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# Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure- Containing and Other Applications, for Low-Temperature Service<sup>1</sup>

This standard is issued under the fixed designation A757/A757M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope\*

1.1 This specification covers carbon and alloy steel castings for pressure-containing and other applications intended primarily for petroleum and gas pipelines in areas subject to low-ambient temperatures. Castings shall be heat treated by normalizing and tempering or liquid quenching and tempering. All classes are weldable under proper conditions. Hardenability of some grades may limit usable section size.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.2.1 Unless the order specifies an “M” designation, the material shall be furnished to inch-pound units.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel](#)

[A703/A703M Specification for Steel Castings, General Requirements, for Pressure-Containing Parts](#)

[A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys](#)

[A985/A985M Specification for Steel Investment Castings General Requirements, for Pressure-Containing Parts](#)

[A1067/A1067M Specification for Test Coupons for Steel Castings](#)

2.2 *American Society of Mechanical Engineers:*<sup>3</sup>

[ASME Boiler and Pressure Vessel Code](#)

2.3 *Manufacturers Standardization Society of the Valve and Fittings Industry Standards:*<sup>4</sup>

[MSS SP-55 Quality Standard for Steel Castings for Valves, Flanges, Fittings, and Other Piping Components - Visual Method for Evaluation of Surface Irregularities](#)

## 3. Terminology

3.1 *Definitions:*

3.1.1 Definitions in [Test Methods and Definitions Specification A370](#), [A703/A703M](#) and [Terminology A941](#) are applicable to this specification.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

<sup>4</sup> Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602, <http://www.mss-hq.com>.

\*A Summary of Changes section appears at the end of this standard



TABLE 1 Chemical Requirements (Maximum Percent Unless Range is Given)

Grade	A1Q	A2Q	B2N B2Q	B3N B3Q	B4N B4Q	C1Q	D1N1 D1Q1 D1N2 D1Q2 D1N3 D1Q3	E1Q	E2N, E2Q	E3N
Type	Carbon	Carbon-Manganese	2½ Nickel	3½ Nickel	4½ Nickel	Nickel Molybdenum	Chromium Molybdenum	Nickel Chromium Molybdenum	Nickel Chromium Molybdenum	Martensitic Chromium Nickel
Carbon	0.30	0.25 <sup>A</sup>	0.25	0.15	0.15	0.25	0.20	0.22	0.20	0.06
Manganese	1.00	1.20 <sup>A</sup>	0.50/0.80	0.50/0.80	0.50/0.80	1.20	0.40/0.80	0.50/0.80	0.40/0.70	1.00
Phosphorus	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.020	0.030
Sulfur	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.020	0.030
Silicon	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	1.00
Nickel	—	—	2.0/3.0	3.0/4.0	4.0/5.0	1.5/2.0	—	2.5/3.5	2.75/3.90	3.5/4.5
Chromium	—	—	—	—	—	—	2.0/2.75	1.35/1.85	1.50/2.0	11.5/14.0
Molybdenum	—	—	—	—	—	0.15/0.30	0.90/1.20	0.35/0.60	0.40/0.60	0.40/1.0
Specified Residual Elements:										
Vanadium	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	—
Copper	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nickel	0.50	0.50	—	—	—	—	0.50	—	—	—
Chromium	0.40	0.40	0.40	0.40	0.40	0.40	—	—	—	—
Molybdenum	0.25	0.25	0.25	0.25	0.25	—	—	—	—	—
Tungsten	—	—	—	—	—	—	0.10	—	0.10	0.10
Total residuals (maximum %) <sup>B</sup>	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.70	0.70	0.50

<sup>A</sup> For each 0.01 % of reduction in carbon below the maximum specified, an increase of 0.04 % manganese over the maximum specified will be permitted up to 1.40 %.

<sup>B</sup> Total residuals includes phosphorus and sulfur.

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3.1.2 Definition of nominal thickness,  $T$ , applies to quenched and tempered castings with a thickness exceeding 2 in. [50 mm]. Nominal thickness,  $T$ , is the maximum thickness of the pressure-containing wall of the casting exclusive of padding added for directional solidification, flanges, appendages, and sections designated by the designer as noncritical.

#### 4. General Conditions for Delivery

4.1 Except for investment castings, castings furnished to this specification shall be in accordance with the requirements of Specification **A703/A703M**, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification **A703/A703M** constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification **A703/A703M**, this specification shall prevail.

4.2 Steel investment castings furnished to this specification shall conform to the requirements of Specification **A985/A985M**, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification **A985/A985M** constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification **A985/A985M**, **A985/A985M** shall prevail.

#### 5. Ordering Information

5.1 Orders for material to this specification should include the following, as required, to describe the material adequately:

- 5.1.1 Quantity,
- 5.1.2 ASTM designation and date of issue,
- 5.1.3 Grade designation (**Table 1**),
- 5.1.4 Description of casting by part, pattern, or drawing number. (Dimensional tolerances and machined surfaces should be indicated on the casting drawing).
- 5.1.5 Options in the specification,
- 5.1.6 Whether the castings are to be produced using investment casting process, and
- 5.1.7 Supplementary requirements desired, if any, including standards of acceptance.

#### 6. Materials and Manufacture

6.1 *Melting Process*—The steel shall be made by the electric furnace process or other primary processes approved by the purchaser. The primary melting may incorporate separate degassing or refining and may be followed by secondary melting.

6.2 *Heat Treatment*:



TABLE 2 Tensile Requirements

Grade	Heat Treatment <sup>A, B</sup>	Tensile Strength, <sup>C</sup> min, ksi [MPa]	Yield Strength (0.2 % offset), min, ksi [MPa]	Elongation in 2 in. [50 mm], min, %	Reduction of Area, min, %
A1Q	QT	65 [450]	35 [240]	24	35
A2Q	QT	70 [485]	40 [275]	22	35
B2N, B2Q	NT/QT <sup>D</sup>	70 [485]	40 [275]	24	35
B3N, B3Q	NT/QT	70 [485]	40 [275]	24	35
B4N, B4Q	NT/QT	70 [485]	40 [275]	24	35
C1Q	QT	75 [515]	55 [380]	22	35
D1N1, D1Q1	NT/QT	85 [585]	55 [380]	20	35
		115 [795]			
D1N2, D1Q2	NT/QT	95 [655]	75 [515]	18	35
		125 [860]			
D1N3, D1Q3	NT/QT	105 [725]	85 [585]	15	30
		135 [930]			
E1Q	QT	90 [620]	65 [450]	22	40
E2N1, E2Q1	NT/QT	90 [620]	70 [485]	18	35
		120 [825]			
E2N2, E2Q2	NT/QT	105 [725]	85 [585]	15	30
		135 [930]			
E2N3, E2Q3	NT/QT	115 [795]	100 [690]	13	30
		145 [1000]			
E3N	NT	110 [760]	80 [550]	15	35

<sup>A</sup> QT = Quenched and tempered.

<sup>B</sup> NT = Normalized and tempered.

<sup>C</sup> Minimum ksi (MPa), unless range is given.

<sup>D</sup> NT/QT indicates that either a normalized and tempered or quenched and tempered heat treatment may be used.

6.2.1 All castings shall be heat treated by either normalizing and tempering or quenching and tempering. Tempering temperature shall be 1100°F [595°C] minimum, except grades B4N and B4Q, which shall be tempered at 1050°F [565°C] minimum.

6.2.2 E3N castings shall be heat treated by heating to 1850°F [1010°C] minimum, and air cooling to 200°F [95°C] maximum before any optional intermediate temper, but shall cool to 100°F [40°C] maximum before the final temper, which shall be between 1050 and 1150°F [565 and 620°C].

6.2.3 Furnace temperatures for heat treating shall be controlled by pyrometers.

6.2.4 Castings shall be allowed to cool below the transformation range directly after pouring and solidification before they are reheated for normalizing or liquid quenching.

## 7. Chemical Composition

7.1 The steel shall be in accordance with the requirements as to chemical composition prescribed in Table 1.

## 8. Tensile Requirements

8.1 Steel used for the castings shall conform to the requirements as to the tensile properties prescribed in Table 2.

## 9. Impact Requirements

9.1 Impact properties shall be determined on each heat by testing a set of three Charpy V-notch specimens. The bar from which the impact specimens are machined shall be prepared in accordance with Section 12. The longitudinal axis of the Charpy specimens shall be parallel to the longitudinal axis of the tensile bar. ~~Testing shall be in accordance with Test Methods and Definitions A370.~~

9.2 Test temperature and absorbed energy requirements for the grade shall be as specified in Table 3, ~~except for those grades that have no values specified, in which, impact properties at temperatures other than specified in Table 3 case, impact energy values and test temperatures shall be agreed upon between the manufacturer and the purchaser. purchaser and Supplementary Requirement S8 shall be specified.~~ The average energy value of three specimens shall not be less than the minimum average specified, with only one value permitted below the minimum average specified and this value not permitted to fall below the minimum specified for a single specimen. Supplementary Requirement S8S52 may be specified if lateral expansion or percent shear area, or both, are desired by the purchaser.

9.3 Impact properties shall also be determined on both the heat-affected zone of the base metal and the weld metal of the welding procedure qualification test. Test temperature, energy absorption, specimen type, and test method shall be the same as specified for the base material.

9.3.1 *Coupons Representing the Weld Deposits*—Impact specimens shall be located so that the longitudinal axis of the specimen is at least one fourth of the thickness of the weld test plate,  $t$ , from the surface of the test assembly and is transverse to the longitudinal axis of the weld with the area of the notch located in the weld metal. The length of the notch of the Charpy specimen shall be normal to the surface of the weld (see Fig. 1).

**TABLE 3 Charpy V-Notch Energy Requirements for Standard Size (10 mm by 10 mm) Specimens<sup>A</sup>**

Grade	Heat Treatment <sup>B,C</sup>	Effective Section Size, max. in. [mm]	Test Temperature		Energy value, ft-lbf [J], min value for two specimens and min average of three specimens	Energy Value, ft-lbf [J], min for single specimen
			°F	°C		
A1Q	QT	1¼ [32]	-50	[-46]	13 [17]	10 [14]
A2Q	QT	3 [75]	-50	[-46]	15 [20]	12 [16]
B2N, B2Q	NT/QT <sup>D</sup>	5 [125]	-100	[-73]	15 [20]	12 [16]
B3N, B3Q	NT/QT	1¼ [32]	-150	[-101]	15 [20]	12 [16]
B4N, B4Q	NT/QT	1¼ [32]	-175	[-115]	15 [20]	12 [16]
C1Q	QT	5 [125]	-50	[-46]	15 [20]	12 [16]
D1N1, D 1Q1	NT/QT	<i>E</i>	<i>E</i>	<i>E</i>	<i>E</i>	<i>E</i>
D1N2, D 1Q2	NT/QT	<i>E</i>	<i>E</i>	<i>E</i>	<i>E</i>	<i>E</i>
D1N3, D 1Q3	NT/QT	<i>E</i>	<i>E</i>	<i>E</i>	<i>E</i>	<i>E</i>
E1Q	QT	<i>E</i>	-100	[-73]	30 [41]	25 [34]
E2N1, E 2Q1	NT/QT	5 [125]	-100	[-73]	30 [41]	25 [34]
E2N1, E 2Q1	NT/QT	5 [125]	-100	[-73]	30 [41]	25 [34]
E2N2, E 2Q2	NT/QT	1¼ [32]	-100	[-73]	20 [27]	15 [20]
E2N2, E 2Q2	NT/QT	1¼ [32]	-100	[-73]	20 [27]	15 [20]
E2N3, E 2Q3	NT/QT	1¼ [32]	-100	[-73]	15 [20]	12 [16]
E3N	NT	1¼ [32]	-100	[-73]	20 [27]	15 [20]

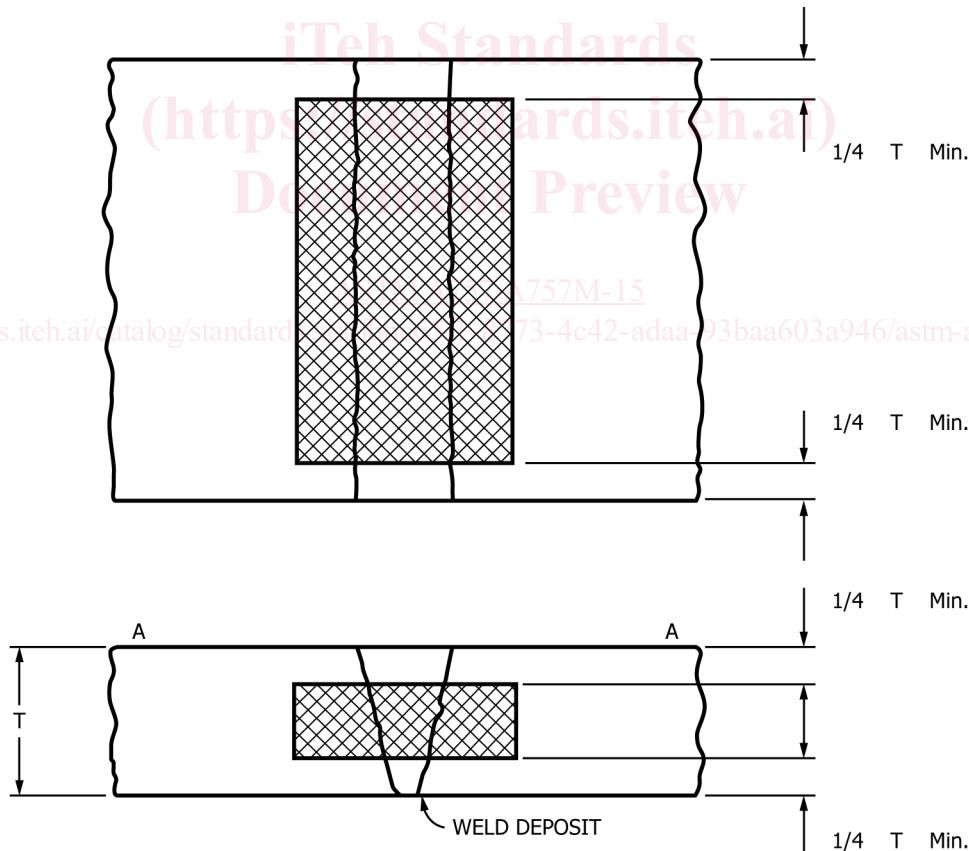
<sup>A</sup> Hardenability and residual elements (primarily P & S levels) in some of the grades may limit the maximum section size in which these impact values can be obtained.

<sup>B</sup> QT = Quenched and tempered.

<sup>C</sup> NT = Normalized and tempered.

<sup>D</sup> NT/QT indicates that either a normalized and tempered or quenched and tempered heat treatment may be used.

<sup>E</sup> Requirements shall be subject to agreement between the manufacturer and the purchaser.



**FIG. 1 Charpy V-Notch Specimen Must Be Within Cross-Hatched Zone With Notch in the Weld Metal Perpendicular to Surface A-A**

**9.3.2 Coupons Representing the Heat-Affected Zone:**

9.3.2.1 Impact specimens in test plate thicknesses greater than 5/8 in. [16 mm] shall be from coupons removed from a location as near as practical to a point midway between the surface and center thickness. Heat-affected zone coupons for impact specimens

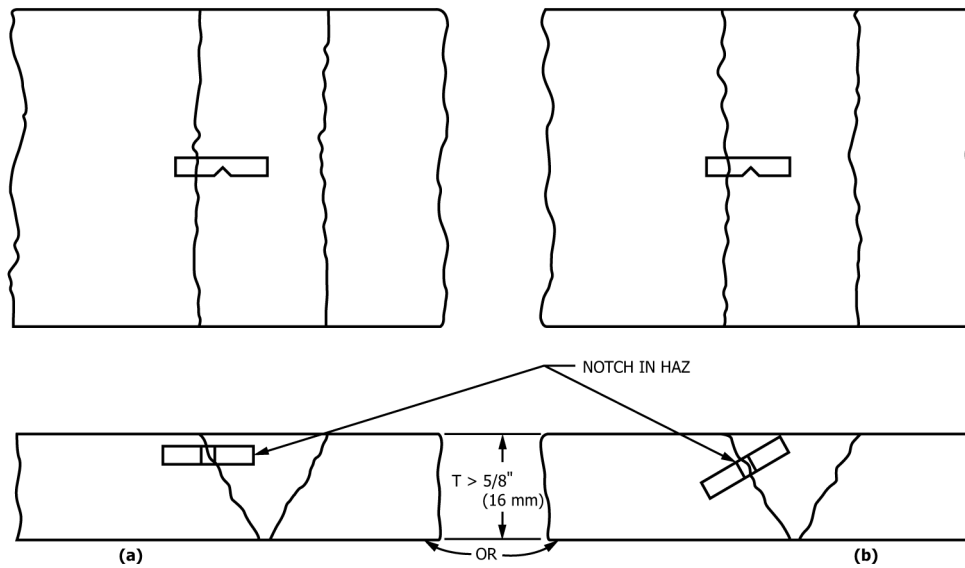


FIG. 2 Location of Notch in Charpy Specimens Shall Be In HAZ Midway Between Center and Surface

shall be taken transverse to the weld and etched to define the heat-affected zone. The notch shall be cut normal to the material surface in the heat-affected zone to include as much heat-affected zone as possible in the resulting fracture (see Fig. 2).

9.3.2.2 Where the material thickness permits, the axis of a specimen may be inclined to allow the root of the notch to align parallel to the fusion line (see Fig. 2).

9.4 Test temperature and impact values for section thickness in excess of those specified in Table 3 may be agreed upon between the manufacturer and the purchaser, in which case, Supplementary Requirement S22S8 shall be specified. Castings shall be marked with this test temperature in accordance with 14.1.

## 10. Workmanship, Finish, and Appearance

10.1 Castings shall conform to the shapes, tolerances, and sizes indicated by patterns or drawings submitted by the purchaser.

10.2 The castings shall not be peened, plugged, or impregnated to stop leaks or disguise rejectable indications.

## 11. Quality

11.1 The surface of the casting shall be examined visually and shall be free of adhering sand, scale, cracks, and hot tears. Other surface discontinuities shall meet the visual acceptance standards specified in the order. Visual Method MSS SP-55 or other visual standards may be used to define acceptable surface discontinuities and finish. Unacceptable visual surface discontinuities shall be removed and their removal verified by visual examination of the resultant cavities. When methods involving high temperatures are used in the removal of discontinuities, the casting shall be preheated to at least the minimum temperatures in Table 4.

11.2 When additional inspection is desired, Supplementary Requirements S4, S5, and S10 may be ordered.

## 12. Test Coupons and Specimen Location

12.1 Test blocks may be cast integrally with the casting or as separate blocks. Test coupons shall be heat treated in production furnaces to the same procedure as the castings they represent.

12.2 *Normalized and Tempered Castings*— Test blocks shall be similar to those shown in Fig. 2 and Table 2-1 in Specification A703/A703M/A1067/A1067M or A985/A985M as applicable.

12.3 *Quenched and Tempered Castings*  $T \leq 2$  in. [50 mm]—Requirements in 12.2 apply.

12.4 *Quenched and Tempered Castings*  $T > 2$  in. [350 mm]—Requirements of 12.2 may be applied when agreed upon between the manufacturer and the purchaser, in place of 12.4.1 – 12.4.4, one of which otherwise shall apply.

12.4.1 The longitudinal centerline of the tensile test specimen shall be taken at least  $\frac{1}{4}T$  from the  $T$  dimension surface and all of the gage length must be at least  $1T$  from any other heat-treated surface, exclusive of the surface opposite the  $T$  dimension surface. For cylindrical castings, the longitudinal centerline of the specimens shall be taken at least  $\frac{1}{4}T$  from the outside or inside and all of the gage length must be at least  $T$  from the as-heat-treated end (see Fig. 3).

12.4.2 Where separately cast test coupons are used, the dimension shall not be less than  $3T$  by  $3T$  by  $T$  and each specimen shall meet the requirements of 12.4.1. The test coupon shall be of the same heat of steel and shall receive substantially the same casting practices as the production casting it represents. Centrifugal castings may be represented by statically cast coupons (see Fig. 4).



TABLE 4 Minimum Preheat Temperatures

Grade	Minimum Preheat Temperature	
	°F	[°C]
A1Q	50	[10]
A2Q	50	[10]
B2N, B 2Q	300	[150]
B3N, B 3Q	300	[150]
B4N, B 4Q	300	[150]
C1Q	300	[150]
D1N, D 1Q	400	[200]
E1Q	300	[150]
E2N, E 2Q	400	[200]
E3N	50	[10]

12.4.3 Where specimens are to be removed from the body of the casting, either the requirements of 12.4.1 shall be met or a steel thermal buffer pad or thermal insulation or other thermal barriers shall be used during heat treatment. Steel thermal buffer pad shall be a minimum of  $T$  by  $T$  by  $3T$  in length and shall be joined to the casting surface by a partial penetration weld completely sealing the buffered surface. Test specimens shall be removed from the casting in a location adjacent to the center third of the buffer pad. They shall be located at a minimum distance of  $\frac{1}{2}$  in. [13 mm] from the buffered surface and  $\frac{1}{4}T$  from other heat-treated surfaces (see Fig. 5). When thermal insulation is used, it shall be applied adjacent to the casting surface where the test specimens are to be removed. The producer shall demonstrate that the cooling rate of the test specimen location is no faster than that of specimens taken by the method described in 12.4.1.

12.4.4 *Test Specimens From Castings*—When agreed upon by the manufacturer and the purchaser, castings that are cast or machined to essentially the finished configuration prior to heat treatment shall have test specimens removed from a prolongation or other stock on the casting at a location below the nearest heat-treated surface indicated on the order. The specimen location shall be at a distance below the nearest heat-treated surface equivalent to at least the greatest distance that the indicated high-tensile-stress surface will be from the nearest heat-treated surface and a minimum of twice this distance from a second heat-treated surface, except that the test specimens shall be no nearer than  $\frac{3}{4}$  in. [19 mm] to a heat-treated surface and  $1\frac{1}{2}$  in. [38 mm] from a second heat-treated surface (see Fig. 6).

### 13. Repair by Welding

13.1 *Qualification*—Repairs shall be made using procedures and welders qualified under Practice A488/A488M or in accordance with the ASME Boiler and Pressure Vessel Code, Section IX.

13.2 *Inspection*—Weld repairs shall be inspected to the same quality standards as used to inspect the casting, except when radiography (see Supplementary Requirement S5) is specified in the order for the original casting. Radiography of weld repairs shall be performed only for the examination of major repairs (see 13.3).

13.3 *Major Weld Repairs*—Weld repairs shall be considered major when the depth of the cavity prepared for welding exceeds 20 % of the wall thickness or 1 in. [25 mm], whichever is smaller, or when the extent of cavity exceeds approximately 10 in. [65 cm], or when a pressure-containing casting leaks on hydrostatic test.

13.4 *Postweld Heat Treatment*—All castings with repair welds shall be thermally stress relieved or reheat-treated completely in accordance with 6.2 and the welding procedure qualification used.

### 14. Product Marking

14.1 In addition to the requirements of A703/A703M, or for investment castings the requirements of A985/A985M, castings marking shall also include the test temperature, if it is other than the standard test temperature or if no test temperature is specified in Table 3. A prefix O to the test temperature shall indicate a less than  $0^\circ$  value.

### 15. Keywords

15.1 alloy steel; carbon steel; ferritic; investment castings; low temperature service; martensitic stainless steel; pressure containing; stainless steel; steel castings