MATERIAL SPECIFICATION FOR HIGH STRENGTH STEEL CASTINGS

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SARA-SAE PVT. LTD. DIV.-I DEHRADUN

CMS-01

MATERIAL SPECIFICATION
FOR HIGH STRENGTH
STEEL CASTINGS

CLASS A

Castings covered by this specification are designated as Class A castings.

A class A casting is a casting in which a single failure would cause significant danger to operations personnel or would result in a significant operational penalty

Where changes have been made in old requirements, a bold vertical line appears in the margin of the paragraph affected as shown. New requirements are also shown in this manner.

Revision	: 0
Date	: July 2013
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Checked by	: USR, Quality Assurance Manager
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0.0 Change history

Changes are indicated with a bold line in the margin of the section.

1.1 Scope

1.2 This specification is intended to cover low alloy steel castings, designated Class A in the heat treated condition, ultimately used in oil field equipment, subjected to high stress applications.

1.3 This specification describes the various material qualification, property and processing requirements for castings used in oilfield hoisting equipment (API 8C) and used in Drilling and Well Servicing Equipment (API 7K).

1.4 A Casting covered by this specification are designated Class A, a class A casting is one in which a single failure could cause significant danger to operating personnel or result in a significant operational penalty.

1.5 Castings furnished to this specification shall be subject to the standard practices, tolerances, methods of manufacture, definitions and other provisions as set forth in ASTM Specification A148 (latest revision), unless specifically stated otherwise in the purchase order or in this specification.

1.6 Additional requirements to this specification are described in separate sections. They shall apply only when specifically called out on the purchase order or on the casting drawing.

2.1 Product Specification levels (PSL's)

2.2 This specification establishes the composition, mechanical property, processing and quality control requirements for two product specification levels, standard level and the PSL 2 level. The standard level fulfills the requirements of API 8C PSL1 and API 7K and the PSL2 level fulfills the additional requirements as required per API 8C PSL2. These two product specification levels define different levels of technical requirements.

2.3 All of the requirements of Sections 1.0 through 19.0 are applicable to both levels. The additional requirements for the PSL 2 level are given in section 20 and when applicable this will be specifically mentioned on the purchase order.

3.1 Applicable documents

The following documents, standards, and other specifications of the issue in effect at the time of inquiry and/or order form a part of this specification to the extent specified herein:

3.2 API Specification 8C Specification for Drilling and Production Hoisting Equipment, ISO 13535 Petroleum and Natural gas industries- Drilling and production equipment-Hoisting equipment

3.3 ANSI/API Specification 7K, ISO 14693, Petroleum and natural gas industries- Drilling and well-servicing equipment

3.4 ASME Boiler and Pressure Vessel Code Section V NONDESTRUCTIVE EXAMINATION

3.5 ASME Boiler and Pressure Vessel Code Section VIII PRESSURE VESSELS, DIVISION 1

3.6 ASME Boiler and Pressure Vessel Code Section IX WELDING AND BRAZING QUALIFICATIONS

3.7 ASNT SNT-TC-1A Recommended Practice for PERSONNEL QUALIFICATION AND CERTIFICATION IN NONDESTRUCTIVE TESTING

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3.8 ASTM A 148 Standard Specification for HIGH-STRENGTH STEEL CASTINGS FOR STRUCTURAL PURPOSES.

3.9 ASTM A 370 Standard Methods and Definitions for MECHANICAL TESTING OF STEEL PRODUCTS.

3.10 ASTM A 488 Standard Practice for QUALIFICATION OF PROCEDURES AND PERSONNEL FOR THE WELDING OF STEEL CASTINGS.

3.11 ASTM A 609 Standard Specification for ULTRASONIC EXAMINATION OF CARBON AND LOW ALLOY STEEL CASTINGS

3.12 ASTM A 781 Standard Specification for COMMON REQUIREMENTS FOR STEEL AND ALLOY CASTINGS FOR GENERAL INDUSTRIAL USE.

3.13 ASTM E 10 Standard Test Method for BRINELL HARDNESS OF METALLIC MATERIALS

3.14 ASTM E 23 Standard Methods for NOTCHED BAR IMPACT TESTING OF METALLIC MATERIALS.

3.15 ASTM E 94 Standard Practice for RADIO GRAPHIC TESTING

3.16 ASTM E 125 Standard Reference Photographs for MAGNETIC PARTICLE INDICATIONS ON FERROUS CASTINGS.

3.17 ASTM E 142 Standard Method for CONTROLLING QUALITY OF RADIOGRAPHIC TESTING

3.18 ASTM E 186 Standard Reference Radiographs for HEAVY WALLED (2 TO 4 1/2-in. (51 TO 114-mm)) STEEL CASTINGS

3.19 ASTM E 280 Standard Reference Radiographs for HEAVY WALLED (4 1/2 TO 12-in. (114 TO 305-mm)) STEEL CASTINGS

3.20 ASTM E 446 Standard Reference Radiographs for STEEL CASTINGS UP TO 2-in. (51-mm) IN THICKNESS

3.21 ASTM E 428 Standard practice for FABRICATION and CONTROL of STEEL REFERENCE BLOCKS USED in ULTRASONIC INSPECTION

3.22 ASTM A 488 Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel

3.23 ASTM A 751 - Test Methods, Practices, and Definitions for Chemical Analysis of Steel Products

3.24 ASTM E 709 Recommended Practice for MAGNETIC PARTICLE EXAMINATION.

3.25 AWS D1.1, Structural Welding Code

3.26 AWS QC 1, Standard for AWS Certification of Welding Inspectors

3.27 EN 287 (all parts), Approval testing of Welders

3.28 ISO 15614-1 Specification and qualification of welding procedures for metallic materials — Welding procedure test – Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys

3.29 EN 10204 METALLIC PRODUCTS - TYPES OF INSPECTION DOCUMENTS

3.30 MSS Standard Practice SP-55 Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components (VISUAL METHOD).

4.0 *Description*

The castings covered by this specification are of various shapes and cross-sectional areas and meet the general requirements of sections 3.0, 4.0, 6.0, 12.0 and 13.0 of ASTM A 148

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5.1 Process

5.2 The steel shall be manufactured by the electric furnace method. Ladle additions for the purpose of adding alloy are not permitted, unless SARA SAE Quality Assurance/Engineering has given specific written approval.

5.3 Unless otherwise specified by the purchase order, the manufacturer shall deliver the castings in a normalized or annealed and quenched and tempered condition, meeting the mechanical property requirements of section 7.0 Mechanical Properties, of this specification

6.0 Chemical composition

Castings furnished to this specification shall be analyzed for all elements listed and meet the chemical composition requirements given in Table 1

7.1 Mechanical properties

7.2 Material furnished to this specification, after a suitable normalize, quench and temper, when tested in an appropriately sized qualification test coupon (QTC) for the casting(s) represented, shall meet the minimum mechanical properties shown in Table 2 using test pieces taken from an envelope at the quarter T thickness position (see Figure 1).

7.3 Property verification shall be accomplished using qualification test coupons meeting the requirements of Section 8.0 Qualification Test Coupons (QTC's). They shall be integrally cast with the casting or poured separately at the same time as the casting as specified in section 8.1 and 8.2. Alternatively a sacrificial production part may be used to determine the casting properties at minimum a quarter T depth.

8.1 Qualification test coupons

8.2 Qualification test coupons shall be representative of each casting or each heat and heat treatment lot used in the manufacture of the castings.

8.3 These test coupons shall be closely controlled to maintain traceability between the test coupons and the castings they represent.

8.4 The foundry shall provide sufficient QTC material to retest the heat treatment lot to allow for a retest in case the mechanical test fails to meet the requirements in the first attempt. The foundry shall keep sufficient QTC material or residual material for retesting for a minimum period of one year, starting on the day of shipment of the castings. This stored QTC material shall be submitted to SARA SAE upon their request.

8.5 The ER-size for a casting shall be mentioned on the casting drawing or in the purchase order.

8.6 For heats consisting of castings requiring different ER keel block sizes, all ER keel block sizes representing the castings in the heat must be poured or one may pour the biggest ER keel block size to use for the mechanical tests to qualify the heat.

8.7 Figure 1 illustrates the procedure for determining the required dimensions of an ASTM a 370 Keel block.

8.8 Integrally cast test coupons shall remain attached to the casting throughout the heat treatment process. Separately cast coupons or sacrificial production parts shall be heat treated at the same time and in the same furnace as the castings they represent

8.9 The test specimens for the required mechanical tests shall be cut form the shaded areas shown in the applicable cross sections see figure 1 and figure 2.

8.10 Figure 2 provide specific dimensional information for several different shapes of qualification test coupons for sizes up to 5 inches (125mm).

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9.1 Type and number of Mechanical tests

9.2 In all cases, the mechanical tests required shall be performed on test specimens cut from qualification test coupons representing the heat and heat treatment lot of the castings represented.

9.3 The complete gage length of a tensile specimen or the notch of an impact specimen shall be at least ¼ thickness from the end of the qualification test coupon. Test specimens cut from sacrificial production parts shall be removed from the center core one-quarter thickness envelope location of the thickest section of the part.

9.4 Test coupons must be legibly marked with the heat number and code

9.5 The certified results of the required mechanical tests for each casting or heat and heat treat lot as applicable shall be submitted with the castings to SARA SAE.

9.6 Tension testing shall be performed in accordance with ASTM A 370

9.7 Impact testing shall be performed in accordance with ASTM E 23

9.8 Hardness testing:

9.8.1 Hardness testing shall be performed in accordance with ASTM E10

9.8.2 Hardness testing shall be on an actual casting with as minimum of one test per heat, when one heat consists of more models than one test per model shall be performed.

10.1 Heat treat

10.2 Unless otherwise agreed to in writing by SARA SAE Quality Assurance/Engineering castings shall be heat treated per procedure in 10.5.

10.3 The foundry or sub-processor shall have a written specification listing the temperature and time requirements.

10.4 Actual temperatures and times used for production castings shall be recorded and the records shall be traceable to the castings represented.

10.5 All heat treatment operations shall be performed utilizing equipment qualified in accordance with the requirements specified by the foundry or sub-processor and approved by SARA SAE Quality Assurance/Engineering

10.6 **Procedure**

1. Anneal or normalize casting at minimum1800° F (980° C), holding the casting at temperature for a minimum of one hour per inch of thickness for the first inch of thickness and one half hour per inch of thickness of thickness over one inch and cool casting in furnace or still air.
2. Castings shall be hardened by austenitizing at minimum 1700° F (925°C) holding the castings at temperature for a minimum of one hour per inch thickness for the first inch of thickness and one half hour per inch of thickness of thickness over one inch and quenching in strongly agitated water.
3. After hardening, grade 120-110 castings shall be tempered at minimum 1100° F (600°C), castings shall be held at the tempering temperature for a minimum of three hours. Castings shall be water quenched from tempering temperature in minimum time possible to avoid air cooling.

11.1 Magnetic particle examination

11.2 The foundry shall subject all accessible surfaces of the castings to magnetic particle examination after final heat treatment.

11.3 The NDE shall be performed at a minimum of 24 hours after the final heat treatment.

11.4 Magnetic particle examination shall be performed according a procedure in accordance with ASTM E709 . The wet fluorescent method shall be used.

11.5 The use of prods must be avoided. In case prods need to be used all prod burn marks shall be removed by grinding and the affected areas shall be rechecked by liquid penetrant examination (LPE).

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11.6 Magnetic particle indications shall be compared with the indications shown in ASTM E 125.

11.7 Definition of indications:

11.7.1 Relevant indication: Only those indications with major dimensions greater 1/16 inch (2 mm) and associated with a surface or near surface rupture shall be considered relevant.

11.7.2 Non-Relevant indication: Inherent indications not associated with a surface or near surface rupture (i.e. magnetic permeability variations, non-metallic stringers, etc.) are considered non-relevant. If magnetic particle indications greater than 2 mm (1/16 inch) are believed to be non-relevant, they shall either be examined by the liquid penetrant method to confirm they are non-relevant or they shall be removed and re-inspected to confirm they are non-relevant.

11.7.3 Linear indication: an indication of which the length is equal or greater than tree times the width.

11.7.4 Rounded indication: an indication which is circular or elliptical with its length less than tree times the width.

11.8 Requirements: The acceptance level for magnetic particle indications in both critical and non-critical areas are defined in Table 3A for standard level

11.9 If there is no critical area drawing or critical areas are not identified on the drawing of the applicable part, than all areas shall be considered critical.

12.1 Volumetric non-destructive examination

12.2 Method:

12.2.1 Radiographic examination of castings shall be in accordance with ASME Section V, subsection A, Article 2 and Subsection B, Article 22. Fluorescent intensifying screens shall not be used.

12.2.2 Ultrasonic examination of castings shall be in accordance with ASME V, Subsection A, Article 5 and subsection B, Article 23

12.2.2.1 The casting shall be examined by the straight beam method in accordance with SA-609 of Article 23

12.2.2.2 In areas where back reflection cannot be maintained during the straight beam examination or where the angle between surfaces of the component is more than 15°, the angle beam method as in T-510, T-520, T-524.4.1, T-541.4.2 and T-542.4.3 of Article 5 shall be used to supplement the straight beam method.

12.3 Sampling:

12.3.1 First article and prototype castings see AR 3

12.3.2 Production castings:

12.3.2.1 One casting out of each production lot of that casting

12.3.2.2 For production lots of less than 10 one out of every 10 production castings shall be volumetric examined in all critical areas as identified on the critical area drawings.

12.3.2.3 For low production castings, less than one casting per month, a minimum of one production casting shall be volumetrically examined each year the casting is produced.

12.3.3 If any casting shows any indications outside the acceptance criteria as defined in 12.3, two more castings from that production lot shall be examined by the same method(s).

12.3.4 If the additional castings are acceptable, the remainder of the batch may be accepted and the initial non-conforming casting shall be repaired or scrapped.

12.3.5 Should either of these castings be found to be non-conforming, all castings of the production lot shall be examined.

12.4 Acceptance criteria

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12.4.1 Radiographic examination:

12.4.1.1 The acceptance criteria are based on the Standard Reference Radiographs of ASTM E 446, ASTM E 186 or ASTM E 280 depending on the wall thickness examined.

12.4.1.2 In all cases cracks, hot tears and inserts (defect types D, E and F, (respectively) are not permitted.

12.4.1.3 All of the other indication types shall meet Severity level 2 in all critical areas and Severity Level 3 in non-critical areas.

12.4.1.4 If there is no critical area drawing or critical areas are not identified on the drawing of the applicable part, than all areas shall be considered critical.

12.4.2 Ultrasonic Examination:

12.4.2.1 The acceptance criteria for both straight beam and angle beam ultrasonic examination are based on SA-609 in ASME V, Subsection B, Article 23.

12.3.2.1.1 Requirements:

- Quality level 1 shall apply within 2" of the casting surface
- Quality level 3 for remaining areas
- Discontinuities indicated to have a change depth of 1 inch or half the thickness, whichever is lesser, are not permitted.

13.1 Casting finish

13.2 Castings made in accordance with this specification shall be subjected to visual examination and dimensional inspection.

13.3 Casting finish in all areas not subsequently machined shall be compared with the photographs of MSS SP 55. Acceptable irregularities for the different defect types are listed in Table 4.

13.4 Any casting found to be dimensionally inaccurate when compared to the applicable drawing revision provided by SARA SAE or to the dimensions predicted by the pattern will not be accepted without prior approval being specified on accepted First Article Report or on the purchase order.

13.5 The surface of the castings shall be free of scale, adhering sand and other irregularities that could hinder the detection of indications at the MPI.

14.1 Welding Requirements for Casting Upgrade and Repair

14.2 Welding Qualifications

The welding procedure specification and welders used in the repair of Class A castings shall as minimum meet the qualification requirements of:

14.2.1 ASTM A 488, AWS D1.1 , EN 288 and or ASME IX and shall be submitted to SARA SAE Quality Assurance/Engineering for approval. Remark: Where the ductility of the parent material is such as to render it incapable of meeting bend test requirements of ASME IX, the bend test shall be conducted in following manner: A bend bar of parent material heat treated to the ductility and strength requirements of this specification shall be bent to failure. The side bend specimen taken from the weld test coupon shall then be capable of being bent to within 5° of the angle thus determined.

14.2.2 The WPS shall meet requirements of DNV-OS-C401 and shall be approved by DNV

14.2.3 Welding shall only be carried out by welders or welding operators who are qualified in accordance with aforementioned standards or EN 287.

14.3 Written documentation

14.3.1 The foundry shall have a Welding Procedure Specification (WPS) meeting the requirements of the applicable standard.

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14.3.2 The foundry shall have a Procedure Qualification Record (PQR) according to the requirements of the applicable standard.

14.3.3 The foundry shall have Welder Qualifications Records (WQR) according to the requirements of the applicable standard.

14.3.4 Changes in the WPS and PQR require the approvals listed in 14.1.1 and 14.1.2

14.3.5 The WPS, PQR and WQR shall be maintained as records in accordance with the requirements of section 18.0 Documentation of this specification.

14.4 Control of consumables

Welding consumables shall confirm to American Welding Society or consumable manufacturer specifications.

14.4.1 The foundry shall have a written procedure for storage and control of weld consumables. Materials of low hydrogen type shall be stored and used as recommended by the consumable manufacturer.

14.5 Weld properties

14.5.1 The mechanical properties including impact properties, that need to be tested according the applicable specification, of the weld and heat affected zone, shall meet the minimum specified mechanical properties of the base material.

14.5.2 All weld testing shall be done after the applicable post-weld heat-treatment.

14.6 The foundry shall provide a copy of the applicable WPS and PQR to SARA SAE

14.7 Quality control requirements

Requirements for quality control of permitted welds shall be in accordance with section 12.0, 13.0 and or 14.0 of this specification as applicable.

14.8 Specific requirements:

14.8.1 Essential variables and supplementary essential variables and equipment shall be monitored during production

14.8.2 There shall be adequate access to evaluate, remove and re-inspect the nonconforming condition which is the cause of the repair.

14.8.3 There shall be adequate access for upgrade/repair welding to insure complete fusion with the base material.

14.8.4 Criteria for permitted repairs:

14.8.4.1 Repairable Defect Types: All defect types are considered repairable.

14.8.4.2 Repairable Defect size limits: All defect sizes are considered repairable.

14.8.4.3 Definition of Major/Minor Repairs

14.8.4.3.1 Major Repair: A repair whose depth exceeds 25% of the original wall thickness or 1 inch (25.4 mm) whichever is less.

14.8.4.3.2 Minor Repair: A repair not otherwise classified as a major repair.

14.8.5 All excavations, prior to upgrade/repair, and the subsequent weld upgrade/repair shall meet the quality control requirements specified in sections 11.0, 12.0, and or 13.0 of this specification as applicable unless specifically stated otherwise in section 15.0 Non-destructive examination of casting upgrade and repair welds, of this specification.

14.8.6 Documentation of upgrade upgrade/repair shall be maintained in accordance with the requirements of section 18.0 Documentation of this specification

15.1 Non-Destructive examination of casting upgrade and repair welds

15.2 Completed repair/upgrade welds, including a minimum of ½ inch (12.7 mm) of the surrounding base metal, shall be examined in accordance with the requirements of this section.

15.3 The non-destructive examination required by this section shall be carried out after final post weld heat treatment.

15.4 Weld preparation examination:

15.4.1 All excavations for upgrade/repair welds shall be examined by the magnetic particle method per section 11.0 of this specification.

15.4.2 Acceptance criteria shall be per Table 3A.

15.5 Finished repair/upgrade weld examination:

15.5.1 All finished repair/upgrade welds shall be visually examined in accordance with the

requirements of ASME Section V, Article 9

15.5.2 All finished repair/upgrade welds shall be magnetic particle examined as required by section 11.0 of this specification.

15.6 Acceptance requirements for finished repair/upgrade welds

15.6.1 Visual examination: Undercuts shall not reduce the thickness in the affected area to below the minimum thickness required per the drawing of the part and shall be ground smoothly into the surrounding material.

15.6.2 Surface NDE

15.6.2.1 No relevant linear indications (11.6.1)

15.6.2.2 No rounded indications greater than 1/8" (3 mm)for welds whose depth is 5/8" (16 mm) or less, or greater than 3/16" (4.8 mm) for welds whose depth is greater than 5/8" (16 mm).

15.6.2.3 No more than 3 relevant indications in a line separated by less than 1/16" (1.6 mm) edge to edge.

16.1 Marking and Certification

16.2 All castings supplied to this specification shall be legibly marked by the foundry as follows:

16.2.1 Each casting shall be marked with:

- The foundry logo.
- The heat number and/or casting code number, traceable to the heat and heat number, the drawing indicates the area for this marking, in case the drawing does not indicates a position for this marking, the position will be mutually agreed by foundry and SARA SAE
- All other marking as required by the applicable casting drawing.

16.3 All markings as mentioned in paragraph 16.1 shall be cast into the components or low stress hard die stamped. Where the available area allows this, stamping should be clearly visible and 3/8 inch (10 mm) high.

16.4 When possible the use of the letters "I", "O" and "Q" should be avoided in the heat code

17.1 Quality control requirements

17.2 All quality control work shall be controlled by the foundry or subcontractor's documented instructions, which shall include appropriate methodology, quantitative, and qualitative acceptance criteria.

17.3 TRACEABILITY:

17.3.1 The foundry shall have a documented traceability procedure

17.3.2 The traceability procedure shall include provisions for maintenance and replacement of identification marks and identification records

17.3.3 All castings shall be traceable by heat and heat treatment lot identification

17.3.4 Identification shall be maintained on all castings through all stages of manufacture.

17.4 Instructions for nondestructive examination (NDE) activities shall be detailed regarding the requirements of this specification and all the applicable referenced specifications, and shall be approved by an ASNT TC-1A Level III examiner or an examiner qualified to an equivalent standard.

17.5 The status of all castings shall be indicated either on the castings or in the records traceable to the castings

17.6 QUALITY CONTROL PERSONNEL QUALIFICATIONS:

17.6.1 NDE personnel shall be qualified and /or certified in accordance with ASNT TC- 1A or an equivalent standard

17.6.2 Personnel performing visual inspection of welding operations and completed welds shall be qualified and certified by AWS QC1 or an equivalent standard or the foundry or subcontractor's documented procedures.

17.7 Equipment used to inspect, test or examine castings shall be identified, controlled, calibrated and adjusted at specific intervals in accordance with documented instructions and consistent

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with a recognized industry standard (e.g. MIL STD 120, BS 5781, ISO10012:2003)

18.1 Documentation

18.2 GENERAL:

18.2.1 Full records of any documentation referenced in this specification shall be kept by the foundry for a period of 11 years after the casting has been manufactured and sold to SARA SAE and shall be made available to SARA SAE on request.

18.2.2 Documentation shall be clear, legible, reproducible, retrievable and protected from damage, deterioration and loss.

18.2.3 All quality control records required by this specification shall be signed and dated.

18.3 DOCUMENTATION TO BE MAINATINED BY THE FOUNDRY:

18.3.1 Qualification records such as:

18.3.1.1 Weld procedure qualification records (WPQR), including the material certificate for the base material used in the qualifying weld procedure

18.3.1.2 Welder qualification records (WQR's)

18.3.1.3 NDE personnel qualification records

18.3.1.4 Measuring and test equipment calibration records

18.3.2 Material test reports covering the following tests as applicable:

18.3.2.1 Chemical analysis

18.3.2.2 Tensile tests

18.3.2.3 Charpy V-notch impact tests

18.3.2.4 Hardness tests

18.3.3 NDE procedure records covering the surface and/or volumetric NDE requirements of sections 11.0, 12.0, 15.0

18.3.4 Special process records:

18.3.4.1 Weld repair records as described in section 14.0

18.3.4.2 Welding filler material storage procedures

18.3.4.3 NDE procedures

18.4 TEST REPORTS TO BE SUPPLIED WITH THE CASTINGS

18.4.1 All certifications shall be in accordance with the requirements of EN 10204-3.1.

18.4.2 A report showing the chemical analysis of each heat used by the foundry to manufacture subject castings shall be submitted with the castings to SARA SAE.

18.4.3 Certified test reports of mechanical properties shall be supplied for each casting or heat lot of castings as required by section 9.0. Certificates shall contain the ER test bar size tested and a statement of the ¼ T testing.

18.4.4 Heat treatment certifications listing time/temperature/Brinell hardness. Groups of castings/range of hardness may be listed on one certification. Heat treatment furnace charts or copies of these charts. The charts will be identified to show the casting part numbers and quantity of each casting heat treated in the load, heat numbers, casting serial/code number, furnace number and the date of heat treatment.

18.4.5 Tests reports of the results of MPI shall be supplied for each casting or a certificate of conformity stating that castings meet the requirements shall be supplied. Groups of castings may be listed on 1 certificate.

18.4.6 The results of the volumetric inspection per section 12.0 of the sample casting per 12.2.2 shall be reported

19.1 Purchase order requirements.

19.2 The material specification number and grade for each casting shall be stated on all applicable purchase orders.

19.3 In case PSL2 is applicable, it shall be stated on the purchase order.

19.4 Required Additional Requirements shall be stated on the purchase order.

19.5 In case AR3 is stated then SARA SAE approval shall be required before the castings for which AR 3 is applicable are shipped to SARA SAE

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20.1 Supplementary requirements for Product Specification Level 2 (PSL 2)

20.2 Phosphorous and sulfur content shall never exceed 0.025 each

20.3 Elongation of grade 135-125 material shall be min 14% ($L_{0=}$=4d), 12% (L_0 = 5d) , L_0 is the gauge length and d_0 is the diameter.

20.4 Magnetic Particle inspection

20.4.1 Acceptance criteria are given in Table 3B

20.5 Ultrasonic inspection acceptance criteria

20.5.1 Quality level 1 shall apply within 2" of the casting surface

20.5.2 Quality level 2 for casting thickness from 2" to 4"

20.5.3 Quality level 3 for casting thickness over 4"

20.6 Welding requirements

20.6.1 Weld procedure and welders shall meet the qualification requirements of ASME IX (see 14.1.1)

20.6.2 For major weld repairs as defined in 14.7.4.3.1 the foundry shall produce a dimensional sketch of the area upgraded/repaired (welding map) and the upgrade/repair sequence.

20.7 Non- destructive examination of casting upgrade and repair welds

20.7.1 Repair upgrade welds classified as major shall additionally be examined by either radiographic or ultrasonic methods.

20.7.2 Acceptance requirements in accordance with the requirements of ASME VIII Div.1, UW-51 and Appendix 12 as appropriate.

20.8 Welding qualifications (ref section 14.1):

The welding procedures specification shall meet the requirements of ASME IX. Remark: Where the ductility of the parent material is such as to render it incapable of meeting bend test requirements of ASME XI, the bend test shall be conducted in following manner: A bend bar of parent material heat treated to the ductility and strength requirements of this specification shall be bent to failure. The side bend specimen taken from the weld test coupon shall then be capable of being bent to within 5° of the angle thus determined.

Welding shall only be carried out by welders or welding operators who are qualified in accordance with aforementioned standard.

20.9 Documentation

20.9.1 For major weld repairs as defined in section 14.7.4.3.1 the foundry shall provide dimensional sketches of the area repaired and the repair sequence.

21.1 Terms and definitions

21.2 Ladle: a container used to transport and pour out molten metals.

21.3 First article or prototype casting: the first casting of a product that is poured.

21.4 Heat: A stated tonnage of metal obtained from a period of continuous melting in a furnace, or the melting period to handle this tonnage

21.5 Heat treatment lot: a furnace load of castings that is heat treated

21.6 Sample casting: a randomly picked casting from a heat which casting is representative for the whole heat.

Additional Requirements

Additional requirements shall apply when specified on the purchase order or on the casting drawing. Details of the supplementary requirements shall be agreed upon in writing by the foundry and SARA SAE. The supplementary requirements shall be fulfilled by the foundry prior to the shipments of the castings.

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AR 1.0: Source inspection

Castings on this order will be inspected at the foundry prior to shipment to SARA SAE. Evidence of such inspection must be indicated on the packing sheet accompanying each shipment.

AR 2.0: Low Temperature testing

When AR 2 is mentioned on the purchase order than the material shall be impact tested at a temperature of -40° C/F.

The material is acceptable when:

1. The impact values at -40° C/F are equal or exceed the values required at -20°C (- 4°F) as mentioned in Table 2. When this is the case testing at -20°C (- 4°F) is not required.
2. The average impact values at -40°C/F of 3 tests are equal or exceed 27 J (20 ft-lbs) with no individual value below 20 J (15 ft-lbs). When this is the case than a second test at -20°C (- 4°F) meeting the requirements of Table 2 must be performed. Both test results shall be reported on the material certificate.

AR 3.0: First Article Inspection

3.1 The requirements of first article inspection apply under the following conditions:

3.1.1 The pattern for the part is new or has never been used by the foundry producing the casting.

3.1.2 A change or modification has been made in the pattern gating or rising since last approved.

3.1.3 The qualified foundry procedure to produce the casting has been changed since last approved by SARA SAE.

3.1.4 Castings from the previous production run failed to meet the requirements of section 12.0, 13.0, and 14.0 without excessive weld repairs

3.2 Acceptance criteria for first article castings

In addition to the acceptance criteria requirements of this specification the following shall apply:

3.2.1 Each first article casting shall be submitted to SARA SAE with a complete dimensional report, showing full dimensional compliance with the casting drawing as supplied by SARA SAE with the purchase order.

3.2.2 Patterns, delivered through SARA SAE to the foundry shall be inspected by the foundry to verify compliance of the pattern to latest drawing revision, before starting the first article procedure. Non compliance of the pattern shall be reported to SARA SAE.

3.2.3 Each first article casting shall be subject to 100% radiographic examination. This examination is to be used by the foundry to verify the integrity of the casting and the production process and procedure of the applicable casting. Cost of this examination is to be negotiated between the foundry and SARA SAE.

3.2.4 Radiography is to be in accordance with 13.1.1

3.2.5 Acceptance criteria are per 12.3.1 unless otherwise noted on the Purchase Order.

3.2.6 Rejected castings shall be replaced by the foundry at no charge

AR 4.0: Additional Volumetric Inspection

4.1 All critical areas of each casting shall be volumetric examined. The requirements of AR 4.0 shall be identical to the method of section 12.1 and the acceptance criteria of section 12.3

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Tables and Figures

Table 1: Chemical composition requirements

Element	Symbol	Contents (weight) %	
		SARA SAE Alloy	G18NiMoCr3-6 W.st nr. 1.6759
Carbon	C	0.14 - 0.20	0.17 - 0.22
Manganese	Mn	0.70 – 1.00	0.80 - 1.10
Phosphorus	Ph	Max. 0.025 *	Max. 0.020
Sulfur	S	Max. 0.025 *	Max. 0.015
Silicon	Si	0.35 – 0.60	0.30 - 0.60
Chromium	Cr	0.55 – 0.90	0.50 – 0.90
Nickel	Ni	1.50 – 2.00	0.60 - 1.00
Molybdenum	Mo	0.35 – 0.45	0.40 – 0.60
Vanadium	V	0.04 – 0.12	
Aluminum	Al	Max. 0.08	
Copper	Cu	Max. 0.50	

* Maximums greater than 0.025 but lower as 0.035 each shall be accepted if the impact properties meet those specified in Table 2

Table 2: Mechanical property requirements

Property	Grade 120-110	Grade 135-125
Ultimate strength :	Min. 120,000 psi (827 MPa)	Min. 135,000 psi (930 MPa)
Yield strength :	Min. 110,100 psi (759 MPa)	Min. 125,000 psi (861 MPa)
Elongation ($L_0 = 4\ d_0$) [1] :	Min. 14 %	Min. 9 % [4]
Elongation ($L_0 = 5\ d_0$) [1] :	Min.12 %	Min.10 % [4]
Reduction of area :	Min. 30 %	Min. 25 %
Charpy V-notch impact		
Test temperature :	-4° F (-20° C)	-4° F (-20° C)
Average of 3 tests :	Min. 31 ft-lbs (42 Joule)	Min. 25 ft-lbs (33 Joule)
No single value less than :	24 ft-lbs (32 Joule) [2]	19 ft-lbs (26 Joule) [2]
Hardness, Brinell	269-302 [3]	277 – 332 [3]

1 L_0 is the gauge length and d_0 is the diameter

2 *If one value is below mentioned value, a re-test of three additional specimen shall be made.*

3 Brinell hardness shall be reported as an index of machinability only. Castings shall not be rejected on the basis of hardness alone. Any deviation outside the hardness range is to be reported to SARA SAE Quality Assurance/Engineering.

4 For PSL2 material elongation requirements see 20.2

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Table 3A: Magnetic Particle Inspection Acceptance Criteria Standard Level

Type	Discontinuity Description	Max. permitted degree	
		Critical areas	Non critical areas
I.	Linear discontinuities (hot tears, cracks)	NONE, see note	Degree 1
II.	Shrinkage	Degree 2	Degree 2
III.	Inclusions	Degree 2	Degree 2
IV.	Internal chills, chaplets	Degree 1	Degree 1
V.	Porosity	Degree 1	Degree 2

Table 3B: Magnetic Particle Inspection Acceptance Criteria PSL2

Type	Discontinuity Description	Max. permitted degree	
		Critical areas	Non critical areas
I.	Linear discontinuities (hot tears, cracks)	NONE, see note	NONE, see note
II.	Shrinkage	NONE	Degree 1
III.	Inclusions	Degree 1	Degree 2
IV.	Internal chills, chaplets	NONE	Degree 1
V.	Porosity	Degree 1	Degree 2

Note:

Only those indications with major dimensions greater than 1/16" (2mm) and associated with a surface rupture shall be considered relevant indications. Inherent indications not associated with a surface rupture (i.e. magnetic permeability variations, non-metallic stringers, etc.) shall be considered non-relevant. If magnetic particle indications greater than 1/16" (2mm) are believed to be non-relevant, they shall be removed and the area shall be re-inspected or the indications shall be re-inspected by the liquid penetrant method to confirm they are non-relevant.

Table 4: Surface Finish Requirements

(Visual Inspection Criteria)

DEFECT TYPE	ACCEPTABLE SURFACE IRREGULARITIES
I,II,III,IV	a, b
V,VI,VII,IX,XI	a, b
VIII,X	a only
XII	a, b, c

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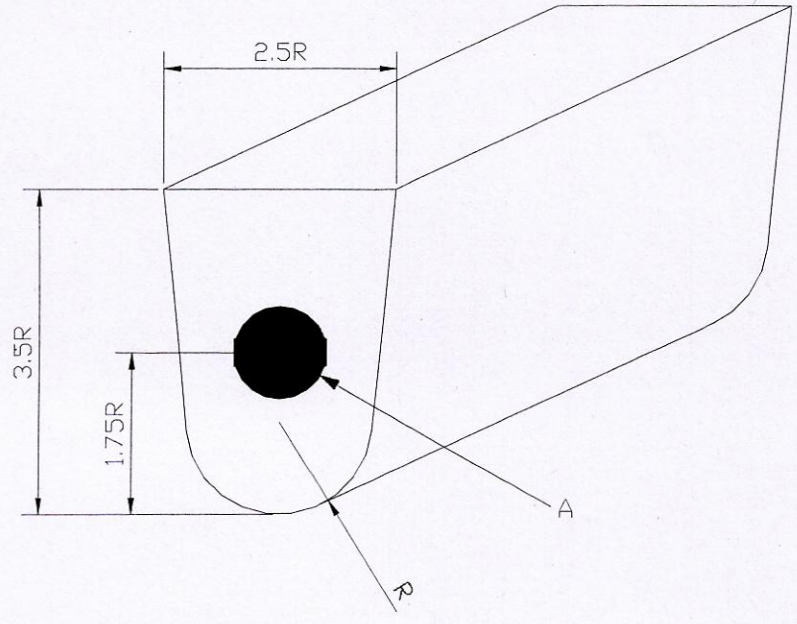
Figure 1:

Keel Block Configuration for irregular shapes



ER (Equivalent round) = 2.3R or R=ER/2.3

Note: Shaded area A indicates ¼ T envelope for test specimen removal
ER values for a casting are on the drawing and/or purchase order.
Example:
ER is 4" than R= 2.67", construct Keel Block as in figure1 using multiples of R.

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Figure 2: Keel block dimensions for different ER's