BRITISH STANDARD

BS EN 61358:1996
IEC 1358:1996

Acceptance inspection for direct connected alternating current static watt-hour meters for active energy (classes 1 and 2)

The European Standard EN 61358:1996 has the status of a British Standard

ICS 17.220.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee PEL/13, Electricity meters, upon which the following bodies were represented:

Building Automation and Mains Signalling Association (BAMSA)
BEAMA Metering Association (BMA)
Department of Trade and Industry
Electricity Association
Electricity Pool of England and Wales
Energy Systems Trade Association
Flag Association
Institution of Electrical Engineers
Office of Electricity Regulations (OFFER)
United Kingdom Automatic Meter Reading Association

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Contents

National foreword

This British Standard has been prepared by Technical Committee PEL/13 and is the English Language version of EN 61358:1996 *Acceptance inspection for direct connected alternating current static watt-hour meters for active energy (classes 1 and 2)* published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 1368:1996 published by International Electrotechnical Commission (IEC).

Cross-references

Publication referred to	Corresponding British Standard
EN 60514:1995 (IEC 514:1975)	BS EN 60514 *Acceptance inspection of class 2 alternating-current watt-hour meters*
EN 61036:1992 (IEC:1990)	BS EN 61036:1993 *Alternating current static watt-hour meters for active energy (classes 1 and 2)*
	BS ISO 3534: *Statistics. Vocabulary and symbols*
ISO 3534-1:1993	BS ISO 3534-1:*1993 Probability and general statistical terms*
ISO 3534-2:1993	BS ISO 3534-2:*1993 Statistical quality control*

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

EUROPEAN STANDARD
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English version

Acceptance inspection for direct connected alternating current static watt-hour meters for active energy (classes 1 and 2)

(IEC 1358:1996)

Contrôle de réception des compteurs statiques d'énergie active pour courant alternatif et à branchement direct (classes 1 et 2)
(CEI 1358:1996)

Annahmeprüfung von elektronischen Wechselstrom-Wirkverbrauchzählern für direkten Anschluß (Klassen 1 und 2)
(IEC 1358:1996)

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 13/1093/FDIS, future edition 1 of IEC 1358, prepared by IEC TC 13, Equipment for electrical energy measurement and load control, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61358 on 1996-03-05.

The following dates were fixed:

— latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop) 1997-01-01
— latest date by which the national standards conflicting with the EN have to be withdrawn	(dow) 1997-01-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A and ZA are normative and annex B is informative.

Annex ZA has been added by CENELEC.

Contents

Introduction

This International Standard describes, in some detail, methods for acceptance inspection, and testing of newly manufactured static watt-hour meters delivered in quantities of 50 and above. IEC 514 serves as a reference document and annex A of that standard should be consulted for explanatory notes concerning sampling procedures.

In this standard, wider error limits than those for type tests specified in the relevant publications have been allowed because:

— acceptance testing conditions have wider tolerances than those for type tests;

— displacing of the zero axis is not applicable for acceptance testing;

— the effects of handling of meters are taken into account.

1 Scope

The methods and procedures included in this International Standard apply to newly manufactured direct connected alternating current static watt-hour meters of classes 1 and 2, covered by IEC 1036, which are produced and delivered in quantities of 50 and above.

They provide for 100 % inspection or sampling inspection for acceptance by the purchaser.

2 General remarks

2.1 Two methods of acceptance inspection are proposed, namely:

— 100 % inspection, and

— sampling inspection.

2.2 The 100 % inspection consists of testing all the meters of a batch.

2.3 The sampling inspection is based upon the principles of mathematical statistics and as a consequence certain specified risks are undertaken both by the manufacturer and the purchaser. However, sampling inspection generally is more economical than 100 % inspection.

In this standard, sampling inspection has been planned so that, in practice, the quality of the meter batches can be judged with nearly the same confidence as with 100 % inspection.

2.4 Two methods of sampling inspection are described:

— inspection by attributes;

— inspection by variables.

These two methods have been chosen so that the judgement of quality is virtually the same for both methods.

2.5 Inspection by *attributes* gives results indicating conformity or non-conformity.

It *shall* be applied when the characteristics under inspection cannot be measured.

It *shall* also be applied when a characteristic can be measured but the values are not of normal distribution (Laplace-Gauss).

It *may* be applied, when the distribution is approximately normal, in place of inspection by variables.

The advantage of inspection by attributes is its simplicity of application.

2.6 Inspection by *variables* gives additional information but it is applicable only when the values of a characteristic are measurable and when those values are approximately normally distributed. In these circumstances, inspection by variables is the recommended method.

The advantage of inspection by variables is a smaller sample size than by attributes for the same risk of decision. However, it requires more calculation.

The test results are represented by:

$\bar{x}$ = sample mean as an estimation of the batch mean;

s = standard deviation
$\overline{w}$ = average range
} as an estimation of the dispersion of the characteristics x in the batch.

NOTE The average range is easier to calculate than the standard deviation. However, when suitable calculating means are available for making a decision and for preparing additional information, the use of the standard deviation enables the efficiency of the method to be increased for the same sample size.

2.7 Inspection by variables is based on normally distributed values. It is recommended to test whether the sample is normally distributed, using e.g.:

— The "w/s" test of David, Hartley and Pearson. For details of the test procedures see [1][1)]
For this test only the figures $w(x_{max} - x_{min})$ and s are needed.

— The Wilk-Shapiro test.
For details of the test procedures see [2].

— The Pearson chi-square test.

[1)] Figures in square brackets refer to the bibliography given in annex B.

3 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents 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 normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 410:1973, *Sampling plans and procedures for inspection by attributes*.

IEC 514:1975, *Acceptance inspection of Class 2 alternating-current watthour meters*.

IEC 1036:1990, *Alternating current static watt-hour meters for active energy (classes 1 and 2)*.

ISO 3534-1:1993, *Statistics — Vocabulary and symbols — Part 1: Probability and general statistical terms*.

ISO 3534-2:1993, *Statistics — Vocabulary and symbols — Part 2: Statistical quality control*.

4 Definitions

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

For definitions concerning meters, reference is made to IEC 1036. The majority of the definitions of sampling techniques are generally in accordance with [3] and with ISO 3534-1 and ISO 3534-2.

4.1
batch

definite quantity of meters of the same type, of the same voltage and current rating and the same register, delivered by one supplier, manufactured or produced under conditions which are presumed uniform

4.2
batch size

number N of meters in a batch [ISO]

4.3
sample

meters taken at random for inspection from a batch

4.4
sample size

number n of meters in the sample [ISO]

4.5
100 % inspection

inspection of every meter in a batch

4.6
sampling inspection

inspection of a limited number of meters, taken at random from the batch, according to a prescribed sampling plan [ISO, modified]

4.7
sampling plan

plan according to which one or more samples are taken to obtain information and possibly to reach a decision [ISO, modified]

4.8
characteristic (quality characteristic)

property (e.g. dielectric strength, starting, accuracy at one test point) of a meter which contributes to the quality and which helps to differentiate between the meters of a given batch. The differentiation may be either quantitative (by variable) or qualitative (by attributes)

if it is measurable, its value for a given meter i is indicated by x_i. [ISO, modified]

4.9
defect

failure of a meter to meet a standard with respect to a characteristic [ISO] modified]

4.10
defective meter

meter having one or more defects [ISO, modified]

4.11
operating characteristic curve

curve showing, for a given sampling plan, the probability of acceptance of a batch as a function of its actual quality for a given characteristic [ISO, modified]

4.12
inspection by attributes

inspection whereby certain characteristics of the sample meters are evaluated, classified as conforming or not conforming to the requirements, the number of defective meters counted and used as the basis for judgement of the batch (EOQC)

4.13
acceptance number

maximum permitted number of defects in a sample for inspection by attributes

4.14
inspection by variables

inspection whereby certain characteristics of the sample meters (e.g. a meter error for a particular current) are measured with respect to a continuous scale (e.g. in per cent), and their mean value, the standard deviation or the average range calculated and used as the basis for judgement of the batch

4.15
sample mean $\bar{x}$

arithmetic mean of values x_i for a characteristic (e.g. a meter error for a particular current) in the sample:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

4.16
range w_j

difference between the maximum and minimum observed values of a given characteristic in a subgroup:

$$w_j = |x_{max} - x_{min}|$$

for subgroup j

NOTE For the purpose of this standard, the size m of a subgroup j is 5 and there are r subgroups in a sample.

4.17
average range $\bar{w}$

arithmetic mean of the r ranges w_j of the r subgroups in a sample

$$\bar{w} = \frac{\sum_{j=1}^{r} w_j}{r}$$

NOTE This is an estimation of the dispersion of the characteristic x in a batch.

4.18
standard deviation of the sample

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

NOTE This is an estimation of the dispersion of the characteristic x in a batch.

4.19
acceptance trapezium

graph, with control limits, on which are plotted two corresponding statistical values (i.e. sample mean $\bar{x}$ and either standard deviation s or average range $\bar{w}$), for each sample

4.20
acceptable quality level (AQL)

for given characteristic, maximum percentage of defective meters in a batch that, for the purpose of sampling inspection, can be considered satisfactory (EOQC)

5 Acceptance conditions for batches

A batch is deemed to comply with the requirements of this standard and shall be accepted if for each inspected characteristic the proportion of defective meters does not exceed the following specified values.

5.1 100 % inspection

The tests shall be made according to clause **8**.

The number of meters failing the test shall not exceed the acceptance number given in Table 6.

5.2 Sampling inspection

In the case of sampling inspection, the above conditions shall be considered satisfied when for each characteristic of the meters in the batch:

— for inspection by attributes, the number of defective meters in the sample is smaller than or equal to the acceptance number given in Table 8;

— for inspection by variables, the graphically presented test result is within the acceptance trapezium or the calculated test result does not exceed the specified limits (see **9.2.3**).

NOTE The risk of a wrong interpretation of the results can be read off from the operating characteristic curves of Table 12a, Table 12b and Table 12c.

6 Place of inspection

The inspection shall be carried out by mutual agreement:

— on the manufacturer's premises, but on test benches other than those on which the adjustments were made;

— or on the purchaser's test benches;

— or on other agreed test benches.

7 Test conditions

7.1 Reference conditions

Tests shall be carried out under conditions given in Table 1.

Table 1 — Reference conditions

Influence quantity	Reference value	Permissible tolerances
Ambient temperature[a]	Reference temperature or, in its absence, 23 °C	± 2 °C
Voltage	Reference voltage	± 1,5 %
Frequency	Reference frequency	± 0,5 %
Waveform	Sinusoidal voltages and currents	Distortion factor less than 5 %
Magnetic induction of external origin at the reference frequency	Magnetic induction equal to zero	Induction value which causes a variation of error not greater than ± 0,3 % but should in any case be smaller than 0,05 mT[b]

[a] For any ambient temperature outside the range 21 °C to 25 °C, but within the range 15 °C to 30 °C, it is permissible to apply a correction for the reference temperature of 23 °C, using the mean temperature coefficient of the meter type as declared by the manufacturer.

[b] The test consists of:

a) for a single-phase meter, determining the errors first with the meter normally connected to the mains and then after inverting the connections to the current circuits as well as to the voltage circuits. Half of the difference between the two errors is the value of the variation of error. Because of the unknown phase of the external field, the test should be made at 0,1 I_b at unity power factor and 0,2 I_b at 0,5 power factor;

b) for a three-phase meter, making three measurements at 0,1 I_b at unity power factor, after each of which the connections to the current circuits and to the voltage circuits are changed over 120° while the phase sequence is not altered. The greatest difference between each of the errors so determined and their average value is the value of the variation of error.

7.2 Uncertainty of measurement

The measuring instruments and other apparatus used for the tests shall be such that the overall uncertainty of measurement does not exceed the following values:

Table 2 — Uncertainty of measurement

Class of meter		Power factor
1	2	
0,2 %	0,4 %	1
0,3 %	0,6 %	0,5 inductive

7.3 Cover and seal

The meters shall be inspected and tested with their covers on and manufacturer's seal unbroken.

The base and cover shall show no signs of damage.

For sampling procedure damaged meters shall be replaced.

8 Inspection and test procedure

The quality of the batch of meters shall be checked by applying the inspection and test procedure detailed in this clause.

NOTE If mechanical aspects have to be tested, the conditions should be agreed on between the parties.

8.1 Preheating

Before any test is made, the circuits shall have been energized for a time sufficient to reach thermal stability (see **3.6.13** of IEC 1036).

8.2 Test no. 1: AC voltage test

The a.c. voltage test shall be carried out in accordance with Table 3.

The test voltage shall be substantially sinusoidal, having a frequency between 45 Hz and 65 Hz, and applied for 1 min. The power source shall be capable of supplying at least 500 VA. During this test no flashover, disruptive discharge or puncture shall occur.

During the tests relative to earth, the auxiliary circuits with reference voltage equal to or below 40 V shall be connected to earth.

Table 3 — AC voltage tests

Test voltage r.m.s	Points of application of the test voltage
2 kV	A) Tests to be carried out with the case closed, the cover and terminal covers in place a) between, on the one hand, all the current and voltage circuits as well as the auxiliary circuits whose reference voltage is over 40 V, connected together, and, on the other hand, earth; b) between circuits not intended to be connected together in service
	B) Additional tests for insulating encased meters of protective class II
4 kV (for text in item a))	a) between, on the one hand, all the current and voltage circuits as well as the auxiliary circuits whose reference voltage is over 40 V, connected together, and, on the other hand, earth[a]; b) a visual inspection for compliance with the conditions of protective class II;
40 V (for text in item c))	c) between, on the one hand, all conductive parts inside the meter connected together and, on the other hand, all conductive parts, outside the meter case that are accessible with the test finger, connected together[b]

[a] The test in item a) of part B) is to be carried out with the case closed, and the cover and terminal covers in place.
[b] The test in item c) of part B) is not necessary if the test in item b) leaves no doubt.

8.3 Test no. 2: Test of no-load condition

For this test the current circuit(s) shall be open circuit and a voltage of 115 % of the reference voltage shall be applied to the voltage circuits.

The minimum test period Δt shall be:

$$\Delta t \geq \frac{600 \cdot 10^6}{k \cdot m \cdot U_n \cdot I_{max}} \text{ (min)} \quad \text{for meters of class 1}$$

$$\Delta t \geq \frac{480 \cdot 10^6}{k \cdot m \cdot U_n \cdot I_{max}} \text{ (min)} \quad \text{for meters of class 2}$$

where

k is the number of pulses emitted by the output device of the meter per kilowatthour (imp/kWh);

m is the number of measuring elements;

U_n is the reference voltage in volts;

I_{max} is the maximum current in amperes.

During this test the test output device of the meter shall not emit more than one pulse.

8.4 Test no. 3: Test of starting condition

With the meter energized at reference voltage and connected as shown in the diagram of connections, the meter shall start and continue to register at a current shown in Table 4.

Table 4 — Starting current

	Class of meter		Power factor
	1	2	
Starting current	0,004 I_b	0,005 I_b	1

8.5 Tests nos. 4 to 9: Tests of accuracy requirements

The tests of accuracy requirements for single-phase and polyphase meters shall be carried out at the current values and power factor values given in Table 5, without waiting for the thermal equilibrium to be attained.

Table 5 — Test points and limits of errors

Test no.	Current	Power factor	Number of phases of the meter	For polyphase, whether balanced or unbalanced	Percentage error limits for meter of class	
					1	2
4	0,05 I_b	1	Single and polyphase	Balanced	± 2,5	± 3,5
5	I_b	1	Single and polyphase	Balanced	± 1,5	± 2,5
6	I_b	0,5 inductive	Single and polyphase	Balanced	± 2,0	± 3,0
7	I_b	1	Polyphase	1 phase loaded	± 2,5	± 3,5
8	I_b	1	Polyphase	1 phase loaded (different phase from test no. 7)	± 2,5	± 3,5
9	I_{max}	1	Single and polyphase	Balanced	± 1,5	± 2,5
NOTE The test sequence must start at test no. 4 and finish at test no. 9.						

8.6 Test no. 10: Verification of meter constant

When measuring a given amount of energy, the increment of the display and the energy calculated from the number of output pulses emitted during this test from the test output shall not differ by more than ± 0,2 %.

The test shall be done for each meter on at least one tariff register.

NOTE The amount of energy used for this test should be sufficiently high to be able to resolve a ± 0,2 % difference.

9 Requirements corresponding to different inspection procedures

The inspection method shall be fixed by mutual agreement between the parties and all tests shall be carried out either by 100 % inspection, or sampling inspection.

9.1 100 % inspection

All meters of a batch shall be tested.

9.1.1 *Acceptance number c*

A meter batch shall be considered as conforming to the requirements of tests nos. 2 to 9 when, for each test, the number of defective meters is not more than *c* as given in Table 6 and when the accumulated number of defective meters for the tests nos. 2 to 9 is not bigger than two times the acceptance number *c* of Table 6.

Table 6 — Acceptance number *c*

Test no.	Kind of test	Batch size *N*	Values of *c*
1	AC voltage test	—	0
2	Running with no load	50 to 149	1
		150 to 249	2
		250 to 349	3
3	Starting	350 to 449	4
		450 to 549	5
		550 to 649	6
		650 to 749	7
4 to 9	Accuracy	750 to 849	8
		850 to 949	9
		950 to 1 000	10
10	Meter constant	—	0

9.1.2 *Procedure to be applied with regard to defective meters*

If the acceptance conditions are satisfied, the defective meters shall be repaired or replaced by meters fulfilling all the conditions required.

If the acceptance numbers are exceeded, then the results shall be discussed between manufacturer and purchaser and, where required, meter(s) shall be opened and examined.

9.2 Sampling inspection

When sampling inspection is used, the purchaser's risk of accepting a poor quality or the manufacturer's risk of rejecting a good quality shall be taken into account.

The risk for every one of the characteristics can be read from the operating characteristics curves (see **4.11** and Table 12a, Table 12b and Table 12c).

9.2.1 ***General remarks for sampling inspection***

9.2.1.1 *Assumptions and selection of the sample*

The decision regarding conformity of a batch of *N* meters to the requirements of this standard shall be taken in accordance with the sampling plans in Table 8 which are based upon the AQLs and manufacturer's risk α as follows:

Depending upon the sample size:

— AQL = 1 %, α = 5 % to 10 % for tests nos. 2 to 9;

— AQL = 0,2 %, α = 3 % to 8 % for tests nos. 1 and 10.

NOTE It would be desirable to have an AQL equal to zero, but this is possible only with 100 % inspection. An AQL different from zero is permitted only in order to make sampling inspection possible.

The sampling plans are valid for batches from 50 up to and including 1 000 meters. Quantities larger than 1 000 meters shall be subdivided accordingly into batches of 500 up to 1 000 meters.

The inspection shall be carried out on a sample of size *n* (for sample size *n*, see Table 8).

The sample shall be chosen to ensure random selection, either by using the serial numbers of the meters in connection with random numbers (e.g. Table 15) or by any other random selection method which is more favourable from the economic point of view.

Example of using random numbers according to Table 15.

The consecutive set of serial numbers of a batch are from 100 to 300.

A list of three-digit numbers is established by choosing the numbers situated at the intersections of three columns e.g. columns nos. 1, 11 and 21 and of the successive lines starting with line no. 6 (the numbers 1, 11, 21 and 6 may be freely chosen):

Table 7 — Example of using random numbers

Random numbers	Numbers of sample meters
908	
795	
295	First sample meter[a]
191	Second sample meter[a]
518	
524	
428	
609	
329	
152	Third sample meter[a]
—	
—	
etc.	

[a] The random numbers come within the range of the batch serial numbers. Duplicated random numbers and those falling outside of the set of serial numbers are disregarded.

9.2.1.2 *Sampling plans*

The sampling plans are given in Table 8 and explanations are given in **9.2.2** and **9.2.3**.

Table 8 — Sampling plans

Test no.	Kind of test	Sampling plans for inspection by attributes Batch sizes												Sampling plans for inspection by variables Batch sizes		
		$50 \leq N \leq 100$		$101 \leq N \leq 500$					$501 \leq N \leq 1\,000$					$50 \leq N \leq 100$	$101 \leq N \leq 500$	$501 \leq N \leq 1\,000$
		n[b]	c_1	n_1	c_1	d_1	n_2	c_2	n_1	c_1	d_1	n_2	c_2	n	n	n
1	AC voltage tests	15	0	30	0	—	—	—	40	0	—	—	—	—	—	—
2	Running with no load	15	0	30	0	2	30	1	40	0	2	40	2	—	—	—
3	Starting	15	0	30	0	2	30	1	40	0	2	40	2	—	—	—
4 to 9	Accuracy[a]	15	0	30	0	2	30	1	40	0	2	40	2	15[b]	30	40
10	Meter constant	15	0	30	0	—	—	—	40	0	—	—	—	—	—	—

N = batch size

n = sample size

n_1 = first sample size

c_1 = acceptance number for the first sample

d_1 = rejection number for the first sample (only when double sampling plan is used)

n_2 = second sample size

c_2 = total acceptance number when both first and second samples have been taken

[a] Inspection by variables is recommended and the samples shall be taken from the first selection of samples chosen for tests nos. 1 to 3.

[b] The sample size of n = 15 may be applied when the quality of the small batch is sufficiently determined, e.g. if the meters in this batch are part of a manufacturer's large quantity. Otherwise 100 % inspection shall be adopted.

9.2.1.3 *Test records*

The meter numbers shall be recorded in the order of random choice, which is necessary for inspection with $\bar{x}$, $\overline{w}$ method. Sample test results shall be recorded and evaluated on inspection sheets as in Table 14.

For inspection by attributes and single sampling plan, the results of tests on 15, 30 or 40 meters for each of the tests nos. 1 to 10 shall be recorded on the inspection sheet columns 1 to 10.

For double sampling plans, two sheets are necessary.

9.2.1.4 *Procedure to be applied with regard to defective meters*

If the acceptance conditions are satisfied, the defective meters shall be repaired or replaced by meters fulfilling all the conditions required.

If the acceptance numbers are exceeded, then the results shall be discussed between manufacturer and purchaser and, where required, meter(s) shall be opened and examined. If meter(s) have failed test no. 1 or 10, all the meters in the batch shall be subjected to the appropriate test.

9.2.2 ***Inspection by attributes***

For inspection by attributes, single and double sampling plans are given in Table 8.

9.2.2.1 *Single sampling plan*

This plan is applicable for the following batch sizes N and tests (see Figure 1):

— $50 \leq N \leq 100$ and for tests nos. 1 to 10;

— $101 \leq N \leq 1\,000$ and for tests nos. 1 and 10 only.

If the number c_n of defective meters in the sample is zero, the batch is considered as conforming to the requirements for the relevant characteristic.

If the number c_n exceeds zero, the batch is considered as not conforming to the requirements for the relevant characteristic.

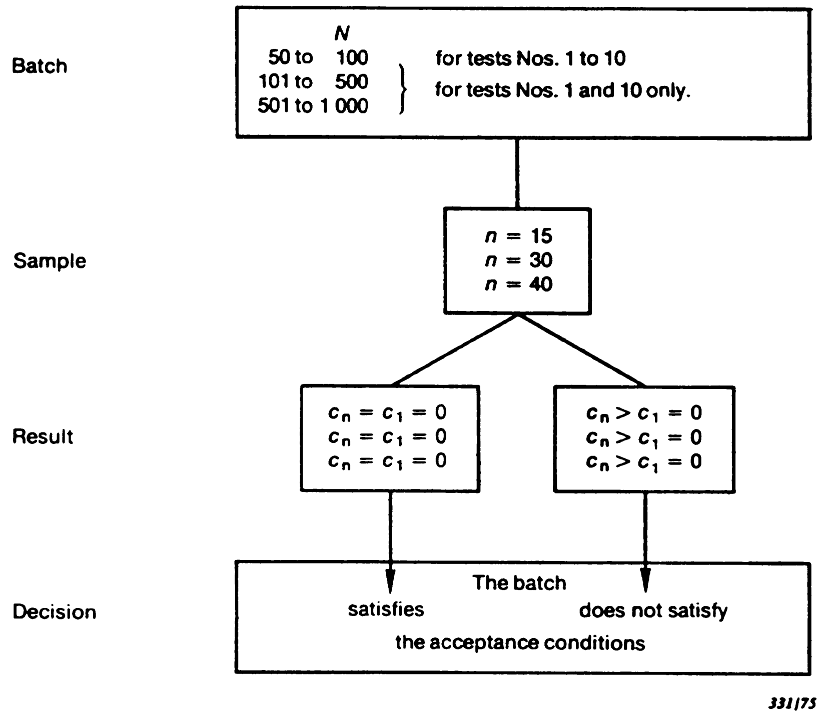


Figure 1 — Diagram of the single sampling plan

9.2.2.2 *Double sampling plan*

This plan is applicable for batch sizes $101 \leq N \leq 1\,000$ (see Figure 2).

The plan operates in two stages with the sample sizes $n_1 = n_2$. At the first stage (sample size n_1), a very good quality will be accepted and a very poor quality will be rejected with a high probability.

In general, it is for medium quality only that a second stage is necessary.

For the first stage:

— if the number c_{n1}, of defective meters is zero, the batch is considered as conforming to the requirements for the relevant characteristic;

— if c_{n1} reaches or exceeds the rejection number d_1, the batch is considered as not conforming to the requirements for the relevant characteristic;

— if c_{n1} exceeds zero but is less than d_1, the second stage (sample size $n_2 = n_1$) shall be applied.

For the second stage, where c_{n2} is the number of defective meters in the second sample:

— if $(c_{n1} + c_{n2})$ is equal to or less than the total acceptance number c_2, the batch is considered as conforming to the requirements for the relevant characteristic;

— if $(c_{n1} + c_{n2})$ exceeds the total acceptance number c_2, the batch is considered as not conforming to the requirements for the relevant characteristic.

Table 9 shows the sample sizes, the acceptance, and rejection numbers.

Table 9 — Double sampling plan

Batch size N	First sample			Second sample	First and second sample $(n_1 + n_2)$.
	Sample size n_1	Acceptance number c_1	Rejection number d_1	Sample size n_2	Total acceptance number c_2
101 to 500	30	0	2	30	1
501 to 1 000	40	0	2	40	2

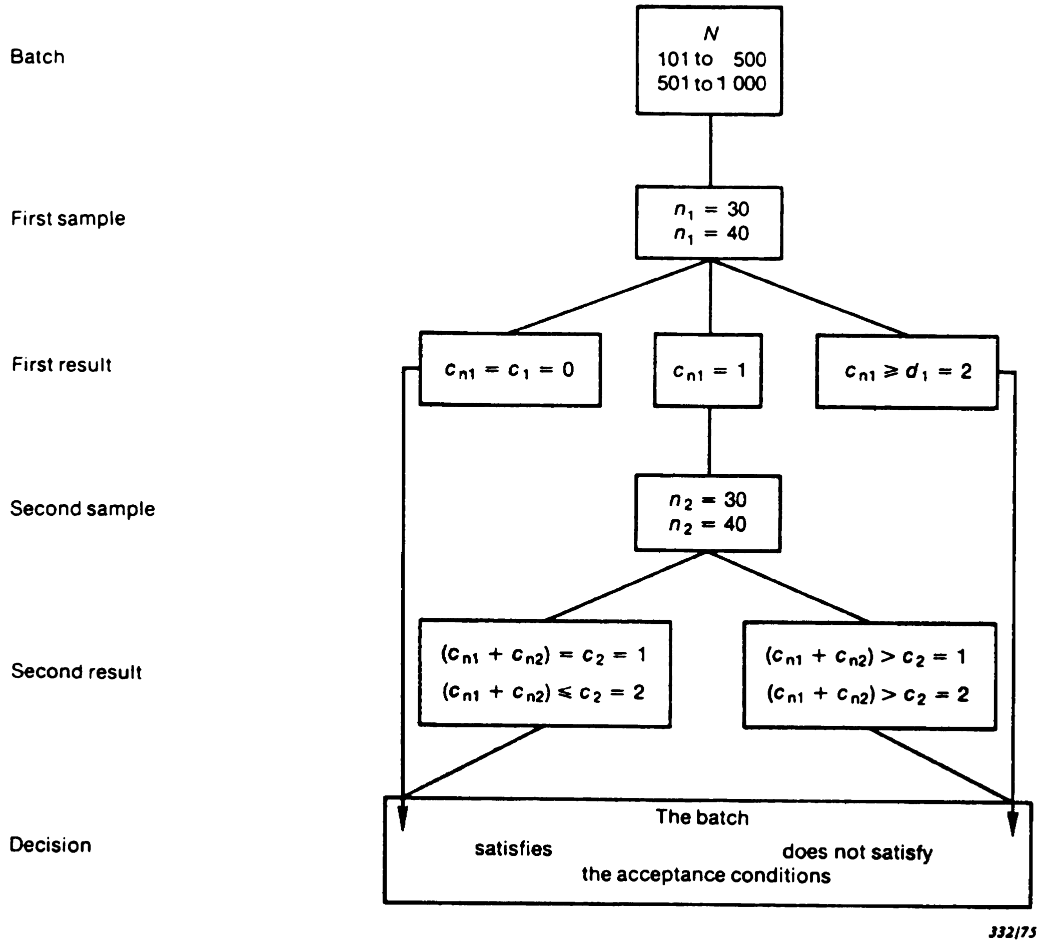


Figure 2 — Diagram of the double sampling plan

9.2.3 ***Inspection by variables***

Inspection by variables is applicable to tests nos. 4 to 9 when the values of the errors follow the normal distribution (Gauss-Laplace), and may employ the standard deviation method or the average range method.

The sample size *n* depends on the batch size *N*, as shown in Table 8.

9.2.3.1 *Standard deviation method*

This method is based on the use of the quantities $\bar{x}$ (sample mean) and *s* (standard deviation of the sample). These values are calculated from the values x_i of the errors of all the meters in the sample for the relevant characteristic, by means of the formulae given in **4.15** and **4.18**.

The test result is considered satisfactory when the pair of quantities $\bar{x}$ and *s* simultaneously satisfy the following three relationships:

$$\bar{x} + k \bullet s \leq +T$$
$$\bar{x} - k \bullet s \geq -T$$
$$s \leq s_{adm}$$

The values of *k* and s_{adm} are given in Table 10. *T* is the absolute value of the limit of error for the relevant test (see Table 5).

Alternatively, the equivalent condition is that point *P* of the coordinates $\bar{x}$ and *s* in a system of rectangular axes $o\bar{x}$ and *os* is situated inside the trapezium shown in Figure 3, the dimensions of which are given in Table 10 (see also Table 13a, Table 13b and Table 13c).

Table 10 — Specified values for the standard deviation method

Sample size n	k	$\frac{s_{adm}}{2T}$	$\frac{s_{max}}{2T}$
15	1,75	0,24	0,29
30	1,86	0,23	0,27
40	1,89	0,23	0,26

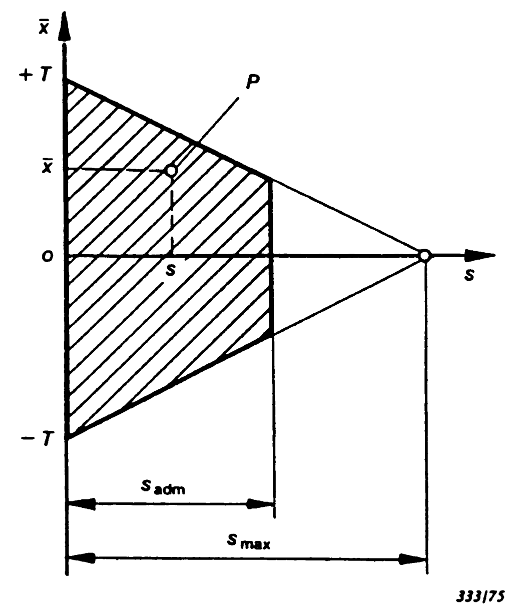


Figure 3 — Acceptance trapezium (standard deviation method)

9.2.3.2 *Average range method*

This method is based on the use of the quantities $\bar{x}$ (sample mean) and et $\overline{w}$ (average range). These values are calculated from the values x_i of the errors of all the meters in the sample for the relevant characteristic and from the values w_j by means of the formulae given in **4.15**, **4.16** and **4.17**.

Calculation of the value of the average range requires the sample to be subdivided into *r* subgroups of size *m* = 5. For this purpose, the sample meters shall be listed on the inspection sheets in the order in which they were chosen. Irrespective of their sequence, the manufacturer's serial numbers are entered in the third column.

The test result is considered satisfactory when the pair of quantities $\bar{x}$, and $\overline{w}$ simultaneously satisfy the following three relationships:

$$\bar{x} + K \bullet \overline{w} \leq + T$$
$$\bar{x} - K \bullet \overline{w} \geq - T$$
$$\overline{w} \geq \overline{w}_{adm}$$

The values of *K* and $\overline{w}_{adm}$ are given in Table 11. *T* is the absolute value of the limit of error for the load point under consideration (see Table 5).

Alternatively, the equivalent condition is that the point *P* of the coordinates $\bar{x}$, and $\overline{w}$ in a system of rectangular axes $o\bar{x}$, and $o\overline{w}$ is situated inside the trapezium shown in Figure 4, the dimensions of which are given in Table 11 (see also Table 13a, Table 13b and Table 13c).

Table 11 — Specified values for the average range method

Sample size n	K	$\frac{\overline{w}_{adm}}{2T}$	$\frac{\overline{w}_{max}}{2T}$
15	0,75	0,56	0,67
30	0,79	0,54	0,63
40	0,80	0,54	0,62

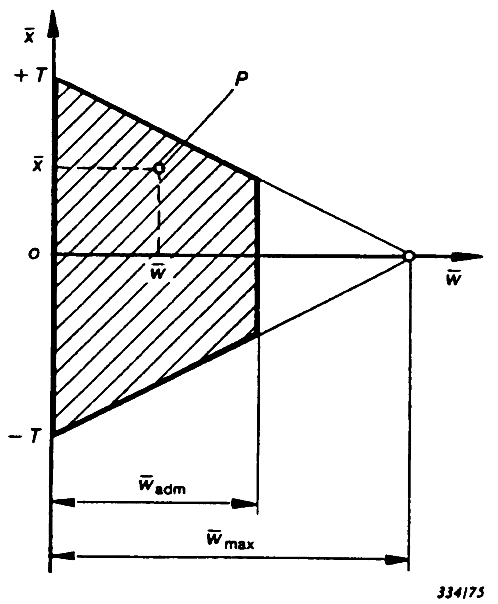


Figure 4 — Acceptance trapezium (average range method)

9.2.3.3 *Procedure to be adopted when test results are unsatisfactory*

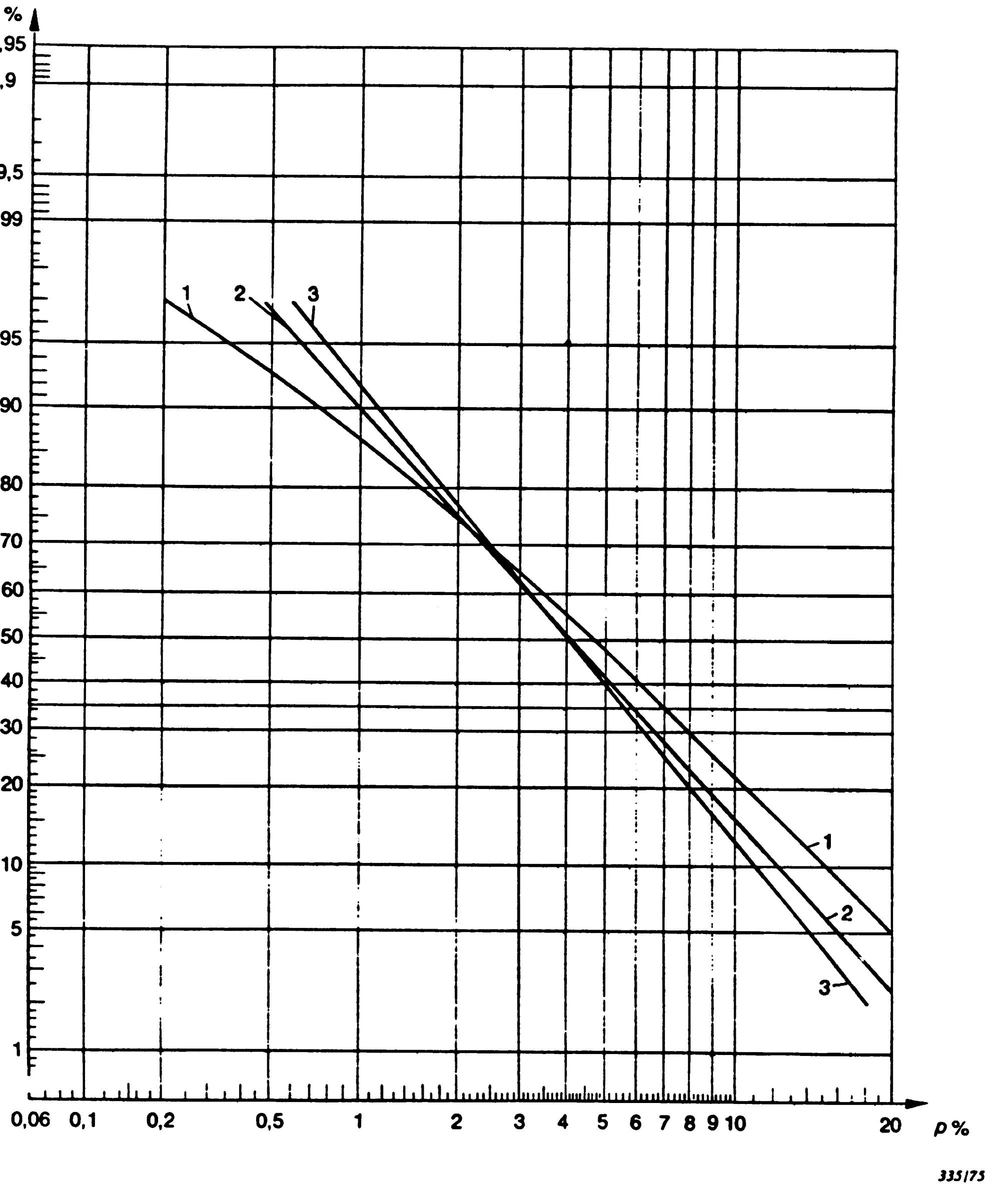
If due to unsatisfactory results it is suspected that the meter errors are not of normal distribution, inspection by attributes or 100 % inspection may be applied subject to agreement between the parties involved.

The application of inspection by attributes may necessitate the selection of a second sample. The batch is then judged solely on the basis of the results obtained by applying the inspection by attributes.

9.2.3.4 *Operating characteristic curves*

The operation characteristic curve shows the probability P_r of batch approval, when using a certain sample size as a function of the percentage of defects in the relevant batch.

Table 12a — Operating characteristic curves $N \leq 100$



Contrôle par attributs { 1 $n = 15$, $c_1 = 0$; plan d'échantillonnage simple (essais n^{os} 1 à 10)

Contrôle par mesures { 2 $n = 15$, méthode $\bar{x}$, $\bar{w}$ (essais n^{os} 4 à 9); 3 $n = 15$, méthode $\bar{x}$, s (essais n^{os} 4 à 9)

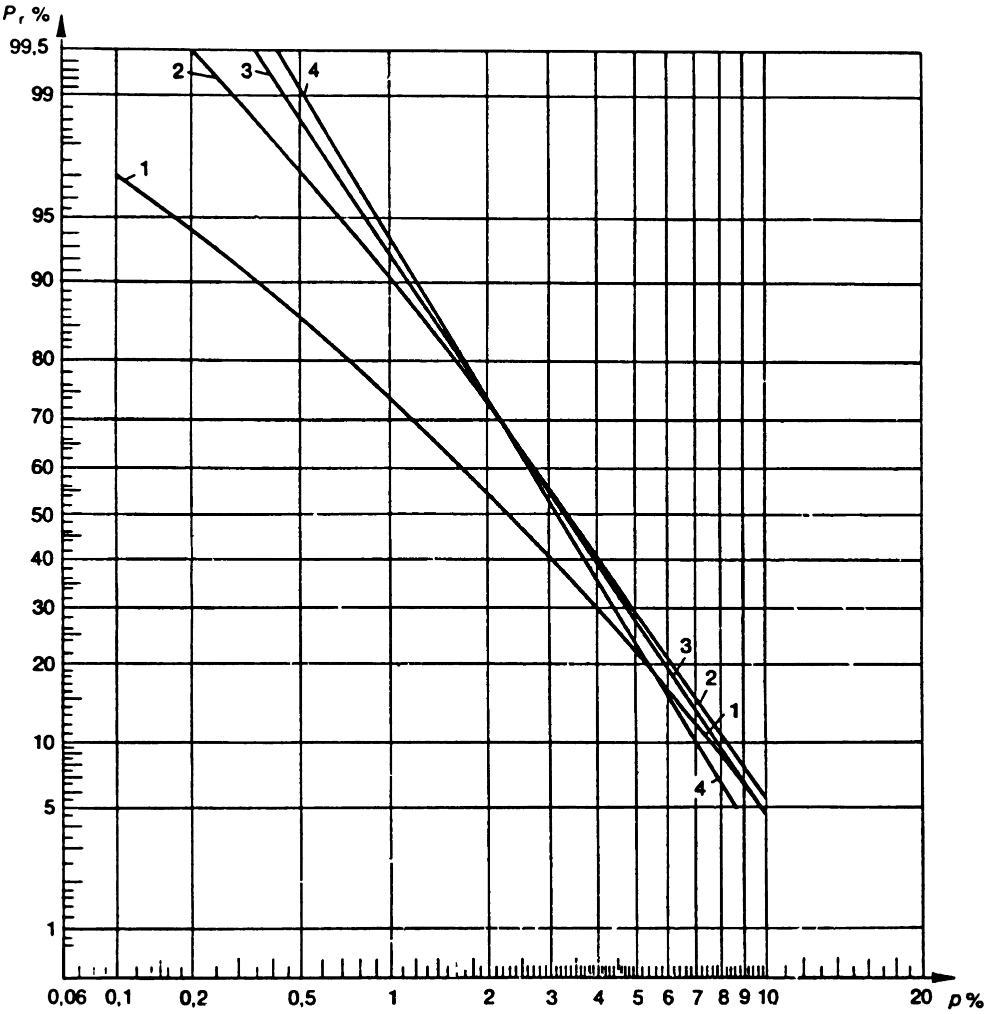
N = effectif du lot
n = effectif de l'échantillon
P_r = probabilité d'acceptation du lot
p = pourcentage de compteurs défectueux dans le lot

Inspection by attributes { 1 $n = 15$, $c_1 = 0$; single sampling plan (tests nos. 1 to 10)

Inspection by variables { 2 $n = 15$, method $\bar{x}$, $\bar{w}$ (tests nos. 4 to 9); 3 $n = 15$, method $\bar{x}$, s (tests nos. 4 to 9)

N = batch size
n = sample size
P_r = probability of acceptance of the batch
p = percentage of defective meters in the batch

Table 12b — Operating characteristic curves 101 ≤ *N* ≤ 500



3.36/75

Contrôle par attributs
1 $n = 30$, $c_1 = 0$; plan d'échantillonnage simple (essais n[os] 1 et 10) (cette courbe représente également la probabilité d'acceptation dès le premier stade du plan d'échantillonnage double)
2 $n_1 = 30$, $c_1 = 0$, $d_1 = 2$; $n_2 = 30$, $c_2 = 1$ — plan d'échantillonnage double (essais n[os] 2 à 9)

Contrôle par mesures
3 $n = 30$, méthode $\bar{x}$, $\bar{w}$
4 $n = 30$, méthode $\bar{x}$, s
(essais n[os] 4 à 9)

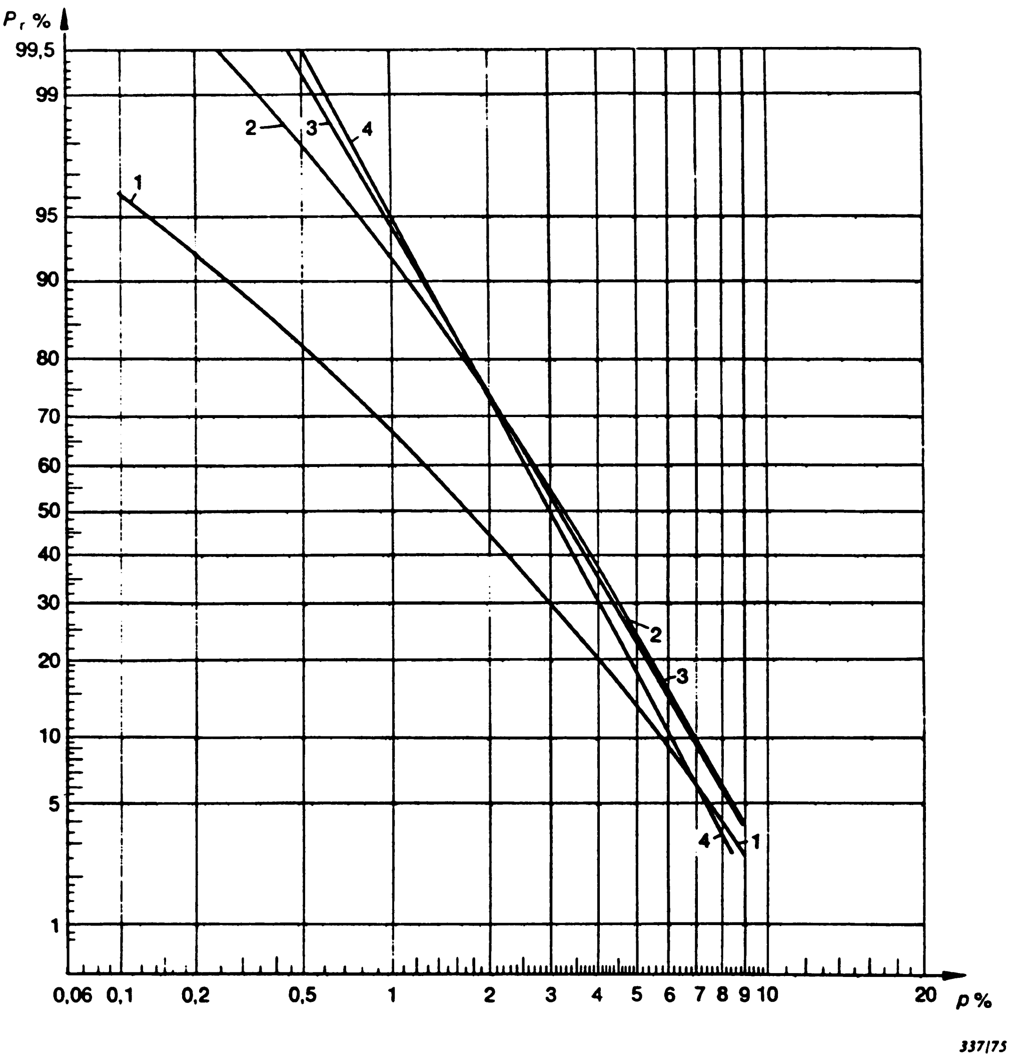
N = effectif du lot
n = effectif de l'échantillon
P_r = probabilité d'acceptation du lot
p = pourcentage de compteurs défectueux dans le lot

Inspection by attributes
1 $n = 30$, $c_1 = 0$; single sampling plan (tests nos. 1 and 10) (this curve represents equally the probability of acceptance for the first stage of the double sampling plan)
2 $n_1 = 30$, $c_1 = 0$, $d_1 = 2$; $n_2 = 30$, $c_2 = 1$ — double sampling plan (tests nos. 2 to 9)

Inspection by variables
3 $n = 30$, method $\bar{x}$, $\bar{w}$
4 $n = 30$, method $\bar{x}$, s
(tests nos. 4 to 9)

N = batch size
n = sample size
P_r = probability of acceptance of the batch
p = percentage of defective meters in the batch

Table 12c — Operating characteristic curves 501 ≤ N ≤ 1 000



Contrôle par attributs
- 1 $n = 40$, $c_1 = 0$; plan d'échantillonnage simple (essais n[os] 1 et 10) (cette courbe représente également la probabilité d'acceptation dès le premier stade du plan d'échantillonnage double)
- 2 $n_1 = 40$, $c_1 = 0$, $d_1 = 2$; $n_2 = 40$, $c_2 = 1$ — plan d'échantillonnage double (essais n[os] 2 à 9)

Contrôle par mesures
- 3 $n = 40$, méthode $\bar{x}$, $\bar{w}$
- 4 $n = 40$, méthode $\bar{x}$, s

(essais n[os] 4 à 9)

N = effectif du lot
n = effectif de l'échantillon
P_r = probabilité d'acceptation du lot
p = pourcentage de compteurs défectueux dans le lot

Inspection by attributes
- 1 $n = 40$, $c_1 = 0$; single sampling plan (tests nos. 1 and 10) (this curve represents equally the probability of acceptance for the first stage of the double sampling plan)
- 2 $n_1 = 40$, $c_1 = 0$, $d_1 = 2$; $n_2 = 40$, $c_2 = 1$ — double sampling plan (tests nos. 2 to 9)

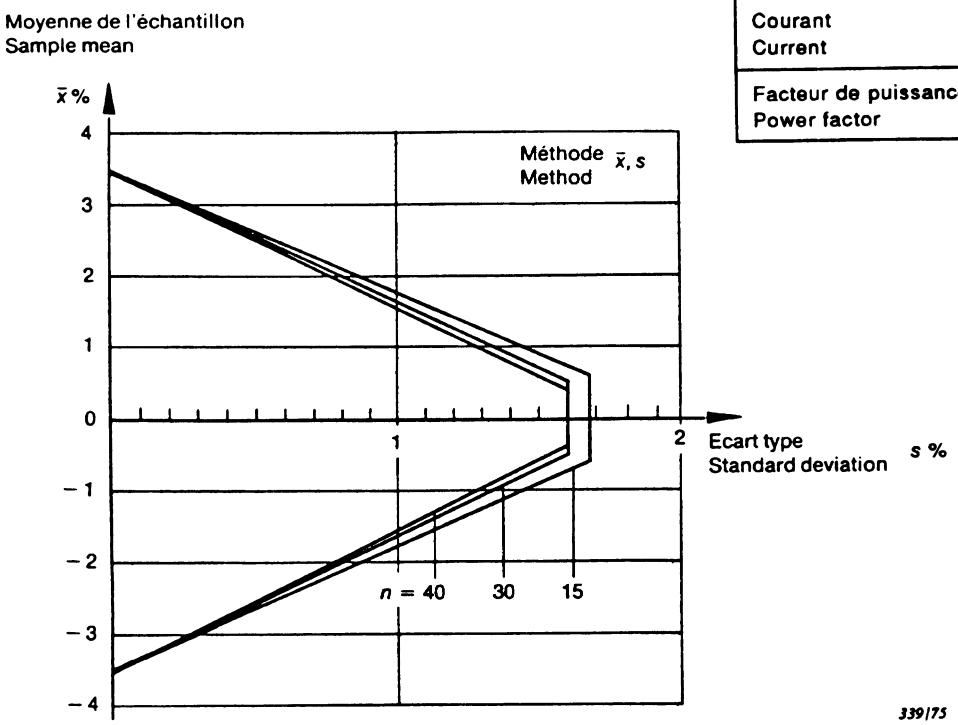
Inspection by variables
- 3 $n = 40$, method $\bar{x}$, $\bar{w}$
- 4 $n = 40$, method $\bar{x}$, s

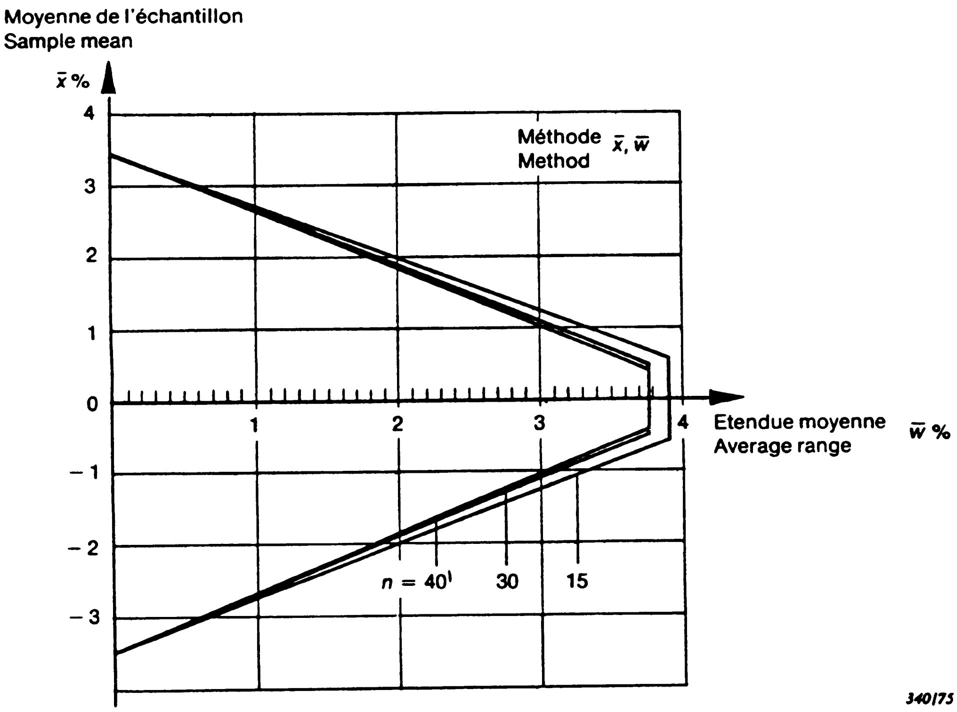
(tests nos. 4 to 9)

N = batch size
n = sample size
P_r = probability of acceptance of the batch
p = percentage of defective meters in the batch

Table 13a — Acceptance trapezium, *T* = 3,5 % (Tests nos. 4, 7 and 8)

Type	
Courant Current	
Facteur de puissance Power factor	

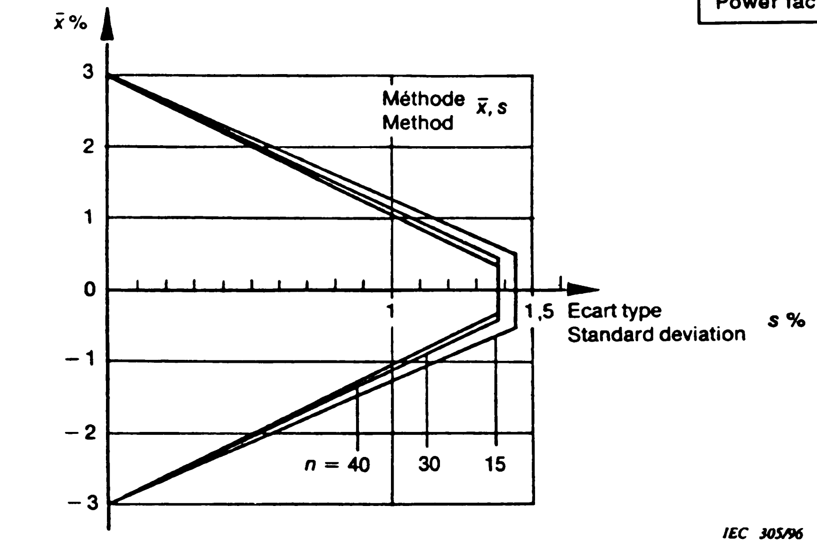


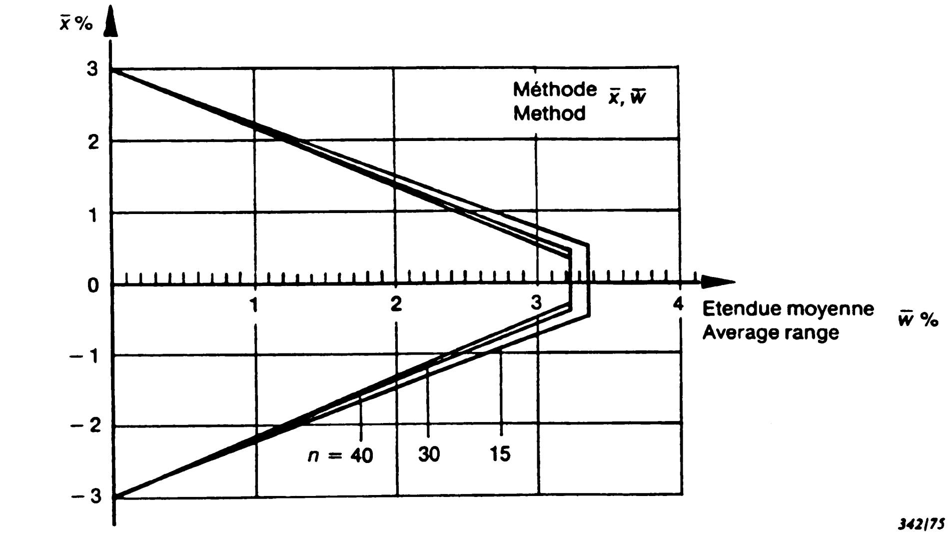


n = effectif de l'échantillon *n* = sample size

Table 13b — Acceptance trapezium, *T* = 3,0 % (Tests nos. 6)

Type	
Courant Current	
Facteur de puissance Power factor	

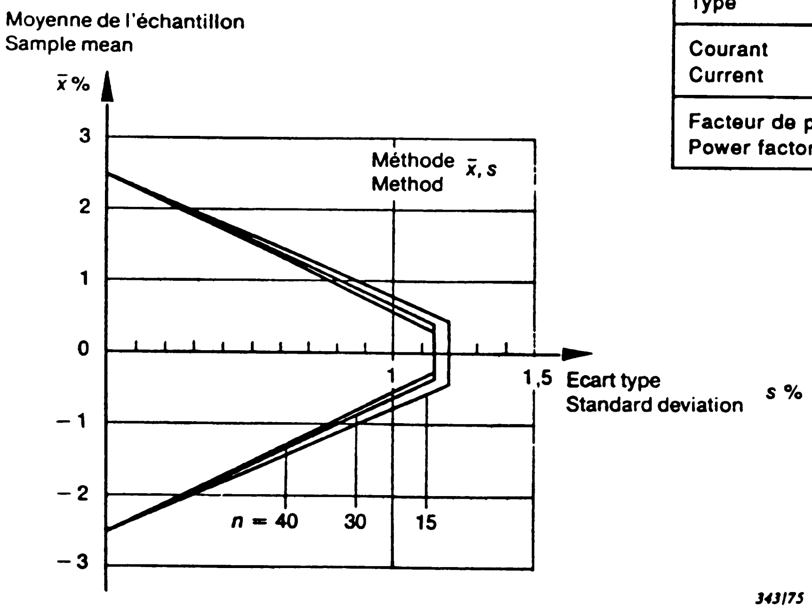


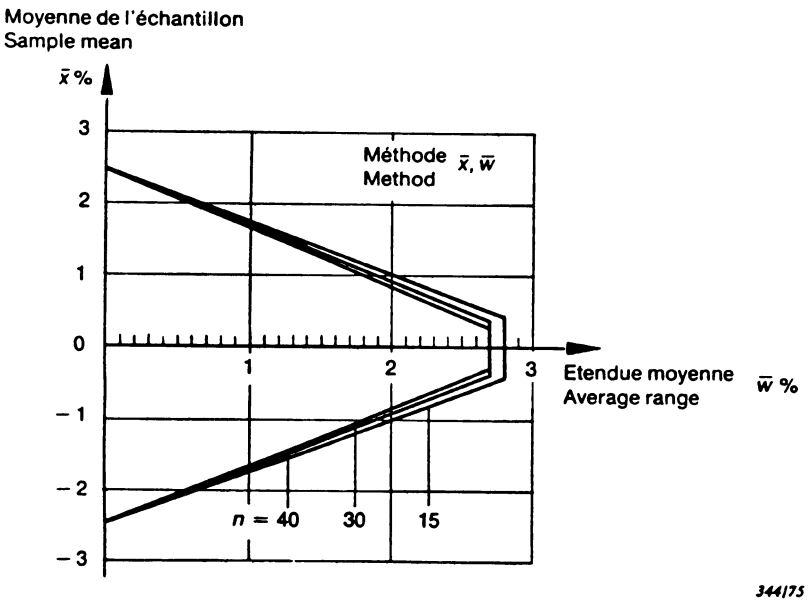


n = effectif de l'échantillon *n* = sample size

Table 13c — Acceptance trapezium, *T* = 2,5 % (Tests nos. 5 and 9)

Type	
Courant Current	
Facteur de puissance Power factor	





n = effectif de l'échantillon *n* = sample size

NOTE The acceptance trapezium in Table 13a, Table 13b and Table 13c are examples of class 2 meters.

Table 14 — Inspection sheet

Compteur Meter	Sous-groupe N° Sub-group No.	Derniers chiffres du N° de fabrication Serial number (last figures)	Essai N°/Test No. Attributs/Attributes						Contrôlé par/Inspection by Attributs ou mesures/Attributes or variables											
			1	2	3	10			4		5		6		7		8		9	
									x	w	x	w	x	w	x	w	x	w	x	w
1																				
2																				
3	1																			
4																				
5																				
6																				
7																				
8	2																			
9																				
10																				
11																				
12																				
13	3																			
14																				
15																				
16																				
17																				
18	4																			
19																				
20																				
21																				
22																				
23	5																			
24																				
25																				
26																				
27																				
28	6																			
29																				
30																				
31																				
32																				
33	7																			
34																				
35																				
36																				
37																				
38	8																			
39																				
40																				
41																				
42																				
Limites d'erreur/Error limits																				
c_1 = 0		C_{n1}																		
d_1 =																				
c_2 =		$C_{n1} + C_{n2}$																		
Moyenne de l'échantillon/Sample mean $\bar{X}$ %																				
Etendue moyenne/Average range $\bar{W}$ %																				
Ecart type/Standard deviation S %																				
		Oui/Yes 0																		
		Non/No x																		
Décision: Decision:			Lot statisfaisant/non satisfaisant/prendre un deuxième échantillon Batch does satisfy/does not satisfy/take second sample																	

Table 15 — Random numbers

	1 5 10	15 20	25 30	35 40	45 50
1	22 17 68 65 84	68 95 23 92 35	87 02 22 57 51	61 09 43 95 06	58 24 82 06 47
	19 36 27 59 46	13 79 93 37 55	39 77 32 77 09	85 52 05 30 62	47 83 51 62 74
	16 77 23 02 77	09 61 87 25 21	28 06 24 25 93	16 71 13 59 78	23 05 47 47 25
	78 43 76 71 61	20 44 90 32 64	97 67 63 99 61	46 38 03 93 22	69 81 21 99 21
5	03 28 28 26 08	73 37 32 04 05	69 30 16 09 05	88 69 58 28 99	35 07 44 75 47
	93 22 53 64 39	07 10 63 76 35	87 03 04 79 88	08 13 13 85 51	55 34 57 72 69
	78 76 58 54 74	92 38 70 96 92	52 06 79 79 45	82 63 18 27 44	69 66 92 19 09
	23 68 35 26 00	99 53 93 61 28	52 70 05 48 34	56 65 05 61 86	90 92 10 70 80
	15 39 25 70 99	93 86 52 77 65	15 33 59 05 28	22 87 26 07 47	86 96 98 29 06
10	58 71 96 30 24	18 46 23 34 27	85 13 99 24 44	49 18 09 79 49	74 16 32 23 02
	57 35 27 33 72	24 53 63 94 09	41 10 76 47 91	44 04 95 49 66	39 60 04 59 81
	48 50 86 54 48	22 06 34 72 52	82 21 15 65 20	33 29 94 71 11	15 91 29 12 93
	61 96 48 95 03	07 16 39 33 66	98 56 10 56 79	77 21 30 27 12	90 49 22 23 62
	36 93 89 41 26	29 70 83 63 51	99 74 20 52 36	87 09 41 15 09	98 60 16 03 03
15	18 87 00 42 31	57 90 12 02 07	23 47 37 17 31	54 08 01 88 63	39 41 88 92 10
	88 56 53 27 59	33 35 72 67 47	77 34 55 45 70	08 12 27 38 90	16 95 86 70 75
	09 72 95 84 29	49 41 31 06 70	42 38 06 45 18	64 84 73 31 65	52 53 37 97 15
	12 96 88 17 31	65 19 59 02 83	60 75 86 90 68	24 64 19 35 51	56 61 87 39 12
	85 94 57 24 16	92 09 84 38 76	22 00 27 69 85	29 81 94 78 70	21 94 47 90 12
20	38 64 43 59 98	98 77 87 68 07	91 51 67 62 44	40 98 05 93 78	23 32 65 41 18
	53 44 09 42 72	00 41 86 79 79	68 47 22 00 20	35 55 31 51 51	00 83 63 22 55
	40 76 66 26 84	57 99 99 90 37	36 63 32 08 58	37 40 13 68 97	87 64 81 07 83
	02 17 79 18 05	12 59 52 57 02	22 07 90 47 03	28 14 11 30 79	20 69 22 40 98
	95 17 82 06 53	31 51 10 96 46	92 06 88 07 77	56 11 50 81 69	40 23 72 51 39
25	35 76 22 42 92	96 11 83 44 80	34 68 35 48 77	33 42 40 90 60	73 96 53 97 86
	26 29 13 56 41	85 47 04 66 08	34 72 57 59 13	82 43 80 46 15	38 26 61 70 04
	77 80 20 75 82	72 82 32 99 90	63 95 73 76 63	89 73 44 99 05	48 67 26 43 18
	46 40 66 44 52	91 36 74 43 53	30 82 13 54 00	78 45 63 98 35	55 03 36 67 68
	37 56 08 18 09	77 53 84 46 47	31 91 18 95 58	24 16 74 11 53	44 10 13 85 57
30	61 65 61 68 66	37 27 47 39 19	84 83 70 07 48	53 21 40 06 71	95 06 79 88 54
	93 43 69 64 07	34 18 04 52 35	56 27 09 24 86	61 85 53 83 45	19 90 70 99 00
	21 96 60 12 99	11 20 99 45 18	48 13 93 55 34	18 37 79 49 90	65 97 38 20 46
	95 20 47 97 97	27 37 83 28 71	00 06 41 41 74	45 89 09 39 84	51 67 11 52 49
	97 86 21 78 73	10 65 81 92 59	58 76 17 14 97	04 76 62 16 17	17 95 70 45 80
35	69 92 06 34 13	59 71 74 17 32	27 55 10 24 19	23 71 82 13 74	63 52 52 01 41
	04 31 17 21 56	33 73 99 19 87	26 72 39 27 67	53 77 57 68 93	60 61 97 22 61
	61 06 98 03 91	87 14 77 43 96	43 00 65 98 50	45 60 33 01 07	98 99 46 50 47
	85 93 85 86 88	72 87 08 62 40	16 06 10 89 20	23 21 34 74 97	76 38 03 29 63
	21 74 32 47 45	73 96 07 94 52	09 65 90 77 47	25 76 16 19 33	53 05 70 53 30
40	15 69 53 82 80	79 96 23 53 10	65 39 07 16 29	45 33 02 43 70	02 87 40 41 45
	02 89 08 04 49	20 21 14 68 86	87 63 93 95 17	11 29 01 95 80	35 14 97 35 33
	87 18 15 89 79	85 43 01 72 73	08 61 74 51 69	89 74 39 82 15	94 51 33 41 67
	98 83 71 94 22	59 97 50 99 52	08 52 85 08 40	87 80 61 65 31	91 51 80 32 44
	10 08 58 21 66	72 68 49 29 31	89 85 84 46 06	59 73 19 85 23	65 09 29 75 63
45	47 90 56 10 08	88 02 84 27 83	42 29 72 23 19	66 56 45 65 79	20 71 53 20 25
	22 85 61 68 90	49 64 92 85 44	16 40 12 89 88	50 14 49 81 06	01 82 77 45 12
	67 80 43 79 33	12 83 11 41 16	25 58 19 68 70	77 02 77 00 52	53 43 37 15 26
	27 62 50 96 72	79 44 61 40 15	14 53 40 65 39	27 31 58 50 28	11 39 03 34 25
	33 78 80 87 15	38 30 06 38 21	14 47 47 07 26	54 96 87 53 32	40 36 40 96 76
50	13 13 92 66 99	47 24 49 57 74	32 25 43 62 17	10 97 11 69 84	99 63 22 32 98

Annex A (normative)
Symbols

Symbol	*Meaning*
N	Batch size
n	Sample size
c	Acceptance number
c_n	Number of defective meters in the sample for a given characteristic
d_1	Rejection number (in double sampling plan)
P_r	Probability of acceptance
P_{c_n}	Probability of finding a number c_n of defective meters in the sample for a given characteristic
p	Proportion of defective meters in the batch for a given characteristic
OC	Operating characteristic curve
x	Variable (e.g. meter error)
x_i	Individual value of x
μ	Mean value of x in a batch for a given characteristic
s	Standard deviation of the variable x in the sample
σ	Standard deviation of the variable x in a batch
σ_j	Standard deviation of the variable x in the batch j
σ_{max}	Maximum standard deviation
σ_{adm}	Admissible standard deviation
λ	Standardized random variable $\lambda = \frac{x - \mu}{\sigma}$
λ_p	Value of λ for the proportion p of the x-values exceeding a defined limit
p_i	Proportion of x-values exceeding the limit T_i
p_s	Proportion of x-values exceeding the limit T_s
T_i	Lower limit of x
T_s	Upper limit of x
AQL	Acceptable quality level
LQ	Limiting quality
AOQL	Average outgoing quality level
AOQ	Average outgoing quality
δ	Range of systematic deviations between μ values of all batches for a given characteristic
$\bar{x}$	Sample mean of the variable x
w_j	Range of the x-values in a subgroup of a sample
α_m	Mean value } of the standardized range $\frac{w}{\sigma}$
β_m	Standard deviation } of the standardized range $\frac{w}{\sigma}$
α	Manufacturer's risk
β	Purchaser's risk
m	Size of a subgroup

r	Number of subgroups in a sample
$\overline{w}$	Average range (from r subgroups of size m = 5)
$\overline{w}_{max}$	Maximum average range
$\overline{w}_{adm}$	Admissible average range
Z	Estimator for average range method $Z = \bar{x} \pm K \bullet \overline{w}$
z	Estimator for standard deviation method $z = \bar{x} \pm k \bullet s$
μ_Z	Mean value of the variable Z
μ_z	Mean value of the variable z
σ_Z	Standard deviation of the variable Z
σ_z	Standard deviation of the variable z
$Q_{(q)}$	Proportion of $Z(z)$ values exceeding the limits T_i or T_s
u	Standardized random variable $u = \frac{Z(z) - \mu_{Z(z)}}{\sigma_{Z(z)}}$
u_β	Value of u for the proportion β of $Z(z)$ values exceeding the limits T_i or T_s
K,K'	Acceptance factors for average range method
k,k'	Acceptance factors for standard deviation method

Annex B (informative) Bibliography

[1] DAVID, HARTLEY, PEARSON, *The distribution of the ratio, in a single normal sample, of range to standard deviation,* Biometrika **41** (1954), p. 482-493.

[2] WILK, SHAPIRO, *An analysis of variance test for normality (complete samples),* Biometrika 52 (1965), p. 591-611.

[3] *Glossary* of the European Organization for Quality Control (EOQC) 1972.

Annex ZA (normative)
Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 410	1973	*Sampling plans and procedures for inspection by attributes*	—	—
IEC 514 (mod)	1975	*Acceptance inspection of Class 2 alternating-current watt-hour meters*	EN 60514	1995
IEC 1036 (mod)	1990	*Alternating current static watt-hour meters for active energy (Classes 1 and 2)*	EN 61036 + corr. March	1992 1994
ISO 3534-1	1993	*Statistics — Vocabulary and symbols Part 1: Probability and general statistical terms*	—	—
ISO 3534-2	1993	*Part 2: Statistical quality control*	—	—

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List of references

See national foreword.

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