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Products in fibre-reinforced cement — Sampling and inspection

Produits en ciment renforcé par des fibres — Échantillonnage et contrôle

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Contents

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 390 was prepared by Technical Committee ISO/TC 77, *Products in fibre reinforced cement Study group for harmonization work*.

This second edition cancels and replaces the first edition (ISO 390:1977), of which it constitutes a technical revision.

Annexes A and B form an integral part of this International Standard. Annexes C and D are for information only.

Products in fibre-reinforced cement — Sampling and inspection

1 Scope

This International Standard establishes rules for batching, sampling and inspection of fibre-reinforced cement products.

These rules apply to all acceptance tests. In certain cases they may also apply to type tests but the sampling scheme for type tests will usually be specified in the product standards.

These rules form a uniform method for determining whether consignments of fibre-reinforced cement products can be considered as conforming to relevant product standards.

This International Standard also gives guidelines for internal sampling and inspection of finished products from a continuous production process, allowing the relaxation of the rules concerning acceptance or rejection of inspection lots providing that the appropriate conditions have been fulfilled.

The quality system of the factory is outside of the scope of this International Standard.[1]

The sampling schemes are based on ISO 2859-1, ISO 3951, ISO 8422 and ISO 8423 with an AQL of 4 % and inspection level S3.[2] According to the results obtained on previous batches, either a reduced or a tightened control is applied in accordance with these Standards.

The methods of switching rules (normal, tightened or reduced inspection) are given in extracts of those Standards reproduced in annexes A and B.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publi-cation, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard 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 395:1983, *Asbestos-cement slates.*

ISO 881:1980, *Asbestos-cement pipes, joints and fittings for sewerage and drainage.*

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 3951:1989, *Sampling procedures and charts for inspection by variables for percent nonconforming.*

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

ISO 8423:1991, *Sequential sampling plans for inspection by variables for percent nonconforming (known standard deviation).*

ISO 9000:1987, *Quality management and quality assurance standards — Guidelines for selection and use.*

ISO 9001:1987, *Quality systems — Model for quality assurance in design/development, production, installation and servicing.*

ISO 9002:1987, *Quality systems — Model for quality assurance in production and installation.*

ISO 9003:1987, *Quality systems — Model for quality assurance in final inspection and test.*

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1) Quality systems are described in ISO 9000, ISO 9001, ISO 9002 and ISO 9003.

2) As an alternative, sequential sampling can be used either by attribute (see ISO 8422) or by variable (see ISO 8423).

3 Definitions

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

3.1 acceptable quality level (AQL): When a continuous series of lots is considered, the quality level which for the purposes of sampling inspection is the limit of a satisfactory process average.

NOTE 1 A sampling scheme with an AQL of 4 % means that batches containing up to 4 % defective items have a high probability of acceptance.

3.2 order: Quantity of a product or material ordered at one time from one producer.

NOTE 2 An order may consist of one or more consignments. See production batch (3.8) and inspection batch (3.9).

3.3 consignment: Quantity of products or material delivered at one time covered by one set of shipment documents.

NOTE 3 A consignment may consist of several lots or parts of lots. See also production batch (3.8) and order (3.2).

3.4 type test: Test for approval of a new product and/or a fundamental change in formulation or method of manufacture, or both. The test is performed on the as-delivered product.

The type test is not to be taken as evidence of the conformity to specification of products subsequently produced in quantity.

3.5 acceptance test: Test to establish whether a batch of products conforms to a specification. The tests are performed on samples drawn either from continuous production or from a consignment.

NOTE 4 Test methods and specification limit values are defined in the individual product standard. Sampling levels and acceptance criteria are defined in this International Standard.

3.6 inspection: Activities such as measuring, examining, testing and gauging one or more characteristics of a product, and comparing the results with designated requirements.

3.7 item: Actual or conventional object that can be individually considered and separately inspected.

NOTE 5 The term "individual" is sometimes used as a synonym for "item". The word "unit" is often used as a synonym for "item".

3.8 production batch: Quantity of product or material manufactured by one supplier under conditions presumed uniform i.e. manufactured from the same formulation on the same forming machine without

prolonged or abnormal interruptions and having the same acceptance requirement for the relevant test.

See also "inspection batch" (3.9), "consignment" (3.3) and "order" (3.2).

3.9 inspection batch: Definite quantity of some product or material collected together and submitted for examination or acceptance.

NOTE 6 An inspection batch may consist of several batches or parts of batches. See also "consignment" (3.3) and "order" (3.2).

3.10 inspected batch: Inspection batch that has been submitted to examination.

3.11 maximum size of inspection batch: Upper size limit of an inspection lot from which a certain sample has to be drawn to be submitted to inspection.

3.12 minimum size of inspection batch: Lower size limit of an inspection lot from which a certain sample has to be drawn to be submitted to inspection.

3.13 inspection by attributes: Method which consists in taking note, for every item of a population or of a sample taken from this population, of the presence or absence of a certain characteristic (attribute) and in counting how many items have or do not have this characteristic.

3.14 inspection by variables: Method which consists in measuring a quantitative characteristic for each item of a population or of a sample taken from this population.

3.15 sample: One or more items taken from an inspection batch at random irrespective of their quality and intended to serve as a basis for a decision on that lot.

3.16 sampling plan: Specific plan which states sample size or sizes to be used and the associated acceptance criteria. Verification of an inspection batch based upon the inspection of a sample.

3.17 single sampling: Sampling inspection in which the decision to accept or not to accept a batch is based on the inspection results obtained from a single sample of predetermined size n.

3.18 double sampling: Sampling inspection in which the inspection of the first sample of size n_1 leads to a decision to accept a batch or not to accept it or to take a second sample of size n_2, and the second sampling inspection then leads to a decision of acceptance or rejection.

3.19 sequential sampling: Type of sampling which consists in taking successively items, or sometimes

groups of items, but without fixing their number in advance, the decision to accept or reject the batch being taken as soon as the results permit it, according to rules laid down in advance.

3.20 sample size: Number of items in the sample.

3.21 test specimen: Item or part of an item prepared for testing.

3.22 range: Difference between the greatest and the smallest observed values of a quantitative characteristic.

3.23 nonconformity: Non-fulfilment of a specified requirement.

3.24 nonconforming item; nonconforming unit: Item (unit) with one or more nonconformities.

3.25 acceptance: Conclusion after inspection that a batch or quantity of products satisfies the requirement criteria based on the results of the inspection.

3.26 non-acceptance; rejection: Conclusion after inspection that a batch, or quantity of products does not satisfy the requirement criteria based on the results of the inspection.

NOTE 7 When it is applied to the consignment from a producer, the term "rejection" means in a more liberal sense "non-acceptance of the batch under the conditions of the contract" (for example, the batch may be placed in another class, subjected to a lowering of price, etc.), and it is usual to specify the disposal of a rejected batch (e.g. return to supplier).

3.27 acceptance number, Ac_n: In sampling inspection by attributes, the highest number of nonconformities or nonconforming items (units) found in the sample that permits the acceptance of the batch.

3.28 rejection number; non-acceptance number, Re_n: In sampling inspection by attributes, the lowest number of nonconformities or nonconforming items (units) found in the sample that requires the rejection of the batch.

4 Symbols

Ac_1, Ac_2 — Maximum number of nonconforming items for which a batch is accepted after inspection of the first or second sample respectively

A_n — Criterion of acceptance at the nth item inspected in case of sequential sampling

$$A_n = Sn - h$$

(after inspection of n units)

A_t — Constant of curtailment, determining whether the batch is to be accepted or not when the sequential inspection is curtailed at rank n

$$A_t = Sn_t - h$$

d_n — Number of nonconforming items, in sequential sampling, counted after testing n samples

h — Ordinate at the origin of the acceptance line

k — Coefficient used for the calculations specified in table 2

n — Rank of the item inspected ($n = 1, 2, ...$)

n_0 — Minimum number of pieces (items or units) to inspect, to accept the batch

n_t — Value of n, fixed in advance, at which the sequential inspection is curtailed where required

Re_1, Re_2 — Minimum number of nonconforming items which may lead to rejection after inspection of the first or second sample respectively

R_n — Criterion of non-acceptance at the nth item inspected in case of sequential sampling

$$R_n = Sn + h$$

(after inspection of n units)

S — Slope shared by the acceptance and the non-acceptance line

5 Inspection of consignment of finished products

5.1 Division into inspection batches

5.1.1 Homogeneous consignments

5.1.1.1 Any homogeneous consignment (or sub-consignment, see 5.1.2) shall be divided by the manufacturer into inspection batches, the maximum size of which shall be as given in the relevant International Standard.

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

3

5.1.1.3 Consignments or fractions of consignments smaller than the minimum batch size given in the relevant International Standard shall not be submitted to sampling and testing except by mutual agreement of all the interested parties.

5.1.2 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 inspected by sampling shall be divided by the manufacturer into assumed homogeneous sub-consignments prior to the division into inspection batches in accordance with 5.1.1.

5.2 Sampling from consignment

5.2.1 From each inspection batch (see 5.1.1.1 and 5.1.1.2), the purchaser may draw a sample, the size of which is indicated in table 1 (see 5.2.2 and 5.2.3).

5.2.2 The entry to table 1 is the size of the inspection batch (column 1).

5.2.3 The products where all units undergo a compulsory non-destructive test during manufacture shall not be tested for this characteristic; if inspection of this characteristic is still required, a reduced sampling (table 5) will be used.

5.2.4 A reduced level of sampling (table 5) will also apply if the conditions of 5.1 are fulfilled.

5.2.5 When test specimens are cut from the units of the sample, the cutting is normally carried out by the manufacturer in the presence of the purchaser or his representative. This may only be modified by agreement between the interested parties.

5.3 Interpretation of results

5.3.1 Presentation and interpretation of table 1

5.3.1.1 Each item shall be inspected or tested as specified in the relevant product standard.

5.3.1.2 The inspection results shall be interpreted either by the method of inspection by attributes (see 5.3.1.4, 5.3.2 and 5.3.3) or by the method of inspection by variables (see 5.3.1.5 and 5.3.4).

5.3.1.3 The method of inspection by attributes is normally employed. However, by agreement between the interested parties prior to the drawing of the samples (see 5.2.1), the method of inspection by variables, if applicable, may be chosen.

5.3.1.4 When the method of inspection by attributes is employed, then the acceptability of the inspection batch shall be determined as prescribed in 5.3.2 and 5.3.3 based on the number of nonconforming items.

5.3.1.5 When the method of inspection by variables is employed, the test results shall be recorded so as to retain the order in which the items are selected and the acceptability of the inspection batch determined as prescribed in 5.3.4.

5.3.2 Inspection by attributes — Double sampling

5.3.2.1 When the number of nonconforming items found in the first sample is equal to or less than the acceptance number Ac_1 (3.27) indicated in column 5 of table 1, the inspection batch from which the sample was drawn is accepted.

5.3.2.2 When the number of nonconforming items found in the first sample is equal to or greater than the rejection number Re_1 (3.28) indicated in column 6 of table 1, the inspection lot is not accepted.

5.3.2.3 When the number of nonconforming items found in the first sample lies between the acceptance number and the rejection number (columns 5 and 6 of table 1), a second sample of the same size as the initial sample shall be drawn and examined.

5.3.2.4 The number of nonconforming items found in the first and second samples shall be combined.

5.3.2.5 If the total number of nonconforming items is equal to or less than the acceptance number Ac_2 indicated in column 8 of table 1, the inspected batch is accepted.

5.3.2.6 If the total number of nonconforming items is equal to or greater than the second rejection number Re_2 indicated in column 9 of table 1, the inspected batch is not accepted.

5.3.2.7 When the relevant International Standard calls for more than one property to be tested, the second sample taken (see 5.3.2.3) shall only be inspected for those properties which in the inspection of the first sample gave a number of nonconforming items between the acceptance number Ac_1 and the rejection number Re_1.

Table 1 — Sampling and acceptance criteria to be used when conditions in 6.1 are not fulfilled

Sampling	Single		Double						Sequential				
Method by:	Variables		Attributes						Attributes				
Batch size	Sample	k	1st Sample			1st + 2nd Sample			Coefficients		Size		
			Size	Ac_1	Re_1	Size	Ac_2	Re_2	h	S	n_0	n_t	A_t
1	2	3	4	5	6	7	8	9	10	11	12	13	14
31 to 50									0,632	0,210 8	3	5	1
51 to 90									0,664	0,132 7	5	8	1
91 to 150									0,898	0,144 6	7	14	2
151 to 3 200	7	0,405	8	0	2	16	1	2	1,030	0,126 4	9	20	2
3 201 to 10 000	10	0,507	13	0	3	26	3	4	1,299	0,131 8	10	30	3
10 001 to 35 000	15	0,536	13	0	3	26	3	4	1,299	0,131 8	10	30	3
35 001 to 150 000	25	0,571	20	1	4	40	4	5	1,540	0,113 6	14	48	5
150 001 to 500 000	30	0,577	20	1	4	40	4	5	1,540	0,113 6	14	48	5
> 500 001	40	0,591	32	2	5	64	6	7	1,912	0,112 8	17	75	8

NOTES

1 This table does not contain single or double sampling plans for batch sizes less than 151 items because they would not be severe enough.

2 For batch sizes less than 31 items, a special sampling plan may be drafted by agreement between the producer and the purchaser.

3 The sampling plan for batch sizes between 31 and 50 items is included for guidance only. A more efficient plan may be drafted by agreement between the producer and the purchaser.

5.3.3 Inspection by attributes — Sequential sampling

5.3.3.1 Draw at random a sample of n_t specimens (table 1, column 13) according to the size of the batch (table 1, column 1) and renumber them from 1 to n_t in the order in which they have been drawn.

5.3.3.2 Test the first n_0 specimens (table 1, column 12) in order of sampling.

5.3.3.3 Count the number of nonconforming items d_n after each test.

5.3.3.4 Compute A_n and R_n (see notes in table 1).

5.3.3.5 If $d_n \leqslant A_n$ the lot is accepted.

5.3.3.6 If $d_n \geqslant R_n$ the lot is not accepted.

5.3.3.7 If $A_n < d_n < R_n$ test the next sample and continue to follow the same procedure as in 5.3.3.3 and determine the acceptability and non-acceptability criterion corresponding to the new number of test. Start again with 5.3.3.5.

5.3.3.8 When $n = n_t$ the test is curtailed.

If $d_n \leqslant A_t$ the batch is accepted.

If $d_n > A_t$ the batch is not accepted.

NOTE 8   The criterion A_n is only relevant for $n_0 \leqslant n < n_t$.

5.3.4 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.

5.3.4.1 Divide the readings in the order in which they have been recorded (see 5.3.1.5) into groups of 5, except when the sample size is 7, in which case the groups size is the same as the sample size.

5.3.4.2 For each group, compute the range R.

5.3.4.3 From the group ranges R compute the average range $\bar{R}$.

5.3.4.4 Compute the sample mean $\bar{X}$ by dividing the sum of the measurements by the sample size.

5.3.4.5 Obtain from table 1 (column 3) the coefficient k.

5.3.4.6 Compute the acceptability limit AL and determine the acceptability by means of table 2.

Table 2 — Acceptance criteria for inspection by variables

Limit prescribed in relevant International Standard	AL	Acceptance if	Rejection if
Lower specified limit L_l	$L_l + k\bar{R}$	$\bar{X} \geqslant AL$	$\bar{X} < AL$
Upper specified limit L_u	$L_u - k\bar{R}$	$\bar{X} \leqslant AL$	$\bar{X} > AL$

6 Inspection of finished products from continuous production process

6.1 General

The sampling scheme for continuous production shall have an AQL of 4 % or better. Alternative schemes[3] (e.g. using the standard deviation) to the following may be used providing that they meet this criterion. For cumulative, large batches, an AQL of 4 % and inspection level S3 is approximately equivalent to a fractile of 5 %.

3) See ISO 3951.

6.2 Sampling

6.2.1 The size of production batch for assessment, whether for initial testing or for retesting is chosen by the manufacturer including up to a maximum of one week's production.

6.2.2 The size limits of inspection batches (see 3.11 and 3.12) do not apply to production batches.

6.2.3 Items are drawn at random during their production, suitably marked, cured and stored in the same manner as the rest of the batch.

6.2.4 The number of items submitted to each test is indicated in tables 3 to 5.

6.2.5 The entry into the tables is the size of the production batch.

6.3 Testing and interpretation of results

6.3.1 Testing shall be carried out as specified in the appropriate product standard.

6.3.2 The sampling and interpretation of results shall be based on either the method of inspection by attributes or by the method of inspection by variables.

6.3.3 The choice of method is at the discretion of the manufacturer.

6.3.4 When the method of inspection by attributes is employed, then the acceptability of the batch shall be determined as prescribed in 5.3.2, based on the number of nonconforming items but using table 3, 4 or 5, depending on the case.

6.3.5 When the method of inspection by variables is employed the test results shall be recorded so as to retain the order in which the items are selected and the acceptability of the batch determined as prescribed in 5.3.4 but using table 3, 4 or 5, depending on the case.

6.4 Retesting of nonconforming batches

6.4.1 When a production batch is deemed to be unacceptable following initial inspection. the products may be subsequently reinspected for those characteristics which failed the initial inspection.

6.4.2 For the purposes of retest, the batch may be resubmitted in its entirety or subdivided into smaller homogeneous batches.

6.4.3 Results shall be interpreted using table 4 irrespective of the initial inspecting scheme (normal, tightened or reduced) according to the schemes of ISO 2859-1 (see annex A) and ISO 3951 (see annex B) but using the same method (attributes or variables).

6.4.4 The entry to table 4 is given by the size of the production batch or the size of the new batches when a subdivision has been made.

Table 3 — Inspection of finished products from continuous production process — Normal inspection

Size of batch	Inspection by attributes — Double sampling					Inspection by variables — Single sampling	
	Sample size[1]	Initial sample		Initial sample + Second sample[1]		Sample size	Acceptance coefficient
		Ac_1	Re_1	Ac_2	Re_2		k
1	2	3	4	5	6	7	8
⩽ 150	3	0	1	NA[2]	NA[2]	3	0,502
151 to 280	8	0	2	1	2	3	0,502
281 to 500	8	0	2	1	2	4	0,450
501 to 1 200	8	0	2	1	2	5	0,431
1 201 to 3 200	8	0	2	1	2	7	0,405
3 201 to 10 000	13	0	3	3	4	10	0,507
10 001 to 35 000	13	0	3	3	4	15	0,536
35 001 to 150 000	20	1	4	4	5	25	0,571
150 001 to 500 000	20	1	4	4	5	30	0,577
⩾ 500 001	32	2	5	6	7	40	0,591

NOTES

1 For inspection by attributes, the table is drawn from table III-A of ISO 2859-1:1989.

2 For inspection by variables, the table is drawn from table RII-A of ISO 3951:1989.

1) In the case of the second sample, its size shall be the same as of the initial sample.

2) NA = Not applicable.

7 Effects of inspection of finished products from continuous production process on inspection of consignments

7.1 With third party certification neither on products nor on quality assurance system

Inspection of consignments should not be required if the quality system of the factory is based on ISO 9001, ISO 9002 or ISO 9003 and if the following conditions for the inspection of the finished products are all satisfied:

a) sampling procedure in accordance, at least, with the requirements given in clause 6;

b) carrying out of compulsory tests as specified in the relevant International Standards;

c) recording of measurements obtained by these tests, these results being supplied to the purchaser if required;

d) limits for acceptance in accordance with the requirements of relevant International Standards;

e) interpretation of the results for acceptance or rejection of production batches in accordance with relevant International Standards.

If a customer requires inspection of a consignment, a reduced level of sampling (see table 5) will be used.

Table 4 — Inspection of finished products from continuous production process — Tightened inspection or retesting of nonconforming batches

Size of batch	Inspection by attributes — Double sampling					Inspection by variables — Single sampling	
	Sample size[1]	Initial sample		Initial sample + Second sample[1]		Sample size	Acceptance coefficient
		Ac_1	Re_1	Ac_2	Re_2		k
1	2	3	4	5	6	7	8
⩽ 150	5	0	1	NA[2]	NA[2]	3	0,587
151 to 280	13	0	2	1	2	3	0,587
281 to 500	13	0	2	1	2	4	0,525
501 to 1 200	13	0	2	1	2	5	0,498
1 201 to 3 200	13	0	2	1	2	7	0,465
3 201 to 10 000	13	0	2	1	2	10	0,579
10 001 to 35 000	13	0	2	1	2	15	0,610
35 001 to 150 000	20	0	3	3	4	25	0,647
150 001 to 500 000	20	0	3	3	4	30	0,654
⩾ 500 001	32	1	4	4	5	40	0,668

NOTES

1 For inspection by attributes, the table is drawn from table III-B of ISO 2859-1:1989.

2 For inspection by variables, the table is drawn from table RII-B of ISO 3951:1989.

1) In the case of the second sample, its size shall be the same as of the initial sample.

2) NA = Not applicable.

7.2 With third party certification on products

Where there is third party certification, no testing of consignment is required.

7.3 With third party certification on quality assurance system

No testing of consignment should be asked for if the quality assurance system is certified by a third party in accordance with ISO 9001 or ISO 9002 and if the efficiency of the system is at least equivalent to the requirements of clause 6 regarding product characteristics.

Table 5 — Inspection of finished products from continuous production process — Reduced inspection or inspection of consignment when conditions of 6.1 are fulfilled

Size of batch	Inspection by attributes — Double sampling					Inspection by variables — Single sampling	
	Sample size[1]	Initial sample		Initial sample + Second sample[1]		Sample size	Acceptance coefficient
		Ac_1	Re_1	Ac_2	Re_2		k
1	2	3	4	5	6	7	8
$\leqslant$ 150	2	0	1	NA[2]	NA[2]	3	0,401
151 to 3 200	3	0	2	0	2	3	0,401
3 201 to 10 000	5	0	3	0	4	4	0,364
10 001 to 35 000	5	0	3	0	4	5	0,352
35 001 to 150 000	8	0	4	1	5	7	0,336
150 001 to 500 000	8	0	4	1	5	10	0,424
$\geqslant$ 500 001	13	0	4	3	6	15	0,452

NOTES

1 For inspection by attributes if after the second sample the acceptance number is exceeded but the rejection number not reached the lot is accepted but normal inspection is re-established.

2 For inspection by attributes, the table is drawn from table III-C of ISO 2859-1:1989.

3 For inspection by variables, the table is drawn from table RII-C of ISO 3951:1989.

1) In the case of the second sample, its size shall be the same as of the initial sample.

2) NA = Not applicable.

Annex A

(normative)

Rules and sampling tables for inspection by attributes

(extract from ISO 2859-1)

9 Normal, tightened and reduced inspection

9.1 Start of inspection

Normal inspection shall be carried out at the start of inspection, unless otherwise directed by the responsible authority.

9.2 Continuation of inspection

Normal, tightened or reduced inspection shall continue unchanged on successive lots, except where the switching procedures (see 9.3) require change. The switching procedures shall be applied to each class of nonconformities or nonconforming units independently.

9.3 Switching rules and procedures (see figure 1)

9.3.1 Normal to tightened

When normal inspection is being carried out, tightened inspection shall be put into operation when two out of five or less consecutive lots have been non-acceptable on original inspection (that is, ignoring resubmitted lots or batches for this procedure).

9.3.2 Tightened to normal

When tightened inspection is being carried out, normal inspection shall be reverted to when five consecutive lots have been considered acceptable on original inspection.

9.3.3 Normal to reduced

When normal inspection is being carried out, reduced inspection shall be put into operation provided that all of the following conditions are satisfied:

a) the preceding 10 lots (or more, as indicated by the note to table VIII) have been submitted to normal inspection and all have been accepted on original inspection; and

b) the total number of nonconforming units (or nonconformities) in the samples from the preceding 10 lots [or such other number as was used for condition a) above] is equal to or less than the

applicable limit number given in table VIII. If a double or multiple sample is in use, all samples inspected should be included, not "first" samples only; and

c) production is at a steady rate; and

d) reduced inspection is considered desirable by the responsible authority.

9.3.4 Reduced to normal

When reduced inspection is being carried out, normal inspection shall be reverted to if any of the following occur on original inspection:

a) a lot is not accepted; or

b) a lot is considered acceptable under the procedures for reduced inspection given in 11.1.4; or

c) production becomes irregular or delayed; or

d) other conditions warrant that normal inspection shall be reverted to.

9.4 Discontinuation of inspection

If the cumulative number of lots not accepted in a sequence of consecutive lots on original tightened inspection reaches 5, the acceptance procedures of this part of ISO 2859 shall be discontinued. Inspection under the provisions of this part of ISO 2859 shall not be resumed until action has been taken by the supplier to improve the quality of the submitted product or service. The responsible authority shall agree that this action is likely to be effective. Tightened inspection shall then be used as if 9.3.1 had been invoked.

11.1.4 Special procedure for reduced inspection

In reduced inspection, the sample may contain a number of nonconforming units or nonconformities per 100 units between the acceptance and rejection numbers. In these circumstances, the lot shall be considered acceptable, but normal inspection shall be reinstated starting with the next lot [see 9.3.4 b)].
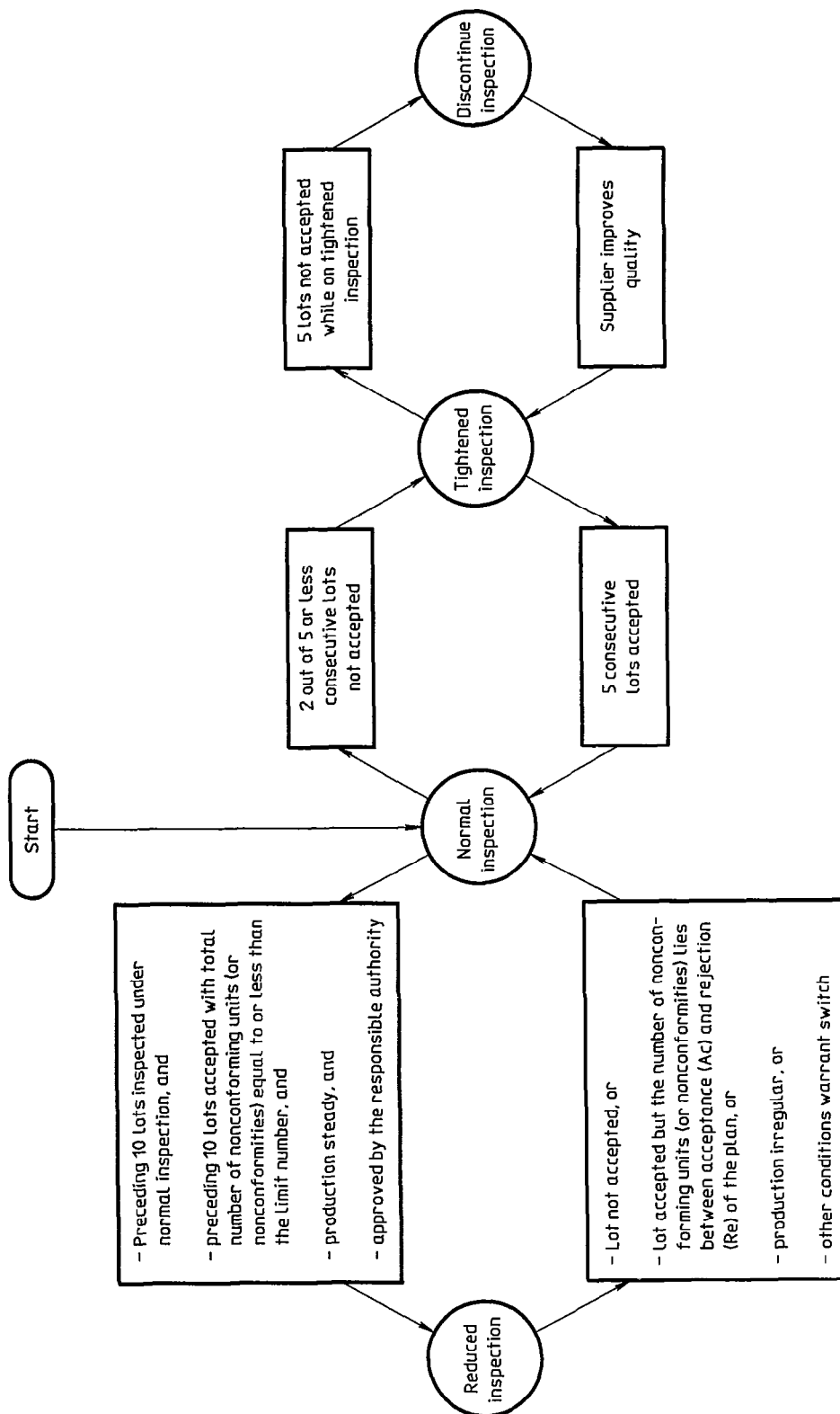
Figure A.1 — Outline of the switching rules (see 9.3)

Table VIII — Limit numbers for reduced inspection (see 9.3.3)

Number of sample units from last 10 lots or batches	Acceptable quality level																									
	0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5	10	15	25	40	65	100	150	250	400	650	1 000
20 – 29	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	2	4	8	14	22	40	68	115	181
30 – 49	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	1	3	7	13	22	36	63	105	177	277
50 – 79	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	2	3	7	14	25	40	63	110	181	301	
80 – 129	*	*	*	*	*	*	*	*	*	*	*	*	0	0	2	4	7	14	24	42	68	105	181	297		
130 – 199	*	*	*	*	*	*	*	*	*	*	*	0	0	2	4	8	13	25	42	72	115	177	301	490		
200 – 319	*	*	*	*	*	*	*	*	*	*	0	0	2	4	8	14	22	40	68	115	181	277	471			
320 – 499	*	*	*	*	*	*	*	*	*	0	0	1	4	8	14	24	39	68	113	189						
500 – 799	*	*	*	*	*	*	*	*	0	0	2	3	7	14	25	40	63	110	181							
800 – 1 249	*	*	*	*	*	*	*	0	0	2	4	7	14	24	42	68	105	181								
1 250 – 1 999	*	*	*	*	*	*	0	0	2	4	7	13	24	40	69	110	169									
2 000 – 3 149	*	*	*	*	*	0	0	2	4	8	14	22	40	68	115	181										
3 150 – 4 999	*	*	*	*	0	0	1	4	8	14	24	38	67	111	186											
5 000 – 7 999	*	*	*	0	0	2	3	7	14	25	40	63	110	181												
8 000 – 12 499	*	*	0	0	2	4	7	14	24	42	68	105	181													
12 500 – 19 999	*	0	0	2	4	7	13	24	40	69	110	169														
20 000 – 31 499	0	0	2	4	8	14	22	40	68	115	181															
over 31 449	0	1	4	8	14	24	38	67	111	186																

LIMIT NUMBERS

* Denotes that the number of sample units from the last 10 lots or batches is not sufficient for reduced inspection for this AQL. In this instance, more than 10 lots or batches may be used for the calculation, provided that the lots or batches used are the most recent ones in sequence, that they have all been subjected to normal inspection and that none has been rejected during the normal inspection.

Annex B

(normative)

Rules and sampling tables for inspection by variables by measuring the percentage of nonconforming items

(extract from ISO 3951)

19 Operation of switching rules

The standard switching rules are as follows.

19.1 Normal inspection is used at the start of inspection (unless otherwise designated) and shall continue to be used during the course of inspection until tightened inspection becomes necessary or reduced inspection is allowed.

19.2 Tightened inspection shall be instituted when two lots on original inspection are not accepted within any five or fewer successive lots.

Tightened inspection is achieved by increasing the values of the acceptability constant. The values are tabulated in table II-B for the "s" method (table RII-B for the "R" method) and table III-B for the "σ" method. In the "s" method (and also in the "R" method), there is no change in the size of the sample, unless the sample size is so small that the tables indicate, with a downward arrow, that an increase in sample size is necessary.

19.3 Tightened inspection shall be relaxed when five successive lots on original inspection have been accepted on tightened inspection; then reinstate normal inspection.

19.4 Reduced inspection may be instituted after ten successive lots have been accepted under normal inspection, provided that

a) these lots would have been acceptable if the AQL had been one step tighter;

NOTE — If a value of k for this tighter AQL is not given in table II-A ("s" method), a sufficiently accurate acceptance curve may be extrapolated by eye in

comparison with the other curves of the appropriate diagram in the "s" series. The same procedure applies to the "σ" method (and the "R" method).

b) production is in statistical control;

c) reduced inspection is considered desirable by the responsible authority.

Reduced inspection is conducted on a much smaller sample than normal inspection and the value of the acceptability constant is also decreased. The values of n and k for reduced inspection are given in table II-C for the "s" method, table III-C for the "σ" method (table RII-C for the "R" method).

19.5 Reduced inspection shall cease and normal inspection be reinstated if any of the following occur on original inspection:

a) a lot is not accepted;

b) production becomes irregular or delayed;

c) other conditions warrant that normal inspection shall be instituted.

20 Discontinuation and resumption of inspection

If the cumulative number of lots not accepted in a sequence of consecutive lots on original tightened inspection reaches 5, the acceptance procedures of this International Standard shall be discontinued.

Inspection under the provisions of this International Standard shall not be resumed until action has been taken by the supplier to improve the quality of the submitted product or service. Tightened inspection shall then be used as if 19.2 had been invoked.

Annex C

(informative)

Examples

The examples in this annex are intended as a guide to using the techniques in this International Standard in practical situations.

The examples in C.1.1 to C.1.3 relate to the inspection of consignments of finished products (see clause 5), and the two examples in C.2.1 and C.2.2 to the inspection from a continuous production process (see clause 6).

C.1 Inspection of consignments of finished products

C.1.1 Example 1 — Slates with inspection by attributes (double sampling)

The objective is to inspect a lot consisting of 20 000 slates size 40 cm × 20 cm in conformance with the thickness specification in ISO 395.

Specified values in ISO 395 are

nominal thickness:	3,30 mm
minimum thickness (L_l):	3,00 mm
maximum thickness (L_u):	3,80 mm

C.1.1.1 Without quality control in plant

The sample size required is 13 (see table 1, column 4) and the following readings, in millimetres, were obtained:

3,55	3,60	3,50	3,85	3,30	3,30
3,45	3,25	3,35	3,45	3,50	3,45
3,55					

One value (3,85) exceeded the upper limit, L_u, (3,80) and by referring to 5.3.2.1, 5.3.2.2 and table 1, columns 5 and 6, the lot was not accepted at the first sample and testing of the second sample (a further 13 samples) was required.

From 5.3.2.3 and table 1, column 7, a further 13 samples (total 26) were required, and the following readings, in millimetres, were obtained:

3,60	3,35	3,50	3,25	3,25	3,90
3,60	3,45	3,30	3,50	3,50	3,35
3,40					

One value (3,90) from this second sample exceeded the upper limit making a total of 2 from the group of 26 (see 5.3.2.4) and by referring to 5.3.2.5, 5.3.2.6 and table 1, columns 8 and 9, the lot was accepted, since the number of nonconforming items (2) was less than Ac_2.

C.1.1.2 With quality control in plant

The sample size required is 5 (see 5.2.4 and table 5) and the following readings, in millimetres, were obtained:

3,55	3,60	3,50	3,40	3,30

There were no nonconforming values and the lot was accepted.

NOTE 9   If nonconforming values had been found, the same procedure would have been adopted as in the example in C.1.1.1 but using table 5 for the Ac and Re numbers.

C.1.2 Example 2 — Pipes with inspection by attributes (sequential sampling)

The objective is to inspect a lot consisting of 100 pipes of diameter 150 for conformance with the bending breaking load specification in ISO 881.

Specified value in ISO 881 is

minimum bending breaking load (L_l): 6,0 kN

C.1.2.1 Without quality control in plant

The sample size required n_t is 14 (numbered sequentially) (see 5.3.3.1 and table 1, column 13).

The minimum number of samples to be tested is 7 (see 5.3.3.2 and table 1, column 12).

After testing the first 7 samples in sequential order, the following results were obtained:

Recorded values in kilonewtons

6,25	6,65	7,00	6,45
5,90	6,70	7,35	

One value (5,90) falls below the lower limit (L_l).

Acceptance criteria after 7 tests

$A_n = (0,144\ 6 \times 7) - 0,898$

$= 0,114\ 2$ (see table 1, columns 10 and 11)

Non-acceptance criteria after 7 tests

$R_n = (0,144\ 6 \times 7) + 0,898$

$= 1,91$ (see table 1, columns 10 and 11)

As the number of nonconforming items d_n (= 1) fell between A_n (= 0,114 2) and R_n (= 1,91) the sequential testing and calculations were continued (see 5.3.3.7).

Sample No.	Test results	d_n	A_n	R_n
8	7,05	1[1]	0,259	2,055
9	6,80	1	0,403	2,199
10	5,85	2	0,548	2,344
11	6,50	2	0,693	2,488
12	7,10	2	0,838	2,633
13	6,60	2	0,982	2,777
14	7,55	2	1,127	2,922

1) $d_n = 1$ from previous 7 test samples.

At completion of inspection ($n_t = n$, $A_t = A_n$), the lot was not accepted as $d_n > A_t$ (see 5.3.3.8).

NOTE 10   The testing could have been curtailed after testing sample No. 10, as although d_n met the criteria to continue testing (i.e. $A_n < d_n < R_n$) it already exceeded the value for A_t. However this observation can only be made if the A_n and R_n values are calculated prior to continuing the sequential testing.

C.1.2.2   With quality control in plant

No reduced sampling is appropriate to this method and the method in C.1.1.2 should be used.

C.1.3   Example 3 — Slates with inspection by variables (single sampling)

The objective is to inspect a batch consisting of 20 000 slates for conformance with the thickness specification in ISO 395.

Specified values in ISO 395 are

nominal thickness:	3,30 mm
minimum thickness (L_l):	3,00 mm
maximum thickness: (L_u):	3,80 mm

C.1.3.1   Without quality control in plant

The sample size required is 15 (see 5.2.1 and table 1, column 2).

Coefficient k is $= 0,536$ (see table 1, column 3).

The following values, in millimetres, were obtained on the 15 samples and the ranges, average range and sample mean calculated (see 5.3.4.1 to 5.3.4.4).

Recorded values					Range R
3,25	3,45	3,10	3,75	3,50	0,65
3,05	3,70	3,60	3,60	3,80	0,75
3,50	3,45	3,30	3,85	3,30	0,55

Sample mean $\overline{X} = 3,48$ mm

Average range $\overline{R} = 0,65$

The acceptance limits (for the sample mean) are then calculated as shown in table 2.

Lower limit $= L_l + k\overline{R} = 3,00 + (0,536 \times 0,65) = 3,3$

Upper limit $= L_u - k\overline{R} = 3,80 - (0,536 \times 0,65) = 3,45$

In this case $\overline{X}$ (3,48) exceeds the upper limit (3,45) and the lot is not accepted (see 3.26).

C.1.3.2   With quality control in plant

The sample size required is 5 (see 5.2.4 and table 5, column 7).

Coefficient k is $= 0,352$ (table 5, column 8).

The following values were obtained on the 5 samples and the range and sample mean calculated (see 5.3.4.1 to 5.3.4.4).

Recorded values					Range R
3,25	3,45	3,10	3,75	3,50	0,65

Sample mean $X = 3,41$ mm

Average range $\overline{R} = 0,65$

The acceptance limits (for the sample mean) were then calculated as shown in table 2.

Lower limit $= L_l + k\overline{R} = 3,00 + (0,352 \times 0,65) = 3,23$

Upper limit $= L_u - k\overline{R} = 3,80 - (0,352 \times 0,65) = 3,57$

In this case $\overline{X}$ (3,41) is between the limits and the batch was accepted (see 3.25).

C.2 Inspection of finished products from continuous production process

C.2.1 Example 4 — Slates inspection by attributes (double sampling)

The objective is to inspect slates size 40 cm × 20 cm from a continuous production process. The batch size chosen (see 6.2.1) was one 8 h shift during which approximately 40 000 units were produced. The check is for conformity with the thickness specification in ISO 395.

Specified values in ISO 395 are

nominal thickness:	3,30 mm
minimum thickness (L_1):	3,00 mm
maximum thickness (L_u):	3,80 mm

The sample size required is 20 (see table 3, column 1) and the following values, in millimetres, were obtained:

Recorded values:

3,60	3,65	3,40	3,20	3,75
3,85	3,70	3,50	3,30	3,65
3,10	3,35	2,95	3,20	3,40
3,55	3,65	3,70	3,30	3,70

One value (3,85) exceeded the upper limit, L_u, (3,80) and one value (2,95) was below the lower limit L_1 (3,00) giving a total of two nonconforming specimens and by referring to 5.3.2.1, 5.3.2.2 and table 3, columns 3 and 4, the batch was not accepted on the first sample and testing of a second sample (a further 20 samples) carried out with the following results.

Recorded values:

3,50	3,20	3,30	3,45	3,75
3,95	3,10	3,40	3,75	3,60
3,35	2,90	3,60	3,70	3,45
3,25	3,75	3,45	3,85	3,65

Two values (3,95; 3,85) exceeded the upper limit, L_u, (3,80) and one value (2,90) was below the lower limit L_1 (3,00). This gave a total of $2 + 3 = 5$ nonconforming specimens from the two sample batches (40 in total). By referring to 5.3.2.5, 5.3.2.6 and columns 5 and 6 in table 3, the lot was not accepted (the number of nonconforming items (5) was greater than Re_2).

C.2.2 Example 5 — Pipes inspected by variables (single sampling)

The objective is to sample pipes diameter 150 from a continuous production process. The batch sizes chosen (see 6.2.1) was a 12 h shift during which 500 pipes were produced. The check is for conformity with the bending breaking load specification in ISO 881. Reduced inspection rules are in effect (see 5.2.4).

Specified value in ISO 881 is

minimum bending breaking load (L_1): 6,0 kN

The sample size required is 3 (see table 5, column 7).

Coefficient k is 0,401 (see table 5, column 8).

The following values were obtained on the 3 samples and the range and sample mean calculated (see 5.3.4.1 to 5.3.4.4).

Recorded values (kN)			Range R
6,25	6,40	6,10	0,30

Sample mean $\bar{X} = 6,25$ kN

Average range $\bar{R} = R = 0,30$
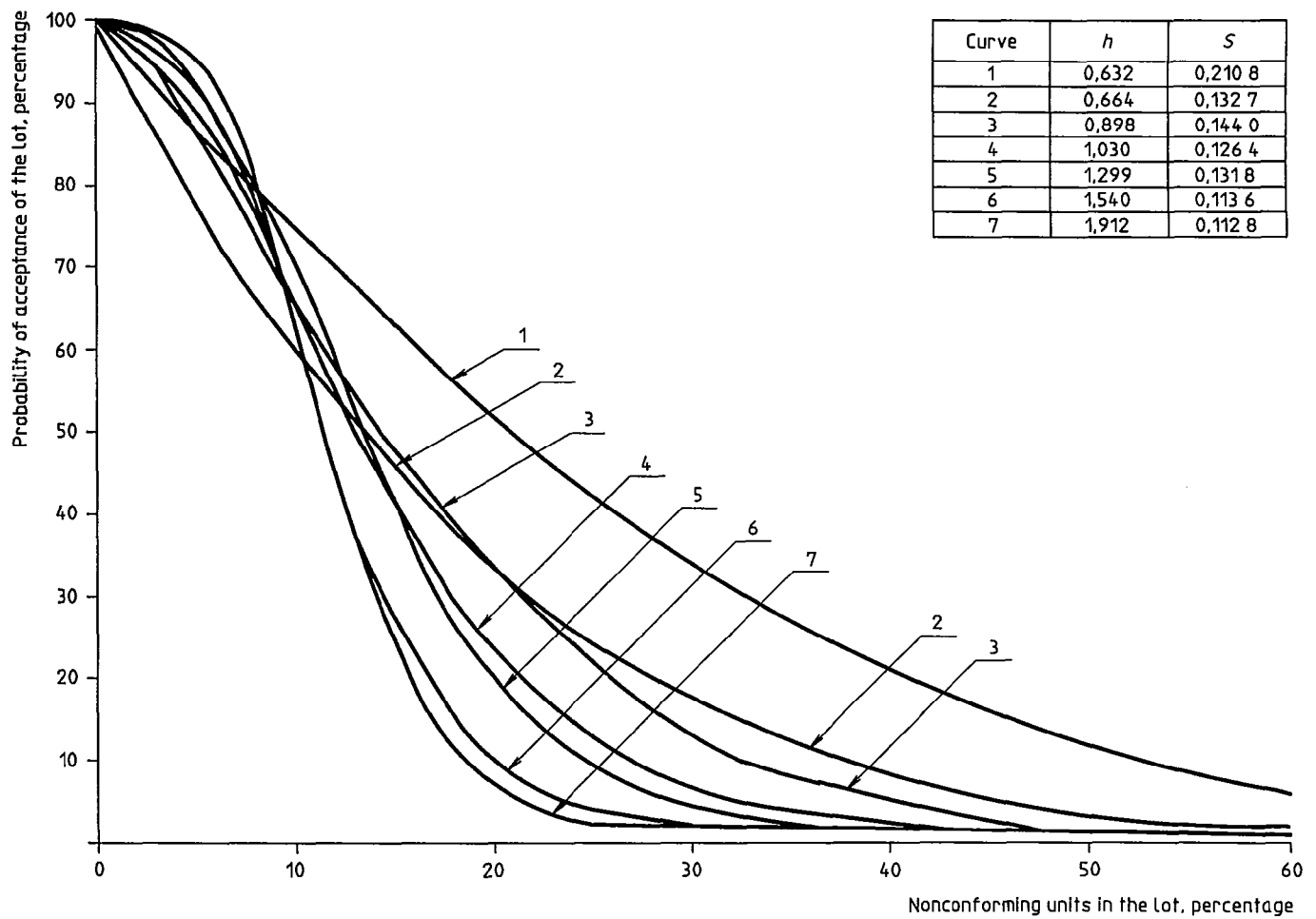
The acceptance limits (for the sample mean) was then calculated as shown in table 2.

Lower limit $= L_1 + k\bar{R} = 6,0 + (0,401 \times 0,3)$
$= 6,12$

In this case $\bar{X}$ (6,25) exceeded the lower limit (6,12) and the batch was accepted.

Annex D
(informative)

OC curves

Curve	h	S
1	0,632	0,210 8
2	0,664	0,132 7
3	0,898	0,144 0
4	1,030	0,126 4
5	1,299	0,131 8
6	1,540	0,113 6
7	1,912	0,112 8

Figure D.1 — OC curves for sequential sampling by attributes
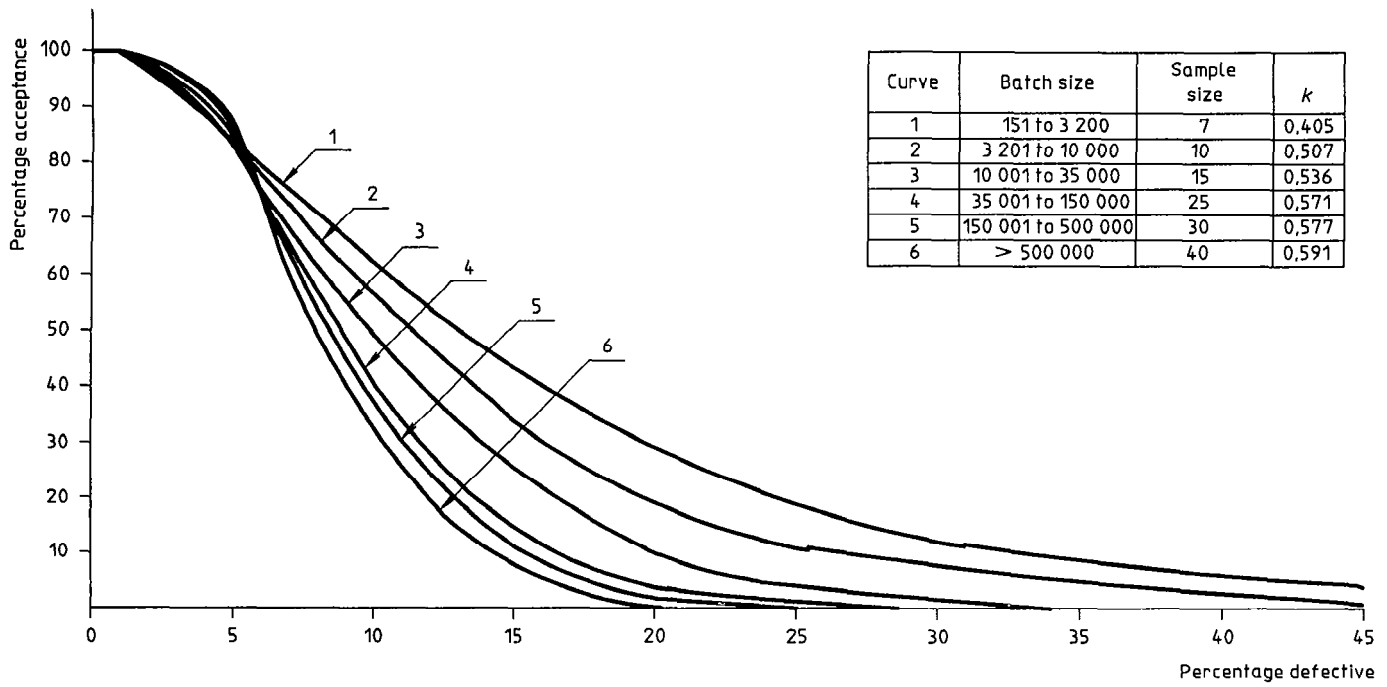
Figure D.2 — OC curves for sampling by variables

Curve	Batch size	Sample size	k
1	151 to 3 200	7	0,405
2	3 201 to 10 000	10	0,507
3	10 001 to 35 000	15	0,536
4	35 001 to 150 000	25	0,571
5	150 001 to 500 000	30	0,577
6	> 500 000	40	0,591
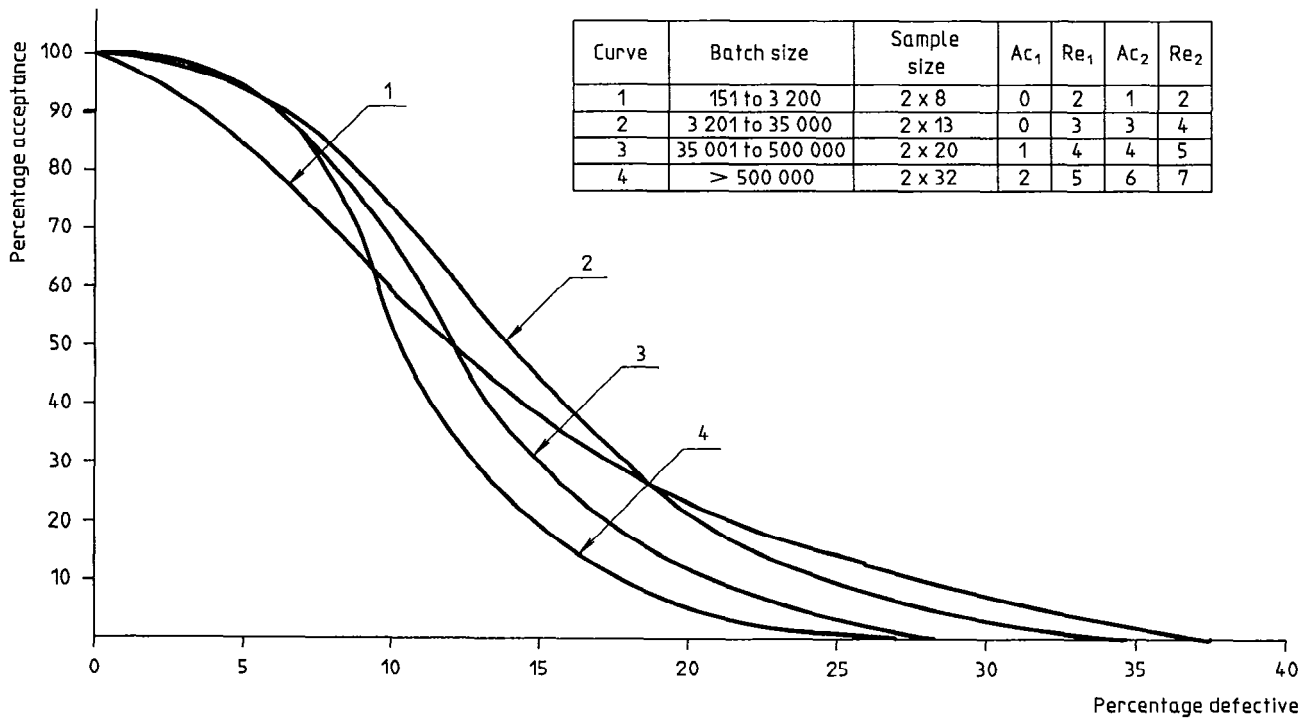
Figure D.3 — OC curves for double sampling by attributes

Curve	Batch size	Sample size	Ac_1	Re_1	Ac_2	Re_2
1	151 to 3 200	2 x 8	0	2	1	2
2	3 201 to 35 000	2 x 13	0	3	3	4
3	35 001 to 500 000	2 x 20	1	4	4	5
4	> 500 000	2 x 32	2	5	6	7