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

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>
</tbody>
</table>

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

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 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 REFREIGERATION 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. wielded 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
\[
\frac{CFM_n}{CFM_o} = \frac{RPM_n}{RPM_o}
\]
\[o = \text{old}, n = \text{new}\]
CFM and RPM are interchangeable.

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

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

Hydronics: \(AP = Sp, \ CFM = \text{GPM}, \ RPM = \text{GPM}\)

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

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

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

\[v = 4005 \times .Jvp \quad \quad \quad Vp = <4:05> \]

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

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

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

\[\text{Area} = 1t \times \text{radius}^2\]

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

\[\text{Circumference} = \pi t\]

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

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

\[\text{FR} = \text{TEL} \quad (\text{IWq}100)\]

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

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

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

\[
\text{Cr (Parallel)} = C1 + C2 + \ldots + Cn
\]
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)

<table>
<thead>
<tr>
<th>TEMP, 0C</th>
<th>0C</th>
<th>22</th>
<th>134a</th>
<th>404A</th>
<th>407C</th>
<th>410A</th>
<th>4220</th>
<th>507</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40</td>
<td>1.6</td>
<td>14.8</td>
<td>4.3</td>
<td>4.6</td>
<td>10.7</td>
<td>2.3</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>-38</td>
<td>1.4</td>
<td>13.9</td>
<td>5.3</td>
<td>3.2</td>
<td>12.0</td>
<td>0.8</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>-36</td>
<td>2.2</td>
<td>13.0</td>
<td>6.3</td>
<td>1.6</td>
<td>13.4</td>
<td>0.4</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>-34</td>
<td>3.1</td>
<td>12.0</td>
<td>7.4</td>
<td>0.0</td>
<td>14.8</td>
<td>1.2</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>-32</td>
<td>4.0</td>
<td>10.9</td>
<td>8.5</td>
<td>0.8</td>
<td>16.2</td>
<td>2.1</td>
<td>9.8</td>
<td></td>
</tr>
<tr>
<td>-30</td>
<td>4.9</td>
<td>9.8</td>
<td>9.6</td>
<td>1.6</td>
<td>17.8</td>
<td>3.0</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td>-28</td>
<td>5.9</td>
<td>8.7</td>
<td>10.8</td>
<td>2.5</td>
<td>19.3</td>
<td>3.9</td>
<td>12.2</td>
<td></td>
</tr>
<tr>
<td>-26</td>
<td>6.9</td>
<td>7.5</td>
<td>12.0</td>
<td>3.5</td>
<td>21.0</td>
<td>4.9</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>-24</td>
<td>8.0</td>
<td>6.3</td>
<td>13.3</td>
<td>4.4</td>
<td>22.7</td>
<td>5.9</td>
<td>14.8</td>
<td></td>
</tr>
<tr>
<td>-22</td>
<td>9.0</td>
<td>5.0</td>
<td>14.6</td>
<td>5.4</td>
<td>24.4</td>
<td>7.2</td>
<td>16.2</td>
<td></td>
</tr>
<tr>
<td>-20</td>
<td>10.2</td>
<td>3.7</td>
<td>16.0</td>
<td>6.5</td>
<td>26.3</td>
<td>8.1</td>
<td>17.6</td>
<td></td>
</tr>
<tr>
<td>-18</td>
<td>11.4</td>
<td>2.3</td>
<td>17.4</td>
<td>7.6</td>
<td>28.1</td>
<td>9.2</td>
<td>19.1</td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>12.6</td>
<td>0.8</td>
<td>18.9</td>
<td>8.7</td>
<td>30.1</td>
<td>10.4</td>
<td>20.6</td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>13.9</td>
<td>0.4</td>
<td>20.4</td>
<td>9.9</td>
<td>32.1</td>
<td>11.7</td>
<td>22.2</td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>15.2</td>
<td>1.1</td>
<td>22.0</td>
<td>11.1</td>
<td>34.2</td>
<td>12.9</td>
<td>23.8</td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>16.5</td>
<td>1.9</td>
<td>23.6</td>
<td>12.3</td>
<td>36.4</td>
<td>14.3</td>
<td>25.5</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>17.9</td>
<td>2.8</td>
<td>25.3</td>
<td>13.7</td>
<td>38.6</td>
<td>15.6</td>
<td>27.3</td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>19.4</td>
<td>3.6</td>
<td>27.0</td>
<td>15.0</td>
<td>40.9</td>
<td>17.1</td>
<td>29.1</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>20.9</td>
<td>4.6</td>
<td>28.8</td>
<td>16.4</td>
<td>43.3</td>
<td>18.5</td>
<td>30.9</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>22.4</td>
<td>5.5</td>
<td>30.7</td>
<td>17.9</td>
<td>45.8</td>
<td>20.1</td>
<td>32.8</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>24.0</td>
<td>6.5</td>
<td>32.6</td>
<td>19.4</td>
<td>48.3</td>
<td>21.6</td>
<td>34.8</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>24.9</td>
<td>7.0</td>
<td>33.6</td>
<td>20.2</td>
<td>49.6</td>
<td>22.5</td>
<td>35.8</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>25.7</td>
<td>7.5</td>
<td>34.6</td>
<td>21.0</td>
<td>51.0</td>
<td>23.3</td>
<td>36.9</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>26.5</td>
<td>8.0</td>
<td>35.6</td>
<td>21.8</td>
<td>52.3</td>
<td>24.1</td>
<td>37.9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>27.4</td>
<td>8.5</td>
<td>36.6</td>
<td>22.6</td>
<td>53.7</td>
<td>25.0</td>
<td>39.0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>28.3</td>
<td>9.1</td>
<td>37.7</td>
<td>23.5</td>
<td>55.0</td>
<td>25.8</td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>29.2</td>
<td>9.6</td>
<td>38.7</td>
<td>24.3</td>
<td>56.5</td>
<td>26.7</td>
<td>41.1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>30.1</td>
<td>10.2</td>
<td>39.8</td>
<td>25.2</td>
<td>57.9</td>
<td>27.6</td>
<td>42.2</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>31.0</td>
<td>10.8</td>
<td>40.9</td>
<td>26.1</td>
<td>59.3</td>
<td>28.5</td>
<td>43.4</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>31.9</td>
<td>11.3</td>
<td>42.0</td>
<td>27.0</td>
<td>60.8</td>
<td>29.5</td>
<td>44.5</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>32.8</td>
<td>11.9</td>
<td>43.1</td>
<td>27.9</td>
<td>62.3</td>
<td>30.4</td>
<td>45.7</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>33.8</td>
<td>12.5</td>
<td>44.3</td>
<td>28.8</td>
<td>63.8</td>
<td>31.3</td>
<td>46.8</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>34.8</td>
<td>13.1</td>
<td>45.4</td>
<td>29.8</td>
<td>65.4</td>
<td>32.3</td>
<td>48.0</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>35.8</td>
<td>13.8</td>
<td>46.6</td>
<td>30.7</td>
<td>66.9</td>
<td>33.3</td>
<td>49.3</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>36.8</td>
<td>14.4</td>
<td>47.8</td>
<td>31.7</td>
<td>68.5</td>
<td>34.3</td>
<td>50.5</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>37.8</td>
<td>15.0</td>
<td>49.0</td>
<td>32.7</td>
<td>70.1</td>
<td>35.3</td>
<td>51.7</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>38.8</td>
<td>15.7</td>
<td>50.2</td>
<td>33.7</td>
<td>71.7</td>
<td>36.4</td>
<td>53.0</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>39.9</td>
<td>16.4</td>
<td>51.5</td>
<td>34.7</td>
<td>73.4</td>
<td>37.4</td>
<td>54.3</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>40.9</td>
<td>17.0</td>
<td>52.7</td>
<td>35.7</td>
<td>75.1</td>
<td>38.5</td>
<td>55.6</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>42.0</td>
<td>17.7</td>
<td>54.0</td>
<td>36.8</td>
<td>76.8</td>
<td>39.6</td>
<td>56.9</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>43.1</td>
<td>18.4</td>
<td>55.3</td>
<td>37.9</td>
<td>78.5</td>
<td>40.7</td>
<td>58.2</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>44.2</td>
<td>19.1</td>
<td>56.6</td>
<td>39.0</td>
<td>80.3</td>
<td>41.8</td>
<td>59.6</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>45.3</td>
<td>19.9</td>
<td>58.0</td>
<td>40.1</td>
<td>82.0</td>
<td>42.9</td>
<td>61.0</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>46.5</td>
<td>20.6</td>
<td>59.3</td>
<td>41.2</td>
<td>83.8</td>
<td>44.1</td>
<td>62.4</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>47.6</td>
<td>21.3</td>
<td>60.7</td>
<td>42.3</td>
<td>85.7</td>
<td>45.2</td>
<td>63.8</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>48.8</td>
<td>22.1</td>
<td>62.1</td>
<td>43.5</td>
<td>87.5</td>
<td>46.4</td>
<td>65.2</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>50.0</td>
<td>22.9</td>
<td>63.5</td>
<td>44.7</td>
<td>89.4</td>
<td>47.6</td>
<td>66.7</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>51.2</td>
<td>23.7</td>
<td>64.9</td>
<td>45.9</td>
<td>91.3</td>
<td>48.8</td>
<td>68.2</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>52.4</td>
<td>24.5</td>
<td>66.4</td>
<td>47.1</td>
<td>93.2</td>
<td>50.1</td>
<td>69.7</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>53.7</td>
<td>25.3</td>
<td>67.8</td>
<td>48.3</td>
<td>95.2</td>
<td>51.3</td>
<td>71.2</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>55.0</td>
<td>26.1</td>
<td>69.3</td>
<td>49.6</td>
<td>97.2</td>
<td>52.6</td>
<td>72.7</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>56.2</td>
<td>26.9</td>
<td>70.8</td>
<td>50.8</td>
<td>99.2</td>
<td>53.9</td>
<td>74.3</td>
<td></td>
</tr>
</tbody>
</table>

CONTINUED
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)

<table>
<thead>
<tr>
<th>TEMP. °C</th>
<th>PRESSURE CHART-atsealevel</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0.0</td>
</tr>
<tr>
<td>33</td>
<td>0.6</td>
</tr>
<tr>
<td>34</td>
<td>1.1</td>
</tr>
<tr>
<td>35</td>
<td>1.7</td>
</tr>
<tr>
<td>36</td>
<td>2.2</td>
</tr>
<tr>
<td>37</td>
<td>2.8</td>
</tr>
<tr>
<td>38</td>
<td>3.3</td>
</tr>
<tr>
<td>39</td>
<td>3.9</td>
</tr>
<tr>
<td>40</td>
<td>4.4</td>
</tr>
<tr>
<td>42</td>
<td>5.6</td>
</tr>
<tr>
<td>44</td>
<td>6.7</td>
</tr>
<tr>
<td>46</td>
<td>7.8</td>
</tr>
<tr>
<td>48</td>
<td>8.9</td>
</tr>
<tr>
<td>50</td>
<td>10.0</td>
</tr>
<tr>
<td>52</td>
<td>11.1</td>
</tr>
<tr>
<td>54</td>
<td>12.2</td>
</tr>
<tr>
<td>56</td>
<td>13.3</td>
</tr>
<tr>
<td>58</td>
<td>14.4</td>
</tr>
<tr>
<td>60</td>
<td>15.6</td>
</tr>
<tr>
<td>62</td>
<td>16.7</td>
</tr>
<tr>
<td>64</td>
<td>17.8</td>
</tr>
<tr>
<td>66</td>
<td>18.9</td>
</tr>
<tr>
<td>68</td>
<td>20.0</td>
</tr>
<tr>
<td>70</td>
<td>21.1</td>
</tr>
<tr>
<td>72</td>
<td>22.2</td>
</tr>
<tr>
<td>74</td>
<td>23.3</td>
</tr>
<tr>
<td>76</td>
<td>24.4</td>
</tr>
<tr>
<td>78</td>
<td>25.6</td>
</tr>
<tr>
<td>80</td>
<td>26.7</td>
</tr>
<tr>
<td>82</td>
<td>27.8</td>
</tr>
<tr>
<td>84</td>
<td>28.9</td>
</tr>
<tr>
<td>86</td>
<td>30.0</td>
</tr>
<tr>
<td>88</td>
<td>31.1</td>
</tr>
<tr>
<td>90</td>
<td>32.2</td>
</tr>
<tr>
<td>92</td>
<td>33.3</td>
</tr>
<tr>
<td>94</td>
<td>34.4</td>
</tr>
<tr>
<td>96</td>
<td>35.6</td>
</tr>
<tr>
<td>98</td>
<td>36.7</td>
</tr>
<tr>
<td>100</td>
<td>37.8</td>
</tr>
<tr>
<td>102</td>
<td>38.9</td>
</tr>
<tr>
<td>104</td>
<td>40.0</td>
</tr>
<tr>
<td>106</td>
<td>41.1</td>
</tr>
<tr>
<td>108</td>
<td>42.2</td>
</tr>
<tr>
<td>110</td>
<td>43.3</td>
</tr>
<tr>
<td>112</td>
<td>44.4</td>
</tr>
<tr>
<td>114</td>
<td>45.6</td>
</tr>
<tr>
<td>116</td>
<td>46.7</td>
</tr>
<tr>
<td>118</td>
<td>47.8</td>
</tr>
<tr>
<td>120</td>
<td>48.9</td>
</tr>
<tr>
<td>122</td>
<td>49.9</td>
</tr>
<tr>
<td>124</td>
<td>50.0</td>
</tr>
<tr>
<td>126</td>
<td>51.7</td>
</tr>
<tr>
<td>128</td>
<td>52.8</td>
</tr>
<tr>
<td>130</td>
<td>53.9</td>
</tr>
</tbody>
</table>

Temperature at 0°F (0°C)