

|   |                                    |         |        |
|---|------------------------------------|---------|--------|
|  | SARA SAE ENGINEERING SPECIFICATION |         |        |
|   | SECTION SES 26-728                 |         |        |
|   | ISSUE "A"                          | Rev "1" |        |
|   | EFF. DATE 20.10.2011               | Page    | 1 of 3 |

**AISI 4140 (Modified) LOW ALLOY STEEL FORGED OR WROUGHT  
100 KSI, MINIMUM YIELD TO NACE 0175/ISO 15156-2 AND API 16C  
FOR SOUR SERVICE, IMPACT TESTED AT -46 °C OR LOWER  
MINIMUM AVERAGE VALUE 27J/20J**

### **1.0 SCOPE**

- 1.1 AISI 4140 (modified) low alloy steel forgings and wrought shapes heat-treated to 100 KSI 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 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.) |                 |             |

- 2.1.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. |
| YIELD 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                 |



**SARA SAE ENGINEERING SPECIFICATION****SECTION SES 26 - 728****ISSUE "A"****Rev "1"****EFF. DATE 20.10.2011****Page 2 of 3**

**2.1.c ) 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.

**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 4:1 or greater;

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

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

**2.1.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 than one of the three test results shall be below the required minimum average.

**2.1.f) Heat Treatment :**

| PROCESS    | ATMOSPHERE/MEDIA | TEMPERATURE                    | TIME AT TEMPERATURE   |
|------------|------------------|--------------------------------|---|
| Normalized | Air or Nitrogen  | 1600 ° F<br>(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<br>(See note<br>2.1.f.1) | Air or Nitrogen | 1575 ° F<br>(857 ° C) minimum. | ½ hour per inch of maximum through thickness. One hour minimum. |
|--------------------------------------|-----------------|--------------------------------|---|

|        |         |   |  |
|--------|---------|---|--|
| Quench | Water   | 100 ° F (38 ° C) maximum before quenching<br>120 ° F (49 ° C) maximum after quenching |  |
|        | Polymer | 50 ° F (10 ° C) minimum before quenching<br>(See note 2.1.f.2)                        |  |
|        | Oil     | -----   |  |

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

Slow cool to room temperature



**SARA SAE ENGINEERING SPECIFICATION****SECTION SES 26 - 728****ISSUE "A"****Rev "1"****EFF. DATE 20.10.2011****Page 3 of 3**

**Note 2.1.f.1:** The austenitizing temperature shall be less than the normalizing temperature.

**Note 2.1.f.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.

**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 ° 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 2.1.g.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.

