IEC TR 62617

Edition 2.0 2015-11

TECHNICAL REPORT

Home laundry appliances – Uncertainty reporting of measurements

IEC TR 62617:2015-11(en)

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Home laundry appliances – Uncertainty reporting of measurements

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 97.060

ISBN 978-2-8322-3033-6

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HOME LAUNDRY APPLIANCES – UNCERTAINTY REPORTING OF MEASUREMENTS

FOREWORD

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 62617, which is a Technical Report, has been prepared by subcommittee 59D: Performance of household and similar electrical laundry appliances, of IEC technical committee 59: Performance of household and similar electrical appliances.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- alternative expression of expanded uncertainties in absolute values;
- expanded uncertainty for horizontal drum washing machines according to IEC 60456:2010;

- expanded uncertainties for washer-dryer according to IEC 62512:2012
- clarifications of the examples of expanded uncertainty calculation.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
59D/430/DTR	59D/432/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

Words in **bold** in the text are specifically defined in Clause 3.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

To encourage the efficient use of energy and other resources, National governments and regional authorities have issued regulations, which mandate the provision of information to consumers regarding the energy and water consumption of household appliances and associated performance characteristics. This information is usually conveyed by labels attached to appliances at the point of sale and also by brochures provided by manufacturers.

Methods for measuring declared values for energy and water consumption and performance characteristics should be of sufficient accuracy to provide confidence to governments, consumers and manufacturers. The accuracy of a test method is expressed in terms of bias and precision. Precision, when evaluating test methods, is expressed in terms of two measurement concepts: repeatability and reproducibility. Therefore, standard procedures should be used for determining the repeatability and the reproducibility of test methods developed by technical committee 59 and its subcommittees. The repeatability of a test method should be sufficiently accurate for comparative testing. The reproducibility of a test method should be sufficiently accurate for the determination of values which are declared and for checking these declared values.

Uncertainty reporting is essential to ensure measured data are interpreted in a correct way. Especially when data of measurements are compared between laboratories or when normative requirements are set up, it is necessary to know the uncertainty with which data can be measured.

HOME LAUNDRY APPLIANCES – UNCERTAINTY REPORTING OF MEASUREMENTS

1 Scope

This Technical Report (TR) applies to uncertainty reporting of measurements of home laundry electrical appliances.

It allows to estimate the uncertainty of a measured result and to predict the range of values that may be measured when the same appliance is measured in another laboratory following the same measurement method.

NOTE The provisions in this TR can also be used to evaluate other kinds of products.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TR 61923:1997, *Household electrical appliances – Method of measuring performance – Assessment of repeatability and reproducibility*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
repeatability conditions
conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time

[SOURCE: IEC TR 61923:1997, 3.6]

3.2
repeatability standard deviation
standard deviation of test results obtained under **repeatability conditions**

[SOURCE: IEC TR 61923:1997, 3.7]

3.3
reproducibility conditions
conditions where test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment

[SOURCE: IEC TR 61923:1997, 3.9]

3.4
reproducibility standard deviation
standard deviation of test results obtained under **reproducibility conditions**

[SOURCE: IEC TR 61923:1997, 3.10]

3.5
statistical uncertainty
repeatability standard deviation obtained in one laboratory under **repeatability conditions**

3.6
expanded uncertainty
confidence interval, which allows to calculate the minimum and maximum value where the average measured result may be found when the measurement is re-done at any other laboratory following **reproducibility conditions**

4 The approach to uncertainty measurement

4.1 The importance of the uncertainty

When a measurement has been performed giving a figure as a result for some quantity (i.e. the measurand), how sure is this figure? In other words:

- if the measurement is repeated, will the same figure be achieved as the result?
- if another group or another laboratory performs the measurement, how close will the results expected to be?

By means of an uncertainty amount an uncertainty interval $y \pm U$ may be calculated, where y is the measurement result and U the **expanded uncertainty** that is determined to give the interval a high probability (often 95%) to cover the true value, y, of the measurand. U is said to be the uncertainty associated with the result y.

The uncertainty interval of a measurement is therefore a basis for qualifying the measurement. The more narrow the confidence interval is desired, i.e. the smaller the value of the uncertainty U is pursued, the more careful the measurement method, the measuring equipment, the training of the operators and the number of repetitions of the same experiment have to be.

4.2 Ways to access uncertainty

There are in principle two ways to estimate uncertainty: a bottom up method and a top down method. The two methods should often be used in parallel to achieve a reliable uncertainty amount.

a) The bottom up method (refer to ISO/IEC Guide 98-3:2008, Clause 2)

   In this method the test result y is expressed as a function of input quantities. This function is often the formula used for the calculation of the result.

   In the case of home laundry appliances, y may be one of the final test results like water consumption, energy consumption, washing performance, spin speed, spin drying performance, program duration or rinsing efficiency. The input quantities may be temperature, masses, times, power etc.

   The magnitude of all the uncertainty contributions of each input quantity is estimated.

   By combining the uncertainties of the input quantities according to the law of propagation of uncertainty (see ISO/IEC Guide 98-3:2008, Clause 2) the uncertainty of the result y can be calculated.

   With this calculation it can be seen how a specific uncertainty contribution from an input quantity does influence the combined uncertainty of the final result and therefore how a reduction in an uncertainty contribution from an input quantity will influence the combined uncertainty of the final result.

Uncertainties may usually be reduced at some cost by making more measurements, using other methods or other equipment. This means that different approaches can be followed to reduce the uncertainty of the final result in the most cost effective way.

b) The top down method (see IEC TR 61923)

In this method the **reproducibility standard deviation** is estimated from testing of the same machine (or the same model) in different laboratories using the same measurement method. This testing is in general named ‘ring test’ or ‘round robin test’. The **reproducibility standard deviation** of the test results can then be seen as the inherent uncertainty of the measuring method as it may be influenced by remaining differences in the ambient, the people and whatever else may be different between different measurements in different laboratories. In principle it is only valid for the machine investigated in each ring test, but results may be also true for similar type of machines.

Therefore the two methods ‘bottom up’ and ‘top down’ may be used in parallel to achieve a reliable uncertainty quantification. But both methods depend on the validity of the model (for the bottom up method) or the data (for the top down method) used.

5 Expanded uncertainty calculation

The uncertainty of a measured result has two sources:

- the **statistical uncertainty** of what is measured, as expressed in the **repeatability standard deviation,** showing the accuracy of the measurement in the laboratory having done the measurement;
- the uncertainty of the measuring method itself. This is expressed as **expanded uncertainty** where it is common to set the borders at a 95 % confidence interval, which give the minimum and maximum value where the average measured result may be found when the measurement is re-done at any other laboratory.

To be meaningful, the uncertainty statement shall have an associated confidence level, i.e. it is necessary to state the probability that the true value lies within the range given. The reasons for choosing a 95 % confidence level in this document are as follows:

- it is established practice throughout much of Europe, North America and Asia;
- the ISO/IEC Guide 98-3 (GUM) assumes that the combined uncertainty has a distribution that is a close approximation to a normal distribution. A 95 % confidence level approximates to a range of 2 standard deviations. It is a widely held view that, for most measurement systems, the approximation to a normal distribution for the distribution of the combined uncertainty is reliable up to 2 standard deviations, but beyond that the approximation is less reliable.

If a normal distribution may be assumed the 95 % confidence interval is given by multiplying the **reproducibility standard deviation** by a factor of 2.

6 Absolute and relative reproducibility standard deviation

Whatever methodology is used to calculate the **reproducibility standard deviation** it is then the responsibility of experts within the relevant standardisation committee to conclude which **reproducibility standard deviation** is the most realistic expression of the uncertainty for a certain product group.

Different values may be communicated for different product groups within the same product category, if necessary and justified. The decisions and the rationale have to be reported.

The **reproducibility standard deviation** can be a value of absolute or relative nature. Depending on the nature of the error either one or the other shall be preferred:

- absolute values of the **reproducibility standard deviation** shall be preferred when the measurement error is not likely to be influenced by the absolute value of the measurand.
- relative values are preferred when the error will grow or diminish with the absolute magnitude of the measurand.

It is the responsibility of the relevant standardisation committee to conclude in which way the **reproducibility standard deviation** shall be expressed. If expressed in absolute values, the **reproducibility standard deviation** shall be given with the term '(abs)', otherwise in '%'.

7 Reporting uncertainty

When reporting test results all information should be given to allow a full judgement of the measurement: average measured value, **repeatability standard deviation** and **expanded uncertainty**.

Example for a repeatability standard deviation of 0,03 kWh and relative expanded uncertainty of 10 %:

- measurement of the energy consumption

  Average measured: 1,44 kWh

  Repeatability standard deviation of measurement: 0,03 kWh

  Expanded uncertainty: 10% (of 1,44 kWh =) 0,14 kWh

- reporting of the result

  Average measured: 1,44 kWh

  Repeatability standard deviation: ±0,03 kWh

  Expanded uncertainty: ±0,14 kWh

- meaning: testing the same machine in another laboratory following **reproducibility conditions**, the expected average value (at 95 % confidence) is between 1,30 kWh and 1,58 kWh.

Example for a repeatability standard deviation of 0,03 kWh and absolute expanded uncertainty of 0,10 kWh (abs):

- measurement of the energy consumption

  Average measured: 1,44 kWh

  Repeatability standard deviation of measurement: 0,03 kWh

  Expanded uncertainty: 0,10 kWh (abs) 0,10 kWh

- reporting of the result

  Average measured: 1,44 kWh

  Repeatability standard deviation: ±0,03 kWh

  Expanded uncertainty: ±0,10 kWh

- meaning: testing the same machine in another laboratory following **reproducibility conditions**, the expected average value (at 95 % confidence) is between 1,34 kWh and 1,54 kWh.

8 Expanded uncertainty values

8.1 General

Expanded uncertainty values reported in 8.2 to 8.5 define the level of **expanded uncertainty** as estimated from the results of performed round robin tests. They are only valid for the assessed machine types. Other machine types may behave differently, also affecting the uncertainty values.

Laboratories shall ensure that they meet the requirements of the relevant measurement method and the **reproducibility conditions** of testing and should check their alignment with other laboratories participating in inter-laboratory testing.

The uncertainty figures are established on the basis of the evaluation of round robin tests. Uncertainty figures of different parameters may be based on different round robin tests and will be updated whenever necessary. The respective sources are referred to with the data.

8.2 Expanded uncertainty of measurement in IEC 60456:2003 (4th edition)

In 2004-2005, a round robin test was performed with 25 laboratories participating from all over Europe. One of the objectives was to check the robustness and precision of IEC 60456:2003 (4th edition). Four washing machines, 2 horizontal drum washing machines and 2 reference machines, were tested in a total of eleven different washing cycles. Household washing machines under test were calibrated to be as identical to each other as possible and delivered to all participating laboratories.

Results were analysed by SC59D and **expanded uncertainties**, rounded to integer, were calculated, as shown in Table 1.

Table 1 – Expanded uncertainty of measured values of IEC 60456:2003 (4th edition) for horizontal drum washing machine

Measured parameter	Relative expanded uncertainty of measured value (k=2)
Wash performance ratio q	4 %
Total energy W_{total} (in kWh)	10 %
Total water V_{total} (in L)	5 %
Remaining moisture RM (in %)	5 %
Programme time (in min)	6 %

8.3 Expanded uncertainty of measurement in IEC 60456:2010 (5th edition)

In 2008, a round robin test was performed with 31 laboratories participating from all over the world. One of the objectives was to check the robustness and precision of IEC 60456:2010 (5th edition). Six types of washing machines, 2 horizontal-axis, 2 vertical-axis (agitator type), 2 vertical-axis (impeller type) machines, plus reference machines were tested in four different washing cycles. Household washing machines under test were calibrated to be as identical to each other as possible and delivered to all participating laboratories.

Results were analysed by SC59D and **expanded uncertainties**, rounded to integer, were calculated for horizontal-axis washing machines only, as shown in Table 2.

Table 2 – Expanded uncertainty of measured values of IEC 60456:2010 (5th edition) for horizontal axis washing machines

Measured parameter	Expanded uncertainty of measured value (k=2)
Wash performance ratio q	0,04 (abs)
Total energy W_{total} (in kWh)	9 %
Total water V_{total} (in l)	4 %
Remaining moisture RM (in %)	5 (abs)
Programme time (in min)	5 (abs)
Rinsing performance	0,70 (abs)

8.4 Expanded uncertainty of measurement in IEC 61121:2002 (3rd edition)

In 2006, a round-robin test was organised in Europe including 19 laboratories. Three condensation dryers, checked before to behave equal, were sent around and were measured in regular cupboard dry and iron dry programme according to IEC 61121:2002 (3rd edition).

Analysis of the data shows no influence of the individual dryer, therefore the 19 laboratories could be considered a set of laboratories fulfilling the requirements of IEC TR 61923:1997, 5.2.

Results were analysed by SC59D, and **expanded uncertainties**, rounded to integer, were calculated as shown in Table 3.

Table 3 – Expanded uncertainty of measured values of IEC 61121:2002 (3rd edition) for condenser tumble dryers

Measured parameter	Relative expanded uncertainty of measured value (k=2)
Corrected energy consumption E (in kWh)	4 %
Corrected programme time t (in min)	8 %
Condensation efficiency C (in %)	10 %

8.5 Expanded uncertainty of measurement in IEC 62512:2012 (1st edition)

A round-robin test was organised in 2013-2014 in Asian countries including 9 laboratories. Three washer-dryers, two with horizontal axis and one with vertical axis without heater, were tested in two programs according to IEC 62512:2012(1st edition)

Results were analysed by SC59D and **expanded uncertainties** were derived as shown in Tables 4 and 5.

Table 4 – Expanded uncertainty of measured values of IEC 62512:2012 (1st edition) for horizontal-axis washer-dryer

Measured parameter	Relative expanded uncertainty of measured value (k=2)
Wash performance ratio q	0,04 (abs)
(Corrected) energy consumption (in kWh): Washing E_w in interrupted operation cycles	9 %
(Corrected) energy consumption (in kWh): Drying E_d in interrupted operation cycles	10 %
(Corrected) energy consumption (in kWh): Washing and drying E_{wD} in continuous operation cycles	10 %
(Corrected) water consumption (in L): Washing L_w in interrupted operation cycles	4 %
(Corrected) water consumption (in L): Drying L_d in interrupted operation cycles	>20 L: 20 % ≤20 L: 4 L (abs)
(Corrected) water consumption (in L): Washing and drying L_{WD} in continuous operation cycles	>60 L: 10 % ≤60 L: 6 L (abs)
(Corrected) program duration (in min): Washing t_w in interrupted operation cycles	5 min (abs)
(Corrected program duration (in min): Drying t_d in interrupted operation cycles	15 %
(Corrected) program duration (in min): Washing and drying t_{wd} in continuous operation cycles	15 %
Final moisture content μf (in %)	5 % (abs)
Rinsing performance	Not applicable