Commercial Refrigeration 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.

- ASHRAE Fundamentals-Latest Edition
- ASHRAE Refrigeration-Latest Edition
- ASHRAE HVAC Applications-Latest Edition
- NSF/ANSI 7-2001-Commercial refrigerators and freezers-Requirements for Food Storage Refrigeration
- Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
- American Society of Mechanical Engineers
- ASTM International
- International Plumbing Code- Latest Edition with Addendum
- International Mechanical Code-Latest Edition with Addendum
- Uniform Mechanical Code-Latest Edition with Addendum
- Uniform Plumbing 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.

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Commercial Refrigeration

Service

n/a

INSTALLATION

FABRICATING COPPER TUBING

REFRIGERANT LINE INSTALLATION
Locating, mounting, and routing
Selecting tubing type
Sizing of refrigerant line
Sloping of refrigerant line
Understanding limitations of length and diameter
Installing line trap(s) in each line rise
Insulating refrigerant lines
Install adequate line/piping supports

CONDENSATE DRAIN LINE INSTALLATION
Locating, mounting, and routing
Selecting tubing type
Sizing of line
Sloping of drain line
Understanding limitations of length and diameter
Installing drain line trap(s) for each room
Insulating condensate drain lines

BENDING COPPER TUBING
Making a proper bend with gear 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
The use of flux to limit oxidation

FLARE FITTINGS
Selecting the correct type (angle) flare fitting
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 PACKAGED REFRIGERATION UNIT

INSTALLING AND CONNECTING PACKAGED UNITS
Locating equipment for proper placement
Preparing site - hole location, weight distribution
Lifting and placing unit(s)
Sealing unit and penetration through openings
Wiring unit to power source

INSTALLING SPLIT SYSTEMS (EXCLUDING EVAPORATOR)

INSTALLING AND CONNECTING
Locating split system components for proper placement
Preparing site(s)
Lifting and placing unit(s)
Connect water lines to condenser for water cooled unit
Wiring unit controls to power source
Wiring compressor unit to condenser
Wiring unit to evaporator unit(s)
Mount and pipe accessories (heat reclaim, etc.)
Installing refrigerant lines & supports
Understanding local codes (seismic, hurricane, etc.)
Sealing penetrations
Understanding the importance of proper ventilation

INSTALLING EVAPORATOR UNIT

INSTALLATION AND CONNECTING EVAPORATOR UNIT
Locating evaporator unit for proper placement
Service access and clearance considerations
Handling - lifting, hanging, and placing unit
Mounting evaporator unit
Connecting refrigerant lines and supports
Connecting condensate, drain lines
Wiring evaporator fan motors
Wiring drain line heaters (for freezers)
Wiring electric defrost heaters & controls (when present)
Wiring room thermostats and liquid line solenoid valve
Installing distribution nozzle
Installing metering devices (TEV, EEV, etc.)
Bulb location selection for TEV’s
Trapping & insulating condensate lines
Double suction line riser considerations
Trapping & insulating refrigeration line rises
Sealing penetrations through building structure

EVACUATION & CHARGING SYSTEM

SAFETY CONCERNS OF MISHANDLING REFRIGERANTS
Freezing
Breathing
Burning

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
Three pass blotter method of evacuation

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

CHARGING METHOD
Weigh-in charge method
Percent of receiver method
Superheat method and where used
Subcooling method and where used
Charging blended refrigerants
Liquid charging
Floating head system considerations
Flooded condenser charging techniques
System charging techniques for specific compressors

**FABRIC DUCT INSTALLATION**

**INSTALLING FABRIC DUCT**
Routing and hanging duct support cable
Connecting duct to special fan guard adapter
Securing methods
Sealing duct to fan guard adapter
Installation technique

**INSTALLING COMPONENTS & ACCESSORIES**

**INSTALLING REFRIGERANT METERING DEVICE (TEV)**
Purpose
Locating, mounting, and placement
Installing distributor nozzle
Protecting from overheating
Brazing to distributor
Connecting to liquid refrigerant line
Insulating refrigerant lines

**INSTALLING THERMOSTAT**
Purpose
Locating, mounting, and placement
Wiring electromechanical thermostats
Wiring electronic thermostats
Setting differential of thermostat
Calibrating display setting of thermostat

**INSTALLING REFRIGERANT LINE SOLENOID VALVE**
Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
Wiring to room thermostats
Wiring interconnection to condensing unit
Selecting proper solenoid for application

**INSTALLING SUCTION LINE ACCUMULATORS & FILTERS**
Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
Selecting suction filter for application

**INSTALLING LIQUID LINE COMPONENTS**
Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
Selecting drier for application

**INSTALLING LIQUID TO SUCTION HEAT EXCHANGER**
Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines

When and when NOT to use

**INSTALLING SUCTION LINE PRESSURE REGULATING VALVES**
Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
INSTALLING HEAD PRESSURE REGULATING VALVES

Purpose
Locating, mounting, and placement - 1 & 2 valve setup
Connect refrigerant lines and supports
Insulating refrigerant lines
Verify receiver capacity

INSTALLING OIL SEPARATORS

Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
When and when NOT to use

INSTALLING LIQUID REFRIGERANT RECEIVERS

Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
When to heat and insulate
Check-valve usage considerations

INSTALLING HOT GAS BYPASS

Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
Design considerations

INSTALLING LIQUID INJECTION SOLENOID

Purpose
Use of de-super heated values
Locating, mounting, and placement
Connect refrigerant lines and supports
Wiring & controlling

INSTALLING WATER REGULATING VALVES

Purpose
Locating, mounting, and placement
Connect water lines and supports
Wiring & controlling

INSTALLING DEFROST CONTROLS

Purpose
Locating, mounting, and placement of time clocks
Locating, mounting, and placement of hold-out relays
Locating, mounting, and placement of lock-out relays
Locating, mounting, and placement of defrost termination (adjustable and non-adjustable)
Wiring with and without fan contactor(s)
Wiring with and without heater contractor(s)
Settings for air defrost / off cycle defrost operation
Settings for electric defrost operation
Settings for hot gas defrost operation

INSTALLING REMOTE CONDENSERS

Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
Wiring interconnection to compressor unit(s)

INSTALLING EVAPORATIVE CONDENSERS

Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines
Wiring interconnection to compressor unit(s)
Wiring sump heater for low ambient operation
Connect water lines and supports

INSTALLING COOLING TOWERS

Purpose
Locating, mounting, and placement
Connect water lines/ accessories and supports
Wiring interconnection to compressor unit(s)
Wiring sump heater for low ambient operation

FIELD WIRING

WIRING UNITS & CONTROL WIRING

Equipment isolation
Connecting electrical power
Connecting control circuits
Meeting manufacturer sizing requirements - wire sizing (size and number)
NEC and local inspector’s requirements

START-UP AND CHECKOUT PRE-START PROCEDURES

Surveying installation
Visual connections – wiring and piping
Check piping traps in refrigerant and drain lines
Set dip switches / jumpers on ECM motors
Set dip switches on electronic system controller
Set wiring taps on multi-speed/voltage motors
Check fan blade alignment
Check for obstructions to operation
Ensure condensate line is flowing
Check pressure control and thermostat settings
Check oil level in compressor
Check compressor mounting
Run crankcase heater 24 hrs. before startup
Check seals of all penetrations (wiring, piping, drains)
Check all hand valve adjustments/settings
Check TEV sensing bulb mounting
Check defrost time clock settings

START-UP PROCEDURES AND CHECKS

Surveying installation - checking equipment match
Supply voltage checks
Check refrigerant match (compressor, TEV, nozzle, etc.)
Motor/compressor checks - amps, voltage, phase, etc.
Checking sequences of operation
Check all fan rotations
Check scroll compressor rotation - high noise level, etc.
Start-up checklist and preparation documentation
Metering device - refrigerant circuit checks
Airflow and condensate/frost patterns checks
Pressure checks - high side and low side
Temperature checks - dry bulb, wet bulb, etc.
Check superheat at compressor inlet
Check safety and operational control settings (hi/low, oil, fan cycling, head pressure, etc.)
Capacity checks - system balance
Check sight glass - charge and moisture indicator
Observe oil level in compressor through cycles
Check drain pan for proper drainage
Check drain line heaters
Jumper freezer motor fan delay for start up
Check defrost heater operation
Check liquid injection solenoid operation
Do not leave system unattended before operating conditions met
Time schedule for pull down of low temp rooms

LEAK DETECTION TOOLS

Bubble 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
- Scale 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

**TEMPERATURE TOOLS**
- Electrical
- Mechanical

**RECOVERY / RECYCLING MACHINES**

**RECOVERY MACHINES**
- Why recover
- 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 commercial refrigeration
- Velocity (FPM)

**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
Formulae for determining CFM of air
Formulae for weight of air
Use of psychrometric chart
Locations for air volume measurements
Airflow volume - CFM / SCFM (Static CFM)

SERVICE

PLANNED MAINTENANCE

MECHANICAL PLANNED MAINTENANCE
Filters (liquid and suction)
Charge
Lubrication
Condenser coil care
Evaporator coil care
Condensate pans and drains
Shell & tube vessels (condensers & chiller barrels)
Packaged unit cabinet care
Fan guards
Fan blades
Entering air coil surface
Performance checks - temperature rise

ELECTRICAL PLANNED MAINTENANCE
Electric motor and contactor checks
General wiring checks - tightness of connections/ aluminum wire/ etc.
Sequence of operation checks
Compressor checks/ voltage/ current
Crankcase heater check
Electric heater – fit into coil

DIAGNOSTICS
PRELIMINARY SYSTEM DIAGNOSTICS
Condenser / condensing unit checks
Evaporator unit checks
Wiring checks
Refrigerant line checks
Thermostat checks & calibration
Condensate drain checks
Accessories

ANALYZING REPORTED SYMPTOMS
No cooling
Low capacity
Humidity problems
Compressor start problems
Noise problems
Not defrosting
System runs continuously
High utility bills
Ice or water on ceiling & floor
Snow on product
Wide swings in space temperatures
Safety control trips
Frequent loss of motors
Frequent loss of compressors
Compressor running hot

SYSTEM AIR SIDE DIAGNOSTICS
Temperature checks - dry bulb, wet bulb, etc.
Airflow checks
Noise problems
Vibration problems
Water “blow-off” problems
Evaporator fan blades
Condenser fan blades

REFRIGERANT SYSTEM DIAGNOSTICS
- Overview
- Using superheat
- Using subcooling
- Using compressor circuiting split
- Analyzing overall refrigerant circuit performance
- Locating problems based on refrigerant circuit temperatures and pressures

ELECTRICAL CHECKS
- Supply voltage checks
- Compressor circuits
- Condenser fan circuits
- Evaporator fan circuits
- Wall thermostat and solenoid circuits
- Transformer circuits
- Defrost heater & timer circuits
- Electronic controllers - input / output

COMPONENT CHECKS - ELECTRICAL
- Compressor
- Thermostat
- Crankcase heaters
- Low ambient controls for cooling
- Transformers
- Fuses and breakers
- Relays and contactors
- Hi-Lo Pressure controls
- Condenser fan motors
- Evaporator fan motors
- Capacitors
- Start relays
- Solenoid valves
- Defrost heaters
- Defrost time clocks
- Programmable electronic system controller
- Phase loss monitors
- Compressor modules
- Discharge line thermostats
- Oil pressure safety switches
- Drain line heaters
- Demand cooling modules
- Defrost termination controls
- Evaporator fan motor fan delays
- Low pressure switch time delays
- Fan cycling controls
- Double suction risers – varying capacity units

REPAIR
- Refrigerant circuit on coils
- Refrigerant leaks
- Electrical wiring
- Leaking seals through building structure
- Damaged piping insulation
- Broken drain line
- Cleanable liquid screens
- Rebuildable control valves - solenoids, pressure control, heat reclaim, etc.
- Metering device

REPLACEMENTS
- Condenser / condensing units
- Compressors
- Condenser fans (motors, blades, and mounts)
- Condenser coils
Evaporator fans (motors/blades/mounts)
Evaporator coils
Evaporator defrost heaters
Metering devices
Transformers
Liquid line filter-driers
Suction line filters
Suction accumulators
 Receivers (vessels & relief)
 Relays and contactors
 Capacitors
 Compressor safety controls
 Drain line heaters
 Distributor nozzles
 Evaporator drain pans
 Head pressure controls
 Fan cycling controls

SYSTEM CLEANUP AFTER COMPRESSOR ELECTRICAL FAILURE
 Compressor
 Metering device
 Oil / acid test
 Oil changing procedures
 Changing compressors start components
 Cleanup filters - suction
 Cleanup driers - acid and moisture
 Suction accumulator - change or clean out

COMPONENT CHECKS - REFRIGERATION
 Compressor
 Metering device
 Filter-drier
 Suction line - oil traps, risers, etc.
 Liquid line - vertical height, static pressure loss, etc.
 Solenoid valves
 Condensate drains
 Check valves
 Evaporator and condenser coils
 Flow control valves - pressure control, heat reclaim, etc
 Suction pressure
 Discharge pressure

PARALLEL PIPE REFRIGERATION
 Rack systems
 Basic operation
 Oil management
 Piping
 Controls operation

OVERVIEW OF ELECTRICAL TROUBLESHOOTING
 LOW VOLTAGE CIRCUITS
 Definition
 Microprocessors
 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
 Definition
Voltage tests
Current tests
Component tests
Circuit tracing line voltages
Troubleshooting with schematics
Troubleshooting without schematics
Equipment continuity tests
Ground tests – Wye and Delta

MOTOR WINDING WIRING
Single phase
Three phase
Part winding start
Permanent split capacitor

RETOFITTING
EQUIPMENT COMPONENT RETROFITTING
Changing out condenser / condensing unit
Understanding design temperature difference (TD)
Matching to evaporator for proper system balance
Changing out an evaporator
Matching proper metering device, nozzle, and drier selections
Modifying unit placement and any piping/electrical changes
Match evaporators to condensing unit and application

COMPLETION OF APPROPRIATE FORMS
Start up form
System diagrams
Understanding readings from forms
Analyzing system performance
Instrument list, including calibration dates

BASIC REFRIGERATION SYSTEM ANALYSIS

NOISE PROBLEMS
Interpreting supply / return air volume
Interpreting supply / return air velocity
Noise problems
Motor / belt noise
Vibration
Metering device noises
Solenoid chattering
Contactor chattering
Defrost heater creeping
Compressor noise

HIGH UTILITY BILLS
Interpreting supply / return air temperature
Interpreting supply / return air volume
Evaluating room air leakage
Evaluating damaged doors or panels - gaskets, door closers, etc.
Room envelope infiltration
Thermostat air sensing/ placement/ calibration
Compressor performance
System performance
Control settings
Frosting/icing of evaporator
Refrigerant charge
Fan motor operation (evaporator & condenser)
Drain line air leakage and icing of evaporator

WIDE TEMPERATURE SWINGS
Interpreting supply / return air temperature
Interpreting supply / return air volume
Evaluating compressor performance
Evaluating system performance
Room envelope infiltration
Thermostat air sensing/ solenoid
Thermostat coil sensing placement/ calibration
Product location
Control settings
Check product loading patterns
Check product temperature when loaded
Check air patterns around refrigerator
Check worker door discipline
Check for fluctuating power conditions
Check system TD
Check TEV operation
Check system filter-driers for high pressure drop
Checking current & voltage with name plate data

ANALYZING REPORTED SYMPTOMS IN COOLING
POOR COOLING
Interpreting supply / return air flow
Determining TD – Room temperature & SST
Interpreting system refrigerant charge
Interpreting compressor performance
Interpreting system performance
Interpreting control settings
Interpreting product location and loading patterns
Calculating frost loading on evaporator
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 frosting on evaporator
Evaluating door management
Determining seal damage through building structure
Evaluating air infiltration
Evaluating system balance and humidity relationship
Flowers and meat cutting rooms

SYSTEM COMPONENTS
INTRODUCTION TO SYSTEMS
HEAT TRANSFER
Heat transfer
Basic refrigeration circuit
Dynamic analysis of temperatures and pressure in the refrigerant circuit
Understanding seasonal effects
Psychrometrics
Subcooling
Superheat
SPLIT SYSTEMS
Introduction to split system configurations and applications
Equipment locations and mounting
Basic pipe sizing
Electrical layouts for split systems
Refrigerant circuits for split systems
Specifications for split systems
Regional considerations in split system designs
Refrigerant circuits for multiple evaporator systems
Specifications for ultra-low ambient designs
Specifications for high humidity designs
Specifications for low humidity designs
Specifications for high ambient designs
Specifications for hanging evaporators
Specifications for special local code compliances
Introduction to refrigerant pipe layout in split systems

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PACKAGED REFRIGERATION SYSTEMS

Introduction to package configurations
Equipment locations for package units
Basic placement designs for packaged equipment
Electrical layouts with packaged units
Packaged equipment in “drop through” applications
Packaged equipment in “side mount” applications
Packaged equipment for indoor applications
Packaged equipment for outdoor applications
Controls & settings for packaged cooler equipment
Controls & settings for packaged freezer equipment
Regional considerations in packaged equipment
Specifications for packaged equipment
Applications for packaged systems

MULTI-CAPACITY SYSTEMS

Overview of multi-capacity systems
Sequencing of multi-capacity refrigeration systems
Refrigerant circuits of multi-capacity systems
Hot gas by-pass usage
Cylinder unloading
Frequency drive usage
VFD
Piping considerations
Oil management considerations

WIRING LAYOUTS

POWER WIRING
Definition
Overview of power wiring

LOW VOLTAGE
Definition
Overview of low voltage wiring

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

COMPONENTS

CONDENSERS
Types - basic designs (air/ water/ evaporative)
Head pressure controls
Fan cycling controls
Multiple circuited basic designs
Multiple circuited seasonal designs
Subcooling circuits
Heat reclaim systems

RECIPIROCATING COMPRESSORS
Fundamentals of reciprocating compressor operations
Design considerations of compressors
Compressor components
Compressor efficiency check

SCROLL COMPRESSORS
Fundamentals of scroll compressors
Scroll compressor components
Design considerations of scroll compressors advanced features
Compressor efficiency check

SCREW COMPRESSORS
Fundamentals of screw compressors
Screw compressor components
Design considerations of screw compressors advanced features
Compressor efficiency check

REFRIGERANTS
P/E chart
Refrigerants used in commercial refrigeration
Properties of refrigerants used commercial refrigeration
Using temperature-pressure chart/tables
Refrigerant conservation
Characteristics of blends/ temperature glide/ and fractionation

SERVICE VALVES
Schrader valves
One way (front seating) service valves
Two-way (back seating) service valves
Gauge port

REFRIGERANT CIRCUIT ACCESSORIES
Receivers & reliefs
Accumulators Filter-driers
Sight glasses, moisture indicators, liquid indicators, etc.
Mufflers / muffler plates
Oil safety controls
Head pressure controls
Oil separators
EPR/ CPR/ hot gas bypass
Flow control valves - heat reclaim, etc
Condenser fan cycling
Condenser fan dampers
Condenser split circuits

EVAPORATOR COILS
Basic designs and operating characteristics
Selection basics
Types of defrosts components and controls
Condensate drains and traps

REFRIGERANT METERING DEVICES - VARIABLE
Metering devices - types and operation, with check valves, bi-directional
Role of distributors in variable metering devices
Externally equalized
Thermostatic charges
Off cycle pressure equalization
Selection of TEV's - Superheat setting, charge
Electric & electronic valves

REFRIGERANT METERING DEVICES - FIXED
Basics of operation - capillary tubes
Basics of operation - expansion valves
Orifice
Role of distributor in metering device performance
Adjustments for required superheat

ELECTRICAL COMPONENTS
Fuses and breakers
Capacitors
Solenoids
Crankcase heaters
Drain line heaters
Transformers
Fan cycling controls
Time delays
Phase loss monitors
Contactors & relays
Current sensing relay
Defrost heaters (drain pan and coil)
Fan delays
Defrost terminators
Defrost time clocks
Damper actuators
Compressor modules
Demand cooling modules
Auxiliary contacts
Room temperature thermostat
Heater limit switches
Pumpdown switches
Thermal overloads
Discharge line thermostat
Electric disconnects
Electronic system controller

FANS
Introduction to indoor fans
Introduction to outdoor fans
Indoor fans - types and selection
Outdoor fans - types and selection
Fan performance
Cycling methods
Basic control characteristics

AIR SIDE COMPONENTS
Dampers & baffles
Fan filters
Fan Guards (wire & plastic)
Fabric duct
Air stack

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

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

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 SPACE THERMOSTATS
Basic thermostat types and operation
Thermostat terminals and wiring
Using electromechanical space thermostats
Selecting space thermostats

ELECTROMECHANICAL TEMPERATURE CONTROLS
Introduction to bimetal controls
Disc type temperature limit controls
Introduction to vapor charged controls
Overview of electric heater high limit controls
Motor overloads
Fuses and fuse links
Fan delay control
Defrost termination control

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

REFRIGERANT CIRCUIT CONTROLS
PRESSURE CONTROLS
- High pressure controls
- Low pressure controls
- Oil failure safety controls
- Head pressure control
- Fan cycling
- Loss of charge
- Dual pressure controls 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
DEFROST TIME CLOCKS
- Introduction to defrost timers
- Basic wiring for off-cycle operation
- Basic wiring for electric/hot gas defrosting
- Basic wiring for reverse cycle air defrost operation
- Basic wiring for water defrost operation
- Basic settings
ELECTRONIC CONTROLS
ELECTRONIC THERMOSTATS
- Fundamentals of electronic thermostats
- Selecting electronic thermostats
- Overview of electronic thermostat operation
ELECTRONIC COMPRESSOR CONTROLS
- Solid-state pressure transducer
- Compressor staging controls
- Compressor time delays
ELECTRONIC DEFROST TIMERS
- Introduction to defrost timers
- Basic wiring for off-cycle operation
- Basic wiring for electric/hot gas defrosting
- Basic settings
OVERVIEW OF ELECTRONIC CONTROLLERS
- Communication
- Input / output operations
- Logic
ELECTRONIC PRESSURE CONTROLS
- High pressure controls
- Low pressure controls
- Dual pressure controls
- Fan cycling controls
- Differential controls
- Modulating controls
REGULATIONS/ CODES/ & DESIGN
EPA REGULATIONS
EPA EMISSIONS
- Fresh air supplies
EPA REFRIGERANT REGULATIONS
- Applicable leakage rates
ELECTRICAL CODE
REQUIREMENTS
- Local inspectors
- Overview of NEC code
- Circuit breaker and fuse requirements
- General wiring practices
- Class I wire sizing
- Class II wire sizing
Conduit sizing
Definitions

REGULATIONS AND CODES
STATE AND LOCAL REGULATIONS
State requirements for technicians

CODES
Plumbing
Municipalities
Emissions or reliefs
Health and sanitation
Fire (NEC, UL, local)

FIRE PROTECTION REGULATIONS AND CODES
REQUIRED COMPONENTS
Return air sensors
Fire dampers

FIRE PREVENTION
Overview

DESIGN CONSIDERATIONS - GENERAL

TEMPERATURE
Designing for capacity
Using ASHRAE standards

HUMIDITY
Using the evaporator TD to control humidity
Role of humidity in quality of products
Using ASHRAE standards

SOUND LEVEL
Equipment location considerations
Isolation, mounting pad, piping, and structure
Sound attenuation insulation techniques

REGIONAL REGULATIONS
Seismic constraints
Tornado or hurricane proof
Refrigerant relief / purge ventilation
Wiring protection
Wiring/power interlocks
Access safety measures

DESIGN CONSIDERATIONS - COMPONENTS

ACCESSORIES
Start components
Filter-driers - When to use? and How to select? (replaceable core vs. welded construction)
Flare vs. sweat connections
E.P.R. and C.P.R. valves
Room thermostat options
Accumulators - When to use? and How to select?
Defrost time clocks options
Time delays
Crankcase heaters
Low ambient controls
Oil separators
Heated & insulated receivers
Lock-out relays
Hold-out relays
Current sensing relays
Lead-lag options
Receivers
Head pressure controls
Capacity control options
Liquid-to-suction heat exchangers

DESIGN CONSIDERATIONS - COMMERCIAL

PACKAGED SYSTEMS
Package system configurations and design
Equipment locations design
Applications for packaged systems
Condensate drain piping design
Electrical layouts with packaged systems
Packaged equipment “drop in” applications
Packaged equipment “side mount” applications
Packaged equipment outdoor applications
Packaged equipment indoor applications
Regional considerations in packaged equipment
Specifications for packaged equipment

SPLIT SYSTEMS
System designs - pad / roof mounting
Refrigerant piping
Equipment location
Electrical layouts
Accumulators
Condensate drains and traps
Defrost options
Regional design considerations
Oil separators
Secondary condensate drains / pans
Mounting of equipment
Piping insulation
Specifying equipment

REMOTE SYSTEMS
System designs - basement, attic, etc.
Refrigerant piping
Equipment location
Electrical layouts
Accumulators
Condensate drains and traps
Defrost options
Regional design considerations
Oil separators
Secondary condensate drains / pans
Mounting of equipment
Piping insulation
Specifying equipment
Fresh/supply air consideration for condenser

MECHANICAL CODE
EQUIPMENT ACCESS
Minimum clearance
Electrical disconnects

REFRIGERANT LINE ROUTING
Support requirements
Inspection requirements
Sloping
Trapping

CONDENSATE DRAINS
Materials
Sizing
Sloping
Trapping

INDUSTRY STANDARDS

EQUIPMENT STANDARDS
Introduction to industry standards
ARI standards for ratings

SYSTEM STANDARDS
Introduction to industry standards
ASHRAE standards

BIDS AND PROPOSALS

SYSTEM SIZING
  Survey of requirements
  Selecting equipment
  Sizing components - high / low side
  Adding accessories

ESTIMATING INSTALLATION
  Design/build
  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 or trapping
  Effects of fittings, pressure drop, and insulation on system performance
  Understanding special system designs

CONDENSATE LINES
  Effects of improper trapping
  Effects of improper heating & insulating

ELECTRICAL
  Effects of electrical power on system devices
  Electrical analysis - power
\[
\frac{CFM_n}{CFM_o} = \frac{RPM_n}{RPM_o} \quad o = \text{old}, n = \text{new} \\
\text{CFM and RPM are interchangeable.}
\]

\[
\left(\frac{CFM_n}{CFM_o}\right)^2 = \frac{Sp_n}{Sp_o} \quad \text{OR} \quad CFM_n = CFM_o \times \sqrt{\frac{Sp_n}{Sp_o}}
\]

\[
\left(\frac{CFM_n}{CFM_o}\right)^3 = \frac{BHP_n}{BHP_o} \quad \text{OR} \quad CFM_n = CFM_o \times \sqrt[3]{\frac{BHP_n}{BHP_o}}
\]

\[
\text{Hydronics:} \quad AP = \text{Sp, CFM} = \text{GPM, RPM} = \text{GPM}
\]

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

\[
0 = \text{Outside} \\
T = \text{Temperature} \\
R = \text{Return} \\
M = \text{Mixed} \\
A = \text{Air}
\]

\[
Btu = \text{hydronic (H2O only)} = 500 \times \text{GPM} \times AT
\]

\[
Btu = \text{sensible (at sea level)} = 1.08 \times \text{CFM} \times AT
\]

\[
Btu = \text{latent (at sea level)} = 0.68 \times \text{CFM} \times AGrains
\]

\[
Btu = \text{total (at sea level)} = 4.5 \times \text{CFM} \times AEnthalpy
\]

\[
\text{AC/Hr} \times \text{Volume}
\]

\[
CFM = \frac{\text{Volume}}{60 \text{min}}
\]

\[
v = 4005 \times Jvp
\]

\[
Vp = <4:05 \mu
\]

Pressure (PSI) = 0.433 x 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 = \(1t \times \text{radius}^2\)

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

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

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

FR = TEL (IWq100)

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

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

\[
\text{Cr (Series)} = \frac{1}{C1 + C2 + \ldots + C_n}
\]

\[
\text{C_r (Parallel)} = C_1 + C_2 + \ldots + C_n
\]
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).

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