

Alloy specifications for magnesium casting alloys in pig form

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Scope / term of validity

- These specifications apply to **all** magnesium casting alloys supplied to the above-mentioned Handtmann organizations.
- These alloy specifications also apply to purchase orders to DIN EN 1753, with the exception of the elements indicated in tables "chemical composition".
- The German version of the alloy specifications shall be binding.
- These specifications are valid from 01.01.2017 and shall supersede all previous issues.

DIN ISO 16016 shall apply with regards to the restriction of use of this document.

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1. References to standards and general restrictions

1.1 General Purchasing Conditions

The general purchasing conditions apply, the current version of which may be mailed on request, together with the framework and quality agreements.

1.2 “Standard”

The standard to which these alloy specifications frequently refer is DIN EN 1753, in the version valid at each time.

1.3 Material testing

1.3.1 Testing at supplier’s/manufacture

- Sampling and testing shall be executed in accordance with internal specifications laid down in writing, usually simultaneously with the casting, by way of a spectral analysis over a representative cross section of the batch produced. The results of each individual sample must lie within the limits of these alloy specifications.
- The necessary quality requirements must be ensured by means of suitable testing and monitoring procedures and documented for later reference.

1.3.2 Testing of chemical composition at *handtmann*

- For block material, the testing is done batch-related by means of a spectral analysis over a representative cross section of disks taken from the pig, if no other procedure is described under section 10.
- Testing may be dynamised, i.e. increased, reduced or set to “skip lot”.

1.4 Rounding rules (to ISO 80000-1, annex B, section B.3, rule A)

The records of the test results of the chemical analyses must indicate the number reflecting the result for each of the elements specified in these alloy specifications with at least the same number of decimal points as the respective number in the alloy specifications to which reference is made.

The following rounding rules apply:

- a) If the digit immediately behind the last digit to be kept is smaller than 5, the last digit to be kept remains unchanged. (e.g. in the case of 1 decimal: 0.14 becomes 0.1);
- b) If the digit immediately behind the last digit to be kept is larger than 5 or is 5, and is followed by at least one more digit, which is not zero, the last digit to be kept will be increased by one (e.g. in the case of two decimals: 1.0451 becomes 1.05);
- c) If the digit immediately behind the last digit to be kept is 5 and is only followed by zeros, the last digit to be kept remains unchanged, provided it is an even number, and is increased by one if it is an uneven number (e.g. in the case of two decimals: 0.3550 becomes 0.36 or 0.3450 becomes 0.34).

The rounded figure may not exceed the limit values.

1.5 Weight %

All indications referring to the composition apply in weight percentage.

1.6 Testing for radioactive radiation at the supplier's

Testing must be done on the material ready for shipping. The contents of the "Ordinance for the protection from ionizing radiation damage (Radiation Protection Ordinance)" apply, in the version valid at each time, as issued by the Federal Ministry for Environment, Environmental Protection and Reactor Safety.

1.7 General limitations

The admissible general limitations indicated are binding, provided that there is no limitation on them in the individual alloys specified under section 10.

Feature	Admissible maximum value
Cadmium (Cd)	0.0075
Radioactive radiation	According to the ordinance mentioned in 1.6 the following applies as of the time of issuance of this procedure: 1 mSv/a (Millisievert per annum) or max. 0.12 µSv/h (Microsievert per hour) respectively.

2. Inspection certificate, origin of goods and environmental protection

2.1 Inspection certificate to DIN EN 10204

An inspection certificate 3.1 (alternatively a German “Abnahmeprüfzeugnis 3.1” or French “Certificat de reception 3.1) shall be enclosed with every delivery.

Excerpt from DIN EN 10204:

Inspection certificates 3.1 confirm that the goods supplied conform to the purchase order, indicating the results of the specific tests carried out.

A person commissioned by the manufacturer, who is independent of the production department, shall confirm this certificate.

One inspection certificate 3.1 per shipment shall suffice.

2.2 Contents of inspection certificate

2.2.1 Purchase order number / part number

Metal goods flows are controlled via a PPS system. An indication of the PO number and the part number, which must be clearly evident from the purchase order, is therefore mandatory. Failure to indicate the PO number and the part number may lead to mistakes during data entry, which may seriously affect our metal inventory and interfere with commercial processing.

2.2.2 Alloy-specific requirements

The inspection certificate 3.1 to DIN EN 10204 must be enclosed with every manufactured batch and contain

- the chemical composition of the elements given in this alloy specification, also the elements/parameters indicated under section 1.8 (general limitations) as well as
- all other requirements (e.g. surface quality etc.) if prescribed.

2.2.3 Radioactive radiation

- If material ready for shipping does not show an increased radioactive radiation exceeding the natural radiation (background contamination), a written confirmation of this condition is sufficient.
- However, if the radioactive radiation of material ready for shipping is above the background contamination, the value measured must be indicated in mSv/a (Millisievert per annum) or μ Sv/h (Microsievert per hour) respectively. However, if it does not exceed the limit value indicated in para.1.8, it is also permissible to indicate the maximum value (e.g. < 1 mSv/a) or < 0.12 μ Sv/h respectively .

2.3 Origin of goods

The origin of the goods, together with the production location and the name of the producer, must be indicated in the documents provided.

2.4 Environmental protection

- The stacks must be bound with plastic or aluminum straps; or with steel straps that are coated with a special insulation layer (protection from contact corrosion).
- Plastic hoods are allowed

Note for melting facilities of the Handtmann company

The straps and plastic hoods/films must be disposed of separately and in accordance with the local regulations!

- Signs of corrosion on the ingots supplied are not permissible.

3. Color markings of ingot stacks

3.1 Tags on goods / labels / inscriptions

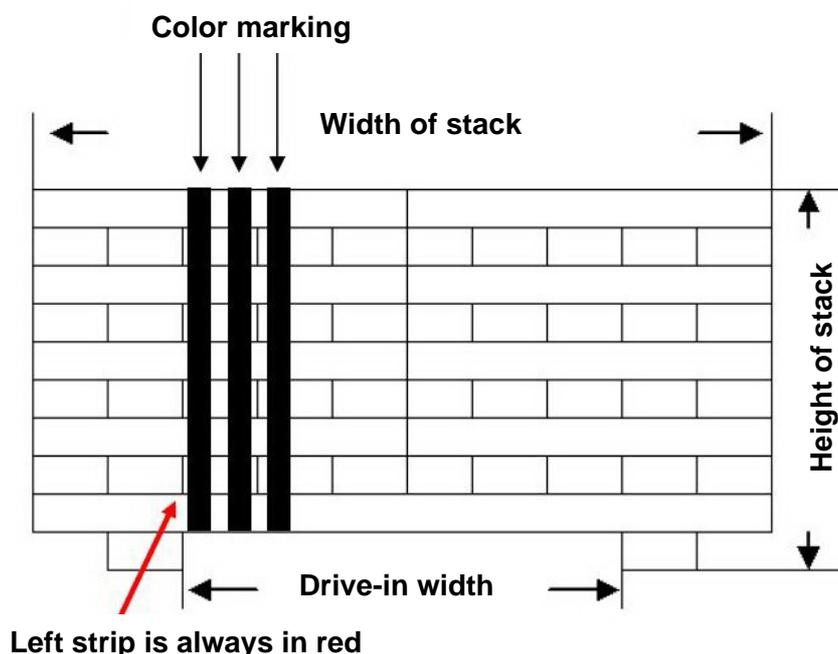
- **on both sides** of the stack, each on the drive-in side of the lift tools
- must contain the following information at a minimum:
 - stack number
 - batch number
 - description of alloy
 - weight

3.2 Color coding

Type of marking: per stack, 3 vertical color stripes, running over the entire height of the stack with a **width of min. 15 mm**.

Place of marking: **on both sides** of the stack, each on the drive-in side of the lift tools,

- also on „feet“,
- not on the fastening straps or plastic hoods



Example of color markings on a stack.

Material	Colors:	left	center	right
3.2.1	Intended use: Die casting			
- MB Mg Al9 Zn1 (A)		red	white	white
- MB Mg Al5 Mn		red	blue	white
- MB Mg Al6 Mn		red	blue	blue
- MB Mg Al8 Ca1 [MRI 153M]		red	green	white
- AJ62		red	white	green
- MB Mg Al3 Si1 [AS31]	-> primary material	red	white	blue
- MB Mg Al3 Si1 [AS31]	-> reworking material	red	yellow	blue
- MB Mg Al4 RE4-2 [AE44-2]	-> primary material	red	blue	green
- MB Mg Al4 RE4-2 [AE44-2]	-> reworking material	red	blue	yellow
- MB Mg Al4 RE4-4 [AE44-4]		red	green	green

3.2.2. Other alloys

Any other alloys in ingot form **may not have any color markings**, but must be marked unambiguously. These markings must be agreed upon in each case.

4. Stack condition

Magnesium pigs must be supplied within the specifications below.

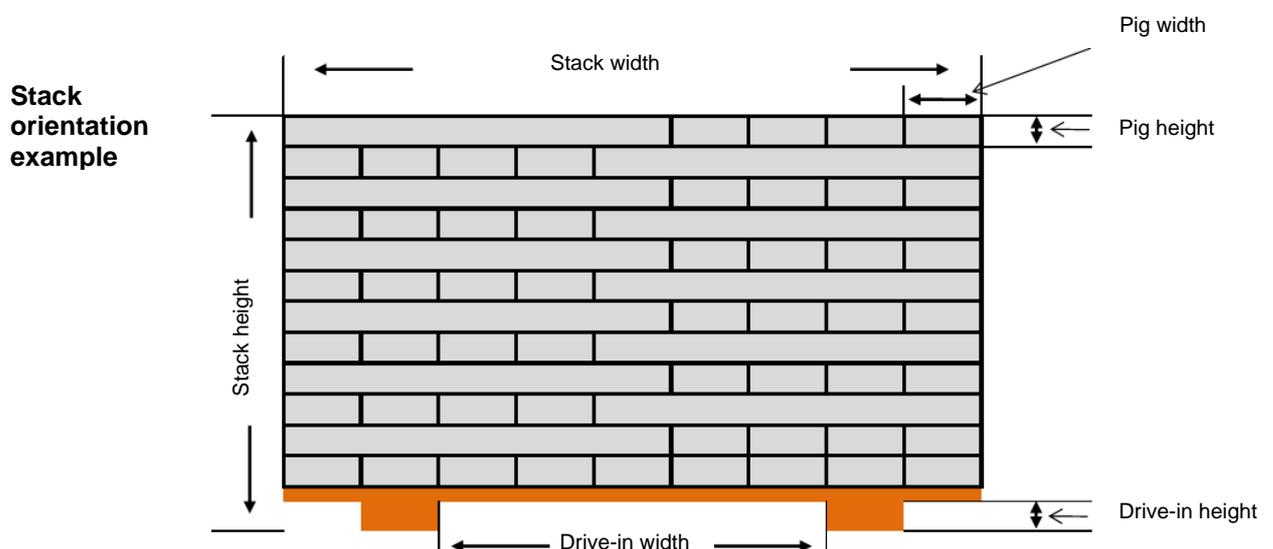
The stacks must be built in such a way that their dimensions do not represent a safety risk both during internal transport and with regards to their stability and stacking height.

In order to ensure the internal automatic pig supply to the melting furnace with the given pig geometry, Handtmann Purchasing will request the supplier to supply a quantity of minimum 10 pigs before a contract is entered into with a new supplier, or if the pig geometry of an existing supplier changes. The pigs supplied for a functional testing

- must possess the geometry intended for later sample or serial supplies
- need not correspond with the envisaged alloy
- must be returned to the supplier after the functional testing at Handtmann was completed or disposed of by Handtmann in accordance with local regulations.

The pig geometry may be approved and released only after a functional test at Handtmann has been completed.

Weight max:	1300 kg
Stack height max.:	1200 mm
Stack width max.:	1300 mm
Pig length max.:	650 mm
Pig width max.:	100/135 mm
Pig height max.:	75 mm
Drive-in height min.:	100 mm
Drive-in width min.:	620 mm
Bundling:	see section 2.4



5. Initial sample inspection of metal

Info to suppliers: Excerpt from the *handtmann* internal work and test specifications for the one-time supply of an alloy group from a supplier.

5.1 Inspection/tests before use

Responsible

5.1.1 Shipping documents

Production Dept.

- Check for completeness of information on the basis of valid alloy specification.
- Measured values must, at a minimum, be indicated for the elements indicated in the valid alloy specifications.
- Purchase order number (Biberach: 40xxxxx; Annaberg:99xxxx; Slovakia:70xxxxxx) and parts number (RM000xx) must be clearly indicated on the documents.

5.1.2 Chemical composition

FE-1

- Must correspond with the valid alloy specifications

5.1.3 Analytic compliance

FE-1

The values determined may deviate from the values indicated in the test certificate by the values hereinafter and depending on the alloy content.

Alloy content in %	Deviation in %	
	Relative	absolute
≥ 0.6	3	0.02
≥ 0.2 - < 0.6		
≥ 0.01 - < 0.2	15	
< 0.01	20	

5.1.4 Macro-section - porosity and inclusions

FE- 1

- Grind one ingot section from each batch to grain 1200.
The section must be documented with photos on a scale of approx. 1:1
The general porosity of the section must be determined. When a pore loss area of 5% is exceeded, the supplier must be informed and requested to initiate improvement actions.
Hard inclusions are not permissible.

5.1.5 Micro-section - condition of structure

FE-1

- From a pig section from each batch a micro-section must be made and etched in accordance with the general rules of metallography.
- The microstructure condition must correspond with the alloy type ordered. A documentation with photos on a scale of 100:1 must be made; additional enlargements may be required, on different scales.

5.1.6 Compliance with delivery deadlines

FE-1

- The deadline (exact date) and quantity ($\pm 2\%$) must correspond with the information on the supplier's acknowledgment. Any deviations will show up negatively in the supplier evaluation.

<p>5.1.7 Decision on items 5.1.1 - 5.1.5:</p> <ul style="list-style-type: none"> • Non-compliance ® refusal • Compliance or insignificant non-compliance ® approval for further processing 	<p>FE-1/Production Dept.</p>
<p>5.1.8 Decision on item 5.1.6:</p> <ul style="list-style-type: none"> • Non-compliance ® info to supplier ® approval for further processing 	<p>FE-1/EK</p>
<p>5.2 Tests during use / Assessment of melt</p>	<p><u>Responsible</u></p>
<p>5.2.1 Condition of stacks</p> <ul style="list-style-type: none"> • Tight bundling • Good transportability and stackability • Straps undamaged 	<p>Production Dept.</p>
<p>5.2.2 Hoop-casing of stack</p> <ul style="list-style-type: none"> • Must correspond with the valid alloy specifications 	<p>Production Dept.</p>
<p>5.2.3 Color markings</p> <ul style="list-style-type: none"> • Must correspond with the valid alloy specifications 	<p>Production Dept.</p>
<p>5.2.4 Properties during melting</p> <ul style="list-style-type: none"> • In particular, the dross contents must be assessed. The dross content must not exceed 1% of the initial weight • Other notable characteristics such as handling etc. may be documented on form sheet “Erstmusterprüfprotokoll für Metall”(Initial sample protocol for metal” (AA1011-A6_2010- 11) in column “Comment”. 	<p>Production Dept.</p>
<p>5.2.5 Decision on item 5.2.1</p> <ul style="list-style-type: none"> • i.O. ® approval for further processing • n.i.O. ® AS (deviation approval application) to manager of manufacturing department <ul style="list-style-type: none"> ® approved: released for further processing ® rejected: refusal 	<p>Production Dept.</p>
<p>5.3 Tests during use: Assessment of casting</p>	<p>Production Dept</p>
<p>5.3.1 Properties during casting</p> <ul style="list-style-type: none"> • Determination in particular of the quality of the castings which were produced with the material to be assessed. The usual tests must be carried out, plus additional X-ray, metallographic tests, specific mechanical key values etc. if required. Comparisons with materials from other, already approved, suppliers may be made. • Any other conspicuous characteristics may be documented on form sheet “Erstmusterprüfprotokoll für Metall”(Initial sample protocol for metal) (AA10 11) in the column “comment”. 	

5.3.2 Decision on item 5.3.1

Production Dept.

- i. O. ® approval for further processing
- not i.O. ® AS application (deviation approval application) to manager of production department
 - > approved: approved for further processing
 - > not approved: refusal

5.4 Documentation and decision

5.4.1 Total decision

**Manager
of Production
Dept.**

- Approval or putting on hold of new supplier or new alloy type if supplier is known, after all individual decisions have been submitted.

5.4.2 Documentation and circulation

FE-1 / EK

- Documentation on form sheet "Initial sample test protocol for metal"
Circulation: 1. Purchasing (original); 2. Manager of the production department concerned (copy) and 3. FE-1 (copy)
- Documentation on form sheet "Supplier approval for incoming metal"

6. Supplier quality monitoring

(Excerpt from the *handtmann* internal procedures for supplier evaluation)

6.1 Terms

Supplier evaluation: Systematic evaluation of each shipment supplied by a supplier and allocation to a category according to the supplier's quality capability.

Supplier evaluation score (LB): Score between +1 and +100 points, showing the supplier's quality capability.

Quality rating (P): The rating awarded each incoming consignment /batch, P1 to P4 as an indication of its quality.

Quality factor (F): Multiplier dedicated to the quality rating (P).

Quality group: Each supplier is allocated to a group, ranging from A to D. Is in direct conjunction with supplier evaluation score.

6.2 Responsibilities

The department FE-1 Materials Testing is responsible for carrying out and documenting the raw materials supplier evaluation (here: magnesium pigs).

6.3 Description regarding the evaluation of product quality

6.3.1 Supplier quality monitoring

Every shipment/batch is checked and evaluated on the basis of specifications, in this case the *handtmann* Alloy Specifications.

The result of the evaluation of each individual shipment or batch is the quality rating.

P1 = Shipment is fully compliant

P2 = Shipment has minor non-compliance(s), the goods may be used without requiring further action

P3 = Shipment has major non-compliance(s); the goods may not be used without further action, e.g. mixing with other batches or alloying.

P4 = Shipment is grossly defective, it cannot / must not be used due to the existing defects.

6.3.2 Criteria for the determination of the quality rating

Quality ratings are allocated by the TFE Materials Testing and are determined on the basis of the following criteria:

Rating 1 ® *Shipment without complaints* will be allocated:

- if the shipment corresponds with the current alloy specifications in all aspects
- if any non-compliance was announced before the shipment of the material, approved by *handtmann* and if the non-compliance was confirmed during the incoming goods inspection.

Rating 2 ® *Shipment has a minor non-conformance* will be allocated

- if the chemical composition is outside the current alloy specifications, but still within DIN EN 1753 for castings or, alternatively, within a valid production standard, and may be accepted;
- if an approved deviation is not confirmed;
- if the purchase order number indicated on the shipping documents does not correspond with the purchase order or is missing altogether;
- if the color markings are not in order;
- if the stack bundling and / or the stack condition is not in order.

Rating 3 ® *shipment has major non-compliance(s)* will be allocated if

- the chemical composition is outside DIN EN 1753 for castings or, alternatively, outside a valid production standard, but can be corrected from an alloy point of view, e.g. by mixing two batches or alloying of the missing element. For this kind of additional work the approval of the production manager must always be obtained.
- if minor non-compliance(s) (rating 2) reoccur(s) after a written notification

Rating 4 ® *shipment is grossly defective* will be allocated:

- if the chemical composition is outside DIN EN 1753 for castings or, alternatively, outside a valid production standard and cannot be corrected by alloying.

6.3.3 Quality factor

The quality rating awarded the shipment/batch is multiplied by the appurtenant quality factor F in order to determine the supplier evaluation score LB.

Quality rating	P1	=	Quality factor (F)	1
Quality rating	P2	=	Quality factor (F)	5
Quality rating	P3	=	Quality factor (F)	30
Quality rating	P4	=	Quality factor (F)	100

6.3.4 Supplier evaluation score

The formula for the calculation of the supplier evaluation score LB is:

$$LB = 101 - \frac{m_{(1)} * F_{(1)} + m_{(2)} * F_{(2)} + \dots + m_{(n)} * F_{(n)}}{m_{(1)} + m_{(2)} + \dots + m_{(n)}}$$

where m = Shipping quantity or batch quantity in tons
 F = Quality factor of each shipment

6.3.5 Quality group

The supplier evaluation is done on a six-monthly basis, by 30 June/31 Dec of each year and will, if necessary or requested by the supplier, be sent to the supplier by the Handtmann Purchasing Dept.

Group A	LB = 100 - 90.1	Supplier with continuously good quality.
Group B	LB = 90 - 80.1	Supplier with fluctuating quality level. Supplier evaluation will be sent to supplier.
Group C	LB = 80 and below	Supplier with insufficient quality level. Supplier evaluation will be sent to supplier, supplier will be put on hold in supplier approval list.

6.3.6 Special actions

If required,

- a supplier evaluation may be issued for any period of time
- a “hit list” of all suppliers may be prepared, in any desired order
- a long-term record may be prepared. For metal suppliers, the usual period is 15 years.

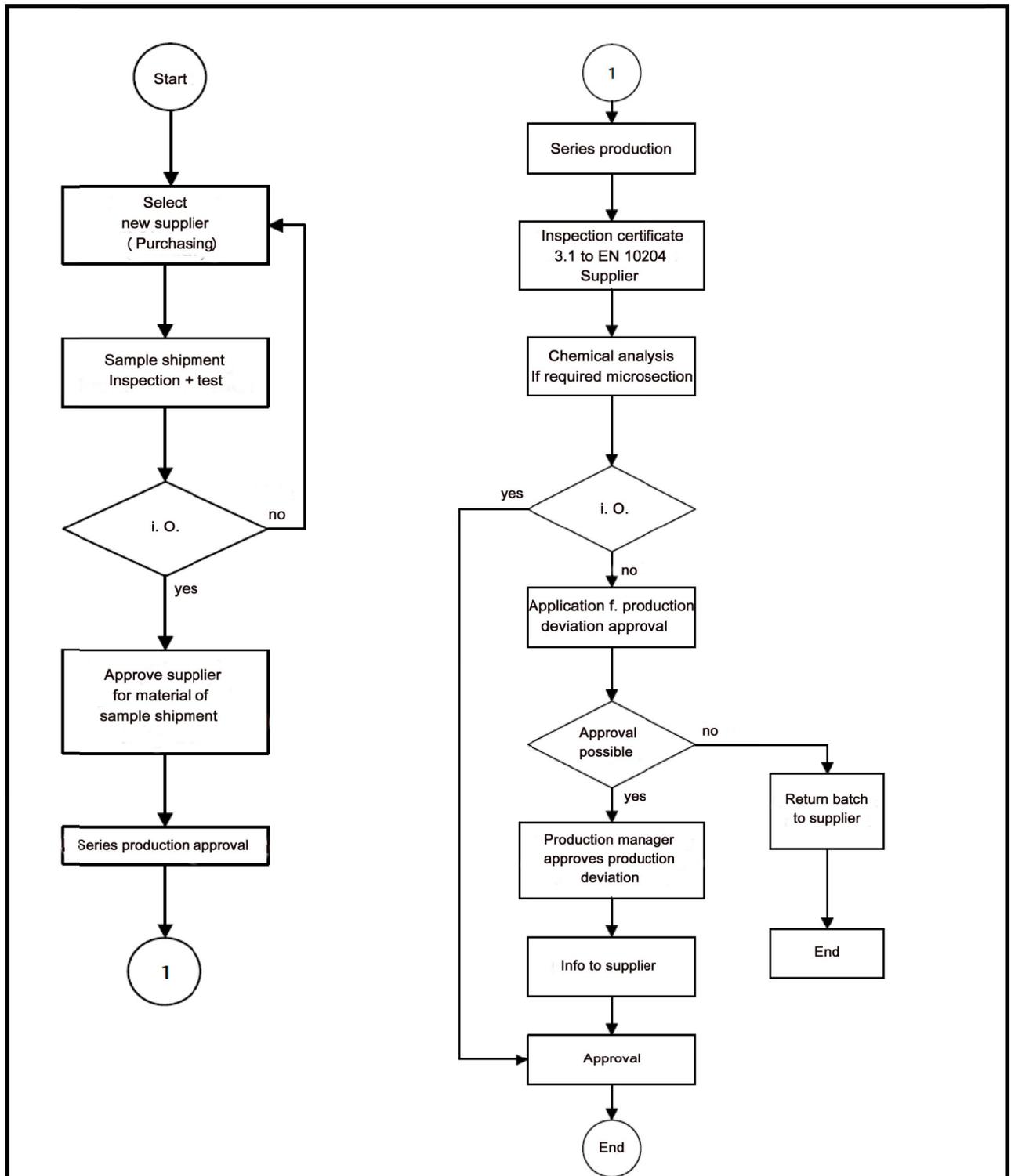
6.3.7 Audit at the supplier's

Purchasing will initiate Quality Assurance Management's auditing of a supplier for the following reasons:

- ◆ Qualification of a supplier who was put in quality group C during the six-monthly supplier evaluation.
- ◆ During the current evaluation period of ½ year, shipments were in several instances each awarded quality rating P3 only.
- ◆ Procurement of a product from a supplier if this product requires auditing as an appropriate quality control action, e.g. because the product is defective and caused high damage incidents, or because the product is in any other way important for Handtmann.
- ◆ **If requested by *handtmann* customers**
- ◆ in all other justified cases.

7. Incoming metal inspection

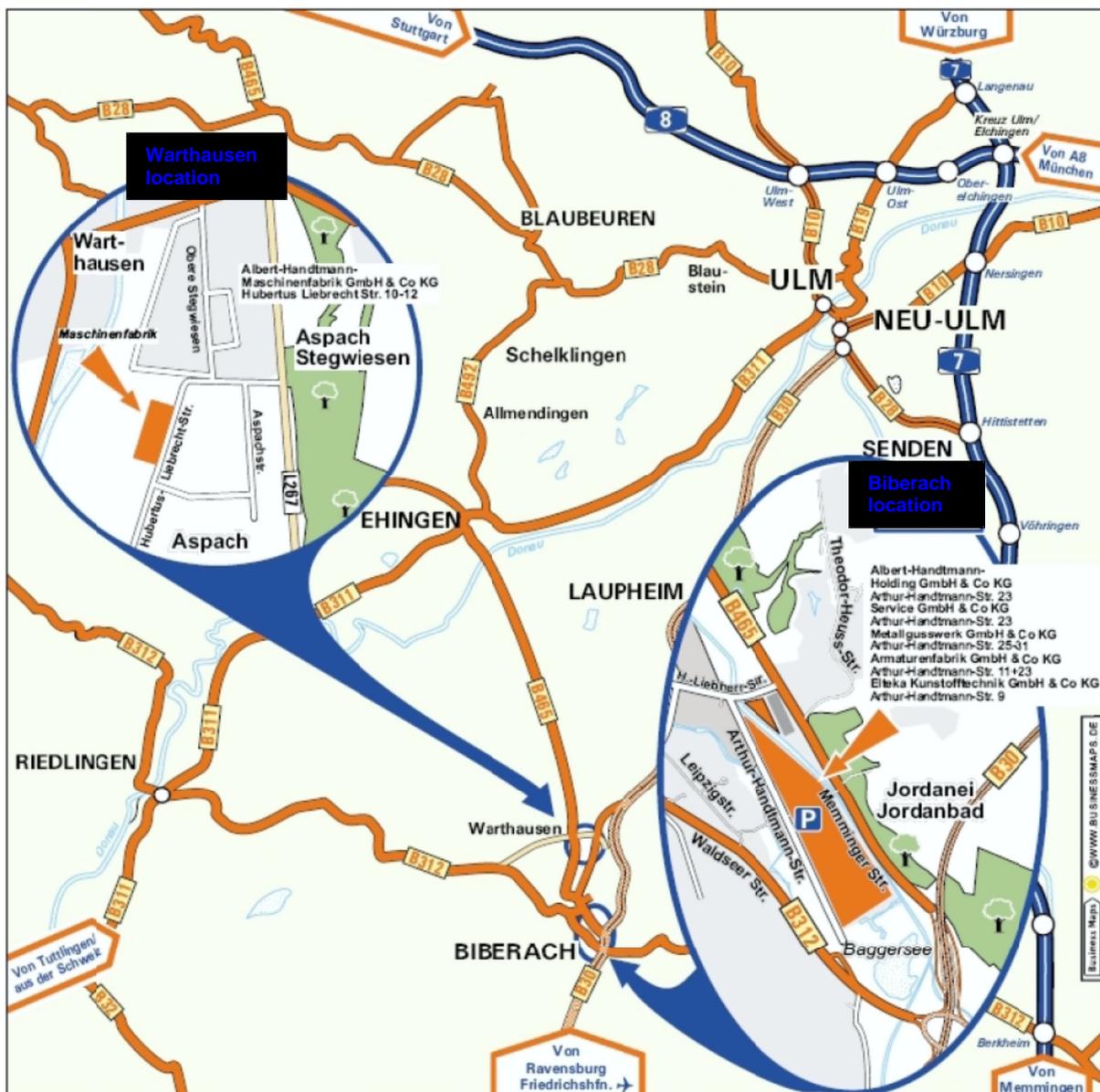
(Excerpt from internal *handtmann* work instructions)



8. Directions

8.1 Biberach Plant

Coming from the north or south on the B 30, take the exit "Biberach - Süd". Continue onto the large traffic circle (Jordan - Ei). Coming from the west or east stay on the B 312, also until you reach the traffic circle. Follow the signs 'Biberach - Nord'. After 1.5 km, turn left into the industrial zone (**handtmann** signpost), continue along the railroad tracks until you arrive at a hall face. Then follow the signposts to the visitors' parking. Please also see the sketch.



8.2 Annaberg-Buchholz plant, Erzgebirge

Leave the motorway A72 at the exit Hartenstein, in the direction of Aue. After about 3.5 km, turn left in the direction of Zwönitz (community of Raum). Continue for another 3.5 km, then turn left in the direction of Chemnitz, onto B169. Leave the B169 after about 1km, turn right, in the direction of Zwönitz. In Zwönitz, follow the signs Annaberg-Buchholz. Leaving Zwönitz, follow the road to Geyer. In and behind Geyer, follow the signs to Wolkenstein, until you reach B95 after about 4 km. Turn right onto B95 in the direction of Annaberg-Buchholz. Stay on B95, cross Schönfeld villlage and continue until you reach a hollow. Go straight across the crossing in this hollow, in the direction of Frohnau, Buchholz (S261). After about 2.5 km, behind a sharp right bend, you have reached our company (see magnifying lens).



9. Chemical compositions

Elements	Alloy
	<i>hab</i> MB Mg Al9 Zn1 (A) Standard EN-MB Mg Al9 Zn1 (A) for GD [EN MB21120)] (formerly: Alloy AZ91)
Al	8.5 - 9.5
Zn	0.45 - 0.9
Mn	min. 0.17
Si	max. 0.05
Fe	max. 0.004
Cu	max. 0.025
Ni	max. 0.001
others, each	max. 0.01

Color code: red, white, white

Part number RM00023

Elements	Alloy
	<i>hab</i> MB Mg Al5 Mn for GD Standard EN-MB Mg Al5 Mn [EN MB 21220)] (formerly: Alloy AM50)
Al	4.5 - 5.3
Zn	max. 0.20
Mn	min. 0.27
Si	max. 0.05
Fe	max. 0.004
Cu	max. 0.008
Ni	max. 0.001
Others, each	max. 0.01

Color code: red, blue, white

Part number RM00077

Elements	Alloy
	<i>hab</i> MB Mg Al6 Mn for GD Standard EN-MB Mg Al6 Mn [EN MB 21230] (formerly: Alloy AM60)
Al	5.6 - 6.4
Zn	max. 0.20
Mn	min. 0.23
Si	max. 0.05
Fe	max. 0.004
Cu	max. 0.008
Ni	max. 0.001
Others, each	max. 0.01

Color code: red, blue, blue

Part number RM00076

Elements	Alloy
	<i>hab</i> MB Mg Al8 Ca1 [MRI 153M] for GD no standard available
Al	7.8 - 8.3
Mn	0.17 - 0.35
Zn	max. 0.05
Ca	0.9 - 1.2
Sr	0.2 - 0.4
Si	max. 0.04
Cu	max. 0.006
Ni	max. 0.001
Fe	max. 0.004
Be	max. 0.0004
Others, each	max. 0.01

Color code: red, green, white

Part number RM00082

Elements	Alloy
	<p>AJ62 (Manufacturer MEL) for GD</p> <p style="text-align: right;">no standard available</p>
	<p>The chemical composition of this material is manufacturer-specific.</p> <p>Tolerances can be determined only after the material has been specified or standardized.</p>

Color code: red, white, green

Part number RM00084

Elements	Alloy
	<i>hab</i> MB Mg Al3 Si1 [AS31] for GD no standard available
Al	3.2 - 3.8
Zn	0.05 - 0.20
Mn	0.30 - 0.46
Si	0.7 - 1.3
Fe	max. 0.003
Cu	max. 0.008
Ni	max. 0.001
Be	0.001- 0.002 Aim for 0.0010 – 0.0015
Σ RE ¹⁾ (Ce, La, Nd, Pr)	max. 0.20
Others, each	max. 0.01

¹⁾ RE = rare earths

Additional tests / specifications	Requirements
Cl content via wet chemical determination (initial samples only)	Max. 50 ppm
Surface quality of ingots	to Daimler TLV 5009 sect. 3.1.1 ²⁾
Internal casting defects	to Daimler TLV 5009 sect. 3.1.2 ²⁾
Microstructure	to Daimler TLV 5009 sect. 3.1.3 ²⁾
Casting and quenching conditions	Recommendation see Daimler TLV 5009 sect. 3.1.4 ²⁾
Analytic scattering between pig top side and bottom side for Al, Mn and Zn	max. 50% of alloy tolerance field

²⁾ Version of Daimler TLV 5009: July 2008

Color code: **Primary material:** red, white, blue
 Reworking material: red, yellow, blue
Part number Primary material RM00091
 Reworking material: RM00204

Elements	Alloy
	<i>hab</i> MB Mg Al4 RE4-2 [AE44-2] for GD no standard available
Al	3.6 -4.4
Mn	0.18 - 0.50
Zn	max. 0.20
Si	max. 0.07
Cu	max. 0.008
Ni	max. 0.001
Fe	max. 0.004
Be	0.0005 - 0.0015
Σ RE ¹⁾ (Ce, La, Nd, Pr)	3.8 - 4.5
Composition of RE	
- Ce	60 - 70
- La	30 - 40
- Σ Nd + Pr	max. 5
Other RE ¹⁾	max. 1.0
Ratio RE/Al	min. 0.9
Others, each (except RE)	max. 0.01

¹⁾ RE = rare earths

Color code: Primary material: red, blue, green
Reworking material: red, blue, yellow
Part number Primary material RM00092
Reworking material: RM00203

Elements	Alloy
	<i>hab</i> MB Mg Al4 RE4-4 [AE44-4] for GD no standard available
Al	3.6 - 4.4
Mn	0.18 - 0.50
Zn	max. 0.20
Si	max. 0.07
Cu	max. 0.008
Ni	max. 0.001
Fe	max. 0.004
Be	0.0005 - 0.0015
Σ RE ¹⁾ (Ce, La, Nd, Pr)	3.8 - 4.5
Composition of RE	
- Ce	>45
- La	20 - 35
- Nd	7 - 20
- Pr	2 - 10
Other RE¹⁾	max. 1.0%
Ratio RE/Al	min. 0.9
Others, each (except RE)	max. 0.01

¹⁾ RE = rare earths

Color code: red, green, green

Part number RM00085

10. Note on the restricted use of these specifications

The dissemination and duplication of the contents of these specifications,
the usage by as well as disclosure to any third party
is not permitted - regardless whether it concerns all or part of the specifications -
except with the express consent of the management of
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