



AEROSPACE MATERIAL SPECIFICATION	AMS2759™/7	REV. E
	Issued 1991-10 Reaffirmed 2014-04 Revised 2021-09	
Superseding AMS2759/7D		
Carburizing and Heat Treatment of Carburizing Grade Steel Parts		

RATIONALE

AMS2759/7E deletes effectivity date as it is no longer applicable (previously 1.1), changes Table 1 Note 5 to default to 3.5.9 for sub-zero requirements, adds 1900 °F normalizing temperature for Pyrowear 675 in Table 1, clarifies sub-zero treatment wording regarding start of sub-zero treatment (3.5.9), clarifies tempering wording regarding start of sub-zero treatment (3.5.10), and adds snap tempering when needed (3.5.10.4).

NOTICE

ORDERING INFORMATION: In addition to that listed in AMS2759, the purchaser shall supply the following information to the heat treating processor.

- AMS2759/7E
- Class of carburizing (see 1.2)
- Type of carburizing (see 3.2.1.1)
- Effective case depth of the finished part (see 3.6.1)
- Amount of material that will be removed during subsequent machining and/or grinding (see 3.6.1.1)
- Method of case depth determination when alloy has a core hardness greater than HRC 48 (see 3.6.1.2.1)
- Case hardness (see 3.6.2)
- Core hardness
- Purchaser to supply test part(s), test specimen(s), or specify otherwise

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1. SCOPE

This specification, in conjunction with the general requirements for steel heat treatment covered in AMS2759, establishes the requirements and procedures for three classes of gas, vacuum, liquid, and low pressure (LPC) carburizing and related heat treatment of parts fabricated from carburizing grade steels. Parts made from steels other than those specified in the detail specifications may be heat treated in accordance with the applicable requirements using processing temperatures, times, and other parameters recommended by the material producer unless otherwise specified by the purchaser. This specification does not cover pack carburizing.

1.1 Classification

Parts shall be carburized to meet specified requirements (typically drawing directive) by processing to one of the following classes:

Class 1: Case depth and case hardness shall be as specified. Subsurface case hardness shall be in accordance with Table 3. Retained austenite shall not exceed 10%. Intergranular carbides shall be scattered and discontinuous and shall not be evident in more than 40% of the grain boundaries (see 3.6.5.2).

Class 2: Case depth and case hardness shall be as specified. Subsurface case hardness shall be in accordance with Table 3. Retained austenite shall not exceed 20%. Continuous carbide network shall not be evident in more than 80% of the grain boundaries (see 3.6.5.3).

Class 3: Case depth and case hardness shall be as specified.

1.1.1 If class is not specified, parts shall be processed to Class 2 requirements.

1.1.2 Case depth requirements specified to the heat treat processor are those expected to be developed by the carburizing heat treatment. The case depth must include both the final case depth for the finished part and any machining/grinding stock the purchaser intends to remove.

1.2 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2418	Plating, Copper
AMS2750	Pyrometry
AMS2759	Heat Treatment of Steel Parts, General Requirements
AMS2769	Heat Treatment of Parts in a Vacuum
ARP1820	Chord Method of Evaluating Surface Microstructural Characteristics

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E3 Preparation of Metallographic Specimens

ASTM E18 Rockwell Hardness of Metallic Materials

ASTM E384 Microindentation Hardness of Materials

2.3 ASM Publications

Available from ASM International, 9639 Kinsman Road, Materials Park, OH 44073-0002, Tel: 440-338-5151, www.asminternational.org.

Metals Handbook Volume 09 - Metallography and Microstructures (1985 Edition), ISBN 10: 0-87170-015-8

ASM Handbook Volume 09 - Metallography and Microstructures (2004 Edition), ISBN: 978-0-87170-706-2

3. TECHNICAL REQUIREMENTS

3.1 Pyrometry

Shall be in accordance with AMS2759.

3.2 Furnace Equipment

Shall be in accordance with AMS2759. Carburizing furnaces shall be Class 5 or better.

3.2.1 Heating Environment

Unless specified otherwise, protective atmosphere, masking, or both shall be used for all heat treatments over 1000 °F (538 °C) to protect part surfaces from unintentional carburization, decarburization, intergranular oxidation, and oxide scale. Protective atmospheres are argon, nitrogen, endothermic gas, exothermic gas, or vacuum. Allowed quench gases used in vacuum furnace processing are listed in 3.5.8.4.

3.2.1.1 Types of Atmospheres

Type 1: Gas

Type 2: Liquid (Salt Bath) Carburizing

Type 3: Vacuum* and Low Pressure Carburizing

*Prior revisions had Vacuum listed as Type 1. Vacuum is now Type 3 and is equivalent to the prior Type 1.

If the type is not specified, any atmosphere type is acceptable provided all specified requirements are met.

3.2.1.2 Carburizing Atmosphere Control

The carburizing atmosphere shall be generated with mixtures of hydrocarbon compounds and/or gases. Circulation and/or through flow of the atmosphere shall be sufficient to provide uniform carburizing.

3.2.1.3 Carbon Potential and Carburizing Devices

For Classes 1 and 2, Type 1, the carbon potential shall be controlled and recorded. For Type 3, gases shall be added using flow meters or mass flow controllers and the furnace pressure shall be recorded. For Type 2 salt baths, the medium shall be analyzed periodically for chemical composition and shown to conform to a specified quality standard.

3.2.1.3.1 The accuracy of devices used for measuring and controlling carbon potential of Type 1 atmospheres and the accuracy of devices used for measuring and controlling gas flow and pressure of Type 3 atmospheres shall be checked as often as necessary to ensure that the equipment is operating properly and shall be calibrated. Calibration shall be performed per manufacturers' recommendations or by a comparison method assuring that the accuracy of the device(s) is sufficient to meet specified requirements.

3.3 Auxiliary Equipment

Shall be in accordance with AMS2759.

3.4 Quenching Media

Shall be in accordance with AMS2759.

3.5 Sequence of Operations

Standard practice shall be (1) preparation for carburizing, (2) carburizing, (3) cooling after carburizing, (4) hardening, (5) sub-zero cooling (if required, see 3.5.9), and (6) tempering. Other treatments such as normalizing before carburizing and sub-critical annealing and stress relieving performed during the sequence of operations are permitted at the discretion of the processor. The hardening operation may be omitted when cooling after carburizing has incorporated a quench in accordance with 3.5.6, and when the conditions of 3.5.1, 3.5.2, or 3.5.3 are satisfied.

3.5.1 Parts that were quenched from the carburizing temperature and when both of the following apply:

3.5.1.1 Case depth is 0.020 inch (0.51 mm) or less.

3.5.1.2 Carburizing temperature was not higher than 1600 °F (871 °C).

3.5.2 Parts that were furnace cooled to the austenitizing temperature, stabilized, and quenched in accordance with 3.5.6 and when either of the following apply:

3.5.2.1 Parts were made from a low hardenability steel (e.g., 1020, 4615, 4620, 8615, or 8620).

3.5.2.2 Parts were made from a high hardenability steel (e.g., 4320, 4820, or 9310), and were carburized to meet Class 3 requirements.

3.5.3 Parts made from a low hardenability steel that were quenched from the carburizing temperature and were carburized to meet Class 2 or Class 3 requirements.

3.5.4 Preparation for Carburizing

3.5.4.1 Starting Condition

Unless otherwise specified, the material starting condition shall be annealed, normalized, normalized and tempered, or quenched and tempered. Conditions such as hot rolled, as cast, as forged, severely formed, or as welded may exhibit unusual and unacceptable growth and/or shrinkage resulting from processing and are undesirable starting conditions. When annealing, normalizing, and austenitizing are performed by processor, the recommended temperatures to be used are stated in Table 1. Quenching shall be as stated in Table 1. Tempering, if required, shall be performed to meet hardness requirements.

3.5.4.2 Cleaning

Cleaning shall be in accordance with AMS2759.

3.5.4.3 Masking

Masking for selective carburizing shall be copper plate, not less than 0.0008 inch (20 µm) in thickness, applied in accordance with AMS2418, or paints or pastes acceptable to the purchaser.

3.5.4.4 Racking

Shall be in accordance with AMS2759. Test specimens, or parts to be destructively evaluated, shall be placed in the working zone in approximately the same locations as the parts they represent.

3.5.5 Carburizing

3.5.5.1 Carburizing Temperature

Carburizing temperature set points shall be within the ranges listed below:

Type 1 - Gas Carburizing	1450 to 1850 °F (788 to 1010 °C)
Type 2 - Liquid Carburizing	1500 to 1750 °F (816 to 954 °C)
Type 3 - Vacuum and Low Pressure Carburizing	1450 to 2100 °F (788 to 1149 °C)

3.5.6 Cooling After Carburizing

Shall be in accordance with one of the following:

3.5.6.1 Direct quenching from the carburizing temperature.

3.5.6.2 Cool in a protective atmosphere to approximately 1000 °F (538 °C) or lower, after which parts may be air cooled to approximately ambient temperature.

3.5.6.3 Furnace cooling between the carburizing temperature and the austenitizing temperature stated in Table 1, stabilizing, and quenching.

Table 1 - Subcritical annealing, normalizing, and austenitizing temperatures and quenchants

Alloy ⁽¹⁾	Subcritical Annealing	Subcritical Annealing	Normalizing	Normalizing	Austenitizing	Austenitizing	Quenchant (2) (3) (5) (6)
	Temperature °F	Temperature °C	Temperature °F	Temperature °C	Temperature °F	Temperature °C	
1020	1300	704	1750	954	1425	774	(4)
4320	1300	704	1750	954	1525	829	Oil, PPGQ
4615	1300	704	1750	954	1500	816	Oil, PPGQ
4620	1300	704	1750	954	1500	816	Oil, PPGQ
4820	1150	621	1750	954	1475	802	Oil, PPGQ
8615	1300	704	1750	954	1550	843	Oil, PPGQ
8620	1300	704	1750	954	1550	843	Oil, PPGQ
9310	1150	621	1750	954	1525	829	Oil, PPGQ
CX13VDW	1256	680	1904	1040	1904	1040	Oil, PPGQ
FADH	1256	680	1742	950	1517	825	Oil
FDG	1256	680	1742	950	1517	825	Oil, PPGQ
FND	1292	700	1742	950	1760	960	Oil, PPGQ
NC310YW	1292	700	1751	955	1724	940	Oil, PPGQ
Pyrowear53	1300	704	1850	1010	1650-1700	898- 926	Oil, PPGQ
Pyrowear 675	1175	635	1900	1038	1900	1038	Oil, PPGQ
M50 NIL	1300	704	N/A	N/A	1975-2050	1079-1121	Oil, PPGQ
Ferrium C61	1256	680	1787	975	1832	1000	PPGQ
Ferrium C64	1256	680	1787	975	1832	1000	PPGQ

(1) Parts made from steels other than those specified in the detail specifications may be heat treated in accordance with the applicable requirements using processing temperatures, times, and other parameters recommended by the material producer unless otherwise specified by purchaser.

(2) Molten salt or synthetic quenchants are permitted (see 3.5.8.2).

(3) Marquenching in nitrate/nitrite salt, hot oil or alternate quenchant is permitted (see 3.5.8.3).

(4) Water, oil, or brine.

(5) See 3.5.9 for sub-zero requirements.

(6) PPGQ = Positive Pressure Gas Quenching (see 3.5.8.4).

3.5.7 Hardening

Shall consist of austenitizing and quenching. It may be preceded by a stress relieve at 900 to 1100 °F or by subcritical annealing in accordance with Tables 1 and 2 followed by cooling in a protective atmosphere to approximately 1000 °F (538 °C) or lower, after which parts may be air cooled.

Table 2 - Recommended soak time for subcritical annealing, normalizing, and austenitizing

Thickness ⁽¹⁾ Inches	Thickness ⁽¹⁾ Millimeters	Minimum Soak Time ^{(2) (4)} Air or Atmosphere Hours:Minutes	Minimum Soak Time ^{(2) (4)} Salt Hours:Minutes
Up to 0.25, incl	Up to 6.4, incl	0:25	0:18
Over 0.25 to 0.50, incl	Over 6.4 to 12.7, incl	0:45	0:35
Over 0.50 to 1.00, incl	Over 12.7 to 25.4, incl	1:00	0:40
Over 1.00 to 1.50, incl	Over 25.4 to 38.1, incl	1:15	0:45
Over 1.50 to 2.00, incl	Over 38.1 to 50.8, incl	1:30	0:50
Over 2.00 to 2.50, incl	Over 50.8 to 63.5, incl	1:45	0:55
Over 2.50 to 3.00, incl	Over 63.5 to 76.2, incl	2:00	1:00
Over 3.00	Over 76.2	⁽³⁾	⁽³⁾

⁽¹⁾ Thickness is the minimum dimension of the heaviest section of the part.

⁽²⁾ Start of soak shall be in accordance with AMS2759.

⁽³⁾ 2 hours, plus 30 minutes for each inch (25 mm) or increment thereof of thickness over 3.00 inches (76.2 mm).

⁽⁴⁾ Parts that are copper plated or coated with reflective coatings that tend to reflect radiant heat shall have their soak times increased by at least 50% unless load thermocouples are used.

3.5.7.1 Austenitizing

Recommended austenitizing temperatures are stated in Table 1. The austenitizing soak times listed in Table 2 are recommended times when carburized parts are heated from ambient to the austenitizing temperature.

3.5.8 Quenching

Following austenitizing, parts shall be quenched in the media specified in Table 1.

3.5.8.1 Oil Quenching

For all Types, oil quenchant requirements shall be in accordance with AMS2759.

For Type 3, quench oil shall be compatible with the vacuum level used during initial evacuation and transfer to quenching chamber.

3.5.8.2 Molten salt or synthetic quenchants are permitted. Salt residues shall be removed by a hot water rinse before air tempering.

3.5.8.3 Marquenching is permitted as follows:

Parts shall be marquenched in a nitrate/nitrite salt bath, oil bath, or alternate quenchant operated at a set temperature selected from 250 to 450 °F (149 to 232 °C) applicable to the alloys processed. The parts shall be in the marquenching bath only for sufficient time to stabilize the parts at the bath temperature, but not less than 2 minutes, followed by cooling to approximately ambient temperature. Salt residues shall be removed by a hot water rinse before air tempering.

3.5.8.4 Positive Pressure Gas Quenching (PPGQ > 1 bar)

When gas quenching is specified, it shall be accomplished by transferring the parts from a heating chamber to a separate chamber or backfilling the heating chamber with He, Ar, N₂, He/CO₂, Ar/N₂, or Ar/He. The quenching system and the pressure of the backfilling gas selected shall be capable of cooling the parts at a rate sufficient to meet the specified material property requirements. Hydrogen shall not be used as a quenching gas unless approved by the cognizant engineering organization.

3.5.9 Sub-Zero Treatment

Sub-zero treatment is required for parts carburized to Class 1 and Class 2 requirements and for steels containing over 3% (total) of alloying elements when carburized to Class 3 requirements. The sub-zero treatment shall be started within 4 hours of the end of quenching. Parts shall be held at -90 °F (-68 °C) or lower for not less than 2 hours starting when the controlling or recording instrumentation recovers to -90 °F (-68 °C). For sub-zero treatments, interruptions of the soaking period are permitted. The total soak time shall not include any time when the temperature is above -90 °F (-68 °C) due to interruptions. Parts shall be warmed to approximately ambient temperature.

3.5.10 Tempering

Tempering temperature shall be 300 °F (149 °C) minimum and shall be started within 4 hours of the end of quenching. If sub-zero treatment is required, tempering shall be started within 4 hours of the parts reaching approximately ambient temperature.

3.5.10.1 Parts may be cleaned before tempering. Molten quench salt and marquenching salt shall be removed by a hot water rinse before air tempering.

3.5.10.2 Parts shall be tempered at a set temperature consistent with the case and core hardness requirements for 2 hours minimum when using load sensors, or when not using load sensors 2 hours plus 1 hour for each additional inch of thickness or fraction thereof above 1 inch.

3.5.10.3 When tempering cannot be started within 4 hours of the end of quenching, parts shall be snap tempered for a minimum of 2 hours at a temperature that is not lower than 300 °F (149 °C) (see 8.6).

3.5.10.4 Snap tempering between 250 and 300 °F (121 and 149 °C) may be used after quenching and prior to the sub-zero treatment when part design and thermal stresses may result in part cracking. The snap temper treatment shall be initiated within 4 hours after start of quench.

3.5.11 Cleaning of Processed Parts

Shall be in accordance with AMS2759.

3.5.12 Visual Inspection and Removal of Maskant

Parts shall be visually inspected after carburizing and hardening for the effects of the maskant blistering, peeling, or otherwise showing lack of coverage. Parts exhibiting lack of coverage conditions shall be rejected (see 8.4).

NOTE: Sub-zero treatment may cause paint and paste maskants to spall off. This is not cause for rejection.

Removal of maskant, if required, shall be as specified by contract and shall be controlled to prevent etching, pitting, and hydrogen embrittlement of parts.

3.5.13 Straightening

Straightening carburized areas of parts is permitted only if done prior to sub-zero treatment and/or tempering and if approved by the cognizant engineering organization.

3.6 Properties

3.6.1 Effective Case Depth

3.6.1.1 It is the purchaser's responsibility to inform the heat treat processor of the specified amount of post-carburized stock that will be removed from carburized parts by machining and/or grinding during subsequent operations (see Ordering Information).

3.6.1.2 Effective case depth measurement technique shall be by microindentation hardness traverse of a part or test specimen sectioned perpendicular to the carburized surface and prepared in accordance with ASTM E3. Hardness shall be determined in accordance with ASTM E384, starting 0.002 to 0.003 inch (0.051 to 0.076 mm) from the carburized and heat treated surface, plus any stock to be removed, and traversing inward in increments of 0.004 inch (0.10 mm) or less to the depth where sub-surface case hardness is determined (see 3.6.3). The hardness traverse can then be restarted at a distance near the specified case depth requirement. Unless otherwise specified, the case depth for the four-digit designated alloys listed in Table 1 shall be the distance from the surface to the location where the hardness is 542 HK 0.5 or 513 HV 0.5 (converted equivalent to Rockwell C scale is 50 HRC). The method of ARP1820 may be used to determine depth of thin cases.

3.6.1.2.1 For alloys with core hardness greater than HRC 48 the technique shall be as specified by purchaser (see Ordering Information).

3.6.2 Case Hardness

Unless otherwise specified, case (surface) hardness (see 8.5) shall be determined in accordance with ASTM E18 on a carburized and heat treated surface of the parts provided the case depth is sufficient to support the load for an accurate measurement, or in accordance with ASTM E384 at a depth of 0.002 to 0.003 inch (0.051 to 0.076 mm) from the carburized and heat treated surface, plus any stock to be removed (see 3.6.1.1).

3.6.3 Sub-Surface Case Hardness

For parts carburized to Class 1 and Class 2 requirements, the subsurface hardness for the four-digit designated alloys listed in Table 1 shall meet the requirements of Table 3, determined in accordance with 3.6.3.1. The 58 HRC column applies to parts that have a specified case hardness of 58 HRC minimum. The 60 HRC column applies to parts that have a specified case hardness of 60 HRC minimum. The subsurface hardness for the trademarked alloys listed in Table 1 shall be specified by the purchaser.

Table 3 - Finished part case depth and case hardness⁽¹⁾

Specified Case Depth Minimum		Minimum Depth of Specified Case Hardness at 58 HRC	Minimum Depth of Specified Case Hardness at 60 HRC
Under	0.030 inch (0.76 mm)	20% ⁽²⁾	10% ⁽²⁾
	0.030 to 0.050 inch (0.76 to 1.27 mm), incl	20% ⁽²⁾	20% ⁽²⁾
Over	0.050 inch (1.27 mm)	0.010 inch (0.25 mm)	0.010 inch (0.25 mm)

⁽¹⁾ In most cases, finished part surfaces are not tested at time of heat treat. The maximum amount of stock to be removed after heat treat shall be taken into account when measuring case depth and case hardness at the time of heat treatment.

⁽²⁾ Percent of specified minimum case depth.

Example: For a specified case depth of 0.030 inch (0.76 mm), the case hardness shall be not less than 58 HRC at 0.006 inch (0.15 mm) from the carburized surface.

3.6.3.1 Sub-Surface Case Hardness Determination

The hardness traverse of 3.6.1.2 shall be used to determine the sub-surface case hardness. The microindentation hardness conversion for 58 HRC shall be 690 HK500 or 653 HV500 and for 60 HRC shall be 732 HK500 or 697 HV500.

3.6.4 Core Hardness

Shall be as specified, determined in accordance with ASTM E18 at a location not less than five times the case depth from the surface, or in accordance with ASTM E384 at a location not less than five times the case depth from the surface, or near the center of a through-thickness cross section. Use of the hardness traverse specimen of 3.6.1 is permitted to measure core hardness. An average of three hardness readings shall be used regardless of the test method used.

3.6.5 Case Microstructure

Shall be predominantly tempered martensite, determined in accordance with 3.6.5.6. The requirements of 3.6.5.1 through 3.6.5.5 apply to carburized and heat treated surfaces from which no material will be removed after heat treatment. A part shall not be rejected on the basis of these requirements if subsequent machining/grinding will provide a surface meeting the requirements of 3.6.5.1 through 3.6.5.5.

- 3.6.5.1 Intergranular oxidation shall not exceed 0.0005 inch (0.013 mm) in depth from the carburized and heat treated surface.
- 3.6.5.2 For Class 1 parts, any intergranular carbides from the carburized and heat treated surface shall be scattered and discontinuous and shall not be evident in more than 40% of the grain boundaries. Massive or blocky carbides are unacceptable. Photomicrographs 12 and 14 on page 220 of ASM Handbook, Volume 09, 1985 Edition, are illustrations of non-acceptable microstructures containing excessive carbides around the grain boundaries and massive carbides. (For more recent references, see Table 4.)
- 3.6.5.3 For Class 2 parts, a continuous carbide network shall not be evident in more than 80% of the grain boundaries. Photomicrograph 13 on page 220 of ASM Handbook, Volume 09, 1985 Edition, is an illustration of the maximum acceptable continuous carbide microstructure. Photomicrographs 12 and 14 on page 220 of ASM Handbook, Volume 09, 1985 Edition, are illustrations of non-acceptable microstructures containing excessive carbides around the grain boundaries and massive carbides. (For more recent references, see Table 4.)
- 3.6.5.4 The microstructure of the carburized and heat treated surface of Class 1 parts shall not show evidence of retained austenite in excess of Figure 16 on page 220 of ASM Handbook, Volume 09, 1985 Edition. If interpretation of the microstructure is questionable, or if it appears to represent retained austenite in excess of this figure, X-ray diffraction shall be performed to determine acceptability. When inspected by X-ray diffraction, retained austenite greater than 10% is unacceptable. (For more recent references, see Table 4.)
- 3.6.5.5 The microstructure of the carburized and heat treated surface of Class 2 parts shall not show evidence of retained austenite in excess of Figure 17 on page 221 of ASM Handbook, Volume 09, 1985 Edition. If interpretation of the microstructure is questionable, or if it appears to represent retained austenite in excess of this figure, X-ray diffraction shall be performed to determine acceptability. When inspected by X-ray diffraction, retained austenite greater than 20% is unacceptable. (For more recent references, see Table 4.)
- 3.6.5.6 Case microstructure determination shall be by examination of a test specimen sectioned perpendicular to the carburized surface and prepared in accordance with ASTM E3. Examine at 400 to 1000X magnification for retained austenite and 400 to 500X for intergranular oxidation and carbides.

Table 4 - Alternate microstructure reference photomicrographs

Paragraph in AMS2759/7	<i>Metals Handbook</i> , Volume 9, Metallography and Microstructures, 9th Edition (1985)	<i>ASM Handbook</i> , Volume 9, Metallography and Microstructures, 2004 Edition
3.6.5.3	Photomicrograph 13, page 220 Photomicrograph 12, page 220 Photomicrograph 14, page 220	Figure 13 (d), page 635 Figure 13 (e), page 635 Figure 13 (f), page 635
3.6.5.4	Figure 16, page 220	Figure 4 (b), page 630
3.6.5.5	Figure 17, page 221 (for 20% retained austenite)	Not in this edition Figure 15 (a), page 636, is 15% retained austenite, and Figure 4 (d), page 630, is 25%