# 1 Exam Prep
# HVAC Basics for Contractors
# Tabs and Highlights

These 1 Exam Prep Tabs are based on the *HVAC Basics for Contractors*.

Each 1 Exam Prep Tabs sheet has five rows of tabs. Start with the first tab at the first row at the top of the page; proceed down that row placing the tabs at the locations listed below. Place each tab in your book setting it down one notch until you get to the bottom of a page. Then start back at the top again.

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****** This concludes the tabs for this book. Please continue with the highlights below. ******

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| 00101-09 | **Basic Safety** |
| 2.0.0 | **Importance of Safety**: Ultimately, your safety is on your own hands. |
| 2.1.0 | **Safety Culture:** There are many benefits to having a safety culture. Companies with strong safety cultures usually have: (5 bullets)<br><br>A strong safety culture can also lower … keeping workers employed. |
| 3.0.0 | **Accidents: Causes and Results**<br>- Near-miss<br>- Property damage<br>- Minor injuries<br>- Serious or disabling injuries<br>- Fatalities |
| 3.2.0 | **What Causes Accidents:** You may already know some of the main causes of accidents. They include the following: (9 bullets) |
| 3.2.1 | **Failure to Communicate**<br><br>All work sites have specific markings and signs … Learn and recognize these types of signs: (5 bullets).<br><br>These signs are blue: (3 bullets)<br><br>The background on these signs is white … green panel with white letters: (5 bullets).<br><br>Caution signs are yellow and have black panel with yellow letters: (3 bullets). |

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| | Danger signs are red, black, and white: (5 bullets). |
| | Safety tags are temporary warnings of immediate and potential hazards. |
| 13.2.6 | **Unsafe Acts:** Here are examples of unsafe acts: (11 bullets) |
| 3.2.7 | **Rationalizing Risks**: The following are common examples of rationalized risks on the job: (4 bullets) |
| 3.2.8 | **Unsafe Conditions:** (12 bullets) |
| 3.4.2 | **The General Duty Clause** |
| 3.4.4 | **Inspections**<br>- Imminent danger inspections<br>- Catastrophe inspections: report to OSHA within 8 hours<br>- Worker complaint and referral inspections<br>- Programmed inspection<br>- Follow-up inspection<br>- Monitoring Inspection<br><br>Inspections are typically performed by conducting a walk around. During a walk around inspection, the inspector typically does the following: (5 bullets) |
| 3.4.5 | **Violations:** Fines for serious safety violations can cost up to $7,000. Willfully -$70,000. |
| 3.6.0 | **The Four High-Hazard Areas**: Construction has for leading cause of death … Here are explanations of the four leading hazard groups: (4 bullets). |
| 5.3.0 | **Unprotected Sides, wall Openings, and Floor Holes:**<br>- Railings … prevent falls<br>- Warning barricades: Red means danger, yellow means caution, yellow and purple means radiation warning<br>- Protective barricades:<br>- Blinking lights:<br>- Hole covers: |
| 6.0.0 | **Ladders and Stairs** |
| 6.2.2 | **Using Extension Ladders:** The highest safe standing level on an extension ladder is the fourth rung from the top. |
| 7.0.0 | **Scaffolds**: That's why it is important to inspect every part of a scaffold before each use. |
| 8.0.0 | **Struck-By Hazards** |
| 8.1.0 | **Vehicle and Roadway Hazards:** Follow these guidelines: (7 bullets)<br><br>Follow these safety guidelines when you operate vehicles on a job site: (10 bullets). |

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| 9.0.0 | **Caught-In-Between Hazards** |
| 9.1.3 | **Protective Systems**<br><br>The maximum allowable slope for sloping or benching systems depends on the type of soil that is being dug.<br>- Type A<br>- Type B<br>- Type C |
| 9.2.0 | **Tool and Machine Guarding**<br><br>The following types of tools and machines must have guards: (8 bullets). |
| 10.0.0 | **Electrical Hazards** |
| 11.0.0 | **Personal Protective Equipment** |
| 12.1.0 | **MSDS Sheets**: The information is found on an MSDS includes: (9 bullets). |
| 13.3.1 | **Heat Cramps**: Symptoms include the following: (5 bullets)<br>If you experience heat cramps, take the following steps:<br>- Step 1<br>- Step 2<br>- Step 3<br><br>Symptoms of heat exhaustion include the following: (8 bullets) |
| 13.3.3 | **Heat Stroke:** The symptoms of heat stroke include: (8 bullets) |
| 13.4.2 | **Hypothermia:** Symptoms of hypothermia include the following: (6 bullets). |
| 13.7.0 | **Construction Ergonomics**<br><br>If you are performing tasks that involve constant repetitive … follow these guidelines: (4 bullets)<br><br>To reduce back injuries when lifting, follow these guidelines: (4 bullets).<br><br>**Glossary**<br>- Competent person<br>- Confined space<br>- EMR<br>- Guarded<br>- Lanyard<br>- Lockout/tagout<br>- MSDS<br>- Maximum allowable slope |

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| | - OSHA<br>- PPE<br>- Toeboard |
| 3103-07 | **Copper and Plastic Piping** |
| 1.0.0 | Copper pipe is used to transport refrigerant in residential and smaller … Black iron, brazed copper, and flexible plastic pipe are used to transport natural gas for heating systems. |
| 2.0.0 | Installation Precautions: Only ACR copper piping and fittings should be used in refrigeration work. |
| 3.0.0 | **Materials:** Residential and small commercial refrigeration systems using halocarbon (halogenated hydrocarbon) refrigerants normally use copper tubing. |
| 3.1.0 | **Selecting Copper Tubing and Fittings:** The size (diameter) of the tubing to be used depends on … Soft copper tubing is suitable for small systems. IKt ranges from 1/8" to 1 3/8" in diameter. |
| 3.3.0 | **Labeling (Markings)** |
| | Table 1 Copper Tubing Color Codes |
| 4.0.0 | **Copper Tubing:** The tubing used in all domestic refrigeration systems is special annealed … for use in air conditioning and refrigeration work. |
| 4.3.0 | **Cutting Tubing:** The tube cutter is the preferred method because it produces a cleaner joint and leaves no metal particles. |
| 4.5.0 | **Joining:** There are two accepted methods of joining tubing … Heat bonding is accomplished by soldering or brazing. |
| 4.5.1 | Flared Connections |
| 4.5.2 | Swaged Joints |
| 4.5.3 | Compression Joints |
| 5.0.0 | **Plastic Pipe** |
| 5.1.0 | **ABS Pipe:** ABS pipe is rigid and has good impact strength at low temperatures. It is used for water, vents, and drains. |
| 5.2.0 | **PE (Polyethylene) Pipe:** PE pipe is used in cold-water systems such as water source heat pumps. |
| 5.3.0 | **PVC (Polyvinyl Chloride) Pipe:** PVC is a rigid pipe with high impact strength. |
| 5.4.0 | **CPVC (Chlorinated Polyvinyl Chloride) Pipe:** CPVC can be used for hot water (up to 180 F) in a pressurized system (up to 1000 psi). |

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| 5.5.0 | **PEX (Crosslinked Polyethylene Tubing):** PEX is a heat transfer tubing that is used in radiant floor heating systems. |
| 5.6.0 | **Joining Plastic Pipe:** When joining pipe, always follow the cement manufacturer's instructions. Step 1 – Step 8. |
| | The procedure for joining ABS pipe with cement is the same as for PVC or CPVC, except that no primer is required. |
| 6.0.0 | **Hangers and Supports:** The principal purpose of hangers and brackets is to keep the piping in alignment and to prevent it from bending or distorting. |
| 7.0.0 | **Insulating:** Insulation should be fire-resistant, moisture-resistant, and vermin-proof. |
| | If it is necessary to install the insulation at the jobsite, it should be added before the tubing is connected. |
| | Some pipes are always insulated, while others are insulated only … job specifications will usually describe insulation requirements. |
| 8.0.0 | **Pressure Testing** |
| 8.1.0 | **Technique:** Exercise caution when using nitrogen to build up pressure for testing at code specifications … Second, there must be a hand shutoff valve, pressure regulator, pressure gauge, and pressure relief valve in the charging line. |
| | A soap solution or commercial test liquid can be used to check for leaks when using nitrogen. |
| 10.0.0 | **Safety:** here are a few general precautions that you should follow: (4 bullets). |
| | **Warning!** Oxygen, compressed air, or acetylene must never be used when pressure testing for leaks. Oxygen will explode when exposed to oil. |
| 03104-07 | **Soldering and Brazing** |
| 1.0.0 | **Introduction:** The difference between soldering and brazing is the temperature needed to melt the filler metal … The filler metals used for brazing melt at temperatures above 650 F. |
| 2.0.0 | **Soldering:** Soldering joints are used in piping systems that carry liquids at temperatures of 250 F or below. Soldered joints are typically used for: (3 bullets). |
| | Soldering involves joining two metal surfaces by using heat and nonferrous filler metal … The melting point must be lower than that of the two metals that are being joined. |
| 2.1.0 | **Solders and Soldering Fluxes:** Solder is a nonferrous metal and metal alloy with a melting point below 800 F… The most common solder used on HVAC copper low-pressure refrigeration tubing is an alloy made of 95 percent tin and 5 percent antimony. |
| | Flux performs the following functions: (4 bullets). |

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| | Fluxes can be classified into three general groups: highly corrosive, less corrosive, and non-corrosive. |
| | The fluxes used for joining copper tubing and copper fittings should be noncorrosive fluxes. |
| 2.2.0 | **Preparing Tubing and Fittings for Solder:** Use the following procedure to prepare the tubing and fittings for soldering. Step 1 – 10. |
| 3.0.0 | **Brazing Copper Fittings and Tubing:** Brazing is performed above 800 F. Brazed tubing and fittings are used in: (7 bullets). |
| 3.1.0 | **Filler Metals and Fluxes:** Filler metals used to join copper tubing are of two groups … and copper alloys that contain phosphorus. |
| 3.2.0 | **Preparing Tubing and Fittings for Brazing:** Use the following procedure to prepare the tubing and fittings for brazing. Step 1 – Step 10. |
| 3.3.0 | **Setup of Brazing Heating and Equipment:** Most brazed joins are made at temperatures between 1,200 F and 1,550 F. |
| 3.3.1 | **Handling Oxygen and Acetylene Cylinders:** Oxygen is supplied in cylinders at pressures of about 2,000 psi. Acetylene cylinders are pressurized at about 250 psi. |
| | A pressure-reducing regulator set for not more than 15 psig must be used with acetylene. |
| 3.4.0 | **Purging:** All the air must be removed from the tubing to be brazed. This can be done best by purging the tubing with nitrogen. |
| | OSHA regulations require that the internal atmosphere of a permit-required confined space be tested … before an employee is allowed to enter the space. |
| 3.5.0 | **Brazing Joints:** Use the following procedure to braze a joint. Step 1 – Step 10. |
| 03105-07 | **Ferrous Metal and Piping Practices** |
| 1.0.0 | **Introduction:** Ferrous metal piping is piping that contains or is made from iron … Steel pipe has many uses in the field, including: (5 bullets). |
| 2.0.0 | **Steel Pipe** |
| 2.1.0 | **Sizes and Wall Thickness:** There are two ways to describe the wall thickness of a pipe … The schedule numbers are 5, 10, 20, 30, 40, 60, 80, 100, 120, 140, and 160. |
| | The second way to describe pipe wall thickness is by manufacture’s weight … In ascending order of wall thickness, they are: (3 bullets). |
| 2.2.0 | **Threads:** Threads diameters refer to the nominal size of steel pipe … the nominal size, number of threads per inch, and the thread series symbols. |

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| 2.3.0 | **Pipe Fittings:** Pipe fittings for steel pipe are generally made of acst iron, malleable iron, or galvanized iron. |
| 2.3.1 | **Tees:** Tees are specified by giving the straight-through (run) dimensions first, then side-opening dimensions. |
| 2.3.5 | **Nipples and Crosses:** Nipples are pieces of 12” or less in length and threaded at both ends. They are used to make extensions from a fitting or to join two fittings. |
| 3.0.0 | **Tools and Materials** |
| 4.0.0 | **Joining Procedures** |
| 4.1.0 | **Measuring:** To determine actual pipe lengths, threaded pipe can be measured by a variety of methods.<br><br>An end-to-end measurement is accomplished by measuring the full length of the piping including the threads at both ends.<br><br>An end-to-center measurement is used for a piece of pipe with a fitting screwed onto one end only.<br><br>A face-to-end measurement differs from an end-to-center measurement in that the length … plus the length of the thread engagement.<br><br>A center-to-center measurement is used to measure pipe with fittings screwed onto both ends.<br><br>Figure 15: Pipe measuring methods |
| 4.4.0 | **Threading** |
| 4.4.1 | Using a Hand Threader and Vise: The cut threads using a hand threader and vise, proceed as follows: Step 1 - Step 8.<br><br>Step 5: When enough thread is cut to keep the die firmly on the pipe, apply some thread-cutting oil.<br><br>Oil the threading die every two to three downward strokes. |
| 4.4.2 | Using a bench or Tripod Threading Machine: Become familiar with the manufacturer’s operating procedures before attempting to operating any threading machine.<br><br>To thread using a power threading machine: Step 1 – Step 8. |
| 4.6.0 | **Installing Steel Piping:** The main thing to remember is that the method used to install a piping system is generally defined by the builder’s specifications. |

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| | Table 3 Recommended Maximum Hanger Spacing Intervals for Carbon Steel Pipe |
| 5.0.0 | **Grooved Pipe:** Grooved pipe is so called because grooves instead of welded, flanged, or threaded joints are used for coupling.<br><br>A standard grooved piping coupling consists of a rubber gasket and two housing halves that are bolted together. |
| 5.1.0 | **Preparing Pipe Ends** |
| 5.3.0 | **Installing Grooved Pipe Couplings:** The procedure used to join grooved pipe is as follows: Step 1 – Step 8. |
| 6.0.0 | **Flanged Pipe:** Flange fittings are joined with gaskets and bolts. |
| 03109-07 | **Air Distribution Systems** |
| 2.0.0 | **Air Distribution Systems**: All adequate air distribution systems must do the following: (6 bullets)<br><br>Most air distribution systems are forced-air systems … The air handler is the device that moves the air in a forced-air system. |
| 2.1.0 | **Airflow and Pressures in the Distribution System Ductwork:** The pressure decreases to its lowest point at blower input … to its highest level at the blower discharge.<br><br>The amount of pressure difference needed to move air through a duct system depends on the velocity, the volume, the cross-section area of the duct … Volume is a measure, in cubic feet, of the amount of air that flows past a point in one minute.<br><br>Volume in cubic feet per minute (cfm) can be calculated by multiplying the velocity …as follows: (highlight equation).<br><br>The three pressures that exist in a duct system are static pressure, velocity pressure, and total pressure.<br><br>Static pressure is the pressure exerted uniformly in all directions within a duct system.<br><br>Velocity pressure is the pressure in a duct system caused by the movement of the air.<br><br>Total pressure is the sum of the static and the velocity pressures in a duct system.<br><br>Due to the low pressures inside a duct system, a manometer is used to measure duct static, velocity, and total pressures in inches of water column. |
| 2.2.0 | **Air Distribution in a Typical Residential System:** As a rule of thumb in HVAC, cooling requires about 400 cfm $\pm$ 50 of air per ton of cooling. |

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| | Figure 6: Typical residential air distribution system. |
| 3.0.0 | **Fans and Blowers:** The blower or fan provides the pressure difference necessary to force the air into the supply duct …and into the conditioned space. |
| 3.2.0 | **Centrifugal Blowers** |
| 3.2.1 | **Forward-Curved Centrifugal Blowers:** Forward curved centrifugal blowers are normally used in residential and light commercial heating and air-conditioning systems. |
| 3.2.2 | **Backward-Inclined Centrifugal Blowers:** Typically, these blowers are used in commercial and industrial heating and cooling systems …stable air delivery. |
| 3.2.3 | **Radial Blowers** |
| 3.3.0 | **Fans:** Fans are typically used in applications where high quantities of are are needed with little resistance to airflow. |
| 3.3.1 | **Propeller Fans:** These fans have good efficiency and near free air delivery and are commonly used as condenser fans in HVAC applications. |
| 3.3.2 | **Duct Fans:** Duct fans are commonly used in spray booths and other ducted exhaust systems. |
| 3.4.0 | **Fan Laws:** Fan laws 1, 2, and 3 are as follows.<br><br>- Fan Law 1<br>- Fan Law 2<br>- Fan Law 3 |
| 4.0.0 | **Air Distribution Systems** |
| 4.1.0 | **Duct Systems Used in Cold Climates:** In cold climates, most buildings use perimeter duct systems. |
| 4.2.0 | **Duct Systems Used in Warm Climates** |
| 5.0.0 | **Duct System Components** |
| 5.2.1 | **Galvanized Steel Trunk and Branch Ducts**<br><br>Table 1 Duct materials and Their Application |
| 5.2.2 | **Fiberglass Duct:** It has more friction losses than metal duct, but is quieter because the duct board absorbs blower and air noises better. |
| 5.2.3 | **Flexible Duct:** Even when properly installed, most flex ducts cause at least two to four times as much …sheet metal duct. |

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| 5.3.0 | **Fittings and Transitions:** each fitting in a duct run adds friction and decreases the quantity of air the duct can carry. It takes energy to overcome the resistance (friction) inherent in a fitting.<br><br>Fittings and/or transitions are rated by equivalent feet of length … adding fitting has the same effect on pressure loss of a duct as increasing its overall length. |
| 5.4.0 | **Air Diffusers, Registers, and Grilles:** Low sidewall registers are excellent for heating when used in perimeter systems.<br><br>High sidewall registers provide poor heating performance ion cold climates … when used with central returns and when used with room-by-room returns, the cooling performance is even better. |
| 5.5.0 | **Dampers:** dampers are used to control and balance airflow in duct systems.<br><br>The built-in dampers on supply diffusers and registers should not be used to balance an air system. |
| 5.6.0 | **Fire and Smoke Dampers:** If a fire occurs, the link will melt and the dampers will close automatically … All fire dampers have a resistance rating of wither 1.5 or 3 hours. |
| 5.7.0 | **Insulation and Vapor Barriers:** ASHRAE Standard 90-80 specifies the minimum acceptable R-value … related to the cooling mode.<br><br>Typically 1” of insulation is equal to an R-value of 4. |
| 6.0.0 | **Duct Hangers and Supports** |
| 6.2.0 | **Riser Supports:** Rectangular risers (vertically running ducts) … metal screws, or blind rivets. |
| 7.0.0 | **Temperature and Humidity Measurement Instruments** |
| 7.2.0 | **Psychrometers:** Pychrometers are used to measure temperature. |
| 7.3.0 | **Hygrometers:** Hygrometers or relative humidity meters are used to measure and give direct readings of relative humidity. |
| 8.0.0 | **Air Distribution System Measurement Instruments** |
| 8.1.0 | **Manometers:** Manometers are used to measure the low-level static, velocity, and total air pressures found in air distribution duct systems. |
| 8.2.0 | **Differential Pressure Gauge:** The differential pressure gauge, also known as a magnahelic gauge, provides a direct reading of pressure. |

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| 9.0.0 | **Air Velocity Measurement Instruments:** Velometers are used to measure the velocity of airflow. |
| 03201-07 | **Commercial Airside Systems** |
| 3.0.0 | **Commercial Systems** |
| 3.1.0 | **Typical All-Air System** |
| | Figure 2 Typical all-air refrigerant system |
| | Chilled water coils are typically used in larger multi-story … less than 100 tons in capacity. |
| | Figure 3 Typical all-air chilled-water system. |
| 4.0.0 | **Outdoor Air and Air Systems:** introducing more ventilation air that is exhausted from a space, and maintaining a space pressure from 0.05 to 0.10 inches water gauge (in wg), is normally sufficient to offset infiltration. |
| 4.4.0 | **Economizers** |
| 4.4.1 | **Dry-Bulb Economizer:** The air temperature normally supplied by the central apparatus to cool … it can be used directly as the supply air to the control zone. |
| 4.4.2 | **Enthalpy Economizer:** The enthalpy economizer measures both dry-bulb and wet-bulb temperatures. |
| | The enthalpy economizer can be operated without the compression equipment … could not operate at outdoor air temperatures above 55 F. |
| 4.4.3 | Integrated Economizer is more sophisticated than the other types … when its temperature is above 60 F. |
| 5.0.0 | **Types of All-Air Systems** |
| 5.1.0 | **Single-Zone Constant Volume:** Two types of equipment are typically used in single-zone … vertical packaged units. |
| | Figure 8 Single-zone constant-volume system |
| 5.2.0 | **Multi-Zone Constant Volume** |
| | Figure 11 Multi-zone constant-volume system |
| 5.2.2 | **Typical Applications:** Permanent zones are favored because it is very expensive to change control zones … department stores, and industrial facilities. |

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| | Furthermore, multi-zone systems are best used with buildings requiring a somewhat limited number of large zones … 10- to 40-ton divisions, would be likely candidates for this system. |
| 5.3.0 | **Variable Volume, Variable Temperature (VVT)** |
| | A heating coil is located in the central unit to provide heating to the zones. |
| | Figure 13 VVT system |
| | Three types of constant-volume central equipment are typically used in VVT systems. They are single-zone rooftop units, vertical packaged units, and split systems. |
| 5.3.1 | **Typical Applications:** For small buildings from 5 tons to 20 tons that have small control zones … VVT is one of the most popular ways to achieve comfort control. |
| 5.4.0 | **Variable Air Volume Control:** Three types of central equipment are typically used in VAV systems. They are VAV rooftop units, central station VAV air handling units, and VAV vertical packaged units. |
| | Figure 16 Variable air volume system |
| 5.4.1 | **Typical Applications:** VAV systems are used in building sizes starting at 20 tons. |
| | Figure 17 Dual-duct VAV system |
| 5.5.0 | **Dual-Duct VAV System** |
| 6.1.0 | Classification: In the past, duct systems were classified in terms of their application, velocity, and pressure. These …replaced by pressure classification values. |
| | Table 1 Pressure-Velocity Duct Classification |
| | The following are some guidelines for determining the maximum airflow velocity to use in selected applications of low-velocity systems: (6 bullets). |
| 6.2.0 | Three basic symmetrical layouts for the main (trunk) ducts (Figure 18): (3 bullets). |
| | The H pattern is the most popular method and is seen in most buildings. |
| | The main (trunk) ducts are usually located above corridors in the cavity above the ceiling … Ducts that connect air terminals to diffusers are called heater ducts. |
| 6.4.0 | **Duct Materials** |
| | Table 2 Duct materials and Their Applications |

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| | Rectangular metal duct is the most flexible when it comes to fitting within limited spaces … under 2.0 in w.g. |
| | In systems with pressures less than 2.0 in wg, instead of metal. |
| | In medium- and high pressure systems (above 4.0 in wg) … it is common to find round, flat, oval ducts. |
| 7.0.0 | **Air Terminals**: Air Terminals are devices that control the distribution and volume of air conditioned air … space or zone from the supply air duct. |
| 7.1.0 | **Supply Outlets:** Normally, supply outlets for cooling are located in the center of the ceiling … phenomenon that dense cool air tends to drop. |
| | The best locations for heating outlets is in the floor next to the outside wall of a perimeter control zone. |
| 7.1.2 | Typically, multiple diffusers are located symmetrically in square or rectangular ceiling areas … The diffuser may be used for both cooling and heating. |
| 7.1.6 | **Concentric Duct Diffuser:** A constant quality of the supply air is discharged through the perimeter … return air enters the center of the diffuser. |
| 7.2.0 | **Air Terminals** |
| 7.2.1 | **Standard VVT Air Terminal:** The most economical installation cost is achieved when the damper size … the number of dampers is minimized. |
| | When a control zone needs heat in a VVT system, and the central unit is … to keep the zone above the heating setpoint. |
| 7.2.3 | **Single-Duct VAV Air Terminal:** The single-duct VAV air terminal (Figure 32) …(zone) controller mounted on the side of the box. |
| 7.2.4 | **Parallel Fan-Powered Mixing Box Air Terminal**: The parallel fan-powered mixing box air terminal (Figure 33) typically consists of a primary … a backdraft damper, a heater, and a damper (zone) controller mounted on the side of the box. |
| | The parallel fan-powered mixing box is designed for perimeter zones in a building with a ceiling plenum return system. |
| | When a drop in zone temperature below the cooling setpoint (typically 74 F) is monitored by the zone sector … The first stage of heat is the activation of the unit's heating fan. |
| 7.2.5 | **Series Fan-Powered Mixing Box Air Terminal:** The series fan-powered mixing box is used as a part of conventional VAV system where … during cooling and heating in a continuous manner as long as the control zone is occupied. |

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| 7.2.6 | **Dual-Duct VAV Air Terminals:** In the dual-duct VAV system, the central air handler is in the cooling mode when the building …factory-installed heater connected to the air terminal discharge. |
| 8.1.0 | **Packaged Equipment** |
| 8.1.1 | **Packaged Air Conditioner (PAC**): A packaged air conditioner (PAC) is a unit that provides cooling capacity only, or cooling capacity with electric heat. |
| 8.1.4 | **Packaged Heat Pumps:** In the heating mode, the refrigerant flow is revered using a four-way valve. |
| 8.2.0 | **Packaged Equipment Components** |
| 8.2.2 | **Coils and Fans:** Evaporator (cooling) coils are generally made of aluminum-plate fins pressed on aluminum or copper tubing, and are usually two or three rows deep.<br><br>Evaporator coils are usually installed in a slanted position so more coil surface can be put into a given package.<br><br>Like evaporator coils, condenser coils are typically made of aluminum plate fins pressed on aluminum or copper tubing.<br><br>The condenser coil is usually two or three rows deep. It is likely to be internally grooved for higher efficiency, and headered to provide … This counterflow arrangement provides for maximum subcooling of 20 F or so for typical aircooled condenser. |
| 8.3.0 | **Packaged Unit Accessories** |
| 8.3.1 | **Roof Curbs:** Rooftop units are generally mounted on the roof deck.<br><br>Most roof curbs are 14 inches high; however in areas of significant snow accumulation, 24-inch curbs are used. |
| 8.3.6 | **Crankcase Heaters:** Rooftop units above 10 tons are equipped with crankcase heaters. |
| 9.0.0 | **Air Handlers** |
| 03202-07 | **Chimneys, Vents, and Flues** |
| 2.0.0 | **Combustion**: During combustion, oxygen combines with fuel to release stored energy in the form of heat. |
| 2.1.0 | **Complete Combustion:** Complete combustion takes place when carbon combines with oxygen to form carbon dioxide. |
| 2.2.0 | **Incomplete Combustion:** Incomplete combustion results from too little oxygen and causes … soot, and aldeheydes (highly reactive compounds). |

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| | Enough air mist be provided to allow for proper combustion to take place, and to avoid incomplete combustion. |
| 2.3.0 | **Combustion Efficiency:** Air entering the furnace at room temperature or lower is heated to flue flue gas temperatures that range from 100 F to 600 F … from 100F to 125 F in a high-efficiency furnace. |
| 3.0.0 | **Flue Gases:** A horizontal metal vent pipe (vent connector) is used to connect the furnace to the chimney or a metal flue, which vents to the outdoors. |
| 4.0.0 | **Furnace Venting:** Gas-fired appliances produce flue gases in quantities about 30 times the volume of gas burned … Vents should include the following features: (4 bullets).<br><br>Condensing furnaces must use outdoor air for combustion. |
| 4.1.0 | **Requirements:** In general, the vent system should meet the following minimum requirements as defined by the National Fuel Gas Code: (3 bullets). |
| 4.3.0 | **Air Supply:** Return air plenums should be lined with an acoustical duct liner to reduce fan noise.<br><br>Return air must not be taken from the furnace room or closet. |
| 5.0.0 | **Vent System Components:**<br>- Category I<br>- Category II<br>- Category III<br>- Category IV<br><br>There are several types of vent construction approved for use with gas appliances.<br><br>Type B vents have inner and outer walls made of corrosion-resistant material … promotes better draft and reduced condensation.<br><br>Type B-W vents have the same type of double-wall construction as the B-vent but are oval.<br><br>Type L vents are also double-wall vents. |
| 6.0.0 | **Natural-Draft Furnaces:** the total volume in a properly operating vent is 30 cubic feet of vent gas for every cubic foot of natural gas burned.<br><br>In natural-draft furnaces, vent gases are not forced or through vent pipes and chimney, but are drawn out instead. |
| 7.0.0 | **Induced-Draft Gas Furnaces:** To avoid condensation that can damage both the vent system and the furnace …when installing an induced-draft furnace: (5 bullets). |

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| 7.1.0 | **Furnace Sizing:** Generally, the furnace heat output rating should be from 95 to 120 percent of the heating load. |
| 7.3.0 | **Temperature Rise Adjustment**: Temperature rise is the temperature difference between the supply air and the return air. |
| 7.5.0 | **Venting Considerations** |
| 7.5.1 | **General Guidelines for Metal Vents and Vent Connectors:** Vent connectors for induced-draft furnaces should also be the double-wall type, which heats up faster, thereby, limiting the risk of condensation.<br><br>Vent connectors should be pitched upward toward the vent at a slope of no less than ¼” per foot and should be short as possible. |
| 7.5.2 | **Venting Through an Masonry Chimney:** However, a fan-assisted furnace cannot be vented through a masonry chimney …or the chimney is suitably lined.<br><br>An unlined chimney must not be used in any circumstance. |
| 8.0.0 | **Condensing Gas Furnaces:** If 45-degree elbows are used, each one increases the length of the run by an equivalent of 5’.<br><br>Table 1 PVC Selection Chart<br><br>The following are good practices to consider when installing vents and intake piping: (5 bullets) |
| 9.0.0 | **Draft Controls:** Draft controls regulate the amount of air feeding a fire. |
| 9.1.0 | **Draft Regulator:** A draft regulator (Figure 13) keeps a constant draft over the fire … on oil-burning furnaces. |
| 03401-09 | **Construction Drawings and Specifications** |
| 2.0.0 | **Reading Drawings:** Use this procedure to familiarize yourself with an available set of drawings: Step 1 -14. |
| 2.1.0 | **Site Plan:** The site plan indicates the location of the building on the land site. It may include topographic features such as contour lines, trees, and shrubs. It may also include some construction features such as walks, driveways, curbs, and gutters.<br><br>Figure 2 Site Plan<br><br>On large commercial jobs, a utility site plan may also be included … power or communication system cables, and other facilities. |

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| 2.2.0 | **Plan Views (Floor, Roof, and Ceiling Plans):** It shows the length and width of the building and the location of the rooms and other spaces that the building contains.<br><br>Figure 3 Floor plans for a building |
| 2.3.0 | **Elevation Drawings:** The elevation view of a structure (Figure 6) shows the exterior features of that structure.<br><br>Figure 6 Elevation drawing |
| 2.4.0 | **Schedules:** They are tables shown on various drawings throughout the drawing set that identify the types and sizes of items used by the different trades in the construction of a building.<br><br>Schedules shown on the related plumbing plans and electrical plans may …. Shows schedules typical of those found on mechanical plans.<br><br>Figure 7 Mechanical equipment schedules |
| 2.6.0 | **Section Drawings:** Section drawings are cutaway views that allow the viewer to see the inside of a structure or how something is put together internally.<br><br>Figure 9 Section drawing showing building construction |
| 2.7.0 | **Plumbing Plans**: Plumbing plans show the layout of fixtures, water supply lines, natural gas piping, and lines to sewage disposal systems. |
| 2.8.0 | **Mechanical Plans:** mechanical plans show the heating, ventilation, and air conditioning systems, as well as other mechanical systems for a building.<br><br>Figure 11 Sanitary plumbing plan<br><br>Figure 12 Plumbing legend<br><br>Details of the mechanical plan are usually overlaid on tracings of the various building floor plans from which … Figure 13 shows an example of a typical HVAC mechanical plan.<br><br>As appropriate, detailed views describing the installation of the HVAC equipment are shown … and the pipe sizes for major items of HVAC equipment.<br><br>Figure 13 HVAC mechanical plan<br><br>Figure 14 Refrigeration piping schematic<br><br>Mechanical plans also normally include an HVAC legend listing the various symbols … (Figure 16) and information about relevant HVAC system specifications (Figure 17). |

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| 2.9.0 | **Electrical Plans:** For smaller construction jobs, the electrical plans are usually shown on the architectural floor plans … information about the electrical system installation. |
| 3.0.0 | **Request for Information:** The general contractor then relays the RFI to the architect or engineer. |
| | Figure 16 Schedule of HVAC systems |
| 4.0.0 | **Specifications** |
| 4.4.0 | **Format** |
| 4.4.1 | **CSI Format:** The most commonly used specification-writing format used in North America is the Master Format. This standard was developed jointly by the Construction Specifications Institute) (CSI). |
| | Figure 20 2004 Master Format. Note: Division 23: Heating, Venting, and Air Conditioning |
| 5.0.0 | **Shop Drawings:** A second type of shop drawing (or submittal pertains to the purchase of special items … out so that the architect or engineer responsible can correct the problem. |
| 5.1.0 | **Cut Lists:** After the shop drawings are complete, or as they are drawn (depending on the workload) … matches the numbers on the shop drawings. |
| 5.1.0 | **Cut Lists:** After the shop drawings are complete or as they are drawn (depending on the workload) … matches the numbers on the shop drawing. |
| 6.0.0 | **Submittals:** Submittals are documents that illustrate special pieces of equipment or accessories that are to be furnished and installed by the subcontractor. |
| 7.0.0 | **As-Built Drawings:** As-built drawings must be made on alteration or addition jobs, on jobs where modifications must be made to make way for other mechanical trades, or to alter the location of a component. |
| 8.0.0 | **Takeoffs:** The takeoff procedure involves surveying, measuring, and counting all materials and equipment … should be taken off in the following order: 1-10. |
| 8.1.0 | **Takeoff Tools and Materials:** The following materials will make the measuring, counting, and calculating tasks easier. (8 bullets) #3: An electronic wheel scaler or similar device for measuring duct and piping runs (should have scales of 1/8", ¼", and ½". |
| 8.2.0 | **Selecting Equipment and Materials** |
| 8.2.1 | **Ductwork:** The materials commonly used in duct run system construction are the following: (9 bullets). Duct construction is classified in terms of operating pressure and air velocity. The common classifications are shown in Table 1. |

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| | Table 1 Pressure and velocity |
| 8.2.2 | **Duct hangers:** Ductwork must not be hung from overhead piping or ceiling hanger irons … Trapeze-type hangers are recommended for large ducts.<br><br>Duct sizes are determined according to airflow rates (cfm), velocity (fpm), and duct friction losses. |
| 03407-09 | **Heating and Cooling System Design** |
| 3.0.0 | **Building Evaluation/Survey:** The types of information you will need to prepare the load estimate and select the equipment and ductwork are as follows: (17 bullets). |
| | Figure 3 Summer cooling loads (heat gains). Note: No gain at on-grade slabs or below-grade walls and floors. Note: Sensible and latent appliance loads. |
| 4.1.0 | **Heat Transfer** |
| 4.1.1 | **Conduction:** Conduction is the transfer of heat energy in a substance from a particle from the warmer region to the colder region. |
| 4.1.2 | **Radiation** |
| 4.1.3 | **Convection:** Convection is the transfer of heat energy due to the movement of fluid. |
| 4.2.0 | **Heat Gain and Loss:** Heat flow through a wall separating two spaces at different temperatures depends on three factors: (3 bullets). |
| | All the preceding factors needs to be considered when calculating overall heat transfer. |
| | Therefore, for nonhomogeneous materials, it is much more convenient to use heat flow … The term U-factor is used to simplify this calculation. |
| | It is defined as the heat flow per hour through one square foot of the material(s) when the temperature difference 1 F between the air on the two sides of the wall or roof. |
| 4.3.0 | **Cooling and Heating Load Factors** |
| | Table 1 Effects of Construction factors on Cooling and Heating Loads. Note: Infiltration. |
| 4.3.1 | **Window Glass:** In cooling, window glass is the single largest load factor … Therefore, the more windows you have and the less energy efficient the windows are, the greater the cooling and heating load. |
| 4.3.3 | **Infiltration:** Infiltration affects both heating and cooling loads. |
| | This factor must be converted to a multiplier that can be used with loads that are stated in Btuh. |
| 5.0.0 | **Equipment Selection:** Four major items of information are necessary to select the equipment for a particular application: (4 bullets). |

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| | Undersized equipment will not be able to handle peak loads and will take longer to return the space to the comfort level. |
| | The condensing unit is placed outside the building, as close to the evaporator unit as possible, but generally not more than 50' away. |
| | The indoor unit of a split system contains a cooling coil, blower, and metering device. |
| 5.3.0 | **Heat Pump Selection**: In colder climates, the heating load drives the equipment selection process … should not exceed cooling the load by more than 15 or 20 percent. |
| | When electric resistance heaters are used, the combined capacity of the heat pump and the electric heaters should not exceed 115 percent of the calculated heating load. |
| 6.0.0 | **Air Distribution System Duct Design** |
| 6.1.0 | **Duct System Basics:** Through the action of the fan, the air pressure is increased to its highest level at the blower discharge. |
| | Velocity is how fast the air is moving and is usually measured in feet per minute (fpm). |
| 6.1.3 | **Dynamic Losses:** Dynamic pressure losses can be expressed as a loss coefficient value or C-value. A loss coefficient value is known … To determine the pressure loss through a specific kind of duct fitting. |
| 6.1.5 | **Duct System External Static pressure and Supply Fan Relationship:** The total pressure loss of the duct system components external to the fan assembly is called … static pressure losses resulting from the system ductwork and its components. |
| 6.2.2 | **Duct Systems Used in Warm Climates:** Regardless of the type of system, the ductwork should be insulated if it is installed in an attic … depending on whether the space above the suspended celling is considered to be conditioned. |
| | The branch ducts are metal, ductboard, or flexible duct and may be insulated, depending on whether or not they are in the conditioned space. |
| 6.5.0 | **Other Duct System Design Considerations** |
| 6.5.2 | **Insulation and Vapor Barriers:** when ductwork passes through an unconditioned space, such as an attic or crawl space, heat transfer takes place between the air in the duct … there is a difference of 15 F from the inside to the outside of the duct. |
| 7.0.0 | **Support Systems** |
| 7.1.0 | **Refrigerant Piping:** A comfort air conditioning system has three refrigerant piping runs (Figure 53): (3 bullets). #1: The suction line conveys low-temperature, low-pressure, superheated vapor refrigerant from the evaporator outlet to the compressor inlet. |
| 7.1.1 | **Suction Line Design:** If the indoor coil is located above the outdoor unit, the suction line should loop up to the height of the indoor coil. |

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| 7.1.2 | **Liquid Line Design:** The liquid line should be insulated wherever it is exposed to direct sunlight or excessive heat, such as in an attic. |
| 7.2.0 | **Condensate Piping:** The condensate drain requires a trap to prevent water from being held in the drain pan by the blower. |
| 03408-09 | **Commercial and Industrial Refrigeration Systems** |
| 1.0.0 | **Introduction:** The major difference between commercial and industrial refrigeration systems and air-conditioning systems is the operating systems is the operating temperature range served by the refrigeration systems. |
| 2.0.0 | **Refrigeration and the Preservation of Food Products** |
| 2.1.0 | **Cold Storage:** Cold storage conditions are determined by the type of food being stored … the food is to be held in storage.<br><br>Airflow is crucial to removing the heat generated during the respiratory cycle of many products in the perishable temperature … Avoiding dehydration requires that humanity be maintained at the proper level for each type of product. |
| 2.1.1 | **Chill Rooms:** Foods stored in chill rooms are typically kept at temperatures just above their freezing point to maintain top product quality.<br><br>Most chill rooms also have a means of controlling the relative humidity to within 3 to 5 percent of the desired level. |
| 2.1.2 | **Freezer Rooms:** Temperatures are typically maintained at levels ranging between 10 F and -10 F. Rooms used to store ice cream are often maintained at a temperature of -20 F. |
| 2.2.0 | **Commercial Freezing Methods** |
| 2.2.1 | **Air Blasting Freezing:** Air blast freezing employs cold air circulated around the product at high velocities, maximizing the heat exchange process. |
| 2.2.2 | **Contact Freezing:** Contact freezing produces packaged or unpackaged frozen products by pressing them between cold metal plates, or by contact with a moving belt exposed to the refrigerated surface. |
| 2.2.4 | **Freeze-Drying:** Freeze drying, also known as lyophilization, is generally a cryogenic process, relaying first on the extremely rapid freezing action of this method.<br><br>The result is a product that no longer requires refrigeration for long-term preservation … its original state by simply adding water. |
| 3.0.0 | **Refrigerated Transport Units** |
| 3.2.0 | **Trailer and Truck Units** |
| 3.2.1 | **Trailer Units:** These units are used to transport products over long distances, typically across the state or even across the country. |

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| 3.2.2 | **Truck Units:** Trucks are not as large as trailers and are typically used for local delivery of cargo in cities or between adjacent cities. |
| 4.0.0 | **Refrigeration Systems and Components:** The function performed by each component is as follows:<br>- Evaporator<br>- Compressor<br>- Condenser<br>- Expansion device<br><br>Figure 15 Basic refrigeration system<br><br>The tubing lines are:<br>- Suction line<br>- Hot gas line<br>- Liquid line<br><br>The lower the required system temperature, the lower the compressor energy efficiency ratio (EER), thus the more expensive it is to operate … ratings at or above 14 with systems operating at or above 40 F evaporator temperatures. |
| 4.1.0 | **Compressors** |
| 4.1.1 | **Single-Compressor Applications:** The compressor sizes commonly range between 0.5 and 30 horsepower (hp) … or coolers (Figure 18) or in multi-temperature mobile refrigeration units. |
| 4.1.2 | **Multiple-Compressor Applications:** The use of multiple compressors connected in parallel allows greater system capacities and the ability to meet varying load conditions more effectively. |
| 4.1.4 | **Use of Two-Stage Compressors:** Single-stage compression means the refrigerant gas is drawn into the suction valve of the compressor cylinder(s) … the required pressure on the compression upstroke of the piston.<br><br>Two-stage compressors are used in ultra low-temperature systems to pump very low-pressure suction line vapor up to the condensing pressure and temperature conditions.<br><br>Two-stage compressors (Figure 22) compress the refrigerant gas in a two-step process involving two sequential cylinders or compressors.<br><br>The compression ratio for two-stage compressor is calculated as follows: (Formulas). |
| 4.2.0 | **Condensers** |
| 4.2.1 | **Condenser Ratings:** Condensers used in refrigeration systems are rated by their total heat rejection (THR) value … as it flows through the condenser. |

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| 4.2.2 | **Control of Air-Cooled Condensers:** Refrigerant-side control can be done by adjusting the amount of active condensing surface used in the condenser coil … meter the proper amount of refrigerant needed to flood the condenser in response to the variable loads. |
| 4.3.0 | **Evaporators** |
| 4.3.1 | **Forced Convection Evaporators (Unit Coolers):** Unit coolers used in areas requiring high humidity levels normally … difference (4F to 8F). |
| 4.3.2 | **Natural Convection Evaporators:** Natural convection evaporators are used in many types of open display cases. Air circulation in these evaporators depends on thermal circulation, where warm air rises and cool air descends. |
| 4.4.0 | **Display Cases (Refrigerators):** The refrigeration load for food store display cases is normally rated by the manufacturer based on ambient summer design conditions of 75 F and 55 percent relative humidity. |
| 4.5.0 | **Accessories** |
| 4.5.1 | **Filter-Driers:** Filters-driers (Figure 31) are used to remove water vapor and foreign matter from the refrigerant steam. |
| 4.5.2 | **Sightglass/Moisture-Liquid Indicators:** The sightglass (Figure 32) is like a window that allows you … It is typically used when checking the refrigerant charge. |
| 4.5.5 | **Oil Separators and Oil Control Systems:** Oil separators minimize the amount of oil that circulates through a refrigeration system … places from which it is difficult to return.<br><br>To reduce the pressure in the reservoir to a level slightly higher than the pressure in the compressor crankcase … back to the low pressure side of the system. |
| 4.5.10 | **Compressor Mufflers**: Mufflers (Figure 41) are used mainly in systems with open or semi-hermetic reciprocating compressors. |
| 4.5.11 | **Vibration Isolators (Absorbers/dampers):** Vibration isolators, also commonly called vibration absorbers or dampers, are flexible …one mounted vertically and the other horizontally. |
| 5.0.0 | **Refrigeration System Control Devices** |
| 5.1.0 | **Crankcase Pressure Regulating Valves:** The valve controls the maximum pressure at the compressor suction line and provides overload protection for the compressor motor. |
| 5.2.0 | **Evaporator Pressure Regulating Valves:** Evaporator pressure regulating valves are installed in the suction line between an evaporator … within close limits. |

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| 5.3.0 | **Air-Cooled Condenser Pressure Regulator:** The condenser pressure regulator (head pressure control) maintains proper condenser pressures … flows through the system in the normal manner. |
| 5.5.0 | **Capacity Control Devices** |
| 5.5.1 | **Hot Gas Bypass:** In cases where short cycling the compressor or using cylinder unloaders is not satisfactory … saturated suction temperature of the evaporator. |
| 5.6.0 | **Pump-Down Control:** The advantages of using a pump-down cycle include the following: (3 bullets).<br><br>When a pump-down cycle is used, a thermostat controls a liquid line solenoid valve that … and prevents the liquid line from sweating. |
| 5.7.0 | **Defrost Systems** |
| 5.7.1 | **Off-Cycle Defrost:** Off cycle defrost is the simplest and most passive of the defrost approaches … allowed to defrost during the normal off cycle. |
| 5.7.2 | **Timed Defrost** |
| 5.7.4 | **Hot Gas Defrost:** Hot gas defrost is widely considered to be the fastest and most efficient … surface of the coil tubing is incorporated into the defrost process.<br><br>Hot gas defrost, in its simplest form, sends discharge gas from the compressor directly to the evaporator … condenses in the cold evaporator as the process begins. |
| 6.0.0 | **Ammonia Systems** |
| 6.1.0 | **Ammonia Refrigerant:** Ammonia is a chemical compound of nitrogen and hydrogen.<br><br>Ammonia is an immiscible refrigerant. |
| 6.2.0 | **Ammonia Refrigeration Systems and Components**: Ammonia systems fall into two classes: mechanical and nonmechanical. |
| 6.3.0 | **Ammonia Safety Considerations**: Five minutes at 50 ppm is the maximum exposure allowed by OSHA … flammable at 150,000 to 270,000 ppm. |
| 7.0.0 | **Secondary Coolants:** A secondary coolant is any cooling liquid that is used as a heat transfer fluid.<br><br>Water is commonly used as the heat transfer medium at temperatures above 32 F … However it cannot be used at temperatures below 32 F. |