

ICS 01.110

Descriptors: Production process, Product release, Master sample release

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Revision:

1 **Scope of validity and purpose**

This Voith standard (VN) specifies the criteria for the classification of castings, the information to be included in drawings, the required tests, the applicable test methods and the permissible faults in unmachined and machined light alloy castings made of aluminum alloys.

It pertains to unmachined and machined light alloy castings made of aluminum alloy cast by the sand or chill casting methods under gravity.

This VN applies generally to castings used in the production of drive components for the market segment Road of Voith Turbo Antriebstechnik unless otherwise specified in the drawings, standards for individual components or in the data sheets or other agreements are made with the order.

This VN also applies to prototype castings from pre-series, series-related or series dies.

The technical terms of delivery according to EN 1559-1, EN 1559-4 and DIN EN 1706 are also fully applicable.

2 **Conditions for approval**

The general terms of delivery as stated in the order and the requirements of the Voith quality assurance agreement are applicable. In specific cases, the conditions for approval of master samples according to VN 3205 are applicable.

3 **Order and drawing specifications**

The following binding rules are contained in the order or drawing:

- Number of the applicable order and delivery specification with reference to this delivery specification.
- Designation and condition of the material.
- Marking of the part (see item 5).
- Mass (see item 6).
- The order or drawing may contain the following supplementary specifications:
- Surface protection.
- Reference to quality features (as per VN 1631), test specifications and methods.
- Designation of the point from which samples for tensile strength tests are to be taken.
- Designation of critical points. If critical points exist, these are indicated in the drawing.
- Testing of the hydraulic and/or pneumatic sealing according to the requirements specified in the drawing. The process parameters and test frequencies must be agreed with Voith in the course of advance quality planning and must be documented in the production control plan (see VN 3205, VN 3206).
- Classification of the part according to its function and/or advance quality planning (VN 3206).

4 **General terms of delivery**

Rough and finished parts must comply with the drawing approved by Voith Turbo.

Castings must be free of coupons, flash, burrs and similar material residues and free of fractures, cracks, signs of overheating and scorches, creases, cavities, depressions, cold shots and porosity which more than substantially restrict the usefulness (function and/or succeeding process steps) are inadmissible and must be eliminated by suitable measures taken by the supplier.

4.1 **Classification by functional requirements**

Classification is conducted by the responsible Voith development departments by selection of the appropriate ordering and delivery specification.

The castings are divided into the following function classes:

- Function class 1: Castings with safety requirements
- Function class 2: Castings, statically and dynamically loaded castings and/or surfaces with special functional requirements
- Function class 3: Castings not included in classes 1 or 2 without specific functional requirements

5 **Quality requirements on aluminum castings**

5.1 **Material**

Al casting alloys to EN 1706.

If heat treatment of the components is necessary, this heat treatment must be specified in the material designation box.

In the enhancement of eutectic and closely eutectic alloys, the quantities of the metal additives (e.g. Na/Sr) must be specified by the supplier in the master sample test report.

5.2 Chemical composition

According to EN 1706 and the drawing. The results of the chemical analysis must be enclosed with the master sample test report with the nominal and actual values. This must be verified by a certificate to EN 10204 upon request (Voith order and delivery specifications).

5.3 Internal and external properties

All castings must be cast without faults according to the latest standards of technology.

5.3.1 Surface faults (unmachined surfaces)

The unmachined surfaces must display a homogenous appearance and must not have cracks or other faults which could impair the suitability for use of the component and/or subsequent machining with tools. Castings must be free of coupons, flash, burrs and similar material residues and free of fractures, cracks, signs of overheating and scorches, creases, cavities, depressions, cold shots and porosity which more than substantially restrict the usefulness (function and/or succeeding process steps) are inadmissible and must be eliminated by suitable measures taken by the supplier.

5.3.2 Surface faults (machined surfaces)

Function class 1: no faults admissible

Function classes 2 and 3: A few scattered and individual pores (max. \varnothing 1.0 mm) are permissible on condition that the correct usage of the parts is not impaired (maximum porosity per reference area 16 cm²).

If the Voith pore class **Voith PK** is specified in the drawing, the following assessment criteria apply to the individual classes (**Voith PK0** to **PK4**):

Voith PK0:

1. Only pores up to max. \varnothing 0.2mm permitted
2. No exceptions permitted

Voith PK1:

1. Reference area 1cm²
2. Permitted pore size max. \varnothing 0.4mm, min
3. Maximum number of pores 2
4. Pores smaller than 0.2mm are not counted

For each uniformly machined surface, the following exceptions are permitted at intervals of min. 80 mm:

- One single pore with a size of max. \varnothing 0.6 mm permitted despite (2)
- Groups of 3 pores permitted with a min. edge distance of 1mm despite (3)
- No other fault are permitted within an area equal to twice the diameter of the threaded hole.

Voith PK2:

1. Reference area 4cm²
2. Permitted pore size max. \varnothing 0.7mm
3. Maximum number of pores 2
4. Pores smaller than \varnothing 0.4mm are not counted

For each uniformly machined surface, the following exceptions are permitted at intervals of min. 80 mm:

- One single pore with a size of max. \varnothing 1.0 mm permitted despite (2)
- Groups of 3 pores permitted with a min. edge distance of 1.5mm despite (3)
- No other fault are permitted within an area equal to the diameter of the threaded hole.

Voith PK3:

1. Reference area 16cm²
 2. Permitted pore size max. Ø 1.0mm
 3. Maximum number of pores 1
 4. Pores smaller than Ø 0.6mm are not counted
- For each uniformly machined surface, the following exceptions are permitted at intervals of min. 80 mm:
- One single pore with a size of max. Ø 1.5 mm permitted despite (2)
 - Groups of 3 pores permitted with a min. edge distance of 2mm despite (3)
 - No other fault are permitted within an area equal to twice the diameter of the threaded hole.

Voith PK4:

1. Reference area 16cm²
 2. Permitted pore size max. Ø 1.5mm
 3. Maximum number of pores 1
 4. Pores smaller than Ø 1.0mm are not counted
- For each uniformly machined surface, the following exceptions are permitted at intervals of min. 80 mm:
- One single pore with a size of max. Ø 2.0 mm permitted despite (2)
 - Groups of 3 pores permitted with a min. edge distance of 2mm despite (3)
 - No other fault are permitted within an area equal to twice the diameter of the threaded hole.
- Note If no particular specifications are made for threads, *Voith PK4* is applicable with the exception that one single pore may occur from the 4th thread (for threaded through-holes as screwed in), as follows:
- for threads ≤ M8, max. extent 3.5 mm
 - for threads ≥ M8, max. extent 5.0 mm

If necessary, tolerance samples or fault catalogues must be agreed with Voith.

5.3.3 Internal faults to ASTM E 155

Transmission/fluoroscopy test (X-ray test, see EN 12681)

The quality classes are specified on the basis of X-ray sample exposures in the following standards:

- ASTM E 155 for castings of aluminum alloys, sand and chill castings, and magnesium alloys.

If a transmission/fluoroscopy test (see EN 12681) for quality monitoring is impossible, spot checks may be made using metallographic sections. The assessment is made according to Section 5.3.2. The use of fracture samples to internal specifications is only admissible if compliance with the requirements stated in Sections 5.3.2 and 5.3.3. has been proven by a transmission/fluoroscopy test and the production process is completely under control. If the demanded material fault frequencies are not fulfilled after a maximum of two sample presentations, a function test by Voith at the expense of the supplier is necessary for qualification of the quality level.

Table 1

Acceptance limits for tests of internal faults					
Function class 1		Function class 2		Function class 3	
Critical areas	Other areas	Critical areas	Other areas	Critical areas	Other areas
Grade A or better	Grade B or better	Grade B or better	Grade C or better	Grade C or better	Grade D or better

Table 2

Acceptance limits for aluminum castings in sand and chill casting (acceptance reference patterns to ASTM E 155)									
Fehlerart (type of fault)		Quality grade A		Quality grade B		Quality grade C		Quality grade D	
		Maximale Wanddicke (max. wall thickness) in mm							
		≤ 10	> 10	≤ 10	> 10	≤ 10	> 10	≤ 10	> 10
Gas-/Lufteinschlüsse (gas holes)		1	1	3	3	5	5	7	7
Gas-Porosität (gas porosity)	Rund (round)	1	1	3	4	6	6	8	8
	Länglich (elongated)	1	1	3	4	5	5	7	7
Schwindungslunker (shrinkage cavity)		1		2		4		6	
Schwindungsporen oder Schwammgefüge (shrinkage sponge)		1	1	2	3	4	5	6	7
Fremdstoffe (foreign material)	Geringer Dichte (less dense)	1	1	3	3	5	5	7	7
	Höherer Dichte (more dense)	1	1	2	1	5	4	7	6

Generally inadmissible fault types are:

- Porenketten (pore chains)
- Seigerungen (segregation)
- Kaltschweißstellen (stuck welded joints)
- Überlappungen (overlaps)
- Warm- und Spannungsrisse (thermal- and stress cracks)
- Kern- und Formversatz (core- and shape offset)
- Oberflächenunregelmäßigkeiten (irregular surfaces)

If two or more faults exist close to the maximum permissible limit, the casting is **UNACCEPTABLE**.

5.4 Hydraulic And / or pneumatic pressure tests

Pressure tests are conducted according to the information contained in the drawing or in the corresponding standards.

Hydraulic and/or pneumatic pressure test (only for castings in function classes 1 and 2). Unless otherwise specified in the drawing, this test is to be conducted with a finished casting.

The technical data for the test and the acceptance conditions must be contained in the drawing or in the corresponding standards (production control plan).

5.5 Strength properties

The mechanical strength properties of the component must be proven (master sample inspection). The sampling points must be made known in the master sample test report by the supplier if these are not specified in the component drawing. Voith Turbo reserves the right to verify the strength properties by a tensile strength sample from the component.

The tensile tests are to be specified according to DIN 50125 and conducted according to EN 10002. The minimum diameter of the tensile test sample is 4 mm.

If a tensile test sample cannot be taken from a component, the strength properties must be proven by a tensile strength test conducted with a separately cast test rod. The tensile tests must be specified according to DIN 50125 and conducted according to EN 10002. The diameter of the separately cast test rod must be at least 12 mm for sand and chill castings.

The measured values must comply with the limits of the material standard (EN 1706) specified in the drawing.

The choice of the test method for strength monitoring during series production is made by the supplier. The use of separately cast test rods is permissible as a part of the process qualifying reference. In cases of doubt, the strength characteristics (tensile strength/hardness) of the component are decisive. The strength properties of the presented master sample provide the general characteristic values.

The manufacturer determines the required number of random samples.

The strength properties of heat treated parts must be constantly monitored by hardness tests.

5.6 Hardness

The hardness must be tested at the surface according to ISO 6506-1 and at pore-free areas of the casting or on a fractured sample which has not been subjected to stress. The areas must be chosen such that the functionality of the casting is not impaired after the surface layer has been ground off. The measured values must comply with the limits contained in the material standards (EN 1706) specified in the drawing. The hardness test positions must be documented in the test report.

5.7 Surface roughness

As specified in the drawing or in the material standard.

5.8 Mass

The mass of the rough casting must be agreed between the supplier and the client by one of the following two methods:

Mathematical calculation on the basis of the dimensions and tolerances specified in the drawing and the density specified in the material standard, taking account of any machining allowances required for shaping.

Arithmetic mean of the values measured with 10 qualified castings.

A tolerance of $\pm 5\%$ applies to the mass specified in the drawing.

5.9 Dimensions and tolerances

The dimensions must be verified on the basis of the drawing and/or the corresponding standards or CAD model.

The profiles, connections and internal dimensions which cannot be measured on a finished casting must be measured on an opened part.

5.10 Marking

Marking is to be conducted as specified in the drawing at a place which is not affected by subsequent machining. It must be clearly legible and must contain the following information:

- Voith Turbo part number.
- Material designation (abbreviation or material number according to EN 1706)
- Number of the mould and the model for parts in function classes
- Date of manufacture or smelt batch number.
- Manufacturer's code.

6 Production specifications**6.1 Removal of coupons, vents and casting channels**

The castings submitted for approval must be deburred and clean. The above material residues must be removed by a suitable method to avoid damage to the component. If removal proves to be difficult, requiring special machinery, this work must be agreed between the client and the supplier.

6.2 Dressing

Any faults on the surfaces of the components which are not accepted can be removed with a file, grinding wheel or milling machine, after which the transitions of the repaired fault must not have edges. In this case, the tests listed in Sections 5.3.2 and 5.3.3 must be repeated and the component will then be accepted if:

- the fault has been completely eliminated;
- the dimensions of the repaired area are within the tolerances specified in the drawing.

6.3 Repairs

Unless otherwise specified in the drawing or in the associated standards, repairs conducted by welding, partial sealing or impregnation are only permissible by agreement with the Voith Turbo development and design departments. The precise procedure, test specifications and acceptance conditions must be agreed for the execution of these repairs. The provisions of EN 1559-4 Chapter 6 and Appendix A are generally applicable to production and repair welding.

For impregnation work, the supplier must provide information on the trade name of the resin used in his chosen process. If the impregnation process is conducted at room temperature using methacryl resin, a further test of the component by repetition of the pressure test described in Section 5.4 of this standard is adequate. If other materials or processes are employed, additional tests of the finished product must be agreed. Fillers are only admissible as agreed with and on consent by Voith.

7 Technical series release

The supplier must comply with the general regulations contained in VN 3205 Production process and product release (master sample release).

7.1 Supplements to master sample inspections

Supplementary requirements for the sample inspection of aluminum parts for Voith Turbo, Market Segment Road (supplement to VN 3205 Production process and product release)

Table 3

		Presentation stage 2 Function class 3	Presentation stage 3 Function classes 1,2
1.	Measurement report	X	X
2.	Chemical analysis (nominal values to EN 1706)	X	X
3.	Mechanical properties (Rm [N/mm], Rp0.2 [N/mm], A5 [%])	X	X
3.1	Proof with separately cast test rod	X	
3.2	Proof by test rod taken from the component		X
4.	Hardness tests of heat treated parts	X	X
5.	Microstructure grinding test as proof of the enhancement parameters in ppm		X
6 .	Internal faults Classification of porosity to ASTM E 155; 100% X-ray testing of the master sample (alternatively saw cuttings as agreed with Voith)	X	X
7.	Surface faults (machined surfaces) according to the above tests 5.2, 5.3 and/or agreement of tolerance samples	X	X

7.2 Delivery and marking of the master samples

Samples must always be delivered separately from series materials. Samples must be sent in separate packages addressed to the goods reception of the recipient factory.

The individual master samples must be numbered to ensure identification of the test documents. The master samples must be supplied with a separate delivery note which must be clearly marked "Master samples" and must contain the part number and designation.

The packages and, if appropriate, the master samples must also be clearly marked with a goods label (VDA label) and a yellow sticker "Master sample".

8

Applicable documents

DIN standards available from:
Beuth Verlag GmbH
Postfach 1145
10772 Berlin

Table 4

01	DIN EN 1706	Aluminum and aluminum alloys - Castings – Chemical composition and mechanical properties
02	DIN EN ISO 9000	Quality management systems – Principles and terms
03	DIN EN ISO 9001:2000	Quality management systems, requirements
04	DIN EN 10002-1	Metallic materials – Tensile test - Part 1: Test methods at room temperature
05	DIN EN ISO 6506-1	Metallic materials, hardness test according to Brinell, Part 1: Test methods
06	DIN EN 10204	Metallic products – Types of test certificates
07	DIN EN 12681	X-ray tests
08	DIN EN ISO14001	Environmental management systems
09	DIN 50125	Testing of metallic materials – Tensile tests
10	DIN 55350-11	Terms of quality assurance and statistics
11	ASTM E 155	Radiographic exposed for testing aluminum and magnesium castings

Verband der Automobilindustrie e.V. (VDA)

Source:

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Qualitätsmanagement Center (QMC)
Karl-Hermann-Flach-Str. 2
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Table 5

12	Volume 1	Certification
13	Volume 2	Quality assurance for supplies to the automotive industry
14	Volume 4	Quality assurance for series employment
15	ISO/TS 16949	Quality management systems, special requirements for the application of ISO 9001:2000 for series and single part production in the automotive industry

Voith standards

Table 6

16	VN 1631	Documentation requirements (test dimensions) in drawings; D and DS parts
17	VN 3205	Production process and product release (master sample release)
18	VN 3206	Advance quality planning (QVP)
19	QSV	Quality assurance agreement with Voith Turbo (latest valid version)