

# GAS 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 **Gas 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 Gas Furnaces systems as a service technician and technical training for theoretical knowledge.

## Test Specifications

**Closed Book    2.5 Hour Time Limit    100 Questions    Passing Score: PASS/FAIL**

Listed are the percentages of questions that will be in each section of the **Gas Furnaces** exam.

SECTION AREA DESCRIPTION	SECTION PERCENTAGE
Installation	20%
Service	45%
System Components	25%
Applied Knowledge	10%

## Gas 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”, “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 Energy Conservation Code - Latest Edition with Addendum
- International Mechanical Code - Latest Edition with Addendum
- International Plumbing Code - Latest Edition with Addendum
- Uniform Mechanical Code - Latest Edition with Addendum
- Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems developed by Consortium for Energy Efficiency (CEE) - Latest Edition with Addendum
- ASHRAE Standard-62.2 - Latest Edition with Addendum
- ANSI / ASHRAE Standard-152-2004 - 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
  - Fibrous Glass Duct Construction Standards, Residential Comfort System Installation Standards Manual, and HVAC Air Duct Leakage Test Manual
- 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
- International Fuel Gas Code – Latest Edition with Addendum
- National Fuel Gas 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

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# Heating - Warm Air - Gas

## Service

### INSTALLATION

#### INSTALLING GAS FURNACES

##### SELECTING GAS 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 UTILITIES

- Installation of gas piping
- Installation of field wiring
- Convert from gas to LP
- Pressure testing

##### 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
- Installation of vent termination

##### INSTALLATION OF PVC / ABS VENTING SYSTEMS

- Determination of routing
- Cutting PVC & ABS pipe to proper length Dry-fitting the assembly
- Sealing PVC pipe
- Sealing ABS pipe
- Securing of pipe
- Installation of vent termination

##### INSTALLATION OF CONDENSATE DRAINS FOR CONDENSING F

- Determination of routing
- Cutting PVC pipe to proper length Dry-fitting the assembly
- Sealing PVC pipe
- Securing of pipe
- Installation of condensate drain pan - attic installations
- Installation of condensate drain pumps

#### 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

## INSTALLING FLEXIBLE DUCT

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

## INSTALLING DUCTBOARD

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

## INSTALLING 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 DUCTS

- Sizing plenums for physical fit
- Types and styles of plenums selected
- Insulation of plenums

## 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

### INSTALLING ECONOMIZERS

- Installing economizers
- Wiring economizers
- Controlling economizers

## START-UP AND CHECKOUT

### PRE-START PROCEDURES

- Gas supply and proper shutoff
- Electrical
- Adequate combustion air provisions
- Venting system

Ductwork system  
Condensate system

## START-UP PROCEDURES AND CHECKS

- Voltage checks
- Check thermostat and set heat anticipator
- Motor checks
- Airflow checks
- Check call for heat sequences
- Manifold gas pressure check
- Flame quality check
- Firing rate

## LEAK DETECTION TOOLS

- Soap solution
- Electronic leak detectors
- Ultrasonic leak detector
- Pressurization for leak detection
- Meter calibration and 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 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

#### MECHANICAL PM CHECKS

- Filters
- Lubrication
- Packaged unit cabinet care
- Fan blades / blower scroll
- Gas connections
- Flue / vent stack inspection
- Combustion air supply
- Duct
- Heat exchanger
- Burner assembly
- Airflow

#### ELECTRICAL PM CHECKS

- General wiring
- Induced draft motor

Supply air motor  
Operation sequence

#### COMBUSTION PM CHECKS

Sequence of operation checks  
Air intake / exhaust  
Flame color  
Flame size  
Ignition  
Temperature rise

#### DIAGNOSTICS

##### 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

##### SYSTEM AIR SIDE DIAGNOSTICS

Temperature checks  
Check system static pressure  
Check system velocity

##### ELECTRICAL CIRCUIT CHECKS

Supply voltage  
Indoor blowers  
Wall thermostat  
Transformers  
Electronic controllers - input / output  
Flame rectification  
Pilot ignition  
Thermocouple / power pile generator  
Gas valve

##### ELECTRICAL COMPONENT CHECKS

Thermostat  
Transformers  
Overcurrent protection  
Relays and contactors  
Capacitors  
Pressure controls  
Limit controls  
Centrifugal switch  
Door interlock switch

##### REPAIR

Electrical wiring  
Electrical components  
Fuel supply  
Flue stack / venting system  
Condensate / drain system

##### REPLACEMENTS

Transformers  
Relays and contactors  
Indoor blowers  
Capacitors  
Heat exchanger

Gas valve



- Safety circuit switches
- Draft motor
- Pilot / ignitor assembly
- Flame sensing rod

#### VENT SYSTEM CHECKS

- Natural / gravity draft
- Forced draft

#### DIAGNOSING GAS COMBUSTION PROBLEMS

- Flame "roll-out"
- Flame "lift-off"
- Discolored flame
- Intermittent flame
- Partial burner flame
- Delayed ignition
- Carbon build up
- Flashback
- Trip on high limit
- Carbon Monoxide

#### 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

#### GAS PRESSURE MEASUREMENTS & DETECTION

##### PRESSURE MEASUREMENTS

- Manometer
- Dial gauge

##### LEAK DETECTION

- Leak detection solution
- Electronic leak detectors

#### FLUE GAS ANALYSIS & LEAK DETECTION

##### FLUE GAS ANALYSIS

- O<sub>2</sub> measurements
- Carbon Dioxide measurements

##### LEAK DETECTION

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

#### AIR BALANCING

##### GATHERING DESIGN INFORMATION

- Interpreting system design
- Interpreting specifications
- Interpreting equipment information
- Interpreting control data
- Modifying system design



- 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



## 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 BASIC SYSTEMS & COMPONENTS

#### HEAT TRANSFER

- Fundamentals of heat transfer
- Psychrometrics

### FURNACE CONFIGURATIONS & APPLICATIONS

#### GAS FURNACES WITH SPLIT SYSTEM AIR CONDITIONER

- Introduction to gas furnace with split system AC
- Electrical layouts
- Specifications
- Attic layouts
- Crawlspace layouts
- Closet layouts
- Basement layouts
- Ventilation options
- Regional considerations

#### MULTI-POSITION FURNACE

- Four-way Three-way Two-way

#### PACKAGED GAS FURNACE SYSTEMS

- Introduction to package gas furnace systems
- Electrical layouts
- Specifications
- Single story applications Multi-story applications
- Applied with crawlspace duct designs
- Ventilation options
- Economizer options
- Regional considerations

### COMBUSTION PROCESS FOR GAS FURNACES

#### COMBUSTION - NATURAL GAS

- Describe methane's role in combustion
- Describe carbon dioxide as a product of combustion
- Describe oxygen's role in combustion
- Describe carbon monoxide as a product of combustion
- Describe ethane's role in combustion

#### COMBUSTION - MANUFACTURED GAS

- Describe liquefied petroleum's role in combustion
- Describe butane's role in combustion
- Describe propane's role in combustion

#### FUNDAMENTALS OF GAS COMBUSTION SYSTEMS

- Category I - Negative pressure vent - non-condensing
- Category II - Negative pressure vent - condensing

Category III - Positive pressure vent - non-condensing

Category IV - Positive pressure vent - condensing

## NATURAL DRAFT GAS FURNACE - COMPONENTS

### HEAT EXCHANGERS

Clamshell construction

Materials

### BURNERS

Describe ribbon burners

## COMBUSTION AIR REQUIREMENTS

### DIRECT VENT (OUTDOOR AIR) SPECIFICATIONS

Attic applications

Crawlspace applications

Closet applications

Basement applications

Rooftop applications

### NON-DIRECT VENT (INDOOR AIR) SPECIFICATIONS

Attic applications

Crawlspace applications

Closet applications

Basement applications

## AIR DISTRIBUTION

### DUCT SYSTEMS

Duct system design

Duct configurations

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 package unit furnace

Power wiring for split system furnace

### LOW VOLTAGE

Overview of low voltage wiring

## NATURAL DRAFT GAS FURNACE - OPERATION

### GAS FURNACE - OPERATION

Overview of operation for standing pilot furnace

Overview of operation for intermittent pilot furnace

Overview of operation for direct ignition furnace

### STANDING PILOT IGNITION

Basics of operation

Flame switch type

Thermocouple type

### INTERMITTENT PILOT IGNITION

Spark ignited pilots

Hot surface ignited pilots

### DIRECT IGNITION

Spark ignited

Hot surface ignition (HSI)

### VENT SYSTEMS

Fundamentals of gravity flow draft systems

Horizontal vent systems

### SEQUENCE OF OPERATION

Typical operation for standing pilot furnace

Typical operation for intermittent pilot furnace  
Typical operation for direct ignition furnace

## CONTROL FUNCTIONS

- Fan control
- Heat exchanger limit control
- Roll-out switch
- Flame proving - flame switch and thermocouple
- Gas valve
- Door interlocks

## INDUCED DRAFT NON-CONDENSING - COMPONENTS

### HEAT EXCHANGERS

- Clamshell construction
- Materials
- Tubular

### BURNERS

- Describe ribbon burners
- Describe in-shot burners

### INDUCED DRAFT BLOWERS

- Introduction
- Role in system operation

## INDUCED DRAFT NON-CONDENSING - OPERATION

### GAS FURNACE - OPERATION

- Overview of operation for standing pilot furnace
- Overview of operation for intermittent pilot furnace
- Overview of operation for direct ignition furnace

### STANDING PILOT IGNITION

- Basics of operation
- Flame switch type
- Thermocouple type

### INTERMITTENT PILOT IGNITION

- Spark ignited pilots
- Hot surface ignited pilots

### DIRECT IGNITION

- Spark ignited
- Hot surface ignition (HSI)

### VENT SYSTEMS

- Vertical vent systems
- Horizontal vent systems

### SEQUENCE OF OPERATION

- Typical operation for standing pilot furnace
- Typical operation for intermittent pilot furnace
- Typical operation for direct ignition furnace

## CONTROL FUNCTIONS

- Fan control
- Heat exchanger limit control
- Roll-out switch
- Flame proving - flame sensor and thermocouple
- Pressure proving switch
- Gas valve
- Door interlocks
- Ignition control

## INDUCED DRAFT CONDENSING - COMPONENTS

### HEAT EXCHANGERS

- Clamshell construction
- Materials
- Tubular
- Secondary heat exchanger

### BURNERS

- Describe in-shot burners

### INDUCED DRAFT BLOWERS

- Introduction





## INDUCED DRAFT CONDENSING - OPERATION

### GAS FURNACE - OPERATION

Overview of operation for intermittent pilot furnace

Overview of operation for direct ignition furnace

### INTERMITTENT PILOT IGNITION

Spark ignited pilots

Hot surface ignited pilots

### DIRECT IGNITION

Spark ignited

Hot surface ignition (HSI)

### VENT SYSTEMS

Vertical vent systems

Horizontal vent systems

### SEQUENCE OF OPERATION

Typical operation for intermittent pilot furnace

Typical operation for direct ignition furnace

### CONTROL FUNCTIONS

Fan control

Heat exchanger limit control

Roll-out switch

Flame proving - flame sensor and thermocouple

Pressure proving switch

Gas valve

Door interlocks

Ignition control

Condensate proving switch 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

### GAS VALVES - SINGLE STAGE

Basics of construction

Basics of operation

Slow opening valves

Snap opening valves

Step opening valves

### GAS VALVES - TWO STAGE

Basics of construction

Basics of operation

### IGNITION CONTROL SYSTEMS

#### OVERVIEW OF IGNITION CONTROLS

Elements of gas furnace ignition systems

Introduction to ignition controls for natural draft / standing pilot furnaces / manually lit

Introduction to ignition controls for induced draft / intermittent pilot spark ignition systems

Introduction to ignition controls for induced draft / intermittent pilot hot surface ignition systems

Introduction to ignition controls for induced draft / direct ignition / spark ignition systems

Introduction to ignition controls for induced draft / direct ignition / hot surface ignition systems

#### STANDING PILOT

Components and functions

Ignition sequence

Safety

#### INTERMITTENT PILOT

Components and functions

Ignition sequence

Safety

#### DIRECT IGNITION

Components and functions



Safety

ELECTRONIC CONTROLS

OVERVIEW OF ELECTRONIC CONTROLLERS

Input / output operations

Logic

ELECTRONIC THERMOSTATS

Fundamentals of electronic thermostats

Selecting electronic thermostats

Overview of electronic thermostat operation

Fossil fuel kits

ELECTRONIC TIMERS

Introduction to blower delay timers

ELECTROMECHANICAL SENSING CONTROLS

ELECTROMECHANICAL WALL THERMOSTATS

Basic thermostat types and operation

Selecting wall thermostats and sub-bases

Thermostat terminals and wiring

Using electromechanical thermostats

Selecting location

ELECTROMECHANICAL TEMPERATURE CONTROLS

Introduction to bimetal controls

Disc type temperature limit controls

Fuses and fuse links

Fossil fuel kits

Motor overloads

PRESSURE CONTROLS

Operation of pressure controls

Using pressure controls

Combustion air proving (pressure) switch

*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

Safety listings - UL / ARL / ETL

STATE AND LOCAL REGULATIONS AND CODES

STATE AND LOCAL REGULATIONS

State requirements for technicians

Use of Carbon Monoxide detectors

Smoke detector requirements

CODES

Plumbing

Municipalities

Gas furnace for Lt. Commercial

Gas furnace for Residential

FIRE PROTECTION REGULATIONS AND CODES

REQUIRED COMPONENTS

Return air sensors

Fire dampers

Components



Overview of fire prevention

## VENTING REQUIREMENTS

Specifications for venting

Types of venting systems to be used

## 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 - GAS FURNACE EQUIPMENT

### GAS 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 gas atmospheric burner - forced air system

### PACKAGED SYSTEMS

System designs

Equipment location

Electrical layouts

Ventilation - fresh air

Mounting of equipment

Combustion air

### COMBUSTION GAS VENTING

Sizing flue pipe - ICC tables

Flue pipe layout - ICC tables

Adapting vent draft control - damper

Roof fittings - cap, collar, flashing, etc.

Pipe types - PVC and B-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

Retrofit automatic ignition kits

Electronic air cleaners (EAC's)

## MECHANICAL CODE

### COMBUSTION AIR

Sizing air intakes in confined spaces

Sources of combustion air

FURNACE ACCESS  
Access to furnace

Access to service panel

## **GAS PIPING**

Sizing for capacity

Length limitations

Attachment to appliance

## **INDUSTRY STANDARDS**

### **EQUIPMENT STANDARDS**

Introduction to industry standards

ARI / IAS standards for ratings

### **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



$$\frac{CFM_n}{CFM_o} = \frac{RPM_n}{RPM_o}$$

*o* = old, *n* = new  
CFM and RPM are interchangeable.

$$CFM_n = CFM_o \times \frac{RPM_n}{RPM_o}$$

$$RPM_n = RPM_o \times \frac{CFM_n}{CFM_o}$$

$$\left(\frac{CFM_n}{CFM_o}\right)^2 = \frac{SP_n}{SP_o} \quad \text{OR} \quad \frac{CFM_n}{CFM_o} = \sqrt{\frac{SP_n}{SP_o}}$$

$$CFM_n = CFM_o \times \sqrt{\frac{SP_n}{SP_o}}$$

$$SP_n = SP_o \times \left(\frac{CFM_n}{CFM_o}\right)^2$$

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

$$CFM_n = CFM_o \times \sqrt[3]{\frac{BHP_n}{BHP_o}}$$

$$BHP_n = BHP_o \times \left(\frac{CFM_n}{CFM_o}\right)^3$$

Hydronics:  $AP = SP$ ,  $CFM = GPM$ ,  $RPM = GPM$

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

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

$$Btuh \text{ hydronic (H}_2\text{O only)} = 500 \times GPM \times AT$$

$$Btuh \text{ sensible (at sea level)} = 1.08 \times CFM \times AT$$

$$Btuh \text{ latent (at sea level)} = 0.68 \times CFM \times AGrains$$

$$Btuh \text{ total (at sea level)} = 4.5 \times CFM \times AEnthalpy$$

$$CFM = \frac{AC/Hr \times Volume}{60min}$$

$$V = 4005 \times .Jvp$$

$$Vp = <4.05 \rangle 2$$

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

$$1 IWC = 0.0360 PSI$$

$$1 PSI = 27.72 IWC$$

$$Pressure 1 \times Volume 1 = Pressure 2 \times Volume 2$$

$$Area = 1t \times radius^2$$

$$A^2 + B^2 = C$$

$$Diameter = \frac{Circumference}{1t}$$

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

$$Round \text{ Duct Area (ft}^2\text{)} = \frac{1t \times diameter}{576}$$

$$mfd = \frac{(2650 \times I)}{E}$$

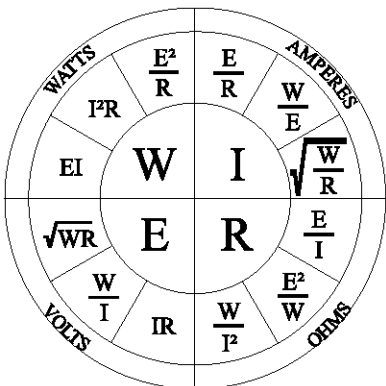
$$FR = \frac{ASP \times 100}{TEL} \quad (IWq100)$$

$$CFM = Velocity (fpm) \times Duct Area (ft^2)$$

$$CFM = \frac{(Watts \times 3.413)}{AT \times 1.08}$$

$$Cr \text{ (Series)} = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \dots + \frac{1}{CN}}$$

$$Cr \text{ (Parallel)} = C1 + C2 + \dots + CN$$



# TEMPERATURE PRESSURE CHART-atsealevel



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)

TEMP.		REFRIGERANT						
Of	OC	22	134a	404A	407C	410A	4220	507
-40	-40.0	0.6	<i>14.8</i>	4.3	4.6	10.7	2.3	5.4
-38	-38.9	1.4	<i>13.9</i>	5.3	3.2	12.0	0.8	6.4
-36	-37.8	2.2	<i>13.0</i>	6.3	1.6	13.4	0.4	7.5
-34	-36.7	3.1	<i>12.0</i>	7.4	0.0	14.8	1.2	8.6
-32	-35.6	4.0	<i>10.9</i>	8.5	0.8	16.2	2.1	9.8
-30	-34.4	4.9	9.8	9.6	1.6	17.8	3.0	11.0
-28	-33.3	5.9	8.7	10.8	2.5	19.3	3.9	12.2
-26	-32.2	6.9	7.5	12.0	3.5	21.0	4.9	13.5
-24	-31.1	8.0	6.3	13.3	4.4	22.7	5.9	14.8
-22	-30.0	9.1	5.0	14.6	5.4	24.4	7.0	16.2
-20	-28.9	10.2	3.7	16.0	6.5	26.3	8.1	17.6
-18	-27.8	11.4	2.3	17.4	7.6	28.1	9.2	19.1
-16	-26.7	12.6	0.8	18.9	8.7	30.1	10.4	20.6
-14	-25.6	13.9	0.4	20.4	9.9	32.1	11.7	22.2
-12	-24.4	15.2	1.1	22.0	11.1	34.2	12.9	23.8
-10	-23.3	16.5	1.9	23.6	12.3	36.4	14.3	25.5
-8	-22.2	17.9	2.8	25.3	13.7	38.6	15.6	27.3
-6	-21.1	19.4	3.6	27.0	15.0	40.9	17.1	29.1
-4	-20.0	20.9	4.6	28.8	16.4	43.3	18.5	30.9
-2	-18.9	22.4	5.5	30.7	17.9	45.8	20.1	32.8
0	-17.8	24.0	6.5	32.6	19.4	48.3	21.6	34.8
1	-17.2	24.9	7.0	33.6	20.2	49.6	22.5	35.8
2	-16.7	25.7	7.5	34.6	21.0	51.0	23.3	36.9
3	-16.1	26.5	8.0	35.6	21.8	52.3	24.1	37.9
4	-15.6	27.4	8.5	36.6	22.6	53.7	25.0	39.0
5	-15.0	28.3	9.1	37.7	23.5	55.0	25.8	40.0
6	-14.4	29.2	9.6	38.7	24.3	56.5	26.7	41.1
7	-13.9	30.1	10.2	39.8	25.2	57.9	27.6	42.2
8	-13.3	31.0	10.8	40.9	26.1	59.3	28.5	43.4
9	-12.8	31.9	11.3	42.0	27.0	60.8	29.5	44.5
10	-12.2	32.8	11.9	43.1	27.9	62.3	30.4	45.7
11	-11.7	33.8	12.5	44.3	28.8	63.8	31.3	46.8
12	-11.1	34.8	13.1	45.4	29.8	65.4	32.3	48.0
13	-10.6	35.8	13.8	46.6	30.7	66.9	33.3	49.3
14	-10.0	36.8	14.4	47.8	31.7	68.5	34.3	50.5
15	-9.4	37.8	15.0	49.0	32.7	70.1	35.3	51.7
16	-8.9	38.8	15.7	50.2	33.7	71.7	36.4	53.0
17	-8.3	39.9	16.4	51.5	34.7	73.4	37.4	54.3
18	-7.8	40.9	17.0	52.7	35.7	75.1	38.5	55.6
19	-7.2	42.0	17.7	54.0	36.8	76.8	39.6	56.9
20	-6.7	43.1	18.4	55.3	37.9	78.5	40.7	58.2
21	-6.1	44.2	19.1	56.6	39.0	80.3	41.8	59.6
22	-5.6	45.3	19.9	58.0	40.1	82.0	42.9	61.0
23	-5.0	46.5	20.6	59.3	41.2	83.8	44.1	62.4
24	-4.4	47.6	21.3	60.7	42.3	85.7	45.2	63.8
25	-3.9	48.8	22.1	62.1	43.5	87.5	46.4	65.2
26	-3.3	50.0	22.9	63.5	44.7	89.4	47.6	66.7
27	-2.8	51.2	23.7	64.9	45.9	91.3	48.8	68.2
28	-2.2	52.4	24.5	66.4	47.1	93.2	50.1	69.7
29	-1.7	53.7	25.3	67.8	48.3	95.2	51.3	71.2
30	-1.1	55.0	26.1	69.3	49.6	97.2	52.6	72.7
31	-0.6	56.2	26.9	70.8	50.8	99.2	53.9	74.3

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# TEMPERATURE PRESSURE CHART-atsealevel



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)

TEMP.		REFRIGERANT						
•F	OC	22	134a	404A	407C	410A	4220	507
32	0.0	57.5	27.8	72.4	52.1	101.2	55.2	75.8
33	0.6	58.8	28.6	73.9	53.4	103.3	56.5	77.4
34	1.1	60.2	29.5	75.5	54.8	105.4	57.9	79.0
35	1.7	61.5	30.4	77.1	56.1	107.5	59.3	80.7
36	2.2	62.9	31.3	78.7	57.5	109.7	60.6	82.3
37	2.8	64.3	32.2	80.3	58.9	111.9	62.0	84.0
38	3.3	65.7	33.1	82.0	60.3	114.1	63.5	85.7
39	3.9	67.1	34.1	83.7	61.7	116.3	64.9	87.5
40	4.4	68.6	35.0	85.4	63.2	118.6	66.4	89.2
42	5.6	71.5	37.0	88.8	66.1	123.2	69.4	92.8
44	6.7	74.5	39.0	92.4	69.2	127.9	72.5	96.4
46	7.8	77.6	41.1	96.0	72.3	132.8	75.6	100.2
48	8.9	80.8	43.2	99.8	75.5	137.8	78.9	104.0
50	10.0	84.1	45.4	103.6	78.8	142.9	82.2	108.0
52	11.1	87.4	47.7	109.2	101.7	148.1	96.1	112.0
54	12.2	90.8	50.0	113.3	105.6	153.5	99.8	116.1
56	13.3	94.4	52.4	117.4	109.6	159.0	103.6	120.4
58	14.4	98.0	54.9	121.7	113.7	164.7	107.4	124.7
60	15.6	101.6	57.4	126.0	117.9	170.4	111.4	129.1
62	16.7	105.4	60.0	130.5	122.3	176.3	115.4	133.7
64	17.8	109.3	62.7	135.0	126.7	182.4	119.5	138.3
66	18.9	113.2	65.4	139.7	131.2	188.6	123.8	143.1
68	20.0	117.3	68.2	144.4	135.8	194.9	128.1	147.9
70	21.1	121.4	71.1	149.3	140.5	201.4	132.5	152.9
72	22.2	125.7	74.1	154.3	145.4	208.0	137.1	158.0
74	23.3	130.0	77.1	159.4	150.3	214.8	141.7	163.2
76	24.4	134.5	80.2	164.6	155.4	221.8	146.5	168.5
78	25.6	139.0	83.4	169.9	160.5	228.9	151.3	174.0
80	26.7	143.6	86.7	175.4	165.8	236.1	156.3	179.5
82	27.8	148.4	90.0	181.0	171.2	243.6	161.3	185.2
84	28.9	153.2	93.5	186.7	176.8	251.2	166.5	191.0
86	30.0	158.2	97.0	192.5	182.4	258.9	171.8	197.0
88	31.1	163.2	100.6	198.4	188.2	266.8	177.2	203.0
90	32.2	168.4	104.3	204.5	194.1	274.9	182.7	209.2
92	33.3	173.7	108.1	210.7	200.1	283.2	188.4	215.5
94	34.4	179.1	112.0	217.0	206.3	291.6	194.1	222.0
96	35.6	184.6	115.9	223.4	212.5	300.3	200.0	228.6
98	36.7	190.2	120.0	230.0	219.0	309.1	206.0	235.3
100	37.8	195.9	124.2	236.8	225.5	318.1	212.1	242.2
102	38.9	201.8	128.4	243.6	232.2	327.2	218.4	249.2
104	40.0	207.7	132.7	250.8	239.0	336.6	224.8	256.3
106	41.1	213.8	137.2	257.8	245.9	346.2	231.3	263.7
108	42.2	220.0	141.7	265.1	253.0	355.9	237.9	271.1
110	43.3	226.4	146.4	272.5	260.3	365.9	244.7	278.7
112	44.4	232.8	151.1	280.1	267.6	376.1	251.6	286.5
114	45.6	239.4	156.0	287.9	275.1	386.4	258.8	294.4
116	46.7	246.1	160.9	295.8	282.8	397.0	265.8	302.4
118	47.8	253.0	166.0	303.8	290.6	407.8	273.2	310.7
120	48.9	260.0	171.2	312.1	298.6	418.8	280.6	319.1
125	51.7	278.0	184.6	333.3	319.2	447.4	299.9	340.8
130	54.4	296.9	198.7	355.6	340.7	477.4	320.2	363.6