

Firetube Boiler Design Construction and Engineering Outline and Summary

July 29th, 2015

1) Q: Please repeat which methodology of tube attachment is used for the different passes.

A: In high pressure and hot water boilers they are rolled, beaded and welded in the 2nd pass. Then the tubes are rolled and beaded in the 3rd pass and rolled and flared in the 4th pass. In low pressure steam units they are rolled and beaded in all passes except the last one where they are rolled and flared.

2) Q: Which have good result, 2 pass, 3 pass or 4 pass?

A: The number of passes in the boiler is strictly a design choice and has little to do with the efficiency PROVIDED the boiler has been properly designed. If all things are equal, and only the number of passes change, the boiler with the greatest number of passes will be the most efficient because it will have the greatest amount of heating surface.

3) Q: Thermal expansion of fire tubes vs shell expansion.

A: Firetube boilers have been designed and built to withstand specific temperature gradients and expansion rates so as to withstand the growth and shrink of the vessel as it encounters the varying heat fluxes due to modulating firing and varying Delta T's.

4) Q: How does the new high efficiency boiler design comply with the normal standard mil-spec that is used in DOD work for the military furnace heat release, etc?

A: It is in full compliance as the heat release is below the requirement.

5) Q: Thermal shocks issue and the need for recirculating pumps.

A: Thermal shock potential in firetube boilers is a concern. The wetback design will be more forgiving in these hydronic applications due to its single tube sheet in the second pass which mitigates temperature gradients to a large extent. It is the second pass of the boiler which normally fails when large temperature swings occur causing excessive expansion and contraction of the vessel. Regardless, to minimize the potential, a belly pump should be installed on all hot water firetube boilers where the water from the bottom of the shell is pumped into the boiler's return, blending and lowering the Delta T. A 3 or 4 way valve should also be installed in the system to also blend boiler supply water with cooler returns to lessen the possibility of shock.

6) Q: I am curious about "passes". I understand the gas flow through the furnace but does it circulate back through using baffles? Is each pass independent of each other?

A: There are some designs of firetube boilers which do reverse flow in the furnace, making essentially 2 passes before exiting to the convection tube section before exiting into the stack. This is fairly rare. Normally, the hot effluent in the furnace makes a single pass within, then hits a rear baffle causing the gas to proceed through convection tubes to the front of the boiler, hit another baffle causing the gas to reverse direction toward the rear of the unit where it exits into the stack (3 pass boiler) or, hits another baffle where it turns again toward the front of the unit and exits to the stack (4 pass unit).

7) Q: If users plug firetubes, is there guidance regarding how many can be plugged without detrimentally effecting the operation of the boiler?

A: Plugging of tubes in a boiler is a risky thing as it affects heat transfer; impacting not only the efficiency but the life of the boiler. This should be a temporary measure, and not conducted before consulting with the designer/manufacturer.

8) Q: How easy is the cleaning and maintenance of those tubes with inner grooves? What happens with the fouling after a few years of operating?

A: Cleaning of the rifled or grooved tubes is similar to a plain tube, and as long as the burner maintains the proper fuel/air ratio, not going fuel rich, excessive fireside fouling should not be a problem.

9) Q: Why not using finned tubes to increase heat transfer area?

A: You can. It all depends on the manufacturer's design criteria. If fins are used; however, it will restrict the type of fuel burned, limiting you to natural or propane gas unless the fins (turbulators) can be removed for cleaning.

10)Q: Are the flue gas discharge temperatures lower in the 4 pass design versus the same size boiler in a 3 pass design?

A: When comparing similar furnace size, plain tubes in the convection areas, same firing rate and operating pressure, yes, the 4 pass will be more efficient, registering a lower stack temperature.

11) Q: Can tubes be upgraded to the spiral tubes that I saw?

A: No, they would need to be replaced or turbulators added to increase turbulence and heat transfer. This should never be done without the expressed consent of the manufacturer as these modifications will affect pressure drop, gas velocity and fan/motor horsepower.

12)Q: Depending where the boiler is, one may really need a water softener system.

A: Yes, if there is any degree of raw water makeup.

13)Q: Is there not more surface area on a corrugated?

A: There is extended surface area, but no more overall area than the plain type.

14)Q: Why do extended surface fire tubes increase efficiency by increasing surface area, but the corrugated furnace tubes do not increase efficiency?

A: It is the emissivity in the furnace involving the huge temperature difference (the power of 4) between fireside and waterside which accounts for the excellent radiant heat absorption, not the extended versus plain surface areas.

15)Q: Where do dimpled tubes fit in the design bag of tricks?

A: Dimpled tubes really do the same thing as fins or spirals. They extend the surface and break up the laminar flow. We used to use dimples in our second pass tubes on occasion, but have found the spirals to be just as effective and more economical to produce. Spirals also don't create the same amount of pressure drop, requiring more blower horsepower.

16)Q: Why are they called Scotch Marine?

A: Because many of these firetube boilers were used on ships to provide motive force and heat for various on-board uses such as heating, cooking and domestic use.

17)Q: Are there energy star ratings and other reports from department of energy designs or recommendations for boilers with recovery systems?

A: Yes, there are, but the specifics would need to be explored.

18)Q: Are all FTB stress relieved, or only if indicated via code?

A: Only as indicated via ASME code.

19)Q: What dictates the number of passes in a boiler design/selection?

A: Minimum efficiency desired.

20)Q: What dictates the selection of wetback vs dryback?

A: Many times it is customer preference because of their desire to get away from the heavy rear door on the dryback, or it could be existing stack location as many wetback boilers are 3 pass meaning the stack outlet is in the rear. Any even numbered pass boiler (2 or 4) will have the outlet in the front. Wetback boilers eliminate the rear door but create a confined space entry concern.

21)Q: In design of the fire tube boiler, the number of tubes in pass 2 is more than pass 3. Why?

A: This has to do with maintaining the proper velocity through the various tube passes. As the gas gives up its heat, the mass volume is reduced; therefore, the cross sectional area gets smaller (less tubes) from the 2nd to the 3rd and 4th pass to maintain the velocity. Think of a water hose nozzle. As you restrict the orifice, the spray velocity increases with the same upstream pressure.

22)Q: Is the wet back more energy efficient than the dry back?

A: No. Depending on the number of passes, it may be less efficient.

23)Q: When we have dual fuel boiler (gas and oil), any specific consideration during design/selection.

A: The main area of scrutiny for a boiler which is to burn a combination of fuels is the burner. How is the oil atomized (pressure or air). Is the oil premixed with air before it is ignited? How is the oil metered and controlled? And finally, how easy is it to switch from one fuel to another?

24)Q: Is the 81-87% efficiency overall efficiency, thermal efficiency, or combustion efficiency?

A: Overall efficiency, in order to get to the higher levels an economizer is required. If you build a firetube boiler over 82% efficiency stack condensation can occur.

25)Q: Would you please revisit the FGR and discuss the burner short cycling

A: FGR does not change boiler efficiency, short cycling is due to limited turndown of the burner compared to the load when FGR is introduced at the higher levels affecting flame stability. Miss adjusted fuel, air and FGR will affect boiler performance.

26)Q: Will installation of O₂-trim increase the turndown ratio of a burner? If so, can you explain how this happens?

A: No, it does not increase turndown. It reduces the drift in tuning of the boiler over time keeping it operating more efficiently. Turndown is dependent on burner/boiler design.

27)Q: From a code standpoint, is it ok to retrofit a vfd on an existing boiler feed water pump to save energy?

A: There should be no code issues impacted by this retrofit option; however, it's important the feed pump operates within the varying evaporation requirements of the boiler as it modulates from low to high fire.

28)Q: Is that efficiency including all heat losses?

A: Yes, radiant and convective losses are included. Heat lost up the stack is the major contributor.

29)Q: Why there is Plain and Corrugated Furnace?

A: It is a simple cost vs stress analysis any boiler that can be made with a plain furnace can also be made with a corrugated furnace unless it is too small for our tooling.

30)Q: Why the tube sheets now are flat? Before was curved ends?

A: Strictly a manufacturing/cost issue. No difference in the integrity of the welded joint.

31)Q: Which tubes have good life?

A: Carbon steel tubes are used in the standard firetube boiler. These will last for an extended period of time as long as the boiler is properly operated and maintained.

32)Q: What liquid carryover is your standard given the limits Steve just discussed?

A: With pressures over 100 PSIG we guaranty 99.5% steam quality below that we expect 98.5% or better.

33)Q: What should be optimum life of tubes?

A: Tube life is primarily dependent on water quality and treatment along with proper operation and maintenance as mentioned above.

34)Q: I have been operating and maintaining C-B Firetube Boilers for 45 years. One problem in the design is there is no way to flush out the boiler. Is it possible to add a handhole either in the Front tube sheet or Rear Tube sheet to allow you to see for flushing??

A: This is possible in some models but will not be universally offered. We can review on a case by case basis and provide as a special.

35)Q: Does C-B get involved with water quality / treatment? The reason I ask is I have seen older boilers with fouled tubes (outside) - and wonder the best way to clean / keep clean / etc.

A: We always recommend you engage a qualified water treatment expert to analyze your needs with regard to the type of chemical(s) to be applied to the boiler on a regular basis. We then supply the mechanical equipment to dispense and/or augment the treatment program.

36)Q: Symmetric and asymmetric design ftb - which is better in term of circulation?

A: This would have to be evaluated with regard to heat fluxes, and pressure/density differentials to determine the best design configuration to attain maximum circulation.

37)Q: What are the advantages of high temperature hot water generators? They were used in campus type systems but their use is reduced.

A: The main attraction for HTHW boilers was the reduction of steam system components and complexities such as traps, feed systems, support accessories (DA systems) and including system piping savings because smaller pipe sizes and supports could be used with the HTHW system. The HTHW system also provided a large “flywheel” effect when interruptions occur, supplying the needed requirement for an extended period of time because of its innate thermal storage capacity. Why the HTHW system of design has fallen into disuse is largely due to the lack of expertise in the field today to both design engineer and service this type of equipment.

38)Q: When you talked about turn down what does that mean?

A: If a burner has a 4:1 turndown capability and it is on a 100 HP boiler, the burner goes from 100% (100 HP) to 25% (25 HP) before cycling off.

39)Q: At one time Firetube Boilers were limited to 750 HP and 250 PSI. Do you know when this changed?

A: Over 20 years ago...

40)Q: Has the old 5 square foot/BHP rule of thumb been replaced by the new technologies?

A: The new technologies are slowly entering the market, replacing the 5 square foot boiler, but it will be many years before the complete change takes place. We humans are slow to change when the thing we have now works pretty well!

41)Q: With the spiral firetubes, do you find that scale builds up more than opposed to the traditional style firetube?

A: No difference as long as the water treatment program is followed and the boiler is properly blown down on a regular basis as recommended by the qualified water treatment expert.

42)Q: How extensive is the maintenance for the extended surface tubes?

A: No difference than the plain tube.

43)Q: Based on turndown ratios, how can operator determine the thermal NOx emissions and how the FGR reduces the operation efficiency and reduces emissions?

A: The overall boiler efficiency is not impacted by FGR. The problem is possibly losing some turndown if the FGR circulation rates are high such as when the requirement is for 15 – 20 PPM NOx or less. It's then the cycling may occur, causing the efficiency loss due to pre and post purge losses encountered through you burner

management system also known as the flame safeguard. Your NOx readings require stack analysis, and your efficiency loss needs to be determined on a case by case basis through bench marking of fuel flow, cycling frequency versus no cycling, and boiler output.

44)Q: Do you find problems with scale build up in the rear section of the wetback boiler? If so, are there recommended cleaning practices?

A: Again this is dependent on a sound water treatment program. If scale occurs in this area, this is difficult to clean, and it may have to be acid cleaned.

45)Q: We are working on designs for LEED Gold and Silver and heating boiler systems are in most projects with some type of recovery system in play

A: Hydronic heating is not the main application for the horizontal firetube boiler we spoke of today. There are vertical firetube boilers such as our Clearfire line which uses finned stainless steel tubes, and can fully condense for maximum efficiencies exceeding 90%.

46)Q: Is there a difference in the type of burners used for land fill gas with NG being 2nd and oil as a last resort, I conduct an internal inspection annually on a boiler that fires 90% on land fill, tubes either have to be replaced or cut cleaned each year.

A: Yes, there is. The land fill gas is laden with sulfur, and as the gas condenses, sulfuric acid forms, corroding the black iron pipe used for the natural gas train and other gas train components. Therefore, a separate gas train needs to be provided with Sstl components and piping to handle the corrosive issue. Also, the land fill gas is about half the calorific value of natural gas so a separate gas ring needs to be designed to properly deliver the correct amount of gas to make capacity. This means the land fill gas needs a larger gas train size and larger orifices in the delivering ring.

47)Q: When comparing Fire Tube Boilers to other technologies, why would the Fire Tube Boilers be a selected application considering the constraints to avoid condensation and turndown? For example vs condensing type or flextubes?

A: Boiler technologies and hot water systems have evolved making the firetube boiler one of the least acceptable designs for these applications. The flextube boiler and other modular type boilers designed for condensing are much better fits for these hydronic applications. ***Tune in to our webinar next month on August 26th at 2 PM EDT wherein we will be discussing this very topic along with other boiler application insights.***

48)Q: Can you give me some reference for rear door temperature, what is considered normal temperature?

A: The rear door temperature on wetback or Dryback boiler is going to run hot as it is only high temperature refractory material which is protecting the outer metal surfaces. Also be careful of the flange areas surrounding the door as they will reach temperatures in excess of 300 degrees F with the insulated backed surfaces in the 250-300 degree range. BTW, this is normal, and the door should not be insulated as this will compromise its integrity, causing it to fail from overheating.

49)Q: Now days, it is very common to hear about the concept Boilers Efficiency, having the measurement of the consumptions (fuel, gas), output (steam), How has this concept been integrated to your solutions?

A: Our design engineers strive to attain the highest efficiency in our boilers as possible while maintaining durability and long asset life. The process followed to achieve the positive outcomes is complex, and involves the latest technologies be applied such as computational fluid dynamics, proven then by finite element analysis.

50)Q: What are the standards or what determines which tube / tubesheet joint is used? Are the tubesheets grooved similar to shell & tube exchangers with rolled tubes?

A: What you are talking about is the prosper roll attachment sometimes used for attaching the tube into the respective tubesheet hole. This involves the further expansion of the tube behind the tubesheet to better secure the tube to prevent it from moving and breaking its seal on the front of the tubesheet, destroying its heat sink. We have found standard methods of expanding tubes and sealing to the outer tubesheet to be a highly dependable way of securing the various tubes. The prosper roll seems to be increasing the possibility of corrosive attack and additional stress; possibly causing accelerated failure.

51)Q: Do you have any webinars on setting up burner combustion? I have multiple boilers (Cleavers) with the parallel control and single point drive control. I have had the local rep start these boilers but had to redo the start-up because of bad combustion.

A: This is really a session which needs to be conducted by one of our field representatives, adjusting and explaining the process as the adjustments on your equipment are made. Every unit is somewhat unique in its tuning application making a general overview limited in its effective instruction outcome.

52)Q: Any idea, what will be next topic?

A: Our next topic is entitled "Boiler Choices, the What, When & Why," and will be covering various boiler types, where they are best applied, and why this choice makes sense.

53)Q: What type of measuring system (instrument) is used to measure the fuel consumption for gas and for fuel oil (HFO, IFO, diesel)?

A: A gas meter or fuel flow meter which can be easily retrofitted for establishing a basis point of reference before and after any modifications are applied which affect efficiency.

54)Q: Can soot blowers be added to firetube boilers?

A: There are some out there, but normally automatic and portable soot vacs are very effective for cleaning the tube surfaces.

55)Q: I need ASME code for design condensing boiler.

A: ASME Section IV will be followed as these are all low pressure boilers. The condensing has nothing to do with the code.

56)Q: I'm having high CO readings on a 800 BHP CB boiler burning propane It has control link control, any advice on how to tune the burner?

A: You are on the left side of the curve and fuel rich. Highly suggest you engage one of our qualified field technicians from our authorized representative force in your area to address the problem. This needs to be addressed soon.

57)Q: Can you explain the proper startup of the boilers? Please describe what you recommend engineers to have in their specs for startup of a boiler.

A: There is a procedure which can be found in our "Boiler Room Guide," form CB-7853. It should be available as a pdf on our website, if not, contact C-B Marketing (Susan McCorvey, 229-337-4432) for a copy.

58)Q: Regarding "Turndown" does VFD help to reduce excess air?

A: Yes, it will, as it would reduce the air amount and pressure delivered to the metering damper, decreasing air flow and brake horsepower.

59)Q: What are typical times required to go from "cold" or off to full fire operation for firetube boilers?

A: This depends on boiler size and capacity. Normally we like to see at least 5-10 pounds of pressure before allowing the boiler to advance to the higher firing ranges.

60)Q: Why you don't use extended surface tubes in the C-B model boilers?

A: These boilers have been designed for plain tubes while achieving excellent efficiencies in the mid 80's.

61)Q: Cost of dry back vs wet back assuming similar pressures?

A: The wetback boiler is actually more expensive to manufacture because of its additional tubesheet and steel turnaround area.

62)Q: I am replacing boiler stacks for multiple boilers design for redundancy. I have been told use of dedicated stacks is preferred than the use of shared stacks. Can you explain this?

A: Use of dedicated stacks is certainly the most reliable from a draft perspective; however, it is more costly than breeching the boilers together into a common stack. If the stack and breeching system is properly engineered and sized, this venting arrangement can be very effective, efficient, and less costly. The key is proper engineering to assure ample but controlled draft for all boilers on the system.