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**An Investigation into the Collection,  
Measurement and Use of Quality Costs Within a  
High Volume Production Environment**

**by**

**David Roy Bamford**

**A thesis submitted to Middlesex University for the  
degree of Master of Philosophy**

**In Collaboration with Courtaulds Packaging**

**December 1995**

## Declaration

No part of the work contained in thesis has been submitted in support of an application for another degree or qualification of this or any other University or Institute of learning.

## Dedication

I dedicate this thesis to my mother, Mrs Laura Bamford, and to the memory of my father, Mr Samuel Bamford.



## Abstract

The thesis describes an investigation into the collection and measurement of quality costs. It goes on to explain the manner in which this information was presented and used as an integral part of a specific (high volume manufacturing) company's total quality drive. Finally, it demonstrates how the cost of quality can help to identify and direct efforts to improve quality. Guidelines are given for the collection and analysis of quality cost data within the packaging industry.

A comprehensive literature survey covering issues directly related to the objectives of the research, and peripheral issues of importance, was carried out. Literature on case studies for the promotion of quality were also included in the survey. The survey was confined to English language publications, using a list of keywords relating to money (i.e. cost, profit, economic, etc.) and topics ranging from the use of "quality improvement" as a business strategy to the quality-related costs associated with specific manufacturing operations. The search was primarily confined to quality related literature. This literature was reviewed and discussed in the light of the research experience, some gaps in the literature and information available were identified. These are discussed as a part of the development of a dedicated methodology, within the final chapter.

A three stage, action research, methodology was adopted. Action research encompasses direct involvement in organisational change whilst providing an increase in the knowledge base for a specific topic. This was the best possible option as the project specification relates to a practical problem with theoretical relevance. The main advantage of action research is that it is carried out in real-time and produces a concrete result, putting something of real practical worth back into an organisation.

Four practical costing models were identified: (i) Prevention, Appraisal, Failure Model; (ii) Process Cost Model; (iii) Economic Balance of Quality (Optimum Quality Cost) Model; and (iv) Total Loss to Society (Quadratic Loss Function) Model. A host firm was used to test (i) and (ii). These two models were chosen because they exhibited certain characteristics. They both form part of British

Standard - BS 6143, have had some publicity in the form of articles within professional journals, and have been utilised within both manufacturing and service industries to provide quality costing data. The British Standard (BS) 6143: Parts 1 (1991) and 2 (1990) was used as the primary guide. A detailed analysis of the applicability of both models was carried out, with necessary modifications being made to suit the host firms' particular industry (plastic injection moulding). This analysis is reported and discussed at length.

Among the key conclusions are that quality costing can have a very positive effect upon an organisations' quality improvement drive, and that the careful development of a specific cost model (in this instance the P.A.F. model) and a methodology for employing it, within a larger framework, should be considered essential. Further conclusions are that all organisations are at various stages in the use of formal measurement systems. As such, the identification of what stage an organisation has progressed to, and the determination of how they should proceed, is important for forward progress in the use of quality measurement systems. A conceptual framework has been designed for this purpose.

A set of guidelines for quality cost collection and analysis within the packaging industry (high volume manufacturing) was created. As was a matrix to show an organisations' current place and potential development within certain key parameters, for example: i) company awareness, ii) costing models used, iii) measurement systems in place. The methodology developed for the host company is being used within other companies from the same corporate group. This is allowing refinement of the original model to take place. Other recommendations for further study are proposed in order to establish the validity of the above measurement system framework.

This research has contributed to the existing knowledge base by trailing and modifying existing models within a specific environment, and through the development of a conceptual framework for assessing an organisations quality measurement system development. The direct contribution to the host company, in terms of practical and theoretical assistance has been considerable. This is fully detailed within the thesis.

## Acknowledgement

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# CHAPTER ONE

## PROJECT SPECIFICATION

1.0 Introduction

The aim of this chapter is to introduce, outline and specify the objectives of the quality costing research project. The following issues are discussed within this chapter:

- 1.1 - Background to the Study.
- 1.2 - Aims and Objectives of the Investigation.
- 1.3 - Research Methodology Employed.
- 1.4 - Expected Outcomes.
- 1.5 - Structure of the Report.

1.1 Background To The Study

Quality management and the costs associated with the provision of improved product quality has received a great deal of attention in recent years. The literature dealing with the costs associated with quality can be divided into the following categories (1):

- (i) Models and methods for assessing the cost of quality;
- (ii) Trade-off between costs of quality and improved level of product quality;
- (iii) Cost of inferior quality; and
- (iv) The relationship between higher level of quality and basic performance.

Much of the published work is not supported by empirical data. The appropriateness of the models for measuring the cost of quality have, so far, been tested in a limited number of industries (2). The relationship between cost categories and the actual usefulness of models has not been tested extensively. Therefore, examining the applicability of the models and identifying the contingency factors that influence the applicability of the models is a useful area for specific research.

The work described in this thesis was carried out under the auspices of a Teaching Company Programme in the area of Quality Management, between an academic partner - Middlesex University Business School and an industrial partner - Courtaulds Packaging, Betts Plastics. The aim of this joint exercise was the implementation of a "Total Quality Management" or "Continuous Improvement" ethos within the host company. Two associates (one of whom is the author), both with previous industrial experience, were recruited for the duration of the two year project.

The host company (Courtaulds Packaging - Betts Plastics) is a multi-site, blue chip, injection moulding firm, in the packaging arena. It had a turnover in 1994-95 of £45 million. Full details of the company are given in chapter 3.

One of the key areas to be covered, as a part of the implementation methodology, was the introduction of quality costing. This was to be used as a tool for giving impetus and immediacy to the Total Quality Management project. It was to focus senior management's minds by talking in a language they would understand - money (3).

During the two year appointment, each Associate was seconded to a senior manager in the host company, who acted as the Industrial Supervisor. In the case of the author it was Mr. M. Hornby - Operations Director of Betts Plastics, Colchester. The Associates were regularly visited by the Academic Supervisor, Professor A. Ghobadian - Middlesex University Business School.

Every quarter a Local Management Committee met to review and discuss the progress of each Associate. The committee consisted of an Academic Supervisor, an Industrial Partner, and a representative from the Teaching Company Directorate, Mr. B. Nuttall - Teaching Company Consultant. This forum provided the ideal opportunity for exchange of research information and ideas.

## CHAPTER TWO

# LITERATURE SURVEY AND SUBJECT INTRODUCTION

## 2.0 Introduction

A comprehensive literature survey covering issues directly related to the objectives of the research and peripheral issues of importance was carried out. Literature on case studies for the promotion of quality were also included in the survey.

The survey was confined to English language publications, using a list of keywords relating to money (i.e. cost, profit, economic, etc.) and topics ranging from the use of "quality improvement" as a business strategy to the quality-related costs associated with specific manufacturing operations. The search was primarily confined to quality related literature.

An analysis of the appropriate literature is presented in this chapter. The chapter is divided into the following sections:

- 2.1 - What is Quality?
- 2.2 - What is Quality Costing?
- 2.3 - History of Quality Costing.
- 2.4 - Determining the Cost of Quality.
- 2.5 - What is Total Quality Management?
- 2.6 - The Role of Quality Costing in Total Quality Management.

### 2.1 What is Quality?

This investigation is about "quality costing". Before moving on to understand about the costing of quality it is essential that the term "quality" is fully understood. This section will clarify what the term "quality" actually refers to.

"Quality" has traditionally been regarded as rather a vague and unspecified term "I know it when I see it!". It is open to individual interpretation, depending on particular areas of interest. What much of the standard literature (3)(9)(10)(11) agrees upon is that it is a relationship between the manufacturer and the consumer - perceived need verses required usage.



Over a period of time a more objective approach was evolved. This uses similar criteria to the more aesthetic approach of the past, but in different ways. There are two base criteria:

- i) Manufacturing a well made product, which exhibits a high level of workmanship (quality of design);
- ii) Satisfying the specific requirement of the customer (quality of conformance) (3).

Together these comprise a large part of what Juran (1988), in his definition of quality, calls "fitness for use" (3). "Fitness for use" is the extent to which the product successfully serves the purpose of the user. Other definitions of quality have, of course, been put forward, such as Feigenbaum's (1983):

"The composite product characteristic of engineering and manufacturing that determines the degree to which the product is used will meet the expectation of the customer" (12).

And that of BS 4778:

"The totality of features and characteristics of a product or service that bear on its ability to satisfy a given need" (9).

Unspoken in such definitions are other characteristics such as reliability and serviceability. Juran does attempt a wider quantitative analysis and categorisation of the particular components of the general term "quality", by including features such as price and delivery date. He thus defines quality by four parameters: quality of design, quality of conformance, availability and field service.

Juran's definition takes into account both an objective standard of manufacturing and the customer's personal feelings. Sitting (13), on the other hand, offers a different perspective definition of product quality. Sitting says that quality is ...

"the degree to which a specific product is adjusted to the demand which it is intended to satisfy".

Although Stitting perhaps intended his definition to cover the personally appealing aspects of quality, this seems to be a definition of quality of conformance only, as no mention is made of features such as taste or craftsmanship. It could therefore be seen as an entirely objective, quantitative definition of quality.

Other definitions of quality include:

- "Quality: The totality of features and characteristics of a product or service that bear on its ability to satisfy a given need". (9)

- "Quality: Is defined by the customer. The customer wants products and services that throughout their life meet his or her needs and expectations at a cost that represents value". (10)

- Quality is customer satisfaction, it is conformance to requirements. It is fulfilling the customers' needs in terms of affordability; delivery at the right time; safety; reliability; and after sales support. It has even been defined as, "never having to say sorry to a customer". (11)

According to Garvin (14) the problem with defining quality is one of terminology. Complex concepts such as quality are "difficult to penetrate", as marketing, engineering, and manufacturing experts often interpret the term differently. He goes on to state that there is no reason to assume business leaders and consumers will be any more in agreement.

Garvin then outlines eight dimensions or categories of quality that can be identified as a framework for analysis:

1. Performance: The primary operating characteristics of a product.
2. Features: The secondary characteristics that supplement the product's basic functioning.

3. **Reliability:** Reflects the probability of a product's malfunctioning or failing within a specified period of time.
4. **Conformance:** The degree to which a product's design and operating characteristics meet pre-established standards.
5. **Durability:** A measure of product life, both technically and economically.
6. **Serviceability:** The speed, courtesy, competence, and ease of repair.
7. **Aesthetics:** How a product looks, feels, sounds, tastes, or smells. Clearly a matter of personal judgement and a reflection of individual preferences.
8. **Perceived quality:** Image, advertising, and brand name. Perceptions of quality rather than the reality itself can be critical.

Using his analysis each category is self contained and distinct, for each product or service can be ranked high on one dimension while being low on another. However, in many cases the dimensions are interrelated. Sometimes an improvement in one may be achieved only at the expense of another; at other times two dimensions, such as reliability and conformance, may move together. Because multiple dimensions allow for multiple strategies, quality competition becomes vastly more complex.

Where all these definitions seem to be in agreement, however, is in the understanding that satisfactory relations between manufacturer and customer are essential. If the product can be customer oriented, in the sense of taking into account their personal feelings as well as more objective interests, quality will be assured.

## 2.2 What is Quality Costing?

The aims of this investigation are targeted towards the use of "Quality Costing" techniques within a specific organisation. As such it is important that the

terminology, and the concepts behind it, are fully understood before detailed work commences. This section will outline what "Quality Costing" is.

"Quality Costing" is one of several techniques available to assist companies with the attainment of top quality. It is important because it expresses quality performance in the language of management, i.e. MONEY. This point is made by many writers on the subject, to the extent that cash savings appear to be the main reason for any form of "quality improvement" (11)(15)(16).

According to Dale and Cooper (5) most company executives want tangible proof of the need for quality improvement, and indeed the need for top-level leadership to attain it. Top management needs to be convinced. One of the means of providing this proof is the collection, reporting and use of quality-related cost information. This helps to quantify the benefits of quality improvement in commercial (and management) terms.

Dale and Cooper go on to disagree with quality management protagonists (17)(18) who say there should be no need to justify investment in quality improvement activities. They put forward the view that;

"Western organisations and their management are judged over relatively short periods of time. Therefore, committing large amounts of money in quality improvement programmes without some measure of cost effectiveness can be considered a blind act of faith, and is contrary to the way in which western businesses operate" (10).

Richardson (19) makes the same point when he cites an example where departmental and general managers were unmoved by quality control data but were galvanised into action when the same data was expressed and presented in monetary terms.

So what are quality related costs? They are the money spent attempting to achieve a quality level of 100 per cent, plus the money wasted through failure.

But why try to achieve a quality level of 100 per cent? Is not a lower level enough? The answer is no, because the ability to make a product "right first time" (20) has commercial, motivational, and practical advantages. Also, if an organisation does not provide total customer satisfaction a competitor undoubtedly will!

Quality related costs are not, as is sometimes thought, just the cost of quality assurance, inspection, test and scrap materials and components. In one of a range of booklets published by the DTI as part of its Enterprise Initiative, "The Case for Quality Costing" (21), quality-related costs are said to arise from a range of activities, all of which impinge on the quality of the product or service. These include:

- sales and marketing;
- design, research, development;
- purchasing, storage, handling;
- manufacturing;
- delivery, installation;
- service.

Clearly suppliers, subcontractors, stockists, agents and consumers all have an influence upon the level of induced quality-related costs.

According to Dale and Plunkett (22), quality costs are important:

"Because firstly, they are so high ... in 1978 quality costs were estimated by the U.K. Government to be £10 billion, equal to ten per cent of the U.K.'s gross national product. There is no reason to suppose that they are any less now. The findings of a National Economic Development Organisation (NEDO) task force on quality and standards published in 1985, claim that some 10 to 20 per cent of an organisation's total sales value is accounted for by quality-related costs and, using the figure of 10 per cent, it is estimated that UK manufacturing industry could save up to £6 billion each year by reducing such costs. Various studies and information volunteered by companies have shown that quality-related costs commonly range from 5 to 25 per cent of companies' sales turnover. The costs

depend on the type of industry, the view taken by the company of what is or is not a quality cost, the way the company manages quality, and the extent to which continuous quality improvement is practised in the organisation.

Secondly, 95 per cent of this cost is expended on appraisal and failure. These expenditures add little to the value of the product, and the failure costs, at least, may be regarded as avoidable. Reducing failure costs by eliminating causes of failure can also lead to substantial reductions in appraisal costs. Evidence suggests that quality-related costs may be reduced to one third of their present level, within a period of three years, by the commitment of the organisation to a process of continuous quality improvement.

Thirdly, unnecessary and avoidable costs make goods and services more expensive. This in turn affects competitiveness and, ultimately, wages and standards of living.

Fourthly, despite the fact that the costs are large, and that a substantial proportion of them are avoidable, it is apparent that the costs and economics of many quality-related activities, including investment in prevention and appraisal activities, are not known. It is estimated that fewer than 40 per cent of companies know how big their quality costs are. Such a state of affairs is surely indefensible in any well-run business" (22).

The research taking place as an integral part of this thesis addresses the above issues within the host company.

Garvin (23) recognised the need for further research on the subject of quality costing when he stated;

"The greatest need is for studies that recognise the multiple dimensions of quality, examine them empirically, and then relate them to cost, market share, profitability, and other measures of business performance. More refined research is vital; otherwise, managers will continue to lack the hard evidence linking quality with the bottom line".

This thesis is specifically directed towards the extrapolation of quality costing information within a specific sector of manufacturing industry. The information generated is intended to be used by the senior management team in order to sustain and develop the continuous improvement ethos within the host company. As such, the work within this thesis will add partially to the body of knowledge that address Garvin`s comments.

### 2.3 History of Quality Costing

The term "quality costs" was first used in western Europe in the early 1960s (26). In 1967 the American Society for Quality Control (A.S.Q.C.) published "Quality Costs - What and How" (25) in which quality costs were defined only by category and by reference to Feigenbaum. This booklet took the quality cost definitions from Feigenbaum`s book "Total Quality Control" (12), added sources for finding cost data and gave advice on what to include or leave out. It also gave advice on how not to misinterpret the results. The booklet went on to give advice on how the costs should be presented to the management team.

Other ASQC publications on quality control include:

- "Guide to reducing Quality Costs" (26), this developed the use of quality costs by directing attention to quality improvement projects and to the involvement of technical, marketing and purchasing functions in quality matters (it uses the Prevention / Appraisal / Failure model - see section 2.4.1).

- "Guide for Managing Supplier Quality Costs " (27), is an acknowledgement that companies actually purchase some of their quality problems. The guide deals with vendor control on two fronts: identifying supplier problems through joint partnership projects, and motivating the supplier to adopt their own quality cost programme.

The British Standards Institutes publication - BS 6143 "Guide to the Determination and Use of Quality Related Costs" (28) is an abridged version of "Quality Costs - What and How". Plunkett and Dale (29), amongst others,

discuss in some detail the flaws in the British Standard, and in later work (24) point out that the criticisms have been taken into account in the revision of the Standard by the Quality Management and Statistics Standard Policy Committee. The Standard is now entitled "Guide to the Economics of Quality" (13), and is published in two parts. The first part of the guide comprises of a Process Cost Modelling approach (see section 2.4.2). The second part is a revised version of the Prevention / Appraisal / Failure model - see section 2.4.1.

## 2.4 Determining the Cost of Quality

From the literature surveyed there are four main cost classification models which will now be examined in turn:

2.4.1 - Cost Categorisation: Prevention, Appraisal, Failure;

2.4.2 - The Process Cost Model;

2.4.3 - Economic Balance of Quality (Optimum Quality Cost); and

2.4.4 - Total Loss to Society (Quadratic Loss Function).

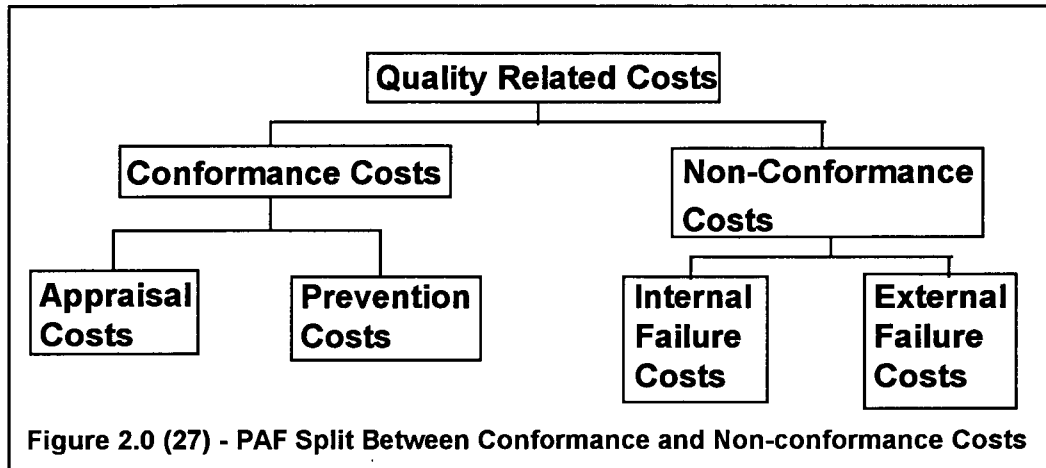
### 2.4.1 Prevention, Appraisal, Failure Model

Since its proposition by Feigenbaum in 1956, the Prevention, Appraisal, Failure (PAF) model has been the principal model for Quality Costing. It was this model which was used by the British Standards Institute until 1992. From this date, the PAF model has been one of two included in BS6143, the other being the Process model (detailed later). According to Porter and Rayner (31);

"There is only one widely recognised scheme for categorising quality costs. After a review of the literature, Plunkett and Dale, state that, the "Feigenbaum" classification is almost universally accepted. (29)"



Quality related costs comprise of both the voluntary costs of achieving a desired level of quality, and the involuntary costs of failing to achieve it. These are respectively called the costs of conformance, and of nonconformance; and according to Musgrove and Fox sometimes also "cost of quality" and "cost of un-quality" (32). Figure 2.0 below represents the split between conformance and nonconformance costs, and the link to the PAF model.



The definitions of the four kinds of cost (outlined in figure 2.0) which follow, are taken from British Standard 4778, "Quality Vocabulary", part 2:

**Costs of Prevention:** "The cost of any action taken to investigate, prevent or reduce defects and failures. For example the cost of planning, setting up and maintaining the quality system."

**Costs of Appraisal:** "The cost of assessing the quality achieved. For example, it includes the cost of inspecting, testing etc., carried out during and on completion of manufacture."

**Failure Costs - Internal:** "The costs arising within the manufacturing organisation of the failure to achieve the quality specified. For example the cost of scrap, re-work and re-inspection, and also consequential losses within the organisation."

**Failure Costs - External:** "The costs arising outside the manufacturing organisation of the failure to achieve the quality specified. For example, the costs of claims against warranty, replacement and consequential losses of custom and goodwill." (9)

Several elements can be identified within each of the above cost categories. There is an "official" list which appeared first in A.S.Q.C. (25) and was then adopted by BS 6143 (28). These are detailed below in table 2.0:

	<b>A.S.Q.C. (1970)</b>		<b>BS 6143 (1990)</b>
	<b>PREVENTION</b>		<b>PREVENTION</b>
1	Quality Engineering	1	Quality Planning
2	Design & development of quality measurement & control equip	2	Design & development of quality measuring & test equip
3	Quality planning by functions other than quality control	3	Quality review & verification of design
4	Quality training	4	Calibration & maintenance of production equip used to measure quality
5	Other prevention expenses	5	Supplier assurance
-	No other costs	6	Quality training
-	No other costs	7	Quality auditing
-	No other costs	8	Acquisition, analysis & reporting of quality data
-	No other costs	9	Quality improvement programmes
	<b>APPRAISAL</b>		<b>APPRAISAL</b>
1	Receiving inspection	1	Pre-production verification
2	Lab acceptance testing	2	Receiving inspection
3	Inspection & test	3	Laboratory acceptance testing
4	Checking labour	4	Inspection & testing
5	Set-up for inspection & test	5	Inspection & test equip
6	Inspection & test materials	6	Materials consumed during inspection & testing
7	Product quality audits	7	Analysis & reporting of test and inspection results
8	Outside endorsements	8	Field performance testing
9	Maint & calibration of test and inspection equip	9	Stock evaluation
10	Review of test & inspection data	10	Record storage

11	Field performance testing	-	No other costs
12	Internal testing & release	-	No other costs
13	Evaluation of field stock & spare parts	-	No other costs
14	Calibration & maint of production equip used to evaluate quality	-	No other costs
15	Data processing inspection and test reports	-	No other costs
16	Special product evaluation	-	No other costs
17	Test and inspection materials	-	No other costs
	<b>FAILURE COSTS - INTERNAL</b>		<b>FAILURE COSTS - INTERNAL</b>
1	Scrap	1	Scrap
2	Rework & repair	2	Replacement, rework or repair
3	Troubleshooting or failure analysis	3	Troubleshooting or defect / failure analysis
4	Reinspection / retest	4	Reinspection & retesting
5	Scrap & rework - fault of vendor	5	Fault of sub-contractor
6	Discrepant material activity	6	Modification permits and concessions
7	Downgrading	7	Downgrading
-	No other costs	8	Downtime
	<b>FAILURE COSTS - EXTERNAL</b>		<b>FAILURE COSTS - EXTERNAL</b>
1	Complaints	1	Complaints
2	Product or customer service	2	Warranty claims
3	Products rejected and returned	3	Products rejected and returned
4	Returned material repair	4	Concessions
5	Warranty replacement	5	Loss of sales
6	Marketing error	6	Recall
7	Engineering error	7	Product liability
8	Factory or installation error	-	No other costs
Table 2.1 - A.S.Q.C. vs BS 6143			

Writing on the subject of the Prevention / Appraisal / Failure model, Dale and Plunkett (33) detail the perceived advantages and disadvantages:

"Among the general advantages are that it may prompt a rational approach to collecting costs and it can add orderliness and uniformity to the ensuing reports. Among the specific advantages of this particular categorisation are:

- i) Its universal acceptance;
- ii) Its provision of relative desirability of different kinds of expenditure;
- iii) That it provides keyword criteria to help to decide whether costs are, in fact, quality - related.

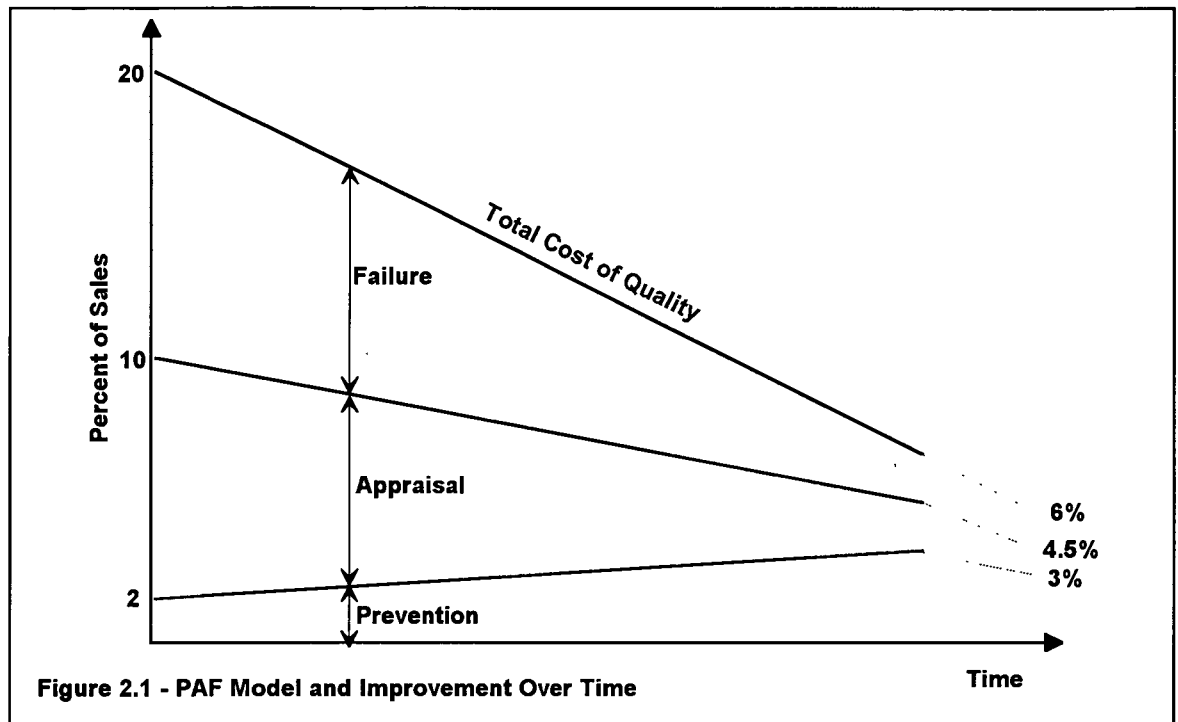
The third point may explain why neither Feigenbaum (12) nor the ASQC (25) defines the term "quality costs". Matters are judged to be quality - related if they satisfy the criteria set by their definitions of prevention, appraisal and failure.

Among its limitations are:

- i) the quality activity elements as defined do not match well with the cost information most commonly available from accounting systems;
- ii) there are many quality - related activities in grey areas where it is unclear to which category they belong;
- iii) in practice the categorisation is often a post - collection exercise done in deference to the perceived wisdom on the topic;
- iv) the categorisation seems to be of interest only to quality department personnel;
- v) it is not an appropriate categorisation for the most common uses of quality related cost information."

The split into prevention / appraisal / internal or external failure has been done purposefully to provide data that may be transformed into information, and then used within the decision making process by managers. Over a period of time, as the continuous improvement programme gains momentum and starts to show tangible results, a graph such as that presented in figure 2.1 should emerge. This diagram clearly indicates a change in emphasis in the spending priorities of

the company concerned. The overall costs have come down and the distribution amongst the four main categories has changed.



This model will be discussed in later chapters as it forms, in part, one of the key methodologies tried out within the host company.

#### 2.4.2 The Process Cost Model:

The Process Cost Model was developed by Ross (34) as the "computer aided manufacturing integrated programme definition methodology" (IDEF), and was first used by Marsh (35) for quality costing. Using this model the Cost of Conformance (COC) and Cost of Nonconformance (CONC) are identified, the latter being intended as a "catalyst for improvement". COC and CONC are defined in BS 6143: Part 1 (31) as:

"COC - The intrinsic cost of providing products or services to declared standards by a given, specified process in a fully effective manner.

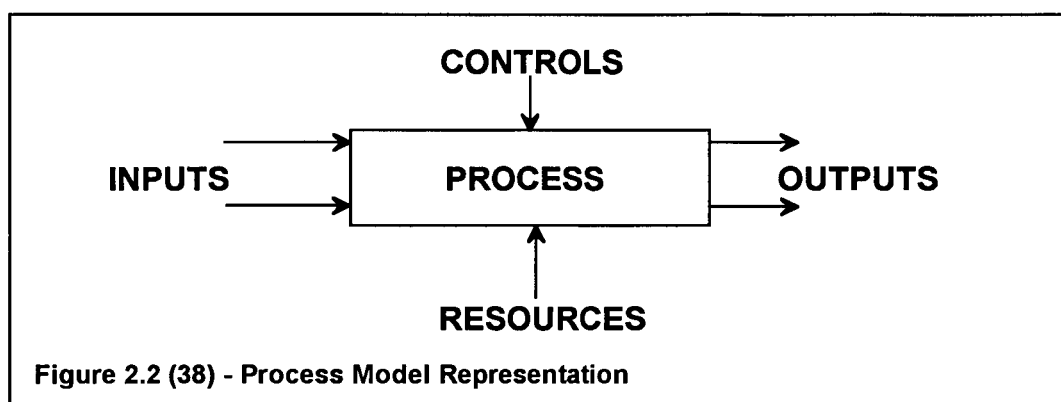
**CONC** - The cost of wasted time, materials and capacity (resources) associated with a process in the receipt, production, despatch and correction of unsatisfactory goods and services".

The process model is put forward as a method for quality costing within Total Quality Management (TQM) as it presents a more integrated approach to quality than the Prevention, Appraisal and Failure model. BS 6143 goes on to say:

"Historically, the concept of a Quality Cost model has suggested that certain identifiable costs are in some way related to the "Quality" of the end result. By contrast, within the total quality management culture, all business activity is related to processes and therefore the Cost model should reflect the total costs of each process rather than an arbitrarily defined cost of quality" (36).

The standard states that the Process Model can be applied to any activity, from a "particular work stage" to the "overall business".

The model essentially involves breaking down all the activities of a company, both internal and external, into interlinked "processes", each process having inputs and outputs, see figure 2.2 below. Some of these are desirable, some not. For example, BS6143 suggests a key activity for a personnel department is training, and for training as a process the cost of conformity is the actual cost of training. The cost of nonconformity therefore is the cost of cancellation of training.



This model is described by Dale and Plunkett (1990):

"The methodology focuses on departmental objectives and process ownership, and helps people to identify the costs of conformance for which they have responsibility. A model of each process is developed. This identifies all the parameters and activities within that process to be monitored and in which area of the two costs they fall. The British Standards Institution is to be applauded for including this methodology in the revision of BS 6143. This will help to extend the concept of quality costing to all functions of an enterprise and to non-manufacturing organisations. It also gets people to consider in more detail the processes being carried out within their organisation" (24).

A claimed advantage of this method is that costs do not have to be identified and categorised as prevention, appraisal, or failure, which can be difficult.

According to Musgrove & Fox (32) categorisation may be unnecessary, but the identification of process elements is essential. Categorisation is said to be helpful because it reminds the collector that costs classed as failure are all potentially avoidable, and can therefore be classed as recoverable.

According to Rawlins (37) the process model is very appropriate for use within a Total Quality Management environment, and will allow the collection and analysis of quality costs in both manufacturing and service functions. Reporting the results of her findings she identified a number of important points. These were:

- i) Process flowcharts have proven to be an effective method for modelling business processes. This method facilitated improved understanding and better interdepartmental communications.
- ii) The workshops encouraged active participation in the design and implementation of the quality cost system, and proved to be a major factor in the high level of "ownership" of the system.
- iii) The participative approach to the implementation of the system appeared to encourage a high degree of honesty with time bookings. Data collected during the first two runs of the process model does not appear to have

suffered the distortion experienced with the old (prevention / appraisal / failure) system.

- iv) The system has successfully identified priority areas for improvement activities, indeed a detailed analysis of raw data has enabled the pinpointing of specific nonconformances. This data will also provide a benchmark against which improvements can be quantified.

Dale and Plunkett (38) take an opposing view:

"It should be noted that whilst this method (process costing) facilitates ownership of the costs by each department they sometimes fail to identify those costs which occur between departments. Consequently, some costs are not identified and even if they are, difficulties are encountered in persuading departmental managers to take responsibility for their ownership and subsequent reduction. It can also lead to departments attempting to minimise their costs at the expense of other departments, so ultimately the benefits to the organisation as a whole are diminished. Cross-functional co-operation is necessary if quality costing is to be a success and perhaps this method is not particularly apt in facilitating co-operation of this type".

This model will also be discussed in later chapters as it forms, in conjunction with the previous model, one of the methodologies tried out within the host company.

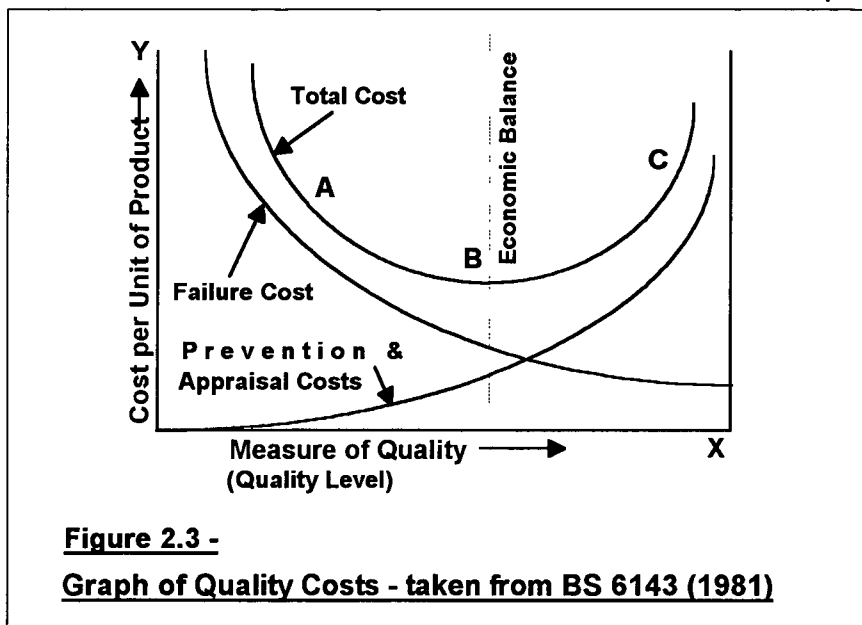
#### 2.4.3 The Economic Balance of Quality (Optimum Quality Cost)

British Standard BS 4778 defines economic quality as;

"The economic level of quality at which the cost of securing higher quality would exceed the benefits of the improved quality". (9)

This concept was illustrated in the original BS 6143 (28) by figure 2.3:





As mentioned before, quality costs can be divided into the COC and CONC, these in turn can be subdivided into "appraisal and prevention", and "external failure and internal failure".

The definition for the Economic Balance of Quality, according to Musgrove and Fox (31), proceeds as follows:

"If there is little or no investment in conformance costs, quality is likely to be poor: i.e. nonconformance costs will be high. If more money and resources are invested in conformance activities; nonconformance costs will decrease, quality will improve. The more quality is improved, the harder it will be to produce further improvement. For example it may cost 25p to eliminate each defective component, compared to a sales value of 22p! At such a point, the conformance cost introduced is greater than the nonconformance cost it is intended to eliminate; improvement activity becomes uneconomic.

There therefore exists a point at which the sum of conformance and nonconformance costs is at a minimum". This is the point of Economic Quality, as indicated in figure 2.4 (32).

However, Hutchins (39) takes an opposing view:

"Protagonists of the model (outlined above - Musgrove and Fox) suggest that continuous and progressive reductions in quality costs will eventually lead to a situation where an optimum value is reached, beyond which the overall costs will rise. For example, in figure 2.3 the company would move from position A, through position B to position C. If this were the case, the optimisation of quality costs would be a very simple matter: move from A in the direction of B until the costs began to rise again. Then, put the brakes on, and say: "we have achieved quality". There is no evidence from anywhere in the world, even from Japan, that this has been achieved or even claimed. Surely, if the argument were valid, it would have happened by now!

The answer is that the argument is severely flawed. There is and can be no such optimum value. The relationship described cannot occur as described in the model because it takes no account of the relative positions of competing products or services and their influence on consumer tolerance of lower quality levels. The fact is that in the correct form of this model, the "best" producer will always be at the optimum quality level, irrespective of other considerations, because by definition that is what the customer wants. Therefore, it follows in the quality cost argument that the performer who has achieved the best overall mix of desirable product or service features, value for money and profitability will always be at the optimum point, and will remain there until someone else does something better, which will only be a matter of time if the currently best performer makes no improvements" (39).

If the Economic Balance of Quality concept has not been proven by empirical research, it would make little sense to put it forward as a hypothesis to adopt as a methodology. The concept will be discussed within chapter eight of this thesis. It is apparent that many of the texts on quality costing, while sound in the theory and intention, lack certain elements in the practical implementation of various models.

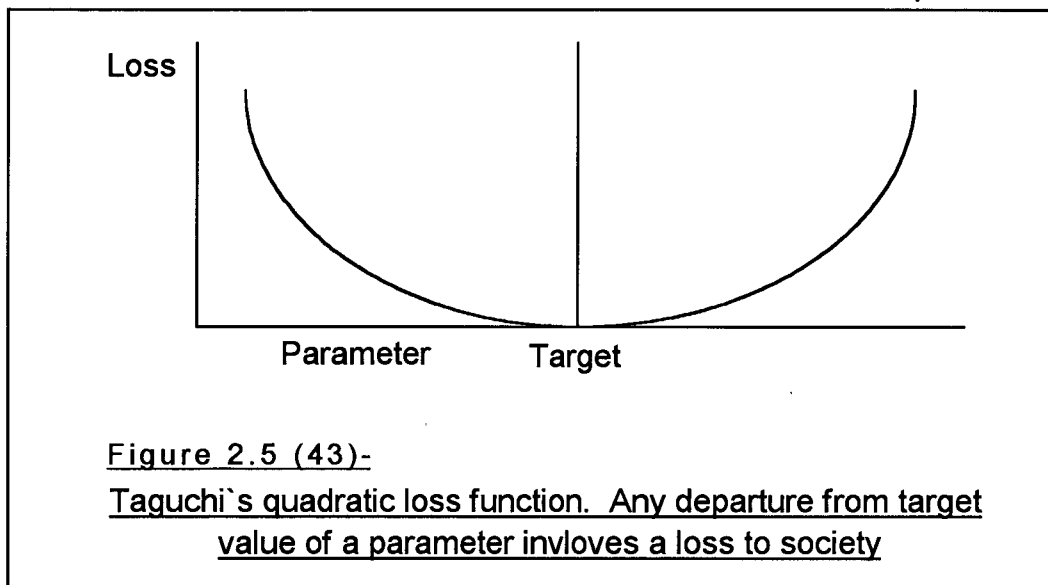
2.4.4 "Total Loss to Society" Model ("Quadratic loss function")

This is essentially a Japanese perception of quality - related costs, promoted by Genichi Taguchi. His definition of quality is "The loss imparted to society from the time a product is shipped" (40).

Loss can be one of two things: either loss caused by variability of function (of the product), or loss caused by harmful side effects. This is an unusual definition, firstly in that it defines quality in a negative sense - lack of quality. Secondly, that it only measures the impact of the finished product: avoidable costs and wastage occurring within the manufacturing plant are not included by Taguchi.

In an example taken from Cullen and Hollingum (4), Taguchi argues that any departure from a specified target value imparts a loss. One example is the AC-DC converting circuit used within a television set, where (in Japan) the AC input is 110 volts, and the DC output is set at plus or minus (+-) 115 volts. These are the target values, and tolerance limits of +- 15 volts may be set around them. However, if one had the choice of taking converters from a factory which is supplying them within the 15 volt limits, or from a factory which is supplying them within 8 volt limits, one would choose the latter, other things being equal.

Taguchi uses this example to underline his point that any variation from the target value incurs a loss, and that this loss becomes greater the more the product deviates from its target value. He has found in practice that the loss frequently approximates to the parabolic form shown in figure 2.5, which he calls the quadratic loss function.



Cullen and Hollingum (41), in discussing this approach, maintain that quality is primarily concerned with reducing variability. This in itself is far more important than simply being within specification.

Taguchi quotes the case of a manufacturer of vinyl sheeting for agricultural use. The manufacturer found he was able to reduce his process variability by 90 per cent, so that instead of producing to a thickness tolerance of  $\pm 0.2\text{mm}$ , he could keep within  $\pm 0.02\text{mm}$ . To minimise his costs he therefore adjusted the average thickness down to the bottom end of the range accepted in his specification. The result was that the vinyl sheet became much more prone to tearing, and resulted in heavy losses to the farmers in damaged crops. For the relatively small saving made by the manufacturer, there was a much greater loss to society as a whole, and to farmers in particular.

Taguchi describes such action by a manufacturer as "more immoral than the actions of a thief", because when the thief steals 10,000 Yen the victim loses 10,000 Yen and society is no worse off. But a manufacturer who moves his or her process mean to the bottom of the specification range imposes a much larger loss - say 20,000 - on his or her customers so that he or she can make a 10,000 Yen profit.

The Total Loss to Society model appears to be more culturally specific than the other models mentioned briefly here. It will undoubtedly come to the forefront in the West over the course of the next few years.

**2.4.5 Common Characteristics of the Cost Models**

Table 2.1 details the four main costing models. The common characteristics of the models are detailed briefly within the third column.

Cost Model	Essential Elements	Common Elements
PAF Model	<ul style="list-style-type: none"> <li>- Site or dept specific.</li> <li>- 4 main categories (P, A, Fi, Fe).</li> <li>- Many individual cost elements.</li> </ul>	<ul style="list-style-type: none"> <li>- Site or dept specific.</li> <li>- Uses a set "formula".</li> <li>- Can be individually tailored.</li> <li>- Generally accepted.</li> </ul>
Process Cost Model	<ul style="list-style-type: none"> <li>- Site or dept specific.</li> <li>- Individual process steps identified.</li> <li>- Inputs &amp; outputs of each process step identified.</li> <li>- 2 main categories (COC, CONC).</li> </ul>	<ul style="list-style-type: none"> <li>- Site or dept specific.</li> <li>- Uses a set "formula".</li> <li>- Can be individually tailored.</li> <li>- Generally accepted.</li> </ul>
Economic Balance of Quality Cost Model	<ul style="list-style-type: none"> <li>- Site or dept specific.</li> <li>- 2 main categories (COC, CONC).</li> <li>- If no investment in COC CONC will be high.</li> <li>- If invest in COC CONC will decrease.</li> </ul>	<ul style="list-style-type: none"> <li>- Site or dept specific.</li> <li>- Uses a set "formula".</li> <li>- Can be individually tailored.</li> <li>- Not generally accepted.</li> </ul>
Total Loss to Society Cost Model	<ul style="list-style-type: none"> <li>- Identifies loss imparted to society from the time a product is shipped. This through either:                             <ul style="list-style-type: none"> <li>- variability of function.</li> <li>- harmful side effects.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>- Focused upon the effect the end product has upon society.</li> <li>- Not generally accepted.</li> </ul>

**Table 2.1 - Common Characteristics of Quality Cost Models.**

Chapter four, section 4.2, details the models chosen for testing within the host company from those outlined above.

## 2.5 What is Total Quality Management?

Total Quality Management (T.Q.M.) is a phrase which has evolved within the past two decades. It is still not widely understood by British industry, but elements of it are becoming more and more widespread, as its effect becomes known. Below are some of the standard definitions given by various quality gurus.

TQM is referred to by Feigenbaum (12) as "Total Quality Control" which encompasses the four principles of control: setting standards; appraising conformance to these standards; acting to ensure standards are met; and planning for improvement in standards. Feigenbaum suggests that this provides an integrated operating system for managing all functions within the organisation.

Oakland (42) states that TQM is an approach to improving the effectiveness and flexibility of business as a whole, and is a method of ridding peoples lives of wasted effort by involving everyone in the process of improvement.

Ishikawa (43) uses the term "Company-wide Quality Control". This describes the involvement of all functions within the organisation in managing quality. Ishikawa makes use of the customer-supplier relationship within the company, stressing that every member of the company has both a supplier and a customer. This approach is designed to encourage cross-fertilisation between departments and sections within the company in order to optimise the value added to the product offered to the end-user.

Dale (44) sums up the above views, and more, when he maintains that "despite the divergence of views on what constitutes T.Q.M. there are a number of common threads running through the various definitions. These include everyone in the organisation is involved in improving on a continuous and never ending basis the processes under their control; each person is committed to satisfying their internal and external customers; teamwork is practised in a number of forms; the development of employees through involvement; participation by everyone in the business is positively encouraged and practised; and customers and suppliers are integrated into the improvement process".

Dale goes on to state that the implementation of TQM should be referred to as a process and not a programme. This is because "any organisation that claims they have achieved TQM will be overtaken by the competition. Once the process of quality improvement has been halted, under the mistaken belief that TQM has been achieved and the ideal state reached, it is much harder to restart the process and gain the initiative of the competition" (45).

## 2.6 The Role of Quality Costing in Total Quality Management.

Fact based decision making is an integral part of T.Q.M., as is the establishment of standards, effective feedback and communications. These crucially depend on the measurement of appropriate variables. In fact, effective data collection, analysis and measurement is a necessary condition for the implementation of a successful T.Q.M. programme (46).

As part of an ethos of T.Q.M. or Continuous Improvement, "Quality Costing" may be used at a number of different levels to produce such data. It may be used to compare the quality cost performance of one plant or production line with another. Not in an effort to berate people, but to educate and transfer successful techniques and ideas within organisations.

In being able to monitor trends in quality costs valuable information, not data, becomes available to management. This can be used as a sound base for decision making. It allows for the budgeting of future quality conformance costs; setting of improvement goals; deciding upon which quality costs need to be reduced; and deciding where more investment in prevention could produce quantifiable savings. It ultimately gives management the required information to formulate strategy.

A common theme of success or failure with quality improvement programmes is the issue of measurement. In many ways the financial indicators used in many businesses have remained static while the environment in which they operate has changed dramatically (47). Therefore for any improvement programme to succeed relevant financial indicators are essential.

According to BS 6143 (28):

"The first step in any improvement programme is the identification of quality problems, and a problem in this context is defined as an area of significantly high quality costs. Every problem so identified by quality costs provides an opportunity for greater customer satisfaction and profit improvement.

The quality costs proposals made in this guide (BS 6143 - 1983) form a sound basis for such an approach. Their application will be most effective when conducted within the framework of an appropriate company strategy, backed by a committed work force, and supported by sound quality costs procedures".

Typical Quality Cost estimates are found to be as much as 25 per cent of turnover (20), and the first attempts to estimate the quality related costs are prone to gross under estimation: Crosby suggests 30 per cent of the true value. The reasons for this are as follows: the information has not been collected previously, the figures are therefore difficult to find, and sometimes inaccurate; those collecting the information sometimes assume that "quality costs" are simply the costs incurred in running the quality department itself; often the costs resulting indirectly from rejected and scrapped work in progress are overlooked.

The importance of measurement is recognised by many of the quality awards. Measurement is an integral element of the Malcolm Baldrige, European, Australian, and Canadian quality awards. The quality measurement system has many roles to play: to provide feedback for driving improvement efforts; to provide standards for establishing comparisons; to highlight quality problems and determine which areas require priority attention; to give an indication of the costs of poor quality; and to justify the use of resources (42).

The actual collection of the costs incurred in running an organisation is usually seen as being the job of the finance department, and more specifically the management accountant. Quality costs have not been treated as an issue for management attention in the past, and the costs have not been routinely collected. It is therefore often difficult to extract them from the management



accounts and to use the information generated effectively. In practice the collection of quality related costs usually falls to the quality department itself, at least to start with.

The finance department needs to be involved in order to do the following: demonstrate what the exercise is trying to achieve; discover where the difficulties lie in presenting the information in a desired format; ensure the quality cost figure determined by the exercise will be fully supported. Finance can also aid in producing figures which are valid within accepted limits of uncertainty, without wasting effort in establishing unnecessary levels of accuracy.

Once collected with the full support of the finance department, presenting the findings to senior management in order to educate is the next task.

Musgrove and Fox (32), suggest that when done in the correct manner, the following gains are possible:

- i) Some measure of quality, and savings potentially available;
- ii) A means of comparison between product and product, production unit against production unit, and possibly between the company and its competitors;
- iii) A base line against which future goals can be set, and improvements measured;
- iv) Encourages the acceptance of quality cost data gathering as a routine financial activity.

Essentially the ability to justify improvements on a cost basis will, to a certain extent, guarantee the success of any improvement initiative. People do listen when money is involved, this therefore makes it a very valuable tool when used in the correct manner. Deming (48) stated that "if it is not measured it would not happen".

Simple measurement and dissemination of results often leads to improved performance. At Texas Eastman, management supplies the operators with an income statement that shows the employees how their decisions affected the bottom line. Once employees were given this information, unit's profits doubled in four months and quality measures improved by 50 per cent (50). The fastest and best way to improve performance is to provide feedback from both the external and internal customers. Once quality measures are established and reported to employees, an immediate and permanent improvement in performance typically results (51).

### 2.7 Conclusions

The value of cost data should not be underestimated. Costs are a most effective way of drawing attention to situations in ways that other data cannot. Unfortunately, the whole process of definition, collection, reporting and use of quality related costs has not yet developed enough so it can be used in the way many other costs are. Size and proportion of costs can be used successfully as criteria for deciding whether to act, what resources should be committed and the ordering of priorities.

Within this chapter a number of cost models have been described. This thesis will explore the use to which a number of them may be put to within a specific industry.

# CHAPTER THREE

## PLASTIC INJECTION MOULDING: COURTAULDS PACKAGING

### 3.0 Introduction

This chapter aims to introduce the host company, its systems and structures to the reader, as well as providing an outline of the plastic injection moulding process. The information presented was gathered through analysis of various documentation and participative observation.

The chapter outlines the company systems and gives a general overview of the plastic injection moulding industry. This will help to provide the necessary background to the specifics of the research, which will aid the understanding and therefore the potential utilisation of the research itself.

The chapter is divided into the following sections:

- 3.1 - Company Background.
- 3.2 - The Wrexham Site.
- 3.3 - Plastic Injection Moulding
- 3.4 - Outline of Manufacturing Production Techniques.
- 3.5 - Quality Assurance within the Company.
- 3.6 - Betts Plastics Continuous Improvement Drive.
- 3.7 - Outline of Present Accounting System.
- 3.8 - Quality Costs within the Company.

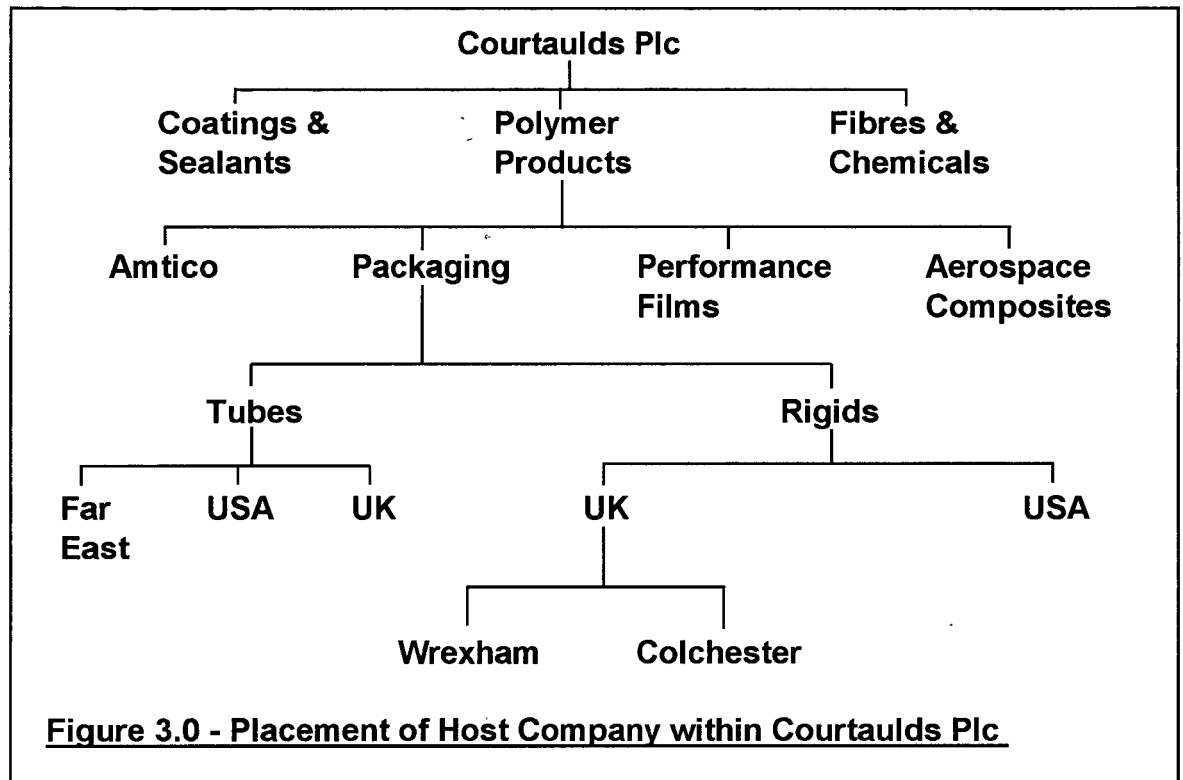
### 3.1 Company Background

This section will outline some of the specifics of the host company. It also details briefly the market sector within which the company operates.

Betts Plastics is an operating division of Betts and Company, which is a wholly owned subsidiary of Courtaulds Packaging. Courtaulds Packaging in turn, is a wholly owned subsidiary of Courtaulds Plc.

Courtaulds Plc employs 21,000 people and operates in 41 countries specialising in the manufacture of products for protection or decoration in a wide range of

environments. The company operates in five broad business areas: coatings; performance materials; packaging; chemicals; fibres and films (see figure 3.0) . In the financial year 1993-1994 it had a turnover of approximately £2 billion.



Courtaulds Packaging employs 1,600 people and it had a turnover of £116 million in the financial year 1993-1994. It produces both rigid and flexible packages and has manufacturing facilities in the U.K. and the U.S.A.

Betts and Company was acquired by Courtaulds in 1958. It employs 570 people and its turnover in the financial year 1992-1993 was £42.5 million. The company manufactures closures, thin wall containers and pharmaceutical products for the food and beverages, pharmaceutical, cosmetic and toiletry industries. Betts Plastics, within which this research project is based, employs 380 people.

Over the preceding thirty years Betts Plastics has developed an unrivalled capability in injection moulded plastic packaging (it produces in excess of two billion mouldings per year). The company has an extensive research and development facility, as well as access to Courtaulds Packaging Technology Centres at Bristol and Coventry which specialise in applied chemistry and

polymer science. In addition, there is an expertise exchange agreement with Knight Engineering in the United States (a Courtaulds Company) and a close relationship with its sister division Betts Tubes, which specialises in the production of plastic, aluminium and laminate tubes.

The company has made substantial investment at its manufacturing centres in Wrexham and Colchester, each centre incorporating the latest moulding and automatic assembly techniques using automatic moulding lines, robotic handling, in-line testing and visual inspection. In order to meet the increasing demand from pharmaceutical and medical companies for contamination free products, both sites have clean room manufacturing facilities.

Betts Plastics also performs a number of "finishing" operations (decoration), which include: silk screen printing, embossing, wadding, foil blocking, and the application of tamper evident solutions.

The customer base is large. Some of the more high profile customers include: Boots Contract Manufacturing, Pitman Moore, Johnson & Johnson, Sara Lee, Glaxo, Fisons, Upjohn, Proctor & Gamble, Pfizer, Robert McBride, Elida Gibbs, L'Oreal Golden and Bristol Myers-Squib.

### 3.2 The Wrexham Site

The Wrexham site was acquired by Courtaulds in 1978. In 1989 the decision was made to expand and in 1990 the new purpose built factory was completed. It is located adjacent to the original site. In 1991 a project to build a clean room within the manufacturing site was started. The project was completed in 1992.

The site is currently at stage two in a three stage development. Stage one saw a purpose-built factory constructed with floor area of 4645 square meters, 61 employees, 23 moulding machines, and 6 finishing machines. The key aspects of the site were the automated raw material handling system (polymer granules drawn under vacuum directly to the moulding machines) and the automated

product handling system (components transferred from conveyors to plastic tote bins, then picked-up by Automated Guided Vehicles - A.G.V.s).

Stage two, the current status of development, sees the site grow to 6039 square meters, 96 employees, 34 moulding machines, have a class "J" clean room (this refers to a 10,000 particle air count, taken within one square meter of air), 6 clean room moulding booths, and 11 finishing machines.

Stage three, for which the capital has already been cleared by Courtaulds and is proposed within the next three years, will see the site expand still further to 7432 square meters, employ 130 people, have 55 moulding machines, 22 clean room moulding booths, and 14+ finishing machines.

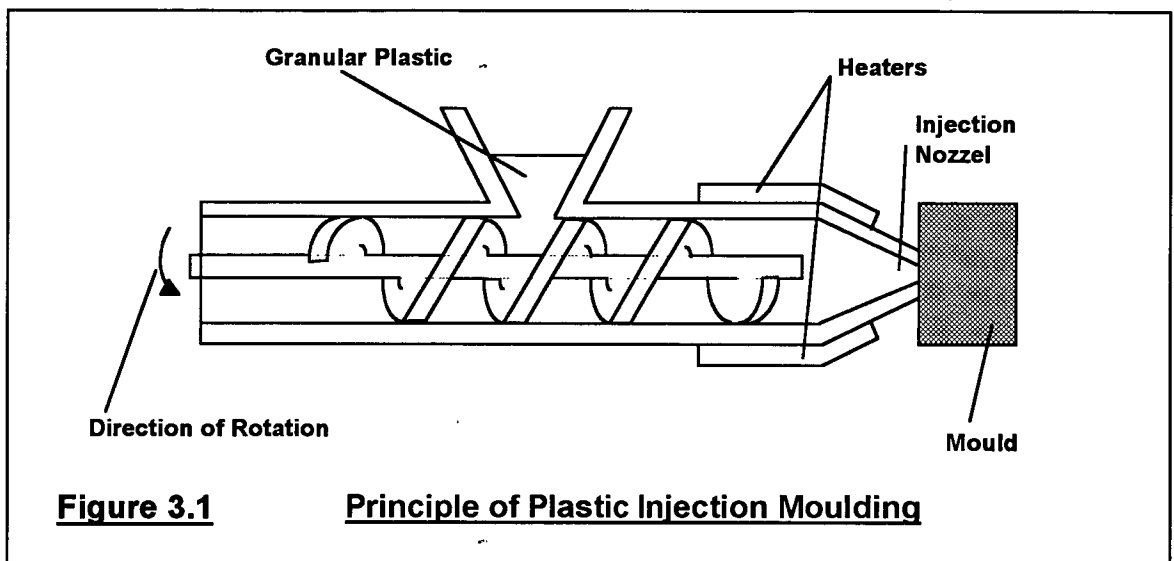
The Wrexham site has three departments: Personal Health Care (P.H.C.) - where components are moulded; Finishing - where moulded components receive secondary treatment; and the Clean Room - where items are moulded and assembled for a range of pharmaceutical customers.

### 3.3 Plastic Injection Moulding

In order to appreciate some of the technical detail discussed in later chapters it is important here to outline the actual process of plastic injection moulding.

More thermoplastic products are produced using injection moulding than by any other process. A diagrammatic representation of the process is shown in figure 3.1. Raw material in the form of cold granular plastic is fed by gravity from a hopper into a chamber containing a large rotating screw. As the screw turns, the granular plastic is forced through a cylinder and is heated to between two and three hundred degrees centigrade. The heaters are generally of the electrical resistance or induction type and can be regulated to the desired temperature to suit the type of plastic in use.

The screw performs a dual function, while rotating it fully plasticises and homogenises the raw material and at the same time it act as an injection ram,



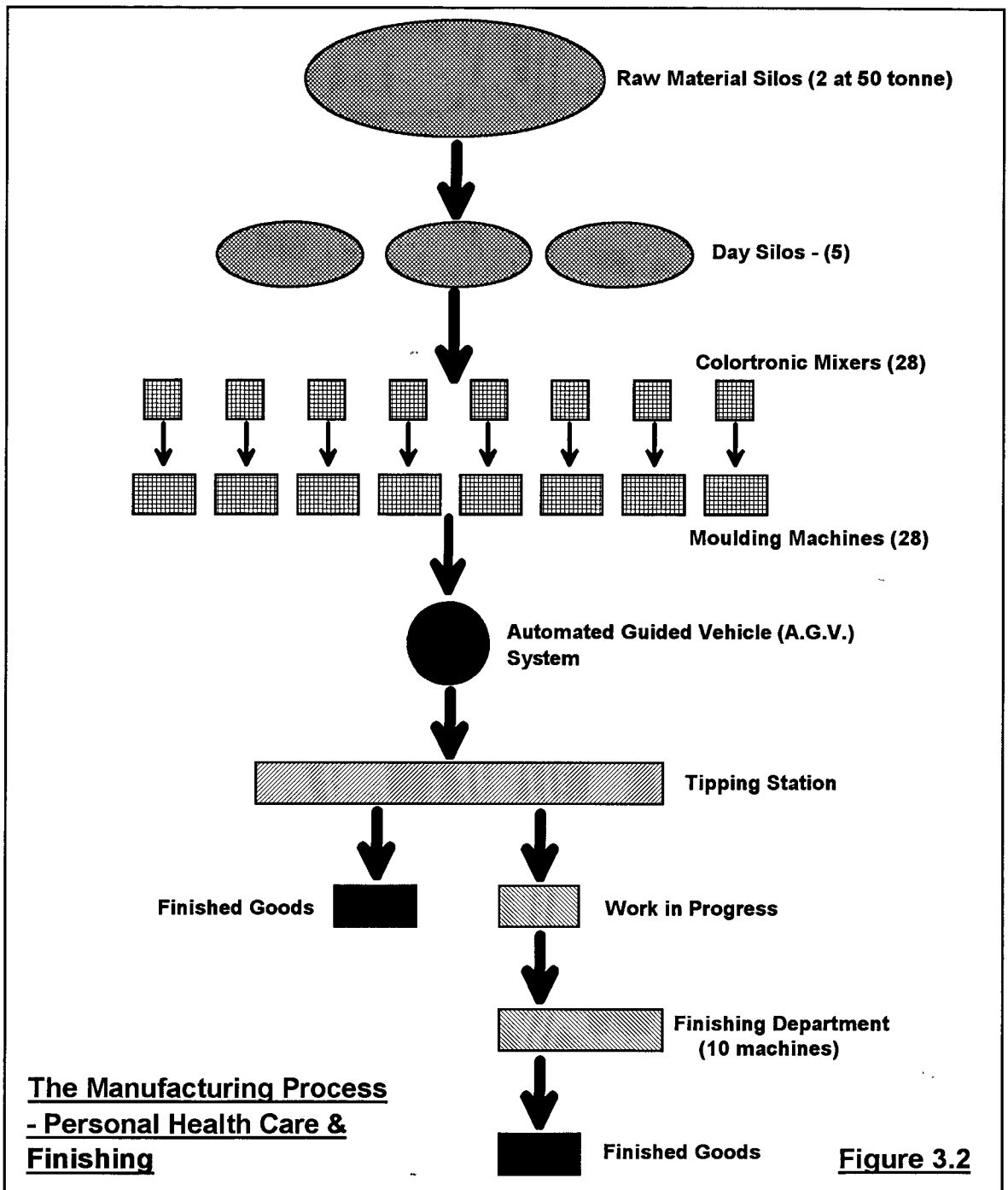
moving back and forth within the injection moulding cylinder. During the start-up cycle the screw rotates and conveys the granular plastic, which is being heated by the cylinder and mechanically worked throughout the length of the screw, to the front of the cylinder into the injection nozzle.

At the injection stage, the plasticised material is forced into the mould cavity by means of the screw acting as a hydraulic ram through the injection nozzle, seated against the mould, this allows the molten plastic to enter the closed die cavities through suitable gates and runners. The die is cold, therefore allowing the plastic to solidify almost as soon as the mould is filled. To ensure proper filling of the die cavity, the plastic is forced into the mould rapidly and under considerable pressure. While the mould is being opened, the parts are ejected. The mould then closes as the material for the next part is being heated. The cycle then starts again.

#### 3.4 Outline of Manufacturing Production Techniques

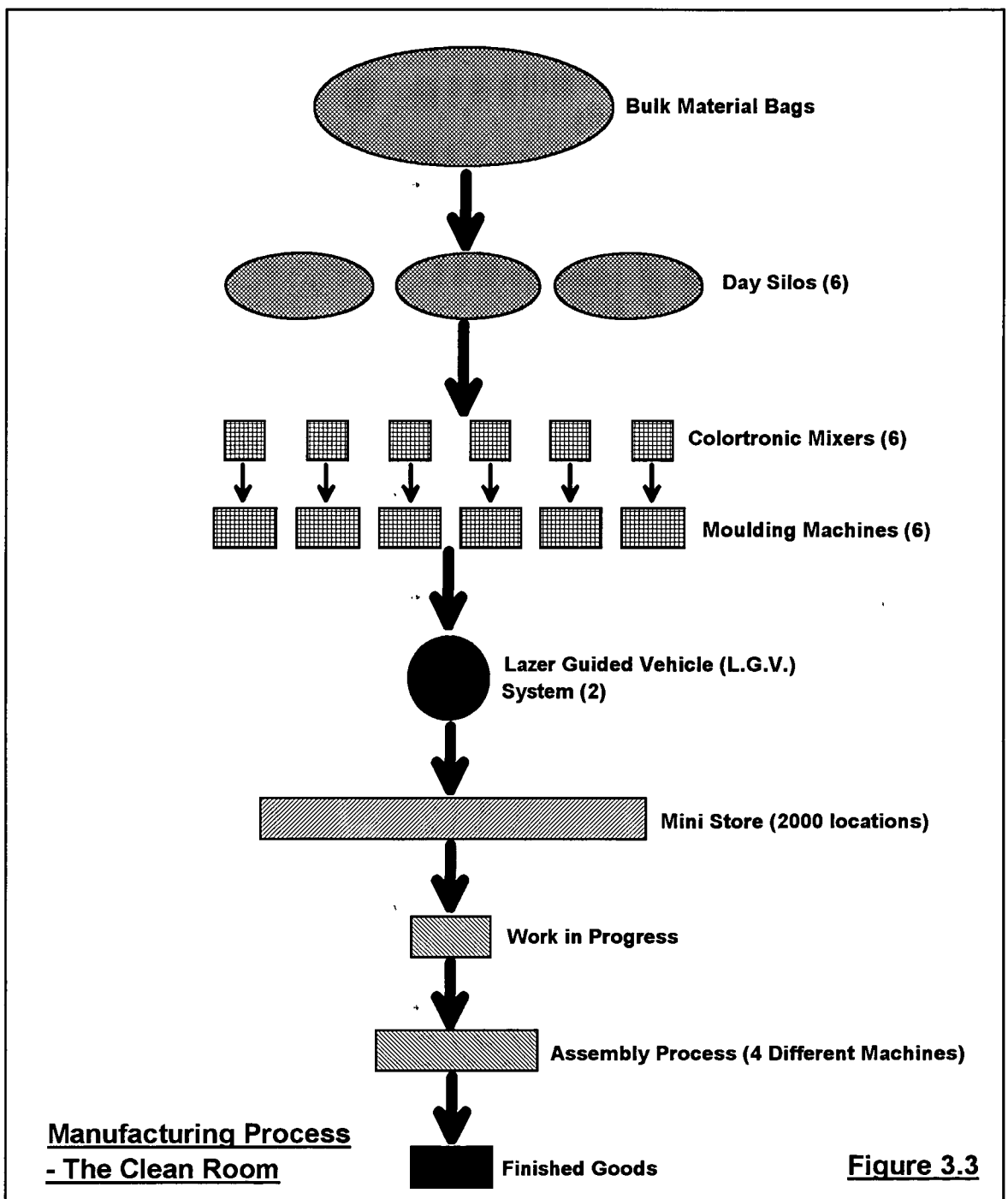
The Wrexham site is quite unique in its operating principles. As such it utilises the most modern equipment available to optimise the efficient production of plastic injection moulded components. It is, therefore, important to describe this operation in order that later discussion may be fully understood.





The chart depicted in figure 3.2 represents the manufacturing process for personal health care, and the feed of components into the finishing department. The natural granulated plastic and Masterbatch dyes (colorant) arrive at the factory by road transport, where they are stored in specific silos. The raw material is then ready for the injection moulding process, and is drawn under vacuum to individual moulding machines (this process is controlled by a computer system).

Immediately prior to being deployed into the injection barrel, the colour match is made. This is done at the moulding machine using Colortronic mixing equipment. Components are produced at the injection moulding machines, then picked up by the A.G.V. system. This system transports the moulded product to an automated packing line. The product is placed on the line, travels a short distance on rollers to a tipping station, and is deposited into automatically made cardboard boxes (lined). The boxes are sealed then placed in the required pallet location. From here the product either goes out as finished goods or is put into Work-In-Progress (W.I.P.) before undergoing a secondary "finishing" operation.



### Chapter Three

The process flow for the Clean Room, demonstrated in figure 3.3, is somewhat similar, although in this instance the specialist raw materials are delivered in bulk bags. These are then decanted into the six dedicated silos (each moulding machine has its own material silo). From here the material is drawn under vacuum to the individual moulding machines (again controlled by the computer system). Components are produced at the injection moulding machines then picked-up by the Laser Guided Vehicle (L.G.V.) system. This system transports components to the mini-store where they are placed in one of 2000 locations and held as W.I.P. When required for assembly, specific components are called out and transported to the dedicated assembly machine at which they are needed.

Once assembled, tested, and passed off to a rigorously high standard, the components are shipped out as finished goods.

The Clean Room is a manufacturing area that has a controlled environment of which access and egress of personnel is strictly monitored. Wrexham's Clean Room is class "J" or class 10,000. This refers to the particle air count which must not exceed 10,000 microns within one square meter of air. This is the highest standard possible with people and assembly machines within the same area. Essentially the Clean Room is a completely separate production environment, and is treated as such during the cost collection phases of this research work.

The Finishing Department (as depicted in figure 3.2) within the main factory is dedicated to performing secondary operations to moulded products. This may take the form of decoration with the customers logos, instructions, or a range of embossing, printing, or perhaps foil blocking. There are ten individual Finishing Machines that perform a variety of tasks. Simple assembly work also takes place, for example, the production of tops for talcum powder bottles.

Any rejects or scrap created as a by-product of the manufacturing process is sold to another company for reuse on lower grade products.

**3.5 Quality Assurance within the Company**

The following section will detail the philosophy behind the host company's approach to quality and the systems it utilises in this particular arena. This is considered important as reference is made to specific areas when discussing the methods used to collect quality cost information.

It is important to recognise that quality is an individual issue for specific organisations. All companies need to tailor their objectives, strategies and goals in order to suit their respective organisational cultures and market positions. The foundation of an improvement culture must include a policy statement on the above. This states clearly and concisely what is expected of all employees, as well as the products and services delivered to customers (52).

Following from the above, Courtaulds Packaging - Betts & Company, in keeping with most other large multi-site organisations, has its own company charter. This is on display at each of the companies production centres and on the reverse of all company business cards (Figure 3.4).

<p><b>Figure 3.4</b> <b>- Betts Charter</b></p>	<p><b><u>Betts &amp; Company</u></b> <b>CHARTER</b></p> <p>The aim of our company, simply stated, is to be</p> <p><b>‘THE BEST’</b></p> <p>To meet our customers` needs faster, better and more distinctively than international competition based upon Service and Quality.</p> <p>What you want, when you want it, better than you thought possible.</p> <p>We are committed to continuous improvement in Communication, Environment, Manufacturing, Training and Health &amp; Safety.</p> <p>Through this aim it is our belief that true partnerships will be forged with customers, employees, suppliers and the community, based upon genuine mutuality.</p>
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The responsibility for quality assurance within Courtaulds Packaging, Betts Plastics (Wrexham), lies with the quality department. Quality assurance is also directly linked with the production operatives, as will be discussed later. The

quality department's actual responsibilities break down into a number of specific areas. These are:

1. BS EN ISO 9000 - The operation and modification of the procedures laid down in the sites Quality Manual. (Both the Wrexham and Colchester sites are registered to BS EN ISO 9001. Both Clean Room operations approved to the B.S.I. Pharmaceutical Code of Practice).
2. Complaint Administration - Speedy resolution of customer complaints and regular review meetings to study the effectiveness of the system.
3. Quality Systems - The initiation, development and auditing of modern quality methods to detect and resolve manufacturing problems prior to them causing the manufacture of defective parts. This will include the development of the 8-Discipline problem solving technique (see appendix 1b), Statistical Process Control, and Failure Mode and Effect Analysis.
4. Problem Identification - The site quality department creates systems that will identify chronic manufacturing problems, areas of waste, effectiveness or ineffectiveness of administration and paperwork, etc.
5. Customer Interface - The Quality Manager organises regular meetings with all site customers to ensure that the quality systems within the operation are in line or better than customers' expectations. This also allows the Quality Department to identify much earlier changes in customers' quality demands. The Quality Department is also responsible for achieving the company's goal that every employee within the business visits at least one customer per year.
6. Communications - The Quality Manager is responsible for ensuring that clear and regular "quality" information is supplied to all company employees, with regard to the products that the Division manufactures.

7. Quality Costing - A system of quality costing that clearly indicates the total cost of quality from each department within the company.

Within the company structure there exist a number of individuals who work specifically within the quality department. At each site a Quality Manager works with a team of four people to fulfil the above responsibilities. Two of these individuals work full-time within the Clean Room environment, the other two working across the rest of the site (Personal Health Care and Finishing). Liaison also exists with the central laboratory function, based at the host company's other site.

One of the many systems put in place to maintain consistently good product quality is the Component Pass-Off procedure. This procedure specifically details what is to be done before any job is considered ready to go into full production. It requires the moulding machine operator, the moulding tool setter, the moulding machine material handler, and the moulding-machine technician to conform to certain set criteria during the set-up of a machine, prior to commencement of production. This is applied for the personal health care area, the finishing department, and the clean room (appendix 1a).

Once the job is passed for production it is handed over to the operator responsible (some of the operators are responsible for up to fourteen machines). The operator continuously inspects product quality, but is called to formally acknowledge this on a two hourly basis on a simple but effective audit sheet (appendix 1a). This sheet, in conjunction with a visual attribute sheet, asks the operator to sign off production during the lapsed time period as conforming to certain pre-set job specific criteria (appendix 1a).

These records have a number of purposes. They allow any operator to determine how effectively a particular machine has been running and to assist the technicians when they problem solve. They are kept for a period of three months in order to aid traceability of any particular problem, and essentially form a production log for individual components.

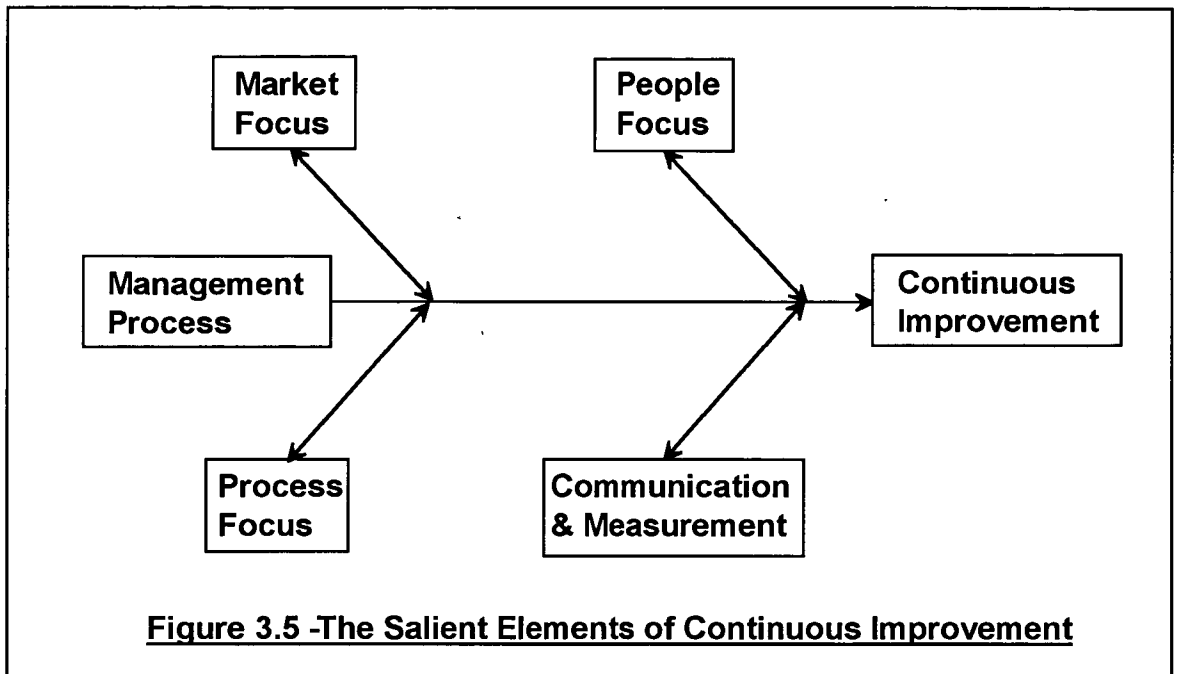
### 3.6 Betts Plastics Continuous Improvement Drive

The host company's continuous improvement initiative was an intrinsic element of the quality costing research which forms the basis of this thesis. This section will briefly detail this enterprise.

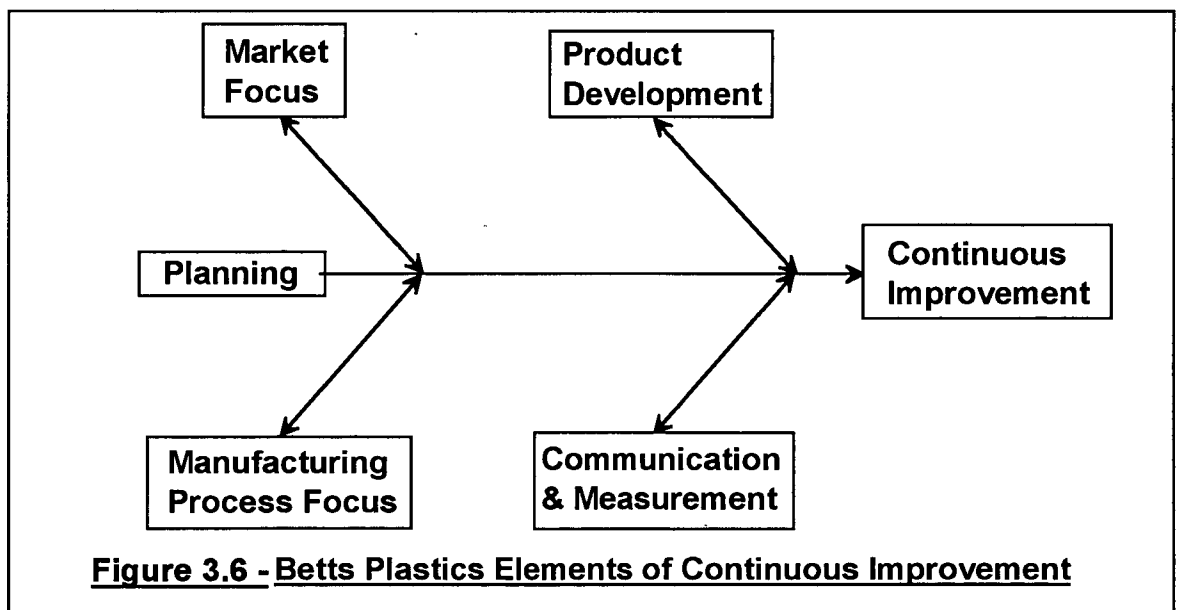
The continuous improvement drive, as already stated in chapter one, started as a collaboration between Betts Plastics and Middlesex University Business School (M.U.B.S.). The aim was to develop a workable methodology for the introduction and sustainment of a "Continuous Improvement" programme at the host company. The initial approach adopted was developed at M.U.B.S., then modified to fit Betts's requirements. It was decided to pilot the model in one manufacturing area before application within the whole company. In accordance with the proposed methodology, a steering committee was established to determine priorities and plan implementation. This process produced an implementation blueprint.

The above programme was initially part of a Teaching Company Scheme that commenced on 1 January 1993, under which two Teaching Company Associates (T.C.A.'s) were employed. The author of this thesis was one of the two T.C.A.'s who facilitated the project for the duration of the two year partnership, before being appointed Quality Manager of the Wrexham site.

The implementation methodology was developed at Middlesex University Business School (53). The fishbone diagram (figure 3.5) depicts the five key elements of the Middlesex approach: market focus; process focus; people focus; communication and measurement; and management process. This methodology, unlike those proposed by Oakland (42), Juran, Crosby, and Deming (Ghobadian and Speller, 1994) is neither sequential or prescriptive (54). The improvement initiative under each major heading is identified by the host organisation, from this an implementation plan is developed.



Shortly after the start of the Teaching Company programme, the Managing Director at Betts set up a steering committee to oversee the company wide implementation of continuous improvement. This committee considered the approach proposed by Middlesex and redefined the five key elements in line with the operational characteristics of the company (figure 3.6).



The committee's work produced a definitive document which would guide the initial improvement within the Containers manufacturing area. This was the first



"blueprint" (figure 3.7) for the implementation programme to be published within the company. The specific steps within the above blue print are shown below:

1. Initial audit of the Containers operation.
2. Introduce Containers personnel to the concept of continuous improvement via presentations.
3. Employ brainstorming sessions to gather suggestions for improvement projects.
4. Perform a communication audit to establish the current state of the documentation system.
5. Perform a supplier review.
6. Use news sheets to communicate the continuous improvement message.
7. Arrange visits to customers for employees, to establish stronger links.
8. Introduce machine monitoring.
9. Introduce scrap graphs.
10. Perform a customer survey to ascertain customer perceptions.
11. Form continuous improvement teams.

At the same time, the steering committee established a number of measures which would be used to monitor the success of the various initiatives. Emphasis was placed on establishing positive measures that could be related to by all company personnel. Such measures included reduction in scrap, percentage late delivery, and percentage first time quality.

The five steering committee project groups analysed the initiatives currently taking place within the specific areas. They had full responsibility for ensuring those initiatives considered essential were completed as quickly as possible. Prior to any action taking place, the group leader presented the outline, and objectives, of new initiatives to the steering committee. It was the committee's role to prioritise limited resources to achieve the best results.

Ten months into the project the decision was taken to go company wide with the original pilot programme in Containers. At this stage the author of this thesis transferred to the Wrexham site to take charge of the continuous improvement

initiative there, while the other Teaching Company Associate remained at the Colchester site to continue the work already started.

The Wrexham continuous improvement initiative can best be summed up by use of a flowchart (figure 3.7). This was developed in conjunction with the management team in order to serve as a blueprint for the implementation of continuous improvement. It was designed to cover a period of approximately twelve months and use was made of a Gantt chart to facilitate the planning and execution of the project (appendix 1b).

The flow chart essentially takes certain elements of the already proven tools and techniques of continuous improvement and blends them together to suit the culture of the Wrexham operation. In keeping with the common theory of total quality management, for example from Deming, Crosby, Juran, Oakland, etc, the central theme of the initiative was full involvement of the workforce in the process. This was encouraged throughout the initial stages until the basic ideas had been assimilated by as many people as possible. The improvement drive encompassed all of the following:

1. Quality Audit of the Wrexham Site

During the authors' first two weeks at the Wrexham site the main task was to conduct an "audit". This audit was to be based on the authors impressions of the site gained over a two week period. During this period of time the author conducted a number of informal interviews with a wide cross section of people.

At the end of this period of time a report of the findings was written, which was circulated amongst senior management and used as a basis for the development of the implementation blueprint (copy of report in appendix 1b).

2 Introduction to Continuous Improvement Presentations

The aim here was to introduce the personnel of Wrexham to the ideas and philosophies surrounding Continuous Improvement, to introduce the author to the

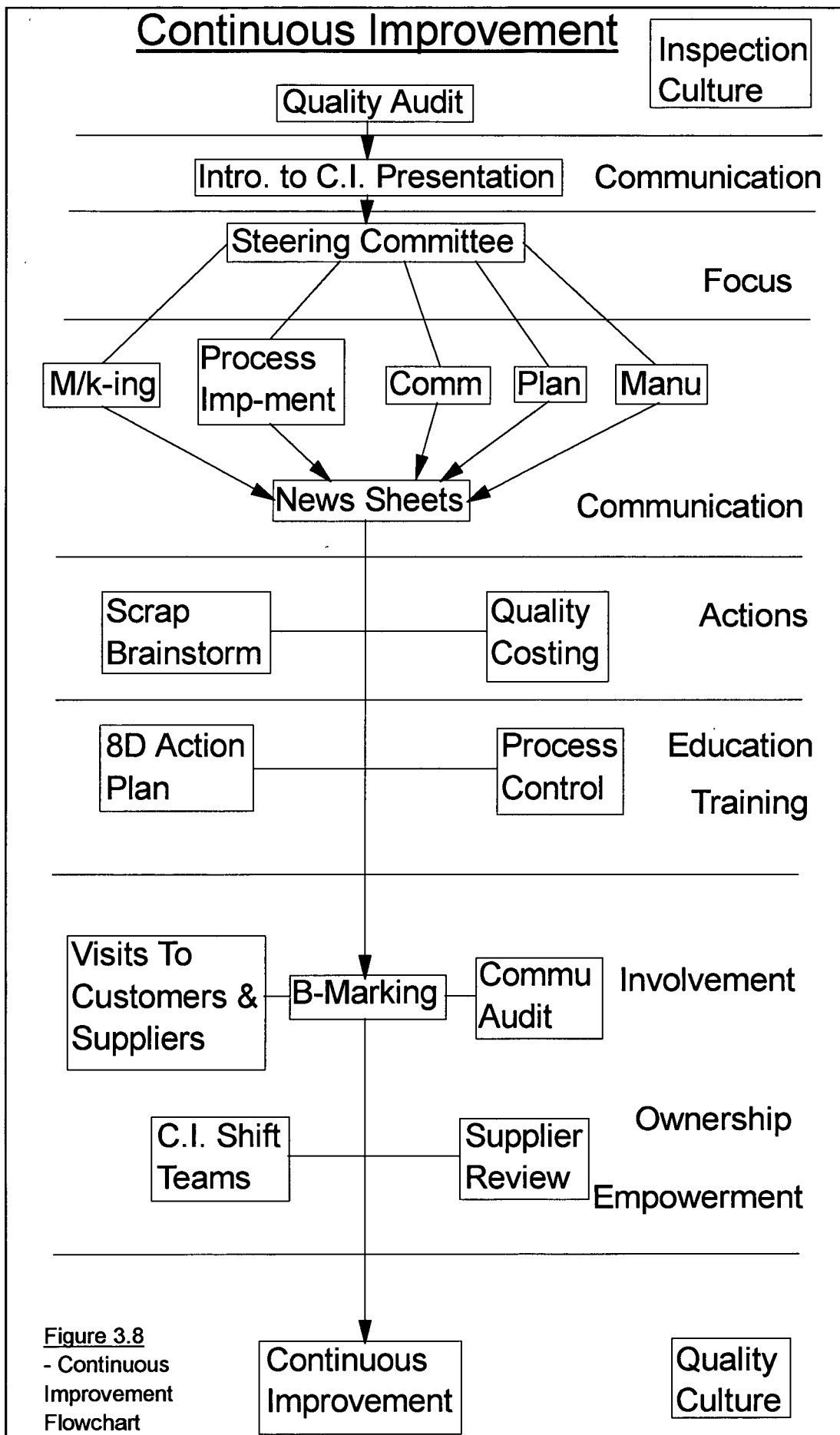


Figure 3.8  
- Continuous Improvement Flowchart

personnel, and to introduce the Teaching Company Scheme.

The sessions provided an ideal opportunity for employees to ask questions, and to air grievances of the management's treatment of them over the preceding three to four years. The presentation covered:

i) Continuous Improvement - What is it?

ii) What does it involve?

iii) Tools and Techniques?

- Quality Costing; Brainstorming; Cause and Effect Diagrams; Benchmarking; Quality Improvement Teams; Check Lists, Charts, Graphs; Statistical Process Control; What are the benefits?; Does it work?; The next step.

The presentations were done over a six week period to all Wrexham personnel, approximately one hundred people (overheads in appendix 1b).

### 3 Steering Committee

In order to guide the implementation of the Continuous Improvement initiative at Wrexham, a "Steering Committee" was set up using the same principles as the Colchester site. The management team was enthusiastic to take part.

### 4 News Sheets

Produced on a fortnightly basis by members of the management team these are displayed on two main notice boards. One is in the company canteen, the other next to the exit from the mould shop. They were and are very well received (appendix 1b).

5 Scrap Brainstorm Team

In order to capture the imagination of the workforce it was necessary to pick a high profile issue to tackle using the brainstorming technique. The elimination of production scrap was chosen as being of the utmost importance. Following a brainstorming session and a monitoring exercise, spillage from the moulding machines was viewed as the biggest single contributing factor. In order to highlight this, a high-profile poster was designed and displayed on all company notice boards (appendix 1b). A number of initiatives then took place, which reduced the £28,000 loss per month by approximately seventy per cent (some of these are detailed within chapter seven section 7.3).

In order to justify the "spend" necessary to solve some of the issues, a "Project Proposal" form was developed (appendix 1b).

6 Quality Costing Initiative

Essentially, the research work for this thesis was an element of both the continuous improvement initiative and the author's daily work. The existing Management Information System provided some data that could be used for quality costing purposes, but not nearly enough. So, in conjunction with other quality initiatives performed at the Wrexham site, the establishment of accurate and regular data recording was essential.

This was tied in with a Project Proposal form developed as part of the quality initiatives. Through using this, people became convinced that they needed accurate data and information in order to justify any proposed improvement activities. This represented a real change in thinking by some individuals.

7 Eight Discipline Action Plan

This is essentially a team approach to solving production problems, both internal and external. The concept has been borrowed from the Ford Motor Company and adapted for use within the plastic injection moulding industry. It is simply one

piece of paper that asks a specifically chosen cross-functional team a series of eight questions, in order to aid the establishment of the root cause and the generation of a solution, to any problem (see appendix 1b).

#### 8      Process Control

This is the control of the moulding process through weighing the components as they are produced. The weights are plotted on attribute charts and this information is used to influence technical decisions about the setting of the moulding process. The exercise started initially on just one moulding machine, it is now in place on all thirty four production units. An example of a process control chart is presented in appendix 1b.

#### 9      Visits to Customers and Suppliers

One of the steering committee's (and quality departments) objectives was to have as many employees as possible visit customers and suppliers. This has a number of positive benefits, such as an improvement in morale (a break in the regular pattern of work), an increase in the level of interest (as people now understand where the product is used), and perhaps more importantly, the problems that can occur when defective components are sent highlighted. It also gives the customer and supplier an image of real people, not just a name on a box. The overall benefits of this initiative are difficult to quantify in monetary terms, but have had an impact on employee moral and customer focused awareness.

#### 10     Benchmarking

This is a joint project run in conjunction with members of the research staff at M.U.B.S. Essentially, the exercise was split into three parts: i) The order placement system; ii) The moulding process; iii) Order dispatch. After finding two companies who were willing to take part in the exercise, M.U.B.S. interviewed three parties and collected a great deal of information. This information was then

used to improve specific areas of the company by "borrowing" successful techniques.

## 11 Communication Audits

These involve attaching all the documentation which is required to run a specific area or department onto a large surface (usually a wall - covered with brown paper to protect the paint or paper, and to allow the exercise to be moved or stored) in order of creation and use from left to right in four specific categories, top to bottom: 1. Forecasting; 2. Planning; 3. Control; 4. Reporting.

At the Wrexham site this was done for the Personal Health Care department and the Finishing Department. The exercise within the personal health care yielded the following results:

- i) Four documents were introduced.
- ii) One document was removed.
- iii) Four documents were updated and redesigned.

The exercise gave employees an overview of the system they operate within, and an opportunity to adapt some of the forms they used on a regular basis. It brought to everyone's attention the fact that they could control the system that they worked within, and that it did not control them.

## 12 Continuous Improvement Shift Teams

These are the real backbone of Wrexham's continuous improvement initiative. The teams are formed from the five shifts that operate on the site. The shift pattern is continental, in that in any one week an individual shift will work mornings, afternoons, and nights. Only three shifts will work in one twenty four hour period, with one of the remaining two shifts being on a two day rest period, the other on a sixteen day break.

The management team decided to invest substantial training in the tools and techniques of Continuous Improvement for the shifts, before asking them to take

part in any problem solving schemes. Five training sessions were developed to introduce fully the basic techniques of Continuous Improvement. They covered;

Session One - Video & Discussion (B.B.C. Kiazen video, purchased by Betts Plastics).

Session Two - Introduction to Continuous Improvement Teams:

1. History.

2. Five stage problem solving approach;

- i) Define the symptoms.
- ii) Finding a solution.
- iii) Submit a proposal.
- vi) Communication and training.
- v) Implementation.

Session Three - Problem Analysis (Three Separate Activities):

i) Problem Identification.

Techniques: Brainstorming & cause and effect diagrams.

ii) Problem Definition.

Techniques: Systematic data collection, Data presentation diagrams, Pareto analysis.

Session Four - Problem Analysis (continued):

Techniques: Recap on pareto analysis.

iii) Generation of solutions.

Technique: Solution and effect diagrams.

Session Five - Pick a specific problem to work through.

Techniques: Brainstorm to find a topic of mutual interest for the entire shift.



The training package developed to complement the above is presented in appendix 1c.

Once the above training sessions were complete, the shifts forged ahead with improvement projects during the weekly continuous improvement sessions held by each shift. These had a substantial impact on the overall performance of the Betts Plastics Wrexham operation. For example, external customer complaints were reduced by forty per cent over a twelve month period because of the direct impact of team working. Scrap produced as a by-product of the moulding process was reduced by ninety per cent during the same period. Machine utilisation increased by fifteen per cent. Other examples of the team initiatives are given in chapter 7 - Quality Improvements Through Quality Costing.

### 13 Supplier Review

The departmental managers (Warehouse Manager, Engineering Manager, Process Development Manager, Tool Room Manager, Commercial Manager, Site Administrator, Clean Room Manager, Quality Co-ordinator) were asked to highlight their individual suppliers from a master listing provided by the purchasing department.

This information was then grouped on a spreadsheet and enquiries were made into suppliers performance and level of service. The listing was categorised into a number of specialist categories:

1. Raw Material.
2. Colorants.
3. Additives.
4. Machines.
5. Packaging.
6. Contractors.
7. Various Equipment.
8. Spares / Supplies.
9. Consumables.

10. Transport.

A "spend" figure (year to date) was provided for each of Betts` suppliers, a total figure, and an average "spend" per company. The document was then passed to the purchasing department for formal enquiries to begin.

Simple improvements made in this area included the holding of stock items by raw material suppliers on their shelves on a three day call off, at no extra charge. The holding by electrical suppliers of specific specialist items on their shelves and free delivery, at no extra charge. These reductions in lead-times have aided the efficiency improvement drive.

The above improvement drive has had a number of quantifiable effects on Betts Plastics, Wrexham. Some of these are detailed within chapter seven. It has also improved company morale.

The initiative itself has moved on from being management driven, and is now truly incorporated into the culture of the company. Effort is now focused on sustaining the existing improvement projects, and maintaining the change towards a true quality culture.

3.7 Outline of Present Accounting System

For part of this research the financial accounting system within the host firm was accessed for specific figures. As such, it is important to understand both what information it can provide, and how it functions in practice. This section will describe in brief detail the accounting system of the host company.

The Integrated Business System (I.B.S.) module feeds financial information into a financial model, this then generates all the information necessary to produce a profit and loss account, and a balance sheet. The accounting system works on a double entry bookkeeping methodology while utilising a standard costing system and a budgetary control system. It is therefore able to set standard costs for raw

materials and standard products, based on a Bill of Material (B.O.M.). This allows the analysis of raw material, work in progress, and finished goods.

An additional feature of the I.B.S. is that a monetary value is created for items as they move from one location to another. The system will also automatically adjust raw material stock figures when finished goods are booked in.

An annual budget is produced and provides a complete financial business plan for the financial year ahead. It is generated from the sales forecast which is produced by the Sales and Marketing Director, the Financial Accountant, and the Director and General Manager of Betts Plastics. This annual budget breaks down into a number of specific areas, the main areas being;

- i) Monthly results.
- ii) Quartley Profit Forecast (Q.P.F.).
- iii) Half yearly results.

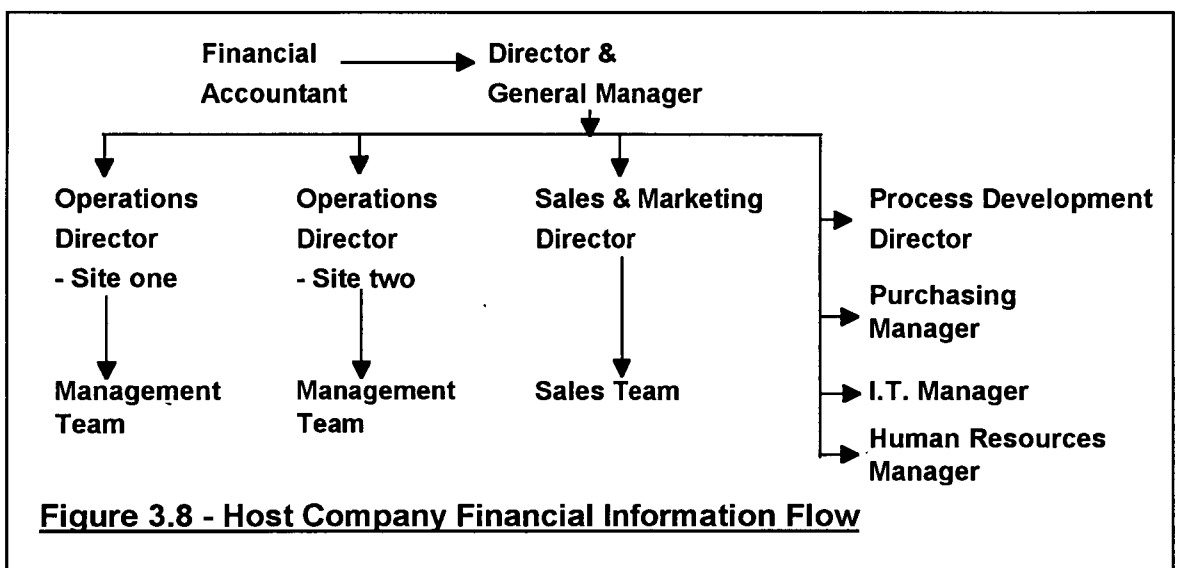
Monthly results are presented in the traditional format of a profit and loss (P+L) account. The Managing Director is provided with a Monthly Operating Report (M.O.R.), which is a slim line detailed P+L and cashflow statement. This gives him a snapshot that provides the required information to be able to establish developing trends. The senior management team is provided with a fully detailed M.O.R.. This contains special reports generated for specific managers - for example, the manager of a production cell may require certain stock control figures. Further reports are tailored for the lower levels of management by asking people what information the cells require in order to make production decisions (usually non-financial measures). For example, an increase in moulding machine cavitation on three machines will effect the bottom line eventually, but this will not be seen for a number of months. This will, however, give an indication of current efficiency levels.

These non-financial measures from the shop-floor give management the information needed to make decisions. People do not necessarily need to see the whole picture in order to make informed decisions.

Eleven key graphs are generated as part of the monthly accounts report (see appendix 1c). The graphs demonstrate actual performance (year to date) against budgeted performance (whole year). They show specifically;

- Sales.
- Adjusted Gross Contribution.
- Factory Costs.
- Profit Before Tax.
- Return on Sales.
- Personnel Costs: Sales (Moving Annual Total - M.A.T.).
- Value Added Per Employee (M.A.T.).
- Stocks (Excluding Mould Tools).
- Capital Employed (M.A.T.).
- Return On Capital Employed (M.A.T.).
- Cumulative Cash Flow (M.A.T.).

Each director is provided with a copy of the full report. Other managers are provided with data specific to their own department, as demonstrated in figure 3.8.



The P+L account breaks down specifically into the following categories;

**SALES VALUE**

Materials at Standard Cost

Normal Scrap

Purchase Price Variance

**GROSS CONTRIBUTION**

Less: Factory Costs

Selling Costs

Warehouse and Distribution

Administration

Development Costs

Process Development

Sundry Items

Exceptional Items

Projects

**TOTAL**

**TRADING PROFIT**

Less: Central Charges

Investment Income

**PROFIT BEFORE TAX**

Less: Cost of Capital

**ECONOMIC PROFIT**

A Quarterly Profit Forecast (Q.P.F.), which is now a requirement within businesses (relevant where you have public companies) is also produced. This gives confidence to the shareholders and the market through demonstrating that the company is in control of its own resources. It has within its make-up statements regarding profit, cash flow, and capital investment, making it almost

the same as the annual budget. It is in fact a complete re-forecast of the budget, based on more up-to-date information (for example, the annual budget can be prepared in September for the following financial year). This allows the document to be signed off by Courtaulds Main Board, and any requests for alterations to be considered.

The Half yearly result indicate the actual performance of the operation against the plan (annual budget). This is generated for much the same reasons as those already stated for the Q.P.F. It is made up of known financial indicators plus predicted values (it is also prepared slightly in advance).

Because standard accounting practice is only relevant for the actual publishing of information, individual companies may determine themselves how they gather the information and what they do with it internally. Courtaulds Main Board defines how the accounts are put together, and they have a standard set of definitions applied across all Direct Reporting Businesses (D.R.B.s). This is done to enable a direct comparison of diverse businesses. For example, all purchasing costs have to be put under general factory costs.

The management accounts were originally put together in such a way as to make individual managers responsible for their own departments (known as cost centre reporting). See appendix 1 for details of host companies cost ratio tree.

### 3.8 Quality Costs within the Company

Until discussions with the management occurred concerning this research, the company was unaware of quality costs as such (the only exception being the acknowledged cost of running the quality department). Senior management knew that a number of "black holes" existed within the organisation (Ref: Martin Hornby - Operations Director). The black hole theory was generated due to a number of inefficient production processes that were "sucking cash out of the business, straight off the bottom line". As management did not know the location of these inefficient processes they could not control them. They did not know of formal techniques for identifying and eliminating these unnecessary costs.

During the course of discussion with all levels of employees, great interest was shown in the possibility of developing a formal tailored package designed to pinpoint such costs. Substantial assistance, in the form of access to reports, confidential information, interviews with senior management, and so on, was freely provided.

The host company's management team identified one potential element of the research as the ability to create business performance measures tailored to identify problem areas. This supports the findings of Geanuracos and Meiklejohn (1993) who reported that managers and senior corporate officials indicated a number of significant problems with traditional business performance measures. These problems include:

- i) the measures encourage the pursuit of the wrong goals;
- ii) the measures are too financially oriented;
- iii) the measures focus on inputs, not outputs;
- iv) the measures reflect functions not processes; and,
- v) the measures lack predictive power (55).

It comes as no surprise to learn that a traditional accounting system has within it what are considered to be traditional problems. The quality costing research was "sold" to the management team on its ability to address a number of the above issues.

The following chapter details the methodology that was developed, modified, and adopted for the identification of quality costs within the host company.

# CHAPTER FOUR

## DATA COLLECTION AND DATA ANALYSIS



## 4.0 Introduction

This chapter aims to introduce the specific steps used within the methodology, in order to fulfil the stated objectives of the research proposal.

The chapter is divided into the following sections:

- 4.1 - Research Method.
- 4.2 - Models Tested.
- 4.3 - Sequence of Research Events.
- 4.4 - Conclusions.

### 4.1 Research Method.

A three stage, action research, methodology was adopted. The action research approach has already been discussed in some detail in chapter one, section 1.3.1. To reiterate briefly, action research poses an aspect of direct involvement in organisation change whilst simultaneously providing an increase of the knowledge base for specific topics. In detailing action research Clark (1972) maintains that:

"The strategy for gaining the utilisation of the research has to be integrated with the research design at the start of any project. It requires the practitioner to devote considerable time to the creation of an infrastructure for receiving the findings and acting upon them" (5).

The methodology developed for this research project involved an extensive survey of the available quality literature, the identification of cost categories, and the adoption and trial of two cost collection systems.

#### 1. An extensive survey of the available quality literature.

This was undertaken in order to identify possible "quality measurement systems" and means of establishing the "cost of quality".

The literature survey targeted issues directly, and peripherally, related to the objectives of the research. For example, literature on the promotion of quality was included in the survey.

The search was primarily confined to quality related literature, although the CD - ROM system at the University of Manchester Institute of Science and Technology (U.M.I.S.T.). This provided a wealth of information from various industrial sources.

The gathering of information started with the key quality costing sources, such as BS 6143 and the American Society for Quality Control (A.S.Q.C.) publications, then broadened to include the references discovered by the computer search.

The information gathered from these sources was used to further the development of a company specific quality costing methodology.

## 2. Identification of cost categories

The key measurables and cost categories were identified through detailed examination of company processes, informal discussion with company personnel, and formal interviews with various employees within the host company. This process, over a period of time, allowed the identification of sources of errors within the host company's systems.

It was possible to achieve the above objective due to the nature of the Teaching Company Scheme within the host company (the implementation of total quality management). To expand this point slightly, it was feasible to call on employees' time for formal interviews within the first month of the teaching company project because all were aware of the importance placed on the success of the project. This aided the development of a quality costing methodology enormously, because without full co-operation and openness the success of the project would have been diminished.

The host company's processes and systems were closely examined by the author through physically following the manufacturing process from beginning to end. This data was recorded in the authors log book in the form of flow charts and detailed description, and formed an essential element of the initial research.

A series of twenty-eight interviews were set up, upon the instruction of the Operations Director. This involved junior, middle and senior management, all of whom had to make themselves available for a meeting of no more than forty-five minutes duration. These interviews took place over a four week period, within the individuals` own office. They provided a detailed insight into the subjective and objective views of the company structure and culture from within different tiers of the management team.

The interviews were semi-structured in nature and allowed for reasonably free flowing discussion around a number of specific points. For example: outline of the individuals functions; their perception of the main driving forces within the company; what were the key success factors for the company now and in the future ?; any previous exposure to the tools and techniques of total quality management or continuous improvement ?; etc. The interviews also allowed information to flow from the interviewer to the interviewee, specifically on the objectives of the exercise.

The research findings from the examination of the host company's processes, and the notes taken during the interviews, were kept as part of the authors` formal "log book" (a requirement of the teaching company scheme). This formed an element within a report putting forward recommendations for the continuation of the project. The log book was essentially a "live" document, in as far as it was constantly updated and served as an accurate record of achievement and progress. This systematic record keeping was indispensable.

Further to the above, a period of two weeks was spent by the author of this thesis, working with various shifts in different departments within the host company. This allowed for the study, on a more informal basis, of the company's information systems. Also during this period of time it was possible to gather

views and opinions from the employees, who knowing the author was not a member of the management team, and was indeed an independent outsider, were very open with their views and opinions. They saw it as an opportunity to put across their points of view to the management team, with the guaranteed assurance of anonymity.

The notes from this period of time were also held within the authors "log book", and formed a part of the recommendations for the continuation of both the quality costing, T.Q.M. and continuous improvement projects.

As the teaching company scheme within the host company progressed a considerable body of knowledge was gathered on the specifics of the company's systems and procedures (the continuous improvement drive is fully detailed within chapter three, section 3.6). This information was gathered on a piecemeal basis, i.e. discussion and interviews took place with specific individuals when necessary to progress a specific aspect of the project. For example, detailed discussions were held with the company's financial accountant to develop a knowledge base of the exact workings and idiosyncrasies of the host company's financial systems.

As before the interviews were semi-structured in nature and allowed for reasonably free flowing discussion around a number of predetermined areas.

### 3. Two cost collection systems adopted and trialed.

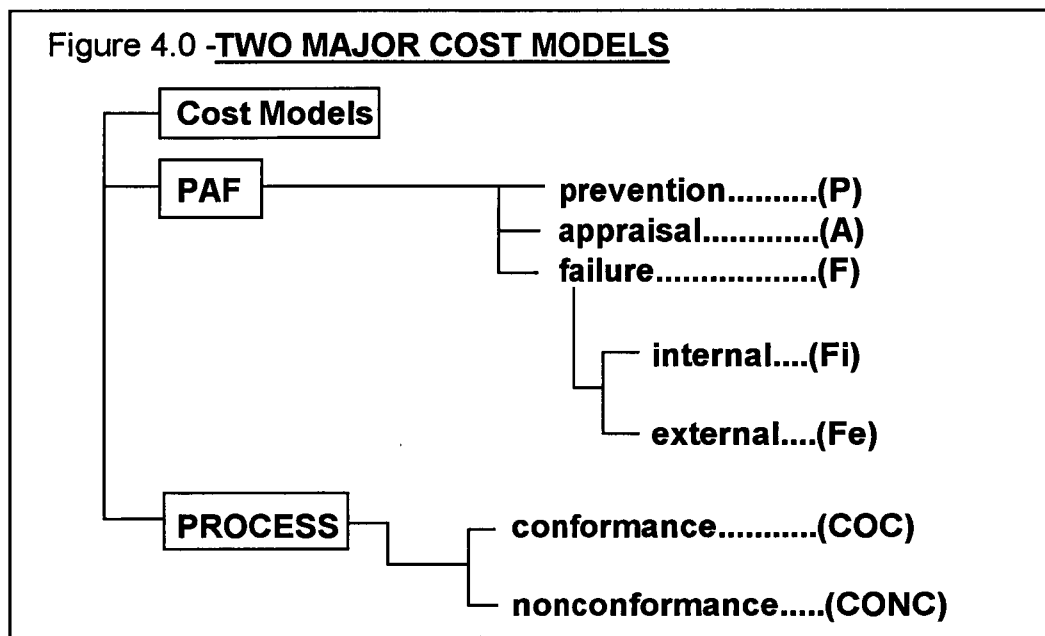
Two measurement and collection systems were then adopted from the literature, adapted to suit the host firms particular industry and trialed. Details of the selection criteria are given in section 4.2.

The collection of data at this stage took place using all available information, with existing data gaps being identified and accommodated for as the research progressed. Other data was requested and collected as its necessity was determined.

## 4.2 Models Tested

As detailed within chapter two, the literature survey found there to be four costing models that have been used previously within industry : (i) Prevention, Appraisal, Failure Model; (ii) Process Cost Model; (iii) Economic Balance of Quality (Optimum Quality Cost) Model; and (iv) Total Loss to Society (Quadratic Loss Function) Model. Two proven quality cost models were to be trialed within the host firm's particular industry (high-volume plastic component manufacturing industry). The two generally popular models are the Prevention, Appraisal and Failure model (P.A.F.) and the Process Cost model (see figure 4.0). Both these models have been used to some extent in other industries (Dale & Plunkett 1991, Bradshaw & Yarrow 1993, Rawlins 1993).

These two models were chosen because they exhibited certain characteristics. They both form part of British Standard - BS 6143, have had some publicity in the form of articles within professional journals, and have been utilised within both manufacturing and service industries to provide quality costing data - admittedly with various degrees of success.



To reiterate slightly on chapter 2, the P.A.F. model involves splitting up the costs generated as part of the quality function and due to production of non conforming

product into four categories. These are prevention costs, appraisal costs, internal failure costs, and external failure costs.

The process cost model involves the complete analysis of a company's activities into interlinked "processes", accurately and without duplication. The cost of failure is then logged for each of these specific charts.

#### **4.3 Sequence of Research Events.**

The total process can be presented in the following steps:

1. Initial continuous improvement trial at host firm's Colchester site.
2. Move to the Wrexham site, development of a blueprint for introduction of continuous improvement.
3. Programme started with large-scale education process.
4. Initial quality cost estimate to get senior management's attention.
5. More detailed approach developed: P.A.F. and Process Model to be tested.
6. Development of information system for decision making purposes (to provide good quality information).
7. P.A.F. Model - Designed specific forms for collection of costs.
8. Process model - flow chart of the manufacturing method.
9. Presented proposed methodology to senior management.
10. Costs collected using P.A.F. method.
11. Process model - stopped.
12. Presented ongoing findings to senior management team.
13. Financial information generated from P.A.F. data.
14. Information analysed and presented to senior management team - subsequently used for strategic decision making.
15. Improvement programme given specific financial targets.

Specific details of each of the research steps are detailed below:

4.3.1 - Initial continuous improvement trial at host firm's Colchester site.

As already detailed in chapter 3 of this thesis, the continuous improvement drive was initiated at the host company's Colchester site. During this phase, the company was introduced to the concept of quality costing for the first time. This took the form of accurately measuring the scrap produced, as part of the manufacturing process. This had a substantial impact as information of this type had not been produced before. The high level of waste in financial terms was unexpected by management, primarily because it was an unknown factor (one of the black holes, reference to Martin Hornby - Operations Director).

Once actual numbers were available the next phase was to use some of the tools and techniques of continuous improvement to reduce the generated figure, or at least to start the process of accurate identification. See chapter seven, section 7.1, for details of these projects.

At this stage no formal quality costing data was generated, as this was very much an examination of what the company's systems could provide in the form of hard facts. What proved to be the case after consultation with the company's finance department, and specifically, the financial accountant, was that the financial system was geared to producing data of a high level of aggregation. It was, therefore, difficult to pinpoint specific areas of problem wastage as these figures were neither asked for or reported.

4.3.2 - Move to the Wrexham site, development of a blueprint for the introduction of continuous improvement.

The development of the Continuous Improvement (C.I.) blueprint has already been covered in chapter 3 (section 3.6). It is worth stressing here that the development of a defined plan for the implementation of C.I. was essential as far as the collection and use of quality costs are concerned. Without the drive, enthusiasm, and understanding of modern quality techniques created by the C.I.

process, accurate quality cost figures could not have been generated. People would not have been willing to take part in the information generation exercise if they did not fully understand firstly, the reason for its collection and secondly, the use to which it would be put.

#### 4.3.3 - Continuous Improvement Programme started with large scale education process.

The actual continuous improvement programme adopted by the host company has already been outlined in some detail in chapter 3, section 3.6. This stage in the development of a company culture, which would support and encourage the quality costing drive, proved to be absolutely essential.

#### 4.3.4 - Initial quality cost estimate to get senior management's attention.

In order to raise senior management's attention, as far as quality costing was concerned, an exercise was carried out to estimate the quality costs of the host firm. This exercise was designed to be "quick and dirty" (3) in as far as it would not go into substantive detail, but would generate a figure which would get management's attention. After discussion with the host company's financial accountant, it was decided to utilise one main source of information from the company accounts and add to this some specifically generated cost categories.

In generating the quality cost estimate, the figure of "other stock adjustments" was taken from the monthly company's accounts. It was felt that as this figure was a result of "things not going to plan" it could be used as a rough reflection of some "costs of quality". It consists of:

1. Exceptional rebates;
2. Purchase rebates;
3. Material usage variance;
4. Change in stock provision;
5. Stock taking differences;
6. Production scrap;



7. Sale of scrap.

This figure was then combined with the approximate cost of quality personnel across the two sites. For full details of the calculation refer to chapter 5, section 5.1.

The figure generated was then communicated to the senior management team. It was agreed that a more detailed breakdown was needed, if the information was to be used for decision making purposes at various levels. The research project therefore proceeded on the basis of providing an accurate breakdown on the origins of the quality costs within the business.

4.3.5 - More detailed approach developed: Prevention, Appraisal, Failure (P.A.F.) and the Process Model to be tested.

With the acceptance of the quality cost estimate figures, and the further development of the continuous improvement initiative, work began on the development of a more detailed approach to quality cost collection.

Of the available methodologies the P.A.F. and Process models were chosen to be trialed within the host company, as detailed earlier. Both models are specified within a dedicated British Standard (BS 6143, parts one and two) and have been the subject of a number of relevant case studies within various industries (see sections 2.4.1 and 2.4.2 for details of the two models, and their respective advantages and disadvantages). This acceptance by the establishment, combined with the need to produce tangible results within the host company, made these two models the favourites to trial within the site.

One of the main objectives of the research project was to produce information that could be used by the host company to drive the T.Q.M. (continuous improvement) project, and to reduce operational costs. The use of existing, proven costing models would serve to speed this process.

From the quality cost estimate previously carried out, it became apparent that certain information required for the exercise would need to be created, or rather, that mechanisms for the accurate collection of it would need to be set up.

### 4.3.6 - Development of a Quality information system for decision making purposes.

The information gathered was to be collated and presented to the Operations Director in the form of a monthly report (see appendix 2). This report was to aid the directors decision making process by providing accurate quality cost data. As such relevant sections were included within the Operation Director's own monthly report to the Managing Director.

The setting up of this regular information flow allowed, for the first time, the sharing of information with the workforce by means of the quality notice boards, which had been installed in two places on the site. See appendix 2 for examples of the notices displayed.

The information generated was, therefore, presented at two levels - Firstly to the senior management within the company and secondly, to the entire workforce. For the first time, the workforce received a regular flow of information which communicated to them how well they were performing, from a quality perspective. Examples are provided within appendix 2.

This publicity exercise was designed to raise people's awareness of quality costs - what they are, how do they effect the organisation and individuals, and what can be done about them.

### 4.3.7 - Prevention, Appraisal, Failure (P.A.F.) - Designed specific forms for collection of costs.

At this stage, having reviewed the available literature, forms for the collection of quality costs using the P.A.F. model were generated. This was done using a

combination of BS 6143 (55) and A.S.Q.C. (25) "Quality Costs - What and How" publications for specific entries in categories.

A series of forms were designed, based around the five stages of the quality cost collection exercise detailed in BS 6143 (30). In designing the forms to be used individual elements from the quality costing categories of BS 6143 (30) were extracted specifically for the host company. The specific details of these selected categories are discussed within chapter five, section 5.2.4, with an explanation as to why they are different from BS6143.

The categories were then put into six individual forms, one for each of the five stages and a final collection summary sheet (see appendix 2 for the actual forms):

- i) Costs directly associated with the quality function:
  - includes payroll cost of people specifically controlled by the quality function; the cost of depreciation of specialised quality control and assessment equipment; the cost of quality training; the cost of smaller items that the organisation does not capitalise.
  
- ii) Quality related costs of functions performed by personnel outside the quality function:
  - these costs are usually incurred by other departments. They should be included in a memorandum account. A number of departments may incur these costs, e.g. purchasing, stores, planning, etc.
  
- iii) Internal cost of budgeted failure:
  - For example it may be normal practice to make a product in batches of 100. To be certain of completing 100 it may be a matter of routine to plan 110. Only experience will eventually tell weather it is worth calculating the cost of the additional 10, but the costs should be calculated, at least for a trial period.

- iv) Internal cost of unplanned failure:
  - related costs may include materials that have been scrapped or the cost of re-working or re-making.
  
- v) Cost of failure after change of ownership.
  - costs include the time spent by the quality department in investigations (offset these against the costs in form 1, to avoid a double count) and those costs of other departments.
  
- vi) P.A.F. cost collection sheet.
  - this sheet collates the costs from the other forms and allows the summation of different categories.

#### 4.3.8 - Process model - flow chart of the manufacturing method.

In order to begin working with the Process Cost model it was necessary to first develop a general flow chart for the host site's manufacturing method (see chapter three, figures 3.2 and 3.3, and appendix 4). Data for this exercise was collected in the same manner as that detailed in section 4.1.2. It was checked for accuracy by communicating the results with the individuals who had furnished the original information. The company quality manual, which had been prepared by the operatives, also provided a detailed cross check.

Once this flow chart had been generated, it was necessary to select a specific area for attention. This was done in conjunction with the management team.

#### 4.3.9 - Presented proposed methodology to senior management.

The proposed quality cost collection methods developed above were communicated to the senior management team. Full details were given at the presentation as well as in a brief information pack (see appendix 2 for details). The presentation served as a further introduction to the subject of quality costing, and outlined the potential savings available by using examples from the literature.

During the in-depth discussion that followed the presentation the senior management team asked a wide range of searching questions. The conclusion to the meeting was the authorisation to proceed with a detailed information gathering exercise.

### 4.3.10 - Costs collected using P.A.F. method.

Over the course of the next fourteen months a body of knowledge was generated in the form of specific cost collection. These costs were collated on the tables previously designed for the purpose, as detailed in 4.3.7.

As it became apparent that specific information was not readily available, systems were set up to facilitate collection. Examples of these are internal scrap reporting and an accurate log of the credit note return file (this is a log of the returns from customers of defective product - the log stated the monetary value of any product return or customer refund).

As previously stated, data was collected over a fourteen month period. After twelve months' worth of figures had been collected and analysed a series of graphs depicting various ratios were created. These are fully detailed in chapter 5, section 5.4.1.

### 4.3.11 - Process model - stopped.

Having built up a picture of the company's process as a whole, and having consulted the senior management team, it was considered highly practical to test the process model in some detail, on a small scale within one area of the company's manufacturing system. A specific product line was targeted within an individual production department.

Work on the Process Model and the P.A.F. model proceeded concurrently when the P.A.F. model was broadened in scope, due to the information already available, and the facilities to provide more information. The P.A.F. model

therefore became much wider in context and data was collected from the company as a whole, and not just an individual department.

The Process Model was, at the same time, proving difficult to work with. This was primarily due to the need to create the necessary forms and diagrams (identification of inputs, outputs, controls and resources) and from these, the information flow required. The assistance of others within the host company was sought in order that interviews might take place for the accurate construction of process flow charts and specific cost models.

The specifics on the progression of the Process model are contained within chapter 6 - Findings: Process Model.

#### 4.3.12 - Presentation of current findings to senior management team.

On a monthly basis, results were presented to the sites senior management team. This took the form of initial results and the revised methodologies. Essentially, these sessions served to inform and educate the management team.

#### 4.3.13 - Financial information generated from P.A.F. data.

A financial figure was generated, representing the quality costs of the host company over a twelve month period. This was developed through the extensive use of a specifically tailored P.A.F. model.

As much of the data required was unrecorded, at that time, a number of very useful new reports were generated (for example the credit note returns and an internal scrap report). These have since become part of the quality management information system.

4.3.14 - Information analysed and presented to senior management team - subsequently used for strategic decision making within the continuous improvement programme.

Data now existed for a fourteen month period and a graph was created which illustrated the monthly cost of conformance against the cost of nonconformance. Specific figures generated are represented within chapter five, section 5.2.

The specifics of the use to which the results were put are detailed within the aforementioned chapter five and chapter seven - Quality Improvements Through Quality Costing.

4.3.15 - Improvement programme given specific financial targets.

The findings generated as a result of this research were presented to the senior management team, with a detailed manufacturing strategy designed to increase perceived product quality and ultimately reduce the quality costs. The plan was linked with the establish continuous improvement programme. The plan formed part of a full manufacturing strategy designed to guide the host company over the next three years.

This plan is being monitored on a month by month basis, and quality costing has now been introduced as part of the monthly quality report produced by the author (Quality Manager) for the Operations Director of the host company.

4.4 Conclusions.

The two cost models used for the collection of quality costs were taken from the body of literature available. However, the research methodology employed was designed to suit the stated objectives of this research. As action research it developed over time and grew to fit the needs of the project.

A critical evaluation of the research methodology employed, is given in chapter 8, section 8.3.

# CHAPTER FIVE

## FINDINGS: PREVENTION, APPRAISAL, FAILURE MODEL.



## 5.0 Introduction

This chapter aims to present the preliminary analysis of the research, followed by the actual findings from the Prevention, Appraisal, Failure (P.A.F.) model. A comparison will then be made with the quality cost data generated by other authors. Critical evaluations of the P.A.F. model and the host company's management information system will conclude the chapter.

The chapter is divided into the following sections:

- 5.1 - Preliminary analysis.
- 5.2 - Findings.
- 5.3 - Figures.
- 5.4 - Comparison between results obtained in the study and those given in the literature.
- 5.5 - Critical evaluation of the management information system in relation to quality issues.
- 5.6 - Critical evaluation of the Prevention, Appraisal and Failure model.

### 5.1 - Preliminary analysis.

After examining the company's profit and loss (P+L) account and detailed discussion with the company's accountant, a specific formula was generated for the exercise. This involved combining an approximate cost for the "quality and inspection personnel", associated with the host site, with the "other stock adjustments" figure from the host company's P+L account for the year to date. The "quality and inspection personnel" are those people associated directly with the quality function within the site.

The "other stock adjustments" figure is generated monthly by combining the following: exceptional rebates; purchase rebates; material usage variance; change in stock provision; stock taking differences; production scrap; sale of scrap. The use of "other stock adjustments" as a collective cost category was agreed with the company accountant. As such it does contain some information

that is not specifically quality related, however for use in a "quick and dirty" quality costing exercise it was thought to be at least seventy per cent accurate.

The acceptability of the first quality cost figure generated would depend upon the credence given to the "other stock adjustment" cost categories by the management team. These categories are:

- Exceptional rebates; purchase rebates; change in stock provision: Reported by exception these were historically of very low value.
  
- Material usage variance: If the production job took more raw material to make the order than was specified on the business information system the difference, when booked on, was recorded as "material usage variance". This was considered to be a cost of not getting the job right first time and was therefore deemed to be a cost of quality. This element did vary substantially month on month.
  
- Stock taking differences: Each month a stock take was carried out. This discovered the differences between material that had been issued by the business information system and the actual amount of material remaining within the company stores. Once again this figure was deemed to be a cost of quality, due to the fact that the "system" thought a certain amount of raw material had been used within the month to manufacture finished goods, while in reality a different amount was used. This material difference would normally be reflected within material usage variance - if the difference had been booked into the business information system at the time. This difference was considered a cost of quality because it represented an actual verses a proposed stock level (therefore more, or less material was used, but not recorded within the business information system).
  
- Production scrap: This figure represents the amount of scrap generated within the calendar month. All production scrap is considered to be a cost of not getting the job right the first time, and therefore a cost of quality.

- Sale of scrap: Production scrap, as detailed above, was offset by the sale of the scrap raw material. This amount was deducted from the production scrap value. As such, even the effort of preparing the scrap for resale could be considered a cost of quality. If the components had been made correctly first time the company would not be in a position to sell on the components as scrap material.

In generating the "other stock adjustments" figure, for use in the quality cost estimate, the year to date total to November 1993 (eight financial periods) was taken from the monthly P+L account. This was divided by eleven to give an average monthly amount and multiplied by twelve to give an approximate figure for one year.

The number of personnel directly or indirectly associated with "quality" within the company were counted then assigned a monetary value dependent upon the approximate percentage of their time spent on quality issues. Where individuals had dual functions within the organisation, assumptions were made to ascertain the proportion of their time spent performing specifically quality related tasks. These assumptions were based upon interviews with the individuals and their superiors.

A figure was provided from the accounts department for each group of personnel. At the host company, personnel are assigned to one of two groups:

Group one - production based day and shift operatives.

Group two - technical and office support staff.

Within the two sites of the host company, the following personnel were deemed to have connections with the quality function:

Site one

Group one - Personal Care department: 5 inspectors (shift).

- Finishing Department: 50% of 5 shift people.

- Clean room: 30% of 5 shift people + 1 day staff.

Group two - Site wide: 1 Quality Co-ordinator.

Site two

- Group one
  - Quality administrator: 30% of 1 person.
  - Quality Technicians: 20% of 2 people.
  - Secretary: 5% of 1 person.
- Group two
  - Graduate trainee: 25% of 1 person.
  - Quality Manager: 15% of 1 person.
  - Quality Assurance Manager: 25% of 1 person.

At site one there were six employees directly employed within the quality department. The other employees are production staff who spend a proportion of their time on quality tasks, the remaining time being spent on production related activities, dependant upon their area of work.

Site two provides support services for site one. As such, the prime role for site two employees is working for site two. The percentages indicated above represent approximate time dedicated to site one tasks.

Taking all the above into consideration, the approximate quality cost for the financial year 1993/94 worked out at 12.7%, as a percentage of sales turnover for the host company's target site.

This figure, and it's cost collection method, were communicated to the senior management team. They were surprised as to how low it appeared to be. The team expected something much higher, given the examples they had previously been provided with, by the author. These examples detailed case studies of other quality cost collection exercises.

This initial estimate led to the management team sanctioning the continuation of the quality cost collection exercise. The management team specifically required an accurate breakdown of the sources of quality costs. They required the detection and location of the "black holes" within the business. Once fully identified these areas would be targeted for improvement.

5.2 - Findings.

After a thorough study of the host company's processes, twenty-two quality cost elements under the categories of Prevention, Appraisal, and Failure, were listed. They were selected to allow a relevant quality costing model to be generated. These elements were chosen on the basis of their suitability for use within the host company, i.e. high volume, plastic injection moulding and finishing operations. For each element, a note on how to calculate its cost, the data sources, and the named contacts for each data source, were then created. The cost elements are quite specific to the company and manufacturing operation.

Although BS 6143 is ostensibly a guide to the operation of quality cost systems within the entire manufacturing industry, it clearly offers more guidance to specific engineering activities than to the plastic injection moulding industry. Therefore, of the thirty six cost elements identified under BS 6143:1990 (ten in prevention, eleven in appraisal, eight in internal failure, seven in external failure) twenty-two were specifically thought to be particularly relevant to the host company due to their ability to be used immediately for data collection purposes. Selecting the relevant cost elements from an established listing, that of BS 6143, proved the most efficient method in which to proceed. This is an important consideration due to the need to produce results which the host company could use. Time was very much a factor, and being able to pick the most relevant cost elements helped enormously.

Of the twenty-two quality cost elements selected, the financial information from only a small number were able to be taken directly from the host company's accounts. The majority of the quality costs had to be generated from data specifically generated within the host company, as described in section 5.2.1.

The data required was gathered in a systematic manner as the exercise progressed and the data became available. The information was collated by the author and held in number of files and databases. As will be detailed in section 5.6, where information was not readily available a collection methods were devised and implemented.

In working out the cost of actually employing personnel, assistance was required from the finance department to provide an estimated average "running" cost for various grades of employee. The figures generated included an allowance for general company overheads. This information had already been generated by the finance function for use in the quality costs estimate, and is fully described in section 5.1.

The figures are as follows:

Group 1	- day shift	= £14,000.
	- 3 shift system	= £16,000.
	- 5 shift system	= £19,000.
Group 2	- management	= £23,000.

The above are approximate average costs generated by the financial accounts department for use specifically within the quality costing exercise.

The company's definitions of the cost categories employed are given below. These are a combination of BS6143, ASQC, and specific company tailoring to suit.

#### 5.2.1. Prevention costs

Prevention activities are perhaps the most difficult to define and cost, as they are frequently integrated within the activities of a number of different departments. It is usual, however, for many preventative activities to be carried out by the quality department.

The prevention costs within the host company are as follows:

##### P1 Quality personnel

This represents the direct costs of employing personnel specifically for the quality function. A total of seven people, who have direct input to the related site's quality function, are employed across both the host company's sites.

These individuals perform a wide variety of quality related tasks. The full cost of their employment (from both sites) has been included within this category.

P2    Process control personnel

Within the host company's targeted site, an individual is employed specifically to introduce, maintain, monitor, and develop statistical process control. The full cost of his employment at group two level is borne here.

P3    Laboratory personnel

An estimation, made in conjunction with the two laboratory personnel and their manager determined that approximately ten per cent of two peoples time is dedicated to carrying out tasks within the host company's laboratory. These tasks are based upon requests made by the host company's targeted site for assistance in particular areas.

P4    Cost of quality training

This represents those costs of developing, implementing, operating and maintaining formal quality training programmes. The majority of training within the host company is carried out on the site by the quality personnel themselves, whose running costs have already been included. The cost of quality training for employees has been accounted for, as it is incorporated within the employees contract (126 hours of training is paid for within the employees salary).

It is important to note that the training does not affect production as all sessions are carried out either before a shift starts or when a shift finishes.

The only figure included specifically under this category is that of a training course on quality costing arranged for the author.

P5 Cost of presenting quality costs to management

As mentioned in the methodology chapter, the status of the project was regularly reported to the senior management team every two months. The approximate figure for holding this meeting (a proportion of the average time the meeting lasted multiplied by number of participants, with an approximate salary figure included - see 5.2) has been included here.

P6 Engineers - planning and directing initial product qualification

This cost was estimated on the basis of a proportion of engineer's time in working with initial product qualification. The actual figures are thirty-three per cent of three peoples` time at one site plus ten per cent of one person's time at the targeted site.

5.2.2. Appraisal costs

Defined as the "cost of assessing the quality achieved", and are broken down into the following cost elements for the host company:

A1 Receiving inspection

A minimal amount of incoming goods inspection is carried out, as the majority of raw material and supplies have, for some time, been shipped in direct to the manufacturing area that requires them. The majority of goods are on either a certificate of conformity, certificate of analysis, or both.

A specific product is, however, checked upon entering the site and this occupies approximately two per cent of an inspector's time.

A2 Supplier audits

This cost represents the auditing of new and existing suppliers to ensure conformance with the host company's quality standard (BS EN ISO 9001 and



9002). The purpose of auditing suppliers, is to assess their manufacturing and quality systems. This provides assurance that they are of a suitable calibre to supply consistently the correct grade of product.

The audits are carried out by a central quality function, which has not been included within the host company's targeted site quality personnel figures. An approximation, using past information, was made allowing for two per cent of an auditor's time on audits performed for the host site.

A3    Lab tests to assess quality acceptance standards

The costs associated with the tests performed by the host company's laboratory in order to ensure the fitness for purpose of newly developed projects. The cost assigned, has been estimated to be twenty per cent of one laboratory technician's time. This was made in conjunction with the technician and his manager.

A4    Review of test and inspection data

This represents the cost of reviewing test and inspection data for the purpose of generating internal certificates of conformity and certificates of analysis. These are subsequently sent to the host company's customers with the finished products. They are an assurance of good quality production, and represent the host company's faith in the systems, which maintain and continually improve the quality of the product.

The costs generated here have been estimated, in conjunction with the personnel concerned, to be twenty per cent of three peoples` time.

A5    Internal testing and release - before shipment

Some of the products produced by the host company require testing for functionality before release for shipment to the customer. Where possible, this function is performed during manufacturing or assembly. The figure generated here, represents the employment of extra personnel to perform specific testing.

The testing performed depends upon production requirements. As such this cost varies from month to month, reflecting the shipments being delivered to the site.

**A6 Calibration and maintenance of equipment used to evaluate quality**

Test equipment used on site is calibrated and maintained internally. It is estimated to occupy approximately ten per cent of one technician's time.

**A7 Inspection and testing**

Inspection and testing tasks were originally carried out by specifically employed inspection staff (five people, one on each of the five shifts). This changed during period four of the data gathering phase of the project, with the specific position of inspector being made redundant. The individuals were employed in alternative positions elsewhere within the host site.

The inspection and testing is now carried out by suitably trained shift personnel and the cost is estimated to be: ten per cent of a shift setter's time, ten per cent of a shift material handler's time and twenty per cent of the machine operator's time. This occurs on all five shifts throughout the year.

**A8 Set-up cost for inspection and testing**

This cost represents the amount that is paid each month in depreciation on the equipment within the host company's laboratory within the targeted site. Other items used for testing purposes are provided by the company's customers free of charge. These tests are performed at the customers request using their own product.

**A9 Inspection and test materials**

As mentioned in the category above, the component product is issued free of charge by the customer, to the host company. A small amount of consumable

products are, however, used within the inspection and testing activity. These are accounted for here.

A10 Maintenance and calibration of test and inspection equipment

Some of the measuring equipment used for quality purposes within the host company is maintained by an outside calibration company (a requirement of BS EN ISO 9001 and 9002). This occurs every six months.

This category is separate from A6 in that it represents work done by people from outside the quality function. It includes the cost of ten per cent of two engineering technician's time.

A11 Inspection and test reports

The costs for collecting, processing and collating the completed production quality audit test reports. This task occupies approximately ten per cent of an engineering technician's time.

5.2.3. Internal failure costs

Defined as the costs arising within the manufacturing organisation from failure to achieve the quality specified (before transfer of ownership to the customer). In general, the main items of cost are production scrap and employees time in finding the reason for failure.

The internal failure costs within the host company are as follows:

Fi 1 Troubleshooting and failure analysis - quality department

These are the costs incurred in analysing nonconforming materials, components or products that have been returned by the host company's customers. The quality staff are responsible for determining specific causes of failure, and the task is carried out by exception. After interviewing the personnel involved, and

the management team the percentage of time spent on this task was estimated to be ten per cent of their working time.

Fi 2 Scrap - planned

Represents a one per cent "planned" scrap figure that the host company has allowed for, within its manufacturing processes. This figure is allowed due to the company policy of costing a scrap rate for all production jobs that enter the site. This is necessary due to the particular nature of the injection moulding process. For example, once an injection moulding tool has been bolted into a moulding machine it requires "running up". This involves putting raw material and colourant, of the correct grade, through the mould to set the process parameters required for the production run. This excess material usage has been averaged out to be approximately one per cent and as such is featured within the costing estimate for any production run.

Fi 3 Scrap - unplanned

This figure represents the scrap and waste that is generated during the host company's manufacturing process. It is accurately recorded and reported within the monthly profit and loss account.

Fi 4 Troubleshooting and failure analysis - outside the quality department

Amongst the traditional engineering roles that the site technicians perform they also provide expertise in establishing the root causes of internal defects. An estimated ten per cent of two peoples time and forty per cent of five peoples time is spent solving quality related problems that should have been "right first time". This figure was agreed with the individual engineers concerned and their respective managers.

**5.2.4. External failure costs**

These are defined as the costs arising outside the manufacturing organisation from the failure to achieve the quality specified after transfer of ownership to the customer.

The cost elements of external failure within the host company are as follows:

**Fe 1 Products rejected and returned**

The value of goods rejected by the host company's customers is accurately logged. This data was available but no collation had occurred prior to this research taking place.

More discussion of this category will take place in the next chapter.

Table 5.0 outlines the differences between the cost elements selected and used by the host company, with those of BS 6143: Part 2:1990. The table is split into three main columns. Details of the host company are in the first, cost elements of BS 6143: Part 2: 1990 in the second, and comments on the inclusion or exclusion of elements are given in column three. The table breaks down specifically the prevention, appraisal, internal and external failure costs for the host company and the British standard.

<b>Table 5.0 - Comparisons of Costing Elements</b>				
	<b><u>Host Company (HC)</u></b>		<b><u>BS6143: Part 2:1990</u></b>	<b><u>Comments</u></b>
	<b><u>Prevention Costs</u></b>			
P1	Quality Personnel.	P1	Quality planning.	Included in HC, P1.
P2	Process Control Personnel.	P2	Design and development of test equipment.	Included in HC, P1.
P3	Laboratory Personnel.	P3	Quality review and verification of design.	Included in HC, P2.
P4	Cost of Quality Training.	P4	Calibration and maintenance of quality measurement equipment.	Included in HC, A6.

P5	Cost of Presenting Quality Costs to Management.	P5	Calibration and maintenance of production equipment used to evaluate quality.	Included in HC, A10.
P6	Engineers - Planning & Directing Initial Product Qualification.	P6	Supplier Assurance.	Included in HC, A2.
	No other costs counted.	P7	Quality Training.	Included in HC, P4.
	No other costs counted.	P8	Quality Auditing.	Included in HC, A2.
	No other costs counted.	P9	Acquisition analysis and reporting of quality data.	Included in HC, P1.
	No other costs counted.	P10	Quality improvement programmes.	Included in HC, P1.
<b><u>Appraisal Costs</u></b>				
A1	Receiving Inspection.	A1	Pre-production verification.	Included in HC, A7.
A2	Supplier Audits.	A2	Receiving inspection.	Included in HC, A1.
A3	Lab Tests to Assess Quality Acceptance / Standards.	A3	Lab acceptance testing.	Included in HC, A3.
A4	Review of Test and Inspection Data.	A4	Inspection and testing.	Included in HC, A7.
A5	Internal Testing & Release.	A5	Inspection and test equipment.	Included in HC, A8.
A6	Calibration & Maintenance of Equipment Used to Evaluate Quality.	A6	Materials consumed during testing.	Included in HC, A9.
A7	Inspection & Testing: Pass-Off / Routine Inspection.	A7	Analysis and reporting of tests and inspection results.	Included in HC, A11.
A8	Set-up Cost for Inspection & Testing .	A8	Field performance testing.	Not counted.
A9	Inspection & Test Materials.	A9	Approvals and endorsements.	Not counted.
A10	Maintenance & Calibration of Test & Inspection Equipment.	A10	Stock evaluation.	Not counted.
A11	Inspection & Test Reports - Costs for Collecting & Processing.	A11	Record storage.	Not counted.

	<b>Internal Failure Costs</b>			
Fi1	Troubleshooting / Failure Analysis - Quality Department.	Fi1	Scrap.	Included in HC, Fi5.
Fi2	Scrap - planned (1%).	Fi2	Replacement.	Not counted.
Fi3	Scrap - unplanned.	Fi3	Troubleshooting / Failure Analysis.	Included in HC, Fi1 and Fi4.
Fi4	Troubleshooting / Failure Analysis - outside Quality Department.	Fi4	Re-inspection and re-testing.	Not counted.
	No other costs counted.	Fi5	Subcontractor fault.	Not counted.
	No other costs counted.	Fi6	Modification permits and concessions.	Not counted.
	No other costs counted.	Fi7	Downgrading.	Not counted.
	No other costs counted.	Fi8	Downtime.	Not counted.
	<b>External Failure Costs</b>			
Fe1	Products Rejected & Returned.	Fe1	Complaints.	Included in HC, Fe1.
	No other costs counted.	Fe2	Warranty claims.	Not counted.
	No other costs counted.	Fe3	Products rejected and returned.	Included in HC, Fe1.
	No other costs counted.	Fe4	Concessions.	Included in HC, Fe1.
	No other costs counted.	Fe5	Loss of sales.	Not counted.
	No other costs counted.	Fe6	Recall costs	Included in HC, Fe1.
	No other costs counted.	Fe7	Product liability.	Not counted.

It should be noted that a number of the cost elements within BS 6143: Part 2:1990 have been combined with single cost elements for the host company. This was necessary as it was the only way some costs could be accounted for. A number of quality costs were not applicable to the host company due to the nature of the manufacturing industry it occupied (some costs simply did not apply).

### 5.3 Figures

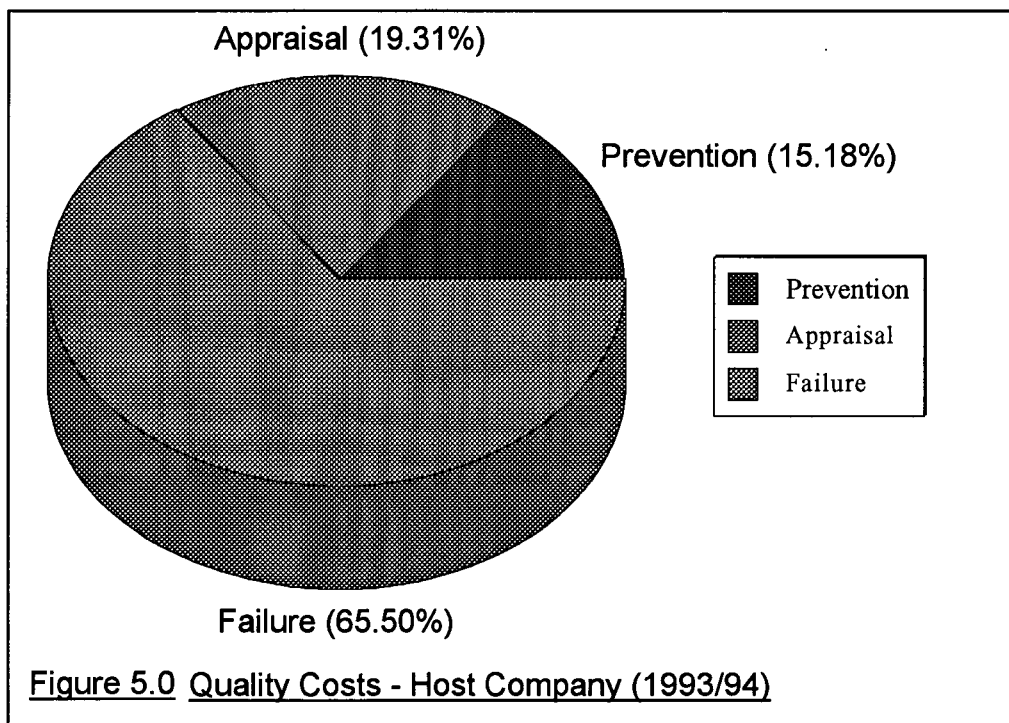
The above categories were turned into a spreadsheet and for fifteen months data was collected. Due to the confidential nature of some of the information

generated by this research, not all the findings may be presented in monetary form. Where this has occurred percentages or designatory numbers have been used.

The breakdown of prevention, appraisal and failure (internal and external), using the total quality costs as a percentage of sales turnover are as follows:

Prevention costs = 1.63%  
 Appraisal costs = 2.07%  
 Failure (internal) = 4.42%  
 Failure (external) = 2.61%  
 Failure (total) = 7.03%

Total quality costs = 11% of sales turnover



As a percentage of the total quality costs the figures break down as follows:

Prevention costs = 15.18%  
 Appraisal costs = 19.31%  
 Failure (internal) = 41.17%



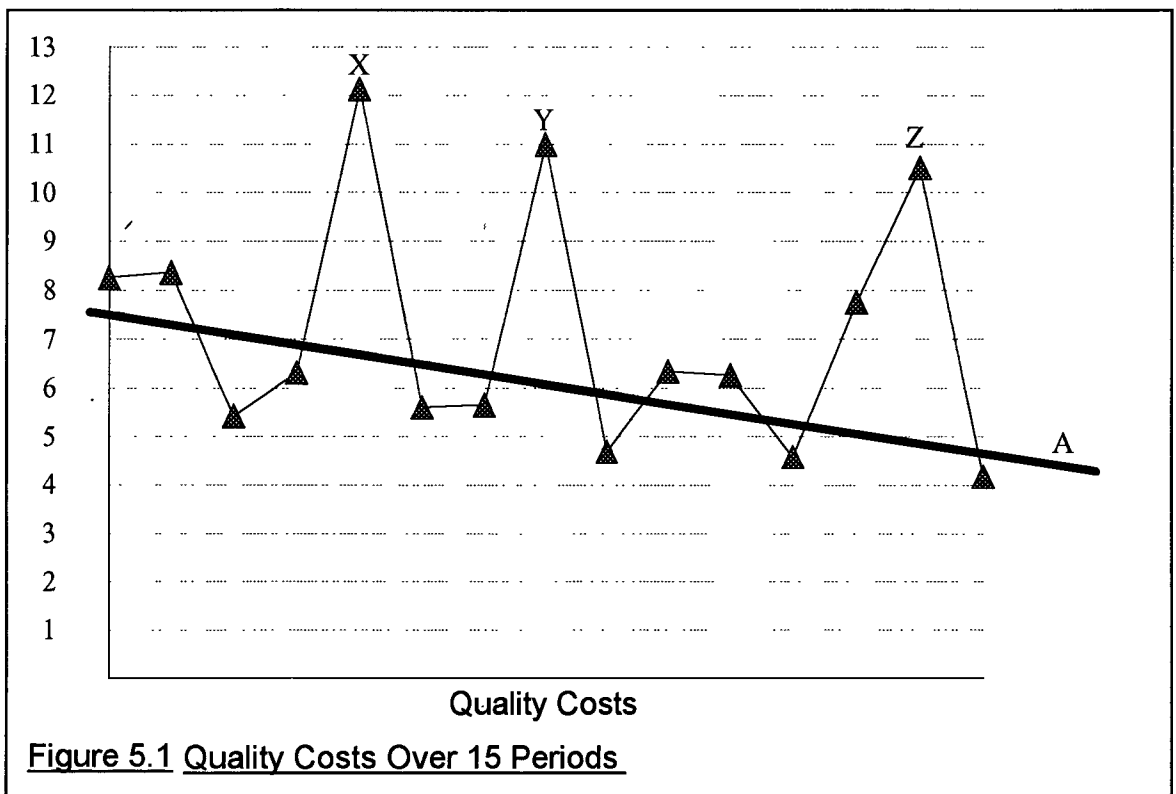
Failure (external) = 24.32%

Failure (total) = 65.50%

These figures are depicted in figure 5.0.

Figure 5.0 represents the results for the financial period 1993 to 1994. It clearly demonstrates the scale of costs attributable to failure, both internal and external. These costs represent a large proportion of the quality costs of the business, and a great proportion is potentially recoverable.

The figures 5.1, 5.2 and 5.3 provide a visual representation of the quality costs within the host company. They cover the full fifteen months period of accurate costs collection, and represent different presentation styles. Each will be discussed in turn. Note: the index in each graph does not show a monetary value, an numerical scale has been used. The time periods are in months.

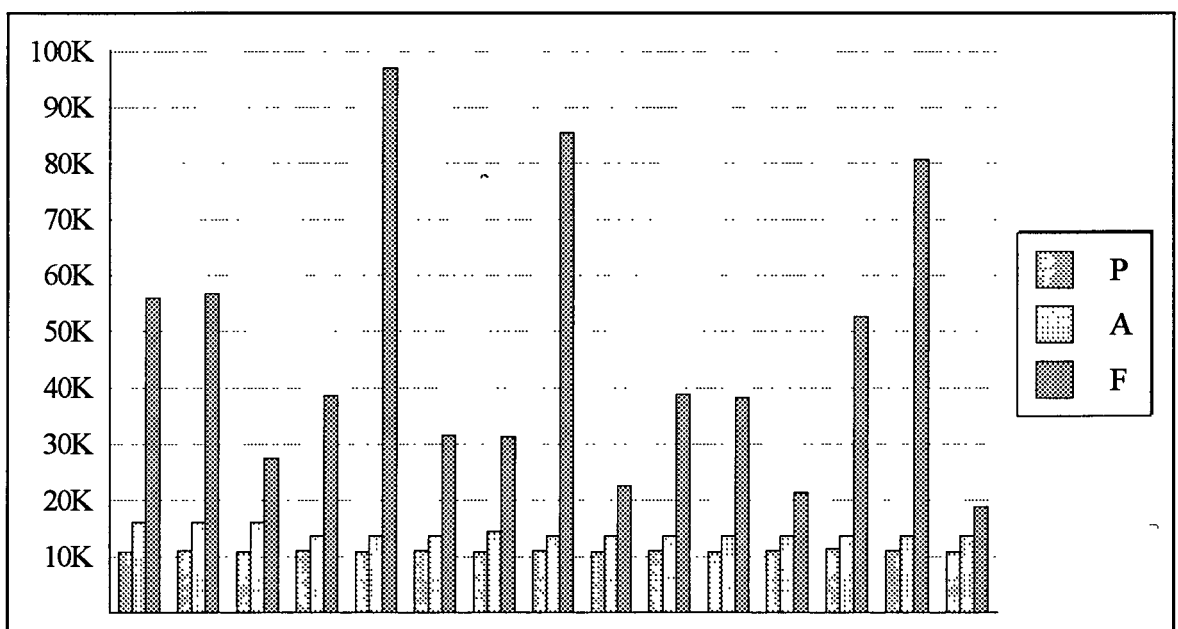


The diagram above (figure 5.1) represents the total quality costs of the manufacturing site where the research was based. This refers to the summation, on a period by period basis, of the prevention, appraisal, internal, and external

failure costs of the business. The costs were generated from the cost categories described in section 5.2.

A clear downwards trend exists within figure 5.1. This is indicated by line "A". The trend is a reflection of a reduction in the return of unsatisfactory product from customers, a reduction in scrap, etc., during the monitoring period. The specifics of the savings are detailed within chapter seven, section 7.3.

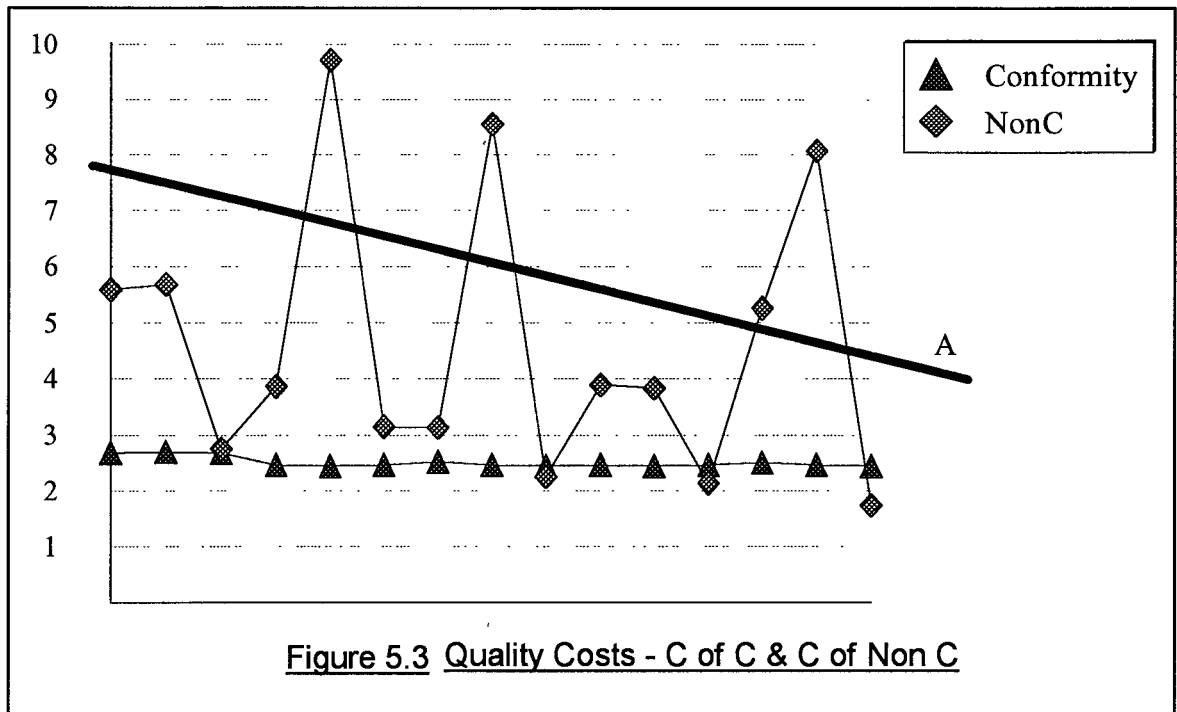
The evident improvement is slightly overshadowed by the three large peaks (X,Y,Z) which represent specific quality-based rejections from the host company's customers. It should be noted that each rejection was for a different problem, and each fault was corrected upon detection. The large customer rejections prompted an in-depth analysis of the company's own quality systems. This has led to the tightening of company policy on quality, and extensive retraining of operatives.



When the basic elements that constitute the make up of figure 5.1 are split into prevention, appraisal, and failure costs and plotted on a bar chart, they form the graph shown in figure 5.2. This diagram clearly demonstrates that the proportion of prevention and appraisal costs are too low when compared directly with the failure costs for the periods shown.

The lack of fluctuation in the prevention and appraisal costs may be due to the high fixed costs of the host company. This high fixed cost is set due to the level

of expensive automated equipment installed within the host site, the high cost of the raw material, and the fixed employment level (the ratio of machines per employee remains constant).



Quality costs can fall into one or other of two major categories. One category is that of the costs deliberately incurred in efforts to maintain or improve quality. In the Prevention, Appraisal, Failure model, this is called the "cost of conformance". It includes the costs of both prevention and appraisal activities.

The other category is that of the costs suffered as a result of bad quality. This is called the "cost of nonconformance", and represents specific failure costs.

Figure 5.3 above shows the cost of conformance and the cost nonconformance for fifteen periods within the host company.

As before, the peaks are attributable to the specific customer rejections of production. As previously mentioned these rejections were anomalies which were manufactured and delivered six months prior to rejection and return by the customers. These returns were very much an exception.

The host company operates a make to order policy, which means that if a customer orders an number of component's they are used within a short space of time. Therefore, any defective product is usually detected and returned within a calendar month. The three peaks were exceptions where customers had developed individual stock build strategies.

A noticeable reduction in nonconformance costs is demonstrated by line "A". The cost of nonconformance goes below that of conformance for three of the last seven periods. This will be explored further in chapter eight - Conclusions and Recommendations.

5.4 - Comparison between results obtained in the study and those given in the literature.

This section will detail the explicit findings of the research within the host firm. It will examine the applicability of specific ratios, then go on to detail the results of other research on this topic within manufacturing industry.

First exercise: Quality costs equal 12.7 per cent of sales turnover - "quick and dirty".

Second exercise: Plastic injection moulding - toiletries and pharmaceuticals, £8M turnover business, 100 people. Results shown below in table 5.1:

Q.Costs % of gross sales		
Category	Qual Costs %	Sales Turnover %
P	15.18	1.63
A	19.31	2.07
Fi	41.17	4.42
Fe	24.32	2.61
	100	10.74

Table 5.1

(P = prevention; A = appraisal; Fi = failure, internal; Fe = failure, external.)

5.4.1 Cost of Quality Ratios

When comparing the quality costs between manufacturing plants, a ratio enables comparisons to be made on a similar basis. Detailed below are the ratios calculated for the host company. The ratio used will depend upon the information available and the use to which it is put. For example, quality costs in relation to labour utilisation, sales value, production costs, etc. The following ratios are taken from BS 6143, Part 2, 1990:

1. Labour base:  $\frac{\text{internal failure costs}}{\text{direct labour costs}}$
2. Cost base:  $\frac{\text{total failure cost}}{\text{manufacturing costs}}$
3. Sales base:  $\frac{\text{total quality costs}}{\text{net sales}}$
4. Unit base:  $\frac{\text{total quality costs}}{\text{units of production}}$
5. Added value base:  $\frac{\text{total quality costs}}{\text{value added}}$

The particular ratio used, would depend upon the nature of the company involved, and the aspect of financial performance that needs to be focused on.

For example, a labour intensive service business which wants to improve utilisation of personnel and reduce human error, would focus on trends in the labour-base ratio. On the other hand, it would be very misleading for a manufacturing organisation in the process of automating its processes to use this ratio, since the reduction in number of employees would change the ratio regardless of any quality improvements

For example, with specific reference to the host company the following ratios were calculated:

$$1. \quad \text{Labour base} = \frac{\text{Internal Failure Costs}}{\text{Direct Labour Costs}} = 3.42$$

This ratio examines the internal failure costs related to the total labour or direct labour cost. For the host company it has been calculated to be 3.42.

This figure does not provide the host company with information that can be used as part of strategic management decision making. This is due to the fixed cost nature of the business - with high capital investment in automated equipment a minimum level of personnel are required. However, this minimum level can not be reduced without physically removing and writing off sections of machinery (hence they are removed from the business and are no longer on the machine register).

The small labour figure can be regarded as a fixed cost within this particular business as the number of personnel required to supervise the equipment does not change. If more machines are brought in, more people are brought in. If machines are removed people are removed.

This ratio would perhaps be more useful in an environment where high levels of manual handling took place, and a "value for money" figure was required.

$$2. \quad \text{Cost base} = \frac{\text{Total Failure Cost}}{\text{Manufacturing Costs}} = 1.27$$

This ratio examines the total failure costs related to the shop cost, manufacturing cost or total material cost. For the host company it has been calculated at 1.27. As with the labour base ratio, this does not provide the host company with particularly useful information. Comparisons are difficult to make due to the specific nature of dissimilar organisations manufacturing costs. Companies would have to be within similar manufacturing industries, which involved capital investment of equivalent scale, to achieve any basis for comparison.

$$3. \quad \text{Sales base} = \frac{\text{Total Quality Costs}}{\text{Net Sales}} = 0.10$$

This ratio looks at the total quality cost related to net sales billed or the value of finished goods. It has been calculated at 0.10 for the host company. This ratio is of some use to the host company due to its comparative wide use within industry for quality costing purposes. A number of other firms have reported quality costs

against this ratio, and it has been used extensively by the Department of Trade and Industry in the promotion of establishing quality costing schemes.

$$4. \quad \text{Unit base} = \frac{\text{Total Quality Costs}}{\text{Units of Production}} = 0.00055$$

The unit base ratio examines the test and inspection costs related to the number of units produced. The quality cost per unit has many advantages but it is necessary to take into account the effect of product mix, volume and value of the finished goods. This ratio was calculated at 0.00055. This is of little use to the host company for comparison purposes due the very large volume of components manufactured and the comparatively low selling price.

This base would be of use were a low number of components were manufactured, and then sold on for a high price.

$$5. \quad \text{Added value base} = \frac{\text{Total Quality Costs}}{\text{Value Added}} = 0.76$$

The value added base ratio examines the relationship between the total quality cost related to a measure of manufacturing activity (this being unaffected by fluctuation in sales and the costs of purchased goods and services). The ratio calculated for this base was 0.76. A figure for the valued added base was established in conjunction with the financial accounting department, who used readily available accounting data.

This ratio does not give a good basis for comparison due to the industry specific nature of "value added" percentages.

Of the available ratios the third, "sales base", was the most applicable to the host firm. This ratio may be used in direct comparison with other firms, industries, etc. Of course, the other ratios may be used by the host firm itself - for comparison of a period on period nature. The industry results discussed in 5.4.2 will show the applicability of the applied sales base ratio.

5.4.2 Industry results:

Musgrove and Fox (1990) maintain that quality costs easily represent twenty-five per cent of the sales volume within manufacturing industry. Within the service industry, sixty per cent of employee's time is spent double checking, rectifying and apologising for errors (32).

According to Crosby (1979), when manufacturing organisations have carefully examined their quality costs, they typically found them to be as much as twenty-five per cent of the sales value. He maintains a similar pattern applies to organisations which provide a service, with a typical quality related cost figure of thirty per cent of operating costs (20).

Crosby goes on to say that the first attempt to estimate quality related costs is notoriously prone to underestimation. He suggests thirty per cent of the true value. This is due to a whole host of reasons, such as;

- i) Information not collected before, therefore the data is difficult to find and often inaccurate.
- ii) some organisations assume that "quality costs" refer to the cost of actually running the quality assurance department.
- iii) the costs of indirects, such as rejected and scrapped work in progress (W.I.P.) is overlooked.

A breakdown of quality costs in terms of prevention, appraisal and failure, and also in the percentages of sales, for the host company, is shown in table 5.0. Quality costs were shown to be 10.74 per cent of sales turnover. An average quality cost figure was compiled from the results of several case studies across a range of industries. For the different industries the average is 10.96 per cent of sales turnover (see appendix 3 for the specific tables consulted and table 5.2 for the averages). The host company's quality costs seem to be approximately the same as this industry average. However, comparison between different



industries should not be given too much importance due to the wide variety of definitions and elements of prevention, appraisal and failure within industries.

The host company's quality costs seem to be approximately the same as an industry average.

Quality costs at the level found seem to suggest that the host firm is performing well in terms of quality, but there are a couple of points that should be taken into consideration. Firstly, it is an acknowledged fact that not all the possible quality costs have yet been identified and included within the host company's figures. This is due to a number of reasons, i.e. the need to produce results within a certain timeframe; the difficulty of identification, collection and categorisation; the lack of sophistication of the host company's accounting system. In addition, a number of costs had to be estimated as it was not possible to accurately extract them without a great deal of undue effort.

Table 5.2 below indicates a direct comparison between the results of this research work and the combined average of six other research studies (see appendix 3 for details of the specifics). The averages from other research studies are shown here to only to indicate the types of figures generally found. Due to the individual way quality costs are collected within different organisations and industries, direct comparisons should never be attempted. Any comparison would not be on a like for like basis.

	Host Company	Industry Average
Prevention	15.18 %	6 %
Appraisal	19.31 %	26 %
Failure	65.5 %	68 %
Total	100 %	100 %
Quality costs as a % of sales turnover	10.74 %	10.96 %
Table 5.2 - Quality Costs		

Table 5.2 shows the quality cost figures for the host company that are very close to the average industry standard. However, within this figure there are some

subtle differences. Firstly prevention costs; these are over double in the host company compared to the industry average. This by itself should be considered a positive reflection on the host company, but curiously the figure for appraisal costs tells a different story. This is down on the industry standard by over 6 per cent. The above two results would not be just as curious if the failure cost were substantially different between the two. Instead the two figures are approximately same.

Forming logical conclusions from limited information is difficult. However, making broad sweeping statements within a piece of work such as this is very tempting. So it may be said that the plastic injection moulding industry produces more residual scrap than the industry average, which may explain the same level of failure costs when compared to the extra investment in prevention. Of course, one could argue that if the host firm spent more money on appraisal, to bring it somewhere in line with the industry average, the failure costs would automatically reduce.

#### 5.5 - Critical evaluation of the management information system in relation to quality issues.

Initially the management information system within the host company reported few items of direct relation to quality. The level of performance on three items were reported monthly by the Commercial Manager to the Operations Director, these were the number of deliveries to customers that were "on time", "on quantity" and "on quality". The level of scrap produced was given in the monthly profit and loss account, but this figure was regarded as inaccurate due to the high level of stock take differences reported monthly (this meant scrap was not being booked onto the business information system, and the difference was seen as unaccounted for stock).

The continuous improvement and quality costing initiatives have produced a number of changes to the above. The Commercial Manager still reports using the three categories and the scrap value is given in the management accounts (it is now accurate given the improvements made in measurement systems - see

chapter seven for specific examples). However, a number of other reports are now provided as a result of this research:

- i) Customer complaints are collated per customer on a trend basis, and cumulative plots are made monthly to ascertain progress. See appendix two for an example.
- ii) A quarantine stock figure is provided monthly. This indicates a financial value for goods requiring sorting or re-work. See appendix two for an example.
- iii) A value of the returns from customers is now plotted monthly.
- iv) The Operations Director now reports on the quality costs of the host company on a monthly basis.

The above are all presently collected and collated by site personnel. The next stage will be to have the accounting system reporting as many as possible.

#### 5.6 - Critical evaluation of the Prevention, Appraisal and Failure model .

The Prevention, Appraisal and Failure (P.A.F.) model worked. It provided a proven system for the collection, presentation and use of quality costs. A number of well documented case studies exist within the literature, consultation of these was possible for advice on particular applications of the P.A.F. model. Indeed, the substantial work already carried out, and reports produced from this work, proved invaluable to the completion of this research.

The model itself was easily understood by all levels within the organisation, from senior management to the operators of the moulding machines.

As already discussed within chapter three - Plastic Injection Moulding: An Introduction to the Host Company, the quality costing research was part of a much bigger programme implementing the concepts and ideas of T.Q.M.

(continuous improvement). As such, quality costing was introduced to the workforce through the use of existing case studies within the literature.

These case studies demonstrated, to a workforce who had not been exposed to any of the modern "quality techniques" (the site had missed the quality revolution of the early eighties), that methods existed which could help their improvement project justifications.

Essentially the workforce, at all levels, were exposed to a methodology that demonstrated that direct actions could affect the "bottom line" of the profit and loss statement.

Specific examples of the above are demonstrated within chapter seven, section 7.3. Chapter seven shows how the five shift teams within the host company used the quality costing justification method to make tangible process improvements, and as a result cost savings.

As a quality cost collection system the P.A.F. model proved easily adaptable to the plastic injection moulding industry. This may have been aided by the fact that a manufacturing organisation was being targeted. The P.A.F. model is seen to favour traditional engineering industry and production processes, perhaps because of the history involved in its development (this has already been detailed within chapter two, section 2.3).

The P.A.F. model does what is required of a quality costing tool - it gets attention, holds attention, and focuses that attention on areas for improvement. It also guides this improvement by providing feedback. As mentioned briefly above, the model was used as an important element within a total quality management improvement drive, as such it provided the necessary impetus to motivate nearly the entire site. Money has a way of focusing peoples attention on specific goals!

A minor disadvantage of the applied model is that it took some time to gather the financial figures for the "macro" level analysis. The shift teams were using financial information for justification of specific projects, this was analysis at a

"micro" level. Actually setting up collection systems for costs not available from the company financial system did not take long (see section 5.2 for full details). However, once established the data was gathered on a monthly basis, and the decision was made in conjunction with the senior management team to collate twelve months figures before discussing trends. This information is still regularly collected and the information base is growing, further progress is discussed in chapter eight, section 8.7.

It is also recognised that not all relevant costs will have been identified and collected, and that some must have been missed. This was a conscious decision, made in conjunction with the company's financial accountant. The major cost areas were identified and targeted for collection, at this stage expanding large amounts of effort to gather costs to the last penny was not considered necessary. The large cost collection areas would fulfil the requirements of the exercise, whilst making best use of limited resources.

Other potential problems that had to be balanced (for the sake of producing some form of result) were:

- i) Omissions;
- ii) Over estimation;
- iii) Double counting;
- iv) Allocation of overheads;
- v) Built-in scrap allowances.

These are fully detailed within chapter eight, section 8.6.1.

During the course of the research, the data collected and presented to the senior management team was used as part of the strategic decision making process. This was a major achievement, primarily because it was one of the main thrusts of the original research proposal. It was also important because the results collected needed to be presented to the senior management team in such a way as to demonstrate the usefulness of this "new" information source. The senior management's continued commitment to the philosophy involved in quality

costing was as important as the shift teams actually using simple justification techniques. Both involved an envelopment of new concepts, and the use of new methods.

Essentially, the data generated by the P.A.F. model enabled the identification of problem areas and the rectification of these problems. It also allowed the investigation and identification of sources of problems, through the identification of the greatest cost areas. Chapter seven details some specifics of the identification of problem areas, and the solutions devised. Examples of the practical application of the P.A.F. model clearly indicate its usefulness within this particular industry.

To conclude this chapter, the work carried out indicates that the categories of prevention, appraisal, and failure are suitable for the collection of costs in the plastic injection moulding industry. It also demonstrates that they can be considered a useful quantitative way of evaluating quality related activities. Many elements are readily identifiable, and through the use of existing cost models the creation of industry specific categories is achievable.

# CHAPTER SIX

## FINDINGS: PROCESS MODEL

## 6.0 Introduction

This chapter aims to present the preliminary findings of the Process model research, then the main findings. It will then compare the quality cost data, generated within industry, with the actual findings of this research. The chapter will conclude with a critical evaluation of the use of the Process model within the plastic injection moulding industry, and specifically, the host company.

The chapter is divided into the following sections:

- 6.1 - Preliminary findings.
- 6.2 - Findings.
- 6.3 - Comparison between results obtained in the study and those given in the literature.
- 6.4 - Critical evaluation of the model.

### 6.1 - Preliminary findings.

In order to begin working with the concept of the Process Cost Model, it was necessary to first develop a general flow chart for the host site's entire manufacturing processes (see appendix 4). Many sources were used for this task, i.e. the quality manual, formal and informal interviews with day staff and shift personnel, and physically following the process through from beginning to end.

The Process model, even at this early stage, was very complex to administer. This was exaggerated because the effort required to establish the model did not seem to generate much data. The resulting flow charts do, however, have the benefit of presenting the organisation's manufacturing process from beginning to end, and are easily understood.

Once this document was generated a specific area was selected for more detailed examination. This was done in conjunction with the senior management team.



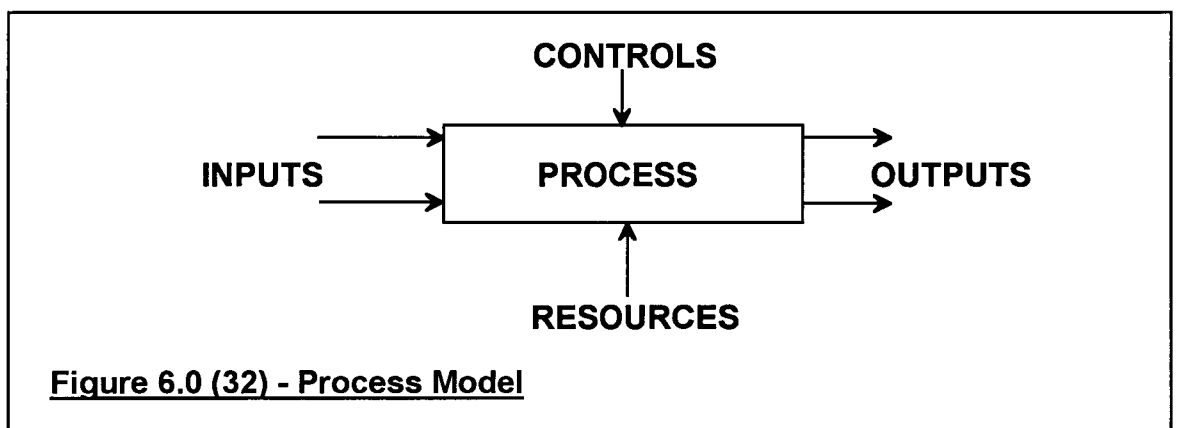
No financial results were generated at this stage. Once the entire manufacturing processes had been flow charted it was obvious that a smaller area would need to be selected for examination, due to the complex nature of the organisation's processes.

6.2 - Findings.

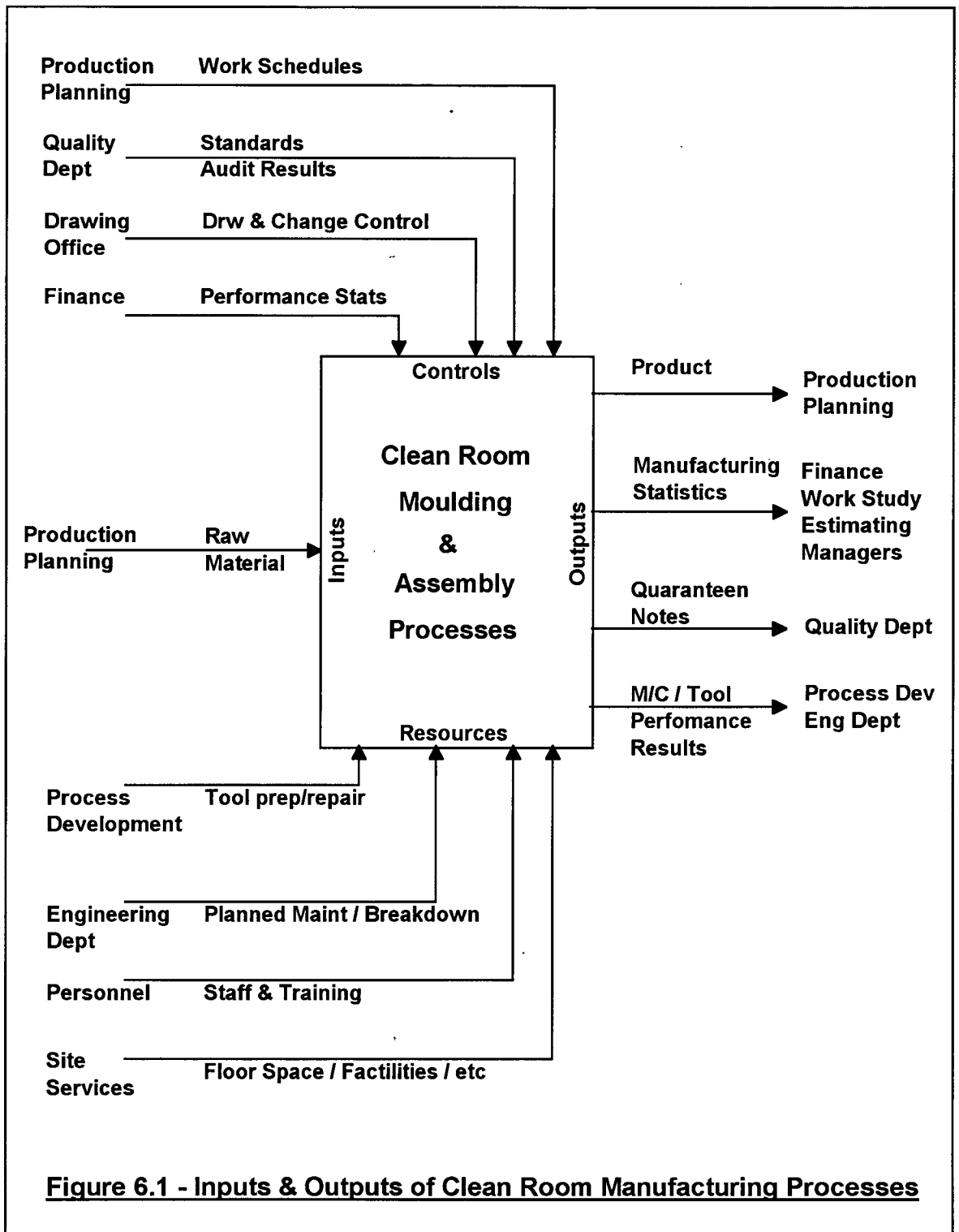
After the development of flow charts for the host company's manufacturing processes the decision was made, again in conjunction with the senior management team, to use the Clean Room as the pilot for the Process Cost model.

The next step in this method was to determine the specifics of the manufacturing process (see flow charts in appendix 4). Therefore the identification of inputs, outputs, controls and resources began, as per BS 6143: Part 1: 1992.

From the basic Process model, as shown in figure 6.0 (repeated from chapter two figure 2.2), which detailed the inputs, outputs, controls and resources, the process cost elements were identified and recorded in some detail, as per BS 6143.



The inputs and outputs for the host company's Clean Room moulding and assembly processes is shown in figure 6.1.



**Figure 6.1 - Inputs & Outputs of Clean Room Manufacturing Processes**

Again, as per BS 6143, a Cost model was generated for the targeted manufacturing department. The Cost model details the key activities, the main cost of conformance categories, and the main cost of nonconformance categories.

According to BS 6143: Part 1: 1992, a cost model may be generated for any process within the organisation. It may be used to identify and monitor process costs within one particular aspect of the organisation such as an invoicing system, works order distribution system or the recruitment process. Alternatively, it may be used to monitor the overall cost of a specific department.

The cost model developed for the host company is shown in figure 6.2.

Key Activity	Cost of Conformance	Cost of Non-Conformance
Planning, production, engineering work study, cost control, materials & process laboratory.	Partial cost	Partial cost (effect of engineering change, planning errors, etc).
Production inspection & test costs.	"Good" hours booked.	Reinspection / retest / fault finding.
Test gear depreciation, calibration and preventative maintenance.	Total cost.	
Breakdowns.		Total cost.
Production costs.	"Good" hours booked.	Rework.
Material costs.	Estimated cost.	Scrap cost, overspend.
Waiting time.		Total cost.
Cost of work held due to shortages.		Total cost.
<u>Figure 6.2 - Cost Model for the manufacturing department.</u>		

BS 6143 goes on to give specific advice as to the generation of cost models: "The cost model is constructed by identifying all the key activities to be monitored and listing them as either cost of conformance (C.O.C.) or cost of nonconformance (C.O.N.C.). The source of the data should also be identified. Ideally this source of data should be from information already collated within the finance function. In some instances, however, it may be necessary to generate synthetic cost data.

Careful setting up of the cost model is critical to the success of the technique and is the first task of the process owner. Once set up, the model is used for regular

reporting on performance. In order to achieve this, the model needs to remain stable to allow comparison with previous periods to be made and cost trends to be monitored" (36).

The final stage in the development of the process model is the generation of the Process Cost report. This is simply a basic form which is used for the actual collection of process costs. The report should contain a complete list of the costs of conformance and nonconformance elements.

The Process cost report developed for the host company is shown in figure 6.3. This has been adapted from BS 6143, Part 1, 1992, and is shown here in abbreviated format. The full form can be seen in appendix 4.

#### 6.2.1 - Results of the process model

Due to the need to concentrate resources on the Prevention, Appraisal, Failure model (P.A.F.), no financial results were generated for the host company as part of the Process model research. However, various process flow charts and basic cost reports were generated (see appendix 4). These will be of great use to the host company at a later stage.

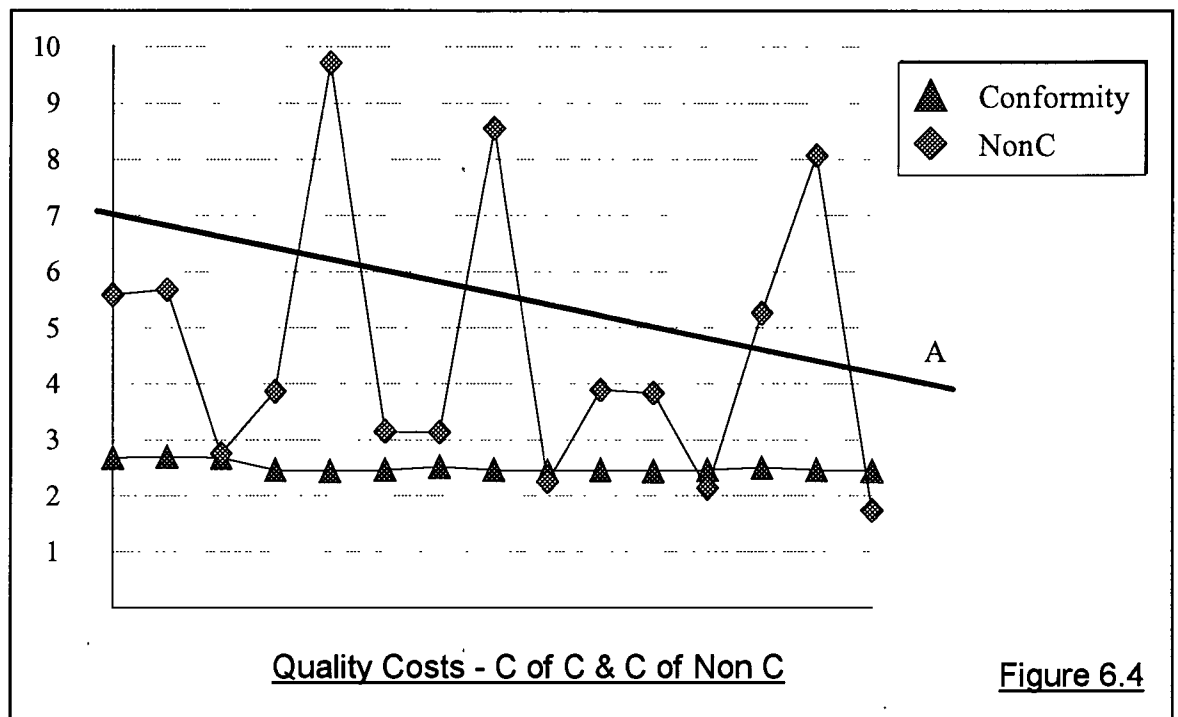
Although no specific cost data was generated it is possible to use the results from the P.A.F. model in order to demonstrate the type of information that may have been presented. This approach is suggested by BS 6143: Part 1: 1992, where it mentions the relationship between the Prevention, Appraisal, Failure model (P.A.F.) and the Process Cost approach. Particularly relevant to this research project is section four of the standard, it states;

"There may be a need to link the P.A.F. model with the process cost model. Particularly where quality costs have been reported in the traditional manner and are understood and accepted by some people within the organisation. In such a case the cost of conformance might initially be considered to comprise prevention and appraisal costs plus the basic process costs, and the cost of nonconformance to be the failure costs." (36)

Process conformance	Cost			Process Nonconformance	Cost			Cost data
	Act	Syn	£		Act	Syn	£	
<b>People</b> Assembly, inspec & test.								Produced hours x hourly rate.
				Rework / retest / reinspect				Hours x hourly rate.
				Waiting time				Hours x hourly rate.
<b>Equipment</b> Cost of equip required for work. e.g. depreciation,								Capital assets inventory.
				Cost of equip for rework				Capital assets
<b>Environment</b> floor space, maint, services								Accounts
				Floor space, etc. for rework				Accounts
<b>Materials &amp; Methods</b> Purchased mat,								Cost estimate
				Scrap, contingencies, mat price vari.				Scrap report
Task allocation, supervision of								Accounts
				Fault finding guides, cost of change. Training.				Accounts
Total process conformance cost				Total process nonconformance cost				
Prepared by:								
<u>Figure 6.3 - Clean Room Process Cost Report.</u>								

Using this suggestion from BS 6143: Part 1: 1992, the results from the Prevention, Appraisal, Failure model research can be taken and combined to produce a "cost of conformance" for fifteen periods (the financial results have been shown as a simple index in order to maintain company confidentiality). The failure costs have been re-labelled "cost of nonconformance".

Figure 6.4 below represents the cost of conformance and nonconformance.



As the data used for the construction of figure 6.3 is the same as that discussed within chapter five - Findings: P.A.F. Model, the analysis is essentially the same here.

To reiterate slightly, the noticeable peaks of the costs of nonconformance are attributable to large customer rejections of finished goods. As before, a noticeable reduction in nonconformance costs is demonstrated. This trend is illustrated by line "A".

Curiously the nonconformance costs go below the cost of conformance for three of the last seven periods, indicating an increasing trend (i.e. performance is improving).

These results could be considered quite a contradiction, in as far as the level of perceived quality appears to be improving (a reduction of nonconformance cost) with no extra investment (increase in conformance cost). As detailed within chapter seven - Quality Improvements Through Quality Costing, these gains have been made as a direct result of the continuous improvement initiative and have not necessitated a large capital investment. Another factor to take into consideration is the increased "quality" awareness of the host company's operators - there are now one hundred "quality inspectors" on the site. Quality is seen as very much everyone's responsibility, not just the quality department's.

### 6.3 - Comparison between results obtained in the study and those given in the literature.

There appears to be very little published on quality costs generated using the Process model, the only example the author of this thesis could find was that of Rawlins (1993). As the results of the process model research within the host firm are very limited, due to the restricted nature of the data collection, no attempt has been made to compare them. However, in order to give a general representation of the type of results potentially available, extracts from a brief paper by Rawlins are presented below.

Rawlins (1993) completed her research work within G.E.C. Alstom Engineering Limited, a division that designed, manufactured and supplied instrumentation and control systems for the power generation industry (37).

Process flow charts were designed, then two company wide runs were completed which lasted one month each. The results of this work are shown in table 6.0.

Using the results from the above table (table 6.0) Rawlins carried out a Pareto analysis. This was used to indicate the major nonconformance activities. Using this information it was then possible for her to define and target the priority areas for improvement within the organisation.

	First Run	Second Run
Time Period	31/05/93 to 25/06/93	30/08/93 to 24/09/93
COC (collected)	£301,000	£357,000
COC (predicted for year)	£3,612,000	£4,272,000
CONC (collected)	£40,000	£35,000
CONC (predicted for year)	£484,000	£420,000
CONC (% of total labour cost)	11.8%	9%
Table 6.0 - Rawlins Results		

As well as the direct impact detailed above an advantage stated by Rawlins was the positive change in peoples attitudes. This, she said, led to "better interdepartmental understanding" and "process ownership by even indirect employees".

Obviously, any exercise that exposes financial waste to a workforce (especially one that is paid a bonus based on the results achieved) is almost certain to provoke interest. This interest, if utilised and managed in the right way, will precipitate a certain degree of process improvements.

#### 6.4 - Critical evaluation of the model.

In so far as the model was adopted, it did not appear to be as "user friendly" as the P.A.F. model. The data required to fulfil the research at this stage was not as readily available as that of the P.A.F. model and was substantially different from that of the P.A.F. model. New information retrieval methods would have been needed and systems for the collection of the required information would have had to be developed essentially from scratch, within what was a traditional accounting structure.

The Process model also proved difficult to work with. This was due to the effort required to create the various flow charts, forms and diagrams needed to even begin the exercise in earnest. The identification of inputs, outputs, controls and resources proved difficult and provided no real return for the labour.



Another factor against the Process model was the attitude of the host company's personnel. They did not understand why it had to be so complicated in order to achieve essentially the same end-result as the P.A.F. model. They were familiar with, and understood the concepts of this simple model due to the continuous improvement team meetings at which they used it for justifying projects (see chapter seven - Quality Improvements Through Quality Costing, for examples). Some of the company's personnel recognised that the complete analysis of the sites activities into interlinked processes would actually have hidden inefficiencies. That is, if a particular area is running according to stated procedure's, even if the procedure's are inefficient, the costs will be allocated to the cost of conformance, not the cost of nonconformance. A measurement system is worth having only if the personnel required to use it actually understand it.

An advantage of the Process model is that costs do not have to be identified and categorised as prevention, appraisal or failure. This, to be fair, can be a difficult task. However, categorisation is helpful because it reminds the user that costs classed as failure are all potentially avoidable.

Of course, in not challenging cost categorisation the Process model does not allow at any stage for the "service" aspect of quality costs. A large proportion of costs could potentially be missing, therefore, from any investigation.

In terms of highlighting opportunities and needs for quality improvements, the author considers the Process Cost model a retrograde step for any organisation embarking on a cost exercise for the first time. This concept is explained more fully in chapter eight - Conclusions and Recommendations.

Conversely, using the categories of people, equipment, materials and environment for analysing what is happening within a process is an excellent aid to understanding and improvement it.

It was therefore determined that the host company was not yet advanced enough, in quality costing techniques, for the use of the Process Cost model. It would

have taken an unprecedented amount of input to achieve essentially the same end-result, a sharp focus on quality issues.

The Process model would perhaps have been of more use at a lower level of aggregation, i.e. in examining a highly specific area, such as an individual moulding machine. It may then have been used in conjunction with the P.A.F. model, which has proven more adept at working at a higher aggregation level.

Finally, the author was acutely aware that the objective of the research project was to determine detailed quality cost results and analysis within the host company. Also important within the research was the need to identify how relevant and usable a cost of quality methodology was within a high volume production environment for the progression of a continuous improvement initiative. Therefore, pursuit of the Process model for the sake of pure research would have wasted valuable resources and time. There was a need to balance the hypothetical research needs of the thesis, with the real life requirements of the host firm for tangible results.

# CHAPTER SEVEN

## QUALITY IMPROVEMENT THROUGH QUALITY COSTING

## 7.0 Introduction

The aim of this chapter is to present some of the improvements made, within the framework of the continuous improvement drive, as a result of the quality costing initiative.

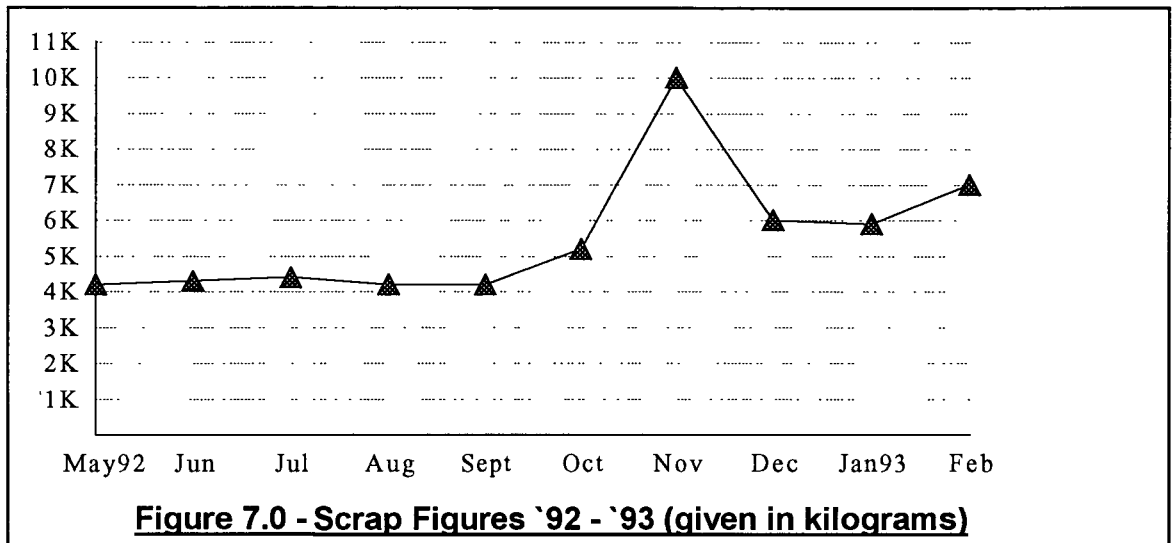
The chapter is divided into the following sections:

- 7.1 - Early results.
- 7.2 - Use as a continuous improvement tool.
- 7.3 - Tangible results.
- 7.4 - Conclusions

### 7.1 - Early results.

As previously detailed within chapter four, section 4.3.1, the initial work for this thesis was started within a single manufacturing unit at one of the host company's two sites in the United Kingdom. The level of scrap produced by the manufacturing process was not accurately recorded within the department at that time. Therefore, to raise management and operatives awareness, it was agreed to measure and plot the scrap produced. As this exercise began, it became apparent that the production manager of the department had actually been collecting the scrap figures for some time, but had not communicated this information to anybody. The first step was to plot this existing information in order to demonstrate to people the extent of the "scrap problem" (figure 7.0).

The general weight of the scrap created was used as the reporting factor. This was done because it proved difficult to work out the individual scrap material cost, as so many different grades of plastic were used. The scrap figures generated did not differentiate between the grades of plastic used. The next step was to select a specific problem area and monitor the scrap produced. This information would then, for the first time, be communicated to everybody in specific cash terms.



The purpose of this exercise would be twofold, to raise management and operatives awareness of the potential for saving within the existing structure, and to demonstrate a formal method of doing so. This exercise would aid both the continuous improvement and quality costing projects by highlighting the hidden potential in various situations. It would demonstrate the possibility of identifying and designing out the "black holes" that were sucking profit out of the business.

One of the first monitoring exercises carried out was of the scrap produced at a particular moulding machine. This scrap was highly visible, and considered extremely wasteful by both operators and management alike, but had never been formally quantified before.

The moulding machine was visually monitored for a representative one hour period. Table 7.0 represents the findings of the analysis. It should be noted that the scrap produced was actually components that had not fallen from the mould tool straight onto the machines handling system (a mechanical conveyor), any such components were either crushed by the mould tool or landed on a machine ledge where they would be contaminated by machine lubrication. In either case the components would be regarded as scrap.

Scrap Analysis

Cycle time - 6.2 seconds  
 Monitoring Period - 60 minutes  
 No. of components produced - 6960  
 No. of visable scrap - 319  
 Approximate scrap = 5%

Scrap Cost

Over twelve hour peroid = £62.89  
 Over seven day period = £440.26  
 Over one month = £1761.04  
 Over one year = £21132.48

Table 7.0 - Scrap Analysis

After a brainstorming session, where this information was shared with production operators, this particular problem was cured at a cost of £150 (the solution generated was the fitting of side guarding to the mould tool). The guarding was manufactured, fitted and the subsequent analysis (using the same method of study) proved the solution one hundred per cent effective.

Within the department this was the first time data was generated and used solely for cost saving and process improvement purposes. Problem areas were identified and prioritised for action by careful measurement and analysis. The size and scale of process waste areas were taken into consideration when allocating improvement resources. This marked the start of a real change in emphasis for the management team who now looked for increases in process efficiencies by making the most of existing resources. That is, they realised the potential of maximising machine efficiencies through identifying waste elements within the manufacturing process. The task of the management team at this point was to utilise the interest of the operatives, and "manage" the enthusiasm for improvement.

The various teams within the department continued analysing problem areas, brainstorming the reasons for the inefficiencies, establishing and implementing long term solutions. Over a period of ten months scrap decreased by fifty per

cent through the team initiatives. This saved approximately £250 per week initially, with an annual saving of over £15, 000.

Other initiatives being implemented at this time (not always directly cost related) included:

- i) Brainstorming sessions on customer specific problems.
- ii) Documentation reviews.
- iii) Review of number of suppliers being used.
- iv) Establishing regular News Sheets for the department.
- v) Setting up visits to customers for department personnel.

These initiatives took place at the same time as the scrap reduction exercise. They had a very positive effect upon the area in terms of moral. Unfortunately, quantifying the savings made as a direct result of the actions was not high on the priority list at the time. This was rectified when the continuous improvement programme became established at the host company's other site.

#### 7.2 - Use as a continuous improvement tool.

The use of quality costing as a continuous improvement tool have already been outlined within chapter two, section 2.2. To reiterate slightly, and to use perhaps the best of the direct quotes, Dale and Cooper (1992) put forward the view that;

"Western organisations and their management are judged over relatively short periods of time. Therefore, committing large amounts of money in quality improvement programs without some measure of cost effectiveness can be considered a blind act of faith, and is contrary to the way in which western businesses operate" (10).

This is the key use to which quality costing models can be put to within any organisation.

During the initial stages of the continuous improvement drive at the host firm focus was required. Quality costing provided that and really got people's attention. A measurement-control-action loop was used to identify specific areas for improvement, this focused on the need to address numerous high profile issues (i.e. to reduce the scrap created during the manufacturing process).

Individual projects targeted by the shift teams had an impact upon a number of manufacturing areas. When combined they had a great impact on the total quality costs within the host company.

As discussed in section 3.6, the concept of quality costing was introduced to the personnel of the host company during the initial presentations on continuous improvement (see appendix 1 for copies of the slides used). This brief introduction covered the simple use that the determination of failure costs could be put to. Examples of the exercises carried out at the other site (see section 7.1) were used.

It was important to demonstrate that quantifiable techniques existed to work in conjunction with the simple tools and techniques of continuous improvement, such as brainstorming, fishbone diagrams, Pareto analysis, etc. The change taking place in the quality culture needed to be supported by methods of identifying and highlighting potential improvement projects. The best way, for the host company, of demonstrating this was for the management team to listen, and act, upon improvement suggestions presented by the teams. The best tool for achieving this was quality costing.

The support for both the quality costing initiative and the continuous improvement drive came from the top of the organisation. For example, the Operations Director, at a team meeting, stated "if you can demonstrate to me that spending £1000 will pay for itself within two months, and continue to save resources after that, you can have the money for any project". This statement had quite an impact upon the teams, who now began to realise the full potential of the opportunity they were presented with.



The results of the improvement team initiatives, presented below, are a direct outcome of both the enthusiasm of the host company's personnel and the senior management's commitment to the continuous improvement programme.

### 7.3 - Tangible results.

The examples that follow are selected from the successful projects instigated by the hosts firms continuous improvement teams. Each of the projects was initiated on the basis of reducing a failure cost, and the actions necessary to eliminate the problem were justified on the basis of an increase in the prevention cost and a predetermined pay back period. The projects vary in terms of the cost of implementation and the impact they achieved, but all prove the benefit of using quality costing as a driver of continuous improvement.

#### Example One

In order to accurately monitor the scrap being generated a new form was introduced to the host company (see appendix 5). This simple form was intended to accurately record the waste material produced during specific shifts. Because of the categories used on the form it was possible to determine a number of things: the type of raw material; the production order against which the scrap would be booked; the part number of the product; the reason for scrapping; the approximate weight. An example of the breakdown analysis can be viewed in appendix 5.

A number of weeks after the introduction of the waste material form a "Scrap Team" was created. This team monitored the results being generated and prompted improvement projects. They also monitored the "stock take differences" on a monthly basis. This is an important area in any manufacturing organisation because it indicates the efficiency and control of the system within which people work. Four months into the waste material monitoring process two members of the scrap team did a series of presentations to the entire workforce. These presentations were essentially a "pat on the back" to the workforce for the

effort they had put into accurately recording scrap. Copies of the presentation slides are presented in appendix 5, and the basic elements are shown below:

#### Raw Material Lost at Stock-take

November 1993	- Polymers	- £15,200
	- Masterbatch	- £4,771
	- Total	= <u>£19,971</u>
December 1993	- Polymers	- £9,500
	- Masterbatch	- £6,400
	- Total	= <u>£15,900</u>
January 1994	- Polymers	- £6,925
	- Masterbatch	- £1,417
	- Total	= <u>£8,342</u>
February 1994	- Polymers	- £700
	- Masterbatch	- £1,600
	- Total	= <u>£2,300</u>

February's figures marked a seventy two per cent improvement on January 1993, an eighty four per cent improvement on December 1993, and an eighty eight per cent improvement on November 1993. Quite an achievement.

The above figures demonstrated that scrap was now being booked onto the business information system. Before this improvement in the reporting of scrap took place the management team knew it was being generated, but were unable to accurately quantify it. This was traditionally another of the "black holes" within the company.

Example Two

Another area targeted for improvement by the scrap team was the "spillage" of components from the moulding machines. This had been a problem since the factory was built. It involved components bouncing off the mechanical conveyor system onto the floor, and once on the floor the components were designated as scrap (due to contamination). The waste material monitoring (example one, detailed above) highlighted this as a major area for improvement. The scrap team held a series of brainstorming sessions with the site shift teams and generated a number of potential solutions. The most likely to succeed was trialed first.

The idea trialed involved mounting what was described as an "inverted fish tank" on the bottom of the machine conveyor. Funding for the project was sought through the use of purposely designed justification sheets (see appendix 5 for copies of these example sheets). Essentially one purpose built guard was required, at a cost of £250, to trial for a one month period on the worst affected moulding machine. This particular machine was identified through the analysis of the data provided by the waste material form, as detailed in example one. The team accurately monitored the spillage on this machine, put the guard in place, and monitored it again. The results were encouraging, a ninety per cent reduction in scrap! The guard was left in place for one month, to ascertain any design modifications that might be required, and to elicit operators' opinions and views.

As all feedback was positive and the trial judged a success, a second justification sheet was filled in asking for £5016 to order twenty two guards (slightly modified to reflect suggestions made by some of the operators). The pay back period was calculated at six weeks, based on the potential savings to be made. This project was signed off by the Operations Director, and the guards were purchased and fitted over a time period of three months (the team had to compromise with a staggered flow of capital). The guards proved to be completely successful and are still in place twenty months later. The estimated saving during this period has

been approximately £20,000, which has been reflected within the company accounts.

### Example Three

The continuous improvement shift teams were also working on reducing the amount of scrap produced. B shift targeted one of the items of automated equipment on the site, the "tipping" station. The tipping station transfers finished goods from the plastic Tote boxes to cardboard boxes for shipment to the customer. The problem with the line was that on some occasions the Tote boxes would queue up behind each other on a sharp corner approaching the lifting mechanism, this then pushes a number of the boxes off the rollers and onto the floor. Once product has been on the floor it is designated as scrap and is unusable. The idea B shift generated involved fitting a hydraulic stop switch to a straight section of track, which would enable the operator at this station to stop boxes proceeding to the sharp corner.

As with the previous example a period of monitoring took place which entailed quantifying the amount of product wasted over a given period. The findings surprised everyone, over a seven day period £344.55 of finished goods were scrapped due to the above problem.

A stop switch was priced at £200 and a justification sheet was again filled in and presented to the Operation Director (copy of the sheet in appendix 5). The pay-back period for this project was four days (£50 per day). The project was passed off and has been in place for fifteen months, savings during this period approximately £20,000.

### Example Four

Another area of component spillage was the automatic in-line counters of the moulding machine handling system. This featured vibrating bowls with built in counters, the components being counted as they fell into the Tote boxes. Problems occurred when the volume of components being deposited into the

vibrating bowls exceeded their physical capacity. When this happened spillage of components onto the floor occurred, and as before, once on the floor the components are scrapped.

C shift generated the idea of fitting a shield around the edge of the vibrating bowl, which would increase the bowls capacity by approximately sixty per cent, hence preventing spillage occurring. The shift members actually trialed this idea by wrapping cardboard around the edge of one bowl and monitoring performance. The results were so encouraging the idea was immediately passed off as approved. Essentially, quantified savings would total approximately £20 per machine per week, on the worst machines. Approximately £10,000 has so far been saved. The cost per vibrating bowl for the modification was £30, a pay-back period of a week and a half.

#### Example Five

E shift targeted two specific moulding machines for improvement in efficiencies. The moulding machines in question were constantly stopping due to a particular process failure. This problem involved the in-line sprue grinder (sprue is a by-product of certain injection moulding tools, it is plastic from the runner system not used in the formation of the finished component which can be ground up immediately for reuse by the machines material handling system) which could not always keep up with the number of sprues put to it. This problem resulted in the moulding machine stopping when it detected an unacceptable number of sprues in the grinder neck. Once the machine stopped it required an operator to purge the sprue (by pulling them out and throwing them away) and restart the machine, this would waste a number of components before the process parameters fully reset themselves.

When the shift fully analysed the problem they concluded the sprue design was at fault because it did not drop into the grinder cleanly every time. This resulted in sprue sitting on a ledge just on top of the grinder, which then resulted in a build up. They trialed various modifications, by cutting out sections of the sprue runner system until they found the correct combination. Eventually four sections of the

runner system were blanked off. The modification successfully prevented any build up of sprue between the grinder and the tool, with the sprue able to fall at any angle and still be taken in by the grinder.

The modification cost £40 for each machine and has provided a quantified annual material saving of £14,000. The operators main benefit is that they are not called to the moulding machine every seven minutes to restart it.

Example Six

Wastage of cardboard boxes was a project tackled by A shift. The site has an automated cardboard box erector which feeds to the tipping station (as described in example three). The equipment was on an annual service contract with the manufacturers, but was seen to produce a large number of unusable boxes. The shift monitored the performance of the equipment and found the following results:

First Study of Box Erector (Study period = 11 shifts, 88 hours).

- Number of boxes lost averaged 2 per hour (176 boxes).
- Cost of each box = £0.47.
- Loss per day = 48 boxes = £22.56.
- Loss per week = 336 boxes = £157.92.
- Loss per year = 17,472 boxes = £8211.84.

On the basis of the above information the Shift Manager issued a memo to the other Shift Managers asking them to take part in a preventative maintenance programme. This was implemented for a three month period, at the end of which the shift performed the same analysis:

- iii) Efficiency improvements of existing equipment:
  - Example five and the fitting of lights example.
  
- iv) Reduction of waste:
  - Example six.

Measurement, improvement, and the cost of quality are linked through the above examples by the fact that over the monitoring period for collecting quality costs many improvement took place. These improvements were reflected, using the Prevention, Appraisal, Failure model, by a recorded reduction in failure costs, i.e. a physical fall in volume of the scrap created. This is an important point because, as will be discussed within chapter eight, section 8.4, the host company is at a certain stage in the progression towards constant and accurate quality cost monitoring (the beginning). As such it has really only started using the quality cost information generated on a micro scale (or high level of aggregation) to push through process and system improvements.

The examples detailed within this chapter are a representation of the efforts being made to reduce the highly visible waste elements within the host company's manufacturing process. Chapter eight will put forward the discussion point that an organisation needs to progress through a number of stages before utilising the information generated as part of a quality costing exercise fully at a macro level. For example, it might be some time before the strategic decision can be made to increase specific prevention costs in an effort to reduce current failure costs. These concepts will be discussed more fully in chapter eight, section 8.4.

#### 7.4 Conclusions

To conclude this chapter, it should be stressed that the quality costing initiative worked towards driving through process and system improvements. In conjunction with the above examples, other quantifiable results include: Customer complaints reduced by forty per cent through team working over a twelve month period. The teams targeted the complaints from customers that

Second Study of Box Erector (Study period = 11 shifts, 88 hours)

- Number of boxes lost averaged 0.34 per hour (30 boxes).
- Cost of each box = £0.47.
- Loss per day = 8.61 boxes = £3.83.
- Loss per week = 60.27 boxes = £28.32.
- Loss per year = 3134.04 boxes = £1472.99.

The above is equal to an eighty two per cent saving on the cost of the wasted boxes (annual saving of £6,738.85). The project proved to the Engineering Manager the benefit of planned preventative maintenance on the box erector. This has now been incorporated into the planned maintenance schedule for the whole site.

Once again a team justified the requested resources through the use of failure costs.

Other examples exist of improvement projects within the host company, some like those above have clear quantifiable benefits, others are less tangible such as the fitting of flashing lights. The lights were placed in a prominent position on the moulding machines, these allowed the operators to see which machine had stopped. ~~The fitting of visual alarms has increased the operator response time by approximately twenty per cent, and also allow the operator to prioritise which machine needs attention more urgently when more than one alarm triggers.~~

The above examples can be categorised into the following four areas:

- i) The scrap recording and analysis established accurate logging of waste raw material and finished goods. This in allowed specific problem areas to be highlighted and targeted for attention.
  - Example one.
- ii) Reduction of finished goods scrap being produced:
  - Examples two, three and four.



traditionally cost the company the most money; "Supplier Excellence" awards have been received from two major customers within the last six months, as a result of increasing supply performance; The combined work of the shift teams has saved approximately £70,000 to date by targeting the failure costs highlighted by the quality costing initiative.

# CHAPTER EIGHT

## CONCLUSIONS AND RECOMMENDATIONS

## 8.0 Introduction

The aim of this chapter is to outline the conclusions that can be drawn from the research, and to put forward a number of recommendations for future study.

This chapter is divided into the following sections:

- 8.1 - Impact and effect of the quality costing research.
- 8.2 - Problems encountered during research.
- 8.3 - Critical evaluation of the research methodology.
- 8.4 - Guidelines for quality cost collection and analysis in the packaging industry.
- 8.5 - Limitations of quality costs.
- 8.6 - Establishing a quality cost reporting system.
- 8.7 - Recommendations for future research.

### 8.1 - Impact and effect of the quality costing research.

A true culture change has taken place within the host company, driven by the continuous improvement and quality costing initiatives. Machine operators now have the means of extracting financial information in order to justify manufacturing process improvement projects and the host company shift teams are selecting projects to tackle within the overall quality cost reduction programme (i.e. all departments are striving to improve continually). Examples of these are outlined in chapter seven, section 7.3.

The quality costing initiative worked in tandem with the continuous improvement drive. This was carefully managed as quality cost information is of little use if it is not accompanied by an effective improvement programme that will design out areas of waste and nonconformance. All personnel were aware of the potential savings to be made, and of the empowerment taking place. The individual shift teams put suggestions forward, which were vetted by the senior management team.

The suggestions had to be plausible improvement projects that were financially viable and would produce tangible results. The shift teams, under the guidance of their facilitator (usually the shift manager) would then be responsible for seeing the project through to completion. Proof of tangible success from an existing project, for example scrap reduction or efficiency improvements, were required prior to launching a proposal for another. This information was given to the senior management team on a monthly basis.

The cost of quality for the host company is now reported on a monthly basis to the Operations Director. This is communicated at a monthly "Target Group" meeting of departmental managers, and is the focus of discussion on the allocation of resources for improvement projects. The Operations Director has begun presenting the quality costing information, with his teams recommendations, to the board of directors at the monthly business review meeting.

At a macro level the quality costing information is being used to monitor and establish trends within the host company, at a micro level individual shift teams are using the data gathering tools (actual failure cost verses forecast prevention cost) to justify improvement projects. As outlined within chapter seven - Quality Improvement Through Quality Costing, this is having a real impact on the bottom line.

### 8.1.1 Outcomes

Specifically the outcomes of the research, within the host company, have been:

- i) The cost of quality is now a recognised tool for providing practical feedback to the host company. It has proven not only useful, but is now considered essential in driving forward the company's continuous improvement programme.
- ii) Factors influencing the cost of quality within high volume manufacturing industry (plastic injection moulding) were identified for the host company.

iii) A methodology on how to ascertain the quality costs in a high volume manufacturing industry was developed from the research experience within the host company.

iv) The nature of the total cost of quality within the host company, compared to industry averages were examined (within chapter six, section 6.3).

v) A management information system was established to report quality related issues and costs on a monthly basis (see chapter five, section 5.5 for details, also appendix two for an example of a report).

Against the original hypothesis set to be tested, as detailed within chapter one (section 1.2.1), these are the results:

(a) An organisations choice of a particular cost model to use depends upon the level of sophistication of its accounting systems, and the quality measurement system in place.

- Yes, this would appear to be the case, as detailed within section 8.4 of this chapter.

(b) The success and establishment of a quality costing ethos is dependant upon many other elements, such as structured training, employee involvement, top management commitment, etc.

- Yes, as detailed within section 8.1.1 of this chapter.

(c) The implementation of T.Q.M. relies upon the availability of certain key information. It therefore depends upon the establishment of an information system to provide specific data.

- Yes, as detailed within section 3.6 of chapter three.

(d) The implementation of T.Q.M. depends upon establishing cost of conformance and nonconformance measurement systems.

- Yes and no, chapter seven, section 7.2, details quality improvements made through quality costing which were part of a wider continuous improvement process.

## 8.2 Problems encountered during research.

Data was gathered by study of the entire accounting system and quality assurance department and production budgets, supplemented by discussions with staff from the quality, production and accounting department. Access to detailed breakdown figures within the company's profit and loss account was readily available, but not always presented in the form required for the research project.

Within the company the collection and analysis of quality related cost was found to be fragmented, mainly attributed to waste, product returns and customer complaints. These costs were collected under different departmental headings (i.e. production, commercial, quality). The available data was incomplete, therefore, it was necessary to establish procedures for the collection and analysis of the required information. These were fully discussed in chapter five, section 5.5.

Until discussions with the management occurred concerning this research the company were unaware of formal quality cost collection methods and relied solely on technical and quality assurance departments budgets for an analysis of quality costs. In the course of discussion, however, interest was shown in the categories and elements suggested by the author and full assistance and co-operation was provided.

No major problems in terms of access to data, availability of required information or assistance from the host company's personnel were encountered during the research.

8.3 - Critical evaluation of the research methodology.

The action research methodology employed in this study for collection and analysis of information was found to be satisfactory. However, as detailed within chapter one, section 1.3.1, it does have some built-in disadvantages. For example, any mistakes made were highly visible. This would only have been dangerous, through people losing interest and motivation, if tangible results had not been produced at an early stage.

The other danger was that data would become outdated during the eighteen month time lapse between conducting the literature survey and actually completing the thesis. This was allowed for during the writing-up stage, but upon review proved not to be a factor.

The methodology provided the author with access to the necessary information and allowed the host company's personnel to become involved in the research process. Through the use of action research the aims of the thesis were accomplished, as detailed in section 8.1.1.

A low level of awareness was demonstrated within the host company, even at top management level, of the existence of BS 6143 or other systems as guides to quality cost collection and measurement. Only when the results of the collection exercises were presented, and the effects of the shift team initiatives began to become common knowledge was this issue addressed.

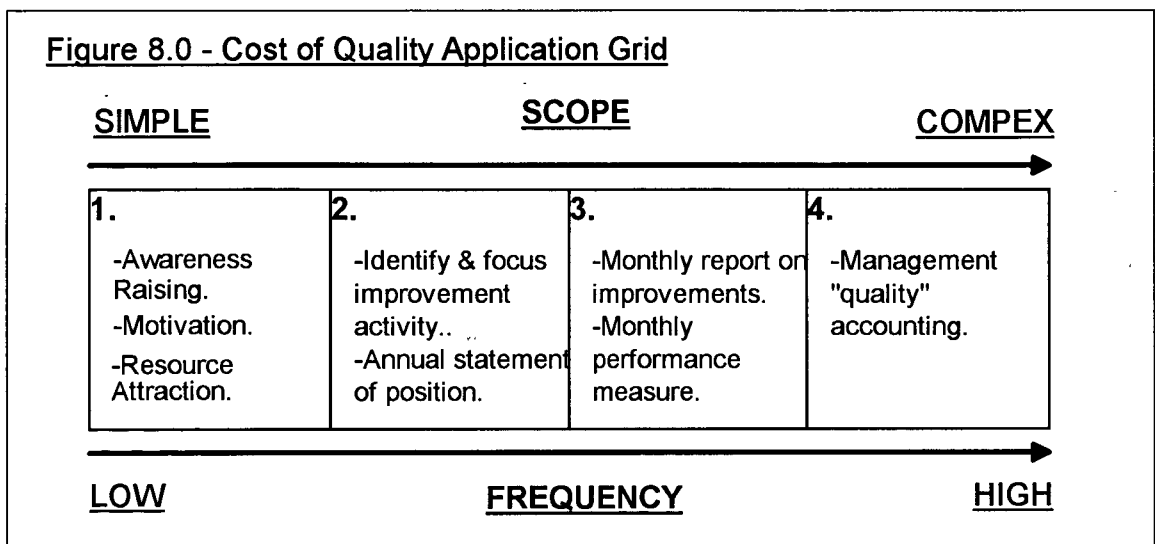
8.4 - Guidelines for quality cost collection and analysis in the packaging industry.

Although the findings of this research have already been outlined within chapters five and six, it is worth reiterating. Essentially the Prevention, Appraisal, Failure (P.A.F.) model provided results that could be used in conjunction with the continuous improvement initiative. The Process model did not.

The P.A.F. model appeared to achieve the desired results because it had already been trialed successfully within the number of disparate industries. It also proved readily acceptable to the host company's personnel. This is because the information systems necessary for data collection already existed, and the concept was easily understood. It was also easily tailored to suit the specific needs of the host company.

As already described in chapter six, the host company was not yet advanced enough, in quality costing techniques, to use the Process Cost model. It would have taken an unprecedented amount of input to achieve essentially the same end result - a sharp focus on quality issues. The Process model would perhaps be of more use at a later stage in the development of quality costing information systems, as proposed below. The suggestion, based on the results obtained during this research, is that the P.A.F. model can be used during the early stages of cost collection. The Process model would then be used when suitable experience, and information gathering systems have been established.

The concept of different levels of information gathering and use has been recognised by other authors. Bradshaw and Yarrow (1994) put forward a "Cost of Quality Application Grid", as shown in figure 8.0 below (56).



Their argument is that an organisation will progress through the grid, eventually arriving at a point where quality cost data is an integral part of business information and performance measurement.



The boxes, one to four, within the grid are defined as follows:

**Box 1** - One off, basic assessment of total quality costs, taking information from wherever available, but not attempting to install systems to measure new data. This is usually performed by consultants and / or special project managers.

**Box 2** - Annual, detailed "snapshot" of total quality costs. Usually undertaken by the finance function. This would use data obtained from both the financial accounts and the interviewing of key personnel.

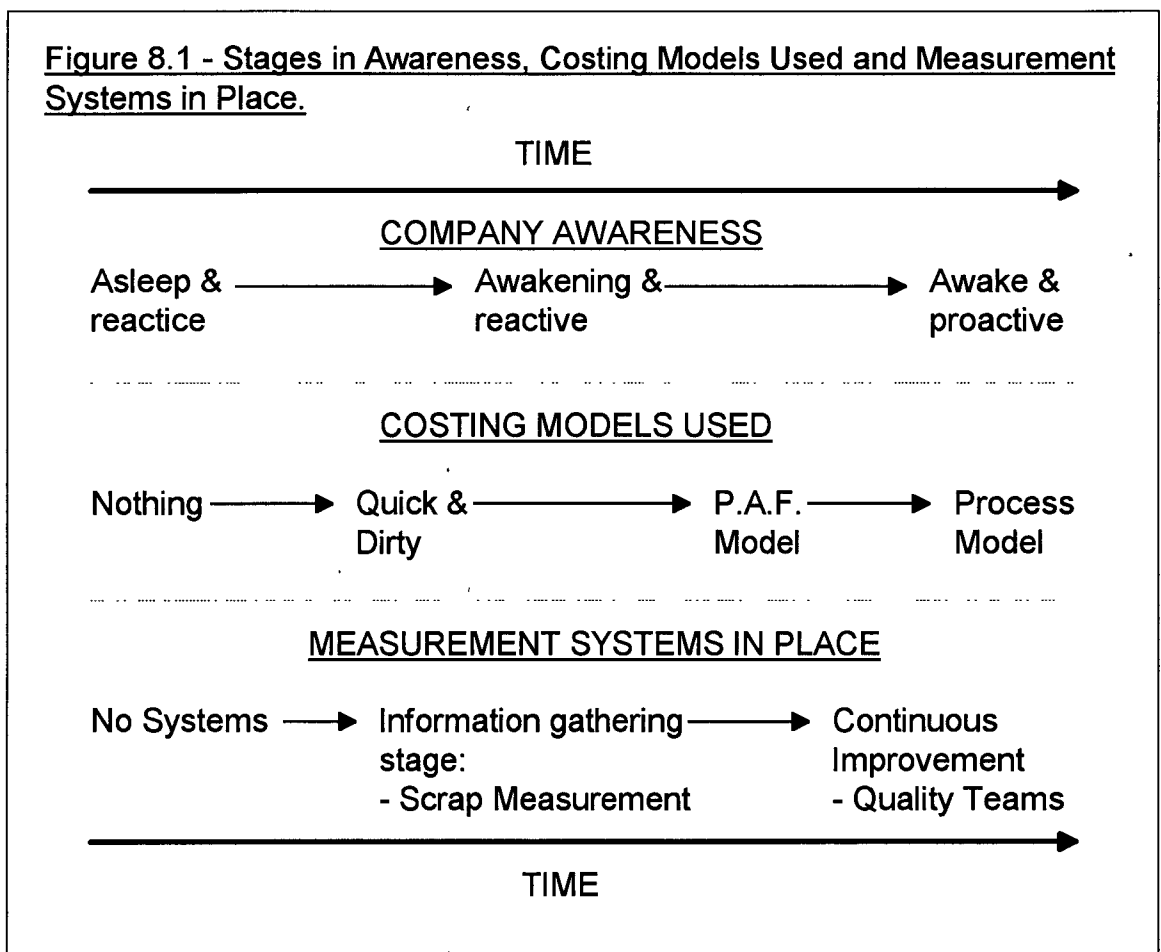
**Box 3** - Monthly / bimonthly reports by improvement teams and / or quality circles with management guidance. Usually produced by the quality function and extracted from production / sales data.

**Box 4** - Monthly detailed management accounts reporting business performance in "quality" terms.

Bradshaw and Yarrow (1993) admit that it is not strictly necessary for an organisation to follow the path of the grid exactly ..."It may be possible to start a quality costing exercise in boxes other than the first, to develop models in several boxes simultaneously, or at least progress quickly along the grid" (56), but it is clear that a form of progression should exist.

Given the above terms and definitions, the host company in which this research has been based would appear to have started in box one (awareness raising, motivating, attracting resources), progressed through box two (identifying and focusing on improvement activities, producing an annual statement of quality costs), and are currently in box three (producing monthly reports on improvements, measuring performance on a monthly basis). The organisation first awoke to the possibilities available through the use of quality costs, then began identifying and focusing upon improvement activities, and is now reporting monthly on quality costs. The host company is currently moving rapidly towards box four, the integration of quality costing into the management accounts (management "quality" accounting).

Another matrix, which may aid the understanding of the development of organisations' quality systems, is that developed by the author and shown in figure 8.1. This diagram shows various stages of progression for an organisation in three specific arenas: i) Company awareness, ii) Costing models currently being used, iii) Measurement systems in place. The elements do not need to travel along the same time line and progression does not need to be linear, i.e. they may exist and develop independently of each other. However, the combination of all three elements would give any organisation a distinct head start in developing, implementing and utilising total quality management and continuous improvement. The elements may even be considered prerequisites to success.



The first element, "company awareness", shows an organisation in three distinct stages; Firstly, asleep and reactive - the organisation only reacts when circumstances dictate it must; Secondly, awakening to the need for change but still reactive - the organisation begins to realise the need for innovation but is frequently caught off guard by developments; Thirdly, the organisation is fully

awake and proactive in implementing internal and external systems to meet a continually changing environment.

The second element, "costing models used", demonstrates the progression in stages of an organisation in the use of available quality costing models. Four stages exist: Firstly, no costing models in use - the organisation does not recognise the need or potential of formal costing systems to identify quality deficiencies; Secondly, a quick and dirty exercise is carried out to give a representation of the quality costs - this was used within the host company to gain the attention of the senior management team; Thirdly, the P.A.F. model is used to provide information on the specific nature of quality costs using a predetermined set of cost categories - this will highlight the current level of quality costs within the organisation; Fourthly, the Process model is used to provide a detailed breakdown of conformance and nonconformance costs within the host company - this will allow the nonconformance costs to be reduced where possible.

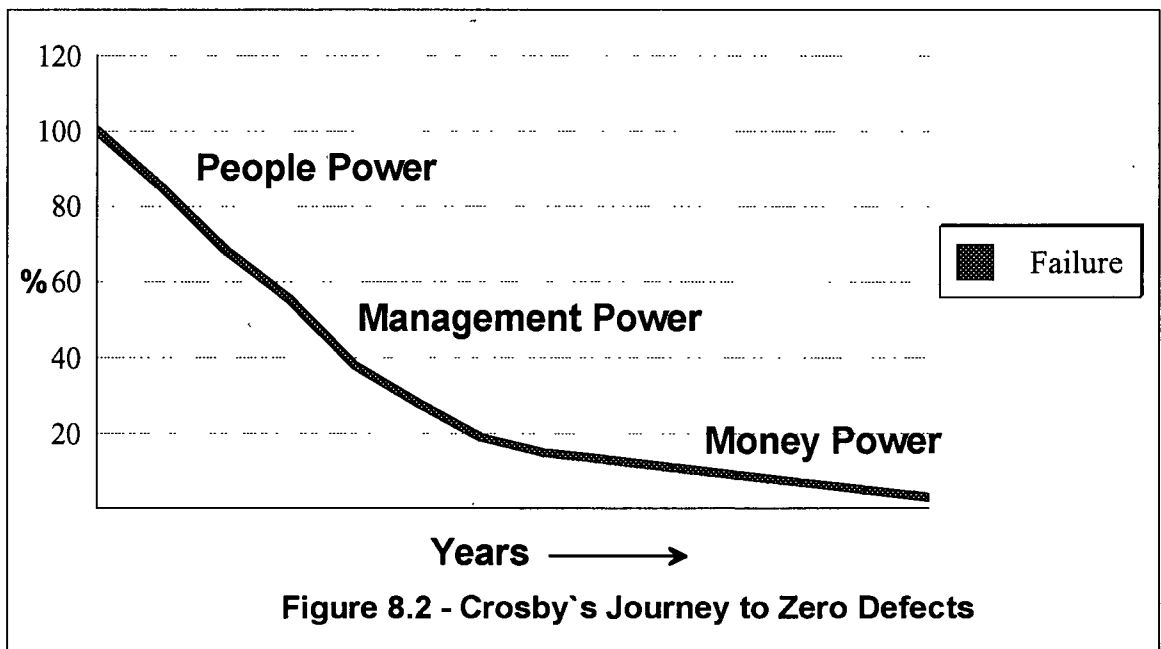
The third element, "Measurement systems", demonstrates the type of measurement systems currently in place within an organisation. Three stages exist within this element: Firstly, no systems in place - the organisation does not collect data to use for justification of improvement projects. Secondly, an information gathering stage - the organisation measures simple items such as the creation of scrap, this information being used as evidence of the need for improvement. Thirdly, measurement systems are a part of the organisations culture that the workforce, at all levels, use data gathering as an intrinsic part of continuous improvement - i.e. they proactively measure suspect processes to ascertain the level of control that exists for that process, then if necessary take the required action or improvement.

As previously mentioned the relationship between the three elements does not need to be linear. An organisation may be at different levels of development with each category, and still making progress. It should also be noted that the three stages are not mutually exclusive, the boundaries have been out on to allow the development of a concept. As with all theories "grey" areas do exist.

The host company would appear to be between stages two and three for i) company awareness, at the third stage with ii) costing models used, and at the third stage with iii) measurement systems in place.

Another model is that proposed by Crosby (1979). Crosby's model (see figure 8.2 below) of "price of nonconformance" links time with resources used and money spent. He proposes that, on average:

- A twenty-five per cent reduction in failure costs (nonconformance costs) can happen in one year by harnessing the workforce - so called "People Power".
- Another fifty per cent reduction in failure costs can be realised by management directed projects - so called "Management Power".
- Only then does money need to be put into the problems remaining - so called "Money Power".



8.4.1 Presenting and using quality cost information

Quality related costs are useful to collect only if there is the intention of taking some action as a result, otherwise any programme may be considered a waste of

time and effort. Such initiatives may be aimed at reducing the costs, or at making people aware of the costs and their importance, as a step towards the same end. When the first report is presented to senior management it is important, as detailed in chapter four, section 4.3, that:

- i) All senior managers are involved who have a direct interest in the financial well being of the company;
- ii) Ensure all figures put forward have the agreement of the finance department.
- iii) Briefly explain the concept behind the quality cost collection.
- iv) Stress the results to be presented are from the first study, and that development of the more accurate costing methods will involve every department at every level.
- v) If possible, relate the figures to an accepted norm or average for the particular industry.
- vi) Highlight the main points, and the areas which seem most amenable to quality improvement and cost reduction.
- vii) Positively encourage comment and suggestions.

It is highly unlikely that the pilot study will disclose the full extent of quality related costs. As already mentioned, at the beginning of the thesis, Crosby (20) suggests that a typical first estimate rarely arrives at more than twenty five to thirty per cent of the true value. It is possible to create a breakthrough in quality awareness as people face the facts that:

- Quality is not vague, but is measurable in monetary terms.
- Poor quality impacts the whole company, not just the quality department.
- Bad quality hits where it hurts most - on the bottom line.
- Substantial savings are waiting to be made.
- Insufficient resources have been inverted in prevention in the past.

The single best way to get attention is through results. Actually using the information to achieve a couple of "quick wins", on quality improvement or

material saving will demonstrate better than any presentation the potential of quality costing within any organisation.

#### 8.5 - Limitations of quality costs.

Quality costing can only be used as a management tool if the data put forward is accepted as accurate. It is therefore limited by two factors: i) the availability of required information and ii) the necessary resources to gather and analyse such information completely (within the host company the author provided this resource).

Within the host company this limitation was demonstrated by a lack of data on "service" costs, i.e. the cost of providing the necessary level of service to its customers. The concept of service does have a financial value. Traditionally known as goodwill, within financial accounting, it is commonly used for putting a monetary value on a trademark or brand name. The concept of measuring this value is not a common theme within traditional manufacturing engineering. Quality costing models are applied within traditional "service" organisations (i.e. organisations that provide a service, not a physical product), such as banks and building societies, but it is rare for the service element to be included within manufacturing engineering.

No "service" cost factor has been included within the quality costing research of the host company. This decision was justified by the fact that the host company had no knowledge, prior to this research, of quality costing. Therefore, the collection of tangible costs such as scrap, would be easier to begin the cost collection process with. The organisation needed to learn the basic elements before progressing to detailed and timely self analysis.

#### 8.6 - Establishing a quality costing system.

This section will propose a methodology for the establishment of a basic quality costing system within a production manufacturing environment. It is based on the authors direct experience within the host company. The methodology proposed

is designed to complement a total quality management or continuous improvement initiative. It can provide the necessary results to justify various improvement projects or to highlight the existence and size of any "black holes".

i) Establish a cross functional team, with representatives from the finance and quality departments.

The initiative needs visible top management support and an identifiable leader. It is also important to involve a representative from the finance department. This is necessary in order to convince them of the benefits of quality cost information, and essential if finance are to eventually take up responsibility for quality cost reporting.

ii) Present the quality-cost concept to senior management, with an initial proposal.

To win top management support a presentation should be made to senior management, outlining the initial proposal and citing the results from other quality costing exercises within the industry. The potential of the project should be highlighted.

iii) Select a trial area.

If possible the costing model chosen should be piloted within a receptive area before wide scale implementation. This should do a number of things: i) give credence to the concept of quality costing within the organisation; ii) win over any sceptics within the management team and personnel; iii) allow those driving the quality costing exercise to tailor the model in use to suit the idiosyncrasies of the organisation.

The trial area selected should have good records, and a low resistance to "change". Ideally the exercise should be part of a structured quality improvement programme, this will give it focus and goals. Personnel in the chosen area should be fully briefed as to the nature of the exercise and the proposed outcomes.

iv) Identify and classify poor-quality-cost elements for the selected area.

The team should identify and list all possible quality costs within the trial area chosen. The decision may be made at a later stage to disregard certain elements, but initially all potential quality costs should be noted.

The complexity of the manufacturing operation will determine the number and type of cost elements included in the exercise, and time and availability of resources may also be important factors. Often a "quick and dirty" exercise may produce enough initial information. Figure 8.2 "Stages in the use of measurement systems" may be used to ascertain the scope of an organisations current measurement system .

v) Determine specific sources of relevant information

Once the cost elements for an area have been selected collection systems will need to be set up. Some of these costs will already exist, within the company accounts, others will need specifically creating, and all will need to be accurately collated.

vi) Establish cost collection procedure

Determine who is to collect the required data, how often it is to be collected and how the information is to be stored. A systematic approach is important to ensure that the necessary data collection takes place on a consistent basis. The use of simple summary forms, such as those advocated by BS 6143, parts one and two, provide a sufficient prompt to collectors.

vii) Establish the format of the quality cost report and to whom it should be distributed

The format chosen depends upon how often, and to whom, the report is to be made. The quality cost report needs to be easily understood by the recipient,



and to this extent thought should be given to the format. For example, lots of simple diagrams, or lots of text.

viii) Review the status of the quality costing information with the management team, and track improvements, at regular intervals.

At regular intervals brief the senior management team on the information being collected. The quality cost report should include a short analysis of results, highlights of specific problems, and a breakdown of major problems. At the end of the trial period a concise and unambiguous report should be written for the senior management team. It should be sufficient to report on progress made and the major categories of quality cost without getting into specific detail. Regular communication is key in convincing the management team of the validity of the exercise.

ix) Improve the cost collection system as company personnel become familiar with the systems.

As the system develops over time it must expand to meet the needs of the organisation. The first quality cost exercise will not be perfect! The continual improvement of the system itself will also aid its acceptability to management and workers. Problems may be in the form of: poor understanding by management of the significance of the report; the sources of information may not be reliable; personnel may not be comfortable with the measurement systems put in place. These, when identified, can all be dealt with.

Personnel will also become aware of costs that are hidden as the exercise progresses and their own experience grows. As the system is used it should be tailored to meet current requirements.

x) Expand the quality costing exercise to the remainder of the organisation.

Once established, accepted, and tailored for the company, thought should be given to expanding the system within the company. The final report on the trial

should make suitable suggestions and recommendations as to the continuation, expansion, or termination of the exercise. For example, quality costing has the potential to provide excellent information on direct comparisons between other sites within the same division or group.

The set-up of any quality costing exercise will, by the very nature of the process, be quite specific to the organisation in which it is based. The above guide is just that, a guide. Basic models, such as the Prevention, Appraisal, Failure model, may be used to excellent effect within most manufacturing organisations. However, clear objectives must be established at the outset (in the example of the host company the quality costing exercise was linked with the continuous improvement programme).

Harrington (52), in his study into the implementation of quality costing, has proposed the following steps:

1. Develop a financial and quality assurance implementation team.
2. Present the poor quality cost concept to top management.
3. Develop an implementation plan.
4. Select a trail area.
5. Start the program in the selected area.
6. Identify and classify poor quality cost elements for the selected area.
7. Determine staging for each poor cost element.
8. Establish inputs to the poor quality cost system.
9. Establish required output format.
10. Establish the additional.
11. Review the status with the plant management team.
12. Review the monthly poor quality cost report.
13. Review the monthly poor quality cost report.
14. Based on findings, modify the program as required.
15. Expand the program to the remainder of the plant and the company.

Harrington (52) makes the point that the start of any cost collection exercise is a crucial time, because the way the collection system is started will have a major

impact on how effective it is and how long it will last. He goes on to stress the need to approach the project with a well organised, systematic method.

A quality costing system can be set-up by an individual or a team. The success of the system will depend upon the seriousness with which it is treated as a management tool, and of course the reliability of the data obtained.

The following quote, from Jefferies et al (57), gives perhaps the best advice for embarking on a quality costing exercise:

"Costs of quality are most effective when the relationship between people is such that both successes and difficulties in cost control can be discussed openly without fear of chastisement.

Where relationships are defensive, to advocate analysis of the cost of quality is a nonsense. People will manipulate the figures, tell half truths and play intellectual (but stupid) games of catching one another out. This results in the cost of quality being a total fabrication and of no value".

Effective communication of the aims, objectives, and set goals will help remove fears and give real credence to the data being supplied.

#### 8.6.1. Problems in establishing quality related costs

The following are some common oversights in establishing quality related costs within manufacturing industry. They apply to all quality costing models:

i) Omissions - the full cost impact of some aspects of quality may only become evident after careful thought, enquiry, or observation. Even when using a checklist. Factors which may easily be overlooked include the cost of secondary operations and activities related to internal failures.

ii) Over estimation - a major problem to guard against, especially in the early stages of developing a quality cost system. It should quickly become clear, for

example, that the estimated cost of consumable materials used in performing product tests is far less than the cost of external rejects. It would therefore be sensible to let the estimation of the consumables stand, to permit more time to be spent quantifying specific external rejects.

iii) Double counting - very easy to introduce this kind of error, especially when evaluating the cost of internal failures. For example, it would not be valid to record both the value of the scrapped items and the value of the replacements. If the rejected items can be salvaged, repaired or sold on as "seconds", then the net loss is the difference between the full value and the reduced value. On the other hand, all the associated extra labour and administration costs of the recovery operation must be included.

iv) Allocation of overheads - if manufacturing costs already carry an overhead allowance which makes provision for the cost of maintaining the quality department, then it may not be valid to identify a separate quality cost for the extra inspection incurred. In fact, it gives a clearer picture of the impact of the cost of poor quality if the overhead is ignored and the inspection included as a charge where and when it actually occurs. The allocation of overheads for quality costing exercises within individual companies does not allow for direct comparisons to be made, due to the different elements that may be incorporated within them.

This is one of the reasons why it is important for the team to seek the advice of the finance department before finalising and presenting any results.

v) Built-in scrap allowances - this is another area which must be treated with care. Standard manufacturing costs may have an allowance built-in for "scrap allowance"; i.e. a certain level of losses may be assumed and built into the price. Equally, production batches may automatically be made a certain percentage oversize, in order to compensate expected losses. This tends to hide and somewhat legitimise the cost of scrap within the manufacturing organisation. Again, the specific way of dealing with and presenting these issues should be agreed in advance with the finance department.

8.7 - Recommendations for future research.

To conclude the thesis this section will put forward a number of recommendations for further research.

Firstly, the work needs to be repeated in other organisations and industries in order to ascertain its applicability and transferability. The next phase in the authors work within the host company will see a larger body of quality cost data becoming established.

As discussed within in chapter five, section 5.2, the prevention and appraisal costs currently appear low when compared directly with the failure costs for the periods measured. It will be very interesting to see how the influx of cash to the prevention and appraisal cost categories (as a direct result of the continuous improvement initiative) can influence further the failure cost results (i.e. a reduction). This type of data can only be gathered over a more lengthy time period, for example five years.

The cost of quality concept is now being implemented elsewhere within the host company's group. This began with a review taking place at the host company's sister site in the U.K. This is beginning to allow a direct comparison to be made between the two sites quality costs and cost ratios. Once this is fully established it will be possible to expand the system yet again to encompass the host company's sister sites overseas, again allowing comparison between the quality costs, and ratios at the individual sites.

This work will establish whether the quality measurement system devised for the host company's first site is generic or not, an important element missing from this original research.

Another element absent from the present quality cost measurement system within the host company is any form of recognition of "service" (see section 8.5). Apart from the obvious measure of customers placing orders elsewhere if dissatisfied with the level of service they receive (which is measurable using sales figures), a

direct measure has not been included within the models trialed at the host company so far. As suggested in figure 8.1 - Stages in the Use of Measurement Systems, this "service" element may become included when an organisations measurement systems have matured to a sufficient level, i.e. they have progressed through a number of the stages detailed, built up system self knowledge, and are productively using it. It is the author`s opinion that only at this stage will real benefit come from the time and effort needed to generate such information for any manufacturing organisation.

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# APPENDIX 1a

## Background and Peripheral Information

STANDARD OPERATING PROCEDURE

WREXHAM PERSONAL CARE

DATE OF ISSUE 27/09/94

DOCUMENT No. WPC0003

PAGE 1 OF 7

ISSUE No. 09

TITLE: QUALITY CONTROL PASS OFF

A OBJECTIVE

To define a procedure to authorise the manufacturing department to 'go into production', by passing off manufactured product after a change over, and doing a line clearance.

B SCOPE

- Each time a line is changed over
  - 1 Tool change
  - 2 Colour change
  - 3 Quality Problem.

C RESPONSIBILITY

It is the responsibility of the Shift Manager to ensure that the procedure is followed and appropriate documentation completed and stored.

It is the responsibility of the Setter/Material Handler/Clean Room Operator to authorise production by completing and signing the Pass Off and Line Clearance check.

D PROCEDURE

Reference to pages 2 of 5 and 3 of 5, and completing the attached forms 4 of 5 (Pass Off sheet) and 5 of 5 (Line Clearance/Batch Start Up).

PREPARED BY: *David Sampson* DATE: *27/9/94*.

AUTHORISED BY: *[Signature]*

**UNCONTROLLED COPY**

FOR INFORMATION PURPOSES ONLY

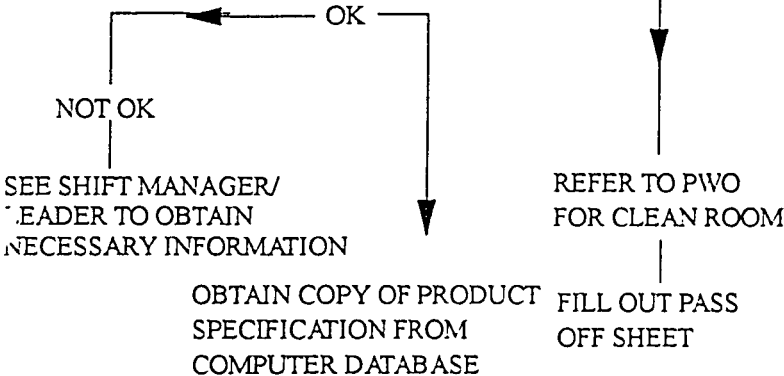
PERSONAL CARE  
PASS OFF FORM AND SAMPLES  
BY SETTER/MATERIALS  
HANDLER

CLEAN ROOM  
PASS OFF SAMPLES  
FROM SETTER

CHECK THE FOLLOWING INFORMATION  
IS RECORDED ON THE ATTACHED FORM

THE FOLLOWING IS RECORDED:

- A THE SPECIFICATION NUMBER
- B THE MACHINE NUMBER
- C THE RAW MATERIALS SPECIFICATION
- D THE MASTERBATCH SPECIFICATION
- E THE CYCLE TIME (SPECIFICATION)
- F THE CYCLE TIME (ACTUAL)
- G THAT THE MACHINE HAS BEEN CLEARED OF FOREIGN COMPONENTS
- H THE SPECIFICATION WEIGHT OF THE COMPONENTS
- I THE MATERIAL HANDLERS SIGNATURE, DATE AND TIME
- J THE DATE AND TIME THE PASS OFF FORM AND SAMPLES WERE TAKEN
- K THE BATCH No. OF RAW MATERIALS (CLEAN ROOM ONLY)



CHECK SPECIFICATION  
INFORMATION AGAINST  
THE PASS-OFF FORM  
INFORMATION

RECORD/CHECK RESULTS IN  
'MATERIALS' SECTION OF THE  
PASS-OFF FORM

- NOT OK
- 1 INFORM THE SHIFT MANAGER.
  - 2 RECORD/CHECK RESULTS IN 'MATERIALS' SECTION OF THE PASS OFF FORM

WEIGHT THE  
PRODUCT

CHECK WEIGHT AGAINST THE  
TEST CARDS, ENTER ON PASS  
OFF SHEET

CARRY OUT VISUAL  
CHECKS

LOOK FOR:

- 1 CONTAMINATION
- 2 MOULDING DEFECTS
- 3 COLOUR NOT TO RS SAMPLES

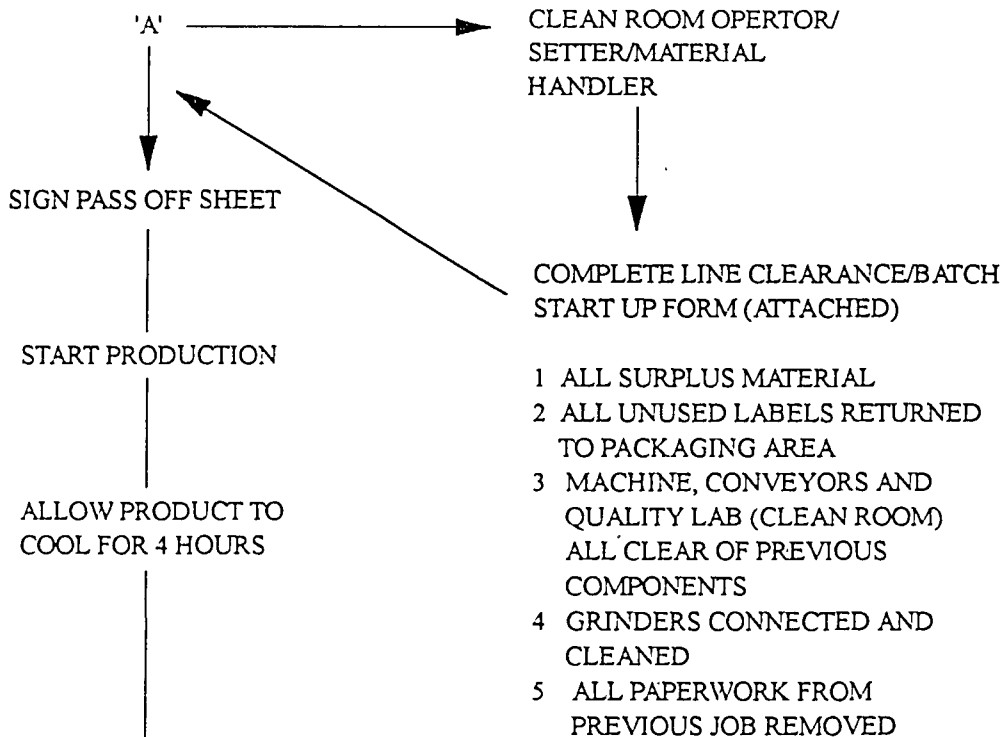
NOT OK

- 1 INFORM SHIFT MANAGER/SETTER
- 2 RECORD/CHECK RESULTS IN 'MATERIALS' SECTION OF THE PASS OFF FORM
- 3 TREAT ALL PRODUCTION SO FAR AS NON-CONFORMING WSP0004 CLEAN ROOM WI1016

**UNCONTROLLED COPY**

RECORD/CHECK RESULTS IN  
VISUAL DEFECTS SECTION OF  
THE FORM  
FOR INFORMATION PURPOSES ONLY

'A'



CLEAN ROOM OPERATOR/  
SETTER/MATERIAL  
HANDLER

SIGN PASS OFF SHEET

START PRODUCTION

ALLOW PRODUCT TO  
COOL FOR 4 HOURS

COMPLETE LINE CLEARANCE/BATCH  
START UP FORM (ATTACHED)

- 1 ALL SURPLUS MATERIAL
- 2 ALL UNUSED LABELS RETURNED  
TO PACKAGING AREA
- 3 MACHINE, CONVEYORS AND  
QUALITY LAB (CLEAN ROOM)  
ALL CLEAR OF PREVIOUS  
COMPONENTS
- 4 GRINDERS CONNECTED AND  
CLEANED
- 5 ALL PAPERWORK FROM  
PREVIOUS JOB REMOVED

RECORD RESULTS ON  
INSPECTION REPORT

CARRY OUT DIMENSIONAL CHECKS, AS  
SPECIFIED ON THE TEST CARD

NOT OK

OK

IF, DURING THE RUN ANY  
IMPRESSIONS ARE BLANKED  
OFF PLEASE RE-TEST AND  
COMPLETE THE  
INFORMATION ON THE PASS  
OFF SHEET

SIGN PASS OFF SHEET

- 1 INFORM SHIFT MANAGER
- 2 RECORD RESULTS ON PASS OFF FORM
- 3 TREAT ALL PRODUCTION SO FAR  
AS NON-CONFORMING WSP0004 AND  
CLEAN ROOM WI1016

RETAIN SIGNED PASS OF SHEET  
AND 1st OFF SAMPLES  
**UNCONTROLLED COPY**  
ALL RECORDS TO BE KEPT BY  
CLEAN ROOM MANAGER/  
QUALITY MANAGER  
FOR INFORMATION PURPOSES ONLY

WPC0003

## WREXHAM SITE PASS OFF SHEET

MACHINE DETAILS

DESCRIPTION \_\_\_\_\_

MACHINE No \_\_\_\_\_ ITEM CODE \_\_\_\_\_

CYCLE TIME \_\_\_\_\_

SPECIFICATION \_\_\_\_\_ ACTUAL \_\_\_\_\_

IMPRESSIONS \_\_\_\_\_

TOTAL \_\_\_\_\_ RUNNING \_\_\_\_\_

SETTERS \_\_\_\_\_

SIGNATURE \_\_\_\_\_

CLEAN ROOM ONLY:

IMPS BLANKED OFF DURING RUN  AT BOX No

RETESTED  P/F QC SIGNATURE

RAW MATERIALS USED (Batch numbers only required for Clean Room)

**POLYMER**

**MASTERBATCH**

Type \_\_\_\_\_ Type \_\_\_\_\_

Part number \_\_\_\_\_ Part number \_\_\_\_\_

Batch number \_\_\_\_\_ Batch number \_\_\_\_\_

Correct Silo?

**RAW MATERIAL No 1**

**RAW MATERIAL No. 2**

Type \_\_\_\_\_ Type \_\_\_\_\_

Part number \_\_\_\_\_ Part number \_\_\_\_\_

Batch number \_\_\_\_\_ Batch number \_\_\_\_\_

Material Handlers Signature \_\_\_\_\_ Date \_\_\_\_\_

Time \_\_\_\_\_

COMPONENTS DETAILS

REFERENCE IS TO BE MADE TO THE PWO AND SPECIFICATION TO CHECK:

	SPECIFICATION	ACTUAL	SIGNATURE
MATERIALS			
WEIGHT			
VISUAL DEFECTS			
DIMENSIONAL CHECKS			
FUNCTIONAL CHECKS			
COLOUR CHECKS TO RS SAMPLES			

PASS FOR INFORMATION PURPOSES ONLY  
**UNCONTROLLED COPY**

DATE \_\_\_\_\_

TIME \_\_\_\_\_

# WREXHAM SITE PASS OFF SHEET

COMMENTS:

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CAVITY	1	2	3	4	5	6	7	8
WEIGHT/g								

CAVITY	9	10	11	12	13	14	15	16
WEIGHT/g								

CAVITY	17	18	19	20	21	22	23	24
WEIGHT/g								

CAVITY	25	26	27	28	29	30	31	32
WEIGHT/g								

CAVITY	33	34	35	36	37	38	39	40
WEIGHT/g								

CAVITY	41	42	43	44	45	46	47	48
WEIGHT/g								

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AVERAGE: \_\_\_\_\_

RANGE: \_\_\_\_\_



## PERSONAL CARE

### LINE CLEARANCE/BATCH START UP

WPC0003

**LINE CLEARANCE**

LAST COMPONENTS/ASSEMBLY \_\_\_\_\_

ITEM CODE \_\_\_\_\_

	PASSED BY		
	SETTER	MATERIAL HANDLER	OPERATOR
All surplus material removed from the area			
All unused labels returned to the Packaging area			
Machines and conveyors all clear of previous components			
Grinders connected and clean			
All paperwork from previous job removed			

**BATCH START UP**

NEW COMPONENTS/ASSEMBLY \_\_\_\_\_

ITEM CODE \_\_\_\_\_

	PASSED BY		
	SETTER	MATERIAL HANDLER	OPERATOR
All material present per PWO/Specification			
All material correctly identified			

**PRODUCTION AUTHORISATION**

SETTER/MATERIAL HANDLER/ OPERATOR \_\_\_\_\_ DATE \_\_\_\_\_

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FOR INFORMATION PURPOSES ONLY

LINE CLEARANCE/BATCH START UP (CLEAN ROOM)  
WPC0003

LINE CLEARANCE

OLD COMPONENT \_\_\_\_\_  
ITEM CODE \_\_\_\_\_  
BATCH NUMBER \_\_\_\_\_

AREA TO CHECK		QC INSP.	SETTER
PRODUCT CONVEYOR	LONG CONVEYOR/ THROUGH WALL		
MACHINE	FIXED HALF PLATTEN		
	MOVING HALF PLATTEN		
	TIE BARS		
	EJECTOR AREA		
	BED OF MACHINE		
	SUPPORT LEGS		
	UNDER MOULD CONVEYOR/ SIDE		
	CHECK 'FLIP FLOP' FLAPS		
	ROLLER AREA		
OUTSIDE	BENEATH BRUSHES		
	EXTERNAL SURFACES		
ALL PAPERWORK AND LABELS REMOVED			
GRINDER CLEANED			
ALL MATERIAL REMOVED			

BATCH START UP

NEW COMPONENT \_\_\_\_\_  
ITEM CODE \_\_\_\_\_  
BATCH NUMBER \_\_\_\_\_

		QC INSP.	SETTER
ALL MATERIAL AS PER PWO/SPECIFICATION			
ALL MATERIAL CORRECTLY IDENTIFIED			
BOOTH CLEANED AND PARTICLE AIR COUNT OK			
PRODUCTION AUTHORISED QC INSPECTOR _____ SETTER _____		<b>UNCONTROLLED COPY</b>  FOR INFORMATION PURPOSES ONLY DATE _____	



# AUDIT RECORD

Sheet No. 1

(2 Hourly Check)

Part Name: <u>ONE OF CLAY PLUG</u>	Customer:
Part No: <u>1511730</u> P.W.O. No: <u>89262P</u>	M/C No: <u>14</u>

Remarks/Action	Tick = Accept	T = Technician Called
	Cross = Reject	CL = Cell Leader Called
		SL = Shift Leader Called

Date	Time	V i s u a l s											Remarks / Action	Initial	
		A	B	C	D	E	F	G	H	I	Defective Parts	Sample Size			
6.5.95	0200	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
6.5.95	0400	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
7.5.95	0600	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
7.5.95	0800	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
7.5.95	1000	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
7.5.95	1200													SHORTS (T) ALL IMP'S	[Signature]
7.5.95	1400	/	/	/	/	/	/	/	/	/	1	10	/	(T) REMOVING NOZZLE (BUCKET)	[Signature]
7.5.95	1600	/	/	/	/	/	/	/	/	/	0	10	/	FLASH IN HOLE	[Signature]
7.5.95	1800	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
7.5.95	2000	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
7.5.95	2200	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
7.5.95	2400	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	0200	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	0400	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	0600	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	0800	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	1000	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	1200	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	1400	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	1600	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	1800	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	2000	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
8.5.95	22.45	/	/	/	/	/	/	/	/	/	0	10	/	Replacing blank 22-00	[Signature]
8.5.95	2400	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
9.5.95	0200	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
9.5.95	0400	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]
7.5.95	0600	/	/	/	/	/	/	/	/	/	0	10	/		[Signature]

Not Made / Short	Sink Marks	Flash	Discolour	Distortion	Stress	Gas Flaws	Oil	Other	Defective Parts	Sample Size	Tick if Acceptable
A	B	C	D	E	F	G	H	I			

Line Clear (Tick):

EVERY TWO HOURS A LIFT SHOULD BE TAKEN AND CRITICALLY EXAMINED

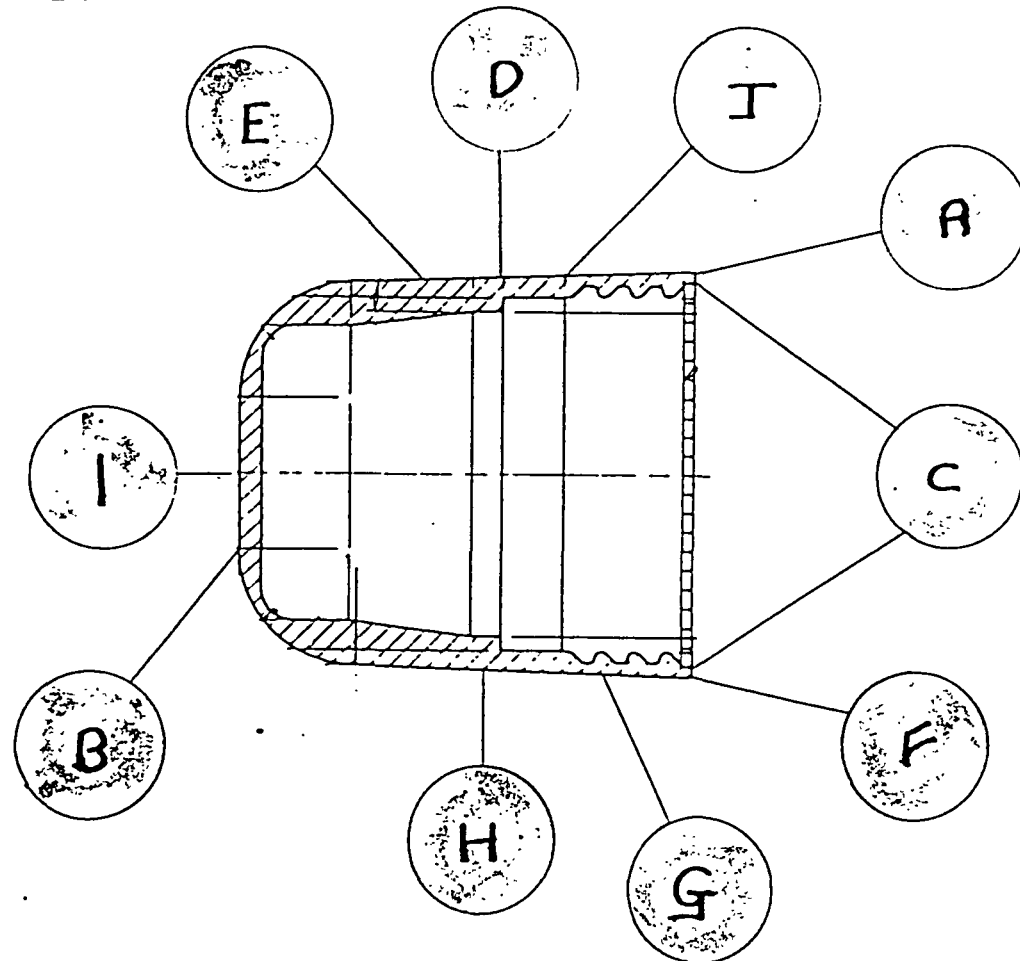
# Betts Plastics

# Quality Attribute Chart

	<u>Characteristics</u>
A	Not Made / Short
B	Sink Marks
C	Flash
D	Discolour
E	Distortion
F	Stress
G	Gas Flaws
H	Oil
I	<b>HIGH GATES</b>
J	<b>THREADS PULLING</b>
K	
L	
M	
N	
O	
	<u>Fit &amp; Function Parts</u>
P	
Q	
R	
S	
T	
U	

Customer:	<b>ELIDA GIBBS</b>
Part Name:	<b>SURE ROLL ON</b>
Customer Part No:	<b>921</b>

## Component Drawing



# APPENDIX 1b

## Continuous Improvement Information

# Continuous Improvement - Betts Plastics (Wrexham)

WEEK NO.	44	45	46	47	48	49	50	51	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
INITIATIVES																															
Audit	█	█	█																												
Intro. Presentations			█	█	█	█	█	█	█	█																					
Scrap Brainstorm						█	█	█	█	█																					
Steering Team								█	█	█	█	█																			
Quality Costing							█	█	█	█	█	█	█	█	█	█	█	█	█	█	█										
8D Action Plan										█	█	█	█	█	█	█	█														
Process Control							█	█	█	█	█	█																			
News Sheets					█	█	█	█	█	█	█	█	█	█	█	█	█														
Visits to Customers	█	█	█	█	█	█	█	█	█	█																					
B-marking							█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█									
Comm Audit														█	█	█	█	█	█	█	█										
Supplier Review																		█	█	█	█	█	█	█	█						
Facilitate Groups						█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█

(Work Program - David Bamford)

MIDDLESEX UNIVERSITY AND BETTS PLASTICS

TEACHING COMPANY SCHEME

WREXHAM  
- CONTINUOUS IMPROVEMENT?

NOVEMBER 1993

AUTHOR:

DAVID R. BAMFORD (TEACHING COMPANY ASSOCIATE)



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1 Introduction

2 Findings

3 Conclusions

4 Recommendations

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## EXECUTIVE SUMMARY

Title: Wrexham - Continuous Improvement?

Author: David Bamford - Teaching Company Associate

### Statement of the problem

As part of an overall programme implementing Continuous Improvement (Total Quality Management), an audit of the current state of affairs at the Wrexham site was considered essential. This was to ascertain the feasibility of starting the same initiative there.

### Investigation

Over a two week period a number of informal interviews were carried out, covering a wide cross section of personnel.

### Conclusions

1. Excellent factory site. Customers want to buy our product.
2. Workforce committed to the Company, if a little demoralised.
3. Communication is stifled within Wrexham, and sometimes between Wrexham and Colchester. This causes confusion and frustration.
4. Formal training required in a number of areas.
5. The potential of the site is enormous - "sitting on a gold mine!".

### Recommendations

1. Carry out a Quality Costing exercise to ascertain the current cost of manufacture. This would serve as a baseline against which progress can be measured, and would prompt management into allocating the resources necessary to support the initiative.
2. Formal training should be instigated within the following areas - Tooling; Injection Moulding; Triffid; A.G.V. System.
3. A formal program for the implementation of Continuous Improvement (Total Quality Management) should be developed. Should involve the EDUCATION, TRAINING, and INVOLVEMENT of the entire workforce.  
This would potentially involve use of some of the proven tools and techniques of continuous improvement.  
The commitment and support of the full management team would be essential.

## INTRODUCTION

### Company Details

Betts Plastics (Rigids) is a wholly owned subsidiary of Courtaulds Packaging. Courtaulds Packaging is in turn a wholly owned subsidiary of Courtaulds Plc.

Courtaulds Plc employs 21,000 people and operates in 41 countries specialising in the manufacture of products for protection or decoration in a wide range of environments. The company operates in five broad business areas: coatings; performance materials; packaging; chemicals; fibres and films. In the financial year 1992-1993 it had a turnover of approximately £2 billion.

Courtaulds Packaging employs 1,600 people and it had a turnover of £116 million in the financial year 1992-1993. It produces both rigid and flexible packages and has manufacturing facilities in the U.K. and the U.S.A.

Betts was acquired by Courtaulds in 1958. It employs 570 people and its turnover in the financial year 1992-1993 was £42.5 million. The company manufacture's closures, thin wall containers and pharmaceutical products for the food and beverages, pharmaceutical, cosmetic and toiletry industries. Betts Plastics (U.K.), within which the Teaching Company Scheme is based, employs 380 people.

### Background To Report

As part of an overall programme implementing Continuous Improvement (Total Quality Management), an audit of the current state of affairs at the Wrexham site was considered essential. This was to ascertain the feasibility of starting the same initiative there.

The audit was carried out by David Bamford, one of two Associates on placement within Betts Plastics.

This report seeks to detail initial impressions, and to put forward a number of recommendations.

Over a two week period a number of informal interviews were carried out, covering a wide cross section of personnel. Some information already existed, in the form of a "Training Needs Analysis" previously carried out on the site (see Appendix 1).

## FINDINGS

Betts Plastics (Wrexham) has been at its present site since May 1991. Before this operations were carried out within a pre-war building on the same industrial estate. The present site is a purpose built facility, incorporating state of the art Clean Room, Moulding Hall, and Finishing Department (see Appendix 2). There are approximately thirty-six plastic injection moulding machines, and two automated guided vehicles (A.G.V.s). Ninety four people are employed there. Turnover for 1992-1993 was approximately £6 million.

For breakdown of personnel see Appendix 3.

The shop floor operates a five shift system (continental), with six people on each shift. At any time one shift is on sixteen days brake.

## ISSUES

- No familiarisation period allowed during the move from the previous site to the present one. The moulding machines were uncoupled two at a time, moved to the new site, recoupled then restarted. There was no induction, no gradual build up.

Personnel feel let down, by having all the high technology equipment but little formal training.

- Very lean manufacturing, no room for error (i.e. they have only enough staff to do the job correctly when all systems run properly. For systems read: A.G.V.s, supporting software, Triffid, etc.). Therefore maintenance and tooling modifications are very difficult to carry out due to work pressure.

- Little communication via the noticeboards. Team briefs are considered good, although it is felt effective use is not made of available information, e.g. scrap information.

- Due to the socio-economic tendencies of the area the majority of personnel consider employment as something long term. They are anxious to see the factory prosper. The workforce will positively welcome any changes that can be seen to encourage this.

- In a similar manner to Colchester the operators are often not formally made aware of the nature of customer complaints.

- Personnel feel frustrated with the perceived lack of co-ordination within Betts management.

- Colchester provide immediate support for specific problem areas (tooling, Triffid, A.G.V. system), fix it, then go back to Colchester again - not enough training is given on solving specific problems.

## APPENDIX 1 b

- The experience and training of some personnel does not match the needs of the function they are required to perform (e.g. clean room personnel).
- Scrap analysis carried out 2 November 1993. £27,000 of material a month being scraped, for a whole host of reasons (incorrect guarding, badly designed tooling, badly set machines, A.G.V. system not collecting boxes in time to prevent spillage, etc.).
- Communication with Colchester is sometimes difficult and can sometimes cause stress. The logistics of having all key resources 230 miles from Wrexham can lead to confusion and frustration. Like a game of Chinese whispers messages may at times be misinterpreted.
- A series of exchange visits with Elida Gibbs (Leeds) have been started in order to help personnel identify with customer needs.
- In addition to the daily morning production meeting, an afternoon production meeting has been set up. This is to enable the management team ascertain how the site has performed against the plan.

## CONCLUSIONS

1. Excellent factory site, lots of high technology equipment. Customers want to buy our product.
2. Morale is low, people realise the potential of the situation but feel thwarted by the perceived lack of co-ordination and support of the management. Their expectations were built up in telling them the plant would be relatively trouble free to run, it is not. Many feel they are struggling to get things anywhere near right.
3. The current set-up whereby technical expertise is brought up from Colchester will not help in the long run. The so-called "Colchester Cavalry" are perceived as charging up, fixing the problem, then charging back down. More often than not if the problem reoccurs their services are required again. There is a real need for formal training in a number of areas.
4. The workforce are committed to the Company, if a little demoralised. They are fully aware of the potential at the site, and of the existence of expansion plans for the future.
5. Although the team brief and the morning and evening production meetings are considered worthwhile, communication appears stifled. Information appears to flow down more than up, and does not travel laterally at all.
6. All the constituent parts exist at the Wrexham site for an extremely efficient manufacturing unit. At the moment however these parts do not fit snugly together. The findings may come across as rather negative, but this is because the personnel are extremely frustrated as they realise the potential of the situation they are in.

### Much quoted phrases:

"We are sitting on a gold mine, if only we could get our act together".

"We have a licence to print money, the trouble is at the moment we are throwing lots of it away".

## RECOMMENDATIONS

1. Carry out a Quality Costing exercise to ascertain the current cost of manufacture. This would serve as a baseline against which progress can be measured, and would prompt management into allocating the resources necessary to support the initiative.
  
2. Formal training should be instigated within the following areas - Tooling; Injection Moulding; Triffid; A.G.V. System.
  
3. A formal program for the implementation of Continuous Improvement (Total Quality Management) should be developed. Involving the EDUCATION, TRAINING, and INVOLVEMENT of the entire workforce. This would potentially involve use of some of the proven tools and techniques of continuous improvement:
  - Quality Costing
  - Brainstorming
  - Cause and Effect Diagrams (fishbone)
  - Benchmarking
  - Quality Improvement Teams
  - Check lists, Bar Charts, Tally Charts, Histograms, Graphs
  - Statistical Process Control

The commitment and support of the full management team would be essential.

APPENDIX 1

VISIT REPORT

COURTAULDS PACKAGING, WREXHAM

29 JUNE 1993

Betts Plastics

Nine people were interviewed, including the Plant Manager, Engineering Manager, Shift Managers, Foreman and the Chief Inspector.

Purpose of Visit :- To identify the specific training needs of those managers involved in manufacturing.

To discuss any issues where the company could help improve the performance of work teams.

Training Needs

The main areas of focus on training in this business are Managing people, Team Building and Computer Awareness.

Additional Matters Arising

1. Role and Responsibility Clarification

This is an area which is causing confusion, particularly among those with responsibility for process workers. A recommendation would be that roles and responsibilities are discussed and clarified. This may also be an appropriate time to raise issues concerning quality ie. what management expects in terms of quality of product and the cost of quality to the business.

2. Communication

- a. The majority of those interviewed consider communication to be adequate.
- b. Team briefings were highlighted as being very successful.



3. Resources - Equipment

- a. Concern was expressed over the amount of waste which is created due to seemingly defective equipment. In particular reference was made to the 'Sprues' and fitting 'Grinders' under every machine.
- b. Those interviewed stated that the high frequency of fault finding with the equipment had a negative effect on the morale of the Process Workers.

People

- c. The majority of those interviewed expressed concern over current manning levels. It was suggested that a 'Floater' in the plant may ease the pressure of work?
- d. Other recommendations related to automating the remaining machines and extending the AGV system to incorporate more of the plant.

4. Maintenance Checks

- a. "Increase frequency of maintenance checks" was a view that was repeatedly expressed.

5. Morale

- a. Almost all of those interviewed were concerned about the current level of morale in the business. Although, as already mentioned equipment issues are considered to be a contributory factor. Other reasons suggested included:-

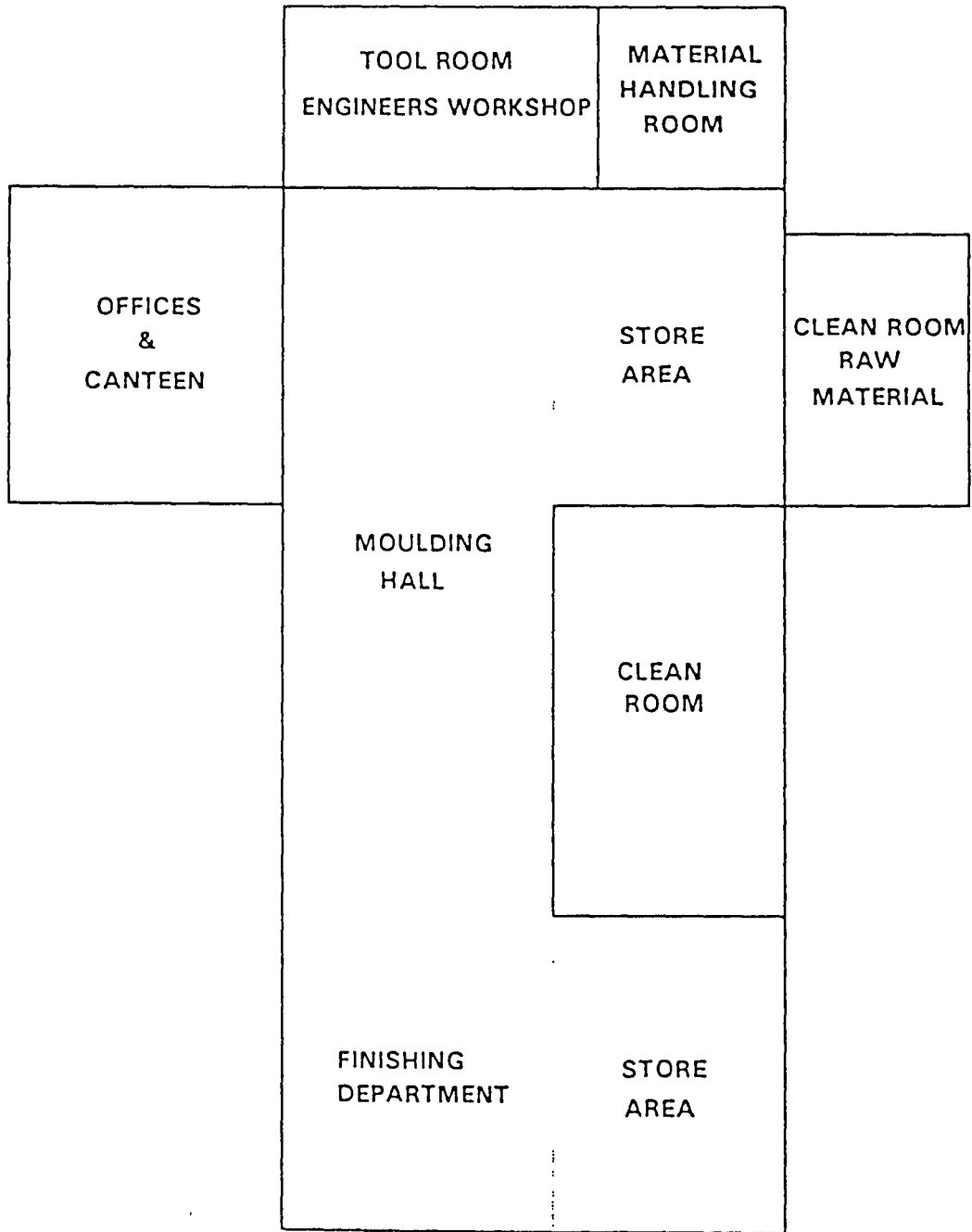
"Raised expectations" relating to the smooth running of the plan and it is perceived that "Management have not delivered".

"Low levels of profit".

"Recent redundancies".

APPENDIX 2

WREXHAM FACTORY PLAN



# BETTS PLASTICS - WREXHAM

3c

D OLIVER  
OPERATIONS MANAGER

S DAVISON

PROCESS  
DEVELOPMENT MGR

C JONES  
ENGINEERING MGR

M ASPINALL  
COMMERCIAL MGR

G CLARKE  
DEVELOPMENT  
TECHNICIAN

M MAZZARELLA  
CHIEF INSPECTOR

A CRESSWELL  
Q.A. TECHNICIAN

ELECTRICIANS  
ENGINEERS  
FITTERS MATE

S PARKER  
TOOLING MGR

P TAYLOR  
SALES LIAISON  
PRODUCTION  
PLANNING

S JONES  
WAREHOUSE  
MANAGER

TOOLMAKERS

STOREMAN

SHIFT INSPECTORS

D LARGE  
PRODUCTION  
TECHNICIAN

M RICHARDS  
M CIBETHAM  
D JONES  
J TROTTER  
A SKINNER

M DAVIES  
FINISHING  
FOREMAN

T THOMPSON  
CLEAN ROOM  
MANAGER

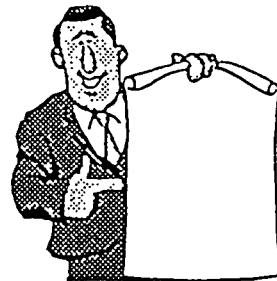
APPENDIX 3

APPENDIX 1b

# CONTINUOUS IMPROVEMENT

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# WREXHAM



David Bamford

Middlesex University  
Betts Plastics

## CONTINUOUS IMPROVEMENT - WHAT IS IT ?

- THERE IS NO SINGLE DEFINITION.
- IT CONSISTS OF A NUMBER OF RELATED ISSUES:
  - Commitment & Leadership
  - Communication
  - Involvement & Teamwork
  - Measurement
  - Education & Training
  - Recognition
  - Planning & Organization
  - Culture change

## CONTINUOUS IMPROVEMENT - WHAT DOES IT INVOLVE ? [1]

- Everyone is involved in continually improving the processes under their control.
- Each person is responsible for the quality assurance of their own process.
- Individuals recognize that anyone for whom they perform a task is a customer.
- Teamwork is practised.
- Every person's skills and abilities are fully used.

## CONTINUOUS IMPROVEMENT - WHAT DOES IT INVOLVE ? [2]

- Participation and development of employees in the business is positively encouraged.
- Training and education is considered an investment.
- Suppliers and customers are integrated into the improvement process.
- Honesty, sincerity, and care are an integral part of the organization.
- Mistakes are considered a learning experience.
- COMMUNICATION

## CONTINUOUS IMPROVEMENT - TOOLS AND TECHNIQUES

- The following are likely to be used here:
  - Quality Costing
  - Brainstorming
  - Cause and Effect Diagrams (fishbone)
  - Benchmarking
  - Quality Improvement Teams
  - Check lists, Bar charts, Tally charts, Histograms, Graphs
  - Statistical Process Control

## CONTINUOUS IMPROVEMENT - QUALITY COSTS

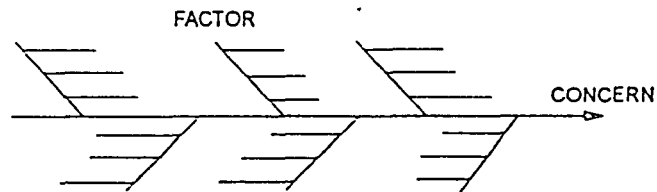
- What are they?
  - Internal Failures; External Failures; Appraisal; Prevention.
- Why are they important?
  - Because they are large.
- Why measure them?
  - Allows quality-related activities to be expressed in the language of management.
- How can quality-related costs be used?
  - Helps shock people into action; enables business decisions to be made in an objective manner.

## CONTINUOUS IMPROVEMENT - BRAINSTORMING

- Brainstorming is a method of generating ideas.
- The process:
  - A group of six to ten people seek solutions to a problem.
  - All ideas produced are written down and remain visible throughout.
  - Wild ideas are encouraged; often bizarre ideas produce good solutions.
  - The task of combining and improving on the ideas of others is encouraged.
  - Criticism of ideas is not allowed until the evaluation stage.

## CONTINUOUS IMPROVEMENT - CAUSE AND EFFECT DIAGRAM

- Also known as a Fishbone diagram, because of its shape.
- The head is the 'effect' or problem, and the ribs list the possible 'causes'.
- This is a good way to organize the ideas produced during a brainstorming session.



## CONTINUOUS IMPROVEMENT - BENCHMARKING

- Best practice.
- Setting standards according to the best practice we can find.
- Finding out how the best companies meet these challenging standards.
- Applying both other people's experience and our own ideas to meet new standards - and, if possible, exceed them.

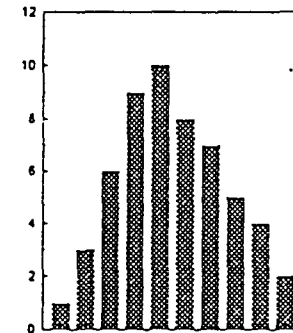
## CONTINUOUS IMPROVEMENT - QUALITY IMPROVEMENT TEAMS

- A team of four to ten people who meet to investigate and solve a problem.
- Any problem relating to the work situation may be tackled.
- Techniques such as Brainstorming and Cause and Effect diagrams may be used.
- The team will present their findings to management.
- The team will be involved in implementing the solutions.

## CONTINUOUS IMPROVEMENT - CHECK LISTS, CHARTS, GRAPHS

- Check Lists and Tally Charts are simple devices for collecting or ordering data.
- A Histogram is a picture of variation or distribution.
- Bar Charts are simple pictorial representations of numerical data.

Histogram



## CONTINUOUS IMPROVEMENT - STATISTICAL PROCESS CONTROL

- As the name suggests, this is a way of controlling the process by using statistical data.
- It can be used to identify:
  - Whether the process is capable of meeting requirements.
  - Whether the process meets those requirements at any point in time.
  - When the process is not meeting those requirements and to make adjustments.
- Data is collected and plotted on Control Charts. This may be done manually or by computer.

## CONTINUOUS IMPROVEMENT - WHAT ARE THE BENEFITS ?

- An increase in Productivity.
- An increase in Communication.
- An increase in Motivation.
- Process Control is Achieved.
- An increase in Quality.
- An increase in Customer Satisfaction.
- An increase in Competitiveness.
- A decrease in Costs.

## CONTINUOUS IMPROVEMENT - DOES IT WORK ?

- There are many examples of the successes brought by continuous improvement.
- PHILIPS COMPONENTS
  - Delivery performance improved from 70% to 100%.
- HILTI (GREAT BRITAIN) LTD
  - Internal rejection rate reduced from 9% to 2%.
- BROOK CROMPTON
  - Scrapping £10,000 per month in 1990, reduced to £3,000 per month in 1991.
- Compare with Tony, Steve, and Mike's £27,000.

## CONTINUOUS IMPROVEMENT - THE NEXT STEP

- Education, Training, Involvement.
  - Introduction to Continuous Improvement (T.Q.M.).
  - Improve Communication at all levels:
    - Noticeboards to display quality information.
  - Training:
    - In the tools and techniques detailed earlier.
  - Set up Brainstorming Sessions.
  - Establish Quality Improvement Teams.
  - Introduce Statistical Process Control.



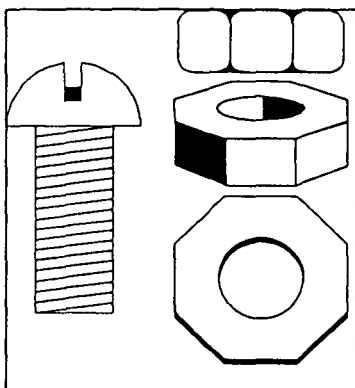
# NEWS

## N.E.B.O.S.H.

Recently John Hughes and David Bamford attended an intensive health and safety course (16 hours a day, five days). This course, and the programme of study at home afterwards, led to them taking the National General Certificate in Occupational Safety and Health. Very well done to both of them for passing, especially to John who stepped in at the last minute and put maximum effort in to passing.



## Continuous Improvement - Engineering Team



The day shift engineers and technicians are currently attending, on a weekly basis, the five continuous improvement training session that the shifts experienced last year.

The sessions have only just started but already the chocolate biscuits are a hit!

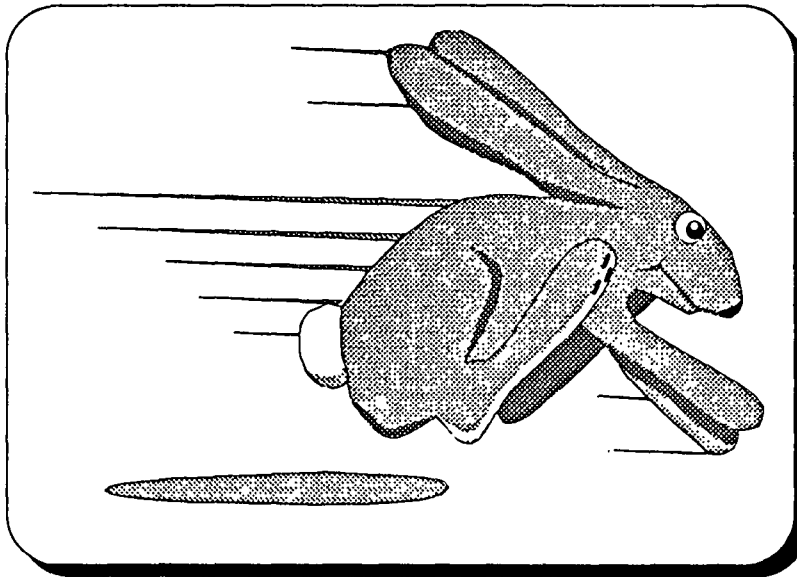
The next few sessions will involve video training a some practical exercises on problem solving.

## General

Interviews will begin later this week (week 32) for the recruitment of an electronics technician. This is a replacement for John Shepard.

ISO. 9000 Re-certification Audit

The audit is scheduled for September 6 & 7 - yes two days! Can all shifts who are "on" during this period ensure that they are fully up to date with their specific procedures, and the requirements that may be made of them during the audit. Thanks.

E Shift - Continuous Improvement Team

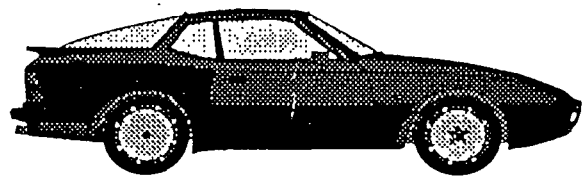
E Shift have just implemented a couple of excellent ideas to increase efficiency on the Rotex assembly jobs.

Steve Morgan, Jim Francis, Glen Evens, and Tony Williams worked together as a team. They firstly fitted air ejectors to the mould tool, on both the

"inner" and "outer" side, this will eliminate spillage and mixing of parts. The second modification involved machining a slot in the "outer" podmore bowl at the assembly machine. This second modification will force out any "inners" that have got into the "outer" bowl. Very well done to the team involved.

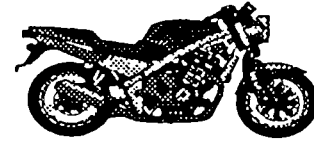
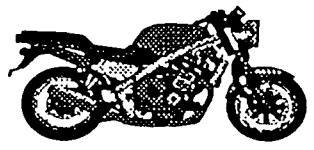
£28,000 of Scrap

(Produced in one month!)

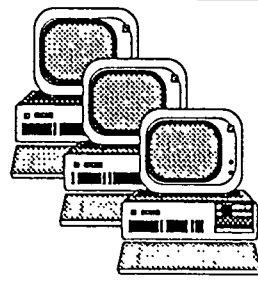
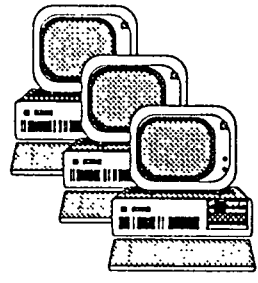
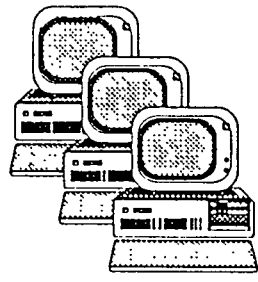
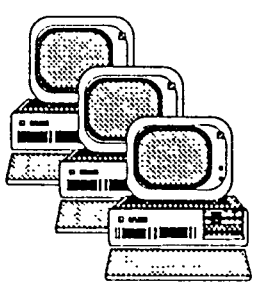
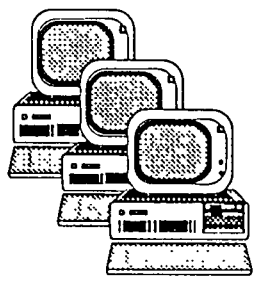
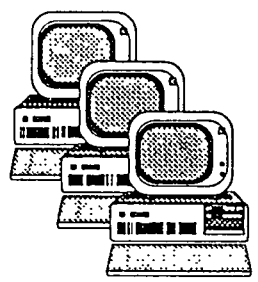


Porsche

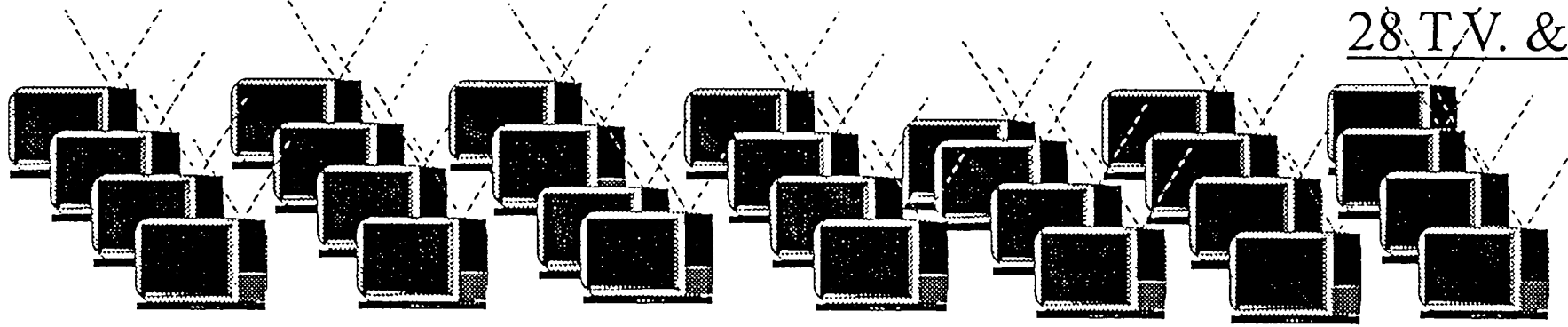
4 GPZ 900's



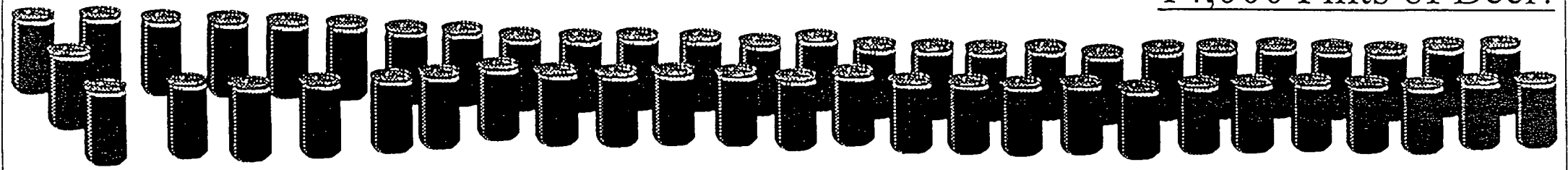
18 Computers



28 TV. & Videos



14,000 Pints of Beer!



# Betts Plastics - Wrexham

PFXXX-X

## Justification - Project Proposal

Project Title: \_\_\_\_\_

Project Champion : \_\_\_\_\_

What is the aim of this project? : \_\_\_\_\_

Is this for a trial period? : YES \_\_\_\_\_ How Long? \_\_\_\_\_  
 NO \_\_\_\_\_

**Cost / Benifit / Payback:**

External:

- materials \_\_\_\_\_
- equipment \_\_\_\_\_
- services/contracts \_\_\_\_\_
- other(\_\_\_\_\_) \_\_\_\_\_

£ \_\_\_\_\_

Internal:

- materials in stock \_\_\_\_\_
- equipment available \_\_\_\_\_
- other(\_\_\_\_\_) \_\_\_\_\_

£ \_\_\_\_\_

Total Cost = £ \_\_\_\_\_

Quantified Benefit : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 = £ \_\_\_\_\_

Other Benifits : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

How long is the payback period? : \_\_\_\_\_ = \_\_\_\_\_ weeks/months  
 (Approximate)

**Authorisation:**

The Project Champion is authorised to spend / consume resources up to the value of:

£ \_\_\_\_\_ on Cost Centre/S.R.M.: \_\_\_\_\_

Note: \_\_\_\_\_  
 \_\_\_\_\_

Signed \_\_\_\_\_

Date \_\_\_ / \_\_\_ /9\_

Operations Manager

D.R.B.

**CUSTOMER COMPLAINT/PROCESS ALERT\* (DELETE AS APPLICABLE)**

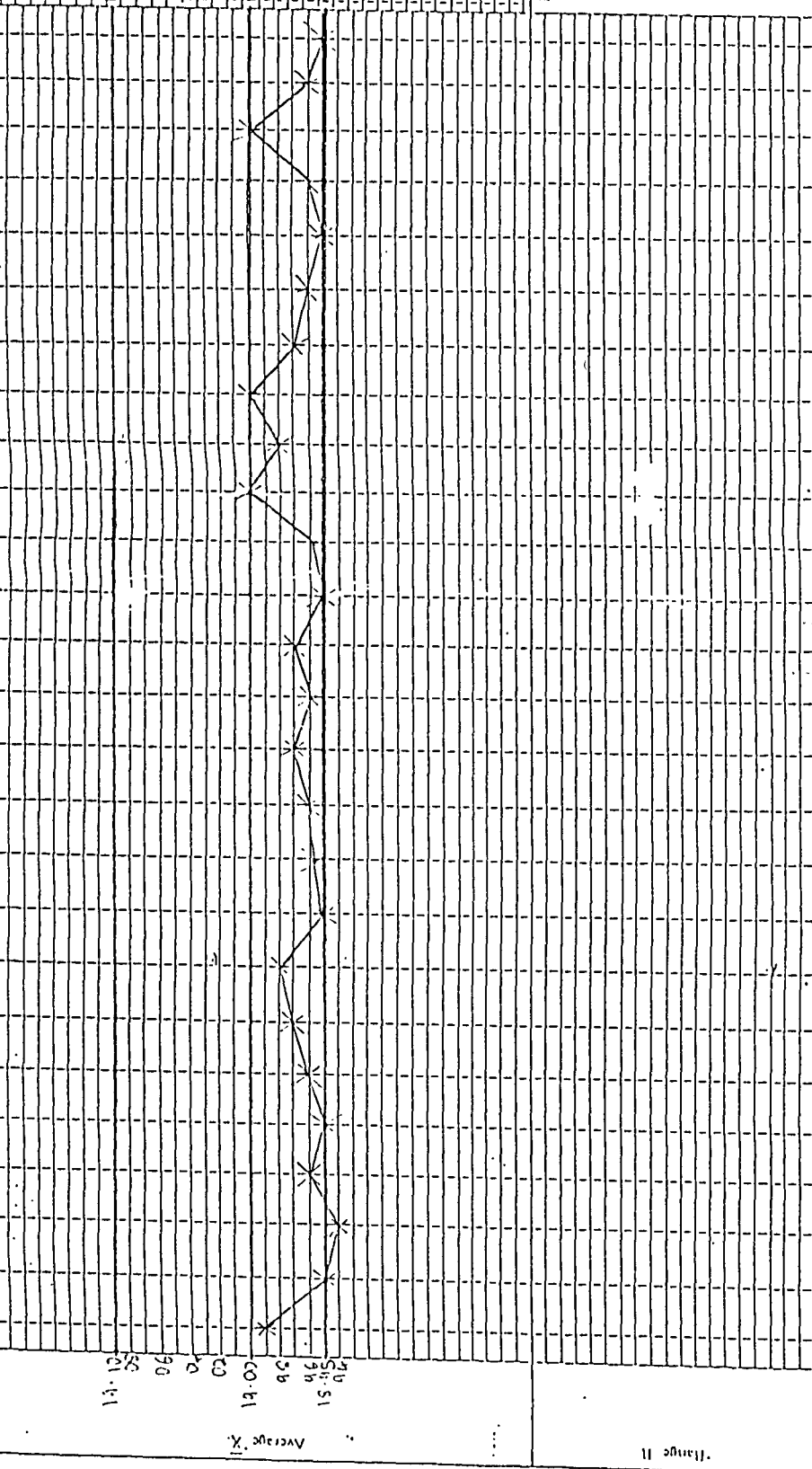
8D CONCERN ACTION REPORT							WSP0023
CONCERN TITLE					REF No	DATE	
Priority			Customer		Part Name		
1	2	3	Contact		Part No		
1. Team			Dept.	2. Problem Description (Definition)			
Champion				SAFETY CRITICAL		YES/NO	
3. Containment Action(s)				% Effect	Implementation Date		
4. Root Cause(s)				% Contribution			
5. Chosen Permanent Corrective Action(s)				Verification	% Effect		
6. Implemented Permanent Corrective Action(s)					Implementation Date		
7. Action(s) to Prevent Recurrence					Implementation Date		
<b>BETTS USE ONLY</b>					Close date	Reported By	
TEAM LEADER	SHIFT MANAGER	QUALITY CO-ORDINATOR	QUALITY MANAGER				
OPERATIONS MANAGER							

**UNCONTROLLED COPY**

FOR INFORMATION PURPOSES ONLY

CONGRATULATE YOUR TEAM

Part Name: OIL OF VLAY PLUS  
 Specification: DIMENSIONS  
 Drawing - Part Number: EVER 4 HRS  
 Machine Number: UNCONTROLLED  
 Date: 10/25/54  
 FOR INFORMATION PURPOSES



APPENDIX 1b  
 IF PARTS FALL OUTSIDE  
 PROCESS BAND STOP  
 MEASURE CAPABILITY ONE.

Shift	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
Time	10/5	11/5	12/5	13/5	14/5	15/5	16/5	17/5	18/5	19/5	20/5	10/5	11/5	12/5	13/5	14/5	15/5	16/5	17/5	18/5	19/5	20/5
Disc	10/5	11/5	12/5	13/5	14/5	15/5	16/5	17/5	18/5	19/5	20/5	10/5	11/5	12/5	13/5	14/5	15/5	16/5	17/5	18/5	19/5	20/5
X	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
X̄	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
R																						

UCL $\bar{X}$  =  $\bar{X} + A_2\bar{R}$  = \_\_\_\_\_  
 UCL $\bar{X}$  =  $\bar{X} - A_2\bar{R}$  = \_\_\_\_\_  
 UCL $R$  =  $D_4\bar{R}$  = \_\_\_\_\_  
 UCL $R$  =  $D_3\bar{R}$  = \_\_\_\_\_

Sample Size	$A_2$	$D_3$	$D_4$
2	1.880	0	0
3	1.023	0	0
4	0.729	0	0
5	0.577	0	0

④

APPENDIX 1c

Continuous Improvement  
Information (Continued)

# Continuous Improvement Teams



Prepared by

David Bamford



# Improvement Teams

The objective of a continuous improvement team is to solve a problem so that it remains solved. This requires a disciplined approach, ie, some kind of structure which guides what team members do. Whenever problems become apparent it is usually the symptoms which are spotted first and the temptation is to start thinking of immediate solutions. This is the "quick fix" which does not remove the original cause of the problem.

A problem-solving structure should ensure that the team:

- fully examines the symptoms that are obvious together with how they affect the business;
- identifies the causes which produce the symptoms;
- decides on a solution or course of action which will remove the cause;
- implements the solution.

To do this systematically we could adopt a five-stage approach to project development:

1. Define the symptoms of the problem.
2. Find a solution.
3. Submit proposals for a solution and plan implementation.
4. Communicate the plan and carry out any training.
5. Implement.

## Stage 1: Defining the Symptoms

At this point the main objective is to decide whether the problem is serious or important enough to justify the costs involved in further investigation. This means addressing three questions:

### **1 - How is the customer affected by the problem?**

It is important to identify who will benefit from the problem being tackled successfully. All internal and external customers should be asked for their views at this stage.

### **2 - How can the scale of the problem be measured?**

The purpose of quality projects is to ensure continuous improvement. Measurement is at the heart of that improvement process. If the project is to be seen to be successful then the team will need to prove that there has been measurable improvement. Hence, before embarking on the project the scale of the problem must be measured so that a comparison can be made with the original situation once a solution has been implemented.

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## 3 - What does the problem cost?

Costs can be measured in financial terms, time, loss of production, reduced customer satisfaction, damage to company or brand image.

## Stage 2: Finding a Solution

At this stage the team carries out thorough research to find out the root causes of the problem and identifies appropriate solutions which will tackle the causes. It may not be possible to find a 100 per cent solution but the objective is to find a cost-effective strategy which will improve the situation. Several techniques for this will be outlined later.

## Stage 3: Submitting Proposals for a Solution, Planning Implementation

Having identified a solution or course of action, the project leader must submit the team's proposal for approval. When doing this three questions need to be considered.

### 1 - What barriers exist to implementation?

If the project is to be successful, inevitably there will be changes in the way things are done. This will have implications for people feel uncomfortable with change; they may feel threatened, fearful, resentful or angry when there are disruptions to the way they do their work or to their working relationships. This is especially true if they are not involved in data collection or decision-making.

The first questions to ask when planning to implement new ideas are, 'Who will be affected by these changes?' and, 'How are they likely to feel about them?' These people will need to have the changes explained to them and be given an opportunity to ask questions and express their feelings about the changes. They may also need time to come to terms with change. If they are ignored the people affected may not support even the most well-meaning change.

### 2 - What actions need to be taken to get things moving?

An action plan should be agreed and carefully recorded so that everyone involved understands his/her role (Betts Plastics "Action Sheet" attached). The action plan should address the following questions:

- What action is to be taken?
- Why is the action to be taken?
- Who will do it?
- When will it be done?
- Where will it be done?
- How will it be done?

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## 3 - How will the new system be maintained?

Once the new system is in place, steps should be taken to ensure that it continues to operate effectively and becomes part of the accepted procedures. The new system will also need documenting to ensure that:

- New staff are quickly made aware of the procedure.
- The procedure continues to be followed.
- There is a recognised base from which future changes can be made.
- Similar systems can more easily be introduced elsewhere in the organisation.
- It becomes part of BS 5750.

## Stage 4: Communication and Training

The next stage involves informing everyone who needs to know and offering appropriate training. This stage is vital. Unless it is carried out well people will not feel committed, they will not know what to do and the project will flounder. During the communication and training stage people will need to know:

- Why the project was carried out.
- Why the changes are to be made.
- What the new system or procedure is.
- How it will affect them.
- What they need to do differently.
- What help they will get.
- When will it start.

Finally in this stage, if people need new skills they will need time to learn, practice and develop them.

## Stage 5: Implementation

A major pitfall at the implementation stage is for the team members to do everything themselves. Their role should be one of monitoring, coaching and helping others overcome any unforeseen difficulties. It may well be advisable to start implementation in a small way as a pilot. This will allow the project team the opportunity to monitor progress and ensure that their solution is actually solving the problem. When success has been achieved the project should be fully documented so that it can be used for reference if a similar problem occurs in the future.

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## What Problem-Solving Techniques are Available?

Problem analysis can be divided into three separate activities:

1. Problem identification.
2. Problem definition.
3. Generation of solutions.

For each activity there are a number of problem-solving techniques available.

**1. The problem identification** stage requires considerable thought and research into the causes of the problem. Techniques available include:

- brainstorming;
- cause and effect diagrams.

**2. The next stage is problem definition** where data are collected, analysed and displayed in a way which crystallises the precise nature of the problem. Techniques available include:

- systematic data collection;
- data presentation diagrams;
- pareto analysis.

**3. Solution generation**, as the name suggests, requires the group to examine systematically courses of action which will eradicate the causes of the problem. Techniques include:

- solution and effect diagrams.

### Brainstorming

The aim of brainstorming is to generate a large number of ideas from a small group of people. Its purpose is to produce creative thought and to encourage people to look beyond the obvious. Generally it is used either at the early stages of a project to generate ideas about what the possible causes of a problem might be, or later on to assist the group identify possible solutions.

To carry out a brainstorming exercise all the members of the team need to sit together (round a table) facing a flip chart. The leader then outlines the nature of the problem and everyone in the group calls out ideas whilst the leader writes them all on the flip chart.

Although the success of brainstorming depends on everyone seeing it as a free-for-all, there are nevertheless certain rules which must be followed to make sure the technique is effective:

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- A leader should be appointed for the brainstorming session. It is his/her responsibility to make sure the rules are followed. The leader need not be the project leader but it is important that it is someone who is free of any pre-formed ideas.

- Don't evaluate. If ideas are criticised during the ideas generation stage it will only serve to inhibit other ideas. All ideas should be recorded without comment.

- The flip chart should be visible to everyone and the ideas recorded so that they can be seen. If the flip chart becomes full then tear off the sheet and stick it on the wall - group members can then look back at it for further inspiration.

- Encourage quality throughout. It should be possible for a group to generate a lot of ideas for most problems.

- Group members should be encouraged to free-wheel and call out their ideas no matter how laughable they appear. Remember that an initially 'silly' idea may contain the seeds of something new and creative. Towards the end of a session use the 'wildest idea' technique to obtain further thoughts not previously generated.

- Finally all of the ideas should be evaluated. The group needs to scrutinise all the ideas for possible winners. They might also try to convert some of the more "way out" ideas into practical possibilities. Next they need to identify the advantages and disadvantages of each and subject each of the best ideas to "reverse brainstorming" by asking "in how many ways can this idea fail?"

### Cause and Effect Diagrams

Cause and effect diagrams or fishbone diagrams are used to help a group identify and understand the underlying cause of a problem rather than the symptoms. By displaying ideas in a pictorial way it becomes easy to make sense of a lot of data while at the same time obtaining a broad picture of a problem.

The first step is for the group to brainstorm the possible causes of a problem and then categorise them under four headings:

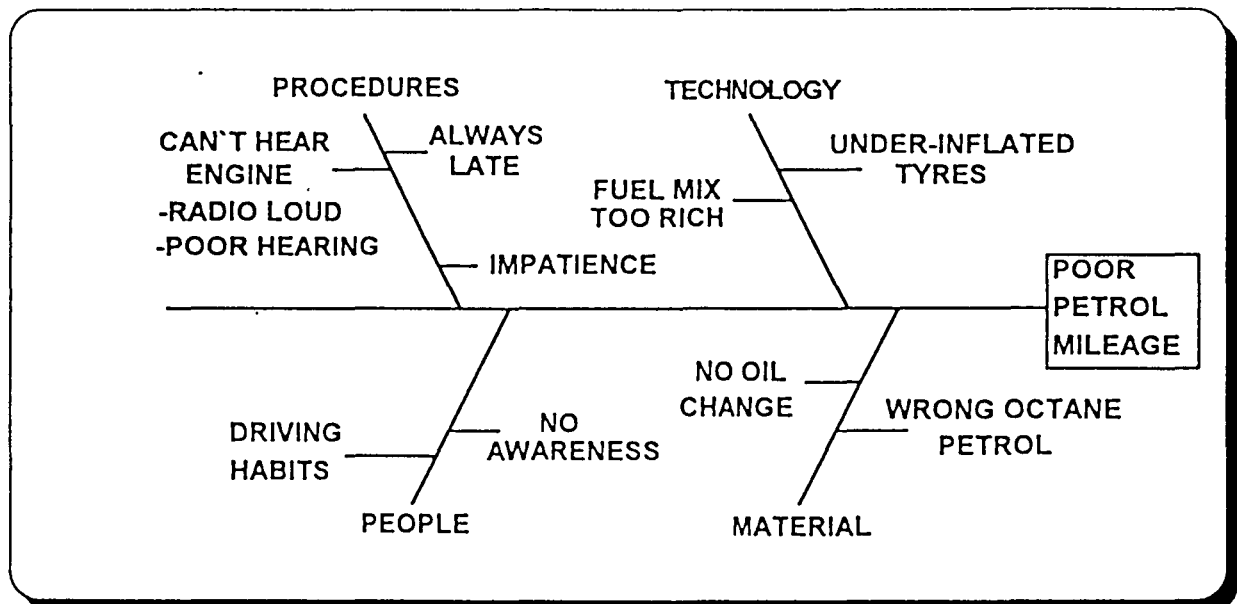
- people;
- procedures;
- technology (including equipment and machinery);
- materials (all materials processes).

All of this information is then fed into the basic diagram. The diagram on the next page shows possible causes of car trouble.

This approach is very simple and deceptively powerful. Almost every situation at work is likely to be affected by the four basic factors - people, procedures,

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technology, materials. When the diagram is complete the group will be able to get a very clear picture of the nature of the problem. Then, working from the information on the diagram they will be able to decide which specific areas to investigate. The process of assessing priorities and elimination will allow the "root cause" of the problem to be found.



## Data Collection

Having identified the possible causes of a problem through brainstorming and applying a cause and effect diagram, the group next needs to research thoroughly the most likely causes and collect as much data as possible about each cause.

The purpose of data collection is to understand thoroughly the current situation in order to be able to analyse and improve it:

- Having a definite purpose - being very clear about why they are collecting particular information.
- Relevance - it is important that the group ignores everything that is not relevant to the problem under investigation. They need to collect only one set of data at a time and keep it simple - this will avoid confusion.
- The data must be accurate and measurable. It needs to be very carefully observed and recorded in terms of quantity, time, quantity and / or cost.
- The data must be representative. It should accurately reflect normal conditions. For example, collecting data at times like Christmas Eve or at the end of the financial year will probably not represent normal conditions.

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## Data Presentation

Having collected the data the group now needs to assemble and present them in a simple and meaningful way. Typically, if people have a choice between figures, words and pictures they are likely to find pictures the easiest to understand. It follows therefore that whenever possible groups should present their data in diagrammatic form using charts or graphs. Techniques for doing this include:

- pie charts;
- bar charts;
- histograms;
- graphs, etc.

## Pareto Analysis

Pareto analysis is named after the Italian economist Vilfredo Pareto who found that 80 per cent of the wealth was in the hands of 20 per cent of the population. This 80-20 rule holds true for a great many things in life. Pareto analysis is a simple system used to differentiate the "vital few from the trivial many" causes of a problem. In problem-solving a group can use the Pareto Principle to identify where the greater part of the problem lies. If 80 per cent of a problem arises from 20 per cent of the causes then it makes sense to tackle the 20 per cent, eliminating most of the problem.

Pareto analysis involves four steps:

**1. Decide which "causes" to collect data about**

Decide the categories of the data items and the period over which data will be collected - then collect the data.

**2. Tabulate the data:**

Arrange the causes in descending order and tabulate the data. Causes that contain only a few items can be combined and categorised as "others" and listed at the end, e.g.:

Cause	Number
A	13
B	7
C	2
D	1
Others	2
Total	25

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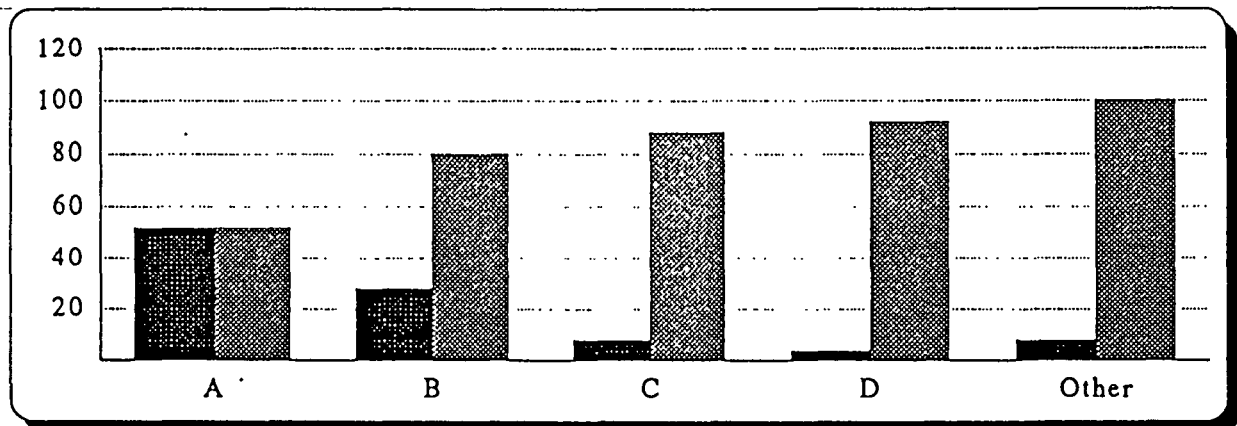
### 3. Calculate the percentage and cumulative percentage

To calculate the percentage, divide the number for each cause by the total and multiply by 100. To calculate the cumulative percentage, put the top figure in the top figure in the new column and going down, Add each new figure to the last, e.g.:

Cause	Number	%	Cum%
A	13	52	52
B	7	28	80
C	2	8	88
D	1	4	92
Others	2	8	100
Total	25	100	100

### 4. Draw a Pareto diagram

See diagram below. This example highlights the fact that 80 per cent of the problem is caused by factors A and B. If these two can be eradicated then most of the problem will be solved.

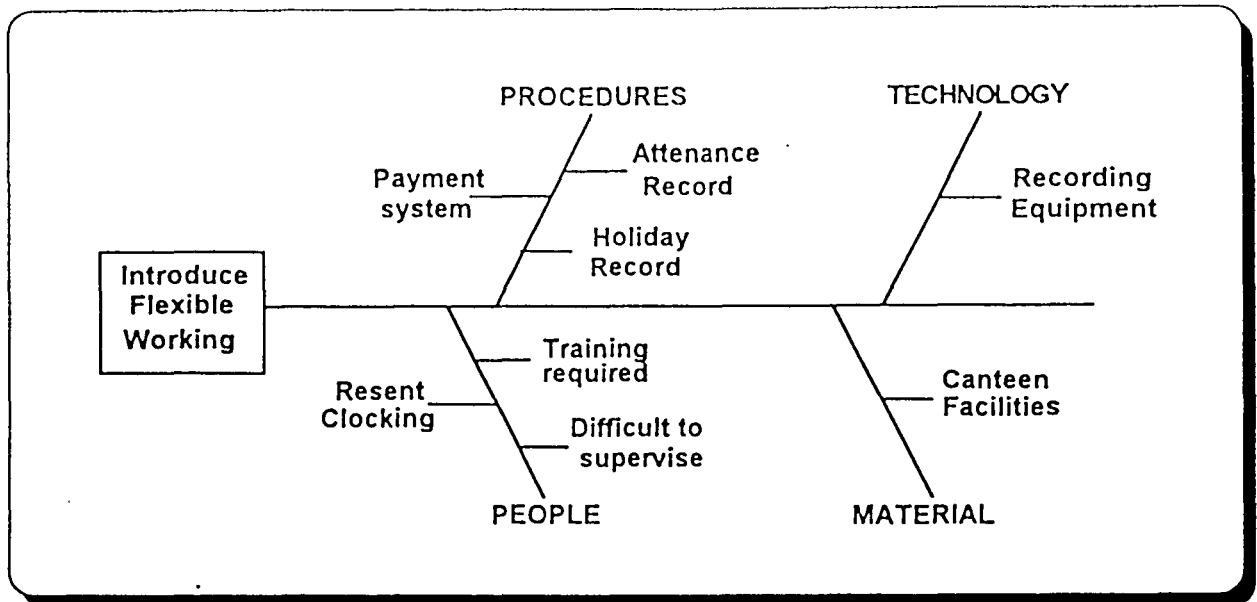


## Solution and Effect Diagrams

This is a similar tool to the cause and effect diagram discussed earlier. Once again it takes the form of a fishbone diagram but this time it is used when a possible solution to a problem has to be chosen. When choosing a solution it would be unwise for a group to press ahead without thinking about costs and consequences. It is important therefore for the group to brainstorm a list of negative outcomes (however improbable) and categorise these under the same headings: people, procedures, technology, materials. An example of a solution and effect diagram is given on the next page. The solution and effect diagram may well uncover undesirable effects that had previously escaped consideration.



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## Other Techniques

The purpose of this guide is not to provide an exhaustive list of problem-solving techniques, others do exist. Here an overview has been given to some of the methods currently used for developing solutions to specific problems. Other techniques can of course be used to suit a given situation.

## Why might Projects Fail?

For projects teams to work successfully they must be seen as important and people must continue to be enthusiastic. Without these prerequisites they will quickly fail. There are many pitfalls; they include:

- Lack of commitment by senior managers - it is essential that managers encourage project teams, provide support and help them to implement their ideas.

- Project teams not being given significant problems - this is another aspect of low management commitment. It is essential that the problem is identified first, is recognised as being significant, and an investigatory team is set up. The alternative is to set up a project team and then look for problems.

- Project teams not being given sufficient authority or resources - it can be demotivating, for example, if a team is set up and then not given sufficient time away from the job to do the project justice.

- Lack of clarity over terms of reference - the group needs to be well briefed.

- Failure to assist in implementation. It is not sufficient simply to investigate a problem and write a report. The team needs encouragement to see the project through to implementation.

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- Status and politics - successful project teams rely on an appropriate management style, i.e., one which genuinely values people's ideas and wants to encourage their creativity.

- Lack of training - you will need to ensure that project leaders are able to facilitate the group and that all group members are trained in using the `tools and techniques` of project management.

- Lack of co-ordination - project teams need to have their efforts co-ordinated. It is also useful to document and keep a register of all projects which have been completed. This can be used as a source of reference if similar problems emerge in other parts of the organisation in the future.

### To Conclude

The key resource in any organisation is the people within it. It is the people who create the systems, processes and procedures: it is their routine and consistent implementation which provides the products and services which, it is hoped, fulfil the customers` expectations.

The increased utilisation of the resident "expert" knowledge that exists within the company is the aim of this Continuous Improvement Team initiative.

Teams lead to the discovery and correction of all sorts of faults that prevent correct working.

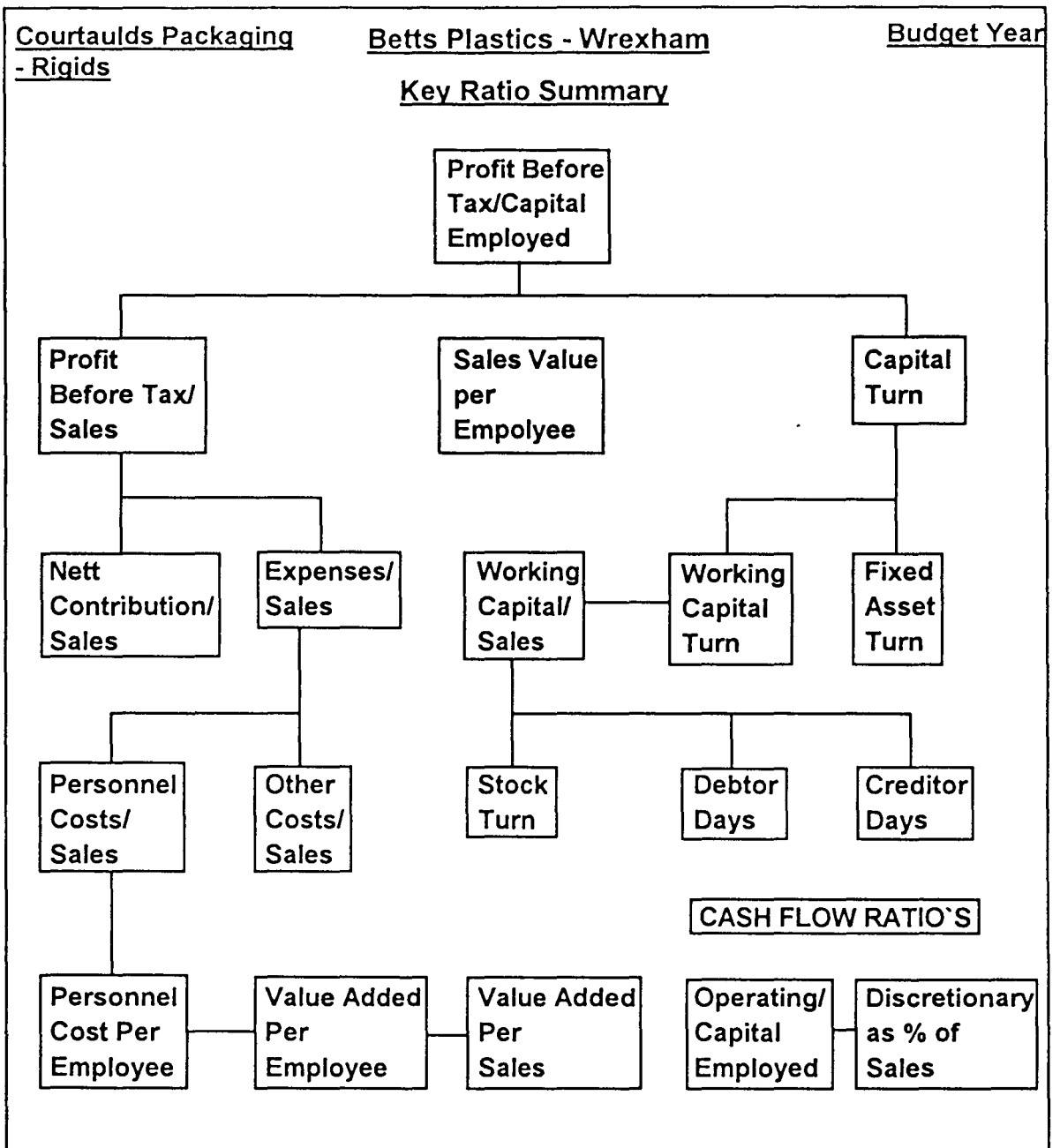
Although some companies do not set out to achieve a pure financial return, most find the benefits are at least double the costs.

David Bamford - Teaching Company Associate

February 1994

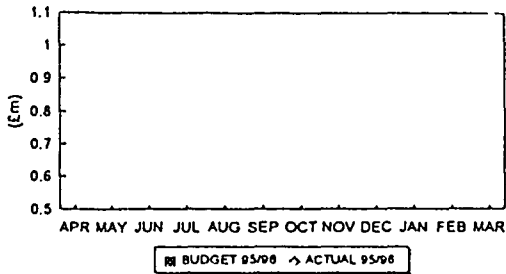
References: Jefferies et al. "Training for Total Quality Management", 1992, Kogan Page Limited.

Department of Trade and Industry, "Quality Circles", 1992.

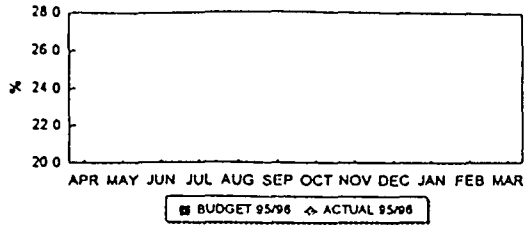


# APPENDIX 1c

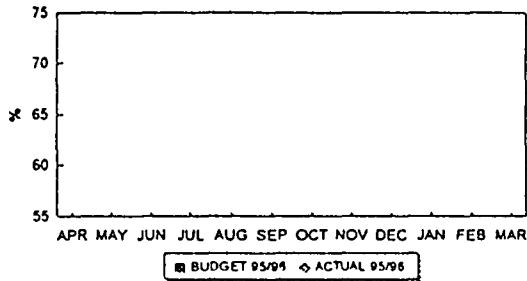
**SALES**



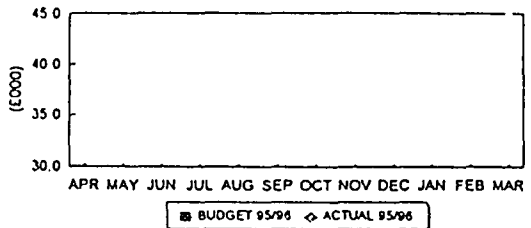
**PERSONNEL COSTS · SALES (MAT)**



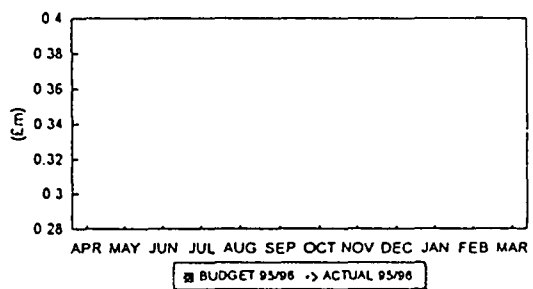
**ADJUSTED GROSS CONTRIBUTION %**



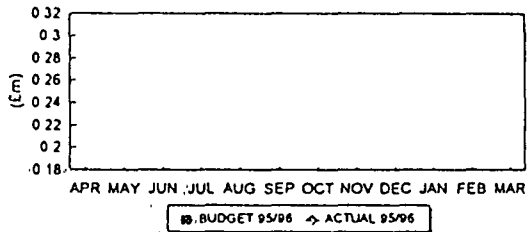
**VALUE ADDED PER EMPLOYEE (MAT)**



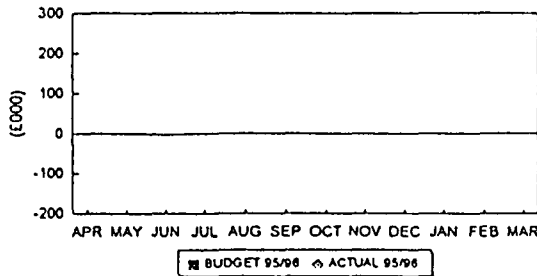
**FACTORY COSTS**



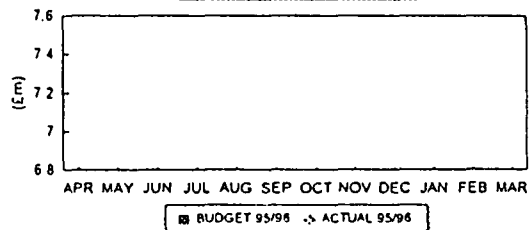
**STOCKS (EXCL MOULDS)**



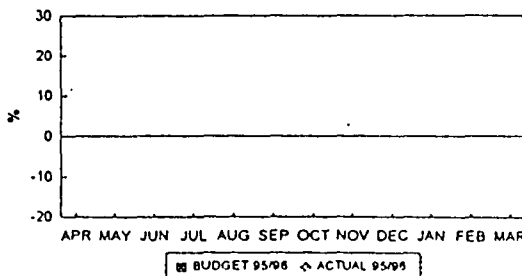
**PROFIT BEFORE TAX**



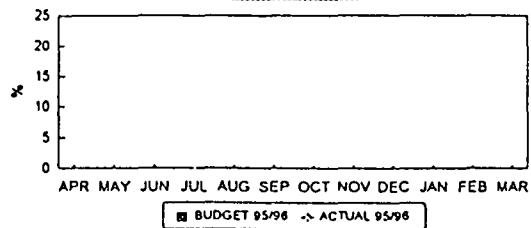
**CAPITAL EMPLOYED (MAT)**



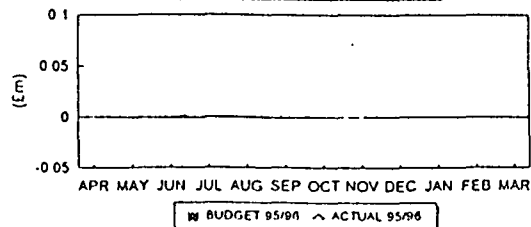
**ROS**



**ROCE (MAT)**



**CUMULATIVE CASH FLOW (MAT)**



## APPENDIX 2

### Quality System Information

# QUALITY INFORMATION

## FEBRUARY 1995

### 1. 15 CUSTOMER COMPLAINTS

- 10 FROM PERSONAL CARE
- 5 FROM CLEANROOM
- 4 RESULTING IN REJECTION

(2 from M+H Plastics, 1 from Wella - Germany, 2 from Glaxo - France, 5 from Betts Tubes, 1 from J + J, 3 from Upjohn, 2 from Statestrong.)

Forty One 8D's: Nineteen live; Twenty Two closed.

### 2. QUARANTINE STOCK

QUARANTINE STOCK VALUE £ 8,379.64.

### 4. CONCESSIONS RAISED

#### 5 CONCESSIONS

- 3 NOT SPECIFIED AS ALTERNATE MATERIAL ON SPEC.
- 2 NO RS TO MATCH COLOUR - SPEC READS "RS T.B.A."
- 1 CORES CHANGED ON 3M CAP, NO RS.

### 5. PASS-OFFS FAILED

NO PASS-OFFS FAILED

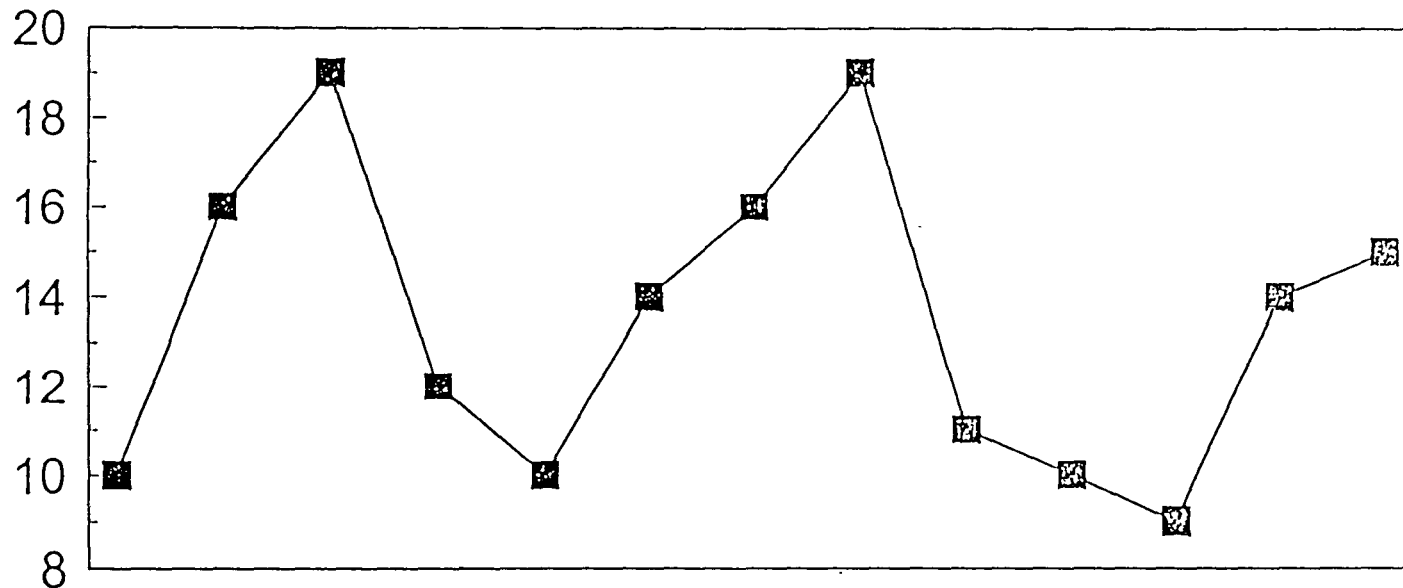
### 6. JOB CHANGES + COLOUR CHANGES

JOB CHANGES PERSONAL CARE - 73  
COLOUR CHANGES PERSONAL CARE - 168  
MOULD CHANGES CLEANROOM - 23  
PAD CHANGES CLEANROOM - 4  
COLOUR CHANGES CLEANROOM - 2

# Customer Complaint Trend

## - Wrexham

No of Complaints

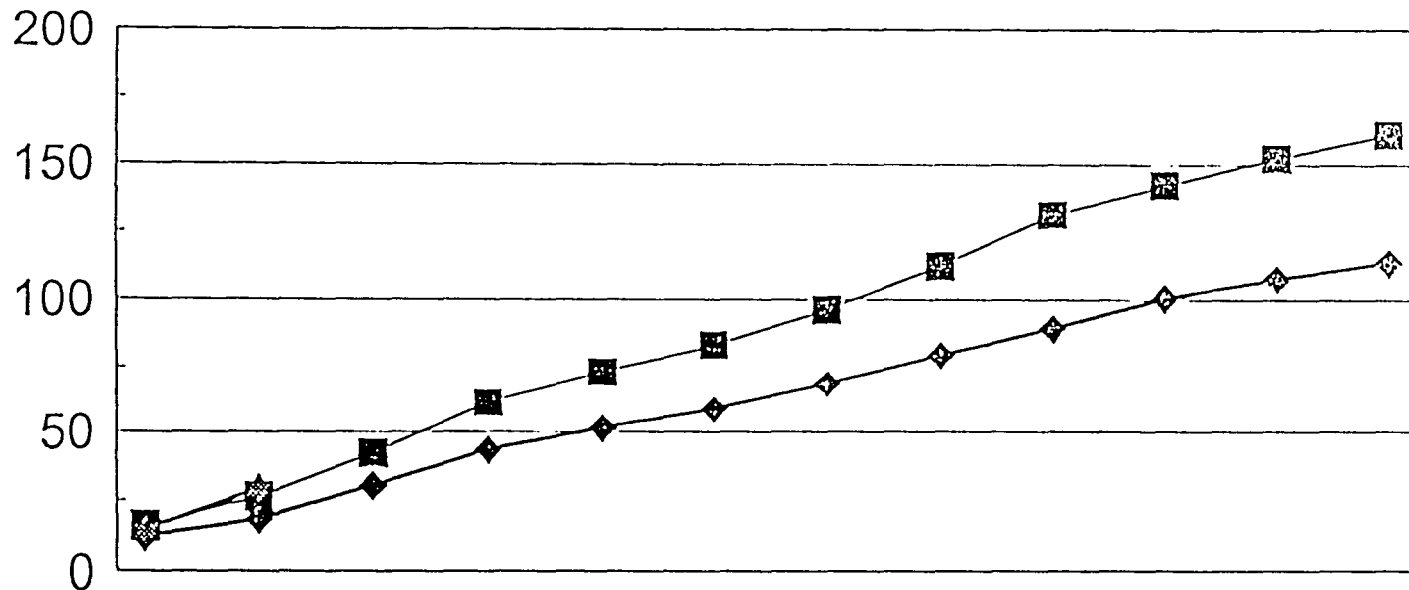


Month	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
SITE TOTAL ■	10	16	19	12	10	14	16	19	11	10	9	14	15

David Bamford

# Wrexham Cumulative Customer Complaints

No of Cust Complaints



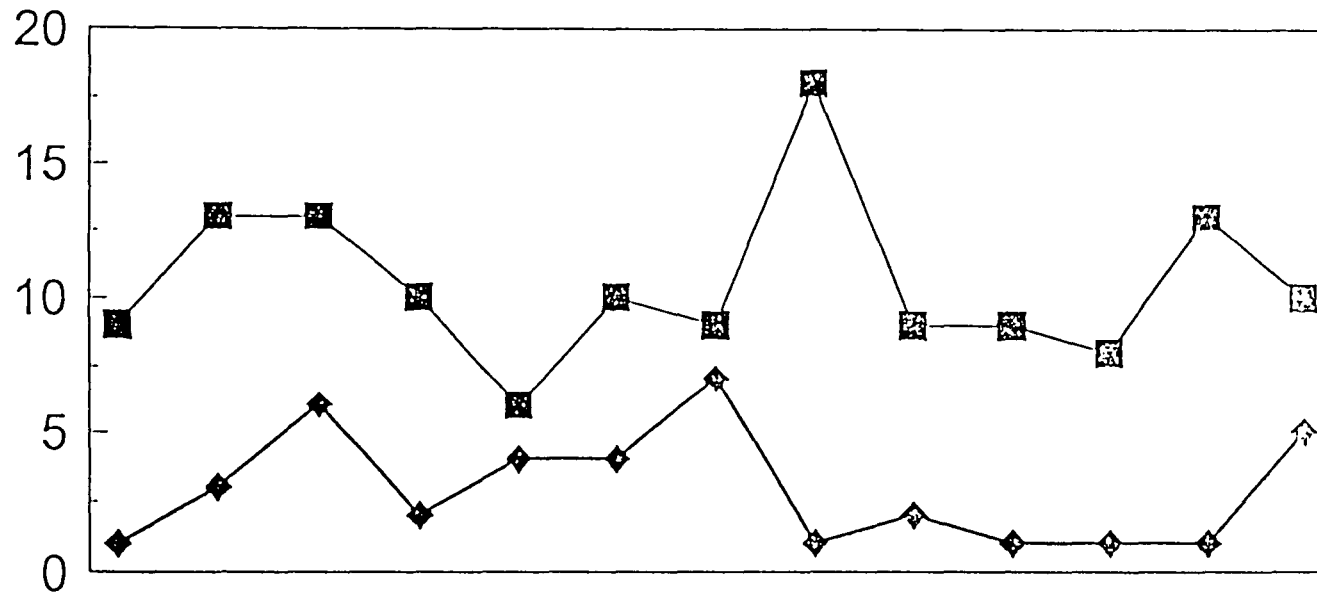
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1994 ■	16	26	42	61	73	83	96	112	131	142	152	161
TARGET ◆	12	18	30	43	51	58	68	79	89	100	107	113
1995 ★	14	29										



# Customer Complaint Trend

## -Wrexham

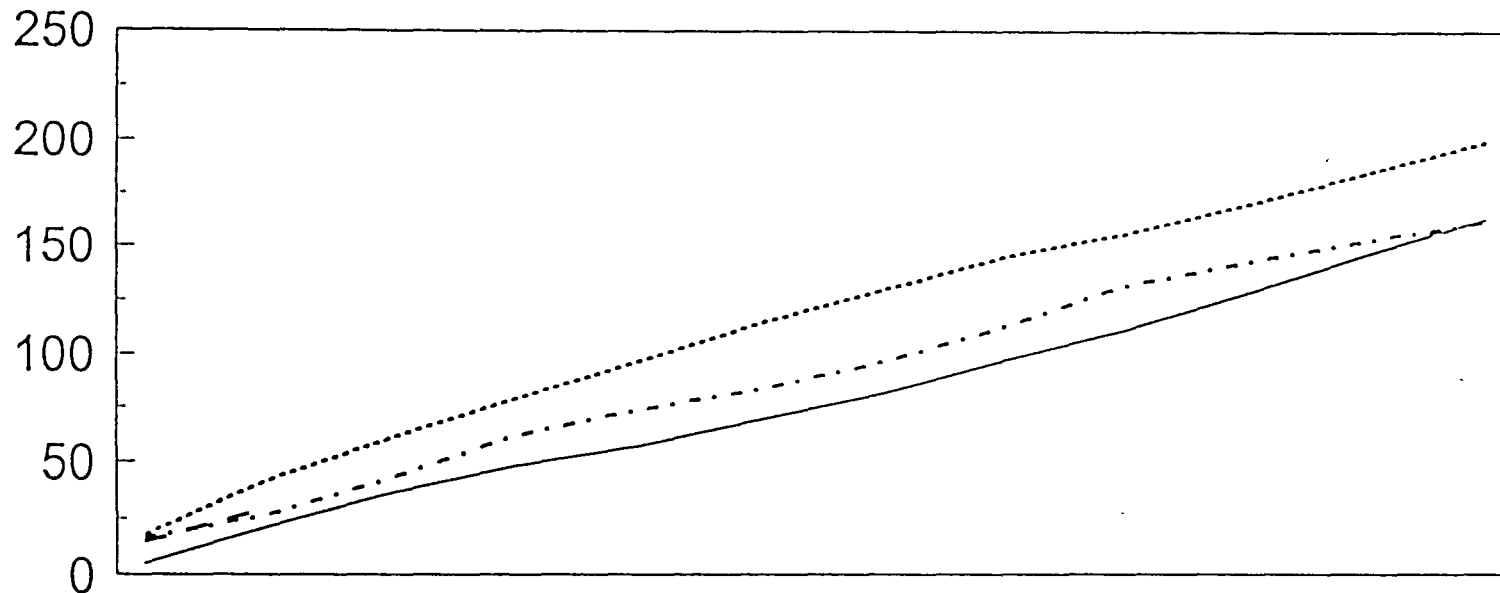
No of Complaints



Month	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
PERSONAL CARE ■	9	13	13	10	6	10	9	18	9	9	8	13	10
CLEAN ROOM ◆	1	3	6	2	4	4	7	1	2	1	1	1	5

# Wrexham Cumulative Customer Complaints

No of Complaints



Month	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1992 —	5	21	36	48	57	69	81	97	111	128	146	163
1993 ....	17	41	60	78	96	114	129	144	155	169	184	199
1994 -·-	16	26	42	61	73	83	96	112	131	142	152	161
1995 -	14	29										

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Quality Costing Exercise

David Bamford

<u>1. Costs Directly Associated with the Quality Function.</u>	<u>Current Period Week / Month</u>
Date: ___/___/___	Cost (£)
<b><u>Prevention Costs</u></b>	
Quality Personnel	
Process Control Personnel	
Laboratory Personnel	
Cost of Quality Training	
Cost of Presenting Quality Costs to Management	
<b><u>Appraisal Costs</u></b>	
Receiving Inspection	
Supplier Audits	
Lab Tests to Assess Quality Acceptance / Standards	
Review of Test and Inspection Data (C of C, C of A)	
Internal Testing & Release - before Shipment (e.g. S.I.D.)	
Calibration & Maintenance of Equipment Used to Evaluate Quality. e.g. Solex Gauges, Scales, Johansson.	
<b><u>Internal Failure Costs</u></b>	
Troubleshooting / Failure Analysis	
<b><u>External Failure Costs</u></b>	
N / A	

Betts Plastics

Quality Costing Exercise

David Bamford

<u>2. Quality Related Costs of Functions performed by Personnel Outside the Q.A. Department.</u>	<u>Current Period Week / Month</u>
Date: ___/___/___	Cost (£)
<u>Prevention Costs</u>	
Engineers - Planning & Directing Initial Product Qualification	
<u>Appraisal Costs</u>	
Inspection & Testing: Pass-Off / Routine Inspection	
Set-up Cost for Inspection & Testing (set up of lab)	
Inspection & Test Materials	
Product Quality Audits: On in-process or Finished Goods	
Maintenance & Calibration of Test & Inspection Equipment	
e.g. Solex Gauges, Scales.	
Inspection & Test Reports - Costs for Collecting & Processing	
<u>Internal Failure Costs</u>	
Troubleshooting & Failure Analysis - Engineers / Technicians / Operators.	
<u>External Failure Costs</u>	
N/A	

<b><u>3. Internal Cost of Budgeted Failures</u></b>	<u>Current Period</u> Week / Month
Date: ___ / ___ / ___	Cost (£)
<b><u>Prevention Costs</u></b>	
N/A	
<b><u>Appraisal Costs</u></b>	
N/A	
<b><u>Internal Failure Costs</u></b>	
Scrap (1%)	
Any Figure for Rework?	
Any Planned Overmakes?	
<b><u>External Failure Costs</u></b>	
N / A	

<b><u>4. Internal Cost of Unplanned Failures</u></b>	<u>Current Period</u> Week / Month
Date: ___/___/___	Cost (£)
<b><u>Prevention Costs</u></b>	
Quality Personnel	
Laboratory Personnel	
<b><u>Appraisal Costs</u></b>	
Lab tests to Assess Quality Acceptance / Standard.	
<b><u>Internal Failure Costs</u></b>	
Scrap	
Rework	
Troubleshooting / Failure Analysis	
Re-inspect / Re-Test	
Scrap & Rework - Fault of Supplier	
<b><u>External Failure Costs</u></b>	
Commercial Error - Paperwork Error, Order Misunderstood	
Engineering Error - Wrong Paperwork Issued	

Betts Plastics

Quality Costing Exercise

David Bamford

<b>5. Cost of Failure After Change of Ownership</b>	<b>Current Period Week / Month</b>
Date: ___ / ___ / ___	Cost (£)
<b><u>Prevention Costs</u></b>	
Quality Personnel	
Laboratory Personnel	
<b><u>Appraisal Costs</u></b>	
Receiving Inspection (of returned goods)	
Lab tests to Assess Quality Acceptance / Standard.	
<b><u>Internal Failure Costs</u></b>	
Scrap	
Rework	
Troubleshooting / Failure Analysis	
Re-inspect / Re-Test	
<b><u>External Failure Costs</u></b>	
Complaints (S.R.N.) - Specific Values	
Products Rejected & Returned - Cost of Handling	
Commercial Error - Paperwork Error, Order Misunderstood	
Engineering Error - Wrong Paperwork Issued	

6. P.A.F. Cost Collation Sheet	As a %.	Week/ Month
Date: ___/___/___		Cost (£)
<b><u>Prevention Costs</u></b>		
Quality Personnel		
Process Control Personnel		
Laboratory Personnel		
Cost of Quality Training		
Cost of Presenting Quality Costs to Management		
Engineers - Planning & Directing Initial Product Qualification		
<b><u>Appraisal Costs</u></b>		
Receiving Inspection		
Supplier Audits		
Lab Tests to Assess Quality Acceptance / Standards		
Review of Test and Inspection Data (C of C, C of A)		
Internal Testing & Release - before Shipment (e.g. S.I.D.)		
Calibration & Maintenance of Equipment Used to Evaluate Quality. e.g. Solex Gauges, Scales, Johansson.		
Inspection & Testing: Pass-Off / Routine Inspection		
Set-up Cost for Inspection & Testing (set up of lab)		
Inspection & Test Materials		
Product Quality Audits: On in-process or Finished Goods		
Maintenance & Calibration of Test & Inspection Equipment		
e.g. Solex Gauges, Scales.		
Inspection & Test Reports - Costs for Collecting & Processing		
Lab tests to Assess Quality Acceptance / Standard.		
Receiving Inspection (of returned goods)		
Lab tests to Assess Quality Acceptance / Standard.		





## PROPOSED QUALITY COSTING METHODOLOGY

### Available Quality Related Cost Data

- Payroll analysis.
- Scrap reports - value in / value out (1% scrap allowed for in estimates?).
- Sorting / rectification.
- Return shipping costs.
- Material usage variance.
- Organisation charts.
- Job descriptions.
- Departmental budgets.
- Std cost of manufacture
- Standard output at all stages of manufacture: Colour change time.  
(Flow chart this process) Pass off time.  
Production standards.  
Over-runs.  
Assembly Operations.  
Goods out.
- Also use: Record of returns and replacement (work out std cost).  
Warranty and liability costs.  
Records of investigation and sources of faults.  
Number of returns.  
Suppliers liability.  
Sources of error and value.

### Five Stages in the Quality Cost Collection Exercise

1. Costs directly associated with the quality function.
2. Quality - related costs of functions performed by personnel outside the Q.A. Dept.
3. Internal cost of "budgeted failures".
4. Internal cost of "unplanned failures".
5. Cost of failure after change of ownership.

Start with an accurate cost of scrap figure - some re-education of personnel may be necessary. Collect on a daily / weekly / monthly basis.

Take Particular Care With:

Oversights: you may overlook some elementary aspects, obtain a consensus opinion before embarking on an elaborate scheme.

Over - elaboration: Don't spend too much time looking for small exact amounts, we are after information that can be used to aid the decision making process.

Double-counting: e.g. don't count scrap and cost of replacement if can use some of the components again. Have to take the difference away.

Overheads: If manufacturing costs already carry an overhead allowance which makes provision for cost of maintaining Q.A. department, then cannot include separate quality cost for extra inspection incurred.  
Clearer if overhead is ignored and inspection is included as a charge when and where it actually occurs.  
Essential to agree basic rules for collection of quality costs with the company accountant before starting.

Standard Output: Check figures for built in scrap (1%).  
E.g. take into account rejecting 5 shots from Impulse collar, after stoppage.

Quality Costing - Categories and Build UpPrevention

1. Quality personnel.
2. Process control personnel.
3. Laboratory personnel.
4. Engineers - planning and directing initial product qualification.
5. Cost of quality training.
6. Cost of presenting quality costs to management.

Appraisal

1. Receiving inspection.
2. Supplier audits.
3. Laboratory tests to assess quality acceptance / standard.
4. Inspection and testing : Pass offs.  
: Routine inspection.
5. Set up cost for inspection and testing (set up of lab).
6. Inspection and test materials.
7. Product quality audits - on in-process or finished goods.
8. Maintenance and calibration of test and inspection equipment.
9. Review of test and inspection data (C of C, C of A).
10. Internal testing and release - before shipment (e.g. SID).

11. Calibration and maintenance of equipment used to evaluate quality - e.g. jigs, Johansson equipment.
12. Inspection and test reports - costs for collecting and processing.

### Failure (Internal)

- 1 Scrap.
- 2 Rework.
- 3 Troubleshooting / failure analysis.
- 4 Re-inspect / re-test.
- 5 Scrap and re-work - fault of supplier.

### Failure (External)

1. Complaints (SRN).
2. Products rejected and returned - cost of handling.
3. Commercial error - paperwork error, order misunderstood.
4. Engineering error - wrong specifications issued.

### So...

- Need to educate the workforce, at all levels, in the purpose of this exercise and the part which they can and must play in its successful completion.

- Need to design a series of forms that can be used to gather the relevant information from the relevant sources, as outlined above.

- This information needs to be collected per shift, per day, per week, per month in order to perfect the collection process.

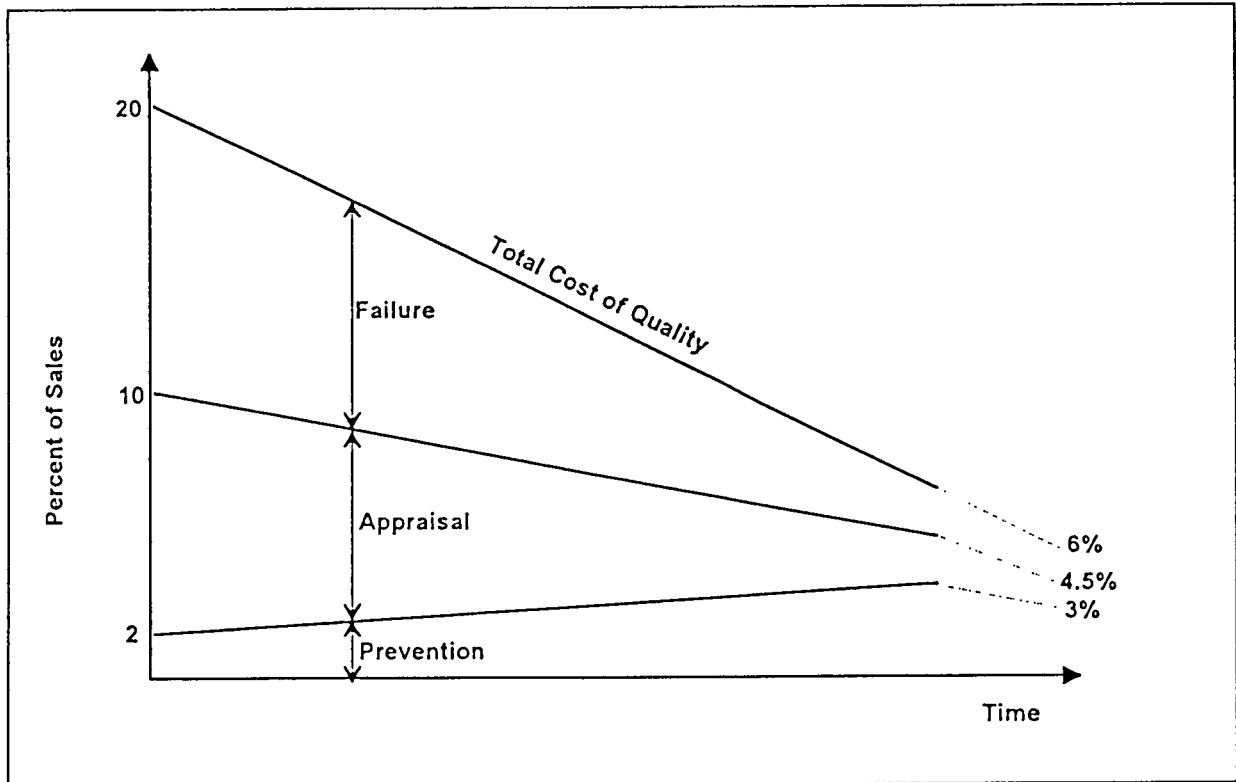
- The information should be reported on a monthly basis, to be seen to be part of the month end reporting format (this will also serve to educate people in the new technique).

- Remember this methodology is being developed to give quality costs for high volume manufacturing industry (Small, Medium Enterprises), and should be adapted to suit any particularly unique situations that arise.

- Trial methodology through one department first (personal health care, finishing, clean room?), adapt it then try plant wide, adapt it again then try on both sites.

- The split into prevention / appraisal / internal or external failure has been done purposefully to provide data that may be transformed into information, and then used within the decision making process by managers. Over a period of time, as the continuous improvement program gains momentum and starts to show tangible results, a graph such as the one shown on the next page should emerge. This diagram clearly indicates a change in emphasis in the spending priorities of the

company concerned. The overall costs have come down and the distribution amongst the four main categories has changed.



Total quality continuously drives down overall costs by effective use of prevention costs.

This process will take years!!!

David Bamford

July 1994

## APPENDIX 3

### Quality Costing Data

## Quality Costing Graphs - from other research

The following graphs have been taken from various sources for comparison use in chapter five - Findings: P.A.F. Model.

David J. Smith (42) in Gower's Handbook of Quality Management, examines a generic breakdown of operating quality costs for a six month period in an organisation which manufactures and assembles electronic equipment. Table A1 below.

Q.Costs % of gross sales		
Category	Qual Costs %	Sales Turnover %
P	10.4	0.91
A	37.71	3.3
F	49.82	4.36
	100	8.75
Table A1		

Lester et. al. (11) established quality costs for their work with the Hawley-Lynch Company. The company manufactures electrical appliances, with a twenty million dollar sales turnover. Table A2 below.

Q.Costs % of gross sales		
Category	Qual Costs %	Sales Turnover %
P	1.88	0.3
A	5.62	0.9
F	92.5	14.8
	100	16
Table A2		

Plunkett (45), in his PhD thesis on the study of the collection and use of quality related costs in manufacturing industry quotes the quality costs for plastic products. The standard industrial classification (S.I.C.) of thirty refers to a specific industry sector - Rubber and Miscellaneous Plastic Products. The source of this data is "Quality", June 1977. This data is shown below in table A3.

Formal Program						
Quality Costs	(% of net sales billed)					
Rubber & Misc.	S.I.C.	Total	P	A	Fi	Fe
Plastic Products	30	14.7	0.4	2.3	9.5	2.5
		100	2.72	15.64	64.62	17
Table A3						

Tables A4, A5, and A6 are taken from Dale and Plunketts work on quality costing (20).

Table A4 below shows the quality costs of a site which forms part of a large group of metal refining and fabrication company. It employees 150 people on the site and has a turnover of five million pounds. Figures are also displayed of general manufacturing industry costs. These were taken by Dale and Plunkett from the publication "Quality", June 1977.

	Q.Costs %	Manufacturing Indus - General	Sales Turnover %	Manufacturing Indus - General
P	3.4	10.3	0.37	0.6
A	29.5	26	3.14	1.5
Fi	54.5	43	5.18	2.5
Fe	12.6	20.7	1.34	1.2
Total	100	100	10.65	5.8
Table <u>Quality</u> A4 <u>Cost</u> <u>Survey</u>				

Table A5 demonstrates the quality costs for a manufacturing site of ancillary equipment for engines. The site has a seventy two million pound turnover.

Categories	Quality Cost %	Sales Turnover %
P	6.6	0.38
A	42.3	2.4
Fi	31.8	1.8
Fe	19.3	1.1
	100	6.1
Table A5 - Quality Costs		



Table A6 demonstrates the quality costs for a manufacturer of diesel engines. The firm employs thirteen thousand people, and has an annual sales turnover of forty-eight million pounds.

Categories	Quality Cost %	Sales Turnover %
P	7.4	0.7
A	24	2.3
Fi	21	2
Fe	47.6	4.1
	100	9.6
Table A6 - Quality Costs		

If the above graphs are combined to provide an industry average table A7 is produced:

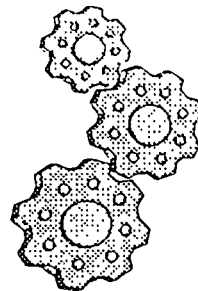
	A1	A2	A3	A4	A5	A6	Average
Prevention	10.4	1.88	2.72	3.4	6.6	7.4	6
Appraisal	37.71	5.62	15.64	29.5	42.3	24	26
Failure	49.82	92.5	81.62	67.1	51.1	68.6	68
Total	100	100	100	100	100	100	
% of Sales	8.75	16	14.7	10.65	6.1	9.6	10.96
Table A7 - Industry Averages							

# APPENDIX 4

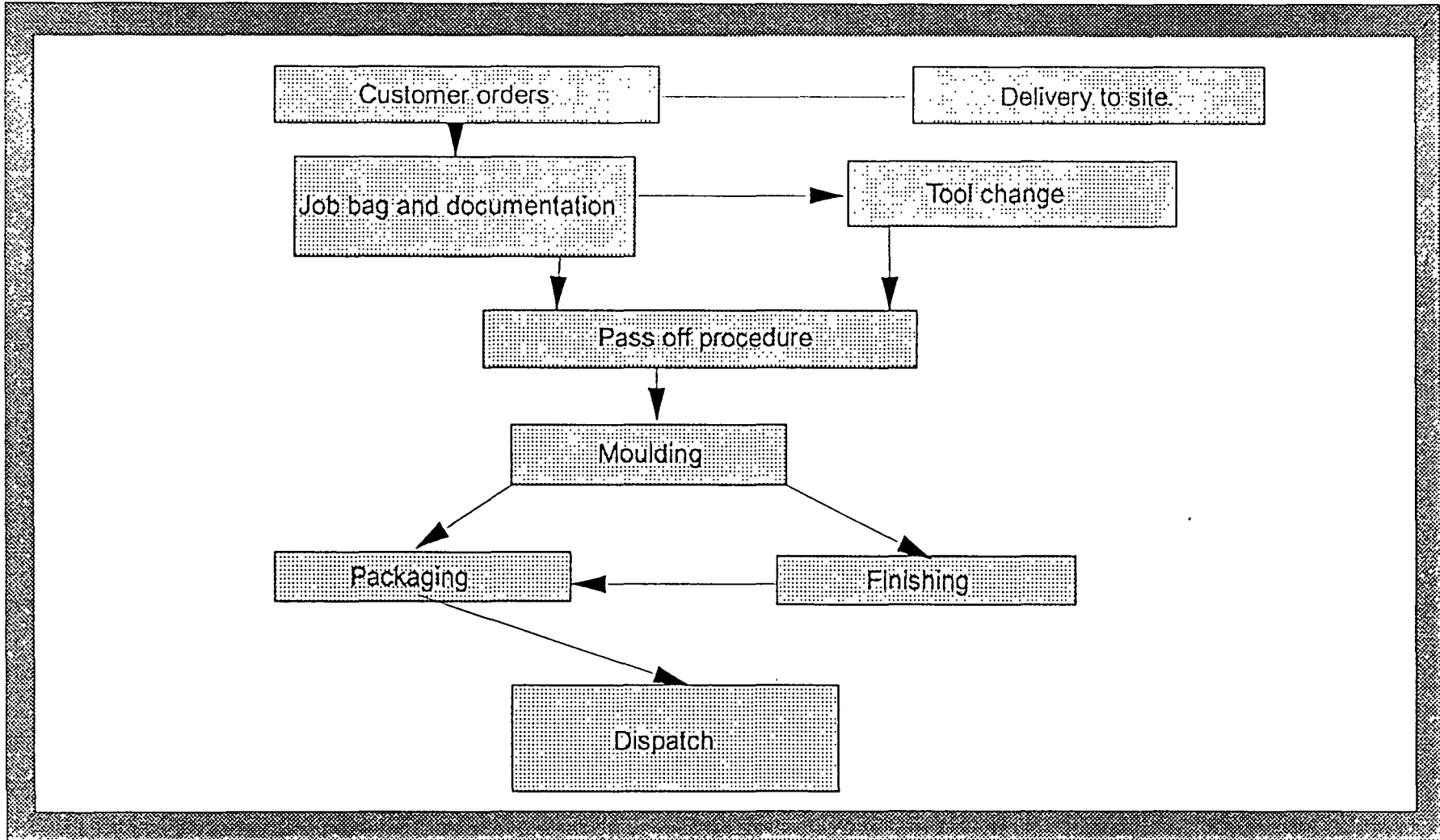
## Process Model Information

# Flow chart of process

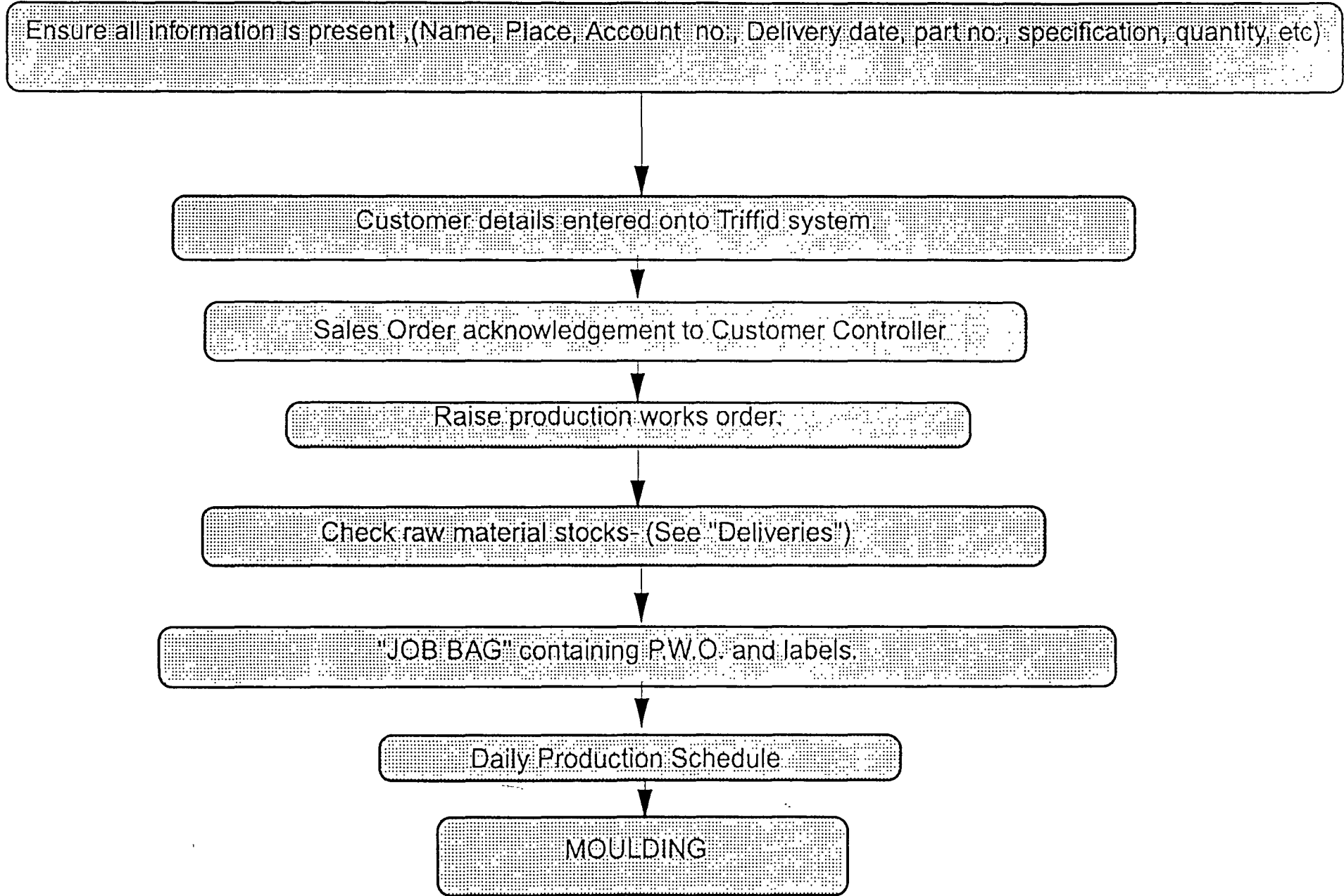
Betts Plastics - Personal care.



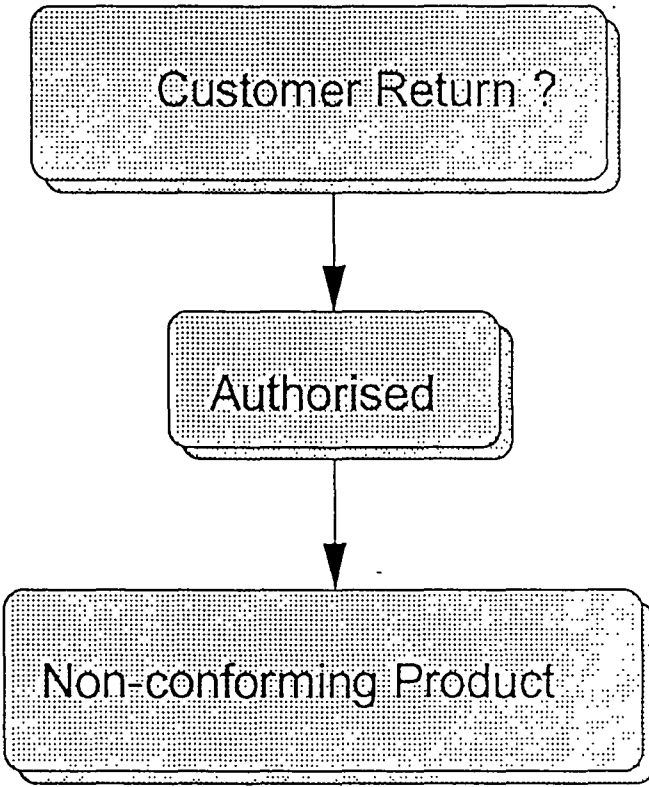
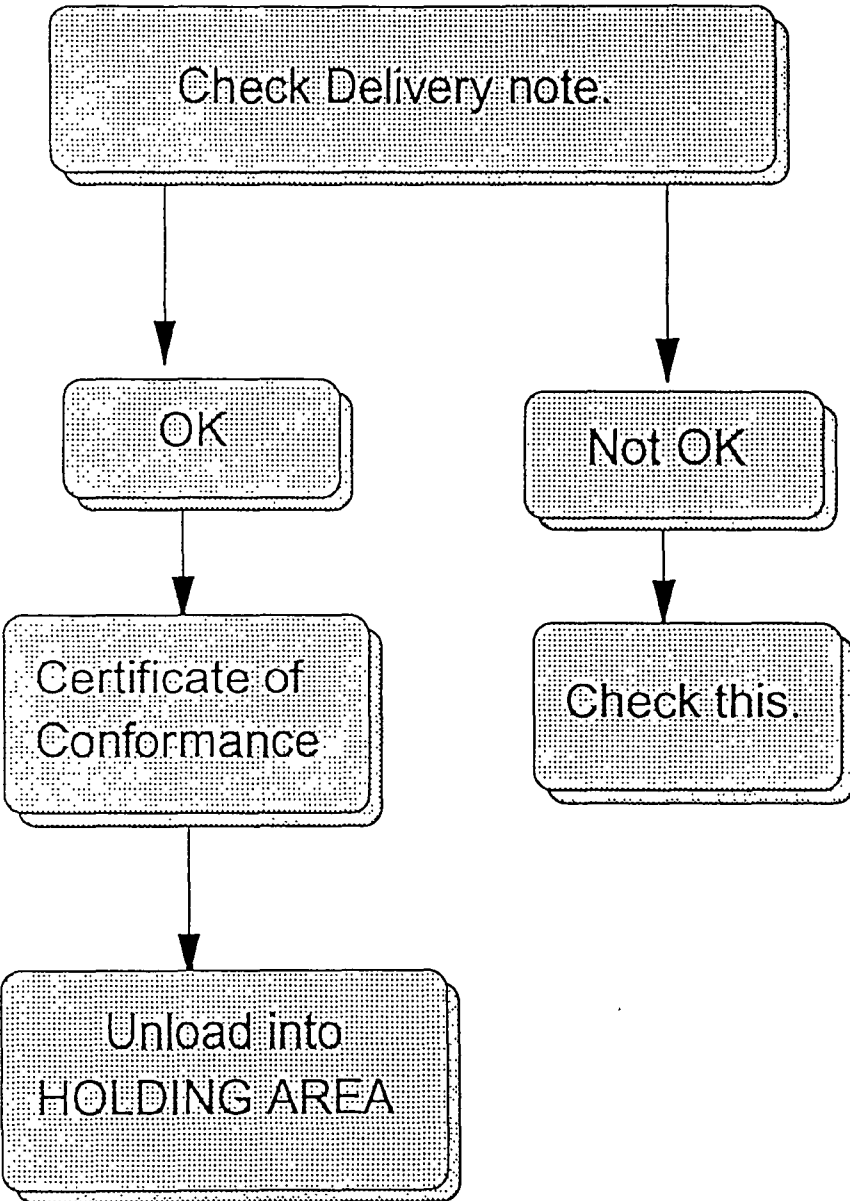
# Process.



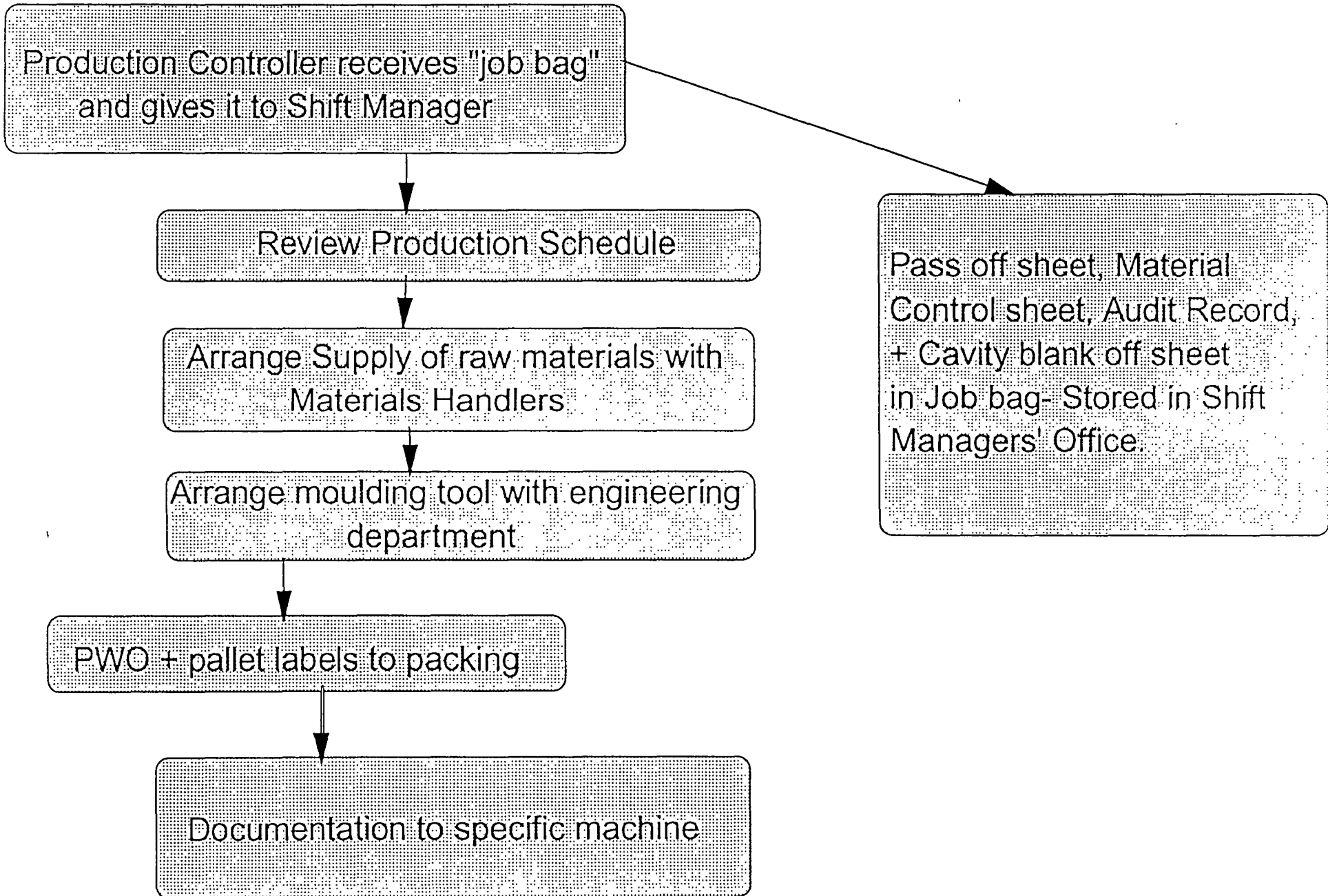
# 1. Customer Orders.



Which department is it for?

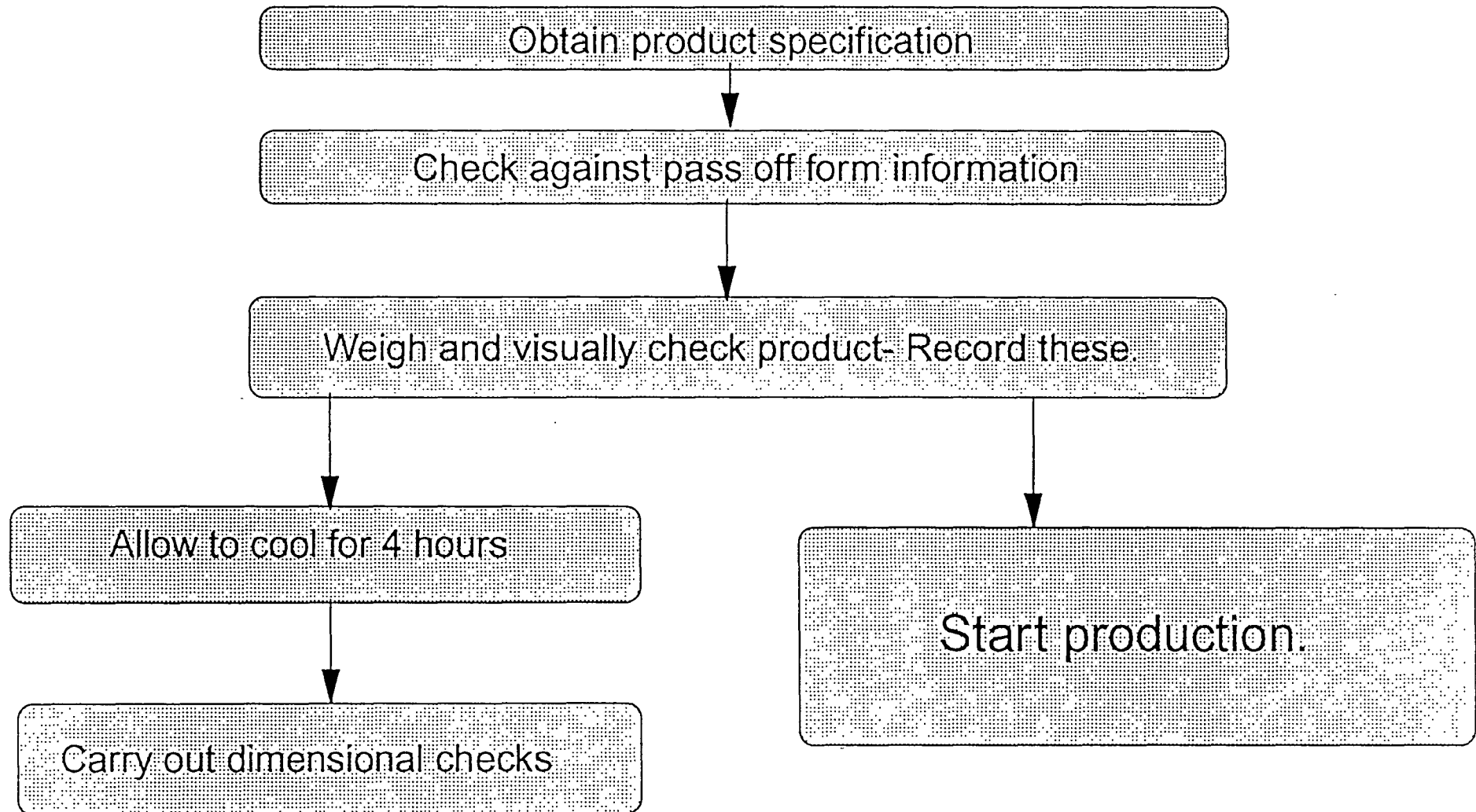


### 3. Job bag and documentation.



## 5. Pass off procedure

(Carried out by Materials Handler/Setter).





## 4. Tool Change

If tool change required...

Setter- Clear area of raw materials and product  
- Remove old tool and install new one.

If tool change not required...

Setter- Clear area of product  
- Remove tote boxes

Raw Materials Handler- Clear all raw materials and product  
- Make new raw materials available  
- Check unit is set up OK.  
- Record materials on Material control sheet, Pass off sheet, and Stock transfer sheet. (See pass off procedure- page 5)

## 6. Moulding.

When unit is set up and running....

Setter takes 3 lift samples and informs shift manager.



Carry out quality control checks.

Operator- Audit record every 2 hours

- Continuous control inspection
- Report any defect to Shift Manager
- Check tote boxes

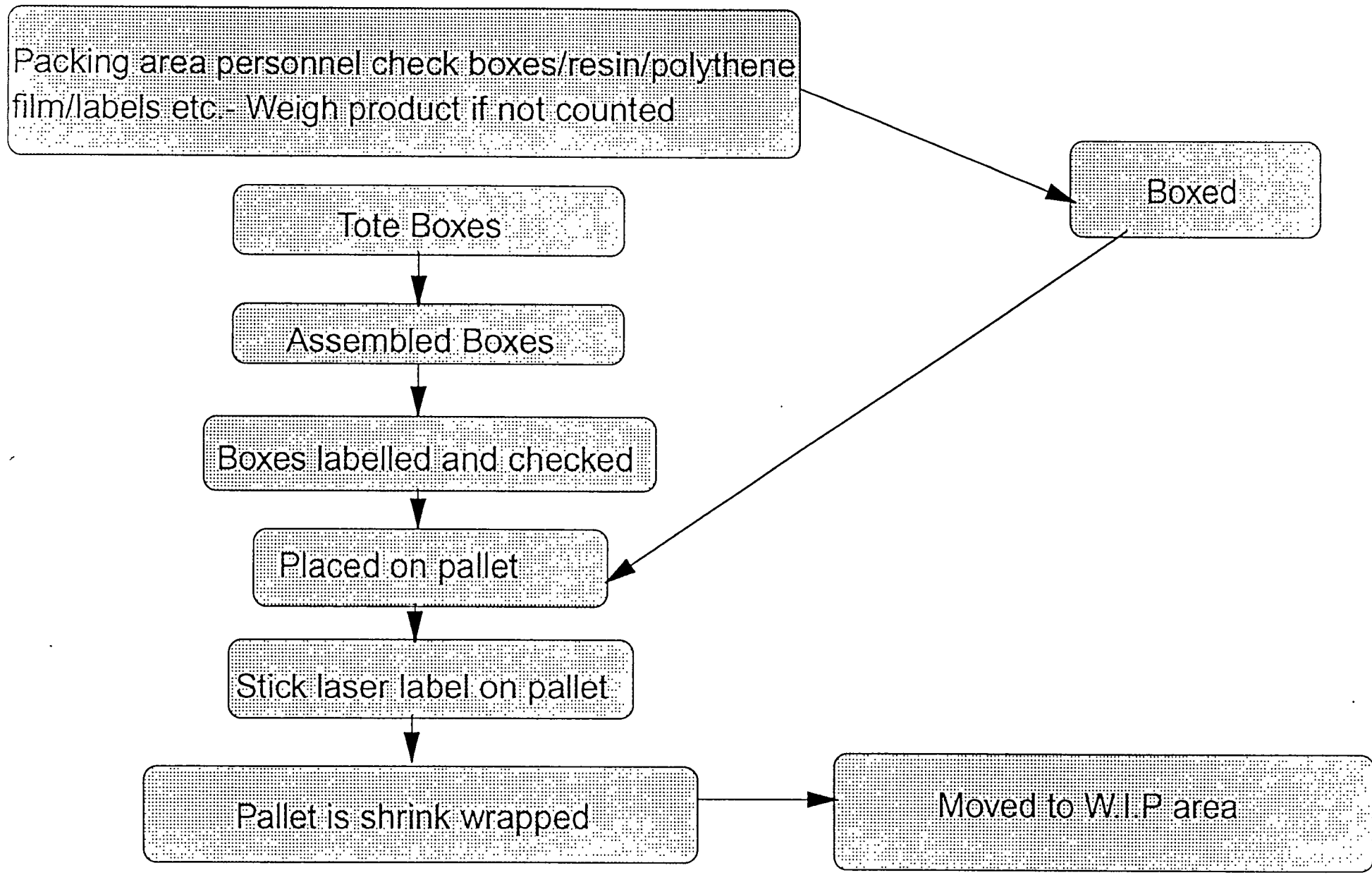
If any problems (if unacceptable)- all treated as NON-CONFORMING PRODUCTS.  
and corrective action taken.



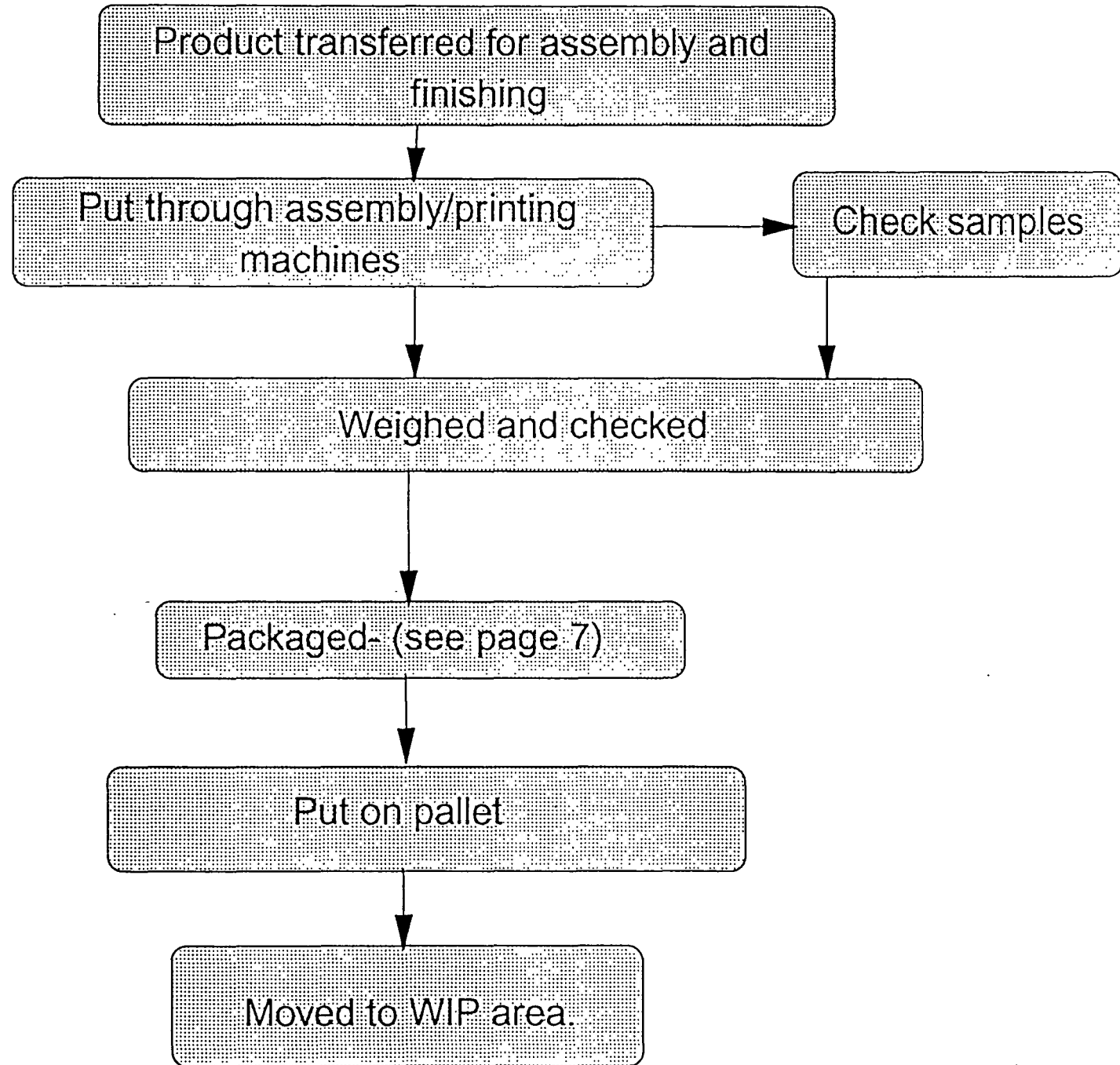
If product is all OK, dispensed into Tote boxes

Transferred to packaging (page 7) or to finishing (page 8) by AGV system.

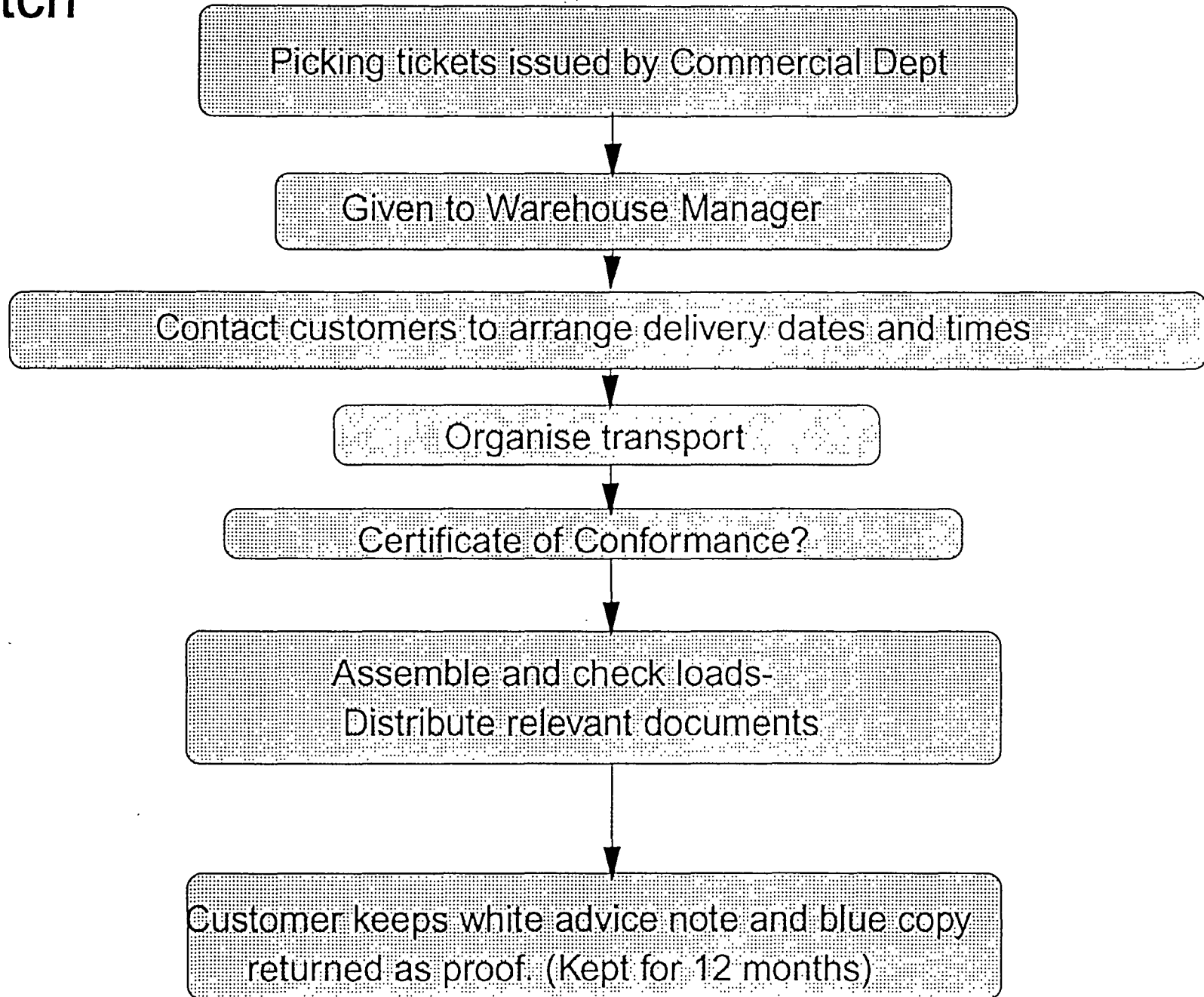
# 7. Packaging.



## 8. Finishing.



# 9. Dispatch

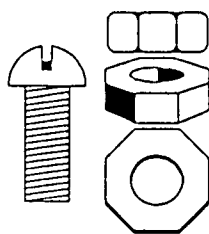


Warehouse and Transport are inspected according to procedure.

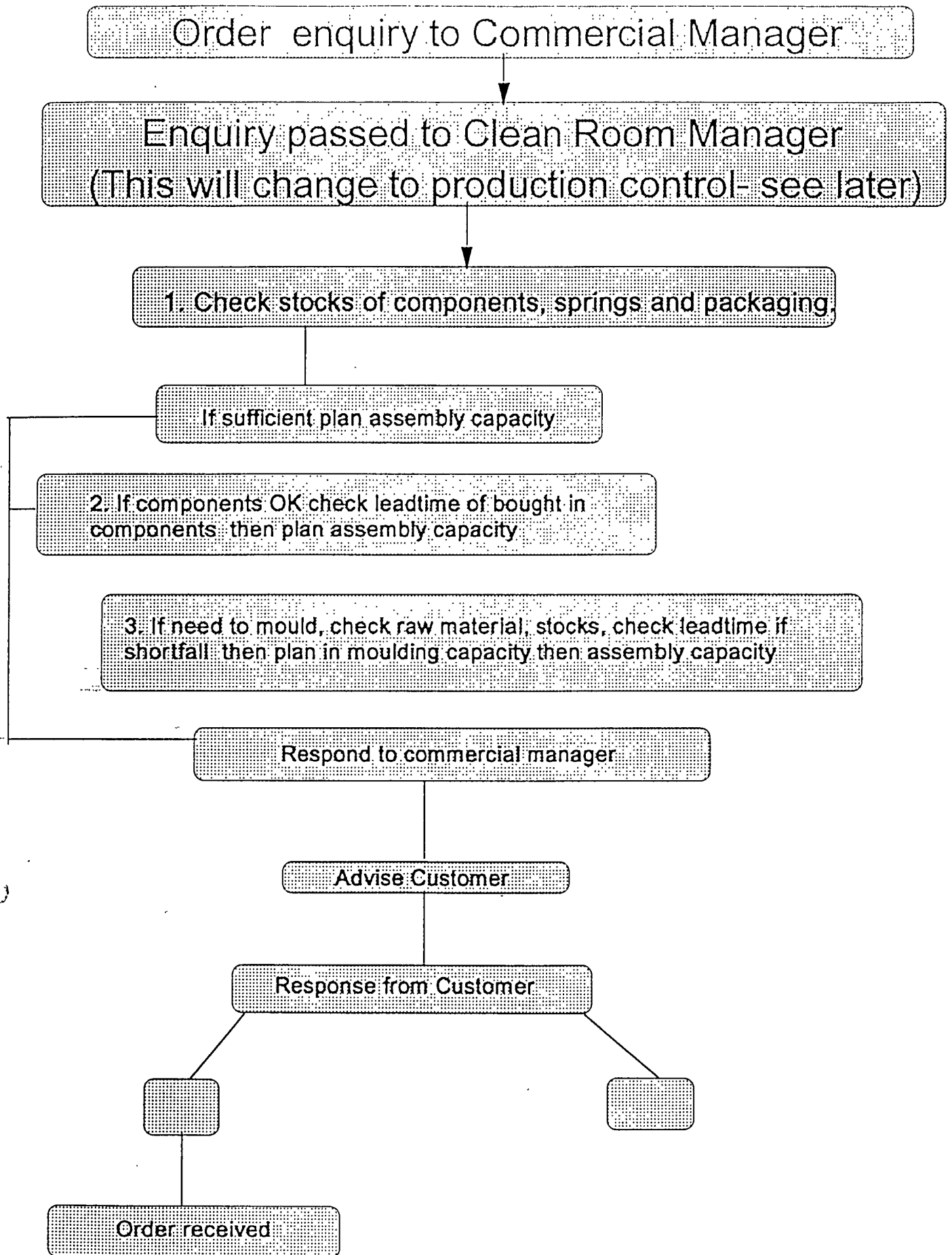
# Flow Chart of Process

Clean Room

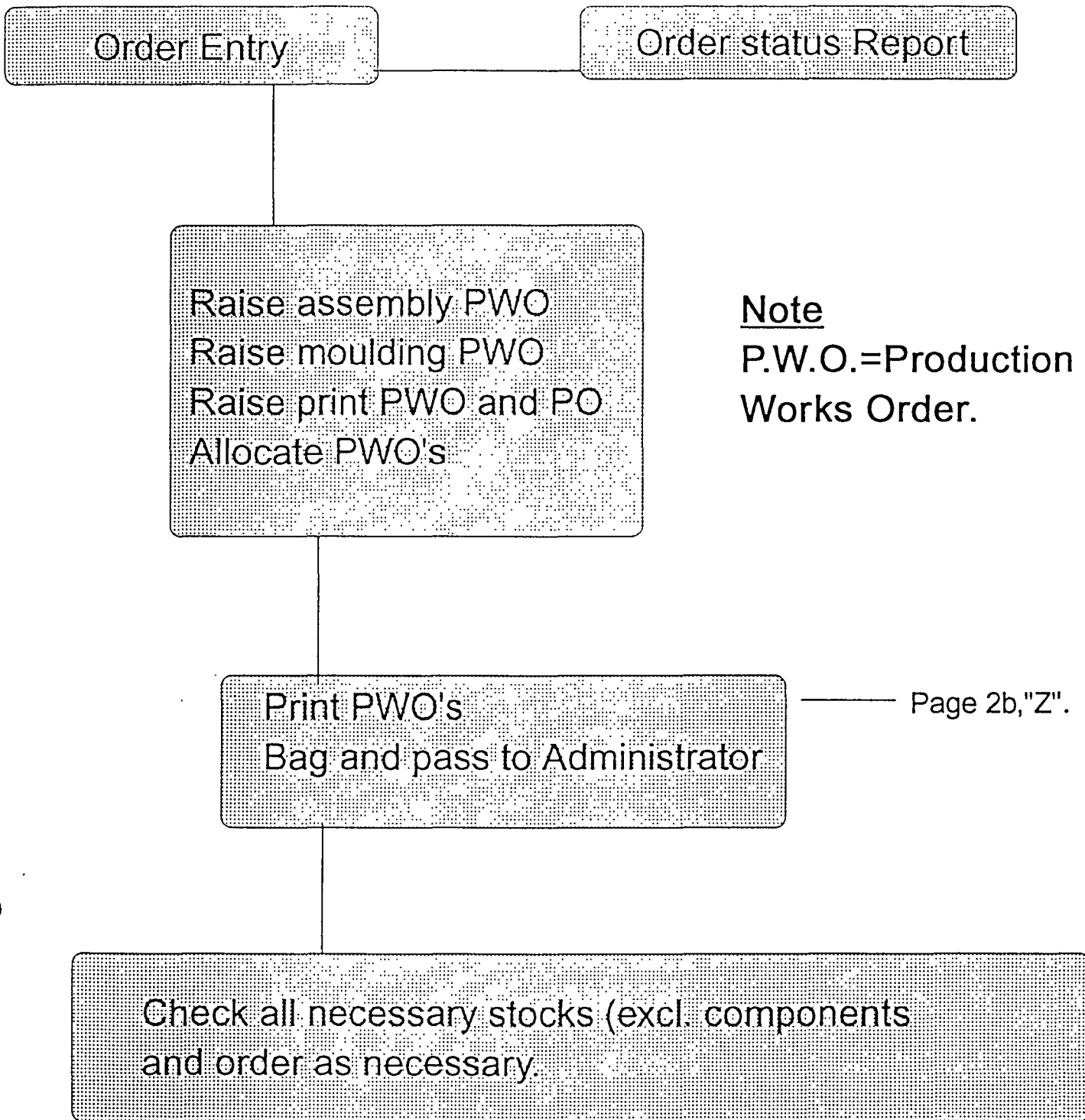
David Bamford



# 1. Order Enquiries.



2a. Present Planning and PWO's.



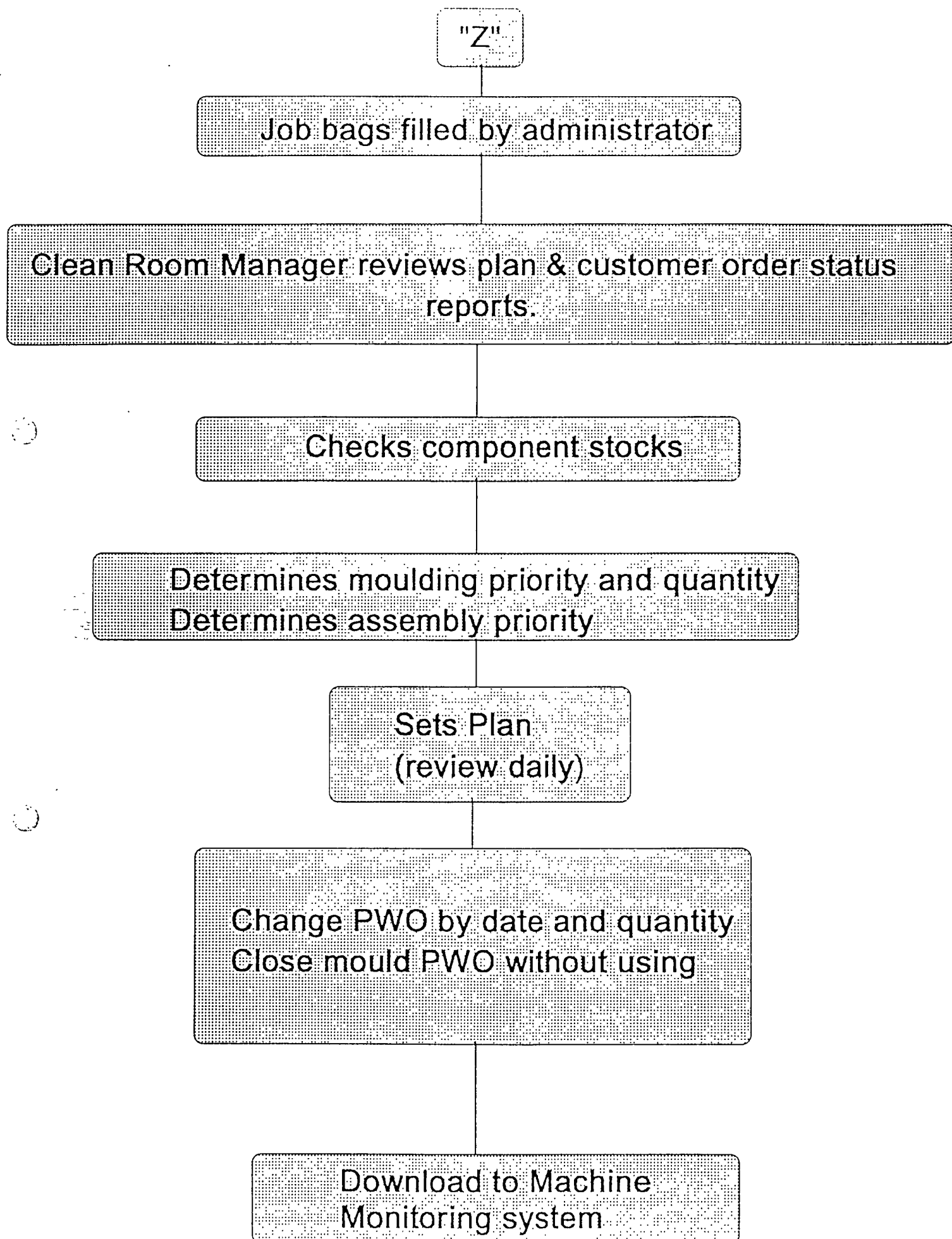
Note

P.W.O.=Production Works Order.

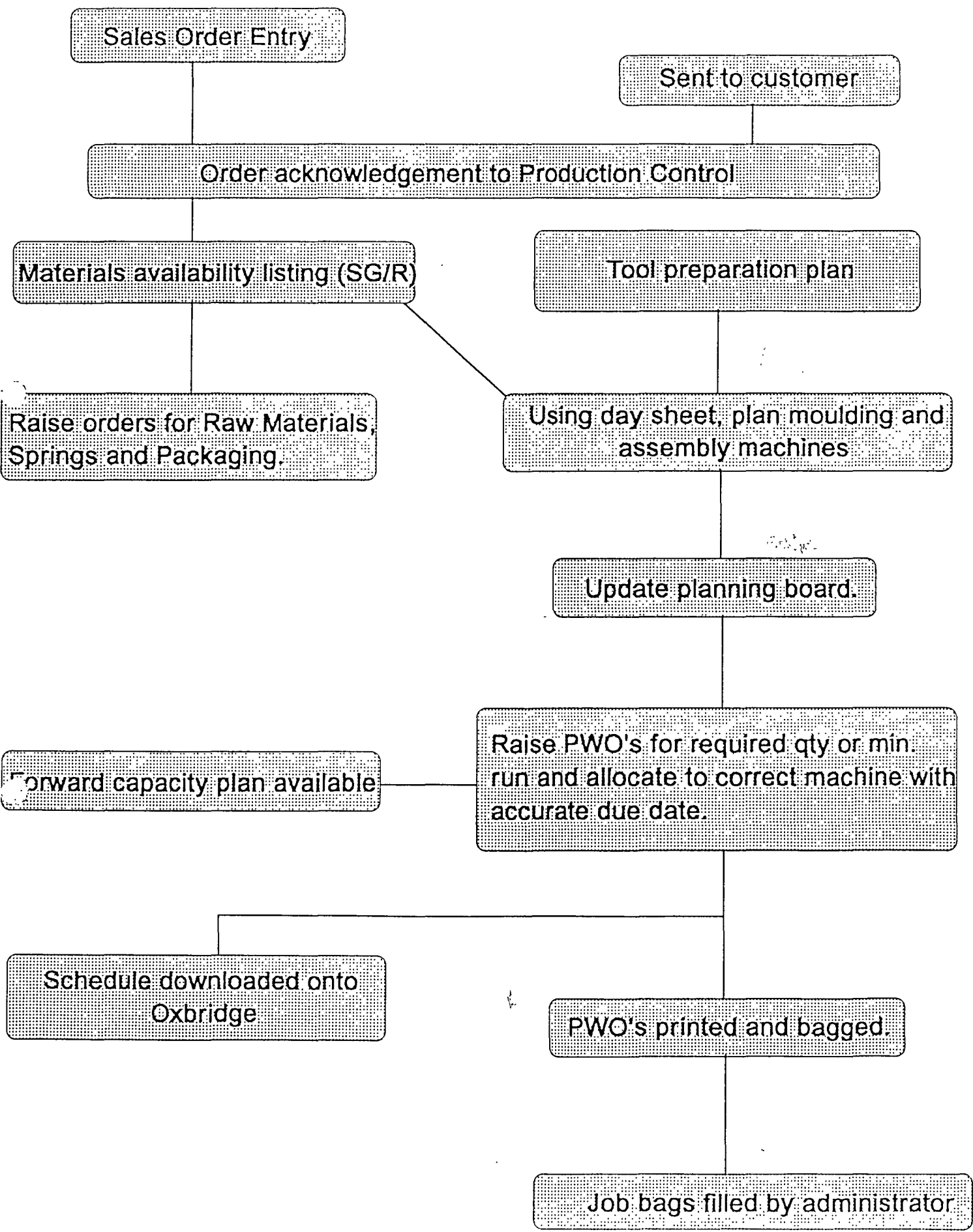
Page 2b, "Z".



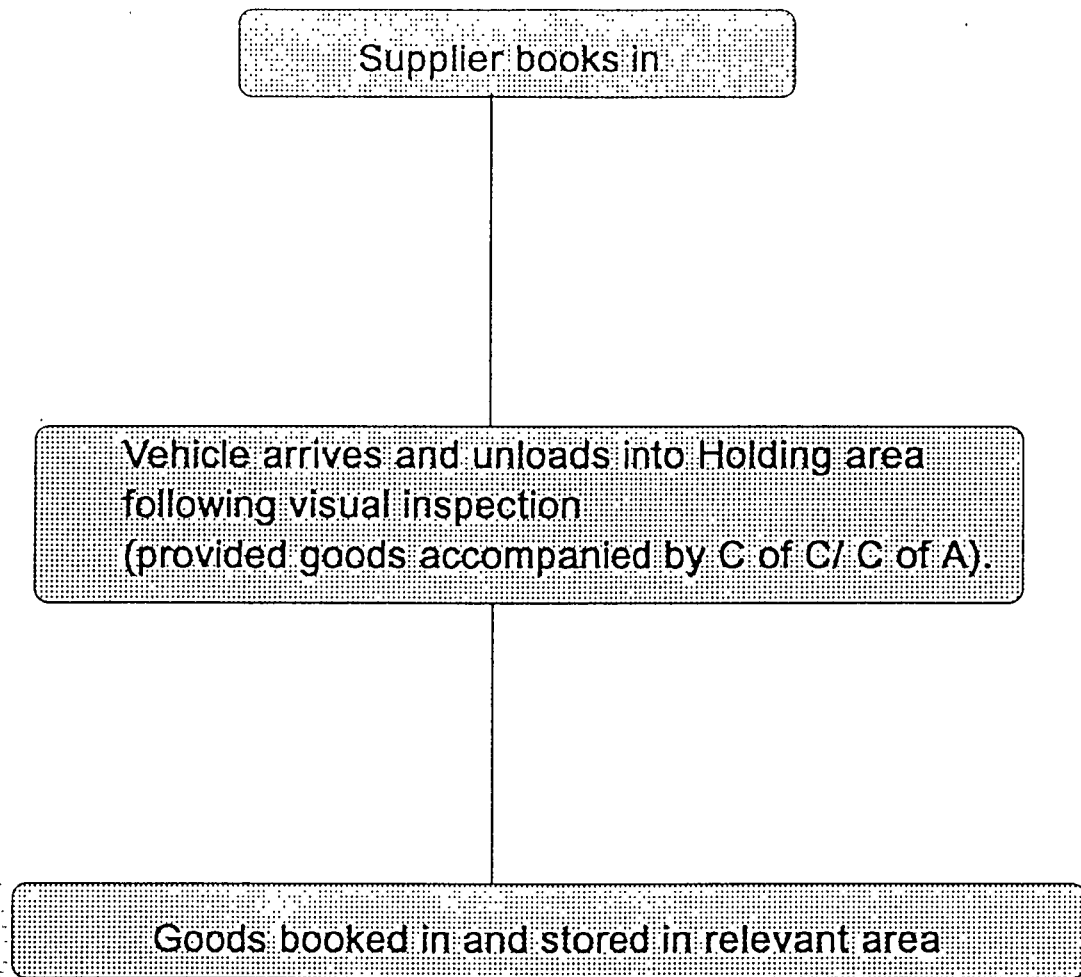
## 2b. Present planning and PWO's



# 2c. Improvement planning and PWO's.

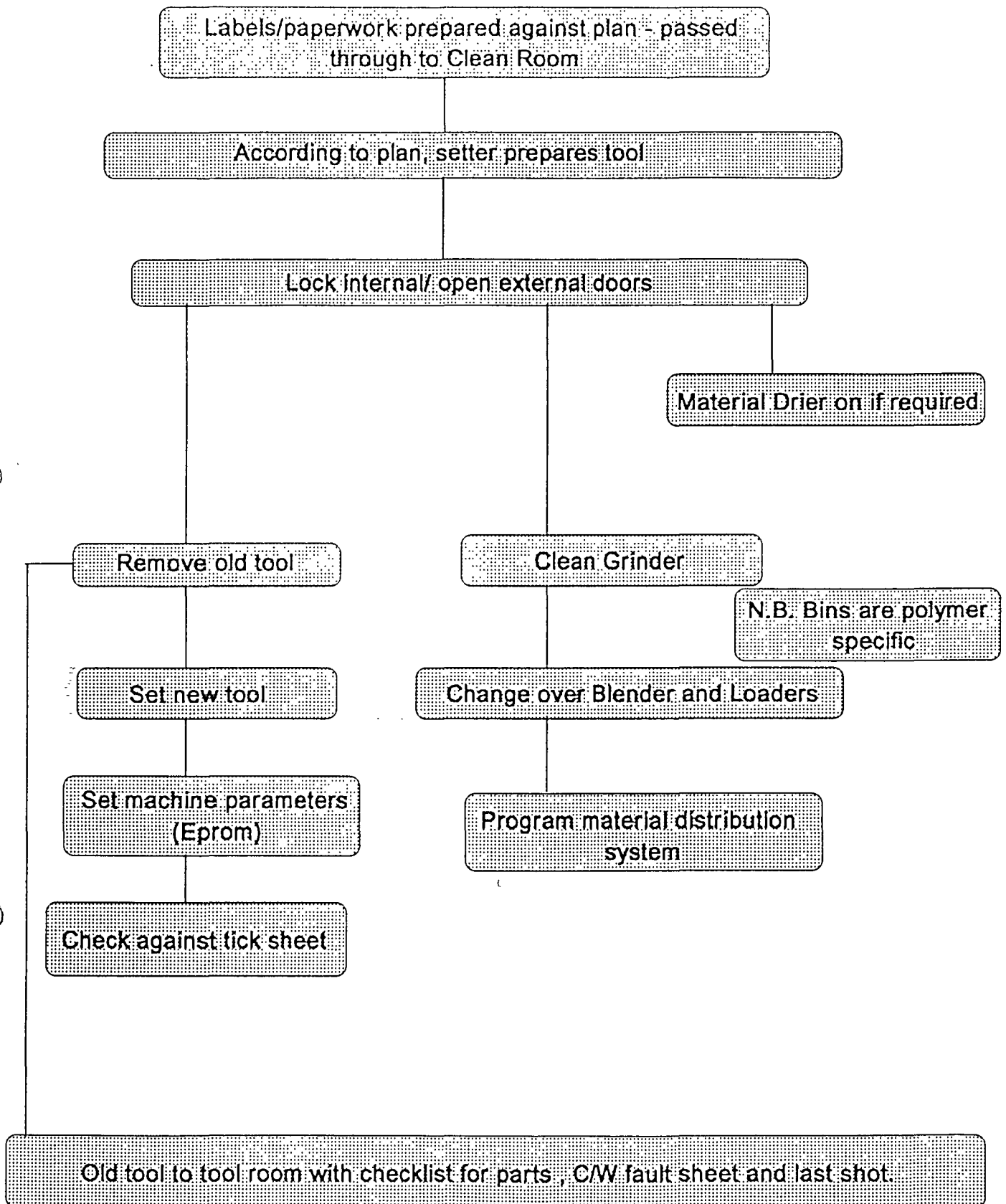


### 3. Goods receiving

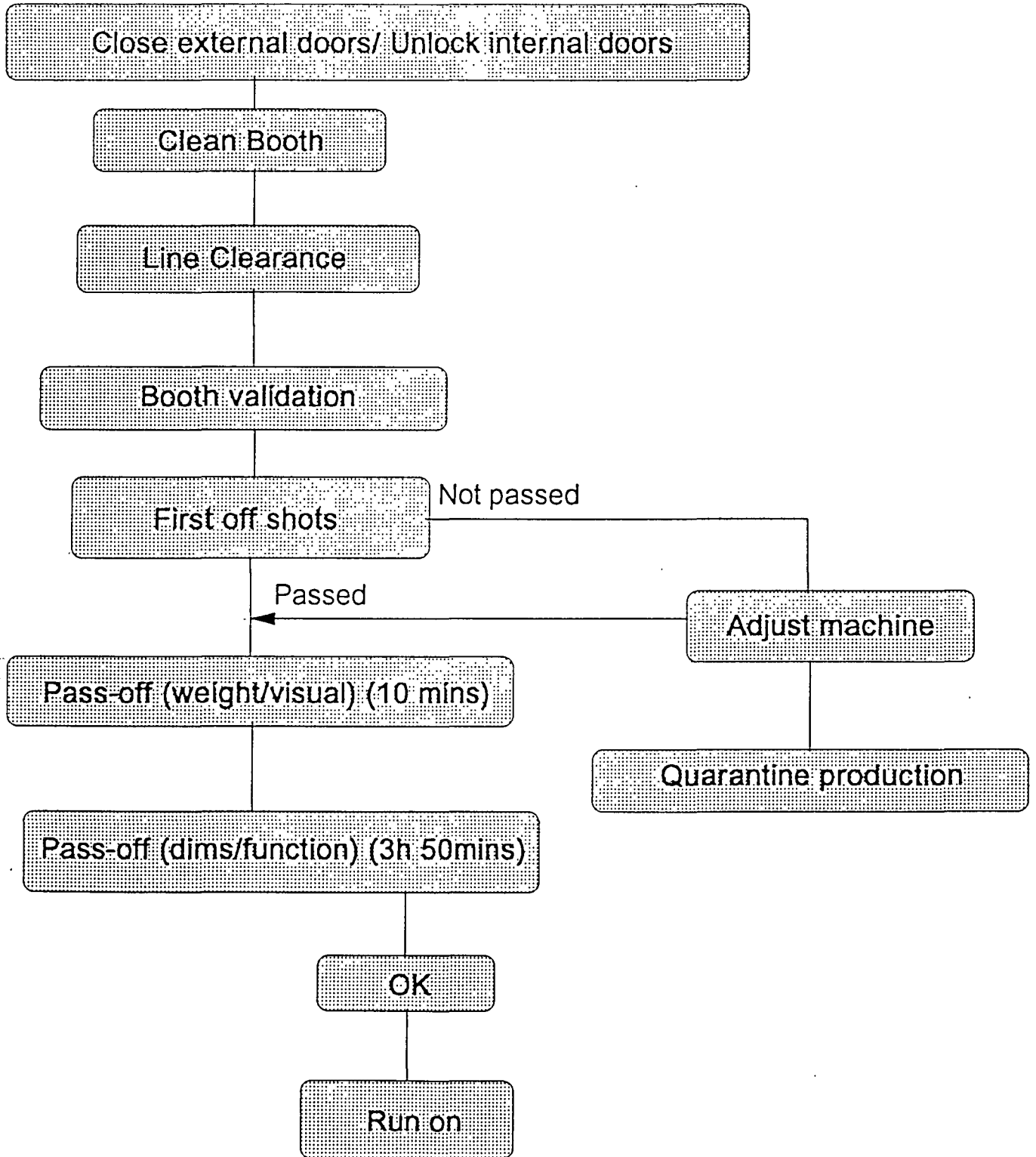


- Notes:
- No testing is carried on raw materials or packaging
  - Testing is carried out on springs
  - On delivery of springs, empty trays are loaded for return..

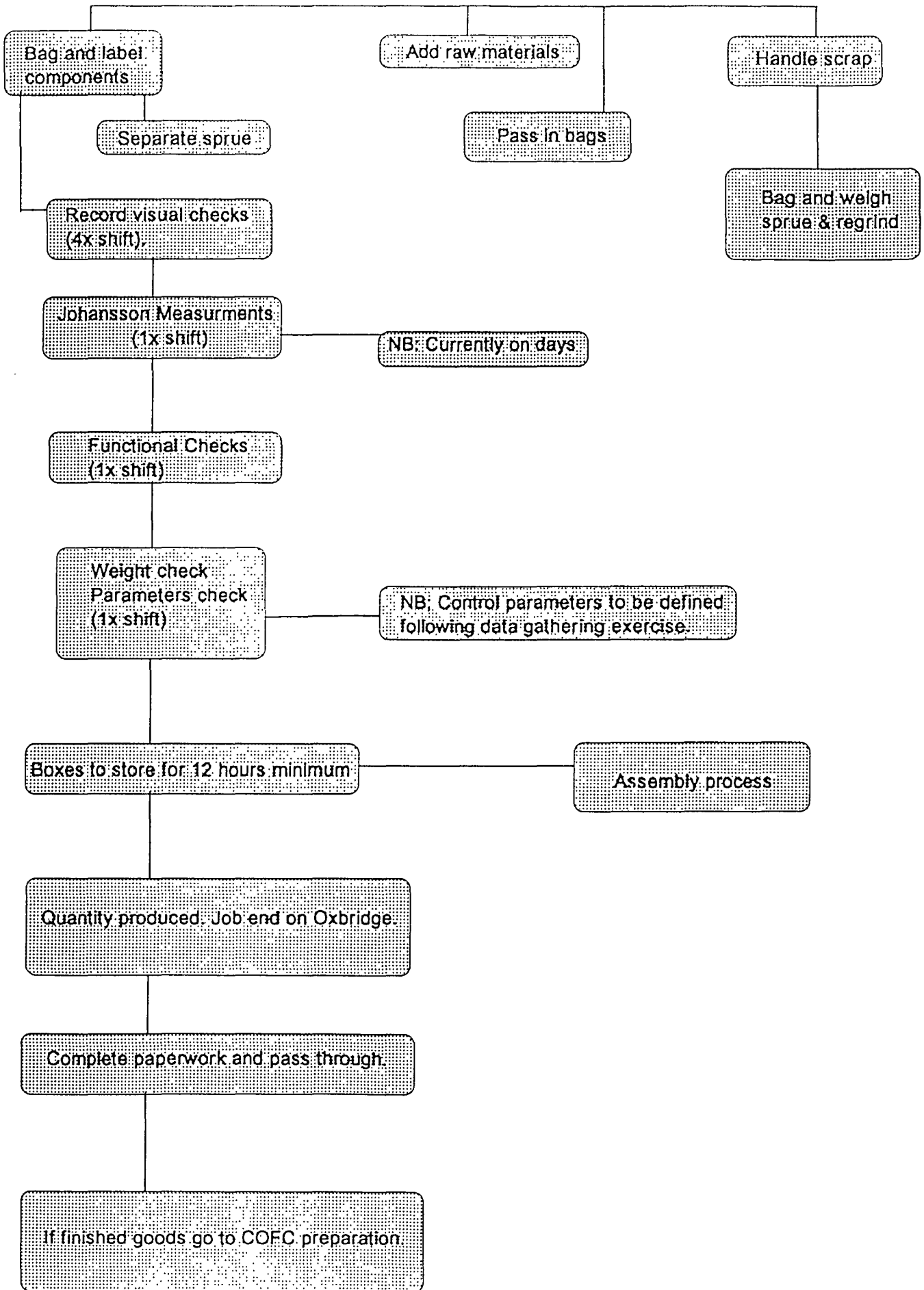
APPENDIX 4  
4. Mould changeover



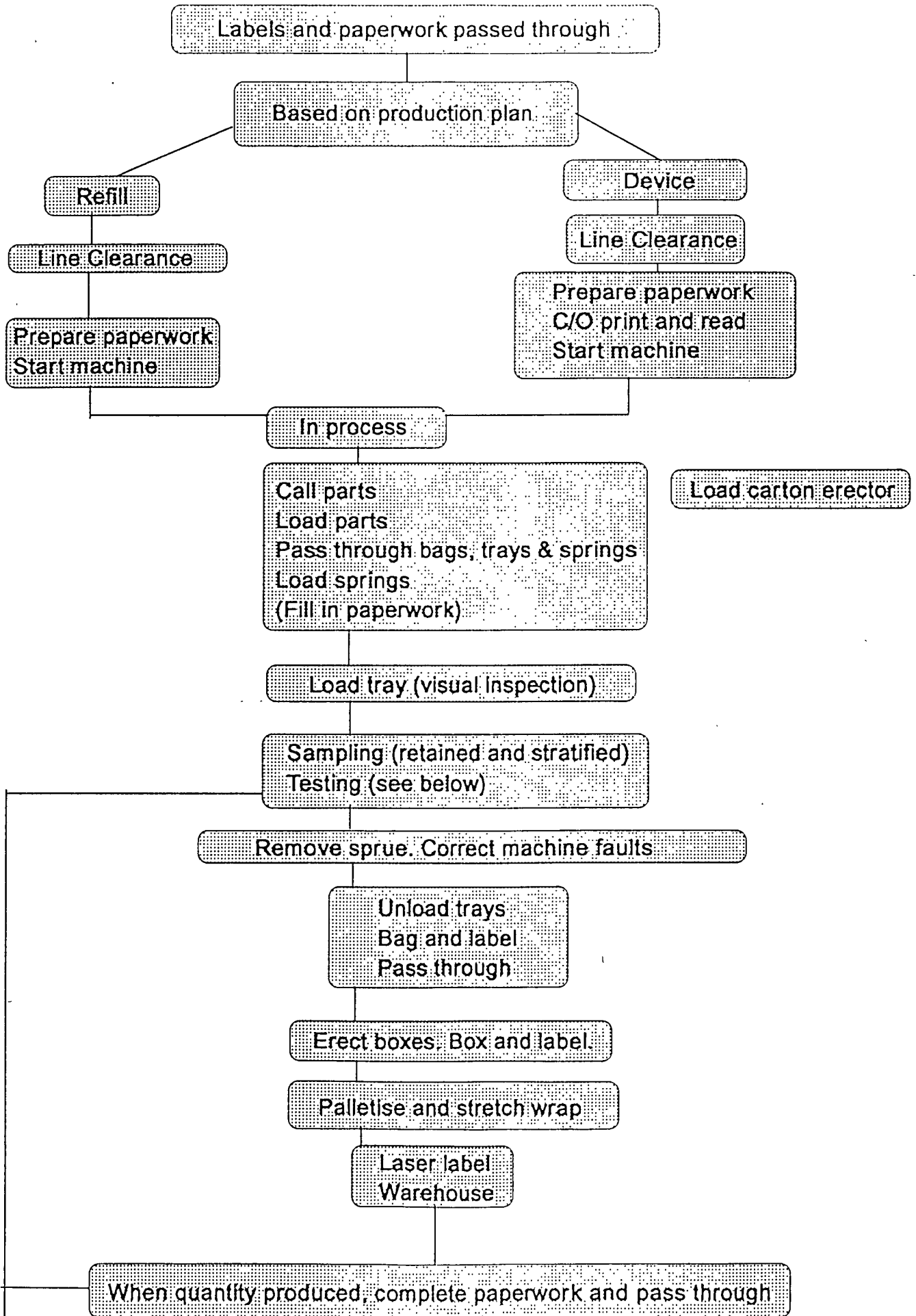
APPENDIX 4  
5. Start-up Moulding



# 6. In Process-Moulding



# 7. Assembly Process



## 8. Assembly Testing

### Device

- Visual inspection as per sheet
- 1 in 50
- 3 dry fires
- Pull test
- Functional tests as per sheet

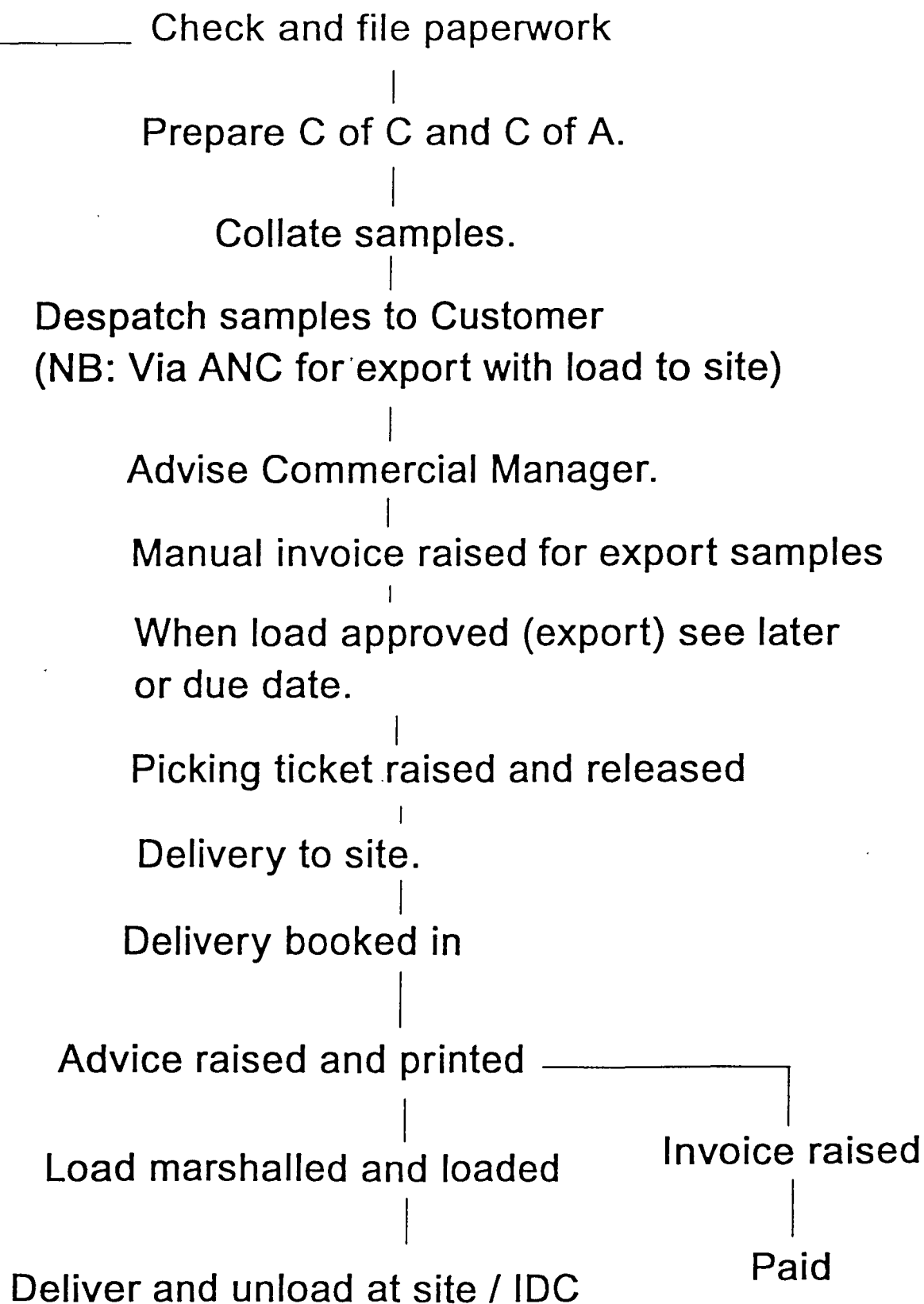
### Refill

- Visual inspection as per sheet
- Measure compressed height of sub assembly
- Gauge for boot retention (do when moulding)
- Functional tests as per sheet



9. Certificate preparation and sample dispatch

(from page 9)



10. Sample approval.

On completion of testing at customer

Either

1. Phone / Fax to OK from customer
- Or
2. Commercial Manager chases customer

## Betts Plastics

Clean Room - Process Cost Report

Date: \_\_\_/\_\_\_/\_\_\_

Process conformance	Cost			Process Nonconformance	Cost			Cost data source
	Act	Syn	£		Act	Syn	£	
<b>People</b> Assembly, inspec & test.								Produced hours x hourly rate.
				Rework / retest / reinspect				Hours x hourly rate.
				Waiting time				Hours x hourly rate.
<b>Equipment</b> Cost of equip required for work. eg depreciation, maint								Capital assets inventory.
				Cost of equip for rework				Capital assets inventory.
<b>Environment</b> floor space, maint, services								Accounts
				Floor space, etc for rework				Accounts
<b>Materials &amp; Methods</b> Purchased mat, handling sys & packing								Cost estimate
				Scrap, contingencies, mat price vari.				Scrap report
Task allocation, supervision of process.								Accounts
				Fault finding guides, cost of change. Training.				Accounts
Total process conformance cost				Total process nonconformance cost				
Prepared by:								

M. Phil &amp; E.

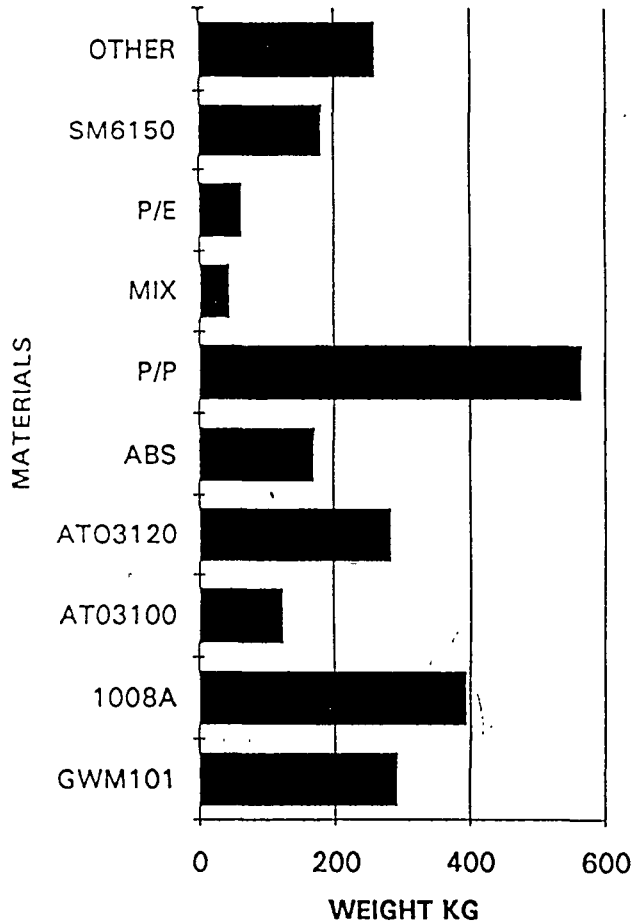
# APPENDIX 5

## Improvement Information

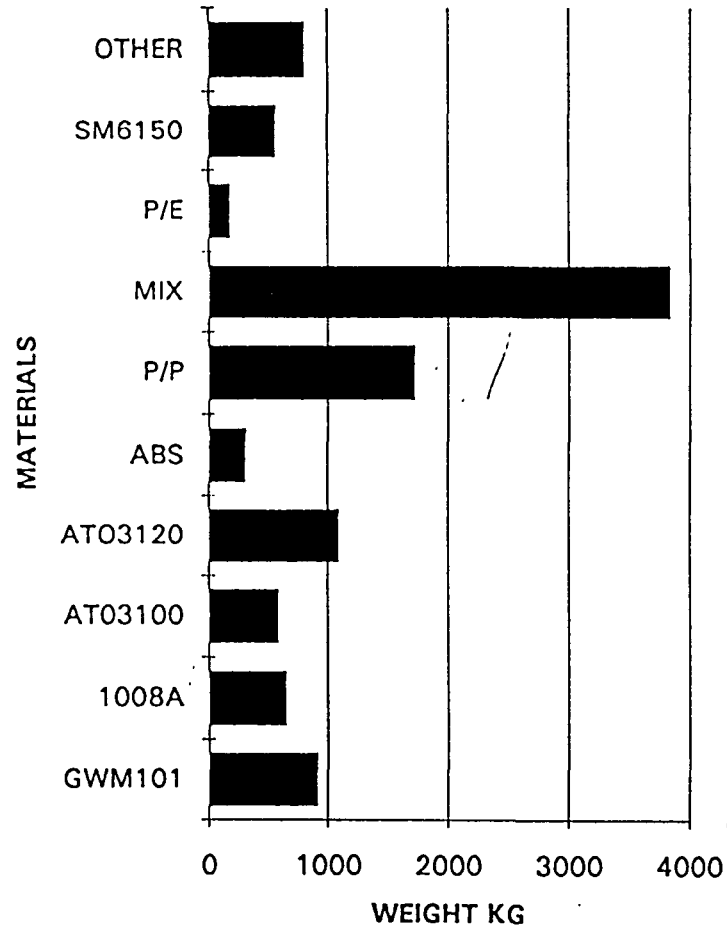


PLASTIC MONTH	GWM101	1008A	AT03100	AT03120	ABS	P/P	MIX	P/E	SM6150	OTHER
DECEMBER	293	395	124	284	171	566	45	64	182	260
JANUARY	922	654	591	1099	317	1729	3838	186	568	816
FEBRUARY	50	148	40	67	12	335	473	114	12	59

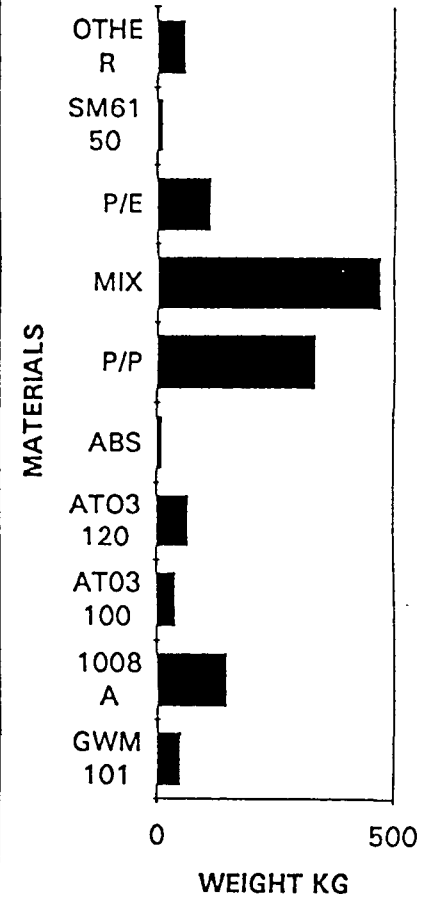
DECEMBER MATERIAL WASTE

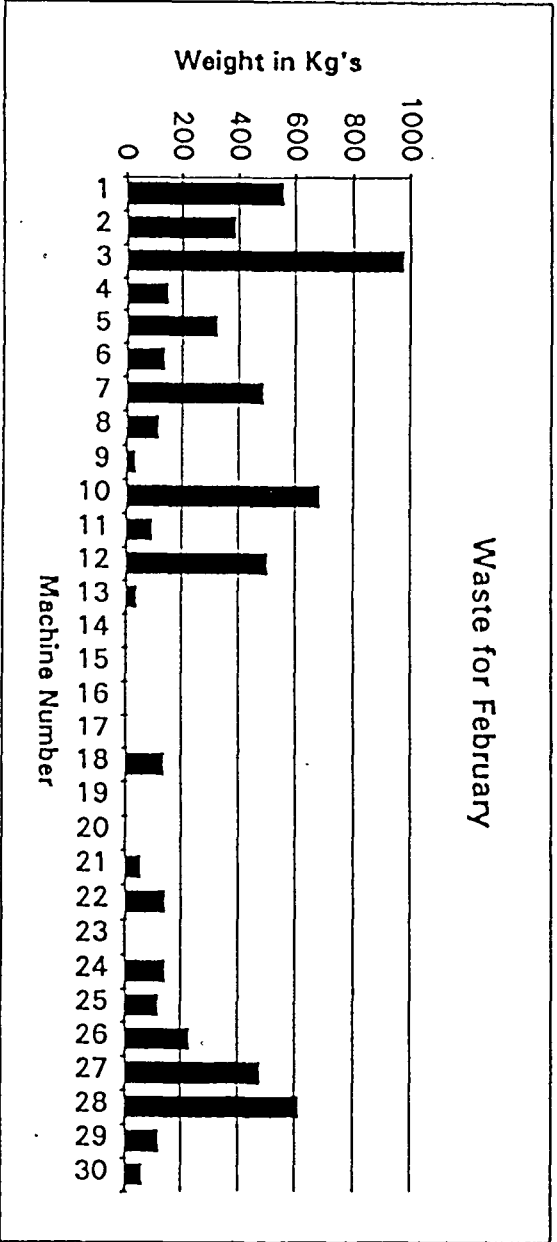
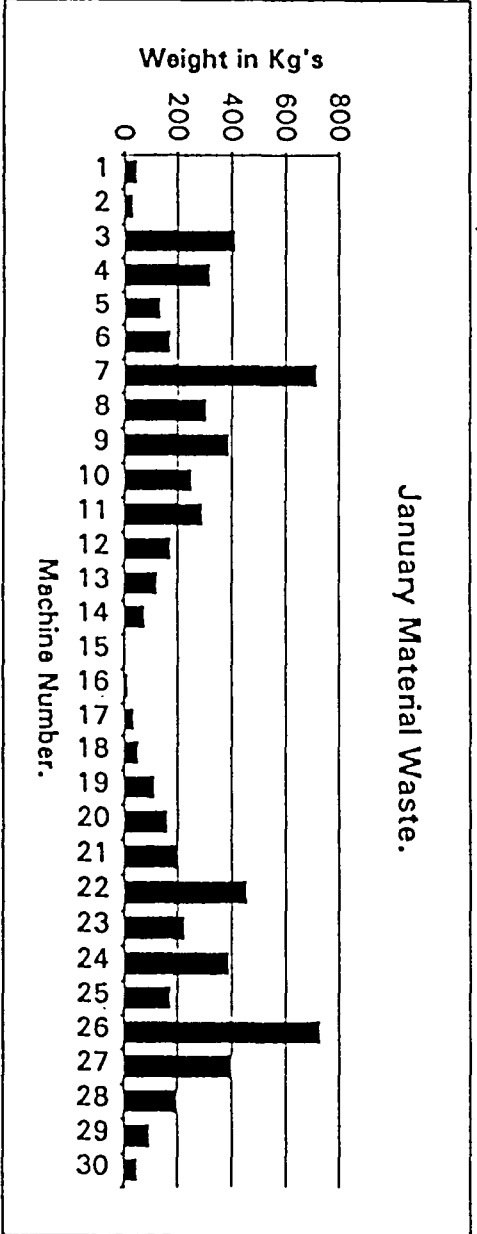
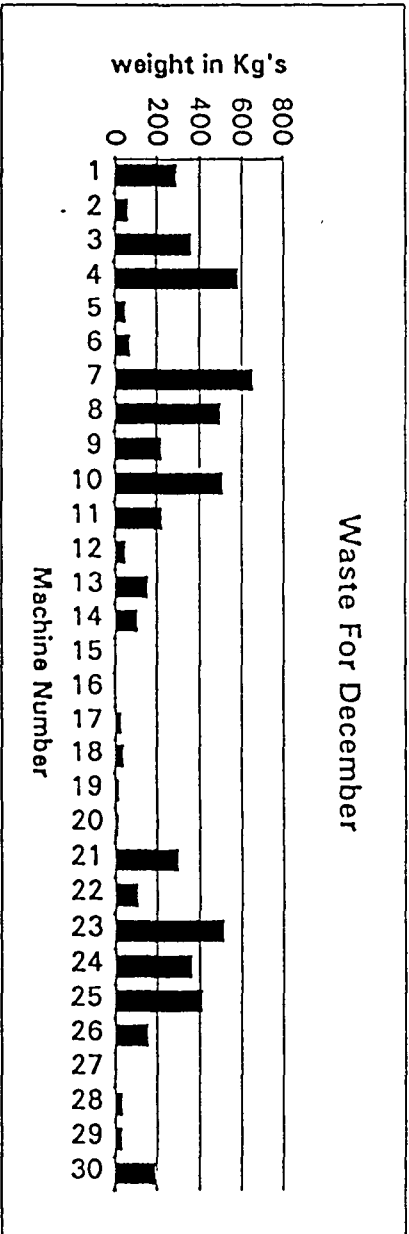


JANUARY MATERIAL WASTE



FEBRUARY MATERIAL WASTE



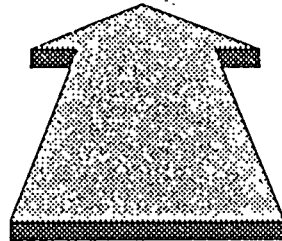


# SCRAP TEAM

---

MATERIAL INPUT SUB-GROUP

Tony Davies & Mike Mazzarella





# "MATERIAL INPUT"

## SUB-GROUP

### ■ MATERIALS LOST AT STOCKTAKE

▷ NOVEMBER 1993:

■ POLYMERS	£15200
■ MASTERBATCH	£4771
■ TOTAL	<u>£19971</u>

▷ NO SCRAP RECORDING!!

# "MATERIAL INPUT"

## SUB-GROUP

---

### ■ MATERIALS LOST AT STOCKTAKE

▷ DECEMBER 1993:

■ POLYMERS	£9500
■ MASTERBATCH	£6400
■ TOTAL	<u>£15900</u>

▷ SCRAP RECORDING BEGINS-21%  
IMPROVEMENT!!

# "MATERIAL INPUT"

## SUB-GROUP

---

### ▣ MATERIALS LOST AT STOCKTAKE

▸ JANUARY 1994:

▣ POLYMERS	£6925
▣ MASTERBATCH	£1417
▣ TOTAL	<u>£8342</u>

- SCRAP RECORDING BECOMING ACCURATE, AND  
TAKEN SERIOUS

- ▣ - 48% IMPROVEMENT ON DECEMBER 1993
- ▣ - 59% IMPROVEMENT ON NOVEMBER 1993

# "MATERIAL INPUT"

## SUB-GROUP

---

### ■ MATERIALS LOST AT STOCKTAKE

– FEBRUARY 1994:

■ POLYMERS	£700
■ MASTERBATCH	£1600
■ TOTAL	<u>£2300</u>

### ■ IMPROVEMENTS:

- 72% IMPROVEMENT ON JANUARY 1993
- 84% IMPROVEMENT ON DECEMBER 1993
- 88% IMPROVEMENT ON NOVEMBER 1993

# Betts Plastics - Wrexham

## Project Proposal

Project Title: CONVEYOR GUARDING

Project Champion : CHRIS JONES

What is the aim of this project? : REDUCE SPILLAGE ON ALL Moulding M/C'S.

Is this for a trial period? : YES  NO  How Long? N/A.

### Cost / Benifit / Payback:

#### External:

- materials \_\_\_\_\_
- equipment \_\_\_\_\_
- services/contracts 228 x 22 m/c.
- other(\_\_\_\_\_) \_\_\_\_\_

£ 5016

#### Internal:

- materials in stock \_\_\_\_\_
- equipment available \_\_\_\_\_
- other(\_\_\_\_\_) \_\_\_\_\_

£ \_\_\_\_\_

### Total Cost

= £ 5016

Quantified Benefit : DURING TRIALS SPILLAGE REDUCED BY APPROX 90%.

IF SPILLAGE = £4355 PER MONTH, 90% = 3919

= £3919 PER MONTH

### Other Benifits

TIME SPENT PICKING UP SPILLAGE CAN BE USED ELSEWHERE  
PRODUCTION RUNS STAY ON TIME.  
PUT ON ALL M/C'S - HAVE FLEXIBILITY TO SWAP  
AND CHANGE JOBS WITHOUT RESTRICTION

How long is the  
payback period?  
(Approximate)


$3919 \div 5016 = 1.27$  =  $1\frac{1}{2}$  weeks/months

### Authorisation:

The Project Champion is authorised to spend / consume resources up to the value of:

£ 5016 on cost code: R+M

Signed



Derek Oliver - Operations Manager

