OIL FURNACES

SERVICE CERTIFICATION

Certification Information

Scope - Tests a candidate's knowledge of the installation, service, maintenance, and repair of HVAC systems. System sizes are limited to 400,000 BTU or less heating capacity.

Qualifications

Y This is a test and certification for TECHNICIANS in the HVAC industry. The test is designed for top level service 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 SERVICE exam.

Y This test will measure what 80% of the Oil Furnaces candidates have an 80% likelihood of encountering at least once during the year on a NATIONAL basis.

Y Suggested requirement is two years of field experience working on Oil Furnaces systems as a service 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>
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</thead>
<tbody>
<tr>
<td>Listed are the percentages of questions that will be in each section of the Oil Furnaces exam.</td>
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<table>
<thead>
<tr>
<th>SECTION AREA DESCRIPTION</th>
<th>SECTION PERCENTAGE</th>
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<tbody>
<tr>
<td>Installation</td>
<td>20%</td>
</tr>
<tr>
<td>Service</td>
<td>45%</td>
</tr>
<tr>
<td>System Components</td>
<td>25%</td>
</tr>
<tr>
<td>Applied Knowledge</td>
<td>10%</td>
</tr>
</tbody>
</table>

Oil Furnaces 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”, “Q” - Quality Installation, and “S”
- ACCA Manuals “I” and “RS” - Latest Editions
- ACCA Residential Duct Diagnostics and Repair - Latest Edition
- AHRI-Hydonics 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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INSTALLING OIL FURNACES

SELECTING OIL TANK LOCATION
- Locating oil tanks outdoors - above ground
- Locating oil tanks outdoors - below ground
- Locating oil tanks in basements

SELECTING OIL FURNACE SITES
- Locating furnaces in attics
- Locating furnaces in crawlspaces
- Locating furnaces in closets
- Locating furnaces in basements
- Locating furnaces in utility rooms
- Locating furnaces in garages
- Locating packaged furnaces on rooftops
- Locating packaged furnaces for outdoor ground level installations

MOUNTING FURNACES
- How to suspend horizontal furnaces in attics
- How to suspend horizontal furnaces in crawlspaces
- How to mount horizontal furnaces on attic floors
- How to mount upflow / downflow furnaces in closets
- How to mount upflow / downflow furnaces in basements
- How to mount upflow / downflow furnaces in utility rooms
- How to mount upflow / downflow furnaces in garages
- How to mount packaged furnaces on rooftops
- How to mount packaged furnaces for outdoor ground level installations

INSTALLATION OF PLENUMS AND DUCT
- Sizing plenums for physical fit
- Types and styles of plenums selected
- Insulation of plenums and ducts

INSTALLATION OF UTILITIES
- Installation of oil supply
- Installation of oil returns
- Wiring oil furnaces

INSTALLATION OF METAL VENTING SYSTEMS
- Determination of routing
- Cutting of metal vent systems to proper length
- Assembly of metal vent systems
- Securing of metal vent systems
- Installing power venters

INSTALLATION OF COMBUSTION AIR INLETS ACCESSORIES
- Combustion air inlets in confined spaces - attics
- Combustion air inlets in confined spaces - basements
- Combustion air inlets in confined spaces - closets
- Combustion air inlets in confined spaces - crawlspaces
- Installation of powered combustion air intakes

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.

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

INSTALLING METAL DUCT
- Assembly methods for rectangular duct
- Installation technique - rectangular metal
Assembly methods for round duct
Installation technique - round metal
Hanging ductwork
Sealing metal duct
Insulation - internal and external, vapor barriers
Assembling for low noise and low pressure drop

INSTALLEDING FLEXIBLE DUCT
Assembly methods - appropriate length
Flexible duct joints
Hanging flexible duct
Installation technique - flex duct
Sealing flexible duct

INSTALLEDING DUCTBOARD
Assembly methods for ductboard - supports
Installation technique - ductboard
Hanging methods for ductboard
Sealing ductboard

INSTALLEDING GRILLES, REGISTERS, DIFFUSERS, & DAMPER
Mounting to ductwork
Securing methods

CHASES USED AS DUCTS
Floor joists as air ducts
Vertical chases

RECONNECTING DUCT WHEN REPLACING EQUIPMENT
Reconnecting metal duct
Reconnecting flexible duct
Reconnecting ductboard duct

INSTALLATION OF PLENUMS AND DUCT
Sizing plenums for physical fit
Types and styles of plenums selected
Insulation of plenums and ducts

INSTALLING ACCESSORIES

INSTALLING THERMOSTATS
Locating and mounting
Wiring electromechanical thermostats
Wiring electronic thermostats
Programming of electronic thermostats

INSTALLING HUMIDIFIERS
Installing humidifiers
Wiring humidifiers
Controlling humidifiers

INSTALLING ELECTRONIC AIR CLEANERS
Installing electronic air cleaners
Wiring electronic air cleaners
Controlling electronic air cleaners

START-UP AND CHECKOUT PROCEDURES
START-UP PROCEDURES
Oil supply and proper shutoff
Electrical
Adequate combustion air provisions
Venting system
Ductwork system
Condensate system for AC

START-UP PROCEDURES AND CHECKS
Voltage checks
Check thermostat and set heat anticipator
Motor checks-burner motor, supply blower motor
Airflow checks - static pressure
Check call for heat sequences
Oil supply checks
OIL BURNER ADJUSTMENTS

- Unit preparations
- Nozzle checks
- Electrode adjustments
- Air adjustment at burner
- Adjusting oil pressure
- Adjusting draft
- Checking smoke readings
- Smoke vs. Carbon Dioxide graph
- Final adjustments
- Measuring stack temperature
- Checking ignition
- Checking pump cutoff

COMBUSTION CHECKS

- Flame checks
- Stack temperature check
- Carbon Dioxide checks
- Smoke test
- Overfire draft check
- Breech draft check
- Oxygen checks
- Efficiency check
- Burner motor checks - output pressure, amp draw, etc.
- Supply and return airflow checks

LEAK DETECTION TOOLS

- Electronic leak detectors
- Ultrasonic leak detector
- Pressurization for leak detection

OIL BURNER COMBUSTION SETUP TOOLS

OIL PRESSURE MEASUREMENTS

- High pressure dial gauges
- Vacuum dial gauges

FLUE GAS ANALYSIS

- Draft gauge
- Smoke tester
- Carbon Dioxide analyzer
- Combustion efficiency slide rule
- Stack Thermometer

LEAK DETECTION - CO

- Carbon Monoxide detector - electrical
- Carbon Monoxide detector - manual-monoxor

SETUP

- Nozzle wrench
- Oiling cans
- Electrode/Nozzle gauge
- Flame mirror

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 Residential HVAC
- Velocity

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
Airflow hood
Formulae for determining CFM of air
Formulae for weight of air
Locations for air volume measurements
Airflow volume - CFM / SCFM (Static CFM)

SERVICE

PLANNED MAINTENANCE

SYSTEM MECHANICAL PM CHECKS
Air filter checks and changeout
Lubrication
Packaged unit cabinet care
Fan blades / blower scroll
Flue / vent stack inspection
Duct
Heat exchanger - inspection, cleaning, replace gaskets etc
System airflow
Oil tank
Combustion tests
Combustion chamber inspection
Barometric regulator
Combustion air supply

BURNER MECHANICAL PM CHECKS
Oil lines / connections
Combustion air supply check and adjustment
Nozzle replacement
Oil pump-pressure, vacuum etc
Pump strainers
Oil filter cleaning and cartridge replacement
Electrodes - clean, inspect and adjust
Ohm cad cell and clean
Combustion head
Transformers
Burner motor

ELECTRICAL PM CHECKS
General wiring
Power burner operation
Burner motor operation
Furnace supply air blower motor
Furnace operating sequence
Thermostat calibration and operation
Fan switch and high limit control

DIAGNOSTICS AND REPAIR

TROUBLESHOOTING SEQUENCE OF OPERATION
Check for proper sequence of operation
Interpreting system at sequence interruption

ANALYZING REPORTED SYMPTOMS
Insufficient / no heat
Short cycle
Humidity problems
Drafty
Noise problems
System runs continuously
High utility bills
Wide swings in room temperatures
Air quality - odors, fumes, etc.

ANALYZING COMBUSTION
Carbon Dioxide checks for efficiency
Interpreting a smoke test
Balancing excess air and the smoke test
Diagnosing air leaks and efficiency loss
Diagnosing low draft-stack, overfire
Diagnosing excessive draft-stack, overfire
Diagnosing excessive draft on off cycle
Interpreting steady state efficiency measurements - stack loss calculations
Interpreting oxygen content for combustion diagnostics

SYSTEM AIR SIDE DIAGNOSTICS
Temperature checks
Checking system static pressure
Checking total CFM
Checking supply CFM at registers and diffusers
Checking return CFM
Checking for leaks in supplies
Checking for leaks in returns

ELECTRICAL CIRCUIT CHECKS
Supply voltage
Supply air blower
High voltage transformer
Low voltage transformer
Power burner
Room thermostat
Electronic controllers - input / output

ELECTRICAL COMPONENT CHECKS
Room thermostat
High voltage transformers
Low voltage transformers
Oil burner motor
Electrodes
Flame sensor/cad cell
Overcurrent protection
Relays and contactors
Capacitor - supply air blower
Limit control-high temperature
Door interlock switch
Supply air motor
Stack switches-flame proving

REPAIR EXCLUDING POWER BURNER
Electrical wiring
Flue stack / venting system
Combustion chamber-lining
Oil lines
Supply air blowers-shafts, bearings, mounts etc

REPAIR - POWER BURNERS
Output pressure adjustment
Bleeding air
Cleaning burner - end cone, blower wheel, blast tube, etc.
Clean and adjust electrodes

COMPONENT REPLACEMENTS
High voltage transformers
Low voltage transformers
Flame retention heads
Electrodes
Nozzle
Combustion chamber
Heat exchanger
Oil burner blower
Relay
Supply air blower- motor, wheel
Capacitors
Oil pump
Safety circuit switches-limit
Barometric damper
Primary control
Cad cells
Blast tubes
Fan and limit switches
Circuit boards - fan

VENT SYSTEM CHECKS
Checking draft
Correcting insufficient draft
Checking for leaks
Checking for obstructions - vent connection and chimney

DIAGNOSING OIL COMBUSTION PROBLEMS
Overheated nozzle
Sooting
Discolored flame
Intermittent flame
Partial burner flame-low viscosity
Delayed ignition - puffback
Carbon build up
Retention head burnoff
Trip on high limit-overfiring
Carbon Monoxide
Off center burn
Airtube burn-off
Nozzle afterdrip
Lack of ignition
Afterburn
Low capacity-clogging, oil supply contamination

OVERVIEW OF ELECTRICAL TROUBLESHOOTING
LOW VOLTAGE CIRCUITS
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
Voltage tests
Current tests
Component tests
Circuit tracing line voltages
Troubleshooting with schematics
Troubleshooting without schematics
Equipment continuity tests
Ground tests

AIR BALANCING
GATHERING DESIGN INFORMATION
Interpreting system design
Interpreting specifications
Interpreting equipment information
Interpreting control data
Modifying system design

PREPARATION OF SYSTEM FOR AIR TESTS
Locating registers, grilles, equipment, controls, and dampers in building walkthrough
Setting dampers for tests
Setting thermostat for tests
Checking for proper fan operation and rotation
Checking for proper static pressure and temperature

PROCEDURES FOR CONDUCTING AIR TESTS
Measurements of each supply outlet - total readings
Measurements of each return inlet - total readings

MAKING ADJUSTMENTS
Adjust airflow to achieve required total airflow
Re-measure total supply and return grille airflow
Adjust dampers to obtain design airflow
Re-measure total airflow to verify that it is within +/- 10%

FINAL TEST
Comparing manufacturer's equipment information with test results
Record sheave, pulley, and belt sizes data
Test and record full load motor amperes
Test and record voltage
Test and record motor and fan RPM
Test and record supply and return static pressures
Test and record supply and return air temperatures - heat and cool

COMPLETION OF APPROPRIATE FORMS
HVAC system report
System diagrams
Duct traverse or data pulley forms
Instrument list - including calibration dates

BASIC HVAC SYSTEM ANALYSIS
NOISE PROBLEMS
Interpreting supply / return air volume
Interpreting supply / return air velocity
Noise problems
Blower cavitation
Oil canning
Motor / belt noise
Vibration

HIGH UTILITY BILLS
Interpreting supply / return air temperature
Interpreting supply / return air volume
Evaluating duct leakage
Evaluating duct insulation
Envelope infiltration
Thermostat air sensing

WIDE TEMPERATURE SWINGS
Interpreting supply / return air temperature
Interpreting supply / return air volume
Evaluating duct leakage
Evaluating duct insulation
Envelope infiltration
Thermostat air sensing

SINGLE AREA IS HOT OR COLD
Interpreting supply / return air temperature
Interpreting supply / return air volume
Evaluating duct leakage
Evaluating duct insulation
Envelope infiltration
Thermostat air sensing

INDOOR AIR QUALITY
- Number of air changes per hour
- Odor control
- Contaminants

ANALYZING REPORTED SYMPTOMS IN HEATING

POOR HEATING
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Interpreting supply / return air velocity
- Evaluating duct leakage
- Using temperature drop across evaporator coil

HUMIDITY PROBLEMS
- Interpreting wet bulb and dry bulb temperatures
- Interpreting supply / return air volume
- Determining the need for additional humidity
- Evaluating duct leakage

DRAFTY
- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Interpreting supply / return air velocity

SYSTEM COMPONENTS

INTRODUCTION TO SYSTEMS

OIL TRANSFER PRINCIPLES
- Fundamentals of oil transfer
- Basic oil supply circuit

FURNACE CONFIGURATIONS & APPLICATIONS

FURNACE CONFIGURATIONS
- Upflow
- Downflow
- Horizontal
- Lowboy

OIL FURNACES WITH SPLIT SYSTEM AIR CONDITIONER
- Introduction to oil furnace with split system AC
- Electrical layouts
- Specifications
- Attic layouts
- Crawlspace layouts
- Closet layouts
- Basement layouts
- Ventilation options
- Regional considerations

MULTI-POSITION FURNACE
- Two way
- Three way

COMBUSTION PROCESS FOR OIL FURNACES

COMBUSTION - FUEL OIL
- Describe combustion of fuel oil
- Describe carbon dioxide as a product of combustion
- Describe oxygen's role in combustion
- Describe carbon monoxide as a product of incomplete combustion
- Water vapor as product of combustion
- Contaminants from improper combustion
- Effects of contaminated oil on combustion

FUNDAMENTALS OF OIL COMBUSTION FURNACES
- Natural draft oil furnaces
- Overview of operation for oil furnaces

VENT SYSTEMS
- Fundamentals of natural draft systems
- Natural draft systems with power venters
Vent system options—masonry chimneys, manufactured chimneys
Role of barometric dampers in vent systems

CONTROL FUNCTIONS
- Fan control
- Heat exchanger limit control
- Flame proving - cad cell
- Introduction to primary controls
- Door interlocks
- Room thermostats

NATURAL DRAFT OIL FURNACE - COMPONENTS

OIL SUPPLY SYSTEMS
- Above ground tanks
- Below ground tanks
- Indoor tanks
- Supply lines
- Filters
- Manual shutoffs
- Single pipe systems
- Two pipe systems
- Single pipe to two pipe conversion
- Electric shutoffs, solenoids
- Check valves

POWER BURNERS
- Functions of the power burner
- Gun type burners
- Single stage pumps
- Two stage pumps
- Combustion air blowers
- Flame retention heads
- Combustion intakes - outdoor

COMBUSTION CHAMBERS
- Construction
- Refractory
- Non refractory
- Stainless steel
- Role of configuration in proper combustion

HEAT EXCHANGERS
- Construction
- Materials
- Functions of heat exchanger

NOZZLES
- Construction
- Flow rates
- Angles and patterns
- Effects of excess air
- Atomization
- Selection of nozzles
- Effects of viscosity on nozzle flowrate and pattern
- Filters for nozzles

COMBUSTION AIR REQUIREMENTS

OUTDOOR AIR SPECIFICATIONS
- Attic applications
- Crawlspace applications
- Closet applications
- Basement applications
- Rooftop applications

AIR DISTRIBUTION

DUCT SYSTEMS
- Duct system design
- Duct configurations - extended plenum, reducing trunk etc.
Return configurations
Return grille locations
Supply locations

SUPPLY BLOWERS
Introduction to supply blowers
Supply blowers - types and selection
Blower operation
Fan laws

WIRING LAYOUTS

POWER WIRING
Power wiring for split system furnace

LOW VOLTAGE
Overview of low voltage wiring

ELECTROMECHANICAL SENSING CONTROLS

ELECTROMECHANICAL ROOM THERMOSTATS
Basic thermostat types and operation
Selecting room thermostats and sub-bases
Thermostat terminals and wiring
Using electromechanical thermostats
Selecting location
Role of anticipators in thermostatic control

ELECTROMECHANICAL TEMPERATURE CONTROLS
Introduction to bimetal controls
Disc type temperature limit controls
Fuses and fuse links
Fossil fuel kits
Motor overloads
Stack temperature controls

PRESSURE CONTROLS
Operation of pressure control-power venters
Using pressure controls-power venters
Vacuum relief valve to regulate inlet combustion air

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

ELECTRONIC CONTROLS

OVERVIEW OF SYSTEM ELECTRONIC CONTROLLERS
Input / output operations
Logic

ELECTRONIC THERMOSTATS
Fundamentals of electronic thermostats
Selecting electronic thermostats
Overview of electronic thermostat operation
Fossil fuel kits for use with heat pumps

ELECTRONIC TIMERS
Introduction to blower delay timers
Purging timers

PRIMARY CONTROLS
Basic construction of oil furnace primary controls
Basics of operation - oil furnace primary controls

APPLIED KNOWLEDGE: REGS, CODES, & DESIGN

AIR QUALITY REGULATIONS
INDOOR AIR QUALITY
Fresh air supplies

FUEL HANDLING AND STORAGE REQUIREMENTS
Storage tank regulations-above the ground
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
- Safety listings - UL / ARL / ETL

STATE AND LOCAL REGULATIONS AND CODES

STATE AND LOCAL REGULATIONS
- State licensing requirements for technicians
- Use of Carbon Monoxide detectors
- Smoke detector requirements

CODES
- Plumbing
- Municipalities
- Oil furnace for light commercial
- Oil furnace for residential

FIRE PROTECTION REGULATIONS AND CODES

COMBUSTION AIR
- Sizing air intakes in confined spaces
- Sources of combustion air

FURNACE ACCESS
- Access to furnace
- Access to service panel

OIL PIPING
- Sizing for capacity
- Length limitations
- Attachment to appliance

INSTALLATIONS
- Installation of oil burning equipment

VENTING REQUIREMENTS
- Venting of oil burning equipment

DESIGN CONSIDERATIONS - COMFORT

TEMPERATURE
- Designing for capacity
- Using industry standards

HUMIDITY
- Role of humidity in comfort
- Using industry standards

INDOOR AIR QUALITY
- Ventilation - comfort
- Air cleaning for comfort
- Industry standards for air quality

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

DESIGN CONSIDERATIONS - OIL FURNACE EQUIPMENT

OIL FURNACES WITH SPLIT SYSTEM AIR CONDITIONER
- System designs - closets, basements, etc.
- Equipment location
- Electrical layouts
- Ventilation - fresh air
- Regional design considerations
- Combustion flue gases
- Ventilation - equipment
- Condensate drains / pans
Mounting of equipment
Combustion air
Fuel oil burner - forced air system

VENTING
Sizing flue pipe
Flue pipe layout
Adapting vent draft control - damper
Roof fittings - cap, collar, flashing, etc.
Pipe types - L-metal

DESIGN CONSIDERATIONS - EXTERNAL COMPONENTS
DIFFUSERS, REGISTERS, AND GRILLES
Selecting diffusers, grilles, and registers for capacity
Selecting diffusers, grilles, and registers for reduced sound
Selecting diffusers, grilles, and registers for throws, spread, and pressure drop
Locations

ACCESSORIES
Humidifier sizing
Twining kits
Electronic air cleaners (EAC's)

INDUSTRY STANDARDS
EQUIPMENT STANDARDS
Performance and safety standards- UL
Efficiency requirements - DOE

SYSTEM STANDARDS
Introduction to industry standards
Industry standards

BIDS AND PROPOSALS
SYSTEM SIZING
Survey of requirements
Selecting equipment
Sizing components
Adding accessories
Basic calculation of heating loads

ESTIMATING INSTALLATION
Installation price
Understanding proposal forms
Understanding bid forms - bid to specs and flat rate pricing
Legal implications of a bid

EFFECT OF ELECTRICAL SUPPLY ON BID
Effects of electrical power on bid
Electrical analysis - power
\[
\frac{CFM_n}{CFM_0} = \frac{RPM_n}{RPM_0} \quad \text{or} \quad \frac{CFM_n}{CFM_0} = \frac{BHP_n}{BHP_0} \quad \text{or} \quad \frac{CFM_n}{CFM_0} = \frac{BHP_n}{BHP_0}
\]

\[
\left(\frac{CFM_n}{CFM_0}\right)^2 = \frac{Sp_n}{Sp_0} \quad \text{or} \quad CFM_0 = \frac{CFM_n}{Sp_0} \quad \text{or} \quad CFM_0 = \frac{CFM_n}{BHP_n}
\]

\[
CFM_0 = CFM_0 \times \sqrt{\frac{Sp_n}{Sp_0}} \quad \text{or} \quad CFM_0 = CFM_0 \times \sqrt[3]{\frac{BHP_n}{BHP_0}}
\]

\[
Hydronics: \quad AP = Sp, \quad CFM = GPM, \quad RPM = GPM
\]

\[
MAT = (OAT \times \%0A) + (RAT \times \%RA)
\]

\[
0 = \text{Outside}
\]

\[
T = \text{Temperature}
\]

\[
R = \text{Return}
\]

\[
M = \text{Mixed}
\]

\[
A = \text{Air}
\]

\[
\frac{AC/Hr \times \text{Volume}}{60\text{min}} = CFM = \frac{v}{4005 \times \text{Jvp}}
\]

\[
Vp = <4:05\)
\]

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

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

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

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

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

\[
\text{Diameter} = \text{lt}
\]

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

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

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

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

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

\[
Cr \ (\text{Parallel}) = C1 + C2 + \ldots + C_n
\]
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)
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>REFRIGERANT</th>
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<tbody>
<tr>
<td></td>
<td>0°C  22 134a 404A 407C 410A 4220 507</td>
</tr>
<tr>
<td>32</td>
<td>0.0 57.5 27.8 72.4 52.1 101.2 55.2 75.8</td>
</tr>
<tr>
<td>33</td>
<td>0.6 58.8 28.6 73.9 53.4 103.3 56.5 77.4</td>
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