

Committee Draft (CD 2) for a Document of OIML drawn up within TC 3/SC 4

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Surveillance of utility meters in service on the basis of sampling inspections

1 Foreword

Two of the most principle elements of metrological control for establishing and maintaining the quality and performance of meters used for revenue purposes are the initial verification of meters before use and the subsequent verification of meters at periodic intervals while in use. Mandatory verification of electricity meters, gas meters, water meters, and heat meters - generally referred to as utility meters in this Document - and the period of validity of such verifications are governed by national regulations. When the period of validity of the meter's verification expires, the meter must normally be submitted for subsequent verification.

The period of the validity of the verification is normally set at a fixed number of years corresponding to the national regulatory authority's confidence with respect to the meter type's reliability (its ability to remain accurate while in use). As meter reliability is affected by numerous factors including those pertaining to design, production, usage, time and environment, the effects of such factors are difficult to assess, the period of validity initially established for the verification of a meter may be either longer or shorter than it should be.

This document provides an objective means to address the above issue, using statistical methods to make an assessment regarding the appropriateness of initially established periods of validity with respect to specified meter performance and conformance standards. It permits lot quality at the time near the expiration of the period of validity to be re-assessed on the basis of sampling inspection. Representative random samples are selected from lots formed from meters which are homogeneous with respect to the factors which affect meter reliability, the sample meters are inspected, and the results of the inspections are compared with criteria based on probability theory to determine whether or not an extension to the period of validity of the verification should be granted to the meters in the lot. As the replacement of in-service meters when their periods of validity expires is a costly matter and the results of sampling inspection may suggest that such replacement is premature, a significant reduction in the meter owner's operating costs is possible when meter reliability is high.

National regulatory authorities will also be able to use the results of the implementation of this Document to make sound decisions regarding increase or reduction of initial periods of validity for the verification of various meter types as experience is gained over time.

The sampling plans as given in the annex 2 are neither suitable for testing the performance of measuring instruments in a production line nor are they

applicable for purposes of the initial verification. The national regulatory authorities might use the outcome of the statistical results within their obligations for the metrological control within their market surveillance activities.

It has to be stated clearly that the selection of the kind of sampling plans is a pure political decision on the level of consumer protection as defined by the limiting quality values (LQ).

Very small LQ values would increase the size of the sample to such an extent that the workload would come close to a (almost complete) re-verification procedure - thus jeopardizing the objective of this document.

Therefore the LQ values chosen for the sampling plans as shown in Annex 2 pretend to reflect a sound compromise between a level of consumer protection being regarded as sufficient for legal metrology purposes and a manageable workload.

2 Scope

- 2.1** The present Working Document relates to the method and procedure according to which the period of validity of the verification of utility meters forming part of a defined lot is extended if the correctness of the meters has been proved by sampling inspections prior to the expiry of the period of validity of the verification. This is basically for meters used at private homes but with a sufficient number of instruments forming the size of a lot.
- 2.2** It is the responsibility of the national regulatory authority to define the maximum permissible error of the utility meters before their subsequent verification as well as the time of period for verification.
- 2.3** Only those type of utility meters are to be taken into account which are subject to legal metrology for the purpose of consumer protection.
- 2.4** The sampling instructions applied have been compiled in the Annex 2 (Sampling plans).

They are valid for a limiting quality (LQ) of 8% in compliance with ISO 2859-2 (Sampling procedures for inspection by attributes; Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection).

3 Terminology

- 3.1** The terms of statistics used in this Document have been defined in the International Standards ISO 3534 (Statistics; Vocabulary and symbols; Part 1: Probability and general statistical terms) and ISO 2859-1; 2001 (Sampling procedures for inspection by attributes; Part 1: Sampling schemes indexed by acceptance quality level (AQL) for lot-by-lot inspection).
- 3.2** The metrological terms used in this Document have been defined in the

relevant international recommendations of OIML:

R 46 (Electrical energy meters)¹⁾
R 6 and R 31 (Gas meters)
R 49 and R 72 (Water meters)
R 75 (Heat meters).

3.3 The most important terms of statistics have been compiled in Annex 1.

4 Carrying-out of the sampling inspection – General

- 4.1** If a sampling inspection is to be carried out in order to extend the period of validity of the verification of utility meters, the owners of the meters (usually public utility undertakings) must file an application with the body responsible for national verification.
- 4.2** The sampling inspection is to be carried out in good time before the expiry of the period of validity of verification so that in the case of non-compliance with the requirements, all utility meters forming part of the lot can be removed from the network prior to the expiry of the period of validity of verification and be replaced by verified meters.
- 4.3** The selection of sample meters and the inspection of these meters may be carried out only by the body responsible for subsequent national verification or under the direct supervision of this body.
- 4.4** If a check is made and if so requested by the body responsible for subsequent national verification, the owner of the utility meters must prove (by indicating the meter number and the place of installation) for which meters and up to which date the period of validity of verification has been extended.

5 Criteria for the assembly and delimitation of a lot

- 5.1** Only such utility meters may be assembled into a lot, which fulfil the same characteristics.
- Manufacturer (including other manufacturers, licensed to make exactly the same meters)
 - Type or model of the meter
 - Class of accuracy
 - Pattern approval number or mark
- The year of manufacture or testing shall not vary more than one year. These meters usually have an identical approval number or mark. All meters must have been used under the same operating and ambient conditions.

Moreover, the following characteristics must be identical in all meters:

¹⁾ R 46 has in fact been withdrawn; a revised version is under preparation within TC 12 dealing with watt-hour meters in the first stage.

(a) Electrical energy meters

- nominal voltage
- transitional current
- maximum current
- reference voltage should not differ more than 10%,
- basic current (for direct meters) up to 30 A,
- current-carrying capacity (maximum current/basic current proportion) up to 4 times or more than 4,
- rated current (for transformer meters) - all values mentioned in electrical energy standards,
- the same class,
- one tariff or more tariffs (for indication meters only)

(b) Gas meters

- maximum flow rate
- membrane material
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(c) Water meters

- permanent flow rate

(d) Heat meters

- nominal flowrate (of the flow sensors)
- limiting flowrate values
- same class (see EN 1434-1 Nr. 9.2.1 April 1997)

As to water meters and flow sensors of heat meters, only such meters may be assembled into a lot, which were operated with water of identical or comparable quality.

5.2 The dates of the last verification for all utility meters may differ at most by 1 year.

5.3 With the approval of the body responsible for subsequent national verification and subject to the conditions stated below, combined lots may be formed of meters

- which are of different type, provided appropriate conditions for the assembly into such a lot have been clearly stipulated by the body concerned;
- which are the property of different public utility undertakings, provided responsibility of the individual undertakings has been made quite clear.

5.4 The once determined lot should be kept for all subsequent verifications based on sampling inspections. The same meter can be selected for one lot only.

6 Application for sampling inspection

The application for sampling inspection must provide the following information in addition to item 5.1:

- (a) type, manufacturer, approval mark, date or dates of the last verification (year),
- (b) **for electrical energy meters:**
reference voltage, transitional current, maximum current

for gas meters:
meter size, membrane material and whether temperature correctors have been provided,

for water meters:
meter size and metrological class,

for heat meters:
nominal flowrate (of the flow sensor) and limiting flowrate values,
- (c) lot size,
- (d) public utility undertaking(s) which is (are) the owner(s) of the utility meters,
- (e) statement by the public utility undertaking or undertakings whether the lot, for which sampling inspection is applied, was previously subjected to sampling inspections,
- (f) date at which the meters selected for sampling inspection will presumably be removed from the network and made available for inspection,
- (g) sampling instruction chosen.

7 Selection and treatment of the sample meters

7.1 The following is to be agreed between the body responsible for subsequent national verification and the applicant:

- (a) Procedure and characteristics for random sampling of the utility meters (for example: by maker's number, owner's number or customer's number; table of random numbers or program for the computer-aided generation of random numbers),
- (b) sampling instruction to be applied,
- (c) date of removal of sample meters from the network and date of their delivery to the inspection place or period between the two operations,

- (d) procedure reducing possibility of inadmissible interventions in the sample meters during the period between their removal from the network and the inspection place.

- 7.2** Depending on the lot size and the sampling instruction chosen, the sample meters and the spare meters are selected from the defined lot. The selection must be made in compliance with the rules of mathematical statistics, i.e. the probability to be selected as a sample meter or spare meter must be the same for each meter forming part of the lot. Cf. Annex 2 for sample size and number of spare meters.
- 7.3** The inlet and outlet sockets of gas meters, water meters and flow sensors of heat meters must be sealed immediately after the devices have been removed from the supply network. Gas meters may be rinsed with air or inert gas for a short time.
- 7.4** The period between the removal of gas meters, water meters and heat meters from the network and the inspection should be as short as possible but should not exceed one month properly sealed.
- 7.5** During transport, the meters may not be subject to extreme mechanical stress.
- 7.6** Any interventions, such as repair, adjustment, exchange of the counter or the like, are inadmissible, except the rinsing of gas meters and of water meters or of the flow sensors of heat meters.

8 Sampling inspection

8.1 Non-conforming meters

8.1.1 Type approval Certificate

A meter forming part of the sample is considered non-conforming if it does not comply with the specifications of the type approval certificate and if it does not meet the regulations of mandatory verification.

8.1.2 Display test

The display should be tested for a correct operation. At least at one test point the meter has to be energized continuously to check the correct operation. The difference of this error to the error measured by a short time test method must be less than 1%, otherwise the meter is non-conforming.

8.2 Test points

The metrological characteristics of the sample meters are tested at the following test points, in the order stated below:

(a) Electrical energy meters

- Running with no load
When the voltage is applied with no current flowing in the current circuit (current circuit shall be open circuit), the meter shall not register energy at any voltage between $0,8 U_{nom}$ and $1,1 U_{nom}$.

The term I_{tr} is the declared value of current at and above which the meter purports to lie within the smallest maximum permissible error corresponding to the class index of the meter. The ratio $\frac{I_{max}}{I_{tr}}$ must be equal to or higher than 50 for direct connected meters.

- Accuracy tests $0,5 I_{tr}$; $1,0 I_{tr}$; $10 I_{tr}$ and $1,0 I_{max}$.
- Starting current
An electrical energy meter is non-conforming if it does not start to register energy at 1,5 times the starting current.

(b) Gas meters¹

Test points

- Q_t and
- $1,0 Q_{max}$

(c) Water meters

Q_1 and Q_2 .

(d) Heat meters or sub-assemblies of heat meters

Flow sensors: $0,1 q_p$, q_i , q_p (in the order stated)

Calculators: $\Delta\Theta_{min}$; $\Delta\Theta_{max}$; $\Delta\Theta = 10 \text{ K}$ or $\Delta\Theta = 20 \text{ K}$

Temperature sensor pairs: $\Delta\Theta_{min}$; $\Delta\Theta_{max}$ and another value, preferably $(\Delta\Theta_{min} + \Delta\Theta_{max})$.

8.3 Spare meters

If the sample meters selected comprise meters

- (a) which are damaged at the outside,
- (b) whose protective mark is damaged,
- (c) which cannot be localized any more or have been incorrectly filed,
- (d) which are not accessible,

replacement of such meters by spare meters is permissible before the inspection process is started.

In the cases (a), (b) and (c) only 3 meters (altogether) may be replaced if

¹ see annex 3

sample size is 50, only 5 meters if sample size is 80, only 8 meters if sample size is 125 and only 12 meters if sample size is 200.

- Replacement can be only done once, just after visual examination
- Spare meters used for replacement are chosen from the spare lots at random.

If it is impossible to complete whole sample according to the rules mentioned above the application for extension of the period of validity of the verification on the basis of sampling inspection must be rejected.

Remark: Limiting of the number of spare meters used for replaced sample meters in the cases (a), (b) and (c) results from assumption that if the limit is exceeded it means that a lot contains too many meters meeting those three criteria.

8.4 Test methods

The test methods applicable in sampling inspections are those specified in the regulations valid in the field of metrology or those established upon type approval for verification. Special attention should be given to the following:

8.4.1 Electrical energy meters

- (a) The individual meters are tested at nominal voltage at unity power factor; single-phase load but with balanced poly-phase voltages applied to voltage circuits.
- (b) The test may be carried out by a short-time test method or by a method with the meter energized continuously. The test performed with the meter energized continuously is to be carried out with a uniform value of at least 4 kWh per test cycle.

8.4.2 Gas meters

Before starting the tests, the volume passed through the meter shall be at least fifty times the cyclic volume of the meter.

8.4.3 Water and heat meters

Water meters and flow sensors for heat meters are to be removed from the network in a way that as much water as possible remains in the meters. Observe the same condition for mounting the meters into the test rig. Having inserted the meters, slowly fill them and the complete measuring section.

Start the test with the maximum flow of Q_2 first, then Q_1 .

After the test, the inlet and outlet sockets must be sealed again to keep the inside of the meters moist for possible re-testing.

8.5 Retention periods

The bodies responsible for national verification may fix a deadline up to

which the sample meters are to be retained unchanged. For water meters, heat meters and flow sensors of heat meters this period should not exceed one month from the day of the sampling inspection in order to prevent the meters from drying out.

9 Sampling plans

- 9.1 The sampling instructions applicable to sampling inspection have been given in Annex 2. From the statistics point of view, the sampling instructions of Tables 1 and 3 are equivalent; these sampling instructions are binding for the body carrying out the inspections, and they must not be deviated from without approval by the supervisory body. For lot sizes larger than 35000 meters, the tables of Annex 2 can be extended in compliance with ISO 2859-2.
- 9.2 In order to achieve a higher acceptance probability for lot sizes, a sampling instruction applicable to larger lot sizes with a correspondingly larger sample size may be chosen.
- 9.3 It is not permitted to switch from the sampling instruction originally chosen to another one after the sampling process has been started with the exception the national regulatory body has agreed upon otherwise.

10 Test result

- 10.1 All test results are to be recorded in a way that can be verified. Re-testing of the sample by the body responsible for national verification must be possible.
- The lot is accepted if the requirements of the sampling instruction have been met and a possible re-test by the competent body has not led to any objection.
- If the lot is rejected, all units of the lot must be put out of service before the period of validity of the verification has expired.
- 10.2 If the lot is accepted after the inspection according to one of the sampling instructions given in Annex 2 has been carried out, the period of validity of the verification of all meters forming part of the lot is extended to 50% of the period valid for initial verification. The initial verification period has to be fixed by the national verification authority according to the level of performance (i.e. durability test) of the utility meters prevailing in the country.
- 10.3 The extension of the period of validity of the verification begins with the month following the month in which the sampling inspection was carried out.
- 10.4 The competent body is to be informed about the result of the sampling inspection. The individual test results are to be submitted upon request.

Terminology Statistical terms

1 Inspection lot

Quantity of items (measuring instruments, parts of measuring instruments) submitted for testing or inspection.

2 Inspection lot size (N)

Number of items in the inspection lot.

3 Sample

Number of items taken from an inspection lot for inspection.

3.1 Sample size (n)

The number of items in the sample.

3.2 Cumulative sample size (n_k)

Cumulative sample sizes in double sampling; for the first sample, the cumulative sample size corresponds to the sample size of the first sample; for the second sample, it corresponds to the sum of the sample sizes of the first and the second sample.

4 Sampling inspection

Inspection based on a sampling instruction in the case of which the inspection lot is assessed in accordance with the result obtained for a single sample or, if necessary, for various samples.

4.1 Single sampling inspection

The decision on whether or not the criteria defined in the sampling instruction are complied with is taken on the basis of a single sample.

4.2 Double sampling inspection

The decision on whether or not the criteria defined in the sampling instruction are complied with is taken already on the basis of the first sample or, if necessary, on the basis of the second sample, depending on the result.

4.3 Sampling instruction

Instruction for taking one or, if necessary, several samples, and for evaluating the result with regard to acceptance or rejection of an inspection lot.

4.4 Sampling plan

Compilation of sampling instructions according to general aspects in order to limit the risk of non-conforming items being tested.

5 Acceptance

The conclusion that an inspection lot satisfies the requirement criteria defined in the sampling instruction.

5.1 Acceptance number (c)

The highest number of non-conforming items specified in sampling instructions, or the specified highest number of non-conformities in the individual samples that permits acceptance of the inspection lot.

6 Rejection

The conclusion that the inspection lot does not satisfy the requirement criteria stated in the sampling instruction.

7 Rejection number (d)

The lowest number of non-conforming items or the lowest number of non-conformities in the individual samples specified in sampling instructions in the case of which the inspection lot is rejected.

8 Inspection by attributes

Inspection of attributes or variable characteristics classified accordingly, in which a distinction is made only between conforming and non-conforming items.

9 Non-conforming items

An item one or more characteristics of which do not meet the requirements.

Sampling plans

Table 1 Single sampling inspection for electricity meters, gas meters and water meters

No.	Lot size	Sample size	Number of non-conforming meters		Spare meters acc. to 8.3
			Criterion for acceptance of lot (c)	Criterion for rejection of lot (d)	
1.1	up to 1200	50	1	2	10
1.2	1201 to 3200	80	3	4	16
1.3	3201 to 10000	125	5	6	25
1.4	10001 to 35000	200	10	11	40

Table 2 Single sampling inspection for complete heat meters

No.	Lot size	Sample size	Number of non-conforming meters		Spare meters acc. to 8.3
			Criterion for acceptance of lot (c)	Criterion for rejection of lot (d)	
2.1	up to 90	24	0	1	5
2.2	91 to 150	26	0	1	8
2.3	151 to 280	28	0	1	10
2.4	281 to 500	32	0	1	10
2.5	501 to 1200	50	1	2	10
2.6	1201 to 3200	80	3	4	16
2.7	3201 to 10000	125	5	6	25
2.8	10001 to 35000	200	10	11	40

Table 3 Single sampling inspection for components of heat meters

No.	Lot size	Sample size	Number of non-conforming meters		Spare meters acc. to 8.3
			Criterion for acceptance of lot (c)	Criterion for rejection of lot (d)	
3.1	up to 90	24	0	1	5
3.2	91 to 150	26	0	1	8
3.3	151 to 280	28	0	1	10
3.4	281 to 500	32	0	1	10
3.5	501 to 1200	50	0	1	10
3.6	1201 to 3200	80	1	2	16
3.7	3201 to 10000	125	2	3	25

Table 4 Double sampling inspection for electricity meters, gas meters, water meters and complete heat meters

No.	Lot size	Sample	Sample size	Cumulative sample size	Number of non-conforming meters**)			Spare meters acc. to No. 8.3
					Criteria for acceptance of lot (c)	Criteria for rejection of lot (d)	Criteria for required 2 nd sample*)	
4.1	up to 1200	first	32	32	0	2	1	6
		second	32	64	1	2		6
4.2	1201 to 3200	first	50	50	1	4	2 to 3	10
		second	50	100	4	5		10
4.3	3201 to 10000	first	80	80	2	5	3 to 4	16
		second	80	160	6	7		16
4.4	10001 to 35000	first	125	125	5	9	6 to 8	25
		second	125	250	12	13		25

Explanations:

*) A second sample of the same size as the first sample is to be randomly drawn from the lot if the non-conforming meters stated in this column are part of the first sample.

**) In each of the lines headed by “second sample”, the number of non-conforming meters relates to the cumulative sample size.

Test Points for Gas Meters

The following paragraphs are taken from the Committee Draft OIML CD3 (TC8/SC8) as well as from OIML R31, 8.2).

The flow rate characteristics of a gas meter shall be defined by the values of Q_{max} , Q_t and Q_{min} as stated in table 1 of the Committee Draft OIML CD3 under point 5.2.

Table 1 - Flow rate characteristics

Q_{max} / Q_{min}	Q_{max} / Q_t
≥ 5 and < 50	≥ 5
≥ 50	≥ 10

Q_t is the transitional flow rate which occurs between the maximum flow rate Q_{max} and the minimum flow rate Q_{min} that divides the flow rate range into two zones, the "upper zone" and the "lower zone", each characterized by its own maximum permissible error.

If the examination is conducted at different flow rates, the assurance shall be at least equal to that obtained by the tests mentioned above.

Q_t is also required to be marked on the identification plate of the meter (see 4.2 of CD3).

References

Further test procedures as applied to the different kind of utility meters

1. ISO 2859-1 (2001), Sampling Procedures for Inspection by Attributes, – Part 1: Sampling Schemes Indexed by Acceptance Quality Limit (AQL) for Lot-By-Lot Inspection
2. ISO 2859-2 (1985), Sampling Procedures for Inspection by Attributes – Part 2: Sampling Plans Indexed by Limiting Quality (LQ) for Isolated Lot Inspection
3. ISO 3534-1 (1993), Statistics – Vocabulary and Symbols – Part 1: Probability and General Statistical Terms
4. Electrical energy meters
OIML IR 46 (TC12/WG1 CD 3 - 2005)
5. Gas meters
OIML R 31 (1995)
OIML CD 3 (TC8/SC8 - 2005)
6. Water meters
OIML R 49-1 (2003)
OIML R 72 (1985)
7. Heat meters
OIML R 72 (1985)
OIML R 75-2 (2002)
8. Temperature sensor pairs
OIML R 75-2 (2002)