CONVENTIONAL HEATING AND COOLING INSPECTIONS CHAPTER 1: HEATING INSPECTION GUIDELINES, REQUIREMENTS, TOOLS AND SAFETY

Welcome and Course Description

We encourage our customers to visit the FAQs section for further information regarding your educational experience. They have complete step-by-step tutorials that we've designed with YOU in mind!

Please note: Upon completion of the final exam, you will need to advance to the survey page and complete the survey. Once that is done, the course will be marked as "Complete" in our system and credit may be issued.

Welcome to McKissock's *Conventional Heating and Cooling Inspections* course.

Course Description

This course focuses on noninvasive inspection of the systems and components we refer to as "conventional" heating and cooling. For the purposes of this course, the training focus and learning objectives are for the thorough observation, noninvasive inspection and informative reporting requirements on permanently installed force air, gas-fired, electric-powered central heating and cooling systems, components, and air-to-air heat pumps.

The focus is not simply on the mechanicals of the heating and cooling system cabinet and equipment. Rather, this course emphasizes and expands upon the inspection routine as guided by industry standards of practice, and focuses on safety parameters, effective communication skills for client understanding, and targeting your eyes on the heating and cooling inspection as you turn into the inspection property driveway that first time.

To enhance the learning experience, the course is seasoned with inspection best practices, in-the-field perspective, and experience gained over time, to review and reinforce basic home inspection requirements to meet or exceed standards/regulations and client satisfaction.

Learning Objectives

- Understand the importance of residential heating and cooling system inspection for occupant safety.
- Identify inspection standards of practice, basic observation actions, and guidelines and requirements of the heating and cooling inspection.
- Understand heating and cooling system inspection key terms to enhance your reporting and client relationship.
- Providing an accurate system life expectancy estimate and determining system age.
- Describe heating and cooling system efficiency types, efficiency levels and main components to be reported on.
- Understand the similarities and differences between gas-fired and electric-powered central systems.
- Understand the components of air-cooled air-conditioning and the refrigerant cycle.
- Understand the similarities and differences between central air conditioning and the air-to-air heat pump.
- Describe the importance of the inspection first step: Safety walk around and system observation.
- Understand general system installation requirements and codes.
- Understand basic system operational tests for client confidence.
- Understand the inspection requirements for standalone systems and through-the-wall units.

Meet the Author

About the Author

Michael P. Leighty, is an Indiana state licensed professional home inspector, with a broad background in the construction trades as a hobbyist (DIY), before it became popular. After a 37-year career with the Department of the Navy, where he was responsible for regulatory compliance and training in safety, facilities, product and quality management, to include employee supervision, he retired and put his love for home remodeling to use by starting his own company. That endeavor was noticed by realtors and homeowners in his region, who encouraged him to become a state licensed home inspector.

He now applies his love for informing and educating others to proudly partner with the real estate industry providing quality professional home inspections for buyer/seller confidence. His extensive construction trades, training and quality management background are the key factors in his success, providing client-focused, quality professional home inspections.

Course Overview

One of the most common questions asked of home inspectors relates to the condition of the home's heating and cooling components. The financial strain of replacing these components soon after purchase can be enormous, so client concern is understandable. Providing a thorough, complete, noninvasive, informative examination of the complete central system, as well as individual components, is a must for the successful home inspector.

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There are generally two kinds of conventional residential heating and cooling systems – central heating and area heating – serviced by a variety of system types. Gas-fired is the most popular fuel for heating homes in America. Approximately 48% to 51% of all U.S. households rely on natural gas as their primary heating fuel, with the most recent Census data from 2022 showing 46.2% of homes heated by natural gas. This represents a gradual decline from 49% in 2010, as electricity use for heating rises.

The use of gas for HVAC is highly regional. Gas heating is dominant in the Midwest and Northeast. These colder regions have the highest adoption, with over 65% of Midwest homes and a growing share in the Northeast using gas, often replacing heating oil. The South relies primarily on electricity, with over 60% of homes using it for heating, largely due to milder winters and the prevalence of heat pumps. In the West, usage is high, with 60% of homes using gas for space heating.

Consequently, most home inspections will be conducted on a gas-fired central heating and cooling system, which can come in varying configurations and efficiency types, not to mention those creative DIY installations. However, while it takes a great variety of equipment to control the different fuels and different applications, the functions required for safe, automatic operation are remarkably similar.

Chapter Overview

Topics

- Heating and cooling inspection key terms.
- Heating and cooling purpose and goals.
- Safety importance of the residential heating inspection; fire danger.
- Professional inspection standards of practice for heating systems.
- Heating inspection guidelines, requirements, inspection best practices.
- System life expectancy estimate and determining system age.
- Basic heating inspection tools and equipment.
- Heating inspection safety concerns – client, inspector, property.

Learning Objectives

Upon completion of this chapter, the student will be able to:

- Understand the importance of the residential heating system inspection for occupant safety.
- Identify inspection standards of practice, basic observation, action guidelines and requirements of the heating inspection.
- Determine system age and estimate remaining life cycle expectancy.
- Understand the basic inspection tools and equipment for a complete evaluation.
- Understand heating inspection safety concerns – do's and don'ts.

Introduction

Chapter one introduces basic information on heating system inspection guidelines, requirements, tools and safety, including some inspection best practices. It provides an overview of what to inspect and report on per standards of practice, including standard observation requirements, specific inspection actions, what to describe in the inspection report, and special cautions for the inspector, client and property.

Generally speaking, there are two classes of conventional forced-air gas-fired and electric-powered residential heating systems. These classes are central heating and zone/area heating. Some structures may actually maintain both classes. The central system class (the focus of this course) can be serviced by a variety of forced-air system types, configurations and manufacture designs.

The majority of home inspections will encounter a central heating system, but this is not always the case. For example, a home could be heated entirely with electricity through the use of baseboard, wall-mounted, or ceiling panel with radiant heating. In this case, each room or area is heated not centrally through a forced-air distribution system but with individual thermostatic control by room or area. Some structures can easily have a mix of central heating and cooling with zone heating, making the inspector's observation skills critical. Older structures could be heated with a gas- or oil-fired hot water or steam boiler.

Definitions and Glossary of Inspection Key Terms

Upon completion of this course, the student should be familiar with the following terms:

Annual fuel utilization efficiency (AFUE): AFUE is the ratio of annual heat output of a furnace compared to the total annual fossil fuel energy consumed by a furnace. A 97 percent AFUE furnace can use 97 percent of the energy it consumes to heat the home or structure (the other 3 percent escapes through the exhaust or ventilation system). AFUE ties to system estimated lifecycle identification and recommendations.

Beyond useful life: An inspector judgement of the heating and cooling system and its components based upon observed condition, maintenance history (if known), functional condition (at time of inspection), safety parameters, and actual researched system age.

Central heating: A system for warming a building by heating air in one place and circulating it through a fan-force ductwork system.

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Component: When used, references any of the visible, readily assessable parts and pieces of a heating and cooling system inspection. Note: Some components are not typically included in the standards of practice of home inspector associations. This is where the experienced home inspector can apply and develop best inspection practices, creating a specific list of exclusions or inclusions for the inspection service agreement with the client.

Condition statement: The observed functional or physical state of the heating and cooling system and its components. Condition statements may range from satisfactory, minor discrepancy, major discrepancy, or nonoperational, and shall include descriptions of physical condition when defects or poor conditions are observed. Condition statements should always be backed by photographs.

Conventional: For the purposes of this course, the term "conventional" refers to forced-air gas-fired heating systems of the three classified efficiency types: Low-efficiency; mid-efficiency; and/or high-efficiency.

Describe: To identify (in writing and/or photo) a system or component by its type or other distinguishing characteristics.

Determine: To officially decide or render a judgement (professional opinion) of unit condition. Typically considered outside the scope of standards of practice and/or a home inspectors' technical expertise, however a judgment the client is anticipating.

Exceptions and exclusions: A pre-inspection list of items, communicated to the client, identifying components considered to be exempt from physical examination and/or operation, and therefore not included in the final report.

Further evaluation: An inspector recommendation for examination and analysis by a qualified professional, tradesman or licensed service technician beyond that provided by a home inspection.

Handyman installation/maintenance: An observed system or component condition that, in the inspector's opinion, has not been professionally installed or maintained, and under normal operating conditions could be considered as suspect in operation and/or functionality relative to design.

Imminent hazard reporting: When an inspector believes a heating and cooling system (either in a static or operated condition) would present an immediate hazard to the inspector and/or occupants of the home, this will be identified in the report to include the observed condition, possible hazard, plus recommended action to avoid the hazard.

Improvement recommendation: A system, component or item that, in the inspector's judgement, is not installed and/or operating as designed or has degraded due to lack of maintenance. Some improvement recommendations can be executed by the homeowner while others may require the attention of a qualified professional, tradesman or licensed service technician to return the system or component to full operating capacity.

Inspect: The process of examining readily accessible systems and components by (1) applying standards of practice; (2) operating normal operating controls; and (3) opening readily openable access panels.

Inspection action: The critical physical action required to perform a complete noninvasive examination of the heating and cooling system or components, including examining readily accessible components by: (1) applying standards of practice; (2) operating normal operating controls; and (3) opening readily openable access panels.

Inspection best practice: An inspector developed process and/or procedure acquired through experience over time. Best practices not only have the client in mind but also include safety components of the inspection to protect personal safety and property.

Inspection observation: The action required to apply critical observation skills to the system, components and area to render a judgement or condition statement of the form, fit and function of the heating system or components.

Inspection routine: The inspector-defined process and procedure for a home inspection, leveraging national standards of practice and knowledge gained over time.

Inspector: A person hired to examine systems and components of a building using a prescribed standard and routine, providing a report as an end product.

Installed: Attached such that removal requires tools.

Judgment: A home inspector's professional opinion. This opinion entails both the questions of durability and serviceability and how the condition described and reported may affect the value and lifecycle of the heating and cooling system.

Need-to-know: A general operational and functional design understanding of the heating and cooling system and its components.

Nonoperational: Any system or component observed as not working or in-use and is not responding to normal operating controls.

Non-invasive examination: A conservative examination of the heating and cooling system and components which does not require removing or disassembling components beyond the removal of readily accessible panels to perform a visual and functional examination.

Normal operating controls: Devices such as thermostats, switches and valves intended to be operated by the homeowner.

Permanently installed: Attached in such a manner that removal requires extensive use of tools, equipment, knowledge and/or experience.

Professionally installed: A system and components that were installed by a professionally licensed company.

Readily accessible components: Visually accessible heating and cooling system components. This includes mechanical equipment such as flues, pipes, ducts and cabinets, as well as inspecting components located behind and through the removal of manufacturer designed access covers and panels.

Readily openable access panel: A panel provided for homeowner inspection and maintenance that is readily accessible, within normal reach, can be opened by one person, and is not sealed in place.

Safety walk-around: A necessary first step-action to visually determine if the system and components are safe to perform an operational inspection.

Shut down: A state in which a system or component cannot be operated by normal operating controls, sometimes referred to as "tagged out."

Standards of practice: A predefined list of the systems and components to observe, inspected and report on, as determined by professional associations for the conduct of the heating and cooling inspection.

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System: A combination of interacting or interdependent components, assembled to carry out one or more functions. The term refers to the heating and cooling system, both interior and exterior to the home or structure; all parts, pieces and components required to make up the functional system installed to heat and cool the structure.

System lifecycle expectancy: A conservative estimate or opinion, not a guarantee, of the heating and cooling system lifecycle expectancy reported to the client based upon observed condition, physical state, serviceability, functionality, and actual researched system age.

Technically exhaustive: An investigation that involves dismantling, the extensive use of advanced techniques, measurements, instruments, testing, calculations, or other means.

Unsafe: A condition in a readily accessible installed system or component that the inspector determines to be a significant risk of serious bodily injury during normal, day-to-day use; the risk may be due to damage, deterioration, improper installation, or a change in accepted residential construction practices.

Visual examination: A non-invasive examination of the heating and cooling system and components for the purpose of rendering a "judgment" by a home inspector. This judgement (opinion) considers the observed condition (both durability and serviceability) of readily accessible components. It encompasses the inspector's determination of whether an observed condition is merely interesting, important, very important, or even critical. In other words, does the observed condition present a safety concern during operation or is it material to the buyer's purchase decision.

Zone/area heating: Heating of certain areas, spaces and rooms – often referred to as zones. Unlike central heating systems, zone heaters concentrate heat to smaller areas, usually where the family spends the most time.

Residential Heating and Cooling Inspection Purpose and Goals

New heating and cooling system designs hit the market annually and it's difficult for the professional home inspector to keep up with every new model. However, the basic purpose of the residential heating and cooling system – to provide air quality and air temperature control for the occupants in a safe, efficient and economical manner – remains unchanged.

This is accomplished with a variety of forced-air fuel type system designs and configurations. These systems all provide the same basic theoretical operational parameters. However, inspecting the varying fuel (gas or electric) and efficiency types, brands, models and design configurations, does present a challenge to the home inspector.

Additionally, the average homeowner knows little about the system they have been living with. Too often, most will discover they have an issue when warm or cool air stops coming out the room vents, revealing it's time to call a technician. Sadly, some homeowners discover they have an issue much too late.

So as not to make the inspection challenge too overwhelming or complicated, keep the following homeowner operational system goals in mind when condensing and providing the inspection report. At the time of system installation, regardless of fuel type, the installer's goal is to provide control of interior temperature, complete air circulation, and an effective level of air filtration, all in an efficient and economical manner while being both unobtrusive and quiet.

Each professionally installed heating and cooling system would have met the above operational system goals for customer satisfaction, therefore making it easy for the home inspector to perform a professional inspection, and giving their client a fair assessment of the system's operational condition on the day of inspection.

Note: It is at this point that the professional home inspector becomes a vital player in informing the client not just about meeting the operational system goals for occupant comfort, but the actual physical condition and safe operating parameters of the system and components.

Safety Importance of Residential Heating and Cooling Inspection

The professional home inspector should have a broad understanding of system types and general skills to provide insight on all aspects of the state, functionality and safe operating conditions of the heating and cooling system and components, but it is not necessary to be an HVAC licensed technical expert with years of experience.

Furthermore, it is not the home inspector's role to determine why or if the system or component is nonoperational and/or not responding to normal operating controls, especially by going further than inspection standards or common sense allow. That being said, the home inspector needs to maintain general technical skills, component operational understanding, and keen observational skills to allow for a quality professional inspection.

We will approach many of these factors during this course. Throughout the course, we will delve into the inspector's general technical compliance, or need-to-know information, to enhance operational understanding of the system and components he/she is responsible for reporting on.

There are seven basic inspection factors involved in a thorough heating and cooling system inspection, regardless of type, manufacturer or model. These factors are:

1. Safety first.
2. Observe that sufficient combustion air is available for optimum performance and systems have been properly installed in proper locations. No measurements / calculations of the air for combustion / ventilation / dilution are required.
3. Determine that the exhaust pipe or flue is properly configured, installed and functioning in accordance with manufacturer's installation requirements and local codes (if applicable).
4. Apply detailed observation skills to ensure critical operating components are continuing to fully function as designed and present no danger to occupants.
5. Determine that the system's mechanical components, outside the system cabinetry envelope, are properly functioning, installed and well-maintained.

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6. Determine that proper clearance to combustibles material requirements have been met for cabinetry and piping and do not present a danger to occupants.
7. Inspect for a common vented appliance for proper compliance or that may/will require a recommended change in the exhaust pipe or flue system.

These seven basic inspection factors, leading to report development, are coupled with the inspector's oral and written communication skills, and lead to a thorough heating and cooling system inspection. The inspector should view him or herself as a partner, not only with the real estate industry, but also the public safety industry since failure of mechanical systems, especially heating components, can present a danger to structures and occupants.

Residential Heating System Fire Safety Statistics

According to the most recent data from National Fire Protection Association (NFPA), between 2012-2016, heating equipment was responsible for an estimated 52,050 home fires annually. NFPA classifies "home" as dwellings, duplexes, manufactured homes, apartments, townhouses, row houses and condominiums. In other words, the world of the professional home inspector.

These fires caused:

- 490 civilian fire deaths.
- 1,400 civilian fire injuries.
- $1.1 billion in direct property damage.

Heating systems and equipment are the leading cause of home fires. Heating fires accounted for 15 percent of all reported home fires in 2012 through 2016 (second to cooking) and 19 percent of home fire deaths. Gas-fueled heating equipment accounted for another 17 percent of fires, 15 percent of civilian deaths, 27 percent of civilian injuries, and 24 percent of direct property damage.

The leading factor contributing to home-heating fires (28 percent) was failure to properly clean and maintain equipment, principally from solid-fueled heating equipment. The leading factor contributing to ignition for home-heating fire deaths (53 percent) was heating equipment too close to flammable items, such as stored materials, upholstered furniture, clothing, mattress or bedding.

Nearly half (48 percent) of all home-heating fires occurred in December, January and February.

According to the United States Fire Administration (USFA), in 2013, adults 50 and older had a greater relative risk of dying in fires than the general population, and ages 80 to 84 had the highest risk of fire death. Children 4 and younger faced an elevated risk of both injury and death in a fire when compared with older children ages 5 to 14 (USFA, 2016).

By 2030, the U.S. Census Bureau estimates that adults 65 or older will constitute 21 percent of the population, which is expected to increase to 24 percent by 2060. As the population ages, more senior citizens are living independently and many reside in aging homes with outdated or inadequate heating systems. In addition, the elderly may require more heat to stay warm, placing a strain on already outdated systems in the field.

Residential geographic location also affects fire safety in the home. Statistics reveal there is a greater risk of dying in a fire for people living in the southern states, than for those in other regions. This is most likely attributed to the intermittent need for occasional heating over seasonal heating (USFA, 2016). Many homes in the south lack central heating and rely on portable heating devices for heat.

Those living in colder Midwestern and northern states have a greater risk of dying in a fire than the general population. This is most likely attributed to antiquated, poorly maintained heating systems. Western residents had a lower risk of residential fatalities from heating fires due to the decreased use of home-heating systems.

With these statistics in mind, this course is designed to reinforce the standards of practice for inspecting conventional forced-air gas-fired/electric-powered heating systems, as well as the importance of safety assessments and condition statements, with a critical eye to protect the inspector, homeowner and community at large.

Residential Inspection Best Practice

An inspection best practice of the professional home inspector includes viewing the inspection as much more than a desire or requirement of a real estate transaction, or to establish property value. It is a relationship in which the professional inspector's job is to instill confidence in the buyer/seller when making an informed decision to purchase/sell a residential structure; the safety of the buyer/seller should be paramount.

No two residential inspections are alike and consequently no two residential heating and cooling system inspections are alike. As previously mentioned, factors such as geographic location, urban or rural environment, housing structures, and system and component types all present variability in inspection methodology.

Structures, systems and components may be substandard, poorly maintained, or compromised by weather or other factors. Mechanical systems may be outdated, poorly maintained, in disrepair, and may lead to a higher incidence of fire or other dangerous failures.

Without a doubt, thorough heating and cooling system inspections by informed, professional home inspectors can improve communities, increase property values and save lives.

Professional Inspection Standards of Practice

American Society of Home Inspectors (ASHI) Standards of Practice [1] for heating inspections are included from the most recent revision, which was updated in January 2026. These standards, as applied to heating and cooling system and component evaluations, will be expanded in further detail throughout this course. The objectives of ASHI's Standards of Practice, as well as InterNACHI, include the promotion of excellence within the profession, and the continual improvement of its members' inspection services to the public.

The ASHI Standards of Practice for Home Inspections simply guide home inspectors in the performance of heating and cooling inspections. Clients tend to look for more information than the standards allow. The experienced home inspector utilizes the standards of practice, continuing education and experience in the field, to define and refine their own inspection routine to serve the client and provide value in the buying decision.

Subject to regular review, the National Standards of Practice for Home Inspections reflects information gained through surveys of field conditions and of the consumers' interests and concerns. Vigilance has elevated ASHI's Standards of Practice for Home Inspections so that today it is the most widely accepted home inspection guideline and is recognized by many government and professional groups as the definitive standard for professional performance.

The ASHI Standards of Practice for Heating, Ventilation and Air Conditioning (HVAC) are as follows:

The inspector shall:

A. Open readily openable access panels.

B. Inspect:

   a. Installed heating equipment.

   b. Vent systems, flues, and chimneys.

   c. Distribution systems.

C. Describe:

   a. Energy source(s).

   b. Heating systems.

The inspector is NOT required to:

A. Inspect:

   a. Interiors of vent systems, flues and chimneys that are not readily accessible.

   b. Heat exchangers.

   c. Humidifiers and dehumidifiers.

   d. Electric air cleaning and sanitizing devices.

   e. Heating systems using ground-source, water-source, solar and renewable energy technologies.

   f. Heat-recovery and similar whole-house mechanical ventilation systems.

B. Determine:

   a. Heat supply adequacy and distribution balance.

   b. The adequacy of combustion air components.

(1) ASHI Standards of Practice are used as the foundation of this course, acknowledging other "standards of practice" exist within the home inspection industry, however, are consistent in their incorporation and application as described above.

Heating Inspection Observation, Reporting Action Requirements and Inspection Best Practices

As previously stated, ASHI Standards of Practice guide home inspectors while performing the inspection. This guidance is executed in the form of inspection observations, to include specific and advanced inspection actions developed by the professional over time. Typically, this is in the form of inspector-designed process or procedure; in other words, your inspection routine in the form of visual examination.

The overall objective of the inspection is to relay confidence to the client that the functional system – readily accessible components – is in good working order (at the time of inspection) in the inspector's judgement.

Any unsafe conditions relative to normal, day-to-day operation and/or potential imminent hazards reporting due to observed condition (either in a static or operated condition) should be identified in the report to include the observed condition and possible hazard, as well as recommended action to avoid the hazard, if one exists.

This is completed through a non-invasive examination and specific actions to identify system deficiencies, provide clear descriptions of those observations and actions, and provide a physical report to the client.

Note: The heating system inspection, as performed in accordance with standards of practice, never requires technically exhaustive analysis. For heating and cooling systems, this should be left to licensed HVAC professionals and, in many cases of observed discrepancies / suspect conditions, this will be the actual report recommendation to the client – Further Evaluation Recommended by a Licensed HVAC Professional.

Observation Requirements and Reporting Guidelines

Aligning to standards of practice, to include inspection best practices gleaned over time, the professional home inspector should observe with a critical eye and report on the following:

- Observation of permanently installed heating system to include: System equipment type and components; normal operating controls; automatic safety features; and condition of chimney, flue and vents.

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- Observation of system fuel or energy source components to include: Fuel or energy type; distribution type; outer jacket; overall interior condition; burner and combustion chamber; and visible portions of the heat exchanger (if viewable).
- Observation of combustion disposal and exhaust piping (flue) for proper installation, slope, corrosion, draft, seal and safety.
- Observation of heat or return air distribution systems to include: Piping; ducts; blowers and fans; supports; dampers; insulation; and filters.
- Observation of exposed forced-air components: External piping and ducts.
- Observation of flame color and consistency.
- Observation of excessive rust or corrosion, either internally or externally, to the system cabinet, flue and piping, to include the possible presence of a waterline mark on the cabinet exterior for basement installs.
- Observation of a heat source or register in each room or living space and report on living space not provided with heating or air.
- Observation of the presence and location of the main fuel shut-off and emergency safety features.

Reporting Action Requirements and Guidelines

Aligning to standards of practice, to include inspection best practices gleaned over time, the professional home inspector should take the following actions when reporting on the condition and safety of the home heating system and components:

- Operate the system using normal system functions and controls, or report failure to operate the system and the general reason why if determinable.
- Open readily accessible panels and compartments provided in the manufacturer's design.
- Test for carbon monoxide (CO) and fuel leaks in interior spaces.
- Report on the presence of proper smoke and CO detection devices in the general vicinity of the operating system.
- Record the system type, fuel source, and fuel piping type, to include proper bonding for CSST fuel lines.
- Record the presence of a heat source in each room or living space and report on living space not provided with heating or air.
- Record the manufacturer's name, model, serial numbers.
- Research and record an estimate of the system's age and estimated remaining useful lifecycle in accordance with manufacturers' estimates.
- Research and record whether or not there is a system or product recall from the Consumer Products Safety Commission (CPSC).

Standards of Practice Do Not Require Actions for the Following:

- Operation of system safety features exterior to the system cabinet.
- Operation or troubleshooting of a system that is shut down (tagged out) or does not respond to normal operation controls.
- Operation or troubleshooting of a system when observed conditions suggest possible equipment, structural or safety harm.

Inspection Best Practice

Since a requested home inspection could result in a new property owner, and based upon observed condition, functionality, and maintenance record, a standard inspection best practice is to recommend that the client obtain a licensed HVAC professional to perform a maintenance check of the system and its components, for client peace of mind. This recommendation builds a valued reputation for the home inspector and adds a layer of safety for the new occupants well into the future.

System Lifecycle Expectancy Estimate and Determining System Age

There are many factors that play a role in determining, estimating and reporting on the heating system lifecycle expectancy. Factors such as observed condition (wet basement conditions) and maintenance record (if available), to determine the actual confirmed system age from the manufacturer's data plate. It is far easier to determine the system's actual age if required data is available, but remember it is not the inspector's job to document or say to the client, "You're going to need a new furnace."

Standards of practice do not require the inspector to estimate the lifecycle expectance; however, during the course of the inspection, data and observations will be available for the professional home inspector to offer a reasonable opinion, not a guarantee. It is the client's decision, based upon the inspector's professional judgement and report detail, to decide on necessary action for servicing, repair or replacement.

Realistically, if you are inspecting a heating and cooling system that you believe has met or exceeded its useful lifecycle (example 20+ years old), this observation most likely will be apparent to the client (if attending the inspection). But again, allow the data, observed condition, operation and report detail to stand on its own merits. The inspector's role is to present the operational and serviceability facts, both visually and through data, to inform the client of a possible deferred cost in the future.

Note**:** If in the inspector's opinion an imminent hazard exists, this MUST be reported with a report recommendation of further evaluation required by a licensed HVAC technician. Render no judgement beyond documenting what is believed to be a safety hazard.

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Heating and Cooling Industry, System Life Expectancy Standards

Heating and cooling industry standards for system and component lifecycle expectancy can assist in rendering a judgement. Standards tend to vary, however; reasonably maintained systems allow for the below estimated life expectancies in accordance with heating and cooling system manufacturer's data. These estimates are rules of thumb because no two systems have experienced the same operational or environmental conditions, as well as routine annual maintenance.

Heating systems	**Life expectancy**
Gas-fired forced-air furnace.	15 to 25 years.
Electric-powered forced-air furnace.	20 to 30 years.
Heat pumps.	15 to 20 years.
Cooling systems/components	**Life expectancy**
Central air conditioning.	12 to 15 years.
AC compressors.	10 to 15 years.
AC evaporators.	Will be replaced with a compressor.

Determining Actual System Age

Depending on manufacturer's type, condition and maintenance record, it is not always easy to estimate the actual age (date of manufacture) of the system during the inspection. Rarely does the manufacturer's tag clearly record the year of manufacture; however, newer systems and larger manufacturers are starting to readily identify this data. That said, manufacturers do imbed or encode the month and year of manufacture in the unit serial number.

If you look closely during the inspection, you might see where a professional HVAC installer has written the installation date on the outside of the cabinet; however, it is not recommended this date be used for the actual manufacture date.

To determine the actual manufacture date, the inspector should locate the manufacturer, model number, and specifically the unit serial number, from the system data plate on the unit side or internal to the cabinet. With this data, the manufacture year and month can be obtained via the Building Intelligence Center website at http://www.buildingcenter.org/.

This website is a very useful tool; it covers 98+ percent of models in the field; it covers water heaters; and it has information available from the Consumer Products Safety Commission (CPSC) associated with manufacturer model recalls.

Figure 1.1 provides an example of a manufacturer's date plate identifying a sample serial number and how the serial number reports to manufacture date. The serial number for this Coleman furnace is WAKM011379. Using this data, you can go to the Building Intelligence Center website, search by manufacturer name or brand, and use the serial number to determine the actual manufactured year and month for the system.

Figure 1.1 - Sample Manufacturer's Engineering Data Plate

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Figure 1.2 shows how the encoded serial number (WAKN011379) will identify the specific month and year of manufacture.

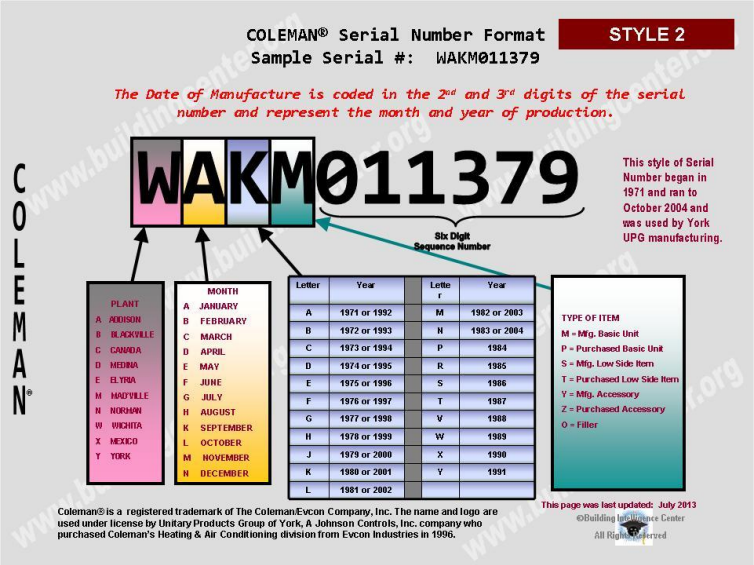

Figure 1.2 - Determining Actual Age from Manufacturer's Serial Number

Note: This data will not provide the actual installation data or when the system was placed in service, but typically the install date is within six months of the manufacture date.

Manufacturer Model Recalls

The homeowner or client rarely knows about a heating or cooling product safety recall. The professional home inspector, via a thorough analysis, is on the front lines and can provide this information to the transitioning homeowner. The Building Intelligence Center website provides a quick point of reference for this information.

Note: For example, in 1997, a major heating and cooling manufacturer issued a recall on all Pulse furnace designs installed from 1982 to January 1989. The recall, covering nearly a 10-year period, was due to an increasing failure rate of the stainless-steel welds on the secondary heat exchanger and carbon monoxide gas leak safety hazards. While the company was responsible enough to take appropriate action, word doesn't always get to the owner – particularly if a property has changed hands two or three times since installation or the original installer went out of business.

Client Lifecycle Expectancy Recommendation

Because there is no exact science in determining when a heating or cooling system is beyond useful life or might fail, the inspector can use the following rule of thumb to provide a reasonable recommendation:

- If an inspected gas-fired central system is 16+ years old, or an electric-powered furnace is 18+ years old, a recommendation in the report for a Service Check for client peace of mind is appropriate.

It's time to educate the client and inform them, in accordance with industry recommendations, that in five-plus years there is a possibility of extensive maintenance and/or system replacement. Remember, the emphasis is on the possibility of replacement. This recommendation is based upon suspected reduced efficiency due to age.

According to the U.S. Department of Energy (DOE) it is probably a wise choice to replace a furnace at its 18- to 20-year mark, when energy efficiency drops to around 78 percent annual fuel utilization efficiency (AFUE) or lower. AFUE is the energy efficiency rating method for a heating system.

Finally, when a furnace reaches 18 to 20 years old, it's smarter to replace an aging system than to repair or overhaul one. Typically, a system of this age is a common-sense observation to both the inspector and client.

For a gas-fired system, the homeowner will get a higher return on investment when replacing an 82 percent AFUE or lower furnace with a high-efficiency system. Again, it is the inspector's job to inform the client of factors and condition of the system and components. The repair or replacement decision is the clients alone.

Basic Inspection Tools and Equipment

The professional home inspector should maintain a basic set of tools and equipment to perform a thorough, non-invasive examination of the heating system.

As has been emphasized, heating systems come in a variety of types, conditions and ages. No two inspections will be alike. This basic inspection tools and equipment list should allow for a complete examination of the home-heating system in accordance with standards of practice and allow the professional home inspector to examine component and system functionality to include inspection best practices.

- **Powerful inspection light:** Required to illuminate the deepest and darkest areas of system components.

- **Inspection mirror with telescopic extension:** To observe internal cabinet components from all possible angles and to read hard-to-access manufacturer data.
- **6-in-1 screwdriver:** Or similar multi-tool to remove access panels. Modern systems allow for easy panel removal without tools, but this is not always the case.
- **Nut-driver set:** Or similar tool to remove bolted-on access panels.
- **Digital thermometer:** Or standard thermometer to perform a temperature rise test and temperature differential test, an inspection best practice.
- **Combustible gas sniffer and leak detector:** To check for gas leaks and combustion byproducts, such as carbon monoxide around the heat exchanger, flue outlets, dampers and draft hood, an inspection best practice.

Heating Inspection Safety Concerns

Again, no matter how many times a home inspector performs a heating system inspection, no two inspections are alike. This is emphasized to ensure the inspector does not get complacent or fall into an inspection rut causing critical oversight. In terms of safety, the heating system inspection, especially gas-fired mechanicals, will always be the most critical element of a residential inspection, both at the time of inspection and long after it is over.

Conditions and factors, such as system efficiency type; age; location internal to the structure; occupied vs. unoccupied home; and professionally vs. handyman installed and maintained, can present inspection issues and even danger. The home inspector must go far enough into the inspection to gather necessary observations and data to report confidently to the client without going too far and endangering him or herself.

Ideally, the first step in a heating inspection is a complete safety walk-around; an observation of the system cabinet, exhaust or flue piping and ductwork to ascertain the general condition and proper working order. But knowing it's safe to proceed with the inspection isn't just about how that air handler looks. The importance of a safety walk-around will be expanded upon as you progress through the course. It is the necessary first-step action to determine whether observed conditions are in fact safe to perform an operational inspection.

Generally, handyman or unprofessional installation and maintenance work is easily identifiable and an indicator to proceed with caution, even on a heating and cooling system that is operational in an occupied home. While performing a safety walk-around, your nose can point to more critical safety issues if you detect a gas odor.

The purpose of the safety walk-around is to observe the surroundings and equipment condition in order to determine whether it's safe to proceed with a deeper evaluation of either part or the entire heating system. In most cases, this is a judgement call on the part of the inspector.

If an inspector decides to limit a full inspection, he should clearly note it in his report, and support such a decision with photos. Explain to the client why you did not perform a deeper examination and recommend that a licensed HAVC professional evaluate the equipment.

Caution: If a strong gas odor is present, you done with the heating inspection, and typically the whole house inspection.

Inspection Best Practice

If you observe a condition you believe warrants no further operational evaluation, stick to your professional judgement. Do not allow the pressure or insistence of a client (if present) to take you down a path that might risk damage to property or personnel. There are plenty of horror stories in the home inspection industry of going just one step too far for an insistent client. It's better to return an upset client's inspection fee than deal with the consequences of engaging a system you suspected was hazardous or dangerous.

Three Basic Safety Concerns and How to Proceed

From what we like to call the 50,000-foot level, there are three basic procedural safety concerns to always remember before, during and after the inspection:

- Client or occupant safety.
- Inspector safety.
- System, component, property safety.

Client or Occupant Safety

Client or occupant safety is paramount during any part of a home inspection. The client most likely will be curious about the condition and operation of major mechanicals like the heating system, but that does not mean they must be by your side. Furthermore, sometimes the occupant sticks around; or worse, follows around.

During the inspection, never allow the client (or the occupant) to peer into the heating chamber of gas-fired equipment or to stick their fingers into an electric-powered furnace. The home inspector is responsible for the safety and well-being of the client and occupant during the inspection. Take this responsibility seriously!

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Inspection Best Practice

It is highly recommended, prior to the operational heating inspection, that the inspector have a frank conversation with the client (if present) about the procedures of the inspection and the potential dangers associated with system operation with panels removed. Request that they stand clear, especially when the heating system is first energized for examination.

Inspector Safety

Obviously, inspector safety is critical as well, specifically for gas-fired furnaces. There is a critical moment when the heating unit is first ignited for operational examination. The inspector should be aware, when openable access panels are removed, of the delay time before the burners fire while gas is pouring into the combustion chamber.

When firing the unit, especially one that has been out of routine operation for some time, it's a good practice for all personnel to stand clear (30 seconds recommended). Use your powers of observation to provide the best defense for keeping everyone safe. That electric-powered furnace is operating at 240 volts, so keep at least one hand in pocket at all times unless removing or replacing access panels.

Inspection Best Practice

Ensure the client is informed of the standards of practice and exclusions for components the inspector is not required to examine or operate. Examples include no inspection of the interior flues, heat exchanger, humidifiers, electronic air filters, etc., and should be well communicated prior to inspection start.

Experienced inspectors know that expanding upon the standards of practice exceptions and exclusions can be critical to ensuring clients are informed of those no-touch components. Ensure your client is well informed prior to the inspection so that if a specific component is not inspected or if a judgement is made that the system not be operated due to an observed condition, it will avoid confusion. Finally, if the client is present and the inspector decides not to operate the system, explain why with the system non-operational and remove all doubt.

System, Component, Property Safety

System, component and property safety are equally as important as client, occupant, and inspector safety. The inspector's task is to make critical observations regarding the system's operability and point out potential defects but not cause them. Do not dismantle equipment or components – other than those referenced in standards of practice – no matter how curious you or the client might be.

One of the standard observations includes looking for rust and corrosion both inside and outside the system cabinetry. Do not scrape or pick at corrosion because this can cause further damage and open holes in exhaust pipes or flue, burners and the heat chamber, which might become dangerous long after the inspection is complete.

Do-Not-Operate Conditions

Under certain observed conditions, the inspector may render a judgement not to operate the heating system. Some observed conditions may lead to system or component damage or present an unsafe condition to occupants. Again, this is a judgement call, however the following four conditions are easily considered do-not-operate conditions:

- **System shut down (no fuel source):** A gas-fired system may be de-energized from its fuel source for good reason, reasons unknown to the inspector, client and/or realtor. Circumstances (disclosed or undisclosed) such as electrical hazards, known gas leak, unsafe piping, or fire risks during operation. Do not turn on a fuel source that is found in the off position. This should be documented in the report, including actions not taken, reason(s) why, and with supporting pictures.
- **System de-energized (switched off at the main panel or sub-panel):** This presents an unknown condition on both heating and cooling components. The inspector should discuss this with the property owner (if available), inquire as to why the system or component has been de-energized, and obtain permission to turn the system back on if believed to be safe to operate.

If you can't determine why the system or component is de-energized electrically or are unable to obtain permission, do not energize the system. This should be documented in the report, along with photos, actions not taken and reason(s) why.

- **Suspect exhaust piping or flue:** On gas-fired systems, if an observation suggests the exhaust piping or flue system is rusted through, disconnected, blocked, or improperly installed leading to a possible leak into the structure, do not energize the system. This should be documented in the report, along with supporting photos, actions not taken and reason(s) why.
- **Suspect chimney:** On gas-fired systems, if an observation identifies an older, single-width, unlined chimney chase with visible damage or mortar deterioration interior to the structure (attic or basement), do not energize the system. This should be documented in the report, with supporting pictures, actions not taken, and reason(s) why.

Inspection Best Practice

With any inspection procedure, an inspection best practice is to conduct the heating system's physical inspection and operation last in your overall routine. In totality, the heating system encompasses a large percentage of the structure (interior and exterior) and the possibility for hidden issues on the system's mechanical components. This practice allows for observation and inspection of heating system exterior mechanical components such as: Electric connections; utility penetrations; chimney, exhaust, flue penetrations including proper height; chimney chase condition; and any possible blockage or leaks.

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Additionally, it allows for observation and inspection of heating system interior components such as: Chimney or flue in the attic area; exhaust vents through walls or in the crawlspace; and system ductwork in the basement, attic or crawlspace.

Being informed of the functionality and condition of these supporting heating system components before system operation and detailed inspection ensures client, inspector and system overall safety. We will discuss the details of these necessary observations as the course progresses.

Chapter 1 Summary

In chapter one, we discussed the purpose and goals of heating and cooling; residential heating fire dangers; heating inspection standards of practice; observation guidelines; action requirements; and inspection best practices. We discussed system life expectancy and determining age; basic heating inspection tools and equipment; and inspection safety concerns – do's and don'ts.

CHAPTER 2: HEATING INSPECTION, VISUAL BEFORE OPERATIONAL

Chapter Overview

Topics:

- Heating system component definitions and inspection key terms.
- Three different efficiency types of gas-fired and electric-powered heating systems.
- Main component differences between gas-fired and electric heating systems.
- Inspection first step: The visual examination for safety and end-to-end analysis.
- System installation requirements and codes, external and internal to the structure.

Learning Objectives:
Upon completion of this chapter, the student will be able to:

- Understand heating system inspection key terms.
- Describe the differences between the three efficiency types of gas-fired systems.
- Understand an electric-powered furnace.
- Describe the importance of the inspection first step – the safety walk-around – system observation.
- Understand system installation requirements and codes for heating systems to include requirements and codes for clearance to combustibles, exhaust and intake requirements, multiple appliance connections, and unconventional installations.

In chapter two, we will look at the differences in efficiency levels of gas-fired and electric-powered systems to help identify system type and basic information, terms and definitions helpful in the necessary dialogue between inspector and client. We will expand the details of heating system inspection visual examination requirements to determine safe operating parameters and the ability to proceed with a functional examination.

Chapter two covers the overall end-to-end system and components mainly external to the system cabinet. Items subject to observation, inspection and reporting to include some inspection best practices.

Chapter two provides an overview of what to inspect per standards of practice, including standard observation requirements, specific inspection actions, what to describe in the inspection report, and special cautions for the inspector, client and property.

Definitions and Glossary of Italicized Inspection Key Terms

Upon completion of this course, students should be familiar with the following key terms:

3-2-10 clearance rule: The general safety rule of thumb for chimney or exhaust pipe structure clearance. That is, the chimney or exhaust pipe should extend 3 feet above the roof surface, and should be 2 feet higher than anything within 10 feet of it, to include the ridge, dormers, parapets, etc.

British thermal unit (BTU): A measurement of heat output. One BTU represents the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

Clearance from combustibles: The required safety distance to maintain from the heating system cabinet and exterior components from combustible materials.

Combustion air: The adequate and necessary amount of air for the effective and efficient operation of gas-fired heating systems. The fire triangle calls for fuel, oxygen, and an ignition source to create a successful combustion.

Condensing furnace: Also referred to as a high-efficiency furnace, it can achieve from 89 to 98 percent fuel efficiency. This style of furnace includes a sealed combustion area, combustion draft inducer and a secondary heat exchanger.

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Convection heating: The transfer of heat through the air, water or steam that moves heat from a warmer location to a cooler location. Convection heating systems ultimately heat the air in the living spaces.

Do it yourself (DIY): The method of building, modifying or repairing without the direct aid of experts or professionals.

End-to-end system: Term used to describe the total HVAC system installed and operated throughout the entire structure.

Health and safety concern: Term used to describe an observation or condition that presents an immediate or sustained danger to any occupants with the operation of the heating system.

Hybrid units: Mixed character; composed of mixed parts. For the purpose of this course, it is used to define field-modified heating systems, which could be a combination of Type 1 and Type 2 parts and pieces.

Induced draft fan: A device located on the system's exhaust side that pulls combustion products through the system during operation. When at rest, the fan reduces heat loss when the burners are off. Adding this component (along with others) to a low-efficiency gas-fired system design increases the system's efficiency rating to a mid-efficiency system.

Intermittent pilot: A device that lights by spark or hot surface ignitors, only when heat is called for by the thermostat. Adding this component (along with others) to a low-efficiency gas-fired system design increases the system's efficiency rating to a mid-efficiency system.

Motorized vent damper: A device which closes the exhaust when the burners are not operational, preventing heat loss up the chimney or exhaust pipe. Adding this component (along with others) to a low-efficiency gas-fired system design increases the system's efficiency rating to a mid-efficiency system.

National Appliance Energy Conservation Act (NAECA): Enacted March 17, 1987, it regulates energy consumption of specific household appliances. These laws and regulations create mandatory standards that deal with the energy efficiency of certain household appliances. These standards were put in place to ensure manufacturers built products that are at the maximum energy efficiency levels.

NFPA 54, ANSI Z223.1: Provides minimum safety requirements for the design and installation of fuel gas piping systems in homes and other buildings.

Retrofit: To install, fit or adapt (a device or system) for use with something older. For home-heating systems, it is not uncommon to find the installation of a newer gas-fired system replacing a coal-fired, oil-fired or even steam boiler. Many times these retrofit installations are linked into the existing electric hook-up, exhaust pipe or flue, ductwork and fuel source. Additionally, some low-efficiency gas-fired units can be found retrofit (altered) to mid-efficiency gas-fired furnace with the addition of components (new or modified parts, equipment, etc.).

Standing or constant pilot: A *standing or constant pilot* on a gas-fired furnace uses a small, continuously burning flame as an ignition source for the main gas burner. This flame, called a *pilot* light, burns a constant flow of a small amount of fuel.

Type 3 system plastic vent: Type 3 high-efficiency gas-forced systems typically use 2-inch / 3-inch PVC plastic exhaust pipe for venting and combustion (intake / exhaust). Modern high-efficiency condensing furnaces use this type of pipe for air intake, exhaust gas, and to carry the corrosive condensation resulting from the combustion process.

Type B – double wall metal pipe: All-metal, double-wall gas vent is listed as Type B by Underwriters Laboratories, Inc., and is approved for a wide range of applications, including natural gas fireplaces, gas-fired furnaces, boilers, and Category 1 water heaters. Can be used for relining masonry chimneys for natural gas or liquid propane systems.

Unconfined space: In accordance with NFPA 31 and NFPA 54, an unconfined space is defined as follows: Any space whose volume is equal to or greater than 50 cubic feet per 1,000 BTU (or 20 BTU/Cubic Foot). Only areas connected to the space with no doors or with fully louvered doors can be considered part of the unconfined space.

Vent snorkeling: A technique used in cold or snowy climates, where the vent terminal should be located 1 foot above the maximum snow level for the defined climate. In most cases, that elevation is 3 feet above the ground.

Vertical-vent termination: The process of vertical ventilation of allowing heat and smoke to travel upward and out of a structure. This occurs by cutting vents or making use of existing openings in the structure's roof.

Understanding Gas-Fired System Efficiencies

In the gas-fired, forced warm-air system, heat is produced when the burning fuel (natural gas / LP) warms the heat exchanger(s). Air circulation occurs when a blower, sensing the warm air available, blows the warm air into a duct system to registers throughout the structure. Cold-air return ducts bring air back to the system, completing the cycle. This type of system is known as convection heating.

Much progress has been made over the years relative to gas-fired heating system efficiencies. When called to perform a home inspection, the pre-inspection research might identify the home with a forced air, central system, but as the inspector knows, this is only a starting point. Rarely does the inspector know the age, type or efficiency rating of the system until he or she lays eyes on it and even then, it can be confusing and complicated. For certain, it is the age, efficiency rating, and maintained condition that will determine the scope and depth of the heating system inspection.

In general, the home inspector has more visual access when inspecting the system and components on low-efficiency and mid-efficiency gas-fired system types (explained below) than with the sealed compartments on high-efficiency systems. The professional home inspector needs to understand and recognize these three basic efficiency configurations of gas-fired systems.

For the purposes of this course, these three efficiency types are labeled Type 1 low-efficiency, Type 2 mid-efficiency, and Type 3 high-efficiency for ease of explanation throughout this course.

Note: From a system operational inspection perspective, the operation and functionality of the heating system is most likely more critical to your client. But inspection conditions, test parameters, time of year and outdoor environment can suspend the system's operation, certain aspects of the inspection, and/or only allow it to be operated in a single mode (heat or cool). This should be considered when reporting to your client.

Type 1 – Low-Efficiency Gas-Fired System

A Type 1 low-efficiency gas-fired system was the standard type available up to the mid-1970s, before system efficiency and engineering upgrades were designed and implemented by law. Believe it or not, a home inspector can still run into one of these old, outdated systems, some over 30 years old, still operating in the field; mostly in southern states where wintertime residential heating requirements are shorter.

In the Type 1 gas-fired system, about 80 percent of the heat produced by burning fuel stays in the structure, while 20 percent goes up the chimney. Another 20 percent of the warm structure air escapes up the chimney or through the structure when the system is not operating, and some additional fuel is wasted keeping the standing pilot burning. So overall, the low-efficiency gas-fired system is rated to be between 55 percent and 65 percent efficient by industry standards if well maintained. If 25+ years old you can count on the efficiency being much less.

In the 1970s (and after), the National Appliance Energy Conservation Act (NAECA) limited the minimum efficiency rating for natural gas heating systems to 80 percent AFUE when tested according to the Department of Energy (DOE) standard (Title 10, Code of Federal Regulations). As we learned in chapter one, AFUE is a thermal efficiency measure of space-heating furnaces and boilers.

There are many types and brands of forced warm-air, gas-fired systems and each manufacturer has its own unique design and layout. However, the Type 1 forced warm-air systems have basic compartments, typically arranged in the following three sections [(1)]:

- **Blower unit:** Containing the fan, fan motor and air filter, typically in the bottom of the cabinet through which cool return air passes (drawn in).
- **Burner area:** The combustion chamber in the middle of the unit where heat is produced.
- **Heat exchanger:** Typically, the top section of the cabinet where exhaust gasses are vented to the exterior and surrounding heated air is distributed throughout the duct system.

The fundamental system cycle for a Type1 gas-fired system is structure air is used for combustion, the combustion chamber is unsealed or partially sealed, and warm exhaust gasses rise natural up the chimney or exhaust piping or are fan induced.

Type 1 systems are quickly identified by their age and general condition. Age alone just says "suspect." The professional home inspector will want to ensure a complete examination of Type 1 aged systems to ensure client safety and to be able to discuss the value of a possible system upgrade relative to energy efficiency and economic (annual fuel costs) requirements should the system be in poor condition. Realistically, most Type 1 systems (regardless of how well-maintained) have reached the end of their useful lifecycle due to reduced efficiency.

Inspection Best Practice

While the inspector may find a Type 1 low-efficiency gas-fired system to be well-maintained, clean and fully functional, a system with 20+ years will only operate at a 65 percent (and probably much less) efficiency level. Most likely in the next five years the owner will have to decide whether to replace it, and it would be considered economically feasible to do so, possibly now. While your report may provide an observed satisfactory rating of the system functionality, this would be a good opportunity for an informative (non-report) discussion with the client on gas-fired system efficiencies (AFUE) and budgeting for a possible upgrade.

(1) This three compartment layout is typical for forced warm-air electric-powered furnaces as well.

Type 2 – Mid-Efficiency Gas-Fired System

The Type 2 mid-efficiency gas-fired system is similar in configuration and component arrangement to the Type 1 system, however, beginning in the mid-1970s modifications and upgrades were made to gas-fired system designs that would increase the overall efficiency to the 80-83 percent range. These efficiency modifications and upgrades were actually mandated through the NAECA.

These design modifications and upgrades included adding system components in production, but sometimes in the field, by licensed professionals. Field-modified systems (upgrade of a Type 1) were viewed as hybrid units, simply because field-modifications are not as textbook as factory manufactured models and may not have included the installation of all three of the components listed below. Field-modified systems are subject to quality of work and training of each individual field technician performing the changes. This is why they could be described as hybrid units.

In general, but not limited to, the three basic modifications and/or component additions creating a Type 2 mid-efficiency gas-fired system were add-ons increasing system operational and fuel consumption efficiency as outlined by law.

Type 2 component modifications and additions creating a mid-efficiency system are:

- **Motorized vent damper:** A device designed to close the spent fuel exhaust when the burners were not operational. This would prevent, heat loss up the chimney or exhaust pipe.
- **Induced draft fan:** Located on the exhaust side of the system, this device pulls combustion products through the system during operation. When at rest, the fan reduces heat loss when the burners are off.
- **Intermittent pilot:** Located in the system main control box, this device eliminates the standing or constant burning pilot. The intermittent pilot lights by spark or hot surface ignitors only when heat is called for by the thermostat.

Caution: Keep a sharp eye out for modifications. For example, one inspection revealed a unit in which the homeowner added a single component – a motorized vent damper – to improve the system's efficiency but left a standing pilot in operation, allowing spent fuel to escape into the living space.

Note**:** Some Type 2 systems exhaust gasses through a stainless-steel flue that passes through a structure wall rather than a conventional chimney, making the inspection for proper clearances from combustibles on exhaust venting very important.

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Inspection Best Practice

From the inspector's viewpoint, the three listed components of a Type 2 system are not physically inspected per standards of practice, but would be observed during the overall system operation, helping to identify the system as mid-efficiency. However, the existence of any of these three components (trust me, you can see a very mixed bag in the field), along with the identified manufactured age, helps you quickly identify a Type 2 mid-efficiency system for the client. If you run across a hybrid system, use your best judgement, but most likely it's more than ready to be taken out of service.

Type 3 – High-Efficiency Gas-Fired System

Type 3 high-efficiency, the latest generation of gas-fired systems, with an efficiency rating in the 90 to 98 percent range, can vary considerably in configuration from manufacturer to manufacturer. These systems have a different principle of operation over the Type 1 and Type 2 designs and are sometimes referred to as condensing furnaces. The changed principle in operation is to remove as much heat as possible from exhaust gasses, consequently reducing the gasses to condensation.

There are three common product categories for a Type 3 system, differentiated by efficiency rating and circulating air blower control or firing rates (single-stage, two-stage, or three-stage):

- **Single-stage system:** With blower motor operating at a single speed, generally 90 to 92 percent AFUE.
- **Two-stage system:** With blower motor operating at multiple speeds, it can range from 92 to 96 percent AFUE.
- **Step-modulating system:** With variable-speed blower motor, it can range from 96 to 98 percent AFUE.

On the Type 3 system, the combustion chamber can be located in the top or the middle of the cabinet, heat exchanger(s) (that's right; more than one, up to three) may be located high or low in the cabinet and be totally inaccessible, with other common components located in various arrangements throughout the cabinet. Type 3 systems maintain an electronic ignition opposed to a standing or intermittent pilot, and in most cases, there is no visible access to the burners; however, you will find peep holes for viewing the combustion chamber.

Type 3 high-efficiency systems typically use outside air as combustion air per manufacturer's recommendations. I say typically, because it's not uncommon to find a Type 3 combustion air intake inside the structure at the cabinet. Multiple heat exchangers extract as much heat as possible from the exhaust gasses, condensing a great portion of the gasses.

The condensate drains to the floor through plastic piping, while the remaining cool gasses are forced with an induced draft fan through 2-inch plastic piping (PVC or other) to the outside. Typically, this is through the structure side wall; however, it would not be uncommon to observe the exhaust piping through a roof penetration (existing or new).

Figure 2.1 provides a general visual representation of the design differences between a Type 2 system compared to a Type 3 system design, however, manufacturer designs do vary.

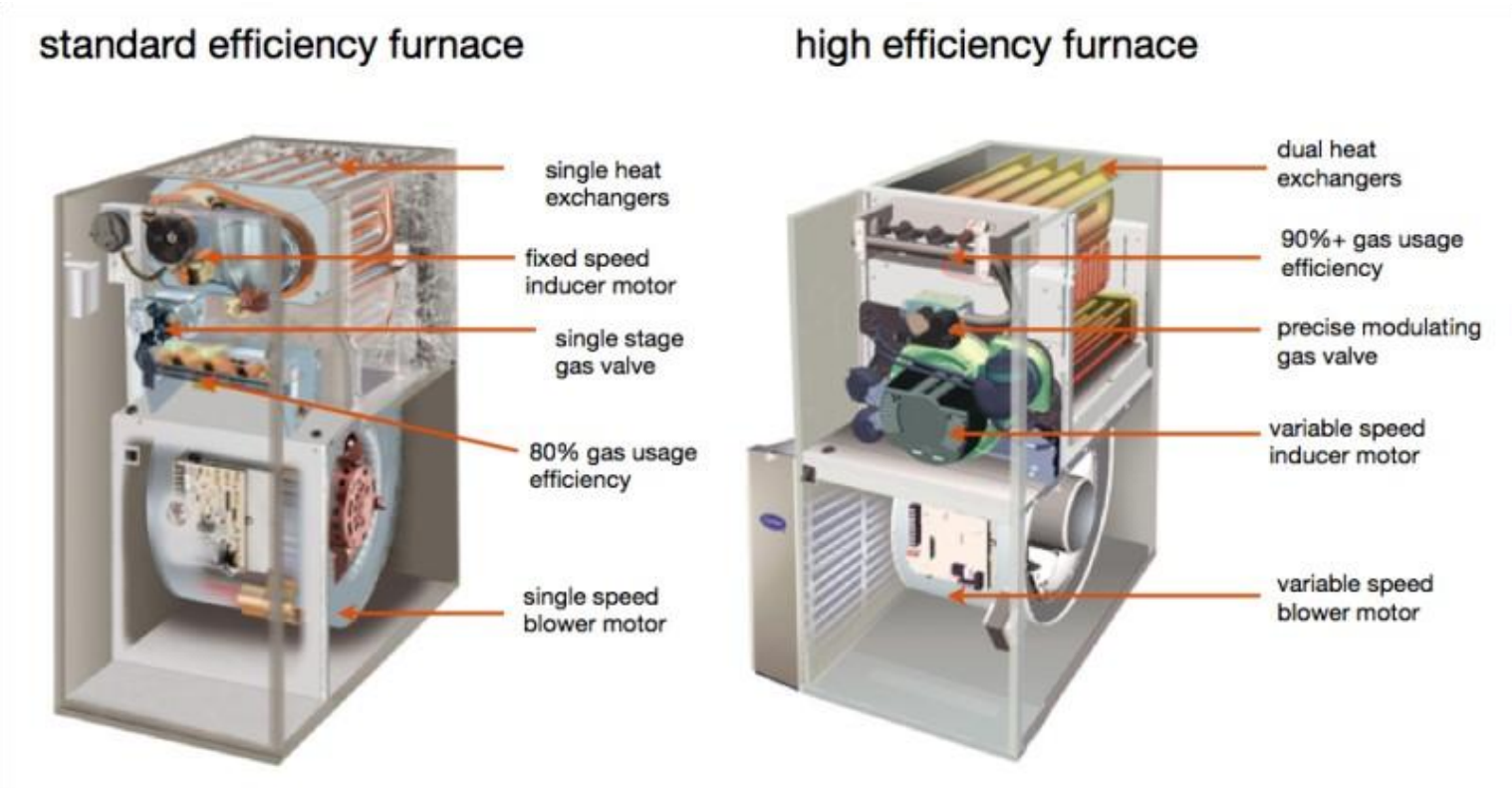

Figure 2.1 - Comparison of Mid-Efficiency and High-Efficiency Heating Systems

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Inspection Best Practice

From the inspector's viewpoint, the presence of a gas-fired Type 3 high-efficiency system can suggest less time on-site performing the heating system inspection, mainly due to the sealed compartments in the design and lack of access for physical examination of components. Nonetheless, never shortchange your client on a thorough examination, both visually and operationally. Common problems observed in the field on Type 3 systems can be the reuse of exterior components in a system upgrade and/or condensation drain clog / overflow creating rust or corrosion damage internal to the system.

Forced-Air Electric-Powered Furnace

Electric-powered furnaces use electricity as the only source of fuel to heat and distribute warm air throughout the structure. The advantage of using electricity is that it is safe and offers a clean-burning operation compared to gas-fired systems. According to the DOE, electric furnaces tend to be the heat source of choice in regions where electricity is the only option and/or in dry climates with primarily hot or mixed temperatures minimizing the need for home heating.

While an electric-powered furnace is highly efficient in the sense that, unlike gas-fired systems, they transform 100 percent of their fuel into heat, electricity is generally a more expensive heating option, making efficient operation costly for the homeowner.

By design, all types of electric furnaces are considered high-efficiency. They all have the same basic heating components; they all convert heat extremely effectively, and the distribution technique (ductwork) is the same as air-forced gas-fired systems. The differences are in the internal components for heat generation, including:

- **Heating relays:** These control electricity flow to the heating elements.
- **Heating elements:** Used for converting electricity into heat.
- **Power relay:** Controls power flow through the furnace.
- **Transformer:** Controls voltage and transforms it to the type required for the furnace.
- **Sequencers:** Switches heating elements on and off in a sequential pattern to avoid overloading.

The home inspector would not inspect any of these components outside of a visual examination of the interior cabinet (if accessible) looking for possible damage from overheating, burnt wiring, etc.

As the name implies, electricity is used to heat and distribute warm air throughout the structure via a ductwork system and vents. Air flow is moving over and through a series of heated coils. Instead of a pilot light, electrical ignition begins the heating process. In place of gas-fired burners, the ignition activates heating elements that contain conductive coils. As current passes through the coils, they begin heating the air for the blowers to handle. The more heat the thermostat calls for, the more heating elements turn on.

This sounds deceptively simple, but electric furnaces contain many components to ensure that the heat exchange and distribution runs smoothly and without safety concerns.

Figure 2.2 provides a visual representation of the general design differences between a gas-fired system compared to an electric-powered furnace.

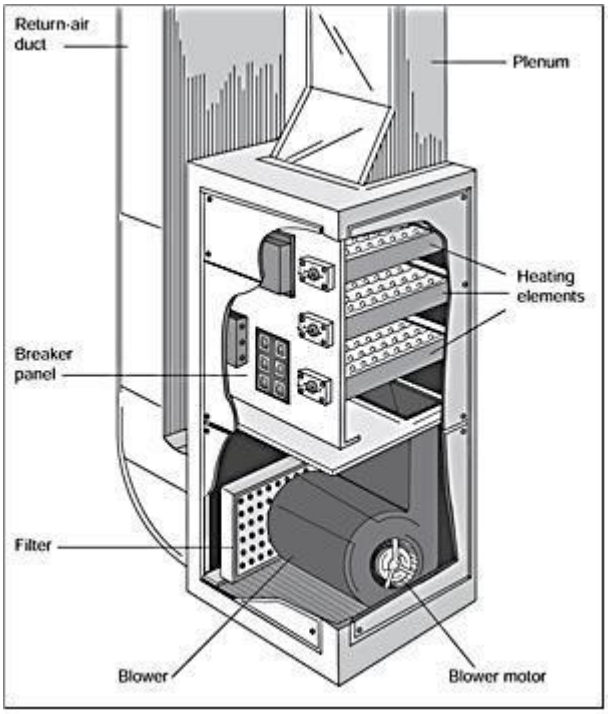

Figure 2.2 - Components of and Electrical Furnace

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First Step – Build an End-to-End Safety Analysis

Safety first is always the recommended conduct when beginning any home inspection – especially for gas-fired equipment. Because of the three identified gas-fired efficiency types, manufacturer configuration differences, and what might be found in the field, the home inspector can face some complexity on what to inspect and report on. The ASHI Standards of Practice provide the guide for what must be reported on, but experience over time teaches the professional home inspector what a true quality home heating system inspection consists of and what the client is looking for, without going too far.

Note**:** Experience has taught, even in an occupied structure, that you never go directly to the heating system or thermostat and begin an operational heating inspection. Chapter two will help explain why.

In many cases, you may inspect a system from a home remodel, taking an older system out of service. In other words, a heating system upgrade from Type 1 to Type 2 or from Type 2 to Type 3, maybe a change-out to an electric-powered unit or heat-pump. While the heating system may have been upgraded (professionally or not), other system mechanical components of the overall end-to-end system, such as duct work, exhaust piping or flue, proper electric hook-up, fuel source type and supply, may have been reused.

By definition, these would be referred to as a system retrofit and require a critical inspector's eye to determine if the reused exterior components are properly connected, installed and performing as designed with the new or replaced heating system. Missing, overextended, disconnected or unused vent pipes, visible deterioration of the exhaust pipe or flue, flue gas discharge, improperly sized breakers, or suspect wiring, are all safety issues that should be addressed immediately and could stop the inspection (operation) due to health and safety concerns.

Caution**:** Chapter one emphasized the fire danger associated with home heating systems' normal operation and occupants caught off guard, some tragically. Therefore, if you don't already, the 12 to 16 minutes it might take to perform complete safety walk-around is time well spent. Sound observations of the system to include: Cabinet; electric hook-up; combustion air availability; exhaust piping or flue; fuel supply and connection; chimney; ductwork; etc., to ascertain the general condition, proper working order, and safety to proceed with an operational examination. Granted, some of this information will be observed long before you approach the physical heating system and that's a good thing.

Safety Walk-Around Expanded

To highlight the importance of completing a safety walk-around, consider the following real-world inspection observations. These pictures, in some cases, were observations prior to the heating system operational inspection. The emphasis is on gas-fired systems and equipment. Keen observations communicate much information regarding what might be experienced later in the inspection and how far to go.

You tell me, if hired to perform a home inspection, especially on a structure which has been unoccupied for some time, if it is good practice to skip the visual Safety Walk-Around and just fire up the heating system? Regardless of whether the structure is occupied or unoccupied, the professional home inspector could discover issues during the heating inspection that even the current occupant is totally unaware of, the following examples are provided:

Figure 2.3 is an aging / failing chimney chase cap. During the roof inspection, the inspector observed evidence of brick-and-mortar failure due to structure age and environmental damage. Additionally, this chimney had no rain cap allowing for prolonged water entry. This is clearly a significant observation in your report, even a potential safety concern; however, the chimney chase condition is communicating to the inspector to sharpen those observation skills.

What will the chimney in the attic or at its base look like? As it turned out, below the roof line, loose bricks and failing mortar were observed with indications of an exhaust leak into the attic area. Keep your focus sharp on the entire system.

Figure 2.3 - Failing Chimney Cap

Figure 2.4 is a scorched register. Here we have evidence of flame rollout and a likelihood of fire danger. After a peek behind the heating system's access panels, there was little need to go any further due to the amount of internal scorching observed . Report recommendation; further evaluation by a licensed HAVC technician required.

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Figure 2.4 - Scorched Register Observed in Room

Figure 2.5 is a "coffee can handyman" repair on the exhaust. Clearly not professional quality workmanship utilizing a 2-pound coffee can as an exhaust pipe extension, not to mention all the elbows, pipe routing, and corrosion at the joints. There is a high likelihood of current or eventual exhaust spillage. Note the fresh color of the duct tape. This fix was completed at about the same time the home was placed up for sale and the inspection was ordered. What was it like before this creative fix?

Figure 2.5 - Coffee Can Used to Piece Together a Vent Pipe

Figure 2.6 shows scorched interior. It's a good thing we didn't fire this system up before a visual inspection of the cabinet interior. After removing the access covers, we observed a significant flame rollout (over time.) Note the lack of combustion air in this enclosed operating space. The home inspector should go no further. Recommendation, further evaluation by a licensed HAVC technician required.

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Figure 2.6 - A Seriously Scorched System Interior

Figure 2.7 asks "what's for dinner?" Here we see cooked mice because a vacant structure is never vacant or unoccupied. This condition was observed in a relatively new structure with a new heating system installed only a couple of months prior. The mice infestation was extensive. Report recommendation, further evaluation by a licensed HAVC technician required.

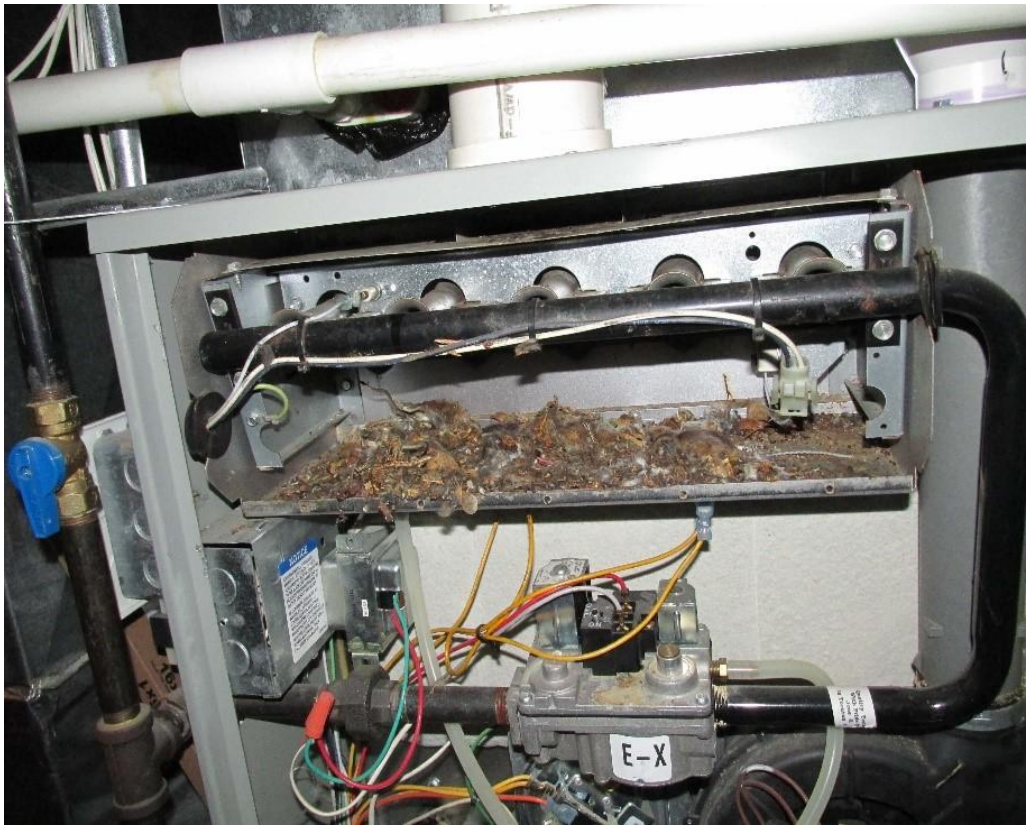

Figure 2.7 - What's for Dinner? Cooked Mice

Again – safety first!

The first step in a home heating inspection is allowing your nonoperation observations to build and communicate the level of safety necessary to proceed with an operational analysis.

System Installation Requirements and Codes – External / Internal to the Structure

The system installation requirements and codes for heating and cooling systems should focus on health, safety and durability of the installation, external and internal to the structure, albeit professionally installed or do-it-yourself (DIY).

In general, gas-fired systems have more requirements and codes relative to installing the cabinetry and exterior components with proper clearance to combustibles; an unconfined space for efficient operation; provision for continuously available combustion air used to mix with fuel before burning; an exhaust vent system with proper clearances and codes observed, including clearance to neighboring buildings if sidewall venting is used. Any discrepancies or violations should be noted in the inspection report.

As part of any safety walk-around, determining heating system and component installation clearances, as well as observing applicable local codes, can sometimes be confusing and vary by location. Usually, the professionally licensed HVAC industry does a fine job adhering to requirements and codes and ensuring professional installations of home heating systems. That said, changes typically occur when the new homeowner moves in, or there's a change in occupancy, and/or a DIY remodel on a home flip.

Therefore, the following section will provide basic guidelines for clearances and codes on system cabinetry and piping internal and external to the structure, as well as considerations on system installation location for proper operability.

Note: National building codes, including local ordinances and construction codes, can vary across the U.S. They can and will apply requirements above and beyond what is listed in this course. Professional home inspectors should always check his or her local codes to ensure adherence.

Chimney Chase, System Exhaust Condition Inspection

When performing the roof inspection, take time to ensure the overall heating system exhaust requirements are met. Type 1 and Type 2 gas-fired heating systems require a masonry chimney or Type B metal chimney for exhausting combustion byproducts. Observe and report on the following:

Masonry Chimney Inspection

Masonry chimneys should have a flue liner, typically metal, clay tile or cement pipe. Furthermore, when large attic areas in older homes are converted to living space and have an exposed brick face chimney as a feature, it can cause a potentially dangerous situation if the chimney is not properly lined.

Observe the general condition of the chimney chase exterior. A chimney that looks perfectly fine on the outside roof line, and even in the basement, could be a disaster in the attic and leaking because of structural shifts or that cut-rate roofer. Therefore, to follow safety protocols, perform a visual examination in the attic prior to system operation. Other areas of necessary observation on a masonry chimney are:

- **Rain cap or spark arrestor:** Lack of a rain cap or spark arrester on the chimney, especially on an older structure, can suggest the need to sharpen your observation of the exhaust or flue connector pipes for rust, corrosion and holes. Identify missing rain caps or spark arrestors as a recommended improvement in the inspection report.
- **Chimney cleanout:** When moving inside, check for a chimney cleanout at the base of the chimney. There should be a cleanout accessible to catch debris from chimney and flue deteriorations. A peek inside this door can speak volumes about the chimney's overall condition, both inside and out. If you observe a great amount of soot and debris, the flue could be restricted or even blocked. A suggested blocked flue should be reported as a safety hazard in your report, as well as a recommendation for regular cleaning at the cleanout to prevent unsafe conditions.

Inspection Best Practice

Per standards of practice, the home inspector is not required to inspect the flue interior, but if possible, advise the client on whether or not the chimney is lined, especially if your client plans to extensively renovate the structure or add other heating appliances to the chimney.

Type B Exhaust Pipe Inspection

For the Type B exhaust pipe external to the structure, we are observing for the following:

- **Heavy rust:** A heavily rusted exhaust pipe reflects its age and lack of system maintenance. Water penetration can be an issue and can enter the system and damage other components down the line toward the heating system. This should be identified as a recommended improvement in the inspection report.
- **Flashing condition:** A roof penetration flashing with signs of damage (pulled away) or rust through lets you know to look deeper in the attic and all exhaust connections down the line toward the heating system. This should be identified as a recommended improvement in the inspection report.

Note: National building codes, including local ordinances and construction codes, can vary across the U.S. They can and will apply requirements above and beyond what is listed in this course. Professional home inspectors should always check his or her local codes to ensure adherence.

Type 1 and Type 2 Chimney, Exhaust Pipe, Flue Location – Clearance Requirements

Note the location and clearance requirements of the chimney or exhaust pipe penetration through the roof on Type 1 and Type 2 systems. The general safety rule of thumb is the 3-2-10 Rule, which states the chimney or exhaust pipe should extend 3 feet above the roof's surface, and it should be 2 feet higher than anything within 10 feet of it, to include the ridge, dormers, parapets, etc.

Figure 2.8 provides a visual example of the 3-2-10 Rule.

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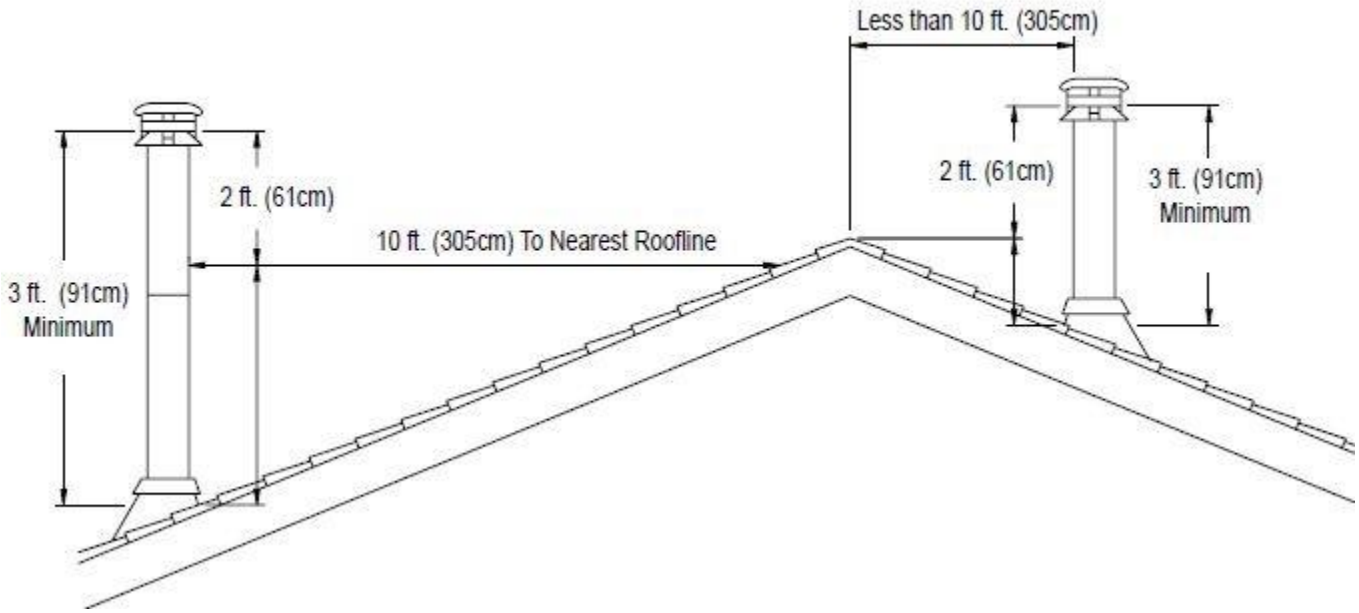

Figure 2.8 - 3-2-10 Rule for Chimney / Exhaust Pipe Clearance

If inspecting a new room addition that is built higher than the existing chimney or exhaust pipe, the exhaust system must extend to meet the 3-2-10 Rule requirements. Chimneys and exhaust pipes that do not meet these standards can experience backdraft problems and spillage and should be noted as a potential health and safety hazard in your report.

Type 3 System Exhaust, Air Intake Clearance Requirements and Codes

Type 3 high-efficiency systems (condensing furnace) are listed as category IV appliances according to industry standards, which require venting systems to be both water- and gas-tight. The heating system uses an exhaust vent motor that pushes the exhaust gas through the vent pipe, creating a positive static pressure in the vent.

The condensing furnace produces condensed exhaust gasses that contain water and carbon dioxide, which together form carbonic acid that results in a corrosive condensate. As such, furnace manufacturers recommend special types of plastic piping for venting and condensate drainage in a condensing furnace.

For Type 3 high-efficiency system inspections, observe that the exhaust pipe or combustion air intake type is properly configured. Not all manufacturers' installation instructions require piping outdoor air for combustion into the system; however, it is considered a best practice in the HVAC industry, for a condensing furnace. Observe and report on the following:

- **Type 3 plastic exhaust pipe material:** Type 3 plastic vents typically use 2-inch / 3-inch pipe for exhaust and combustion; however the type may vary. Vent piping should be made from PVC (poly-vinyl chloride), CPVC (chlorinated poly-vinyl chloride) and ABS (acrylonitrile-butadiene-styrene) plastic pipe, depending on the furnace's specified exhaust gas temperature.

Note: These different plastics have different maximum heat service temperatures: PVC has the lowest rating at 140 degrees F.; CPVC has the highest at 194 degrees F.; and ABS falls in between, at a maximum service temperature of 160 degrees F. The functional difference in the field is related to pipe failure, such as sagging or leakage, which may occur if sustained temperatures exceed these recommended service temperatures.

Observe the following requirements and if you note any discrepancies, identify them as a recommended improvement in the inspection report.

- **Type 3 exhaust pipe location:** May not be located near windows and doors. Verify correct clearances to doors and windows per local code and manufacturer requirements. Exhaust pipes can be a straight pipe or maintain a 45-degree elbow to control direction of exhaust gasses away from structure or combustion air intake.
- **Type 3 combustion air intake:** Found on the outside of structures; should not be located above vent exhaust to avoid recirculation of the flue gasses and nuisance outages of the furnace; typically maintain a 90-degree elbow and vent screen.
- **Type 3 sidewall venting:** Sidewall venting is the preferred configuration; however, in some colder regions, local codes prohibit sidewall venting to avoid ice formation on adjacent buildings if the separation between buildings is too narrow. Local codes should be consulted before the inspection.
- **Type 3 ground height:** In snowy climates, the vent terminal should be located 1 foot above the maximum snow level for that climate. In most cases that elevation will be 3 feet above the ground. This technique is called vent snorkeling.

Figure 2.9 represents a proper configuration for a high-efficiency system intake or exhaust to meet the requirements listed.

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Figure 2.9 - Proper High Efficiency System Intake / Exhaust

Figure 2.10 shows a suspect venting configuration (pipe size, arrangement, location) for a high-efficiency system. This was a DIY system upgrade. This observation would not stop the home inspector from performing an operational inspection; however, it should be identified in the report as a necessary improvement observation for the system's optimized performance.

Figure 2.10 - Suspect High Efficiency System Intake / Exhaust

Vertical-vent termination or through-the-roof penetration for high-efficiency systems are not uncommon in the field with many creative installation configurations observed. Some even use the existing chimney (taken out of service for a Type 1 or Type 2 exhaust) for routing the piping intake and exhaust.

Figure 2.11 represents a proper configuration for through-the-roof vertical-vent termination, whereas clearance requirements apply.

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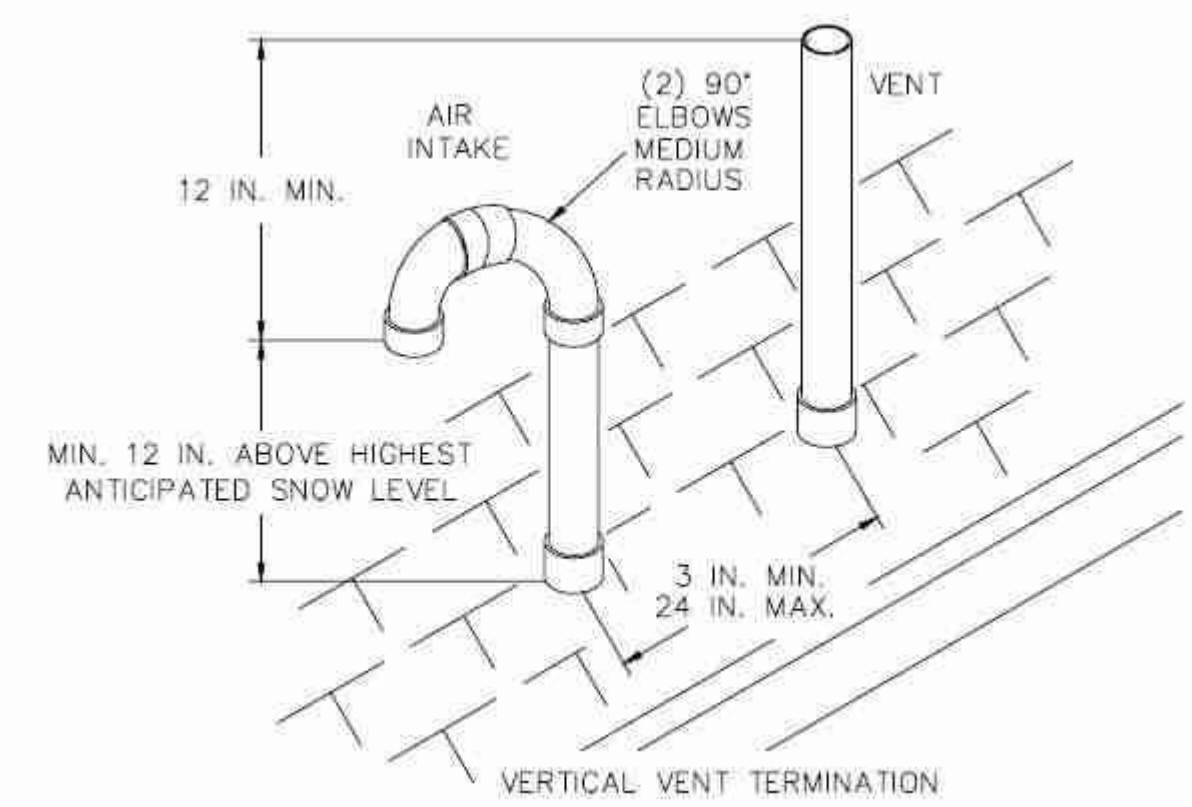

Figure 2.11 - Generally Accepted Vertical-Vent Termination

Note: If you observe a Type 3 exhaust vertical-vent termination with a 90-degree elbow, it is not a proper installation configuration due to the corrosive nature of exhaust gasses and ice formation on the roof, which damage roof components over time.

Cabinetry, Exhaust Piping – Installation Requirements and Codes

Moving inside, quickly observe the exterior of the system cabinet and pay close attention to proper clearances to combustibles around the heating system, including the first few feet of the duct distribution system, exhaust pipes or flue and vents. The proper clearances must meet or exceed all local and national building, fire, electrical fuel-gas codes.

Note: Various manufacturer models may have different clearances from combustible material requirements. If in doubt, consult NFPA54 / ANSI Z223.1 or the manufacturer's installation guide.

As a general rule of thumb, the following clearances from combustibles and safety installation parameters applies for gas-fired / electric-powered heating systems.

Observe and report on the following for all gas-fired systems:

- **Combustion air and ventilation openings:** Not blocked or obstructed by anything, including snow on Type 3 exterior intakes or exhaust.
- **Unit sides to combustible surface:** 1 inch minimum, model dependent.
- **Unit front to combustible surface:** 18 inches minimum.
- **Unit top to combustible surface:** 3 to 6 inches, model dependent.
- **Exhaust flue, type 3 unit, plastic vent:** 0 inches to combustible surface.
- **Type B – double wall metal pipe:** 1 inch clearance to combustible material in the structure.
- **Service / working space – front:** 18 to 24 inches. Any access door or panel must permit removal of the largest component interior to the cabinet at that location.

Observe and report on the following for all electric-powered systems:

- **Ventilation openings:** Not blocked or obstructed.
- **Unit sides to combustible surface:** 0 inch minimum, model dependent.
- **Unit front to combustible surface:** 20 inches minimum.
- **Unit top to combustible surface:** 0 inches, model dependent.
- **First 3 feet of supply duct to combustibles:** 1 inch minimum
- **Service, working space – front:** 18 to 24 inches. Any access door or panel must permit removal of the largest component interior to the cabinet at that location.

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Proper Exhaust Pipe or Flue, Slope, Length, Connector Seals

On Type 1 and Type 2 gas-fired systems, perform a critical examination of the exhaust pipe or flue for proper slope, including length, holes, open joints, and corrosion at connector seals. This is an important visual examination prior to operation, and can point to other more serious, increasing issues, even if the system is operational at the time of inspection. Surprisingly, the occupant is typically unaware of these issues.

Observe and report on the following for Type 1 and Type 2 gas-fired systems:

- **Exhaust Pipe or Flue – Slope:** A properly installed exhaust pipe or flue for Type 1 and Type 2 systems is required to:
- Slope upwards at a slope of ¼ inch per foot of length.
- Be well-supported to avoid sagging over time.
- Be as short as possible.

Identify any observed discrepancies relative to slope as a recommended improvement (minimum) in the inspection report and possibly a health and safety issue.

Note: For example, installation of a heating system in a wet / constantly damp basement, where the system is placed on blocks to avoid dampness rather than fixing the occasional water intrusion problem. Typically, in a short-ceiling basement, the system is elevated to a level that diminishes the ability for proper slope when creatively attaching the exhaust pipe or flue to an existing chimney penetration. Such a condition is an indication for a very close examination.

- **Exhaust pipe or flue – length and support:** If the exhaust pipe or flue is longer than 10 feet or has more than one elbow, be sure the draft is not affected. An exhaust pipe or flue of this length, especially if very old or poorly supported, could easily show signs of mortar cracking or broken seal where the pipe enters the chimney. Identify an exhaust pipe or flue with excessive length and poor support as a recommended improvement in the inspection report.
- **Exhaust pipe or flue – seals and connection:** Observe and inspect each joint in the run for proper seal and connection. Exhaust pipes or flues are required to be secured with sheet metal screws at all joints and connections. These connections may be covered with duct tape and should be examined for the presence of screws. The age of the seal, connection, duct tape or insulation can communicate much information relative to a properly maintained system. Improvement recommendations are typical in this area.
- **Exhaust pipe / flue – corrosion and rust:** Remember that missing rain cap and/or rusty exhaust pipe flashing. Observe and inspect the overall exhaust pipe or flue for rust, corrosion and water penetration, particularly at the point where the piping enters the chimney chase or through the roof penetration. Identify observations of rust, corrosion and water damage as a recommended improvement in the inspection report because these areas will eventually fail (rust through) and possibly leak dangerous exhaust into living space.
- **Exhaust pipe / flue – holes:** Naturally, any observed holes in exhaust pipes or flues should be identified as a health and safety risk to occupants. You should not perform an operational heating inspection of a system with an observation of this type.

Note**:** For homes built prior to 1960 (in colder climates), it is not uncommon to find the installation of a newer gas-fired or electric-powered system replacing a coal-fired, oil-fired system or boiler. Many times (to save on remodeling costs) these installations are linked into the existing exhaust pipe, flue or ductwork. Asbestos-like material, such as plaster and insulation, may be present. Licensed home inspectors typically are not EPA specialists; nonetheless, at a minimum, your report should record the presence of asbestos-like material for client awareness and possible further action.

Exhaust Pipe, Flue Sharing for Multiple Appliance Connection

In some homes, there may be another gas-fired appliance (Water Heater) sharing the same vertical exhaust pipe, flue or chimney as the existing Type 1 or Type 2 heating system. Inspect for common vented appliances that will require a possible recommended change in the vent system in accordance with ANSI Z223.1. Observe and report on the following for Type 1 and Type 2 systems:

- A gas-fired appliance exhaust pipe or flue being shared with a fireplace or wood burner is typically not allowed by local code and should be reported as a potential health and safety hazard.
- In general, Type B gas vent system will not require significant modifications with draft-hood equipped appliances other than attention being paid to proper slope. However, special situations may require relining of masonry chimneys if the furnace is removed from a common vent system with another atmospheric appliance.

There are many system upgrades from Type 1 to Type 2 systems in the field that fail to consider the existing vent system modifications, resulting in deterioration and failure of the existing Type B gas vent system or masonry chimney. DIY installers can be very creative in connecting exhaust systems together, and close observation should be made in this area.

Identify any observed discrepancies relative to exhaust pipe or flue sharing slope as a recommended improvement (minimum) in the inspection report and possibly a health and safety issue.

Figure 2.12 shows an example of a paired venting system with questionable configuration and slope. The system has a fan-assisted exhaust which creates a backdraft though the paired appliance (water heater).

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Figure 2.12 - Improper Exhaust Pairing and Exhaust Slope

Unconventional Heating System Installation Clearance Requirements

With remodeling, home flipping, and DIY activity being all the rage, many times non-professionals perform upgrades while overlooking logic and codes. This is where the inspector will notice many shortcuts or failure to observe system installation clearance requirements.

Bottom line, gas-fired heating systems (especially Type 1 and Type 2 systems) must rely on a continuous supply of combustion and draft air for efficient and safe operating parameters. Requirements and codes apply for the installation of all heating system types. The following unconventional system installation location should be closely examined during a home inspection.

Identify any observed discrepancies regarding installation requirements and codes as a recommended improvement (minimum) in the inspection report and possibly a health and safety issue.

- **Type 1 and Type 2 system – closet / enclosed room installation:** When heating systems are located in closets and/or tightly enclosed rooms (utility closets), codes require 1 square inch of ventilation per 1,000 BTU of output. Closet doors must be louvered, and/or rooms should be ventilated at the top and bottom of the doorways to ensure proper combustion and draft air is available. Identify observations of improper or poor ventilation as a recommended improvement in the inspection report.
- **Type 1 and Type 2 system – garage installation:** Any gas-fired system located in a garage must sit with the burner at a minimum of 18 inches above the floor. This allows gasoline vapors, which hug the floor, to dilute before reaching the system's burner (open flame) level. Additionally, manufacturer's recommendations typically require that furnaces installed in garages have outdoor air for combustion to avoid a possible heat-exchanger failure due to accelerated corrosion from paint and solvents. The installer rarely observes this requirement. As a result, home inspectors need to look a little deeper for rust and corrosion on garage installations. Identify observations of improper garage installation as a recommended improvement and/or safety concern as appropriate in the inspection report.
- **Type 3 system – attic installation:** A horizontal gas-fired system installation in an attic should be located on a service platform large enough to allow for proper clearances on all sides as well as service access to the front of the system. Identify observations of improper attic installation as a recommended improvement in the inspection report.
- **Type 3 system – attic installation, suspended:** A horizontal gas-fired system may also be suspended from the joists using 3/8-inch all-thread rods with pieces of angle iron underneath the unit to form a hanging rack at both ends and the midpoint. The rods must be of sufficient length to allow for proper clearances from combustible materials. The angle iron must be at least 32 inches long to allow for access to service panels. Identify observations of improper attic installation as a recommended improvement in the inspection report.
- **Type 3 system – attic installation, ventilation:** Gas-fired systems installed in ventilated attics may not require additional combustion air piping to the outdoors. If combustion air from the space is used (other than direct-vent method), consult provisions in local codes or ANSI Z223.1 related to installation and operation in confined spaces, as well as number and size of ventilation openings. Additionally, pay close attention to where the system exhaust and condensate drain is going. Identify observations of improper attic installation as a recommended improvement in the inspection report.
- **Type 3 system – crawl space installation:** The gas-fired system may be placed horizontally in a crawl space on a pad or other noncombustible material which will raise the unit for sufficient moisture protection. If combustion air from the space is used (other than direct-vent method), consult provisions in local codes or ANSI Z223.1 related to installation and operation in confined spaces, as well as number and size of ventilation openings. Additionally, pay close attention to where the system exhaust and condensate drain is going. Identify observations of improper crawlspace installation as a recommended improvement in the inspection report.
- **Electric-powered furnace installation:** The electric-powered systems have fewer restrictions relative to location, however, the installation should provide adequate structural support, space in the front of the unit for service access, clearance for return air and supply duct connections, space for refrigerant piping connections and condensate drain line connections, and clearance for filter removal.

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A common installation mistake for the DIY installer is overlooking clearances from combustible materials as specified on unit rating plate, as well as using plastic lined or combustible flexible ducting within 36 inches of the supply end of the air handler. Report an observation of this type as a potential fire hazard in the report.

Chapter Summary

In chapter two, we discussed the differences between the labeled Type 1, Type 2 and Type 3 gas-fired system efficiencies; electric-powered furnace component differences; first step visual examination requirements; clearance, exhaust, installation requirements and codes internal and external to the structure.

CHAPTER 3: HEATING INSPECTION, CRITICAL OPERATIONAL COMPONENTS

Chapter Overview

Topics

- Heating system component definitions and inspection key terms.
- Inspecting electric components external to the cabinet.
- Inspecting fuel-source components external to the cabinet.
- Inspecting components internal to the system cabinet with the system off.
- Inspecting components internal to the system cabinet with the system on.
- Inspecting electric-power furnace in heat mode.

Learning Objectives

- Understand heating system inspection key terms.
- Identify critical inspection components external to the heating unit.
- Identify critical inspection components internal to the heating unit.
- Understand the basic temperature rise test.

Chapter three details the physical examination of critical heating components subject to operational and functional observation, inspection and reporting. This chapter covers the overall heating system and components internal and external to the system cabinetry.

This chapter provides an overview of what to inspect per standards of practice, including standard observation requirements, specific inspection actions, what to describe in the inspection report, and special cautions for the inspector, client and property, and provides some inspection best practices.

Definitions and Glossary of Italicized Inspection Key Terms

Upon completion of this course, the student should be familiar with the following terms:

Anticipator: A device (internal to the thermostat) that turns the heating or cooling system on and off just before reaching pre-set temperature settings.

Back-draft: In heating systems, a backdraft is an air current (exhaust) that flows backward down a chimney, exhaust pipe or flue.

Black iron piping: Slang term referring to steel pipe with black paint on it. This type of pipe is still used in many homes and businesses to convey natural gas or propane fuel, and is a popular choice in fire sprinkler systems due to its high heat resistance.

Condensate assist pump: A specific type of system “add-on” component used to pump the condensate (water) produced in an HVAC (heating or cooling system), refrigeration, condensing boiler furnace or steam system to an appropriate gravity drain.

Condensate drain line: Central heating or cooling systems generate a certain amount of condensation during operation. The condensation ultimately has to go somewhere, which is the purpose of the condensate drain line. It is a critical interface attached to the heating and cooling system and directs the flow of condensate outside the home. The drain line is often assembled using PVC pipe.

Condensate trap: The primary purpose of a condensate trap is to prevent air from moving in or out of the coil box or air handler during operation. Without a trap, this doesn't happen. Air that is lost through the condensate drain in blow-through systems primarily is an efficiency issue.

Directly bonded: The National Electric Code (NFPA 70) stipulates the requirements for bonding gas piping systems in NEC Section 250.104(B) Other Metal Piping. Section 250.90 of the National Electric Code (NEC) provides guidance on the general purpose of bonding. It states: “Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault currents likely to be imposed.” The 2008 edition of the NEC goes on to define the term bonded as: “Connected to establish electrical continuity and conductivity.”

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Fan control: A switch located on the thermostat to control the system blower. It can be set for the blower to operate automatically when the system is on, or operate continuously for constant air circulation.

Flame color as an indicator of problems: A natural gas flame should be blue, which indicates proper combustion of the fuel source. Long streaks of yellow or orange through the flame means the burner is not receiving enough air for complete combustion and needs adjustment or cleaning by a professional service technician.

Flame pattern as an indicator of problems: The normal *flame pattern* is substantially blue and the *flame* is stable. It should not waver or lift off the burner, nor should it float around the edges of the burner or drift out. The normal *flame* indicates complete combustion. The blue color is not brilliant or intense.

Gas appliance connector: A *gas connector* is used to get from the *gas* piping to the *appliance* – that's all. *Gas connectors* should never be used as a substitute for *gas* piping. If you ever see two *connectors* joined together, it's an improper installation.

Gravity drain / floor drain: The structure drainage system, which uses gravity as the main driving force, and *drains* into the *sewer*.

Hard lockout: On an electric furnace, hard lockout means safety conditions will not allow a system to restart. Hard lockout occurs typically after up to four soft lockout failures.

Main control / combination box: A combination of several gas-fired system components in a single unit to control all functions (fuel regulation, electric, ignition, safety control, etc.) required to operate gas-fired heating equipment.

Manual fuel shut-off: A device used to stop a supply or operation of the fuel (gas) supply.

Master shut-off: Also called the "safety switch," it turns off the electricity to the heating system and its controls in case of an emergency and/or system maintenance. Note: The serviceman's switch serves the same purpose as the safety switch and may be the very same switch.

Mechanical thermostat: A simple temperature sensor made up of two pieces of metal that are laminated together.

Motorized damper (zone control): A valve or plate that stops or regulates air flow inside a duct or air-handling equipment. A damper may be used to cut off central air conditioning (heating or cooling) to an unused room for zone control, or to regulate it for room-by-room temperature and climate control.

Overshooting: Describes when a house is heated or cooled higher or lower than the thermostat is set for.

Physical examination: An evaluation of the system and components, their function and operation, without conducting an invasive analysis or dismantling operating components.

Programmable thermostat (analog or digital): Designed to adjust the temperature according to a series of programmed settings that take effect at different times of the day. Programmable thermostats may also be called setback thermostats or clock thermostats.

Safety float switch: *Typically installed on a condensate drain line or pan, this switch* provides a cost-effective solution against potentially critical issues or structural damage from condensate drain overflow. A properly installed safety float switch prevents this.

Setback feature: A feature located on a modern thermostat that can be set to raise or lower temperature settings automatically during certain hours.

Short cycling: A condition where the heating or cooling system turns on and off too often.

Smart thermostat: A device used with home automation that controls a home's heating and cooling system. It performs the same functions as a programmable thermostat, allowing the user to control the temperature throughout the day using a schedule, such as setting a different temperature at night.

Soft lockout: On an electric furnace, soft lockout means safety conditions shut the system down. It resets itself, usually after one hour, and tries again. Usually, this is related to an over-heat detection.

Supply line drip leg: A sediment trap, sometimes called a drip leg (although technically different), that is a capped-off section of gas line installed in such a way that any debris or moisture in the line will be caught in the trap where it can be cleaned out easily.

System cabinetry: For the purposes of this course, "system cabinetry" is defined as the main unit, housing all of the defined critical system components required for inspection.

Temperature limit switch: Also called a fan limit switch, it senses the furnace temperature and tells the blower fan to turn on and off at the appropriate times. It also can shut down the furnace burners if it's getting too hot inside the furnace.

Temperature rise: The difference between the temperature of the return air and the heated supply air to the furnace.

Thermostat: A temperature-sensitive device that opens and closes a circuit in response to temperature internal to the structure and/or area to be heated or cooled.

Yellow corrugated stainless-steel tubing (CSST): A type of conduit or supply line used for fuel gas distribution in structures. It has a flexible corrugated stainless steel inner layer and an outer non-conductive plastic yellow jacket.

Zone control: Zoned heating and cooling breaks the home into different areas, or *zones*, each controlled separately by a thermostat. Zoning allows for several benefits including elimination of hot and cold spots and individual control of different rooms' temperatures.

Critical System Operational Components to Inspect and Report On

Chapter three focuses on the actual operation (functional analysis) of the heating system and components. There are several critical components internal and external to the heating system cabinet the home inspector is responsible for observing, inspecting and reporting on per standards and practice, in order to ensure a thorough examination. Additionally, the experienced home inspector knows to provide a quality inspection report, you are required to observe (operation and functionality) several components above and beyond the those identified in the standards of practice.

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Once we know it's safe to proceed with an operational inspection from building observations during the safety walk-around, we move to actual physical examination of these critical components. Several of these components will be discussed in greater detail and may or may not be available for observation depending upon the system type (gas-fired or electric-powered) and/or efficiency type under inspection.

If you are lucky enough to be using one of the many home inspection software programs for report development, many of the following components either by standard or through report development require a visual analysis and/or a physical examination to determine overall operability for heating system adequacy.

Critical Electrical Inspection – Components External to the System Cabinet

We will start with the main or normal operating control for a heating and cooling system, the thermostat. This section may appear to be overkill for this single component, however, the experienced home inspector knows (1) the thermostat is the brain of the heating and cooling system and can present problems; (2) it's the one (maybe the only) component the homeowner is familiar with; (3) the plethora of thermostats encountered in the field can be endless. For certain, a properly functioning thermostat is critical for effective and efficient heating and cooling system performance.

The thermostat is a temperature-sensitive device that opens and closes a circuit in response to changes in temperature. In the modern era of digital or wireless technology, this simple device can become complex, and come in many shapes, sizes and options; nonetheless each maintains the same basic functionality for system operation. It senses the air temperature and signals the heating or cooling system for operation, resulting in occupant comfort.

Most thermostats, regardless of age, have a fan control function for force-air systems. This control can be set, so the blower operates automatically when the system is on or operates continuously for constant air circulation.

Most thermostats, regardless of type or age, have an anticipator, which anticipates the preset point on the thermostat and turns the heating system on before the preset temperature is reached. This compensates for the lag time between closing the circuit and delivering the needed temperature change. The anticipator also turns off the heating system just before the desired temperature is reached, allowing the remaining heat in the combustion chamber to be expelled, bringing the temperature up those last few degrees to the set point.

This anticipating function is critical to prevent system overshooting and/or short cycling. A properly installed thermostat should be calibrated to the particular system installed in the structure. Either of these conditions (i.e., overshooting or short cycling) can be observed during the home inspection, if you are paying attention and know the signs.

Observe the following conditions, and if you note any discrepancies, identify them as a recommended improvement in the inspection report.

- **Overshooting:** Occurs when the remaining heat in the combustion chamber heats the house higher than the preset temperature after the burner is shutoff. This indicates a calibration issue with the thermostat.
- **Short cycling:** Can occur when the anticipator is not properly calibrated, actually shutting the system down too soon and never reaching the desired temperature. Then the heating unit immediately kicks on again, only to shut down too soon again. There can be other causes for short cycling, but it is an easily observable condition during a home inspection.

Mechanical Thermostats

Older mechanical thermostats typically operate at a low voltage (24 volts). The mechanical thermostats, represented in Figure 3.1 and Figure 3.2, simply start the system on a call for heat or cooling and turn it off when the thermostat is satisfied. These types typically have mechanical contacts and anticipator functions.

Figure 3.1 - Mechanical, Low Voltage, Heat and Cool Thermostat

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Figure 3.2 - Mechanical, Low-Voltage, Heat and Cool Thermostat

Note: These types of mechanical thermostats, with their contacts exposed to the air, can present a system efficiency problem over time. For example, a layer of dust or even nicotine (if the homeowner is a smoker) can accumulate on the exposed contacts and interfere with normal operation. In modern thermostats, the contacts are typically enclosed in glass or have a sealed mercury switch in which a drop of mercury makes or breaks the circuit.

Inspection Best Practice

If during a home inspection, you encounter an older mechanical thermostat such as the ones shown in Figure 3.1 or Figure 3.2, and observe possible overshooting and/or short cycling, this is an opportunity to discuss the less-than-efficient nature of these older components and the benefits of a possible upgrade, depending upon the age of the overall heating and cooling system. I have inspected homes upgraded (DIY) to a Type 3 high-efficiency system installation with an old (substandard) thermostat remaining in place.

Programmable Thermostats

As previously stated, there are countless thermostats available today. Programmable thermostats, represented in Figure 3.3, (analog type) were introduced in the 1980s with an analog clock function. Digital programmable thermostats, represented in Figure 3.4 and Figure 3.5, have continued to be redesigned and modernized with technological advancements. Modern programmable thermostats are battery operated, which can present a problem during the inspection (dead batteries).

The main function of the programmable thermostat is the setback feature, which is used to save energy. Programmable (sometimes referred to as electronic) thermostats can be set to lower temperature settings to engage automatically at night and raise the temperature automatically each morning. Some can be programmed for a double setback function, where the property owner can also raise and lower the heat automatically during both daytime and nighttime hours.

Figure 3.3 - Programmable, Analog Clock, Low-Voltage Thermostat

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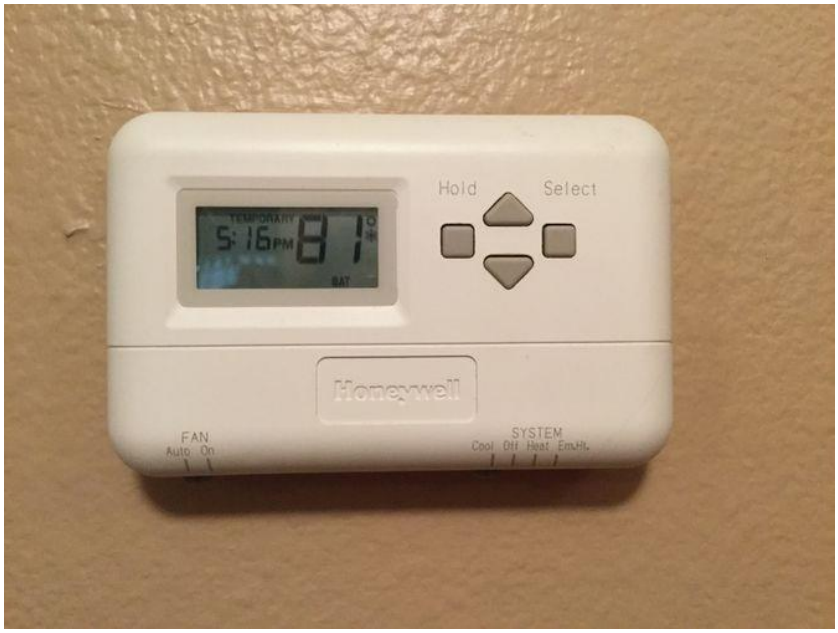

figure 3.4 - Programmable, Digital Clock, Low-Voltage Thermostat

Figure 3.5 - Modern Programmable, Digital Clock, Dual Setback Thermostat

Note**:** Use caution during the inspection to ensure you do not disturb the programmed thermostat settings applied by the home occupants. Always ensure that any setting changes for the purpose of the inspection are returned to the original settings.

Smart Thermostats

The age of wireless technology and even Artificial Intelligence (AI) has introduced the smart thermostat. Smart thermostats, such as the one in Figure 3.6, can be used with home automation and provide even greater control of the heating and cooling system. They perform the same functions as a programmable thermostat, as they allow the user to control the temperature of their home throughout the day/night using a schedule.

Unlike a wired thermostat, these are mostly battery operated, connected to the Internet, and allow users to adjust heating settings from other Internet-connected devices, such as a smartphone. This allows users to easily adjust the temperature remotely. This ease of use is essential for ensuring energy savings; however, studies have shown that households with programmable thermostats have higher energy consumption than those with simple thermostats, because residents program them incorrectly or disable them completely.

Some smart thermostats track internal and external temperatures and the time the system has been running; they can even notify the occupant if the air filter needs replacing. This information is typically displayed on an Internet-connected device.

Some smart thermostats can automatically learn or record occupant habits, such as when the house is likely to be occupied, and when it is likely to be empty. This allows it to automatically pre-heat or pre-cool the house, offering a comfortable temperature when a resident returns home. If the resident's lifestyle changes, these smart thermostats will gradually adjust the schedule, maintaining energy savings and comfort.

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Figure 3.6 - Smart Programmable Thermostat

Inspecting the Thermostat

During the course of the heating or cooling system inspection, the home inspector should operate each thermostat (normal operating control) to ensure it functions properly and turns the system on and off. But again, be sure to note any settings – particularly the temperature setting – before you test the thermostat, so you can return it to its original setting.

Observe the following conditions and if you note any discrepancies, identify them as a recommended improvement in the inspection report.

- **Improper location:** Thermostats should be located on the inside walls of the home. They should be in locations where factors other than normal home conditions will not unduly affect the temperature of the area. For example, thermostats in cold drafts or near the outside exits or windows can turn the system on or off too often. Those located in the path of direct sunlight or fireplace operation will not turn the heating system on often enough.
- **Loose or not level:** If a thermostat is loose on the wall or unlevel, the mercury switch can open and close the circuit inaccurately, and calibrations will not correspond to the actual room temperature.
- **Not working:** If the heating and cooling system does not turn on when the thermostat is operated, it can be due to several factors, such as the system may be turned off at the unit or a dead battery. If the heating or cooling system does not operate from the thermostat operation, the situation should be further evaluated to determine if the problem is with the system or the thermostat.

For example, if inspecting a system in a vacant home, extensive dirt and dust collection on the open contacts can prohibit the circuit from closing. This non-operational condition should be noted in the report as a recommended improvement observation, or, depending on other observed conditions, a recommendation for further evaluation by a licensed HAVC technician might be advised.

Attempting to diagnose a malfunctioning thermostat outside these three parameters is not recommended. Thermostats are required to be properly calibrated to the system they communicate with; improper operation can lead to carbon monoxide poisoning in gas-fired systems, and potential high-voltage shocks in electric-powered systems. An appropriate recommendation in the report would be further evaluation by a licensed HAVC technician.

Inspection Best Practice

Some home inspectors carry a thermometer to test the actual room air temperature against the thermostat settings and/or calibrations. This is good practice, especially for older systems and structures. If you find a difference (3 degrees or more), note it in the report as a possible thermostat calibration problem. Clients should be advised that loose or unlevel thermostats should be fixed to optimize performance. These conditions are best handled by a licensed HAVC technician.

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Zone Heating

Wrapping up with thermostats, the term “zone control” refers to different areas of the structure (upstairs, downstairs, add-on), or zones, that are controlled by different thermostats. Sometimes structure zone control is achieved by installing totally independent heating and cooling systems for an upstairs/downstairs configuration, each with its own thermostat. Some structures can be found with most of the home under a gas-fired system and an attic-installed electric-powered system providing heating and cooling to a portion of the home identified as an add-on.

However, if zone control is implemented with a single heating or cooling system, this is typically achieved by installing motorized dampers in the ductwork for various areas of the home. Inspection of this component is outside the scope of the standards of practice and best left to a licensed HVAC technician. If you observe this type of motorized damper, note it in the report to make the client aware of this functionality and the possibility for monitoring.

System Master Shut-Off

As the inspection moves toward the heating system cabinet, another normal operating control is the master shut-off or safety switch. A heating or cooling system isn’t an inherently dangerous piece of equipment as long as its safety features are working properly. The inspector should always note the presence of this safety feature and it is recommended it be tested to ensure the system is fully disengaged when the switch is thrown.

This safety feature is designed to turn off the electricity to the entire system in case of an emergency and/or for system maintenance. With this switch in the off position, adjusting the thermostat will no longer allow the system to operate.

- **Gas-fired systems:** The master shut-off is either near the equipment (preferably mounted on the side) or at a remote location nearby (within arm's reach), as required by code in some areas of the country. If you observe a defective switch, or the lack of a master shut-off, identify it as a recommended improvement in the inspection report or, depending on other observed conditions, a further evaluation recommendation by a licensed HAVC technician.
- **Electric furnaces:** The most important safety feature is one that applies to much of the structure: A circuit breaker. In this case, the master shut-off will typically be installed in the main electric panel. To prevent a power overload or possibly a fire, the circuit breaker will trip and shut off the system.

Figure 3.7 represents the proper configuration for a master shut-off switch on a gas-fired system. This switch (external to the system cabinet) should not be confused with the manufacturer-installed button switch located behind a system access panel. This access panel switch typically only de-energizes the fan or blower unit for maintenance when the access panel is removed.

During the internal inspection, this button switch should be noted; tested for proper operation by removing and returning the access panel. Push on the switch with the panel removed to get the fan to operate during the internal inspection.

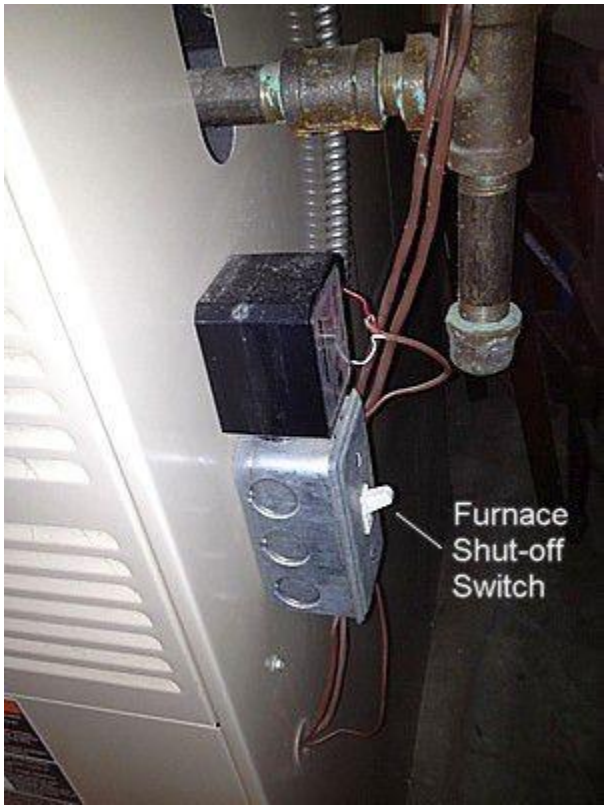

Figure 3.7 - Master Shut-Off or Remote Safety Switch

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Critical Fuel Source Inspection Components – External to the System Cabinet: Fuel Supply and Gas Piping Types

The supply fuel for gas-fired heating system can come in two forms:

- **Natural gas:** Drawn from the underground, purified, and blended before being piped to the home by the local utility company.
- **Bottled or LP gas:** LP stands for liquefied propane or petroleum and can be a single gas or a mixture of propane, butane or iso-butane.

Because of home remodels, gas-appliance change out, or heating system retrofits by non-licensed professionals, the home inspector can find a plethora of fuel piping configurations and materials. Pay special attention in this area, especially if inspecting an older Type 1 or Type 2 gas-fired system. Some dangerous health and safety observations can be made in this area and should be detailed in your report.

Note: The home inspector typically has little concern with the system piping to the meter or the meter itself for natural gas distribution. However, if a gas meter is found interior to ANY structure during an inspection, it is a safety concern. Natural gas meters typically maintain a pressure-relief valve or regulator to allow pressurized gas to escape. This regulator must be on the exterior of a structure. A natural gas meter on the interior of the home is a major concern and should be noted as such in the report.

Black Iron Gas Piping verses Yellow CSST

Typically for gas-fired heating systems (all efficiency types), the home inspector will observe 1-inch or ¾-inch black iron piping installed to carry fuel from the exterior meter or source to the heating system. This piping must be properly secured and will typically run on the underside of the floor joists (although overhead piping is not uncommon) dropping to the level of the system burner. The inspector should observe and record the type of supply piping and the adequacy to which it is secured in the report.

Since 1990, in many new construction homes, the home inspector might observe the use of Yellow Corrugated Stainless-Steel Tubing (CSST) throughout the structure or on specific sections of the structure. This flexible, semi-rigid stainless-steel tubing uses brass-attachment fittings terminating in NPT pipe fittings for integration into traditional black iron pipe systems or direct connection to gas meter systems.

Note: Let's avoid some confusion on the product. The Yellow CSST (listed above) used for gas piping runs in structures is *not* the same product as the yellow, flexible, gas appliance *connector tubing purchased in the big box stores.* I have heard many a non-professional or even a realtor refer to this type of appliance connector tubing as CSST.

Yellow CSST gas piping is used to route natural gas throughout a structure, while the flexible, short length, yellow gas tubing is specifically designed for the connection of gas appliances to the gas piping system (that's all). Some locations have code restrictions and special installation requirements.

Figure 3.8 identifies the basic visual differences between Yellow CSST and a flexible yellow gas appliance connector.

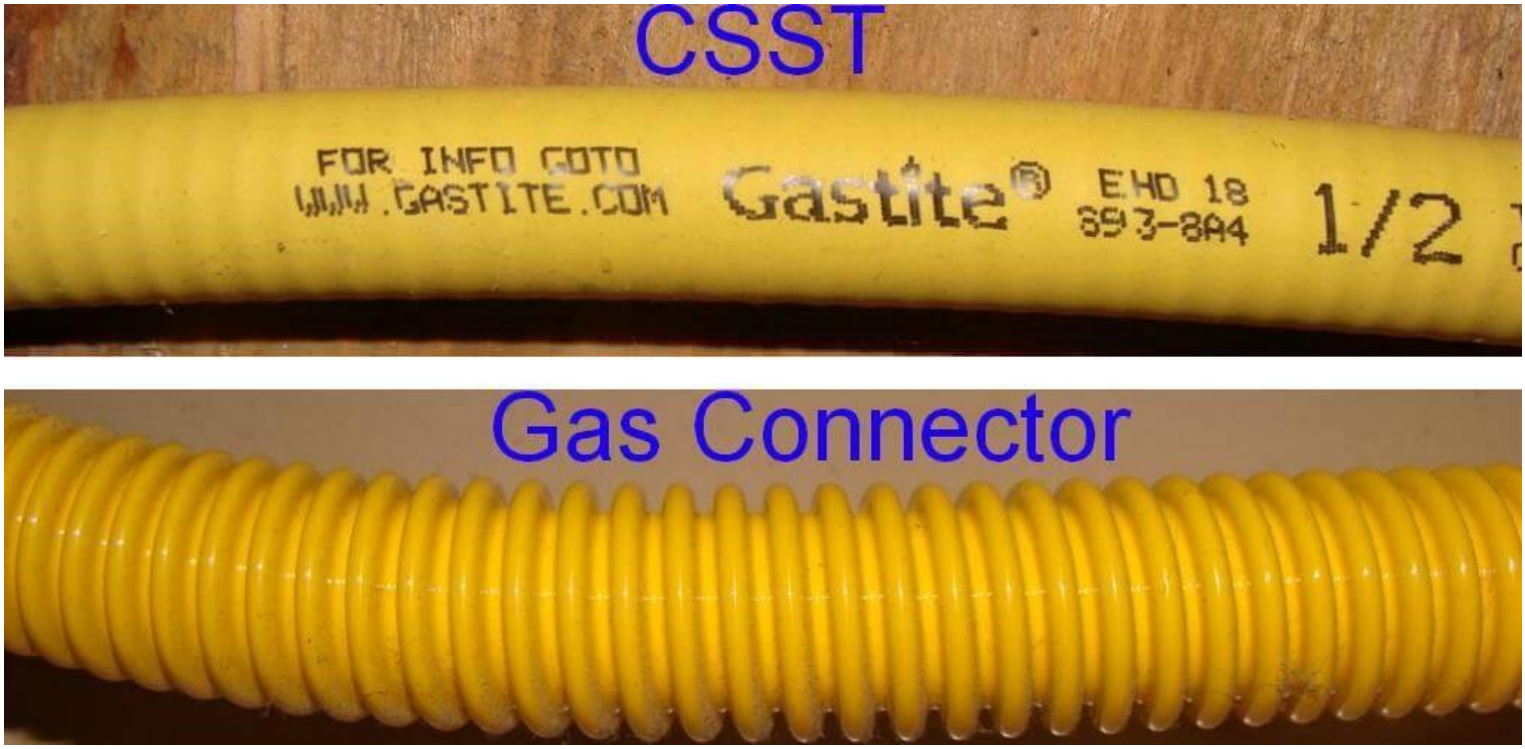

Figure 3.8 - Yellow CSST vs. Yellow Flexible Gas Appliance Connector

The fuel supply, either natural or bottled gas, and all hook-up requirements internal to the structure can easily be a highly regulated installation by location. For example, some municipalities regulate the use of Yellow CSST connectors and require a permit and fire department inspection to verify that the system has been directly bonded to the electrical grounding system.

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Caution: Short-length gas appliance connectors (jumpers) are not a substitute for gas piping (long runs) and should never be used as such. This means that if you ever see two short gas connectors (jumpers) or more (any type or length) joined together, this is an improper and unsafe installation and should be called out in your report as a safety hazard requiring change by a license plumber.

Other Types of Gas Supply Piping

It's difficult to name the many different types and configurations of gas supply piping the home inspector might observe in the field. Non-professional installers can be very creative when their only focus is to simply get the heat on. Because of these handyman installations, many inspection observations can be recorded relative to the condition in the area of the gas line installation, and many can be described as unsafe for occupants.

If any of the following gas supply piping types or connections are observed it should be noted in the report (1) as a potential improvement observation to be performed by a licensed plumber, or (2) a safety hazard as appropriate to the observed condition.

The following provides the basic guidelines for the various fuel piping types:

- **Copper piping:** May be permitted in some areas for bottled gas but also may be restricted for metered natural gas from black iron piping to appliance. If copper is observed, the proper style must be Type M (red)-rated copper for indoor gas distribution. Restrictions for its use with natural gas in some regions is related to fuel sulfur content which can cause interior flaking. If copper piping is observed and known restrictions apply to the location, identify it as a recommended improvement in the inspection report, requiring change by a licensed plumber.
- **Plastic lines (PVC or other):** Never allowed on the interior (meter to appliance) of the structure but can be allowed for underground application to the meter in some areas. If observed, report it as a safety hazard, requiring change by a licensed plumber.
- **Case iron or rubber lines:** Never allowed. If observed, report it as a safety hazard, requiring change by a licensed plumber.
- **Galvanized:** Never allowed. Cannot be used for gas lines because the zinc coating can clog the lines when it begins to flake. If observed, report it as a safety hazard, requiring change by a licensed plumber.

Heating System Gas Appliance Connection

Many non-professional installers know the requirements for appropriately sized gas appliance connectors, which either run from the entry piping (black iron) to the heating system or, more appropriately, are the jumper running from the shut-off valve to the heating system. The length of this supply connection is determined by the BTU rating of the appliance. Gas appliance connectors come in three available sizes typically referred to as low-demand, moderate-demand and large-demand connectors.

The current standard for gas connectors is ANSI Z21.24. If you are inspecting a unit that is not hard-piped to the master control with black iron piping, the recommended gas supply connection is either of the following:

- Yellow corrugated stainless-steel tubing (CSST): To bring the gas supply from the entry piping downstream of the heating system manifold and typically regulated at a maximum of 3 feet.
- Braided jacket – stainless-steel connector: To bring the gas supply from the entry piping downstream of the heating system manifold and typically regulated at a maximum of 3 feet.

Heating System Gas Appliance Connection Safety

Health and safety are a big deal when using gas-fired heating systems, and your client is relying on you to a high degree. That is why old or improperly installed gas connectors should be recommended for replacement. This is clearly an inspector's judgement, but if you observe any of the following listed conditions or connection types (supply to appliance), note it in the report as an improvement item and possibly a health and safety issue, per standard. Corrective action should only be performed by a licensed plumber.

- **Connector length:** If the observed connector on the gas-fired heating system exceeds 3 feet, note it in the report as a possible improvement item. Check local regulations to see if more than 3 feet of connection is allowed.
- **Two connector types / lengths used:** If two connector lengths and/or two connector types (e.g., flexible copper/flexible CSST) are joined together, either to create length for installation or just connected, this is a violation. This should be noted in the report as a safety violation and recommended for improvement.
- **Hard copper piping:** If the Type M (red)-rated copper cannot be verified, note it in the report as a potential safety violation and recommended for further evaluation by a licensed plumber.
- **Flexible copper piping:** May be permitted in some areas for natural gas connections between black iron and heating system, but this will be an old type of connector and could exceed the 3-foot minimum length requirement. A recommendation for improvement is a reasonable observation.
- **Flexible coated / uncoated brass:** May be permitted in some areas for natural gas connections between black iron and heating system. Coated or uncoated brass is typically very old and identifiable by either a brass color or a dull-gray coating. These may exceed the 3-foot minimum length requirement as well, and a recommendation for improvement is a reasonable observation.
- **Disappearing connector:** If an observed connector disappears (e.g., through a wall, floor, ceiling, cabinet) into a concealed location from the point of supply connection, it is an improper installation. Only proper gas supply piping (e.g., CSST or black iron) should penetrate these spaces and typically terminate with a supply valve.

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Figure 3.9 shows an improper disappearing gas supply connector. An observation of this type should be noted in the report as a safety violation and recommended for improvement, requiring change by a licensed plumber.

Figure 3.9 - Disappearing Gas Connector

Manual Fuel Shut-Off and Supply Line Drip Leg

The home inspector should observe and record, with a picture, the presence and location of a fuel supply manual shut-off valve for either maintenance requirements or an emergency. Manual shut-offs are typically located inline on the black iron piping and hopefully a gas appliance connector is used from the valve to the heating system. Failure to observe a manual fuel shut-off installed inline, (preferably in close proximity to the heating system), should be noted in the report as a safety violation and recommended for improvement, performed only by a licensed plumber.

Figure 3.10 provides an example of an improper manual fuel shut-off in black iron piping. A master shut-off was observed in close (very close) proximity to the heating system; however, the shut-off is internal to the heating system, which is an improper configuration.

Figure 3.10 - Improper Fuel Supply Manual Shut-Off

Note: As a reminder, if during the inspection the home inspector finds the fuel supply turned off or tagged out, do not turn it on. The inspector doesn't know why it is off. This condition should be documented in the report and that an operational inspection of the heating could not be performed due to fuel being shut off.

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Additionally, as part of the fuel supply for gas-fired systems, the home inspector should observe the presence of a supply line drip leg, sometimes referred to as a sediment trap. The drip leg is installed to trap sediment, metal shavings and moisture content of the fuel supply. These are configured two ways:

1. Where the gas line (black iron) turns to engage directly into the heating unit such as shown in Figure 3.11.
2. At the end of black iron or CSST supply piping, which terminates with a main supply shut-off valve, the drip leg will be below the valve and a gas connector will jump (plumb) to the heating system.

Failure to observe a supply line drip leg should be noted in the report as an improvement recommendation, to be performed only by a licensed plumber.

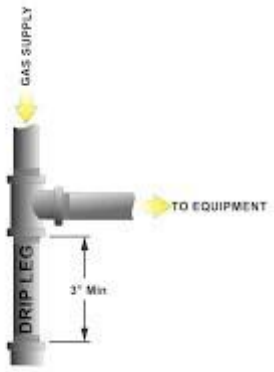

Figure 3.11 - Proper Gas Supply Line Drip Leg Configuration

Testing for Gas Leaks and LP Gas Tank Location

Clearly the most common areas to detect a gas leak is at all the connection (plumbing) points, beginning at the black iron supply pipe entering the home to the heating system. All connections (if accessible) should be tested for possible leaks, especially at all the installed gas connectors, even if the smell of gas cannot be detected. This is particularly important if conditional observations suggest a DIY installation.

Caution: If during the inspection the home inspector finds a detectable gas leak, the inspection is done. The inspector should tag the property with gas leak location details, notify the homeowner/realtor, and depart. This observed condition should be documented in detail in the report as a health and safety violation with a recommendation for further evaluation to be performed only by a licensed plumber.

Additionally, communities typically have requirements and restrictions for the location of LP gas tanks. Because of the tanks' explosive nature, they should never be inside the structure, basement or garage. Additionally, LP tanks should not be located next to the structure, under or near windows.

In general, LP gas tanks are required to be located at a minimum of 10 feet from any structure. If not, the observed condition should be documented in the report as a safety violation and improvement recommended.

Note: Bottled gas fuel can easily be a highly regulated installation. Different areas of the country and/or local ordinances can or will apply requirements and enforcement above and beyond what you will find listed in this course. Professional home inspectors should always check on his or her local codes and requirements to ensure adherence.

3.5.7 Condensate Drain Line and Trap for Heating and Cooling Systems

Sometimes the simplest components create the most problems. Most homeowners, and many home builders, give little thought to the requirements for a system condensate drain line and condensate trap for heating and cooling systems. The home inspector should look for appropriate drain piping, with a trap installed, and the availability of a gravity drain or floor drain below the level of the condensate trap during the inspection. Failure to observe these components should be reported and can result in either an improvement recommendation or possibly a safety issue based upon the extent of the conditional observation.

Type 1 and Type 2 gas-fired central systems require a condensate drain when a cooling function is present. A clogged drain line associated with an over-heat exchanger A-coil on these systems can cause unseen damage (rust and corrosion) internal to the system, and are known to seriously damage heating components if defective. It is not uncommon to have negative observations in these system types when cooling is present. For systems that are not annually maintained, too often the homeowner discovers an issue long after the rust and corrosion begin to appear on the exterior of the unit at the base.

Home inspectors must pay close attention to Type1 and Type 2 system cooling coil location when inspecting. If the system has yet to be operated in the cooling mode, there will be little evidence of a problem, and the client will be at the mercy of the inspector's experience and training. On the other hand, if the system has been operated in the cooling mode, in some cases even if only for a few months, the evidence is usually glaring. The failure of a properly operating condensation drain component can age a furnace dramatically.

Figure 3.12 provides an example of the extent of unseen damage that can occur internally to the cabinet when proper maintenance is not performed. Condensate was found leaking throughout the unit, damaging several critical components (burners, heat exchanger) and aging the system.

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Figure 3.12 - Rust and Corrosion Damage from Clogged Condensate Drain

Type 3 high-efficiency gas-fired systems produce condensate during both the heating and cooling operations. In heating mode, they produce condense water from flue gasses as the temperature drops below the dew point, therefore a properly configured condensate drain and trap is required for both heating and cooling and is absolutely mandatory. This is because the drain taps into the exhaust system. If left open to the air (trap-less), it allows for a potential exhaust or flue gas leak into the living space, creating an occupant health and safety concern.

Additionally, if not properly configured, the inducer motor would suck air through the drain, which could affect combustion and prevent proper drainage. Note that Type 3 gas-fired heating condensate is acidic, and some local codes may require the condensate to be neutralized prior to draining.

Inspection Best Practice

Your client may be totally unfamiliar with the importance and maintenance of this simple system interface component. Take the opportunity in your report to educate them on the downside of condensate trap blockage. Recommending the trap to be cleaned out annually (beginning of the cooling season) for gas-fired or electric-powered central heating and cooling systems and heat pumps is appropriate.

Condensate Trap Designs

The primary purpose of a condensate trap is to prevent air from moving in or out of the coil box or air handler during operation. Traps must be installed in a manner that will stop the air from passing through, but still allow the condensate to drain. This is a common piping mistake.

For all system types (with a cooling function), without proper trapping, air can be pulled back into the equipment causing the water to lift off the condensate drain pan, like sucking water up into a straw. This can cause internal components to become wet. Microbes in the water can become a problem if they grow on internal components. As microbes multiply, they can release spores into the airstream, raising the probability of health risks for occupants.

Equipment manufacturers often recommend a drop from the condensate pan at a minimum of 2 inches and then a minimum of a 2-inch trap seal. If the trap is outside of these parameters, look closely for signs of moisture concerns in or around the system. Anything outside of these parameters (excessively short or long) would suggest a closer observation for moisture concerns in or around the equipment. A recommendation for monitoring would be appropriate.

Figure 3.13 is an illustration from Trane installation manual which shows trap configurations most likely seen in the field, either manufactured or field fabricated types.

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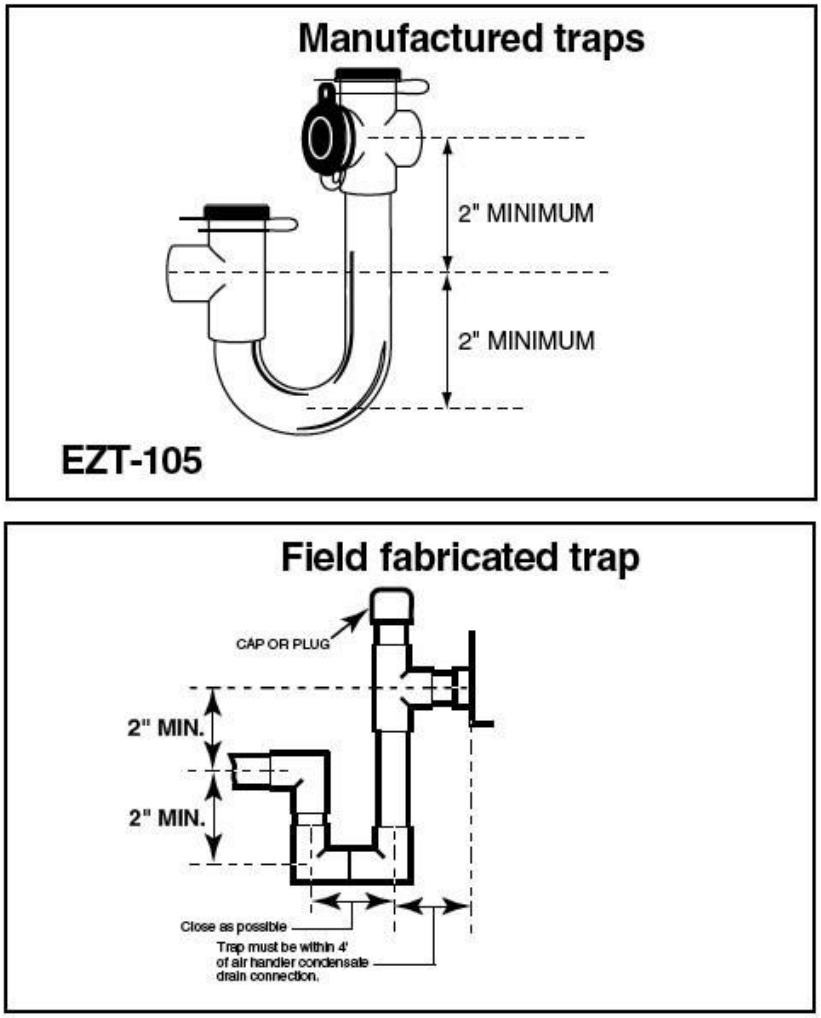

Figure 3.13 - Recommended Trap Configurations

Most likely with the introduction of the Type 3 high-efficiency gas-fired system, trap designs have improved greatly and kits are available to get rid of all those plumbing mistakes in the field. In the modern era of Type 3 systems, translucent piping for quick homeowner observation, safety float switches capable of monitoring condensate flow to prevent an overflow and shutting off equipment, and even alarm systems to promote maintenance can be observed. Home inspectors should observe and report on such modern options for the purpose of educating the client and a recommendation for monitoring would be an appropriate observation.

Figure 3.14 shows a fairly sophisticated condensate trap with clear components for observation and the addition of a safety-float switch.

Figure 3.14 - Manufactured Trap with Safety Float Switch

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Inspection Best Practice

Your client may be totally unfamiliar with the purpose and criticality of this simple external component. If you observe one that is improperly configured, an appropriate recommendation would be an improvement by installing a manufactured trap with the possible addition of a safety float switch. This relatively easy and inexpensive upgrade can be a big money-saver down the road.

3.5.7.4 Condensate Trap Common Mistakes

There are a number of piping mistakes to be observed in the field relative to the system condensate trap. The home inspector must remember that this is a critical system interface device that, if not installed or functioning properly, can cause serious problems, and degrade the system rapidly over time. Look for and report on the following:

- **Open clean-out:** A common observation on a field fabricated trap is an open clean-out (uncapped). Any open clean-out should be covered, which can be easily accomplished by installing a cap or plug as shown in Figure 3.13, field fabricated trap. An open clean-out at this location allows air to bypass the trap altogether and should be reported as an improvement item during the next service cycle.
- **Multiple unit connections:** Connecting multiple appliances to a single trap often allows air to be pulled through one or more of the appliances, bypassing the trap as well. Each appliance in the home requiring a drain should have its own individual trap.

Condensate Assist Pump

If a gravity drain (floor drain) is not available close to the heating and cooling system location, you may observe a condensate assist pump. They are common on some basement-installed systems or retrofits in older homes where the need to pump condensate to a higher drain is necessary due to lack of a floor drain.

The system condensate drains to the pump's reservoir. As the water level rises, a float switch turns the pump on and water is pumped from the reservoir, usually through flexible plastic tubing, to a safe area. Should the pump fail, or should the discharge line become blocked, a second switch will shut down the system and an alarm will sound.

A common observation with a condensate assist pump is proper installation or possibly disconnected emergency switches and alarm. Typically, this can be observed with wiring left dangling above the pump. Reporting this as an improvement item during the next service cycle would be an appropriate improvement recommendation, possibly saving the client from moisture damage should the pump fail.

Figure 3.15 identifies a typical condensate assist pump to be found in the field. These come in many styles.

Figure 3.15 - Typical Condensate Assist Pump

NOTE: In cold climates, flue gas condensate should be drained into the house sanitary drain system only, never outdoors. Local codes may restrict how to drain exhaust flue gas condensate systems.

Inspection Best Practice

Your client may be totally unfamiliar with a condensate assist pump and its purpose. If properly wired, an unfamiliar alarm can be unnerving to the uninformed new resident. If the use of one is discovered, for any system type – heating or air conditioning – it should be called out in the report to inform and educate the client on its purpose, and possible need for monitoring. These can become clogged and overflow.

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Observations Internal to the Heating System Cabinet – System Off

This section focuses specifically on the internal inspection of gas-fired heating systems, with the master shut-off / safety switch in the off position. This is where understanding the efficiency type, as was discussed in chapter two, becomes important. The overall unit efficiency type will determine the scope and depth of internal observations and reporting requirements.

Regardless of type, each will maintain a main control or combination box. The main control responds to the electric signals from the thermostat to start gas flow and ignites the system burners. For the low-efficiency and mid-efficiency Type 1 and Type 2 gas-fired systems, the home inspector does not need to concern themselves with the mechanics of the main control or combination box; however, having a working understanding of its components (limit control, pilot control valve, standing pilot or intermediate pilot, and thermocouple) is important to providing the client an informed analysis relative to the system's functionality and operation.

Figure 3.16 identifies the simplicity of the internal components of a Type 1 low-efficiency gas-fired system. While simple in design, its proper operation and maintenance dictates what remains to be observed and reported internally to the unit.

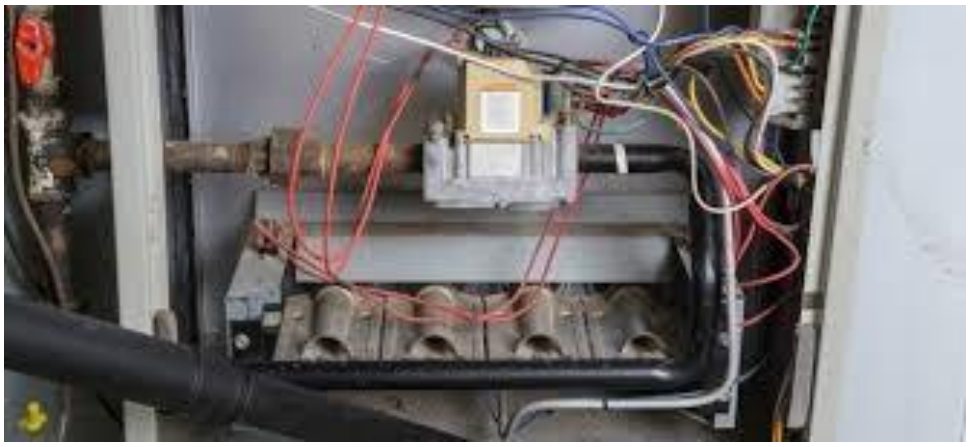

Figure 3.16 - Internals of a Typical Low-Efficiency Gas-Filled System

Before Igniting the System – Especially an Older System

Before the system is ever fired up, especially a system that has been out of operation for an extended period, conduct a critical visual analysis of its internal cabinet area, the low, middle and high sections. Conduct a general visual examination for obvious rust and corrosion because either can be an indicator of developing serious problems, such as CO production, backdraft, exhaust pipe and flue leaks, and condensation drain line clogs.

Areas of internal system rust and corrosion, all three gas-fired efficiency types (to include electric-powered furnaces), should be closely examined to determine cause and extent of damage. These observations should be well-documented in the report, with a possible recommendation for further evaluation by a licensed HAVC professional. Extensive rust observation is communicating the potential of some serious safety concerns.

Inspect the burners for signs of rust, corrosion and soot build-up. Look for indications of mechanical damage internal to the combustion chamber, displacement of components, damaged wiring, dirt on the burners, or even a little friend nesting inside. Anything that in the inspector's judgement would interfere with normal operating parameters, routine safety expectations, and/or would interfere with conducting an operational analysis of the heating system.

Figure 3.17 identifies the internal condition of a low-efficiency Type 1 system with years of handyman maintenance. Needless to say, after removing the access panel, taking basic observations and pictures to document the condition, the heating system inspection stopped. The amount of soot and corrosion (zinc oxide) observed is clear evidence of CO production and inefficient or suspect operation. The report recommended further evaluation required by a licensed HAVC technician.

Figure 3.17 - Internal View of an Aging System, Major Concern

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Figure 3.17 – Internal View of an Aging System, Major Concern Note: This quick but complete visual analysis of the internal cabinet (low, middle and high sections) prior to operation can be very critical for any system efficiency type. While Figure 3.17 allows you to reach an obvious quick conclusion and recommendation, I refer you back to chapter two and all the cooked mice. That was a relatively new installation on a vacant structure. The heat had been turned down, but the mice knew where to find a safe, warm environment. You just don't know what you might find behind that access panel until it's removed. Don't be deceived.

Internal Corrosion and the Heat Exchanger

The most critical component of a forced-air gas-fired heating system is the heat exchanger(s). While standards of practice do not require the physical inspection of the heat exchanger, it's hard to ignore giving it a good look if access is possible. Many observed operational conditions can point to potential heat exchanger issues, such as flame pattern, flame color, and excessive rust and corrosion internal to the system.

Some home inspectors carry and use an inspection mirror for inspecting the heat exchanger, however this is an unsound inspection practice due to the fact you can only observe approximately 20 percent of this component (at best) in a non-invasive inspection. Detailed inspection of this critical component is best left to the licensed HAVC professionals.

Note**:** If you are inspecting a heating system with signs of extensive internal corrosion, whereas there is an air conditioning A-coil or humidifier sitting on top of the heat exchanger, you have most likely discovered a developing major issue. The report should provide detailed photos and a recommended further analysis by a licensed HAVC technician.

Observations Internal to the Heating System Cabinet – System On

The following section focuses specifically on the internal inspection of gas-fired heating systems, with the master shut-off / safety switch in the on position. Once the home inspector has determined it is safe for an operational analysis, he or she can observe the system in operation.

Operational Inspection of Critical Components – Type 1 and Type 2 Systems

The physical inspection of the combustion chamber, gas burners, and flame patterns and color are the most critical observations when inspecting low-efficiency and mid-efficiency Type 1 and Type 2 gas-fired systems. We will detail these observations here.

Combustion Chamber / Gas Burners

The combustion chamber of the Type 1 and Type 2 systems are a semi-sealed major component, open at the bottom where the gas burners are located. Burners in older gas-fired systems come in differing designs, from star-shaped or circular, to ribbon burners or vertical tubes. However, each has in common a row of small holes or ports where the ignited fuel comes out and the flames can be observed.

Figure 3.18 provides an example of the combustion chamber for a Type 2 mid-efficiency system. Please note the proper flame color (blue) for a gas-fired systems.

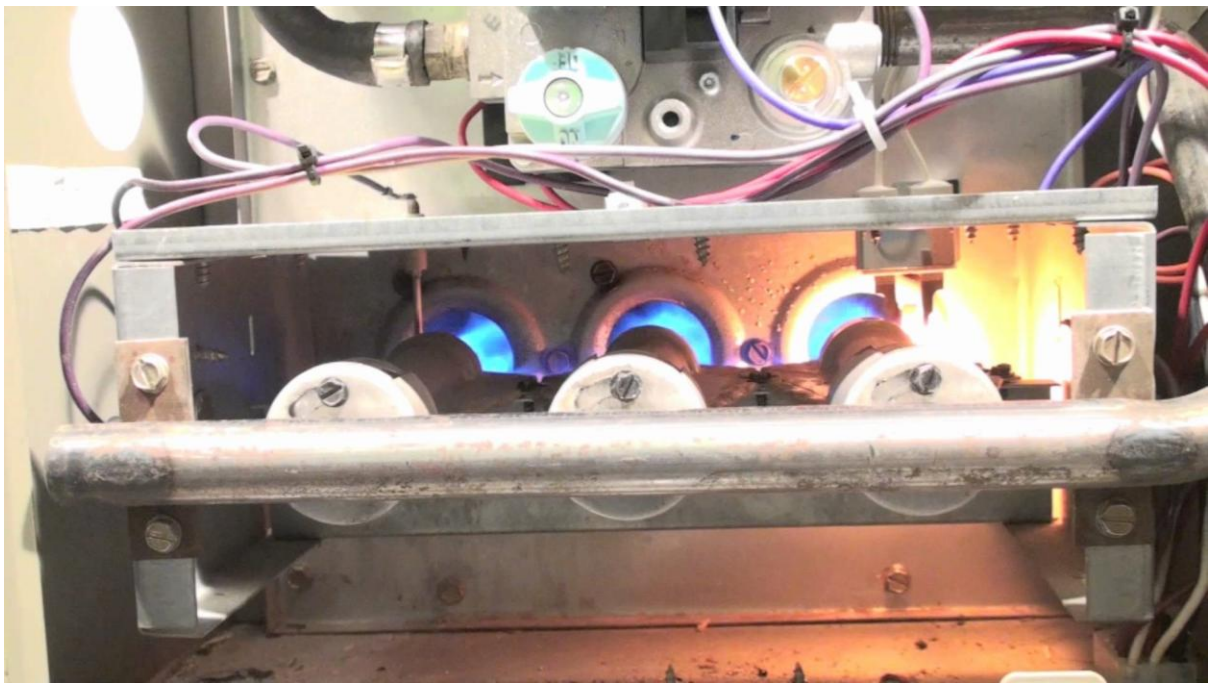

Figure 3.18 - Combustion Chamber Example

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Combustion Flame Patterns as an Indicator of Problems

Regardless of gas-fired system type, the inspector should be able to observe the operation of the combustion chamber and frames of 99 percent of the systems in the field. During the inspection of the gas burners, the home inspector should note the condition of the flames and make a judgement if the proper mixture of fuel and combustion air is present by observing flame patterns. Over time, gas burners can become corroded and their ports clogged, interfering with proper burner operation.

The following observed conditions on Type 1 or Type 2 systems will alert the inspector to potential problems to report, all of which could be classified as potential health and safety concerns with an appropriate report recommendation of further evaluation by a licensed professional.

- **Flames roaring and dancing on the burners:** This condition indicates that the flow velocity of the fuel/air mixture is greater than the burning rate. This condition allows unburned fuel to escape up the flue and creates CO due to incomplete combustion. Adjustment can be performed by a licensed technician and should be recommended.
- **Flashback or flames with a blowtorch sound:** This condition occurs when the flow velocity of the fuel/air mixture is lower than the burn rate. This condition causes soot build-up and CO due to incomplete combustion. Adjustment can be performed by a licensed technician and should be recommended.
- **Bang or pop when the burner shuts down:** This condition may be followed by burning in the burner head. This condition can represent a number of things from too much combustion of air present, a low fuel flow, or a faulty burner. Further evaluation should be recommended by a licensed HVAC professional.
- **Fluctuating flames:** If flames vary greatly during the burner operation, it may be caused by dirty burners or erratic fuel pressure. Further evaluation should be recommended by a licensed HVAC professional.
- **Floating flames:** When flames are observed as long and shapeless, and seem to float above the burners, it is usually caused by a lack of combustion air. However, it could indicate dirty burners, or a blocked flue or exhaust pipe. Further evaluation should be recommended by a licensed HVAC professional.

Caution: This condition is dangerous because flames can roll out of the combustion chamber, causing a fire hazard. Additionally, the production of CO is always a result of floating flames. This observation should be identified as a potential health and safety issue.

- **Flames rolling out of the combustion chamber:** Flame rollout is the end result of a floating flame condition, indicating that ignited fuel is spilling out of the combustion chamber. In addition to being a fire hazard, rollout can scorch other unit components, including wiring and safety controls. This observation should be identified as a potential safety hazard with further evaluation recommended by a licensed HVAC professional.
- **Flame disturbance or color change when the blower kicks on:** In heating systems, a disturbance in flame structure or changing flame color when the blower is operating indicates a potential failing or faulty heat exchanger. During this observation, flames may lift off the burner, distort or roll out of the combustion chamber. This observation should be identified as a potential major defect with further evaluation recommended by a licensed HVAC professional.

Combustion Flame Color as an Indicator of Problems

Improper flame color can rapidly communicate volumes of information during the internal operational inspection. A proper flame color should be dark blue at the source (bottom) and light blue in the middle, with a slight orange tip at the top.

Flames with yellow tips indicate dirty or clogged burners or a system operating with a lack of combustion air. However, in extreme cases, this is an indication of heat exchanger problem and/or the system is air starved and most likely emitting poisonous CO.

Note: Every professional home inspector should have in their toolbox a sniffer to locate the presence of escaping CO from the system and/or exhaust into the structure's interior. This is especially true when inspecting older low-efficiency and mid-efficiency gas-fired systems to insure and report a safe environment exists for the client.

Figure 3.19 provides a view of a semi-sealed, four-burner combustion chamber with several years of operation. Burner #2 is clearly having issues and #3 is beginning to show signs of the same. Further evaluation should be recommended by a licensed HVAC professional.

Figure 3.19 - Dangers of Observed Flame Color

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Note**:** An observed flame color other than dark blue at the bottom, light blue in the middle, with a slight orange tip at the top, is communicating a recommendation of further evaluation required by a licensed technician.

Inspection Best Practice

Due to the age and operating design of Type 1 and Type 2 heating systems, coupled with the fact that residence occupancy could be changing, clients should be advised and reminded of the importance to examine and/or reassess the quantity and type of smoke and CO detectors on the property. A standard home inspection observation should include in all reports the presence and location of smoke and CO detectors in the structure and whether they are appropriate for the new owners' safety. This is an appropriate recommendation for any home inspection.

Gas Burners – High-Efficiency Type 3 System

In Type 3 gas-fired high-efficiency systems, the combustion chamber is sealed. In most designs, there is a porthole the home inspector can use to verify ignitions and observe flame color and patterns. Any observed flame discrepancies, as listed previously, should be documented in the report as further evaluation required by a licensed HVAC technician.

Back Draft / Spillage from the Draft Hood or Diverter

For the Type 1 gas-fired low-efficiency systems, b*ack*-drafting can occur due to insufficient air flow (draft air) on the exhaust side of the unit endangering occupants. These systems use atmospheric venting relying on the natural buoyancy of warm air in the exhaust pipe, flue or chimney to carry exhaust gasses from the structure. Back-drafting is the reverse flow of gas-fired exhaust that results in the intrusion of combustion byproducts into the living space.

The presence of soot is an indication of back-drafting, although its absence does not guarantee that back-drafting has not occurred. Improperly configured exhaust pipes or flues, flue or chimney blockages; exterior location and clearance requirements can also cause back-drafting. Combustion gasses that back-draft into a house may leave a dark residue on the top of system components at the exhaust point. Any evidence of back-drafting should be reported as a health and safety hazard in the report.

Figure 3.20 provides an example of a system with a draft hood and how to perform a back-drafting test:

- **Simple test:** Hold a lit match or lighter beside the draft diverter to see whether there is sufficient draft to pull the flame in the direction of the flue.
- **Best test:** Use a sniffer or carbon monoxide analyzer to test for back-drafting.

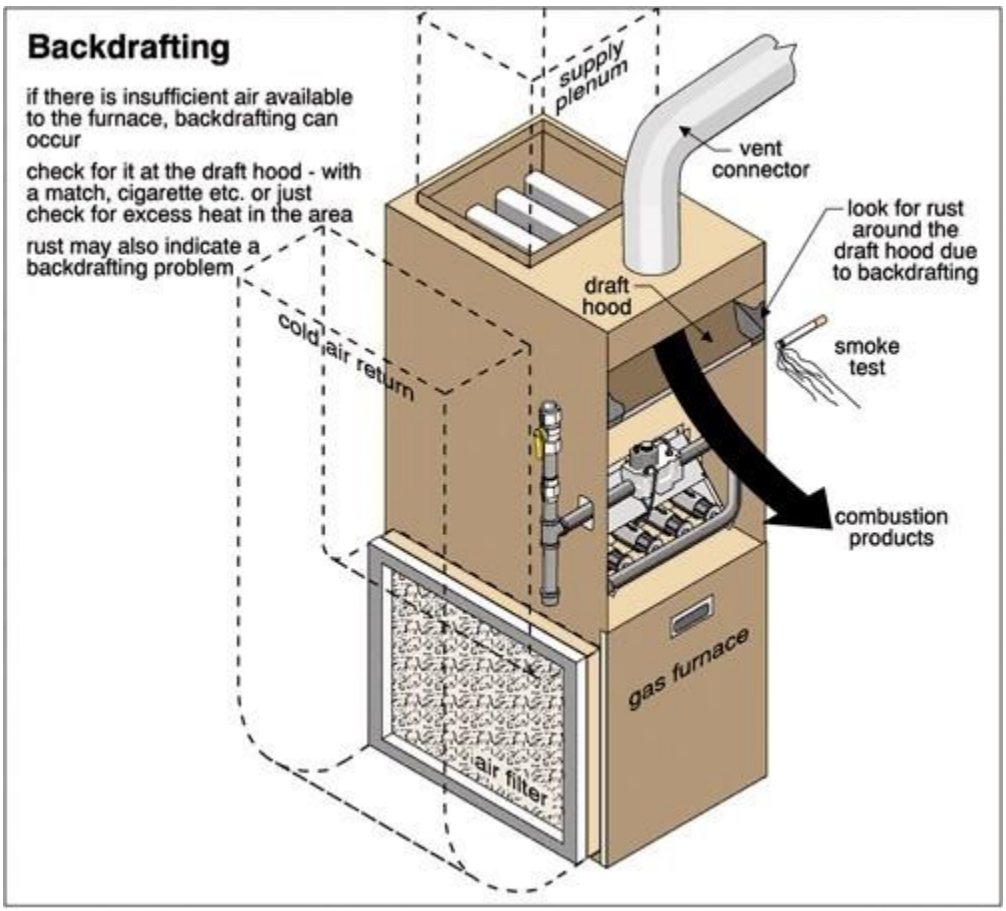

Figure 3.20 - Testing for Backdraft

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Inspection Best Practice

In the case of paired vented appliances, (e.g., gas water heater and furnace using the same exhaust or flue), the draft hood of each appliance should be tested for excessive spillage. Generally, this is spillage that occurs for more than 60 seconds after ignition. If this occurs, shut off the power to the furnace and report the condition as requiring further evaluation by a licensed HVAC technician.

Blower Unit

All gas-fired system types maintain a blower unit containing a circulating fan and fan motor. Its purpose is to draw return air, push it through the heat exchanger(s) area, and send it out through the supply ducts as heated air.

Most circulating blower units are squirrel cage impellers, where the fan blades are on the interior surface of the cylinder that spins in its casing. The blower unit should be observed, noting the type, and if wobbling and/or squealing occurs at start up and stop. This condition can be a sign of loose mountings or worn bearings. Examine the inside of the squirrel cage to see if it is clean and no blades are broken or missing.

Note: Some home inspection software programs require the identification of the type of blower unit drive, either direct-drive or belt-drive, and the air filter type and condition, typically located within very close proximity to the blower unit. This is good information for the client to have relative to maintenance. The two blower types are:

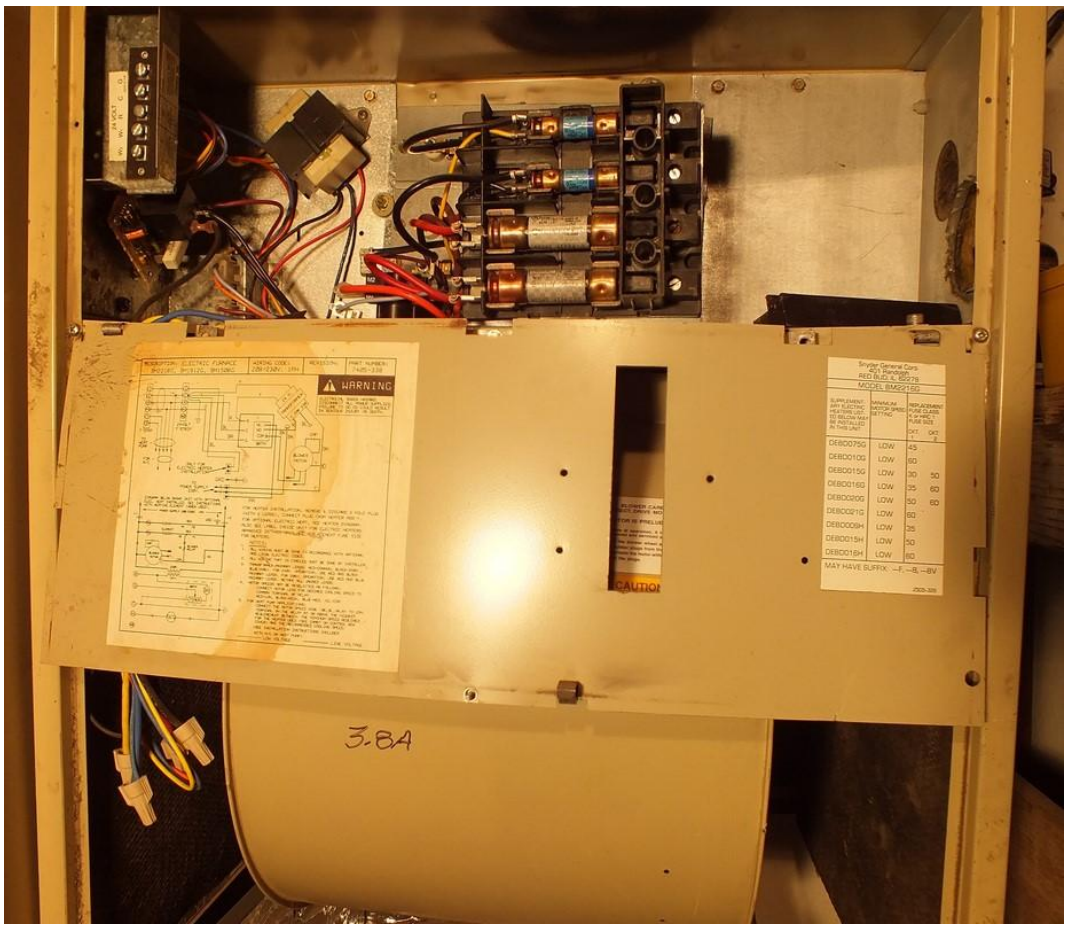
- **Direct-drive blower unit:** Has the fan motor mounted within the fan casing. Failure would require replacement by a licensed HVAC technician.
- **Belt-drive blower unit:** Typically, on older systems, has the motor mounted on the outside of the fan casing. It is driven by a pair of pulleys and a belt. Belt slippage or breaking can occur and maintenance can be performed by the homeowner.

Internal Inspection of an Electric-Powered Furnace – Heat Mode

The internal inspection of an electric-powered furnace in heat mode is less extensive than that for gas-fired systems due to the operational nature of the system and components. Perform the same basic visual examination for overall system condition but remember with this system you are dealing with 240 volts. After removal of assess panels – hands in pockets.

Removing the manufacturer-provided access panels allows for viewing internal components and a number of electrical connections. Inspecting for rust and corrosion on electrical components due to a clogged condensate line is always recommended.

Figure 3.21 is of a fully operational electric-powered system with signs of an internal condensate overflow. If allowed to go unchecked (no annual maintenance) extensive damage and eventual failure will occur.



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Electric-powered furnaces are characterized by one to three heavy-duty wire circuits. Each circuit is typically 5 kilowatt and the furnace may have from two to six heating elements, usually Nichrome wire, a high-temperature wire. The elements are controlled by contactors or sequencers which turn the elements and the circulating fan on to distribute heat throughout the structure.

Electric-powered furnaces use high-temperature limit switches for safety to shut off the elements if the temperature exceeds a preset number, typically 145 degrees F. The temperature limit responds to over-temperature conditions in the air duct. The system will shut down when the temperature exceeds the rating and automatically resets when the temperature drops.

For electric-powered furnaces, the inspector should conduct an operational analysis observing for normal operating parameters, response to controls, and the following possible conditions:

- **Limit operation:** If the temperature limit trips, the electric heater relays will be de-energized and the fan relay will be energized. Once the limit resets, the control will resume normal operation. If the limit trips four times during a single call for heat, the control will go into aa 1-hour soft lockout.
- **Soft lockout:** During the soft lockout, the fan relay will respond to thermostat inputs but the heater relays are disabled. If the control detects a limit trip during the soft lockout, the control will go into a hard lockout.
- **Hard lockout:** Once in a hard lockout, the fan relay is locked on and the heater relays are disabled. Turning the power to the unit off and then on will reboot this state.

Note: This limit of operation can be similar to the short-cycling condition found in gas-fired systems indicating an abnormal condition. The important thing to note during operation is if you observe an electric-powered furnace in heat mode repeatedly tripping the circuit breakers; the obvious report recommendation is further analysis required by a licensed HVAC technician.

Temperature Rise – All System Types

Although not a requirement of the standards of practice, some home inspectors, when dealing with suspect systems, go the extra mile and perform a temperature rise test. Temperature rise is the difference between the temperature of the return air and the heated supply air on any heating system. Ideally, it is first tested during installation, but the performance of a temperature rise test during an inspection will report to the overall continued efficiency of the system or identify if a system has degraded significantly.

The system's temperature rise parameters are listed on its data plate. This is important not only for the longevity of the system but also for customer comfort. A system operating outside the manufacturer's parameters suggests a much deeper analysis must be performed by a licensed HVAC technician.

Basic Temperature Rise Testing

The following procedure is for performing a temperature rise test using a laser pointer thermometer:

- Allow the system to operate for at least 15 to 20 minutes so the house can come to some form of equilibrium (the air and heat have had a chance to blend in the house and ductwork).
- Obtain the system temperature rise data from the system data plate. If this information is not available, you can still report the test results, but understanding if the test results are within specific system or model parameters may be difficult.
- Record the temperature of the return air into the furnace and then record the air temperature of the supply air leaving the furnace. The supply air temperature should be taken about 6 feet away from the furnace so as to not pick up *radiant heat* from the heat exchanger.
- Subtract the return air temperature from the supply air temperature to obtain the temperature rise through the unit. Hopefully your test number falls within the high and low temperatures listed on the data plate.

Generally, systems identify 35 degrees F (low-end) to 65 degrees F (high-end). Some conclusions to be reached from this test are:

1. If the system is operating toward the low-end, the air coming off the system is going to feel cool; the structure could feel drafty, or simply not warm. An indication of lost efficiency.
2. If you are below the low-end, this could be an indication the primary heat exchanger has a rusting out / leaking issue.
3. The truly important number is the high-end number. When near the high-end, the system is likely to start cycling on the limit control. This is an indication the system is reaching an over-heating condition and will cause problems with the heat exchanger and other components.

A temperature rise test allows you to report basic system performance at the time of inspection. Results below the low-end or nearing the high-end should be a report recommendation of further analysis required by a licensed HVAC technician.

Chapter Three Summary

In chapter three, we discussed the physical and functional inspection requirements for gas-fired and electric-powered heating systems, internal and external to the system cabinetry, power on and power off, to include basic inspection test which can be performed for client confidence.

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CHAPTER 4: CENTRAL AIR-COOLED AIR CONDITIONING

Chapter Overview

Topics

- Cooling system component definitions and inspection key terms.
- Air-cooled air-conditioning.
- Professional inspection standards of practice for cooling systems.
- Cooling inspection guidelines, requirements and inspection best practices.
- Understanding the basic components of the central air system.
- Observing and inspecting outdoor components.
- Observing and inspecting indoor components.
- The standalone air-cooled system and through-the-wall units.
- Inspecting air-to-air heat pumps.

Learning Objectives

- Understand cooling system inspection key terms.
- Identify basic observation and action guidelines and requirements of the cooling inspection.
- Understand the components of air-cooled air-conditioning and the refrigerant cycle.
- Describe the inspection requirements for air-cooled air-conditioning.
- Understand the inspection requirements for standalone systems, through-the-wall units and air-to-air heat pumps.

Chapter four will bring the heating and cooling system inspection full circle by looking at the inspection guidelines and requirements for the cooling system, typically referred to as central air conditioning. It will include inspection of heat pump systems and, as always, include some inspection best practices.

It provides an overview of what to inspect per standards of practice, including standard observation requirements, specific inspection actions, what to describe in the inspection report, and special cautions for both the inspector, client and property.

Definitions and Glossary of Italicized Inspection Key Terms

Upon completion of this course, the student should be familiar with the following terms:

Auxiliary condensate drip pan: Typically used where an evaporator coil is located in an attic or anywhere above finished living space. Installed as backup protection for leaks in the main condensate line and tray.

Auxiliary condensate line: A secondary condensate drain typically used where an evaporator coil is located in an attic or anywhere above finished living space.

Central air conditioning: The most common central cooling system is a split system, which includes an outdoor unit containing a condenser coil and compressor, and an indoor evaporator coil, usually installed in conjunction with the central furnace or air handler.

Compressor: An air conditioner works by transforming a refrigerant compound from a gas to a liquid and back again in a continuous cycle. Air conditioners consist of four basic mechanical parts: a compressor; condenser; expansion valve; and evaporator. In residential construction, the compressor is the outdoor unit of the cooling system.

Condenser: A condenser unit used in central air conditioning systems typically has a heat-exchanger section to cool down and condense incoming refrigerant vapor into liquid; a compressor to raise the pressure of the refrigerant and move it along; and a fan for blowing outside air through the heat exchanger section to cool the refrigerant inside.

Describe: To identify (in writing and/or photo) a system or component by its type or other distinguishing characteristics.

Evaporator coil: The evaporator coil (sometimes referred to as an A-coil because of its shape) works with the indoor unit, functioning with the air conditioner or heat pump to cool and condition indoor air that flows over it by drawing out heat and moisture. An evaporator coil is located indoors and is either installed on the furnace unit or as part of an air handler.

Expansion valve: Sometimes called a metering device, thermal expansion valve (often abbreviated as TEV, TXV or TX valve) is a component in refrigeration and air conditioning systems that controls the amount of refrigerant released into the evaporator, thereby controlling superheat.

Heat pump: A mechanical-compression cycle refrigeration system that can be reversed to either heat or cool a controlled space. Heat pumps do not generate heat from a fuel source. Instead, they use electricity and refrigerant to transfer heat from outdoor air to the interior living space. Heat pump systems operate on electricity and are ideal for homes in moderate climates. Installation for this type of system typically consists of two parts: An indoor unit called an air handler and an outdoor unit similar to a central air conditioner, but referred to as a heat pump.

Inspect: The process of examining readily accessible systems and components by (1) applying this standard; (2) operating normal operating controls; and (3) opening readily openable access panels.

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Inspection best practice: An inspector-developed process or procedure acquired through experience and over time. Best practices not only have the client in mind but also include safety components of the inspection to protect personal safety and property.

Installed: Attached such that removal requires tools.

Non-invasive examination: A conservative examination of the heating and cooling system and components that does not require the removal or disassembly of components beyond the removal of readily accessible panels to perform a visual / functional examination.

Operational confidence check: A simple, non-technical operating-parameters check that can be performed to ascertain proper operation without going into deep testing mode.

R-22: A colorless gas refrigerant (commonly referred to as Freon). Previously, the standard for systems manufactured before 2010, is now phased out and only available in recycled or stocked piled quantities. Scientifically referred to as chlorodifluoromethane or difluoro monochloromethane is a hydrochlorofluorocarbon (HCFC).

R-410a: A chlorine-free gas refrigerant (commonly referred to as Puron). Since January 1, 2010, all manufacturers are required to use R410a refrigerant exclusively in all charged central air conditioners and heat pumps. This new refrigerant replaces R-22, which was commonly used prior to the development of chlorine-free R410a.

Readily accessible components: Visually accessible heating and cooling system components, including mechanical equipment such as flues, pipes, ducts and cabinets, and includes inspection of components located behind and through the removal of manufacturer-designed access covers and panels.

Readily openable access panel: A panel provided for homeowner inspection and maintenance that is readily accessible, within normal reach, can be opened by one person, and is not sealed in place.

Refrigerant: Refrigerants are what makes air conditioning possible. Contained within the coils of an air conditioner, these liquid agents cool and dehumidify indoor air. For years, the most common refrigerant used in air-conditioning systems was R-22 (Freon). In response to growing environmental concerns, production of systems using R-22 refrigerant is being phased out, replaced by R-410A chlorine-free, ozone-friendly refrigerant.

Refrigerant cycle: The typical vapor compression, vapor absorption refrigeration cycle, the common method for transferring heat from a low temperature to a high temperature.

Reversing valve: A component in a heat pump that changes the direction of refrigerant flow. By reversing the flow of refrigerant, the heat pump refrigeration cycle is changed from cooling to heating or vice versa.

Seasonal energy efficiency ratio (SEER2): The efficiency of air conditioners is often rated by the seasonal energy efficiency Ratio (SEER2) which is defined by the Air Conditioning, Heating, and Refrigeration Institute in its 2008 standard AHRI 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment. The SEER2 measures air conditioning and heat pump cooling efficiency, which is calculated by the cooling output for a typical cooling season divided by the total electric energy input during the same time frame. A SEER2; rating is a maximum efficiency rating, similar to the miles per gallon for your car. Your car might get 28 miles per gallon on the highway, but if you're stuck in city traffic it could be lower. If your air conditioner is 21 SEER2, that's its maximum efficiency.

System: A combination of interacting or interdependent components, assembled to carry out one or more functions. When used, references the heating and cooling system as a whole, both interior and exterior to the home or structure. All parts, pieces and components required to make up the functional system installed to heat and cool the structure.

Standards of practice: A predefined list of the systems and components to observe, inspect and report on, as determined by professional associations for the conduct of the heating and cooling inspection.

System lifecycle expectancy: A conservative estimate – not a guarantee – of the heating and cooling system lifecycle expectancy reported to the client based upon observed condition, physical state, serviceability, functionality, and actual researched system age.

Technically exhaustive: An investigation that involves dismantling, the extensive use of advanced techniques, measurements, instruments, testing, calculations, or other means.

Temperature differential test: The purpose of this test is to evaluate whether or not an air conditioning system is operating correctly by measuring the temperatures of both the air intake side and the exhaust side of the unit in the adjoining room(s). The majority of problems found with cooling units result from inadequate ventilation on the exhaust (back) side of the unit; therefore, taking these measurements is critical in ensuring the optimal performance of the product while minimizing operation costs. Standards vary but an approximate 12-degree temperature differential between the inlet air temperature and the outlet air temperature on the evaporator (front) side of the unit should be observed.

Through-wall AC unit: Standalone units, typically found on a seasonal sun porch or enclosed patio, permanently mounted in the wall, providing zone cooling. They install on a slide-out chassis (sleeve) and vent through the sides and back of the unit. These are inspected for proper condensate drain ensuring clogged or improper drainage is not damaging structure components.

Visual examination: A non-invasive examination of the heating and cooling system and components for the purpose of rendering a judgment by a home inspector. This judgement considers the observed condition (both durability and serviceability) of readily accessible components. It encompasses the inspector's determination of whether an observed condition is merely interesting, important, very important, or even critical. In other words, might the observed condition present a safety concern during operation or be material to the buyer's purchase decision.

Air-Cooled Air-Conditioning

Air-cooled air-conditioning, commonly referred to as central air conditioning in residential applications, operates in conjunction with forced warm-air systems, utilizing the blower unit or air handler, duct system and condensate drain as common system components. An air-cooled system can operate as a standalone system if the structure heating does not utilize a gas-fired or electric-powered heating system, with its own blower and ductwork; however, the inspection requirements are basically the same.

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As discussed during the residential heating inspection, the average homeowner knows little about their system. Too often most will discover they have an issue when warm or cool air stops coming out the room registers, discovering it's time to call a technician. Therefore, a complete visual examination of the air conditioning side of the system is very important.

During the inspection of the central air system, the home inspector should, at a minimum, identify the type of system, determine its age, and estimate its remaining useful life / need for servicing. The inspector should make a determination as to whether to operate the system due to observed condition or seasonal factors.

Note: From a system operational inspection perspective, the operation and functionality of the heating system is most likely more critical to your client. But inspection conditions, test parameters, time of year, and outdoor environment can suspend the operation of the system and only allow it to be operated in a single mode (heat or cool). This should be considered when reporting to your client and any restrictions / limitations clearly documented.

Professional Inspection Standards of Practice

American Society of Home Inspectors (ASHI) *Standards of Practice* (updated 1-8-2026) for Air Conditioning (cooling) inspections are included below from the most recent revision. These topics, as applied to system and component evaluations, will be explained in further detail. ASHI's Standards of Practice objectives include the promotion of excellence within the profession, and the continual improvement of its members' inspection services to the public.

The ASHI Standards of Practice for Home Inspections simply guide home inspectors in performing their inspections. The experienced home inspector utilizes the standards of practice to define their own inspection routine and procedures to inform the client and provide value in the buying decision.

The ASHI Standards of Practice for air conditioning are as follows:

The inspector shall:

A. Open readily openable access panels.

B. Inspect:

   1. Central and permanently installed cooling equipment.

   2. Distribution systems.

C. Describe:

   1. Energy source(s).

   2. Cooling systems.

The inspector is NOT required to:

A. Inspect electric air cleaning and sanitizing devices.

B. Determine cooling supply adequacy and distribution balance.

C. Inspect cooling units that are not permanently installed or that are installed in windows.

D. Inspect cooling systems using ground-source, water-source, solar, and renewable energy technologies.

Cooling Inspection Observation, Reporting Action Requirements, Best Practices

As previously stated, ASHI Standards of Practice guide home inspectors in performing the inspection. This guidance is executed in the form of inspection observation training and skills, to include specific inspection actions developed by the professional over time. The inspection routine is in the form of visual examination.

The overall objective to the inspection is to relay confidence to the client that the functional system – readily accessible components – are in fact in good working order (at the time of inspection) in the inspector's judgement.

Any unsafe conditions relative to normal, day-to-day operation and/or potential imminent hazards reported due to observed condition (either in a static or operated condition) should be identified in the report to include the observed condition, possible hazard, plus recommended action to avoid the hazard. This is all done through non-invasive examination and specific actions to identify deficiencies in the system, clear descriptions of those observations and actions, and a physical report to the client.

Note: The cooling system inspection as performed in accordance with standards of practice never requires a technically exhaustive analysis. Leave that to the licensed HVAC professionals; in many cases of observed discrepancies, this will be the actual recommendation to the client in the inspection report of further evaluation recommended.

Observation Requirements and Reporting Guidelines

Aligning to standards of practice, including inspection best practices gleaned over time, the professional inspector should observe with a critical eye and report on the following on the overall home cooling system and components:

- Observation of permanently installed cooling system including central air conditioning equipment and components (indoor and outdoor units), through-wall AC units, and normal operating controls.
- Observe distribution systems to include ducts, piping with supports, dampers, piping insulation, and fan or blower units.

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Reporting Action Requirements and Guidelines

Aligning to standards of practice, to include inspection best practices gleaned over time, the professional inspector should take the following specific actions to report on the condition of the home cooling system and components:

- Operate the system using normal system functions and controls or report failure to operate the system and reason why.
- Open readily assessable panels and compartments provided by the manufacturer.
- Record the system type: Central system; standalone system; through-the-wall unit.
- Record the presence of a cooling source or register in each room.
- Record the manufacturer's name, model, and serial number(s).
- Research and record an estimate of the system's age and estimated remaining useful lifecycle.
- Research and record the existence or nonexistence of a system or product recall from the Consumer Products Safety Commission (CPSC).

Standards of Practice Typically DO NOT Require Actions for the Following

- Observing window air conditioners.
- Uniformity or adequacy of cool-air supply to each room.
- Operating a system that is shut down or does not respond to normal operation controls.
- Operating a system when observed conditions suggest possible equipment, structural or safety harm will result.

Understanding the Components of the Central Air Conditioning System

While the standards of practice provide an outline or guide of what is to be inspected and reported on, a greater understanding of the system components is required. For the cooling inspection, there are fewer components to observe, examine and report on than in the heating system inspection and the majority are sealed from performing an actual physical examination. There are two main (high-level) components, internal and external to the structure which houses the critical operating components of the system. We will discuss these, as well as their proper operation. The overall system is configured as follows:

- **Outdoor unit:** Housing the compressor, condenser, coils and fan.
- **Indoor unit:** Plenum unit housing an expansion device, evaporator coils, condensate tray and condensate line drain.
- **Refrigerant lines:** System plumbing connecting the outdoor and indoor components for circulation of vapor (gas) refrigerant and liquid refrigerant.

The Refrigerant Cycle

Four main system components are required for the effective operation of the refrigerant cycle: The compressor; a condenser; an expansion valve (metering device); and an evaporator. These components are connected in a sealed system in two locations, which are not inspected in detail; however, they are observed operationally. The system also includes a means of removing heat from the condenser and a means of circulating air across the evaporator and through the structure.

The sealed system (plumbing) contains a refrigerant (also called a coolant) that changes from liquid to gas and back to liquid during the system operation cycle. Until a few years ago, many residential air conditioning systems sold in the United States used the refrigerant chlorodifluoromethane, usually referred to R-22.

R-22 is one of a number of gasses marketed under the brand name Freon. *Freon* is a registered trademark of the Chemours Company. Depending upon the compressor's age and/or last service, the system under inspection could contain R-22, but this will be unknown to the inspector.

Note: R-22 is an extremely effective coolant, making it popular among HVAC manufacturers for many years. However, it was discovered that it causes damage to the ozone layer, and that it is also a powerful greenhouse gas. This is why, in 1987, the United States agreed to an international accord that would call for the reduction of HCFC (hydrochlorofluorocarbon) production beginning in 2004. R-22 is one of the products affected by this agreement. It remains available but is highly expensive.

Figure 4.1 shows the basic operating principle of the refrigerant cycle as follows.

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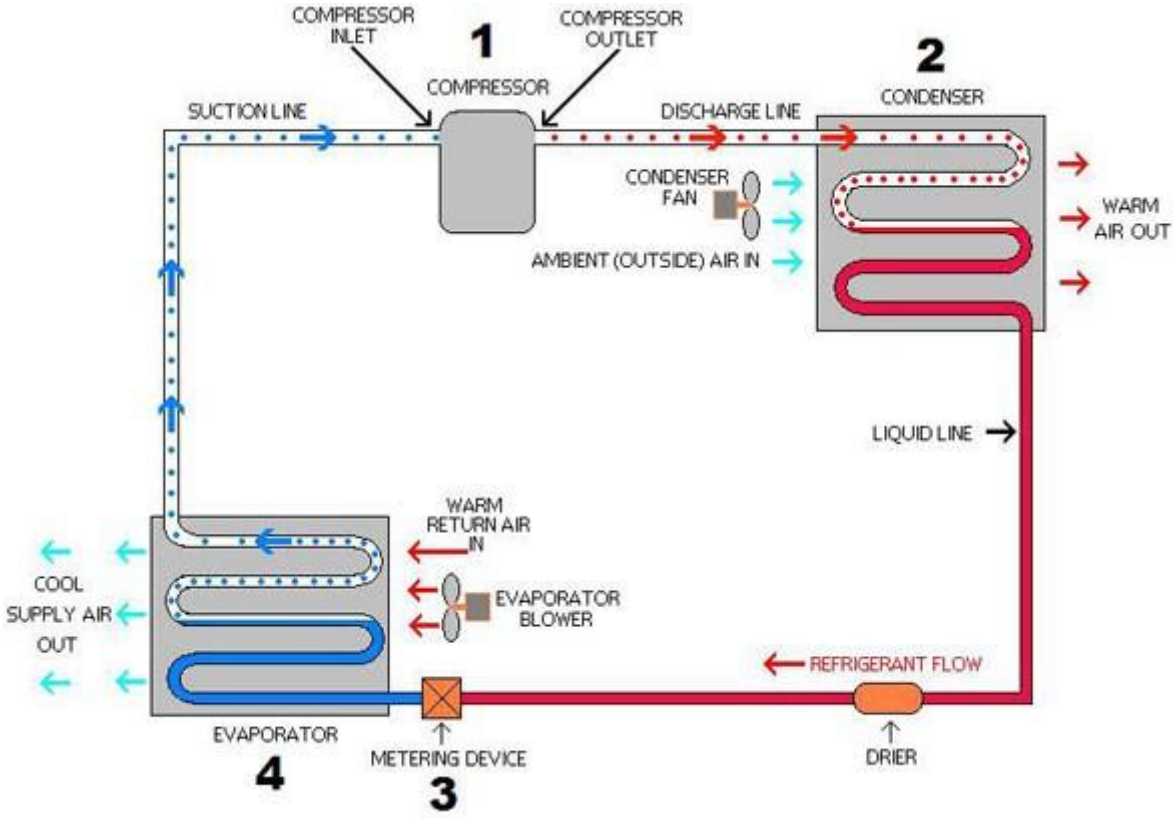

Figure 4.1 - The AC Refrigerant Cycle

- **Gas heats up as it is pressurized:** Figure 4.1, Component 1, the compressor (outside air handler) increases the pressure of the refrigerant when in vapor (gas) state; the temperature rises, making it capable of giving off heat. The compressor is the heart of the system; it keeps the refrigerant flowing through the system at specific flow rates and specific pressures. It takes refrigerant vapor from the low-pressure side of the plumbing and discharges it at a much higher pressure into the high-pressure side of the plumbing.
- **Heat is removed from the gas – turning the gas to liquid:** Figure 4.1, Component 2, condenser. The red dots inside the piping diagram represent discharge vapor. The solid red color represents high-pressure liquid refrigerant. As the pressurized vapor circulates through the condenser coils, heat is removed by means of a fan (air-cooled function), and the vapor condenses to a warm liquid that is under high-pressure.

Most air-cooled refrigeration systems are designed so that the refrigerant will condense at a temperature of about 25 to 30 degrees F above the ambient air temperature around the condenser.

- **Liquid cools as pressure drops:** Figure 1, Component 3, Expansion/Metering Device. The high-pressure liquid passes through an expansion/metering device, (pressure reducing device), causing its temperature to drop below room temperature.

The device is the dividing point between the high-pressure and low-pressure sides of the system and is designed to maintain a specific rate of refrigerant flow into the low side of the system. When the high-pressure liquid refrigerant passes through the metering device, its pressure will drop to a low-pressure that will be equivalent to about 10 to 15 degrees F below the design temperature of the evaporator. It starts evaporating immediately.

- **Liquid absorbs heat and turns back into gas:** Figure 1, Component 4, the evaporator (A-coil on central air handlers). There will be relatively warm air flowing over the evaporator coil. As the liquid refrigerant passes through the evaporator coils and absorbs heat from air passing over the coil, the result is cooling of the air. As the liquid absorbs heat, it returns to cool low-pressure gas and the cycle begins again.

The system blower circulates the cool air throughout the structure. Condensate is a byproduct in the evaporator, collected in the condensate tray and discharged through the condensate line and trap to a gravity drain.

Refrigerant Concerns vs System Upgrade

The EPA has approved several new coolants, the most popular of which is R-410a, commonly marketed under the brand name Puron. Many cooling systems currently utilizing R-22 can be adapted to use R-410a however, some of the system's parts will have to be replaced, and adding new components to old on a cooling system is questionable; there are many variables in such an option, the most concerning being the actual system age.

System upgrade is not a condition or observation that would be formally documented in an inspection report. However, more times than not it can be a follow-on discussion with the client seeking an opinion from a home inspection. This situation can be a difficult subject to approach and a recommendation of replacement or upgrade is not the inspector's job; however, it is their job to ensure that the client is informed.

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Therefore, cost studies have shown the most advisable option is to simply replace the existing outdoor unit with a new one designed to use R-410a, or other permitted coolants. While this is the most costly option in the short term, data shows that other options (i.e., purchase of R-22 or conversion of the system to utilize R-410a), prove to be more costly in the long run. Report and discuss wisely.

Inspecting Outdoor Cabinet and Components

The general condition and operation of the outdoor unit components, electrical connections and plumbing are all observed, examining inside and outside for defective operation, dirt, noise, unrestricted air-flow and location restrictions, condensate restrictions, leveling, elevation, signs of leaking, determining age, and estimating remaining system lifecycle expectancy.

Note: There are two general "Do Not Operate" rules for the conduct of the cooling system operational inspection:

1. Do not operate the cooling system if the outside temperature is less than 65 (some say 60) degrees (at the time of inspection), and/or has been 48 hours prior.
2. Do not operate the cooling system if it is shut down. Manufacturers typically recommend before restarting at the beginning of the season that the power be turned on 24 hours before start-up to allow the compressor heater time to warm the oil.

In either of these cases, which could potentially damage equipment, note this restriction / limitation information in the report to notify the client of conditions that prevented the operational inspection.

Figure 4.2 provides a cutaway view of a typical cooling system compressor (outdoor unit).

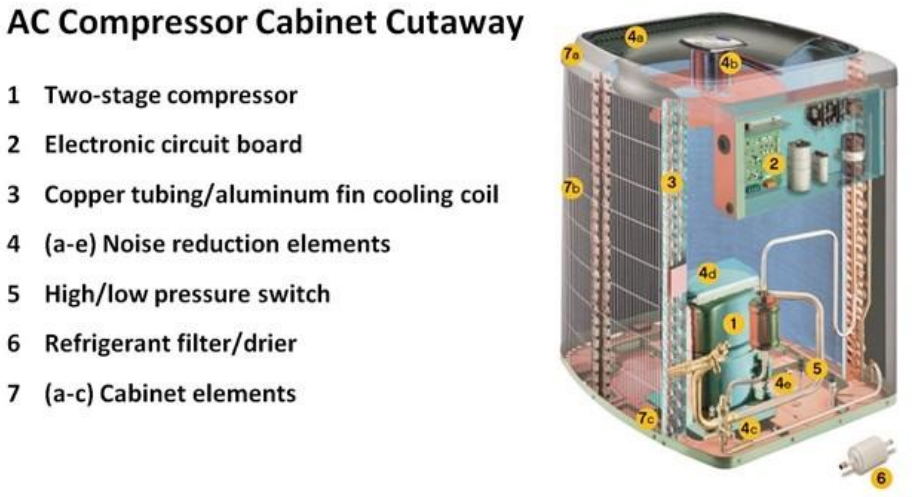

Figure 4.2 - Typical Compressor Cutaway View

Observation and Reporting Requirements – Outdoor Components

When inspecting the outdoor cooling system components you will observe and report on the following:

- **Estimating age:** As detailed in chapter one, estimating age is performed using the manufacture, model and serial number and the Building Intelligence Center website for accurate information. You will estimate the age and remaining useful life expectancy of the compressor unit (outside).

Most central cooling systems have an operational life of 12 to 15 years, with the compressor lasting about 10 to 15 years; however, many are in service that are much older. In the Sun Belt, due to increased use and environmental conditions, these estimates can be significantly reduced. Regardless of regional location, a central cooling system observed with more than 15 years of age should be reported as an item most likely needing replacement within five years.

- **Operation:** Observe the operation of the outdoor components, listening for groans or squeals and short cycling. The compressor should run smoothly, so any unusual sounds or noises indicate a problem. The system should go off and on only in response to the thermostat – not on and off repeatedly. If you observe any of these conditions, recommend further evaluation by a licensed HVAC technician.
- **Air flow:** The outdoor cabinet requires sufficient air to breathe, typically on all four sides (three for sure). There should be a minimum of 12 inches of side clearance from foliage or structure and 4 to 6 feet of clearance directly above. Any observed airflow restrictions should be reported as an improvement recommendation in the report.

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- **Unit location:** The cabinet should be located where there is a minimum of direct sunshine, or if in direct sunlight should be shaded if possible. This is because a cooler air flow over the interior components (condenser), results in a more efficient refrigerant cycle. Any observed location issues should be reported as an improvement recommendation in the report.
- **Unit leveling:** The cabinet should be level, slightly elevated (3 inches minimum) off the ground to avoid standing water, preferably mounted on a concrete pad, and securely fastened. Excessive settlement of the concrete pad (or unit if directly on the ground) from operation can damage refrigerant lines, causing them to fracture and leak. A 10-degree tilt can damage the compressor over time. Any observed leveling issues should be reported as an improvement recommendation in the report.
- **Electrical disconnect:** An electrical disconnect should be located nearby for maintenance purposes. Typically, a single, wall-mounted breaker box on a 240-volt (30amp) circuit, containing either a circuit breaker or removable fuse block. During the off-season, the circuit should be off to prevent accidental system start-up from the thermostat. Any observed electrical issues or the lack of an exterior disconnect should be reported as an improvement recommendation in the report.
- **Utility penetrations:** Utility penetrations for electric and plumbing lines should be observed (inside and outside) to ensure they are properly sealed. Report any observed improper or missing seals as an improvement recommendation.
- **Damaged, dirty, rusted equipment:** Ideally all the operating components should be kept clean and free from dust, debris, pet hair, rust and corrosion. A unit with excessive rust is communicating to the inspector its age and lack of routine maintenance. Dirty, smashed, clogged condenser fins can be a system efficiency killer. Even the occasional observation of where the family dog has chosen to mark his territory can cause efficiency problems over time. Any observed poor condition should be reported as an improvement recommendation.
- **Condenser fan and coils:** Observe the condenser fan and coils (inside and out) for bent, damaged, missing fins or damage to the coils. Condenser fans are typically placed vertically in the cabinet and viewed from the top, although horizontal mounts can be found. While observing the fan, view the inside of the cabinet housing for cleanliness (excessive dirt, leaves, etc.) or the occasional nesting of wasps for systems that have been out of operation for a season.

A common observation with exterior coils is damage from yardwork. This restricts air flow and efficient operation if excessive. Figure 4.3 provides an example found in the field and this observation would result in reduced efficiency. Any observed damage should be reported and depending on condition, possibly further evaluation by a licensed HVAC technician.

Figure 4.3 - Common Damage Found on Compressors

- **Refrigerant lines:** There are two, differently sized copper lines that move the refrigerant through the system during operation. The low-pressure line (larger line) carries cool low-pressure vapor from the evaporator to the compressor (indoors-to-outdoors). It is important for this line to be well-insulated (foam insulation wrap) to avoid the formation of condensate in the line. During operation, the low-pressure line should be cool to the touch.

The high-pressure line (small line) carries warm high-pressure liquid to the evaporator (outdoors-to-indoors). During operation, the high-pressure line is warm or hot to the touch. These lines should be examined for kinks, twists, or damage and should not be bundled together with insulation. If the larger line is observed as frosted, this can indicate the system is low on refrigerant.

Common observations with refrigerant lines include improper insulation, degrading insulation due to the environment (age), or lack of low-pressure line insulation. Figure 4.4 provides a common failure found in the field: Degraded insulation and exposure to environment). Report any observed refrigerant line issues as an improvement recommendation and, depending on condition, possible further evaluation by a licensed HVAC technician.

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Figure 4.4 - Refrigerant Line Insulation Decay

Let Note: Insulation repair is something your client typically can handle so do not your observation and recommendation for improvement scare them. This is an opportunity to spend some quality time educating them on one of the many annual maintenance requirements of home ownership.

- **Frost or icing:** The system should be operated for at least 15 minutes. Any sign of frost or ice buildup on the evaporator coils or refrigerant lines is an indication the system is not operating properly. This is commonly caused by insufficient air flow through the coil and/or not enough refrigerant in the system. This condition should be reported as recommend for further evaluation by a licensed HVAC technician.

Seasonal Energy Efficiency Ratio (SEER2)

Effective As of January 1, 2023, the federal minimum SEER2 requirements for residential cooling systems vary by region and system capacity. SEER2 is the updated metric used for these 2023 standards, replacing the older SEER rating. Compliance in the North is based on the date of manufacture, whereas the South and Southwest enforce compliance based on the date of installation. Systems with higher SEER2 ratings (up to 21.5 SEER2 or higher for premium models) offer greater energy efficiency but come with higher upfront costs

In the North, all split-system air conditioners must have a minimum 13.4 SEER2 (equivalent to 14 SEER). In the Southeast and Southwest, the requirements are stricter based on capacity:

SYSTEM TYPE	Capacity (< 45,000 BTU/h)	Capacity (≥ 45,000 BTU/h)
Split System AC	14.3 SEER2	13.8 SEER2
Split System Heat Pump	14.3 SEER2	14.3 SEER2
Single-Packaged Units	13.4 SEER2	13.4 SEER2

If you observe less than 13 SEER2, it does not mean a system must be replaced. But when a replacement decision is made by the owner, installation of a 13 SEER2 or higher system will provide maximum efficiency for the structure.

Note: If significant damage, poor operation, or excessive age is observed, resulting in the identification of a major defect on the system, this SEER2 requirement is good information to provide the client to educate them on the needs for replacement.

Inspecting Indoor Cabinet and Components

Indoor components that work in conjunction with the furnace typically are sealed, therefore not inspected in detail, and only observed in operation. The evaporator coil is typically an A-coil configuration, as shown in Figure 4.5, typically located in the top section of the indoor central air handling system. This component, along with the expansion device, typically cannot be observed during an inspection.

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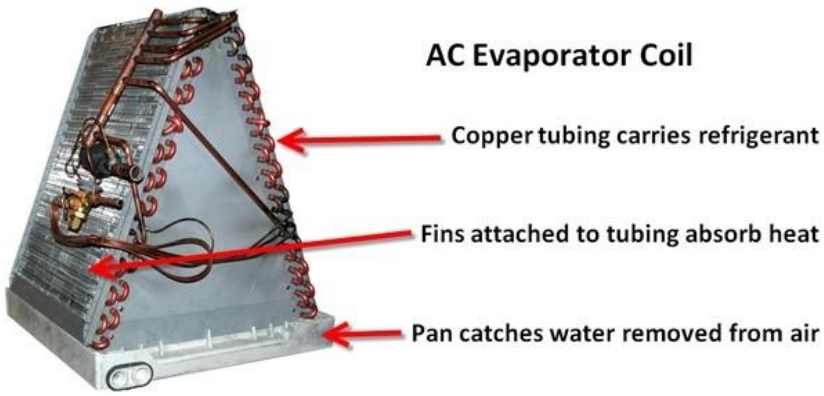

Figure 4.5 - Indoor Evaporation A-Coil

If you choose to report on the age of the A-coil, the age should be reported as the same age as the air handler (heating system) opposed to the age of the outdoor compressor unit. Barring any unknown major overhaul of the evaporator, this is a safe conclusion to report.

Observation and Reporting Requirements – Indoor Components

The following interior cooling system components can be observed:

- **Distribution system:** The cooling system's means of distribution throughout the structure will typically be the same as the forced-air gas-fired system, including the blower, air filter and duct work. Observation will be the same as what would have been reported during the heating inspection.
- **Refrigerant line:** The requirement for insulating the low-pressure (larger line) continues internal to the structure, all the way to its connection with the air handler. Refrigerant lines should be properly secured internal to the structure as any plumbing line would be. Any observed refrigerant line issues should be reported as an improvement recommendation in the report and depending on condition, possible further evaluation by a licensed HVAC technician.
- **Utility penetrations:** Utility penetrations for electric and plumbing lines should be observed (inside and outside) to ensure they are properly sealed. Any observed improper or missing seals be reported as an improvement recommendation.
- **Condensate drain line / drain trap / condensate pump:** The inspection of these system interface components was detailed in chapter three because inspectors are seeing the Type 3 high-efficiency system more often.

Nonetheless, never overlook the inspection and reporting on these critical interface components of the central air conditioning system. If you are not inspecting a Type 3 system, these components are tied solely to the cooling system.

NOTE: As a reminder from chapter three, interior rust and corrosion can be a common observation and is typically the result of a leaking or clogged condensate drain pan / condensate drain line on the A-coil. This should be a very close observation on systems with an upper (over the heating system components) A-coil configuration. If you observe significant rust or corrosion and/or excessive age, the typical recommendation of further evaluation by a licensed HVAC technician is appropriate.

Temperature Differential Testing

While not a requirement of the standard of practice, many home inspectors perform a simple temperature differential test(s) in the cooling system for client confidence. These are system performance tests. The purpose is to evaluate whether or not the cooling system is operating correctly by measuring the temperatures of both the inlet side and the exhaust side in an adjoining room.

There are three basic tests, which can be performed in three different areas. Two are considered less than technical. When performing this test, ensure 15 to 20 minutes of operation first:

- **Test 1:** Temperature difference in air flow into and out of the outdoor unit. By hand, feel if air being blown out of the outside unit is considerably warmer than the outside air. This is an indication of effective performance. Test 1 can also be measured with a thermometer to record actual temperature ranges. This should be referred to as an operational confidence check at best.
- **Test 2:** Temperature differences between the larger and smaller refrigerant lines. By hand, feel the two refrigerant lines. The larger line should feel cold, while the smaller line should feel warm. If the larger line is not cold after several minutes of operation, the overall system is most likely low of refrigerant and requiring servicing. Test 2 can also be measured with a thermometer to record actual temperature ranges. This should be referred to as an operational confidence check at best.

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- **Test 3:** Provides for a more technical test and ascertains the actual temperature differences in air flow both into and out of the evaporator coil using a digital thermometer. This test registers if there is a proper differential of 15 to 20 degrees F (some manufacturers report 10 to 15 degrees F) between the return and supply side to the evaporator coil.

Reference to the 15-to-20 degree range is an indication of the following:

- **Less than 15 degrees:** Can indicate the low refrigerant, a malfunctioning compressor, or the system is too old to transfer heat properly. Further evaluation by a licensed HVAC technician recommended.
- **Greater than 20 degrees:** Can indicate restricted air flow from a dirty evaporator or air filter, or malfunctioning blower. Further evaluation by a licensed HVAC technician recommended.

The Standalone Air-Cooled System

When inspecting a residence without a forced-air gas-fired furnace, any central air conditioning system must be operated independently as a standalone system. A system of this type would be identical in operation and functionality to the air-cooled central air system and components described in chapter four. Outside components are the same, however the inside air handler will not be attached to or function with any installed heating system components. The inspection and reporting for a standalone air-cooled system would be handled the same as well.

On older structures, it is not uncommon to find standalone systems installed in the attic, creating some special concerns and inspection observation requirements. Inspectors should observe the following closely for any attic installations:

- **Ductwork:** A residence originally without air conditioning and/or associated ductwork requires installation of a distribution system. Most will have small, round, flexible insulated ductwork throughout the attic. Air velocity is increased to better distribute airflow through this smaller diameter ductwork. Discharge nozzles, approximately 2 inches in diameter, are typically mounted in the ceiling of each room. Return air vents are mounted in the ceiling as well in a central location.

A common observation on the attic system is restricted air flow due to crushed or disconnected ductwork. This condition can be observed in each room by feeling for proper air flow at the discharge nozzle. Any suspected conditions should be reported as further evaluation required by a licensed technician.

- **Condensate drainage:** This is a particular concern if the system is in fact an attic installation. If a system is installed in a basement, secondary drainage is not necessary. However, attic installations do require backup or secondary drainage because, if not, the first indication of problems, such as clogs, blockage and leaks, by the homeowner is typically from soak-through to the ceiling below.

Figure 4.6 shows the extent of the damage that can be found when proper installation codes are not followed. Ceiling collapse and mold growth are both possible if the clog is not fixed promptly and it's almost always discovered too late. Just a few added dollars during installation will avoid a major expense down the road.

Components of condensate drainage from the system condensate tray are configured and function the same as described in chapter three. However, the International Residential Code (IRC) for attic systems requires installation of an auxiliary or secondary condensate drain line or auxiliary condensate drip pan. This is a protection against ceiling damage should a blockage or clog occur.

The auxiliary condensate line should be configured to drain through the lower portion of the roof or an exterior wall to the outside, but not over porches or walkways. The drain should not terminate into plumbing vent stacks. The location of the exterior drain should be pointed out in the report for client monitoring purposes.

During the inspection, if an auxiliary drain line is not installed, the whole system should be sitting on an auxiliary condensate drip pan with its own drain line as a backup precaution.

Note: The condensate tray drain and auxiliary drain line must be two independent lines to ensure safe and proper operation. Joined drain lines defeat the purpose of the configuration drainage protections. An observed joined drain line should be reported as a recommended improvement item in the report.

Figure 4.6 - Extensive Ceiling Damage from Failure to Install Secondary Drain Line

Through-the-Wall Air-Cooled Units

Through-the-wall air conditioners are commonly overlooked. Some inspectors view them as a window air conditioner and restrict them from their inspection routine and reporting requirements. However, these units are considered permanently installed due to their location in the structure walls.

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They are typically found on enclosed sun porches or patios and are classified as a zone cooling device servicing a single room. They are very common in hotel and motel rooms and some provide a heating component as well.

Depending on the time of the year, an operational analysis may not be performed, which is fine. The most critical item to inspect – operational or not – is the condensate drain. These units have a reputation for creating structural damage due to improper condensate drain configuration.

The inspector should look closely (inside and out) at the base of the unit and surrounding wall to see if any water stains, mold damage or rot is present. If a removable access panel is present, look inside for wasp nesting. Any observed issues should be an improvement recommendation with possible further evaluation by a licensed technician.

Figure 4.7 shows the extent of the damage that can occur when proper installation requirements are not followed and the homeowner neglects annual monitoring to ensure proper condensate drainage. A through-the-wall unit can drain condensate inside the walls for a number of seasons because their use can be limited. During this time, unseen damage and mold growth can occur resulting in a major expense.

Figure 4.7 - Structural Damage from Failure to Monitor Proper Drainage

Inspection Best Practice

An inspection best practice for attic systems and through-the-wall units is to advise the client in the report of condensate drain locations and seasonal monitoring requirements. During the cooling season, if they do not see condensate draining to the outside, this most likely is communicating a developing serious issue.

Air-to-Air Heat Pumps

Closing out this extensive study in conventional heating and cooling system inspections, we will take a look at heat pumps. The uninformed or untrained will probably refer to the exterior system casing as an air conditioner. In reality, air-to-air heat pumps are air conditioners, which are capable of reversing the flow of refrigerant to produce heat.

As we previously studied on central air conditioners, because a gas heats when compressed and cools as it expands, the result is expelling heat outdoors and cool air into the structure. The heat pump has a dual mode (heat or cool) and the refrigerant cycle is seasonally reversed, expelling cool air outdoors in the winter months and warm air into the structure.

Therefore, from the home inspector perspective, a central air handling system utilizing a heat pump is basically the same as a central forced-air gas-fired/electric-powered furnace with one exception – the heating element is not a gas burner or electric-powered element. Rather, it's a component of an electric-powered reverse-cycle air conditioner. When operating in heat mode, the evaporator becomes the condenser, producing warm air for the structure, and the condenser becomes the evaporator, discharging cool air to the outdoors. This is accomplished by adding a reversing valve designed to change the direction of the refrigerant cycle. In reality, this reversing valve is the only difference between the heat pump and standard central air conditioner.

The basic heat pump is typically referred to as a split system, whereas the compressor, reversing valve, outdoor coil and fan are all located in the outdoor cabinet and the indoor components consist of an indoor coil, condensate tray, condensate line and trap, all operating in a standalone system, which should sound very familiar because we just studied how that works.

Note: Home inspectors could find what is referred to as a triple-split system where the condenser and reversing valve operate from a separate cabinet located inside the structure. However, the functions of the components all remain the same, excluding the need for additional plumbing between cabinets.

Reversing Valves

While not a requirement to inspect the reversing valve, it is an electro-mechanical device and subject to failure. Although it doesn't happen often, when it does, it can cause a lot of confusion for the homeowner and even a service technician. The closest the home inspector will get to suspicion of such a failure is operating the system in the appropriate seasonal mode (i.e. heat mode) and getting all cool air. Clearly the report recommendation of further evaluation by a licensed HVAC technician is warranted without further speculation.

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Air-to-Air Heat Pump Limitations

The heat pump does come with limitations in terms of homeowner comfort, or in technical terms referred to as coefficient of performance (COP). Without going into the technical jargon, this is basically when the outside air temperature falls too low. The outdoor coil loses the ability to collect heat from the outside air, and therefore, it is no longer able to produce enough heat to warm up the structure (input power to performance output).

Studies show heat pumps begin becoming inefficient at temperatures below 35 degrees F (equipment/design dependent). To combat this condition, most heat pumps are equipped with auxiliary heat elements as a standard or recommended backup heating source. These systems typically utilize electric resistance heating coils (often called heat strips) installed within the indoor air handler, or they may be paired with a gas furnace in a dual-fuel configuration.

The auxiliary heat serves as a supplementary source that activates automatically when the primary heat pump cannot efficiently maintain the desired temperature. This generally occurs under the following conditions:

- Freezing outdoor temperatures (typically below 35–40°F), where the heat pump struggles to extract enough warmth from the air.
- Rapid thermostat adjustments, such as raising the temperature by more than 3–4 degrees, to help reach the new setpoint faster.
- Defrost cycles, where the heat pump temporarily reverses operation to melt ice on the outdoor unit, and auxiliary heat prevents cold air from blowing into the home.

While electric resistance strips are the most common form of auxiliary heat, they are less energy-efficient than the heat pump itself. Therefore, they are designed to run only temporarily to assist the primary system, helping to prevent high energy bills and system strain during extreme weather or defrosting. Auxiliary heat is a normal, automatic function designed to support the primary heat pump during challenging conditions.

Note: When a home inspection is on a heat pump in colder regions, be on the lookout for inspection requirements for other permanently installed heating sources inside the structure, such as radiant ceiling heat.

Inspecting Air-to-Air Heat Pumps

During the home inspection, operate the system in only one of its modes (heat or cool). It will not matter which mode the system is operated in because any observed issues or defects will be apparent in either mode; so if it runs in one mode, it will run in the other.

The actual operational inspection procedure will be no different than what we studied for air-cooled air-conditioning because of the same basic components and will require a basic operational observation and report. The reporting requirements are also the same, in accordance with standards of practice, such as air flow restrictions, equipment location, electric disconnect, utility penetration, damage, cleanliness and condition of refrigerant lines is certainly critical.

That said, there are a couple of added points to consider with the heat pump to observe and report on:

- **Elevation:** As with air-cooled air-conditioners, the cabinet should be level; however, due to the dual mode function (heat/cool) heat pumps in snowy climates should be elevated a minimum of 12 inches off the ground or above the highest expected snow level to prevent snow packing into the base and ensure proper airflow. Failure to do so will restrict operability as snow forms and blows around the outside unit coils.
- **Defrost cycle:** If inspecting a heat pump in the heart of winter (temperatures below freezing) with the client present, the outdoor system may start to frost up. A client unfamiliar with heat pumps may become concerned with the unit's appearance. This is an opportunity to educate the client on normalcy and the defrost cycle, which typically occurs every 90 minutes and lasts approximately 10 minutes.

Note: Inspect the system in the mode it is operating in when you arrive or if the system is shut down, operate it in the mode appropriate for the season, once you determine it's safe to turn on a de-energized system.

Chapter Four Summary

In chapter four, we discussed the cooling system inspection key terms; basic observation and action guidelines and requirements of the cooling inspection; the components of air-cooled air-conditioning; and the refrigerant cycle. We described the inspection requirements for air-cooled air-conditioning, standalone systems, through-the-wall units, and air-to-air heat pumps.

References

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Home Inspection State Requirements

Always be aware of state-specific regulations and guidance above and beyond inspection standards of practice. Each state can have its own unique requirements, standards, and regulations that govern home inspection practices, are considered add-on inspection requirements, and can change without notice. It is recommended that you verify annually any current regulations with your state's home inspection regulatory authority.

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Understanding and following your state's specific requirements is essential for maintaining compliance and providing professional home inspection services. Be sure to thoroughly review all applicable state laws and regulations before conducting inspections in any new jurisdiction. Examples of unique add-on inspection requirements are provided below.

While many jurisdictions follow national standards like the International Residential Code (IRC) and ASHI and InterNACHI guidelines for general home inspections, specific state-level mandates often focus on safety and efficiency benchmarks:

- **Kentucky**: Requires permits for new heating and air conditioning system installations in one- or two-family dwellings, multi-family dwellings, and commercial buildings, with inspections available for homeowners requesting them on replacements.
- **California**: Requires duct leakage testing for all HVAC improvements to ensure compliance with energy efficiency standards, with the HERS rate reporting findings directly to the state and local building departments.
- **Washington State**: Enforces specific residential mechanical rough-in requirements under the 2018 Washington State Energy Code (WSEC), including duct air leakage limits (3 CFM per 100 SF without an air handler) and mandatory combustion air and clearance regulations.
- **HUD Properties**: While federal, many states adopt the NSPIRE standards which mandate functional heat sources during heating seasons (typically October through April) and require combustion appliance safety checks for carbon monoxide risks.

Most other states do not have unique statewide mandates for routine home inspections but rely on local municipal codes that enforce permit posting, electrical disconnect requirements, and insulation levels (e.g., R-8 for ducts in unconditioned spaces) based on national codes like the International Energy Conservation Code (IECC).

Carbon Monoxide Detectors: While not always part of the HVAC inspection itself, detector presence and placement are often evaluated, especially in regulated housing. For example:

- **California** requires detectors in homes with fossil fuel appliances or attached garages (effective 2011 for single-family homes).
- **Massachusetts** ("Nicole's Law") mandates detectors in all residences with fuel-burning systems or attached garages.
- **HUD/NSPIRE** standards require CO alarms in units with fuel-burning appliances, based on the 2018 International Fire Code.

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