Investigating HVAC Failures

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Objectives

• Understand HVAC Systems and Components
• Develop a working knowledge of these systems
• Understand common failures associated with these systems
Furnaces

Electric

Gas

Oil
Furnaces

• What are the components of a furnace?
• How do they work?
• What are the possible failure modes?
Gas Furnace
Gas Furnace

Heat exchanger heat flow in forced air gas furnace

**house air side**
- The furnace blower drives household air across the outside of the heat exchanger and on to the ductwork distribution system.
- Most modern heat exchangers have dimpled or curved surfaces to slow down the air flow and encourage heat transfer.

**combustion side**
- Heat from the ribbon burners flows up the inside of the heat exchanger.
- After emerging from the top of the heat exchanger, it is channelled into the vent connector (and ultimately to the chimney).

- Heat exchangers are an air tight barrier between the house side and the combustion side. Any damage to the heat exchanger can let excess house air into the combustion side.

**cutaway heat exchanger section**
- Number of sections varies with the size of the furnace.

**Excess air in the combustion side**
- Can create carbon monoxide or cause combustion gases to spill out of the vent connector at the draft hood. (Not shown)
Gas Furnace

Types of Ignition Systems

• There are three styles of electronic ignition systems in use on gas fired heating equipment. One common method is to light a pilot which then lights the main burner. The pilot flame must be proven (the ground of the control module senses the DC current flow) before the main burner gas valve is energized. This system is known as an Intermittent Ignition Device (IID).

• A second system uses a silicon-carbide element heated to a high temperature to light the main burner directly. This system is referred to as a Hot Surface Ignition (HSI).

• The third system uses a spark to light the main burner directly. This system is commonly referred to as a Direct Spark Ignition (DSI).
Gas Furnace

IID System Operation

- In Intermittent Ignition Device (IID) systems, the ignition control’s spark transformer and pilot gas valve are automatically energized when the thermostat calls for heat. The spark lights the pilot on each operating cycle. The flame sensor proves the presence of the flame. The ignition control then shuts off the spark, and at the same time, the main gas valve is opened. (Some systems allow the spark to continue for a short period of time after the main burner lights.)

Lockout models provide for shutdown of the entire system when the pilot does not light within some fixed period of time and/or number of ignition trials (usually 60 seconds and 1 to 3 tries). Non-lockout systems, which are no longer used on new equipment, will continue to spark indefinitely and attempt to light the pilot until the pilot is lit, or the power is removed. After the main burner ignites, the system continues normal operation until the temperature control is satisfied and the main-burner and pilot valves are de-energized, shutting off all gas flow.
Gas Furnace
Gas Furnace

HSI System Operation

• In HSI/DSI systems, a call for heat energizes and warms the ignition element for a number of seconds or establishes a spark before opening the gas valve. When the valve is opened, the hot surface igniter lights the main burner gas. If ignition is not sensed (proven) within a predetermined period of time, the unit shuts down and recycles. Depending on the control module design, ignition timing may be from 2 to 12 seconds, and the number of tries may vary from 1 to 3.

• These ignition systems use solid state electronic circuitry and a flame sensor to replace the safety pilot valve and thermocouple normally associated with standing pilot systems. Flame sensing is a very important aspect of the ignition controls operation and is accomplished through the phenomenon of flame conduction and rectification. The area of conduction within a flame (pilot or main burner) is the outer area of the flame where most of the burning occurs and the atmosphere becomes ionized. This ionization within the flame allows an electrical current to be conducted through the flame. If two probes are placed in the area of the pilot flame, a current can be conducted from one point to another through the flame. To identify and isolate the current conducted by the flame, the principle of flame rectification is used.
Gas Furnace
Gas Furnace

Diagram:
- AC Current
- DC Current
- Flame Rod (Smaller)
- Flame Ground (Larger)
- Ceramic Insulator
- Pilot/Burner
- Ground
Flame Rectification Definition

Flame Rectification is a method of flame sensing whereby the flame sensor is located in the pilot or burner flame and a current applied to the sensor flows through the flame to the pilot assembly or the burner head and then to ground. Because the flame sensor is smaller than the ground electrode, an alternating current (AC) applied to the flame sensor flows in one direction and the AC current is rectified to a pulsating direct current (DC), or rectified current. This current tells the control module that a flame is present and the system operates as long as the DC signal from the flame rod is present. When the signal ceases, drops below a specific level, or is interrupted, the control module closes the main gas valve immediately to prevent an unsafe condition. The system either recycles itself or locks out and must be reset by cycling the thermostat or in some instances, by cycling the power.
Gas Furnace
Gas Furnace

Common Furnace Failures

- Clogged air filter and/or ductwork
- Oxidized flame sensor or thermocouple
- Clogged pilot tube
- Ignition module or furnace control board failure
- Exhaust pressure switch failure
- Exhaust venter motor failure
- Circulating fan motor failure
Oil Furnace
Oil Furnace
Oil Furnace

Common Furnace Failures

- Clogged air filter and/or ductwork
- Clogged fuel filter
- Clogged nozzle
- Burned off igniter rods
- Ignition transformer failure
- Cad cell failure
- Safety control failure
- Burner motor failure
Oil Furnace
Electric Furnace Components
<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Automatic Limit</td>
</tr>
<tr>
<td>2</td>
<td>Season Select Switch</td>
</tr>
<tr>
<td>3</td>
<td>Speed Selector Switch</td>
</tr>
<tr>
<td>4</td>
<td>Thermostat Indicator Light</td>
</tr>
<tr>
<td>5</td>
<td>Electric Motor</td>
</tr>
<tr>
<td>6</td>
<td>Blower Wheel</td>
</tr>
<tr>
<td>7</td>
<td>Motor Capacitor</td>
</tr>
<tr>
<td>8</td>
<td>Element Assembly 5000 W, 240 V</td>
</tr>
<tr>
<td>10</td>
<td>20 A Relay</td>
</tr>
<tr>
<td>12</td>
<td>Manual Reset Limit</td>
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<tr>
<td>13</td>
<td>Electronic Control (PC Board)</td>
</tr>
<tr>
<td>14</td>
<td>Transformer 240 V</td>
</tr>
<tr>
<td>15</td>
<td>Fiberglass Filter</td>
</tr>
<tr>
<td>16</td>
<td>Service Blower Assembly</td>
</tr>
</tbody>
</table>
Electric Furnace
Electric Furnace

Common Furnace Failures

- Heating element(s) failure
- Circulating fan motor failure
- Circulating fan switch failure
- High limit switch failure
Condensing Units and Rooftop Units
Condensing Units
Condensing Units

Diagram of a condensing unit system, including:
- Evaporator
- Expansion Valve (or Orifice Tube)
- Compressor
- Condenser
- High Side Tap
- Receiver Dryer
• Components
  – Compressor (13)
  – Condenser Fan Motor (11)
  – Contactor (18)
  – Condenser coil (3)
  – Capacitor (9)
Condensing Units

Common A/C System Failures

- Clogged condenser coil
- Condenser cooling fan failure
- Capacitor failure
- Corroded electrical connections
- Compressor failure
Condensing Units

Mechanical and electrical components operating together.

Heat from refrigerant and operation of compressor trapped inside shell.

Vibration from operation shaking components.
Rooftop/Package Units

• Heater
  – Gas
  – Electric

• Air Handler

• Condensing Unit
  – 1 or more compressors
Rooftop/Package Units
• What is a Chiller?
• How do they work?
• What are they used for?
Types of Chillers

• By type
  – Screw
  – Reciprocating
  – Scroll
  – Centrifugal

• By application
  – Air cooled
  – Water cooled
Types of Chillers

- **Screw**
  - Uses two (2) mating screws to compress gas
- **Reciprocating**
  - Has pistons and valves
- **Scroll**
  - Has interlocking scrolls to compress gas
- **Centrifugal**
  - Typically operates at pressures lower than atmospheric
  - Can have adjustable vanes
Types of Chillers

- **Air Cooled**
  - Intended for outdoor installation/operation.
  - Directly cooled using fans to expel heat from the units condenser coil to the atmosphere.

- **Water Cooled**
  - Intended for indoor installation/operation.
  - Cooled by a separate water loop connected to a cooling tower to expel heat to the atmosphere.
Types of Chillers

• Air Cooled
Types of Chillers

- Water Cooled
Diagram of a cooling system:
- Condenser water pump
- Cooling tower with fan
- Chiller
- Chilled water pump
- Air-handling unit with cooling coil

Cool water and very cool water flow through the system.

Courtesy: E source; adapted from EPA
System Control

- Chiller Controls
- Building Automation
- Equipment Demands
Questions & Answers
Thank you for your participation

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