Fireman

Lesson Plan
and
WorkBook

(Generic Version)

Version 1

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IMPORTANT NOTICE

This booklet is one of a series of generic training and assessment templates developed by the Association of Tourist & Heritage Rail Australia Inc (ATHRA) as guides for heritage railway operators seeking to develop or upgrade their local training and assessment resources.

This booklet and others in the series are not intended to be training resources in their own right but rather to be suitably customised, embellished and adapted by railway operators to match the specific context of their own railway, e.g. types of locomotives, rollingstock and associated equipment, the track layout and infrastructure, the local standard procedures and rules, the safety management and safeworking systems, the railway organisational structure, and the roles and functions of personnel in the railway, etc.

Railway operators seeking to use this booklet and others in the series should initially refer to the ***ATHRA Customisation Guidelines Booklet*** which provides important information on how the generic templates should be used.

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1 HOW TO USE THIS WORKBOOK

This section of the workbook provides an overview of the contents of your workbook and how you should use it for your lessons.

The workbook is intended to provide you with a systematic approach to the learning of the skills, knowledge and understanding you need to fulfil the role and responsibilities of a fireman on your railway. A mentor who is already a qualified and highly experienced fireman has been appointed by your railway to assist you in this learning process.

The first part of the booklet includes a simple summary of the structure and contents and the learning activities contained in the booklet for the development of what you need to know and what you need to be able to do. It describes the mutual roles of you and your mentor and summarises other publications issued by your railway that you need to use such as operating and service manuals, checklists, safeworking rules, standard procedures, timetables, route maps, safety management systems, etc.

There are five topic areas covered by the booklet. Each topic section outlines the theory and practical for a number of listed sub-topics. The outline gives a basic framework of what you need to know and be able to do in the topic area concerned. However, you will need to ***build your knowledge*** further by having discussions with your mentor and by reading the relevant sections of the publications issued by your railway to firemen.

Each topic section also contains space for you to write your own notes on the various sub-topics based on discussions with your mentor and your own experiences during training and guided practice.

2 LIST OF REFERENCE MATERIAL

The following is a list of key reference material which will be available to you during the course of your learning activities for the lesson:

- Your railway's job description for a ***fireman on a steam locomotive***, describing a fireman's role and responsibilities
- Rail Operator's Standard Operating Procedures (SOPs) for the operation of steam locomotives
- Safety management system
- rail safety requirements and practices
- Locomotive and boiler manuals and handbooks
- Pre-operational checklists
- Rail Operator's Rule book and General Instructions, including:
  - Safeworking forms
  - Special Notices / Train Notices
  - Route maps
  - Timetables
  - Yard and shed diagrams
  - etc.

3 OBJECTIVES OF THE LESSON PLAN

This Lesson Plan aims to provide a program of learning that will enable the learner to develop the theory (i.e. what you need to know and understand) and the practical requirements (i.e. what you need to be able to do) in a number of topic areas ...,,

- The role and responsibilities of a fireman on a steam locomotive,
- Conducting pre-operational checks on a steam locomotive boiler,
- Lighting fire and raising steam on a steam locomotive,
- Operating the boiler during a train journey,
- Handling emergency and other abnormal situations. and
- Cleaning and checking the boiler after service

Your **mentor** will work with you in the following ways:

- Help you to develop the required understanding and skills through interactive discussions and explanations,
- Demonstrate required tasks and equipment functions,
- Assist you to obtain, read and interpret your railway's documents and manuals as well as applicable regulatory requirements,
- Observe and comment on your practice of the required skills in real and simulated situations, and
- Periodically check of what you have learnt (i.e. your knowledge and understanding and what you are able to do).

At all times, if you are in doubt or need to clarify an issue, check with your mentor or other qualified and experienced drivers and firemen on your railway.

4 ROLE AND RESPONSIBILITIES OF A FIREMAN ON A STEAM LOCOMOTIVE

4.1 FUNCTIONS AND DUTIES OF A FIREMAN

Theory

The job of a fireman on a steam locomotive may involve a variety of tasks including:

Duties prior to locomotive service

- Signing on, checking notices, timetables, etc.
- Checking roster, notice boards, operational instructions, locomotive availability and other information needed to work as a fireman on a steam locomotive
- Assisting in the performance of pre-operational checks on the locomotive and in particular its boiler
- Checking that tool kit, fire extinguisher, first aid kit and other locomotive equipment is on the locomotive and is in good working order
- Lighting up of the steam locomotive and raising steam
- Recording, rectifying, isolating and/or tagging defects and deficiencies (as applicable) or reporting to relevant personnel
- Oiling and greasing the locomotive
- Filling of lubricators taking the required safety precautions when filling a hydrostatic lubricator.
- Correctly using the injectors
- Checking systems are operating correctly
- Starting the turbo and checking the head and marker lights
- Adherence to safeworking rules when preparing a locomotive for service
- Dosing the required amount of boiler water chemicals to boiler or chemical dosing system

Duties during a journey

- Adhering to safeworking rules'
- Following standard operating procedures
- Responding to the driver's instructions
- Taking required precautions and following standard operating procedures when approaching and traversing level crossings

- Assisting the driver during a journey by checking the performance of the locomotive and taking any required action
- Filling of locomotive water tanks/tender from standpipes/tanks,
- Firing of locomotive, typically involving the hand shovelling of coal from tender to firebox,
- Manipulating fire irons to deal with clinkered fire (Note that the use of fire irons with high-ash coals will cause clinker),
- Assisting in the coupling of a steam locomotive to other steam locomotives for double heading operations, or when working with a diesel locomotive (where required),
- Maintaining of adequate steam pressure and water level, involving reading of gauges and the operation of controls associated with the fireman's duties,
- Observing all lineside signals, point stand indicators, signage and indicators. These are to be called by one locomotive crew member and acknowledged by the other,
- Operating the train brake under the supervision of the driver from time to time (to maintain competency for emergency purposes),
- Giving and interpreting hand signals correctly
- Remaining vigilant throughout a journey, including looking back to train
- Assisting in the stopping and securing of a train in an emergency as per standard operating and emergency procedures
- Assisting the driver in the identification of faults and defects and associated trouble-shooting activities
- Dealing with abnormal situations that may occur during train operations, including applicable emergency communication and evacuation procedures
- Performance of tasks outside the cab including checking/filling of sand boxes, cleaning ash pans (may include climbing in and out of a pit) and smoke boxes, shovelling down and trimming coal in tender and coupling/uncoupling locomotives from rolling stock
- Handing over a steam locomotive to a replacement crew

Duties after service

- Assisting the driver in uncoupling a locomotive from rollingstock (during these processes the fireman and the driver will follow the standard operating procedures for the type of braking system used on that railway)
- After locomotive service, confirming it is secured prior to post-operational cleaning and checking operations

- Completing all required post-operational lubrication and greasing tasks (Note that the fireman doesn't lubricate or grease after a trip but does withdraw trimmings from siphon pipes and shuts down the hydostatic lubricator)
- Topping up water level in boiler as per standard procedures
- Conducting cleaning operations including the smoke box, fire cleaning, dumping of ash and other cleaning duties
- Conducting a visual inspection and other post-operational checks of boiler and associated equipment
- Checking that tool kit, fire extinguisher, first aid kit and other locomotive equipment is in operational condition and is correctly stowed
- Checking and confirming that boiler and associated equipment has been restored to required post-operational condition
- Assisting the driver in securing the locomotive
- Completing required post-operational documents and reporting any faults or defects for appropriate action

> ***Practical***
>
> Obtain a copy of your railway's job description or duty statement for a fireman and read it carefully. Describe to your mentor the various functions and duties you must perform when working as a fireman on a steam locomotive in service. Travel with a steam locomotive crew and observe these various functions as they are being performed by the fireman. Clarify with the driver and fireman any aspects of these functions that are unclear.

4.2 STATUTORY RESPONSIBILITIES INCLUDING RAIL SAFETY AND SAFEWORKING REQUIREMENTS AND REGULATIONS RELATED TO THE FUNCTIONS OF A FIREMAN AND THE OPERATION OF BOILERS

Theory

The work of a fireman involves working with fire and high pressure steam and involves the shovelling of coal to keep the locomotive fired. Firemen must therefore be very familiar with the Occupational Health and Safety (rail safety) requirements related to their work and all pertinent safeworking rules and requirements including trackside safety awareness procedures.

They must also have a good working knowledge of the basic regulatory requirements for the operation of boilers. You need to make sure you are familiar with the railway and other documents that describe your statutory responsibilities and that you understand their contents and the implications for your work as a fireman on a steam locomotive. .

Familiarity and expertise with regulatory requirements will increase as the fireman becomes more experienced.

A particularly important responsibility is to be aware of the hazards involved in working as a fireman on a steam locomotive and following the rail operator's strategies for minimising or eliminating the risks involved. Examples of hazards that exist on steam locomotives include:

- Falling from heights
- Working in confined spaces
- Working under wires
- Chemicals
- Fire irons
- Hot surfaces
- Scalding/burns
- Moving work platform
- Oil spills on floors
- Dehydration and fatigue
- Noise
- Flashbacks
- Working with electric lights and power
- Exposed steam pipes
- Broken hand rails
- Leaking fittings

Hazard management strategies may include:

- Taking required precautions when using oil as the locomotive fuel,
- Ensuring public safety (e.g. checking when the public is in the vicinity of loco before using injectors, blowing down, cleaning fires, etc.),
- Using personal protective equipment or PPE,
- Using fire extinguishers and water hoses to control fire emergencies, including fire control strategies when working steam locomotives in bushfire conditions, and
- Following the railway's established risk management procedures.

Practical

In conjunction with your mentor, make sure you have a copy of the relevant documents and understand the requirements and responsibilities described in them. If in doubt on any aspect of your statutory responsibilities ask your mentor to clarify them with you and if necessary demonstrate to you how these responsibilities need to be fulfilled in practice. Demonstrate to your mentor your understanding of your responsibilities and how these are applied in your role as a fireman.

4.3 STANDARD PROCEDURES OF THE RAIL OPERATOR APPLICABLE TO A FIREMAN, INCLUDING RECORD KEEPING AND THE REPORTING OF DEFECTS AND INCIDENTS

Theory

Make sure you have a copy of those standard procedures of the operator of your railway that apply to the functions and duties of a fireman. You should read these procedures and make sure that you are thoroughly familiar with them and can apply them when performing fireman tasks.

It is important that you not only can follow these procedures but also understand their significance and the reasons why following them is so important. These procedures will include record keeping and the required action to be taken in the event of an equipment defect or a safety incident.

Practical

In conjunction with your mentor, make sure you have a copy of the relevant standard procedures and understand how they must be applied in the day to day work of a fireman.

If in doubt on any aspect of the procedures, ask your mentor to clarify them with you and if necessary, demonstrate to you how the various procedures should be carried out. In turn, you should learn how to apply these procedures yourself progressively through your training -- gradually developing your expertise through guided practice, as instructed by your mentor.

4.4 ROLE AND RESPONSIBILITIES OF A FIREMAN ON A STEAM LOCOMOTIVE -- LEARNER'S NOTES

Insert your own notes here

5 CONDUCTING PRE OPERATIONAL CHECKS ON A STEAM LOCOMOTIVE BOILER

5.1 IDENTIFYING AND DESCRIBING THE COMPONENTS OF THE BOILER OF A STEAM LOCOMOTIVE AND ITS ASSOCIATED EQUIPMENT

Theory

As a fireman on a steam locomotive, it is important that you know and are able to identify the components of the boiler on the locomotive and its associated equipment. For the boiler and its equipment, you must be able to describe their:

- purpose
- principal parts
- functions and operation
- potential defects and related action required to isolate, repair and/or report the defects as per standard procedures

The internal health of Boilers will be a major part of Steam Heritage Rail in the future. All drivers and firemen should be competent in boiler water treatment theory, testing, and interpretation of test results. Heritage railways should refer to the *'RISSB Boiler Code of Practice, Appendix M - Boiler Water Treatment'* for details of the information on boiler water treatment to be included in their training and assessment materials for both firemen and steam locomotive drivers (suitably customised to their own local circumstances and standard procedures).

Across the heritage rail industry in Australia there are a range of different types and classes of steam locomotive in service. While there are some components and associated equipment common across the various types of steam locomotives, you need to be familiar with the features and particular components and equipment that are specific to the steam locomotive(s) used on your railway.

Typical components of boiler equipment may include those in the list below
[*Note that the list may be adjusted and customised to match the locomotive and the railway concerned]*:

- **ashpan** *(The ash pan is positioned below the fire grate to receive ashes and clinkers from a coal-fire boiler as they fall from the fire bed. Oil-fired boilers have a brick pan that contains the fire within the firebox. Some ash- and brick pans regulate, via the dampers, the amount of primary air entering the grate. The shape of the pan varies with the width of the grate and the position of the axles and the design of the locomotive. It may be formed in the shape of a hopper to facilitate emptying.)*
- **blower** *(A blower is fitted on all locomotives to supply artificial draught for the fire when the engine is not working. A small pipe is fitted on top of the blast pipe in the smoke box and is perforated with small holes and bent in the form of a circle. By turning on the blower steam valve in the cab, a jet of steam is directed up the chimney. This creates a vacuum in the smoke box, causing the air to be drawn through the grate and ejected out through the stack)*
- **blower valve** *(controls the flow of steam to the blower ring that creates a draft to draw the heat through the boiler tubes)*
- **blow down valve** (valve to blow out sediment contained in the boiler water and to drain the boiler empty for inspection and cleaning**)**
- **boiler (***a closed vessel or arrangement of enclosed tubes in which water is heated to supply steam to drive an engine.)*

- **boiler barrel** *(the cylindrical portion of the boiler between the firebox and the smoke-box. At each end is the tube plate to hold securely in position the tubes which connect the firebox. Placed on top is the dome where dry steam is collected. The regulator valve may be placed in it, which is secured to the internal steam pipe. Other steam pipes are placed there to supply steam for various auxiliaries.)*
- **brick arch** *(situated inside the firebox, it protects the tubes from cold air when the fire door is opened. It lengthens the path for the gases from the fire to the tubes and so ensures more complete combustion. Maintains an even temperature is maintained in the firebox.)[Further detail on the brick arch can be found in the RISSB Boiler Code of Practice]*
- **clack valve** *(a non-return valve to ensure feed water only flows in one direction – i.e. into the boiler. It also ensures that water is retained within the boiler)*
- **crosshead** *(A knuckle joint connection which joins the piston rod to the connecting rod)*
- **dampers** *(control the draft through the boiler by regulating the amount of primary air that enters the grate)* **)**
- **dome** *(placed on top of the barrel to provide a receptacle for collecting the steam well above the water level)*

- **expansion brackets.** *(moving joints fitted to the rear of a locomotive boiler to allow the expansion of the boiler. It is important that these are maintained in good working order. Seized expansion brackets could damage the boiler.)*
- **fire-hole** *(opening in the back head to allow the stoking of the boiler. It also provides secondary air to complete combustion)*
- **firebox** *(the combustion area of the boiler. It is surrounded by water on the top and all sides. At the bottom is a grate for the containing and burning and distributing primary air flow to combustible materials. An ash pan is attached below so that combusted materials may be contained)*
- **firebox wrapper plate and backplate** *(important outer components of the firebox. The boiler consists of a steel shell which includes the boiler barrel, the outer firebox wrapper plate, the back plate, throat plate, smoke box tube plate, also the inner firebox and smoke tubes)*
- **foundation ring** *(the foundation ring, also known as the mud ring, unites the lower edges of the inner and outer firebox plates (sheets). It can be forged, cast, welded or a pressed U-section. Because of the tight radius of corners in riveted foundation rings, the plates are held in place with boilermaker's (or patch) screws.)*
- **fusible plug** *(a safety device used to provide a warning of that the water level has already fallen to a dangerous level. The lead filled plugs are fitted in the top of the fire box crown. Under normal circumstances, the water covering the firebox crown prevents the lead melting. If the water level falls below the top of the firebox crown, the plug overheats and melts. The resulting blast of water and steam acts as a warning (and may perhaps subdue the fire to some extent preventing further damage))*
- **gauge glasses** – *see water gauge*
- **gudgeon pin** *(The pin that joins the crosshead to the connecting rod)*
- **injector** (*Is a device containing a series of nozzles so designed and arranged that steam entering will expand and strike a quantity of water and condense, The increased velocity, due to expansion and heat energy imparted to the water creates sufficient movement to force the water into the boiler against the pressure contained within. They are usually located one on either side of the boiler. Injectors may be classified as lifting and non-lifting. The lifting injector is placed above the high water line in the tank, requiring a vacuum created by starting the injector to fill the suction pipe with water The non lifting injector is placed below the bottom of the water tank, the suction pipe is always flooded All injectors work upon the same general principle, differing only in the details of construction.).*
- **piston rod** *(A rod that connects the piston in the cylinder to the cross-head axle)*

- **regulator or throttle** *(a valve that controls the delivery of steam to the steam chests and cylinders)*
- **safety valves** *(pressure relief valves to stop the boiler pressure exceeding the operating limit. They relieve the boiler of excess pressure above the registered pressure.)*
- **slidebars** *(also known as **Guide Bars,** They contain and allow the free movement of the crosshead **also hold** the piston rod parallel to the guides and the piston in the cylinder)*
- **steam pressure gauge** (*shows the steam pressure in the boiler above the atmospheric pressure*)
- **steam stop valve (also known as the manifold or turret)** (*isolates the boiler from the auxiliary equipment: i.e. L and R injectors, lubricators, blower, air compressor, vacuum ejector, etc.*)
- **superheater elements** *(Superheater elements are manufactured from steel tube and typically comprise multiple lengths of tubing joined by return bends. The inlet and outlet ends are joined to either the saturated steam chamber or the superheated steam chamber of the superheater header.*
- **tube plates--** *front* **and fire-box** *(the end plates that support the tubes in the boiler. The front tube plate is made of steel and attached to the boiler barrel. It has holes bored to receive tubes, the main steam pipe, inspection plugs and longitudinal stays etc. The firebox tube-plate is the plate into which the tubes are inserted, to allow the firebox gases to flow to the smoke-box)*
- **tubes** *(are surrounded by water on the outside. On the inside hot products of combustion pass. Heat from the combustion process is given up to the heating surface through the tube walls to the water and carry away the hot gases and smoke from the firebox to the smoke box.) [Further detail on tubes can be found in the RISSB Boiler Code of Practice]*
- **washout plugs** (*A small 'mudhole' used for washing out the boiler. Plugs, as compared to mudholes, are usually screwed into a taper thread)*
  [Further details on washout plugs can be found in the RISSB Boiler Code of Practice]
- **waterspace stays** *(used to tie the inner and outer plates of a firebox together to prevent them buckling and collapsing) Further detail on stays can be found in the RISSB Boiler Code of Practice]*
- **water gauge:**
  - water gauge glasses (*show by sight the quantity of water in the boiler above the vital part, .Two gauge glasses are fitted to enable one to be checked against the other)*

  - steamway cock on water gauge *(an isolating cock used to shut off steam to the gauge glass as required, i.e. to isolate the steamway passage if the gauge glass were to break. Used when applying the independent test.)*
  - steam way passage *(the passage which connects the boilers steam space to the gauge glass)*
  - waterway cock on water gauge) *(an isolating cock to shut off steam to the gauge glass as required i.e. to isolate the waterway passage if the gauge glass were to break Used when applying the independent test.)*
  - water way passage *(the passage which connects the boilers water space to the gauge glass)*
  - *blow through cock (For testing and draining the gauge glass)*
- ***vital part of a boiler (t****hat part of the boiler which first becomes exposed during a low water condition i.e. the crown of a locomotive firebox.)*
- **whistle valve** *(controls the flow of steam to the locomotive's whistle)*

Some Key Terms

The following is a summary of some key terms related to steam locomotive boiler operation (Note that this in not an exhaustive list and you should refer to your railway's documentation and reference material, as well as having appropriate discussions with your mentor)…..

- **Saturated Steam** is steam taken directly from a boiler steam space and is characterised by having a constant temperature, volume and density for any given pressure. Because saturated steam is always generated in the presence of water it contains water droplets in suspension (This is the vapour seen issuing from cocks).

  The advantages and disadvantages of using of using saturated steam for driving reciprocating steam engines are:

  Advantages of saturated steam:

  - The wetness of saturated steam acts as a lubricant for all the components it comes in contact with, including: the governor, slide valves and the piston and its rings.
  - The gland packing relies on a small steam leak and the resultant condensate to keep it lubricated and prevent it from drying out.
  - Assists in distributing the steam oil fed from the lubricator.
  - Most reciprocating engines are designed to operate on saturated steam.
  - For a given pressure the temperature is constant.

Disadvantages of saturated steam:

- When using saturated steam an amount of heat is given up in heating steam lines and the engine, as a result much of the steam is converted back to water.
  - This is an economic loss as no mechanical work has been performed.
  - The condensate formed can cause damage such as broken pistons or forcing the cylinder covers off the engine due to its incompressibility. .

- **Superheated Steam** (Cannot be made in the presence of water) it is steam that has passed through elements where its temperature is raised above the corresponding saturation temperature for the pressure.

- The *advantages and disadvantages of using of using superheated steam for driving reciprocating steam engines are…..*

  Advantages of superheated steam:

  - The hotter the steam is the less work it has to do.
  - Uses less coal.
  - Uses less water
  - Gives greater efficiency
  - Super heated steam has a less volume than saturated steam at the same pressure and therefore provides greater power and efficiency.
  - With sufficient super heat, expansion can take place in the engine forming less condensation, which can damage the engine.

  Disadvantages of superheated steam:

  - Lubrication must be provided, as super heated steam is an invisible odourless gas that does not have any lubricating properties.
  - Engines using high temperature super heat must be supplied with the correct grade of lubricant designed to resist vaporization and oxidization.
  - The temperature of the steam supplied to the engine can only be accurately determined with a temperature gauge.
  - **Safety Note:** Because superheated steam is invisible and odourless, it presents a danger to operational personnel. Care should be taken if a leak is suspected as this steam has the potential to cause life threatening injuries

- All steam made in the presence of water is Saturated Steam, the lower the pressure the wetter it is.

Priming: - The following are the actions a driver should take if a locomotive is ***priming***:

- Reduce the demand for steam by easing the Regulator.
- Place locomotive in Full Gear in the direction of running.

- Open drain cocks.

Foaming: -- With foaming, the true water level in the boiler may be difficult to ascertain, this may bring uncertainty in the minds of the driver and fireman. Foaming is bought about by different conditions to priming. The actions a driver should take if a locomotive is ***foaming*** are.

- Reduce the demand for steam by easing the regulator.
- Place locomotive in full gear in the direction of running.
- Open Drain Cocks.
- If Foaming is persistent water in the boiler may need replacing by blowing down then topping for as long as foaming persists.

Practical

1. In conjunction with your mentor and from the available railway reference documents, learn to how to locate and identify the various boiler components and the associated boiler equipment. Learn how to describe to your mentor the purpose of each component and piece of associated boiler equipment and its function.

2. Develop a list of typical defects that could occur to the boiler, its components and its associated equipment and the actions you would be required to take within the limits of your responsibilities as a fireman on a steam locomotive. This action may include isolation of the faulty component or piece of equipment, its repair, tagging the faulty component or piece of equipment, reporting the problem to appropriate personnel and/or recording the defect and action taken in the appropriate log or record book.

3. Check the duties and responsibilities of a fireman and the standard procedures for boiler maintenance in your railway and confirm your understanding with your mentor.

5.2 CONDUCTING A VISUAL INSPECTION AND OTHER PRE-OPERATIONAL CHECKS OF BOILER AND ASSOCIATED EQUIPMENT

Theory

Prior to commencing your day's shift on a locomotive, you need to sign on, check the duty roster and read and interpret the notice boards, operation instructions, locomotive allocation and other information you need to determine your second person duties for the shift.

Each railway will have its own specific sign on procedures and ways of informing second persons of their operational instructions, notices, locomotive allocation and the other required information. You need to be thoroughly familiar with the procedures and sources of information and how the information should be interpreted and used by you in the course of your fireman's duties.

When preparing a steam locomotive for service, firemen will check the locomotive's log book and reports from previous use and work done (e.g. loco operation and repair book) to confirm that all previously identified problems have been rectified. Firemen on steam locomotives are initially required to carry out a visual inspection of the locomotive and range of other required pre-operational checks. These may include:

- An examination of the **firebox** including…
  - checks if there are any leaking tubes, flues, stays or fusible plugs
  - check that the brick arch is complete and in good condition
  - confirm that fire grates are in good condition and correct alignment and the operating mechanism (in the case of rocking grates) is working
  - make sure that the fire-hole door is in good condition and works correctly
- An examination of the **smoke box** including…
  - checks for signs of water or steam leaks from boiler tubes and steam pipe joints
  - make sure that the spark arrester mesh is clean and undamaged and that the baffle plates are in good condition and are not loose
  - confirm that all ashes have been removed
  - observe that the foundation is in good condition
  - confirm that the smoke box door ring is clean of any ashes
  - closing and tightening the smoke box door and testing for leaks with the blower turned on (a lighted flare lamp can be used by running it around the door joint)
- An examination of the **water gauge glasses**
  - Checking that the water gauge glasses are in good condition
  - Testing of the gauge glasses
- Checking and replenishing the supply of oil to the air cylinder lubricator of all **Brake Air Compressors** (where applicable)
- Checking that all maintenance requirements for ejectors (vacuum) (where applicable) are carried out correctly
- Checking that the **sandboxes** are filled with clean dry sand and that the strainers where fitted are in position
- Checking that all **fire irons** are in position and are in working order

- Checking the operational readiness of the….
  - tool kit
  - fire extinguisher
  - first aid kit
  - communication equipment
- Filling of the **Cylinder Lubricators** (if hydrostatic), taking the necessary precautions

The completion of these pre-operational checks in collaboration with the driver of the locomotive ensures that the locomotive is fully ready for the planned operations and that the train crew will be suitably prepared for a range of possible emergencies and other abnormal situations that might occur en route.

Where defects and deficiencies are found in the course of the inspection and checks, they will be recorded and rectified, isolated, tagged (where applicable) or reported as per the railway's standard operating procedures and regulatory requirements.

Railways treat boiler water with chemicals to protect the boiler metal from corrosion and scale forming properties to condition the water to reduce the likelihood of foaming. Water treatment processes including the choice of chemicals and the dose rates for a particular boiler and the testing of boiler water are usually conducted in house in consultation with *Boiler Water Treatment Specialists*. All drivers and firemen in the Heritage Rail Industry should have considerable knowledge on Boiler Water Treatment and the processes used to prevent corrosion and scale build up. **It is recommended that boiler water treatment should be a mandatory part of training for all firemen in heritage railways**.

Drivers and firemen need to be aware of their own railway's policy and procedures for boiler water treatment and who carries out the various water testing and treatment tasks. A useful reference is *the 'RISSB Boiler Code of Practice, Appendix M - Boiler Water Treatment'*

Practical

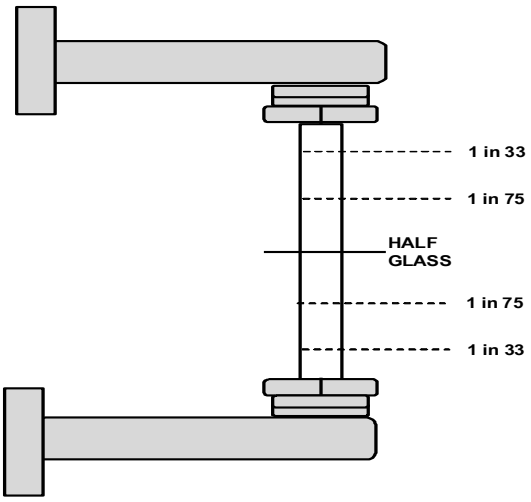
Under the supervision of your mentor, observe and practice how to conduct the required visual inspection and other pre-operational checks of the boiler and associated equipment. Discuss with your mentor the importance of boiler water treatment and the processes used in your railway to prevent corrosion and scale build up. Learn and demonstrate to your mentor how you can conduct the required visual inspection and checks.

5.3 CHECKING THE LEVEL OF WATER IN THE BOILER

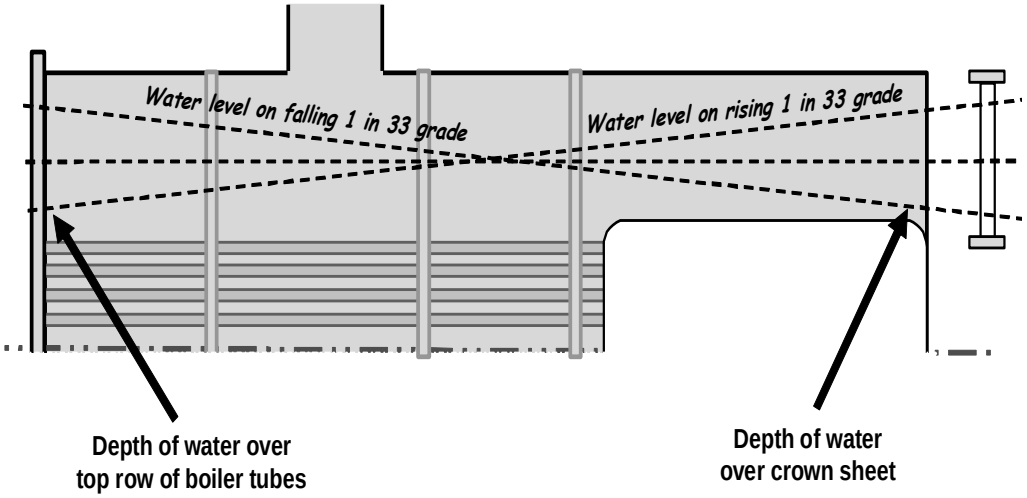
Theory

The water in the boiler must always be kept at a safe working level to protect the firebox crown sheet, the superheater flues and the boiler tubes by overheating by keeping them adequately covered with water, otherwise these components will be exposed and will overheat. The maintenance of the correct water levels is particularly important when the locomotive is working over steep grades. The level of water above the vital parts in the boiler is indicated by the water gauge glass. On a level road, the water level should be a half glass. However, on rising or falling grades the required water levels will be above or below the half glass level depending on the steepness of the grade (see example in diagram).

EXAMPLE ONLY



Water levels in gauge glass for level road and various rising and falling grades



Minimum level at which water must be maintained in gauge glasses when working over rising and falling 1 in 33 grades

Practical

Under the supervision of your mentor, observe and practice how to check the level of water in the boiler.

Learn and demonstrate to your mentor how you can check the water level when preparing a steam locomotive for service.

5.4 LUBRICATING THE LOCOMOTIVE

Theory

The prime purpose of lubrication on a steam locomotive is the reduction of friction by maintaining a thin film of oil between two metal surfaces in contact with one another. If the film of oil is broken at any time, friction increases, causing the parts to be overheated and possibly damaged. The higher friction also means that more power is required with consequent reduction in the performance of the locomotive. It is therefore very important, that all bearings and other moving parts on the locomotive are well and constantly lubricated.

A fireman must follow the pre-operational lubrication checklist issued by the rail operator for the type and class of steam locomotive concerned. All firemen and Steam Locomotive drivers should be able to make a replacement trimming in the case that one may need replacing. The following are typical lubrication points on a locomotive (Note that in most railways, oil up is primarily the driver's responsibility):

- Ensure all trimmings are in place
- Lubricate with bearing oil (or grease where applicable) the following parts (where fitted) below the footplate…
  - All axle boxes (if oil lubricated)
  - All oil cups
  - Eccentric straps, expansion links
  - Valve spindle glands
  - Knuckle joints
  - Spring gear equipment
  - Motion gear
  - Crosshead
  - Guidebars
- Lubricate with bearing oil (or grease where applicable) the following parts (where fitted) above the footplate…
  - Precision air reversing gear lubricator and its piston rod gland
  - Spot oil reversing shaft universal coupling pins

  - Reach rod brackets
  - Tender brake gear bearings
  - Air operating cylinder
  - Mechanical lubricators

- Lubricate with cylinder oil the following parts (where fitted) above the footplate:
  - Auxiliary oil cups for the piston rod and valve spindles of the locomotive
  - Mechanical Lubricators
  - Hydrostatic Lubricators
- Check the oil levels showing in the sight glasses or on the dip stick of the mechanical lubricators. The oil pipes need to be primed by rotating the ratchet handle of the lubricator at least 12 times. (where fitted and/or may be required by rail operator for the locomotive concerned)
- Where a hydrostatic lubricator is fitted), the fireman must fill the lubricator with the necessary quantity of cylinder oil, as may be required by rail operator for the locomotive concerned.

Steam locomotive drivers and firemen need to understand their railway's policy and procedures for: (1) oiling and cleaning lubrication trimmings, (2) replacing lubrication trimmings, and (3) making a replacement trimming.

Drivers and firemen need to be aware of any responsibilities they may have for these tasks under their railway's standard operating procedures.

A useful reference on lubrication of steam locomotives including the maintenance and replacement of trimmings is *'Steam Locomotive Lubrication - Its Development and Practice' by P.W. Skellon (*ISBN No 0953041700).

[NOTE FOR RAIL OPERATORS -- As each class of locomotive has different locomotive lubrication systems, it is important that the railway provides specific information on the procedures for their locomotives rather than have general notes]

Practical

Under the supervision of your mentor, observe and practice the required pre-operational lubrication procedures for your steam locomotive. Learn and demonstrate to your mentor how you can complete all the required lubrication tasks.

5.5 CARRYING OUT OTHER REQUIRED PRE-OPERATIONAL CHECKS THAT ARE THE RESPONSIBILITY OF A FIREMAN

Theory

Fireman on steam locomotives are required to carry out a range of other required pre-operational checks. It should be noted that some of these may to be rechecked again prior to running the train and its departure. The pre-operational checks may include:

- Determining the fuel, water and lubricating oil quantities required to meet light up and scheduled journey
- Checking and topping up the level of fuel and water
- If boiler water chemical is used, topping up the chemical levels
- Assisting the driver in the checking of the brake system. This requires a fireman to have a basic understanding of the brake system (e.g. vacuum brake or Westinghouse brake) including its principal parts, their positioning and the purpose of each part.
- Checking the operational readiness of the….
  - locomotive's cab
  - tool kit
  - fire extinguisher
  - first aid kit
  - communication equipment

The completion of these additional checks ensures that the train is fully ready for the planned operations and that train crew is suitable prepared for a range of possible emergencies and other abnormal situations that might occur en route. All required paperwork related to the visual inspection and pre-operational checks is completed as per the railway's standard operating procedures.

Practical

1. Identify in conjunction with your mentor the type of braking system used on the locomotive and train and its principal parts. Locate the various parts and discuss with your mentor the purpose of each.

2. In conjunction with your mentor, confirm the additional pre-operational checks you are required to carry out as a fireman working on a steam locomotive on your railway. Study the standard procedures for each of these checks. Your mentor will also show you how the various tasks should be completed. You should practise these and demonstrate your ability to complete them as per the railway's standard procedures.

5.6 CONDUCTING PRE OPERATIONAL CHECKS -- LEARNER'S NOTES

Insert your own notes here

6 LIGHTING FIRE AND RAISING STEAM

6.1 ENSURING ADEQUATE VENTILATION WITHIN A CONFINED ENVIRONMENT SUCH AS A LOCOMOTIVE SHED

Theory

When lighting up and preparing a steam locomotive for service, you need to make sure that there is adequate ventilation in the area where the locomotive is located (such as a locomotive shed).

During firing up and preparation the locomotive is giving off large volumes of potentially poisonous gases, fumes and smoke. There must be adequate means of through ventilation to allow these noxious gases and fumes to escape. Always check that doors, windows and other forms of ventilation available are functioning correctly before lighting fire and raising steam on a steam locomotive.

> ***Practical***
>
> In conjunction with your mentor, check the facilities in your locomotive shed to provide adequate ventilation. Learn, practice and demonstrate how you need to set up the appropriate forms of ventilation before firing the locomotive and raising steam.

6.2 CONDUCTING PRE-LIGHT UP PROCEDURES

Theory

Before lighting fire on a locomotive it is important that you complete the pre-light up procedures. This is to make sure that there are no unexpected hazards during the light up process that may be a risk to the safety of either personnel or the locomotive. Typical pre-light up procedures will include

- checking reports from previous use (locomotive operation and repair book) and details of any action taken
- making sure there is sufficient water in the boiler
- checking that the handbrake is on
- checking that the regulator is closed,
- confirming that the cylinder cocks are open,
- making sure that the locomotive is in mid gear
- ensuring that the wheels are chocked where required

Practical

In consultation with your mentor, obtain a copy of the pre-light up procedures for steam locomotives on your railway. Prepare a checklist of the pre-start up procedures that you will need to perform and make sure that you can carry them all out. If in doubt have your mentor demonstrate the procedures to you and point any issues you should particularly address.

Practice the procedures and check your understanding of them and why they are important.

6.3 LIGHTING THE FIRE

Theory

To light a fire on a steam locomotive the following steps are usually followed:

1. Follow the light up procedures of the rail operator for the steam locomotive concerned,
2. Regularly check the water gauge levels to check that they are satisfactory,
3. Boiler pressure should be gradually raised to a level that will allow the injectors to be tested satisfactorily. This will ensure that water can be added to the boiler when required to maintain a safe water level. (Unless your boiler has an extreme leak, it will “gain” water level due to the expansion of the water when heated).

Practical

Under the supervision of your mentor, observe and practice how to light a fire on a steam locomotive. Learn and demonstrate how you can light and build a fire and conduct all the necessary checks as you gradually build the firebed.

6.4 RAISING STEAM

Theory

The burning of coal in a locomotive requires air, which must be admitted through dampers or ash-pan, grates and fire-door. Smoke means imperfect combustion and waste of coal.

Once lit, the size of the fire should be managed so that there is sufficient live coal available to spread over the whole of the fire grate. The boiler pressure and water levels should be gradually adjusted so they will be adequate by the time the driver needs to take charge of the locomotive. Check the local instructions and procedures of your rail operator. If required the blower can be used to ensure there is sufficient draft of the firebed when raising steam (as discussed in the next section)

Take care not to raise steam too quickly as it could damage the boiler itself. Closely follow the rail operator's local instructions on raising steam.

Identify and report any leaks from valves, fittings, pipes, washout plugs, from within the boiler cladding, from the sides of the firebox and other unexpected locations as per the rail operator's standard procedures.

> ***Practical***
>
> Under the supervision of your mentor, observe and practice how to raise steam on a steam locomotive.
>
> Learn and demonstrate how you can manage the size of the banked fire and control the water level so as to create the required pressure of steam to hand over charge of the locomotive to the driver.

6.5 USING A BLOWER WHEN RAISING STEAM AND TAKING REQUIRED PRECAUTIONS

Theory

The blower creates a vacuum in the smoke box that produces draft which draws the products of combustion through the tubes, the firebed and grates. Aids in steam raising prevent flames and smoke entering the cab, and to draft the fire when the locomotive is not working.

It consists of a length of pipe leading from a valve on the side of the locomotive and fitted to a ring around the nozzle of the blast pipe.

A number of holes are drilled in the upper surface of the ring so that when steam is turned on it will pass up through the petticoat pipe and out via the funnel.

It should be noted that it takes little steam to make sufficient draft when the locomotive is stopped. The misuse of the blower is probably the most common abuse of a steam locomotive.

Adjust the blower sufficiently to prevent smoke from coming into the cab via the firebox door.

Turning on the blower too hard draws too much cold air into the firebox which can lead to leaky tubes and stays, as well as unnecessarily stressing the crown sheet, tube sheet, knuckle, and other components.

The use of the blower and fire irons with high ash content coal during light up will lead to clinkering of the ashbed.

Some railways may use an external blower when lighting up. The loco blower can only be used when there is sufficient steam to do so. Many railways therefore have an external blower which is inserted into the funnel to work in place of the loco blower until there is sufficient steam to turn on the loco blower.

> ***Practical***
>
> Under the supervision of your mentor, observe and practice how to use the blower to assist in providing sufficient draft on a steam locomotive.
>
> Discuss with your mentor when and how the blower should be used and the problems with using it inappropriately.

6.6 MINIMISING SMOKE GENERATION WHILE RAISING STEAM

Theory

The creation of black smoke while raising steam, indicates that, at that time, too heavy a fire has been put on and a large quantity of volatile hydrocarbons are being wasted due to temporary insufficiency of air for the combustion of the large volume of gases being emitted. Black smoke indicates there is not enough air for the amount of coal being fired.

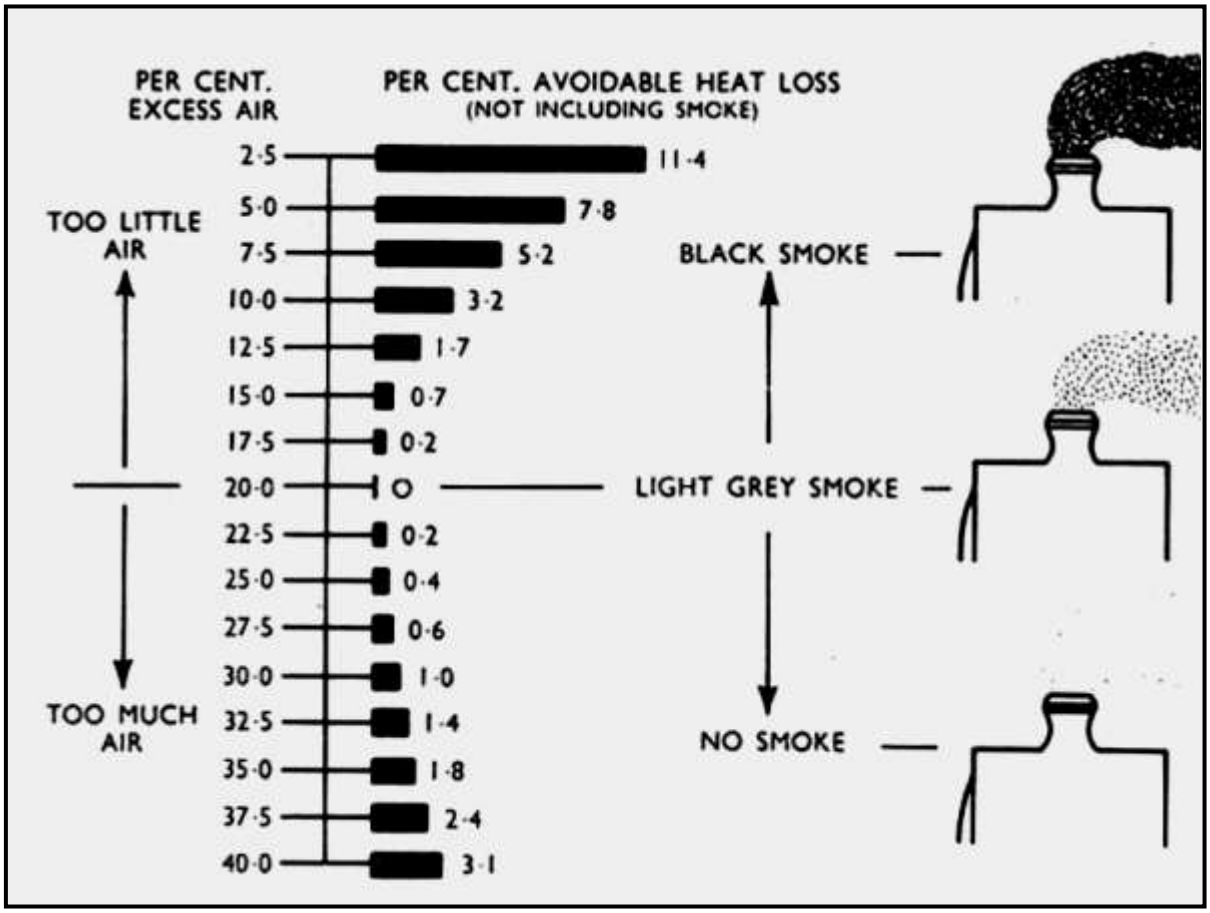
This can often be minimise or rectified by spreading the firebed and increasing the draft of air over the firebed in the firebox. Increased draft can also be temporarily increased by opening the fire-hole door and/or briefly using the blower. The fire-hole door is the source of secondary air that completes the combustion process.

Creating black smoke should be avoided for a number of reasons:

- It is **wasteful and inefficient** as the much of the energy producing gases emitted from the coal are being discharged through the chimney,
- It is **environmentally** bad practice, as it is contributing to pollution of the air, and

- It can be **discomforting** to passengers, as the acrid smoke may blow into carriages or onto platforms at stations

White smoke indicates too much air for the amount of coal being fired and the fuel is not up to ignition temperature.



Excess Air, Heat Loss and Smoke

(*Referenced from 'Handbook for Railway Steam Locomotive Enginemen' – Ian Allan)*

Practical

With the assistance of your mentor, create the conditions that produce black smoke (e.g. put on too heavy a fire with inadequate draft).

Learn and demonstrate how to rectify the problem by spreading the fire and taking appropriate action to increase the draft over the firebed.

6.7 TESTING AND OPERATION OF THE WATER GAUGE GLASS FITTINGS

Theory

There are two types of water gauge glass – tubular and reflex.

Before attempting to test water gauge glass fittings, check that the gauge glass protectors (if they are fitted) are in position (Note that no tubular gauge glass should be operated without its gauge glass protector). If they are found to be defective or missing, you should immediately advise the driver who will take appropriate action.

The type of water gauge glass fittings and the related testing procedures tend to vary from one type of locomotive and rail operator to another. To test water gauge glass fittings, you therefore need to follow the procedures of the rail operator for the specific locomotive concerned. It should be noted that there are only two types of tests for gauge glasses, (1) the '*independent test'* and (2) the *'quick test'*

Every fireman and boiler operator should fully competent with these tests. It is important that there should be no variation of test from one fireman or operator to another.

Practical

Ask your mentor to demonstrate to you the two types of tests for the water gauge glass on your steam locomotive. In conjunction with your mentor, learn, practice and demonstrate how to test and operate the water gauge glass for the locomotive concerned.

6.8 TESTING THE INJECTORS

Theory

What is an injector?

An injector is a device containing a series of nozzles so designed and arranged that steam entering will expand and strike a quantity of water and condense. The increased velocity, due to expansion and heat energy imparted to the water creates sufficient movement to force the water into the boiler against the pressure contained within). They are usually located one on either side of the boiler. Injectors may be classified as lifting and non-lifting. The lifting injector is placed above the high water line in the tank requiring a vacuum created by starting the injector to flood the suction pipe with water The non-lifting injector is placed below the bottom of the water tank. The suction pipe is always flooded.

There are a great many different injectors on the market. All work upon the same general principle, differing only in the details of construction.

The injector operates by converting the thermal and kinetic energy of steam to momentum in the water. This is done via a series of converging and diverging cones in which the steam condenses into the incoming water. In the simplest injector, there is a converging steam cone, from which the steam emerges into the injector at high velocity (having both kinetic and thermal energy). Next is a combining cone, in which the steam jet and water combine. This cone is convergent. Water enters the injector between the steam, and combining, cones. The water and condensed steam emerge from this cone at high velocity (thus having a high kinetic energy but lower thermal energy), and enter a diverging cone (the delivery cone), where the velocity is reduced, However, the overall energy is maintained, and as the mass of water is unchanged, the energy is essentially unchanged in quantity and now manifests itself as pressure, which for the injector to work must be greater than the boiler pressure. The whole device is a practical example of the Law of Conservation of Energy.

When and how should injectors be tested and used?

When sufficient steam pressure is available both fed water injectors should be tested. The type of injectors and the related testing procedures tend to vary from one type of locomotive and rail operator to another. Hence the steps involved in testing and using the injectors are as specified by the rail operator for the specific locomotive concerned. After the test of the injector, the steam valve and the water valve should be shut off in sequence. A blow of steam from the overflow pipe will indicate either steam starting valve has not seated or is leaking. A combination of boiler water and steam blowing from the overflow pipe indicates that the clack valve has not seated or is blowing through.

Practical

Ask your mentor to walk you through the steps involved in testing and using the injectors on your steam locomotive.

Under the supervision of your mentor, learn and demonstrate how you can test and use the injectors on the locomotive.

6.9 PREPARING THE TURBO AND TESTING THE LIGHTS

The turbo on a steam locomotive provides power for lighting the various parts of the locomotive and may also provide power for the head light on the locomotive. In preparation of the locomotive, the turbo is lubricated in accordance with the general instructions relating to turbo operation as published by the railway concerned. Once lubricated, all power requirements should be turned off whilst steam is admitted to the slowly to turbo and as condensate is dispersed. The turbo speed is gradually run up to operating speed. Once the turbo is at normal operating speed, the lights are tested as per the railway's standard operating procedures.

Practical

Under the supervision of your mentor, observe the procedures for preparing the turbo and testing the lights on a steam locomotive. Learn and demonstrate to your mentor how you can prepare the turbo and test the lights as per the standard operating procedures of your rail operator for the type and class of locomotive concerned.

6.10 LIGHTING FIRE AND RAISING STEAM - LEARNER'S NOTES

Insert your own notes here

Insert your own notes here

7 OPERATING THE BOILER DURING A TRAIN JOURNEY

7.1 FOLLOWING APPLICABLE SAFEWORKING PROCEDURES

Theory

All railways follow a system of **safeworking**, -- i.e. a system of rules and equipment used to prevent conflict between trains (and between trains and track workers).

In safeworking systems used on the tourism and heritage lines, the track is divided into sections within which only one train is normally permitted. The end points of these sections may be a place where trains may cross or pass (such as a Station or Crossing Loop), a place where trains leave the main line (a Siding) or just a specially marked location (a Block Point). Permission for a train to enter a section is referred to as an Authority. Each form of safeworking goes about the granting of these Authorities to trains in a different way.

The two most common safeworking systems used by Tourist and Heritage Railways are:

1. STAFF AND TICKET (S&T)

S&T is a token system. It comprises the issue of a Proceed Authority in the form of a staff, or where there is to be a following train in the same direction, a ticket. The system generally allows for only one train to be in the section at one time. However, on sections where following movements are authorised within the section, tickets are kept in the staff box at each end of the section. The staff box can only be unlocked by the train staff for the particular section. The safety of the system depends upon the correct handling of the staff, and where required, the tickets.

The Authority to enter the section is the staff or ticket. Each train entering the section is required to be in possession of the staff or ticket for that section and when provided, comply with signal indications. When trains are proceeding on a ticket, the train crew is required to sight the staff for the relevant section prior to departure. The setting and verification of points is undertaken by the train crews themselves or by workers at attended locations...

2. TRAIN ORDER WORKING (TOW)

TOW is a communications-based system and comprises the issue of a Proceed Authority in the form of a Train Authority, which authorises a train to move between specified points and is issued by train control to the train crew or to workers who arrange delivery to the train crew. The train crew is required to comply with the instructions in the train order together with any additional signal indications. The route over which a train is authorised to move by a Train Authority is verified as clear either through manual procedures or with computer assistance. The setting and verification of points is undertaken by the train crew themselves at unattended block locations or by workers at attended locations and are required to comply with instructions contained with the train order or by rules which include the requirements for crossing or passing of trains.

You must be thoroughly familiar with the safeworking system used on your railway and be able to apply the rules and requirements of the safeworking system correctly when fulfilling your role on the railway. ***This is critical for the safety of the railway, personnel and passengers.***

Note that you will be trained separately in safeworking systems and procedures[1].

> ***Practical***
>
> Discuss with your mentor the safeworking system used on your railway.
>
> Learn and demonstrate to your mentor how to interpret and apply the rail operator's safeworking system when carrying out the duties of a fireman on the railway'.

7.2 RESPONDING TO THE DRIVER'S INSTRUCTIONS

Theory

The locomotive driver is in charge of the operation of the locomotive. It is important that the second person remains attentive to the driver's instructions and responds to them promptly when given.

[1]See ***Safeworking Lesson Plan and WorkBook*** and related resources

Practical

Ride in the cab of a steam locomotive for a train journey and observe the teamwork of the locomotive crew and the way that the fireman assists the driver and responds to his instructions.

Discuss with your mentor the importance of the teamwork and in particular the need for the fireman to respond to the driver's instructions.

7.3 CHECKING AND MAINTAINING THE WATER LEVEL IN THE BOILER THROUGHOUT THE JOURNEY

Theory

During a train journey, it is important that you regularly check the level of water in the boiler to confirm that there is water continues to cover the boiler tubes and crown sheet at all times. This is particularly important when the locomotive is traversing steep grades. Refer to Section 5.3 earlier on checking the water level of a boiler. Should crown sheets ever become exposed while the locomotive is under steam, they will quick overheat and be seriously damaged.

Practical

1. During a journey on a locomotive, observe how the fireman regularly checks the level of water in the gauge glass. Note also how the fireman changes the point of reference on the gauge glass to allow for the grade over which the locomotive is working.

2. Make sure you can read the gauge glass on your steam locomotive and know how to read the gauge glass when working on rising and falling grades. Demonstrate how you can adjust the level of water in the boiler to make sure that the boiler tubes and crown sheet continue to be adequately covers while traversing the grades

7.4 FIRING AND MANAGING THE BOILER THROUGHOUT A TRAIN JOURNEY

Theory

While the train is **on the road**, the coal should be applied lightly and often, spread evenly all over the grates.

It should not be fired with large lumps of coal as the cool air will pass around the lumps, which may cause a hole in the fire. Coal broken to about the size of the fist lies closer together and burns better. Draft should be adjusted to optimise the burning of the coal and the volatile flammable gases given off.

Water should be fed to the boiler as required to ensure sufficient water over the crown. Firing the boiler and water feeding form a partnership (between fireman and driver) to ensure adequate power for operations while still maintaining economical and safe operation of the boiler.

The control of water and the firing of the boiler will vary according to the character of the road ahead.

When approaching a rising grade in the road, it will be necessary to prepare the locomotive for steaming by building up the firebed for the increase in steam demand.

When approaching a falling grade, it will be necessary to ensure there is enough water in the boiler to cover the crown when going over the top of the grade. Prepare the locomotive for drifting by reducing the depth of fire and lowering the level of combustion and temperature. Firemen usually use this period to fill the boiler and prepare the fire for the next section of the road

When **approaching a station** be careful not to put on a fire, as this could cause black smoke. It is also important that you do not perform duties which will distract attention from signals. When **stopping at a station** with a passenger train the fire should be bright and clean with no smoke from the funnel. However, it is always important to have a body of fire, sufficient to maintain the steam pressure when the train is leaving the station.

Practical

1. During a journey on a steam locomotive, observe how the fireman manages the firing of the boiler. Note particularly how and when he adds coal to the fire and how he 'spreads' the fire to optimise combustion. Observe how he uses the combination of the dampers and the fire-hole door to control the draft to the fire and how he manages the boiler water level using the injector.

   Note the importance of using route knowledge to prepare for the characteristics of the road ahead (e.g. approaching a rising grade, a falling grade or a station) and the planning and work the fireman must undertake to ensure the boiler is prepared appropriately to have optimum combustion, temperature and steam pressure for the task ahead.

2. During a journey on a steam locomotive with your mentor, practice (under supervision) the management of the boiler for a range of conditions including (1) standing at a station, (2) starting from a station, (3) steaming up a steep grade, (4) drifting down a falling grade, and (5) approaching and stopping at a station.

7.5 MONITORING AND TESTING EQUIPMENT AND GAUGES REGULARLY TO ENSURE AN ADEQUATE SUPPLY OF FUEL AND WATER TO THE BOILER

Theory

It is important to regularly monitor and test equipment and instruments to ensure that there is an adequate supply of fuel and water to the boiler. This includes:

- Water gauge glass *(Indicates the level of water in boiler. Gauge may need to be periodically tested to ensure correct operation)*
- Steam pressure gauge *(Indicates pressure of steam in the boiler)*
- Injector *(Controls feed of water into the boiler)*

Practical

In conjunction with your mentor during a train journey, monitor the various pieces of testing equipment and gauges on the boiler of the locomotive. Learn and demonstrate how you can test that each is functioning correctly.

7.6 OPTIMISING THE BURNING OF THE FIRE AND THE LEVEL OF STEAM THROUGHOUT A TRAIN JOURNEY

Theory

Combustion is the chemical union of carbon and oxygen in the proper proportions at a high firebox temperature to produce heat. Perfect combustion consists of 2 parts of oxygen and 1 part of carbon brought together at the right temperature of 1370 C°. Imperfect combustion consists of 1 part of oxygen and 1 part of carbon at a much lower firebox temperature of 700 C° producing Carbon Monoxide. Perfect combustion produces Carbon Dioxide.

To optimise the burning of the fire and level of steam, it is important that the fire is kept clean and bright and as thin as conditions will permit.

It is important also that the dampers are fully open and the grates clean to allow air to pass through the fire bed and be heated.

Apply the coal lightly or in small quantities and distribute it over the grate evenly.

Read the fire to determine if the levels of combustion and temperature are sufficient for the road characteristics ahead and build the firebed accordingly.

The optimum depth of the firebed can only be determined by experience as the quality and type of coal and the grades, loads and different types of trains will need various amounts of fire. The depth of the fire should always be kept as thin as possible for the efficient production of steam.

Practical

Under the supervision of your mentor, during a train journey, learn and demonstrate how you optimise the burning of the fire and the level of steam and water in the boiler throughout the journey.

In the course of the activity demonstrate how you read a fire, maintain the firebed and control the water feed to the boiler.

7.7 ENSURING ADEQUATE DRAFT IN FIREBOX

Theory

The air drawn through the grates as a result of the vacuum created in the smoke box is essential for the combustion of the fuel.

Primary air required for initial combustion can be controlled by the use of the dampers. ***Primary air*** passes through the grate and is a vital component for optimising the combustion process and temperatures within the firebox. Usually ***Secondary air*** (i.e. air required to complete combustion) is controlled through the fire-hole door and or holes in the fire hole door.

The airflow is vital for combustion and optimising the temperatures within the firebox. Because the pressure reduction is dependent on the volume of steam being exhausted up the chimney, the amount of air drawn in increases as the engine is worked harder. This provides a measure of self regulation of steam generation, with the fire being forced to work harder as the steam consumption is increased. The effect may be limited if there is an inadequate updraft through the chimney (normally a design issue) or if the grate becomes blocked with ash and clinker, or the spark arrestor screens are blocked.

When the engine is not steaming (i.e. stationary, or drifting downhill, some measure of draft is required. As there is no cylinder exhaust at this time, the boiler is provided with a secondary means of generating some smoke box pressure reduction. This “blower” is a steam jet (usually placed near the cylinder exhaust nozzle) manually controlled by the fireman, which acts in similar fashion to the cylinder exhaust, but not as fiercely.

Practical

During a train journey under the supervision of your mentor, learn and demonstrate how you can monitor the draft in the firebox under various conditions.

In particular, demonstrate how you ensure the grate does not become blocked by spent ash or clinker.

7.8 CHECKING AND CLEANING ASH PAN (WHERE APPLICABLE)

Theory

Depending on the rail operator concerned, the type of locomotive and the fuel being burned, its may be necessary to check and clean the ashpan of the locomotive. Check the standard operating procedures of your railway to determine a fireman's responsibilities and the standard operating procedures for checking and cleaning an ash pan during a journey. The following is an example of such procedures:

During a journey, ash will gradually accumulate in the ashpan. You should regularly check that the ash pan is not becoming overfull as this will affect the available draft under the firebed (in extreme cases this may cause firebars and carriers to melt). During service it may become necessary to clean the fire and empty the ash at an ash pit. Your Railway's standard operating procedures will advise on the precautions to be taken when cleaning the ash pan.

Prior to approaching the pit, the fire should be allowed to gradually burn down. In most cases a light fire is put on so that there is a bed of burning coals to remake the fire on. The *water level should be adjusted to allow the injector to be turned on periodically while standing on the pit to prevent the safety valves blowing off.*

Once over the pit, the ash pan should be opened and the rocker grates operated (ashpan cages or hopper doors) as per standard procedures for the type of ashpan fitted. Once the de-ashing operations are completed the flushers (ashpan wetter) must be turned off and the hopper doors or ashpan cages closed tightly and secured. The fire is then remade ready for further service. The ash discharged from the locomotive must be quenched and left in a condition as detailed in your Railway's standard operating procedures.

> ***Practical***
>
> During a train journey under the supervision of your mentor, learn and demonstrate how you can check and clean the ashpan (where applicable).

7.9 TAKING ON WATER AND FUEL

Theory

It is important that at appropriate stages of service, the locomotive takes on water and coal to ensure there is an adequate supply of both for planned operations.

When taking on water, the water level of the tank should be monitored as it fills and the control valve should be slowly closed to reduce the flow of water as the final

inches of the tank are filled. After filling the tank, the water supply jib should be returned to its normal position and the tender tank lid closed as per standard procedures for your railway. Prior to taking coal, the fireman should close and secure the coal bunker doors and secure all fire irons on their brackets. The railway's standard procedures should then be followed for taking on coal at the designated re-fuelling points.

Practical

During a train journey under the supervision of your mentor, learn and demonstrate how you can take on fuel and water as required.

Note that some railways use chemicals to treat boiler water. You should check if your railway has requirements for treating boiler water control salt levels and hardness> If so discuss with your mentor the railway's procedures for chemically treating boiler water and the responsibilities of the fireman in this process.

7.10 ASSISTING THE DRIVER WHEN APPROACHING AND TRAVERSING FIXED LINESIDE SIGNALS, POINT STAND INDICATORS, TRACKSIDE SIGNS AND LEVEL CROSSINGS

Theory

Prior to departure from the commencing location, the locomotive crew must sight the appropriate safe working authority and ensure that it is retained on the locomotive. When entering another section, the locomotive crew must have confirmed -- before entry -- that the safe working authority for the section had been obtained and sighted.

When operating a steam locomotive during a train journey, its is crucial for effective safeworking that correct procedures are followed when approaching and traversing fixed lineside signals, point stand indicators, check points, trackside signs and level crossings. The driver and the fireman work in partnership to observe the signals and to scutinise for any abnormal situation that might occur at a level crossing. The fireman assists the driver by double checking the situations at fixed signals, point stand indicators, check points, track side signs and level crossings and aiding the driver in taking all required action as per safeworking rules and standard procedures. All signs and signals must be called and acknowledged.

Practical

1. Ride in the cab of a steam locomotive for a train journey and observe the teamwork of the locomotive crew and the way that the fireman assists the driver in the observance of fixed signals, point stand indicators, check points and track side signs and the procedures for approaching and traversing level crossings..
2. Discuss with your mentor, the procedures for observance of fixed signals, point stand indicators, check points, track side signs and level crossings and potential abnormal situations that can occur at level crossing and related action that needs to be taken should they occur.
3. Learn and demonstrate during a train journey how you must assist a locomotive driver in the observance of fixed lineside signals, point stand indicators, check points, trackside signs and level crossings

7.11 REMAINING VIGILANT INCLUDING LOOKING BACK TO TRAIN

Theory

During a train journey it is vital that the fireman remains vigilant at all times to identify any situation that may potentially be unsafe or cause a problem in the safe and efficient running of the train. This may include problems on the road ahead, on the locomotive itself or and the train being drawn. In this regard it is the fireman's special duty to regularly look back at the train being drawn to check that there are no problems occurring.

Practical

During a train journey under the supervision of your mentor, learn and demonstrate how you can practice being vigilant and recognise any situations that may potentially be unsafe or cause a problem in the safe and efficient running of the train. In particular demonstrate how you regularly 'look back' at the following train.

7.12 RESPONDING TO ABNORMAL SITUATIONS THAT MAY ARISE DURING A TRAIN JOURNEY

Theory

There are a range of abnormal and emergency situations that may occur during a train journey. You should be aware of recognising abnormal and emergency situations and your railway's procedures in the event that they occur. The following are some examples of potential abnormal and emergency situations.

- failure of a fusible plug or other safety device (see below)
- a track obstruction
- trespassers crossing the track
- equipment failure
- wheel slip and uncontrolled slide
- signals in stop mode
- incorrect information or failure in communications
- a passenger emergency (e.g. illness or injury)
- an ill crew member (note that in the event of the driver becoming incapacitated, the fireman may need to take over the driving of the locomotive on a temporary emergency basis)
- a passenger initiated alarm
- a false alarm
- a derailment
- a collision
- a chemical spill
- a fire and explosion on the locomotive or train
- a bomb threat
- head or marker light or whistle failure

Note that you should refer to your railway's policy and procedures for the action to be taken by train crew in the event of a **locomotive breakdown.**

Failure of a fusible plug

A fusible plug is a safety device used to provide a warning of that the water level in the boiler has already fallen to a dangerous level. The plugs are fitted in the top of the fire box crown. Under normal circumstances, the water covering the firebox crown prevents the lead melting. If the water level falls below the top of the firebox crown, the plug overheats and melts. The resulting blast of water and steam acts as a warning (and may perhaps subdue the fire to some extent preventing further damage)

A fireman needs to be aware of their railway's specific emergency procedures that must be followed in the event that a fusible plug melts.

An example of such procedures is:

> *Remove or extinguish the fire, but keep the blower going strongly to keep steam from entering the cab. In the case of oil, turn it off. In the case of a solid fuel, if there is a drop grate arrangement, drop the fuel into the ash pan, with the ash wetter turned on. In some arrangements, where the fire cannot be easily dropped it may be necessary to smother the fire with earth or sand. However, any practice that requires the fire door to be open has risk of burning for the crew, so this must be done with due care, and with the blower operating. Do not inject feed water, as this may flash to steam on the overheated plates of the boiler, causing greater volumes of steam and/or water to pass through the fusible plug. In all cases, steam is to be vented from the boiler by whatever auxiliary devices are available. (For example, the steam still ends up in the same place with the water turned off).*

The failure of a fusible plug indicates a very serious emergency situation and is a reportable occurrence. It is extremely important to know the emergency procedures of your railway in terms of action that must be taken in the event of the failure of a fusible plug.

Emergencies and Emergency Management Plans

Ensure you are familiar with your Railway's Emergency Management Plan and how it is applied in conjunction with the Emergency Services in your area. In the case of an emergency, confirm who is initially in charge of the site and when and how this responsibility changes to the Emergency Services and the Senior Combatant Agency at the site.

You need to be familiar with your responsibilities in the case of emergency and the requirement not to undertake any activity that is likely to destroy any evidence unless it is essential to do so in the treating of injured persons.

The incident site is controlled by the Senior Combatant Agency on site until such time as it is cleared and declared a wreck, then the Railway becomes responsibility for clearing of the track.

Prior to allowing work to commence on site, the Railway must ensure that it has undertaken an investigation to establish ensure and that all necessary evidence has been obtained.

Note: Emergency Services terminology varies from State to State, hence some terms will need to be changed to reflect the terminology of the State in which the training materials to be used. In all States, the Senior Combatant Agency is the Police except where a *Dangerous Goods Spill* occurs in which case the Emergency Services will take charge.

Notifiable Occurrences

Rail Safety Regulations require that all incidents which occur on a railway are deemed as either Category A or B. A category A incident must be reported by the railway to the Rail Safety Regulator immediately or at least within 2 hours of the incident by the person nominated by the railway concerned. A written notification is required on the appropriate form within 72 hours. Incidences deemed as Category B are to be reported within 48 hours on the appropriate form by the designated person from the railway. Each railway will have its own procedures for handling of the investigation and reporting or emergencies and all workers need to be aware of these requirements. In some instances, the Rail Safety Regulator may advise that an investigation will be conducted by that organisation and therefore nothing is permitted to be shifted until such time as the investigation has been undertaken.

If the incident occurs on a railway operated by another organisation, the railway concerned will have an operating agreement detailing the actions to be taken.

(Note: *In some States, the time frame for reporting of Category B incidences may vary and customised training materials based on the generic Lesson Plans will need to reflect the requirements of the State in which they are to be used.)*

Practical

Check your railway's documentation regarding abnormal and emergency situations and what action should be taken when they occur. In particular identify the role of the fireman in these situations.

Discuss potential abnormal and emergency situations that could occur on your railway with your mentor and the action you would need to take if they should occur. Discuss also the *Emergency Management Plan* of your railway and the policy and procedures related to *Notifiable Occurrences*,

7.13 GIVING AND INTERPRETING HAND SIGNALS

Theory

Firemen work directly with other members of the train crew and other qualified railway personnel in the safe and effective operation of locomotives and trains. A key skill required of all the railway personnel concerned is being able to give and interpret the standard railway hand signals.

In various circumstances, these hand signals may be complemented by the use of flags and lights (e.g. where night work is involved). It is important therefore that you are proficient in giving such signals as per your railway's standard procedures. You must also be able to recognise and correctly interpret signals given by others.

Note: If a hand signal is not received when one is expected, or a hand signal cannot be interpreted, the movement must be brought to an immediate and smooth halt until the correct hand signal is again received.

Practical

In conjunction with your mentor obtain and study your railway's procedures for the signals you need to be able to give and interpret when working with other railway personnel during the operation of a steam locomotive / train. In particular, identify and discuss with your mentor the various situations in which the signals are used during locomotive and train operations.

Ride in the cab of a steam locomotive for a train journey and observe the use of hand, flag and light signals by the train crew and other railway staff during the journey. Note how the crew watch for and observe the Guard's hand signal when arriving at a platform. Where the platform is on the fireman's side, the fireman will relay the hand signals to the driver.

Learn and demonstrate to your mentor the giving and interpretation of the various hand, flag and light signals used on your railway.

7.14 STOPPING AND SECURING A TRAIN IN AN EMERGENCY, INCLUDING THE SAFE MANAGEMENT OF THE BOILER

Theory

When a train has been stopped such as in an emergency and has been brought to a stand and will remain stationary for a lengthy or unknown period and may be left unattended, the procedure for securing the train is as follows:

- Fully apply the brake, screw on the engine hand brake,
- Place the reversing gear in centre position and open the cylinder and steam chest drain valves,
- Secure the regulator by placing the locking pin in position,
- Check the boiler water levels and ensure that the boiler will be left with sufficient water in it,
- Close all steam valves and head valve (where fitted), and
- Where the locomotive is to be left unattended for a period, close the boiler water isolating valves.
- Ensure the fire is left in an appropriate state, this may involve dropping the fire (Note that by law a boiler cannot be left unattended with a fire on the grate and pressure on the gauge)

Practical

During a test drive of a train in conjunction with the locomotive driver and under the supervision of your mentor, demonstrate the procedures you would follow as a fireman during a simulated emergency halting of the train.

In the simulation, take all required measures to secure the train including the safe management of the boiler.

7.15 OPERATING THE BOILER DURING A TRAIN JOURNEY - LEARNER'S NOTES

Insert your own notes here

8 CLEANING AND CHECKING THE BOILER AFTER OPERATIONS

8.1 CONFIRMING LOCOMOTIVE IS SECURED PRIOR TO POST-OPERATIONAL CLEANING AND CHECKING OPERATIONS

Theory

When shutting down and stabling a steam locomotive you must first move it to the ash pit or allocated location. Manage the fire as for example, holes in the firebed whilst using the blower and injectors might start the tubes leaking. Nor should there be a heavy green fire, as this is wasteful. There should be enough fire to fill the boiler before dropping the fire. Water should not be injected into a boiler when there is no fire on the grate. You should ensure there is a full glass of water, so as to avoid the use of the injector, when the fire-box temperature is low. Make sure you have a good pressure of steam to enable the locomotive to be moved to the allotted position in the shed.

> ***Practical***
>
> Under the supervision of your mentor and in conjunction with the train driver, progressively move the locomotive to the positions where you can replenish coal, sand and water. The locomotive should then be positioned over the ash pit and the brakes applied ready for emptying the ash pan prior to the conduct of required post-operational checks, cleaning and lubrication.

8.2 CLEANING OF SMOKEBOX

Theory

Normally, the smokebox is cleaned when the locomotive is parked on the ashpit prior to stabling and dropping the fire. The typical sequence is:

1. Clean smoke box.
2. Fill boiler with water whilst there is fire on grate.
3. Drop fire into ashpit.
4. Ensure firebars and ashpan clear and clean
5. Ensure fire-hole door is shut.
6. Ensure ashpan doors are shut.

7. Shut the dampers.
8. Stable and secure loco.

Check the procedures of your rail operator for the cleaning of the smokebox on your locomotive. Typically the procedures will be as follows.

Prior to opening the smokebox door, the firehole door should be closed. The door should be opened slowly allowing any accumulated combustible gases to escape. The smokebox should be examined and including….

- Checking for indications of water or steam leaks from boiler tubes and steam pipe joints,
- Checking that the spark arrester mesh is clean and undamaged,
- Checking that the spark arresters and baffle plates are not broken or loose, do not have excess gaps and that there are no steam blows,
- Removing any cinders/ flyash which may be in the smokebox,
- Making sure that the smokebox door ring is clean of any ashes and the door seal intact, and
- Closing and tightening the smokebox door and testing for leaks with the blower turned on (a lighted flare lamp can be used by running it around the door joint).

> ***Practical***
>
> Under the supervision of your mentor, learn and demonstrate the procedures for the examination and cleaning of the smokebox on a steam locomotive.

8.3 CONDUCTING CLEANING OPERATIONS INCLUDING FIRE CLEANING, DUMPING OF ASH AND OTHER CLEANING DUTIES

Theory

Once the locomotive is moved to the ash-pit, open the ashpan slides and apply the ash-wetter (if fitted). Open the dead plate (if fitted), then use the handle provided to shake the rocking grates to remove the fire. The pricker and/or rakes may in some instances have to be used to push the ashes through the dead plate (grate) opening, or to break up clinker which is too large to pass through the grates.

After the ash pan has been emptied, shut off the ash-wetter (if fitted) and blower and close the dampers. Examine the ash pan and make sure it is clean and secure. Close the dead plate (if fitted) and the ash-pan..

In the case of heritage and tourist railways, the fireman will also assist in cleaning the locomotive to ensure that all grime and grease is removed and paintwork and brassware cleaned as per the standard procedures of the rail operator. It is important during fire cleaning and dumping and other cleaning operations to follow all standard procedures and rail safety requirements to prevent injury and damage

Practical

Under the supervision of your mentor, learn and demonstrate how to conduct cleaning operations on a steam locomotive after service including dumping of ash cleaning of the firebox and other cleaning duties as per your rail operator's standard procedures.

8.4 CONDUCTING A VISUAL INSPECTION AND OTHER POST-OPERATIONAL CHECKS OF BOILER AND ASSOCIATED EQUIPMENT

Theory

After service it is important that all required post operational checks are undertaken as per the rail operator's checklist and standard procedures. Any identified problems should be recorded, reported and rectified (if possible and appropriate).

Firemen need to be aware of their railway's policy and procedures for the washing out of a locomotive boiler and any responsibilities they may have in the process. A useful reference is *the 'RISSB Boiler Code of Practice, Appendix T - Washouts*

Practical

Under the supervision of your mentor, learn and demonstrate how to conduct a visual inspection and other post-operational checks of boiler and associated equipment.

8.5 COMPLETING ALL REQUIRED POST-OPERATIONAL LUBRICATION AND GREASING TASKS

Theory

As discussed in Section 5.4 above, it is very important, that all bearings and other moving parts on the locomotive are well and constantly lubricated.

When stabling a locomotive therefore, a fireman must follow the post-operational lubrication checklist issued by the rail operator for the type and class of steam engine concerned.

> ***Practical***
>
> Under the supervision of your mentor, learn and demonstrate how to conduct all required post operational lubrication and greasing requirements as per the rail operator's standard procedures for the type and class of locomotive concerned.

8.6 TOPPING UP WATER LEVEL IN BOILER AS PER STANDARD PROCEDURES

Theory

Before leaving a steam locomotive after service, you should apply the hand brake and check the level of water in the boiler. If necessary, add water to make sure that there is a minimum of 3/4 of a glass of water in the boiler.

> ***Practical***
>
> Under the supervision of your mentor, learn and demonstrate how to top up the water level in the boiler prior to stabling the locomotive after service as per the rail operator's standard procedures.

8.7 CHECKING THAT TOOL KIT, FIRE EXTINGUISHER, FIRST AID KIT AND OTHER LOCOMOTIVE EQUIPMENT IS IN OPERATIONAL CONDITION AND IS CORRECTLY STOWED

Theory

When stabling a locomotive its is important that all ancillary equipment such as the tool kit, fire irons, fire extinguisher, first aid kit and other locomotive equipment (including communication equipment) is checked to make such they are complete and are in operational condition.

If there are any defective or broken components or if some parts of the kits or equipment are missing, take appropriate action to report and rectify the problem.

Make sure that the tool kit, fire irons, fire extinguisher, first aid kit and other locomotive equipment are properly stowed and/or returned to store and are ready for use when the locomotive is next prepared for service.

> ***Practical***
>
> Under the supervision of your mentor, learn and demonstrate how to check that the tool kit, fire extinguisher, first aid kit and other locomotive equipment is in operational condition and is correctly stowed or returned as per the rail operator's standard procedures.

8.8 CHECKING AND CONFIRMING THAT BOILER AND ASSOCIATED EQUIPMENT HAS BEEN RESTORED TO REQUIRED POST-OPERATIONAL CONDITION

Theory

Before leaving the locomotive in the shed, the fireman should make one final check that the boiler and all of its associated equipment is in its required post-operational condition and properly secured as per the rail operator's requirements

> ***Practical***
>
> Under the supervision of your mentor, learn and demonstrate how to conduct a final check that the boiler and all of its associated equipment is in its required post-operational condition and properly secured as per the rail operator's requirements.

8.9 COMPLETING REQUIRED POST-OPERATIONAL DOCUMENTS AND REPORTING ANY FAULTS OR DEFECTS FOR APPROPRIATE ACTION

Theory

Prior to signing off make sure that all necessary paperwork has been completed as per the rail operator's requirements. This may include:

- Time sheet,
- Log or record of boiler operations,
- Reports of operational problems with boiler operation and/or any defective equipment identified and details of any action taken or required,
- Reports of any safety incidents as per rail operator's procedures and regulatory requirements, and
- Paper work related to the return of kit to store.

Practical

Under the supervision of your mentor, learn and demonstrate how to complete all require post-operational paperwork prior to signing off as per the rail operator's requirements.

8.10 CLEANING AND CHECKING THE BOILER AFTER OPERATIONS-- LEARNER'S NOTES

Insert your own notes here

Insert your own notes here

SEPARATE ATTACHMENT 1

FIREMAN

KNOWLEDGE

CHECKLIST

SEPARATE ATTACHMENT 2

FIREMAN

PERFORMANCE

CHECKLIST