PG-77.1 When the boiler is completed, there shall remain visible on shell plates, furnace sheets, and heads, one group of the plate manufacturer's stamps, consisting of the manufacturer's name, plate identification number, material specification number with grade, class, and type as appropriate, except that heads containing tube holes and buttstraps shall have visible at least a sufficient portion of such stamps for identification.

PG-77.2 It is permissible for an authorized representative of the boiler Manufacturer to transfer the markings on the plate provided a record is made of such transfer. In lieu of the above and PG-77.1, identification may be by applying a coded marking traceable to the original required markings or by recording the required markings using methods such as material tabulations or as built illustration which ensure identification of each piece of material during fabrication and subsequent identification in the completed boiler. Such transfers of markings shall be made prior to cutting, except that the Manufacturer may transfer markings immediately after cutting, provided the control of these transfers is described in his written Quality Control System (A-301 and A-302). The procedure for making such transfer shall be acceptable to the Authorized Inspector.

PG-77.3 An authorized representative of the plate manufacturer may duplicate the required stamping on any material wherever located.

PG-77.4 When plate specification heat treatments are not performed by the mill, they shall be performed by or under the control of the fabricator, who shall then place the letter "T" following the letter "G" in the mill plate marking (see SA-20) to indicate that the material specification heat treatments have been performed. The fabricator shall also show by a supplement to the appropriate Mill Test Report that the specified heat treatment has been performed.

PG-77.5 For other than plate material, the maintenance of identification shall be at least to the type of material. This can be achieved through any suitable method found acceptable to the Inspector, such as color coding, abbreviated marking, written record, etc.

PG-78 REPAIRS OF DEFECTS IN MATERIALS

Defects in material may be repaired by the boiler Manufacturer provided acceptance by the Inspector is first obtained for the method and extent of repairs. Material that cannot be satisfactorily repaired shall be rejected.

PG-79 TUBE HOLES AND ENDS

Tube holes shall be drilled full size from the solid plate, or they may be punched at least 3/4 in. (13 mm) smaller in diameter than full size, and then drilled, reamed, or finished full size with a rotating cutter. The thermal- or plasma-arc cut holes, when made, shall be sufficiently smaller in diameter than full size, such that subsequent machining to full size shall completely remove all metal whose mechanical and metallurgical properties have been affected as a result of the thermal- or plasma-arc cutting. Tube holes may be counterbored where the metal is thicker than that required to get a proper bearing by expanding, so as to form narrow seats into which the tube ends can be properly expanded, provided there is space available to permit a proper amount of flare of the tube end.

The sharp edges of tube holes shall be taken off on both sides of the plate with a file or other tool.

PG-80 PERMISSIBLE OUT-OF-ROUNDNESS OF CYLINDRICAL SHELLS

PG-80.1 Internal Pressure. Finished cylindrical sections of headers, shells, drums, and similar components shall be circular at any section within a limit of 1% of the mean diameter, based on the differences between the maximum and minimum mean diameters at any section. To determine the difference in diameters, measurements may be made on the inside or the outside, and when the component is made of plates of unequal thicknesses, the measurements shall be corrected for the plate thicknesses as they may apply, to determine the diameters at the middle line of the plate thickness.

PG-80.2 External Pressure. Welded cylindrical furnaces and other cylindrical parts subjected to external pressure shall be rolled to practically a true circle with a maximum plus or minus deviation not to exceed the following:

(a) For components greater than 24 in. (600 mm) O.D., the maximum permissible deviation, e, shall be obtained from Figure PG-80. The symbols L, D, and t are as defined in PG-28.3.1.1.

(b) For components equal to or less than 24 in. (600 mm) O.D., the maximum deviation shall not exceed 1% of the O.D.

PG-81 TOLERANCE FOR FORMED HEADS

Where the component at any cross section is made of plates having different thicknesses, t is the nominal thickness of the thinnest plate.

variation from this true ellipse shall not exceed 0.0125 times the inside diameter of the head.

PG-82 HOLES FOR STAYS

PG-82.1 Holes for threaded stays shall be drilled full size or punched and subsequently drilled or reamed. Punched holes shall not exceed 3/8 in. (6 mm) less than full diameter for plates over 3/4 in. (8 mm) or 3/8 in. (3.2 mm) less than full diameter for plates not exceeding 3/4 in. (8 mm) thickness prior to finished drilling or reaming. Threaded holes shall be tapped flat and true with a full thread.
Figure PG-80
Maximum Permissible Deviation From a Circular Form, $\varepsilon$, for Cylindrical Parts Under External Pressure

GENERAL NOTES:
(a) The above chart applies to cylinders over 24 in. (600 mm) O.D.
(b) Use the curves $\varepsilon = 1.0L_f$ or $\varepsilon = 0.2L_f$, respectively, for points falling above or below those curves.

PG-90.2 Holes for welded stays shall be cut and prepared in accordance with PW-29.

INSPECTION AND TESTS
PG-90.1 Each boiler, superheater, waterwall, or economizer shall be inspected during construction and after completion by an Authorized Inspector (AI). The AI may perform inspections at other stages of the work as he may designate (PW-46.2). Each Manufacturer or Assembler is required to arrange for the services of Authorized Inspectors (see Foreword and PG-91) to perform inspections on all of his work within the scope of this Section, whether performed in the shop or in the field. Duties of the AI are described elsewhere in this Section and include the following:

PG-90.1.1 Verifying that the Manufacturer or Assembler has a valid ASME Certificate of Authorization covering the scope of his Code activities (PG-104.2.1, PG-105.5).

PG-90.1.2 Monitoring compliance with the accepted Quality Control Program and verifying that any changes meet the requirements of this Section (PG-105.4, PEB-18, A-301 and A-302).

PG-90.1.3 Verifying that the Certificate Holder has the necessary Code books, Addenda, and Code Cases to cover the work being performed.
Figure PG-28
Maximum Internal Projection of Welded Access or Inspection Openings

GENERAL NOTE: For other acceptable weld configurations, see Figure PW-16.1.

$L_e$ = one-half of the distance from the center line of the stiffening ring to the next line of support on one side, plus one-half of the center line distance to the next line of support on the other side of the stiffening ring, both measured parallel to the axis of the cylinder. (See PFT-17.11 for design of stiffening rings.) A line of support is

(a) a stiffening ring that meets the requirements of PFT-17.11

(b) a circumferential connection to a tubesheet or jacket for a jacketed section of a cylindrical shell

(c) a circumferential line on a formed head at one-third the depth of the head from the head tangent line

$P$ = external design pressure

$P_a$ = calculated value of allowable external working pressure for the assumed value of $t$

$S$ = the maximum allowable stress value at design metal temperature

$t$ = minimum required thickness of cylindrical components

$t_n$ = nominal thickness of cylindrical components

PG-28.3.1.2 Cylindrical Components. The required minimum thickness of a cylindrical component under external pressure, either seamless or with longitudinal butt joints, shall be determined by the following procedure:

(a) cylinder having $D_o/t$ values equal to or greater than 10

Step 1. Assume a value of $t$ and determine the ratios $L/D_o$ and $D_o/t$.

Step 2. Enter Section II, Part D, Subpart 3, Figure G at the value of $L/D_o$ determined in Step 1. For values of $L/D_o$ greater than 50, enter the chart at a value of $L/D_o = 50$. For values of $L/D_o$ less than 0.05, enter the chart at a value of $L/D_o = 0.05$.

Step 3. Move horizontally to the line for the value of $D_o/t$ determined in Step 1. Interpolation may be made for intermediate values of $D_o/t$; extrapolation is not permitted. From this point of intersection, move vertically downward to determine the value of Factor $A$.

Step 4. Using the value of $A$ calculated in Step 3, enter the applicable material chart in Section II, Part D, Subpart 3 for the material under consideration. Move vertically to an intersection with the material/temperature line for the design temperature. Interpolation may be made between lines for intermediate temperatures. If tabular values in Section II, Part D, Subpart 3 are used, linear interpolation or any other rational interpolation method may be used to determine a $B$ value that lies between two adjacent tabular values for a specific temperature. Such interpolation may also be used to determine a $B$ value at an intermediate temperature that lies between two sets of tabular values after first determining $B$ values for each set of tabular values. In cases where the $A$ value falls to the right of the end of the material temperature line, assume an intersection with the horizontal projection of the upper end of the material/temperature line. If tabular values are used, the last (maximum) tabulated value shall be used. For values of $A$ falling to the left of the material/temperature line, see Step 7.

Step 5. From the intersection obtained in Step 4, move horizontally to the right and read the value of Factor $B$. 

B90-37  PG-80, Permissible Out of Roundness of Cylindrical Shell
        (Design)

Mr. Molvie Presented this item and suggested the revision to the original proposal as shown on pages 23–24. It was moved, seconded and unanimously VOTED to approve the revisions referenced above.

The above referenced change was included in the Main Committee Handout.

B92-44  Code Case for the Use of Thermostatic Device
        (Design)

Mr. Bernstein Presented this item and suggested the revision to the original proposal shown on pages 25–27.

The above referenced change was included in the Main Committee Handout.

B93-59  PW-40, A-100.4, Preheat for P-No.5B Group 2 Material
        (Fab & Exam)

Mr. Berger Presented this item and suggested the revision to the original proposal shown on pages 28.

The above referenced change was included in the Main Committee Handout.

B94-12  Code Cases for Seamless 9Cr-2W and 12Cr-2W Material
        (Materials)

Dr. French presented this item and agreed to delete paragraph 5 on the proposed Code Case. It was moved, seconded and unanimously VOTED to approve the revision to the Code Case referenced above.

It was agreed to present this revision to the Main Committee verbally.
PG-80 PERMISSIBLE OUT-OF-ROUNDNESS OF CYLINDRICAL SHELLS

PG-80.1 Internal Pressure

The cylinder or barrel of a drum or shell shall be circular at any section within a limit of 1% of the mean diameter, based on the differences between the maximum and minimum mean diameters at any section, and if necessary to meet this requirement shall be reheated, rerolled or reformed. To determine the difference in diameters, measurements may be made on the inside or the outside, and when the cylinder or barrel is made of plates of unequal thickness, the measurements shall be corrected for the plate thickness as they may apply, to determine the diameters at the middle line of the plate thickness.

PG-80.2 External Pressure

Welded cylindrical furnaces and other cylindrical parts subjected to external pressure shall be rolled to practically a true circle with a maximum permissible deviation from the true circle of not more than 1/4 in.

Revised Text:

PG-80 DISTORTION

The cylinder or barrel of a drum or shell shall be circular at any section within a limit of 1% of the mean diameter, based on the differences between the maximum and minimum mean diameters at any section, and if necessary to meet this requirement shall be reheated, rerolled or reformed. To determine the difference in diameters, measurements may be made on the inside or the outside, and when the cylinder or barrel is made of plates of unequal thickness, the measurements shall be corrected for the plate thickness as they may apply, to determine the diameters at the middle line of the plate thickness.

Replaced pages:

41 - 43
FIG. 64-00.5 MAXIMUM PERMISSIBLE DEVIATION FROM A CIRCULAR FORM FOR VESSELS UNDER EXTERNAL PRESSURE

notes:
1) The above chart applies to cylinders over 24 in. O.D.
   The curves use $e = 0.02t_s$ or $e = 0.2t_s$, respectively, for points falling above or below these curves.
(a) **Internal Pressure.** The shell of a completed vessel shall be substantially round and shall meet the following requirements:

1. The difference between the maximum and minimum inside diameters at any cross section shall not exceed 1% of the nominal diameter at the cross section under consideration. The diameters may be measured on the inside or outside of the vessel. If measured on the outside, the diameters shall be corrected for the plate thickness at the cross section under consideration (see Figure UG-80.2).

2. When the cross section passes through an opening or within 1 L.D. of the opening measured from the center of the opening, the permissible difference in inside diameters given above may be increased by 2% of the inside diameter of the opening. When the cross section passes through any other location normal to the axis of the vessel, including head-to-shell junctions, the difference in diameters shall not exceed 1%.

For vessels with longitudinal lap joints, the permissible difference in inside diameters may be increased by the nominal plate thickness.

(b) **External Pressure.** The shell of a completed vessel to operate under external pressure shall meet the following requirements at any cross section:

1. The out-of-roundness limitations prescribed in (a)(1) and (a)(2) above.

2. The maximum plus-or-minus deviation from the true circular form, measured radially on the outside or inside of the vessel, shall not exceed the maximum permissible deviation \( e \) obtained from Figure UG-80.1. Use \( e = 1.0t \) or \( e = 0.2t \), respectively, for points falling above or below these curves. Measurements shall be made from a segmental circular template having the design inside or outside radius (depending upon where the measurements are taken) and a chord length equal to twice the arc length obtained from Figure UG-29.2. The values of \( L \) and \( D_o \) in Figures UG-29.2 and UG-80.1 shall be determined as follows:

   \( L = L_1 D_o(D_1/D_2) \)

   \( D_o = D_L \)

   \( L = L_2 \) at the small diameter end,

   \( D_0 = D_L \)

   \( L = L_3 \) at the midlength diameter,

   \( D_0 = 0.5(D_L + D_1) \)

   \( L = L_4 \) at any cross section having an outside diameter of \( D_x \),

   \( D_0 = D_L \)

   \( L = L_5 \) for spheres, \( L \) is one-half of the outside diameter \( D_o \).

\( t \) for cylinders and spheres, the value of \( t \) shall be determined as follows:

   \( t = \) for vessels with butt joints, \( t \) is the nominal plate thickness less corrosion allowance.

   \( t = \) for vessels with longitudinal lap joints, \( t \) is the nominal plate thickness and the permissible deviation is \( t + e \).

   \( t = \) Where the shell at any cross section is made of plates having different thicknesses, \( t \) is the nominal thickness of the thinnest plate less corrosion allowance.

4. For cones and conical sections, the value of \( t \) shall be determined as in (3) above, except that \( t \) in (3)(a), (3)(b), and (3)(c) shall be replaced by \( t_e \) as defined in UG-33(b).

5. The requirements of (2) above shall be met in any plane normal to the axis of revolution for cylinders and cones and in the plane of any great circle for spheres. For cones and conical sections, a check shall be made at locations (2)(b)(-1), (2)(b)(-2), and (2)(b)(-3) above and such other locations as may be necessary to satisfy manufacturers and inspectors that requirements are met.

6. Measurements shall be taken on the surface of the base metal and not on welds or other raised parts of the material.
(7) The dimensions of a completed vessel may be brought within the requirements of this paragraph by any process which will not impair the strength of the material.

(8) Sharp bends and flat spots shall not be permitted unless provision is made for them in the design.

(9) If the nominal thickness of plate used for a cylindrical vessel exceeds the minimum thickness required by UG-28 for the external design pressure, and if such excess thickness is not required for corrosion allowance or loadings causing compressive forces, the maximum permissible deviation \( e \) determined for the nominal plate thickness used may be increased by the ratio of factor \( B \) for the nominal plate thickness used divided by factor \( B \) for the minimum required plate thickness; and the chord length for measuring \( e_{\text{max}} \) shall be determined by \( D_{o}/t \) for the nominal plate thickness used.
Figure UG-28
Diagrammatic Representation of Variables for Design of Cylindrical Vessels Subjected to External Pressure

\[ E = \text{modulus of elasticity of material at design temperature.} \]
For external pressure design in accordance with this Section, the modulus of elasticity to be used shall be taken from the applicable materials chart in Section II, Part D, Subpart 3. (Interpolation may be made between lines for intermediate temperatures.)

\[ L = \text{total length, in. (mm), of a tube between tube sheets, or design length of a vessel section between lines of support (see Figure UG-28). A line of support is:} \]

(a) a circumferential line on a head (excluding conical heads) at one-third the depth of the head from the head tangent line as shown on Figure UG-28;

(b) a stiffening ring that meets the requirements of UG-29;

(c) a jacket closure of a jacketed vessel that meets the requirements of 9-5;

(d) a cone-to-cylinder junction or a knuckle-to-cylinder junction of a toriconical head or section that satisfies the moment of inertia requirement of 1-8.

\[ P = \text{external design pressure [see Note in (f)]} \]

\[ P_a = \text{calculated value of maximum allowable external working pressure for the assumed value of } t, \text{ [see Note in (f) below]} \]

\[ R_e = \text{outside radius of spherical shell} \]

\[ t = \text{minimum required thickness of cylindrical shell or tube, or spherical shell, in. (mm)} \]

\[ t_s = \text{nominal thickness of cylindrical shell or tube, in. (mm)} \]

(c) Cylindrical Shells and Tubes: The required minimum thickness of a cylindrical shell or tube under external pressure, either seamless or with longitudinal butt joints, shall be determined by the following procedure:

1. Cylinders having \( D_o/t \) values \( \geq 10 \):

Step 1. Assume a value for \( t \) and determine the ratios \( L/D_o \) and \( D_o/t \).

Step 2. Enter Section II, Part D, Subpart 3, Figure G at the value of \( L/D_o \) determined in Step 1. For values of \( L/D_o \) greater than 50, enter the chart at a value of \( L/D_o = 50 \). For values of \( L/D_o \) less than 0.05, enter the chart at a value of \( L/D_o = 0.05 \).

Step 3. Move horizontally to the line for the value of \( D_o/t \) determined in Step 1. Interpolation may be made for intermediate values of \( D_o/t \); extrapolation is not permitted. From this point of intersection move vertically downward to determine the value of factor \( A \).

Step 4. Using the value of \( A \) calculated in Step 3, enter the applicable material chart in Section II, Part D, Subpart 3 for the material under consideration. Move vertically to an intersection with the material/temperature line for the design temperature (see UG-20). Interpolation may be made between lines for intermediate temperatures. If tabular values in Section II, Part D, Subpart 3 are used, linear interpolation or any other rational interpolation method may be used to determine a \( B \) value that lies between two adjacent tabular values for a specific temperature. Such interpolation may also be used to