

https://dspace.org/

Quality improvement programme in a Just-in-Time manufacturing environment

Aronson, Wayne

2014-10-15
http://hdl.handle.net/10539/15741

Downloaded from a DSpace repository. https://dspace.org/

To illustrate this principle and how it applies to quality improvement, a Pareto analysis case study was conducted at MSN Products. The analysis was done to determine which process in the manufacture of printed circuit boards produced the highest level of scrapped or defective boards. Figure 15 on page 84 lists the number of defective boards produced by each manufacturing process.

Note that although the entries: suppliers claims and missing boards are strictly not manufacturing processes, the contribution to lower productivity is important and must therefore be considered. In the figure, the processes are shown in an order reflecting the extent to which they produce defective boards during a period of a week. The data for the analysis was taken over a period of 20 weeks.

It is seen that there are striking differences in the extent of defects. Appraisal scrap accounts for 447 scrapped boards, or 10.45% of all unusable boards, whereas several other processes had less than 2%. When the data is accumulated, it is at once evident that 4 of the processes (the vital few) account for near on 40% of the defects, whereas to obtain the same accumulated defect rate, using the lowest processes (the trivial many), we must add more than 10. It is therefore evident from this which areas of the manufacturing process require the most attention so as to improve productivity and quality by the most amount. Very little benefit would be derived from addressing the problems experienced in the nickel plating process since this only accounts for 0.21% of the overall problem. Clearly all improvement effort should be directed at the processes of electroless copper, photo-printing and post etching, which together account for nearly 30% of the overall problem.

PROCESS	PRIORITY ORDER	PERCENTAGE
appraisal scrap	447	10.45
electroless copper	421	9.84
photo-printing	402	9.40
post etching	397	9.28
electro tin/lead	337	7.88
drilling	322	7.53
unit size	312	7.29
suppliers claims	283	6.62
solder mask	277	6.48
missing boards	250	5.85
reflow soldering	243	5.68
electro gold	186	4.35
ident	146	3.41
electro copper	131	3.06
screen printing	65	1.15
strip resist	49	1.15
nickel plating	9	0.21
		100 %

(The units of PRIORITY ORDER are: defective boards/week)

Figure 15. Pareto Analysis Showing Weekly Rate of Defective Boards

Further use of the Pareto analysis is illustrated in the Zero Defects budget contained in Appendix 1. In this instance it was necessary to isolate the individual scrap rates of each process so that the percentage scrap rate for appraisal scrap could be determined.

The foregoing listing of processes is an example of a Pareto analysis in its most rudimentary form, that is by unusable p.c. boards. The analysis may also be made in a variety of other ways, that is by types of defects, work shift, date of manufacture, production operators, etc.

7.2.3 FISHBONE DIAGRAM

The value of visual aids in understanding a problem is tremendous. Diagrams, charts, and other representations contribute to better communication by organising data and focusing attention on specific issues (Riggs,1981). A fishbone diagram is a portrait of a problem. It shows the inputs that affect the problem. The fishbone diagram was originated by Professor Kaoru Ishikawa in 1953, in his works on quality control. Such displays have also come to be known as Ishikawa diagrams (Ishikawa,1985).

The first step in constructing a fishbone diagram is to develop a statement of the problem or objective. The possible causes of the problem are represented by an arrow entering from the left that points to the statement of the problem. After the basic structure is set, the inclusive or dominant factors are identified. These are shown on the diagram by labelled ribs; the labels are entered in ovals at the shaft end of the cause arrows pointing to the spinal cause shaft. Then smaller arrows identifying subfactors run to the main ribs. In turn, sub-subfactor arrows can lead to these. Each additional level of arrows provides greater detail.

To illustrate the construction of a fishbone diagram, the process of electroless copper plating of p.c. boards at MSN Products was selected. This selection was based on the results of the Pareto analysis performed at the company. (See previous section). The statement of the problem is to identify the cause of defects in the electroless copper plating process. With the problem stated, the key factors are identified:

- Raw material

- Catalisation
- Operator
- Hole Preparation
- Copper Plating
- Finishing and Rework
- Rinsing
- Drying

These 8 factors represent the primary arrows. The next level of arrows is determined by questioning each of the main causes in terms of what components, actions, categories, or factors are involved within it. For example, the raw material causes includes the storage conditions, the handling and the initial quality of the raw materials. These subfactors can be further refined by identifying more detailed ingredients or alternatives. Detailing can continue to any level deemed appropriate by the analysts. A four-level detailed fishbone diagram of the electroless copper plating process is shown in Figure 16 on page 87

Fishbone diagrams can assist both solo and group efforts in seeking new ideas. When an individual is searching for ideas, the entries in the fishbone diagram suggest additional relationships. The diagram format can also serve as a recording device for ideas generated by a group. Although capturing and organising ideas by connected arrows may inhibit a free wheeling brainstorming session, it can reveal relationships that might otherwise have escaped detection (Riggs,1981).

Another aspect of fishbone diagramming is the ease with which the quality of the diagrams can be assessed. A reviewer can easily tell how thoroughly a problem was probed by the pattern of its fishbone portrait. A wealth

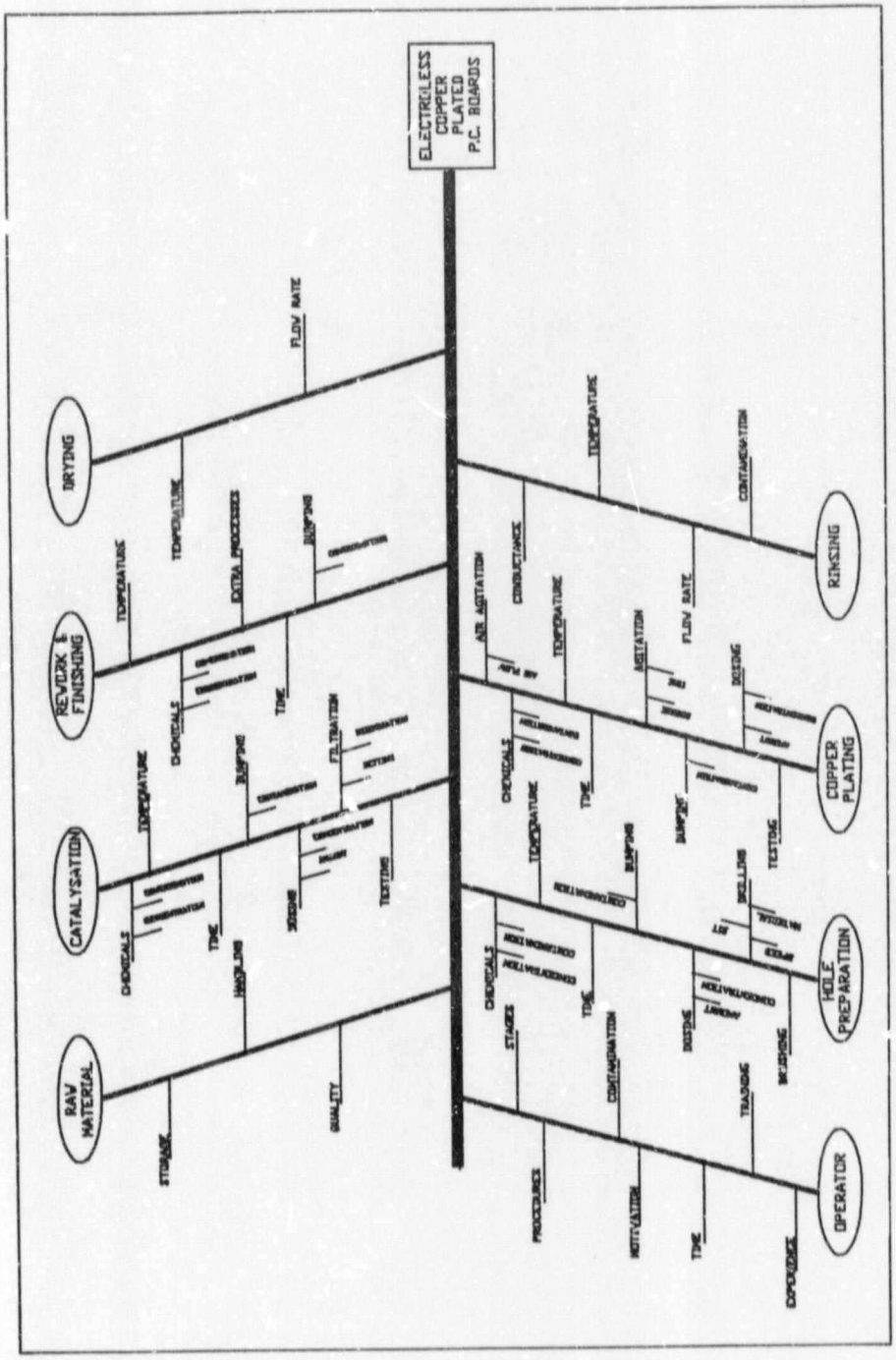


Figure 16. Fishbone Diagram for Electroless Copper Plating Process

of detail, if legitimate, indicates an exhaustive effort. A bare skeleton means either the problem was negligible or the solver was negligent.

7.2.4 HISTOGRAM ANALYSIS

The fishbone diagram is very useful for identifying all possible areas where defects in a process might be caused. The next step to identifying problem areas is to record all relevant data for each process. Having collected all data, it is then necessary to summarise it. Practical methods of summarising data stress simplicity. Three key methods for achieving this are the frequency distribution, the histogram, and measures of central tendency and dispersion; the most popular being the frequency histogram since it represents the data in graphical form (Juran et al,1974). A histogram is a vertical bar chart of a frequency distribution. The simplicity of construction and interpretation of the histogram makes it an effective tool in the elementary analysis of data.

7.2.4.1 Construction of a Histogram

A random sample is selected from a chosen process and measurements are made for the selected quality characteristics. A histogram is prepared and specification limits are added. Figure 17 on page 90 shows a typical histogram of a process with its specified limits. As a general rule, at least 50 measurements are needed for the histogram to reveal the basic pattern of variation (Juran et al.,1974). Histograms based on too few measurements can lead to incorrect conclusions, because the shape of the histogram may be incomplete without the observer realising it. Knowledge of the manufacturing process is then combined with insights provided by

the histogram to draw conclusions about the ability of the process to meet the specifications. The analyst is encouraged to interpret the histogram by asking two questions:

1. Does the process have the ability to meet the specification limits?
2. What action, if any, is appropriate for the process?

These questions can be answered by analysing:

1. The centring of the histogram. This defines the aim of the process.
2. The width of the histogram. This defines the variability about the aim.
3. The shape of the histogram. Histograms with two or more peaks may reveal that several 'populations' have been mixed together.

7.2.4.2 Analysis of a Histogram

Histograms illustrate how variables data provide much more information than do attributes data. Figure 18 on page 91 shows 15 typical histograms. For the purpose of illustration we will analyse and interpret some of these histograms.

Histograms: b, d, g, and i warn of potential trouble even though all units in the sample are within specification limits. With attributes measurement, all the units would simply be classified as acceptable and the inspection report would have stated that there were zero defects - therefore

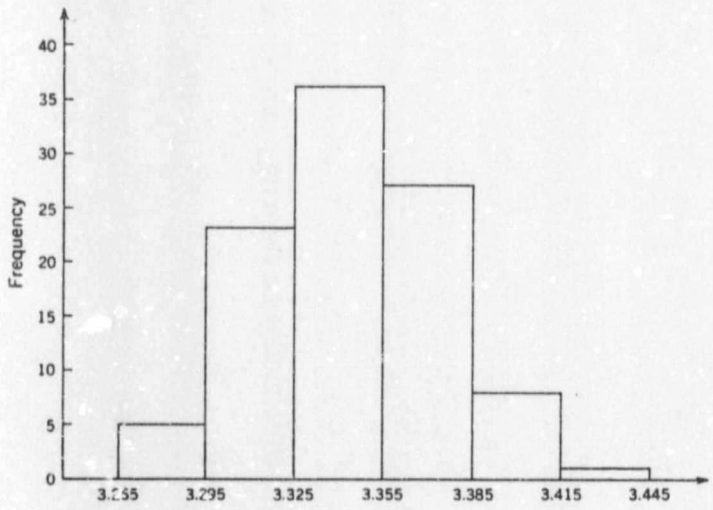


Figure 17. Example of a Typical Histogram

no problem. Juran and Gryna (1980) cite a case where one customer had a dramatic experience based on a lot which yielded a sample histogram similar to histogram i. Although the sample indicated that the lot met quality requirements, the customer realised that the vendor must have made much scrap and screened it before delivery. A rough calculation indicated that full production must have been about 25% defective. The histogram enabled the customer to deduce this without ever having been inside the vendor's plant. As the customer would eventually pay for this scrap (in the selling price), he wanted the situation corrected.

Clearly it can be seen that the histogram is an effective analytical tool. The key to its usefulness is its simplicity. It speaks a language that everyone understands - comparison of product measurements against specification limits. To draw useful conclusions from this comparison re-

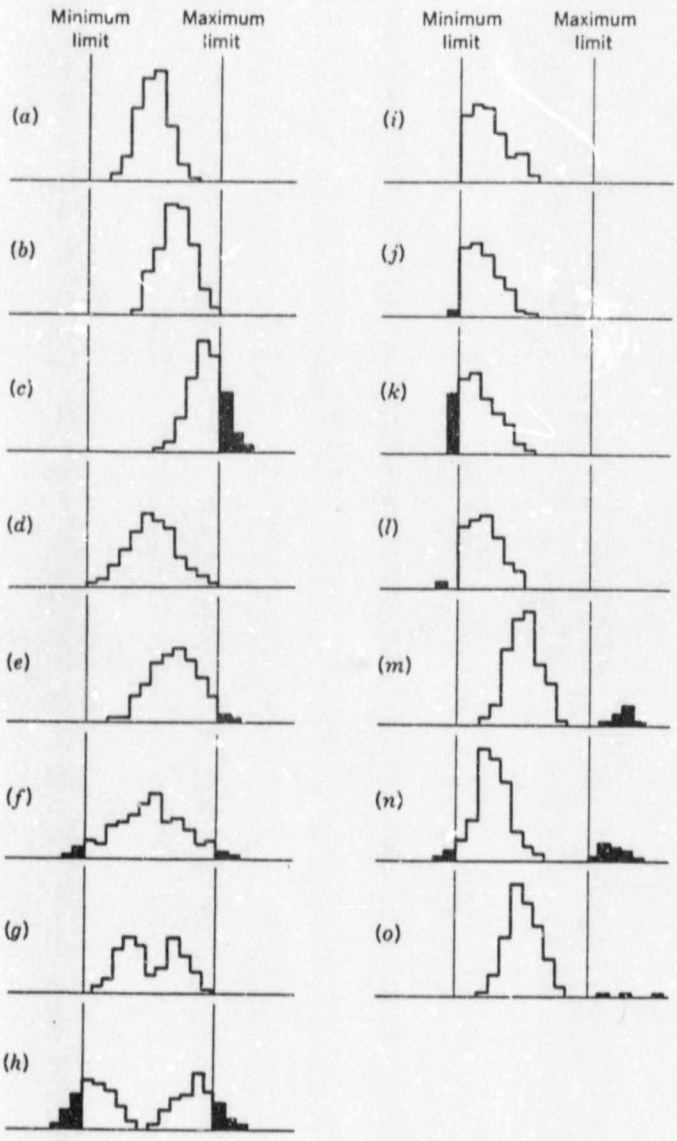


Figure 18. 15 Examples of Histograms Related to Tolerances

quires little experience in interpreting frequency distributions, and no formal training in statistics. This experience soon expands to include applications in development, manufacturing, vendor relations and field data.

7.2.5 CONTROL CHARTS

Process control using statistical techniques is perhaps the most important of all the statistical quality control methods (Groocock,1986). Process analysis using histograms represent the performance but not necessarily the full potential capability of the process. Histograms generally do not take into account measurements from several populations, such as different machine settings or different stations on the same machine (Juran and Gryna, 1980). This leads to the need for a more powerful analysis tool - the control chart. A control chart is a graphic comparison of process performance data to computed 'control limits' drawn as limit lines on the chart. The process performance data usually consists of groups of measurements selected in regular sequence of production while preserving the order. The control chart and its fundamental ideas was established by W.A. Shewhart in the 1920s and was published in his 1931 book, 'Economic Control of Quality of Manufactured Products', (Van Nostrand, New York).

There are four basic control charts, although many variations of these do exist:

- The average of the measurements in the sample. This is known as an $\bar{X}$ Chart. Averages are used because they are more sensitive to change than individual values. The average measures the aim or centring of a process.
- The range of the measurements in the sample. This is known as an R Chart. The range measures variability about the aim of the process.
- The percent defective in the sample. This is known as a p Chart.

- The number of defects in the sample. This is krown as a c Chart.

For the purpose of this report a lengthy discussion about each chart is not necessary as this can be found in most quality control text books dealing with the subject. All that is required is to identify the different charts and explain the areas where they are most useful.

The $\bar{X}$ and R Charts are particularly useful for machine-dominant processes. From the point of view of efficient utilisation of all information contained in a series of measurements, a pair of charts - one showing average ($\bar{X}$) values and one showing range (R) values - is best. The range R is determined by: maximum values minus minimum values.

The chart of $\bar{X}$ values tells when a change has occurred in central tendency. This might be due to such factors as tool wear, gradual increase in temperature, a new batch of material of greater toughness or a different method used by a night-shift workman. The chart of R values indicates when a significant gain or loss of uniformity has taken place. A loss in uniformity might be due to such causes as worn bearings, an erratic supply of coolant, careless handling of stock, or lack of concentration of the operator. $\bar{X}$ and R control charts require that actual numerical measurements be made, for example a length. This differs from control charts for attributes data such as p or c charts which require only a count of observations of a characteristic.

The p chart determines percentage defectives and is most useful when tests are of a 'go/no-go' nature and may also be used when measurements made on a scale are recorded. A control chart for p works well for both machine-dominant and operator-dominant processes. The c chart, which de-

termines the number of defects in a sample, is particularly effective when the number of defects possible on a unit is large but the percentage of any single defect is small. Examples are physical defects such as surface irregularities, flaws or pin holes on continuous or extensive products such as yarn, wire, paper or other sheeted materials. The chance of a defect occurring at any one spot may be small but the overall opportunity for defects may be great.

7.3 CONCLUSION

In this chapter brief descriptions have been given of the methods of process analysis and statistical process control. Neither are very difficult. The difficulty lies in carrying through the steps which are necessary for the methods to be converted into practical implementation. Groocock (1986) outlines the preparation that needs be done to remove any difficulties:

- The division manager has to assign the plan a sufficiently high priority - in competition with all of the division's normal work and other improvement programmes - so it will actually be implemented.
- A multifunctional plan has to be established that defines all of the activities that have to be performed. This should include a realistic assessment of the resources that are required to implement the actions, balanced against the time required. The consequence of ignoring this is such that the resources needed are grossly underestimated and the rate of progress is very slow.

Statistical process control is an unnatural process for an operator. It is natural for a craftsman to control a process by feel, experience, and flair. It is not a natural operation, hour after hour, day after day, week after week, to measure the pieces, plot the points, perform the arithmetic and constrain all personal actions by the results (Groocock, 1986). Even with training, some operators will have difficulty with the arithmetic, and many will feel a reluctance to plot points that show the process is out of control, and to seek assistance in solving problems. First line supervisors may also resent the plan especially if they are required to stop a process, which would result in loss of output, while a special case is being investigated.

So the introduction of process analysis and statistical process control is a major challenge to management because of the psychological factors, technical difficulties and financial constraints. Having identified quality problems, the next stage is corrective action and this will be dealt with in the following chapter.

8.0 CORRECTIVE ACTION

8.1 INTRODUCTION

Checking through effects to find exceptions or something unusual does not in itself serve the interests of the company (Ishikawa, 1985). The cause factors for these exceptions must be found and appropriate actions taken. In taking corrective action, it is important to take measures to prevent recurrence of these exceptions. In any instance, making adjustments to the cause factors involved will not be enough. One must endeavour to remove the cause factors which have been responsible for the exceptions. Adjustment and prevention of recurrence are two separate things, both conceptually and in terms of the action to be taken. In removing the causes for exceptions, one must go back to the very source of the problem to take measures to prevent recurrence. it is simple to say 'prevent recurrence', but such prevention is very difficult to practice. More often than not, temporary measures are applied to patch up problems for the time being.

Ishikawa (1985) has listed the following three steps as measures for preventing recurrence:

1. To remove the symptom.
2. To remove a cause.
3. To remove the fundamental cause.

In reality, only steps 2 and 3 are measures for preventative recurrence, and unless one takes step 3, there can be no true recurrence prevention. Step 1 is merely a temporary measure. The concept of these three steps is best illustrated by means of the following example (Ishikawa, 1985):

> In a factory, the bolts which attached a metal plate to a machine kept snapping off. It was decided that larger bolts should be used. After a time, the metal plate began to shear, so a thicker metal plate was used. The company then claimed that it had succeeded in preventing recurrence of the problem.

The company did succeed in removing the phenomena of the snapping bolts and shearing plate, examples of step 1 above. It merely applied emergency measures. It had not done recurrence prevention. Closer examination of the problem would have shown that vibrations in the machine were responsible for the phenomena of the snapping and shearing. Only by removing the vibrations, would the company have taken a recurrence prevention measure as described in step 2 above.

The removal of the vibrations does not imply that step 3 has been fulfilled. The fundamental cause of the problem still remains. The company must re-examine its testing procedure and develop a new one which will alert to the existence of vibrations that could cause snapping of bolts in other machines. The one method of preventing problem recurrence is to return to the basics and re-examine everything step by step. This is the only way to remove the fundamental cause listed above in step 3.

Speaking in more general terms, elimination of the fundamental cause is directly related to improvements both in-house and outside:

- Vendors and suppliers must be carefully selected to ensure high quality materials.
- Customers must be consulted to ensure correct design and specifications.
- Processes must be arranged to ensure organisation, visibility and traceability of problems.

This chapter deals primarily with step 3 - removal of the fundamental cause - and how it affects the above three points: vendors, customers and processes.

8.2 VENDOR RELATIONS

Many types of materials, components and subassemblies are purchased by companies and contribute to the ultimate reliability and safety of the end product in use. With today's increasingly complex products, the quality of these purchased materials becomes increasingly important. That a safety problem in the field was caused by a part or component made by someone else is of little comfort to the producer faced with mounting customer complaints, profit-eroding warranty expenses, or the obligation to trace and recall large numbers of products to the factory (Feigenbaum, 1983). Activities for ensuring the consistent high quality of purchase materials are therefore basic to programmes for total quality control.

In the past, approaches to controlling the quality of incoming materials has ranged widely - from the very informal to the excessively rigid. At

one extreme, there have been companies whose 'control' of purchased materials has largely depended upon what might be though of as blind trust in the quality standards and performance of their suppliers. At the other extreme, some companies have virtually inspected their incoming materials 'to death', spending more time and money than is necessary to gain adequate control for material quality (Feigenbaum, 1983). Neither approach is satisfactory in today's fast moving market place. The high price of the latter extreme is prohibitive, while the former extreme can increase the safety/liability risk beyond reasonable bounds. The objective is to establish and maintain close and positive purchaser/vendor relationships which reflect the reality that each person's success is dependent upon the others'.

8.2.1 VENDOR RELATION'S POLICY

A prerequisite to obtaining a close and positive relationship with a vendor is the development of the quality objective and the quality policy for the company (Feigenbaum, 1983). Until the company knows where it is going with respect to material quality standards and material quality levels, no foundation is provided upon which to build purchaser-vendor relations. Policy must be established to provide the limits within which quality related decisions will ensure a proper course of action in meeting quality objectives. Policies are often useless generalities, that is, 'we will only buy from capable vendors'. However, policies can be specific and provide useful guidance both internal and external to the company (Juran and Gryna, 1980). These policies are the broad strategic patterns

to guide and govern all management decisions in the vendor quality areas, including vendor cooperation, vendor rating and appraisal, and other necessary vendor quality characteristics. So that the quality objectives be clearly understood by every employee of the company, it is important that they be explicitly stated in a formal, written document. In its statement of quality policy, management has the opportunity to make its vendor quality targets crystal clear. Appendix 2 contains a vendor relations policy that was developed for MSN Products as part of the study for this report.

8.2.2 APPRAISAL OF NEW VENDORS

When procuring materials and parts from outside sources, the purchaser must investigate or audit and pass judgement on the vendor's abilities, especially those relating to quality control (Ishikawa, 1985). It is not enough to rely solely on the purchasing agreements and the rejection of non-conforming incoming materials. Such rejections are too costly to the buyer (Lester et al, 1977).

There are times when the purchase can select suppliers freely and there are times when that is not possible. Occasions when which a purchaser cannot select freely arise when the purchaser uses his own products, when the vendors are company subsidiaries, when there is only one source of supply or when, owing to contractual obligations or governmental regulations, a specific company is designated as the supplier. Ishikawa (1985) states, based on his own experience, that in the long run the best system

is that of free selection, which will help both the purchaser and the supplier. When such a system is not available, often one party becomes a burden on the other. Furthermore, Ishikawa suggests that the purchaser should consider the following before selecting his suppliers:

1. The supplier knows the management philosophy of the purchaser and continuously and actively maintains contact with the purchaser.
2. The supplier has a stable management system that is well respected by others.
3. Supplier maintains high technical standards and has the capability of dealing with future technological innovations.
4. The supplier can supply precisely those raw materials and parts required by the purchaser, and these meet the latter's quality specifications.
5. The supplier has the ability to control the amount of production or has the ability to invest in such a way as to ensure its ability to meet the amount of production needed.
6. There is no danger of the supplier breaching corporate secrets.
7. The price is right and the date of delivery is met precisely. In addition, the supplier is easily accessible in terms of transportation and communication.
8. The supplier is sincere in implementing contract provisions.

To ascertain that the above conditions will be met, the purchaser must visit the prospective supplier to conduct an appraisal. The vendor relations policy in Appendix 2 contains a typical vendor appraisal form together with an evaluation check list which ensures that no important factors are overlooked.

8.2.3 VENDOR RATING

Companies using formal supplier rating systems usually base them on price, delivery, and quality, sometimes adding other factors such as flexibility and response to change (Hall, 1987). Such ratings assist in selecting suppliers from a large supplier base.

In order to bring the three rating factors into a unified rating; weighting factors representing relative degrees of importance are applied. A typical set of weights, as used in the vendor relations policy in Appendix 2, is given below:

- Quality 40%
- Cost 30%
- Delivery 30%

The weighting should be flexible from one type of business to another and may be varied to fit a given type of business. Quality is measured in terms of the percentage of shipments accepted; cost is given in the form of unit price; and delivery is evaluated as the percentage of time when promised shipping deadlines were actually met. An example of the type of form used for vendor performance rating can be found in the vendor relations policy in Appendix 2.

8.3 CUSTOMER RELATIONS

Customers are the source of income to manufacturing and service companies, and it is for this reason that customer satisfaction is paramount.

8.3.1 CUSTOMER SATISFACTION SURVEYS

It is always beneficial, and sometimes necessary, for companies to conduct surveys regarding customer satisfaction. Too many times top management, deeply involved with the pressing logistics of running a business, loses sight of its customers' needs and desires. There is a tendency to delegate these kinds of problems to the sales manager. That road only leads to disaster (Smith, 1979). Control must be maintained over customer satisfaction just as it is maintained over factory inventories and quality. Customer satisfaction surveys are best handled by independent concerns that specialise in that kind of activity. Smith (1979) feels that this will ensure an objective unbiased look at the state of customer satisfaction. This can be achieved by conducting preparatory discussions between the independent auditor and the company official, to ensure that the auditor has the necessary background and does not ask the customer the wrong questions.

8.3.2 NEW CUSTOMER CONTRACTS

When dealing with new customers, set procedures should be followed to ensure that the customers' contracts can be fulfilled. Smith (1979) suggests the following:

1. All customer order contracts are first subject to quality engineering, product engineering, and manufacturing review **before** contracts are signed.
2. Product engineering must pass the feasibility of producing the products ordered by the customer.
3. Quality engineering must review the contracts to ensure that past customer quality problems do not find their way into the new product. Following which, a more detailed review of each contract must be performed, to spot potential areas.
4. Both product engineering and quality engineering must work together to 'design out' any identified problems.
5. Manufacturing must be informed of any problem areas and they must acquire the appropriate equipment, tooling and gauging to minimise these problems.

8.3.3 RESPONSE TO CUSTOMER PROBLEMS

After the service department has handled the immediate customer problem through replacement or repair of the product, how can the company assure

itself that the problem will not repeat itself? There are two recognised and proven techniques for corrective action of field quality problems (Smith, 1979). The first technique involves use of quality engineers to act as middle men between customer and product engineering or manufacturing. A problem received must be given to quality engineering to define the problem further, determine what caused the failure, assign functional responsibility and follow up for corrective action.

An alternative method for field quality correction is to form a quality improvement task force to resolve field quality problems. Task force should be chaired by the product engineer and representation on the task force must include marketing, manufacturing, product engineering and quality assurance.

8.4 PROCESS REVIEW

When dealing with process review for the purpose of improving quality, it is the factors that affect the process that become important, not the actual manufacture of the product. The quality of a manufactured product can easily be determined through the use of specifications and measurements, but the factors that affect the process are often overlooked (Hall, 1987). Three factors that have an important bearing on the product are (Hall, 1987; Smith, 1979):

- Workplace organisation
- Visibility

- Traceability

8.4.1 WORKPLACE ORGANISATION

Workplace organisation starts in the plant, but its reverberations extend to the entire manufacturing organisation. Hall (1987) has listed five important steps to obtaining organisation:

1. Cleaning and Simplifying. Remove everything not needed for production activity in the near future. Much of this may be work-in-progress inventory, but also includes excess equipment, tooling, gauges, supplies, personal effects and rubbish. While this should make some cosmetic improvement, the intent is not to create a showroom but rather a clarified work environment.
2. Locating. The principle is to have a place for everything and keep everything in its place, and ready for use at any time. The general rules of location are commonsense. Return things frequently used to a standard, fixed location, handy for use. Keep things used together grouped together. Devise general location rules for all operations, and specific ones for specific operations.
3. Cleaning. A clean workplace makes the unspoken statement that quality work is expected. A work area should be clean, relative to the type of work performed. The general rules are: clean enough to avoid quality and maintenance problems; clean enough to avoid health and safety problems; and clean enough to promote visibility.

4. Discipline. Discipline is consistently working by the rules and standards. It comes from training, understanding and positive reinforcement. Everybody learns to live by both the general rules and the special area rules that should come out of workplace organisation. It helps discipline if workers have the opportunity for input when rules are made and revised.
5. Participation. The changes on the shop floor should be basically understood by everyone, and everyone participates in them in some way. Participation in the broad sense is participation in all activities that promote the effort. A company should become a beehive of projects to improve production, design, paperwork, tools, equipment and marketing.

8.4.2 VISIBILITY

Visibility is unwritten, unspoken communication, not only of shop floor conditions among shop floor people, but a road map of company conditions to all who read the physical signs. Its major purpose is instant response from anyone who should take action. On a shop floor, visibility is obtained by many means (Hall, 1987):

- Posted Schedules. A board or electronic screen showing the current day's assembly schedule and completions to schedule so that everyone can see where they stand.
- Signal Lights. A counter used on a machine can trigger a signal for setup change, tool change, quality checks or breakdowns. In this way,

if a machine malfunctions, operators and maintenance can be alerted immediately.

- Charts, Logs and Goals. Posted charts emphasise what is important and should convey matters of current direction and action.
- Layout. The layout of the factory has a great effect on visibility. If the assembly line or fabrication line is designed in a U-shape, it increases the visibility of the production by allowing the back end of the line to see what is happening at the front. This also offers the worker a chance to identify the final product into which his components go.

8.4.3 TRACEABILITY

Traceability is the ability to identify the individual parts of any component, and that could mean people, tools, materials, dates, shifts, and any other particulars that could pinpoint the origination of quality problems. One of the most difficult aspects of solving quality problems is identifying where and when the problem originated. Without that information, the ability to solve problems decreases inordinately. This is to say, if we do not know what caused the problem, it is only reasonable to expect that the problem will not be solved (Smith,1979).

Traceability has other implications when it is related to operators, maintenance men, material handlers, clerks and other people responsible for doing a job. If people are aware that defective work can be traced to them, they will be likely to take more care with their work. Thus ac-

cording to Smith (1979), to be fully effective, traceability should be established to the lowest common denominators:

1. Manufacturing:	Date and Shift Machine Operator Material
2. Administrative:	Department Source Document Clerk
3. Indirect Labour Functions:	Operator Maintenance Materials
4. Product Engineering:	Engineering Drawing Draftsman Checker Designer
5. Marketing:	Salesman Serviceman Contract Service Literature Editions

8.5 CONCLUSION

This chapter has attempted to illustrate an important point about corrective action. Corrective action is not the systematic removal of a problem's symptoms but it involves far more. The fundamental cause of the problem has to be addressed to ensure that the problem will not recur.

tomer relations, vendor relations and process revie are three areas where corrective action can be applied, since they represent potential problem areas which are generally overlooked.

In a sense, this chapter forms the final step of the quality improvement programme. It is, however, not possible to end it there, since without a maintenance plan and new goals for improvement, the company will quickly lapse back into its old ways and lose any ground that it has gained (Crosby,1980). The next chapter deals with maintaining newly acquired quality levels, while setting goals for future improvements.

9.0 QUALITY MAINTENANCE AND IMPROVEMENT

9.1 INTRODUCTION

Quality improvement is not an easy-money game. It is work. It demands improved performance by all constituencies of the company. Corporate leaders must be aware of the effects of their actions on each constituency because all have a part. Even a chief executive officer must test the wind and sense the mood before setting direction. The leadership role in the beginning is more akin to leading a training expedition than a cavalry charge (Hall, 1987). Generating the culture of continuous improvement among all employees and the other constituencies of the company is top managements responsibility. Continuous improvement is not a national or regional culture. It is a management culture, deliberately and painstakingly created by management. If upper management nurtures and protects the culture, workers can do many marvellous things, but workers cannot develop improvement from a culture that rejects it (Hall, 1987).

The previous chapters of this report have dealt with the actions that must be taken to improve quality - from top management down to the workers and onto the processes. Each aspect has been carefully examined. The tasks of setting goals for even higher levels of quality, while still maintaining newly acquired levels, resets on top management. This idea is dealt with in this chapter.

9.2 PRINCIPLES OF MANAGEMENT

Robert Hall (1987) has listed several principles, which management must follow, to ensure that all the benefits that have been gained by a quality improvement programme are not lost. the list of points is by no means complete and has not been arranged in any order of importance:

1. Develop quality councils, who can monitor the progress and can determine actions necessary to upgrade and improve the quality. These councils are the best source of information on the status of programmes and ideas for action. They also bring the professionals together on a regular basis.
2. Maintain an active programme to understand customer needs and desires in detail. Base improvements on that which add value to the customer and eliminate any activity that does not.
3. Study and improve operations first, then buy tooling and equipment as needed. Avoid and eliminate waste in any form, either with equipment or with systems.
4. Create flexibility through employee cross-training, equipment development, setup time reduction, and so forth. As many operations as possible must be physically organised for short lead times, so as to minimise dependency on long lead time forecasts. As few decisions as possible must be based on forecasts. Try to make only what is wanted when wanted.
5. Make maximum use of workplace organisation. Use it to continuously seek ways to improve operations on the shop floor and away from the shop floor. Make problems and conditions visible to everyone. With

visibility, foster an atmosphere in which problems are openly seen and addressed.

6. Evaluate the competition carefully and determine what competitive advantages are available and which can be developed.
7. Always seek simple solutions to problems and keep it integrated.
8. Once manufacturing practices have been developed, standardise them in order to hold the level of gains obtained.

9.3 FUTURE GOAL SETTING

Everything cannot be done at once. The goals of change depend on the current company situation, but, for most companies, emphasising quality first is most appropriate. Primary concentration on quality may last a while, even years, because people and process development is not quickly done despite remarkable improvements now and then. The long-term nature of reform is probably best conveyed to most people as eliminating waste to improve quality (Hall, 1987).

While developing goals for the company, one must keep thinking of strategy:

- What is necessary to capture or hold market?
- What do we do well now?
- What should we learn to do quickly?
- What can only come after long adaptation?

Selection of goals should have as its purpose the progressive stimulation of a total manufacturing work force into higher and higher levels of performance.

Other goals of great concern to many companies that have not been directly addressed so far are:

- Environmental control
- Product liability
- Safety

Attention to all these is improved by an open, problem-solving atmosphere and all the other concepts advocated. Where appropriate, special goals should be established and recognition of the fact that attaining them is embedded in the work of attaining the fundamental goals of quality manufacturing.

A popular view is that attention to environmental control must add cost. Sometimes it unavoidably does, but also study the matter from the viewpoint of eliminating waste. In the past, companies have paid for environmental control by making by-products of recovered pollutants.

Careful study of customer use and simplification of both designs and processes, help to prevent oversights leading to product liability problems. Attention to customer-service quality helps prevent irritation that can build up to lawsuits.

Accidents by their very nature are unexpected events. Their possibility is a part of detailed study of all operations by many people. Making as

many operations as possible into standard procedures helps to prevent accidents. Many accidents are caused by non-standard approaches to setup or maintenance - sometimes by people unfamiliar with the equipment. Improving work practices helps to meet the objectives of safety in the environment, safety of the customer, and safety of the employee. In the end, it is the best insurance policy.

9.4 CONCLUSION

This chapter represents the last stage of a quality improvement programme. Although it is not a definite step in the programme, it is a stage that cannot be overlooked. The typical improvement programme takes a year to eighteen months to be implemented and by that time turnover and changing situations will have wiped out much of the education effort (Crosby, 1980). Therefore, it is necessary to set up a new quality improvement team and begin again. The point to be understood is that the programme is never over. Repetition makes the programme perpetual. If quality is not ingrained in the organisation, it will never happen.

many operations as possible into standard procedures helps to prevent accidents. Many accidents are caused by non-standard approaches to setup or maintenance - sometimes by people inexperienced with the equipment. Improving work practices helps toward the objectives of safety in the environment, safety of the customer, and safety of the employee. In the end, it is the best insurance policy.

9.4 CONCLUSION

This chapter represents the last stage of a quality improvement programme. Although it is not a definite step in the programme, it is a stage that cannot be overlooked. The typical improvement programme takes a year to eighteen months to be implemented and by that time turnover and changing situations will have wiped out much of the education effort (Crosby, 1980). Therefore, it is necessary to set up a new quality improvement team and begin again. The point to be understood is that the programme is never over. Repetition makes the programme perpetual. If quality is not ingrained in the organisation, it will never happen.

10.0 CONCLUSION

Quality is the last accessible frontier for cost reduction (Smith, 1979). Although company forms and functions may change drastically in the future, those changes are essentially evolutionary. The pressures for increasing return-on-investment with workable cost reduction efforts, however, are intense right now and quality costs are one of the last costs to be addressed under known management techniques. As a result, more and more companies will be turning to quality professionals to help them with those efforts. This report aims to assist those companies that are looking for improvement.

This report has concentrated on the quality improvement of products sold by suppliers to customers. The reason for limiting this scope is that quality improvement is most advanced in application to products. However, the need for quality improvement in the service industry is, on the whole, greater than that for products, though the incentive is usually less. This is because service businesses are exposed to less international competition than product businesses. With a result that a service business's success is determined by its quality status relative to local competition, not international competition. It is, however, useful to note that many of the concepts and techniques for product quality discussed in this report are also applicable to service quality.

The structure of the report comprises of 3 stages. The first stage deals with background to the report. In the first 2 chapters many of the ideas and philosophies, that are used later in the report, are introduced and

explained to the reader. Chapter 3 represents the second stage where several existing improvement programmes are discussed and analysed. The remainder of the chapters, chapter 4 to chapter 10, form the third stage which deals with the proposal for an updated improvement programme based on the findings in chapter 3. The report has been organised to ensure readability and simplicity so that it is of practical value to the layman as well as the quality professional.

In concluding it must be noted that the reader should not be misled by this or any other quality improvement report, which lays out a simple quality pla... What has been detailed here is an easy to follow programme which has avoided complicated explanations and instructions. This, however, should not give the impression that quality improvement is an easy-money game. It is work and it demands improved performance by all constituencies of the company. Results will not come easy and in some cases may take months or even years to reach. But when they are achieved, the rewards will be great and the efforts worth it.

11.0 APPENDIX 1

ZERO DEFECTS (ZD) BUDGET

The ZD budget is a method of isolating the complete price of non-conformance, and non-conformance to specifications is the true definition of quality problems.

The ZD budget can be explained in terms of the following equations:

BUSINESS EXPENSES = PONC + POC + PROFIT

ZERO DEFECTS = POC + PROFIT

PONC = BUSINESS EXPENSE - ZERO DEFECTS

where PONC : price of non-conformance

POC : price of conformance

In all companies the data that is readily available is:

- Business Expenses : value of sales
- POC : the cost of manufacturing, without problems, including labour, materials, machinery
- Profit : the difference between manufacturing costs and sales figure

Thus the total loss due to non-conformance can be determined. Note, this method can only yield a good "guesstimate".

DETERMINING THE COSTS

Professional PCB's pass through several departments, each of which represents a different process in the manufacturing link. The throughput of PCB's is measured in terms of area (square decimetre). The cost of each process per sq dm has been calculated and includes materials, labour and machinery.

Process Costs (in rands per sq dm)

process:

drilling PCB holes	: 0.36
electroless copper plating	: 0.54
photographic printing	: 0.24
electro copper plating	: 0.67
electro tin/lead plating	: 0.27
stripping and etching	: 0.47
reflow solder	: 0.22
TOTAL	: 2.77

Destructive testing or appraisal scrap is the total cost up to and including reflow solder (R2.77 per sq dm) plus a cost of R1.50 per test.

The process further includes:

solder masking	: 0.21
routing	: 0.28
ident screen-printing	: 0.08
electro gold plating	: 0.20

TOTAL : 0.77

cost of board material : 1.01

Total cost of process (2.77 + 0.77 + 1.01) = R4.55 per sq dm.

Cost of final inspection = R0.15 per sq dm.

Based on averages taken over 20 weeks, the following data is available:

- Average business expense per week : R 258 000
- Average throughput per week : 30 110 sq dm
- Average scrap rate per week : 2 821 sq dm
- Average number of destructive tests per week : 160

For determining the price of non-conformance, the cost of appraisal testing has been included since these tests are required to be done. The appraisal costs have been calculated based on a pareto analysis of percentage contribution of each process to overall scrap rate, taken over a 20 week period (See later: Pareto Chart).

Price of Conformance

cost of:

process @ R4.55 per sq dm = 4.55 * 30110 = R 137 000

appraisal scrap (10.45% of scrap rate)

@ R2.77 per sq dm = 2.77 * 295 = R 817

appraisal test (160 per week)

@ R1.50 per test = 1.50 * 160 = R 240

final inspection

@ R0.15 per sq dm = 0.15 * 30110 = R 4 516

TOTAL PRICE OF CONFORMANCE = R 142 573

PRICE OF NON-CONFORMANCE

Business Expenses = R 258 000 per week

Price of Conformance = R 142 573 per week

Profit = R 103 200 per week

Therefore:

Zero Defect = POC + Profit

= R 142 573 + R 103 200

= R 245 773

Price of Non-conformance = Business Expense - Zero defect

= R 258 000 - R 245 773

= R 12 227 per week

Thus the price of non-conformance per month (calculated at 4.333 weeks per month) is R 53 000

PARETO CHART

PROCESS	PRIORITY ORDER	PERCENTAGE
appraisal scrap	447	10.45
electroless copper	421	9.84
photo-printing	402	9.40
post etching	397	9.28
electro tin/lead	337	7.88
drilling	322	7.53
unit size	312	7.29
suppliers claims	283	6.62
solder mask	277	6.48
missing boards	250	5.85
reflow soldering	243	5.68
electro gold	186	4.35
ident	146	3.41
electro copper	131	3.06
screen printing	65	1.15
strip resist	49	1.15
nickel plating	9	0.21
		100 %

(The units of PRIORITY ORDER are: defective boards/week)

12.0 APPENDIX 2

VENDOR RELATIONS POLICY DEVELOPED FOR MSN PRODUCTS

This policy, for the control of vendors, has been designed specifically for use by MSN Products. Use of, and reference to, SABS 0157-part 1:1979 edition as well as DEF STAN 05/21 has been made in the compilation of this document.

INTRODUCTION

The vendor policy described within this document is divided into 4 sections, each of which covers a different aspect of vendor relations. In order that this system be effective, each section must be addressed fully.

PURPOSE

The purpose of this policy is to provide the basic requirements for the selection and the establishment of reliable vendors.

The intention of such a policy is to provide for smooth and continuous operation of the plant by assuring the quality of purchased materials. Whole or part of this policy document, where applicable, shall be specified as a contractual requirement on suppliers to MSN.

SECTION 1 : VENDOR RESPONSIBILITY

The department or section involved in, and responsible for vendor relations shall be defined, according to a responsibility matrix, as follows.

Responsibility Matrix - Vendor Relations

ACTIVITY	PARTICIPATING DEPARTMENTS		
	PRODUCT DESIGN	PURCHASING	QUALITY CONTROL
1. Establishment of Vendor Quality Policies	X	X	XX
2. Evaluate Capability of Potential Vendors	X	X	XX
3. Specify Requirements for Vendors	XX	/	X
4. Conduct Joint Quality Planning	X	/	XX
5. Conduct Vendor Surveillance	/	X	XX
6. Evaluate Delivered Products	X	/	XX
7. Use Quality Ratings in Selecting Vendors	/	XX	X

X : Collateral Responsibility

XX : Principle Responsibility

The vendor company or organisation upon whom this policy is invoked shall be responsible for complying with specified requirements.

SECTION 2 : VENDOR APPRAISAL AND AUDIT

Element 1 The quality department of MSN shall appoint a qualified person to perform an in-house evaluation of the proposed vendor's ability to meet the specified quality requirements. The evaluation of the vendor shall be based on the points covered in this company's vendor appraisal checklist. (See: Checklist and Figure 19 on page 129).

Element 2 In the event that the vendor has already been chosen, an in-house evaluation shall be carried out periodically, so as to alert this company to arees where the vendor may need help in meeting requirements.

SECTION 3 : VENDOR COOPERATION

Element 1 Where appropriate, the facilities and personnel of both this company and the vendor's company shall be made available to each other to assist in achieving mutual objectives.

Element 2 Where possible, the vendor shall produce certificates of conformance for material which is not inspected at this company.

Element 3 If required, data on vendor quality shall be made available for use in determining priorities on incoming inspection of purchased items.

Element 4 At all times, both vendors and this company, shall strive to comply with SABS 0157 and DEF STAN 05/21 Code of Practice for quality management systems, or in the case of overseas suppliers to that country's present code of practice for quality management systems.

SECTION 4 : VENDOR RATINGS

Element 1 Data on vendor shipments shall be recorded for use in the quality performance rating of vendors. This data must include percentage lots accepted, promised due dates and actual due dates.

Element 2 Vendor performance ratings shall be established based on the quality, price, and delivery of purchased supplies (Figure 20 on page 130).

Element 3 Vendor performance ratings shall be used in selecting vendors.

VENDOR APPRAISAL

Name and Address:	Part Supplied:	Date:

Vendor Operations	Total Points Assignable	Actual Points Assigned
Incoming materials control	5	
Station control	20	
Quality plans	15	
Housekeeping	5	
Final inspection and testing	20	
Analysis, feedback and reports	10	
Packed stock audits	5	
Manufacturing equipment condition	15	
Personnel	5	
Total	100	

Notes:

Rating:

☐ Excellent ☐ Good ☐ Fair

☐ Poor ☐ Unsatisfactory

Recommendations:

Prepared By:

Figure 19. Specimen Of Vendor Appraisal Report Sheet

Author Aronson Wayne
Name of thesis Quality Improvement Programme In A Just-in-time Manufacturing Environment. 1987

PUBLISHER:
University of the Witwatersrand, Johannesburg
©2013

LEGAL NOTICES:

Copyright Notice: All materials on the University of the Witwatersrand, Johannesburg Library website are protected by South African copyright law and may not be distributed, transmitted, displayed, or otherwise published in any format, without the prior written permission of the copyright owner.

Disclaimer and Terms of Use: Provided that you maintain all copyright and other notices contained therein, you may download material (one machine readable copy and one print copy per page) for your personal and/or educational non-commercial use only.

The University of the Witwatersrand, Johannesburg, is not responsible for any errors or omissions and excludes any and all liability for any errors in or omissions from the information on the Library website.