INTERNATIONAL STANDARD

# ISO 2859-0

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# Sampling procedures for inspection by attributes —

## Part 0:
## Introduction to the ISO 2859 attribute sampling system



*Règles d'échantillonnage pour les contrôles par attributs —*

*Partie 0: Introduction au système d'échantillonnage par attributs de l'ISO 2859*



Reference number
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# Contents







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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.



International Standard ISO 2859-0 was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 5, *Acceptance sampling*.

This first edition of ISO 2859-0 cancels and replaces ISO 2859:1974 and Addendum 1:1977.

ISO 2859 consists of the following parts, under the general title *Sampling procedures for inspection by attributes*:



— *Part 0: Introduction to the ISO 2859 attribute sampling system*

— *Part 1: Sampling plans indexed by acceptable quantity level (AQL) for lot-by-lot inspection*

— *Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection*

— *Part 3: Skip-lot sampling procedures*

# Introduction

This general introduction to sampling inspection describes the attribute sampling schemes set forth in parts 1 to 3 of ISO 2859 and in ISO 8422. This introduction treats the subject of sampling inspection by attributes in a general way; it introduces the essential operating procedures and the ways the schemes were designed to be used. To understand fully the concepts and their applications, it would be helpful to consult ISO 2859-1, ISO 2859-2, ISO 2859-3, ISO 8422 and ISO/TR 8550.

The individual parts of these International Standards extend this introductory explanation to more specific uses of the procedures which are appropriate for the particular part or standard.

It is emphasized that ISO 2859-1 provides sampling schemes indexed by AQL. The quality measure used can be percent nonconforming or the number of nonconformities per 100 items. ISO 2859-1 was developed primarily for the inspection of a **continuing series of lots** all originating from the same source, as in this situation adequate protection (of the maximum process average percent nonconforming) is possible by use of the switching rules (i.e. from normal to tightened inspection) should a certain (limiting) number of unacceptable lots be found in a short series of successive lots.

ISO 2859-2 provides sampling plans arranged for use when individual or isolated lots are to be sampled. These sampling plans are in many instances identical to those in ISO 2859-1. All the tables of sampling plans in ISO 2859-2 include information regarding the quality level required to assure a high probability of lot acceptance. It is recommended that ISO 2859-2 rather than ISO 2859-1 be used for individual or isolated lots.

ISO 2859-3 provides skip-lot procedures for use when the process quality is **markedly superior** to the AQL for a defined long period of delivery or observation. When the quality level is in this state of excellence, it is sometimes more economical to use ISO 2859-3 than to use the reduced sampling procedure of ISO 2859-1. Like ISO 2859-1, ISO 2859-3 is applicable to a continuing series of lots from a single source.

ISO 8422 provides a method of establishing sequential sampling plans of discriminatory power essentially equivalent to that of individual plans of ISO 2859-1 and ISO 2859-2.

A complementary system of sampling plans for inspection by variables, also indexed by AQL, is provided by ISO 3951:1989, *Sampling procedures and charts for inspection by variables for percent nonconforming* and by ISO 8423:1991, *Sequential sampling plans for inspection by variables for percent nonconforming (known standard deviation)*.

NOTE 1 Use of the masculine gender in this part of ISO 2859 is not meant to exclude the feminine gender where applied to persons. Similarly, use of the singular does not exclude the plural (and vice versa) when the sense allows.

# Sampling procedures for inspection by attributes —

# Part 0:
Introduction to the ISO 2859 attribute sampling system

## Section 1: General

### 1.1 Scope

This part of ISO 2859 explains the terms used in acceptance sampling, describes the various schemes and plans, gives practical advice on sampling inspection and discusses some of the theoretical aspects.

Section 2 gives general information on methods of acceptance sampling inspection with particular reference to the sampling procedures and tables for inspection by attributes given in parts 1, 2 and 3 of ISO 2859 and in ISO 8422.

Section 3 extends the introduction to acceptance sampling given in Section 2 and amplifies the introductory text and instructions contained in ISO 2859-1, by giving detailed comments and examples to assist in using the method of sampling inspection that constitutes the ISO 2859-1 sampling system.

### 1.2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 2859. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 2859 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2859-1:1989, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

ISO 2859-2:1985, *Sampling procedures for inspection by attributes — Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection.*

ISO 2859-3:1991, *Sampling procedures for inspection by attributes — Part 3: Skip-lot sampling procedures.*

ISO 8422:1991, *Sequential sampling plans for inspection by attributes.*

ISO/TR 8550:1994, *Guide for the selection of an acceptance sampling system, scheme or plan for inspection of discrete items in lots.*

### 1.3 Definitions

For the purposes of this part of ISO 2859, the definitions given in ISO 2859-1 and ISO 2859-3 apply.

# Section 2: General introduction to acceptance sampling

## 2.1 Aim of sampling inspection

A major aim of acceptance sampling inspection is to see that the producer submits lots at a quality which is at or better than a mutually agreed level, so that the consumer receives lots of a quality that is acceptable.

The producer may use these sampling procedures to assure that the quality level will be acceptable to the consumer. In all these procedures, it has to be recognized that the financial resources are not unlimited. The cost of the article has to reflect the cost of inspection as well as the cost of production.

A real effort should be made to ensure that a system is devised that clearly places responsibility for quality with the producer. Inspection can appear to divert the responsibility for quality from the producer to the inspector. This may happen whenever there is a feeling that the inspector is there to sort things out, so that, within limits, what happens in production will be caught by inspection. This feeling is completely misplaced and may result in hard work, high cost and poor quality for the consumer and the producer. The inspector has no means of inserting quality into a product if the producer has not done so.

## 2.2 Acceptance sampling

Acceptance sampling inspection has the merit of putting the responsibility for quality fairly and squarely where it belongs — with the producer. The inspector is no longer regarded as the person who sorts things out. The producer has to see that the quality of the product is right, otherwise there will be much trouble and expense with unacceptable lots. Sampling inspection can and should lead to less inspection work, lower cost and good quality for the consumer.

The sampling inspection schemes of parts 1, 2 and 3 of ISO 2859 and of ISO 8422 provide for quantification of the risks of accepting unsatisfactory product (known as "consumer's risk") and the risks of not accepting satisfactory product ("producer's risk") and for choosing a plan that allows no more risk than is acceptable.

In addition to the ISO sampling plans which are based on the mathematical theory of probability, there are several other practices:

a) sampling based on experience with the product, the process, the supplier and the consumer (see 2.2.1);

b) *ad hoc* sampling, for example the inspection of a fixed percentage, or occasional random checks (see 2.2.2);

c) 100 % inspection (see 2.2.3);

d) other "sampling" practices (see 2.2.4).

### 2.2.1 Statistical sampling

Sampling based on experience with the product, the process, the producer and the consumer can be statistically evaluated.

An example is the procedure described in ISO 2859-1 which uses a set of switching rules. When quality is very good, it is possible to go to reduced inspection. This provides a procedure where, if smaller samples are used, the producer's risk is reduced but the consumer's risk is increased. If experience is good, this is justifiable, particularly when the process average has been consistently smaller than the acceptable quality level (AQL) specified. When the process average over at least 10 lots has been very much smaller than the AQL, some consumers resort to skip-lot procedures (see ISO 2859-3). This can be even more economical than the reduced inspection described in ISO 2859-1.

In some instances, particularly when routine or non-critical items are involved, some consumers may feel safe in resorting to the practice of inspecting small samples of the product and, provided there are zero nonconforming items, accepting the lot. For example, with a sample size of eight this is equivalent to the small lot single sampling plans with an AQL of 1,5 % normal, or 0,65 % reduced inspection. See tables II-A and II-C in ISO 2859-1:1989.

Conversely, in ISO 2859-1, when two out of five successive lots fail acceptance, normal inspection is discontinued, and tightened inspection is instituted. Once tightened inspection has been instituted, normal inspection is not restored until five successive lots have been accepted on tightened inspection. This requirement is intentionally severe, because evidence of unacceptable quality has been found. The producer then forfeits the right to the benefit of the doubt. If, while operating on tightened inspection, the cumulat-

ive number of lots not accepted on original tightened inspection reaches five, inspection by sampling should be discontinued until there is evidence that corrective action has been taken and has been effective. See 2.11.

### 2.2.2 *Ad hoc* sampling

*Ad hoc* sampling is not to be recommended as it will lead to uncalculated risks that may be unjustifiably high; furthermore, there is no formal basis for either the acceptance or non-acceptance of the lot.

### 2.2.3 100 % inspection

100 % inspection can be a formidable task unless the 100 % inspection is performed with automatic test equipment. In addition, it is not always successful, particularly when a large number of items have one or more characteristics that are marginal dimensionally, in appearance or in performance (close to or concentrated about a tolerance or limit of appearance or performance). Under these conditions, sorting by manual or automatic methods is likely to classify some conforming items as nonconforming, and vice versa. In addition, 100 % testing by manual, visual or automatic methods can be unsatisfactory. It can sometimes degenerate into superficial 100 % inspection when, in fact, sufficient money, time and staff are not available. 100 % inspection is not viable if the inspection method necessitates destructive testing.

It has to be understood, however, that 100 % inspection may form a necessary part of the inspection process for both the consumer and the producer. There are situations in which it cannot be avoided, for example when inspecting for critical nonconformities, as will be clear from a study of this part of ISO 2859. Some types of nonconformity are so important that every item has to be examined when tests are non-destructive. When the tests are destructive, some risk has to be accepted. (See 2.15).

### 2.2.4 Other "sampling" practices

Various sampling systems exist but only those available as International Standards will be considered in detail in this part of ISO 2859. This should not be taken as meaning that the others are unimportant; it is merely that the main purpose of this part of ISO 2859 is to help people to use parts 1, 2 or 3 of ISO 2859 or ISO 8422.

In many instances, consumers do not perform any regular sampling but rely on their experience and supporting evidence that the producer is maintaining statistical control of his production process and is forthright in his evaluation of what is being shipped.

If, in a particular situation, information is available of the true costs of the mistaken non-acceptance of good articles and the acceptance of bad ones, and if from long experience it is known how often lots of any given quality are presented, this may be one of the occasions when compromise is not desirable. It may be possible to calculate a more efficient scheme on the basis of the economic information available.

## 2.3 Choosing between attributes and variables inspection

The attributes method of inspection consists of examining an item, or characteristics of an item, and classifying the item as "conforming" or "nonconforming". The action to be taken is decided by counting the number of nonconforming items or the number of nonconformities found in a random sample.

The variables method starts with selecting a sample of a number of items and measuring dimensions or characteristics so that information is available not only on whether a dimension, for example, is within certain limits but on the actual value of the dimension. The decision whether or not to accept a lot is made on the basis of calculations of the average and the variability of the measurements in accordance with the procedures of ISO 3951 or ISO 8423.



Provided certain assumptions are true, the variables method has the advantage of requiring a smaller sample size than the attributes method to attain a given degree of protection against incorrect decisions. Also it provides more information as to whether quality is being adversely affected by process mean, process variability or both. The attributes method has the advantage that it is more robust (not subject to assumptions of distributional shape) and that it is simpler to use. The larger sample sizes and the increased costs associated with using attribute sampling methods may be justifiable for these reasons.

It should be noted that go, no-go gauging is faster and requires less skill than measurement.

Both methods have advantages and typical fields of application.

Although occasionally reference is made to ISO 3951 and ISO 8423 in subsequent clauses, variables schemes, as such, are not considered further in this part of ISO 2859. ISO 3951 and ISO 8423 include guidance on their use.

## 2.4 Lot inspection

### 2.4.1 Lot

For the purposes of ISO 2859, ISO 8422, ISO 3951 and ISO 8423, items are offered for acceptance in groups, not on a single item basis. Each group of items is called a lot.

Each lot should, as far as is practicable, consist of items manufactured under essentially the same conditions during one time period. This is of the utmost importance if the acceptable quality level concept is adopted and there are a series of lots to be delivered.

If two or more sources of supply are mixed, the presence of a large number of nonconforming items from one of the sources can result in non-acceptance of the product from all the sources. Conversely, product of marginal quality from one source can be masked by mixing with product from sources of excellent quality.

From each lot a sample is drawn and inspected. Under attributes inspection, each lot is classified as acceptable or unacceptable on the basis of the number of nonconforming items or nonconformities found in the sample. Each successive lot is therefore dealt with as a more or less independent unit (although the rules for sentencing may sometimes vary according to the results from preceding lots).

For single lots offered in isolation, see 2.5.2.

### 2.4.2 Lot size

The responsible authority (see 3.10 in ISO 2859-1:1989) has the right to specify what is to be the lot size, but it clearly makes sense that, where possible, this should be done in consultation with the producer, so that a quantity that is mutually convenient may be chosen. Certainly, specifying the lot size (and other parameters of the sampling plan) should never be done in ignorance of the production process. It is not essential that an inviolable quantity should be chosen. Sometimes variation may be allowed, although it will nearly always be desirable that upper and lower limits of the lot size should be specified.

From the sampling inspection point of view, there is an advantage in large lots, as from a large lot it is economical to take a large sample, thereby achieving better discrimination between good lots and bad ones. With large lots, the required sample size is a smaller proportion of the lot than with small lots for the same AQL.

This "large lot" policy should not be overdone, however. If making up a large lot necessitates putting together smaller lots that could have remained separate, then a large lot is advantageous only if the smaller lots are of a similar quality. If there is likely to be any substantial difference between the qualities of the smaller lots, then it is much better to keep them separate. For this reason, lots should consist of items of product produced under essentially the same conditions.

Examples of the formation of lots are given in 3.4. More information on the lot size/sample size relation is given in ISO/TR 8550.

## 2.5 Sequence or isolated lot inspection

### 2.5.1 Lot-by-lot inspection

Lot-by-lot inspection is the inspection of product submitted in a series of lots.

If a sequence of lots is to be offered for acceptance at the time of production, the inspection results from the preceding lots can be avaible before the later lots are made. It is therefore possible that the inspection performed can beneficially influence the quality of subsequent production. The lots should be submitted and inspected in the same sequence as they are manufactured and inspection should be made promptly. Information obtained from a lot may indicate that the process appears to have deteriorated. The information obtained from several lots in sequence can be used to invoke a switching procedure which requires the use of a more rigorous sampling procedure in the event that the process deteriorates. This is important because, in the long run, it provides the best protection a consumer has against poor quality. If the quality remains poor, then under the more rigorous sampling practice more lots will be returned to the vendor for sorting. This tighter sampling increases the producer's risk of having an acceptable lot judged unacceptable. The identification of possible deterioration in product quality is a signal to initiate corrective action.

If the quality is very much better than that agreed upon, the consumer may, with the permission of the responsible authority, elect to adopt reduced or skip-lot sampling.

ISO 2859-1, ISO 2859-3, ISO 8422, ISO 3951 and ISO 8423 are designed principally for use with a sequence of lots.

### 2.5.2 Isolated lot inspection

Inspection may sometimes be performed on an isolated lot, just a few isolated lots, or on stored lots at a time when production has been finished. Under these circumstances, there is insufficient opportunity for the switching rules to be invoked and hence to influence the quality to be offered.

If a single lot is to be delivered, then it is helpful to know whether the lot is one of many similar lots delivered to other consumers and consists of material from a controlled process or whether it is a mixed lot containing items from different processes and different times. (See also ISO/TR 8550 and ISO 2859-2).

Whereas ISO 2859-1 and ISO 2859-3 call for establishing the AQL value and the inspection level in advance, ISO 2859-2 requires the establishment of the limiting quality (LQ). In order to provide appropriate producer and consumer protection when lots are sampled under the limiting-quality procedure, information is needed as to whether the lot came from a continuing series of acceptable lots, or is a mixed lot, consisting of product made on different production lines and/or different dates.

The tables in ISO 2859-2 are designed principally for use with isolated lots.

## 2.6 Acceptable quality level (AQL)

### 2.6.1 Description

The acceptable quality level is used as an indexing device in the tables of ISO 2859-1, in ISO 3951, and in some of the tables of ISO 8422 and ISO 8423.

When using these AQL-indexed sampling plans, inspection lots taken from a process whose quality is equal to or better than the AQL will be accepted most of the time.

When a continuing series of lots is considered, the AQL is a quality level which for the purposes of sampling inspection is the limit of a satisfactory process average.

The AQL is a chosen borderline between what will be considered acceptable as a process average, and what will not. As such, it in no way describes a sampling plan, but is a requirement of what the production should be like, and is a useful quantity to consider in defining a tolerable process.

The fact that an AQL is specified should not be taken to imply that a percentage of nonconforming items up to the specified value is wanted, or is completely acceptable. It is always better to have no nonconforming items than any percentage whatever, and the more the percentage can be reduced below the AQL the better. This reduction improves the probability that each lot is accepted.

### 2.6.2 Setting an AQL

In setting an AQL, it has to be remembered that the AQL provides an indication of the quality that is required in production. The producer is being asked to produce lots of an average quality better than the AQL. On the one hand, this quality has to be reasonably attainable, whilst on the other hand it has to be a reasonable quality from the consumer's point of view. Frequently this will mean a compromise between the quality the consumer would like and the quality he can afford, for the tighter the requirement the more difficult it may be for the production to meet it, and the more expensive may be the inspection to ensure that it is met.

A properly designed and controlled process may be capable of producing product with a smaller percentage nonconforming than the AQL value. When a better process average is obtainable from a process, the cost of production plus the cost of inspection will be lower for the better quality.

The primary consideration has to be the consumer's requirement, but it is necessary to make sure that the consumer is being realistic and is not demanding something tighter than is really needed. It is necessary to take into account how the items in question are to be used and the consequences of a failure. If the items are to be available in large numbers and the failure is simply a failure to assemble so that the nonconforming item can be put aside and another used in its place, a relatively generous AQL may be tolerable. If, on the other hand, a failure is going to cause a failure to function of an expensive and important piece of equipment at a time and place where a replacement of the nonconforming item cannot be made, a tighter AQL will be required.

More information and guidance on setting an AQL is given in 3.9 and in ISO/TR 8550.

## 2.7 Process average

The process average is the average quality submitted over a series of lots, resubmitted lots being excluded.

It is particularly important to realize that, in contrast to the AQL, the AOQL (see 2.12) or the LQ (see 2.8), the process average is not something that can be calculated or chosen, or is a property of a particular

sampling plan. The process average relates to what is actually produced, irrespective of what inspection is performed.

Generally, the estimation of a process average is not an essential part of a sampling scheme. However, the process average is important in its own right. Both the inspector and the producer are interested not only in the lot-by-lot decisions but also in the long-term picture of the quality of production.

It is, therefore, desirable to keep a record of the overall estimated process average being achieved because this gives a useful measure of quality and is also invaluable information for those who have to decide what sampling plans should be adopted when similar products are being designed and made in the future.

Special rules need to be observed where the sampling is of the double or multiple form. Only the results of the first sample in double and multiple sampling should be used to estimate the process average.

Occasionally a recommendation is made that abnormal results should be excluded. This is a dangerous practice that should be used very sparingly, if at all. The only time this practice may safely be adopted is if the abnormal results are known to be due to a specific cause which is known to have been eliminated. Even then it is good practice to quote figures which include and which exclude these abnormal results to indicate that these nonconformities did exist.

Separate process averages have to be estimated in the case of multiple characteristics or multiple AQL classes.

## 2.8 Limiting quality (LQ)

Limiting quality is an indexing device used in ISO 2859-2. When a lot is considered in isolation, LQ is a quality level in percent nonconforming (or nonconformities per 100 items) which for the purposes of sampling inspection is limited to a low probability of acceptance. This small probability of acceptance is called the "consumer's risk".

Specifying a limiting quality is in fact the specification of a quality that is not wanted! To have lots regularly prove to be acceptable, the fraction of nonconforming items has to be much smaller than the LQ (usually less than a quarter of the LQ).

ISO 2859-2 provides procedures for the application of LQ sampling plans. These sampling plans and tables are for the most part consistent with the sampling plans used in ISO 2859-1.

Limiting quality plans are used primarily for isolated lots. When the product is in manufacture and there are a series of lots being produced, the procedures of ISO 2859-1 are more appropriate.

## 2.9 Normal and tightened inspection

An AQL, it will be remembered, is the borderline in the quality scale between the good and the bad when a sequence of lots is inspected. When the AQL has been specified for any particular product, the ideal would be to have a system whereby lots could be always accepted when their quality was better than the AQL and always not accepted when worse than the AQL. This ideal is not attainable with any sampling plan.

To meet the requirements of both the producer and the consumer, some compromise is needed, and the device adopted in ISO 2859-1 and ISO 8422 is to join normal inspection with tightened inspection; i.e. two sampling plans are specified for any given situation, together with rules for determining when to switch from one to the other and when to switch back again.

Normal inspection is designed to protect the producer against having a high proportion of lots not accepted when quality is better than the AQL. In fact, the producer is being given the benefit of any doubt that arises due to sampling variability.

But the consumer needs protection too, and this is achieved by arranging that the producer is not given the benefit of the doubt blindly and invariably, but only for as long as he proves worthy of it. If at any time the sampling results show that his process average is probably worse than the AQL, he forfeits his right to the benefit of the doubt (that is, his right to normal inspection), and tightened inspection is instituted to protect the consumer.

Further details with examples are contained in 3.11 and 3.12.

## 2.10 Reduced inspection

Sometimes there is evidence that the product quality is consistently better than the AQL. Where this happens and there is reason to believe that good production will continue, sampling inspection no longer serves the purpose of segregating the good lots from the bad ones. However, inspection cannot be dispensed with altogether, as a warning is needed if the production quality worsens.

In these circumstances, considerable savings can be made if so desired by using the reduced-inspection sampling plans described in ISO 2859-1 or the skip-lot

sampling plans described in ISO 2859-3. The special rules for allowing the use of these plans, if permitted by the responsible authority, are described in ISO 2859-1, ISO 2859-3 and also in Section 3 of this part of ISO 2859.

Reduced inspection is further discussed, with examples, in 3.15.

## 2.11 Switching rules

Subclause 2.9 introduced normal inspection and tightened inspection and their purpose. This subclause discusses the switching rules by means of which the decision is taken to change from normal to tightened inspection or back again when using ISO 2859-1.

If the actual value of the quality being offered by the producer were known, the knowledge would be used to sentence the lots instead of submitting them to acceptance inspection. As the actual quality is never known, the best that can be done is to use the knowledge that is available, i.e. the sampling inspection results themselves.

As normal inspection is designed to accept nearly all the lots offered, provided that the quality is at least as good as the AQL, it follows that if a high proportion of lots is not being accepted, the quality cannot be as good as the AQL. The question is: "What proportion of non-acceptance is high enough to be convincing?" A rule is required that will give reasonably quick reaction if quality becomes worse than the AQL, while having a low probability of calling, in error, for tightened inspection when the quality is really better than the AQL.

The rule used is that tightened inspection has to be used for the following lots as soon as two out of any five or fewer successive lots on original inspection have not been accepted. The qualification "on original inspection" means that if lots are not accepted but resubmitted after rectification, these resubmitted lots are not counted for switching-rule purposes.

Once tightened inspection has been instituted, it remains in force for every lot until five successive lots have been accepted on tightened inspection, then normal inspection is restored. This requirement is quite a severe one, as acceptance on tightened inspection is more difficult than on normal inspection, but once there is evidence that quality worse than the AQL has been produced, the producer's right to the benefit of the doubt cannot be restored until it is safe to do so.

There is one further safeguard for the consumer. This is the rule that acceptance inspection should be discontinued, pending action to improve the quality, if the cumulative number of lots not accepted in a sequence of consecutive lots on original tightened inspection reaches five. This is a most important principle; if the quality is bad, action is needed, and the inspector has to be entitled to refuse to inspect any further lots until he has evidence that suitable action has been taken.

An example is given in 3.13.

## 2.12 Average outgoing quality (AOQ) and its limit (AOQL)

As with the AQL concept, the concept of average outgoing quality and its limit is only meaningful when a long sequence of lots is submitted to a defined system of sampling inspection, e.g. in accordance with the provisions of ISO 2859-1. When the number of nonconforming items in the sample is equal to or less than the acceptance number, the lot will be accepted. Conversely, when the number of nonconforming items in the sample is equal to or greater than the rejection number, the lot will not be accepted. When the supply (or source) process operates at a process average close to the specified AQL, most of the lots will be accepted. Provided that process quality is constant and non-accepted lots are discarded rather than rectified, the effect of sampling on the quality is nil.

In some instances, particularly when the transfer is between departments rather than companies, the result of a lot failing to pass sampling inspection is that the lot is 100 % inspected and the nonconforming items removed (and perhaps replaced with conforming items). This is termed "rectifying inspection".

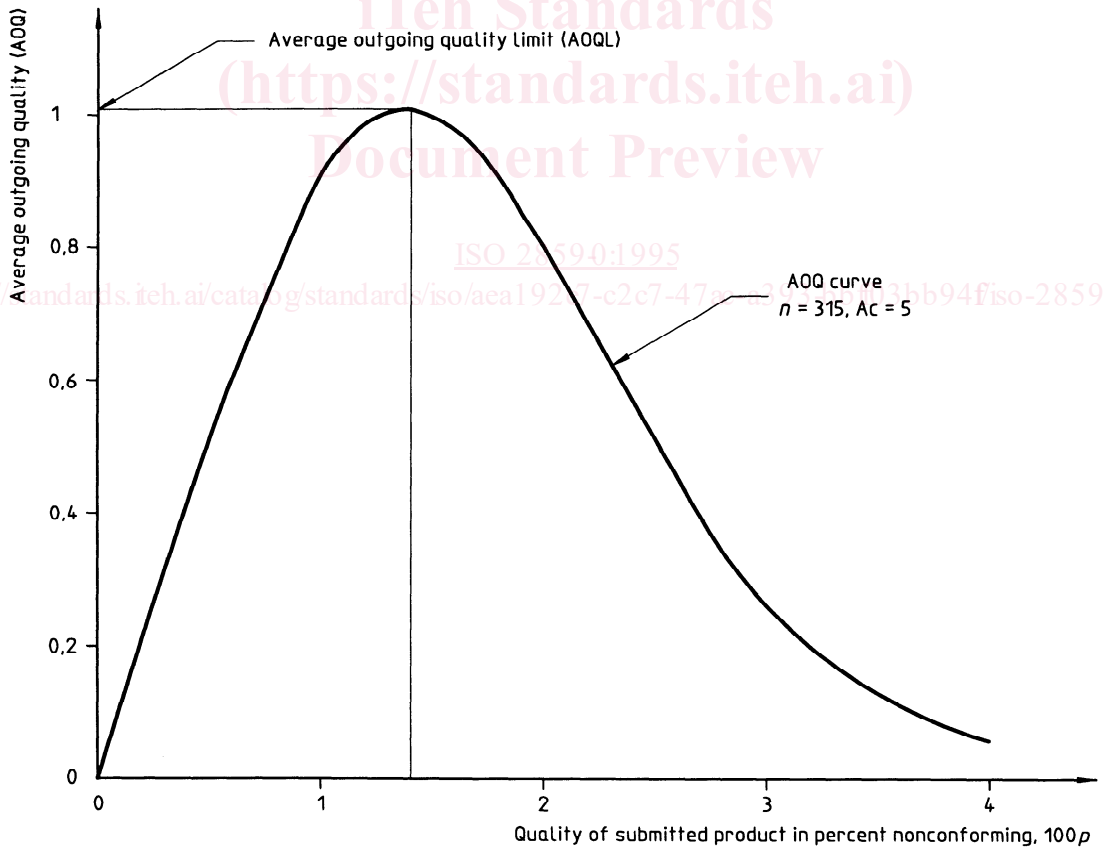
When lots are submitted to rectifying inspection, the lot is either accepted with no further inspection or, when the sample indicates non-acceptance, all the items in the lot are inspected and nonconforming items discarded or replaced by conforming items. In the first case, the outgoing quality is, for practical purposes, the same as the incoming quality; in the second case, all items conform to the specification. Even though the incoming quality may be constant at $p$ (fraction nonconforming) the process average, the outgoing quality will vary from lot to lot, taking either the value $p$ or zero depending on whether the lot is accepted on the sample result or is subjected to rectifying inspection. It is possible, however, to think of the average of these outgoing qualities over a long run in which the incoming quality was constant at $p$. This average of the outgoing quality will clearly not be

greater than $p$ and, where a large proportion of lots is completely inspected, it can be very much less.

The term "average outgoing quality" can be thought of as the average percent nonconforming over many lots from a process continually delivering product of quality $p$. Each lot is examined and sentenced by the same sampling plan which has a probability $P_a$ of accepting the lot. Those lots which are not accepted by the sampling plan are cleared (theoretically) of all nonconforming items. The result, on the average, is that, after inspection, $100(1 - P_a)$ % lots are 100 % conforming and the $100P_a$ % lots, which have been inspected by sampling alone, contain a percentage $100p$ of nonconforming items (minus a few removed during sampling). The average outgoing quality, in percent nonconforming, will be approximately $100(P_a \times p)$ %. The approximation is good if the lot size ($N$) is at least 10 times the sample size ($n$).

Performing this calculation for varying values of $p$, each of which has a different probability of acceptance, will result in an average outgoing quality curve as in figure 1. It is clear from this figure that outgoing quality can be good either because incoming quality was good or because the lot was completely inspected. It is further clear that there is an intermediate incoming quality ($p$) for which the average outgoing quality achieves a maximum value. This maximum value is the AOQL. It is not a limit on the outgoing quality from any one particular lot nor is it a limit on the actual outgoing quality averaged over a short sequence of lots. In a long sequence of lots, however, the actual outgoing quality average over that sequence will not be significantly different from this AOQL. If the input quality has varied from the incoming quality ($p$), then the actual quality may be very much better than the AOQL. It is therefore good practice to estimate the actual average quality directly rather than to rely on the AOQL as an upper boundary.






$n$ = sample size

Ac = acceptance number

**Figure 1 — AOQ and its limit AOQL**