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Microstructure of cast irons

Part 3: Matrix structures

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National foreword

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Part 3: Matrix structures

Microstructure des fontes —

Partie 3: Structures de matrice

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 25, *Cast irons and pig irons.*

ISO 945 consists of the following parts, under the general title *Microstructure of cast irons*:

— *Part 1: Graphite classification by visual analysis*

— *Part 2: Graphite classification by image analysis* [Technical Report]

— *Part 3: Matrix structures* [Technical Report]

The following parts are under preparation:

— *Part 4: Determination of nodularity in spheroidal graphite cast irons*

Introduction

The designation of cast iron matrix structures as given in this part of ISO 945 is in conformity with the designations published by several national foundry organisations[1][2][3] or other publishers[4].

This Technical Report aims to

— give the designations, precise descriptions and reference micrographs of the matrix structures of cast irons, and

— facilitate the discussion and to avoid misunderstanding between manufacturer and purchaser regarding the identification of matrix structures.

Microstructure of cast irons —

Part 3: Matrix structures

1 Scope

This Technical Report gives the designations, descriptions and reference micrographs of the matrix structures of cast irons.

It applies to the following types of cast irons:

— grey cast irons (Table 4.1);

— spheroidal graphite cast irons (Table 4.2);

— austenitic cast irons (Table 4.3);

— malleable cast irons (Table 4.4);

— compacted (vermicular) graphite cast irons (Table 4.5);

— ausferritic spheroidal graphite cast irons (Table 4.6);

— abrasion-resistant cast irons (Table 4.7).

Each matrix structure is defined with explanations and micrographs.

Unless otherwise stated in Clause 4, the micrographs shown correspond to samples etched with a solution of 2 % nitric acid in ethanol (Nital).

2 Designations and descriptions of cast iron microstructures

2.1 Ferrite

Ferrite also known as α-ferrite (α-Fe) or alpha iron is a materials science term for iron, or for a solid solution with iron as the main constituent, with a body-centred cubic crystal structure. It is this crystalline structure which gives to steels and cast irons their magnetic properties, and is the classic example of a ferromagnetic material.

Since pearlite has ferrite as a component, any iron-carbon alloy will contain some amount of ferrite if it is allowed to reach equilibrium at room temperature. The exact amount of ferrite will depend on the cooling processes the iron-carbon alloy undergoes when it cools from liquid state.

2.2 Pearlite

Pearlite is a two-phased, lamellar (or layered) structure composed of alternating layers of alpha-ferrite (according thermal dynamical condition 88 % by mass) and cementite (12 % by mass). The lamellar appearance is misleading since the individual lamellae within a colony are connected in three dimensions; a single colony is therefore an interpenetrating bicrystal of ferrite and cementite. Pearlite is a common microstructure occurring in many grades of cast irons.

If cast iron is cooled very slowly or as a result of heat treatment, the cementite can occur in globules instead of in layers. This structure is designated as globular pearlite.

2.3 Austenite

Austenite, also known as gamma phase iron (γ-Fe), is a non-magnetic allotrope of iron or a solid solution of iron, stabilized by an alloying element, e.g. nickel. Austenite is the face-centred cubic crystal structure of iron.

2.4 Acicular ferrite

Acicular ferrite is a microstructure of ferrite that is characterized by needle shaped crystallites or grains when viewed in two dimensions. The grains, actually three dimensional in shape, have a thin lenticular shape. This microstructure is advantageous over other microstructures because of its chaotic ordering, which increases toughness.

2.5 Ausferrite

Ausferrite is a special type of multi-phase microstructure that occurs when cast irons with a silicon content of about 2 % or higher are austempered.

Austempering consists of rapidly cooling the fully austenitic iron to avoid the formation of pearlite to a temperature above that of martensite formation and holding for the time necessary to precipitate the ausferrite matrix. This microstructure consists primarily of acicular ferrite in carbon enriched austenite.

2.6 Bainite

Bainite is a multi-phase microstructure, consisting of acicular ferrite and cementite that forms in cast irons during rapid cooling. It is one of the decomposition products that can form when austenite is cooled rapidly below the eutectoid temperature, but above the martensitic starting (M_S) temperature. Bainite can also form from the decomposition of ausferrite upon extended heating above the temperature at which it was formed.

2.7 Cementite

Cementite, also known as iron carbide, is a compound of iron and carbon, with the formula Fe_3C.

By mass, it is 6,7 % carbon and 93,3 % iron. Cementite has an orthorhombic crystal structure.

In the iron-carbon system cementite is a common constituent because ferrite contains maximum 0,02 % by mass of carbon. Therefore, in cast irons that are slowly cooled, a part of these elements is in the form of cementite. In the case of white cast irons, cementite precipitates directly from the melt. In grey cast irons or spheroidal graphite cast irons, cementite forms either from austenite during cooling or from martensite during tempering, or from the decomposition of ausferrite. An intimate mixture of cementite with ferrite, the other product of austenite, forms a lamellar structure called pearlite (see 2.2).

2.8 Ledeburite

Ledeburite is an eutectic mixture of austenite and cementite and is formed when the melt at least partly solidifies according the metastable Fe-C-Si system.

2.9 Martensite

Martensite is formed from austenite by rapid cooling (quenching) which traps carbon atoms that do not have time to diffuse out of the crystal structure. The martensite lattice is body-centred tetragonal composed of ferrite and carbon. This martensitic reaction begins during cooling when the austenite reaches the martensite start temperature (M_S) and the parent austenite becomes mechanically unstable. At a constant temperature below M_S, a fraction of the parent austenite transforms rapidly, after which no further transformation occurs. When the temperature is decreased, more of the austenite transforms to martensite. Finally, when the martensite finish temperature (M_f) is reached,

the transformation ends. Martensite can also be formed by application of stress in ausferritic spheroidal graphite cast irons (SITRAM effect: stress induced transformation from austenite to martensite). Thus, martensite can be thermally induced or stress induced.

3 Sampling and preparation of samples

3.1 Samples taken from castings and cast samples

The location from which samples are taken should be agreed between the manufacturer and purchaser and should take into account the requirements specified in the appropriate material standard. If an examination report is required, the location from where the final sample is taken shall be recorded.

The sample should be of sufficient size to provide a true representation of the matrix structure in the agreed location from which it is taken.

3.2 Sample preparation

Attention should be paid to the careful cutting, grinding, polishing and etching of samples, so that the matrix structure appears in its original form. Inappropriate preparation can cause alteration of the microstructure and misinterpretations.

Sample preparation should be carried out in four stages:

1) sectioning;

2) grinding;

3) polishing;

4) etching.

NOTE In some cases mounting of the sample in a polymeric material can be necessary.

The examination of the matrix structure shall be carried out in the etched condition.

4 Matrix structures

4.1 Grey cast irons

Table 4.1 — Grey cast irons according to ISO 185[5]

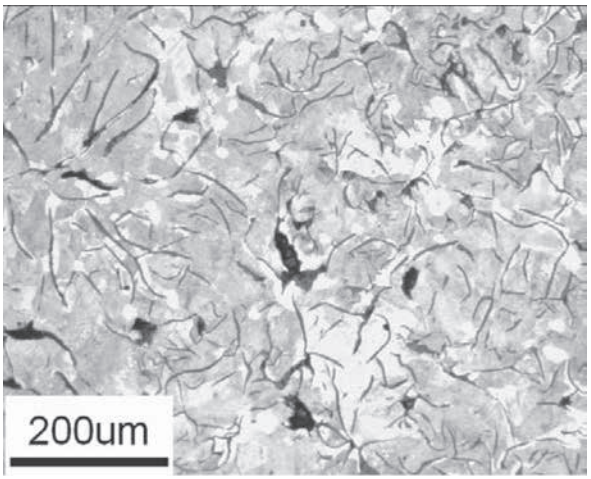
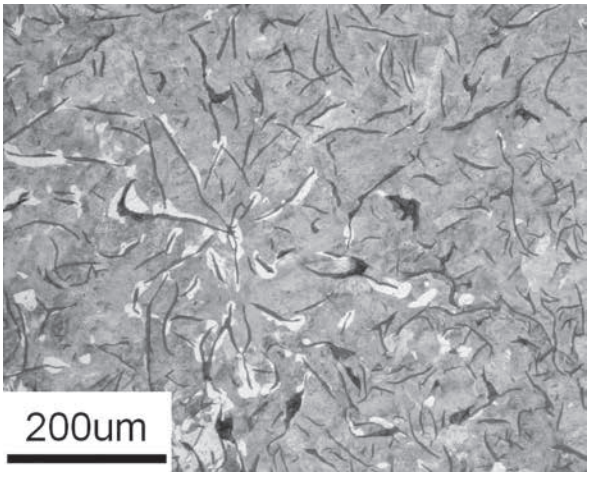
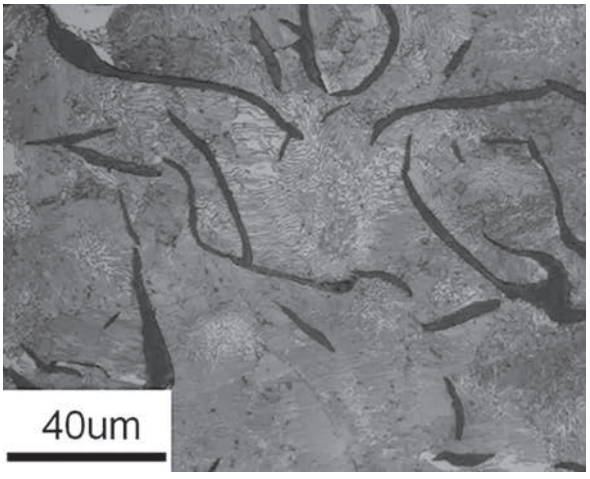
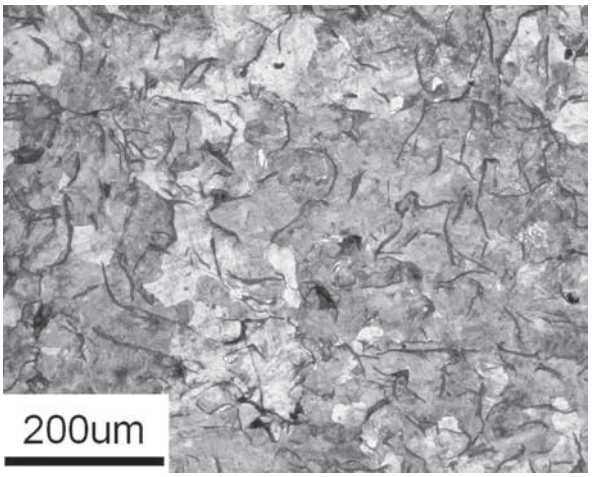
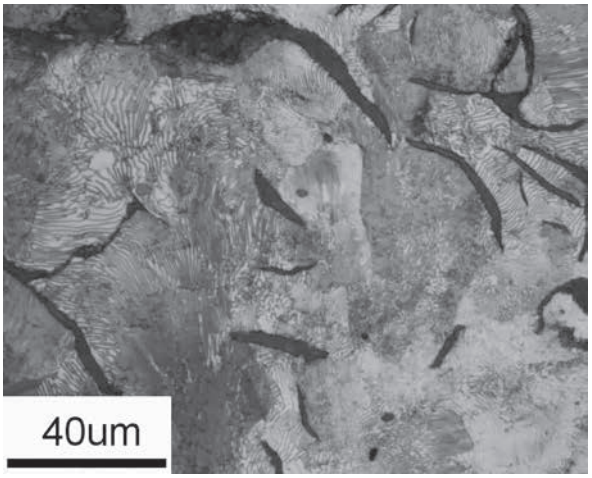
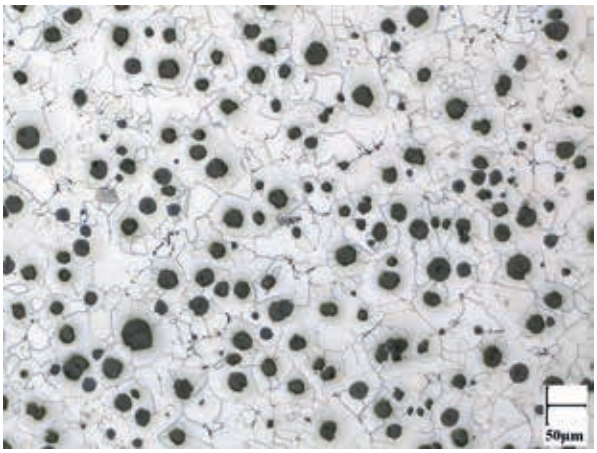
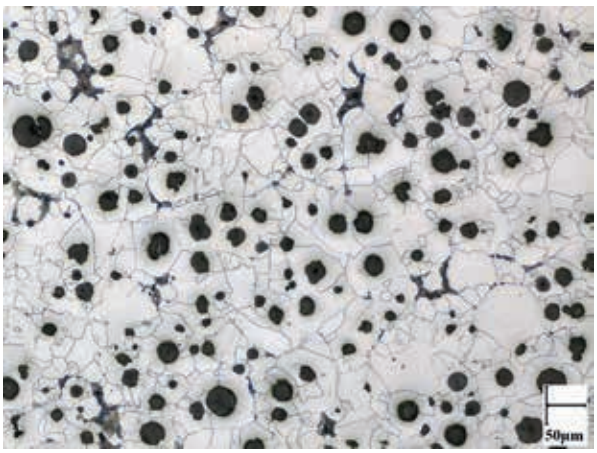
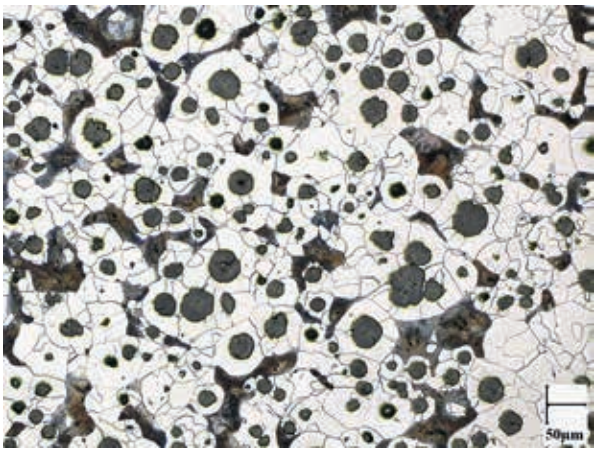
Micro-graph	Material designation	Matrix structure	
4.1.1	ISO 185/JL/100 ISO 185/JL/HBW155	Pearlite – ferrite 100 x 200 µm	
4.1.2	ISO 185/JL/150	Pearlite – ferrite 100 x 200 µm	
4.1.3	ISO 185/JL/HBW175	Pearlite – ferrite 500 x 40 µm	

Table 4.1 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.1.4	ISO 185/JL/200 ISO 185/JL/225 ISO 185/JL/250 ISO 185/JL/275 ISO 185/JL/HBW195 ISO 185/JL/HBW215	Predominantly pearlite 100 x Shown is JL/250 200 µm	
4.1.5		Predominantly pearlite 500 x Shown is JL/250 40 µm	
4.1.6	ISO 185/JL/300 (shown) ISO 185/JL/350 ISO 185/JL/HBW235 ISO 185/JL/HBW255	Pearlite 100x 200 µm	

4.2 Spheroidal graphite cast irons

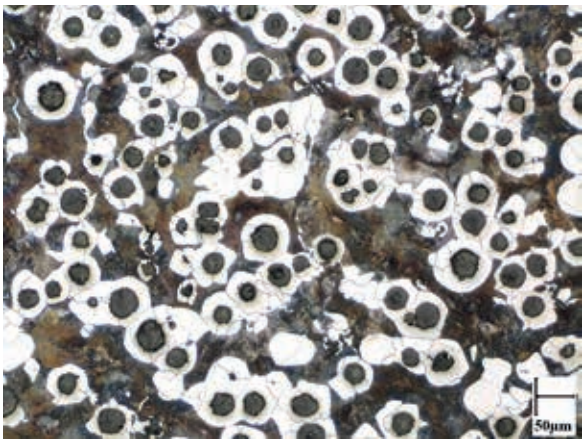
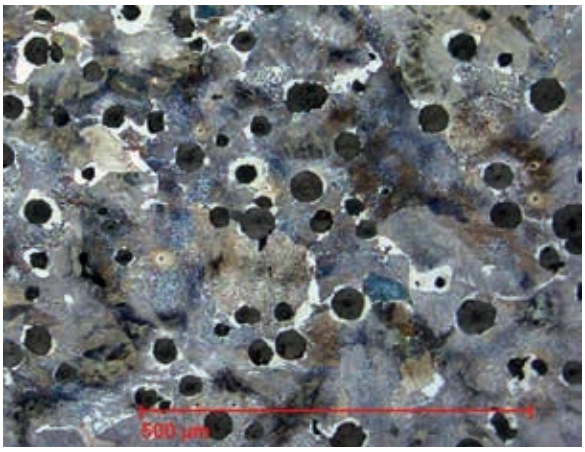
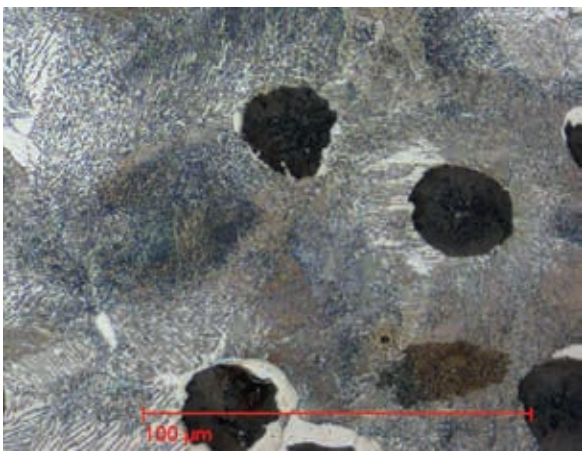
Table 4.2 — Spheroidal graphite cast irons according to ISO 1083[6]

Micro-graph	Material designation	Matrix structure	
4.2.1	ISO 1083/JS/350-22 ISO 1083/JS/400-18 ISO 1083/JS/400-15 ISO 1083/JS/500-10 ISO 1083/JS/HBW130 ISO 1083/JS/HBW150 ISO 1083/JS/HBW155	Ferrite 100x 200 µm	
4.2.2	ISO 1083/JS/450-10 ISO 1083/JS/HBW185	Predominantly [a] ferrite 100x 200 µm	
4.2.3	ISO 1083/JS/500-7 ISO 1083/JS/550-5 ISO 1083/JS/HBW200 ISO 1083/JS/HBW215	Ferrite – pearlite 100x 200 µm	

[a] The term "predominantly" does not appear in ISO 1083, only "ferrite".

NOTE Information regarding the evaluation of the pearlite content of the matrix of spheroidal graphite cast iron is given in Annex A.

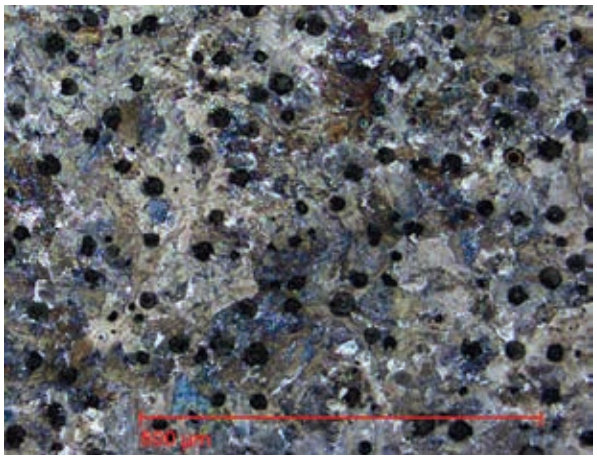
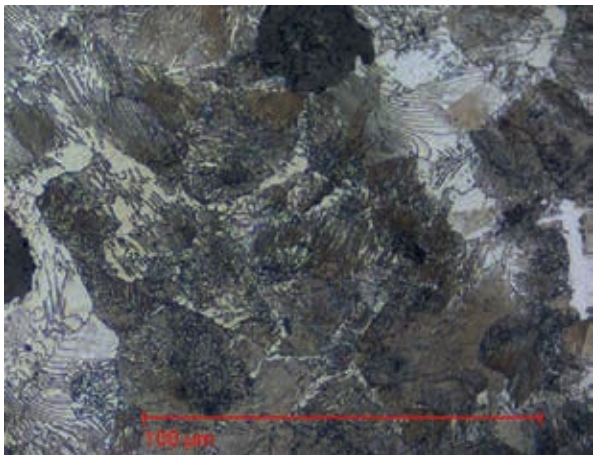
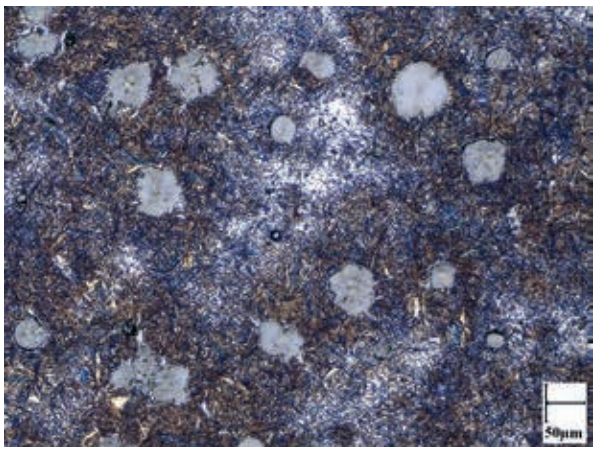
Table 4.2 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.2.4	ISO 1083/JS/600-3 ISO 1083/JS/HBW230	Pearlite – ferrite 100x 200 µm	
4.2.5	ISO 1083/JS/700-2	Predominantly [a] pearlite 100x 200 µm	
4.2.6	ISO 1083/JS/HBW265	Pearlite 500x 40 µm	

[a] The term "predominantly" does not appear in ISO 1083, only "ferrite".

NOTE Information regarding the evaluation of the pearlite content of the matrix of spheroidal graphite cast iron is given in Annex A.

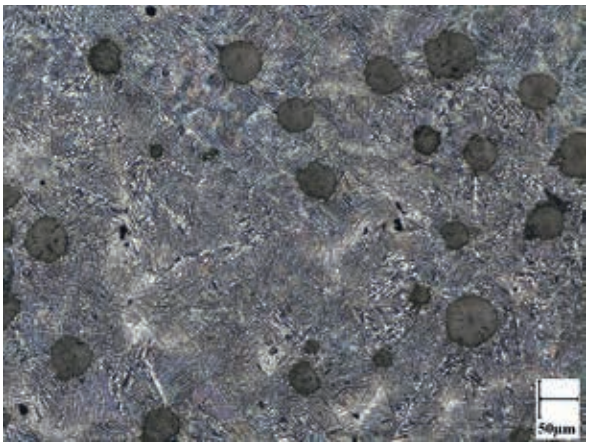
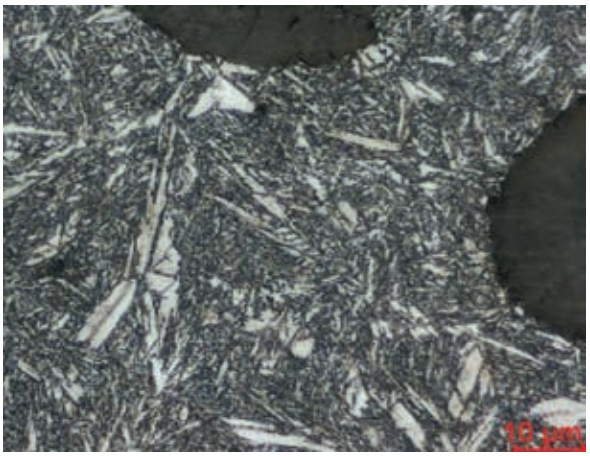
Table 4.2 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.2.7	ISO 1083/JS/800-2 ISO 1083/JS/HBW300	Pearlite (shown) or tempered martensite (shown in 4.2.9) 100x	
4.2.8		Pearlite 500x	
4.2.9		Tempered martensite 100x	

[a] The term “predominantly” does not appear in ISO 1083, only “ferrite”.

NOTE Information regarding the evaluation of the pearlite content of the matrix of spheroidal graphite cast iron is given in Annex A.

Table 4.2 *(continued)*

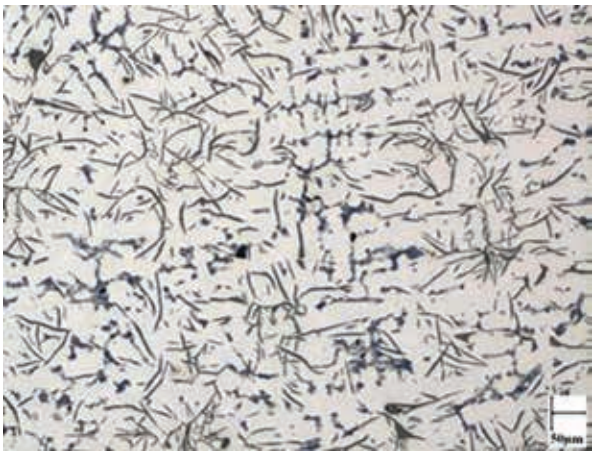
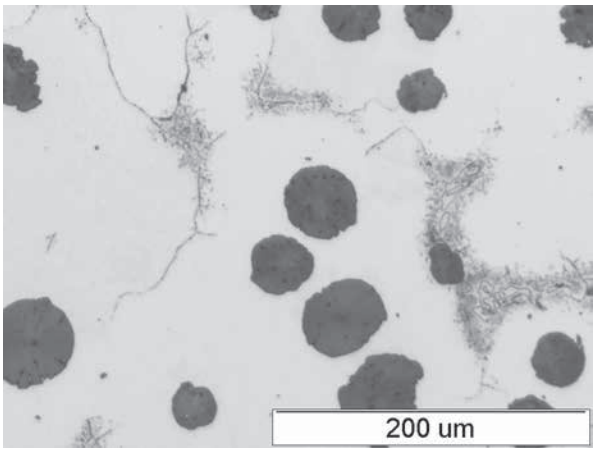
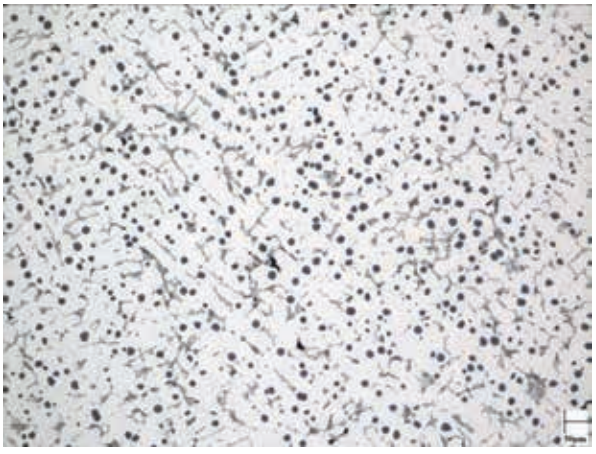
Micro-graph	Material designation	Matrix structure	
4.2.10	ISO 1083/JS/900-2	Bainite-martensite (shown) or tempered martensite (shown in 4.2.9) 100x 200 µm	
4.2.11	ISO 1083/JS/HBW330	Bainite-martensite 1 000x 20 µm	

[a] The term “predominantly” does not appear in ISO 1083, only “ferrite”.

NOTE Information regarding the evaluation of the pearlite content of the matrix of spheroidal graphite cast iron is given in Annex A.

4.3 Austenitic cast irons

Table 4.3 — Austenitic cast irons according to ISO 2892[7]

Micro-graph	Material designation	Matrix structure	
4.3.1	ISO 2892/JLA/XNi15Cu6Cr2 ISO 2892/JLA/XNi13Mn7	Austenite 100x Shown is JLA/XNi15Cu6Cr2 200 µm	
4.3.2	ISO 2892/JSA/XNi20Cr2 ISO 2892/JSA/XNi23Mn4 ISO 2892/JSA/XNi20Cr2Nb ISO 2892/JSA/XNi22 ISO 2892/JSA/XNi35	Austenite Shown are JSA/XNi20Cr2 200x 100 µm	
4.3.3	ISO 2892/JSA/XNi35Si5Cr2 ISO 2892/JSA/XNi13Mn7 ISO 2892/JSA/XNi30Cr3 ISO 2892/JSA/XNi30Si5Cr5 ISO 2892/JSA/XNi35Cr3	and JSA/XNi35Cr3 100x 200 µm	

4.4 Malleable cast irons

Table 4.4 — Malleable cast irons according to ISO 5922[8]

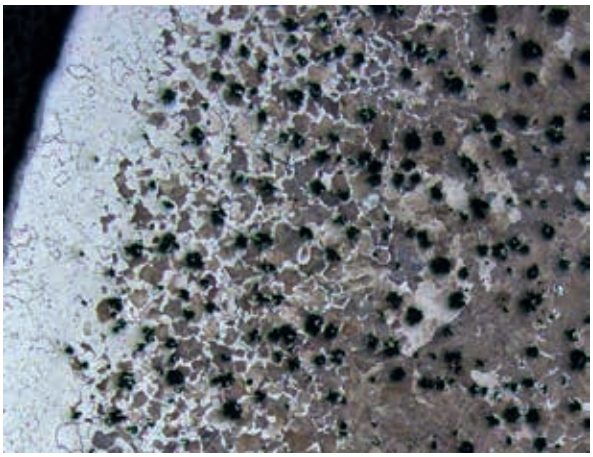
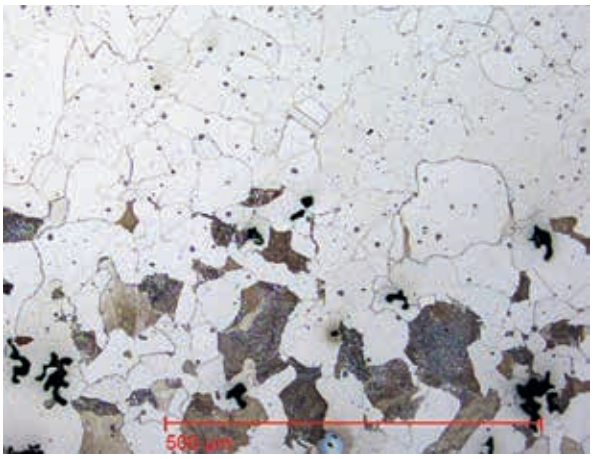
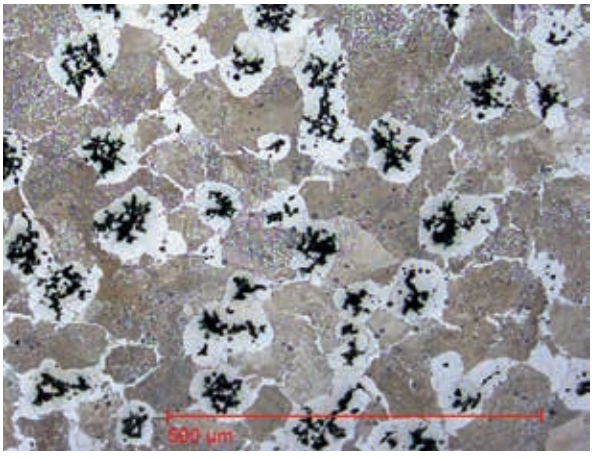
Micro-graph	Material designation	Matrix structure	
4.4.1	ISO 5922/JMW/350-4 Furnace cooled	Ferrite and pearlite 25x	
4.4.2		Surface zone Predominantly ferritic 100x	
4.4.3		Core zone Pearlite and ferrite 100x	

Table 4.4 *(continued)*

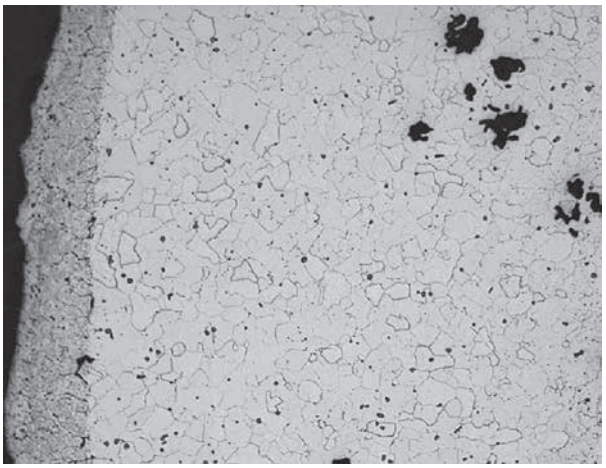
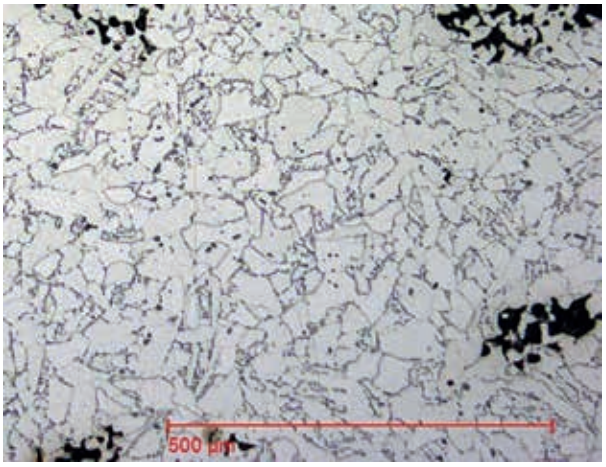
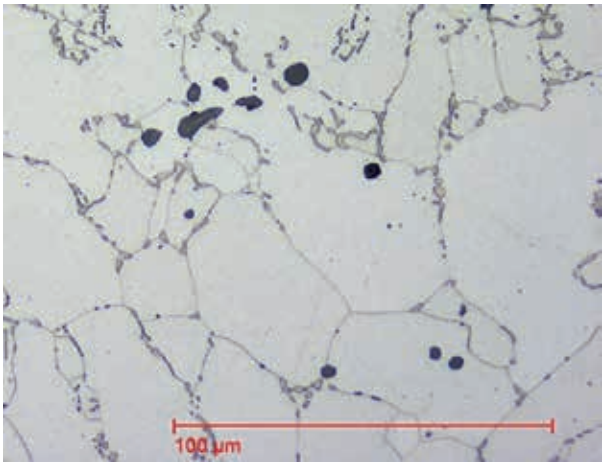
Micro-graph	Material designation	Matrix structure	
4.4.4	ISO 5922/JMW/360-12 Air quenched	Surface zone Ferrite 50x	
4.4.5		Core zone Predominantly ferritic 100x	
4.4.6		Core zone Predominantly ferritic 500x	

Table 4.4 — (*continued*)

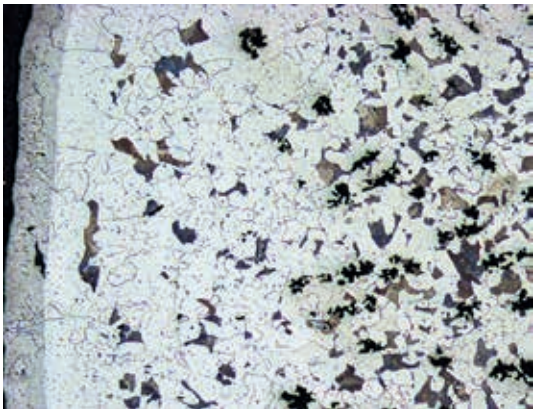
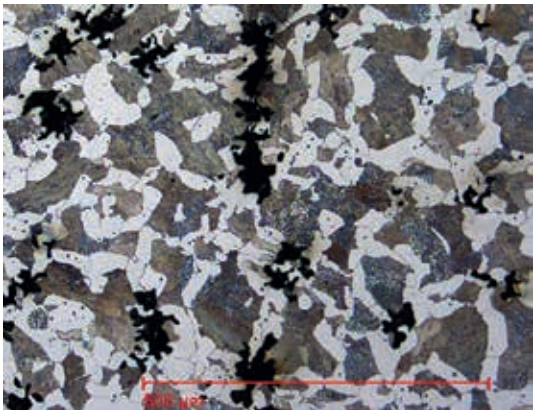
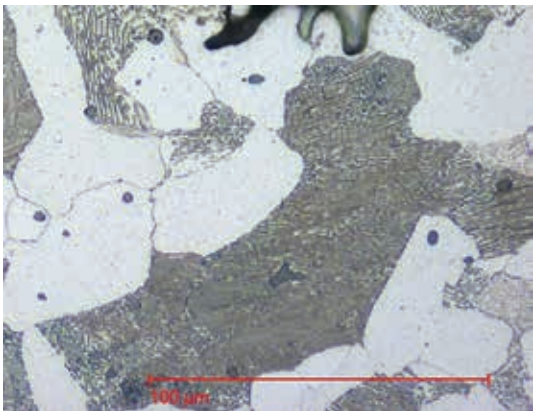
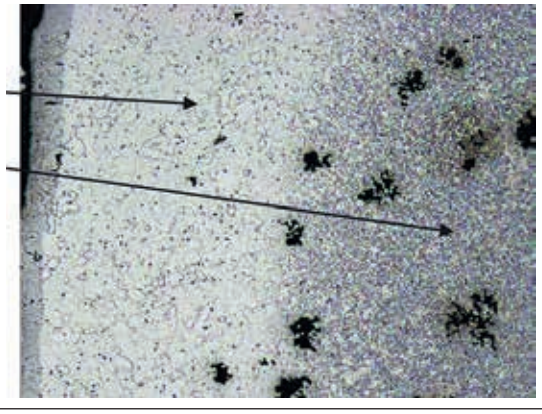
Micro-graph	Material designation	Matrix structure	
4.4.7	ISO 5922/JMW/400-5 Furnace cooled	Surface zone Predominantly ferritic 50x	
4.4.8		Core zone Ferrite and pearlite 100x	
4.4.9		Core zone Ferrite and pearlite 500x	
4.4.10	ISO 5922/JMW/450-7 Air quenched	Surface zone Ferrite and globular pearlite 50x	

Table 4.4 — (*continued*)

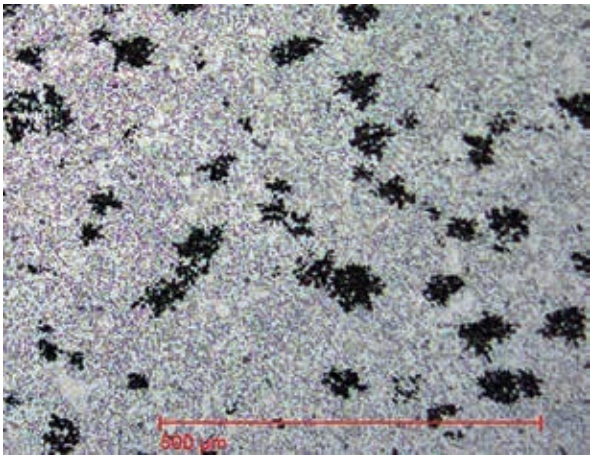
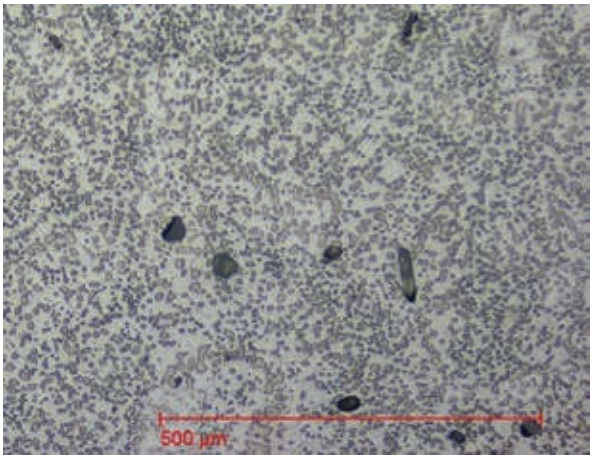
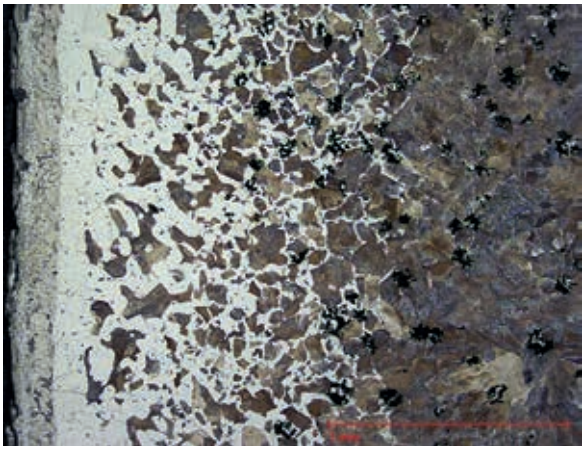
Micro-graph	Material designation	Matrix structure	
4.4.11		Core zone Globular pearlite 100x 200 µm	
4.4.12		Core zone Globular pearlite 100x 200 µm	
4.4.13	ISO 5922/JMW/550-4 Furnace cooled	Surface zone Transition of ferrite (surface) to pearlite (core) 30x 67 µm	

Table 4.4 — (*continued*)

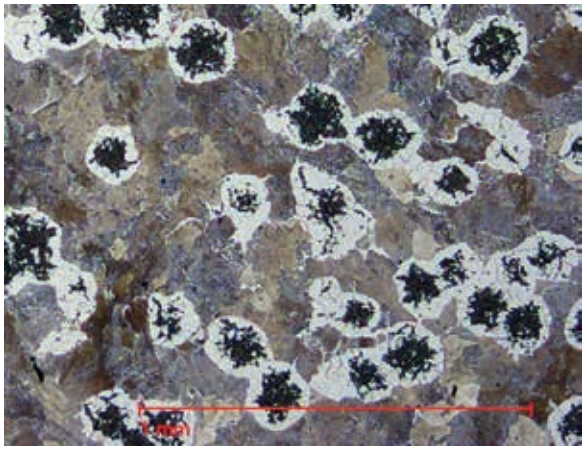
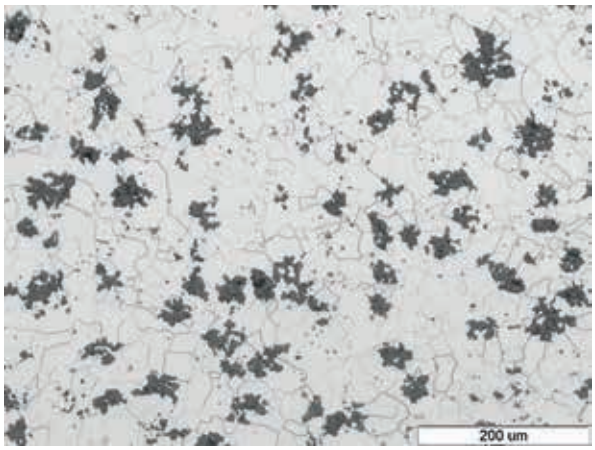
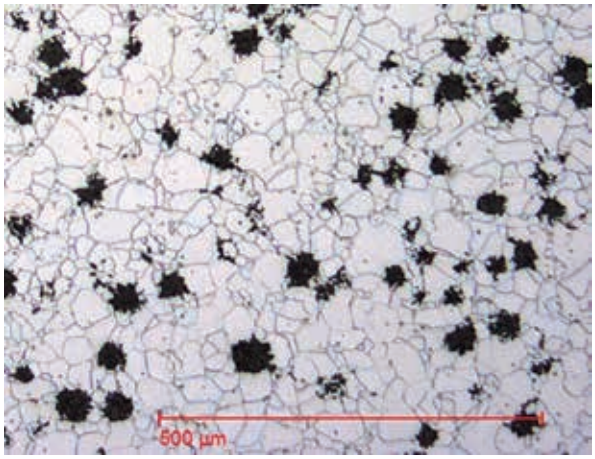
Micro-graph	Material designation	Matrix structure	
4.4.14		Core zone Pearlite and ferrite 100x 200 µm	
4.4.15	ISO 5922/JMB/275-5 ISO 5922/JMB/300-6 Furnace cooled	Ferrite 100x Shown is JMB/275-5 200 µm	
4.4.16	ISO 5922/JMB/350-10 Furnace cooled	Ferrite 100x 200 µm	

Table 4.4 *(continued)*

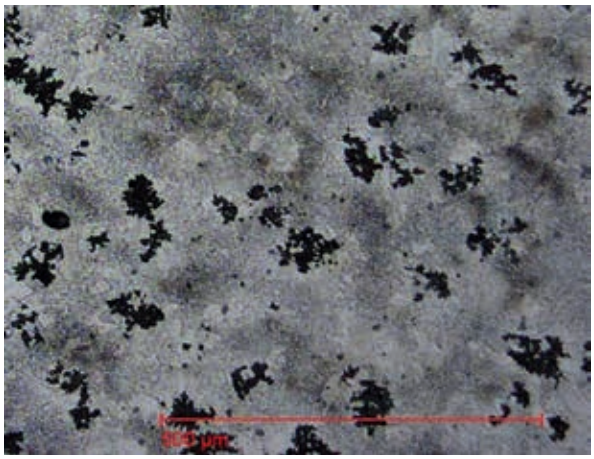
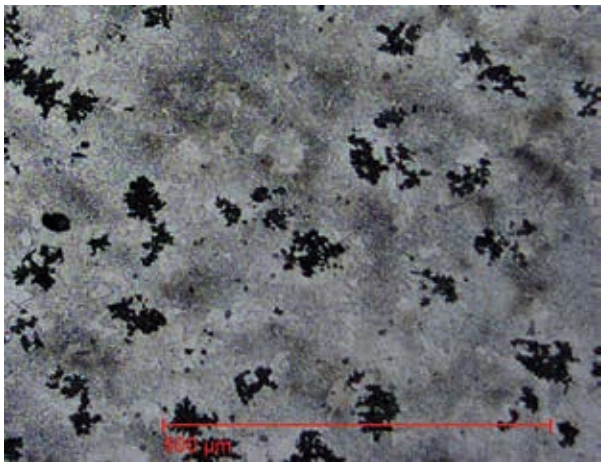
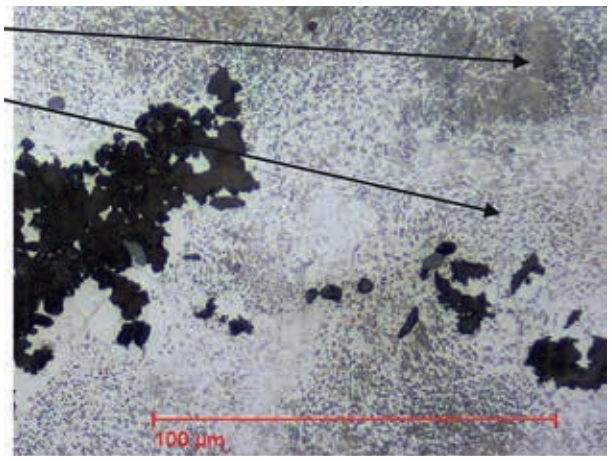
Micro-graph	Material designation	Matrix structure	
4.4.17	ISO 5922/JMB/450-6 Air quenched	Pearlite and globular pearlite 100x (see also 4.4.9) 200 µm	
4.4.18	ISO 5922/JMB/500-5 ISO 5922/JMB/550-4	Pearlite and globular pearlite 100x Shown is JMB/550-4 200 µm	
4.4.19	Air quenched	Pearlite Globular pearlite 500x Shown is JMB/550-4 40 µm	

Table 4.4 *(continued)*

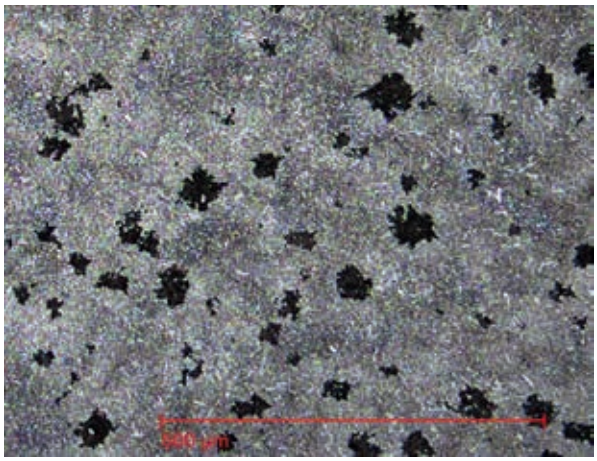
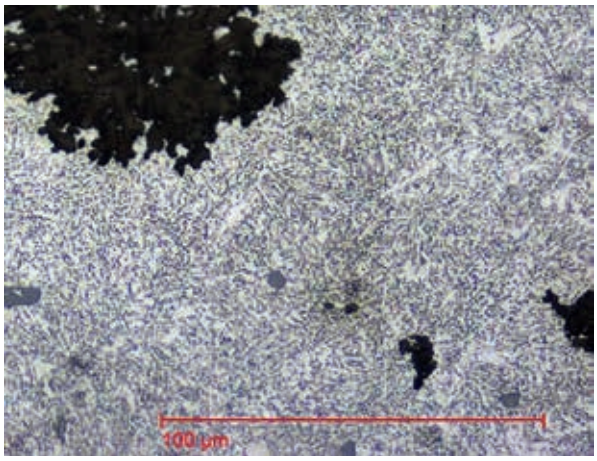
Micro-graph	Material designation	Matrix structure	
4.4.20	ISO 5922/JMB/500-5 ISO 5922/JMB/550-4 Oil quenched	Globular pearlite 100x Shown is JMB/550-4 200 µm	
4.4.21		Globular pearlite 500x Shown is JMB/550-4 40 µm	

Table 4.4 *(continued)*

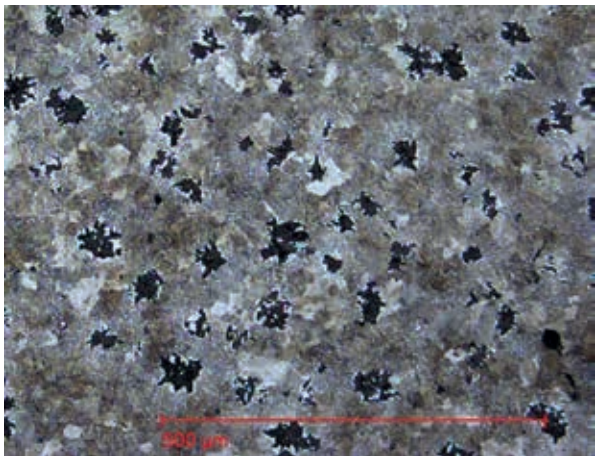
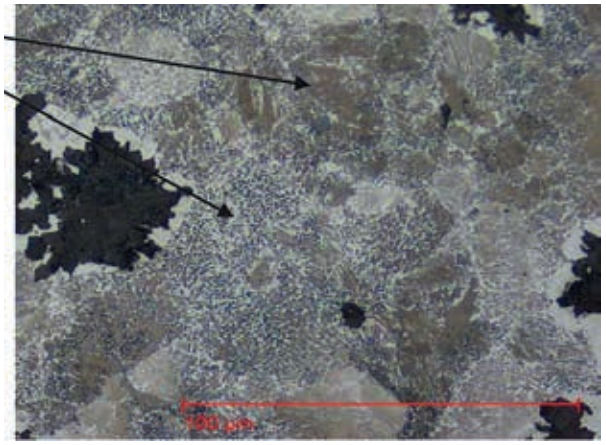
Micro-graph	Material designation	Matrix structure	
4.4.22	ISO 5922/JMB/600-3 Air quenched	Pearlite and globular pearlite 100x 200 µm	
4.4.23		Pearlite Globular pearlite 500x 40 µm	

Table 4.4 *(continued)*

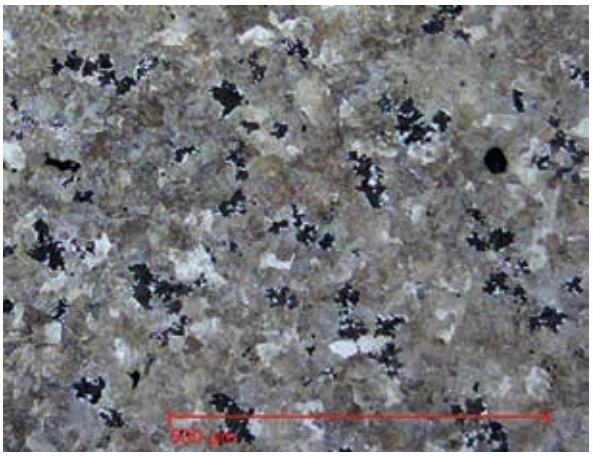
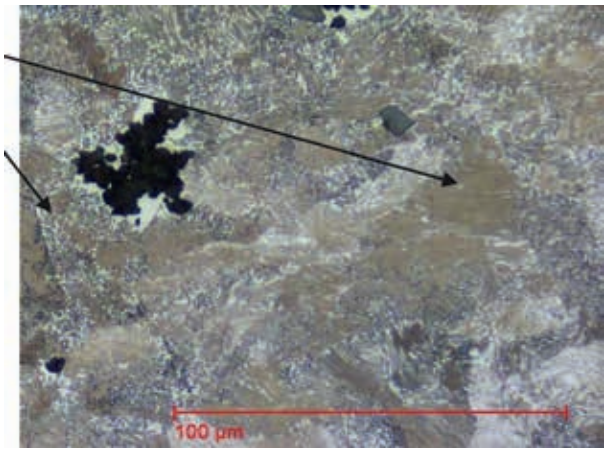
Micro-graph	Material designation	Matrix structure	
4.4.24	ISO 5922/JMB/650-2	Pearlite and globular pearlite 100x	
4.4.25	Air quenched	Pearlite Globular pearlite 500x	

Table 4.4 *(continued)*

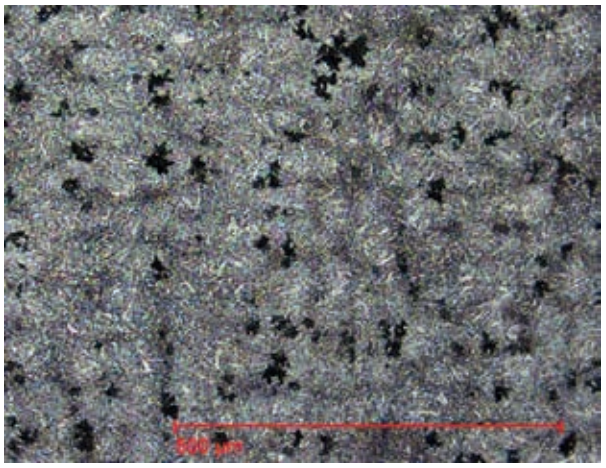
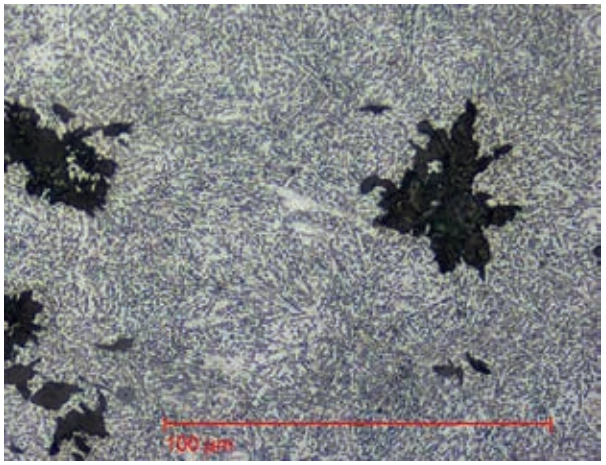
Micro-graph	Material designation	Matrix structure	
4.4.26	ISO 5922/JMB/650-2 Oil quenched	Globular pearlite 100x	
4.4.27		Globular pearlite 500x	

Table 4.4 *(continued)*

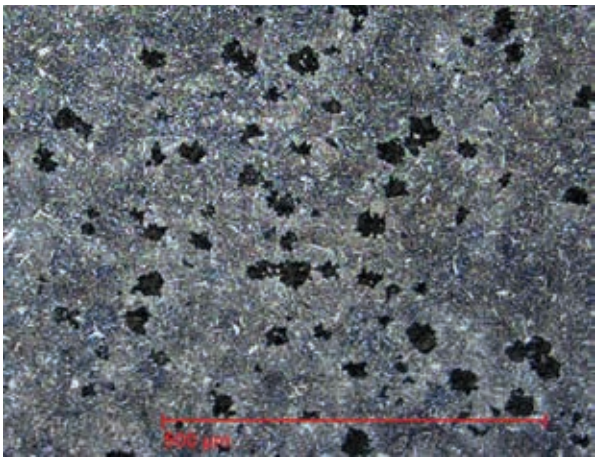
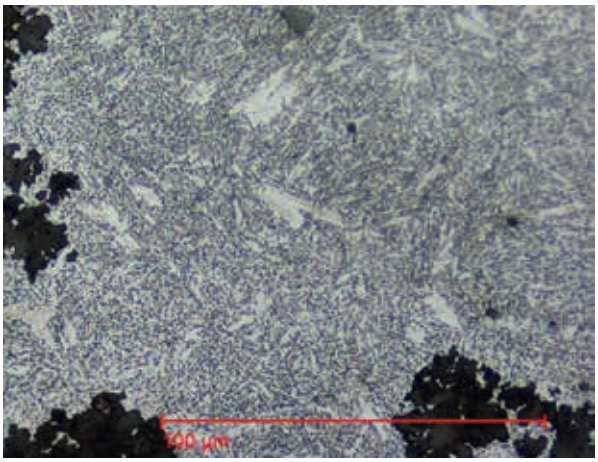
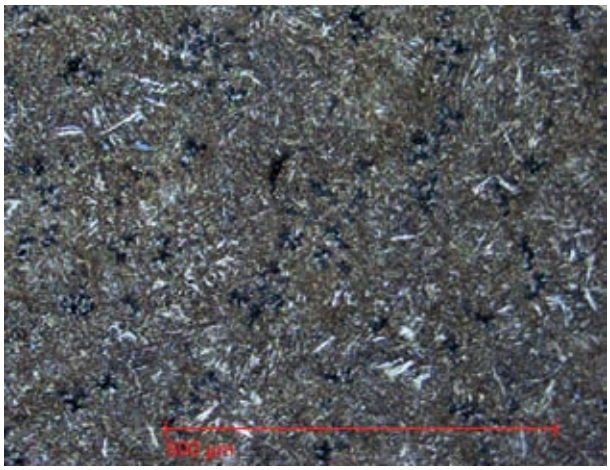
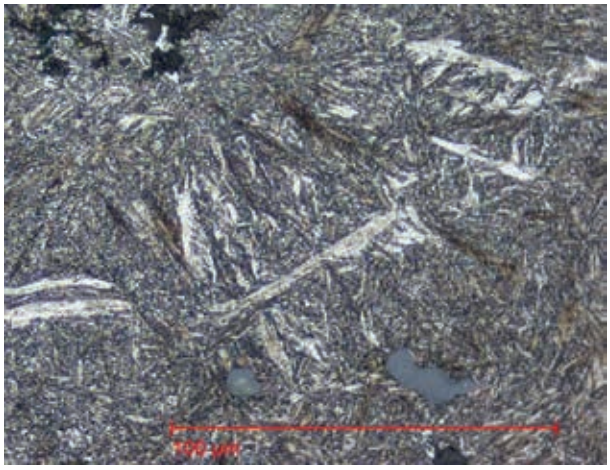
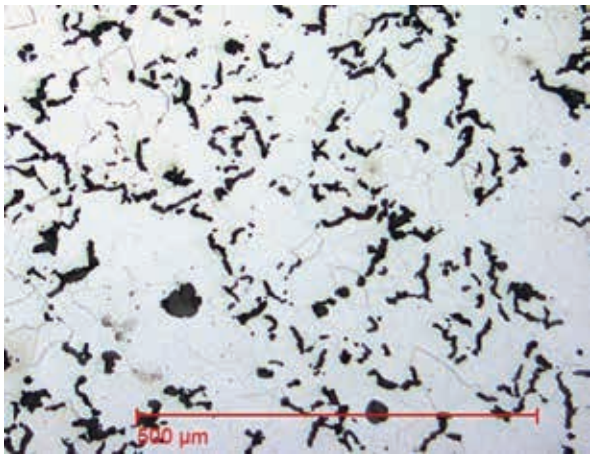
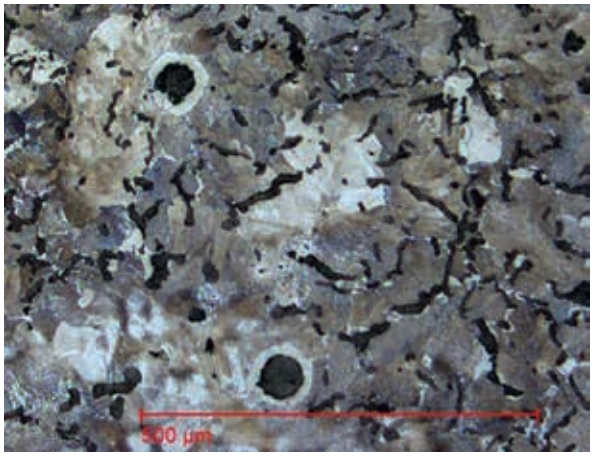
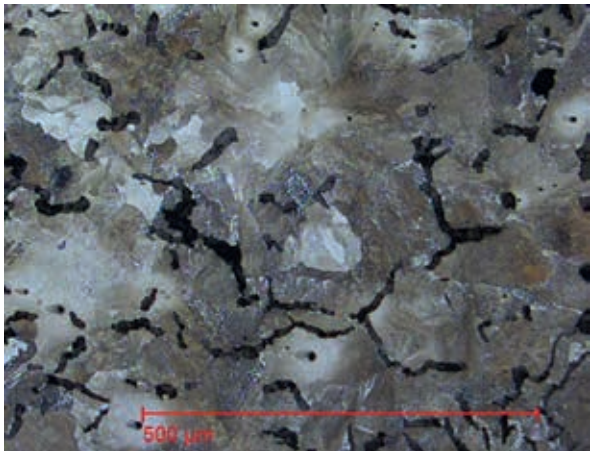
Micro-graph	Material designation	Matrix structure	
4.4.28	ISO 5922/JMB/700-2 Oil quenched	Globular pearlite 100x	
4.4.29		Globular pearlite 500x	

Table 4.4 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.4.30	ISO 5922/JMB/800-1	Tempered martensite 100x 200 µm	
4.4.31	Oil quenched	Tempered martensite 500x 40 µm	

4.5 Compacted (vermicular) graphite cast irons

Table 4.5 — Compacted (vermicular) graphite cast irons according to ISO 16112[9]

Micro-graph	Material designation	Matrix structure	
4.5.1	ISO 16112/JV/300	Predominantly ferrite 100x	
4.5.2	ISO 16112/JV/350 ISO 16112/JV/400	Pearlite and ferrite 100x Shown is JV/400	
4.5.3	ISO 16112/JV/450 ISO 16112/JV/500	Predominantly pearlite 100x Shown is JV/450	

4.6 Ausferritic spheroidal graphite cast irons

Table 4.6 — Ausferritic spheroidal graphite cast irons according to ISO 17804[10]

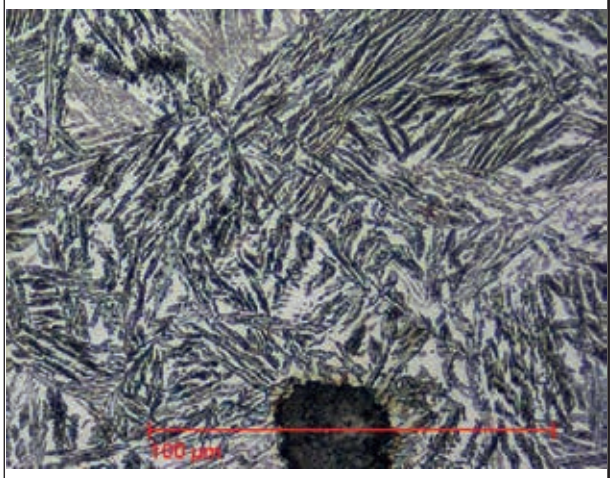
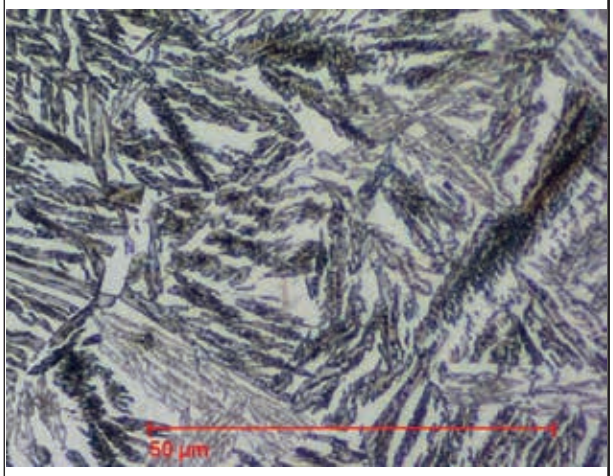
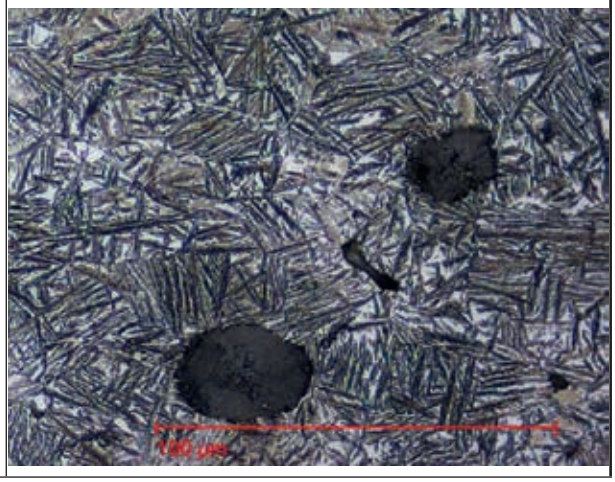
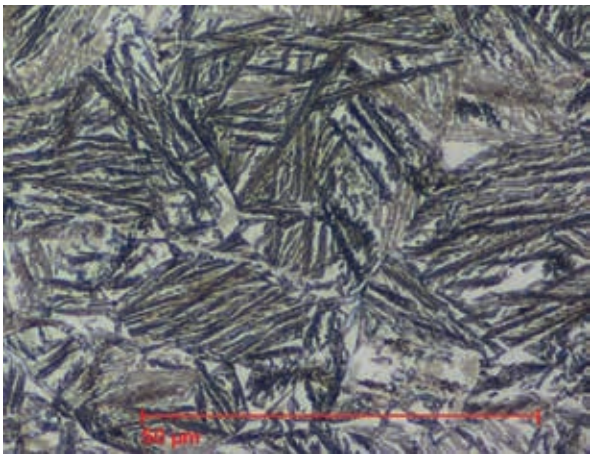
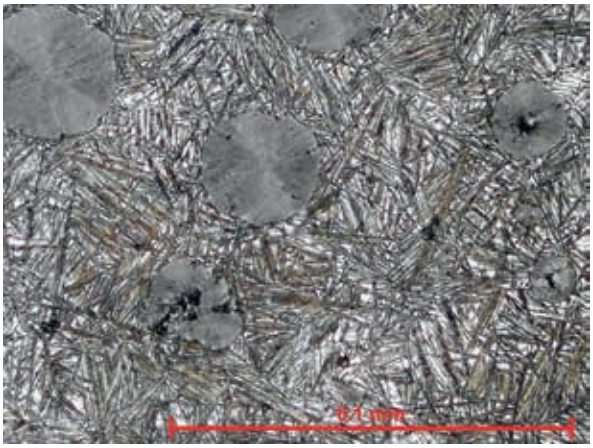
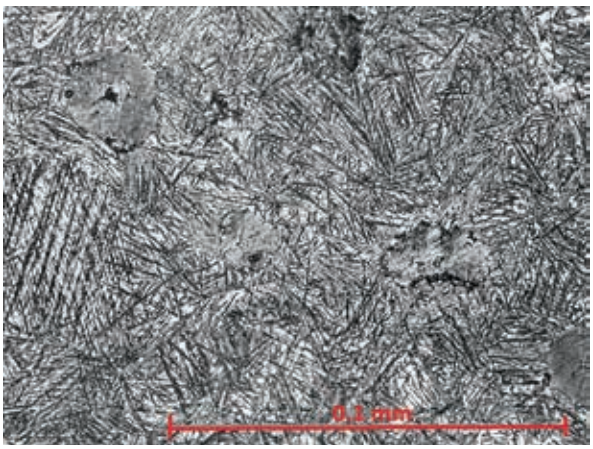
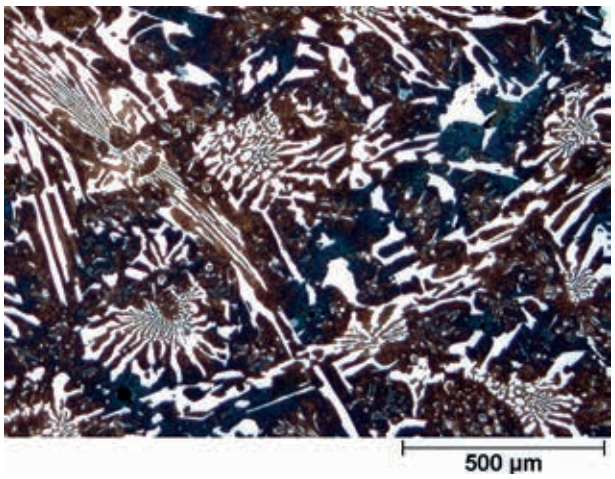
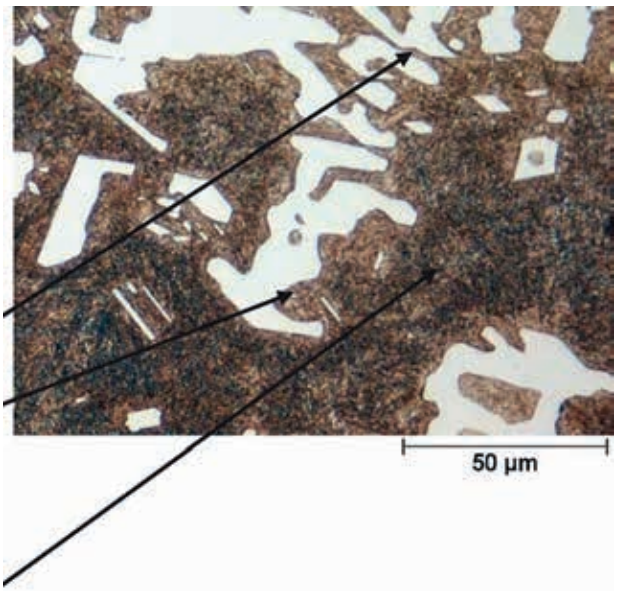
Micro-graph	Material designation	Matrix structure	
4.6.1	ISO 17804/JS/800-10	Ausferrite 500x Shown is JS/800-10 40 µm	
4.6.2	ISO 17804/JS/900-8	Ausferrite 1000x Shown is JS/800-10 20 µm	
4.6.3	ISO 17804/JS/1050-6 ISO 17804/JS/1200-3	Ausferrite 500x Shown is JS/1050-6 40 µm	

Table 4.6 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.6.4	ISO 17804/JS/1050-6 ISO 17804/JS/1200-3	Ausferrite 1000x Shown is JS/1050-6 20 µm	
4.6.5	ISO 17804/JS/1400-1 ISO 17804/JS/HBW400	Ausferrite 500x 40 µm	
4.6.6	ISO 17804/JS/HBW450	Ausferrite 500x 40 µm	

4.7 Abrasion-resistant cast irons

Table 4.7 — Abrasion-resistant cast irons according to ISO 21988[11]

Micro-graph	Material designation	Matrix structure	
4.7.1	ISO 21988/JN/HBW340 ISO 21988/JN/HBW400		No micrographs were available for these two grades of unalloyed or low alloyed abrasion resistant cast irons
4.7.2	ISO 21988/JN/HBW480Cr2 ISO 21988/JN/HBW510Cr2		No micrographs were available for these two grades of unalloyed or low alloyed abrasion resistant cast irons
4.7.3	ISO 21988/JN/HBW500Cr9 ISO 21988/JN/HBW555Cr9 ISO 21988/JN/HBW630Cr9	50x Shown is JN/HBW555Cr9 400 µm	
4.7.4		500x Eutectic austenite partially transformed to martensite and fine secondary carbides by heat treatment Eutectic M_7C_3 carbides Primary austenite dendrites partially transformed to martensite and fine secondary carbides by heat treatment Shown is JN/HBW555Cr9 40 µm	

NOTE 1 Etchant used on the samples 4.7.3 up to and including 4.7.8 is acidic ferric chloride (AFC) in ethanol.

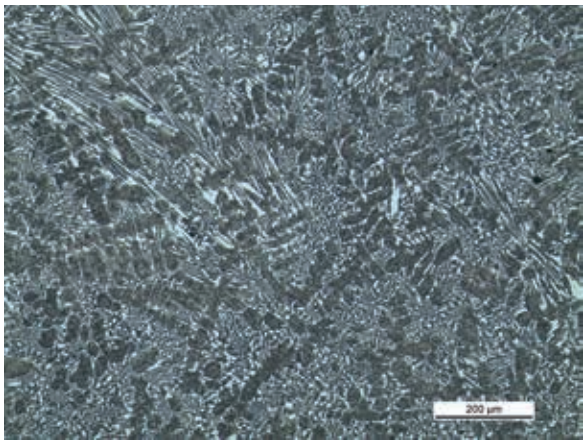
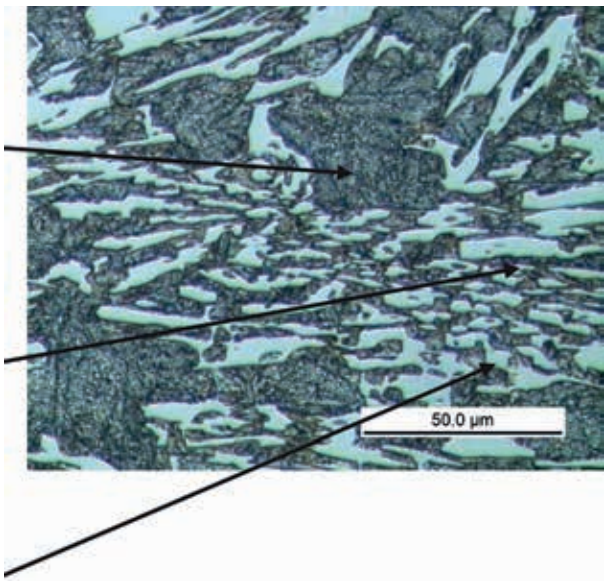
NOTE 2 Information on etchant:

— add 25 ml of HCl to 100 ml of ethanol;

— progressively add 25 g of ferric chloride and stir until fully dissolved;

— dilute the solution of AFC to approximately 5 % to 50 % with additional ethanol to suit.

Table 4.7 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.7.5	ISO 21988/JN/ HBW555XCr13 ISO 21988/JN/ HBW555XCr16	100x Shown is JN/ HBW555XCr16 200 µm	
4.7.6		500x Primary austenite dendrites partially transformed to martensite and fine secondary carbides by heat treatment Eutectic M_7C_3 carbides Eutectic austenite partially transformed to martensite and fine secondary carbides by heat treatment Shown is JN/ HBW555XCr16 40 µm	

NOTE 1 Etchant used on the samples 4.7.3 up to and including 4.7.8 is acidic ferric chloride (AFC) in ethanol.

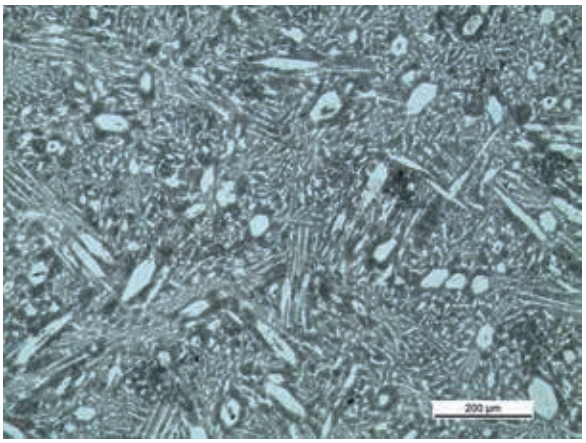
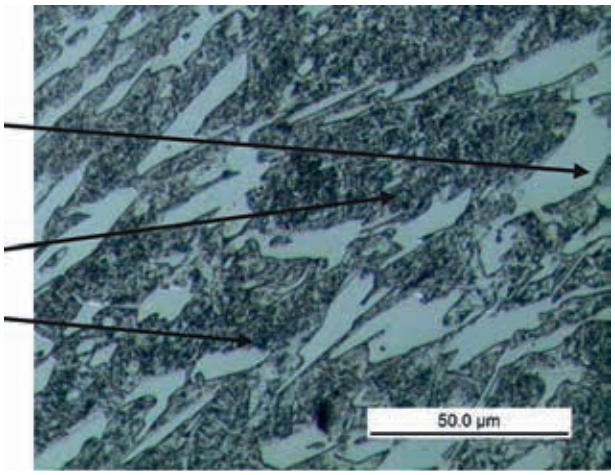
NOTE 2 Information on etchant:

— add 25 ml of HCl to 100 ml of ethanol;

— progressively add 25 g of ferric chloride and stir until fully dissolved;

— dilute the solution of AFC to approximately 5 % to 50 % with additional ethanol to suit.

Table 4.7 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.7.7	ISO 21988/JN/ HBW555XCr21	100x 200 µm	
4.7.8		500x Primary M_7C_3 carbides Eutectic M_7C_3 carbides Eutectic austenite partially transformed to martensite and fine secondary carbides by heat treatment 40 µm	

NOTE 1 Etchant used on the samples 4.7.3 up to and including 4.7.8 is acidic ferric chloride (AFC) in ethanol.

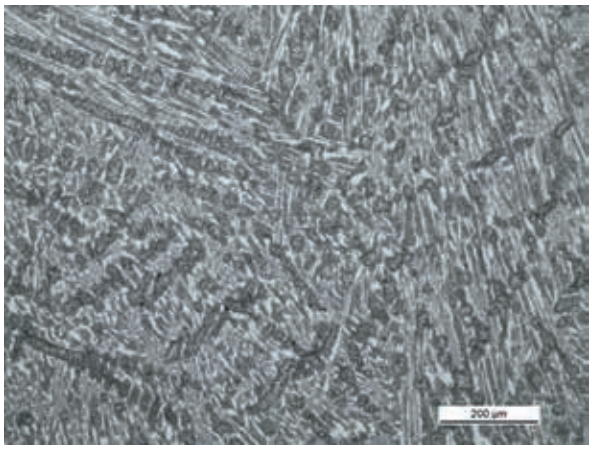
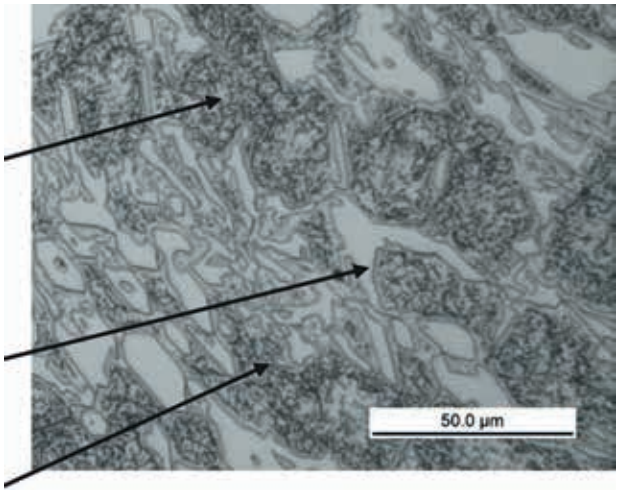
NOTE 2 Information on etchant:

— add 25 ml of HCl to 100 ml of ethanol;

— progressively add 25 g of ferric chloride and stir until fully dissolved;

— dilute the solution of AFC to approximately 5 % to 50 % with additional ethanol to suit.

Table 4.7 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.7.9	ISO 21988/JN/ HBW555XCr27	100x 200 µm	
4.7.10		500x Primary austenite dendrites partially transformed to martensite and fine secondary carbides by heat treatment Eutectic M_7C_3 carbides Eutectic austenite partially transformed to martensite and fine secondary carbides by heat treatment 40 µm	

NOTE 1 Etchant used on the samples 4.7.3 up to and including 4.7.8 is acidic ferric chloride (AFC) in ethanol.

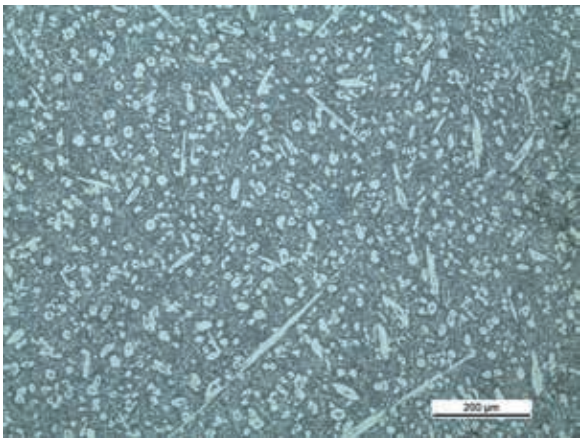
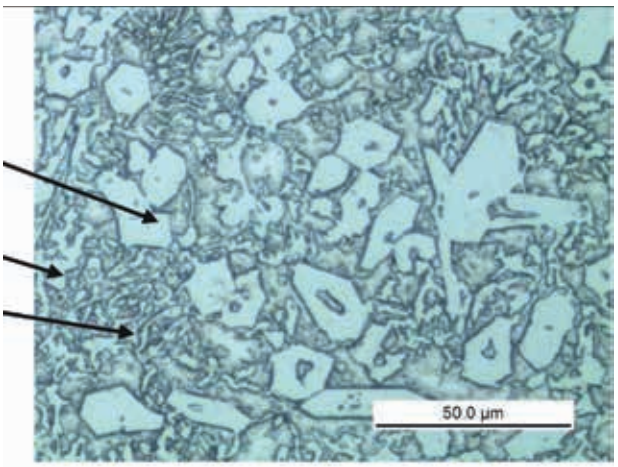
NOTE 2 Information on etchant:

— add 25 ml of HCl to 100 ml of ethanol;

— progressively add 25 g of ferric chloride and stir until fully dissolved;

— dilute the solution of AFC to approximately 5 % to 50 % with additional ethanol to suit.

Table 4.7 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.7.11	ISO 21988/JN/HBW600X-Cr35	100x 200 µm	
4.7.12		500x Primary M_7C_3 carbides Eutectic M_7C_3 carbides Eutectic austenite partially transformed to martensite and fine secondary carbides by heat treatment 40 µm	

NOTE 1 Etchant used on the samples 4.7.3 up to and including 4.7.8 is acidic ferric chloride (AFC) in ethanol.

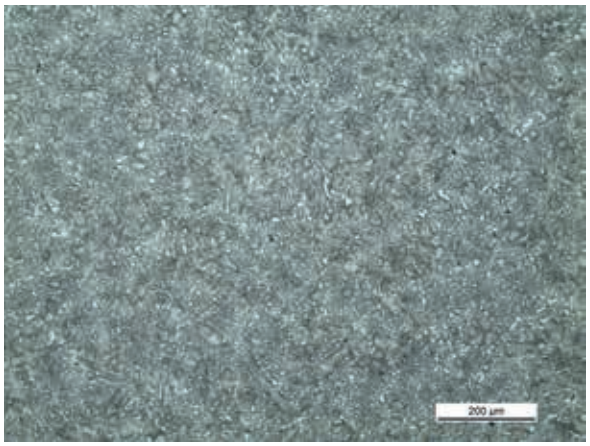
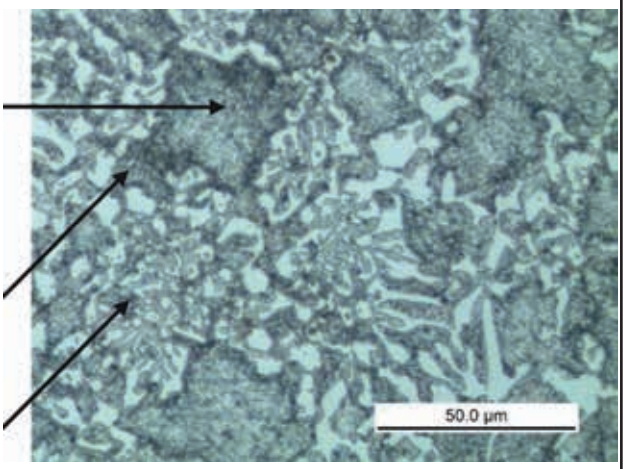
NOTE 2 Information on etchant:

— add 25 ml of HCl to 100 ml of ethanol;

— progressively add 25 g of ferric chloride and stir until fully dissolved;

— dilute the solution of AFC to approximately 5 % to 50 % with additional ethanol to suit.

Table 4.7 *(continued)*

Micro-graph	Material designation	Matrix structure	
4.7.13		100x 200 µm	
4.7.14	ISO 21988/JN/ HBW600XCr20Mo2Cu	500x Primary austenite dendrites partially transformed to martensite and fine secondary carbides by heat treatment Eutectic M_7C_3 carbides Eutectic austenite partially transformed to martensite and fine secondary carbides by heat treatment 40 µm	

NOTE 1 Etchant used on the samples 4.7.3 up to and including 4.7.8 is acidic ferric chloride (AFC) in ethanol.

NOTE 2 Information on etchant:

— add 25 ml of HCl to 100 ml of ethanol;

— progressively add 25 g of ferric chloride and stir until fully dissolved;

— dilute the solution of AFC to approximately 5 % to 50 % with additional ethanol to suit.

Annex A
(informative)

Spheroidal graphite cast irons: Evaluation of pearlite content

Pearlite content, expressed as area percentage, is defined by Formula (A.1):

$$Pearlite\ content = \frac{area\ with\ pearlitic\ structure}{total\ area - area\ of\ graphite\ particles} \times 100 \quad \text{(A.1)}$$

Typical spheroidal graphite cast iron reference images, corresponding to 20 % to 100 % pearlite, are shown in Figure A.1 for the evaluation of the pearlite content.

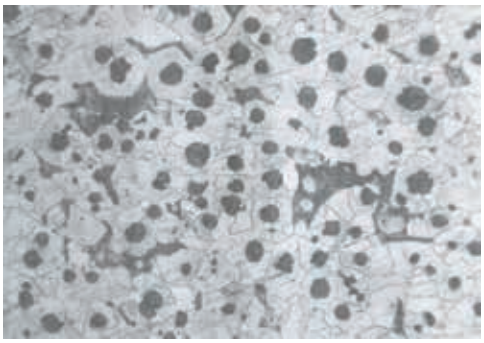
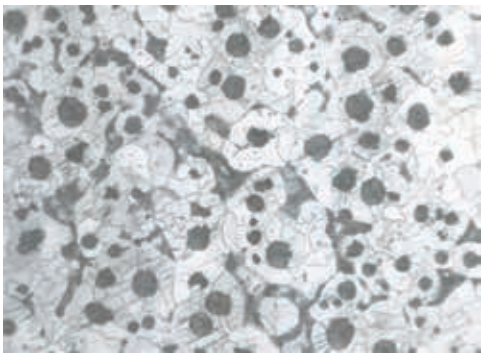
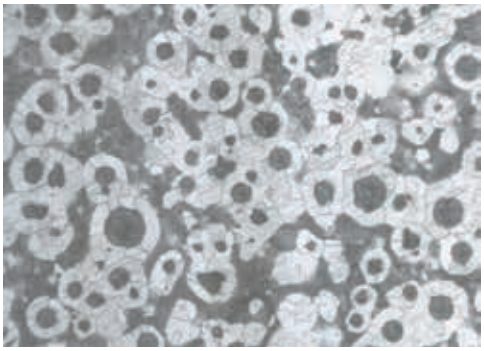
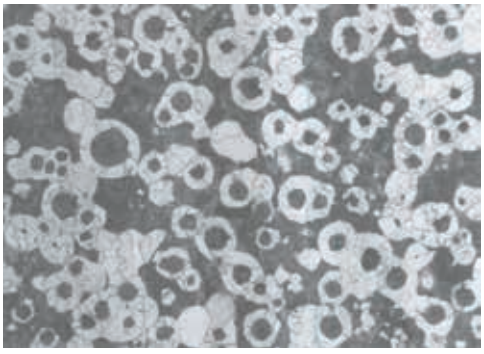
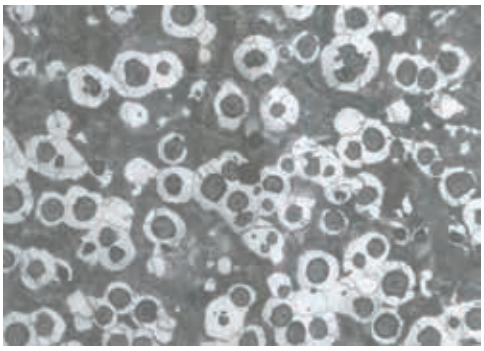
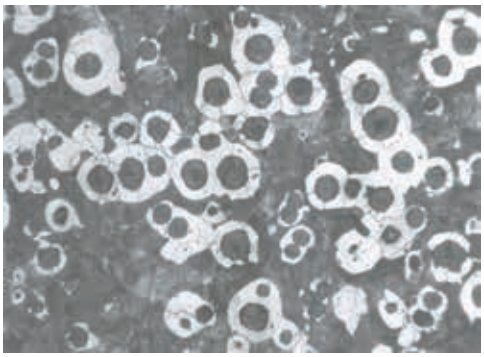
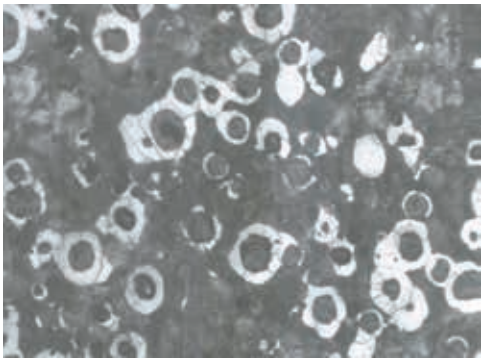
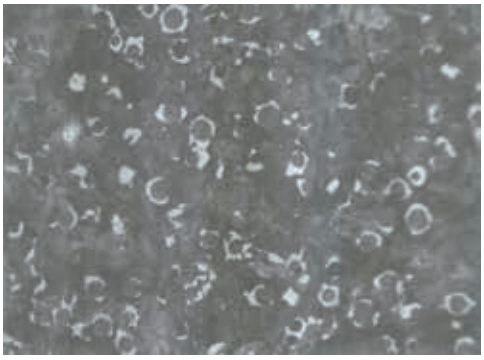
	
20 % pearlite	**30 % pearlite**
	
40 % pearlite	**50 % pearlite**
	
60 % pearlite	**70 % pearlite**
	
80 % pearlite	**90 % pearlite**

Figure A.1 — Spheroidal graphite cast irons matrix structure reference images

Annex B
(informative)

List of European and some national cast iron material designations corresponding to the ISO designations

Table B.1 — Grey cast irons

Organization and country	ISO	CEN Europe	ASTM North America		SAC China	JIS Japan	BIS India	EOS Egypt
Standard/ Micrograph	**ISO 185**	**EN 1561**	**A48**	**A48M**	**GB/T 9439**	**JIS G 5501**	**IS 210**	**ES 1**
4.1.1	ISO 185/JL/100	EN-GJL-100			HT100	FC100		ES 1/JL/100
	ISO 185/JL/HBW155	EN-GJL-HB155			H155			ES 1/JL/HBW155
4.1.2, 4.1.3	ISO 185/JL/150	EN-GJL-150	Class 25	Class 150	HT150	FC150	FG 150	ES 1/JL/150
	ISO 185/JL/HBW175	EN-GJL-HB175			H175			ES 1/JL/HBW175
4.1.4, 4.1.5	ISO 185/JL/200	EN-GJL-200	Class 30	Class 200	HT200	FC200	FG 200	ES 1/JL/200
	ISO 185/JL/225		Class 35	Class 225	HT225			ES 1/JL/225
	ISO 185/JL/250	EN-GJL-250		Class 250	HT250	FC250	FG 250	ES 1/JL/250
	ISO 185/JL/275		Class 40	Class 275	HT275			ES 1/JL/275
	ISO 185/JL/HBW195	EN-GJL-HB195			H195			ES 1/JL/HBW195
	ISO 185/JL/HBW215	EN-GJL-HB215			H215			ES 1/JL/HBW215
4.1.6	ISO 185/JL/300	EN-GJL-300	Class 45	Class 300	HT300	FC300	FG 300	ES 1/JL/300
	ISO 185/JL/350	EN-GJL-350	Class 50	Class 350	HT350	FC350	FG 350	ES 1/JL/350
	ISO 185/JL/HBW235	EN-GJL-HB235			H235			ES 1/JL/HBW235
	ISO 185/JL/HBW255	EN-GJL-HB255			H255			ES 1/JL/HBW255

Table B.2 — Spheroidal graphite cast irons

Organization and country	ISO	CEN Europe	ASTM North America	SAC China	JIS Japan	BIS India	SIS Sweden
Standard/ Micrograph	**ISO 1083**	**EN 1563**	**A 536**	**GB/T 1348**	**JIS G 5502**	**IS 1865**	**SS 140720 and SS 140725**
4.2.1	ISO 1083/JS/350-22	EN-GJS-350-22		QT350-22	FCD 350-22	SG 350/22	
	ISO 1083/JS/400-18	EN-GJS-400-18	60-40-18	QT400-18	FCD 400-18	SG 400/18	
	ISO 1083/JS/400-15	EN-GJS-400-15		QT400-15	FCD 400-15	SG 400/15	
		EN GJS-450-18					SS 0720 (Class 450/12)
	ISO 1083/JS/500-10	EN-GJS-500-14		QT500-10			SS 0725 (Class 500/10)
		EN-GJS-600-10					
	ISO 1083/JS/HBW130			QT-HBW130			
	ISO 1083/JS/HBW150			QT-HBW150			
	ISO 1083/JS/HBW155			QT-HBW155			
4.2.2	ISO 1083/JS/450-10	EN-GJS-450-10	65-45-12	QT450-10	FCD 400-15	SG 400/15	
	ISO 1083/JS/HBW185			QT-HBW185			
4.2.3	ISO 1083/JS/500-7	EN-GJS-500-7		QT500-7	FCD 500-7	SG 500/7	
	ISO 1083/JS/550-5		80-55-06	QT550-5			
	ISO 1083/JS/HBW20, 0			QT-HBW200			
	ISO 1083/JS/HBW21, 5			QT-HBW215			
4.2.4	ISO 1083/JS/600-3	EN-GJS-600-3		QT600-3	FCD 600-3	SG 600/3	
	ISO 1083/JS/HBW23, 0			QT-HBW230			
4.2.5, 4.2.6	ISO 1083/JS/700-2	EN-GJS-700-2	100-70-03	QT700-2	FCD 700-2	SG 700/2	
	ISO 1083/JS/HBW26, 5			QT-HBW265			
4.2.7 to 4.2.9	ISO 1083/JS/800-2	EN-GJS-800-2	120-90-02	QT800-2	FCD 800-2	SG 800/2	
	ISO 1083/JS/HBW30, 0			QT-HBW300			
4.2.10, 4.2.11	ISO 1083/JS/900-2	EN-GJS-900-2		QT900-2		SG 900/2	
	ISO 1083/JS/HBW33, 0			QT-HBW330			

Table B.3 — Austenitic cast irons

Organization and country	ISO	CEN Europe	ASTM North America		SAC China	JIS Japan	BIS India
Standard/ Micrograph	ISO 2892	EN 13835	A436 (gray)	A439 (ductile)	GB/T 26648	JIS G 5510	IS 2749
4.3.1	ISO 2892/JLA/ XNi15Cu6Cr2	EN-GJLA-XNiCuCr15-6-2	Type 1 Type 1b		HTANi15Cu6Cr2	FCA-NiCuCr 15 6 2	AFG Ni15Cu6Cr2
	ISO 2892/JLA/ XNi13Mn7	EN-GJLA-XNiMn13-7			HTANi13MN7	FCA-NiMn 13 7	AFG Ni13Mn7
4.3.2, 4.3.3	ISO 2892/JSA/ XNi20Cr2	EN-GJSA-XNiCr20-2		D-2	QTANi20Cr2	FCDA-NiCr 20 2	ASG Ni20Cr2
	ISO 2892/JSA/ XNi23Mn4	EN-GJSA-XNiMn23-4			QTANi23Mn4	FCDA-NiMn 23 4	ASG Ni23Mn4
	ISO 2892/JSA/ XNi20Cr2Nb	EN-GJSA-XNiCrNb20-2			QTANi20Cr2Nb	FCDA-NiCrNb 20 2	
	ISO 2892/JSA/ XNi22	EN-GJSA-XNi22			QTANi22	FCDA-Ni 22	ASG Ni22
	ISO 2892/JSA/ XNi35	EN-GJSA-XNi35		D-5	QTANi35	FCDA-Ni 35	ASG Ni35
	ISO 2892/JSA/ XNi35Si5Cr2	EN-GJSA-XNiSi-Cr35-5-		D-5S	QTANi35Si5Cr2	FCDA-NiSiCr 30 5 5	
	ISO 2892/JSA/ XNi13Mn7	EN-GJSA-XNiMn13-7			QTANi13Mn7	FCDA-NiMn 13 7	ASG Ni13Mn7
	ISO 2892/JSA/ XNi30Cr3	EN-GJSA-XNiCr30-3		D-3	QTANi30Cr3	FCDA-NiCr 30 3	ASG Ni30Cr3
	ISO 2892/JSA/ XNi30Si5Cr5			D-4	QTANi30Si5Cr5	FCDA-NiSiCr 30 5 5	ASG Ni30Si5Cr5
	ISO 2892/ JSA/XNi35Cr3			D5B	QTANi35Cr3	FCDA-NiCr 35 3	ASG Ni35Cr3

Table B.4 — Malleable cast irons

Organization and country	ISO	CEN Europe	ASTM North America		SAC China	JIS Japan	BIS India
Standard/ Micrograph	**ISO 5922**	**EN 1562**	**A47 (ferritic)**	**A47M (ferritic)**	**GB/T 9440**	**JIS G 5705**	**IS 14329**
4.4.1 to 4.4.3	ISO 5922/JMW/350-4	EN-GJMW-350-4			KTB350-04	FCMW35-04	WM 350
4.4.4 to 4.4.6	ISO 5922/JMW/360-12	EN-GJMW/360-12			KTB360-12		
4.4.7 to 4.4.9	ISO 5922/JMW/400-5	EN-GJMW/400-5			KTB400-05	FCMW40-05	WM 400
4.4.10 to 4.4.12	ISO 5922/JMW/450-7	EN-GJMW/450-7			KTB450-07	FCMW45-07	
4.4.13, 4.4.14	ISO 5922/JMW/550-4	EN-GJMW/550-4			KTB550-04		
4.4.15	ISO 5922/JMB/275-5				KTH275-05	FCMB27-05	
	ISO 5922/JMB/300-6	EN-GJMB/300-6			KTH300-06	FCMB30-06	BM 300
4.4.16	ISO 5922/JMB/350-10	EN-GJMB/350-10	Grade 32510	Grade 22010	KTH350-10	FCMB35-10	BM 350
			A220 (pearlitic)	**A220M (pearlitic)**			
4.4.17	ISO 5922/JMB/450-6	EN-GJMB/450-6	Grade 45006 Grade 45008	Grade 310M6 Grade 310M8	KTH450-06	FCMP45-06	PM 450
4.4.18 to 4.4.21	ISO 5922/JMB/500-5	EN-GJMB/500-5	Grade 50005	Grade 340M5	KTH500-05	FCMP50-05	PM 500
	ISO 5922/JMB/550-4	EN-GJMB/550-4	Grade 60004	Grade 410M4	KTH550-04	FCMP55-04	PM 550
4.4.22, 4.4.23	ISO 5922/JMB/600-3	EN-GJMB/600-3	Grade 70003	Grade 480M3	KTH600-03	FCMP60-03	PM 600
4.4.24, 4.4.25	ISO 5922/JMB/650-2	EN-GJMB/650-2	Grade 80002	Grade 550M2	KTH650-02	FCMP65-02	
4.4.26, 4.4.27	ISO 5922/JMB/700-2	EN-GJMB/700-2	Grade 90001	Grade 620M1	KTH700-02	FCMP70-02	PM 700
4.4.30, 4.4.31	ISO 5922/JMB/800-1	EN-GJMB/800-1			KTH800-01	FCMP80-01	

Table B.5 — Compacted (vermicular) graphite cast irons

Organization and country	ISO	CEN Europe	ASTM North America	SAC China	JIS Japan	BIS India
Standard/ Micrograph	**ISO 16112**	**EN 16079**	**A842**	**GB/T 26655**	**JIS G 5505**	**No standard published**
4.5.1	ISO 16112/JV/300	EN-GJV/300	Grade 300	RuT300	FCV300	
4.5.2	ISO 16112/JV/350	EN-GJV/350	Grade 350	RuT350	FCV350	
	ISO 16112/JV/400	EN-GJV/400	Grade 400	RuT400	FCV400	
4.5.3	ISO 16112/JV/450	EN-GJV/450	Grade 450	RuT450	FCV450	
	ISO 16112/JV/500	EN-GJV/500		RuT500	FCV500	

Table B.6 — Ausferritic spheroidal graphite cast irons

Organization and country	ISO	CEN Europe	ASTM North America		SAC China	JIS Japan	BIS India
Standard/ Micrograph	**ISO 17804**	**EN 1564**	**A897**	**A897M**	**GB/T 24733**	**JIS G 5503**	**No standard published**
4.6.1, 4.6.2	ISO 17804/JS/800-10	EN-GJS/800-10			QTD 800-10		
	ISO 17804/JS/900-8	EN-GJS/900-8	Grade 130/90/09	Grade 900/650/09	QTD 900-8	FCAD 900-8	
4.6.3, 4.6.4	ISO 17804/JS/1050-6	EN-GJS/1050-6	Grade 150/110/07	Grade 1050/750/07	QTD 1050-6		
	ISO 17804/JS/1200-3	EN-GJS/1200-3	Grade 175/125/04	Grade 1200/850/04	QTD 1200-3	FCAD 1200-2	
4.6.5	ISO 17804/JS/1400-1	EN-GJS/1400-1	Grade 200/155/02	Grade 1400/1100/02	QTD 1400-1	FCAD 1400-1	
	ISO 17804/JS/HBW400	EN-GJS/HB400			QTD HBW400		
4.6.6	ISO 17804/JS/HBW450	EN-GJS/HB450			QTD HBW450		

Table B.7 — Abrasion-resistant cast irons

Organization and country	ISO	CEN Europe	ASTM North America	SAC China	JIS Japan	BIS India
Standard/ Micrograph	**ISO 21988**	**EN 12513**	**A532/A532M**	**GB/T 8263**	**No standard published**	**IS 4771**
4.7.1	ISO 21988/JN/HBW340	EN-GJN/HB340				
	ISO 21988/JN/HBW400	EN-GJN/HB400				
4.7.2	ISO 21988/JN/ HBW480Cr2	EN-GJN-HB480	Class I, Type A	KmTBCr2		NiLCr 30/500
	ISO 21988/JN/ HBW510Cr2	EN-GJN-HB510		KmTBCr2		NiLCr 34/510
4.7.3, 4.7.4	ISO 21988/JN/ HBW500Cr9	EN-GJN/HB500		KmTBCr8		NiHCr 27/500
	ISO 21988/JN/ HBW555Cr9	EN-GJN/HB555	Class I, Type D	KmTBCr8		NiHCr 30/550
	ISO 21988/JN/ HBW630Cr9	EN-GJN/HB630				NiHCr 34/600
4.7.5, 4.7.6	ISO 21988/JN/ HBW555XCr13	EN-GJN-HB555(XCr13)	Class II, Type A	KmTBCr12		
	ISO 21988/JN/ HBW555XCr16	EN-GJN-HB555(XCr14)	Class II, Type B	KmTBCr15Mo		CrMoHC 34/500 CrMoLC 28/500
4.7.7, 4.7.8	ISO 21988/JN/ HBW555XCr21	EN-GJN-HB555(XCr18)	Class II, Type D	KmTBCr20Mo		
		EN-GJN-HB555(XCr23)	Class III, Type A			
4.7.9, 4.7.10	ISO 21988/JN/ HBW555XCr27	EN-GJN-HB555(XCr27)		KmTBCr26		
4.7.11, 4.7.12	ISO 21988/JN/ HBW600XCr35					
4.7.13, 4.7.14	ISO 21988/JN/ HBW600XCr20Mo2Cu					

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[11] ISO 21988, *Abrasion-resistant cast irons — Classification*

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