MATERIAL SPECIFICATION CARBURIZED AISI 4715 STEEL FORGINGS AND BARSTOCK FOR BENT PIPE SWIVELS AND MISCELLANEOUS PARTS

Rev	Reason of Change	Date	Made By	Reviewed By	Approved By	Status
0	Initial release	14-12-2018	MN	AS	KKD	Released

1.0 SCOPE:

This specification is for 4715 low alloy steel hot worked to produce forgings or bar stock that will be carburized after machining to produce bent pipe swivels and other miscellaneous parts. AMS 2759/7 (Carburizing and Heat Treatment of Carburizing Steel Grades) should be used as a carburizing process and testing guide for good practice.

NOTE: The properties of Table 1 apply only to the post-carburized material. The requirements for raw material are addressed in Section 3.0 through 5.0 of this specification. The requirements for the Carburizing process are addressed in Section 6.0 through 8.0 of this specification.

Table 1

Effective Case Depth, in (mm)	Surface Hardness (minimum)	Impact Requirements (Longitudinal)
0.060-0.080 (1.524-2.032)	58 HRC	20 ft-lbs @ -22°F

2.0 APPLICATION:

Wrought material to produce high surface hardness by carburizing using the procedures detailed in Section 7.0.

3.0 MANUFACTURING REQUIREMENTS:

3.1 Melting Practice

The steel shall be melted using any one of the following procedures:

A. Basic Oxygen Furnace

B. Electric Arc Furnace

Material supplied to this specification shall be made to fully-killed, fine grain melting practice. Vacuum degassing, vacuum melting, or consumable arc re-melting are optional.

3.2 Forging (Hot Work) Practice

The degree of hot work shall be sufficient to produce a wrought grain structure throughout all sections of the forgings or bar. The minimum hot work reduction shall be 3:1.

3.3 Material Quality

Vendor shall guarantee that the forgings and/or bars are homogenous in quality and free of bursts, pipes, banding, seams, cracks, porosity or any other defects which are detrimental to the mechanical properties or machining properties of the material.

3.4 Pre-Carburizing Material Condition

Material may be supplied in the annealed, process annealed, normalized, normalized and tempered, or quenched and tempered condition prior to carburizing.

3.5 Pre-Carburizing Material Hardness

The Brinell hardness shall be 270 HBW maximum when tested in accordance with ASTM E10 (latest revision).

4.0 QTC

4.1 Material supplied in accordance with this specification shall be qualified using a Qualification Test Coupon that is either a sacrificial part or a test bar of similar size and shape.

4.2 For SQF, sacrificial piece is 1 No. as QTC, For single layer, location of QTC will be taken from center of branch, for double layer, QTC will be taken from bottom layer center of the batch.

5.0 CHEMICAL COMPOSITION:

AISI 4715 (Reference UNS G47150)

TABLE 2
Chemical Composition

Element	Weight %
Carbon	0.13-0.18
Manganese	0.70-0.90
Phosphorous	0.035 Max.
Sulfur	0.040 Max.
Silicon	0.15-0.35
Nickel	0.70-1.00
Chromium	0.45-0.65
Molybdenum	0.45-0.65
Copper*	0.35 Max.
Vanadium*	0.05 Max.

*These elements as residual need not be reported.

6.0 BASE MATERIAL PROPERTY REQUIREMENTS (POST-CARBURIZED)

A single full-sized (0.500" diameter) tensile specimen and two sets of full-sized Charpy V-notch (10 mm x 10 mm) specimens shall be taken (whenever possible) from the QTC in the carburized condition at the 1/4T, or mid-radius location.

The tensile specimen may be taken in either the longitudinal or transverse orientation. All specimens shall be tested in accordance with ASTM E8 and A370 (latest editions) at room temperature and meet the requirements in Table 3 below. Sub-sized tensile specimens shall only be allowed when the standard full-sized specimens cannot physically be taken from the QTC.

For the Charpy V-notch specimens, one set shall be taken in the longitudinal orientation, and one set shall be taken in the transverse orientation. All of the specimens shall be tested in accordance with

ASTM E23 and A370 (latest editions) at the appropriate temperature based on the requirements of Table 4. Sub-sized Charpy specimens shall only be allowed when standard full-sized specimens cannot physically be taken from the QTC. When sub-sized specimens are necessary, the Charpy V-Notch impacts shall be equal to that of the full-sized specimens listed in Table 4 multiplied by the appropriate adjustment factor listed below in Table 5.

TABLE 3
Tensile Property Requirements

Tensile Strength, Min. psi	1,20,000
Yield Strength, Min. psi	95,000
Elongation, % min. 2 inch	15
Reduction of Area, % Min.	35

TABLE 4
Charpy V-Notch Impact Requirements

	Minimum Impact Value					
	Transverse Direction			Longitudinal Direction		
Maximum Test Temp. ^{0}F (^{0}C) (Note 1)	**Minimum Avg. Value of Each Set of Three Specimens ft-lbs (J) (Note 2)**	**Minimum Value of One Specimen Only of a Set ft-lbs (J) (Note 2)**	**Minimum Lateral Expansion of Each Specimen in. (mm)**	**Minimum Avg. Value of Each Set of Three Specimens ft-lbs (J)**	**Minimum Value of One Specimen Only of a Set ft-lbs (J) (Note 2)**	**Minimum Lateral Expansion of Each Specimen in. (mm))**
-22 (-30)	17 (23)	14 (19)	N/A	20 (27)	13 (18)	N/A

Note 1: Impact tests shall be performed at or below the indicated temperature. Note 2: 10 mm x 10 mm impact specimens.

Note 3: If the size (i.e. wall thickness) of the QTC does not allow for a set of samples to be taken from a certain orientation, then testing in the particular orientation will not be required.

TABLE 5
Adjustment Factors for Sub-Sized Charpy V-Notch Specimens

Specimen Dimension (mm)	Adjustment Factor
10 x 7.5	0.833
10 x 5.0	0.667
10 x 2.5	0.333

7.0 CARBURIZED CASE REQUIREMENTS:

The carburized case shall meet the properties listed in Table 6.

TABLE 6
Carburized Case Depth Requirement

Effective Case Depth, in (mm)	Surface Hardness (minimum)
0.060-0.080 (1.524-2.032)	58 HRC

7.1 Effective Case Depth

Effective case depth is the depth normal to the surface of the part that exhibits an equivalent hardness greater than 50 HRC. The effective case depth shall be determined by use of a test bar or sacrificial part on a carburizing heat treatment load basis. The test bar shall be 4715 grade material, but need not be from the same heat as the parts it is qualifying.

The sacrificial part or test bar material shall be sectioned normal to the carburized surface, polished, and then hardness tested using a Vickers, Knoop, or Rockwell microficial hardness tester. The depth at which a 50 HRC hardness (50 HRC = 513 HV = 542 Hk = 870 HRMF) is maintained shall be determined and shall meet the case depth specified by the applicable dash number above in Table 2 as described in Section 3.11.1.2 (case depth) in AMS 2759/7. If a test bar is used as the QTC, then the case depth will be checked on a surface that is well away from any corner, external edge, or internal bore.

7.2 Surface Hardness

The surface hardness of carburized surface shall be equivalent to 58 HRC minimum.

7.3 Hardness Testing

7.3.1 When surface hardness testing the actual parts, the method used shall be Vickers, Knoop, superficial Rockwell, or EQUOTIP. Other methods must be pre-approved by Sara.

7.3.2 When hardness testing a test bar, the methods used shall be Vickers, Knoop or superficial Rockwell.

Note: Test bars may be used for hardness acceptance of production parts provided
(1) the test bar material is of the same material grade and
(2) it has been processed through all carburizing and heat treat cycles with the parts it represents.

8.0 CARBURIZING TREATMENT:

8.1 Carburize at 1700-1750°F (927-954°C) and hold for a sufficient time to achieve the effective case depth given in Table 6 above (see note below).

8.2 Vendor has the option of either direct quenching (Option A) or re-heating and quenching (Option B).

Option A

Furnace cool from the carburizing temperature to 1500-1550°F (816-843°C), hold ½ hour, and then oil quench to below 400°F (204°C).

Option B

Air or furnace cool from carburizing temperature. Re-austenitize by heating to 1500-1550°F (816-843°C) and hold at temperature for one hour. Oil quench to below 400°F (204°C).

8.3 Temper at 325-375°F (163-191°C) for two hours minimum.

8.4. Air cool.

Note: The carburizing furnace shall be controlled so that a carbon potential of 0.80 minimum to 0.90 maximum is maintained