**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**

- This is a test and certification for **TECHNICIANS** in the Refrigeration industry. The test is designed for the top level installation 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 INSTALL** exam. Once certification is obtained it lasts for five years.
- This test will measure what 80% of the **Refrigeration Installation** candidates have an 80% likelihood of encountering at least once during the year on a **NATIONAL** basis.
- Suggested experience is one year of field experience working on Refrigeration Systems as an installation technician and technical training for theoretical knowledge.

**Test Specifications**

<table>
<thead>
<tr>
<th>Closed Book</th>
<th>2.5 Hour Time Limit</th>
<th>100 Questions</th>
<th>Passing Score: PASS/FAIL</th>
</tr>
</thead>
</table>

Listed below are the percentages of questions that will be in each section of the **Commercial Refrigeration Installation** exam.

<table>
<thead>
<tr>
<th>SECTION AREA DESCRIPTION</th>
<th>SECTION PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>60%</td>
</tr>
<tr>
<td>Service</td>
<td>10%</td>
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<tr>
<td>Components</td>
<td>25%</td>
</tr>
<tr>
<td>Applied Knowledge</td>
<td>5%</td>
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</tbody>
</table>

**Commercial Refrigeration Industry References**

The reference materials listed below will be helpful in preparing for this exam. These materials may **NOT** contain all of the information necessary to be competent in this specialty or to pass the exam.

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

**Passing Score Development Process**

The passing scores for the NATE tests were established using a systematic procedure (a Passing Score Study). This procedure employed the judgment of experienced HVAC professionals and educators representing various HVAC specialties and geographical areas. The passing scores were set using criteria defining competent performance. The passing score for different test forms may vary slightly due to the comparative difficulty of the test questions.

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Commercial Refrigeration
Installation

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

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 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
- 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
- Connecting refrigerant liquid 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
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 and control 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 (adjustable and non-adjustable)
Wiring with and without fan contactor(s)
Wiring with and without heater contractor(s)
Settings for air defrost / off cycle defrost operation
Settings for electric defrost operation
Settings for hot gas defrost operation

INSTALLING REMOTE CONDENSERS

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

INSTALLING EVAPORATIVE CONDENSERS

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

INSTALLING COOLING TOWERS

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

FIELD WIRING

WIRING UNITS & CONTROL WIRING

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

START-UP AND CHECKOUT

PRE-START PROCEDURES

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

START-UP PROCEDURES AND CHECKS

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

AIRFLOW PRESSURE MEASUREMENTS
- Static pressure
- Air pressure measurement terminology
- Velocity pressure
- Total pressure

AIR VOLUME MEASUREMENTS
- Formulae for determining CFM of air
- Airflow volume - CFM / SCFM (Static CFM)

SERVICE
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

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)
  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

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)

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
- Flow control valves – pressure control/ heat reclaim etc
- AXV’s
- Capillary tubes
- Suction pressure
- Discharge pressure

PARALLEL PIPE REFRIGERATION
- 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

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

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
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

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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

RECIROCATING 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

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

REFRIGERANTS
P/E chart
Refrigerants used in commercial refrigeration
Properties of refrigerants used in 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 - condenser fan cycling
Operation fundamentals - condenser fan dampers
Operation fundamentals - condenser split circuits

EVAPORATOR COILS
Basic designs and operating characteristics
Selection basics
Types of defrost components and controls
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
- 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
- Damper actuators
- Compressor modules
- Demand cooling modules
- Auxiliary contacts
- Room temperature thermostat
- Heater limit switches
- Pumpdown switches
- Thermal overload switches
- Discharge line thermostat
- Electric disconnects
- Electronic system controller

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

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

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

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

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

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**

**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

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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
\[
\frac{CFM_n}{CFM_o} = \frac{RPM_n}{RPM_o} \quad o = \text{old, } n = \text{new}
\]

CFM and RPM are interchangeable.

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

\[
CFM_n = CFM_o \times \frac{RPM_n}{RPM_o} \quad \text{RPM}_n = \text{RPM}_o \times \left(\frac{CFM_n}{CFM_o}\right)^2
\]

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

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

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

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

\[
\begin{align*}
\text{Btuhr hydronic (H}_2\text{O only)} &= 500 \times \text{GPM} \times \Delta T \\
\text{Btuhr sensible (at sea level)} &= 1.08 \times \text{CFM} \times \Delta T \\
\text{Btuhr latent (at sea level)} &= 0.68 \times \text{CFM} \times \Delta \text{Grains} \\
\text{Btuhr total (at sea level)} &= 4.5 \times \text{CFM} \times \Delta \text{Enthalpy}
\end{align*}
\]

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

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

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

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

\[
1 \text{ IWC} = 0.0360 \text{ PSI} \\
1 \text{ PSI} = 27.72 \text{ IWC}
\]

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

\[
\begin{align*}
\text{Area} &= \pi \times \text{radius}^2 \\
A^2 + B^2 &= C^2 \\
\text{Diameter} &= \frac{\text{Circumference}}{\pi}
\end{align*}
\]

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

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

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

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

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

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

\[
C_T \text{ (Parallel)} = C_1 + C_2 + \ldots + C_n
\]
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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Temperature Pressure Chart – at sea level

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)
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Note: Temperatures and pressures are approximate and should be verified using specific equipment and conditions.