Condensation of High Efficiency Commercial Gas Water Heaters

Rheem's high efficiency model is called the AdvantagPlus and has a thermal efficiency rating of 95%. Water heaters are normally classified as high efficiency when their efficiency rating is over 92%. Simply put, this means that 92% of the fuels heating capacity is transferred into the water; and only 8% of the heating capacity of the fuel is exhausted as flue gas. High efficiency gas water heaters are notorious for producing large amounts of water condensation. When operating properly, it will produce a large amount of water through its' condensate removal system. This bulletin explains how and why that condensate is formed.

Gas fired water heaters fall in three basic categories when we are talking about the units ability to produce condensation. The first category is normally lower BTU input models with an efficiency rating of up to approximately 80%. Models in this range produce some condensation on the outside (combustion side) of the flue tubes. You will normally see this as small drops of water that will fall on the burner assembly and produce a sizzling sound. This condensation will evaporate quickly as the main burner heats up the flue tube. The second category includes models with efficiency ratings between 83% and approximately 91%. These models may transfer their heat through the flue tubes, or use a device called a 'heat exchanger' located inside the water heater. These models are in the range design engineers refer to as wet-dry. Because of the amount of condensation that is produced, the heat exchanger stays wet for a longer period of time. This effect causes premature destruction of the heat exchanger due to the rapid rusting and deterioration of the metals. The term 'high efficiency' refers to models with efficiency ratings of 92% or better. The models are fully condensing (wet), meaning as long as the water heater's main burner is on, the combustion and escaping flue gas process is constantly producing condensation.

Combustion is defined as a chemical reaction of oxygen with a combustible material, such as a gas fuel. This chemical reaction that we call 'fire' produces light and heat. The chemical process of the gas fuel and the oxygen also produce a by-product we call flue gas. During incomplete combustion, the principle flue gasses are composed of carbon monoxide, hydrogen, carbon dioxide and ***water vapo***r. Incomplete combustion is always present when the efficiency rating of the water heater is below 92%. Anytime you have the presence of carbon monoxide in the flue gas, you have incomplete combustion.

Perfect combustion is the complete burning of a gas fuel with a careful balance of the required amount of fuel, air and oxygen. The principle by-products of a perfect combustion process are essentially carbon dioxide, ***water vapor*** and nitrogen. As the combustion process is improved, so does the thermal efficiency of the water heater. Assuming we had 100% complete combustion of a cubic foot of natural gas (mostly methane), the combustion by products would be one cubic foot of carbon dioxide and <u>two cubic feet of water vapor.</u>

Now you can see that any combustion process produces some amount of water vapor; the more efficient the combustion process, the more water vapor produced. So how does this water vapor return as condensation? Quite simply, it is due to a phenomenon called the *dew point*. The weather anchors talk about the dew point all the time. Sometimes, we wake up in the morning and the car and grass is covered in water – yet it didn't rain last night. Why? *Dew Point*. The dew point is the temperature at which condensation begins. Stated another way, water vapor will begin to condensate, or reform into water drops, when it cools to a specific temperature called the dew point.

The Condensate Problem

High efficiency in gas water heating appliances is achieved when heat from the flue gas is extracted before venting it to the atmosphere. Although natural gas is relatively clean burning, the products of combustion typically include nitrogen oxides, sulfur oxides and hydrogen chloride, as well as the expected water vapor and carbon dioxide. The hydrogen chloride comes from the combustion of chlorides (salt dust), chlorinated solvents, chlorofluorocarbons, and hypochlorite (bleach) vapors contained in the combustion air supply. Nitrogen oxides are a typical by-product of combustion air. Sulfur is present at very low concentrations as odorant compounds added to natural gas. Condensation of these products of combustion yields an acidic solution which contains concentrations of nitric, nitrous, sulfuric, sulfurous and hydrochloric acids.

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The Condensation Process in the AdvantagePlus

Fuel and air are introduced into the combustion chamber and ignited producing a flame. As the fuel-air mixture continues to burn, the hot combustion gasses are cycled through the heat exchanger by a blower motor. The blower motor pushes the hot gasses through the heat exchanger allowing the heat to transfer through the cupronickel heat exchanger and into the water inside the water heater. As this process occurs, the combustion gasses are cooling off at a rapid rate. Temperatures inside the combustion chamber reach 1800 degrees Fahrenheit; but by the time the flue gasses are exhausted, they are normally under 120 degrees Fahrenheit. The difference, about 1680 degrees of temperature (heat), has been transferred into the water through the heat exchanger.

As the combustion gasses, principally carbon dioxide and water vapor, are exhausted, they cool rapidly. Eventually, the water vapor reaches the *dew point* and forms into water droplets. These water droplets form at a rapid rate and present themselves in the form of a stream of water called condensate. By design, the condensate is carried away from the venting assembly and the water heater by a condensate removal system.

Local Code enforcement note:

Because of the chemical process involved in combustion, condensation may be acidic. Check your local codes to determine if you can safely evacuate the condensation to a floor drain. If not, you may need to install a condensate neutralizer to reduce the acidity level of the condensate before introducing it into the sewer system.