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AMENDMENT 1
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Magnesium and magnesium alloys — Magnesium alloy ingots and castings

AMENDMENT 1: Additional alloys

Magnésium et alliages de magnésium — Lingots et pièces moulées en alliage de magnésium

AMENDEMENT 1: Alliages supplémentaires

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Foreword

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Amendment 1 to ISO 16220:2005 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 5, *Magnesium and alloys of cast or wrought magnesium*.

Introduction

The purpose of ISO 16220:2005/Amd.1:2007 is to include two new commercial alloys based on the combination of rare earth metals, gadolinium and zirconium as alloying elements.

Magnesium and magnesium alloys — Magnesium alloy ingots and castings

AMENDMENT 1: Additional alloys

Page 5, Table 1 — Chemical composition of magnesium alloy ingots

Replace the existing Table 1 with the following new Table 1, where two new grades are added: ISO-MgAl4RE4 and ISO-MgRE3Gd1Zr.

NOTE 1 The new grades ISO-MgAl4RE4 and ISO-MgRE3Gd1Zr are not included in EN 1753.

Page 6, Table 2 — Chemical composition of magnesium alloy castings

Replace the existing Table 2 with the following new Table 2, where two new grades are added: ISO-MgAl4RE4 and ISO-MgRE3Gd1Zr.

NOTE 2 The new grades ISO-MgAl4RE4 and ISO-MgRE3Gd1Zr are not included in EN 1753.

Page 7, Table 3 — Mechanical properties of sand-cast magnesium alloys

Replace the existing Table 3 with the following new Table 3, where the new grade ISO-MgRE3Gd1Zr is added at the bottom of the table.

NOTE 3 The new grade ISO-MgRE3Gd1Zr is not included in EN 1753.

Page 7, Table 4 — Mechanical properties of permanent-mould cast magnesium alloys

Replace the existing Table 4 with the following new Table 4, where the new grade ISO-MgRE3Gd1Zr is added at the bottom of the table.

NOTE 4 The new grade ISO-MgRE3Gd1Zr is not included in EN 1753.

Page 8, Table 5 — Mechanical properties of pressure die cast magnesium alloys

Replace the existing Table 5 with the following new Table 5, where the new grade ISO-MgAl4RE4 is added.

NOTE 5 The new grade ISO-MgAl4RE4 is not included in EN 1753.

Table 1 — Chemical composition of magnesium alloy ingots

Alloy group	Material designation: In accordance with ISO 2092:1981 [a]	Material designation: In accordance with EN 1753	Min. or max.	Composition % by mass: Mg	Al	Zn	Mn [b]	RE [c]	Zr	Ag	Y	Gd	Li	Si	Fe	Cu	Ni	Others each	RE/Al ratio
MgAlZn	ISO-MgAl9Zn1 (A)	ISO-MB21120	min. max.	Rem.	8,5 9,5	0,45 0,9	0,17 0,40	- -	- -	- -	- -	- -	- -	- 0,08	- 0,004	- 0,025	- 0,001	- 0,01	- -
	ISO-MgAl9Zn1 (B)	ISO-MB21121	min. max.	Rem.	8,0 10,0	0,3 1,0	0,1 0,50	- -	- -	- -	- -	- -	- -	- 0,3	- 0,03	- 0,20	- 0,01	- 0,05	- -
MgAlMn	ISO-MgAl2Mn	ISO-MB21210	min. max.	Rem.	1,7 2,5	- 0,20	0,35 0,60	- -	- -	- -	- -	- -	- -	- 0,05	- 0,004	- 0,008	- 0,001	- 0,01	- -
	ISO-MgAl5Mn	ISO-MB21220	min. max.	Rem.	4,5 5,3	- 0,30	0,28 0,50	- -	- -	- -	- -	- -	- -	- 0,08	- 0,004	- 0,008	- 0,001	- 0,01	- -
	ISO-MgAl6Mn	ISO-MB21230	min. max.	Rem.	5,6 6,4	- 0,30	0,26 0,50	- -	- -	- -	- -	- -	- -	- 0,08	- 0,004	- 0,008	- 0,001	- 0,01	- -
MgAlSi	ISO-MgAl2Si	ISO-MB21310	min. max.	Rem.	1,9 2,5	- 0,20	0,2 0,6	- -	- -	- -	- -	- -	- -	0,7 1,2	- 0,004	- 0,008	- 0,001	- 0,01	- -
	ISO-MgAl4Si	ISO-MB21320	min. max.	Rem.	3,7 4,8	- 0,20	0,2 0,6	- -	- -	- -	- -	- -	- -	0,7 1,2	- 0,004	- 0,008	- 0,001	- 0,01	- -
MgAlRE [d]	ISO-MgAl4RE4	ISO-MB21410	min. max.	Rem.	3,6 4,4	- 0,20	0,15 0,50	3,6 4,6	- -	- -	- -	- -	- -	- 0,08	- 0,004	- 0,008	- 0,001	- 0,01	0,9 -
MgZnCu	ISO-MgZn6Cu3Mn	ISO-MB32110	min. max.	Rem.	- 0,2	5,5 6,5	0,25 0,75	- -	- -	- -	- -	- -	- -	- 0,20	- 0,05	2,4 3,0	- 0,01	- 0,01	- -
MgZnREZr [d]	ISO-MgZn4RE1Zr	ISO-MB35110	min. max.	Rem.	- -	3,5 5,0	- 0,15	1,0 1,75	0,1 1,0	- -	- -	- -	- -	- 0,01	- 0,01	- 0,03	- 0,005	- 0,01	- -
	ISO-MgRE3Zn2Zr	ISO-MB65120	min. max.	Rem.	- -	2,0 3,0	- 0,15	2,4 4,0	0,1 1,0	- -	- -	- -	- -	- 0,01	- 0,01	- 0,03	- 0,005	- 0,01	- -
MgREAgZr [e]	ISO-MgAg2RE2Zr	ISO-MB65210	min. max.	Rem.	- -	- 0,2	- 0,15	2,0 3,0	0,1 1,0	2,0 3,0	- -	- -	- -	- 0,01	- 0,01	- 0,03	- 0,005	- 0,01	- -
	ISO-MgRE2Ag1Zr	ISO-MB65220	min. max.	Rem.	- -	- 0,2	- 0,15	1,5 3,0	0,1 1,0	1,3 1,7	- -	- -	- -	- 0,01	- 0,01	0,05 0,10	- 0,005	- 0,01	- -
MgYREZr [f, g]	ISO-MgY5RE4Zr	ISO-MB95310	min. max.	Rem.	- -	- 0,20	- 0,15	2,0 4,0	0,1 1,0	- -	4,75 5,5	- -	- 0,20	- 0,01	- 0,01	- 0,03	- 0,005	- 0,01	- -
	ISO-MgY4RE3Zr	ISO-MB95320	min. max.	Rem.	- -	- 0,20	- 0,15	2,4 4,4	0,1 1,0	- -	3,7 4,3	- -	- 0,20	- 0,01	- 0,01	- 0,03	- 0,005	- 0,01	- -
MgREGdZr [h]	ISO-MgRE3Gd1Zr	ISO-MB65410	min. max.	Rem	- -	0,20 0,50	- 0,03	2,6 3,1	0,1 1,0	- 0,05	- -	1,0 1,7	- -	- -	- 0,010	- 0,01	- 0,0020	- 0,01	- -

a Withdrawn in 2002.

b For maximum manganese content, see Annex B.

c RE = rare earth metals.

d Cerium-rich.

e Neodymium-rich

f Neodymium- and heavy RE-rich

g Improved corrosion resistance may be obtained by reducing the maximum manganese content to 0,03 %, the maximum iron content to 0,01 %, the maximum copper content to 0,02 % and the maximum zinc + silver content to 0,2 %.

h Neodymium is 2,6 % to 3,1 %; other rare earth metals may also be present to a total maximum of 0,4 %. These RE shall principally be cerium, lanthanum and praseodymium.

Table 2 — Chemical composition of magnesium alloy castings

Alloy group	Material designation: In accordance with ISO 2092:1981 [a]	Material designation: In accordance with EN 1753	Casting process	Min. or max.	Composition % by mass: Mg	Al	Zn	Mn [b]	RE [c]	Zr	Ag	Y	Gd	Li	Si	Fe	Cu	Ni	Others each	Fe/Mn ratio [d]	RE/Al ratio
MgAlZn	ISO-MgAl9Zn1(A)	ISO-MC21120	D	min.	Rem.	8,3	0,35	0,15	-	-	-	-			-	-	-	-	-	-	-
				max.		9,5	0,9	0,50	-	-	-	-			0,08	0,005	0,025	0,001	0,01	0,032	-
	ISO-MgAl9Zn1(A)	ISO-MC21120	S, K, L	min.	Rem.	8,3	0,40	0,17	-	-	-	-			-	-	-	-	-	-	-
				max.		9,7	1,0	0,35	-	-	-	-			0,20	0,005	0,030	0,001	0,01	0,032	-
	ISO-MgAl9Zn1(B)	ISO-MC21121	D, S, K, L	min.	Rem.	8,0	0,3	0,1	-	-	-	-			-	-	-	-	-	-	-
				max.		10,0	1,0	0,6	-	-	-	-			0,3	0,03	0,20	0,01	0,05	-	-
MgAlMn	ISO-MgAl2Mn	ISO-MC21210	D	min.	Rem.	1,6	-	0,33	-	-	-	-			-	-	-	-	-	-	-
				max.		2,5	0,20	0,70	-	-	-	-			0,08	0,004	0,008	0,001	0,01	0,012	-
	ISO-MgAl5Mn	ISO-MC21220	D	min.	Rem.	4,4	-	0,26	-	-	-	-			-	-	-	-	-	-	-
				max.		5,3	0,30	0,60	-	-	-	-			0,08	0,004	0,008	0,001	0,01	0,015	-
	ISO-MgAl6Mn	ISO-MC21230	D	min.	Rem.	5,5	-	0,24	-	-	-	-			-	-	-	-	-	-	-
				max.		6,4	0,30	0,60	-	-	-	-			0,08	0,005	0,008	0,001	0,01	0,021	-
MgAlSi	ISO-MgAl2Si	ISO-MC21310	D	min.	Rem.	1,8	-	0,18	-	-	-	-			0,7	-	-	-	-	-	-
				max.		2,5	0,20	0,70	-	-	-	-			1,2	0,004	0,008	0,001	0,01	0,022	-
	ISO-MgAl4Si	ISO-MC21320	D	min.	Rem.	3,5	-	0,18	-	-	-	-			0,5	-	-	-	-	-	-
				max.		4,8	0,20	0,70	-	-	-	-			1,2	0,004	0,008	0,001	0,01	0,022	-
MgAlRE [e]	ISO-MgAl4RE4	ISO-MC21410	D	min.	Rem.	3,5	-	0,15	3,5	-	-	-	-	-	-	-	-	-	-	-	0,8
				max.		4,5	0,20	0,50	4,5	-	-	-	-	-	0,08	0,005	0,008	0,001	0,01	-	-
MgZnCu	ISO-MgZn6Cu3Mn	ISO-MC32110	S, K, L	min.	Rem.	-	5,5	0,25	-	-	-	-			-	-	2,4	-	-	-	-
				max.		0,2	6,5	0,75	-	-	-	-			0,20	0,05	3,0	0,01	0,01	-	-
MgZnREZr [e]	ISO-MgZn4RE1Zr	ISO-MC35110	S, K, L	min.	Rem.	-	3,5	-	0,75	0,4	-	-			-	-	-	-	-	-	-
				max.		-	5,0	0,15	1,75	1,0	-	-			0,01	0,01	0,03	0,005	0,01	-	-
	ISO-MgRE3Zn2Zr	ISO-MC65120	S, K, L	min.	Rem.	-	2	-	2,5	0,4	-	-			-	-	-	-	-	-	-
				max.		-	3	0,15	4,0	1,0	-	-			0,01	0,01	0,03	0,005	0,01	-	-
MgREAgZr [f]	ISO-MgAg2RE2Zr	ISO-MC65210	S, K, L	min.	Rem.	-	-	-	2	0,4	2,0	-			-	-	-	-	-	-	-
				max.		-	0,2	0,15	3	1,0	3,0	-			0,01	0,01	0,03	0,005	0,01	-	-
	ISO-MgRE2Ag1Zr	ISO-MC65220	S, K, L	min.	Rem.	-	-	-	1,5	0,4	1,3	-			-	-	0,05	-	-	-	-
				max.		-	0,2	0,15	3,0	1,0	1,7	-			0,01	0,01	0,10	0,005	0,01	-	-
MgYREZr [g, h]	ISO-MgY5RE4Zr	ISO-MC95310	S, K, L	min.	Rem.	-	-	-	2,0	0,4	-	4,75		-	-	-	-	-	-	-	-
				max.		-	0,2	0,15	4,0	1,0	-	5,5		0,2	0,01	0,01	0,03	0,005	0,01	-	-
	ISO-MgY4RE3Zr	ISO-MC95320	S, K, L	min.	Rem.	-	-	-	2,4	0,4	-	3,7		-	-	-	-	-	-	-	-
				max.		-	0,2	0,15	4,4	1,0	-	4,3		0,2	0,01	0,01	0,03	0,005	0,01	-	-
MgREGdZr [i]	ISO-MgRE3Gd1Zr	ISO-MB65410	S, K, L	min.	Rem.	-	0,20	-	2,6	0,4	-	-	1,0	-	-	-	-	-	-	-	-
				max.		-	0,50	0,03	3,1	1,0	0,05	-	1,7	-	-	0,010	0,01	0,0020	0,01	-	-

[a] Withdrawn in 2002.

[b] For maximum manganese content, see Annex B.

[c] RE = rare earth metals.

[d] If the minimum Mn limit is not met.

[e] Cerium-rich.

[f] Neodymium-rich.

[g] Neodymium- and heavy RE-rich.

[h] Improved corrosion resistance may be obtained by reducing the maximum manganese content to 0,03 %, the maximum iron content to 0,01 %, the maximum copper content to 0,02 % and the maximum zinc + silver content to 0,2 %.

[i] Neodymium is 2,6 % to 3,1 %; other rare earth metals may also be present to a total maximum of 0,4 %. These RE shall principally be cerium, lanthanum and praseodymium.

Table 3 — Mechanical properties of sand-cast magnesium alloys

Alloy group	Material designation		Temper designation	Tensile strength R_m N/mm² min.	0,2% proof stress $R_{p0,2}$ N/mm² min.	Elongation ΔL % min.	Brinell hardness HBW [a]
	In accordance with ISO 2092:1981 [b]	In accordance with EN 1753					
MgAlZn	ISO-MgAl9Zn1(A)	ISO-MC21120	F	160	90	2	50 to 65
			T4	240	110	6	55 to 70
			T6	240	150	2	60 to 90
MgZnCu	ISO-MgZn6Cu3Mn	ISO-MC32110	T6	195	125	2	55 to 65
MgZnREZr	ISO-MgZn4RE1Zr	ISO-MC35110	T5	200	135	2,5	55 to 70
	ISO-MgRE3Zn2Zr	ISO-MC65120	T5	140	95	2,5	50 to 60
MgREAgZr	ISO-MgAg2RE2Zr	ISO-MC65210	T6	240	175	2	70 to 90
	ISO-MgRE2Ag1Zr	ISO-MC65220	T6	240	175	2	70 to 90
MgYREZr	ISO-MgY5RE4Zr	ISO-MC95310	T6	250	170	2	80 to 90
	ISO-MgY4RE3Zr	ISO-MC95320	T6	220	170	2	75 to 90
MgREGdZr	ISO-MgRE3Gd1Zr	ISO-MC65410	T6	248 [c]	145 [c]	2	70 to 90

NOTE 1 Values given are for separately cast test pieces. The properties of the casting are expected to be 70 % of the values from separately cast test pieces, for thicknesses of casting up to 20 mm, except for ISO-MgRE3Gd1Zr where samples cut from castings are the same as separately cast test bars, see footnote c.

NOTE 2 1 N/mm² is equivalent to 1 MPa.

[a] These values are for guidance only.

[b] Withdrawn in 2002.

[c] This value applies to both separately cast test pieces and samples cut from castings, for thicknesses up to 30 mm.

Table 4 — Mechanical properties of permanent-mould cast magnesium alloys

Alloy group	Material designation		Temper designation	Tensile strength R_m N/mm² min.	0,2% proof stress $R_{p0,2}$ N/mm² min.	Elongation ΔL % min.	Brinell hardness HBW [a]
	In accordance with ISO 2092:1981 [b]	In accordance with EN 1753					
MgAlZn	ISO-MgAl9Zn1(A)	ISO-MC21120	F	160	110	2	55 to 70
			T4	240	120	6	55 to 70
			T6	240	150	2	60 to 90
MgZnCu	ISO-MgZn6Cu3Mn	ISO-MC32110	T6	195	125	2	55 to 65
MgZnREZr	ISO-MgZn4RE1Zr	ISO-MC35110	T5	210	135	3	55 to 70
	ISO-MgRE3Zn2Zr	ISO-MC65120	T5	145	100	3	50 to 60
MgREAgZr	ISO-MgAg2RE2Zr	ISO-MC65210	T6	240	175	3	70 to 90
	ISO-MgRE2Ag1Zr	ISO-MC65220	T6	240	175	2	70 to 90
MgYREZr	ISO-MgY5RE4Zr	ISO-MC95310	T6	250	170	2	80 to 90
	ISO-MgY4RE3Zr	ISO-MC95320	T6	220	170	2	75 to 90
MgREGdZr	ISO-MgRE3Gd1Zr	ISO-MC65410	T6	248 [c]	145 [c]	2	70 to 90

NOTE 1 Values given are for separately cast test pieces The properties of the casting are expected to be 70% of the values from separately cast test pieces for thicknesses of casting up to 20 mm, except for ISO-MgRE3Gd1Zr where samples cut from castings are the same as separately cast test bars, see footnote c.

NOTE 2 1 N/mm² is equivalent to 1 MPa.

[a] These values are for guidance only.

[b] Withdrawn in 2002.

[c] This value applies to both separately cast test pieces and samples cut from castings, for thicknesses up to 30 mm.

Table 5 — Mechanical properties of pressure die cast magnesium alloys

Alloy group	Material designation		Temper designation	Tensile strength R_m N/mm^2	0,2% proof stress $R_{p0,2}$ N/mm^2	Elongation ΔL %	Brinell hardness HBW
	In accordance with ISO 2092:1981 [a]	In accordance with EN 1753					
MgAlZn	ISO-MgAl9Zn1(A)	ISO-MC21120	F	200 to 260	140 to 170	1 to 9	65 to 85
MgAlMn	ISO-MgAl2Mn	ISO-MC21210	F	150 to 220	80 to 100	8 to 25	40 to 55
	ISO-MgAl5Mn	ISO-MC21220	F	180 to 230	110 to 130	5 to 20	50 to 65
	ISO-MgAl6Mn	ISO-MC21230	F	190 to 250	120 to 150	4 to 18	55 to 70
MgAlSi	ISO-MgAl2Si	ISO-MC21310	F	170 to 230	110 to 130	4 to 14	50 to 70
	ISO-MgAl4Si	ISO-MC21320	F	200 to 250	120 to 150	3 to 12	55 to 80
MgAlRE[b]	ISO-MgAl4RE4	ISO-MC21410	F	220 to 260	130 to 160	6 to 15	60 to 80

NOTE 1 The values given in this table are for guidance only, see 4.2.

NOTE 2 Values given are for separately cast test pieces of 20 mm^2 cross-sectional area and a minimum thickness of 2 mm. For MgAlRE see footnote b.

NOTE 3 1 N/mm^2 is equivalent to 1 MPa.

[a] Withdrawn in 2002.

[b] Values given are from separately cast test bars produced in a cold chamber machine using a multicavity die giving 6 mm round tensile test bars (L_0 = 50 mm).