Janus Technology Group's

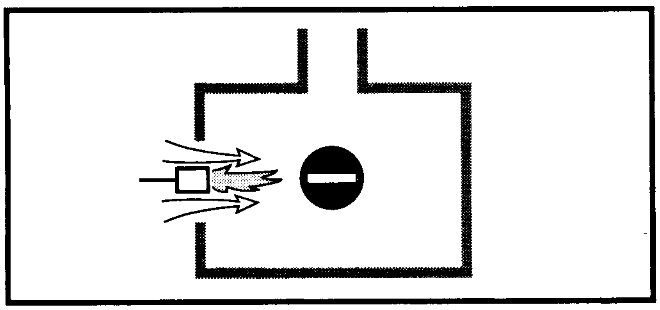
Foresight & Hindsight No. 5

Combustion Chamber Pressure

In F & H #2, 3 & 4, we reviewed furnace and oven flue systems and how they work. Now, let's look at the end result of all this — the combustion chamber pressure.

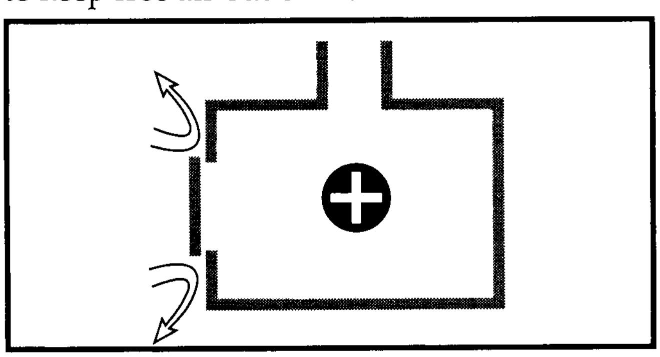
What should combustion chamber pressures be?

It depends on the application. If the burner is an open type, with secondary air entering the chamber as part of the combustion air supply, the pressure has to be negative to pull in the air.



Many old boilers and furnaces lacked steel shells and were run negative to keep hot gases from leaking out of every opening, and many modern ovens and dryers operate at negative pressures to prevent solvent fumes or moisture from escaping into the work area.

Positive pressure, on the other hand, is needed to keep free air out of the furnace or oven.

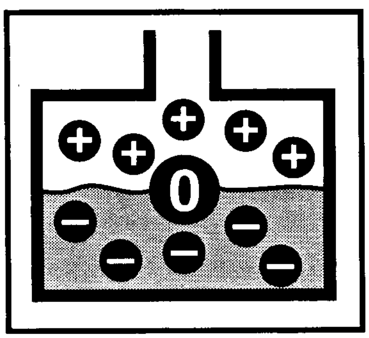


This air lowers process efficiency by absorbing heat and taking it out the stack, and it creates an oxidizing environment inside the furnace. In high temperature metallurgical furnaces, like forging and steel reheating furnaces, this accelerates scaling of the metal. In nonferrous metal melting furnaces, it promotes the formation of oxides and dross on the metal surface.

Too much of a good thing can be worse than nothing at all, though. Too positive a pressure can force hot furnace gases past door seals and out available openings, deteriorating insulation and warping and buckling structures.

If both positive and negative pressures have drawbacks, and the burners don't need secondary air,why not operate at a neutral (atmospheric or zero gauge) pressure?

Holding neutral pressure in an oven or furnace is tougher than it looks. It's an inherently unstable condition, like walking along the top of a fence — one misstep, and you fall off, and it could be to either side.



The other problem is that neutral pressure is only an average. In chambers where gases aren't moving around much, thermal head (the natural tendency for hotter gases to rise) creates a pressure differential between the top and bottom of the chamber — more positive or less negative the higher you go. So in practice, zero pressure exists only along some imaginary plane in the furnace.

In addition, the velocity of moving gases from burners, fans and recirculating air inlets creates localized areas of more positive pressure.

(over)

What sort of pressure are we talking about ?

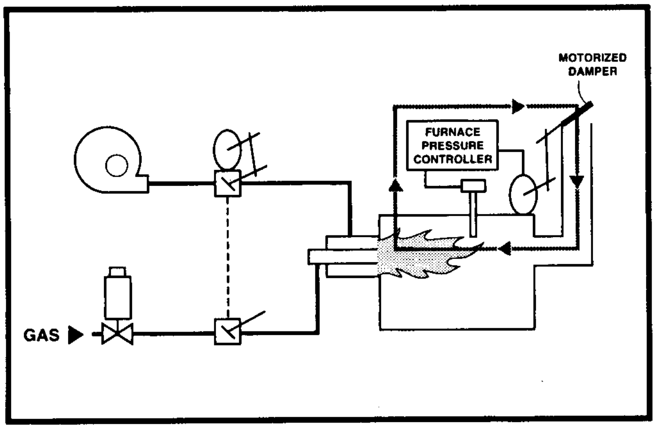
Not much. Typically, it ranges from positive 0.25" water column for sealed process furnaces with forced air burners to negative 0.75" water column for some old natural draft boilers.

Does burner firing rate affect chamber pressure?

You bet. On one hand, the flue system or exhaust fan is trying to pull gases out of the chamber at a more-or-less fixed rate. On the other hand, the burner system is trying to replace them with fresh combustion products. If the burner is operating at high fire, the pressure might be positive or perhaps slightly negative. Turn the burners down to low fire, and the flows go out of balance. The flue system takes over, making the chamber less positive or more negative. This is where most of the air infiltration problems arise in furnaces.

How do you deal with it?

With a variable capacity exhaust system — one that opens and closes with the burner firing rate. If the furnace has a fixed stack and no fan, it can be fitted with a damper to regulate the volume the stack draws. An automatic furnace pressure or draft controller is usually needed to drive the system.



If a fan provides the draft, its flow can be controlled with a damper valve or variable speed drive.

If the combustion chamber pressure gets out of control, can it upset the ratio or firing rate of the burners?

With open burners, a loss of draft (less negative pressure) in the combustion chamber reduces the secondary air flow. The burner ratio will go richer. If it crosses over from lean to rich, some fuel will go unburned, reducing the firing rate and producing combustible gases, which are toxic and a fire hazard.

Sealed burners are less susceptible, partly because they usually operate at air and gas pressure drops much higher than the furnace pressure. For example, a gas burner operating at air and gas pressures of 10" wc at high fire is set up against a positive furnace pressure of 0.1" wc, but that pressure creeps up to + 0.2" wc. The decrease in air and gas flow can be calculated from the pressure drops across the burner. Originally, they were (10 - 0.1) = 9.9 "wc. After the furnace pressure change, they're (10 - 0.2) = 9.8" wc. The flow change is proportional to the square root of the pressure drop change, or

$$\sqrt{9.8 / 9.9} = 0.995$$

In other words, doubling the furnace pressure cost you only 1/2 of 1% of the firing rate, a change so small you probably won't even notice it. The gas-air ratio is unaffected.

If the burner and its controls are set up so the air and gas pressure drops are normally unequal, a change in furnace pressure **will** change the fuel-air ratio, but the effect will most likely be negligible, too.

Janus Technology Group is a leading provider of consulting services and training to users and manufacturers of industrial process heating equipment and to energy providers. For technical support, training, process troubleshooting or marketing assistance, contact us at:
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