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PART UHT
REQUIREMENTS FOR PRESSURE VESSELS CONSTRUCTED OF FERRITIC STEELS WITH TENSILE PROPERTIES ENHANCED BY HEAT TREATMENT

GENERAL

UHT-1 SCOPE

The rules in Part UHT are applicable to pressure vessels and vessel parts that are constructed of ferritic steels suitable for welding, whose tensile properties have been enhanced by heat treatment, and shall be used in conjunction with the general requirements in Subsection A, and with the specific requirements in Part UW of Subsection B. The heat treatment may be applied to the individual parts of a vessel prior to assembly by welding, to partially fabricated components, or to an entire vessel after completion of welding. This part is not intended to apply to those steels approved for use under the rules of Part UCS but which are furnished in such thicknesses that heat treatment involving the use of accelerated cooling, including liquid quenching, is used to attain structures comparable to those attained by normalizing thinner sections. Integrally forged vessels, quenched and tempered, which do not contain welded seams, are not intended to be covered by the rules of this Part.

MATERIALS

UHT-5 GENERAL

(a) Steels covered by this Part 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 UHT-23.

The thickness limitations of the material specifications shall not be exceeded.

(b) Except when specifically prohibited by this Part [such as in UHT-18 and UHT-28], steels listed in Table UHT-23 may be used for the entire vessel or for individual components which are joined to other Grades listed in that Table or to other steels conforming to specifications listed in Parts UCS or UHA of this Division.

(c) All steels listed in Table UHT-23 shall be tested for notch ductility, as required by UHT-6. These tests shall be conducted at a temperature not warmer than the minimum design metal temperature (see UG-20) but not warmer than +32°F (0°C). Materials may be used at temperatures colder than the minimum design metal temperature as limited in (1) and (2) below.

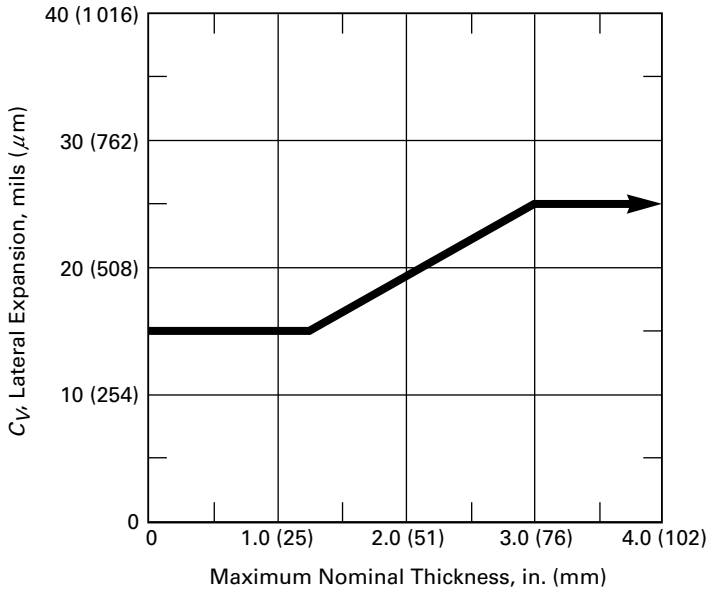
(1) When the coincident ratio defined in Fig. UCS-66.1 is 0.35 or less, the corresponding minimum design metal temperature shall not be colder than −155°F (−104°C).

(2) When the coincident ratio defined in Fig. UCS-66.1 is greater than 0.35, the corresponding minimum design metal temperature shall not be colder than the impact test temperature less the allowable temperature reduction permitted in Fig. UCS-66.1 and shall in no case be colder than −155°F (−104°C).

(d) All test specimens shall be prepared from the material in its final heat treated condition or from full-thickness samples of the same heat similarly and simultaneously treated. Test samples shall be of such size that the prepared test specimens are free from any change in properties due to edge effects. When the material is clad or weld deposit overlayed by the producer or fabricator prior to quench and temper treatments, the full thickness samples shall be clad or weld deposit overlayed before such heat treatments.

(e) Where the vessel or vessel parts are to be hot formed or postweld heat treated (stress relieved), this identical heat treatment shall be applied to the test specimens required by the material specifications including the cooling rate specified by the fabricator which

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01 FIG. UHT-6.1 CHARPY V-NOTCH IMPACT TEST REQUIREMENTS
For Table UCS-23 Materials Having a Specified Minimum Tensile Strength of 95,000 psi (655 MPa) or Greater, and for Table UHT-23 Materials

shall in no case be slower than that specified in the applicable material specification.

(f) All material shall be heat treated in accordance with the applicable material specifications.

01 UHT-6 TEST REQUIREMENTS

(a)(1) One Charpy V-notch test (three specimens) shall be made from each plate as heat treated, and from each heat of bars, pipe, tube, rolled sections, forged parts, or castings included in any one heat treatment lot.

(2) The test procedures, and size, location and orientation of the specimens shall be the same as required by UG-84 except that for plates the specimens shall be oriented transverse to the final direction of rolling and for circular forgings the specimens shall be oriented tangential to the circumference.

(3) Each of the three specimens tested shall have a lateral expansion opposite the notch not less than the requirements shown in Fig. UHT-6.1.

(4) If the value of lateral expansion for one specimen is less than that required in Fig. UHT-6.1 but not less than $^{2}/_{3}$ of the required value, a retest of three additional specimens may be made, each of which must be equal to or greater than the required value in Fig. UHT-6.1. Such a retest shall be permitted only when the average value of the three specimens is equal to or greater than the required value in Fig. UHT-6.1. If the values required are not obtained in the retest or if the values in the initial test are less than the values required for retest, the material may be reheat treated. After reheat treatment, a set of three specimens shall be made, each of which must be equal to or greater than the required value in Fig. UHT-6.1.

(b) Materials conforming to SA-353 and SA-553 for use at minimum design metal temperatures colder than −320°F (−196°C), materials conforming to SA-508, SA-517, SA-543, and SA-592 for use at minimum design metal temperatures colder than −20°F (−29°C), and materials conforming to SA-645 for use at minimum design metal temperatures colder than −275°F (−171°C) shall have, in addition to the Charpy tests required under UHT-6(a), drop-weight tests as defined by ASTM E 208, Conducting Drop-Weight Tests to Determine Nil Ductility Transition Temperatures of Ferritic Steels, made as follows.

(1) For plates $^{5}/_{8}$ in. (16 mm) thick and over, one drop-weight test (two specimens) shall be made for each plate as heat treated.

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(2) For forgings and castings of all thicknesses, one drop-weight test (two specimens) shall be made for each heat in any one heat treatment lot using the procedure in SA-350 for forgings and in SA-352 for castings.

(3) Each of the two test specimens shall meet the "no-break" criterion, as defined by ASTM E 208, at test temperature.

DESIGN

UHT-16 GENERAL

The rules in the following paragraphs apply specifically to the design of pressure vessels and vessel parts that are constructed of heat treated steels covered by this Part and shall be used in conjunction with the general requirements for Design in Subsection A and in Subsection B, Part UW.

UHT-17 WELDED JOINTS

(a) In vessels or vessel parts constructed of heat treated steels covered by this Part *except as permitted in (b) below*, all joints of Categories A, B, and C, as defined in UW-3, and all other welded joints between parts of the pressure containing enclosure which are not defined by the category designation, shall be in accordance with Type No. (1) of Table UW-12. All joints of Category D shall be in accordance with Type No. (1) of Table UW-12 and Fig. UHT-18.1 when the shell plate thickness is 2 in. (51 mm) or less. When the thickness exceeds 2 in. (51 mm), the weld detail may be as permitted for nozzles in Fig. UHT-18.1 and Fig. UHT-18.2.

(b) For materials SA-333 Grade 8, SA-334 Grade 8, SA-353, SA-522, SA-553, and SA-645, the joints of various Categories (see UW-3) shall be as follows.

(1) All joints of Category A shall be Type No. (1) of Table UW-12.

(2) All joints of Category B shall be Type No. (1) or (2) of Table UW-12.

(3) All joints of Category C shall be full penetration welds extending through the entire section at the joint.

(4) All joints of Category D attaching a nozzle neck to the vessel wall and to a reinforcing pad, if used, shall be full penetration groove welds.

UHT-18 NOZZLES

(a) All openings regardless of size shall meet the requirements for reinforcing, nozzle geometry, and nozzle attachments and shall conform to details shown in Fig. UHT-18.1 or as shown in Fig. UHT-18.2 or sketch (y-l) or (z-l) in Fig. UW-16.1 when permitted by the provisions of UHT-17(a), or as shown in Fig. UW-16.1 when permitted by the provisions of UHT-17(b).

(b) Except for nozzles covered in (c) below, all nozzles and reinforcement pads shall be made of material with a specified minimum yield strength within ±20% of that of the shell to which they are attached; however, pipe flanges, pipe, or communicating chambers may be of carbon, low, or high alloy steel welded to nozzle necks of the required material provided:

(1) the joint is a circumferential butt weld located not less than $\sqrt{Rt_n}$ which, except for the nozzle type shown in Fig. UHT-18.1 sketch (f), is measured from the limit of reinforcement as defined in UG-40. For Fig. UHT-18.1 sketch (f), the $\sqrt{Rt_n}$ is measured as shown on that Figure. In these equations,

R = inside radius of the nozzle neck except for Fig. UHT-18.1 sketch (f) where it is the inside radius of the vessel opening as shown in that Figure, in. (mm)

t_n = nominal thickness of the nozzle, in. (mm)

(2) the design of the nozzle neck at the joint is made on the basis of the allowable stress value of the weaker material;

(3) the slope of the nozzle neck does not exceed three to one for at least a distance of $1.5t_n$ from the center of the joint;

(4) the diameter of the nozzle neck does not exceed the limits given in 1-7 for openings designed to UG-36 through UG-44.

(c) Nozzles of nonhardenable austenitic-type stainless steel may be used in vessels constructed of steels conforming to SA-353, SA-553 Types I and II, or SA-645 provided the construction meets all of the following conditions.

(1) The nozzles are nonhardenable austenitic-type stainless steel conforming to one of the following specifications: SA-182, SA-213, SA-240, SA-312, SA-336, SA-403, SA-430, or SA-479.

(2) The maximum nozzle size is limited to NPS 4.

(3) None of the nozzles is located in a Category A or B joint.

(4) The nozzles are located so that the reinforcement area of one nozzle does not overlap the reinforcement area of an adjacent nozzle.

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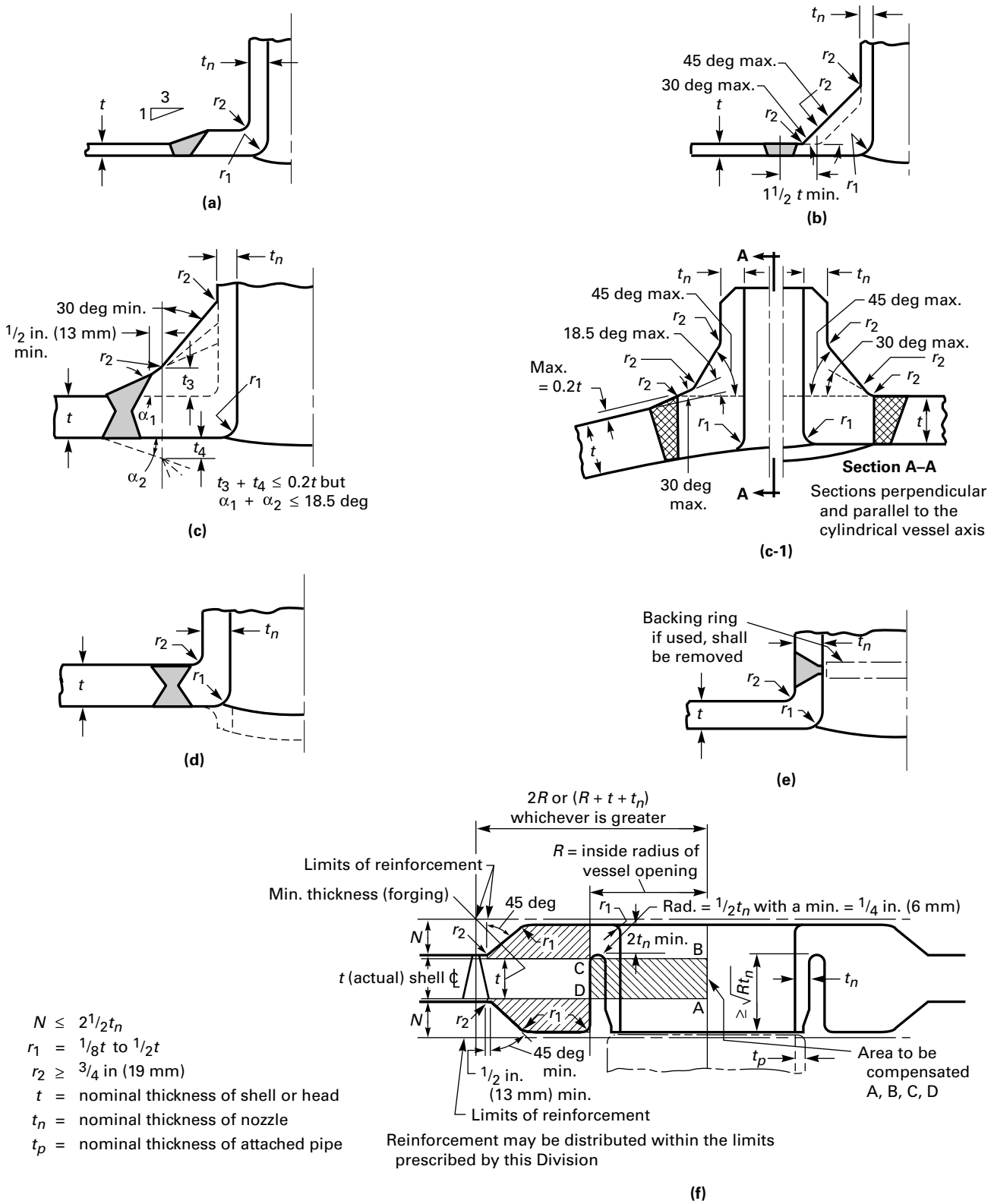
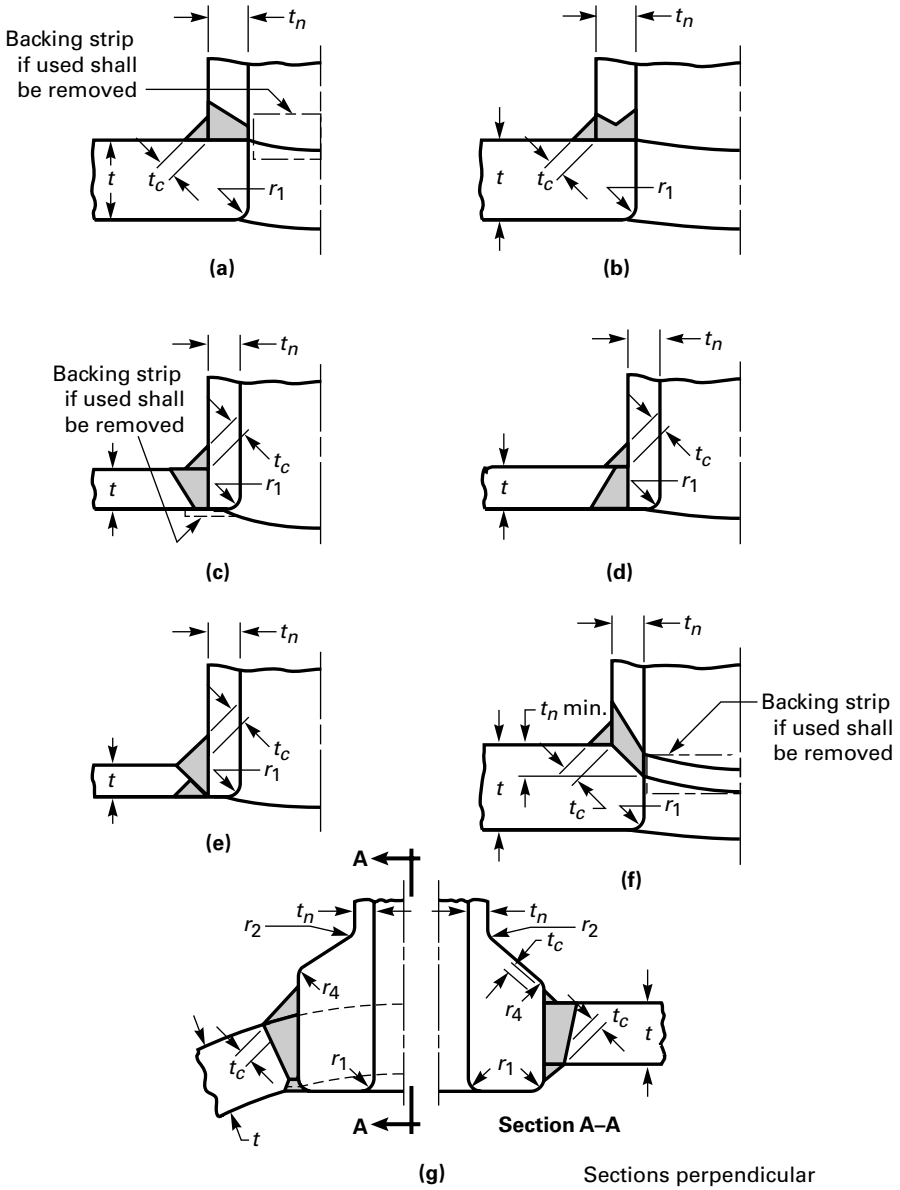


FIG. UHT-18.1 ACCEPTABLE WELDED NOZZLE ATTACHMENT READILY RADIOGRAPHED TO CODE STANDARDS

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r_1 = $^1/_8t$ to $^1/_2t$
r_2 ≥ $^3/_4$ in. (19 mm)
r_4 ≥ $^1/_4$ in. (6 mm)
t = nominal thickness of shell or head
t_c ≥ $0.7t_n$ or $^1/_4$ in. (6 mm), whichever is less
t_n = nominal thickness of nozzle

FIG. UHT-18.2 ACCEPTABLE FULL PENETRATION WELDED NOZZLE ATTACHMENTS RADIOGRAPHABLE WITH DIFFICULTY AND GENERALLY REQUIRING SPECIAL TECHNIQUES INCLUDING MULTIPLE EXPOSURES TO TAKE CARE OF THICKNESS VARIATIONS

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UHT-19 CONICAL SECTIONS

Conical sections shall be provided with a skirt having a length not less than $0.50\sqrt{rt}$ (where r is the inside radius of the adjacent cylinder and t is the thickness of the cone), or $1\frac{1}{2}$ in. (38 mm) whichever is larger. A knuckle shall be provided at both ends of the conical section; the knuckle radius shall not be less than 10% of the outside diameter of the skirt, but in no case less than three times the cone thickness.

UHT-20 JOINT ALIGNMENT

The requirements of UW-33 shall be met except that the following maximum permissible offset values shall be used in place of those given in UW-33(a):

Section Thickness, in. (mm)	Joint Direction	
	Longitudinal	Circumferential
Up to $\frac{1}{2}$ (13), incl.	0.2t	0.2t
Over $\frac{1}{2}$ to $\frac{15}{16}$ (13 to 24), incl.	$\frac{3}{32}$ in. (2.4 mm)	0.2t
Over $\frac{15}{16}$ to $1\frac{1}{2}$ (24 to 38), incl.	$\frac{3}{32}$ in. (2.4 mm)	$\frac{3}{16}$ in. (4.8 mm)
Over $1\frac{1}{2}$ (38)	$\frac{3}{32}$ in. (2.4 mm)	Lesser of $\frac{1}{8}t$ or $\frac{1}{4}$ in. (6 mm)

UHT-23 MAXIMUM ALLOWABLE STRESS VALUES

(a) Table 1A of Section II, Part D gives the maximum allowable stress values at the temperatures indicated for materials conforming to the specifications listed therein. Values may be interpolated for intermediate temperatures (see UG-23). For vessels designed to operate at a temperature colder than −20°F (−29°C), the allowable stress values to be used in design shall not exceed those given for temperatures of −20°F (−29°C) to 100°F (38°C).

(b) Shells of pressure vessels may be made from welded pipe or tubing listed in Table 1A.

UHT-25 CORROSION ALLOWANCE

Provision for possible deterioration due to the environment in which the vessel operates is the responsibility of the designer.

UHT-27 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.

UHT-28 STRUCTURAL ATTACHMENTS AND STIFFENING RINGS

(a) Except as permitted in (b) below, all structural attachments and stiffening rings which are welded directly to pressure parts shall be made of materials of specified minimum yield strength within ±20% of that of the material to which they are attached.

(b) All permanent structural attachments welded directly to shells or heads constructed of materials conforming to SA-333 Grade 8, SA-334 Grade 8, SA-353, SA-522, SA-553, and SA-645 shall be of the material covered by these specifications or austenitic stainless steel of the type which cannot be hardened by heat treatment. If suitable austenitic stainless steel is used for permanent attachments, consideration should be given to the greater coefficient of expansion of the austenitic stainless steel.

UHT-29 STIFFENING RINGS FOR SHELLS UNDER EXTERNAL PRESSURE

Rules covering the design of stiffening rings are given in UG-29. The design shall be based on the appropriate figure in Subpart 3 of Section II, Part D for the material used in the ring.

UHT-30 ATTACHMENT OF STIFFENING RINGS TO SHELLS

Rules covering the attachment of stiffening rings are given in UG-30. Attachments shall be made using a welding procedure qualified to Section IX for vessels constructed to Part UHT.

UHT-32 FORMED HEADS, PRESSURE ON CONCAVE SIDE

Except as provided in UG-32(e) and 1-4(c) and (d), formed heads shall be limited to ellipsoidal and/or

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hemispherical heads designed in accordance with UG-32(d) or (f).

UHT-33 FORMED HEADS, PRESSURE ON CONVEX SIDE

Ellipsoidal, hemispherical, and conical heads having pressure on the convex side (minus heads) shall be designed by the rules of UG-33, using the applicable external pressure charts referenced in Table 1A of Section II, Part D and given in Subpart 3 of Section II, Part D.

UHT-34 HEMISPHERICAL HEADS

When hemispherical heads are used, the head-to-shell transition of Fig. UW-13.1 sketch (l) or Fig. UW-13.1 sketch (n) shall be used. When the weld is in or adjacent to the tapered section, it shall be finished in a manner that will maintain the required uniform slope for the full length of the tapered section.

UHT-40 MATERIALS HAVING DIFFERENT COEFFICIENTS OF EXPANSION

When welding materials with austenitic electrodes, the differences between the coefficients of expansion and the strengths of the base material and the weld metal should be carefully considered, particularly for applications involving cyclic stresses.

UHT-56 POSTWELD HEAT TREATMENT

(a) Before applying the detailed requirements and exemptions in these paragraphs, satisfactory weld procedure qualifications of the procedures to be used shall be performed in accordance with all of the variables in Section IX including conditions of postweld heat treatment or lack of postweld heat treatment and including restrictions listed below. When determining the thickness requiring postweld treatment in Table UHT-56 for clad or weld deposit overlayed vessels or parts of vessels, the total thickness of the material, including the clad and weld deposit overlay, shall be employed.

(b) Vessels or vessel parts constructed of steels listed in Table UHT-23 shall be postweld heat treated when required in Table UHT-56, except that postweld heat treatment shall be required for all thicknesses when joining the materials with the inertia and continuous drive friction welding processes.

(c) Postweld heat treatment shall be performed in accordance with UCS-56 as modified by the requirements of Table UHT-56. In no case shall the PWHT temperature exceed the tempering temperature. PWHT and tempering may be accomplished concurrently. The maximum cooling rate established in UCS-56(e)(5) need not apply. Where accelerated cooling from the tempering temperature is required by the material specification, the same minimum cooling rate shall apply to PWHT.

(d) All welding of connections and attachments shall be postweld heat treated whenever required by Table UHT-56 based on the greatest thickness of material at the point of attachment of the head or shell [see UHT-56(b) and (c)].

(e) When material of SA-333 Grade 8, SA-334 Grade 8, SA-353, SA-522, SA-553, and SA-645 are postweld heat treated, the complete vessel or vessel component being so heat treated shall be maintained within the permissible temperature range defined in Table UHT-56.

UHT-57 EXAMINATION

(a) Radiography. Radiographic examination for the complete length of weld in accordance with the requirements of UW-51 is required for all welded joints of Type No. (1) of Table UW-12. The required radiographic examination shall be made after any corrosion-resistant alloy cover weld has been deposited.

(b) Nozzle Attachment Welds. Nozzle attachment welds as provided for in UHT-18, Figs. UHT-18.1 and UHT-18.2 shall be radiographically examined in accordance with the requirements of UW-51, except that Fig. UHT-18.2 type nozzles having an inside diameter of 2 in. (51 mm) or less shall be examined by a magnetic particle or liquid penetrant method. For nozzle attachments illustrated as sketches (a), (b), and (f) of Fig. UHT-18.2, the exposed cross section of the vessel wall at the opening shall be included in the examination.

(c) All corrosion resistant overlay weld deposits shall be examined by the liquid penetrant method.

(d) Magnetic Particle Method. All welds, including welds for attaching nonpressure parts to heat treated steels covered by this Part, shall be examined by the magnetic particle method after the hydrostatic test, except that those surfaces not accessible after the hydrostatic test shall be examined by the magnetic particle method at the last feasible stage of vessel fabrication. A magnetization method shall be used that will avoid arc strikes. Cracks shall be repaired or removed.

(e) Liquid Penetrant Method. As an acceptable alternative to magnetic particle examination or when mag-

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TABLE UHT-56
POSTWELD HEAT TREATMENT REQUIREMENTS FOR MATERIALS IN TABLE UHT-23

Spec. No.	Grade or Type	P-No./ Gr. No.	Nominal Thickness Requiring PWHT, in. (mm)		Notes	PWHT Temp., °F (°C)	Holding Time	
							hr/in. (25 mm)	Minimum, hr
Plate Steels								
SA-353	9Ni	11A/1	Over 2	(51)	...	1025–1085 (552–585)	1	2
SA-517	Grade A	11B/1	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4
SA-517	Grade B	11B/4	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4
SA-517	Grade E	11B/2	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4
SA-517	Grade F	11B/3	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4
SA-517	Grade J	11B/6	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4
SA-517	Grade P	11B/8	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4
SA-533	Types B, D, Cl. 3	11A/4	Over 0.58	(15)	...	1000–1050 (538–566)	1/2	1/2
SA-543	Types B, C, Cl. 1	11A/5	...	...	(1)	1000–1050 (538–566)	1	1
SA-543	Types B, C, Cl. 2	11B/10	...	...	(1)	1000–1050 (538–566)	1	1
SA-543	Types B, C, Cl. 3	11A/5	...	...	(1)	1000–1050 (538–566)	1	1
SA-553	Types I, II	11A/1	Over 2	(51)	...	1025–1085 (552–585)	1	2
SA-645	5Ni–1/4Mo	11A/2	Over 2	(51)	...	1025–1085 (552–585)	1	2
SA-724	Grade A, B	1/4	None		...	NA	NA	NA
SA-724	Grade C	1/4	Over 1 1/2	(38)	...	1050–1150 (566–621)	1	1/2
Castings								
SA-487	Class 4B	11A/3	Over 0.58	(15)	...	1000–1050 (538–566)	1	1/4
SA-487	Class 4E	11A/3	Over 0.58	(15)	...	1000–1050 (538–566)	1	1/4
SA-487	Class CA 6NM	6/4	Over 0.58	(15)	...	1050–1150 (566–621)	1	1/4
Pipes and Tubes								
SA-333	Grade 8	11A/1	Over 2	(51)	...	1025–1085 (552–585)	1	2
SA-334	Grade 8	11A/1	Over 2	(51)	...	1025–1085 (552–585)	1	2
Forgings								
SA-508	Grade 4N Cl. 1	11A/5	...	...	(1)	1000–1050 (538–566)	1	1
SA-508	Grade 4N Cl. 2	11A/5	...	...	(1)	1000–1050 (538–566)	1	1
SA-522	Type I	11A/1	Over 2	(51)	...	1025–1085 (552–585)	1	2
SA-592	Grade A	11B/1	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4
SA-592	Grade E	11B/2	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4
SA-592	Grade F	11B/3	Over 0.58	(15)	(2)	1000–1100 (538–593)	1	1/4

NOTES: NA = not applicable
(1) PWHT is neither required nor prohibited. Consideration should be given to the possibility of temper embrittlement. The cooling rate from PWHT, when used, shall not be slower than that obtained by cooling in still air.
(2) See UHT-82(f).

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netic particle methods are not feasible because of the nonmagnetic character of the weld deposits, a liquid penetrant method shall be used. For vessels constructed of SA-333 Grade 8, SA-334 Grade 8, SA-353, SA-522, SA-553 Grades A and B, and SA-645 materials, welds not examined radiographically shall be examined by the liquid penetrant method either before or after the hydrotest. Cracks are unacceptable and shall be repaired or removed. Relevant indications are those which result from imperfections. Linear indications are those indications in which the length is more than three times the width. Any relevant linear indications greater than $^{1}/_{16}$ in. (1.6 mm) shall be repaired or removed.

FABRICATION

UHT-75 GENERAL

The rules in the following paragraphs apply specifically to the fabrication of pressure vessels and vessel parts that are constructed of heat treated steels covered by this Part and shall be used in conjunction with the general requirements for fabrication in Subsection A, and, when applicable, with the specific requirements for fabrication in Subsection B, Part UW.

UHT-79 FORMING SHELL SECTIONS AND HEADS

(a) The selected thickness of material shall be such that the forming processes will not reduce the thickness of the material at any point below the minimum value required by the rules.

(1) Pieces that are formed after heat treatment at a temperature lower than the final tempering shall be heat treated in accordance with Table UHT-56 when the extreme fiber elongation from forming exceeds 5% as determined by the formulas in UCS-79(d).

(2) Pieces that are formed at temperatures equal to or higher than the original tempering shall be reheat treated in accordance with the applicable material specification, either before or after welding into the vessel.

UHT-80 HEAT TREATMENT

(a) Heating Furnace. Furnaces for heating, for quenching, for normalizing, and for tempering shall be provided with suitable equipment for the automatic recording of temperatures. The temperature of the vessel or vessel part during the holding period shall be recorded and shall be controlled within ±25°F (±14°C).

(b) Liquid quenching of flat plates and individual parts shall be done as required by the applicable material specifications.

(c) Formed plates for shell sections and heads may be quenched by sprays or immersion.

(d) Entire vessels, after completion of all welding operations, may be quenched by sprays or immersion.

(e) The design and operation of spray equipment and the size of tanks and provision for forced circulation shall be such as to produce a severity of quench in the quenched item sufficient to meet, in representative test specimens after tempering, the requirements of the materials specifications.

UHT-81 HEAT TREATMENT VERIFICATION TESTS

(a) Tests shall be made to verify that the heat treatments, and subsequent thermal treatments, performed by the fabricator have produced the required properties.

(b) One or more test coupons representative of the material and the welding in each vessel or vessel component shall be heat treated with the vessel or vessel component.

The requirements of (c) and (d) below are to be taken as minimum steps toward these objectives.

(c)(1) One or more test coupons from each lot of material in each vessel [see UHT-81(d)] shall be quenched with the vessel or vessel component. A lot is defined as material from the same melt, quenched or normalized simultaneously and whose thicknesses are within plus or minus 20% or $^{1}/_{2}$ in. (13 mm) of nominal thickness, whichever is smaller. The test coupons shall be so proportionated that tensile and impact tests may be taken from the same locations relative to thickness as are required by the applicable material specifications. Weld metal tests shall be taken from the same locations relative to thickness as are required by the materials specifications for plates used in the component to be treated. The gage length of tensile specimens and the middle third of the length of impact specimens must be located at a minimum distance of $1 \times t$ from the quenched edge and/or end of the test coupon, where t is the thickness of the material which the test coupon represents. If desired, the effect of this distance may be achieved by temporary attachment of suitable thermal buffers. The effectiveness of such buffers shall be demonstrated by tests.

(2) In cases where the test coupon is not attached to the part being treated, it shall be quenched from the same heat treatment charge and under the conditions

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as the part which it represents. It shall be so proportioned that test specimens may be taken from the locations prescribed in (1) above.

(d) Tempering

(1) Attached Test Coupons. The coupons shall remain attached to the vessel or vessel component during tempering, except that any thermal buffers may be removed after quenching. After the tempering operation and after removal from the component, the coupon shall be subjected to the same thermal treatment(s), if any, to which the vessel or vessel component will be later subjected. The holding time at temperature shall not be less than that applied to the vessel or vessel component (except that the total time at each temperature may be applied in one heating cycle) and the cooling rate shall be no faster.

(2) Separate Test Coupons. Test coupons which are quenched separately as described in (c)(2) above shall be tempered similarly and simultaneously with the vessel or component which they represent. The conditions for subjecting the test coupons to subsequent thermal treatment(s) shall be as described in (c)(1) above.

(e) Number of Tests. One tensile test and one impact test shall be made on material from coupons representing each lot of material in each vessel or vessel component heat treated. A lot is defined as material from the same melt quenched simultaneously and whose thicknesses are within plus or minus 20%, or $\frac{1}{2}$ in. (13 mm), of nominal thickness, whichever is smaller.

(1) Coupons not containing welds shall meet the complete tensile requirements of the material specification and impact requirements of this part.

(2) Coupons containing weld metal shall be tested across the weld and shall meet the ultimate tensile strength requirements of the material specifications; in addition, the minimum impact requirements shall be met by samples with notches in the weld metal. The form and dimension of the tensile test specimen shall conform to QW-462.1(d) of Section IX. Yield strength and elongation are not a requirement of this test. Charpy impact testing shall be in accordance with the requirements of UHT-6.

01 UHT-82 WELDING

UHT-82(a) The qualification of the welding procedure and the welders shall conform to the requirements of Section IX, and such qualification tests shall be performed on postweld heat treated specimens when a postweld heat treatment is used.

UHT-82(b) Filler metal containing more than 0.06% vanadium shall not be used for weldments subject to postweld heat treatment.

UHT-82(c) For welded vessels in which the welds are not subject to quenching and tempering, the deposited weld metal and the heat affected zone shall meet the impact test requirements of UG-84, except that the Charpy V-notch tests and requirements of UHT-6(a) shall apply.

UHT-82(d) The following materials are exempt from production impact tests of the weld metal in accordance with UG-84 under the conditions given in (1) through (5) below:

Specification No.	UNS No.	P-No./Group No.
SA-353	K81340	11A/1
SA-522 Type I	K81340	11A/1
SA-553 Type I	K81340	11A/1
SA-553 Type II	K71340	11A/1
SA-645	K41583	11A/2

UHT-82(d)(1) One of the following high nickel alloy filler metals is used:

Specification No.	Classification	F-No.
SFA-5.11	ENiCrMo-3	43
SFA-5.11	ENiCrMo-6	43
SFA-5.11	ENiCrFe-2	43
SFA-5.11	ENiCrFe-3	43
SFA-5.14	ERNiCr-3	43
SFA-5.14	ERNiCrFe-6	43
SFA-5.14	ERNiCrMo-3	43
SFA-5.14	ERNiCrMo-4	44

UHT-82(d)(2) All required impact tests shall be performed as part of the procedure qualification tests as specified in UG-84.

UHT-82(d)(3) Production impact tests of the heat affected zone are performed in accordance with UG-84(i).

UHT-82(d)(4) The welding processes are limited to gas metal arc, shielded metal arc, and gas tungsten arc.

UHT-82(d)(5) The minimum allowable temperature of the vessel shall be not less than −320°F (−196°C).

UHT-82(e) For materials SA-508 and SA-543, the following, in addition to the variables in Section IX, QW-250, shall be considered as essential variables requiring requalification of the welding procedure:

UHT-82(e)(1) a change in filler metal SFA classification or to weld metal not covered by an SFA specification;

UHT-82(e)(2) an increase in the maximum interpass temperature or a decrease in the minimum specified preheat temperature. The specified range be-

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tween the preheat and interpass temperatures shall not exceed 150°F (83°C).

UHT-82(e)(3) a change in the heat treatment (Procedure qualification tests shall be subjected to heat treatment essentially equivalent to that encountered in fabrication of the vessel or vessel parts including the maximum total aggregate time at temperature or temperatures and cooling rates.)

UHT-82(e)(4) a change in the type of current (AC or DC), polarity, or a change in the specified range for amp, volt, or travel speed;

UHT-82(e)(5) a change in the thickness *T* of the welding procedure qualification test plate as follows:

(a) for welded joints which are quenched and tempered after welding, any increase in thickness [the minimum thickness qualified in all cases is $\frac{1}{4}$ in. (6 mm)];

(b) for welded joints which are not quenched and tempered after welding, any change as follows:

T less than $\frac{5}{8}$ in. (16 mm)	Any decrease in thickness (the maximum thickness qualified is 2*T*)
$\frac{5}{8}$ in. (16 mm) and over	Any departure from the range of $\frac{5}{8}$ in. (16 mm) to 2*T*

UHT-82(e)(6) consumables control, drying, storage, and exposure requirements shall be in accordance with the following:

(a) due consideration shall be given to protection of electrodes and fluxes for all welding processes in order to minimize moisture absorption and surface contamination;

(b) electrodes for shielded metal arc welding shall be low-hydrogen type conforming to SFA-5.5. Electrodes shall be purchased or conditioned so as to have a coating moisture content not greater than 0.2% by weight. Once opened, electrode storage and handling must be controlled so as to minimize absorption of moisture from the ambient atmosphere. Practices used for controlling the moisture content shall be developed by the vessel manufacturer or those recommended by the electrode manufacturer.

UHT-82(e)(7) preheat shall be 100°F (38°C) minimum for material thickness up to and including $\frac{1}{2}$ in. (13 mm); 200°F (93°C) minimum for material above $\frac{1}{2}$ in. (13 mm) to and including $1\frac{1}{2}$ in. (38 mm); 300°F (149°C) minimum above $1\frac{1}{2}$ in. (38 mm). Preheat temperature shall be maintained for a minimum of 2 hr after completion of the weld joint.

UHT-82(f) For SA-517 and SA-592 materials the requirements of (e)(1), (2), (3), (4), and (6), in addition to the variables in Section IX, QW-250, shall be considered as essential variables requiring requalification of the welding procedure.

UHT-82(g) The PWHT as required by Table UHT-56 may be waived for SA-517 and SA-592 materials with a nominal thickness over 0.58 in. to $1\frac{1}{4}$ in. (15 mm to 32 mm), inclusive, provided the following conditions are met:

UHT-82(g)(1) a minimum preheat of 200°F (93°C) and a maximum interpass of 400°F (204°C) is used;

UHT-82(g)(2) after completion of welding and without allowing the weldment to cool below the minimum preheat temperature, the temperature of the weldment is raised to a minimum of 400°F (204°C) and maintained at that temperature for at least 4 hr; and

UHT-82(g)(3) all welds are examined by nondestructive examination in accordance with the provisions of this Part.

UHT-83 METHODS OF METAL REMOVAL

(a) Plate edges, welding bevels, chamfering and other operations involving the removal of metal shall be by machining, chipping, or grinding except as provided in (b) below.

(b) When metal removal is accomplished by methods involving melting, such as gas cutting or arc-air gouging, etc., it shall be done with due precautions to avoid cracking. Where the cut surfaces are not to be subsequently eliminated by fusion with weld deposits, they shall be removed by machining or grinding to a depth of at least $\frac{1}{16}$ in. (1.6 mm) followed by inspection by magnetic particle or liquid penetrant methods.

CAUTIONARY NOTE: The properties of the base metal may be adversely affected by excessive local heat inputs.

UHT-84 WELD FINISH

The requirements of UW-35(a) and UW-51(b) shall be met except that for SA-517 material the maximum weld reinforcement shall not exceed 10% of the plate thickness or $\frac{1}{8}$ in. (3.2 mm), whichever is less. The edge of the weld deposits shall merge smoothly into the base metal without undercuts or abrupt transitions; this requirement shall apply to fillet and groove welds as well as to butt welds.

UHT-85 STRUCTURAL AND TEMPORARY WELDS

(a) Welds for pads, lifting lugs and other nonpressure parts, as well as temporary lugs for alignment, shall

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be made by qualified welders in full compliance with a qualified welding procedure.

(b) Temporary welds shall be removed and the metal surface shall be restored to a smooth contour. The area shall be inspected by magnetic particle or liquid penetrant method for the detection and elimination of cracks. If repair welding is required, it shall be in accordance with qualified procedures, and the finished weld surface shall be inspected as required in UHT-57(b) or (c). Temporary welds and repair welds shall be considered the same as all other welds so far as requirements for qualified operators and procedures and for heat treatment are concerned.

UHT-86 MARKING ON PLATES AND OTHER MATERIALS

Any steel stamping shall be done with "low stress" stamps as commercially available. Steel stamping of all types may be omitted on material below $\frac{1}{2}$ in. (13 mm) in thickness. For the use of other markings in lieu of stamping, see UG-77(b).

INSPECTION AND TESTS

UHT-90 GENERAL

The provisions for inspection and testing in Subsections A and B shall apply to vessels and vessel parts constructed of steels covered by this Part.

MARKING AND REPORTS

UHT-115 GENERAL

The provisions for marking and reports in UG-115 through UG-120 shall apply to pressure vessels constructed in whole or in part of steels covered by this Part, except that the use of nameplates is mandatory for shell thicknesses below $\frac{1}{2}$ in. (13 mm). Nameplates are preferred on vessels constructed of steels covered by this Part in all thicknesses in preference to stamping. In addition to the required marking, the letters UHT shall be applied below the U Symbol.

PRESSURE RELIEF DEVICES

UHT-125 GENERAL

The provisions for pressure relief devices in UG-125 through UG-136 shall apply without supplement to pressure vessels constructed in whole or in part of steels covered by this Part.

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