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PART UCD
REQUIREMENTS FOR PRESSURE VESSELS CONSTRUCTED OF CAST DUCTILE IRON

GENERAL

UCD-1 SCOPE

The rules in Part UCD are applicable to pressure vessels and pressure vessel parts that are constructed of cast ductile iron,[1] and shall be used in conjunction with the general requirements in Subsection A insofar as these requirements are applicable to cast material.

UCD-2 SERVICE RESTRICTIONS

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

(a) to contain lethal[2] substances, either liquid or gaseous;

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

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

UCD-3 PRESSURE–TEMPERATURE LIMITATIONS

(a) The maximum design temperature shall not be higher than 650°F (343°C). The minimum design temperature shall not be less than −20°F (−29°C), and the design pressure shall not exceed 1000 psi (6900 kPa) unless the requirements in UG-24 for a casting quality factor of 90% are met, and the vessel contains liquids only.

(b) Cast ductile iron flanges and fittings covered by ASME/ANSI B16.42 may be used in whole or as a part of a pressure vessel at the pressure–temperature ratings listed in that standard.

NOTE: Cast ductile iron flanges and fittings conforming in dimension to the Class 125 and 250 American National Standard for cast iron flanges and fittings may be used in whole or as a part of a pressure vessel at the pressure–temperature ratings listed in ASME/ANSI B16.42, except that NPS $3\frac{1}{2}$ and smaller screwed and tapped flanges conforming in dimensions to the Class 125 ASME/ANSI B16.1 for cast iron flanged fittings shall have identical ratings specified in ASME/ANSI B16.1.

(c) Cast ductile iron flanges and fittings, Class 400 and higher, conforming in dimension to the carbon steel pipe flanges and flanged fittings in ASME/ANSI B16.5 may be used in whole or as a part of a pressure vessel at the pressure–temperature ratings for carbon steel, material category 1.4, in that standard provided the temperature is not less than −20°F (−29°C) nor greater than 650°F (343°C) and provided that the pressure does not exceed 1000 psi (6900 kPa).

MATERIALS

UCD-5 GENERAL

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

UCD-12 BOLT MATERIALS

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

[1] It is the intent that cast ductile irons with an elongation of less than 15% in 2 in. (51 mm) be treated as cast iron and that vessels or pressure parts of such material be designed and fabricated in accordance with the rules in Part UCI.

[2] 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 UCD-23
MAXIMUM ALLOWABLE STRESS VALUES IN TENSION FOR CAST DUCTILE IRON, ksi (MPa)

Spec. No.	Class	Note	Specified Min. Tensile Strength [Note (1)]	For Metal Temp., °F (°C) Not Exceeding –20 (–29) to 650 (343)	Ext. Pressure Chart Fig. No. [Note (2)]
SA-395	...	(1)	60 (414)	12.0 (82.7)	CD-1

GENERAL NOTE:
To these stress values, a quality factor as specified in UG-24 shall be applied.

NOTES:
(1) The yield stresses in compression and tension for cast ductile iron are not sufficiently different to justify an increase in the allowable stress for bending except as permitted in 2-8(a).
(2) Refer to Subpart 3 of Section II, Part D.

DESIGN

UCD-16 GENERAL

The rules in the following paragraphs apply specifically to the design of pressure vessels and pressure vessel parts of cast ductile 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 UCD-101 apply.

UCD-23 MAXIMUM ALLOWABLE STRESS VALUES

Table UCD-23 gives the maximum allowable stress values at the temperatures indicated for castings conforming to the Specification listed therein. These stress values shall be limited to the stress values in Table UCD-23 multiplied by the applicable casting quality factor given in UG-24.

UCD-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 charts in the figures for the design of vessels under external pressure are given in Appendix L.

UCD-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.

UCD-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 UG-33.

UCD-35 SPHERICALLY SHAPED COVERS (HEADS)

(a) Circular cast ductile 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 UCD-37.

(b) Circular cast ductile 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) Flanges made of cast ductile iron in compliance with SA-395 and conforming in dimensions to American National Standard for carbon steel given in ASME/ANSI B16.5 may be used at pressures not exceeding 80% of the pressures permitted in those standards at their listed temperatures provided the temperature is not less than −20°F (−29°C) nor greater than 650°F (343°C) and provided that the adjusted service pressure does not exceed 1000 psi (6900 kPa).

NOTE: Cast ductile iron flanges conforming in dimension to the 125 and 250 lb American National Standard for cast iron flanges may be used for pressures not exceeding 80% of the American National Standard pressure ratings for 150 lb and 300 lb carbon steel flanges, respectively, at their listed temperatures provided the temperature is not less than −20°F (−29°C) nor greater than 650°F (343°C), except as in Note to UCD-3(b).

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UCD-36 OPENINGS AND REINFORCEMENTS

(a) The dimensional requirements in UG-36 through UG-46 are applicable to cast ductile 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 ductile 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.

TABLE UCD-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)

UCD-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.

(1) 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.

(2) Transitions between pressure containing walls of different contours shall have a radius not less than three times the thickness of the thinner wall.

FABRICATION

UCD-75 GENERAL

The rules in the following paragraphs apply specifically to the fabrication of pressure vessels and pressure vessel parts of cast ductile 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.

UCD-78 REPAIRS IN CAST DUCTILE IRON MATERIAL

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

(1) the vessel or vessel parts operate within the temperature limits of UCD-3(a), and the design pressure does not exceed 1000 psi (6900 kPa);

(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;

(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 UCD-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 UCD-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 UCD-78.2;

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TABLE UCD-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)

(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 UCD-99.

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

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

(2) no welding is performed;

(3) 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;

(4) the depth of the plug is not greater than 20% of the thickness of the section and its diameter is not greater than its engaged length;

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

INSPECTION AND TESTS

UCD-90 GENERAL

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

UCD-99 STANDARD HYDROSTATIC TEST

Cast ductile iron pressure vessels and pressure vessel parts 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.

UCD-101 HYDROSTATIC TEST TO DESTRUCTION

(a) The maximum allowable working pressure of identical cast ductile iron vessels, based on testing one of them to destruction in accordance with UG-101(m), shall be

$$P_R = \left(\frac{P_B f}{5}\right)\left(\frac{\text{Specified min. tensile strength}}{\text{Avg. tensile strength of test specimens}}\right) \quad **$$

where

f = casting quality factor as defined in UG-24, which applies only to identical cast ductile iron vessels put into service
P_B = destruction test pressure, psi (kPa)
P_R = maximum allowable working pressure of identical cast ductile iron vessels, psi (kPa)

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

(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 pressure vessels or pressure vessel parts of the same material, design, and construction, whose maximum allowable working pressure is based on the destruction test of a sample vessel or part, shall be subjected to a hydrostatic test pressure of not less

** For some of the terms of the above equation(s), it may be necessary to convert millimeters to meters to obtain a rational result in SI units.

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than twice the maximum allowable working pressure determined by the application of the rules in (a).

MARKING AND REPORTS

UCD-115 GENERAL

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

PRESSURE RELIEF DEVICES

UCD-125 GENERAL

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

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