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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.

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Boiler & Engineering Skills Training Trust

Boiler Mountings, Pipework and fittings

Proposed Syllabus 2013

To be used in conjunction with:

HRA Guidance Note HGR-B9007- Is01

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

Proposed BESTT Syllabus Assessment Plan

Module: BESTT 9007

Boiler Mountings, pipework and fittings
This module is to used in conjunction with HRA Guidance sheet BS9007 – Is01

Aim

This unit will give the learners an understanding of the function of boiler mountings, pipework and fittings.

Introduction

This unit will give practical knowledge of:

- Maintenance plan
- Materials
- Mounting studs
- Pipe joints
- Pressure gauges
- Gauge glasses
- Blow down valves
- Regulators
- Inspection for frost damage
- Forming copper pipe
- LNER/Air Ministry flanges

Learning Outcomes

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

LO1

1. Safety Critical Components, Knowledge of fittings on a typical boiler (3)
2. Use of Brass for boiler fittings (9)
3. Copper pipework (10)
4. Thread cracking (10)
5. Jointing of flange faces (11)
6. Engineers studs (12)
7. Engineers studs (12)

LO2

1. Boiler pressure gauges (13ii)
2. Injectors (13iii)
3. Water level gauge (13iv)
4. Water level gauge glasses (13iv)
5. Cocks (13iv)
6. Gauge protectors (13iv)
7. Blow down valves (13v)
8. Regulators (13vi)
9. Inspection for frost damage (13v)

LO3

1. Forming Copper pipe (Appendix B)
2. Forming Copper pipe (Appendix B)
3. LNER/Air Ministry flanges (Appendix C)

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.

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Issue No: 01
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HERITAGE RAILWAY ASSOCIATION

GUIDANCE NOTE

BOILER MOUNTINGS, PIPEWORK & FITTINGS

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

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Supply

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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

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.

‘Asbestos’ may still be encountered when stripping locomotives. If found it must be disposed of properly, complying with the appropriate Regulations.

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. General

All locomotive boilers are equipped with various fittings and associated pipework. This section covers all these items except Safety Valves and Carriage Warming Apparatus (see separate Guidance Notes).

Most locomotive boilers are equipped with the following items:

- 2 sets water level gauge glasses (or 1 set + ‘try cocks’)
- blowdown valve(s)
- regulator valve + gland assembly
- manifold or turret
- boiler pressure gauge + shut off cock

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
3	LO1 1	Safety critical components	Items directly mounted on the boiler are classed as safety critical components. Why? List components mounted directly on a typical boiler	Classroom	

- clack valves
- injectors
- shut off valves for other items
- Carriage warming equipment.

Items mounted directly to the boiler are considered safety critical as shutting off the steam in case of a problem will not be possible. Any steam pressurised pipework or fitting is a potential source of danger as immediate shutting off may be difficult or impossible. For this reason pipework and fittings should be maintained to the same high standards as other boiler components. It should be noted also that leakage from poorly maintained fittings can cause considerable external wastage to the boiler shell, rivets etc, and potentially shortening overall boiler life.

5. Competency

The inspection and fitting of boiler fittings and steam pressurised pipework are safety critical tasks. Only those trained, competent and authorised should be responsible for inspection and fitting of these items. The pressure systems safety regulations (PSSR) require that the written scheme of examination must cover all protective devices. It must also include every pressure vessel and those parts of pipelines and pipework which, if they fail, may give rise to danger. The PSSR also places requirements on the Designers, Manufacturers and Suppliers of components of pressure systems –refer to regulation 4 of the PSSR here- http://www.legislation.gov.uk/uksi/2000/128/regulation/4/made

6. Maintenance Plan

The boiler maintenance plan and written scheme of examination should reference the identification and location of all critical fittings. See Appendix A for a suggested Maintenance Record sheet.

7. Materials for Pipework

New copper pipework: Copper BS 2871, C106 or C107.

Non ferrous Flanges: BS1400 SC B6 or LG4

Steel Pipework to BS3602 HFS320, BS1387

Steel Flanges: BS970 EN3A or 070M20 or BS1501

8. Materials for Mounting Studs/Fixings

BS 970 EN 3B or 070M20

BS 970 EN8 or 080M40

BS 970 EN16 or 605M36

Monel (can be used in potentially high corrosion situations)

9. Materials for Fittings

The correct material choice is essential; malleable iron fittings are not suitable for steam being prone to sudden brittle fracture. Brass can be subject to dezincification and resultant loss of strength.

Extruded brass may be used particularly for small steam fittings where the part is away from the boiler water in a non de-zincification environment, indeed this was common practice on GWR locos.

Some typical materials are listed below:

Union nuts, nipples, injector cones etc:

High tensile brass (also called Manganese bronze)- BS2874 -CZ114 now CW721R

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
9	LO1 2	Use of Brass on boiler fittings	Why is brass a problem for some fittings? What would you use instead?	Classroom	

Bodies, general:

Leaded gunmetal- BS1400 , BS EN 1982:1999 grades LG4 or LG2

ASTM B 505 , ASTM B 271- SAE660

Naval Brass to BS2874 CZ112

Cast iron may be considered if this is in a 'like for like' situation, however consideration should be given to using a more ductile material-the competent person should be consulted in this situation

Water level glass: BS3463-'Specification for observation and gauge glasses for pressure vessels'- fused ends rather than cut ends.

10. Pipework

External and internal pipework should be removed for examination at least every 10 years or less as the competent person may require-this should be set out in the written scheme of examination.

Copper pipework should be taken down and annealed by heating (to approx 500C˚-dull red and may be quenched) and examined for cracks which can occur anywhere over its length, but are more likely near flanges or union fittings. NB: Care should be taken to support long copper pipe lengths during the annealing process as 'sagging' can occur.

Examination should be carried out for thinning, in and around pipe clips and anywhere else that may have been chafing and also for more general wastage through corrosion. Larger (greater than 2" diameter) pipes should be checked with a thickness meter or hammer test and all pipes may also be tested hydraulically at twice the recommended working pressure. Main steam pipes both steel or copper and associated fittings are especially examined for internal and external corrosion which is known to be a problem on some locos. All smokebox pipework is very prone to corrosion and should therefore be regularly examined. It is recommended that all steel and copper small bore pipes in the smokebox should be renewed at major overhauls.

Pipe flanges and unions should be examined for cracks and/or distortion. The back of union nuts especially should be examined for flaws. Both the male and female threads on unions need to be examined for soundness. Any replacement copper pipe should match the original design specification in diameter and wall thickness (domestic thin walled pipe must not be used).

Typical Wall thickness of copper pipework in loco use-

Up to 5/8" Outside Diameter - 0.080" to 0.090" wall (13-14 swg)

5/8"-1" Outside Diameter- 0.104" wall (12 swg)

1"-2" Outside Diameter- 0.125" wall (10 swg)

A typical procedure for forming copper pipes is given in Appendix B.

11. Boiler Mountings/Fittings

It is good practice to stamp fittings with an identification number and with suitable paperwork in place it will ensure that the fitting is examined at appropriate intervals and a record kept of repairs. Stamps used should be of 'low stress' or 'soft' type to reduce danger of cracking the fitting. The identification number is helpful, particularly if spare fittings are used or fittings swapped from loco to loco, in order to keep track of things. The paperwork is also used for fitters to sign off the fitting for further use and/or that the fitting is refitted to the boiler and is safe to use.

All fittings should be removed for thorough inspection/overhaul at periods agreed with the 'competent person'. It is recommended that a 'rolling programme' of examination is developed with work recorded in a table (see Appendix A) so that no areas are missed.

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
10	LO1 3	Copper pipework	Copper pipework needs to be annealed every 10 years, What is annealing and what does it achieve?	Classroom	
10	LO1 4	Fittings	Threads on fittings are prone to cracking where and why?	Classroom	

After stripping, items should be cleaned by soaking in citric acid, formic acid or hydrochloric acid to clean externally and internally, precautions must be taken with acid using appropriate PPE. For concentration of acid and duration of soak the supplier's instructions should be followed, it is advisable to practice on a suitable test piece. Exterior surfaces may be fine bead blasted which will help to reveal any cracking. (However if blasting is used, care must be taken to ensure that no small passages can be blocked by the media).

Particular attention should be given to areas prone to cracking, notably on items that are threaded at the base of the thread (undercut). Any suspect items should be subjected to further NDT. Hydraulic testing is also recommended. This should be at the appropriate pressure for the boiler, or if new pipework and off the boiler then up to twice working pressure.

Where possible on boiler reassembly, fittings should be hydraulically tested, mounted on the boiler, at the appropriate pressure for the main vessel. Where practicable all joints to boiler fittings should be made metal to metal where this practice was an original design feature otherwise joints should be made using a high grade jointing material of minimum thickness to make a seal. The joint material manufacturer should be consulted on applications and fitting techniques. Some jointing materials should be assembled dry, other types are graphited.

Where lubricating sealant is required a graphite grease should be used; no hard setting sealant or jointing compound is to be used as it is difficult to remove. Suitable graphite grease compounds are petroleum jelly based; compounds with linseed oil are hard setting and not suitable

Asbestos is no longer permitted and any remaining stocks of asbestos should be disposed off as hazardous waste.

12. Mounting Studs/Fixings

Studs and nuts or other methods of locating fittings on the boiler are of critical importance. They should be carefully examined as per fittings above and renewed as required. Threads within the boiler should be inspected and if damaged may require re-tapping to the next largest size. Specially manufactured stepped diameter replacement studs may be needed to avoid opening holes in fitting flanges. Engineers studs only (i.e. with plain, unthreaded portion) should be used, not studding or bolts.

Any component that is threaded live into the boiler should be subjected to particular examination, as any failure here means the boiler is open to atmosphere. Threads here should be to BS588 'close' fit standard. Checking of these threads should be carried out with a thread gauge against a white background and any non-conformance should be regarded as a failure. Internal threads can be checked with a tap which should neither remove metal nor ought it rock in the threads.

It is good practice to renew all studs at major overhaul.

13. Specific Components

i. Pipe joints

Pipe joints – see Appendix C for LNER 'Air Ministry' square feed pipe joint.

ii. Boiler Pressure Gauges

Calibration should be checked annually against a certified master gauge or deadweight tester. The gauge must be marked with a red line at maximum working pressure. Gauges should be checked for accuracy within +/- 5% and have a certificate to this effect, +/- 1% at red line. The record of the Calibration should be maintained with the other boiler records, and visibly stickered. The competent person should be consulted on acceptable gauge calibration methods.

Gauges must be connected to the steam space of the boiler (not to auxiliary manifolds etc, that may be isolated otherwise from the boiler, unless this is an original feature), provided with a cock which shall be readily discernible and accessible to the crew and which shall have a lever handle which lies parallel to the direction of flow from the cock when open.

The connecting pipe between gauge and cock shall be set to form a condensing coil.

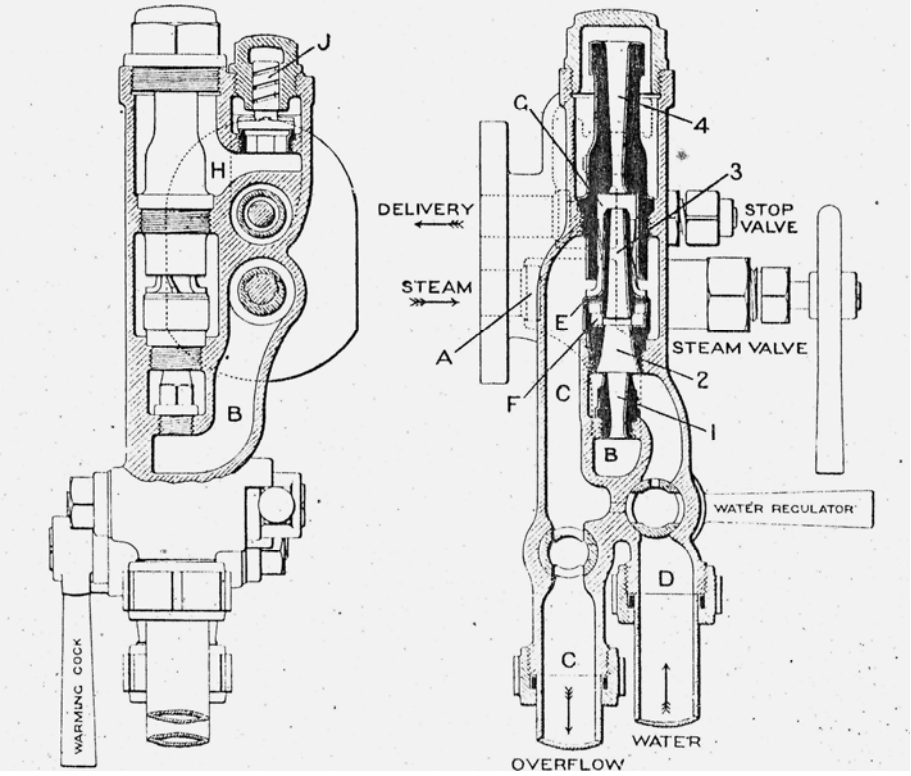
Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
11	LO15	Jointing of flange facings	How are joints made between fittings and a boiler?	Classroom	
12	LO16	Engineers studs	How do you check existing studs are satisfactory? How do you remove a stud? How do you replace a stud?	Classroom	
12	LO17	Engineers Studs	Remove and replace studs in a boiler under the supervision of your mentor	Workshop	
13 (ii)	LO21	Boiler pressure gauges	What are the rules on calibration and recalibration? There must be a coil between the boiler and pressure gauge. Why?	Classroom	

iii. Backhead mounted Combination injectors

It is not intended that this document should cover all injector types and procedures for repair, as this is covered widely in many other publications, however because of their particularly safety critical nature a section on this type of injector is appropriate. These injectors are mounted directly to the boiler backhead and have no separate means of shutting off live steam at boiler pressure- a component failure here could directly endanger the loco crew.

A typical Gresham and Craven type backhead combination injector is shown below-



The cones of this injector are as follows-

1 Steam Cone. 2 Lifting Cone. 3 Combining Cone. 4 Delivery Cone.

Basic operation is as follows-Live steam from the boiler travels form the loco dome or other take off point via the internal steam pipe to Steam valve (A) which when opened passes steam via (B) through the steam cone (1) which forces open combining cone (3) and passes out to overflow passage (C)and out of the overflow pipe. In doing so a vacuum is created in water pipe (D) and the water rises to the injector. The water coming into contact with the steam travels with it through the lifting cone (2) and condenses it. The velocity of the steam being now largely transferred to the water, the latter passes from the lifting cone (2) and through the combining cone (3) (which move down onto its face at (E) owing to the vacuum created in the chamber (F) by the passage of the jet)and these two cones (2) and (3) become effectively one combing cone. After passing through this combining cone the jet flows out at the overflow space (G) and down the passage and overflow pipe (C) until such time as it attains sufficient velocity to carry itself past this space and enter the delivery cone (4) .when it reaches this point its velocity is so great that it is sufficiently powerful to pass by the passage (H) and lift the clack (or back pressure) valve (J) and so enter the boiler.

This type of injector was often found on older loco designs and many industrial locos and often suffered abuse from loco crews hitting the body of the injector to encourage them to start. Therefore body distortion and cracking may be found. Threads on cap nuts and of the valves should be particularly checked for damage. Leakage past the steam and clack valve seats can cause overheating of the injector and consequent failure to start particularly when lifting. Any air leaks on the water suction piping from tank or tender or at the water valve will quickly cause the injector to fail. Internal piping within the boiler should be

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
13 (iii)	LO2 2	Injectors	Describe the operation of an injector. What are its weaknesses? Draw an annotated diagram of a simple injector. Where are most injector faults found?	Classroom	

examined in accordance with the piping section of this document- particular attention should be given to the delivery pipe becoming restricted by scale build up.

iv. Boiler Water Level Gauge Glasses

Maintenance of these items is of particular importance as loss of water level over the firebox crown when in service could result in severe damage to the boiler and danger to persons.

Defective gauge glasses could present the operating crew with a false water level. This would be most likely caused by a partial blockage of passages from the boiler, within the cock or glass.

Renewing Glasses (apart from the Klinger Reflex type)

The glass should be to BS3463: 1975 In particular section 5;Material- the glass must be for steaming conditions. This means a Borosilicate glass and able to withstand shock due to low thermal expansion. Section 7 ;Dimensions of the glass – must be of selected grade .Table 1 provides details of the sizes available to ensure that the glasses fit GWR and BR Standard Gauge frames made to selected grade is required. Section 8 ; Finish of ends- the glass must be fused and flame cooled.

There are several variations on the shape of the sealing rubbers available and care should be taken to select the correct type to match the fittings. Old rubbers and/or broken glass should be prised carefully out of the fittings. Threads and other components should be carefully cleaned before reassembly.

When fitting new glasses and rubbers, care should be taken that the glass is held in place whilst the new rubber is tightened so that the end of the glass cannot be restricted by the sleeve rubber slipping over the end of the tube and partially closing the bore.

Flow restrictors are generally fitted in bottom cocks and sometimes top ones also which operate in case of a burst glass and reduce the escape of steam into the cab. Care should be taken not to lose these on dismantling as the restrictors are often a ball type.

Periodic Examination

The glass should be inspected and preferably changed at each washout as prolonged use results in thinning at the top edge of the glass especially if blown through regularly as advised.

It is recommended that water gauge openings are rodded through at washouts and other out of steam examinations. An appropriately sized rod is passed through into the boiler space and used to remove any build up of scale that could interfere with the correct operation of the gauges. The safety ball valves and restrictors should also be examined and cleaned (see ‘General’ section) as build up of scale or corrosion here could prevent these from seating properly in case of glass breakage in service.

Cocks

More modern valves will almost certainly be fitted with sleeve packed cocks. Replacement sleeves with stainless steel eyelets are recommended to help maintain the openings shape and size. If a packing sleeve is used without a stainless steel eyelet particular monitoring should be carried out to determine that the sleeve will not collapse with use blocking the waterway. When assembling with new sleeves care should be taken to ensure the eyelet stays in place. Modern cocks usually have ‘D’ shapes on the spindle ends to ensure that the handle cannot be fitted in the wrong orientation, however if older valves with just a square location are encountered, great care should be taken to ensure correct orientation on fitting. The spindle end should be marked with a small saw cut line to indicate the orientation if this is encountered.

GWR and some other types have top and bottom fittings screwed into the supporting column, and in older castings these threads are prone to fracturing at the undercut of the thread-it is recommended that this type of fitting is subjected to an extra thorough inspection .particularly as the temptation exists to over tighten the thread to get the top and bottom fittings to line up.

Protectors (except the Klinger Reflex type)

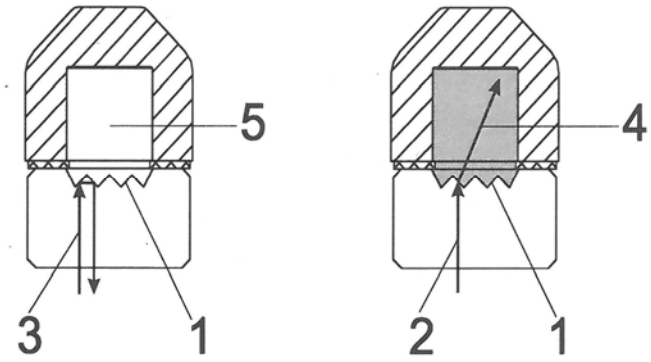
These should always be in place when the loco is in steam and be fitted with a striped diagonal backplate to enhance level visibility.

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
13 (iv)	LO2 3	Water Level gauges	Glasses need to be regularly changed, why?	Classroom	
13 (iv)	LO2 4	Change a set of glasses	Be able to change a set of glasses under the supervision of the mentor. What precautions should you take? How will you ensure the water/steam ways are clear?	Workshop	
13 (iv)	LO2 5	Cocks	Why is it important that a small saw cut is made on the end of the cock spindle to mark where the cross hole is?	Workshop	
13 (iv)	LO2 6	Gauge protectors	What purpose does a gauge glass protector serve? When must it be used and what is the purpose of the diagonal markings?		

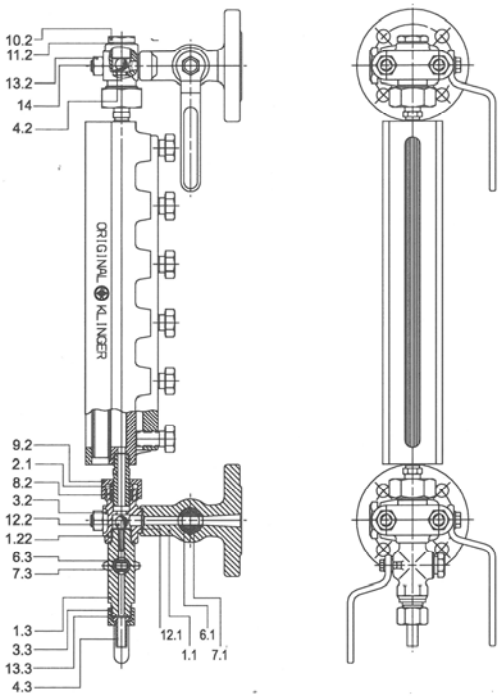
Klinger reflex water gauge fittings.

These gauges consist of a thick glass plate mounted in a metal body. The glass has right angled prismatic grooves (1) on the side facing the liquid chamber. Because of the different indices of refraction , light rays (2) and (3) entering the glass are absorbed in the liquid zone (4) but totally reflected in the steam space (5).The liquid space therefore appears black , the steam space a silvery white. The thickness of the glass means there is little risk of breakage in service and so no separate protector glasses are necessary.



Dismantling Klinger Reflex gauges

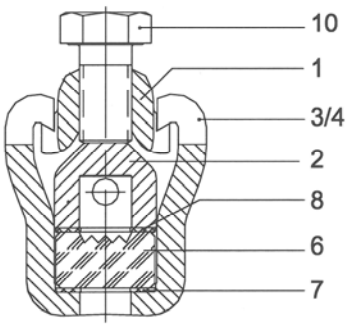
Remove hexagon nuts (13.2) and lift off stuffing box heads together with gauge from gauge cocks. Slacken off union nut (9.2) and pull off stuffing box heads from end tubes. Place gauge horizontally face downwards and slacken off bolts (10).Push wedge piece (3) along the gauge body and lift out upwards. Lift off centre piece (2) ,reflex glass (6) and cushion joint (7)Carefully clean sealing surfaces of the cover (1) and centre piece (2)



	components
1	Gauge cover
2	Centre piece
3/4	Wedge piece
6	Reflex glass
7	Cushion joint
8	Sealing joint
10	Hexagon headed screw
1.1	Gauge cock body
7.1	Cock plug
6.3	Packing sleeve
10.2	Joint ring
4.3	End tube
13.2	Hexagon nut
1.3	Drain cock body
9.1	Tightening nut
9.2	Union nut
12.1	Joint ring
12.2	Hexagon headed screw
1.21/22	Stuffing box body
2.1	Thrust ring
8.2	Gland ring 23,5/16x10
13.3	Joint ring
3.3	Union nut
14	Stud bolt
4.2	Pressure spring
11.2	Joint ring
3.2	Anti black spring

Reassembly

Insert new cushion joint (7) into the cover plate (1) .Place the new reflex glass on top (groove facing toward centre piece) followed by new sealing joint (8) and centre piece (2)Insert wedge piece (3) and push along gauge body to correct position. Tighten bolts (10) to maximum torque of 60Nm, tightening opposite sides alternately.



New Gauge Glass Installations

Correct accurate alignment of cocks is essential to ensure that glasses are not stressed on assembly. Flanged installations are preferred to screwed locations (as accurate alignment is then reliant on thread tightening against a washer or 'back nut'). Flanged installations using a 'lens ring' type sealing ring allow for accurate alignment even if the flanges themselves are imperfect.

Any new installation of this type should be approved by the competent person.

Care must be taken in selection of fittings so that sufficient level of water above the firebox crown when in service will always be maintained.

Where necessary, for operation in poor visibility and hours of darkness the water gauge should be illuminated.

v. Blowdown Valves

It is desirable that every boiler be provided with at least one blow down valve, connected to it at the lowest practicable point of water space. The issue of installation is very important - the connection between boiler and valve must be of high integrity. New designs of installations of blowdown valves (or any other fitting) should be approved by the competent person. Flanged rather than screwed mountings are preferred. Steps must be taken to ensure rotation of valve or fitting cannot result from force applied to operate the valve or reaction from blowdown discharge. Additionally the weight of valve, piping and silencer (if fitted) must be accounted so as not to overload the mountings. The valve shall be secured to the boiler direct or connected thereto by the shortest practicable pipe of adequate capacity.

A secondary lock or latching device must be provided to deter accidental opening.

Discharge and operating arrangements shall be provided to minimise risk to persons.

vi. Regulators and Regulator Rods.

These items are particularly safety critical as a failure here could result in loss of control of the locomotive. Bottom 'J' pipes of regulator valves are commonly made of cast iron and can be subject to erosion and corrosion therefore regular examination here is required.

Regulator rods are also subject to corrosion and cracking, particularly in the gland area where the rod exits the boiler. Procedures such as dye-penetrant-testing or MPI can be used if there is any doubt. Careful building up with weld and re-machining may be appropriate in some cases to this area, if in doubt the competent person should be consulted.

Regulator handles can be subject to fatigue cracking from footplate vibration and even here regular examination is important.

vii. Left hand/Right hand Threaded Nuts.

Ex GWR locomotives in particular, make a lot of use of nuts having a right hand thread at one end and a left hand thread at the other to join components together such as injector steam valves to steam manifolds or fountains. Particular attention must be paid to ensure that equal turns are engaged in both ends of the nut when fitting and the quality of thread.

14. Inspection for Frost Damage

Boiler fittings and pipework are particularly prone to damage by freezing of water trapped in 'pockets' – the expansion on freezing can overstress and split subject areas. If it is possible that a locomotive may have to be stored in conditions that may be subject to freezing then steps should be taken to drain all areas that may be holding water pockets. Injectors can be particularly prone. If any frost damage is suspected then the area in question should be given extra examination and a hydraulic test before use.

Any hydraulic testing should be to the appropriate procedure and the water used should be maintained at a temperature above 7 degrees centigrade.

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
13 (v)	LO27	Blow down valves	What is the purpose of a blow down valve? Why does it have to be special?	Classroom	
13 (vi)	LO28	Regulator	What is a 'J' pipe and how may it become safety critical?	Classroom	
14	LO29	Inspection for frost damage	Water can be trapped in pockets and injectors are particularly prone. What precautions should be taken?	Classroom	

15. References

British Standards

BS3463:1975

Specification for observation and gauge glasses for pressure vessels

BS1780:1975

Specification for Bourdon Tube pressure and vacuum gauges (Replaced by BS EN837-1:1998)

BS2871: Part 1:1971

Specification for copper and copper alloys, tubes (Replaced by BS EN1057:1996)

BS1400:1985

Specification for copper alloy ingots and copper alloy and high conductivity copper castings

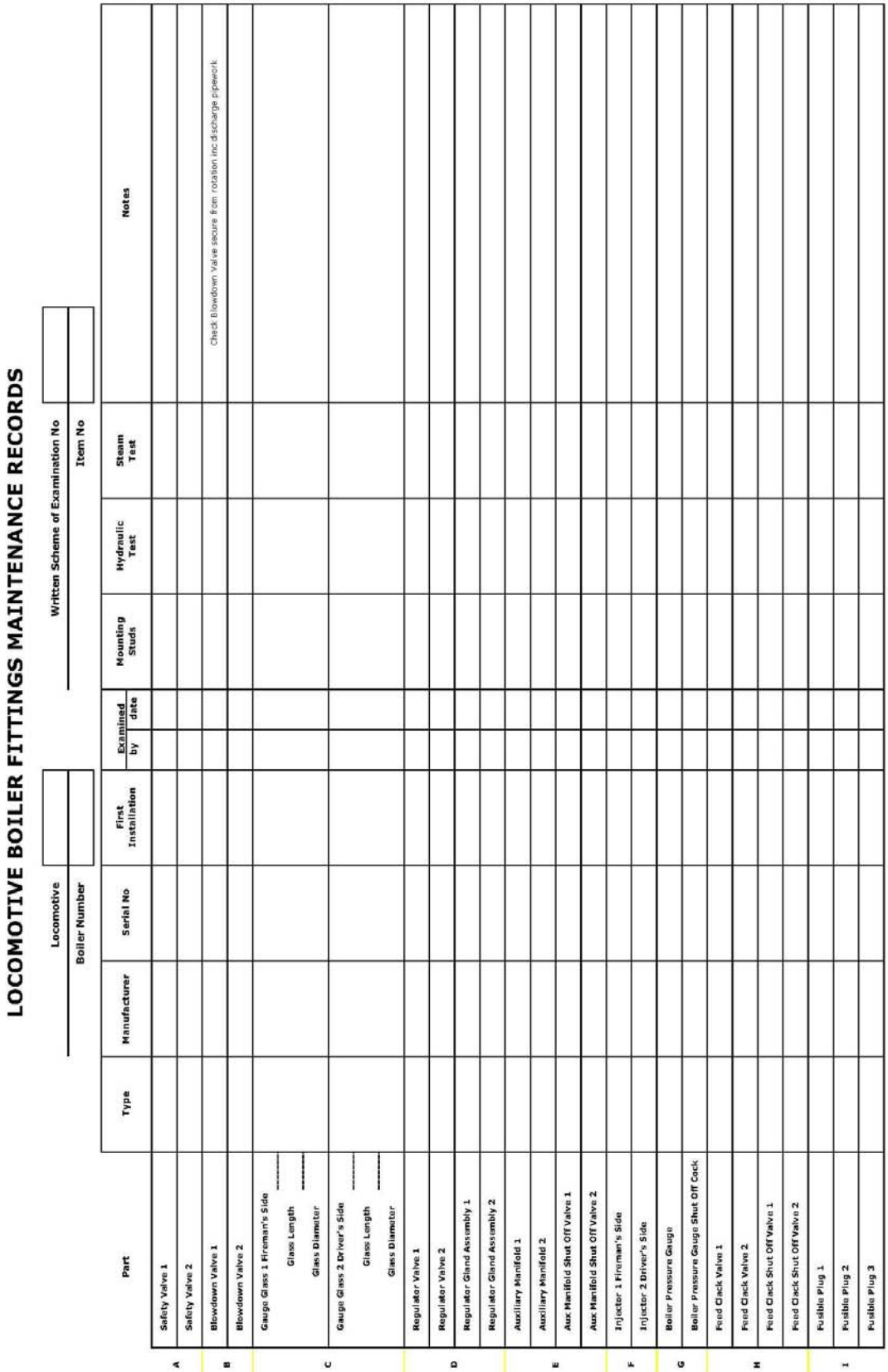
'Copper and Copper Alloy Castings – Properties and Applications' by the Copper Development Association

'The Management of Steam Loco Boilers' – ORR Railway Safety Publication 6

Journal of Institution of Locomotive Engineers : Paper No 356 1936 'Locomotive Piping and Pipe Fittings' by P L Falconer

end of main document

Appendix A – Suggested Maintenance Record Sheet



LOCOMOTIVE BOILER FITTINGS MAINTENANCE RECORDS

Locomotive _____ Written Scheme of Examination No _____

Boiler Number _____ Item No _____

	Part	Type	Manufacturer	Serial No	First Installation	Examined by	Examined date	Mounting Studs	Hydraulic Test	Steam Test	Notes
A	Safety Valve 1										
	Safety Valve 2										
B	Blowdown Valve 1										Check Blowdown Valve secure from rotation inc discharge pipework
	Blowdown Valve 2										
C	Gauge Glass 1 Fireman's Side										
	Glass Length _____										
	Glass Diameter _____										
	Gauge Glass 2 Driver's Side										
	Glass Length _____										
	Glass Diameter _____										
D	Regulator Valve 1										
	Regulator Valve 2										
	Regulator Gland Assembly 1										
	Regulator Gland Assembly 2										
E	Auxiliary Manifold 1										
	Auxiliary Manifold 2										
	Aux Manifold Shut Off Valve 1										
	Aux Manifold Shut Off Valve 2										
F	Injector 1 Fireman's Side										
	Injector 2 Driver's Side										
G	Boiler Pressure Gauge										
	Boiler Pressure Gauge Shut Off Cock										
H	Feed Clack Valve 1										
	Feed Clack Valve 2										
	Feed Clack Shut Off Valve 1										
	Feed Clack Shut Off Valve 2										
I	Fusible Plug 1										
	Fusible Plug 2										
	Fusible Plug 3										

Appendix B: A typical procedure for forming copper pipes

Copper pipes may be bent using 2 main methods – 'hot' or 'cold' forming.

The 'hot' method is described in the following section. 'Cold' bending is similar in process except that following heating of a section of pipe, that section is quenched then bent (only a few degrees at a time – some 'feel' is required to detect the onset of work hardening – once this is felt then the section should be reannealed).

A procedure for the forming of large copper pipes for use in the restoration and new build Steam Locomotives.

Introduction:

Most copper pipework on locomotives is very visual and needs to look a decent and professional job, these notes should ensure decent and even bends for pipework of up to 2 ½" diameter.

Tooling required:

A large bench vice securely fixed to a metal or wood bench of sufficient size to enable it to remain stable when the force for bending pipes is applied. It needs to have a large working area around it to enable long lengths of pipe to be handled without fouling other workshop equipment.

Soft vice jaws are required, which fit the shape of the pipe being formed; these jaws will need to be fixed to the vice.

Soft iron rod is required to make up a template for use when bending the pipes; a ¼" diameter is ideal for large pipes.

Heating:

For heating the copper pipes oxy/propane is ideal. On no account use oxy/acetylene, as the heat is too local and too hot and could burn the copper.

A deflector plate is recommended to fit around the pipe to deflect the heat from the burner to the opposite side of the pipe when heating.

Fine DRY sand is required to fill the pipes to stop the pipe collapsing during bending, (using damp sand may result in the plugs being blown out during heating). Tapered wooden plugs are required to seal the ends and keep the sand in.

Procedure:

Before proceeding, be aware of any H&S requirements for the equipment being used, especially the oxy/propane set up.

1) Form a template from the soft iron rod to the shape of the pipe run required. This template needs to be positioned for the centre of the completed pipe.

Mark on the template the start and end of each bend by chalking a line around the rod.

The pipe here will form a steam brake exhaust pipe of only 1" diameter but the procedure is the same for larger pipes.

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
Appendix B	LO3 1	Forming copper pipe	Observe and assist in copper pipes being bent using fine sand and plugs	Workshop	
Appendix B	LO3 2	Forming copper pipe	Create a pipe to the satisfaction of your mentor, the pipe should be at least 1.5”ø	Workshop	

2) The copper pipe is now cut overlong to allow a straight portion at the ends to grip in the vice. A tapered wooden bung is driven into one end. An alternative method is to braze a flat steel plate to one end.

3) Fine DRY sand is now poured into the pipe's open end. The pipe will need to be tapped gently during this process to get it compacted sufficiently. Once filled, a second plug is driven in ensuring compacted sand fills the pipe.

There are other materials used for filling pipes for bending, namely Cerrobend and resin, but more sophisticated equipment is required to use these materials. Sand has been found to be the ready acceptable method for use in railway workshops as it is usually readily available.

4) One end of the pipe is now gripped in the specially made soft vice jaws for the size of pipe being formed, hold the end of the pipe in the vice and support the other end on suitable supports so that the pipe can be moved parallel to the floor when bending. Alternatively to using a vice a large block of timber can be used with appropriately radiused holes.

5) The steel template bar is marked with chalk at the start and end of bends. Then the chalk marks are transferred to the copper pipe (chalk will stay visible even when heated). You can see here the copper pipe is overlong to leave a straight portion at the end for holding in the vice jaws.

6) The oxy propane torch is now used to heat the pipe in the section to be bent between chalk marks. Only a short section is bent at one go between heating. An assistant is needed as soon as heating starts or the pipe will sag under its own weight.

7) The pipe is heated to a dull red colour (you cannot see it here because of the camera flash) and the assistant pulls the pipe end round gently whilst the template is used to judge progress.

For large radius bends it will be necessary to heat the bend in several stages, by heating the first 6-8 inches to a dull red heat and pulling the pipe around to form the bend. Use the template often by placing it on the centreline and checking the radius is forming correctly. Be patient when forming and do not try to form too much at one time. Re heat the next 6-8 inches and proceed all round the bend with this method.

For forming tighter bends, heat the outer side of the bend more than the inside. This will enable the outer thickness to stretch and the inner to compress. If the inside only is heated then there is a chance that the material on the inside of the bend will pucker and ripple.

8) The process is repeated for each bend down the pipe following the template.

9) Quenching between heating sections removes oxidisation scale. Do not let the water cover the ends.

10) The bungs and sand are removed and then the pipe is trimmed to the correct overall length. Ends are deburred and the pipe should be thoroughly cleaned by passing a rag through pulled by a piece of string or a pressure hose.

11) The pipe end is thoroughly cleaned and flux coated ready for silver soldering. Bronze brazing is an alternative. The higher temperature required meaning that accidental melting when re-annealing is less likely.

12) If it's the second end of the pipe to have fittings, remember to slide the nut on before soldering on the cone or other end fitting. The cone or collar should be a loose slide fit on the pipe to allow the solder to flow down.

13) Heating and soldering the pipe end fitting.

14) The finished pipe

end of appendix

Appendix C: LNER 'Air Ministry' square feed pipe joint

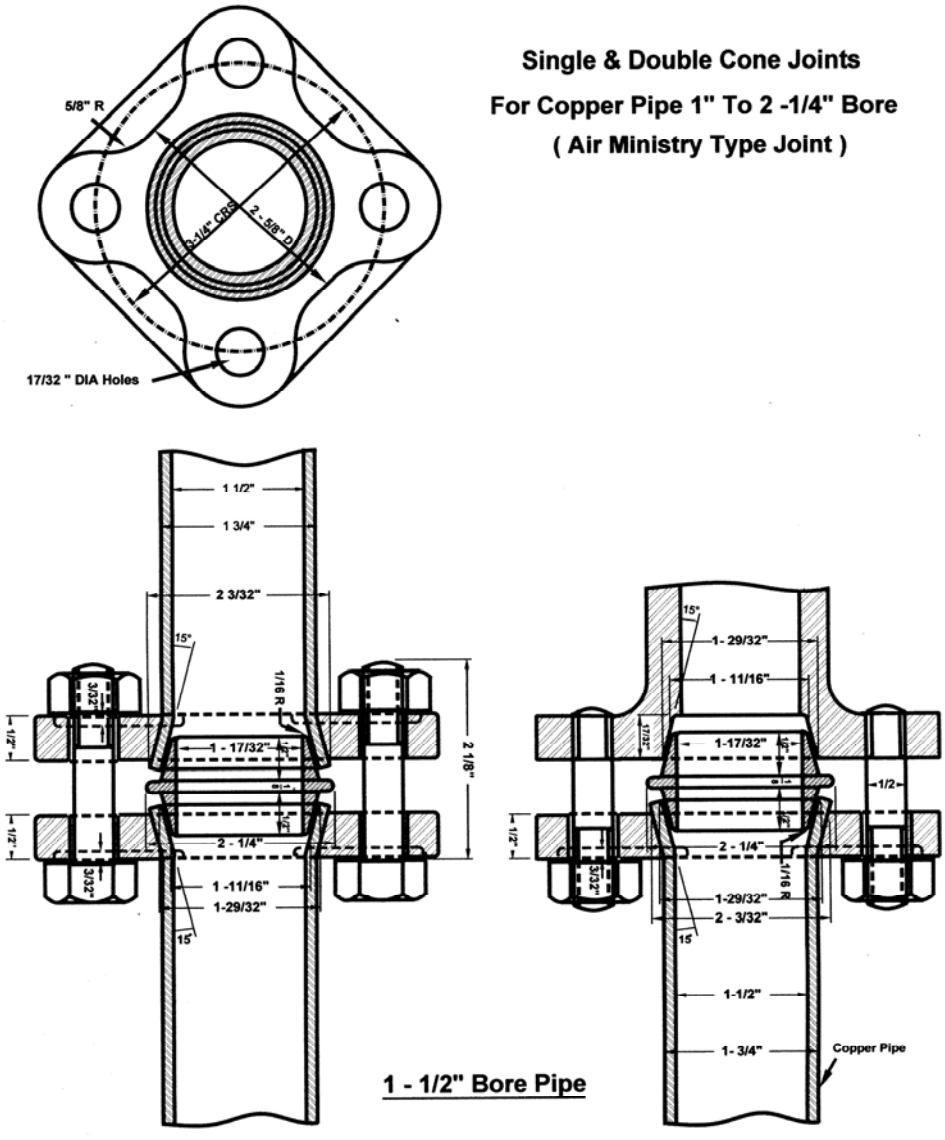
There are many variants on pipe joint types and providing detail on every type is not possible here however this joint as developed by the LNER from aircraft technology needs particular care so as not to put excessive tension loads onto the pipes which could lead to early failure of the pipe.

Resorting to extended length olives is not the best solution to poorly sealing joints - the pipes should be replaced with new of the correct length to produce a good sealing joint with normal bolt torques

Alternatively the old flared end can be cut off and a new short pipe end can be brazed on, if the rest of the pipe is still serviceable.

Correct flaring of the pipe end is critical to achieving a correctly fitted tight joint and is best done using split dies clamped around the pipe end and flaring carried out with a tapered mandrel of the correct taper.

It is most important that the pipe ends can be seen to protrude beyond the flange when fully tightened up to ensure full conical contact.



end of appendices

Proposed BESTT Syllabus Assessment Plan

Section Number	LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
Appendix C	LO3 3	LNER/Air Ministry square flange pipe fittings	Draw a section through a joint and explain what is critical and why and what can go wrong?	Workshop	

BESTT
Boiler Mountings, Pipework and fittings - Module B9007

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

LO1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Supervisor Initials and date when completed									
LO2	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Supervisor Initials and date when completed									
LO3	**1**	**2**	**3**	**4**	**5**	**6**	**7**		
Supervisor Initials and date when completed									

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