

1.0 Scope.

1.1 This specification describes 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 include: bolts, nuts, rivets, screws, washers and special formed parts manufactured cold.

1.2 Wire size range includes 0.062 inches to 1.375 inches.

1.3 Rod size range usually includes 7/32 inches to 47/64 inches and generally offered in 1/64th increments.

1.4 Bar size range includes 3/8 inches to 1½ inches.

1.5 Sizes for wire, rod and bar outside the ranges of paragraphs 1.2, 1.3 and 1.4 may be ordered by agreement between purchaser and supplier.

1.6 Material is furnished in many application variations. 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. The purchaser should advise the supplier regarding their 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 commonly furnished for all five application variations.

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

1.7 Conformance of all test data shall be determined in accordance with ASTM E29.

1.8 Heat treating terms not defined in this standard are included in SAE J415.

2.0 Referenced Documents.

2.1 ASTM Specifications:

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 700 Practices for Packaging, Marking and Loading Methods for Steel Products for Domestic Shipment

E 10 Test Method for Brinell Hardness of Metallic Materials

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specification

E 30 Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron

E 112 Test Methods for Determining Average Grain Size

E 1077 Standard Test Methods for Estimating the Depth of Decarburization of Steel Specimens

2.2 SAE Standards:

J403 Chemical Compositions of SAE Carbon Steels

J404 Chemical Compositions of SAE Alloy Steels

J406 Methods of Determining Hardenability of Steels

J415 Definitions of Heat Treating Terms

IFI
STANDARD®

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CARBON AND ALLOY STEEL WIRE, RODS AND BARS FOR MECHANICAL FASTENERS

IFI-140

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2.3 IFI Standards:

IFI Spheroidization Rating – Plate 1

3.0 Definitions.

3.1 Carbon Steel: Steel is considered to be carbon steel when no minimum content is specified or required for chromium, molybdenum and nickel, or any other element added to obtain a desired alloying effect; or when the maximum content specified for manganese does not exceed 1.65%. When specified, boron may be added to killed carbon steel with a maximum allowable of 0.003%.

3.2 Alloy Steel: Steel is considered to be alloy steel when the maximum of the range given for manganese exceeds 1.65% or in which a definite range or definite minimum quantity for any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels; chromium, molybdenum, and nickel or any other alloying element added to obtain a desired alloying effect.

3.3 Annealing: Annealing is 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 and/or produce changes in the microstructure of the steel to enhance formability and reduce tensile strength.

3.4 Spheroidizing: 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 have a higher degree of formability.

3.5 Wire: Wire is 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 8. Sizes include those specified in paragraph 1.2.

3.6 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.

3.7 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.

3.8 Rods: Rods are 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 9. Rods are furnished as-rolled, annealed or spheroidize annealed in sizes found in paragraph 1.3.

3.9 Bars: Bars are 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 shown in Table 10. Bars are furnished as-rolled, annealed, or spheroidize annealed and in sizes found in paragraph 1.4.

3.10 A lot is defined as a quantity of raw material of one size and heat number submitted for testing at one time.

3.11 Seams: 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.

3.12 Voids: A shallow pocket or hollow on the surface of the material.

3.13 Laps: A longitudinal surface discontinuity extending into rod, bar, or wire caused by doubling over of metal during hot rolling.

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4.0 Manufacture.

4.1 Melting practice: The steel typically is melted in a basic oxygen or electric furnace process.

4.2 Casting practice: Steel may be ingot cast, or continuous cast with controlled procedures to meet the requirements of this specification.

4.3 Deoxidization practice and grain size:

4.3.1 Silicon killed fine grain: Ordinarily produced with aluminum for grain refinement. When vanadium or columbium are used for grain refinement, agreement by the material purchaser is required.

4.3.2 Silicon killed coarse grain

4.3.3 Silicon killed coarse grain practice

4.3.4 Aluminum killed fine grain

4.3.5 Rimmed (grain size not specified)

4.4 Thermal Treatment:

4.4.1 Material may be furnished without thermal treatment, but when required and depending upon end use, material may be ordered as follows:

4.4.1.1 Annealed

4.4.1.2 Spheroidized

4.4.1.3 Drawn from annealed rod or bar

4.4.1.4 Drawn from spheroidize annealed rod or bar

4.4.1.5 Spheroidized at finished size wire

4.4.1.6 Annealed-in-process wire

4.4.1.7 Spheroidize annealed-in-process wire

5.0 Ordering Information.

5.1 Wire orders shall state the following:

5.1.1 Quantity

5.1.2 Diameter

5.1.3 Steel grade

5.1.4 Deoxidization practice and grain size

5.1.5 Application variation per paragraph 1.6

5.1.6 Thermal treatment

5.1.7 Surface coating

5.1.8 Coil weight and dimensions as required

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5.1.9 Packaging

5.1.10 Tagging

5.1.11 Mill certification as required

5.1.12 Special requirements, e.g., steel making method and practice, special shipping instructions, single heat, etc.

Example: 40,000 lbs., IFI-140, 0.250 inches, carbon steel wire, IFI-1022A, silicon killed coarse grain, Recessed Head, spheroidize annealed-in-process, phosphate and lube, 1500 lb. coils, 28 inch coil i.d., on 18 inch tubular carriers, three bands per carrier, one metal tag per coil, mill certification, do not ship Fridays.

5.2 Rod orders shall state the following:

5.2.1 Quantity

5.2.2 Diameter

5.2.3 Steel grade

5.2.4 Deoxidization practice and grain size

5.2.5 Cold Heading

5.2.6 Thermal treatment

5.2.7 Surface coating

5.2.8 Coil weight and dimensions as required

5.2.9 Packaging

5.2.10 Tagging

5.2.11 Mill certifications as required

5.2.12 Special requirements, e.g., descaling practice, steelmaking method and practice, special shipping instructions, etc.

Example: 200,000 lbs., IFI-140, 21/64 inches, carbon steel rod, IFI-1022B, silicon killed fine grain, Cold Heading, spheroidize annealed, pickled and lamed, 3,000 lb. coils, 48 inch 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.

5.3 Bar orders shall state the following:

5.3.1 Quantity

5.3.2 Diameter

5.3.3 Steel grade

5.3.4 Deoxidization practice and grain size

5.3.5 Cold Heading

5.3.6 Thermal treatment

5.3.7 Surface coating

5.3.8 Coil weight and dimensions as required

5.3.9 Packaging

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5.3.10 Tagging

5.3.11 Mill certification as required

5.3.12 Special requirements, e.g., steelmaking method and practice, special shipping instructions, single heat, etc.

Example: 90,000 lbs., IFI-140, 0.610 inches, carbon steel bars, IFI-1038, silicon killed coarse grain, spheroidize annealed, Cold Heading, phosphate & lime, 5,400 lb. coils, 54 inch coil i.d., three bands per coil, one metal tag per coil, lead end of each coil paint red.

6.0 Chemical Requirements.

6.1 A number of compositions particularly appropriate to the cold forging industry processes have been developed in a joint producer/user effort and are included in this standard as IFI designated steel grades. IFI carbon steel grades are in Table 1 and IFI alloy steel grades in Table 4. The chemical composition range of these IFI grades may not necessarily be identical to those of SAE J403 or SAE J404.

6.2 Compositions other than those designated in this standard as IFI grades, such as those in SAE J403 and SAE J404, may be applicable based on agreement between supplier and purchaser.

6.3 Cast or Heat Analysis (Formerly Ladle 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), preferably 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 (Formerly Check Analysis) - A product analysis may be made by the purchaser. 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 except for ingot cast material.

6.4.1 Rimmed or capped steels are characterized by a lack of uniformity in their chemical composition, especially for the elements carbon, phosphorus, and sulfur, and for this reason product analysis is not technologically appropriate unless misapplication is clearly indicated.

6.4.2 For referee purposes, Method ASTM E30 shall be used.

6.5 Residual Limits: Material grades defined in this standard shall conform to the following residual limits to provide optimum formability and tool life during the cold forming operation:

Residual limits for Carbon and Alloy Steels

Cu = 0.20 max
Ni = 0.10 max
Cr = 0.10 max (Note 1)
Mo = 0.04 max (Note 2)
Sn = 0.02 max

Note 1: Cr may be present to 0.20 max if so specified.

Note 2: Mo may be present to 0.06 max if so specified.

To further enhance formability, reduced residual limits below those specified in this paragraph may be required, and shall be based upon agreement between supplier and user.

6.6 IFI Engineered Steel Grades: The carbon steel chemical ranges and limits are shown in Table 1. Permissible variations for product analysis of carbon steel are as shown in Table 2. The silicon limits as influenced by the deoxidation practice are shown in Table 3. The alloy steel chemical ranges and limits are shown in Table 4. Permissible variations for product analysis of alloy steel are shown in Table 5.

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7.0 Metallurgical Structure.

7.1 When a coarse austenitic grain size is specified, the steel shall have a grain size number of 1 to 5 inclusive, as determined in accordance with Test Methods ASTM E112. Conformance to this grain size of 70% of the grains in the area examined shall constitute the basis of acceptance. One test per heat shall be made. Grain size requirements do not apply to material ordered to "coarse grain practice."

7.2 When a fine austenitic grain size is specified, the steel shall have a grain size number of 5 or higher as determined in accordance with Test Methods ASTM E112. Conformance to this grain size of 70% of the area examined shall constitute the basis of acceptance. One test per heat shall be made unless the provision of 7.2.1 is exercised.

7.2.1 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 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 shall be the referee test.

7.2.2 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 5 or higher.

7.2.3 By agreement between purchaser and supplier, columbium or vanadium or both may be used for grain refining instead of or with aluminum. The maximum contents shall be:

Cb	0.05 max
V	0.08 max
Cb + V	0.06 max

The content of the elements shall be reported with the heat analysis and the austenitic grain size test shall be required.

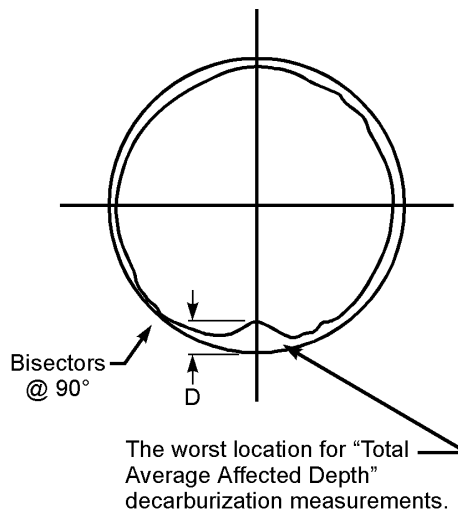
7.3 Spheroidize annealed material shall meet a minimum rating of G2 or L2 in the IFI spheroidization rating – Plate 1.

8.0 Decarburization.

Using the basic procedures of ASTM E1077, the entire periphery of a sample prepared of the rod, wire or bar shall be examined for decarburization at a magnification of 100 diameters, unless otherwise agreed to. Free ferrite shall not exceed the maximum depth shown in Table 6. 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 shown in the example identified as Drawing No. 1.

That average shall not exceed the limits for total average affected depth (TAAD) shown in Table 6. The depth (D) of the worst location shall not exceed the maximum allowed in Table 6.

Drawing No. 1



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9.0 Hardenability.

Hardenability shall be determined in accordance with SAE J406: Methods of Determining Hardenability of Steels. The Appendix A or B of that standard may be used upon agreement between producer and purchaser.

10.0 Mechanical Properties.

10.1 Tensile strength is determined using the test methods of ASTM A370. Values for tensile strength are included in Table 7 for the following conditions:

- annealed or spheroidize annealed rod & bar
- spheroidize annealed at finish size wire
- annealed-in-process or spheroidize annealed-in-process wire

Material which has not been thermally treated is not usually produced to a specific tensile strength.

The values listed in Table 7 are designed to provide optimum headability and tool life in the cold forming process. Modifications to those limits require agreement between producer and purchaser. Table 7 shows only maximum tensile strengths, however, minimum tensile requirements may be stipulated by agreement between producer and purchaser.

10.2 Percent reduction in area is determined by the test method included within ASTM A370. Values for minimum percentages are included in Table 7.

10.3 Yield Strength/Percent Elongation: Used for special applications when agreed upon between purchaser and manufacturer. Method of determination shall be in accordance with ASTM A370.

10.4 Hardness: May be used as an option when agreed to between producer and purchaser in lieu of tensile/reduction of area testing of wire or bar over 1" in diameter. Test method shall be in accordance with ASTM E10.

10.5 No individual test value shall be out of specification, and for steels with a maximum specified carbon content over 0.30%, the maximum of the range shall not exceed the minimum by more than 10% in any lot.

$$\text{e.g.: } \frac{(80 \text{ KSI} - 74 \text{ KSI}) \times 100}{74 \text{ KSI}} = 8.1\% \text{ accept}$$

Test one sample per coil/bundle on at least 20% of randomly selected coils/bundles in the lot, with no fewer than two (2) tests and no more than five (5) tests. Other sampling plans may be employed as agreed upon between the purchaser and the supplier.

10.6 Traceability shall include the mill order and steel heat number with all specified mechanical data on mill test certification.

10.7 Tensile/reduction in area equipment shall be calibrated and verified in accordance with ASTM E4, and operated by personnel with documented qualifications.

11.0 Size Tolerance.

Reducing diameter variability increases control of both the physical and mechanical properties during the forming process. Less variability permits engineering for reduced tool wear and consistent product quality.

11.1 Wire tolerances are shown in Table 8.

11.2 Rod tolerances are shown in Table 9.

Note: Inherent mill design of rod mills does not permit the same control of size as bar mills.

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