HERITAGE RAILWAY ASSOCIATION

BOILER CODE OF PRACTICE (BCOP)

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GUIDANCE NOTE

STEAM LOCOMOTIVE BOILERS
- Introduction to Guidance Documentation & Glossary of Terms

HGR-B9000-Is02__ Steam Locomotive Boilers – Introduction & Glossary

Purpose

This document describes good practice in relation to its subject to be followed by Heritage Railways, Tramways and similar bodies to whom this document applies.

Development

This document has been developed by boiler experts in consultation with His Majesty's Railway Inspectorate (HMRI) a directorate of the Office of Rail and Road (ORR). The origins of the Boiler Codes of Practice (BCOP) Committee stem from an initiative by ORR to ensure a consistent and informed set of standards to apply to all matters relating to the repair of old and the manufacture of new boilers. It includes expert practitioners across the industry from those constructing and repairing boilers and their constituent parts, to boiler inspectors, those who provide insurance across the industry, current and former Chief Mechanical Engineers (CMEs) to metallurgists and others who share the need for a consistent and safe approach and standards to all work carried out. The Heritage Railway Association has for many decades hosted and supported the BCOP initiative in its role to provide guidance notes on a myriad of subject areas associated with preserved railways. The Committee also includes experts from the National Traction Engine Trust to whom the same standards apply and whose knowledge adds to the guidance notes produced.

Disclaimer

The Heritage Railway Association and its Boiler Code of Conduct (BCOP) Committee has used its best endeavours to ensure that the content of this document is accurate, complete and suitable for its stated purpose. However, it makes no warranties, express or implied, that compliance with the contents of this document shall be sufficient to ensure safe systems of work or operation. Accordingly, neither the Heritage Railway Association nor BCOP will be liable for its content or any subsequent use to which this document may be put.

Supply

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Copies are available electronically via its website www.hra.uk.com

Users of this Guidance Note should check the HRA website, www.hra.uk.com , to ensure that they have the latest version.

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1. Introduction

a) This Guidance Note is the introductory document to a series of guidance notes dealing with locomotive boilers and associated components that were produced and are updated as required by the Heritage Railway Association's Boiler Code of Practice (BCOP) Committee.

b) This series of Guidance Notes has been developed from documentation generated over the last hundred years in many countries which was reviewed by a panel of UK industry experts under the guidance of HRA and ORR. It represents the current view on Good Practice in the Industry and as such is subject to change without notice. The latest version of this document and any subsidiary documents is available on the Heritage Railway Association website www.hra.uk.com

c) This series of documents is focussed on the requirements of main-line, standard gauge and narrow-gauge railway locomotive boilers typically running on 15" (381mm) or greater gauges. It may also be helpful for operators of stationary steam engines with similar boilers, traction engines and miniature steam locomotives.

2. Recommendations

a) This guidance note is issued as recommendations to duty holders.

b) Where duty holders decide to take actions that are not in agreement with these recommendations following appropriate risk assessments or for other reasons, it is recommended that those decisions are reviewed by the senior management body of the organisation concerned and a formal minute is recorded of both the decision reached and the reasons for reaching it. On heritage railways, the advice and expertise of the Chief Mechanical Engineer (CME) will be vital in reaching any decisions on the safety of steam locomotives, whether resident or visiting and any risks associated with their steaming. Just because a locomotive owner has his or her own insurance, or a locomotive is covered by the railway's insurance or has had a boiler inspection by a competent boiler inspector is not carte blanche for that locomotive to be steamed without the approval of the CME. The adequacy of the locomotive owner's Written Scheme of Examination (see B9260) must play a major role in any assessment to steam that locomotive.

3. General

a) Railway locomotive boilers are designed to create, store and distribute steam at high pressure. The working life of such a boiler can be considerably shortened if due care is not taken at all stages of inspection, repair, running maintenance and day-to-day running.

b) In the past there have been a series of accidents and explosions due to work being undertaken without having due regard to the inherent risks involved. It is with that in mind that ORR and HRA set up the series of meetings of boiler practitioners across the railway and insurance industries to discuss the issues; distil good practice and codify it into a series of Guidance Notes.

c) This guidance is written for the assistance of people competent to perform these tasks. In places the terminology used may be specific to such practitioners.

d) This guidance should also be useful to those in a supervisory or more general role. However, no work should be undertaken unless the persons concerned are deemed competent to do so in accordance with prevailing regulations.

4. Scope of this Series of Documents

a) The initial aim was to create the definitive Guidance Notes on Boiler Repair and Reconstruction. It was quickly realised that two other strands were needed; one for general, legal and background information and the other for those areas where operating procedures and techniques can affect safety or seriously shorten the life of boilers.

b) The work therefore divides into three areas:

i) Repair and reconstruction;

ii) Operations related; and

iii) General and Legal.

c) The series covers all aspects of the boiler including those identified on the diagram below

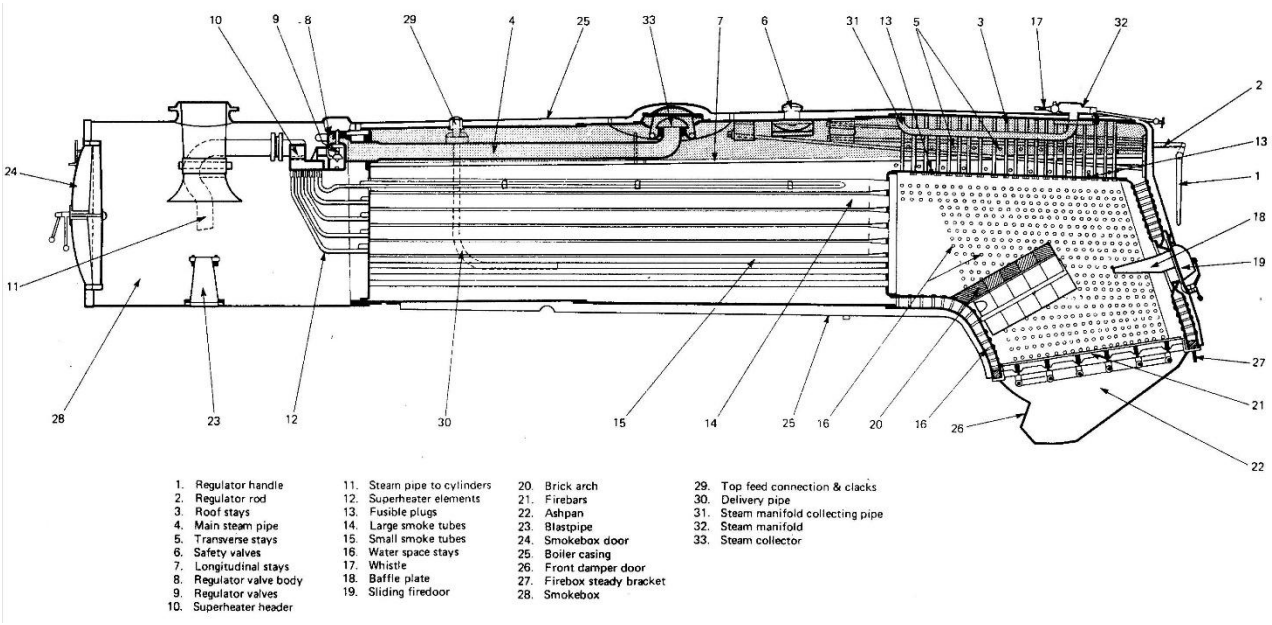


Diagram 1- Typical Large Superheated Boiler

5. Dimensional Notation

a) The dimensions in this document are variously described in a mixture of imperial and metric units. Where practical, equivalent dimensions have been shown but, in some cases, the dimensions do not easily equate and so the units in force at the time that the original designs were documented have been used.

6. Terminology

a) A Glossary has been provided in an Appendix to cover the main specialist terms used as well as definitions of some common terms to explain their particular application. It also includes examples of terminology which should not be used in common parlance.

7. Documentation Control

a) The issued documents are available on the HRA website: www.hra.uk.com

b) The top of each page of each document gives the reference number, Issue number, date of issue and when it will be reviewed (generally after three years unless there are other significant changes that need to be relayed to those in the industry). Issue numbers will change as any periodic or review changes are made.

c) Users are encouraged to advise HRA of any suggested changes or comments on existing Guidance Notes by e-mailing those comments to the HRA with the relevant number in the title line. These will be reviewed by the lead authors of each document and, if approved by a majority of existing BCOP members, will be incorporated into the document and updated on the HRA website.

d) The BCOP Committee currently meets twice a year and comprises experts across all aspects of boiler repair and manufacture, insurers, CMEs, metallurgy, safety standards generally and the ORR.

8. Series Framework

The issue number at the head of each Guidance Note will be the latest available to practitioners. This is dated and gives the next occasion when a review will be undertaken by current BCOP members. However, there may be occasions when a change in Regulations occurs or where additional advice has been provided by such bodies as the HRA, ORR, RAIB (Rail Accident Investigation Branch), HSE (Health & Safety Executive) or others and when this occurs and is relevant to an existing Guidance Note, an updated version will be uploaded to the HRA website. Technological and material changes will also trigger the need for a review which may be earlier that the specified date.

a) This document is the key introductory document:

HGR-B9000 Steam Locomotive Boilers

It includes an Introduction to Guidance Documentation, Glossary & Reference Documentation and Repair and Reconstruction Guidance Notes

a) This section provides guidance on all aspects of boiler repairs.

b) The documents in this section are in the series HGR-B90xx

HGR-B9001 Tubing of Locomotive Boilers

HGR-B9002 Boiler Stays

HGR-B9003 Superheaters

HGR-B9007 Boiler Mountings, Pipework and Fittings

HGR-B9008 Fusible Plugs

HGR-B9009 Washout Plugs

HGR-B9011 Safety Valves

HGR-B9014 Mudhole Doors

HGR-B9020 Platework

HGR-B9021 Inner Firebox Repair and Renewal

HGR-B9022 Thermic Syphons & Arch Tubes

HGR-B9023 Steel Rivets and Riveting

HGR-B9024 Welding Procedures & Processes (applicable to Loco Boilers)

HGR-B9025 Patch Screws

HGR-B9030 Smokeboxes

HGR-B9050 Steam Heating Apparatus (for Locomotives and Carriages)

9. Operations related Guidance Notes

a) This section provides guidance only on those aspects of operations that affect the safety and life of the boiler.

b) These operations related guidance notes are not about “how to drive” but very much about making sure that safety is assured in the short and long term due to effect of driving and firing techniques.

c) The documents in this section are in the series HGR-B91xx

HGR-B9118 Boiler Water Treatment

HGR-B9140 Preparation, Operation & Disposal

HGR-B9155 Washout and Examination

HGR-B9160 Examination in service

HGR-B9170 Frost and Corrosion Protection

10. General Legal and Reference Guidance Notes

a) This section provides general background information.

b) The documents in this section are in the series HGR-B92xx

HGR-B9220 Materials and Non-Destructive Testing

HGR-B9230 Quality Assurance

HGR-B9260 Written Scheme of examination

11. Acknowledgements

a) The project was initiated by ORR's HMRI and the HRA to document best practice across the industry. We owe a significant debt to HMRI and in particular to former ORR HMRI David Keay, and his successor Steve Turner for providing the initial drive for the whole of this project and to the HRA's Bill Hillier who chaired the committee's first 35 meetings over almost three decades until his retirement in 2021.

b) Most of the personnel actively engaged in locomotive boiler construction and repair in the U.K. were involved in the creation of this series of documents and gave comments and/or engaged in discussions at the many co-ordination meetings. Some only made a few crucial comments. Others, to whom we owe a huge debt, were deeply involved in the creation of the framework and the many individual Guidance Notes.

c) Some, alas, are no longer with us but all contributed their expertise in order that the steam locomotive boiler maintenance process could be documented and made available to future practitioners and their managers. Without all these contributions we would have been unable to create the documentation that has contributed hugely to the continued safety of steam locomotive operations in the UK. Even when some have retired from the industry, they have continued to provide a valuable input into individual GN updating, a constantly ongoing exercise as our understanding of the materials in boiler construction increases with new technology and new techniques.

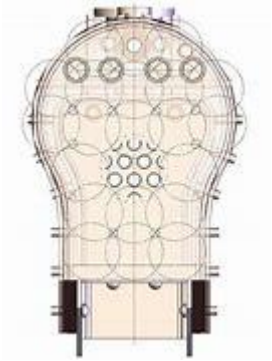
Appendix A – Glossary of Terms

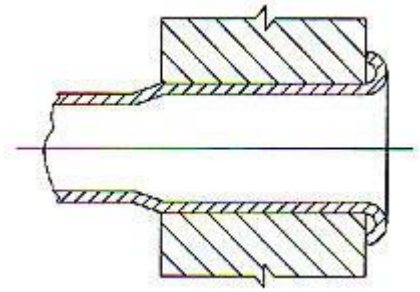
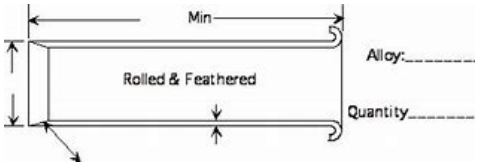
Scope

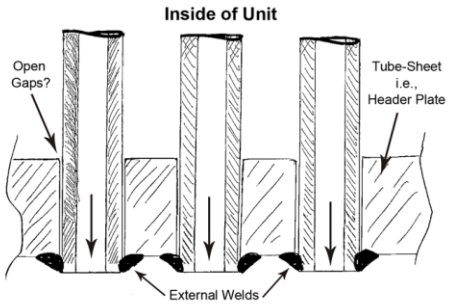
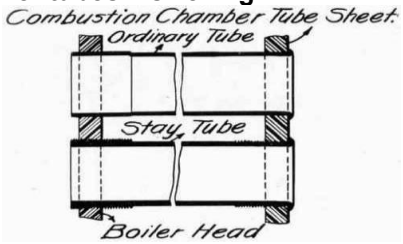
This glossary covers items and the specialised process associated with the document suite forming the Boiler Code of Practice and gives guidance and explanation to steam system and pressure system terminology. Terminology listed below in **RED** should not be used as it is either colloquial, potentially misleading or a non-recommended alternative.

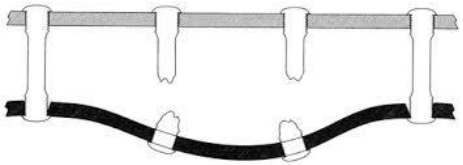
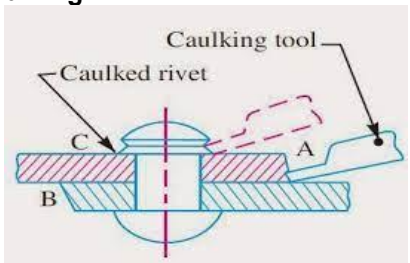
Boiler code of Practice preferred terminology (in black)	Alternative/colloquial terminology	Definition or Description of item or process	Additional notes
Accumulation test. .		A test applied to a steam boiler where the boiler is put in a full firing condition for at least 15 minutes and the Safety Valve and Pressure Gauge observed to ensure that the pressure does not rise above 10% of the normal operating pressure. The 10% rise in pressure should be within the design parameters of the boiler and associated steam system. A performance test to prove safety valves' ability to prevent excessive over pressurisation of a boiler producing steam approaching its maximum steaming rate	The old Board of Trade rules state that the accumulation test should be undertaken with the boiler under full firing conditions with the feed water shut off and steam take-offs closed (except steam to essential auxiliaries). The test is to be continuous for as long as the water supply in the boiler permits, but the duration of test need not exceed 15 minutes for a shell type boiler. The accumulation of pressure should not exceed 10% of the working pressure. The boiler should at all times remain within certified design parameters. **SAFED PEC12 issue date 16/09/0211.** The accumulation test should be carried out with the boiler under full firing conditions, the stop (crown) valve closed, the feed pump stopped and with the correct water level within the boiler. The boiler water level must be safely maintained above low water level and feed water may need to be

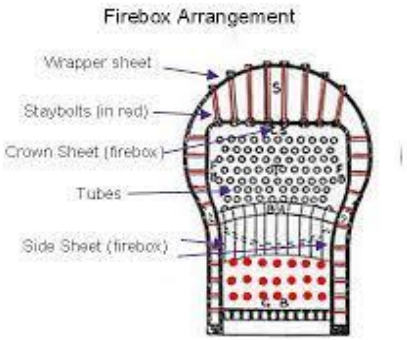
			supplied to the boiler during the test. The amount of water supplied should be the minimum required to maintain a safe working level. **Page 3 of 3 I:\Technical committees\TC1- Pressure Eqpt\GUIDANCE\PEC\PEC 12\PEC 12 - Dual fuel guidance - Issue 01 - Dated 16-09-1.doc** The safety valve should start to open at or below the safe operating limit. The firing should continue until there is no further increase in pressure or until the boiler pressure rises to a maximum of 110% of the safe operating limit. Generally the test should not run for longer than 15 minutes to prevent damage to the safety valve. A maximum pressure rise, after the initial lift at the set point, of less than 10% above the safe operating limit means the accumulation test is acceptable.
Annealing.		The process of softening (by heating and cooling).	
Approved welder.	*See also Coded welder.*	A suitably qualified and experienced welder who has undertaken and passed the appropriate welding qualification and procedure tests for a particular welded joint design.	
Arch Tube.		Steel tubes fitted in the firebox and connected to the lower portion of the firebox tube plate at their lower end and to points near the top of the firebox door plate at their upper end.	

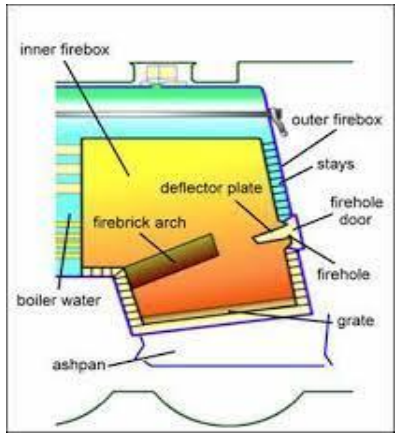
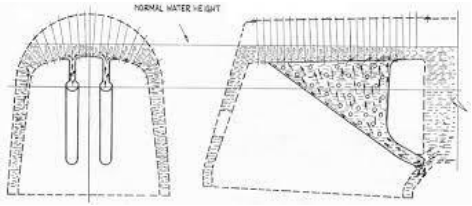
Backhead. 	Back Plate. Back Head. Door Plate. Firehole Plate	The rear outer flanged plate of a boiler where fittings controls are mounted and firing takes place	Back head an industrial and marine term.
Back Plate.	*See Backhead.*		
Belling	Flaring	Expanding process for tubes.	
Blowdown valve.		A valve fitted to the lowest part of the boiler to facilitate the removal of sediment.	
Boiler door. 	Manhole. Handhole. Mudhole.	Normally an oval door fitted to the boiler shell to allow access for examination and cleaning.	Located normally on boiler shell, smokebox and foundation ring. Larger manholes are uncommon in railway practice.
Boiler tube – beading.	Belling/Flaring	A finishing process carried out on the short protruding tube ends. This consists	

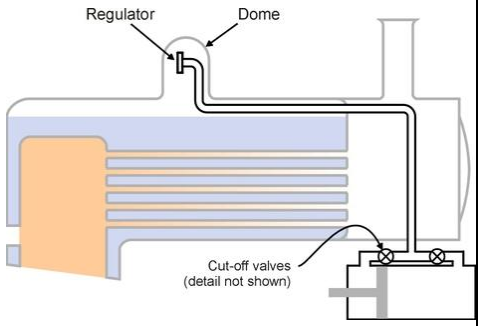
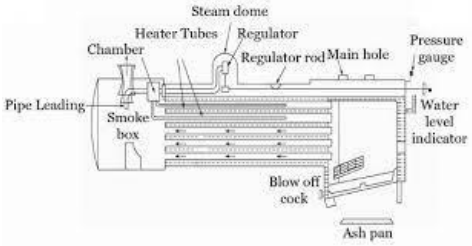
		of flaring the tube and then tooling it down onto the tube plate making a neat tube end closed tightly in contact with the tube plate in order to minimise the tendency for the tube end to “burn”.	
Boiler tube – ferrule. 	Tube sleeve.	A special sleeve (that has the appearance of a beaded over tube end) inserted into the firebox end of a boiler or super heater tube. The purpose being to protect the tube end from the effects of overheating.	
Boiler tubes - fire tubes.	Smoke tubes - ‘smalls’. Plain Tubes. Fire Tubes. Generating Tubes.	A group of tubes typically between 1 and 2 inches in diameter in the boiler barrel connecting the firebox to the smoke box. A proportion of heat from the fire is transferred via the tube wall to the water surrounding them.	
Boiler tubes - hole bush.		A thin metal bush designed to be neatly fitted into an oversized tube plate hole. This is intended to reduce the tube hole diameter back to a size that allows standard/original sized tubes to be refitted.	

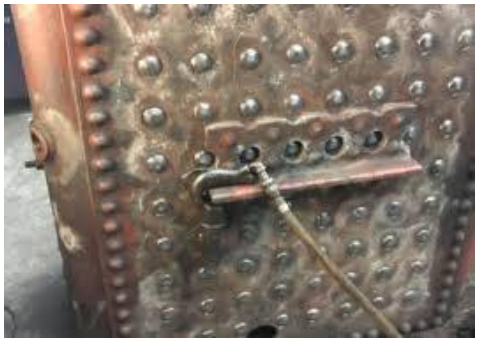
Boiler tubes - seal welding.  		Welding of the protruding boiler tube that forms an extra seal in a steel tube plate after tube expanding. This consists of a small fillet weld between the outside of the tube and the tube plate.	
Boiler tubes – small.	*See Boiler tubes - fire tubes.*		
Boiler tubes – swaging. 		A forging process that reduces the boiler tube diameter at one end to suit the tub plate hole size.	
Boiler tubes – swelling.  		A forging process that increases the boiler tube outside diameter (normally the smoke box end) to suit the tube plate hole size.	

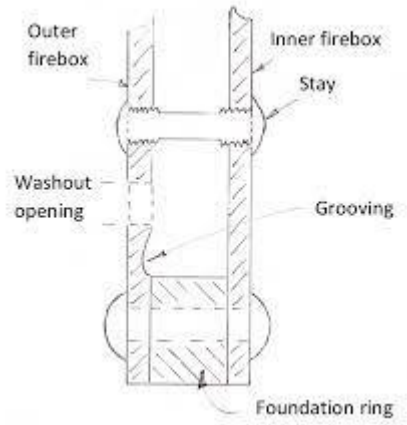
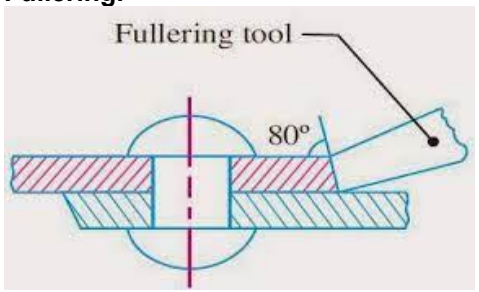
Boxing up.		Closing and sealing up of a boiler; refitting all mountings and plugs.	
Bridge (dog).		Fastening clamp used to draw the mudhole door onto its seat.	
Bulging. 	*See also Quilting.*	Bulging is normally associated with pressure loaded plate overheating often in the presence of broken stays where the boiler pressure has pushed the firebox plate towards the fireside in an area that can extend beyond some stays. Bulging of tube-plates may also be due to tube over expansion or poor tube removal (see also Quilting).	
Butt strap.	Welt.	A steel plate riveted to and joining the ends of the butt joint of a longitudinal seam.	
Caulking. 	*See also Fullering.*	Closing the edge of a rivet or seam with a tool similar to a blunt chisel in order to make the joint leak proof.	
Certified welder	*See Coded welder.*		
Change.		Remove the original, and fit new or overhauled part or assembly in its place.	
Check.		Determine a particular nominated condition before, during or after repair, e.g. completeness, security, position, corrosion, etc.	

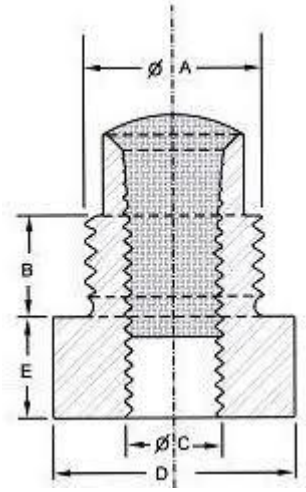
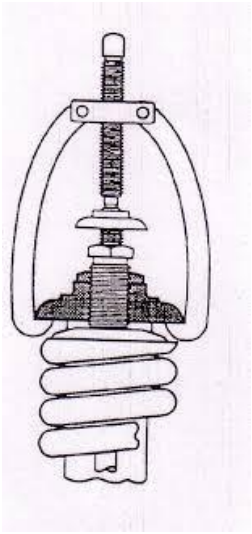
Coded welder.	Approved welder Certified welder.	A suitably qualified and experienced welder who has undertaken and passed the appropriate welding qualification and procedure tests for a particular welded joint design. This requirement is in accordance with British, European and other Internationally recognised standards.	
competent person.		A person competent and qualified to undertake the task described	
Competent Person. (Pressure Systems Only).		A competent individual person or a competent body of persons corporate or unincorporated; as referenced in the Pressure Systems Safety Regulations (2000).	Note the essential differentiation in railway terms between a competent person and a Competent Person as referenced in these Guidance Notes.
Crinoline bands.		Framework to support boiler cladding.	
Crown plate.	*See Crown sheet*		
Crown sheet.  	Crown plate. Wrapper crown. Wrapper plate. Wrapper sheet.	The upper sheet of the inner firebox exposed to fire, often made of copper. The outer crown sheet normally made of steel, forms the outer crown of the firebox and maybe flat or rounded.	

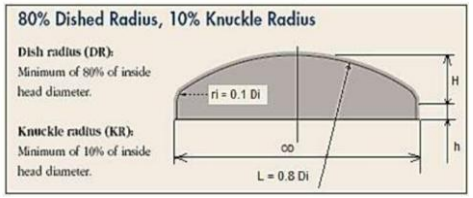
Defect/defective.		Any fault or faults in a component or assembly, which may prevent the component or assembly from fulfilling its designed purpose, e.g. cracking.	
Deflector plate. 	.	A removable semi-circular plate normally retained in position above the fire hole intended to deflect secondary air into the fire stream and away from the tube ends.	
Dezincification.		Corrosion of an alloy containing zinc (usually brass) involving loss of zinc.	
Diaphragm (thermic siphon). 	Siphon neck. Nicholson Thermic Syphon.	A triangular shaped water leg, used singly or in multiple adding to the heating surface designed to improve water circulation in the firebox.	In the UK found these are found in boilers designed by Oliver Bulleid on the Southern Region. 
Dismantle.		Take to pieces	

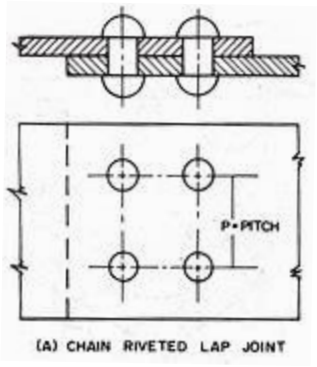
Dome.  	Steam Dome. Steam Collector.	A steam space set as high up as practicable, normally on the boiler barrel, arranged to house the regulator/steam collector and auxiliary steam pipes where the steam is at its driest condition.	
Door plate – inner firebox.  	*See Backhead* Firehole plate Firehole plate copper	The rear inner firebox plate containing the fire door ring or forged flanging.	
Door plate – outer.		The rear outer flanged plate of a boiler	
Examiner.		A person qualified in the appropriate trades necessary to undertake examination of a locomotive prior to it entering service. The tasks are not to be confused with duties of Operating Personnel during preparation of motive power for service.	
Examining fitter.		A maintenance craft person qualified in the appropriate trades necessary to undertake examination of a locomotive prior to it entering service. The duty	

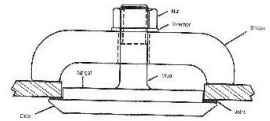
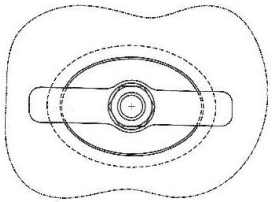
		relates to the Railway Safety Critical Work Regulations 1994. The tasks are not to be confused with the duties of Operating Personnel during the preparation of motive power for service.	
Expansion bracket. 		Normally 'L' shaped steel sections fitted to each side of a firebox. This supports the weight of the boiler at the firebox end. The lower section is arranged to rest on the locomotive frame, the arrangement having clearance in order to allow sliding due to boiler expansion when hot. It should be noted that locomotives fitted with fireboxes not located between the frames have different support arrangements.	
Fire tubes.	*See Boiler tube – fire tubes.*		
Firebox ring/mud ring.	*See Foundation ring.*		
Firehole plate or Firehole plate copper.	*See Door plate – inner firebox.*		
Flanged plates corner radius	*See Knuckle joint radius*		
Flaring.	Belling	Expansion process for tubes.	
Flue tubes.	*See Superheater – flue tubes*		
Foundation ring.	Firebox ring/mud ring. Ogee ring. Z ring	A steel ring shaped to correspond with the perimeter of the lower extremity of a firebox, rounded at the corners and of a thickness that separates the inside and outside sheets of the firebox to which it is riveted. In some boiler designs the need for a foundation ring is removed by the	

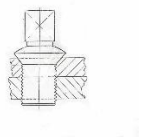
		forming of the inner plates into a “Z” or Ogee ring shape where the water space is created and then inner and outer plates are directly riveted together	
Fullering. 	*See Caulking* Lap edge tooling	As for caulking except that a broader tool is used to act on the full plate thickness of a riveted seam.	
Fusible plug.	Lead plug	A warning device or devices in the form of a screwed plug inserted into the crown of a firebox. Having a core normally in the UK of 99% pure lead. – designed to melt in the event of firebox crown becoming overheated due normally to low boiler water level.	Fusible plugs are not fitted or designed to extinguish the fire

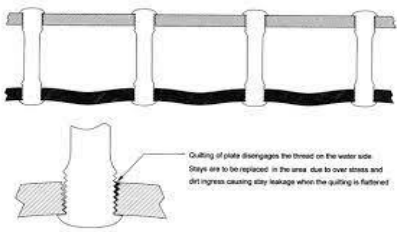
			
Gag. 	Valve Gag Valve Clamp	This is a clamp type of device used to prevent a safety valve from lifting. It is only used during the safety valve setting operation by trained and authorised maintenance and inspection personnel. Where more than one safety valve needs to be set individually it is convenient to restrain the other valves from lifting for the purpose of valve adjustment.	

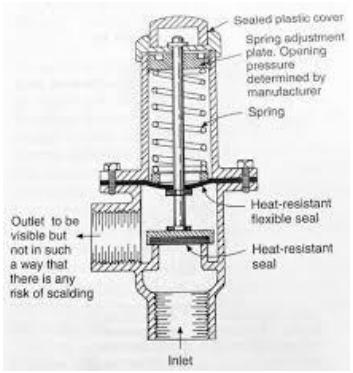
Gauge.		Determine a nominated dimension by using suitable measuring equipment, e.g. ruler, micrometer, callipers, feeler gauge, or Go/NoGo gauge	
Gauge glass.	*See Water level indicator*.		
Generating tubes.	*See Boiler tube – fire tubes*		
Girder bars.	*See Stays – Girder.*		
Grooving.		Fatigue corrosion acting in certain areas where cyclic stresses are applied	
Grooving.		Fatigue corrosion acting in certain areas where cyclic stresses are applied	
Handhole.	*See Mudhole door.*		
Heat treatment.		A combination of heating and cooling operations applied to a metal or alloy to obtain desired metallurgical conditions or properties	
HSE.		Health & Safety Executive	Workplace accidents may well involve the HSE.
Inspect.		Determine conformity to required standards during and after overhaul and repair.	
Inverted tee link stays	*See Stays – Sling.*		
Knuckle joint Radius. 	Tubeplate radius. Flanged plates corner radius. Plate lap corner radius	Flanged plates corner radius from flat to lap edge	Knuckle joint radius is the radius formed when a flat or flanged plate is formed to make a riveted or welded joint at a plate attachment.

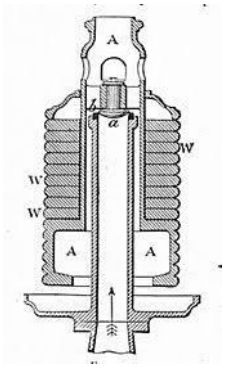
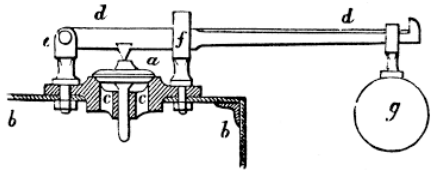
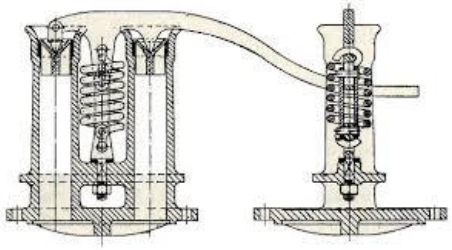
Lacing.	*See Patch Screws.*		
Lagging.		Material with insulating properties applied to hot surfaces to retain heat.	
Lap edge tooling.	*See Fullering.*		
Lap joint.  (A) CHAIN RIVETED LAP JOINT		A method of joining the ends of boiler plate or of two plates laying the edge of one over the other then riveting them together such that they overlap.	
Lead plug.	*See Fusible plug.*		
Manhole.	*See Boiler door.*		
May.		Used to express opportunity or permission based on judgment for a specific circumstance and where the guidance suggests options.	
MHD bridge plate.	*See also Mudhole door below*	An arch shaped clamp which bears on the boiler plate work. It has a hole in the middle to accept the mudhole door stud upon installation.	
MHD check plate.	*See Mudhole door and MHD spigot below.*		
MHD spigot.	*See Mudhole door below* MHD check plate	A raised portion of the elliptical mudhole door providing a close fitting location	It is critical that the spigot clearance be kept as tight as possible with a

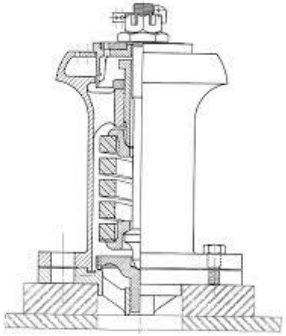
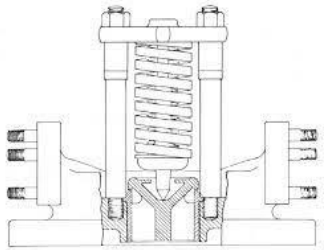
		within an elliptical aperture in the boiler plate.	maximum total clearance around the hole no greater than 3 mm.
MHD stud.	*See Mudhole door below*	A screwed stud fitted into a mudhole spigot for clamping it in position. On assembly; this is retained in the hole in the bridge. A nut is screwed onto the stud to provide the clamping force in order to secure it.	
Mudhole door.  	Handhole	A small oval door normally fitted at foundation ring level specifically for cleaning purposes. These sized doors are also fitted in other parts of the boiler such as the outer firebox crown top radius to allow for access.	
Must.		A compulsory task/process to be undertaken. A regulatory requirement which is considered to be a vital principle in the achievement of functionality or safety.	
NDT.		Non Destructive Testing.	
Nicholson thermic syphon.	*See Diaphragm (thermic siphon).*		
Normalise.		A heat-treatment process that has the object of relieving internal stresses and refining the grain structure.	

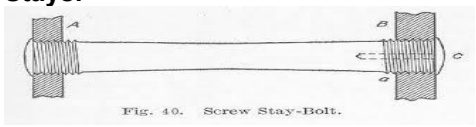
Ogee ring.	*See Foundation ring.*		
ORR.		Office of Road and Rail.	Inspecting authority for mainline and heritage railways.
Patch screws. 	Set screws. Lacing.	Special countersunk screw designed to screw into a specially prepared threaded and countersunk rivet hole in order to replace worn out rivets where a seam cannot be re riveted. Also used in repair situations.	
Pipework.		A pipe or system of pipes together with associated valves, pumps, compressors and other pressure containing components and includes hose or bellows. This description does not include any protective devices	
Pitting.		Localised severe corrosion	
Plain tubes.	*See Boiler tubes-fire tubes*		
Plate lap corner radius.	*See Knuckle joint radius.*		
Pressure system.		A system comprising of one or more Pressure Vessels of rigid construction, associated Pipework and Protective Devices	
Progressive threads.	Stepped studs, oversized, incremental threads	A method of redeeming thread condition by re cutting an existing threaded hole slightly larger (normally 1/16 inch increment) in order to recover a damaged or worn thread form.	Progressive threads are often associated with boiler stays.
Protective devices.		Devices designed to protect against system failure and designed to give warning that system failure might occur.	

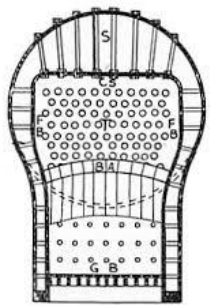
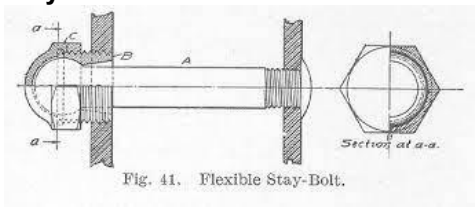
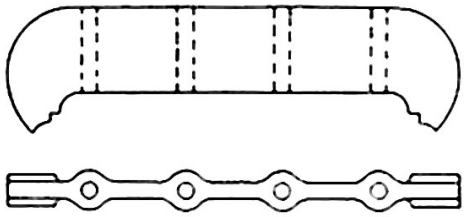
Quilting. 	*See also Bulging.*	Quilting is usually due to overheating and/or thinned plates where boiler pressure has pushed the firebox plate towards the fireside in an area between a number of stays. May also be formed by excessive hammering of firebox stay heads (particularly copper stays and plate).	
Reassemble.		Put back together.	
Record/records.		Put down in writing or enter in a computer system, the result of any specified examination, test or inspection, in accordance with defined procedures.	In the event of an accident, these records will be requested by the inspecting organisation be it ORR, RAIB or HSE and will be vital evidence in any resultant investigation
Refit.		The term is used where an item is removed made good and refitted. The term “Refit” is to be used as the term “Replace” can lead to confusion in terms of work carried out	
Relevant Fluid.		Steam at any pressure and/or Compressed Air with a pressure at or above 0.5 bar should also be considered a relevant fluid (See PSSR2000)	
Remove.		Disconnect and take off	
Renew.		To replace an item with a new or overhauled item.	
Replace.	*See Refit*		
Responsible person.		The individual appointed by that part of a preserved heritage railway organisation responsible for the use of a boiler. This	

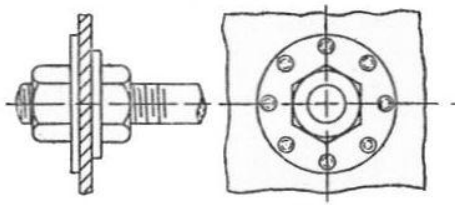
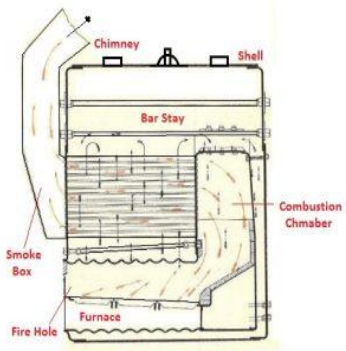
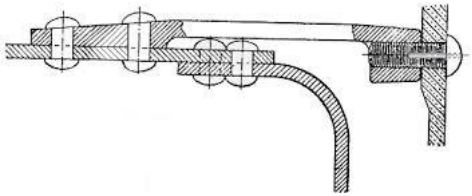
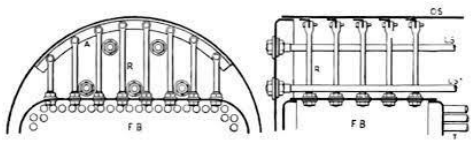
		person will have responsibility to co-ordinate all the necessary work and to ensure the safety of the boilers and pressure vessels on a railway and to maintain and co-ordinate the collation of the necessary paper or online records.	
Rivet.		A fastener installed through multiple plates where the shank is formed into a head.	
Roof stay.	*See Stays – crown.*		
Safe operating limits.	*See Working pressure.*		
Safety critical.		A system or component whose malfunction or failure may result in injury or death.	
Safety valve  		Steam generators (boilers) are fitted with safety valves directly mounted to the outer boiler shell normally at a high point arranged such that they operate to vent to atmosphere steam so preventing the boiler becoming over pressurised. These valves are normally spring operated. Steam boilers are to be fitted with two safety valves. For small boilers with a heating surface less than 9.5 m squared one safety valve may be used These valves should be so adjusted to ensure that the working pressure is not exceeded under normal steaming conditions.	
Safety valve – dead weight type.		A valve directly mounted onto the upper boiler shell with the valve held in position by a dead weight. The weight is fitted	Often to be found on Cornish and Lancashire Boilers

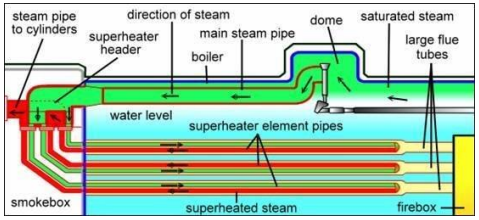
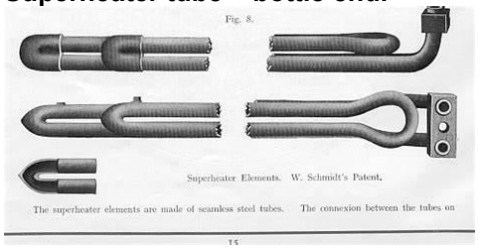
		directly to the top of the relief valve such that the steam pressure will overcome the applied weight to prevent the stipulated steam pressure from being exceeded.	
Safety valve – lever and weight Type. 		A valve directly mounted onto the upper boiler shell with the valve held in position by a lever fitted with a weight. The weight and its position on the lever are set such that the steam pressure will overcome the applied weight to prevent the stipulated steam pressure from being exceeded.	Locomotive Rocket is so fitted
Safety valve – Ramsbottom type 		This type of safety valve developed in 1856 to be a tamper proof valve consisting of two plug valves held in position by a pivot arm and a central spring with one valve either side of the spring. Originally the spring was tensioned by a bolt with the nut positioned within the steam space. On later valves often the tension nut was situated outside the steam space. The pivot arm allowed for the valves operation to be checked regularly.	

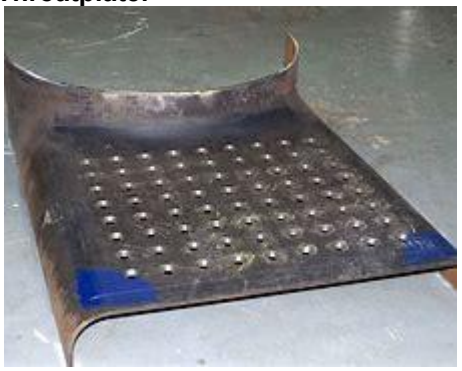
Safety valve – Ross 'pop' type. 		A significant refinement on a basic directly loaded spring safety valve; A compression spring is contained within the body of the unit which applies force to load the valve against the boiler pressure. The valve has an outer rim upon which the escaping steam acts to assist the valve in opening and also to shut in a positive manner. The sudden opening action of this type of valve gives rise to the term 'Pop' valve.	
Safety valve – Salter type. 		Similar in principle to a lever and weight valve, except that the lever is loaded via a spring balance. The spring balance is adjustable but should be fitted with ferrules so that the valve cannot be adjusted as part of normal day to day running.	
Safety valve – spring loaded. 		A valve directly mounted onto the upper boiler shell with the valve held in position by a spring. The spring is tensioned to allow the valve to operate at the desired pressure.	

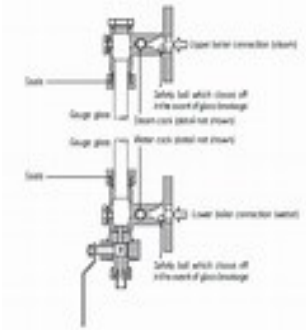
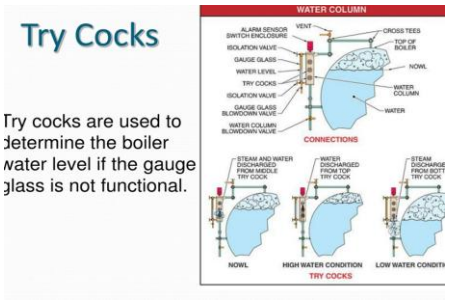
Scale.		A layer of foreign material adhered to a surface, e.g. corrosion scale or deposits of boiler water contaminants.	
Scrap.		Dispose of an item, in a safe manner (especially where Asbestos Regulations apply), which prevents its re-use.	
Set screws.	*See Patch Screws.*		
Shall.		A task or process that is compulsory to be carried out. A regulatory requirement is indicated with no discretion permitted and no judgment to be made.	
Should.		Advisory guidance which, in most circumstances, is expected to be carried out. This is a requirement which is considered to be sound advice for the achievement of safety but where judgment may be necessary when some additional information or amplification will enhance effectiveness.	
Side stay	*See Stays.*		
Siphon neck.	*See Diaphragm (thermic syphon).*		
Sling stays.	*See Stays – Sling*		
Smoke tubes – 'smalls'.	*See Boiler Tubes – fire tubes*		
Stays.  Fig. 40. Screw Stay-Bolt.	Side stay. Stay bar.	Flat surfaces particularly with regards to firebox's need to be supported by threaded or welded bars which support the inner and often the outer plates which need support.	Round top firebox's stays often support the inner firebox only whereas with Belpaire or flat topped firebox's support is to both plates.

Stays - crown. 	Roof stay. Crown stay.	Generic term for ordinary screwed stays which are screwed between the firebox roof and the boiler outer wrapper sheet.	
Stays - flexible.  Fig. 41. Flexible Stay-Bolt.		Stays that allow a degree of flexibility of movement. They incorporate a spherical head that fits into a corresponding cup socket in the outer wrapper sheet to facilitate flexibility.	
Stays: girder. 	Girder bars. Girder stay.	A longitudinal girder which has sufficient stiffness to support the fire box crown These stay bars maybe directly bolted, attached by stay bars or welded into position.	
Stays – longitudinal.	Stay bar.	This is a supporting stay bar directly connected between the front tube plate and boiler back head. These stays may also in certain designs be in two parts and riveted to the boiler barrel.	The Scotch Marine Boiler is shown for clarity concerning the alternative Bar Stay.

	 Scotch Marine Boiler		
Stays – palm. 	Waist sheet stay.	A steel forging riveted to the boiler barrel which is then fitted with a stay connecting the firebox below the tube bank, in order to support the area of plate not supported by stays, due to the throat plate radius.	
Stays – sling. 	Inverted ‘Tee link ‘stays.	A special design of vertical stays which allows upward movement of the firebox crown, often adjacent to the firebox tubeplate.	
Stay bar.	*See Stays.*		
Steam Collector.	*See Dome.*		
Steam Dome	*See Dome.*		

Stepped studs, oversized, incremental threads	*See Progressive threads.*		
Strip.		Take off covering, e.g. paint, polish, fabric.	
Stud.		A threaded fastener.	
Stud Driver.		A device used when fitting studs.	
Superheater elements and header 		A series of return tubes in which saturated vapour is converted to superheated steam. These tubes are fitted within larger flue tubes. The steam is supplied from the boiler via a header normally manufactured from cast iron.	It should be noted that cast iron is not normally used for superheater headers outside their use in locomotive type boilers
Superheater flue firebox end.	*See Superheater tube – bottle end.*		
Superheater flue tubes.	Flue tubes.	As Fire tubes except that flue tubes are larger in diameter (typically between 5 and 6 inches in diameter), designed to accommodate the superheater elements within the bore of the flue tube.	
Superheater tube – bottle end. 	Superheater flue firebox end.	A tube adaptor section that connects the super heater flue tube to the firebox. Depending on design, this can be either a copper swaged tube, brazed to the flue tube and expanded into the firebox, or a thick walled steel swaged tube, welded to the flue and screwed into the firebox tube hole.	

System Failure.		Unintentional release of stored energy or the scalding effect of steam from a pressure system.	
Test.		Prove correct operation by specified trial.	
Test Cock.		Supplementary boiler water level indicator.	
Thermic syphon.	*See Diaphragm (thermic siphon).*		
Trial Cock.	*See Test Cock*		
Throatplate. 		Front plate of the outer firebox casing which joins the foundation ring to the barrel. Commonly known as a throat plate due to the large radius where the plate is formed to attach to the boiler barrel.	
Tube flaring		Tube flaring is a cold process of forming a funnel to the short protruding end of the tube to start the beading process.	
Tube sleeve	*See Boiler tube – ferrule.*		
Tubeplate radius	*See Knuckle radius*		
User.		In relation to a pressure system, means the employer or self-employed person	

		who has control of the operation of the pressure system.	
Valve Clamp/Gag	*See Gag*		
Waist sheet stay.	*See Stays - Palm*		
Washout.		The process of cleaning scale, sludge and sediment from the water spaces of the boiler.	
Water leg.	*See Water space.*		
Water level indicator. 	Gauge Glass.	A tubular or plate glass fitting fitted such that the level of water within the boiler can be ascertained. This device is fitted such that when the water level falls to a low point in the glass the firebox crown is still covered with water and the fusible plug will not activate. Normally locomotive boilers are fitted with two tubular or plate glass water level indicators, but some locomotives are fitted only with one and try cocks.	Board of Trade rules 1956 state That – Every boiler should have at least two independent means of indicating the water level one of which must be a glass water gauge. *See also note 1 at the end of the glossary.*
Water level test cocks.	*See Water level try cocks.*		
Water level try cocks 	Water level test cocks.	Cocks, normally three, fitted to the boiler so that the water level can be ascertained by carefully cracking them open. These devices were commonly fitted particularly to ex-Great Western Locomotives.	In railway practice, two test cocks are often found.

Water space.	Water leg.	The part of the boiler between the firebox and outer wrapper that is filled with water. Designated as side, front or back water spaces/legs.	
Welt.	*See Butt strap*		
Working pressure.	Safe operating limits. (Pressure Systems Regulations terminology).	The maximum steam pressure that the boiler is allowed to operate at. This pressure is set by the design of the boiler. It is protected from over pressurisation by safety valves set at this pressure.	It should be noted that in non-locomotive boiler operation, the working pressure is normally 10% lower than the safe operating limit.
Wrapper crown, plate or sheet.	*See Crown sheet.*		
Written scheme of examination.		The written scheme for the periodic examination by a competent person, of the following parts of the system: i. All protective devices; ii. Every pressure vessel in which a defect may give rise to danger; and iii. Those parts of the Pipework in which a defect may give rise to danger.	
Z ring.	*See Foundation ring.*		

Notes:

1 Boiler level indicators – It is a requirement of Board of Trade rules for a boiler with a diameter above 2 feet 6 inches to have two means of ascertaining the water level, one of which must be a gauge glass. Test cocks may be the other method, industrially normally 3 in number, but may be reduced to 2. Water level indicators should be such that the lowest reading of water level should indicate 1.5” of water above the crown sheet

Appendix B – Selected references on the Care & Maintenance of Locomotive Boilers – note that copies of these booklets are not held by the HRA but should be available via websites of the specific organisations and from libraries (specialist and otherwise). The National Railway Museum may hold copies that can be viewed in York and a direct request to the NRM should be made before visiting.

	A	B	C	D	E	F	H
1	**Title**	**Author**	**Paper**	**Journal**	**Source**	**Year**	**Comment on contents**
2	**Reference Books**						
3	A Manual of Steam Locomotive Restoration and Preservation (Hardback book)	Harvey D. W.			D & C	1980	
4	Handbook for Railway Steam Locomotive Enginemen (Hardback Book)	Harvey R.F. ?			B.T.C.	1957	Standard BR reference book
5	Locomotive Engineers' Pocket Book				Locomotive Publishing Company		
6	Steam Locomotive Design: Data and Formulae	E.A. Phillipson			Locomotiv	1936	Cambden reprint 2004
7	Industrial Water Treatment	Hamer, Jackson & Thurston			Butterwort	1961	
8	Locomotive Management -Cleaning, Driving Maintenance	Lee C. E.odgson & Lake			St Margar	1948	General locomotive care - One chapter on the Boiler. (editions 8, 9 or10) (Hodgson & Lake)
9	Maintenance of Locomotive Boilers (Hardback book)	Garraway A			Ian Allan	1999	
10	Motive Power Organization and Practice (Hardback official)	Rudgard H.	53894		B.T.C.	1946	Contains details of 'X' scheme of repair (p38)
11	Locomotive Boiler Explosions	Hewson C H			D & C	2003	
12	Raising Steam on the L.M.S. - The Evolution of LMS Locomotive Boilers (Hardback book)	Cook A. F.			RCTS	1999	
13	**Published papers**						
14	Tube Failures	Groom S.W.	72	39	I.Loc.E.	1919	
15	Engine Failures	Clayton J.	232	85	I.Loc.E.	1928	
16	The Taper Boiler	Thompson J.W.	361	134	I.Loc.E.	1936	
17	Locomotive Feed Water Treatment	Hancock J. S.	366	136	I.Loc.E.	1937	
18	The Locomotive Boiler	Turner J.	375	138	I.Loc.E.	1937	
19	Copper and Copper Alloys for Locomotive Firebox Construction	Cook M.	393	146	I.Loc.E.	1938	
20	Economical Locomotive Running Shed Operation	Pargiter G.M.	397	147	I.Loc.E.	1939	
21	A treatment of Locomotive Feed Water	Pinchen D. B.	404	149	I.Loc.E.	1938	
22	The Solution to Some After Problems of Water Softening	Topham W.L.	410	152	I.Loc.E.	1939	
23	Modern Locomotive Boiler Shop Practice	Fell E.W.	414	154	I.Loc.E.	1940	
24	Corrosion of Boiler Tubes	Turner T.H.	438	170	I.Loc.E.	1942	Chief Chemist LNER. How tubes corrode; prevention of corrosion. Paper also in I.Mech. E. Volume 149 of 1943.
25	The Work of their Craft (Presidents Address)	Whalley F.S		193	I.Loc.E.	1946	
26	A Brief History of the Application of Base Exchange Water Softeners on Railways (South America)	Walter A.J.	463	195	I.Loc.E.	1947	

	A	B	C	D	E	F	H
1	**Title**	**Author**	**Paper**	**Journal**	**Source**	**Year**	**Comment on contents**
27	Organisation and Carrying Out Exams. & Repairs of Locos at Running Sheds in Relation to Loco Pref. & Availability	Rudgard H.	464	196	I.Loc.E.	1947	L.M.S. 'X' scheme details, Cooling (9hrs), washing-out (2 hrs), filling & raising steam (8hrs) for cl. 5-7 boilers
28	Water Softening for Locomotive Boilers	Hancock J. S.	468	198	I.Loc.E.	1947	L.M.S. Hardness levels at which you should soften as well as treat water.
29	Some Developments in Locomotive Workshop Practice 1939-1948	Forsyth I.C.	485	209	I.Loc.E.	1949	
30	The Influence of the Treatment of Boiler Waters on the Maintenance and Utilisation of Steam Locomotives.	Armand. L		210	I.Loc.E.	1949	This is the reference paper on the SNCF TIA 'In Tank Water Treatment System'.
31	The Early History and Later Application and Development of Superheating in Locomotive Practice	York R. S.		211	I.Loc.E.	1949	The paper was presented in New South Wales. Tube and element faults.
32	The Application of Welding to Locomotive Boiler Copper Fireboxes	Harrison J. F.	511	227	I.Loc.E.	1952	Mechanical & Electrical Engineer BR (LM) Derby. Discussion includes K.J.Cook, R.C. Bond
33	The Design and Construction of Steel Fireboxes	Compton J. N.	525	234	I.Loc.E.	1953	Yorkshire Engine Company. Identifies stress points.
34	A Brief History of Locomotive Feed Water Treatment on the L.M. Region of British Railways	Hancock J. S.	573	257	I.Loc.E.	1957	Water Treatment Assist. to CM & EE BR(LM) Derby. Common discussion with paper 572. + Bibliography by TH Turner.
35	Some Aspects of Locomotive Boiler Feedwater Treatment	Parsons A. J.	572	257	I.Loc.E.	1957	Technical Officer, Railway Section I.C.I Alkali Division (Alfloc Water Treatment) In depth paper
36	Experience with the Steel Fireboxes of the Southern Region Pacific Locomotives	Burrows M. G. Wallace A. L.	584	262	I.Loc.E.	1958	15 years of operating experience with MN & BoB boilers. Modifications justified.
37	Steel for Railway Purposes	Dearden & Roberts	586	263	I.Loc.E.	1958	
38	Corrosion of Boiler Tubes	Turner T.H.		149	I.Mech.E	1943	Copy of I.Loc E. J170 Vol 32
39	Presidential Address	Bulleid O.V.S.		156	I.Mech.E	1947	A review paper - Photos of Stays and Boilers
40	Some Notes on the 'Merchant Navy' Class Locomotives of the Southern Railway	Bulleid O.V.S.			I.Mech.E	1946	Design, construction and early operation. Novel features including welding and assembly of fireboxes covered.
41	Fusion-Welded Boiler on D & H Locomotive (USA)	Edmonds G.S.		Journal	A.S.M.E.	1946	
42	Locomotive Boilers - Welded Construction (USA)	Partington J		Journal	A.S.M.E.	1946	
43	Experience with Intercrystalline Cracking on Railroads (USA)	Bardwell & Laudemann		Transaction	A.S.M.E.	1940	
44	Heat Transfer in the Locomotive Boiler (USA)	Fry L. H.		Transaction	A.S.M.E.	1946	
45	Boilers, The Heart of the Matter - Part 1 Certification	Anderson J	1	USA	L&RP	1986	Practical loco boiler maintenance

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46	Boilers, The Heart of the Matter - Part 2 - The Firebox	Anderson J	2	USA	L&RP	1987	Practical loco boiler maintenance
47	Boilers, The Heart of the Matter - Part 3 - Boiler Inspection	Anderson J	3	USA	L&RP	1987	Practical loco boiler maintenance
48	Boilers, The Heart of the Matter - Part 4 - Tools	Anderson J	4	USA	L&RP	1987	Practical loco boiler maintenance
49	Boilers, The Heart of the Matter - Part 5 - Tube & Flue Removal	Anderson J	5	USA	L&RP	1987	Practical loco boiler maintenance
50	Boilers, The Heart of the Matter - Part 6 - Preparing & Installing Tubes	Anderson J	6	USA	L&RP	1988	Practical loco boiler maintenance
51	Boilers, The Heart of the Matter - Part 7 - Staybolts	Anderson J	7	USA	L&RP	1988	Practical loco boiler maintenance
52	Boilers, The Heart of the Matter - Part 8 - Keeping Valves Tight	Anderson J	8	USA	L&RP	1988	Practical loco boiler maintenance
53	Boilers, The Heart of the Matter - Part 9 - Throttle & Special Valves	Anderson J	9	USA	L&RP	1989	Practical loco boiler maintenance
54	Boiler Corrosion and Water Treatment B.R. 1335	Admiralty	1335		HMSO	1945	Types of Corrosion with illustrations
55	Modern water treatment and Sodium Aluminate for Railways	Beal & Stevens	179	ndon Eng	GWR	1930	Basic Discussion
56	**Notes of Current Practice**						
57	Apexior Paint Trials	Pickering P.			Swanage	2002	Controlled trial results
58	Boiler Water Treatment	Heintzman M			SVR	2001	Overview of Current Best Practice
59	Locomotive Boiler Maintenance, Tubes and Retubing	Snell J.B.			RH&DR	2000	Review of RH&DR boiler issues.
60	Steel Boiler Materials and Use (paper for Bulleid Pacific Locomotive Association)	Johns M.A.			WSR	2002	Past BR (S) Boiler Water Expert
61	SVR Water Treatment & Corrosion References	Heintzman M			SVR	2001	
62	Feed Water Treatment for Road Engine Boilers	Garnett R.J.			N.T.E.T.		Water Treatment Basics for Traction Engine Owners

