



GUIDANCE NOTE

FUSIBLE PLUGS

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 document HGR B9000 sets out the background to setting up the Boiler Code of Practice Committee (BCOP).

Disclaimer

The Heritage Railway Association and BCOP 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

This document is published by the Heritage Railway Association (HRA).

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.

Table of Contents

1.	Introduction	3
2.	Recommendations.....	3
3.	Scope of this Guidance	3
4.	Dimensional Notation.....	3
5.	Personal Protective Equipment	3
6.	Inspection	4
7.	General	4
8.	Competency.....	4
9.	Maintenance plan	4
10.	Materials	5
11.	Tabulation of sizes.....	5
12.	Thread form and tolerance	7
13.	Fusible plug thread length	7
14.	Methods of manufacture	7
15.	Re-leading	8
16.	Methods of sealing plug in boiler	8
17.	Removal and cleaning	8
18.	Inspections and faults of fusible plugs.....	8
19.	Fitting plugs	9
20.	Testing in boiler	9
21.	References	9
	Appendix A: Typical Method of leading new and used fusible plugs BR type	10

1. Introduction

- 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 HMRI and HRA set up the series of meetings of boiler practitioners to discuss the issues, distil good practice and codify it into this 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.

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.

3. Scope of this Guidance

- a) This guidance is ONLY concerned with those actions that could adversely affect the life and / or the safe operation of the boiler. Duty holders should consider all aspects of each of the sections covered before determining their procedures.

4. 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 the original designs were documented have been used. Psi where used indicated per square inch.

5. Personal Protective Equipment

- a) Before undertaking any work, a risk assessment must have been conducted.
- b) Protective equipment is to be supplied and used at work wherever there are risks to health and safety that cannot be adequately controlled in other ways.
- c) The equipment must be:
 - i) Compliant with the latest Personal Protective Equipment Regulations;
 - ii) Properly assessed before use to ensure it is suitable;
 - iii) Maintained and stored properly;
 - iv) Provided with instructions on how to use it safely; and
 - v) Used correctly by those undertaking the work.

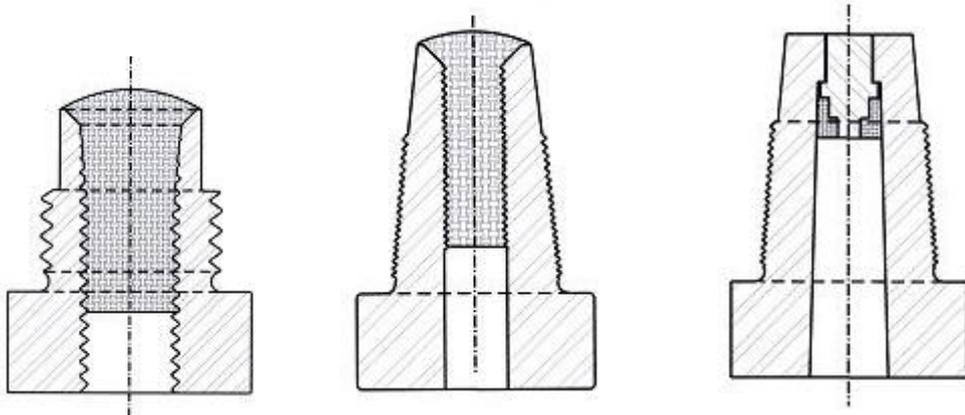
6. Inspection

- a) The inspection should take account of the requirements in the 'Written Scheme of Examination' for the boiler under the Pressure Systems Regulations 2000.
- b) In the event of finding any fusible plug to be defective or suspect seek guidance from the boiler Competent Person and replace the fusible plug with a new item.

7. General

- a) Most locomotive boilers designed to operate in the UK incorporate one or more fusible plugs fitted to the crown of the inner wrapper of the firebox. In the event of the water level within the boiler falling below the level of the crown, the temperature of the wrapper plate work rises. A low melting point alloy within the fusible plug melts with this rise in temperature allowing steam from the boiler to escape into the firebox. This escape of steam, if serious, alerts the crew to the low water level.
- b) Fusible plugs take the form of a bronze or brass threaded plug which screws into a tapped hole in the wrapper. The thread may be either tapered or parallel depending upon its design. If tapered, the plug seals on the thread, if parallel, it seals against a flanged face. The centre of the fusible plug is hollow with a hole drilled through on the axis of the thread. This hole is filled with either low melting point alloy or lead. Alternatively, it is filled with a combination of low melting point alloy or lead retaining a bronze or brass billet. Fusible plugs are usually screwed into the wrapper crown from the fire side of the plate and have a head, usually square, for driving the plug, see diagrams:

Sectional views of common types of plugs are shown below:



Parallel thread plug

Taper thread plug

Proprietary plug, NABIC type

The NABIC type plug may be fitted from fireside or waterside depending upon design. **IT CANNOT BE RELEADED.** It must be fitted in accordance with the manufacturer's instructions.

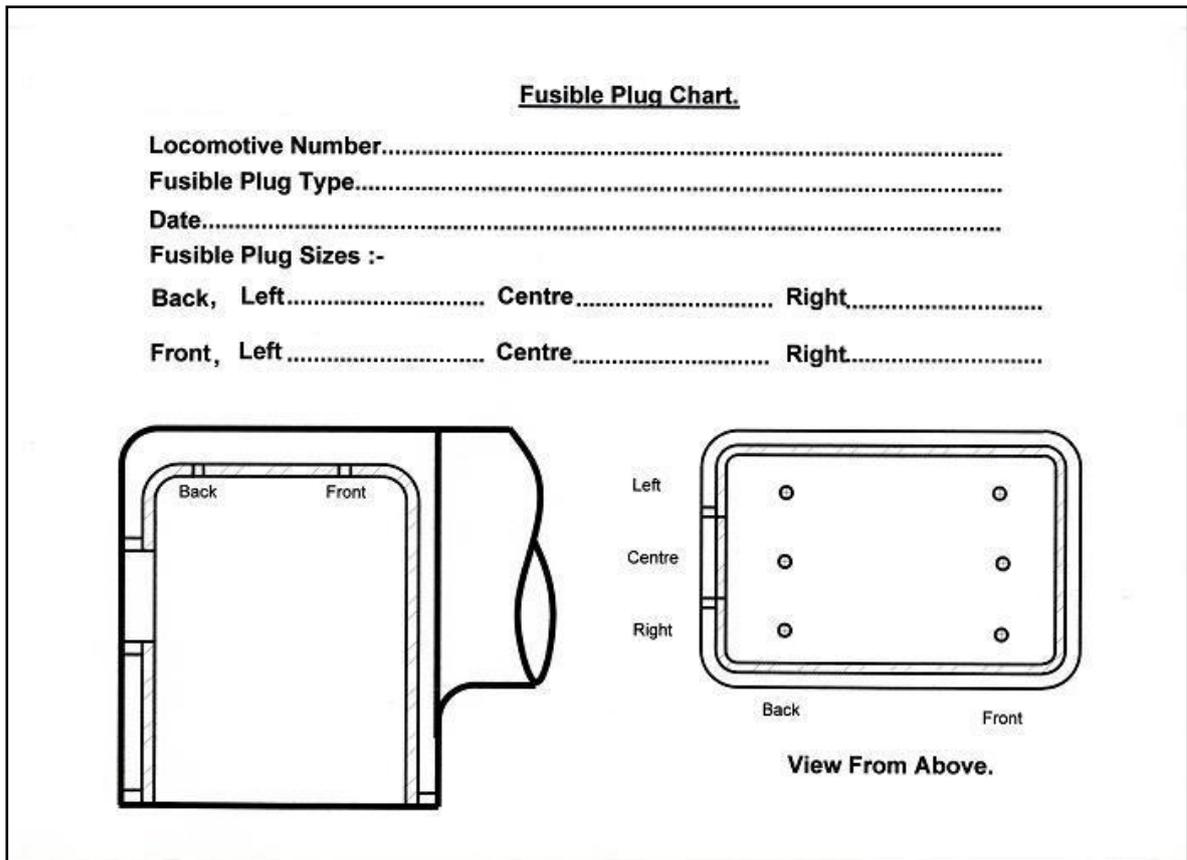
8. Competency

- a) The manufacture, inspection and fitting of fusible plugs are safety critical tasks. Only those trained, deemed competent and authorised should be responsible for the inspection of fusible plugs and plug holes, and refitting of fusible plugs. Records should be kept of the action taken at each washout and by whom and included in the Written Scheme of Examination.

9. Maintenance plan

- a) The boiler maintenance documentation should reference the identification and location within the firebox of each fusible plug. If the boiler has more than two fusible plugs, this should preferably be in pictorial form on a diagram (see example overleaf).

- b) Each plug should be identifiable in accordance with the plan to ensure that it is always replaced in the correct position. The maintenance plan should record the thread size of each threaded hole in the wrapper crown to ensure the correct size plug is used.



10. Materials

Body

- a) The material for the body of the plug should be leaded gunmetal LG4 (or alternately brass CZ121)

Core

- b) Pure lead 99.97%, melting point 327 degrees C

Material records

- c) Certificates of chemical analysis and mechanical tests to the appropriate standards for the materials concerned should be held for the life of the plug.

11. Tabulation of sizes

- a) To accommodate the progressive wear of threads in boiler plates, particularly copper, fusible plugs are manufactured in a range of sizes.
- b) The diagrams to which the figures in the tables refer are given on the next page.

Parallel threads

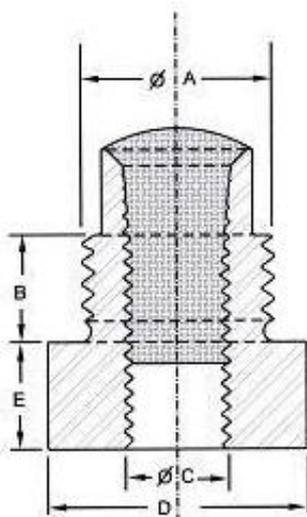
- c) The threads are usually coarse and the common sizes are detailed in Table 1 below.
- d) It is recommended that where possible the 'BR late' set of dimensions are followed for all new works.

Plug type	Drawing	External thread			Internal thread			Square	
		Dia	TPI	length	Dia	Dia oversize	TPI	AF	Length
	Diagram ref	A	-	B	C	-	-	D	E
BR late	SL/SW/88 Post 1956	1 1/8 to 1 5/16 by 1/16	8	5/8	1/2	9/16	12	1 1/2	5/8
BR early	SL/SW/88	1 1/8 to 1 5/16 by 1/16	8	5/8	5/8	11/16	11	1 1/2	5/8
GWR	101077	1 1/8 to 1 5/16 by 1/16	8	5/8	5/8	11/16	11	1 1/2	1/2
LMS		1 1/8 to 1 5/16 by 1/16	8						

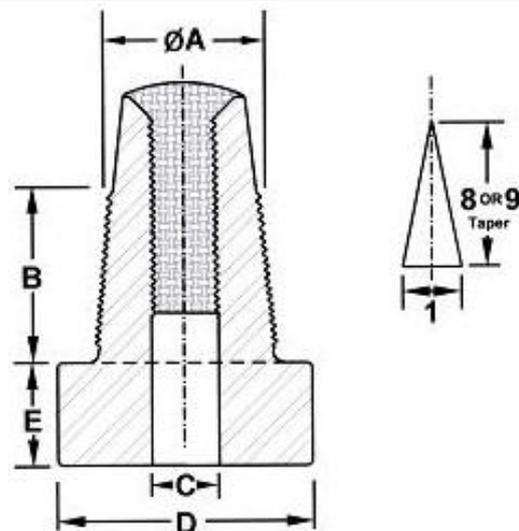
Taper threads

e) The threads are usually fine and the common sizes are detailed in Table 2 below.

Plug type	Drawing	External thread				Internal thread		Square	
		Dia	Taper	TPI	length	Dia	TPI	AF	Length
	Diagram ref	A	-	-	B	C	-	D	E
LNER	822N	1 1/8 to 1 5/8 by 1/16	1 in 9	11	7/8	1/2	12	1 3/8	3/4
Southern		1 1/4 to 1 3/4 by 1/16	1 in 8	12	1 1/4	5/8	11	1 7/8	3/4
NABIC type Fig 5 fireside		1/2 - 3/4 - 1 - 1 1/4	BSPT					HEX head	
NABIC type Fig 8 waterside		3/4 - 1 - 1 1/4 - 1 1/2	2 BSPT					HEX head	



Parallel thread plug dimensions – Table 1

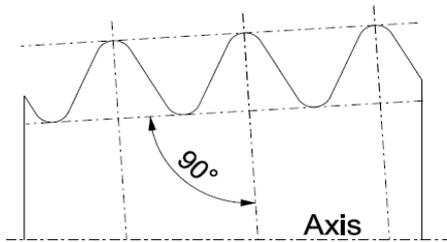


Taper thread plug dimensions – Table 2

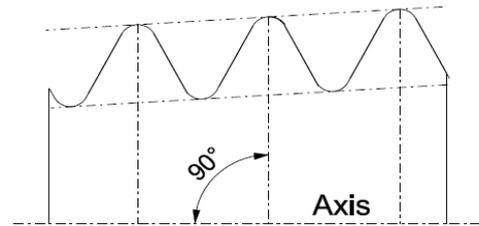
f) Particular sizes of plug hole and corresponding plug should be recorded on the maintenance plan plug chart.

12. Thread form and tolerance

- a) Parallel threads will vary according to design but most are Whitworth form “close fit” as defined in BS 84. Taper threads will vary according to design but, usually, the threads are of Whitworth form. The TPI of the thread is always measured along the centreline of the fusible plug. There are two methods of cutting the threads on the plug, either a) square to the taper (this allows modern full form threading inserts to be used), or b) square to the centre line of the fusible plug. This requires especially ground full form chasers to cut the correct profile thread (see figure below).



Threads Normal to Taper



Threads Normal to Centreline

- b) Both methods are acceptable. However it is important that the two thread forms are not mixed up and that both boiler thread and fusible plug are to the same standard. Only one type should be used on any single boiler. It is important that the boiler records and plug diagram (see item 7 above) detail which form is in use on a boiler and that the fusible plugs and any spares are appropriately marked.

13. Fusible plug thread length

- a) For parallel threads, the thread of the fusible plug should be the same length as the thickness of the boiler plate and no thread should protrude through into the water space, as this will become encrusted with scale, damaging the boiler plate on removal. In some works, it was practice to fit a threaded ring into the crown when the maximum size of plug hole was reached, akin to a stay bush. Fusible plugs for holes, so modified, require to be longer as the ring is thicker than the parent plate.
- b) For tapered threads, there should be at least two threads clear through the boiler plate and at least two threads clearance between the boiler plate and the end of the thread at the head of the fusible plug.

14. Methods of manufacture

- a) Users are advised to purchase plugs from an experienced and reputable manufacturer. Various methods of manufacture have been adopted by different manufacturers and railway companies, all of which have advantages and drawbacks.
- b) A typical method of leading plugs is detailed in Appendix A. Whichever method is used the following should be taken into consideration:
- i) The lead filling of fusible plugs is toxic and appropriate precautions must be taken;
 - ii) The use of tinning agents will affect the purity of the lead and produce an alloy; tinning agents should therefore be kept to a minimum;
 - iii) Cleanliness is critical in producing a satisfactory product;
 - iv) Only new pure lead should be used in manufacture as alloying elements rapidly reduce the melting point of the metal. They are also subject to enhanced corrosion;
 - v) Used lead must be disposed of as hazardous waste;
 - vi) Each fusible plug should be subjected to a hydraulic test; and
 - vii) Plugs should be stored individually to avoid damage to threads or lead inserts.
- c) The finished plug should be marked with an indication of the size, manufacturer and date of manufacturing on a flat of the head of the plug.

15. Re-leading

- a) Fusible plugs which require the lead replacing because of corrosion should have the old lead melted out. Due to the difficulty in ensuring a suitably clean surface for the new lead to bond to the hole, they should be tapped out oversize, exposing fresh metal for tinning. This tapping out process should take place only once on each body. For leading details see previous section. Once re-led, the plug should have a suitable identification stamp to indicate that re-leading has taken place. The use of a capital 'R' on the side of a flat of the head is recommended.

16. Methods of sealing plug in boiler

- a) Fusible plug threads should be sealed with a lubricating sealant such as Graphite grease; no hard setting sealant or jointing compound is to be used, as this builds up over time in the thread forms and is difficult to remove from the fusible plug and hole. Suitable Graphite grease compounds are petroleum jelly based; compounds with linseed oil are hard setting and unsuitable.
- b) The use of PTFE and PTFE tapes can cause toxic fumes at elevated temperatures (300+ degrees C) and their use should be avoided in locations where elevated temperatures may be encountered.

17. Removal and cleaning

Period of removal

- a) Details of when plugs are to be removed for inspection should form part of the boiler records. It is recommended that fusible plugs be removed at every washout for inspection.

Plug cleaning

- b) Fusible plugs are to be cleaned with fine hand wire brush to remove all deposits of Graphite grease and scale to leave a bright surface suitable for inspection. It is important to ensure that all boiler scale is removed from the surface of the lead on the water side and that all sooty build up is removed from the surface of the lead on the fire side.

Hole cleaning

- c) Holes are to be cleaned with a small wire brush, or tap if necessary; paraffin or similar solvent used with a tooth brush will leave a surface suitable for inspection.

Storage of plugs

- d) Use of a partitioned tray is recommended to avoid plug threads becoming damaged by bruising.

18. Inspections and faults of fusible plugs

- a) The bodies of fusible plugs will suffer from corrosion on the fire side and chemical attack on the water side. As a result, their life is limited and it is recommended that the boiler records detail the number of washouts before a plug is refilled and the total number of washouts before a fusible plug is scrapped. Typically the life of the lead filling is 2 or 3 washout periods and the total life of the fusible plug is 4 or 6 washout periods. Cracking at the undercut of the thread on parallel thread fusible plugs is a common mode of failure and requires special attention. Inspect for pulled threads especially on steel firebox plate work. Scrapped plugs are to be rendered unusable and destroyed.
- b) The lead filling will suffer from corrosion on the water side to an extent which varies with the quality of the boiler water. The lead/body interface will suffer from corrosion, particularly if tinning has been used in the manufacture of the plug. Unserviceable plugs that have already been re-led once are to be rendered unusable and destroyed.
- c) Holes in wrapper crowns will suffer from pulled threads and ripped threads. Copper is particularly prone to pulled threads. Any holes with signs of damage should be tapped to the next size up, removing all traces of damage or cross threading. When tapping threads, use a sharp tap in conjunction with a cutting compound, ensure the tap is perpendicular to the plate and advance the tap by up to ½ turn per cut and back off as required to free swarf. Avoid the end of the tap causing damage to internal components within the boiler, such as pipes and stays. When the maximum size hole has been reached and it requires renewal and either the hole requires bushing or a new location is required, seek the advice of the Competent Person. When inspecting holes, sufficient light must be

available to illuminate all of the surfaces and, if necessary, use a mirror to inspect parts of the thread not directly visible. For parallel thread plugs which seal on the face, the wrapper plate requires a flat surface to form a seal so always inspect this face for damage.

- d) Fit of plug in hole. For parallel thread fusible plugs if there is any detectable movement of the plug in the crown thread, the fit is no longer close and the thread will need re-cutting to the next size. After re-cutting the thread, the seat will need re-cutting to bring it square to the thread. For tapered threads there should be at least 2 threads clear through the boiler plate and at least 2 threads clearance between the boiler plate and the end of the thread at the head of the fusible plug.

19. Fitting plugs

- a) The boiler records should be consulted prior to re-fitting to ensure that the correct fusible plug is always fitted to the correct hole. This will avoid fitting the wrong plug to a hole. Plug threads should be coated with Graphite grease (see thread sealant above). No hard setting lubricant or jointing compound is permitted.
- b) Firstly, insert the plug into the hole and tighten by hand. To fully tighten, use a purpose made socket which is a good fit on the head of the plug; push the socket hard up against the end of the head to avoid damaging the plug or twisting the head. When fitting plugs, it is important that this is done as a single operation on each plug without distraction, the plug is either 'out in the tray' or 'fitted tight'. Do not put all plugs in by hand and follow around with the socket. For most plugs, a 12" T bar on the square socket will give an appropriate torque when operated by hand (approximately 100Nm (75 ft lbs)). Do not over tighten by using an extension on the T bar handle.

20. Testing in boiler

- a) Plugs are to be inspected for leakage when the boiler is first steamed following the removal of any fusible plug. If leakage is detected no attempt is to be made to tighten the plug whilst the boiler is in steam. A further check on the tightness of the plug may be made when the boiler is cold, if necessary partly drain the boiler of water, remove the plug, inspect, clean and refit.

21. References

SL/SW/88 BR Standard fusible plugs.

GWR 101077 Standard stays and plugs for locomotive boilers.

LMS "Red book" section B11.

LNER "Fusible plugs in locomotive boilers" May 1940.

HSE Free leaflet - indg305 Lead and you – A guide to working safely with lead

HSE Free leaflet – indg304 Understanding Health Surveillance At Work-An Introduction for employers

HSE L132 - Control of Lead at Work Regulations 2002. Approved code of practice and guidance

end of main document

Appendix A: Typical Method of leading new and used fusibile plugs BR type**Leading new plugs**

1. Paint internal thread and countersink with a zinc chloride activated (Sn40 Pb60) solder paint;
2. Warm plug until tinned;
3. Warm up lead;
4. Place warm plug in the mould;
5. Pour lead and let it set;
6. When the plug is cold enough, remove and lightly hammer the crown; drift lightly bottom of lead;
7. Remove excess lead from crown; and
8. Wire brush and examine.

Re-leading previously used plugs***N.B. Plugs may only be re-leaded once***

1. Melt out lead in a ventilated area, allow to cool;
2. Wire brush;
3. Clean out the threaded portion with a tap one size larger;
4. Clean out countersink with a suitably ground hand drill;
5. Examine the general condition of square and external thread for distortion and deterioration of size;
6. Check undercut for any signs of cracking; and
7. If items 5 and 6 are OK, proceed as for new plugs.

end of appendix
