Certification Information

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

Qualifications

- 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. Once certification is obtained it lasts for five years.
- 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.
- 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 Light Commercial Refrigeration Service exam.

<table>
<thead>
<tr>
<th>SECTION AREA DESCRIPTION</th>
<th>SECTION PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>20%</td>
</tr>
<tr>
<td>Service</td>
<td>50%</td>
</tr>
<tr>
<td>Components</td>
<td>20%</td>
</tr>
<tr>
<td>Applied Knowledge</td>
<td>10%</td>
</tr>
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Light 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.

Exam Copyrights

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Suggested Retail Price: $240
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
Installing heat tape on drain lines
Drain line heaters when required

BENDING COPPER TUBING
Making a proper bend with gear benders
Making a proper bend with cam type benders
Making a proper bend with spring 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 OUTDOOR CONDENSING UNIT

Locating unit for proper placement
Preparing site
Lifting and placing unit(s)
Wiring outdoor unit to power source
Wiring outdoor unit to evaporator unit(s)
Mount and pipe outdoor accessories
Installing refrigerant lines & supports
Understanding local codes (seismic/hurricane/etc.)
Sealing penetrations through building structure

INSTALLING AND CONNECTING AIR COOLED CONDENSING UNIT

Locating unit for proper placement
Preparing site
Lifting and placing unit(s)
Wiring outdoor unit to power source
Wiring outdoor unit to evaporator unit(s)
Mount and pipe outdoor accessories
Installing refrigerant lines & supports
Understanding local codes (seismic/hurricane/etc.)
Sealing penetrations through building structure

INSTALLING INDOOR CONDENSING UNIT

Locating condensing/compressor unit for proper placement
Locating condenser unit for proper placement with remotes
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 for remote unit
Wiring unit to evaporator unit(s)
Mount and pipe all high side accessories
Installing refrigerant lines & supports
Understanding local codes (seismic/hurricane/etc.)
Sealing penetrations through building structure
Understanding the importance of proper ventilation
CFM requirements for air cooled units

INSTALLING 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
TEV’s external equalizer line location

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

INSTALLING COMPONENTS & ACCESSORIES
INSTALLING REFRIGERANT METERING DEVICE (TEV)
Purpose
Locating, mounting, and placement
Installing distributor nozzle and selecting
Protecting from overheating
Brazing to distributor
Connecting to liquid refrigerant line
Insulating refrigerant lines
Selection based on capacity, refrigerant, and application

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 liquid 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

INSTALLING OIL SEPARATORS
Purpose
Locating, mounting, and placement
Connect refrigerant lines and supports
Insulating refrigerant lines

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 LIQUID INJECTION SOLENOID
Purpose
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 & adjusting

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)
Locating, mounting, and placement of fan delay
Wiring with and without fan contactor(s)
Wiring with and without heater contactor(s)
Settings for air defrost / off cycle defrost operation
Settings for electric defrost operation
Settings for hot gas defrost 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 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
Check condenser air flow for recirculation and to and from other condensers

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
How to properly remove gauges from system
Types and styles of gauge sets
Using the gauge set for diagnostics
Low loss fitting connections
Gauge calibration and maintenance

EVACUATION TOOLS
Vacuum pump
Matching the vacuum pump capacity to the system size
Vacuum pump maintenance
Micron gauge
Valve opening tools - core removers/ etc.
Gauge calibration and maintenance

CHARGING TOOLS
Charging scales
Scale 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
- Control checks and adjustments
- 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 condenser split
- Using condenser TD
- Using evaporator split (or evaporator TD)
- Check distributor feeds
- 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
Phase loss monitors
Discharge line thermostats
Oil pressure safety switches
Drain line heaters
Defrost termination controls
Evaporator fan motor fan delays
Low pressure switch time delays
Fan cycling controls

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.
Thermostatic Expansion valves (TEVs)

REPLACEMENTS
Condenser / condensing units
Compressors
Condenser fans (motors, blades, and mounts)
Condenser coils
Evaporator fans (motors/blades/mounts)
Evaporator coils
Evaporator defrost heaters
 Thermostatic Expansion valves (TEVs)/ automatic expansion valves (AXVs) or capillary tubes
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
Thermostatic Expansion Valves (TEV’s)
Acid test
Oil changing procedures
Changing compressor start components
Oil test
Cleanup filters - suction
Cleanup driers - acid and moisture
Suction accumulator – change or clean out
Capillary tube cleaning and replacement

COMPONENT CHECKS - REFRIGERATION
Compressor
Metering devices
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
AXV’s
Capillary tubes
Suction pressure
Discharge pressure

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
Current relay
Potential relay
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 TEV, nozzle, and drier selections
Modifying unit placement and any piping/electrical changes
Match evaporators to condensing unit and application

BASIC REFRIGERATION SYSTEM ANALYSIS

COMPLETION OF APPROPRIATE FORMS
Troubleshooting without gauges
Start up form
System diagrams
Understanding readings from forms
Analyzing system performance
Instrument list, including calibration dates

NOISE PROBLEMS
Interpreting supply / return air volume
Interpreting supply / return air velocity
Noise problems
Motor / belt noise
Vibration
TEV chattering / 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 AND THE BASIC COOLING CYCLE**
Heat transfer and cooling
Basic refrigeration circuit
Dynamic analysis of temperatures and pressure in the refrigerant circuit
Understanding seasonal effects
Cascade system
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

**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

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

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

ROTARY COMPRESSORS
Fundamentals of rotary compressors
Rotary compressor components
Design considerations of rotary compressors advanced features

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
Operation fundamentals - receivers & reliefs
Operation fundamentals - accumulators
Operation fundamentals - filter-driers
Operation fundamentals - sight glasses, moisture indicators, liquid indicators, etc.
Operation fundamentals - mufflers / muffler plates
Operation fundamentals - oil safety controls
Operation fundamentals - head pressure controls
Operation fundamentals - oil separators
Operation fundamentals - EPR, CPR
Operation fundamentals of flow control valves - heat reclaim, etc
Operation fundamentals - condenser fan cycling
Operation fundamentals - condenser fan dampers
Operation fundamentals - condenser split circuits

EVAPORATOR COILS
Basic designs and operating characteristics
Selection basics
Types of defrosts components and controls (air/ elec/ hot gas/ water/ glycol)
Condensate drains and traps

REFRIGERANT 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 - Superheat setting, charge
Electric & electronic valves

REFRIGERANT METERING DEVICES - FIXED
Basics of operation - capillary tubes
AEV high side/low side float
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 and potential relays
Defrost heaters (drain pan and coil)
Fan delays
Defrost terminators
Defrost time clocks
Auxiliary contacts
Room temperature thermostat
Heater limit switches
Pumpdown switches
Thermal overloads
Discharge line thermostat
Electric disconnects

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
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

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

ELECTROMECHANICAL SENSING CONTROLS

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

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 DEFROST TIMERS
- Introduction to defrost timers
- Basic wiring for off-cycle operation
- Basic wiring for electric/hot gas defrosting
- Basic settings

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
- Wiring and the NEC
- 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
Receivers
Head pressure controls
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
CONDENSATE LINES
    Effects of improper trapping
    Effects of improper heating & insulating
ELECTRICAL
    Effects of electrical power on system devices
    Electrical analysis - power
\[
\frac{\text{CFM}_n}{\text{CFM}_0} = \frac{\text{RPM}_n}{\text{RPM}_0}
\]
\(o = \text{old}, n = \text{new}\)

CFM and RPM are interchangeable.

\[
\left(\frac{\text{CFM}_n}{\text{CFM}_0}\right)^2 = \frac{\text{Sp}_n}{\text{Sp}_0}
\]
\[
\text{CFM}_n = \text{CFM}_0 \times \frac{\text{RPM}_n}{\text{RPM}_0}
\]
\[
\text{RPM}_n = \text{RPM}_0 \times \left(\frac{\text{CFM}_n}{\text{CFM}_0}\right)^2
\]

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

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

\[
Btu\text{h hydronic (H}_2\text{O only)} = 500 \times \text{GPM} \times \Delta T
\]

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

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

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

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

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

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

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

1 IWC = 0.0360 PSI
1 PSI = 27.72 IWC

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

\[
\text{Area} = \pi \times \text{radius}^2
\]

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

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

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

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

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

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

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

\[
\text{CFM} = \frac{(\text{Watts} \times 3.413)}{(\Delta T \times 1.08)}
\]

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

\[
C_T \text{ (Parallel)} = C_1 + C_2 + \ldots + C_n
\]
# Temperature Pressure Chart

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

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

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

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<th>134a</th>
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<th>404A</th>
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CONTINUED
Pressure (PSIG), Vacuum (in. Of Hg) – Bold Italic Figures
To determine subcooling for 404A, 407C, and 422D, use BUBBLE POINT values (temperatures above 50°F – gray background)
To determine superheat for 404A, 407C, and 422D, use DEW POINT values (temperatures 50°F and below)

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