

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

- 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 **Light Commercial Refrigeration Service** exam.

SECTION AREA DESCRIPTION	SECTION PERCENTAGE
Installation	20%
Service	50%
Components	20%
Applied Knowledge	10%

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
- 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.

Exam Copyrights

All testing documents and questions are the copyrighted property of North American Technician Excellence Inc.-NATE. It is forbidden under federal copyright law to copy, reproduce, record, distribute or display these documents or questions by any means, in whole or part, without written permission from NATE. Doing so may subject you to severe civil and/or criminal penalties, including imprisonment and/or fines for criminal violations.

Light Commercial Refrigeration

Service

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

INSTALLING & 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

INSTALLING AND CONNECTING 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

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
- 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
- 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 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 contractor(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
- 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 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

RECIPROCATING 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

High temp breakdown

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

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

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

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

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

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

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

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

$$V = 4005 \times .Jvp$$

$$Vp = <4.05 \rangle 2$$

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

$$1 IWC = 0.0360 PSI$$

$$1 PSI = 27.72 IWC$$

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

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

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

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

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

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

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

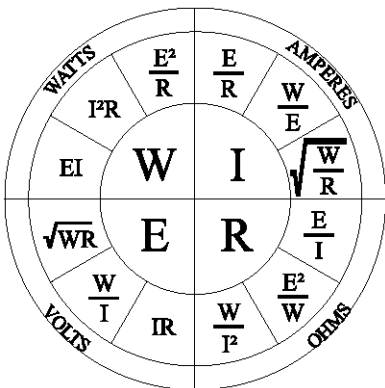
$$FR = \frac{ASP \times 100}{TEL} \quad (IWq100)$$

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

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

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

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



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