Certifying the finest in HVACR

Senior Level Efficiency Analyst

KATE

Knowledge Areas of Technician Expertise

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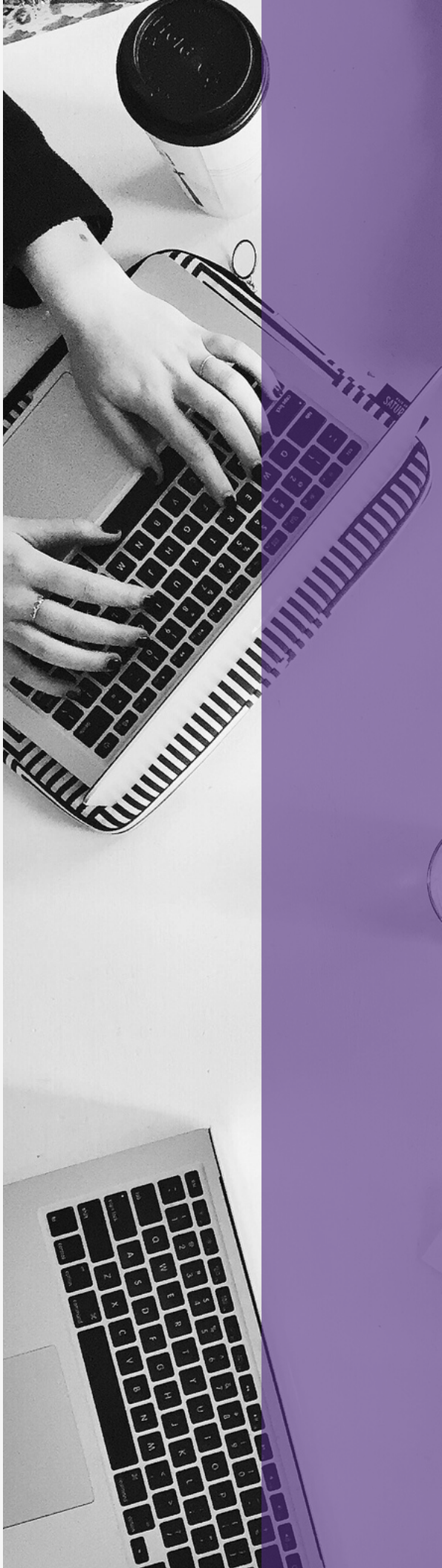

Senior Level Efficiency Analyst Exam

Exam Information & Qualifications

The Senior Level Efficiency Analyst exam tests a candidate's knowledge of the installation, service, maintenance, and repair of HVAC systems operations to maintain high levels of energy efficiency. System sizes are limited to 10 tons or less of Air Conditioning and 325,000 BTU or less heating capacity. This is a test and certification for technicians in the HVAC industry. The test is designed for the highest level senior technicians. This test for certification is not intended for the HVAC system designer, sales force, or the engineering community.

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

As a pre-requisite to sit for the HVAC Efficiency Analyst exam, the candidate shall hold two (2) certifications by NATE in Service Sector Specialties as follows:

- Air Conditioning (AC) plus one of the following: AD, GS, OL, HG, or HO
- Air Distribution (AD) plus one of the following: AC, GS, HP, OL, HG, or HO
- Gas Heating (GS) plus one of the following: AC, AD, or HP
- Heat Pump (HP) plus one of the following: AD, GS, OL, HG, or HO
- Oil Heating (OL) plus one of the following: AC, AD, HP, HG, or HO
- Hydronics Gas (HG) plus one of the following: AC, AD, or HP
- Hydronics Oil (HO) plus one of the following: AC, AD, or HP

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 Subject Areas

Percentages of questions that will be in each section of the exam:

- LOAD CALCULATION - 15%
- EQUIPMENT SELECTION - 10%
- AIR DISTRIBUTION - 20%
- HYDRONIC DISTRIBUTION - 7%
- SYSTEM PERFORMANCE - 35%
- INDOOR AIR/ENVIRONMENT QUALITY - 7%
- PLANNED MAINTENANCE - 6%

Exam Specifications:

- **Passing Score: Pass/Fail**
- **4 Hour Time Limit**
- **Open Book**
- **100 Questions**

Industry References

> The reference materials list 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.

- Duct Calculators – Sheet Metal, Ductboard, and Flexible Duct
- 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
- 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

References continue on next page

Industry References (continued)

- International Energy Conservation Code - Latest Edition with Addendum
- Air Diffusion Council Flexible Duct Performance & Installation Standards
- North American Insulation Manufacturers Association (NAIMA) Manuals
  - Fibrous Glass Duct Construction Standards and A Guide to Insulated Air Duct Systems
- International Mechanical Code - Latest Edition with Addendum • International Fuel Gas Code – Latest Edition with Addendum
- National Fuel Gas 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

KATES Knowledge Areas of Technician Expertise

All NATE exams are based on Knowledge Areas of Technician Expertise (KATEs), statistically proven job task analysis from experts in the HVACR industry. This KATEs outline covers all information tested in the **Senior Level Efficiency Analyst Exam** and should be used as reference material.

Load Calculation

Customer Survey

- WEATHER DATA
  - Design temperature - summer
  - Design temperature - winter
  - Heating degree days
  - Cooling degree days
  - Equivalent full load hours
- BUILDING ORIENTATION
  - Building orientation
- BUILDING SETTING OPTIONS
  - On slab construction
  - Crawlspace
  - Partial basement (cellar)
  - Full basement
- TAKE OFFS - BLUEPRINT OR ACTUAL SITE REVIEW
  - Construction of walls
  - Area of walls
  - Insulation of walls
  - Number of windows (fenestration)
  - Area of windows (fenestration)
  - Construction of windows (fenestration)
  - Orientation of windows (fenestration)
  - Shading of windows (fenestration)
  - NFRC window ratings (thermal effectiveness)
  - Construction of floors Area of floors
  - Insulation of floors
  - Construction of ceilings
  - Area of ceilings
  - Insulation of ceilings
  - Construction of roof
  - Area of roof
  - Insulation of roof

KATES Knowledge Areas of Technician Expertise

Load Calculation (continued)

    - Area of skylight(s)
    - Thermal effectiveness of skylight(s)
- COORDINATION W/ ARCHITECT/DESIGNER/BUILDER/OTHER
    - Developing a good system design plan
    - Ensuring good practices amongst the trades

Zoning

- SINGLE ZONE
    - Ducted Hydronic
- MULTIPLE ZONES
    - Ducted Hydronic

Infiltration

- AIR CHANGES PER HOUR
    - Equal exchange requirements
    - Heat gain / loss per CFM
    - Latent loss / gain per CFM
    - Building assembly air leakage - normal / tight
- OCCUPANCY STANDARDS
    - Code requirements per occupancy
- EQUIPMENT REQUIREMENTS
    - Combustion air
    - Ventilation air
    - Dilution air
- DIAGNOSTIC TOOLS
    - Envelope pressurization test (blower door)
    - Duct leakage test (duct blaster)
- HOME SEALING
    - Standards
    - Requirements

Exfiltration - Exhaust Requirements

- OCCUPANCY STANDARDS
    - Code requirements per occupancy
- EQUIPMENT REQUIREMENTS
    - Boiler / furnace venting requirements
    - Combustion air zone requirements

KATES Knowledge Areas of Technician Expertise

Load Calculation (continued)

Ventilation

- HEAT RECOVERY VENTILATOR (HRV)
- ENERGY RECOVERY VENTILATOR (ERV)
- NTERNAL LOADS
  - Human occupancy
  - Equipment loads

Heat Lost

- TOTAL
- SENSIBLE
- LATENT

Heat Gain

- TOTAL
- SENSIBLE
- LATENT

Duct Loads

- GAIN
  - Total
  - Sensible
  - Latent
  - Infiltration
- LOSS
  - Total
  - Sensible
  - Latent
  - Infiltration
- DUCT DESIGN LOSS
  - Efficiency impact
  - Comfort impact
  - Improper duct design impact
  - Improper duct
  - installation impact
  - Improper duct location impact

KATES Knowledge Areas of Technician Expertise

Load Calculation (continued)

Regulations

- INDOOR AIR QUALITY
  - Fresh air supplies

Codes

- Energy
- Plumbing
- Mechanical
- Fire
- Municipalities

Design Considerations - Comfort

- TEMPERATURE
  - Designing for capacity
  - Using standard
- HUMIDITY
  - Role of humidity in total comfort
  - Using standards
  - Humidity control related to cooling equipment size (over-sizing)
- INDOOR AIR QUALITY
  - Ventilation - total comfort
  - Air cleaning for total comfort
  - Standards for air quality
  - Outside air
  - Filter ratings (MERV) related to system efficiency
  - Filter effect on system efficiency related to static pressure during load calculation
- SOUND LEVEL
  - Equipment location considerations
  - Isolation, mounting pad, duct, and structure
  - Duct systems - flex joints
- ZONING
  - Single zone
  - Multi-zone

KATES Knowledge Areas of Technician Expertise

Load Calculation (continued)

Design Considerations - Residential

- SPLIT SYSTEMS
  - Ventilation - fresh air
  - Ventilation - equipment
- AIR BALANCING
  - Duct sizing
  - Blower speed adjustments
  - Damper position adjustments
  - Estimated air-flow rate for proper capacity
- HYDRONIC BALANCING
  - Pipe sizing
  - Pump speed adjustments
  - Flow control position adjustments
  - Estimated flow rate for capacity

Design Considerations - Components

- IMPACT OF DIFFUSERS, GRILLES, & REGISTERS
  - Energy use Comfort
  - Temperature stratification
- IMPACT OF TEMPERATURE STRATIFICATION
  - Energy use Comfort
- IMPACT OF DIFF., GRILLES,& REGISTERS ON VSM'S SELECTING DIFFUSERS FOR ENERGY EFFICIENCY
  - Selecting diffusers for capacity Selecting diffusers for reduced sound
  - Selecting diffusers for spread, throw, and pressure drop Locations
- SELECTING GRILLES FOR ENERGY EFFICIENCY
  - Selecting grilles for capacity
  - Selecting grilles for reduced sound
  - Selecting location
- SELECTING REGISTERS FOR ENERGY EFFICIENCY
  - Selecting registers for capacity
  - Selecting registers for reduced sound
  - Selecting registers for spread, throw, and pressure drop
  - Locations
  - Impact of registers on temperature stratification and energy use
- DUCTS & FITTINGS - IMPACT ON ENERGY USE
  - Specifying physical dimensions
  - Sketching duct layout
  - Duct fitting equivalency - Equivalent Length to duct size

KATES Knowledge Areas of Technician Expertise

Load Calculation (continued)

- SPECIAL DUCTS & FITTINGS
  - Working drawingsvs. Isometric drawings
  - Markings and abbreviations for duct fitting and manufacturing Measurement for replacement of special duct or fitting
  - STATIC PRESSURE LOSSES
  - Energy impacts of fan motors with variable speed Energy impactson PSC fan motors
  - Filter grilles
  - Electronic Air Cleaner (EAC) Electrostatic
  - Media type filters
  - Use of alerts / reminders to change filters
- SELECTING HYDRONIC COMPONENTS
  - Selecting radiant outputdevices
  - Selecting different in-floor configurations
  - Selecting boiler temperature control devices
  - Selecting valves based on pressure drop / capacity
  - Selecting coils by capacity
  - Selecting pumps
  - Selecting pipe insulation
  - Selecting other distribution devices (hydronic specialties)
- BLUEPRINT READING
  - Determination of dimension from scale blueprint / plans
  - Reading blueprints / plans
  - Visualizing duct layout from blueprints / plans

Mechanical Code

- EQUIPMENT ACCESS
  - Minimum clearance
  - Electrical disconnects
  - Fire dampers
- REFRIGERANT LINE ROUTING
  - Support requirements
  - Inspection requirements
- CONDENSATE DRAINS
  - Materials
  - Sizing
  - Location and routing
  - Clean outs and cut-offs

KATES Knowledge Areas of Technician Expertise

Installation (continued)

- EQUIPMENT STANDARDS
  - Introduction to industry standards
  - ARI standards for ratings
- SYSTEM STANDARDS
  - Introduction to industry standards
  - ASHRAE standards
  - SMACNA standards
  - ACCA standards
  - CEE specifications

Design Considerations - Light Commercial

- SPLIT SYSTEMS
  - System designs - closets, basements, etc.
  - Air distribution systems
  - Ventilation - fresh air
  - Ventilation - equipment
- PACKAGED SYSTEMS
  - System designs
  - Economizers
  - Ventilation - equipment
- AIR BALANCING
  - Duct sizing
  - Blower speed adjustments
  - Damper position adjustments
  - Measurement of air flow rate
  - Fan laws

Design Considerations - Incorrect Load

- CONSEQUENCES OF OVER-SIZING
- BIDS AND PROPOSALS
- SYSTEM SIZING
  - Survey of requirements
  - Selecting equipment
  - Selecting accessories
- PREPARATION FOR PROPOSAL
  - Understanding forms for proposals and bids
  - Understanding legal implications of a bid

KATES Knowledge Areas of Technician Expertise

Equipment Selection

Capacity

- DESIGN HEATING LOAD
  - Total load
  - Sensible load
  - Latent load
  - CFM / FPM Requirements
  - GPM / PSI Requirements
  - Ventilation requirements
  - Matching of condenser and evaporator coil capacity - heat pumps
  - Impacts of heat recovery or energy recovery ventilators
  - Impacts of over-sizing and/or under-sizing
- DESIGN COOLING LOAD
  - Total load
  - Sensible load
  - Latent load
  - CFM / FPM Requirements
  - GPM / PSI Requirements Ventilation requirements
  - Impact of airflow on humidity removal
  - Matching of condenser and evaporator coil capacity
  - Use of thermostats to control humidity through airflow control
  - Impacts of heat recovery or energy recovery ventilators
  - Impacts of over-sizing and/or under-sizing
- DESIGN VENTILATION LOAD
  - Total load
  - Sensible load
  - Latent load
  - CFM / FPM Requirements
  - Ventilation requirements - natural / mechanical
  - Impact of airflow on humidity removal
  - Use of controls for humidity through airflow control
  - Impacts of heat recovery or energy recovery ventilators
  - Impacts of over-sizing and/or under-sizing
  - Impacts of night ventilation Impacts of attic ventilation
  - Impacts of evaporative coolers

KATES Knowledge Areas of Technician Expertise

Equipment Selection (continued)

Efficiency

- SYSTEM EFFICIENCY
  - Steady state efficiency
  - Define ducts inside conditioned space
  - Ducts outside conditioned space
  - Ducted system gains / losses
  - Hydronic system gains / losses
- HEATING EFFICIENCY
  - Gas furnace / boiler - Annual Fuel Utilization Efficiency (AFUE)
  - Efficiency gains with condensing furnaces vs. 80%
  - Comfort / efficiency gains with variable speed blower systems
  - Comfort / efficiency gains with two stage heating
  - Discussion of reduced comfort / efficiency of over-sizing heating systems Impact of furnace fan
  - Oil furnace / boiler - combustion efficiency
  - Electric furnace / boiler efficiency
- COOLING EFFICIENCY
  - Seasonal Energy Efficiency Ratio (SEER)
  - Importance of coil selection on efficiency and capacity (sensible/latent)
  - Energy Efficiency Ratio (EER)
  - Impact of furnace fan

Capacity Controls

- AIR DISTRIBUTION SYSTEM
  - Constant fan speed selection - 1, 2, 3, 4
  - Variable fan speed selection
  - Thermostat control
  - CFM selection for humidity removal
  - Constant CFM per ton
  - Zoning control system
- WATER DISTRIBUTION SYSTEM
  - Constant pump speed selection
  - Variable pump speed selection
  - Zoning control system - valves or pumps

KATES Knowledge Areas of Technician Expertise

Equipment Selection (continued)

- BOILER / FURNACE COMPONENTS
  - Constant firing rates
  - Variable firing rates
  - Electrical sequencing
  - Flow controls
- COOLING COMPONENTS
  - Single compressor
  - Dual speed compressors
  - Unloading compressors
  - Multiple compressors
  - Variable speed compressors
  - Metering devices

Low Ambient Controls

- HEATING
  - Outdoor reset control
  - Electric heating element sequencing
  - Electric heating element lockout
- COOLING
  - Variable condenser fan operation
  - On / off condenser fan
  - Two-stage air conditioner with variable speed fan
  - Bypass

Air Distribution

Systems and Components

- HEAT TRANSFER AND THE HEATING / COOLING CYCLE
  - Heat transfer and cooling
  - Refrigeration circuit - components
  - Dynamic analysis of temperatures and pressure in the refrigerant circuit
  - Psychrometrics
  - Subcooling
  - Superheat

KATES Knowledge Areas of Technician Expertise

Air Distribution (continued)

Duct Systems

- IMPACT ON ENERGY USE OF BASIC DUCT SYSTEMS
  - Overview of duct systems for split and package systems
  - Duct configuration - extended plenum
  - Duct configuration - reducing extended plenum
  - Duct configuration - perimeter radial
  - Duct configuration - perimeter loop
  - Duct configuration - overhead radial
  - Duct configuration - branching flexible
  - Duct configuration - concentric
- IMPACT ON ENERGYUSE OF DUCT LOCATION
  - Attic
  - Basement
  - Crawlspace
  - Slab
  - Roof
  - Furred down
  - Exposed
  - Chases
  - Inside the envelope - avoid non-insulated areas
- BASIC ZONE SYSTEMS
  - Equipment zoned
  - Air side zoned
- IMPACT ON ENERGY USE OF DUCT MATERIALS
  - Define / recognize ductboard
  - Define / recognize metal duct
  - Define/ recognize flexibleduct
  - Define / recognize PVC pipe Insulating material
- FITTING NOMENCLATURE
  - Define / recognize plenum
  - Define / recognize transition
  - Define / recognize elbow - 90 degrees and 45 degrees
  - Define / recognize round duct
  - Define / recognize rectangular duct
  - Define / recognize turning vanes
  - Return configurations - ducted, central, etc.
  - Define / recognize wye - rectangular and round
  - Define / recognize damper - rectangular and round
  - Sheet metal duct joints - "s" and drive, snaplock, button lock, etc.

KATES Knowledge Areas of Technician Expertise

Air Distribution (continued)

- IMPACT ON ENERGY USE OF DAMPERS
  - Balancing
  - Splitters
  - Economizers
  - Fresh air
  - Fire
- GRILLES
  - Types and uses
  - Selecting grilles by volume and velocity
  - Selecting grilles by purpose (floor, wall, and ceiling)
  - Proper installation techniques (follow installation instructions)
- IMPACT ON ENERGY USE OF REGISTERS
  - Types and uses
  - Selecting registers
  - Selecting registers by use of fan specifications
  - Selecting registers by air spread and throw capacity
  - Proper installation techniques (follow installation instructions)
- DIFFUSERS
  - Types and uses
  - Selecting diffusers
  - Selecting diffusers by use of fan specifications
  - Selecting diffusers by air spread and throw capacity
  - Proper installation techniques (follow installation instructions)
- IMPACT ON ENERGY USE OF FILTRATION SYSTEMS
  - Filter access closures system
  - Media type filters
  - Electronic Air Cleaner(EAC)
  - Electrostatic filters - non-electric
  - Static pressure increases energy by ECM fan motors
- VENTILATION SYSTEMS
  - Depressurization criteria
  - Draft of conditioned air into non-conditioned areas
  - Pressurization criteria
  - Forcing conditioned air into non-conditioned areas
  - Attic exhaust
  - Residential exhaust(s)
  - Lt. Commercial exhaust(s)
  - Heat / energy recovery ventilators
  - Infiltration
  - Passive venting
  - Soffits vents
  - Ridge vents
  - Gable vents
  - Power venting

KATES Knowledge Areas of Technician Expertise

Air Distribution (continued)

- Humidifiers
  - Fundamentals of operation
  - Types
  - Duct material requirements
  - Installation support
  - Installation location(s)

Duct Fabrication

- DUCT FABRICATION EQUIPMENT
  - Ductboard tools - 90 V-groove, end cutoff, femaleshiplap, hole cutter,stapler, etc.
  - Flex tools - tensioning strap tools, knives, etc.
  - Metal tools - metal snips, sheers, benders, breaks, hand formers, calipers, rulers, stapler, etc. -
- FABRICATION TECHNIQUES FOR METAL DUCT
  - Seam types - pittsburgh and snap lock
  - Joint types - gasketed connectors (J or G), drive cleats, reinforced drive cleats, "s" slip, and standing "s" slip
  - Use of strength breaks in rectangular duct
- FABRICATION TECHNIQUES FOR DUCTBOARD
  - Layout of duct fitting
  - Groove cutting - hand / machine
  - Proper use of joint tape
  - Approved type of joint tape
  - Foil faced Mastic type UL181

Duct Installation

- FIELD CONSTRUCTION / INSTALLATION
  - Ductboard installation technique
  - Techniques for joining dissimilar duct
  - Duct of alternate materials- wood, aluminum, etc.
- INSTALLING METAL DUCT
  - Assembly methods for rectangular duct
  - Installation technique - rectangular metal
  - Assembly methods for round duct
  - Installation technique - round metal
  - Hanging ductwork
  - Sealing metal duct
  - Insulation - internal and external

KATES Knowledge Areas of Technician Expertise

Air Distribution (continued)

INSTALLING FLEXIBLE DUCT
Assembly methods Appropriate length
Follow installation instructions Flexible duct joints
Hanging flexible duct Allowed deflection Unacceptable deflection
Installation technique - flex duct Sealing flexible duct
INSTALLING DUCTBOARD
Assembly methods for ductboard - supports Installation technique-ductboard
Hanging methods for ductboard Sealing ductboard
DUCT SEALING MATERIALS
Duct mastic Approved tapes
INSTALL. GRILLE, REGISTER, DIFFUSER, & DAMPER
Mounting to ductwork Securing methods
CHASES USED AS DUCTS
Floor joists as air ducts Vertical chases
Floor joists as air ducts - impact on energy use Verticalchases - impact on energy use
RECONNECTING DUCT WHEN REPLACINGEQUIPMENT
Reconnecting metal duct Reconnecting flexibleduct Reconnecting ductboard duct
INSTALLATION OF PLENUMS AND DUCT
Sizing plenums for physical fit
Types and styles of plenums selected for oil furnace Insulation of plenums and ducts
AIRFLOW PRINCIPLES
AIRFLOW
Velocity Static pressure
Airflowvolume - CFM /SCFM (Standard Air CFM) BLOWERS AND FANS
Define sequence of operation Air side requirements
AIRFLOW MEASUREMENTS
TOOLS
Using temperaturesto determine airflow
Using manufacturer's airflow charts and/or tables Measuring total supply and return airflow
AIRFLOW VELOCITY MEASUREMENTS
Pitot tube and manometer in measuring static pressure Discharge velocity equipment
Static pressure drop across evaporator coil
Fan laws using known static pressure drop at specific flow(s) Velometer - electronic and mechanical
Anemometer
Velocity measurement procedures Gauge calibration
Airflow Velocity

KATES Knowledge Areas of Technician Expertise

Air Distribution (continued)

- 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 (Standard Air CFM) Powered flow hood test
- Flow plate
- DUCT LEAKAGE MEASUREMENTS(ALLOWANCE)
- Duct leakage allowance to outdoors Duct leakage allowance from outdoors Duct leakage allowance to ambient Duct leakage allowance from ambient Total duct leakage allowance
- AIR BALANCING
- GATHERING DESIGNINFORMATION
- Interpreting plans Interpreting specifications
- Interpreting equipment information Interpreting control data Interpreting as-built plans
- PREPARATION OF SYSTEM FOR AIR TESTS
- Locating registers, grilles, equipment, controls, and dampers in building walk-through Setting dampers for tests
- Setting thermostat for tests
- Checking for proper fan operation and rotation Checking for proper static pressure and temperature
- PROCEDURES FOR CONDUCTING AIR TESTS
- Measurements of each supply outlet - total readings Measurements of each return inlet - total readings
- MAKING ADJUSTMENTS
- Adjust airflow to achieve required total airflow Re-measure total supplyand return grilleairflow Adjust dampersto obtain designairflow
- Re-measure total airflow to verify that it is within specification 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 andrecordsupply and return static pressures
- Test and record supply and return air temperatures - wet bulb and dry bulb

KATES Knowledge Areas of Technician Expertise

Air Distribution (continued)

- COMPLETION OF APPROPRIATE FORMS
- HVAC system report System diagrams
- Duct traverse or data pulley forms Instrument list - including calibration dates
- HVAC SYSTEM ANALYSIS
- NOISE PROBLEMS
- Interpreting supply / return air volume Interpreting supply / returnair velocity Noise problems
- Blower cavitation Oil canning Motor / belt noise Vibration
- HIGH UTILITY BILLS
- Understanding of utility bills – interpretingenergy usage
- Assess customer practices or characteristics impacting energy use WIDE TEMPERATURE SWINGS
- Interpreting supply / return air temperature Interpreting supply / return air volume Evaluating duct leakage
- Evaluating duct insulation Envelope evaluation Thermostat air sensing
- Assess thermal reasons for temperature stratification Understanding system interactions
- Locational impact of supply registers and return Evaluating throw and/or velocity
- SINGLE/MULTIPLE AREA IS HOT OR COLD
- Interpreting supply / return air temperature Interpreting supply / return air volume Evaluating duct leakage
- Evaluating duct insulation Envelope evaluation Thermostat air sensing
- Understanding system interactions
- Locational impact of supply registers and return Evaluating throw and/or velocity
- INDOOR AIR QUALITY
- Number of air changes per hour Source control
- Assess fan operation (ex. continuous) Type of filter
- Filter maintenance practices Humidity or mold issues
- ANALYZING REPORTED SYMPTOMSIN COOLING
- POOR COOLING
- Interpreting supply / return air temperature Interpreting supply / return air volume Interpreting supply / return air velocity
- Determining and interpreting the sensible heat ratio Evaluating duct leakage
- Evaluating envelope infiltration
- Using wet bulb temperature drop across evaporator coil

KATES Knowledge Areas of Technician Expertise

Air Distribution (continued)

- HUMIDITY PROBLEMS
- Interpreting wet bulb and dry bulb temperatures Interpreting supply / return air volume Determining and interpreting the sensible heat ratio Evaluating duct leakage
- Evaluating envelope infiltration DRAFTY
- Assess return and supply issues Interpreting supply / return air temperature Interpreting supply / return air volume Interpreting supply / return air velocity Evaluating envelope infiltration
- ANALYZING REPORTED SYMPTOMSIN HEATING
- POOR HEATING
- Interpreting supply / return air temperature Interpreting supply / return air volume Interpreting supply / return air velocity Evaluating duct leakage
- Using temperature rise across the heat exchanger HUMIDITY PROBLEMS
- Interpreting wet bulb and dry bulb temperatures Interpreting supply / return air volume Determining the need for additional humidity Evaluating duct leakage
- DRAFTY
- Interpreting supply / return air temperature Interpreting supply / return air volume Interpreting supply / return air velocity
- DEALING WITH CONFLICTS
- CODES
- Codesvs. standards STANDARDS
- Standards vs. codes BUILDING SCIENCE

Building science vs. codes or standards

KATES Knowledge Areas of Technician Expertise

Hydronics Distribution

Heating Components

- PROPER SELECTION
- Baseboard units (finned, cast, radiant, etc.) Kickspace heaters
  - Types of unit heaters
  - Radiant ceiling heating or cooling panels Duct mounted heating coils
  - Hot water coil air handlers Circulation pumps
  - Sizing of zoning distribution
  - Placement and location of types of heating units Placement of air vents (manual or auto)
  - Radiant floor heating – how to maximize comfort with proper insulation with installation
- PROPER SIZING
  - Baseboard units (finned, cast, radiant, etc.)
  - Kickspace heaters Types of unit heaters
  - Radiant ceiling heating or cooling panels Duct mounted heating coils
  - Hot water coil air handlers Circulation pumps
  - Sizing of zoning distribution
  - Placement and location of types of heating units Placement of air vents (manual or auto)
  - Radiant floor heating – how to maximize comfort with proper insulation with installation
- PROPER INSTALLATION
  - Baseboard units (finned, cast, radiant, etc.) Kick space heaters
  - Types of unit heaters
  - Radiant ceiling heating or cooling panels Duct mounted heating coils
  - Hot water coil air handlers Circulation pumps
  - Sizing of zoning distribution
  - Placement and location of types of heating units
  - Placement of air vents (manualor auto)
  - Radiant floor heating– how to maximize comfort with proper insulation with installation
- AUXILLARY COMPONENTS
  - Location and selection 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 water treatment access Installation of indirect water heaters Installation of low water cutoffs

KATES Knowledge Areas of Technician Expertise

System Performance

Gas Heating

- COMPONENTS
  - Define heat exchanger
  - Define limit controls
  - Define vent system
  - Define burners
  - Define fan controls
  - Define gas valve
  - Combustion air proving (pressure) switch
  - Hydronic controls
- OPERATION
  - Define combustion air system
  - Air side requirements
  - Wet side requirements
  - Define sequence of operation
  -

Oil Heating

- COMPONENTS
  - Define heat exchanger Define limit controls Define vent system Define oil burners
  - Retention head burners energy efficiency gains
  - Hydronic controls
- OPERATION
  - Define combustion air system
  - Air side requirements
  - Wet side requirements
  - Define sequence of operation

Air Conditioning/Heat Pumps

- COMPONENTS
  - Define evaporator
  - Define condenser
  - Define compressor Define metering device Reversing valves Defrost controls
- OPERATION
  - Define sequence of operation
  - Airside requirements
  - Metering device performance

KATES Knowledge Areas of Technician Expertise

System Performance (continued)

ELECTRONIC CONTROLS

- ELECTRONIC CONTROLLERS
  - Input / output operations Logic
  - Electronic interface Tap boards
- ELECTRONIC THERMOSTATS
  - Selecting electronic thermostats Electronic thermostat operation
- ZONE CONTROLS
  - Selecting zone controls Typical zone controllogic Bypass dampers
- Types of zone controls
- ELECTRONICCOMPRESSOR CONTROLS
  - Compressor staging controls Compressor time delays
- ELECTRONIC TIMERS
- Blower delay timers ECONOMIZERCONTROLLERS
- Dry bulb controllers Enthalpy controllers Potentiometers Sensors

Electromechanical Sensing Controls

- ELECTROMECHANICAL WALL THERMOSTATS
- Thermostat types and operation Thermostat terminals and wiring Selecting wall thermostats and sub-bases Using electromechanical thermostats
- ELECTROMECHANICAL TEMPERATURE CONTROLS
- Bimetal controls
- Disc type temperature limit controls Electric heat high limits
- Fuses and fuse links Motor overloads Fossil fuel kits
- PRESSURE CONTROLS
- Disc type pressure controls and hi/low controls Selection of disc type pressure controls
- Using disc type pressure controls Low ambient cooling controls
- ELECTROMECHANICAL OUTDOOR THERMOSTATS
- Outdoor thermostats Outdoor thermostat wiring
- TROUBLESHOOTING SEQUENCE OF OPERATION
- Check for proper sequence of operation Interpreting system at sequence interruption
- ANALYZING REPORTED SYMPTOMS
- Insufficient / no heat Short cycle Humidity problems Drafty
- Noise problems
- System runs continuously High utility bills
- Wide swings in room temperatures Air quality
- Noisyconditions due to air in piping SYSTEM AIR SIDE DIAGNOSTICS
- Temperature checks
- Check system staticpressure Check system velocity

KATES Knowledge Areas of Technician Expertise

System Performance (continued)

- ELECTRICAL CIRCUIT CHECKS
  - Supply voltage Indoor blowers Wall thermostat Transformers
  - Electronic controllers - input / output Flame rectification
  - Pilot ignition
  - Thermocouple / power pile generator Fuel valve
- ELECTRICAL COMPONENT CHECKS
  - Thermostat Transformers Fuses and breakers
  - Relays and contactors Capacitors
  - Pressure controls Limit controls Centrifugal switch
  - Door interlock switch
  - Circulators Zone valves
  - Boiler water controls (aquastats) REPAIRS
  - Electrical wiring Electrical components Fuel supply
  - Flue stack / venting system Condensate / drain system
- REPLACEMENTS
  - Transformers
  - Relays and contactors Indoor blowers Capacitors
  - Heat exchanger Fuel valve
  - Safety circuit switches Draft motor
  - Pilot / igniters assemblies Flame sensing rod Circulators
  - Zone valves
  - Boiler water controls
  - VENT SYSTEMCHECKS
- Natural / gravitydraft Forced draft
- Induced draft
- DIAGNOSING 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
- Carbon Dioxidechecks for efficiency Interpreting a smoketest
- Balancing excess air and the smoke test Diagnosing air leaks and efficiency loss Diagnosing low draft-stack, overfire Diagnosing excessive draft-stack, overfire Diagnosing excessive draft on off cycle
- Interpreting steady state efficiency measurements - stack loss calculations Interpreting oxygen content for combustion diagnostics
- Duct leakage induced combustion venting problems Heating plants and water heaters

Problems with / caused by attic fans

KATES Knowledge Areas of Technician Expertise

System Performance (continued)

- LOW VOLTAGE CIRCUITS
  - Voltage tests
  - Control string analysis
  - 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
- FUEL PRESSURE MEASUREMENTS
  - Manometer Dial gauge
- LEAK DETECTION - FUEL LINES
  - Leak detection solution Electronic leak detectors
- FLUE GAS ANALYSIS
  - O2 measurements
  - Carbon Dioxide measurements
- LEAK DETECTION- FLUE PASSAGES
  - Carbon Monoxide detector- electrical Carbon Monoxide detector - manual
- NOISE PROBLEMS
  - Interpreting supply / return air volume Interpreting supply / returnair velocity Noise problems - air and water
  - Blower and pump cavitation Oil canning
  - Motor / belt noise Vibration
- HIGH UTILITY BILLS
  - Baseline utility expenses in relation to heating / cooling expenses Interpreting supply / return air and water temperature Interpreting supply / return air and water volume
  - Interpreting supply / return air and water pressures Evaluating duct leakage
  - Evaluating duct insulation Envelope insulation Envelope infiltration Thermostat air sensing

KATES Knowledge Areas of Technician Expertise

System Performance (continued)

- WIDE TEMPERATURE SWINGS
  - Interpreting supply / return air and water temperature Interpreting supply / return air and water volume Interpreting supply / return air and water pressures Evaluating duct leakage
  - Evaluating duct insulation Envelope insulation Envelope infiltration Thermostat air sensing
- AREA(S) BEING HOT / COLD
  - Interpreting supply / return air and watertemperature (TD) Interpreting supply / return air and water volume Interpreting supply / return air and water pressures Evaluating duct leakage
  - Evaluating duct insulation Envelope infiltration Envelope insulation Thermostat air sensing
  - Zone controls - dampers and valves
  - Circulator(s) Blower(s) Circulator controls
  - Outdoor reset control
  - Evaporator coil temperature drop INDOOR AIR QUALITY
  - Number of air changes per hour Source control
  - Economizer operations
- HUMIDITY PROBLEMS
  - Interpreting wet bulb and dry bulb temperatures Interpreting supply / return air volume Determining the need for additional humidity Evaluating duct leakage
  - Evaluating envelope infiltration
- DRAFTS
  - Interpreting supply / return air temperature Interpreting supply / return air volume Interpreting supply / return air velocity Evaluating envelope infiltration
- REFRIGERANT SYSTEM DIAGNOSTICS
  - Using superheat Using subcooling
  - Refrigerant charge specification Refrigerant charge adjustment Energy impacts of undercharging Energy impacts of overcharging
  - Energy impacts of metering devices - TXV / fixed Analyzing overall refrigerant circuit performance
  - Analyzing effects of refrigerant circuits on reversing valve operation Locating problems based on refrigerant circuit temperatures

KATES Knowledge Areas of Technician Expertise

Indoor Air/Environment Quality

DESIGNING FOR ACCEPTABLE IAQ / IEQ

- UNDERSTANDING VENTILATION AND ACCEPTABLE IAQ
  - Requirement for mechanical and natural ventilation
- INSTALLING IAQ / IEQ SYSTEMS
- PREVENTING RE-ENTRAINMENT & CROSS-CONTAMINATION
- OPERATING & MAINTAINING IAQ / IEQ SYSTEMS FILTRATION SYSTEMS
- RECOVERY VENTILATORS ULTRAVIOLET C (UVC)
- EXHAUST/VENTILATION FANS
- TROUBLESHOOTING IAQ / IEQ SYSTEMS REVIEW PLANS
- CONDUCT INTERVIEWS DIAGNOSTICS
- DOCUMENT RESULTS
- IAQ / IEQ CONTROLSTRATEGIES
- POLLUTANTPATHWAYS
  - Doors Windows Elevator shafts Chimneys Garages
  - Plumbing stacks Stairs
  - Ducts
  - Chases
  - Basements
- SOURCE CONTROL - REMOVE / CONTAIN
  - Volatile Organic Compounds (VOC) - Formaldehyde, Ozone, Tobacco Smoke Inorganic Compounds - NOx, Radon, CO, CO2
  - Moisture Biological
- FILTRATION
  - Particulate Gases
- DILUTION AIR LOCAL EXHAUST
  - Bathrooms Kitchens Copiers
- WHOLE HOUSE VENTILATION

KATES Knowledge Areas of Technician Expertise

Planned Maintenance

Planned Maintenance

- ELECTRICAL
  - Connection checks Control checks General wiring Induced draft motor Forced draft motors Supply air motor Operation sequence
- AIR DISTRIBUTION
  - Fan blades / blower scroll Diffusers, grilles, and registers Lubrication of blowers
  - Coil cleaning
  - Filter cleaning / replacement Duct leakage check Velocity
  - Volume
- HYDRONIC
  - Pumps Lubrication Valves Vents Relief Flow rates Pressure
  - Expansion tank Water treatment Pump strainers
- FIRE SIDE
  - Oil burner assembly service Sectional cleaning
  - Gas burnerassembly service
  - Performance checks - heat exchanger temperature rise Flue / vent stack inspections
  - Combustion air supply check and adjustment Fuel supply connections
  - Sequence of operation checks Air intake / exhaust
  - Flame Ignition CO test Draft test
  - CAZ Test
- REFRIGERATION SYSTEM
  - Using superheat Using subcooling
  - Refrigerant charge specification Refrigerant charge adjustment Energy impacts of undercharging Energy impacts of overcharging
  - Energy impacts of metering devices - TXV / fixed Analyzing overall refrigerant circuit performance
  - Analyzing effects of refrigerant circuits on reversing valve operation
  - Locating problems based on refrigerant circuit temperatures
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