Consulting, Resource, Education, Training, and Support Services for Home Inspectors
"A candle loses no light when it lights another candle."

Gas-Fired, Residential Storage Type Water Heaters

Most inspectors are familiar with modern, residential, conventionally aspirated/atmospheric draft, gas-fired storage water heaters. They have been around for years. But, other than improving the insulation between the tank and the outer jacket and changes in tank materials, they've remained pretty much the same since they were introduced.

These water heaters utilize the natural draft that's created when the burner is ignited to draw combustion air (also referred to as make up air) into the combustion chamber through openings in the bottom of the combustion chamber and through the combustion chamber access opening. This same natural draft is utilized to move the combustion by-products from the combustion chamber, past the draft diverter/hood into the flue, and finally, to the outside atmosphere.

A storage water heater tank is shaped like an elongated torus or doughnut. The flue which runs from the top of the combustion chamber to the top of the tank forms the hole of the doughnut. This portion of the flue acts as a heat exchanger by transferring some of the heat of the flue gases to the surrounding water in the tank. In this way, the water in the tank is heated by the flue as well as by the heat applied by the burner to the bottom of the tank.

A baffle hangs down into the flue from the top of the tank and serves two purposes. It slows down the flow of the hot combustion by-product gases, allowing more heat to be transferred to the water in the tank, and it reduces the potential for the pilot to be extinguished by downdrafts when the burner is not in operation.

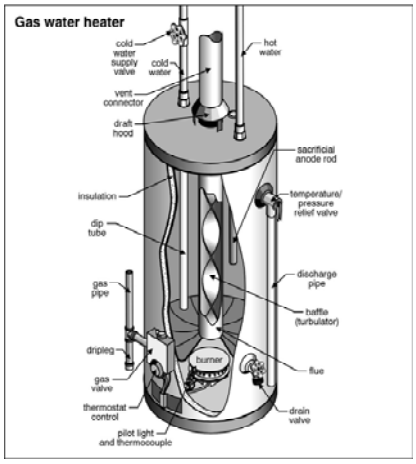
As the hot combustion by-product gases rise through the tank's internal vent and past the draft diverter, dilution air is drawn in around the diverter reducing their temperature. The function of the draft diverter is both to ensure a constant low draft condition in the combustion chamber and to maintain the stability of the air supply for the combustion process. Without a draft diverter there would be the potential for two conditions to occur, either of which could result in extinguishing the burner and/or the pilot light. These conditions are excessive chimney draft (too much air moving too rapidly into and through the combustion chamber) and downdrafts during times when the burner is not operating.

As the combustion by-products pass into and through the draft diverter at around 500° F, they're mixed with cooler room air (dilution air) and their temperature drops to around 300 - 350° F. At this temperature the combustion by-products are still warm enough to rise up the vent by their own buoyancy and to prevent the acidic water vapor in the combustion by-products from condensing out and running down the inside of the vent and into the appliance causing corrosion damage to both.

If flammable vapors such those produced by gasoline, paint thinner, or other volatile materials are present, this design permits them to be drawn into the combustion chamber where they can ignite and flash back out of the combustion chamber, causing explosive combustion of the vapors in the space where the water heater is located. According to the Consumer Product Safety Commission, there are approximately 800 residential flashback fires each year in the United States resulting in 5 deaths and 130 injuries.

It is for this reason that building codes were adopted requiring not only this type of gas-fired water heater, but any device or equipment that generates an open spark, an open flame, or an open glow to be installed a minimum of 18" above garage floors to reduce the potential for ignition of heavier-than-air flammable vapors.

Conventionally Aspirated, Gas-Fired Storage Water Heater



This cutaway diagram illustrates the major components of a typical conventionally aspirated, gas-fired, residential storage water heater.

In recent years both gas-fired water heater efficiency and safety improvements have been introduced in the form of six different types of tank-type water heaters.

- **Atmospheric induced draft water heaters**
- **Direct vent, induced draft water heaters**
- **Atmospheric forced draft water heaters**
- **Direct vent, forced draft water heaters**
- **Flammable Vapor Ignition Resistant (FVIR) water heaters**

ATMOSPHERIC, INDUCED DRAFT WATER HEATERS

Atmospheric induced draft units are equipped with a fan located between the top of the heater and the upstream end (the end nearest the water heater) of the vent connector or flue.

These units take their combustion air from the space in which they are located. The automatically actuated draft inducing fan creates a controlled draft by mechanically drawing combustion air into the combustion chamber and past the burner during combustion. This reduces standby losses (air and heat losses through the flue when the burner in not ignited) at the same time that dilution air needs are reduced.

By inducing a positive and controlled flow of combustion by-products through and out of the downstream, exterior outlet of the flue, the potential for backdrafting problems are significantly reduced. While this makes the unit more energy efficient, it can actually increase the potential for drawing flammable vapors into the combustion chamber. Therefore, this type of water heater should be installed a minimum of 18" above the floor where materials that produce volatile or flammable vapors are stored.

These units have the advantage of being able to be vented through a side wall, eliminating the need for a vertical flue. This is a potential cost-saving benefit if installed where no vent previously exists such as when replacing an electric water heater with a gas-fired unit.

Atmospheric, Induced Draft Water Heater

Courtesy of A. O. Smith & State Industries

DIRECT VENT, INDUCED DRAFT WATER HEATERS

Like atmospheric, induced draft water heaters, these units are equipped with a fan located between the top of the heater and the upstream end (the end nearest the water heater) of the vent connector or flue. However, they have sealed combustion chambers and they take all their combustion air from the exterior of the house.

The automatically actuated draft inducing fan creates a controlled draft by mechanically drawing combustion air from the exterior into the combustion chamber and past the burner during combustion. This reduces standby losses (air and heat losses through the flue when the burner in not ignited) at the same time that dilution air needs are reduced.

Direct Vent, Induced Draft Water Heater

Courtesy of A. O. Smith

DIRECT VENT WATER HEATERS

These water heaters take all of their combustion air from outside of the home as well as venting all of their combustion by-products to the exterior. Combustion air is drawn directly into the sealed combustion chamber from the outside through a sealed combustion air duct or pipe and combustion by-products are vented to the exterior through a separate sealed flue.

On atmospheric, sealed combustion chamber units, it's common for the combustion air duct to run concentrically with the combustion by-product flue – one inside the other.

Because these water heaters have sealed combustion chambers, take combustion air from the exterior, and have no draft diverters, not only are backdrafting and downdrafting problems reduced, they also can be placed directly on a garage floor.

These units also have the advantage of being able to be vented through a side wall, eliminating the need for a vertical flue. This is a potential cost-saving benefit if installed where no vent previously exists such as when replacing an electric water heater with a gas-fired unit.

Direct Vent Water Heater

Courtesy of A. O. Smith

ATMOSPHERIC AND DIRECT VENT, FORCED DRAFT WATER HEATERS

Forced draft units are equipped with a fan located at the base of the water heater. This automatically actuated fan is coupled to a jet burner similar to an oil-fired blower/burner unit. By introducing more air into the combustion process, more heat is produced, resulting in higher efficiency and a faster recovery rate.

Both open and sealed combustion chamber forced draft units reduce standby losses and backdrafting problems. The sealed combustion chamber type takes all of its combustion air from the exterior. If the forced draft motor is protected against exposed arcing, these units can reduce the potential for ignition of flammable vapors as well.

This is a Bock Turboflue® water heater. It utilizes a forced draft fan to generate higher combustion temperatures in the combustion chamber and a large diameter heat exchanger fitted with internal fins to transfer the maximum amount of heat to the surrounding water in the tank. This design reduces waste heat and the potential for flue downdrafts.

FLAMMABLE VAPOR IGNITION RESISTANT (FVIR) WATER HEATERS

On July 1, 2003 a voluntary safety standard for residential water heaters sold in the United States went into effect. This voluntary safety standard for water heaters is American National Standards Institute (ANSI) Z21.10.1 – 2002.

It requires that all new, conventionally aspirated/atmospheric draft 30, 40, and 50 gallon capacity water heaters built and sold by water heater manufacturers who choose to comply with ANSI standards must incorporate specific design features that make them resistant to igniting flammable vapors outside of the water heater.

These water heaters are referred to as "Flammable Vapor Ignition Resistant" or FVIR water heaters. This standard became effective for 30, 40, and 50 gallon capacity induced draft models on July 1, 2004 and will apply to larger gallon capacity water heaters and water heaters for use in manufactured homes on July 1, 2005.

FVIR water heaters incorporate the latest technological improvements for reducing the potential for ignition of flammable vapors in conventionally aspirated / atmospheric draft and induced draft/direct vent water heaters.

FVIR technology utilizes several new design features. Instead of having combustion air enter the combustion chamber as it does in a conventionally aspirated unit, combustion air enters the combustion chamber through special inlets at the base of the water heater or on the side of the water heater. It then passes through a finely perforated plate called a flame arrestor which allows it to be evenly distributed to the burner where it is mixed with the fuel gas and the mixture is ignited by a pilot device.

The function of the flame arrestor is to create a one way path for flames. The air holes or slots in flame arrestor plates are designed so that the velocity of the airflow entering the combustion chamber through the arrestor is higher than the flame speed of any vapors that are ignited in the combustion chamber.

This prevents flashback out of the combustion chamber. In the event that flammable vapors are drawn into the combustion chamber along with the combustion air and are ignited, the flames are unable to escape back down through the fine openings in the arrestor and the vapors burn off harmlessly on the top surface of the flame arrestor.

To reduce the potential for clogging the fine perforations in the flame arrestor, FVIR water heaters are equipped with filter screens, baffled combustion air ducts, or other design elements to trap the lint, dust, and oil (LDO) that are often present in the air in garages, laundry rooms, basements, and other areas in which water heaters are often located. If an arrestor plate becomes obstructed by LDO or other contaminants, it can reduce or cut off the combustion air resulting in improper combustion and the production of carbon monoxide and soot.

In addition, there is a thermal cut-off device in the combustion chamber which automatically shuts off the gas supply to the burner and pilot when it senses excessive temperatures that are generated when flammable vapors ignite inside of the combustion chamber or when LDO filters become clogged.

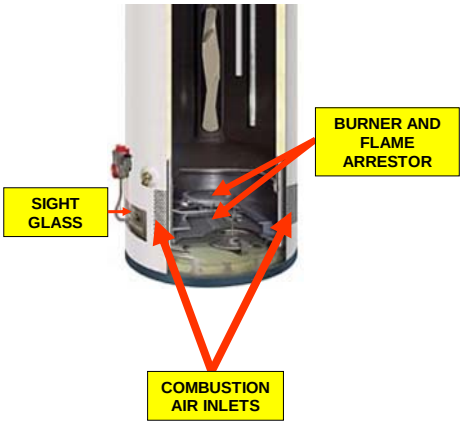
The maintenance access opening into the combustion chamber is sealed with an airtight cover which is mechanically fastened (screwed) in place. This prevents flammable vapors from entering the combustion chamber through the access opening, bypassing the flame arrestor, igniting, and flashing back out through the access opening.

The sealed access opening cover is fitted with a small sight glass which permits the pilot and part of the interior of the chamber to be observed. A. O. Smith and State Industries use a flame arrestor made of a ceramic material called Corderite. Bradford White, Rheem, and Ruud use a stainless steel flame arrestor plate. Most other water heater brands are actually manufactured for retailers by one of the above referenced companies.

Because FVIR water heaters have sealed/non-homeowner maintenance combustion chamber access openings, igniting the pilot light is accomplished by the use of a push button, piezoelectric igniter similar to those found on many gas fireplaces and gas cooking grills.

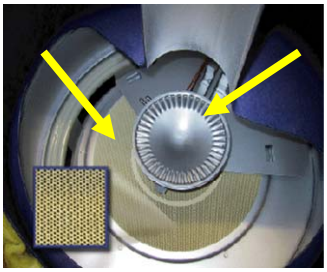
While, at the time of this writing, FVIR water heaters have been approved under the National Fuel Gas Code for installation directly on the floor of a garage or any area which opens directly into a garage, an inspector may still find them raised. This may be because they have replaced existing water heaters which were already installed on raised platforms or because building codes often lag behind new technologies and some jurisdictions may still require conformance to the 18" minimum elevation rule.

Cutaway View of a Rheem / Rudd FVIR Water Heater

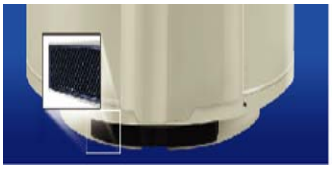


Note the combustion air inlets on the sides of the unit. The combustion air follows a path down and under the combustion chamber, then up through the flame arrestor to the burner.

STATE INDUSTRIES
Conventionally aspirated, atmospheric draft, FVIR



Flame arrestor and burner



Combustion air intake LDO filter

BRADFORD WHITE
Conventionally aspirated, atmospheric draft, FVIR

ADDITIONAL FVIR WATER HEATER INFORMATION

If an FVIR unit is installed with a collection pan, there must be sufficient clearance between the water heater and the sides of the pan to prevent obstruction of combustion air flow and the heater itself must be raised high enough above the flood level or drain outlet of the pan to prevent immersion of the combustion air inlets.

Rheem / Ruud manufacturing incorporates an additional technology into their FVIR water heaters. Rheem / Ruud recognized that, while a flame arrestor is designed to prevent ignition of vapors outside of the combustion chamber, it does not prevent a sustained flammable vapor event in which the vapors continue to burn inside of the combustion chamber. To address this issue, in addition to shutting off the gas when there is a vapor ignition event in the combustion chamber, Rheem / Ruud FVIR water heaters also shut off the combustion air supply at the same time.
Most FVIR water heaters incorporate a “one-shot” type fusible link technology to shut off the gas supply if there is a flammable vapor ignition event in the combustion chamber. This means that if such an event occurs, extensive repairs to the combustion chamber or complete replacement of the water heater will be required.