AISI4140 (Modified) LOW ALLOY STEEL FORGED OR WROUGHT 100 KSL MINIMUM YIELD TON ACE 0175/ISQ 15156-2 AND API 16C FOR SOUR SERVICE, IMPACT TESTED AT -46 °C OR LOWER MINIMUM AVERAGE VALUE 27J/20J

Rev	Reason of Change	Date	Made By	Reviewed By	Approved By	Status
1	Re- written	20-10-2011	KKM	USR	KKD	Released
2	Quenching media temperature requirements amended as per API 6A 21^{SI} edition.	05-10-2019	MN	USR	AS	Released

SCOPE

1.0 AISI 4140 (modified) low alloy steel forgings and wrought shapes heat-treated to 100 KSI minimum yield strength for sour service.

1.1 Product forms covered by this specification are closed die. Open die and ring forgings, bar and mill shapes.

1.0 REQUIREMENTS

2.1 The requirements of specification S.E.S. 26-590 shall apply in addition to the following specific requirements.

2.1. a) 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. Reporting of residual elements is not required, but total residuals must not exceed 1%.

ELEMENT	COMPOSITION	ELEMENT	COMPOSITION
CARBON (C)	0.38-0.43	SILICON (Si)	0.15-0.35
MANGANESE (Mn)	0.75-1.00	CHROMIUM (Cr)	0.80- 1.20
PHOSPHORUS (P)	0.025 (max.)	MOLYBDENUM (Mo)	0.15-0.30
SULPHUR (S)	0.025 (max.)		

b) 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	1,20,000 PSI (827 MPa) Min.
YLELD STRENGTH	1,00,000 PSI (690 MPa) Min.
ELONGATION IN 2" Gage Length	14% Min.
REDUCTION IN AREA	35% Min.
BRINELL HARDNESS	248-327 BHN
LATERAL EXPANSION	0.38 mm Min

2.1. **c) Melt practice:** The steel shall be made by the electric furnace process with

2.2. subsequent vacuum treatment (EFVD). Steel made by vacuum induction melting (VIM) vacuum arc re-melting (VAC), or electro-slag re-melting (ESR) shall also be acceptable.

2.1. **d) 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:

2.1. d. 1 Forgings with a forging reduction of 3:1 or greater;

2.1. d.2 Rolled tubing or extruded tubing with a wail thickness of 3" or less;

2.1. d.3 Bar stock with a diameter of 8" or less;

e) Impact testing: Impact testing shall be performed at -46 ° C Average 27 joules each set of three specimens with minimum of 20 joules of one specimen. Similarly, no more then one of the three test results shall be below the required minimum average.

2.1. f) Heat Treatment:

Slow cool to room temperature.

PROCESS	ATMOSPHERE/MEDIA	TEMPERATURE	TIME AT TEMPERATURE
Normalized	Air or Nitrogen	1600 °F (871 ° C) minimum.	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.l)	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 0 F (10 0 C) minimum before quenching fSeenote2.1.f.2I
	Oil	

Temper _____	Air or Nitrogen	1200 °F (649 • C) Minimum.	% hour per inch of maximum through thickness. One hour Minimum.

Tempering Chart

Tempering Temp. °C	Hardness HRC	Elongation %
200	54-57	10
300	50-54	12
400	45-50	14
500	38-48	16
600	30-38	18
700	22-30	20
800	17-22	22

Note 2.1.0: The austenitizing temperature shall be less than the normalizing temperature.

Note **2.1X2:** The minimum start temperature of 50 ° F (10 ^{0} C) for oil and polymer Quenching shall be followed

except when a lower minimum start temperature is permitted for a specific quenching by the quenching manufacturer. The start temperature shall be documented for ail products.

2.1.g) 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 ^{0} F (829 ° C) 5
Minimum time in austenitizing furnace	minutes (see note 2.1.g.l) zone of temperature
Minimum bar temperature exiting final	furnace 1150 ^{0} F (621^{0} C) 5 minutes (see note
Minimum time in tempering furnace	2.1.g.l)
Temperature of quench water	120 ^{0} F (49 ° C) max.

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Note 2.1.g.l: 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