Bringing the home in the lab: consumer relevant testing for household electrical products

Christoforos Spiliotopoulos
European Environmental Citizens' Organisation for Standardisation (ECOS)
26 rue d'Edimbourg
B 1050 Brussels
Belgium
chris.spiliotopoulos@ecostandard.org

Rainer Stamminger
University of Bonn
Nussallee 5
D-53115 Bonn
Germany
stamminger@uni-bonn.de

Hans-Paul Siderius
Netherlands Enterprise Agency
Croeselaan 15
NL-3521 BJ Utrecht
Germany
hans-paul.siderius@rvo.nl

Keywords
energy efficient products, appliances, testing, standardisation, measurement and verification, consumer behaviour

Abstract
Product testing is widely used to assess the characteristics, e.g. performance, energy consumption of a product. The procedures for executing the tests, including measurements and processing of measurement results, can be contained in standards. Standards should – amongst other – ensure that product tests are carried out in a uniform, standardized way so that the results accurately reflect product characteristics and differences between products in case several products are tested, and are not due to variations in conditions. Therefore, standards should produce results that are repeatable, reproducible and valid at a reasonable cost.

A number of stakeholders have questioned the validity of several standards: the results that these standards provide are different from what a consumer may experience in practice. In the end this can have negative consequences for the trust of consumers in the policy instruments (energy labels, minimum efficiency requirements) that use these standards and an energy savings deficit compared to what was expected by policy-makers. They call for standards that better reflect 'real-life' conditions, meaning those conditions that consumers experience at home. However, unlike the other criteria that standards should meet, there is no methodology to assess the correspondence to real life (validity) of a standard. This paper develops such a methodology and presents the results for several household electrical appliances: washing machines, refrigerators and vacuum cleaners.

Introduction
Product testing is widely used to assess the characteristics, e.g. performance, energy consumption of a product. The results of this assessment are then used to determine whether the product meets requirements, the energy label classification is correct, or to benchmark the product against others. The procedures for executing the tests, including measurements and processing of results, can be contained in standards. Standards should – amongst other things – ensure that tests are carried out in a uniform, standardized way so that results accurately reflect product characteristics and demonstrate in a fair way the differences between products in case several are tested.

Since such tests regularly take place within the context of European legislation, such as ecodesign and energy labelling, whereby the results are used to provide presumption of conformity and also inform consumers through e.g. product information and energy labels, this product testing should also be relevant to consumers.

Investigations by consumer and environmental organisations (Marketwatch, 2015; ComplianTV, 2015; Sivitos et al, 2015; Spiliotopoulos, 2014, Spiliotopoulos 2016) indicate that several standards describe test procedures that provide results which differ from what consumers may experience in practice. Member States are starting investigations as well (Bundesanstalt für Materialforschung und -Prüfung, 2016). Considering that the purpose of energy labelling is to influence end user's choice with the provision of accurate, relevant and comparable information on the specific energy consumption of products, information that is not accurate or relevant can be misleading to consumers if energy and financial savings materialised are far from what those expected. Although the notion that tests, especially those outlined in standards supporting legislation, should reflect typical usage conditions is not new (Toulouse, 2014), there is currently no methodology to assess the correspondence of a test method to real-life. This paper describes what consumer-relevant testing is and proposes a methodology for its evaluation within the context of standards that support ecodesign and energy labelling legislation.

Three examples are drawn from the household appliances sector, namely washing machines, refrigerators and vacuum cleaners, to demonstrate how the methodology can be applied. It is, however, the view of the authors that the methodology is relevant beyond household electrical appliances, e.g. other energy-related products. Finally, conclusions and recommendations for future study are provided, with the view to stimulate systematic discussion on the topic, and contribute to standards developed and revised being more consumer-relevant.

What is consumer relevant product testing?

INTRODUCTION: GENERAL REQUIREMENTS FOR PRODUCT TESTING

Criteria to evaluate a test procedure/standard are (Siderius, 1991):

- Repeatabililty: the consistency of results, e.g. regarding energy consumption or performance when the same product is retested under the same conditions, e.g. in the same laboratory by the same staff;
- Reproducibility: the consistency of results when the same product is retested under somewhat different conditions, e.g. in another laboratory, but using the same test procedure;
- Validity: the correspondence of the results from applying the test procedure to the results obtained in practice (at the end-users);
- Costs: the costs for carrying out the test procedure.

Consumer relevant testing relates mainly to the third bullet point: the validity of the standard. However, one could argue that also the other criteria influence the consumer relevance of product testing. A test procedure that has a low repeatability provides inaccurate results which in turn lead to less useful information for consumers.

An ideal test procedure should provide the same results when the product is retested in the same or in another laboratory (high repeatability and reproducibility), provide the same results found in practice (high validity) and have low costs. Clearly, this combination is unlikely to be encountered in practice: a test procedure that is highly repeatable and reproducible will require, amongst others, a more detailed testing procedure, more expensive test equipment, more repetitions for statistical reasons and therefore a higher price tag. Furthermore, products can be used under different conditions, with different settings and in different modes; covering every single possible usage variation at the end-users would require multiple tests, which may in turn be associated with a higher cost.

Sometimes the term "real life testing" is used to mean measuring the product performance and/or energy consumption in practice at an end-user's dwelling. Based on the general requirements for product testing in this section, it is clear that testing according to a standard is not and cannot be "real life testing" because the requirements of repeatability and reproducibility will not be sufficiently fulfilled. However, the information on the use, performance and energy consumption in practice is necessary for assessing the validity of a standard.

CONSUMER RELEVANT PRODUCT TESTING

Consumer relevant product testing is product testing that provides results that correspond to results obtained when consumers use the product in practice. The key word in the definition of consumer relevant product testing is "correspond". This section describes what is needed to assess the correspondence.

Products are operated by users and work under certain conditions (e.g. temperature, humidity), consume energy or water and other resources (e.g. detergent) to deliver a desired performance (cold space, clean laundry or dishes) within a certain time period. All these parameters influence each other. Conditions may depend on the placing of the product (e.g. kitchen, cellar, garage, attic) and may vary over the year. Relevant parameters are those that influence the performance and/or energy consumption or other inputs. This is illustrated in Figure 1.

The following lists some of these parameters for household appliances:

- Situational conditions: ambient temperature, humidity, ventilation (air circulation), lighting level.
- Input conditions: frequency, voltage and quality of the power supply, caloric value of gas, temperature and hardness of water.
- Product features: available programmes, capacity.
- User behaviour: settings (installation/set-up, choice of programme), frequency of use, loading (amount and type), choice of detergent (composition and amount).

The general assumption is that, for a product with a given set of features, if the situational conditions, input conditions and user behaviour defined in the standard correspond to those commonly found in practice by consumer usage then the measured performance and energy consumption can be said to be 'consumer relevant'.

To demonstrate correspondence, it is important that: (1) the test procedure includes all parameters relevant for performance and energy consumption, (2) the variation in these parameter values reflect the variation of values at the consumers, and (3) the

Figure 1. Demonstration of relationship and influences of parameters to performance in product testing.

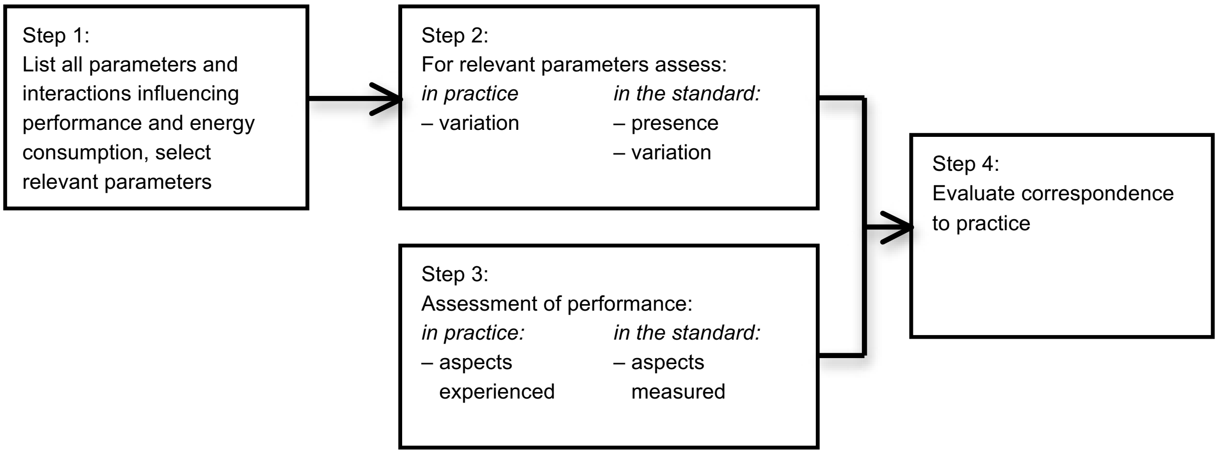

Figure 2. Steps of the methodology for assessing the consumer relevance of standards.

measured performance reflects the performance experienced by the consumer.

The methodology for assessing consumer relevant testing (validity) is based on these three aspects and is presented in the next section.

METHODOLOGY FOR ASSESSING THE CONSUMER RELEVANCE OF STANDARDS

The proposed methodology for checking consumer relevance of standards consists of the following steps.

1. List the parameters (product features, situational conditions, input conditions and user behaviour) that influence product performance or energy consumption; analyse the interactions and then select the (most) relevant parameters.
2. For the chosen parameters, indicate the variation found in practice and check whether it is considered in the standard being evaluated.
3. Identify the main performance aspects expected by consumers and how these are experienced by consumers. Assess how these expected performance aspects are measured in the standard.
4. Evaluate the correspondence to practice (consumer relevant testing) of the standard according to:
   - Missing relevant parameters.
   - Variation in parameters taken into account.
   - Missing performance aspects.
   - Correspondence of the measurement of the performance with the experienced performance.

These steps are illustrated in Figure 2.

Step 1 involves consideration of available literature, knowledge of the principles of product operation testing and experience with the product. The number of parameters can be very large, but the assessment focuses on the relevant parameters. Therefore, the choice of the most relevant parameters can be guided by the influence of a parameter on performance or energy consumption. Caution is needed regarding interaction between parameters.

In **Step 2 and 3** data on the product usage in practice is collected. Existing literature, including preparatory studies for ecodesign and energy labelling measures, measured data from actual consumer use, consumer surveys, and expert interviews can all be sources of data. The variation of product usage in practice can be due to consumer segmentation (households with more persons use the dishwasher more often) but also geographical segmentation (northern Europe households use clothes driers more often than southern Europe ones). Knowledge of the variation is important because average values cover the fact that the values for any individual consumer are never at the average but always below or above.

Analysis of the text of the standard should provide information on how the relevant parameters are operationalized, including consideration of expected variation of consumer behaviour. It also has to be noted that, in order to ensure that certain relevant performance levels are met in real life at all times, a value (far) above the average may need to be used in the standard, e.g. a washing machine is tested with soils which cannot completely be removed. Also, testing declared performance claims may require a different level than the average. For example, a washing machine is (also) tested at the declared maximum capacity and not only at the average load size at consumers'.

Step 4 will be a qualitative evaluation, listing the areas that "cause" a reduction of the validity of the standard. This could be due to relevant parameters which are not evaluated, less variation captured by the standard, divergence between the values considered in the standard and those observed in practice or differences in assessment of the performance. It has to be noted that on one hand a less valid standard can still be sufficiently valid whereas on the other hand failing on one (important) parameter might render a standard invalid.

The use of three examples and evaluation of the corresponding standards is not the result of an official standardisation process or a consensus-building exercise amongst a wide pool of technical experts. Its purpose is to stimulate discussion on the methodology and provide the basis for further investigations, e.g. to identify potential shortcomings and/or the reasons for not including relevant parameters in a standard. Subsequently recommendations could be made to improve the consumer relevance of that standard if it is found that the validity is too low and/or should be improved. These recommendations need to take into account impacts on other criteria as mentioned above: repeatability, reproducibility and costs.

APPLICATION OF THE METHODOLOGY TO STANDARDS RELATED TO HOUSEHOLD ELECTRICAL APPLIANCES

In this section the specific aspects of applying the methodology to standards related to the performance of household electrical appliances are discussed. Household electrical appliances can be categorized in the following groups:

- Appliances that perform continuously, e.g. cold appliances.
- Appliances that perform per cycle, e.g. washing machines and dish washers.
- Appliances where continuous consumer interaction is necessary to deliver the performance, e.g. vacuum cleaners.

Each of these categories will put emphasis on a different type of parameter. Appliances that perform continuously are set-up once, probably using the default settings, and then are used by the consumer without much change. Appliances that perform per cycle will probably offer a (large) number of cycles, including settings of individual features, where the choice of the cycle has a large influence on the energy consumption.

Appliances where the consumer is active during the operation probably require extra attention how the consumer experiences the performance during operation since this will directly impact operation (and performance).

Consumer relevance evaluation of example standards

INTRODUCTION TO THE EXAMPLES

This chapter presents the results of assessing the consumer relevance of three example standards:

- Washing machines (EN 60456)
- Household refrigerators (EN 62552:2013 with notes on future impact of IEC 62552 under development)
- Vacuum cleaners (EN 60312)

This section offers general observations, discusses specific issues on each example and then comments on the relation between the standard, the regulation and consumer relevance. The detailed assessment of each example is in the Annex.

GENERAL OBSERVATIONS REGARDING CORRESPONDENCE

The assessments show that, generally, variation of situational conditions in practice is not reflected in the standards. On the contrary, situational conditions and inputs mostly have a narrowly specified variation to achieve good test reproducibility. If the variation in practice is to be captured, this has to be done with multiple tests at various combinations of conditions and inputs, or by using a model approach. It has to be noted that using the average value of the range observed in practice does not mean that this is also the most probable value.

A second general observation is that assessment of performance in the standard is done through measurement instruments and not, as in practice, by human observations or senses. As such, this difference does not necessarily signify a correspondence problem of the standard, but that it is difficult to assess the correspondence as such. This would need separate, dedicated research, which in some cases (e.g. artificially soiled cloths) has been done in the past. The rationale for assessing performance aspects lies on the need to prevent product design that ensures low energy consumption, but not the fulfilment of the product's intended function.

Related to the above is that important parts of the user behaviour, especially regarding the type of load, are implemented as "artificial" in the standards, e.g. the washing machine standard prescribes artificially-soiled strips to reflect the soiling of cloths, while the vacuum cleaner one uses specially prepared dust. Whereas the artificial soiling for washing machines takes into account a number of soil types, the artificial dust for the vacuum cleaner test is less varied than the dust and soils found in practice on floors. Again, this does not necessarily signify a correspondence problem, but the difficulty of assessing correspondence. The reason for using artificial materials and measurement instruments is mainly reproducibility, repeatability and costs.

SPECIFIC OBSERVATIONS REGARDING CORRESPONDENCE ON EXAMPLE TEST STANDARDS

Refrigerators

The new IEC standard allows for the *calculation* of the energy consumption at any ambient temperature between the two ambient temperatures for which the consumption is measured. Furthermore, the new IEC standard allows for measuring the energy consumption of door openings and freezing and cooling capacity. The EN version will choose – as in the past – to emulate the effect by using a higher ambient temperature: 25 °C as opposed to 20 °C average kitchen temperature. Calculations (VHK (2015)) show that this difference in ambient temperature reflects a worse case situation. Although the correspondence to practice regarding door openings and the entry of food (that has a higher temperature) is considered to be sufficiently captured, revisions of the standard need to ensure that the assumptions are still valid and therefore the results of the emulation correspond to practice. Furthermore, the influence of ambient humidity and door openings on the energy consumption related to an automatic defrost cycle needs further investigation.

There are several points where correspondence is considered low, e.g. regarding refrigerator volume and the load content. In these cases, a higher repeatability was prioritized over correspondence to practice.

Washing machines

The washing machine standard can capture in principle a large number of washing programmes (type of cloths, temperatures). However, in practice, the performance delivered is not only determined by the appliance, but also by the detergent used. This combination varies with consumers and over time, since different consumers may use different detergents and the composition of commercial detergents varies over time. It is therefore apparent that similarly the correspondence to practice cannot be determined for the washing machine standard alone.

Vacuum cleaners

In practice, there is direct feedback to consumers during vacuum cleaning: the experienced drag or force needed to move the head, visual inspection of dust pick-up. In the standard, this type of feedback is not implemented.

RELATION BETWEEN STANDARD AND LEGISLATION REGARDING CORRESPONDENCE

Although this paper concentrates on consumer relevance of the standards, this discussion cannot be seen outside the established legislative context, which uses the test results to provide information to consumers, and therefore plays important role. In the three standards assessed in this document, especially for washing machines, choices made in the regulation have impact on the correspondence to practice of the energy label. In this regard, two situations are identified and presented with examples.

First, a standard can in principle cover a (large) range of options (from those observed in practice) but the legislation needs to choose from these options in order to keep costs reasonable, or in order to provide confined information to the consumer. Of course, these choices should reflect practice and indeed are very important for the correspondence to practice of the information. In the washing machine standard example, a large range of washing programmes to be tested is allowed. However, the energy label for washing machines has a single efficiency indicator and the regulation needs to consider testing costs. Consequently, from the large number of programmes most washing machines have, two are chosen for the energy label: 60 °C and 40 °C cotton. Regarding the costs, the standard also influences the regulation. If the standard is revised in such a way that the cost per test decreases significantly, the regulation could choose to use more programmes without increasing the overall cost.

Second, the standard provides a result, but the evaluation of that result is done in the legislation. An example is how to deal with certain features, e.g. no-frost or climate class for refrigerators, in the energy labelling regulation. The standard specifies how a product with such a feature shall be measured, but it is the regulation that specifies whether the product will get a certain allowance on its energy consumption for this feature, how large this allowance will be and how it may be considered in the determination of the labelling class. If the allowance is larger than the impact during the test, then the label class may not reflect the efficiency in practice.

Conclusion and recommendations

This paper presents a methodology to assess the validity (defined as correspondence to practice) of a standard and applies it to three standards: washing machines, refrigerators and vacuum cleaners. Conclusions and recommendations regarding the methodology and the results of the examples are presented.

The methodology produces insight into the correspondence to practice of a standard, albeit at a qualitative level. It identifies and qualifies various sources that influence correspondence to practice. In general, the assessment of performance is the most difficult to evaluate because the type of assessment differs between practice and test. In the laboratory, the assessment of performance is preferably done through measurement instruments to arrive at objective results whereas, in practice, the assessment is in principle done by human observation. Without additional research, it is difficult to assess the correspondence of practice on performance aspects.

It has to be clarified that the assessments conducted here for three product standards are only examples, and not the product of official standardisation processes. Nevertheless, the following observations can be made:

- Generally, variation in situational conditions in practice is not reflected in the standards.
- As described above, the correspondence of performance in the standard versus real-life performance requirements on a product can only partially be fulfilled.
- In the washing machine standard, the artificial types of soil used show a variation that is intended to reflect variation of soil in practice. Furthermore, the detergent co-determines the correspondence to practice; however detergent composition is kept constant.
- In the refrigerator standard, no qualitative variation is applied to reflect the different load types and loading patters; only quantitative. Door openings and food load are emulated by a higher ambient test temperature. Other parameters (e.g. storage volume) are considered of low correspondence; in this case repeatability was prioritized over correspondence.
- In the vacuum cleaner standard, the variation of the dust particle size is smaller than in practice. Also, no feedback loop is implemented in the laboratory when measuring performance, whereas in practice consumers react on the force they need to use for moving the head or dust that is not picked up.
- Finally, from the assessment is becomes clear that not only the standards but also the legislation determines the correspondence to practice related to product information.

The following recommendations are proposed:

- This methodology assesses consumer relevance qualitatively. Quantitative assessment can be explored.
- A criterion which was not examined here but could be of future interest, is that of 'defeatability' of a standard, in other words how easy it is for a standard to be circumvented.
- A future application of this methodology to other energy-related products and with different specificities, would validate and enhance confidence in it.
- Improvements should be sought for aspects considered of low correspondence. Also, when it is decided to compensate low correspondence with other means, either in standards or regulations, assumptions and emulations should be re-evaluated during reviews, and see whether a more balanced prioritisation of criteria (e.g. repeatability over correspondence) is feasible or desirable.
- Systematic consideration of the criterion of consumer relevance for standards that used to support Ecodesign legislation. The methodology proposed in this paper could act as basis for such evaluations.
- Promote consumer-behavior studies to acquire better understanding of typical product usage at home.

References

AEA, 2009: Work on Preparatory Studies for Eco-Design Requirements of EuPs (II) Lot 17 Vacuum Cleaners.

Bundesanstalt für Materialforschung und –Prüfung, 2016: http://www.bam.de/de/aktuell/presse/pressemitteilungen/pm_2016/pm02_2016.htm.

CEN/CENELEC Ecodesign-Coordination Group, N169, 2016: Guide to assess measurement uncertainties for products under eco-design.

CLC/TR 50619:2014, Guidance on how to conduct Round Robin Tests.

EU Commission, 2015: Standardisation request on vacuum cleaners, M/540; ftp://ftp.cencenelec.eu/CENELEC/EuropeanMandates/M540_EN.pdf.

ComplianTV, 2015: http://www.compliantv.eu/eu/about-the-project/all-documents/.

JRC, 2016. Ecodesign and Energy label revision: Household Washing machines and washer-dryers. http://susproc.jrc.ec.europa.eu/Washing_machines_and_washer_dryers/.

Marketwatch, 2015: http://www.market-watch.eu/2015/01/20/atlete2/.

Siderius, P.J.S., 1991: Testing washing machines; test methods for measuring performance. SWOKA research report 112, The Hague.

Sivitos S., Spiliotopoulos C., Stamminger R., Toulouse E., 2015: http://ecostandard.org/wp-content/uploads/Appliance-Settings-and-product-efficiency.pdf.

Spiliotopoulos, C., 2014: http://www.coolproducts.eu/blog/eco-button-loophole.

Spiliotopoulos, C., 2016: http://ecostandard.org/wp-content/uploads/ECOS-Testing-Methods-Paper-Final.pdf.

TC59X/(Sec.)0554/INF, 2014, Internal Guide, version 1.0, Household and similar appliances – Method for calculation of uncertainty of measurement.

TC59X/Sec0644/NP, 2016, Guidelines for Verification of Household Appliances under Ecodesign (Draft).

Toulouse, E. 2014: Developing measurement methods for EU Ecodesign and Energy Labelling measures. A discussion paper, Published by CLASP http://clasp.ngo/~/media/Files/SLDocuments/2014/2014_02_Measurement-Methods-ED-and-EL-Measures.pdf.

VHK and Armines, 2016: Preparatory study revision cold appliances regulations. http://www.ecodesign-fridges.eu/Pages/introduction.aspx.

Acknowledgements

The authors would like to thank all the members of CLC/TC 59X, especially Dr Gerhard Fuchs, Mr Alain Roux, Mr Paul van Wolferen and Mr Jeremy Tait for their contribution to the paper and provision of data.

Annex: Assessment of consumer-relevance of three example standards

EXAMPLE 1: WASHING MACHINES

Step 1, 2, 4: Listing parameters, selecting (most) relevant parameters, assessment of correspondence.

Parameters	Relevance for energy consumption (E) or performance (P)*		Range; average at consumer# (Sources: preparatory study, EN 60160)	Setting / variation in standard (Source: EN 60456, IEC‹60734)	Assessment of correspondence	Explanation of differences between standard and practice
Situational conditions						
Temperature	Medium	E	>0 °C to 40 °C; average?	23 ± 2 °C	Average corresponds; variation not	Variation in standard is smaller than practice to respect working conditions and air conditioning costs in the lab.
Humidity	Low		0 to ~100 % r.h.; average?	Not specified	No assessment possible	
Inputs						
Voltage	Medium	E, P	207–253 V; 230 V	230 V ± 1 %	Average corresponds; variation not	Rated voltage in Europe
Frequency	Low		49–51 Hz; 50 Hz	50 Hz ± 1 %	Average and variation correspond	Rated frequency in Europe
Harmonic distortion	Low	E	Distorted	Plane sinus	No correspondence	
Water hardness	High	P	0 to > 10 mmol/l; average?	2.5 mmol/l	Average corresponds; variation not	Performance assessment at different water hardness is subject of detergent manufacturer.
Water composition (e.g. metal content)	Medium	P	Potable water	Not specified. Water has to fulfil the water hardness specification. If total water hardness needs to be adjusted, it shall be prepared according to IEC 60734.	No assessment possible	Performance assessment at different water composition is subject of detergent manufacturer.
Water temperature	High	E, P	4 °C to ~ 25 °C; 15 °C	15 ± 2 °C	Average corresponds; variation not	Global average
User behaviour						
Washing programme choice (Depends on type, soiling and load)	High	E, P	Cotton (60 % choice), mixed, synthetic, wool + temperature	Standard allows a wide range of programmes.	Standard corresponds with practice, by offering capture of various programmes.	Regulatory provisions specify the programmes to be tested.

The table continues on the next page.

Parameters	Relevance for energy consumption (E) or performance (P)*		Range; average at consumer# (Sources: preparatory study, EN 60160)	Setting / variation in standard (Source: EN 60456, IEC‹60734)	Assessment of correspondence	Explanation of differences between standard and practice
Type of cloths	High	E,P	Cotton, cotton – synthetic blends (20:80; 35:65; 50:50; etc.), wide range of synthetic fibers (PE, PAS, PP); wool, cellulose, viscose	(Standard-) Cotton; Standard also allows for other fabrics than cotton to be tested	Standard corresponds with practice, by offering capture of various fabrics.	Regulatory provisions specify the fabrics to be tested.
Soiling of cloths – quality – quantity	High	P	Natural soiling from food, body soils, ambient soil. Type of soils: soluble and insoluble soils, particular soil, color soil P&G research report: A typical 3 kg Western European laundry load contains an average of 40 g of soil.	Artificial soiling of: carbon/oil, cacao, sebum, red wine, and blood, with as little variation as possible. One soil strip used per kg of loading capacity. One strip contains about 2.5 g of dried-on soils. Note that standard soil is more challenging to remove than natural soiling.	Correspondence on type of soil, not on quantity	High soil level needed to prove the machine is able to extract soil even at those conditions. Adherent soil needed to allow to detect measureable differences. Artificial soiling in standard for reproducibility and cost reasons.
Load	High	E, P	< 1 kg to maximum of drum capacity (11 kg); average 3 kg	Standard allows testing from 1 kg to 15 kg.	Standard corresponds with practice.	Regulatory provisions specify the loads to be tested: maximum (rated) capacity and its 50 %.
Detergent type and amount	High	P	Powder, liquid, gel, or tablet; heavy duty / light duty; various compositions depending on brand / time. Amount according to detergent manufacturer or fixed amount or relative to load / soiling. Consumer research in Germany shows average amount of detergent dose of about 70 g (Kruschwitz 2014) for an average load of 3.3 kg.	Heavy duty powder detergent of fixed composition and dosed following formula depending on load size. Formula to calculate: 40 g + 12 g/kg load. Fixed amount (40 g) needed for an empty drum. 12 g are added per kg of textile load (and soil strip) to achieve about an equal concentration for all load sizes, as more water is taken by the machine the more load is washed.	Average amount corresponds with practice. Differences in composition not. Differences in type (liquid) not.	Artificial detergent in standard for reproducibility reasons. Market detergents are changing continuously with time.
Product features						
Capacity	High	E, P	3 kg to 11 kg; average 6.5 kg.	Manufacturer must show that the machine allows to clean clothes at highest level of filling which can be assumed to happen (with those clothes used for testing)	Standard corresponds with practice.	Maximum capacity captured by regulatory provisions.

** Categorical assessment: low, medium, high /// # Range: minimum – maximum (without extreme values); Average: EU average (unless mentioned otherwise).*

Step 3: Assessment of performance.

Aspects of performance	Remarks	Assessment in practice	Assessment in standard
Removal of stains	Wide range of stains. Not all stains get always removed	Visual inspection of stains	Measured with reflectometer
Greying	Multi cycle effect	Visual inspection	Not assessed
Incrustation	Depending on washing conditions	Hardening of the textile	Not assessed
Textile strength loss	Multi cycle effect	Damage of textiles	Not assessed
Gentleness of action?	Multi cycle effect	Damage of textiles	Not assessed
Pilling effect	Multi cycle effect	Visual inspection	Not assessed
Color damage	Depending on dye	Visual inspection	Not assessed
Dye transfer	Depending on dye	Visual inspection	Not assessed
Rinsing of soluble parts	Depending on detergent used	feeling	Alkalinity (EN 60456)
Rinsing of insoluble parts		Particles remaining	Not assessed
Rinsing of surface active ingredients		Feeling soapy	LAS rinsing (t.b.d.)
Rinsing Performance – Foam bubbles at end of cycle		Visual inspection	Not assessed
Wool shrinkage		Visual inspection	Measurable acc. to EN 60456
Germ reduction		infection	Not assessed
Spinning efficiency		Tactile inspection	Remaining moisture content (RMC) at max spin speed
Water consumption		Not assessed	measured
Energy consumption		Not assessed	measured
Duration of programme		Experienced	measured
Noise of washing		Experienced	measured
Noise of spinning		Experienced	measured
Annoyance of noise?		Experienced	Not measured

Step 4: Correspondence of assessment of performance.

A number of aspects of performance are not assessed in the standard. For the aspects that are assessed in the standard, this is done through measurement instruments and not by human senses (seeing, feeling, smelling, hearing) as it is in practice.

EXAMPLE 2: HOUSEHOLD REFRIGERATORS

Step 1, 2 and 4: Listing parameters, selecting (most) relevant parameters, assessment of correspondence.

Parameters	**Relevance for energy consumption (E) or performance (P)***		**Range; average at consumer**[#] (Source: VHK (2015))	**Setting/variation in standard** (Source: EN 62552: 2013, impact of IEC62552:2015)	**Assessment of correspondence**	**Explanation of differences between standard and practice**
Situational conditions						
Temperature	High	E, P	>0 °C to 40 °C; 20 °C	16 °C and 32 °C.	Average to be determined; decision yet to be taken by the Commission on which ambient temperature to adopt as that for the EU test.	Via interpolation any value between 16 °C and 32 °C can be assessed. Likely that higher than usually encountered will be used for test to compensate for no door openings, no heat loading (food).
Humidity	Low (if no door openings)	E, P	?	< 75 % r.h.		Humidity is of limited relevance in test if doors closed. But it is of higher significance in real use where doors are opened regularly. Hence, typical EU ambient humidity should be considered.
Air flow	Low (if no door openings)	E	No evidence identified on what is a typical air speed in EU kitchens.	Air flow ≤ 0,25 m/s.		Zero/low speed air is expected in a home most of the time. Also, the condenser is close against a partition and so the air flow is of little direct impact on condenser effectiveness. Air flow would have far more impact if door is opened.
Placing of the appliance during use / test	Medium		Refrigerators often pressed close against wall and between cabinets. Some are 'Built-in' type. No evidence identified on what is the most common arrangement in EU homes.	Placing against partition at rear unless specified (max. 50mm from partition and 300mm from sides, no partition above). Built-in appliances enclosed per manufacturer instructions.	Correspondence is reasonable for rear position, although most fridges in real use are pressed in from side without 300 mm gap to any partition.	Close fitting side panels would impact thermal performance of appliance walls and reduce reproducibility. This could explain 300 mm gap introduced.
Inputs						
Voltage	Low	E	207–253 V	230 V ± 1 %	Average corresponds; variation not	Rated voltage in Europe
Frequency	Low	E	49–51 Hz	50 Hz ± 1 %	Average and variation correspond	Rated frequency in Europe
Harmonic distortion	Low	E	Distorted	Plane sinus	No correspondence	

Parameters	Relevance for energy consumption (E) or performance (P)*		Range; average at consumer# (Source: VHK (2015))	Setting/variation in standard (Source: EN 62552: 2013, impact of IEC62552:2015)	Assessment of correspondence	Explanation of differences between standard and practice
User behaviour						
Load: – Type (heat capacity) – Temperature – Amount	High	E, P	Various liquid and solid foods, input at various temperatures (5 °C to 40 °C)	No inserted heat load for EU regulation tests.	Appliance always has food or other loads in reality, but test for EU regulations is with appliance empty. Correspondence is poor, but compensation made via higher ambient test temperature.	(Warm) load insertion under normal usage for energy label purposes (the energy efficiency test) is emulated by using higher ambient temperature than EU typical).
Door openings	Low	E	20 per day.	Currently not, but possible future simulation option via 'load processing efficiency test': loading with bottles of ambient temperature water (in one opening operation).		Door openings are emulated by higher ambient temperature (around 25 °C) and effect of door openings is small.
Defrost interval as a result of user behavior and ambient conditions.	Medium	E, P	No evidence sources identified so far.		Lack of door openings may not allow for consideration of frost thickness, defrost intervals, and realistic energy consumption of defrost function.	
Thermostat setting	High	E, P	?	Target average air temperature of compartments specified; thermostat settings such that target temperatures achieved.		
Arrangement of drawers/ shelves	Medium	E, P	?	Instructions to maximize volume of colder space.	Average corresponds; variation not	Arrangement in standard to measure at max conditions.
Product features						
Internal volume (Capacity)	High	E, P	Difference between volume as measured by standard and volume experienced as 'available' to user for storing food: presence or not of shelves etc for the measurement is a key element.	'Storage volume' ('usable') currently basis of calculation of equivalent volume used for EU regulation tests. However, IEC 62552: 2015 may no longer include 'storage volume', but 'total internal volume' (closer to 'gross volume').	Usable capacities substantially less than tested. Possible new 'total internal volume' substantially larger than 'storage volume' and over-statement would be even more exacerbated.	New IEC approach of total internal volume aims to simplify and improve repeatability, but in the expense of correspondence.
Climatic class	Medium	E, P	Difference between the average/ typical EU climatic conditions, and the functionality (allowed to be) declared by the supplier for each test.	SN, N, ST, T	Nearly 3/4 of fridges claim tropical performance capability (>38 ºC), temperature rarely existing in EU. Hence there is poor correspondence with EU situation.	Compensation factor for T and ST class in regulation makes attractive to claim tropical (and sub-tropical) allowance. Fridges suitable for tropical usage get allowance of 20 % higher equivalent volume in regulation; sub-tropical of 10 %.

The table continues on the next page.

Parameters	Relevance for energy consumption (E) or performance (P)*		Range; average at consumer# (Source: VHK (2015))	Setting/variation in standard (Source: EN 62552: 2013, impact of IEC62552:2015)	Assessment of correspondence	Explanation of differences between standard and practice
Built-in	High	E	Set-up per manufacturer's instructions?	Specification per manufacturer's instructions.	OK	
Frost free (defrost)	High	E	Market data: 40 % has frost free function	Standard allows for measuring energy consumption of defrost.		
Ice-maker	Low (depend on ice production)	E		Measuring energy consumption of ice-maker when 'ready for use', but no ice production.		
Anti-condensation heaters				IEC 2015: If always on in normal use, then on for test; if user-controlled, test at max and min.		
Other features, e.g. touchscreen/ internet			To be determined			

** Categorical assessment: low, medium, high /// # Range: minimum – maximum (without extreme values); Average: EU average (unless mentioned otherwise).*

Step 3: Assessment of performance

Aspects of performance	Remarks	Assessment in practice	Assessment in standard
Cooling performance		Ability to cool food within an hour or two and keep it cool despite door openings.	Cooling capacity test covers this well. Variation in temperature measured
Freezing performance		Ability to freeze several items of food at once and keep all frozen over time.	Freezing capacity test covers this well. Variation in temperature measured
Freshness of food		Visual assessment	None at present.
Size of storage space	Metric for measured storage volume, as available over shelves for foodstuff storage no longer in IEC and draft EN test.	As experienced by the user when filling the space.	Was measured as 'storage volume' but no longer in IEC. The new metric of total internal volume is much larger and less useful to users.
Food storage duration		Sensory assessment	Not assessed
Energy consumption		Not assessed (although indicated by proportion of time for which compressor is heard running)	Measured (with separate for defrost, ice-maker and anti-condensation but these do not appear on Label)
Noise		Experienced	Measured

EXAMPLE 3: VACUUM CLEANERS

Step 1, 2 and 4: Listing parameters, selecting (most) relevant parameters, assessment of correspondence.

Parameters	**Relevance for energy consumption (E) or performance (P)***		**Range; average at consumer#** (Source: AEA (2008))	**Setting / variation in standard** (Source: EN60312)	**Assessment of correspondence**	**Explanation of differences between standard and practice**
Situational conditions						
Temperature	Low	E	>0 °C to 40 °C; 21 °C	23 +/- 2 °C	Average corresponds; variation not	Stricter variation in test due to lab climate conditions.
Humidity	Low	P	?	50 +/- 5 % rH	No assessment possible	
Inputs						
Voltage	Low	E, P	207 – 253 V; 230 V	230 V ± 1 %	Average corresponds; variation not	Rated voltage in Europe
Frequency	Low		49 – 51 Hz; 50 Hz	50 Hz ± 1 %	Average and variation correspond	Rated frequency in Europe
Harmonic distortion	Low	E	Distorted	Plane sinus	No correspondence	
User behaviour						
Choice of nozzle – type – number	Medium High	E, P	Consumers use one multi-purpose nozzle. Not/hardly using special nozzles for special purposes.	Not included, but under development (currently in EU guidance documents)	No assessment possible	
Cleaning head setting	Medium High	E P	?	Not included but under development (currently in EU guidance documents)	No assessment possible	
Motor settings	High	E, P	Full power	Maximum continuous airflow	Standard corresponds to practice	
Surface to be cleaned	High	P	Hard floor, carpet, furniture	Hard floor, carpet. 4 carpets specified, including the Wilton wool carpet.	Variation in carpets in principle captured, but not implemented (single carpet used (Wilton)).	Use of single carpet due to cost and repeatability.
Dust particle size	High	P	?	Between 0,3 µm and 10 µm	No assessment possible	Discussion started to evaluate options with different types of dust like debris.
Product features						
Capacity	Medium	P	?	Not assessed		Capacity

** Categorical assessment: low, medium, high/// # Range: minimum – maximum (without extreme values); Average: EU average (unless mentioned otherwise).*

Step 3: Assessment of performance.

Aspects of performance	Remarks	Assessment in practice	Assessment in standard
Dust pick-up	Depends on receptacle load. Half-loaded receptacle test under preparation.	Visual inspection.	Amount of dust in receptacle when test on carpet. On hard floor, dust amount left on floor is measured. Both after 5 double strokes.
Motion resistance		Experienced drag during operation	Force to move head measured
Filter water loss		Experienced.	Measured
Filtration efficiency			Amount of dust in the intake aerosol channel.
Dust re-emission	A good evaluation of total system given, not only filters used.	If experienced, then on the long run.	Measured
Energy consumption			
Energy consumption		Not assessed	Measured
Operational aspects			
Noise		Experienced	Measured

Step 4: Correspondence of assessment of performance.

The main aspects of performance are assessed in the standard. However, the way in which these aspects are assessed does not include any feedback during the operation. Contrary in practice, a consumer gets visual feedback about dust pick-up, feels the force needed to move the head, and will react on this. The dust re-emission is almost impossible to relate to consumer experience, because the particle sizes are chosen to reflect particles harmful for the health of the consumer.