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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

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(R) DECARBURIZATION IN HARDENED AND TEMPERED UNIFIED THREADED FASTENERS

1. ***Scope***—This SAE Recommended Practice covers methods for measuring, classifying, and specifying decarburization in the threaded section of hardened and tempered steel bolts, screws, studs, and similar parts. It is not intended to cover products which are specifically carburized to achieve special properties.

2. ***References***

2.1 Applicable Document—The following publication forms a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J419—Methods of Measuring Decarburization

2.2 Definitions—According to SAE J419, "decarburization" is the loss of carbon at the surface of commercial ferrous materials which have been heated to facilitate fabrication or heated to modify mechanical properties. SAE J419 defines also "complete decarburization," "partial decarburization," and "effective decarburization," as related to unhardened steels. This document extends these definitions, as follows, to cover more specifically hardened and tempered steel bolts, screws, studs, and similar products.

2.2.1 PARTIAL DECARBURIZATION—Decarburization with loss of carbon sufficient to cause a lighter shade of tempered martensite than that of the immediately adjacent base metal, when examined metallographically by the method outlined in 4.1, but insufficient carbon loss to show clearly defined ferrite grains. (The hardness traverse method, outlined in 4.2, is the referee method for determining that partial decarburization is not present at a point below that shown in Figure 1 for each classification.)

2.2.2 GROSS DECARBURIZATION—Decarburization with sufficient carbon loss to show only clearly-defined ferrite grains under metallographic examination by the method outlined in 4.1. This is sometimes called "Complete Decarburization."

2.2.3 CARBON RESTORATION—A process of restoring surface-carbon loss by heat treating in an atmosphere furnace of properly controlled carbon potential. (This process is permitted but not recommended for threaded fasteners unless furnace atmosphere is adequately controlled.)

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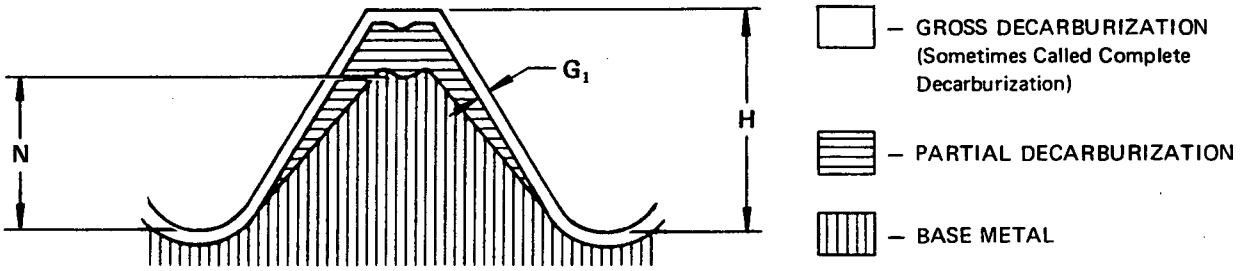

Limits for Unified Threads[4]—in				
		Decarburization Class C (1/2 H)[2]	Decarburization Class B (2/3 H)[2]	
		N	N	G[4]
Threads Per in	Thread Height H[1]	min	min	max
28	0.02191	0.011	0.015	0.0006
24	0.02556	0.013	0.017	0.0006
20	0.03067	0.015	0.020	0.0006
18	0.03408	0.017	0.023	0.0006
16	0.03834	0.019	0.025	0.0006
14	0.04382	0.022	0.029	0.0006
13	0.04719	0.024	0.032	0.0006
12	0.05112	0.026	0.035	0.0006
11	0.05577	0.028	0.037	0.0006
10	0.06134	0.031	0.041	0.0006
9	0.06816	0.034	0.045	0.0006
8	0.07668	0.038	0.051	0.0006
7	0.08763	0.044	0.059	0.0006
6	0.10224	0.051	0.068	0.0006

All dimensions are inches.

1. H is height of external thread at its maximum boundary nonplated condition.
2. Decarburization Class C (1/2 H) and Class B (2/3 H) were formerly referred to as X and 4/3 X, respectively (where X equals one-half thread height).
3. G shall be measured perpendicular to the flank of the thread midway between crest and root. (The additional depth of gross decarburization shown at thread crest is due to "thread enfoliation" caused by thread rolling.)
4. See Section 3 for limits applicable to other threaded products.

FIGURE 1—DECARBURIZATION LIMITS FOR COMMONLY USED UNIFIED THREADS

2.2.4 CARBURIZATION—A darker shade of tempered martensite than that of the immediately adjacent base metal, when examined metallographically by the method outlined in 4.1, and harder by at least 30 points (Knoop or Vickers DPH) than the hardness at root diameter when checked by the method outlined in 4.2. (The limits established by this document exclude this condition.)

2.2.5 BASE-METAL HARDNESS—For purposes of this document, hardness at root diameter on a line bisecting the included angle of the thread (Position 1 in Figure 2) is considered "base-metal hardness."

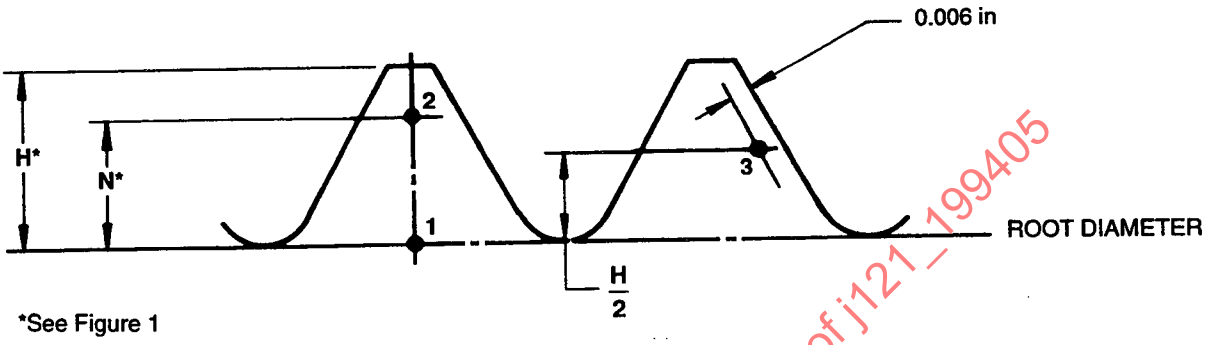

FIGURE 2—POSITIONS FOR DETERMINING HARDNESS

3. Classes of Decarburization—This document establishes two classes of decarburization for inch-series threaded products. Each class is characterized by dimensional limits for decarburized zone, gross-decarburized zone, and/or base-carbon zone (as applied to longitudinal sections through the thread axis). Decarburization limits appliable to the more commonly used Unified Threads (in) are shown in Figure 1. Limits applicable to other threaded products are as follows:

a. For Class C (1/2 H)—N = 0.50 H; G = 0.0006 in
b. For Class B (2/3 H)—N = 0.67 H; G = 0.0006 in

NOTE—This document recognizes that the surface may vary in carbon content from the base-metal carbon content, and stipulates that this variation shall be either "partial decarburization" or "gross decarburization" or a "carbon-restored surface" to the extent allowed in Figure 1 for the different classes. "Carburization" is not permitted in the surface zone.

4. Methods for Measuring Decarburization—Two methods for measuring decarburization are provided. The microscopic method is intended primarily for routine inspection purposes. The hardness method is intended primarily for referee purposes. In the case of gross decarburization, however, only the microscopic method is applicable.

4.1 Microscopic Method[1]

4.1.1 SPECIMENS—Use longitudinal sections taken through the thread axis of the bolt, screw, or stud, after all heat-treating operations have been performed on the product. If specimens are prepared from surface-coated fasteners, care should be used when interpreting the substrate-coating interface.

[1] Same as outlined in SAE J419, except "Specimen."

4.1.2 PREPARATION

a. Mount specimen for grinding and polishing. Protection from rounding the surface to be examined is essential. The specimen should be mounted in a clamp or in a plastic mount, the latter being the preferred method.
b. After mounting, grind and polish the surface in accordance with good metallographic practice.
c. Etching in a 3% nital (concentrated nitric acid) or picral (saturated picric acid) is usually suitable for showing changes in microstructure caused by decarburization.

4.1.3 MEASUREMENT—Unless otherwise agreed on between purchaser and producer, examine at 100X magnification. Compare with Figure 1 and definitions in 2.2.1, 2.2.2, and 2.2.3.

If the microscope is of a type with a ground-glass screen, the extent of decarburization can be measured directly with a scale. If an eye-piece is used for measurement, it should be an appropriate type containing a cross hair or a scale.

4.2 Hardness Method[2]

4.2.1 Prepare specimens as outlined in 4.1.1 and 4.1.2.

4.2.2 Determine hardness at three positions, as shown in Figure 2, using a Knoop indenter with a 500 g load or Vickers DPH with 300 g load.

4.2.3 Interpret hardness readings as follows:

a. A decrease of more than 30 hardness points from Position 1 to Position 2 indicates that the part does not conform to the classification specified.
b. An increase of more than 30 points between Point 1 and Position 3 is regarded as "carburization," and indicates that part does not conform to the classification specified.

NOTE—Careful differentiation must be made between an increase in hardness caused by carburization or by cold working the surface (such as from thread rolling).

5. Notes

5.1 Marginal Indicia—The (R) is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

[2] Hardness Method applicable only for threads of 28 threads per inch and larger.

PREPARED BY THE SAE FASTENERS COMMITTEE