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Cast copper alloys – Composition and mechanical properties

Cupro-alliages moulés – Composition et caractéristiques mécaniques

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1338 was developed by Technical Committee ISO/TC 26, *Copper and copper alloys*, and was circulated to the member bodies in December 1975.

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It has been approved by the member bodies of the following countries :

Australia	Germany	Spain
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The member body of the following country expressed disapproval of the document on technical grounds :

U.S.A.

Cast copper alloys — Composition and mechanical properties

1 SCOPE AND FIELD OF APPLICATION

The International Standard specifies the composition of cast ingots and castings and the minimum mechanical properties of castings of the following copper alloys:

- copper-zinc alloys (brasses),
- copper-aluminium alloys (aluminium bronzes),
- copper-tin alloys (bronzes),

currently available in commercial quantities.

The properties of separately cast test bars used for sand and permanent mould castings are for information only until test bar designs have been standardized.

For continuous and centrifugal castings, the mechanical properties should be fixed by agreement for sections greater than 50 mm.

2 COMPOSITION

The compositions given in tables 1 to 22 show the principal elements. If the purchaser's requirements necessitate different limits for certain elements other than those included in the alloy designation, these should be by agreement.

All elements shall be analysed in ingots. It is the responsibility of the founder to ensure that the appropriate composition limits apply to castings.

3 MECHANICAL PROPERTIES

The following mechanical properties of test bars included in the tables are minimum values:

R_m : the tensile strength, in newtons per square millimetre;

$R_{p0,2}$: 0,2 % proof stress, in newtons per square millimetre;

A : the elongation in per cent, calculated on the basis of an initial gauge length L_0 given by the formula $L_0 = 5,65\sqrt{S_0}$, where S_0 is the initial cross-section of the gauge length of the test piece.

4 TEST BARS

In the case of sand casting and permanent mould casting, the test bars are cast separately. In the case of continuous casting, the test bars are taken from the casting and in the case of centrifugal casting, they may be taken from the casting.

The test bars may be tested either as cast or machined.

Cast test bars shall have diameters between 12 and 25 mm; machined test bars shall have a finished diameter between 10 and 18 mm. In the latter case, a diameter of $14,0 \pm 0,5$ mm is recommended.

In the case of sand castings for alloys with a long freezing range, for example copper-tin alloys (gun metals, phosphorus bronzes) and copper-lead-tin alloys (leaded bronzes), a test bar fed at one or both ends is recommended.

For other alloys, for example short freezing range alloys like copper-aluminium alloys (aluminium bronzes) and copper-zinc alloys (brasses), a test bar fed all along its length is preferred.

NOTE — When special requirements are indicated "by agreement", this means "agreement between the supplier and purchaser".

TABLE 1 – Cu Zn33 Pb2

Composition %				Process of casting	Minimum mechanical properties		
Ingots		Castings			R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %
Cu ¹⁾	63,0 to 66,0	Cu ¹⁾	63,0 to 67,0	Sand	180	70	12
Sn	1,5 max.	Sn	1,5 max.				
Pb	1,0 to 2,8	Pb	1,0 to 3,0				
Zn ²⁾	Remainder	Zn ²⁾	Remainder				
Fe	0,7 max.	Fe	0,8 max.				
Ni	1,0 max.	Ni	1,0 max.				
P	0,02 max.	P	0,05 max.				
Al	0,1 max.	Al	0,1 max.				
Mn	0,2 max.	Mn	0,2 max.				
Si	0,03 max.	Si	0,05 max.				

1) Including Ni.

2) The zinc content is determined by difference.

TABLE 2 – Cu Zn40 Pb

Composition %				Process of casting	Minimum mechanical properties		
Ingots		Castings			R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %
Cu ¹⁾	58,0 to 62,0	Cu ¹⁾	58,0 to 63,0	Sand	220	—	15
Sn	1,0 max.	Sn	1,0 max.				
Pb	0,5 to 2,5	Pb	0,5 to 2,5	Permanent mould or pressure die	280	120	15
Zn ²⁾	Remainder	Zn ²⁾	Remainder				
Fe	0,7 max.	Fe	0,8 max.				
Ni	1,0 max.	Ni	1,0 max.				
Al ³⁾	0,2 to 0,8	Al	0,2 to 0,8				
Mn	0,5 max.	Mn	0,5 max.				
Si	0,05 max.	Si	0,05 max.				

1) Including Ni.

2) The zinc content is determined by difference.

3) For the ingots to be used for the manufacture of sand castings, the aluminium content shall be 0,05 % maximum by agreement.

TABLE 3 – Cu Zn35 Al Fe Mn

Composition %		Process of casting	Minimum mechanical properties				
Ingots	Castings ¹⁾		R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %		
Cu	57,0 to 65,0	Cu	57,0 to 65,0	Sand	450	170	20
Sn	1,0 max.	Sn	1,0 max.				
Pb	0,5 max.	Pb	0,5 max.				
Zn ²⁾	Remainder	Zn ²⁾	Remainder	Permanent mould or pressure die	475	200	18
Fe	0,5 to 2,0	Fe	0,5 to 2,0				
Ni	3,0 max.	Ni	3,0 max.	Continuous or centrifugal	475	200	18
Al	0,5 to 2,5	Al	0,5 to 2,5				
Mn	0,1 to 3,0	Mn	0,1 to 3,0				
Si	0,10 max.	Si	0,10 max.				
Sb+P+As	0,40 max.	Sb+P+As	0,40 max.				

1) The minimum percentage of α phase may be fixed by agreement.

2) The zinc content is determined by difference.

TABLE 4 – Cu Zn26 Al4 Fe3 Mn3

Composition %		Process of casting	Minimum mechanical properties				
Ingots	Castings		R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %		
Cu	60,0 to 66,0	Cu	60,0 to 66,0	Sand	600	300	18
Sn	0,20 max.	Sn	0,20 max.				
Pb	0,20 max.	Pb	0,20 max.	Continuous or centrifugal	600	300	18
Zn ¹⁾	Remainder	Zn ¹⁾	Remainder				
Fe	1,5 to 4,0	Fe	1,5 to 4,0				
Ni	3,0 max.	Ni	3,0 max.				
Al	2,5 to 5,0	Al	2,5 to 5,0				
Mn	1,5 to 4,0	Mn	1,5 to 4,0				
Si	0,10 max.	Si	0,10 max.				

1) The zinc content is determined by difference.

TABLE 5 – Cu Zn25 Al6 Fe3 Mn3

Composition %		Process of casting	Minimum mechanical properties				
Ingots	Castings		R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %		
Cu	60,0 to 66,0	Cu	60,0 to 66,0	Sand	725	400	10
Sn	0,20 max.	Sn	0,20 max.				
Pb	0,20 max.	Pb	0,20 max.	Continuous or centrifugal	740	400	10
Zn ¹⁾	Remainder	Zn ¹⁾	Remainder				
Fe	2,0 to 4,0	Fe	2,0 to 4,0				
Ni	3,0 max.	Ni	3,0 max.				
Al	4,5 to 7,0	Al	4,5 to 7,0				
Mn	1,5 to 4,0	Mn	1,5 to 4,0				
Si	0,10 max.	Si	0,10 max.				

1) The zinc content is determined by difference.

TABLE 6 – Cu Al9

Composition %		Process of casting	Minimum mechanical properties				
Ingots	Castings		R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %		
Cu ¹⁾	88,0 to 91,5	Cu ¹⁾	88,0 to 92,0	Permanent mould	450	—	15
Sn	0,20 max.	Sn	0,30 max.				
Pb	0,20 max.	Pb	0,30 max.				
Zn	0,40 max.	Zn	0,50 max.				
Fe	1,0 max.	Fe	1,2 max.				
Ni	1,0 max.	Ni	1,0 max.				
Al	8,2 to 10,2	Al	8,0 to 10,5				
Mn	0,50 max.	Mn	0,50 max.				
Si	0,10 max.	Si	0,20 max.				
Cu+Al	> 98						

1) Including Ni.

TABLE 7 – Cu Al10 Fe3

Composition %		Process of casting	Minimum mechanical properties				
Ingots	Castings		R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %		
Cu	83,0 to 89,3	Cu	83,0 to 89,5	Sand	500	180	13
Sn	0,20 max.	Sn	0,30 max.				
Pb ¹⁾	0,10 max.	Pb ¹⁾	0,20 max.	Permanent mould	550	200	15
Zn	0,40 max.	Zn	0,40 max.				
Fe ²⁾	2,0 to 4,5	Fe ²⁾	2,0 to 5,0	Continuous or centrifugal	550	200	15
Ni	3,0 max.	Ni	3,0 max.				
Al	8,7 to 10,7	Al	8,5 to 11,0				
Mn	1,0 max.	Mn	1,0 max.				
Si	0,10 max.	Si	0,20 max.				

1) For welded assemblies, lead shall not exceed 0,02 %.

2) For permanent mould castings, the minimum iron content may be reduced to 1,0 % by agreement.

TABLE 8 – Cu Al10 Fe5 Ni5

Composition %		Process of casting	Minimum mechanical properties				
Ingots	Castings		R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %		
Cu	> 76,0	Cu	> 76,0	Sand	600	250	10
Sn	0,10 max.	Sn	0,20 max.				
Pb ¹⁾	0,10 max.	Pb ¹⁾	0,10 max.	Centrifugal or continuous	680	280	12
Zn	0,50 max.	Zn	0,50 max.				
Fe	3,5 to 5,2	Fe	3,5 to 5,5				
Ni	3,5 to 6,3	Ni	3,5 to 6,5				
Al	8,2 to 10,7	Al	8,0 to 11,0				
Mn	3,0 max.	Mn	3,0 max.				
Si	0,08 max.	Si	0,10 max.				
Cu+Fe+Ni+Al+Mn	> 99,2	Cu+Fe+Ni+Al+Mn	> 99,2				

1) For welded assemblies, lead shall not exceed 0,02 %.

TABLE 9 – Cu Sn12

Composition %				Process of casting	Minimum mechanical properties		
Ingots		Castings			R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %
Cu ¹⁾	85,5 to 88,3	Cu ¹⁾	85,0 to 88,5	Sand	240	130	7 5 ⁶⁾
Sn	10,7 to 13,0	Sn	10,5 to 13,0				
Pb	0,8 max.	Pb	1,0 max.	Permanent mould	270	150	5 3 ⁶⁾
Zn	2,0 max.	Zn	2,0 max.				
Fe ²⁾	0,15 max.	Fe ²⁾	0,25 max.	Centrifugal or continuous	270	150 ⁷⁾	5 3 ⁶⁾
Ni	1,8 max.	Ni	2,0 max.				
Sb	0,2 max.	Sb	0,2 max.				
P ³⁾	0,05 max.	P ^{4) 5)}	0,05 to 0,40				
Al	0,01 max.	Al	0,01 max.				
Mn	0,2 max.	Mn	0,2 max.				
Si	0,01 max.	Si	0,01 max.				
S	0,05 max.	S	0,05 max.				

- 1) Including Ni.
- 2) Fe : 0,05 % max. in special cases (susceptibility to magnetism).
- 3) This content may be increased to 0,40 % by agreement with the founder.
- 4) The phosphorus content shall be fixed by agreement.
- 5) For centrifugal and continuous castings, the phosphorus content may be increased to a maximum of 1,5 % by agreement.
- 6) The lower values for elongation apply to P > 0,10 %.
- 7) The value given is for information only, unless specified by the purchaser.

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TABLE 10 – Cu Sn12 Ni2

Composition %				Process of casting	Minimum mechanical properties		
Ingots		Castings			R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %
Cu	84,5 to 87,3	Cu	84,5 to 87,5	Sand	280	160	12
Sn ⁵⁾	11,2 to 13,0	Sn ⁵⁾	11,0 to 13,0				
Pb	0,2 max.	Pb	0,3 max.	Centrifugal	300	180 ⁶⁾	8
Zn	0,4 max.	Zn	0,4 max.				
Fe ¹⁾	0,15 max.	Fe ¹⁾	0,20 max.	Continuous	300	180 ⁶⁾	10
Ni	1,5 to 2,0	Ni	1,5 to 2,5				
Sb	0,1 max.	Sb	0,1 max.				
P ²⁾	0,05 max.	P ³⁾⁴⁾	0,05 to 0,40				
Al	0,01 max.	Al	0,01 max.				
Mn	0,2 max.	Mn	0,2 max.				
Si	0,01 max.	Si	0,01 max.				
S	0,05 max.	S	0,05 max.				

- 1) Fe : 0,05 % max. in special cases (susceptibility to magnetism).
- 2) This content may be increased to 0,40 % by agreement with the founder.
- 3) The phosphorus content shall be fixed by agreement.
- 4) For centrifugal and continuous castings, the phosphorus content may be increased to a maximum of 1,5 % by agreement.
- 5) For thin-walled continuous castings, the tin content may be reduced to 10,5 % by agreement.
- 6) The values given are for information only, unless specified by the purchaser.

TABLE 11 – Cu Sn12 Pb2

Composition %		Process of casting	Minimum mechanical properties		
Ingots	Castings		R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %
Cu ¹⁾ 84,0 to 87,3	Cu ¹⁾ 84,0 to 87,5	Sand	240	130	7 5 ⁶⁾
Sn ⁷⁾ 11,2 to 13,0	Sn ⁷⁾ 11,0 to 13,0				
Pb 1,0 to 2,0	Pb 1,0 to 2,5	Centrifugal	280	150 ⁸⁾	5
Zn 2,0 max.	Zn 2,0 max.	Continuous	280	150 ⁸⁾	7
Fe ²⁾ 0,15 max.	Fe ²⁾ 0,20 max.				
Ni 2,0 max.	Ni 2,0 max.				
Sb 0,2 max.	Sb 0,2 max.				
p ³⁾ 0,05 max.	p ⁴⁾ 5) 0,05 to 0,40				
Al 0,01 max.	Al 0,01 max.				
Mn 0,2 max.	Mn 0,2 max.				
Si 0,01 max.	Si 0,01 max.				
S 0,05 max.	S 0,05 max.				

- 1) Including Ni.
- 2) Fe : 0,05 % max. in special cases (susceptibility to magnetism).
- 3) This content may be increased to 0,40 % by agreement with the founder.
- 4) The phosphorus content shall be fixed by agreement.
- 5) For centrifugal and continuous castings, the phosphorus content may be increased to a maximum of 1,5 % by agreement.
- 6) The lower value for elongation applies to P > 0,10 %.
- 7) For thin-walled continuous castings, the tin content may be reduced to 10,5 % by agreement.
- 8) The values given are for information only, unless specified by the purchaser.

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TABLE 12 – Cu Sn10

Composition %		Process of casting	Minimum mechanical properties		
Ingots	Castings		R_m N/mm ²	$R_{p0,2}$ N/mm ²	A %
Cu ¹⁾ 88,0 to 90,8	Cu ¹⁾ 88,0 to 91,0	Sand	240	130	12 7 ⁵⁾
Sn 9,2 to 11,0	Sn 9,0 to 11,0				
Pb 1,0 max.	Pb 1,0 max.				
Zn 0,5 max.	Zn 0,5 max.				
Fe ²⁾ 0,15 max.	Fe ²⁾ 0,20 max.				
Ni 2,0 max.	Ni 2,0 max.				
Sb 0,2 max.	Sb 0,2 max.				
p ³⁾ 0,05 max.	p ⁴⁾ 0,20 max.				
Al 0,01 max.	Al 0,01 max.				
Mn 0,2 max.	Mn 0,2 max.				
Si 0,01 max.	Si 0,01 max.				
S 0,05 max.	S 0,05 max.				

- 1) Including Ni.
- 2) Fe : 0,05 max. in special cases (susceptibility to magnetism).
- 3) This content may be increased to 0,40 % by agreement with the founder.
- 4) The phosphorus content shall be fixed by agreement.
- 5) The lower value for elongation applies to P > 0,10 %.

TABLE 13 – Cu Sn10 P

Composition %			Process of casting	Minimum mechanical properties		
Ingots	Castings	R_m N/mm ²		$R_{p0,2}$ N/mm ²	A %	
Cu	87,0 to 89,3	Cu 87 to 89,5	Sand	220	130	3
Sn	10,2 to 11,5	Sn 10,0 to 11,5				
Pb	0,25 max.	Pb 0,25 max.	Permanent mould	310	170	2
Zn	0,05 max.	Zn 0,05 max.				
Fe	0,10 max.	Fe 0,10 max.	Continuous	360	170 ¹⁾	6
Ni	0,10 max.	Ni 0,10 max.				
P	0,60 to 1,0	P 0,50 to 1,0	Centrifugal	330	170 ¹⁾	4
Al	0,01 max.	Al 0,01 max.				
Si	0,02 max.	Si 0,02 max.				
Sb	0,05 max.	Sb 0,05 max.				
Mn	0,05 max.	Mn 0,05 max.				
S	0,05 max.	S 0,05 max.				

1) The values given are for information only, unless specified by the purchaser.

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TABLE 14 – Cu Sn11 P

Composition %			Process of casting	Minimum mechanical properties		
Ingots	Castings	R_m N/mm ²		$R_{p0,2}$ N/mm ²	A %	
Cu ¹⁾	86,0 to 89,5	Cu ¹⁾ 86,0 to 89,5	Sand	220	–	3
Sn	10,2 to 12,0	Sn 10,0 to 12,0				
Pb	0,5 max.	Pb 0,5 max.	Permanent mould	270	–	2
Zn	0,5 max.	Zn 0,5 max.				
Fe ²⁾	0,10 max.	Fe ²⁾ 0,10 max.	Continuous	320	–	6
Ni	0,2 max.	Ni 0,2 max.				
P	0,25 to 1,5	P ³⁾ 0,15 to 1,5	Centrifugal	300	–	4
Al	0,01 max.	Al 0,01 max.				
Si	0,02 max.	Si 0,02 max.				

1) Including Ni.

2) Fe : 0,05 % max. in special cases (susceptibility to magnetism).

3) The phosphorus content shall be fixed by agreement.