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Smoke Troubleshooting Checklist For Outdoor Furnaces

I. Installation Issues (Improper Smoke Dispersal)
   A. Chimney height relative to nearest downwind neighbor
      1. If located 50 feet or less to any residence not served by the furnace, it is recommended that the stack be at least 2 feet higher than the eave line of that residence.
      2. If located more than 50 feet but no more than 100 feet to any residence, it is recommended that the stack be at least 75% of the height of the eave line of that residence, plus an additional 2 feet.
      3. If located more than 100 feet but no more than 150 feet to any residence, it is recommended that the stack be at least 50% of the eave line of that residence, plus an additional 2 feet.
      4. If located more than 150 feet but no more than 200 feet to any residence, it is recommended that the stack be at least 25% of the height of the eave line of that residence, plus an additional 2 feet.
   B. Furnace located in sheltered area; insufficient wind to disperse smoke.
   C. Furnace sizing. Similar to other heating appliances, furnace should be properly sized based on the estimated heat loss of the served structure.

II. Fueling Issues
   A. Burning less than optimal wood
      1. Moisture content: Optimal moisture content should be between 20% and 30% (seasoned wood)
      2. Species: Hardwoods generally tend to burn cleaner than softwoods
      3. Size: Larger pieces of wood tend to burn cleaner than smaller pieces
   B. Burning less than optimal fuel loads
      1. Loading: Firebox should be loaded based on outdoor temperature, anticipated heat load requirements and the manufacturer's instructions. Do not overload the chamber.
      2. Charging intervals: Firebox should be charged regularly at the intervals specified by the manufacturer's instructions. Optimally, the firebox will be charged "hot," i.e., the fire will not go out between chargings.
   C. Burning improper fuels
      1. Only burn fuels approved by the manufacturer
      2. Do not use volatile starters (such as lighter fuels, gasoline, chemicals) unless approved by the manufacturer
      3. Do not burn the following:
         a. Trash or household garbage
         b. Plastics

c. Gasoline
d. Rubber or tires
e. Naphtha
f. Material coated with petroleum products (e.g., particle board, railroad ties, pressure-treated wood)
g. Leaves
h. Paper products or cardboard

III. Operational Issues

A. Improper combustion air – Natural Draft Units (No Blower):

1. Air inlet not restricted by debris (creosote, ash, etc.)
2. Flame baffle/flue not restricted by debris
3. Chimney not restricted by debris
4. Door seal in satisfactory condition (provides air-tight seal when door is shut)
5. Air inlet (damper or flapper) operates properly (opens/shuts per manufacturer's instructions, provides air-tight seal when shut)
6. Door seal in satisfactory condition (provides air-tight seal when door is shut)

B. Improper combustion air – Forced Draft Units (Blower):

1. Verify combustion blower operates in accordance with the manufacturer's instructions
    a. Blower starts and stops properly
    b. Combustion blower wheel spins properly
    c. Blower runs at proper speed – verify voltage to blower motor
2. Combustion blower tube not restricted by debris (creosote, ash, etc.)
3. Flame baffle/flue not restricted by debris
4. Chimney not restricted by debris
5. Air inlet (damper or flapper) for blower operates properly (opens/shuts per manufacturer's instructions, provides air-tight seal when shut)
6. Door seal in satisfactory condition (provides air-tight seal when door is shut)

C. Verify controls operate in accordance with the manufacturer's instructions

1. Water temperature controls set properly
2. Draft controls set properly

IV. Maintenance Issues

A. Verify that the furnace is being maintained in accordance with the manufacturer's instructions. Specifically, inspect:

1. Excessive ash buildup
    a. Grates blocked, restricting air flow
    b. Combustion fan blocked, restricting air flow
2. Excessive creosote buildup
    a. Combustion fan blocked, restricting air flow
    b. Flame baffle blocked, restricting air flow
    c. Chimney blocked, restricting air flow

V. Discussion

Wood, like other fuels is made up of various amounts of carbon, hydrogen, and other elements. The burning of wood is a chemical reaction that depends on many factors. The essential factors to complete wood burning are time, temperature, and turbulence. Some other factors to take into consideration are: intake air; amount and placement, density and moisture content of the fuel, size of the firebox compared to the size of the wood load, and adequate room for the combustion process to take place.

The smoke that is seen coming out of a chimney is essentially a combination of unburned fuel (carbon and hydrogen) and moisture in the form of water vapor. The reason for the smoke is usually attributed to: (i) not enough time for complete combustion, (ii) not enough mixing (turbulence) to complete the chemical process, (iii) not enough temperature to get the fuel to that chemical conversion stage, or (iv) a combination of the above. In many cases, excessive smoke can be reduced by adopting practices that improve complete combustion, reducing visible emissions in the form of smoke.

A. Fuel

1. Moisture Content

Moisture content of the wood, either too high or too low, will affect the amount of visible smoke. Wood with a low moisture content (less than 10%) will burn relatively quicker, resulting in some of the fuel going up the chimney in the form of smoke, i.e., time was insufficient to complete the burn process. Wood with a moisture content too high (more than 35%) can quench the flame causing smoke, i.e., temperature was insufficient to burn completely.

Wood moisture in the 20% to 30% range can be the best of both scenarios. It is dry enough to burn without quenching the flame, yet the moisture is high enough to self-regulate the burn, giving it plenty of time to complete combustion.

2. Density

The density of wood plays a part in the combustion process in the same way as moisture content. Softwoods are by definition less dense and tend to burn more rapidly than hardwoods. Softwoods tend to create more smoke – due generally to insufficient time to complete the burn. Denser hardwoods will burn more slowly and evenly, allowing more time for the conversion of fuel to heat.

3. Size

The size of the wood can also be a factor in the amount of smoke produced. The surface area of a piece of wood is one of the factors that will affect burn rate. Larger diameter logs tend to burn slower than smaller logs, allowing for a more complete burn.

4. Improper Fuels

Burning materials not recommended by the manufacturer can play a major role in visible emissions. Materials such as plastics, garbage, rubber tires, and even wood products such as cardboard and paper that may be coated with petroleum products may emit excessive smoke. Fire starters such as gasoline, oil, and other chemicals can also make an ordinary wood fuel load seem very dirty once burned. If people who own outdoor furnaces start fires with some kindling and load with wood fuel as recommended above, they can eliminate a lot of the smoke that others see and the problems that go with it.

5. Loading

The amount of wood loaded into an outdoor furnace in relation to the firebox size also has an effect on visible emissions. For every size of wood load there is a minimum amount of space needed to complete the combustion process. For instance, if a person were to load a relatively small firebox completely and load a larger firebox with the same amount of wood, with all of the other factors being the same, the larger firebox would burn cleaner. In the smaller firebox, the combustion process does not have enough room to expand, heat up, and mix before exiting the firebox (insufficient time, temperature, and turbulence). Just because a firebox is large does not mean that it should be filled completely. This large volume is used in part for what happens AFTER it is loaded.

B. Furnace Size

The size of a furnace should be large enough to provide sufficient heat without constant reloading. If the target burn time is 12 hours, an adequately sized furnace will provide enough heat for 90% of all heating days. There will always be the extraordinarily cold days for which no one can plan. A small furnace that needs constant reloading will unavoidably be left unattended and will lose much of its available heat. In these situations, the firebox is left relatively cold and restarting will be dirtier because of flame quenching on the cool firebox walls. A good rule to follow is be that if the furnace cannot stay within 20% of its set point under regular reloading, then it is undersized and a larger furnace is needed.

C. Chimney Considerations

Although chimney height has little to do with overall emissions, it should be considered in ALL installations of outdoor furnaces. Installers and dealers should first take a look at the proposed location and take a few things into account. Location of nearby buildings, structures, and natural geography all affect the furnace's ability to draft. While higher is generally better, it is sometimes tough to convince the furnace owner to add length to the chimney because of the extra cost.

VI. Conclusions

The proper use of an outdoor furnace can significantly reduce the visible emissions that it produces. Simple fuel considerations with regard to moisture content, size, and amount help hinder the production of smoke and ultimately help improve efficiency. Other obvious ways to

help reduce smoke is to only burn fuels recommended by the manufacturer and to not overload the furnace. In addition, the furnace size should be properly matched to the heat load so that cold starts and overfilling are avoided. Chimney height should be in accordance with the state and local codes, as well as surroundings, including neighbors. These areas, along with the "Best Burn Practices for Outdoor Furnaces," can greatly help in providing clean, safe heat from all outdoor wood burning furnaces.

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