GAS HYDRONICS SERVICE CERTIFICATION

Certification Information

Scope - Tests a candidate's knowledge of the installation, service, maintenance, and repair of hot water heating 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 Hydronics** 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 Hydronics 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 Hydronics** exam.

SECTION AREA DESCRIPTION	SECTION PERCENTAGE
Installation	15%
Service	45%
Components	30%
Applied Knowledge	10%

Gas Hydronics 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
- 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

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

Heating - Hydronics - Gas

Service

INSTALLATION

INSTALLING GAS BOILERS

SELECTING GAS BOILER SITES

- Locating boilers in attics
- Locating boilers in crawlspaces
- Locating boilers in closets
- Locating boilers in basements
- Locating boilers in utility rooms
- Locating boilers in garages
- Locating boilers outdoor

PLACEMENT OF BOILERS

- How to place boilers in attics
- How to place boilers in crawlspaces
- How to place boilers in closets
- How to place boilers in basements
- How to place boilers in utility rooms
- How to place boilers in garages
- How to place boilers outdoor

INSTALLATION OF UTILITIES

- Installation of gas piping
- Installation of field wiring
- Convert from natural 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

INSTALL CONDENSATE DRAINS - CONDENSING BOILERS

- 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

INSTALLATION OF COMBUSTION AIR INLET 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

SIZING GAS BOILERS

- Sizing for structure capacity
- Sizing for domestic water capacity
- Sizing for radiant capacity
- Sizing for total capacity
- Sizing for snow melt capacity

DUCT INSTALLATION FOR HOT WATER HEATING SYSTEMS

DUCT FAB EQPMNT - INSTALL/REPAIR DUCTS TO HW COILS

- 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/INSTALL - CONNECTING HW COILS

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

INSTALL/REPAIR METAL DUCT - CONNECTING HW COILS

- 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

INSTALL/REPAIR FLEXIBLE DUCT - CONNECTING HW COILS

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

INSTALL/REPAIR DUCTBOARD - CONNECTING HW COILS

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

INSTALL GRILLE, REGISTER, DIFFUSER, DAMPER-HW COIL

- Mounting to ductwork
- Securing methods

CHASES USED AS DUCTS FOR HOT WATER COIL SYSTEMS

- Floor joists as air ducts
- Vertical chases

REPAIR DUCT WHEN REPLACING EQUIPMENT - HW COILS

- Reconnecting metal duct
- Reconnecting flexible duct
- Reconnecting ductboard duct

INSTALL/REPAIR OF PLENUMS & DUCT - HW COIL SYSTEMS

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

HYDRONIC COMPONENT INSTALLATION

INSTALLATION OF HEATING COMPONENTS (EMITTERS)

- Sizing and placement of baseboard units
- Sizing and placement of kickspace heaters
- Sizing and placement of unit heaters
- Sizing and placement of duct mounted heating coils
- Sizing and placement of hot water coil air handlers
- Sizing and placement of heating units
- Sizing and placement of air vents (manual or auto)
- Sizing and placement of domestic hot water heating
- Sizing and placement of radiant panels-floor and ceiling
- Sizing and placement of radiators
- Sizing, placement, and conversion of steam radiators to hot water radiators
- Sizing, placement, and conversion of steam systems to hot water systems

INSTALLATION OF COMPONENTS

- Location, selection, and sizing of circulators
- Location and sizing of Expansion tanks

- Location of Air Separators
- Location of Pressure Reducing Valve
- Location of Backflow Preventer
- Location and sizing of Relief Valves
- Location of Zone Valves
- Location of Flow Check Devices
- Location of indirect hot water heating
- Location and placement of heat emitters
- Location of Low water cutoffs
- Location of manual reset aquastats

INSTALLATION OF PIPING SYSTEMS

- Installation of Series-loop system
- Installation of One-pipe system
- Installation of Two-pipe system (Reverse return)
- Installation of two-pipe system (direct return)
- Installation of Primary-secondary piping system
- Installation of multiple zone systems
- Installation of system bypass and boiler bypass piping
- Installation of Indirect Water Heaters
- Installation of Low Water Cutoffs
- Installation of direct water heaters
- Installation and selection of antifreeze solutions

INSTALLING ACCESSORIES

INSTALLING THERMOSTATS

- Locating and mounting
- Wiring electromechanical thermostats
- Wiring electronic thermostats
- Programming of electronic thermostats
- Installation of Outdoor Reset Controls

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

PRE-START PROCEDURES

- Gas supply and proper shutoff
- Electrical
- Adequate combustion air provisions
- Venting system
- Coils connected to ducted systems
- Condensate system
- Filling and purging boiler and piping system

START-UP PROCEDURES AND CHECKS

- Voltage checks
- Check thermostat and set heat anticipator
- Motor checks
- Water circulation checks
- Airflow checks for coils connected to ducted systems
- 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 - DUCTED SYSTEMS W/ HOT WATER COILS

AIRFLOW VELOCITY MEASUREMENTS

Pitot tube and manometer in measuring static pressure
Discharge velocity equipment
Velometer - electronic and mechanical
Anemometer
Velocity measurement procedures
Gauge calibration
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)

WATER MEASUREMENTS

TEMPERATURE MEASUREMENTS

Temperature Rise
Temperature Drop

WATER PRESSURE MEASUREMENTS

Pressure Requirements
Pump head
Static fill pressure
Pressure Drop

WATER VOLUME MEASUREMENTS

GPM Requirements

FREEZE PROTECTION FLUID

Checking and correcting acidity

SERVICE

PLANNED MAINTENANCE

SYSTEM MECHANICAL PM CHECKS

Filters - check and change
Lubrication
Cabinet care
Fan blades / blower scroll
Gas connections
Flue / vent stack inspection
Combustion air supply
Duct inspection for systems with hot water coils installed in ducts
Heat exchanger - inspection, cleaning, replace gaskets etc
Burner assembly
System airflow
Expansion tank
Water treatment
Circulators

COMBUSTION PM CHECKS

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

ELECTRICAL PM CHECKS

- General wiring
- Induced draft motor
- Supply air motor
- Operation sequence
- Thermostat calibration and operation
- Fan switch and high limit control
- Limit controls operation
- Aquastat operation
- Low Water Cut Off (LWCO) Operation

DIAGNOSTICS AND REPAIR

TROUBLESHOOTING SEQUENCE OF OPERATION

- Check for proper sequence of operation
- Interpreting system fault during 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
- Noisy conditions due to air in piping

ANALYZING COMBUSTION

- CO2 and O2 checks for efficiency
- Balancing combustion, ventilation, primary and secondary air
- Analyzing air leaks and efficiency loss
- Analyzing low draft-stack, overfire
- Analyzing excessive draft-stack, overfire
- Analyzing excessive draft on off cycle
- Interpreting steady state efficiency measurements - stack loss calculations

SYSTEM AIR SIDE DIAGNOSTICS - SYSTEMS W/ HW COILS

- 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
- 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-high temperature
- Centrifugal switch
- Door interlock switch
- Circulators
- Zone valves
- Boiler water controls (high limit, low limit, operating)
- Low water cut-off
- Flow switch

REPAIR

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

COMPONENT REPLACEMENTS

- Transformers
- Relays and contactors
- Indoor blowers
- Capacitors
- Heat exchanger
- Gas valve
- Safety circuit switches
- Draft motor
- Pilot / ignitor assembly
- Flame sensing rod
- Circulators
- Zone Valves for non-radiant systems
- Zone Valves for radiant systems
- Boiler water controls
- Bearing Assemblies
- Low Water Cut Off (LWCO)
- Indoor/Outdoor Resets
- Modulating Valves
- Mixing Valves
- Boiler Protection

VENT SYSTEM CHECKS

- Natural / atmospheric draft
- Forced draft
- Induced 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

SYSTEM WATER SIDE DIAGNOSTICS

- Temperature checks
- Checking system water pressure
- Checking zone valve operation
- Checking supply GPM

Checking for leaks in supplies
Checking for leaks in returns
Checking low water cutoffs
Checking flow control valves
Checking mixing valves
Checking relief valves

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

O2 measurements
Carbon Dioxide measurements

LEAK DETECTION

Carbon monoxide detector

AIR BALANCING FOR SYSTEMS WITH HOT WATER COILS

GATHERING DESIGN INFORMATION

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

PREPARATION OF SYSTEM FOR TESTS

Locating registers, grilles, equipment, controls, dampers and valves in building walkthrough
Setting dampers and valves for tests
Setting thermostat for tests
Checking for proper fan pump 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 water-flow and air-flow to verify that it is within design requirements

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

WATER BALANCING

GATHERING DESIGN INFORMATION

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

PREPARATION OF SYSTEM FOR WATER TESTS

- Locating equipment and controls building walkthrough
- Setting equipment and controls for tests
- Setting thermostat for tests
- Checking for proper pump operation and rotation
- Checking for proper pressure and temperature

PROCEDURES FOR CONDUCTING WATER TESTS

- Measurements of each supply outlet - total readings
- Measurements of each return inlet - total readings

MAKING ADJUSTMENTS

- Adjust flow to achieve required total flow
- Re-measure total supply and return flow
- Adjust valves to obtain design flow
- Re-measure total flow to verify that it is within +/- 10%

FINAL TEST

- Comparing manufacturer's equipment information with test results
- Record equipment data
- Test and record full load motor amperes
- Test and record voltage
- Test and record motor and pump RPM with visible components
- Test and record supply and return pressures
- Test and record supply and return temperatures - heat and cool

COMPLETION OF APPROPRIATE FORMS

- HVAC system report
- System diagrams
- Instrument list - including calibration dates

BASIC HVAC SYSTEM ANALYSIS

NOISE PROBLEMS

- Interpreting supply / return water volume
- Noise problems
- Pump cavitation
- Oil canning
- Motor / belt noise
- Vibration

HIGH UTILITY BILLS

- Interpreting supply / return water temperature
- Interpreting supply / return water volume
- Evaluating Leakage
- Evaluating Insulation
- Envelope infiltration

Thermostat location and adjustment

WIDE TEMPERATURE SWINGS

Interpreting supply / return water temperature
Interpreting supply / return water volume
Interpreting Leakage
Interpreting Insulation
Envelope infiltration
Thermostat air sensing

SINGLE AREA IS HOT OR COLD

Interpreting supply / return water temperature
Interpreting supply / return water volume
Evaluating Leakage
Evaluating Insulation
Envelope infiltration
Thermostat air sensing
Zone Valves
Circulator
Circulator controls
Venting
Variable speed pumps Multi-
zone controls
Set point boiler protection

INDOOR AIR QUALITY

Number of air changes per hour
Odor control
Contaminants
Humidity

ANALYZING REPORTED SYMPTOMS IN HEATING

IMPROPER HEATING

Interpreting supply / return water temperature (TD)
Interpreting supply / return water volume
Interpreting system sizing
Evaluating leakage
Temperature Drop/Rise of air in ducted hot water coil systems
Zone Valves
Circulators
Circulator controls
Outdoor Reset Control
Venting

HUMIDITY PROBLEMS

Interpreting Low Humidity
Interpreting High Humidity
Interpreting Correct Humidity

DRAFTY

Interpreting supply / return water and air temperature
Interpreting supply / return water and air volume

SYSTEM COMPONENTS

INTRODUCTION TO BASIC SYSTEMS & COMPONENTS

HEAT TRANSFER

Fundamentals of heat transfer
Psychrometrics

BOILER CONFIGURATIONS & APPLICATIONS

BOILER CONFIGURATIONS

Gravity hot water
Forced hot water
Diverter T
Series loop
Direct return
Reverse return
Pump Return

- Air handling systems
- Zone Control
- Wet-base Dry-base
- Horizontal Tube
- Copper fin boilers
- Condensing Boilers
- Wall hung boilers
- Near boiler piping
- Radiant
- Primary / secondary loop piping

GAS BOILERS WITH SPLIT OR HYDRO-AIR AC SYSTEMS

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

COMBUSTION PROCESS FOR GAS BOILER SYSTEMS

COMBUSTION - NATURAL GAS

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

COMBUSTION - MANUFACTURED GAS (LPG)

- Describe commercial propane's role in combustion
- Describe commercial butane'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 BOILER - COMPONENTS

HEAT EXCHANGERS

- Cast Iron
- Steel
- Stainless Steel

BURNERS

- Describe ribbon/slot burners In-shot burners
- Power burners

COMBUSTION AIR REQUIREMENTS

OUTDOOR AIR SPECIFICATIONS

- Attic applications
- Crawlspace applications
- Closet applications
- Basement applications
- Outdoor applications

INDOOR AIR SPECIFICATIONS

- Attic applications
- Crawlspace applications
- Closet applications
- Basement applications

AIR DISTRIBUTION FOR SYSTEMS WITH HOT WATER COILS

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

HYDRONIC DISTRIBUTION

WATER DISTRIBUTION

Pumps
Two way valves
Three way valves
Diverter tee systems

PIPING SYSTEM

Piping system design
Piping configurations

FLUID FLOW

Introduction to circulators
Zone Valves
Flow Checks
Mixing valves
Thermostatic valves
Diverter tee systems
Balancing Zones
Compression / expansion tanks

WIRING LAYOUTS

POWER WIRING

Power wiring for boiler
Power wiring for split system Air Handler

LOW VOLTAGE

Overview of low voltage wiring
Zone control wiring
Outdoor reset wiring

NATURAL DRAFT GAS BOILER - OPERATION

GAS BOILER - OPERATION

Overview of operation for standing pilot boiler
Overview of operation for intermittent pilot boiler
Overview of operation for direct ignition boiler

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 ignited pilots

VENT SYSTEMS

Fundamentals of atmospheric draft systems
Horizontal vent systems

SEQUENCE OF OPERATION

Typical operation for standing pilot boiler
Typical operation for intermittent pilot boiler
Typical operation for direct ignition boiler

CONTROL FUNCTIONS

Fan control
Heat limit control Roll-
out switch

- Flame proving
- Gas valve

INDUCED DRAFT NON-CONDENSING - COMPONENTS

HEAT EXCHANGERS
- Cast Iron
- Steel
- Stainless steel

BURNERS
- Ribbon/slot burners
- In-shot burners

INDUCED DRAFT BLOWERS
- Introduction
- Role in system operation

INDUCED DRAFT NON-CONDENSING - OPERATION

GAS BOILER - OPERATION
- Standing pilot boiler
- Intermittent pilot boiler
- Direct ignition boiler

STANDING PILOT IGNITION
- Basics of operation
- Flame proving

INTERMITTENT PILOT IGNITION
- Spark ignited pilots
- Hot surface ignited pilots

DIRECT IGNITION
- Spark ignited
- Hot surface ignited pilots

VENT SYSTEMS
- Vertical vent systems
- Horizontal vent systems

SEQUENCE OF OPERATION
- Typical operation for standing pilot boiler
- Typical operation for intermittent pilot boiler
- Typical operation for direct ignition boiler

CONTROL FUNCTIONS
- Venting fan control
- Heat limit control
- Roll-out switch
- Flame proving
- Air pressure proving switch
- Gas valve
- Pump/circulator control
- Ignition control
- Gas pressure proving switch

INDUCED DRAFT CONDENSING - COMPONENTS

HEAT EXCHANGERS
- Cast Iron
- Steel
- Stainless streel
- Aluminum
- Secondary heat exchanger

BURNERS
- In-shot burners

INDUCED DRAFT BLOWERS
- Introduction
- Role in system operation

INDUCED DRAFT CONDENSING - OPERATION

GAS BOILER - OPERATION
- Intermittent pilot boiler
- Direct ignition boiler

- INTERMITTENT PILOT IGNITION
  - Spark ignited pilots
  - Hot surface ignited pilots
- DIRECT IGNITION
  - Spark ignited
  - Hot surface ignited pilots
- VENT SYSTEMS
  - Vertical vent systems
  - Horizontal vent systems
- SEQUENCE OF OPERATION
  - Intermittent pilot boiler
  - Direct ignition boiler
- CONTROL FUNCTIONS
  - Fan control
  - Heat limit control
  - Roll-out switch
  - Flame proving
  - Air pressure proving switch
  - Gas valve
  - Door interlocks
  - Ignition control
  - Gas pressure proving switch

NON-SENSING CONTROLS

- RELAYS AND CONTACTORS
  - Relay and contactor operation - inrush and holding
  - Selecting relays and contactors
  - Applications for relays and contactors
- GAS VALVES - SINGLE STAGE
  - Construction
  - Operation
  - Slow opening valves
  - Snap opening valves
  - Step opening valves
- GAS VALVES - TWO STAGE
  - Construction
  - Operation

IGNITION CONTROL SYSTEMS

- OVERVIEW OF IGNITION CONTROLS
  - Elements of gas boiler ignition systems
  - Ignition controls for natural draft / standing pilot boiler / manually lit
  - Ignition controls for induced draft / intermittent pilot spark ignition systems
  - Ignition controls for induced draft / intermittent pilot hot surface ignition systems
  - Ignition controls for induced draft / direct ignition / spark ignition systems
  - 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
  - Ignition sequence
  - Safety

ELECTRONIC CONTROLS

- ELECTRONIC CONTROLLERS
  - Input / output operations
  - Logic

ELECTRONIC THERMOSTATS
- Fundamentals of electronic thermostats
- Selecting electronic thermostats
- Electronic thermostat operation
- Outdoor Reset Controllers for non-zone systems
- Outdoor Reset Controllers for zone systems (pump and/or zone valves)

ELECTRONIC TIMERS
- Blower delay timers

ELECTROMECHANICAL SENSING CONTROLS

ELECTROMECHANICAL WALL THERMOSTATS
- Thermostat types and operation
- Selecting wall thermostats and sub-bases
- Thermostat terminals and wiring
- Using electromechanical thermostats
- Selecting location
- Role of anticipators in thermostatic control

ELECTROMECHANICAL TEMPERATURE CONTROLS
- Bimetal controls
- Disc type temperature limit controls
- Fuses and fuse links
- Motor overloads

PRESSURE CONTROLS
- Operation of pressure controls
- Using pressure controls
- Air proving pressure switch
- Gas proving pressure switch

APPLIED KNOWLEDGE: REGS, CODES, & DESIGN

REGULATIONS FOR ENVIRONMENTAL PROTECTION

INDOOR AIR QUALITY
- Fresh air supplies

ELECTRICAL CODE

ELECTRIC REQUIREMENT
- Overview of electric code
- Overcurrent protection
- Wiring methods and materials
- Line voltage wiring sizing
- Low voltage wiring 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
- Gas detectors

CODES
- Plumbing
- Municipalities
- Gas boiler for Lt. Commercial
- Gas boiler for Residential

FIRE PROTECTION REGULATIONS AND CODES

REQUIRED COMPONENTS
- Return air sensors
- Fire dampers
- Smoke dampers
- Components

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

BOILER ACCESS
- Access to boiler for service
- Access to utilities for service

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

INSTALLATIONS
- Installation of gas burning equipment

FIRE PREVENTION
- 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 BOILER EQUIPMENT

GAS BOILERS WITH SPLIT OR HYDRO-AIR AC SYSTEMS
- 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

COMBUSTION GAS VENTING
- Sizing flue pipe
- Flue pipe layout
- Adapting vent draft control - damper
- Roof fittings - cap, collar, flashing, etc.
- Pipe types - PVC and B-metal

DESIGN CONSIDERATIONS - EXTERNAL COMPONENTS

FLUID DISTRIBUTION ACCESSORIES
- Distribution for capacity including baseboard, floor, kick-space, panel and other emitters
- Distribution for reduced sound including baseboard, floor, kick-space, panel and other emitters
- Locations

AIR SIDE ACCESSORIES
- Humidifier sizing
- Twinning kits
- Electronic air cleaners (EAC's)
- Selecting diffusers, grilles, registers for systems with distribution devices in ducts.

MECHANICAL CODE

COMBUSTION AIR
- Air intakes in confined spaces

- Sources of combustion air

BOILER ACCESS

- Access to boiler for service
- Access to utilities for service

GAS PIPING

- Sizing for capacity
- Length limitations
- Attachment to appliance

WATER PIPING

- Cross Contamination/backflow prevention

INDUSTRY STANDARDS

EQUIPMENT STANDARDS

- Performance and safety standards
- Efficiency requirements
- Manufacturers specifications

SYSTEM 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.

$CFMn = CFMo \times \frac{RPM}{o}$ $RPMn = RPMo \times \frac{CFM}{o}$

$\left(\frac{CFM_n}{CFM_o}\right)^2 = \frac{Sp_n}{Sp_o}$ OR $CFMo = JSPP;$ $CFM_n = CFM_o \times \sqrt{\frac{Sp_n}{Sp_o}}$ $Sp_n = Sp_o \times \left(\frac{CFM_n}{CFM_o}\right)^2$

$(\frac{CF}{CFM_o})^3 = \frac{BHPn}{BHP_o}$ OR $CFM_o = \frac{BHPn}{BHP_o}$ $CFM_n = CFM_o \times \sqrt[3]{\frac{BHP_n}{BHP_o}}$ $BHPn = BHPo \times (\frac{CFMn}{CFM_o})^3$

Hydronics: AP =Sp, CFM = GPM, RPM= GPM

$MAT = (OAT \times \%0A) + (RATx\ \%RA)$

0 =Outside
T = Temperature
R =Return
M=Mixed
A=Air

Btuh hydronic (H_20 only) = 500 x GPM x AT
Btuh sensible (at sea level) = 1.08 x CFM x AT
Btuh latent (at sea level) = 0.68 x CFM x AGrains
Btuh total (at sea level)= 4.5 x CFM x AEnthalpy

$CFM = \frac{AC/Hr \times Volume}{60min}$ $V = 4005 \times .Jvp$ $Vp = <4:05)2$

Pressure (PSI)= 0.433 x Head (feet of water)

1 IWC = 0.0360 PSI
1 PSI= 27.72 IWC

Pressure 1 x Volume 1 = Pressure 2 x Volume 2

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

$Area = 1t \times radius^2$

$A^2 + B^2 = C$

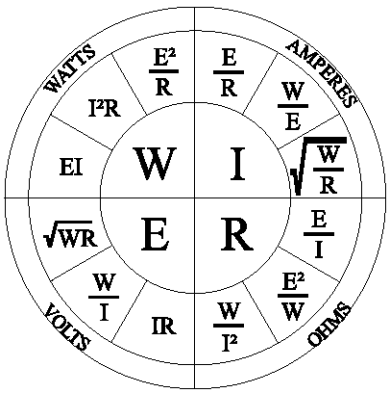
Round Duct Area (ft2) = $\frac{1t \times diameter}{576}$

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

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

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

CFM = Velocity (fpm) x Duct Area (ft^2)



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

$Cr\ (Series) = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \ldots + \frac{1}{}}$

$C_T\ (Parallel) = C_1 + C_2 + \ldots + C_N$

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	*14.8*	4.3	*4.6*	10.7	2.3	5.4
-38	-38.9	1.4	*13.9*	5.3	3.2	12.0	*0.8*	6.4
-36	-37.8	2.2	*13.0*	6.3	*1.6*	13.4	0.4	7.5
-34	-36.7	3.1	*12.0*	7.4	0.0	14.8	1.2	8.6
-32	-35.6	4.0	*10.9*	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

CONTINUED

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	0C	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	1092	101.7	148.1	96.1	112.0
54	12.2	90.8	50.0	1133	105.6	153.5	998	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	1305	122.3	176.3	1154	133.7
64	17.8	109.3	62.7	1350	126.7	182.4	1195	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	1594	150.3	214.8	1417	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	185.8	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	1867	176.8	251.2	1665	191.0
86	30.0	158.2	97.0	1925	182.4	258.9	1718	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	2170	206.3	291.6	1941	222.0
96	35.6	184.6	115.9	2234	212.5	300.3	2000	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	2578	245.9	346.2	2313	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	287.6	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	2958	282.8	397.0	2658	302.4
118	47.8	253.0	166.0	3038	290.6	407.8	2732	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