HVAC-R

COURSE NUMBER	COURSE NAME	COURSE DESCRIPTION
HVC100	Employability	This course is designed to identify, improve, track and acknowledge traits and performance specific to improved employability in the chosen field of HVACR. Course will be offered in all four terms and will be directive in timeliness, cleanliness, attention, listening, learning and general ability to be prepared to enter the workforce.
HVC110	Introduction to HVAC-R	Understand career clusters and career pathways. Evaluate HVACR career options. Determine which exams and corresponding certifications are most suited for achieving your career goals. Understand the tools needed for success in the workplace. Understand the importance of professional certifications. Understand the value of an accredited HVACR program. Explain the value of continuing education and training. Understand EPA regulations as they relate to air conditioning and refrigeration. Become involved in HVACR service organizations and trade associations. Describe OSHA and its purpose. Properly assess electrical, fire, temperature, pressure, refrigerant, chemical, and breathing hazards. Explain the components of a safety data sheet (SDS). Discuss the need for personal protective equipment (PPE) for head, hearing, eye, and respiratory protection. Exercise safe practices when lifting, using a ladder or scaffold, for fall protection, in confined spaces, and for hand and power tools. Describe three general categories of HVACR service. Explain the steps in a standard troubleshooting procedure. Evaluate a problem in a logical and systematic sequence. Select a remedy for a problem using a three-step procedure. Explain how a technician's appearance and conduct affects customer relations. Understand the basics for writing service estimates and service contracts. Differentiate between matter and energy. Summarize the relationship between force, work, and power. Differentiate between the Fahrenheit, Celsius, Rankine, and Kelvin temperature scales. Use the appropriate formulas to calculate enthalpy, specific enthalpy, and changes in heat for a given substance. Compare the radiation, convection, and conduction methods of heat transfer. Illustrate the differences between the three states of matter. Differentiate between sensible heat and latent heat. Predict the effect of a drop in temperature or an increase in pressure on a saturated vapor. Summarize the relationships between mass, weight, and density. Explain the concepts of specific gravity and relative density. Compare the different units used to measure refrigeration effect. Describe the effect on gas pressure and temperature when its volume is increased or decreased. Describe Pascal's law and provide examples of it in the HVACR industry. Illustrate the effect of pressure and heat on the three states of matter. Differentiate between gauge pressure and absolute pressure. Understand how the concepts of Boyle's law, Charles' law, Gay-Lussac's law, and the combined gas law explain the behavior of refrigerant in the operation of a mechanical refrigeration system. Describe Dalton's law and explain how it can be applied to HVACR work. Explain the significance of saturated vapors in a refrigeration system. Describe how the processes of air exchange, pressure change, and state change provide a cooling effect. Explain how phase changes are used in refrigeration systems to transfer heat. Describe how phase change is possible through pressure change or the addition or removal of heat. Summarize the four phases of the compression refrigeration cycle. Identify the components that divide the low and high sides of a compression refrigeration system. Understand the purpose of each of the components in a compression refrigeration system. Explain how to use various hand tools. Select the appropriate hand tool for a specific task. Select the appropriate power tool for a specific task. Monitor temperature with various thermometers. Identify different types of fastening methods and devices. Compare cleaning methods and the use of various solvents. Identify basic supplies needed on a typical installation or service call. Follow approved safety procedures. Distinguish among the various types of tubing and piping used in refrigeration work. Explain the uses of the various types of tubing and piping in refrigeration work. Perform tube cutting and bending procedures using proper methods. Complete various tubing and piping connecting procedures using approved methods. Use safe and accepted soldering and brazing techniques. Follow approved safety procedures. Recognize the effect of halogenated refrigerants on the ozone layer. Summarize Environmental Protection Agency regulations governing refrigerants. Differentiate between CFC, HCFC, HFC, and blended refrigerants. Identify refrigerants according to their series number and cylinder color code. Interpret pressure-temperature curves, pressure-enthalpy tables, and pressure-enthalpy diagrams. Summarize the properties and common applications of different refrigerants. Identify which types of refrigerants are compatible with which lubricants. Distinguish between the different types of refrigerant cylinders and identify the proper use of each type. Identify the different kinds of pressure gauges and how they are used. Recognize the various types of service valves used on refrigeration systems. Understand the purpose, construction, and operation of a gauge manifold. List the types of leak detection methods and their advantages and disadvantages. Explain the purpose for using a vacuum pump. Describe the types of equipment used for refrigerant recovery and recycling. Check refrigerant charge by determining a system's superheat or sub cooling. Implement both passive and active refrigerant recovery procedures. Charge a system with an inert gas to pressure test for leaks. Carry out refrigeration system leak repairs using either epoxy resin or brazing. Evacuate a refrigeration system using both deep vacuum and triple evacuation methods. Charge a specific amount of refrigerant into a system as either a liquid or vapor. Follow approved safety procedures when recovering and charging refrigerant.

HVC200	Employability	This course is designed to identify, improve, track and acknowledge traits and performance specific to improved employability in the chosen field of HVACR. Course will be offered in all four terms and will be directive in timeliness, cleanliness, attention, listening, learning and general ability to be prepared to enter the workforce.
HVC210	Electrical	Many of the components in an HVACR system are electrically operated. For example, the majority of com- pressors and fans are driven by electrically powered motors. These electrically powered motors operate by using magnets to generate motion. Electricity not only operates many parts of an HVACR system, but it also controls many parts of the system. For instance, electric relays open and close compressor and fan motor circuits when a desired temperature has been reached or when operating conditions become unsafe. Having a good understanding of basic electricity, electrical circuits, and the relationship between electricity and magnetism will help a technician install and troubleshoot electrical and electronic components. To understand electrical power, a technician must first understand how to calculate power in a circuit and how factors such as resistance and capacitance affect a circuit's power. A technician must also understand the types of power supplied by utility companies, the types and sizes of wire used in circuits, and the methods for properly connecting, grounding, and bonding an electrical system. In addition, being familiar with the different types of overcurrent protection devices and common electrical problems will make diagnosing electrical issues much easier for an HVACR technician. Understanding electrical power will enable a technician to install new components and troubleshoot malfunctioning components based on the power available in a given application. The basis of all electronic devices is semiconductor material. Having a good understanding of how semiconductors can be used to conduct or block the flow of cur- rent in a circuit will help a technician comprehend how individual electronic devices function. Electronic devices are used in control circuits to regulate an HVACR system and maintain stable conditions. Electronic devices help to prevent a system from operating outside of its designed boundaries. Some electronic devices monitor conditions outside of an HVACR system and tell the system when to turn on or off. Other devices are used to control or alter the flow of electricity in a circuit, which can be useful for converting current from one form to another, varying the speed of a motor, or turning a motor on or off. In addition, other devices are used to control the flow of refrigerant or other fluids in a system. Motors play a major part in HVACR systems. By con- verting electrical energy to mechanical energy, motors drive the compressor that compresses refrigerant, circulate hot and cold air around the evaporator and con- denser, and perform many other essential tasks. Although most motors operate on similar principles, not all motors are identical. Because they are used in different applications, motors starting and running characteristics vary, along with the amounts of torque and speed they pro- duce. Understanding how electric motors operate is essential for a technician to be able to troubleshoot a malfunctioning motor or replace a motor with the proper type. Understanding a motor's application within a system is key to properly diagnosing a problematic HVACR system. Electrical control systems are used to regulate the operation of an HVACR system and protect its components from operating outside of their designed boundaries. From controlling a compressor's On and Off cycles to modifying the position of a damper in an air duct, electrical controls help an HVACR system automatically produce the desired condition in a space. In addition, control system components can be used as safety devices to detect unsafe operating conditions and shut down a system before any damage occurs. This chapter focuses on the fundamental operation of control systems and explains how the components used in those systems function. More detailed information about application- specific controls, such as defrost controls, is presented in the chapters dealing with those systems. HVACR technicians must know how to test electrical circuits in order to properly troubleshoot and service electric motors and controls. The service of electric motors and controls also requires knowledge of the system design and an understanding of how electrical devices operate within the system. Consistently following good safety practices and being able to read wiring diagrams are the first steps to mastering a skill that requires practice and experience. However, an HVACR technician can still achieve a high degree of success, regardless of skill level, by following an established procedure and performing electrical troubleshooting one step at a time. Safety is the most important aspect of working on electrical equipment. Before any service is performed, power to a motor or control should be shut down and locked out when possible.
HVC220	Introduction to Refrigeration	The compressor is the "heart" of a refrigeration sys- tem. It compresses low-temperature and low-pressure refrigerant vapor into a much smaller volume. As the refrigerant is compressed into a smaller volume, its temperature and pressure increase. The pressure is increased from a low-pressure level (suction) at the compressor's inlet to a high-pressure level (discharge) at the compressor's outlet. Cool refrigerant enters the compressor through the suction valve. The refrigerant contains the heat that was absorbed when the refrigerant vaporized in the evaporator. The compressor pumps this vapor to the condenser, where the heat is released from the refrigerant as it condenses and subcools. Of the four basic devices in any HVACR sys- tem (compressor, condenser, evaporator, and metering device), the compressor is the most expensive. It is important that compressors operate safely and are maintained to perform at peak efficiency for a long and useful operational life. A compressor should be applied within the manufacturer's recommended temperature and pressure conditions. Long-term operation also requires that the oil and refrigerant entering the compressor is clean and of the correct quality. In order for a refrigeration system to function properly, the proper quantity of refrigerant must be circulated through the system at the proper pressures. Metering devices restrict the flow of refrigerant to create the proper pressure drop between the high-side and low-sides of the system. Metering devices may be

		orifices of fixed size that provide a continuous restriction in the flow of refrigerant, or they may be valves, which can vary the flow to meet the demands of varying loads. A heat exchanger is any device that transfers heat from one medium to another. In a refrigeration system, low-pressure refrigerant flows through an evaporator and absorbs heat from indoor air. This heat is later released from the now high-pressure refrigerant in a condenser to outside air. Both evaporator and condenser are examples of heat exchangers. A heat exchanger uses two separate mediums. One medium is releasing heat, and the other is absorbing heat. In many cases, these two mediums are refrigerant and air. However, different types of systems, such as chillers and hydronic systems use water as a medium. Heat exchangers in forced-air heating systems are dependent on the method of heat production. Those will be covered in the heating chapters. In addition to metering devices, many different types of mechanical and electromechanical devices are used to regulate refrigerant flow, pressure, quality, and storage. They ensure that the correct amount of clean oil and refrigerant are circulated in the system for safe operation. In addition to the many automatic valves used through- out a system, manual valves also allow access for service, repair, and maintenance. One of the most common modern refrigeration products is the household refrigerator-freezer. Almost every home has some form of self-contained refrigeration system that provides safe storage of perishable goods. This chapter explains the causes of food spoilage. It also describes the construction and operation of the various types of domestic refrigeration systems used to prevent spoilage. The differences between domestic refrigeration systems and commercial refrigeration systems are also addressed. As with all refrigerant-based systems, four basic components are needed to produce cooling for a conditioned space inside a refrigerator or freezer cabinet. The four components are the compressor, condenser, metering device, and evaporator. A filter-drier is usually included in the sealed system, and an accumulator may also be present. Refrigerators may have additional specialized systems, including defrost and condensation controls, ice makers, and ice and water dispensers. In order to effectively troubleshoot a domestic refrigerator-freezer, a technician must first have a good understanding of how the system works. Good trouble- shooting begins by eliminating the simplest and most common possible problems first. After the simplest possible causes have been eliminated, other potential causes of problems should be methodically checked and eliminated. Before servicing refrigeration units, a technician should check all service information and system specifications. System specifications are usually located on an identification plate mounted on the compressor. This information will help you determine the type of refrigerant, refrigerant charge, compressor hp, compressor speed, running amperes, voltage, phase, and other data for the unit. The servicing of refrigerators with hermetic systems can be divided into three areas, external servicing, internal servicing, and overhaul.
HVC300	Employability	This course is designed to identify, improve, track and acknowledge traits and performance specific to improved employability in the chosen field of HVACR. Course will be offered in all four terms and will be directive in timeliness, cleanliness, attention, listening, learning and general ability to be prepared to enter the workforce
HVC310	Air Conditioning	Temperature, humidity, air movement, and air cleanliness are all conditions that affect how comfortable an environment is. A specific range of values for each of these conditions provides the most comfort. However, if one of these conditions falls outside of the comfort range, the other conditions can often be adjusted to compensate. For instance, high relative humidity tends to be uncomfortable. However, a relatively low temperature and rapid air movement may counteract it. In many homes during the wintertime, an increased room temperature and little air movement compensate for low relative humidity. This chapter addresses the temperature and humidity conditions that an HVAC system must maintain in order to pro- vide for human comfort. As the seasons change, accommodations must be made to ensure comfort. Winter heating conditions require automatic control of the heating source to maintain desired room temperatures. The lower the humidity, the higher the temperature required. Humidity control for winter conditions may require the addition of moisture by a humidifier. In the summertime, air-conditioning systems are used to maintain the desired room temperature. As warm, moist air is blown over the evaporator coil, the air is cooled and dehumidified. A good air-conditioning system delivers clean air to the space being conditioned. Air quality control includes more than just the removal of contaminants. Indoor air quality (IAQ) includes the status of indoor air as measured by temperature, humidity, fresh airflow, pollutants, and chemicals in an enclosed space. Air-conditioning systems condition the air and distribute it. They are designed to distribute air to the proper space in amounts that provide the most comfort to the occupants of the conditioned space. When a radiator or a room convector system is used, air distribution is simple. An example of this type of air distribution is a radiator. The heat exchange units are located along the outside walls. During the heating season, heated air rises from the radiator along the wall. It mixes with the cold air adjacent to the cold wall. Natural air currents (convection) then move the air mixture throughout the room. Many heating systems use motor- driven fans to help circulate the air. A good air-conditioning system delivers clean air to the space being conditioned. Proper ventilation can also help control humidity levels in indoor air. Uncontrolled humidity from bathrooms, laundry rooms, and shower rooms can cause condensation on windows and walls. Proper ventilation can also control odors from cooking, smoking, or other household activities. Air distribution systems are designed to circulate clean air without causing discomfort to the occupants. Two common air circulation issues are drafts and noise. Monitors are available to determine sources of noise or drafts. The airtightness of a building envelope can be tested using blower door testing, which creates a pressure differential between the indoor and outdoor air. Ducts can be tested by

		pressurizing the ducts themselves. A system must be balanced to avoid inconsistencies in room temperatures and humidity. Air ducts present a potential indoor air quality (IAQ) issue. They must be monitored for contaminants. The technician should take care to check air filters for cleaning and replacement. Comfort cooling systems are systems that reduce the temperature and humidity in living and work spaces to a level comfortable for the occupants. Comfort cooling systems often use a mechanical refrigeration system to maintain the high-temperature refrigeration range (between 55°F to 90°F). The refrigerant evaporating temperature of most comfort cooling systems is 40°F to 50°F (4°C to 10°C). The information in this chapter is applicable to the most popular designs of ductless systems using mechanical refrigeration for cooling and dehumidifying. The ability to comfortably and cost effectively condition the air within multiple rooms in homes has led to an increased demand for central air conditioning. What was once considered a luxury for homeowners is now a standard feature. Therefore, it is important for the technician to be familiar with these systems. Commercial air conditioning differs from residential air conditioning in several ways. A commercial conditioned space is generally larger than a residential conditioned space. This does not just mean more square footage. It may also mean having a higher ceiling. Compare the height of a home's kitchen ceiling to that of a department store ceiling. This increase of square foot- age and having a higher ceiling can equate to a very large volume of conditioned space. Another major difference is how a building is used and accessed. A busy store or supermarket may have people going in and out frequently. This opening and closing of doors can mean much more heat and humidity entering a building than a residence that is accessed many fewer times throughout a day. This results in an increase of sensible and latent heat that must be removed. The amount of heat in Btu that must be moved is generally more in commercial than in residential. Because of these two differences, commercial air conditioning may employ different methods of transferring heat, such as using chillers. Much of commercial air conditioning uses forced-air systems. The benefit of using forced-air is that ventilation needs can also be addressed within the same system. Chillers often have greater potential for heat absorption, but they do not always have ventilation capabilities. These may need to be incorporated using other components. The comfort cooling systems described previously in the book have been based on the familiar compression refrigeration system. In this chapter, you will be introduced to two additional methods of cooling a space. These methods are absorption cooling and evaporative cooling. Good, complete air-conditioning systems must pro- vide heat, remove heat, and clean and circulate the air. Most systems accomplish all of these tasks. However, many systems do not completely control the relative humidity of the air. To control relative humidity, there must be two devices in the system ready to be used at any time, winter or summer: • A device to add water vapor to the air (humidifier). • A device to remove water vapor from the air (dehumidifier). In some central air-conditioning systems, a humidi- stat causes the system to operate if the air is too moist. The evaporator is located in the plenum chamber of the central air-conditioning system. When the air- conditioning system is operating, the cold surfaces of the evaporator will condense out moisture, drying the air. This method provides fairly effective humidity control during the cooling season. Another method of controlling humidity is to bring in and mix cool air and warm air to achieve the desired temperature and relative humidity. Both cool and warm air should have a normal (50%) relative humidity. By mixing these air volumes in different proportions, the needed temperature and relative humidity conditions can be produced. One of the most common control devices in HVACR systems is the thermostat. A thermostat is a sensing device that reacts to temperature change. Often, a thermostat reacts in order to control a system's starting and stopping when preset temperature conditions are reached. Conditioned space temperature is usually the primary variable that must be measured, but many other temperatures can be measured to monitor system operation and efficiency. Heating and cooling systems must be properly sized for the size and environmental conditions of the space being conditioned. The heating system should be capable of keeping the occupied space warm even on the coldest winter days for the given location. In much of the United States, typical heating systems are called upon to maintain a 70°F (21°C) inside temperature while outside temperatures fall below 0°F (–18°C) with strong winds. Air conditioning systems must be sized to provide adequate cooling capacity for the warmest days in the summer. As new buildings are constructed and existing buildings are renovated, architects and builders strive to incorporate sustainable design. Sustainable design is the use of materials and processes that lower energy costs, reduce operating and maintenance costs, increase productivity, and decrease the amount of pollution that is generated. All of a building's heating and cooling loads must be accurately accounted for in order to determine the specific needs for HVAC equipment. The calculation of the heating and cooling loads should be the first step in an energy audit of a building, which includes identifying sources of heat leakage and recommendations for improvement.
HVC320	Heating	Heating systems can be classified in a number of ways. Two common ways of classifying heating systems are by heat source and by heat distribution method. Common heat sources include oil, gas, electricity, geo- thermal energy, and air. Methods of heat distribution include forced-air, hydronic, and radiant distribution. Forced air and hydronic are the types of heating systems most commonly used in homes and offices. Radiant heating systems are often used in large, open commercial environments, such as warehouses and workshops. A complete heating system combines one or more heat sources with one or more methods of heat distribution. Gas, oil, and electric heating systems can all transfer heat through forced-air, hydronic, or radiant distribution. This chapter provides an overview of heating systems that distribute heat using the forced-air method. Later chapters in this section will address

		hydronic and radiant distribution and provide more detailed information about the various methods of generating heat. Hydronic systems distribute conditioned water or steam to occupied spaces in order to heat or cool those spaces. Since this section of the textbook deals with heating, this chapter focuses on hydronic heating systems rather than hydronic cooling systems, which utilize chillers. Compared to forced-air heating systems, hydronic heating systems offer the following benefits: • More consistent temperature levels. Even when a hydronic system's pump is not circulating water, the piping still contains heated water that continues to radiate heat. For this reason, temperatures remain steady for longer periods of time in hydronic systems than in forced-air systems. Maintains increased heat transfer efficiency. Hydronic tubing requires less room than standard air ducts in forced-air systems. Less moisture removed from indoor air than in forced-air systems. Do not introduce any dust, allergens, or mold into the conditioned space. Hydronic systems are used in some single-family homes and apartment buildings. The boilers that are used to heat water for hydronic systems may also be used for domestic water heating. Although hydronic systems can be designed to distribute either water or steam, water is now more commonly used than steam. This choice allows the system to be more easily modified to provide comfort cooling with chilled water. Using hot water instead of steam also allows the user to adjust the temperature of the circulating water based on heating demand, which is not possible with steam. The ability to reduce the circulating water's temperature during periods of low demand makes hot-water hydronic systems more efficient than their steam counterparts. A heat pump is a compression refrigeration system that can reverse the circulating flow of refrigerant in order to add heat or remove heat from a conditioned space, depending on its mode of operation. Heat is absorbed by one coil in one location and released by another coil in another location. In this way, heat pumps are similar to standard comfort cooling systems. However, unlike com- fort cooling systems, heat pumps can reverse the flow of refrigerant in order to change their operation from cooling to heating. A reversing valve controls the direction of refrigerant flow through a heat pump's refrigerant circuit. The direction of refrigerant flow determines whether the heat pump heats or cools a conditioned space. When the refrigerant flow is reversed, the coil that previously functioned as an evaporator begins functioning as a con- denser. The other coil, which functioned as a condenser, now begins functioning as an evaporator. Heat pumps can use a variety of system arrangements and distribution methods. These can be found in residential, commercial, and industrial applications. This chapter covers the process of combustion, the fuel gases used in heating, and the operation of the components in gas-fired heating. The operation of a gas-fired, forced-air furnace starts when a thermostat or other controller calls for heat. When the temperature in the conditioned space drops to the cut-in temperature, the thermostat initiates a call for heat. At the furnace, the heating process begins with the fuel gas. Oil-fired heating systems use the combustion of vaporized fuel oil to create heat for distributing throughout a conditioned space. Oil-fired systems come in a variety of designs, such as forced-air oil furnaces, oil-fired boilers, and oil-fired unit heaters. Heat from fuel oil combustion is transferred through a heat exchanger into a medium, such as air or water, which then distributes the heat throughout a conditioned space. The products of combustion are piped from a combustion chamber into a flue leading outdoors. Oil furnaces are available in a broad range of Btu capacities and in up flow, down flow, and horizontal designs. The minimum allowable annual fuel utilization efficiency (AFUE) rating for an oil furnace is 78%. Manufacturers of standard oil furnaces have mostly kept AFUEs below 85% to minimize problems resulting from flue gases that cool and condense into a corrosive liquid. However, some manufacturers have produced oil-fired condensing furnaces with over 90% AFUE that can capture additional heat from flue gas and safely pipe away corrosive condensation. Many buildings in the United States were built when energy was relatively cheap and few people understood the need to conserve and the benefits of conserving. Energy types, sources, and costs have changed dramatically since then. Older buildings are now being modified for better efficiency, and new buildings are designed to operate using less energy. Computer-controlled systems that condition different building areas independently are now used not only for precise comfort control but also for energy efficiency. There is a growing movement in the HVACR industry toward "going green". This includes offering cost- effective, environmentally friendly energy conservation options to both business and residential customers. In the context of HVACR, energy conservation is a reduction in the amount of energy needed for HVACR-related processes and equipment operation. However, energy conservation consists of more than just installing newer, more efficient systems. It also includes installing the new systems correctly and servicing or upgrading existing systems to improve their efficiency. A building's energy efficiency depends both on the physical characteristics of a building and on its existing HVAC system. An efficient building design and efficient HVAC equipment can save a building owner a significant amount of money and reduce the building's impact on the environment.
HVC400	Employability	This course is designed to identify, improve, track and acknowledge traits and performance specific to improved employability in the chosen field of HVACR. Course will be offered in all four terms and will be directive in timeliness, cleanliness, attention, listening, learning and general ability to be prepared to enter the workforce.
HVC410	Commercial Refrigeration	Commercial refrigeration systems vary greatly to meet their different applications. Many are high-capacity systems with aluminum and stainless steel cabinets for greater durability and ease of maintenance. Commercial refrigeration systems may also use multiple compressors, condensing units with multiple fans and flow controls, and specialized evaporators. Examples of commercial systems include supermarket refrigeration units, food dis- play cases, refrigerated beverage and ice cream dispensers, and ice machines. The refrigeration

		systems that have been described up to this point have mainly been mechanical compression systems used in stationary locations, such as super- markets. This chapter covers systems that are designed to be mobile, systems used in spaces with limited access, and systems that achieve extremely cold temperatures. Some of the specialized systems covered are adaptations of compression refrigeration systems. Others use methods other than mechanical compression to produce refrigeration temperatures. Because of the broad range of applications for commercial refrigeration, a wide variety of system configurations have been developed. Commercial refrigeration systems may be custom designed and constructed to meet the specific needs of the customer. These systems may use any of a number of methods to achieve the desired cooling capacities under the expected operating conditions. Commercial refrigeration often requires the installation of custom systems that are designed for a specific application. For instance, the existing space available in a building may dictate the size of a walk-in cabinet. The first step in sizing a custom refrigeration system is to determine the purpose of the system. The product to be refrigerated determines the type of refrigerant and the size of equipment to be used. Low-temperature applications, such as freezers that operate from 0°F to –60°F (–18°C to –51°C), may use R-404A or R-508B with multiple compressors in a cascade system to achieve low temperatures. Mid- temperature applications, such as grocery display cases that operate from 35°F to 45°F (2°C to 7°C), may use a secondary loop refrigeration system circulating a non- phase changing refrigerant that absorbs heat but does not vaporize. Higher-temperature applications, such as florist cabinets, may use R-134a with a hermetic compressor and require high humidity. Since each application is unique, the condensing and evaporating units must be matched to the specific refrigeration requirements of the conditioned space. Installing commercial refrigeration equipment is a major part of the HVACR industry. Regulating bodies and authorities inspect and examine installations for proper workmanship, safety concerns, and code-required practices. Commercial installation codes are very strict to ensure the safety of the building occupants at all times. Improper installations can lead to equipment failure, which can result in companies losing valuable work time and refrigerated or frozen products. A thorough knowledge of HVACR fundamentals is essential. Before trying to troubleshoot a commercial refrigeration system, review its basic operating characteristics, such as compressor current draw, superheat, sub- cooling, suction and head pressures, and evaporator and condenser temperature. When a measurement or a reading differs from normal operating characteristics, consider what might be causing that off measurement. Be aware that some obvious symptoms may be caused by less obvious root problems. Common sense is an invaluable asset needed to service, troubleshoot, and diagnose problems in commercial refrigeration system. The financial investment in a commercial refrigeration installation is significant. Since so many mechanisms are dependent on the proper function of another mechanism, one system problem often causes other problems. The system operation and diagnosis information covered in the previous chapter was in preparation for trouble- shooting a system down to specific component level. This chapter will cover how to check specific components in a system to tell whether they are responsible for a system's poor operation. The servicing of commercial refrigeration systems is much like working on domestic systems. However, in commercial refrigeration, multiple evaporators on a single suction line is common. Also, a single suction line may flow into one or several compressors in parallel. Since commercial refrigeration condensers operate throughout the year, they use some method of head pressure control, such as fan cycling, variable frequency drives, louver opening and closing, pressure-regulating valves (low-ambient controls), split condenser arrangements, and electric heaters. Unloading and defrosting subsystems add to service complications. Career Services Review for EPA 608 Exam