The Facts About Venting And Efficiencies

Today's heating professionals are faced with a bewildering selection of vent materials and appliance exhaust configurations. Making the right venting choice is critical; an incorrect decision can result in vent or boiler failure. Please take a minute to review the following information before specifying or installing your next gas-fired appliance.

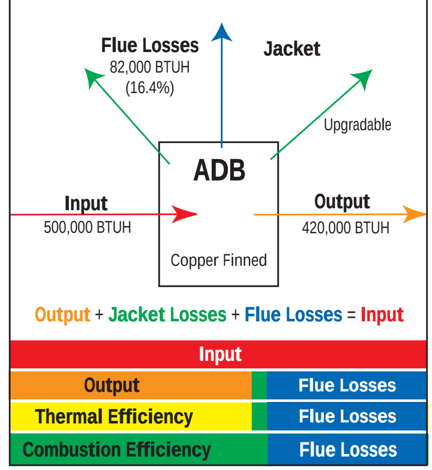
Condensation

The most common cause of vent failure is condensation. Condensation occurs when the water vapor created in the combustion process cools below the dew point. As the water vapor condenses, it combines with other combustion by-products to form an acidic solution. The resultant acid will collect in and eventually destroy the joints and seams of any vent not designed for condensing operation.

In response to a rash of condensate related vent failures of high efficiency appliances in the late eighties, the Gas Research Institute contracted the Batelle Institute to conduct a study to identify the best methods of preventing potentially hazardous vent failures. After extensive testing, the Institute determined that if at least 16.4% of the boiler's input energy is vented with the flue gases, the flue gases will remain hot enough to significantly reduce the risk of condensate related vent failure.

Batelle's findings provide a benchmark for determining which gas appliances are likely to experience excessive condensation and therefore require a corrosion resistant vent. Specifically, if flue losses are less than 16.4%, harmful condensation is likely; if flue losses are 16.4% or greater, harmful condensation should not occur. Despite the importance of flue loss in determining the appropriate type of vent to use, few manufacturers list FLUE LOSS percentage in their literature. The more commonly encountered terms found in manufacturer's specifications are combustion efficiency and thermal efficiency.

Figure 1. Boiler Thermodynamics



Combustion Efficiency and Thermal Efficiency

COMBUSTION EFFICIENCY is a bit of a misnomer, as it has little to do with the efficiency of the actual combustion process. As shown in **Figure 1**, combustion efficiency really measures the percentage of total energy that is absorbed into the heating medium or escapes from the boiler jacket. The only input energy not accounted for by combustion efficiency is that energy which leaves via the vent as flue loss. Combustion efficiency can be readily calculated by using the following equation:

Combustion Efficiency = 100% - Flue Loss Percentage **(Equation 1)**

By inserting Battelle's critical flue loss of 16.4% into **Equation 1***, we find that if a boiler has a combustion efficiency of 83.6% or less, the flue gases will have enough energy to properly vent without condensing. Conversely, if a boiler has a combustion efficiency greater than 83.6%, there is significant risk of condensing in the vent and therefore corrosion resistant vent material should be used.

Some manufacturers do not list combustion efficiency on their specification sheets . Instead, they list THERMAL EFFICIENCY. Thermal efficiency measures the percentage of energy created at the burner that is absorbed into the heating medium. Thermal efficiency is defined as the ratio of output to input at full fire and steady state conditions. **Equation 2** shows the relationship between thermal and combustion efficiency:

Combustion Efficiency = Thermal Efficiency + Jacket Loss Percentage **(Equation 2)**

Even if a manufacturer's spec sheet only gives thermal efficiency, it is still easy to determine an appliance's combustion efficiency. Simply add the appropriate jacket loss from **Table 1** to the published thermal efficiency. This estimate can then be used for vent selection. Please note that due to the First Law of Thermodynamics, thermal efficiency can never be greater than combustion efficiency. If you determine that thermal efficiency is greater than combustion efficiency, an error has been made – recheck your math or recalibrate your test instruments.

Table 1. Typical Jacket Losses

Copper finned tube, atmospheric	1.0 - 1.5%
Copper finned tube, powerburner	0.5 - 1.5%
Copper finned tube, A D B	0.5 - 0.6%
Cast iron, all types	2.2 - 3.0%

*Note: Due to differences in "Category" (Stack Performance) and "Efficiency" test procedures, plus rounding, it is possible to have a Category I (Non Condensing Vent) Appliance that is rated at 84% efficiency.

Gas Tight and Non-Positive Pressure Vent Systems

Proper material choice is only one half of the vent option selection equation. The vent system must also be chosen with regard for operating pressure. Vent systems fall into two pressure classifications: negative and positive pressure systems. Negative pressure systems, also known as non-positive pressure systems, operate at static pressures that are less than the surrounding room pressure. The joints of negative pressure systems do not need to be gas tight - if vent leakage occurs, room air will be sucked into the lower pressure flue. On the other hand, positive pressure systems require gas tight seals. If a leak occurs in a positive pressure system, flue gases will flow into the equipment room or, even worse, into the living space. Needless to say, the consequences of improper vent selection can be fatal.

As a general rule, if flue gases are vented vertically through a suitable stack, most appliances will operate at non-positive pressures. Conversely, if the flue gases are vented horizontally, most appliances will operate at positive pressures, and will require gas tight vent. Furthermore, the use of draft inducers or extractors may mandate the use of a different vent type. Therefore, vent selection should be made with regard to good engineering practices, and plain old common sense.

Venting Authorities

A leading authority for the installation of gas appliances in the United States is the National Fuel Gas Code (NFGC) ANSI Z223.1. Every specifier or installer of gas fired equipment should own a copy and be intimately familiar with the NFGC. The NFGC divides gas appliances into four categories based on vent operating pressure and the likelihood of condensation occurring in the vent. The four categories, which are used to determine which type of vent is appropriate for a given appliance, are listed in **Table 2**.

Table 2. Appliance Categories Per NFGC and ANSI Z21.13

Appliance Category	Vent Pressure or	Condensing Non-Condensing
I	Non-Positive	Non-Condensing
II	Non-Positive	Condensing
III	Positive	Non-Condensing
IV	Positive	Condensing

The American National Standards Institute has also revised ANSI Z21.13, the gas-fired low-pressure steam and hot water boiler code, to reflect the above categories. ANSI Z21.10.3, the water heater standard, is expected to be updated in the near future. As a result to the changes in ANSI Z21.13, most manufacturers specifically identify the appropriate appliance category in their operating and installation instructions. A word of caution: do not rely solely on the manufacturer's installation instructions. The temptation for manufacturers to "fudge" vent category requirements is very strong. In fact, several appliance manufacturers misleadingly list units with thermal efficiencies greater than 84% as being Category I appliances. Ultimately, it is the engineer and contractor who bear the responsibility for ensuring that installations function properly and comply with national and local codes.

Conclusion

Armed with sufficient knowledge and a little foresight, vent system selection and design is very straightforward. Please check, then double check, the vent system of any gas-fired appliance you specify or install to insure overall safety. If in doubt, please err on the side of conservatism.

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