**Certification Information**

**Scope** - Tests a candidate's knowledge of the installation, service, maintenance, and repair of HVAC systems. System sizes are limited to 30 tons or less cooling capacity.

**Qualifications**

- This is a test and certification for TECHNICIANS in the HVAC industry. The test is designed for top level installation technicians. This test for certification is not intended for the HVAC 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 **Air Conditioning** candidates have an 80% likelihood of encountering at least once during the year on a NATIONAL basis.
- Suggested requirement is one year of field experience working on Air Conditioning 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 are the percentages of questions that will be in each section of the **Air Conditioning** exam.

<table>
<thead>
<tr>
<th>SECTION AREA DESCRIPTION</th>
<th>SECTION PERCENTAGE</th>
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</thead>
<tbody>
<tr>
<td>Installation</td>
<td>43%</td>
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<tr>
<td>Service</td>
<td>10%</td>
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<tr>
<td>System Components</td>
<td>27%</td>
</tr>
<tr>
<td>Applied Knowledge</td>
<td>20%</td>
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</tbody>
</table>

**Air Conditioning 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.

- American National Standards Institute (ANSI) / Air Conditioning Contractors of America (ACCA) Manuals - Latest Edition
  - “D”, “J”, “QI” - Quality Installation, and “S”
- ACCA Manuals “T” and “RS” - Latest Editions
- ACCA Residential Duct Diagnostics and Repair - Latest Edition
- AHRI-Hydronics Section-IBO/RAH Latest Edition
- International Mechanical Code - Latest Edition with Addendum
- International Plumbing Code - Latest Edition with Addendum
- Uniform Mechanical Code - Latest Edition with Addendum
- ENERGY STAR™ Home Sealing Standards - Latest Edition with Addendum
- Duct Calculators – Sheet Metal, Ductboard, and Flexible Duct
- American National Standards Institute (ANSI) / Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
  - HVAC Duct Construction Standards - Metal and Flexible
- Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
- Air Diffusion Council Flexible Duct Performance & Installation Standards
- North American Insulation Manufacturers Association (NAIMA) Manuals
  - Fibrous Glass Duct Construction Standards and A Guide to Insulated Air Duct Systems

**Passing Score Development Process**

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

**Exam Copyrights**

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INSTALLATION

FABRICATING COPPER TUBING

REFRIGERANT LINE INSTALLATION
Locating, mounting, and routing
Understanding limitations of length and diameter

BENDING COPPER TUBING
Making a proper bend with spring benders
Making a proper bend with cam type benders

COPPER TUBING PREPARATION
Cutting copper tubing
Reaming copper tubing
Cleaning copper tubing
Swaging copper tubing

BRAZING
Overview of brazing copper to copper
Oxyacetylene brazing
Using air / fuel to solder
Use of purging gas when brazing
Overview of brazing copper to brass
Overview of brazing copper to steel
Selection of brazing materials

FLARE FITTINGS
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 CONDENSING UNIT

INSTALLING AND CONNECTING CONDENSING UNIT
Locating unit
Preparing site
Placing unit
Wiring outdoor units
Installing refrigerant lines

INSTALLING PACKAGED UNITS

INSTALLING AND CONNECTING
Locating equipment
Preparing site
Lifting unit
Sealing unit
Wiring

INSTALLING INDOOR EQUIPMENT

INSTALLATION OF INDOOR AIR HANDLERS / FURNACES
Installing coil and air handler / furnace
Connecting ductwork
Connecting refrigerant lines
Connecting condensate lines
Wiring air handler / furnace
Wiring thermostats
Wiring electronic air cleaners
TEV’s - installation
Installing fixed metering devices
Bulb location selection for TEV’s
 Auxiliary heat
 Handling - lifting, hanging
 Trapping for condensate lines
 Service access and clearance considerations

 **EVACUATION & CHARGING**

 **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

 **LEAK CHECKING & DETECTION**
 Overview of leak checking and detection
 Leak checking with electronic leak detectors
 Leak checking with soap solutions
 Gas pressurization for leak checking
 Leak checking with ultrasonic leak detectors

 **CHARGING METHOD**
 Weigh in method
 Superheat method and where used
 Subcooling method and where used
 Charging blended refrigerants

 **DUCT INSTALLATION**

 **DUCT FABRICATION EQUIPMENT**
 Ductboard tools - 90 V-groove, end cutoff, female shiplap, hole cutter, stapler, etc.
 Flex tools - tensioning strap tools, knives, etc.
 Metal tools - metal snips, sheers, benders, breaks, hand formers, calipers, rulers, stapler, etc.

 **INSTALLING METAL DUCT**
 Assembly methods for rectangular duct
 Assembly methods for round duct
 Hanging ductwork
 Sealing metal duct
 Insulation - internal and external

 **INSTALLING FLEXIBLE DUCT**
 Assembly methods - appropriate length
 Hanging flexible duct
 Sealing flexible duct
 Installation technique

 **INSTALLING DUCTBOARD**
 Assembly methods for ductboard - supports
 Hanging methods for ductboard
 Sealing ductboard
 Installation technique

 **INSTALLING GRILLES, REGISTERS, DIFFUSERS, & DAMPER**
 Mounting to ductwork
 Securing methods
 Sealing methods

 **FIELD CONSTRUCTION / INSTALLATION**
 Techniques for joining dissimilar duct
 Duct of alternate materials - wood, aluminum, etc.

 **CHASES USED AS DUCTS**
 Floor joists as air ducts
 Vertical chases

 **INSTALLING ACCESSORIES**
INSTALLING THERMOSTATS
- Locating and mounting
- Wiring electromechanical thermostats
- Wiring electronic thermostats
- Setting anticipators when used
- Installing air side low ambient control
- Installing outdoor thermostat
- Setting balance point on outdoor thermostat

INSTALLING ELECTRONIC AIR CLEANERS
- Installing to a unit - sealing
- Wiring
- Controlling electronic air cleaners

INSTALLING ECONOMIZERS
- Installing
- Wiring
- Controlling economizers

FIELD WIRING
WIRING UNITS & CONTROL WIRING
- Connecting electrical power
- Connecting control circuits
- Meeting manufacturer sizing requirements - wire sizing (size and number)

START-UP AND CHECKOUT
PRE-START PROCEDURES
- Surveying installation - checking equipment match
- Inspect connections for tightness
- Set dip switches / jumpers on ECM motors
- Set speed taps on multi-speed motors
- Set adjustable pulleys on belt driven blowers
- Ensure clean filter is in place and accessible
- Ensure condensate line is flowing

START-UP PROCEDURES AND CHECKS
- Surveying installation
- Supply voltage checks
- Motor checks
- Checking sequences
- Check fan rotation
- Check scroll compressor rotation - high noise level, etc.
- Start-up checklist and preparation
- Metering device - refrigerant circuit checks
- Airflow checks
- Pressure checks
- Temperature checks - dry bulb, wet bulb, etc.

LEAK DETECTION TOOLS
- Soap solution
- Electronic leak detectors
- Ultrasonic leak detector
- Halide leak detector
- Use of dye leak detectors
- Pressurization for leak detection
- Meter calibration and maintenance

REFRIGERANT CIRCUIT TOOLS
MANIFOLD GAUGE SET
- Manifold gauge set
- How to read the gauge set
- How to connect the gauge set for different purposes
- Types and styles of gauge sets
- Using the gauge set for diagnostics
- Low loss fitting connections
- Gauge calibration and maintenance

EVACUATION TOOLS
Vacuum pump
Micron gauge
Valve opening tools - core removers, etc.
Gauge calibration and maintenance

CHARGING TOOLS
Charging scales
Gauge calibration and maintenance

RETROFITTING
EQUIPMENT COMPONENT RETROFITTING
Changing out an outdoor unit
Changing out an indoor unit
Modifying ductwork for replacement equipment

BASIC DUCT FABRICATION
FABRICATION TECHNIQUES FOR METAL DUCT
Seam types - pittsburgh and snap lock
Joint types - drive slips, reinforced drive slips, "s" slip, and standing "s" slip
Use of strength breaks in rectangular duct

FABRICATION TECHNIQUES FOR DUCTBOARD
Layout of duct fitting
Groove cutting - hand / machine
Use of joint tape

AIRFLOW MEASUREMENTS
INTRODUCTION TO AIRFLOW MEASUREMENTS
Introduction to airflow
Static pressure

AIRFLOW VELOCITY MEASUREMENTS
Introduction to airflow velocity
Velometer - electronic and mechanical
Anemometer
Velocity measurement procedures
Gauge calibration

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

AIRFLOW VOLUME MEASUREMENTS
Introduction to volume
Airflow hood
Formulae for determining CFM of air
Formulae for weight of air
Locations for air volume measurements

AIRFLOW CHECKS & DESIGN TOOLS
Using manufacturer's airflow charts and tables
Using a duct calculator and design charts

SERVICE
DIAGNOSTICS
PRELIMINARY SYSTEM DIAGNOSTICS
Outdoor unit checks
Indoor unit checks
Wiring checks
Refrigerant line checks
Thermostat checks
Condensate drain checks
Accessories

ELECTRICAL CHECKS
Supply voltage checks
Compressor circuits
Condenser fan circuits
Indoor blower circuits
Wall thermostat circuits
Transformer circuits
Electronic controllers - input / output

COMPONENT CHECKS - ELECTRICAL
Thermostat
Transformers
Overcurrent protection
Relays and contactors
Condenser fan motors
Indoor blower motors
Solenoid valves coils

REPAIR
Refrigerant circuit on coils
Ductwork
Electrical wiring

INTRODUCTION TO ELECTRICAL TROUBLESHOOTING

LOW VOLTAGE CIRCUITS
Voltage tests
Equipment continuity tests
Ground tests

LINE VOLTAGE CIRCUITS
Voltage tests
Equipment continuity tests
Ground tests

SYSTEM COMPONENTS

INTRODUCTION TO SYSTEMS

HEAT TRANSFER PRINCIPLES
Heat transfer - evaporations and condensation
Basic refrigeration circuit - 7 components
Temperature and pressure in the refrigerant circuit.

SPLIT SYSTEMS
Introduction to split system AC configurations and applications
Equipment locations and mounting
Duct designs for split systems air conditioners
Electrical layouts for split systems air conditioners
Refrigerant circuits for split systems air conditioners
Specifications for split system air conditioners
Attic / Crawlspace layouts for split systems air conditioners
Closet layouts for split systems air conditioners
Basement layouts for split systems air conditioners
Heat options with split system air conditioners
Ventilation options split systems air conditioners
Regional considerations in split system air conditioner designs
Special consideration of indoor coils above living space

PACKAGED SYSTEMS
Introduction to package AC configurations
Equipment locations for package air conditioners
Basic duct designs for packaged equipment
Electrical layouts with packaged air conditioners
Packaged equipment in single story applications
Packaged equipment in multi story applications
Packaged equipment applied with crawlspace duct designs
Heat options with packaged air conditioners
Ventilation options for packaged air conditioners
Economizer options
Regional considerations in packaged equipment
Specifications for packaged equipment
MULTI-CAPACITY SYSTEMS
   Overview of multi-capacity systems
   Sequencing of multi-capacity air conditioners
   Refrigerant circuits of multi-capacity air conditioners

DUCT SYSTEMS

DUCT SYSTEMS
   Duct system design
   Duct configurations - extended plenum, reducing extended plenum, perimeter radial, perimeter loop,
   overhead radial
   Return configurations - ducted, central, etc.
   Return grille locations - low sidewall, high sidewall, etc.
   Supply locations - floor, sidewall, ceiling, etc.

WIRING LAYOUTS

POWER Wiring
   Overview of power wiring

LOW VOLTAGE
   Overview of low voltage wiring

COMPONENTS

OUTDOOR COILS
   Types - basic designs
   Airflow characteristics

COMPRESSORS
   Fundamentals of compressor operations
   Compressor types

REFRIGERANTS
   Refrigerants used in Res./Lt. Com air conditioners
   Properties of refrigerants used in Res./Lt. Com air conditioners
   Using temperature-pressure chart
   Refrigerant conservation

SERVICE VALVES
   Front seating service valves
   Back seating service valves
   Gauge port

REFRIGERANT CIRCUIT ACCESSORIES
   Operation fundamentals - accumulators
   Operation fundamentals - filter-driers
   Operation fundamentals - sight glasses, moisture indicators, liquid indicators, etc.
   Operation fundamentals - mufflers

INDOOR COILS
   Types - basic designs and operating characteristics of A-coil, slab, and slant indoor coils
   Basics of selection
   Condensate drains

METERING DEVICES
   Types
   Selection

BLOWERS AND FANS
   Role of indoor blowers
   Role of outdoor fans
   Blower and fan performance

LINE SETS
   Introduction to line sets
   Application considerations when using line sets

AIR SIDE COMPONENTS
   Dampers
   Ventilation fittings
   Electronic air cleaners (EAC’s)
   Electrostatic filters - non-electric
   Media type filters
   Fixed outdoor air damper
   Economizers
Insulating material
Flexible connectors

GRILLES, REGISTERS, & DIFFUSERS
Types and uses

FASTENERS
Screws
Bolts
Nuts and washers
Lockpins
Rivets

ELECTRICAL COMPONENTS
Overcurrent protection
Capacitors
Solenoids
Crankcase heaters
Auxiliary strip heat
Transformers

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 WALL THERMOSTATS
Basic thermostat types and operation
Thermostat terminals and wiring
Using electromechanical thermostats

ELECTROMECHANICAL TEMPERATURE CONTROLS
Introduction to bimetal controls
Disc type temperature limit controls
Introduction to vapor charged controls
Overview of electric heat high limits
Motor overloads

PRESSURE CONTROLS
Introduction to disc type pressure controls and hi/low controls
Operation of disc type pressure controls

ELECTROMECHANICAL OUTDOOR THERMOSTATS
Overview of outdoor thermostats
Outdoor thermostat wiring
Low ambient cooling controls

REFRIGERANT CIRCUIT CONTROLS
PRESSURE CONTROLS
High pressure limit controls
Low pressure limit 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

ELECTRIC HEAT CONTROLS
Sequencers

ELECTRONIC CONTROLS

ELECTRONIC THERMOSTATS
Fundamentals of electronic thermostats
Overview of electronic thermostat operation

ZONE CONTROLS
Fundamentals of zone controls
Typical zone control logic

ELECTRONIC COMPRESSOR CONTROLS
Fundamentals of compressor controls
Operation of compressor controls

**ELECTRONIC TIMERS**
- Introduction to blower delay timers
- Introduction to compressor delay timers

**APPLIED KNOWLEDGE: REGS, CODES, & DESIGN**

**AIR QUALITY REGULATIONS**

**INDOOR AIR QUALITY**
- Fresh air supplies

**ELECTRICAL CODE**

**REQUIREMENTS**
- Overview of electrical code
- Circuit breaker and fuse requirements
- General wiring practices
- Class I wire sizing
- Class II wire sizing
- Conduit sizing
- Definitions

**STATE AND LOCAL REGULATIONS AND CODES**

**STATE AND LOCAL REGULATIONS**
- State requirements for technicians

**CODES**
- Plumbing
- Municipalities
- HVAC for Lt. Commercial

**FIRE PROTECTION REGULATIONS AND CODES**

**REQUIRED COMPONENTS**
- Return air sensors
- Fire dampers

**FIRE PREVENTION**
- Overview

**DESIGN CONSIDERATIONS - COMFORT**

**TEMPERATURE**
- Designing for capacity

**HUMIDITY**
- Role of humidity in comfort

**INDOOR AIR QUALITY**
- Ventilation - comfort
- Air cleaning for comfort
- Outside air

**SOUND LEVEL**
- Equipment location considerations
- Isolation, mounting pad, duct, and structure
- Duct systems

**DESIGN CONSIDERATIONS - EQUIPMENT**

**SPLIT SYSTEMS**
- System designs - closets, basements, etc.
- Refrigerant piping
- Equipment location
- Electrical layouts
- Duct design / balancing
- Condensate drains
- Ventilation - fresh air
- Regional design considerations
- Ventilation - equipment
- Secondary condensate drains / pans
- Mounting of equipment

**PACKAGED SYSTEMS**
- Package system configurations and design
- Equipment locations design

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Applications for packaged systems
Basic duct designs for packaged equipment
Condensate drain piping design
Electrical layouts with packaged air conditioners
Packaged equipment in single story applications
Packaged equipment in multi story applications
Packaged equipment in crawlspace applications
Heat options with packaged systems
Ventilation options
Regional considerations in packaged equipment

DESIGN CONSIDERATIONS - COMPONENTS

DIFFUSERS, REGISTERS, AND GRILLES
Selecting diffusers, grilles, and registers
Modifying locations

ACCESSORIES
Start components
Filter-driers - When to use? and How to select?
Filtering - EAC, media, HEPA, electrostatic

RECOVERY / RECYCLING MACHINES

RECOVERY MACHINES
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
Recovery machine maintenance and cylinder maintenance

MECHANICAL CODE

EQUIPMENT ACCESS
Minimum clearance
Electrical disconnects
Fire dampers

REFRIGERANT LINE ROUTING
Support requirements
Inspection requirements

CONDENSATE DRAINS
Materials
Sizing
\[ \frac{\text{CFM}_n}{\text{CFM}_o} = \frac{\text{RPM}_n}{\text{RPM}_o} \quad \text{o = old, } n = \text{new} \]

CFM and RPM are interchangeable.

\[ \left( \frac{\text{CFM}_n}{\text{CFM}_o} \right)^2 = \frac{\text{Sp}_n}{\text{Sp}_o} \quad \text{OR} \quad \frac{\text{CFM}_n}{\text{CFM}_o} = \sqrt{\frac{\text{Sp}_n}{\text{Sp}_o}} \]

\[ \text{CFM}_n = \text{CFM}_o \times \sqrt{\frac{\text{Sp}_n}{\text{Sp}_o}} \]

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

\[ \left( \frac{\text{CFM}_n}{\text{CFM}_o} \right)^3 = \frac{\text{BHP}_n}{\text{BHP}_o} \quad \text{OR} \quad \frac{\text{CFM}_n}{\text{CFM}_o} = \sqrt[3]{\frac{\text{BHP}_n}{\text{BHP}_o}} \]

\[ \text{CFM}_n = \text{CFM}_o \times \sqrt[3]{\frac{\text{BHP}_n}{\text{BHP}_o}} \]

\[ \text{BHP}_n = \text{BHP}_o \times \left( \frac{\text{CFM}_n}{\text{CFM}_o} \right)^3 \]

**Hydronics:**

\[ \Delta P = \text{Sp} \]

\[ \text{CFM} = \text{GPM}, \quad \text{RPM} = \text{GPM} \]

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

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

Btuhr hydronic (H₂O only) = 500 \times \text{GPM} \times \Delta T

Btuhr sensible (at sea level) = 1.08 \times \text{CFM} \times \Delta T

Btuhr latent (at sea level) = 0.68 \times \text{CFM} \times \Delta \text{Grains}

Btuhr total (at sea level) = 4.5 \times \text{CFM} \times \Delta \text{Enthalpy}

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

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

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

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

1 IWC = 0.0360 PSI

1 PSI = 27.72 IWC

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

**Area** = π \times radius²

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

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

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

**Rectangular Duct Area** (ft²) = \frac{\text{Length} \times \text{Width}}{144}

**Round Duct Area** (ft²) = \frac{\pi \times \text{diameter}²}{576}

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

\[ \text{CFM} = \text{Velocity (fpm)} \times \text{Duct Area (ft²)} \]

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

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

\[ C_T \text{ (Parallel)} = \frac{1}{C_1 + C_2 + \ldots + C_n} \]
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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<th>TEMP.</th>
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<th>°C</th>
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CONTINUED
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)
To determine superheat for 404A, 407C, and 422D, use DEW POINT values (temperatures 50°F and below)

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