

BLUE_TS_CST_01

General Technical Specification

ROLLING STOCK CASTING COMPONENTS

0	20/01/2017	Base Release	D.Pisano	M.Borlo	M.Gorlani
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1 SCOPE

The present specification defines criteria for classification of casting components, the data to be indicated on the drawings, the tests to be performed, the testing methods to be used, as well as the admissible defects at the unmachined and machined parts.

This specification is applied to prototype cast parts for pre-series, close-to-series or series tools.

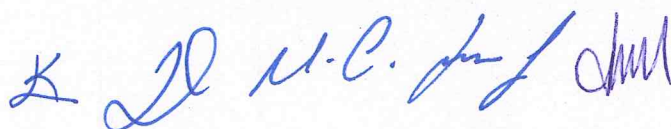
2 AREA OF APPLICATION

Applies to unmachined and machined parts of cast iron and steel casting according to EN 1559-1, EN 1559-2 and 1559-3 applied to the full extent.

3 REFERENCE STANDARD

Number	Title
ASTM A 247	Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings
ASTM E186	Reference Radiograph for Heavy Walled (2 to 4.5 inch) Steel Castings
ASTM E280	Reference Radiograph for Heavy Walled (4.5 to 12 inch) Steel Castings
ASTM E446	Reference Radiograph for Steel Castings Up to 2 inch in Thickness
ASTM E689-10	Standard Reference Radiographs for Ductile Iron Castings
DIN 55350 11	Concepts for quality management - Part 11: Supplement to DIN EN ISO 9000:2005
EN 444	Non-destructive testing - General principles for radiographic examination of metallic materials by X and gamma rays
EN 583-1	Non-destructive testing – Ultrasonic testing – Part 1: General principles
EN 1011-2	Welding - Recommendations for welding of metallic materials - Part 2: Arc welding of ferritic steels
EN 1011-8	Welding - Recommendations for welding of metallic materials - Part 8: Welding of cast irons
EN 1369	Founding - Magnetic particle inspection
EN 1370	Founding - Examination of surface condition
EN 1371-1	Founding - Penetration test - Part 1: Sand, gravity castings and low-pressure casting parts
EN 1559-1	Founding – Technical conditions of delivery - Part 1: General
EN 1559-2	Founding – Technical conditions of delivery – Part 3: Additional requirements for steel castings
EN 1559-3	Founding – Technical conditions of delivery – Part 3: Additional requirements for iron castings
EN 1560	Founding - Designation system for cast iron - Material symbols and material numbers
EN 1561	Grey cast iron
EN 1563	Spheroidal graphite cast iron

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EN 1564	Ausferritic spheroidal graphite cast irons
EN 10027-1	Designation system for steels - Part 1: steel names
EN 10204	Metallic Products – Types of Inspection Documents
EN 12454	Visual examination of surface discontinuities
EN 12680-3	Founding – Ultrasonic examination - Part 3: Spheroidal graphite cast iron castings
EN 12681	Radiographic testing
EN 12890	Founding - Patterns, pattern equipment and coreboxes for the production of sand moulds and sand cores
ISO 148-1	Metallic materials -- Charpy pendulum impact test Test method
ISO 571-1	Non-destructive testing – Penetrant testing – Part 1: General principles
ISO 643	Steels -- Micrographic determination of the apparent grain size
ISO 945-1	Microstructure of cast irons - Part 1: Graphite classification by visual analysis
ISO 945-2	Microstructure of cast irons - Part 2: Graphite classification by image analysis
ISO 8062-3	Geometrical product specifications (GPS) – Dimensional and geometrical tolerances for moulded parts – Part 3: General dimensional and geometrical tolerances and machining allowances for casting.
ISO 6506-1	Metallic materials – Brinell hardness test – Part 1: Test method
ISO 6892-1	Metallic materials - Tensile testing - Part 1: Method of test at room temperature
ISO 8785	Surface imperfections - Terms, definitions and parameters
ISO 9000	Quality management systems - basics and terms
ISO 9001: 2000	Quality Management Systems - Requirements
ISO 9934-1	Non-Destructive Testing - Magnetic Particle Testing - Part 1: General Principles
ISO 14001	Environmental Management Systems
ISO 15614-1	Specification and qualification of welding procedures for metallic materials -- Welding procedure test Arc and gas welding of steels and arc welding of nickel and nickel alloys
ISO 15614-3	Specification and qualification of welding procedures for metallic materials. Welding procedure test. Fusion welding of non-alloyed and low-alloyed cast irons
ISO/TR 945-2	Microstructure of cast irons - Part 2: Graphite classification by image analysis
AAR M-201	Casting, Steel specification

Table 1 – Applicable standards

4 CLASSIFICATION

All rolling stock castings (cast iron and steel casting) are grouped into following function:

Function class 1: Castings with safety requirements.

Function class 2: Castings statically and dynamically stressed and/or castings with special function requirements.

Function class 3: Castings not belonging to classes 1 and 2, without specific function requirements.

5 GENERAL REQUIREMENTS

5.1 Mandatory information

In the purchase order and/or drawing, the following binding specifications and data are included:

- Number of castings.
- Material designation.
- Standard wall thickness.
- Marking of part.
- Mass.
- Indication of function class.

In the purchase order and/or drawing, the following additional stipulations may be included:

- Surface protection.
- Reference to quality features, test specifications, test procedures.
- Marking of critical areas. If there are critical areas, they are indicated on the drawing including the admissible properties and tests.
- Indication of required hydraulic and/or pneumatic tightness.

5.2 Material designation

Designation of cast materials shall be in accordance with the following Standards:

Cast Iron: EN 1560.

Steel Casting: EN 10027-1 or AAR M-201.

5.3 Drawings tolerances

Moulding tooling definition and draft values for casting obtained by sand method shall comply with EN 12890 standard.

For general tolerances and machining allowances for castings EN ISO 8062-3 shall apply.

In particular, on drawing shall be indicated at least the following tolerance grades:

- DCTG (dimensional casting tolerance grade)
- GCTG (geometrical casting tolerance grade)
- RMAG (required machining allowance grade)

5.4 Strength properties

The mechanical strength properties shall be verified on master sample component.

The tensile test pieces are to be defined according to the corresponding material standard; the tensile test shall to be carried out acc. to ISO 6892-1.

The results are indicated by the supplier on the inspection report. The measured values must correspond to the limiting values of the material standard indicated on the drawing.

The test method of series strength monitoring is selected at the supplier's discretion. The use of separately cast test bars is admissible as part of process monitoring. In referee cases, the strength characteristics (tensile strength/hardness) of the component are decisive.

The strength properties of the presented master samples provide the general characteristic values. The required number of samples is defined at the supplier's discretion. The strength properties of heat-treated parts must be monitored continuously by a hardness test.

5.5 Hardness

The hardness shall be determined as Brinell test acc. to ISO 6506-1 at the surface and at flawless areas of the casting that was not subjected to any stress.

The areas must be chosen in a way to ensure that the functionality of the casting is not affected after grinding off the surface layer. If hardness test positions have been agreed, they must be documented on the blank drawing.

The measured values shall correspond to the prescribed limiting values of the material standard stated on the drawing. The hardness test positions must be documented in the inspection report.

5.6 Impact energy

The impact test shall be carried out on three Charpy V-notched impact test pieces in accordance with ISO 148-1 at temperature given in material standard.

The average value of energy shall not be smaller than the specified value indicated in the material standard for the specified grade (one of the individual values may be smaller than specified but it is not smaller than 70% of this specified value).

5.7 Mass

For iron casting the mass can be calculated using the mass density given in the corresponding material standard.

The mass of casting made of non-alloyed or low-alloyed steel shall be calculated on a basis of a density of 7,80 kg/dm³. For alloyed steels, the mass shall be calculated using the mass density given in the corresponding material standard.

Arithmetic mean of the values measured at 10 qualified castings.

For the mass stated on the drawing, a tolerance of $\pm 5\%$ applies.

5.8 Marking

Each casting shall be legibly marked to allow traceability through inspection documents.

The minimum identifications are:

- Material designation
- Model number
- Number of casting
- Date of manufacture or batch number
- Supplier code number (optional)

5.9 Hydraulic and/or pneumatic leakage test

The leakage test is done in accordance with the indications (tightness class, tightness range, leakage test) on the drawing or on the respective standards. Hydraulic and/or pneumatic leakage test is only done for castings of function classes 1 and 2. Unless stated otherwise on the drawing, this test must be made on the finish-machined casting.

5.10 Master Sample

Sample shall be made from the same material as that used to produce the castings which they represent.

Samples must always be despatched separately from series-manufactured material. When the mass of casting exceeds 2000 kg and its relevant wall thickness is 60 mm, cast on sample or side by sample should preferably be used.

Samples must be addressed in separate package units to the goods reception of the recipient factory.

The individual master samples shall be numbered to ensure that they can be correlated with the test documents.

The thickness and the shape of sample shall be in accordance with the relevant wall thickness of the casting as specified in the applicable material standard (e.g. EN 1563 par.8.2 for cast iron and EN 1559-2 par.8.4).

5.11 Delivery Conditions

The shape and size of finished parts must correspond to the drawing, model or templates, according to the tolerances indicated.

Castings must be free from inclusions, gas porosities, dross and scrubs.

The inner and outer surfaces of the castings shall be removed by sticking sand, sharp edges, burrs and slag. The castings shall be shot-blasted, and the surface of the castings subjected to shot blasting shall not have oxide flakes and sticky sand.

Defects seriously affecting usability (function and/or subsequent process steps) are not admissible and must be removed by the supplier using suitable measures.

6 SPECIFIC REQUIREMENTS FOR CAST IRON PARTS

6.1 Material

Cast iron acc. to

- EN 1561 Grey cast irons
- EN 1563 Spheroidal graphite cast irons (preferred material EN-GJS-400-18-LT)
- EN 1564 Ausferritic spheroidal graphite cast irons

6.2 Metallography: graphite structure

The graphite structure shall be mainly of form V and VI, according to EN ISO 945-1.

Alternatively, the use of ISO/TR 945-2 - Microstructure of cast irons - Part 2: Graphite classification by image analysis - or ASTM A247 - Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings - is admissible.

The metallographic results shall be enclosed to the master sample inspection report and certified acc. to EN 10204

6.3 Internal and external quality

The required tests shall be defined specifically for the component and must be introduced both on the drawing with the relevant areas with defect acceptance criteria or be defined in a separate document.

Terms and definitions for surface quality discontinuities are defined by EN 1559-2.

The surface quality is determined by the processes described in the following standards:

Visual inspection (VT)

EN 1370 Founding - Examination of surface condition.

EN 12454 Visual examination of surface discontinuities.

Magnetic particle testing (MT)

EN 1369 Founding - Magnetic particle testing

ISO 9934-1 Non-destructive testing - Magnetic particle testing - Part 1: General principles

Liquid penetrant testing (PT)

EN 1371-1: Founding - Liquid penetrant testing - Part 1: Sand, gravity die and low pressure die castings

ISO 571-1 Non-destructive testing - Liquid penetrant testing - Part 1: General principles

Internal flaws are primarily determined by the procedures described in the following:

Radiographic testing (RT)

EN 12681 Founding - Radiographic examination

EN 444 Non-destructive testing - General principles for radiographic examination of metallic materials by X- and gamma rays

ASTM E689-10 Standard Reference Radiographs for Ductile Iron Castings

ASTM E446 Reference Radiograph for Steel Castings and Iron Casting Up to 2 inch in Thickness.

ASTM E186 Reference Radiograph for Heavy Walled (2 to 4.5 inch) Steel Castings.

ASTM E280 Reference Radiograph for Heavy Walled (4.5 to 12 inch) Steel Castings

6.3.1 Surface quality discontinuities: unmachined surfaces

The unmachined surfaces must show a homogenous appearance and must neither contain cracks and other defects which might affect the functionality of the component and/or the subsequent machining with tools.

In any case in accordance with EN 1370, the quality surface roughness of castings shall be equal or greater than 3S1 or A3 level and the acceptance level for surface irregularities shall be VD4 / VC2.

6.3.2 Surface quality discontinuities: machined surfaces

The levels indicated on following table determine the surface discontinuities of machined surfaces; the indications do not refer exclusively to pores, but to all discontinuities mentioned.

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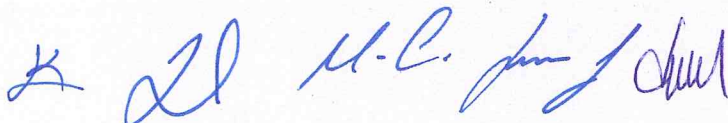
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LEVEL	SURFACE QUALITY	EXCEPTIONS ALLOWABLE DEFECT	FUNCTION CLASS
A	<ul style="list-style-type: none"> Only discontinuities up to max. \varnothing 0,2 mm are admissible 	No exceptions are admissible	1
B	<ul style="list-style-type: none"> Reference area 1cm² Admissible discontinuity size max. \varnothing 0.4mm min Max. discontinuity number 2 Discontinuities smaller than 0.2mm are not considered 	<p>For each uniform, finish-machined surface, the following exceptions are admissible at a distance of min. 80 mm:</p> <p>A single discontinuity with a max. dimension of \varnothing 0.6 mm is admissible</p> <p>Accumulation of 3 discontinuities is admissible with a max. edge distance of 1mm,</p> <p>Within an area equal to double the diameter of the tapped hole, no further flaws are admissible</p>	2
C	<ul style="list-style-type: none"> Reference area 4cm² Admissible discontinuity size max. \varnothing 0.7mm min Max. discontinuity number 2 Discontinuities smaller than \varnothing 0,4mm are not considered. 	<p>For each uniform, finish-machined surface, the following exceptions are admissible at a distance of min. 80 mm:</p> <p>A single discontinuity with a max. dimension of \varnothing 1.0 mm is admissible.</p> <p>Accumulation of 3 discontinuities is admissible with a max. edge distance of 1.5mm,</p> <p>Within an area equal to double the diameter of the tapped hole, no further flaws are admissible.</p>	2 - 3
D	<ul style="list-style-type: none"> Reference area 16cm² Admissible discontinuity size max. \varnothing 1.0mm min Max. discontinuity number 1 Discontinuities smaller than \varnothing 0,6mm are not considered 	<p>For each uniform, finish-machined surface, the following exceptions are admissible at a distance of min. 80 mm:</p> <p>A single discontinuity with a max. dimension of \varnothing 1.5 mm is admissible</p> <p>Accumulation of 3 discontinuities is admissible with a max. edge distance of 2mm,</p> <p>Within an area equal to double the diameter of the tapped hole, no further flaws are admissible</p>	2 - 3
E	<ul style="list-style-type: none"> Reference area 16cm² Admissible discontinuity size max. \varnothing 1.5mm min Max. discontinuity number 1 Discontinuities smaller than \varnothing 1.0mm are not considered 	<p>For each uniform, finish-machined surface, the following exceptions are admissible at a distance of min. 80 mm:</p> <p>A single discontinuity with a max. dimension of \varnothing 2.0 mm is admissible,</p> <p>Accumulation of 3 discontinuities is admissible with a max. edge distance of 2mm,</p> <p>Within an area equal to double the diameter of the tapped hole, no further flaws are admissible.</p>	3

Table 2 – Surface quality level on machined parts

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6.3.3 Internal quality

Radiographic examination shall be carried out in critical areas specified in the drawing component.

The assessment according to EN 12681, shall be within the following limits:

Gas porosity not exceeding level 3 - category A;

Sand and slug inclusions not exceeding level 1 - category B;

Shrinkage not exceeding level 1 - Category C.

Crack not permitted – Category D

The presence of defects involves the extension of the examination to the entire batch.

6.4 Cleaning and repairs

Any flaws on the surface of components not removed by mechanical machining can be removed by means of file, grinding wheel or milling machine; the transition zones of the repaired flaw must not show any edges. In this case, the tests stated under par.6.3 shall be repeated and the component is accepted if:

- the flaw has been completely removed;
- the dimensions of the repaired area are within the tolerances indicated on the drawing.

Repairs by welding, partial sealing or impregnating are only admissible after consultation with the Customer. For carrying out such repairs, exact procedures, inspection instructions and acceptance conditions must be agreed.

In general, welding shall be performed by a qualifier welder, in accordance with EN287-6. Welding procedure shall be in accordance with EN ISO 15614-3 and based on the recommendations given in EN 1011-8.



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7 SPECIFIC REQUIREMENTS FOR STEEL CASTING PARTS

7.1 Material

Steel casting acc. to

- EN 10293 Steel castings for general engineering uses (preferred material G20Mn5)
- AAR-M201 Steel casting (preferred material Grade B or B+)

7.2 Chemical composition

The chemical composition determined by a cast analysis shall conform to EN 10293 Table 1 or ARR M-201 par. 6.1

For EN steel, permissible deviation between the specified cast analysis and the check analysis on the test block are indicated on Table 1 of EN 1559-2.

7.3 Heat treatment

For EN steel the type of heat treatment shall be comply with EN 10293 Table 3.

For AAR steel see standard AAR M-201 par. 5.

7.4 Metallography: determination of grain size

The grain size results, in accordance with ISO 643, are to be enclosed to the master sample inspection report. This shall contain the following information:

- Grade of steel exanimated
- Type of grain determined
- Method used, operating condition
- Grain size index G or the value of mean segment.

In any case, the grain size index G shall be at least equal to 5 or higher.

7.5 Internal and external quality

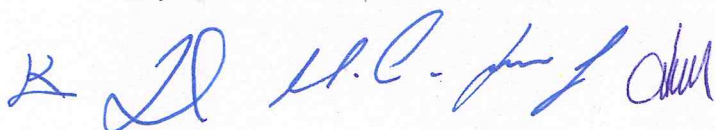
See par.6.3 (6.3.1; 6.3.2; 6.3.3)

7.6 Cleaning and repairs

Any flaws on the surface of components not removed by mechanical machining can be removed by means of file, grinding wheel or milling machine; the transition zones of the repaired flaw must not show any edges. In this case, the tests stated under par.6.3 shall be repeated and the component is accepted if:

- the flaw has been completely removed;
- the dimensions of the repaired area are within the tolerances indicated on the drawing.

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Repairs by welding, partial sealing or impregnating are only admissible after consultation with the Customer. For carrying out such repairs, exact procedures, inspection instructions and acceptance conditions must be agreed.

In general, welding shall be performed by a qualifier welder, in accordance with EN287-6. Welding procedure shall be in accordance with EN ISO 15614-1 and based on the recommendations given in EN 1011-2.

For AAR steel, welding procedure shall be in accordance with standard AAR M-201 par. 13

8 INSPECTION

8.1 Inspection plan

Each "manufacturing batch" (it means, each batch of components come from the same casting, subjected to the same heat treatments) shall be subjected to the tests described in the following table, depending by the function class.

For the prototypes, all tests are required.

It is faculty of the Customer to repeat one or more tests planned at the Supplier.

Par.	Test	Function class		
		1	2	3
5.3 5.11	Measuring report	100%	25%	10%
5.4	Strength properties	3 / batch	3 / batch	-
5.5	Hardness	10%	10%	5%
5.6	Impact energy	3 / batch	3 / batch	-
6.2 7.2 7.4	Metallography / Chemical composition	1 / casting	1 / casting	-
6.3	Surface quality discontinuities			
6.3.1	(VT)	100%	100%	5%
6.3.2	(LP) / (MT)	100%	100%	-
6.3.3	Internal quality (internal flaws) (RT)	100%	10%(#)	-

(#) 100% if required to drawing.

Table 3 – Inspection plan



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8.2 Certification required

All castings of this specification, shall be certified according to the EN 10204 with type documents "3.1".

In particular, it's required:

1. Manufacturing plan (when specifically requested to order);
2. Certification testing according to par.8.1 with the following prescriptions:
 - Number of purchase order
 - Number of drawing model and quantities and pieces of the batch;
 - Reference number of casting or casting code of the batch;
 - Number of batch which the documents relate.
3. Sampling certification: preparation of samples and test pieces.

9 PACKAGING AND SURFACE PROTECTION

Packaging and/or surface protection, if any, for the transport or storage of castings shall be at discretion of the manufacturer unless a specific agreement made by the time of acceptance of the order.

END of DOCUMENT

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