CHAPTER 2
METHODOLOGY AND LITERATURE REVIEW

2.1 Introduction Of Supplier Involvement In Supplier Quality Management System

Supplier Quality Assurance is a part of total quality management as shown in figure 2.2. This chapter describes overview of TQM concept and its tool (Quality Cycle of Dr. Deming) that generally is used for problem solving in several purpose. Quality cycle of Dr. Deming was developed to link the production of the product with consumer needs and focusing the resources of all departments in a cooperative effort to meet those needs.

Total Customer Satisfaction can be only achieved through the proactive involvement of the suppliers in continuous improvement process. We will focus on developing full partnership with a select number of high quality suppliers through the development of the Supplier Quality Assurance (SQA). Supplier Quality Assurance, which relates to process and product quality assurance, bases all the models, methods and technologies the organization develops on proactive, rather than reactive decision making as shown in figure 2.1 .

Supplier Quality Assurance system identifies and prioritizes critical materials that impact the quality of MOLEX LTD products. It evaluates the supplier's quality systems and the quality of the materials that they deliver. This includes establishing specifications, setting targets, and assessing control and capability of the incoming materials and equipment.

One theory that concerns with supplier quality assurance is *incoming inspection, sampling for attribute for incoming inspection and its standard sampling plan*that will be also explained in this chapter.

The supplier quality assurance model is one of the components of Total Quality Assurance Model which is part of the overall Total Quality Management system

As shown in figure 2.2, the supplier quality assurance model comprises :

1) Supplier Selection and Qualification
   - Supplier Selection

   - Supplier Qualification

   - Categories of Supplier Approval

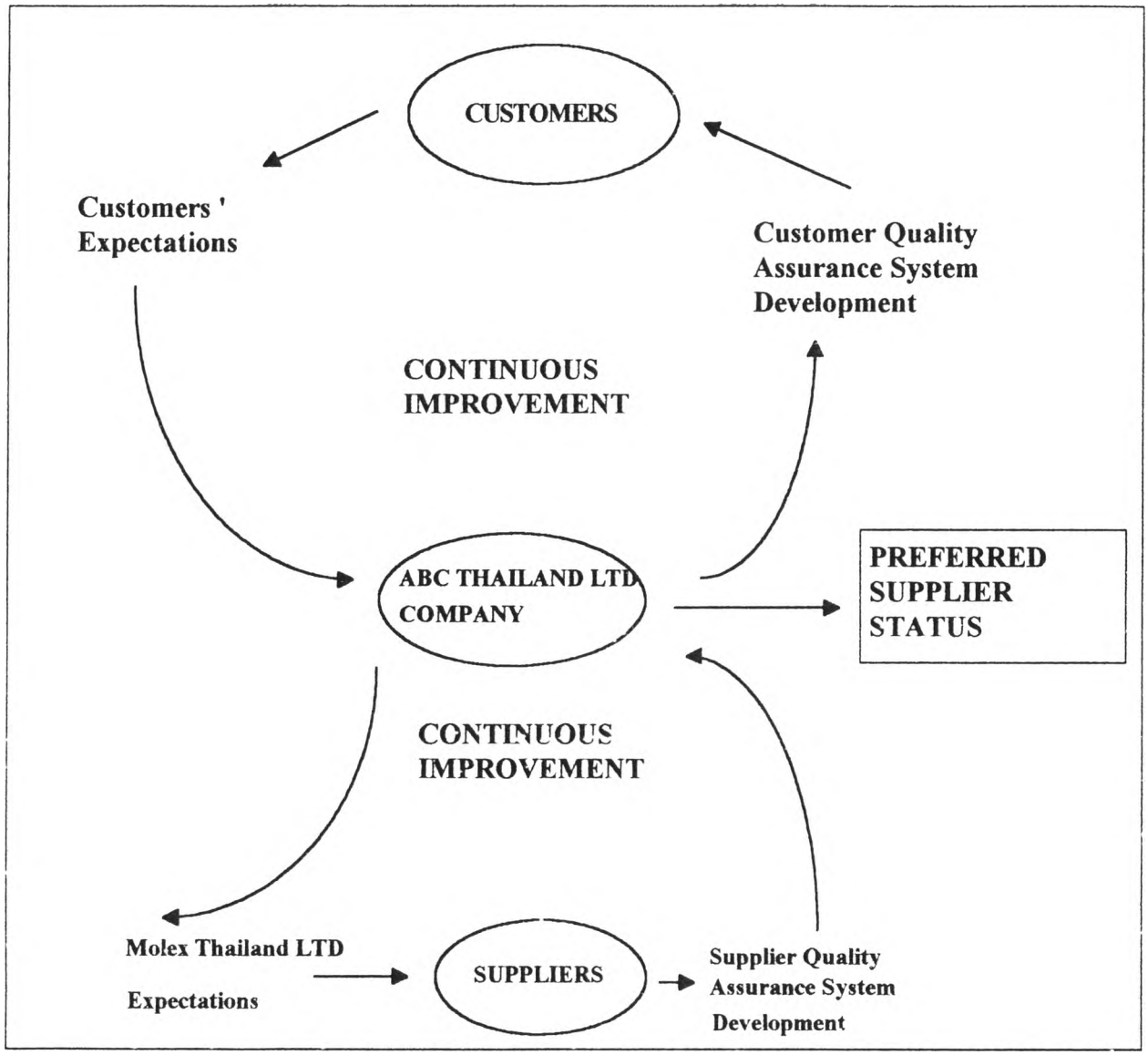

Figure 2.1 : Customer satisfaction through the proactive involvement of SQA

2) Critical Characteristics Approval and Review System

- Identification of critical characteristics
- Critical characteristics capability index review

3) Cost of Quality

- Total Usage Cost of material purchased from each supplier
- Review of total cost versus the buying price

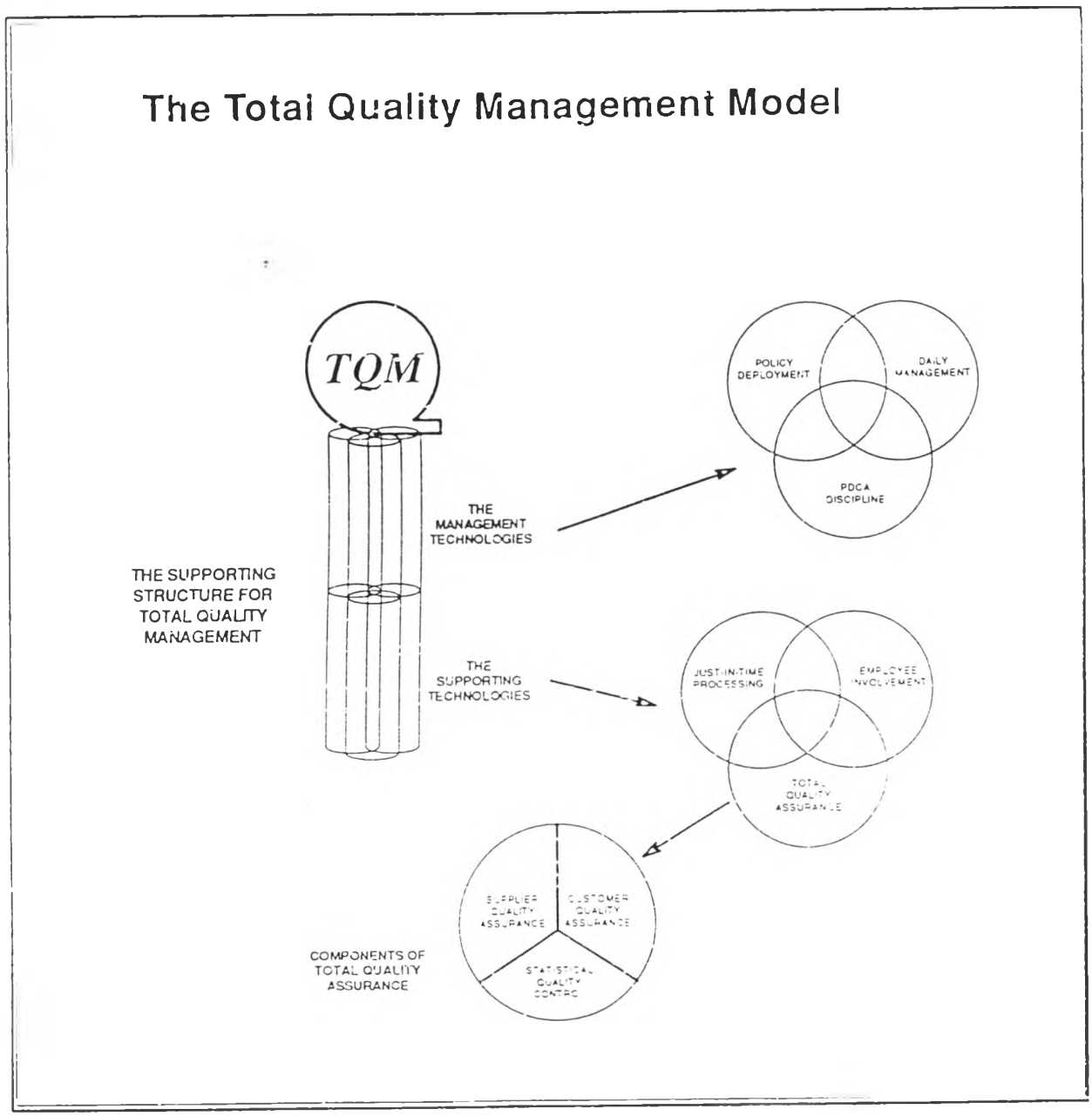

Figure 2.2: Total Quality Management system

Overview Total Quality Management

Figure 2.2 presents Total Quality Management system that is the " Modern approach" based on philosophy and use Theory Y to approach Total Quality Management was influenced by developments in Japan, but it can not be branded" Made in Japan " . As we can see that TQM has many of its roots in American. TQM 's elements are rooted in theories and practices of management that were developed in America. TQM and TQC are philosophy that need several tools, techniques, motivation to drive quality system work effectively. And more advanced than ISO9000 quality standard.

TQM's root include:

1. Scientific Management: Finding the best way to do a job.
2. Group Dynamics: Enlisting and organizing the power of group experience.
3. Training and Development : Investing in human resource.
4. Achievement Motivation: People get satisfaction from accomplishment.
5. Employee Involvement: Workers should have some influence in the organization.
6. Sociotechnical Systems: Organizations operate as open systems.
7. Organization Development (OD) : Helping organization to learn and change.
8. Corporate Culture: Beliefs, myths, and values that guide the behavior of people throughout the organization.
9. The New Leadership Theory : Inspiring and empowering others to act.
10. The Linking-Pin Concept of Organizations: Creating cross-functional teams.
11. Strategic Planning : Determining where to take the organization and how and when to get there.

While its roots are in American management theories and practices. TQM attempts to reconfigure these into a whole approach to management that is more than the simple sum of its parts. These parts may have existed before the Strategic Quality Management era and the popularity of TQM. However, they were not usefully configured into an integrated approach that

is focused on the themes of the emerging paradigms. This make TQM fundamentally different from past tradition of management.

TQM, people should to know importance of understanding customer needs, formulating strategies to provide value to customers, and continuously improving organizational systems to provide that value.

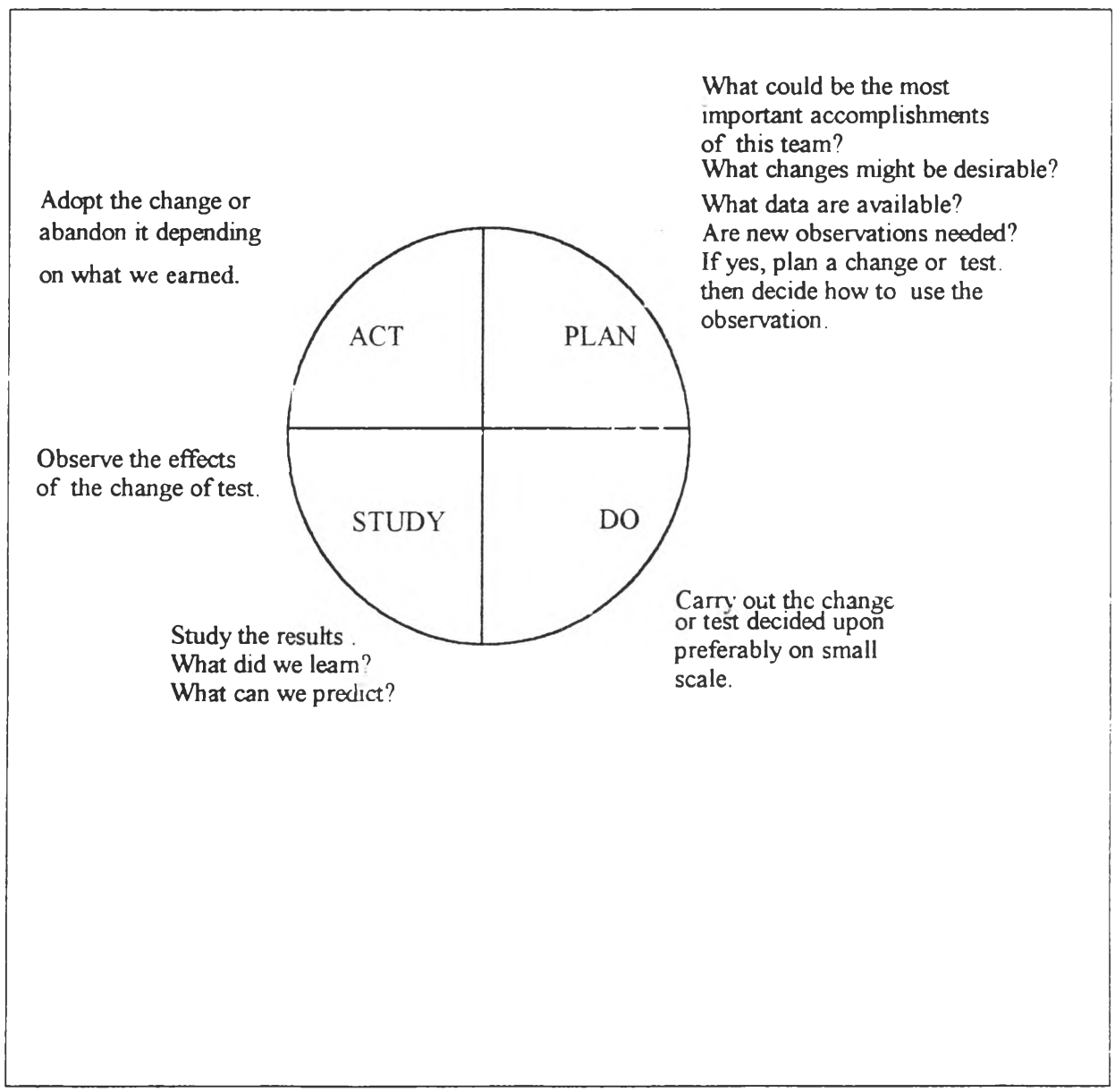

Figure 2.3: Deming Cycle Plan, Do, Study, Act (PDSA)

Quality Circle is a tool of TQM , and need to apply the principle of scientific thinking to drive it (quality circle). The scientific thinking consisted of the Plan, Do, Study, Act(PDSA) cycle. The PDSA cycle provides managers and people with a scientific method for learning how to make improvements as shown in figure 2.3. Deming introduced the Japanese to modern approaches to consumer research and suggested methods for relating the research to continuous improvement. While American seemed to discount these approaches as war time efforts not relevant to a booming postwar economy, the Japanese subscribed to them as the means of rebuilding their country. They continued to develop and apply methods for continuous improvement with an emphasis on quality. And they advanced the concept of quality. In addition other techniques introduced to support an approach to continuous improvement which focused on the causes and the results like cause/effect or fish bone diagram, and statistical quality control, with process sampling and charting techniques and etc. . Statistical techniques is one of 20 elements of ISO9000. ISO9000 do not care for how to implement it and how it work effectively. ISO 9000 would audit in accordance with procedure establishing by supplier. What action do you need to take if it is out of control as defining in procedure. TQM, we need it to work effectively. Statistical Process Control established through quality circle and work in PDSA cycle. Supplier Quality Assurance , Customer Quality Assurance and Statistical Quality Control are the components of total quality assurance.

Over the years, Dr. Deming has developed 14 points that describe what is necessary for a business to survive and be competitive today. At first encounter, their meaning may not be clear. But they are the very heart of Dr. Deming 's philosophy. They contain the essence of all his teachings. Read them think about them, talk about them with your co workers or with experts who deeply understand the concepts. And then come back to think about them again. Soon you will start to understand how they work together and their significance in the true quality organization. Understanding the 14 points can shape a new attitude toward work and the work environment that will foster continuous improvement.

A Synopsis of Dr. W. E. Deming's 14 Obligations of Management

1. Create a constancy of purpose toward improvement of product and service, with a plan to become competitive and to stay in business.

2. Adopt a new philosophy. We are in a new economic age. We can no longer live with commonly accepted levels of delays, mistakes, defective materials, and defective workmanship.

3. Cease dependence on mass inspection. Require, instead, statistical evidence that quality is built in, to eliminate the need for inspection on a mass basis.

4. End the practice of awarding business to the lowest bidder. Instead, depend upon meaningful measures of quality, along with price. Eliminate suppliers that cannot qualify with statistical evidence of quality. Preface

5. Find problems. Provide everyone with appropriate statistical methods by which to learn which faults can be corrected locally, and which faults belong to the system and require the attention of management.

6. Institute modern methods of training on the job.

7 Institute modern methods of supervision. Remove the barriers that rob the hourly worker of his right to pride of workmanship. Improvement of quality will automatically improve productivity. Management must take immediate action on reports from first line supervisors concerning barriers such as inherited defects, machines not maintained, poor tools, and fuzzy operational definitions.

8. Drive out fear, so that everyone may work effectively for the company.

9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production that may be encountered with various materials and specifications.

10. Eliminate numerical goals, posters, and slogans for the work force, asking for new levels of productivity without providing methods. Eliminate work standards that prescribe numerical quotas.

12. Remove barriers that stand between the hourly worker and his right to pride of workmanship.

13. Institute a vigorous program of education and retraining.

14. Create a structure in top management that will push every day on the above 13 points.

2.2 Incoming Inspection

2.2.1 Strategies For Incoming Inspection

Incoming inspection has two main purposes:

1. To prevent defective purchased items entering production

2. To provide information on the defectives of items to facilitate production, to control payment of suppliers, to use in discussion with suppliers, and to transmit to customers.

Most of the incoming inspection money is spent for the first of these purposes. Defective items that enter production affect the costs and scheduling of production, and the quality of the product going to the customer adversely. Incoming inspection should minimize these adverse effects for the lowest incoming inspection cost.

Some important questions include: How much incoming inspection manpower is optimum? What sampling level is appropriate? What sampling plan is the best? To answer these questions the purists say: Count how many lots of particular sizes are received in a week; sample these according to MIL STD 105, Inspection Level II, and the contractually agreed AQLs; and take account of the requirements for tightened and reduced inspection. Provide manpower and inspection facilities accordingly. Other theorists prefer the use of LQ sampling. In practice, most incoming inspection sections do not work this way. This is not because of incapable. They do have to respond to financial and personnel limitations, the effects of earlier disaster, and the realities of cost reduction objectives.

The nine different strategies are summarized as follows, (the strategies at the start of the list require a high level of inspection and those at the end require progressively lower amount)

1. Identify every defective item.

2. Identify lots for which 100 percent screening is cost efficient

3. Reject lots that are worse than a contractually agreed percent defective

4. Reject lots that are worse than the average quality of previous lots

5. Reject lots that are worse than a standard percent defective

6. Reject lots whose percent defective is such that they would cause a major problem in manufacturing.

7. Inspect at a level sufficient to keep the incoming inspectors busy, but with no overtime and no inventory of waiting lots.

8. Reject lots in which every item is defective.

9. Accept all lots

The simplest way to control the quality of purchased items is through incoming inspection. In principle, every item received could be inspected for every feature and characteristic defined on its product requirement specification. The items that passed would go on through to manufacturing. Those that failed would be returned to the supplier. If a substantial proportion passed 90 % or more, manufacturing would not be held up by the loss of the rejected items. Suppliers would be motivated to minimize their proportion defective by having to deal, at their expense, with the rejected items. This system is very attractive . The whole responsibility for ensuring the quality of purchased items is given to the incoming inspection section. The members of this section are specialists who like doing incoming inspection. They have a well routine that they perform. The people in purchasing, engineering and the rest of the quality department have no worry about the quality of purchased items, and can get on with the things important to them.

Attribute sampling is the most widely applied statistical quality control technique. All of the other techniques - process capability and control, designed experiments, sampling by variable, regression analysis, and so on - are actually used by only a minority of product manufacturers, but attribute sampling is used by virtually every one for incoming inspection, and it is also used for many other purposes as well.

2.2.2 Lot by Lot Acceptance Sampling for Attributes

Acceptance Sampling for attributes theory is the necessary concept for incoming quality control inspection. This is a major field of statistical quality control. Example for a typical application of acceptance sampling, A company receives a shipment of product from a supplier. This product is often a component o. raw material used in the company's manufacturing process. A sample is taken from the lot, and some quality characteristic of the units in the sample is inspected. A decision is made regarding lot disposition, either to accept or to reject the received lot. Sometimes, we refer to this decision as lot sentencing. Accepted lots are released to production; rejected lots may be returned to the vendor or may be evaluated to some other lot disposition action upon verification result then the rejected may be reworked, sorted or scrapped.

Acceptance sampling can be considered as a receiving inspection activity, there are other uses of sampling method. For example, frequently a manufacturer will sample and inspect its own product (production self inspection) at various stages of production. Lot that are accepted are

moved forward to the next operation, while the rejected lots may be reworked , scrapped or sorted.

Three Aspects Of Sampling Are Important:

1. It is the purpose of acceptance sampling to sentence lots, not to estimate the lot quality. Most acceptance - sampling plans are not designed for estimation purposes.

2. Acceptance-sampling plans do not provide any direct form of quality control. Acceptance sampling simply accept and rejects lots. Even if all lots are of the same quality, sampling will accept some lots and reject others, the accepted lots being better than the rejected ones. Process controls are used to control and systematically improve quality, but acceptance sampling is not.

3. The most effective use of acceptance sampling is not to "inspect quality into the product," but rather as an audit tool to ensure that the output of a process conforms to requirements.

There Are Three Approaches To Lot Sentencing:

1. Accept with no inspection

2. 100% inspection , that is, inspect every unit in the lot, removing all defective units found that will be deposited for further action.

3. Acceptance sampling.

The skip inspection (no-inspection) alternative is applied in situations where the vendor's process is so good that defective units are almost never encountered or where there is no economic justification to look for defective units. For example, if the vendor's process capability ratio is 3 or 4, acceptance sampling is unlikely to discover any defective units. Generally, 100% inspection in situations where the component is extremely critical and passing any defectives would result in an unacceptably high failure cost at subsequent stages, or where the vendor's process capability is insufficient to meet specifications.

The Situations That Acceptance Sampling Is Mostly Used.

1. When testing is destructive.

2. When the cost of 100% inspection is very high and take extremely long time to inspect.

3. When 100 % inspection impact to the production scheduling seriously.

4. When there are many items to be inspected and the inspection error rate is sufficiently high that 100% inspection might cause a higher percentage of defective units to be passed then would occur with the use of a sampling plan.

5. When the supplier has an excellent quality history, and some reduction in inspection from 100% is desired, but the vendor's process capability ratio is sufficiently low to make no inspection an unsatisfactory alternative.

6. When there are potentially serious product liability risks, and although the vendor's process is satisfactory, a program for continuously monitoring the product is necessary.

Advantages and Disadvantages of Sampling

It seem that acceptance sampling is contrasted with 100% inspection, it has the following advantages:

1. Less expensive (labor cost) because there is less inspection.

2. It is applicable to destructive testing also, there is less handling of the product, thus reduced damage.

3. Fewer inspectors are involved in inspection activities.

4. The amount of inspection error often greatly is reduced.

5. The rejection of entire lots as opposed to the simple return of defectives often provides a stronger motivation to the vendor for quality improvements.

On the other hand, acceptance sampling also has many disadvantages as follows,

1. There are risks of accepting "bad" lots and rejecting "good" lots.

2. Less information is usually generated about the product or about the process that manufactured the product.

3. Acceptance sampling requires planning and documentation of the acceptance sampling procedure but 100% inspection does not requires planning or procedures.

Acceptance sampling is a middlestage between the extremes of 100% inspection and no inspection. If often provides a methodology for moving between these extremes as sufficient information is obtained on the control of the manufacturing process that produces the product. While there is no direct control of quality in the application of an acceptance plan to an isolated lot, when that plan is applied to a stream of lots from a vendor, it becomes a means of providing protection for both the producer of the lot and the consumer.

It also provide an accumulation of quality history of the product regarding the process that produces the lot, and it may provide feedback to vendor' plant in order to determine the process control. This is useful in process control.

2.2.3 Single Sampling Plan

To meet zero defect, single sampling plan with switching rules at c = 0 can be considered . Whenever a rejected part is found, that means whole lot is rejected. This method is used depending on the policy of the company. Some companies acceot to use single sampling plan, double sampling plan or multiple-sampling plan (lot sentencing depending on the master table (MIL STD 105E) that is likely that the lot which the rejected part is found, can be accepted. Some companies ' policy, it accepts only zero defect. That means every lots of the products that are inspected, only the lot that have zero defect will be accepted as called c = 0.

A single sampling plan is a lot - sentencing procedure in which one sample of n units is selected at random from the lot, and the disposition of the lot is determined based on the information contained in that sample. For example, a single sampling plan for attributes would consist of a sample size n and an acceptance number c. The procedure would operate as follows:

Select randomly n parts from the lot. If there are c or fewer defectives in the sample, the lot is accepted, and if there are more than c defective parts in the sample, the lot is rejected.

Definition of a Single Sampling Plan

A lot size N has been received then inspection required. A single sampling plan is defined by the sample size n and the acceptance number c. For example, the lot size is N =5,000, then the sampling plan

n = 200
c = 2

means that from a lot of size 5,000 a random sample of n = 200 units is inspected and the number of nonconforming or defective items d observed. If the number of observed defectives d is less than or equal to c = 2, the lot will be accepted. If the number of observed defectives d is greater than 2, the lot will be rejected. Since the quality characteristic inspected is an attribute, each unit in the sample is judged to be either conforming or nonconforming. One or several attributes can be inspected in the same sample; generally, a unit that is nonconforming to specification on one or more attributes is known as a defective part. This procedure is called a single - sampling plan because the lot is justified based on one sample of size n .

2.2.4 The OC Curve

An important measure of the performance of an acceptance sampling plan is the operating characteristic (OC) curve. This curve plots the probability of accepting the lot versus the lot fraction defective. Thus, the OC curve displays the discriminatory power of the sampling plan., that shows the probability that a lot submitted with a certain fraction defective will be either accepted or rejected. The OC curve of the sampling plan n=89, c=2 is shown in figure 2.4. It is easy to describe how the points on this are obtained.

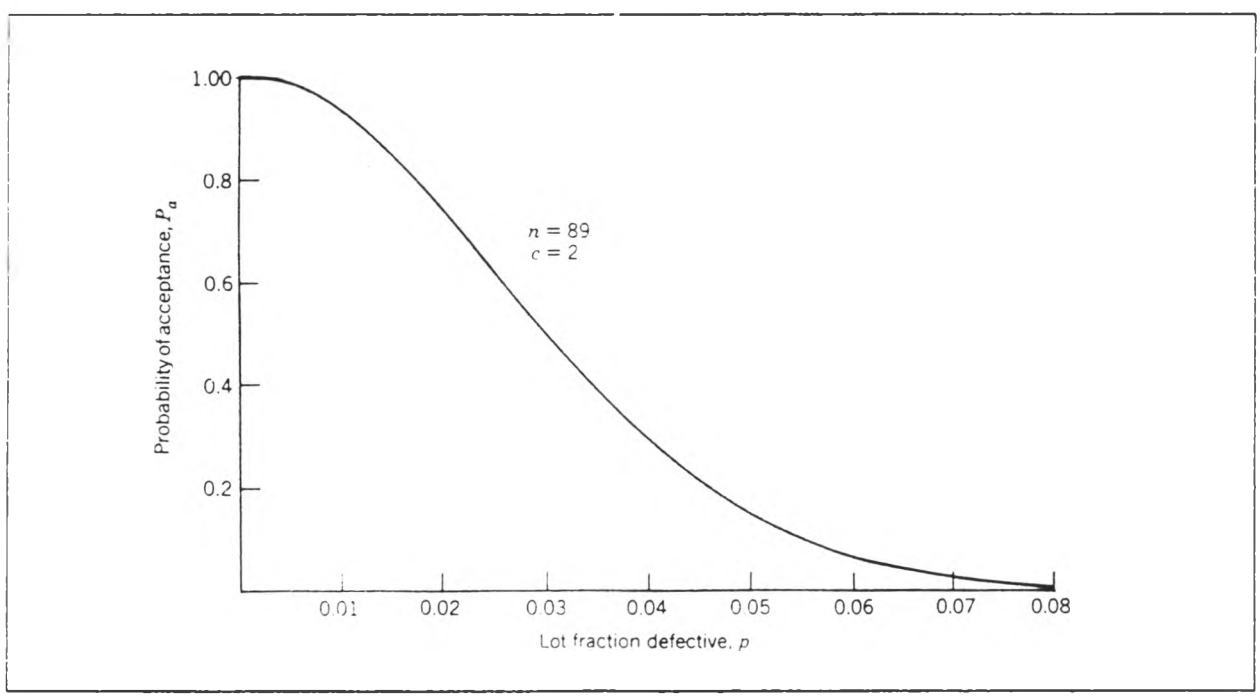

Figure 2.4: OC curve of the single sampling plan, n = 89, c = 2

For example, the lot size N is large, the distribution of the number of defectives d in a random sample of n items is binomial with parameters n and p, where p is the fraction of defective items in the lot. An equivalent way to conceptualize this is to draw lots of N items at random from

a theoretically infinite process, and to draw random samples of n from these lots. Sampling from the lot in this manner is the equivalent of sampling directly from the process.

The probability of observing exactly d defective is

$$P\{d \text{ defectives}\} = f(d) = (n! /(d!(n-d)!))p^d(1-p)^{n-d}$$

The probability of acceptance is just the probability that d is less than or equal to c, or

$$P_a = P\{d < c\} = \sum_{d=0}^{c} (n!/d!(n-d)!)\, p^d(1-p)^{n-d} \quad \text{----------(2.1)}$$

For example, if the lot fraction defective is p = 0.05, n = 89 and c = 2, then

$$P_a = P\{d < 2\} = \sum_{d=0}^{c} (89!/d!(89-d)!)\, 0.05^d(1-0.99)^{n-d}$$

$$=(89!/0!89!)(0.05)^0(0.99)^{89} + (89!/1!88!)(0.05)^1(0.99)^{88} + (89!/2!87!)(0.05)^2(0.99)^{87}$$

$$=0.9397$$

The OC curve is developed as shown in figure 2.4 for various values of p, Table 2.1 displays the calculated value of several points on the curve.

Fraction Defective, p	**Probability of Acceptance, P_a**
0.005	0.9897
0.01	0.9397
0.02	0.7366
0.03	0.4985
0.04	0.3042
0.05	0.1721
0.06	0.0919
0.07	0.0468
0.08	0.023
0.09	0.0109

Table 2.1 : Probabilities of acceptance for the single sampling plan n=89, c=2

The OC curve shows the discriminatory power of the sampling plan. For example, in the sampling plan n= 89, c = 2 . From table 2.1, if the lots are 2% defective,(fraction defective = 0.02), the probability of acceptance is approximately 0.74. This means that 100 lots, 74 lots will be expected to accept and reject 26 of them.

The policy of a company who accept the product with zero defect acceptance, c will be equal to 0. Therefore P{d = c = 0 } = 1. That means , 100 lots from a process that manufactures 0% defective product are submitted to this sampling plan, All of 100 lots will be expected to accept. On the other hand, no rejected lot occurs.

2.2.5 Effect of n and c on OC curves

A sampling plan that discriminated perfectly between good and bad lots would have an OC curve that looks like figure 2.5. The OC curve runs horizontally at a probability of acceptance $P_a = 1.00$ until a level of lot quality that is considered "bad" is reached, at which point the curve drops vertically to a probability of acceptance $P_a = 0.00$, and then the curve runs horizontally again for all lot fraction defectives greater than the undesirable level. If such a sampling plan could be employed, all lots of "bad" quality would be rejected, and all lots of " good" quality would be accepted.

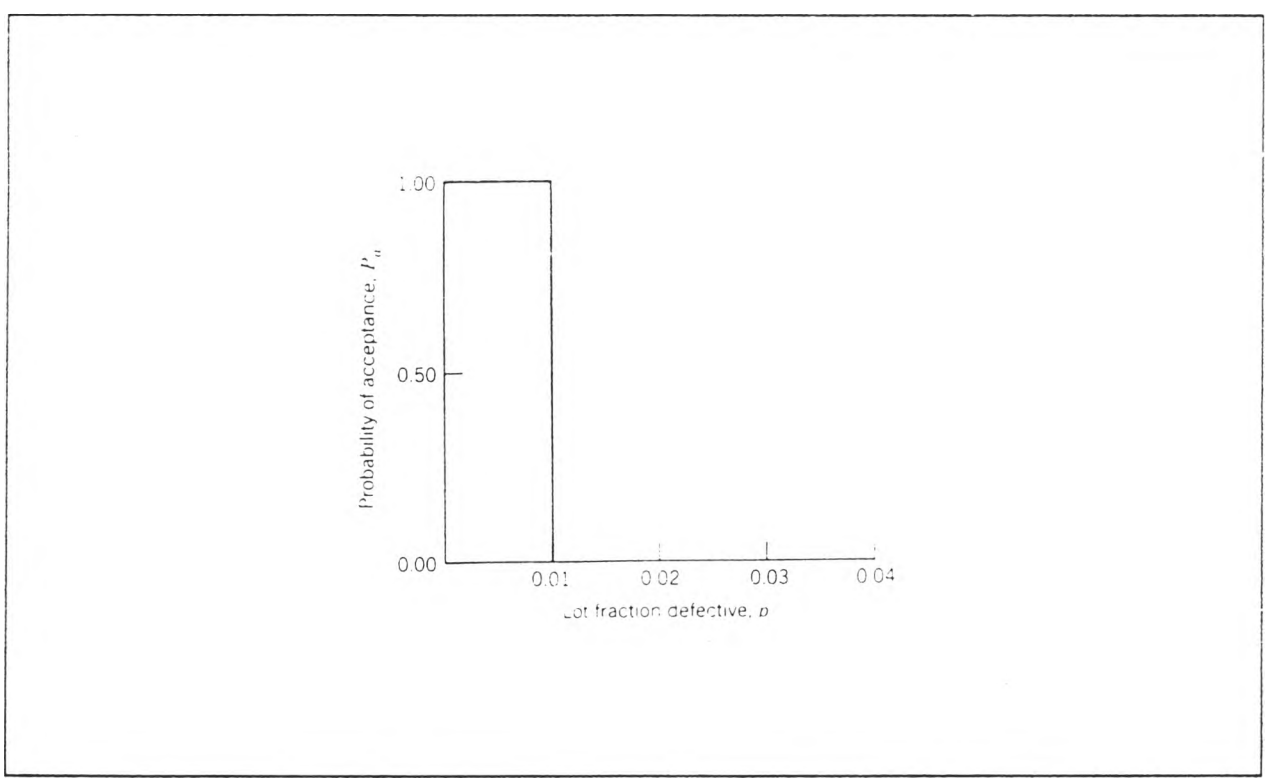

Figure 2.5 : Ideal OC curve

However, the ideal OC curve in figure 2.5 have never been occurred in practice. In theory, it could be realized by 100 % inspection, if the inspection were error free. The ideal OC curve shape can be approached, however, if the sample size is increased , then OC curve becomes more like the idealized OC curve shape as the sample size increases as presented in figure 2.6. Thus, the precision with which a sampling plan differentiates between good and bad lots increases with the size of the sample. The greater slope of the OC curve, the greater the discriminatory power.

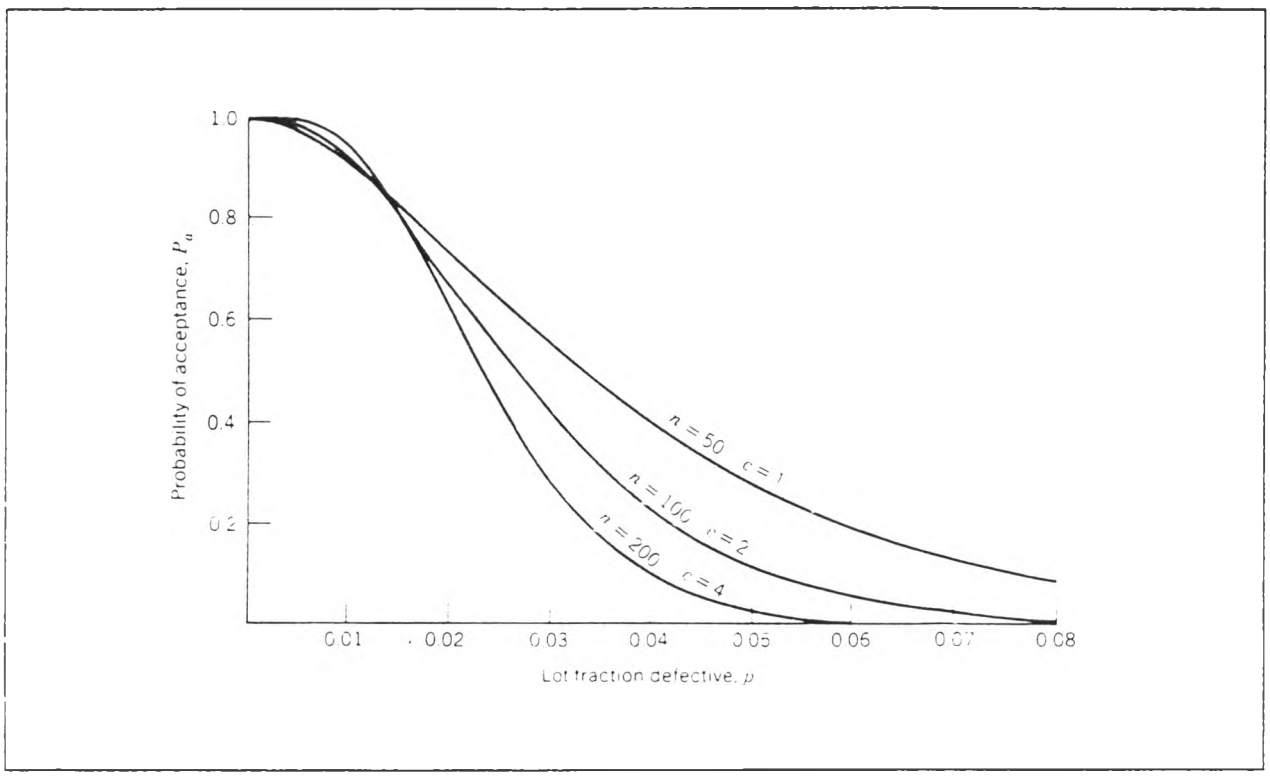

Figure 2.6 : OC curves for different sample sizes

Figure 2.7 presents OC curve changes as the acceptance number changes. Normally, changing the acceptance number does not dramatically change the slope of the OC curve. As the acceptance number is decreased, the OC curve is shifted to the left. Plan with smaller values of c provide discrimination at lower levels of lot fraction defective than do plans with larger values of c.

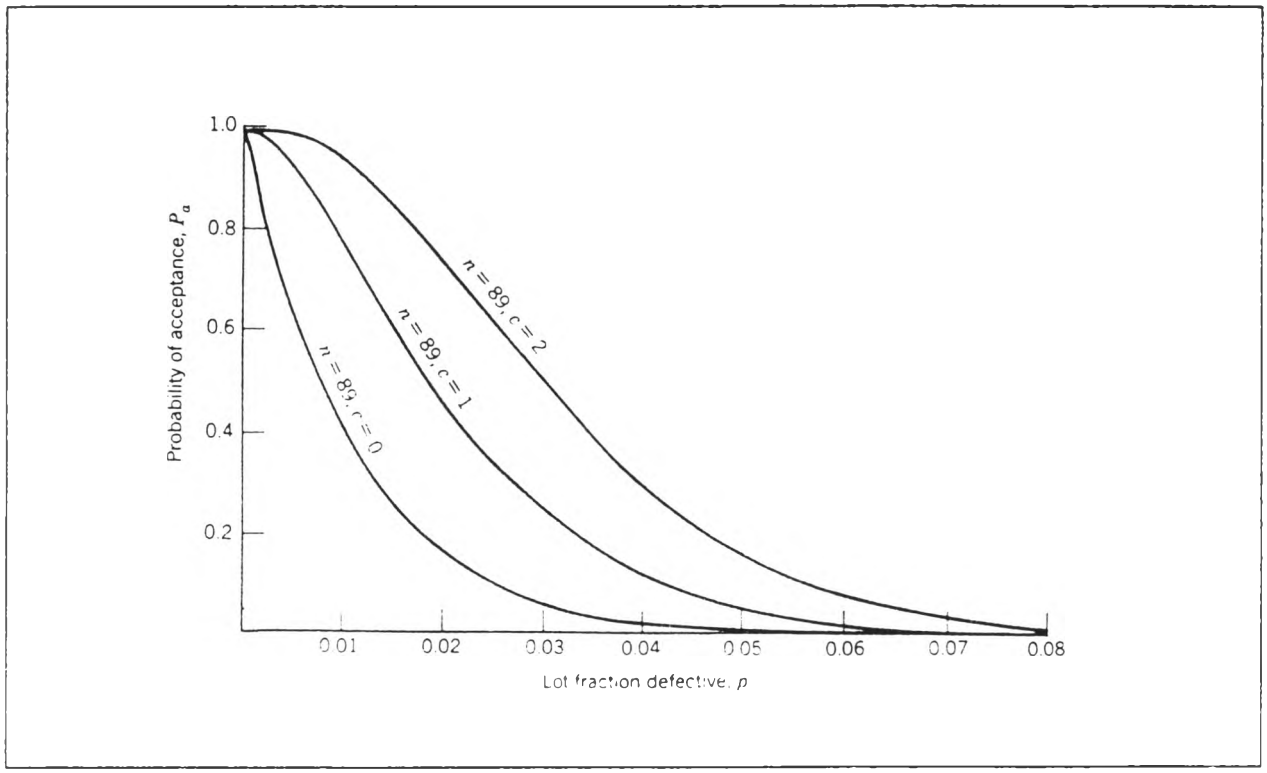

Figure 2.7 : The effect of changing the acceptance number on the OC curve.

2.2.6 Specific Points on the OC Curve

The quality engineer's interest frequently focuses on certain points on the OC curve. The supplier is usually interested in knowing what level of lot or process quality would yield a high probability of acceptance. For example, the supplier might be interested in the 0.95 probability of acceptance point. This would indicate the level of process fallout that could be experienced and still have a 95% chance that the lots would be accepted. In the another hand, the consumer might be interested in the other end of the OC curve. That is , what level of lot or process quality will yield a low probability of acceptance ?

A consumer often establishes a sampling plan for a continuing supply of components or raw material with reference to an acceptable quality level or AQL. The AQL represents the poorest level of quality for the vendor's process that the consumer would consider to be acceptable as a process average. Note that the AQL is a property of the supplier's manufacturing process; it is not a property of the sampling plan. The consumer will often design the sampling procedure so that the OC curve gives a high probability of acceptance at the AQL. Furthermore, the AQL is not usually intended to be a specification on the product, nor is it a target value for the

supplier's production process. It is simply a standard against which to judge the lots. It is hoped that the supplier's process will operate at a fallout level that is considerably better than the AQL.

The consumer will also be interested in the other end of the OC curve, that is , in the protection that is obtained for individual lots of poor quality. In such a situation, the consumer may establish a lot tolerance percent defective (LTPD). The LTPD is the poorest level of quality that the consumer is willing to accept in an individual lot. Note that the lot tolerance percent defective is not a characteristic of the sampling plan. It is a level of lot quality specified by the consumer. LTPD can be called as reject quality level (RQL). or the limiting quality level (LQL). It is possible to design acceptance-sampling plans that give specified probabilities of acceptance at the LTPD point.

2.2.7 OC Curve For Single Sampling Plan With C = 0.

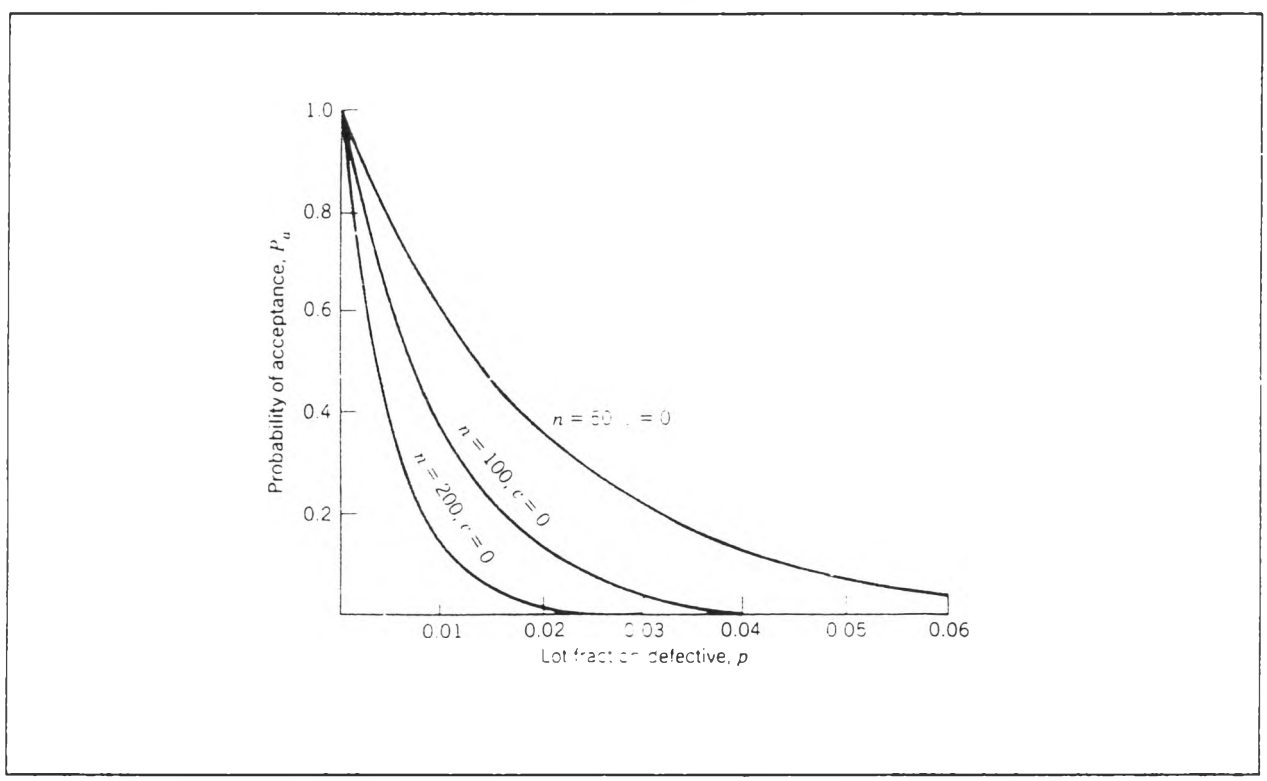

Figure 2.8 : OC Curve for single sampling plan with c = 0 .

Figure 2.8 presents several OC curves for acceptance sampling plans with c = 0. Comparing with figure 2.7. it can be seen that plans with zero acceptance numbers have OC curves that have a very different shape than the OC curves of sampling plans for which c > 0. Generally, sampling plans with c = 0 have OC curves that are convex throughout their range.
As a result of this shape, the probability of acceptance begins to drop very rapidly, even for small values of the lot fraction defective. This is extremely hard on the supplier and in some

circumstances, it may be extremely uneconomical for the consumer. For example, consider the sampling plans in figure 2.7. Suppose that the acceptable quality level is 1 %. This implies that we would like to accept lots that 1 % defective or better. Notice that if sampling plan n = 89, c = 1, is used, the probability of lot acceptance at the AQL is about 0.78. While, if the plan n = 89, c = 0, is used , the probability of acceptance at the AQL is approximately 0.41. That is , nearly 60% of the lots of AQL quality will be rejected if we use an acceptance number of zero. If rejected lots are returned to the supplier, then a large number of lots will be unnecessarily returned, perhaps creating production delays at the consumer 's manufacturing site. If the consumer screen or 100% inspects all rejected lots, a large number of lots that are of acceptable quality will be screened. This is , at best, an inefficient use of sampling resources. An alternative approach to using zero acceptance numbers called chain-sampling plans. Under certain circumstances, chain sampling works considerably better than acceptance - sampling plans with c = 0.

2.2.8 Chain Sampling

In situations where testing is destructive or very expensive, sampling plans with small sample size are usually selected. These small size plans often have acceptance numbers of zero. Plans with zero acceptance numbers are often undesirable, however, in that their OC curves are convex throughout . This means that the probability of lot acceptance begins to drop very rapidly as the lot fraction defective becomes greater than zero. This is often unfair to the producer, and in situations where rectifying inspection is used, it can require the consumer to screen a large number of lots that are essentially of acceptable quality. Figure 2.7 and 2.8 present OC curve of sampling plan that have acceptance numbers of zero and acceptance numbers that are greater than zero.

Dodge(1955) suggested an alternate procedure, known as chain sampling, that might replace the ordinary single sampling plans with zero acceptance number in certain circumstances. Chain sampling plans make use of the cumulative result of several preceding lots. The general procedure is as follows,

1. For each lot , select the sample of size n and observe the number of defectives.
2. If the sample has zero defectives, accept the lot; if the sample has two or more defectives, reject the lot; and if the sample has one defective, accept the lot provided there have been no defectives in the previous i lots.

For a chain - sampling plan given by n = 5, i = 3, a lot would be accepted if there were no defectives in the sample of five, or if there was one defective in the sample of five and no defectives had been observed in the samples from the previous three lots . This type of plan is known as a ChSP-1 plan as shown in figure 2.9 .

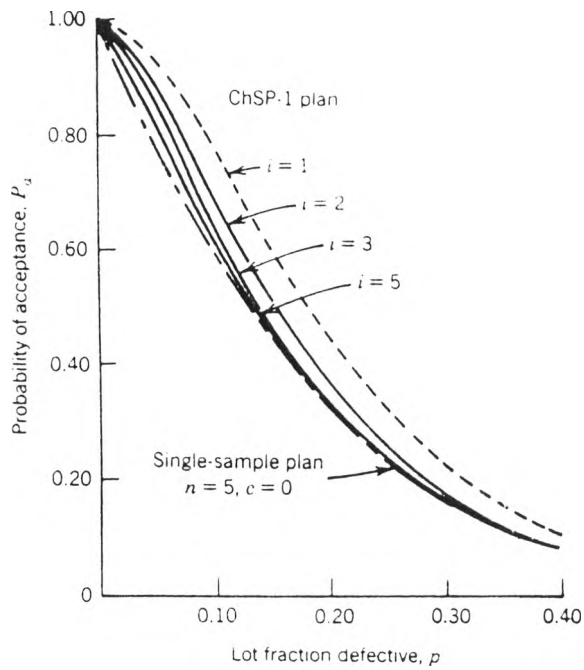

Figure 2.9 : OC curves for ChSP-1 plan with n = 5, c = 0 and i = 1,2,3,5
(Reproduced with permission from H.F Dodge, " Chain Sampling Inspection Plans " Industrial Quality Control, Vol. 11 No. 4, 1955.

The effect of chain sampling is to alter the shape of the OC curve near the origin so that it has a more desirable shape. That is, it is more difficult to reject lots with very small fraction defectives with a ChSP-1 plan than it is with ordinary single sampling. Figure 2.7 shows OC curves for ChSP-1 plans with n = 5, c = 0 , i = 1,2,3 and 5. The curve for i = 1 is dotted, and it is not a preferred choice. In practice, values of i usually vary between three and five, since the OC curves of such plans approximate the single sampling plan OC curve. The point on the OC curve of a ChSP-1 plan are given by the equation

$$P_a = P(0,n) + P(1,n)[P(0,n)]^i$$

where P(0,n) and P(1,,n) are the probabilities of obtaining 0 and 1 defectives, respectively, out of a random sample of size n. To illustrate the calculations, consider the ChSP-1 plan with n = 5, c = 0 and i = 3. For p = 0.10, we have

$P(0,n) = (n!/d!(n-d)!)* p^d(1-p)^{n-d} = (5!/0!5!)*(0.10)^0(0.90)^5 = 0.590$
$P(1,n) = (n!/d!(n-d)!)* p^d(1-p)^{n-d} = (5!/1!(5-1)!) * (0.10)^1(0.90)^4 = 0.328$

$P_a = P(0,n) + P(1,n)[P(0,n)]^i$
$= 0.590 + (0.328)(0.590)^3$
$= 0.657$

The proper use of chain sampling requires that the following conditions be met:

1. The lot should be one of a series a continuing stream of lots, from a process where there is repetitive production under the same conditions, and where the lots of products are offered for acceptance in substantially the order of production.

2. Lots should usually be expected to be of essentially the same quality.

3. The sampling agency should have no reason to believe that the current lot is of poorer quality than those immediately preceding.

4. There should be a good record of quality performance on the part of the supplier.

5. The sampling agency must have confidence in the supplier, in that the supplier will not take advantage of its good record and occasionally send a bad lot when such a lot would be have the best chance of acceptance.

2.2.9 Standard Sampling Plan

Military Standard 105E standard procedures for inspection by attributes is used widely for acceptance system. The original version of the standard, MIL STD 105A, was issued in 1950. Then it is developed to be MIL STD 105E.

The sampling plan theory in this study focuses on the single sampling type. This concept is applied together with normal inspection, tightened inspection, or reduced inspection. Normal inspection is used at the start of the inspection activity. Tightened inspection is used when the product quality history has deteriorated. Acceptance requirements for lots under tightened inspection are more stringent than under normal inspection. Reduced inspection is used in case that the product quality history has been exceptionally good. The sample size generally used under reduced inspection is less than that under normal inspection.

The primary focal point of MIL STD 105E is the acceptable quality level (AQL). The standard is indexed with respect to a series of AQLs. When the standard is used for percent defective plans, the AQL range from 0.1% to 10 %. For defects per units plans , there are an additional 10 AQLs running up to 1000 defects per 100 units. It should be noted that for the

smaller AQL levels, the same sampling plan can be used to control either a fraction defective or a number of defects per unit. The AQLs are arranged in a progression, each AQL approximately 1.585 times the preceding one.

The sample size is defined upon lot size and the choice of inspection level. Three general levels of inspection, level II is designated as normal, level I is about one half the amount of inspection in level II. Level III requires about twice as level II. For a specified AQL and inspection level and a given lot size, MIL STD 105E provides a normal sampling plan that is to be used as long as the supplier is producing the product at AQL quality or better. It also provide a procedure for switching to tightened and reduced inspection whenever there is an indication that the vendor's quality has changed. The switching procedure between normal, tightened and reduced inspection are shown in figure 2.10.

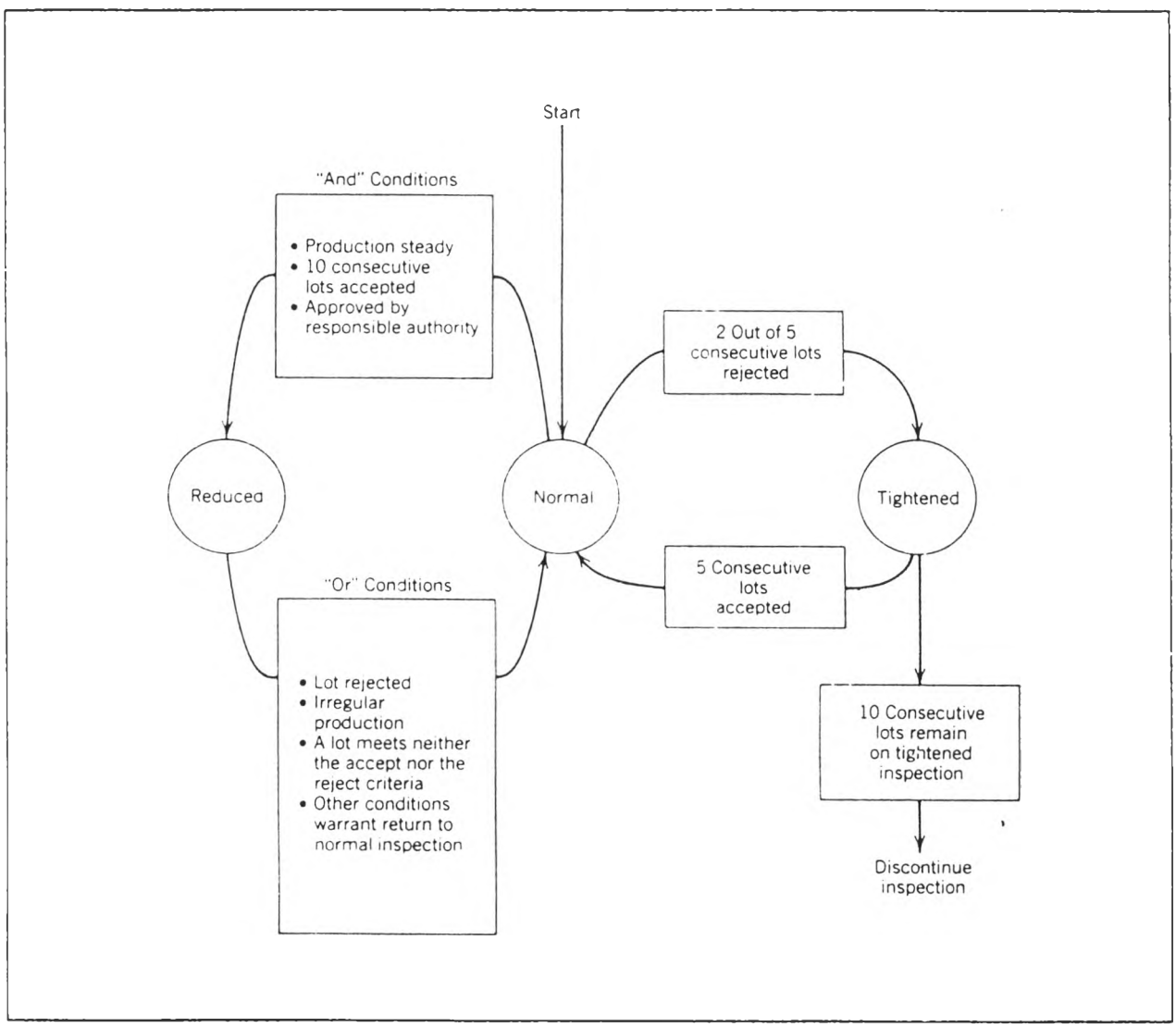

Figure 2.10 : Switching rules for normal, tightened, and reduced inspection

Normal to tightened. When normal inspection is in effect, tightened inspection is instituted when two out of five consecutive lots have been rejected on original submission.

Tightened to normal. When tightened inspection is used for inspection, normal inspection is instituted when five consecutive lots are accepted.

Normal to reduced. Reduced inspection is instituted as the following conditions,

- The preceding 10 lots have been on normal inspection, and none of the lots has been rejected on original inspection.

- Production is in state of control, that is , no difficulty such as machine breakdowns, material shortages, or other problems have recently occurred.

- Reduced inspection is considered desirable by the authority responsible for sampling.

Reduced to normal. When a lot or batch is rejected. When the sampling procedure terminates with neither acceptance nor rejection criteria having been met, the lot or batch is accepted, but normal inspection is reinstituted starting with the next lot. Production is irregular or delayed. And other conditions warrant that normal inspection be instituted.

Discontinuance of inspection. In the event that ten consecutive lots remain on tightened inspection, inspection under the provision of MIL STD 105E should be terminated, and action should be taken at the vendor level to improve the quality of submitted lots.

Table 2.2 presents the sample size code letters for MIL STD 105E. This table is used together with master table for single sampling plan inspection as shown in table 2.3, 2.4, 2.5 that present the single sampling plans for normal inspection, tightened inspection , and reduced inspection, respectively. To illustrate the use of MIL STD 105E, suppose that a product is submitted in lots of size N = 2000. The acceptable quality level is 0.65%. From table 2.2, the lot of size of 2000 under general inspection level II (Normal level), the appropriate sample size code letter is K. Therefore, from table 2.3 single sampling plans for normal inspection is n = 125, c = 2. From table 2.4, indicates that the corresponding tightened inspection plan is n = 125, c=1. Switching from normal to tightened inspection, the sample size remains the same but the acceptance number is reduced by one .This general strategy is throughout MIL STD 105E for a transition to tightened inspection. If the normal inspection acceptance number, is 1,2 or 3, the acceptance number for the corresponding tightened inspection plan is reduced by one. If the normal inspection acceptance number is 5,7,10 or 14, the reduction in acceptance number for tightened inspection is two. For a normal acceptance number of 21, the reduction is three.

	General Inspection Levels		
Lot or Batch Size	**I**	**II**	**III**
2 to 8	A	A	B
9 to 15	A	B	C
16 to 25	B	C	D
26 to 50	C	D	F
51 to 90	C	E	F
91 to 150	D	F	G
151 to 280	E	G	H
281 to 500	F	H	J
501 to 1200	G	J	K
1201 to 3200	H	K	L
3201 to 10000	J	L	M
10001 to 35000	K	M	N
35001 to 150000	L	N	P
150001 to 500000	M	P	Q
500001 and over	N	Q	R

Table 2.2 : Sample size code letters (MIL STD 105E),

(Source: developed from table 13-7 of chapter 13 , introduction To Statistical Quality Control , Douglas C. Montogomery)

2.3 Literature Review

2.3.1 *Quality Audit In Food Production Of Aviation Industry Research*

This study has been done by Miss Supatkul Chaijindasut:The purpose of this study is establish the process to audit quality system in food production factory. After, that improvement plan on quality system for food production factory is proposed to improvement on the factory 's weakness. Audit would be started from incoming inspection for raw material and selection of raw material, quality inspection in the production line. The quality control plans(process management plans) have been establish to identify all processes of food production including inspection gates along the operations.

This study provides the concept of quality improvement in aspect of incoming inspection on the food that its storage will have to be arranged under environment control. Inspection gate and inspection criterion would be identified in according to its quality control plans.

2.3.2 Improvement Of Quality Control System For Sanitary Ware Production Process Research.

This study has been done by Mr. Ananchai Sakolrak. This research is to study the suitable way for the quality control improvement of sanitary ware processing in model factory. The major of raw material is natural thing which causespoor quality control system as incoming inspection control, and also no standard value of raw material inspection criterion, production control and set up the specification for process control.

This study provides guideline in aspect of incominginspection. How to consider the poor quality control at incoming inspection section? How to improve incoming inspection control section such as critical criterion for incoming inspection, process to handle the defective material? The research mentions the quality aspect of raw material which supplies to the manufacturing plant, through the method and point of quality control such lot acceptance rate and line feed back on the material quality and supplier quality evaluation method.

2.3.3 Improvement Of Quality Inspection System In The Production Line Of A Refrigerator Factory Research

This study has been done by Mr. Thana Boonprasit. This study focuses on the improvement of the quality inspection system for incoming inspection. The objective of this study is to improve the efficiency of the quality system from incoming inspection and operation inspection and provide the performance indication system to maintain continuously the efficiency of the operation and ensure the product reliability to the customers.

This study provides the concept of incoming inspection system that would effect to the manufacturing (production line). If incoming inspection method is very weak in its effectiveness such as sampling technique, improper inspection criterion it would create the problems to the operation that cause in low productivity, high rework, sorting cost. The efficiency of the incoming inspection is a important part of the quality system of the factory.