



BS 5169 : 1975

UDC 621.642.02 : 621.54 : 669.14 : 621.791.7

Specification for
**Fusion welded
steel air receivers**

British Standards Institution

AVA Documents
Document Sharing Hub

This British Standard, having been approved by the Pressure Vessel Industry Standards Committee, was published under the authority of the Executive Board on 30 May 1975.

© British Standards Institution, 1975

ISBN: 0 580 08560 0

British Standards Institution

Incorporated by Royal Charter, BSI is the independent national body for the preparation of British Standards. It is the UK member of the International Organization for Standardization and UK sponsor of the British National Committee of the International Electrotechnical Commission.

Copyright

Users of British Standards are reminded that copyright subsists in all BSI publications. No part of this publication may be reproduced in any form without the prior permission in writing of BSI. This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols and size, type or grade designations. Enquiries should be addressed to the Publications Manager, British Standards Institution, Linford Wood, Milton Keynes MK14 6LE. The number for telephone enquiries is 0908 320033 and for telex 825777.

Contract requirements

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.

Revision of British Standards

British Standards are revised, when necessary, by the issue either of amendments or of revised editions. **It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.** Information on all BSI publications is in the *BSI Catalogue*, supplemented each month by *BSI News* which is available to subscribing members of the Institution and gives details of new publications, revisions, amendments and withdrawn standards. Any person who, when making use of a British Standard, encounters an inaccuracy or ambiguity, is requested to notify BSI without delay in order that the matter may be investigated and appropriate action taken.

The following BSI references relate to the work on this standard:

Committee reference PVE/1/-/6 Draft for comment 72/31681 DC

Co-operating organizations

The Pressure Vessel Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations.

- *Associated Offices Technical Committee
- *Association of Consulting Engineers
- Association of Shell Boilermakers
- *British Chemical Engineering Contractors' Association
- *British Gas Corporation
- British Insurance (Atomic Energy)
- British Mechanical Engineering Confederation
- *British Steel Industry
- *Chemical Industries Association
- *Council of British Manufacturers of Petroleum Equipment
- *Department of Employment
- *Department of Energy
- Department of Trade

- *Electricity Supply Industry in England and Wales
- *Engineering Equipment Users' Association
- *Institution of Chemical Engineers
- *Institution of Gas Engineers
- *Institution of Mechanical Engineers
- *Lloyd's Register of Shipping
- *Oil Companies Materials Association
- *Process Plant Association
- *United Kingdom Atomic Energy Authority
- University of Manchester-Institute of Technology and Science
- *Water-tube Boilermakers' Association
- *Welding Institute

The Government departments and scientific and industrial 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.

- British Compressed Air Society
- British Electrical and Allied Manufacturers' Association
- London Transport Executive

- Ministry of Defence.
- Railway Industry Association
- Society of Chemical Industry
- Society of Motor Manufacturers and Traders Ltd.

**BS 5169 : 1975**

UDC 621.642.02: 621.54: 669.14: 621.791.7

Specification for Fusion welded steel air receivers

Amendments issued since publication

Amd. No.	Date of issue	Text affected
2621	June 1978	Indicated by a line in the margin
2745	October 1978	Indicated by a line in the margin
3520	March 1981	Indicated by a line in the margin

British Standards Institution · 2 Park Street · London W1A 2BS

Telephone 01-629 9000

Telex 266933

**Documents**

Document Sharing Hub

BS 5169 : 1975

Contents

	Page		Page
Co-operating organizations	Inside front cover	Section four. Rules for scantlings	
Foreword	2	29. General	15
Specification		30. Notation	15
Section one. General		31. Thickness of cylindrical shell plate	16
1. Scope	3	32. Thickness and shape of ends and diaphragms	17
2. References	3	33. Openings in cylindrical shells and end plates	18
3. Definitions	3	34. Design of flanges and bolting	18
4. Provision of information	3	Section five. Inspection, testing, marking and certification	
5. Compliance	4	35. Inspection	19
6. Corrosion	4	36. Hydraulic pressure test	19
Section two. Materials		37. <i>Text deleted.</i>	19
7. Materials for construction	4	38. Marking	19
8. Impact tests for materials	5	39. Certificate of construction and test	19
9. Test certificates for materials	5	Tables	
Section three. Construction		0. Design strength values	
10. Cylindrical shell	5	1. Examination holes and manholes for air receivers	14
11. End plates	5	2. Summary of designated welding procedures	16
12. Types of welded joints	6	3. <i>Text deleted.</i>	16
13. Weld preparation and procedure	7	Figures	
14. Attachment of non-pressure bearing fittings	7	1. Joint details	21
15. Forced vibrations	7	2. Details of test plates when attached to both ends of the shell	22
16. Filler materials	8	3. Details of test plates when attached to one end of the shell	23
17. Quality of welding	8	4. Details of test plates	23
18. Approval of welders	8	5. Test piece 1: tensile test for joint	24
19. Tests of welded seams	8	6. Bend test pieces	24
20. Test plates	8	7. Bend test	24
21. Retests	10	8. Connections of end to shell	25
22. Non-destructive tests	11	9. Flange attachments	28
23. Repairs to welded seams after radiographic examination	12	10. Standard weld details for branches	30
24. Stress relieving heat treatment	12	11. Boss and pad connections	35
25. Access	12	12. Inlet and outlet connections	36
26. Connections	14	13. Dished end plates	38
27. Drainage	15	14. Compensation for openings	39
28. Circularity of shell	15	15. Compensation for openings	40

Foreword

This British Standard has been prepared under the authority of the Pressure Vessel Industry Standards Committee.

It embodies the 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 I requirements' and BS 1099 'Small fusion-welded steel air receivers', which are now superseded by this standard.

It is recognized that the rationalized British Standard for fusion welded pressure vessels, currently being drafted, will ultimately include requirements for the simpler type of vessel, and it is envisaged that the experience obtained by industry in the use of this standard will be of benefit when the relevant part of the rationalized standard is drafted.

Certification. Attention is drawn to the certification facilities described on the inside back cover of this standard.

British Standard Specification for Fusion welded steel air receivers

Section one. General

1. Scope

This British Standard specifies requirements for class I, class II and class III fusion welded steel air receivers, with the following limitations.

Class I. No limitation is placed on the size or design pressure for the receiver but the standard requires non-destructive examination of all seams, and consideration should be given during design to the practicability of applying these tests.

Class II. For class II receivers, the design pressure shall not exceed 35 bar* and the product of the design pressure (in bars) and the internal diameter (in millimetres) shall not exceed 37 000.

Class III. For class III receivers, the design pressure shall not exceed 17.5 bar and the product of the design pressure (in bars) and the internal diameter (in millimetres) shall not exceed 8800.

This standard does not apply to:

- (a) containers used for the independent conveyance of compressed air or 'permanent' or 'liquefiable' gases for which provision is made in BS 5045 : Part 2;
- (b) pressure containers for paint and other substances (these are already provided for in BS 1101);
- (c) air receivers for road and railway vehicles (these are covered by BS 3256).

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 arc 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 (this is the safe working pressure referred to in Sections 36 and 37 in the Factories Act 1961).

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 : Part 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. Provision of information

4.1 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 clause 31, table 2).
- (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 temperature, high temperature, excessive vibration (see clause 15) corrosion (see clause 6))

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

BS 5169 : 1975

(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).

4.2 Information to be provided by the manufacturer. For class I receivers, the manufacturer shall supply the Inspecting Authority with fully dimensioned drawings showing in full detail the construction of the receiver for approval before putting the work in hand.

5. Compliance

Fusion welded steel air receivers purporting to comply with this standard shall conform in all respects to the relevant requirements herein prescribed.

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 four.

Section two. Materials

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.

(See table 0 for design strength values.)

BS 1501-151, grades 360, 400 and 430

BS 1501-154, grades 360, 400 and 430

BS 1501-161, grades 360, 400 and 430

BS 1449 : Part 1, grades 37/23 HR, 37/23 CR and 43/25 HR

BS 4360, grades 40B, 40C, 43A and 43B

The use of materials conforming to BS 1449 : Part 1 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 (See table 0 for design strength values.)

BS 3601, grades S 320, S 360 and S 410

BS 3602, grades CFS 360, CFS 4 and CFS 460

HFS 360, HFS 410 and HFS 460

7.2.3 Bars. Bar material shall comply with the requirements of the following British Standards (see table 0 for design strength values).

BS 1502-151, grade 430

BS 1502-161, grade 430

BS 970 : Part 1, grade 070M20.

7.2.4 Forgings. Forgings shall comply with the requirements of the following British Standards (see table 0 for design strength values).

BS 1503-221, grades 410, 430 and 460

BS 1503-223, grades 410, 430 and 460

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

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

7.3 Alternative carbon steel materials. Other carbon steel materials than those specified in 7.2 permitted to be used for pressure parts, shall be 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 sulphur 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 0.

7.4.2 Design strength values for materials specified in 7.3 shall be derived using the methods of calculation given in appendix K of BS 5500 : 1988.

Table 0. Design strength values (N/mm^2)

Plates

Grade, type and method of manufacture	R_m	R_e	Thickness	Values of f for design temperatures ($^{\circ}\text{C}$) not exceeding					
				50	100	150	200	250	300
N/mm ² N/mm ² mm									
Carbon steel (semi-killed with aluminium) to BS 1501 : Part 1									
154, 360A	360	205	3 to 9.5	108	108	103	101	90	77
154, 400A	400	235	3 to 9.5	120	120	120	117	104	87
154, 430A	430	250	3 to 9.5	129	129	129	129	115	96
Carbon steel (semi-killed or fully-killed) to BS 1501 : Part 1									
151, 161, 360 (A and B)	360	205	3 to 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 to 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 to 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 : Part 1									
37/23 HR and CR	370	230		106	106				
43/25 HR	430	250		123	123				
Carbon steel to BS 4360									
40B	340	215		97	97				
40C	340	215		97	97				
43A	430	255		123	123				
43B	430	255		123	123				



Table 0 (concluded)
Steel pipes and tubes for pressure purposes

Grade, type and method of manufacture	R_m	R_e	Values of f for design temperatures ($^{\circ}\text{C}$) not exceeding					
			50	100	150	200	250	300
N/mm ² N/mm ²								
Seamless carbon and carbon manganese steel to BS 3601								
320S	320	195	96	96	96	93	83	74
360S	360	215	108	108	108	103	92	83
410S	410	235	123	123	123	115	105	94

Seamless carbon and carbon manganese steel to BS 3602 : Parts 1 and 2

360 HFS and CFS	360	215	108	108	108	105	100	87
410 HFS and CFS	410	245	123	123	123	116	107	94
460 HFS and CFS	460	280	138	138	138	132	121	109

Sections and bars

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

Forgings

Grade, type and method of manufacture	R_m	R_e	Ruling section (See note)	Values of f for design temperatures ($^{\circ}\text{C}$) not exceeding					
				50	100	150	200	250	300
N/mm ² N/mm ² mm									
Carbon manganese steels to BS 1503									
164 - 490	490	305	100	147	147	147	140	128	115
		280	100, 150	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.

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 : 1988.

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 $+100^{\circ}\text{C}$ 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.

Section three. 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 $\frac{1}{8}D$ (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 to 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.

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

BS 5169 : 1975

that the material has retained the minimum specified properties and has not been rendered otherwise unsuitable for the intended service.

Cold formed dished ends shall be normalized after forming.

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 figures 8 (d), (e) and (f)) shall be a close fit before welding, but if dished ends in accordance with figures 8 (g) and (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 figures 8(d) and (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 figures 8(a), (b) and (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 figures 9(a), (b) or (c). The types of joint shown in figures 9(a) and (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 figures 8(a) to (g) inclusive. Where the thickness of the cylindrical shell exceeds 13 mm, the types of joint shown in figures 8(e) and (f) shall not be used.

Flat end plates shall be welded to the cylindrical shell in the manner shown in figures 8(i) to (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 figures 9(a) to (e) inclusive. The type of joint shown in figure 9(d) shall not be used for pressures exceeding 17.5 bar*.

12.3 All classes of receiver. In all cases, where a dished end plate is welded to the shell by a butt weld as shown in figures 8(a), (b) or (c), the parallel portion of the flange at the outside and inside shall form a continuous line at the joint with the cylindrical shell plate, and the inside or outside, or both shall be tapered down where necessary.

* 1 bar = 10^5 N/m² = 100 kPa.



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 figures 1(a) to (i) inclusive. The use of square edge butt welds in accordance with figures 1(a) and (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. 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 hydraulic 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.

BS 5169 : 1975

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 1856.

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 4872 : Part 1, except that 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 figures 2 and 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 figures 2, 3 and 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 figures 2 and 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 figures 2, 3 and 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 18. 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 %.

BS 5169 : 1975

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 131:Part 2:1972.

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 1 of BS 131:Part 2:1972. 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.

22.2.3 When use is made of an image quality indicator of the wire type (see BS 3971) the smallest diameter wire which can be seen in the radiograph shall have a diameter not greater than 1.5 % of the weld metal thickness if the weld thickness is 10 mm up to and including 50 mm. The diameter shall be not greater than 1.25 % of the weld metal thickness if the thickness is greater than 50 mm up to and including 200 mm.

22.2.4 When use is made of an image quality indicator of the stephole type it shall have a hole in each step of a diameter corresponding to its thickness at that step or shall have some similar device whereby the step thickness can be identified when the radiographic film is examined. The smallest diameter hole visible in the radiograph shall not exceed 3 % of the weld thickness for welds not exceeding 50 mm thick, or 2.5 % for welds exceeding 50 mm thick. The steps shall bear these proportions to the weld thickness radiographed and the radiographic technique shall be capable of revealing changes in metal thickness of these percentages. In the case of welds with reinforcement, the step provided shall have a thickness which, added to that of one step, conforms to the sum of the main thicknesses of the reinforcements.

22.2.5 Lead type shall be fixed to the plate adjacent to the weld to identify the portion of weld covered by each exposure. The length of weld covered by each exposure shall be such that the metal thickness measured along the incident beam at the extremity of the exposure shall not exceed the actual thickness by more than 10 %.

22.2.6 Radiographs shall be examined on the original films using a viewing device of suitable illuminating power; the acceptability of the welds shall be decided by the inspecting authority, if any, in accordance with 22.2.7. The welds deemed unsatisfactory shall be held not to comply with the requirements of this standard or shall be dealt with under the conditions specified in clause 23.

22.2.7 Any one of the following imperfections shall be judged unacceptable.

(a) Any type of crack or zone of incomplete fusion or penetration.

(b) Any elongated slag inclusion which has a length greater than:

3 mm for t up to 10 mm

6 mm for t from 10 mm up to 19 mm

$\frac{1}{3} t$ for t from 19 mm up to 57 mm

19 mm for t over 57 mm

where t is the thickness of the thinner part being welded.

(c) Any group of slag inclusions in line that have an aggregated length greater than t in a length of $12t$, except when the distance between the successive imperfections exceeds $6L$ (where L is the length of the longest imperfection in the group).

(d) A total area of porosity, projected radially through the weld, exceeding 6 mm^2 (equivalent to three areas 1.6 mm in diameter) per 25 mm of wall thickness in any 645 mm^2 of projected weld area, considering the thinner of the components being joined.

BS 5169 : 1975

23. Repairs to welded seams after radiographic examination

23.1 General. Any repair to a welded seam shall be agreed with the Inspecting Authority, if any.

When the defects are contained in a single continuous length, the permissible extent of the repair shall be agreed between the Inspecting Authority, if any, and the manufacturer.

23.2 Intermittent defects. Where defects occur in seams, the total length of repairs to replace defective welding shall not exceed 15 % of the total length of the seam.

23.3 Longitudinal seams. If the weld metal in any way fails to comply with the requirements specified in this standard, the whole of the weld metal may be removed and the seam rewelded, provided that:

- (a) the original test plates are similarly treated; or
- (b) new test plates of the same thickness as the joint and of similar quality of material are attached to the end of the seam and rewelded with it.

In either case, the plates shall be tested in accordance with clauses 20, 21 and 22 and heat treated in accordance with clause 24.

23.4 Circumferential seams. Circumferential seams shall be treated in the same manner as longitudinal seams with regard to repairs. The Inspecting Authority, if any, shall be entitled to call for representative tests on a rewelded circumferential seam.

23.5 Removal of defects. Defects shall be cut out by chipping, machining or other approved methods.

23.6 Examination before rewelding. Where a defective part has been cut out, the Inspecting Authority, if any, shall be entitled to make an examination before rewelding is carried out.

23.7 Process used for repairs. Repairs shall be fusion welded as defined in 3.2.

23.8 Radiographical examination after repairs. All repaired areas shall be subjected to radiographic examination.

23.9 Diagram of welded repairs. On completion of all welded repairs the manufacturer shall, if requested, supply for record purposes a detailed diagram showing the position, length, depth and width of all such repairs.

24. Stress relieving heat treatment

24.1 If any of the air receiver plates exceed 20 mm thick, the air receiver shall be given a stress relieving heat treatment. This shall be done after completion of all welding, including repair welding, and before applying the hydraulic test. For this heat treatment any relevant test plates shall be placed inside the receiver which shall be placed in a furnace sufficiently large to accommodate the whole receiver. The furnace shall be slowly raised to a temperature of $600 \pm 20^\circ\text{C}$ which shall be maintained for a period of not less than 1 h per 25 mm of shell thickness. The receiver may be allowed to cool in the furnace, but if withdrawn, shall be screened from draughts while cooling.

24.2 If the manufacturer wishes to submit an alternative procedure for the heat treatment of the receiver and/or test plates, it shall be submitted to the Inspecting Authority, if any, for approval.

25. Access

25.1 Access and inspection openings

25.1.1 All vessels shall be provided with manholes and/or examination holes in accordance with table 1 situated so that they permit examination of the inside of the vessel. The table details the minimum number and types of holes depending on the diameter, length and shape of the vessel. The minimum dimensions of holes shall be maintained in the case of lined vessels where the lining is applied to the inside of the hole.

25.1.2 Detachable ends or covers can be used instead of all the other holes provided they are of dimensions at least equal to the minimum dimensions required for examination of manholes.

25.1.3 One detachable end or cover can replace all the other examination holes if, by its dimensions and its position, it permits a general view of the interior at least equivalent to that obtained by the examination holes which would otherwise be required.

25.1.4 Inspection openings shall not be situated near a welded seam and, where necessary, compensation shall be provided as specified in clause 33. The welding of any compensating ring shall not encroach on a welded seam.

NOTE. Special attention is drawn to BS 470, and to Section 30 of the Factories Act 1961 which requires manholes of certain minimum sizes in vessels which persons may enter and in which dangerous fumes, gas or vapour are liable to be present to such an extent as to involve risk of persons being overcome thereby.

25.2 Types and minimum dimensions of the holes in the vessel

25.2.1 Sight holes. Holes of which the inside diameter is at least 30 mm (small sight holes) or 50 mm (large sight holes). The neck height shall not exceed the diameter of the hole.

25.2.2 Hand holes. Holes into which the hand and a lamp can be inserted. A hand hole shall have a width of span at least 80 mm x 100 mm or an inside diameter of 100 mm. The height of the neck or ring shall not exceed 65 mm or, in the case of a conical shape, 100 mm. If one hand hole only is provided it shall be not less than 100 mm x 120 mm, or 120 mm inside diameter.

25.2.3 Head holes. Holes into which the head, an arm and a lamp can be introduced simultaneously. Their dimensions shall be at least 220 mm x 320 mm, or 320 mm inside diameter. The height of the neck or ring shall not exceed 100 mm.

25.2.4 Manholes. Holes permitting entry and exit of a person not carrying auxiliary equipment. They shall be not less than 300 mm x 400 mm, or 400 mm inside diameter. The height of the neck or ring shall not exceed 150 mm or, in the case of a conical shape, 170 mm.

25.2.5 Rescue holes. Holes permitting entry and exit of a person equipped with rescue and protective equipment. They shall be 600 mm diameter. If it is not possible due to design considerations to achieve an opening of 600 mm the size of the rescue hole can be reduced to not less than 460 mm providing the height of the neck does not exceed 250 mm.

25.2.6 Neck heights. Where neck heights exceed the limiting values given in 25.2.1 to 25.2.5 the size of hole shall be increased to give an adequate inspection or access facility.

25.3 Single hand holes. Single hand holes shall be located in the central third of the length of the cylindrical body.

25.4 More than one inspection hole. Any additional inspection holes should be disposed so as to give the maximum vision and accessibility.