this was their first exposure to a formal quality system (such as DEF-Stans in Britain) and Statistical Quality Control (SQC). Quality was at the top of the agenda for all the companies involved because of the following reasons;

- **The nature of the product**. The production of weapons, ammunition, etc. The war effort required strict control because of the possibility of explosions and loss of life. It was therefore imperative that all employees followed procedures and working practices as specified.
- **Lack of resources**. During the war waste had to be minimised, there was a great demand for the products and therefore scrap, waste, etc. could not be tolerated. Also the erratic supply meant that the cost of materials had risen sharply.
- **Intended use of the product**. If the product did not work when required it may mean life or death to members of the forces and also the outcome of the war would depend upon it.

To help implement the new quality systems and statistical procedures the military, in conjunction with the universities, established training courses held around the country for all companies involved in the war effort.

> "... (The United States Office of Education) sponsored an intensive 10 day course in Statistical Quality Control (SQC) at Stanford University in July 1942. The attendees were drawn from the war industries and procurement agencies of the armed services. .
>
> ... Responsible for the planning of these courses were Eugene L. Grant and Holbrook Working of Stanford University and W. Edwards Deming of the United States Census Bureau." (Lightstone M et al. ASQC 1993 Congress)

The message of SQC rapidly spread around America and Britain through a series of short courses based upon the original 10 day course at Stanford.

There were now a core of people trained in the SQC methodology working in industry actively attempting to assure quality and reduce scrap, waste, etc.

In 1945, with the end of World War Two, there was also an end to the push for quality in the civilian industries that supported the military during the previous 6 years. As commercial manufacturers returned to their primary business the lessons learned were put aside in an attempt to satisfy the awaiting demand for their products. These were boom years for the western manufacturers.

In these post war years of 1945-1950 Japan had to start the process of rebuilding its country's economy. The problems they faced appeared insurmountable.

> "Japan had in fact in 1950 negative net worth. Japan was, as now, devoid of natural resources - oil, coal, iron ore, copper, manganese, even wood. Moreover, Japan had a well earned reputation for shoddy consumer goods, cheap but worth the price. Japan must export goods in return for food and equipment. This battle could only be won with quality. The consumer will from now on be the most important part of the production line." (Deming, 1982)

American and European manufacturers continued to concentrate on quantity rather than quality in the knowledge that the post war boom market would absorb whatever it produced, regardless of the finished quality.

> "Car companies found they could sell anything that came off the assembly line, whether it was driven, pushed or towed off into the plant yard" (Lightstone, M et al, ASQC Congress 1993 p769)

Japan instead learned from the American statisticians who played such an important part in the American war effort, men such as Walter A. Shewhart, W. Edwards Deming and Joseph Juran. For, in Japan, Quality was as big an issue for their economic rebirth, as it had been for the Americans and British during the war.

The fundamental difference in the two philosophies was that Western manufacturing philosophy stated that if quality increased, productivity would fall, whereas the Japanese believed that improved quality was the fundamental criteria to allow productivity to rise.

Improve Quality
↓
Costs decrease because of less rework, fewer mistakes,
fewer delays, snags; better use of machine time and materials
↓
Productivity improves
↓
Capture the market with better quality and lower price
↓
Stay in business
↓
Provide jobs

(W. E. Deming, 1982)

The early years of the American influence was concentrated on the statistical theory advocated by Deming and primary intended for engineers, although Deming was keen to learn from the mistakes of not involving senior management during the second world war in America. (Naguchi, 1995).

It was Joseph M. Juran whom first widened the scope of the Quality initiative to Japanese management.

> "In July 1954 J. M Juran was invited to Japan to conduct a JUSE (Japanese Union of Science and Engineering) seminar on quality control management. This was the first time QC was dealt with from the overall management perspective." (Imai, 1986)

Japan promoted the work of these Americans through radio lectures across the country, sponsored by JUSE. Many of these original lectures are still taught in Japan today (Naguchi, 1995)

Initially these teachings were applied to the heavy industries such as the steel industry. Since these industries required instrumentation control the application of SQC tools was vital for maintaining quality. Soon these tools spread into the machinery and automotive industries where controlling the process was essential in building quality into the product.

In only four years since Deming's first lecture, Japan started to make an impact on the world's market place and causing genuine concern from other commercial nations.

Japan absorbed all of these different viewpoints and constructed their own interpretation to suit the Japanese manufacturing systems. This was not the sole reason for their success. Japan also adopted some unique strategies to create a revolution in quality.

1. The upper managers personally took charge of leading the revolution
2. The companies trained their engineers and the workforce in how to use statistical methods as an aid to control quality. The seed courses for this training were Deming's 1950 lectures
3. They trained their entire managerial hierarchy in how to manage for quality. The seed courses for this training were Juran's 1954 lectures
4. They undertook quality improvement at a revolutionary rate, year after year
5. They evolved the QC circle concept to enable the workforce to participate in quality improvement.
6. They enlarged their business to include quality goals.

(Juran, 1995)

While the Japanese concentrated on engineering based quality control techniques and methodologies to ensure product quality Armand V. Feigenbaum was the first to address Quality in the wider context of the whole company, a concept which his christened "Total Quality Control" in 1951.

His book described the relationship of the marketing, engineering, production, industrial relations, finance and service functions upon product and process quality. He states that the reason for this breadth of scope is that the quality of any product is affected by many stages of the 'industrial cycle', as illustrated in Figure 2.1

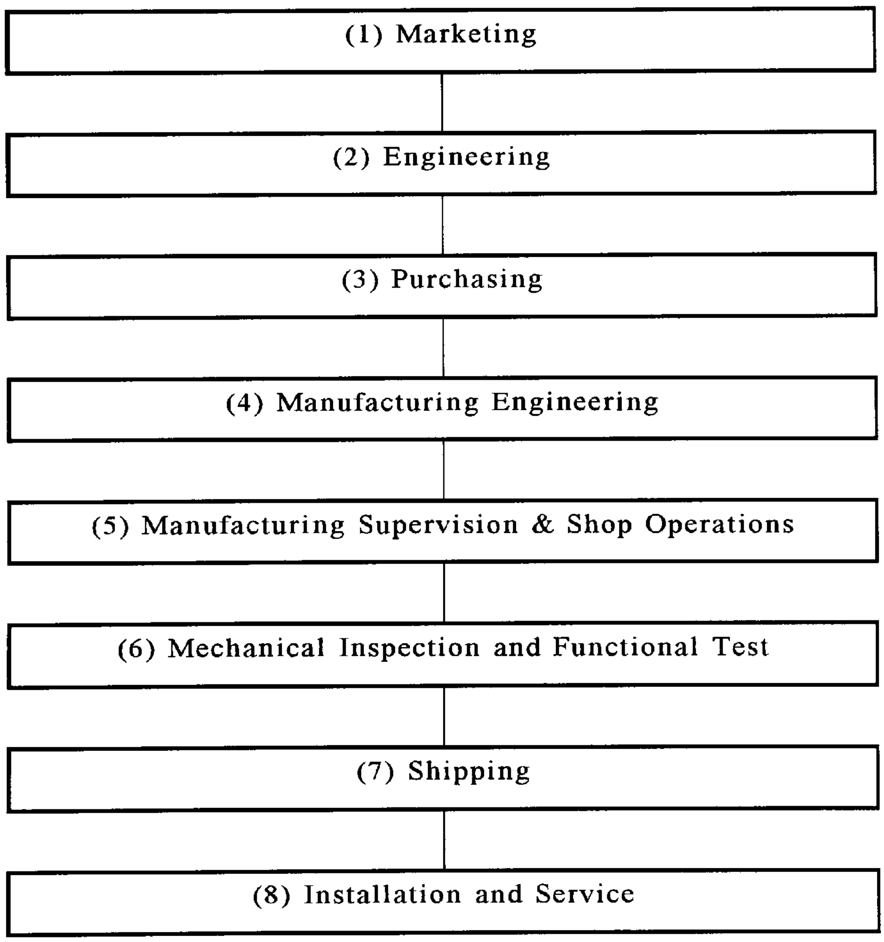


Figure 2.1 - Feigenbaum's Eight Stages of the Industrial Cycle.

Where,

(1) **Marketing** evaluates the level of quality which customers want and for which they are willing to pay

(2) **Engineering** reduces this marketing evaluation to exact specifications

(3) **Purchasing** chooses, contracts with, and retains vendors for parts and materials

(4) **Manufacturing Engineering** selects the jigs, tools, and processes for production.

(5) **Manufacturing Supervision and Shop Operators** exert a major quality influence during parts making, sub assembly and final assembly.

(6) **Mechanical Inspection and Functional Test** check conformance to specifications.

(7) **Shipping** influences the calibre of the packaging and transportation.

(8) **Installation** and **Product Service** help ensure proper operation by installing the product according to proper instructions and maintaining it through service.

Feigenbaum points out that in order for companies to effectively control these activities it is necessary to establish a system approach to manage all the actions required to assure quality to the customer.

Quality systems were primarily used by the Defence Industry to control supplier quality. The first of these was developed by the Aeronautical Quality Assurance Directorate in 1920 and was known as the Approved Firms Inspection System. Suppliers were assessed on their ability to manage the inspection function and guarantee the quality of the delivered parts. They also reviewed the record system, product identification, bonded stores and inspector training procedures.

Suppliers who failed to meet the standard could still be awarded contracts if they provided facilities for the Department of Defence's inspectorate to carry out the work.

This system was replaced in 1973 when the Ministry of Defence adopted a series of Quality Assurance standards based upon a series of North Atlantic Treaty Organisation (NATO) standards first produced in 1968. These standards focused on the prevention of defects instead of inspection and were known as Allied Quality Assurance Publications (AQAP's) and included the following;

1. AQAP1. Quality control system requirements for industry
2. AQAP2. Guide for the evaluation of a contractors quality control system for compliance with AQAP1
3. AQAP 3. NATO sampling schemes
4. AQAP4. Inspection system requirements for industry
5. AQAP 5. Guide to the evaluation of a contractors inspection system for compliance
6. AQAP6. Measurement and calibration system requirements for industry
7. AQAP7. Guide for the evaluation of a contractors calibration system for compliance with AQAP6
8. AQAP9. Basic inspection requirements for industry

The Ministry of Defence made some changes to these standards and issued them as Defence Standards (Def-Stans). (Hutchins, 1995)

Large organisations such as Ford Motor Company, Central Electricity Generating Board, National Coal Board, etc. adapted these standards for their own use and included many industry specific requirements. e.g. Ford included Statistical Process Control requirements during the 1980's.

The effect on many suppliers was that they were subjected to multiple assessments by their customers, many of whom had similar requirements to other customers. This resulted in extra cost being introduced into the supply chain.

In 1979, because of such pressures, the British Standards Institute (BSi) issued BS5750 which was heavily based upon the Defence Standards. It was designed so that companies could specify suppliers had to comply with the requirements of BS5750. Assessment was to be carried out by an independent accredited organisation and certification would be recognised by customers and therefore reduce the need for second party audits. (Fox, 1993)

The use of the standard became more popular during the 1980s particularly in the UK. In 1987 an International version of this standard was published by the International Standards Organisation (ISO), called 1SO9000.

Some industries, the motor industry in particular, resisted the urge to accept BS5750 in place of its own customer specific requirements. Their argument for this was that as BS5750 was a generic standard it did not ensure that process control and process capability was defined and effectively implemented. They argued that there were many companies which had been accredited to BS5750 but which they found to have an unacceptable quality performance.

In 1992, America's 'Big Three' automobile manufacturers, Ford, General Motors and Chrysler worked together on a common quality standard for use amongst their global supply base. For the first time the 'Big Three' adopted the ISO9001 standard as part of its requirements adding to them their own product and process specific clauses. The standard they produced is QS-9000 and is designed to be assessed by approved third party accreditation bodies. (Riggs, 1997)

This standard is far more prescriptive than ISO9001 including as it does specific quality techniques and continuous improvement methodologies, many found in the previous automotive quality standards. The aim of QS-9000 is defined as ;

> "The goal for Quality System Requirements QS-9000 is the development of fundamental quality systems that provide for continuous improvement, emphasising defect prevention and the reduction of variation and waste in the supply chain" (AIAG, 1995)

This aim follows closely the quality philosophy of Philip B. Crosby, once vice president of Quality at ITT and author of "Quality is Free", the first major selling business book in America. (Crosby, 1979)

Crosby advocated the concept of "Zero Defects" which he believed was an attainable goal provided top management of the company was truly committed to it. He also provided the Four Absolutes of Quality in which he defined his meaning of Quality (Crosby, 1984).

Absolute No. 1 - Definition of Quality.

Quality is conformance to requirements.

Absolute No. 2 - Quality System

The system of Quality is prevention.

Absolute No. 3 - Quality Standard.

The performance standard is Zero Defects.

Absolute No. 4 - Quality Measurement.

Quality should be measured in financial terms -
the price of non conformance.

Although popular, Crosby did have some critics regarding his definitions. Deming and Dr Joseph Juran argued that conformance to requirements was not sufficient as stated in Absolute No.1. Instead they argued, the system should be that all processes are set on target and continuous effort is made to reduce variation. (Deming, 1982)

Absolutes 2 and 3 are very much the basis of current Quality thinking. Prevention not detection is the cornerstone to all of today's Advanced Quality Planning programs where the quality of a product is designed into it not inspected out. Japan again took the lead in this. It is their philosophy to introduce new products regularly and in short time frame to continually meet the ever-changing customer requirements. This has proved very successful using such disciplines as Simultaneous Engineering, Quality Function Deployment (QFD), etc.

Crosby's third absolute - The Quality Standard of Zero defects - He argues that this is not just a motivational target but a real and achievable goal. This has been successfully illustrated by Shigeo Shingo at Toyota and called "Poke Yoke" (mistake proofing). This involved the assembly type operations being designed so that parts can only fit one way, thus minimising possible defects. (Shingo, 1985)

The idea came from studying press change overs at Toyota and realising that it was the design of the press and tooling which relied so heavily on operator settings that took most of the time. Shingo applied his methodology by,

1. Finding where in the process, and what kind of defects are liable to be generated
2. Utilising 100% in-process inspection aimed at the particular anticipated fault
3. Devising methods which prevent operator errors occurring.

Shingo was not convinced like many of his colleagues that SPC was the best method to ensure quality. Instead he argued that his methodology was the only way to ensure defects were not produced.

The fourth absolute - Quality Measurement - made companies sit up and take notice as Crosby estimates that upto 30% of Sales Revenue is wasted through poor quality.

Crosby applies these absolutes to all areas of the business not just manufacturing. Indeed his philosophy identified that there was no such thing as a 'Quality Problem' or in other words the problems that affect quality are not the responsibility of the Quality department but of the person or machine that created them. Crosby also stressed that the Quality Philosophy of any company is set at the highest management level and needs to be effectively communicated to all levels. These philosophies became the basis of the 1980's development of Total Quality Management.

Continuous improvement within Japanese companies did not only rely on engineering solutions such as Poke-Yoke or Design of Experiments. Many of the improvement ideas were generated from the workers through suggestion schemes. This became known as Kaizen, which literally means "the continuous improvement of everything we do." (Imai, 1986)

The range of Kaizen activities ranged from informal suggestions from individual workers to formal teams given a set task, to solve a problem or improve productivity over a short time period.

Western Management adopted the principles of continuous improvement as the basis of what became known as Total Quality Management (TQM). This concept embraced the ideas of Crosby, Deming, Juran and Feigenbaum as well as the principles of Japanese Kaizen and extended the idea of quality from its traditional product and production process background to every activity within the organisation. It also emphasised that quality was not the sole responsibility of the Quality department, but instead it was the responsibility of everyone to ensure that the activities they carried out met the requirements expected.

The British Standard for Total Quality Management, BS7850, published in 1992 defines TQM as the,

> "Management philosophy and company practices that aim to harness the human and material resources of an organisation in the most effective way to achieve the objectives of an organisation"

The title Total Quality Management itself does not convey the true intent of the philosophy conjuring up as it does the image that TQM is a "Quality Management" issue or merely a “Management” issue tends to alienate the rest of the workforce. Therefore TQM is also known by other names such as Continuous Improvement, Company-wide Quality Improvement or Business Excellence.

There are many references available describing the key elements of a Total Quality initiative. Rover Group adopted a Total Quality approach in 1987 called Total Quality Improvement. Rover defined Total Quality Improvement in the following way;

QUALITY is:

Continuously satisfying customer requirements

Customers are the only real judge of whether we are a Quality Company or not. They set the standards and we must strive to exceed them

TOTAL QUALITY is:

Achieving Quality at lowest cost.

By eliminating waste, by getting things right first time and hence reducing our total costs

TOTAL QUALITY IMPROVEMENT is:

Achieving Total Quality by Harnessing everyone's commitment

Rover Group's TQI philosophy was described by key seven principles;

Principle No. 1 - The Philosophy is Prevention not Detection

Principle No. 2 - The Approach is Management Led

Principle No. 3 - The Scale is Everyone Responsible

Principle No. 4 - The Measure is the Cost of Quality

Principle No. 5 - The Standard is Right First Time

Principle No. 6 - The Scope is Company Wide

Principle No. 7 - The Theme is Continuous Improvement

In 1991 Rover Group spread their TQI approach to their supply base and introduced an assessment process to identify areas of improvement amongst its tier one suppliers. (Rover Group, 1991)

Two other approaches to assess an organisations approach and deployment of Total Quality philosophies are the Malcolm Baldridge Award in the USA and the Business Excellence Model (formerly known as the Total Quality Model) developed by the European Foundation for Quality Management (EFQM).

The Malcolm Baldridge National Quality Award (USA)

Established in 1987 the Malcolm Baldridge National Quality Award (MBNQA) is a framework for the assessment of an organisation against the key elements of TQM. Similar in many ways to the criteria used in Japan for the Deming Prize the MBNQA aims to promote ;

- Awareness of quality as an increasingly important element in competitiveness
- Understanding the requirements for quality excellence
- Sharing of information on successful quality strategies and the benefits to be derived from their implementation

The award criteria focuses on ten key concepts, these are ;

1. Customer-driven quality
2. Leadership
3. Continuous Improvement
4. Employee participation and development
5. Fast response
6. Design quality and prevention
7. Long range outlook

8. Management by fact
9. Partnership by development
10. Corporate responsibility and citizenship

Many U.S companies have adopted the criteria as a method for self assessment and as a means to identify business and strategic issues as apart of the business planning process.

The criteria is also used for the MBNQA assessment that is presented each year by the President of the United States in recognition of the organisations Total Quality approach. (Oakland, 1993)

European Foundation for Quality Management (EFQM) Business Excellence Model

Similar in theme to both the Deming Prize and the MBNQA criteria the EFQM developed an assessment model in 1992. Originally called the European Model for Total Quality Management its title was changed in 1996 to the Business Excellence Model to help identify the model as a company wide initiative and not and extension of the Quality System.

The European Model is illustrated in Figure 2.2 and consists of nine elements, 5 enabler criteria and four result criteria. (EFQM, 1995)

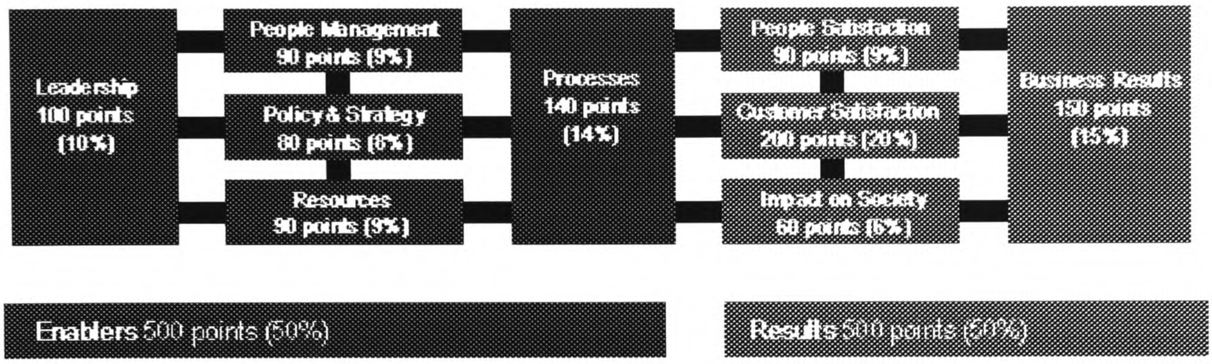


Figure 2.2 - The European Business Excellence Model

The Enabler criteria are concerned with how the organisation approaches each of the criterion parts. Information is required on the excellence of the approach used and the extend of the deployment of that approach throughout the organisation.

The Result criteria are concerned with what the organisation has achieved and is achieving. The organisations results and trends for all result criteria should be addressed in terms of ;

- the organisations actual performance

- the organisations own targets

and wherever possible

- the performance of competitors

- the performance of best in class

This model is used to assess companies who enter the European Quality Awards, The British Quality Award and the Wales Quality Award, amongst others.

Both the MBNQA and EFQM models represent a snapshot in time and do not replace the need for effective quality systems to manage the day to day issues within the organisation. (Hilary, 1996)

The concept of what is meant by Quality has changed constantly over the past 100 years, and it seems certain that it will continue to do so in the future. The challenge for Quality professionals is to ensure that their craft is applied to all areas of the business including strategic management. (Silverman & Propst, 1996)

The EFQM and MBNQA criteria provide the performance based framework by which the true Quality of an organisation can be measured.

CHAPTER THREE - COST OF QUALITY OVERVIEW

What are 'Quality Costs'?

The British Standard BS4778: Part 2 defines Quality Costs as:

> "The expenditure incurred by the producer, by the user and by the community, associated with the product or service quality."

It defines Quality-Related Costs as:

> "The expenditure in defect prevention and appraisal activities plus the losses due to internal and external failure."

This second definition refers to the traditional Prevention-Appraisal-Failure Model (P-A-F) where,

Prevention Costs

The costs of all activities specifically designed to prevent poor quality in products or services. Examples are the costs of new product review, quality planning, supplier capability surveys, process capability evaluations, quality improvement team meetings, quality improvement projects, quality education and training.

Appraisal Costs

The costs associated with measuring, evaluating or auditing products or services to assure conformance to quality standards and performance requirements. These include costs of incoming and source inspection/test of purchased material, in process and final inspection/test product, process or service audits, calibration of measuring and test equipment and the costs of associated supplies and materials.

Failure Costs

The costs resulting from products or services not conforming to requirements or customer/user needs. Failure costs are divided into internal and external failure costs.

Internal Failure Costs

Failure costs occurring prior to delivery or shipment of the product, or the furnishing of a service, to the customer. Examples are the costs of scrap, rework, reinspection, retesting, material review and downgrading

External Failure Costs

Failure costs occurring after delivery or shipment of the product and during or after furnishing of a service to the customer. Examples are the costs of processing customer complaints, customer returns, warranty claims and product recalls.

(Campanella, 1990)

In recent years the scope of the quality costing activity has changed to fit in with the concepts of Total Quality Management (TQM). Whereas they were once associated with the cost of the Quality department, inspection, the cost of scrap and external failures, today they encompass all costs that related to 'not getting things right the first time.' This concept is now applied to the administration and service functions as well as the manufacturing areas. (Dale & Plunkett, 1992)

Why measure 'Quality Costs'?

The 'Cost of Quality' concept has been established for nearly fifty years since the term was first coined by General Electric in the USA. General Electric used an analysis of the cost of non-conformance associated with a particular process to determine the need for corrective action. (Crosby, 1989)

Many publications on the subject of Quality Costs state that up to 30% of Sales income of manufacturing companies and 50% in service companies can be attributed to Quality Costs. (Dale & Plunkett, 1995)

This technique is now widely referenced within most writings on Total Quality Management as a fundamental measure of Quality Performance. In the automotive industry many of the major car companies have included the requirement to measure Quality Costs within their Supplier Quality Manuals e.g. QS-9000 Quality System Requirements, issued by Ford, General Motors and Chrysler, RG2000 - Supplier Business Specification, issued by Rover Group, VDA-6 issued by the German automotive car industry and the Nissan Quality Standard for Suppliers - Quality Management System Requirement issued by Nissan Motor Manufacturing (UK) Ltd.

These companies perceive Quality Costs to be a key measure that enables suppliers to identify opportunities to reduce costs and meet the year on year cost reduction targets set by their purchasing functions. Indeed Ford Motor Company have actively sought 5% year on year cost reductions amongst its supply base consistently over the past 6 years, since 1992.

In the early 1990's Rover Group established Best Practice Teams comprising of Rover Engineers and Purchasing personnel with the aim of investigating cost improvements amongst its supply base. The practice required 'open book' pricing by Rover's suppliers for the Rover Best Practice Team to identify cost saving opportunities. The teams also reviewed the production facilities with the aim of identifying other cost improvement ideas. Any savings made as a result of the team would be shared 50/50 in the first year with Rover claiming 100% in the following years.

Both Ford's and Rover's approach have encouraged their supply base to establish a system to identify 'waste' in the production system (also referred to as non-value adding activities or as the Japanese say 'MUDA') and to use this analysis as the focus for reducing costs. Hence the 'Cost of Quality' Concept is an integral part of most Automotive Component suppliers continuous improvement effort.

Development of the concept of the 'Cost of Quality'

One of the earliest references to the 'Cost of Quality' was made by Dr J. M. Juran in his definitive work on Quality Management "The Quality Control Handbook" (Juran, 1951). In Chapter 1 of his book, entitled "The Economics of

Quality" he refers to the potential savings through the analysis of Quality costs as "The gold in the mine."

Juran defines the term Quality Costs as those costs associated solely with defective product - the costs of making, finding, repairing or avoiding defects. The costs of making good products are not included as part of Quality Costs within this definition, neither are administrative errors. (Juran, 1990)

Juran recommended the use of quality cost analysis for two different but interrelated purposes :

1. To provide a new scoreboard as an added form of cost control

2. To identify opportunities for reducing Quality Costs.

Armand V. Feigenbaum provides us with a detailed definition of Quality Costs within his book "Total Quality Control" published in 1951. In it he defines Operating Quality Costs as,

> "Those costs associated with the definition, creation, and control of quality as well as the evaluation and feedback of conformance with quality, reliability, and safety requirements, and those costs associated with the consequences of failure to meet the requirements both within the factory and in the hands of customers." (Feigenbaum, 1986)

Feigenbaum's definition splits Quality Costs into two principle areas, the 'cost of control' and the 'cost of failure to control.'

The costs of control comprises of two segments, prevention costs and appraisal costs where prevention costs are the costs associated with the prevention of non-conformities from occurring and appraisal costs, which refer to the cost of ensuring product/services meet the required standard.

Figure 3.1 illustrates how the costs of failure to control can also be split into two segments, internal failure costs and external failure costs, where internal failure costs refer to scrap, rework encountered by the company before the product is shipped to the customer and external failure costs refer to customer complaints, warranty, etc.

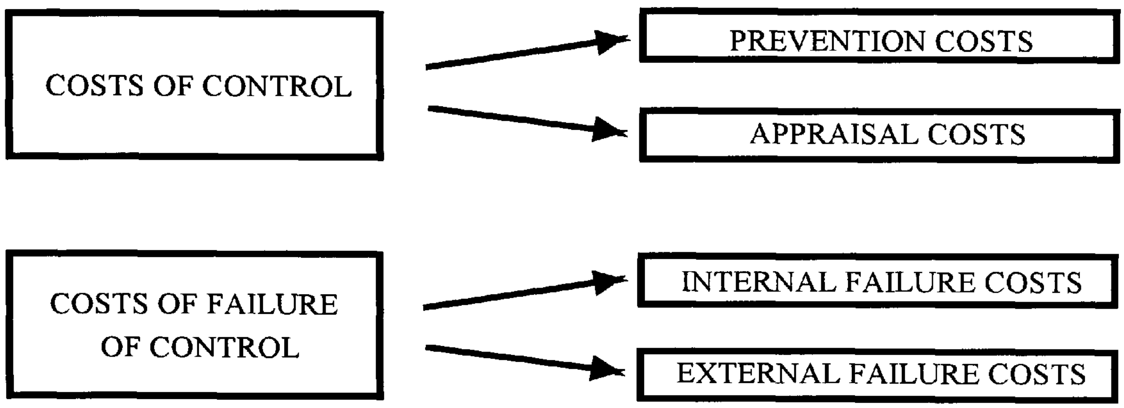


Figure 3.1 - Principal Quality Cost Areas

Quality Costs were first referenced in the UK when they were featured in a 1957 Productivity Council film "Right First Time." In the discussion notes accompanying the film Quality Costs were broken down into the same four categories as Feigenbaum. Furthermore it stated that the costs associated with each category could be built up as follows,

- Failure - 70 %
- Appraisal 25%
- Prevention 5%
- The total may well amount to between 4 and 14 per cent of the turnover of the company.

(Dale & Plunkett, 1995)

Juran also uses the four categories to describe Quality Costs and developed the concept of optimum cost of conformance. (Juran, 1990) To illustrate this concept he plotted the costs of appraisal and prevention costs against those of failure costs on the same axis, as shown in Figure 3.2. The graph shows the prevention and appraisal costs rise from zero to infinity as perfection is approached and the failure line drops from infinity to zero as perfection is approached. The Total Quality Costs reach an optimum (lowest) value between the two infinities.

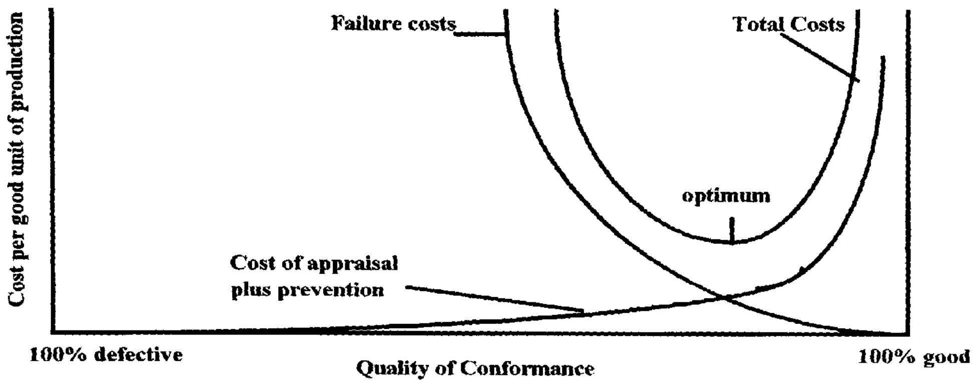


Figure 3.2 - Optimum Cost of Conformance

Juran divides the Total Quality Cost Curve into 3 distinct zones as illustrated in Figure 3.3.

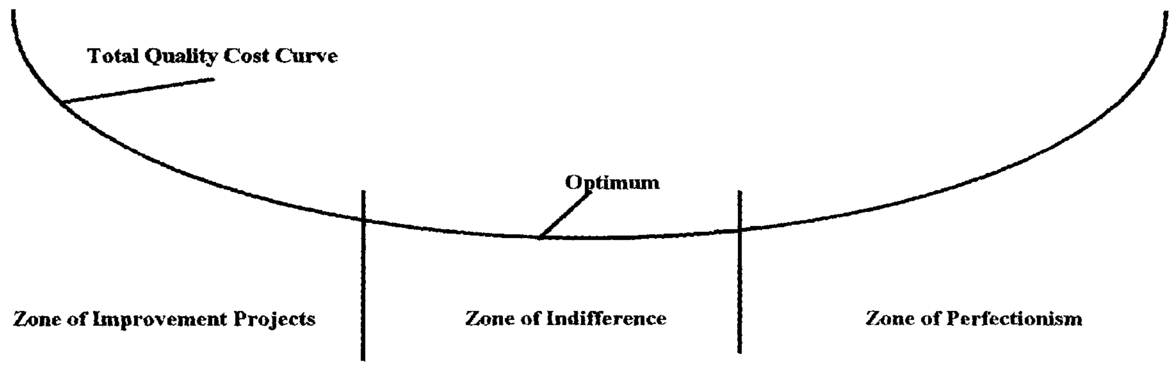


Figure 3.3 - Cost of Quality Zones

The Zone of Improvement Projects is where failure costs dominate, greater than 70% of Total Quality Costs and there are many opportunities to make improvements in scrap, rework etc. The Zone of Perfectionism is where appraisal costs dominate and the main areas for improvement lie with the reduction of quality standards, more efficient sampling inspection, etc. Within the Zone of Indifference the emphasis for Quality Costs shifts to control and the maintenance of the current standard.

The implication of this model is that companies should find the optimum quality cost to minimise its overall cost of production. In doing this the company must also accept that there will be an 'acceptable' level of non conforming product produced. This concept is at odds with the concept of zero defects and continuous improvement discussed later in this chapter. (Schneiderman, 1986)

Juran later revised his model for Optimum Quality Costs in the 4th edition of the Quality Control Handbook. As a result of proven examples of error proofing processes (e.g. Shigeo Shingo's poke-yoke) and improved automated inspection systems at relatively low cost it is now possible to achieve perfection at a finite cost. Juran's new model is illustrated in Figure 3.4.

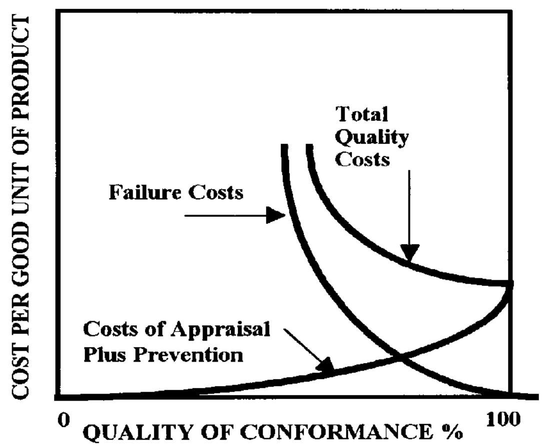


Figure 3.4 - Revised Economic Cost of Quality Model

BS6143 Part 2:1990 also illustrates that investment in prevention costs can substantially reduce both internal and external failure costs. Figure 3.5 shows how an increased awareness of quality failure costs leads to, first, an increase in appraisal costs, and then to an increase in prevention costs. The result is that eventually all costs reduce.

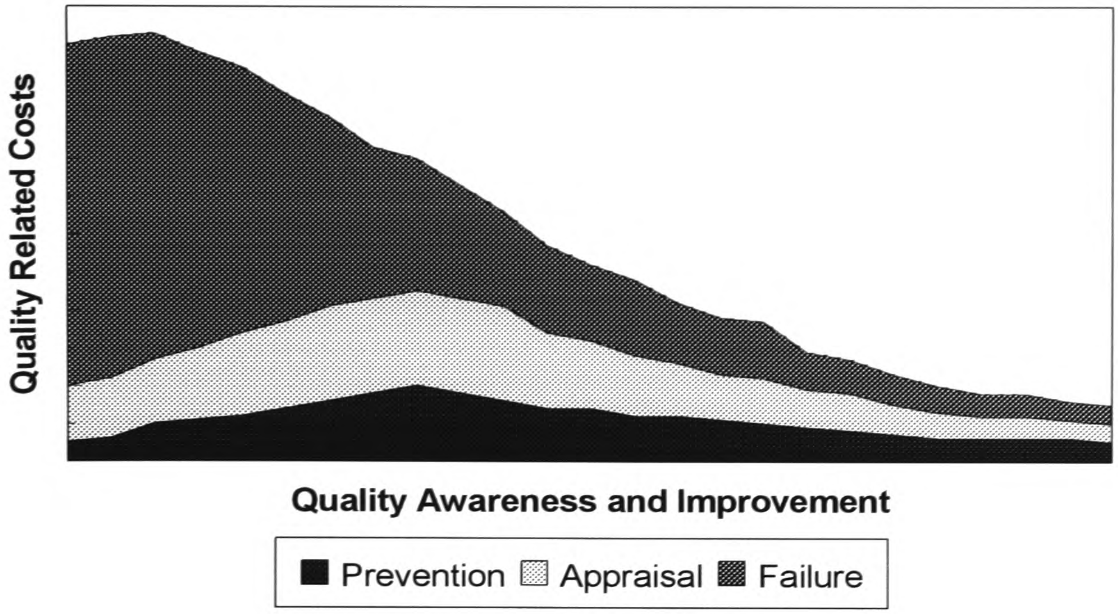


Figure 3.5 - Increasing quality awareness and improvement activities (Taken from BS6143:Part 2:1990)

By 1963 the use of Quality Costs data was formally recognised by the U.S Department of Defense (D.O.D) who issued a Supplier Quality Program Requirement specification MIL-Q-9858A. Paragraph 3.6 of MIL-Q-9858A requires the supplier to:

> "... maintain and use quality cost data as a management element of the quality program. These data shall serve the purpose of identifying the cost of both the prevention and correction of non-conforming supplies (e.g. labour and material involved in material spoilage caused by defective work and for quality control exercised by the contractor at subcontractor's or vendor's facilities). The specific quality cost data to be maintained and used will be determined by the contractor. These data shall, on request, be made available for "on site" review by the government representative."

MIL-Q-9858A requires the supplier to establish procedures for collecting and analysing quality related costs and to make them available to the government's representative for review. When the standard was first issued the Quality Cost data was treated as proprietary and therefore although the government's representative could review the data on site, they were not authorised to take copies of the data off site. In 1985 this changed and the revised standard specified that Quality Cost data must be submitted to the governments representative "for use in determining the effectiveness of the contractors quality program."

The concern raised by many suppliers was that the data would be used for comparison purposes and may be used as part of the decision criteria for awarding contracts. This was seen as unfair as the standard did not specify the quality cost categories to be used, instead this was left up to the supplier. Therefore the scope of each supplier's quality cost data would be different making comparisons impossible.

Another D.O.D specification MIL-STD-1520C, Corrective Action and Disposition System for Nonconforming material includes the requirements for collecting Quality Costs associated with internal failure such as;

> "... scrap, rework, repair, use as is, and return to supplier costs, plus other costs as determined appropriate by the contractor."

Whereas the D.O.D promoted the use of Quality Cost data amongst its suppliers it was the American Society for Quality Control (ASQC) which took on the task of promoting this concept to industry in general. In 1961 the ASQC formed a Quality Costs Committee with the aim of raising the profile of the use of Quality Costs as a management tool.

In 1967 they published a key work on Quality Costs called "Quality Costs - What and How." This work provided the detail on what should be contained within a Quality Costing program and provided the definitions for categories and elements of Quality Costs. Such was the success of the book that it soon became the largest seller of any ASQC publication. As a result the ASQC became recognised as the main authority on Quality Cost systems. Further publications issued by the ASQC were "Guide for reducing Quality Costs", "Guide for managing Supplier Quality Costs" and "Quality Costs: Ideas and Applications."

These key works have now been collected together and published under the title "Principles of Quality Costs". (Campanella, 1990)

In 1979 Philip B. Crosby raised the profile of Quality Costs by publishing his book "Quality is Free." Within this book he raised the issues of the costs associated with doing things wrong and stated that typical American corporations spend 15-20 % of its sales dollar on reworking, scrapping, repeated service, inspection, tests, warranties and other quality related costs. In Part One - The Understanding - he states

> "Quality is free. It's not a gift, but it is free. What costs money are the unquality things - all the actions that involve not doing jobs right the first time. *
>
> If you concentrate on making quality certain, you can probably increase your profit by an amount equal to 5 to 10 percent of your sales. That is a lot of money for free." (Crosby, 1979)

Such language caught the imagination of company directors and managers everywhere who were reminded once again that 'the gold was still in the mine.' Indeed even today many mangers still quote Quality Costs at 15-20% of sales, nearly twenty years after Crosby's research.

In this book, and its successor "Quality without Tears" published in 1984 he defines the Four Absolutes of Quality as ;

1. The definition of Quality is Conformance to requirements
2. The system of Quality is prevention
3. The performance standard is zero defects
4. The measurement of Quality is the price of nonconformance

(Crosby, 1984)

Like Feigenbaum before him, Crosby divides the cost of quality into two areas - the price of nonconformance (PONC) and the price of conformance (POC). The price of conformance refers to the costs associated with the prevention of quality defects and the necessary inspection activities which Crosby estimates to be in the order of 3 to 4 percent of sales in a well run company.

The price of non conformance refers to the cost of doing things wrong and includes scrap, warranty, correcting administration errors etc. Crosby estimates that these costs can equate to 15-20% of sales within manufacturing companies and upto 35% in service companies.

Crosby managed to get the issue of Quality Costs raised to a management concern instead of a technical measurement of ratios or indices. The power to do this, he states, lies with the representation of the true costs of non-conformance expressed as a percent of sales.

Another model categorises all costs into those which add value and those which add cost. In this model costs associated with the normal working of the process plus prevention costs are identified as 'adding value' to the business. Appraisal and failure costs are seen as negative costs. This is illustrated in Figure 3.6. (Asher & Kanji, 1993)

This would appear to differ from Crosby's philosophy where 'necessary appraisal' costs are part of the costs of conformance and are therefore seen as legitimate.

In 1981 The British Standards Institute published BS6143 Guide to the Determination and Use of Quality Related Costs. The standard was designed to promote the use of quality related costs and provided guidance for manufacturing companies to establish a Cost of Quality System. This standard was based heavily on the ASQC publication "Quality Costs- What and How". Its main flaw was that it was heavily biased towards the heavy manufacturing industries and was therefore not flexible to use across a wider manufacturing and service industries. (Dale & Plunkett, 1995)

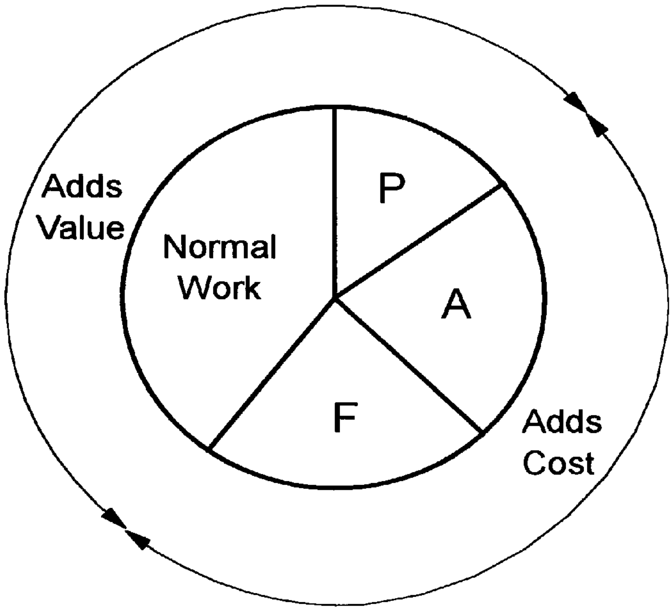


Figure 3.6 - Asher's Total Cost of Quality Model

The standard was revised in 1990 and was published in two parts. Now titled the Guide to the Economics of Quality Part One describes the Process Cost Model approach and outlines a model for applying quality costing to a manufacturing or service process. The Process Cost Model uses the Crosby method of categorising Costs as either the price of conformance (POC) or price of non conformance (PONC). Part 2 describes the traditional Prevention-Appraisal Failure Model and is an improved version of the 1981 standard.

Cost of Quality Classification

One difficulty facing any company introducing a Quality Costing process is the determining of the quality cost elements within each category of Prevention-Appraisal-Failure. Indeed for many managers this seems to take as much time as the collection of the costs themselves. (Juran, 1992)

Campanella provides the definitive list in the ASQC's Principles of Quality Costs publication. In his list he includes 31 Prevention elements, 25 Appraisal elements, 26 Internal Failure elements and 10 External Failure elements. These are included in detail in Appendix A along with explanations of each element.

BS6143: Part 2 also includes a list of elements for each P-A-F category. These elements are described in Appendix B. The standard states that they are included for guidance only and may not be appropriate in all situations. This inevitability means that companies must modify their Quality Cost system to delete some of the identified elements or to add their own unique elements.

The extent to which a company will modify these guidance documents rests upon the objective of the quality cost program or process. Companies that have a TQM approach to quality costing will include a company-wide approach to the P-A-F model and adapt it to suit their administration functions as well as manufacturing facilities.

This customisation precludes the final data from ever being compared to other companies, within or outside the industry sector. This is because it is impossible to determine whether or not the data collection and classification procedures used are consistent enough to compare meaningfully.

Although the P-A-F model was designed, and is best suited to, manufacturing environments there have been case studies where it has successfully applied to non-manufacturing activities. For instance in banking, meat processing and health care. (Dale & Plunkett, 1995)

An alternative approach to Quality Costing is described in BS6143:Part 1:1992 which illustrates the use of the Process Cost Model. It is based upon the computer aided manufacturing integrated program definition (IDEF) method for representing complex systems (see Figure 3.7).

The Process Cost Model has only two categories -

- the cost of conformance (COC), and
- the cost of nonconformance (CONC).

Both these categories added together equal the process cost.

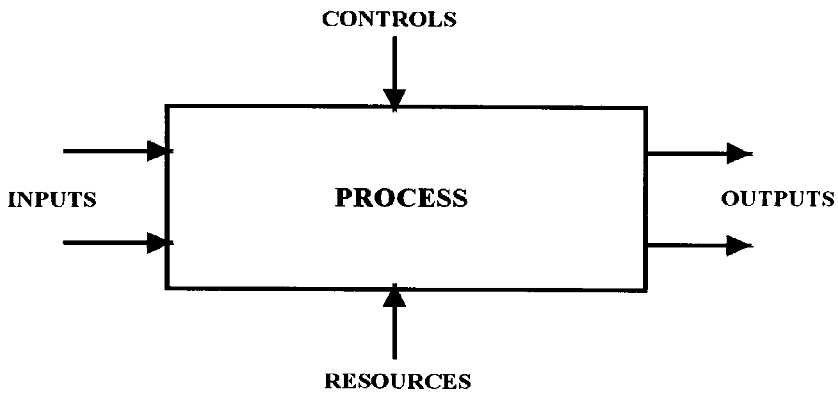


Figure 3.7 - Process Diagram

The Process Cost Model can be used for any process within an organisation, both manufacturing and non-manufacturing. Each activity within the process needs to be identified and categorised as either a cost of conformance or a cost of non conformance.

Great care is needed when setting up the model to ensure that all key activities are listed and that collection of the costs is repeatable. A detailed example of the construction of a Process Cost Model is included in Chapter 5.

The standard also recognises the fact that there may be a need to link the P-A-F model to the Process Cost Model where a company has been using the P-A-F model to report Quality Costs. In such a case it suggests that the cost of conformance may initially be considered to be the cost of prevention and appraisal along with the basic process cost. The cost of nonconformance would then consist of the internal and external failure costs.

Not everyone believes that the Process Cost Model is a useful tool. Fox, suspects that,

> "... the complete analysis of a company's activities into interlinked 'processes', accurately and without duplication and consequent

> double counting of costs, is likely to be more onerous than the traditional categorisation of Quality Costs. Furthermore, the classification of the running costs of inefficient or unnecessary processes' running exactly according to the book into the COC hides the inefficiency." (Fox, 1993)

The standard does allow for inefficiencies that are accepted as part of the process to be counted as Cost of Conformance which is clearly at odds with the philosophies of TQM. The standard does however state that there are opportunities within both the cost of conformance and the cost of non conformance for cost reduction. When using the Process Cost Model care must be taken not to accept the cost of conformance as a 'good' or a 'necessary' cost but merely as the cost of producing products or services with the current capability and efficiencies.

The advantage of the Process Cost Model is its simplicity of classification and its ease of application within any organisation, department or process. However, there is always the risk that whilst the model works well within definite departmental or process boundaries, it will sometimes fail to include those costs which occur between departments. This in turn may lead to self interest of the process owner at the expense of other departments and the company as a whole. (Dale & Plunkett, 1995)

Collecting Quality Costs

When deciding which categories are to be included within the Quality Costing study the organisation must first specify the purpose of collecting the Quality Costs. This may range from the measurement of all Quality Costs to costing only specific quality cost improvement projects.

In most cases the quality cost information will be provided from 3 main sources

1. Company Accounts
2. Special financial data recorded by the Finance department
3. Synthetic costs

Whichever source is used the definition for each must be clearly understood and agreed by the originating department and concurred by the Finance department. (Daisley, Plunkett & Dale, 1984)

Dale & Plunkett also suggest that as a guide, collect all costs that are readily available but the cost elements that are likely to be under £1000 per annum are not worth persuing. (Dale & Plunkett, 1995)

The accuracy of the data can often be a distraction when establishing a quality costing study. Whereas it is important to be factual with the data to give the study credibility the purpose should not be to verify the accuracy of the costing management system or to establish absolute costs. As Aristotle once wrote,

> "It is the mark of an instructed mind to rest content with that degree of precision which the nature of the subject permits and not to seek exactness where only approximation or the truth is possible."

The collection of Quality Costs is a complex issue that will require input and agreement from the process owner, the Quality department and the Finance department. It is therefore recommended that the quality costing exercise is carried out by a cross functional team to give it the right level of quality, technical and accounting knowledge. (Dale & Plunkett, 1995)

This is particularly true when deciding on how to apportion overheads to Quality Costs and how to ensure double counting is avoided. This is best left to the accounts specialist. (Fox, 1993)

Analysis and Reporting of Quality Costs

Once the data collection system is established it must be analysed and reported to senior management in order for them to review and take action. The type of report and the frequency of reporting will depend upon the company's own reporting system. It is usual for most companies to report Quality Costs monthly or quarterly along with its other financial information.

Most literature on the subject of Quality Cost reporting use the P-A-F model categories as key headings on a summary sheet. Each category is often trended over time to show performance.

In all cases reports must be easily accessible and useful and highlight key information such as areas of opportunity. Different departments may require particular information at particular frequencies to aid their quality improvement initiative. e.g. a production department may require scrap and rework costs to be provided weekly to the supervisors. The senior management team however will be better suited to a monthly summary overview of the key cost areas as well as reports on current cost improvement initiatives.

A typical example of a summary report is illustrated in Table 3.1. The summary uses the traditional P-A-F model to categorise the costs and each element, as well as the category overall cost, is reported as an absolute figure and as a percentage of sales.

This is one cost base which is frequently used to express the organisations Total Cost of Quality as a percentage of Net Sales. Other bases frequently used are ;

1. Labour Based : Internal Failure Costs / Direct Labour Costs
2. Cost Based : Total Failure Costs / Manufacturing Costs
3. Unit Based : Total Quality Costs / Units of Production
4. Added Value Based : Total Quality Costs / Value Added

(Fox, 1993)

Bases however should be used with care. No one base can define the Quality Costs for an organisation, each base can be misleading if used alone. (Campanella, 1990)

Table 3.1 - Example of a Monthly Cost of Quality Report

	Current month			Year to date		
Quality Cost Category	Quality Cost	% of Sales	% conv cost	Quality Cost	% of sales	% conv cost
1. Prevention Costs						
a. Quality Engineering	32	0.4	1.19	224	0.5	1.4
b. Quality Training	-	-	-	-	-	-
Total Prevention Costs	32	0.4	1.19	224	0.5	1.4
2. Appraisal Costs						
a. Supplier Quality	15.6	0.19	0.58	116.6	0.27	0.7
b. In-process and finished product	49	0.61	1.8	380	0.9	2.3
c. Final inspection + VSR + gas stand	13	0.16	0.49	102	0.23	0.6
d. Appraisal equipment	12	0.15	0.45	86.1	0.2	0.5
Total Appraisal Costs	89.6	1.11	3.32	684.7	1.6	4.1
3. Internal Failure Costs						
a. Rework	3.4	0.04	0.13	23.4	0.05	0.14
b. Scrap	49.5	0.6	1.8	380	0.9	2.3
c. Substandard product	-	-	-	-	-	-
d. Extra operations	9	0.1	0.34	68	0.16	0.4
e. Other	22	0.27	0.8	159.4	0.37	0.97
Total Internal Failure Costs	83.9	1.01	3.07	558.3	1.28	3.37
4. External Failure Costs						
a. Customer returns	4.4	0.06	0.17	30.5	0.07	0.18
b. On site insp. & test	-	-	-	-	-	-
c. Warranty expenses	32	0.4	1.19	154	0.36	0.9
d. Other	1.6	0.02	0.06	11.6	0.03	0.07
Total External Failure Costs	38.1	0.48	1.42	196.1	0.46	1.15
1993 Actual Quality Costs	243.6	3	9	1663	384	10.02
1993 Plan Quality Costs	273	3.4	10.2	1456	3.4	8.8
1992 Actual Quality Costs	226	4.18	9.91	1541	3.6	9.91

(Dale & Plunkett, 1995)

Although this type of report is very useful for detail it is necessary to also include a graphical representation to show the trend over a given period. An example of which is shown in Figure 3.8.

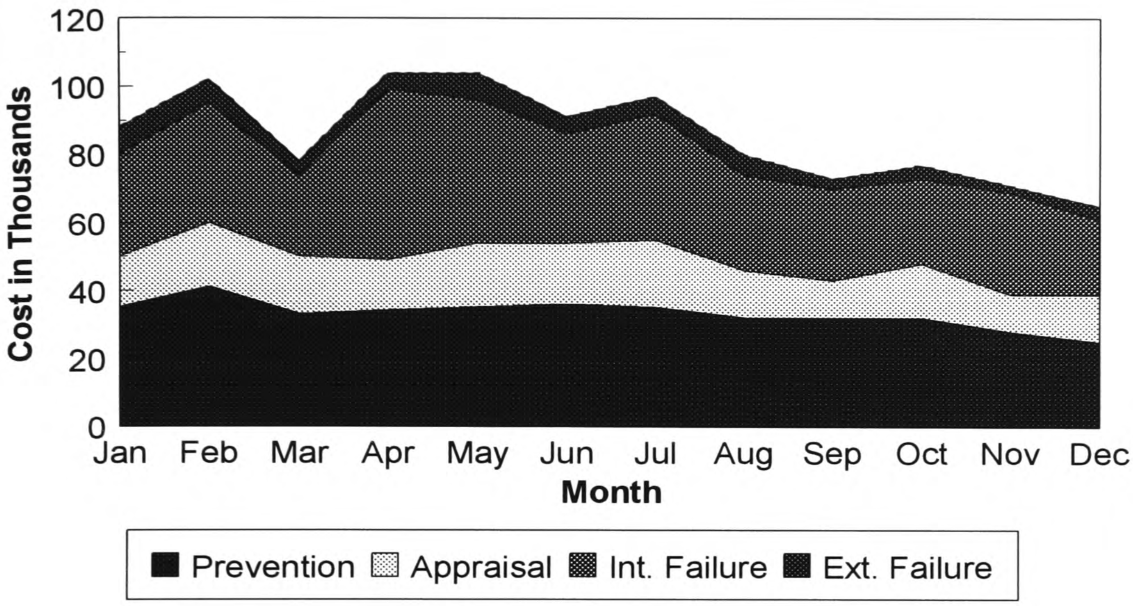


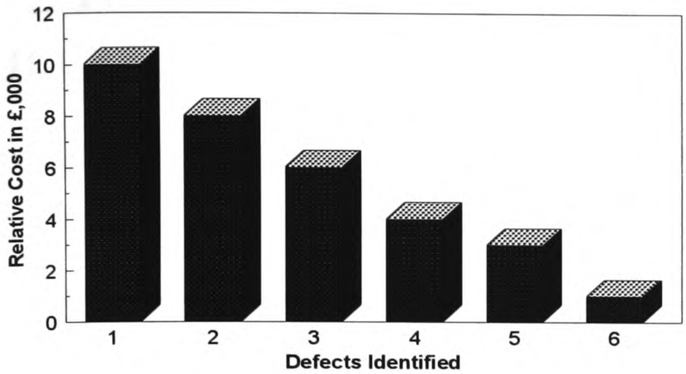
Figure 3.8 - Cost of Quality Trend Graph

Quality Cost Improvements

Having defined the Quality Cost elements and collected cost data from the relevant areas it is possible to focus on the real purpose of Quality Costing.

The purpose of a cost of quality system is to identify areas that can be improved. Once the data collection and analysis is complete it is then possible to identify cost elements that require further investigation to provide the detail necessary for improvements to be made.

In order to prioritise the improvement effort it will be necessary to sort the data in order using simple techniques such as Pareto Analysis. Pareto Analysis involved the listing of data in order of magnitude, with the largest figures first. This will help identify where the largest improvements can be made. Figure 3.9 illustrates a typical Pareto chart.



Defects Identified

1. Pressure switch malfunction
2. Scoring in machine bores
3. Broken terminal points
4. Hole not threaded
5. Pitting on machined surfaces
6. Others

Figure 3.9 - An example of a Pareto Chart for Internal Failure Analysis adapted from BS6143:Part 2 1990

Normally the key cost areas that will provide the most benefit will be the failure and appraisal categories. It is important to make the data attributable to the department where it originated and to give them the responsibility for improvement.

Analysis of the data must be treated with great care. Warranty costs for example may be attributed to product shipped over the previous two years and it will therefore be difficult to identify potential root causes.

Improvement teams should be established to identify and implement improvement actions based upon the data in the Quality Cost Report.

CHAPTER FOUR - TRICO'S PREVENTION, APPRAISAL AND FAILURE COST MODEL.

Trico Limited has used a Quality Costing system since late 1993 based upon the traditional Prevention - Appraisal - Failure model.

The Quality Cost report is published each month within the Company's Business Operating Statistics (B.O.S) book and is reviewed by the Executive Team along with key financial information and other operational key measures.

It is the responsibility of the Quality department to collate the cost information and produce these monthly reports with the assistance of Finance and other departments as necessary.

The cost elements for each category are included in Table 4.1 and Table 4.2.

Table 4.1 - Trico Limited's Conformance Cost Elements

Conformance Costs	
Prevention Costs	**Appraisal Costs**
Quality Management	Laboratory Acceptance Testing
Quality Engineering	In-process Inspection (SPC)
Reliability Assessment	Inspection & Test Equipment
Quality Audit	Goods Receiving Inspection
Supplier Assessment	
Training	
Calibration	
Quality Budget	

Prevention Costs Description

Quality Management.

This cost refers to the employment costs of the Quality Manager and Quality Director. (Since January 1995 these roles have been merged). Company car costs and general expenses are included within the general Quality Budget element.

Quality Engineering

These are the costs associated with those Quality Engineers whose tasks are primarily concerned with quality system auditing or continuous improvement. Other Quality Engineering costs appear in Appraisal (Inspection and Test Laboratory Engineer) and External Failure (Warranty/Customer Concerns Engineer) categories.

Again these costs relate to direct pay costs and include overtime payments. General expenses are included within the general quality budget code.

Reliability Assessment

This element refers to the management of the reliability and chemical laboratories along with the cost of two Laboratory Technicians. Again the costs refer to direct wages paid. Laboratory running costs are included within Appraisal Costs under Laboratory Acceptance Testing.

It may be argued that these cost should be under Appraisal Costs rather than Prevention although it is true to say that they are Cost of Conformance costs.

Audit

This relates to the cost of conducting process/product audits in the manufacturing and administration areas. The procedure is carried out by a Quality Technician and this element relates to the employment cost (including overtime).

It does not include the associated costs of the audit such as corrective action costs, sorting/re-inspection, etc. These costs are not included in the report.

Supplier Assessment

This is the employment cost of the Supplier Quality Assurance Engineer who carries out Quality Assessments and Supplier Development amongst Trico's supply base.

Training

During 1995 this element was expanded to include the total cost of training carried out by Trico. The training budget and actual spend is taken directly from the Finance department.

In addition the employment costs of the Personnel Co-ordinator are included.

Calibration

This refers to the cost of employing a Calibration Technician to manage the calibration program within Trico. It also includes the costs of external calibration.

Quality Budget

This is a general category which includes all Quality Budget elements not covered elsewhere within the Quality Cost report. Key items are company car expenses, travel expenses, entertaining customers, consultancy (incl. 3rd party audits), and stationary.

Appraisal Costs Description

Laboratory Acceptance Testing

This element includes the employee costs for a Laboratory Engineer and Technician.

In-process Inspection

This element refers to the cost of managing the SPC process within production departments (where required). They are made up of estimated time spent to complete SPC charts, including the time required to conduct the measurements.

Inspection and Test Equipment

This element refers to the equipment used by the laboratories only and not the rest of the factory.

Goods Receiving Inspection

This element refers to the cost of Goods Inwards personnel employed to book goods onto the Trico system and carry out sample inspection.

Table 4.2 - Trico Limited's Non-Conformance Elements

Non-Conformance Costs	
Internal Failure	**External Failure**
Scrap	Warranty
Rectification & Rework	Field Concerns
Cost of Change	Product Liability
Concessions	Additional Transport
Credit Notes	Customer Returns

Internal Failure Costs Description

Scrap

This is the recorded value allocated to physical scrap by the Finance department based upon scrap notes raised by the Production departments. It includes the material content only and does not include any labour, processing or overhead allocation expended.

The published figure also takes into account the value of the selling price of the scrap for that month which is deducted from the scrap figure.

Rectification and Rework

This element is calculated from estimated time spent by operators to rectify or rework product within manufacturing.

Cost of Change

This refers to the time spent administrating the Engineering Change procedure. A cost has been calculated for the time taken by the Managers and Engineers involved with the Engineering Changes to approve a change. This is currently estimated at £200 per change. The actual value is then calculated from the number of changes in an actual month multiplied by £200.

The costs do not include any other associated costs such as drawing changes, testing requirements, piece part costs etc.

Concessions

This element is calculated in the same manner as for Engineering Changes except that the cost per concession is quoted at £20 each. Again no costs are recorded for any additional costs such as increased scrap, additional operations/processes, etc.

Credit Notes

This element refers to the cost of administration of credit notes within the company. Credit notes are raised for warranty returns, reject products, delivery errors, pricing errors and rebates. The administration cost of each credit note is estimated to be £15 and this figure is used to calculate the total cost.

External Failure Cost Description

Warranty Returns

This is the cost of warranty claims made by customers during a particular month. Requests for payment are often made on a quarterly basis which distorts the warranty cost figures in certain months.

Included within this cost is the employment cost of a Warranty Technician responsible for the investigation, analysis and reporting of warranty failures.

Field Concerns

This is the cost of responding to Customer Complaints by Trico personnel. It includes travel costs, employee costs and any associated rework costs. It also includes the cost of containment and corrective actions required to deal with the concern.

Included within the cost is a Quality Engineer who is responsible for facilitating this process and for liasing with the customer on response to concerns.

Product Liability

This element includes any payment made for damage as a result of faulty goods such as a scratched windscreen.

Additional Transport Costs

This is the cost of providing non routine transportation of goods due to late delivery, quality problems, downtime, etc.

Customer Returns

This cost deals with line-side rejections returned to Trico from customer manufacturing plants. The cost information is taken from the value of credit notes raised by the Customer Services department.

The cost elements are summarised each month in a Quality Cost Report which is reviewed by the Executive Team. A typical cost report is shown in Table 4.3.

Cost bases are used to allow for comparison of actual costs incurred against sales or manufacturing costs. The cost bases reported monthly as part of the Quality Cost report are ;

- Total Cost of Quality as a percentage of sales income
- Scrap cost as a percentage of manufacturing costs
- Rectification and Rework costs as a percentage of direct labour costs
- Warranty costs as a percentage of sales income

The Quality Cost Summary Report calculates each category as a percentage of Sales Revenue, both for the calendar month and the year to date. Comparisons are made to the same period in the previous year (refer to Table 4.4). In addition the cost data is also presented as a twelve month trend as illustrated in Figure 4.1.

Table 4.3 - Trico Prevention-Appraisal-Failure Model Cost Report

Cost Category	Month			Year to Date		
	Budget	Actual	Variance	Budget	Actual	Variance
PREVENTION COSTS						
Quality Management	3,572	3,572	0	35,720	35,720	0
Quality Engineering	6,000	5,737	262	60,000	55,598	4,401
Reliability Assessment	4,584	313	4,271	45,840	5,611	40,228
Audit	1,066	1,128	-62	10,660	11,326	-666
Supplier Development	1,490	1,454	36	14,900	3,430	11,470
Training	11,772	15,050	-3,278	117,720	189,033	-71,313
Calibration	1,300	968	312	13,000	13,328	-328
Quality Budget	7,456	7,768	-312	74,560	97,597	-23,037
Total Prevention Costs	**37,240**	**36,011**	**2,682**	**372,400**	**411,643**	**-39,243**
APPRAISAL COSTS						
Laboratory Testing	3,000	2,974	26	30,000	29,709	291
In-process Inspection	7,100	6,792	308	71,000	68,259	2,741
Inspection & Test Equip.	1,425	227	1,198	14,250	8,730	5,520
Goods Receiving Insp.	4,886	4,629	257	48,860	45,116	3,744
Total Appraisal Cost	**16,411**	**14,622**	**1,789**	**164,110**	**151,814**	**12,296**
INTERNAL FAILURE COST						
Scrap	17,000	10,293	6,707	170,000	75,992	94,008
Rectification & rework	3,177	3,576	-399	31,770	35,883	-4,113
Cost of Changes	0	3,600	-3,600	0	36,600	-36,600
Concessions	0	780	-780	0	6,920	-6,920
Credit Notes	0	1,560	-1,560	0	11,400	-11,400
Total Internal Failure Costs	**20,177**	**19,809**	**368**	**201,770**	**166,795**	**34,975**
EXTERNAL FAILURE COST						
Warranty Returns	1,421	1,468	-47	14,210	56,832	-42,622
Field Concerns	1,600	1,576	24	16,000	15,744	256
Product Liability	0	0	0	0	0	0
Add. Transport Costs	0	13,500	-13,500	0	89,832	-89,832
Customer Returns	0	123	-123	0	1,068	-1,068
Total External Failure Cost	**3,021**	**16,667**	**-13,646**	**30,210**	**163,477**	**-133,267**
Total Cost of Quality	**76,849**	**85,655**	**-8,806**	**768,490**	**893,730**	**-125,240**
Sales Revenue	3,205,000	3,548,000	343,000	27,959,000	28,674,000	715,000

Table 4.4 - Trico Quality Cost Summary Report

	Month	1997 YTD	1996 YTD	1996 Full Year
Total Cost of Quality	85,655	893,730	955,971	1,107,961
% Sales	2.41	3.78	4.16	3.81
Prevention Costs	36,011	411,643	347,402	423,697
% Sales	1.52	1.74	1.5	1.46
Appraisal Costs	14,622	151,814	161,776	191,803
% Sales	0.64	0.64	0.68	0.66
Internal Failure Costs	19,809	166,795	330,895	368,333
% Sales	0.87	0.7	1.45	1.27
External Failure Costs	16,667	163,477	115,897	124,126
% Sales	0.47	0.69	0.53	0.43

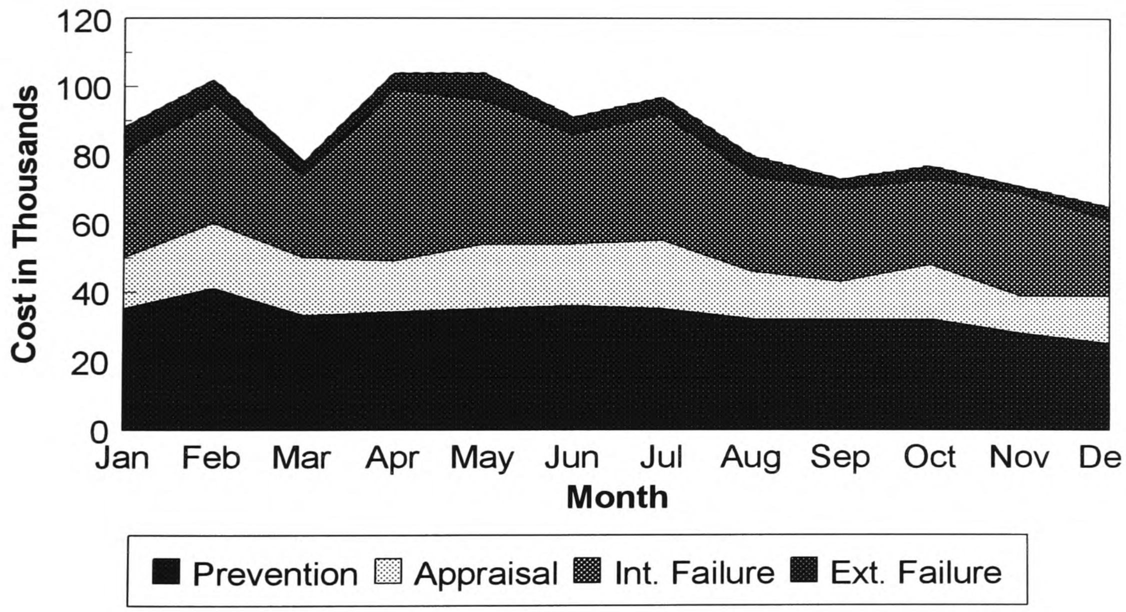


Figure 4.1 - Trico Quality Cost Trend Graph

Quality Cost reporting is not used to generate specific cost improvement actions within the company, although it does highlight where improvements or adverse trends occur.

Instead it is used to monitor the quality costs and ensures that are controlled to budgeted figures. The data does highlight significant cost improvements since it was first introduced in 1993. For instance the cost of scrap has been reduced by 87% over the past four years as a direct result of a cross functional scrap improvement team being established to focus on the causes of scrap (refer to Table 4.5).

Table 4.5 - Scrap Reduction Results 1994 - 1997

	1994	1995	1996	1997
Total Cost of Scrap	652,000	637,000	326,000	84,578

This improvement is reflected in the Cost Base data, in particular, the Total Cost of Quality as a percentage of Total Sales and Scrap as a percentage of Manufacturing Cost (refer to Table 4.6).

Table 4.6 - Cost Base Data - 1994 - 1997

Cost Base	1994	1995	1996	1997
% COQ/Sales	6.65	4.37	3.21	3.04
Scrap/Manufacturing cost	4	1.55	1.07	0.52
Rectification / Direct Labour	1.62	0.86	1.64	0.81
Warranty / Sales	0.13	0.13	0.07	0.05

Assessment of Trico's P-A-F Model

At first glance the Trico Quality Cost data suggests that at 3.04% of Sales the Cost of Quality is low compared to the typically quoted figures of 10 - 25 % (Crosby, 1979) or 4 - 15% (Dale & Plunkett, 1995).

The data for 1997 shows that the Total Cost of Quality is made up as follows ;

Prevention Costs - 45.51 %

Appraisal Costs - 16.75 %

Internal Failure Costs - 18.29 %

External Failure Costs - 19.36 %

This is very different from typical figures quoted for quality cost categories such as Abed and Dale whose research showed figures of ;

Prevention Costs - 5%

Appraisal Costs - 28%

Failure Costs - 67%

This range of figures is also supported by N. B. Webb (1972) whose research compared the meat industry costs to general industry costs.

The automotive industry does put great emphasis on Prevention techniques such as Failure Mode and Effects Analysis, Capability Assessment, Control Plans, etc. Within QS-9000 there is a specific manual dedicated to the management of new product introduction using cross functional teams. This would account for a higher than average prevention quality cost compared to industry in general.

When comparing the Trico P-A-F cost elements against those included in BS6143 Part 2 or the ASQC's comprehensive list, included in Appendix A, it is clear that the Trico model can be enhanced to capture other quality costs. This would inevitably increase the percentage of Quality Costs as a percentage of Sales and may raise the current figure of 3.24% closer to the expected 15%.

A review of both BS6143 Part 2 and ASQC's "Principles of Quality Costs" identified the following additional cost elements for inclusion in the Trico Quality Cost report.

Prevention Costs

Quality Planning

These are the costs of the Advanced Quality Planning activities such as feasibility reviews, design reviews, process planning, failure mode and effects analysis, control plans, capability studies, gauge planning and evaluation and initial sample reporting.

Preventative Maintenance

This is the cost of the scheduled preventative maintenance activities within the company. It includes man-hours and materials.

Quality Overhead Allocation

This are the costs of associated overheads and rented floor space etc.

Quality Improvement Costs

This is the cost of formal quality improvement initiatives within Trico. It includes the team based suggestion scheme, Encouraging Excellence, and the Supplier Development Program included within the activities of the Trico Supplier Association.

Appraisal Costs

Production Set-up verification

These are the costs of carrying out set up verification for the assemble cells and press shop along with last off inspection.

It also includes the cost of setting up the paint plant and carrying out monitoring inspections.

Inspection and Testing

This includes the costs of 100% operator inspection carried out on the assembly cells and the hourly inspection costs within the press shop.

Tooling Checks

At the end of each press run the tool is removed and checked in the toolroom to ensure it is still within specification for the next run.

Internal Failure Costs

Downtime

This is the cost of unplanned downtime due to material shortages, equipment failure or quality problems.

Sorting

This cost was previously hidden within the downtime classification for manufacturing areas. Improved recording of this activity has allowed Trico to monitor these costs separately from other downtime codes.

Engineering Changes

Although the administration cost for Engineering Changes has been recorded the actual cost of implementing the changes has not. This will include the cost of modifying drawings, process change cost, obsolete stock, etc.

External Failure Costs

This section has remained unchanged.

Using the revised Cost Elements a study was conducted over a three month period, May to July 1997, to evaluate the effect on Trico's Quality Cost reporting. Tables 4.7, 4.8 and 4.9 include the results of the study which identifies the additional costs of each additional cost element.

The study demonstrated that over the three month period the additional elements increased the reported cost of quality by 70%. If this trend continued for the full year then the expected Total Cost of Quality as a percentage of Sales would be 5.5% compared to the currently quoted 3.04%

Even though the revised model produced a significant increase in the total cost of quality reported the figure of 5.5% still appears low compared to the commonly quoted figures of 15 - 25%.

It may be possible that this figure is a fair representation of Trico's Cost of Quality performance, or alternatively there may yet be hidden costs which have not been identified

Table 4.7 - Additional Prevention Costs

Original Cost Elements		Additional Cost Elements	
Cost Element	**£**	**Cost Element**	**£**
Quality Management	10,716	Quality Planning	19,400
Quality Engineering	18,000	Preventative Maintenance	3,200
Reliability Assessment	13,500	Quality Overheads	6,900
Audit	3,250	Quality Improvement Costs	3,900
Supplier Assessment	4,600		
Training	35,000		
Calibration	3,900		
Quality Budget	25,000		
Total Prevention Cost	**113,966**	**Additional Cost**	**33,400**
An increase of 29.3%			

Table 4.8 - Additional Appraisal Costs

Original Elements		Additional Elements	
Cost Element	**£**	**Cost Element**	**£**
Laboratory Acceptance Testing	8,700	Set-up Verification	34,000
In-process Inspection	23,000	100% Inspection	74,000
Inspection & Test Equipment	4,200	Tooling Checks	7,600
Goods Receiving Inspection	13,980		
Total Appraisal Costs	**49,880**	**Total Additional Costs**	**115,600**
An increase of 231 %			

Table 4.9 - Additional Internal Failure Costs

Original Cost Elements		Additional Cost Elements	
Cost Element	**£**	**Cost Element**	**£**
Scrap	27,000	Downtime	26,000
Rectification & Rework	10,100	Sorting	3,500
Cost of Changes	11,100	Engineering Changes	8,700
Concessions	2,600		
Credit Notes	4,480		
Total Appraisal Costs	**55,280**	**Total Additional Costs**	**38,200**
An increase of 69%			

From analysis of the origin of Trico's quality costs it is apparent that not all departments are represented. This can be clearly seen in Table 4.10.

Table 4.10 - Departmental Contribution to the Total Cost of Quality

Department	% Contribution
Manufacturing	32
Quality	25
Design & Development	9
Purchasing	0
Personnel	17
Customer Services	2
Marketing	0
Finance	0
Despatch	15
Warehouse	0

The Total Quality philosophy states that there are quality cost opportunities in all functions and activities. Table 4.10 therefore shows that there are gaps in the identification of quality costs in many areas. This may be due to the use of the traditional P-A-F model which is very much focused on manufacturing activities.

In order to investigate Trico's quality costs further the author decided to evaluate the use of the Process Cost Model described within BS6143 Part 1:1992. The evaluation will compare and contrast the use of the model in a manufacturing area and a support function.

CHAPTER FIVE - PROCESS COST MODEL PILOT STUDY

As described in Chapter Four the reasons for Trico developing a Process Cost Model approach to Quality Costing were;

1. To refine the data collection method within the company and identify 'hidden costs'
2. To extend the concept of Quality Costing to those departments not normally included within the scope of the P-A-F model in order to support Trico's Total Quality Approach.
3. To allow departmental Quality Cost reporting and hence provide ownership of the Quality Costing process.

Before implementing this process throughout the company the author decided to carry out a pilot study in two areas to evaluate this approach. The areas selected for the study were the Original Equipment (O.E) Wiper Blade Assembly section and the Personnel department. This provided a manufacturing and an administration function to compare and contrast the use of the Process Cost Model.

BS6143: Part 1: 1992 was used as the reference for establishing the Process Cost Model in these two areas.

Creating a Process Cost Model

The Process Cost Model method of identifying, collecting and reporting Quality Costs is described in the British Standard BS6143 : Part 1 :1992. The model uses process modelling to identify cost elements and classifies them simply as either Cost of Conformance or Cost of Non-Conformance. Where,

Cost of Conformance (COC) is the cost of operating the process as specified in a 100% effective manner. This does not infer that it is efficient, nor even a necessary process, but rather that the process, when operated within its specified procedures, cannot be achieved at lower cost. This is the minimum cost for the process as specified.

Cost of Nonconformance (CONC) is the cost of inefficiency within the specified process, i.e. over resourcing of excess costs of people, materials and equipment arising from unsatisfactory inputs, errors made, rejected outputs and various other modes of waste. These are considered non essential process costs.

The standard clearly states that both areas offer opportunities for improvement.

This approach has the advantage that it can be applied to any process in a manufacturing or service environment and thus makes it suitable for companies measuring company-wide Quality Costs as part of a Total Quality approach.

The other advantage of this approach is that it allocates responsibility to the process owner and hence gives ownership to the quality costing process. It is important that the Quality Costing process is regarded as a key performance measure by the process owner and not a measure only used by the Quality or Finance departments.

The Process Cost Model

The Process Cost Model is developed from an understanding of the process under investigation and is represented by a block diagram as illustrated in Figure 5.1.

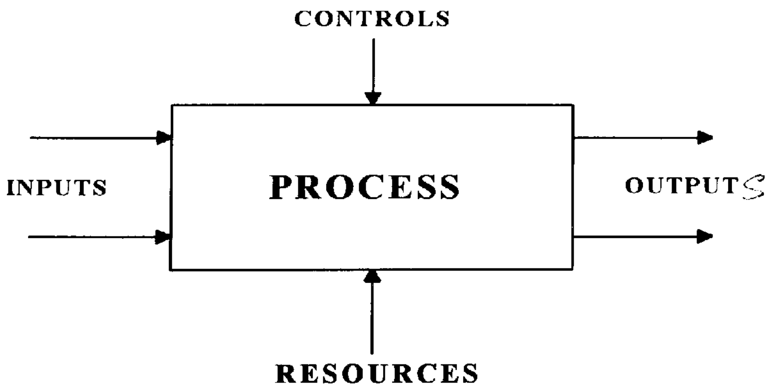


Figure 5.1 - The basic process model

This model may be used to represent a single process, such as an assembly operation or invoicing process, or it may be used to describe the activities of a whole department. The model is based upon the computer aided manufacturing integrated program definition (IDEF) method which was originally developed to represent manufacturing system. The only difference is that in the IDEF model 'resources' is replaced by 'mechanism.' (Dale and Plunkett, 1995)

The IDEF model is essentially an activity diagram that pictorially identifies the inputs to the activity and its related outputs. The control elements relate to the factors or situations that regulate the activity e.g. standards, procedures, regulations. The mechanism refers to the location of the activity or the thing that performs the activity. In the Process Cost Model 'mechanism' is replaced by 'resources,' i.e. the people or equipment required to carry out the activity.

There are three main steps to create a Process Cost Model as described within the Standard. These are ;

1) Create a Process Model to illustrate the elements of the process under review
2) Develop a Cost Model from the Process Model created in step 1.
3) Develop a Process Cost Report from the Cost Model in step 2.

Cross Functional Team

Two teams were established to define and implement the pilot studies, one in the Blade Assembly area and one in the Personnel Department. Both teams were provided with training in Quality Costing techniques and given an overview of BS6143 Parts One and Two. The team members were;

Wiper Blade Assembly

Ian Riggs	Quality Director
John Brooking	Management Accountant
Andrew Bonthron	Wiper Blade Assembly Manager
Andrew Wilks	Material Controller
Janice Lloyd	O.E Blade Team Leader

Personnel department

Ian Riggs	Quality Director
John Brooking	Management Accountant
Dave Cross	Personnel Co-ordinator
Kathy Cleveland	Personnel Administrator

Wiper Blade Assembly Pilot Study

Process Description.

The Wiper Blade Assembly department comprises of 3 main sections, these are;

i. Original Equipment Product Assembly

ii. Aftermarket Product Assembly

iii. Aftermarket Packaging

The assembly operations are carried out by small, self-contained, manufacturing cells each with three to five operators, depending upon the complexity of the product. In total there are thirty manufacturing cells, twelve for O.E product and eighteen for Aftermarket (including Intercompany product). Between them the cells can produce up to 90,000 wiper blades a day over a single shift operation.

O.E wiper blade product is packed directly into its final packaging as part of the assembly process and is then taken directly to the Despatch area where it is collected by the customer's transport. Aftermarket blades are packed into tote bins and then stored on the shop floor in a Kanban (first in, first out storage) area. They are then packed into customer designed cartons by the Aftermarket packaging section and shipped to the customer.

Figure 5.2 illustrates a typical wiper blade assembly construction.

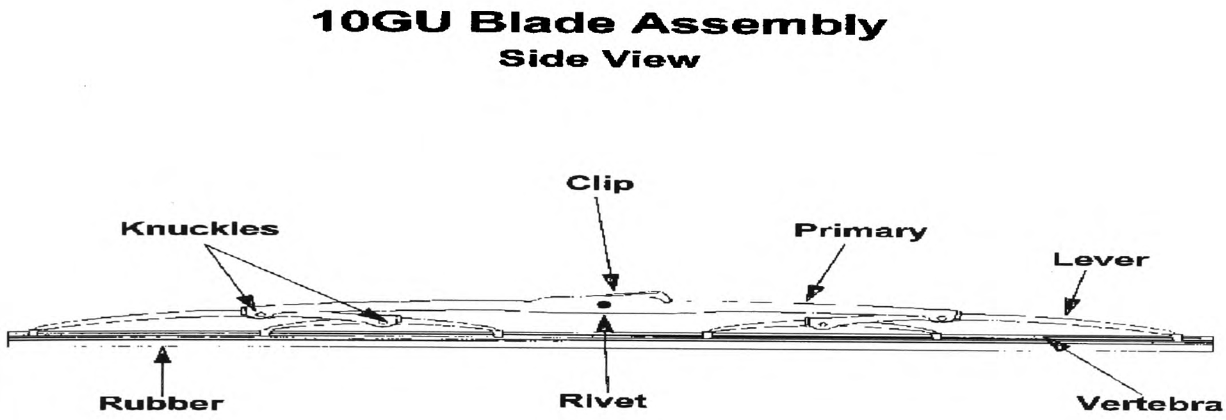


Figure 5.2 – Wiper Blade Assembly

i. Defining the Scope

The scope of the pilot study was limited to the manufacture of Original Equipment Wiper Blades. This consists of 12 manufacturing cells, which can produce up to 36,000 wiper blades per day for customers such as Ford, General Motors, Rover Group and Jaguar.

The cells each have three operators and are supervised by a single team leader. In addition there are two support operators (line-feeders) who supply the cells with components and remove completed product for despatch.

ii. The Process Cost Model

The team followed the guidance of BS6143 and developed a Process Model for the O.E wiper blades section. Tables 5.1 to 5.4 lists the outcomes of several brainstorming sessions held to identify the elements required to build the Process Model. The headings used were ;

a) Customers and Outputs – Table 5.1

b) Suppliers and Inputs – Table 5.2

c) Resources – Table 5.3

d) Controls – Table 5.4

Table 5.1 – O.E Wiper Blade Assembly - Customers & Outputs

Output	Customer
Good Product	Despatch
Scrap Product	Scrap Co-ordinator
Packaging Waste	Cleaners
Scrap Reports	Blade Assembly Manager, Finance, Material Control
Production Reports	Blade Assembly Manager, Finance

'Good product' refers to wiper blades that have passed final inspection and are packed into their transport packaging ready for despatch to the customer. The line feeders for the section remove completed pallets of product and take them to the Despatch department where they await collection by the customer's own transport.

'Scrap product' refers to components and assemblies that have been rejected by the operators on the cell, for fit, function or appearance reasons. These parts are collected on the cells until the end of the production run. They are then sorted to salvage any reusable parts before passing them to the scrap co-ordinator to be counted and disposed of. The scrap co-ordinator is responsible for completing scrap tickets for the components, which are then passed on to Finance and Material Control functions. If any of the rejected items are due to supplier defects then the Team Leader or Scrap Co-ordinator will raise a Supplier Concern Notification Form and submit it to the Supplier Quality Assurance Engineer for action.

'Packaging waste' refers to cardboard and plastic shrink-wrap used in the packaging of components, which is then discarded after use.

'Scrap reports' are raised by the Scrap Co-ordinator and are used by Finance to determine the cost of scrap by department and by Material Control to adjust the stock level of the components.

'Production reports' are produced by each individual cell and are summarised by the Team Leader for use by the departmental manager and the Finance department. They include information such as production output levels and downtime analysis.

Table 5.2 - O.E Wiper Blade Assembly - Suppliers & Inputs

Input	Supplier
Metal Components for Blade Harness	Press Shop (via Paint Plant)
Rubber Elements for Blade Assembly	Avon Automotive
Steel Coil for Rubber Vertebra	Sandvik
Rivets	Stockists
Plastic Components for Knuckles and Clip	Plastic Engineers, Landers
Packaging	Castle Corrugated

'Metal components' refer to yokes and levers required to construct the harness of the wiper blade assembly. They are made of galvatite coated mild steel and are produced in Trico's Press shop. The components are then painted using a two-coat electrocoat process, which provides 1,000 hours of salt spray resistance.

Compressed moulded 'Rubber elements' are made from a natural rubber compound and are supplied solely by Avon Automotive. The elements are produced in 'tandems' which are two elements moulded together.

The tandems are then cut into individual elements in Trico's rubber cutting department and are then checked for wipe quality on a test screen. Depending upon the size of the cutter used the trim length of the rubber can be varied to give an optimum wiping performance on the vehicle.

'Vertebra' refers to two metal strips, which are inserted into grooves, either side of the rubber element to provide the rubber with it required shape or 'bow'. The metal harness slides over the vertebra and is crimped to retain the rubber and vertebra assembly. The vertebra is produced within the Blade Assembly department from coiled stainless steel wire.

'Rivets' are used to provide support for the plastic clip. These are purchased from various stockists.

'Plastic components' consist of 'knuckles' which join the metal yoke to the metal levers and allow them to pivot. Plastic is used to prevent metal to metal contact which would result in corrosion. Also plastic clips are fitted to the yoke rivet for attachment to the wiper arm. These components are purchased from two suppliers based in the West Midlands, Landers Automotive and Plastic Engineers.

'Packaging' consists of cardboard boxes designed to hold 5 layers of 20 wiper blades. Layer cards are used to separate each layer of wiper blades. These boxes are stacked onto wooden pallets and then banded ready for shipping to the customer. This packaging is purchased from a local company, Castle Corregated, in Monmouth.

Table 5.3 - O.E Wiper Blade Assembly - Resources

Resource	Owner
Operators – Direct Staff	Blades Department
Operators – Line Feeders – Direct Support	Blades Department
Team leader, Supervisor	Blades Department
Production Engineering	Blades Department
Quality Support	Quality Assurance
Manufacturing Engineering	Manufacturing Engineering
Floorspace, Facilities, etc.	Manufacturing Department
Tools, Equipment and Gauges	Manufacturing Engineering
Management Support	Manufacturing

'Operators – direct staff' are grade one employees who are responsible for the manufacture, inspection and packing of the O.E product.

'Linefeeders' are responsible for delivering components to the cells for assembly and for taking completed product to the despatch area ready for shipping.

In this section there is one 'Team Leader' responsible for the 38 operators. She is responsible for ensuring that the product is manufactured according to the production plan and for producing and analysing performance data

There is one 'Supervisor' in the Blade Assembly section whose time is split between the three main sections. We have assumed that his time is divided equally between these sections.

'Engineering support' consists of two Production Engineers each with two technicians reporting to them. They are responsible for the equipment maintenance and technical support for the blade assembly and packing section.

'Quality support' is provided by the Quality Assurance department. It includes dealing with supplier quality concerns, internal quality standards, calibration of gauges, etc.

'Manufacturing Engineering' is responsible for the implementation of new and/or changed processes. They supply work instructions and control plans to the section as well as ensuring that appropriate gauges are available.

'Floorspace, facilities, etc.' refer to the amount of space that the section requires to carry out its activities as well as a proportion of the electricity, gas, etc used by the manufacturing area.

'Tools, equipment and gauges' refers to the depreciation costs of equipment used in the manufacture and test of O.E wiper blade products.

'Management support' refers to the Blade Assembly manager's time as well as that of the Manufacturing Director.

Table 5.4 – O.E Wiper Blade Assembly - Controls

Control	Originator
Work Instructions, Control Plans	Manufacturing Engineering
Quality System Procedures	Quality Assurance
Health & Safety Procedures	Quality Assurance
Environmental Procedures	Quality Assurance
Work Schedule	Material Control
Drawings, Specifications	Design & Development
Customer Requirements	Customer

The Manufacturing Engineering department prepares 'work instructions' for each operation used within the manufacturing area. Work instructions also include control (inspection) plans, gauge and packaging instructions.

'Quality', 'Health & Safety' and 'Environmental' procedures are prepared by the Quality department in conjunction with the operating departments. They are issued to relevant departments and are subject to document control procedures carried out by the Quality department. Regular audits of these procedures are carried out and the results are fed back to the Supervisors and Team Leaders for action.

'Work schedules' are produced by the Material Controller and translate customer orders into a production plan.

'Drawings and Specification' are produced by the Design & Development function and define the design requirements of the product.

'Customer requirements' influence the information required in the work instructions, control plans and procedures.

Using the information identified during the brainstorming a Process Model was constructed as illustrated in Figure 5.3.

Having reviewed the Process Model the team then set about identifying the key activities carried out within the scope of the process.

It was important that the activities included in the study must be directly controllable by the Team Leader of the O.E section. It was felt that activities such as process changes, work instructions, procedure updates, etc, which are carried out by other functions, were difficult to attribute exactly to the O.E section. There was also the risk of duplicating these costs when studying other functions within the company such as Quality Assurance and Manufacturing Engineering.

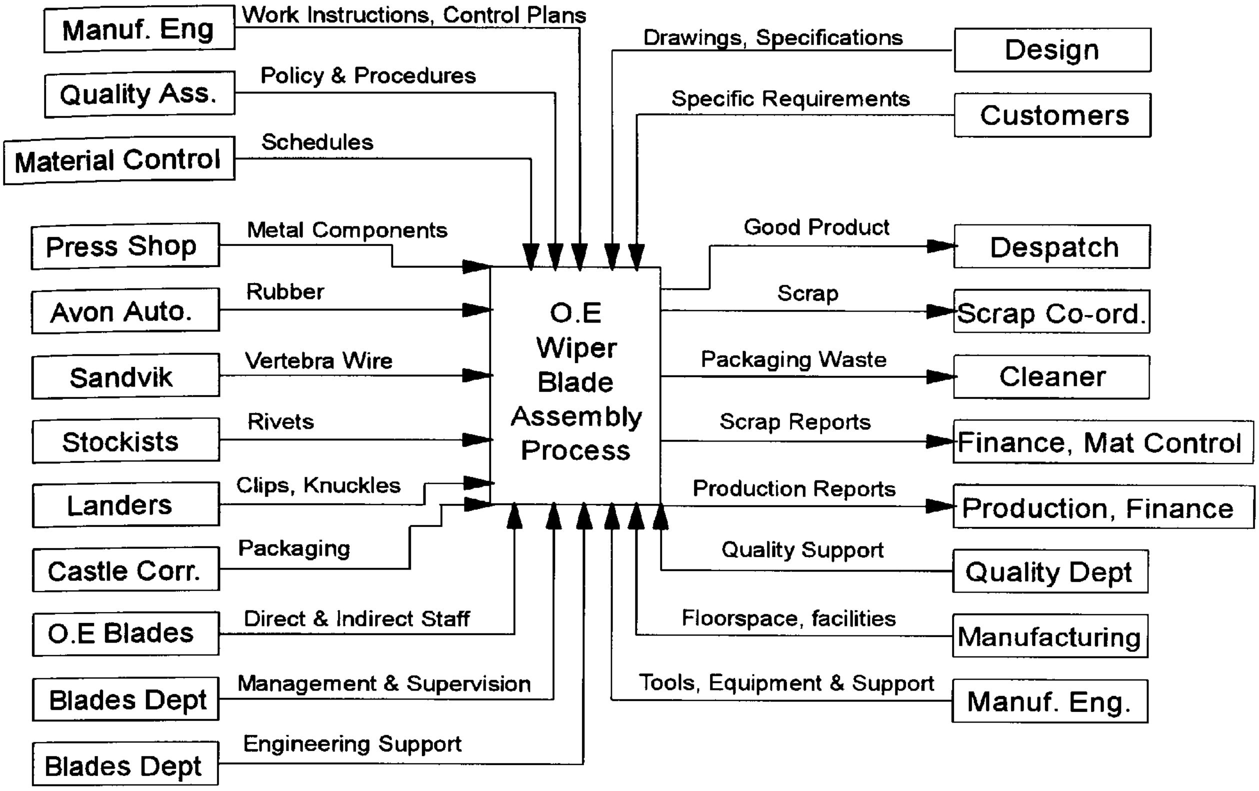


Figure 5.3 – O.E Wiper Blade Process Model

The identification of the Key Activities was initially done as a brainstorming exercise with a further review taking place to evaluate the outcome of the brainstorming session and to place the activities in order. The following headings were used in the brainstorming session, as proposed in BS6143 : Part 1 : 1992, along with e) which, although not included within the standard, is normally a key heading for a brainstorming exercise.

a) People;

b) Equipment;

c) Materials;

d) Environment;

e) Methods

Once the activities were identified they were reviewed to identify costs of conformance and/or nonconformance associated with them. E.g. for blade assembly the costs associated with this activity was 'good product' and 'scrapped product'. The next step was to establish how to quantify each of the costs from the existing financial data or if necessary to collect the costs locally.

As described in BS6143 Part 1 a Cost Model was developed from the Process Model to describe the key activities and categorise the cost of conformance and non-conformance.

Table 5.5 - Cost Model for the O.E Wiper Blade Assembly Department.

Key Activity	Cost of Conformance	Cost of Non-Conformance
Assembly, inspection and packing	Good hours booked	Hours spent doing rework
Downtime due to,		Waiting
	Meetings	
	Projects	Awaiting material
	Changeovers	Sorting material
	Training	Equipment breakdowns
	Non measured work	
Supervision	Team leader, supervisor	
Material cost	Estimated cost	Scrap cost
Equipment	Depreciation of equipment	
Floor space	Overhead allocation	

The Cost Model was then developed further to create the Process Cost Report as illustrated in Table 5.6. Once complete the form was used to collect data over a three-month period of January to March 1998. The results are analysed and presented in Chapter Six.

With the exception of the allocation of the Supervisor's time spent on O.E wiper blade production, all the costs identified were already available from the Labour Efficiency report (L.E report), production reports and other financial data held by the Management Accountant.

Table 5.6 – Process Cost Report for O.E Wiper Blade Assembly

O.E Wiper Blade Assembly Process Cost Report								
Process Owner : Janice Lloyd (Team Leader)				Date :				
	Cost				Cost			
Process conformance	Act	Syn	£	Process nonconformance	Act	Syn	£	Cost data source
Assembly, Inspection & Packing	√							Production reports
				Rework	√			Labour Efficiency (L.E) report
Meetings, training	√							L.E report
				D/time due to waiting material	√			L.E report
				D/time due to Faulty material	√			L.E report
				D/time due to repacking	√			L.E report
Changeovers	√							L.E report
				D/time due to machine fault	√			L.E report
Setting	√							L.E report
D/time due to Non measured work	√							L.E report
Breaks	√							L.E report
D/time due to new starters	√							L.E report
Projects	√							L.E report
Materials	√							Finance
				Scrap components	√			Production report
Floorspace, facilities		√						Finance
Linefeeding	√							Finance
Supervision		√						Finance
Cost of capital equipment depreciation	√							Finance

Personnel Department Pilot Study

The Personnel department was chosen to take part in the study because it was already represented within the traditional Prevention-Appraisal-Failure model and therefore it would be useful to compare the costs of both approaches. The Personnel department is also useful because it is a function, which is represented in most organisations and may therefore be of use to the reader.

Process Description

The department consists of a Personnel Co-ordinator and two Personnel Administrators. The Personnel Co-ordinator reports directly to the Finance Director who has executive responsibility for Human Resource function.

The Personnel department within Trico Limited is responsible for the co-ordination of the company's training budget, employee time and attendance system and for providing support to other departments on Human Resource issues. These issues include employee recruitment, disciplinary procedures, conducting leaving interviews and liaison with regulatory bodies such as the Health & Safety Executive in response to reportable accidents.

Training

The training budget is set at £150,000 for the 1997/8 financial year. This represents an investment of 7.5% of Trico's budgeted profit for this period. A training plan is established by the Personnel Co-ordinator based upon individual employee appraisals and company objectives. Once approved by the Executive Team the training budget is monitored each month against the training plan.

Time and Attendance System

Each employee is issued with a clock card upon joining Trico. Employees are required to clock in and out of each shift using the swipe machines located around the offices and factory.

These clock-in stations are connected to a computer located in the personnel office. It is programmed to analyse the clock-ins from each station and produce a daily exception report for each department. This report highlights absences, late clock-ins and overtime worked.

It is vital that this system is kept up to date as the reports are used by Finance to prepare the companies pay-roll. Any errors may result in under or over payment.

The Personnel Administrator will also advise departments when an employee reaches any of the disciplinary stages due to absence.

Human Resource Support

All recruitment requests are directed to the Personnel department for approval. Initially all positions are advertised internally on company notice boards. Only if a suitable candidate cannot be found within Trico will the position be advertised externally. Trico has managed to recruit 80% of all positions advertised from internal candidates.

The Personnel Co-ordinator provides advice on disciplinary issues to other departments and the company council. The company council is made up of elected members representing each grade of employee. The council is chaired by the Managing Director and is empowered to decide company policy and wage negotiation.

All accidents and incidents are logged by the Personnel department and the time lost due to injury is established. Should the accident or incident need to be reported to the HSE then the Personnel Co-ordinator shall do so.

The Personnel department is also responsible for the compliance to the Fire Precautions procedure. This involves the regular testing of the system and for ensuring adequate training is given to relevant personnel. In the event of a fire, the Personnel department produces an attendance list, and liaises with the Fire Authorities.

i. Defining the Scope of the Study

The team chose to apply the Process Cost Model to all the activities described above. Again it was agreed only to consider costs which were directly controllable by the Personnel department and where there was no risk of duplicating costs from other departments.

ii. The Modelling Process

Just as with the Blade Assembly team it was decided to use BS6143 Part One as the basis of the modelling process. Key procedures were reviewed to assist in the development of the model and to enable a clear understanding of the scope of the processes under review.

Having reviewed the Process Cost Model the team began brainstorming the following categories to develop the model;

a) Customers and Outputs – Table 5.7

b) Suppliers and Inputs – Table 5.8

c) Resources – Table 5.9

d) Controls – Table 5.10

Table 5.7 – Personnel Department – Customers and Outputs

Output	Customer
Training Plan	All Departments
Induction Training	New Personnel
Payroll Data	Finance
Attendance Exception Reports	All Departments
Executive Reports	Executive Team
Company Notices	All Departments
Accident Reports	Health & Safety Executive, Quality Assurance

The 'Training Plan' is established using identified training needs from individual employee appraisals and from the current business plan. All employees have a formal appraisal each year with their supervisor in which their performance is reviewed and opportunities for improvement are highlighted. The business plan is defined each year by the Executive Team based upon the company's strategic plan. The business plan will highlight new or modified processes that will require training support to implement.

The Personnel department carries out 'Induction Training' with support from other departments such as Quality, Finance and Production. All new employees undergo a full day's induction where they are given an overview of the company's activities, quality, environment, health, safety and personnel policies.

The company's 'Payroll Data' is generated from the time and attendance system via the employee clocking system. The Personnel department is responsible for ensuring that any exceptions are highlighted and resolved before the data is sent to the Payroll section of the Finance department for progressing.

'Exception Reports' are produced automatically from the time and attendance system and highlight employees who are absent without authorisation (i.e. without an approved absence request form) or who are late. These reports are issued to the relevant departments who are then required to confirm the data and raise the necessary paperwork for the absence e.g. a sick note, lost/forgotten clock card, etc.

Each month the Executive Team reviews key performance data from every department. The Personnel department produces reports on time and attendance, staff turnover and accident reports.

All 'Company Notices' are prepared and issued by the Personnel department. These include job vacancies, minutes of the company council, health and safety notices, etc.

All 'Accident Reports' are submitted to the Personnel department for review. If required the Health & Safety Executive (HSE) will be notified.

Table 5.8 – Personnel Department – Suppliers and Inputs

Input	Supplier
Staff Requisitions	All Departments
Completed Appraisals	All Departments
Business Plan – Training Requirements	Executive Team
Training Requests	All Departments
Accident Reports	All Departments
Responses to Exception Reports	All Departments
Absence Requests	All Departments

All 'Staff Requisitions' must first be approved by the Personnel Co-ordinator and Finance Director. Once approved the Personnel department will advertise the post internally.

'Completed Employee Appraisals' are submitted to the Personnel department for filing in the employee files. They are reviewed to record any identified training requirements in order to prepare the company's training plan.

A copy of the 'Business Plan' will be reviewed to identify any training requirements necessary to be included within the training plan.

Departments who require training raise 'Training Nomination' forms. The training nomination must be approved by the departmental head and the Personnel Co-ordinator. Once approved the training will be organised by the Personnel department.

'Accident Reports' are submitted to the Personnel department by departmental supervisors for review, filing and follow up action, if required.

Responses to 'Exception Reports' are submitted by the originating department to enable the Personnel department to update the time and attendance system.

'Absence Requests' are required for personnel who will be off site during normal working hours due to company business, holidays, doctor's appointments etc. These must be approved by the departmental supervisor or manager prior to the date the absence is required. This will allow the Personnel Administrator to update the system before the date of absence and therefore it will not be identified within the exception report.

Table 5.9 – Personnel Department – Resources

Resource	Owner
Staff	Personnel Department
Floorspace, Facilities, etc.	Trico

The Personnel department consists of a Personnel Co-ordinator (grade four employee) and two Administrators (grade two employees). The Finance Director has overall responsibility for the Personnel department.

The Personnel department is situated on the first floor of the main office building. The cost here includes floor space, telephones, computers and computer support for the time and attendance system.

Table 5.10 – Personnel Department – Controls

Control	Source
Legislation	Government
Business Policy	Executive Team
Investors in People Standard	Gwent Training & Enterprise Council
Company Procedures	Quality Assurance

'Legislation' on employee rights and health and safety plays a key role in setting the company's personnel policy.

The 'Business Policy' sets the guide-lines for the personnel policy within the company. This is reviewed by the company council at their quarterly meetings and by the Executive Team each month.

The 'Investors in People Standard' sets out the criteria for a proactive training and development management system and is used within Trico to benchmark its performance in this area.

'Quality', 'Health & Safety' and 'Environmental' procedures are prepared by the Quality department in conjunction with the operating departments. They are issued to relevant departments and are subject to document control procedures carried out by the Quality department. Regular audits of these procedures are carried out and the results are fed back to the supervisors and team leaders for action.

Using the results of these brainstorming sessions the Process Model was defined as illustrated in Figure 5.4.

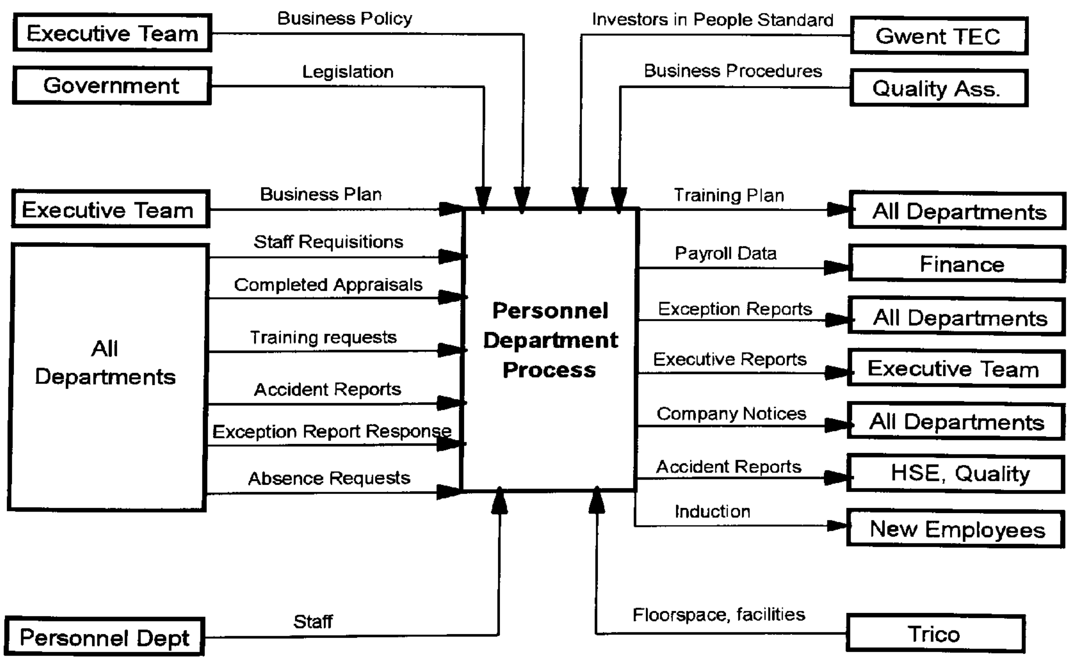


Figure 5.4 – Personnel Department Process Model

Review of this Process Model, along with the personnel procedures, allowed the team to identify the key process activities to be included in the Cost Model. The key activities identified are listed in Table 5.11.

Table 5.11 – Personnel Department – Cost Model

Key Activity	Cost of Conformance	Cost of Non-Conformance
Training	Preparation of training plan	
	Training costs (minus cancellations)	
		Cancellations & Non attendance
Time and Attendance	Preparation of Payroll data	
		Preparing exception reports
		Updating system as a result of exception reports
	Updating system as a result of absence requests	
Recruitment	Advertising	
	Agency Costs	
Staff Turnover		Leaving interviews
Accident reporting		Total cost
Fire procedure	Planned testing	False alarms, actual fires
Disciplinary meetings, appeals etc.		Total cost
Executive reports	Total cost	
Company council	Total cost	

Unlike the O.E wiper blade team there were very few costs which were already recorded by the Personnel department or Finance. The exceptions were the cost of training, training cancellations and recruitment costs.

It was therefore necessary to establish a method to record the time spent on the activities identified. A time sheet was developed to aid the members of the Personnel department to record the proportion of their time on each activity. A copy of this report is shown in Appendix C.

Although traditional advocates of Quality Costing have recognised the difficulty of measuring non-production personnel's time they also tend to discourage 'estimated costs' such as this. (Daisley, Plunkett & Dale, 1984)

To overcome this issue it was decided to use synthetic data as a more reliable and consistent calculation of quality costs e.g. number of reports x cost per report.

Table 5.12 – Personnel Department – Cost Report

Personnel Department Process Cost Report

Process Owner : Dave Cross (Co-ordinator) Date :

Process Conformance	Cost			Process Non-Conformance	Cost			Cost Data Source
	Act	Syn	£		Act	Syn	£	
Training plan admin		√						Activity report -
Training budget	√							Finance (Training cost – non attendance cost)
				Training cancellations	√			Finance
				Non attendance at training courses	√			Training delegate list attendance % x cost of training
Induction Training		√						Activity Report
Time and Attendance		√						Activity report
				Exception report admin		√		No of exceptions x 3 mins x hourly rate
				Updating system due to exception reports		√		
Updating system due to absence requests		√						
Recruitment – advertising		√						Finance
Recruitment – Agency costs		√						Finance
				Staff turnover – leaving interviews		√		Activity Report
				Accident reporting admin		√		No. of accidents x 10 minutes x hourly rate
Testing fire procedure		√						Activity Report
				False alarms, fires		√		Activity Report
				Disciplinary meetings, appeals		√		Activity Report
Routine reports		√						Activity Report
Company council		√						Activity Report
				Special reports		√		Activity Report

CHAPTER SIX – PILOT STUDY RESULTS

The data for both studies was collected during the first three calendar months of 1998. This chapter discusses the team's views on the data collection, analysis of results and some initial improvement actions based on the analysis of results.

1. O.E Wiper Blade Assembly Study

Data Collection

The O.E Wiper Blade team had no problems with the data collection required. The Production department and Finance department had already developed a detailed cost report for labour efficiency, scrap and material usage, which were the main constituents of the Process Cost Report. These production reports have been included in the executive review of business key measures for the past two years and have been used to focus the Production department on cost improvement initiatives.

The key difference with this approach was to have the data at O.E wiper blade assembly level rather than at the overall departmental level. This allowed the Team Leader to focus on the issues that they had direct responsibility for whereas the previous data had been lost in the overall departmental cost report. Hence the reporting of costs at this level encouraged ownership of the process and proved to be a strong motivator for improvement ideas.

This idea of making the lowest management/supervisory level responsible for the process is reflected in the development of self managed teams at Trico where the Team Leader and operators are responsible for all activities, from supplier scheduling to the shipment of the completed product. In this context the Process Cost Report has proved to be a useful tool to help enable the Team Leader report the cost analysis of the section. Indeed Dobbins clearly states that Quality Cost objectives should be part of the personal goals of the lowest managers who have control of the process. (Dobbins, 1978)

The Process Cost Report for the Blade Assembly study is shown in Table 6.1.

Table 6.1 – O.E Blade Assembly Process Cost Report

O.E Wiper Blade Assembly Process Cost Report								
Process Conformance	Cost			Process Nonconformance	Cost			Cost Data Source
	Act	Syn	£		Act	Syn	£	
Assembly, Inspection & Test	√		15900					Production report
				Rework	√		120	L.E report
D/Time due to meetings, training, etc.	√		180					L.E report
				D/Time due to awaiting material	√		400	L.E report
				D/Time due to faulty material	√		39	L.E report
				D/Time due to repacking	√		0	L.E report
D/Time due to changeovers	√		900					L.E report
				D/Time due to machine fault	√		700	L.E report
Setting of Equipment	√		1100					L.E report
D/Time due to non measured work	√		800					L.E report
D/Time due to breaks	√		2000					L.E report
D/Time due to new starters	√		400					L.E report
D/Time due to projects	√		320					L.E report
Material Cost	√		200000					Finance
				Scrap cost	√		2000	Finance
Floorspace, facilities, etc		√	2000					Finance
Linefeeding	√		2300					
Team leader	√		980					
Supervision		√	500					
Cost of equipment depreciation	√		1500					
Total Process Conformance Cost			228880	Total Process Nonconformance Cost			3259	

Analysis of Results

For the production team the results shown in the Process Cost Report, Table 6.1, provided very little in the way of new data. It represented a clearer picture of individual costs for the O.E cells, whereas the production reports used before included the other sections within the Blade Assembly area.

When comparing the Process Cost Report for this area against the current Quality Cost report used within Trico there were some differences between them. The existing Quality Report included scrap costs and rework costs only. The end of line inspection costs were not included as this was categorised as part of the production process.

The labour efficiency report, although reviewed monthly by the Executive Team and used by production management to identify improvement opportunities, produced key cost of non-conformance data, which was previously not included in the P-A-F model.

Improvement Actions

Two Pareto charts were created to represent the data in the Process Cost Report. Figure 6.1 shows the costs of conformance and Figure 6.2 shows the costs of non-conformance. These charts helped to prioritise the improvement actions. The element references for both figures are included in Tables 6.2 and 6.3 respectively.

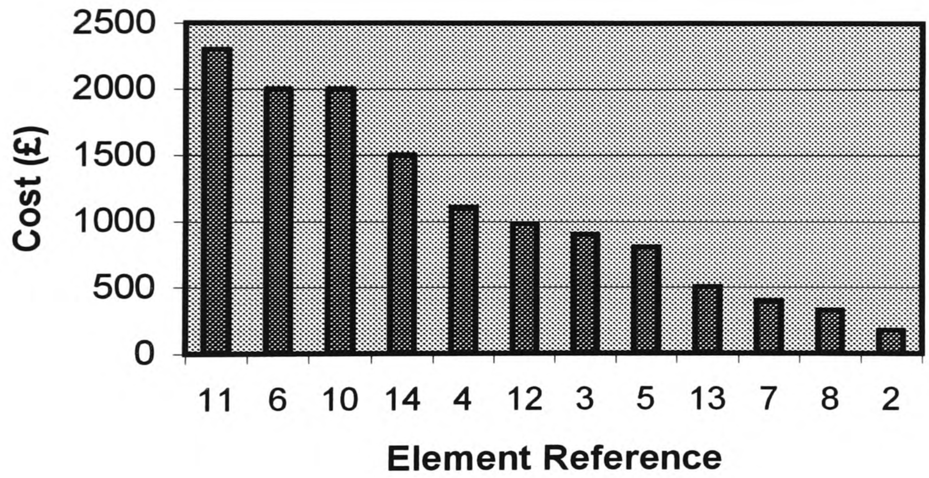


Figure 6.1 – O.E Wiper Blade Assembly – Cost of Conformance Pareto Chart

Table 6.2 - Cost of Conformance Elements for the O.E Wiper Blade Assembly Cost Report.

No.	Description	No.	Description
1	Assembly, Inspection and Test	8	Downtime due to Projects
2	Downtime due to Meetings, Training	9	Material Costs
3	Downtime due to Changeovers	10	Floor space, Facilities etc.
4	Downtime due to Machines Setting	11	Linefeeders
5	Downtime due to Non Measured Work	12	Team Leader
6	Downtime due to Breaks	13	Supervision
7	Downtime due to New Starters	14	Cost of Equipment Depreciation

It was decided to omit the two largest cost elements, as they would adversely affect the scale of the graph. The two categories, material costs, item 9, and assembly, inspection and packing, item 1, were not deemed a key area for improvement at this time.

'Change overs', item 3, and 'setting', item 4, represented two of the significant reasons for downtime in the cost of conformance category. 'Change overs' and 'setting' involves the modification of the cell to accept the new components and also the production of the first off samples to verify the production set-up by carrying out key measurements on the wiper blade assembly. While the technician is adjusting the equipment the three operators have nothing to do. The average time for a cell change over is twenty minutes.

It was decided to tackle the problem in two ways;

a) Establish an extra production cell that the cell team could transfer directly on to it after they had finished production of the current part number. The cell would already be set up for the next production run by the technicians. This would eliminate the time lost due to changeovers.

b) Train the operators to set the production cells themselves and share the tasks of adjusting the fixtures and measuring the first off samples. This would reduce the time lost due to setting.

'Non standard work', item 5, needs to be investigated further. Non standard work is a 'catch all' category, which because it is a significant cost needs to be broken down further to understand its component parts.

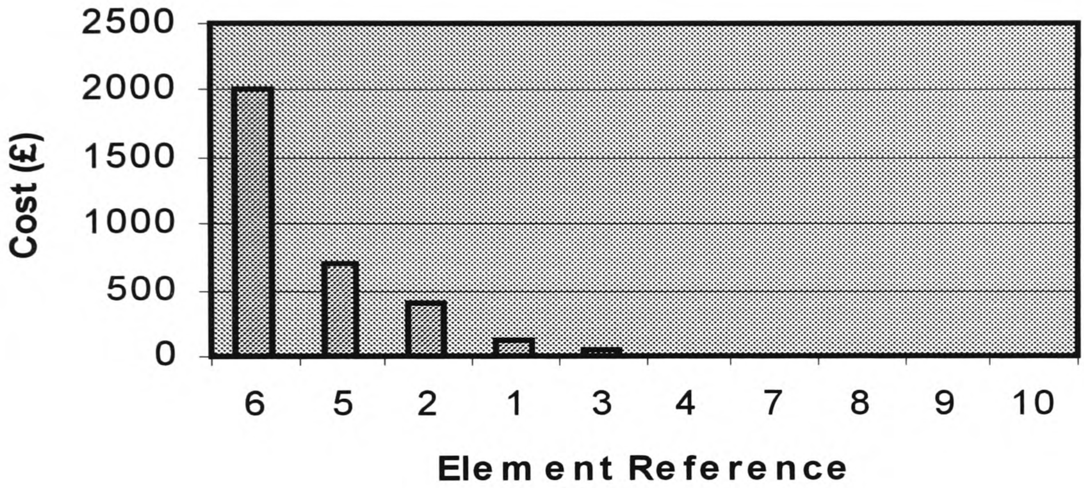


Figure 6.2 – O.E Wiper Blade Assembly – Cost of Non-Conformance Pareto Chart

Table 6.3 – Costs of Non-Conformance for the O.E Wiper Blades Assembly section

No.	Description	No.	Description
1	Rework	4	Downtime due to Repacking
2	Downtime due to Awaiting Material	5	Downtime due to Machine Fault
3	Downtime due to Faulty Material	6	Scrap Cost

'Scrap', item 6, is already the subject of an improvement exercise by the Blade Assembly department and therefore it was decided to leave this element out of the improvement action list.

'Machine faults' were chosen as the key non-conformance cost to be investigated further. A separate team was established to gather data on the problem and to define improvement activities. The team included production engineers and cell operators.

2. Personnel Department Study

Data Collection

The Personnel department team's experience was quite different. With one or two exceptions all the data required to complete the report had to be gathered using local cost capture mechanisms. An activity report was developed for this purpose (refer to Appendix C).

The activity reports were not popular with the team as it meant trying to apportion working time to each category, which at the end of a busy day proved to be quite a task. There were instances where the reports were not completed for several days making the data potentially unreliable. The team decided however that the data, although not strictly accurate, would represent an order of magnitude for the activities. This would still allow the team to prioritise improvement opportunities.

One improvement was made to the data collection early on in the data collection phase. Because of the problems with the activity report the team changed the way in which the cost of administrating the exception reports on the time and attendance system was calculated. The time taken to administrate one exception report for an individual was established and then used to calculate the overall cost by multiplying the individual cost by the number of exception reports listed. This synthetic cost would be more consistent than the rough estimate of the time taken to complete the task. The cost would now be proportional to the number of exception reports raised and would be repeatable month to month.

The use of the activity report, where estimated time spent carrying out an activity is recorded, would only be used as a last resort where no better method to determine the costs involved was available. The Process Cost Report for the Personnel department is shown in Table 6.4.

Table 6.4 – Personnel Department Process Cost Report

Personnel Department Process Cost Report								
Process Conformance	Cost			Process Nonconformance	Cost			Cost Data Source
	Act	Syn	£		Act	Syn	£	
Training plan admin		√	200					Activity Report
Training costs	√		8000					Finance
				Non attendance at company specific training courses	√		250	Training cost x % absent
				Training course cancellation	√		400	Training cost
Induction training		√	100					Activity Report
Time and Attendance admin		√	100					Activity Report
				T&A exception report admin		√	150	No. of instances x 2 minutes x hourly rate
				T&A exception system update		√	200	
Absence request admin		√	100					Finance
Recruitment advertising	√		1500					Finance
Recruitment agency costs	√		1000					Activity Report
				Leaving interviews		√	80	Activity Report
				Accident reporting admin		√	130	Activity Report
Testing fire procedures		√	100					Activity Report
				Fire emergencies		√	0	Activity Report
				Disciplinary meetings		√	90	Activity Report
Routine reports		√	120					Activity Report
Company council meetings		√	60					Activity Report
				Special reports		√	0	Activity Report
Total Process Conformance Costs			11280	Total Process Nonconformance Costs			1300	

There is one issue encountered during the data collection phase, which is worth documenting here. When collecting costs for a false fire alarm, the cost of shutting down the entire factory for twenty minutes as a result of the subsequent drill, was included. This involved the cost of lost time for the 550 employees as well as factory costs (overheads etc.). The cost for the drill was estimated at £2500. However the disruption was also recorded in the labour efficiency downtime used in the production areas under the 'non-standard work' category. An example of the problem of duplicating costs identified by Fox in Chapter 3. (Fox, 1993) It was therefore decided not to include this cost in the Personnel report as the majority of the costs were outside their direct control and would be included in other departmental costs.

This gave rise to another dilemma. The cost of the fire drill to the company was large yet because it was now broken down into individual areas it became diffused and did not appear to require any special attention.

Analysis of Results

The Personnel department's Process Cost Report, Table 6.4, provided a new picture of how the time was allocated to the key activities. In the existing quality cost report only the cost of training was included in the monthly report. Other data, such as absence, late clock-ins and accident reports, were presented in the monthly key statistics data but was not represented as cost data but rather as number of occurrences.

Pareto charts were constructed to represent the Cost Data. Figure 6.3 illustrates the Personnel department's conformance costs and Figure 6.4 illustrates the costs of non-conformance.

The cost elements for both figures are identified in Table 6.5 and Table 6.6 respectively.

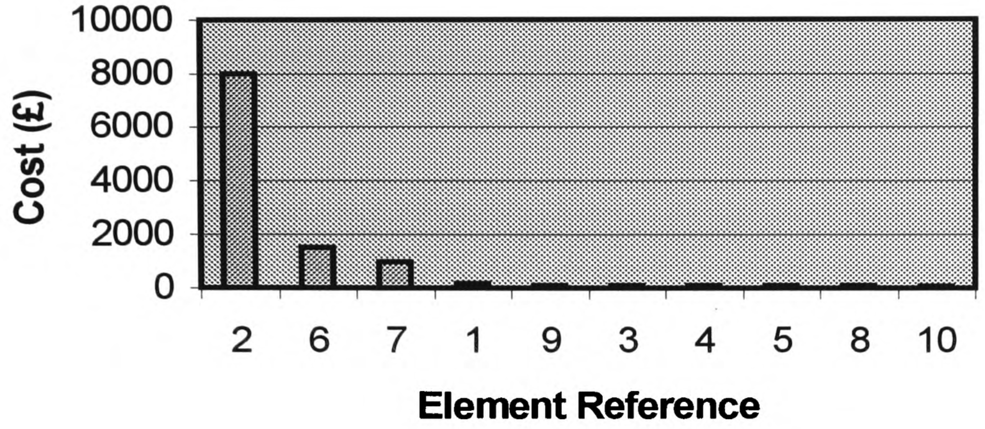


Figure 6.3 – Personnel Department's Costs of Conformance

Table 6.5 – Personnel Department Cost of Conformance Elements

No.	Description	No.	Description
1	Training Plan Administration	6	Recruitment Advertising
2	Training Costs	7	Recruitment Agency Costs
3	Induction Training	8	Testing Fire Alarm System
4	Time and Attendance Administration	9	Routine Reports
5	Absence Request Administration	10	Company Council Meetings

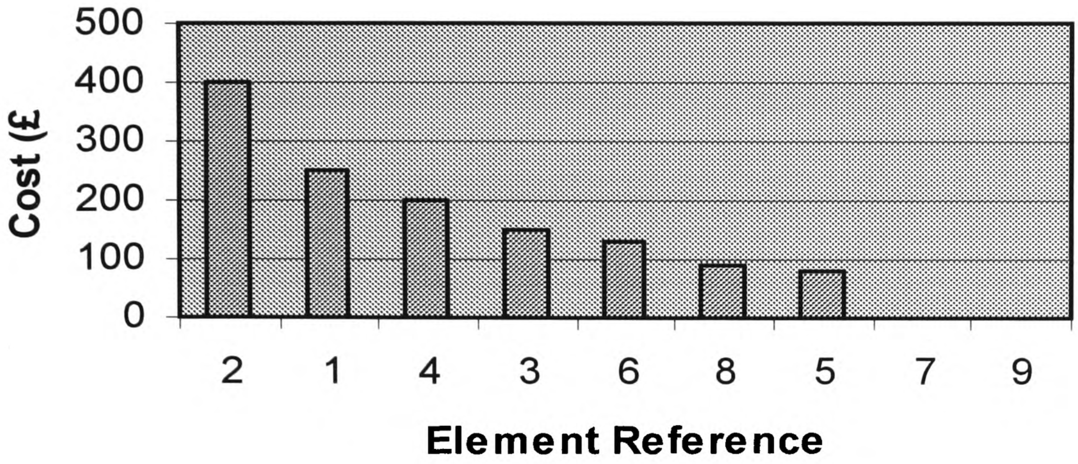


Figure 6.4 – The Personnel Department's Costs of Non-Conformance

Table 6.6 – The Personnel Department's Cost of Non Conformance Elements

No.	Description	No.	Description
1	Non Attendance at Company Specific Training Courses	6	Accident Reporting Administration
2	Training Course Cancellations	7	Fire Emergencies, False Alarms
3	Time & Attendance Exception Report Administration	8	Disciplinary Meetings
4	Time & Attendance Exception Report System Update	9	Special Reports
5	Leaving Interviews		

Improvement Actions

Two key areas in the Process Cost Report were selection for improvement. These were;

a) Non attendance at company specific training courses (Figure 6.4 – item 1)

b) Number of non-clockings by employees (Figure 6.4 – items 3 & 4)

These issues were investigated to try to understand the causes of the problems.

Attendance at company specific training courses was approximately 75-85% during 1997. This meant that some courses had to be run again because key staff did not attend. All those who had not attended company specific training courses during 1997 were interviewed to establish the main reasons. The results are shown in Table 6.7.

Table 6.7 – Reasons for non-attendance at company specific training courses

Reason	%
Problem in Department	44
Illness	7
Not Informed of Details by Supervisor	28
Forgot	5
Other	16

It appeared from the responses that 44% of those not attending had become involved with work related issues while waiting for the course to start. These employees had been requested by their supervisors or managers to see the problem through to its conclusion and therefore missed the course.

The other major cause appeared to be the lack of communication between the supervisor and employee regarding the arrangements for the course.

To remedy these concerns it was decided to investigate the cost of running training courses off-site to prevent distractions to those attending. Also a system would be introduced where each employee required to attend a course would receive an individual memo from the Personnel department with the details of the training course.

'Non-clockings' were also investigated, as this was a major cause of the exception reports raised. From interviews with employees who had failed to clock-in it was clearly established that the main reason was that they had simply forgotten their cards. They then had to complete a 'forgotten/lost clock card' form and submit it to their supervisor for approval before it was finally sent to the Personnel department to update the time and attendance system.

It was decided to produce duplicate clock cards for all employees that would be held by the supervisors in each area. If anyone forgot or lost their card then they could get their duplicate from the Supervisor until a replacement was issued. This alone reduced the number of instances of non clock-ins by over 70% in the first month of introduction.

Pilot Study Comparison

Table 6.8 shows how the two pilot study 'Costs of Non-Conformance' results compare to the existing Failure Costs in the P-A-F quality cost report. Comparing Cost of Conformance to Prevention and Appraisal costs was felt to be unfair as the Cost of Conformance also includes 'normal work' activities not included in prevention and appraisal categories.

Table 6.8 – Pilot Study Comparison – Non-Conformance Costs

	Existing Monthly Average – P-A-F	Process Cost Monthly Average	Increase
O.E Wiper Blade Assembly	3,400	7,800	4,400
Personnel	0	4,250	4,250

It can be seen that there is a significant increase in the nonconformance costs of both areas compared to the currently reported costs within the P-A-F model. This would appear to confirm that the use of the Process Cost Model will increase the overall Cost of Quality figures reported by companies using the P-A-F model.

CHAPTER SEVEN – CONCLUSION & RECOMMENDATIONS

General

It can be seen from this research into Quality Costing that it is by no means an exact science.

Using the Prevention-Appraisal-Failure Model, difficulties arise in the classification of what constitutes quality costs. This tends to result in a distinctive set of criteria for each company. Accounting practices further complicate these measures to make them unique.

Table 7.1 compares seven sources of Quality Cost Classifications.

Table 7.1 - Comparison of Quality Cost Elements

	Number of Elements				
Source	**Prevention**	**Appraisal**	**Int. Failure**	**Ext. Failure**	**Total**
Juran (1990)	7	5	6	4	22
Feigenbaum (1983)	7	13	4	5	29
Campanella (1990)	32	25	26	10	93
Oakland (1993)	6	4	6	6	22
BS6143 (1990)	10	11	8	7	36
Asher (1993)	13	5	16		34
Dwyer (1970)	10	5	8		23

Although this comparison may not be wholly accurate, as some of the definitions presented are vague and open to interpretation on what sub-elements it may contain. This also contributes to potential ambiguities with cost classification.

Thus it can be seen that benchmarking of quality cost data is dangerous and should be treated with great caution.

Another issue raised by this research is the often-quoted figure of Quality Costs as a percentage of Net Sales. All literature since the late 1950's refers to quality costs in the region of 4 - 40 % of sales (refer to Table 7.2).

On the face of it these figures suggest that there has been no real improvement in the past forty years regarding Quality Costs as a percentage of sales. Alternatively it may reflect the changing nature of what we term to be Quality Costs i.e. The TQM approach which includes all business processes has now increased the scope of the Quality Costing elements.

Table 7.2 - Quoted Cost of Quality figures as a % of sales

Data Source	Date	Quoted %
British Productivity Council	1957	4 - 14
Dobbins	1976	5 - 15
Crosby in manufacturing companies	1984	20 +
Crosby in Service companies	1984	35 +
Campanella & Corcoran	1983	15 – 20
Peters in manufacturing companies	1990	25%
Peters in service industries	1990	40%
Oakland	1993	10 – 15
Dale & Plunkett	1995	5 - 25

These figures are well known by senior management and are often quoted when discussing the potential magnitude of Quality Costs. This may have one of two reactions within a company implementing a quality cost system.

1. If the % of sales figure is less than, say, 10% management may be satisfied that they do not have a significant problem and not support the initiative in favour of other priorities
2. The Quality & Accounting personnel may concentrate on capturing other hidden costs in the belief that they need to get the figures to be close to 15 - 20%.

The most commonly used measure of Quality Cost data appears to be Total Quality Cost as a percentage of Total Sales. This may also exaggerate the actual scale of the problem of comparisons as different industries will have different profit margins that can distort the final Quality Cost percentage. (Not that comparisons are recommended between different companies).

The prime purpose of a Quality Costing system should be as an internal driver for cost improvement. It is a method that a company can use to identify costs associated with the quality of the product and service not otherwise highlighted in the management reporting system.

This data should then be used as one of the continuous improvement measures as part of an overall TQM philosophy. In this context the traditional P-A-F model is limited, focussing as it does on manufacturing classifications. The use of the Process Cost Model will allow the Quality Costing activity to widen its scope to the whole business.

Process Cost Model

The pilot studies have shown that the Process Cost Model is capable of establishing a very detailed cost analysis of the function / process under investigation. It's approach is very much in line with a Total Quality Management philosophy as it identifies any cost associated with 'not doing the job right first time'. This extends the typical quality costing elements to include health, safety and environmental non conformance costs.

The model represents the total cost of the key activities identified by the process owner. In this way it is a useful mechanism to measure the effectiveness of the management of the process and/or department. It encourages ownership of the process and promotes understanding of the key costs issues by the process participants.

It is true that the Process Cost Model requires a detailed understanding of both Quality Costing concepts and Process Modelling. Most people are familiar with the traditional Prevention – Appraisal – Failure model used in a wide variety of industries and taught within the many academic courses.

At first the Process Model appears to be a more complicated approach and requires careful introduction. Team members responsible for the introduction of this technique need to be trained in the concept and early meetings need careful facilitation by a quality-costing specialist.

In a production environment where there has been a history of continuous improvement philosophy the advantages of the Process Cost Model are limited. In Trico's experience with the model it provided nothing significant in the way of new data. This is likely to be a similar finding in other automotive manufacturing environments where the pressure to reduce costs and the customer's focus on process and product improvement has meant that these companies have developed detailed cost reports.

BS6143 Part 1 1992 provided the basis of the pilot studies as this is the main reference on the subject. The standard, although clearly written, does not explain the process in sufficient detail to logically develop the model. Some assumptions had to be made. In particular some team members expressed doubt regarding the link between developing the Process Model and the Cost Model. It was suggested that a process owner who had a detailed knowledge of the process could develop an effective Cost Model without first developing a Process Model. Indeed it was suggested that the development of the Process Model was the most difficult part and by deleting it would reduce the amount of training required and the time to implement the Cost Model.

It was noted however that the effectiveness of the Cost Model depended upon input from other functions such as Quality and Finance and that their knowledge of the process was positively enhanced through the development of the Process Model. It also allows the scope of the study to be clearly defined.

Implementing the model in non-manufacturing areas will prove to be the most difficult issue to overcome. The majority of the costs required will not be part of the current financial data available, unlike production costs. This will inevitably mean that local cost capture will be required. Where possible these costs will be based upon synthetic data e.g. No. of instances x time taken to complete task x hourly rate.

The use of guessed estimates should be actively discouraged, as these can not only be inaccurate but will also prevent reliable trend data being produced.

The capture of local cost data will undoubtedly cause a negative reaction in some departments. It may be seen as an unnecessary burden to spend valuable man-hours recording the time spent on key activities for the sake the quality cost report. Clearly the effort and cost of data collection must be perceived to be worth while.

For this reason when using the Process Cost Model the team must identify the key activities for monitoring, where there is a need for cost control or cost improvement. It is important to note that the key activities identified in the Cost Model are not necessarily 'all activities'.

Process Cost Reports contain a lot of detail about the cost of conformance and cost of non-conformance. This is useful for the process owner and represents the process costs clearly and is easy to analyse. However it is difficult to summarise as a company overview because of the amount of detail.

It is therefore necessary to establish a quite different type of cost report to that suggested by BS6143 Part 1: 1992 or the traditional P-A-F report illustrated by BS6143 Part 2: 1990

One suggested method is defined in Appendix D. The summary report identifies each department or process providing cost data. The report includes the cost of conformance and non-conformance for each and compares this cost against the targeted cost. The data is shown for the current calendar month as well as the year to date.

It is important to note that improvement actions can, and should be, developed for the conformance costs as well as those of non-conformance.

The Pilot Study produced the following recommendations based upon the experience of implementing the Process Cost Model.

Recommendations

1. Establish a cross-functional team to implement the Process Cost Model.

The team must include the process owner, along with process specialists such as the operators and/or technicians. These will be responsible for the identification of the key activities and for developing the detailed Process Model.

The Management Accountant will be required to help establish the source of the cost data and to provide advise on defining new data capture methods. The Quality specialist will need to provide assistance on the quality costing process, facilitate the implementation process and provide support for the improvement initiatives.

Team members should be trained in quality costing techniques.

2. The process owner should be the person closest to the process under review.

They must have the authority over the key activities included within the Cost Model and be able to influence the process performance.

3. The Scope

The scope of the study must be within the control of the process owner. Costs, which are experienced by other, support functions, should be ignored.

Focus on 'key activities' or 'costs' and do not endeavour to include all costs, as the effort needed to collect small costs will not be efficient.

4. Avoid guessed data wherever possible.

It will often prove difficult to find a robust measurement method for activities involving people's time, especially in non-manufacturing areas. Where this is the only method examine the scale of the cost to determine whether or not it is worth recording. If not leave it out.

It will be more reliable to establish synthetic cost data where actual cost data is not available.

5. Conduct a trial.

After setting up the Process Cost Report conduct a trial for 3 months to ensure that no obvious costs have been omitted and that the method of data collection is robust and will be consistent. Once proven, report the findings to management along with a priority listing of improvement actions.

6. Publish Results

The results of the Process Cost Report should be made available to those involved with the process as well as management. Discussion of the main issues and improvement areas with the process members will encourage involvement in the improvement process and promote ownership of the costs.

7. Share experience

In order to extend the use of the Process Cost Model within the company use the experience of team members who have successfully implemented it in their areas to train and coach other departments and process owners.

For many companies the idea of creating a quality costing process, which relies on the combination of established financial data and new local cost collection mechanisms, will not be viewed favourably. This will be especially true for companies who do not perceive that they have a significant quality costing issue not already identified using their existing P-A-F reporting process.

For those companies who are giving responsibility to the lower management levels, such as manufacturing cells, then the Process Cost Model is an ideal method of tracking quality performance and for prioritising improvement actions.

Trico Limited will continue to develop the Process Cost Model within all functions with the aim of using the information gathered as a key measure of business performance. As it is likely to take a couple of years to implement effectively, the traditional P-A-F model described in Chapter Four will remain in place to ensure consistency of the quality cost reporting.

REFERENCES

AIAG, Quality System Requirements – QS-9000, second edition, AIAG, 1995

Asher, M & Kanji G. K, Total Quality Management Process, Carfax Publishing, 1993

BS4778: Part 2, Quality Vocabulary, British Standards Institute, 1991

BS6143, Guide to the Determination of Quality Costs, British Standards Institute, 1981

BS6143 Part 2, Guide to the Economics of Quality Part 2: Prevention, Appraisal and Failure Model, British Standards Institute, 1990

BS6143 Part 1, Guide to the Economics of Quality Part 1: Process Cost Model, British Standards Institute, 1992

BS7850, Total Quality Management, British Standards Institute, 1992

Campanella, J & Corcoran, F., Principles of Quality Costs, Quality Progress, 1983

Campanella, J., Principles of Quality Costs, ASQC Quality Press, 1990

Crosby, P., Quality is Free, McGraw Hill, 1979

Crosby, P., Quality Without Tears, McGraw Hill, 1984

Crosby, P., Let's Talk Quality, McGraw Hill, 1989

Daisley, P. A, Dale, B.G & Plunkett, J.J, Quality Costing in the UK, European Organisation for Quality Control Annual Conference Proceedings, 1984

Dale, B.G & Plunkett, J.J, Quality Costing, Chapman & Hall, 1995

Dale, B.G & Plunkett, J.J, The Case for Costing Quality, Department of Trade and Industry, 1990

Deming, W. Edwards, Out of the Crisis, Cambridge Press, 1982

Dobbins, R.K, Extending effectiveness of quality cost programs, Annual Technical Conference Transactions, American Society for Quality Control, 1978

Drew, H.E, Quality – Its Origin and Progress in Defense Procurement, The Quality Engineer, January 1972

Dwyer, M. J, Cost Effective Quality, Annual Technical Conference Proceedings, American Society for Quality Control, 1970

Europe's Automotive Components Business, 1st Quarter 1996, The Economic Intelligence Unit Limited, 1996

European Business Excellence Model, European Foundation for Quality Management, 1995

Feigenbaum, A.V, Total Quality Control, McGraw Hill, 1986

Fox, M. J, Quality Assurance Management, Chappel and Hall, 1993

Grant E.L & Leavenworth R.S, Statistical Quality Control, McGraw Hill, 1988

Hilary, R., Quality Progress, January 1996

Hutchins, D., History of Quality Assurance in the U.K, ASQC Press, 1995

Imai, M., Kaizen, McGraw Hill, 1986

ISO9000, 9001, 9002, 9003, 9004 Series on Quality Systems, International Standards Organisation, 1994

Juran, J.M, Quality Control Handbook, McGraw Hill, 1951

Juran, J.M, Quality Planning and Analysis, Tata McGraw Hill, 1990

Juran, J.M, A History of Managing for Quality, ASQC Quality Press, 1995

Juran, J.M, Leadership for Quality, McGraw Hill, 1992

Lightstone, M et al, ASQC Quality Press, 1993

MIL-Q-9858A, Quality Program Requirements, U.S. Department of Defense, 1963

MIL-Q-STD-1520B, Corrective Action and Disposition System for Nonconforming Material, U.S. Department of Defense, 1980

Naguchi, J., The Legacy of W. Edwards Deming, Quality Progress, December 1995

Nissan Quality Standard for Suppliers – Quality System Requirements, Nissan Motor Manufacturing (UK) Ltd, 1992

Oakland, J. S, Total Quality Management, Butterworth & Heinemann, 1993

Peoples Century 1900 – 1999, 'Mass Production', BBC Productions, 1995

Peters, Tom, Video, The Tom Peters Experience, A speech delivered to CEO's in London, Video Cassette, BBC Training and Education Video, 1991

Riggs, I, QS-9000, Castings Development Conference Proceedings, 1997

Schneiderman, A.M., Optimum Quality Costs and Zero Defects, Quality Progress, November 1986

Shingo, Shigeo, Zero Quality Control, 1985

Silverman & Propst, Quality Progress, July 1996

Total Quality Improvement – A Suppliers Guide, Rover Group, 1991

Webb, N. B., Auditing Meat Processing Quality Control Costs, Quality Progress, February 1972

Womack, James P., Jones, Daniel T. & Roos, Daniel, The Machine that Changed the World, Rawson Associates, 1990

BIBLIOGRAPHY

Agnone, A.M., C.C. Brewer, and R.V. Caine., "Quality Cost Measurement and Control.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1973.

Akerlung, O.O., et al., "Money - 1 : A Measure of Value.", Quality Progress 8, No. 9, 1975

Albrecht, Glenn R., "Scrap Cost Analysis in a Mass Production Industry.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1967.

Alford, "Quality Cost - Where to Start? Part I.", Quality 18, No.8, 1979

Alford, "Quality Costs - Where to Start? Part II.", Quality 18, No.9, 1979

Alford, "Quality Costs - Where to Start? Part III.", Quality 18, No.10, 1979

ASQC Aircraft-Missile Division, "Quality Cost Analysis Implementation Handbook.", Milwaukee: ASQC Quality Press, 1964.

ASQC Quality Costs Committee. W.O. Winchell, editor, "Guide for Managing Supplier Quality Costs.", Milwaukee: ASQC Quality Press, 1986.

ASQC Quality Costs Committee. W.O. Winchell, editor, "Guide for Reducing Quality Costs.", Milwaukee: ASQC Quality Press, 1986.

Armstrong, Francis, "Reliability and Cost as Factors in Standards Enforcement.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1972.

Aubrey, Charles A., II, and Debra A. Zimbler, "A Banking Quality Cost Model, Its Uses and Results.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1982.

Aubrey, Charles A., II, and Debra A. Zimbler, "The Banking Industry: Quality Costs and Improvement.", Quality Progress 16, No12, 1983

Aubrey, Charles A., II, and Debra A. Zimbler, "Quality + or - Quality Costs Equals Productivity.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1983.

Baker, W.R., "The impact of Quality Cost.", Quality Progress 2, No.11, 1969

Ball, A.M., "Quality Cost and Management.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1967.

Barker, E.M., "Counting Costs: Another Approach to Supplier Ratings.", Quality Progress 17, No.11, 1984

Baugher, John, "Profitable Quality Control.", Production, No.10, 1968

Bayer, Harmon S., "Quality Control Programs Should Be Cost Reduction Programs.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1960.

Bhuyan, Samar K., "Cost of Quality as a Customer Perception.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1960.

Bicking, Charles A., "Cost and Value Aspects of Quality Control.", Industrial Quality Control 24, No.12 , 1967

Blanchard, Ben S., "Cost Effectiveness Analysis - A Case Study Approach.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1969.

Blank, L. and Solorzano, J., "Using Quality Costs Analysis for Management Improvement.", Industrial Engineering 10, No. 2, 1978

Boerckel, Albert., "The Formula for Survival - Optimum Quality at Optimum Cost.", Paper presented at annual Reliability and Maintainability Symposium, 1973.

Booth, B., "Charge Back-Accountability Systems Reduce Quality Costs to 2.1% of Annual Sales.", Quality Progress, No.4,1971

Boudrealt, Authur, L., "Quality Control, A Savings Centre.", Quality 16, No 10, 1977

Breeze, J.D and J.R.Farrell.,"Quality Costs Can Be Sold - Part II.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1981.

Brewer, C.W., "Quality Costs - View and Preview.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1980.

Brewer, C.W., "Zero Based Profit Assurance.", Quality Progress 11, No.1, 1978

Brisac, A., G.Oistrach, and O.Yanez., "Quality Cost Data in Three Spanish Automotive Companies.", Quality 10, No.4, 1971

Brown, F.X., "How to Win Friends and Influence Profits.", In Annual Quality Congress Transactions. Milwaukee: American Society For Quality Control, 1981.

Brown, F.X. and R.W. Kane., "Quality Cost and Profit Performance.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1978.

Burchfield, P.B. and P.A. Thorton., "Quality Costing Procedures Reduce Cable Losses.", Wire Technology 3, No.1, 1982

Burns, V.P., "Warranty Prediction: Putting a £ on Poor Quality.", Quality Progress 3, No.12, 1970

Cabral, W.O., "Quality Cost Myopia.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1983.

Calahan, C.C., "Reporting Analysis and Control of Costs in a Multifactory Company.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1966.

Campanella, Jack., "The Fairchild Republic Company Quality Cost Program.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1979.

Campanella, Jack., "Quality Costs: Principles and Implementation.", Paper presented at Annual Rocky Mountain Quality Conference, 1987.

Campanella, Jack., "A Simplified Approach to the Use of Costs Related to Quality.", Paper presented at All Day Conference, Long Island Section, 1975.

Cerosimo, R.R., "Honeywell's Cost Effective Defect Control Through Quality Information Systems.", In Annual Technical Conference Transactions. Milwaukee: American Society for Quality Control, 1972.

Condon, J.E., J.L. Kidwell, and O.O.Akerlund., "Quality Cost Panel.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1975.

Corcoran, Frank J., "Quality Costs Principles - A Preview.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1980.

Cound, D.M., "Quality System Analysis - Key to Recurring Cost Reduction.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1965.

Cox, B., "The role of the management accountant in quality costing.", Quality Assurance, 1982

Crosby, P., "Cost of Quality - Elements by Discipline.", The Quality College. October, 1982.

Crosby, P., " Cutting the Cost of Quality.", Quality, No.8, 1978

Crosby, P., "Don't Be Defensive About the Cost of Quality.", Quality Progress 16, No.4, 1983

Crosby, P., " The Quality Man. (video)", BBC Education and Training, 1985

Dale, B.G., Boaden, R.J and Lasceles, D.M, "Total Quality Management: An overview.", (ed. B.G Dale), Prentice Hall, 1994

Dale, B.G and Plunkett, J.J, "Quality-related costing: findings from an industry based research study.", Engineering Management International, 1988

Dawes, E.W., "Is your Quality Cost Dollar Really Effective?", Paper presented at 27th Northeast Conference, 1973.

Dawes, E.W., "Optimising Attribute Sampling Costs - A Case Study.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1973.

Dawes, E.W., "Quality Costs - A Place on the Shop Floor.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1976.

Dawes, E.W., "Quality Costs - A Tool for Improving Profits.", Quality Progress 8, No.10, 1975

Dawes, E.W., "Reducing Appraisal Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1983.

Dauton, J.D., "Fine Tuning Inspection for Minimum Costs.", Quality 16, No.11, 1977

Dean, T.J., "A Successful Quality Cost Program.", Paper presented at 28th Northeast Conference, 1974.

de Ferrara, Ing. Allessandro Codeca., "Inspection and Quality Costs.", Proceedings VII EOQC Conference, 1982.

Demetriou, J., "Cost of Quality System - A Management Tool.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1983.

Demetriou, J., "Quality Costs - Pay.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1982.

Dobbins, R.K., "Cost Effectiveness of Corrective Action.", Paper presented at Philadelphia Section Annual Symposium, 1972.

Dobbins, R.K and Brown, F.X, "Quality Cost Analysis: QA versus accounting.", Quality Forum (17), 1991

Dobbins, R.K and Brown, F.X, "Extending Effectiveness of Quality Cost Programs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1978.

Dobbins, R.K and Brown, F.X, "Quality Cost Trend Analysis and Corrective Action.", Paper presented at 26th Annual Conference on QC and Statistics in Industry, 1974.

Dobbins, R.K and Brown, F.X, "Quality Costs - A Place for Decision Making and Corrective Action.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1976.

Ekvall, D.N., "Measuring the Profitability of QC Effectiveness.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1972.

Elgabry, A.C., "Integrated Quality Control Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1976.

Enters, J.H., "Design and Quality Costs, Quality of Design and Design of Quality.", Proceedings VII EOQC Conference, 1989.

Esterby, L.J., "Measuring Quality Costs by Work Sampling.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1982

Esterby, L.J., "Quality Cost Analysis: A Productivity Measure.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1981.

Filer, J.M., "Quality Cost Reporting.", Paper presented at 23rd Western Regional Conference, 1987.

Filer, R.J. and L.R. Eiswerth, "Quality Control and Associated Costs.", Management Accounting 48, 1966

Fox, M.J, "The Great Economic Quality Hoax.", Quality Assurance (15), 1989

Freeman, H.L., "How to put Quality Costs to Work.", Paper presented at 12th Metropolitan Section All Day Conference, 1960.

Fruehwirth, M.Z., "PSQL - An Economic Criterion for Minimising Overall Inspection and Repair Cost.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1974.

Funk, B.I., "Costs of Reliability.", Industrial Quality Control 17, No.9, 1960

Georgis, G.S., "How Much Does Poor Quality Cost.", Management Review 62, No.5, 1973

Gilmore, H., "Consumer Product QC Cost Revisited.", Quality Progress 16, No.4, 1983

Goeller, W.D., "The Cost of Software Quality Assurance.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1981.

Goeller, W.D., "On the Road to Quality Savings.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1985.

Goetz, V.J., "Developing a Cost Effectiveness Program - How to Start.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1979.

Gonet, J.J., "Improving the Management of Quality Cost.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1968.

Grau, D., "Quality is Inexpensive if a Way of Life.", Quality Progress 5, No.2, 1972

Grenier, R., "Recover Those Defective Material Costs.", Quality Management and Engineering, No.2, 1975

Groocock, J.M, "Quality Cost control at ITT Europe.", Quality Assurance (6), 1980

Groocock, J.M, "ITT Europe's quality cost improvement programe.", Quality Assurance, 1975

Gryna, F.M., "Quality Costs - User vs Manufacturer.", Quality Progress 10, No 6, 1977

Gryna, F.M., "Quality Costs - What Does Management Expect?", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1978.

Gryna, F.M., "User Quality Costs.", Quality Progress 5, No.11, 1972

Gunneson, A.O., "How to Effectively Implement a Quality Cost System.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1981.

Hagen, J.T., "After the Commitment, Then What?", In Annual Quality Congress. Milwaukee: American Society for Quality Control, 1981.

Hagen, J.T., "Quality Costs - Detailed Definitions.", Paper presented at Akron/Canton Fall Workshop, 1976.

Hagen, J.T., "Quality Costs II.", In Annual Quality Congress. Milwaukee: American Society for Quality Control, 1985.

Hagen, J.T., "Quality Costs at Work.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1973.

Harrington, H.J., "Poor Quality Costs", Milwaukee: ASQC Quality Press, 1986.

Harrington, H.J., "Quality Costs - A Key to Productivity.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1981.

Harrington, H.J., "Quality Costs - The Whole and its Parts.", Quality 15, No. 5, 1976

Hoekstra, C.D., "Quality Costs as a Basis for Efficient Quality Control.", Paper presented at ASQC 10th Western Regional Conference, 1963.

Holguin, R., "Do You Know What Cost Reductions Can Do For You?", Quality Progress 1, No.1, 1968

Ireson, W.G., "The Control and Optimisation of Quality Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1965.

Harrington, H.J., "Use of Quality Cost Information in Planning and Managing Quality Assurance Programs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1967.

Jones, H.C., "Selecting Consumer's Risk to Minimise Cost.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1966.

Judelson, P.J., "Estimating Quality Control Engineering Costs for Proposals.", Industrial Quality Control 24, No. 11, 1967

Juran, J.M., "The Quality Profit Relationship.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1976.

Juran, J.M., "Whose Quality Costs.", Industrial Quality Control 22, No.8 , 1965

Kahn, H.R., "Quality Costs = Critical Factor in the Reliability Business.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1967.

Kennedy, W.J., "A Cost Determined Quality Control Plan for Adjustable Processes.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1970.

Kivendo, K., "Quality Costs - A Place for the Quality Control Organisation.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1976.

Kofoed, C.A., "Applied Methods and Techniques for Control of Quality Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1966.

Koga, Y., "Activities for Reduction of User's Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1970.

Kolacek, O.G., "Quality Costs - A Place for Financial Impact.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1976.

Kroeger, R.C., "Quality Costs - A New Perspective.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1979.

Lascelles, D.M and Dale, B.G, "Quality Management: The Chief Executives perception and role", European Management Journal, 1990

Latzko, W.J., "Minimising the Cost of Inspection.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1982.

Latzko, W.J., "Reducing Clerical Quality Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1974.

Lesser, W.H., "Cost of Quality.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1953.

Liebman, M.E., "A Management Quality Cost Reporting System.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1969.

Mandel, B.J., "Quality Costing Systems.", Quality Progress 5, No. 12, 1972

Masser, W.J., "The Quality Manager and Quality Costs.", Industrial Quality Control 14, 1957

Mayben, J.E., "Assurance of Availability and Life Cycle Costs.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1982.

Mayben, J.E., "Computer Isolation of Significant Quality Costs.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1981.

Moore, W.N., "The Philosophy and Usefulness of Quality Costs." In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1978.

Moore, W.N., "Reducing Quality Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1972.

Morse, W.J., "Measuring Quality Costs", Cost and Management July/August, 1983

Morse, W.J., Roth, H.P and Poston, K.M, "Measuring, Planning and Controlling Quality Costs", Institute of Management Accountants/ASQC Quality Press, 1987

Moseley, R.Z., "Component Failure Cost.", Quality Progress 13, No.1, 1980

Mottley, H.E., "Quality Costs in Taiwan.", Quality Progress 5, No.10, 1972

Mundel, A., "Quality Cost Breakthroughs in US Production.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1983.

Murthy, V., "Quality Costs - A Management Tool.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1962.

Nambo, H., "Quality Cost System in Nippon Kayaku Co.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1966.

Nickel, K.W., "Quality Costs - A Method for Rating Vendors.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1962.

Noz, W., B. Redding, and P. Ware., "The Quality Manager's Job: Optimise Costs.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1983.

Oak, A.D., "Cost Approach to SQC Charts.", Quality Progress 7, No.10, 1974

Ortwein, W.J., "Increased Profits Through Company-Wide Commitment.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1985.

Ortwein, W.J., "Study Cost and Improve Productivity.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1982.

Plunkett, J.J and Dale, B.G, "Quality Costs: a critique of some 'econimic cost of quality models", International Journal of Production Research, 1988

Pyzdek, T., "Impact of Quality Cost Reduction on Profits.", Quality Progress 9. No.11, 1976

Rhodes, R.C., "Implementing a Quality Cost System.", Quality Progress 5, No.2, 1972

Rogers, C.B., "Uncovering the Hidden Costs of Defective Material.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1972.

Roth, H.P. and W.J. Morse., "Let's Help Measure and Report Quality Costs.", Management Accounting 65, No 8, 1983

Rozenzweig, G., "Cost of Quality in the Service Industries.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1978.

Rydeski, J.A., "Expose Losses with Quality Costs.", Quality 7 No.5, 1978

Scanlon, F., "Cost Improvement Through Quality Improvement.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1981.

Scanlon, F., "Cost Reduction through Quality Management.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1980.

Shainin, D., P.D. Krensky, and E.W. Dawes., "Can Quality Cost Principles be Applied to Product Liability?", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1989.

Siff, W., "Quality Costs in the Process Industries.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1983.

Sink, S., "Using Quality Costs in Productivity Measurement.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1983.

Sitting, J., "Defining Quality Costs", Proceedings of the 7th EOQC Conference, Copenhagen, 1963

Stenecker, R.G., "Attacking Quality Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1974.

Sullivan, Edward, "Quality Costs: Current Ideas.", Quality Progress 16, No.4, 1983

Sullivan, Edward, and D.A.Owens.,"Catching a Glimpse of Quality Costs Today.", Quality Progress, 16, No.12, 1983

Szymanski, Earl T., "Overcoming Regulatory Constraints in Quality Costs.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1982.

Szmanski, Earl T., "Relationship of Financial Information and Quality Costs.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1984.

Triplett, W.A., "Support System Cost Effectiveness.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1969.

Williams H.D., "Quality Plus Productivity Plus Cost Equals Profit.", Quality Progress 17, No.10, 1984

Williams, R.J., "Guide for Reducing Quality Costs.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1982.

Winchell, William O., "Focusing Quality Costs Using the Basics.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1986.

Winchell, William O., "Guide for Managing Vendor Costs.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1981.

Winchell, William O., "Reducing Failure Costs and Measuring Improvement.", In Annual Quality Congress Transactions. Milwaukee: American Society for Quality Control, 1983.

Winchell, W.O and C.J. Bolton., "Quality Cost Analysis: Extend the Benefits.", Quality Progress 20, No.9, 1987

Zerfras, J.F., "Guide for Reducing Quality Costs.", In Annual Technical Conferences Transactions. Milwaukee: American Society for Quality Control, 1980.

APPENDIX A - ASQC'S PRINCIPLES OF QUALITY COSTS CLASSIFICATION

1.0 PREVENTION COSTS

The costs of all activities specifically designed to prevent poor quality in products or services.

1.1 Marketing/Customer/User

Costs incurred in the accumulation and continued evaluation of customer and user quality needs and perceptions (including feedback on reliability and performance) affecting their satisfaction with the company's product or service.

1.1.1 Marketing Research

The cost of that portion of marketing research devoted to the determination of customer and user quality needs - attributes of the product or service that provide a high degree of satisfaction.

1.1.2 Customer/User Perception Surveys/Clinics

The cost of programs designed to communicate with customer/users for the expressed purpose of determining their perception of product or service quality as delivered and used, from the viewpoint of their expectations and needs relative to competitive offerings.

1.1.3 Contract/Document Review

Costs incurred in the review and evaluation of customer contracts or other documents affecting actual product or service requirements (such as applicable industry standards, government regulations, or customer internal specifications) to determine the company's capability to meet the stated requirements, prior to acceptance of the customer's terms.

1.2 Product/Service/Design Development

Costs incurred to translate customer and user needs into reliable quality standards and requirements and manage the quality of new product or service developments prior to the release of authorised documentation for initial production. These costs are normally planned and budgeted, and are applied to major design changes as well.

1.2.1 Design Quality Progress Reviews

The total cost, included planning, of interim and final design progress reviews, conducted to maximise conformance of product or service design to customer or user needs with regard to function, configuration, reliability, safety, producibility, unit cost, and as applicable, serviceability, interchangeablility, and maintainability. These formal reviews will occur prior to release of design documents for fabrication of prototype units or start of trial production.

1.2.2 Design Support Activities

The total cost of all activities specifically required to provide tangible quality support inputs to the product or service development effort. As applicable, design support activities include design document checking to assure conformance to internal design standards; selection and design qualification of components and/or materials required as an integral part of the end-product or service; risk analyses for the safe use of end - product or service; producibility studies to assure economic production capability; maintainability or serviceability analyses; reliability assurance activities such as failure mode and effects analysis and reliability apportionment; analysis of customer misuse and abuse potential; and preparation of an overall quality management plan.

1.2.3 Product Design Qualification Test

Costs incurred in the planning and conduct of the qualification testing of new products and major changes to existing products. Includes costs for the inspection and test of a sufficient quantity of qualification units under ambient conditions and the extremes of environmental parameters (worst-case condition). Qualification inspections and tests are conducted to verify that all product design requirements have been met or, when failures occur, to clearly identify where redesign efforts are required. Qualification testing is performed on prototype units, pilot runs, or a sample of the initial production run of new products (some sources consider this an appraisal cost).

1.2.4 Service Design

Costs incurred in the qualification or overall process proving of new service offerings and major changes to existing offerings. Involves planning for and performing a pilot or trial run using prototype or first production supplies as required. Includes detailed measurements or observations of each aspect of the service offering under normal and worst conditions, for a sufficient quantity of units or time as applicable, to verify consistent conformance to requirements, or to identify where redesign efforts are required (Some sources consider this an appraisal cost).

1.2.5 Field Trials

The costs of planned observations and evaluation of end-product performance in trial situations - usually done with the co-operation of loyal customers but also includes sales into test markets. At this stage of product or service life a company needs to know much more than "Did it work?" or "Did it sell?" (Some sources consider this an appraisal cost).

1.3 Purchasing Prevention Costs

Costs incurred to assure conformance to requirements of supplier parts, materials, or processes, and to minimise the impact of supplier nonconformances on the quality of delivered products or services. Involves activities prior to and after finalisation of purchase order commitments.

1.3.1 Supplier Reviews

The total cost of surveys to review and evaluate individual supplier's capabilities to meet company quality requirements. Usually conducted by a team of qualified company representatives from affected departments. Can be conducted periodically for long-term associations.

1.3.2 Supplier Rating

The cost of developing and maintaining, as applicable, a system to ascertain each supplier's continued acceptability for future business. This rating system is based on actual supplier performance to establish requirements, periodically analysed, and given a quantitative or qualitative rating.

1.3.3 Purchase Order Tech Data Reviews

The cost for reviews of purchase order technical data (usually by other than purchasing personnel) to assure its ability to clearly and completely communicate accurate technical and quality requirement to suppliers.

1.3.4 Supplier Quality Planning

The total cost of planning for the incoming and source inspections and tests necessary to determine acceptance of supplier products. Includes the preparation of necessary documents and development costs for newly required and test equipment.

1.4 Operations (Manufacturing or Service) Prevention Costs

Costs incurred in assuring the capability and readiness of operations to meet quality standards and requirements; quality control planning for all production activities; and the quality education of operating personnel.

1.4.1 Operations Process Validation

The cost of activities established for the purpose of assuring the capability of new production methods, processes, equipment, machinery, and tools to initially and consistently perform within required limits.

1.4.2 Operations Quality Planning

The total cost for development of necessary product or service inspection, test, and audit procedures; appraisal documentation system; and workmanship or appearance standards to assure the continued achievement of acceptable quality results. Also includes total design and development costs for new or special measurement and control techniques, gauges, and equipment.

1.4.2.1 Design and Development of Quality Measurement and Control Equipment

The cost of test equipment engineers, planners, and designers; gauge engineers; and inspection equipment engineers, planners, and designers.

1.4.3 Operations Support Quality Planning

The total cost of quality control planning for all activities required to provide tangible quality support to the production process. As applicable, these production support activities include, but are not limited to, preparation of specifications and the construction or purchase of new production equipment; preparation of operator instructions; scheduling and control plans for production supplies; laboratory analysis support; data processing support; and clerical support.

1.4.4 Operator Quality Education

Costs incurred in the development and conduct of formal operator training programs for the expressed purpose of preventing errors - programs that emphasise the value of quality and the role that each operator plays in its achievement. This includes operator training programs in subjects like statistical quality control, process control, quality circles, problem-solving techniques, etc. This item is not intended to include any portion of basic apprentice or skill training necessary to be qualified for an individual assignment within a company.

1.4.5 Operator SPC/Process Control

Costs incurred for education to implement program.

1.5 <u>Quality Administration</u>

Costs incurred in the overall administration of the quality management function.

1.5.1 Administrative Salaries

Compensation costs for all quality function personnel (e.g.. Managers and Directors, Supervisors, and Clerical) whose duties are 100 per cent administrative.

1.5.2 **Administrative Expenses**

All other costs and expenses charged to or allocated to the quality management function not specifically covered elsewhere in this system (such as heat, light, telephone, etc).

1.5.3 **Quality Program Planning**

The cost of quality (procedure) manual development and maintenance, inputs to proposals, quality record keeping, strategic planning, and budget control.

1.5.4 **Quality Performance Planning**

Costs incurred in quality performance data collection, compilation, analysis, and issuance in report forms designed to promote the continued improvement of quality performance. Quality cost reporting would be included in this category.

1.5.5 **Quality Education**

Costs incurred in the initial (new employee indoctrination) and continued quality education of all company functions that can affect the quality of product or service as delivered to customers. Quality education programs emphasise the value of quality performance and role that each function plays in its achievement.

1.5.6 **Quality Improvement**

Costs incurred in the development and conduct of company-wide quality improvement programs, designed to promote awareness of improvement opportunities and provide unique individual opportunities for participation and contributions.

1.5.7 **Quality Systems Audits**

The cost of audits performed to observe and evaluate the overall effectiveness of the quality management system and procedures. Often accomplished by a team of management personnel. Auditing of product is an appraisal cost. (see 2.2.1)

1.6 **Other Prevention Costs**

Represents all other expenses of the quality system, not previously covered, specifically designed to prevent poor quality of product or service.

2.0 APPRAISAL COSTS

The costs associated with measuring, evaluating, or auditing products or services to assure conformance to quality standards and performance requirements.

2.1 Purchased Appraisal Costs

Purchasing appraisal costs generally can be considered as the costs incurred for the inspection an/or test of purchased supplies or services to determine acceptability for use. These activities can be performed as part of a receiving inspection function or as a source inspection at the supplier's facility.

2.1.1 Receiving or Incoming Inspections and Tests

Total costs for all normal or routine inspection and/or test of purchased materials, products, and services. These costs represent the baseline costs of purchased goods appraisal as a continuing part of a normal receiving inspection function.

2.1.2 Measurement Equipment

The cost of acquisition (depreciation or expense costs), calibration, and maintenance of measurement equipment, instruments, and gauges used for appraisal of purchased suppliers.

2.1.3 Qualification of Supplier Product

The cost of additional inspections or tests (including environmental test) periodically required to qualify the use of production quantities of purchased goods. These costs are usually one-time costs but they may be repeated during multi-year production situations. The following are typical applications.

a. First article inspection (detailed inspection and worst-case tests) on a sample of the first production buy of new components, materials or services.
b. First article inspection for second and third sources of previously qualified end-product key components.
c. First article inspection of the initial supply of customer-finished parts or materials.
d. First article inspection of the initial purchased quantity of goods for resale.

2.1.4 Source Inspection and Control Programs

All company-incurred costs (including travel) for the conduct of any of the activities described in 2.1.1 and 2.1.3 at the supplier's plant or at an independent test laboratory. This item will normally include all appraisal costs associated with direct shipments from supplier to the customer, sales office, or installation site.

2.2 Operations (Manufacturing or Service) Appraisal Costs

Operations appraisal costs generally can be considered as the costs incurred for the inspections, tests, or audits required to determine and assure the acceptability of product or service to continue into each discrete step in the operations plan from start of production to delivery. In each case where material losses are an integral part of the appraisal operation, such as machine set-up pieces or destructive testing, the cost of the losses is to be included.

2.2.1 Planned Operations, Inspections, Tests, Audits

The cost of all planned inspections, tests, and audits conducted on product or service at selected points or work areas throughout the overall operations process including the point of final product or service acceptance. Also includes the total cost of any destructive test samples required. This is the baseline operations appraisal cost. It does not include the cost of troubleshooting, rework, repair, or sorting rejected lots, all of which are defined as failure costs.

2.2.1.1 Checking Labour

Work performed by individuals other than inspectors as in-process evaluation. Typically part of a production operator's job.

2.2.1.2 Product or Service Quality Audits

Personnel expense as a result of performing quality audits on in-process or finished products or services.

2.2.1.3 Inspection and Test Materials

Materials consumed or destroyed in control of quality, e.g., by tearing down inspections, over-voltage stressing, drop testing, or life testing.

2.2.2 Set-Up Inspections and Tests

The cost of all set-up or first piece inspections and tests utilised to assure that each combination of machine and tool is properly adjusted to produce acceptable products before the start of each production lot, or that service processing equipment (including acceptance and test devices) is acceptable for the start of a new day, shift, or other time period.

2.2.3 Special Tests (Manufacturing)

The cost of all nonroutine inspections and tests conducted on manufactured product as a part of the appraisal plan. These costs normally include annual or semi-annual sampling of sensitive product for more detailed and extensive evaluations to assure continued conformance to critical environmental requirements.

2.2.4 Process Control Measurements

The cost of all planned measurements conducted on in-line product or service processing equipment and/or materials (e.g., oven temperature or material density) to assure conformance to pre-established standards. Includes adjustments made to maintain continued acceptable results.

2.2.5 Laboratory Support

The total cost of any laboratory tests required in support of product or service appraisal plans.

2.2.6 Measurement (Inspection and Test) Equipment

Since any measurement or process control equipment required is an integral part of appraisal operations, its acquisition (depreciation or expense), calibration, and maintenance costs are all included. Control of this equipment assures the integrity of results, without which the effectiveness of the appraisal program would be in jeopardy.

2.2.6.1 Depreciation Allowances

Total depreciation allowances for all capitalised appraisal equipment.

2.2.6.2 Measurement Equipment Expenses

The procurement or build cost of all appraisal equipment and gauges that are not capitalised.

2.2.6.3 Maintenance and Calibration Labour

The costs of all inspections, calibration, maintenance, and control of appraisal equipment, instruments, and gauges used for the evaluation of support processes, products, or services for conformance to requirements.

2.2.7 Outside Endorsements and Certifications

The total cost of required outside endorsements or certifications, such as Underwriter's Laboratory, ASTM, or an agency of the U.S. government. Includes the cost of sample preparation, submittal, and any liaison necessary to its final achievement. Includes cost of liaison with customers.

2.3 External Appraisal Costs

External appraisal costs will be incurred any time there is need for field set-up or installation and checkout prior to official acceptance by the customer. These costs are also incurred when there is need for field trials of new products or services.

2.3.1 **Field Performance Evaluation**

The total cost of all appraisal efforts (inspections, tests, audits, and appraisal support activities) planned and conducted at the site for installation and/or delivery of large, complex products or the conduct of merchandised services. (e.g, repairs or leasing set-ups)

2.3.2 **Special Product Evaluations**

Includes life testing, and environmental and reliability tests performed on production units.

2.3.3 **Evaluation of Field Stock and Spare Parts**

Includes cost of evaluation testing or inspection of field stock, resulting from engineering changes, storage time (excessive shelf life), or other suspected problems.

2.4 **Review of Test and Inspection Data**

Cost incurred for regularly reviewing inspection and test data prior to release of the product for shipment, such as determining whether product requirements have been met.

2.5 **Miscellaneous Quality Evaluations**

The cost of all support area quality evaluations (audits) to assure continued ability to supply acceptable support to the production process. Examples of areas included are stores, packaging, and shipping.

3.0 INTERNAL FAILURE COSTS

Costs resulting from products or services not conforming to requirements or customer/user needs. Internal failure cost occur prior to delivery or shipment of the product, or the furnishing of a service, to the customer.

3.1 **Product/Service Design failure Costs (Internal)**

Design failure costs can generally be considered as the unplanned costs that are incurred because of inherent design inadequacies in released documentation for production operations. *They do not include billable costs associated with customer-directed changes (product improvements) or major redesign efforts (product upgrading) that are part of a company-sponsered marketing plan.*

3.1.1 Design Corrective Action

After initial release of design for production, the total cost of all problem investigation and redesign efforts (including requalification as necessary) required to completely resolve product or service problems inherent in the design. (Some sources consider this a prevention cost.)

3.1.2 Rework Due to Design Changes

The cost of all rework (material, labour, and applicable burden) specifically required as part of design problem resolutions and implementation plan (effectivity) for required changes.

3.1.3 Scrap Due to Design Changes

The cost of all scrap (materials, labour, and applicable burden) required as part of design problem resolutions and implementation plan (effectivity) for design changes.

3.1.4 Production Liaison Costs

These costs of unplanned production support efforts required because of inadequate or incomplete design description and documentation by the design organisation.

3.2 Purchasing Failure Costs

Costs incurred due to purchased item rejects.

3.2.1 Purchased Material Reject Disposition Costs

The costs to dispose of, or sort, incoming inspection rejects. Includes the cost of reject documentation, review and evaluation, disposition orders, handling and transportation(except as charged to the supplier).

3.2.2 Purchased Material Replacement Costs

The added cost of replacement for all items rejected and returned to supplier. Includes additional and expediting costs (when not paid for by the supplier).

3.2.3 Supplier Corrective Action

The cost of company-sponsered failure analyse and investigations into the cause of supplier rejects to determine necessary corrective actions. Includes the cost of visits to supplier plants for this purpose and the cost to provide necessary added inspection protection while the problem is being resolved (Some sources consider this a prevention cost).

3.2.4 **Rework of Supplier Rejects**

The total cost of necessary supplier item repairs incurred by the company and not billable to the supplier - usually due to production expediencies.

3.2.5 **Uncontrolled Material Losses**

The cost of material or parts shortages due to damage, theft, or other (unknown) reasons. A measure of these costs may be obtained from reviews of inventory adjustments.

3.3 **Operations (Product or Service) Failure Costs**

Operations failure costs can almost always represent a significant portion of overall quality costs and can generally be viewed as the costs associated with defective product or service discovered during the operation process. They are categorised into three distinct areas: material review and corrective action, rework/repair costs, and scrap costs.

3.3.1 **Material Review and Corrective Action Costs**

Costs incurred in the review and disposition of nonconforming product or service and the corrective actions necessary to prevent recurrence.

3.3.1.1 **Disposition Costs.**

All costs incurred in the review and disposition of nonconforming product or service, in the analysis of quality data to determine significant areas for corrective action, and in the investigation of these areas to determine the root causes of the defective product or service.

3.3.1.2 **Troubleshooting or Failure Analysis Costs (Operations)**

The cost of failure analysis (physical, chemical, etc.) conducted by, or obtained from, outside laboratories in support of defect cause identification (Some sources consider this a prevention cost).

3.3.1.3 **Investigation Support Costs**

The additional cost of special runs of product or controlled lots of material (designed experiments) conducted specifically to obtain information useful to the determination of the root cause of a particular problem (Some sources consider this a prevention cost).

3.3.1.4 **Operations Corrective Action**

The actual cost of corrective actions taken to remove or eliminate the root causes of nonconformances identified for correction. This item can include such activities as rewriting operator instructions, redevelopment of specific processes or flow procedures, redesign or modification of equipment or tooling, and the development and implementation of specific training needs. Does not include design (3.1.1) or supplier (3.2.3) corrective action costs (some sources consider this a prevention cost).

3.3.2 **Operations Rework and Repair Work**

The total cost (labour, material, and overhead) of reworking or repairing defective product or service discovered within the operation process.

3.3.2.1 **Rework**

The total cost (material, labour, and burden) of all wok done to bring nonconforming product or service up to an acceptable (conforming) condition, as authorised by specific work order, blueprint, personal assignment, or a planned part of the standard operating process. Does not include rework due to design change.

3.3.2.2 **Repair**

The total cost (material, labour, and burden) all work done to bring nonconforming product up to an acceptable or equivalent, but still nonconforming, condition; normally accomplished by subjecting the product to an approved process that will reduce but not completely eliminate the nonconformance.

3.3.3 **Reinspection/Retest Costs**

That portion of inspection, test, and audit labour that is incurred because of rejects (includes documentation of rejects, re-inspection or test after rework/repair, and sorting of defective lots.

3.3.4 **Extra Operations**

The total cost of extra operations, such as touch-up or trimming, added because the basic operation is not able to achieve conformance to requirements. These costs are often hidden in the accepted (Standard) cost of operations.

3.3.5 **Operations Scrap Costs**

The total cost (material, labour, and overhead) of defective product or service that is wasted or disposed of because it cannot be reworked to conform to requirements. *The unavoidable losses of material (such as the turnings from machining work or the residue in a food mixing pot) are generally known as waste (check company cost accounting definitions) and are not to be included in the cost of quality.* Also, in the definition of quality costs, the amount received from the sale of scrap failure costs.

3.3.6 **Downgraded End-Product or Service**

Price differential between normal selling price and reduced selling price due to nonconforming or off-grade end-products or services because of quality reasons. Also includes any costs incurred to bring up to saleable condition.

3.3.7 **Internal Failure Labour Losses**

When labour is not lost because of nonconforming work, there may be no concurrent material losses and it is not reflected on scrap or rework reports. Accounting for the cost of labour for such losses is the intent of this item. Typical losses occur because of equipment shutdowns and reset-up or line stoppages for quality reasons and may be efficiency losses or even allocated for by "labour allowances."

3.4 **Other Internal Failure Costs**

4.0 EXTERNAL FAILURE COSTS

Costs resulting from products or services not conforming to requirements or customer/user needs. External failure costs occur after delivery or shipment of the product, and during or after furnishing of a service, to the customer.

4.1 **Complaint Investigations/Customer or User Service**

The total cost of the investigating, resolving, and responding to individual customer or user complaints or inquiries, including necessary field service.

4.2 **Returned Goods**

The total cost of evaluating and repairing or replacing goods not meeting acceptance by the customer or user due to quality problems. It does not include repair accomplished as part of a maintenance or modification contract.

4.3 **Retrofit Costs**

Costs to modify or update products or field service facilities to a new design change level, based on major redesign due to design deficiencies. Includes only that portion of retrofits that are due to quality problems.

4.3.1 **Recall Costs**

Includes costs of recall activity due to quality problems.

4.4 **Warranty Claims**

The total cost of claims paid to the customer or user, after acceptance to cover expenses, including repair cost such as removing defective hardware from a system or cleaning costs due to a food or chemical service accident. In cases where a price reduction is negotiated in lieu of warranty, the value of this reduction should be counted.

4.5 **Liability Cost**

Company-paid costs due to liability claims, including the cost of product of service liability insurance.

4.6 **Penalties**

Cost of any penalties incurred because of less than full product or service performance achieved (as required by contracts with customers, or government rules and regulations).

4.7 **Customer/User Goodwill**

Costs incurred, over and above normal selling costs, to customers or users who are not completely satisfied with the quality of delivered product or service such as costs incurred because customers' quality expectations are greater than what they receive.

4.8 **Lost Sales**

Includes value of contribution margin lost due to sales reduction because of quality problems.

4.9 **Other External Failure Costs**

APPENDIX B - BS6143 PART TWO : 1990 - GUIDANCE NOTES ON THE COST ELEMENTS OF PREVENTION, APPRAISAL AND FAILURE

A. 1 PREVENTION COSTS

These costs are incurred to reduce failure and appraisal costs to a minimum. The usual categories include the following.

(a) *Quality planning.* The activity of planning quality systems and translating product design and customer quality requirements into measures that will ensure the attainment of the requisite product quality. It includes that broad array of activities that collectively create the overall quality plan, the inspection plan, the reliability plan and other specialised plans as appropriate. It also includes the preparation and vetting of manuals and procedures needed to communicate these plans to all concerned. Suck quality panning may involve departments other that the quality organisation.

(b) *Design and development of quality measurement and test equipment.* Included are the costs of designing, developing and documenting any necessary inspection, testing or proving equipment (but not the capital cost of the equipment in question).

(c) *Quality review and verification of design.* Quality organisation monitoring activity monitoring activity during the product's design and development phase to assure the required inherent design review activities and in verification activity during the various phases of the product development test programme including design approval tests and other tests to demonstrate reliability and maintainability.

This includes quality organisation effort associated with that part of process control which ids conducted to achieve defined quality goals.

(d) *Calibration and maintenance of quality measurement and test equipment.* The cost of calibration and maintenance of templates, jigs, fixtures and similar items should be included.

(e) *Calibration and maintenance of production equipment used to evaluate quality.* The costs of calibration and maintenance of templates, jigs, fixtures and similar measurement and evaluating devices should be included but not the cost of equipment used to manufacture the product.

(f) *Supplier assurance.* The initial assessment, subsequent audit and surveillance of suppliers to ensure they are able to meet and maintain the requisite product quality. This also includes the quality organisation's review and control of technical data in relation to purchase orders.

(g) *Quality training.* Includes attending, developing, implementing, operating and maintaining formal quality training programmes.

(h) Quality audits. The activity involving the appraisal of the entire system of quality control or specific elements of the system used by an organisation.

(i) *Acquisition analysis and reporting of quality data.* The analysis and processing of data for the purpose of preventing future failure is a prevention cost.

(j) *Quality improvement programmes.* Includes the activity of structuring and carrying out programmes aimed at new levels of performance, e.g. defect prevention programmes, quality motivation programmes.

A.2 APPRAISAL COSTS

These costs are incurred in initially ascertaining the conformance of the product to quality requirements; they do not include costs from rework or reinspection following failure. Appraisal costs normally include the following:

(a) *Pre-production verification.* Cost associated with testing and measurement of pre-production for the purpose of verifying the conformance of the design to quality requirements.

(b) *Receiving inspection.* The inspection and testing of incoming part, components and materials. Also included is inspection at the supplier's premises by the purchaser's staff.

(c) *Laboratory acceptance testing.* Costs related to tests to evaluate the quality of purchased materials (raw, semi-finished or finished) which become part of the final product or that are consumed during production operations.

(d) *Inspection and testing.* The activity of inspection and testing first during the process of manufacture, and then as final check to establish the quality of the finished product and its packaging. Included are product quality audits, checking by production operators and supervision and clerical support for the function. It does not include inspection and testing and testing made necessary by initial rejection because of inadequate quality.

(e) *Inspection and test equipment.* The depreciation costs of equipment and associated facilities; the cost of setting up and providing for maintenance and calibration.

(f) *Materials consumed during inspection and testing.* Materials consumed or destroyed during the course of destructive tests.

(g) *Analysis and reporting of test and inspection results.* The activity conducted prior to release of the product for transfer of ownership in order to establish whether quality requirements have been met.

(h) *Field performance testing.* Testing is performed in the expected user environment, which may be the purchaser's site, prior to releasing the product for the customer acceptance.

(i) *Approvals and endorsement.* Mandatory approvals or endorsement by other authorities.

(j) *Stock evaluation.* Inspecting and testing stocks of products and spares which may have limited shelf life.

(k) *Record storage.* The storage of quality control results, approval and reference standards.

A.3 FAILURE COSTS

These are subdivided into internal and external failure costs: internal costs arising from inadequate quality discovered before the transfer of ownership from supplier to purchaser and external costs arising from inadequate quality discovered after transfer of ownership from the supplier to the purchaser.

The internal failure costs include the following.

(a) *Scrap.* material, parts, components, assemblies and product end item which fail to conform to quality requirements and which cannot be economically reworked. Included is the labour and labour overhead content of the scrapped items.

(b) *Replacement, rework and repair.* The activity of replacing or correcting defectives to make them fit for use including requisite planning and the cost of the associated activities by material procurement personnel.

(c) *Troubleshooting or defect or defect/failure analysis.* The costs incurred in analysing non-conforming products are usable and to decide on their final disposition.

(d) *Reinspection sand retesting.* Applied to previously failing material that has subsequently been reworked.

(e) *Fault of subcontractor.* The losses incurred due to failure of purchased material to meet quality requirements and payroll costs incurred. Credits received from the subcontractor should be deducted, costs of idle facilities and labour resulting from product defects should not be overlooked.

(f) *Modification permits and concessions.* The costs of the time spent in reviewing products, designs and specifications.

(g) *Downgrading.* Losses resulting from a price differential between normal selling price due to non-conformance for quality reasons.

(h) *Down time.* The cost of personnel and idle facilities resulting from product defects and disrupted production schedules.

The external failure costs include the following.

(1) *Complaints.* The investigation of complaints and provision of compensation where the latter is attributable to defective products or installation.

(2) *Warranty claims.* Work to repair or replace items found to be defective by the purchaser and accepted as the supplier's liability under the terms of the warranty.

(3) *Products rejected and returned.* The cost of dealing with returned defective components. This may involve action to either repair, replace or otherwise account for the items in question. Handling charges should be included.

NOTE. While loss of purchaser goodwill and confidence is normally associated with external failure costs, it is difficult to quantify.

(4) *Concession.* Cost of concession, e.g. discount made to purchasers due to non-conforming products being accepted by the purchaser.

(5) *Loss of sales.* Loss of profit due to cessation of existing markets as a consequence of poor quality.

(6) *Recall costs.* Costs associated with recall of defective or suspect product from the field including the cost of preparing plans for product recall.

(7) *Product liability.* Cost incurred as a result of a liability claim and the cost of premiums paid for insurance to minimise liability litigation damages.

PERSONNEL ACTIVITY REPORT

NAME: **WEEK No.:**

Activity	Hours Worked							Total		
	M	T	W	T	F	S	S	Total Hours	Hourly rate	Total Cost
Training Planning										
Induction Training										
Time and Attendance										
Leaving interviews										
Fire procedure (routine)										
Fire procedure – false alarms										
Disciplinary meetings										
Routine reports										
Special reports										
Company council										

PROCESS COST REPORT - SUMMARY

Month: March 1998

Process Name	Process Owner	Cost of Quality Data – Current Month				Cost of Quality Data – Year to Date			
		COC	COC Target	CONC	CONC Target	COC	COC Target	CONC	CONC Target
O.E Wiper Blades	J. Lloyd								
Personnel	D. Cross								
Paint Plant	M. Cogzell								
O.E Wiper Arms	B. Clarke								
Commercial Arms	K. Evans								
Linkage	I. Cornock								
A/Market Blades	C. Inch								
A/Market Packing	A. Thomas								
Despatch	P. Batterick								
Q. A	I. Riggs								
Purchasing	P. Nicholson								
Customer Services	G. Harris								
Marketing	N. Farren								
Design	J. Bosley								
Manufacturing Engineering	G. Armstrong								
Toolroom	C. Delahaye								
Press Shop	T. Motzkiet								
	TOTAL								

Compiled by: Ian Riggs