BS EN 60734:2012

BSI Standards Publication

Household electrical appliances — Performance — Water for testing

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National foreword

This British Standard is the UK implementation of EN 60734:2012. It is identical to IEC 60734:2012. It supersedes BS EN 60734:2003 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee CPL/59, Performance of household electrical appliances, to Subcommittee CPL/59/1, Dishwashers and washing machines.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

The text of document 59D/398/FDIS, future edition 4 of IEC 60734, prepared by SC 59D, Home laundry appliances, of IEC TC 59, Performance of household and similar electrical appliances was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60734:2012.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2013-05-01
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2015-08-01

This document supersedes EN 60734:2003.

EN 60734:2012 includes the following significant technical changes with respect to EN 60734:2003:

a) four types of standard water, from soft to very hard, are defined with specification for hardness**,** **alkalinity** and **conductivity**;

b) preparation method A is no longer maintained; and

c) method C3 is added to prepare water of specified hardness, **conductivity** and **alkalinity** starting with natural water while the natural water based methods C1 and C2 focus on **water hardness** only, without allowing control or setting of **alkalinity** and **conductivity**.

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

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Endorsement notice

The text of the International Standard IEC 60734:2012 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

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

Publication	Year	Title	EN/HD	Year
ISO 6059	-	Water quality - Determination of the sum of calcium and magnesium - EDTA titrimetric method	-	-
ISO 7888	-	Water quality - Determination of electrical conductivity	EN 27888	-
ISO 9963-1	-	Water quality - Determination of alkalinity - Part 1: Determination of total and composite alkalinity	EN ISO 9963-1	-
ISO 10523	-	Water quality - Determination of pH	EN ISO 10523	-

CONTENTS

INTRODUCTION

This publication specifies water qualities with regard to hardness, **alkalinity** and **conductivity** and describes several methods to prepare water to be used for testing household appliances in cases where the water quality is important for the reproducibility of the test results. The described methods allow the preparation of water complying with all three target requirements (hardness, **alkalinity**, **conductivity**), or just hardness – depending on the requirements set out in the referring appliance test method.

Compared to the third edition of IEC 60734 (2001), method A is no longer maintained and another method, method C3, is added.

Method B is used to prepare water of the correct **total hardness**. Preparation starts with demineralised water in which hardening salts are dissolved. It will give water specified temporary as well as **permanent hardness**, whilst complying with the specifications for **alkalinity** and **conductivity**.

Method C1 starts with natural water with higher hardness than required, while method C2 starts with soft natural water, which is hardened. Depending on the composition of the natural water, several other ions might be present. Restrictions regarding the amounts are given for some ions, which may influence the cleaning results when testing washing machines and dishwashers. No specification regarding **temporary** and **permanent hardness** is given.

The development of method C3 appreciates the need for water of specified **conductivity** and **alkalinity** for testing the performance of tumble dryers. While synthetic method B meets this need, the natural water based methods C1 and C2 focus on **water hardness** only without allowing control or setting of **alkalinity** and **conductivity**. The new method C3, which starts with natural water, fills that gap.

HOUSEHOLD ELECTRICAL APPLIANCES – PERFORMANCE – WATER FOR TESTING

1 Scope

This International Standard describes the preparation of four types of water of different hardness, conductivity and alkalinity, intended to be used for testing the performance of household appliances such as washing machines, dishwashers, tumble dryers, steam irons etc.

It defines the characteristics of these waters and establishes various methods to be used for obtaining them. It also includes specifications for required measurements.

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.

ISO 6059, *Water quality – Determination of the sum of calcium and magnesium – EDTA titrimetric method*

ISO 7888, *Water quality – Determination of electrical conductivity*

ISO 9963-1, *Water quality – Determination of alkalinity – Part 1: Determination of total and composite alkalinity*

ISO 10523, *Water quality – Determination of pH*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
water hardness
parameter indicating the quantity of alkaline earth salts (bicarbonates, sulphates, chlorides etc.) present in the water

3.1.2
total hardness
sum of calcium and magnesium ions in the water

3.1.3
temporary hardness
fraction of the **total hardness** equivalent to the bicarbonate content

3.1.4
permanent hardness
difference between the **total hardness** and the **temporary hardness**

3.1.5
alkalinity
ability of a solution to neutralize acids to the equivalence point of carbonate or bicarbonate, i.e. equals the stoichiometric sum of the bases in the solution

3.1.6
conductivity
ability of a solution to conduct an electric current, i.e. measure of the stoichiometric sum of the ions dissolved in the solution

3.2 Symbols

Symbol	Unit	Definition
A_0	mmol/l	initial **alkalinity**
A_{req}	mmol/l	target **alkalinity**
$c_0(Fe)$	mg/l	initial iron content
$c_{max}(Fe)$	mg/l	maximum iron content
$c_0(Cu)$	mg/l	initial copper content
$c_{max}(Cu)$	mg/l	maximum copper content
$c_0(Mn)$	mg/l	initial manganese content
$c_{max}(Mn)$	mg/l	maximum manganese content
$c_0(Cl^-)$	mmol/l	initial chloride content
$c_{max}(Cl^-)$	mmol/l	maximum chloride content
$cond_0$	µS/cm	initial **conductivity**
$cond_{req}$	µS/cm	target **conductivity**
dil	–	dilution factor
dil_{min}	–	lowest possible dilution factor that allows the preparation of water to meet all requirements
$dil_{min(h,A,cond)}$	–	lowest possible dilution factor that allows the preparation of water to meet the **total hardness**, **alkalinity** and **conductivity** requirements
$dil_{min(Fe)}$	–	lowest possible dilution factor that allows the preparation of water to meet the maximum iron content requirement
$dil_{min(Cu)}$	–	lowest possible dilution factor that allows the preparation of water to meet the maximum copper content requirement
$dil_{min(Mn)}$	–	lowest possible dilution factor that allows the preparation of water to meet the maximum manganese content requirement
$dil_{min(Cl-)}$	–	lowest possible dilution factor that allows the preparation of water to meet the maximum chloride content requirement
k_A	–	constants
k_H	–	constants
h_0		initial **total hardness**
h_{req}		target **total hardness**
$addition_A$	ml	quantity of solution to be added to reach required **alkalinity**
$addition_h$	ml	quantity of solution to be added to reach required **total hardness**
$addition_{cond}$	ml	quantity of solution to be added to reach required **conductivity**

4 Measurements and accuracy

Measurements according to this International Standard shall comply with the following specifications in Table 1:

Table 1 – Measurement specifications

Parameter	Unit	Minimum accuracy	Additional requirements and remarks
Total hardness	mmol/l	± 2 %	See ISO 6059 for specifications of such determination.
Alkalinity	mmol/l	± 5 %	The **alkalinity** is measured as the concentration of (HCO^{3-}). If determined by titration with hydrochloric acid the endpoint shall be pH 4,5 – the stoichiometric factor then is 1. See ISO 9963-1 for specifications of such determination.
Conductivity	µS/cm	± 5 % at 20 °C	See ISO 7888 for specifications of such determination.
pH	-	± 0,05	The accuracy requirement shall be met over a temperature range of 15 °C to 25 °C. See ISO 10523 for specifications of such determination.
Content of iron, copper, manganese or chloride	-	-	The requirements for these parameters are maximum content requirements. The accuracy of the measurement shall be sufficient to prove compliance with these requirements.

5 Standard water

5.1 Water types

In Table 2, different water types are defined, which are all referred to by their level of **total hardness** and specified with specific levels of **total hardness**, **alkalinity, conductivity** and pH.

Table 2 – Composition of soft, medium hard, hard and very hard water

Property	Unit	Water type			
		Standard soft water	Standard medium hard water	Standard hard water	Standard very hard water
Total hardness	mmol/l (Ca^{2+}/Mg^{2+})	0,50 ± 0,20	1,50 ± 0,20	2,50 ± 0,20	3,50 ± 0,20
Alkalinity	mmol/l (HCO_3^-)	0,67 ± 0,20	2,00 ± 0,20	3,35 ± 0,20	4,70 ± 0,20
Conductivity (at 20 °C)	µS/cm	150 ± 50	450 ± 100	750 ± 150	1050 ± 250
pH (at 20 °C)	-	8,0 to 8,5	7,5 to 7,9	7,3 to 7,7	-

Other test methods and standards referring to the water types in this International Standard may require to meet all or only selected properties given in Table 2.

NOTE With the specification of these four standard waters it is possible to select one or more standardised waters, which would approximate the local natural waters available. If any other **water hardness** is needed, it can be prepared in a similar way by interpolation of the given specifications.

5.2 Additional requirements

Other test methods and standards referring to the water types described in this International Standard may also require that any or all of the specifications shown in Table 3 are met.

Table 3 – Maximum content of heavy metal ions and chloride

Property	Unit	Water type			
		Standard soft water	Standard medium hard water	Standard hard water	Standard very hard water
Max. iron content, $c_{max}(Fe)$	mg/l	0,1			
Max. copper content, $c_{max}(Cu)$	mg/l	0,05			
Max. manganese content, $c_{max}(Mn)$	mg/l	0,05			
Max. chloride content, $c_{max}(Cl^-)$	mmol/l	4,5			Not applicable
NOTE Iron, copper and manganese can influence bleach performance if the water is used for cleaning purposes. The chloride content may be of relevance for testing dishwashers. Standard very hard water does not meet the chloride content requirement.					

6 Preparation of standard water

6.1 Demineralisation of natural water

Natural water is demineralised so that its specific resistance is 100 000 Ω/cm or more (i.e. its **conductivity** is 10 µS/cm at maximum). Water of this quality can be obtained e.g. using mixed cation and anion exchange resins or by reverse osmosis.

When an ion exchange resin is new, the first one or two preparations should be discarded. This is not necessary after each normal regeneration.

6.2 Preparation of standard water method B

6.2.1 Principle

This preparation method starts with demineralised water to which salts are added to achieve the specified water properties.

6.2.2 Procedure

Prepare the following solutions of salts in demineralised water:

– Solution 1 $NaHCO_3$ 67,2 g/l (800 mmol/l)
– Solution 2 $MgSO_4 \cdot 7H_2O$ 38,0 g/l (154,2 mmol/l)
– Solution 3 $CaCl_2 \cdot 2H_2O$ 65,6 g/l (446,1 mmol/l)

Add specified amounts of the three solutions as given in Table 4 to 0,7 l of demineralised water and add up to 1,0 l for preparation of the desired standard water. If large amounts of water are prepared, the addition may be performed through automatic dosage. Finally, adjust the pH to the range specified in Table 2 with HCl or NaOH before use.

Table 4 – Amounts of salt solutions to be added to 1 l of demineralised water

Solution	Water type			
	Standard soft water	Standard medium hard water	Standard hard water	Standard very hard water
Solution 1 ($NaHCO_3$)	0,83 ml	2,50 ml	4,17 ml	5,84 ml
Solution 2 ($MgSO_4 \cdot 7H_2O$)	0,83 ml	2,50 ml	4,17 ml	5,84 ml
Solution 3 ($CaCl_2 \cdot 2H_2O$)	0,83 ml	2,50 ml	4,17 ml	5,84 ml

6.2.3 Composition of standard water prepared by method B

The **temporary hardness** component of the water consists of calcium and magnesium hydrogen carbonates $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$. The **permanent hardness** component consists of the chlorides and sulphates of calcium and magnesium ($CaCl_2$, $CaSO_4$, $MgCl_2$, $MgSO_4$). Composition of standard water achieved by method B is shown in Table 5.

Table 5 – Expected composition of standard water achieved by method B

Ions	Mol. weight	Water type			
		Standard soft water	Standard medium hard water	Standard hard water	Standard very hard water
		Ion concentrations (mmol/l)			
Ca^{2+}	40,0	0,37	1,11	1,85	2,59
Mg^{2+}	24,3	0,13	0,39	0,65	0,91
HCO_3	61,0	0,67	2,00	3,35	4,68
Cl^-	35,5	0,75	2,23	3,75	5,23
SO_4	96,0	0,13	0,39	0,65	0,91
Na^+	23,0	0,67	2,00	3,35	4,68
Temporary hardness (mmol/l)		0,33	1,00	1,67	2,34

6.3 Preparation of water methods C1 and C2

6.3.1 Principle

Methods C1 and C2 allow to prepare standard water of specified **total hardness** starting with natural water. Methods C1 and C2 do not adjust **alkalinity** or **conductivity**.

6.3.2 Composition of standard water prepared by methods C1 and C2

If the test method or standard referring to the water types in this standard also requires any or all of the specifications of Table 3 to be met (maximum content of heavy metals and chloride), the natural water shall be analyzed regarding the respective (required) properties. If the content of iron, copper, manganese or chloride in the natural water exceeds the limits specified in 5.2, first dilute the natural water with demineralised water.

No differentiation is made between **temporary hardness** and **permanent hardness**. The Ca^{2+}/Mg^{2+} ratio shall be 1,5 to 9.

The hardness of the natural water is analyzed for its calcium and magnesium content. If the calcium/magnesium ratio is outside the limits, adjustments are made by dissolving some of the missing ions in the form of calcium chloride ($CaCl_2 \cdot 2H_2O$) or magnesium sulphate ($MgSO_4 \cdot 7\ H_2O$).

6.3.3 Hardness adjustment method C1

Method C1 is used if the adjusted natural water is harder than the required **total hardness**. Some of the natural water is softened by replacing calcium and magnesium against sodium by means of a cation exchange resin or by use of demineralised water for dilution. If the pH is too low, some CO_2 shall be removed by air bubbling.

6.3.4 Hardness adjustment method C2

Method C2 is used if the natural water is too soft. The soft natural water is mixed with calcium and magnesium salts in such a way that the required hardness is obtained.

6.4 Preparation of water method C3

6.4.1 Principle

Method C3 allows to prepare standard water of specified **total hardness**, **alkalinity** and **conductivity** starting with natural water.

6.4.2 Determination of initial water properties

The natural water shall be analyzed regarding **total hardness** h_0, **alkalinity** A_0 and **conductivity** $cond_0$.

If the test method or standard referring to the water types in this standard also requires any or all of the specifications of Table 3 to be met (maximum content of heavy metals and chloride), the natural water shall additionally be analyzed regarding the respective (required) properties:

$$c_0(Fe),\ c_0(Cu),\ c_0(Mn),\ c_0(Cl^-)$$

6.4.3 Dilution with demineralised water

6.4.3.1 Determination of the dilution factor

With the determined values for initial **total hardness** h_0, **alkalinity** A_0 and **conductivity** $cond_0$ and the target values for these measures, a minimum dilution factor $dil_{\text{min (h,A,cond)}}$ for these parameters can be calculated as:

$$dil_{\text{min (h,A,cond)}} = \frac{cond_0 - k_A A_0 - k_H h_0}{cond_{req} - k_A A_{req} - k_H h_{req}}$$

with k_A and k_H being the following constants:

$$k_A = 100 \frac{\mu S / cm}{mmol/l} \qquad k_H = 224 \frac{\mu S / cm}{mmol/l}$$

Other dilution factors $dil_{\text{min(h,A,cond)}}$ will also allow preparation of water of specified **total hardness**, **alkalinity** and **conductivity** as long as the calculation of salt additions according to 6.4.4 results in quantities equal to or larger than 0 ml.

If the test method or standard referring to the water types in this standard also requires any or all of the specifications of Table 3 to be met (maximum content of heavy metals and chloride), the respective minimum dilution factors are determined as:

$$dil_{\min(\mathrm{Fe})} = \frac{c_0(\mathrm{Fe})}{c_{\max}(\mathrm{Fe})}, \quad dil_{\min(\mathrm{Cu})} = \frac{c_0(\mathrm{Cu})}{c_{\max}(\mathrm{Cu})}, \quad dil_{\min(\mathrm{Mn})} = \frac{c_0(\mathrm{Mn})}{c_{\max}(\mathrm{Mn})}, \quad dil_{\min(\mathrm{Cl}^-)} = \frac{c_0(\mathrm{Cl}^-)}{c_{\max}(\mathrm{Cl}^-)}$$

The overall minimum required dilution factor is the highest of the determined minimum dilution factors:

$$dil_{\min} = \max\{dil_{\min(\mathrm{h,A,cond})};\ dil_{\min(\mathrm{Fe})};\ dil_{\min(\mathrm{Cu})};\ dil_{\min(\mathrm{Mn})};\ dil_{\min(\mathrm{Cl}^-)}\}$$

Depending on the result of the calculation, two cases can be distinguished:

$dil_{\min} > 1$	Dilution with demineralised water is required. The minimum dilution factor in that case is the calculated value $dil_{\min}$.
$dil_{\min} \leq 1$	No dilution is necessary. The minimum dilution factor in that case is $dil_{\min} = 1$.

The established value for the required minimum dilution factor $dil_{\min}$ represents the lowest possible dilution that allows the preparation of water to meet all requirements. For practical reasons, any actual dilution factor greater than $dil_{\min}$ may also be selected, e.g. in order to run the process with a rounded dilution factor. The calculations in the following preparation steps are based on the selected actual dilution factor dil:

$$dil \geq dil_{\min}$$

6.4.3.2 Dilution

The natural water shall be diluted with demineralised water to reach the selected dilution factor dil.

6.4.4 Determination of the required salt additions

6.4.4.1 General

The adjustment of **alkalinity**, **total hardness** and **conductivity** is done with highly concentrated salt solutions in water. The addition of the salt content adjusts the respective parameters. The addition of the water in which the salts are dissolved represents a dilution. However, the resulting dilution factor is very close to 1 (due to the highly concentrated solutions) and is therefore negligible.

6.4.4.2 Adjusting alkalinity

In case **alkalinity** needs to be adjusted, this shall be done with a solution of 800 mmol/l (67,2 g/l) $NaHCO_3$ in demineralised water.

The quantity of that solution in ml to be added to each litre of water is:

$$addition_{\mathrm{alkalinity}} = \frac{A_{\mathrm{req}} - \frac{A_0}{dil}}{0{,}8 \times \mathrm{mmol/ml}}$$

NOTE Depending on the initial and target **alkalinity** and the selected dilution factor, the result of calculating the required quantity of the solution above may also be 0 ml/l.

6.4.4.3 Adjusting total hardness

In case **total hardness** needs to be adjusted, this shall be done with a solution of 446,1 mmol/l (65,6 g/l) $CaCl_2 \cdot 2H_2O$ in demineralised water.

The quantity of that solution in ml to be added to each litre of water is:

$$addition_{\mathrm{h}} = \frac{h_{\mathrm{req}} - \frac{h_0}{dil}}{0{,}4461 \times \mathrm{mmol/ml}}$$

NOTE Depending on the initial and target **total hardness** and the selected dilution factor, the result of calculating the required quantity of the solution above can also be 0 ml/l.

6.4.4.4 Adjusting conductivity

In case **conductivity** needs to be adjusted, this shall be done with a solution of 500 mmol/l (29,22 g/l) NaCl and 500 mmol/l (71,02 g/l) Na_2SO_4 in demineralised water.

The quantity of that solution in ml to be added to each litre of (diluted) water is:

$$addition_{\mathrm{cond}} = \frac{(cond_{\mathrm{req}} - k_{\mathrm{A}} A_{\mathrm{req}} - k_{\mathrm{H}} h_{\mathrm{req}}) - \frac{(cond_0 - k_{\mathrm{A}} A_0 - k_{\mathrm{H}} h_0)}{dil}}{120 \times \mu\mathrm{S/cm}} \times \mathrm{ml/l}$$

NOTE Depending on the initial and target **conductivity** and the selected dilution factor, the result of calculating the required quantity of the solution above can also be 0 ml/l.

6.4.5 Adjusting PH

Adjust the pH to within the ranges given in Table 2 with HCl or NaOH before use.

7 Storage of standard water

7.1 General

Preferably standard water shall be stored in closed tanks to exclude both air and light, to prevent loss of CO_2 and also to prevent contamination and growth of organic matter. If the tank is kept closed, the storage life is about one month but if the tank is left open the storage life is about one day.

7.2 Effects of heat on standard water

When standard hard water is heated from 20 °C to 90 °C, scale forming will start at about 85 °C depending on the rate of heating. If it is heated to a lower temperature and kept heated, scale formation will also occur. Over 60 °C, crystalline aragonite will be formed. Under 40 °C, crystalline calcite will be formed.

NOTE Aragonite is voluminous with a needle structure and can rapidly obstruct small openings. Calcite is less voluminous but has a hard structure.

8 Checking

Check all required water parameters prior to use.

Annex A
(informative)

Water hardness – Conversion table

A.1 Correspondence of water hardness units

1 mmol/l = 2,0 milliequivalents = 2 mval/l
= 100 ppm of $CaCO_3$
= 10 parts per 100 000
= 10 French degrees (°f)
= 7,0 English degrees (°e)
= 5,6 German degrees (°dH)
= 5,8 US grains per gallon (gpg)

A.2 Conversion into different degrees of hardness

Table A.1 gives the values for French degrees, English degrees, German degrees and grains per gallon (US) corresponding to the values of **total hardness** used in this standard.

Table A.1 – Conversion in French, English, German degrees and grains per gallon (US) for the values of specified total hardness

Total hardness mmol/l	**French degree**	**English degree**	**German degree**	**Grains / gallon (US)**
0,50	5	3,5	2,8	2,9
1,50	15	10,5	8,4	8,8
2,50	25	17,5	14,0	14,6
3,50	35	24,5	19,6	20,5

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