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

✓ 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.

✓ 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.

✓ 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

<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>
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Listed are the percentages of questions that will be in each section of the Gas Hydronics exam.

<table>
<thead>
<tr>
<th>SECTION AREA DESCRIPTION</th>
<th>SECTION PERCENTAGE</th>
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<tbody>
<tr>
<td>Installation</td>
<td>15%</td>
</tr>
<tr>
<td>Service</td>
<td>45%</td>
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<tr>
<td>Components</td>
<td>30%</td>
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<tr>
<td>Applied Knowledge</td>
<td>10%</td>
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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”, “Q1” - Quality Installation, and “S”
- ACCA Manuals “T” and “RS” - Latest Editions
- ACCA Residential Duct Diagnostics and Repair - Latest Edition
- AHRI-Hydronics Section-IBO/RAH Latest Edition
- International Mechanical Code - Latest Edition with Addendum
- International Plumbing Code - Latest Edition with Addendum
- Uniform Mechanical Code - Latest Edition with Addendum
- ENERGY STAR™ Home Sealing Standards - Latest Edition with Addendum
- 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

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 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 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 - crawlspaces
- Combustion air inlets in confined spaces - closets
- 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 steel
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
\[
\frac{\text{CFM}_n}{\text{CFM}_o} = \frac{\text{RPM}_n}{\text{RPM}_o} \quad o = \text{old, } n = \text{new}
\]

CFM and RPM are interchangeable.

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

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

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

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

Hydronics:

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

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

\[
Btu\text{hydronic (H}_2\text{O only)} = 500 \times \text{GPM} \times \text{AT}
\]

\[
Btu\text{sensible (at sea level)} = 1.08 \times \text{CFM} \times \text{AT}
\]

\[
Btu\text{latent (at sea level)} = 0.68 \times \text{CFM} \times A\text{Grains}
\]

\[
Btu\text{total (at sea level)} = 4.5 \times \text{CFM} \times A\text{Enthalpy}
\]

\[
\text{AC/Hr} \times \text{Volume}
\]

\[
\text{CFM} = \frac{\text{v}}{60\text{min}}
\]

\[
\text{v} = 4005 \times Jvp
\]

\[
Vp = <4:05\text{ hj}
\]

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

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

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

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

\[
\text{Area} = 1t \times \text{radius}^2
\]

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

\[
\text{Circumference} = 1t
\]

\[
\text{Diameter} = \frac{1t}{2}
\]

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

\[
\text{FR} = \text{TEL} \quad (\text{IWq}100)
\]

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

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

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

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

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

\[
\text{Cr (Series)} = \frac{1}{c1 + \frac{1}{c2 + ... + \frac{1}{cn}}}
\]

\[
\text{Cr (Parallel)} = c1 + c2 + ... + cn
\]
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)

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To determine subcooling for 404A, 407C, and 4220, use BUBBLE POINT values (temperatures above 50°F -gray background)
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Pressure (PSIG), Vacuum (in. Of Hg)-Bold Italic Figures

Figures atsealevel and below)