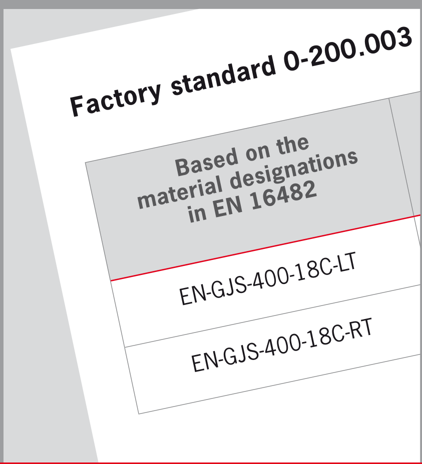



ACO Eurobar® Concast Iron

Technical Documentation

The ACO Eurobar® factory standard WN 0-200.003 based on EN 16482
The current "ACO Eurobar® Concast Iron – Technical Documentation" factory standard forms the basis for the technical specification of the ACO Eurobar® quality continuous-cast iron.

It is based on the European standard "EN 16482 – Cast Iron – Continuous Casting", in which ACO Eurobar GmbH has been intensively involved as a member of the Standards Committee as an experienced producer of high-quality continuous-cast iron.
Apart from providing detailed explanations and specifications on the quality of ACO Eurobar® products for customers, the technical documentation facilitates preparations of offers.

Advantages – quality above the standard

ACO Eurobar GmbH guarantees its customers the following additional properties and special characteristics for the ACO Eurobar® quality continuous-cast iron, over and above the EN 16482 standard:

- Colour coding based on the international RAL system (exclusive to ACO Eurobar)
- Explanations for using tables and related specifications (example: machining allowances)
- Confirmation of the Brinell hardness for each material in accordance with the "mechanical properties" tables
- Graphite and matrix microstructures over the entire cross-section and for all types of cast iron
- Both hardness and mechanical properties are guaranteed – not stipulated in EN 16482

Added value - Catalogue on typical features of concast materials

- The „Catalogue on typical characteristics of continuous-cast iron", which is unique in the market, describes not only process-related surface appearance, but also provides all information about the material and the defects which might occur.

With the help of the **additional tips and hints** in the Technical Documentation of ACO Eurobar, our customers are also able to

- better compare continuous cast iron products
- submit enquiries quickly and accurately
- minimise sources of errors and
- generally improve the efficiency of their operations.

Please call us if you have any questions or suggestions related to the current ACO Eurobar® factory standard. We consider feedback from our customers to be essential in order to further improve our manufacturing processes, products and services.

Your team at ACO Eurobar

Table of contents

Material designations as per EN 16482 and ACO Eurobar® colour coding

ACO Eurobar® grey iron

Material designation as per EN 16482		Matrix	Colour coding* ACO Eurobar®
Designation	Number		
EN-GJL-150C	5.1102	ferritic	grey/red
EN-GJL-250C	5.1203	ferritic-pearlitic	grey
EN-GJL-300C	5.1308	pearlitic	black

ACO Eurobar® ductile iron

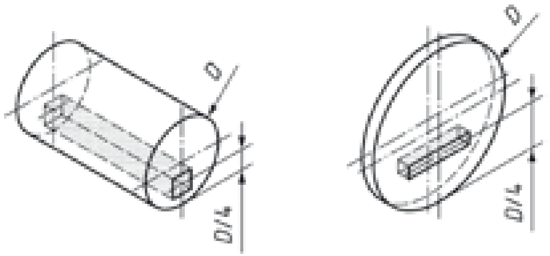
Material designation as per EN 16482		Matrix	Colour coding* ACO Eurobar®
Designation	Number		
EN-GJS-350-22C-LT	5.3120	ferritic	yellow/red
EN-GJS-350-22C-RT	5.3121	ferritic	yellow/red
EN-GJS-350-22C	5.3122	ferritic	yellow/red
EN-GJS-400-18C-LT	5.3123	ferritic	yellow/red
EN-GJS-400-18C-RT	5.3124	ferritic	yellow/red
EN-GJS-400-18C	5.3125	ferritic	yellow/red
EN-GJS-400-15C	5.3126	ferritic	yellow/red
EN-GJS-500-7C	5.3203	ferritic-pearlitic	yellow
EN-GJS-500-14C	5.3129	ferritic	green
EN-GJS-600-3C	5.3204	pearlitic-ferritic	blue
EN-GJS-700-2C	5.3303	mainly pearlitic	white

*) All color codes are based on the international RAL colour-code system. We are happy to inform you on request which RAL colors are used by ACO Eurobar. If desired, we can supply the appropriate color as spray paint.

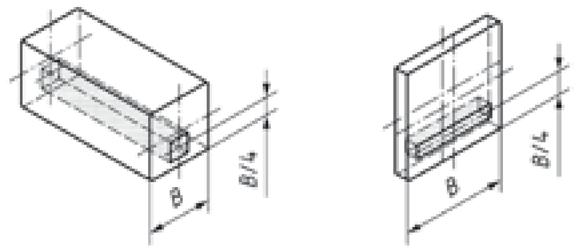
Sample-taking

Sample positions

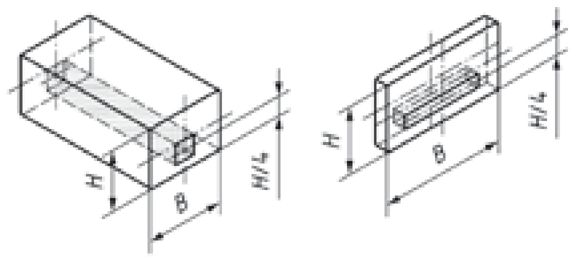
Round



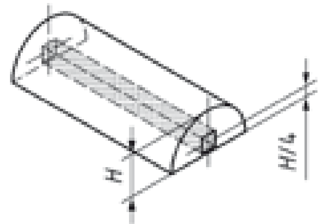
Square



Rectangular



Half round



If D/4, B/4 and/or H/4 ≤ 10 mm, take samples directly at the outer contour.
D = Diameter
H = Height
B = Width

Notes regarding this specification:

For rectangular cross-sections, the smallest dimension is the reference.
In round bars, the diameter is the reference.

Example

Material: EN-GJS-400-15C

Dimensions: rectangle 130 x 90 x 3150 mm

→ Reference dimension 90 mm

Aim specification (extract from table 5.1)

Material designation		Bar diameter D	0.2 % proof stress $R_{p0.2}$ MPa	Tensile strength R_m MPa	Elongation A %	Brinell hardness a) HBW	
Designation	Number	[mm]	min.	min.	min.	min.	max.
EN-GJS-400-15C	5.3126	20 < D ≤ 60	250	400	15	130	180
		60 < D ≤ 120	250	390	14		
		120 < D ≤ 400	240	370	11		

a) Brinell hardness is guaranteed (not stipulated in EN 16482).

Concast grey iron

1. Mechanical properties, grey iron

1.1 Tensile strength/Brinell hardness

Material designation		Bar diameter D	Tensile strength R_m MPa	Brinell hardness a) HBW	
Designation	Number	[mm]	min.	min.	max.
EN-GJL-150C	5.1102	20 < D ≤ 50	110	110	180
		50 < D ≤ 100	100		
		100 < D ≤ 200	90		
		200 < D ≤ 400	80		
EN-GJL-250C	5.1203	20 < D ≤ 50	195	170	240
		50 < D ≤ 100	180		
		100 < D ≤ 200	165		
		200 < D ≤ 400	155		
EN-GJL-300C	5.1308	20 < D ≤ 50	220	200	290
		50 < D ≤ 100	205		
		100 < D ≤ 200	195		
		200 < D ≤ 400	185		

a) Brinell hardness is guaranteed (not stipulated in EN 16482).

2. Microstructure

2.1 Matrix type

Material designation	Matrix
EN-GJL-150C	ferritic
EN-GJL-250C	pearlitic-ferritic
EN-GJL-300C	mainly pearlitic

2.2 Graphite morphology as per EN ISO 945

Sample-taking locations	Bar dimensions [mm]	Graphite configuration
Surface zone	all	Type I, Configuration D (max. 15% of E and A together)
Centre	H and/or D ≤ 100	Type I, Configuration A (max. 20% of B, D and E together)
Centre	H and/or D > 100 ≤ 150	Type I, Configuration A (max. 20% of B, D and E together)
Centre	H and/or D > 150	Type I, Configuration A (max. 20% of B, D and E together)

C-configuration graphite is not admissible.

2.3 Microstructure of matrix

Material designation	Pearlite content [%]	
	Surface zone	Centre
EN-GJL-150C	≤ 10	≤ 10
EN-GJL-250C	> 10	> 60
EN-GJL-300C	> 10	> 80

2.4 Chemical composition

Chemical compositions are defined in appropriate factory standards designed to meet the mechanical-property stipulations in EN 16482.

3. As-cast dimensional tolerances

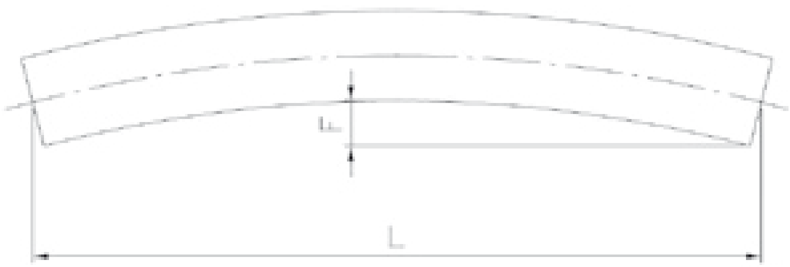
3.1 General tolerances (dimensions)

Diameter [D]/Height [H]/Width [B] [mm]	Tolerance [mm]
≤ 100	± 1.0
> 100 ≤ 150	± 1.5
> 150 ≤ 300	± 2.0
> 300	± 3.0

3.2 Straightness

Length [mm]	Maximum height of arc (F) [mm]	
l	as-cast	annealed
1 000	2	3
2 000	4	6
3 000	6	9

Illustration:

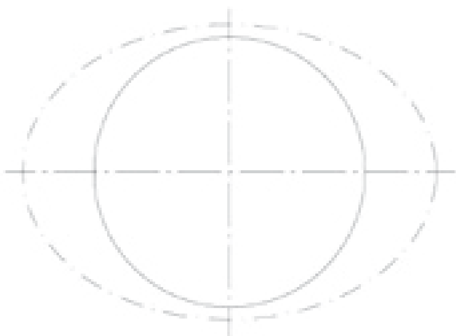


3.3 Ovality and flatness

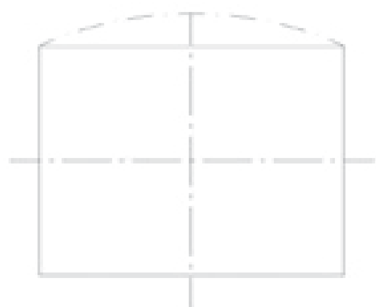
Diameter [D]/ Height [H]/Width [B] [mm]	Maximum allowed ovality (round dimensions) [mm]	Maximum allowed flatness deviation (rectangular and square dimensions) [mm]
$20 < D < 50$	-	5
$50 < D < 100$	1	7
$100 < D < 200$	2	10
$200 < D < 300$	4	12
$300 < D < 400$	5	15
D > 400	to be agreed	

Illustrations:

Ovality



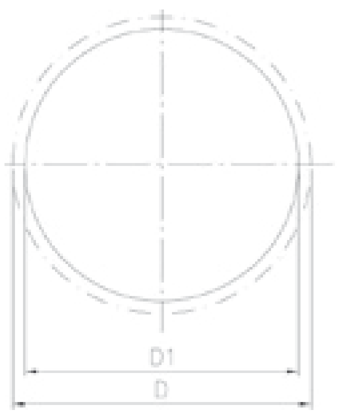
Flatness

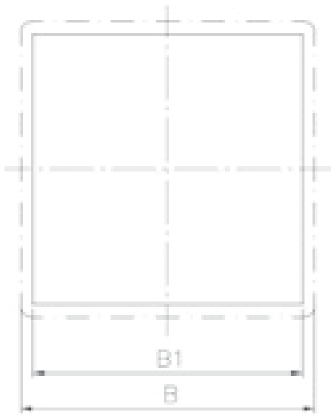


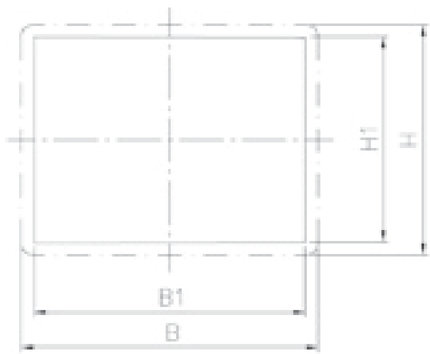
4. Minimum machining allowances

Bar diameter D or bar width B a) [mm]	Minimum machining allowance relative to the radius or half the width of the bar circular [mm]	rectangular [mm]
20 < D or B < 50	2.0	2.5
50 < D or B < 100	3.0	3.5
100 < D or B < 200	4.0	4.5
200 < D or B < 300	6.0	6.5
300 < D or B < 400	7.0	7.5
400 < D or B < 500	9.0	9.5
500 < D or B < 650	11.0	11.5

a) In rectangular castings, the width is the longest cross-sectional dimension.







Notes regarding this specification:

In round bars, the diameter is the reference dimension.
In rectangular bars, machining allowances may be different for height and width.

Example

Material: EN-GJL-250C

Dimensions: rectangular 130 x 90 x 3150 mm

→ Minimum machining allowance
Width 130 mm = 4.5 mm per side
Height 90 mm = 3.5 mm per side

Concast ductile iron

5. Mechanical properties, ductile iron

5.1 Tensile strength/Brinell hardness

Material designation		Bar diameter D	0.2 % proof stress $R_{p0.2}$ MPa	Tensile strength R_m MPa	Elongation A %	Brinell hardness HBW c)	
Designation	Number	[mm]	min.	min.	min.	min.	max.
EN-GJS-350-22C-LT	5.3120	20 < D ≤ 60	220	350	22	110	150
		60 < D ≤ 120	210	330	18		
		120 < D ≤ 400	200	320	15		
EN-GJS-350-22C-RT	5.3121	20 < D ≤ 60	220	350	22	110	150
		60 < D ≤ 120	220	330	18		
		120 < D ≤ 400	210	320	15		
EN-GJS-350-22C	5.3122	20 < D ≤ 60	220	350	22	110	150
		60 < D ≤ 120	220	330	18		
		120 < D ≤ 400	210	320	15		
EN-GJS-400-18C-LT	5.3123	20 < D ≤ 60	240	400	18	130	180
		60 < D ≤ 120	230	380	15		
		120 < D ≤ 400	220	360	12		
EN-GJS-400-18C-RT	5.3124	20 < D ≤ 60	250	400	18	130	180
		60 < D ≤ 120	250	390	15		
		120 < D ≤ 400	240	370	12		
EN-GJS-400-18C	5.3125	20 < D ≤ 60	250	400	18	130	180
		60 < D ≤ 120	250	390	15		
		120 < D ≤ 400	240	370	12		
EN-GJS-400-15C a)	5.3126	20 < D ≤ 60	250	400	15	130	180
		60 < D ≤ 120	250	390	14		
		120 < D ≤ 400	240	370	11		
EN-GJS-500-14C a), b)	5.3129	20 < D ≤ 60	400	500	14	180	220
		60 < D ≤ 120	390	480	12		
		120 < D ≤ 400	360	470	10		
EN-GJS-500-7C a)	5.3203	20 < D ≤ 60	320	500	7	150	240
		60 < D ≤ 120	300	450	7		
		120 < D ≤ 400	290	420	5		
EN-GJS-600-3C a)	5.3204	20 < D ≤ 60	370	600	3	200	290
		60 < D ≤ 120	360	600	2		
		120 < D ≤ 400	340	550	1		
EN-GJS-700-2C a)	5.3303	20 < D ≤ 60	420	700	2	235	310
		60 < D ≤ 120	400	700	2		
		120 < D ≤ 400	380	650	1		

a) Depending on the process applied, these materials may contain free carbides in small quantities.
b) Solid-solution strengthened ferritic cast iron with nodular graphite.
c) Brinell hardness is guaranteed (not stipulated in EN 16482).

5.2 Charpy V-notch impact energy EN-GJS-400-18C-LT and -RT

Material designation	Dimensions: Diameter [D]/ Height [H]/Width [B]	Minimum KV (J) at -20°C+/-2°C		Minimum KV (J) at 23°C+/-5°C	
	[mm]	Mean of 3 tests	Single value	Mean of 3 tests	Single value
EN-GJS-400-18C-LT	20 < D ≤ 120 120 < D ≤ 400	12 10	9 7		
EN-GJS-400-18C-RT	20 < D ≤ 120 120 < D ≤ 400			14 12	11 9

5.3 Charpy V-notch impact energy EN-GJS-350-22C-LT and -RT

Material designation	Dimensions: Diameter [D]/ Height [H]/Width [B]	Minimum KV (J) at -40°C+/-2°C		Minimum KV (J) at 23°C+/-5°C	
	[mm]	Mean of 3 tests	Single value	Mean of 3 tests	Single value
EN-GJS-350-22C-LT	20 < D ≤ 120 120 < D ≤ 400	12 10	9 7		
EN-GJS-350-22C-RT	20 < D ≤ 120 120 < D ≤ 400			17 14	14 11

5.4 Additional information: modulus of elasticity and fracture toughness

(Examples of mechanical properties measured on bar with as-cast dimension 160 mm.)

Material designation	Test temperature	0.2 % proof stress $R_{p0.2}$ MPa a)	Tensile strength R_m MPa a)	Elongation A % a)	Elasticity modulus E GN/m² b)	Fracture toughness K_I MPa√m a), c)
EN-GJS-400-18C-LT	RT	256	372	22.5	169	43.7
	- 20 °C	277	397	19.5	170	-
EN-GJS-400-18C	RT	300	424	26.0	171	50.3
	- 20 °C	330	453	23.5	172	-
EN-GJS-500-7C	RT	354	533	15.0	177	41.0
	- 20 °C	382	558	16.0	178	-
EN-GJS-500-14C	RT	391	504	19.5	173	46.5
	- 20 °C	421	535	20.5	175	-
EN-GJS-600-3C	RT	448	782	7.0	166	23.3 (K_{IC})
	- 20 °C	473	753	3.0	167	-

a) Mean of 3 measurements
b) Mean of 5 measurements
c) Tested in conformance with ISO 12135, test bar SE (B) 10

6. Microstructure

6.1 Matrix type

Material designation		Matrix
EN-GJS-350-22C-LT		ferritic
EN-GJS-350-22C-RT		ferritic
EN-GJS-350-22C		ferritic
EN-GJS-400-18C-LT		ferritic
EN-GJS-400-18C-RT		ferritic
EN-GJS-400-18C		ferritic
EN-GJS-400-15C		ferritic
EN-GJS-500-14C	a), b)	ferritic
EN-GJS-500-7C	a)	ferritic-pearlitic
EN-GJS-600-3C	a)	pearlitic-ferritic
EN-GJS-700-2C	a)	mainly pearlitic

a) Depending on the method employed, these materials may contain free carbides in small quantities.
b) Solid-solution strengthened ferritic cast iron with nodular graphite.

6.2 Graphite morphology as per EN ISO 945

Sample-taking locations	Bar dimensions [mm]	Graphite configuration
Surface zone	all	> 80 % types VI + V
Centre	H and/or D ≤ 100	> 95 % types VI + V
Centre	H and/or D > 100 ≤ 150	> 95 % types VI + V
Centre	H and/or D > 150	> 90 % types VI + V

Graphite belonging to types I and II is not admissible across the entire section.
Graphite belonging to type III is admissible up to 5% max. across the entire section.
Graphite belonging to type IV is admissible up to 10% max. at the centre of bars with > 150 mm H and/or D.

6.3 Microstructure of matrix

Material designation		Pearlite content [%]	
		Surface zone	Centre
EN-GJS-350-22C-LT		≤ 10	≤ 10
EN-GJS-350-22C-RT		≤ 10	≤ 10
EN-GJS-350-22C		≤ 10	≤ 10
EN-GJS-400-18C-LT		≤ 10	≤ 10
EN-GJS-400-18C-RT		≤ 10	≤ 10
EN-GJS-400-18C		≤ 10	≤ 10
EN-GJS-400-15C		≤ 10	≤ 10
EN-GJS-500-14C	a), b)	≤ 10	≤ 10
EN-GJS-500-7C	a)	> 10	> 20 ≤ 80
EN-GJS-600-3C	a)	> 10	> 60
EN-GJS-700-2C	a)	> 10	> 80

a) Depending on the method employed, these materials may contain free carbides in small quantities.
b) Solid-solution strengthened ferritic cast iron with nodular graphite.

6.4 Chemical composition

Chemical compositions are defined in appropriate factory standards designed to meet the mechanical-property stipulations in EN 16482.

7. As-cast dimensional tolerances

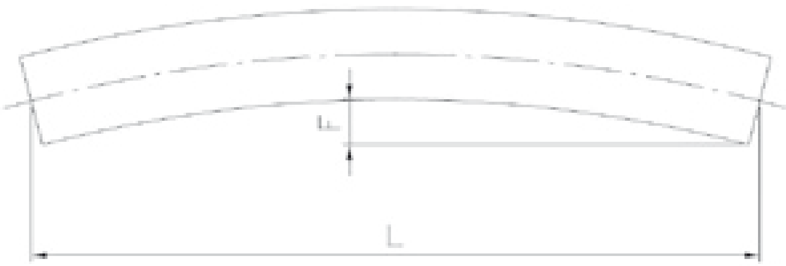
7.1 General tolerances (dimensions)

Diameter [D]/Height [H]/Width [B] [mm]	Tolerance [mm]
≤ 100	± 1.0
> 100 ≤ 150	± 1.5
> 150 ≤ 300	± 2.0
> 300	± 3.0

7.2 Straightness

Length [mm]	Maximum height of arc (F) [mm]	
l	as-cast	annealed
1 000	2	3
2 000	4	6
3 000	6	9

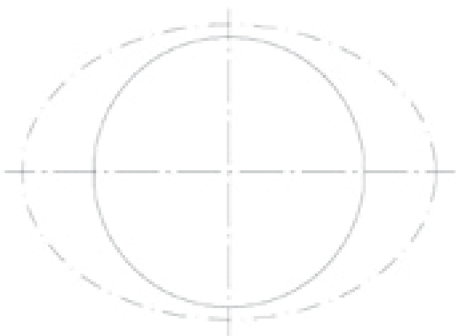
Illustration:

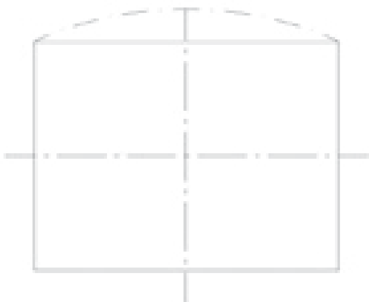


7.3 Ovality and flatness

Diameter [D]/ Height [H]/Width [B] [mm]	Maximum allowed ovality (round dimensions) [mm]	Maximum allowed flatness deviation (rectangular and square dimensions) [mm]
20 < D < 50		5
50 < D < 100	2	7
100 < D < 200	3	10
200 < D < 300	4	12
300 < D < 400	5	15
D > 400	to be agreed	

Illustrations: **Ovality** **Flatness**

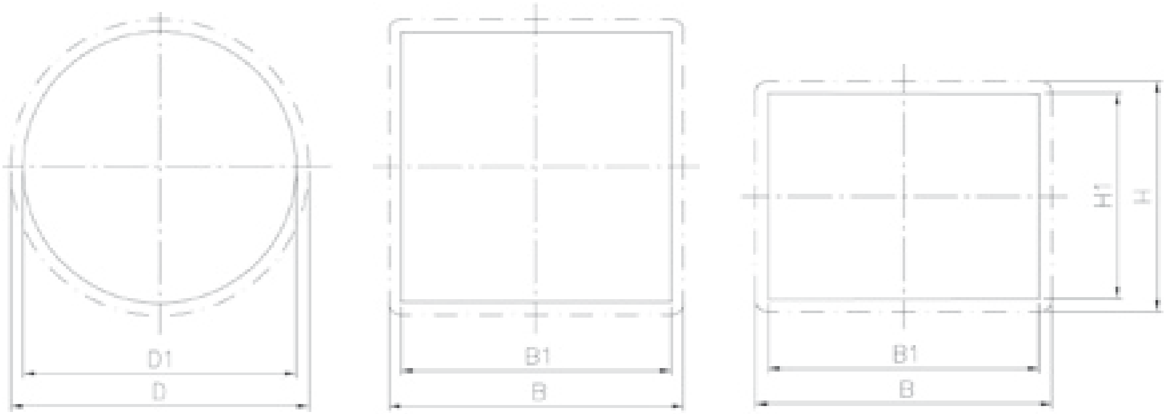




8. Minimum machining allowances

Bar diameter D or bar width B a)	Minimum machining allowance relative to the radius or half the width of the bar	
[mm]	circular [mm]	rectangular [mm]
20 < D or B < 50	3.0	3.5
50 < D or B < 100	4.0	4.5
100 < D or B < 200	5.0	5.5
200 < D or B < 300	7.0	7.5
300 < D or B < 400	8.0	8.5
400 < D or B < 500	10.0	10.5
500 < D or B < 650	12.0	12.5

a) In rectangular castings, the width is the longest cross-sectional dimension.



Notes regarding this specification:

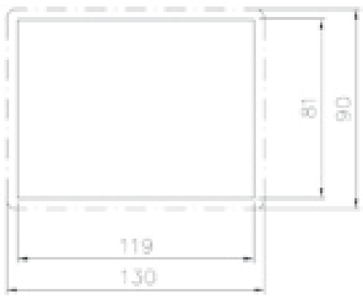
In round bars, the diameter shall be the reference dimension.
In rectangular bars, machining allowances may be different for height and width.

Example

Material: EN-GJS-400-15C

Dimensions: rectangular 130 x 90 x 3150 mm

→ Minimum machining allowance
Width 130 mm = 5.5 mm per side
Height 90 mm = 4.5 mm per side



9. Acceptable limits

9.1 Surface defects

Scoring and overlapping draw marks are admissible only if their depth is within the range of the machining allowance.

9.2 Inhomogeneities

Macroscopically visible defects exposed by machining do not constitute cause for complaint so long as they do not affect the function of the part being processed.

10.0 Bibliography

[1] DIN EN 1561, Gießereiwesen – Gusseisen mit Lamellengraphit
[2] DIN EN 1563, Gießereiwesen – Gusseisen mit Kugelgraphit
[3] Herfurth, K.: Gusseisen-Strangguss für eine innovative Teilefertigung, Konstruieren + Gießen 20 (2005) Nr. 3, S. 2-17.[1])
[4] Herfurth, K.: Gusseisen-Strangguss, Qualitätsbewertung, Konstruieren + Gießen 33 (2008) Nr. 2, S. 11-20.[2])
[5] EN 1560, Gießereiwesen – Bezeichnungssystem für Gusseisen – Werkstoffkurzzeichen und Werkstoffnummern
[6] EN ISO 1101, Geometrische Produktspezifikation (GPS) – Geometrische Tolerierung – Tolerierung von Form, Richtung, Ort und Lauf (ISO 1101:2004)
[7] WN 0-200.001 Gusseisen aus Kugelgraphit ACO Eurobar® Ausgabe 2007
[8] DIN EN 16482 Gießereiwesen – Gusseisen – Strangguss
[9] CAEF, Continuous Casting Section, Prüfbericht: Ermittlung der Kennwerte des statischen J-integrals nach ISO 12135 an sechs unterschiedlichen Werkstoffen bei -20° C sowie bei Raumtemperatur, January 2012.

Introduction

Some features, visible to the naked eye, on bars of continuous-cast iron are often interpreted differently by manufacturers and users. These might be referred to by different names and opinions could differ in relation to their significance in the final application for which the material is used.

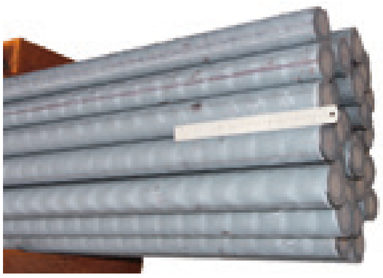
A mutual understanding is therefore clearly desirable if only from the point of view of minimising disputes. These few pages will hopefully serve as a base for this common ground and for a consistency of nomenclature.

Process-related characteristics

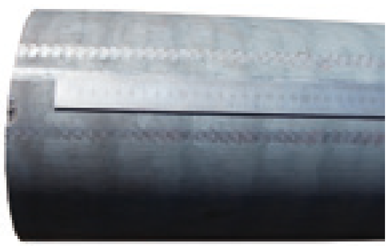
The term process-related characteristics refers to features that are indigenous to continuous casting of bars as a manufacturing method. Examples are surface draw marks, divergent near-surface microstructure and shape deviations. In most instances, these irregularities occur within the machining allowance and are thus eliminated in the final component. A relevant technical documentation, like this one, or an agreed product specification must define to what degree such characteristics are inadmissible, thus constituting a defect and thereby the basis for a claim.

Marks on bar surfaces

The drawing cycle in continuous casting of cast iron bars is made up of a pull phase with intermittent periods of holding. This results in circumferential draw marks on the bar surface, the spacing of which corresponds to the step length of the pull phase. This spacing can vary with dimension, section shape and type of iron. Clearly visible to the naked eye, these draw marks are also coupled with local variations in near surface microstructure. Removal of the bar surface in accordance with stipulated machining allowances eliminates such irregularities. Longitudinal marks, which originate from the pulling device used in the continuous casting process, can also sometimes be observed on bars. These are often more prevalent in the corner regions of square or rectangular bars. Again, these features are eliminated in removal of the machining allowance.



Circumferential drawing marks with spacing 55 mm.



Longitudinal marks derived from the pulling device.

Machining allowances

The rapidly solidified chill zone of a bar of continuous-cast iron is characterised by a microstructure which deviates considerably from that in the major part of the section which solidifies more slowly. Furthermore, the bar surface region is characterised by other irregularities such as draw marks, shape deviations, oxidation and excessive roughness.

The recommended machining allowances are designed to ensure that all such unwanted features are eliminated. The actual depths of material which need to be removed depends on dimension, shape and type of iron, grey or ductile. Any irregularities within the stipulated machining allowances can not to be considered as non-conformities.

1. Material characteristics and defects

1.1 Mechanical properties

Tensile strength

This is the engineering stress corresponding to the maximum load on the tensile-test curve, most often denoted by the symbol R_m.

Tensile strength is usually expressed in the completely equivalent units N/mm^2 or MPa.

Proof stress

The transition from elastic to plastic deformation, corresponding to the yield stress, is often quite difficult to establish unambiguously, especially in routine testing for quality control. For this reason, yielding is often defined in terms of a proof stress, which is the stress corresponding to a very small degree of plastic strain, usually 0.2% and denoted $R_{p0.2}$. This quantity can be accurately established from the load elongation curve as measured in a tensile test. $R_{p0.2}$ in common with R_m is measured in N/mm^2 or MPa.

Elongation at fracture

Prior to yielding, the tensile-test sample reverts to its original length if the load is removed (elastic deformation). Once the yield point has been passed, however, the sample will have undergone a permanent elongation (plastic deformation). The elongation at fracture is defined as the ratio of the elongation of the broken sample in relation to an original reference length, usually expressed as a percentage.

Impact toughness

Toughness defines the resistance of a material to fracture by the initiation and spread of cracks. It can be measured in many ways but the simplest, which readily lends itself to quality control, is the notched impact test, of which the most common is the Charpy V-notch test. In this test, a notched sample with specific geometry is broken in a testing machine which is calibrated to record the energy absorbed in fracture. A brittle material is characterised by low energy absorption while if the absorbed energy is high, the material is tough. Charpy-V impact toughness is measured in Joules.

Hardness

Hardness is the resistance of a material to indentation by an external force applied via an indenter made of a hard material. For cast iron, the normal method used for hardness measurement is Brinell in which the indenter is a sphere of hardened steel or cemented carbide. The Brinell hardness is calculated from the load used in kg divided by the area of the hardness impression in square mm. It is usually presented as a number followed by the letters HB or HBW, where the “W”, if applicable, signifies that a cemented-carbide ball indenter has been used.

1.2 Microstructural characteristics and defects

Matrix

The matrix of a cast iron is the iron-rich constituent which surrounds and binds together graphite which takes the form of flakes in grey iron or nodules in ductile iron. The matrix can contain some residual carbon as iron carbide (cementite) which together with ferrite (virtually pure iron) forms a finely-divided phase mixture called pearlite. The matrix microstructure in cast iron is defined in terms of the relative amounts of ferrite and pearlite. The microstructure of the matrix can be influenced by alloying the iron or by heat treating it. For example, pearlite is virtually eliminated by annealing resulting in a fully ferritic matrix.

Graphite morphology

The graphite morphology classification defines the size, shape, distribution and type of graphite particles in cast iron. The most usual graphite types are lamellae in grey iron or nodules in ductile iron but other intermediate forms also exist. The morphological characteristics of the graphite are defined in standards such as DIN EN ISO 945 or the American standard ASTM A247 06.

Carbides

Chill Carbides

If a cast-iron melt solidifies quickly, there is a tendency for the carbon to combine with iron as iron carbide (cementite) instead of precipitating as graphite. The carbide particles so formed can be relatively large and detract from mechanical properties, the principal negative effect being brittleness. Chill carbides can be a problem in thin walled castings but are normally not an issue for continuous-cast bar which cools relatively slowly. They can, however, be found in the surface chill zone of continuous-cast iron which is embodied in the machining allowance. Thus, the experience often is that tool life is lowered during removal of the outer region of a bar of continuous-cast iron.

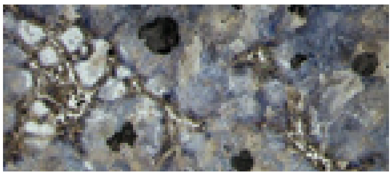
Fracture surface displaying chill.

Inverse chill

This is a characteristic of large diameter round bars for which solidification of the centre region takes a long time. Depletion of silicon (which promotes graphite) and concentration of carbide-stabilising impurities with a high affinity for oxygen both contribute to increasing the probability for nucleation of carbides in this central zone.

Intergranular carbides

Such carbides arise through segregation of carbide-promoting elements at the boundaries of the eutectic cells which on a microscopic scale solidify last. Carbide particles of this intergranular type are relatively small but can impair machinability.



Intergranular carbides, magn. 100

Three different modes of segregation some of which can play a part in carbide formation

Segregation due to density differences

This type of segregation derives from density differences between primary crystals and the remaining melt.
The constituents with highest density will sink and those which are lighter will rise. The most pronounced consequence of this mechanism is so-called graphite flotation in ductile iron and kish graphite in grey iron. These assemblages of degenerate graphite can extend from the surface and deep into the interior of a continuous-cast bar.

Macro-segregation

Can originate from stratification or inadequate homogenisation of the molten iron prior to casting. Furthermore, the outer part of a continuous-cast bar which solidifies first has a lower content of alloying elements leading to their concentration in the remaining melt. Hence, the central regions of the bar tend to be alloy rich compared with the surface.

Micro-segregation

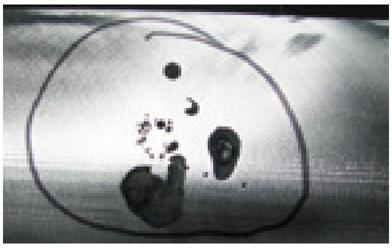
Micro-segregation or coring occurs because certain alloy elements tend to concentrate around the graphite in a eutectic cell whereas others are concentrated in the regions which solidify last. Sometimes these compositional differences are not evened out via diffusion and, micro-segregation results. Impurities and trace elements can slow down diffusion and thereby promote this type of segregation.

1.3 Macroscopic inhomogeneities

Inclusions

Cast iron contains alloying additions which oxidise easily, for example silicon and in ductile iron, magnesium. Reaction of these additions with oxygen gives rise to slag on the surface of the melt and this is reduced to a minimum by de-slagging and skimming. With modern practice and process control technology, it is possible to prevent most of this slag from entering the cast product, but smaller inclusions in the continuous-cast bar might be found from time to time. They are normally of indefinable shape and have irregular interfaces. Slag inclusions being lighter than the iron are normally concentrated to the zones of the bar which have faced upwards during the casting process.

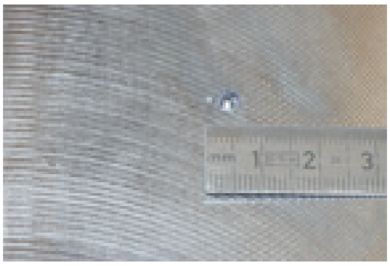
Slag inclusion with a rough, irregular interface.



Cluster with larger and smaller inclusions.

Pores

Pores derive from gas dissolved in the melt. Most of this will diffuse out of the melt before it solidifies but the little that remains can precipitate in the form of bubbles which after solidification remain as pores that are spherical in shape and have smooth walls. Pores if present are found mostly in the side of the bar which has been upwards during casting since gas bubbles naturally migrate upwards in the melt. They can occur singly or in irregularly-spaced groups.



Pore with smooth, shiny surface.

Cluster of pores with diverse sizes.

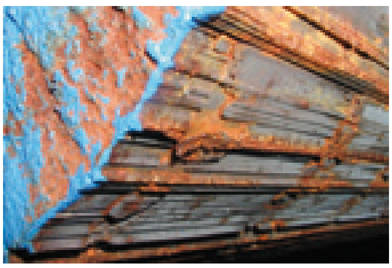
2. Manufacturing

2.1 Defects derived from the manufacturing process

Scores

Scores are longitudinal grooves originating from a damaged continuous-casting mould. They are removable by machining have no negative effects for the mechanical properties of the underlying material. Increased tool wear when machining a scored surface can be lessened by judicious selection of machining parameters such that the tool is loaded as evenly as possible to mitigate the degree of abrasion.

Score along an edge.



Scores on a large diameter round bar.

Drawing-step overlaps

The origin of draw marks has been explained previously on p.16. The distance that the bar is pulled forward in each draw is called the drawing step. During holding when the bar is not being pulled, the outer shell defining the external shape of the bar solidifies in the mould. If inside the mould there is insufficient binding between solidified material and the liquid next in line to solidify, the result may well be a drawing-step overlap.

Such defects are regularly spaced and tend to be restricted to the side of the bar which faces upwards during casting. These defects can sometimes be so deep that they are still evident even after removal of the machining allowance. In less severe instances, they will appear in the form of edge cracks after machining. Exceptionally, drawing-step overlaps can actually extend across an entire bar section.

Appearance of drawing-step overlaps at the end of a bar.

Drawing-step overlaps on a rectangular bar as cast.

Drawing-step overlaps on a round bar as cast.

Drawing-step overlap on a rectangular bar machined on one face.

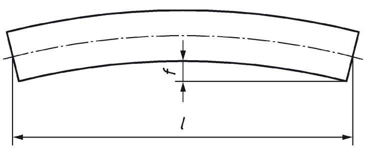
2.2 Definitions related to dimension and shape

Dimensional tolerance and straightness

The dimensional tolerance defines the allowable difference between a measured and the nominal dimension of a bar. The surface contour of a bar must lie between two lines separated by the allowed dimensional tolerance, t, as shown.

Permitted variance of surface profile.

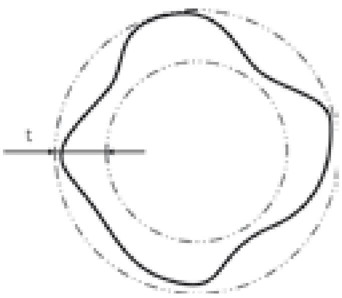
Straightness is measured as height of arc (f) when the bar is placed on a flat surface.



Straightness defined as height of arc.

Out of roundness

For cast-iron round bar made by continuous casting, the out of roundness or ovality (t) is defined as the distance between inscribed and circumscribed circles into which the bar cross section can be placed. The permitted out of roundness depends on the type of cast iron, grey or ductile, and increases with increasing diameter.



Defining out of roundness.

Flatness

For cast-iron square or rectangular bars made by continuous casting, the flatness (t) is defined as the distance between two parallel planes within which the entire surface must lie. The permitted flatness deviation increases with increasing dimension.

Defining flatness.

3. Non-conformances that may occur during machining

3.1 Administrative errors

An event that occurs during or before the generation of a work order, preventing the implementation of the customer's specifications. Such events include communication errors, omission of necessary data, and deadline scheduling.

3.2 Semi-finished machined product

Semis: nominal size
Non-conformance caused by the use of semis having unsuitable initial dimensions.

Semis: material
Non-conformance caused by the use of semis with incorrect material.

3.3 Oxidation

Corrosion results from a reaction between a material and its environment which gives rise to measurable changes in the material and may impair the function of a component or system. Corrosion of cast iron results in rusting.

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EN 16482, current version

About us

ACO Eurobar – the specialist for continuous casting

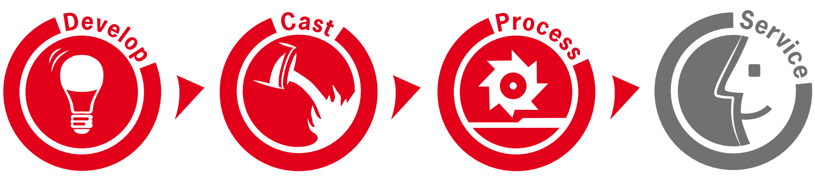
Based upon know-how and competence, ACO Eurobar has become the largest producer of continuous-cast iron in Germany and one of the key players in Europe. As a full-service provider with complete mechanical machining, ACO Eurobar is your expert contact for quality continuous casting.

Innovative materials with considerable potential as substitutes for others, along with cost-efficient, high-quality and increasingly more sophisticated machined continuous-cast products are the top priority for our customers. Our job as a continuous casting specialist is to provide tailored solutions based upon state-of-the-art plant technology: e.g. as-cast parts in the most varying materials as well as pre-machined semis or fully-finished parts from our efficient machine park. ACO Eurobar can offer sawing, turning, peeling and milling. All products and solutions are individually tailored to the needs of our customers and to their area of application. Quality continuous-cast products from ACO Eurobar are used for example in the hydraulics industry, mechanical and machine-tool engineering, in glass manufacture or the automotive industry.

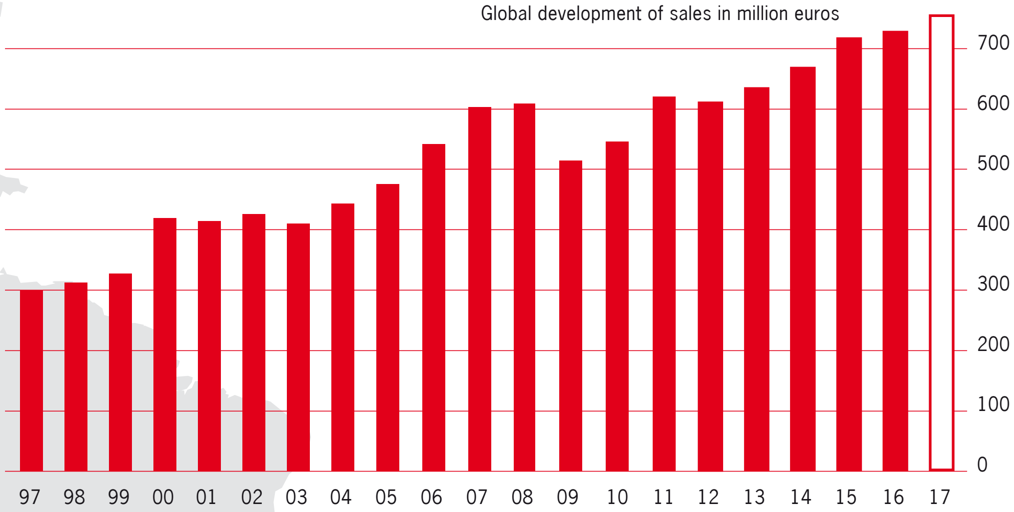
Backed by the competence of a modern foundry with tradition: ACO Guss

ACO Eurobar GmbH is a subsidiary of ACO Guss GmbH, which is a specialist in iron casting and one of the leading foundries in Europe with a long history and tradition based upon competence and expertise. The current high-tech production facility in Kaiserslautern has a melting capacity of 75,000 tons per year and employs a staff of several hundreds of casting experts to produce customized machine-moulded castings, continuous-cast iron bars and construction casting.

Our competences



Together with its national and international production and sales companies, ACO Guss GmbH strives to collaborate with its customers in a spirit of partnership. We work closely together throughout the entire development, production and machining process, thus enabling us to implement customer-specific, high-quality and economical products. ACO remains the reliable consultant even beyond the product itself, offering comprehensive service and support. Consistently expanding our production and sales companies, we assure competent support in each region, quick delivery and the availability of a wide range of products of proven ACO Guss and ACO Eurobar® cast iron quality across Europe and South Africa.



The ACO Group.

A strong family you can build on.

As a member of the ACO Group headquartered in Büdelsdorf near Rendsburg, we are part of a strong and healthy family-owned company.

As a global market leader, ACO creates drainage solutions for the environmental conditions of tomorrow. Ever more extreme weather conditions demand increasingly more complex drainage concepts in underground and over-ground civil engineering and in building technology. ACO creates system solutions that help protect people against the water and vice versa.This core competency is complemented by special business areas such as construction casting, continuous casting, special stainless steel construction, process engineering, amphibian protection and animal husbandry systems.

All over the world, customers benefit from the strengths of the ACO Group:

- the continuity of management offered by a family-owned company,
- market leadership in the core business surface drainage
- the majority of development and production in-house
- local presence in the growth markets across the world
- and the clear positioning as a leader in quality and innovation

As a family company with reliable values and principles, ACO, under the management of Hans-Julius Ahlmann and his son Iver Ahlmann, attaches the utmost importance to transparency and continuity with respect to customers, partners and employees. The sharing and exchanging of knowledge, among other places, for example at the ACO Academy, and a lively multi-cultural corporate culture round off the image of a global player, but which never forgets its roots and keeps its feet firmly on the ground.

ACO at a glance

- 1946 foundation of the company by Josef-Severin Ahlmann
- 4,400 employees in over 40 countries (Europe, North and South America, Asia, Australia, Africa)
- 30 production sites in 15 countries
- Sales 2016: 711 million euros

ACO Eurobar GmbH

Am Gusswerk 8
67663 Kaiserslautern
Germany
Tel. +49 631 2011-0
Fax +49 631 2011-459
info@aco-eurobar.com
www.aco-eurobar.com

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