BS EN 12451:2012

BSI Standards Publication

# Copper and copper alloys — Seamless, round tubes for heat exchangers

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**National foreword**

This British Standard is the UK implementation of EN 12451:2012. It supersedes BS EN 12451:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee NFE/34/1, Wrought and unwrought copper and copper alloys.

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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**Compliance with a British Standard cannot confer immunity from legal obligations.**

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EUROPEAN STANDARD

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# EN 12451

May 2012

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Supersedes EN 12451:1999

English Version

# Copper and copper alloys - Seamless, round tubes for heat exchangers

Cuivre et alliages de cuivre - Tubes ronds sans soudure pour échangeurs thermiques

Kupfer und Kupferlegierungen - Nahtlose Rundrohre für Wärmeaustauscher

This European Standard was approved by CEN on 20 April 2012.

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**Tables**

# Foreword

This document (EN 12451:2012) has been prepared by Technical Committee CEN/TC 133 “Copper and copper alloys”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2012, and conflicting national standards shall be withdrawn at the latest by November 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12451:1999.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 97/23/EC Pressure Equipment Directive (PED).

For relationship with EU Directive 97/23/EU, see informative Annex ZA, which is an integral part of this document.

In comparison with EN 12451:1999, the following significant technical changes were made:

a) for Cu-DHP (CW024A):

   1) the material condition R220 in Table 2 was added;

   2) elongation values were modified for R250 and R290.

Within its programme of work, Technical Committee CEN/TC 133 requested CEN/TC 133/WG 3 "Copper tubes (installation and industrial)" to revise the following standard:

EN 12451:1999, *Copper and copper alloys — Seamless, round tubes for heat exchangers*

This is one of a series of European Standards for copper and copper alloy tubes. Other products are specified as follows:

EN 1057, *Copper and copper alloys — Seamless, round copper tubes for water and gas in sanitary and heating applications*

EN 12449, *Copper and copper alloys — Seamless, round tubes for general purposes*

EN 12450, *Copper and copper alloys — Seamless, round copper capillary tubes*

EN 12452, *Copper and copper alloys — Rolled, finned, seamless tubes for heat exchangers*

EN 12735-1, *Copper and copper alloys — Seamless, round copper tubes for air conditioning and refrigeration — Part 1: Tubes for piping systems*

EN 12735-2, *Copper and copper alloys — Seamless, round copper tubes for air conditioning and refrigeration — Part 2: Tubes for equipment*

EN 13348, *Copper and copper alloys — Seamless, round copper tubes for medical gases or vacuum*

EN 13349, *Copper and copper alloys — Pre-insulated copper tubes with solid covering*

EN 13600, *Copper and copper alloys — Seamless copper tubes for electrical purposes*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## 1 Scope

This European Standard specifies the composition, property requirements and tolerances on dimensions and form for seamless round drawn copper and copper alloy tubes for heat exchangers, condensers, evaporators and desalination equipment. It is applicable to copper and copper alloy tubes supplied in the size range from 6 mm up to and including 76 mm outside diameter and from 0,5 mm up to and including 3 mm wall thickness.

The sampling procedures and the methods of test for verification of conformity to the requirements of this European Standard are also specified.

## 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.

EN 1655, *Copper and copper alloys — Declarations of conformity*

EN 1971-1, *Copper and copper alloys — Eddy current test for measuring defects on seamless round copper and copper alloy tubes — Part 1: Test with an encircling test coil on the outer surface*

EN 1971-2, *Copper and copper alloys — Eddy current test for measuring defects on seamless round copper and copper alloy tubes — Part 2: Test with an internal probe on the inner surface*

EN 10204:2004, *Metallic products — Types of inspection documents*

EN 16090, *Copper and copper alloys — Estimation of average grain size by ultrasound*

EN ISO 196, *Wrought copper and copper alloys — Detection of residual stress — Mercury (I) nitrate test (ISO 196)*

EN ISO 2624, *Copper and copper alloys — Estimation of average grain size (ISO 2624)*

EN ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method (ISO 6507-1)*

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1)*

EN ISO 8493, *Metallic materials — Tube — Drift-expanding test (ISO 8493)*

ISO 6957, *Copper alloys — Ammonia test for stress corrosion resistance*

## 3 Terms and definitions

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

**3.1**
**seamless round tube**
hollow semi-finished product, circular in cross-section, having a uniform wall thickness, which at all stages of production has a continuous periphery

**3.2**
**mean wall thickness**
arithmetical mean of the maximum and minimum wall thicknesses at the same cross-section of the tube

**3.3**
**deviation from circular form**
difference between the maximum and minimum outside diameters measured at any one cross-section of the tube

[SOURCE: EN 1057:2006+A1:2010, 3.6]

# 4 Designations

## 4.1 Material

### 4.1.1 General

The material is designated either by symbol or by number (see Table 1).

### 4.1.2 Symbol

The material symbol designation is based on the designation system given in ISO 1190-1.

NOTE Although material symbol designations used in this European Standard might be the same as those in other standards using the designation system given in ISO 1190-1, the detailed composition requirements are not necessarily the same.

### 4.1.3 Number

The material number designation is in accordance with the system given in EN 1412.

## 4.2 Material condition

For the purposes of this European Standard, the following designations, which are in accordance with the system given in EN 1173, apply for the material condition:

R... Material condition designated by the minimum value of tensile strength requirement for the product with mandatory tensile property requirements;

H... Material condition designated by the minimum value of hardness requirement for the product with mandatory hardness requirements.

S (suffix) Material condition for a product which is stress relieved.

NOTE 1 Products in the H... condition can be specified to Vickers or Brinell hardness. The condition designation H... is the same for both hardness test methods.

NOTE 2 Products in the R... or H... condition can be specially processed (i.e. mechanically or thermally stress relieved) in order to lower the residual stress level to improve the resistance to stress corrosion (see 6.5.2).

Exact conversion between material conditions designated R... and H... is not possible.

Except when the suffix S is used, the material condition is designated by only one of the above designations.

## 4.3 Product

The product designation provides a standardized pattern of designation from which a rapid and unequivocal description of a product can be conveyed in communication. It provides mutual comprehension at the international level with regard to products which meet the requirements of the relevant European Standard.

The product designation is no substitute for the full content of the standard.

The product designation for products to this European Standard shall consist of:

— denomination (Tube);

— number of this European Standard (EN 12451);

— material designation, either symbol or number (see Table 1);

— material condition designation (see Table 2);

— nominal cross-sectional dimensions (outside diameter × wall thickness).

The derivation of a product designation is shown in the following example.

EXAMPLE Tube conforming to this European Standard, in material designated either CuNi10Fe1Mn or CW352H, in material condition H075, with nominal outside diameter 22 mm and nominal wall thickness 2,0 mm, shall be designated as follows:

**Tube EN 12451 – CuNi10Fe1Mn – H075 – 22 × 2,0**

or

**Tube EN 12451 – CW352H – H075 – 22 × 2,0**

Denomination

Number of this European Standard

Material designation

Material condition designation

Nominal dimensions in millimetres

## 5 Ordering information

In order to facilitate the enquiry, order and confirmation of order procedures between the purchaser and the supplier, the purchaser shall state on his enquiry and order the following information:

NOTE 1 Heat exchanger tube can also be supplied as U-bend tube. For specific product and ordering information, see Annex A.

a) quantity of product required (number of pieces, length or mass);

b) denomination (Tube);

c) number of this European Standard (EN 12451);

d) material designation (see Table 1);

e) material condition designation (see 4.2 and Table 2);

f) nominal cross-sectional dimensions (outside diameter × wall thickness);

g) nominal length (see 6.3.4).

NOTE 2 It is recommended that the product designation, as described in 4.3, is used for items b) to f).

In addition, the purchaser shall also state on the enquiry and order any of the following, if required:

h) whether minimum wall thickness is required (see 6.3.3.2);

i) whether the tubes in alloy CuNi10Fe1Mn (CW352H) are for sea water application (see Table 1), and if so, the composition limits required;

j) whether the tubes are required to pass a stress corrosion resistance test (see 6.5.2);

k) whether the tubes in hard condition are required with annealed ends;

l) whether the tubes are required to pass freedom from defects tests (see 6.5.4), and if so, which test method is to be used (see 8.5) if the choice and/or the acceptance criteria is (are) not to be left to the discretion of the supplier;

m) whether the tubes are for subsequent welding applications (see Table 1);

n) whether special surface quality is required (see 6.4);

o) whether a declaration of conformity is required (see 9.1);

p) whether an inspection document is required, and if so, which type (see 9.2);

q) whether there are any special requirements for marking, packaging or labelling (see Clause 10).

EXAMPLE Ordering details for 1 000 m tube conforming to EN 12451, in material designated either CuNi10Fe1Mn or CW352H, in material condition H075, with nominal outside diameter 22 mm, nominal wall thickness 2,0 mm and nominal length 3 000 mm:

**1 000 m Tube EN 12451 – CuNi10Fe1Mn – H075 – 22 × 2,0**

**– nominal length 3 000 mm**

or

**1 000 m Tube EN 12451 – CW352H – H075 – 22 × 2,0**

**– nominal length 3 000 mm**

# 6 Requirements

## 6.1 Composition

The composition shall conform to the requirements for the appropriate material given in Table 1.

## 6.2 Mechanical properties

The properties shall conform to the appropriate requirements given in Table 2. The tests shall be carried out in accordance with either 8.2 (tensile test) or 8.3 (hardness test).

Products in stress relieved condition shall conform to the same mechanical property requirements as for non-stress relieved material.

## 6.3 Dimensions and tolerances

### 6.3.1 General

The geometrical properties of the tubes are defined by outside diameter, wall thickness and length.

The dimensional tolerances are applied on the outside diameter and wall thickness, if not otherwise agreed between the purchaser and the supplier.

### 6.3.2 Outside diameter

The diameter of the tubes shall conform to the tolerances given in Table 3.

### 6.3.3 Wall thickness

#### 6.3.3.1 General

The wall thickness, measured at any point, shall conform to ± 10 % of the specified nominal wall thickness.

#### 6.3.3.2 Minimum wall thickness

When minimum wall thickness is specified [see Clause 5, list entry h)], the wall thickness measured at any point shall be neither less than the nominal thickness nor more than 15 % greater than the nominal thickness; and the mean wall thickness at any cross-section shall be not more than 10 % greater than the nominal thickness.

### 6.3.4 Length

Tubes ordered as "fixed lengths" shall conform to the tolerances given in Table 4.

### 6.3.5 Tolerances on form

#### 6.3.5.1 Deviation from circular form

For tubes in straight lengths, the deviation from circular form is included in the tolerance on diameter given in Table 3.

#### 6.3.5.2 Straightness

The depth of arc measured in any 1 m portion of length shall be not greater than 3 mm.

#### 6.3.5.3 Squareness of cut

The deviation from squareness of the ends of the tubes shall not exceed the tolerances given in Table 5.

## 6.4 Surface quality

The external and internal surfaces shall be clean and smooth.

The tubes may have a superficial film of drawing lubricant or, if annealed or thermally stress relieved, a superficial, dull, iridescent oxide film, securely adhered to both the internal and external surfaces.

Discontinuous irregularities on the external and internal surfaces of the tubes are permitted if they are within the dimensional tolerances.

Special requirements (e.g. pickling, degreasing, etc.) relating to the surface quality shall be agreed between the purchaser and the supplier [see Clause 5, list entry n)].

The cut ends of the tubes shall be deburred unless otherwise specified.

### 6.5 Technological requirements

#### 6.5.1 Drift expanding

No crack shall be visible to the unaided eye, corrected for normal vision if necessary, when tubes in the annealed or end annealed condition are tested in accordance with 8.4.1.

#### 6.5.2 Residual stress level

No crack shall be visible to the unaided eye, corrected for normal vision if necessary, when tubes in the stress relieved condition and when requested by the purchaser [see Clause 5, list entry j)] is tested in accordance with 8.4.2.

#### 6.5.3 Grain size

The average grain size of tubes in the annealed condition shall be in the range 0,010 mm up to and including 0,050 mm. The test shall be carried out in accordance with 8.4.3.

#### 6.5.4 Freedom from defects

When requested by the purchaser [see Clause 5, list entry l)], tubes shall be tested in accordance with 8.5 and the acceptance criteria, unless otherwise agreed between the purchaser and the supplier, shall be at the discretion of the supplier.

## 7 Sampling

### 7.1 General

For the purpose of demonstrating conformity of this European Standard to the requirements of Clause 6, the sampling rate to be taken at random shall be in accordance with Table 6.

Results may be used from analyses carried out at an earlier stage of manufacturing the product, e.g. at the casting stage, if the material identity is maintained.

NOTE For the purpose of demonstrating maintained material identity it is recommended to certify the quality management system of the manufacturer, e.g. as conforming to EN ISO 9001.

### 7.2 Analysis

The sampling rate shall be in accordance with Table 6. A test sample, depending on the analytical technique to be employed, shall be prepared from each sampling unit and used for the determination of the composition.

NOTE 1 When preparing the test sample, care should be taken to avoid contaminating or overheating the test sample. Carbide tipped tools are recommended; steel tools, if used, should be made of magnetic material to assist in the subsequent removal of extraneous iron. If the test samples are in finely divided form (e.g. drillings, millings), they should be treated carefully with a strong magnet to remove any particles of iron introduced during preparation.

NOTE 2 In cases of dispute concerning the results of analysis, the full procedure given in ISO 1811-2 should be followed.

### 7.3 Mechanical tests and stress corrosion resistance test

The sampling rate shall be in accordance with Table 6. Sampling units shall be selected from the finished products. The test samples shall be cut from the sampling units. Test samples, and test pieces prepared from them, shall not be subjected to any further treatment, other than any machining operations necessary in the preparation of the test pieces.

## 8 Test methods

### 8.1 Analysis

Analysis shall be carried out on the test pieces, or test portions, prepared from the test samples obtained in accordance with 7.2. Except in cases of dispute, the analytical methods used shall be chemical or spectrographic according to EN or ISO standards in force. For expression of results, the rounding rules given in 8.7 shall be used.

NOTE In cases of dispute concerning the results of analysis, the method of analysis to be used should be chemical.

### 8.2 Tensile test

The tensile properties shall be determined in accordance with EN ISO 6892-1 on test pieces obtained in accordance with 7.3.

### 8.3 Hardness test

Hardness shall be determined on the test pieces prepared from the test samples obtained in accordance with 7.3. The test shall be carried out in accordance with EN ISO 6507-1 and the indentation made on the outside surface, unless otherwise agreed.

### 8.4 Technological tests

#### 8.4.1 Drift expanding test

The drift expanding test shall be carried out in accordance with EN ISO 8493. The outside diameter of the tube end shall be expanded by the values for the appropriate material given in Table 2 using a conical mandrel with an angle of 45°.

#### 8.4.2 Stress corrosion resistance test

When required, the test method given in either EN ISO 196 or ISO 6957 shall be used on the test pieces prepared from the test samples obtained in accordance with 7.3. The choice of which of these tests is used shall be at the discretion of the supplier.

#### 8.4.3 Average grain size determination

The estimation of average grain size shall be carried out in accordance with EN ISO 2624 or EN 16090.

### 8.5 Freedom from defects tests

#### 8.5.1 General

Each tube shall be subjected to one of the following tests:

— eddy current test;

— hydrostatic test;

— pneumatic test.

If not otherwise agreed between the purchaser and the supplier, the eddy current test shall be carried out. The method of testing shall be in accordance with 8.5.2.

### 8.5.2 Eddy current test

The eddy current test shall be carried out in accordance with EN 1971-1 or EN 1971-2 and calibration determined by the use of a reference standard tube containing holes in accordance with the requirements given in Table 7.

Eddy current testing systems are generally not able to detect discontinuities adjacent to the ends of the tube. The eddy current test shall be supplemented with a visual examination of the untested length at each end to establish freedom from harmful defects, or the untested length shall be removed.

### 8.5.3 Hydrostatic test

Each tube shall be subjected for at least 5 s to an internal hydrostatic pressure, which shall be calculated from the following equation:

$$P = \frac{2 \times S \times t}{D} \quad (1)$$

where

$P$ is the internal hydrostatic pressure, in megapascals (MPa);

$t$ is the nominal wall thickness of the tube, in millimetres (mm);

$D$ is the nominal outside diameter of the tube, in millimetres (mm);

$S$ is half of the minimum 0,2 % proof strength indicated in Table 2 for the appropriate alloy and material condition, in megapascals (MPa).

The tube need not be tested at hydrostatic pressure of over 6,9 MPa unless otherwise agreed between the purchaser and the supplier.

NOTE Hydrostatic tests are intended to determine the soundness of the tube wall and should not be regarded as an indication of the strength or safe working pressure.

### 8.5.4 Pneumatic test

Each tube shall be subjected for at least 5 s to an internal air pressure of at least 0,4 MPa.

The test method used shall permit detection of any leakage, such as having the tube under water or by using the pressure differential method.

Any tube which shows signs of leakage during the test shall be deemed to have failed the test.

NOTE Pneumatic tests are intended to determine the soundness of the tube wall and should not be regarded as an indication of the strength or safe working pressure.

### 8.6 Retests

#### 8.6.1 Analysis, tensile, hardness, drift expanding and grain size tests

If there is a failure of one, or more than one, of the tests in 8.1, 8.2, 8.3, 8.4.1 or 8.4.3, two test samples from the same inspection lot shall be permitted to be selected for retesting the failed property (properties). One of these test samples shall be taken from the same sampling unit as that from which the original failed test piece was taken, unless that sampling unit is no longer available, or has been withdrawn by the manufacturer.

If the test pieces from both test samples pass the appropriate test(s), then the inspection lot represented shall be deemed to conform to the particular requirement(s) of this European Standard. If a test piece fails a test, the inspection lot represented shall be deemed not to conform to this European Standard.

#### 8.6.2 Stress corrosion resistance test

If a test piece fails the test, the inspection lot represented by the failed test piece shall be permitted to be subjected to a stress relieving treatment. A further test sample shall then be selected in accordance with 7.3.

If a test piece from the further test sample passes the test, the stress relieved material shall be deemed to conform to the requirements of this European Standard for residual stress level; it shall then be subjected to all the other tests called for on the purchase order, except for analysis. If the test piece from the further test sample fails the test, the stress relieved material shall be deemed not to conform to this European Standard.

### 8.7 Rounding of results

For the purpose of determining conformity to the limits specified in this standard, an observed or a calculated value obtained from a test shall be rounded in accordance with the following procedure, which is based upon the guidance given in ISO 80000-1:2009, Annex B. It shall be rounded in one step to the same number of figures used to express the specified limit in this European Standard. Except for tensile strength and 0,2 % proof strength, the rounding interval shall be 10 $N/mm^2$ [1)] and for elongation the value shall be rounded to the nearest 1 %.

The following rules shall be used for rounding:

a) if the figure immediately after the last figure to be retained is less than 5, the last figure to be retained shall be kept unchanged;

b) if the figure immediately after the last figure to be retained is equal to or greater than 5, the last figure to be retained shall be increased by one.

## 9 Declaration of conformity and inspection documentation

### 9.1 Declaration of conformity

When requested by the purchaser [see Clause 5, list entry o)] and agreed with the supplier, the supplier shall issue for the products the appropriate declaration of conformity in accordance with EN 1655.

### 9.2 Inspection documentation

When requested by the purchaser [see Clause 5, list entry p)] and agreed with the supplier, the supplier shall issue for the products the appropriate inspection document in accordance with EN 10204:2004.

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1) 1 $N/mm^2$ is equivalent to 1 MPa.

NOTE When ordering material for pressure equipment applications, the equipment manufacturer has the obligation to request appropriate inspection documentation in accordance with EN 10204:2004, Annex ZA.

## 10 Marking, packaging, labelling

Unless otherwise specified by the purchaser and agreed by the supplier, the marking, packaging and labelling shall be left to the discretion of the supplier [see Clause 5, list entry q)].

**Table 1 — Composition of copper and copper alloys**

| **Material designation** | | **Composition** % (mass fraction) | | | | | | | | | | | | | | | **Density** [a] g/cm$^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Symbol | Number | Element | Cu | Al | As | C | Co | Fe | Mn | Ni | P | Pb | S | Sn | Zn | Others total | approx. |
| **Cu-DHP** | **CW024A** | min. | 99,90 [b] | — | — | — | — | — | — | — | 0,015 | — | — | — | — | — | 8,9 |
| | | max. | — | — | — | — | — | — | — | — | 0,040 | — | — | — | — | — | |
| **CuAl5As** [c] | **CW300G** [c] | min. | Rem. | 4,0 | 0,1 | — | — | — | — | — | — | — | — | — | — | — | 8,2 |
| | | max. | — | 6,5 | 0,4 | — | — | 0,2 | 0,2 | 0,2 | — | 0,02 | — | 0,05 | 0,3 | 0,3 | |
| **CuNi10Fe1Mn** [c] | **CW352H** [c] | min. | Rem. | — | — | — | — | 1,0 [e] | 0,5 | 9,0 | — | — | — | — | — | — | 8,9 |
| | | max. | — | — | — | 0,05 | 0,1 [d] | 2,0 [e] | 1,0 | 11,0 | 0,02 | 0,02 | 0,05 [f] | 0,03 | 0,5 [f] | 0,2 | |
| **CuNi30Fe2Mn2** [c] | **CW353H** [c] | min. | Rem. | — | — | — | — | 1,5 | 1,5 | 29,0 | — | — | — | — | — | — | 8,9 |
| | | max. | — | — | — | 0,05 | 0,1 [d] | 2,5 | 2,5 | 32,0 | 0,02 | 0,02 | 0,05 [f] | 0,05 | 0,5 [f] | 0,2 | |
| **CuNi30Mn1Fe** [c] | **CW354H** [c] | min. | Rem. | — | — | — | — | 0,4 | 0,5 | 30,0 | — | — | — | — | — | — | 8,9 |
| | | max. | — | — | — | 0,05 | 0,1 [d] | 1,0 | 1,5 | 32,0 | 0,02 | 0,02 | 0,05 [f] | 0,05 | 0,5 [f] | 0,2 | |
| **CuZn20Al2As** [c] | **CW702R** [c] | min. | 76,0 | 1,8 | 0,02 | — | — | — | — | — | — | — | — | — | Rem. | — | 8,4 |
| | | max. | 79,0 | 2,3 | 0,06 | — | — | 0,07 | 0,1 | 0,1 | 0,01 | 0,05 | — | — | — | 0,3 | |
| **CuZn28Sn1As** | **CW706R** | min. | 70,0 | — | 0,02 | — | — | — | — | — | — | — | — | 0,9 | Rem. | — | 8,5 |
| | | max. | 72,5 | — | 0,06 | — | — | 0,07 | 0,1 | 0,1 | 0,01 | 0,05 | — | 1,3 | — | 0,3 | |
| **CuZn30As** | **CW707R** | min. | 69,0 | — | 0,02 | — | — | — | — | — | — | — | — | — | Rem. | — | 8,5 |
| | | max. | 71,0 | 0,02 | 0,06 | — | — | 0,05 | 0,1 | — | 0,01 | 0,07 | — | 0,05 | — | 0,3 | |

[a] For information only.
[b] Including Ag, up to a maximum of 0,015 %.
[c] These alloys may be used for sea water application.
[d] Co max. 0,1 % is counted as Ni.
[e] For sea water applications, the composition limits shall be agreed between the purchaser and the supplier [see Clause 5, list entry i)].
[f] When the product is for subsequent welding applications and so specified by the purchaser [see Clause 5, list entry m)], Zn shall be max 0,2 % and S max 0,02 %.

**Table 2 — Mechanical properties of copper and copper alloys**

| Designations | | Material condition | Tensile strength | 0,2% proof strength | Elongation | Drift expansion | Hardness | |
|---|---|---|---|---|---|---|---|---|
| Material | | | | | | | HV | |
| Symbol | Number | | $R_m$ N/mm² min | $R_{p0,2}$ N/mm² min | $A$ % min | % min | min | max |
| **Cu-DHP** | **CW024A** | R220 | 220 | | 40 | | | |
| | | R250 | 250 | 150 | 30 | 20 | — | — |
| | | H075 | — | — | — | 20 | 75 | 100 |
| | | R290 | 290 | 250 | 3 | — | — | — |
| | | H100 | — | — | — | — | 100 | - |
| **CuAl5As** | **CW300G** | R350[a] | 350 | 110 | 50 | 30 | — | — |
| | | H075 [a] | — | — | — | 30 | 75 | 110 |
| **CuNi10Fe1Mn** | **CW352H** | R290 [a] | 290 | 90 | 30 | 30 | — | — |
| | | H075 [a] | — | — | — | 30 | 75 | 105 |
| | | R310 | 310 | 220 | 12 | 20 | — | — |
| | | H105 | — | — | — | 20 | 105 | 150 |
| | | R480 | 480 | 400 | 8 | 8 | — | — |
| | | H150 | — | — | — | 8 | 150 | - |
| **CuNi30Fe2Mn2** | **CW353H** | R420 [a] | 420 | 150 | 30 | 30 | — | — |
| | | H090 [a] | — | — | — | 30 | 90 | 125 |
| **CuNi30Mn1Fe** | **CW354H** | R370 [a] | 370 | 120 | 35 | 30 | — | — |
| | | H090 [a] | — | — | — | 30 | 90 | 120 |
| | | R480 | 480 | 300 | 12 | 20 | — | — |
| | | H120 | — | — | — | 20 | 120 | - |
| **CuZn20Al2As** | **CW702R** | R340 [a] | 340 | 120 | 55 | 30 | — | — |
| | | H070 [a] | — | — | — | 30 | 70 | 100 |
| | | R390 [a] | 390 | 150 | 45 | 30 | — | — |
| | | H085 [a] | — | — | — | 30 | 85 | 110 |
| **CuZn28Sn1As** | **CW706R** | R320 [a] | 320 | 100 | 55 | 30 | — | — |
| | | H060 [a] | — | — | — | 30 | 60 | 90 |
| | | R360 [a] | 360 | 140 | 45 | 30 | — | — |
| | | H080 [a] | — | — | — | 30 | 80 | 110 |
| **CuZn30As** | **CW707R** | R340 [a] | 340 | 130 | 45 | 30 | — | — |
| | | H075 [a] | — | — | — | 30 | 75 | 105 |

NOTE 1 N/mm² is equivalent to 1 MPa.

[a] Annealed condition.

**Table 3 — Tolerances on diameter**

Dimensions in millimetres

| Nominal outside diameter | | Tolerances on diameter including deviation from circular form |
|---|---|---|
| over | up to and including | |
| 6 [a] | 14 | $^{0}_{-0,12}$ |
| 14 | 26 | $^{0}_{-0,20}$ |
| 26 | 76 | $^{0}_{-0,30}$ |

[a] Including 6 mm.

**Table 4 — Tolerances on length**

| Nominal length mm | | Tolerances |
|---|---|---|
| over | up to and including | |
| — | 2 000 | $^{+2}_{0}$ mm |
| 2 000 | 8 000 | $^{+1}_{0}$ ‰ [a] |
| 8 000 | — | $^{+0,7}_{0}$ ‰ |

[a] But not more than 5 mm.

**Table 5 — Tolerances on squareness of cut**

Dimensions in millimetres

| Nominal outside diameter | | Tolerances |
|---|---|---|
| over | up to and including | |
| 6 [a] | 35 | 0,50 |
| 35 | 51 | 0,80 |
| 51 | — | 1,1 |

[a] Including 6.

**Table 6 — Sampling rate**

| Number of tubes in the inspection lot | Number of tubes required for testing |
|---|---|
| up to and including 2 000 | 0,4 %, but at least 2 |
| over 2 000 up to and including 4 000 | 0,25 %, but at least 8 |
| over 4 000 | 0,2 %, but at least 10 |

**Table 7 — Drill sizes for production of reference standard tubes**

Dimensions in millimetres

| Nominal outside diameter | | Diameter of drilled holes | Tolerance on diameter |
|---|---|---|---|
| over | up to and including | | |
| — | 19 | 0,6 | ± 0,05 |
| 19 | 25 | 0,8 | |
| 25 | 32 | 0,9 | |
| 32 | 38 | 1,05 | |
| 38 | 45 | 1,15 | |
| 45 | 50 | 1,3 | |
| 50 | — | by agreement | |

# Annex A
(normative)

# U-bend seamless copper and copper alloy heat exchanger tubes

## A.1 General

U-bend heat exchanger tubes shall be manufactured using straight tubes that conform to this European Standard.

Tubes after U-bending operation shall conform to requirements for residual stress level (see 6.5.2) on the U-bend portion and, if agreed between the purchaser and the supplier, shall be subjected to a hydrostatic test (see 8.5.3) or a pneumatic test (see 8.5.4).

If not otherwise requested by the purchaser, the U-bend tubes shall conform to the dimensional requirements in A.3 to A.6.

## A.2 Ordering information

In addition to the relevant ordering information given in Clause 5, the purchaser shall also state on his enquiry and order the following information:

a) centerline bend radius;

b) length of tube legs.

## A.3 Diameter of tube in the U-bend section

The outside diameter of the tube at any cross-section included within the points of tangency of the bend shall not deviate from the nominal diameter prior to the bending by more than ± 10 %.

## A.4 Wall thickness in U-bend section

The wall thickness of the tube at the apex of the U-bend section shall be not less than the value determined by the following equation:

$$t_f = \frac{t \times 2R}{2R + D} \qquad \text{(A.1)}$$

where

— $t_f$ is the thickness after bending, in millimetres (mm);

— $t$ is the wall thickness obtained from nominal wall thickness in millimetres (mm), minus its tolerance (see 6.3.3.1) or the minimum wall thickness, in millimetres (mm) (see 6.3.3.2);

— $R$ is the centerline bend radius, in millimetres (mm);

— $D$ is the nominal outside diameter of the tube, in millimetres (mm).

The centerline bend radius of tubes in annealed condition shall be not less than two times the tube outside diameter. Otherwise the bend radius shall be agreed between the purchaser and the supplier.

## A.5 Leg spacing of U-bend section

The leg spacing shall not vary from the value $2R - D$ by more than 1,6 mm, where $R$ is the specified centerline bend radius and $D$ is the specified tube outside diameter.

## A.6 Length of U-bend tube legs

The length of the tube legs measured from the point of tangency of the bend to the end of the tube leg shall not vary from the specified length by more than the amount of tolerance given in Table 4.

The difference in length of the tube legs shall be not greater than 3 mm unless otherwise specified.

# Annex ZA
(informative)

## Relationship between this European Standard and the Essential Requirements of EU Pressure Equipment Directive (PED) 97/23/EC

This European Standard has been prepared under a Mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the Clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

For this harmonized supporting standard for materials, presumption of conformity to the Essential Requirements of the Directive is limited to technical data of the material in the standard and does not presume adequacy of the material to specific equipment. Consequently, the technical data stated in the material standard should be assessed against the design requirements of the specific equipment to verify that the Essential Requirements of the Pressure Equipment Directive (PED) are satisfied.

**Table ZA.1 — Correspondence between this European Standard and Directive 97/23/EC**

| Clause(s)/ sub-clause(s) of this EN | Subject | Qualifying remarks/Notes |
|---|---|---|
| 6.2 | Mechanical properties | Annex I 4.1(a) of the Directive |
| 9.2 | Conformity of product and manufacturer's certified documentation | Annex I 4.3 of the Directive |

NOTE Brittle fracture prevention: Copper, having a face-centred cubic crystal structure, does not suffer a transition from ductile to brittle failure like some other materials.

**WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.**

# Bibliography

EN 1057:2006+A1:2010, *Copper and copper alloys — Seamless, round copper tubes for water and gas in sanitary and heating applications*

EN 1173, *Copper and copper alloys — Material condition designation*

EN 1412, *Copper and copper alloys — European numbering system*

EN ISO 9001, *Quality management systems — Requirements (ISO 9001)*

ISO 1190-1, *Copper and copper alloys — Code of designation — Part 1: Designation of materials*

ISO 1811-2, *Copper and copper alloys — Selection and preparation of samples for chemical analysis — Part 2: Sampling of wrought products and castings*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

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