William A. Lotz, P.E.
CONSULTING ENGINEER
1307 ACTON RIDGE ROAD
ACTON, MAINE 04001

PHONE 207-636-2625
FAX # 207-636-3528

March 2013

Direct Fired Heaters Can Result in Excessive Moisture and Condensation

By
William A. Lotz, PE
Consulting Engineer
Acton, ME

Thermo-Cycler Industries, Inc. has asked me to set the record straight on the issue of Direct Fired Heaters. At least one manufacturer of Direct Fired equipment is attempting to rewrite the laws of physics and chemistry for their products! Good luck!

Let's calculate:

- Natural Gas (methane CH_4) when burned produces 2 cubic feet of water vapor for every cubic foot of gas.
- Propane Gas (C_3H_8) when burned produces 4 cubic of feet of water vapor for every cubic foot of gas
- From the North American Combustion Handbook

When you burn one of these hydrocarbon gases the fuel chemically combines with the oxygen in the combustion air to form water vapor (H_2O). For a typical 1million Btu/hour natural gas burner the combustion process releases approximately 90 pounds of water per hour. In a 24 hour period that adds up to over a ton of water that a direct fired unit puts into the building. Propane produces twice as much water vapor as natural gas on a pound for pound basis propane is heavier than natural gas but has a higher Btu content:

Propane- 8.45 cubic feet per pound, hence: 48 pounds per million Btu

Natural gas- 23.61 cubic feet per pound, hence: 42 pounds per million Btu

Calculating the quantity of water vapor in the exhaust gas for a million Btu burner in 24 hours:

Propane: 48 pounds X 4 $\frac{\text{pounds } H_2O}{\text{pound of propane}}$ X 24 hrs = over 2 tons of water

Natural Gas: 42 pounds X 2 $\frac{\text{pounds } H_2O}{\text{pound of natural gas}}$ X 24 hrs = over a ton of water

So, depending upon the fuel, burning 1,000,000 Btu/hour in a direct fired unit puts between one and 2 tons of water vapor into the building per 24 hour day.

Waving a magic wand over the unit is not going to change this.

One solution:

When I design a direct fired make-up air system I include an exhaust system that matches CFM for CFM with the make-up air. In other words when there is a 50,000 CFM direct fired make-up air unit I include a 50,000 CFM exhaust system. That way there is no buildup of moisture in the building.

In one building in Pennsylvania the owner told the electrician "do not connect the exhaust fan." During the building's first winter the direct fired heater filled the building with water vapor and it rained indoors. The owner sued the general contractor and lost the suit. (I testified for the contractor.)

The International Mechanical code requires: "the amount of supply air shall be approximately equal to the amount of return and exhaust air." In other words, a building with a 10,000 CFM make up air heater needs a 10,000 CFM ± exhaust system.

Real World

I have consulted on thousands of buildings with severe moisture/insulation system failures. Included in these problem buildings were many manufacturing/warehouse buildings with Direct Fired heating equipment and a 200 CFM bathroom exhaust system. The typical direct fired heater is 10,000 CFM to

50,000 CFM. Put this in a typical metal building with glass fiber insulation and there is very likely to be condensation raining inside the building and a law suit.

There are many other causes of excessive moisture in buildings. The solution frequently however is to remove the Direct Fired system and install an indirect fired heater.

In cold climates (North of St. Louis) where the humidity inside the building is above 30% in cold weather most of the manufacturers of glass fiber (and laminators and distributors) tell you to use someone else's insulation, not theirs (as they don't want to be sued again). Glass fiber is a good insulation, but should not be used in high humidity applications. Glass fiber depends 100% upon a thin, fragile vapor retarder for its thermal performance. Also, when there are holes in the vapor retarder and air flows through the holes the R value is reduced to zero.

Summary

With a Direct Fired heating system, as we have calculated, large quantities of water vapor are inserted into the building. Where does this moisture go? With no major exhaust system the moisture finds all of the holes/gaps/seams in the insulation system vapor barrier and condenses on the (usual) steel structure. Two results of this condensation are rain into the building and corrosion. The corrosion can cause perforation of the steel panels (roof and wall) in 5- 10 years.

In my consulting practice we have solved countless severe building moisture problems by having the owner remove any Direct Fired Heaters and replacing them with Indirect Fired Heaters.

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Lotz in a Professional Engineer licensed in 8 states. He has been a member of ASHRAE for over 50 years and is an ASHRAE Fellow, Life Member and Distinguished Lecturer. Lotz has published upwards of 300 technical articles and papers on HVAC, Energy conservation, Insulation and Moisture issues. He has consulting clients all over the United States and Canada. He loves to testify in court.