

1.0 SCOPE

This specification covers the reheat and quench of carburized parts that require the case and core to be austenitized.

2.0 APPLICATIONS

This heat treatment is applicable to carburized parts, which require the combination of hard case with an intermediate degree of hardness in the core. The hardness of the core is dependent upon the hardenability of the material and section size. Core properties will be specified on the part number drawing if required.

3.0 QUALIFYING SPECIFICATIONS

1E2617 General Requirements - Heat Treat

1E2532 Microstructure Standards - Carburize Hardening Heat Treatments

4.0 DRAWING DESIGNATIONS

This is a multi-variation specification; the designations A, B, C, and D describe the temper condition, see Figure 1. Additional information concerning temper designations can be found in 1E2617.

Former Designation	Current Designation	Temper
1E2203	1E2203A	Furnace tempering required by reheating quenched parts to 150°C minimum. Drawings of parts other than gears calling for carburize hardening with no temper designation are in this classification.
	1E2203B	Furnace tempering or residual tempering at 150°C minimum permitted
	1E2203C	Tempering is optional and is not a functional requirement of the part. Drawings of gears without a temper designation are in this classification.
	1E2203D	All tempering including preheating for subsequent assembly is prohibited.

Figure 1

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5.0 PROCESSING REQUIREMENTS

5.1 Machining Operations

5.1.1 All machining operations including grinding shall be performed before carburizing and hardening, unless stock removal after hardening is permitted or required on the drawing. The only permissible exception is CBN grinding of gear tooth profiles. CBN grinding of gear profiles is allowed provided that:

5.1.1.1 The CBN process is controlled to eliminate grinding burns.

5.1.1.2 The specified surface carbon, surface hardness, hardened depths and microstructure are attained. To ensure attainment of the required hardened depths after grinding, the carburize depth may be increased up to the amount of stock removal permitted. See gear cutter specification.

5.1.2 CBN grinding is not permitted after heat treatment on gears in which the actual hardened depth is less than 0.7 mm, and cannot be used as a salvage operation without approval from Engineering Design Control P418.

5.2 Heat Treating Operations


5.2.1 Austenitize by reheating above the A_{c3} temperature of the core in a protective atmosphere.

5.2.2 The quench rate shall be commensurate with section size and hardenability of the material to meet the quality requirements of this specification and the part number drawing.

6.0 QUALITY REQUIREMENTS

6.1 Control of Heat Treat Special Process Characteristics

6.1.1 These requirements apply only when tighter control of heat treat process parameters beyond normal heat treat process controls are required by a 1E2966 Special Characteristics

note  on the part drawing.

6.1.2 Special Process Requirements

6.1.2.1 Temperature control throughout the furnace workspace shall be checked when furnace is placed in service, after major overhauls, or at a frequency specifically requested by the customer. Temperature uniformity throughout the furnace part workspace shall be within $\pm 5^{\circ}\text{C}$.

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6.1.2.2 Thermocouples and temperature controllers shall be checked, managed and results recorded in accordance with ME1004 and MQ1010-90.

6.1.2.3 Furnaces shall be equipped with atmosphere composition- and carbon potential control systems capable of maintaining carbon potentials within ± 0.1 wt.% C in the furnace atmosphere. For control systems utilizing oxygen probe control only, accuracy should be checked with shim stocks per ME1033 at least once a week at each normal operating temperature/atmosphere setpoint. For control systems utilizing oxygen probe and infrared CO/CO₂ control, it is sufficient to check accuracy with shim stocks monthly. Records for each furnace shall be kept by Heat Treat Manufacturing. Control or supervisory system calculated atmosphere levels shall not be substituted for shim stock checking.

6.1.2.4 When new equipment is placed in service, after major overhauls, or at a frequency specifically requested by the customer, the atmosphere uniformity shall be determined by 1) running either test pieces or piece parts throughout furnace workspace, and 2) analyzing for proper surface carbon levels and microstructure.

6.1.2.5 A piece part (or test piece with a section size representative of the piece part that has been carburized with the piece parts) shall be hardened and destructively analyzed with each load on batch type furnaces. On continuous furnaces, test pieces shall be run at least daily or any time cycle times are changed. The depth shall be within production process limits established by Heat Treat Engineering. The use of control system 'calculated depth' shall not be a substituted for the actual test pieces, but with customer approval, the frequency of test piece checks may be modified if 'calculated depth' control systems are employed.

6.1.2.6 When new equipment is placed in service, after major overhauls, or at a frequency specifically requested by the customer, the quench uniformity shall be determined by running piece parts throughout quench workspace and analyzing for proper surface bainite levels and core hardness.

6.1.2.7 Quench system shall be equipped with a means of proving adequate quench flow on continuous basis and alarms shall be provided to alert operator in event of inadequate quench flow.

6.1.2.8 A maximum transfer time to the quench shall be established for each part number.

6.1.2.9 Parts from each load shall be file tested for as-quenched surface hardness per MH1023.

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6.2 Hardness

6.2.1 Unless otherwise qualified, where finish stock removal allowed after heat treat does not exceed 1/3 of the specified minimum hardened depth, superficial hardness on the finished surfaces shall be equivalent to the required hardness values specified on the part number drawing. Where the drawing allows more than 1/3 of the specified minimum hardened depth to be removed, hardness on the finished surfaces shall be commensurate with the remaining amount of hardened depth.

6.2.2 Hardness required at specified depth applies only to the location shown on the part number drawing. Hardness at other locations in the part shall be commensurate with section size, distance from the surface, and hardenability of the material. It is intended that hardness testing of the core be performed only when sample parts are sectioned for complete metallurgical evaluation.

6.2.3 The surface hardness specified for gears is required along the entire surface of the gear tooth, including the root. In addition, the hardened depth in the root (C location) shall be at least 60% of that specified for the active profile.

6.2.4 When this specification is used for parts calling for 1E0115, hardened depth shall be no less than the specified minimum case (or carburized) depth.

6.3 Microstructure on Finished Product

6.3.1 Grain size shall be 5 or finer.

6.3.2 All parts processed to this specification shall meet the minimum microstructure requirements of this specification, see Figure 2 (last page of specification), and 1E2532 photomicrograph standards on acceptance levels of secondary constituents in a martensitic matrix as described below when examined at 500X. Quality photomicrograph copies are available through PDCOE Heat Treat Engineering, Design Control A556. Deep-freezing to meet microstructure requirements is prohibited. Ammonia additions are prohibited without Engineering Design Control P418 approval.

6.3.3 The surface carbon of the case shall be 0.7 - 1.0%. Microstructural ratings of less than A1 combined with C1 or less is borderline and indicates low case carbon content.

6.3.4 The case microstructure shall consist primarily of martensite (tempered as required).

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6.3.5 Retained Austenite - Acceptability of piece parts shall be based on hardness and microstructure. Hardness shall be measured at a depth of 0.1 mm below the surface using either a 500 g Knoop Hardness (HK) or a 1 kg Vickers Hardness (HV). Measurement using other hardness scales is not permitted for this requirement. The minimum hardness shall exceed HK 670 (500g load), or HV 653 (1 kg load). For parts that are subsequently ground or otherwise hard-finished, hardness and austenite levels shall be measured at the nominal grind depth on as-hardened and tempered parts (i.e., prior to stock removal).

6.3.6 Carbides - Parts that are processed according to 1E2204 and 1E2203 shall be rated according to the network carbide series (C1- C6) in 1E2532. Parts produced by the allowable alternate 1E2318 - Carburize and Harden - Direct Quench Case and Core shall be rated according to the direct quench carbide series (DC1 – DC5) in 1E2532.

6.3.7 Microcracks - Microcracks are sometimes observed in microstructures when retained austenite and carbon levels are near or above maximum limits. Detection should cause steps to be taken to ensure that retained austenite, surface microhardness, and carbon levels meet the specification requirements. Samples exhibiting microcracks should be completely re-polished, lightly etched and observed immediately to determine if microcracks are still present. Often microcracking will occur in a delayed manner after etching. Samples that do not exhibit microcracks upon observation immediately following etching, but exhibit delayed microcracking, are not rejectable for microcracks, providing retained austenite, surface carbon, surface microhardness, and grain size meet specification. Parts, which do exhibit microcracking immediately following light etching, are rejectable if more than seven (7) microcracks are observed in a single field of view (0.2 mm X 0.15 mm actual size) in the region between the surface and 0.5 mm depth. No microcracks longer than 8 microns actual length are permitted.

7.0 ALTERNATE HEAT TREATMENT

Where it is advantageous to the manufacture of gears, the 1E2318 - Carburize and Harden - Direct Quench Case And Core heat treatment may be substituted as an alternate to the combination of 1E2204 - Standard Carburize and 1E2203 - Harden Carburized Case and Core heat treatments; however, no change to the specified temper designation is permitted.

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8.0 SUBSIDIARY SPECIFICATIONS (FOR CATERPILLAR REFERENCE ONLY)

8.1 At the time of release of 1E2203, Change 13, the following subsidiary versions of 1E2203 were in use by Caterpillar Facilities outside of the United States:

Caterpillar Materiels Routiers S.A. (Rantigny)	"H" Version
Caterpillar Brazil Ltda. (Piracicaba)	"G" Version
Caterpillar France S.A. (Grenoble)	"H" Version
Caterpillar Japan Ltd. (Sagami)	"X" Version
Caterpillar Japan Ltd. (Akashi)	"X" Version

Figure 3

8.2 Subsidiary versions may be changed, released, or canceled without a change to this version of 1E2203. The Engineering Data System (EDS) provides information on the status of subsidiary version specifications and should be referenced for current information.

9.0 REFERENCES

Caterpillar Specifications	1E0115, 1E2204, 1E2318, 1E2966
Caterpillar Manufacturing Practices	ME1004, ME1033, MH1023, MQ1010-90

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1E2532 Quality Levels Samples Polished, Light Nital Etched, and Observed at 500 Magnification (Except Oxides Unetched)									
Retained Austenite	Bainite or Pearlite				Carbides	Decarb	Micro-cracks	Grain Boundary Oxides	Ferrite
	Surface to 0.02 mm Depth								
A3 Acceptable A4 Borderline A5 Rejectable Note: See 6.3.5	Gears and External Splines	Loc "X"	B1 Acceptable B2 Borderline B3 Rejectable		Other Parts *	B3 Borderline B4 Rejectable	For 1E2204/1E2203 Processed Parts: C2 Acceptable C3 Borderline C4 Rejectable	For Altn HT (1E2318) Parts: DC1 Borderline DC2 Rejectable	For 1E2204/1E2203 Processed Parts: C2 Acceptable C3 Borderline C4 Rejectable
		Loc "C"	B7 Acceptable (0.02 mm MAX Depth)						
	0.02 to 0.20 mm Depth								
	Gears and External Splines	At "X" Location BB3 Borderline BB4 Rejectable At "C" Location BB5 Borderline BB6 Rejectable							
*Other Parts	BB4 Borderline BB5 Rejectable								
Note: See 6.3.7									
Gears and Splines O2 Acceptable O3 Borderline O4 Rejectable					Gears and Splines O2 Acceptable O3 Borderline O4 Rejectable				
Other Parts O3 Acceptable O4 Borderline					Other Parts O3 Acceptable O4 Borderline				
Note: Any evidence of undissolved ferrite (incomplete austenization) in the core shall be cause for rejection.									

Figure 2

Note*: B7 and BB7 bainite is permitted on internal splines, trunnions, trunnion bearings, and trunnion caps provided surface hardness and hardened depth are attained.

Note:** D0 decarb shall show no visual evidence of carbon depletion (affected depth).

Definition: Borderline means marginally acceptable. Continued production at this level is unacceptable. Supplier shall act to bring microstructure within acceptable range. Additional auditing by the supplier is required until process capability is proven.

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