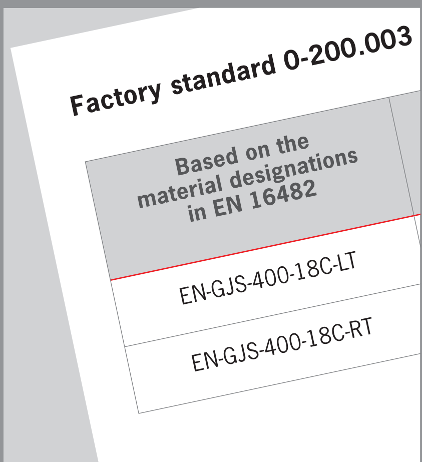


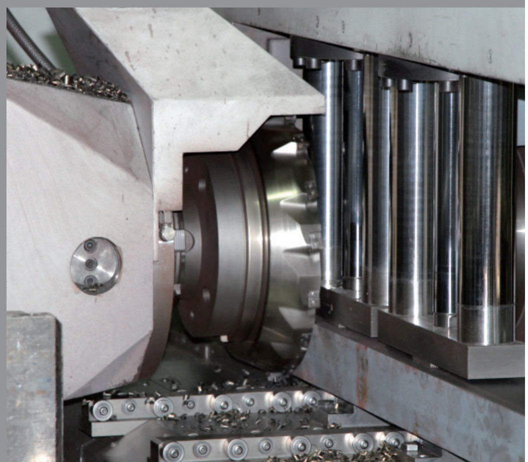

ACO Eurobar® Concast Iron

Technical Documentation

It gives us great pleasure to present the new ACO Eurobar® works standard.
We at ACO Eurobar, a specialist for continuous-cast iron, have revised the Technical Documentation pertinent to our high-quality continuous-cast iron bar products.

There has for some time existed a need for a standard for continuous-cast irons. Apart from providing a guidance for manufacturers, such a standard would facilitate preparation of offers while at the same time constituting a basis for comparison between materials from various sources. Hence, it is especially gratifying that a European standard "EN 16482 – Cast Iron – Continuous Casting" is now agreed upon and available. It is the publication of this new standard that is the primary driving force for us to amend the Technical Documentation that you are now reading.

The first section of the Technical Documentation furnishes a detailed description of the ACO Eurobar programme in relation to product characteristics and quality with particular emphasis on the changes which accrue from the instigation of EN 16482. Further, the extent to which ACO Eurobar products exceed the requirements in the new standard is emphasised. Examples of assured properties over and above what is stipulated in EN 16482 are:

- Guaranteed levels of Brinell Hardness;
- Graphite shape specification;
- Quantitative specifications for matrix microstructure;
- For some products, guarantees for minimum levels of Charpy-V impact energy.

These supplementary guarantees ensure that you are supplied with a product which exceeds the regular market standard.

The second part of the document focusses upon some typical features and characteristics of continuous-cast irons and their influence on mechanical properties. The aim here is to provide an unambiguous interpretation so that the basis for eventual stipulations additional to those in EN 16482 is well-founded from the point of view of users as well as manufacturers.

In addition to supplying a product with outstanding quality, which at least conforms to and in many respects exceeds the requirements of the new EN 16482 standard, you may rest assured that our speed of response and delivery, flexibility and absolute attention to customer demands remain unchanged. If you have any questions concerning this revised Technical Documentation, you are very welcome to contact us directly.

We look forward to a continued fruitful collaboration.

Your team at ACO Eurobar.

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Comparison of EN 16482 and ACO Eurobar® material designations incl. colour coding

ACO Eurobar® cast iron with grey cast iron and nodular graphite

Material designation as per EN 16482		Material designation as per ACO Eurobar®	Colour coding* ACO Eurobar®
Designation	Number		
EN-GJL-150C	5.1102	GG-F	grey/red
EN-GJL-250C	5.1203	GG-FP	grey
EN-GJL-300C	5.1308	GG-P	black

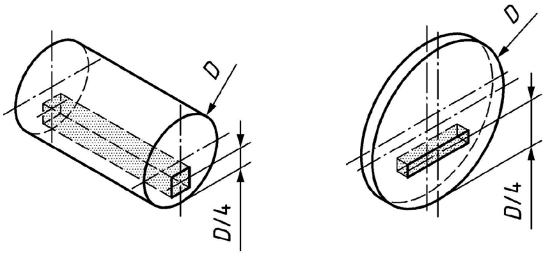
Material designation as per EN 16482		Material designation as per ACO Eurobar®	Matrix	Colour coding* ACO Eurobar®
Designation	Number			
EN-GJS-350-22C-LT	5.3120	GGG 35.3 LT	ferritic	yellow/red
EN-GJS-350-22C-RT	5.3121	GGG 35.3 RT	ferritic	yellow/red
EN-GJS-350-22C	5.3122	GGG 35.3	ferritic	yellow/red
EN-GJS-400-18C-LT	5.3123	GGG 40.3 LT	ferritic	yellow/red
EN-GJS-400-18C-RT	5.3124	GGG 40.3 RT	ferritic	yellow/red
EN-GJS-400-18C	5.3125	GGG 40.3	ferritic	yellow/red
EN-GJS-400-15C	5.3126	GGG 40	ferritic	yellow/red
EN-GJS-500-7C	5.3203	GGG 40/50	ferritic-pearlitic	yellow
EN-GJS-500-14C	5.3129	EN-GJS 500-14	ferritic	green
EN-GJS-600-3C	5.3204	GGG 60	pearlitic-ferritic	blue
EN-GJS-700-2C	5.3303	GGG 70	mainly pearlitic	white

*) All color codes are based on the international RAL color code. 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.

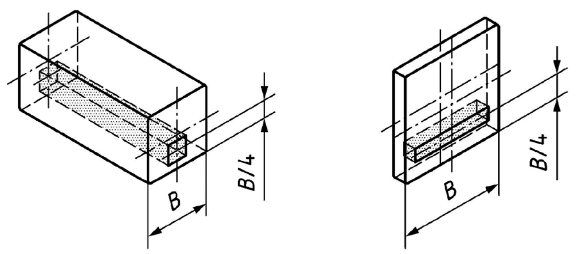
Sample-taking

Sample locations

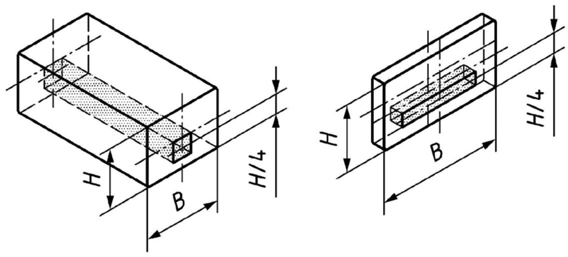
Round



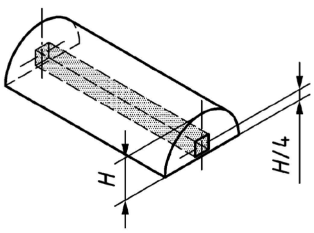
Square



Rectangular



Half round



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

Notes and/or instructions regarding this specification:

In rectangular cross-sections, the smallest dimension shall be the reference strand dimension. In round bars, the diameter shall be the reference dimension.

Example (explanation)

Material: EN-GJS-400-15C

Dimensions: rectangle 130 x 90 x 3150 mm

→ Controlling strand dimension 90 mm

Target specifications (extract from table 5.1)

Material designation		Strand diameter D	0,2 % Proof stress $R_{p\,0,2}$ MPa	Tensile strength R_m MPa	Elongation A %	Brinell hardness HBW	
Designation	Number	[mm]	min.	min.	min.	min.	max.
		20 < D ≤ 60	250	400	15		
EN-GJS-400-15C a)	5.3126	60 < D ≤ 120	250	390	14	130	180
		120 < D ≤ 400	240	370	11		

a) Brinell hardness guaranteed in deviation from EN 16482

Concast iron with grey cast iron graphite

1. Mechanical properties, cast iron with grey cast iron graphite

1.1 Tensile strength/Brinell hardness

Material designation		Strand 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		

2. Microstructure

2.1 Matrix

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

2.2 Graphite structure as per EN ISO 945

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

C-configuration graphite is not admissible.

2.3 Matrix structure

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 subject to applicable factory analysis standards.

3. As-cast dimensional tolerances

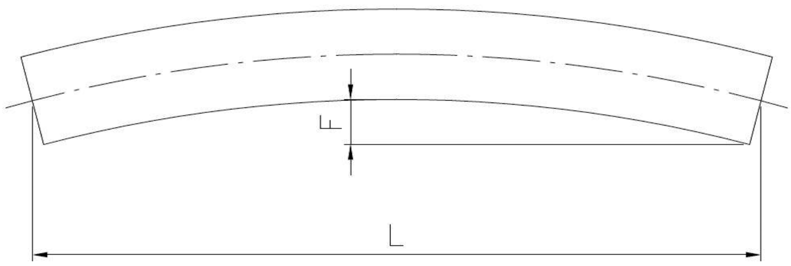
3.1 General tolerances (dimensions)

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 deviation from the straight [mm]	
l	as-cast	annealed
1 000	2	3
2 000	4	6
3 000	6	9

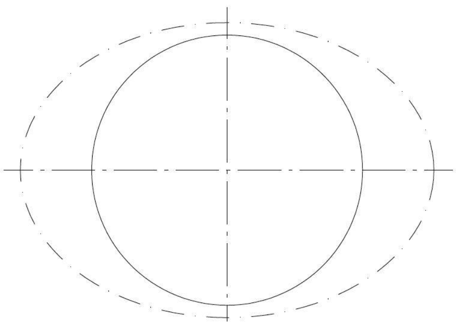
Illustration:

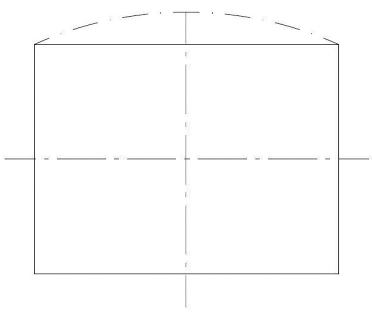


3.3 Ovality and curvature

Diameter [D]/ Height [H]/Width [B] [mm]	Maximum ovality allowance (round dimensions) [mm]	Maximum curvature allowance (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	

BIllustrations: **Ovality** **Curvature**

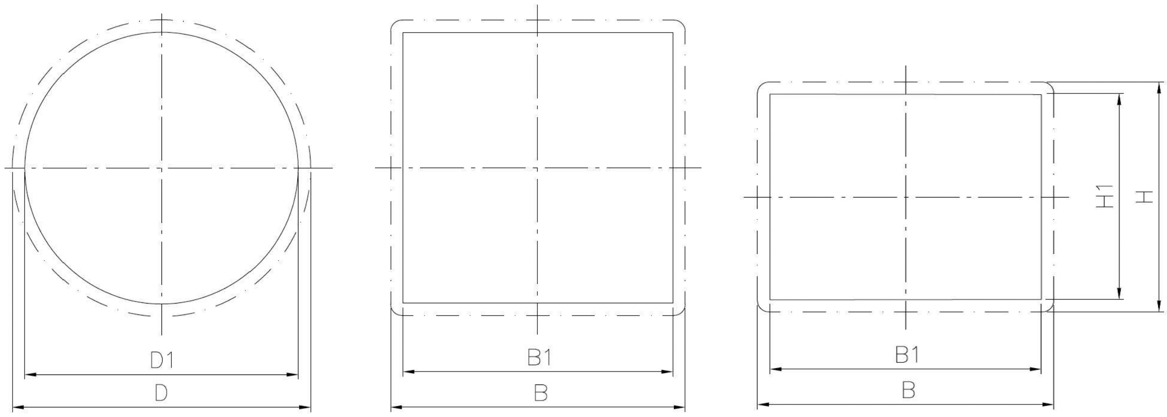




4. Minimum machining allowances

Strand diameter D or strand width B a), b) [mm]	Minimum machining allowance relative to the radius or half the width of the strand	
	circular [mm]	rectangular [mm]
20 < D oder B < 50	2,0	2,5
50 < D oder B < 100	3,0	3,5
100 < D oder B < 200	4,0	4,5
200 < D oder B < 300	6,0	6,5
300 < D oder B < 400	7,0	7,5
400 < D oder B < 500	9,0	9,5
500 < D oder B < 650	11,0	11,5

a) In rectangular castings, the width is the longest cross-sectional dimension.
b) Machining allowances are specified relative to the radius or half the width of the strand.



Notes and/or instructions regarding this specification:

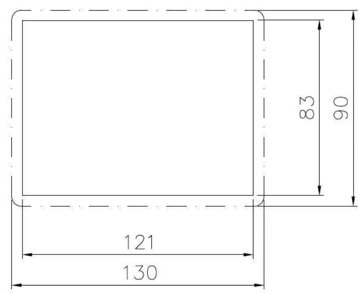
In round bars, the diameter is the reference dimension.
In rectangular bars, machining allowances may vary depending on height and width.

Example (explanation rectangular dimensions)

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



In rectangular strands, therefore, machining allowances may actually vary from side to side.

Concast iron with nodular graphite

5. Mechanical properties, cast iron with nodular graphite

5.1 Tensile strength/Brinell hardness

Material designation		Strand diameter D	0,2 % Proof stress Rp 0,2 MPa	Tensile strength Rm 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 guaranteed in deviation from EN 16482.

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

Material designation	Dimensions: Diameter [D]/ Height [H]/Width [B]	Minimum v-notch impact energy (J) at -20°C+/-2°C		Minimum v-notch impact energy (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 V-notch impact energy EN-GJS-350-22C-LT and RT

Material designation	Dimensions: Diameter [D]/ Height [H]/Width [B]	Minimum v-notch impact energy (J) at -40°C+/-2°C		Minimum v-notch impact energy (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: elasticity modulus and fracture toughness

Material designation	Test temperature	0,2 % Proof stress Rp 0,2 MPa a)	Tensile strength Rm 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	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	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 after fracture
b) Mean of 5 measurements
c) Tested in conformance with ISO 12135, test bar SE (B) 10

Samples of mechanical properties measured on a strand with a diameter of 160 mm.

6. Microstructure

6.1 Matrix

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 formation as per EN ISO 945

Sample-taking locations	Strand dimensions [mm]	Graphite configuration
Surface zone, Sz	all	> 80 % types VI + V
Centre	H bzw. D ≤ 100	> 95 % types VI + V
Centre	H bzw. D > 100 ≤ 150	> 95 % types VI + V
Centre	H bzw. 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 strands measuring > 150 mm H and/or D

6.3 Matrix structure

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 subject to applicable factory standards for analysis.

7. As-cast dimensional tolerances

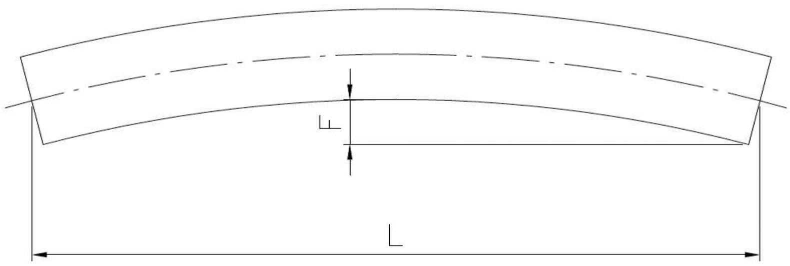
7.1 General tolerances (dimensions)

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

Lenght [mm]	Maximum deviation from the straight [mm]	
l	as-cast	annealed
1 000	2	3
2 000	4	6
3 000	6	9

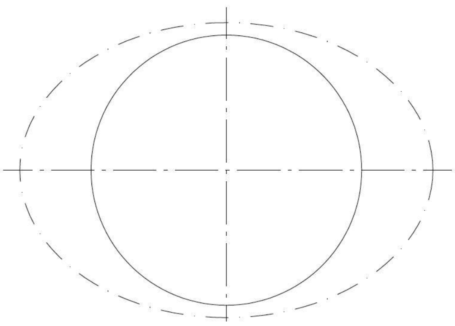
Illustration:

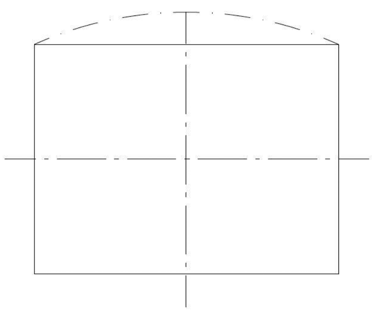


7.3 Ovality and curvature

Strand Diameter D [mm]	Maximum ovality allowance [mm]	Maximum curvature allowance [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** **Curvature**

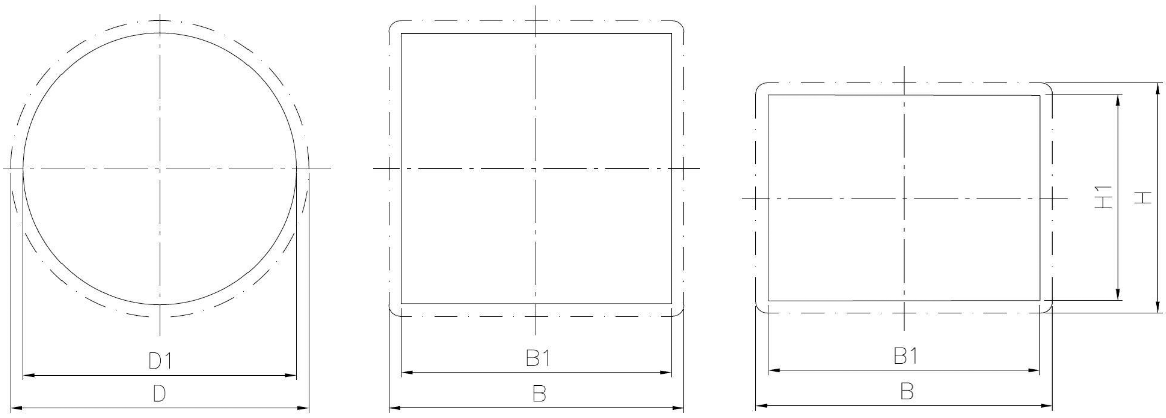




8. Minimum machining allowances

Strand diameter D or strand width B a)	Minimum machining allowance relative to the radius or half the width of the strand	
[mm]	circular [mm]	rectangular [mm]
20 < D oder B < 50	3,0	3,5
50 < D oder B < 100	4,0	4,5
100 < D oder B < 200	5,0	5,5
200 < D oder B < 300	7,0	7,5
300 < D oder B < 400	8,0	8,5
400 < D oder B < 500	10,0	10,5
500 < D oder B < 650	12,0	12,5

a) In rectangular bars, width is the longest dimension of the cross-section.



Notes and/or instructions regarding this specification:

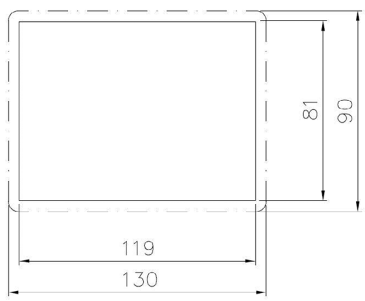
In round bars, the diameter shall be the reference dimension.
In rectangular bars, machining allowances may vary depending on height and width.

Example (explanation rectangular dimensions)

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. Limits of admissibility

9.1 Surface defects

Scoring and drawing-step overlaps are admissible only within the range of the machining allowance.

9.2 Inhomogeneities

Macroscopically visible defects exposed by machining that are of no functional relevance do not constitute a cause for complaint.

10.0 Bibliography

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[3] Herfurth, K.: Gusseisen-Strangguss für eine innovative Teilefertigung, Konstruieren + Gießen 20 (2005) Nr. 3, S. 2-17.[1])
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[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

When conspicuous features turn up on concast strands, the interpretations of manufacturers and customers differ quite often, be it only that a feature is called by different names or its significance is interpreted differently. To avoid friction in the collaboration between manufacturers and customers, therefore, it is important that the (technical) language used should be consistent, and that there should be a basic understanding about the features of concast strands and their significance in the concast iron context.

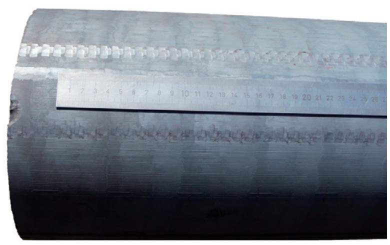
Process-related features

The term 'process-related features' describes microstructure and property non-conformances that are caused by the continuous casting process itself and are therefore unavoidable. In concast iron, these process-related features include draw marks at the strand surface, special subsurface microstructures, and shape non-conformances. Some of these peculiarities are located within the machining allowance and, consequently, outside the future component. What is common to all these features is that only a comparison with applicable technical documentations and/or delivery agreements will reveal whether they are inadmissible and thus constitute a defect.

Draw marks at the strand surface

The drawing cycle comprises a movement and a hold phase (waiting period). The surface of a strand shows coloured rings spaced at a distance that corresponds to the step length of the movement phase. Clearly visible to the naked eye, these so-called draw marks also influence the microstructure. Draw marks in no way affect the quality of concast strands.
The drawing process may also produce marks that run along the strand. They are caused by the drawing station which transports the strand during the production process. In square strands, these marks are generally found at the corners.

Circumferential drawing marks spaced 55 mm apart



Marks left by the drawing station paralleling the steel measuring rod on both sides

Machining allowance at the strand surface

A machining allowance is a layer of material on a cast product that is machined away to eliminate peculiarities related to the casting process (casting skin, inadequate surface roughness, inadequate shape and position tolerances). Due to the nature of the process, the machining allowance contains layers of oxide and silicate. For concast iron, machining allowances depending on the strand dimensions have been defined for round and square strands of cast iron with grey cast iron graphite and cast iron with nodular graphite. Deviations from technical agreements that are located within the machining allowance are not regarded as defects in a consignment.

1. Material

1.1 Mechanical properties

Tensile strength
The maximal nominal tension (Rm) measured in a tensile test before fracture. Tensile strength is measured in N/mm^2 or MPa.

Proof stress
The maximum tension that can be measured at the end of elastic deformation. As the transition from plastic to elastic deformation is not always unambiguous in technical materials, the figure quoted is normally the substitute proof strength Rp0.2. This point can always be unambiguously determined from the stress-strain diagram.
Proof stress is measured in N/mm^2 or MPa.

Elongation at break
Relative length of a test bar under load. Both the initial length of the sample and its length after fracture are measured. In the elastic range of the material, elongation disappears after the sample has been unloaded. Plastic deformation begins as soon as proof stress is reached. If a sample is unloaded in that range or further loaded until rupture, elongation can be measured.
Elongation at break is given in percent of the initial length.

V-notch impact energy
Characterises the toughness of a notched material sample under impact loading. V-notch impact energy can be determined at various temperatures. It is measured in Joule.

Hardness
Resistance opposed by a solid substance to mechanical or dynamic penetration by a harder body. The test method used is the Brinell hardness test. Hardness is measured in HB (Brinell hardness).

1.2 Microstructural defects (microscopic)

Matrix
The matrix of a casting consists of pure carbon (graphite) precipitated either in spheroidal (nodular iron) or grey cast iron form (grey cast iron). The carbon is embedded in a matrix of ferrite and pearlite (a finely grey cast iron mixture of ferrite and cementite [Fe3C]). Heat-treated material may also contain ausferrite, bainite and martensite. The ferrite-pearlite ratio determines the properties of the material.

Graphite structure
Describes the structure of the pure-graphite content of the matrix based on shape, distribution, size, and configuration. Graphite should normally be present in nodular or grey cast iron form. Standard structure photographs for both forms are contained in DIN EN ISO 945 or the American ASTM A247 06 standard.

Carbides

Chill

Chill develops when the cooling rate is too high and the saturation of the melt is insufficient at the surface of a strand. Small and/or thin-walled components are particularly susceptible to chill, which is why it is rare in concast iron.

Occurring mostly in the form of Fe3C, chill changes mechanical properties. Affecting surface machinability first and foremost, it causes tools to wear out quickly.

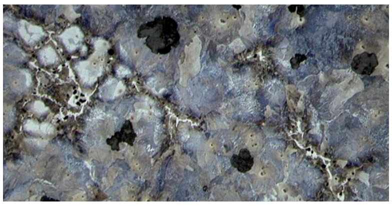
Fracture surface displaying chill

Inverse chill

Develops mainly at the centre of large round strands where long solidification times prevail. Metastable solidification accompanied by the formation of carbides is caused by silicon impoverishment in the residual melt as well as by enrichment of carbide-stabilising oxygen-affine elements that affect nucleation.

Intergranular carbide

In most cases, intergranular carbide is produced by segregation.
Concentrating at grain boundaries, individual carbides impair machinability.



Intergranular carbides, magn. 100

There are three chief variants of segregation that are responsible for the formation of carbide:

Gravitational segregation

Gravity segregation is caused by an increased difference in density between the primary crystals and the residual melt. This causes melt elements with a higher specific gravity to sink and those with a lower gravity to rise. This, in turn, may cause what is called graphite flotation in nodular iron and kish graphite in grey iron. Resembling cracks, these graphite skins may extend from the surface deep into the interior of a strand.

Macro-segregation

Caused either by segregation or by concentration differences in the melt. Consequently, the surface of a strand contains less of the alloy elements that are subject to segregation than its interior.

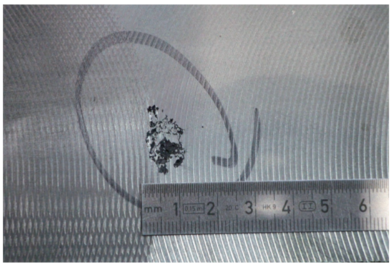
Micro-segregation

Coring or micro-segregation is caused by disruptions in the diffusion balance between individual mixed crystals and the residual melt.
Normally, mixed crystals should have one and the same composition at the end of the solidification process. However, if tramp and trace elements interfere with diffusion, segregation will occur at the edges of the mixed crystals.

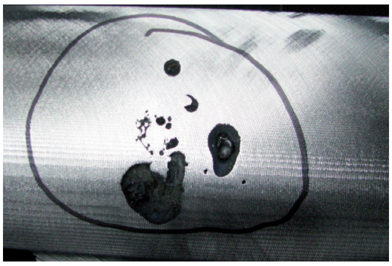
1.3 Inhomogeneities (macroscopic)

Inclusions

Since slag inclusions occur most frequently within this category, they will be considered in the following.
Slag forms during the melting process. It is reduced to a minimum by skimming or slagging. In addition, further measures relating to equipment and process technology keep slag from the product.
Most inclusions are of indeterminate shape and have rough inner walls.
Normally, slag is found at the (in the casting position) upper face of a strand because slag is lighter than the melt.



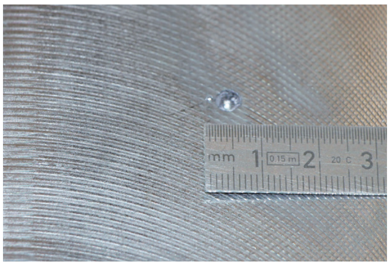
Slag inclusion with a rugged surface


Small and big slag inclusions

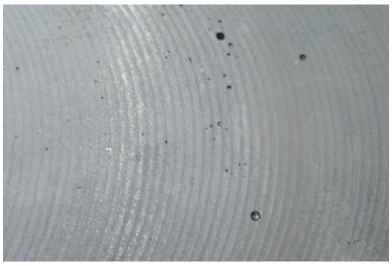
Pores

Pores are caused by gas dissolved in the melt. Any gas that does not escape completely during cooling will leave cavities behind that are markedly spherical in shape and have smooth walls. Pores may occur singly or in irregular groups.

This kind of defect occurs only in the upper zone of a strand because gas bubbles are lighter than the melt and drift upward.



Gas bubble with a smooth, shiny surface


Gas bubbles of different size

2. Production

2.1 The production process

Scores

Scores develop when a continuous casting mould is damaged. Scores run lengthwise along the strand. This feature does not affect the mechanical properties of a product.
To avoid increased tool wear during machining, a tool feed should be set to ensure that tools are evenly loaded and abrasive wear of the castings surface is avoided.


Score along an edge


Scores on a round strand

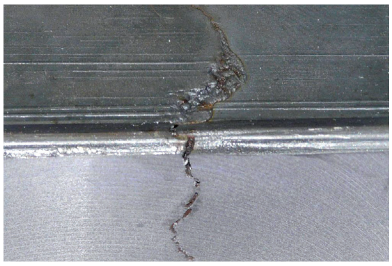
Drawing-step overlaps

Regularly spaced drawing-step marks are found mostly on the upper side of a strand. The discontinuous process of strand casting consists of a drawing step and a holding step. At defined intervals (holding time), the strand is pulled forward by one position (drawing step). During the holding time, an outer shell defining the external shape of the strand forms within the element that controls the cross section: the mould. Processes going on within the mould may lead to insufficient amalgamation between flowing and solidified material. The result is a drawing-step overlap. Marked drawing-step overlaps may occasionally be identified even in the semi-finished product. If this is not the case, they may be identified as cracks along the edges after machining. In exceptional cases, these drawing steps may extend across the entire cross-section of a strand.

Drawing-step overlap at the end of a bar

Drawing-step overlaps on a rectangular semi

Drawing-step overlap on a round semi



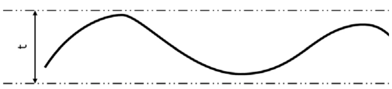
Drawing-step overlap, partially machined

2.2 Geometry definitions

Definition: manufacturing tolerance

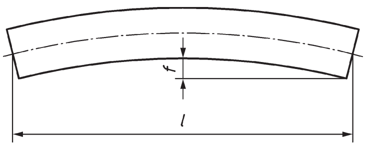
The term manufacturing tolerance refers to the difference between a measured and a nominal strand dimension.

Each surface line of a strand must lie between two parallel straight lines running at a distance of t.



Permitted variance of upper and lower edge

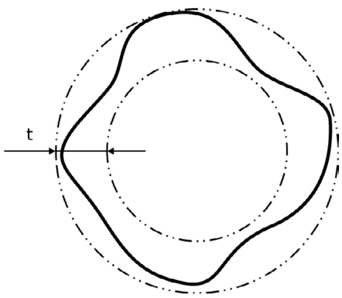
Measurements are made using a straightedge as reference.



Straightness measurement

Definition: roundness

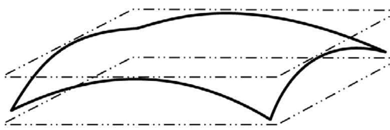
For concast iron, ovality has been defined in relation to the strand dimensions for cast iron with grey cast iron graphite (unannealed and annealed) and cast iron with nodular graphite.
The line of every cross-section of a round strand must be contained within a circle having a width of t.



Permitted variance of roundness

Definition: planeness

For concast iron, curvature limits have been set in relation to the strand dimensions for strands of cast iron with grey cast iron graphite (unannealed and annealed) and cast iron with nodular graphite.
Each surface section of a rectangular or square strand must lie between two parallel planes spaced a distance of t apart.



Permitted variance of planeness

3. Non-conformances that may occur during machining

3.1 Work order

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 Semis

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 consisting of unsuitable material.

3.3 Finished parts: geometry

Dimensional non-conformance (machine-related)
Infringement of a dimensional tolerance caused by a machine.

Dimensional non-conformance (operator-related)
Infringement of a dimensional tolerance caused by an operator.

Shape non-conformance (machine-related)
Infringement of a shape tolerance caused by a machine.

Shape non-conformance (operator-related)
Infringement of a shape tolerance caused by an operator.

Position non-conformance (machine-related)
Infringement of a position tolerance caused by a machine.

Position non-conformance (operator-related)
Infringement of a position tolerance caused by an operator.

Surface structure (machine-related)
Infringement of a surface tolerance caused by a machine.

Surface structure (operator-related)
Infringement of a surface tolerance caused by an operator.

3.4 Corrosion

Corrosion results from a reaction between a material and its environment which causes measurable changes in the material and may impair the function of a component or system. Probably the best-known type of corrosion is rust, i.e. the oxidation of iron.

4. Bibliography

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S. Hasse, Guss- und Gefügefehler, Berlin: Schiele & Schön, 2003.

EN 16482, current version

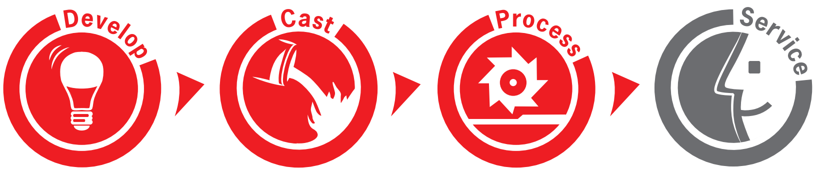
ACO Eurobar – the continuous casting specialist

For years, ACO Eurobar GmbH has been selling quality concast iron across Europe under the brand name of ACO Eurobar®. Thanks to continued investments in leading-edge system technology, the company is able to supply classical as-cast strands as well as pre-machined concast iron. In conformance with its own factory standard and technical documentation, ACO Eurobar sells top-quality grey and nodular concast iron, guided by EN 16482. The company specialises in turning, milling, drilling and sawing ACO Eurobar quality concast iron.

ACO Guss – a producing parent company with leading-edge foundry technology in the heart of Europe

ACO Eurobar GmbH is a subsidiary of ACO Guss GmbH, one of Europe's leading foundries which looks back on experience and tradition accumulated since the 19th century. Featuring a melting capacity of 75,000 tons per year, our high-tech production facility in Kaiserslautern employs a staff of around 240 to produce machine-moulded castings as well as concast strands.

Our competences



Together with its national and international subsidiaries and sales companies, ACO Guss GmbH strives to collaborate with its customers in a spirit of partnership.
In cooperation with our customers we develop ideas and translate them into customised products and we remain their reliable consultants even beyond the product itself, offering comprehensive service and support. Consistently expanding our subsidiaries 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® concast quality across Europe.

The ACO Group

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

Across the world, the name ACO stands for quality, experience and innovative power in drainage for construction and civil-engineering projects as well as for building services, using construction elements made of polymer concrete, cast iron, stainless steel, and plastic. This key competence, which has made ACO the world market leader, and is rounded off by other products belonging to special ranges, such as continuous casting, customised casting, engineered stainless steel constructions, garden and landscape engineering, and sports facility equipment.

The company was founded in 1946 on the site of the Carlshütte foundry in Büdelsdorf, which has been the focus of the Ahlmann family's business activities for four generations.

ACO at a glance

- 3,800 employees in more than 40 countries (Europe, America, Asia, Australia)
- 29 production facilities in 15 countries
- Turnover in 2013: 624 million Euro

The ACO Group. A strong family you can build on.

ACO Eurobar GmbH

Hohenecker Straße 5
67663 Kaiserslautern
Tel. +49 631 2011-0
Fax +49 631 2011-459

info@aco-eurobar.com
www.aco-eurobar.com

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