Section IV

Inspection Procedures

PART A
Principles of Inspection

This part of the Handbook covers the general philosophy of inspection as applied at Western Electric locations, where the term "inspection" relates strictly to the activities of personnel reporting to the formal Inspection organization and does not include either process checking or sorting of the product when performed by the Operating organization. The purpose of this Section is to explain the relationship between inspection and process control, and to emphasize the difference between the acceptance-and-rejection procedures used by Inspection and the "operational sorting" which may be done by the shop.

While inspection is not the primary purpose of a quality control program, there are important benefits to be derived from the application of quality control principles to inspection planning. One important by-product is a reduction in the necessary amount of inspection. Another is the fact that, with properly planned inspection, the Operating organization becomes in fact responsible for the quality of its products.

A-1 PLACE OF INSPECTION IN THE QUALITY CONTROL PROGRAM

A quality control program tries to prevent defects by improvement and control of the process. Checks are made by Operating at regular intervals and are used as a basis for action regarding the process; that is, to tell whether the process should be left alone or whether action should be taken to correct undesirable conditions. This action on the process almost invariably results in a steady improvement in quality and at the same time a steady reduction in cost.

However, an overall quality control program requires more than a check on the process. To achieve the objective of satisfactory quality at minimum cost it is necessary to include proper inspection also. The term "inspection" as used here means *"acceptance inspection,"* which consists of examining a specific quantity of product to provide a basis for action with regard to that particular product; that is, to decide whether the product should be accepted and passed on to the user, or whether some other action should be taken, such as scrap, repair, etc.

Acceptance inspection provides, in effect, a check on the adequacy of the process controls. If the process has been controlled satisfactorily by Operating and Engineering, the product should slip past the acceptance inspection without trouble or delay. On the other hand, if the process controls have broken down, Inspection must step in and provide emergency protection by setting up a "screen" and attempting, as effectively as possible, to keep the bad product from getting out.

Emergency inspection is almost never economical. Part of the science of inspection planning consists in keeping inspection at a low economical level during normal conditions and minimizing the amount of time when inspection must furnish emergency protection. The better the control of the process, the less frequent and shorter will be the periods when emergency protection is needed. Thus there is a definite connection between inspection economy and process control.

There is one other way in which Inspection may contribute to the quality control program.

In the early stages of the program, inspection results are frequently used to pinpoint the trouble areas and to determine where process controls are needed. Inspection personnel sometimes take an active part in making the initial measurements or setting up the earliest charts.

It is important, however, that the actual operation of the program in the shop should be left as soon as possible in the hands of Operating and Engineering. Inspection should be a completely separate function which is concerned with evaluating the end result.

A-2 WHY INSPECTION CAN BE REDUCED BUT NEVER COMPLETELY ELIMINATED

One of the aims of a quality control program is to reduce or minimize the amount of inspection performed. However, it is never possible to eliminate inspection entirely. The Inspection organization has certain responsibilities which cannot be delegated to any other organization. One of these is the responsibility of certifying the quantity and quality of the product for Operating payment purposes. This should be done by an organization separate from the one responsible for making the product.

In addition to this, Inspection represents the user. The user may be another Operating organization or it may be the ultimate customer. Acceptance or rejection of the product before it leaves the Operating group can eliminate extensive handling and negotiation which might result later if the user performed his own inspection.

Inspection, therefore, must (1) assure that the Operating organization has performed its functions properly, and (2) provide adequate safeguards against the shipment of defective product. This may be accomplished by examining each unit of product in detail. This is called 100% or "detail" inspection. The same purposes may also be accomplished by reaching a decision to accept or reject the product after examining only part of it. This is called sampling inspection. Sampling inspection is, as a rule, the more economical procedure.

A-3 USES OF SORTING AND SAMPLING INSPECTION

Prior to the start of a quality control program it is quite common for 100% inspection to be performed by the Inspection organization under any of the following conditions:

(1) Where a job is just going into production, or production is extremely limited. In this case it may not be practical to set up sampling.

(2) Where a requirement is so critical that it is felt that every unit must be checked. For example, a defective may be able to cause personal injury.

(3) Where the product is such that continual sorting of defects from the process is necessary to bring the product to an acceptable level of quality. That is, sorting is necessary for quality improvement.

Most of the 100% inspection performed in industry has been done for the third reason.

In a quality control program it is considered proper for the Inspection organization to do 100% inspection for either of the first two reasons. In the third case, however, where sorting is done to improve quality, the Operating organization should do the sorting, while Inspection takes only a sample. This makes the Operating organization responsible for quality, which is an essential element in a quality control program. It also opens the door to much more rapid improvement of the process, by providing an incentive to do away with the operator sorting.

A-3.1 Operational sorting vs. corrective sorting

When sorting is done by the Operating organization, a distinction is made between necessary or unavoidable sorting, resulting from the nature or capability of the operation, and the unnecessary or avoidable sorting which results from failure to do the job properly. Process capability studies are used to determine how much sorting is to be considered unavoidable.

When a process capability study shows that the process is not capable of turning out product of an acceptable quality, even when the processing is properly done, sorting must be provided to weed out the defectives. This type of sorting is known as "operational sorting" because it has been shown to be an essential part of the "make operations."

On the other hand, if the process is capable of turning out product of acceptable quality, but defectives are produced as a result of poor workmanship or failure to run the process properly, sorting to remove these defectives is called "avoidable sorting" or "corrective sorting." If the capability of the process is such that only 2% would be defective normally, but as a result of carelessness or inattention the product has been running 12% defective, then sorting to remove the unnecessary 10% is "corrective sorting."

The following steps may be taken to determine the need for operational sorting:

A. Make process capability studies to find the normal behavior of the process. Eliminate, as far as possible, the assignable causes which are due to failure to run the process properly. If the resultant capability is good enough to meet the required quality standards, no operational sorting is needed.

B. If the normal capability is not good enough to meet the required quality standards, determine what must be done to bring about the necessary improvement. Sometimes the required changes can be introduced by very simple means: For example, putting a chamfer on a fixture, reducing the amount of play in a jig, installing a magnet to hold the parts in position during assembly, changing the operation to a different machine, installing an automatic timer, modifying a requirement, etc. Any of these can result in a significant and rapid improvement. Also, putting control charts in the shop will improve the performance of almost any process that depends largely on the operator's technique. In any case where sufficient improvement can be obtained in a very short space of time, it will not be necessary to make provision for operational sorting.

C. If the capability of the present process is not good enough to meet the quality standards and it is not possible to improve it immediately, operational sorting should be provided as a temporary measure until the process can be improved. The "capability" percentage of defects is obtained from the process capability study.

Except for the rare cases where Inspection may be required to do 100% inspection (new or limited production, or an occasional extremely critical requirement), the relationship between Operating and Inspection in a quality control program should be one of those shown below.

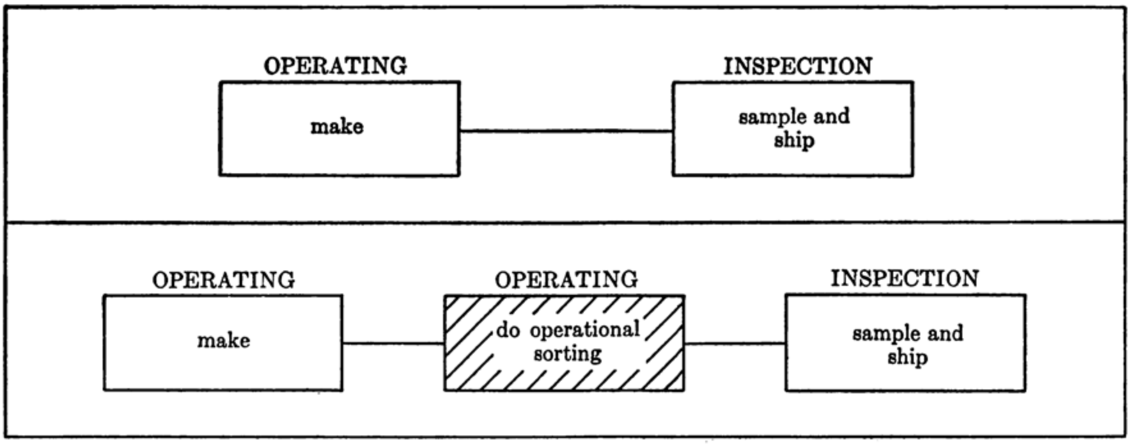

Fig. 225. Permissible relationships between Operating and Inspection.

In any case where the second alternative is used, one of the duties of the Quality Control Team should be to eliminate the operational sorting as soon as possible by process improvement.

A-3.2 Total amount of effort expended in checking the product

In cases where Inspection has been performing 100% inspection and this activity is now to be transferred to the Operating organization as "operational sorting," while Inspection takes a subsequent sample, this will result in a temporary increase in the total amount of checking. There will now be 100% checking by one organization plus an additional sample by another.

However, experience shows that when sorting is transferred to the Operating organization, it is much more likely to be reduced promptly. In a short time the sorting by Operating should be reduced sufficiently to make the total effort of Operating and Inspection considerably less than the original 100% inspection.

A-3.3 Summary of the advantages of sampling inspection

For acceptance purposes, sampling has three advantages over 100% inspection:

(1) It puts the responsiblity for quality in the hands of the Operating organization where it belongs.

(2) It is more economical as far as inspection costs are concerned.

(3) It tends to encourage more rapid improvement of the process than is the case under 100% inspection.

In addition, sampling inspection is usually more accurate than 100% inspection, since it allows less opportunity for "inspection fatigue." Product which has passed 100% inspection is sometimes found to contain a surprising number of defects.

A-4 INSPECTION PLANNING

The cost of inspection is usually small in comparison with the total cost of a product. Nevertheless, inspection procedures can have an important effect not only on the cost of inspection but on the cost of manufacture as well. For this reason inspection procedures of any kind require careful planning. Many individuals can contribute to the successful planning of inspection.

(1) The manufacturing engineer is responsible for planning inspection and for writing a layout describing the inspection procedures.

(2) Quality control engineers generally assist in the statistical aspects of inspection planning, including the selection of suitable quality levels and the provision of suitable inspection methods. In addition to this, they help to check the reasonableness and economy of inspection plans and make sure that consistent practices are followed throughout the plant. They frequently assist in the writing of inspection layouts.

(3) Inspection supervisors contribute many helpful suggestions with respect to inspection planning. Their experience provides a valuable source of information for the manufacturing and quality control engineers.

(4) Shop supervisors should also take part in the planning of inspection, since it has a direct effect on shop procedures and on manufacturing costs. It is advisable for the Quality Control Team to discuss in advance any proposed changes in inspection procedures. This serves to promote good understanding as well as to make sure that the procedures adopted will be practical and economical.

For the purpose of planning or discussing inspection, the inspection supervisor may serve as a temporary member of the Quality Control Team.

PART B
Acceptance Sampling

B-1 ELEMENTARY CONCEPTS

B-1.1 General

Suppose we have a large amount of product which is 4% defective. If we were to take a sample of 100 pieces from this product, and if the sample were exactly representative of the product, we would expect to find four defective pieces in the sample. However, we find from experience that our sample of 100 may contain more or less than four defective pieces. The following is a record of what was actually observed in a series of samples of 100 from product that was known to be 4% defective.

Product Is Actually 4% Defective	
Sample Number	*Number of Defective Pieces in Sample*
1	3
2	2
3	6
4	4
5	3
6	5
7	7
8	5
9	1
10	4

Fig. 226. Varying numbers of defective pieces in samples of 100.

In process control we would plot such samples on a p-chart, and the chart would plainly show a fluctuating pattern. In sampling inspection the results are not ordinarily plotted on p-charts, but use is made of the fluctuating pattern.

A sampling plan establishes a certain limit called an "acceptance number" which defines the maximum allowable number of defects or defectives in a sample. When the sampling fluctuation is such that the allowable number is exceeded, the inspector rejects the product. When the sampling fluctuation is such that the allowable number is not exceeded, the inspector accepts the product. Product of poor quality will have a different fluctuating pattern from product of good quality and because of this the sampling plan will reject a greater proportion of the poor quality product.

A simplified picture of the operation of a sampling plan is shown on page 238.

In the case described, the inspector was told to take samples of 100 and use an acceptance number of 5. At first the incoming product was 4% defective, and two out of 10 samples exceeded the acceptance number. The inspector rejected the product represented by those samples. Later on, when the product became 8% defective, eight of the inspector's samples exceeded the acceptance number. He therefore rejected the product represented by those eight samples.

If the inspector had been told to use an acceptance number of 4, he would have rejected more product which was 4% defective, and almost all of the product which was 8% defective.

Two important things about the operation of a sampling plan are illustrated in this example:

(a) When the product becomes worse, the sampling plan does not necessarily reject all the product which is submitted. It only rejects a larger *proportion* of the product as the quality becomes poorer.

(b) An individual quantity of product which is rejected by the sampling plan is not necessarily worse than a quantity of product which is accepted. A sampling plan is based on the proportion of product, *represented by a long series of samples,* which will, in the long run, be accepted or rejected.

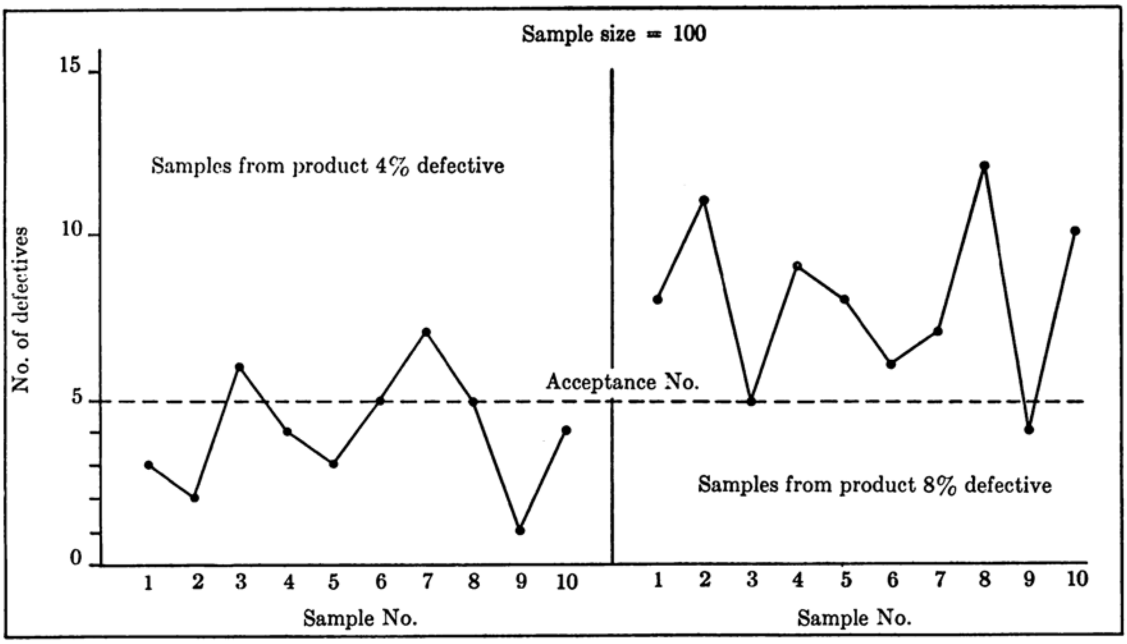

Fig. 227. Operation of a sampling plan as the quality of the product becomes poorer.

B-1.2 Sample size and acceptance number

The sample size is the number of pieces selected to be inspected. It is represented by the symbol "n." The acceptance number, as indicated above, is the largest number of defectives (or defects) in the sample that will permit the product to be accepted. It is represented by the symbol "c." Together, the sample size and acceptance number determine what proportion of product of a given quality will in the long run be accepted or rejected.

In the case of "double" or "multiple" sampling the inspector is given more than one sample size and acceptance number.

B-1.3 Probability of acceptance

The "probability of acceptance" of a sampling plan is the percentage of samples out of a long series of samples which will cause the product to be accepted. If the product is 4% defective and we tell the inspector to take samples of 100 and allow an acceptance number of 5 (as shown in Figure 227), the inspector will in the long run accept about 80% of the product. We say that the probability of acceptance for such product is about 80%. If the product is 8% defective and we tell the inspector to take samples of 100 and use an acceptance number of 5 (as shown in Figure 227), the inspector will in the long run accept about 20% of the product. We say that the probability of acceptance for such product is about 20%.

It is possible to calculate the probability of acceptance for product of any quality using any desired combination of sample size and acceptance number. The probability of acceptance is usually expressed in decimal form rather than as a percentage. It is represented by the symbol "P_a."

B-1.4 OC curves

It is characteristic of sampling plans that the probability of acceptance is large as long as the product is very good and becomes less as the product becomes worse. A complete plotting of the probability of acceptance for product at all possible levels of percent defective is known as an "Operating Characteristic Curve." This term is frequently abbreviated to "OC curve."

Some typical examples of OC curves are shown on page 243. The OC curve for the sampling plan in Figure 227 is shown below.

The OC curve is interpreted as follows:

To find what proportion of product will be accepted if the product is 4% defective, find .04 along the scale at the base of the curve and draw a line vertically upward until it intersects the curve. (See dotted line in Figure 228.) The probability of acceptance can then be read along the left-hand scale opposite the point of intersection.

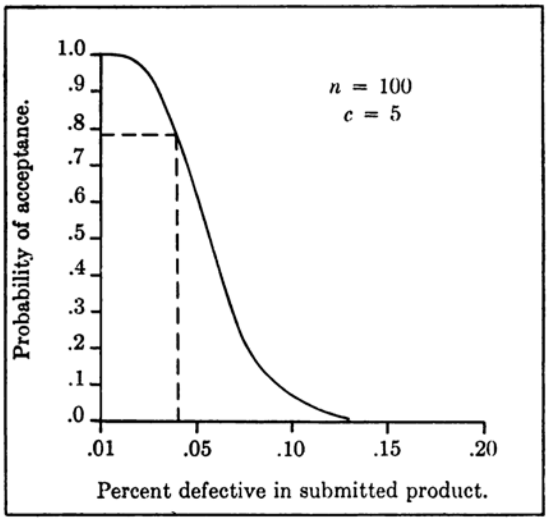

Fig. 228. OC curve for the sampling plan $n = 100$, $c = 5$.

In the above example, the probability of acceptance for product 4% defective is a little less than .8. This means that slightly less than 80% of such product will be accepted. Another way of saying this is that slightly more than 20% will be rejected.

If the product submitted by Operating were 6% defective, about 45% would be accepted and 55% rejected. If the product submitted by Operating were 12% defective, practically all of it would be rejected by an inspector using this plan.

The probabilities of acceptance shown by an OC curve are based on the assumption that samples are drawn at random from the submitted product. If samples are not drawn at random, the calculated probabilities do not apply. A random sample is defined as one selected in such a way that every unit in the product has an equal chance of being chosen in the sample.

By a suitable combination of sample size and acceptance number, it is possible to devise a sampling plan that will reject most of the product that we would like to have rejected and accept most of the product that we would like to have accepted. In most cases the actual choice of a sampling plan is dictated by economic considerations as well as by the probabilities of acceptance and rejection.

B-2 METHODS OF CALCULATING THE PROBABILITY OF ACCEPTANCE

For attributes sampling plans, where each unit of product is classified merely as defective or non-defective, there are three equations which can be used to calculate the probability of acceptance. These are:

a. The Hypergeometric.
b. The Binomial.
c. The Poisson.

Discussions of these equations and their uses can be found in the standard texts. A simplified explanation is given in Reference No. 20.

The Poisson equation is the most widely used of these three. It is used, with certain restrictions, not only where the inspector counts the *defective units*, but also where he counts the *actual number of defects*. Since the Poisson equation is used in many of the situations encountered in practical work, all examples of probabilities of acceptance in this Handbook, unless otherwise noted, will be Poisson probabilities.

The Poisson probabilities can be found in convenient published tables and curves. Two useful sources are the following:

(1) The numerical probabilities, carried out to 6 decimal places, are given in the book "Poisson's Exponential Binomial Limit" by E. C. Molina (D. Van Nostrand Company, New York, 1947). Two tables are provided—individual terms in Table I and cumulative terms in Table II.

(2) The probabilities can also be read more roughly from a set of curves based on the Poisson equation. A set of Poisson curves is shown in Figure 229.

To determine the probability of acceptance, using the Poisson tables or curves, begin by determining:

"n" (the size of the sample).
"p" (the proportion of defectives or defects in the product).
"c" (the acceptance number which is to be used by the inspector).

It is not necessary to know p and n individually if we know the product of these two — the "expected number of defects," pn.

In Molina's tables the product of $n \times p$ is called "a." On the curves in Figure 229 the product of $n \times p$ is called "pn."

B-2.1 How to use Molina's Tables

To calculate the probability of acceptance for a single sampling plan (that is, a plan which tells the inspector to accept or reject on the basis of a single sample), proceed as follows:

(1) Start with the combination of sample size and acceptance number which you wish to study. Call the sample size "n" and the acceptance number "c."

(2) Take any percent defective value in which you are interested. Express it as a decimal. Call this "p."

(3) Multiply $n \times p$ to obtain "a."

(4) Consult Molina's Table II (Cumulative Terms). Look up the value of "a" obtained in Step 3. Follow down in the table until you come to $c + 1$ defects. For example, if the acceptance number in your sampling plan is 4, follow down in the Table until you come to 5. The probability opposite $c + 1$ defects is the probability of rejection.

(5) Finally calculate the probability of acceptance. This is always 1 minus the probability of rejection.

Example:

For the sampling plan $n = 100$, $c = 5$, find the probability of acceptance where $p = 8\%$.

$$n \times p = 100 \times .08 = 8$$

Look up "$a = 8$" in Molina's Table II. Follow down in the table until you come to $5 + 1$ (or 6) defects. The probability of rejection is .808764.

Subtracting this from 1, we get .191236. This is the probability of acceptance. It can also be expressed as 19.1%.

B-2.2 How to use the curves in Figure 229

(1) Start with the combination of sample size and acceptance number which you wish to study. Call the sample size "n" and the acceptance number "c."

(2) Take any percent defective value in which you are interested. Express it as a decimal. Call this "p."

(3) Multiply $n \times p$ to obtain "pn."

(4) Look up the value of "pn" on the scale at the bottom of Figure 229. Follow upward along that vertical line until it intersects the curve which corresponds to the acceptance number "c." Then move horizontally to the left and find the probability of acceptance along the left-hand vertical scale.

Example:

For the sampling plan $n = 100$, $c = 5$, find the probability of acceptance where $p = 8\%$.

$$n \times p = 100 \times .08 = 8$$

Read up on the vertical line at 8 to the heavy curve marked 5. Then read across to the left-hand scale. The probability of acceptance is approximately .19, or 19%.

B-2.3 Calculating and plotting an OC curve

To plot an OC curve for a single sampling plan proceed as follows:

(1) Set up a table of various values of percent defective as shown in Figure 230.

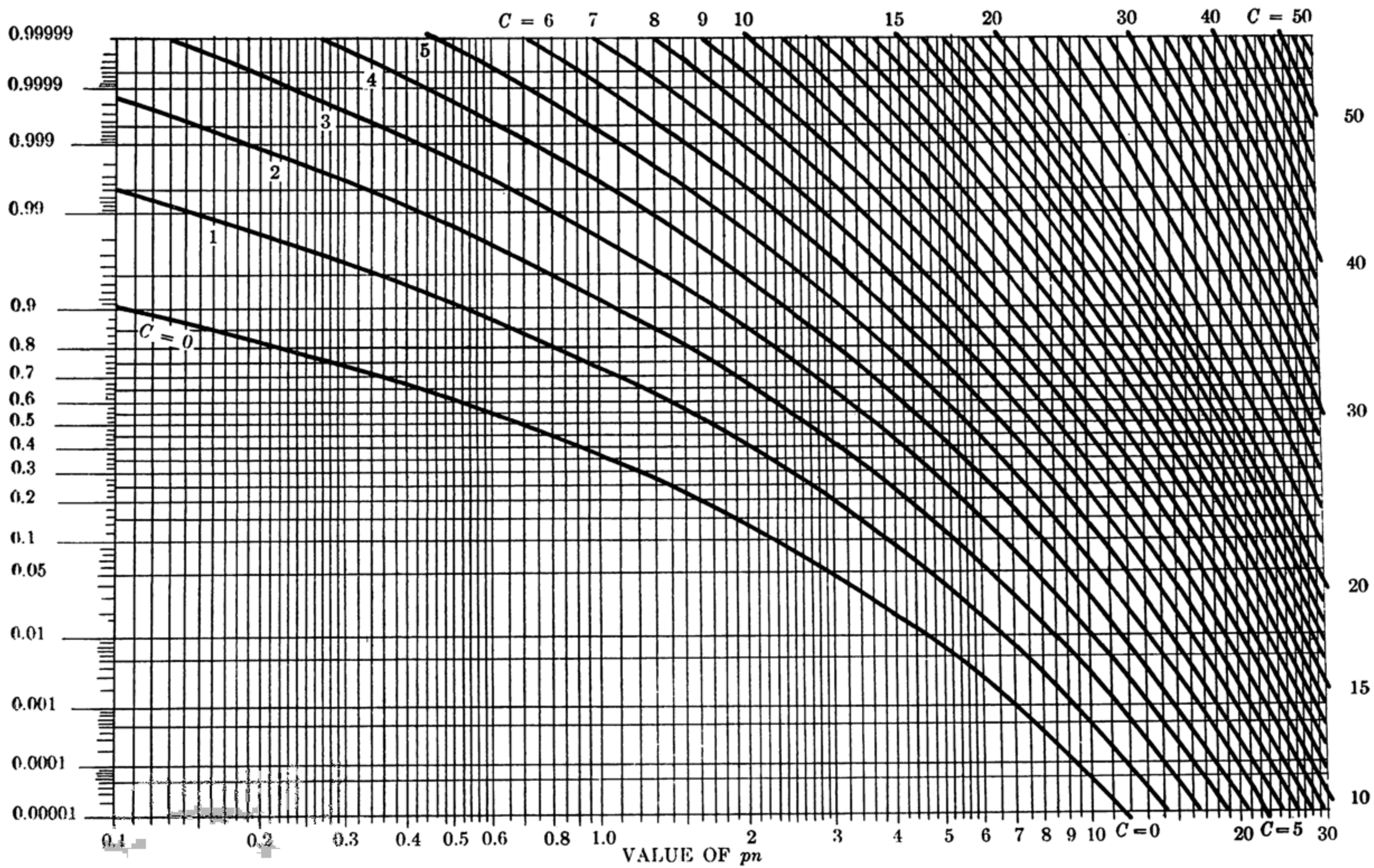

Fig. 229. Poisson curves.

Sampling Plan $n = 100, c = 5$

p	"pn" or "a"	Probability of Acceptance
.01	1	.999
.02	2	.983
.03	3	.916
.04	4	.785
.05	5	.616
.06	6	.446
.07	7	.301
.08	8	.191
.09	9	.116
.10	10	.067
.11	11	.048
.12	12	.020
.13	13	.011

Fig. 230. Calculations required for plotting an OC curve.

Express "p" (the percent defective) as a decimal fraction. Make the values of "p" cover a suitable range of both good and bad product.

(2) Fill in the second column in the table by multiplying each of the listed values of "p" by "n." If "n" is 100, the values in the second column will be 1, 2, 3, etc.

(3) Find the probability of acceptance by using either Molina's Tables or the curves in Figure 229.

(4) Plot the probability of acceptance corresponding to each value of "p" as shown in Figure 228. If a number of OC curves are to be compared, be sure to use the same horizontal and vertical scales.

B-2.4 Probability of acceptance for other than single sampling plans and for cases where it is not appropriate to use Poisson probabilities

For double or multiple sampling plans, where the inspector may take two or more samples before reaching a decision to accept or reject, the probability of acceptance is more difficult to calculate. The calculations are explained in Reference No. 20. It is also more difficult to calculate the probability of acceptance for a "variables" type sampling plan. A discussion of this is given in Reference No. 4.

In some situations it is necessary to use the Hypergeometric or Binomial equations rather than the Poisson. Binomial probabilities have been published in tables rather similar to the Poisson tables. One useful source is "Applied Mathematics Series No. 6, Tables of the Binomial Probability Distribution," published by the Government Printing Office in Washington, D. C.

In certain cases, particularly in thc case of some of the most frequently used plans, OC curves have already been plotted and published. In these cases it is not necessary to make the calculations at all. One example of this is the Mil.-Std. 105A tables (see Reference No. 30) which show approximate OC curves for single, double and multiple sampling plans. OC curves are also available for many of the sampling plans in the Dodge-Romig tables (Reference No. 11). In Bowker and Goode's "Sampling Inspection by Variables" (Reference No. 4), OC curves are given for single and double variables-type plans.

Caution should be used in comparing, or drawing conclusions from, published OC curves, since the curves may not be plotted on comparable scales.

B-3 ECONOMIC IMPORTANCE OF OC CURVES

An OC curve can be plotted for any combination of sample size (n) and acceptance number (c). Each combination results in a different curve. Some of the most important things to remember about OC curves can be seen by comparing the curves in Figure 231.

Note that, in general, a larger sample size tends to result in a steeper curve. Such plans are said to have greater "discriminating power" than plans with smaller samples and shallower curves. Plan A has greater discriminating power than Plan B. This means that it can distinguish more sharply between products having different percents defective.

Note also that a larger acceptance number tends to change the shape of the curve, creating a flat "shoulder" at the top while retaining a thin "tail" at the bottom. Plans E and F have more pronounced shoulders than Plans G and H or plans C and O.

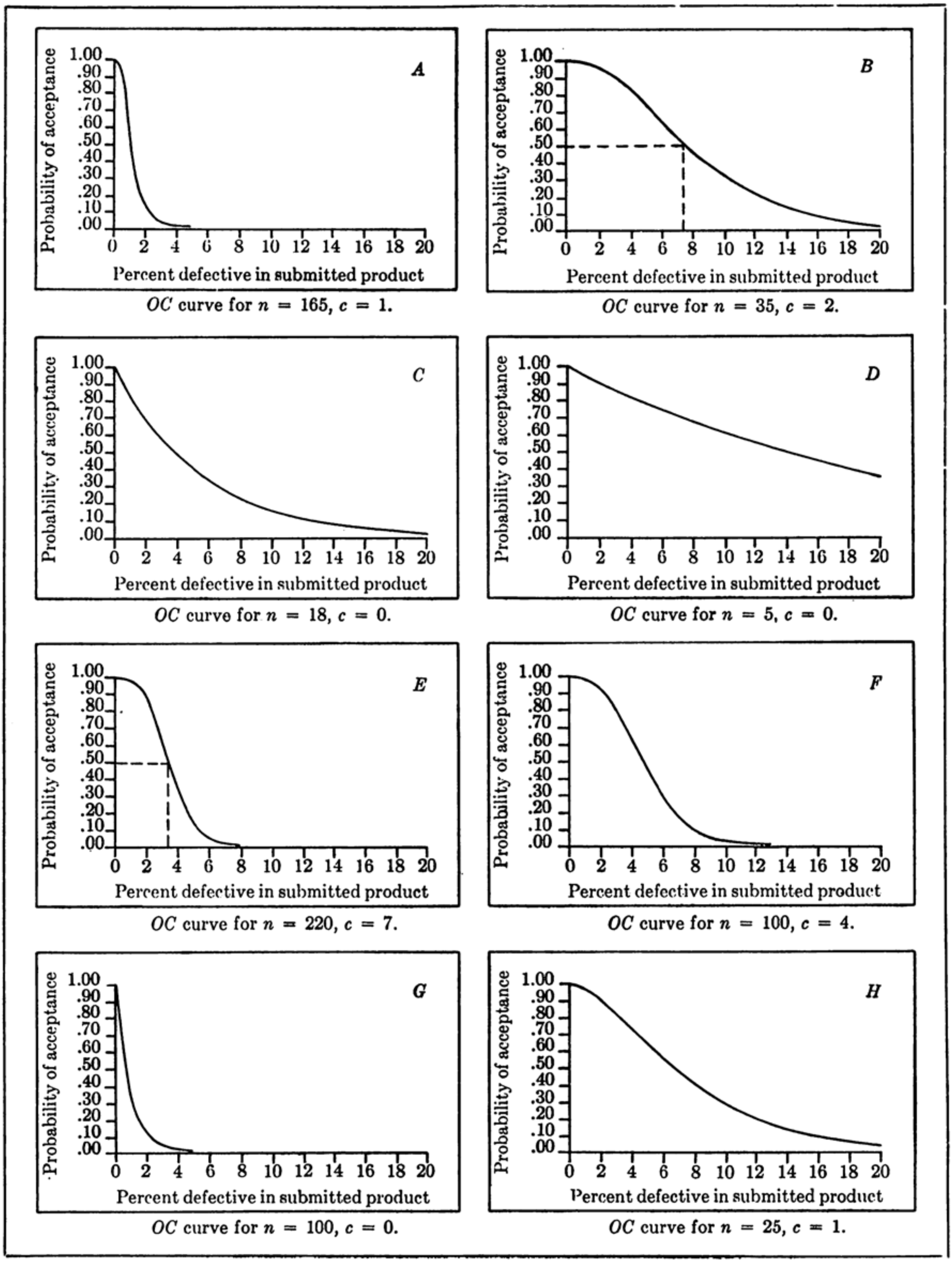

Fig. 231. OC curves for some frequently used sampling plans.

In learning to use an OC curve, it is helpful to think of the curve as "beginning" (with respect to the percent defective scale at the bottom) at zero; and as "extending" to the point where the tail approaches the bottom line. The curve in Plan G extends to about 5% defective. The curve in Plan D extends beyond the confines of this particular diagram, which is plotted only to 20% defective.

It is also helpful to think of the OC curve as having three parts in which we are primarily interested:

(1) *The shoulder (or peak) at the top.* This may be a flat portion extending for a considerable distance as in Plan F or Plan B; or it may be only a sharp peak as in Plans C and G.

This part of the curve is important because it shows the quality of product that will be accepted by the sampling plan without question. Plan F will accept practically all product up to about 2% defective. Plan A will accept practically all product up to 0.5% defective. Plan C will reject part of the product if it is anything but 0% defective.

(2) *The thin part of the tail at the bottom.* The thin part may be short and sharp as in Plans A and G, or it may extend for considerable distances as in Plans H and C.

This part of the curve is important because it shows the quality of product that is almost certain to be rejected by the plan. Plan A will reject virtually all product if it is worse than about 3% defective. Plan H will not reject comparable quantities of product unless it is more than 20% defective.

(3) *The middle portion of the curve, between the shoulder and the tail.* At the exact center of the curve, where the probability of acceptance is 50%, product of the corresponding quality has a 50-50 chance of being either rejected or accepted.

Example:

If the plan in use is B, product which is 7.5% defective will have about a 50-50 chance of being accepted.

If the plan in use is E, product which is 3.5% defective will have about a 50-50 chance of being accepted.

The above examples illustrate the importance of knowing the OC curve in selecting a sampling plan for use on a given product. In general, the engineer should make sure that the "shoulder" of the curve corresponds to the product he is willing to have accepted, and that the "tail" of the curve corresponds to the product he is willing to have rejected.

Maximum economy is likely to be obtained when the process is running at or near its capability level and when this capability matches the shoulder of the OC curve to be used.

B-3.1 Producer's risk

Sampling plans are often spoken of as having a certain "Producer's Risk." The Producer's Risk is defined as the probability or risk of rejecting the product when the lot quality or process quality, as the case may be, is relatively good. For engineers and supervisors, this means the risk that the normal product made by Operating will be rejected by Inspection. The engineer tries to see that the Producer's Risk is kept as small as possible.

To estimate the Producer's Risk of a sampling plan proceed as follows:

(1) First plot the OC curve for the sampling plan you wish to study.

(2) Find the percent defective in the process when it is running at its capability. For exploratory purposes it is sufficient to make a rough estimate. For a more accurate check, it is necessary to have a process capability study or shop control chart.

(3) Find this process capability percentage on the scale below the OC curve, and use the curve to determine the probability of acceptance.

(4) Take the difference between this probability of acceptance and 1. This is the Producer's Risk for the particular process capability which you are using in your estimate.

It would be possible to calculate the Producer's Risk directly, without first plotting the

OC curve. Merely take the process capability percentage determined in Step 2 and calculate the probability of rejection as explained on page 240. However, most engineers and supervisors are interested in the entire region around the process capability level. For this it is desirable to have the complete OC curve.

Example:

Refer to the OC curve in Figure 228. Suppose the process runs normally at 3% defective. Following up at 3% until we reach the curve, we find that this corresponds to a probability of acceptance of about 92%. The Producer's Risk, for this particular process, is the difference between 92% and 100%, or 8%.

B-3.2 Consumer's risk

Sampling plans are also said to have a certain "Consumer's Risk." The Consumer's Risk is defined as the probability or risk of accepting the product when the lot quality or process quality, as the case may be, is relatively poor. For engineers and supervisors, this means the risk that product considered unsatisfactory to the customer may be accepted by Inspection. The engineer tries to see that the Consumer's Risk also is kept as small as possible, considering the needs of the user in each particular case.

The Consumer's Risk of a sampling plan can be estimated as follows:*

(1) First plot the OC curve for the sampling plan you wish to study.

(2) Discover the percent defective which the consumer wants to reject. This is interpreted as meaning the quality which is so poor that the consumer would be willing to accept it only a small percent of the time.

(3) Find this value on the scale below the OC curve, and use the curve to determine the probability of acceptance. This gives the risk of accepting unsatisfactory quality under the conditions assumed in Step 2, *provided* that product of such poor quality is actually submitted.

As in the case of the Producer's Risk, it would be possible to calculate the Consumer's Risk directly without plotting the OC curve. However, engineers and supervisors (as well as customers) are generally interested in the entire region around the percent defective which was chosen in Step 2. For this reason, it is an advantage to have the complete OC curve.

Example:

Refer to the OC curve shown in Figure 228. Suppose the consumer wants to reject product which is 9% defective. Reading up at this point until we reach the curve and then across to the probability of acceptance, we find it is approximately 10%. This is the Consumer's Risk for product of the assumed percent defective.

In the same way, the Consumer's Risk could be calculated for any other percent defective.

It is important to note that the Consumer's Risk of 10%, which was calculated above, does not mean that the consumer has a 10% chance of receiving poor product. The meaning of the Consumer's Risk is that such product would have a 10% chance of being accepted *if it were actually submitted to Inspection.* However, if the process is running near its capability, and if that capability is near the shoulder of the curve, then product as bad as 9% defective would probably not be made. In that case no 9% defective product would be submitted to Inspection, and the real risk of receiving poor quality product would be practically zero.

B-3.3 Costs associated with Producer's and Consumer's Risks

The engineer will find that every part of the OC Curve is associated in some way with the costs of running the job. He should try to select a curve that will minimize this cost. Many of the most important costs are associated with the Producer's Risk: that is, with the risk of having product rejected when it is relatively good product.

* In "Sampling Inspection Tables," by Dodge and Romig, the term "Consumer's Risk" is defined more restrictively than it is defined here. For information on this consult the index in Reference No. 11.

(1) When lots are rejected unnecessarily they must not only be re-checked but must also be loaded and unloaded and trucked about from place to place.

(2) Storage space has to be provided for lots that are being held up.

(3) The unnecessary checking and rechecking may hold up testing facilities that are badly needed for more productive work.

(4) The Operating routine is interrupted unnecessarily.

(5) The repeated handling and checking may make the quality of shipped product worse instead of better.

(6) If the screening of rejected lots is done by Operating, further inspection must be done afterward before the product is finally accepted.

(7) There may be costly delays in getting hold of needed parts.

In addition to all the above, the economic gains which result from a quality control program are due primarily to the increased stability of the production process. Rejection of "normal" product to Operating does not tend, in general, to promote stability of the process.

There are also costs associated with the Consumer's Risk: that is, with the chance that unsatisfactory product will be accepted and sent out. These costs include the effect on customer good will; the cost of handling and answering complaints; the cost of investigations and conferences; a possible effect on the overall quality rates; additional expenditures of engineering effort and time.

Against these two costs the engineer must balance the cost of the inspection itself. As a rule, large sample sizes and large acceptance numbers will provide a better balance between the Producer's and Consumer's risks, but the large samples may be expensive or impractical. Among the things which can be done to avoid these large samples are the following:

(1) Set up a sampling plan with two inspection levels instead of one—the first level to be used when the process is running normally, and the second level to be used when quality is seriously threatened. The emphasis can then be put on the Producer's Risk during normal periods and on protection of the consumer during periods of trouble. One way of doing this is shown on pages 273–274.

(2) Set up a control chart to be used during normal periods instead of a formal sampling plan. When quality is satisfactory as it comes from Operating, this plan will operate with a fairly large Consumer's Risk. However, if the incoming quality shifts to an unsatisfactory level, this will tend to show up in the pattern on the control chart. This can be used to set in motion some pre-determined action which will furnish additional protection to the consumer: for example, reversion to a standard-type sampling plan until the abnormal period is over.

B-4 CLASSIFICATION OF SAMPLING PLANS ACCORDING TO AQL, LTPD AND AOQL

B-4.1 AQL sampling plans

Suppose we have plotted the OC curves for a number of different sampling plans as on page 243. It is possible to classify these curves in various ways for convenience. For example, we might group together all the curves which have a high probability of acceptance for product 2% defective. These would include Plans B, D, E, F and H.

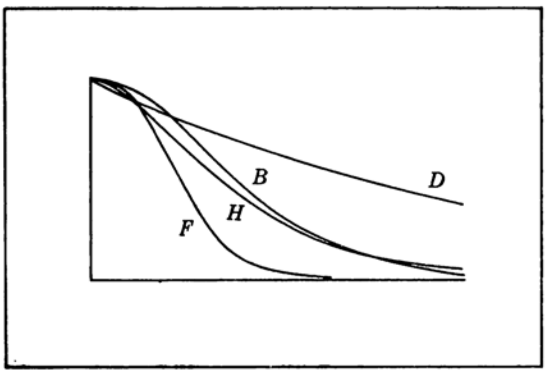

Fig. 232. 2% AQL sampling plans.

Note that these plans are fairly similar at the shoulder (the product they will accept) but are not at all similar at the tail (the product they will reject). Plans classified on this basis are called AQL (Acceptable Quality Level) sampling plans because their point of similarity is the product that will be accepted.

AQL is defined as "the maximum percent defective (or the maximum number of defects per 100 units) which can be considered satisfactory as a process average." To engineers and supervisors, this means the maximum percent defective which will be accepted regularly by Inspection, or in other words, the maximum percent defective for which the probability of acceptance is very high.

When an engineer chooses a "2% AQL sampling plan," he is choosing a plan which will regularly accept 2% defective product. The fact that the plan is classified as "2% AQL" does not tell him anything about the remainder of the OC curve—that is, about the product that will regularly be rejected.

Government purchase contracts frequently specify AQL's for various groups of inspection items. In such cases, the government inspection agency will select a sampling plan which has a high probability of acceptance at the specified AQL.

To make it easier for government inspectors to select sampling plans on this basis, the U. S. Department of Defense has published a book of sampling plans classified according to their AQL's. See Reference No. 30. This book is popularly referred to as the "Mil. Std. 105A Tables." It covers a range of AQL's from .015% defective to 10% defective. Other AQL's for use with complicated equipments and products are expressed in terms of "defects per 100 units."

These plans are widely used in industry as well as by the Army, Navy and Air Force. They provide a useful classification of sampling plans wherever we wish to make sure that the product in which we are interested will have a high probability of acceptance.

Two of the sampling plans shown on page 243 can be found in the Mil. Std. Tables: Plans H and B. These could properly be called 2% AQL sampling plans but the Mil. Std. Tables do not happen to list plans for 2% defective. Consequently, these two plans are listed under 2.5% AQL. The instructions at the beginning of the tables tell us to use the 2.5% plans for specified AQL's ranging from 1.65% to 2.79% defective.

A typical AQL sampling table is shown in Figures 233 and 234. The captions give a general idea of how the table is used. For further information see Reference No. 30.

AQL SAMPLING TABLE

TABLE III. Sample Size Code Letters

Lot Size	Inspection Levels I	II	III
2 to 8	A	A	C
9 to 15	A	B	D
16 to 25	B	C	E
26 to 40	B	D	F
41 to 65	C	E	G
66 to 110	D	F	H
111 to 180	E	G	I
181 to 300	F	H	J
301 to 500	G	I	K
501 to 800	H	J	L
801 to 1300	I	K	L
1301 to 3200	J	L	M
3201 to 8000	L	M	N
8001 to 22,000	M	N	O
22,001 to 110,000	N	O	P
110,001 to 550,000	O	P	Q
550,001 and over	P	Q	Q

Fig. 233. Excerpt from Mil. Std. 105A Tables: table for determining the size of the sample. To use this table proceed as follows:

(a) Determine the usual lot size in which product will be submitted.
(b) Find the corresponding letter in the column headed "Inspection Level II."
(c) Use this letter to find the appropriate sample size and acceptance number in Figure 234.

A government inspector will normally use the letters in Inspection Level II. Level I is looser than Level II, and Level III is tighter.

AQL SAMPLING TABLE

TABLE IV-A. Master Table for Normal and Tightened Inspection (single sampling)

Sample Size Code Letter	Sample Size	Acceptable Quality Levels (normal inspection)—in percent												
		0.015	0.035	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↕
D	7	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↕	↕
E	10	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↕	↕	1 2
F	15	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↕	↕	1 2	2 3
G	25	↓	↓	↓	↓	↓	↓	↓	0 1	↕	↕	*1 2	2 3	3 4
H	35	↓	↓	↓	↓	↓	↓	0 1	↕	↕	1 2	†2 3	3 4	5 6
I	50	↓	↓	↓	↓	↓	0 1	↕	↕	1 2	2 3	3 4	4 5	6 7
J	75	↓	↓	↓	↓	0 1	↕	↕	1 2	2 3	3 4	4 5	6 7	9 10
K	110	↓	↓	↓	0 1	↕	↕	1 2	2 3	3 4	4 5	6 7	8 9	12 13
L	150	↓	↓	0 1	↕	↕	1 2	2 3	3 4	4 5	5 6	8 9	11 12	17 18
M	225	↓	0 1	↕	↕	1 2	2 3	3 4	4 5	5 6	8 9	11 12	17 18	24 25
N	300	0 1	↕	↕	1 2	2 3	3 4	4 5	5 6	7 8	10 11	14 15	20 21	32 33
O	450	↕	↕	1 2	2 3	3 4	4 5	5 6	7 8	10 11	14 15	20 21	29 30	43 44
P	750	↕	1 2	2 3	3 4	4 5	6 7	8 9	11 12	15 16	20 21	31 32	45 46	68 69
Q	1500	1 2	2 3	3 4	5 6	7 8	9 10	13 14	18 19	25 26	35 36	56 57	81 82	124 125
		0.035	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10.0
		Acceptable Quality Levels (tightened inspection)—in percent												

* This is Plan H.
† This is Plan B.

Fig. 234. Excerpt from Mil. Std. 105A Tables: table for selecting sample size and acceptance number. To use this table, select the appropriate "sample size code letter" from Fig. 233, get the sample size from column 2 and read the acceptance number under the proper value of AQL. This table shows a "rejection number" as well as an acceptance number. The rejection number is one more than the acceptance number.

B-4.2 LTPD sampling plans

Referring again to the OC curves on page 243, we might decide to group together all the curves which have a low probability of acceptance for product 2% defective. These would include Plans A and G.

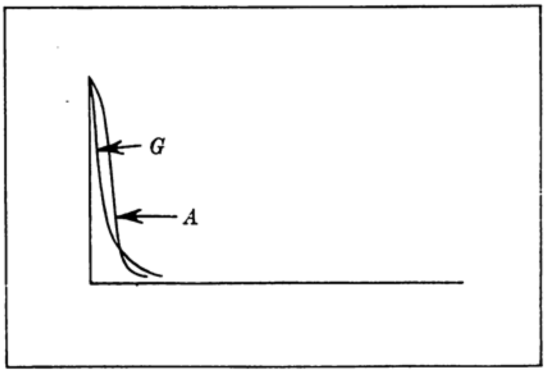

Fig. 235. 2% LTPD sampling plans.

These plans are fairly similar at the tail (the product they will reject) but are not necessarily similar at the shoulder (the product they will accept). Plans classified on this basis are called LTPD (Lot Tolerance Percent Defective) sampling plans because their point of similarity is the quality level or percent defective which can just be tolerated in a small percentage of the product.

LTPD is defined in the Dodge-Romig "Sampling Inspection Tables" as "an allowable percentage defective; a figure which may be considered as the borderline of distinction between a satisfactory lot and an unsatisfactory one." To engineers and supervisors this means the percent defective which will regularly be rejected by Inspection—that is, the percent defective for which the probability of acceptance is very low.

When an engineer chooses a "2% LTPD sampling plan," he is choosing a plan which will regularly reject 2% defective product. The fact that the plan is classified as "2% LTPD" does not tell him the characteristics of the remainder of the OC curve—that is, what quality of product will regularly be accepted.

Customers sometimes specify a certain value of LTPD for a particular product. In such cases, the manufacturer of the product will try to select a sampling plan which has a low probability of acceptance at the specified LTPD.

To make it easier to select sampling plans on this basis, Dodge and Romig have published tables of sampling plans classified according to their LTPD's. See Reference No. 11. The values of LTPD range from 0.5% to 10% defective. These tables provide a useful classification of sampling plans wherever we wish to make sure that product of a particular quality will have a low probability of acceptance.

Both of the sampling plans shown in Figure 235 can be found in the Dodge-Romig LTPD Tables. In Dodge-Romig notation, LTPD is denoted by the symbol "p_t%."

A typical LTPD sampling table is shown on page 250. The caption gives a general idea of how the table is used. For further information see Reference No. 11.

B-4.3 AOQL sampling plans

It is possible to classify sampling plans on a third basis also, according to their AOQL (Average Outgoing Quality Limit). The AOQL is a value which can be calculated for any sampling plan that is used for product which can, if necessary, be 100% inspected. The AOQL is a "limiting value of percent defective" which becomes associated with the sampling plan as soon as we make provision for doing 100% inspection on all lots rejected by the plan. In any case where 100% inspection cannot or will not be done on all rejected lots, do not attempt to select a sampling plan on the basis of its AOQL.

The meaning of the term AOQL can be illustrated as follows. Consider the sampling plan labeled "C" on page 243. When product is 2% defective, this plan will accept approximately 70% of it; when product is 4% defective, it will accept approximately 50%; when product is 8% defective, it will accept approximately 25%, etc.

Suppose we make a rule that all lots rejected by this sampling plan must be 100% inspected; that all defective units found by this inspection must be replaced with good units; and that the rejected lots which have had all defects removed must then be considered together with the accepted lots in such a way as to make one total quantity of product. It is possible to

LTPD SAMPLING TABLE

TABLE SL-7. Lot Tolerance Percent Defective = 7.0%

Process Average, %	0–.07			.08–.70			.71–1.40			1.41–2.10			2.11–2.80			2.81–3.50		
Lot Size	*n*	*c*	AOQL, %	*n*	*c*	AOQL, %	*n*	*c*	AOQL, %	*n*	*c*	AOQL, %	*n*	*c*	AOQL, %	*n*	*c*	AOQL, %
1–25	All	0	0	All	0	0	All	0	0	All	0	0	All	0	0	All	0	0
26–50	24	0	.80	24	0	.80	24	0	.80	24	0	.80	24	0	.80	24	0	.80
51–100	28	0	.95	28	0	.95	28	0	.95	28	0	.95	28	0	.95	28	0	.95
101–200	30	0	1.0	30	0	1.0	49	1	1.3	49	1	1.3	49	1	1.3	65	2	1.4
201–300	31	0	1.1	31	0	1.1	50	1	1.4	70	2	1.5	85	3	1.6	85	3	1.6
301–400	32	0	1.1	55	1	1.4	70	2	1.6	90	3	1.7	105	4	1.8	125	5	1.8
401–500	32	0	1.1	55	1	1.4	75	2	1.6	90	3	1.8	110	4	1.9	140	6	2.0
501–600	32	0	1.1	55	1	1.4	75	2	1.7	95	3	1.8	125	5	2.0	145	6	2.1
601–800	32	0	1.1	55	1	1.4	75	2	1.7	110	4	2.0	130	5	2.1	160	7	2.2
801–1,000	33	0	1.1	55	1	1.4	95	3	1.9	110	4	2.1	145	6	2.2	180	8	2.4
1,001–2,000	55	1	1.5	75	2	1.8	95	3	2.0	130	5	2.3	185	8	2.5	230	11	2.8
2,001–3,000	55	1	1.5	75	2	1.8	115	4	2.1	150	6	2.4	215	10	2.8	300	15	3.0
3,001–4,000	55	1	1.5	75	2	1.8	115	4	2.2	165	7	2.6	235	11	2.9	330	17	3.2
4,001–5,000	55	1	1.5	75	2	1.8	130	5	2.4	185	8	2.7	250	12	3.0	350	18	3.3
5,001–7,000	55	1	1.5	75	2	1.8	130	5	2.4	185	8	2.7	270	13	3.1	385	20	3.4
7,001–10,000	55	1	1.5	95	3	2.0	150	6	2.5	200	9	2.9	285	14	3.2	415	22	3.6
10,001–20,000	55	1	1.5	95	3	2.0	*150	6	2.5	220	10	2.9	320	16	3.3	470	25	3.7
20,001–50,000	55	1	1.5	115	4	2.2	170	7	2.6	235	11	3.1	355	18	3.5	530	29	3.9
50,001–100,000	55	1	1.5	115	4	2.2	185	8	2.7	270	13	3.1	370	19	3.5	530	29	3.9

n = Size of Sample; entry of "All" indicates that each piece in lot is to be inspected.
c = Allowable Defect Number for Sample.
AOQL = Average Outgoing Quality Limit. This is given as supplementary information.

* This plan appears also in Figure 240.

Fig. 236. Excerpt from "Sampling Inspection Tables" by Dodge and Romig: 7% LTPD. To use this table, determine (1) the usual lot size and (2) the "process average" (percent defective at which the product normally runs). The sample size is given in column "*n*" under the applicable process average, and the acceptance number is given in column "*c*." Ignore the AOQL column unless you plan to use this as an AOQL plan also.

calculate the percentage of defectives which will be left in the mass of product if this procedure is followed. For example, when product is 4% defective, about 50% of the lots will be passed without screening while 50% will be rejected and then "100% inspected." Since half of the product will now be free from defects (theoretically) and the other half of the product will still be 4% defective, the average percent defective in the total product will be half of 4%, or 2% defective.

This is expressed as follows:

$$\text{AOQ} = p \times P_a \times \frac{N - n}{N}$$

where

AOQ = the Average Outgoing Quality.

p = the percent defective.

P_a = the probability of acceptance.

n = size of the sample.

N = size of the lot from which the sample is taken.

This equation can be used to calculate the AOQ value for various sampling plans and various values of percent defective. For example, assume that we are using the sampling plan labeled "C" on page 243, and that the lot size is 2000. We first calculate the probability of acceptance using Molina's tables and, from this, the average outgoing quality.

Incoming % Defective	*Probability of Acceptance*	*AOQ*
2%	.698	1.38%
4%	.487	1.93%
8%	.237	1.88%
12%	.115	1.37%
16%	.056	0.89%

These values of AOQ may be plotted on a chart having an appropriate vertical scale for AOQ (in percent defective) and having the same horizontal scale for the incoming product (in percent defective) that was used in Plan "C." The AOQ curve is shown in Figure 237.

This curve shows that when the incoming product is 10% defective, the outgoing product will be only 1.6% defective—provided the requirements of the sampling plan, including 100% inspection, have been faithfully carried out.

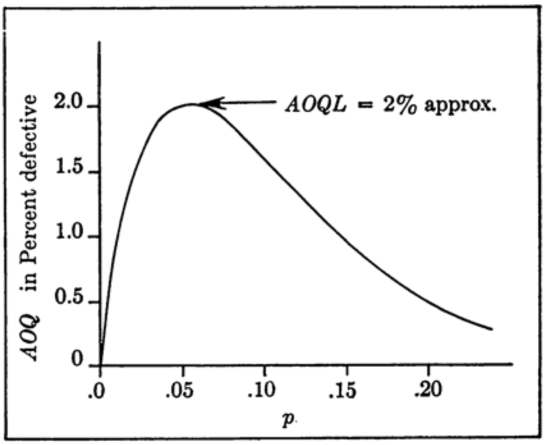

Fig. 237. AOQ curve for the sampling plan $n = 18$, $c = 0$.

Note that the AOQ curve rises until it reaches a certain maximum point, after which it falls off again as a result of more and more product being "100% inspected." The AOQL is the maximum point which is reached by the AOQ curve.

The AOQL of a sampling plan is therefore defined as follows: The AOQL is the worst average quality that can exist, in the long run, in the outgoing product, after the rejected lots have been 100% inspected and all the defectives have been replaced by good units.

B-4.4 Calculation of AOQL

There are two ways to calculate the AOQL of a sampling plan. One is to calculate a series of AOQ values, as shown above, plot them on a graph and determine the maximum point on the curve. By this method we determine that the AOQL of the sampling plan called "C" (page 243) is approximately 2%. See Figure 237.

The same result could be obtained more rapidly by the following equation.

$$AOQL = \frac{y}{n} - \frac{y}{N}$$

where y is a factor depending on the acceptance number of the sampling plan as shown in Figure 238, n is the sample size and N is the lot size. The values in Figure 238 are taken from page 49 of the Dodge-Romig "Sampling Inspection Tables." See Reference No. 11.

c	0	1	2
y	0.368	0.841	1.372
c	3	4	5
y	1.946	2.544	3.172
c	6	7	8
y	3.810	4.465	5.150
c	9	10	11
y	5.836	6.535	7.234

Fig. 238. Table for values of "y," to be used in calculating AOQL.

This table can be used wherever we would normally use Poisson probabilities.

For the sampling plan called "C" (page 243),

$y = 0.368$ (because the acceptance number is zero).

$n = 18.$

Assume that the lot size is $N = 2000$.

$$AOQL = \frac{0.368}{18} - \frac{0.368}{2000} = .0204 - .0002$$

$$= .0202, \text{ or } 2.02\%$$

This agrees with the AOQ curve in Figure 237.

The following are the AOQL values for each of the sampling plans on page 243:

Plan	*n*	*c*	*AOQL*
A	165	1	0.47%
B	35	2	3.86%
C	18	0	2.02%
D	5	0	7.34%*
E	220	7	1.81%
F	100	4	2.41%
G	100	0	0.35%
H	25	1	3.32%

* If we used Binomial probabilities for this plan, the calculated AOQL would be 6.68% instead of 7.34%.

B-4.5 Classification of sampling plans according to their AOQL

Suppose we wish to group together plans having similar AOQL's. From the above list, we would group together Plans C and E, since both have AOQL's of approximately 2%.

These plans are not alike at the shoulder (the product they will accept). Neither are they alike at the tail (the product they will reject). Their only similarity is that, when they are used with 100% inspection of all the rejected lots, the outgoing product will not, on the average, be worse than 2%.

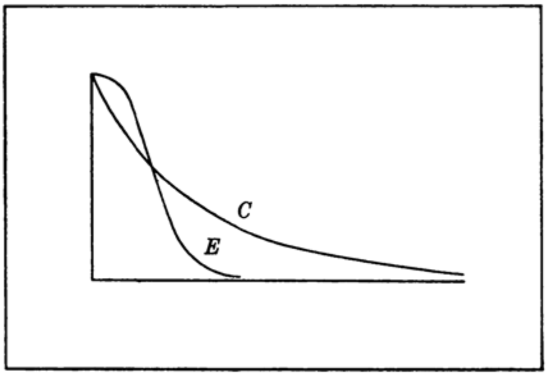

Fig. 239. 2% AOQL sampling plans.

When an engineer chooses a "2% AOQL sampling plan," he is choosing a plan which will limit the outgoing product, in the long run, to a 2% average or less. The outgoing quality may be, and frequently is, limited to some point much lower than the stated AOQL. For example, the curve in Figure 237 shows that if the submitted product were 20% defective, this particular plan would force the shop to do sufficient screening to cut it down (theoretically) to 0.5%. The plan imposes, under these circumstances, a much tighter standard of quality than the stated 2%.

The fact that a sampling plan is classified as "2% AOQL" does not tell the engineer anything about any part of the OC curve. He is not able to tell what quality of product will be regularly accepted, or what quality will be regularly rejected.

Just as it is possible to specify an AQL value or LTPD value (paragraphs B-4.1 and B-4.2)

AOQL SAMPLING TABLE

TABLE SA-2.5. Average Outgoing Quality Limit = 2.5%

Process Average, %	0–.05			06–.50			.51–1.00			1.01–1.50			1.51–2.00			2.01–2.50		
Lot Size	n	c	p_t, %	n	c	p_t, %	n	c	p_t, %	n	c	p_t, %	n	c	p_t, %	n	c	p_t, %
1–10	All	0	—	All	0	—	All	0	—	All	0	—	All	0	—	All	0	—
11–50	11	0	17.6	11	0	17.6	11	0	17.6	11	0	17.6	11	0	17.6	11	0	17.6
51–100	13	0	15.3	13	0	15.3	13	0	15.3	13	0	15.3	13	0	15.3	13	0	15.3
101–200	14	0	14.7	14	0	14.7	14	0	14.7	29	1	12.9	29	1	12.9	29	1	12.9
201–300	14	0	14.9	14	0	14.9	30	1	12.7	30	1	12.7	30	1	12.7	30	1	12.7
301–400	14	0	15.0	14	0	15.0	31	1	12.3	31	1	12.3	31	1	12.3	48	2	10.7
401–500	14	0	15.0	14	0	15.0	32	1	12.0	32	1	12.0	49	2	10.6	49	2	10.6
501–600	14	0	15.1	32	1	12.0	32	1	12.0	50	2	10.4	50	2	10.4	70	3	9.3
601–800	14	0	15.1	32	1	12.0	32	1	12.0	50	2	10.5	50	2	10.5	70	3	9.4
801–1000	15	0	14.2	33	1	11.7	33	1	11.7	50	2	10.6	70	3	9.4	90	4	8.5
1,001–2,000	15	0	14.2	33	1	11.7	55	2	9.3	75	3	8.8	95	4	8.0	120	5	7.6
2,001–3,000	15	0	14.2	33	1	11.8	55	2	9.4	75	3	8.8	120	5	7.6	145	6	7.2
3,001–4,000	15	0	14.3	33	1	11.8	55	2	9.5	100	4	7.9	125	5	7.4	195	8	6.6
4,001–5,000	15	0	14.3	33	1	11.8	75	3	8.9	100	4	7.9	*150	6	7.0	225	9	6.3
5,001–7,000	33	1	11.8	55	2	9.7	75	3	8.9	125	5	7.4	175	7	6.7	250	10	6.1
7,001–10,000	34	1	11.4	55	2	9.7	75	3	8.9	125	5	7.4	200	8	6.4	310	12	5.8
10,001–20,000	34	1	11.4	55	2	9.7	100	4	8.0	*150	6	7.0	260	10	6.0	425	16	5.3
20,001–50,000	34	1	11.4	55	2	9.7	100	4	8.0	180	7	6.7	345	13	5.5	640	23	4.8
50,001–100,000	34	1	11.4	80	3	8.4	125	5	7.4	235	9	6.1	435	16	5.2	800	28	4.5

n = Size of Sample; entry of "All" indicates that each piece in lot is to be inspected.
c = Allowable Defect Number for Sample.
p_t = Lot Tolerance Per Cent Defective corresponding to a Consumer's Risk (P_c) = 0.10.

* This plan appears also in Figure 236.

Fig. 240. Excerpt from "Sampling Inspection Tables" by Dodge and Romig: 2.5% AOQL. To use this table, determine (1) the usual lot size and (2) the "process average" (percent defective at which the product normally runs). The sample size is given in column "n" under the applicable process average, and the acceptance number is given in column "c."

In addition to having a stated AOQL (in this case, 2.5%), each of the above plans will have a particular value of "lot tolerance percent defective" or LTPD. This is given in the column marked "p_t %." While it is not a necessary part of the AOQL plan, this figure is often useful in showing how bad a lot might be and still have a 10% chance of being accepted. Note that the same sampling plan may be listed under AOQL and also LTPD (shown by asterisk and note).