

Technical Information No. 2

Spheroidal cast iron EN-GJS (formerly GGG)

Definition

Spheroidal cast iron is an iron carbon based material, the carbon being present mainly in the form of spheroidal graphite particles. Spheroidal cast iron is also known as ductile, and less commonly as nodular iron. This spheroidal graphite is already present in the as cast state and characterises the material properties of spheroidal cast iron. Due to the nodular shape of the graphite the notch effect is minimised. Thereby high values for tensile strength and elongation at fracture are achieved.

Relevant standards

Material designation and material properties: DIN EN 1563

General Tolerances and machining allowance: DIN ISO 8062 valid for all designs made since August 1998 (DIN 1685, valid for designs created before August 1998)

Metallic materials – Brinell hardness test: DIN EN ISO 6506, published in October 1999

Metallic Material – Tensile testing at ambient temperature: DIN EN 10002-1 – DIN 50125

Metallic Materials – Charpy Impact tests: DIN EN 10045-1

Influence of the chemical composition

a) Basic elements

Spheroidal cast iron essentially contains the same elements as grey (lamellar graphite) iron – but in different concentrations. To achieve the nodular morphology a certain amount of Mg is necessary. The accompanying elements C, Si and Mn show the most significant influence on tensile strength, elongation at fracture and Brinell hardness. The higher the C- and Si-level, the lower are the strength and Brinell hardness whereas elongation at fracture rises.

b) Alloying elements

By adding alloying elements special properties such as hardenability, corrosion- or high temperature resistance can be achieved.

Special alloys

Mechanical and other important properties such as resistance to thermal fatigue, wear resistance or resistance to high temperature corrosion can be optimised by varying alloy composition or by special heat treatment.

By adding Si and Mo resistance to thermal fatigue as well as high temperature strength can be risen. These so called SiMo cast iron materials have therefore become typical materials for high temperature components such as exhaust pipes and turbo-charger housings.

By a special heat treatment the group of ausferritic ductile cast irons (ADI) can be produced (see Technical Information No. 8). Compared with conventional ductile iron this group of materials offers twice the strength of that of conventional ductile iron grade at about the same values of elongation. Therefore ADI competes with steel castings and even with forged steel.

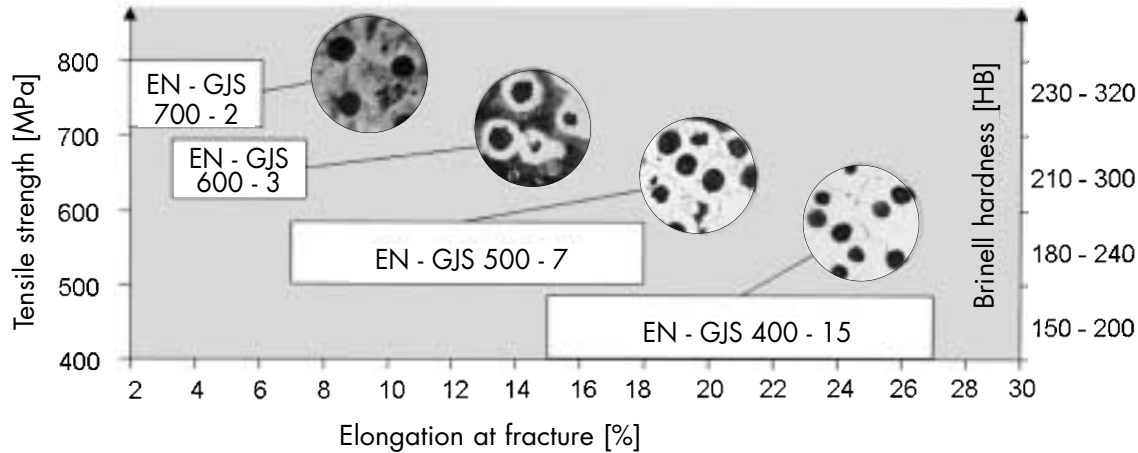
Mechanical and physical properties of spheroidal cast iron

Material designation	EN-GJS-400-15	EN-GJS-450-10	EN-GJS-500-7	EN-GJS-600-3	EN-GJS-700-2	EN-GJS-800-2	EN-GJS-400-18/IT		
Material No.	ENJS 1030		ENJS 1050	ENJS 1060	ENJS 1070	ENJS 1080	ENJS 1025		
Out-dated designation DIN 1693 (bis 1.3.1998)	GGG-40		GGG-50	GGG-60	GGG-70	GGG-80	GGG-40.3		
Tensile strength	R_m	N/mm ²	400	450	500	600	700	800	400
0.2 % proof strength ¹⁾	$R_{p0,2}$	N/mm ²	250	310	320	370	420	480	240
Elongation at fracture	A	%	15	10	7	3	2	2	18
Reduction of area at fracture	Z	%	30 – 15		20 – 2	8 – 3	6 – 2	4 – 2	32 – 17
Fracture toughness K_{Ic}	$MPa\sqrt{m}$		23	25	20	15	14	30	
Brinell hardness HB			135 – 180	160 – 210	170 – 230	190 – 270	225 – 305	245 – 335	130 – 175
Modulus of elasticity	E_o	kN/mm ²	169	169	169	174	176	176	169
Poisson ratio	μ		0,275	0,275	0,275	0,275	0,275	0,275	0,275
Notch strength	–	N/mm ²	> R_m	> R_m	~ R_m	~ R_m	< R_m	> R_m	
Shear modulus	G	kN/mm ²				0,4 · E_o			
Shear strength	T	N/mm ²	(405) ³⁾	405	450	540	630	720	360
Fatigue limit bending	σ_{bW}	N/mm ²				~(0,61 – 0,00026 R_m) · R_m			
Impact strength	A_v	J				–	–	12 ¹⁾²⁾	
Fatigue limit tensile compression	σ_{zdW}	±N/mm ²				~(0,43 – 0,000192 R_m) · R_m			
Density	ρ	kg/dm ³	7,1	7,1	7,1	7,2	7,2	7,1	
Thermal conductivity	λ	W/(m · K)	(36,2) ³⁾	36,2	35,2	32,5	31,1	31,1	36,2
Linear expansion coefficient	α	10 ⁻⁶ m/(m · K)	12,5	12,5	12,5	12,5	12,5	12,5	

¹⁾ Guaranteed minimum values according to DIN EN 1563, Table 1

²⁾ at (-20 ± 2)°C

Relationship between microstructure and mechanical properties for EN-GJS material grades



Spheroidal cast iron according to DIN EN 1563

Material designation	Material No.	mechanical properties measured on test pieces machined from separately cast samples*					Micro-structure
		Tensile strength R_m N/mm ² min.	0,2%-Proof stress $R_{p0.2}$ N/mm ² min.	Elongation A % min.	Impact resistance values Mean value from 3 tests min. J	Impact resistance values Individual value min. J	
EN-GJS-400-15	EN-JS 1030	400	250	15	–	–	predominantly ferrite
EN-GJS-500-7	EN-JS 1050	500	320	7	–	–	ferrite/pearlite
EN-GJS-600-3	EN-JS 1060	600	370	3	–	–	pearlite/ferrite
EN-GJS-700-2	EN-JS 1070	700	420	2	–	–	predominantly pearlite
EN-GJS-800-2	EN-JS 1080	800	480	2	–	–	pearlite
EN-GJS-400-18-LT	EN-JS 1025	400	240	18	12 bei –20°C	9 bei –20°C	–

* Especially at wall thickness $t > 50$ mm special agreements between the manufacturer and the purchaser are recommended.

Spheroidal graphite cast iron, un- or low alloyed

Properties of test pieces cut from cast on samples according to DIN EN 1563

Material designation	Material No.	Relevant wall thickness t mm	Thicknes of the cast on sample mm	Tensile strength		Elongation A % min.	Impact resistance values Mean value from 3 tests J min.	Impact resistance values Individual value J min.	Micro-structure
				R_m N/mm ² min.	$R_{p0.2}$ N/mm ² min.				
EN-GJS-400-18U-LT	EN-JS 1049	von 30 – 60 über 60 – 200	40 70	390	230	15	12	9	predominantly ferrite
				370	220	12	10	7	
EN-GJS-400-15U	EN-JS 1072	von 30 – 60 über 60 – 200	40 70	390	250	14	–	–	predominantly ferrite
				370	240	11	–	–	
EN-GJS-500-7U	EN-JS 1082	von 30 – 60 über 60 – 200	40 70	450	300	7	–	–	ferrite/ pearlite
				420	290	5	–	–	
EN-GJS-600-3U	EN-JS 1092	von 30 – 60 über 60 – 200	40 70	600	360	2	–	–	pearlite/ ferrite
				550	340	1	–	–	
EN-GJS-700-2U	EN-JS 1102	von 30 – 60 über 60 – 200	40 70	700	400	2	–	–	predominantly pearlite
				660	380	1	–	–	

Guidance values for 0,2% proof stress for test pieces in N/mm² for wall thickness t

Material grade	bis 50 mm	>50 bis 80 mm	>80 bis 120 mm	>120 bis 200 mm
EN-GJS-400-15	250	240	230	230
EN-GJS-500-7	290	280	270	260
EN-GJS-600-3	360	340	330	320
EN-GJS-700-2	400	380	370	360