

Specification for

# Pressure vessel details (dimensions) —

Part 4: Standardized pressure vessels

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- Associated Offices Technical Committee\*
- Association of Shell Boilermakers
- British Chemical Engineering Contractors' Association\*
- British Compressed Gases Association
- British Gas Corporation\*
- British Insurance (Atomic Energy) Committee
- British Steel Industry\*
- CBMPE\*
- Chemical Industries Association\*
- Department of Trade (Marine Division)
- Electricity Supply Industry in England and Wales\*
- Engineering Equipment Users' Association\*
- Health and Safety Executive
- Institution of Chemical Engineers
- Institution of Gas Engineers\*
- Institution of Mechanical Engineers\*
- Lloyd's Register of Shipping\*
- Oil Companies Materials Association\*
- Process Plant Association\*
- The Welding Institute
- United Kingdom Atomic Energy Authority
- University of Manchester — Institute of Science and Technology
- Water-tube Boilermakers' Association

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- Association of Consulting Engineers
- Association of Hydraulic Equipment Manufacturers
- British Valve Manufacturers' Association
- National Association of Drop Forgers and Stampers

This British Standard, having been prepared under the direction of the Pressure Vessel Standards Committee, was published under the authority of the Executive Board on 31 August 1977

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## Foreword

This British Standard has been prepared under the direction of the Pressure Vessel Standards Committee to cover the dimensions of pressure vessel details. It has been arranged in Parts as follows:

- *Part 1: Davits for branch covers;*
- *Part 2: Saddle supports for horizontal cylindrical pressure vessels (in course of preparation);*
- *Part 3: Dimensional tolerances for pressure vessels (currently Draft for Development DD 42);*
- *Part 4: Standardized pressure vessels.*

This Part replaces BS 3161 and is confined to unfired cylindrical pressure vessels for horizontal and vertical use in the chemical and allied industries. Only one of the shapes of domed ends previously shown in BS 1966 is specified; this is the torispherical 2 : 1 radius/height ratio in terms of the inner profile (domed ends with 6 % and 10 % knuckle radii are not currently included).

It is intended that the module system adopted for the shell cylinder lengths will lead to economies in the manufacture of carbon steel and carbon manganese steel vessels by reducing the number of plate sizes used and minimizing the equipment required for fabrication.

This Part covers dimensions and pressure ratings for basic unpierced vessels thereby providing an aid to selection of standardized vessels and is intended for use in conjunction with BS 5500 “*Unfired fusion welded pressure vessels*”.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

### Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

## 1 Scope

This Part of this British Standard specifies requirements for cylindrical vessels with torispherical domed ends. The lengths and thicknesses of the shell cylinders are based on standard carbon and carbon manganese steel plates. Permissible internal pressures for the domed ends and shell cylinders, not taking account of openings, can be calculated using the dimensions and pressure coefficients stated in this standard together with the relevant stress values obtained from BS 5500.

The overall design of vessels, their fabrication and testing shall be in accordance with BS 5500.

For vessels that are outside the range of sizes covered, it is recommended that shell cylinder lengths should be derived using the modular method described in 5.2.1.

## 2 References

The titles of the publications referred to in this standard are listed on the inside back cover.

## 3 Terms and symbols

For the purposes of this British Standard the terms and symbols illustrated in Figure 1 apply.

## 4 Shapes

**4.1** Standard diameters and lengths of shell cylinders shall be as shown in Table 1 and Table 2 together with the nominal volumes contained within the vessels and their aspect ratios (length : diameter). Table 1 facilitates the selection of a standardized vessel for a required capacity, diameter and aspect ratio.

**4.2** Domed ends shall be torispherical as defined in Table 4 in terms of inner profile.

## 5 Dimensions

**5.1 General.** Linear dimensions are specified in millimetres, volumes in cubic metres.

Diameters of vessels are based on metric inside diameters and, in order to enable manufacturers to utilize existing “inch size” forming tools for the domed ends, a variation of  $\pm 12$  mm is permissible on diameters up to and including 1 300 mm. This is a temporary measure and manufacturers are strongly recommended to adopt nominal sizes when re-tooling.

### 5.2 Shell cylinders

**5.2.1 Modular lengths.** A standardized range of modular lengths shall be as given in Table 1 and Table 2. These lengths are based on the use of a single standard width of plate, purchased 2 500 mm wide. Shell cylinder lengths are built up in modular form using full plate widths where possible and fractions of these where necessary. Allowance is made for edge preparation, resulting in fabrication strakes of 2 480 mm (full plate), 1 860 mm ( $\frac{3}{4}$  plate), 1 235 mm ( $\frac{1}{2}$  plate) and 610 mm ( $\frac{1}{4}$  plate). The use of alternative widths to achieve the overall shell cylinder lengths is not, however, precluded.

**5.2.2 Thicknesses.** Shell cylinder thicknesses  $e_{\text{cyl}}$ , which include 1.5 mm corrosion allowance, associated with each diameter shall be as given in Table 3.

### 5.3 Domed ends

**5.3.1 Profile.** The dimensions of the inner profile shall be as given in Table 4.

It is permissible to use any values of crown and knuckle radii between the stated limits provided that the head height is as specified. Appropriate values may be selected using Appendix A. For practical purposes the profiles headed “ellipsoidal” are indistinguishable from ellipsoids of vessel radius/height ratio 2 : 1, which are also acceptable.

In the manufacture of domed ends where advantage is taken of the permissible variation of  $\pm 12$  mm on the nominal diameter (see 5.1) the inside crown radius shall be between  $0.75D_i$  and  $0.95D_i$ , the inside knuckle radius shall be between  $0.125D_i$  and  $0.1805D_i$  and the inside height shall be not less than  $0.25D_i$  where  $D_i$  is equal to the inside diameter, as manufactured, of the end concerned.

**5.3.2 Lengths of straight flanges.** The straight flanges shall be 50 mm long for vessels up to and including 1 700 mm diameter and 65 mm long for vessels above 1 700 mm diameter.

**5.3.3 Thicknesses.** Minimum thicknesses  $e_{\text{end}}$ , which include 1.5 mm corrosion allowance, associated with each diameter shall be as given in Table 3. These have been calculated to match the corresponding thickness  $e_{\text{cyl}}$  of the shell cylinder on the basis of equivalent strength. It is the responsibility of the manufacturer to select a suitable plate thickness to ensure that, after forming, the thickness shall at no point in the profile be less than  $e_{\text{end}}$  and that the thickness of the straight flange when prepared for welding shall be not less than the thickness  $e_{\text{cyl}}$  of the shell cylinder.

**5.4 Dimensional tolerances.** These shall be in accordance with BS 5500 except that the tolerance on the circumference (4.2.4.1.1 of BS 5500:1976) shall be increased by  $\pm 38$  mm for diameters up to and including 1 300 mm (see 5.1).

General dimensional tolerances for completed vessels shall be in accordance with DD 42.

## 6 Internal pressure rating of basic unpierced vessels

**6.1 Procedure.** To determine the shell cylinder and domed end thicknesses for a given pressure and stress, calculate the ratio  $p \div f$  to find the value of the pressure coefficient,  $k$ .

$$k = \frac{p}{f}$$

where

$p$  is the maximum permissible gauge pressure (in bar<sup>a</sup>) for vessel (including static head where significant).

$f$  is the maximum allowable design stress in material (in N/mm<sup>2</sup>).

<sup>a</sup> 1 bar = 10<sup>5</sup> N/m<sup>2</sup> = 100 kPa.

Enter Table 3 at the appropriate diameter and find a value of  $k$  equal to or greater than the calculated value.

Read off  $e_{\text{cyl}}$  and  $e_{\text{end}}$  for the thicknesses of the shell cylinder and the domed end respectively.

**6.2 Derivation of pressure coefficient  $k$**  (see Table 3). Coefficients are based on calculations to BS 5500:1976 as follows:

Shell cylinders, 3.5.1.2 a)

Unpierced ends, 3.5.2.3

The calculations include a corrosion allowance of 1.5 mm. In the case of vessels up to and including 1 300 mm diameter calculations are made for diameters inclusive of tolerance and variation (see 5.1).

## 7 Other requirements

Irrespective of the category of vessel, if the ends are made from more than one plate, the welds within each end shall be completely radiographed or examined ultrasonically before the end is formed. After forming, the knuckle region of these welds shall be examined by radiography or ultrasonic means.

The following information shall be supplied by the vessel fabricator when ordering ends.

- a) Inside diameter.
- b) Minimum thickness ( $e_{\text{end}}$ ).
- c) End preparation of the straight flange and the associated shell cylinder thickness ( $e_{\text{cyl}}$ ).
- d) The material specified in accordance with the appropriate British Standard.
- e) Any heat treatment requirements.
- f) Any further inspection requirements.
- g) Surface finish, if necessary.