TIP SHEET:
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Why Ultra-High Turndown is Bad for Hydronic Condensing Boilers

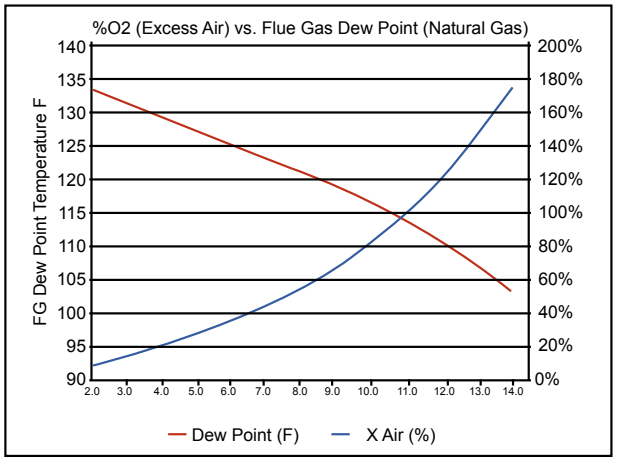
Today, hydronic boilers can approach near-perfect efficiency due to the advancements of condensing technology. Several manufacturers promote ultra-high turndown as the solution to efficiently meeting low seasonal, partial-load demands. By understanding condensing boiler operation and the basics of thermodynamics, one will realize that an extremely high-turndown burner on a hydronic condensing boiler does not promote the highest system efficiency, but actually can make the system less efficient.

It is widely understood that in a traditional steam boiler and in a high-temperature firetube hot water boiler, higher excess air is required at low fire. This ensures clean, safe, stable combustion at lower firing rates but also results in lower combustion efficiency at these rates. Since these boilers are larger and commonly operate at higher firing rates, this was considered a good trade-off.

With today's hydronic condensing boilers, the rules have changed. New premix burner technology has led to the development of burners that provide a proportionate air-to-fuel ratio across the entire firing range and provide reasonable turndown. This allows for no loss in combustion efficiency and contributes to what is referred to as an inverse efficiency characteristic, wherein the condensing boiler can be more efficient at low fire rather than at high fire.

Moving beyond a reasonable turndown, compromises must often be made. The compromise is that excess air must be added at higher turndown to protect the premix burner materials from overheating while still ensuring clean and stable combustion. Remember, during normal combustion, adding excess air reduces efficiency.

While adding excess air lowers combustion efficiency, the effects are even more detrimental when operating condensing boilers. Because condensing boilers extract latent energy from the flue gas, it is important to look at the impact excess air has on the flue gas dew point. The boiler's return water operating temperature relative to this flue gas dew point is the most essential factor in achieving condensing efficiency (greater than 90%).



Graph illustrates the effect of excess air with high turndown on flue gas dew point.

As the excess air level increases, the flue gas dew point decreases. A normal excess air level for a natural gas-fired condensing boiler is around 5% O2 (or 30% excess air). This correlates to a flue gas dew point of 127°F. Therefore, in order to

begin to achieve condensing performance, the return water temperature must be below 127°F.

If additional excess air is added with the goal of improving turndown, notice what happens. By increasing the excess air level as required to 10% O2 (or 80% excess air) in this example, the flue gas dew point now drops to 117°F. In order to achieve the same level of condensing performance, the return water must be below 117°F.

Condensing is the process by which boilers extract the latent heat that is in the combustion gas. So the lower the return water temperature is below the flue gas dew point, the more condensing can occur and the higher the efficiencies can be. Return water temperature is not the only factor, but it does play a major role in the boiler's ability to extract the available latent heat energy.

Unlike in steam systems, hydronic systems rely on mechanical pumping, and since the boilers must maintain a constant system supply water temperature, the return water temperature will increase at reduced firing rates. It is critical to understand that excess air must be increased to achieve ultra-high turndown, and the result is that the flue gas dew point is decreased, making it more difficult, if not impossible, to condense.

By trying to save energy with the ultra-high turndown burner, you actually move further away from the flue gas dew point, which dramatically decreases a condensing boiler's efficiency.

Cleaver-Brooks ClearFire® line of hydronic condensing boilers can achieve efficiencies up to 99 percent. To learn more about hydronic boilers or for help designing a hydronic boiler system, visit **cleaverbrooks.com**.