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START UP, OPERATION & MAINTENANCE GAS OR OIL FIRED PACKAGED BOILER

This manual contains important information regarding the operation of and the maintenance required on your HURST boiler. Failure to read and follow the instructions contained herein can lead to damaged equipment, or injury to those personnel involved with the daily operation.

WARRANTY ISSUES

HURST will gladly assist you in the return of items for warranty consideration. Our policy for handling such returns is stated below:

The first step for returning items for warranty is to call 229-346-3545 ext. 1104 and request a "Return Goods Authorization" (RGA) number. When making this call, you need to have the following information available:

- Customer name
- Job location
- Job number
- Date equipment was installed
- Reason for return – specify the problem
- Where to ship replacement
- To whom billing is to be directed

All replacement items are shipped on a Net-30 day schedule. **Payment is expected within this period**. Any warranty will be credited upon receipt of credit from the vendor for the defective part.

All RGA shipments to HURST must have the RGA number on the outside of the shipping container.

Any item not received at HURST within 21 days of the RGA request, will be deemed "not returned" and no credit consideration will be made.

GENERAL FEATURES OF YOUR HURST BOILER

Your Hurst boiler has been designed, constructed and certified to meet the requirements of the American Society of Mechanical Engineers (ASME) Code for boilers.

HURST maintains its own quality control personnel with all the necessary equipment and instrumentation to verify constructions standards equal to or greater than those required by the ASME.

All units are first inspected by HURST personnel and then by a "third party" inspector who is a member of the National Board of Boiler and Pressure Vessel Inspectors to verify compliance with all Code requirements. Then, he witnesses the hydrostatic pressure test performed on the pressure vessel and authorizes the stamping of the proper ASME symbol on the vessel.

A manufacturer's Data Report is then completed and the unit is registered with the National Board. A copy of the Data Report is available from HURST or from the National Board.

After completion of the pressure vessel and the addition of certain other features of the unit, a burner and associated fuel train are added to the package. The burner may have the UL or cUL Label, and may have the Factory Mutual (FM), GE Gap (IRI) or other agency identifications.

Many state and local authorities have laws/codes governing the installation or operation of boilers and pressure vessels. You should verify with those local authorities regarding compliance with their requirements.

BOILER IDENTIFICATION

PRESSURE VESSEL:

Each boiler is stamped with a Serial Number and a National Board Number. These numbers can be found on the identification plate that is attached to the front door of the boiler and they are stamped on the boiler shell near the front tubesheet on the right hand side of the boiler.

Besides simply identifying this unit, the Serial Number and National Board number identify the characteristics of this boiler for Maximum Allowable Working Pressure (MAWP) and temperature, if applicable and the Fireside Heating Surface available.

Both of these numbers are unique to this particular boiler, so when inquiring about your unit regarding warranty, service or parts, having these numbers available for reference will speed the service we can provide.

BURNER:

If supplied by HURST, the burner on your unit will also have a recorded Serial Number that is unique to this unit. Should you need to make an inquiry regarding this burner for service or parts, it is helpful to HURST for you to provide this serial number. Other burner plate information will include maximum BTU throughput and the UL registration number for that burner.

INSTALLATION

The installation of your boiler should have been planned long before you take delivery of the unit. Drawings and specifications are often prepared by individuals familiar with steam or hot water systems.

This document assumes that the installation has been planned out and documented. Here, we only suggest some approaches to issues that might need a little additional detail.

General:

The boiler should be placed on a flat, level concrete slab or on housekeeping pads that run the full length of the base rails.

If the boiler is not in a building, be sure that all the controls, the control panel and the burner – at a minimum – are designed for outdoor operation.

If the unit is inside a building, the space allowed on either side, at the front and at the back of the unit must be adequate to maintain the required maintenance and operation of the boiler. Minimum dimensions for these clearances are set by UL and perhaps by other local codes. Be sure to determine whether your unit meets these ordinances before you place the unit. Most codes require a minimum of 7 feet clear of obstruction above the manway for access on high pressure boilers and 5 feet clear on low pressure boilers. These obstructions include piping, catwalks or building structure. Your local codes may be even more conservative.

Building openings:
We suggest one opening large enough for the boiler to pass. Additionally, one man door and adequate openings for admission of combustion air (see Combustion Air Requirements in this manual) are absolutely necessary. Other openings may be supplied as the owner sees fit. Be sure to check with local authorities for building code requirements.

Lighting:
Adequate lighting is a must for proper operation and maintenance. Be sure to include enough lighting in the boiler room so that the operator can read nameplates and instructions on the equipment without the use of supplemental lighting.

Power:
The motor(s) and controllers that are part of your boiler system all depend on a constant supply of electrical power. The interconnection of these devices is accomplished through the pre-wired electrical control panel that has been furnished with your unit. Normally, the power supply will only be required to be made to one point on the control panel. That power requirement is specific to your unit and will be specified by HURST. It is the responsibility of the customer to supply that power to the panel.

Steam boilers typically have a feedwater system supplied with electric motor driven pumps that requires a separate power supply to the panel supplied with it.

Piping:
No piping should be at or near the floor level to cause tripping accidents. Floor drains and pipe trenches are essential for maintaining an orderly, clean facility. Piping may be placed in drains so you will not need separate trenches. These trenches should drain to a point outside the boiler room or to a sump to be pumped out as required. All trenches should be covered with adequate grating or floor plate.

Connections:
There are several connection points on the boiler that must be connected to other systems within the scope of the installation. Some of these connections are common to both steam and hot water systems. Others will be designated as “steam” or “hot water”.

1. Safety Valve: The safety valve(s) will be located on the top centerline of the boiler. The outlet of the safety valve must be piped to a point of safe discharge, and it must be the size of the valve outlet or larger. NEVER reduce the discharge line size.

2. Vent Stack: This is the large opening at the end of the boiler through which the gases from the combustion process must be vented to some point outside of the boiler room. When using factory manufactured stacks, we recommend the use of stacks rated for pressurized systems. UL Listed double wall stack systems may be a good choice. It must be gas-tight to eliminate the chances of leakage into the boiler room. Check with local authorities for any requirement they may have for height requirements above the roof.

3. Fuel: The fuel connection(s) will be for natural gas, manufactured gas, light oil or "heavy" oil. The connection points are on the sides of the boiler or near the burner (for oil). The gas piping must be approved by the local gas company and will be inspected by their personnel. Oil piping must be appropriate for the application, and insulated if firing oil that requires heating.

4. Supply: This is generally the largest opening on the boiler, and it will be on the top. This is the opening through which steam or hot water is allowed to exit the boiler to enter the external system. This must be piped as required by local jurisdictional requirements and as good construction requirements demand. In multiple boiler installations, some of this piping may need to be constructed and stamped according to the ASME Code.

Connections that are specific to Steam Boilers:

1. Feedwater: This is the opening on the side of the boiler through which water enters to re-supply water lost through evaporation. This must be connected from the feedwater supply system. The design requirements for pressure in this line must be greater than the MAWP of the boiler.

2. Bottom Blowdown: This opening or openings are in the lowest part of the boiler at the bottom centerline. There will be one or more bottom blowdown openings. See Blowoff-Blowdown in this manual.

3. Water Column Blowdown: This refers to the piping directly below the water column/gauge glass. This is the valve through which the unwanted contaminants will be expelled from the Low Water Cutoff/Pump Control device. See Blowoff-Blowdown in this manual.

4. Surface Blowoff: This opening is generally on the top centerline of the boiler and is the opening through which surface contaminants will be expelled. See Blowoff-Blowdown in this manual.

Connections that are specific to Hot Water Boilers:

1. Return: This opening will be located on the top centerline of the boiler and will generally be the same size as the Supply Nozzle. Water returns from the system and re-enters the boiler at this point to be reheated.

2. Drain: The drain connection on a hot water boiler is similar to the bottom blowdown opening on a steam boiler, and it will be located at the lowest part of the boiler at the bottom centerline. This discharge should be piped to a point of safe release such as a blowdown tank or pit.

3. Water column Blowdown: Some hot water boilers may have a blowdown connection on the water column. This should be piped to a point of safe discharge.

COMBUSTION AIR

The burner on your boiler requires oxygen to support combustion of the fuel. This oxygen supply comes from the air in the boiler room, so an adequate supply of "combustion air" is essential for efficient operation of your boiler.

Allow 8 cubic ft per minute (cfm) of air for each rated boiler horsepower up to 1000 ft elevation, and it is suggested to limit the velocity of the air movement in the boiler room to 250 ft per min (fpm). Above 1000 ft elevation, add 3% additional volume for each additional 1000 ft.

Two (2) air supply openings should be supplied in the outer walls of the boiler room, preferable on opposite ends or sides of the boiler. Fans are not required nor recommended, but simple louvered openings are suggested. These openings may be covered with wire mesh, but the mesh should have at least ½" openings.

Example:

250HP
Requires 250 x 8 = 2000 cfm
Then 2000 cfm/250fpm = 8 sq ft opening.
So, 2 openings of 4 sq ft each in opposite walls are required.

Even for the smallest boiler, the air supply opening should be at least 1 sq ft.

CLEANING – BOIL OUT

After the installation of your boiler has been completed, and before any operation is begun it is highly advisable to clean the water side surfaces of the **boiler** and the **piping system** to which the boiler is connected.

The piping system may contain oil, grease, welding slag, thread cuttings and other contaminates that should **not** be left in the system piping. If left in the piping, it is only a matter of time before it will find its way to the boiler. Slag and thread cuttings can block or damage gaskets, valves and control devices.

A new boiler is likely to have oil, grease, or other protective coatings that were on the metal parts during the manufacturing process. These contaminants must be removed prior to beginning operation since any one of them may cause priming, foaming, inefficient heat transfer or contamination of the process to which the steam is directed.

Most boiler chemical suppliers can supply the chemicals and the expertise to affect an appropriate method for cleaning your boiler.

However, in the absence of such consultation, suggested procedures are outlined below.

Before beginning any internal cleaning procedure, you must determine the experience level of anyone who will be assisting in the cleaning procedure and make suitable safety garments available to each of them. It is preferable that all personnel be familiar with the procedure and what the results could be if they are not careful with handling the chemicals involved.

As a minimum, the safety equipment should include face mask, goggles, rubber gloves, and apron. Severe burns can result from improper handling of caustic chemicals.

PROCEDURE: Please read the entire procedure before beginning any part of the procedure.

Steam boilers:

1. Close all external valves, such as feedwater, steam supply, chemical feed, and blowdown to avoid loss of chemical and to isolate the boiler internal parts.
2. Remove the safety valves.
3. Remove the manway cover, if so supplied and if it is in the uppermost part of the shell.
4. Fill boiler with fresh water to a level 2-3 inches above the top of the top row of tubes. Just basic tap water is acceptable for this filling.
5. Determine how many gallons of water the boiler will contain when completely filled.
6. Mix Tri-sodium phosphate and caustic soda (Sodium Hydroxide) in the amount of one (1) pound of each for each 100 gallons of water content in the boiler. Add the chemicals slowly into a bucket or barrel with water as necessary to dissolve them. Stir constantly to be sure that the chemicals are thoroughly dissolved.
7. Add the dissolved chemicals carefully through the largest opening available in the top of the boiler.
8. Complete filling of the boiler to the top.
9. Begin firing the boiler at the lowest rate possible and intermittently, as necessary to get the water temperature just above 200 degrees F. During this early firing, the water volume will swell and tend to overflow the openings in the top, so operate the bottom blowdown as necessary to maintain flooded condition in the vessel while minimizing overflow.
10. Continue this low heat input for a minimum of 4 hours, and shut the burner off.
11. Allow boiler water to cool to a temperature of 120 degrees F or less, and drain to a point of safe discharge.
12. Remove all handhole plates or other inspection openings and wash the interior thoroughly with high pressure water. On large boilers, a fire hose is recommended.
13. If interior surfaces are not clean, you may repeat the above procedure.
14. If you determine the water side to be adequately clean, proceed to replace the safety valves, re-close the handhole and manhole plates with new gaskets, and refill the boiler with treated water from your feedwater system. (Additional information about treatment of boiler water is in another section of this manual)
15. When filled to the normal level, the boiler should be checked for leaks and may be fired normally. Allow the trapped air to escape the boiler during this initial filling.

Hot Water boilers:

1. Close all external valves, such as feedwater, Supply, Return, and drains to avoid loss of chemicals and to isolate the boiler internal parts.
2. Remove the safety valves
3. Remove the manway cover, if so supplied and if it is in the uppermost part of the shell
4. Fill the boiler with fresh water to a level 2-3 inches above the top of the top row of tubes. Just basic tap water is acceptable for this filling.
5. Determine how many gallons of water the boiler will contain when completely filled.
6. Mix Tri-sodium phosphate and caustic soda (Sodium Hydroxide) in the amount of one (1) pound of each for each 100 gallons of water content in the boiler. Add the chemicals slowly into a bucket or barrel with water as required to dissolve them. Stir constantly to be sure that the chemicals are thoroughly dissolved.
7. Add the dissolved chemicals carefully through the largest opening available in the top of the boiler.
8. Complete filling of the boiler to the top.
9. Begin firing the boiler at the lowest rate possible and intermittently, as necessary to get the water temperature just above 200 degrees F. During this early firing, the water volume will swell and tend to overflow the openings in the top, so operate the bottom drain as necessary to maintain flooded condition in the vessel while minimizing overflow.
10. Continue this low heat input for a minimum of 4 hours, and shut the burner off.
11. Allow boiler water to cool to a temperature of 120 degrees F or less, and drain to a point of safe discharge.
12. If interior surfaces are not clean, you may repeat the above procedure.
13. If you determine the water side to be adequately clean, proceed to replace the safety valves, re-close the handhole and manhole plates with new gaskets, and refill the boiler. (Additional information about treatment of boiler water is in another section of this manual)
14. When filled to the normal level, the system should be checked for leaks and the boiler may be fired normally. Allow the trapped air to escape the system during this initial filling.

PRE START-UP – STEAM

HURST assumes that everyone involved with the start-up or operation of this boiler has some training or experience with similar equipment. If not, he/she should not be allowed to be directly involved with the operation or maintenance of the unit. Training is available and should be pursued.

Satisfactory operation of your boiler system depends on attention to details. The following steps should be attended to at initial startup and after any period of shutdown.

1. Check the Feedwater tank (deaerator) to verify that water level is correct and that feed valve that supplies water to the tank is open.
2. Pump suction valves are open
3. Power is available to the pump(s)
4. Main steam supply valve(s) is open
5. Safety valve(s) is correct for this boiler design for pressure and capacity
6. Boiler water is at correct level and Feedwater valve(s) is open
7. Verify low water cutoff operation by opening water column blowdown valve until alarm sounds and feed pump starts
8. Verify that Auxiliary Low Water Cutoff is operational. (You may close feed valve and open bottom blowdown for this check. Be sure to re-open feed valve after you close blowdown valve.) Pump should start and bring water level in the boiler back to normal operating level
9. Verify water treatment system(s) is operational and valves are open
10. All control cabinets should be clean –inside and out – with completely functional doors that are closed
11. Equipment guards should be in place
12. Fuel valves should **not** be open at this time

PRE START-UP – HOT WATER

HURST assumes that everyone involved with the start-up or operation of this boiler has some training or experience with similar equipment. If not, he/she should not be allowed to be directly involved with the operation or maintenance of the unit. Training is available and should be pursued.

Satisfactory operation of your boiler system depends on attention to details. The following steps should be attended to at initial startup and after any period of shutdown.

1. Check that feed valve that supplies water to the system is open
2. Supply and return valves are open
3. Safety valve(s) is correct for this boiler design for pressure and capacity
4. System water is at correct level
5. Verify low water cutoff operation
6. Verify chemical treatment has been performed and is satisfactory
7. All control cabinets should be clean – inside and out – with completely functional doors that are closed
8. Equipment guards should be in place
9. Fuel valves should **not** be open at this time

STARTING FROM COLD

HURST assumes that everyone involved with the start-up or operation of this boiler has some training or experience with similar equipment. If not, he/she should not be allowed to be directly involved with the operation or maintenance of this unit. Training is available and should be pursued.

Be sure to read PRE START-UP in this manual before attempting any start up.

When all points in the PRE START-UP have been completed, you may proceed to start the unit.

Open the vent on top of the boiler to allow trapped air to escape as pressure is building in the boiler. This may be accomplished by opening the vent valve – if supplied – or by removing the plug from the top of the water column balancing line.

See the manufacturer's manual for the particular burner on your boiler for instructions regarding initial firing.

Set the firing rate controller to the lowest firing rate possible. This will allow the burner to begin heating the water at a rate that will minimize stresses to the metal parts. It will also allow the lower, colder, zones to warm at a rate more consistent with that of the higher, hotter, zones. The firing rate should not be increased until after steam pressure is evident on the steam pressure gauge.

Remember, there is some refractory in your boiler that has not been completely cured. Therefore, the initial firing should be at a very low rate for a minimum of 2-3 hours to completely drive out any free moisture that remains in the refractory.

When steam is detected at the vent valve, close the air vent.

Maintain this low fire rate as steam pressure begins to build after which the firing rate can be increased and fuel/air ratios can be adjusted for optimum combustion at various rates per the manufacturer's instructions.

Subsequent firing, from cold, may require a cursory re-reading of the manufacturer's instructions. Unless changes have been made to linkages, valves, or other components, further starts, after shutdowns should only require assuring yourself of the points found in PRE START-UP.

Verifying combustion conditions should be made at time of start up and periodically thereafter using a combustion gas analyzer. No other special tools are required.

FUEL INPUT

To know the rate of fuel consumption in your boiler is important for maintaining cost records and to know when you are under firing or over firing your unit.

OIL FIRING:

To determine oil consumption rate, you need to place an oil meter in your fuel train and simply record meter readings at specific times. By doing this, you can calculate the oil consumed within that period of time.

Example: Assume you are firing No. 2 oil (140,000 Btu per gallon)

8:00 AM meter reading = 1020 gallons
9:00 AM meter reading = 1048 gallons
Difference= 28 gallons

Time = 1 hour,

So, 28 gallons in 1 hour = 28 x 140,000 = 3,920,000 Btuh (input)

At 85% efficiency, = 3,920,000 x .85 = 3,332,000 Btuh (output)

1 Boiler HP = 33,475 Btuh (output), So, 3,332,000/33475 = 99.5 HP

If you are firing a 100 HP boiler, your firing rate is almost perfect.

GAS FIRING:

To determine gas consumption you must have access to a gas meter – which your gas supplier probably has already installed in your gas line.

If the boiler is not the only load on the meter, you may have to further isolate that supply or stop operating the other equipment while measuring boiler input.

You need to verify the gas pressure and temperature at the meter and determine the inlet gas pressure and temperature that was used to calibrate the meter. Your gas supplier should be able to help you with all of this information.

You will need pressure and temperature correction factors as shown on the following chart bases on the values determined above.
Example:

8:00 AM meter reading = 5000
9:30 AM meter reading = 5040
Difference = 40

Time = 1.5 hour (90 minutes)

Assuming a value of 1000 Btu per cu ft of natural gas (typical). Your gas supplier can be more specific about your particular gas.

Assuming a pressure correction factor or 1.324,
Assuming a temperature correction factor of 1.020,
Using 3600 as the number of seconds in one hour,

Multiply 40 x 3600 x 1.324 x 1.020 = 194,469
Then divide by 90 = 2160.8 CFH

2160.8 x 1000 = 2,160,800 Btu (input)

At 82% efficiency = 2,160,800 x .82 = 1,771,856 (output)

1 Boiler Horsepower = 33,475 Btuh (output)

So, 1,771,856 / (33475 x 1.5) = 35.3 HP

If you are firing a 35 HP boiler, you are firing it about 1% over rating.

GAS PRESSURE CORRECTION FACTORS

PSIG at Meter	Meter Base Pressure				
	4 oz. (7 iwc)	8 oz. (14 iwc)	10 oz. (17.5 iwc)	1 Lb. (28.0 iwc)	2 Lbs. (56.0 iwc)
0	0.983	0.966	0.958	0.935	0.878
1/4	1.000	0.983	0.975	0.951	0.893
1/2	1.017	1.000	0.992	0.968	0.909
5/8	1.026	1.008	1.000	0.976	0.916
1	1.051	1.034	1.025	1.000	0.939
2	1.119	1.101	1.092	1.065	1.000
3	1.188	1.168	1.158	1.130	1.061
4	1.256	1.235	1.225	1.195	1.122
5	1.324	1.302	1.291	1.260	1.183
6	1.392	1.369	1.358	1.325	1.244
7	1.461	1.436	1.424	1.390	1.305
8	1.529	1.503	1.491	1.455	1.366
9	1.597	1.570	1.557	1.520	1.427
10	1.666	1.638	1.624	1.584	1.488
12	1.802	1.772	1.757	1.714	1.610
14	1.939	1.906	1.890	1.844	1.732
16	2.075	2.040	2.023	1.974	1.854
18	2.212	2.174	2.156	2.104	1.976
20	2.348	2.309	2.290	2.234	2.098
22	2.485	2.443	2.423	2.364	2.220
24	2.621	2.577	2.556	2.494	2.341
26	2.758	2.711	2.689	2.623	2.463
28	2.894	2.846	2.822	2.753	2.585
30	3.031	2.980	2.955	2.883	2.707
35	3.372	3.315	3.288	3.208	3.012
40	3.713	3.651	3.621	3.532	3.317
45	4.055	3.987	3.953	3.857	3.622
50	4.396	4.322	4.286	4.182	3.927
60	5.078	4.993	4.952	4.831	4.537
70	5.761	5.664	5.617	5.481	5.146
80	6.444	6.336	6.283	6.130	5.756
90	7.126	7.007	6.948	6.779	6.366
100	7.809	7.678	7.614	7.439	6.976
110	8.491	8.349	8.280	8.078	7.585
120	9.174	9.020	8.945	8.727	8.195
130	9.857	9.691	9.611	9.377	8.805
140	10.540	10.360	10.280	10.030	9.415
150	11.220	11.030	10.940	10.680	10.020
160	11.900	11.70	11.610	11.320	10.630
170	12.590	12.380	12.270	11.970	11.240
180	13.270	13.050	12.940	12.620	11.850
190	13.950	13.720	13.600	13.270	12.460
200	14.630	14.390	14.270	13.920	13.070

GAS TEMPERATURE CORRECTION FACTORS

Gas Temp °F	Meter Calibration Temperature				
	60° F	65° F	68° F	70° F	72° F
0	1.130	1.141	1.148	1.152	1.157
5	1.118	1.129	1.135	1.140	1.144
10	1.106	1.117	1.123	1.128	1.132
15	1.095	1.105	1.112	1.116	1.120
20	1.083	1.094	1.100	1.104	1.108
25	1.072	1.082	1.089	1.093	1.097
30	1.061	1.071	1.078	1.082	1.086
35	1.051	1.061	1.067	1.071	1.075
40	1.040	1.050	1.056	1.060	1.064
45	1.030	1.040	1.046	1.050	1.053
50	1.020	1.029	1.035	1.039	1.043
55	1.010	1.019	1.025	1.029	1.033
60	1.000	1.010	1.015	1.019	1.023
65	0.990	1.000	1.006	1.010	1.013
70	0.981	0.991	0.996	1.000	1.004
75	0.972	0.981	0.987	0.991	0.994
80	0.963	0.972	0.978	0.981	0.985
85	0.954	0.963	0.969	0.972	0.976
90	0.945	0.955	0.960	0.964	0.967
95	0.937	0.946	0.951	0.955	0.959
100	0.929	0.938	0.943	0.946	0.950
105	0.920	0.929	0.935	0.938	0.942
110	0.912	0.921	0.926	0.930	0.933
115	0.904	0.913	0.918	0.922	0.925
120	0.897	0.905	0.910	0.914	0.917

ATMOSPHERIC PRESSURE 14.4 PSI
BAROMETER 29.31 INCHES

OPERATION – STEAM (Gas or Oil fired)

The design of your HURST boiler is such that in general operation, the starting, ramping up, slowing, and stopping is all controlled automatically. (See START UP in this manual).

Some of the devices you may find on your unit are the Burner, Firing Rate Controls, Feedwater Controls, Low Water Cutoff, Auxiliary Low Water Cutoff, and High Level Alarm.

As with any automatically controlled device, the key to continued successful operation is to maintain the correct operating characteristics of the devices that are doing the controlling.

LWCO

This is especially true with a float-type low water cutoff (LWCO). This device will protect your boiler from firing when the water level is too low, but there are several things that can go awry and cause this device to fail.

The first, is allowing the interconnecting piping from the boiler to the device to become plugged with sludge. “Sludge” is an all-encompassing term for material that has settled out of the water and blocked normally open paths where water or steam should pass. This sludge may also enter the float chamber of the LWCO and block the float from properly responding to changing water levels in the boiler.

DAILY attention to controlling this sludge buildup by blowing down and physical inspection is a must.

Modifying the electrical or mechanical characteristics of the LWCO in any way may cause it to incorrectly sense boiler water level. If there is any question as to the proper operation of the LWCO, you should shut the boiler down and correct the malfunction.

ALWCO

The Auxiliary Low Water Cutoff (ALWCO), if fitted, is a back-up device in the event of failure of the LWCO. However, it is never a good idea to simply begin to rely on the ALWCO if you know something is wrong with the LWCO. A failure of the ALWCO could also occur leaving you with no safety device to shut the burner off in the event of low water. The ALWCO may be a float-type device or it may be a probe-type control.

FIRING RATE CONTROLLER:

The unit firing rate is controlled by pressure (temperature) sensitive devices that have limits within which they cause the burner to respond. The limits of this control must always be within the range of the safety valve(s) setting.

Example: *150 psi designed boiler, 150 psi safety valve setting, and Operating Control range not higher than 135 psi (about 90% of safety valve setting with a High Limit control set at 138-140 psi. The High Limit Control is another backup device that only functions if the Operating Control fails.*

The Operating Control starts and stops the burner in response to pressure in the vessel.

If fitted, the Modulating Control varies the firing rate of the burner within the range of the start-stop action of the Operating Control. The full modulating range must be lower than the upper limit of the operating control.

The High Limit Control is a backup to the Operating Control, so that in the event pressure in the boiler continues to go higher than the Operating Control set point, the High Limit control will shut down the burner. This control generally requires operator involvement for manual re-set before the unit will recycle.

BURNER:
The burner on your unit is a "forced draft" design meaning that the combustion air fan provides oxygen to the combustion process in a pressurized fashion and pushes the products of combustion through the boiler and out the exhaust stack.

All modern forced draft burners are supplied with an automatic ignition device and a flame safeguard control. These devices sequence the burning of the fuel in a proper, systematic fashion. **No effort should ever be made to bypass any of these devices.**

FEEDWATER CONTROL:
As steam is allowed to escape the boiler, water must be forced into the unit to maintain the Normal Operating Water Level. This make-up water is normally supplied from a pump that is dedicated to this one unit.

The starting and stopping of the feedwater pump (on smaller units) is typically controlled by the same device that acts as the LWCO. When the water level drops to a point just above the LWCO point, it starts the pump and allows it to run and pump water through the feedwater line until the upper level limit is satisfied. Then, the pump is allowed to stop until the next cycle is required.

On larger units, the water is normally fed continuously to the boiler through a Modulating Feedwater Valve allowing only the amount of water to pass as is necessary to maintain the Normal Operating Water Level in the boiler. This means that the feedwater pump runs continuously. The Modulating Feedwater Valve may be pneumatic or electric and it monitors the water level in the boiler to control the rate of water allowed into the unit.

HIGH WATER ALARM:
On some units there may also be a High Water Level Alarm. Normally, this control does not shut anything down, but sounds an audible alarm to alert the operator that a higher than normal water level exists in the boiler. High water level can lead to wet steam and may cause problems in the system by the introduction of water into the steam lines.

We urge the use of **Operational Logs** to maintain optimum operational efficiency of your boiler system. Maintaining regular, systematic recordings of operational data such as steam pressure, stack temperature, Feedwater temperature, fuel meter readings, boiler water

chemical levels, and any other data – even the outdoor temperature – can be very helpful in analyzing problems that may arise. Some owners/operators prefer hourly recordings, while others may feel daily recordings to be appropriate for their operation.

Remember that during periods of cold weather, the piping that supplies fresh water to the system must be protected from freezing.

OPERATION – HOT WATER (Gas or Oil fired)

The design of your HURST boiler is such that in general operation, the starting, ramping up, slowing, and stopping is all controlled automatically. (See START UP in this manual).

Some of the devices you may find on your unit are the Burner, Firing Rate Controls, Feedwater Controls, Low Water Cutoff, and High Temperature Cutoff.

As with any automatically controlled device, the key to continued successful operation is to maintain the correct operating characteristics of the devices that are doing the controlling.

LWCO

This is especially true with a float-type low water cutoff (LWCO). This device will protect your boiler from firing when the water level is too low.

DAILY operational check of this device is a must

Modifying the electrical or mechanical characteristics of the LWCO in any way may cause it to incorrectly sense boiler water level. If there is any question as to the proper operation of the LWCO, you should shut the boiler down and correct the malfunction.

FIRING RATE CONTROLLER

The unit firing rate is controlled by temperature sensitive devices that have limits within which they cause the burner to respond.

Example: *Operating to maintain 180 degree F bulk water temperature within the boiler. (Temperature range must not exceed 250 degrees F). Operating control will be set at 180 so that any time the bulk temperature drops below 180, the burner will fire to bring the temperature back up to 180 at which time the burner will shut down.*

If fitted, the Modulating Control varies the firing rate of the burner within the range of the start-stop action of the Operating Control. The full modulating range must be lower than the upper limit of the operating control.

HIGH TEMPERATURE CUTOFF:

The High Temperature Cutoff is a backup to the Operating Control. In the event temperature in the boiler continues to go to a higher temperature than the Operating Control range, the High Temperature Cutoff will shut down the burner. This control generally requires operator involvement for manual re-set before the unit will recycle.

BURNER:

The burner on your unit is a “forced draft” design meaning that the combustion air fan provides oxygen to the combustion process in a pressurized fashion and pushes the products of combustion trough the boiler and out the exhaust stack.

All modern forced draft burners are supplied with an automatic ignition device and a flame safeguard control. These devices sequence the burning of the fuel in a proper, systematic fashion. **No effort should ever be made to bypass any of these devices.**

FEEDWATER CONTROL:
As water is allowed to escape the boiler, water must be forced into the unit to maintain the Normal Operating Water Level. This make-up water may be introduced at the boiler or in an expansion tank and may be available from a pumping system or other system that delivers at a pressure adequate to overcome system pressure.

We urge the use of Operational Logs to maintain optimum operational efficiency of your boiler system. Maintaining regular, systematic recordings of operational data such as supply temperature, return temperature, stack temperature, fuel meter readings, water makeup meter readings, chemical additions and any other data – even the outdoor temperature – can be very helpful in analyzing problems that may arise. Some owners/operators prefer hourly recordings, while others may feel daily recordings to be appropriate for their operation.

BLOWOFF-BLOWDOWN

Steam:

Part of a water maintenance program will include “blowing off” or “blowing down”.

Because of the nature of introducing hot water under pressure to a point outside the boiler, it is advisable to utilize a blowdown vessel or pit to minimize the obvious hazards.

Blowoff/Blowdown is required on all steam boilers and will help maintain the quality of boiler water that is required for proper steam purity, control of dissolved or suspended solids that are in the boiler water that can lead to encrustation on the heated parts of the boiler. No water treatment program can completely eliminate all undesirable substances from your boiler water.

The most efficient method for removal of sludge that may accumulate in the bottom of your boiler along with some dissolved solids suspended in the boiler water is through **Bottom Blowdown.**

This is an intermittent, manual opening of the water space to the outside. This exercise will generally be performed once every 8 hours of operation, but the final schedule should be determined by your water quality consultant.

Functionally, the typical unit will have one or more “slow-opening” globe valves and one “quick opening” valve mounted to piping that is connected at one or more points along the belly of the boiler.

The operation is such that the “quick opening” valve is opened first, followed by opening of the globe valve(s). As soon as the globe valve is fully open, begin immediately to close it. When it is closed, close the “quick opening” valve. This process should probably lower the level in the gage-glass approximately one-half inch.

Surface Blowoff is a common method for removing oil and other impurities that accumulate at the surface of the water in the boiler.

Functionally, this method utilizes a collection pipe or pipes that are mounted just below the normal water level in the boiler. This piping culminates just outside the boiler with a control valve that controls the rate at which water is allowed to flow depending on the analysis of the collected water. This analysis may be intermittent with manual valve adjustments or it may be automatic with instrumentation that will adjust the valve accordingly.

The ultimate discharge of this water must also be directed properly to avoid contact with property or personnel.

Water Column Blowdown is another procedure for controlling or eliminating sediment from the low water cutoff device and the associated piping. This procedure should be executed at least one time every 12 hours of operation. The operation of the **pump control** and the **low water cutoff** should be verified each time this blowdown is executed. The importance of this procedure must never be underestimated and is probably the most important function you can perform to help eliminate low-water failures in your boiler.

Hot Water:

Normally, no blowdown is required on a water boiler because there is little make-up of water in a closed system. However, water quality should be checked periodically to determine need for adjustment to your water quality program.

SHUT DOWN

Steam Boilers:

Short term:

If you intend to shut your boiler down for a period not to exceed 3 days, (72 hours), you may simply turn off the power, close the valves and leave the water at the normal operating level without further preparation.

Long term:

If you intend to shut your boiler down for a period exceeding 3 days – up to 14 days, you should turn off the power, fill the boiler completely with water, close all the valves, and take no further steps of preparation.

However, in both cases sited above, if there are other boilers connected in the system with this unit, precautions must be taken to ascertain that no bleed-over is taking place that would pressurize the idled boiler either through the introduction of feedwater or steam.

Extended period:

For periods of shutdown beyond 14 days, you must consider either a “wet layup” or a “dry layup”.

Wet layup means to fill the boiler completely with treated water, close all valves on the boiler, and to carefully monitor the quality of the water at least weekly during the layup period. You must also verify weekly that leakage or other influences have not lowered the water level in the boiler. If it is not full, you must add water to maintain a condition of full.

The success of this storage method depends largely upon eliminating any air coming in contact with any of the water side of the unit while maintaining good boiler-quality water inside.

Dry layup means to drain all the water from the boiler, wash and flush as necessary to remover all sludge from the water side, and use whatever method is available to COMPLETELY dry the water side of the unit.

Then, when the unit is completely dry inside, place moisture absorbing material inside on pans, if possible, and seal the water side as tightly as possible from the outside environment. The absorbing materials must be checked weekly and replaced when they become damp.

The success of this storage method depends largely upon eliminating any moist air from coming in contact with any metal surface inside the boiler for the entire period of lay up.

If you are in an area subject to freezing temperatures, be sure to disconnect and drain all connecting lines.

For this extended period of shutdown, it is recommended that all gas-side surfaces be brushed to remove all soot or other foreign deposits which could lead to corrosion of the metal parts during the time of shutdown.

Hot Water Boilers:

Wet and Dry Layup procedures are the same for hot water systems (as steam systems) that are to shut down for extended periods of time.

Danger of freezing with wet layup is of particular concern in a water system because of the volume of water involved and the piping system that may extend to no-heated areas of the facilities.

MAINTENANCE

The importance of maintenance cannot be overemphasized when discussing boiler operations.

The cleanliness of the entire boiler room will impact how long some of the controls will continue to function and how accurate that functionality will be.

DAILY:

- Sweep or wash down the floor
- Wipe up oil spills
- Clean the dust from top of control panels and other flat surfaces
- Blow down water column every 12 hours to prove functionality (steam)
- Blow down bottom blow ever 8 hours (steam)
- Record stack temperature. This is helpful in determining the need for cleaning the fireside of the boiler.
- Note feedwater temperature (and tank pressure, if system is pressurized) (steam)
- Note by visual inspection that the water level in the boiler is at the normal operating level. (steam)
- Note steam (or water) pressure gauge reading
- Perform water quality analysis and record results
- Check for leaks at all piping connections and inspection opening on the boiler**. Reduce boiler pressure to below 15psi before attempting any tightening of handholes, gage glass fittings or the like.** Replace gaskets as soon as practicable.
- Check softener tanks and re-supply, if applicable
- Always be sensitive to tube leaks. Water dripping to the floor at the front or rear of the boiler especially when the unit is shut down, or when steam vapor in the stack, this should be investigated immediately. **Do not attempt to expand tubes while the boiler is under pressure.**

WEEKLY:

- Verify the operation of the steam pressure controls (steam)
- Perform water quality analysis and adjust surface blowoff rate, if applicable (steam)
- Check softener supplies and re-order as needed
- Check handhole and manway gasket inventory and re-order as needed
- Compare stack temperature reading records and note trend in temperature gradient (Increasing temperatures may indicate a need for fireside cleaning).

Remember, many motors and other moving components start and stop automatically. Be sure to disconnect power before servicing to avoid possible injury to yourself or others.

Steam and hot water can severely injure or kill. Do not attempt adjustments or repairs while system is "hot" and under pressure.

SEMI ANNUALLY OR ANNUALLY:

- Plan ahead for the periodic insurance company or jurisdictional inspection. Have manpower and tools available to minimize the time required for this important inspection.

- Be sure to have new gaskets available for all the gasketed openings that must be disassembled.

All jurisdictions and insurance companies require periodic waterside and fireside inspections. These vary with the states and companies, so you need to determine their schedule requirement so you will be prepared. These inspections can usually be carried out at the same time to minimize down time for your operation.

- Each time the boiler is opened for an internal inspection, use this time to note any sludge buildup on any surface, especially in the belly of the boiler and wash this out thoroughly.

- Also, note any suspicious area of pitting or chemical buildup on the tubes or furnace. Involve your chemical supplier for a possible re-evaluation of your water treatment program; and after his inspection, thoroughly wash these areas clean.

- Note the condition of the fireside of the boiler. The furnace, tubes, front and rear smokeboxes and the stack should all be brushed, or vacuumed as necessary to remove any foreign materials. Note especially any evidence of tube leaks on the front and rear tube sheets and in the turnaround space, if so fitted. This is the time to contact your local boiler service company and have those leaking tubes repaired.

When preparing for a waterside inspection, stop all fuel input at least 18 hours prior to the inspection. Allow the boiler to cool slowly to minimize stresses in the heated parts. On steam boilers, blow the bottom blowdown frequently during this cool down period to introduce cooler water and flush out settled sludge.

About 6 hours before the inspection, open front and rear doors. As soon as boiler pressure has gone to 0 psig, close feedwater valves and remove manway. Open top air vent. Turn off all power to the boiler.

Open all bottom blowdown (drain) valves to begin draining the boiler. As water is drained, you may begin washing down as you see fit until internal parts are clean.

WATER QUALITY

The life expectancy of your boiler is greatly impacted by the quality of the water you place into it. If you take steps to assure the water to be free of contaminants and solids and to have the correct pH, only periodic waterside inspections are necessary to maintain an efficient, long-life operation.

STEAM BOILERS:

When the water that you place into your boiler is converted into steam; that steam leaves the boiler, but the contaminants that were in the water stay in the boiler and have the potential to form sludge and scale.

Sludge is generally a soft, settleable material that over time will drop to the bottom of the boiler and may be removed through bottom blowdown. It can impact heat transfer since it will also build up on furnace the tubes. Left uncontrolled, it can contribute to foaming and priming thereby compromising steam quality.

Scale however, is that material that will cake on the furnace and tubes in a hard, baked-on layer that will lead to poor heat transfer and may cause overheating of those surfaces to the point of rupture. Ultimately, this scale must be removed, so it is better to take steps to eliminate the very formation of the scale. Removal of scale from the water side of a boiler can be very labor intensive and costly.

pH is the measure of how acidic the water is. If the pH is not properly adjusted, the metal surfaces can experience conditions that can lead to corrosion, pitting and ultimate failure.

Sludge, scale and pH are all controllable. The condition of the raw boiler water must be analyzed and corrected before it is introduced into the boiler. Filters, softeners, dealkalizers and chemical feed systems are some of the pre-treatment methods used to create suitable boiler water. Additional chemical treatment is sometimes required to be injected internally into the boiler.

A water quality consultant can make an analysis of your boiler water and make recommendations for treatment.

Some recommendations for conditions of acceptable boiler water are:

Oxygen	<.007 ppm
Total hardness	<5 ppm
Total Alkalinity (CACO3)	<700 ppm
Total Iron (Fe)	<10 ppm
Silica (SI02)	<150 ppm
Suspended Solids	<300 ppm – (up to 300psi)
	<250 ppm – (300 - 450psi)
	<150 ppm – (450 - 600psi)
Total Solids	<3000 ppm
pH	7.5 – 11

Hot Water Boilers:

At the time of filling the system for the first time, the water quality should be checked and treated. Chemicals to prevent scale formation, elimination of dissolved gases and control of pH should be of particular importance.

Although these systems are considered “closed”, there are conditions that can lead to water losses which must be made up. Leakage through handholes, threaded pipe fitting, pump seals and a variety of other issues in the system can lead to make-up water being required in the system water.

A meter on the make-up water line is a good method for determining the amount of water that has been added to the system over a given period of time. This will alert the operator to verify system water quality and adjust treatment as necessary.

Shot-type feeders are generally the method used for introducing chemicals into the system.

SATURATED STEAM PROPERTIES

ABS Press.	Temp	Specific Volume (ft^3/lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,F)			INTERNAL ENERGY (Btu/lb)		
PSIA	°F	Sat. Liquid	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor
P	t	v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	u_f	u_{fg}	u_g
14.696	212.00	0.01672	26.80	180.07	970.3	1150.4	0.3120	1.4446	1.7566	180.02	897.5	1077.5
15	213.03	0.01672	26.29	181.11	969.7	1150.8	0.3135	1.4415	1.7549	181.06	896.7	1077.8
16	216.32	0.01674	24.75	184.42	967.6	1152.0	0.3184	1.4313	1.7497	184.37	894.3	1078.7
17	219.44	0.01677	23.39	187.56	965.5	1153.1	0.3231	1.4218	1.7449	187.51	892.0	1079.5
18	222.41	0.01679	22.17	190.56	963.6	1154.2	0.3275	1.4128	1.7403	190.50	889.9	1080.4
19	225.24	0.01681	21.08	193.42	961.9	1155.3	0.3317	1.4043	1.7360	193.36	887.8	1081.2
20	227.96	0.01683	20.089	196.16	960.1	1156.3	0.3356	1.3962	1.7319	196.10	885.8	1081.9
21	230.57	0.01685	19.192	198.79	958.4	1157.2	0.3395	1.3885	1.7280	198.73	883.9	1082.6
22	233.07	0.01687	18.375	201.33	956.8	1158.1	0.3431	1.3811	1.7242	201.26	882.0	1083.3
23	235.49	0.01689	17.627	203.78	955.2	1159.0	0.3466	1.3740	1.7206	203.71	880.2	1083.9
24	237.82	0.01691	16.938	206.14	953.7	1159.8	0.3500	1.3672	1.7172	206.07	878.5	1084.6
25	240.07	0.01692	16.303	208.42	952.1	1160.6	0.3533	1.3606	1.7139	208.34	876.8	1085.1
26	242.25	0.01694	15.715	210.62	950.7	1161.3	0.3564	1.3544	1.7108	210.54	875.2	1085.7
27	244.36	0.01696	15.170	212.75	949.3	1162.0	0.3594	1.3484	1.7078	212.67	873.6	1086.3
28	246.41	0.01698	14.663	214.83	947.9	1162.7	0.3623	1.3425	1.7048	214.74	872.1	1086.8
29	248.40	0.01699	14.189	216.86	946.5	1163.4	0.3652	1.3368	1.7020	216.77	870.5	1087.3
30	250.33	0.01701	13.746	218.82	945.3	1164.1	0.3680	1.3313	1.6993	218.73	869.1	1087.8
31	252.22	0.01702	13.33	220.73	944.0	1164.7	0.3707	1.3260	1.6967	220.63	867.7	1088.3
32	254.05	0.01704	12.940	222.59	942.8	1165.4	0.3733	1.3209	1.6941	222.49	866.3	1088.7
33	255.84	0.01705	12.572	224.41	941.6	1166.0	0.3758	1.3159	1.6917	224.31	864.9	1089.2
34	257.58	0.01707	12.226	226.18	940.3	1166.5	0.3783	1.3110	1.6893	226.07	863.5	1089.6
35	259.28	0.01708	11.898	227.91	939.2	1167.1	0.3807	1.3063	1.6870	227.80	862.3	1090.1
36	260.95	0.01709	11.588	229.60	938.0	1167.6	0.3831	1.3017	1.6848	229.49	861.0	1090.5
37	262.57	0.01711	11.294	231.26	936.9	1168.2	0.3854	1.2972	1.6826	231.14	859.8	1090.9
38	264.16	0.01712	11.015	232.89	935.8	1168.7	0.3876	1.2929	1.6805	232.77	858.5	1091.3
39	265.72	0.01714	10.750	234.48	934.7	1169.2	0.3898	1.2886	1.6784	234.36	857.2	1091.6
40	267.25	0.01715	10.498	236.03	933.7	1169.7	0.3919	1.2844	1.6763	235.90	856.1	1092.0
41	268.74	0.01716	10.258	237.55	932.6	1170.2	0.3940	1.2803	1.6743	237.42	855.0	1092.4
42	270.21	0.01717	10.029	239.04	931.6	1170.7	0.3960	1.2764	1.6724	238.91	853.8	1092.7
43	271.64	0.01719	9.810	240.51	930.6	1171.1	0.3980	1.2726	1.6706	240.37	852.7	1093.1
44	273.05	0.01720	9.601	241.95	929.6	1171.6	0.4000	1.2687	1.6687	241.81	851.6	1093.4
45	274.44	0.01721	9.401	243.36	928.6	1172.0	0.4019	1.2650	1.6669	243.22	850.5	1093.7
46	275.80	0.01722	9.209	244.75	927.7	1172.4	0.4038	1.2613	1.6652	244.60	849.5	1094.1
47	277.13	0.01723	9.025	246.12	926.7	1172.9	0.4057	1.2577	1.6634	245.97	848.4	1094.4
48	278.45	0.01725	8.848	247.47	925.8	1173.3	0.4075	1.2542	1.6617	247.32	847.4	1094.7
49	279.74	0.01726	8.678	248.79	924.9	1173.7	0.4093	1.2508	1.6601	248.63	846.4	1095.0
50	281.01	0.01727	8.515	250.09	924.0	1174.1	0.4110	1.2474	1.6585	249.93	845.4	1095.3
51	282.26	0.01728	8.359	251.37	923.0	1174.4	0.4127	1.2442	1.6569	251.21	844.3	1095.5
52	283.49	0.01729	8.208	252.63	922.2	1174.8	0.4144	1.2409	1.6553	252.46	843.3	1095.8
53	284.70	0.01730	8.062	253.87	921.3	1175.2	0.4161	1.2377	1.6538	253.70	842.4	1096.1
54	285.90	0.01731	7.922	255.09	920.5	1175.6	0.4177	1.2346	1.6523	254.92	841.5	1096.4
55	287.07	0.01732	7.787	256.30	919.6	1175.9	0.4193	1.2316	1.6509	256.12	840.6	1096.7
56	288.23	0.01733	7.656	257.50	918.8	1176.3	0.4209	1.2285	1.6494	257.32	839.7	1097.0
57	289.37	0.01734	7.529	258.67	917.9	1176.6	0.4225	1.2255	1.6480	258.49	838.7	1097.2

ABS Press.	Temp	Specific Volume (ft^3/lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,F)			INTERNAL ENERGY (Btu/lb)		
PSIA	°F	Sat. Liquid	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor
P	t	v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	u_f	u_{fg}	u_g
58	290.50	0.01736	7.407	259.82	917.1	1176.9	0.4240	1.2226	1.6466	259.63	837.8	1097.4
59	291.61	0.01737	7.289	260.96	916.3	1177.3	0.4255	1.2197	1.6452	260.77	836.9	1097.7
60	292.71	0.01738	7.175	262.09	915.5	1177.6	0.4270	1.2168	1.6438	261.90	836.0	1097.9
61	293.79	0.01739	7.064	263.20	914.7	1177.9	0.4285	1.2140	1.6450	263.00	835.2	1098.2
62	294.85	0.01740	6.957	264.30	913.9	1178.2	0.4300	1.2112	1.6412	264.10	834.3	1098.4
63	295.90	0.01741	6.853	265.38	913.1	1178.5	0.4314	1.2085	1.6399	265.18	833.4	1098.6
64	296.94	0.01742	6.752	266.45	912.3	1178.8	0.4328	1.2059	1.6387	266.24	832.6	1098.8
65	297.97	0.01743	6.655	267.50	911.6	1179.1	0.4342	1.2032	1.6374	267.29	831.8	1099.1
66	298.99	0.01744	6.560	268.55	910.8	1179.4	0.4356	1.2006	1.6362	268.34	831.0	1099.3
67	299.99	0.01745	6.468	269.58	910.1	1179.7	0.4369	1.1981	1.6350	269.36	830.2	1099.5
68	300.98	0.01746	6.378	270.60	909.4	1180.0	0.4383	1.1955	1.6338	270.38	829.4	1099.8
69	301.96	0.01747	6.291	271.61	908.7	1180.3	0.4396	1.1930	1.6326	271.39	828.6	1100.0
70	302.92	0.01748	6.206	272.61	907.9	1180.6	0.4409	1.1906	1.6315	272.38	827.8	1100.2
71	303.88	0.01749	6.124	273.60	907.2	1180.8	0.4422	1.1881	1.6303	273.37	827.0	1100.4
72	304.83	0.01750	6.044	274.57	906.5	1181.1	0.4435	1.1857	1.6292	274.34	826.3	1100.6
73	305.76	0.01751	5.966	275.54	905.8	1181.3	0.4447	1.1834	1.6281	275.30	825.5	1100.8
74	306.68	0.01752	5.890	276.49	905.1	1181.6	0.4460	1.1810	1.6270	276.25	824.7	1101.0
75	307.60	0.01753	5.816	277.43	904.5	1181.9	0.4472	1.1787	1.6259	277.19	824.0	1101.2
76	308.50	0.01754	5.743	278.37	903.7	1182.1	0.4484	1.1764	1.6248	278.12	823.3	1101.4
77	309.40	0.01754	5.673	279.30	903.1	1182.4	0.4496	1.1742	1.6238	279.05	822.5	1101.6
78	310.29	0.01755	5.604	280.21	902.4	1182.6	0.4508	1.1720	1.6228	279.96	821.7	1101.7
79	311.16	0.01756	5.537	281.12	901.7	1182.8	0.4520	1.1698	1.6217	280.86	821.0	1101.9
80	312.03	0.01757	5.472	282.02	901.1	1183.1	0.4531	1.1676	1.6207	281.76	820.3	1102.1
81	312.89	0.01758	5.408	282.91	900.4	1183.3	0.4543	1.1654	1.6197	282.65	819.6	1102.2
82	313.74	0.01759	5.346	283.79	899.7	1183.5	0.4554	1.1633	1.6187	283.52	818.9	1102.4
83	314.59	0.01760	5.285	284.66	899.1	1183.8	0.4565	1.1612	1.6177	284.39	818.2	1102.6
84	315.42	0.01761	5.226	285.53	898.5	1184.0	0.4576	1.1592	1.6168	285.26	817.5	1102.8
85	316.25	0.01761	5.168	286.39	897.8	1184.2	0.4587	1.1571	1.6158	286.11	816.8	1102.9
86	317.07	0.01762	5.111	287.24	897.2	1184.4	0.4598	1.1551	1.6149	286.96	816.1	1103.1
87	317.88	0.01763	5.055	288.08	896.5	1184.6	0.4609	1.1530	1.6139	287.80	815.4	1103.2
88	318.68	0.01764	5.001	288.91	895.9	1184.8	0.4620	1.1510	1.6130	288.63	814.8	1103.4
89	319.48	0.01765	4.948	289.74	895.3	1185.1	0.4630	1.1491	1.6121	289.45	814.1	1103.6
90	320.27	0.01766	4.896	290.56	894.7	1185.3	0.4641	1.1471	1.6112	290.27	813.4	1103.7
91	321.06	0.01767	4.845	291.38	894.1	1185.5	0.4651	1.1452	1.6103	291.08	812.8	1103.9
92	321.83	0.01768	4.796	292.18	893.5	1185.7	0.4661	1.1433	1.6094	291.88	812.2	1104.1
93	322.60	0.01768	4.747	292.98	892.9	1185.9	0.4672	1.1413	1.6085	292.68	811.5	1104.2
94	323.36	0.01769	4.699	293.78	892.3	1186.1	0.4682	1.1394	1.6076	293.47	810.9	1104.4
95	324.12	0.01770	4.652	294.56	891.7	1186.2	0.4692	1.1376	1.6068	294.25	810.2	1104.5
96	324.87	0.01771	4.606	295.34	891.1	1186.4	0.4702	1.1358	1.6060	295.03	809.6	1104.6
97	325.61	0.01772	4.561	296.12	890.5	1186.6	0.4711	1.1340	1.6051	295.80	808.9	1104.7
98	326.35	0.01772	4.517	296.89	889.9	1186.8	0.4721	1.1322	1.6043	296.57	808.3	1104.9
99	327.08	0.01773	4.474	297.65	889.4	1187.0	0..473 1	1.1304	1.6035	297.33	807.7	1105.0
100	327.81	0.01774	4.432	298.40	888.8	1187.2	0.4740	1.1286	1.6026	298.08	807.1	1105.2
101	328.53	0.01775	4.391	299.15	888.2	1187.4	0.4750	1.1268	1.6018	298.82	806.5	1105.3
102	329.25	0.01775	4.350	299.90	887.6	1187.5	0.4759	1.1251	1.6010	299.57	805.9	1105.4
103	329.96	0.01776	4.310	300.64	887.1	1187.7	0.4768	1.1234	1.6002	300.30	805.3	1106.6
104	330.66	0.01777	4.271	301.37	886.5	1187.9	0.4778	1.1216	1.5994	301.03	804.7	1105.7

ABS Press.	Temp	Specific Volume (ft^3/lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,F)			INTERNAL ENERGY (Btu/lb)		
PSIA	°F	Sat. Liquid	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor
P	t	v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	u_f	u_{fg}	u_g
105	331.36	0.01778	4.232	302.10	886.0	1188.1	0.4787	1.1199	1.5986	301.75	804.1	1105.9
106	332.05	0.01778	4.194	302.82	885.4	1188.2	0.4796	1.1182	1.5978	302.47	803.5	1106.0
107	332.74	0.01779	4.157	303.54	884.9	1188.4	0.4805	1.1166	1.5971	303.19	802.9	1106.1
108	333.42	0.01780	4.120	304.26	884.3	1188.6	0.4814	1.1149	1.5963	303.90	802.4	1106.3
109	334.10	0.01781	4.084	304.97	883.7	1188.7	0.4823	1.1133	1.5956	304.61	801.8	1106.4
110	334.77	0.01782	4.049	305.66	883.2	1188.9	0.4832	1.1117	1.5948	305.30	801.2	1106.5
111	335.44	0.01782	4.015	306.37	882.6	1189.0	0.4840	1.1101	1.5941	306.00	800.6	1106.6
112	336.11	0.01783	3.981	307.06	882.1	1189.2	0.4849	1.1085	1.5934	306.69	800.0	1106.7
113	336.77	0.01784	3.947	307.75	881.6	1189.4	0.4858	1.1069	1.5927	307.38	799.4	1106.8
114	337.42	0.01784	3.914	308.43	881.1	1189.5	0.4866	1.1053	1.5919	308.05	798.9	1106.9
115	338.07	0.01785	3.882	309.11	880.6	1189.7	0.4875	1.1037	1.5912	308.73	798.4	1107.1
116	338.72	0.01786	3.850	309.79	880.0	1189.8	0.4883	1.1022	1.5905	309.41	797.8	1107.2
117	339.36	0.01787	3.819	310.46	879.5	1190.0	0.4891	1.1007	1.5898	310.07	797.2	1107.3
118	339.99	0.01787	3.788	311.12	879.0	1190.1	0.4900	1.0992	1.5891	310.73	796.7	1107.4
119	340.62	0.01788	3.758	311.78	878.4	1190.2	0.4908	1.0977	1.5885	311.39	796.1	1107.5
120	341.25	0.01789	3.728	312.44	877.9	1190.4	0.4916	1.0962	1.5878	312.05	795.6	1107.6
121	341.88	0.01790	3.699	313.10	877.4	1190.5	0.4924	1.0947	1.5871	312.70	795.0	1107.7
122	342.50	0.01791	3.670	313.75	876.9	1190.7	0.4932	1.0933	1.5865	313.35	794.5	1107.8
123	343.11	0.01791	3.642	314.40	876.4	1190.8	0.4940	1.0918	1.5858	313.99	793.9	1107.9
124	343.72	0.01792	3.614	315.04	875.9	1190.9	0.4948	1.0903	1.5851	314.63	793.4	1108.0
125	344.33	0.01792	3.587	315.68	875.4	1191.1	0.4956	1.0888	1.5844	315.26	792.8	1108.1
126	344.94	0.01793	3.560	316.31	874.9	1191.2	0.4964	1.0874	1.5838	315.89	792.3	1108.2
127	345.54	0.01794	3.533	316.94	874.4	1191.3	0.4972	1.0859	1.5832	316.52	791.8	1108.3
128	346.13	0.01794	3.507	317.57	873.9	1191.5	0.4980	1.0845	1.5825	317.15	791.3	1108.4
129	346.73	0.01795	3.481	318.19	873.4	1191.6	0.4987	1.0832	1.5819	317.77	790.7	1108.5
130	347.32	0.01796	3.455	318.81	872.9	1191.7	0.4995	1.0817	1.5812	318.38	790.2	1108.6
131	347.90	0.01797	3.430	319.43	872.5	1191.9	0.5002	1.0804	1.5806	318.99	789.7	1108.7
132	348.48	0.01797	3.405	320.04	872.0	1192.0	0.5010	1.0790	1.5800	319.60	789.2	1108.8
133	349.06	0.01798	3.381	320.65	871.5	1192.1	0.5018	1.0776	1.5793	320.21	788.7	1108.9
134	349.64	0.01799	3.357	321.25	871.0	1192.2	0.5025	1.0762	1.5787	320.80	788.2	1109.0
135	350.21	0.01800	3.333	321.85	870.6	1192.4	0.5032	1.0749	1.5781	321.40	787.7	1109.1
136	350.78	0.01800	3.310	322.45	870.1	1192.5	0.5040	1.0735	1.5775	322.00	787.2	1109.2
137	351.35	0.01801	3.287	323.05	869.6	1192.6	0.5047	1.0722	1.5769	322.59	786.7	1109.3
138	351.91	0.01801	3.264	323.64	869.1	1192.7	0.5054	1.0709	1.5763	323.18	786.2	1109.4
139	352.47	0.01802	3.242	324.23	868.7	1192.9	0.5061	1.0696	1.5757	323.77	785.7	1109.5
140	353.02	0.01802	3.220	324.82	868.2	1193.0	0.5069	1.0682	1.5751	324.35	785.2	1109.6
141	353.57	0.01803	3.198	325.40	867.7	1193.1	0.5076	1.0669	1.5745	324.93	784.8	1109.7
142	354.12	0.01804	3.177	325.98	867.2	1193.2	0.5083	1.0657	1.5740	325.51	784.3	1109.8
143	354.67	0.01804	3.155	326.56	866.7	1193.3	0.5090	1.0644	1.5734	326.08	783.8	1109.8
144	355.21	0.01805	3.134	327.13	866.3	1193.4	0.5097	1.0631	1.5728	326.65	783.3	1109.9
145	355.76	0.01806	3.114	327.70	865.8	1193.5	0.5104	1.0618	1.5722	327.22	782.8	1110.0
146	356.29	0.01806	3.094	328.27	865.3	1193.6	0.5111	1.0605	1.5716	327.78	782.3	1110.1
147	356.83	0.01807	3.074	328.83	864.9	1193.8	0.5118	1.0592	1.5710	328.34	781.9	1110.2
148	357.36	0.01808	3.054	329.39	864.5	1193.9	0.5124	1.0580	1.5705	328.90	781.4	1110.3
149	357.89	0.01808	3.034	329.95	864.0	1194.0	0.5131	1.0568	1.5699	329.45	780.9	1110.4
150	358.42	0.01809	3.015	330.51	863.6	1194.1	0.5138	1.0556	1.5694	330.01	780.5	1110.5
152	359.46	0.01810	2.977	331.61	862.7	1194.3	0.5151	1.0532	1.5683	331.10	779.5	1110.6
154	360.49	0.01812	2.940	332.70	861.8	1194.5	0.5165	1.0507	1.5672	332.18	778.5	1110.7

ABS Press.	Temp	Specific Volume (ft^3/lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,F)			INTERNAL ENERGY (Btu/lb)		
PSIA	°F	Sat. Liquid	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor
P	t	v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	u_f	u_{fg}	u_g
154	360.49	0.01812	2.940	332.70	861.8	1194.5	0.5165	1.0507	1.5672	332.18	778.5	1110.7
156	361.52	0.01813	2.904	333.79	860.9	1194.7	0.5178	1.0483	1.5661	333.26	777.6	1110.9
158	362.53	0.01814	2.869	334.86	860.0	1194.9	0.5191	1.0459	1.5650	334.23	776.8	1111.0
160	363.53	0.01815	2.834	335.93	859.2	1195.1	0.5204	1.0436	1.5640	335.39	775.8	1111.2
162	364.53	0.01817	2.801	336.98	858.3	1195.3	0.5216	1.0414	1.5630	336.44	775.0	1111.4
164	365.51	0.01818	2.768	338.02	857.5	1195.5	0.5229	1.0391	1.5620	337.47	774.1	1111.5
166	366.48	0.01819	2.736	339.05	856.6	1195.7	0.5241	1.0369	1.5610	338.49	773.2	1111.7
168	367.45	0.01820	2.705	340.07	855.7	1195.8	0.5254	1.0346	1.5600	339.51	772.3	1111.8
170	368.41	0.01822	2.675	341.09	854.9	1196.0	0.5266	1.0324	1.5590	340.52	771.4	1111.9
172	369.35	0.01823	2.645	342.10	854.1	1196.2	0.5278	1.0302	1.5580	341.52	770.5	1112.0
174	370.29	0.01824	2.616	343.10	853.3	1196.4	0.5290	1.0280	1.5570	352.51	769.7	1112.2
176	371.22	0.01825	2.587	344.09	852.4	1196.5	0.5302	1.0259	1.5561	343.50	768.8	1112.3
178	372.14	0.01826	2.559	345.06	851.6	1196.7	0.5313	1.0238	1.5551	344.46	767.9	1112.4
180	373.06	0.01827	2.532	346.03	850.8	1196.9	0.5325	1.0217	1.5542	345.42	767.1	1112.5
182	373.96	0.01829	2.505	347.00	850.0	1197.0	0.5336	1.0196	1.5532	346.38	766.2	1112.6
184	374.86	0.01830	2.479	347.96	849.2	1197.2	0.5348	1.0175	1.5523	347.34	765.4	1112.8
186	375.75	0.01831	2.454	348.92	848.4	1197.3	0.5359	1.0155	1.5514	348.29	764.6	1112.9
188	376.64	0.01832	2.429	349.86	847.6	1197.5	0.5370	1.0136	1.5506	349.22	763.8	1113.0
190	377.51	0.01833	2.404	350.79	846.8	1197.6	0.5381	1.0116	1.5497	350.15	763.0	1113.1
192	378.38	0.01834	2.380	351.72	846.1	1197.8	0.5392	1.0096	1.5488	351.07	762.1	1113.2
194	379.24	0.01835	2.356	352.64	845.3	1197.9	0.5403	1.0076	1.5479	351.98	761.3	1113.3
196	380.10	0.01836	2.333	353.55	844.5	1198.1	0.5414	1.0056	1.5470	352.89	760.6	1113.5
198	380.95	0.01838	2.310	354.46	843.7	1198.2	0.5425	1.0037	1.5462	353.79	759.8	1113.6
200	381.79	0.01839	2.288	355.36	843.0	1198.4	0.5435	1.0018	1.5453	354.68	759.0	1113.7
205	383.86	0.01842	2.234	357.58	841.1	1198.7	0.5461	0.9971	1.5432	356.88	757.1	1114.0
210	385.90	0.01844	2.183	359.77	839.2	1199.0	0.5487	0.9925	1.5412	359.05	755.2	1114.2
215	387.89	0.01847	2.134	361.91	837.4	1199.3	0.5512	0.9880	1.5392	361.18	753.2	1114.4
220	389.86	0.01850	2.087	364.02	835.6	1199.6	0.5537	0.9835	1.5372	363.27	751.3	1114.6
225	391.79	0.01852	2.0422	366.09	833.8	1199.9	0.5561	0.9792	1.5353	365.32	749.5	1114.8
230	393.68	0.01854	1.9992	368.13	832.0	1200.1	0.5585	0.9750	1.5334	367.34	747.7	1115.0
235	395.54	0.01857	1.9579	370.14	830.3	1200.4	0.5608	0.9708	1.5316	369.33	745.9	1115.3
240	397.37	0.01860	1.9183	372.12	828.5	1200.6	0.5631	0.9667	1.5298	371.29	744.1	1115.4
245	399.18	0.01863	1.8803	374.08	826.8	1200.9	0.5653	0.9627	1.5280	373.23	742.4	1115.6
250	400.95	0.01865	1.8438	376.00	825.1	1201.1	0.5675	0.9588	1.5263	375.14	740.7	1115.8
255	402.70	0.01868	1.8086	377.89	823.4	1201.3	0.5697	0.9549	1.5246	377.01	739.0	1116.0
260	404.42	0.01870	1.7748	379.76	821.8	1201.5	0.5719	0.9510	1.5229	378.86	737.3	1116.1
265	406.11	0.01873	1.7422	381.60	820.1	1201.7	0.5740	0.9472	1.5212	380.68	735.6	1116.3
270	407.78	0.01875	1.7107	383.42	818.5	1201.9	0.5760	0.9436	1.5196	382.48	733.9	1116.4
275	409.43	0.01878	1.6804	385.21	816.9	1202.1	0.5781	0.9399	1.5180	384.26	732.3	1116.6
280	411.05	0.01880	1.6511	386.98	815.3	1202.3	0.5801	0.9363	1.5164	386.01	730.7	1116.7
285	412.65	0.01883	1.6228	388.73	813.7	1202.4	0.5821	0.9327	1.5149	387.74	729.1	1116.8
290	414.23	0.01885	1.5954	390.46	812.1	1202.6	0.5841	0.9292	1.5133	389.45	727.5	1116.9
295	415.79	0.01887	1.5689	392.16	810.5	1202.7	0.5860	0.9258	1.5118	391.13	725.9	1117.0
300	417.33	0.01890	1.5433	393.84	809.0	1202.8	0.5879	0.9225	1.5104	392.79	724.3	1117.1
310	420.35	0.01894	1.4944	397.15	806.0	1203.1	0.5916	0.9159	1.5075	396.06	721.3	1117.4
320	423.29	0.01899	1.4485	400.39	803.0	1203.4	0.5952	0.9094	1.5046	399.26	718.3	1117.6
330	426.16	0.01904	1.4053	403.56	800.0	1203.6	0.5988	0.9031	1.5019	402.40	715.4	1117.8
340	428.97	0.01908	1.3645	406.66	797.1	1203.7	0.6022	0.8970	1.4992	405.46	712.4	1117.9

ABS Press.	Temp	Specific Volume (ft^3/lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,F)			INTERNAL ENERGY (Btu/lb)		
PSIA	°F	Sat. Liquid	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor	Sat. Liquid	EVAP	Sat. Vapor
P	t	v_f	v_g	h_f	h_{fg}	h_g	S_f	S_{fg}	S_g	U_f	U_{fg}	U_g
350	431.72	0.01913	1.3260	409.69	794.2	1203.9	0.6056	0.8910	1.4966	408.45	709.6	1118.0
360	434.40	0.01917	1.2895	412.67	791.4	1204.1	0.6090	0.8851	1.4941	411.39	706.8	1118.2
370	437.03	0.01921	1.2550	415.59	788.6	1204.2	0.6122	0.8794	1.4916	414.27	704.0	1118.3
380	439.60	0.01925	1.2222	418.45	785.8	1204.3	0.6153	0.8738	1.4891	417.10	701.3	1118.4
390	442.12	0.01930	1.1910	421.27	783.1	1204.4	0.6184	0.8683	1.4867	419.88	698.6	1118.5
400	444.59	0.0193	1.1613	424.0	780.5	1204.5	0.6214	0.8630	1.4844	422.6	695.9	1118.5
410	447.01	0.0194	1.1330	426.8	777.7	1204.5	0.6243	0.8578	1.4821	425.3	693.3	1118.6
420	449.39	0.0194	1.1061	429.4	775.2	1204.6	0.6272	0.8527	1.4799	427.9	690.8	1118.7
430	451.73	0.0194	1.0803	432.1	772.5	1204.6	0.6301	0.8476	1.4777	430.5	688.2	1118.7
440	454.02	0.0195	1.0556	434.6	770.0	1204.6	0.6329	0.8426	1.4755	433.0	685.7	1118.7
450	456.28	0.0195	1.0320	437.2	767.4	1204.6	0.6356	0.8378	1.4734	435.5	683.2	1118.7
460	458.50	0.0196	1.0094	439.7	764.9	1204.6	0.6383	0.8330	1.4713	438.0	680.7	1118.7
470	460.68	0.0196	0.9878	442.2	762.4	1204.6	0.6410	0.8283	1.4693	440.5	678.2	1118.7
480	462.82	0.0197	0.9670	444.6	759.9	1204.5	0.6436	0.8237	1.4673	442.9	675.7	1118.6
490	464.93	0.0197	0.9470	447.0	757.5	1204.5	0.6462	0.8191	1.4653	445.2	673.4	1118.6
500	467.10	0.0197	0.9283	449.5	755.8	1205.3	0.6487	0.8147	1.4645	449.5	671.7	1118.6

Circulation Rates - Hot Water Systems

BOILER HP	BOILER OUTPUT (Btu/Hr/1000)	System Temperature Drop - Degrees F			
		10	20	30	40
		MAXIMUM CIRCULATION RATE - GPM			
15	500	100	50	33	25
20	670	134	67	45	34
30	1005	201	101	67	50
40	1340	268	134	89	67
50	1675	335	168	112	84
60	2010	402	201	134	101
70	2345	469	235	156	117
80	2680	536	268	179	134
100	3350	670	335	223	168
125	4185	837	419	279	209
150	5025	1005	503	335	251
200	6695	1339	670	446	335
250	8370	1674	837	558	419
300	10045	2009	1005	670	502
350	11720	2344	1172	781	586
400	13400	2680	1340	893	670
500	16740	3348	1674	1116	837
600	20080	4016	2008	1339	1004
700	23450	4690	2345	1563	1173
750	25125	5025	2513	1675	1256
800	26780	5356	2678	1785	1339
900	30125	6025	3013	2008	1506
1000	33500	6700	3350	2233	1675
1200	40170	8034	4017	2678	2009

HURST BOILER & WELDING CO., INC.
P. O. DRAWER 530, 100 BOILERMAKER LANE, COOLIDGE, GA. 31738
PHONE: 229-346-3545 --- FAX: 229-346-3874

Hot Water Boiler Design Parameters

Minimum outlet temperature = 170°F

Minimum return temperature = 150°F

Minimum circulation rate thru the boiler = 1 gpm per boiler horsepower. The 50°F temperature differential below must not be exceeded.

Maximum temperature differential = 50° F

A constant 20°F temperature differential (3.35 gpm per boiler horsepower) across the boiler is preferred for long boiler life, and low maintenance.

When starting a cold boiler the water temperature should not rise more than 1°F per minute.

Pressure drop across Hurst Hot Water Boiler waterside is less than 1.5 psi.

STANDARDS

American Society of Mechanical Engineers (ASME)
345 East 47th Street
New York, NY 10017
212-705-8500

American National Standards Institute (ANSI)
11 West 42nd Street
New York, NY 11036
212-642-4900

Canadian Standards Association (CSA)
178 Rexdale Boulevard
Etobicoke, Ontario, Canada M9W 1R3
416-747-4044

Canadian Gas Association (CGA)
55 Scarsdale Road
Don Mils, Ontario, Canada M3B 2R3
416-447-6465

National Board of Boiler and Pressure Vessel Inspectors (NB)
1055 Crupper Avenue
Columbus, OH 43229
614-888-8320

National Electric Code (NEC)
1 Batterymarch Park
Quincy, MA 02269

Underwriters Laboratories (UL and cUL)
333 Pfingsten Road
Northbrook, IL 60062

Underwriters Laboratories of Canada (ULC)
7 Crouse Road
Scarborough, Ontario, Canada M1R 3A9