NATIONAL TRACTION ENGINE TRUST

Preserving our Heritage with Steam on the Road

ENGINE OWNERS CODES OF PRACTICE

PART 6

REPAIRS
(SAFed Approved)

PART 6 REPAIR of the Pressure Systems of Traction Engines and other Steam Driven Road Vehicles with Locomotive or Vertical Water/Fire Tube Boilers

6.1 INTRODUCTION

6.1.1 This section is approved by the Safety Assessment Federation (SAFed) and is intended primarily as a source of advice and standards for the **REPAIR** of *boiler*s and associated pressure equipment as applied to road or portable machines.

6.1.2 For the **CONSTRUCTION** of new *boiler*s, the appropriate EU standards should be applied.

6.1.3 A number of British Standards and other Standards are quoted in this document, for a complete list of those standards please refer to Appendix A and Appendix C for extracts from the relevant British Standards.

6.1.4 The need for repairs to the *boiler* and/or other parts of the *pressure system* usually becomes apparent at a periodic *examination*. Unless the *engine* is new to the current *Owner* and undocumented, progressive deterioration may have been recorded in reports of previous periodic *examination*s and thus should not come as an unpleasant surprise to the *Owner*.

6.1.5 The purpose of this section is to set out procedures based upon past experience and sound practices which are in line with current standards and legislation. The Code places an obligation on the Repairer and the *Boiler Inspector* to carry out and properly certify work to a defined specification and upon the *Owner* to maintain comprehensive records of all repair work. The procedures detailed in later paragraphs should meet the requirements of Regulations 4 (Design and Construction) and 5 (Provision of information and marking) of the Pressure Systems Safety Regulations (2000).

6.1.6 Most *boiler*s covered by this Code will have been built before the introduction of relevant British Standards. Special design features such as cylinder blocks, other cast or forged *engine*, steering or axle mountings, are attached to and may form part of the pressure vessel. These features are neither described nor covered by reference in the standards. However it should be borne in mind that loading conditions on traction, ploughing and road roller *boiler*s differ from those on stationary and railway locomotive *boiler*s. Considerable mechanical forces can be applied as a result of towing/pushing, scarifying, winching etc.

6.1.7 References to British Standards are intended as a guide to the use of correct materials, standards of workmanship, inspection and certification procedures. However it must be emphasised that BS931 and BS2790 were introduced for the construction of new *boiler*s. In addition the material grades to which these standards refer are no longer available and a suitable nearest equivalent that possess the required mechanical and chemical properties should be used instead. The Boiler Inspector or other competent person should be consulted to ensure that the proposed repair materials are suitable – refer to Appendix B. Many of the recommendations contained in the standards above will be applicable to repair work. Careful interpretation is necessary and users of this Code

should bear in mind the original design features described in 6.1.6 above and recommendations in 6.4.4 (Calculations). Nothing prevents the use of other codes such as ASME or EU Harmonised codes. However the use of these codes must be justified and mix and matching of different codes is strongly discouraged. Where mixing of codes is unavoidable, their use must be carefully justified.

6.1.8 The Pressure Equipment Directive (*PED*) may influence repairs and advice should be sought.

6.1.9 The majority of Heritage Locomotive and Vertical Water/Fire Tube type *boiler*s are of riveted construction. However high repair costs, together with continued improvement in welding techniques and equipment, has resulted in welded repairs being carried out when in commercial use and by subsequent *Owner*s in preservation. The replacement of flanged and riveted fireboxes by welded fabrications is now commonplace. Proper use of the information in both *boiler* standards should ensure high quality of repair work. Corner Welding of fireboxes is permitted under BS2790 when the box is fully stayed, i.e. the sides and roof are directly supported.

6.2 ENGAGING A REPAIRER

6.2.1 Once it has been established that repairs to the *pressure system* are necessary, it has to be decided whether any other work should be carried out at the same time. The cost of transporting an *engine* to the Repairer, dismantling it, re-erecting it after the repairs have been completed and then returning it to its *Owner* represent a very substantial part of the overall cost of any repair; it is therefore a false economy to put off work which may require the whole expensive process to be repeated after a relatively short period of time.

6.2.2 After considering the written reports, the *Owner* should meet with the *Boiler Inspector* and table a formal proposal of works to be carried out, including any post repair testing. Unless the *Owner* has a preference or knowledge of a particular company, copies of the work schedule can be sent to a number of prospective Repairers with a request for a quotation.

6.2.3 Specialist engineering contractors having the necessary skills, experience and workshop facilities would normally carry out major repairs. It is a requirement of this Code that major repair work be independently inspected and certified. *Owner*s who have the knowledge and facilities to produce work of acceptable standard may carry out the work themselves, but should ensure that the requirement for *Competent Person* (Third Party) inspection and certification is met. (See also 6.6.1 Repairer's Facilities)

6.2.4 The choice of a suitable person or firm to carry out the work can be a matter of some difficulty. The recommendations of other *engine Owner*s and/or the *Boiler Inspector* go a very long way but other factors to be taken into account include the distance which the *engine* will have to be transported, the time and cost of travelling to observe the work in progress, the period of time within which the Repairer undertakes to complete the work and the cost.

6.2.5 Once prospective Repairers have been identified, it is recommended that the *Owner* makes visits to enable him to firstly inspect the work in progress on other *engine*s and the facilities available and, secondly to discuss the schedule of work and quotation.

6.2.6 Any good Repairer will be proud of his works and the standard of workmanship achieved, and should be pleased to show them to prospective customers; do remember however, that they are busy people and do not have unlimited time for that purpose.

6.2.7 When the *Owner* is satisfied with the quotation, he should ensure that in any agreement the following clause should is included: “if any unforeseen/undetected work is required following the commencement of work, that work should be quoted for and accepted before proceeding further with the work”.

6.3 AVOIDING DISPUTES

6.3.1 Once a Repairer has been selected and has provided an acceptable quotation, it is wise to draw up a budget for the whole operation. It must be borne in mind that, almost invariably, defects, which had not previously been evident, will show up as dismantling progresses. Other costs which must be taken into account include transporting the *engine* to and from the Repairer, your own and your *Boiler Inspector*’s time and expenses in visiting the Repairer’s works to inspect the work in progress, the costs of any Non Destructive Testing (NDT) that may be required, any additional insurance that may be required and a contingency sum to cover the unexpected.

6.3.2 Depending on the complexity of the repairs, detailed drawings may be required. Before the order for the work is confirmed by the *Owner*, the Repairer should prepare a detailed specification and drawings, if necessary, setting out the work to be done, the quality of materials and workmanship and naming the appropriate standards to which the work will be carried out. This specification should be to the satisfaction of the *Competent Person* as agreed by the *Boiler Inspector*.

6.3.3 The agreed quotation should be confirmed. Arrangements for inspection of the work by the *Boiler Inspector*, and the *Owner* if he so desires, should be confirmed and it is helpful if the Repairer can give warning of the sort of snags or extra work, which, in his experience, may be likely to arise when the *boiler* has been dismantled. At this stage it is essential for the *Owner* and Repairer to agree who will be responsible for dismantling and re-assembly of wheels, shafts, tender and other components mounted or attached to the *boiler*, and for cleaning and preparation.

6.3.4 It should also be made clear at this stage that the specification will not be changed or any additional work carried out, unless those changes or additions have been clearly specified and confirmed in writing by all parties.

6.3.5 The agreement between the parties should make provision for reporting any hitherto unknown internal defects and the procedure for rectification as part of or as addition to the repair contract as the work proceeds. (See also 6.6.4, 6.8.7, 6.8.8, 6.8.9, 6.9.7 plate edges, grooving, pitting and internal *fittings*).

6.3.6 When the agreed dismantling has been completed, particularly if the firebox has been removed, all internal surfaces thus exposed should be thoroughly descaled and external surfaces cleaned and degreased.

6.3.7 Where major dismantling is necessary The *Boiler Inspector* (Engineering Inspector) should carry out a thorough internal *examination* as specified in the Class 2 *examination* described in Part 4 of this Code. All pressure *fittings* including mud doors,

inspection doors, washout, fusible and filling plugs should be removed, dismantled, thoroughly cleaned and examined to check for mechanical or frost damage. The condition of all plugs, internal seatings and screw threads should be assessed for further safe use, repair or replacement. On *blowdown* or other taper plug valves/cocks particular attention should be given to the condition of the backnut and thread and/or gland nuts and studs, which retain the plug. Where alignment of the hole in the plug is critical (Water level gauges) or is indicated by a marked line, this should be checked to ensure that there is no distortion of the operating handle or square for key or spanner operation. Where fitted, feed water pre-heaters and /or superheaters subjected to steam or water at *boiler* pressure should be dismantled and examined for corrosion and other defects.

6.3.8 *Fittings*, including safety valves and gauges may be sent to specialist companies for overhaul, re-testing and if appropriate, calibration. It is advisable to ensure that such companies are UKAS Accredited (United Kingdom Accreditation Service). Test certificates for *fittings* repaired by other contractors should be shown to the *Boiler Inspector* and filed with the repair records. All pressure *fittings* should be capable of withstanding the normal hydraulic test pressure without leakage. (See also 6.10 Testing after major repair.)

6.3.9 Boiler mountings/steam manifolds, seatings or faces should be examined and tested. It is good practice at a major overhaul to replace all studs with new ones of the same thread. All nuts and studs on mud doors and inspection doors should be physically checked for fit and full depth of thread engagement. Studs and nuts that are wasted, worn, distorted or overstrained should be renewed. Inspection openings, bridges or dogs should be free from distortion and should bed closely at the outer end. The nut should seat squarely on the faced area, compressing the joint evenly all round when load is applied. The door joint face, inside joint seating and surrounding area should be examined for signs of previous leakage and wasting. The door should be visibly checked with a new door joint in position to ensure that the locating spigot:

(a) projects well above the new joint to locate the door when fitting

(b) fits the opening within the limits specified in 6.8.8 (repair of mudhole/inspection doors).

6.3.10 The condition of all screwed plug *fittings* together with the mating screw threads in the steel shell, firebox, manifold or mounting should be carefully assessed. Fusible and washout plugs should have threads of correct form and engage over the full thickness of plate or opening. Where wastage of plate has occurred the number of full threads in engagement may well determine the extent of renewal or repair. Where threads are damaged the hole may need to be re-tapped and an oversize plug fitted. When dismantling, care should be taken to mark each fitting so that it can be returned to the correct hole.

6.3.11 On completion of the initial *examination* after dismantling, the *Boiler Inspector* should submit a supplementary written report detailing any additional repair work, which, may be necessary. All parties should agree the extent of the work together with any drawings, specifications, procedures and the requirements for NDT in writing before further work proceeds. The Repairer can then provide a written quotation for the agreed work. The need for agreement in writing cannot be over emphasised. Almost all

disputes concerning repairs have arisen because of lack of communication and, although putting everything in writing may seem tedious and even unfriendly, it is the only sure way to avoid disputes or, if the worst came to the worst, that each party will have clear evidence as to what was or was not agreed.

6.3.12 Some repairers have an arrangement with a local *Boiler Inspector* to carry out *examination*s of work in progress on behalf of the *Owner* and his own *Boiler Inspector*. Provided the relevant parties are in agreement, this is a perfectly acceptable practice, which can save substantial cost in time and travelling expenses. In these circumstances, however, it is essential that the local *Boiler Inspector* provides detailed written reports for all parties. **It is essential that the Company(ies) employing the *Owner*'s *Boiler Inspector* agree(s) in writing that they will accept this arrangement.**

6.4 DETAILED SPECIFICATION OF REPAIRS

6.4.1 The specification of repairs should state which Code is being applied and describe plate work including method of fabrication, flanging, forming and bending. It shall be supplemented by detailed scale drawings showing size and pitch of rivets, stays, inspection doors and mountings; number, size, gauge and pitch of tubes, welded joint details etc. to the satisfaction of the *Boiler Inspector,* or where applicable to the Notified Body where the *PED* is applicable.

6.4.2 In the design of new plate work there shall be a strong presumption in favour of replacement on a like for like basis, with regard to thickness, shape and method of support or staying, in order to return the *boiler* to original manufactured condition and designed working pressure.

6.4.3 Exceptionally, in the case of proven design weakness, or where total replacement of a component to original specification would be impractical or uneconomic, then strengthening or modification is acceptable provided that such work complies with the appropriate standards, is fully documented and agreed in writing by all parties.

6.4.4 Where re-calculation of design stresses, plate form and thickness, stay size and pitch etc., is necessary, reference shall be made to the relevant clauses contained in BS931:1951 and/or BS2790:1956 (**See note after 6.7.3) or other Codes as specified and properly justified. Subject to the provisions of 6.4.3 above, non-compliance with the requirements of these or other modern standards, when compared to the original *boiler* design, shall not in itself be a reason for reducing the *safe working pressure* below the original design pressure.

6.5 MATERIALS

6.5.1 The written repair specification shall contain details of the grade or quality of all materials to be used by the Repairer. Reference should be made to current British Standards. Refer to Appendix B Plates to be used in the repair should be stamped with the cast number to ensure traceability. Rivets should conform to BS1633:1958 and BS425:1943. These last two standards, together with BS931:1951 and BS2790:1956 have been withdrawn but are none the less still valid. (**See note after 6.7.3)

6.5.2 Materials produced to other modern equivalent, e.g. European or American, specifications may be accepted by agreement between the parties.

6.5.3 The Repairer shall be responsible for ensuring that all materials used are fit for the purpose and shall make these available for inspection as required. Copies of all test/mill certificates shall be provided for the *Boiler Inspector* and for the *Owner*'s repair records.

6.5.4 Rivets shall be subject to bend and flattening tests as specified in BS1633, page 9 to the satisfaction of the *Boiler Inspector*.

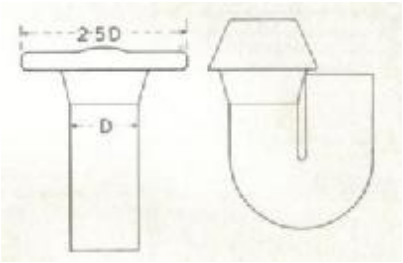
To expand on this, irrespective of paper work supplied the following procedure as specified in BS1633 should be applied.

Testing of Rivets

A few rivets from each batch and size shall be selected and tested as follows:

- The rivet shanks shall be bent cold and hammered until the two parts of the shank touch without fracture of the outside bend

- The rivet heads shall be flattened while hot, until their diameter is two and a half times the diameter of the shank, without cracking at the edges



Tensile Strength of Boiler rivets should be from 26 to 30 tons with a contraction of area during a tensile strength test of around 60%

6.5.5 Should the Repairer fail to satisfy the *Boiler Inspector* as to the quality or origin of materials, certification of the repair work may be withheld. Alternatively, tests, carried out on samples, to establish analysis and mechanical properties, may be required.

6.5.6 Where part of the work is to be sub-contracted, contract arrangements should include provision for inspection and material certification to comply with 6.5.3 and the following paragraphs concerning workmanship.

6.6 WORKMANSHIP - GENERAL

6.6.1 The Repairer must be able to satisfy the *Owner* and the *Boiler Inspector*, so far as is reasonably practicable that he has the skilled staff, machinery, tools and handling facilities to complete the work in accordance with good *boiler* trade practice.

6.6.2 The repairer shall in general adhere to the procedures outlined in the relevant clauses of BS931:1951 and BS2790:1956. It may be necessary, by reason of original design or impracticability, or the need to substitute a modern material for one no longer available, to deviate from or employ methods or procedures not defined by these standards, but which are nevertheless in accordance with sound trade practice. Any such procedures not already covered by the specification should be subject to written agreement between the parties.

6.6.3 Where repairs are to be carried out using a combination of welded and riveted connections they shall be treated separately in the matter of joint design and repair procedure. Where the barrel is to be renewed reference should be made to BS931 Clauses 8, 9 and 26 together with Amendment No.2 April 1961. With the exceptions as detailed in Clause 8 and defined in 6.7.10, welding and riveting at the same joint will not be permitted. (see 6.8.5)

6.6.4 When rivets securing existing defective plate work are removed prior to re-riveting, the Repairer and *Boiler Inspector* shall ensure that the exposed plates and rivet holes are lightly ground to remove any scale and the area about the holes and plate edges carefully checked for cracks or other defects.

6.6.5 Where new plates are inserted by means of welding or riveting, the *Boiler Inspector* shall check the 'fit-up' of the new material prior to the deposition of the first root pass or insertion of rivets.

6.7 RIVETING

6.7.1 Flanged or overlapping plates for riveted joints should be fitted in close contact and existing or new edges prepared for subsequent caulking. Sufficient additional length should be allowed for tapered overlaps where necessary. The minimum overlap of a seam on new work should be 1.5 x Diameter of the rivet i.e. that is the distance from the centre line of the rivet to the plate edge. All new plates should be drilled undersize, burrs or sharp edges removed and bolted in position prior to final reaming. Riveting procedures shall be in accordance with BS931:1951 section 3 clauses 22 and 23, or ASME Riveting Code. Rivets should be closed by hydraulic squeeze or pneumatic percussion. Hand riveting should be avoided whenever possible.

6.7.2 The *Boiler Inspector* should ensure that: -

(a) The method of heating to be employed can be controlled to heat the rivet uniformly without undue oxidation or burning;
(b) rivets are heated to correct temperature (950 – 1050 degrees Centigrade), de-scaled before placement, and correctly closed whilst hot. Cold hammering should not be permitted;
(c) pneumatic hammers, holders on and snaps are in good mechanical condition and are being operated at the correct pressures;
(d) pneumatic or hydraulic riveting machines are in good condition to apply and maintain correct pressure at the snaps.

6.7.3 At the request of the *Boiler Inspector* a test plate, produced by the riveter/s doing the work and using the equipment designated, shall be submitted as proof of competence and work quality. The test shall be witnessed, and results examined in

accordance with the procedures given in 6.7.7 to 10. Where riveting machines are used in addition to pneumatic percussion equipment a separate test plate should be produced.

NOTE ** BS 931:1951 Loco-Type Multitubular Boilers of Riveted Construction and the relevant extracts from **BS 2790:1956** Cylindrical Land Steam Boilers of Welded Construction, **BS1633: 1958** Steel for Land Boilers, Receivers and Other Pressure Vessels and **BS 425:1943** Forms and Dimensions of Boiler Rivets as Manufactured, can be found in Appendix C

6.7.4 The test described in 6.7.3 is at the discretion of the *Boiler Inspector*. Riveters employed on pressure vessel construction or repair on a regular basis would not normally be required to undertake a test.

6.7.5 Rivet test pieces shall be cut from steel plates to the dimensions indicated in Fig. 6.7.12. The rivets used shall be of minimum nominal diameter 3/4ins and shall be selected from stock manufactured to BS 1633:1958 and BS 425:1943. The plates shall be clean and flat and may be welded, clamped, or bolted at the ends for support during the test. The plates shall be hard stamped with an identification number and date at the positions indicated. Four holes shall be prepared, at least one of which shall be countersunk to a depth of 2/3rds of the plate thickness for the test piece only.

6.7.6 Riveting should be witnessed by the *Boiler Inspector* who should be satisfied that this is carried out in accordance with 6.7.1 and 6.7.2. The completed test plates should be visually examined to check head form. The use of a shallow snap to form a raised head for the countersunk rivet is acceptable. Where riveting machines are used there shall be no undue deformation of the plates about the rivet hole.

6.7.7 The completed test plates should be cold sawn in the manner shown in Fig. 6.7.12 to produce two separate pieces. The sectioned rivets in each piece should be tight with the heads in close contact with the plate surface. Loose rivets are not acceptable. The rivets should be removed using a hammer and punch and the shanks carefully examined and compared to the respective holes. The *Boiler Inspector* should be satisfied that the shank produced completely fills the hole and that no scale is present. The head should be of correct form and be concentric with the shank.

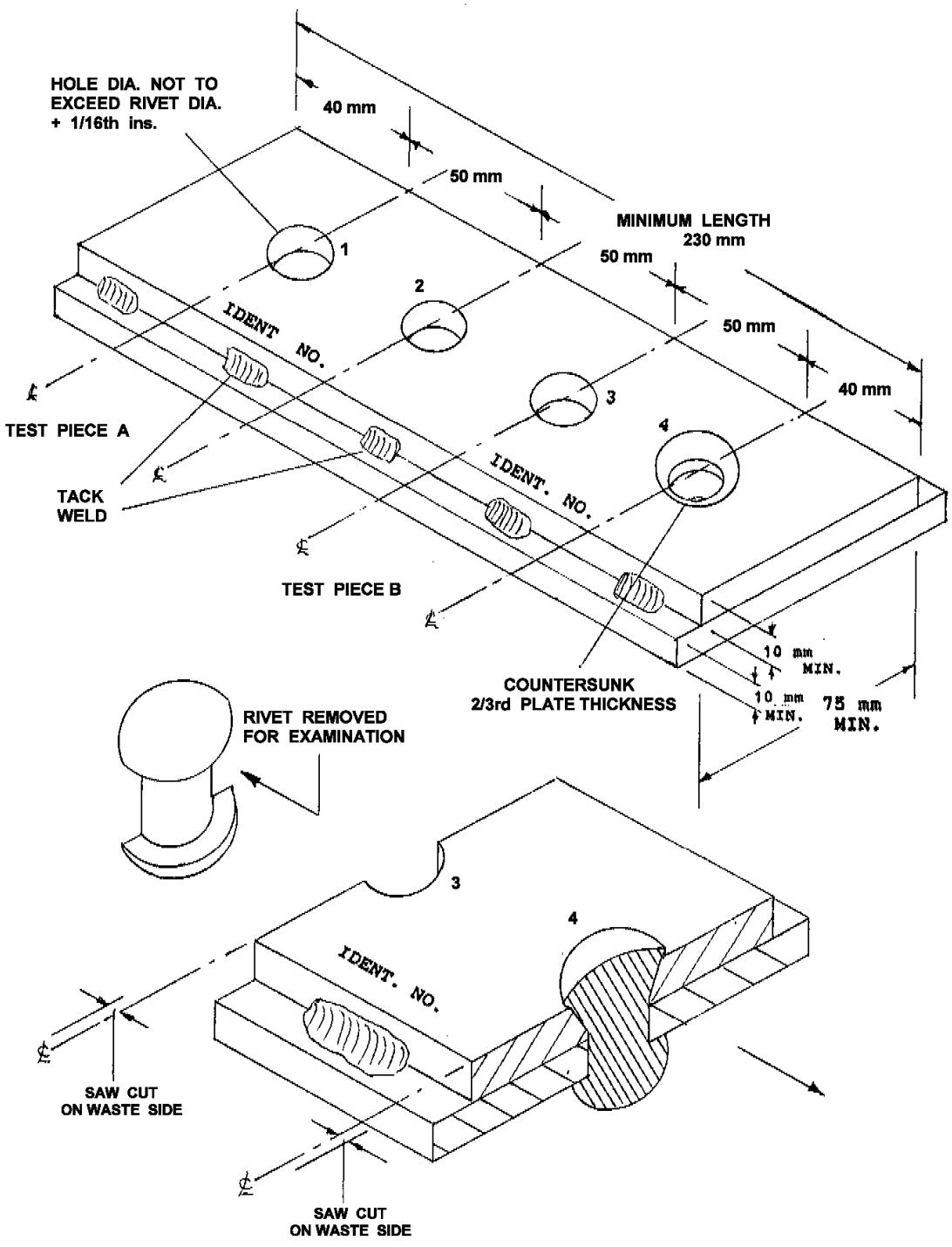
6.7.8 Details of the test should be recorded as shown in 6.7.13, the completed form being held by the Repairer. In the event of failure the reason should be recorded and the cause established before re-test.

6.7.9 When riveting by pneumatic means, the riveter should check that the rivets are tight following the completion of riveting by a hammer test. If they are slack, they should be replaced.

6.7.10 The use of fillet welds, at a riveted connection, as a substitute for caulking or fullering will not be permitted. The seal welding of foundation rings and Firehole rings is undesirable. However by prior agreement between all parties, seal welding of solid steel foundation or firehole rings may be allowed. Where this procedure is used the provisions of 6.8.4 (suitability of material for welding) should be met and all welding should be carried out in the 'down hand' position i.e. with the *boiler* inverted. It is also permitted to weld screw stays instead of riveting over as per BS 931.

6.7.11 Care should be taken when new or existing seams are caulked using hand tools or pneumatic equipment. Tools should be correctly designed to present a flat face to the plate edge, displacing or upsetting only sufficient material to seal the joint. Sharp edged or pointed tools, which would cause indentation or grooving at the seam and around rivet and stay heads, should not be used.

FIGURE 6.7.12. RIVETING TEST PIECE



6.7.13 RECORD OF RIVETING TEST

1. Details of Operator and Supervising Organisation

(a) Reference No. …… Date of test.....

(b) Name and Address of Manufacturer/Repairer and location of works .....
.....

(c) Name and Address of Inspecting Organisation .....
.....
.....

(d) Name of Boiler Inspector or Surveyor Supervising the Test .....

(e) Full Name of Riveter .....

2. Equipment and Procedure

(a) Description of procedure (EG. Pneumatic Percussion)(Hammer and Holder up, Hydraulic) (Riveting Machine) .....
.....
.....

(b) Make, model, size and type of Rivet Hammer and Holder up, Pneumatic or Hydraulic Riveting Machine .....
.....
.....
.....

(c) Air supply and pressure at tool or machine..... Load applied by machine and time held
…….....

(c) Method of rivet heating .....

3. Examination of Test Plate (as detailed in 6.7.7)

(a) Thickness:……Rivet Nominal Diameter:..……Hole Diameter:.……..

(b) Position	Identification Number	Head Form	Concentricity	Shank
1				
2				
3				
4				

4. Result of Test: CODE OF PRACTICE Part 6 Paragraphs 6.7.5 to 6.7.10

(a) Result Pass/Fail ……Remarks …….
……
……
……

(b) Signature …… Date ……..

FIGURE 6.8.5.a WELDED REPAIR: FIREBOX CASING

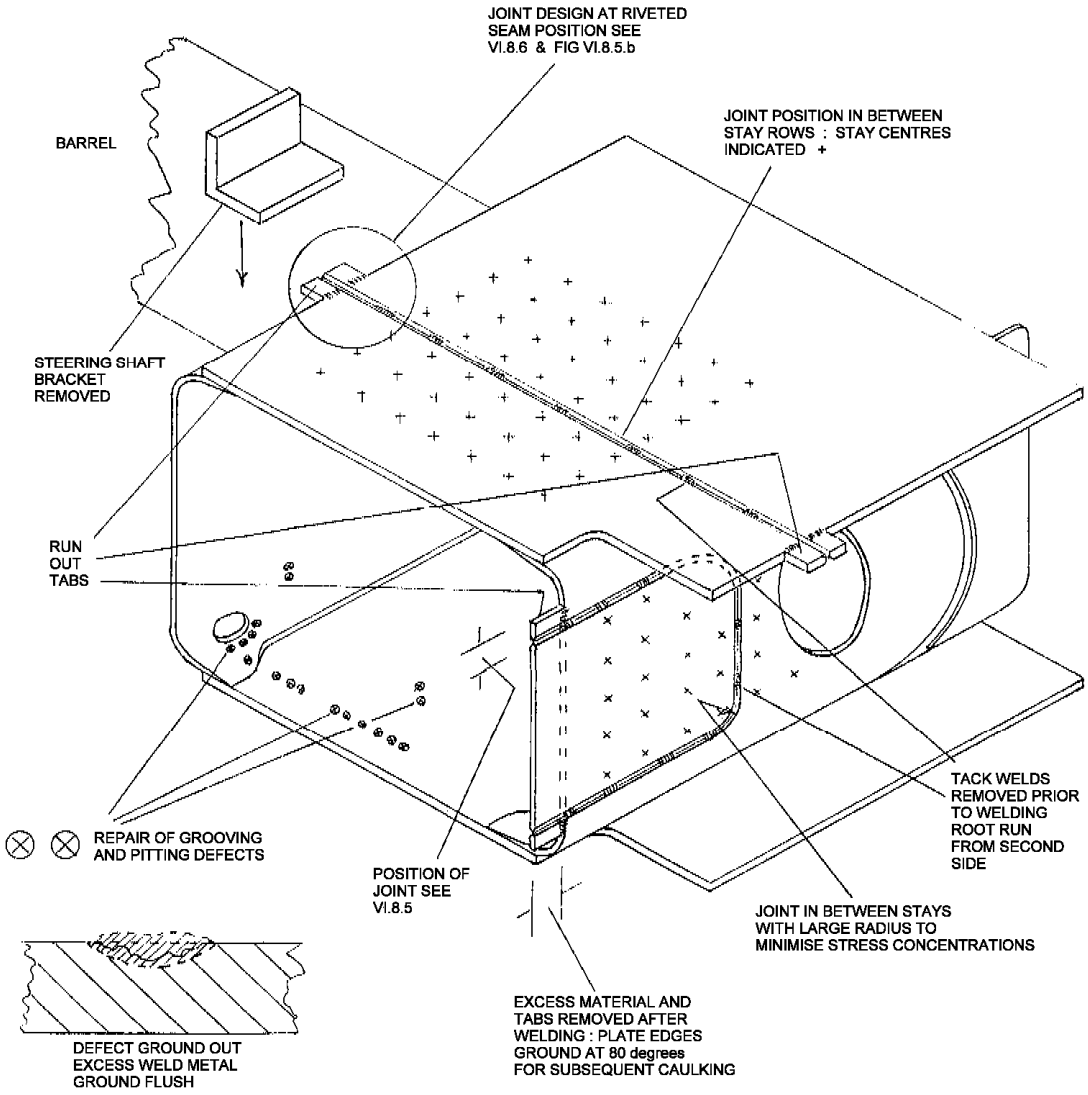
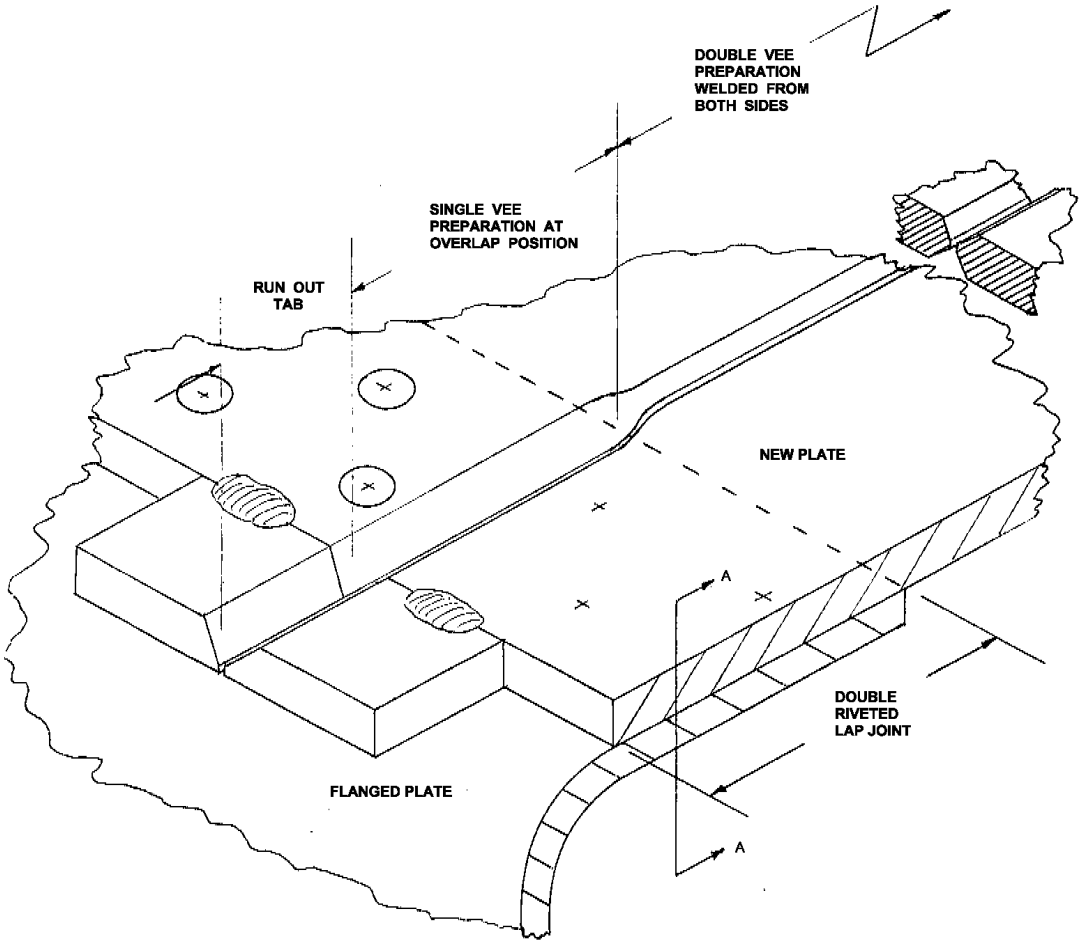


FIGURE 6.8.5.b DESIGN AND WELDING PROCEDURE
LAP RIVETED JOINT



6.8 WELDING

6.8.1 All references to welding assume the use of the manual metal arc process. Other processes e.g. Metal Active Gas and submerged arc, commonly used within the *boiler* construction industry are not excluded subject to prior agreement by the parties. Mild steel electrodes with either rutile or low hydrogen coatings will be suitable for most applications. However the Repairer should ensure that these are stored correctly and are dried and baked before use in accordance with manufacturers' instructions.

6.8.2 Welding shall be carried out by operators suitably qualified for work on pressure vessels. The recognised British Standards are BS EN 9606-1:2013 (was BS EN 287 Part 1) and BS EN ISO 15614 Pt1:2004 plus A2:2012 (was BS EN 288 Part 3). Other recognised welder qualifications may be accepted by agreement between the parties. The Repairer shall make available welding operator and procedure certification for inspection.

6.8.3 Completed welds may be examined by ultrasonic or other approved method of non-destructive testing under the Code being applied. As a guide, this test shall be mandatory for 100% of longitudinal barrel joints and 25% of circumferential seams. Copies of the report of any NDT *examination* shall form part of the repair record and shall be supplied to the *Owner* and Repairer.

6.8.4 Where wasted or damaged areas of plate are to be replaced by welded inserts the Repairer shall ensure that the original boilerplate is of a composition and quality suitable for welding. Where there is any doubt and particularly on very old *boiler*s a test piece shall be cut and sent for analysis before welding is attempted. The *Boiler Inspector* or Repairer shall provide the *Owner* with a copy of the analysis report, which shall be filed, with the record of repair.

6.8.5 Inserts for firebox casing plates shall be cut with a generous radius at the corners (square cornered inserts should not be allowed) and shall be carried through to the base of the foundation ring. Welding procedures should be designed to avoid undue stresses on adjacent riveted connections. Run out tabs should be used to ensure weld continuity at plate edges. Single sided welds may be permitted where suitable procedures are applied. If the inserted plate carries or bridges other brackets or *fittings* these shall be removed prior to welding and be re-drilled and fitted after completion. Except by specific agreement of the *Boiler Inspector*, a welded joint parallel to a riveted seam shall be at least 2" (50mm) from the overlapping plate edge and shall be located on the flat portion of the plate. (See Figs. 6.8.5a, 6.8.5b)

6.8.6 Joint design and welding procedure for inserts, as allowed by the applicable code, should allow for full penetration butt-welding as illustrated in figures 2 and 4 on page 59 of BS 2790:1956 with the proviso that in some locations a single sided preparation and weld process may be allowed if agreed with the Boiler Inspector or competent person. For example as shown in Fig 6.8.5b where the new plate overlaps a plate underneath that is being retained.

6.8.7 Subject to the provisions in 6.8.4 and by agreement with the *Boiler Inspector*, local pitting or grooving defects may be repaired by welding. This procedure should be limited to defects the depths of which do not exceed ½ original plate thickness. The use

of an angle grinder will be required to remove the surface oxide in the groove or pit, to produce good parent metal. Very often a black oxide layer can be seen as the grinding takes place, this must all be removed. When a bright clean surface has been achieved, NDT with Dye Penetrant or Magnetic Particle Fluid will show any surface breaking defects, which still exist. Welding rods should be dried to manufacturers' specifications, and the area to be welded pre-heated slightly. Areas restored by this method should, afterwards, be ground flush and NDT inspected for surface breaking defects. Size and type of welding rod should be recorded in the record of repair.

6.8.8 Subject to the provisions of 6.8.4 wastage about the areas of the mudhole/inspection seatings and on the doors may be restored by welding and re-profiling. The *Boiler Inspector* shall ensure that, after repair, (a) the inspection door beds closely to the corresponding plate surface or ring over the full width of joint face, and (b) the spigot positively locates the door within the limits specified in BS 931:1951 paragraph 19, 1.6mm (1/16") all round. (See also 6.3.9)

6.8.9 The use of welding to build up large areas of plate (sometimes referred to as 'wash welding') will not be permitted. As a general guide building up should only be used to repair localised defects. On barrel plates no one area repaired using this procedure shall exceed 4 sq.ins. nor shall the total area of welding in any one foot square of plate area exceed 4 sq.ins. Where this method of restoration is used, due consideration should be given to the effect of heat and induced stresses. In particular the effect of shrinkage and distortion on adjacent riveted connections should always be taken into account. Rectification of leakage from seams, screwed stays, rivets and *fittings*, by means of welding will not be permitted. Welding in of leaking mudhole/inspection doors will not be permitted.

6.8.10 Where fireboxes, tubeplates or other components are replaced by welded fabrications the *Boiler Inspector* shall ensure that joint preparation and fit up conforms to the relevant standard. The Repairer shall supply details of welding procedure and consumables. New barrels with welded longitudinal seams shall conform to BS2790:1956 Clauses 17 and 18 with respect to circularity, the completed joint being subject to an approved form of non destructive testing.

6.9 FLAT PLATE SUPPORT - Screwed and Bar Stays, Stiffeners and Doubling Plates.

6.9.1 Screwed firebox stays, stay tubes and/or longitudinal stays may be replaced as a result of breakage, wastage, or when the firebox, tubeplate or end plates are repaired or renewed. The parties shall agree at contract stage as to the design of the replacement stays with particular regard to the relevant standards, method of attachment and sealing of projecting ends. Where stays are replaced on existing or recut threads, the threads should be full form and free from cracking.

6.9.2 Materials used for stay bars shall be specified in Appendix B. Selection of the type of material must be compatible with the stay end sealing method chosen. For example, riveted over or welded in accordance with BS 931:1951 Clause 16 (as amended) or BS 2790:1956 figures 52, 53 and 54.

6.9.3 Where screwed firebox stays are to be replaced the defective material shall be removed carefully to avoid damage to threads in the firebox and/or casing plates. After

removal the area about the holes should be examined for cracks and wastage. For riveted stay heads that have been previously welded (not acceptable under this code. See 6.8.9) particular attention should be given to crack detection. If cracks or other serious defects are found then consideration must be given to complete replacement of defective plates.

6.9.4 When stay threads in the firebox and casing plates are to be re-tapped to the next size up, the same thread form and pitch must be used and shall conform to the requirements of BS931 Clause 16 (as amended). In the case of *boiler*s originally designed with screwed stays coarser than 9tpi. or finer than 12 tpi., the new stays may be of the same pitch provided that the re-tapped thread is of correct form with full depth of engagement.

6.9.5 If stays of a different thread pitch and form are to be used the old thread shall be completely removed by reaming prior to tapping. A record of all stay sizes and thread pitch shall be supplied by the Repairer and shall be filed by the *Owner* as a record of repair.

6.9.6 Screwed stays or stay tubes shall be machine cut and shall be a tight fit in both plates. Where the stay ends are riveted the heads shall be of 'mushroom' form and shall be free from edge cracking. Where oversize stays are fitted the central portion shall be machined to the original core diameter.

6.9.7 Where stay bars, attached to internal brackets, end plate stiffening T bars or doubling plates, become accessible as a result of major repair, these should be checked for corrosion and security. Particular attention should be given to the condition of knuckle ends, pins, cotters and rivets or bolts securing anchor plates and T-bars to end plates and barrels.

6.10 TESTING AFTER MAJOR REPAIRS

6.10.1 On completion of any repairs, at the discretion of the Boiler Inspector or competent person, a hydraulic test as detailed under Part 4.13 of this Code may be applied and witnessed by the *Boiler Inspector*. Before testing, the safety valve should be removed and the opening blanked off. Alternatively the springs shall be removed and suitable gags or spacers fitted for the duration of the test. Ensure that the gags are removed on completion of the test. The pressure gauge should be calibrated. This requirement may be omitted only if the gauge has been separately overhauled, proof tested and certified as detailed in Part 4 for a Class 2 examination. The superheater and/or feed water heater (where fitted) and all other *fittings* should be in position on the *boiler*.

6.10.2 The test pressure will normally be 1.5 times designed working pressure. It should be noted that BS2790 requires a test pressure of 1.43 times designed working pressure for steel fireboxes and a test pressure of 1.3 times the designed working pressure for copper fireboxes (Railway practice). The written report issued by the *Boiler Inspector* shall specifically record that all *fittings* were subjected to proof test pressure.

6.10.3 Upon satisfactory completion of the hydraulic test, and before the *boiler* is steamed on any public road or in any public place, an *examination* in steam shall be carried out in accordance with Part 4 of this Code.

6.11 INSPECTION AND CERTIFICATION

6.11.1 The method, frequency and reporting of inspections during major repair work will depend upon the extent of the repairs and should be agreed by all parties prior to contract. A summary of inspection procedure is listed under 6.12.2

6.11.2 It is the aim of this Code of Practice to encourage thorough and detailed unbiased inspection in order to build a comprehensive record of *boiler* condition and history.

6.11.3 It is therefore of vital importance that *Owner*s, *Boiler Inspectors* and Repairers use the opportunity presented by major repairs to ensure that nothing is overlooked in order that the *boiler* can continue to be used in complete safety.

6.12 RECORDS OF MAJOR REPAIRS

6.12.1 All repair specifications, drawings, material test/mill certificates, inspection reports, non destructive test reports, welding/riveting operator records etc. shall be filed by the *Owner* in Part 8 of this Code. Should the *Owner* subsequently sell the *engine* the complete records of operation and repair should be included in the sale contract.

6.13 SUMMARY OF INSPECTION: MAJOR REPAIRS: LOCOMOTIVE TYPE BOILERS

INSPECTION STAGE	CODE PARAGRAPH REFERENCES
A Agree written specification, drawings and calculations. Contract Procedure and NDT Requirements.	Specification, drawings and fabrication 6.4.1, 6.4.2. Materials 6.5.1. Riveted and Welded Joint Design - Working Procedures 6.7.1, 6.8.5, 6.8.6, 6.8.10. Flat Plate Support - Method of Staying 6.9.1, 6.9.2. Calculations 6.4.2, 6.4.3, 6.4.4. Non Destructive Testing 6.8.3. Unknown Defects 6.3.5.
B Repairers Facilities, Operator Competence	Tooling and Lifting Capacity 6.6.1. Storage of Welding Consumables 6.8.1. Examination of Welding Operator and Procedure Documents 6.8.2. Riveting Equipment - Riveting Test 6.7.2, 6.7.3, 6.7.7 – 6.7.11
C Thorough internal and external examination after dismantling	Class 2 Examination of Boiler and fittings 6.3.7. Examine Test Certificates for fittings 6.3.8. Mountings, Inspection and Mud Doors 6.3.9.
Examination of all pressure fittings and attachments	Analysis of Existing Material for Welding 6.8.4.
Report condition and any defects	Additional Work 6.3.4.
Agree additional repair	Examination of Materials and Sub-Contract

	procedures. Inspect materials and documents	Components Examine Test and/or Mill Certificates 6.5.3.
D	Inspect 'Fit-Up' of new plate work. Internal Repairs	Rivet Joint Drilling, Bolting and Fit 6.6.5, 6.7.1. Welded Joint Preparation - Tack up - Root Runs 6.8.5, 6.8.6. Repair of Defects 6.8.7, 6.8.8.
E	Examination of completed plate work and NDT Documents	NDT Reports 6.8.3. Barrel Longitudinal Seams 6.8.10.
	Check screwed stay threads and fit of new stays	Screwed stays 6.9.3, 6.9.4, 6.9.5, 6.9.6.
F	Witness Hydraulic Test of Boiler and Fittings.	Hydraulic Test 6.10.1, 6.10.2.
G	Carry out Test in Steam	Test in Steam 6.10.3.
	Issue Final Report	

Part 6

Appendix A

Standards

British and other Standards relevant to Part 6.

Below is a list of the common British Standards (BS) and other European (EN) and American Standards (ASME) relevant to our hobby. A number of quoted standards are long withdrawn or superseded. These standards however are still often quoted by enthusiasts and repairers for historic reasons and that modern standards often do not cover items or proposed repairs.

BS931: 1951 – Loco-Type Multitubular Boilers of Riveted Construction. Does not apply to boilers for railway locomotives or to those boilers having shells less than 24” in diameter.

BS425 Forms and dimensions of boiler rivets (as manufactured) (1/2 in to 2 in diameter) Withdrawn

BS537 Lancashire and Cornish boilers of riveted construction.
BS609 Horizontal multitubular boilers of riveted construction.
BS665 Vertical cross tube boilers of riveted construction.

BS761 Vertical multitubular boilers of riveted construction.

BS1501 Steels for fired and unfired pressure vessels: Plates Part1 1980; Carbon and Carbon Manganese Steels. Withdrawn but still widely quoted by steel stock holders and for reference purposes.

BS1502 Steels for fired and unfired pressure vessels. Sections and bars carbon and carbon manganese steels. Withdrawn but still widely quoted by steel stock holders and for reference purposes.

BS3059 Steel for boiler and Superheater tubes. Withdrawn

All the above quoted codes are now withdrawn but still available and often referred to at the time of repair.

BS2790 now replaced by BSEN 12953-2002 Shell Boilers. The code that should be referred to for all components manufactured using welded construction techniques should comply with its requirements.

EN1561 Founding – Grey Cast Iron

EN1563 Founding – Spheriodal graphite cast iron.

EN10028 Flat products made of steels for pressure purposes – Part1 general requirements. Part2 Non-alloy and alloy steels with elevated temperature properties.
Part3 Weldable fine grain steels, normalized.

EN10216- Seamless steel tubes for pressure purposes. Part 1 non-alloy steel tubes with specified room temperature properties. Part2 non-alloy and alloy steel tubes with specified elevated temperature properties.

EN10217 Welded steel tubes for pressure purposes. Part 1 Non alloy steel tubes with specified room temperature purposes. Part 2 Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties. Part 5 Submerged arc welded non-alloy and alloy steel tubes with specified elevated temperature properties.

EN10222 Steel forgings for pressure purposes. Part 1 General requirements for open die forging. Part 2 Ferritic and martensitic steels with specified elevated temperature properties.

EN12074 Welding consumables.

EN 12952 Water-tube boilers and auxiliary installations. The code for coil superheaters etc.

ASME I – General Requirements for Steam Boilers

ASME I Appendix 3 Steam Locomotive Firetube Boiler Inspection and Repair.

ASME I Appendix C Historical Boilers

ASME I Part PR Requirements for Boilers Fabricated by Riveting

ASME IV General Welding Requirements.

BS51 Wrought Iron for general engineering purposes (Grades A, B and C). This code should be applied for foundation and firehole rings where they are made of wrought iron and should be of grade A quality.

Part 6

Appendix B

SPECIFICATIONS FOR COMMON STEELS USED IN REPAIR WORK

Steel Material grades for boiler repair and cross references to equivalent standards.
Other standards/materials likely to be encountered in boiler repair.

(Material grades are not always exactly equivalent between different national/international and obsolete standards – nearest equivalents are quoted – **in all cases it is recommended that reference should be made to the competent person overseeing the pressure system repair before purchasing the material**)

En number to BS970:1955 (obsolete)	**BS970/PD970**	**American ASME/ASTM**	**European standard/ISO**	**DIN (Germany)**	**BS 4360 (obsolete)**	**BS1501-1:1980 (obsolete)**	**European steel name to BS EN 10027-1**	**European steel number to BS EN 10027-2**	**NOTES** BS EN10027 is a naming convention for steels – the specification is not fully complete unless the standard for the steel is also referenced.
-	-	ASTM A516 grade 60	EN10028-2 P265GH	17155 H11	-	BS1501-161-430A or 430B	P265GH	1.0425	**Boiler plate**
			BS EN 10216-2:2002 (seamless) grade P235GH BS EN 10217-2:2002 (welded) grade P235GH				P235GH	1.0345	**Boiler Tubes**

Table contd...									
En number to BS970:1955 (obsolete)	**BS970/PD970**	**American ASME/ASTM/ SAE**	**European standard/ISO**	**DIN**	**BS 4360 (obsolete)**	**BS1501:xxxx (obsolete)**	**European steel name to BS EN 10027-1**	**European steel number to BS EN 10027-2**	**Notes**
En3B En32B	070M20 080A15	SAE 1021 SAE 1016	EN10083-1:2006 C22E EN10083-1:2006 C16	CK20 CK15			C22E C16	1.1151 1.0407	**Boiler stays** (threaded) (Note free cutting steel EN1a (230M07) is no longer considered suitable for boiler stays)
		ASTM A516 grade 60	EN10028-2 P265GH	17155 H11		BS1501-161-430A or 430B	P265GH	1.0425	**Boiler stays** (from plate)
			BS-EN 10025-2 S275JR	17100 ST44-2	43A or 43B		S275JR	1.0044	**Boiler stays/brackets** (Angle. Tee etc) (alternatively sections may be fabricated from plate as per "boiler stays from plate" provided the correct welding procedures consumables and operators are used.)
En3A, B, C	070M20	SAE 1021		CK20			C22E	1.1151	**Rivets** There is no exact
En32B	080A15	SAE1016		CK15			C16	1.0407	
En32C	080M15	SAE					C15	1.1141	

		1015/1016							comparable material available that will in all delivery conditions match the historical requirements for boiler rivets so the grades quoted will all potentially be suitable, provided that a sample is checked against the requirement of BS1633.1958 Additionally the rivets should pass the cold bend and hot heading tests detailed in **6.5.4** In accordance with BS1633
			BS-EN 10025-2 S235 JR	17100 RSt 37-2	40A or B				
			BS-EN 10025-2 S275JR	17100 ST44-2	43A or 43B		S275JR	1.0044	
En3B	070M20	SAE 1021		CK20			C22E	1.1151	**Mud doors and bridges** (forged)
BS3100:1991 Obsolete			BS EN 10293:2015 A1				GS200	1.0449	**Mud door** (cast)
En3B	070M20	SAE 1021		CK20			C22E	1.1151	**Mud door studs** (Note free cutting steel EN1a

									(230M07) is no longer considered suitable for boiler work – studs etc)
Leaded gunmetal (BS1400:1985 LG4 or LG2), BS EN 1982:2017 CC492K or CC491K respectively									**Fittings** (cast) clacks, etc (BS 1400 is withdrawn but the grades are frequently quoted)
Leaded gunmetal (BS1400:1985 LG4 or LG2), BS EN 1982:2017 CC492K or CC491K respectively									**Washout Plugs** (BS 1400 is withdrawn but the grades are frequently quoted)
ASTM B271 1996 A C93200(SAE660)									
Leaded gunmetal BS1400:1985 LG4, BS EN 1982:2017 CC492K (body) – core pure lead (99.97% pure)									**Fusible Plugs** (BS 1400 is withdrawn but the grades are frequently quoted)
BS1780:1975 (withdrawn) BS EN 837-1:1998 (current)									**Pressure gauges** (the obsolete standard is included in case a new old stock gauge is used)
BS3643:1975									**Gauge glasses**

PART 6

APPENDIX C

Extracts from British Standards

BS 425: 1943 Forms and Dimensions of Boiler Rivets
BS 931: 1951 Loco-type Multi-tubular boilers of riveted construction
BS 1633: 1958 Steel for Land Steam Boilers
BS 2790: 1956 Cylindrical Land Steam Boilers of Welded Construction

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