Chapter **1** INTRODUCTION TO OILBURNERS



IN THIS CHAPTER

- How an oilburner works
- The high-pressure, atomizing, flame retention oilburner
- Ignition, the nozzle assembly and air adjustments



Figure 1-1:

Oilburner operation

Chapter 1

Introduction to Oilburners

Air

Introduction

To understand oilburners, we must understand a bit about combustion. Combustion (burning) is the rapid combining of oxygen and the elements in the fuel. When the oxygen and the fuel combine, they create heat, light-and combustion gases. (We cover Combustion Theory in detail in Chapter 7.) In order for something to burn, we need three things:

- 1. Oxygen from the air
- 2. A fuel that will easily combine with the oxygen
- 3. Heat

Heating oil will not burn as a liquid. To burn, the liquid oil must be converted into a vapor. In today's burners, this is done by breaking the oil into tiny droplets (atomizing it). Next, each droplet is heated until it turns into a vapor. Then, to accomplish clean combustion, the oilburner must mix the oil vapor with the proper amount of air. The combined air and vapors are raised to the temperature at which they will burn. Therefore, every oilburner must atomize the oil, vaporize it, mix it with air, and heat the mixture above its ignition point.

High pressure atomizing

Today's oilburners are called highpressure burners because they use a fuel pump to pressurize the oil to 100 pounds per square inch (PSI) or more. This pressure forces the oil through a nozzle designed to break (atomize) the oil into the small droplets that are vaporized and burned in suspension in the combustion area. An electric spark, from electrodes installed close to the nozzle, supplies heat for ignition. A fan supplies the air required for combustion. Figure 1-1 shows how a burner operates, Figure 1-2 shows the combustion process.



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Although the high-pressure burner has been the mainstay of the industry almost from the beginning of the modern oilburner era, it has gone through many modifications. An advantage of oil is that parts are largely interchangeable, and thus it has been possible to keep many burners operating for years. In fact, some burners made in the 1930s are still operating in the field because of interchangeable parts.

Flame retention oilburners

In the 1960s, the current design for oilburners was introduced, which is called the *flame retention burner*. As the name implies, the flame is held very close to the face of the combustion head. The flame is smaller and more compact than with older burners. This design's primary characteristics are its head or end-cone, high

motor operating speeds (typically 3450 RPM) and high combustion air static pressures. Figure 1-3 shows pictures of modern flame retention burners.

Figure 1-3: Flame retention burners



The flame retention head provides a modified airflow pattern for radically improved air-oil mixing. The basic idea is to produce a strongly swirling air pattern that recirculates combustion products for more complete mixing of fuel and air. This is called *recirculation*.

As the air rushes out of the end of the burner, it sucks air from the combustion

Air Pattern-Non-Flame Retention Burner



Air Pattern—Flame Retention Burner



area back toward it. This recirculation is what pulls the fire back toward the head, creating the flame retention effect. The flame stabilizes near the burner head, hence the name *flame retention*. The air swirling is achieved with airflow shaping heads and turbulators and by running the burner motor and fan at high speed.

The flame retention head produces more air swirl and combustion air recirculation flow, which improves fuel-air mixing. This permits operation with less excess air and with lower smoke levels. Cleaner and more stable combustion is produced and system efficiency is typically 5 to 15 percent

	Non-flame Retention (Turbulator or Choke)	Flame Retention Head Burners
Percent CO ₂	7-9	11-13
Percent Excess Combustion Air	50-100	20-30
Bacharach Smoke Number	1-3	0-1
Percent Flue Heat Loss (on cycle)	30	10-20

higher than with older burners. See Figures 1-4 and 1-5.

Flame retention heads produce hotter flames because less excess combustion air is used than with non-flame retention head oilburners. Therefore, the combustion chamber construction materials and general condition must be checked carefully whenever a high efficiency oilburner is installed or serviced.

Construction of the high-pressure atomizing flame retention oilburners

The high-pressure retention head burners are precision-built and constructed for durability and long service. Every high-pressure burner consists of a motor, fan (C), fuel unit (A), ignition transformer or igniter (E), nozzle assembly (B & D), and a housing to which all of these parts are attached, as illustrated in Figure 1-6 on following page.

Motor

The electric motor drives the fan and the fuel pump. The motor is manufactured in one of two designs, either a split phase type or permanent split capacitor (PSC) type motor. The motor is mounted to the housing of the burner by means of a two, three, or four bolt flange. Removing these bolts allows easy removal of the motor and access to the fan, which is attached to the motor shaft. In the event of motor failure, be sure Figure 1-4: Comparison of burner performance

Figure 1-5: Difference in flame between a nonflame retention burner and a flame retention burner





to replace the motor with a new motor of the same rotation, frame size, and revolutions per minute (RPM). Figure 1-7 shows a motor, fan and coupling. The coupling attaches to the motor shaft on one end and the pump shaft on the other, taking power from the motor and transferring it to the pump. (Motors and couplings are covered in Chapter 10.)



Multiblade fan and air shutter

A fan wheel within the burner housing is driven directly by the motor shaft, and provides the necessary air to support combustion. An adjustable air shutter on the burner housing controls the volume of air handled by the fan.

The oilburner fan, or blower wheel as it is often called, supplies the combustion air for the flame. See Figure 1-8. They are of the squirrel cage type with beveled blades that must be kept free of dirt and lint. The slightest amount of dirt will



reduce the blade bevel and reduce the amount of air delivered. They are precision balanced and every effort must be made to prevent bending the wheel at its hub.

Figure 1-8: Oilburner fan or blower wheel A blower wheel with a bent or broken blade will be out of balance. This

can cause a vibration and put an extra strain on the motor bearings. Any fan wheel that does not slip off the motor shaft without needing to be pried off with a screwdriver must be removed with a wheel puller.

When replacing the burner fan, one must pay strict attention to the rotation as indicated by the beveled blades. Also, remember that the burner manufacturer has provided the proper fan for the proper amount of combustion air needed. Always replace it with one that has the same dimensions.

Fuel pump

The fuel pump, also referred to as the fuel unit, is driven by the motor. The pump shaft is attached to the motor shaft by the burner coupling. The pump consists of three basic parts:

1. Strainer—to remove any foreign matter from the oil before it enters the pump gears.

2. Pump—to lift the oil from the tank and deliver it to the regulating valve.

3. Regulating valve—to build up and maintain the proper operating pressure for atomizing the oil. (See Chapter 4 for more details on Fuel Units.)

Ignition transformer or solid state igniter

The ignition transformer or solid-state igniter (on new burners) provides a "step up" from the line voltage of 120 volts to over 10,000 volts. The high voltage spark produced by these components jumps across the gap between the electrode tips. This spark provides the heat necessary to vaporize the atomized oil from the nozzle and achieve ignition. (See Chapter 9 for more information on Ignition Systems.)

The nozzle assembly

The nozzle assembly also known as the "drawer" assembly, or firing assembly, consists of the oil feed pipe (called the nozzle line), the nozzle, nozzle adapter, electrodes, transformer connections, and on some burners, a flame retention ring. The entire assembly is located in the air tube of the burner. An opening at the rear, top or side of the burner housing permits access to and removal of the nozzle assembly.

Combustion heads

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The combustion head (also referred to as the turbulator, fire ring, retention ring, and end cone) creates a specific pattern of air at the end of the air tube. The air is directed in such a way as to force oxygen into the oil spray so the oil can burn. In order to do so, the combustion head must have the right amount of air delivered to it down the air tube from the fan, and the fuel pump and nozzle must deliver the right amount of fuel at the proper pressure.

Elements needed for combustion

As we have discussed, the three elements we need for combustion are oil, air, and spark. If we examine these three elements one at a time we will see that:

• The amount of oil is based on the flow rate in gallons per hour (GPH) that you wish to burn. The size of the nozzle orifice (in GPH) and the pressure setting of the fuel unit determine the flow rate.

• The spark is the ignition source for the fuel oil. With new advanced

control systems, the spark is only on for a short period of time (usually 25 seconds maximum) at the beginning of the running cycle of the burner. Once flame is established, the heat from the flame keeps combustion going. Continuing to have the spark on after ignition is accomplished will only detract from the performance of the burner.

• The air is the key element and the final adjustment of a burner. Air is introduced into the air tube by the fan through the air intake controlled by adjustable shutters or bands.

The flame retention head incorporates three basic air-directing elements: the center opening for primary air, the secondary slots, and the



tertiary opening. See Figure 1-9. The center opening is the orifice in the center of the head that allows clearance for the oil spray and the electrode spark to pass through the head without interference. The secondary slots are the slots that radiate out from the center opening towards the outside of the head. The tertiary opening is a slot that is concentric to the center opening and follows the circumference of the combustion head. All three openings affect the way air is delivered to the oil spray.

• The **primary air is** the air that exits through the center opening hole in the flame retention ring where the oil from the nozzle is sprayed. Primary air has the least desirable effect on combustion. Air will always take the path of least resistance, so the larger the center opening, the more the air will tend to pass through this opening and push the flame out away from the face of the head. This air travels in a forward motion only. The smaller the center opening, the more air will be forced to seek its passageway through the other openings in the combustion head. (Figure 1-9).

• The **secondary air** is the air that exits through the slots cut into the flame retention ring. The secondary slots are where the most important mixing of oil and air occurs. The slot width regulates the velocity of the air passing through the slot. This is where the air acquires a spinning action. The air moves mostly in a rotary motion with little forward movement. Narrow slots will cause the air to spin faster and move forward less. This will cause the best mixing of oil and air and create a compact, intense, and efficient flame.

The secondary slots also aid in keeping the surface of the head clean and free of carbon. This air is turbulated by the flame retention ring and it is this Secondary Air that creates the flame retention effect. By spinning this secondary air, the flame is actually pulled back toward the flame retention ring. (Figure 1-9).

• The **tertiary air** is the air that exits around the outside of the flame retention ring or through the tertiary slots. For clean oil combustion, every droplet of atomized oil MUST be completely blanketed with air in order to provide total combustion.

Tertiary Air ensures that any droplets of atomized oil escaping the oil spray pattern will contact this air and burn. Creating an envelope or curtain of air between the main swirl area of the flame and the walls of the combustion area or the chamber. The width of the slots in the outside ring control the amount of tertiary air entering the combustion area. The larger the slots the more tertiary air and less secondary air, thus the size of the slots affects the firing rate of the burner. (Figure 1-9).

Fixed and adjustable heads

Flame retention heads fall into one of two categories: fixed or adjustable (sometimes called variable heads). The difference between them is the method by which they control the tertiary opening and hence, the firing rate of the burner.

The fixed head group's tertiary opening is pre-set to a specific opening size for a specific firing rate range. There are a variety of one-piece heads available with fixed tertiary slots sized according to the firing rate for which it was designed. To change firing rates, you have to change the head.

With an adjustable head burner, the head is designed to move against or away from a ring, thus closing or opening the tertiary slot according to the firing rate requirements.

The adjustable head operation is based on the relationship between what is called the "throttle ring" and the "flame retention ring." The throttle ring is a ring at the end of the air tube that works in conjunction with the flame retention ring to create an air restriction and provide for the tertiary air effect. The adjustable head group allows the technician to move the head forward or backward in order to change the tertiary opening to accommodate different firing rate requirements, allowing fine-tuning of the burner.

The fixed head is simple and easy to use; but remember that each head is only good for a specific range of firing rates. When you are installing a new burner or changing a firing rate to optimize performance, you must be sure you have installed the proper head for the specific firing rate. The variable head burner allows an infinite ability to fine-tune the burner for hard-tofire applications.

With the wide variety of adjustments possible, you must be careful in picking the correct adjustments. Most variable head burners come with adjustment guides to help you set the head properly.

Static pressure

Static pressure is the means of produc-

ing and maintaining flow against resistance. Oilburners on the market today create much higher static pressures than units made in the 1980s and earlier.

Some of these burners create such high static pressures that they can force the products of combustion through the heat exchanger and out of the building without the use of a chimney or power venter. See the section on direct venting in the Venting Chapter. (Chapter 6).

High static pressure burners have been developed to accommodate the modern, flow resistive appliances (boilers, furnaces, and water heaters) and to assist with low or no draft conditions. A drop in static pressure can cause problems that range from delayed ignition, rumbles, and pulsation to the inability to adjust the burner for clean operation.

The fan in a high static pressure burner starts with enough pressure to effectively push the products of combustion through the appliance without interruption. The higher static pressure also acts like a shock absorber or tightly wound spring to resist and absorb flame pulsations.

This is especially needed in most modern appliances, which are designed with tighter, more efficient heat exchanger passages and increased draft drop that results in great heat absorption by the heat exchanger, and thus, greater efficiency.