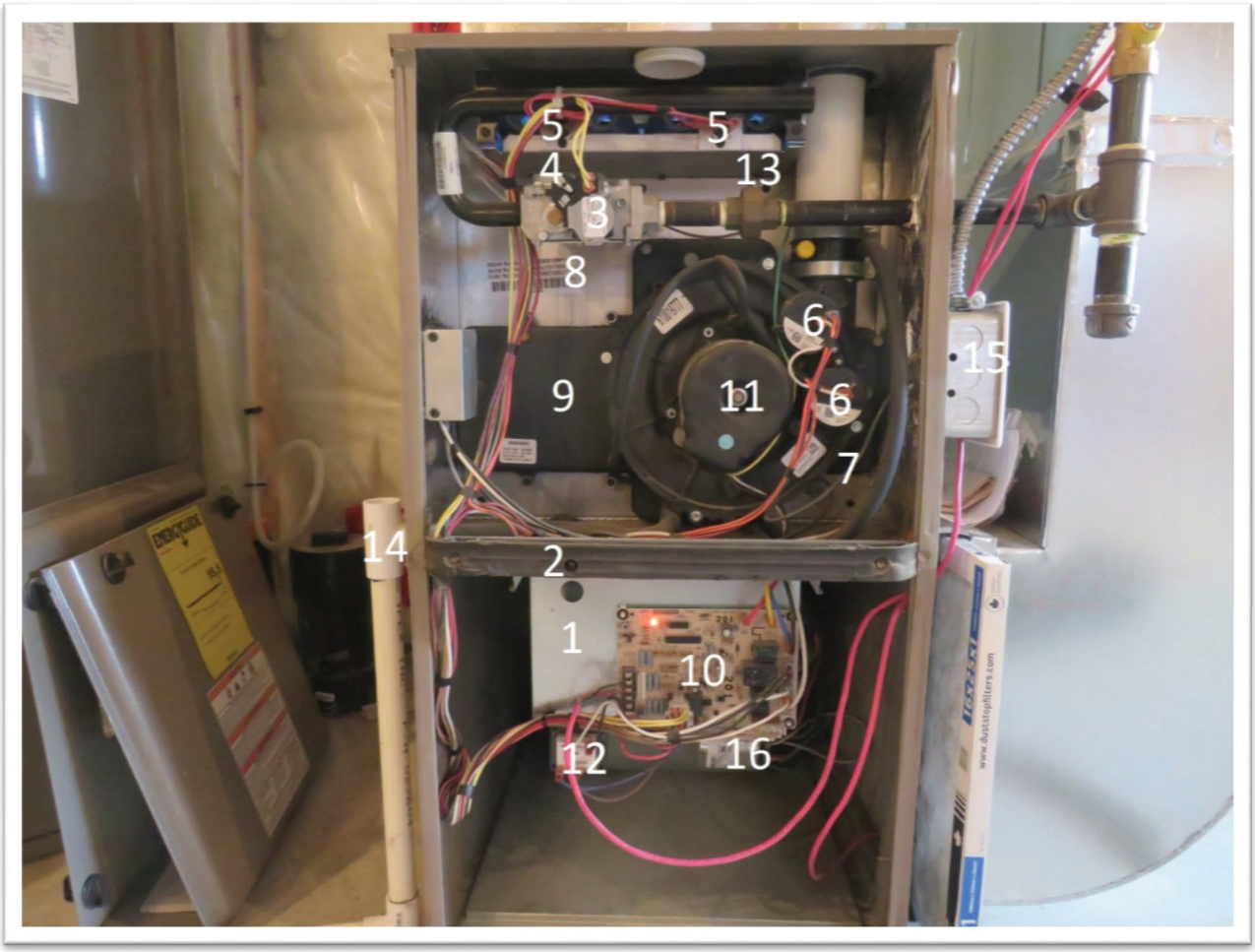
A category 4 furnace (commonly known as a high efficiency furnace) contains many of the same components as a category 1 appliance.

1. Blower Fan
2. Safety Door Switch
3. Gas Valve
4. Hot Surface Ignitor
5. Roll Out Safety Switches
6. Pressure Switches
7. Condensate Pan
8. Primary heat exchanger
9. Secondary heat exchanger
10. Electronic control board
11. Induced draft motor (ventor motor)
12. 24V transformer
13. Flame Sensor
14. Condensate collection system
15. Furnace Disconnect (Incorrect Installation)
16. Capacitor

The components outlined in the section are intended to provide a general list. Components found during an inspection may vary by the age of the appliance, manufacturer, and model.

Fig. 1-23 Category 4 Furnace Components
Image Source: CIHI



1.10 Safety Components

Atmospherically vented category 1 appliances effectively have two safety components. The thermocouple which supervises the flame, and the high limit switch (commonly in the form of a combination fan/high limit switch).

This high limit switch serves to ensure air flow through the appliance. As air flow across the appliance decreases; the temperature rise of the appliance will increase and eventually the high limit switch will "open" and shut off the burner prior to the temperature reaching a dangerous point.

Aside from the improvements in efficiency, category 1 mid-efficiency appliances were equipped with several additional safeties. Depending upon the model, there may be one or more roll out switches, additional high temperature limit switches, as well as a "proof" of the inducer draft motor operation.

In the event of a heat exchanger failure, it is possible for the supply air from the conditioned space to communicate with the products of combustion. The static pressure of the supply air surrounding the heat exchanger is greater than the static pressure of the products of combustion inside of the heat exchanger. Should there be a compromise to the integrity of the heat exchanger shell, the supply air could be forced into the heat exchanger and result in the flame "burning back" or "rolling-out".

A roll-out occurs when the flame is no longer drawn into the burner tube as designed and "licks back" into the appliance cabinet.

The roll-out safety detects the temperature of the flame and opens the safety circuit resulting in the safe shutdown of the appliance. A roll-out condition may also occur if there is a partial or full vent blockage.

Some furnace models may contain automatic reset roll out and / or limit switches. An automatic reset switch will automatically return to the closed state once the temperature or condition has returned to the normal set operating range of the switch.

Manual reset switches require human intervention in order for the appliance to return to normal operation. Once a manual reset safety switch is activated; the system will remain in lock-out until such time as the condition is acknowledged. Depending upon the appliance, this acknowledgement may require a manual reset button on the limit switch to be depressed, or the power to the unit cycled.

As mentioned, an automatic reset switch can cycle on its own, and in some cases, the conditioned space is maintained not by the thermostat being satisfied but instead by the safety constantly opening and closing. The thermostat is never satisfied, but the occupant may or may not even notice any issue with the faulty operation depending on the frequency with which the safety resets.

Signs such as scorched paint or damaged wires in the area of the burner may be a sign that this has occurred. Service will be required but this condition may prevail for some time unnoticed.

Fig. 1-24 Flame Roll-out
Image Source: CIHI

An air switch is typically used to "prove" the inducer draft motor is operating, as well as confirming the vent is clear. If there is a restriction in the heat exchanger or venting system: the vent or induced draft motor will not be able to achieve the pressure required to open or close the pressure switch preventing the operation of the unit.

1.11 Heat Exchanger

As mentioned earlier; the purpose of the heat exchanger is to separate the products of combustion from the air that is heated and circulated through the conditioned space, known as the supply air.

Early appliances contained heavy, thick walled, cast iron or steel heat exchangers that were welded together and unlikely to develop a crack or hole.

With the drive to improve appliance efficiency, new deigns of more restrictive heat exchangers capable of extracting additional heat from the flue gases were introduced. Different alloys are used in the construction of these units in order to decrease the amount of heat energy required to warm the heat exchanger itself.

The alloy walls of the heat exchangers are often pressed or crimped together and are more likely to develop unwanted and dangerous communication between the products of combustion and the air being supplied to the conditioned space.

Although not required, it is highly recommended that the heat exchanger be visually inspected. A snake camera can be utilized on many models to view the heat exchanger without disassembling the ductwork or furnace cabinet.

There will typically be other symptoms of a failed heat exchanger such as erratic flame patterns when the indoor blower fan is operating, or roll out and air switches faulting if an appliance is so equipped with them.

A heat exchanger crack can be difficult to recognize as the crack may or may not be easily visible. The crack may contract as the heat exchanger cools causing it to be even more difficult to identify. Carbon monoxide is almost always found in the flue products of an appliance with a faulty heat exchanger, but seldom is CO found in the supply air.

The static pressure, or the outward force of the air created by the indoor fan blower motor, is typically at a much higher pressure than the vent pressure. Therefore, it is likely that the supply air will enter the heat exchanger and effect the ratio of air being supplied for the combustion process. When the fuel to air ratio is affected, there is a high possibility that

carbon monoxide will be produced. The pressure from the supply air will force the flame back and out of the burner tube. A condition previously discussed known as roll-out.

An improper venting installation or failed venting component is likely to be blamed if CO is detected in the conditioned space.

An ambient CO detector is designed to sense CO in a large area at room temperature. The sensor of an ambient air CO detector may not be temperature compensated or designed for the velocity of the air if placed in a supply air duct and may result in a false reading.

There are specific testers, detectors, and analyzers that should be employed for testing for the presence CO in the flue products or in the supply air. It is important to know the capabilities and limitations of your test equipment.

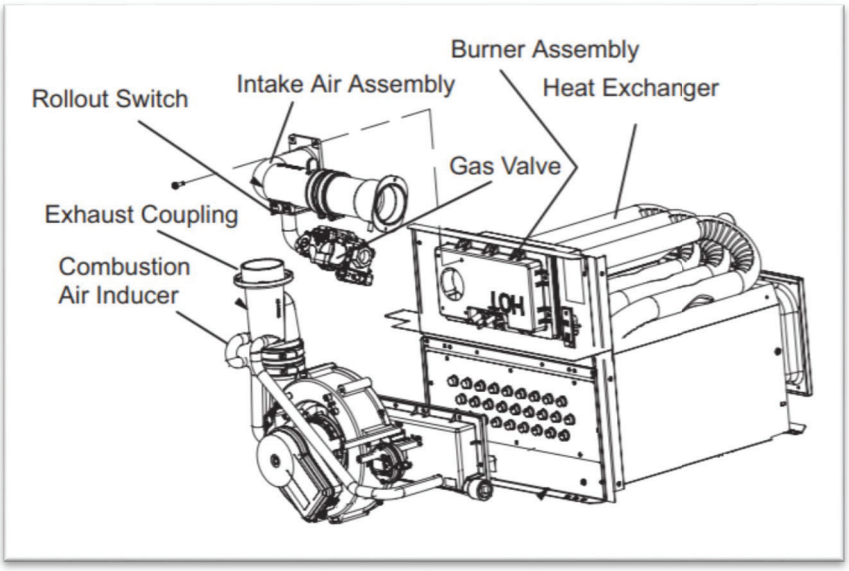
1.12 Flame Disturbance Test

To help assess the integrity of a heat exchanger; a simple test known as the “flame disturbance test” can be performed by observing the flame characteristics.

After initiating a call for heat on the thermostat: with the furnace door off; we observe the color and behavior of the flame pattern. With the fan off, the flames should appear blue and burning just off the burner(s) which is evidence of the correct fuel to air ratio.

Once the heat exchanger is hot, the indoor blower fan motor will energize. This is where we want to note if there is a significant change in the color and behavior of the flame.

Fig. 1-25 Furnace Components
Image Source: Lennox



Should there be a crack in the heat exchanger; the static pressure created by the blower will force supply air through that crack and into the combustion chamber. This will affect the correct fuel to air ratio. The flames will no longer be blue and will behave erratically, typically lifting off the burner surface.

If this is found during the inspection process, the appliance should be immediately turned off and a licensed HVAC contractor called upon.

Clause 4.21 of the **B149.1-15** states that where the heat exchanger in a dwelling unit is found to be defective: it shall be replaced. Unless the appliance is under warranty, it is often more cost effective to replace the entire appliance in a residential application.

1.13 Filtration

The most basic filter is installed in the return duct at the entrance to the furnace in order to remove the largest particles prior to entering the appliance.

From there, filtration is available (in the residential sector) to remove particles as small as 0.3 microns. The filtration used in a home is a complex part of what many consider building science and indoor air quality.

For the home inspector, it is most important to identify the type of filter, condition, and installation / operation of a filter.

The most basic and common filter is a 25mm / 1" wide pleated filter located in a filter rack often referred to as a "throw-away". During an inspection, the filter should be inspected on its cleanliness, proper sizing, and installation orientation. Unfortunately, it is not uncommon to find a 16x20 in a frame designed for a 20x25.

It will also be possible with the filter removed to inspect the duct work through the filter rack to see the amount of dust and dirt that may be in the ductwork.

Fig. 1-26 Basic Pleated Disposable Filter
Image Source: CIHI

A common misconception is that a 4" filter provides better filtration or cleaner air than a 1" filter. The thickness only provides a greater surface area; and therefore requires less frequent filter changes.

When the frequency of changes versus cost difference of a 1" and 4" filter is considered; it comes down to the convenience of less filter changes.

The MERV, or Minimum Efficiency Reporting Value, is what describes a filter's ability to remove particles from the airstream. The higher the MERV rating, the smaller the particles it can remove but this comes with a greater airflow restriction.

If a filter is too restrictive, this can affect the volume of air moving across the heat exchanger or coil air conditioning coil which over time will can damage to the appliance. A high MERV filter in a system not designed for the significant

pressure drop, created by the filter, can also affect the static pressure in the duct system.

Pressure drop is the amount of restriction caused by a resistance to flow. In this case, the more restrictive the filter is; the more resistive to flow and the greater the pressure drop across the filter.

A furnace or air handler equipped with an Electronically Commutated Motor (ECM), is a great efficiency gain on a high efficiency furnace. This motor can vary the speed or torque in order to maintain airflow through the duct work. If we create a high pressure drop due to a restrictive filter that a system was not designed for; the motor will work harder to maintain the air flow and thus efficiency will be lost. This is to say that; a higher MERV and more expensive filter is not always the best method for filtering air or the best solution for home.

1.13.1 Electronic Air Cleaners

Electronic air cleaners are sometimes referred to as “ionizers” because they create a positive and negative charge to “hold” particles rather than “catch” them. A pre-filter traps the large particles prior to the air passing over the charged plates.

Fig. 1-27 Electronic Air Cleaner
Image Source: CIHI

Although electronic air cleaners have become less popular in recent years, they can capture smaller particles with a lower pressure drop. The initial purchase of an electronic air filter is more than a mechanical filter; but when compared to the cost of a high MERV pleated disposable filter: the long-term investment is less with better performance in the removal of microscopic particles.

One deterrent from electronic air cleaners is the formation of ozone, which is considered an asthma and lung irritant. Newer systems have acceptable levels and are tested in accordance with government standards, yet some people may still consider the smell created by the ozonation process a nuisance.

1.14 Condensate Drains

Because category 4 furnaces condense their flue gases, the condensation from the heating process must be disposed. The condensate from a furnace or condensing appliance is acidic due to a reaction when nitrogen and oxygen are heated. The formation of nitrogen dioxide and nitrous oxide when dissolved in water vapor forms nitric acid.

In many newly built residential homes, a drain is often piped into the floor and tied into the building drain. These allow the condensation from high efficiency appliances to be disposed of easily. Drain(s) should be checked to ensure they are sloped towards the inlet and no leaks are occurring.

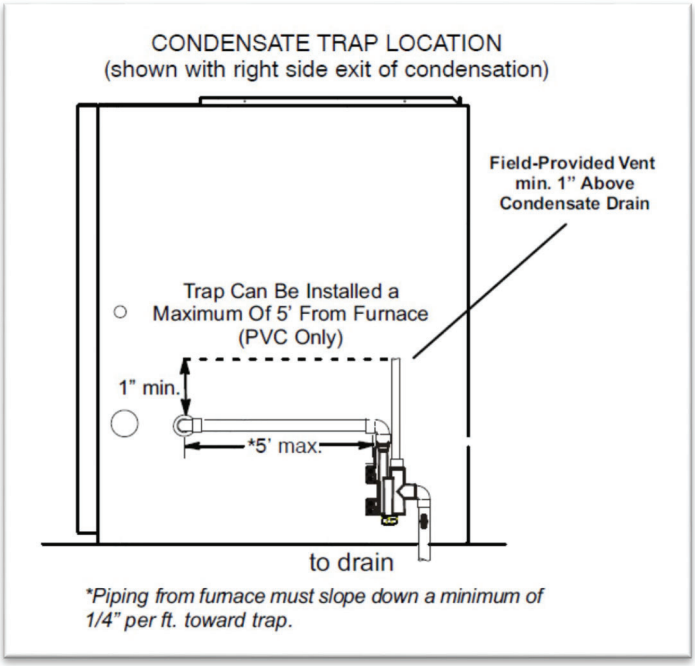


Fig. 1-28 Condensation Drain Line Discharge
Image Source: Lennox

Some condensate drains are piped into nearby sump pits. If this is acceptable by local code, it is important to check for deterioration of the pump and pit from the corrosive condensate. It should be noted that if the home has a septic system, the acidic discharge may affect the bio-organisms and modifications may need to be designed if recommended by a septic specialist.

A condensate pump is often utilized in homes where no floor drain exists for the runoff. The pump may eject the discharge into a drain further away, sometimes elevating the line above the furnace. If a pump is found in the home, and inspector can test the unit by pouring water from a water bottle into the pump to ensure it operates correctly and there are no leaks.

Fig. 1-29 Condensation Drain Pump
Image Source: CIHI

In order to protect the sewer infrastructure, many municipalities require a condensate neutralizer to be installed for the condensation discharge. This is also discussed in the **Plumbing** module. A condensate neutralizer is simply a box or tube containing stones or pellets that are basic in their PH level. As the acidic condensate flows through the neutralizer; the PH of the condensate should leave the neutralizer with a PH reading above 5.

1.15 Additional Tests

1.15.1 Temperature Rise Test

A test that a home inspector may choose to perform on an operating furnace is called a "temperature rise test". With one, or ideally two, thermometers; an inspector can measure the "rise" in dry bulb temperature from the return to the supply duct. This dry bulb reading is one that is taken with a standard thermometer and does not take into account the enthalpy or total heat content of the air.