Some Criteria for Choosing a Steam Boiler for a Microbrewery

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Breweries rely on steam heating for a number of functions, primarily to heat the brew kettle and produce hot water for cleaning but also for CIP operations to keep solutions at the proper temperatures and for pasteurizer heating in the bottling area. Selection of the proper steam boiler for the brewery is critical to ensure expected performance without sacrificing efficiencies in energy consumption. The discussion below entails the process for determining the selection of a boiler for a small brewery.

A low pressure steam boiler is an ASME Code Section IV Boiler stamped for 15 PSI. It can be operated up to 13- 14 PSI maximum. A high pressure steam boiler is a Section I boiler and they are usually stamped for 100, 125 or 150 PSI. There is a direct correlation between steam pressure and temperature. 10 PSI steam equates to 240° F (115° C)and 15 PSI steam = 250° F (121° C). 12-14 PSI is where most low pressure boilers operate. By contrast, a high pressure boiler can produce up to 150 PSI steam at about 365° F (185° C).

High pressure boilers are more expensive and they require higher standards of installation and monitoring than low pressure steam boilers. To determine whether a low pressure steam boiler or a high pressure steam boiler is needed the brewer should consult the company providing the brewing equipment, or look at the pressure rating of the equipment using the steam. Each vessel using steam, i.e. jackets, tubes or a calandria, should have a stamp showing its MAWP = maximum allowable working pressure, expressed in pounds per square inch (gauge) either as PSIG or PSI. A vessel with a 15 PSI rating cannot receive steam at a higher pressure without risk of vessel failure. If all the plant vessels carry an ASME rating less than 15 PSI then a low pressure steam boiler is all that is needed. If the vessels are rated over 15 PSI then high pressure steam boiler should be considered as processing with higher pressure steam will provide a faster boil.

Steam systems include support components including: A condensate return tank/boiler feed system, condensate transfer unit, blow-down tank, water softener, chemical feed system.

Figure 1. Condensate Return/Boiler Feed System

Figure 1 shows a condensate return tank. As steam vapor releases its heat in jacketed kettles and elsewhere, it condenses into hot water. This hot condensate flows into steam traps. When the steam traps are full they open and release the condensate back to the boiler feed system—either directly or through a condensate transfer unit. The feed-water tank vents off unwanted gasses like oxygen and carbon dioxide which can cause corrosion problems. The feed water tank has a float or probe control valve to allow make-up (soft) water to keep it at a set level range. The tank will also be fitted with a pump to feed water back into the boiler which is constantly developing and sending out steam vapor. Small condensate transfer units, as shown in Figure 2 are usually situated close to the point of use and are a quick and simple way to transfer condensate from the steam traps back to the condensate return tank when the condensate return run is long or if the return tank is located above the return piping. Condensate (steam that has condensed and turned back into water) can be lifted 2.31 feet for every 1 PSI at the steam trap. For relatively short runs from the traps back to the condensate return tank, there is usually enough steam pressure to get the condensate back to the boiler but situations should be reviewed on a case by case basis with the steam system supplier. Condensate Transfer units are not designed to feed water directly back into a boiler.

Figure 2. Condensate Transfer Unit

Figure 3. ASME Code Blowdown Tank

The blow-down tank (Figure 3) receives the water that gets "blown down" (drained while the boiler is under steam pressure) from the boiler and the steam column. The purpose of the blow down is to get rid of the minerals and solids that build up inside the boiler that would otherwise stick to the heating surfaces (think of the white lime scale inside a tea kettle). This water is very hot and cannot be put directly into the sewer if over 135^{o} to 140^{o} F (60^{o} C). A blow-down tank stores water that has cooled off from previous blow-downs, and tempers the incoming 220-240 F water down to 135 F before it discharges. A blow-down separator accomplishes the same thing – but because it can't store water before it directly discharges to the sewer, a separator requires an after-cooler assembly with a cold water supply. Both have a vent connection that must be piped outdoors to a safe point of discharge. The number and duration of blow downs per day depends on what your water treatment specialist recommends to keep the total dissolved solids down at a safe level – usually around 2500 PPM.

Figure 4. Twin Tank Zeolite Water Softener with Brine Tank

A water softener (Figure 4) is used to soften incoming make-up water. It should be a Zeolite salt exchange type. Avoid using de-ionized (DI) or reverse osmosis (RO) softeners for the boiler. DI and RO water can lower the boiler's water conductivity and pH to unsafe levels and actually scavenge metals from the piping and equipment causing pitting and corrosion. In order to size a softener, you must know the grains of hardness and the expected hours of boiler operation per week. Most boiler manufacturers can supply water softeners. If the boiler is small enough, a bottle exchange program from a local soft water company might be recommended instead of a rechargeable system.

Figure 5. Chemical Feed Tank with Chemical Metering Pump

Chemical feed systems (Figure 5) consist of 5 to 30 gallon plastic chemical drums with a small liquid metering pump on top. The drum may have a paddle mixer to keep the chemicals in suspension. Chemicals are "fed" either directly in to boiler through a tee in the feed water piping or else are fed into the condensate return tank (Figure 1). The blend of chemicals is should be determined by your water treatment specialist who will sometimes supply the equipment as well. The supplier can be utilized for training to demonstrate proper blow-down procedures to the person responsible for operating the boiler. The boiler operator must follow these procedures closely. The job of a water treatment specialist is to help keep the waterside of the boiler free from scale and corrosion. After the first 6 months of operation, schedule an internal waterside inspection with the water treatment specialist. If scale or corrosion is found then the water treatment program should be adjusted. Once an effective program is in place, waterside inspections can take place annually. It is important to monitor the chemical usage of the system to make sure proper dosing is actually taking place as pumps can fail or become inoperative. Boiler operations should include a daily log to record blow-down activity and soft water/chemical feed maintenance.

Steam boilers are often required to be installed in a separate "boiler room." In some cases the boiler may installed inside a large, open building space provided there is enough combustion and ventilation air that infiltrates the space. This is a Uniform Mechanical Code question that should not be guessed upon. The question of separate one hour fire rated enclosure or open space for a particular installation must be reviewed by an architect, contractor, and ultimately must be approved by your local Building and Safety Department.

Some manufacturers offer weatherproof steam boilers that can be installed outdoors. These can be a good choice but they are generally recommended for milder climates only. The advantages are the boiler sits in the open in a concrete pad, saving indoor space and the construction cost of a boiler room. The negatives are the steam and return pipe insulation must be covered in watertight metal jacketing; and servicing equipment outdoors can be difficult in bad weather. Some gas valves don't operate below 32^{o} F (0^{o} C) and if the water in the boiler or piping freezes it could cause significant damage. The best approach is to consult local mechanical codes and advise the manufacturer ahead of time of where you want to install the boiler (indoors, outdoors or under a lean-to) and let the manufacturer help you choose the best option.

Boilers require fuel and there are different fuel options. Natural gas, if available, will usually be the best option. If not available then propane and diesel (#2 oil) would be the other two options. Some manufacturers also offer electric boilers, but the cost of electricity usually makes them very expensive to operate.

Figure 6. Atmospheric Low Pressure Steam Boiler (15 PSI MAWP) Natural gas or Propane Fired

What is the difference between an atmospheric burner and a power burner? An atmospheric gas burner requires no electric motor. It uses the venturi principle to pre-mix combustion air with natural gas or propane (see Figure 6). A power burner uses an electric motor and blower wheel to supply the combustion air and a diffuser plate to mix the air and fuel (see Figure 7).

Figure 7. Power Burner Fired Low Pressure Steam Boiler (Required for Low NOx or Diesel Fuel)

Is a power burner more efficient than an atmospheric burner? On larger boilers, the answer is yes, but for most microbreweries with boilers 50 horsepower and smaller – the answer is generally no. This is because on-off fired atmospheric burners will maintain fuel-air ratios similar to what power burners can achieve. Add to that the electrical consumption of a motor driven power burner and there is no appreciable energy savings of a power burner over an atmospheric on smaller boilers.

What are the other advantages of atmospheric over power burner? Atmospheric boilers are so quiet that you can stand right next to them and not know they're firing. There is no burner motor so there is almost no electrical load. Every time there is a call for steam, the atmospheric will start to fire and make steam almost immediately. The power burner must go through a pre-purge cycle that forces ambient air through the heat exchanger for up to 90 seconds during that time until the burner comes on. Power burners with linkages should be seasonally adjusted to keep the air-fuel ratios correct. This requires a burner/boiler technician with a combustion analyzer. An atmospheric burner on the other hand, has nothing to adjust other than the gas pressure regulator using a screwdriver and a gas pressure gauge or manometer. This can be done once during start up. The cost of an atmospheric boiler is generally much less than a power burner fired boiler.

Diesel (#2 oil) requires a power burner. In cases where low NOx boilers are mandated (most of California and Texas) a low NOx power burner is required. At higher altitudes (2500 feet and above) power don't have to be de-rated for elevation.

Regardless of the type of boiler it should deliver at least 80% efficiency. Keeping the heating surfaces free from scale is the most important issue with boiler energy efficiency. Most steam boilers will experience waterside scaling at some point. A water softener fails to regenerate, someone forgets to blow the boiler down, the chemical pump fails or the chemical drum runs dry. All these issues will lead to scale build up inside the boiler and a steam boiler should be designed so that the scale can easily be removed.

There are other devices, such as automatic stack dampers on atmospheric boilers that will increase the overall efficiency (AFUE) of the boiler. Some things, like oxygen trim sensors, linkageless air-fuel systems and stack economizers are cost effective on large boilers but not for smaller units. Insulating steam piping and condensate return lines is a must for maintaining steam pressure and reducing fuel costs. Ask the boiler manufacturer what energy savings devices would best fit your application.

Each brewery situation is different and it is important in considering selection to focus on what the highest duty applications will be, usually the wort boil, and to size the boiler to handle that and other peak demand duties, ie hot water generation, so as to not over or under size the equipment. Consider the steam boiler as an entire system and make sure that the supplier and installer design the system to be efficient in terms of condensate capture and re-use. Remember that the steam system will consume large amounts of fuel it is in your best interest to choose the boiler and support components wisely.

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