

Bringing a Steam Boiler On-Line from Cold.

To help understand what needs to be done and why things need to be done in a certain way, the following procedure presumes that the boiler is completely cold and dry, such as after a prolonged shutdown or annual inspection.

Steps can be omitted for boilers with some residual heat still in them and a typical example of this could be the start up after a weekend shutdown where the boiler has dropped in pressure and cooled, yet still has heat in it.

Note: The need to heat the boiler slowly will be explained throughout this procedure and it can take many hours for a large cold boiler to be heated correctly to operating temperature and pressure. Timing will also depend on how much treated water is available to fill the boiler, so be prepared for a long day and you may have to include a shift handover procedure to safely complete the task.

Please pay special attention to the fact that:

1. Under no circumstances should the boiler be left unattended until all of the following steps have been completed and the boiler is up to pressure and temperature and back on-line if appropriate.
2. Also take care when handling chemicals or working on live steam etc.; always ensure that PPE appropriate to the task is worn.
3. Also remember that most accidents in boilerhouses are falling from height; pay special attention to this fact when working on or above your boiler or other equipment. Also note working at height can include pits and trenches as a “working at height hazard”.

The following points have been carefully put together to help you bring a cold steam boiler back into service and back on-line safely. However, CEA cannot accept any responsibility for errors or omissions if this does not exactly fit your site requirements, your “Technical Boilerhouse Risk Assessment” (TBRA) should highlight any anomalies, and your site procedures must include and take these into account.

1. Ensure all connections on the boiler are tight and that the boiler itself is in good condition with all of the valves, probes, etc. in their correct places and that the water treatment system is in full working order. Additionally check that all of the lagging is fitted, spades and tell tales removed from any interventions, flue dampers are operational etc. Ideally there will be a tried and tested procedure with a pre-filling check list available for your boiler/s, often these are referred to as Standard Operating Procedures.
2. Open the air vent - this could be a valve by the pressure gauge or another valve fitted for that purpose. The vent should discharge in a safe manner and it must be possible to safely close the vent valve when steam is discharging to prevent scalding.
3. Make sure there is enough treated water for the boiler – is the water treatment plant capable of continual supply to keep filling the boiler? Never use raw untreated water to fill your boiler as this will lead to scale formation and possible longer-term problems.

4. Fill the boiler to a point clear of the low level alarms or limiters, but not all the way to normal working level; water must be visible in the gauge glasses. This will require you to manually turn the pump off and/or close the modulating valve, etc. As the boiler heats up, the water will expand, rising up the glass, and by stopping the boiler filling all the way to normal working level you reduce the amount of fuel, water and chemical used when bringing the boiler on-line and reduce the amount of blowdown necessary in later steps.
5. Start the burner or the fuel supply, ensuring that the burner is placed into its lowest firing position. Usually there is a button or switch marked "low-fire hold" although it may be necessary to use the burner controls to select a low firing rate.
6. As the boiler heats up the metal surfaces expand:
 - a. A 5 metre long boiler will be 11mm longer at 10 bar working pressure than it is at room temperature!
 - b. As the steel accepts heat more readily than water, putting too much heat into the boiler while cold will cause uneven expansion of the various parts.
 - c. This in turn creates large amounts of stress where the hot, expanding bits and cold static bits meet (e.g. at the furnace where it meets the front tube plate), leading to cracks in the welds and eventual failure. Imagine this construction as per the image below bending like a banana if its heated up incorrectly, inducing lots of thermal stress on the steel. If a boiler is put through repeated heating cycles from cold to hot this will increase the risk of stress fractures and ultimately a failure will be created.
 - d.

Photo of boiler construction courtesy of Byworth Boilers.



Furnace Tube 800 mm diameter and Tube plate 2.5 metres in diameter being inserted into the boiler shell 5 metres long.

7. To ensure that the boiler is heated up evenly:
 - a. Allow the burner to run for only around 15 minutes at a time at a low firing rate.
 - b. Allow the boiler to stand without the burner running for the same amount of time between periods of firing. This allows heat built up in the furnace and the tube passes to get into the water, which in turn will begin to heat the outer shell.
 - c. It may be necessary to take the size and age and working pressure of the boiler into account and periodically turn the burner off for an extended period of time to allow the temperature to equalise.

- d. Where very large and old boilers are still in use (say 30 - 40 years old converted boilers) it could take several days to bring them up to pressure.
8. Once steam begins to escape from the air vent with some force (think of a whistling kettle blowing steam from the spout), close the air vent. The boiler is now over half way to its operating temperature and so it is safe to leave the burner in the low-fire position without repeatedly starting and stopping it.
9. Check that all connections on the boiler are tight; tighten up if necessary:
- a. Don't forget the manways, hand and head holes and mud doors which must be correctly seated, pay attention to these as they have been known to blow out causing serious injury.
 - b. If they weep you will have to stop firing and start the process again after remedying the fault, but do not over-tighten the oval inspection openings, the design is such that the increasing steam pressure will do this for you by pushing the cover harder into its seat as the pressure increases.
10. The pressure in the boiler will now begin to rise, and the water will be seen to rise up the gauge glasses. Once the boiler reaches around 20 – 30% of its normal working pressure, blow the boiler down for 8-10 seconds.
- a. This promotes circulation in the boiler and will avoid stratification of the water within the shell.
 - b. If the water stratifies within the boiler shell you will have uneven heating and again potential stress issues.
11. The boiler is now most of the way to full working temperature so the burner and water level controls can now be returned to fully automatic control.
12. Visually check the flame, in particular check for impingement when on high fire if starting-up after a service;
13. Blowdown the gauge glasses as soon as there is sufficient pressure to do so, this ensures that the gauge glass assemblies are functioning correctly.
14. Use short bursts of boiler bottom blowdown periodically, this will prevent the water level getting too far above normal working level and promote good circulation of boiler water.

NOTE: Keep checking for leaks.

15. Once the boiler reaches working pressure, begin to open the crown valve. The valve will be cold at the top so it is important to open it very slowly to allow the valve to warm through thoroughly.
- Note:** Always ensure that the crown valve is a cast steel product; cast iron or other brittle materials are not allowed.
16. Do not place any part of your body over the top of the crown valve to reduce the potential risk of falling or scalding injury from an unintended steam leak.
- a. The amount of time taken to open the valve will depend on the length and diameter of cold steam main pipework after the valve.
 - b. Generally, it is appropriate to only open the crown valve sufficiently to allow the pressure to equalise in the system.

- c. Any standing water should be drained as far as practicable from the steam system prior to starting the boiler; this can be achieved using drain valves on dirt legs throughout the steam distribution system.
- d. Operators should be aware however that condensate loads are very much higher during start up than during normal operation so the risk of water hammer is greatest at this stage. If there are any signs of water hammer, the operator should begin closing the crown valve until the signs disappear; wait a minute or so, and then continue to slowly open the valve again.
- e. If you experience severe water hammer this indicates something may be wrong with your system and or steam mains drainage which can lead to catastrophic failure and serious injury, hit the E-stop as you immediately leave the boiler house.

Have a look at what water hammer can do. [Video link here.](#)

- f. To put this into perspective, imagine somebody throws a full two litre bottle of water at you, if it's a gentle underarm throw the force of catching it isn't too great, but if that same bottle was thrown to you from a car passing at 25 m/sec it would cause you serious harm if not kill you. The forces involved in excessive condensate in your steam main could do the same and destroy pipes and fittings leading to serious injury or worse.

Note. A well designed steam system should operate at approximately 25 m/sec but often systems are changed and loads changed which can often increase the speed to 40 m/sec in pipelines.

17. If the operator considers that the water hammer is so severe that there are doubts as to the safety of closing the crown valve, they should retreat and wait until the water hammer dissipates.
18. Assuming everything has worked successfully up to this point and there are no issues such as those listed above, leaks, water hammer, flame impingement, gauge glass operation, blowdown operation etc. you can then proceed to open the crown valve to its fully open position.

NOTE: When you have fully open the crown vale, immediately wind the crown valve hand wheel back one full turn to prevent it jamming open as the valves reaches full operating temperature and the metal has expanded to its normal operating condition.

19. A full weekly test including an evaporation test must be carried out before the boiler can be left unattended.
 - a. The time that the boiler was started up and the time it was left online should be recorded in the boiler logbook along with the results of all of the weekly tests.
 - b. You should also check that any dosing pumps are working correctly and that all other controls (feed pumps, gauges etc.) are functioning normally.
20. You will need to stay with the boiler long enough to observe normal performance under production conditions of the burner and feed water pump/valve in response to load changes. Having done this and observed that all equipment is functioning correctly during the normal production operating cycle it will give you the confirmation you require to sign off as complete.

NOTE: One subject for debate is whether or not the crown valve should be closed during start up.

It is arguable that a single boiler system could be started with an open crown valve; this both aids in managing the water level without the need for blowdown, and provides the most gentle start up for the steam system as it effectively acts as an extension of the boiler steam space. This clearly takes much longer to do.

In a multi-boiler system the distribution pipework will already be warm and we do not want to run the risk of backflow from the running boiler(s) raising the pressure in the cold boiler through a leaking non-return valve, so on a range (often called a Header) we would always expect the boiler to be started with the crown valve closed.

21. A boiler that cools naturally against closed valves will form a vacuum inside and will only draw air into the system if there are leaks. So long as the vacuum itself is not causing any problems, it is not necessary to open the air vent on boilers that have been cooled but not drained before re-starting.

Author - Adrian Rhodes – CEA Chairman

Additions by:

Paul Whitehead – Energy Efficiency Solutions

Kim Stopher – Stopher Associates

Ian Roberts – Durur

David Kilpatrick – CEA Director