1.0 Purpose & Scope

The purpose of this document:

a) Establishes the minimum specified required for low alloy steel castings used in high strength applications of oil field drilling equipment,
b) Ensures castings meet the American Petroleum Institute (API) Specification 8C, *Specification for Drilling and Production Hoisting Equipment (PSL1 & PSL2)*,
c) Ensures castings meet the American Petroleum Institute (API) Specification 7K, *Specification for Drilling and Well Service Equipment*,
d) Establishes KET specific & supplier specific requirements, and
e) Affects casting that are various shapes and cross-sectional areas. In general, the affected castings must meet sections 3.0, 4.0, 6.0, 10.0, 11.0, 12.0, and 13.0 of ASTM A148 / A148M, unless otherwise stated in this specification.

Materials affected by this specification are identified below and are called out of KET product specific drawings.

Material	Requirement
MS-004	As per this specification including a -4° F temperature test
MS-004 SR2	As per this specification including a -45° F low temperature test
AISI 4318	AISI 4318, 110 ksi min yield strength

2.0 Specification Requirements

2.1 The raw material supplier shall satisfy the requirements below.

2.1.1 Manufacture steel castings:

a) Using the electric furnace method,
b) That meet the below specified chemical properties,

Chemical	Symbol	Requirement
Carbon	C	0.15 – 0.25
Manganese	Mn	0.70 – 1.20
Phosphorus	Ph	.025 Max.
Sulphur	S	0.025 Max.
Silicon	Si	0.30 – 0.60
Chromium	Cr	0.55 – 0.90
Nickel	Ni	1.40 – 2.00
Molybdenum	Mo	0.35 – 0.50
Vanadium	V	0.03 - 0.10
Copper	Cu	0.50 Max.
Tungsten	W	0.10 Max.
Aluminum	Al	0.08 Max.

Note 1: Ladel additions for the purpose of adding alloy are not permitted after final chemical analysis is performed.
Note 2: The total maximum combined residuals shall not exceed 0.60.

c) That meet the specified mechanical properties below.

Property	Requirement
Tensile Strength	120,000 PSI Min.
Yield Strength	110,000 PSI Min.
Elongation in 2"	14% Min.
Reduction of Area	25% Min.
Brinell Hardness	269 - 302

d) That meet the below specified Charpy V-Notch Impact Test requirements.

Property	Requirement
Test Temperature	-4 ° F (-20 degrees C) Max.
3 Test Average	31 ft-lbs. Min (42 J)
No single Test Less Than	24 ft-lbs. Min (33 J)

* If one value is below 24 ft/lbs. (33J), a re-test of three additional specimens is required

2.1.2 Including the -4° F Charpy V-Notch Impact Test, the below -45 ° F test is required to be conducted on all castings when SR2 requirements are specified.

Property	Requirement
Test Temperature	-45°F (-42.8 Degrees C)
3 Test Average	20 ft-lbs. (27 J)
No single Test Less Than	15 ft-lbs. (20 J)

* If one value is below 15 ft/lbs., a re-test of three additional specimens is required.
*If supplier chooses to perform -45° F SR2 requirements only, the actual Charpy impact values must meet the actual specified values at -4 Degree F SR1. See below listed values.

Property	Requirement
Test Temperature	-4 ° F (-20 degrees C) Max.
3 Test Average	31 ft-lbs. Min (42 J)
No single Test Less Than	24 ft-lbs. Min (33 J)

* If one value is below 24 ft/lbs. (33J), a re-test of three additional specimens is required

NOTE: The above tests are performed in accordance with ASTM A370

2.1.3 Provide Castings:

a) In a heat-treated condition,
b) That were normalized prior to hardening by heating to 1700° F and holding it for a minimum of one hour for each inch of maximum cross section and then air cooled,
c) That were austenitized hardened at 1650-degrees F for one hour for each inch of maximum cross section and quenched in water for 1.5 hours, and
d) After hardening, were tempered 1100° F minimum tempering temperature to achieve the required mechanical properties. Casting shall be held at the required temperature for a minimum of 3 hours then water quenched within 45 seconds.

NOTE: With the exception of the minimum tempering temperature, the above are for reference only and are only used to meet the mechanical and Charpy V Notch requirements stated in 2.1.1 & 2.1.2.

2.1.4 The casting supplier shall record actual casting-specific temperatures and times used for production and provide that information with the castings.

2.1.5 Provide Qualification test coupons as described below:

a) **Equivalent Round Test Bars:** shall be poured from the same heat as the castings and must be heat treated together with the castings they represent. The ER bars may be integrally cast together with the castings or poured separately a as their representative castings. A minimum of two ER bars is required to allow heat treatment re-trial in cases where the mechanical properties do not meet specified requirements.
b) **Bar Gage Length**: the gauge length of a tensile / V Notch specimen shall be at least 1/4" thick at the ends of the test coupon.
c) **ER Test Bar Size**: the specific bar size shall be specified on all KET drawings and standard A370 test keel blocks.
d) **Qualification Test Coupons:** used for mechanical properties testing must be taken from the ER test bar in such a way that the centerline axis is wholly within the center pocket at ¼ T depth.

2.1.6 Apply the following welding requirements:

a) Use welding procedures qualifications:
   - PSL 1: use welding procedures in accordance with ASME B31.3, ASME IX, AWS D1.1 and/or ASTM A488.
   - PSL 2: use ASME IX.

b) Submit the below listed documents to KET for approval.
   - Welding Procedure Specifications (WPS)
   - Procedure Qualification records (PQR)
   - Welder Qualification records (WQR)

c) Use welding consumables that conform to American Welding Society AWS specifications or to the consumable manufacture's specifications.

d) Stress relieves heat treated welded castings to 1050° F minimum and in accordance with a qualified Welding Procedure Specification or too KET-WP-001.

e) Magnetic particles examine and visually/dimensionally inspect excavated castings.

f) Retain the below listed records:
- Welding Procedure Specifications
- Welder Qualification Records
- Procedure Qualification Records

g) Ensure any heat affected zone (HAZ) meets the mechanical properties identified in 2.1.1 and 2.1.2.

2.1.7 Repair Welds

a) PSL 1 – All repair welds in castings shall be examined in accordance with section 2.1.8 of this procdedure.

b) PSL 2 – If weld repair exceeds 25% of the wall thickness or 1" depth whichever is less, the repair will be classified as a major repair and the affected area shall be examined by magnetic particle examination see section 2.1.8 of this procedure. Provide a dimensional sketch of all casting repairs areas, including repair sequences for all major weld repairs.

2.1.8 Magnetic particles examine 100% of all accessible areas of each casting as described below:

a) User the wet fluorescent method described in ASTM E709 to perform a 100% magnetic particle examination of all accessible casting surfaces.
b) Use Level II inspectors qualified in accordance with American Society of Nondestructive Testing (ASNT) TC-1A (latest edition).
c) Do not perform a magnetic particle examination until 24-hours after final heat-treatment.
d) Compare examination indications to the indications shown in ASTM E125

Area	Discontinuity Description	Critical Area	Non-Critical Areas
I	Linear indications, cracks, or hot tears	None	None
II	Shrinkage	None	Degree 1
III	Inclusions	Degree 1	Degree 2
IV	Internal chills, or chaplets	None	Degree 1
V	Porosity	Degree 1	Degree 2

NOTE: If critical areas are not specifically identified, then all areas shall be considered critical.

2.1.9 Visually and dimensionally inspect casting to ensure compliance with specified requirements. The visual acceptance of castings shall be determined by comparing the photographs of MSS standard practice SP-55 for steel castings. Defect-specific acceptance of surface irregularities is provided below.

Defect Type	Acceptable Irregularities
I, II, III, and V	a & b
V, VI, VII, IX, and XI	a & b
VIII, and X	a
XII	a, b, & c

2.1.10 Perform the below described volumetric non-destructive examinations:

a) Radiographic Examination

- **Requirement** - shall be performed in accordance with ASME Section V (2010), Subsection A, Article 3 and Subsection B, Article 22. Fluorescent intensifying screens shall not be used.

- **Qualifications-** Personnel performing this method shall be qualified/certified level II minimum in accordance with ASNT SNT-TC-1A.

- **Lot Sampling –** this examination is used to verify product quality and is performed at the foundry's expense.

- **Production Castings** – a minimum of 1 casting per production lot shall be subject to 100% radiographic examination.

- **Acceptance Criteria** - Examination acceptance shall be based on the standard reference radiographs of ASTM E446, ASTM E186, or ASTM E280, as appropriate for the casting thickness being examined. In all cases, cracks, hot tears, and inserts (Defect Type D, E, and F) are not permitted. All other indication types shown shall meet severity Level 2 or better in critical areas, all Level 3 or better in non-critical areas.

b) Ultrasonic Examination

- **Requirement** - Performed in accordance with ASME Section V (2010), Sub-section A, Article 5 and Sub-section B, Article 23. The components shall be examined by the straight beam method as prescribed in SA-609 of Article 23 and supplemented by angle examination as in T-510,T-520, T-541.4.2 and T-542.4.3 of Article 5 in areas where a back reflection cannot be maintained during the straight beam examination, or where the angle between the two component surfaces is more than 15-degrees.

- **Qualifications-** Personnel performing this method shall be qualified/certified level II minimum in accordance with ASNT SNT-TC-1A.

- **Lot Sampling –** this examination is used to verify product quality and is performed at the foundry's expense.

- **Production Castings** – a minimum of 1 casting per production lot shall be subject to 100% ultrasonic examination.

- **Acceptance Criteria** - Examination acceptance shall be based on SA-609 in ASME Section V (2010), Subsection B, Article 23. The acceptance criteria shall be as follows:

  1. PSL 1: Quality Level 3
  2. PSL 2:
     a. Quality Level 1 for casting thickness up to 50mm (2in),
     b. Quality Level 2 for casting thickness up to 50mm (2in) to 100mm (4in),
     c. Quality Level 3 for casting thickness over 100mm (4in),
  3. PSL 1 and PSL 2:
     Regardless of casting thickness, Quality Level 1 shall apply within 50mm (2in) of the casting surface. Discontinuities indicated as having a change in depth of 25mm (1 in) or half the thickness, whichever is less, are not permitted.

Perform NDE on a minimum of one casting out of each production lot. The examination shall be performed on the critical areas. If any casting shows any indications outside the specified acceptance criteria, two castings from the affected production lot shall be examined by the same method. If the 2 additional castings meet specified requirements, the original sample is to be repaired and the lot accepted. If they fail to meet specified requirements, the lot shall be rejected.

Note: If critical areas are not identified on critical area drawings, then all areas are considered critical.

Note: API 8C NDE examination specifies the ASME Section V 2010 edition but API 7K specifies the most current edition. When producing castings for elevators use the 2010 edition and when producing 7K spiders use the most current edition.

2.1.11 Provide its logo, heat code, part number and additional KET-required markings (if any) shall be inspected for legibility and accepted prior to casting shipment. Castings with illegible markings will not be accepted by KET unless written approval is obtained from the KET Quality Manager, Vice President or Production, or President.

2.1.12 Replace all rejected castings without charge to KET.

2.1.13 Legibility identify castings (i.e., size permitting) with the below-listed Information:

a) Foundry Name –including foundry logo, the traceable heat number code, and KET specific markings.
b) Load Rating- mark each casting with the load rating in metric tons (Conversion: 1short-ton=0.908 metric-tons).
c) Location- markings that cannot be removed in subsequent processing operations.
d) Casting and Stenciling stamps- all above-identified markings shall be Legibly cast. If any additional stamping is required, use low stress hard die Stamps with numbers clearly visible and 3/8 inches high (where space allows)

2.1.14 Provide a Certificate of Conformity with each heat of material shipment. The certificate must include the below listed specific information.

a) Chemical Analysis
b) Mechanical Properties (i.e., for each casting heat)
c) Heat treatment Certification
d) ER Statement (e.g., Equivalent round tested at ¼ depth test 13 AR size
e) T x T =XXX

2.1.15 Required cast texts on castings as specified on KET drawings.

a) API 8C Elevators and slips when used for hoisting devices:
- KET Logo
- KET Part Number
- Rev. No.
- Rating in short tons and MT
- API 8C
- Heat Code
- Foundry Logo
- PSL 1

b) API 7K Spiders and Slips when not used as hoisting devices:
- KET Logo
- KET Part Number
- Rev. No.
- Rated Load
- API 7K
- Heat Code
- Foundry Logo
- Taper (delineated as inches of diametrical change per foot with two decimal precision)

3.0 Revision History

Revision #	Section #	Brief Description of Change	Date
G	3.0/Footer Header	Added revision history/added copyright statement/adjusted format	03/29/2021
08	Header	Change revision format from alphabetic to numeric	04/23/2021
09	2.1.1 clause c)	Changed the minimum yield requirements from 100,000 psi to 100,001 psi	04/23/2021
10	2.1.6	Defined PSL 1 & PSL 2 repair welds more specific to API 8C requirements	12/08/2021
11	2.1.1/2.1.15/2.1.2	Change Yield Strength from 110,001 to 100,000 / changed Brinell Hardness range from 269-318 to 269-302 / updated required text / added note for SR2 Charpy testing	08/22/2022
12	All	Updated format and added API 7K product references and requirements	09/08/2023