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BRITISH STANDARD 931:1951

LOCOMOTIVE MULTITUBULAR BOILERS

of Riveted Construction

BRITISH STANDARDS INSTITUTION

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BRITISH STANDARD SPECIFICATION

LOCO-TYPE MULTITUBULAR BOILERS

OF RIVETED CONSTRUCTION

B.S. 931 : 1951

Price 6/– net, post free

BRITISH STANDARDS INSTITUTION
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THIS BRITISH STANDARD, having been approved by the Mechanical Engineering Industry Standards Committee, was published under the authority of the General Council on 10th December, 1951.

First published, December, 1936.
First revision, December, 1951.

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 1700, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook, price 7s. 6d. post free.

This standard makes reference to the following British Standards :—

B.S. 10. Tables of pipe flanges (for land use). Part 2. For working steam pressure up to 450 lb/sq. in. (Tables D to P).
B.S. 21. Pipe threads. Part 1 : Basic sizes and tolerances.
B.S. 84. Screw threads of Whitworth form.
B.S. 425. Forms and dimensions of boiler rivets (as manufactured) ½ in. to 2 in. diameter.
B.S. 494. Cold drawn seamless mild steel boiler and superheater tubes for design steam temperatures not exceeding 850°F. (454°C.).
B.S. 512. Hot finished seamless mild steel boiler and superheater tubes for design steam temperatures not exceeding 850°F. (454°C.).
B.S. 639. Covered electrodes for metal arc welding wrought iron and mild steel.
B.S. 759. Valves, gauges and similar fittings for land boiler installations.
B.S. 806. Ferrous pipes and piping installations for and in connection with land boilers.
B.S. 916. Black bolts and nuts. Hexagon and square, B.S.W. and B.S.F.
B.S. 1633. Steel for land boilers, receivers and other pressure vessels.
B.S. 1654. Electrically welded mild steel boiler and superheater tubes for design steam temperatures not exceeding 850°F. (454°C.).
B.S. 1678. Cold drawn electrically welded mild steel boiler tubes for design steam temperatures not exceeding 850°F. (454°C.).

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or edition.

MEE/34/3

CO-OPERATING ORGANIZATIONS

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations :—

Admiralty
Air Ministry
*Associated Offices Technical Committee
*Association of Consulting Engineers (Incorporated)
British Chemical Plant Manufacturers' Association
British Compressed Air Society
*British Electrical and Allied Manufacturers' Association
*British Engineers' Association
British Internal Combustion Engine Manufacturers' Association
*British Iron and Steel Federation
*British Railways, The Railway Executive
*Crown Agents for the Colonies
Department of Scientific and Industrial Research
Engineering Equipment Users' Association
*Institute of Marine Engineers
Institute of Petroleum
*Institution of Civil Engineers
*Institution of Gas Engineers
*Institution of Heating and Ventilating Engineers
*Institution of Mechanical Engineers
Institution of Mechanical Engineers (Automobile Division)
Institution of Production Engineers
*Locomotive Manufacturers' Association
Machine Tool Trades Association
*Ministry of Fuel and Power
*Ministry of Labour and National Service (Factory Department)
Ministry of Supply
*Ministry of Transport
*Ministry of Works
*Office of the High Commissioner for India.
War Office

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, and the following scientific and industrial organizations were directly represented on the committee entrusted with the preparation of this standard :—

British Coal Utilization Research Association
British Electricity Authority and Area Boards
British Welding Research Association
Combustion Engineering Association
Institute of Welding
Institution of Electrical Engineers
Insurance Engineers Ltd.
Lloyds Register of Shipping
Individual boiler makers
Individual tube manufacturers

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BRITISH STANDARD SPECIFICATION FOR

LOCO-TYPE MULTITUBULAR BOILERS OF RIVETED CONSTRUCTION

FOREWORD

This British Standard, first published in 1936, forms one of a series for Land Boilers the preparation of which was authorized by the Mechanical Engineering Standards Committee.

The original edition has been extensively revised and now forms the present edition. The terms ' maximum permissible working pressure ' and ' safety valve blow-off pressure ' in the Factories Act, 1937 and 1948, have been deleted and replaced by the term ' design pressure.'

Other new provisions to bring the standard into line with present day practice have been included, notably that for standpipes fabricated, and secured to the boiler shell, by fusion welding.

The formulae in Section Four of this standard give in all cases the minimum scantlings and apply to boilers constructed throughout under competent supervision.

Other British Standards in this series are :—

B.S. 537. Lancashire and Cornish boilers of riveted construction.
B.S. 609. Horizontal multitubular boilers of riveted construction.
B.S. 665. Vertical cross tube boilers of riveted construction.
B.S. 761. Vertical multitubular boilers of riveted construction.
B.S. 1113. Water tube boilers and their integral superheaters.
B.S. .....* Electrode boilers for water heating and steam generation, riveted, fusion welded and cast iron.
B.S. .....* Steam receivers and separators.
B.S. .....* Cylindrical land boilers of welded construction (other than water tube boilers).

SPECIFICATION

SECTION ONE : GENERAL

SCOPE

1. This standard applies solely to loco-type multitubular boilers for stationary, semi-portable or portable purposes and for road rollers and traction engines, exclusive of brickwork setting and insulation and exclusive of mountings†, chimney, damper and furnace fittings. The boiler(s) shall, nevertheless, be complete with mountings, chimney, damper and furnace fittings unless they are specifically excluded in the

* In course of preparation.
† See B.S. 759, ' Valves, Gauges and similar fittings for Land Boiler installations.

enquiry and order. The type of mountings and furnace fittings, and the diameter and height of the chimney and the type of damper to be supplied shall be agreed between the purchaser and the manufacturer. In the absence of specific instructions to the contrary, in the enquiry and order, the furnace fittings shall be for hand firing and natural draught and the mountings shall be suitable for the boiler working as an independent unit.

Mechanical stokers, gas or oil burning equipment, forced or induced draught equipment, or other accessories which may be required by the purchaser, are extraneous to this standard and are matters for mutual arrangement between the purchaser and the manufacturer. Where such accessories are required or contemplated, it is recommended that all particulars which would affect the boiler(s) be disclosed by the purchaser to the manufacturer at the time of the enquiry and order.

Where welding is referred to in this standard, unless otherwise stated, it shall be by the metal arc process using Class A electrodes in accordance with B.S. 639.*

It does not apply to boilers for railway locomotives or to boilers having shells less than 24 in. in diameter.

INFORMATION TO BE SUPPLIED BY THE MANUFACTURER

2. The manufacturer shall, on request, supply to the purchaser or his representative for approval, a fully dimensioned sectional drawing showing in full detail the construction of the boiler.

COMPLIANCE WITH LAW OR REGULATION

3. The purchaser shall disclose to the manufacturer at the time of the enquiry and order any special statutory or other regulations with which the boiler is required to comply. The manufacturer shall undertake that the boiler will comply in all respects with such statutory or other regulations.

INTERPRETATION

4. If any ambiguity be found or doubt arise as to the meaning or effect of any part of this standard or as to whether anything ought to be done or omitted to be done in order that this standard should be complied with in full, the question shall be referred to the Land Boilers Technical Committee of the British Standards Institution whose interpretation of the requirements of this standard upon the matter at issue shall be given free of charge and shall be final and conclusive. Parties adopting this standard for the purposes of any contract shall be deemed to adopt this provision unless by their contract they either expressly exclude it or else import an arbitration provision in terms extending to the interpretation of this standard. But this provision is limited to questions of interpretation

* B.S. 639, ' Covered electrodes for metal arc welding wrought iron and mild steel.

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and does not confer on the Committee any power or jurisdiction to adjudicate upon the contractual rights or duties of any person under a contract except in so far as they may necessarily be affected by the interpretation arrived at by the Committee.

Findings or rulings of the Committee upon matters of interpretation may be incorporated as 'addenda' to the standard and if so incorporated shall be treated as amendments thereto.

SECTION TWO : MATERIALS

PLATES, SECTIONS, BARS AND RIVETS

5. Plates, sections, bars and rivets used in the construction of boilers complying with this standard shall in all respects satisfy the requirements of B.S. 1633.*

The tensile range of the plates and bars used in the boiler shall be as agreed between the purchaser and the manufacturer at the time of the enquiry or order.

TUBES

6. Tubes shall comply with the following standards as may be agreed between the manufacturer and the purchaser :—

B.S. 494 : 1950. Cold drawn seamless mild steel boiler and superheater tubes for design steam temperatures not exceeding 850°F. (454°C.).

B.S. 512 : 1950. Hot finished seamless mild steel boiler and superheater tubes for design steam temperatures not exceeding 850°F. (454°C.).

B.S. 1654 : 1950. Electrically welded mild steel boiler and superheater tubes for design steam temperatures not exceeding 850°F. (454°C.).

B.S. 1678 : 1950. Cold drawn electrically welded mild steel boiler and superheater tubes for design steam temperatures not exceeding 850°F. (454°C.).

(See also Clauses 41 and 42).

SECTION THREE : CONSTRUCTION AND WORKMANSHIP

PREPARATION OF PLATES

7. With the exception of gusset plates, which may be sheared, the edges of all plates and butt straps shall be machined or flame-cut by machine, and the caulking edges shall be at an angle of approximately 80° with the surface of the plate.

* B.S. 1633, 'Steel for land boilers, receivers, and other pressure vessels.'

Plates which are to be flame cut by machine without subsequent heat treatment, grinding or machining shall not have a carbon content higher than 0·26 per cent.

Where the carbon content exceeds 0·26 per cent, heat treatment, grinding or machining shall be carried out.

The edges of all plates shall have a smooth finish.

CYLINDRICAL SHELLS

8. Each ring shall be formed from one plate only, (see Clause 26), and shall be bent, while cold, to cylindrical form, to the extreme ends of the plate. The bending shall be done entirely by machine; heating or hammering shall not be used.

Longitudinal joints may be lapped or fitted with double butt straps (see Clause 23). Where the longitudinal joints are lapped, the plates at the junction of the longitudinal and circumferential joints shall be tapered by machining to provide a fair inner surface to the joint.

The ends of the butt joints of shell rings may be welded for a length not exceeding 3 times the overlap at the circumferential joint, provided that the butt straps are run as closely as practicable up to the circumferential joint.

Where practicable, the longitudinal joints shall be arranged in the steam space. The joints for successive rings shall not fall in line, but shall be arranged alternately on each side of the boiler, breaking joint as much as possible.

BUTT STRAPS

9. Butt straps shall be cut from the shell plates; alternatively, all the butt straps of each required thickness shall be cut from one plate. The length of the straps shall be transverse to the direction of the rolling of the plate. Straps shall be pressed or bent in rolls to the shell curvature.

OUTER CASING PLATES, FIREBOX PLATES AND SMOKEBOX TUBE PLATES

10. Flanging of plates shall be done by machine. Such flanging shall be done hot, preferably in one operation, but where this is impracticable, sectional or creep machine flanging may be permitted, provided that the plate is worked at a suitable temperature and the plate is heated to an adequate distance beyond the portion under immediate treatment. Care must be taken to see that the flanges are circular, of good surface, and free from local irregularities.

On completion of all flanging and machining operations flat portions of end plates shall be flat and free from set or distortion.

All flanges shall be a good fit to the connecting parts. Flogging and/or hammering shall not be used in the fitting of these parts.

The caulking edges of all flanged plates shall be machined, or flame cut by machine (see Clause 7).

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Smokebox tubeplates shall be flanged for attachment to the shell or shall be flat and connected thereto by an external riveted angle ring. Wrapper plates shall be bent to form by machine while cold, and heating or hammering is prohibited.

Where the side plates of the outer casing are extended upwards to carry bearings for mechanism, the longitudinal joints for securing the crown plate to the sides shall be at least double riveted.

Rings for firehole mouthpieces or foundation rings shall be made of wrought iron (Grade 'A' quality, B.S. 51)* or of mild steel of welding quality (B.S. 1633)†.

The use of Z angle for foundation joints is not permissible.

Fireboxes may be of all-welded construction with the front and back plates flanged for butt welding to the wrapper plate and stress-relieved by heat treatment on completion of welding (see Clause 12). Fireholes may be flanged outwards from the firehole plate and inwards from the boiler front plate, and butt welded together.

Where the outer casing and the firebox plate are flanged towards the water side to form the firehole, a ring of screwed stays located at not more than half the average pitch of the stays distant from the commencement of curvature of the flanging shall be provided.

STRESS RELIEVING

11. For the purposes of relieving internal stresses, all plates which have been dished, flanged or locally heated, shall afterwards be efficiently annealed, unless, during the last stage of manufacture, they have been uniformly heated throughout.

FIREBOXES

12. Firebox wrapper plate sides shall preferably be tapered. The minimum water space at the bottom between the firebox and the shell shall be not less than 2½ in.

The firebox may have either :—

(i) Riveted joints, or

(ii) Fusion butt welded seams.

Where riveted construction is employed, the depth of the flange of the firehole and tube plates shall be sufficient to meet the requirements of the appropriate figures in Table 2.

Where the firebox is fusion welded, the firehole and tube plates shall be flanged and butt welded by the metal-arc process to the firebox wrapper-plate, the position of the weld being between the commencement of curvature of flanging of firehole or tube plate and the first row of screwed stays. The depth of the flange of the firehole plate and the tube

* B.S. 51, 'Wrought iron for general engineering purposes (Grades A, B and C).
† B.S. 1633, 'Steel for land boilers, receivers, and other pressure vessels.'

plate from the commencement of curvature of flanging shall be not less than 1 in. The edges of the firehole plate, tube plate and wrapper plate shall be bevelled in accordance with Figs. 1 to 4. On completion of all welding the whole firebox shall be stress relieved by heat treatment.

Where the seams are fusion-welded the following precautions shall be observed :—

Plates ⅝ in. thick and over shall be bevelled from both sides of each abutting edge, but the bevel need not necessarily be the same on each side. Plates less than ⅝ in. in thickness may be bevelled from one side only of each abutting edge.

The weld metal shall be built up to a thickness 10 per cent more than the thickness of the plate and, if desired, the excess metal may be subsequently removed by grinding, provided the finished thickness is not less than the thickness of the plate.

For V bevel grooves the included angle between the bevel edges shall be not less than 60° and the minimum width of a U groove at the surface of the plate should be not less than $\frac{1}{2}T + \frac{3}{16}$ inch, where T = thickness of the plate in inches.

In order to obtain full penetration of the weld metal a gap shall be maintained between the plates when they are being welded. Seams shall be welded from both sides, and the slag shall be removed after making each run. Before the second side of the seam is welded the bottom of the first shall be gouged out to provide a clean metallic surface. There shall be no appreciable undercutting of the plate (see Figs. 1, 2, 3 and 4).

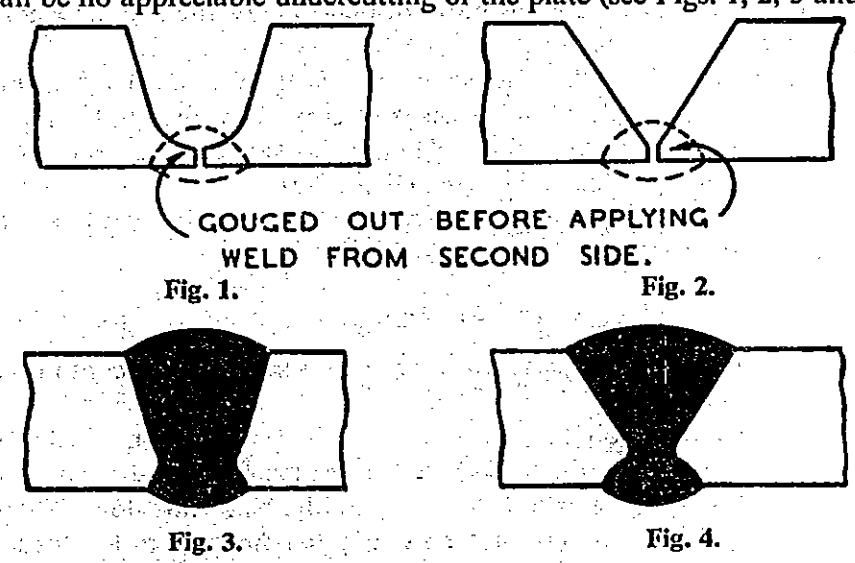

Fig. 1. Fig. 2. Fig. 3. Fig. 4.

The electrodes used shall comply in all respects with B.S. 639.*

Where automatic or submerged arc welding is used the edges of the plates shall be prepared in accordance with the requirements for those processes.

* B.S. 639, 'Covered electrodes for metal arc welding, Class A.'

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ANGLE RINGS

13. The angle ring, for the attachment of a smokebox tube-plate to the shell, shall be rolled and welded; it shall be a close fit to the flat and cylindrical surfaces to be connected and shall be machined or flame-cut by machine on the caulking edges (see Clause 7).

GUSSET STAYS

14. Gusset plates shall be flat and perpendicular to the end plates. The gusset angles shall be fitted to bed closely to the shell, end plate and gusset plates. Gusset plates shall not be subjected to cranking or setting.

BAR STAYS

15. Bar stays shall not be welded at any part. Where plus threads are used, the end of the stays shall be upset or the middle portion reduced for this purpose. Bar stays which have been worked in the fire shall be subsequently annealed. The axis of each stay shall preferably be normal to the plate surface it supports but where it is not normal the stay shall be fitted with tapered washers under the nuts (see Clause 49).

The stays may be either screwed into the end plates or fitted into clearing holes.

Where a bar stay passes through clearing holes in the end plates nuts shall be fitted on both sides of each plate.

Where a bar stay is screwed into both end plates the stay and holes shall have continuous threads.

The screw threads on the stays shall be of British Standard Whitworth (B.S.W.) form and pitch of full depth and correct profile, and shall be clean and free from checks or imperfections. Nuts shall be a good fit to the threaded portion of the stays (see Clause 47).

Non-ferrous metal jointing washers or rings may be employed to ensure steam tight joints.

SCREWED STAYS

16. Screwed stays and the holes for these shall be screwed with a continuous thread.

The screw threads on the stay shall be clean, free from checks or imperfections, of full depth, of correct Whitworth form and a good fit in the holes. The middle portion shall, preferably, be turned down to the bottom of the thread. In no case shall a pitch finer than 12 threads per inch nor coarser than 9 threads per inch, be used. Crown stays shall be screwed through both plates and be fitted with nuts on the fire side; alternatively, they may be fitted with solid forged heads on the fireside. The outer ends of crown stays and the ends of all other screw stays shall be fitted with nuts or riveted over to form substantial heads.

By agreement between the manufacturer and the purchaser or his representative, stays may be screwed through shell and firebox plates and the projecting ends substantially fillet welded in an approved manner. The projection of the end of the stay from the surface of the plate shall be not less than one-quarter of the diameter of the stay but in no case less than ¼ in. The full end of the stay shall be visible on completion of the welding.

GIRDER STAYS FOR FIREBOX CROWNS

17. *a.* Each girder, when of the normal type and fitted with stay bolts and nuts, shall be of the double plate interconnected type, of sufficient strength to support its proportion of the load on the crown plate independently of the crown plate.

b. The clear waterway between the crown plate and the underside of the girder bars shall be as large as practicable but not less than 1½ in. deep. The ends of the girders shall not rest on the landing of the flat crown plate, but shall be carefully fitted to bed directly on the bends of the corners of the vertical end or side plates (see Fig. 5). The toes of the girders shall be solid with the girder plates and not separate pieces attached thereto.

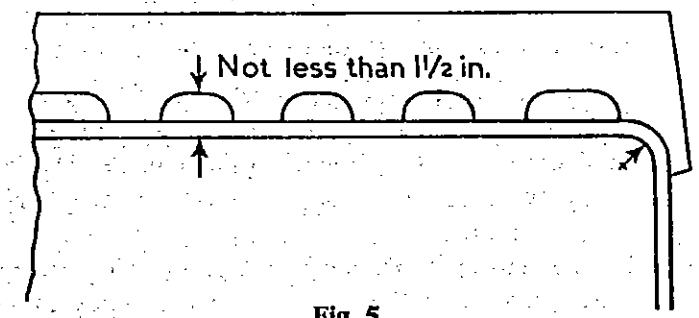

Fig. 5.

c. Where an all welded firebox is fitted, the girder stays may be welded to the box prior to it being stress-relieved. The girder stays shall be recessed for waterways (see paragraph *b* and Fig. 5).

ACCESS

18. Sufficient sight and cleaning holes shall be provided to permit of internal examination and cleaning.

At least one manhole or sighthole shall be provided, the dimensions of which shall be not less than those in Table 1 for the given size of boiler :

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TABLE 1. DIMENSIONS OF MANHOLES OR SIGHTHOLES

Diameter of boiler	Size of hole
	in.
2 ft. and over but not exceeding 2 ft. 6 in.	9 × 7
Over 2 ft. 6 in. and not exceeding 3 ft.	12 × 9
Over 3 ft. and not exceeding 3 ft. 6 in.	14 × 10
Over 3 ft. 6 in.	15 × 11

Where the size or construction of the boiler does not permit of entry for cleaning and inspection of the firebox crown plate, cleaning holes shall be provided in the shell sufficiently numerous for this purpose.

Cleaning holes or mudholes shall be provided at each bottom corner of the outer firebox casing. The cleaning holes shall not be less than 3½ in. × 2½ in. In the case of small boilers or where the foregoing provisions are impracticable, the cleaning holes or mudholes shall be as nearly as possible in the corner of the outer firebox casing and the holes as large as circumstances permit.

MANHOLE FRAMES, DOORS AND CROSSBARS

19. Manhole frames shall be of wrought steel and without welds. Preferably the frames shall be of the oval flanged or pressed type but this type shall be fitted in all cases where the thickness of the shell plate exceeds 9/16 in. Such frames shall be flanged or pressed to provide a flat jointing surface for the door.

All frames shall bed closely to the surfaces to which they are connected and, wherever practicable, should be riveted to the inside of the shell. Frames 12 in. × 9 in. or larger, shall be at least double riveted. All caulking edges shall be machined or flame-cut by machine (see Clause 7).

Doors shall be made from steel plate, formed to bed closely to the internal surface, and shall be fitted with studs, each provided with an integral collar, screwed through the plate with a nut, in accordance with B.S. 916,* on the inside of the door. Doors for openings larger than 10 in. × 7 in. shall have two studs, but for those of size 10 in. × 7 in. or less, only one stud need be fitted; doors for openings not larger than 5 in. × 3½ in. may have the stud forged solid with the door. The crossbars shall be of mild steel.

The spigot or recess shall have a clearance not greater than 1/16 in. all round. Flat surfaces for the jointing material shall be machined.

* B.S. 916, 'Black bolts and nuts. Hexagon and square. B.S.W. and B.S.F.'

SEATINGS FOR MOUNTINGS

20. For pressure not exceeding 130 lb/sq. in., mountings with screwed ends not exceeding 1 in. British Standard Pipe Thread (B.S.P.) may be used, complying with B.S. 84,* the screwed portion of any such mounting shall be an integral part thereof.

The mountings may be screwed :

(i) Directly into the plate, nuts being fitted on the water side or,

(ii) into steel distance pieces (see Fig. 6), the length of the thread engaged being, in no case, less than the bore of the mounting plus ¼ in.

The distance pieces shall be made from solid mild steel. They shall be screwed into the plate and fitted with nuts on the water side. The walls of the distance pieces shall be not less than ¼ in. at the bottom of the thread.

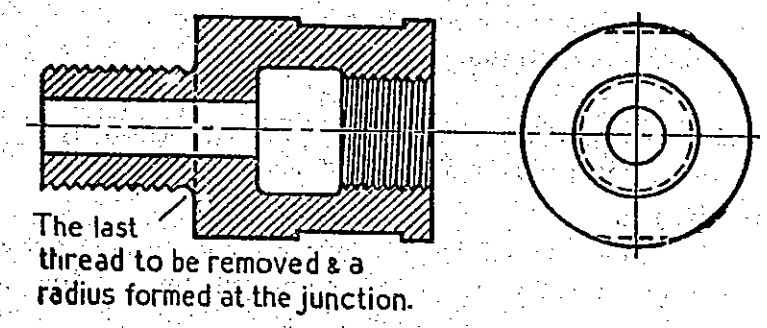

Fig. 6. Typical mild steel distance piece for mountings

Mountings over 1 in. bore shall not be attached direct to any curvilinear plate, but shall be carried on suitable seatings made of wrought, cast or fabricated steel. These seatings shall take the form of short standpipes, saddles, forged pads or pads cut from round bar as may be most convenient and shall be secured to the boiler by riveting or welding.

Where a flanged mounting is attached direct to a flat plate, such mounting shall be provided with a substantial spigot the full thickness of the plate. Where the boiler is lagged, the lagging shall be kept clear of the joint between mounting and boiler.

Where seatings are fabricated by fusion welding they shall be stress-relieved by heat treatment before attachment to the boiler.

Water gauges and pressure gauge syphons may be attached directly to the boiler shell without the intervention of a pad or standpipe, provided they are flanged and secured by studs. If the studs are screwed through the plate, nuts of full thickness in accordance with B.S. 916† shall be fitted on the inside of the boiler.

* B.S. 84, 'Screw threads of Whitworth Form.'

† B.S. 916, 'Black bolts and nuts. Hexagon and square, B.S.W. and B.S.F.'

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Flanges and pads in contact with the boiler shall be formed to bed closely to the plate to which they are attached.

a. Standpipes. Where short standpipes are used, the flanges shall be machined or flame-cut by machine on the edges. The bolting flanges shall be machined on the jointing and bolting surfaces.

b. Saddles. Where saddles are used, the edges of the flanges shall be machined or flame-cut by machine. The jointing surfaces shall be machined. The studs for the attachment of the mountings, if screwed through the saddle, shall be fitted with nuts on the inside of full thickness in accordance with B.S. 916*. Where the stud holes do not penetrate through the saddles the length of the screwed portion of the stud in the plate shall be not less than the diameter of the stud.

c. Pads. Where pads are used, the jointing surfaces shall be machined. The pads shall have sufficient thickness to allow the drilling of stud holes for mountings without the inner surface being pierced and the length of the screwed portion of the stud in the pad shall be not less than the diameter of the stud.

d. Methods of attachment. The seating shall be attached to the shell or front plate by one of the following methods :—

(i) Riveting.

(ii) Where the internal diameter of the standpipe does not exceed 1 in. the standpipe may be screwed through the plate and fitted with a nut on the water side, or seal-welded. The screwing shall be British Standard pipe (B.S.P.), vanishing thread, complying with B.S. 84.†

NOTE. The vanishing portions of the thread shall be not less than 3 pitches in length, and the diameter at the root of the thread shall increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies. The tapped hole shall be tapered out to correspond.

(iii) Where the bore of the seating does not exceed 5 in. or, in the case of a pad or saddle, the diameter of the opening in the plate does not exceed 5 in. plus twice the thickness of the plate to which it is attached, the seating may be welded to the plate without subsequent heat treatment. If these limits are exceeded the whole plate to which the seating is attached shall be stress relieved by heat treatment on completion of welding.

Seatings welded to the shell or front plate, shall be welded internally and externally. Typical methods of attachment are shown in the Appendix, Figs. 22 to 28, but other methods of equivalent efficiency may be used, subject to agreement between the inspecting authority and the manufacturer. The electrodes used shall comply with the requirements of Class A of B.S. 639.‡

* B.S. 916, 'Black bolts and nuts. Hexagon and square, B.S.W. and B.S.F.'
† B.S. 84, 'Screw threads of Whitworth form.'
‡ B.S. 639, 'Covered electrodes for metal arc welding, wrought iron and mild steel.'

e. Bolts and nuts. All bolt and stud holes shall be drilled and bolts and nuts shall be machined where in contact with the flanges.

DOUBLING PLATES AND COMPENSATING RINGS

21. Doubling plates and compensating rings shall be of mild steel without welds and, before attachment, shall bed closely to the plates to which they are to be connected.

RIVET HOLES

22. Rivet holes shall not be punched but they shall be drilled full size from the solid plate. Wherever possible, rivet holes shall be drilled in place, in plates, straps and ends, bolted in position. After drilling, the plates shall be separated, the burrs and the sharp edges of the holes shall be removed and the contact surfaces of the plate shall be cleaned. All tacking holes shall be drilled to a size which will allow the holes to be enlarged to the required rivet size by drilling or reaming. All rivet holes shall be slightly countersunk under each head. The diameter of the rivet hole shall be not more than 1/16 in. larger than the standard diameter of the cold rivet as manufactured (see Clause 23).

RIVETS AND RIVETING

23. The rivets used shall comply with B.S. 425.*

Rivets shall be closed by hydraulic machinery wherever the design of the boiler permits, but rivets may be closed by hand or pneumatic hammer in positions where hydraulic riveting is impracticable.

Rivets shall be of sufficient length to fill the rivet holes and form sound and substantial heads. The heads shall be finished concentrically with the rivet shanks. Rivets shall be heated uniformly throughout their full length.

Drift pins shall not be used with such force as to distort the rivet holes. If the rivet holes are not fair when the plates are bolted up for riveting, the holes shall be reamed fair before the riveting is commenced. For hydraulic riveting the pressure shall be the least necessary to ensure a tight joint and only sufficient pressure shall be used to close the rivets properly and securely without indenting, buckling or otherwise damaging the plate. The rivets shall be allowed to cool while under pressure from the riveting machine.

FULLERING AND CAULKING

24. All riveted joints shall be fullered or caulked inside and outside in such a manner that the plates are not unduly deformed or indented.

* B.S. 425, 'Forms and dimensions of boiler rivets (as manufactured) (½ in. to 2 in. diameter)'.

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