MATERIAL SPECIFICATION WROUGHT NICKEL-CHROME-MOLY LOW ALLOY STEELS AISI 4340

Rev	Reason of Change	Date	Prepared By	Reviewed By	Approved By	Status
0	Initial release	22-05-2019	MN	AS	KKD	Released

1.0 SCOPE

1.1 This specification defines the requirements for wrought AISI 4340 (or equivalent) forgings and bar stock to be used.

1.2 Product forms covered by this specification are closed die; open die and ring forgings, bar and mill shapes.

2.0 REQUIREMENTS

2.1 The requirements of specification SES 26-590 (General Requirements for Forged or Wrought Materials PSL 1 through 4), SES 26-740 (Specification for general requirements of heat treatment of alloy steels for use in well head, Christmas tree, manifold and related equipment) & SES 26-744 (General requirements of raw material) shall also apply in addition to the following specific requirements.

2.2 It is the responsibility of raw material/metal supplier/machined parts supplier of carbon, low alloy and martensitic stainless steel to have practices and procedures in place to assure that raw materials/parts delivered to Sara Sae do not have excessive amounts of residual magnetism. Excessive residual magnetism is defined as greater than 3 gausses. (Residual magnetism can occur due to factors such as lifting with magnets, magnetic particle inspection or stray welding current).

The supplier's procedures/testing methods will be subject to verification during supplier audits.

2.3 The raw material supplier shall assure that Sara Sae does not receive material with greater than background level of radioactivity. Background levels of radioactivity vary depending on the location. As a minimum, scrap used for melting of materials shall be checked for radiation prior to melting. The melt contractor shall assure the material is free from radiation greater than applicable background levels. It is the responsibility of the raw material contractor to ensure that this requirement is met.

3.0 <u>CHEMICAL COMPOSITION</u>: Chemical composition limits are listed below. An analysis of each heat of steel be made by the manufacturer, preferably from a ladle sample taken at or near the time of pouring. The listed elements shall be reported in weight percent.

ELEMENT	COMPOSITION	ELEMENT	COMPOSITION
CARBON (C)	0.37 - 0.44	MOLYBDENUM	0.20 – 0.30
MANGANESE (Mn).	0.55 – 0.90	NICKEL	1.65 – 2.00
PHOSPHORUS (P).	0.025 (max.)	COPPER*	0.35 (max.)
SULPHUR (S).	0.025 (max.)	VANADIUM*	0.05 (max.)
SILICON (Si).	0.15- 0.35	IRON	Balance
CHROMIUM	0.65 – 0.95		

***** These elements as residuals need not be reported provided they comply with the above requirements.

Elements (other than those used for grain refinement/ deoxidation) not specified in Table shall not be intentionally added. Any element over 0.25% shall be reported. The total amount of residual elements shall not exceed 1.00%.

3.1 Melt practice: The steel shall be melted to a fully killed fine grain practice using one of the following procedures.

A. Basic Oxygen Furnace followed by Vacuum Degassing (BOFVD) or Argon Oxygen Decarburization (BOFAOD).
B. Electric Furnace (EF) or Electric Furnace followed by Vacuum Degassing (EFVD) or Argon Oxygen Decarburization (EFAOD).
C. Vacuum Induction Melting (VIM).
D. Any of the above followed by Electroslag Remelting (ESR) or Vacuum Arc Remelting (VAR).

3.2 Condition: All products shall be normalized (N) then quenched (Q) and tempered (T) (N+Q&T), except that normalizing shall not be required for the following:

- **a.** Forgings with a forging reduction of 3:1 or greater;
- **b.** Rolled tubing or extruded tubing with a wall thickness of 3" or less;
- **c.** Bar stock with a diameter of 8" or less;

4.0 Mechanical Properties: Mechanical property requirements are listed below. Each heat shall be tested and the listed mechanical properties shall be reported.

MECHANICAL PROPERTIES	RANGE
TENSILE STRENGTH, PSI	125,000 (862 MPa) Min.
YLELD STRENGTH, PSI	105,000- 125,000 (725-862 MPa)
ELONGATION IN 2" GAGE LENGTH	15 % Min.
REDUCTION IN AREA	35% Min.
BRINELL HARDNESS (FINISHED)	255- 300 BHN

4.1 Charpy V-notch Impact Properties

	Minimum Impact Value						
	Transverse Direction			Longitudinal Direction			
Maximum Test Temp ^{0}F (^{0}C) (Note1)	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) (Note 2)	Minimum Value of One Specimen Only of a Set ft-lbs (J) (Note 2)	Minimum Lateral Expansion of Each Specimen in. (mm))	CVN Specimen Orientation
-22 (-30)	21 (28)	14 (19)	0.015 (0.38)	31 (42)	21 (28)	0.015 (0.38)	L and T

Note 1: Impact tests shall be performed at or below the indicated temperature.

Note 2: 10 mm x 10 mm impact specimens

5.0 Heat Treatment :

PROCESS	ATMOSPHERE/MEDIA	TEMPERATURE	TIME AT TEMPERATURE
Normalized	Air	1600 ºF – 1675 ºF (885 ºC – 913 ºC)	30 Minutes / Inch of T, Minimum Time is 1 hour.

Still air cool to below 400 degrees F (204 degrees C) before further processing

Austenitize (Ref. Note 1& 2)	Air	1550 ºF - 1625 ºF (843 ºC – 885 ºC)	30 Minutes / Inch of T, Minimum Time is 1 hour.

Quench	Oil or polymer	104 ºF (40 ºC) - 158 ºF (70 ºC)

Quench baths shall permit complete immersion of material, provide for adequate circulation of the media or agitation of material, and provide a means for indicating the temperature of the media. Baths shall be adequate to produce the required properties in the most massive material to be quenched. There shall be at least one gallon of quenchant per pound of material quenched. Location of Quenching Equipment - Quenching equipment shall be located in such a manner and handling facilities shall function with sufficient speed to prevent the initiation of transformation or sensitization prior to quenching. Quenching shall take place in less than 60 seconds from the time the heat treatment load exits the furnace.

Temper	Air	900 ºF – 1300 ºF (482 ºC – 704 ºC).	45 Minutes / inch of maximum through thickness. 1 hour Minimum.

Cooling after tempering shall be air cooling or faster. Furnace cooling is not permitted. For heavy cross sections, rapid cooling after tempering may improve impact properties. The minimum tempering temperatures must be met in all cases to ensure that later steps of manufacturing,

Note: Maximum holding time shall not exceed Five times (5X) the minimum holding time. In all case, holding time shall not start until parts or materials have reached specified heat treatment temperature. The 5X rule does not apply to the separate QTC (e.g. ER 5")

Note 1: The short blasting shall be carried out after normalizing & Tempering if applicable.
Note 2: The austenitizing temperature shall be less than the normalizing temperature.
Note 3: Retempering to meet the mechanical property requirements of section 4.0 may be performed.

5.1 Continuous Heat Treatment

Screw, walking-beam, pusher furnaces, mesh or cast link type furnaces utilized for continuous heat treatment are permitted. Continuous induction, electrical resistance or infra-red heat treatment is not permitted. Times outside the specified ranges may be used, as long as the minimum time at temperature is 15 minutes per inch of thickness. Tempering temperature minimum shall be met. Other thermal operations may use temperatures outside the ranges specified. Mechanical properties shall be met on a prolongation or sacrificial part.

6.0 NDE REQUIREMENTS

6.1 Volumetric NDE- the entire volume of each part shall be volumetrically inspected (ultrasonic) after heat treatment for mechanical properties and prior to machining operations that limit effective interpretation of the results of the examination.

6.2 Surface NDE- Part shall be examined after final machining by surface NDE (Magnetic Particle or Liquid Penetrant examination).

7.0 WELD REPAIR REQUIREMENTS

7.1 Welding repair is not allowed.

8.0 MATERIAL TRACEABILITY

8.1 Each forging/bar shall be identified by the heat number and heat lot (or equivalent) for traceability.

9.0 DOCUMENTATION REQUIRED

9.1 Each shipment shall be accompanied by material certifications for each lot of material, the certifications must be positively relatable to the lot of material represented.

a) Mill certificate of raw material.

b) Chemical certificate for each lot of forging.

9.2 Mechanical properties certification as per section 4.0

9.3 Impact testing certification as per section 4.1

9.4 Certification of heat treatment including cycle time, temperature, cooling media, hardness and graphs.

9.5 Calibration certificate of furnace.

9.6 Ultrasonic test report certification of raw material.