

---

# INTERNATIONAL STANDARD



# 390

---

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

---

## Asbestos-cement products — Sampling and inspection

*Produits en amiante-ciment — Échantillonnage et contrôle*

First edition — 1977-08-01

STANDARDSISO.COM : Click to view the full PDF of ISO 390:1977

---

UDC 691.328.5 : 620.113

Ref. No. ISO 390-1977 (E)

**Descriptors:** asbestos-cement products, construction materials, sampling, tests, quality control, inspection by attributes, inspection by variables, sampling tables, instructions.

Price based on 12 pages

## FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 390 was developed by Technical Committee ISO/TC 77, *Products in fibre reinforced cement*, and results from the merging of ISO Recommendations R 390-1964 and R 1260-1970, which are cancelled and replaced by the present document.

It was submitted directly to the ISO Council, in accordance with clause 6.12.1 of the Directives for the technical work of ISO, and with the agreement of the experts of Technical Committee ISO/TC 69, *Applications of statistical methods*.

ISO Recommendations R 390-1964 and R 1260-1970 (which now constitutes the annex to this International Standard) had been approved by the member bodies of the following countries :

Australia	Iran**	Portugal
Austria	Ireland	Romania
Belgium	Israel	South Africa, Rep. of
Brazil	Italy	Spain
Colombia*	Japan*	Sweden
Czechoslovakia*	Korea, Rep. of*	Switzerland
Denmark	Lebanon*	Turkey
Egypt, Arab Rep. of	Morocco*	United Kingdom
Finland*	Mexico	U.S.A.
France	Netherlands	U.S.S.R.*
Germany	New Zealand	Venezuela
Greece	Norway	Yugoslavia
Hungary	Peru	
India	Poland	

\* approved ISO/R 390 only.

\*\* approved ISO/R 1260 only.

No member body expressed disapproval of the documents.

<b>CONTENTS</b>	Page
1 Scope .....	1
2 Field of application .....	1
3 Definitions .....	1
4 Division of a consignment into inspection lots .....	2
5 Sampling .....	2
6 Inspection .....	2
7 Determination of acceptability of inspection lots .....	3
<b>Annex : Guide to the use of this International Standard</b> .....	5
A.1 Scope and field of application .....	5
A.2 Unit of product .....	5
A.3 Conforming and non-conforming units .....	5
A.4 Inspection lot .....	6
A.5 Division of a consignment into inspection lots .....	6
A.6 Sampling .....	7
A.7 Definitions of inspection by attributes and inspection by variables ...	7
A.8 Operating characteristic of a sampling plan .....	8
A.9 Use of sampling inspection by attributes .....	8
A.10 Use of sampling inspection by variables .....	10
A.11 Reduction of sample size .....	11
A.12 Resubmission of rejected lots .....	11

STANDARDSISO.COM · Click to view the full PDF of ISO 390:1977

STANDARDSISO.COM : Click to view the full PDF of ISO 390:1977

# Asbestos-cement products – Sampling and inspection

## 1 SCOPE

This International Standard establishes certain rules for batching, sampling, inspection and acceptance/rejection of asbestos-cement products.

## 2 FIELD OF APPLICATION

The purpose of this International Standard is to provide a uniform method to be used in determining whether supplies of asbestos-cement goods should be accepted as conforming to the relevant International Standard requirements for such products.

It provides for a double sampling plan for the method of inspection by attributes as well as for an alternative single sampling plan for the method of inspection by variables.

## 3 DEFINITIONS

For the purpose of this International Standard, the following definitions apply.

**3.1 inspection** : The process of measuring, examining, testing, gauging or otherwise comparing the unit of product with the applicable requirements.

**3.2 inspection by attributes** : A system of inspection whereby the decision to accept or reject an inspection lot is based on the number of tested units of product classified as conforming or not conforming to certain requirements.

**3.3 inspection by variables** : A system of inspection whereby the decision to accept or reject an inspection lot is based on the average and variability of the measurements of a quality characteristic of the tested units of product.

**3.4 sample** : One or more units of product drawn from an inspection lot, the units of the sample being selected at random without regard to their quality.

**3.5 range** : The difference between the largest and smallest readings within a sample or group of samples.

**3.6 consignment** : That part of a delivery which comprises units of the same category.<sup>1)</sup>

**3.7 homogeneous consignment** : A consignment comprising units of product made of the same ingredients and under essentially the same conditions (see 4.2).

**3.8 sample size** : The number of units of product in a sample.

**3.9 unit of product** : The entity of product inspected.

**3.10 inspection lot** : A fraction of a consignment/sub-consignment accepted or rejected as a whole depending on the quality found by inspection of a sample drawn from the lot.

**3.11 maximum inspection lot** : The largest inspection lot which could, *a priori*, be expected to be homogeneous.

**3.12 minimum inspection lot** : The smallest inspection lot from which samples should be drawn.

**3.13 double sampling plan** : A sampling plan containing at most two samples, the initial (first) and the second samples. The final decision to accept or reject the inspection lot may be reached after inspecting the initial or both samples according to the provisions of clause 7.

**3.14 single sampling plan** : A sampling plan containing one sample only. The decision to accept or reject the inspection lot may be reached after inspecting the sample according to the provisions of clause 7.

**3.15 relevant International Standard** : The International Standard prepared by ISO/TC 77 for the particular type of asbestos-cement products.

### 1) Examples :

Pipes of different diameters are regarded as belonging to different categories.

Sheets of different profiles are regarded as belonging to different categories.

Sheets of the same profile but of different lengths may be regarded as belonging to the same category.

**3.16 sub-consignment :** A homogeneous fraction of a consignment known or supposed to be non-homogeneous.

**3.17 conforming unit :** A unit of product which conforms to one of the applied tests of the relevant International Standard (in statistical text books, also termed "non-defective").

**3.18 non-conforming unit :** A unit of product which does not conform to one of the applied tests of the relevant International Standard (in statistical text books, also termed "defective").

## 4 DIVISION OF A CONSIGNMENT INTO INSPECTION LOTS

### 4.1 Homogeneous consignments

**4.1.1** Any homogeneous consignment (or sub-consignment, see 4.2) shall be divided by the manufacturer into inspection lots, the maximum size of which shall be as given in the relevant International Standard.

**4.1.2** Any fraction of a consignment remaining after removal of the highest possible number of maximum inspection lots and any homogeneous consignment (or sub-consignment) smaller than the maximum lot size, shall form an inspection lot if larger than the minimum lot size given in the relevant International Standard.

**4.1.3** Consignments or fractions of consignments smaller than the minimum lot size given in the relevant International Standard shall not be submitted to sampling and testing.

### 4.2 Non-homogeneous consignments

Any consignment which is known to be or is expected to be non-homogeneous as regards any of the properties to be tested by sampling shall be divided by the manufacturer into assumed homogeneous sub-consignments prior to the division into inspection lots in accordance with 4.1.

## 5 SAMPLING

**5.1** From each inspection lot (4.1.1 and 4.1.2), the purchaser may draw a sample, the size of which is indicated in table 1 (see 5.2 and 5.3).

**5.2** The entry to table 1 is the number of units of product in the inspection lot (column 1), the sample size being indicated in column 2.

**5.3** For products where all units undergo a compulsory non-destructive test during manufacture<sup>1)</sup>, the reduced sample size obtained by entering table 1 at column 7 may be applied.

**5.4** The possibility mentioned in 5.3 is also available when the manufacturer guarantees his production or has it guaranteed by an independent control organization.<sup>2)</sup>

**5.5** When test pieces are cut from the units of the sample, the cutting shall be carried out by the manufacturer in the presence of the purchaser.

**5.6** When the relevant International Standard calls for more than one property to be tested, the sample size shall be appropriately multiplied so as to secure for each test a number of test pieces equal to the sample size (see 5.2 and 5.3). From one unit of a sample, one test piece only shall be cut for a particular test, but for different tests, the necessary test pieces may be cut from the same unit of the sample.

## 6 INSPECTION

**6.1** Each unit of the sample shall be tested as specified in the relevant International Standard.

**6.2** The test results shall be evaluated either by the method of inspection by attributes (see 6.4 and 7.1) or by the method of inspection by variables (see 6.5 and 7.2).

**6.3** The method of inspection by attributes should normally be employed. However, by agreement between the interested parties prior to the drawing of the samples (see 5.1), the method of inspection by variables, if applicable, may be employed.

**6.4** When the method of inspection by attributes is employed, the number of non-conforming units in the sample shall be deduced from the test results and the acceptability of the inspection lot determined as prescribed in 7.1.

**6.5** When the method of inspection by variables is employed, the test results shall be recorded so as to retain the order in which they are made and the acceptability of the inspection lot determined as prescribed in 7.2.

1) Such as the watertightness test for pipes.

2) For example, use of statistical quality control methods in the works.

TABLE 1

1	2	3	4	5	6	7	8
Size of inspection lot	Sample size	Initial sample		Initial + second samples		Size of inspection lot for products tested during manufacture	Inspection by variables
		Acceptance number $Ac_1$	Rejection number $Re_1$	Acceptance number $Ac_2$	Rejection number $Re_2$		Acceptability criterion <sup>1)</sup> $k$
up to 100	3	0	2	1	2	up to 200	0,29
101 to 200	4	0	2	1	2	201 to 400	0,34
201 to 400	5	0	2	1	2	401 to 800	0,37
401 to 800	7	0	2	1	2	801 to 1 500	0,40
801 to 1 500	10	0	2	2	3	1 501 to 3 000	0,50
1 501 to 3 000	15	0	3	3	4	3 001 to 8 000	0,51
3 001 to 8 000	25	1	4	5	6	8 001 to 20 000	0,52
8 001 to 20 000	35	2	5	7	8		0,53

1) In applying this International Standard to the simultaneous inspection of the two limits of a given property, see the annex.

## 7 DETERMINATION OF ACCEPTABILITY OF INSPECTION LOTS

### 7.1 Inspection by attributes

7.1.1 When the number of non-conforming units found in the sample is equal to or less than the acceptance number  $Ac_1$  indicated in column 3 of table 1, the inspection lot from which the sample was drawn shall be considered acceptable.

7.1.2 When the number of non-conforming units found in the sample is equal to or greater than the rejection number  $Re_1$  indicated in column 4 of table 1, this may justify rejection of the inspection lot.

7.1.3 When the number of non-conforming units found in the sample lies between the acceptance number and the rejection number (columns 3 and 4 of table 1), a second sample of the same size as the initial sample (5.2, 5.3 and 5.4) shall be drawn and examined.

7.1.4 The second sample shall be inspected as indicated in 5.5, 5.6 and 6.4.

7.1.5 The number of non-conforming units found in the initial and in the second samples shall be totalled.

7.1.6 If the total number of non-conforming units is equal to or less than the acceptance number  $Ac_2$  indicated in column 5 of table 1, the inspection lot shall be considered acceptable.

7.1.7 If the total number of non-conforming units is equal to or greater than the second rejection number  $Re_2$  indicated in column 6 of table 1, this may justify rejection of the inspection lot.

7.1.8 When the relevant International Standard calls for more than one property to be tested, the second sample taken (see 7.1.3) shall only be inspected in accordance with those tests which at the inspection of the initial sample gave numbers of non-conforming units between the acceptance number  $Ac_1$  and the rejection number  $Re_1$ .

### 7.2 Inspection by variables

The inspection shall be carried out on one sample, the size of which is given in column 2 of table 1, as follows :

- divide the readings in the order made into groups of 5, except when the sample size is 3, 4, 5 or 7, in which cases the group size is the same as the sample size;
- for each group, compute the range  $R$ ;
- of the group ranges  $R$  compute the average range  $\bar{R}$ ;
- compute the sample mean  $\bar{X}$  by dividing the sum of the measurements by the sample size;
- derive from table 1 (column 8) the acceptability criterion  $k$ ;
- compute the acceptability limit  $AL$  and determine the acceptability by means of table 2.

TABLE 2

Limit prescribed in the relevant International Standard	$AL =$	Acceptable if	Rejection justified if
Lower specified limit, $L$	$L + k\bar{R}$	$\bar{X} \geq AL$	$\bar{X} < AL$
Upper specified limit, $U$	$U - k\bar{R}$	$\bar{X} \leq AL$	$\bar{X} > AL$

STANDARDSISO.COM : Click to view the full PDF of ISO 390:1977

## ANNEX

## GUIDE TO THE USE OF THIS INTERNATIONAL STANDARD

## FOREWORD TO THE ANNEX

In drawing up this International Standard, ISO/TC 77 studied the American Military Standards 105 B and 414 and adopted many of the principles underlying those documents. It was felt, however, that the relationship between the manufacturer and purchaser of asbestos-cement products is very often quite different from the typical relationship in military procurements. For this and various other reasons, the committee decided to prepare its own standard concerning asbestos-cement products, together with an associated guide (the present annex).

With respect to this guide, it is also appropriate to refer to additional works of a more extensive character, for example :

- *Administration of sampling procedures for acceptance inspection*, Handbook H 105, Department of Defense, Washington D.C., 1954;
- *Defence guide to sampling inspection*, Ministry of Defence, London, 1962;
- *Mathematical and statistical principles underlying Military Standard 414*, Department of Defense, Washington D.C., 1958.

Those interested in systems of sampling inspection will profit from reading the latest editions of these handbooks.

The present guide, however, has the much more limited purpose of explaining the use of the very simple collection of sampling plans in this International Standard, which represents a balanced compromise between theoretical statistical points of view and practical economical considerations. It is the hope of the committee that the sampling plans will prove applicable in practice, and they will certainly give a safer basis for the distinction between good and inferior material than do the rules and methods hitherto used, thus providing greater protection to the user.

The sampling plans recommended have approximately the same properties as certain plans for which the *acceptable quality level (AQL)* is equal to 4 % in the military Standards studied.

### A.1 SCOPE AND FIELD OF APPLICATION

This annex explains in more detail the rules laid down for batching, sampling and inspection, and clarifies the consequences of using the methods of sampling inspection recommended. Also, a number of examples are given. In addition, the conditions are described under which rejected lots may be resubmitted for inspection.

### A.2 UNIT OF PRODUCT

The term "unit of product" means the entity to be inspected in order to determine its quality characteristics. The unit of product is specified in the relevant International Standard.

The unit of product is used as a counting unit in determining lot size, sample size, number of conforming units, etc.

### A.3 CONFORMING AND NON-CONFORMING UNITS

A conforming unit is a unit of product having quality

characteristics in conformity with the specified requirements in the relevant International Standard.

#### *Examples :*

ISO/R 391, *Building and sanitary pipes in asbestos-cement* (sub-clause 2.4.3.1) specifies : The unit bursting stress  $R_t$  of pipes of type A should be not less than 100 kgf/cm<sup>2</sup> (10 MN/m<sup>2</sup>).

This means that a building and sanitary pipe of type A (i.e. one unit of product) having  $R_t$  equal to or larger than 100 kgf/cm<sup>2</sup> (10 MN/m<sup>2</sup>) is a conforming unit, whereas a pipe having  $R_t$  less than 100 kgf/cm<sup>2</sup> (10 MN/m<sup>2</sup>) is a non-conforming unit.

ISO/R 393, *Asbestos-cement corrugated sheets for roofing and cladding* (sub-clause 2.5.3) specifies : During the 24 h of the impermeability test, traces of moisture may appear on the lower surface, but in no instance should there be any formation of drops of water.

This means that the corrugated sheet from which the test piece is cut and which shows formation of drops of water during testing is a non-conforming unit.

**A.4 INSPECTION LOT**

An inspection lot is a collection of units of product which is accepted or rejected as a whole, depending on the quality characteristics established by inspection of the units of product drawn from the lot.

The manufacturer shall arrange for the dividing of the consignment into inspection lots and provide for identification and segregation of each lot. It is important to maintain a separate identity until a decision regarding acceptance or rejection of the lot has been taken on the basis of the results of the sampling and testing.

The inspection lot shall be presented in such a form that every unit of product is accessible as far as is practically possible.

Inspection lots shall be homogeneous, i.e. shall consist of units of product made under essentially the same conditions. This may be attained by forming the lots from units that are produced

- within a relatively short period;
- from similar raw materials;
- by means of similar moulds (or patterns);
- under similar conditions of manufacture, hardening and maturing, etc.

It should be emphasized that by selection of homogeneous lots, the system of sampling inspection employed will lead to a better discrimination between lots of good quality and lots of bad quality.

The relative sample size (the sample size as a fraction of the lot size) is decreased considerably as the lot size is increased. Therefore, taking into account the costs of sampling, inspection and testing, it will be advantageous to use as large inspection lots as possible, subject to the limitation discussed above with respect to the homogeneity of the inspection lot. The discriminating power of the sampling system will likewise increase with increasing sample size.

It is therefore recommended that the interested parties agree upon a maximum lot size as large as possible without coming into conflict with the homogeneity requirements and other obviously practical considerations. To avoid unreasonable inspection and testing costs for small lots, a minimum inspection lot size shall also be agreed upon. In the event of agreement not being reached, the figures for maximum and minimum inspection lot sizes given in the relevant International Standard shall be used.

*Example :*

Size of inspection lot	Sample size	Relative sample size, %
200	4	2
2 000	15	0,75
20 000	35	0,175

**A.5 DIVISION OF A CONSIGNMENT INTO INSPECTION LOTS**

By a consignment is meant a delivery or part of a delivery which comprises units of the same category.

*Examples :*

Sheets of the same profile but of different lengths may be regarded as being of the same category.

Sheets of different profiles are regarded as being of different categories.

Pipes of the same diameter, class, type, or series, but of different lengths, may be regarded as being of the same category.

Pipes of different diameters are regarded as being of different categories.

Pipes of the same diameter but of different classes or types are regarded as being of different categories.

Any consignment which is known to be, or is expected to be, non-homogeneous as regards any of the properties to be tested by sampling shall be divided by the manufacturer into assumed homogeneous sub-consignments prior to the division into inspection lots.

Any homogeneous consignment or sub-consignment shall be divided by the manufacturer into inspection lots.

If larger than the minimum inspection lot size, any fraction of a consignment remaining after the highest possible number of maximum inspection lots has been taken out forms an inspection lot. Similarly, if larger than the minimum inspection lot size, any homogeneous consignment or sub-consignment smaller than the maximum inspection lot size forms an inspection lot.

Consignments or fractions of consignments smaller than the minimum inspection lot size shall not be submitted to sampling and testing.

However, should the testing of one or more of the inspection lots justify rejection of any of these lots, the interested parties may agree to disregard this provision and to submit the remaining fraction to sampling and inspection.

*Example to show the importance of having the largest possible inspection lot :*

Suppose that a consignment consists of 1 400 building and sanitary pipes of diameter 250 mm and that the maximum and the minimum inspection lot sizes agreed upon are 400 and 100 pipes respectively (see ISO/R 391, sub-clause 4.2.2) : the consignment shall be divided into 3 inspection lots of size 400 and 1 inspection lot of size 200. According to table 1 (see page 3), the sample size for lots of size 400 is 5 pipes and for lots of size 200 is 4 pipes, making a total of 19 pipes.

If the consignment consists of 1 250 pipes, it shall be divided into 3 inspection lots of 400 pipes – from each lot 5 pipes, totalling 15, are drawn – and a remainder of 50 pipes which is not normally submitted to sampling and testing.

If the interested parties had instead agreed upon a maximum inspection lot size of 1 500 pipes and the same minimum lot size, then the sample size would in both cases have been 10 pipes, which represents a saving of 9 and 5 pipes respectively.

## A.6 SAMPLING

A sample comprises one or more units of product drawn from an inspection lot. Since the decision to accept or reject the lot depends on the quality of the units of product in the sample, it is of the utmost importance that the sample is representative of the lot. This may be achieved by drawing the units at random from the lot, which means that each unit of the lot should have an equal chance of being included in the sample. Ideally, the units of product should be numbered and the units of the sample determined by drawing numbers at random as in a lottery. Instead of actually drawing numbers at random, a table of random numbers may be used.

In practice, truly random sampling from large lots may be difficult. It should, however, always be ensured that sample units of product are drawn from all parts of the lot and that units are selected without regard to their expected quality.

The drawing of samples is normally carried out by the purchaser, in the presence of a representative of the manufacturer, who has the right to advise the purchaser as to the correct way of drawing samples, so as to avoid common mistakes illustrated by the following examples.

### *Examples :*

From a stack of 100 corrugated sheets from which a sample of 3 should be drawn, the 3 top sheets shall not be taken. Further, the 3 bottom sheets, or the top sheet, the centre sheet, and the bottom sheet shall not be taken.

Moreover, if a sample of 3 should be taken from a pile of 100 sheets, the purchaser shall not be allowed to go through the stack as the leaves are turned in a book in order to "select" the samples. On the contrary, he shall mark on the edges the 3 sheets he desires to be tested while the pile is still intact.

When a consignment of sheets or slates is placed, for instance, on several pallets or in several piles, the units of product of the sample shall not be drawn only from the piles that are easiest of access. If it appears, for instance, that there are different climatic conditions in the part of the stock shed where the consignment is stored (but not so much as to make the consignment non-homogeneous), the different climatic conditions shall be represented in the sample, and the sampling shall be carried out as far as possible without regard to the "expected properties" of the units of product of the sample.

A unit of product which has been marked during the sampling may later appear to be unsuitable for testing. It may occur, for instance, that one of the sheets which the purchaser has marked in a stack is found to be completely broken and unsuitable as a sample. Common sense should then be applied and a neighbouring sheet substituted for the failing sample, or the sample should be regarded as a non-conforming unit of product. In the case illustrated, the purchaser and the manufacturer may alternatively agree to take out the whole stack of the consignment and insert another.

Both interested parties should keep in mind the fact that random sampling is the ideal and that they should apply common sense to approach the ideal as closely as possible.

## A.7 DEFINITIONS OF INSPECTION BY ATTRIBUTES AND INSPECTION BY VARIABLES

In inspection by attributes, the unit of product is classified as conforming or non-conforming with respect to each of the quality requirements specified in the relevant International Standard.

In inspection by variables, the quality characteristic specified in the relevant International Standard is measured on a numerical scale and the values found by measuring the units of product sampled are taken into account.

The results of inspection by variables may therefore always be converted to attributes. For instance, a quality characteristic of the pipes of type A is the unit bursting stress, and ISO/R 391 specifies that this should be not less than 100 kgf/cm<sup>2</sup> (10 MN/m<sup>2</sup>). An inspection by variables on a sample of 5 pipes will take into account the 5 values of the unit bursting stress, for example :

110-107-98-103-105

In inspection by attributes, it will only be registered that out of 5 pipes submitted to the tests, 4 have been conforming and 1 non-conforming. When inspection by variables is possible, it is therefore necessary to decide whether to treat the observation as a variable or to convert it into an attribute. Such a decision must be taken before sampling and inspection, since the decision must be independent of the actual outcome of the inspection.

Inspection by attributes is simpler to understand, requires less detailed records, and the testing is often cheaper than the corresponding measurement. In inspection by variables, more information is obtained per unit of product, with the consequence that inspection by variables on the average requires a smaller sample than inspection by attributes to obtain the same power of discrimination between lots of good quality and lots of bad quality. To be carried out correctly, inspection by variables requires some skill in arithmetic.

Further, the sampling plans for inspection by variables are based on the assumption that the measurements are normally distributed (the distribution of Laplace-Gauss). This will generally be the case of the product in question.

It is stated in 6.3 that inspection by attributes shall normally be employed, but the manufacturer may, prior to the drawing of the sample, opt to employ inspection by variables if applicable.

As far as inspection by variables is concerned, the sampling plans given in this document are limited to cases where the relevant International Standard specifies either a lower or an upper limit for the quality characteristic in question.

Therefore, when double limits are specified (for example, for certain geometric characteristics), inspection by attributes shall be employed, and it should be kept in mind that all measurements outside the two specified limits must be counted as non-conforming (see footnote to table 1, column 8).

Quality characteristics which are measurable on a numerical scale and which, consequently, make inspection both by attributes and by variables applicable are, for instance

- unit bursting, crushing and bending stresses of pipes;
- unit bending stresses of slates and flat and corrugated sheets;
- density of flat sheets and slates.

Quality characteristics which are not measurable on a numerical scale and which, consequently, make only inspection by attributes applicable are, for instance

- impermeability;
- frost cracking;
- visual aspects.

**A.8 OPERATING CHARACTERISTIC OF A SAMPLING PLAN**

The operating characteristic (or OC) curve of a sampling plan indicates the average percentage of the submitted lots which are accepted (the percentage probability of acceptance) in relation to the quality of submitted lots, expressed as the percentage of non-conforming units in the lot.

Any sampling plan has its own OC-curve, which makes it possible to predict what will happen in the long run by using the sampling plan under alternative assumptions regarding the quality of submitted inspection lots. In the example in figure 1, the OC-curve shows that the probability of acceptance equals 97 % for lots containing 4 % non-conforming units. This means that by using the sampling plan for a long series of lots, all of quality 4 %, 97 lots out of 100 will be accepted, while the remaining 3 lots out of 100 will be rejected.

The OC-curves are computed on the assumption that the sample units of product are selected from the inspection lot by a truly random procedure, and that no errors are committed in the classification or evaluation of the sample units.

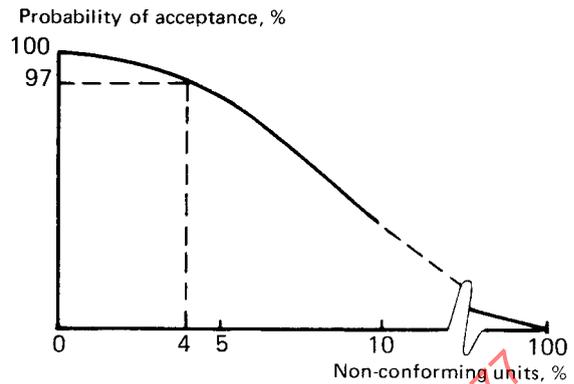


FIGURE 1 - Operating characteristic (OC) curve

The OC-curves for the sampling plans in this International Standard are shown in figures 2 and 3. They have been derived by means of the theory of probability and are almost independent of the lot size  $N$  when the sample size  $n$  is less than, say, 10 % of the lot size, which is always the case for the sampling plans provided in this document.

From the diagrams, it will be seen that the probability of acceptance is nearly 100 %, if submitted lots contain less than 2 % non-conforming units. For plans with a sample size of 7 or more, the curves intersect approximately at the point corresponding to a lot quality of about 9 % non-conforming units and a probability of acceptance for such lots of about 70 %. For a lot quality of 20 % non-conforming units, the probability of acceptance is rather low for all these plans.

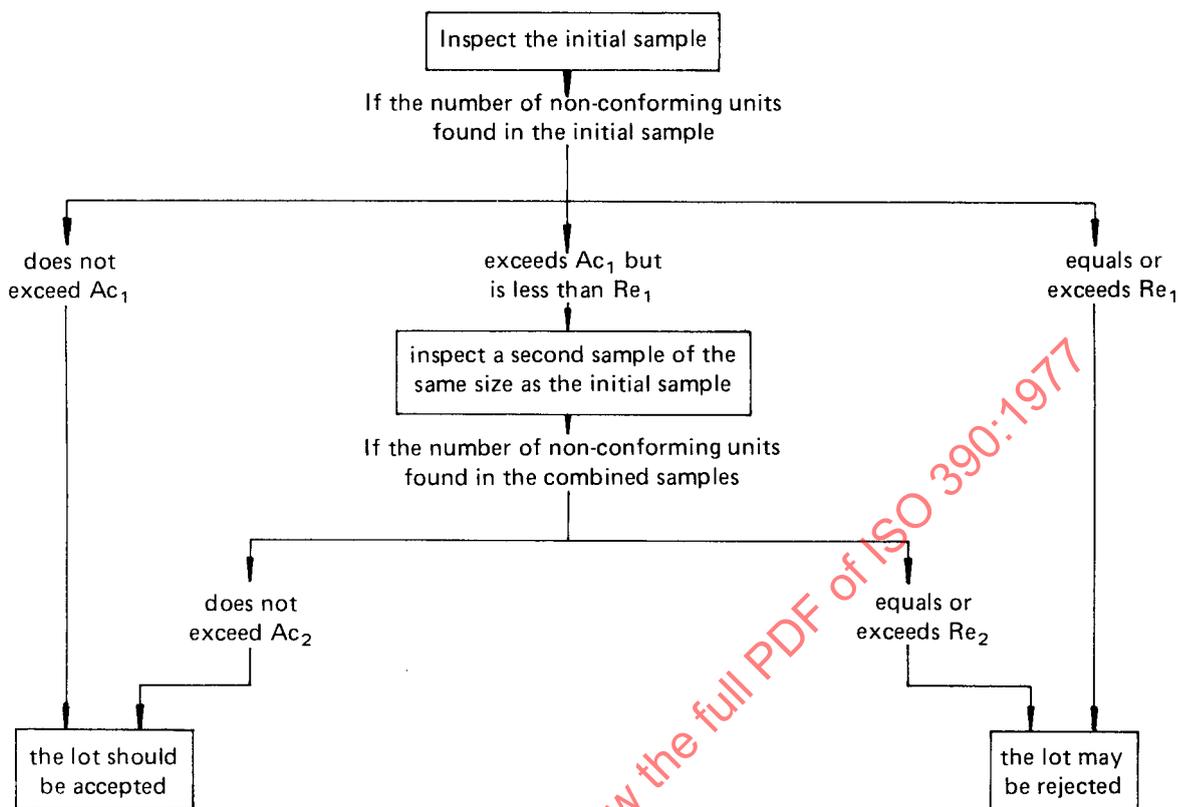
Comparing the two diagrams, it will be seen that the corresponding curves are almost identical, which means that the sample sizes and the acceptability criteria have been chosen in such a manner that the sampling inspection plans by attributes and by variables have almost the same discriminating power.

To demonstrate what can be read from the diagrams, consider for example double sampling inspection by attributes with an initial sample of 25 units and a second sample (if necessary) of another 25 units. If submitted inspection lots contain 3 % non-conforming units, then, on the average, 99 of such lots out of 100 will be accepted and 1 lot will be rejected (the probability of acceptance is about 99 %). If, on the other hand, submitted lots contain 20 % non-conforming units, then, on average, 6 of such lots out of 100 will be accepted, whereas 94 will be rejected (the probability of acceptance is about 6 %).

Using single sampling inspection by variables with a sample size of 25 units, the corresponding probabilities of acceptance are 99 and 10 %, respectively.

**A.9 USE OF SAMPLING INSPECTION BY ATTRIBUTES**

The system of sampling inspection by attributes given in this International Standard is a system of double sampling with the first and second sample of the same size. The following diagram shows the steps to be followed when using a double sampling inspection procedure.



The sample size depends on the size of the inspection lot and is given in table 1.

*Example 1 :*

Consider an inspection lot of 7 000 slates.

Table 1 shows that the initial sample will contain 25 slates and that the corresponding acceptance and rejection numbers are 1 and 4, respectively. If the sample contains 0 or 1 non-conforming unit, the lot should be considered acceptable. If, however, the sample contains 4 or more non-conforming units, the lot may be rejected. In intermediate cases, i.e. if the sample contains 2 or 3 non-conforming units, a second sample of 25 slates shall be inspected. From the table it will be seen that the acceptance number for the combined samples is 5 and the rejection number is 6. If the number of non-conforming units in the two samples together does not exceed 5, the lot should, therefore, be accepted; otherwise (i.e. if the number of non-conforming units exceeds 5) the lot may be rejected.

*Example 2 :*

Consider an inspection lot of 300 pipes.

Table 1 shows that the initial sample will contain 5 pipes and that the corresponding acceptance and rejection numbers are 0 and 2, respectively. If the sample does not contain any non-conforming units, the lot should be considered acceptable. If, however, the sample contains 2 or more non-conforming units, the lot may be rejected. In the intermediate case, i.e. if the

sample contains 1 non-conforming unit, a second sample of 5 pipes shall be inspected. From the table it will be seen that the acceptance number for the combined samples is 1 and the rejection number 2. If the number of non-conforming units in the two samples together does not exceed 1 (i.e. if the second sample does not contain any non-conforming units), the lot shall be considered acceptable; otherwise the lot may be rejected.

It will be noted that the average sample size in a double sampling system depends on the quality of the inspection lot. For inspection lots of very high or very low quality, the decision to accept or reject the lot will always be made from the results of the initial sample. In intermediate cases, however, there is a certain probability, depending on the quality of the lot, that a second sample will have to be drawn to reach a final decision. The average sample size will, therefore, be a number lying between the initial sample size and the combined sample size.

The advantage of using a double sampling system as compared with a single sampling system by attributes with the same OC-curve lies in the fact that double sampling has the same discriminating power as single sampling, with an average sample size which is normally smaller than the corresponding single sample size.

The use of a double sampling plan will also tend, on average, to reduce the amount of testing work since the second sample will only be tested for those properties which, at the initial test, gave numbers of non-conforming units between the acceptance number  $Ac_1$  and the rejection number  $Re_1$ .

When the relevant International Standard calls for more than one property to be tested, the decision as to acceptance or rejection shall be taken on the basis of the results for each property, independently of the results for other properties from the same sample.

#### A.10 USE OF SAMPLING INSPECTION BY VARIABLES

The system of sampling inspection by variables given in this International Standard is a system of single sampling with a sample size equal to the initial sample of the double sampling system by attributes. By using inspection by variables, the sample size will always be less than the average sample size by using inspection by attributes.

The sample size is specified in table 1 and depends on the inspection lot size in the same way as for inspection by attributes.

The system is based on the assumption that the sample units of product are drawn at random from the lot and that the test results (the measurements) are recorded in the order made.

First, a measure of the variability of the results is computed by means of the range  $R$ . By the range of a group of numbers is understood the difference between the largest and the smallest number in the group. If the sample size is 7 or less, the range of measurements is used directly, whereas for sample sizes of 10 or more, the measurements are divided into groups of 5, the range is found for each group and the average range  $\bar{R}$  is computed by dividing the sum of the group ranges by the number of groups.

Next, the average  $\bar{X}$  of all the measurements (the sample mean) is computed by dividing the sum of the measurements by the sample size.

Each sample size in table 1 is given a number  $k$  (the acceptability criterion), which shall be multiplied by the average range  $\bar{R}$  or, if the sample size is 7 or less, by the range  $R$ .

For each type of product for which inspection by variables is appropriate, the relevant International Standard will contain one specified limit for the quality characteristic in question. This limit may be a lower limit  $L$  or an upper limit  $U$ <sup>1)</sup>.

The acceptability limit  $AL$  is derived from the specified limit and the number  $kR$  as  $AL = L + k\bar{R}$ , or  $AL = U - k\bar{R}$ .

The acceptability of the lot is determined by comparing the average of the measurements with the acceptability limit.

If the relevant International Standard prescribes a lower limit, then the lot shall be considered acceptable if  $\bar{X} \geq AL$ ; otherwise the lot may be rejected.

If the relevant International Standard prescribes an upper limit, then the lot shall be considered acceptable if  $\bar{X} \leq AL$ ; otherwise the lot may be rejected.

##### Example 1 :

The sample size is 3, 4, 5 or 7.

From an inspection lot of 500 corrugated sheets, a sample of 7 was drawn and tested for unit bending stress  $R_f$  (see ISO/R 393, sub-clause 2.5.2.1). The following measurements were recorded :

$$180-177-167-182-188-172-158$$

The range  $R$  is equal to the difference between the largest and the smallest measurement :

$$R = 188 - 158 = 30$$

The sample mean  $\bar{X}$  is equal to the sum of the measurements divided by the sample size :

$$\begin{aligned} \bar{X} &= \frac{180 + 177 + 167 + 182 + 188 + 172 + 158}{7} \\ &= \frac{1\ 224}{7} \approx 175 \end{aligned}$$

To the sample size 7 corresponds the acceptability criterion  $k = 0,40$ .

Lower specified limit  $L = 160$

$$\text{Acceptability limit } AL = L + kR = 160 + (0,40 \times 30) = 172$$

As  $\bar{X} = 175 \geq AL = 172$ , the lot is acceptable.

##### Example 2 :

The sample size is 10, 15, 25 or 35.

From an inspection lot of 2 000 corrugated sheets, a sample of 15 was drawn and tested for unit bending stress  $R_f$  (see ISO/R 393, sub-clause 2.5.2.1). The

1) ISO 160, 881, 4486 and 4488, and ISO/R 391, 392, 393, 394, 395, 396 and 880 do not apply upper limits for quality characteristics that may be verified by sampling. Some of these documents apply double limits for some of the geometrical characteristics that might be tested by sampling. For these characteristics the inspection by variables is not applicable since the sampling plans in table 1 (see footnote to column 8) have been worked out on the assumption that one limit only has been specified. The method prescribed in the present clause shall, therefore, not be applied simultaneously to the two limits. Inspection by attributes should be used instead, counting all measurements outside the two specified limits as non-conforming (see A.7).