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. Once certification is obtained it lasts for five years.
- 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>
</tr>
</thead>
</table>

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>
</tr>
<tr>
<td>Components</td>
<td>30%</td>
</tr>
<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”, “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 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 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 control 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

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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
\[
\frac{\text{CFM}_n}{\text{CFM}_o} = \frac{\text{RPM}_n}{\text{RPM}_o} \quad o = \text{old}, \; n = \text{new} \\
\text{CFM and RPM are interchangeable.}
\]

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

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

**Hydronics:** \[\Delta P = \text{Sp}, \quad \text{CFM} = \text{GPM}, \quad \text{RPM} = \text{GPM}\]

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

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

\[
\text{Btuhradonic (H}_2\text{O only)} = 500 \times \text{GPM} \times \Delta T
\]

\[
\text{Btuhr sensible (at sea level)} = 1.08 \times \text{CFM} \times \Delta T
\]

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

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

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

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

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

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

\[
1 \text{ IWC} = 0.0360 \text{ PSI} \\
1 \text{ PSI} = 27.72 \text{ IWC}
\]

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

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

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

\[
\text{Diameter} = \frac{\text{Circumference}}{\pi}
\]

\[
\text{FR} = \frac{\text{ASP} \times 100}{\text{TEL}} \quad \text{(IWC/100)}
\]

\[
1 \text{Watt} = 3.413 \text{ BTU/hr}
\]

\[
\text{CFM} = \frac{\text{Velocity (fps)} \times \text{Duct Area} (ft^2)}{(\Delta T \times 1.08)}
\]

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

\[
C_T (\text{Parallel}) = C_1 + C_2 + \ldots + C_n
\]
### TEMPERATURE PRESSURE CHART

**Pressure (PSIG), Vacuum (in. Of Hg) – Bold Italic Figures**

To determine subcooling for 404A, 407C, and 422D, use BUBBLE POINT values (temperatures above 50°F – gray background)

To determine superheat for 404A, 407C, and 422D, use DEW POINT values (temperatures 50°F and below)

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# Temperature Pressure Chart

Pressure (PSIG), Vacuum (in. Of Hg) – Bold Italic Figures

To determine subcooling for 404A, 407C, and 422D, use BUBBLE POINT values (temperatures above 50°F – gray background)

To determine superheat for 404A, 407C, and 422D, use DEW POINT values (temperatures 50°F and below)

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