Exam Information

Scope - Tests a candidate's general knowledge, construction knowledge, and HVACR specific knowledge in the areas of safety, tools, soft skills, heat transfer, comfort, and electrical.

Qualifications

This is a test for TECHNICIANS in the HVACR industry. The test is designed for top level service technicians. This test is a requirement for NATE certification.

Test Specifications

Closed Book 1.5 Hour Time Limit 50 Questions Passing Score: PASS/FAIL

<table>
<thead>
<tr>
<th>SECTION AREA DESCRIPTION</th>
<th>SECTION PERCENTAGE</th>
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<tr>
<td>Safety, Tools, &amp; Soft Skills</td>
<td>30%</td>
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<tr>
<td>Heat Transfer &amp; Comfort</td>
<td>20%</td>
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<tr>
<td>Electrical</td>
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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 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 Code Council - Latest Editions
- Mechanical, Plumbing, Energy Conservation, and Residential
- 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
- Generally accepted HVACR textbooks
- Generally accepted construction textbooks
- OSHA safety standards
- National Fire Protection Association - Latest Editions
- Gas, Oil, and Electric

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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Suggested Retail Price: $240
SAFETY, TOOLS, & SOFT SKILLS

COMMUNICATIONS FOR HVAC TECHNICIANS

WRITING FOR TECHNICIANS
- Symbols of writing - letters, numbers, Roman numerals
- Writing for easy reading
- Composing and generating writing. Descriptive, narrative and explanatory writing.
- Writing with appropriate language
- Writing with clarity, unity of thought and coherence
- Writing to persuade
- Writing informal documents
- Vocabulary. Choosing appropriate words to say what you mean. Uses of slang and jargon.

READING AND ENGLISH COMPREHENSION
- Setting priorities on main ideas and supporting information
- Seeing cause and effects relationships in instructions
- Adjusting reading rates to purpose
- Following complex written instructions
- Determining word meanings from context clues
- Using dictionaries to determine word meaning
- Recognizing important details
- Determining sequence of events
- Following directions involving substeps
- Interpreting diagrams and graphs
- Using reference books
- Responding to non verbal or written communications such as warning signs and material conditions
- Adjusting reading based on writers style and vocabulary

GRAMMAR, PUNCTUATION & SPELLING IN WRITING
- Use of proper written style and grammar
- Basics of punctuation Keys to better spelling
- Good grammar for effective communications

REPORT WRITING
- Interpreting data - fact and opinion
- Reporting from sources other than personal
- Matching reports to readers
- Writing accurate, proper forms with complete data

ORAL COMMUNICATIONS
- Giving proper oral instructions
- Using diction, voice control, posture, gestures, eye contact, and confidence to achieve effective oral communication
- Social implications of non verbal language
- Communicating with analogy, repetition, and figurative language
- Logical delivery of ideas
- Recognizing and using defensive / non-defensive producing language
- Questioning techniques

MATHEMATICS

ARITHMETIC
- Whole numbers - add, subtract, multiply and divide
- Fractions - add, subtract, multiply and divide Decimals - add, subtract, multiply and divide
- Percentages, ratios, and proportions
- Rounding off of values
- Interpolation
- Using sequences and series to predict results
Calculators
Combined calculations
Mixed numbers
Conversion of number forms

ALGEBRA
Basic linear single variable equations
Using algebraic graphs
Using basic algebra in problem solving
Transposing formulas

TOOLS & SCALES - BASIC MATH MEASUREMENT
Rulers, compass, square, protractor, etc.
Improvised measuring techniques
Basic scale drawings
Measurements - inches, feet, centimeters, millimeters, etc.
Understanding tolerances

GEOMETRY
Geometric figures used in HVAC - points, lines, rectangles, parallelograms, rhombuses, squares, trapezoids, etc.
Units of measurement. Typical computations using geometry. The right triangle. 30-60-90, 45-45-90.
Parallels and perpendiculars
Estimating areas, perimeters, and volumes of irregular figures

GRAPHS, CHARTS & TABLES
Introduction to basic graphs, plots, and tabular data
Graphs and tables used in instruction sheets
Blueprint reading

PROBLEM SOLVING - NON CUSTOMER
Understanding the nature of a problem
Using mathematical induction
Selecting strategic options
Introduction to logical problem solving. Using estimates to solve reasonableness.
Separating "validity of argument" from "truth of statement"
Using points of view for problem solving

USE OF COMPUTERS
Introduction to basic computers
Use of computers in recordkeeping
Use of computers in the field

PERSONAL ETHICS AND CONDUCT

PERSONAL CHARACTERISTICS
Understanding what honesty means
Understanding what dependability means
Understanding what a positive work ethic means
Understanding what patience means
Understanding what tolerance means
Understanding cultural differences

BEHAVIOR HABITS IN THE WORKPLACE
Understanding what integrity means
Understanding what a good attitude means
Understanding what loyalty means
Understanding in the workplace
Proper dress in the workplace
Understanding what teamwork means
Understanding what time management means
Consequences of substance abuse

INTERPERSONAL RELATIONS

RESPONDING TO CUSTOMER NEEDS
Understanding customer requirements
Gathering information on a service request
Evaluating customer service information
HANDLING CUSTOMER COMPLAINTS
Using listening skills with a customer complaint
Evaluating complaint information
Selecting response options with customer complaints
Resolving customer complaints
Using good questioning skills with a customer conflict
Understanding the consumers rights
Understanding manufacturers and dealer warranties
Reconciling differences of opinions
Understanding verbal agreements

THE TECHNICIAN'S ROLE IN SALES
Determining technician involvement in sales
Determining needs
Understanding features and benefits
Making a good sales presentation
Understanding customer sales requests
Planning reaction to sales requests
Importance of accurate and crisp communication
Listen to purchasing needs

TECHNICIAN'S ROLE AS CUSTOMER EDUCATOR
Evaluating a need for customer education - questioning skills
Putting an educational strategy together
Executing an educational strategy

FABRICATION TOOLS
HAND TOOLS
Screwdrivers and nut drivers
Wrenches, pliers, and allen wrenches
Socket sets
Levels and squares
Tool maintenance and care
Saws and files
Drills, countersink, reamers, and bits
Punches, taps, and dies
Hammers
Metal tools - metal snips, sheers, benders, breaks, hand formers, calipers, rulers, stapler, etc.

TUBING TOOLS
Benders - spring, lever, etc.
Flaring tools Tube cutters
Swaging tools
Reamers

HANDLING HAZARDOUS MATERIALS
GOVERNMENT REGULATIONS
Transportation regulations for hazardous materials
Health and safety regulations for hazardous materials
Environmental regulations for hazardous materials

SAFETY
PERSONAL SAFETY AND WORK PRACTICES
Regulations concerning confined spaces, hard hats, etc.
Safety with hand tools
Safe handling of hazardous materials
Using ladders and scaffolds
Safety within confined spaces
Safe driving practices
Clothing, safety equipment, and hard hats
Safety glasses
Hearing protection
Safe practices in troubleshooting and repair
Using warning symbols

PERSONAL SAFETY AROUND MOVING MACHINERY
Blowers
Condenser fans
Pulleys
Clothing requirements

ELECTRICAL SAFETY
Overview of electrical safety
Grounding - GFI requirements on outdoor extension cords
Personal protection

SAFE SOLDERING PRACTICES
Overview of safety
Oxygen and acetylene safety
Using purging gases - Nitrogen, Carbon Dioxide, etc.
Fire extinguishers
Documentation for hazardous materials - Material Safety Data Sheets (MSDS)

HAZMAT TRAINING
Signage for hazardous materials
Securing hazardous materials for transport

BASIC CONSTRUCTION DESIGNS
PLANS AND SPECIFICATIONS
Construction
Materials
Layout

PLUMBING (PIPING) LAYOUTS
Construction
Materials
Layout

ROOM SPECIFICATIONS - CLEAR SPAN & CEILING HEIGHTS
Construction
Materials
Layout

ROOFS
Construction
Materials
Layout

CEILINGS
Construction
Materials
Layout

WALLS
Construction
Materials
Layout

FLOORS
Construction
Materials
Layout

ROOFING
Construction
Materials
Layout

GIRDERS & TRUSSES
Construction
Materials
Layout

CHIMNEYS
Construction
Materials
Layout

HEAT TRANSFER & COMFORT
TEMPERATURE AND HUMIDITY MEASUREMENTS
PHYSICAL MEASUREMENTS - TEMPERATURE & HEAT

Latent heat
Sensible heat Temperature
Fundamentals of humidity
Convection Conduction
Radiation
BTU - Definition and use

THERMOMETERS

Liquid column thermometers
Mechanical thermometers
Electronic thermometers
Infrared thermometers
Gauge / meter calibration
Recording thermometers - digital and analog
Dry bulb and wet bulb Delta T

HUMIDITY MEASUREMENTS

Sling psychrometer
Wet and dry bulb thermometers
Electronic humidity measurement
Gauge / meter calibration Using
psychrometric chart
Humidity probes attachments for use with electrical meters
Enthalpy

COMFORT

TEMPERATURE

Role of temperature in comfort
Regional temperature considerations and comfort

HUMIDITY

Role of humidity in comfort
Adjusting system performance for humidity control

INDOOR AIR QUALITY

Ventilation - comfort
Air cleaning for comfort
Odor control

SOUND

Equipment
Airflow

BASIC SCIENCE

CHEMISTRY BASICS

Properties of matter - atoms, elements, and molecules
How chemicals react with each other
Role of chemistry at the jobsite
Oxidation and combustion
Weight and density of materials

PHYSICAL MEASUREMENTS - PRESSURE

Overview of pressure systems
Pressure laws and pressure measurement terminology
Temperature vs. Pressure

MECHANICS

Simple machines - levers, gears, etc.
Conservation of energy
Gas laws
Complex machines - how mechanisms work
Basics of electricity and magnetism
Basics of fluid mechanics

ELECTRICAL

BASIC ELECTRICITY

Electrons in electricity
Fundamental electrical concepts - volts, amps, etc.
Electrical charge, negative, positive, ions, ionization
Conductors
Insulators

ELECTRICAL BASIC TERMS
Voltage - volts, potential difference, polarity, and ground
Amps - milliamps, microamps, etc. Resistance
- Ohm's, megohms, etc.
Power - watts

MAGNETISM
Magnetic principles in electricity
Magnetic components - coils
Magnetic components - transformer

DC CIRCUITS
Simple DC circuit
Basic control and loads
Ohm's Law in DC circuits
Polarity

AC CIRCUITS
Introduction to AC circuits
Effects of AC on controls and loads

INTRODUCTION TO BASIC CIRCUIT ANALYSIS
Difference between AC & DC power
Ohm's Law
Current distribution in multiple load circuits
Complex circuits
Series circuits
Parallel circuits

ELECTRICITY - GENERATION AND DISTRIBUTION
Introduction to electrical distribution - phases & voltages
Impact of available electrical power on electrical equipment - total load
Transformer distribution

SOLID STATE ELECTRONICS
Introduction to basic solid state components - diodes, triacs, etc.
Fundamental solid state circuits
Overview of solid state devices in HVAC
Solid state sensing devices - temperature, pressure, light, etc.

POWER
Electrical power formulae - conversion of power
Introduction to power factor

ELECTRICAL LOADS
Capacitive - momentary and continuous
Inductive - momentary and continuous Resistive - momentary and continuous

AC MOTORS
SINGLE PHASE MOTORS
Types - mount, enclosure, other mechanical characteristics, etc.
Components - stator, rotor, start relay, capacitor, number of poles, etc.
Operating principles - inductive, capacitive reactance, power factor, etc.
Torque characteristics
Tapped multi-speed
Selecting single phase motors

SINGLE PHASE MOTOR TYPES
Capacitor start induction run motor (CSIR)
Capacitor start capacitor run motor (CSCR)
Permanent split capacitor (PSC)
Shaded pole
Split-phase motor (RSIR)
Variable speed motors - ECM, BPM, and VSIM

THREE PHASE MOTORS
Types - mount, enclosure, other mechanical characteristics, etc.
Components - stator, rotor, etc.
Operating principles - power factor, etc.
Selecting multi-phase motors
Rotation
Torque characteristics

ACTUATOR MOTORS
Overview of damper motors
Dual position Proportional

ELECTRICAL DIAGRAMS
SYMBOLS
Introduction to basic symbols
Use of symbols in diagrams
Symbol standards
FIELD WIRING DIAGRAMS
Basics of field diagram layout
Use of field diagrams
PICTORIAL DIAGRAMS
Basics of pictorial diagram layouts
Use of pictorial diagrams
SCHEMATIC (LADDER) DIAGRAMS
Basics of schematic (ladder) diagram layouts
Reading schematics for determining sequences
Reading schematics for wiring connections

ELECTRICAL METERS
ANALOG ELECTRICAL METERS
Identify meters and instruments
Analog electrical meters - use, setups, and RMS limitations - Recommended AC Installer
Voltage measurements
Resistance measurements Amperage measurements
Use with temperature probes
Meter calibration and maintenance
Millivolt measurements
Milliampere measurements

DIGITAL ELECTRICAL METERS
Identify meters and instruments
Digital electrical meters - use and setups
Voltage measurements
Resistance measurements Amperage measurements
Use with temperature probes
Meter calibration and maintenance RMS - correction and meter types
Millivolt measurements
Milliampere measurements
\[
\frac{\text{CFM}_n}{\text{CFM}_o} = \frac{\text{RPM}_n}{\text{RPM}_o} \\
\text{or old, } n = \text{new} \\
\text{CFM and RPM are interchangeable.}
\]

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

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

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

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

**Hydronics:** \( \Delta P = \text{Sp}, \text{ CFM} = \text{GPM}, \text{ RPM} = \text{GPM} \)

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

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

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}

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

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

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

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

1 IWC = 0.0360 PSI
1 PSI = 27.72 IWC

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

**Area** = \( \pi \times \text{radius}^2 \)

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

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) = \( \frac{\pi \times \text{diameter}^2}{576} \)

\[
mfd = \frac{(2650 \times 1)}{E}
\]

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

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

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

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

**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>134a</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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**Note:** The chart provides values for different refrigerants and temperatures, helping in the determination of subcooling and superheat at sea level conditions.