1.0 SCOPE

This specification covers a direct hardening and tempering heat treatment which is employed where control is required to minimize the amount of stock removal after hardening and is applied as an intermediate or final processing operation. This treatment is further qualified by 1E2617 General Requirements - Heat Treat specification.

2.0 APPLICATION

This heat treatment is to be applied to parts made from forgings, castings, and other ferrous commodities which must have excess stock removed prior to direct hardening such that the maximum depth of hardening is attained in the finished part. All parts will be either rough machined such that there will be a minimum of stock removal after direct hardening or, if dimensional tolerances permit, finish machining may be performed before direct hardening.

3.0 PROCESSING REQUIREMENTS (SEE NOTE)

3.1 Unless otherwise controlled by the drawing, complete rough machining on outside diameters, inside diameters, and faces prior to hardening leaving only a minimum of stock to permit clean up on finish machining operations. A maximum of 3 mm stock removal is permitted on a diameter (1.5 mm on a surface) after hardening. If tolerances permit, manufacturing may elect to finish machine any or all dimensions before hardening.

3.2 Hypoeutectoid alloys shall be fully austenitized prior to quenching. Hypereutectoid alloys shall be austenitized prior to quenching such that final microstructure requirements are attained.

3.3 Any method of heating may be used (furnace, liquid bath, induction, etc.) which does not produce excessive grain growth or distortion. Prior austenitic grain size for finished parts shall not exceed ASTM Grain size 5.

3.4 Quench per the following conditions:

3.4.1 Parts shall be quenched with the maximum possible severity that can be achieved without quench cracking, to produce the maximum expected as-quenched surface hardness and depth of hardening. A uniform martensitic structure shall be produced on all surfaces, below the MAD, to a depth commensurate with material hardenability and section size. Spotty hardening shall not be permitted and is evidence of insufficient quench flow velocity (Figure 1 gives a schematic of spotty hardening shown by a mixture of light and dark etching at the part surface, and a uniform martensitic structure shown by light etching at the part surface).

3.4.2 Achieving this microstructure specification typically requires an impingement quench flow velocity on the entire surface of a part in excess of 0.76 m/s (2.5 ft/sec) for water and 1.07 m/s (3.5 ft/sec) for oil.

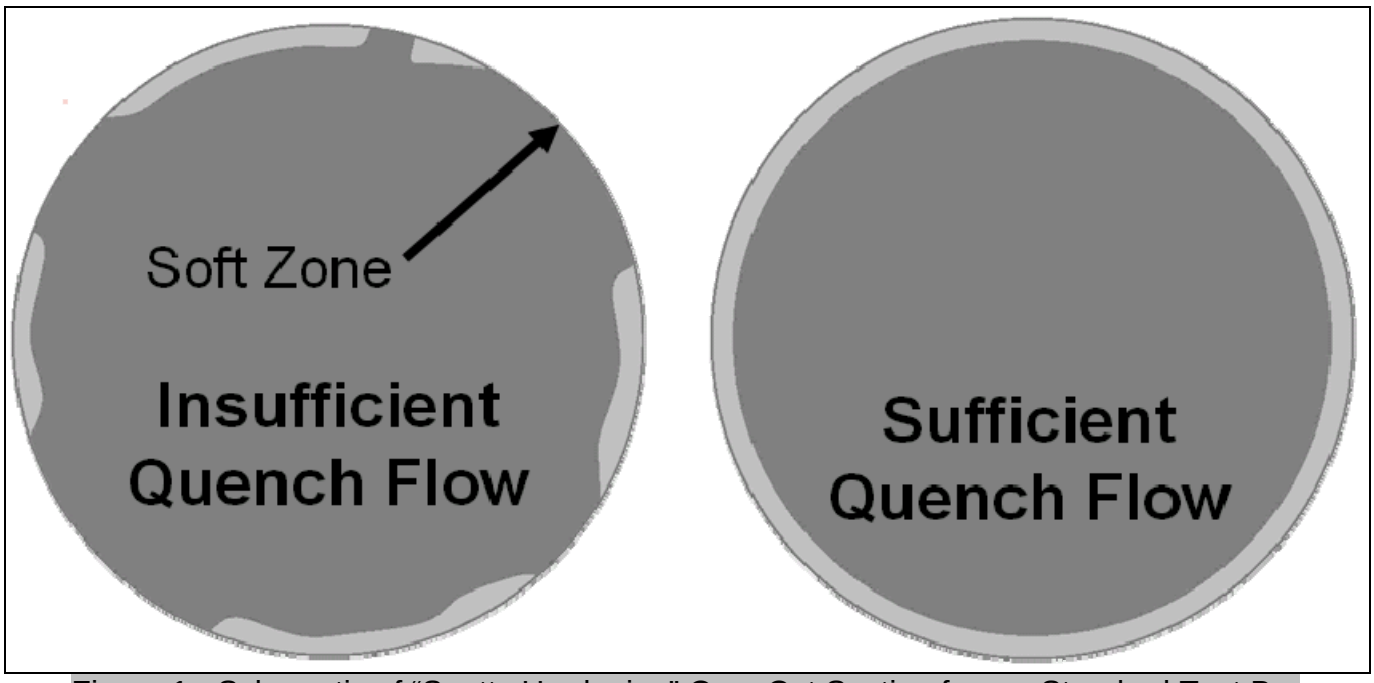

Figure 1 - Schematic of “Spotty Hardening” On a Cut Section from a Standard Test Bar

3.4.3 To assure process control, as quenched surface hardness and tempering temperature should remain constant for a specified material and section size from batch to batch. For parts heat treated at Caterpillar Facilities, consult Caterpillar Manufacturing Practice ME4000 for relationships between material, as quenched surface hardness and tempering temperature. Non-Caterpillar facilities performing this heat treatment should contact the purchasing facility of the requisitioning plant to get this information from the appropriate metallurgical or heat treat personnel.

3.5 Temper to the specified hardness by reheating for a sufficient length of time to permit temperature equalization in all sections. Care should be exercised to avoid tempering in the brittle temperature range of the material. The minimum tempering temperature is 150°C.

Note: Requirements of Paragraphs 3.2 through 3.5 do not apply to “S” lengths.

4.0 METALLURGICAL REQUIREMENTS

4.1 The hardened and tempered part shall exhibit proper heat treatment as indicated by the following:

4.1.1 Machined surfaces shall have a uniform martensitic microstructure on all surfaces containing no free ferrite and little or no retained austenite (does not apply to “S” lengths).

4.1.2 Freedom From Harmful Decarburization Or Carburization - There shall be no carbon free depth (CFD) on machined surfaces, except as noted in Paragraph 4.1.2.2, or on as rolled surfaces specified as 1E2252A or 1E2252B on the part number drawing, and partial decarburization is restricted commensurate with meeting the specified hardness.

4.1.2.1 As-rolled surfaces (except those covered by 1E2252A or 1E2252B), as-cast, and as-forged surfaces inherently exhibit decarburization commensurate with the product, but a uniform and fully martensitic structure is required below the maximum affected depth (MAD).

4.1.2.2 Machined surfaces intended to serve as wear surfaces, such as some Moving Undercarriage or G.E.T. (Ground Engaging Tool) components, may have up to 0.03 mm CFD and up to 0.35 mm MAD.

4.1.2.3 The carbon content at the surface or immediately below the surface shall not exceed the carbon content of the base metal.

5.0 QUENCH SEVERITY EVALUATION

5.1 An individual quench tank shall be evaluated in the following manner:

5.1.1 Test Pieces

5.1.1.1 Whenever possible, the actual piece part should be evaluated. The part shall be sectioned in all areas of interest, i.e., critical functional surfaces which must be consistently hardened.

5.1.1.2 For initial screening of a supplier, or in cases where sectioning the actual part is not possible, a standard sample may be used to characterize the quench (ability to break the vapor blanket).

5.1.1.2.1 100 ±2 mm diameter by 300 mm long is the standard sample (SAE 1045).

5.1.1.2.2 1E0107 evaluations must use a clean machined bar.

5.1.1.3 Use of a standard test bar in lieu of the actual part requires written approval from Caterpillar.

5.1.2 1E0107 Test Procedure

5.1.2.1 Austenitize and quench the sample (actual part or test bar).

5.1.2.2 For actual parts, cut 13 mm to 25 mm thick cross-sections through all critical areas. Shot blasting will often reveal soft areas to assist selection of test locations. For test bars, cut two 13 mm to 25 mm thick discs one-half bar diameter in from each end.

5.1.2.3 Grind the section flat, then fine grind (400-grit wet grind or equivalent) and macroetch the section to confirm uniform hardening.

5.1.2.4 Photograph each sample to document uniform hardening.

5.1.2.5 Report no less than four equally spaced hardness traverses for each sample. (i.e., 0°, 90°, 180°, 270°).

6.0 REFERENCES

Caterpillar Specifications	1E2252A, 1E2252B, 1E2617
Caterpillar Manufacturing Practices	ME4000
SAE	1045