

SARA SAE ENGINEERING SPECIFICATION	
Section: SES 26 – 798	
Issue: "A"	Rev No.: "1"
Eff. Date: 03.10.2019	Page: 1 of 5

SPECIFICATION FOR AISI 4135 LOW ALLOY STEEL FORGED OR WROUGHT PRODUCT

Rev	Reason of Change	Date	Prepared By	Reviewed By	Approved By	Status
0		11-04-2016	M Namchu	A Semwal	K K Dhiman	Released
1	Quenching media temperature requirements amended & retention period added in clause 7.3 added as per API 6A 21st edition.	03-10-2019	M Namchu	U S Rawat	A Semwal	Released

SARA SAE ENGINEERING SPECIFICATION	
Section: SES 26 – 798	
Issue: "A"	Rev No.: "1"
Eff. Date: 03.10.2019	Page: 2 of 5

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1.0 SCOPE

- 1.1** AISI 4135 low alloy steel forgings and wrought shapes heat-treated to 110,000 PSI minimum yield strength for sour service.
- 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 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	COMPOSITION	ELEMENT	COMPOSITION
CARBON (C)	0.33 - 0.38	VANADIUM	0.10 (max.)
MANGANESE (Mn).	0.70 - 0.90	CHROMIUM	0.80-1.10
PHOSPHORUS (P).	0.025 (max.)	MOLYBDENUM	0.15 – 0.25
SULPHUR (S).	0.025 (max.)	NICKEL	0.50 (max.)
SILICON (Si).	0.15- 0.30	IRON	Balance

SARA SAE ENGINEERING SPECIFICATION	
Section: SES 26 – 798	
Issue: "A"	Rev No.: "1"
Eff. Date: 03.10.2019	Page: 3 of 5

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 (%)
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) or vacuum arc remelting (VAC), or electroslag remelting (ESR) shall also be acceptable provided the properties ; grain size and inclusions are properly controlled .

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:

- Forgings with a forging reduction of 3:1 or greater;
- Rolled tubing or extruded tubing with a wall thickness of 3" or less;
- 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	110,000 (758 MPa) Min.
ELONGATION IN 2" GAGE LENGTH	For 6A products --17 % Min. For 16A products – 18 % Min For 16C products – 18% Min
REDUCTION IN AREA	35% Min.
BRINELL HARDNESS (FINISHED)	277-321 BHN

Note : - A minimum of two Brinell hardness tests shall be performed on QTC for API 16C Products.

4.1 Charpy V-notch Impact testing: Impact testing shall be performed at -60 °C (- 76 °F) or lower as applicable. The average value of 27 joules each set of three specimens with minimum of 20 joules of one specimen shall be acceptable. Similarly, no more than one of the three test results shall be below the required minimum average. Charpy V-notch impact testing will be carried out as per ASTM A-370.

5.0 Heat Treatment :

PROCESS	ATMOSPHERE/MEDIA	TEMPERATURE	TIME AT TEMPERATURE
Normalized	Air	1598 °F – 1697 °F (870 °C – 925 °C)	30 Minutes / Inch of T, Minimum Time is 30 Minutes.

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

Austenitize (Ref. Note 1& 2)	Air	1562 °F - 1652 °F (850 °C – 900 °C)	30 Minutes / Inch of T, Minimum Time is 30 Minutes.
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.	

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	1138 °F – 1300 °F (614 °C – 700 °C).	1 hour per inch of maximum through thickness. One-hour Minimum.
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Cooling after tempering shall be air cooling or faster (By Water). 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")

SARA SAE ENGINEERING SPECIFICATION	
Section: SES 26 – 798	
Issue: “A”	Rev No.: “1”
Eff. Date: 03.10.2019	Page: 5 of 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: The minimum tempering temperature for bar stock under 6 inches (152mm) in diameter may be 1150°F (620°C)

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 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 4.1
- 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.

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** Suppliers shall retain heat treat charts in a secure area for a period of no less than 10 years (e.g. electronic or paper).
- 7.4** 100% MPI testing after machining.