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White Paper

From Non-Condensing to **Condensing Vent Systems:**

Requirements for Understanding the Best Solutions

Condensing to Non-Condensing
Challenges to Solutions

In response to consumer demand for higher efficiency boilers and updated regulations from the Department of Energy, the conversion from non-condensing to condensing vent systems becomes necessary. The benefits of higher efficiency are clear, but this transition comes with its own set of challenges.

Venting 101

To understand the best solution for converting to a condensing vent system, it is important to start with the basics of venting. Most are familiar with the combustion triangle. Combustion requires fuel, oxygen, and heat (ignition source) in proper proportion to occur. The purpose of gas/oil fired appliance venting is to safely remove products of combustion (POC) from the appliance to the outside atmosphere. Some POC include carbon dioxide, heat, water vapor, and acids/oxides.

For non-condensing boilers and furnaces, the heating temperatures are kept high enough to prevent water vapor in the flue gas from condensing. This is important, because if it does condense, the condensate causes corrosion due to its acidity.

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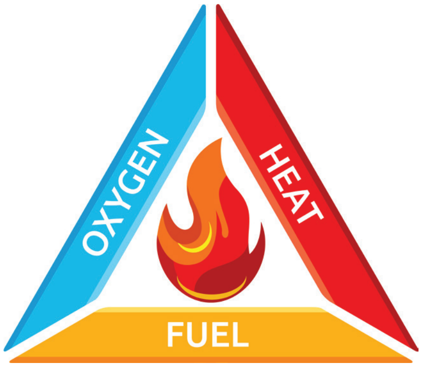


Fig 1: Combustion Triangle

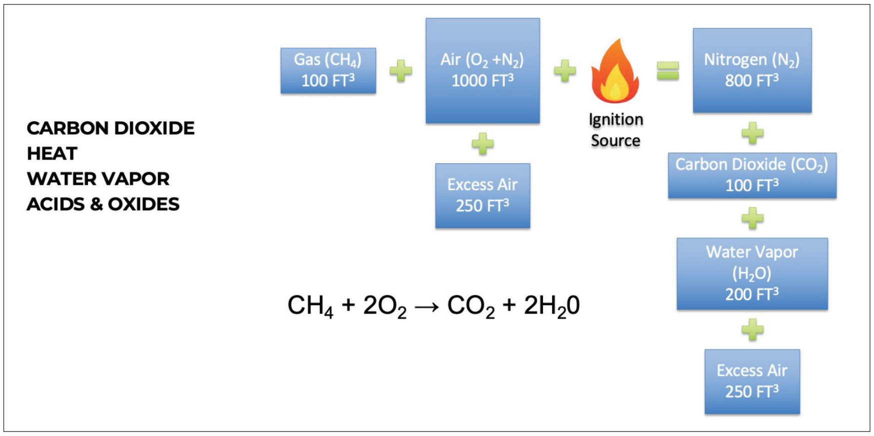


Fig 2: Products of Combustion

The presence of heat creates buoyancy, leading to natural draft.

DRAFT
NATURAL DRAFT
MECHANICAL DRAFT
ACTUAL DRAFT

$F_b = \rho g V$

Where:

F_b is the buoyant force

ρ is the density of the fluid

g is the gravitational acceleration

V is the volume of the fluid displace

Fig 3: Draft

And keeping heating temperatures high means less efficiency. By converting to condensing systems, the efficiency of boilers can be significantly increased.

The Importance of Draft

In the world of vent systems, it's essential to understand draft - the pressure differential vs. atmospheric pressure that drives the flow of gas in a vent. Natural draft is the upward suction caused by the buoyant movement of warm gas within a vertical column. As hot gas rises at the base of a vertical column due to being less dense, it can create a continuous vacuum with a sufficient supply of replacement warm gas. Factors like temperature differential, height, and diameter of the vertical column play a significant role in this process.

When it comes to mechanical draft, there are different types to consider:

- Forced draft: Creates positive pressure at the beginning and requires a liquid/airtight setup.
- Induced draft: Operates on negative pressure.
- Combination with in-line systems: Utilizes negative pressure up to the inlet and positive pressure after.

Natural Draft

+ Mechanical Draft

- Pressure Losses

= Actual Draft

Actual draft is the pressure differential existing in the chimney, which is equal to the sum of natural draft and mechanical draft, minus pressure losses due to flue resistance. By comprehending these draft mechanisms, we can ensure optimal performance in a venting system.

Category Review

Venting systems are divided into 4 categories based on whether there is positive or negative pressure in the vent and whether condensation is continuous. To read what category a system falls into, see the Venting Categories Chart (Fig. 4).

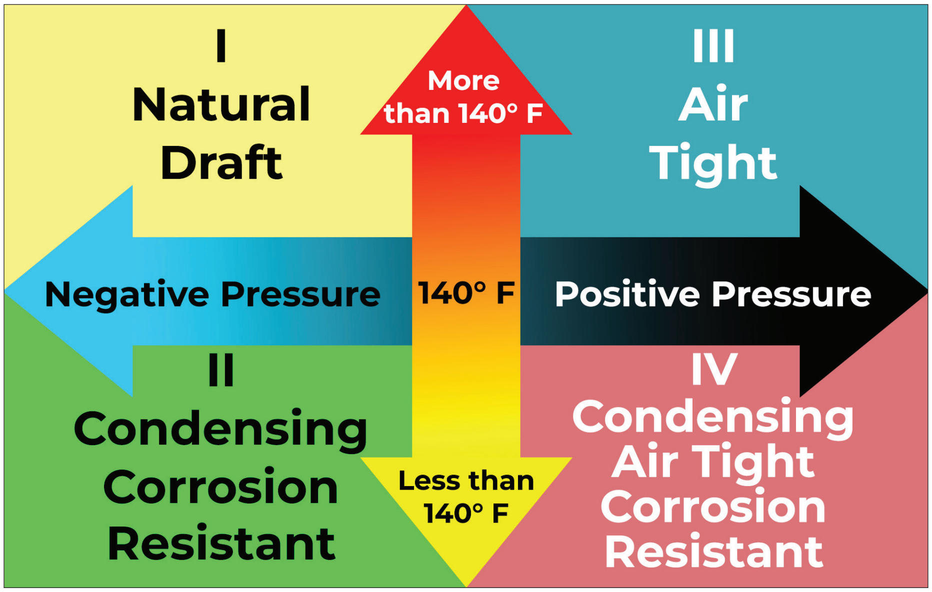


Fig 4: Venting Categories Chart

The vertical line through the center portrays negative and positive pressure.

- To the left of the line are negative pressure chimney systems
- To the right of the line are positive pressure

The horizontal line through the center portrays condensing and non-condensing.

- Above that line are non-condensing (or not continuously condensing) categories I and III.
- Below the line are continuously condensing vent systems in cateories II and IV.

In transitioning to condensing vent systems, a common scenario is that we are converting older systems in categories I or III into the condensing categories II or IV.

Why Materials Matter

When it comes to a venting solution, the selection of materials is crucial to ensure the longevity and efficiency of the system. Materials can vary in durability, from low temperature plastics (LTP) to the most durable stainless steels. Stainless steel such as 29-4C and 316L are used in applications for condensing vent systems due to their ability to withstand exposure to acidic and wet environments. This is especially important as the products of combustion contain a significant amount of water vapor and different types of acids, resulting in a highly acidic condensate with a pH of 3-5, with 7 being neutral. Failure to use the appropriate materials can lead to a short-lived and inefficient venting system. Hence, it is essential to choose

You can create a venting categories chart with a piece of retangular paper. Draw a horizontal line through the center. Above the line are the non-condensing systems, below are condensing systems. Next, draw a vertical line through the center. To the left left are the negative pressure systems, and to the right are the positive pressure systems. Label the 4 categories left side top to bottom, I and II. Right side top to bottom, III and IV.

Though it may be temping, reuse of existing vents is not recommended for several reasons.

resilient materials like specific types of stainless steel to ensure the durability and functionality of the venting system.

Upgrading ventilation is crucial for high-efficiency appliance venting and though it may be tempting to reuse existing vents, it is not recommended. Existing vents are most likely not adequate materials or construction to handle the POC which would lead to corrosions as they rust, rot, or deteriorate. It is possible that relining an existing chimney with a single-wall vent or flexible stainless product can bring it up to standard and allow for high-efficiency appliance venting as will be shown in the examples that follow.

In cases where a new stack is needed, it's important to consider the height and size of the stack. We often replace a couple of large, individually-vented, lower-efficiency boilers with multiple smaller, higher-efficiency appliances to achieve the same heat load requirements. So, the size of the stack would have to accommodate more appliances being common vented.

Additionally, seasonal load or appliance turn down and the potential of a redundant appliance needs to be considered for the stack. In sizing a vent system, you size for the worst-case scenario, that is full fire for every appliance on the same stack. The challenge is now how to control lower input levels for a high fire sized stack.

Draft Control

When designing a common vent system that can function efficiently from low to high fire, an ideal solution is natural draft, which utilizes the buoyancy force of hot POC to create a flow in the system.

Mechanical draft, which involves the use of external fans to create a flow of POC through the system, can be useful in situations where natural draft is not sufficient, or when a more precise control over the system is required.

A fixed blade damper, also known as the "set it and forget it" type of damper, allows for easy control of the system. By adjusting the blade, the draft level can be tuned and locked down for consistent performance at one setting.

An on/off damper uses an actuator to open and close the damper blade. When there's a call for heat from an appliance, a signal goes to the damper, and it opens. When no more heat is needed, it closes. A major benefit of this system is that it is a closed loop. Moreover, on/off dampers prevent movement within the entire vent system. Without one, natural draft could start occurring in an appliance vent that is not in operation (for example, because of a temperature difference between the condition space of the building and the exterior). It will start pulling air through the system.A non-operating appliance bringing cold air in could cause freezing issues and other problems. Additionally, in a positive pressure system an exhaust vent section can be closed off preventing backflow into an idle appliance.

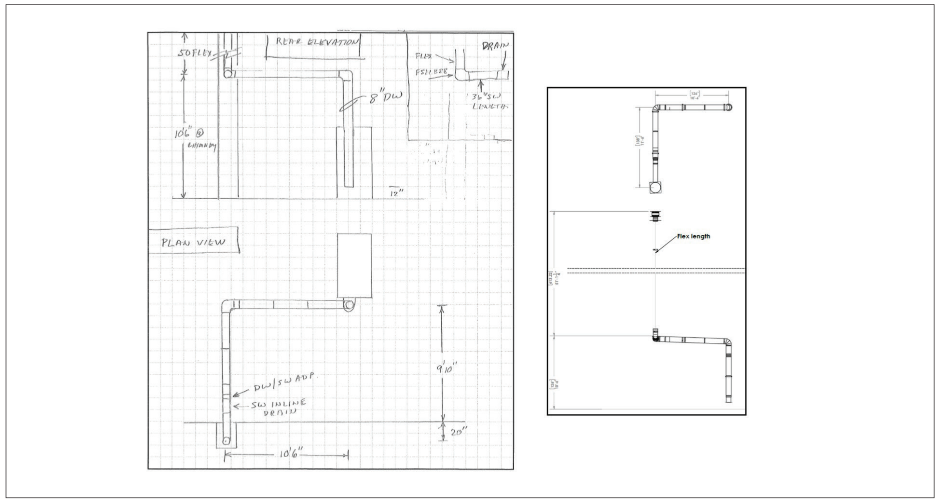
A modulating damper provides the most control to handle all different types of load conditions. It is a combination of a fixed and an on/off damper. The difference is a modulating damper reads pressure in the vent system and the blade will move to hit a specific set point. The damper blade moves up or down to automatically adjust to a specific pressure that the user sets to accurately provide just what is needed for each individual appliance or a common vent.

Fig 5: Evidence of corrosion

Misguided attempts to reuse existing venting for new appliances are often quick to fail and easy to identify. See Figure 5. A custom manufactured vent had a cap of unknown material applied and has corroded in just one heating season (Left). Existing material was reused on a conversion from a Category I to Category IV (Right). Evidence of condensate eating away at the vent is obvious.

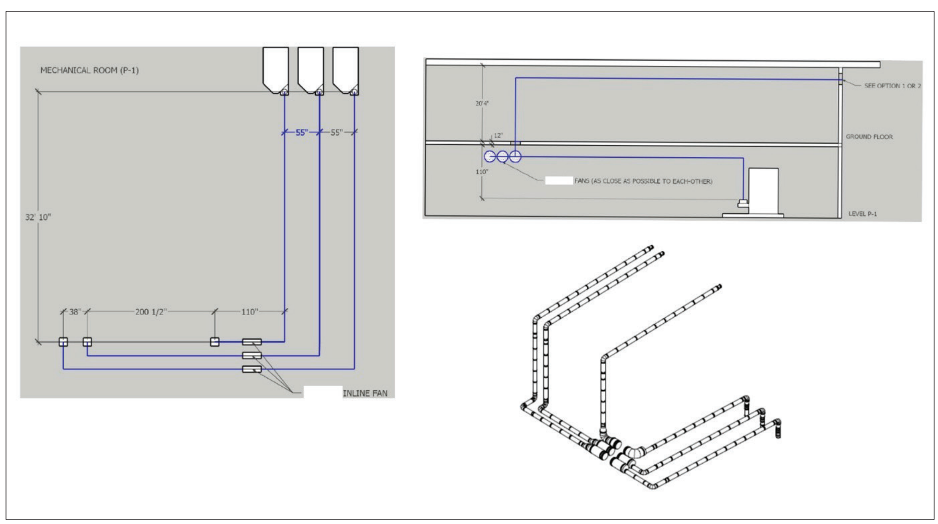
Challenges & **Solutions**

Example 1:
Individually Vented Re-Line

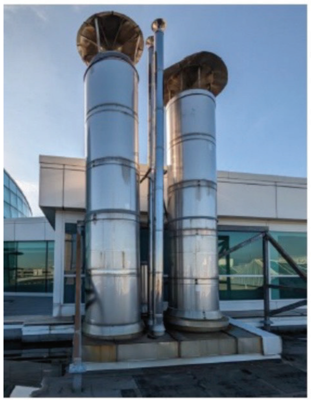


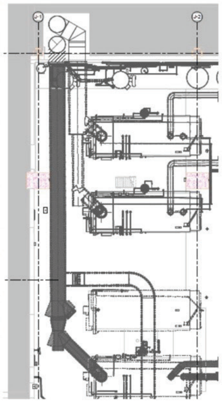
At this public building (a courthouse), it was important to check the vent system size on the appliance. In this case, natural draft was able to be utilized without additional devices. As a result, the existing brick chimney was able to be relined with stainless steel. This was a simple solution using the push from the appliance and natural draft that also protected the integrity of the brick chimney with a reline.

Example 2:
Side Wall Venting



When upgrading a multi-dwelling building, the building didn't offer a lot of height for natural draft and reusing the existing vent by relining would have been difficult due to several directional changes. The length of horizontal venting on two separate floors exceeded the manufacturer's allowable equivalent length. The length of vent before the appliance could not push the POC through. To solve this, mechanical draft was created with in-line fans to assist the boiler in pushing POC through and to overcome the pressure losses caused by the changes in direction and horizontal runs. This allowed the exhaust vent to be placed out the side wall, rather than up a tall chimney.





Example 3: **Common Venting**

A more complex conversion at an airport presented a common vented system and many factors to consider. The solution involved relining existing category III chimneys. Several sets of modulating dampers (one for each appliance, one per each fan inlet) were also utilized. This solution included the addition of many different types of devices, a redundancy with the fans, multiple dampers and boilers, all needing to work in tandem.

In **Conclusion**

Overall, the specific needs and requirements will ultimately determine the best approach to a venting solution. With careful consideration of materials and construction, and natural and mechanical draft options (including dampers), it is possible to design a system that can effectively and efficiently address many venting conditions. In short, material matters, draft is your friend, and dampers differ.

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Duravent Group is a recognized global climate technological leader in the venting, filtration and air control industries, known for first-to-market innovations moving the industry into the future.

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1 Mike Heavener, "Converting from Non-Condensing to Condensing Vent Systems: Challenges and Solutions", *Today's Boiler*, May 2024, www.abma.com.