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|  A JOULON COMPANY | SARA SAE ENGINEERING SPECIFICATION | | |
| | Section: SES 26 – 323 | | |
| | Issue: "C" | Rev No.: "5" | |
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AISI 4130 LOW ALLOY STEEL FORGED OR WROUGHT
75,000 PSI MINIMUM YIELD FOR HIGH PRESSURE HAMMER
UNION IMPACT TESTED
AT -29 ° C (-20 °F) OR LOWER AVERAGE IMPACT VALUE 27 J

| Rev | Reason of Change | Date | Prepared By | Reviewed By | Approved By | Status |
|-----|----------------------------------------------------------------------------------|------------|-------------|-------------|-------------|----------|
| 2 | Revised Mechanical Properties for Elongation & Charpy | 29-09-2012 | KKM | USR | K.C. Raturi | Released |
| 3 | Revised Mechanical Properties for Brinell Hardness in Table 4 | 30-04-2016 | MN | AS | KKD | Released |
| 4 | Electric induction furnace- bottom poured & Argon purged added to melt practice. | 23-04-2019 | MN | AS | KKD | Released |
| 5 | Quenching media temperature requirements amended | 24-09-2019 | MN | USR | AS | Released |

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1.0 SCOPE

***1.1 AISI 4130 low alloy steel forgings and wrought shapes heat-treated to 75,000 PSI minimum yield strength for standard service & For non API Marked Hammer Union, For API Marked Hammer Union refer SES 26-604 of low Sulpher Phosphorus AISI-4130**

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, SES 26-740 & SES 26-744 shall apply in addition to the following specific requirements.

2.2 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 is 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) | 0.28 – 0.33 | CHROMIUM | 0.80-1.10 |
| MANGANESE (Mn). | 0.40 – 0.60 | MOLYBDENUM | 0.15– 0.25 |
| SILICON (Si). | 0.15- 0.30 | NICKEL | 0.50 (max.) |
| SULPHUR (S). | 0.025 max. | VANADIUM | 0.10 (max.) |
| PHOSPHORUS (P). | 0.025 max. | IRON | Balance |

3.1 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) or electric arc furnace (EAF) or electric induction furnace- bottom poured & Argon purged shall also be acceptable.

3.2 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 | | 95,000 (655 MPa) Min. |
| YIELD STRENGTH, PSI | | 75,000 (517 MPa) Min. |
| ELONGATION IN 2" Gage Length | | 18 % Min. |
| REDUCTION IN AREA | | 35% Min. |
| BRINELL HARDNESS | | 197-237 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 -29 °C (-20 °F) 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. Acceptance for charpy V-notch impact testing is per ASTM A-370.

5.0 Heat treatment:

| PROCESS | ATMOSPHERE/MEDIA | TEMPERATURE | TIME AT TEMPERATURE |
|----------------|-------------------------|---------------------------------------|----------------------------------------------------------|
| Normalized | Air or Nitrogen | 1598 °F – 1697 ° (870 °C – 925 °C) | 30 Minutes/inch of thickness. Minimum time 30 minute. |

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

| | | | |
|-------------|-----------------|----------------------------------------|-------------------------------------------------------|
| Austenitize | Air or Nitrogen | 1562 °F - 1652 °F (850 °C – 900 °C) | 30 Minutes/inch of thickness. Minimum time 30 minute. |
|-------------|-----------------|----------------------------------------|-------------------------------------------------------|

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|--------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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.e.2) |
| | Oil | ----- |

| | | | |
|--------|-----------------|----------------------------------------|-----------------------------------------------------------------|
| Temper | Air or Nitrogen | 1184 °F – 1300 °F (640 °C – 700 °C) | 1 hour per inch of maximum through thickness. One hour Minimum. |
|--------|-----------------|----------------------------------------|-----------------------------------------------------------------|

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").

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.

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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 (if required).