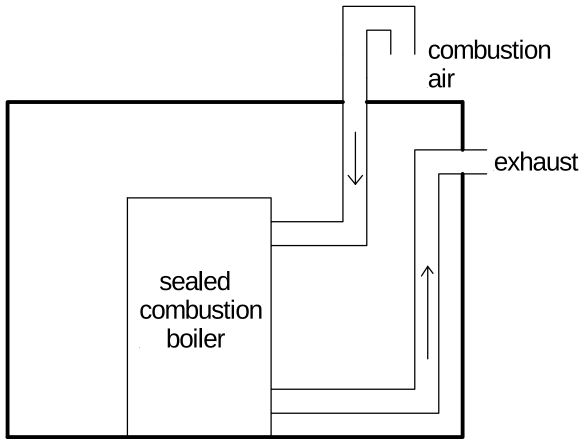
Sealed Combustion means that air required for combustion is brought to the boiler's burner by means of a duct connected to the outdoors. When installed that way, the boiler is stand-alone device, not affected by barometric or pressure changes within the room.



The primary benefit of using sealed combustion is that, in many areas, fire rated room construction is avoided. Secondary benefits include the elimination of damper systems mounted on an outside wall or make-up air units designed to bring air into the room for combustion. Boiler rooms are warmer and the danger of frozen pipes is lessened.

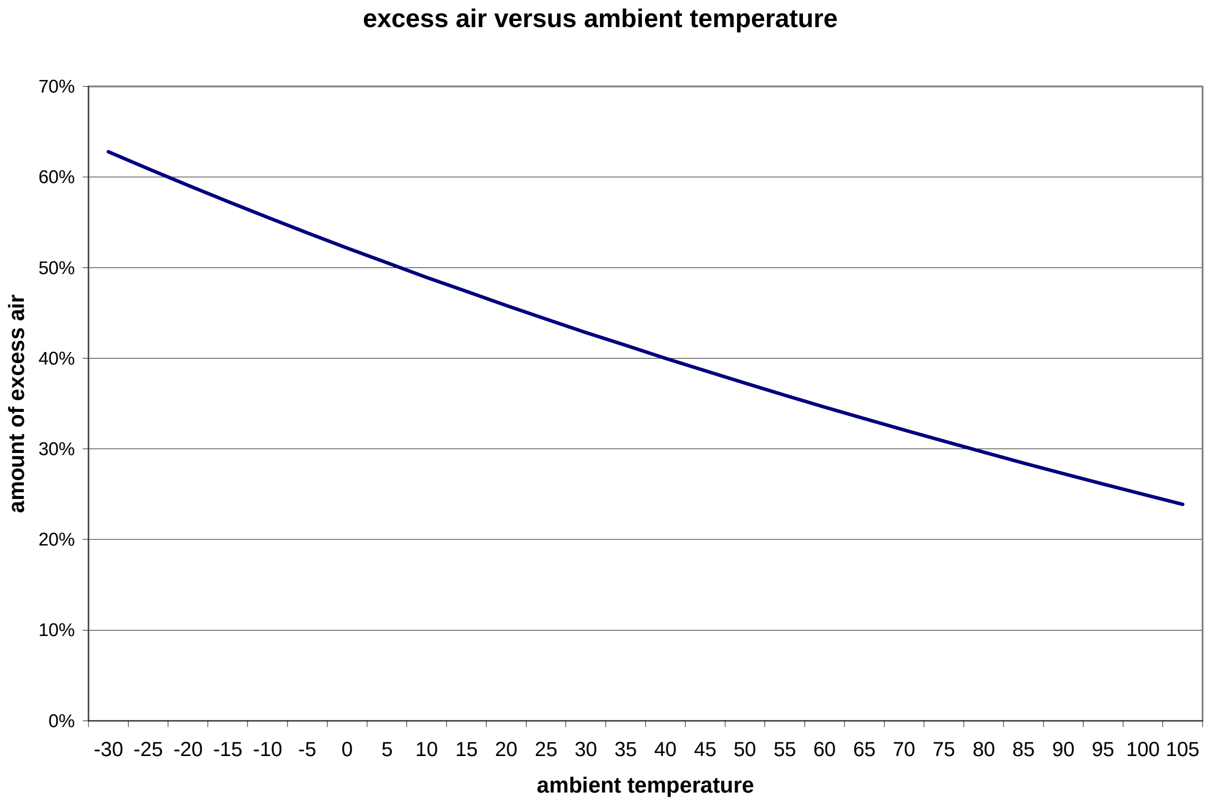
While all that is good, there is a significant drawback unless the boiler is properly designed to overcome it! <u>The combustion can become incredibly poor or even dangerous in sealed combustion systems.</u>

A burner uses fuel that has a certain chemical make up. To burn it properly and safely, the proper number of oxygen molecules must mix with the fuel in the burner. Each burner has a range of oxygen molecules that can be admitted to give safe, efficient operation. If more than the right range of oxygen molecules are admitted then the excess air increase not only lowers the boiler's efficiency but can cause unstable combustion leading to rumbling and pulsation. If too few oxygen molecules are admitted then there is not enough excess air for combustion and dangerous carbon monoxide is generated at best. Pulsation or even an explosion is a possible result.

How does that happen? Air, which is used to supply the oxygen, changes volume in relationship to its temperature. When the outside air is "cold," compared to room air, more molecules are present per cubic foot. When the air is "warm," fewer molecules are present in a cubic foot. The burner's fan moves a constant *volume* of air, so more or less molecules are moved depending on the temperature of the air. Any given burner runs well within a range of excess air levels, but when it becomes too warm or cold, the excess air gets out of that range and the burner can become unstable.

When a burner is commissioned at a given ambient air temperature it might run great. But when the weather changes . . .

Air is what is called an “ideal gas.” We know that because it adheres to Dalton’s Rule (don’t ask how we know that, just believe) As such, it follows the “ideal gas law” (or else it gets arrested?) The chart below uses that law to show how the excess air levels change with the weather.



There is quite a difference in excess air as the temperature changes isn’t there?

Let’s assume that a burner technician commissioned a 1 million BTUH input sealed combustion boiler when it was 60 degrees outside. The boiler manual says that the combustion should be set so that the CO_2 level should be within a range of 6% to 8%. That is the same as saying that the excess air range must be between 47% and 96%. He sets up the boiler to run at 7% CO_2 (that’s 69% excess air), right in the middle. Perfect. Good job! Then he leaves.

Three months later he gets an emotion-packed call from the boiler's owner. The man was scared out of his wits. And VERY angry. He explained that when he came to work, he heard what he thought were rapid explosions. He called the police. While waiting for them to arrive, he realized that the explosions were rhythmic and not guns or bombs. He walked toward the blasts and saw the walls of the mechanical room pulsing. In a fit of panic he thought that he should have called the fire department instead of the police. A few seconds later, with sweat running down his face, he got brave. He cracked the door open, reached in and pushed the red "emergency stop" button for the boilers.

The noise stopped. That's when he called the poor service tech that caused the anguish.

What happened?

The burner was destroyed because the air to fuel ration became out of spec when the outside temperature changed.

But why did it happen?

The colder air increased the mass flow of air. The excess air went up.

The chimney "pulled" harder. The colder ambient air created a greater suction. But because the technician couldn't keep the boiler running for long periods of time when he set it up, the chimney never really go hot. But now, the boiler stayed on longer because of the higher heat demand. The chimney material heated up and the suction effect was huge compared to when the boiler was commissioned. That caused the excess air to go up even further.

The excess air increase literally made the combustion so poor that it burned a tiny hole in the burner material. The hole got bigger over a few days until the combustion sounded like a terrorist attack to the owner.

Not surprisingly, the owner did not want to pay for the tech's time or for the several hundred dollars of parts.

Note that the same thing might have occurred if the weather had turned warmer. Then the stack wouldn't work as well and the air is less dense.

Does this have to happen?

No, but certainly something has to be different! There are two possibilities to minimize the above horror story.

The burner can be adjusted two or three times a year, at various ambient temperatures, so that the change in weather minimizes the air to fuel ratio changes. That might cost about $1000 per year.

A second way is to utilize boilers that have in-built feedback control so that the air to fuel ratio changes only a minimal amount when the ambient temperature changes. Patterson Kelley Modufire and Mach Series boilers have exactly that in-built feedback control.