

Certification Information

Scope - Tests a candidate's knowledge of the installation, service, maintenance, and repair of Commercial Refrigeration systems. System sizes are limited to 7.5 Horsepower to 80 Horsepower.

Qualifications

- Y This is a test and certification for **TECHNICIANS** in the Refrigeration industry. The test is designed for the top level service technician. This test for certification is not intended for the Refrigeration system designer, sales force, or the engineering community. To become NATE-certified, you must pass this specialty and a CORE SERVICE exam.
- Y This test will measure what 80% of the **Refrigeration Service** candidates have an 80% likelihood of encountering at least once during the year on a **NATIONAL** basis.
- Y Suggested experience is two years of field experience working on Refrigeration 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 below are the percentages of questions that will be in each section of the **Commercial Refrigeration Service** exam.

SECTION AREA DESCRIPTION	SECTION PERCENTAGE
Installation	20%
Service	55%
Components	20%
Applied Knowledge	5%

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
- ASHRAE Standard-62.1-Latest Edition with Addendum
- ANSI/ASHRAE Standard-152-2004-Latest Edition with Addendum
- 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 Energy Conservation Code-Latest Edition with Addendum
- 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
- NFPA 70-National Electrical 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 valves
- 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
- Jump 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 compressor 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

RETROFITTING

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
- Contactors 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

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

RECIPROCATING 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 tem 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

$$\frac{CFM_n}{CFM_o} = \frac{RPM_n}{RPM_o}$$

o = old, *n* = new
CFM and RPM are interchangeable.

$$CFM_n = CFM_o \times \frac{RPM_n}{RPM_o}$$

$$RPM_n = RPM_o \times \frac{CFM_n}{CFM_o}$$

$$\left(\frac{CFM_n}{CFM_o}\right)^2 = \frac{SP_n}{SP_o} \quad \text{OR} \quad \frac{CFM_n}{CFM_o} = \sqrt{\frac{SP_n}{SP_o}}$$

$$CFM_n = CFM_o \times \sqrt{\frac{SP_n}{SP_o}}$$

$$SP_n = SP_o \times \left(\frac{CFM_n}{CFM_o}\right)^2$$

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

$$CFM_n = CFM_o \times \sqrt[3]{\frac{BHP_n}{BHP_o}}$$

$$BHP_n = BHP_o \times \left(\frac{CFM_n}{CFM_o}\right)^3$$

Hydronics: AP = SP, CFM = GPM, RPM = GPM

$$MAT = (OAT \times \%OA) + (RAT \times \%RA)$$

O = Outside
T = Temperature
R = Return
M = Mixed
A = Air

$$Btuh \text{ hydronic (H}_2\text{O only)} = 500 \times GPM \times AT$$

$$Btuh \text{ sensible (at sea level)} = 1.08 \times CFM \times AT$$

$$Btuh \text{ latent (at sea level)} = 0.68 \times CFM \times AGrains$$

$$Btuh \text{ total (at sea level)} = 4.5 \times CFM \times AEnthalpy$$

$$CFM = \frac{AC/Hr \times Volume}{60min}$$

$$V = 4005 \times .Jvp$$

$$Vp = <4.05 \rangle 2$$

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

$$1 IWC = 0.0360 PSI$$

$$1 PSI = 27.72 IWC$$

$$Pressure 1 \times Volume 1 = Pressure 2 \times Volume 2$$

$$Area = 1t \times radius^2$$

$$A^2 + B^2 = C$$

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

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

$$Round \text{ Duct Area (ft}^2\text{)} = \frac{1t \times diameter}{576}$$

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

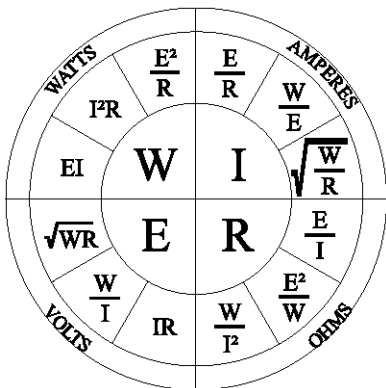
$$FR = \frac{ASP \times 100}{TEL} \quad (IWq100)$$

$$CFM = Velocity (fpm) \times Duct Area (ft^2)$$

$$CFM = \frac{(Watts \times 3.413)}{AT \times 1.08}$$

$$Cr \text{ (Series)} = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \dots + \frac{1}{CN}}$$

$$Cr \text{ (Parallel)} = C1 + C2 + \dots + CN$$



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	<i>14.8</i>	4.3	4.6	10.7	2.3	5.4
-38	-38.9	1.4	<i>13.9</i>	5.3	3.2	12.0	0.8	6.4
-36	-37.8	2.2	<i>13.0</i>	6.3	1.6	13.4	0.4	7.5
-34	-36.7	3.1	<i>12.0</i>	7.4	0.0	14.8	1.2	8.6
-32	-35.6	4.0	<i>10.9</i>	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

CONTINUED

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	OC	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	109.2	101.7	148.1	96.1	112.0
54	12.2	90.8	50.0	113.3	105.6	153.5	99.8	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	130.5	122.3	176.3	115.4	133.7
64	17.8	109.3	62.7	135.0	126.7	182.4	119.5	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	159.4	150.3	214.8	141.7	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	165.8	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	186.7	176.8	251.2	166.5	191.0
86	30.0	158.2	97.0	192.5	182.4	258.9	171.8	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	217.0	206.3	291.6	194.1	222.0
96	35.6	184.6	115.9	223.4	212.5	300.3	200.0	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	257.8	245.9	346.2	231.3	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	267.6	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	295.8	282.8	397.0	265.8	302.4
118	47.8	253.0	166.0	303.8	290.6	407.8	273.2	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