

Specification for

**Design and
manufacture of carbon
steel unfired pressure
vessels for use in
vapour compression
refrigeration systems**

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- Associated Offices Technical Committee
- British Refrigeration Association
- British Steel Industry
- Department of the Environment (Property Services Agency)
- Department of Trade and Industry [Mechanical Engineering and Manufacturing Technology Division (MMT)]
- Engineering Equipment and Materials Users' Association
- Health and Safety Executive
- Institute of Refrigeration
- Welding Institute
- Coopted members

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Foreword

This British Standard has been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Committee. The object has been to produce a safe but economical standard for the design, manufacture, inspection and testing of serially produced vessels for use in refrigeration systems complying with BS 4434.

This specification closely limits the choice of material, the overall dimensions, the design pressures and temperatures in order to obtain economic manufacture of pressure vessels specifically for refrigeration systems. It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

The standard applies to pressure vessels containing group classifications 1 and 2 refrigerants. As in the case with pressure vessels manufactured in accordance with any other recognized standards, or design codes, e.g. BS 5500, the safe compliance with the requirements of the standard is assured by the survey and approval of vessels and their manufacture by an independent inspection authority or organization. However, unlike other recognized pressure vessel standards based upon surveys by inspection authorities appointed by the purchaser, the purchasers of vessels complying with this standard will typically not be known at the time of manufacture. In this special circumstance, provision is made for verification or surveillance by an inspection authority appointed by the manufacturer. In developing this provision, particular note has been taken of both:

- a) the Council Directive of 25 June 1987 (87/404/EEC) of the European Economic Community, on the harmonization of the laws of the Member States relating to simple pressure vessels (of series production and containing only air or nitrogen); and
- b) the corresponding draft European standard for simple unfired pressure vessels designed to contain air or nitrogen, being prepared by CEN/TC 54.

Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier's quality systems against the appropriate Part of BS 5750.

Enquiries as to the availability of third party certification schemes will be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

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 to iv, pages 1 to 24, 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.

Section 1. General

1.1 Scope

1.1.1 This British Standard specifies requirements for the design and the manufacture, including materials and design stresses, workmanship, inspection, testing, documentation and marking of carbon steel unfired pressure vessels for use in vapour compression refrigeration systems.

NOTE Information that should be supplied by the purchaser at the time of enquiry and/or order is given in Appendix A.

1.1.2 This British Standard applies to vessels within the following limitations.

a) Vessels intended for use in static permanently located refrigeration systems in the UK, containing non-corrosive group classifications¹⁾ 1 and 2 refrigerants, with design pressures not exceeding 28 bar²⁾ and with maximum permissible design temperatures not exceeding 200 °C.

b) Vessels of simple construction comprising, basically, lengths of tube or pipe with welded-on end caps and constructed from either:

1) low carbon ferritic steel tube or pipe with the material specification complying with BS 3602 or BS 3603, the dimensions complying with BS 3600 and corresponding end caps complying with BS 1965; or

2) low carbon ferritic steel pipe of equivalent analysis and properties to the corresponding steel grades in BS 3602 and BS 3603, but with the dimensions specified complying with BS 1600 and with end caps of similar analysis complying with BS 1640.

c) Vessels with outside diameters not less than 100 mm and not more than 610 mm and with lengths up to but not exceeding 6 m.

1.1.3 Determination of the dimensions of pressure parts under any of the following vessel conditions requires special consideration outside the scope of this British Standard:

- a) vessels subject to internal corrosion;
- b) vessels subject to external corrosion exceeding 0.75 mm;
- c) vessels used as part of a larger structure that are subject to substantial imposed loads, vibrations or abnormal thermally induced forces or moments, from integral piping.

1.1.4 This standard applies only to pressure vessels manufactured under the survey of a competent engineering inspection authority or organization. An inspection department maintained by the manufacturer does not satisfy this condition except:

- a) that specific responsibilities may be delegated at the discretion of the inspection authority or organization; or
- b) in the case of vessels for the manufacturer's own use and not for resale.

This standard applies only to vessels made by manufacturers who can satisfy the inspection authority or organization that they are competent and suitably equipped to fulfil the appropriate requirements of this standard.

1.1.5 This standard does not apply to containers for independent conveyance of refrigerants or to vessels containing heat exchange elements (tubes or plate).

1.1.6 Section 4 of this standard (manufacturing and workmanship) includes requirements applicable to the normal function of the vessel manufacturer. The requirements for the quality of workmanship of pipes and fittings in the condition in which they are normally supplied to the vessel manufacturer are included in the standards to which such materials are ordered.

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

1.2 Definitions

For the purposes of this British Standard the following definitions apply.

1.2.1 design pressure

the pressure used in determining the necessary materials, thickness and construction for components with regard to their ability to withstand pressure

1.2.2 design stress

the stress value used in the formulae in this standard for the calculation of the minimum scantling thicknesses of the pressure parts

1.2.3 design temperature

the highest metal temperature either in use or at rest, as may be appropriate

¹⁾ BS 4434 classifies refrigerants into three groups according to the predominance of flammability or toxic hazards. Group 1 refrigerants are non-flammable in vapour form in any concentration in air at atmospheric pressure and 20 °C and are all of a low order of toxicity; toxic decomposition products may result from contact with flames or hot surfaces in contact with air. Typical group 1 refrigerants are R11, R12, R13, R13B1, R22, R113, R114, R115, R500, R502 and R503. Group 2 refrigerants have toxicity as a dominant characteristic: the common group 2 refrigerant is ammonia (R717).

²⁾ 1 bar = 10⁵ Pa.

**1.2.4
family (of vessels)**

similar vessels complying with this standard that can be described on a composite drawing, or set of drawings

**1.2.5
inspection authority**

the independent organization that verifies that the vessel has been designed, constructed and tested in accordance with this standard

**1.2.6
manufacturer**

the organization with total responsibility for the design, fabrication, testing and installation of the pressure vessel. These separate tasks may be carried out by different organizations

**1.2.7
manufacturer's certificate of compliance**

the procedure whereby the manufacturer certifies vessels to be in compliance with this standard (see also Appendix B)

**1.2.8
minimum design temperature**

the lowest metal temperature at which the vessel is intended to operate, or 0 °C, whichever is the lower

**1.2.9
purchaser**

the organization or individual who buys the finished pressure vessels for its own use or as an agent for the owner

**1.2.10
serial production**

the manufacture of vessels to a common design and to a design and manufacturing schedule (see Appendix C) approved by the inspection authority

NOTE Permissible variations that do not require confirmation of design acceptability are length, nozzle position, number of nozzles and support location.

**1.2.11
surveillance**

the procedure carried out by an inspection authority during manufacture, see **D.3**, to ensure that the manufacturer duly fulfils the requirements of this standard in the case where the manufacturer elects to provide a certificate of compliance in accordance with **1.4.3 a) 1)** and Appendix D

**1.2.12
verification**

the procedure adopted to check and certify that individual vessels manufactured comply with this standard (see Appendix E)

1.3 Responsibilities of the manufacturer

The manufacturer shall be responsible for the completeness and accuracy of all design calculations and for compliance with all applicable requirements of this standard for the whole pressure vessel. During fabrication, unexpected factors may arise which do not affect the safety as intended by this standard; such deviations shall be recorded in the vessel dossier.

The manufacturer shall also be responsible for appointing an independent inspection authority to carry out the surveys and approvals of procedures and vessels in accordance with **1.4**.

A certificate of compliance shall be provided by the manufacturer in accordance with **6.3** and Appendix B.

1.4 General requirements

1.4.1 Vessels and their manufacture shall comply with sections 2 to 6.

1.4.2 Prior to the production of vessels, the manufacturer shall submit to the inspection authority, for approval in accordance with Appendix C, a design and manufacturing schedule (see **C.1**).

1.4.3 Prior to being placed on the market, vessels for which manufacture has been approved in accordance with **1.4.2** shall be subject to the following.

- a) For vessels intended for use with group 1 refrigerants, and at the manufacturer's option, either:
 - 1) the manufacturer's certificate of compliance (see Appendix B) coupled with surveillance by the inspection authority in accordance with Appendix D; or
 - 2) verification by the inspection authority in accordance with Appendix E.
- b) For vessels intended for use with group 2 refrigerant, i.e. ammonia, verification by the inspection authority in accordance with Appendix E.

Section 2. Materials and design stresses

2.1 Steels

2.1.1 Steels for pressure parts

2.1.1.1 Pipes, tubes and bosses

2.1.1.1.1 Steel pipes and tubes used for the construction of the shell and for branch connections shall be either:

- a) selected from the steel grades given in Table 1 and comply with the corresponding British Standards; or
- b) comply with 2.1.1.1.3.

NOTE This standard has been drafted on the basis of experience with the materials specified in Table 1 and these are recommended.

2.1.1.1.2 Bosses shall be manufactured from steel bars, plates or forgings complying with either:

- a) any of the following steel grades:
BS 970-070M20
BS 1501-151-430
BS 1502-161-430
BS 1503-221-490; or
- b) the requirements of 2.1.1.1.3.

2.1.1.1.3 Steel pipes, tubes and bosses not selected in accordance with 2.1.1.1.1 a) or 2.1.1.1.2 a), as appropriate, shall comply with a written specification at least as comprehensive as the British Standards referred to in 2.1.1.1.1 a) or 2.1.1.1.2 a) for the nearest equivalent steels.

The ladle analysis for the carbon steel shall contain less than 0.25 % (m/m) carbon and not more than 0.05 % (m/m) each of sulphur and phosphorus.

Welded pipes and tubes shall not be manufactured from rimming steels.

NOTE Appendix F gives guidance on steels that are recognized as near equivalents to those given in Table 1.

2.1.1.2 End caps. End caps shall be manufactured from steel plates or forgings complying with the following designations:

- a) plates:
BS 1501-151-430 (A or B), or
BS 1501-161-430 (A or B);
- b) forgings:
BS 1503-221-430 or 430E.

2.1.2 Steels for non-pressure parts

Steels for supports, mounting brackets, lugs, baffles and similar non-pressure parts welded to the pressure vessel shall be of established identity and shall be compatible with the steels to which they are attached.

Studs, bolts and nuts shall comply with BS 4882.

2.2 Design stresses

2.2.1 General

For materials covered by Table 1, the design stress (f) shall be not more than the appropriate nominal design stress value given in the table for the material of construction at the design temperature.

For alternative materials in accordance with 2.1 the nominal design stress for the shell shall be not more than 20 % of the minimum tensile strength at room temperature ($R_m/5$), and the design stress for calculating the local reinforcement around the branches shall be not more than two thirds of the minimum yield strength at a maximum design temperature (T) of 200 °C ($R_e T/1.5$), for the grade of material concerned.

2.2.2 Design temperature

2.2.2.1 The design maximum temperature used to evaluate the nominal design stress (f_2) shall be not less than the maximum temperature of the fluid inside the vessel.

2.2.2.2 The minimum temperature used to determine the appropriate grade of steel shall be the minimum mean wall temperature of the pressure part and shall be not more than the design saturated refrigerant temperature at the working pressure of the vessel or 0 °C whichever is the lower.

2.2.2.3 When the vessel is not subject to abnormal loads from pipe connections and is not subject to impact loads, the minimum design temperature for vessels designed and manufactured in accordance with this standard shall be as shown in Figure 1.

NOTE For temperatures below those shown in Figure 1, or for vessels subject to abnormal loads due to pipe connections or other external loads, or subject to impact loads, reference should be made to Appendix D of BS 5500:1988.

For the purpose of this standard, abnormal loads from pipe connections may be regarded as those for which the piping system does not satisfy the following criterion.

$$\frac{DY}{(L - U)^2} \leq \frac{2083S_A}{E_c}$$

where

- D is the nominal pipe size (in mm);
- Y is the resultant of movements to be absorbed by the pipe line (in mm) (in practical terms, this is the change in the distance between pipe ends, due to temperature changes, for an unconstrained pipe);
- U is the anchor distance, length of straight line joining anchors (in m);
- L is the developed length of line axis (in m);
- S_A is the allowable stress range (in N/mm²);

E_c is the modulus of elasticity of the piping material in the cold condition (in N/mm^2).

This criterion does not apply when the piping system:

- a) is not of uniform size;
- b) has more than two points of anchorage and one or more intermediate restraints;
- c) has not been designed for non-cyclic service, i.e. less than 7 300 total cycles.

Table 1 — Steel pipes and tubes for pressure purposes

Type: grade and method of manufacture	Minimum tensile strength at room temperature (R_m) N/mm ²	Minimum yield strength at room temperature (R_e) N/mm ²	Design stress (f_1) for the shell N/mm ²	Design stress (f_2) for branch compensation N/mm ²
Seamless and electrical resistance, including induction or submerged arc, welded carbon steel tubes complying with BS 3602-1 and BS 3602-2				
360 (HFS, CFS, ERW, CEW)	360	215	72	117
410 (HFS, CFS, ERW, CEW, SAW)	410	245	82	129
460 (HFS, CFS, ERW, CEW, SAW)	460	280	92	147
Seamless and electric resistance, including induction, welded carbon steel tubes complying with BS 3603				
410 LT 50 (HFS, CFS, ERW, CEW)	410	235	82	121