

BACK TO THE BASICS

by Rhamy L. Morrison

As heating season approaches, it's a good time to brush up on troubleshooting today's increasingly complex gas heating appliances.

Remember when heating service didn't require an understanding of electronics and the use of sophisticated test instruments that today's furnaces and heating plants do? Were those the "good old days?" Maybe, but the same basic knowledge of heat transfer, chemical reactions, gases, and air pressures are required today -- as they've always been -- to correctly troubleshoot and diagnose failures of these appliances.

Today, there's a need to understand venting principles, the theories and principles of AC electricity and circuitry, AC motors, Bunsen burners, DC electrical circuits, AC and DC motor theory, flame rectification principles, grounding applications and practices, and analog and digital logic. Each generation of technological advances requires technicians to improve their knowledge and hone their troubleshooting skills.

What's important to remember, however, is the basic operating principles of central heating furnaces and the physics of combustion haven't changed. All systems use specific concepts to protect the primary component, the heat exchanger, and provide safety for the consumer. These principles remain the same regardless of the number of components, how they're arranged, or their complexity.

The unknown has always sparked reluctance until it's understood. But even in the face of change, you can do well by relying on basic operating principles, understanding a particular model's sequence of operation, and elevating your education level to coincide with technological advances.

Today's Operating Principles

Basic operating principles for today's furnaces deal with thermodynamics, psychometrics, Ohm's law, air patterns, airflow, rapid combustion, gas laws, and heat losses. It's important that a technician has an understanding of these principles in order to diagnose high efficiency furnaces.

Gas burners are still designed on the Bunsen principle where air is premixed with gas prior to ignition. Even though the industry has migrated from the atmospheric burner to the induced draft burner, spontaneous combustion hasn't changed. The combustion process associated with these types of burners requires 10 cu. ft. of air for each cu. ft. of natural gas burned, and each cu. ft. of propane (lp fuel) requires 24 cu. ft. of air. Basically, 50% of this air (primary air) is premixed in the burner vortex prior to ignition and the remaining portion (secondary air) is used to sustain ignition. This air must come from somewhere.

In the past, structures weren't built as tightly as they are today. Consequently, in modern construction, combustion air sometimes has to be ducted in from the outside to provide the correct amount needed by the furnace. Whatever air is taken from the structure has to be replaced from the exterior, or else a vacuum occurs and no air will be available for combustion, let alone venting.

Proper combustion emits carbon dioxide and water vapor. Improper combustion also produces carbon monoxide, creates more condensation, reduces efficiencies, and provides inadequate heating.

Flue gases contain moisture and are naturally removed from the structure by the vent system. In modern furnaces, combustion gases stay in the heat exchanger longer, and consequently are cooled to a lower temperature. If the vent system isn't sized properly or is misapplied, the flue gases can reach their dew point and

release moisture in the form of condensation on the walls of the vent system or heat exchanger. This condensation is mildly acidic and can be detrimental to metals used to build furnaces and vent systems.

Ideally, condensation occurs only in category IV or "condensing" furnaces. However, when any furnace isn't fine-tuned, gases-of-combustion can condense. Over a long period of time, this can cause significant corrosion to the metal surfaces with which the gases come in contact.

Many factors cause condensation of flue gases on metal surfaces. If you see it in a furnace you're servicing, look for:

- Incorrect vent sizing
- Excessive airflow across heat exchangers
- Misapplied vents
- Incorrect air patterns
- Improper gas pressures
- Improper orifice sizes
- Insufficient combustion air
- Excessively cold return air
- Short cycling
- Oversized furnace
- Incorrect vent termination.

The Role of Airflow

Indoor airflow plays a significant role in ensuring that a heating appliance performs to its tested guidelines. Airflow is usually thought of as the quantity of air passed across the heat exchanger. Generally that's true, but air currents, or air patterns, are as critical to the reliability and safe operation of the furnace as airflow.

Pay close attention to the size of the return inlet, the location of the appliance return-air tap relative to the manufacturer's recommendations, supply plenums, and ductwork restrictions.

Air patterns are dictated by the application of ductwork and accessories attached to the appliance. An evaporative coil and ductwork are part of the external static

the furnace is designed to work against. External static is usually the primary consideration when air conditioning is applied to a heating appliance.

Airflow is just as important to the heating application. In fact, it's so important to the efficiency and longevity of the furnace, manufacturers are required to post a temperature rise range for the heat exchanger on the unit's nameplate. If this range isn't accomplished at startup, it usually means problems exist with airflow, the air pattern, gas pressure, or burn-rate of the fuel. If these issues aren't immediately corrected, then the heat exchanger will experience a premature failure.

Airflow and air patterns are important to the safe operation and maximum efficiency of any gas furnace. Typically, if the return isn't properly connected to an appliance, the air current tends to hold to the opposite side of the appliance cabinet. This will create too much airflow to one side of the heat exchanger, and one section of the heat exchanger will become too hot while the other section may or may not operate within its design limits.

High external static causes turbulence or restricted airflow around the heat exchanger that can lead to limit trips, cold spots, condensation, or excessive expansion of the metals within the heat exchanger. Over a period of time, excessive expansion and contraction fatigues the metal and it fails. Conversely, condensation causes corrosion that leads to degradation of the metal.

Many air current and airflow problems can be prevented by proper application, correct sizing of ductwork, correctly calculating external static pressure, and applying good ductwork guidelines to installations or retrofits.

The Electrical End

Grounding an appliance has always been important from a safety aspect, but now it's also important for correct operation. Applied electronic components and circuits depend on a good ground path (green wire/chassis ground) to function correctly. If flame sensors aren't properly grounded, they won't work. These circuits are dependent on a completed path for the flame-rectified AC signal to

detect the presence of a flame, usually in micro-amps. Ignition lockout is frequently the result of improper grounding.

Remember DC voltage and motor theory? Within the past few years we've seen a steady increase in variable speed motor application for indoor airflow, and now it's used for combustion air on gas heating appliances as well.

Sometimes, diagnosing a furnace malfunction requires you to determine the speed of the motor. This usually requires a meter that will read frequency or rpm. How does this help diagnose the operation of the furnace? By knowing this information, you can determine if the inducer motor is operating correctly, and you should be able to determine the correct method to repair the problem.

Without this knowledge, unnecessary parts replacement can occur.

Many technicians still rely on their non-technical skills to get them through. These individuals understand how AC and DC electricity work within a circuit, but often don't understand how the potential works. If they're confronted with a new application, an attempt is made to repair the problem by replacing parts or shorting ("jumping") out controls. In circuits used on today's furnaces, jumper-wire troubleshooting may cause significant damage, which leads to costly repairs for the consumer or manufacturer.

Customers have come to expect professional diagnosing and feel they are being taken advantage of if several parts have to be replaced without any intelligent or logical explanation. Learn to properly use the correct electrical instruments and trust what they tell you.

Making the Diagnosis

Here are the steps to correctly diagnose a fault or problem with a heating appliance:

- Acquire the necessary installation and operational manuals from the appliance's manufacturer
- Read and understand these instructions and the parameters the appliance is designed to operate within. In order to know if an operation is wrong, you must know what the proper sequence should be

- Listen to the consumer and think through what the correct approach to troubleshooting the problem should be
- Use the manufacturer's troubleshooting guides, if available
- Use proper diagnostic instruments to isolate the problem component or function and confirm the diagnosis
- Attempt to determine the reason for failure by applying basic principles and experience.
- Correct the reason for failure
- Replace the faulty component
- Confirm that the system conforms to the manufacturer's specifications by operating the system under normal conditions. If not, you have more work to do.

As you troubleshoot a gas heating appliance, keep in mind the most common failures are caused by external circumstances such as:

- Misapplication of the equipment
- Design problems with the ductwork
- Under-sizing or over-sizing equipment
- Improper electrical practices
- Misapplied installation codes
- Poor installation practices

Proper installation is the key to successful and safe operation of any piece of equipment or system.

Skills and Education

The heating industry has entered a new age where technicians are required to work harder today than ever before to maintain their knowledge and skill level. The industry is changing rapidly. That's why continuing education at factory schools and seminars, community colleges, and technical schools is more important than ever.

Consumer expectations are rising as well. With the rising costs of components and skilled labor, consumers expect a service technician to be able to perform the skills of diagnosing and repairing more rapidly than in previous times.

While the basics haven't changed, more is expected from the same process, so appliances must meet closer tolerances. The comparison between working on an older vintage automobile versus fine tuning an Indy race car is fairer today than ever before.

Rhamy L. Morrison is *Technical Consultant-Indoor Products, The Trane Company -- a division of American Standard, Inc.* He joined the HVAC industry in 1965 as an installer and service technician. He ran his own HVAC company for 15 years and also served as an instructor for a proprietary air conditioning technical night school. He can be reached at 903/509-7316.