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.

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Standard Specification for Quality Assurance Requirements for Carbon and Alloy Steel Wire, Rods, and Bars for Mechanical Fasteners[1]

This standard is issued under the fixed designation F2282; 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 specification establishes quality assurance requirements for the physical, mechanical, and metallurgical requirements for carbon and alloy steel wire, rods, and bars in coils intended for the manufacture of mechanical fasteners which includes: bolts, nuts, rivets, screws, washers, and special parts manufactured cold.

NOTE 1—The Steel Industry uses the term "quality" to designate characteristics of a material which make it particularly well suited to a specific fabrication and/or application and does not imply "quality" in the usual sense.

1.2 Wire size range includes 0.062 to 1.375 in.

1.3 Rod size range usually includes 7⁄32 in. (0.219) to 47⁄64 in. (0.734) and generally offered in 1⁄64 increments (0.0156).

1.4 Bar size range includes 3⁄8 in. (0.375) to 1½ in. (1.500).

1.5 Sizes for wire, rod and bar outside the ranges of paragraphs 1.2 – 1.4 may be ordered by agreement between purchaser and supplier.

1.6 Material is furnished in many application variations. The purchaser should advise the supplier regarding the manufacturing process and finished product application as appropriate. Five application variations are:

Cold Heading
Recessed Head
Socket Head
Scrapless Nut
Tubular Rivet

1.6.1 Wire is furnished for all five application variations.

1.6.2 Rod and bar are furnished to the single application variation; Cold Heading.

1.7 *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]

A29/A29M Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
A370 Test Methods and Definitions for Mechanical Testing of Steel Products
A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment
A751 Test Methods and Practices for Chemical Analysis of Steel Products
E4 Practices for Force Calibration and Verification of Testing Machines
E10 Test Method for Brinell Hardness of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E112 Test Methods for Determining Average Grain Size
E381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings
E407 Practice for Microetching Metals and Alloys
E1077 Test Methods for Estimating the Depth of Decarburization of Steel Specimens
F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
F1789 Terminology for F16 Mechanical Fasteners

2.2 *AIAG Standard:*

B-5 Primary Metals Tag Application Standard[3]

2.3 *IFI Standard:*

IFI-140 Carbon and Alloy Steel Wire, Rods, and Bars for Mechanical Fasteners[4]

2.4 *SAE Standards:*

J403 Chemical Compositions of SAE Carbon Steels[5]
J404 Chemical Compositions of SAE Alloy Steels[5]
J406 Methods of Determining Hardenability of Steels[5]

[1] This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.93 on Quality Assurance Provisions for Fasteners.

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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.

[3] Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48033, http://www.aiag.org.

[4] Available from Industrial Fasteners Institute (IFI), 6363 Oak Tree Blvd, Independence, OH 44131, http://www.indfast.org.

[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

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

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J415 Definitions of Heat Treating Terms[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *annealing*—a process of heating to and holding steel at a given temperature for a given time and then cooling at a given rate, used to soften or produce changes, or both, in the microstructure of the steel to enhance formability and reduce tensile strength.

3.1.2 *bars*—produced from hot rolled or cast billets or blooms rolled single strand into coils. Bars have a greater precision in cross section than rods. Size tolerances are in Table 1. Bars are finished as-rolled, annealed or spheroidize annealed, and in sizes included in 1.4.

3.1.3 *exogenous inclusions*—particles contained in steel resulting from incidental reoxidation, slag entrainment, refractory erosion, or other sources, that can occur during the processes of steel making, refining, and casting.

3.1.4 *lap*—a longitudinal surface discontinuity extending into rod, bar, or wire caused by doubling over of metal during hot rolling.

3.1.5 *lot*—a quantity of raw material of one size and heat number submitted for testing at one time.

3.1.6 *rods*—produced from hot rolled or cast billets, usually rolled in a multiple strand mill to a round cross section then coiled into one continuous length to size tolerances shown in Table 2. Rods are furnished as-rolled, annealed, or spheroidize annealed in sizes found in 1.3.

3.1.7 *seam*—a longitudinal discontinuity extending radially into wire, rod, or bar. Seams in raw material used for the manufacture of fasteners or formed parts may lead to the formation of bursts.

3.1.8 *spheroidizing*—a form of annealing, involves prolonged heating at temperatures near the lower critical temperature, followed by slow cooling, with the object of forming spheroidal metallic carbides that allow a higher degree of formability.

3.1.9 *void*—a shallow pocket or hollow on the surface of the material.

3.1.10 *wire*—produced from hot rolled or annealed rods or bars by cold drawing for the purpose of obtaining desired size, dimensional accuracy, surface finish, and mechanical properties. Wire is furnished in the following conditions: direct drawn (DD); drawn from annealed rod or bar (DFAR or DFAB); drawn from spheroidized annealed rod or bar (DFSR or DFSB); drawn to size and spheroidized (SAFS); drawn, annealed in process, and finally lightly drawn to size (AIP); and drawn, spheroidize annealed in process, and finally lightly drawn to size (SAIP). Wire size tolerances are shown in Table 3. Sizes include those specified in 1.2.

3.1.10.1 *Discussion*—Spheroidize annealed-at-finish size wire (SAFS) is wire that has been spheroidize annealed after final cold reduction. One or more annealing treatments may precede the final cold reduction.

3.1.10.2 *Discussion*—Annealed-in-Process (AIP) or Spheroidize Annealed-in-Process (SAIP) wire is produced as drawn carbon or alloy steel wire. In producing AIP and SAIP wire, rods or bars are drawn to wire and thermal treatment (followed by a separate cleaning and coating operation) is done prior to final drawing to produce a softer and more ductile wire for applications in which direct drawn wire would be too hard. Thermal treatment may also be employed when controlled mechanical properties are required for a specific application.

3.2 Heat treating terms not defined in this standard are included in Terminology F1789 or SAE J415.

TABLE 1 Bar Size Tolerances

Fractional Diameter, in.	Diameter ± Tolerance, in.	Out of Round max, in.
7/16 to 5/8	0.006	0.009
>5/8 to 7/8	0.007	0.011
>7/8 to 1	0.008	0.012
>1 to 1 1/8	0.009	0.014
>1 1/8 to 1 1/4	0.010	0.015
>1 1/4 to 1 3/8	0.011	0.017
>1 3/8 to 1 1/2	0.013	0.020

TABLE 2 Rod Size Tolerances

Diameter, in.	Diameter ± Tolerance, in.	Out of Round max, in.
7/32 to 47/64 (0.219 to 0.734)	0.012	0.018

4. Ordering Information

4.1 Wire orders shall state the following:

4.1.1 Quantity,

4.1.2 Specification number and issue date,

4.1.3 Diameter,

4.1.4 Steel grade,

4.1.5 Deoxidation practice and grain size or refinement practice (coarse or fine); see 5.3.1 – 5.3.5,

4.1.6 Application variation per 1.6,

4.1.7 Thermal treatment; see 5.5,

4.1.8 Surface coating,

4.1.9 Coil weight and dimensions as required,

4.1.10 Packaging,

4.1.11 Tagging,

4.1.12 Mill certification as required,

4.1.13 Special requirements, for example, steel making method and practice, specific hardenability, special shipping instructions, single heat, etc., and

4.1.14 *Example*—40 000 lb, ASTM F2282, 0.250 in., carbon steel wire, IFI-1022A, silicon killed coarse grain, Recessed Head, spheroidize annealed-in-process, phosphate and lube, 1500 lb coils, 28 in. coil i.d., on 18 in. tubular carriers, three bands per carrier, one metal tag per coil, mill certification, do not ship Fridays.

TABLE 3 Wire Size Tolerances and Out of Round

Diameter, in.	Diameter ± Tolerance, in.	Out of Round max, in.
< 0.076	0.0010	0.0010
0.076 < 0.500	0.0015	0.0015
≥ 0.500	0.0020	0.0020

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4.2 Rod orders shall state the following:
4.2.1 Quantity,
4.2.2 Specification number and issue date,
4.2.3 Diameter,
4.2.4 Steel grade,
4.2.5 Deoxidation practice and grain size or refinement practice (coarse or fine),
4.2.6 Cold Heading,
4.2.7 Thermal treatment,
4.2.8 Surface coating,
4.2.9 Coil weight and dimensions as required,
4.2.10 Packaging,
4.2.11 Tagging,
4.2.12 Mill certifications as required,
4.2.13 Special requirements, for example, descaling practice, steelmaking method and practice, specific hardenability, special shipping instructions, etc., and
4.2.14 *Example*—200 000 lb, ASTM F2282, 21⁄64 in., carbon steel rod, IFI-1022B, silicon killed fine grain, Cold Heading, spheroidize annealed, pickled and limed, 3000 lb coils, 48 in. coil i.d., compacted and unitized in packages of two, banded with three steel straps per coil, two metal tags per coil attached to lead end on inside of bundle, put separators between coils.

4.3 Bar orders shall state the following:
4.3.1 Quantity,
4.3.2 Specification number and issue date,
4.3.3 Diameter,
4.3.4 Steel grade,
4.3.5 Deoxidation practice and grain size or refinement practice (coarse or fine),
4.3.6 Cold Heading,
4.3.7 Thermal treatment,
4.3.8 Surface coating,
4.3.9 Coil weight and dimensions as required,
4.3.10 Packaging,
4.3.11 Tagging,
4.3.12 Mill certification as required,
4.3.13 Special requirements, for example, steelmaking method and practice, specific hardenability, special shipping instructions, single heat, etc., and
4.3.14 *Example*—90 000 lb, ASTM F2282, 0. 610 in., carbon steel bars, IFI-1038, silicon killed coarse grain, spheroidize annealed, Cold Heading, phosphate and lime, 5400 lb coils, 54 in. coil i.d., three bands per coil, one metal tag per coil, lead end of each coil paint red.

5. Manufacture

5.1 *Melting Practice*—The steel shall be melted in a basic oxygen or electric furnace process.

5.2 *Casting Practice*—Steel shall be ingot cast, or continuous cast with controlled procedures to meet the requirements of this specification.

5.3 *Deoxidation Practice and Grain Size*—The material shall be furnished in one of the deoxidation and grain size practices included in 5.3.1 – 5.3.5, as specified by the purchaser. When not specified, the practice shall be at the option of the manufacturer.

5.3.1 Silicon killed fine grain shall be produced with aluminum for grain refinement. The material purchaser's approval shall be obtained for the use of vanadium or columbium for grain refinement.
5.3.2 Silicon killed coarse grain practice.
5.3.3 Silicon killed fine grain practice.
5.3.4 Aluminum killed fine grain practice.
5.3.5 Rimmed (grain size not specified).

5.4 *Hardenability:*
5.4.1 Hardenability for steels with a specified minimum carbon content of 0. 20 % or greater shall be determined for each heat and the results furnished to the purchaser when requested on the purchase order. SAE J406, Appendix A shall be used for referee purposes in the event of dispute.

5.5 *Thermal Treatments:*
5.5.1 The purchaser shall specify one of the following options for thermal treatment on the purchase order:
5.5.1.1 No thermal treatment.
5.5.1.2 Annealed.
5.5.1.3 Spheroidized.
5.5.1.4 Drawn from annealed rod or bar.
5.5.1.5 Drawn from spheroidize annealed rod or bar.
5.5.1.6 Spheroidized at finished size wire.
5.5.1.7 Annealed-in-process wire.
5.5.1.8 Spheroidized annealed-in-process wire.

6. Chemical Requirements

6.1 The material shall have a chemical composition conforming to the requirements specified in Tables 4-8 for the applicable IFI grade specified by the material purchaser.

NOTE 2—The chemical compositions have been developed in a joint producer/user effort and are particularly appropriate to the cold forging industry process. The chemical composition ranges of these IFI grades may not be identical to those of SAE J403, SAE J404, or AISI.

6.2 Compositions other than those designated in this standard may be applicable when specified by the purchaser.

6.3 *Cast or Heat Analysis*—An analysis of each cast or heat shall be made by the producer to determine the percentage of the elements specified. The analysis shall be made from a test sample(s) taken during the pouring of the cast or heat. The chemical composition shall be reported, if required, to the purchaser or his representative.

6.4 *Product Analysis:*
6.4.1 Product analysis may be made on the finished material from each heat. The composition thus determined shall conform to the requirements in Table 4, Table 6, or Table 7 for the specified grade subject to the permissible variations for product analyses in Table 5 or Table 8, as applicable.

NOTE 3—A product analysis is optional. The analysis is not used for a duplicate analysis to confirm a previous result. The purpose of the product analysis is to verify that the chemical composition is within specified limits for each element, including applicable permissible variations in product analysis. The results of analyses taken from different pieces of a heat may differ within permissible limits from each other and from the heat or cast analysis. The results of the product analysis obtained shall not vary both above and below the specified range.

6.4.2 Rimmed or capped steels are characterized by a lack of uniformity in their chemical composition, especially for the

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TABLE 4 Carbon Steels, Chemical Ranges and Limits, %

Conditions Furnished	IFI Steel Grade Designation	Carbon		Manganese		Phosphorous Max	Sulfur Max	Silicon
		Min	Max	Min	Max			
R, AlK	IFI-1006	. . .	0.08	0.25	0.40	0.020	0.020	See Table 6
R, AlK, SiFg, SiCg	IFI-1008	. . .	0.10	0.30	0.50	0.020	0.020	See Table 6
R, AlK, SiFg, SiCg	IFI-1010	0.08	0.13	0.30	0.60	0.020	0.020	See Table 6
AlK, SiFg, SiCg	IFI-1018	0.15	0.19	0.65	0.85	0.020	0.020	See Table 6
AlK, SiFg	IFI-10B21	0.19	0.23	0.80	1.10	0.020	0.020	See Table 6
AlK, SiFg, SiCg	IFI-1022/A	0.18	0.21	0.80	1.00	0.020	0.020	See Table 6
AlK, SiFg, SiCg	IFI-1022/B	0.20	0.23	0.90	1.10	0.020	0.020	See Table 6
AlK	IFI-1033	0.31	0.36	0.70	0.90	0.020	0.020	See Table 6
AlK, SiFg, SiCg	IFI-1035	0.33	0.38	0.70	0.90	0.020	0.020	See Table 6
AlK, SiFg, SiCg	IFI-1038	0.35	0.42	0.70	0.90	0.020	0.020	See Table 6
SiFg	IFI-10B38	0.35	0.42	0.70	1.00	0.020	0.020	See Table 6
SiFg	IFI-1541/A	0.36	0.41	1.35	1.60	0.020	0.020	See Table 6
SiFg, SiCg, CgP	IFI-1541/B	0.38	0.43	1.35	1.60	0.020	0.020	See Table 6

NOTE 1—Carbon steels which have added boron use a B designation between the first and last two digits of the grade designation. A boron steel has a minimum boron content of 0.0008 % and a maximum of 0.003 % together with a minimum titanium content of 0.01 %.

AlK = Aluminum killed
R = Rimmed
SiFg = Silicon killed fine grain
SiCg = Silicon killed coarse grain
CgP = Coarse grain practice

TABLE 5 Permissible Variations from Specified Chemical Ranges, and Limits for Carbon Steel, %

Element	Limit or Max of Specified Range, %	Variation % Over Max Limit or Under Min Limit
Carbon	To 0.25 incl	0.02
	Over 0.25 to 0.55 incl	0.03
Manganese	To 0.90 incl	0.03
	Over 0.90 to 1.65 incl	0.06
Phosphorus	Over max only	0.008
Sulfur	Over max only	0.008
Silicon	To 0.30 incl	0.02
Copper	Over max only	0.03
Tin	Over max only	0.01
Nickel	Over max only	0.03
Chromium	Over max only	0.03
Molybdenum	Over max only	0.01
Vanadium	Over max only	0.01
Boron		N/A[A]

[A] Unless misapplication is indicated.

TABLE 6 Silicon Limits for Four Deoxidation Practices, %

	Deoxidation Practice					
	Silicon Killed		Silicon Killed		Aluminum Killed	Rimmed
	Fine Grain		Course Grain and Course Grain Practice		Fine Grain	
	Min	Max	Min	Max	Max	Max
IFI-1006	. . .	. . .	. . .	. . .	0.10	0.02
IFI-1008	0.10	0.20	0.10	0.25	0.10	0.02
IFI-1010	0.10	0.20	0.10	0.25	0.10	0.02
Boron Grades	0.10	0.30	N/A	N/A	N/A	N/A
All Other Grades	0.15	0.30	0.15	0.30	0.10	N/A

NOTE 1—Fine Grain—Normally Si/Al killed or aluminum killed. Vanadium or Columbium (niobium) can be used upon agreement between raw material supplier and user (purchaser). See Supplementary Requirement S.2.

NOTE 2—The values listed in this table are designed to provide optimum headability and tool life in the cold forming process. Modifications to these limits require agreement between producer and purchaser.

elements carbon, phosphorus, and sulfur, and for this reason product analysis is not technologically appropriate unless misapplication is clearly indicated.

6.4.3 Test Methods A751 shall be used.

6.5 *Residual Element Limits*—Material grades defined in this standard shall conform to the residual element limits in Table 9.

7. Metallurgical Structure

7.1 *Coarse Austenitic Grain Size:*

7.1.1 When a coarse grain size is specified, the steel shall have a grain size number of 1 to 5 inclusive.

7.1.2 Conformance to this grain size of 70 % of the grains in the area examined shall constitute the basis of acceptance.

7.2 *Fine Austenitic Grain Size:*

7.2.1 When a fine grain size is specified, the steel shall have a grain size number greater than five, as determined in accordance with Test Methods E112.

7.2.2 Conformance to this grain size of 70 % of the grains in the area examined shall constitute the basis of acceptance.

7.2.3 When aluminum is used as the grain refining element, the fine austenitic grain size requirement shall be deemed to be fulfilled if, on heat analysis, the total aluminum content is not less than 0.020 % total aluminum or, alternately, 0.015 % acid soluble aluminum. The aluminum content shall be reported. The grain size test specified in 7.2.1 shall be the referee test.

7.2.4 If columbium or vanadium or both are to be used, Supplementary Requirement S.2 shall be specified.

7.2.5 If specified on the order, one grain size test per heat shall be made and the austenitic grain size of the steel, as represented by the test, shall be number 6 or higher.

7.3 *Spheroidized Annealed Materials:*

7.3.1 Spheroidize annealed material shall meet a minimum test rating of G2 or L2 in the IFI spheroidization rating—Plate 1 (see Fig. 1).

7.3.2 Optimum spheroidization is equal to or greater than 90 %. The spheroidization rating shall be performed on a polished transverse sample etched with a 2% nital or 4%

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TABLE 7 Chemical Ranges and Limits for Alloy Steels, %

IFI Steel Grade Designation	Carbon		Manganese		Nickel		Chromium		Molybdenum		Phosphorous	Sulfur
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max
IFI-1335	0.33	0.38	1.60	1.90	. . .	. . .	. . .	. . .	. . .	. . .	0.020	0.020
IFI-4037[A]	0.35	0.40	0.70	0.90	. . .	. . .	. . .	. . .	0.20	0.30	0.020	0.020
IFI-4042	0.40	0.45	0.70	0.90	. . .	. . .	. . .	. . .	0.20	0.30	0.020	0.020
IFI-4118	0.18	0.23	0.70	0.90	. . .	. . .	0.40	0.60	0.08	0.15	0.020	0.020
IFI-4140	0.38	0.43	0.75	1.00	. . .	. . .	0.80	1.10	0.15	0.25	0.020	0.020
IFI-5140	0.38	0.43	0.70	0.90	. . .	. . .	0.70	0.90	. . .	. . .	0.020	0.020
IFI-8637	0.35	0.40	0.75	1.00	0.40	0.70	0.40	0.60	0.15	0.25	0.020	0.020

[A] Furnished in AlK or SiFg or SiCg or CgP. All other grades in SiFg-Fg only.

TABLE 8 Permissible Variation from Specified Chemical Ranges and Limits for Alloy Steels, %

Element	Limit or Max of Specified Range, %	Variation, %, Over Max Limit or Under Min Limit
Carbon	To 0.30 incl	0.01
	Over 0.30 to 0.75 incl	0.02
Manganese	To 0.90 incl	0.03
	Over 0.90	0.04
Phosphorus	Over Max only	0.005
Sulfur	Over Max only	0.005
Silicon	To 0.40 incl	0.02
Nickel	To 1.00 incl	0.03
Chromium	To 0.90 incl	0.03
	Over 0.90	0.05
Molybdenum	To 0.20 incl	0.01
	Over 0.20 to 0.40 incl	0.02
Vanadium	Over Max only	0.01
Copper	Over Max only	0.03

TABLE 9 Residual Element Limits[A]

Element	Residual Limit[B] max, %
Copper	0.20
Nickel	0.10
Chromium	0.10[C]
Molybdenum	0.04[C]
Tin	0.02
Nitrogen	0.009
Boron	0.0007[D]

[A] Residual limits for a given element do not apply to alloy steel if that element has a specified range.
[B] Controlling residual limits provides optimum formability and tool life during cold forming operations.
[C] See Supplementary Requirements.
[D] Not applicable to boron steels (see Table 4). Titanium shall not exceed 0.01 % for steels which do not have an intentional addition of boron and titanium.

Picral solution in accordance with Practice E407. The examination area for spheroidization shall be at or near the center of the material. The resulting structure shall be compared at 1000× magnification to Plate 1. The following descriptions may be used to better compare to Plate 1.

Spheroidization Rating Descriptions for Plate 1

% Spheroidization[A]	Description
>95	Spheroidal carbides are homogeneously distributed in a matrix of ferrite.
90 G1/L1	All carbides are spheroidal with a good distribution. Grain boundaries are not so obvious.
80 G2/L2	Most of the carbides are spheroidal with an average distribution. Some lamellar carbides and grain boundaries are present.
50 G3/L3	Approximately ½ of the carbides have been spheroidized. All carbides are in prior pearlitic colonies; grain boundaries are prevalent.
20 G4/L4	A very slight breakup of the lamellar carbides; mainly pearlite and ferrite.
0 G5/L5	The entire microstructure consists of pearlite and ferrite.

[A] All percentages are approximations based on visual observations.

8. Decarburization

8.1 The entire periphery of a sample prepared of the rod, wire, or bar for killed steels having carbon content exceeding 0.15 % shall be examined for decarburization at a magnification of 100 diameters. Free ferrite shall not exceed the maximum depth as specified in Table 10. The worst location shall be used to draw perpendicular bisectors, and the depth of decarb at the points where the bisectors intersect the circumference, shall be measured and the four (4) readings averaged as defined in the example identified as Fig. 2.

8.2 That average shall not exceed the limits for total average affected depth (TAAD) as specified in Table 10. The depth (D) of the worst location shall not exceed the maximum allowed in Table 10.

9. Mechanical Properties

9.1 Bars, rod, and wire furnished in the conditions below shall conform to the tensile strength and reduction in area requirements specified in Table 11.

9.1.1 Annealed or spheroidize annealed rod and bar.

9.1.2 Spheroidize annealed at finish size wire.

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