Designation: F2328 – 17 (Reapproved 2022)

Standard Test Method for Determining Decarburization and Carburization in Hardened and Tempered Threaded Steel Bolts, Screws, Studs, and Nuts[1]

This standard is issued under the fixed designation F2328; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers procedures for measuring, classifying, and determining the presence of decarburization and carburization in the threaded section of hardened and tempered inch series steel bolts, screws, studs, nuts, and similar parts which have been heated to facilitate fabrication or to modify their mechanical properties. This test method is not intended to address products which are intentionally carburized to achieve specific results.

1.2 Two routine methods are described for measuring the limits of and determining the presence of decarburization or carburization—the optical method and the microindentation method 1. Either method is appropriate for routine examinations. The microindentation method 2 shall be considered the referee method.

1.3 For the purpose of these tests, there are four classes of hardened and tempered steel products for which specific measurements must be made with respect to their physical properties.

1.4 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E3 Guide for Preparation of Metallographic Specimens

E384 Test Method for Microindentation Hardness of Materials

F1789 Terminology for F16 Mechanical Fasteners

3. Terminology

3.1 *Definitions:*

3.1.1 *carburization*—process or result of increasing the carbon content of the surface layers of the steel fastener product.

3.1.2 *decarburization*—in accordance with Terminology F1789, is a loss of carbon from the surface layer of the fastener, normally associated with heat treatment.

3.1.3 *gross decarburization*—also known as *complete decarburization*, is characterized by a sufficient carbon loss to show only clearly defined ferrite grains.

3.1.4 *partial decarburization*—characterized as a loss of carbon sufficient to cause a lighter shade of tempered martensite than that of the immediately adjacent base metal, but as being of insufficient carbon loss to show clearly defined ferrite grains.

4. Significance and Use

4.1 Decarburization and carburization are two surface conditions created, either intentionally or unintentionally, as with a pre-existing condition created during the rod rolling process, the rod/wire annealing process, or while heat treating threaded steel products. Too much of either will adversely affect the safety and performance of the threaded product. Therefore, limits have been established for three different product groups: the harder and greater the tensile strength of the product, the more susceptible to failure the product becomes if these limits are exceeded.

[1] This test method is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.01 on Test Methods.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

4.2 When testing to a particular product specification that lists the dimensions and microindentation data to be used, that data shall take precedence over the tables in this test method.

4.3 There are only two viable methods available to detect these deficiencies, either by the visual method or the microindentation method. Both methods are used for routine inspections when evaluations are conducted at a single location on the product sample.

4.3.1 Because an evaluation at a specific location may not be representative of the whole part, the referee method employs the microindentation method taken as an average of evaluations conducted on four adjacent threads. This procedure significantly reduces the random test variables when compared to testing on a single thread.

4.4 Specifying this test method does not specify or imply that testing shall be for either decarburization or carburization alone or for both conditions. When either test method is performed, both conditions will be apparent and shall be reported. For example, if an order is placed to test for decarburization and none is found, but the presence of carburization is detected, it shall be reported on the test report that carburization was found.

5. Class of Decarburization

5.1 *Class Determination*—These measurements by Class are predicated upon their relationship between the height (H) of the external thread at its maximum boundary, disregarding any surface coating, and N, which is the minimum thread height in the non-decarburized zone (see Figs. 1-3). The dimensions for N and H are listed in Table 2 for each Class. Dimension G (Table 1 and Fig. 1) represents the maximum depth of gross or complete decarburization.

NOTE 1—Refer to the product standard for specific requirements. When limits are not specified, use Table 1 as a suggested reference.

6. Preparation

6.1 The use of either the optical or microindentation method requires the finished product to be longitudinally cross-sectioned, approximately through the threaded axis, and mounted for grinding and polishing in any suitable medium which will provide edge retention of the specimen. This shall be performed in accordance with good metallographic practice. See Practice E3.

7. Evaluation by the Optical Method

7.1 Etch the mounted specimen (Section 6) in a 2 to 4 % nital or picral solution to exhibit the microstructure. Examine the specimen at 100× magnification using a method capable of measuring distances to at least 0.001 in. resolution. The width of any light-etching band of martensite defines the depth of decarburization. Compare the image with Fig. 1 for the maximum limits for G by taking a measurement on a line perpendicular to the flank of the thread midway between the thread crest and root (pitch diameter).

7.2 *Interpretation of Results:*

7.2.1 Allowable limits for partial decarburization shall be in accordance with 3.1.4 and Fig. 1, and the measured values shall be in accordance with Table 2, when measured in accordance with the illustrations in Figs. 2 and 3.

7.2.2 Allowable limits for gross decarburization (G) shall be in accordance with 3.1.3 and the measured values as defined in Table 1. The optical method is the only valid method for evaluating the depth of gross decarburization. Gross decarburization is prohibited in Class 3 products.

7.2.3 Carburization is identified when the tempered martensite is a darker shade than the immediately adjacent base metal. If visible evidence of surface carburization is present on the surface zone, the microindentation method, in accordance with Section 8, shall be used.

7.2.4 The optical method may not be appropriate for specimens with certain coatings, such as zinc, where the coating can affect the etching process and distort the appearance of the base material microstructure. These coatings shall be removed prior to mounting if the coating prevents proper etching. Care must also be exercised to not alter the surface condition of the substrate during the coating removal process.

7.2.5 If the results of the optical method indicate a possible nonconformance in the measurement of partial decarburization or carburization, or are otherwise inconclusive, the microindentation method (Section 8) shall be performed after the specimens are repolished.

8. Evaluation by the Microindentation Hardness Method

8.1 Prepare the sample in accordance with Section 6 and perform measurements in accordance with Test Method E384 on polished and unetched specimens. Use either a Vickers (136°) indenter or a Knoop indenter with the following load requirements:

Threads per Inch	Load	
	Knoop (HK)	Vickers (HV)
Less than 40	500 gf	300 gf
40 through 48	200 gf	200 gf
Greater than 48	100 gf[A]	100 gf[A]

[A] Lighter loads shall be used if the size of the part warrants.

8.2 *Routine Decarburization/Carburization Test Method 1—Measurement:*

8.2.1 Determine the base metal hardness (Position 1) that is near the intersection of a plane at the thread root diameter and

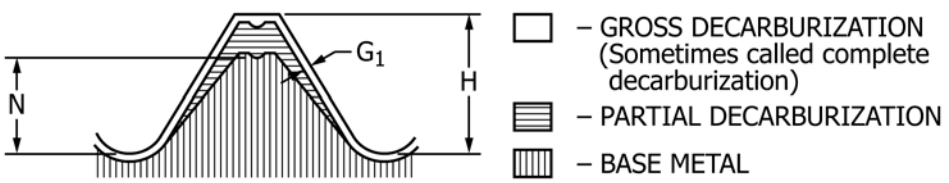

FIG. 1 Decarburization Zones

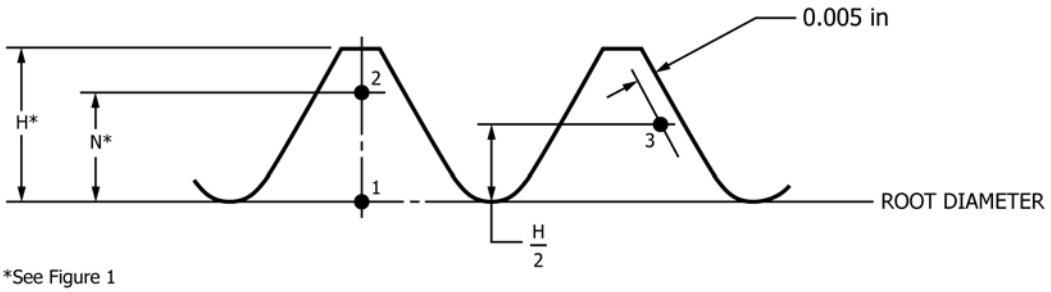

FIG. 2 Position for Microindentation Measurements

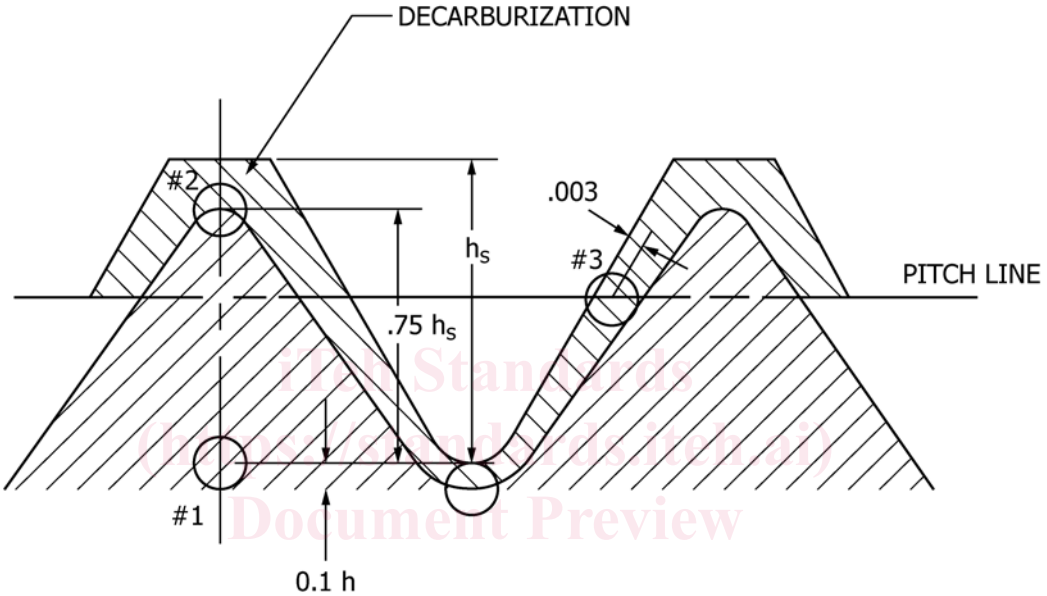

FIG. 3 Microindentation Measurements for Class 3 Products

TABLE 1 Classes of Decarburization: Guide

Class	N	G. max	Typical Applications
1	½ H	0.0006 in.	For heat treated products which have tensile strengths up to 120 000 psi and those with a specified minimum tensile strength of 120 000 psi or a hardness range of 24 to 34 HRC, or both
2	⅔ H	0.0006 in.	For products with a minimum tensile strength of 150 000 psi or a hardness range of 33 to 39 HRC, or both
3	¾ H	none permitted	For products with a minimum tensile strength of 170 000 psi or a minimum specified hardness of 37 HRC, or both
4	½ H	0.0006 in.	For heat treated nuts with hardness 24–38HRC

a perpendicular line bisecting the thread crest. Measurement at Position 2 is taken on the same thread crest bisector line from Position 1 to an approximate distance N as determined in Table 2, and as specified by the product classification or product specification. See Figs. 2 and 3.

8.2.2 For Class 1, 2, and 4 products, Position 3 hardness shall be measured at a depth of 0.005 in. from the thread flank at an approximate distance of H/2 as measured from the plane of the thread root diameter (Fig. 2).

8.2.3 For Class 3 products, Position 3 hardness shall be measured at an approximate depth of 0.003 in. from the thread flank at an approximate distance of H/2, as measured from the plane of the thread root diameter (Fig. 3).

8.2.4 Position 3 readings shall be taken on the same or adjacent thread and at the same time as the readings at Positions 1 and 2 using the same hardness scale. The long axis of the Knoop indenter shall be aligned approximately parallel with the thread pitch angle at Position 3.

8.3 *Interpretation of Results:*

8.3.1 A decrease of more than 30 hardness points of either HK or HV between Position 1 to Position 2 indicates excessive decarburization and that the part does not conform to the specification. If a nonconformance is indicated, proceed to Referee Test Method in 8.4 for verification.

8.3.2 An increase of more than 30 hardness points of either HK or HV between Position 1 to Position 3 shall be regarded as excessive carburization and the part does not conform to the specification. If a nonconformance is indicated, proceed to Referee Test Method in 8.5 for verification.

8.4 *Decarburization Referee Test Method 2—Measurement:*