AIR-TO-AIR HEAT PUMPS

Certification Information

Scope - Tests a candidate’s knowledge of the installation, service, maintenance, and repair of HVAC systems. System sizes are limited to 30 tons or less cooling capacity.

Qualifications

Y This is a test and certification for TECHNICIANS in the HVAC industry. The test is designed for top level service technicians. This test for certification is not intended for the HVAC system designer, sales force, or the engineering community. To become NATE-certified, you must pass this specialty and a CORE SERVICE exam.

Y This test will measure what 80% of the Heat Pumps candidates have an 80% likelihood of encountering at least once during the year on a NATIONAL basis.

Y Suggested requirement is two years of field experience working on Heat Pumps systems as a service technician and technical training for theoretical knowledge.

Test Specifications

Listed are the percentages of questions that will be in each section of the Heat Pumps exam.

<table>
<thead>
<tr>
<th>SECTION AREA DESCRIPTION</th>
<th>SECTION PERCENTAGE</th>
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<tbody>
<tr>
<td>Installation</td>
<td>15%</td>
</tr>
<tr>
<td>Service</td>
<td>45%</td>
</tr>
<tr>
<td>System Components</td>
<td>30%</td>
</tr>
<tr>
<td>Applied Knowledge</td>
<td>10%</td>
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</tbody>
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Heat Pumps Industry References

The reference materials listed below will be helpful in preparing for this exam. These materials may NOT contain all of the information necessary to be competent in this specialty or to pass the exam.

- American National Standards Institute (ANSI) / Air Conditioning Contractors of America (ACCA) Manuals - Latest Edition
  - “D”, “J”, “QI” - Quality Installation, and “S”
- ACCA Manuals “T” and “RS” - Latest Editions
- ACCA Residential Duct Diagnostics and Repair - Latest Edition
- AHRI-Hydronics Section-IBO/RAH Latest Edition
- International Mechanical Code - Latest Edition with Addendum
- International Plumbing Code - Latest Edition with Addendum
- Uniform Mechanical Code - Latest Edition with Addendum
- ENERGY STAR™ Home Sealing Standards - Latest Edition with Addendum
- Duct Calculators – Sheet Metal, Ductboard, and Flexible Duct
- American National Standards Institute (ANSI) / Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
  - HVAC Duct Construction Standards - Metal and Flexible
- Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
- Air Diffusion Council Flexible Duct Performance & Installation Standards
- North American Insulation Manufacturers Association (NAIMA) Manuals
  - Fibrous Glass Duct Construction Standards and A Guide to Insulated Air Duct Systems

Passing Score Development Process

The passing scores for the NATE tests were established using a systematic procedure (a Passing Score Study). This procedure employed the judgment of experienced HVAC professionals and educators representing various HVAC specialties and geographical areas. The passing scores were set using criteria defining competent performance. The passing score for different test forms may vary slightly due to the comparative difficulty of the test questions.

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Heating - Reverse Cycle Air to Air
Service

INSTALLATION

FABRICATING COPPER TUBING

REFRIGERANT LINE INSTALLATION
Locating, mounting, and routing
Understanding limitations of length and diameter

BENDING COPPER TUBING
Making a proper bend with spring benders
Making a proper bend with cam type benders

COPPER TUBING PREPARATION
Cutting copper tubing
Reaming copper tubing
Cleaning copper tubing
Swaging copper tubing

BRAZING
Overview of brazing copper to copper
Oxyacetylene brazing
Using air / fuel to solder
Use of purging gas when brazing
Overview of brazing copper to brass
Overview of brazing copper to steel
Selection of brazing materials

FLARE FITTINGS
Making a flare fitting - single and double
Installing with flare fittings

BRAZING & SOLDERING EQUIPMENT
Brazing products - rods, flux, etc.
Oxyacetylene brazing equipment
Gas purging equipment in field brazing
Air / Fuel systems - acetylene, propane, MAP, etc.
Soldering products - solder, flux, and torches
Tool maintenance and care

INSTALLING OUTDOOR UNITS
INSTALLING AND CONNECTING OUTDOOR UNITS
Locating unit
Preparing site
Placing unit
Wiring outdoor units
Connecting refrigerant lines

INSTALLING PACKAGED UNITS
INSTALLING AND CONNECTING PACKAGED UNITS
Locating equipment
Preparing site
Lifting unit
Sealing unit
Wiring

INSTALLING INDOOR EQUIPMENT
INSTALLATION OF INDOOR AIR HANDLERS / FURNACES
Installing coil and air handler / furnace
Connecting ductwork
Connecting refrigerant lines
Connecting condensate lines
Wiring air handler / furnace
Wiring thermostats
Wiring electronic air cleaners
TEV’s - installation
Installing fixed metering devices
Bulb location selection for TEV’s
Auxiliary heat
Handling - lifting, hanging

EVACUATION & CHARGING

SAFE HANDLING OF REFRIGERANT CONTAINERS
- Disposal
- Securing refrigerants for transport
- Signage and documentation for refrigerants
- Proper storage
- Proper container filling

EVACUATION
- Overview - use of a vacuum pump
- Overview - use of a micron gauge
- Use of a manifold gauge set in evacuation
- Deep single evacuation process
- Removing core of access valves

LEAK CHECKING & DETECTION
- Overview of leak checking and detection
- Leak checking with electronic leak detectors
- Leak checking with soap solutions
- Gas pressurization for leak checking
- Leak checking with ultrasonic leak detectors
- Leak checking with ultraviolet leak detectors

CHARGING METHOD
- Weigh in method
- Superheat method and where used
- Subcooling method and where used
- Charging blended refrigerants
- Liquid charging

DUCT INSTALLATION

DUCT FABRICATION EQUIPMENT
- Ductboard tools - 90 V-groove, end cutoff, female shiplap, hole cutter, stapler, etc.
- Flex tools - tensioning strap tools, knives, etc.
- Metal tools - metal snips, sheers, benders, breaks, hand formers, calipers, rulers, stapler, etc.

INSTALLING METAL DUCT
- Assembly methods for rectangular duct
- Assembly methods for round duct
- Hanging ductwork
- Sealing metal duct
- Insulation - internal and external

INSTALLING FLEXIBLE DUCT
- Assembly methods - appropriate length
- Hanging flexible duct
- Sealing flexible duct

INSTALLING DUCTBOARD
- Assembly methods for ductboard - supports
- Hanging methods for ductboard
- Sealing ductboard

INSTALLING GRILLES, REGISTERS, DIFFUSERS, & DAMPER
- Mounting to ductwork
- Securing methods
- Sealing methods

CHASES USED AS DUCTS
- Floor joists as air ducts
- Vertical chases

RECONNECTING DUCT WHEN REPLACING EQUIPMENT
- Reconnecting metal duct
- Reconnecting flexible duct
- Reconnecting ductboard duct

INSTALLATION OF PLENUMS AND DUCT
- Sizing plenums for physical fit
Heating - Reverse Cycle Air to Air - Service

Types and styles of plenums selected
Insulation of plenums and ducts

INSTALLING ACCESSORIES

INSTALLING THERMOSTATS
   Locating and mounting
   Wiring electromechanical thermostats
   Wiring electronic thermostats
   Setting anticipators when used
   Installing air side low ambient control

INSTALLING ELECTRONIC AIR CLEANERS
   Installing to a unit - sealing
   Wiring
   Controlling electronic air cleaners

INSTALLING HUMIDIFIERS
   Installing
   Wiring
   Controlling humidifiers

INSTALLING ECONOMIZERS
   Installing
   Wiring
   Controlling economizers

FIELD WIRING

WIRING UNITS & CONTROL WIRING
   Connecting electrical power
   Connecting control circuits
   Meeting manufacturer sizing requirements - wire sizing (size and number)

START-UP AND CHECKOUT

PRE-START PROCEDURES
   Surveying installation
   Inspect connections for tightness
   Set dip switches/jumpers on ECM motors
   Set speed taps on multi-speed motors
   Set adjustable pulleys on belt driven blowers
   Ensure clean filter is in place and accessible
   Ensure condensate line is flowing

START-UP PROCEDURES AND CHECKS
   Surveying installation
   Supply voltage checks
   Motor checks
   Checking sequences
   Check fan rotation
   Check scroll compressor rotation - high noise level, etc.
   Start-up checklist and preparation
   Metering device - refrigerant circuit checks
   Airflow checks
   Pressure checks
   Temperature checks - dry bulb, wet bulb, etc.
   Reversing valve checks
   Capacity checks
   Fixed orifice refrigerant circuit checks

LEAK DETECTION TOOLS
   Soap solution
   Electronic leak detectors
   Ultrasonic leak detector
   Halide leak detector
   Use of dye leak detectors
   Pressurization for leak detection
   Meter calibration and maintenance

REFRIGERANT CIRCUIT TOOLS
   MANIFOLD GAUGE SET
Manifold gauge set
How to read the gauge set
How to connect the gauge set for different purposes
Types and styles of gauge sets
Using the gauge set for diagnostics
Low loss fitting connections
Gauge calibration and maintenance

**EVACUATION TOOLS**
Vacuum pump
Micron gauge
Valve opening tools - core removers, etc.
Gauge calibration and maintenance

**CHARGING TOOLS**
Charging scales
Gauge calibration and maintenance

**RECOVERY / RECYCLING MACHINES**

**RECOVERY MACHINES**
Introduction to recovery machines
Types and styles of recovery machines
Typical recovery procedures
Recovery machine maintenance and cylinder maintenance

**RECYCLING MACHINES**
Introduction to recycling machines
Types and styles of recycling machines
Typical recycling procedures
Recycling machine maintenance and cylinder maintenance

**AIRFLOW MEASUREMENTS**

**AIRFLOW VELOCITY MEASUREMENTS**
Pitot tube and manometer in measuring static pressure
Discharge velocity equipment
Velometer - electronic and mechanical
Anemometer
Velocity measurement procedures
Gauge calibration
Introduction to airflow in Residential HVAC
Velocity

**AIRFLOW PRESSURE MEASUREMENTS**
Overview of static pressure measurements
Inclined manometer
Diaphragm type differential pressure gauge U-tube manometer
Electronic manometer / pressure measurement
Gauge / meter calibration
Absolute vs. Gauge Pressure
Static pressure
Air pressure measurement terminology
Velocity pressure
Total pressure

**AIR VOLUME MEASUREMENTS**
Airflow hood
Formulae for determining CFM of air
Formulae for weight of air
Locations for air volume measurements
Airflow volume - CFM / SCFM (Static CFM)

**SERVICE**

**PLANNED MAINTENANCE**
**MECHANICAL PLANNED MAINTENANCE**
Filters
Charge
Lubrication
Outdoor coil care
Indoor coil care
Roof seals - packaged
Ducts
Diffusers, grilles, and registers
Performance checks - temperature rise

**ELECTRICAL PLANNED MAINTENANCE**

Electric motor checks
General wiring checks - tightness of connections, aluminum wire, etc.
Sequence of operation checks
Compressor checks, voltage, current
Crankcase heater check

**DIAGNOSTICS**

**PRELIMINARY SYSTEM DIAGNOSTICS**

Outdoor unit checks
Indoor unit checks
Wiring checks
Refrigerant line checks
Thermostat checks
Condensate drain checks
Accessories
Attic ventilation

**ANALYZING REPORTED SYMPTOMS**

No cooling
Low capacity
Humidity problems
Start problems
Noise problems
No heating
Drafty - cold air
Runs continuously
High utility bills
Air quality
Thermostat, droop
Steam from outdoor unit

**SYSTEM AIR SIDE DIAGNOSTICS**

Temperature checks - dry bulb, wet bulb, etc.
Airflow checks
Static pressure checks - noise problems and drafts
Ductwork - supply checks
Ductwork - return checks

**REFRIGERANT SYSTEM DIAGNOSTICS**

Overview
Using superheat
Using subcooling
Analyzing overall refrigerant circuit performance
Analyzing effects of refrigerant circuits on reversing valve operation
Locating problems based on refrigerant circuit temperatures

**ELECTRICAL CHECKS**

Supply checks
Compressor circuits
Condenser fan circuits
Indoor blower circuits
Thermostat circuits
Transformer circuits
Indoor auxiliary heat circuits
Electronic controllers - input / output
Defrost control circuits
Reversing valve solenoid circuits

**COMPONENT CHECKS - ELECTRICAL**
Compressor
Thermostat
Crankcase heaters
Low ambient controls for cooling
Transformers
Overcurrent protection
Relays and contactors
Pressure controls
Condenser fans
Indoor blowers
Capacitors
Start relays
Solenoid valves coils
Defrost termination control
Defrost controls
Outdoor thermostats
Reversing valve coils

**REPAIR**
Refrigerant circuit on coils
Ductwork
Electrical wiring

**REPLACEMENTS**
Outdoor units
Compressors
Outdoor fans
Indoor coils
TEV's
Transformers
Liquid line bi-flow filter-driers
Relays and contactors
Fixed orifice metering devices
Indoor blowers
Capacitors
Defrost controls
Suction line filter-driers
Reversing valves

**SYSTEM CLEANUP AFTER COMPRESSOR ELECTRICAL FAILURE**
Compressor
TEV's
Acid test
Reversing valves
Check valves

**COMPONENT CHECKS - REFRIGERATION**
Compressor
TEV's
Filter-drier
Suction line - oil traps, risers, etc.
Liquid line - vertical height, static pressure loss, etc.
Solenoid valves
Condensate drains
Check valves
Indoor and outdoor coils
Fixed orifice metering devices / piston
Reversing valves

**OVERVIEW OF ELECTRICAL TROUBLESHOOTING**

**LOW VOLTAGE CIRCUITS**
Voltage tests
Control string analysis
Understanding the logic of low voltage troubleshooting
Troubleshooting equipment with electronic devices.
Troubleshooting with schematics
Troubleshooting without schematics
Current tests
Equipment continuity tests
Ground tests

LINE VOLTAGE CIRCUITS
Voltage tests
Current tests
Component tests
Circuit tracing line voltages
Troubleshooting with schematics
Troubleshooting without schematics
Equipment continuity tests
Ground tests

RETROFITTING
EQUIPMENT COMPONENT RETROFITTING
Changing out an outdoor unit
Changing out an indoor unit
Matching split system components - efficiency and capacity
Modifying ductwork for replacement equipment

AIR BALANCING
GATHERING DESIGN INFORMATION
Interpreting system design
Interpreting specifications
Interpreting equipment information
Interpreting control data
Modifying system design

PREPARATION OF SYSTEM FOR AIR TESTS
Locating registers, grilles, equipment, controls, and dampers in building walkthrough
Setting dampers for tests
Setting thermostat for tests
Checking for proper fan operation and rotation
Checking for proper static pressure and temperature

PROCEDURES FOR CONDUCTING AIR TESTS
Measurements of each supply outlet - total readings
Measurements of each return inlet - total readings

MAKING ADJUSTMENTS
Adjust airflow to achieve required total airflow
Re-measure total supply and return grille airflow
Adjust dampers to obtain design airflow
Re-measure total airflow to verify that it is within +/- 10%

FINAL TEST
Comparing manufacturer's equipment information with test results
Record sheave, pulley, and belt sizes data
Test and record full load motor amperes
Test and record voltage
Test and record motor and fan RPM
Test and record supply and return static pressures
Test and record supply and return air temperatures - heat and cool

COMPLETION OF APPROPRIATE FORMS
HVAC system report
System diagrams
Duct traverse or data pulley forms
Instrument list - including calibration dates

BASIC HVAC SYSTEM ANALYSIS

NOISE PROBLEMS
Interpreting supply / return air volume
Interpreting supply / return air velocity
Noise problems
Blower cavitation

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HIGH UTILITY BILLS
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Evaluating duct leakage
- Evaluating duct insulation
- Envelope infiltration
- Thermostat air sensing

WIDE TEMPERATURE SWINGS
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Evaluating duct leakage
- Evaluating duct insulation
- Envelope infiltration
- Thermostat air sensing

SINGLE AREA IS HOT OR COLD
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Evaluating duct leakage
- Evaluating duct insulation
- Envelope infiltration
- Thermostat air sensing

INDOOR AIR QUALITY
- Number of air changes per hour
- Odor control
- Contaminants

ANALYZING REPORTED SYMPTOMS IN COOLING
POOR COOLING
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Interpreting supply / return air velocity
- Determining and interpreting the sensible heat ratio
- Evaluating duct leakage
- Using temperature drop across evaporator coil

HUMIDITY PROBLEMS
- Interpreting wet bulb and dry bulb temperatures
- Interpreting supply / return air volume
- Determining and interpreting the sensible heat ratio
- Evaluating duct leakage

DRAFTY
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Interpreting supply / return air velocity

ANALYZING REPORTED SYMPTOMS IN HEATING
POOR HEATING
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Interpreting supply / return air velocity
- Evaluating duct leakage
- Using temperature drop across evaporator coil

HUMIDITY PROBLEMS
- Interpreting wet bulb and dry bulb temperatures
- Interpreting supply / return air volume
- Determining the need for additional humidity
- Evaluating duct leakage

DRAFTY
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
SYSTEM COMPONENTS

INTRODUCTION TO SYSTEMS
HEAT TRANSFER AND THE BASIC COOLING CYCLE
  Heat transfer and cooling
  Basic refrigeration circuit - 10 components
  Dynamic analysis of temperatures and pressure in the refrigerant circuit.
  Psychrometrics
  Subcooling
  Superheat

SPLIT SYSTEMS
  Introduction to split system heat pump configurations and applications
  Equipment locations and mounting in residential split system heat pump applications
  Duct designs for split systems heat pumps
  Electrical layouts for split systems heat pumps
  Refrigerant circuits for split systems heat pumps
  Specifications for split system heat pumps
  Attic / crawlspace layouts for split systems heat pumps
  Closet layouts for split systems heat pumps
  Basement layouts for split systems heat pumps
  Auxiliary heat options with split system heat pumps
  Ventilation options heat pumps
  Regional considerations in split system heat pump designs
  Special consideration of indoor coils above living space
  Introduction to refrigerant pipe layout in split systems heat pump

PACKAGED SYSTEMS
  Introduction to package heat pump configurations
  Equipment locations for package heat pumps
  Basic duct designs for packaged equipment
  Electrical layouts with packaged heat pumps
  Packaged equipment in single story applications
  Packaged equipment in multi story applications
  Packaged equipment in crawlspace applications
  Heat options with packaged heat pumps
  Ventilation options for packaged heat pumps
  Economizer options
  Regional considerations in packaged equipment
  Specifications for packaged equipment
  Applications for packaged heat pump systems
  Refrigerant circuits for packaged heat pump equipment

MULTI-CAPACITY SYSTEMS
  Overview of multi-capacity systems
  Sequencing of multi-capacity heat pumps
  Refrigerant circuits of multi-capacity heat pumps

BASIC HEAT PUMP REFRIGERANT CIRCUIT
  Basic circuit layout for a heat pump
  Role of compressor
  Role of evaporator
  Role of condenser
  Role of metering device
  Role of high pressure vapor line
  Role of low pressure suction line
  Role of reversing valves

HEAT PUMP REFRIGERATION CYCLE OPERATING MODES
  Heat pump circuit operation in the cooling mode
  Heat pump circuit operation in the heating mode
  The defrost cycle

DUCT SYSTEMS

Duct system design
Duct configurations - extended plenum, reducing extended plenum, perimeter radial, perimeter loop, overhead radial
Return configurations - ducted, central, etc.
Return grille locations - low sidewall, high sidewall, etc.
Supply locations - floor, sidewall, ceiling, etc.

WIRING LAYOUTS

POWER Wiring
Overview of power wiring
Single phase wiring
Three-phase wiring

LOW VOLTAGE
Overview of low voltage wiring

CONTROL SEQUENCE
Overview of control sequence used in split systems
Overview of control sequence used in packaged systems

COMPONENTS

OUTDOOR COILS
Basics of selection

RECIROCATING COMPRESSORS
Fundamentals of compressor operations
Compressor types
Design / operation of compressors
Compressor components

REFRIGERANTS
Refrigerants used in Res./Lt. Com heat pumps
Properties of refrigerants used in Res./Lt. Com heat pumps
Using temperature-pressure chart
Refrigerant conservation
Characteristics of blends, temperature glide, and fractionalization

SERVICE/CHECK VALVES
Front seating service valves
Back seating service valves
Gauge port
Check valves

REFRIGERANT CIRCUIT ACCESSORIES
Operation fundamentals - receivers
Operation fundamentals - accumulators
Operation fundamentals - filter-driers, bi-directional
Operation fundamentals - sight glasses, moisture indicators, liquid indicators, etc.

INDOOR COILS
Types - basic designs and operating characteristics of A-coil, slab, and slant indoor coils
Basics of selection
Condensate drains

METERING DEVICES - FIXED
Basics of operation - captubes
Basics of operation - fixed restrictors
Role of distributor in metering device performance
Selection of pistons with fixed metering devices

BLOWERS AND FANS
Introduction to indoor blowers
Introduction to outdoor fans
Indoor blowers - types and selection
Outdoor fans - types and selection
Blower and fan performance

LINE SETS
Introduction to line sets
Selecting line sets
Application considerations when using line sets

AIR SIDE COMPONENTS
Dampers
Ventilation fittings
Electronic air cleaners (EAC's)
Electrostatic filters - non-electric
Media type filters
Fixed outdoor air damper
Insulating material
Flexible duct materials
Ductboard
Metal duct components

GRILLES, REGISTERS, & DIFFUSERS
Types and uses
Selecting diffusers, grilles, and registers

FASTENERS
Screws
Bolts
Nuts and washers
Lockpins
Rivets

ELECTRICAL COMPONENTS
Overcurrent protection
Capacitors
Solenoids
Crankcase heaters
Auxiliary strip heat
Transformers

SCROLL COMPRESSORS
Fundamentals of scroll compressors
Scroll compressor components
Design / operation of scroll compressors advanced features

LUBRICANTS
Mineral oil-based refrigerants and properties
Alkylbenzenes (AB)
Polyolesters (POE)
Lubricant / system compatibility
Evaluating lubricants after removal from system
Disposal of lubricants

METERING DEVICES - VARIABLE
TEV's - types and operation, w/ check valves, bi-directional, w/ external bridge
Role of distributors in variable metering devices
Externally equalized
Thermostatic charges
Off cycle pressure equalization
Selection of TEV's - SH setting, charge

START ASSIST COMPONENTS
Introduction to start components
Selecting start components
Considerations in using start components
Hard start kits - potential relay and start capacitor
Soft start PTCR assists

REVERSING VALVES
Introduction to reversing valves
Basics of operation
Components

CONSTANT AIRFLOW MOTORS
Intro to variable speed motors - ECM, BPM, and VSIM
Motor mounting and installation requirements
Electronic interface and setting for airflow requirements

ELECTROMECHANICAL SENSING CONTROLS
ELECTROMECHANICAL WALL THERMOSTATS
Basic thermostat types and operation
Thermostat terminals and wiring
Selecting wall thermostats and sub-bases
Using electromechanical thermostats

ELECTROMECHANICAL TEMPERATURE CONTROLS
Introduction to bimetal controls
Disc type temperature limit controls
Introduction to vapor charged controls
Overview of auxiliary heat high limits
Motor overloads
Fuses and fuse links
Fossil fuel kits

PRESSURE CONTROLS
Introduction to disc type pressure controls and hi/low controls
Operation and selection of disc type pressure controls
Using disc type pressure controls

ELECTROMECHANICAL OUTDOOR THERMOSTATS
Overview of outdoor thermostats
Outdoor thermostat wiring
Low ambient cooling controls

REFRIGERANT CIRCUIT CONTROLS
PRESSURE CONTROLS
High pressure limit controls
Low pressure limit controls

SYSTEM FLOW CONTROLS
TEV's
Fixed orifices
Check valves
Reversing valves

NON-SENSING CONTROLS
RELAYS AND CONTACTORS
Introduction to relays and contactors
Basics of relay and contactor operation - inrush and holding
Selecting relays and contactors
Application considerations for relays and contactors

ELECTRIC HEAT CONTROLS
Sequencers

ELECTRONIC CONTROLS
ELECTRONIC THERMOSTATS
Fundamentals of electronic thermostats
Selecting electronic thermostats
Overview of electronic thermostat operation
Electronic fossil fuel kits

ZONE CONTROLS
Fundamentals of zone controls
Selecting zone controls
Typical zone control logic

ELECTRONIC TIMERS
Fan delay timers - delay on break
Introduction to compressor delay timers

ELECTRONIC COMPRESSOR CONTROLS
Compressor staging controls
Time delays

OVERVIEW OF ELECTRONIC CONTROLLERS
Input / output operations
Logic

ELECTRONIC DEFROST CONTROLLERS
Fundamentals of electronic defrost controls
Straight time electronic defrost controls
Electronic defrost controls
Temperature differential electronic defrost controls
Time-initiated electronic defrost controls

**APPLIED KNOWLEDGE: REGS, CODES, & DESIGN**

**AIR QUALITY REGULATIONS**

**INDOOR AIR QUALITY**
- Fresh air supplies

**ELECTRICAL CODE REQUIREMENTS**
- Overview of electrical code
- Circuit breaker and fuse requirements
- General wiring practices
- Class I wire sizing
- Class II wire sizing
- Conduit sizing
- Definitions

**STATE AND LOCAL REGULATIONS AND CODES**

**STATE AND LOCAL REGULATIONS**
- State requirements for technicians

**CODES**
- Plumbing
- Municipalities
- HVAC for Lt. Commercial

**FIRE PROTECTION REGULATIONS AND CODES**

**REQUIRED COMPONENTS**
- Return air sensors
- Fire dampers

**FIRE PREVENTION**
- Overview

**DESIGN CONSIDERATIONS - COMFORT**

**TEMPERATURE**
- Designing for capacity
- Using industry standards

**HUMIDITY**
- Role of humidity in comfort
- Using industry standards

**INDOOR AIR QUALITY**
- Ventilation - comfort
- Air cleaning for comfort
- Outside air
- Industry standards for air quality

**SOUND LEVEL**
- Equipment location considerations
- Isolation, mounting pad, duct, and structure
- Duct systems

**DESIGN CONSIDERATIONS - RES. & LT. COMM.**

**SPLIT SYSTEMS**
- System designs - closets, basements, etc.
- Refrigerant piping
- Equipment location
- Electrical layouts
- Duct design / balancing
- Condensate drains
- Ventilation - fresh air
- Regional design considerations
- Ventilation - equipment
- Secondary condensate drains / pans
- Mounting of equipment
- Auxiliary heat options
- Specifying equipment

**PACKAGED SYSTEMS**
Package system configurations and design
Equipment locations design
Applications for packaged systems
Basic duct designs for packaged equipment
Condensate drain piping design
Electrical layouts with packaged heat pumps
Packaged equipment in single story applications
Packaged equipment in multi story applications
Packaged equipment in crawlspace applications
Heat options with packaged systems
Ventilation options
Regional considerations in packaged equipment
Specifications for packaged equipment

DESIGN CONSIDERATIONS - COMPONENTS

DIFFUSERS, REGISTERS, AND GRILLES
Selecting diffusers, grilles, and registers for capacity
Locations
Selecting diffusers, grilles, and registers for throws, spread, and pressure drop
Selecting diffusers, grilles, and registers for reduced sound

ACCESSORIES
Start components
Filter-driers - When to use? and How to select?
Filtering - EAC, media, HEPA, electrostatic
Outdoor thermostats - lockout auxiliary heat
Wall thermostat options
Accumulators - When to use? and How to select?
Humidifier sizing
Time delays
Crankcase heaters
Low ambient cooling controls

MECHANICAL CODE
EQUIPMENT ACCESS
Minimum clearance
Electrical disconnects
Fire dampers

REFRIGERANT LINE ROUTING
Support requirements
Inspection requirements

CONDENSATE DRAINS
Materials
Sizing

INDUSTRY STANDARDS
EQUIPMENT STANDARDS
Introduction to industry standards
ARI standards for ratings

SYSTEM STANDARDS
Introduction to industry standards
Industry standards

BIDS AND PROPOSALS

SYSTEM SIZING
Survey of requirements
Selecting equipment
Sizing components - high / low side
Adding accessories
Duct sizing - new and retrofit application
Basic calculation of residential heating and cooling loads - Manual J fundamentals

ESTIMATING INSTALLATION
Installation price
Understanding proposal forms
Understanding bid forms - bid to specs and flat rate pricing
Legal implications of a bid

SIZING REFRIGERANT LINES
- Capacities of refrigerant lines - effects of improper sizing
- Effects of fittings, pressure drop, and insulation on system performance

ELECTRICAL
- Effects of electrical power on system devices
- Electrical analysis - power

DESIGN CONSIDERATIONS - DUAL FUEL KITS

MODES OF OPERATION
- Restrictive Non-restrictive
- Modified non-restrictive

BALANCE POINT
- Thermal
- Economic balance point
\[
\frac{\text{CFM}_n}{\text{CFM}_o} = \frac{\text{RPM}_n}{\text{RPM}_o} \quad o = \text{old}, n = \text{new}
\]

CFM and RPM are interchangeable.

\[
\left(\frac{\text{CFM}_n}{\text{CFM}_o}\right)^2 = \frac{\text{Sp}_n}{\text{Sp}_o} \quad \text{OR} \quad \text{CFM}_n = \text{CFM}_o \times \sqrt{\frac{\text{Sp}_n}{\text{Sp}_o}}
\]

\[
\left(\frac{\text{CFM}_n}{\text{CFM}_o}\right)^3 = \frac{\text{BHP}_n}{\text{BHP}_o} \quad \text{OR} \quad \text{CFM}_n = \text{CFM}_o \times \sqrt[3]{\frac{\text{BHP}_n}{\text{BHP}_o}}
\]

Hydronics: \( \text{AP} = \text{Sp}, \ \text{CFM} = \text{GPM}, \ \text{RPM} = \text{GPM} \)

\[
\text{MAT} = (\text{OAT} \times \%0A) + (\text{RAT} \times \%RA)
\]

\( 0 = \text{Outside} \)

\( T = \text{Temperature} \)

\( R = \text{Return} \)

\( M = \text{Mixed} \)

\( A = \text{Air} \)

\[
\text{AC/Hr} \times \text{Volume} = \frac{\text{CFM}}{60\text{min}}
\]

\[
\text{v} = 4005 \times .Jvp
\]

\[
\text{Vp} = <4:05)
\]

Pressure (PSI) = 0.433 \times \text{Head (feet of water)}

\[
1 \text{IWC} = 0.0360 \text{PSI}
\]

\[
1 \text{ PSI} = 27.72 \text{ IWC}
\]

\[
\text{Pressure 1} \times \text{Volume 1} = \text{Pressure 2} \times \text{Volume 2}
\]

Area = \( \pi \times \text{radius}^2 \)

\[
A^2 + B^2 = C
\]

\[
\text{Diameter} = \frac{C}{\pi}
\]

\[
\text{ASP} \times 100
\]

\[
\text{FR} = \text{TEL} \quad (\text{I} \text{Wq}100)
\]

\[
\text{CFM} = \text{Velocity (fpm)} \times \text{Duct Area (ft}^2\text{)}
\]

\[
\text{CFM} = \left(\frac{\text{Watts} \times 3.413}{\text{AT} \times 1.08}\right)
\]

\[
\text{Cr (Series)} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n}
\]

\[
\text{Cr (Parallel)} = C_1 + C_2 + \ldots + C_n
\]
To determine subcooling for 404A, 407C, and 4220, use BUBBLE POINT values (temperatures above 50°F -gray background)
To determine superheat for 404A, 407C, and 4220, use DEW POINT values (temperatures 50°F and below)

<table>
<thead>
<tr>
<th>TEMP. (°C)</th>
<th>DEW POINT (PSIG)</th>
<th>BUBBLE POINT (PSIG)</th>
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