AIR-TO-AIR HEAT PUMPS

SERVICE CERTIFICATION

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

- 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. Once certification is obtained it lasts for five years.
- 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.
- 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

<table>
<thead>
<tr>
<th>Closed Book</th>
<th>2.5 Hour Time Limit</th>
<th>100 Questions</th>
<th>Passing Score: PASS/FAIL</th>
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<tbody>
<tr>
<td>Installation</td>
<td>15%</td>
<td></td>
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<tr>
<td>Service</td>
<td>45%</td>
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<td>System Components</td>
<td>30%</td>
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<tr>
<td>Applied Knowledge</td>
<td>10%</td>
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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
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 AND 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.

**CHARGING TOOLS**
- Charging scales

**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 line 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
Oil canning
Motor / belt noise
Vibration

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
Interpreting supply / return air velocity

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

RECYCINGATING 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
\[
\frac{\text{CFM}_n}{\text{CFM}_o} = \frac{\text{RPM}_n}{\text{RPM}_o}
\]

Where \(o\) = old, \(n\) = new

CFM and RPM are interchangeable.

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

\[
\frac{\text{CFM}_n}{\text{CFM}_o} = \sqrt{\frac{\text{Sp}_n}{\text{Sp}_o}}
\]

\[
\text{CFM}_n = \text{CFM}_o \times \frac{\text{RPM}_n}{\text{RPM}_o}
\]

\[
\text{RPM}_n = \text{RPM}_o \times \left(\frac{\text{CFM}_n}{\text{CFM}_o}\right)^2
\]

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

\[
\frac{\text{CFM}_n}{\text{CFM}_o} = \frac{3}{576}
\]

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

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

\text{Btuhr hydronic (H}_2\text{O only)} = 500 \times \text{GPM} \times \Delta T

\text{Btuhr sensible (at sea level)} = 1.08 \times \text{CFM} \times \Delta T

\text{Btuhr latent (at sea level)} = 0.68 \times \text{CFM} \times \Delta \text{Grains}

\text{Btuhr total (at sea level)} = 4.5 \times \text{CFM} \times \Delta \text{Enthalpy}

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

\[
V = 4005 \times \sqrt{V_p}
\]

\[
V_p = \left(\frac{V}{4005}\right)^2
\]

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

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

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

\[
\text{Rectangular Duct Area (ft}^2\text{)} = \frac{\text{Length} \times \text{Width}}{144}
\]

\[
\text{Round Duct Area (ft}^2\text{)} = \frac{\pi \times \text{diameter}^2}{576}
\]

\[
mfd = \frac{(2650 \times \text{I})}{E}
\]

\[
\text{FR} = \frac{\text{ASP} \times 100}{\text{TEL}} \quad \text{(IWC/100)}
\]

\[
\text{CFM} = \frac{\text{Velocity (fpm)} \times \text{Duct Area (ft}^2\text{)}}{(\Delta \text{T} \times 3.413)}
\]

\[
\text{C}_T \text{ (Series)} = \frac{1}{\text{C}_1} + \frac{1}{\text{C}_2} + \ldots + \frac{1}{\text{C}_n}
\]

\[
\text{C}_T \text{ (Parallel)} = \text{C}_1 + \text{C}_2 + \ldots + \text{C}_n
\]
# Temperature Pressure Chart

**Pressure (PSIG), Vacuum (in. of Hg) – Bold Italic Figures**

To determine subcooling for 404A, 407C, and 422D, use BUBBLE POINT values (temperatures above 50°F – gray background)

To determine superheat for 404A, 407C, and 422D, use DEW POINT values (temperatures 50°F and below)

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