

Boiler Operator Training

North Dakota
Boiler Inspection Program

Hot Water Heat and Low Pressure Steam

Guidelines for operating hot water heat and low pressure steam boilers:

- ❑ Controls - location, types, what they do
- ❑ Resets - where to find them, what to look for, checks before restarting the boiler
- ❑ Shutdowns - lockouts to reset, checks to make before restarting the boiler
- ❑ Daily checks
- ❑ Monthly checks
- ❑ Annual inspection
- ❑ Preparation for internal inspection - low pressure steam - fire tube

Storage Water Heater

- ❑ Controls and equipment
- ❑ Daily check
- ❑ Monthly check
- ❑ Annual check

Important Tip for All Boiler Controls and Safety Devices

IMPORTANT:

Never impair the function of any boiler control or safety device. These controls ensure the safe operation of all types of fired pressure vessels. Bypassing or removing a control to keep the vessel operating is never allowed and can cause a serious accident.

Hot Water Boilers

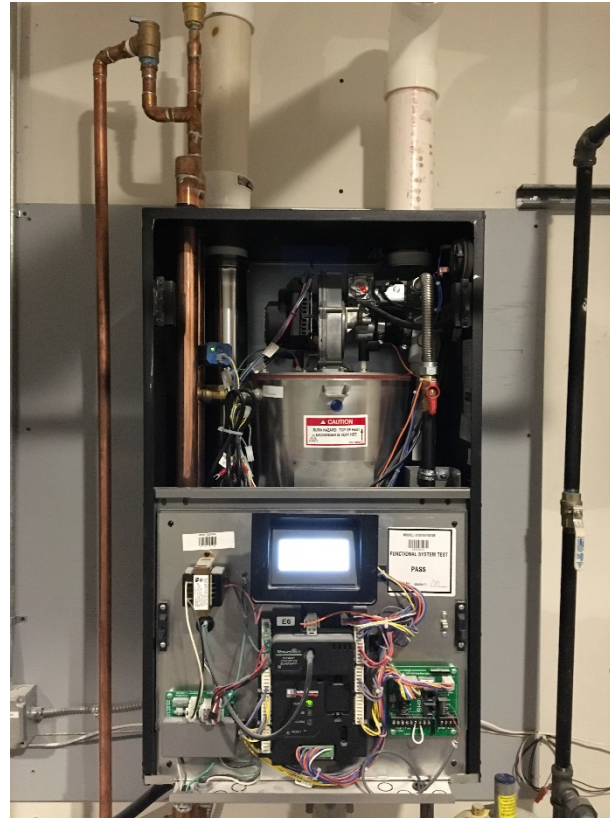
Different types of boilers - have same controls but they may look different or be in a different location.

- ❑ Cast iron boilers - water in the casting and fire between the sections/castings
- ❑ Fire tube boilers - fire in the tubes, with water completely surrounding the tubes, system completely full of water, no operating waterline on the boiler, only a safe waterline for controls
- ❑ Water tube boilers - water in the tubes with fire/gases/firebox space passing by the tubes full of water
- ❑ Fire tube vertical tube boilers - fire tubes arranged vertically rather than horizontally
- ❑ Electric boilers - can be vertical or horizontal elements immersed in water

Hot Water Boilers



Water Tube



Fire Tube Vertical Tube

Controls and Safety Devices for Hot Water Boilers

- ❑ Pressure/Temperature gauge
- ❑ Operating control
- ❑ High limit control (may be manual reset)
- ❑ Low water cutoff
- ❑ Flow switch
- ❑ Safety relief valve
- ❑ Expansion tank
- ❑ Feed water
- ❑ Drains for high efficiency boilers - stack drain and condensate drains
- ❑ Electrical switch
- ❑ Emergency shutdown switch

Pressure/Temperature Gauge



The pressure/temperature gauge will be located on the boiler proper or the outlet (hot side) piping before the first isolation valve.

- ❑ The pressure in the boiler system will usually be 10-20 psi for a boiler with a 30 psi safety relief valve.
- ❑ Monitor your pressure and temperature a few times per day to get a feel for what is typical for your system. The temperature on the gauge will be determined by the setpoints of your operating control and also may be affected by a building management system and the outside temperature if you have outdoor reset control.

Operating Control



The operating control can be found on the boiler proper or the outlet piping (hot side) before the first isolation valve. This is common for cast iron and steel boilers. The operating control may also be internal to the programming of the boiler - this would be more common for a high efficiency boiler.

- ❑ Setpoints for the operating control will vary for each type of boiler and can vary by the season - winter vs. spring/fall
- ❑ Typical setpoint for most boilers in the winter is 180F
- ❑ Temperature can sometimes be set lower for high efficiency boilers or floor heat boilers (floor heat may not be common in a school setting) or the spring/fall season of cast iron and steel boilers. 160F or lower may be common.

NOTE: if the manual reset control is tripping and the setpoints are far enough apart, one problem could be a faulty operating control.

High Limit Control



Manual Reset Control

The high limit control can be found on the boiler proper or the outlet piping before the first isolation valve. The control will look exactly like the operating control if it is not a manual reset control. The controls will be external for cast iron and steel boilers. May be internal or in the programming for high efficiency boilers. Or may be located under the sheet metal cover of the boiler.

- ❑ The dial range for the high limit control may not be set higher than the MAWT (maximum allowable temperature) of the boiler. For cast iron and steel this is usually 250F (Slant Fin 240F) and for stainless steel boilers this is 200/210F.
- ❑ The high limit temperature control should be set with at least a 20-30F differential from the operating control to prevent nuisance tripping of the high limit, especially a manual reset control.
- ❑ Test the manual reset high limit control by turning the setting down to just under the current temperature of the boiler and the red reset button should pop out. Turn the control back up to its former setting and reset the control.

NOTE: May be manual reset depending on the age of the boiler, required to be manual reset after 2006.

Low Water Cutoff - Probe Style



Probe Style Low Water Cutoff

Low water cutoffs are installed on the boiler proper above the safe waterline or in the outlet piping of the boiler (hot side) but before the first isolation valve. Most common on hot water boilers is a probe style low water cutoff.

- ❑ Testable low water cutoffs were first required to be installed in 1994, in 2006 the control was required to be testable and have manual reset and lockout.
- ❑ The low water cutoff on hot water heat boilers should be tested weekly. The burner must be firing when the control is tested, it should shut down the burner. If the burner does not shut down, repair or replace the control.
- ❑ The manual reset feature on the low water cutoff is activated in different ways - most require the TEST button to be held in for a period of 30 seconds on the newer controls, older controls may require a shorter time period for activation of the manual reset feature. Once activated, you will depress the manual reset button to reset the control.

Low Water Cutoff - Float Style



Float Style - MM 150 (L) and 63 (R)

Float style low water cutoffs are not as common on hot water heat boilers. They might be more common on a boiler that has been converted from steam to hot water.

A new boiler would be able to meet the code with a float style low water cutoff as long as it has a manual reset and lockout feature.

- ❑ A MM 63M is a common hot water heat low water cutoff - it can be tested by tipping the float with your finger or a pen to test and it has a manual reset on the switch head of the control.
- ❑ Older boilers with float control may have a MM 150 that can be tested by opening the electrical portion of the control and tipping the bar that the electrical switches and float is attached to. This should be done with caution as the power is on the boiler.
- ❑ Other float type low water cutoffs are non-testable such as the MM 764 - the inlet to the control is much larger than the outlet and the switching mechanism is enclosed.
- ❑ All float type low water cutoffs should be drained weekly to flush out the mud that may accumulate in the float bowl.

Flow Switch



A flow switch (paddle switch) will be located in the boiler primary piping. It is not allowed in the secondary of primary/secondary piping. Test the flow switch on the boiler weekly.

- ❑ To test the flow switch - with the boiler burner running momentarily close the inlet or outlet valve to the boiler, the burner should shut down. If the burner does not shut down the flow switch must be repaired or replaced.

NOTE: It is easier to watch the movement of the control/paddle if you open the top cover of the switch during the test.

Safety Relief Valve



Dedicated Tapping

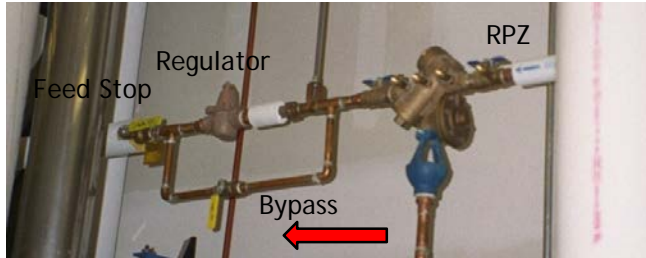


In Piping

The safety relief valve is located on the boiler proper or on the outlet (hot side) piping as close to the boiler as possible and before the first isolation valve. There may be a tapping on the boiler dedicated to the safety relief valve.

- ❑ The safety relief valve is for over pressure of the boiler. It is a spring loaded valve with a test lever.
- ❑ The safety relief valve on the boiler should be tested monthly by lifting the test lever. If the valve does not reseal after testing, it must be replaced.

Feed Water Piping



- ❑ The feed water piping is connected directly to the boiler system in the boiler return piping or in the line to the expansion tank of the boiler. RPZ Backflow preventer, feed water regulator (with piped bypass) and feed line stop valve before entering the system.
- ❑ The feed water regulator will add water automatically to the system if the pressure drops below 12 psi.
- ❑ To add water pressure above 12 psi, you must open the valve in the bypass line and close when finished.
- ❑ The water in this picture is going right to left to enter the system.



- ❑ No direct connected feed water piping - water is added manually through hose bib or a drain connection to the system.
- ❑ The city water side where the connection is made must have a vacuum breaker as minimum backflow prevention per the Plumbing Code.

Expansion Tanks - Non ASME



The three tanks shown to the left are all non-ASME expansion tanks. The two grey tanks are bladder type tanks and the blue tank is a hanging expansion tank.

- ❑ When non-ASME tanks are installed in the system the boiler is only allowed to have a 30 psi safety relief valve. These tanks have a rating on them but do not have an ASME stamping plate.
- ❑ Bladder type tanks are charged before the system is filled and do not require much maintenance, however, these tanks do develop leaks quite easily and must be replaced.
- ❑ Hanging tanks have problems with the air/water balance and become waterlogged in some systems. The blue tank shown here does not have an airtrol fitting - that fitting is crucial to allow the tank to be drained and serviced easily.

Expansion Tank - ASME



ASME code expansion tanks are required to install greater than a 30 psi safety relief valve.

- ❑ The tanks shown to the left can be identified as ASME tanks as they have an ASME code symbol stamped in the nameplate data affixed to the tank.
- ❑ There are bladder type tanks and hanging overhead tanks, usually with a sight glass on the hanging tank.
- ❑ The hanging tank may have issues with the air/water balance and become waterlogged. The tank must be drained down if this happens.

High Efficiency Boiler Condensate Drains



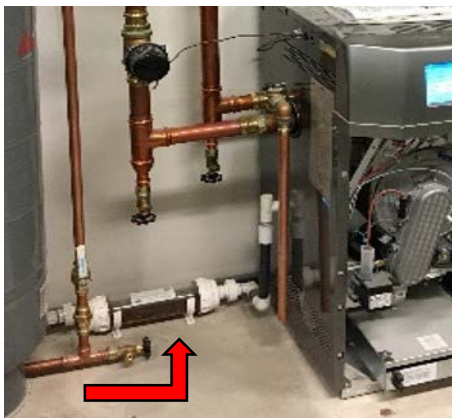
*Condensate Loop Seal
at Back of Boiler*



Neutralizer



*Drain without Neutralizer
(less than three years)*



Installed Neutralizer

Condensate neutralizers and condensate traps and drains are very important on high efficiency boilers.

- ❑ The loop seal/trap for the condensate is an important feature or the exhaust gases will leak back into the boiler room.
- ❑ Condensate neutralizers are installed to protect the drains, concrete and area around the boiler from the acidic condensate water.

Electrical Switch and Emergency Stop



Electrical Switch

The electrical switch is located near the boiler in order to turn the boiler off for regular service and maintenance items. The electrical switch may not always secure all power to the boiler. Make sure to check with your multi-meter before performing any electrical maintenance.



Emergency Stop

The emergency stop switch is located just outside the boiler room door. It is required for boilers over 400,000 Btu/Hr input. The switch will shut off the burner of the boiler, but also may not disconnect all power to the boiler. Check before performing any electrical maintenance.

Checks for Hot Water Heat Boilers

Daily:

- ❑ Monitor pressure and temperature of the boiler three to four times, logging observed operating parameters.

Weekly:

- ❑ Test the low water cutoffs and/or flow switch installed.

Monthly:

- ❑ Test the safety relief valve.

Annually:

- ❑ Test the operating temperature control and high limit/manual reset high limit temperature control.
- ❑ Clean the float bowl of float-type low water fuel cutoffs.

Resets for Hot Water Heat Boilers

Resets/Shutdowns for hot water boilers (*not all will apply to each boiler*):

- ❑ Temperature: Manual reset high limit temperature control
- ❑ Water level: Manual reset on low water cutoff
- ❑ E-Stop: Check that the emergency stop button has not been tripped outside the boiler room door
- ❑ On/Off Switch: Should be "On"
- ❑ Cast iron boilers with stack draft sensor: Check sensor on draft hood
- ❑ Larger boilers: Check gas pressure switches - high and low for trip
- ❑ Flow switch: Not a resettable control - but if not proved will not allow boiler to start

Low Pressure Steam

- ❑ Cast iron boilers - water in the casting and fire between the sections/castings, the operating level of the boiler is above the safe water line of the boiler.
- ❑ Fire tube boilers - fire in the tubes, with water completely surrounding the tubes, the operating level of the boiler is above the safe water line of the boiler.
- ❑ Water tube boilers - water in the tubes with a fire space for gases to pass around and through the tubes, the operating level of the boiler is above the safe water line of the boiler. Not very common for low pressure steam - usually a bent tube boiler, not straight tubes.
- ❑ Electric boilers - can be vertical or horizontal elements completely immersed in water, the operating level of the boiler is above the safe water line of the boiler.

Controls and Safety Devices for Low Pressure Steam

- ❑ Pressure gauge
- ❑ Gauge glass
- ❑ Operating control
- ❑ High limit control (may be manual reset)
- ❑ Primary float low water cutoff
- ❑ Secondary low water cutoff (may be float or probe, may be manual reset)
- ❑ Safety valve
- ❑ Blowdown valves
- ❑ Condensate/Feedwater tank
- ❑ Electrical switch
- ❑ Emergency shutdown switch

Pressure Gauge



The pressure gauge will be located on the boiler proper or on a line off the boiler proper with the pressure controls.

- ❑ The pressure gauge must have a pigtail siphon or other water seal to prevent live steam from entering the gauge.
- ❑ The pressure on the gauge for low pressure steam is determined by the operating pressure control for the boiler and the building management or outdoor reset control.
- ❑ The pressure should not normally run higher than 13 psi to prevent the safety valve blowing off and discharging steam.

Gauge Glass



The gauge glass is an extremely important device for determining the water level of the boiler. The gauge glass is located on the boiler proper or on the primary low water cutoff.

- ❑ The gauge glass has shutoff valves on the top and bottom of the glass - must remain open during normal operation to determine the water level in the boiler. If both of the valves are not open you will get a false reading of the water level.
- ❑ The top of the bottom nut on the glass should be above the safe operating level of the boiler.
- ❑ The low water cutoffs are set to operate above this level, so the burner will trip out when you can still see a visible waterline barely in the glass.
- ❑ If gauge cocks are installed on your boiler - the top is steam, the middle a steam/water mix and the bottom is water. If the gauge glass breaks you may use the gauge cocks to determine the water level.

Operating Control



This boiler shown above has three pressure controls - operating, high limit and the third could be for modulation or high/low fire.

The pressure control is located with a direct tapping to the boiler in the steam space. The operating pressure control is installed on the boiler with a loop or water seal so that live steam does not enter and damage the control.

- ❑ The setpoint of the operating pressure control where the burner should shut down, and will restart when the pressure drops below the differential set on the device.
- ❑ The main setpoint is 0-15 psi scale and the differential setpoint is next to it.
- ❑ The operating control should not be set higher than 12-13 psi - to give the boiler a range to operate without tripping the safety valve.
- ❑ Test the pressure control by turning the setpoint down under the pressure on the gauge to prove that it shuts down, then reset the control to where it was originally set for normal conditions.

High Limit Control



Manual Reset Pressure Control

The high limit pressure control is located with a direct tapping to the boiler in the steam space. The high limit pressure control is installed on the boiler with a loop or water seal so that live steam does not enter and damage the control.

- ❑ The high limit control on the boiler is required to be manual reset if the boiler was installed after 2006.
- ❑ The high limit control should not be set above 13-14 psi so that the burner will shut down without tripping the safety valve on the boiler.
- ❑ The pressure range of the high limit for a low pressure boiler is 0-15 psi.
- ❑ Test the manual reset high limit control by turning the setting down to just under the current pressure of the boiler and the red reset button should pop out. Turn the control back up to its former setting and reset the control.

Primary Float Low Water Cutoff



The MM 157 low water cutoff shown above has a gauge glass and gauge cocks installed.

The primary low water cutoff is located on the boiler with a high connection to the steam space of the boiler and a low connection to the water space of the boiler. The operating level of the low water cutoff must be above the safe water line of the boiler.

- ❑ The primary low water cutoff will usually have two switches inside the control, the first switch operates the feed water pump and the second shuts down the burner.
- ❑ Test the low water cutoff by draining water out of the blowdown valve under the low water cutoff. The feed water pump should start and then if you continue draining the water the burner will shut down when there is water visible just above the bottom nut in the gauge glass.
- ❑ The low water cutoff must be tested daily to flush mud out of the float bowl and to perform a burner shutdown test.

Secondary Low Water Cutoff



The secondary low water cutoff is installed in direct connection to the steam space and set to operate below the water level of the primary low water cutoff, but still above the safe water level of the boiler (a probe only has a steam connection and a float has a steam and water connection).

- ❑ The secondary low water cutoff on a steam boiler can be probe or float style. It must be manual reset if the boiler was installed after 2006.
- ❑ The probe low water cutoff will have a test button and manual reset feature if required.
- ❑ The float low water cutoff must be drained to test and have a manual reset feature if required.
- ❑ The secondary low water cutoff should be tested at the same interval as the primary low water cutoff daily.
- ❑ The float low water cutoff must have the float bowl drained to prevent mud and sludge from building up in the control.

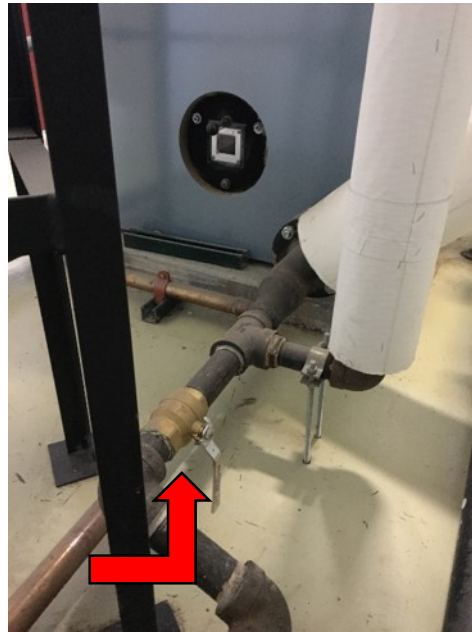
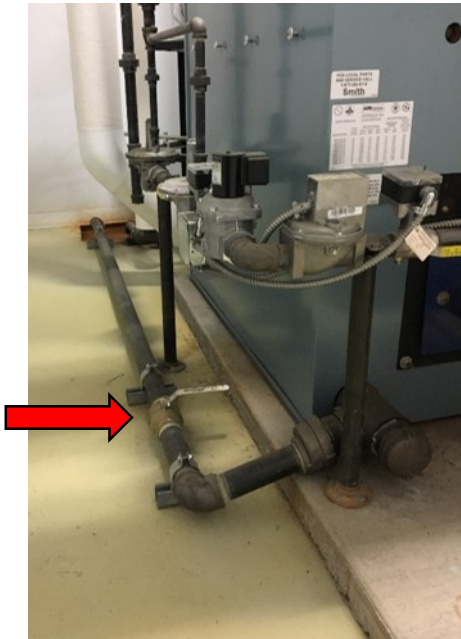
Safety Valve



The safety valve of a low pressure steam boiler must be installed on the boiler proper.

- ❑ The set point of the safety valve is 15 psi.
- ❑ The safety valve has a spring loaded test lever and must be tested monthly.
- ❑ The discharge piping of the safety valve should run to a safe location.

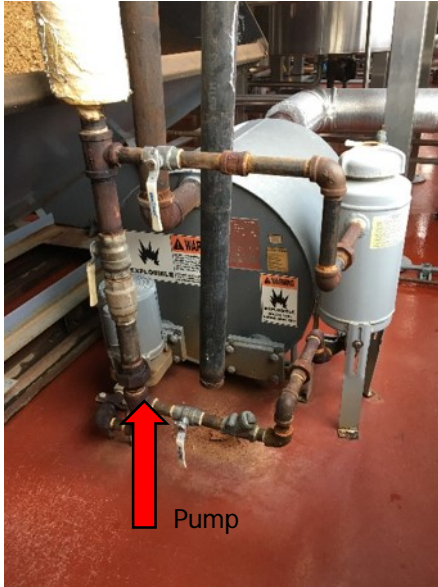
Blowdown Valve



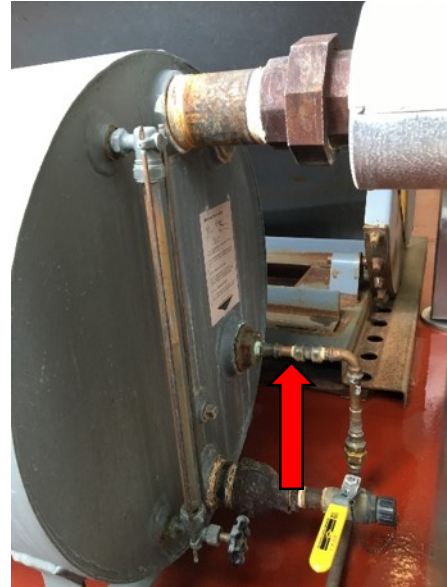
Blowdown valves are installed in the boiler to be able to drain mud, sludge and loose scale out of the boiler legs and boiler bottom.

- ❑ Blowdown valves are also located on the low water cutoff float bowls to flush mud out of the controls to keep them clear.
- ❑ Boiler blowdown should be done on a weekly basis to control the sediment in the boiler.

Condensate/Feedwater Tank



*Condensate Tank with Pump
(pump is behind piping)*



*Float in Tank Attached
to This Line*

The condensate/feedwater tank is the makeup water that is added to the boiler via a pump when the boiler is low on water.

- ❑ The condensate tank collects the water that is returned from the boiler system.
- ❑ The feedwater pump - usually activated by the low water cutoff primary float - adds water to the boiler until the float is satisfied and then shuts off.
- ❑ The condensate/feedwater tank will usually maintain its own level with a float in the tank. If the water level in the tank is low, the float will activate the city water to add water to the tank.

Electrical Switch and Emergency Stop



Electrical Switch

The electrical switch is located near the boiler in order to turn the boiler off for regular service and maintenance items. The electrical switch may not always secure all power to the boiler. Make sure to check with your multi-meter before performing any electrical maintenance.



Emergency Stop

The emergency stop switch is located just outside the boiler room door. It is required for boilers over 400 Lbs/Hr input. The switch will shut off the burner of the boiler, but also may not disconnect all power to the boiler. Check before performing any electrical maintenance.

Checks for Low Pressure Steam

Daily

- ❑ Monitor pressure of the boiler three to four times, logging observed operating parameters.
- ❑ Flush the low water cutoff float bowls.

Weekly

- ❑ Test the low water cutoffs for a burner shut down.
- ❑ Blowdown all boiler blowdown valves for the mud legs and boiler bottoms.

Monthly

- ❑ Test the safety relief valve.

Annually

- ❑ Test the operating pressure control and high limit/manual reset high limit pressure control.
- ❑ Clean the float bowls of low water fuel cutoffs.

Resets for Low Pressure Steam

Resets/Shutdowns for low pressure steam boilers (*not all will apply to each boiler*):

- ❑ Pressure: Manual reset high limit pressure control
- ❑ Water level: Manual reset on low water cutoff
- ❑ E-Stop: Check that the emergency stop button has not been tripped outside the boiler room door
- ❑ On/Off Switch should be "On"
- ❑ Larger boilers: Check gas pressure switches - high and low for trip

Preparation for Internal Inspection - Fire Tube



Fire sides of tubes brushed clean. Check for leaking tubes/tube rolls. Condition of tube sheet.



Firebox - no distortion of metal, no leaking stays, refractory/firebrick in good condition.

For internal inspection we must have the boiler cooled, drained and opened for inspection.

- ❑ The inspector needs access to the fire and water sides of the boiler and the low water cutoff float bowls opened.
- ❑ The tubes must be brushed clean.
- ❑ All of the water, mud and loose scale removed from the water side of the boiler to be able to check the condition of the boiler metal surfaces.

Internal Inspection - Fire Tube Boilers



*Water side of fire tubes and shell of boiler.
Check for scale and pitting on tubes and shell.
Distortion of any parts.*



Check stays for thinning. Check shell plate distortion, pitting and scale. Check bottom of mud legs for corrosion and pitting.



Low water cutoff float bowls split open to see inside bowl and check for scale/mud. Check condition of float.

Boiler Logbook

A boiler log book should be kept:

- Boiler temperature and pressure trends
- Daily checks
- Monthly checks
- Annual checks
- Maintenance items
- Parts replaced

Storage Water Heater

Storage water heaters are the standard for most hot water supply in a building. They are a forgotten piece of equipment, except in a failure situation. Storage water heaters should receive daily attention and basic maintenance testing each month at a minimum.



Atmospheric Draft



High Efficiency

Storage Water Heater Controls

Storage water heater controls:

- ❑ Operating temperature control - set point of the storage water heater where burner shuts down, temperature drops by a differential and the burner fires again
- ❑ High limit temperature control - shuts down the storage water heater burner if it reaches this temperature, usually a fixed 180-210F, can also be manual reset on some models
- ❑ Temperature/Pressure Safety Relief Valve - a spring loaded safety relief valve with a test lever - installed in a dedicated opening within the top six inches of the tank, allowed to be installed in the horizontal position so the temperature probe is inserted into the tank (vertical if installed in the top of the tank), discharge piping is required from the safety relief valve to a safe location. The T&P safety relief valve will discharge if the pressure (usually 125 or 150 psi) or the temperature (210F) is exceeded.
- ❑ Condensate neutralizer - recommended to be installed in the condensate drain of high efficiency storage water heaters

Storage Water Heater Maintenance

Daily:

- ❑ Check temperature on digital control or thermometer

Monthly:

- ❑ Check the T&P safety relief valve by lifting the test lever and allowing it to spring back closed.

Annually:

- ❑ Test the operating control by adjusting the temperature up for the burner to fire and shut down at the new higher set point, reset the operating temperature to the original set point when test completed.
- ❑ Clean the sediment from the storage water heater tank.

Contact Us

Bismarck

Trevor Seime
Chief Inspector
(701) 220-4723 (*cell*)
tsseime@nd.gov

Renee Skraba
Deputy Inspector
(701) 400-1043 (*cell*)
rskraba@nd.gov

(701) 328-5200 (*fax*)

Fargo

Nicolle Fowler
Deputy Inspector
(701) 541-2113 (*cell*)
nfowler@nd.gov

Vincent Rolczynski
Deputy Inspector
(701) 781-0528 (*cell*)
vrolczynski@nd.gov

(701) 328-5200 (*fax*)

Website: <https://deq.nd.gov/Director/BIP/>

Thank You!