CHAPTER 4

IMPLEMENTATION OF QUALITY COST PROGRAM

4.1 Introduction

Before the quality cost program start, the company has its own quality system to collect some quality costs, even they are few, namely scrap and rejects in the factory, and compensation charge from customer. Other quality costs such as approval (payment to third parties, i.e. SGS (ISO9002), AJA (ISO14001), CSA, UL, etc.), Incoming Quality Control (IQC), Quality training and improvement programs, were not calculated, even thought the activities exist.

4.1.1 Product selection

In order to kick off this project within the limited time. There are total 5 different models in this company. We plan to take a product as case study. The selection use the comparison of major failure cost against manufacturing cost as table 4.1

Table 4.1 Major failure cost comparison among different product in year 2000

Unit: Baht

Product Model	Failure cost (scrap & compensation charge)		Sales	$\frac{\text{Failure cost}}{\text{Sales value}}$ X 100%
A	11,201,049	6,644,304 4,556,745	797,357,790	1.40%
B	678,426	6,918,502 30,529,170	1,154,763,900	3.24%
C	37,447,672	2,392,631 -	737,514,585	0.32%
D	2,392,631	893,237 -	148,499,145	0.60%
E	893,237	209,752 40,193,325	93,949,965	43%

The data on the table 4.1 are from the appendix F.

We can see product E and product B have high failure cost.

For the product E total produced 69,831 pcs. Consisting of only 2.67% of total product volume. Also, the product have a serious design issue, it is very exceptional. It is therefore not selected as the product for quality costs.

We select product B as the product index to perform the quality cost improvement. This is based on:

a. The ratio of failure cost against sales is high.
b. It is the main product of the company. Total produced 812,191 sets. Consisting of 36.4% in term of production volume.
c. The product has a relatively long product lifetime, therefore we have enough time to carry out the program.

4.1.2 Cost of quality (COQ) model

As the literature survey, the PAF model is usually used for the organization which is engaged in the mechanical or electrical products, and it is suitable for those do not set up activity based costing system. As the company use standard costing system. Therefore, the PAF model is selected as the research.

4.2 Application of BS 6143 (part 2)

BS 6143 (part2) is applied for this case study. Firstly each element of BS 6143 part 2 was listed and checked against current working practice in the company.

Quality costs are presented in a format such that the costs are split into the following three categories:

Prevention cost; Appraisal cost; and failure cost. The failure cost is split into internal failure cost and external failure cost.

The costs are collected per financial month. To facilitate the collection of relevant information, data collection forms are distributed the relevant personnel. The information on these forms is coded such that it can be allocated to the relevant cost section. The relevant information is compiled into the appropriate format prior to presentation.

For the case of a time being quoted on the data collection forms, then the appropriate loaded labor cost per hour will be used to calculate the cost.

In order to finish the project in a half year time frame, the cost element is reviewed and selected.

4.2.1 Prevention cost

Prevention cost is calculated based on the time spend on each activity.

Basically, QA have three engineer to perform quality system and approved. There are six main products in the company. Therefore, it is difficult to identify the quality cost in some elements.

A1 Quality planning

The calculation of this cost is based on the time spent in carrying out activities such as overall quality plan, FMEA's compiling quality plans, meetings with customers with regard to quality requirements for new products, and time spent implementing these requirements. As the calculation difficulty, we simply calculate the responsible engineer's time input and allocate the cost to the ratio of product quantity.

This work mainly falls in QA department. PE also shares some jobs.

A2 Design and development of quality measurement and test equipment.

This cost can be based on the time taken to design develop and manufacture inspection, test and measuring equipment such as jigs, fixtures, templates, etc.

The company is a manufacturing firm, without design function. The activity is mainly performed in its headquarter.

As the calculation difficulty, it will not be calculated in this project.

A3 Quality review and verification of design

This cost is based on the time spent on new product review / verification in design perspective. Activities include reliability test, performance inspection, etc.

This work mainly falls in HQ R&D and QA. This manufacturing company involves some of them.

This element will not be calculated in this project.

A4 Calibration, verification and maintenance of inspection and test equipment

Calibration cost is taken as the cost of external calibration of equipment, the hours worked by calibration personnel, and the cost of the purchase of equipment for calibration purposes.

Verification and maintenance of inspection test measurement equipment is based on the hours works by personnel in carrying out the above mentioned activities.

The cost will cover for calibration, verification and maintenance of quality department. It is recorded and allocate to product refer to product ration. Those cost on equipment for manufacturing the product is not included.

This work falls in PE department.

A5 Supplier assurance

This cost is based on the hours worked by suppliers assurance team in carrying out supplier assurance activities such as vendor surveillance, and on the expenses incurred on related activities. such as supplier visits.

This work falls in QA department. Purchasing department and PE department.

As the calculation difficulty, this is not included in this project.

A6 Quality training

This cost is taken as being the cost of external quality related courses attended by employees, also taken into account is the time spent by employees in attending by internal quality related courses.

This work falls in HR department. It can be got from accounting department.

A7 Quality auditing

The number of hours worked in ensuring that the departmental procedures meet ISO9000 requirements and the hours spent on carrying out internal system audits.

The whole of this work falls in QA department.

A8 Acquisition, analysis and reporting of quality data

The calculation of this cost is based on the time spent by quality department employees in collecting, analysis, recording and reporting the quality data used for the daily updating of the process control charts for each product, the weekly internal manufacturing and process reject rate reports, and the data used in the monthly reports.

This work falls in QA department.

A9 Quality improvement program

This cost is based on the time and actual cost spent in attending quality improvement steering committee meetings, any product quality improvement meetings held, also quality incentive scheme.

This work falls in QA department, PE department and production department.

Considering the research time limit.

In summary, A1 quality planning, A4 calibration, verification and maintenance of inspection and test, A6 quality training and A9 quality improvement program will be calculated in prevention cost.

4.2.2 Appraisal costs

B1 Pre-production verification

The cost is based on hours worked on new product pre-production stage. Activities include new product inspection, verification test.

This job mainly falls in QA and PE department.

As the calculation difficulty, this is not included in the project.

B2 Receiving Inspection

This cost is based on the hours worked by personnel in carrying out goods inwards inspection activities.

This job falls wholly in QA department.

B3 Laboratory Acceptance Testing

This cost is based on cost of laboratory acceptance testing, such as EMI and other safety evaluation and test.

Currently only a few test performed in the company as HQ already performed it. This will not be included in the project.

B4 Inspection and testing

The following areas are taken into consideration:

a. Inspection in process

This calculation is based on the hours worked by personal in carrying out inspection activities

b. Testing

This calculation is based on the hours worked on testing product in reliability perspective.

c. Product audit / line audit

This calculation is based on the hours spent by personal in carrying out line audits, and daily / shift first-off checks, and on the hours worked in auditing products.

All above jobs fall wholly in QA department. The calculation will be based on cost of working hours.

B5 Inspection and test equipment

This cost is based on cost for the purchasing of new inspection and test equipment, and cost of existing inspection and test equipment.

All above jobs fall wholly in QA department.

B6 Materials consumed during inspection and testing

This cost is based on the cost of material consumed during inspection and testing such as jigs, tapes, etc.

This will be calculated by QA department. This cost is only small portion on the appraisal cost, it will not be included in the project.

B7 Analysis and reporting of test and inspection results

The cost is based on the hours used by QA department for analysis and reporting of test and inspection results.

Above jobs fall wholly in QA department.

As the cost is only small portion of the appraisal cost, this will not be included in the project.

B8 Stock evaluation

This cost is based on hours to evaluate the stock (shelf life, accuracy, etc.)

This job falls in material control department and QA department. As this cost is only small portion on the appraisal cost, it will not be included in the project.

B9 Approvals and acceptance testing

This cost is based on the cost of approvals, as quoted on the monthly budget appraisal and on the time spent by personal involved with second or third party assessment and approvals.

Above jobs wholly fall in QA department.

B10 Field performance testing

This cost is based on product test in the field. This job mainly fall in HQ R&D department. It will not be calculated in the project.

In summary, B2: Receiving inspection, B4: Inspection and testing, B5: Inspection and testing equipment, B9: Approval and acceptance testing will be calculated in appraisal cost.

4.2.3 Failure costs

1) Internal failure costs

C1 Scrap

This is taken as being the cost of wasted material

This work falls in QA department.

C2 Rework / repair cost

The calculation of the cost is based on the rework and repair times incurred by reworking failure occurring at production process.

This work falls in IE department.

C3 Trouble shouting / defect analysis

The calculation of this cost is based on the time taken for the analysis of failures from all test positions. Also taken into account is the time spent by personal in dealing with the problems.

This work falls in QA and PE departments. As calculation difficulty, it will not be included in the project.

C4 Re-inspection / re-testing

The calculation of this cost is based on the time. time taken up by re-inspection of first-off, final audit or source inspection fails.

This work falls in QA department.

C5 Fault of subcontractor

The calculation of his cost is based on time to investigate the failure from the subcontractor cost related to rework, correction, etc.

This work falls in QA and IE departments. As this is small portion of failure cost, it will not be included in the project.

C6 Modifications permits and concessions

The cost is calculated by the time to investigate and verify the conditional acceptance of the product.

This work mainly falls in HQ R&D department. Therefore, it will not be calculated in the project.

C7 Downgrading

The cost is calculated by the lost value for items as seconds.

This work falls in Accounting department. As this case is very few in the company, it will be not calculated in the project.

C8 Downtime

The cost is calculated by the down time, which equals cost.

This work wholly falls in IE department. As some down time is not related to quality, such as conveyor down, also current downtime is for efficiency calculation, not quality cost perspective, this will not be included in the project.

In summary, C1 Scrap, C2 Rework / repair, C4 Re-inspection / re-testing will be calculated in the internal failure cost.

2) External failure costs

D1 Customer complaints

The cost is based on the time taken up, and any expenses incurred, as a result of customer complaints. It takes into account the following factors.

i) Time spent by personal at the premises of the customer, for such activities as reworking product or attending meeting relating to the complaints.

ii) Time spent by personal such as attending meetings relating to the complaints, investigating the cause of the complaint, purging stock, compiling reports, etc.

iii) Expenses incurred while visiting the customer in response to the complaint, such as travel, accommodations, etc.

iv) Expenses on necessary field service.

Above works fall in QA and PE departments. As this case is very few on the selected product, it will not be included in the project.

D2 Warranty claims

The cost is based on cost of claims from customer after acceptance to cover expense. Also the cost on price reduction which is negotiated in lieu of warranty where applicable.

Usually the customer will set up average failure returns (AFR) target. If the target is over, a compensation will be claimed.

Above works fall in QA and Accounting department.

D3 Product repeated and returned

The calculation of this cost is based on the hours worked by personal in reworking product returned by customer. It also takes into account the time spent in investigating the cause of the returns, and in the compilation of the relevant reports, etc.

Above works fall in service department. As this case is very few on selected product, it will not be included in the project.

D4 Concessions (deviations)

The calculation is based on the hours to contact to accept the concession, and probably including the experiment to convince the customer.

Above works fall in QA and HQ R&D department. As the calculation difficulty, it will not be included in the project.

D5 Lost of sales

The calculation is based on the profit loss after sales lost.

This cost is difficult to measure, it will not be included in the research.

D6 Recall cost

The calculation is based on the hours to handle the recall sets, as well as cost to handing custom clearance transportation.

Above works fall in Accounting department.

D7 Product liability

The calculation is based on the cost due to liability claims.

Above works fall in QA department. As calculation difficulty, also it is very few in this company, it will not be included in this project.

In summary, D2: Warranty claims, D6: Recall cost will be calculated in the project.

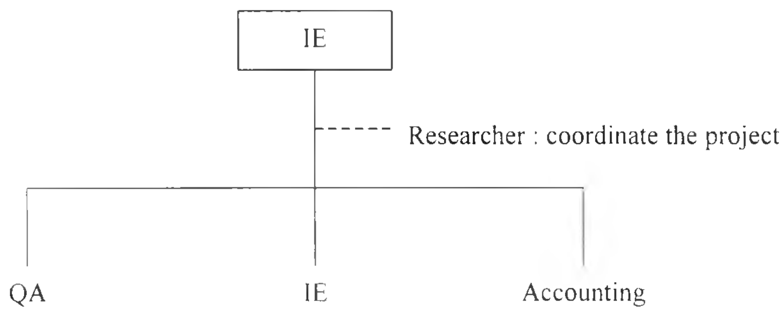
4.2.4 Report format

After review the company situation against BS 6143, following format is developed is for recording and reporting (Appendix A).

The report for product B is as appendix B.

4.3 Persons involved in this activity

As a high failure cost concerned, also it affect the profitability, a quality cost program is proposed. In order to smoothly carry out the project, a committee is assigned. The committee is consisted of quality department, accounting department and IE department. Considering the available time and professional capability, IE is assigned to be the leader.



- IE is the leader to coordinate, guide and follow up the progress
- QA is responsible for identifying the element of quality cost and their allocation
- Accounting department supports the related data on costing perspective
- Researcher assists the leader to coordinate the group and summarize, analyze the collected data.

4.4 Implementation approach

As per Gryna (1988), Cen Kaner (1996) and Juran & Gryna (1980) point out, some problems may lead to failure of quality cost program.

First it's unwise to try to achieve too much. To this end, we select only one product as the case study.

Second, beware of insisting on controversial costs. To this end, we only select some key elements as the case study.

Also, quality cost program usually take several years, need many people involved also need complicated reporting / analyzing system. However, the research is only allowed one and half year time frame and three people on part time. Therefore. we select one product, key quality cost element, also reporting period is monthly not weekly.

4.5 Procedure of the program

Based on literature survey and internal committee meeting. we follow following procedure for this program

- Measurement of quality cost and appropriate bases.
- Tie-in with basic quality measurements.
- Establishment of key trend analysis charts.
- Identification of improvement opportunities and goals.
- Leadership and support of problem identification. analysis and solution.
- Strict enforcement of necessary corrective actions.
- Summary reporting of progress.

If one model is successful. the procedure can be applied to other models.

4.6 Data gathering and analysis

We select product B as the case study and concentrate on certain quality cost element as described on previous section. We can therefore get following table for product B between January to May year 2001 (before program started).

Table 4.2 Preventive Costs for product B (Jan - May, 2001)

Unit: Million Baht

Cost element		Cost	Source	Sales Value	Source	Ratio to sales (%)
A1	Quality planning	0.091	QA	294.1	Accounting	0.031
A2	Calibration. verification	0.187	Account			0.06
A3	Quality training	0.019	Account			0.006
A4	Calibration improvement	0.147	Account			0.050
Total		0.444		294.1		0.151

Table 4.3 Appraisal costs for product B (Jan – May, 2001)

Unit: Million Baht

Cost element		Cost	Source	Sales Value	Source	Ratio (%) (Cost/Sales value)
B1	Receiving inspection	0.137	QA	294.1	Accounting	0.047
B2	Inspection and testing	0.98	Accounting			0.333
B3	Equipment for testing and inspection	0.753	Accounting			0.256
B4	Approval and acceptance testing	0.138	QA			0.047
Total		2.008		294.1		0.683

Table 4.4 Internal failure costs for product B (Jan – May, 2001)

Unit: Million Baht

Cost element		Cost	Source	Sales Value	Source	Ratio (%) (Cost/Sales value)
C1	Scrap	1.187	QA	294.1	Accounting	0.404
C2	Rework/repair	0.379	IE/Account			0.129
C3	Re-inspection/re-testing	0.277	IE/Account			0.094
Total		1.843		294.1		0.627

Table 4.5 External failure costs for product B (Jan – May, 2001)

Unit: Million Baht

Cost element		Cost	Source	Sales Value	Source	Ratio (%) (Cost/Sales value)
D1	Warranty claims	2.198	Account	294.1	Accounting	0.747
D2	Recall cost	0.009	Account			0.003
Total		2.207		294.1		0.750

Grand total = 6.502 million Baht

Sales value = 294.1 million Baht

Ratio to sales = 2.21%

Summarized the above costs, we can get table 4.6

Table 4.6 Summarized table

Cost categories	Cost	% of total	Ratio to sale
Prevention	0.444	6.83	0.151
Appraisal	2.008	30.88	0.683
Internal failure	1.843	28.35	0.627
External failure	2.207	33.94	0.750
Total	6.502	100	2.211
Ratio to sale		2.21%	

A. Quality cost analysis and problem finding

Based on above data, we can get quality cost as figure 4.1

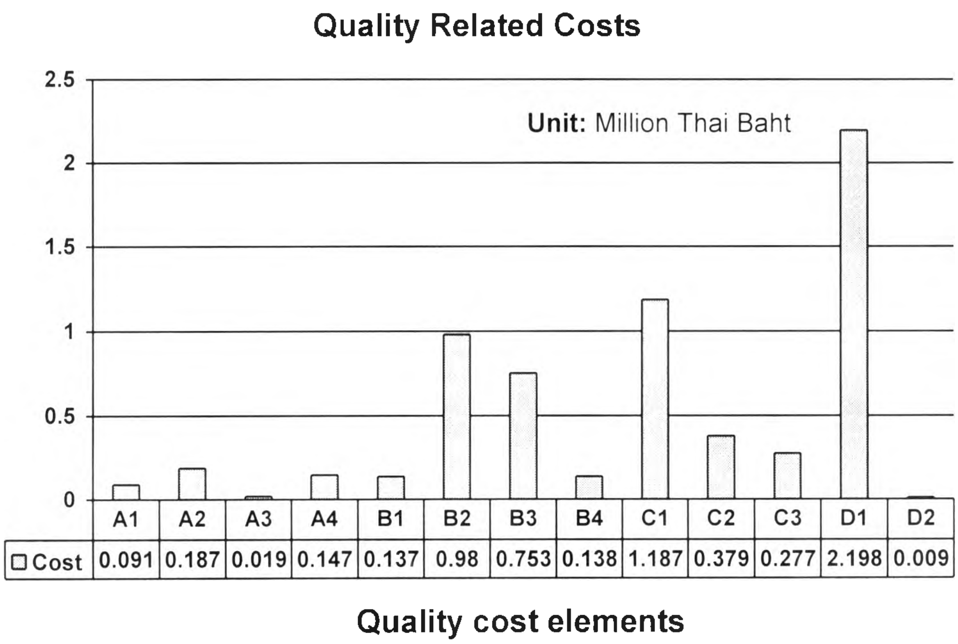


Figure 4.1 Quality cost statistical status chart for product B (Jan – May, 2001)

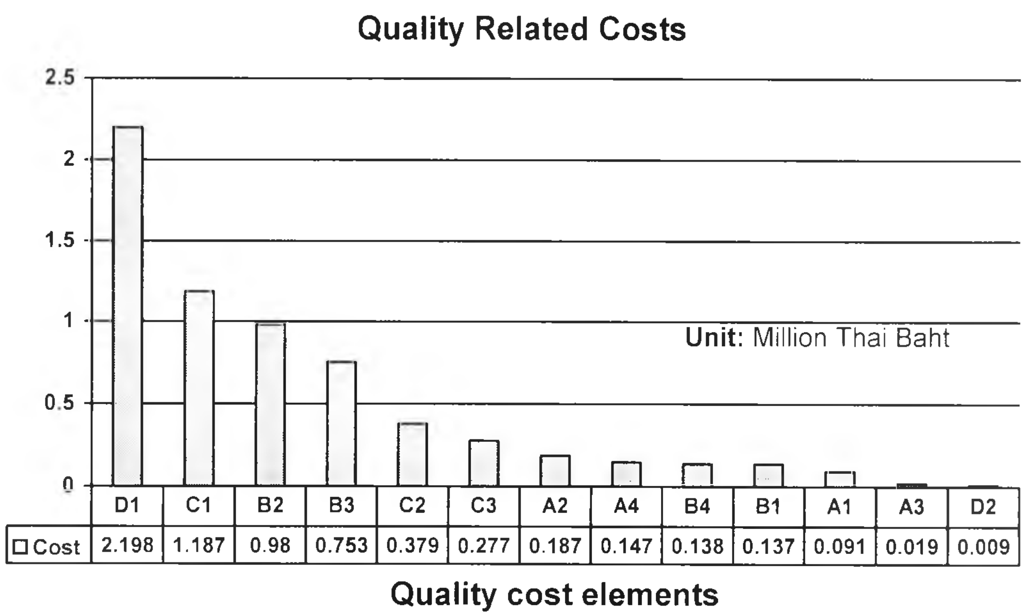
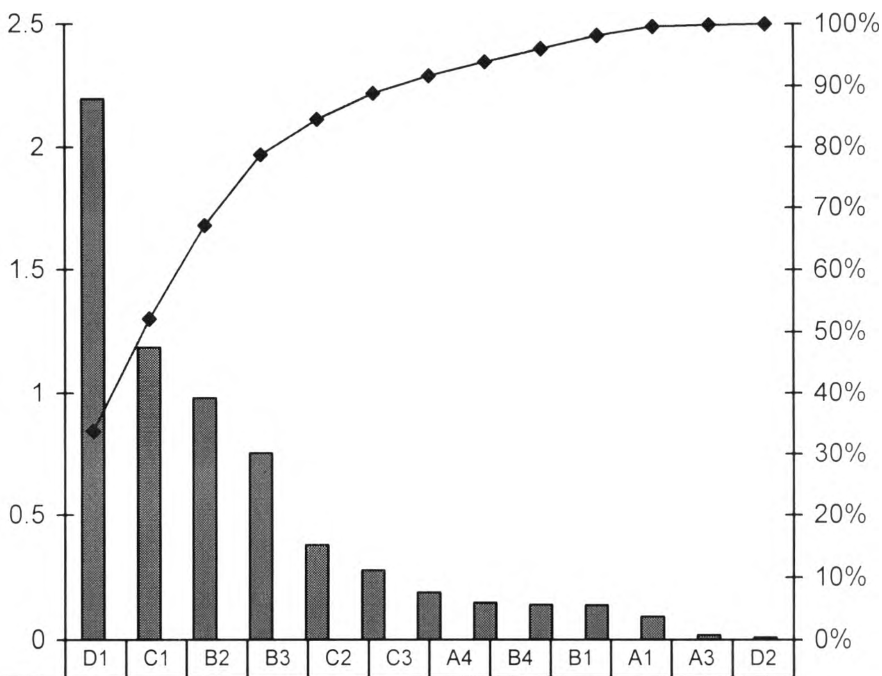


Figure 4.2 Quality cost statistical analysis chart

B. Cumulative and Pareto analysis can be shown as table 4.7 and figure 4.3

Table 4.7 Cumulative and Pareto analysis

Item	Annual cost	Cumulative	Ratio (%)
1	2.198	2.198	33.8%
2	1.187	3.385	52.06%
3	0.980	4.365	67.13%
4	0.753	5.118	78.71%
5	0.379	5.497	84.54%
6	0.277	5.774	88.8%
7	0.187	5.961	91.68%
8	0.147	6.108	93.94%
9	0.138	6.246	96.06%
10	0.137	6.383	98.17%
11	0.091	6.474	99.56%
12	0.019	6.493	99.86%
13	0.009	6.502	100%
Total	6.502		



	D1	C1	B2	B3	C2	C3	A4	B4	B1	A1	A3	D2
Annual cost	2.198	1.187	0.98	0.753	0.379	0.277	0.147	0.138	0.137	0.091	0.019	0.009
Ratio	34%	52%	67%	79%	85%	89%	94%	96%	98%	100%	100%	100%

Figure 4.3 Pareto analysis to product B

4.7 Problem identification and implementation

In order to kick off and implements the quality cost program, we set up a committee. The committee consists of 4 persons.

The leader is PE manager also in charge of IE. He holds a M.Sc. and M. Eng. degree has 10 years experience in design and production engineering field.

The member from accounting is accounting manager. She hold a B.A. degree and has more than 15 years experience.

The member from QA is senior quality engineer who is from U.K. and have more than 15 years experience in quality system & approval (QS & A) field. He is very helpful on the whole quality cost program as he ever did some similar activities in his previous UK company. His major responsibility is to identify the element of quality cost and their allocation.

I co-ordinate on the program. My role in this project is based on research, to develop analytical skill. After assist the leader to design the project. I co-ordinate the group to collect and summarize the different source of data. and perform the data analysis. In the meanwhile. I also consult this research with thesis advisor and QA manager. The QA manager also come from UK and hold a M.Sc. in quality management field.

The committees have routine meeting to discuss. A quality improvement team was set up to communicate and follow the problem solving progress. Skip the monitor problems and we list the key points in terms of 5M as figure 4.4

A. High AFR rejects

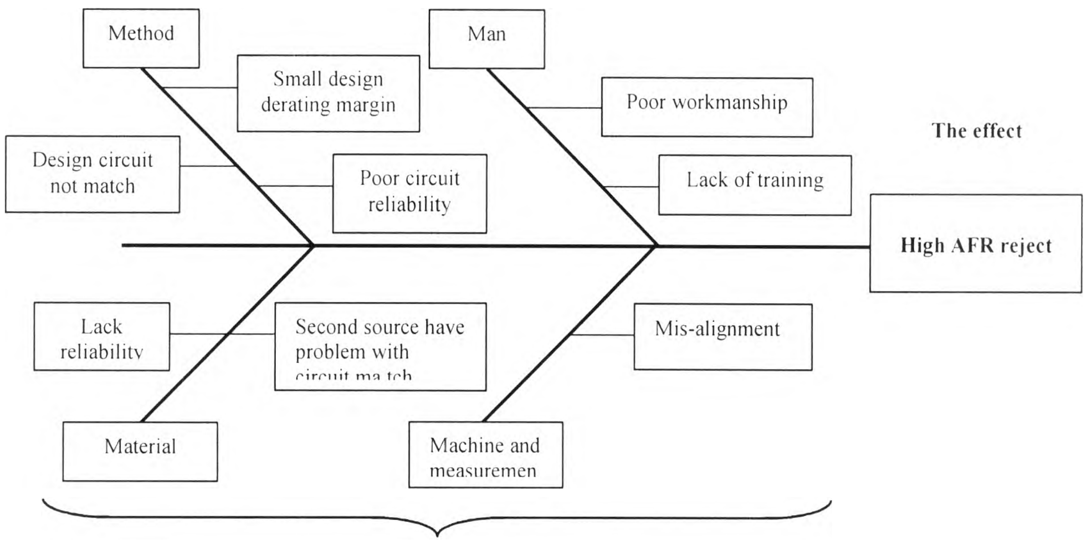


Figure 4.4 Cause and effect diagram of high AFR (Average Field Returns)

1. Man factors

This includes poor workmanship and lack of training issue.

1) For training, we can develop several programs for those temporary operators. and also for other staff.

As the order is fluctuant, each operator needs several skills so that can achieve flexible requirement. We develop each operator have to have at least two skills. and use different colour on their ID card. As a result. only those who have qualification perform the job. The error is reduced. The training identification can be shown on appendix G.

2) For workmanship. we develop foolproof process and also some automation to reduce the workmanship.

On implementation stage, we mainly introduce computer aided system to assist operation to reduce the workmanship problem. e.g., we develop automatic DDC judgement system. Previously operator have to check the data one by one, which may lead to mis-judge problem. use automatic DDC program, workmanship error was reduced to zero. This is shown on appendix H.

2. Material

Component problem mainly come from component itself. Part of it is reliability and we lack method to inspect them when goods coming in. the reason is that some components can't be inspected at all, such as some ICs. Another problem is from 2nd source component. Usually it is for either cost down or component availability. As usually 2nd source component is not trial in a large quality, it's easy have problem such as not match the circuit.

1) Component reliability problem

Some component is semi-conductor which is not capable inspected in factory side. However, we can put more finished product in reliability area to solve this problem. We can require supplier attach inspection report to confirm the reliability. Also, we start to follow up these failure components above 500 DPPM (Defect Part Per Million).

2) 2nd source component have problem with circuit match

For 2nd source component, we can enlarge the pre-production (PP) quantity (from 20 sets to 50 sets) and quality to enhance the reliability. After put more quantity, immediately there have some component failure. We quickly review this item, then we can come out countermeasure before cut-in mass production.

3. Method

For designer issue, these mainly have three problems. Namely circuit match, small derating margin and unreliable circuit:

When designer performs new design, he will be based on existing circuit, recommendation from supplier recommended circuit and the new product specification. The existing design should be already verified from the market, however, the new specification need some modification which is different from the current circuit. Also, because of cost consideration, the design has to do the derating. Further more, as some new circuit or components will be applied, these require significant amount of calculation and trial run. As the quantity on verification stage (pilot run) usually is small, some unreliable circuit may not be screened out.

If the design made a mistake in terms of above three factors, big problem will occur as the design is the beginning point of product.

To overcome this, we implemented below countermeasure

1) Design circuit match problem

This can be verified on pilot production (PP) stage by increasing quantity from 50 sets to 200 sets, and more verification item will be introduced. The method is that on PP stage, the circuit match will be deeply discussed and tested to prevent potential problem. To achieve this, the designer will defend their circuit before MP release.

From the program started, we encounter many obstacle from the designer and factory side, as this added work loads. After management strong backup and we put many communications, this item was improved. As a result, the failure was reduced to 20% of the original level.

2) Derating margin is small

Typically, it is verified by calculation and demonstrated testing.

Based on existing data, the major problem come from small derating margin problem is on driver or output circuit. In these key positions, upgrade component level lead to high cost. In the past, in order to save cost designer put some discount on the component rating level. However, the high failures tell us that this is not economical. Therefore, the factory side increase demonstrated testing quantity from 50 to 200, also the test condition go to more destructive. After implemented this, more than 30% problem was raised and solved after the test.

3) Poor circuit reliability

In order to review the reliability, the designer is required to systematically review the circuit and defend it during the verification process. This was written down in SOP. However, as time going on, the procedure was particle skipped. Usually, poor circuit reliability problem can be screened out during process but it add internal failure cost. After program started, the designer was invited to factory to defend the circuit.

B. High rejects in process and rework

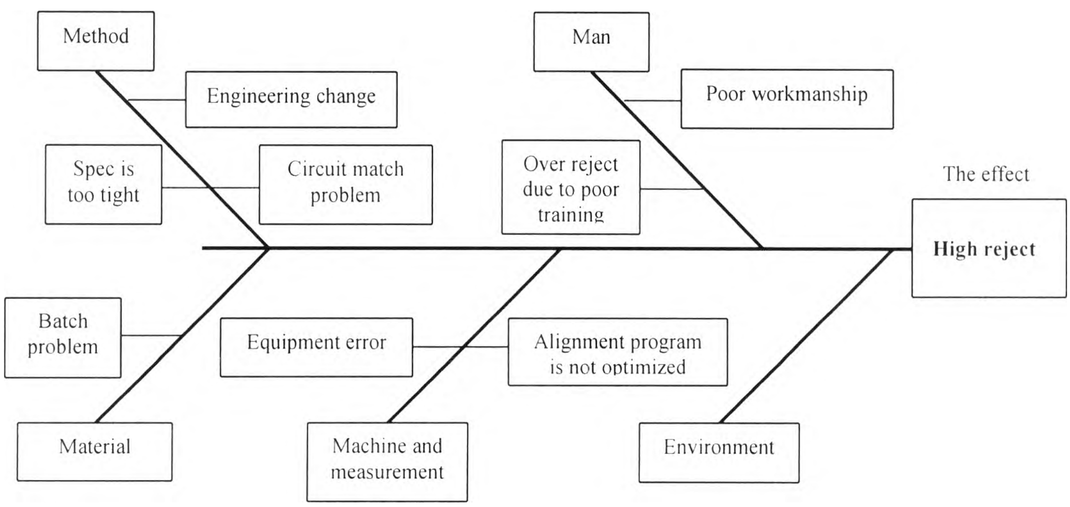


Figure 4.5 Cause and effect diagram for high rejection

Some items already discussed in AFR rejects.

Besides that, further problems and action are as below,

1) Man factors

As the product changed very fast, the criteria for inspection must be educated and understand by operator. If the training is not enough, the over reject will occur.

To overcome, all the operators and related staffs receive training in class, then are confirmed to understand the criteria via practical work.

On implementation stage, we ask production engineer or QA engineer to train the spec to operator. After that, we require QA engineer or PE engineer to double confirm the training effectiveness. Each operator has quality record which reveal his/her performance before and after training.

2) Material

Some materials have batch related problem and causes rejects in the process. To overcome this, on one hand, tight control in incoming quality inspection for those measurable components must be performed, on the other hand, follow up of corrective action must be performed until the quality is achieved.

Before the program, due to communication problem such as most materials are bought from Taiwan or Japan, but most of vendor can not communication in English. this cause the problem for follow up. To solve this, as the program start, we assigned some Chinese Thai to be in charge of follow up. After this, the effectiveness of follow up has big improvement.

3) Method

Sometimes the spec is too tight, but may not be necessary for end user. Tight spec can contribute to high reject / rework.

To overcome this, communication among customer, designer and factory sides need improvement.

For example, the monitor and TV are display products. The end user may not notice some defects such as small dot on the tube. As the tube is a key component. We review the quality with supplier every months, and review the acceptance criteria every half year. This makes the communication easier.

Sometimes, for some controversial issue, we may require designer to fly to factory to discuss, such as packaging material on drop test issue.

4) Machine and measurement

Equipment error and un-optimized alignment program are two main reasons for high reject / rework in measurement perspectives.

To overcome this, daily correlation on those critical and easy error equipment must be performed. Also, based on feedback from QA, the alignment program can be optimized. To achieve this, a real time SPC was developed. Previously, the alignment performance was measured and calculated the first day, then the result was reported the second day. From time, it is late. The engineers therefore developed a real time SPC which can check the alignment performance in real time manner. As a result, the alignment was improved. This can be referred to appendix I.

5) Environment

Basically no environment issue contribute to the high reject and rework. However, a tidy and comfortable working place is a must. A good housekeeping (5S) can indirectly contribute to good quality (should not be too hot, therefore, the air conditioning is operating when there is a work).

C. High scrap

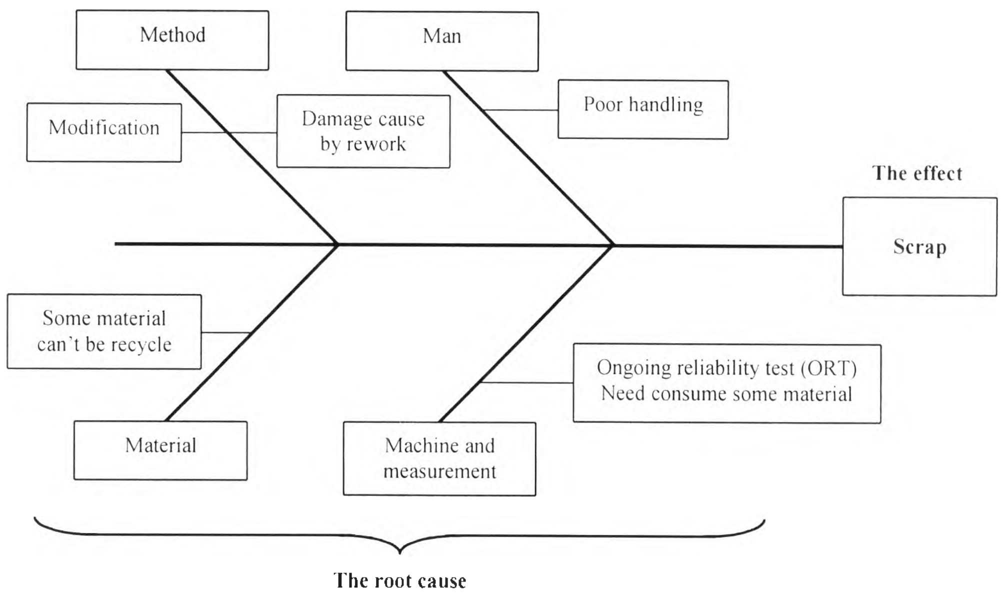


Figure 4.6 Cause and effect diagram of scrap

1) Man

Poor handling can damage the component and product. If they can not be repaired, then scrap occur.

To overcome this, in one hand, appropriate training and discipline need be in place. On the other hand, necessary automation need phase in to reduce the human error impact. For example, we have some tags need be twisted in copper side. When perform this job, the component side will fall down, therefore, some component may fall down. To overcome this, a automatic tag twist was developed.

2) Method

The frequent engineering change or rework can cause damage or redundant material. This will include the scrap.

Engineering change can not be fixed in short term, but can be improved via FMEA and other techniques in long term. In this research, since the time frame is short, it may not see the effective result. Therefore we did not implement it. But we suggest to apply it in the near future when we perform the whole quality cost program.

For rework, a good rework procedure area follow up need be in place. Previously, when QA rejected product, production reworked by themselves. Currently, when QA reject product, a meeting is called to identify the root cause, then a rework instruction is raised. The rework is effective and also can prevent the same problem happen again.

3) Material

Some material can not be recycled. If fail, just scrap. For example, if PWB is overflowed in solder machine, all the PWB assembly must be scrap.

Improvement on this is to identify all areas in this perspective, and develop its countermeasure. To push on this, a weekly review meeting was held and follow up. As a result, the scrap was reduced.

For PWB overflow program, a supporting bar was introduced to support PWB while soldering to prevent the overflow.

4) Machine and measurement

In order to confirm the quality, a regular ORT is performed. For some items such as drop test, the packing material need scrap. This is necessary for quality. However, in new product introduction stage, if closely work with R&D and vendor, the ORT quantity on packaging material can be reduced to minimum. Therefore, scrap reduction can be achieved.

Scrap mainly come from design modification, poor handling on workmanship, or damage from reliability test.

After new product is finished from production line. They will be tested by QA department. Some test such as drop test, high temperature test may damage the product thus come scrap. Poor handling can also cause scrap, such a wrong handling the carton.

To overcome this, how to reduce design change and prevent wrong handling is the key area for improvement.

4.8 After review the top 3 problems and possible solution, it is realized that all them are interacted. To solve this, we need to go up whole process level on the improvement

4.8.1 According to Armand V. Feigenbaum, quality control in the quality activity cycle is as figure 4.7

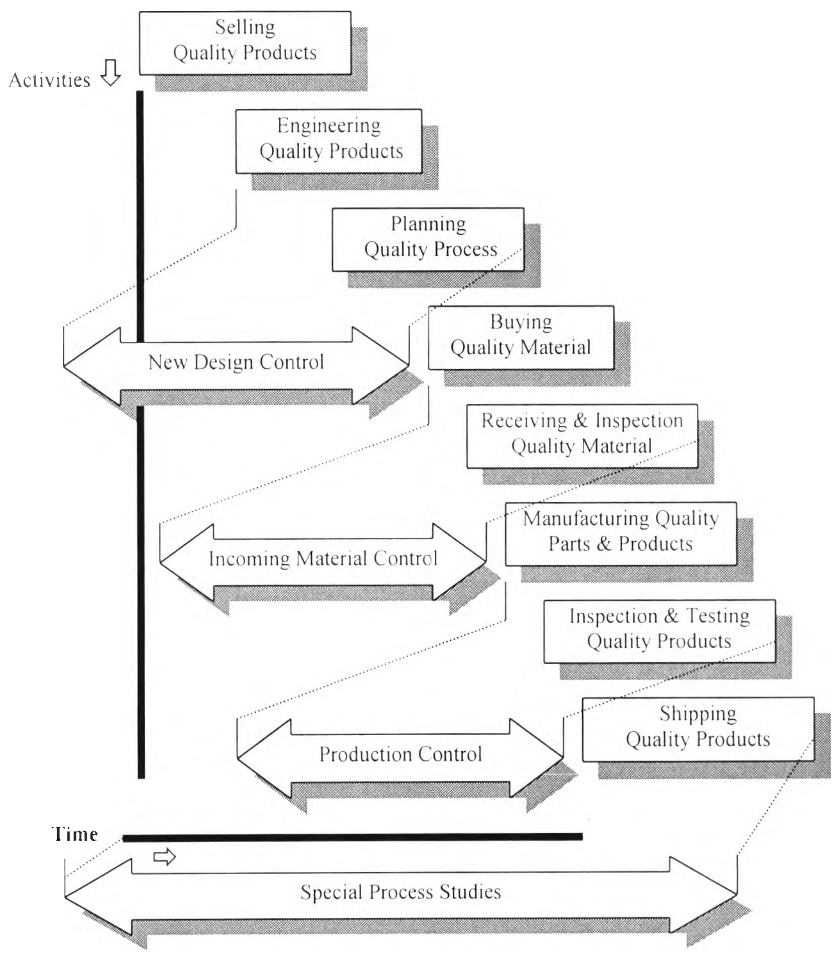


Figure 4.7 Quality control in the quality activity cycle

The each function of quality control is interactive from each other. This certainly requires us to integrate them rather than optimize some of them. A systematic approach should be applied. This requires many interface and cooperation.

For example, if we try to fix a problem, then we must look through customer supplier interfaces, both internally and externally. If a component problem occur, the problem must be feedback from shop-floor to IQA immediately. IQA must take action and follow up it until the problem is solved. Then the loop is closed.

For providing fast feedback, we can provide the training and set up the equipment that enable the operators to continuously monitor the quality problems on the spot. The operator or some certain signal can stop the line for fast feedback the problem and solve it.

If compare with the company, it is considered to improve on design verification, incoming material control, IPQC, OQA, and customer feedback analysis.

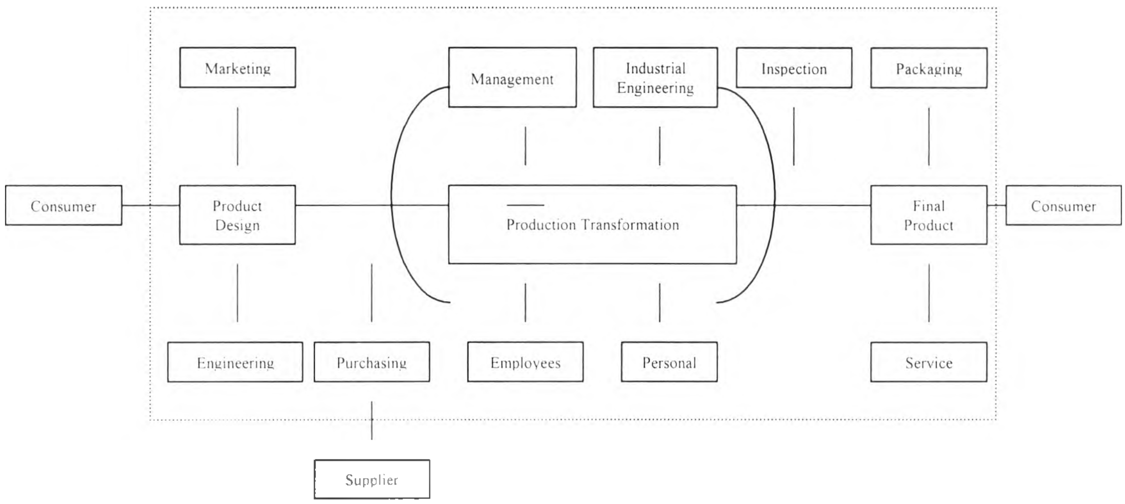


Figure 4.8 Quality management system

To achieve this, the quality organization can be reviewed,

This orients the role of quality assurance department. Currently the quality engineers and inspectors are controlling the quality. However, as QA only inspect the product, a lot of rework occurred and some problems of ten repeat.

To solve this a build-in quality concept should be applied. Even though it seems common sense that production build the quality but in reality many companies failed doing this because they lack the quality concept and consistent implementation.

We should re-design the quality engineers provide quality improvement advice, training and quality system control. Inspectors should be reduced and they should carry out in process control function rather than simply screen out the defects.

(1) The structure of quality assurance department should be flat type instead of hierarchy type. The hierarchy type structure will slow down the information transmission and cause communication barrier. In flat organization, the information can quickly reach the concerning persons then action may be quickly taken.

(2) IPQC function should be transferred from production to QA and keep the engineer for coordination and instruction. The inspectors won't judge and reject only instead involve in adjustment. The operators and the inspectors will supervise each other. If any problems occur, They will not wait only instead they will follow the concerning department immediately to solve the problem. Thus can improve the efficiency.

(3) As the company produces more than 2 million sets per years, the quality function can be split into two areas, quality assurance in term of quality control and quality system in term of system and approval.

In March year 2001, the organization was revised as figure 4.9

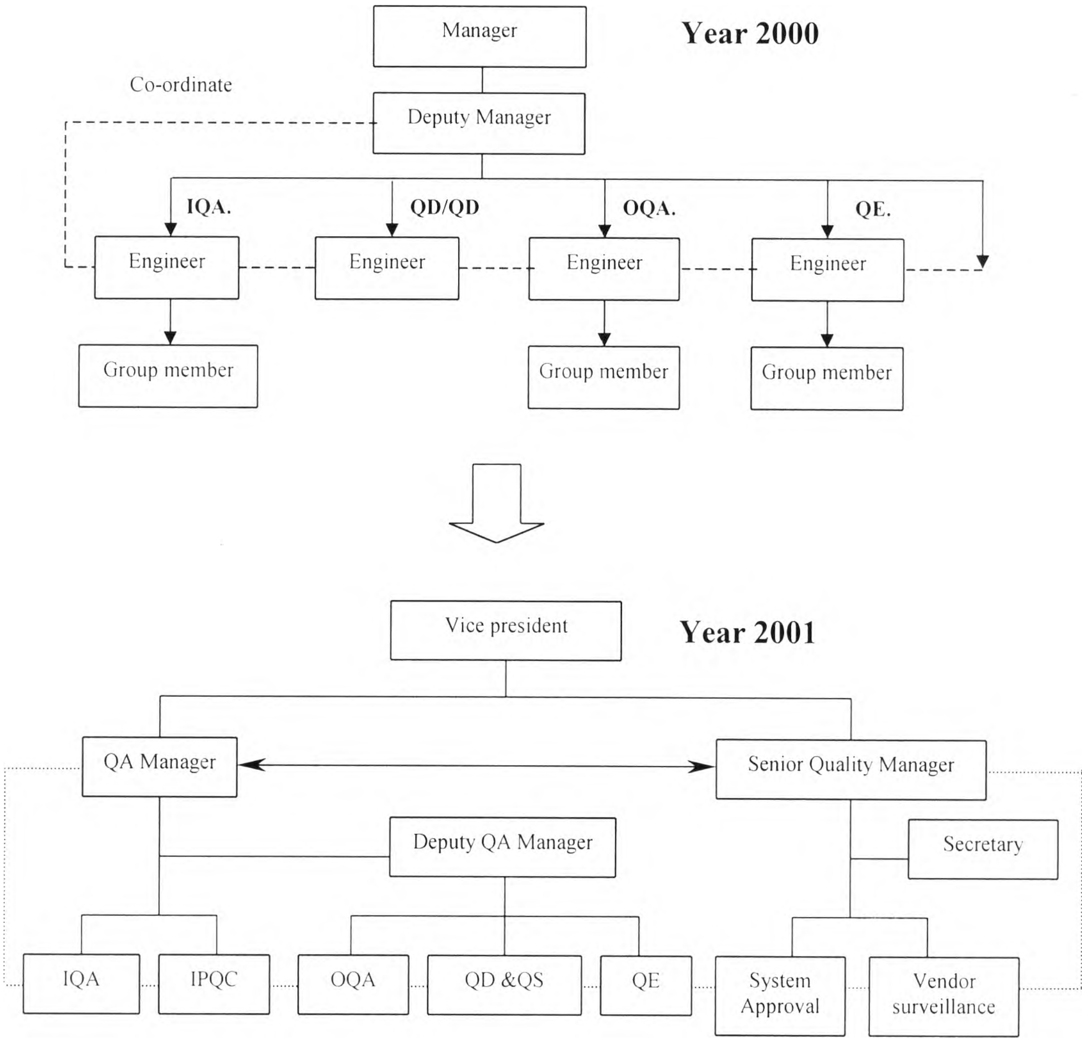


Figure 4.9 QA organization chart

Besides the QA organization changes, several quality improvement activities were introduced such as suggestion box activity (employee involvement), communication improvement, new product and second source component introduction improvement, fool-proof process introduction, corrective action to field failure, etc...

4.8.2 Review the quality control methods, it is realized that some quality control tools were not really performed

1. SPC is a statistical method of data collection (sampling) and analysis that works in such a way as to monitor the critical parameters of processes, with the goal of keeping them operating within desired level that are how to provide quality results. This enables the operation to be carried out in confidence that the final product will be good.

The objective of SPC for manufacturing is used to reduce the variations to achieve continuous process improvement, thus decrease quality cost and produce a qualified product.

Control chart is commonly used for SPC to monitor and control process variation on an ongoing basis.

SPC is about predictability. The purpose of running SPC charts is to predict common cause and special cause of variation, to allow appropriate action to be taken in the process to ensure that the process is in control and capable.

In the company, SPC charts such as X-R control chart and p control chart were performed. However, it is just appear work, piled there, nobody really see it and use it. It was just used when customer came to visit and want to see it. It did not play the functions in the work really.

Since the management did not pay attention to the SPC charts and very few people know about it. The operator who collected the data and made the chart just followed the formula that built in the computer to fill in the chart. Because nobody checked it and nobody cared the problems related even sometimes the chart showed the abnormal data the chart maker would make the data to complete the chart, thus the chart looked beautiful and the customer would have no question about it. Then the uncontrollable or incapable processes were hidden until the problem occurs. The quality cost could be happened.

When we review the process and find out these waste sources, the management realized should do it effectively. To achieve this, the following steps is required to do.

- Training SPC concept from management to employee especially QA people.
- Supervisor if it is performed really and correctly.
- Find out the root cause and follow up the corrective action to prevent the problem.

SPC is not only a useful quality control tool but also a quality management strategy. The important thing is implementing. Only the tidy document is the resource waste.

2. Management By Objective (MBO). This is a management system that managers and employees participate into the objective setting up and perform "self-control" trying to achieve the objectives.

The procedures can be,

1) Set up the business quality objective, usually the objective cycle is one year.
2) Set up sub-objective.

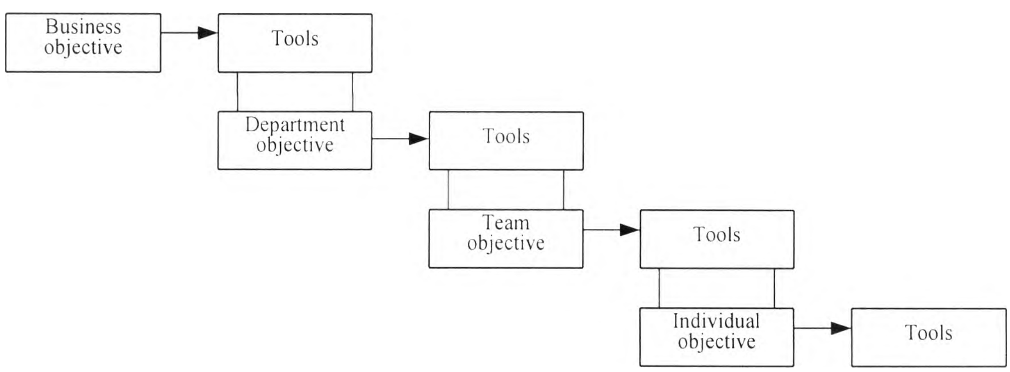


Figure 4.10 MBO management system

3) Based on the each level's objective, set up quality objective

management operating system.

4) Evaluate the performance.

To apply in quality cost program, targets were set up for each category. The target is changeable but also achievable. After the target is achieved, a new target will be set up. If the target can not be achieved, a review meeting will be held and discuss how to achieve it.

5) PDCA cycle

As a tool for improvement, the methodology of "Plan-Do-Check-Act" (PDCA) can be applied. According to ISO9001:2000, PDCA can be briefly described as follows,

Plan: Establish the objectives and processes necessary to delivery results in accordance with customer requirements and the organization's policies.

Do: Implement the processes.

Check: Monitor and measure processes and product against policies, objectives and requirements for the product and report the results.

Act: Take actions to continually improve process performance.

PDCA can be summarized as 8 steps procedure.

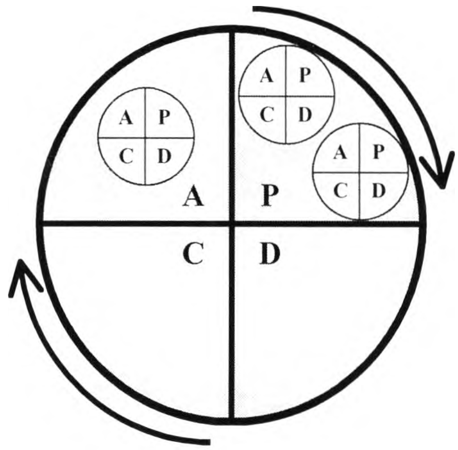
P
1) Analyze the current data and find out the existing quality problem.
2) Analyze the effect factors of the quality problem.
3) Work out the key effect factors.
4) Raise the corrective action to the key causes to improve the quality.

D
5) Implement.
6) Check the performance of the implementation against

the expected results.

C { 7) Summarized the leanings from the action.

A { 8) Take the unsoluted problem into the next PDCA cycle.



PDCA cycle

Figure 4.11 Deming's cycle

4.9 Summary of the quality improvement effort

1). AFR handling

Before program: we receive AFR data from customer every month, analyze it and take corrective action for those top 5

After program: sort the data further down to manufacturing month, then compare the failure rate against corrective action date to check the effectiveness. The result of it is the effectiveness is improved.

2). Scarp handling

Before program: report the scrap value by work center and by line and report to the top management

After program: sort the scrap value and Pareto analyzes top 5 scrap items. Then feedback to the owner to find out the cause and follow up the corrective action. The result is the poor handling problems reduced too much.

3). High rejects in process and rework handling

Before program: Set up the target. IPQC calculates the production yield and reports the problem and follows up the solution. OQA requires the corrective action for re-inspection. IE records it by reject rate and rework hours with the reasons.

After program: Set up the target. IPQC calculates the production yield. Daily meeting to report the problem and follows up the corrective action and verifies the effectiveness of the corrective action. OQA calls the meeting for re-inspection problem requires the corrective action and follow up the corrective action. IE records it by reject rate and rework cost with the reasons, reports to the management weekly.

The implementation of the quality improvement activities can be shown as below.

Table 4.8 Quality improvement activities

Perspective	Before	After	Result
Workmanship	Only tighten discipline	Develop foolproof process and automation to prevent problems. E.g. 1. 3D lens was used to confirm the good soldering quality 2. Automatic judge & highlight the failure code if DDC NG 3. Bar-code system to control the accessory and correct product 4. Vacuum packing to reduce workmanship problem	1. Workmanship problem reduced, related quality improved 2. Scrap also reduced
Training	1. Only incoming basic training 2. No special train when criteria change	1. Develop job training program. Each operator must have at least two skills. Use different color on their ID card to identify the qualification 2. Train the inspection criteria in class when product change, then confirm on job	The error is reduced Over reject reduced

Perspective	Before	After	Result
Design issue & alternative component introduction	For pilot run of new product and second source component introduction, the quantity is 20 sets	1. Increase the P/P quantity to 50 – 200 sets to improve 2. Feedback the problem to designer and follow up. If necessary, the designer flight to the factory to defined the circuit	Can identify the potential problem and solve it. 20%- 30% potential problem was raised and solved. However, it bring into engineering change often and cause the scrap increased
Equipment error and un-optimized alignment program	Correlate when model change, QA follow up	1. Daily correlation on those critical and easy error 2. Real time SPC detect the alignment performance in real time manner	1. Alignment program optimization improved 2. Reject / rework rate is reduced
Design change, engineering change	Follow the changing	Follow the changing in short term, feedback to designer	FMEA is to be applied in long term Quality can be improved but scrap cost increased
Communication	1. Weekly meeting 2. Any problem will be feedback to the responsible line	1. Daily meeting 2. Any problem will be feedback to responsible production line and other production line 3. QIT coordinate to solve the problem	Communication improved Team approach make the problem optimized to avoid the same problem occur again
Organization	Hierarchy	Separate into two groups	Concentrate on own responsibility

Take AFR as example, a task force was set up on AFR reject. After the failure data is feedback, the task force will review and take action. The action data and product serial number is recorded. Then the item will be monitored by compare the failure rate before and after the corrective action. If the trend is reducing, it means the corrective action is effective. Otherwise, further action will be taken.

The AFR analysis and corrective action report is as appendix E

From the appendix D, we can see the AFR is in reducing trend. The top five failures are reducing, meaning the corrective action is reducing.

In top 1 and top 3 the failures were reducing after program started in June.

In top 2 and top 5 the failure in June were jumped. This was because that high internal reject and rework can cause cosmetic problem on back cover and CRT surface. After this was highlighted, it was improved.

In top 4, the program was not well resolved. This is semi-conductor failure. Even several actions were taken, the failure trend is still not reducing. This means the root cause is not identified. The corrective actions are not effective.

4.10 Result after improvement

The first five months January to May of year 2001 were taken as the data before improvement, and June to October was taken as the data after improvement. These data can be shown on table 4.8, 4.9, 4.10, 4.11 and 4.12

4.10.1 Quality cost summary report after the program (Jun – Oct., 2001)

As a summary, the COQ for project is an below,

Table 4.9 Preventive costs (Jun – Oct., 2001)

Unit: Million Baht

Cost element		Cost	Source	Sales Value	Source	Ratio: (Cost/Sales value) %
A1	Quality planning	0.105	QA	481.6	Accounting	0.022
A2	Calibration, verification	0.234	Account			0.049
A3	Quality training	0.025	Account			0.005
A4	Calibration improvement	0.175	Account			0.036
Total		0.539		481.6		
Ratio to sales turnover (%)		0.112				

Table 4.10 Appraisal costs (Jun – Oct., 2001)

Unit: Million Baht

Cost element		Cost	Source	Sales Value	Source	Ratio: (Cost/Sales value) %
B1	Receiving inspection	0.158	QA	481.6	Accounting	0.033
B2	Inspection and testing	1.085	Accounting			0.225
B3	Equipment for testing and inspection	0.78	Accounting			0.162
B4	Approval and acceptance testing	0.179	QA			0.037
Total		2.202		481.6		0.457
Ratio to sales turnover (%)		0.457				

Table 4.11 Internal failure costs (Jun – Oct., 2001)

Unit: Million Baht

Cost element		Cost	Source	Sales Value	Source	Ratio: (Cost/Sales value) %
C1	Scrap	1.36	QA	481.6	Accounting	0.28
C2	Rework/repair	0.96	IE/Account			0.20
C3	Re-inspection/re-testing	0.512	IE/Account			0.11
Total		2.83		481.6		0.59
Ratio to sales turnover (%)		0.59				

Table 4.12 External failure costs (Jun – Oct, 2001)

Unit: Million Baht

Cost element		Cost	Source	Sales Value	Source	Ratio: (Cost/Sales value) %
D1	Warranty claims	0.34	Account	481.6	Accounting	0.07
D2	Recall cost	0.05	Account			0.01
Total		0.39		481.6		0.08
Ratio to sales turnover (%)		1.17				

Total = 5.961

Ratio to sales = 1.24%

Table 4.13 Summary cost after program (Jun – Oct., 2001)

Cost categories	Cost	% of total	Ratio to sale
Prevention	0.539	9.04	0.11%
Appraisal	2.202	36.9	0.46%
Internal failure	2.83	47.5	0.59%
External failure	0.39	6.54	0.21%
Total	5.96	100%	1.24%

Example of C2 and C3 can be shown on appendix C and appendix D

If we refer to quality cost curve (refer figure 2.3), the failure cost is about 54%. and prevention cost is about 9%. meaning the quality is under control.

Still. we need further reduce failure cost to about 50% and increase prevention cost to about 10% to achieve the optimized quality cost.

Result for the product B before and after quality cost program is as table 4.14

Table 4.14 Quality cost program before and after

	Before		**After**	
	Cost	Sales value	Cost	Sales value
Prevention	0.444	294	0.539	481.6
Appraisal	2.008		2.202	
Internal failure	1.843		2.83	
External failure	2.207		0.39	
Total	6.502		5.961	
Ratio to sales	2.21%		1.24%	

Unit: Million Baht