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Ballot #6239

Carbon Steel, Alloy Steel, Stainless Steel, and Nickel Base Alloy Casting for Use in the Petroleum and Natural Gas Industry

Introduction

Changes from the 2nd to the 3rd Edition

This specification is the result of updating the requirements from API Specification 20A, 2nd Edition including Addendum 1 and Addendum 2. The revision of API 20A, 3rd Edition, is developed based on input from the API 20A Task Group technical experts globally. The technical revisions have been made to accommodate the needs of industry to move this specification to a higher level of service to the petroleum and natural gas industry.

Highlights of some of the significant changes between the 2nd edition and 3rd edition, include:

- Added and deleted some Normative Reference
- Removed the figures in section 4 that identified size and shape of qualification test coupons,
- Modified text content in some table and renumber
- Removed all CSI-4 and Sacrificial castings from Qualification and Production sections and moved to Informative Annex A.
- Moved the Minimum Facilities Requirement table from section 5 to section 4.
- Added guidance throughout the document reference to other API 20 series standards.

1 Scope

This specification identifies requirements for the foundry qualification, production, design, marking and documentation of carbon steel, alloy steel, stainless steel, and nickel-base alloy castings used in the petroleum and natural gas industries when referenced by an applicable API product standard or otherwise specified as a requirement for compliance.

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This specification applies to castings used in the manufacture of pressure containing, pressure-controlling, and primary load-bearing components. Castings manufactured in accordance with this API Specification may be produced using any industry standard casting method.

This specification provides manufacturers with a fixed methodology to examine a qualification casting and to compare the results of that examination to a defined set of acceptance criteria. The results of the qualification testing by material grouping are then used to establish a baseline casting specification level (CSL) for subsequently produced castings.

This specification also provides manufacturers with a fixed production testing methodology to determine if subsequently produced castings conform to the minimum requirements for the intended CSL. The intent is that the production castings meet the minimum CSL requirements proven during qualification testing by material grouping and/or the minimum CSL specified by the purchaser.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies.

For undated references, the latest edition of the referenced document (including any amendments) applies, except that new editions may be used on issue and shall become mandatory upon the effective date specified by the publisher or six months from the date of the revision (where no effective date is specified).

API Specification Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

API Specification 6A, *Specification for Wellhead and Tree Equipment*

API Specification 6D, *Specification for Valves*

API Standard 20H, *Heat Treatment Services – Batch Type for Equipment Used in the Petroleum and Natural Gas Industry*

ANSI/NACE MR 0175¹/ISO 15156, *Materials for use in H₂S-containing environments in oil and gas production.*

ASME Boiler and Pressure Vessel Code (BPVC)², Section VIII, Division 1, *Pressure Vessels ASME Boiler and Pressure Vessel Code (BPVC), Section IX, Welding and Brazing Qualifications*

ASME Boiler and Pressure Vessel Code (BPVC), Section V, *Nondestructive Examination*

ANSI /ASQZ1.4 *Sampling procedure and table for inspection by attributes*

ASNT SNT-TC-1A³, *Recommended Practice No. SNT-TC-1A—Personnel Qualification and Certification in Non-Destructive Testing*

ASTM A370⁴, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

¹ NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77084-4906, www.nace.org.

² ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

³ American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, Ohio 43228, www.asnt.org.

⁴ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

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ASTM A488/A488M, *Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel*

ASTM A609, *Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof*

ASTM A1067, *Standard Specification for Test Coupons for Steel Castings*

ASTM E8, *Standard Test Methods for Tension Testing of Metallic Materials*

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E23, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*

ASTM E110, *Standard Test Method for Indentation Hardness of Metallic Materials by Portable Hardness Testers*

ASTM E112, *Standard Test Methods for Determining Average Grain Size*

ASTM E165, *Standard Practice for Liquid Penetrant Examination for General Industry*

ASTM E186, *Standard Reference Radiographs for Heavy-Walled (2 to 4 1/2-in. (50.8 to 114-mm)) Steel Castings*

ASTM E280, *Standard Reference Radiographs for Heavy-Walled (4 1/2 to 12-in. (114 to 305-mm)) Steel Castings*

ASTM E340, *Standard Test Method for Macroetching Metals and Alloys*

ASTM E127, *Standard Practice for Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Blocks*

ASTM E446, *Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness*

AWS D1.1⁵, *Structural Welding Code—Steel*

EN-10204⁶, *Metallic products—Types of inspection documents*

ISO 148-1⁷, *Metallic materials—Charpy pendulum impact test—Part 1: Test method*

ISO 2859-1, *Sampling procedures for inspection by attributes—Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 6506-1, *Metallic materials—Brinell hardness test—Part 1: Test method*

ISO 6508-1, *Metallic materials—Rockwell hardness test—Part 1: Test method*

ISO 6892-1, *Metallic materials—Tensile testing—Part 1: Method of test at room temperature*

⁵ American Welding Society, 8669 NW 36 Street, #130, Miami, Florida 33166-6672, www.aws.org.

⁶ European Committee for Standardization, Avenue Marnix 17, B-1000 Brussels, Belgium, www.cen.eu.

⁷ International Organization for Standardization, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

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ISO 9001, *Quality management systems—Requirements*

ISO 9606-1, *Qualification testing of welders—Fusion welding—Part 1: Steels*

ISO 9712, *Non-destructive testing—Qualification and certification of NDT personnel*

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*

ISO/IEC 17020, *Conformity assessment—Requirements for the operation of various types of bodies performing inspection*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO/IEC 17065, *Conformity assessment—Requirements for bodies certifying products, processes and services*

ISO 17655, *Destructive tests on welds in metallic materials—Method for taking samples for delta ferrite measurement*

ISO 17781, *Petroleum, petrochemical and natural gas industries — Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels*

MSS SP-55⁸, *Quality Standard for Steel Castings for Valves, Flanges, Fittings, and Other Piping Components— Visual Method for Evaluation of Surface Irregularities*

SAE AMS 2750⁹, *Pyrometry*

3 Terms, Definitions, and Abbreviations

3.1 Terms and Definitions

For purposes of this specification, the following terms and definitions apply.

3.1.1

acceptance criteria

Defined limits placed on characteristics of materials, processes, products, or services.

3.1.2

as-cast weight range

The finished weight of a casting after all processing, removal of all gates, risers, feeds and finished cleaning prior to any machining.

3.1.3

calibration

Process of comparison to a standard of known accuracy, comparison of results against TMMDE (testing, measuring, monitoring, and detection equipment) acceptance criteria, and, if applicable, making any needed adjustment(s).

⁸ Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180- 4602, www.mss-hq.com.

⁹ SAE International, 400 Commonwealth Drive, Warrendale, PA 15096, www.sae.org.

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NOTE Calibration of non-adjustable equipment can be referred to as verification.

**3.1.4
carbon steel**

Alloy of carbon and iron containing a maximum of 2 % mass fraction carbon, 1.65 % mass fraction manganese, and residual quantities of other elements, except those intentionally added in specific quantities for deoxidation (usually silicon and/or aluminum).

**3.1.5
casting practice**

General method for producing a casting.

NOTE This includes the molding practice. Examples of molding practice include, but are not limited to, sand, centrifugal, investment, shell, permanent mold, die or lost foam casting.

**3.1.6
corrosion resistant alloy
CRA**

Nonferrous-based alloy in which, any one or the sum of the specified amount of the element's titanium, nickel, cobalt, chromium, and molybdenum exceeds 50 % mass fraction.

NOTE 1 This definition is different from that in NACE MR 0175/ISO 15156 (see Clause 2).

NOTE 2 This definition is the same as that in API Spec 6A.

**3.1.8
duplex stainless steel**

Stainless steels with a high chromium mass fraction (19 % to 33 %) with or without molybdenum additions up to 5 %, and a nickel mass fraction intermediate to those of ferritic and austenitic stainless steels.

NOTE Added elements can secure special properties.

**3.1.09
heat (noun)**

Material originating from a final melt or from re-melted alloys or the raw material originating from a single remelted ingot.

NOTE Different heats of the same material can vary in chemical composition within prescribed limits. Stock from a single heat will have a consistent analysis and more uniform properties.

**3.1.10
heat lot**

Cast material from one single heat of material.

**3.1.11
heat treating**

Specified, timed sequence of controlled heating and cooling of materials for the purpose of changing physical or mechanical properties.

**3.1.12
low alloy steel**

Steel containing less than 5 % mass fraction total alloying elements, or steels with less than 11 % mass fraction chromium, but more than that specified for carbon steel.

**3.1.13
major welding repair**

Welding repair of an excavated cavity that exceeds 20 % of the part wall thickness or 1 in. (25 mm) depth, whichever is smaller, or surface areas greater than 10 in.² (65 cm²).

**3.1.14
melt practice**

Procedure and equipment used to create a heat of metal.

NOTE Includes the type of melting furnace used such as air induction melting, electric arc furnace, and the refining process used, such as AOD, when applicable.

**3.1.15
on-site**

Activity performed at the foundry, by foundry personnel.

**3.1.16
outsource**

Function or process that is performed by an external supplier approved by the foundry.

**3.1.17
pattern**

The wood, metal, wax, foam, or plastic replica of the final product to be made.

NOTE Patterns can include gating systems.

**3.1.18
rigging**

Gates, risers, loose pieces, etc., on the pattern that produce a sound casting.

**3.1.19
production casting**

Casting based on requirements derived from section 5 of this specification in combination with purchasing documents.

- Process control variables, requirements for patterns and marking requirements are derived from this specification.
- Requirements regarding mechanical testing, NDE methods and acceptance are defined by purchasing documents.

NOTE Requirements can apply to raw and machined castings.

**3.1.20
qualification casting**

Casting that is used to qualify a foundry based on section 4 of this specification.

NOTE The qualification is based on weight range and material group and contains limitations regarding weld repairs. Requirements regarding mechanical testing, NDE methods and acceptance are defined by this specification.

**3.1.21
sample casting**

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3.1.22
stainless steel

Steel containing 11 % or higher, mass fraction of chromium to render the steel corrosion-resistant.

NOTE Added elements can secure special properties.

3.1.23
substantive change

Change to the design, identified by the casting manufacturer/purchaser, which affects the performance of the product.

3.1.24
traceability

The ability to verify the history, location, or application of an item by means of documented recorded identification.

3.2 Abbreviations

For purposes of this specification, the following abbreviations apply.

AOD	argon oxygen de-carburization
CSL	casting specification level
CRA	corrosion resistant alloy
CVN	Charpy V-Notch
MPS	manufacturing process specification
NDE	nondestructive examination
PQR	procedure qualification record
PWHT	post-weld heat treatment
QMS	quality management system
WPS	welding procedure specification

4 Foundry Qualification

4.1 General

4.1.1 This specification gives the requirements for three casting specification levels (CSL). The CSLs are numbered in increasing levels of level/extent of requirements from 1 to 3 to reflect increasing technical, quality and qualification criteria. The following sections describe the conditions that, when met, allow the casting to receive the appropriate CSL classification level and material groups. The MPS shall be used to define the required process control used during foundry qualification.

NOTE See Informative Annex A for CSL-4 Casting requirements.

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4.1.2 The process activities associated with the manufacturing of castings shall be as identified in Table 1 for each casting manufacturing site. The casting manufacturer shall maintain equipment and personnel to ensure conformance to the requirements listed in Table 1 for all activities performed by the manufacturer.

Table 1—Facility Requirements

Item	Process Activity	Where Performed
1	Pattern design, including mounting and rigging	On-site or outsourced
2	Core making, molding	On-site or outsourced
3	Melting and pouring	On-site only
4	Ladle chemical testing	On-site only
5	Final certification chemical testing	On-site or outsourced
6	Cleaning	On-site or outsourced
7	Heat treatment	On-site or outsourced
8	Mechanical testing	On-site or outsourced
9	NDE	On-site or outsourced
10	Welding repair	On-site or outsourced
11	Product marking	On-site only
12	Final inspection/release	On-site only

NOTE Definition for on-site and outsource are found in 3.1.15 and 3.1.16.

4.2 Quality Management System (QMS)

The foundry shall establish, document, implement, and maintain at all times a QMS conforming to an internationally recognized QMS such as Q1 or ISO 9001.

API Specification Q1 or ISO 9001. In addition, the foundry shall be responsible for conforming to all the applicable requirements of this specification.

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4.3 Qualification Casting

4.3.1 A qualification casting shall be produced, tested, and evaluated by the casting manufacturer to establish qualification for a range of products listed in Table 2. Castings shall be produced in accordance with a manufacturing process specification, as specified in 5.2. The material group of the qualification casting shall be in accordance with Table 3.

Qualification castings shall be in their completed cast form, with the addition of any specified rough machining and full heat treatment to establish the final mechanical properties required of the finished product. Qualification castings shall be produced conforming to Table 2, Table 3, Table 4 and the acceptance criteria of Table 5, Table 6, Table 7 and 4.5.3. One or more qualification test coupons shall be poured at the same time and from the same heat as the qualification casting.

4.3.2 Verification of mechanical properties from a qualification casting shall be determined by one of the following methods:

- 4.3.2.1 The qualification test shall be conducted at independent test laboratories. Test laboratories shall conform to ISO/IEC 17025 for the applicable processes or.
- 4.3.2.2 The qualification test shall be performed at the foundry's in-house laboratory and the laboratory shall issue qualification records to meet EN-10204-Type 3.2 inspection certificate. The inspection certificate shall be endorsed by an independent third party conforming to ISO/IEC 17020 or ISO 17065.

4.3.3 A casting qualified to a higher CSL within the same material group also shall be qualified for lower CSLs (e.g., CSL-3 is qualified for CSL-2 and CSL-1).

a) **4.3.4** . The maximum allowable amount of welding repairs shall conform to Table 4.

Table 2—As-cast Weight Range

CSL Level	As-cast Weight in Pounds (kilogram)			
	1-499 (1-226)	500-2499 (227-1134)	2500-9999 (1135-4537)	10,000+ (4538+)
CSL-1	1 Qualification			
CSL-2	1 Qualification		1 Qualification	
CSL-3	1 Qualification	1 Qualification	1 Qualification	1 Qualification

NOTE: 1 Any one (1) weight range in CSL 1 qualifies all weight ranges per each specific material group.
 Any two (2) weight ranges in CSL 2 qualifies all weight ranges per each specific material group.
 All four (4) weight ranges in CSL 3 qualifies all weight ranges per each specific material group.

NOTE 2 Definition for as cast weight range is found in 3.1.2.

Table 3—Material Groups

Material Group	Description
Group A	Carbon steels
Group B	Low alloy steels
Group C	Stainless steels (other than duplex)
Group D	Duplex stainless steels
Group E	CRA

Table 4—Qualification Casting Weld Repair Limitations

CSL	% Total internal & External Surface Area	% Wall Thickness
CSL-1	50 %	50 %
CSL-2	25 %	25 %
CSL-3	20 %	20 %

4.4 Qualification Test Coupon (QTC)

4.4.1 General

4.4.1.1 Qualification test coupons shall either be integral to the components they represent, separate from the components or be taken from sacrificed production part(s). In all cases, test coupons shall be from the same heat as the components they qualify and shall be heat treated together with the components.

4.4.1.2 Test specimens shall be removed from integral or separate qualification casting or its qualification test coupon so that their longitudinal centerline axis is entirely within the center core 1/4 thickness envelope for a solid test coupon, or within 0.125 in. (3 mm) of the mid-thickness of the thickest section of a hollow test coupon. The gauge length of a tensile specimen, or the notch of an impact specimen shall be at least 1/4 thickness from the ends of the test coupon.

4.4.1.3 Test specimens taken from sacrificial production parts shall be removed from the center core, 1/4 thickness envelope location of the thickest section of the part.

4.4.2 Size and Shape of Qualification Test Coupon

Geometry cast test coupons shall conform to ASTM A1067.

4.5 Casting Qualification Testing

4.5.1 Examination Procedure

All examinations and testing described in this section and summarized in Table 4 shall apply to the qualification casting and its QTC(s), as applicable.

Table 5—Summary of Qualification Examination/Testing Requirements

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CSL	Visual	Inspection	Hardness	Surface	Volumetric NDE	Mechanica I	Micro-structure	Chemistry	Additional Testing
	CSL-1	4.5.2	4.5.3	4.5.4	—	—	4.5.6	—	4.5.8
CSL-2	4.5.2	4.5.3	4.5.4	4.5.5.1 4.5.5.2	—	4.5.6	—	4.5.8	4.5.9 Group D
CSL-3	4.5.2	4.5.3	4.5.4	4.5.5.1 4.5.5.2	4.5.5.3	4.5.6	4.5.7	4.5.8	4.5.9 Group D

4.5.2 Visual Examination

4.5.2.1 Surfaces of the qualification casting shall be visually inspected and shall be in accordance with MSS SP-55, No internal chills or permanent metal chaplets are allowed. Chaplets or core supports made of molding media shall be permitted. In the instance where these molding media chaplets are used, the hole remaining in the casting wall shall be welded and the requirements for repair welding shall apply. Results shall be documented.

4.5.3 Casting Dimensional Inspection

The casting manufacturer shall identify critical dimensions, critical areas or features, and the acceptance criteria in the casting manufacturer's MPS. Results shall be documented.

4.5.4 Hardness Testing

When required, Brinell and/or Rockwell hardness testing shall be in accordance with ASTM E10, ISO 6506-1, ASTM E110, ASTM E18 or ISO 6508-1 shall be performed on the external surfaces of each qualification casting within the CSL, weight range and material group, to ensure the casting is within the specified limits for the finished product.

A minimum of three (3) locations per casting shall be required and shall be averaged. When NACE MR 0175/ISO 15156 is specified, the restrictions for averaging hardness values shall apply. The casting manufacturer shall specify the number indentations and location for the tests in the MPS. Results shall be documented.

4.5.5 Nondestructive Examination

4.5.5.1 Magnetic Particle Examination

All accessible surfaces of each ferromagnetic casting shall be magnetic particle inspected per Table 6. The acceptance criteria shall conform to Table 6. Results shall be documented.

4.5.5.2 Liquid Penetrant Examination

All accessible surfaces of each nonferromagnetic casting shall be liquid penetrant inspected in conformance with Table 6. The acceptance criteria shall be as specified in Table 6 and results shall be documented.

Table 6—Surface Examination Acceptance

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API SPECIFICATION 20A

Relevant Indication	Surface-rupture NDE indication with major dimensions greater than 1/16 in. (1.6 mm)
Nonrelevant Indication	Inherent indications not associated with a surface rupture (i.e., magnetic permeability nonmetallic stringers)
Linear Indication	Any indication in which the length is equal to or greater than three (3) times the width
Rounded Indication	Any indication that is circular or elliptical with its length less than three (3) times the width
Magnetic Particle Examination	<p>a) sampling: All accessible surfaces of each part shall be magnetic-particle inspected after final heat treatment.</p> <p>b) test method: Magnetic particle examinations shall be per ASME BPVC Sec VIII-Div.1, Appendix 6.</p> <p>c) acceptance criteria: Acceptance standards shall be as given in ASME BPVC Sec VIII-Div. 1, Appendix 7.</p>
Liquid Penetrant Examination	<p>a) sampling: All accessible surfaces of each part shall be liquid-penetrant inspected after final heat treatment.</p> <p>b) test method: Liquid-penetrant examinations shall be per ASME BPVC Sec. VIII, Div.1 Appendix 8.</p> <p>c) acceptance criteria: Acceptance standards shall be as given in ASME BPVC Sec VIII-Div. 1, Appendix 7.</p>

4.5.5.3 Volumetric Examination

4.5.3.1 General

As far as practical, the entire volume of each casting shall be volumetrically inspected (radiography or ultrasonic) after final heat treatment for mechanical properties.

4.5.3.2 Radiographic Examination

Radiographic examinations shall be performed in accordance with Table 7. The acceptance criteria shall be as specified in Table 7. Results shall be documented.

NOTE The first number of the quality level designation refers to the image quality indicator or penetrometer thickness expressed as a percentage of the specimen thickness; the second number refers to the diameter of the image quality indicator hole necessary to be able to see on the radiograph, expressed as a multiple of penetrometer thickness.

4.5.3.3 Ultrasonic Examination

Ultrasonic examination of castings shall be performed in conformance with Table 7. The acceptance criteria shall conform to Table 7. Results shall be documented.

Table 7—Volumetric Examination Acceptance Criteria

<p>Radiography</p>	<p>Sampling: As far as practical, the entire volume of each part shall be volumetrically inspected (radiography or ultrasonic) after heat treatment.</p> <p>Test method: Radiographic examinations shall be performed in accordance with the procedures specified in ASME Section V, Article 2, with a minimum sensitivity of 2 % (2-2 T).</p> <p>Both X-ray and gamma ray sources are acceptable within the inherent thickness range limitation of each. Real-time imaging and recording/enhancement methods may be used, provided the designated hole image quality indicator or essential wire is displayed as required by ASME Section V, Article 2.</p> <p>Acceptance criteria:</p> <p>ASTM E186, <i>Standard Reference Radiographs for Heavy-Walled (2 to 4¹/₂ in. (50.8 to 114 mm)) Steel Castings</i></p> <p>ASTM E280, <i>Standard Reference Radiographs for Heavy-Walled (4¹/₂ to 12 in. (114 to 305 mm)) Steel Castings</i></p> <p>ASTM E446, <i>Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness</i></p> <p>Maximum defect classification as follows:</p> <table border="0" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;"><u>Defect Type</u></th> <th style="text-align: center;"><u>Maximum Defect Class</u></th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">A</td> <td style="text-align: center;">2</td> </tr> <tr> <td style="text-align: center;">B</td> <td style="text-align: center;">2</td> </tr> <tr> <td style="text-align: center;">C</td> <td style="text-align: center;">2 (All types)</td> </tr> <tr> <td style="text-align: center;">D</td> <td style="text-align: center;">None acceptable</td> </tr> <tr> <td style="text-align: center;">E</td> <td style="text-align: center;">None acceptable</td> </tr> <tr> <td style="text-align: center;">F</td> <td style="text-align: center;">None acceptable</td> </tr> <tr> <td style="text-align: center;">G</td> <td style="text-align: center;">None acceptable</td> </tr> </tbody> </table>	<u>Defect Type</u>	<u>Maximum Defect Class</u>	A	2	B	2	C	2 (All types)	D	None acceptable	E	None acceptable	F	None acceptable	G	None acceptable
<u>Defect Type</u>	<u>Maximum Defect Class</u>																
A	2																
B	2																
C	2 (All types)																
D	None acceptable																
E	None acceptable																
F	None acceptable																
G	None acceptable																
<p>Ultrasonic</p>	<p>Sampling: As far as practical, the entire volume of each part shall be volumetrically inspected (radiography or ultrasonic) after heat treatment.</p> <p>Test method: Ultrasonic examinations of castings shall be performed in accordance with the flat bottom hole procedures specified in ASTM A609 (except immersion method may be used) and ASTM E127.</p> <p>Calibration: The distance amplitude curve (DAC) shall be based on a maximum 1.6 mm (1 /16 in.) flatbottom hole (straight-beam technique) for metal thicknesses through 38 mm (1 1/2 in.), on a maximum 3.2 mm (1 /8 in.) flat-bottom hole for metal thicknesses from 38 mm (1 1/2 in.) through 150 mm (6 in.), and on a maximum 6.4 mm (1 /4 in.) flat-bottom hole for metal thicknesses exceeding 150 mm (6 in.).</p> <p>Acceptance criteria:</p> <ul style="list-style-type: none"> -no single indication exceeding reference DAC — no multiple indications exceeding 50 % of reference DAC; multiple indications are defined as two or more indications (each exceeding 50 % of the reference DAC) within 13 mm (1 /2 in.) of each other in any direction. 																

4.5.3.4 Examination Results

All volumetric examination results shall be documented.

4.5.6 Mechanical Testing

4.5.6.1 The mechanical tests required by this specification shall be performed on the qualification casting or its qualification test coupons representing the heat and heat treatment lot used in the manufacture of the casting. For the purposes of material qualification testing, stress relief following welding is not considered heat treatment, provided that the PWHT temperature is below that which changes the heat-treated condition of the base material. Weld repair is not permitted on test coupons. If a sacrificial casting is being tested, all testing shall be performed after any weld repair is completed.

4.5.6.2 Tensile test specimens shall be tested in accordance with ASTM A370, ASTM E8 or ISO 6892-1, using material in the final heat treated condition. Mechanical properties shall be in accordance with the material specification used. The results shall be documented.

4.5.6.3 Charpy V-Notch (CVN) impact specimens shall be tested in accordance with ASTM A370, ASTM E23 or ISO 148-1, using material in the final heat treated condition. When using ISO 148-1, a striker with a radius of 8 mm shall be used.

NOTE: Refer to ISO 148-1 for further details.

4.5.6.4 CVN test temperature and acceptance criteria shall be in accordance with the material specification used. At the option of the casting manufacturer, CVN tests may be performed on material not requiring impact testing. Test specimen removal shall be in accordance with 4.4. The results shall be documented.

4.5.7 Microstructure Examination

4.5.7.1 Prepare a micro-specimen from the grip end of one of the tensile specimens by making a transverse cut through the center of the grip end of one of the tensile specimens.

4.5.7.2 Provide a photomicrograph of the as-polished, un-etched specimen at 100x for carbon, and alloy steel. For stainless steel, duplex steel and corrosion resistant alloy (CRA), provide a photomicrograph taken at 400x or greater magnification. Results shall be documented.

4.5.7.3 Etch the specimen using the appropriate reagent. Provide a photomicrograph of the etched specimen at 100x showing the typical microstructure. For stainless steel and duplex steel, provide a photomicrograph taken at 400x or greater magnification showing the typical microstructure. Any anomalies such as intermetallic and/or heavy precipitates or carbides in the grain boundaries, inhomogeneous structure, or un-tempered structure, shall be reported. Results shall be documented.

4.5.7.4 Grain size for material group A and B shall be determined in conformance with ASTM E112. Photomicrographs of grain size shall be taken. Results shall be documented.

4.5.8 Chemical Analysis

4.5.8.1 The casting manufacturer shall specify the nominal chemical composition, including composition tolerances, of the material used for the qualification casting.

4.5.8.2 Material composition shall be determined on a heat basis (or on a remelt-ingot basis for remelt-grade materials), in accordance with a nationally or internationally recognized standard.

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4.5.8.3 An analysis of each heat shall be made by the foundry in conformance with the nationally or internationally recognized chemical analysis procedure referenced in the applicable material standard, to determine the percentages of the specified elements. If a nationally or internationally recognized procedure is not referenced in the applicable material standard, the manufacturer shall use a nationally or internationally recognized chemical analysis procedure. The analysis shall be made from a test sample, preferably taken during the pouring of the ladle. When drillings are used, they shall be taken not less than 1/4 in. (6.4 mm) beneath the surface. The chemical composition thus determined shall be documented and shall conform to the requirements in the individual specification for the grade being poured.

4.5.9 Group D—Duplex Material Testing

Duplex stainless steels shall be in accordance with ISO 17781 for the following.

- Microstructural examination
- Ferrite content measurement
- CVN impact toughness test (QL II)
- Corrosion test

4.6 Acceptance of the Qualification Casting

4.6.1 Results of the examinations specified in Table 4 shall conform to the acceptance criteria specified in 4.5.2.2, Table 5 and Table 6, and the casting manufactures MPS procedures. Results shall be documented.

4.6.2 Qualification castings failing to satisfy the acceptance criteria shall be cause for re-evaluation of foundry practice and the casting design. Requalification is required. Results shall be documented.

4.6.3 Records of Qualification

The following records shall be required, at a minimum, to document qualification of the casting:

- a) Heat/heat lot number, material specification, and actual chemistry with minimum and maximum tolerances and cleanliness (if applicable).
- b) Casting parameters such as molding media, wash type (if applicable), melt practice, ladle refining (if applicable), and tap temperature, pouring temperature.
- c) Heat treatment, including PWHT, parameters such as specification, ramp rate, temperature, total time at temperature, cooling rate, and/ or cooling media, time to quench (if applicable), heat treat equipment used, actual heat treatment chart.
- d) Test records, records of the examinations (NDE), mechanical testing, and metallographic evaluations, as all other records required in this specification.
- e) Weld maps for major weld repair.

4.7 Limits of Casting Qualifications

Requalification of qualification castings shall be performed based on the requirements of the limited by CSL (see 4.8.1-4.8.3) specified in Table 7

Table 7—Limits of CSL Qualification Summary

Requirement	Reference(s)	CSL 1	CSL 2	CSL 3
Change in material group	4.8.1	X	X	X
As-cast weight range class	4.8.2	—	X	X
Change in melt refining practice	4.8.3	—	X	X

4.8.1 CSL-1

A change in the material group as shown in Table 2 from the casting that was previously qualified shall require requalification.

4.8.2 CSL-2

4.8.2.1 Qualification requirements specified for CSL-1 shall apply to CSL-2.

4.8.2.2 A change in the as-cast weight range class as shown in Table 1 from the casting that was previously qualified shall require requalification.

4.8.2.3 When metal-refining steps, such as argon oxygen de-carburization (AOD) or ladle refining, are used to produce the qualification casting, the elimination of any of these steps from the melting/casting practice shall require requalification.

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4.8.3 CSL-3

4.8.3.1 Qualification requirements specified for CSL-2 shall apply to CSL-3.

5 Production Castings

5.1 General

Castings, including sample castings, shall be produced in conformance with the manufacturing process specification (MPS) specified in 5.2 and conform to the limits specified in Table 9.

NOTE See Informative Annex A for CSL-4 Casting requirements.

5.2 Manufacturing Process Specification (MPS)

The casting manufacturer shall prepare an MPS, to include, at a minimum, allowable levels for all casting parameters, including the process control variables listed in 5.3.1 and the heat treatment parameters listed in 5.3.2. As part of the MPS, pattern equipment and rigging shall be documented and made available for review.

5.3 Process Control Variables

5.3.1 General Variables and Requirements

The following shall be process variables and other essential elements of the production of castings:

- a) pattern equipment.
- b) core equipment.
- c) sand/wax/ceramic control
- d) mold/core equipment maintenance.
- e) rigging design documented.
- f) molding parameters defined, such as sand and wash type, dipping sequence for investment.
- g) chaplets are used to support the mold during metal pouring, and their location.
- h) metal charge control
- i) melt practice, including pouring temperature.
- j) molds preheat (if applicable).
- k) cleaning room practices.
- l) welding repair, if required, including PWHT.
- m) NDE and inspection procedures.

- n) material traceability system.
- o) qualification casting and its qualification test coupon per heat.
- p) chemical analysis.
- q) mechanical properties.
- r) hardness testing.
- s) microstructural examination and additional testing, as applicable.

5.3.2 Heat treating parameters

The following are heat treating parameters, as applicable:

- a), test coupons shall be from the same heat as the components they qualify and shall be heat treated together with the components.
- b) furnace loading diagram and orientation of parts.
- c) temperatures and times for all individual heat treating cycles.
- d) casting configuration and dimensions at time of heat treatment.
- e) quenching medium and type of agitation (water/polymer, forced, horizontal or vertical quench, ID/OD, etc.).
- f) loading temperature.
- g) heating rate.
- h) holding temperature.
- i) holding time.
- j) cooling medium.
- k) time to quench.
- l) furnace chart(s).
- m) maximum quench media temperature at the start and end of quenching.

5.4 Sample Casting

5.4.1 General

Sample castings verify the casting technique used to fulfill the production casting requirements.

NOTE 1 Exceeds the requirements of a standard production casting.

Requirements only apply to raw castings.

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Casting(s) made and tested as part of the initiation and development of the production method.

NOTE 2 The first casting(s) from a new pattern using the identical foundry practice, i.e., risering, gating, chilling, coring, and molding as the production castings it is intended to represent.

The casting manufacturer shall produce a sample casting(s) and obtain approval from the purchaser. The casting manufacturer shall perform all required tests and examinations and certify that the sample casting(s) meets the requirements of this specification.

At the discretion of the purchaser, the first production order of castings may be considered the qualification or sample. In this case, at least one of the castings shall be processed as a sample by the casting manufacturer.

5.4.2 Definition of a Sample Casting

A casting shall be deemed a "sample" in one or more of the following instances:

- a) first use of a pattern.
- b) a pattern is re-rigged.
- c) a new pattern is made.
- d) a pattern is revised.
- e) a change in processing (i.e., core making, sand/wax/ceramic control, melt practice).
- f) a pattern received from another foundry.
- g) A change in material group

5.4.3 Evaluation of Sample Castings

5.4.3.1-Dimensional inspection shall be performed in accordance with the purchaser's drawings.

5.4.3.2 Visual examination shall be performed in accordance with the purchaser's specification, if provided. No internal chills or permanent metal chaplets shall be allowed. Chaplets or core supports made of molding media shall be permitted as agreed upon between the casting manufacturer and purchaser. In the instance where these molding media chaplets are used, the hole remaining in the casting wall shall be welded. If the purchaser does not provide requirements for visual examination, visual examination shall be performed as specified in 4.5.2.

5.4.3.3 Magnetic particle examination of ferromagnetic castings shall be performed in accordance with the purchaser's specification, if provided. If the purchaser does not provide requirements for magnetic particle examination, magnetic particle examination shall be performed as specified in 4.5.5.1.

5.4.3.4 Liquid-penetrant particle examination of nonferromagnetic castings shall be performed in accordance with the purchaser's specification, if provided. If the purchaser does not provide requirements for liquid-penetrant examination, liquid-penetrant examination shall be performed as specified in 4.5.5.2.

5.4.3.5 Volumetric examination shall be performed in accordance with the purchaser's specification, if provided. If the purchaser does not provide requirements for volumetric examination, the examination shall be performed as specified in 4.5.5.3.

5.4.3.6 Brinell and/or Rockwell hardness testing shall be performed in accordance with ASTM E10, ISO 6506-1, ASTM E110, ASTM E18 or ISO 6508-1. Hardness test locations shall be as specified in the purchaser's specification. If the purchaser does not provide hardness test locations, testing shall be as specified in 4.5.4.

5.4.3.7 Mechanical testing shall be performed as specified in 4.5.6.

5.4.3.8 Chemical analysis shall be performed as specified in 4.5.8.

5.4.3.9 Material testing for Group D material shall be performed as specified in 4.5.9.3.

5.4.4 Sample Casting Acceptance

Upon completion of all required examinations and tests, results shall be sent to the purchaser for approval. Subsequent castings shall require be approved by the purchaser.

5.5 Design and Maintenance of Pattern Equipment

5.5.1 Design

NOTE The foundry may use casting simulation software in developing the rigging and gating system to enhance the casting quality.

Records of the simulation analysis and revisions shall be maintained as objective evidence that the casting design was validated.

5.5.1.1 Design of patterns /tooling/dies and cores used to produce castings in accordance with this specification shall include documentation of those designs. This documentation as related to patterns shall include, as applicable:

- design requirements.
- assumptions.
- analysis methods.
- comparison with previous designs or operating history of similar products.
- calculations.
- manufacturing drawings and specifications.
- design reviews.
- physical testing results (such as design validation testing).

5.5.1.2 Design documentation for patterns shall be reviewed by a qualified person.

5.5.1.3 Design documents and data for patterns shall be maintained for ten years after the date of last manufacture of that casting.

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5.5.2 Maintenance

Maintenance of patterns and related equipment shall be conducted in accordance with documented procedures. Records of maintenance shall be kept.

5.5.3 Allowable Design Changes

Design changes shall be documented and reviewed by the casting manufacturer against the design documents to determine if the change is a substantive change.

All substantive design changes shall be documented, reviewed, and approved by a qualified person before their implementation, and shall continue to meet the applicable requirements of this specification. When required by purchase order, all substantive design changes shall be approved by the purchaser.

5.6 Inspection, Quality Control, Marking

5.6.1 Calibration

Equipment used to inspect, test, or examine material or other equipment used for acceptance or control of the process shall be identified, controlled, calibrated, and adjusted at specified intervals in accordance with documented foundry instructions, and consistent with nationally or internationally recognized standards specified by the manufacturer, to maintain the accuracy required by this specification.

5.6.2 Furnace Calibration

Heat treatment furnaces shall have a temperature uniformity survey performed in accordance with API 20H-HSL 1, API 6A, API 6D, or AMS 2750. Furnace instrumentation shall be calibrated at least once every three months. Records of furnace calibration shall be maintained in accordance with API 20H.

5.6.3 Nondestructive Examination (NDE)

5.6.3.1 NDE shall be performed as specified in the purchasing documents.

5.6.3.2 NDE personnel shall be qualified in accordance with the manufacturer's documented training program that is based on and meets the minimum requirements specified in ASNT SNT-TC-1A, or ISO 9712, Level 2, minimum for evaluation and interpretation.

NOTE Alternative standards are acceptable, provided they meet the minimum requirements of ASNT SNT-TC-1A.

5.6.3.3 NDE procedures shall be detailed regarding the requirements of this specification and those of all applicable nationally or internationally recognized standards specified herein. All NDE procedures shall be approved by a qualified level III in accordance with ASNT SNT-TC-1A, or ISO 9712.

5.6.4 Dimensional Inspection

Dimensional inspection shall be performed on products produced to this specification. Sampling shall be in accordance with ANSI /ASQZ1.4 or ISO 2859-1, Level II, 1.5 AQL, with c equals 0. The casting manufacturer shall verify critical dimensions. Critical dimensions and acceptance criteria shall be as required by the purchaser's specification.

5.6.5 Welding

5.6.5.1 Welding and welding repair shall be performed in accordance with the following:

- a) Welding shall be performed using weld procedures and personnel qualified in accordance with:
- CSL-1 and CSL-2—ASME BPVC, Section IX, ISO 15614-1, ISO 9606-1, AWS D1.1, ASTM A488/A488M, or equivalent standards.
 - CSL-3—ASME BPVC, Section IX, ISO 15614-1, or ISO 9606-1.
- b) Welding shall be performed by welders or welding operators qualified in accordance with specifications listed in item a).
- c) Welding consumables shall conform to the consumable manufacturer's specifications. The casting manufacturer shall have a written procedure for the storage and control of welding consumables.
- d) Materials of low-hydrogen type shall be stored and used as recommended by the welding consumable manufacturer to retain their original low-hydrogen properties.
- e) PWHT shall conform to the requirements of the foundry's approved weld procedure and where applicable, NACE MR 0175/ ISO 15156 (all parts).
- f) The welding repair area shall be re-examined by the NDE method that originally disclosed the defect following PWHT (when post-weld heat treatment is performed). The acceptance standards shall be as in the original examination.
- g) . The maximum allowable amount of welding repairs shall be in accordance with Table 8.
- h) Repair welding on duplex stainless steel shall be permitted provided that the ferrite content (volume fraction) is in accordance with ISO 17781. as part of the WPS and PQR.
- i) Major welding repairs shall be documented.

Table 8—Production Casting Weld Repair Limitations

CSL	% Total internal & External Surface Area	% Wall Thickness
CSL-1	50 %	75 %
CSL-2	25 %	65 %
CSL-3	20 %	50 %

5.6.6 Ferrite Inspection on Group D Material

5.6.6.1 A portable ferrite meter shall be used to test the casting at five randomly selected locations on the casting surface and exhibit a ferrite content of 35 % to 65 %.

5.6.6.2 The portable ferrite meter shall be used to test ferrite content at all locations where major welding repair is performed, and values shall be between 35 % and 65 %.

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5.6.7 Documentation

All documentation and records shall be required in conformance with this specification.

5.7 Limits on the Qualification of Production Castings by CSL

Table 9 shall apply to the limits of a CSL (see 5.7.1-5.7.3) that shall require resampling of production castings.

Table 9—Limits of CSL Production Casting Summary

Requirement	Ref.	CSL 1	CSL 2	CSL 3
Change in material group	5.7.1.1	X	X	X
Revision or new pattern	5.7.1.2	X	X	X
Pattern is re-rigged	5.7.1.3	X	X	X
Change in risers or padding	5.7.1.3	X	X	X
Change in external chills	5.7.1.3	X	X	X
As-cast weight range class	5.7.2.2	—	X	X
Casting practice	5.7.2.3	—	X	X
Change in melt-refining practice	5.7.2.4	—	X	X

5.7.1 CSL-1

5.7.1.1 A change in material group as shown in Table 1 from the qualification casting shall require requalification.

5.7.1.2 A new sample casting shall be required when the pattern of the production casting is revised, or a new pattern is made.

5.7.1.3 A new sample casting shall be required when the pattern of the production casting is re-rigged, including padding, riser, and external chills.

5.7.2 CSL-2

5.7.2.1 Qualification requirements specified for CSL-1 shall apply to CSL-2.

5.7.2.2 A change in the as-cast weight range class as shown in Table 2 from the qualification casting shall require requalification

5.7.2.3 Requalification shall be required when the general casting practice is changed from the qualification casting practice, such as changing from an investment casting to a sand casting.

5.7.2.4 When metal refining steps, such as AOD or ladle refining, are used to produce the qualification casting, the elimination of any of these steps from the melting/casting practice used for production castings shall require requalification.

5.7.3 CSL-3

5.7.3.1 Qualification requirements specified for CSL-2 shall apply to CSL-3.

5.8 Traceability

5.8.1 Traceability of castings shall be maintained with respect to material heat, manufacturing procedure specification, and heat lot. All testing/inspections performed, and process parameters considered critical to the casting process.

5.8.2 Casting qualification records shall be traceable to the Manufacturing Process Specification (MPS).

5.8.3 Castings produced to this specification shall be traceable to the applicable casting qualification record.

5.9 Marking

5.9.1 Each casting shall be marked with the following:

- 1) casting manufacturers name, mark, or symbol.
- 2) pattern number or part number.
- 3) material grade.
- 4) 20A, CSL number, and material group.
- 5) Heat, heat lot, or traceability number.
- 6) Annex A CSL-4, when applicable.

See Table 10 for an example of the required marking(s).

Table 10—Example: Casting Marking

Casting Mark	Example
Casting manufactures name, mark, or symbol	ABC
Pattern number or part number	21179-01
Material grade	A995-6A
20A, CSL number, and material group	20A-2-D
Heat, heat lot, or traceability number	L424

5.9.2 Manufacturing drawings shall identify where stamping is permitted. The above marking listed in 5.9.1 shall be applied using cast-on or low-stress (dot, vibration, or rounded V) stamps or cast-on lettering. Conventional sharp V-

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stamping is acceptable in low-stress areas, such as raised pads designed for stamping. Sharp V-stamping is not permitted in high-stress areas.

5.9.3 All markings that are required by this specification shall be legible.

5.9.4 Record Retention

The casting manufacturer shall establish and maintain documented procedures to control all documents and data required by this specification. Records required by this specification, unless otherwise specified herein, shall be maintained for 10 years from the date of shipment.

Documents and data shall be in any type of media (hard copy or electronic)

Documents shall be:

- legible.
- retained and readily retrievable.
- stored in an environment to prevent damage, deterioration, or loss.
- available and auditable by the purchaser.

5.10 Documentation Provided with the Castings

As a minimum, a certificate of conformance to this specification shall be supplied by the foundry. The certificate(s) shall identify the following.

1. product specification number
2. CSL,
3. material group,
4. part number/pattern number,
5. quantity,
6. All requirements of the purchase order have been met.
7. a statement that castings are in full conformance with this product specification edition and all addenda. Also, the foundry shall furnish the following.
- 8) Material test report (MTR) in conformance with EN-10204 Type 3.1 to include, at a minimum, melting practice, chemical analysis, heat treatment, mechanical properties, hardness, and microstructure results, as applicable.
- 9) NDE reports as required by Section 5 of this specification.

5.11 Handling, Storage, and Shipping

Castings shall be packaged for storage or transit in conformance with the written procedure of the casting manufacturer.

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Annex A (Informative)

CSL-4 Casting Requirements

A.1 General

A.1.1 This annex may be specified, in whole or in part, by the purchaser for castings when used for critical applications.

A.1.2 The requirements called out in this Annex are in addition to the requirements in the main body of this standard unless otherwise specified in prior editions these requirements were in the main body of the specification.

A.2 CSL-4 Qualification Casting Requirements

A.2.1 In addition to the Qualification requirements in Section 4, additional testing in this section shall be performed.

A.2.2 Qualification requirements specified for CSL-3 shall apply to CSL-4

A.2.3 Weight ranges are not applicable to qualification for CSL-4 as each casting shall require qualification.

Requirements for qualification examination/testing for CSL4 shall be performed based on the requirements specified in Table A.1

Table A.1—Guidance for Qualification Examination/Testing Requirements

CSL	Section References									
	Visual	Inspection	Hardness	Surface	Volumetric NDE	Mechanical	Micro-structure	Sacrificial Casting	Chemistry	Additional Testing
CSL-4	4.5.2	4.5.3	4.5.4	4.5.5.1 4.5.5.2	4.5.5.3	4.5.6	4.5.7	A.2.4	4.5.8	4.5.9 Group D

A.2.4 Sacrificial Casting—CSL-4

A casting prepared in accordance with 4.3 shall serve as a test piece for the following:

A.2.4.1 Section the casting into four approximately equally sized quadrants.

A.2.4.2 Visually inspect all surfaces of each quadrant for cracks, voids, porosity, or other anomalies. Photograph all anomalies of each surface.

A.2.4.3 Liquid penetrant examination shall be of the cut surface of each quadrant per ASTM E165 and document results.

A.2.4.4 Macro-etch one quadrant shall be in accordance with ASTM E340 to show the grain structure and internal quality. The surface closest to the centerline shall be used. Photographs shall be taken with a

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measurement scale visible to provide size reference. Any indications noted shall be clearly marked for later evaluation.

A.2.4.5 A set of hardness traverses shall be made across the cut surface of one quadrant taken 90 degrees to each other. The hardness and specific locations shall be documented A photograph shall also be taken.

A.2.4.6 Groups D and E, (Duplex Alloys and Ni-based Alloys), castings shall have an integral cast test coupon per 4.4.2. For section size smaller than 2 in. (50mm), the test coupon shall be removed at T/2.

A.2.5 CSL-4 Requalification castings Requirements

A.2.5.1 Qualification requirements specified for CSL-3 shall apply to CSL-4.

A.2.5.2 A change in the specific material specification/grade from the casting that was previously qualified shall require requalification of the casting as specified in Table A.2.

Table A.2—Limits of CSL-4 Qualification Summary

Requirement	Reference(s)	CSL 1	CSL 2	CSL 3	CSL-4
Change in material group	4.8.1	X	X	X	X
As-cast weight range class	4.8.2	—	X	X	—
Change in melt refining practice	4.8.3	—	X	X	X
Material specification/grade	4.8.4	—	—	—	X

NOTE 1: This table provides a matrix of requirements and should be used as a reference only, since it may not include all requirements.

NOTE 2: CSL-4 is independent of Weight Range as all castings require qualification.

A.2.6 Repair welding for CSL-4 qualification castings shall conform to the requirements in the main body of the standard and the limitations specified in Table A.3

Table A.3—Qualification Casting Weld Repair Limitations

CSL	% Surface Area	% Wall Thickness
CSL-4	10 %	10 %

A.3 CSL-4 Production Castings

A.3.1 Castings shall an internationally recognized QMS such as Q1 or ISO 9001.

conform to the manufacturing process specification (MPS) established for the Qualification casting. (See 5.2).

A.3.2 Welding performed on production castings shall be limited to the requirements of the main body of this specification and the requirements specified in Table A.4.

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Table A.4—Production Casting Weld Repair Limitations

CSL	% Surface Area	% Wall Thickness
CSL-4	10 %	10 %

A.3.3 CSL-4 Production Requalification Requirements

A.3.3.1 A change in the specific material specification/grade from the qualification casting shall require requalification in accordance with Section 4 and this annex.

A.3.3.2 Requalification in accordance with Section 4 and this annex shall be required when, within a Material Group (Table 2), there is a change in the material type where a specified element's tolerance changes by 15 %.

Example: If a qualification casting is made from ASTM A351 – Grade CF3 with 0.50 maximum molybdenum, and a production casting is to be made from ASTM A351 – CF3M with a molybdenum range of 2.0 % to 3.0 %, requalification is required.

A.3.3.3 Changes to the casting process or materials noted in Table A.5 shall require requalification of the casting process. Limits of a CSL that shall require requalification of production castings shall conform to the requirements specified in Table A.5.

Table A.5—Limits of CSL Production Casting Summary

Requirement	Ref.	CSL 1	CSL 2	CSL 3	CSL-4
Change in material group	5.7.1.1	X	X	X	X
Revision or new pattern	5.7.1.2	X	X	X	X
Pattern is re-rigged	5.7.1.3	X	X	X	X
Change in risers or padding	5.7.1.3	X	X	X	X
Change in external chills	5.7.1.3	X	X	X	X
As-cast weight range class	5.7.2.2	—	X	X	—
Casting practice	5.7.2.3	—	X	X	X
Chemistry tolerance outside the UNS range by greater than 15 %	5.7.4.3	—	—	—	X
Change in melt-refining practice	5.7.2.4	—	X	X	X
Material specification/grade	5.7.4.2	—	—	—	X

NOTE 1: This table provides a matrix of requirements and should be used as a reference only since it may not include all requirements.

NOTE 2: This Table is the same as Table 9 except the CSL-4 requirements have been added.

NOTE 3: CSL-4 is independent of weight range as all castings require qualification.

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