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PART UCI
REQUIREMENTS FOR PRESSURE VESSELS CONSTRUCTED OF CAST IRON

GENERAL

UCI-1 SCOPE

The rules in Part UCI are applicable to pressure vessels and vessel parts that are constructed of cast iron, cast nodular iron having an elongation of less than 15% in 2 in. (51 mm), or of cast dual metal (see UCI-23 and UCI-29) except standard pressure parts covered by UG-11(b), and shall be used in conjunction with the general requirements in Subsection A insofar as these requirements are applicable to cast material.

UCI-2 SERVICE RESTRICTIONS

Cast iron vessels shall not be used for services as follows:

(a) to contain lethal[1] or flammable substances, either liquid or gaseous;

(b) for unfired steam boilers as defined in U-1(g);

(c) for direct firing [see UW-2(d)].

UCI-3 PRESSURE–TEMPERATURE LIMITATIONS

(a) The design pressure for vessels and vessel parts constructed of any of the classes of cast iron listed in Table UCI-23 shall not exceed the following values except as provided in (b) and (c) below:

(1) 160 psi (1100 kPa) at temperatures not greater than 450°F (232°C) for vessels containing gases, steam, or other vapors;

(2) 160 psi (1100 kPa) at temperatures not greater than 375°F (191°C) for vessels containing liquids;

(3) 250 psi (1720 kPa) for liquids at temperatures less than their boiling point at design pressure, but in no case at temperatures exceeding 120°F (49°C);

(4) 300 psi (2070 kPa) at temperatures not greater than 450°F (232°C) for bolted heads, covers, or closures that do not form a major component of the pressure vessel.

(b) Vessels and vessel parts constructed of stress relieved material conforming to Classes 40 through 60 of SA-278 may be used for design pressures up to 250 psi (1720 kPa) at temperatures up to 650°F (343°C), provided the distribution of metal in the pressure containing walls of the casting is shown to be approximately uniform.

(c) Vessels and vessel parts constructed of stress relieved material conforming to SA-476 may be used for design pressures up to 250 psi (1720 kPa) at temperatures up to 450°F (232°C).

(d) Cast iron flanges and flanged fittings conforming to ASME/ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings, Classes 125 and 250 may be used in whole or in part of a pressure vessel for pressures not exceeding the American National Standard ratings at temperatures not exceeding 450°F (232°C).

MATERIALS

UCI-5 GENERAL

All cast iron material subject to stress due to pressure shall conform to one of the specifications given in Section II and shall be limited to those listed in Table UCI-23 except as otherwise provided in UG-11.

UCI-12 BOLT MATERIALS

The requirements for bolts, nuts, and washers shall be the same as for carbon and low alloy steels in UCS-10 and UCS-11.

[1] By "lethal substances" are meant poisonous gases or liquids of such a nature that a very small amount of the gas or of the vapor of the liquid mixed or unmixed with air is dangerous to life, when inhaled. For purposes of this Division, this class includes substances of this nature which are stored under pressure or may generate a pressure if stored in a closed vessel.

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TABLE UCI-23
MAXIMUM ALLOWABLE STRESS VALUES IN TENSION FOR CAST IRON

Spec. No.	Class	Specified Min. Tensile Strength, ksi (MPa)	Maximum Allowable Stress, ksi (MPa), for Metal Temperature Not Exceeding		Ext. Press. Chart Fig. No. [Note (1)]
			450°F (232°C) and Colder	650°F (343°C)	
SA-667	...	20 (138)	2.0 (13.8)	...	CI-1
SA-278	20	20 (138)	2.0 (13.8)	...	CI-1
SA-278	25	25 (172)	2.5 (17.2)	...	CI-1
SA-278	30	30 (207)	3.0 (20.7)	...	CI-1
SA-278	35	35 (241)	3.5 (24.1)	...	CI-1
SA-278	40	40 (276)	4.0 (27.6)	4.0 (27.6)	CI-1
SA-278	45	45 (310)	4.5 (31.0)	4.5 (31.0)	CI-1
SA-278	50	50 (345)	5.0 (34.5)	5.0 (34.5)	CI-1
SA-47	(Grade 3-2510)	50 (345)	5.0 (34.5)	5.0 (34.5)	CI-1
SA-278	55	55 (379)	5.5 (37.9)	5.5 (37.9)	CI-1
SA-278	60	60 (414)	6.0 (41.4)	6.0 (41.4)	CI-1
SA-476	...	80 (552)	8.0 (55.2)	...	CI-1
SA-748	20	16 (110)	1.6 (10.0)	...	CI-1
SA-748	25	20 (138)	2.0 (13.8)	...	CI-1
SA-748	30	24 (165)	2.4 (16.5)	...	CI-1
SA-748	35	28 (179)	2.8 (17.9)	...	CI-1

NOTE:
(1) Figure CI-1 is contained in Subpart 3 of Section II, Part D.

DESIGN

UCI-16 GENERAL

The rules in the following paragraphs apply specifically to the design of pressure vessels and pressure vessel parts of cast iron and shall be used in conjunction with the general requirements for *Design* in Subsection A, insofar as these requirements are applicable to cast materials.

For components for which the Code provides no design rules, the provisions of UG-19(b) and (c) apply. If a proof test is performed, the rules of UCI-101 apply.

UCI-23 MAXIMUM ALLOWABLE STRESS VALUES

(a) Table UCI-23 gives the maximum allowable stress values in tension at the temperatures indicated for castings conforming to the specifications listed therein. For dual metal cylinders conforming to SA-667 or SA-748, the maximum calculated stress, including all applicable loadings of UG-22, shall not exceed the allowable stress given in Table UCI-23 computed on the basis of the gray cast iron thickness of the cylinder.

(b) The maximum allowable stress value in bending shall be $1\frac{1}{2}$ times that permitted in tension, and the maximum allowable stress value in compression shall be two times that permitted in tension.

UCI-28 THICKNESS OF SHELLS UNDER EXTERNAL PRESSURE

(a) Cylindrical and spherical shells under external pressure shall be designed by the rules in UG-28, using the applicable figures in Subpart 3 of Section II, Part D and the temperature limits of UG-20(c).

(b) Examples illustrating the use of the charts in the figures for the design of vessels under external pressure are given in Appendix L.

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UCI-29 DUAL METAL CYLINDERS

The minimum wall thickness of dual metal cylinders conforming to SA-667 or SA-748 shall be 5 in. (127 mm), and the outside diameter of such cylinders shall not exceed 36 in. (914 mm).

UCI-32 HEADS WITH PRESSURE ON CONCAVE SIDE

Heads with pressure on the concave side (plus heads) shall be designed in accordance with the formulas in UG-32 using the maximum allowable stress value in tension.

UCI-33 HEADS WITH PRESSURE ON CONVEX SIDE

The thickness of heads with pressure on the convex side (minus heads) shall not be less than the thickness required in UCI-32 for plus heads under the same pressure nor less than 0.01 times the inside diameter of the head skirt.

UCI-35 SPHERICALLY SHAPED COVERS (HEADS)

(a) Circular cast iron spherically shaped heads with bolting flanges, similar to Fig. 1-6 sketches (b), (c), and (d), shall be designed in accordance with the provisions in 1-6, except that corners and fillets shall comply with the requirements of UCI-37.

(b) Circular cast iron spherically shaped heads with bolting flanges other than those described in (a) above shall be designed in accordance with the following requirements.

(1) The head thickness shall be determined in accordance with the requirements in UG-32.

(2) The spherical and knuckle radii shall conform to the requirements in UG-32.

(3) Cast iron flanges and flanged fittings conforming to ASME/ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings, Classes 125 and 250 may be used in whole or in part of a pressure vessel for pressures not exceeding American National Standard ratings at temperatures not exceeding 450°F (232°C). Other flanges may be designed in accordance with the provisions of Appendix 2 using the allowable stress values in bending.

UCI-36 OPENINGS AND REINFORCEMENTS

(a) The dimensional requirements in UG-36 through UG-46 are applicable to cast iron and shall be used in the design of openings and reinforcements in pressure vessels and pressure vessel parts which are cast integrally with the vessel or vessel part. In no case shall the thickness of the reinforcement, including the nominal thickness of the vessel wall, exceed twice the nominal thickness of the vessel wall.

(b) Cast iron flanges, nozzles, and openings shall not be attached to steel or nonferrous pressure vessels or pressure parts by welding or brazing, nor shall they be considered to contribute strength to the vessel or part.

UCI-37 CORNERS AND FILLETS

A liberal radius shall be provided at projecting edges and in reentrant corners in accordance with good foundry practice. Abrupt changes in surface contour and in wall thickness at junctures shall be avoided. Fillets shall conform to the following.

(a) Fillets forming the transition between the pressure containing walls and integral attachments, such as brackets, lugs, supports, nozzles, flanges, and bosses, shall have a radius not less than one-half the thickness of the pressure containing wall adjacent to the attachment.

FABRICATION

UCI-75 GENERAL

The rules in the following paragraphs apply specifically to the fabrication of pressure vessels and vessel parts of cast iron and shall be used in conjunction with the general requirements for *Fabrication* in Subsection A insofar as these requirements are applicable to cast materials.

UCI-78 REPAIRS IN CAST IRON MATERIALS

(a) Imperfections which permit leakage in cast iron materials may be repaired by using threaded plugs provided:

(1) the vessel or vessel parts are to operate within the limits of UCI-3(a) or (b);

(2) no welding is performed;

(3) the diameter of the plug shall not exceed the diameter of a standard NPS 2 (DN 50) pipe plug;

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TABLE UCI-78.1

NPS Plug or Equivalent (DN)		Minimum Thickness of Repaired Section, in. (mm)	
1/8	(. . .)	11/32	(9)
1/4	(. . .)	7/16	(11)
3/8	(10)	1/2	(13)
1/2	(15)	21/32	(17)
3/4	(20)	3/4	(19)
1	(25)	13/16	(21)
1 1/4	(32)	7/8	(22)
1 1/2	(40)	15/16	(24)
2	(50)	1	(25)

TABLE UCI-78.2

NPS Plug or Equivalent (DN)		Minimum Radius of Curvature of Cylinder or Cone, in. (mm)	
1/8	(. . .)	9/16	(14)
1/4	(. . .)	11/16	(18)
3/8	(10)	1 1/16	(27)
1/2	(15)	1 1/4	(32)
3/4	(20)	2	(51)
1	(25)	2 1/2	(64)
1 1/4	(32)	4	(102)
1 1/2	(40)	5 1/4	(134)
2	(50)	8 1/8	(207)

(4) the plugs, where practical, shall conform in all dimensions to standard NPS pipe plugs, and in addition they shall have full thread engagement corresponding to the thickness of the repaired section. (See Table UCI-78.1.) Where a tapered plug is impractical because of excess wall thickness in terms of plug diameter and coincident thread engagement, other types of plugs may be used provided both full thread engagement and effective sealing against pressure are obtained. Where possible, the ends of the plug should be ground smooth after installation to conform to the inside and outside contours of the walls of the pressure vessel or pressure part;

(5) the material from which the plug is manufactured shall conform in all respects to the material specification which applies to the pressure vessel or pressure vessel part;

(6) the machined surface of the drilled or bored hole before tapping shall be free from visible defects and the adjacent metal shown to be sound by radiographic examination;

(7) the thickness of any repaired section in relation to the size of plug used shall not be less than that given in Table UCI-78.1;

(8) the minimum radius of curvature of repaired sections of cylinders or cones in relation to the size of plug used shall not be less than that given in Table UCI-78.2;

(9) the ligament efficiency between any two adjacent plugs shall not be less than 80% where

$$E = \frac{p - \left(\frac{d_1 + d_2}{2}\right)}{p}$$

and

E = ligament efficiency
p = distance between plug centers
d_1, d_2 = respective diameters of the two plugs under consideration

(10) the pressure vessel or pressure vessel part meets the standard hydrostatic test prescribed in UCI-99.

(b) Surface imperfections, such as undue roughness, which do not permit leakage in cast iron materials may be repaired using driven plugs provided:

(1) the vessel or vessel parts operate within the limits of UCI-3(a)(1), (2), or (4);

(2) no welding is performed;

(3) the material from which the plug is manufactured conforms in all respects to the material specification which applies to the pressure vessel or pressure vessel part;

(4) the depth of the plug is not greater than 20% of the thickness of the section and its diameter is not greater than the larger of 3/8 in. or 20% of the thickness of the section;

(5) the pressure vessel or pressure vessel part meets the standard hydrostatic test prescribed in UCI-99.

(c) Surface imperfections, such as undue roughness, which do not permit leakage in cast iron vessels that are to operate under the limits of UCI-3(a)(3) may be repaired under (a) or (b) above or by welding. Where welding is used, the weld and the metal adjacent to it shall be examined by either the magnetic particle or liquid penetrant method and shown to be free of linear indications.

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INSPECTION AND TESTS

UCI-90 GENERAL

The rules in the following paragraphs apply specifically to the inspection and testing of pressure vessels and vessel parts of cast iron and shall be used in conjunction with the general requirements for *Inspection and Tests* in Subsection A insofar as these requirements are applicable to cast material.

UCI-99 STANDARD HYDROSTATIC TEST

Cast iron pressure vessels shall be hydrostatically tested by the method prescribed in UG-99 except that the test pressure shall be two times the maximum allowable working pressure to be marked on the vessel for maximum allowable working pressures greater than 30 psi (207 kPa) and $2\frac{1}{2}$ times the maximum allowable working pressure but not to exceed 60 psi (414 kPa) for maximum allowable working pressure under 30 psi (207 kPa).

UCI-101 HYDROSTATIC TEST TO DESTRUCTION

(a) The maximum allowable working pressure of identical cast iron vessels or vessel parts, based on testing one of them to destruction, limited to the service conditions specified in UCI-3 and in accordance with UG-101(m) shall be

$$P_R = \frac{P_B}{6.67} \times \frac{\text{(Specified minimum tensile strength)}}{\text{(avg. tensile strength of test specimens)}}$$

where

P_R = maximum allowable working pressure at operating temperatures listed in Table UCI-23, psi (kPa)

P_B = destruction test pressure, psi (kPa)

The principle of UG-101(c) shall be followed.

NOTE: It is assumed that failure will occur in bending.

(b) The value of the average tensile strength of test specimens in the foregoing equation shall be determined from the test results of three test bars from the same ladle of iron as used in the part, or from three test specimens cut from the part.

(c) All vessels or vessel parts of the same material, design, and construction, whose maximum allowable working pressure is based on a test to destruction of a sample vessel in accordance with (a) above, shall be considered to have a design pressure equal to the maximum allowable working pressure thus determined, except as limited by the rules of UCI-3, and shall be subjected to a hydrostatic test pressure in conformity with the rules of UCI-99.

MARKING AND REPORTS

UCI-115 GENERAL

The provisions for marking and reports in UG-115 through UG-120 shall apply without supplement to vessels constructed of cast iron.

PRESSURE RELIEF DEVICES

UCI-125 GENERAL

The provisions for pressure relief devices in UG-125 through UG-136 shall apply without supplement to vessels constructed of cast iron.

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