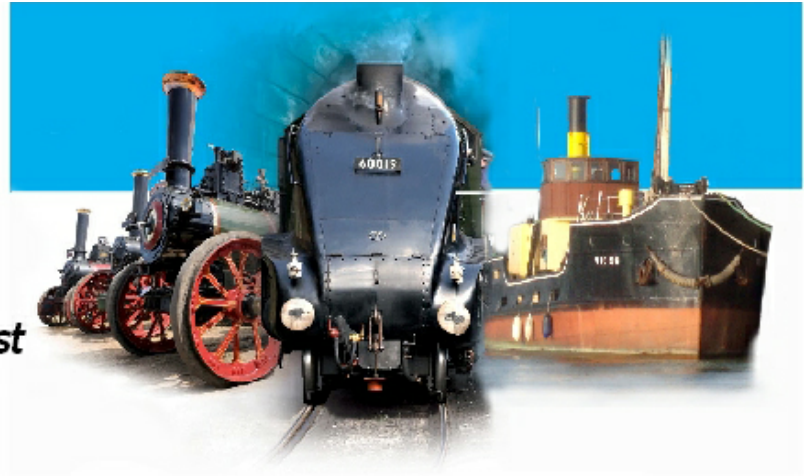


Bestt

Boiler & Engineering Skills Training Trust



Please note that this Content may change.

These boiler training modules, incorporating sections of the HRA/ORR boiler code of practice, were prepared in 2013 as part of the HLF funded BESTT training plan project and will be progressively reviewed and updated by the BESTT Technical Committee.

Bestt

Boiler & Engineering Skills Training Trust



Superheaters

Proposed Syllabus 2013

To be used in conjunction with:

HRA Guidance Note HGR-B9003- Is01

BESTT acknowledges the support of the HRA for allowing the use of the Guidance Notes

DISCLAIMER. ISSUE 2018

The Boiler and Engineering Skills Training Trust (BESTT) has used its best endeavours to ensure that the content shown herein 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 BESTT will not be liable for its content or any subsequent use to which this document may be put.

Proposed BESTT Syllabus Assessment Plan

Module: BESTT 9003

Superheaters

This module is to be used in conjunction with HRA Guidance sheet BS9013-Is01

Aim

This unit will give the learners an understanding of the function of Superheaters

Introduction

This unit will give practical knowledge of:

- Maintenance Plan
- Materials
- Headers
- Elements
- Return Bends
- Repairs
- Testing

Learning Outcomes

The numbers in parenthesis refer to the HRA Guidance note section.
Learning outcome 1 could be delivered in a classroom environment.

L01

1. Superheating equipment (5)
2. Maintenance of superheaters (6)
3. Superheater operating temperature (8)
4. Hydraulic testing of superheater (9)
5. Practical Hydraulic testing (9)
6. Securing of superheater elements (10)
7. Element Tubes (11)
8. Element abrasion (12)

L02

1. Keeping elements central in flue (14)
2. Element to header joint (15)
3. Removal of elements (18)
4. Repairing of elements (19)
5. Header repairs (20)
6. Robinson type superheaters (21)
7. Testing of systems (22)
8. Practical test (22)

Proposed BESTT Syllabus Assessment Plan

Assessment

Learners could demonstrate competence in this unit by:

- Documental evidence
- Photographic evidence
- Witness statements e.g. written or verbal statement from a competent person stating that they have completed tasks satisfactorily.
- Underpinning knowledge questions e.g. written questions, multi choice answer sheets, on-line tests, and assignments.
- Practical training tasks

BESTT acknowledges the support of the Heritage Railway Association in allowing us to use their Guidance Notes in this Syllabus.

HERITAGE RAILWAY ASSOCIATION

GUIDANCE NOTE

SUPERHEATERS

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.

Endorsement

This document has been developed with and is fully endorsed by Her Majesty's Railway Inspectorate, a directorate of the Office of Rail Regulation (ORR).

Disclaimer

The Heritage Railway Association 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 the Heritage Railway Association will not 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.heritagerailways.com

Users of this Guidance Note should check the HRA website to ensure that they have the latest version.

Table of Contents

SECTION	Page Number
1. Introduction	3
2. Units.....	3
3. Personal Protective Equipment	3
4. Inspection	3
5. General	3
6. Competency.....	4
7. Maintenance plan	4
8. Materials	5
9. Headers	5
10. Elements.....	7
11. Element tube.....	7
12. Return Bends, header blocks and bifurcation Castings.	7
13. Built up return bends.....	8
14. Bands and feet.....	9
15. Element to header seals	9
16. Welding of elements	9
17. Brazing of elements to header block, GWR pattern	9
18. Element removal.....	9
19. Element repairs.....	9
20. Header repairs	10
21. Robinson type	11
22. Testing elements in service	11
23. References.....	11

1. Introduction

This Guidance Note is one of a series dealing with Locomotive Boilers that were produced by the "Steam Locomotive Boiler Codes of Practice" practitioners meetings.

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.

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 H.M.R.I. and H.R.A. 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.

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.

This guidance will also be useful to those in a supervisory or more general role, however no work should be undertaken unless the people concerned are deemed competent to do so.

Where managements 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 and a formal minute is recorded of both the reasons for and the decision reached.

2. Units

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.

The term "p.s.i." is used to indicate pressures in pounds per square inch.

3. Personal Protective Equipment

Before undertaking any works a risk assessment must be conducted.

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.

The equipment must be

- In accordance with the latest Personal Protective Equipment regulations.
- Properly assessed before use to ensure it is suitable.
- Maintained and stored properly
- Provided with instructions on how to use it safely
- Used correctly by those undertaking the work.

4. Inspection

In the event of finding any superheater element to be defective or suspect seek guidance from the boiler Competent Person before proceeding with any repair.

5. General

Most modern locomotive boilers with the exception of small and industrial locomotive boilers are fitted with superheaters for the purpose of raising the temperature of the boiler steam above saturation temperature. Almost without exception the superheaters fitted are of the smoke tube type. Diagram 1 shows the header for distributing the steam to the superheater elements. Diagram 2 shows the arrangement of the superheater elements within the flue tubes.

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
5	LO1 1	Superheating equipment as used in large rail locomotives and in Sentinel road locomotives	Why and how is superheated steam used?	Classroom	
6	LO1 2	Maintenance of superheaters	Heritage railway use is different from when they were used on mainline, why? How could this form of water entrapment be avoided during long periods of non usage?		

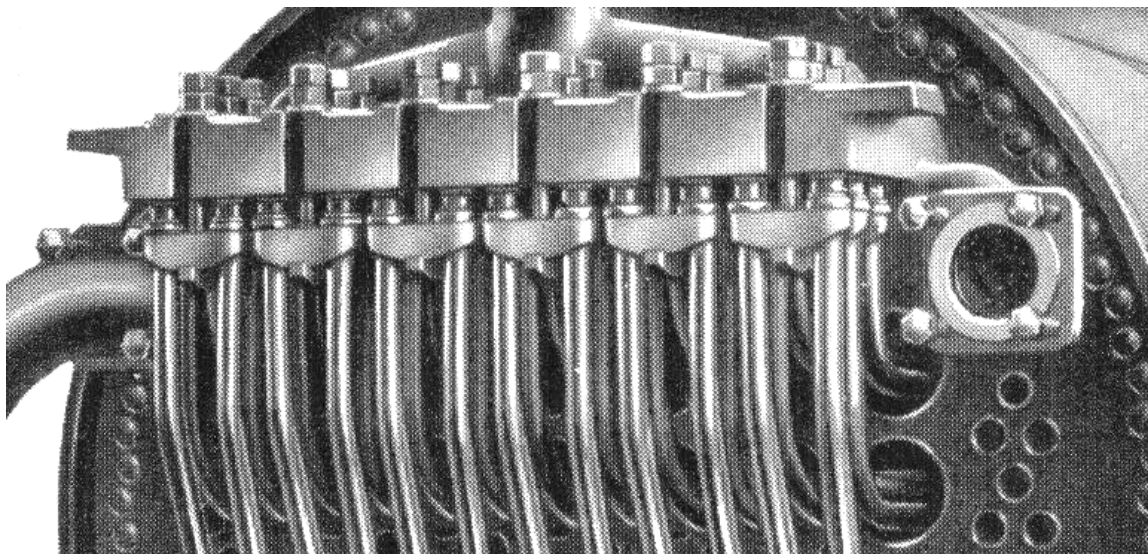


Diagram 1. Superheater header, MeLeSco type.

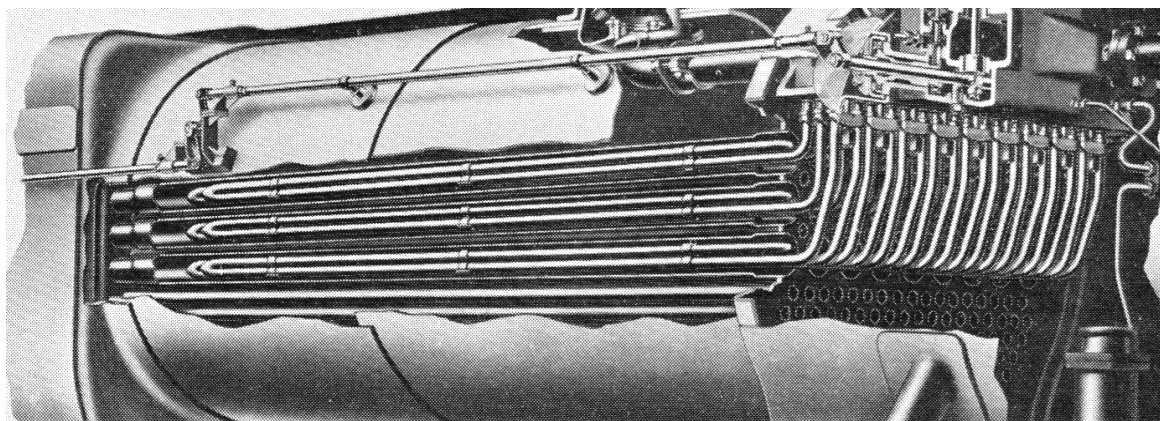


Diagram 2. Arrangement of typical superheater elements and header.

6. Competency

The inspection, fitting and repair of superheaters are safety critical tasks. Only those trained, deemed competent and authorised should be responsible for the fitting and inspection of superheaters. Records should be kept of the action taken at each inspection, or repair, and by whom.

7. Maintenance plan

The boiler maintenance documentation should reference the identification, origin, materials, test certification and age of any superheaters fitted to a boiler.

8. Materials

Headers:-

Material for superheater headers varied with design, some were of cast iron and some cast steel. It is important that the correct grade of material is adopted for the particular design.

Cast Steel – BR spec 118 A. BS3100 A1

Cast Iron – LMS cylinder quality 14 tons min. BS EN 1561 grade 250

Elements:-

BS EN 10216-1:2002 (Seamless steel tubes for pressure purposes)

BS EN 10217-1:2002 (welded steel tubes for pressure purposes)

Return bends:-

Cast Steel – BS3100 A1

Clamp bolts or studs:-

High tensile steel – EN 16 condition T. BS 970, 605M36 condition T.

Nuts – EN8. BS 970, 080M40 condition P.

Clamp:-

Forged steel – BS 970 070M20

Cast Steel – BS3100 A1

Header block:-

Steel- BS 970 070M20

9. Headers

Superheater headers are of two basic types with sub categories, the two basic types are those which incorporate the regulator within the main casting and those that are separate to the regulator.

Superheater headers which incorporate the regulator are bolted directly to the boiler and they form part of the pressure vessel, as such they should be inspected as part of the pressure vessel and subject to a hydraulic and steam test in conjunction with the boiler.

Superheater headers which do not incorporate the regulator are either:- separate from the boiler and joined via one or two pipes, or bolted to the boiler. In both cases where the superheater header does not incorporate the regulator and does not form part of the pressure vessel it need not be tested in conjunction with the boiler but should be tested separately being part of a pressure system.

Headers should be manufactured in accordance with original drawings and specifications. Changes of design or material need to be subject to formal approval by the Competent Person. When new all superheater headers should be hydraulically tested to 360psi for 30 minutes. A separate hydraulic test should be independently undertaken to both the saturated and superheated compartments. A new header should be subjected to NDT such as radiography to confirm that it is free from surface breaking and volumetric defects.

Elements can be attached to the header by a variety of methods:-

- Clamped by means of a through bolt and clamp (MeLeSco pattern). Diagram 3.
- Clamped by means of a stud and clamp (Midland Rly and GWR new pattern). Diagram 4 and 5.
- Directly bolted by means of a stud (GWR old pattern). Diagram 6.
- Expanded (Robinson type).

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
8	LO1 3	Superheater operating temperature	Superheaters often operate at elevated temperatures. Dull red heat, and at high pressure. What special precautions need to be taken to ensure safe operation	Classroom	
9	LO1 4	Hydraulic testing of superheaters, new or repaired	What pressure would you test a superheater header at? Describe how that test would be carried out and why?	Classroom	
9	LO1 5	Hydraulic testing	Witness and help prepare a superheater header for testing	Workshop	

Diagram 3. MeLeSco through bolt fixing.

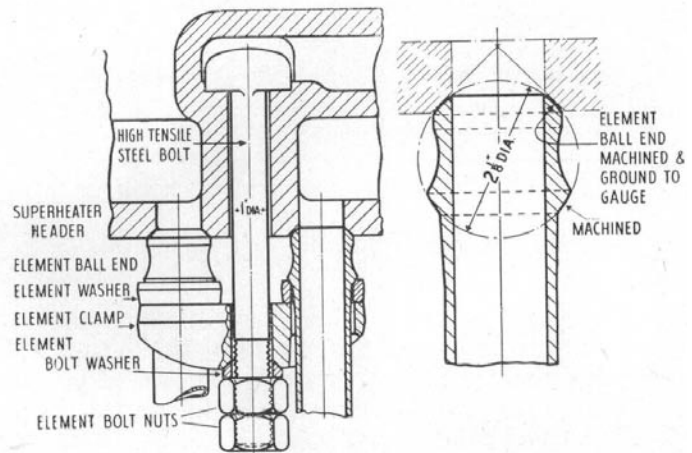


Diagram 4 Midland railway flat ended elements with stud and clamp.

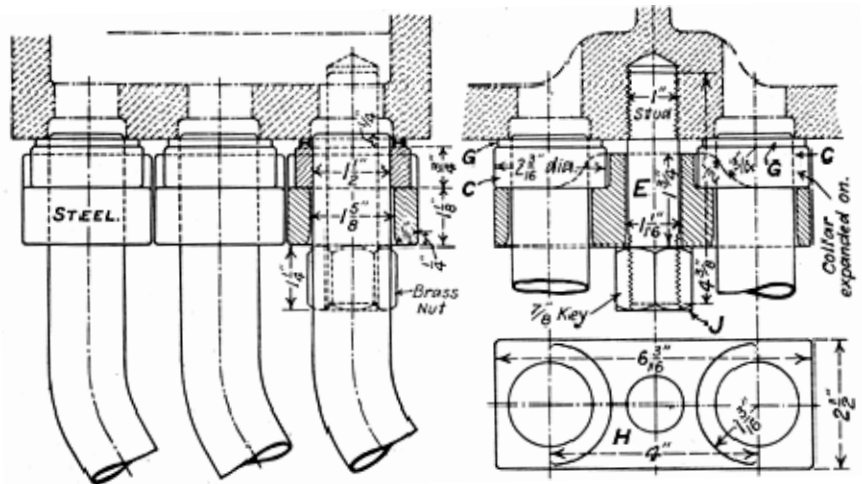
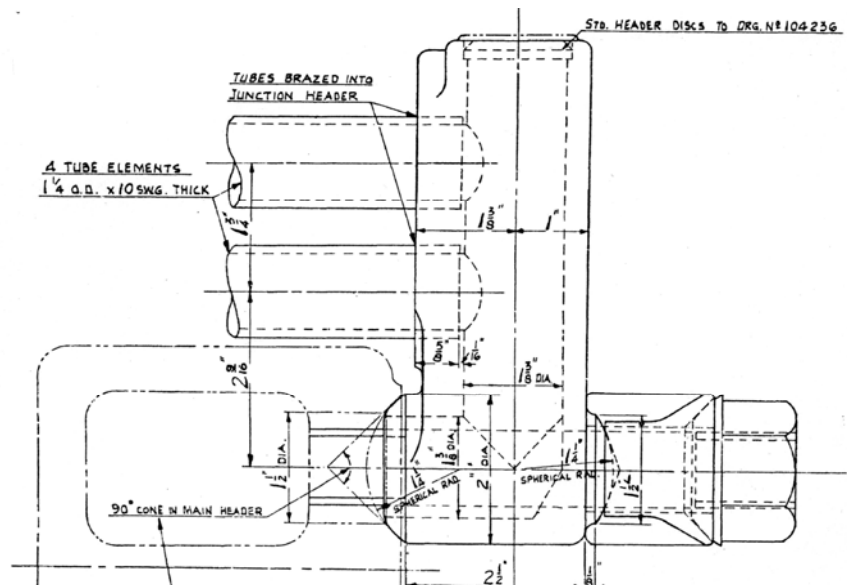


Diagram 5 GWR new pattern spherical ended element block with stud and clamp.



Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
10	LO1 6	Principle ways of fastening superheater elements	What are the 4 principle ways of fastening elements into headers. Produce an annotated diagram of one method of holding the elements into the header.	Classroom	
11	LO1 7	Element tube	What diameter and grade of tube would you use for superheater elements?	Classroom	

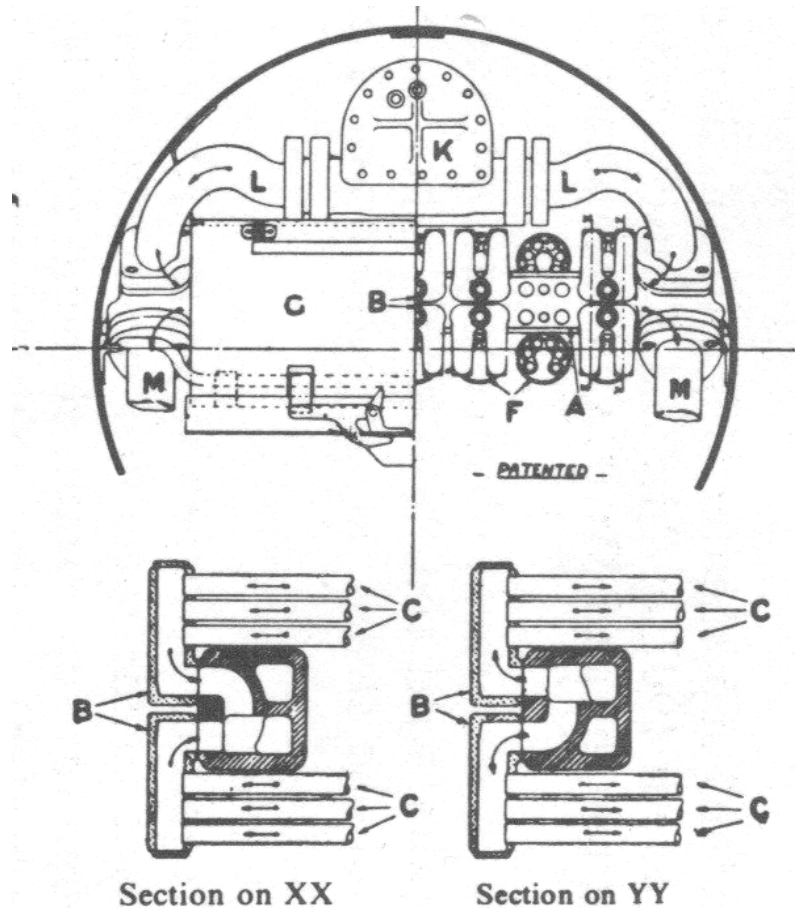


Diagram 6 GWR old pattern flat ended element block.

10. Elements

Elements can be of varying patterns but all will have an out (or saturated) tube from the header and a return (or superheated) tube going back to the header. One or more return bends are incorporated to increase the length of tube in each element. In some patterns the tubes are bifurcated to produce two tubes with parallel flows.

Except where expanded directly into the header the element tubes are welded or brazed to a fitting which is clamped to the header. Return bends and bifurcation castings are welded to the tube.

After manufacture or repair elements should be subjected to light hammer blows to remove scale and debris before being filled with water and tested under hydraulic pressure to 1,000 psi.

11. Element tube

Material for element tube should be to one of the specifications above. OD and ID of tube vary with design but most are 1.25" od, other sizes being 1.5" or 1". In all cases the gauge of the tube is 9 or 10 swg except for GWR old pattern 6 tube elements which were 1" od by 14 swg.

Element tubes must be supplied with material certificates to ensure traceability.

12. Return Bends, header blocks and bifurcation Castings.

Return bends, header blocks and bifurcation castings should be of cast or forged steel free from defects. The castings must be supplied with material certificates and preferably X-ray results to indicate that the casting is not porous which would fail later on hydraulic test.

13. Built up return bends

Return bends can be manufactured by:-

- Tightly bending the tube back on itself, it is important that the metal is thickened by the process and not thinned, especially on the outside of the bend.
- Welding together the curved ends of two tubes to form a spear end, Diagram 7.
- Welding a cast return bend onto the end of two tubes.
- Manipulating and forging together the ends of two tubes to form a forged return bend, a process used by MeLeSco, Diagrams 8 and 9.

If necessary the end face of the bend may be further protected by the addition of metal plates or layered up weld material.

Diagram 7. Spear end formed by welding shaped tube together and building up with weld material

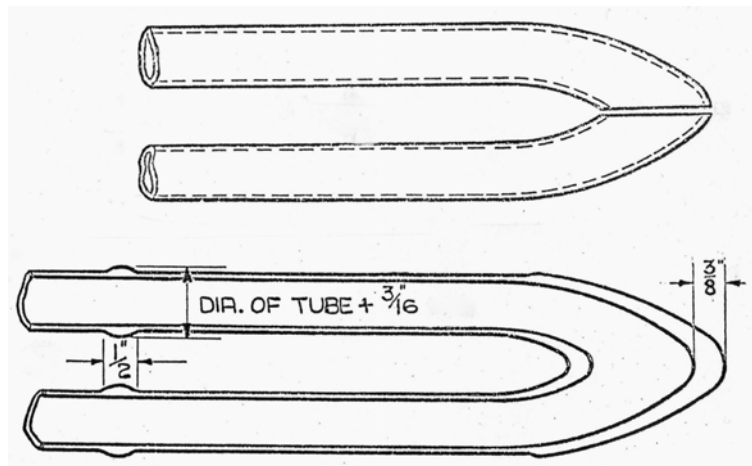


Diagram 8. Progressive stages in the manufacture of MeLeSco solid machine forged return bends.

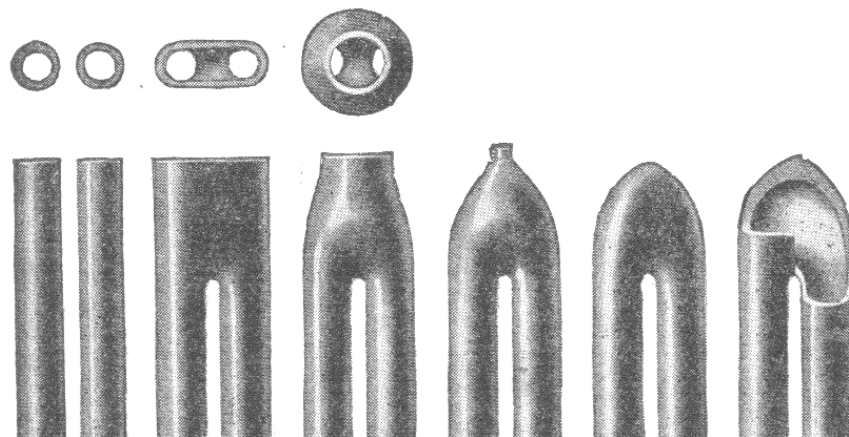
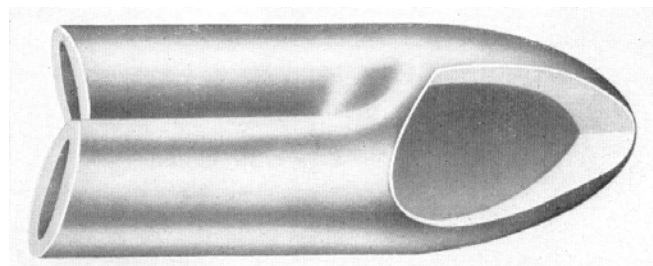


Diagram 9. A MeLeSco forged return bend indicating thickening of material on the bend.



Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
12	LO1 8	Elements suffer from abrasion and pin holing	Create a new dummy superheater end from plain pipe and layered weld. Hydraulic test it and then section the final product and photograph it for your portfolio. What test pressure will you use? Hammer during testing to shock load it	Workshop	

14. Bands and feet

Strip steel bands are shaped and used to space the element tubes apart at intervals down the length of the element, this spacing is typically every 4 feet. The band nearest the return bend end of the element will have two small feet to support the free end of the element and centralise it within the flue tube.

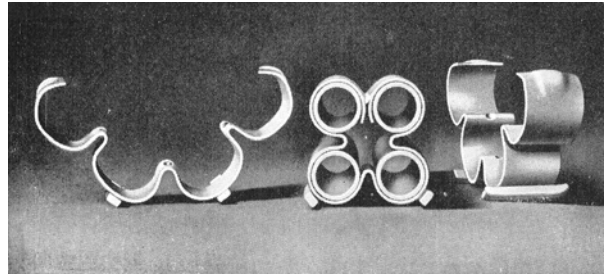


Diagram 10. Element bands and feet.

15. Element to header seals

To seal the individual elements to the header face to face joints are commonly used, occasionally on old headers an asbestos impregnated copper ring will be found that should be disposed of in compliance with appropriate Regulations. In every case a graphite grease sealing compound should be applied to the surfaces before assembly and an anti-seize compound to the bolt or stud threads.

16. Welding of elements

All welding of element tubes and fittings should be undertaken by a coded welder; welding and welder qualifications should conform to BS EN 287/1, 2011 and BS EN 288/1, 2004. Welds should be tested for cracking using processes to establish surface breaking and volumetric defects.

17. Brazing of elements to header block, GWR pattern

If brazing is adopted to join tubes to the sockets in the header block this should be carried out by a competent person to BS EN 14324:2004. Braze material should be to BS EN ISO 17672, 2010. Upon completion the braze must appear to have flowed freely and formed a fillet around all element tubes. It is important that all four element tubes are to the same length and engage fully into the header block before assembly. All tubes should be raised in temperature uniformly during brazing to avoid any differential expansion which will alter the engagement of other tubes. New assemblies which have not previously been brazed may be welded, welding and welder qualifications should conform to BS EN 287/1, 2011 and BS EN 288/1, 2004. Welds should be tested for cracking using processes to establish surface breaking and volumetric defects.

18. Element removal

Elements are removed by undoing the clamp nut, in practice this is often rusted to the stud in which case the nut can be heated to expand it and break the joint. Care should be taken when heating as any significant rise in temperature will affect the heat treated condition of the alloy steel stud. If damaged the stud and nut should be replaced. Old elements can be difficult to remove from flue tubes as they often distort and jamb, it may be necessary to attach a "pull lift" to the element to extract it from the flue.

19. Element repairs

Over time elements will be eroded by the effects of ash passing over with the products of combustion and corrosion to both the external and internal surfaces.

Repair by oxy acetylene welding, MIG or TIG is possible but may not be economic in the long term. All welding repairs should be carried out by a coded welder. Care must be taken to ensure complete fusion without leaving rough metal fouling the interior of the tubes. All welds must be slightly reinforced by means of additional filler rod material built up around the periphery of any holes.

Ball ended elements can have the spherical surface of the joint cleaned up by means of a cup shaped grinding wheel held in a portable air or electric drill. The cup must be to the correct profile and dressed when worn.

Header blocks will corrode and thin over time; minimum material thickness for GWR steel header blocks is typically 5/16" when new. Thinning below 1/4" should be brought to the attention of the Competent Person and tested ultrasonically to confirm the actual thickness.

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
14	LO2 1	Keeping elements central in flues	Draw the clamp that is used to space superheater elements. How frequently is it necessary to support the element?	Classroom	
15	LO2 2	Element to header joint	Describe how you would make the joint between element and header	Classroom	
18	LO2 3	Removal of elements, problems due to distortion	Remove 10 elements under the supervision of your mentor	Workshop	
19	LO2 4	Repairing of elements	It is probably uneconomic to repair the outside of an element, why? Describe how a coded welder will tackle a pin hole in an element.	Classroom	

20. Header repairs

Both cast iron and steel headers will corrode and loose thickness over time, in addition cracking of cast iron may occur. The assembly should be inspected annually by the competent person and stripped at intervals defined in the written scheme of examination for the competent person to inspect. At each interval the condition of the header should be confirmed and it's suitability to continue in service established, in addition the Competent Person should have the opportunity to thoroughly inspect the header on the bench after it has been cleaned and hydraulic tested to 150% of boiler safe operating limit. Defects such as cracking will indicate that the header has reached the end of its service life and a replacement should be manufactured. Cast iron welding or stitching is not recommended.

Damaged element seats can be either refaced by machine whilst the header is removed from the locomotive, the preferred option, or by means of a specially shaped grinding wheel held in a portable air or electric drill.

If using the grinding method it is important that the grinding wheel is regularly dressed to a true profile and when in use it is held perpendicular to the face of the header, progress can be monitored by the use of an appropriate diameter ball and high spot blue. See diagram 11.

On flat faced headers a seat cutting tool may be adopted which is clamped to the header via the stud and is located by a pin into the adjacent hole. See diagram 12.

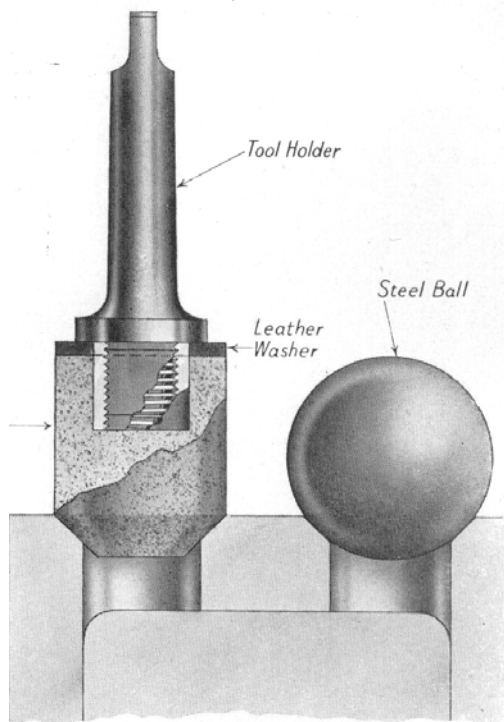


Diagram 11. Grindstone for cleaning up the coned seat of a header joint.

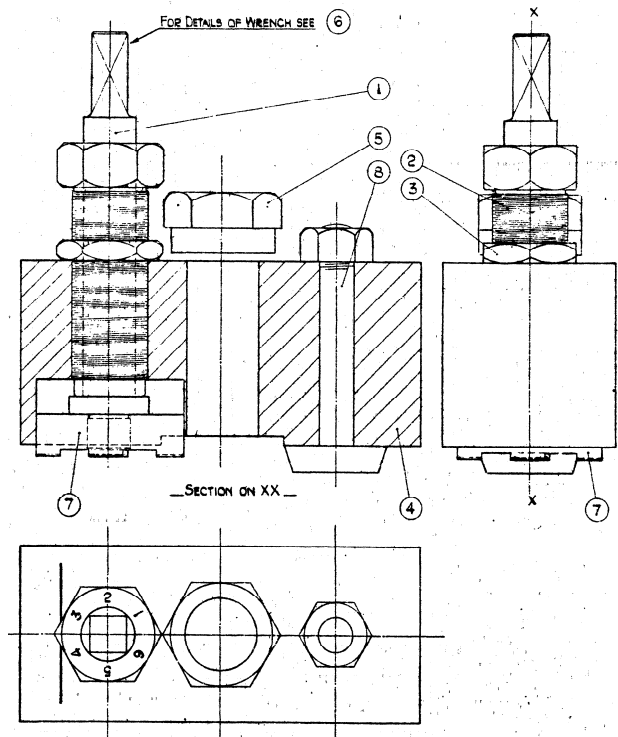


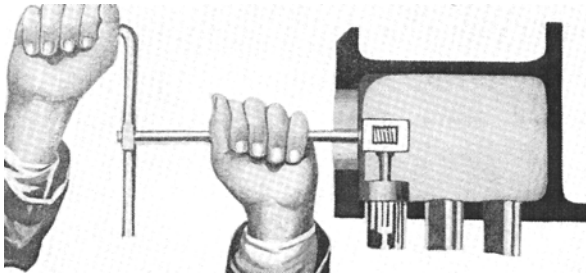
Diagram 12. GWR tool for facing up the element joint face, flat joint type, using cutter item 7

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
20	LO2 5	Header repairs	If the element seats on the header are damaged, they need to be repaired as a face to face seal is required. How would you ensure this? Draw what you could use.	Workshop	

21. Robinson type

The Robinson type superheater is similar to all others with the exception of the means of fixing the elements



into the header. In Robinson type superheaters the tubes are expanded into the header using special worm drive expanders, once expanded the element and header are as one piece similar to smoke tubes in a boiler see Diagram 13. The special expander must be of the parallel pattern to avoid the tube coming loose in the header and blowing out. The access hole for the expander is covered by a bolted plate when not required. Ends of tubes and tube holes in the header should be clean and free from oil before expanding.

Diagram 13. Expanding Robinson superheater tubes into the header with special expander

To remove Robinson type superheater tubes it is normal to firstly cut off the element below the header and slit the tube, using drifts the remains of the tube are forced out of the header.

22. Testing elements in service

Superheaters and headers should be subjected to regular inspection and testing in service. Inspection should be via both the smoke box and fire box during washout, signs of leaking elements or joints are indicated by the presence of water or staining from boiler salts. When in steam the following process should be adopted to test for leaks, one person must stay in the cab at all times for safety:

- Secure the locomotive by applying the power brake and place scotches under the wheels.
- Ensure reverser is in mid gear with drain cocks shut.
- Close fire hole doors and dampers, shut off blower and open smoke box door.
- Open regulator to pressurise steam chest and superheater assemblies.
- Apply a lighted taper on the end of a long wire to each of the joints between element and header.
- Apply the taper to the end of each of the flue tubes.

The presence of a blowing joint or element will be indicated by the deflection of the flame from the taper. Depending upon the location and severity of the blow the taper may be either blown out or flattened by the jet of steam, alternatively if it is sucked down a flue then it is an indication that the blow is towards the fire box end of the element.

During this process it is easiest if the fire in the fire box is out or almost out otherwise the absence of oxygen close to the tube ends makes the taper difficult to keep lit.

23. References

- Red Book section B13 superheater elements.
- Red Book section J6 and J7 manufacture of new superheater elements by welding.
- GWR drawing 108602A, lengths of standard superheater elements.
- GWR drawing 118297, superheater with combined regulator.
- GWR drawing 125892, standard junction header spherical type.
- GWR drawing 134481, 4 tube superheater.
- The superheater company booklet "Installation, maintenance and operation of MeLeSco locomotive superheaters"

end of main document

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
21	LO2 6	Robinson type superheaters	Draw a Robinson system of superheater element attachments showing how the elements are fastened into the superheater header	Classroom	
22	LO2 7	Regular testing of superheater elements and steam pipe systems	Explain how you can safely test for leaks in superheater elements with the boiler in steam. What precautions do you need to take?		
22	LO2 8	Testing	Carry out the tests on a boiler in steam under the supervision of your mentor. How are you going to look for visible and audible signs of leaking?		

BESTT

Superheaters - Module 9003 Is01

Assessment Record for: Training Centre: Year: August 14 – July 15

L01	1	2	3	4	5	6	7	8	9
<i>Supervisor Initials and date when completed</i>									
L02	1	2	3	4	5	6	7	8	9
<i>Supervisor Initials and date when completed</i>									
L03	1	2	3	4	5	6	7	8	9
<i>Supervisor Initials and date when completed</i>									

Witness Statement

The trainee has completed the Learning outcomes to a satisfactory standard

Signed: Internal Supervisor **Print Name:** Internal Supervisor **Date:** December 14

Verified by BESST Assessor **Name:** TBC **Assessor Number:** 12345 **Date:** December 14