

Specification for

Fusion welded steel air receivers

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Health and Safety Executive
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Foreword

This British Standard has been prepared under the direction of the Pressure Vessel Industry Standards Policy Committee. It supersedes BS 5169:1975 which was withdrawn as a consequence of the issue of:

BS EN 286, “*Simple unfired pressure vessels designed to contain air or nitrogen*”.

BS EN 286-1:1991, “*Design, manufacture and testing*”.

This British Standard has been issued to allow the continued manufacture of the fusion welded air receivers which are outside the scope of EN 286.

It includes types of air receiver previously covered by BS 487 “Fusion-welded steel air receivers”, Part 1 “For pressures not exceeding 500 lb/sq in” and Part 2 “Receivers to Class 1 requirements” and BS 1091 “Small fusion-welded steel air receivers” which were superseded by BS 5169:1975.

This edition introduces technical changes, but it does not reflect a full review or revision of the standard.

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 48, 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 Scope

1.1 This British Standard specifies the requirements for fusion welded steel air receivers.

1.2 It specifically excludes all products subject to conformity with EN 286-1, EN 286-2, EN 286-3 or EN 286-4.

NOTE 1 The full scope of BS EN 286-1:1991 and of Parts 2, 3 and 4 of EN 286 are reproduced in Annex A.

NOTE 2 The list of standards referenced in BS EN 286-1:1991 is given in Annex B.

1.3 This standard does not apply to:

- a) containers used for the independent conveyance of compressed air (see BS 5045-2);
- b) pressure containers for paint and other substances (see BS 1101).

2 References

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

3 Definitions

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

3.1

air receiver

any fusion welded vessel intended to contain air or inert gas above atmospheric pressure

NOTE See clause 1 for exceptions.

3.2

fusion welding

the metal are process with covered electrodes or any other electric process in which protection against atmospheric contamination is provided during welding

NOTE See clause 16.

3.3

design pressure

a pressure not less than the highest pressure at which any associated safety valve is to be set to lift

NOTE To prevent unnecessary lifting of the safety valve it is desirable that there is a margin between the actual pressure at which the vessel receives and delivers air and the pressure at which any associated safety valve is set to lift (see BS 1123 and BS 6759-2).

3.4

minimum design temperature

either the lowest metal temperature at which the receiver is intended to operate or -10°C , whichever is lower (colder) (see clause 8)

3.5

maximum design temperature

the highest metal temperature at which the receiver is intended to operate but in no case greater than 300°C

4 Construction categories

There shall be three classes of receiver as follows.

- a) *Class I.* No limitation is placed on the size or design pressure for the receiver but there shall be non-destructive examination of all seams, and consideration should be given during design to the practicability of applying these tests.
- b) *Class II.* The design pressure shall not exceed $35\text{ bar}^{1)}$, and the product of the design pressure (in bars) and the internal diameter (in millimetres) shall not exceed $37\,000\text{ bar millimetres}$.
- c) *Class III.* The design pressure shall not exceed $17.5\text{ bar}^{1)}$, and the product of the design pressure (in bars) and the internal diameter (in millimetres) shall not exceed $8\,800\text{ bar millimetres}$.

5 Provision of information

5.1 Information to be supplied by the purchaser.

The purchaser shall provide the manufacturer with the following information at the time of enquiry.

- a) The class and grade of receiver required (see Table 1).
- b) In the case of class III receivers, whether weld bend tests are required.
- c) Any adverse or exceptional conditions under which the receiver will be required to operate [e.g. low or high temperature, excessive vibration (see clause 15), corrosion (see clause 6)].
- d) Whether the receiver is to comply with any requirements additional to those contained in this standard including any special statutory or other regulations.
- e) Whether detailed drawings are required by the purchaser.
- f) The name of the Inspecting Authority, if any, representing the purchaser.

NOTE The use of the term "Inspecting Authority" in this standard refers to the person or organization appointed by the purchaser to undertake the work of supervision provided for in this standard.

- g) Whether test certificates for materials are required (see clause 9).

¹⁾ $1\text{ bar} = 10^5\text{ N/m}^2 = 100\text{ kPa}$.

Table 1 — Summary of designated welding procedures

Class	Grade	Weld tests required (see clause 19)	Longitudinal seam welds (see clause 12)	Joint factor	Material for shells, ends etc. (see clause 7)
I	A	Yes	Both sides or one side with removable backing bar	0.95	Plate
I	B	Yes (circumferential seams only, see 20.2)	—	1.00	Seamless tube
II	C	Yes	Both sides or one side with removable backing bar	0.75	Plate
II	D	Yes (circumferential seams only, see 20.2)	—	1.0	Seamless tube
III	E	For mechanized welding only	Both sides or one side with removable backing bar	0.65	Plate
III	F	No	One side without backing bar	0.40	Plate
III	G	No		0.90	Seamless tube

5.2 Information to be supplied by the manufacturer. The manufacturer shall provide the purchaser with the following information.

- For class I receivers, the manufacturer shall supply the inspecting authority with fully dimensioned drawings showing the construction of the receiver, and shall obtain approval before manufacture commences.
- For class II and III receivers, the manufacturer shall provide with each receiver a signed and dated certificate of construction and test (see clause 38).

6 Corrosion

Where corrosion can be expected to occur the additional thicknesses to be allowed on either or both surfaces of the vessel walls shall be based on evidence or tests and shall be specified by the purchaser.

Unless there is adequate experience to indicate that, for specified service conditions, corrosion will be negligible, the standard gives minimum total additional thickness requirements in the equations in section 4.

Section 2. Materials

7 Materials for construction

7.1 Selection of materials. All materials used in the manufacture of receivers complying with the requirements of this standard shall comply with the requirements of the appropriate British Standards given in either 7.2 or 7.3, those given in 7.2 being preferred.

7.2 General

7.2.1 Plate materials. The steel plate used in the construction of the air receiver shall comply with the requirements of the following British Standards:

- BS EN 10207, grades SPH 235 and SPH 265
- BS EN 10028-2, grades P235 GH and P265 GH
- BS 1501-151, grades 360, 400 and 430
- BS 1501-161, grades 360, 400 and 430
- BS 1449-1.4, grades 37/23 HR, and 43/25 HR
- BS 1449-1.5, grade 37/23 CR
- BS 4360:1986, grades 40B, 40C, 43A and 43B

The use of materials conforming to BS 1449 and BS 4360 are limited to class III receivers with a maximum design temperature of 100 °C and shall comply with the following additional requirements.

- a) The copper content shall not exceed 0.3 %.
- b) Rimming steel shall not be used.
- c) The steel supplier shall supply a test certificate for materials which shall also state:
 - 1) the ladle analysis of the material supplied;
 - 2) the results of mechanical tests (tensile and bending) taken from samples representing the materials supplied.
- d) Cold rolled material shall be in the annealed and skin passed condition.

The negative tolerance on thickness permitted in the material standards shall be taken into account in specifying the ordering thickness.

7.2.2 Seamless shells, branches and nozzles. Tubes for seamless shells, branches and nozzles, shall comply with the following British Standards:

BS 3601, grades S 360 and S 430

BS 3602-1, grades HFS 360 and HFS 430

BS 3602-1, grades CFS 360 and CFS 430

7.2.3 Bars Bar material shall comply with the requirements of the following British Standards:

BS 1502-151

BS 1502-161

BS 970-1, grade 070M20

7.2.4 Forgings. Forgings shall comply with the requirements of the following British Standards:

BS 1503-221, grades 410 and 430

BS 1503-223, grades 410 and 430

BS 1503-164, grade 490

7.2.5 Sockets. Steel sockets shall be of a quality not inferior to BS 1387 and may be used within the limitations specified in **26.6**.

7.2.6 Cross bars. Cross bars for securing inspection covers shall be forged or cut from steel plates.

7.2.7 Bolting. Bolting material shall comply with the requirements of the following British Standards:

BS 1506-681, grade 820

BS 4882, grades B7, L7 and B7A

BS 3692, grade 8.8

Additionally, for class III receivers only, bolting to BS 1083 and BS 1768 is permitted.

7.3 Alternative carbon steel materials. Carbon steel materials other than those specified in **7.2** shall be permitted to be used for pressure parts, subject to agreement between the purchaser and the manufacturer, provided that the material is covered by a written specification as comprehensive as the equivalent British Standard for materials listed in these clauses.

NOTE Limits on carbon content. For ferritic steels intended for welding, the upper limit of the carbon range (in the ladle analysis) should not exceed 0.25 %. Steels with a higher carbon content which are intended for welding may be used subject to special agreement on welding procedures between the parties concerned. The maximum allowable phosphorus and sulfur content should not exceed 0.05 % in the ladle analysis.

7.4 Design strength values for materials (f)

7.4.1 Design strength values for materials specified in **7.2** are given in Table 2.

7.4.2 Design strength values for materials specified in **7.3**, and the values of *f* for materials specified in **7.2** and not given in Table 2, shall be derived using the methods of calculation given in Appendix K of BS 5500:1994, except that the factor of 2.35 used with R_m shall be replaced by:

- a) 3.33 for killed or semi-killed steels; or
- b) 3.5 for other types of steel.

8 Impact tests for materials

8.1 Unless specified by the purchaser, impact tests on the materials specified are not required down to the limiting minimum design temperature of – 10 °C, where the thickness, as defined in BS 5500, is less than 12 mm.

8.2 In all other cases the requirements for the impact testing of materials, including weld metal, shall be in accordance with Appendix D of BS 5500:1991.

9 Test certificates for materials

In the case of class I receivers, test certificates for the material shall be supplied and it is permissible for the Inspecting Authority to examine plates at the plate mills, to select and mark test pieces and to witness tests thereon. For class II and class III receivers, if the design temperatures are outside the range of – 10 °C to + 120 °C, test certificates shall be available for all pressure part materials. Test certificates shall give the full chemical analysis, details of the test results and a statement of the process of manufacture of the steel.

NOTE If the customer requires test certificates for pressure part materials he should state this in his order.

Table 2 — Design strength values (N/mm²)

Plates

Grade, type and method of manufacture	R_m	R_e	Thickness	Values of f for design temperatures (°C) not exceeding					
	N/mm ²	N/mm ²	mm	50	100	150	200	250	300
Non-alloy quality steel to BS EN 10207									
SPH 235	360/480	235	≤ 16	108	102	97	91	81	70
		225	≤ 40						
SPH 265	410/530	215	≤ 60						
		265	≤ 16						
		255	≤ 40						
		245	≤ 60	123	116	111	105	94	84
Non-alloy quality steel to BS EN 10028-2									
P235 GH	360/480	235	≤ 16	108	108	108	102	90	78
		225	≤ 40						
P265 GH	410/530	215	≤ 60						
		265	≤ 16						
		255	≤ 40						
		245	≤ 60	123	123	123	117	105	93
Carbon steel (semi-killed or fully-killed) to BS 1501-1									
151, 161, 360 (A and B)	360	205	3 ≤ 16	108	108	103	101	90	77
		195	≤ 40	108	107	102	97	86	77
		185	≤ 63	108	103	94	91	85	77
151,161, 400 (A and B)	400	225	3 ≤ 16	120	120	120	117	105	87
		215	≤ 40	120	120	115	111	99	87
		205	≤ 63	120	116	109	105	97	87
151,161, 430 (A and B)	430	250	3 ≤ 16	129	129	129	129	115	96
		240	≤ 40	129	129	126	121	109	96
		230	≤ 63	129	129	120	115	107	96
Carbon steel to BS 1449-1.A									
HR 37/23	370	230		106	106				
HR 43/25	430	250		123	123				
Carbon steel to BS 1449-1.5									
CR 37/23	370	230		106	106				
Carbon steel to BS 4360:1986									
40B	340/500	235		97	97				
40C	340/500	235		97	97				
43A	430/580	275		123	123				
43B	430/580	275		123	123				

Table 2 — Design strength values (N/mm²)

Steel pipes and tubes for pressure purposes

Grade, type and method of	R_m	R_e	Values of f for design temperatures (°C) not exceeding					
	N/mm ²	N/mm ²	50	100	150	200	250	300
Seamless carbon to BS 3601								
360S	360	215	108	108	108	103	92	83
430S	430	255	123	123	123	115	105	94
Seamless carbon and carbon manganese steel to BS 3602-1								
360 HFS and CFS	360	215	108	108	108	105	100	87
430 HFS and CFS	430	245	123	123	123	116	107	94

Bars

Grade, type and method of manufacture	R_m	R_e	Thickness	Diameter	Values of f for design temperatures (°C) not exceeding					
	N/mm ²	N/mm ²	mm	mm	50	100	150	200	250	300
Carbon steel (semi-or fully-killed) to BS 1502										
151, 161	430	250	≤ 16	≤ 25	129	129	129	129	115	96
		240	≤ 40	≤ 63	129	129	126	121	109	96
		230	≤ 63	≤ 100	129	129	120	115	107	96
		220	≤ 100	≤ 160	129	121	112	109	103	96
Carbon steel to BS 970-1										
070M20	430	215	Up to 63		132	128	120	117	111	97

Forgings

Grade, type and method of manufacture	R_m N/mm ²	R_e N/mm ²	Ruling section (See note) mm	Values of f for design temperatures (°C) not exceeding					
				50	100	150	200	250	300
Carbon manganese steels to BS 1503									
164 – 490	490	305	≤ 100	147	147	147	140	128	115
		280	> 100	147	147	143	130	123	115
221 – 410	410	215	≤ 100	123	121	112	109	101	90
		205	> 100	123	113	104	102	97	90
221 – 430	430	225	≤ 100	129	127	120	116	107	96
		215	> 100	129	120	112	109	103	96
223 – 410	410	245	≤ 100	123	123	123	117	108	95
		230	> 100	123	123	116	109	103	95
223 – 430	430	260	≤ 100	129	129	129	125	115	103
		245	> 100	129	129	121	116	111	103
NOTE Overall thickness limits are as defined in the relevant material specifications. In the case of forgings the term ruling section is to be interpreted in accordance with BS 5046.									

NOTE Overall thickness limits are as defined in the relevant material specifications. In the case of forgings the term ruling section is to be interpreted in accordance with BS 5046.

Section 3. Construction

10 Cylindrical shell

Cylindrical shells made from plate shall, where practicable, be made from a single plate.

If the dimensions are such that the shell cannot be made from a single plate, it shall be made with the minimum number of joints and the longitudinal seams in adjacent sections shall be as far apart as practicable.

11 End plates

11.1 For class I receivers, welded-on end plates shall be outwardly dished (i.e. concave to pressure) and shall be in one piece made from one rolled plate; when this is impracticable owing to the large diameter, and subject to agreement between the manufacturer and the purchaser or Inspecting Authority, end plates may be made from two or more plates butt welded together.

11.2 With certain limitations (see **32.1.4**), end plates for class II or class III receivers may be outwardly or inwardly dished, but no end plate may have reversed curvature [see Figure 13(d)].

11.3 For end plates manufactured from two or more plates, a double sided butt weld shall be used. The joint shall lie within $\frac{1}{5}D$ (where D is the cylindrical shell diameter) either side of a diameter and all welding and dressing of the weld shall be completed before the end is formed or dished. The welded seam shall comply with the requirements specified for the longitudinal or circumferential seams (see **12.1**). If more than two plates are considered necessary, the agreement of the manufacturer and the purchaser or Inspecting Authority shall be obtained for the proposed method of construction.

11.4 Plates for shell sections and end plates shall be formed to the required shape by any process that will not impair the quality of the material. Shell plates shall be formed to the correct contour up to the extreme edges of the plate. As far as possible hot and cold forming shall be by machine; local heating or hammering shall not be used. All plates which have been locally heated and cylindrical parts formed to an internal diameter of less than 20 times the plate thickness shall be given an appropriate heat treatment unless, during the last stage of manufacture, they have been uniformly heated to a temperature within the normalizing range.

NOTE The necessity for this heat treatment does not apply to vessels which will be given final heat treatment provided the material has been demonstrated to have maintained the specified minimum properties or has not otherwise been rendered unsuitable for the intended service.

Where plates are hot formed, the manufacturer who undertakes the forming may be required to demonstrate that the material has retained the minimum specified properties and has not been rendered otherwise unsuitable for the intended service.

Ends with thickness less than or equal to 6 mm may be used without post forming heat treatment. Ends with thickness over 6 mm but less than or equal to 8 mm shall undergo post forming heat treatment where the minimum design temperature is colder than -10°C . Ends with thickness greater than 8 mm shall not be used without post forming heat treatment. Shell sections and end plates with extruded branches shall be heat treated. The heat treatment after cold forming shall be normalizing.

After forming, plate edges to be welded shall be machined or flame cut by machine and shall be clean and free from rust, oil or other foreign matter. Any scale remaining after forming shall be removed.

11.5 Dished ends inserted into the shell [see Figure 8(d), Figure 8(e) and Figure 8(f)] shall be a close fit before welding, but if dished ends in accordance with Figure 8(g) and Figure 8(h) are used they should be a drive fit.

Ends convex to pressure [see Figure 8(f)] shall be assembled so that the outer end of the flange lies a distance not less than 1.5 times its thickness within the shell.

Ends concave to pressure [see Figure 8(d) and Figure 8(e)] shall be assembled in such a manner as to ensure that the fillet weld is clear of the knuckle.

Bolted-on end plates may be flat or outwardly dished but for class I receivers flat end plates shall not be used where the shell exceeds 600 mm internal diameter.

12 Types of welded joints

The types of welded joint used in the construction of the receiver shall be as in **12.1** to **12.3**. (See also clause **13**.)

12.1 Class I receivers. Except in the special circumstances-detailed in this subclause, longitudinal and circumferential shell seams in class I receivers shall be made with double sided butt welds of the types referred to in **13.1.3**. Notwithstanding the above, certain types of full penetration butt welds, deposited from one side against the temporary backing strip, may be regarded as equivalent to double sided butt welds and a joint factor of 0.95 used in the appropriate equation, by agreement with the inspecting authority, subject to the completion of satisfactory procedure tests (see **13.2**). Circumferential seams for the attachment of dished and flanged end plates shall be of the type referred to in **13.1.3** and shown in Figure 8(a), Figure 8(b) and Figure 8(c), except that for receivers less than 600 mm internal diameter and having a shell thickness not exceeding 16 mm a single sided weld using a technique approved by the inspecting authority is permitted.

Flanges for bolted joints in the shell, or at the end of a receiver, or on a branch connection, shall be welded in accordance with Figure 9(a), Figure 9(b) or Figure 9(c). The types of joint shown in Figure 9(a) and Figure 9(b) shall not be used when the internal diameter of the shell exceeds 600 mm.

Welded-on flat end plates shall not be used for class I receivers.

12.2 Class II and class III receivers. Except in the special circumstances detailed in this subclause, longitudinal and circumferential shell seams in class II and class III receivers shall be made with double sided butt welds of the type referred to in 13.1.3. Notwithstanding the above, certain types of full penetration butt welds, deposited from one side against a temporary backing strip, may be regarded as equivalent to double sided butt welds, subject to the completion of satisfactory procedure tests (see 13.2). In such cases the appropriate joint factor may be used. Where a seam is not reasonably accessible on the inside and the receiver is less than 600 mm internal diameter, welding may be carried out from the outside only, provided the procedure is such as to ensure sound positive root penetration [see Figure 1(c)]. Backing strips as shown in Figure 1(i) may be used for circumferential seams only, but this practice shall be avoided where internal welding is practicable. Circumferential seams in the cylinder shell may be of the type shown in Figure 1(j). Circumferential seams for the attachment of dished and flanged end plates may be made with any of the types of joint shown in Figure 8(a) to Figure 8(g) inclusive. Where the thickness of the cylindrical shell exceeds 13 mm, the types of joint shown in Figure 8(e) and Figure 8(f) shall not be used.

Flat end plates shall be welded to the cylindrical shell in the manner shown in Figure 8(i) to Figure 8(m) inclusive for the internal diameters and pressures specified.

Flanges for bolted joints in the shell, or at the ends of a receiver, or on a flanged branch connection shall be welded in accordance with any of Figure 9(a) to Figure 9(e) inclusive. The type of joint shown in Figure 9(d) shall not be used for pressures exceeding 17.5 bar.

12.3 *Text deleted.*

13 Weld preparation and procedure

13.1 Weld preparation

13.1.1 General. The surface of all plates at and adjacent to the weld shall be clean, dry, and free from scale, slag and irregularities before welding is commenced.

All slag shall be removed from each run of weld metal before a further run is superimposed. There shall be no perceptible undercutting of the plate.

13.1.2 Preparation of fillet welds. In a lap joint the length of each leg of a fillet weld shall be not less than the full thickness of the thinner of the two parts being welded. No part of the exposed face of the weld shall be within a line joining the edge of the plate with the toe of the fillet weld as thus defined. The contour of fillet welds shall be free from marked irregularities.

13.1.3 Preparation of butt welds. Plate edges shall be prepared for welding by machining or flame cut by machine in accordance with Figure 1(a) to Figure 1(i) inclusive. The use of square edge butt welds in accordance with Figure 1(a) and Figure 1(b) is permitted only for plate up to 5 mm thick.

13.1.4 Other considerations. Other preparations may be used provided that satisfactory weld procedure tests are carried out in accordance with the requirements of 13.2. The agreement of the inspecting authority, if any, shall be obtained.

The requirements of this clause with respect to plate edge preparation do not necessarily apply to mechanized welding processes for which special forms of preparation may be necessary.

Butt joints shall be welded from both sides subject to the exceptions referred to in clause 12.

Before welding is commenced the surface of the plates at the longitudinal and/or circumferential seams shall at no part be out of alignment with one another by more than 10 % of the plate thickness and in no case shall the misalignment exceed 3 mm for longitudinal seams or 5 mm for circumferential seams. It is permissible to achieve the alignment by tapering the surfaces with a slope of 1 : 5 over a width that may include the width of the weld [see Figure 8(b) and Figure 8(c)]. Tapering of surfaces is not permitted where this reduces the thickness below the required minimum. Before the second side of a butt joint is welded the root of the first run shall be removed to provide a clean metallic surface, unless the welding technique employed renders this unnecessary. In such cases, when the removal of the root of the first run may be waived, the seam shall satisfy a spot radiographic check. The agreement of the inspecting authority, if any, shall be obtained to this procedure.

For class I receivers the weld metal shall be built up to a thickness of not less than 2 mm or more than 5 mm in excess of the plate thickness and, for class II and class III receivers, the weld metal shall be built up to a thickness of 10 % more than the plate thickness. For class I receivers the excess metal shall then be removed by chipping or grinding but the finished thickness shall not be less than the thickness of the plate. For single sided butt welds the internal excess metal need not be removed but the outstand of the bead shall not exceed 10 % of the plate thickness. The bead shall be symmetrical, of smooth contour and free from undercutting.

13.2 Welding procedure tests. Where required by 12.1, 12.2, 13.1.2 and 13.1.3, the manufacturer shall conduct the tests required to approve the procedure and the tests shall be witnessed by the Inspecting Authority, if any, before production commences. The procedure test plates shall be of the same nominal composition as that to be used in the fabrication of the receivers and the range of thickness qualified shall be between 50 % more and 30 % less than the thickness of the procedure test plate. The welding technique, materials and heat treatment shall be the same as those to be used in production and if there is any significant change in these the procedure shall be requalified. One test plate representing each weld procedure shall be prepared, welded and tested in accordance with the requirements for test plates for class I receivers, set out in clause 20. If the test weld fails to pass any of the required tests, the cause of failure shall be established and rectified, and the whole of the procedure test shall be repeated.

14 Attachment of non-pressure bearing fittings

If non-pressure bearing fittings such as fixing brackets are attached to an air receiver by welding, all welding shall be completed before the receiver is heat treated, if this is required, and before hydrostatic testing. Where compressors and/or motors are mounted on air receivers, the mounting brackets and air receiver support brackets shall not be welded directly to the vessel, but to separate intermediate reinforcing plates welded to the shell or end. These reinforcing plates shall be of a material compatible with the shell or end and shall be continuously welded on all sides. Such plates are intended to spread any loads, other than pressure loads, over the shell surface.

The attachments shall be so positioned that the attachment welds are not less than $3t$ from any existing weld in the receiver, where t is the thickness of the receiver at the point of attachment. The length of the leg of any fillet weld used for the attachment welds shall be equal to the thickness at the point of attachment of the receiver or the fitting, whichever is the less.

15 Forced vibrations

15.1 If forced vibrations could occur and might be excessive, the source of the vibration should be isolated or damping introduced at the site of the local vibration.

15.2 Pulsation of pressure, wind excited vibrations or vibrations transmitted from plant (e.g. rotating or reciprocating machinery) may cause vibrations of piping or local resonance of the shell of an air receiver.

If such vibration can be anticipated, steps should be taken to isolate its cause or provide suitable damping.

15.3 It will be advisable to make an examination of the plant following initial start-up. If such vibration occurs and is considered to be excessive the source of the vibration should if possible be isolated otherwise suitable damping should be introduced.

16 Filler materials

Electrodes, filler wires and filler rods shall comply with the requirements of the relevant British Standards. In the absence of a relevant British Standard the filler materials shall be agreed between the manufacturer, the purchaser and the Inspecting Authority, if any.

17 Quality of welding

Unless otherwise specified in this standard, details of workmanship and the forms of weld preparation shall be as specified in BS 5135.

18 Approval of welders

18.1 In the case of class I and class II receivers, the approval of the welder will be established by tests carried out on the weld test pieces, supplemented in the case of class I vessels by the non-destructive examination of the production welds.

18.2 In the case of class III receivers, routine approval tests shall be made and recorded in accordance with the requirements of BS EN 287-1, and for bend tests, the diameter of the former shall be three times the thickness of the plate and the angle of the bend shall be 180° .

18.3 Test welds, simulating all types of welds employed in the manufacture of the receiver, shall be made under the same conditions. When the seam is welded from one side only, the tests shall also include a reverse bend through 90° in order to check the penetration of the weld.

18.4 Qualification of a welder for class III work shall be valid for a maximum period of 6 months provided he remains in the employment of the same manufacturer and is employed with reasonable continuity on the same type of work.

18.5 Requalification of a welder for class III work shall be required:

- a) at the end of the 6 month period;
- b) if his work is unsatisfactory for any reason;
- c) if he changes his employer.

18.6 For all three classes, welders employed on attachment weldings (see clause 14) shall be suitably qualified.

19 Tests of welded seams

The following tests shall be carried out.

19.1 Test for class I receivers. The tests specified in clauses 20, 21 and 22 shall be carried out for each receiver except that if a number of similar small receivers are welded by the same welder in a reasonably continuous operation, two or more receivers may at the discretion of the Inspecting Authority, if any, be represented by one set of test pieces.

19.2 Test for class II receivers. The tests specified in clauses 20 and 21 shall be carried out for each receiver except that where a number of receivers are made in a reasonably continuous operation by the same welder and the plate thicknesses do not vary by more than 5 mm, each 40 m of welded seam (longitudinal plus circumferential) may be regarded as equivalent to one receiver, the required number of test pieces being provided accordingly. In such cases test pieces shall be provided for the receiver with the thickest shell and shall be of the same thickness as that shell.

19.3 Test for class III receivers. Tests related specifically to receivers are not required except in the case of mechanized welding, but the welder shall demonstrate his competence in accordance with clause 18. Where machine welding is employed one normal and one reverse bend test piece shall be selected and tested in accordance with the requirements of clause 13 prior to the commencement of production welding, and after completion of welding of every 50 m of seam in any period of production welding.

20 Test plates

Before any tests are carried out all test plates shall be heat treated similarly to the receiver which they represent (see clause 24).

20.1 Longitudinal seams. Test plates shall be prepared at each end of each longitudinal seam of the receiver or equivalent as defined in clause 19 (see Figure 2 and Figure 4). By agreement with the inspecting authority, if any, in the case of class I receivers the test plates may be attached at one end of the longitudinal seam only (see Figure 3). The test plates shall be of sufficient size for the preparation of the test pieces specified and any repeat tests that may be required. The material for each set of test plates shall be cut from the plate or plates forming the appropriate seam and before being cut shall be stamped by the inspector. Where a shell is formed in two or more rings a staggered longitudinal seam may be regarded as a continuous longitudinal seam provided the welding is carried out in a reasonably continuous operation and by the same operator or operators.

One complete set of test pieces (see Figure 2, Figure 3 and Figure 4) may be used to represent such a staggered longitudinal welded seam of the shell provided the inspecting authority, if any, has been informed of the manufacturer's intention to adopt this procedure prior to the commencement of welding.

The weld preparation in the test plates shall be similar to that adopted for the corresponding edges of the longitudinal seam and the test plates shall be secured to the shell plates so that the respective fusion faces are in continuous alignment.

Test plates warped during welding by not more than 5° may be straightened cold before heat treatment.

20.2 Circumferential seams. Test plates are not required for circumferential seams except in cases where the receiver has circumferential seams only or where the method of welding the circumferential seams is significantly different from that used for the longitudinal seams, in which case test plates shall be prepared having a welded joint which as far as possible is a duplication of the circumferential seams. The materials for these test plates shall conform to the same specifications as the shell and end plates of the receiver.

20.3 Selection of test pieces. From each set of test plates, test pieces shall be selected, stamped by the inspector for identification, and cut out as appropriate to the class of receiver as follows.

- a) *Class I receivers* (see Figure 2 and Figure 3)

One transverse tensile test piece for the welded joint

One all weld metal tensile test piece
 One normal bend test piece
 One reverse bend test piece
 Three impact test pieces
 One specimen for micro and macro examination (see Figure 3).

b) *Class II receivers* (see Figure 4)

One transverse tensile test piece for the welded joint
 One normal bend test piece
 One reverse bend test piece
 One nick break test piece.

The disposition of the test pieces shall be as indicated in the appropriate figures (see Figure 2, Figure 3 and Figure 4) and the remainder of each set of test plates shall be retained for any retests required. Any test piece for retest shall be cut from the same set of test plates as the original test piece.

Surfaces of tensile test, weld metal, bend test and impact test pieces corresponding to the outside or inside of the receivers shall be only lightly dressed so that the rolled surface of the parent metal is not wholly removed; where the rolled surfaces of the abutting plates are not level with one another the projecting plate may be machined at each face of the weld provided the depth of metal removed does not exceed 1 mm.

20.4 Tensile test piece

a) *Transverse seams*. The form and dimensions of the test piece shall be in accordance with Figure 5 and the test piece shall be cut transversely to the welded seam. If the capacity of the available testing machine does not allow the full thickness of a single test piece to be tested, the test piece shall be cut into such portions of the thickness as shall be agreed between the manufacturer and the Inspecting Authority, if any. Each of these portions shall comply with the specified requirements.

b) *All weld metal*. The form and dimensions of the test piece shall be in accordance with BS EN 10002-1. The test piece shall be cut longitudinally from the seam and the reduced portion thereof shall consist entirely of deposited metal. Where the standard proportional round test piece is too small, the method of testing shall be as agreed with the Inspecting Authority, if any.

20.5 Tensile tests

a) *Transverse seams*. The tensile strength shall be not less than the lower limit specified for the plate.

b) *All weld metal*. The tensile strength shall be not less than the lower limit specified for the plate. The elongation shall be not less than 16 % on a gauge length of 5.65 times the square root of the cross-sectional area of the test piece, and the reduction in area not less than 35 %.

20.6 Bend test pieces. The test pieces shall be rectangular in section and shall be cut transversely to the weld so as to have a width equal to 1.5 times the thickness of the test pieces. The corners of the test pieces shall be rounded to a radius not exceeding 10 % of the thickness of the test piece.

If the plate thickness does not exceed 30 mm the thickness of the test piece shall be equal to the full thickness of the test plate. If the plate thickness exceeds 30 mm the test piece shall in all cases have a thickness of at least 30 mm. The test piece to be tested with the outer surface of the weld in tension shall be prepared by cutting to waste the metal local to the inner surface of the weld so that the desired test piece thickness is obtained (see Figure 6, test piece A). The test piece to be tested with the inner surface in tension shall be prepared by cutting to waste the metal local to the outer surface of the weld so that the desired test piece thickness is obtained (see Figure 6, test piece B). Where the thickness of the plate permits, both test pieces may be cut from the same piece of plate, the test pieces being located in the plate one above the other (see Figure 6, test piece C). In the case of class III air receivers with mechanized welded longitudinal seams the “run-on” and “run-off” plates may be used for the purposes of bend test pieces provided they comply with all the appropriate requirements of this clause.

20.7 Bend tests. One test piece shall be tested with the surface corresponding to the outer surface of the shell in tension and the other with the surface corresponding to the inner surface of the shell in tension. The test piece shall be mounted on supports, the faces of which are separated by a distance not more than 5.2 times the thickness of the test piece, and shall be pushed through the supports by a former having a diameter equal to 3 times the thickness of the test piece (see Figure 7).

On completion of the test no crack or defect on the outer surface of the test piece shall be greater than 1.5 mm measured across the test piece or 3 mm measured along the length of the test piece. Premature failures at the corners of the test pieces shall not be considered cause for rejection.

20.8 Impact tests. The dimensions of the three test pieces shall, where possible, be in accordance with Figure 1 of BS EN 10045-1.

The test pieces shall be taken transversely to the weld, parallel to the plate surface, and as near as possible to the face side of the last pass of the weld.

If plates are less than 12 mm thick, three test pieces shall be provided to the largest dimensions possible in accordance with Table 2 of BS EN 10045-1. These shall have the notch cut in the narrow face with the notch at right angles to the plate surface.

Each test shall show a minimum Charpy impact test value of 27 J taken as the average for the three specimens with no individual value less than 20 J. The test should be carried out at ambient temperatures, but in no case at a temperature greater than 50 °C.

20.9 Nick break tests. A slot shall be cut in each side of the test piece through the centre of the weld and perpendicular to the outer face of the receiver as shown in Figure 4. The test piece shall then be broken in the weld and the fracture shall reveal a sound homogeneous weld substantially free from slag inclusion, porosity and coarse crystallinity.

21 Retests

21.1 Should any of the test pieces taken in accordance with clause 20 fail to meet the specified requirements the following procedure shall be adopted.

21.1.1 Class I receivers. One retest shall be allowed for each test piece that fails, provided the following minimum figures have been obtained.

Reduction in area: 30 %.

Any other test except the bend and impact tests: 90 % of the specified requirements. Should a bend test piece fail to meet the specified requirements two retests shall be made from the same test plate and these shall comply with the requirements of clause 20.

Should an impact test fail to meet the specified requirements the manufacturer shall adopt the following procedures.

Take two further test pieces from the test plate, one from each side of the original test piece and separated from it by not more than 6 mm. Both retests shall show a minimum impact test value of 34 J. Reheat treat the receiver and related test pieces and retest in accordance with clause 20.

21.1.2 Class II receivers. For every test piece which fails two further test pieces shall be taken and retested.

21.1.3 Class III receivers. In the event of a mechanized weld production test piece failing to meet the specified requirements all production welding completed since the previous satisfactory test shall be re-examined by radiographic or ultrasonic means to establish the extent of the defective welding. Should this examination fail to determine the cause of the defects two test pieces shall be cut from the last receiver to be welded prior to the test and these shall be tested in accordance with the requirements of clause 20.

21.2 Should it be found that there is insufficient metal to permit the preparation of test pieces for retest from the remainder of the test plate from which the original test piece was taken the test piece for retest may be cut from the test plate relating to the opposite end of the same longitudinal seam.

Should any of the retests fail to meet the specified requirements the welded seams represented by these tests shall be considered not to comply with the requirements of this standard.

22 Non-destructive tests

The following requirements apply to class I receivers only.

22.1 Microscopic and macroscopic examination. A test piece, the full thickness of the plate and not more than 12 mm wide, shall be taken from each set of test plates for the purposes of microscopic and macroscopic examination.

22.2 Radiographic examination

22.2.1 Every portion of the butt welded seams in the shell and end plates of the receiver shall be subjected to radiographic examination. The recommendations of BS 2600 and BS 2910 should be followed. Where the surface finish of any weld is such that it will prevent accurate radiographic examination, the surface shall be machined or ground to provide a smooth contour. Radiographic examination shall be carried out after heat treatment.

22.2.2 For each radiographic exposure, an image quality indicator of the wire or the stephole type complying with the requirements of BS 3971 shall be placed on the surface nearest to the source of radiation. The stephole type of image quality indicator should be placed close to and parallel with the weld; the wire type of indicator should be placed across the weld with the wire situated at right angles to the axis of the weld.