SECTION XII

SPECIFICATIONS

UNS numbers and corresponding American specifications							
Standard	**Numbers/Grades**						
UNS	**F3000**	**F32800**	**F32900**	**F33100**	**F33101**	**F33800**	**F34100**
ASTM A395		60-40-18					
ASTM A536		60-40-18		65-45-12		80-55-06	
ASTM A476							80-60-03
ASTM A716			******				
AMS					5315		5316
SAE J434	DQ & T	D4018		D4512		D5506	
MIL-I-24137					(A)		
UNS	F34800	F36200	F43000	F43001	F43002	F43003	F43004
ASTM A439			D-2	D-2B	D-2C	D-3	D-3A
ASTM A536	100-70-03	120-90-02					
SAE J434	D7003						
UNS	F43005	F43006	F43007	F43010	F43020	F43021	F43030
ASTM A439	D-4	D-5	D-5B				
ASTM A571				D-2M			
AMS							5395
MIL-I-24137					(B)	(C)	

SPECIFICATIONS

Introduction

The purpose of standard specifications for Ductile Iron castings is to provide a body of information which can be used with confidence by both designer and foundry to select, define and agree upon a set of specific properties which will ensure that the castings meet the intended use of the designer. The use of standard specifications simplifies the purchase of castings from multiple suppliers because it defines a standard casting whose properties meet the designer's needs, regardless of where, or how the castings were produced.

Specifications should be chosen carefully and used sparingly to ensure that they adequately define the designer's needs without adding superfluous constraints which needlessly restrict the suppliers' options, complicate the casting process and increase the cost of the casting. It is the responsibility of both the designer and the foundry to be aware of the role and the limitations of specifications and to agree upon a specification that provides the optimum ratio of performance to cost. It is up to the designer to specify a set of properties – mechanical, physical, chemical or dimensional – which best suit the casting to its purpose.

Once the specification has been selected, the foundry must ensure that all castings delivered meet or exceed the specification. The raw materials and production methods used by the foundry to provide conforming castings are not normally restricted by the designer or the specification unless the specification includes such instructions, or the designer and foundry agree to append additional instructions to a specification. Such instructions should be used judiciously, because they almost invariably increase the casting cost and restrict the number of foundries which can provide competitive bids.

North America

The ASTM has five standards covering Ductile Iron castings. ASTM A 536 is the most frequently used, covering the general engineering grades of Ductile Iron. The other standards cover austenitic and special Ductile Iron applications. The ASTM has issued in 1990 a new specification defining the properties of Austempered Ductile Iron. The SAE standard J434 is commonly used for specifying automotive Ductile Iron castings. In an attempt to create a single, comprehensive system for designating metals and alloys the ASTM and SAE have jointly developed the Unified Numbering System (UNS). While not itself a specification, the UNS designation is gaining some degree of acceptance in North America as a useful means of simplifying and correlating the various existing specifications. The UNS designations for Ductile Irons, cross-referenced to the corresponding ASTM, AMS, SAE and MIL specifications, are shown on the opposite page.

Other Standards

This section also summarizes the national standards for Ductile Iron for the other major industrialized countries and the international ISO stan-

dard. This standard, and its replacement, the EuroNorm standard EN will become increasingly important with the growth of the European Community. There are many additional standards for Ductile Iron, some national, and others valid only within a specific technical or commercial organization. While each specification may have its own distinguishing characteristics, there are also many similarities between specifications. Before using any specification, the designer should obtain a complete copy of the current issue from the specifying body to familiarize himself with both the properties specified and the conditions under which they are to be measured.

Standard specifications for Ductile Iron are normally based on mechanical properties, except for those defining austenitic Ductile Iron, which are based on composition. Mechanical property values are given in the units normal to the particular specifying body. Conversions for SI, metric non-SI, and non-metric units are given at the end of this section to assist in comparing specifications.

Beyond Specifications

Standards and specifications ensure uniformity and assist both the designer and the foundry in defining the most important properties of the castings. However, most of the specifications identify either minimum properties, or ranges of properties, inferring that all castings whose properties either exceed the minimum or lie anywhere within the range, are equally acceptable. This inference is incorrect, and high quality castings, whose properties either consistently exceed requirements, or fall well within specified ranges, offer the designer a competitive edge. Through commitments to SPC and continual quality improvement, many foundries have developed the capability to produce castings whose higher quality can be demonstrated statistically. Designers should take advantage of these capabilities to obtain assured quality which is superior to that required by specifications.

REFERENCES

Annual Book of ASTM Standards, Volume 01.02, Ferrous Castings, 1997.

I. C. H. Hughes, "Ductile Iron," *Metals Handbook*, American Society for Metals, Vol. 15, 9th edition, 1988.

American Society of Automotive Engineers Inc., Warrendale, PA, 1989.

ASTM A 395 FERRITIC DUCTILE IRON PRESSURE-RETAINING CASTINGS FOR USE AT ELEVATED TEMPERATURES

This standard specifies chemical, physical, and hardness requirements.

Chemical Requirements

The castings shall conform to the following requirements for chemical composition (Note 3):

Total carbon, min, %	3.00
Silicon, max, %	2.50
Phosphorus, max, %	0.08

Physical Requirements

Tensile Properties – The Ductile Iron as represented by the test specimens shall conform to the following requirements for tensile properties:

Tensile strength, min, psi (MPa)	60 000 (414)
Yield strength, min, psi (MPa)	40 000 (276)
Elongation in 2 in. or 50 mm min.	18%

Hardness: – The hardness of the heat-treated Ductile Iron as represented by the test specimens and castings shall be within the following limits:

HB, 3000-kgf load	143 to 187

ASTM A 439 AUSTENITIC DUCTILE IRON CASTINGS

Chemical Requirements

Element	Type								
	D-2[A]	D-2B	D-2C	D-3[A]	D-3A	D-4	D-5	D-5B	D-5S
	Composition, %								
Total carbon, max	3.00	3.00	2.90	2.60	2.60	2.60	2.40	2.40	2.30
Silicon	1.50-3.00	1.50-3.00	1.00-3.00	1.00-2.80	1.00-2.80	5.00-6.00	1.00-2.80	1.00-2.80	4.90-5.50
Manganese	0.70-1.25	0.70-1.25	1.80-2.40	1.00 max[B]	1.00 max[B]	1.00 max[B]	1.00 max[B]	1.00 max[B]	1.00 max
Phosphorus, max	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Nickel	18.00-22.00	18.00-22.00	21.00-24.00	28.00-32.00	28.00-32.00	28.00-32.00	34.00-36.00	34.00-36.00	34.00-37.00
Chromium	1.75-2.75	2.75-4.00	0.50 max[B]	2.50-3.50	1.00-1.50	4.50-5.50	0.10 max	2.00-3.00	1.75-2.25

[A] Additions of 0.7 to 1.0% of molybdenum will increase the mechanical properties above 800°F (425°C).
[B] Not intentionally added.

Mechanical Requirements

Element	Type								
	D-2	D-2B	D-2C	D-3	D-3A	D-4	D-5	D-5B	D-5S
	Properties								
Tensile strength, min, ksi (MPa)	58 (400)	58 (400)	58 (400)	55 (379)	55 (379)	60 (414)	55 (379)	55 (379)	65 (449)
Yield strength (0.2 percent offset), min, ksi (MPa)	30 (207)	30 (207)	28 (193)	30 (207)	30 (207)	–	30 (207)	30 (207)	30 (207)
Elongation 2 in. or 50 mm, min, %	8.0	7.0	20.0	6.0	10.0	–	20.0	6.0	10
Brinell hardness (300 kg)	139-202	148-211	121-171	139-202	131-193	202-273	131-185	139-193	131-193

ASTM A 476 DUCTILE IRON CASTINGS FOR PAPER MILL DRYER ROLLS

Chemical Requirements

The castings shall conform to the following chemical requirements:

Total carbon, min, %	3.0
Silicon, max, %	3.0
Phosphorus, max, %	0.08
Sulfur, max, %	0.05

The castings shall have a carbon equivalent of 3.8 to 4.5 inclusive.

Tensile Requirements

Test Coupon Section Thickness	1 in.	3 in.
Tensile strength, min, ksi	80	80
Yield strength, min, ksi	60	60
Elongation in 2 in., min, %	3.0	1.0

ASTM A 536 DUCTILE IRON CASTINGS

Tensile Requirements

	Grade 60/40/18	Grade 65/45/12	Grade 80/55/06	Grade 100/70/03	Grade 120/90/02
Tensile strength, min, psi	60 000	65 000	80 000	100 000	120 000
Tensile strength, min, MPa	414	448	552	689	827
Yield strength, min, psi	40 000	45 000	55 000	70 000	90 000
Yield strength, min, MPa	276	310	379	483	621
Elongation in 2 in. or 50 mm, min, %	18	12	6.0	3.0	2.0

Tensile Requirements for Special Applications

	Grade 60/42/10	Grade 70/50/05	Grade 80/60/03
Tensile strength, min, psi	60 000	70 000	80 000
Tensile strength, min, MPa	415	485	555
Yield strength, min, psi	42 000	50 000	60 000
Yield strength, min, MPa	290	345	415
Elongation in 2 in. or 50 mm, min, %	10	5	3

ASTM A 571 AUSTENITIC DUCTILE IRON CASTINGS FOR PRESSURE-CONTAINING PARTS SUITABLE FOR LOW-TEMPERATURE SERVICE

This standard specifies that all castings shall be heat treated by annealing between 1600 and 1800°F for 1 hour per inch of casting section and furnace cooling.

Chemical Requirements

Element	Composition, %
Total carbon	2.2-2.7[A]
Silicon	1.5-2.50
Manganese	3.75-4.5
Nickel	21.0-24.0
Chromium	0.20 max
Phosphorus	0.08 max

[A] For castings with sections under 1/4 in., it may be desirable to adjust the carbon upwards to a maximum of 2.90%.

Mechanical Property Requirements[A]

	Class 1	Class 2
Tensile Strength, min, ksi	65	60
Yield Strength 0.2% (offset), min, ksi	30	25
Elongation, min, %	30	25
Brinell Hardness, 3000 kg	121-171	111-171
Charpy V-notch, ft-lbf		
min, average 3 tests	15	20
min, individual test	12	15

[A] Heat-treated condition

ASTM A 897 A 897 M AUSTEMPERED DUCTILE IRON

Grade	Min. Tensile Str.		Min. Yield Str.		Elongation	Impact Energy*		Hardness
	MPa	Ksi	MPa	Ksi	Percent	Joules	Ft-lb	BHN**
125/80/10		125		80	10		75	269-321
850/550/10	850		550		10	100		269-321
150/100/7		150		100	7		60	302-363
1050/700/7	1050		700		7	80		302-363
175/125/4		175		125	4		45	341-444
1200/850/4	1200		850		4	60		341-444
200/155/1		200		155	1		25	388-477
1400/1100/1	1400		1100		1	35		388-477
230/185/–		230		185	***		***	444-555
1600/1300/–	1600		1300		***	***		444-555

* Values obtained using unnotched Charpy bars tested at 72 deg. F (20 deg. C). The values in the table are the average of the three highest of four tested samples.
** Hardness is not a mandatory specification and is shown for information only.
*** Elongation and impact specifications are not required.

Complete specifications may be obtained from:
American Society for Testing Materials, 100 Barr Harbor Drive, West Conshocken, PA 19428.
Society of Automotive Engineers Inc., 485 Lexington Ave., New York NY 10017.
American Society of Mechanical Engineers, 345 East 47th Street, New York NY 10017.

NOTE: SAE specification for Ductile Iron casting and austempered Ductile Iron casting are currently been revised so they were not available as of the time of this printing.

SAE J434C AUTOMOTIVE DUCTILE IRON CASTINGS

Grade	Tensile strength, R_{m1} min.				Proof stress, $R_{po.2}$ min.				Elongation A, min.	Hardness	Structure
	N/mm²	kgf/mm²	tonf/in²	lbf/in²	N/mm²	kgf/mm²	tonf/in²	lbf/in²	%	HB	
D4018	414	42.2	26.8	60 000	276	28.1	17.9	40 000	18	170 max.	Ferrite
D4512	448	45.7	29.0	65 000	310	31.6	20.1	45 000	12	156-217	Ferrite & pearlite
D5506	552	56.2	35.7	80 000	379	38.7	24.6	55 000	6	187-255	Ferrite & pearlite
D7003	689	70.3	44.6	100 000	483	49.2	31.3	70 000	3	241-302	Pearlite
DQ&T**	–	–	–	–	–	–	–	–	–	–	Martensite

*These irons are primarily specified on hardness and structure. The mechanical properties are given for information only.
**Quenched and tempered grade; hardness to be agreed between supplier and purchaser.

JAPAN AUSTEMPERED SPHEROIDAL GRAPHITE IRON CASTINGS
JIS G 5503-1995

Mechanical properties of separately cast test sample

Symbol of grade	Tensile strength N/mm²	Yield strength N/mm²	Elongation %	Hardness HB
FCAD 900-4	900 min.	600 min.	4 min.	–
FCAD 900-8	900 min.	600 min.	8 min.	–
FCAD 1000-5	1000 min.	700 min.	5 min.	–
FCAD 1200-2	1200 min.	900 min.	2 min.	341 min.
FCAD 1400-1	1400 min.	1100 min.	1 min.	401 min.

JAPAN
JIS G 5502-1995

SPHEROIDAL GRAPHITE IRON CASTINGS

Mechanical properties of separately cast test sample

Symbol of grade	Tensile strength N/mm²	Yield strength N/mm²	Elongation %	Charpy absorption energy			(Informative reference)	
				Test Temperature °C	Mean value of 3 pieces J	Individual value J	Hardness HB	Matrix structure
FCD 350-22	350 min.	220 min.	22 min.	23 ± 5	17 min.	14 min.	150 max.	Ferrite
FCD 350-22L				-40 ± 2	12 min.	9 min.		
FCD 400-18	400 min.	250 min.	18 min.	23 ± 5	14 min.	11 min.	130 to 180	
FCD 400-18L				-20 ± 2	12 min.	9 min.		
FCD 400-15			15 min.	–	–	–		
FCD 450-10	450 min.	280 min.	10 min.				140 to 210	
FCD 500-7	500 min.	320 min.	7 min.				150 to 230	Ferrite + pearlite
FCD 600-3	600 min.	370 min.	3 min.				170 to 270	Pearlite + ferrite
FCD 700-2	700 min.	420 min.	2 min.				180 to 300	Pearlite
FCD 800-2	800 min.	480 min.					200 to 330	Pearlite or tempered structure

Mechanical properties of cast-on test sample

Symbol of grade	Chief thickness of iron casting mm	Tensile strength N/mm²	Yield strength N/mm²	Elongation %	Charpy absorption energy			(Informative reference)	
					Test Temperature °C	Mean value of 3 pieces J	Individual value J	Hardness HB	Matrix structure
FCD 400-18A	Over 30, up to and incl. 60	390 min.	250 min.	15 min.	23 ± 5	14 min.	11 min.	120 to 180	Ferrite
	Over 60, up to and incl. 200	370 min.	240 min.	12 min.		12 min.	9 min.		
FCD 400-18AL	Over 30, up to and incl. 60	390 min.	250 min.	15 min.	-20 ± 2				
	Over 60, up to and incl. 200	370 min.	240 min.	12 min.		10 min.	7 min.		
FCD 400-15A	Over 30, up to and incl. 60	390 min.	250 min.	15 min.	–	–	–		
	Over 60, up to and incl. 200	370 min.	240 min.	12 min.					
FCD 500-7A	Over 30, up to and incl. 60	450 min.	300 min.	7 min.				130 to 230	Ferrite + pearlite
	Over 60, up to and incl. 200	420 min.	290 min.	5 min.					
FCD 600-3A	Over 30, up to and incl. 60	600 min.	360 min.	2 min.				160 to 270	Pearlite + ferrite
	Over 60, up to and incl. 200	550 min.	340 min.	1 min.					

Mechanical properties measured on test pieces machined from separately cast samples

Material designation		Tensile strength R_m N/mm²	0.2% proof stress $R_{p0.2}$ N/mm²	Elongation A %
Symbol	Number	min.	min.	min.
EN-GJS-350-22-LT[1]	EN-JS1015	350	220	22
EN-GJS-350-22-LT[2]	EN-JS1014	350	220	22
EN-GJS-350-22-LT	EN-JS1010	350	220	22
EN-GJS-400-18-LT[1]	EN-JS1025	400	240	18
EN-GJS-400-18-LT[2]	EN-JS1024	400	250	18
EN-GJS-400-18-LT	EN-JS1020	400	250	18
EN-GJS-450-15	EN-JS1030	400	250	15
EN-GJS-450-10	EN-JS1040	450	310	10
EN-GJS-500-7	EN-JS1050	500	320	7
EN-GJS-600-3	EN-JS1060	600	370	3
EN-GJS-700-2	EN-JS1070	700	420	2
EN-GJS-800-2	EN-JS1080	800	480	2
EN-GJS-900-2	EN-JS1090	900	600	2

[1] LT for low temperature.
[2] RT for room temperature.

NOTE 1. The values for these materials apply to castings cast in sand moulds of comparable thermal diffusivity. Subject to amendments to be agreed upon in the order, they can apply to castings obtained by alternative methods.

NOTE 2. Whatever the method used for obtaining the castings, the grades are based on the mechanical properties measured on test pieces taken from samples separately cast in a sand mould or a mould of comparable thermal diffusivity.

NOTE 3. 1 N/mm² is equivalent to 1 MPa.

NOTE 4. The material designation is in accordance with EN 1560.

Minimum impact resistance values measured on V-notched test pieces machined from separately cast samples

Material designation		Minimum impact resistance values (in J)					
		At room temperature (23 ± 5) °C		At (-20 ± 2) °C		At (-40 ± 2) °C	
Symbol	Number	Mean value from 3 tests	Individual value	Mean value from 3 tests	Individual value	Mean value from 3 tests	Individual value
EN-GJS-350-22-LT[1]	EN-JS1015	–	–	–	–	12	9
EN-GJS-350-22-RT[2]	EN-JS1014	17	14	–	–	–	–
EN-GJS-400-18-LT[1]	EN-JS1025	–	–	12	9	–	–
EN-GJS-400-18-LT[2]	EN-JS1024	14	11	–	–	–	–

[1] LT for low temperature.
[2] RT for room temperature.

NOTE 1. The values for these materials apply to castings cast in sand moulds of comparable thermal diffusivity. Subject to amendments to be agreed upon in the order, they can apply to castings obtained by alternative methods.

NOTE 2. Whatever the method used for obtaining the castings, the grades are based on the mechanical properties measured on test pieces taken from samples separately cast in a sand mould or a mould of comparable thermal diffusivity.

NOTE 3. The material designation is in accordance with EN 1560.

EUROPEAN STANDARD
EN 1563:1997 (continued)

Mechanical properties measured on test pieces machined from separately cast samples

Material designation		Relevant wall thickness t mm	Tensile strength R_m N/mm²	0.2% proof stress $R_{p0.2}$ N/mm²	Elongation A %
Symbol	Number		min.	min.	min.
EN-GJS-350-22U-LT[1]	EN-JS1019	$t \leq 30$	350	220	22
		$30 < t \leq 60$	330	210	18
		$60 < t \leq 200$	320	200	15
EN-GJS-350-22U-RT[2]	EN-JS1029	$t \leq 30$	350	220	22
		$30 < t \leq 60$	330	220	18
		$60 < t \leq 200$	320	210	15
EN-GJS-350-22U	EN-JS1032	$t \leq 30$	350	220	22
		$30 < t \leq 60$	330	220	18
		$60 < t \leq 200$	320	210	15
EN-GJS-400-18U-LT[1]	EN-JS1049	$t \leq 30$	400	240	18
		$30 < t \leq 60$	390	230	15
		$60 < t \leq 200$	370	220	12
EN-GJS-400-18U-RT[2]	EN-JS1059	$t \leq 30$	400	250	18
		$30 < t \leq 60$	390	250	15
		$60 < t \leq 200$	370	240	12
EN-GJS-400-18U	EN-JS1062	$t \leq 30$	400	250	18
		$30 < t \leq 60$	390	250	15
		$60 < t \leq 200$	370	240	12
EN-GJS-400-15U	EN-JS1072	$t \leq 30$	400	250	15
		$30 < t \leq 60$	390	250	14
		$60 < t \leq 200$	370	240	11
EN-GJS-450-10U	EN-JS1132	$t \leq 30$	450	310	10
		$30 < t \leq 60$	} To be agreed between the manufacturer and the purchaser.		
		$60 < t \leq 200$			
EN-GJS-500-7U	EN-JS1082	$t \leq 30$	500	320	7
		$30 < t \leq 60$	450	300	7
		$60 < t \leq 200$	420	290	5
EN-GJS-600-3U	EN-JS1092	$t \leq 30$	600	370	3
		$30 < t \leq 60$	600	360	2
		$60 < t \leq 200$	550	340	1
EN-GJS-700-2U	EN-JS1102	$t \leq 30$	700	420	2
		$30 < t \leq 60$	700	400	2
		$60 < t \leq 200$	660	380	1
EN-GJS-800-2U	EN-JS1112	$t \leq 30$	800	480	2
		$30 < t \leq 60$	} To be agreed between the manufacturer and the purchaser.		
		$60 < t \leq 200$			
EN-GJS-900-2U	EN-JS1122	$t \leq 30$	900	600	2
		$30 < t \leq 60$	} To be agreed between the manufacturer and the purchaser.		
		$60 < t \leq 200$			

[1] LT for low temperature.
[2] RT for room temperature.

NOTE 1. The properties of a cast-on test piece cannot reflect exactly the properties of the casting itself, but can be a better approximation than those obtained on a separately cast sample. Further values are given in annex D for guidance.

NOTE 2. 1 N/mm² is equivalent to 1 MPa.

NOTE 3. The material designation is in accordance with EN 1560.

Material designation		Brinell hardness range HB	Other properties (for information only)	
			R_m	$R_{p0.2}$
Symbol	Number		N/mm²	N/mm²
EN-GJS-HB130	EN-JS2010	Less than 160	350	220
EN-GJS-HB150	EN-JS2020	130 to 175	400	250
EN-GJS-HB155	EN-JS2030	135 to 180	400	250
EN-GJS-HB185	EN-JS2040	160 to 210	450	310
EN-GJS-HB200	EN-JS2050	170 to 230	500	320
EN-GJS-HB230	EN-JS2060	190 to 270	600	370
EN-GJS-HB265	EN-JS2070	225 to 305	700	420
EN-GJS-HB300[1)]	EN-JS2080[1)]	245 to 335	800	480
EN-GJS-HB330[1)]	EN-JS2090[1)]	270 to 360	900	600

[1)] EN-GJS-HB300 (EN-JS2080) and EN-GJS-HB330 (EN-JS2090) are not recommended for thick section castings.

NOTE 1. 1 N/mm² is equivalent to 1 MPa.

Minimum impact resistance values measured on V-notched test pieces machined from cast-on samples

Material designation		Relevant wall thickness t	Minimum impact resistance values (in J)					
			At room temperature (23 ± 5) °C		At (-20 ± 2) °C		At (-40 ± 2) °C	
			Mean value from 3 tests	Individual value	Mean value from 3 tests	Individual value	Mean value from 3 tests	Individual value
Symbol	Number	mm						
EN-GJS-350-22U-LT[1)]	EN-JS1019	$t \leq 60$ $60 < t \leq 200$	–	–	–	–	12 10	9 7
EN-GJS-350-22U-RT[2)]	EN-JS1029	$t \leq 60$ $60 < t \leq 200$	17 15	14 12	–	–	–	–
EN-GJS-400-18U-LT[1)]	EN-JS1049	$30 < t \leq 60$ $60 < t \leq 200$	–	–	12 10	9 7	–	–
EN-GJS-400-18U-RT[2)]	EN-JS1059	$30 < t \leq 60$ $60 < t \leq 200$	14 12	11 9	–	–	–	–

[1)] LT for low temperature.
[2)] RT for room temperature.

NOTE 1. The values for the materials normally apply to castings with thicknesses between 30 mm and 200 mm and with a mass greater than 2 000 kg or when the relevant wall thickness may vary between 30 mm and 200 mm.

NOTE 2. The properties of a cast-on test piece cannot reflect exactly the properties of the casting itself, but can be a better approximation than those obtained on a separately cast sample. Further values are given in annex D for guidance.

NOTE 3. 1 N/mm² is equivalent to 1 MPa.

NOTE 4. The material designation is in accordance with EN 1560.

EUROPEAN STANDARD EN 1564:1997 — AUSTEMPERED DUCTILE CAST IRONS

Mechanical properties measured on test pieces machined from separately cast samples

Material designation		Tensile strength R_m N/mm²	0.2% proof stress $R_{p0.2}$ N/mm²	Elongation A %
Symbol	Number	min.	min.	min.
EN-GJS-800-8	EN-JS1100	800	500	8
EN-GJS-1000-5	EN-JS1110	1000	700	5
EN-GJS-1200-2	EN-JS1120	1200	850	2
EN-GJS-1400-1	EN-JS1130	1400	1100	1

NOTE 1. The values for these materials apply to castings cast in sand moulds of comparable thermal diffusivity. Subject to amendments to be agreed upon in the order, they can apply to castings obtained by alternative methods.

NOTE 2. Whatever the method used for obtaining the castings, the grades are based on the mechanical properties measured on test pieces taken from samples separately cast in a sand mould or a mould of comparable thermal diffusivity.

NOTE 3. 1 N/mm² is equivalent to 1 MPa.

NOTE 4. The material designation is in accordance with EN 1560.

Hardness range

Material designation		Brinell hardness range
Symbol	Number	HB
EN-GJS-800-8	EN-JS1100	260 to 320
EN-GJS-1000-5	EN-JS1110	300 to 360
EN-GJS-1200-2	EN-JS1120	340 to 440
EN-GJS-1400-1	EN-JS1130	380 to 480

NOTE The material designation is in accordance with EN 1560.

SOUTH AFRICA SABS 936/937 — SPHEROIDAL GRAPHITE IRON CASTINGS

	Tensile strength R_m min.			Proof stress $R_{p0.2}$ min.			Elongation A min.	Hardness	
Grade	N/mm²	kgf/m²	ton/in²	N/mm²	kgf/m²	ton/in²	%	HB	§ Structure
SG 38	375	38.0	24.2	245	25.0	16.0	17	≤ 180	Ferrite
SG 42	410	42.0	2.5	275	28.1	17.7	12	≤ 200	Ferrite
SG 50	490	50.0	31.7	345	35.2	22.3	7	§ 170 - 240	Ferrite & pearlite
SG 60	590	60.0	38.1	390	39.8	25.2	4	§ 210 - 250	Pearlite
SG 70	685	70.0	44.4	440	44.9	28.5	3	§ 230 - 300	Pearlite
SG 80	785	80.0	50.8	490	50.0	31.7	2	§ 260 - 330	Pearlite or temper structure

§ For information only.

SOUTH AFRICA SABS 1656:1995 AUSTEMPERED DUCTILE IRON CASTINGS

Grade	Minimum tensile strength R_m MPa	Minimum proof stress $R_{p0.2}$ MPa	Minimum elongation %	Impact strength (energy loss) J	Hardness[1)]
ADI 850	850	550	10	100	269 - 321
ADI 1050	1050	700	7	80	302 - 363
ADI 1200	1200	850	4	60	341 - 444
ADI 1400	1400	1100	1	35	388 - 477
ADI 1600	1600	1300	–	–	444 - 555

[1)] For information only.

SOUTH AFRICA AUSTENITIC SPHEROIDAL GRAPHITE IRON CASTINGS

	Tensile strength R_m min.			Proof stress $R_{p0.2}$ min.			Elongation A min.	Hardness max.
Grade	N/mm²	kgf/m²	ton/in²	N/mm²	kgf/m²	ton/in²	%	HB
ASG-2A	375	38.0	24.2	205	21.0	13.3	8	200
ASG-2B	375	38.0	24.2	205	21.0	13.3	6	255
ASG-3A	375	38.0	24.2	195	20.0	12.5	20	170
ASG-4A	375	38.0	24.2	205	21.0	13.3	10	230
ASG-5A	375	38.0	24.2	205	21.0	13.3	7	200
ASG-6A	410	42.0	26.5	205	21.0	13.3	25	170

PHYSICAL PROPERTIES OF SOME ELEMENTS

Element	Symbol	Atomic Weight	Melting Point °F	Melting Point °C	Boiling Point °F	Density grs/cc
Aluminium	Al	26.97	1220	660	3272	2.70
Antimony	Sb	121.76	1167	630	2516	6.62
Barium	Ba	137.36	1562	850	2084	3.50
Beryllium	Be	9.02	2462	1350	2732	1.82
Bismuth	Bi	209.00	520	271	2642	9.80
Boron	B	10.82	4172	2282	4622	2.30
Cadmium	Cd	112.41	610	321	1408	8.65
Calcium	Ca	40.08	1564	851	2522	1.55
Carbon	C	12.00	–	–	6512	2.22
Cerium	Ce	140.13	1427	640	2552	6.79
Chromium	Cr	52.01	3326	1812	3992	7.14
Cobalt	Co	58.94	2696	1480	5252	8.90
Columbium	Nb	92.91	3542	1932	5972	8.57
Copper	Cu	63.57	1982	1082	4259	8.94
Gold	Au	197.20	1945	1062	4712	19.30
Iron	Fe	55.84	2795	1535	5430	7.87
Lead	Pb	207.22	621	327	2948	11.35
Lithium	Li	6.94	367	186	2437	0.53
Magnesium	Mg	24.32	1204	652	2007	1.74
Manganese	Mn	54.94	2273	1245	3452	7.20
Mercury	Hg	200.61	-38	–	676	13.55
Molybdenum	Mo	96.00	4748	2602	6692	10.20
Nickel	Ni	58.69	2645	1452	5252	8.85
Palladium	Pd	106.70	2831	1555	3992	12.00
Phosphorus	P	31.02	111	42	536	1.82
Platinum	Pt	195.23	3224	1755	7772	21.45
Potassium	K	39.09	144	62	1400	0.86
Rhodium	Rh	102.91	3551	1882	4532	12.50
Selenium	Se	78.96	428	220	1270	4.81
Silicon	Si	28.06	2588	1420	4712	2.40
Silver	Ag	107.88	1761	961	3542	10.50
Sodium	Na	22.99	207	97	1616	0.97
Strontium	Sr	87.63	1472	800	2102	2.60
Sulfur	S	32.06	235	112	832	2.07
Tantalum	Ta	180.88	5162	2832	7412	16.60
Tellurium	Te	127.61	846	451	2534	6.24
Thallium	Ti	204.39	578	302	3002	11.85
Thorium	Th	232.12	3353	1827	5432	11.50
Tin	Sn	118.70	450	232	4100	7.30
Titanium	Ti	47.90	3272	1782	5432	4.50
Tungsten	W	184.00	6098	3334	10526	19.30
Uranium	U	238.14	3074	1672	6332	18.70
Vanadium	V	50.95	3110	1692	5432	5.68
Zinc	Zn	65.38	787	419	1661	7.14
Zirconium	Zr	91.22	3092	1682	5252	6.40

CONVERSIONS: English, SI units, and non-SI metric units

1 lbf/in^2	=	1 psi
1 ksi	=	1000 psi
	=	6.895 N/m^2
	=	6.895 MPa
	=	0.7031 kgf/mm^2
	=	0.4464 $tonf/in^2$
1 N/mm^2	=	1 MN/m^2
	=	1 MPa
	=	0.06475 $tonf/in^2$
	=	145.04 lbf/in^2
	=	0.10197 kgf/mm^2
1 kgf/mm^2	=	9.8067 N/mm^2
	=	0.63497 $tonf/in^2$
	=	1422.4 lbf/in^2
1 $tonf/in^2$	=	15.444 N/mm^2
	=	1.5749 kgf/mm^2
	=	2240 lbf/in^2
1 ft-lbf	=	1.3558 J
	=	0.1369 kgf-m
1 J	=	0.73757 ft-lbf
	=	0.10197 kgf-m
1kgf-m	=	9.8067 J
	=	7.3068 ft lbf

	Units English	Multiplication Factor	SI Units
Area	in^2	6.45	cm^2
Area	ft^2	.093	m^2
Length	in	2.54	cm
Length	ft	.305	m
Mass	lb	.454	kg
Temp	(°F - 32)	.556	°C