Method Statement
Operation and Maintenance of the Beam Engine

Version	7
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The HTA is responsible for ensuring that this Method Statement is kept up to date	

Issue History

Version N°	Date of Adoption	Details of Change Made
1-4		Versions 1-4 bear no relation to Version 5, which was a new document
5	4/3/2014	Approved and issued as a new document.
6	21/03/14	Version 5 modified by Resolution of the Board to remove the discretionary sub clauses in paragraph 5 of Section 2.1
7	29/03/24	Complete rewrite with significant updates

Acknowledgement

The rewriting of this Method Statement has been a major team effort. Special mention must be made of the contribution made by Peter Hirst (late Head of the Beam Engine Technical Area). Right up to his last visit to the Mill Peter was determined to do what he could to ensure this project was successful. Sadly he died before it was completed.

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1. Introduction, Purpose and Scope

1.1. Introduction

The Combe Mill Beam Engine is an operating Heritage machine. As such it has no supporting original documentation. This document known to the Society as a method statement stands in its stead. All members who operate or work on the engine are expected to be familiar with its contents. Members coming fresh to the Beam Engine will initially be given a tour of the beam engine and encouraged to read the Society's booklet entitled "Combe Mill Beam Engine". The booklet, prepared by long time member Tony Simmons describes the work that was done by the early members to rescue the engine from its delapidated state and to establish the basic principles on which it was and still is operated.

1.2. Purpose and Scope

This method statement sets out the instructions that must be followed when starting up, operating and closing down the Beam Engine that operates the line shafting in Combe Mill (the Beam Engine).

It also covers:

1 the inspection, testing and maintenance of the engine

2 the operation of the steam processing system in the Engine House that also supplies steam to the small engines and

3 the interconnection between the cooling system and the small engines' steam condenser.

2. Safety

2.1. Operation of the Beam Engine

1 The Beam Engine operates using steam supplied by an oil fired boiler located adjacent to the Engine House. The wet steam is supplied to the equipment in the Engine House via a steam main operating at 100psi[*]. Prior to its use in the beam engine its pressure is reduced to approximately 30psi.

2 Overall control of the operation and maintenance of the Beam Engine and its steam supply system is vested in the Head of Technical Area (HTA). The HTA is appointed by the Board and has overall control of the operation and maintenance of the Beam Engine and its associated equipment in the Engine House.

- ◊ **Note**: Whenever the term HTA is used in this document it is to be interpreted (except in those cases where the local context forbids this interpretation) as including any person authorised to act on behalf of the actual office holder[†].

3 The engine must only be operated and maintained by approved operators or by trainees under the personal supervision of an approved supervisor. Approved operators come in two categories:

[*] In this document all pressures are quoted as pounds per square inch gauge (psig). The registered pressure on the engine's gauges is that above the local atmospheric pressure and they read zero when exposed to atmospheric pressure.

[†] Such authority can be bestowed either by the formal holder of the office of HTA or by the Board

a **Proficient Persons (PP)** who are persons approved by the HTA as qualified to carry out all the procedures set out in this Method Statement and to oversee the work of Competent Persons.

b **Competent Persons (CP)** who are persons approved by the HTA as competent to control the normal operation of the engine and to shut it down in an emergency.

◊ A Proficient Person must be available on the Combe Mill site whenever the engine is under the control of a Competent Person.

4 **Trainees** must only have control of the engine if they are personally supervised by a Proficient Person who is present at the engine and able to take immediate control.

5 Only engine operators and, when appropriate, trainees are allowed within the operating area when the engine is in steam.

a The PP in charge of the Engine may admit a person if he/ she believes it to be necessary.

b When the Engine is temporarily under the control of a CP the request for access must be denied.

2.2. Warnings

1 **General**: Normally when the engine is to be run the line shafting is connected directly to the engine by a belt. As a result when the engine starts the line shafting starts to rotate.

a This direct linkage poses significant risks to members and visitors

b To minimise these risks the system has two basic safety arrangements; They are:

◊ A red and green disc system (see Sections 2.5.3 and 4.4.2); and

◊ A bell system whose sounding indicates that the status of the line shafting is about to change (see Section 2.5.2).

c There is a third communication system. This was installed when it was expected that the heritage workshop machinery would be in regular use. It allowed an exchange of signals between the engine operator and machinists working on the heritage machinery. This expectation was not realised and the equipment although still in place is not in use. The use of this signalling system is described in Method Statement 14 (MS_14), which has been archived.

2 **Important Safety Notice**: The presence of the green disc means that an appropriately qualified person could legitimately start up the engine. As a consequence a person wishing to work on a task that requires the engine and its associated line shafting remains stationary must:

a Ensure that the engine's steam inlet valve is closed

◊ The closed valve provides an additional level of protection against the accidental admission of steam to the engine,

b Remove the green safety disc

◊ This action transfers control of the potential start-up of the engine to the person at risk.

At the end of the work for which the potential start-up of the engine was embargoed the person undertaking the work must:

c Return the green disc to its normal position

3 **Engine inertia**: The engine and its attached machinery have considerable inertia and cannot be stopped instantaneously.

4 **Dropped Objects**: Much of the engines machinery is located below ground level in a Sump Tank and is subject to damage from dropped heavy objects. Some of the actions in this method statement involve handling heavy and/or unwieldly equipment. To minimise the associated risk, this method statement sometimes requires the presence of a second person.

◊ The HTA may determine that other operations, not specifically designated in this method statement, require the assistance of a second person. Where such decisions are made they are mandatory in the same way as they would have been had they been made in this method statement.

◊ Where an operation requires the presence of a second person, it **must not be attempted in the absence of this person**. In certain circumstances the second person need not necessarily be a Competent or Proficient Person.

5 **Entry to Engine Sump**: If it becomes necessary to enter the Engine Sump, the flywheel **must be locked** with a bar before entry is attempted and a second person must **always** be present (see Section 2.6 on Lone Working).

6 **Lubrication**: Never attempt to adjust or lubricate moving parts of the engine while it is running unless the part was designed to be so operated.

◊ The obvious example is control valves.

◊ Any exceptions to this instruction must be authorised by the HTA and entered in the Beam Engine's Log Book.

7 **Cleanliness and Obstructions**: Keep the operating area around the engine clear of obstructions at all times.

8 **Potential injury to fingers**: When using the manual slide-valve control lever be aware that when the lever is at the top of its travel there is very little clearance between it and the hand wheel of the steam inlet valve. Keep fingers clear. The need to observe correct procedure is highlighted in paragraph 4.4.2 on page 14

2.3. Emergency procedure(s)

1 To shut the engine down in an emergency:

a Close the inlet steam valve on the engine

◊ If the steam inlet valve cannot be closed, close the main stop valve (V) (see Figure 1 which forms part of the Appendix)

⇒ The main stop valve is coloured blue and is located, at a high level, on the rear wall of the Engine House

b In the event of a major steam leak requiring the immediate evacuation of the operating area the engine must be stopped using the Crown Valve on the boiler

◊ The Crown Valve is located immediately on top of the boiler and it too is coloured blue

⇒ All engine operators must know the location of this valve.

2 The operational procedures set out in this method statement are designed to ensure that the steam pressure fed to the engine is approximately 30 psi.

- ◊ A detailed description of the steam treatment system is given in the Appendix (Section 7.1).

2.4. PPE and Consumables

1 Proficient Persons before attempting to operate the engine must ensure that appropriate PPE is available and used, and that appropriate consumables are available.

2 The following PPE is necessary for working on the engine when it is being steamed:

a Close fitting gloves

b Overalls: worn in such a fashion as to prevent any undergarment, neck tie or scarf from becoming entangled in the moving machinery.

- ◊ If overalls are not worn, the chosen clothing must be close fitting and contain no items that might come into contact with moving machinery.

c Persons with long hair must additionally wear an appropriate close fitting cap or hair net.

3 Members supervising others must ensure that persons under training, contractors, other volunteers and visitors wear any required PPE. Persons declining to do so must not be allowed to undertake the operation.

4 The following consumables are required:

- ◊ Steam Oil
- ◊ Gland Packing
- ◊ Gasket Material
- ◊ Neats Foot Oil
- ◊ Plumber's Mait
- ◊ General Lubricating Oil: as used elsewhere in the Mill

2.5. Relationship to other systems / equipment

2.5.1. The Boiler

1 The beam engine is dependent on a supply of steam from the boiler.

a The main stop valve (see figure 1) must not be opened without the permission of the person responsible for the operation of the boiler.

b In the event that the steam supply from the boiler fails, the main stop valve and the steam inlet valve on the engine must be closed and the drain cock on the engine steam supply pipe opened.

- ◊ Following closure, the stop valve must not be reopened without the specific approval of the person responsible for the operation of the boiler.

2.5.2. Small Engines

1 The beam engine's steam supply system also supplies the steam that powers the small engines.

2 The beam engine also supplies the cooling water for the small engines' condenser.

◊ A consequence of these arrangements is that the operation of the beam engine, the Society's boiler and its small engines are interdependent (see Appendix 1).

2.5.3. The Line Shafting and Equipment Attached to it.

1 In normal operation the beam engine is connected directly to the line shafting. As a result when the engine starts the line shafting starts to rotate. In addition some machinery may be attached to the line shafting: even when it is not rotating.

a To minimise the associated risks, the system has two in built safety arrangements:

◊ A red and green disc system (see Section 4.4.2)

⇒ This provides a clear indication to the engine operator that the engine must not be started.

➢ **Warning when the green disc is absent, the display shows red and the engine must not be started.**

⇒ The system ensures that the state of the beam engine is under the control of the person who is at risk.

◊ A bell system whose sounding indicates that the status of the line shafting is about to change.

⇒ This system is under the control of the engine operator

⇒ If the line shafting is rotating, the sounding of the bell means that it is about to stop

⇒ If the line shafting is stationary, the bell's sounding means that the engine operator is intending to start the engine.

2.6. Lone Working

1 Operation of the engine also requires the operation of the boiler and one person cannot be in two places at once. The beam engine cannot therefore be steamed on a lone working basis.

2 Approved operators may carry out routine maintenance on a 'lone working' basis subject to the following conditions:

a All such operators must be approved by the Beam Engine's HTA, and be aware of and abide by the requirements set out in the method statement on Lone Working (MS_12).

◊ Lone working introduces new hazards and increases the risks associated with others

b **Embargo**: No person may enter either the hot or the cold wells in the engine sump on a lone working basis.

c The HTA may ban the execution of operations on a 'lone working' basis as he/she sees fit

d All such additional banned operations must be recorded by the HTA on a list

◊ The list must be incorporated into the Beam Engine's logbook

- ◊ The tasks placed on the list must be reviewed on a regular basis
  - ⇒ The maximum permitted period between reviews is 12 months

e Prior to starting a maintenance operation on a 'lone working' basis the operator concerned must satisfy him/ herself that the proposed work is not on the banned list.

- ◊ An operation that is on the banned list must not be undertaken unless at least two approved operators are present at the Mill

f Once placed on the banned list an operation remains banned until it is removed from the list.

3. Periodic Inspection, Testing and Maintenance

1 Prior to each steaming the HTA or other Proficient Person must inspect the engine and:

a ENSURE that any recorded faults have been addressed

- ◊ In the case of a minor fault it would be sufficient to record that in the opinion of the inspector the fault was minor and did not prevent safe steaming and could be addressed at a later date.

b ENSURE any necessary maintenance, other than that included as part of the start-up procedure, has been carried out.

c ENSURE by visual inspection that no reason that would prevent the safe steaming of the engine has been highlighted.

2 RECORD the outcome of the inspection in the logbook, dated and signed.

3 In the event that the engine has not been inspected, a Proficient Person may inspect and self-certify the engine.

4. Start up

4.1. Overall View

1 Operators of the Beam Engine have always recognised that to get the engine moving steam pressure on the piston for most of a full stroke may be needed. Under automatic control the slide-valve cuts off steam part way through the stroke (at ½ stroke on the up-stroke and ⅓ on the down-stroke). Skilled manual control of the slide-valve allows the steam supply to be maintained for the best part of a full stroke. So for starting, use of the manual control facility might be necessary.

2 Whatever the technique used there is a better chance of a successful start if the piston is initially near the beginning of its working stroke. There is a consequent need to check the positions of the crosshead and crank and, if necessary, to put the engine in a favourable position. This is achieved by:

- ◊ Either manually moving the position of the piston in the engine using a now otherwise redundant former major drive pulley*, or
- ◊ by positioning the slide-valve for the desired direction of motion and admitting a little steam via the inlet valve to push the piston up or down.

* Historically the engine was turned to a favourable position by barring it with a removable lever which engaged with the flywheel teeth. Given the engine's historic significance, although not now in use, this latter process is described in Appendix 7.3.

3 This general approach has been retained in the present version of the Method Statement.

4.2. Essential Preliminaries

1 AIM to carry out the actions in this section on a day immediately before the steaming day:

a Typically, when the engine is to be steamed on a Sunday, the actions should be completed on the previous Wednesday.

b The actual timing is determined by the HTA or the Proficient Person who is proposing to run the engine.

c **All must be satisfactorily completed before steam is first admitted to the engine.**

2 The person in charge of the engine must:

a ENSURE that the beam engine is correctly connected to the line shaft and, if necessary,

b CONSULT with the HTA and agree a way forward If the line shaft is disconnected

3 ENSURE the engine and shafting has been adequately lubricated.

a If necessary, carry out any required oiling in accordance with the instructions in MS_15.

b Never start up the engine if it is coupled to an inadequately oiled line shafting.

4.3. Pre-Use Checks and Actions

1 LUBRICATE all points on engine and outrigger bearings

2 INSPECT visually the engine for damage, missing parts etc.

3 Prepare the engine ready to run by carrying out the following actions:

a PUMP out any water that has entered the flywheel pit.

b ENSURE the engine's river water pump is in place and correctly installed.

◊ If the engine has been out of use for some time, this pump will have to be reassembled and reinstalled (see instructions h and i below)

c ENSURE that the electrical pump that pumps river water into the Cold Well is in place and ready to run.

◊ Be aware that this pump is known locally as the Plan B Pump to distinguish it from the engine's own cooling water pump.

⇒ The pump is in the Water Wheel Room and may have to be lowered into the tail leat.

⇒ The pump's control switch is mounted on the wall of the Wheel Room adjacent to the pump's position in the tail leat.

d FIT the cold well drain plug in the hole in the bottom of the cold well.

◊ The drain plug is a tapered plug on the end of a long pole;

◊ It is stored in the corner of the engine room nearest to the steam inlet valve

e CLOSE the manifold drain valve using the special long reach tool.

- ◊ The manifold drain valve is a stop cock in the cold well between the condenser, which is under the steam chest, and the condenser pump, which delivers the condensed steam/water into the hot well.
  - ⇒ The condenser pump is the local name applied to what is normally called a scavenge pump.
  - ⇒ The drain valve allows the condenser pump to be drained, when required.
  - ⇒ The special long reach tool consists of a tube with a slot at one end that engages with a handle on the valve. It is stored in the corner of the engine room nearest to the steam inlet valve.
    - ➢ **In use take care not to drop the tool it could damage the drain valve.**

f LEAVE the hot well drain valve permanently open; no action is required

- ◊ For information the drain valve is in the bottom of the crank shaft pit and is difficult to operate

g LOWER the Plan B pump into the water in the wheel room and then part fill the cold well with river water using the pump

- ◊ Be aware that this task may have been completed earlier

h INSERT the engine's water pump foot valve,

- ◊ Careful cleaning of the pump's structure normally allows for the pump to mate with its housing.
  - ⇒ In the past there has been a problem getting the pump to mate with its seating. The solution adopted at the time was to first coat the seating's tapered surface with a 2-3 cm band of Plumber's Mait. This solved the immediate problem but created difficulties of its own.
- ◊ Use the long handled hook to lower it into the correct position and a wooden thumping tool to set it in place.

i INSERT the engine's water pump using the following procedure:

- ◊ WARNING this action requires the assistance of a second person
- ◊ LINE UP the arrow heads on the pump assembly and the main pump block before fixing with 4 bolts
  - ⇒ The threads are in a poor condition so do not over tighten
- ◊ TURN the water pump piston rod so that the lubricating hole is on the crankshaft side
- ◊ RAISE the pump piston rod to mate with the upper coupling rod then insert the coupling from the rear of the engine and insert a cotter pin to hold the assembly in place.
  - ⇒ **Note**: there is a slight taper on the hole in the clevis pin so that the split pin can only be inserted one way. As a consequence the split pin that is being used as a cotter pin and need not be splayed any further.

j DRAIN any water from the lubricator on the steam pipe and then fill with steam oil.

- ◊ Note: there is a second lubricator on the steam chest. This is not used.

k MOVE manually the engine's piston to the correct position to allow the engine to be warmed-up as quickly as possible when the time comes.

◊ The piston is in the correct position when the crank on the flywheel's shaft is in the 7 o'clock position when viewed from the front of the engine.

◊ This places the engine's piston so that it is towards the top of the cylinder and has the desirable side effect of ensuring that, during the warming-up process, the majority of the condensate is formed below the piston.

◊ The technique for carrying out this operation is described in item 5 in sub section 4.4.3.

4.4. How to Start the Engine

4.4.1. Placing the Piston in an Optimal Position

1 Experience has taught that in order to get the best results when warming the engine up or setting it in motion it is essential to first place the piston in the optimal position. Any required position can be deduced by observing the crank that connects the engine's main connecting rod to the flywheel's shaft.

2 There are two key positions. When viewed from the front of the engine they are:

a When the crank on the end of the flywheel's shaft points to 1 o'clock, the piston is just past Bottom Dead Centre (BDC) and ready to start on the UP stroke. This is best for automatically starting the engine.

b When the crank points to 7 o'clock, the piston is just past Top Dead Centre (TDC) and the upper chamber is at its near minimum volume. During warm-up the steam flow has to be switched manually to each side of the piston. This arrangement allows the majority of the warm-up steam to condense in the larger volume below the piston from which it is more easily drained.

◊ This volume below the piston is an artefact of the positioning of the piston.

4.4.2. Warming up the Steam System

1 Before starting the beam engine from cold, the supply pipework and the engine's steam system need to be warmed-up using the instructions in paragraph 2 immediately below.

◊ Following a prolonged temporary shutdown, some or all of these instructions may be necessary, even if the engine has previously been warmed-up.

◊ In the instructions that follow the valve and pipe section references are those shown in Figure 1

2 To warm the system up, carry out the following steps.

a ENSURE that the green 'OK to Start' disc is in place

◊ If the green disc is absent a red disc will show in its stead

⇒ The missing disc will be in the possession of the person requiring the engine and line shafting to be stationary and will be replaced once the embargo is no longer required.

b BE ABSOLUTELY CLEAR: (s)he who has control of the Green Disc has control of the engine.

- ◊ If the green disc is absent, none of the instructions in this Section must be carried out
- ◊ Attempting to warm or start up the engine in the absence of the green disc is a serious breach of safety.

c ENSURE the crank on the flywheel's shaft is in the 7 o'clock position when viewed from the front of the engine.

- ◊ This should have been done at the end of the Pre-Use Checks and Actions Section (Section 3)
- ◊ Steam nudging will not work at this stage

d ENSURE that:

- ◊ ENSURE the main stop valve in the Engine House is closed
  - ⇒ The valve handle is painted blue and its location is shown on the layout diagram in Figure 1
- ◊ ENSURE the steam inlet valve on the engine is closed.
- ◊ ENSURE the drain valve on the U bend in the pipework to pressure gauges PG1 is closed
- ◊ ENSURE the drain valve on the U bend in the pipework to pressure gauge PG2 is closed.

e BRIEFLY OPEN the drain valves in the pipework to pressure gauges PG1 and PG2 to ensure that any water is drained out; then close the valves.

f REQUEST the boiler operator to open the Crown Valve on the top of the boiler.

- ◊ Once the crown valve has been opened the beam engine is deemed to be in steam and the gate separating the control area from the walkway must be kept locked whenever the engine is temporarily shut down and there are no operators in the control area.
- ◊ When the engine is 'in steam' any person wishing to enter the control area, other than approved operators on official business, must seek the approval of the Proficient Person in charge of the Beam Engine.
  - ⇒ If the PP is absent and control of the engine is in the hands of a Competent Person that CP **must** refuse the entry request and invite the would be visitor to return later when a PP was present.
    REMEMBER only the HTA, or a PP can grant a person permission to enter the Beam Engine's Control Area.
- ◊ **NOTE it is strictly forbidden for all approved operators to leave the control area if the engine is running.**
  - ⇒ **If all operators find it essential to leave: the last to leave must ensure that the engine is shut down and lock the entry gate as he/ she leaves.**

g CRACK OPEN the main stop valve to allow steam to enter the supply pipework

- ◊ Periodically cautiously open the drain valve below pressure gauge PG2
- ◊ If steam is emitted close the drain valve and go to h immediately below. Otherwise:

- ◊ Allow any water to drain out and then close the valve and repeat the cycle at regular intervals until steam is emitted.

h ALLOW the pressure to settle at about 25 psi; then open the valve further.

i ENSURE the drain valve on the steam chest and both snifters on the cylinder are open.

j ENSURE the condenser spray valve is closed

- ◊ This closure enhances the warm-up process

k ENSURE the piston is positioned so that it is towards the top of the cylinder

- ◊ This operation should have been carried out during the preliminaries (see Instruction 3k in Section 4.3).
- ◊ CRACK OPEN the steam inlet valve to the beam engine to allow steam to warm-up the steam chest and cylinder
- ◊ Condensed steam will issue from the drain cocks.

l While steam is being admitted, the manual slide-valve control must be moved periodically to alternately admit steam to both ends of the cylinder.

- ◊ For this purpose, the cam lever on the eccentric rod is used to disengage it from the slide-valve mechanism and a manual operating lever is fitted onto its stub. The manual valve control lever is used to change the valve's position.
  - ⇒ Take care when carrying out this manoeuvre. There is little clearance between the control lever and the stop valve when the lever is at the top of its stroke. Failure to take appropriate precautions can lead to a nasty blow to the hand.
- ◊ The engine is double acting and this alternate admission of steam ensures that both ends of the cylinder are evenly and adequately warmed-up.

m Continue warming until the emissions from the drain cocks are effectively steam then:

- ◊ CLOSE the engine's steam inlet valve;
- ◊ POSITION the slide-valve for the normal direction of motion: move the cam on the drive from the eccentric into its run position, and re-engage the valve drive by moving the valve control lever, and then remove the manual valve control lever;
- ◊ RESET the drain cock on the steam chest and the snifters on the cylinder to the just cracked open position. .
  - ⇒ The engine is now ready to run.

4.4.3. Starting the Engine

1 There are two basic methods for starting a warmed engine. Both involve moving the piston in the engine to allow the first working stroke to be optimal either:

a by nudging (see paragraph 3 immediately below) the crank connected to the flywheel shaft into the 1 o'clock position and then attempting an automatic start;

b Or by adjusting the crank's position manually and then attempting an automatic start (see paragraph 4 immediately below);

⇒ **WARNING**: if the engine is stopped because the piston is at Top or Bottom Dead Centre the engine's mechanism is 'locked' and only the manual procedure in this paragraph will enable the engine to be turned.

2 Whichever method is chosen it must be preceded by the following instructions:

a CONFIRM that steam is available at the engine

b CARRY OUT any parts of the warm-up procedure in Section 4.4.2 that prove to be necessary

◊ Operational experience allows the engine's operator to make the necessary call.

c Ensure the slide-valve is in the correct position for the normal rotational direction of the engine

◊ Re-engage the eccentric drive if necessary and remove the hand lever Adjust if necessary

d RING the bell to indicate the intention to start the engine.

3 NUDGE the crank on the Flywheel's Shaft to Optimise the Engine's Start Position

a The most favourable start position is when the piston is at the start of its stroke and steam is admitted to the engine's bottom cylinder. This equates to the crank being at the 1 o'clock when viewed from the front of the engine and allows steam admission at the start of the up stroke.

b To place the engine in this optimal position, disengage the valve drive and use the manual valve control and the engine's steam valve to nudge the engine into the required position.

c Once the piston is in the required starting position; ensure that the slide valve is correctly placed, re-engage the valve drive and then remove the manual valve position control.

d Attempt to start the engine by opening the engine's main steam valve.

◊ If it starts go to paragraph 6 below.

◊ Otherwise attempt to restart the engine by manually setting the crank's starting position (see paragraph 4 immediately below)

4 Manually setting the crank's starting position

a If the above method does not restart the engine, the piston's starting position can be set manually for a final attempt.

◊ This method requires less manual dexterity than nudging and, because of the gearing available, is capable of greater precision in the setting.

◊ It replaces the procedure known as barring, which is no longer used*.

b The method is best carried out by two operators but can be carried out safely by a single Proficient Person.

c ENSURE that any necessary preparatory work has been completed.

* Given the heritage significance of the engine the barring process is described in Appendix 3 (Section 7.3). 7.3 is an historical record and is not formally part of the Method Statement

d ROTATE, using the large pulley at the rear of the engine, the flywheel thus altering the piston's position.

e When the piston is in the optimal position, attempt to start the engine, using the manual technique described in paragraph 5 below

◊ If it starts go to paragraph 6 below.

◊ If after a number of attempts the engine cannot be restarted, report the failure, as necessary, to the small engine operators, the Boiler Operator and the HTA. The engine will of necessity have to be closed down and taken out of service.

5 Manual Engine Start

a Manual starts are only used when the other methods have failed. It allows the operator to overrule the automatic steam cut off but is more difficult to apply.

◊ Beam engines were traditionally designed so that the same amount of steam is admitted to the cylinder on both the up and down strokes. A non-standard modification to the Combe Mill engine means that more steam is admitted on the upstroke than on the down. Unfortunately this change means that whereas optimal conditions for automatic starting require first admission of steam on the upstroke the opposite is true for manual starts. These must be started on the down stroke.

b SET the crank on the flywheel shaft to the 7 o'clock position.

◊ Starting at the 7 o'clock position has the additional advantage that the valve lever is in the upward position, and is readily accessible for the required downward push.

c Set the steam slide valve for manual operations

◊ For this purpose the cam lever on the eccentric rod is used to disengage it from the slide-valve mechanism and a manual operating lever is fitted onto its stub

d MANUALLY POSITION the slide-valve for the normal direction of motion at the end of its travel.

e FLIP the cam lever on the eccentric rod, so that it is ready to be re-engaged

f OPEN the steam inlet valve

◊ Once the inlet valve is opened the engine should start to move.

g WATCH the crosshead and be prepared to move the slide-valve with the hand lever.

h As the end of the stroke is reached the engine should have acquired enough momentum to run normally. At that point:

◊ MOVE the slide-valve towards the other end of its travel until the mechanism which drives it engages with the slot on the eccentric rod and remove the hand lever.

⇒ The engine should go on turning to complete a full revolution and start running normally.

⇒ If the engine fails to start further attempts to start it should be made.

⇒ If it cannot be restarted report the failure .to the small engine operators, the Boiler Operator and the HTA

➢ Formally shut the engine down

i .

6 Completing the start-up of the engine

a PRIME the engine's cold well river water pump using a hose connected to a tap in the main's water supply.

◊ **Do not use this supply for longer than necessary.**

b CHECK the water flow from the engine's own cold well river water pump. Once the flow is established

◊ ENSURE that any mains supply to the hose has been turned off.

◊ TURN OFF the Plan B Pump, if not already off

◊ ADJUST the condenser spray control valve to give a vacuum of 20 to 25 inches mercury gauge.

c If the water flow into the cold well cannot be established after 4 minutes, shut down the engine and go to Section 4.5.2.

d PLACE a small amount of steam oil on the piston rod:

◊ This reduces the wear rate of the gland packing and improves the vacuum.

e ACTIVATE the displacement lubricator on the steam pipe as follows:

◊ OPEN its steam inlet valve

◊ ADJUST its control valve to deliver 2 drops per minute.

⇒ As noted above, the lubricator on the steam chest is not used.

4.5. Other issues / problems arising during start up

The standard methods for starting the engine and repositioning it prior to the admission of steam are described in Section 4.4.3. Other issues that may arise are described in the sub sections 4.5.1 and 4.5.2 immediately following.

4.5.1. Steam Supply problems

1 If there is a failure in the steam supply system.

a CLOSE the blue handled main stop valve (see Figure 1).

◊ The valve is positioned between the boiler, and the self-acting pressure regulator in the engine house. It needs to be closed to ensure that any subsequent actions on the boiler cannot have any unforeseen effects on the beam engine.

Warning: This action also interrupts the steam supply to the small engines. Be sure to keep the small engine operators briefed.

b CONSULT with the boiler operator and agree a way forward.

⇒ Be aware that the plan will need to include the re-entry into this method statement at an appropriate stage.

4.5.2. Failure to establish a normal water input to the cold well

As part of the start-up procedure a temporary flow of cooling water is established to the engine using the plan B pump. This supply is switched off when the pump on the beam engine starts to supply water (see Section 4.4.3). If the normal cooling water supply cannot be established, shut down the engine in accordance with the instructions in Section 6.1.1

5. Operation of the Engine: on-going actions / observations

1 While the engine is running the operator should:

a MONITOR the level of water in the cold well: the aim is to keep the level such that it covers the majority of the air pump / scavenge pump

◊ ADJUST if necessary the water level using the condenser spray control valve

⇒ Opening this valve reduces the level in the cold well

⇒ Shutting the valve increases the water level in the cold well.

⇒ The cold well is fitted with an overflow so that too large a water supply to the well is not an intrinsic problem.

b CONFIRM that water continues to be pumped into the cold well.

◊ If the water supply fails take the actions set out in Section 6.1.1

c Occasionally briefly open the drain valves on the U shaped supply pipes to the high (PG1) and low (PG2) pressure gauges to expel any accumulated condensate (see Figure 1).

d MONITOR the condenser vacuum gauge.

◊ The vacuum gauge is calibrated in inches of mercury. It reads zero at atmospheric pressure and the reading increases as the pressure falls.

⇒ 1bar is equivalent to ~29.5 inches mercury.

◊ The aim is to keep a vacuum of at least 15 inches of mercury: on a good day it may rise to 25.

⇒ If the vacuum falls below 15 inches then there is a serious air leak.

➢ The most likely source is the gland on the piston rod.

⇒ The leak needs to be investigated and rectified at the earliest opportunity

➢ Start by nipping up the piston rod gland nut.

e MONITOR the pressure gauges on the steam supply pipe. There are two pressure gauges one (PG1) is upstream of the blue valve (V) and the other (PG2) downstream of the self-acting pressure regulator.

◊ The upstream valve reads the boiler pressure typically 70-100 psi.

⇒ This pressure is not under the control of the engine operator.

◊ The downstream gauge reads the steam pressure supplied to the engine and is typically 25-28 psi:

⇒ If it reaches 30 psi the self-acting pressure regulator **must** be adjusted.

➢ **If the pressure cannot be reduced to below 30 psi, the engine must be shut down.**

f MONITOR the operation of the displacement lubricator on the steam pipe

◊ The lubricator is fitted with a sight glass and the oil flow should be adjusted to a flow rate of 2 drops per minute.

◊ A flow rate of 3 drops per minute is acceptable

⇒ A flow rate outside the range 2-3 drops per minute requires adjustment and, if necessary, refilling of the lubricator's reservoir

g CHECK and if necessary re-oil the piston rod

h LISTEN OUT for unusual mechanical noises.

◊ If detected, consider the need to shut the engine down

⇒ Remember that excessive noise implies accelerated wear.

i LOG BOOK ENTRIES: Any faults or observations, whether leading to engine shutdown or not, should be logged in the logbook and signed and dated for future attention.

j If stopping and starting the engine is being demonstrated, then the engine may be started from its stopped position, if the operator so wishes and the crank is in a favourable position.

6. Controlled Shut downs

6.1. Temporary Shutdown during a Normal Steaming Period

6.1.1. Shutdown for Operational Reasons

1 To temporarily shut down the engine, carry out the following instructions:

a RING the bell to indicate that the engine is stopping

b TURN OFF the engine by screwing fully home the hand valve on the steam inlet valve on the engine.

◊ If the engine is not to be restarted immediately, open the snifter valves on the engine cylinder and the drain valve on the steam-chest.

c DETERMINE if the small engines are operational

◊ if 'yes', go to instruction d immediately below

◊ If 'no', omit instruction d and go to instruction e**.**

d TURN ON the Plan B pump and re-establish a cooling water supply for the small engines;

◊ Inform the small engine operators of the action taken

Warning: because the small engines are operational the temporary shutdown finishes at this point. It remains the responsibility of the Beam Engine's HTA to ensure that the engine is supervised in such a way as to ensure that

◊ the cooling water flow to the Small Engines is maintained if required and

◊ the Beam Engine cannot accidentally be restarted.

e Further actions if small engines are shut down

◊ INFORM the boiler operator and ask him/her to isolate the steam supply at the Crown Valve on the top of the boiler.

⇒ In the absence of the boiler operator, the engine operator must him/herself close this stop valve.

➢ If the engine operator closes the valve (s)he must immediately find and inform the boiler operator of the action taken.

- ➢ The valve closure is necessary to ensure that the build-up of water in the steam supply piping is minimised as the piping cools down.

f Following closure of the boiler crown valve, open the drain valve on the steam supply pipe

◊ The drain valve is in the pipe leading to pressure gauge PG2 (see Figure 2).

6.1.2. Shutdown at the Request of Other Persons

1 Any person requiring a shutdown of the beam engine must approach the engine driver and request that the engine be shut down. The engine driver will, if appropriate, then shut the engine down in accordance with the instructions in Section 6.1.1.

6.2.Engine Shutdown at the End of a Session

This Section describes the procedure to be followed to allow the Boiler, Beam Engine and Small Steam Engines to be closed down in an orderly fashion so that the systems can be safely left unattended. Because of the interlinkages, the operations of the three systems are interactive and the Beam Engine's involvement is pivotal. It is therefore important to first liaise with the relevant operators.

1 LIAISE with the operators of the small engines and the boiler

a CONFIRM with the person running the small engines that the engines either are or can be shut down.
Warning: DO NOT apply the procedure described in this section if the small engines need to continue operation. The operation of the beam engine may be temporarily stopped using the procedure in Section 6.1.1. The practical difference between the two procedures is that the procedure in this section prepares the engine for unsupervised storage whilst that in Section 6.1.1 merely stops the engine, meaning that it could be started by anyone and must therefore be kept under control at all times

b AGREE with the boiler operator the time at which steaming operations are to cease.

◊ Synchronising the closures minimises the amount of fuel consumed by the boiler.

⇒ The boiler continues to generate steam as the surplus heat in the water is consumed in the production of the steam.

2 Closure of the engine

a WARN the operators of the small engines and any machines connected to the line shaft of the imminent closure of the engine by ringing the bell

b ENSURE that the boiler operator has closed the main steam crown valve on the boiler

Warning: Do not proceed to instruction c until you have this assurance. Then

c Carry out the following actions:

◊ CLOSE the blue stop valve (valve V)

◊ CLOSE the condenser spray control valve

◊ OPEN the snifter valves on the engine's cylinder.

◊ OPEN the drain valve on the steam-chest.

◊ OPEN the drain cock on the steam supply to pressure gauge PG2 (see Figure 1)

- ◊ OPEN the drain cock on the steam supply pipe between the pressure reducing valve and the engine's inlet valve.
  - ⇒ The drain cock is in the pipe leading to pressure gauge PG2 (see Figure 1).

3 Place the engine and its ancillaries in a storage condition

a Drain the cold well by removing the drain plug

b When the cold well is empty, OPEN the Condenser Pump Drain Valve

c ENSURE that all drain valves are open. There are drain cocks on the:

- ◊ cold well
- ◊ hot well
- ◊ side arms leading to pressure valves PG1 and PG2 (see Figure 1).

d Remove the engine's river water supply pump:

- ◊ REMOVE the clevis pin coupling the pump to the coupling rod.
- ◊ TIE the rod to the side, replace the clevis pin in the rod and insert the split pin
- ◊ REMOVE the 4 fixing bolts
- ◊ LIFT OUT the pump and leave it on the stand on the bench
- ◊ REPLACE the 4 fixing bolts in their original positions
- ◊ REMOVE the foot valve using the long handled hook and a bar to lever it up
  - ⇒ The hooked tool is stored in the corner of the engine room nearest to the steam inlet valve. It might be necessary to free the foot valve by rotating it.
- ◊ Leave the foot valve on the bench

4 Finally to ensure that the engine is in a state to be left unsupervised, confirm that:

a The steam inlet control valve to the beam engine is left closed

b The main blue steam stop valve on the wall adjacent to the pressure reducing valve is closed

c The green safety disc is in place.

d Once the engine is in a safe condition the entry gate to the control area maybe left unlocked.

5 **Delayed Actions**: A few days after carrying out the actions above (in typical practice on the Wednesday following the use of the steam engine on a Sunday) give the water pump's leather bucket and leather flap valves a coat of Neats Foot Oil.

- ◊ Failure to do this greatly reduces the leather's life span.

7. Appendices:

7.1. The Beam Engine's Steam Supply System

The steam required to operate all of the Society's steam powered equipment is produced by a boiler located in an adjacent building and is distributed to the Beam Engine and the Society's smaller engines by the steam supply system illustrated diagrammatically in Figure 1. This system's basic features are described in the following paragraphs.

1 The system is connected to the crown valve on the boiler by a steam main that effectively terminates with its connection to the Beam Engine's main stop valve in the Engine House. The steam is supplied at approximately 100 psi, is not superheated and is consequently supplied wet. The effect of this arrangement is that, since the Beam Engine's HTA can isolate the steam from the Beam Engine at the stop valve in the Engine House, the responsibility for supplying steam to the Engine House is under the control of the Boiler's HTA.

2 The steam supply for the small engines is taken from a side stream downstream of the main stop valve in the Engine House (see paragraph 8). Although the Small Engines have their own isolating stopcock, closing the main stop valve in the Engine House also shuts off the steam supply to the Small Engines.

3 Immediately prior to arriving at the stop valve the steam is separated from any water that it may contain by a steam separator and associated automatic drainage valve.

- ◊ Following expulsion from a drain valve, the water passes into the engine room's vent pipe from whence it is ultimately discharged to atmosphere.

4 The separator is followed by a pressure gauge (PG1). This measures the input steam pressure to the system:

a The expected pressure is essentially the same as that at the boiler;

b Given the position of the gauge's off take, any water present gathers in the U bend of the gauge's connection pipe. The system is therefore fitted with a manually operated drain valve that allows any water that does accumulate to be drained off.

5 The main stop valve (it is painted blue for ease of identification) is located just downstream of the gauge off take.

6 Steam flows from the stop valve, passing through a Y strainer to remove any entrained debris and then through a pressure reducing valve where its pressure is dropped to approximately 30 psi.

7 Finally the steam flows through a pressure relief valve that is set to release at approximately 35 psi.

8 The steam flows past the regulating valve to the stop valve on the beam engine via a pipe that contains a tee piece that connects the main steam supply to a branch pipe that terminates at a stop valve in the Blacksmith's Shop next door. The Small Engines are attached to this side stream. As in the case of the crown valve, this arrangement raises safety issues.

9 In this case the Beam Engine's HTA is responsible for the system up to and including the stop valve, whilst the Small Engine's HTA controls the engines and their operation. These

issues are addressed elsewhere in this method statement and are mirrored by the instructions covering the operation of the Small Engines (MS08).

10 When saturated steam is at a pressure of 70 psi it will have a temperature of 160^{o}C. Reducing the pressure to 30 psi will reduce the temperature to about 149^{o}C, but the saturation temperature is now about 134^{o}C, so the steam is now slightly superheated.

7.2.The Engine's Steam Related Components

Figure 2 is an engineering sketch of the basics of the construction of the Beam Engine as originally installed. This section outlines the original construction of the engine and indicates where the present is different from the historic arrangements. The majority of the equipment is installed in a sump pit and is below ground and, as a consequence, is not readily visible.

The engine essentially consists of 4 basic parts. Above ground there is the engine itself: labelled in the sketch as Main cylinder. Below ground there are:

- A steam condenser and a condenser pump. These sit in a large tank of water known as the cold well
- The remains of the hot well that was used to return the condensed steam to the Cornish Boiler.
- A water pump that extracts water from the river and delivers it to the cold well.

1 Steam flows from the engine's stop valve to a throttle valve. This valve is connected to the centrifugal governor at the opposite end of the engine assembly by a complex assembly of rods and cranks which serves to control the rate at which the engine rotates. The system is still operational but the control action is not immediately apparent as the engine is always running light and the controlling butterfly valve seldom moves.

2 The steam flows from the throttle valve into the steam chest which is an integral part of the Engine itself. The engine has one cylinder and is double acting. The steam is alternately streamed to the top and bottom of the engine's cylinder by a slide valve.

   a During normal (automatic) operation the slide valve cuts off the steam supply when the cylinder is ½ full on the up-stroke and ⅓ on the down: thereby greatly reducing the steam consumption.

   b During warm-up and starting the slide valve drive has to be disconnected and the valves controlled manually (see main text).

3 At the end of a working stroke the exhausted steam is transferred to the condenser where it is condensed by cold water injected from the cold well as a spray.

4 The resulting condensate flows via a flap valve to the bottom of the condenser pump that transfers the water to the Hot Well and exhausts any trapped permanent gases.

5 The Hot Well once allowed the hot condensate to be recycled to the Cornish boiler for re use. This was of major value because the local feed water was both dirty and hard. Recycle allowed the feed water to be used many times thus greatly increasing the intervals between boiler clean outs. The system became redundant when the Cornish Boiler was condemned and the boiler feed pump was removed. A careful comparison of the existing engine with the model in the Engine house shows that the model has one more rod connecting the beam to machinery in the pit. The rod powered a pump which returned water to the Cornish Boiler.

6 The present system uses treated and softened water on a once through basis and the discharged condensate is accumulated in the Hot Well container before discharge to the main drain.

7 The Beam Engine's water pump, to the left as you look at the engine, continues its historic role and draws water from the river and circulates it through the Cold Well before returning it to the river.

7.3. Historical Note: Barring the Engine

The Beam Engine is a Heritage Engine in preservation. This Note is an historical record of a procedure mentioned in the main text but, as a consequence of no longer being used, is not formally part of the Method Statement.

Barring allowed the manual movement of the engine under any conditions and, though laborious, allowed precise positioning of the piston. Unfortunately, when members of the public are present, its use would now pose safety issues that must be managed.

As its name implies, barring involves the use of an iron bar that engages with teeth on the flywheel to allow the wheel to be manually leveraged to a new position. Thus by a series of small steps the flywheel is moved until the piston is in the required position.

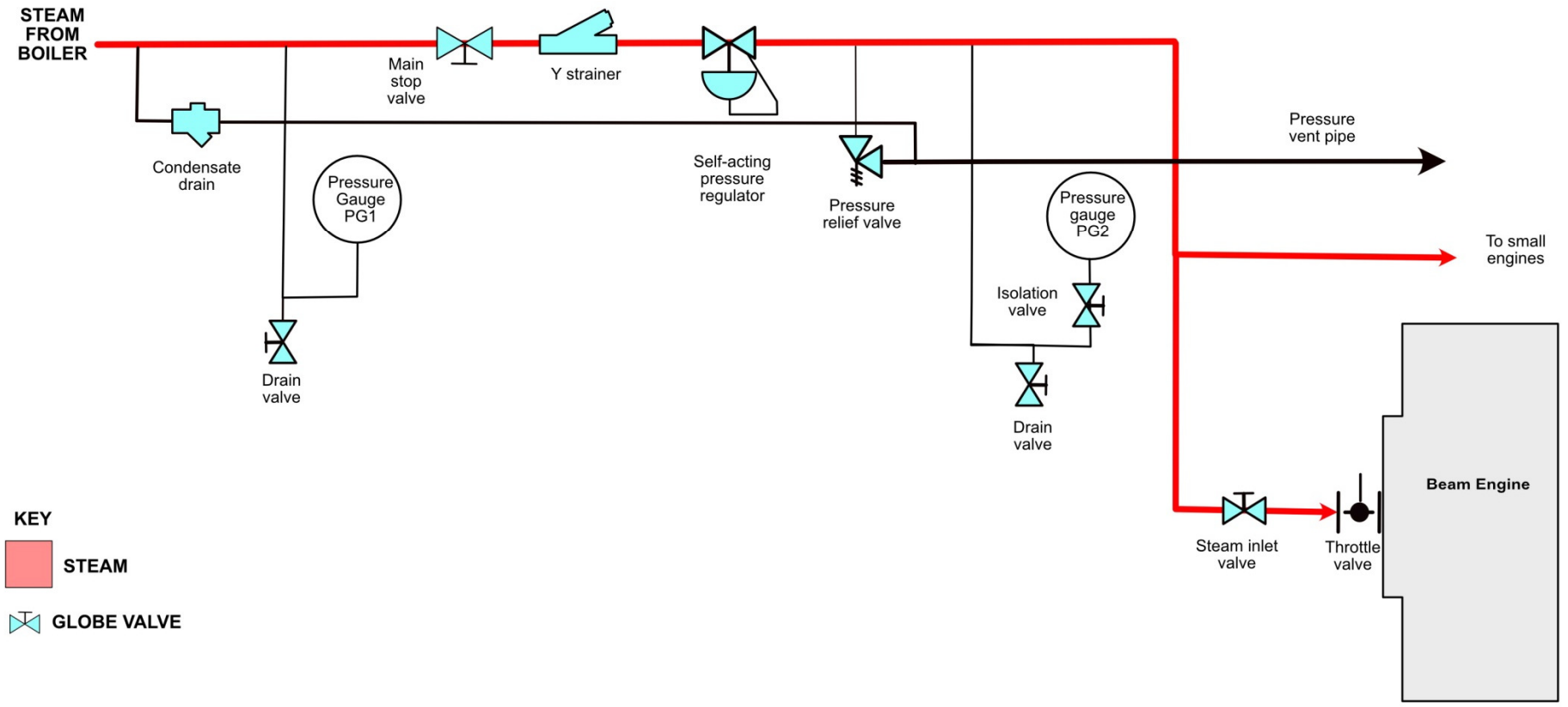

Figure 1 Schematic Layout of the steam supply system to the steam-chest

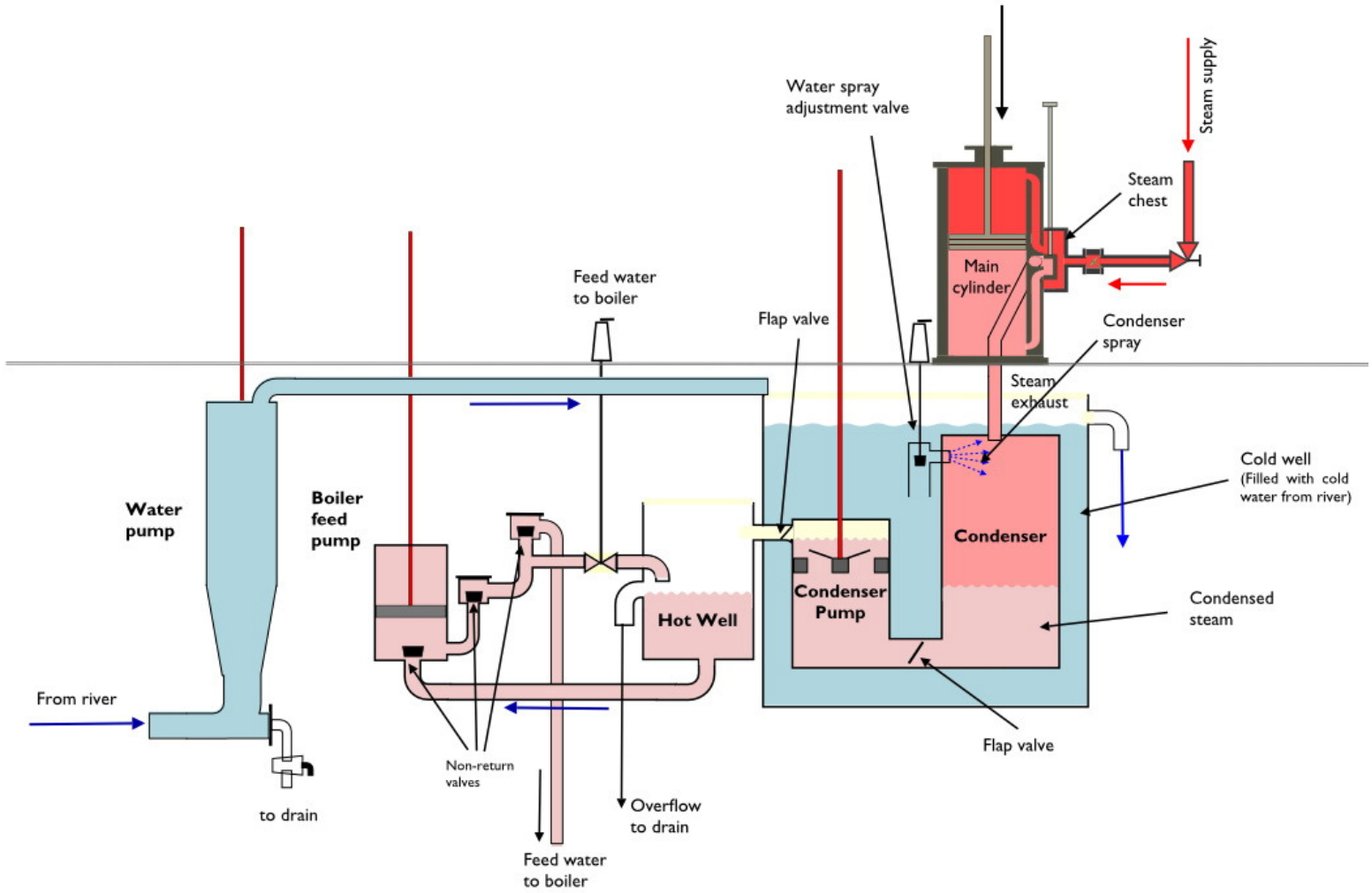

Figure 2 The Combe Mill Beam Engine showing the Steam Related Components