AISI 4140 LOW ALLOY STEEL FORGED OR WROUGHT 75,000 MINIMUM YIELD TO NACE 0175/ISO 15156-2 AND API 6A/16C FOR SOUR SERVICE, IMPACT TESTED AT -20 DEG. F OR LOWER 20.3J/13.5J

Rev	Reason of Change	Date	Prepared By	Reviewed By	Approved By	Status
1	Revised Mechanical Properties for Elongation & Charpy.	20.10.2011	KKM	USR	KKD	Released
2	Quenching media temperature requirements amended & clause 6.7 added as per API 6A 21st edition.	04-10-2019	MN	USR	AS	Released

SARA-SAE PVT. LTD. DEHRADUN

1.0 SCOPE

1.1 AISI 4140 low alloy steel forgings and wrought shapes heat-treated to 75 KSI minimum yield strength for sour service.

1.2 Product forms covered by this specification are closed die, Open die and ring forgings for hammer unions.

2.0 REQUIREMENTS

2.1 The requirements of specification SES 26-590, SES 26-740 & SES 26-744 shall 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 gauss. 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.

3.0 CHEMICAL COMPOSITION: 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	COMPOSTION	ELEMENT	COMPOSITION
CARBON (**C**)	0.38 – 0.43	SILICON (**Si**)	0.15 – 0.30
MANGANESE (**Mn**)	0.75 – 1.00	CHROMIUM (**Cr**)	0.80 – 1.10
PHOSPHORUS (**P**)	0.025 (max.)	MOLYBDENUM (**Mo**)	0.15 – 0.25
SULPHUR (**S**)	0.025 (max.)	Nickel (**Ni**)	0.50 (max.)

3.1 Elements that are not included in the application material specification but that may have been intentionally added by the mill shall be reported and are limited as follows. Total residuals must not exceed 1%.

ELEMENTS	COMPOSITION RANGE (%)
Vanadium (V)	0.08 (max.)
Aluminum (Al)	0.055 (max.)
Nitrogen (N)	0.010 (max.)

Hydrogen (H)	0.010 (max.)
Niobium(Columbium)+Titanium +Vanadium	0.12 (max.)
Boron	0.0005 (max.)

3.2 **Melt practice:** The steel shall be made by the electric furnace process with subsequent vacuum treatment (EFVD). Steel made by vacuum induction melting (VIM) vacuum arc remelting (VAC), or electroslag remelting (ESR) shall also be acceptable.

3.3 **Condition:** All product 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	95,000 PSI (655 MPa) Min.
YLELD STRENGTH	75,000 PSI (517 MPa) Min.
ELONGATION IN 2" Gage Length	18 % Min.
REDUCTION IN AREA	35% Min.
BRINELL HARDNESS	207-237 BHN (17-22 HRC)

4.1 **Impact testing:** Impact testing shall be performed at -20 ° F Average 20 joules each set of three specimens with minimum of 13.5joules of one specimen. Similarly, no more then one of the three test results shall be below the required minimum average.

5.0 Heat Treatment :

PROCESS	ATMOSPHERE/MEDIA	TEMPERATURE	TIME AT TEMPERATURE

Normalized	Air or Nitrogen	1600 ° F (871 ° C) minimum.	½ hour per inch of maximum through thickness. One hour minimum.

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

Austenitize (See note 2.1.f.1)	Air or Nitrogen	1575 ° F (857 ° C) minimum.	½ hour per inch of maximum through thickness. One hour minimum.

Quench	Water	The temperature of quenching medium shall not exceed 100 °F (38 °C) at the start of the quench nor exceed 49°C (120°F) at any time during the quench cycle.
	Polymer	50 ° F (10 ° C) minimum before quenching (See note 2.1.f.2)
	Oil	----------

Temper	Air or Nitrogen	1200 ° F (649 ° C) Minimum.	3/4hour per inch of maximum through thickness. One hour Minimum.

Slow cool to room temperature

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 austenitizing temperature shall be less then the normalizing temperature.

Note 2: The minimum start temperature of 50 ° F (10 ° C) for oil and polymer Quenchant shall be followed except when a lower minimum start temperature is permitted for a specific quenchant by the quenchant manufacturer. The start temperature shall be documented for all products.

5.1 **Continuous Furnace Heat Treatment:** Continuous furnace heat treatment shall be an acceptable alternative to conventional batch-type heat treatment for bars with diameters of 8 inches (203mm) or less. The following parameters shall be followed and reported in accordance with SES-26-590.

Minimum bar temperature exiting final zone of austenitizing furnace 1525 ° F (829 ° C)
Minimum time in austenitizing furnace 5 minutes (see note 2.1.g.1)
Minimum bar temperature exiting final zone of temperature furnace 1150 ° F (621 ° C)
Minimum time in tempering furnace 5 minutes (see note 2.1.g.1)
Minimum temperature of quench water 120 ° F (49 ° C)

Note 1: Continuous furnaces consist of several different temperature zones through which the bar travels. The zone temperatures in the austenitizing furnace are chosen so as to heat the bar to a completely austenitic in a relatively short time. The bar is then spray quenched before entering the tempering. Zone temperatures in the tempering furnace are chosen to produce the desired tempering effect, again in a relatively short time. The time spent in the austenitizing and tempering furnaces depends primarily upon the length of the furnace and the travel speed. Travel speed varies according to the diameter of the bar. The time in each furnace shall be sufficient to attain the desired mechanical properties and to produce a microstructure to that obtained in a conventional quench-and-temper heat treatment.

6.0 DOCUMENTATION REQUIRED

6.1 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.

6.2 Mechanical properties certification as per section 4.0.

6.3 Impact testing certification as per section 5.0.

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

6.5 Calibration certificate of furnace.

6.6 Ultrasonic test report certification of raw material.

6.7 Suppliers shall retain heat treat charts in a secure area for a period of no less than 10 years (e.g. electronic or paper).

7.0 TESTING TO BE CARRIED OUT BY Sara Sae

7.1 At the time of lifting forgings re-verification of chemical properties.

7.2 Recheck of tensile strength, yield strength, elongation, reduction in area, hardness, impact testing and UT testing.

7.3 100% MPI testing after machining.

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