FIRE BOX DESIGN CAN HOLD THE KEY

During recent service problems my attention has been drawn to the importance of fire box design and size, especially on burner-conversion equipment. This is not a rare problem. It has existed for years but like many of our installation problems they surface more regularly now. This is because of the increase in the number of conversion units being installed. As with many of our service problems, they go back to the original estimating and installation.

Whether it is because of the inexperience of the estimators and mechanics, which I doubt, or because of an increased schedule due to the demand for burner conversions, some items are overlooked. These items only lead to future service problems and customer dissatisfaction.

Problem #1: The customer called for a combustion efficiency test, claiming he could see excess oil entering the combustion zone. The boiler was a fire tube, brick set, two pass boiler. The burner was a very popular pressure-atomized unit, firing twenty gallons per hour.

Upon arriving it was noticed the fire box was filled in and the burner was fired through the door. When we observed the fire we saw an oil mist surrounding the flame which was not burning. We ran the combustion tests and found we had 7% CO_2, and a 210° stack temperature, with #1 smoke. The CO was also higher than normal. We cleaned the burner and tried to adjust the fire with the existing nozzle but could not improve the results we had originally. We next changed the nozzle size.

The unit we were working on was a high-low fire burner with a 300 psi oil pump. Figuring if we went smaller with the nozzle and raised the oil pressure we would atomize the oil finer, we proceeded with the change.

We discovered the burner was underfired and found we could not fire it to capacity without adding a target wall to the boiler. We were able to raise the CO_2 to 9½% and the stack temperature to 240° with a #1 smoke. Our CO was still higher than we would have liked and although our visable oil mist was still existing it was not as great.

Firing into the water legs of a boiler is fine in many cases. It is undoubtably true that you do not waste valuable Btu's heating up the refractory materials in the fire box. However, the bricks in the fire box serve a definite purpose, besides insulation. They hold the heat around the flame to evaporate the oil for a fast, and more complete, combustion.

If you have a hot water boiler and are firing against the water legs it is a certainty that you are going to lose the heat intensity necessary for proper combustion. Thus, you are going to save the BTU's necessary to heat up the refractory and sacrifice total combustion of the oil being pumped into the boiler.

Another problem which may arise is that of heating a cold boiler up to the proper operating temperature or pressure, especially if the boiler has been off for a long period of time. The water in the boiler, as well as the boiler itself, may be as cold as 70°F. If the heat of combustion is immediately applied to the water leg area of the boiler, the expansion which takes place cannot help the life of the stay bolts, etc. The obverse will take place upon shut down.

I am not stating that this is not an efficient manner in which to fire an oil burner. It is common knowledge that stack temperature accounts for the largest amount of wasted heat, this method will lower stack temperature as well as heat loss. As combustion technicians, our main concern is proper operation and the most complete combustion possible of an oil burner. A dutch oven, arch, or some other means of holding the heat around the flame should have been installed in this application. Also a target wall should have been added so the boiler could have been fired to capacity.

Problem #2: Three water tube, brick set, 400-horsepower boilers with new forced draft air atomized burners. When the burners were installed, the electrician who wired the job ran rigid conduit along the front of the boilers approximately three inches from the front plate, which is fine. The burners had been operating for two months with no problems whatsoever. Then burner #3 burned up a compressor motor and three days later burner #1 started blowing fuses. Upon checking out the electrical system it was found that every wire in the control cabinet was shorted out.

The short was eventually traced to the conduit running along the front of the boiler. When the wires were pulled out, they were all melted. The #2 boiler was the only one operating so we checked the front plate and found it very hot. A check of the nozzle size and pressure showed that the burner was under fired. However, the fire box was full of fire, so it was apparent that the burners were never fired to capacity. A combustion test showed excellent efficiency.

There was a welded plate covering the secondary air opening from the old rotary burner, which was replaced. This plate was very hot. We shut down boiler #2, the only one running at this time, and in about five minutes we blew all the fuses in that control cabinet also.

The inside fire box dimensions were 61" wide and 83" long with the burner centerline 17" from the floor. The burner specifications call for a fire box 120" long and the burner to be mounted 24" high, centerline to the bottom of the fire box. This meant we were 36" short and 7" too low for proper operation.

The checker work on the floor of the fire box had been filled in and cemented over but there was a space between the secondary air opening plate and the floor of the fire box, with no insulation.

What was happening was the floor would heat up and the heat would transfer through the welded plate. The floor was removed and a new one installed, giving us 24" to the floor of the fire box.

The length was still not correct but we had to settle for this as the boiler could not be extended. Our only alternative would have been to install a 3' dutch oven and extend out the front of the boiler.

The reason the boiler had operated fine for two months was that there was a separate hot water boiler and it had been carrying the domestic hot water until the day before. When the boiler got under the heavy load it heated the fire box more and our troubles started.

There are constants which may be used when sizing a fire box, such as 90 square inches of combustion floor per gallon of oil. These are fine to use sometimes but the safest way to be certain the fire box is the proper size to use the manufacturer's specifications for the particular burner. These specifications come from many experiments and years of experience with that burner.

Know your burner. Some burners will only fire certain size spray angles, check this and know what your burner will do. It may be better to pass up a sale than to get involved in a job that will give problem after problem because the burner will simply not fit the application. Everyone will suffer, the customer as well as the installer.

As with every aspect of a burner application, the correct and proper job starts with the estimator and ends with the installer. If a future problem exists, note: all burners will not fit all applications correctly.

In many cases it may be necessary to install a dutch oven. This will serve two purposes; first it will lengthen the depth of the fire box, and secondly, it will hold the heat around the nozzle area of the fire, where most of your combustion takes place. Many times when the high CO_2 cannot be obtained, a simple dutch oven can raise the reading considerably, causing the oil to evaporate faster thus burning more completely. This will also help a burner which has been oversized or undersized reach a good combustion efficiency. This is by no means a cure all but in many cases will help the problem considerably.

A target wall in the rear of the fire box will help prevent burning up the existing fire box and will enable you to fire more gallons per hour, but will do little to increase combustion efficiency. We will be able to fire more gph in the already too short fire box but it must be remembered that the more oil which impinges on the target wall the higher the CO.

There are many other design features which should be examined; wing walls, arches, etc., but the final line is that if the burner is not correct for the application only a certain amount of gain will be achieved from the installation of these features.

A boiler is designed a certain way, as is a burner. Too much deviation from these standards will only bring problems, the exact things we are trying to stay away from.