# 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.
- 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

**Closed Book 2.5 Hour Time Limit 100 Questions Passing Score: PASS/FAIL**

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

| SECTION AREA DESCRIPTION | SECTION PERCENTAGE |
|---|---|
| Installation | 15% |
| Service | 45% |
| System Components | 30% |
| Applied Knowledge | 10% |

## 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 Energy Conservation Code - Latest Edition with Addendum
- International Mechanical Code - Latest Edition with Addendum
- International Plumbing Code - Latest Edition with Addendum
- Uniform Mechanical Code - Latest Edition with Addendum
- Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems developed by Consortium for Energy Efficiency (CEE) - Latest Edition with Addendum
- ASHRAE Standard-62.2 - Latest Edition with Addendum
- ANSI / ASHRAE Standard-152-2004 - 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
  - Fibrous Glass Duct Construction Standards, Residential Comfort System Installation Standards Manual, and HVAC Air Duct Leakage Test Manual
- 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
- International Fuel Gas Code – Latest Edition with Addendum
- National Fuel Gas Code – Latest Edition with Addendum

## 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.

## Exam Copyrights

# 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 & 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

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 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

RECIPROCATING 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

$\frac{CFM_n}{CFM_o} = \frac{RPM_n}{RPM_o}$ $o$ = old, $n$ = new CFM and RPM are interchangeable.

$CFMn = CFMo \times \frac{RPM}{o}$ $RPMn = RPMo \times \frac{CFM}{o}$

$\left(\frac{CFM_n}{CFM_o}\right)^2 = \frac{Sp_n}{Sp_o}$ OR $CFMo = JSPP;$ $CFM_n = CFM_o \times \sqrt{\frac{Sp_n}{Sp_o}}$ $Sp_n = Sp_o \times \left(\frac{CFM_n}{CFM_o}\right)^2$

$\left(\frac{CF}{CFM_o}\right)^3 = \frac{BHPn}{BHP_o}$ OR $CFM_o = \frac{BHPn}{BHP_o}$ $CFM_n = CFM_o \times \sqrt[3]{\frac{BHP_n}{BHP_o}}$ $BHPn = BHPo \times \left(\frac{CFMn}{CFM_o}\right)^3$

Hydronics: $AP$ =Sp, CFM = GPM, RPM= GPM

$MAT = (OAT \times \%0A) + (RATx\ \%RA)$

0 =Outside
*T = Temperature*
*R =Return*
*M=Mixed*
*A=Air*

*Btuh hydronic ($H_20$ only) = 500 x GPM x AT*
*Btuh sensible (at sea level) = 1.08 x CFM x AT*
*Btuh latent (at sea level) = 0.68 x CFM x AGrains*
*Btuh total (at sea level)= 4.5 x CFM x AEnthalpy*

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$CFM = \frac{AC/Hr \times Volume}{60min}$ $V = 4005 \times .Jvp$ $Vp = <4:05)2$

*Pressure (PSI)= 0.433 x Head (feet of water)*

*1 IWC = 0.0360 PSI*
*1 PSI= 27.72 IWC*

*Pressure 1 x Volume 1 = Pressure 2 x Volume 2*

*Rectangular Duct Area (ft2) =* $\frac{Length \times Width}{144}$

$Area = 1t \times radius^2$

*Round Duct Area (ft2) =* $\frac{1t \times diameter}{576}$

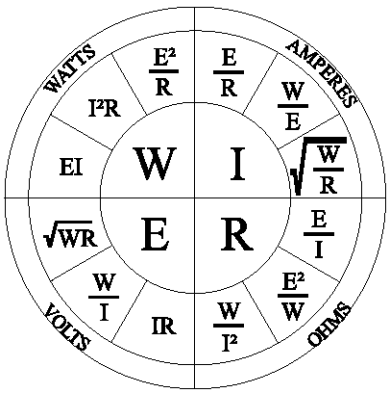
$A^2 + B^2 = C$

$Diameter = \frac{Circumference}{1t}$

$mfd = \frac{(2650 \times I)}{E}$

$FR = \frac{ASP \times 100}{TEL}$ (IWqIOO)

*CFM = Velocity (fpm) x Duct Area ($ft^2$)*




$CFM - \frac{(Watts \times 3.413)}{\{ATx\ 1.08)}$

$Cr\ (Series) = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \ldots + \frac{1}{}}$

$C_T\ (Parallel) = C_1 + C_2 + \ldots + C_N$

# TEMPERATURE PRESSURE CHART-atsealevel

Pressure (PSIG), Vacuum (in. Of Hg)- Bold Italic Figures
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)

| TEMP. | | REFRIGERANT | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Of | OC | 22 | 134a | 404A | 407C | 410A | 4220 | 507 |
| -40 | -40.0 | 0.6 | *14.8* | 4.3 | *4.6* | 10.7 | 2.3 | 5.4 |
| -38 | -38.9 | 1.4 | *13.9* | 5.3 | 3.2 | 12.0 | *0.8* | 6.4 |
| -36 | -37.8 | 2.2 | *13.0* | 6.3 | *1.6* | 13.4 | 0.4 | 7.5 |
| -34 | -36.7 | 3.1 | *12.0* | 7.4 | 0.0 | 14.8 | 1.2 | 8.6 |
| -32 | -35.6 | 4.0 | *10.9* | 8.5 | 0.8 | 16.2 | 2.1 | 9.8 |
| -30 | -34.4 | 4.9 | *9.8* | 9.6 | 1.6 | 17.8 | 3.0 | 11.0 |
| -28 | -33.3 | 5.9 | *8.7* | 10.8 | 2.5 | 19.3 | 3.9 | 12.2 |
| -26 | -32.2 | 6.9 | 7.5 | 12.0 | 3.5 | 21.0 | 4.9 | 13.5 |
| -24 | -31.1 | 8.0 | 6.3 | 13.3 | 4.4 | 22.7 | 5.9 | 14.8 |
| -22 | -30.0 | 9.1 | *5.0* | 14.6 | 5.4 | 24.4 | 7.0 | 16.2 |
| -20 | -28.9 | 10.2 | *3.7* | 16.0 | 6.5 | 26.3 | 8.1 | 17.6 |
| -18 | -27.8 | 11.4 | 2.3 | 17.4 | 7.6 | 28.1 | 9.2 | 19.1 |
| -16 | -26.7 | 12.6 | *0.8* | 18.9 | 8.7 | 30.1 | 10.4 | 20.6 |
| -14 | -25.6 | 13.9 | 0.4 | 20.4 | 9.9 | 32.1 | 11.7 | 22.2 |
| -12 | -24.4 | 15.2 | 1.1 | 22.0 | 11.1 | 34.2 | 12.9 | 23.8 |
| -10 | -23.3 | 16.5 | 1.9 | 23.6 | 12.3 | 36.4 | 14.3 | 25.5 |
| -8 | -22.2 | 17.9 | 2.8 | 25.3 | 13.7 | 38.6 | 15.6 | 27.3 |
| -6 | -21.1 | 19.4 | 3.6 | 27.0 | 15.0 | 40.9 | 17.1 | 29.1 |
| -4 | -20.0 | 20.9 | 4.6 | 28.8 | 16.4 | 43.3 | 18.5 | 30.9 |
| -2 | -18.9 | 22.4 | 5.5 | 30.7 | 17.9 | 45.8 | 20.1 | 32.8 |
| 0 | -17.8 | 24.0 | 6.5 | 32.6 | 19.4 | 48.3 | 21.6 | 34.8 |
| 1 | -17.2 | 24.9 | 7.0 | 33.6 | 20.2 | 49.6 | 22.5 | 35.8 |
| 2 | -16.7 | 25.7 | 7.5 | 34.6 | 21.0 | 51.0 | 23.3 | 36.9 |
| 3 | -16.1 | 26.5 | 8.0 | 35.6 | 21.8 | 52.3 | 24.1 | 37.9 |
| 4 | -15.6 | 27.4 | 8.5 | 36.6 | 22.6 | 53.7 | 25.0 | 39.0 |
| 5 | -15.0 | 28.3 | 9.1 | 37.7 | 23.5 | 55.0 | 25.8 | 40.0 |
| 6 | -14.4 | 29.2 | 9.6 | 38.7 | 24.3 | 56.5 | 26.7 | 41.1 |
| 7 | -13.9 | 30.1 | 10.2 | 39.8 | 25.2 | 57.9 | 27.6 | 42.2 |
| 8 | -13.3 | 31.0 | 10.8 | 40.9 | 26.1 | 59.3 | 28.5 | 43.4 |
| 9 | -12.8 | 31.9 | 11.3 | 42.0 | 27.0 | 60.8 | 29.5 | 44.5 |
| 10 | -12.2 | 32.8 | 11.9 | 43.1 | 27.9 | 62.3 | 30.4 | 45.7 |
| 11 | -11.7 | 33.8 | 12.5 | 44.3 | 28.8 | 63.8 | 31.3 | 46.8 |
| 12 | -11.1 | 34.8 | 13.1 | 45.4 | 29.8 | 65.4 | 32.3 | 48.0 |
| 13 | -10.6 | 35.8 | 13.8 | 46.6 | 30.7 | 66.9 | 33.3 | 49.3 |
| 14 | -10.0 | 36.8 | 14.4 | 47.8 | 31.7 | 68.5 | 34.3 | 50.5 |
| 15 | -9.4 | 37.8 | 15.0 | 49.0 | 32.7 | 70.1 | 35.3 | 51.7 |
| 16 | -8.9 | 38.8 | 15.7 | 50.2 | 33.7 | 71.7 | 36.4 | 53.0 |
| 17 | -8.3 | 39.9 | 16.4 | 51.5 | 34.7 | 73.4 | 37.4 | 54.3 |
| 18 | -7.8 | 40.9 | 17.0 | 52.7 | 35.7 | 75.1 | 38.5 | 55.6 |
| 19 | -7.2 | 42.0 | 17.7 | 54.0 | 36.8 | 76.8 | 39.6 | 56.9 |
| 20 | -6.7 | 43.1 | 18.4 | 55.3 | 37.9 | 78.5 | 40.7 | 58.2 |
| 21 | -6.1 | 44.2 | 19.1 | 56.6 | 39.0 | 80.3 | 41.8 | 59.6 |
| 22 | -5.6 | 45.3 | 19.9 | 58.0 | 40.1 | 82.0 | 42.9 | 61.0 |
| 23 | -5.0 | 46.5 | 20.6 | 59.3 | 41.2 | 83.8 | 44.1 | 62.4 |
| 24 | -4.4 | 47.6 | 21.3 | 60.7 | 42.3 | 85.7 | 45.2 | 63.8 |
| 25 | -3.9 | 48.8 | 22.1 | 62.1 | 43.5 | 87.5 | 46.4 | 65.2 |
| 26 | -3.3 | 50.0 | 22.9 | 63.5 | 44.7 | 89.4 | 47.6 | 66.7 |
| 27 | -2.8 | 51.2 | 23.7 | 64.9 | 45.9 | 91.3 | 48.8 | 68.2 |
| 28 | -2.2 | 52.4 | 24.5 | 66.4 | 47.1 | 93.2 | 50.1 | 69.7 |
| 29 | -1.7 | 53.7 | 25.3 | 67.8 | 48.3 | 95.2 | 51.3 | 71.2 |
| 30 | -1.1 | 55.0 | 26.1 | 69.3 | 49.6 | 97.2 | 52.6 | 72.7 |
| 31 | -0.6 | 56.2 | 26.9 | 70.8 | 50.8 | 99.2 | 53.9 | 74.3 |

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# TEMPERATURE PRESSURE CHART-atsealevel

Pressure (PSIG), Vacuum (in. Of Hg) - Bold Italic Figures
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)

| TEMP. | | REFRIGERANT | | | | | | |
|---|---|---|---|---|---|---|---|---|
| •f | 0C | 22 | 134a | 404A | 407C | 410A | 4220 | 507 |
| 32 | 0.0 | 57.5 | 27.8 | 72.4 | 52.1 | 101.2 | 55.2 | 75.8 |
| 33 | 0.6 | 58.8 | 28.6 | 73.9 | 53.4 | 103.3 | 56.5 | 77.4 |
| 34 | 1.1 | 60.2 | 29.5 | 75.5 | 54.8 | 105.4 | 57.9 | 79.0 |
| 35 | 1.7 | 61.5 | 30.4 | 77.1 | 56.1 | 107.5 | 59.3 | 80.7 |
| 36 | 2.2 | 62.9 | 31.3 | 78.7 | 57.5 | 109.7 | 60.6 | 82.3 |
| 37 | 2.8 | 64.3 | 32.2 | 80.3 | 58.9 | 111.9 | 62.0 | 84.0 |
| 38 | 3.3 | 65.7 | 33.1 | 82.0 | 60.3 | 114.1 | 63.5 | 85.7 |
| 39 | 3.9 | 67.1 | 34.1 | 83.7 | 61.7 | 116.3 | 64.9 | 87.5 |
| 40 | 4.4 | 68.6 | 35.0 | 85.4 | 63.2 | 118.6 | 66.4 | 89.2 |
| 42 | 5.6 | 71.5 | 37.0 | 88.8 | 66.1 | 123.2 | 69.4 | 92.8 |
| 44 | 6.7 | 74.5 | 39.0 | 92.4 | 69.2 | 127.9 | 72.5 | 96.4 |
| 46 | 7.8 | 77.6 | 41.1 | 96.0 | 72.3 | 132.8 | 75.6 | 100.2 |
| 48 | 8.9 | 80.8 | 43.2 | 99.8 | 75.5 | 137.8 | 78.9 | 104.0 |
| 50 | 10.0 | 84.1 | 45.4 | 103.6 | 78.8 | 142.9 | 82.2 | 108.0 |
| 52 | 11.1 | 87.4 | 47.7 | 1092 | 101.7 | 148.1 | 96.1 | 112.0 |
| 54 | 12.2 | 90.8 | 50.0 | 1133 | 105.6 | 153.5 | 998 | 116.1 |
| 56 | 13.3 | 94.4 | 52.4 | 117.4 | 109.6 | 159.0 | 103.6 | 120.4 |
| 58 | 14.4 | 98.0 | 54.9 | 121.7 | 113.7 | 164.7 | 107.4 | 124.7 |
| 60 | 15.6 | 101.6 | 57.4 | 126.0 | 117.9 | 170.4 | 111.4 | 129.1 |
| 62 | 16.7 | 105.4 | 60.0 | 1305 | 122.3 | 176.3 | 1154 | 133.7 |
| 64 | 17.8 | 109.3 | 62.7 | 1350 | 126.7 | 182.4 | 1195 | 138.3 |
| 66 | 18.9 | 113.2 | 65.4 | 139.7 | 131.2 | 188.6 | 123.8 | 143.1 |
| 68 | 20.0 | 117.3 | 68.2 | 144.4 | 135.8 | 194.9 | 128.1 | 147.9 |
| 70 | 21.1 | 121.4 | 71.1 | 149.3 | 140.5 | 201.4 | 132.5 | 152.9 |
| 72 | 22.2 | 125.7 | 74.1 | 154.3 | 145.4 | 208.0 | 137.1 | 158.0 |
| 74 | 23.3 | 130.0 | 77.1 | 1594 | 150.3 | 214.8 | 1417 | 163.2 |
| 76 | 24.4 | 134.5 | 80.2 | 164.6 | 155.4 | 221.8 | 146.5 | 168.5 |
| 78 | 25.6 | 139.0 | 83.4 | 169.9 | 160.5 | 228.9 | 151.3 | 174.0 |
| 80 | 26.7 | 143.6 | 86.7 | 175.4 | 185.8 | 236.1 | 156.3 | 179.5 |
| 82 | 27.8 | 148.4 | 90.0 | 181.0 | 171.2 | 243.6 | 161.3 | 185.2 |
| 84 | 28.9 | 153.2 | 93.5 | 1867 | 176.8 | 251.2 | 1665 | 191.0 |
| 86 | 30.0 | 158.2 | 97.0 | 1925 | 182.4 | 258.9 | 1718 | 197.0 |
| 88 | 31.1 | 163.2 | 100.6 | 198.4 | 188.2 | 266.8 | 177.2 | 203.0 |
| 90 | 32.2 | 168.4 | 104.3 | 204.5 | 194.1 | 274.9 | 182.7 | 209.2 |
| 92 | 33.3 | 173.7 | 108.1 | 210.7 | 200.1 | 283.2 | 188.4 | 215.5 |
| 94 | 34.4 | 179.1 | 112.0 | 2170 | 206.3 | 291.6 | 1941 | 222.0 |
| 96 | 35.6 | 184.6 | 115.9 | 2234 | 212.5 | 300.3 | 2000 | 228.6 |
| 98 | 36.7 | 190.2 | 120.0 | 230.0 | 219.0 | 309.1 | 206.0 | 235.3 |
| 100 | 37.8 | 195.9 | 124.2 | 236.8 | 225.5 | 318.1 | 212.1 | 242.2 |
| 102 | 38.9 | 201.8 | 128.4 | 243.6 | 232.2 | 327.2 | 218.4 | 249.2 |
| 104 | 40.0 | 207.7 | 132.7 | 250.8 | 239.0 | 336.6 | 224.8 | 256.3 |
| 106 | 41.1 | 213.8 | 137.2 | 2578 | 245.9 | 346.2 | 2313 | 263.7 |
| 108 | 42.2 | 220.0 | 141.7 | 265.1 | 253.0 | 355.9 | 237.9 | 271.1 |
| 110 | 43.3 | 226.4 | 146.4 | 272.5 | 260.3 | 365.9 | 244.7 | 278.7 |
| 112 | 44.4 | 232.8 | 151.1 | 280.1 | 287.6 | 376.1 | 251.6 | 286.5 |
| 114 | 45.6 | 239.4 | 156.0 | 287.9 | 275.1 | 386.4 | 258.8 | 294.4 |
| 116 | 46.7 | 246.1 | 160.9 | 2958 | 282.8 | 397.0 | 2658 | 302.4 |
| 118 | 47.8 | 253.0 | 166.0 | 3038 | 290.6 | 407.8 | 2732 | 310.7 |
| 120 | 48.9 | 260.0 | 171.2 | 312.1 | 298.6 | 418.8 | 280.6 | 319.1 |
| 125 | 51.7 | 278.0 | 184.6 | 333.3 | 319.2 | 447.4 | 299.9 | 340.8 |
| 130 | 54.4 | 296.9 | 198.7 | 355.6 | 340.7 | 477.4 | 320.2 | 363.6 |