SAE International STANDARD	SAE, J406 MAR2009
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Methods of Determining Hardenability of Steels	

## RATIONALE

The example in Table A3 is incomplete and incorrect in that some math symbols and factors are missing. The change is editorial in nature and makes the equation correct and complete.

## 1. SCOPE

This SAE Standard prescribes the procedure for making hardenability tests and recording results on shallow and medium hardening steels, but not deep hardening steels that will normally air harden.

Included are procedures using the 25 mm (1 in) standard hardenability end-quench specimen for both medium and shallow hardening steels and subsize method for bars less than 32 mm (1-1/4 in) in diameter. Methods for determining case hardenability of carburized steels are given in SAE J1975.

Any hardenability test made under other conditions than those given in this document will not be deemed standard and will be subject to agreement between supplier and user. Whenever check tests are made, all laboratories concerned must arrange to use the same alternate procedure with reference to test specimen and method of grinding for hardness testing.

For routine testing of the hardenability of successive heats of steel required to have hardenability within certain limits, it is sufficient to designate hardenability simply in terms of distance from the quenched end to the point at which a certain hardness is obtained. This designation may also be adequate for comparing steels of different compositions to see whether they have similar hardenability.

Hardenability limits for specifying steel in this manner are obtained by measuring the hardenability of a steel which has proved satisfactory for the use intended. The hardenability test may be used in this way as an empirical test.

For new components where manufacturing experience is lacking, hardenability data may be effectively used to estimate the hardness profile provided by any given steel. Attendantly, the ability to predict hardenability from chemical composition has become increasingly important when comparing various steel grades or developing new steels for specific applications. One such procedure is described in Appendix A. Other hardenability prediction methods are available from the selected references in Section 2. However, it should be emphasized that the use of any hardenability prediction procedure does not preclude the importance of conducting Jominy end-quench tests to determine the actual hardenability of any specific grade of steel.

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Hardenability data may be used to estimate hardnesses obtainable with any steel in new machine parts not yet in production and not similar to any parts on which production experience is available. Various hardenability application methods are described in the selected references, Section 2.1, 23 to 25. It appears none of these methods are precise, but these are often useful for estimation purposes. Final correlation on actual parts is necessary.

- 2. REFERENCES
- 2.1 Applicable Publications

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

## 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), <u>www.sae.org</u>.

- 1. SAE J417 Hardness Test and Hardness Number Conversion
- 2. SAE EA 406 Hardenability Prediction Calculator
- W. E. Jominy and A. L. Boegehold, "A Hardenability Test for Carburizing Steel," ASM Transactions, Vol. 26 (1938, No. 2, pp 574–599)
- J. L. Burns, T. L. Moore, and R. S. Archer, "Quantitative Hardenability," ASM Transactions, Vol 26 (1938), No. 1, pp 1–33
- 5. W. E. Jominy, "A Hardenability Test for Shallow Hardening Steels," ASM Transactions, Vol. 27 (1939) pp 1072–1085
- 6. Symposium on Hardenability of Alloy Steels, ASM 1939
- M. Asimow and M. A. Grossmann, "Hardening Characteristics of Various Shapes," AMS Transactions, Vol. 28 (1940) pp 949–977
- "Standardization Sought in Determining the Hardenability of Steels" (A symposium), SAE Journal, Vol. 49, No. 1 (July 1941) pp 266–293
- A. E. Focke, "Hardenability of Steel," Iron Age, Aug. 20, 1942 pp 37–40: Aug. 27, 1942, pp. 43–51; Sept. 3, 1942, pp 56–59
- 10. Morse Hill "The End-Quench Test: Reproducibility," ASM Transactions, Vol. 31 (1943), P 923 ff.
- 11. Symposium on the Hardenability of Steel, Special Report No. 36, British Iron and Steel Institute, 1946
- 12. G. K. Manning, "End Quench Hardenability Versus Hardness of Quenched Rounds," Metal Progress, Vol. 50, No. 4 (October 1946) pp 674-650
- E. W. Wienman, R. F. Thomson, and A. L. Boegehold, "Correlation of End Quenched Test Bars and Rounds in Terms of Hardness and Cooling Characteristics," ASM Transactions, Vol. 44 (1952) pp 802–834
- G. K. Manning, "Comparison of Tests of Hardenability of Shallow Hardening Steels," SAE Journal, Vol. 61, July 1953, pp 30–36
- 15. D. J. Carney, "Another Look at Quenchants, Cooling Rates and Hardenability," ASM Transactions, Vol. 46 (1954), pp 882–925

- 16. John Birtalan, R. G. Henley, Jr., and A. L. Christenson, "Thermal Reproducibility of the End-Quench Test," ASM Transactions, Vol. 46 (1954), P 928 ff
- 17. M. A. Grossman and R. L. Stephenson, "The Effect of Grain Size on Hardenability," ASM Transactions, Vol. 29 (1941), pp 1–19
- 18. M. A. Grossmann, "Hardenability Calculated from Chemical Compositions," AIME Transactions, Vol. 150 (1942) pp 227–259
- 19. I. R. Kramer, S. Siegel, and J. Brooks, "Factors for the Calculation of Hardenability," ASM Transactions, Vol. 163 (1946), p 670 ff
- 20. C. F. Jatczak and D. J. Girardi, "Multiplying Factors for the Calculation of Hardenability of Hypereutectoid Steels Hardened from 1700 F," ASM Transactions Vol. 51 (1960) p 335 ff
- 21. E. Just, "New Formulas for Calculating Hardenability Curves," Metal Progress, November 1969, pp 87–88
- 22. C. F. Jatczak, "Determining Hardenability from Composition," Metal Progress, Vol. 100, No. 3 (September 1971), p 60
- D. H. Breen, G. H. Walter, C. J. Keith, and J. T. Sponzilli, "Computer-Based System Selects Optimum Cost Steels," Metal Progress, I: Dec. 1972, p. 42; II: Feb. 1973, p. 76; III: April 1973, p. 105; IV: June 1973, p. 83; V: Nov. 1973, p. 43
- 24. C. S. Siebert, D. V. Doane, and D. H. Breen, "The Hardenability of Steels," American Society for Metals, Metals Park, OH 1977, p 64 ff
- 25. D. V. Doane, J. S. Kirkaldy, "Hardenability Concepts with Applications to Steel," The Metallurgical Society of AIME, Warrendale, PA 1978
- 26. C. T. Kunze and G. Keil," A New Look at Boron Effectiveness in Heat Treated Steels," Symposium on Boron Steels, TMS-AIME, Milwaukee, WI Sept. 18, 1979
- 27. W. Hewitt, "Hardenability Its Prediction form Chemical Compositions," Heat Treatment of Metals, Vol. 8, 1981, pp 33–38
- 28. Deb. M. C. Chaturvedi and A. K. Jena, "Analytical Representation of Hardenability Data for Steels," Metals Technology, 1982, Vol 9, p 76
- 29. J. M. Tartaglia and G. T. Eldis, "Core Hardenability Calculations for Carburizing Steels," Met. Trans., Vol. 15A, No. 6, June 1984, pp. 1173–1183
- 2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 ASTM Publications

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

ASTM A 255 End-quench Test for Hardenability of Steel