AHRI Air-Conditioning, Heating, and Refrigeration Institute

Fundamentals of HVACR

Carter Stanfield and David Skaves

Third Edition

Fundamentals of HVACR

Third Edition

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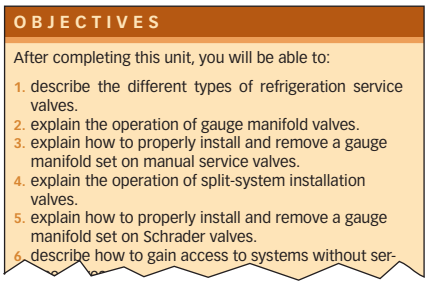
Take the Guided Tour

Fundamentals of HVACR, 3rd Edition

Created with a clear-cut vision of what students need, this groundbreaking text provides comprehensive coverage of heating, ventilating, air conditioning, and refrigeration. This edition has been fully updated, including additional coverage of electrical, commercial, codes, and sustainability.

Learning Objectives

Each unit begins with clearly stated objectives that enable you to focus on what you should achieve by the end of the unit.



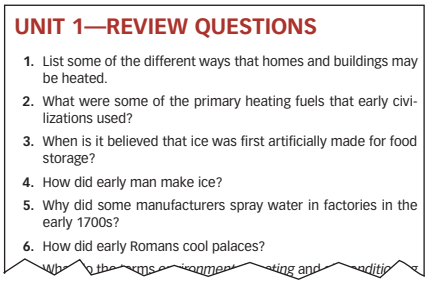
OBJECTIVES

After completing this unit, you will be able to:

1. describe the different types of refrigeration service valves.
2. explain the operation of gauge manifold valves.
3. explain how to properly install and remove a gauge manifold set on manual service valves.
4. explain the operation of split-system installation valves.
5. explain how to properly install and remove a gauge manifold set on Schrader valves.
6. describe how to gain access to systems without ser-

Review Questions

Every unit has a set of review questions to help the reader assess his or her understanding of the material.

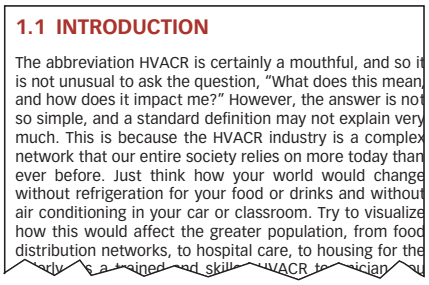


UNIT 1—REVIEW QUESTIONS

1. List some of the different ways that homes and buildings may be heated.
2. What were some of the primary heating fuels that early civilizations used?
3. When is it believed that ice was first artificially made for food storage?
4. How did early man make ice?
5. Why did some manufacturers spray water in factories in the early 1700s?
6. How did early Romans cool palaces?

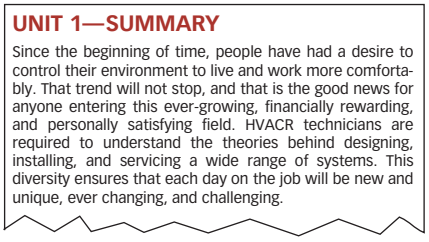
Unit Introductions and Unit Summaries

These pull together the main points of the unit to prepare and remind students of what they should remember.



1.1 INTRODUCTION

The abbreviation HVACR is certainly a mouthful, and so it is not unusual to ask the question, "What does this mean, and how does it impact me?" However, the answer is not so simple, and a standard definition may not explain very much. This is because the HVACR industry is a complex network that our entire society relies on more today than ever before. Just think how your world would change without refrigeration for your food or drinks and without air conditioning in your car or classroom. Try to visualize how this would affect the greater population, from food distribution networks, to hospital care, to housing for the

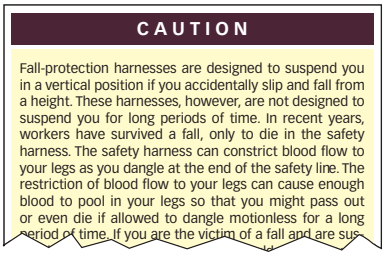


UNIT 1—SUMMARY

Since the beginning of time, people have had a desire to control their environment to live and work more comfortably. That trend will not stop, and that is the good news for anyone entering this ever-growing, financially rewarding, and personally satisfying field. HVACR technicians are required to understand the theories behind designing, installing, and servicing a wide range of systems. This diversity ensures that each day on the job will be new and unique, ever changing, and challenging.

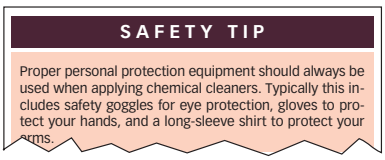
Caution Tips and Safety Tips

These tips contain information students should know to operate equipment properly and protect themselves from harm.



CAUTION

Fall-protection harnesses are designed to suspend you in a vertical position if you accidentally slip and fall from a height. These harnesses, however, are not designed to suspend you for long periods of time. In recent years, workers have survived a fall, only to die in the safety harness. The safety harness can constrict blood flow to your legs as you dangle at the end of the safety line. The restriction of blood flow to your legs can cause enough blood to pool in your legs so that you might pass out or even die if allowed to dangle motionless for a long



SAFETY TIP

Proper personal protection equipment should always be used when applying chemical cleaners. Typically this includes safety goggles for eye protection, gloves to protect your hands, and a long-sleeve shirt to protect your

Tech Tips and Service Tips

These tips provide extra detail and information for students who want to go beyond the basics and get practical applications for the information in the unit.

TECH TIP

Many people find the relationship of fractions with different denominators confusing. To compare two fractional sizes, multiply the bottom number (denominator) of the fraction with the smaller number on the bottom by 2 until it equals the denominator of the other fraction. Then multiply the top number (numerator) by 2 the same number of times. For example, comparing 3/4 inch and 11/16 inch: multiply 4 by 2 twice to get 16 (2 × 4 = 8, 8 × 2 = 16). Then multiply 3 by 2 twice get 12 (3 × 2 = 6, 6 × 2 = 12). Now you can easily see that 12/16 is larger than 11/16.

SERVICE TIP

To determine how many quarts of oil are required for an oil charge stated in fluid ounces, divide the quantity of fluid ounces by 32. For example, an oil charge of 64 ounces would require 2 quarts: 64 fluid ounces/32 = 2 quarts.

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Guide to the NATE/Ice Certification Exams by Featherstone and Riojas, order ISBN-10: 0-13-231970-5

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UNIT 1

Introduction to Heating, Ventilation, Air Conditioning, and Refrigeration

OBJECTIVES

After completing this unit, you will be able to:

1. give a brief history of HVACR.
2. define environmental heating and air conditioning.
3. give the advantages of freezing foods quickly.
4. explain the importance of having a clean background.
5. list the various types of HVACR jobs and explain what they might do.
6. list the HVACR professional organizations.

1.1 INTRODUCTION

The abbreviation HVACR is certainly a mouthful, and so it is not unusual to ask the question, "What does this mean, and how does it impact me?" However, the answer is not so simple, and a standard definition may not explain very much. This is because the HVACR industry is a complex network that our entire society relies on more today than ever before. Just think how your world would change without refrigeration for your food or drinks and without air conditioning in your car or classroom. Try to visualize how this would affect the greater population, from food distribution networks, to hospital care, to housing for the elderly. As a trained and skilled HVACR technician, you can make a positive impact on society. You can contribute to this growing industry to ensure that systems work efficiently and safely and are environmentally friendly (Figure 1-1).

Figure 1-1 Think green! New innovative technologies will allow some HVACR systems to operate on power supplied by wind turbines.

1.2 HISTORY AND OVERVIEW OF HVACR

Heating

In an attempt to better understand HVACR, let's break it down component by component. The *H* for *heating* seems easy. The history of heating a space by burning wood starts in our earliest times and continues to the present. Elaborate systems using firewood heated Roman buildings. Channels were built underneath the floors to draw heat from a fire, thus warming the building and creating the first central heating systems (Figure 1-2).

Wood, peat, and coal remained the primary heating fuels for centuries. Many early buildings had open fireplaces. But fireplaces are an inefficient way of heating because too much of the heat produced is drawn up the chimney. Although early seventeenth-century European masonry-type stoves burned wood safely at high efficiency,

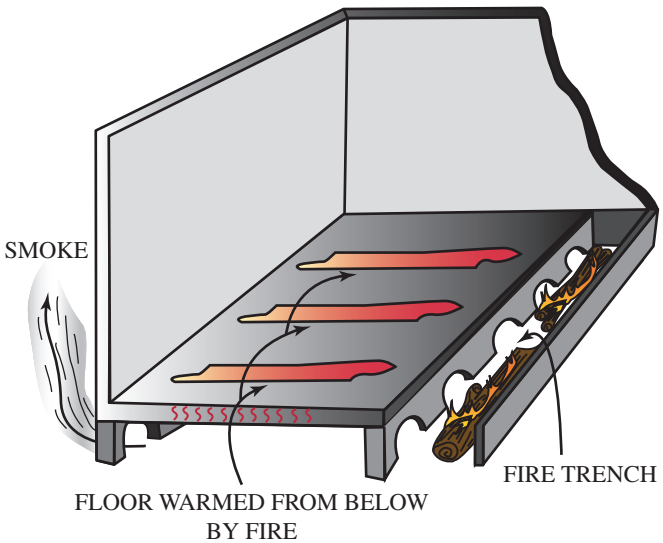

Figure 1-2 Romans used fires channeled below floors as early heating systems.

Figure 1-3 Woodstove.

the next major step in heating technology in America was the metal stove. Benjamin Franklin is credited with inventing a cast-iron stove that was several times more efficient than any other stove at that time. Many people still use decorative, efficient stoves to provide much, if not all, of their heating needs (Figure 1-3).

However, wood heat is only one alternative, because today there are many more choices for heating. Gas heat, oil heat, electric heat, and solar heating systems are common. Heat pumps that use a refrigeration system for heating can be very efficient. Geothermal heating systems that utilize the heat from within the earth are becoming more popular. New, environment-friendly ideas and efficient designs are continually being developed, tested, operated, and maintained by people just like you entering the industry. So you can see that just the *H* alone is a large and important sector.

Ventilation

Next comes the *V* for *ventilation*. Before the invention of chimneys, fires were burned in the center of a room with smoke having to escape through holes in the roof. When early homes were heated by wood fires, the smoke would permeate the entire building. Although people were warm, the health hazards from this smoke exposure were harmful. As an improvement, early Norman fireplaces in England were designed to allow the smoke to escape through two holes in the side of the building. It was obvious that something needed to be done to improve the air quality.

A properly ventilated building allows for the air to flow and exchange so that harmful particulates such as those in smoke are not allowed to accumulate. Fresh air also brings oxygen into the space, but it becomes depleted over time. A simple ventilation system can consist of only a fan and some minor ductwork for transporting the air. More complex systems circulate air throughout entire buildings through a vast network of ducts and blowers.

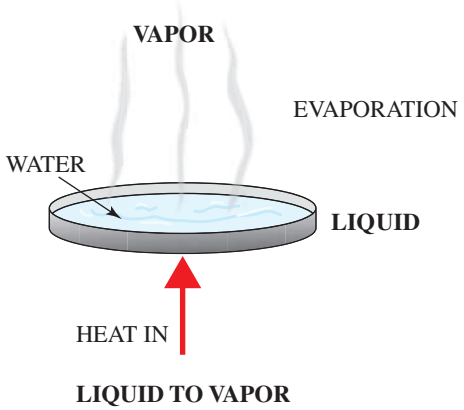

Figure 1-4 When water evaporates, heat is absorbed. This change of state is also referred to as a phase change.

Air Conditioning

The *AC* stands for *air conditioning*. Generally this is considered by most people to be a way to cool a space, but as you will learn, this term encompasses much more. Artificially cooling the air in a living space dates back to the earliest centuries. In ancient Greece, large wet woven tapestries were hung in natural drafts so that the air flowing through and around the tapestries was cooled by the evaporating water. As the water evaporated, it would remove heat, just like when you perspire to remain cool (Figure 1-4). Some manufacturers sprayed water in factories for cooling as early as the 1720s. Evaporative cooling is still used extensively in residences and businesses throughout the southwestern United States, where typical summer conditions are very hot and dry.

Ice was the primary means of cooling air for many years. The Romans packed ice and snow between double walls in the emperor's palaces. John Gorrie patented the first mechanical air-conditioning system in 1844. His system was used to cool sick rooms in hospitals in Florida. The United States capitol building in Washington, DC, was first air conditioned using ice in 1909. Rumor has it that when the legislators got really involved in controversial debates, more ice was required to keep the building cool. The phrase "tons of air conditioning" we use today came from this era in history, when tons of ice were used for cooling (Figure 1-5).

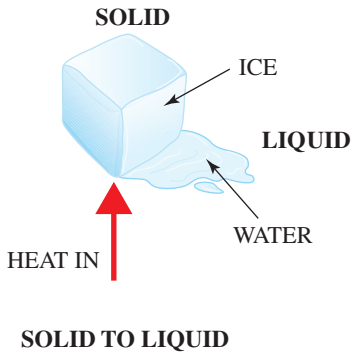

Figure 1-5 When ice melts, heat is absorbed.

TECH TIP

Refrigerant capacity is measured in tons. One ton of capacity is equivalent to the amount of heat that 2,000 lb of ice can absorb in one day. The amount of latent heat required to change 1 ton of ice into 1 ton of water is 288,000 BTU. If this amount is divided by 24 hr per day, the equivalent is 12,000 BTU/hr.

Refrigeration

Finally, the *R* stands for *refrigeration*, which is a necessary component for most air-conditioning systems; however, refrigeration systems are more commonly considered to be used for keeping food cold. That is why very often you may see the abbreviation HVAC, which implies air conditioning only. The broader term HVACR includes both air conditioning and refrigeration systems.

The first use of refrigeration was for the preservation of food. Ice was harvested from frozen lakes and stored for later use. Sometimes it could be kept all summer long in ice houses. Ice harvesting remained a flourishing industry well into the twentieth century.

Archeologists have discovered that the first evidence of man making ice appeared more than 3,000 years ago, about 1,000 BC. Peoples living in northern Egypt, the Middle East, Pakistan, and India made ice using evaporation. Archeological excavations in these regions have discovered ice-producing fields that covered several acres. The ice was produced in shallow clay plates, about the size of a saucer. The water in these clay plates wept through the clay. This water dampened the small straw mats holding the clay plates in racks a few feet above the ground (Figure 1-6). The straw aided evaporative cooling of the water. Under the right conditions of temperature and humidity, a thin film of ice would form overnight on each clay plate.

Producing ice in this way is also the principle behind modern snow-making equipment. A snow-producing machine like the one in Figure 1-7 can make snow by evaporative cooling even when the temperatures on the ski slopes are above freezing.

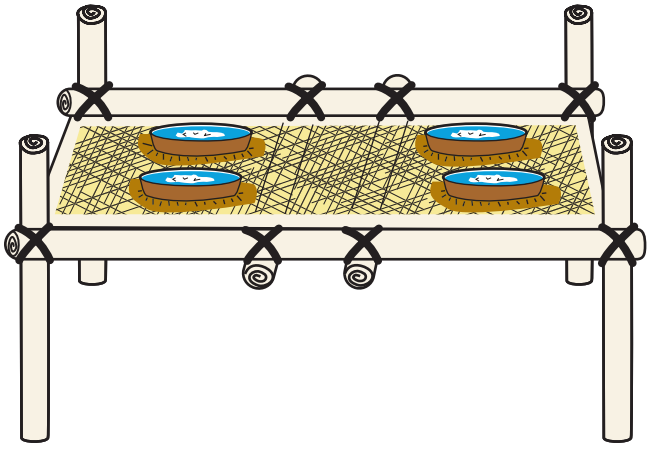

Figure 1-6 Ice was first artificially produced to be used for food preservation more than 3,000 years ago.

Figure 1-7 Snowblowers can produce artificial snow by evaporative cooling. *(Courtesy of Red River Ski Area)*

Today, a majority of refrigeration systems use what is referred to as mechanical vapor compression. The mechanical process of compressing a gas to produce cooling can be traced back to coal mines in England. Large steam-driven or water-powered compressors were used to force air into the deepest mines so miners could work in a safe atmosphere. Over long hours of operation, miners observed the formation of ice around the air nozzles (Figure 1-8). This ice was collected and used for food preservation. The construction of steam-powered compressed-air plants that produced ice soon followed. The first maritime refrigeration units were made by putting steam-powered compressors on sailing ships to make it possible for beef to be shipped from Australia to England, starting in 1876.

HVACR and the Refrigeration Cycle Now that you have a better understanding of what HVACR means, it is easy to see that it encompasses a broad spectrum of needs and applications. Although the methods for heating can vary considerably, the majority of cooling applications are based on the refrigeration cycle. When ice changes to water, heat

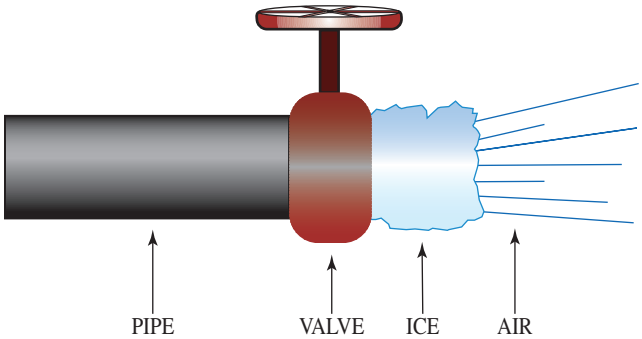

Figure 1-8 Ice forming around an air nozzle.

is absorbed, which makes ice a viable refrigerant. But ice is hard to store and takes up a lot of space. Water is easier to use because it can be pumped and doesn't need the insulation that ice requires. When water evaporates to vapor it also absorbs heat, but then the water needs to be replaced, and this uses up a lot of water over time.

If the vapor can be recovered and turned back into water, then this cycle reduces the total amount of water needed (Figure 1-9). Even so, the major disadvantage with this type of evaporative cooling is that the lowest temperature that can be reached is dependent on the properties of water.

Notice that with both ice and water, it is their change of state that allows for heat to be absorbed. It is this important principle that serves as the basis for most refrigeration systems today, but instead of using water, other fluids with different properties and lower boiling points, called refrigerants, are now used. This allows for much colder temperatures, far below freezing. The "refrigeration cycle" therefore continually evaporates and condenses refrigerants to absorb and then throw away the heat.

A compressor is used like a pump to raise the pressure and circulate the refrigerant through the system (Figure 1-10). A condenser is used to remove heat from the refrigerant as it turns into a liquid. An expansion device drops the pressure to allow the refrigerant to change back from liquid to vapor in the evaporator. Heat is absorbed in the evaporator and then thrown away in the condenser. The refrigerant does not wear out and circulates around and around during operation. Most refrigeration systems in use today operate using this type of cycle.

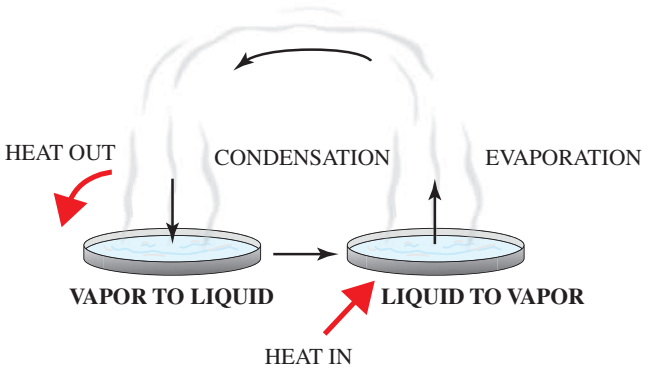

Figure 1-9 Water evaporates to vapor and absorbs heat, and then the vapor is condensed back to water to release its heat.

1.3 TODAY'S HEATING, AIR CONDITIONING, AND REFRIGERATION

"Environmental heating and air conditioning" refers to the control of a space's air temperature, humidity, circulation, cleanliness, and freshness, and it is used to promote the comfort, health, and/or productivity of the inhabitants. Homes, offices, schools, colleges, factories, sporting arenas, hotels, cars, trucks, and other vehicles such as aircraft and spacecraft are heated and cooled. The main purpose of environmental heating or cooling is to help maintain the body temperature within its normal range. Generally, the term *air conditioning* is used when the space temperature is above 60°F (15°C), and *refrigeration* is the term used when the space temperature is below 60°F (15°C).

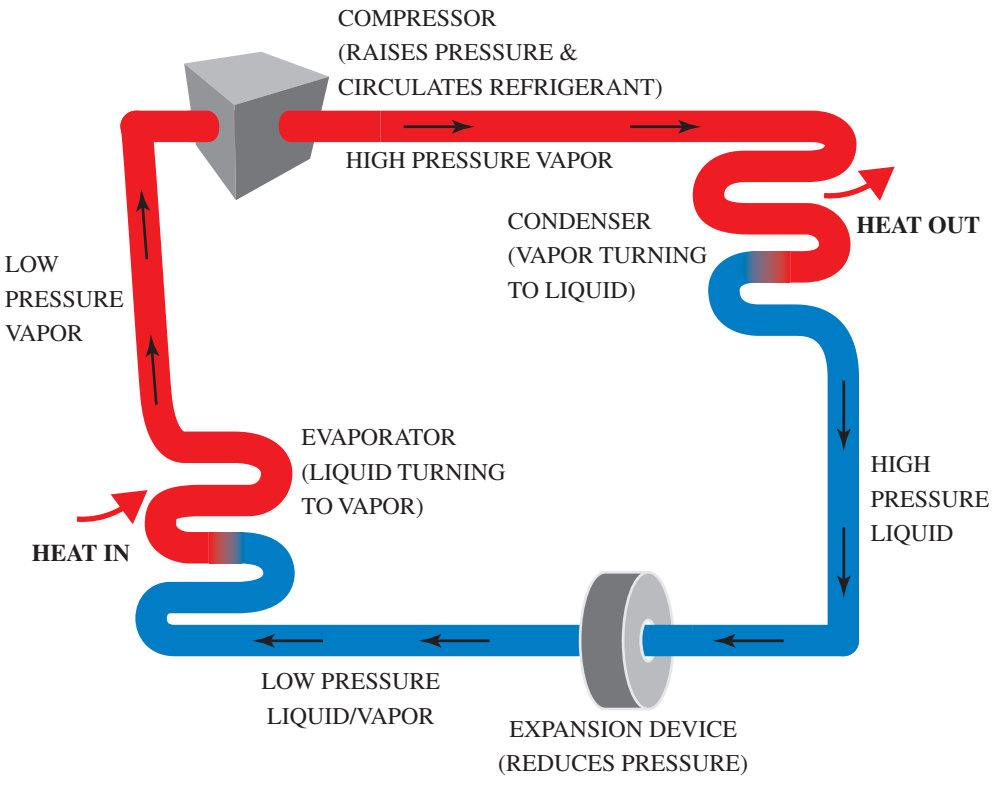

Figure 1-10 The basic refrigeration cycle consists of four major components: compressor, condenser, expansion device, and evaporator.

TECH TIP

Without our ability to control the environment, it would be impossible for us to explore space or the bottom of the ocean, or even to enjoy the comfort of a transcontinental jet ride at 35,000 ft. So, our ability to control our environment has served both to improve the quality of life and to enhance our scientific endeavors.

Process heating and cooling are used to aid in manufacturing or to keep equipment at a desired temperature. An area used to process meat or vegetables may be cooled to help preserve the product. Computer rooms are cooled so the equipment lasts longer and is able to stay online due to the heat being removed from the space. Computers would not operate properly if heat was not absorbed from the space. Remote pumping stations may be heated to prevent pipes from freezing. The main purpose of process heating or cooling is to maintain the temperature of things or processes within their required range.

TECH TIP

An operating room is cooled to aid with the surgery as well as for the comfort of the patient or surgeon. Therefore, an operating room is an example of process cooling even though it may be within the normal air-conditioning temperature range.

Modern Heating

Central heating of homes and businesses dates back to ancient times, but the first commercial warm-air fan-driven system was marketed in the 1860s. By the 1900s a number of different central warm-air systems were available for residential and commercial applications, and in 1908, the essential elements for heating, cooling, humidifying, dehumidifying, and filtering air were defined.

Today central heating systems can use warm air, hot water, steam, electric resistance, or a reverse refrigeration cycle (heat pump). The basic theory for the heat pump dates back to 1852.

Modern Air Conditioning

The development of modern air conditioning is often credited to Dr. Willis Carrier. Dr. Carrier, an engineer, was confronted with a problem facing printers. As paper was printed with one color, the dampness in the ink caused the paper to stretch slightly, and it was nearly impossible for the second color to be printed without being misaligned. Dr. Carrier determined that a means for controlling the humidity was necessary and developed the first air-conditioning system for the printing industry. His invention, called an "Apparatus for Treating Air," was patented in 1906 (Figure 1-11). His invention quickly found favor not only for dehumidifying but also for cooling. Through the 1940s and 1950s, businesses would proudly display signs reading "Air

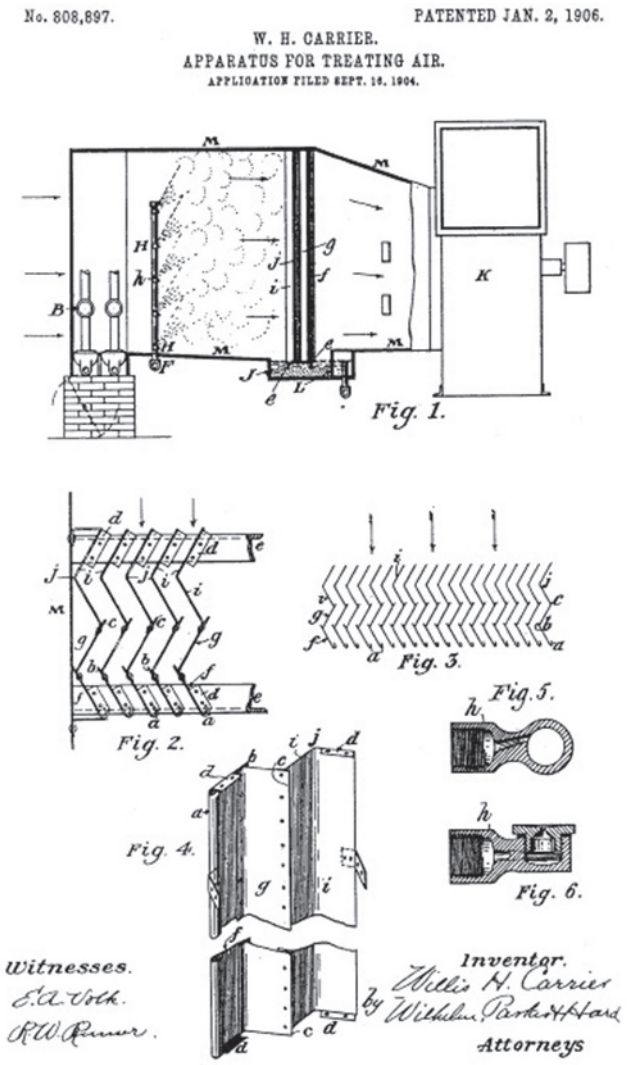

Figure 1-11 The patent for the first apparatus for cooling air, invented by Willis Carrier.

Source: Patent Drawing for W. H. Carrier's Apparatus for Treating Air, The National Archives Catalog

Conditioned." Dr. Carrier designed the psychrometric chart as we know it today. (This chart displays the properties of air, such as temperature, humidity, and volume, and is commonly used for many HVAC applications.)

Mass air conditioning of homes began in the late 1950s with window air conditioners. Central residential air conditioning started to become popular in the mid-1960s. Today most of us cannot imagine living in a home anywhere in the country that does not have air conditioning.

Modern Refrigeration

Clarence Birdseye made another major contribution to the industry. He developed the process of freezing foods in 1922. Today, supermarket freezer displays provide us with a variety of food products that would not be possible to preserve any other way (Figure 1-12). In 2006, a new era in eating occurred when the American public purchased more heat-to-eat and thaw-to-eat foods than any other type of food.

Figure 1-12 Modern refrigeration display cases provide us with a variety of food products that would not be available without refrigeration.

- **Frozen foods** Before Clarence Birdseye began commercially freezing food, people had allowed food to freeze naturally during the winter months as a way of preserving it for later use. Food frozen this way did not always taste that good, so the trick was to come up with a way of freezing food and having it still taste good when it was thawed.
- **Quick freezing** The process of rapidly freezing food using air blast, contact, and/or immersion freezing was the key to improving the quality and taste of thawed frozen foods. The problem with freezing food slowly is that when ice crystals form over time, they become much larger. These large, sharp ice crystals grow through the cell walls of the food, and when the food thaws, all of the nutrients in the food are allowed to drain away. Quick freezing causes the ice crystals to be very small and less likely to penetrate cell walls, so the food retains nutrients and flavor when it is thawed.

1.4 EMPLOYMENT OPPORTUNITIES

The HVACR industry represents one of the largest employment occupations in the country. Our industry, for example, is one of the largest consumers of electric and gas utilities in the nation. More electricity and natural gas is consumed producing heating and cooling than for any other single use. The size of the industry has been growing steadily since the late 1960s, when residential central systems became popular. The installation and servicing of HVACR systems will always be an expanding occupation. No one builds a home or business without some type of heating and/or cooling system, which requires designing, installing, and servicing by skilled and trained technicians.

Residential Air Conditioning and Heating

Most residential heating systems have a heating capacity of 50,000 to 150,000 BTU/hr. The majority of residential air-conditioning systems are 5 tons or less. Both of these sizes will obviously vary greatly, depending on the region of the country you are working in. In addition, there are many very large homes being built, requiring systems that could easily be classified as light commercial because of their size and/or complexity.

TECH TIP

To protect the public from potentially dangerous individuals, some businesses and/or local and state governments require criminal background checks on anyone involved with in-home service work. These checks may go back 25 years or more into an individual's past. Check with your local or state governmental department that regulates in-home service work if you feel there is something in your past that might affect your ability to work in residential service. In most states these checks are only required for in-home service work, so you may still be able to work in new construction or in the commercial or industrial areas.

Commercial Air Conditioning and Heating

The term *commercial* is used to refer to any system that is used in commercial buildings (for business) that provides cooling or heating. These systems may be as small as a fraction of a ton in size to several thousand tons in cooling capacity and/or from 1,000 BTU/hr to hundreds of thousands of BTU/hr.

Commercial systems may be operated independent of any other system or be integrated with a building automation system. Because of the vast differences in the types of equipment and system complexity, commercial technicians often specialize in a single type of system or group of systems.

Commercial and Industrial Refrigeration

The terms *commercial refrigeration* and *industrial refrigeration* are applied to retail food and cold-storage equipment and facilities. Examples of commercial equipment and systems include refrigeration equipment found in supermarkets, convenience stores, restaurants, and other food service establishments. Industrial refrigeration can include long-term storage either as cold storage or medium or low-temperature refrigeration systems that are generally larger-scale operations.

Types of Jobs

There are a variety of occupational specialties offered within the HVACR industry. These occupations range from the basic entry-level helper to the systems designer. Although the work involved with heating, air conditioning, or refrigeration equipment and systems is similar in theory, there is a significant difference between the work done in the areas of residential, light commercial, commercial, and industrial. These areas of heating, air conditioning, and refrigeration generally relate to the size (capacity) and complexity of the system. However, technicians may find the exact same equipment used in one home being used in a commercial shop or factory. In these cases the distinguishing factor is whether you are working in someone's home or in a business.

- **Entry-level helper** The entry-level helper (first-year apprentice) provides the senior technician with assistance installing and servicing equipment. Most medium and large mechanical contracting companies use a number of helpers to assist with the installation and service of residential and commercial systems. A helper may be expected to assist in lifting, carrying, or placing equipment or components. He or she may also run errands to pick up parts and clean up the area following installation or service. Helpers receive basic safety training, and if they will be driving, they must have good driving records.
- **Rough-in installer** The initial installation process is referred to as rough-in. In this process the technician (first- through third-year apprentice) will install the refrigerant lines, electrical lines, thermostat and control lines, duct boots, and duct run and set the indoor and outdoor units. The rough-in technician must have an understanding of duct layout, blueprint reading, and basic hand tools and good brazing skills.
- **Start-up technician** Once the system has been installed and all of the components are ready for operation, a start-up technician (fourth- and fifth-year apprentice) will go through the manufacturer's recommended procedures to initially start a system. Because much of the HVAC system has been field installed, this checkout procedure is essential to ensure safe and efficient operation. The start-up technician records all of the information requested by the manufacturer's warranty. Start-up technicians must be skilled with electrical troubleshooting and refrigerant charging and have good reading comprehension and writing skills.
- **Service technician** The service technician (fourth-year apprentice to journeyman) is the individual who provides the system owner with repair and maintenance. Service technicians are the people who must be able to diagnose system problems and make the necessary repairs. Service technicians must be skilled in diagnosing electrical problems, refrigerant problems, and air-distribution problems.

TECH TIP

Technology has enabled the field tech to stay in close contact with his service manager. This allows the highly experienced service managers to provide assistance to technicians as they come upon new problems. The technician can also call upon the office to research unique problems to determine the best, most efficient way of making the repair.

- **Sales** HVACR sales are divided into two major categories: inside sales and outside sales. Inside sales deal primarily with system sales to other air-conditioning contractors. Outside sales may be to both contractors and end users. Working in outside sales or consumer sales requires the technician to have a good understanding of cost and value of equipment so that the owner can make an informed choice.
- **Equipment operator** Equipment operators are required by local ordinance and state law to be present anytime large central heating and air-conditioning plants are in operation. Their primary responsibility is to ensure the safe and efficient operation of these large systems. They must have a good working knowledge of the system's mechanical, electrical, and computer control systems to carry out their job. They sometimes need to hold a city or state license to become an operator. Equipment operators generally work by themselves or as part of a small crew. They often are required to have good computer skills when buildings have computerized building-management systems.
- **Facilities maintenance personnel** Facilities-maintenance personnel are responsible for planned maintenance and routine service on systems. They may work at a single location or have responsibilities for multiple locations, such as school systems. Facilities-maintenance personnel typically maintain systems and provide planned maintenance. They may work alone or as part of a crew, depending on the size of the facility. Maintenance personnel may from time to time have duties and responsibilities outside of the HVACR trades, such as doing minor electrical plumbing and carpentry projects for the upkeep of the building.
- **Service manager** A service manager is typically a skilled HVACR technician with several years of experience. This individual oversees the operation of a company or maintenance department. He or she must have good management skills, communication skills, and technical expertise. Service managers typically assign jobs to other technicians and employees. They must then oversee these individuals' jobs.
- **Systems designer** For small buildings, contractors normally size and select HVAC systems and equipment. There are many industry-standard sizing and design guides available from trade associations such as the ACCA (Air Conditioning Contractors of America). For larger buildings, mechanical, architectural, or building services engineers may be required by law to design and specify the HVAC systems. Specialty mechanical contractors will work with the design plans to build and commission these systems.

1.5 TRADE ASSOCIATIONS

With the rapid growth and variety of interests, trade associations naturally evolved to represent specific groups. The list includes manufacturers, wholesalers, contractors, sheet metal workers, and service organizations. Each is important and makes a valuable contribution to the field. Space does not permit a detailed examination of all of these organizations, or all of their activities, but throughout the book many of these associations will be acknowledged as specific subjects are covered.

Certifications

Many trade associations offer training programs and competency examinations for the industry to help ensure a workforce of qualified technicians. In addition, the 1990 Clean

Air Act passed by the United States Congress requires that anyone who performs maintenance, service, repair, or disposal that could be reasonably expected to release refrigerants must be certified. To become certified, technicians are required to pass an Environmental Protection Agency (EPA)–approved test given by an EPA-approved certifying organization. Four different types of certifications have been developed to address different types of equipment. A person meeting the requirements for all four types is issued a universal certification. This is certification process is further described in Unit 26, Refrigerant Management.

Air-Conditioning, Heating, and Refrigeration Institute (AHRI)

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) is a national trade association representing manufacturers of over 90 percent of U.S.-produced central air-conditioning, gas appliances, and commercial refrigeration equipment. AHRI was formed in 2007/2008 when ARI (Air Conditioning and Refrigeration Institute) merged with GAMA (Gas Appliance Manufacturers Association). ARI, now AHRI, was originally formed in 1954 through a merger of two related trade associations and traces its history back to 1903 when it started as the Ice Machine Builders Association of the United States. Today AHRI has over 180 companies as members.

Many services are provided by AHRI to assist HVACR technicians. Some of these services, which would supplement this text, are as follows:

- ICE is an industry competency exam. This test is made available to students of educational institutions to test their knowledge of fundamental and basic skills necessary for entry-level HVACR technician positions. The information in this text covers the topics in the AHRI curriculum guide and would assist the student in taking this examination. A directory of those who pass the examination is published nationally to assist prospective employers in identifying job candidates.
- Equipment donations to schools participating in the ICE competency exam. AHRI contacts industry sources having no-cost or low-cost equipment available to supply a school's laboratory needs.
- Technician certification program. In accordance with EPA's enforcement of the Clean Air Act, the sale of refrigerants is made only to those technicians who have been certified. AHRI is among the many approved by EPA to administer the test for certification. In addition, AHRI provides study material to prepare for the test.
- Reclaimer certification program. EPA also requires certification of any processor of recovered refrigerant for resale. AHRI is among those assigned by EPA to carry out a certification program for companies that seek to reclaim refrigerants. Technicians handling reclaimed refrigerant should become familiar with the *Directory of Certified Reclaimed Refrigerants*, published every March and September by AHRI.
- Certification program for equipment used to recover and recycle refrigerant. AHRI is one of the companies approved by EPA to certify equipment used to recover and recycle refrigerants. Technicians should become familiar with the *Directory of Certified Refrigerant Recovery/Recycling Equipment*, published every March and September by AHRI.
- HVACR equipment certification program. AHRI maintains a certification service, which tests a wide variety of equipment and products to verify the performance described by the manufacturer. Certified directories for various products are published semiannually and annually.

AHRI has a full program of educational activities geared toward helping the nation's vocational and technical schools improve and expand their education and training programs. Under the direction of AHRI's education director and its Education and Training Committee, AHRI serves as a resource for manufacturers, school instructors, department heads, and guidance counselors. In addition to this textbook and its companion materials, AHRI produces the *Bibliography of Training Aids*, a career brochure, and a promotional video for schools to use to recruit students into HVACR programs. Many schools around the country have adopted the ICE competency exams as final exams for their programs. AHRI's most recent efforts involve participation in developing national HVACR competency standards.

Having students pass the ICE competency exams and training toward national competency standards will improve the quality of installation and service. New HVACR technicians will be better prepared, resulting in three basic advantages:

- Limited training required for contractors
- Limited rework or repeat calls due to error
- Limited warranty/replacement for manufacturers

The cost of repeat service calls, which is borne by contractors, may be reduced substantially by employing properly trained technicians. Every new technician receives training and serves as an apprentice for a period of time. That is essentially a period where contractors pay two people to do one job. A properly trained technician will generally require less training time and function sooner than a poorly trained technician.

In co-sponsorship with AHRI, ASHRAE holds an annual international Air Conditioning Heating Refrigeration Exposition, which may draw 30,000 to 50,000 people in the field. Product exhibits, technical displays, and business seminars highlight the event.

American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) is an organization started in 1904 as the American Society of Refrigeration Engineers (ASRE) with seventy members. Today its membership is composed of thousands of professional engineers and technicians from all phases of the HVACR industry. ASHRAE also creates equipment standards for the industry. Its most important contribution probably has been a series of four books that have become the reference books of the industry: *HVAC Applications, Refrigeration, Fundamentals,* and *HVAC Systems and Equipment*.

TECH TIP

Becoming an active participating member in a professional trade association will provide you with an opportunity to continue your HVACR education. The HVACR field is such a dynamic and evolving industry that to stay competitive you must continually attend seminars and take classes. This is a field where your success will depend on your continued education.

American Society of Mechanical Engineers (ASME)

The American Society of Mechanical Engineers is an organization composed of engineers in a wide variety of industries. Among other functions, ASME writes standards related to safety aspects of pressure vessels.

Air Conditioning Contractors of America (ACCA)

The Air Conditioning Contractors of America is a service contractor's association concerned with the education of technicians and service managers with business-improvement techniques. ACCA provides technician EPA certification.

Refrigeration Service Engineers Society (RSES)

The Refrigeration Service Engineers Society is the international professional association for all HVACR workers and is dedicated to education and certification of technicians in the HVACR industry. RSES offers Specialist Certification for senior technicians in eight HVACR areas and has a technician EPA certification program. RSES chapters conduct classroom training in technical areas and are a source for educational printed material and books.

HVAC Excellence

HVAC Excellence is a not-for-profit organization that has been serving the HVACR industry since 1994. The organization's goal is to improve competency through validation of the technical education process by offering progressive levels of technician certification through its HVAC Excellence programs.

SERVICE TIP

The AHRI list of certified equipment is available to anyone through the Internet. This material is very helpful when trying to make a determination of the best equipment to recommend for customers and their specific application needs. On the Web, very often all of the various pieces of equipment are available.

UNIT 1—SUMMARY

Since the beginning of time, people have had a desire to control their environment to live and work more comfortably. That trend will not stop, and that is the good news for anyone entering this ever-growing, financially rewarding, and personally satisfying field. HVACR technicians are required to understand the theories behind designing, installing, and servicing a wide range of systems. This diversity ensures that each day on the job will be new and unique, ever changing, and challenging.

UNIT 1—REVIEW QUESTIONS

1. List some of the different ways that homes and buildings may be heated.
2. What were some of the primary heating fuels that early civilizations used?
3. When is it believed that ice was first artificially made for food storage?
4. How did early man make ice?
5. Why did some manufacturers spray water in factories in the early 1700s?
6. How did early Romans cool palaces?
7. What do the terms *environmental heating* and *air conditioning* refer to?
8. What does the term *process heating and cooling* refer to?
9. When did central warm-air systems for residential and commercial applications become well defined?
10. Who developed what is referred to as modern air conditioning?
11. When did mass air conditioning of homes with window units begin?
12. Why is it important to freeze foods quickly?
13. Why do some businesses and/or local and state governments require criminal background checks for HVACR workers?
14. What size range might a commercial air conditioner fit into?
15. Give an example of some of the types of equipment that a commercial refrigeration technician might work on.
16. What type of things might an entry-level helper do?
17. Whose job is it to do the initial installation process, such as install the refrigerant lines, electrical lines, thermostat and control lines, duct boots, and duct run, as well as setting the indoor and outdoor units?
18. What skills must a service technician have?
19. What are some of the things that a service manager must be able to do?
20. What is the ICE exam, and who might take it?
21. What are some of the RSES's activities?