HVAC PERFORMANCE VERIFIER CERTIFICATION

Certification Information

Scope - Tests a candidate's knowledge of a whole-system approach related to the environment being conditioned including reviewing load calculations and quality assurance reviews of the quality of installation of HVAC systems for such programs as EPA's ENERGY STAR Certified Homes, HVAC Quality Installation programs and ACCA's Residential Service & Installation (RSI) Program.

Qualifications

This is a test and certification for **HERS Raters**.
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 exam. The certification is valid for three years.

In order to qualify for this certification, individuals must hold current/active HERs rater certification from Residential Energy Systems Network (RESNET).

Test Specifications

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

Listed are the percentages of questions that will be in each section of this exam.

SECTION AREA DESCRIPTION	SECTION PERCENTAGE
Equipment Selection	5%
Indoor Air/ Environment Performance	9%
Load Calculation Design	15%
System Performance	20%
Air Flow	51%

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", and "S"
- ACCA Manuals "P", "T" , "RS", and "Z" - Latest Editions
- ASHRAE Standard 62.2 – Latest Edition with Addendum
- Air Diffusion Council: Flexible Duct Performance & Installation Standards, Installation Guidelines
- ACCA Technician Guide for Quality Installation (Support Document for Standard 5)
- Residential Energy (Krigger & Dorsi)
- Energy Star Version 3
- Consortium for Energy Efficiency: Efficient Installation and Maintenance Practices for Residential HVAC Systems
- ASHRAE 62.2
- ASHRAE 52.2
- ACCA Standard 9, "Quality Installation Verification Protocols"
- Cleveland State Community College Energy Efficient Residential Construction Volume 3- HVAC_2006

Passing Score Development Process

The passing score for this test was established using a systematic procedure (a Passing Score Study). This procedure employed the judgment of experienced RESNET professionals and educators. The passing scores were set using criteria defining competent performance.

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HVAC Performance Verifier

LOAD CALCULATION - DESIGN

- CUSTOMER SURVEY
  - WEATHER DATA
  - BUILDING ORIENTATION
  - TAKE OFFS - BLUEPRINT OR ACTUAL SITE REVIEW
- ZONING
  - SINGLE ZONE
  - MULTIPLE ZONES
- INFILTRATION
  - AIR CHANGES PER HOUR
  - OCCUPANCY STANDARDS
  - EQUIPMENT REQUIREMENTS
  - DIAGNOSTIC TOOLS
- EXFILTRATION - EXHAUST REQUIREMENTS
  - OCCUPANCY STANDARDS
  - EQUIPMENT REQUIREMENTS
- VENTILATION
  - HEAT RECOVERY VENTILATOR (HRV)
  - ENERGY RECOVERY VENTILATOR (ERV)
  - INTERNAL LOADS
  - CALCULATION - ASHRAE 62.2
- HEAT LOSS
  - TOTAL
  - SENSIBLE
  - LATENT
- HEAT GAIN
  - TOTAL
  - SENSIBLE
  - LATENT
  - INTERNAL GAIN
- DUCT LOADS
  - GAIN
  - LOSS
  - DUCT DESIGN LOSS
- REGULATIONS
  - INDOOR AIR QUALITY
- DESIGN CONSIDERATIONS - COMFORT
  - TEMPERATURE
  - HUMIDITY
  - INDOOR AIR QUALITY
  - SOUND LEVEL
  - ZONING
- DESIGN CONSIDERATIONS - RESIDENTIAL
  - SPLIT SYSTEMS
  - AIR BALANCING
  - HYDRONIC BALANCING
- DESIGN CONSIDERATIONS - COMPONENTS
  - IMPACT OF DIFFUSERS, GRILLES, & REGISTERS
  - DUCTS & FITTINGS - IMPACT ON ENERGY USE
  - SPECIAL DUCTS & FITTINGS
  - STATIC PRESSURE LOSSES
  - BLUEPRINT READING
- MECHANICAL CODE
  - EQUIPMENT ACCESS
  - REFRIGERANT LINE ROUTING
  - CONDENSATE DRAINS

- INDUSTRY STANDARDS
  - EQUIPMENT STANDARDS
  - SYSTEM STANDARDS
- DESIGN CONSIDERATIONS - INCORRECT LOAD
  - CONSEQUENCES OF UNDER-SIZING
  - CONSEQUENCES OF OVER-SIZING

EQUIPMENT SELECTION

- CAPACITY
  - DESIGN HEATING LOAD
  - DESIGN COOLING LOAD
  - DESIGN VENTILATION LOAD
- EFFICIENCY
  - SYSTEM EFFICIENCY
  - HEATING EFFICIENCY
  - COOLING EFFICIENCY

AIR FLOW

- DUCT SYSTEMS
  - IMPACT ON ENERGY USE OF BASIC DUCT SYSTEMS
  - IMPACT ON ENERGY USE OF DUCT LOCATION
  - BASIC ZONE SYSTEMS
  - IMPACT ON ENERGY USE OF DUCT MATERIALS
  - GRILLES
  - IMPACT ON ENERGY USE OF FILTRATION SYSTEMS
  - VENTILATION SYSTEMS
- DUCT INSTALLATION
  - FIELD CONSTRUCTION / INSTALLATION
  - INSTALLING METAL DUCT
  - INSTALLING FLEXIBLE DUCT
  - INSTALLING DUCTBOARD
  - DUCT SEALING MATERIALS
  - INSTALL. GRILLE, REGISTER, DIFFUSER, & DAMPER
  - CHASES USED AS DUCTS
  - RECONNECTING DUCT WHEN REPLACING EQUIPMENT
  - INSTALLATION OF PLENUMS AND DUCT
- AIRFLOW PRINCIPLES
  - AIRFLOW
  - BLOWERS AND FANS
- AIRFLOW MEASUREMENTS
  - TOOLS
  - AIRFLOW VELOCITY MEASUREMENTS
  - AIRFLOW PRESSURE MEASUREMENTS
  - AIR VOLUME MEASUREMENTS
  - DUCT LEAKAGE MEASUREMENTS (ALLOWANCE)
- AIR BALANCING
  - GATHERING DESIGN INFORMATION
  - PREPARATION OF SYSTEM FOR AIR TESTS
  - PROCEDURES FOR CONDUCTING AIR TESTS
  - MAKING ADJUSTMENTS
  - FINAL TEST
  - COMPLETION OF APPROPRIATE FORMS
- HVAC SYSTEM ANALYSIS
  - NOISE PROBLEMS
  - HIGH UTILITY BILLS
  - WIDE TEMPERATURE SWINGS
  - SINGLE/MULTIPLE AREA IS HOT OR COLD
  - INDOOR AIR QUALITY
- ANALYZING REPORTED SYMPTOMS IN COOLING
  - POOR COOLING

- HUMIDITY PROBLEMS
- DRAFTY

ANALYZING REPORTED SYMPTOMS IN HEATING
- POOR HEATING
- HUMIDITY PROBLEMS
- DRAFTY

SYSTEM PERFORMANCE

GAS HEATING
- COMPONENTS
- OPERATION

OIL HEATING
- COMPONENTS
- OPERATION

AIR CONDITIONING / HEAT PUMPS
- COMPONENTS
- OPERATION

ELECTRONIC CONTROLS
- ELECTRONIC CONTROLLERS
- ELECTRONIC THERMOSTATS
- ZONE CONTROLS
- ELECTRONIC COMPRESSOR CONTROLS
- ELECTRONIC TIMERS

ELECTROMECHANICAL SENSING CONTROLS
- ELECTROMECHANICAL WALL THERMOSTATS
- ELECTROMECHANICAL TEMPERATURE CONTROLS
- PRESSURE CONTROLS
- ELECTROMECHANICAL OUTDOOR THERMOSTATS
- TROUBLESHOOTING SEQUENCE OF OPERATION
- ANALYZING REPORTED SYMPTOMS
- SYSTEM AIR SIDE DIAGNOSTICS
- VENT SYSTEM CHECKS
- DIAGNOSING COMBUSTION PROBLEMS
- LEAK DETECTION - FUEL LINES
- FLUE GAS ANALYSIS
- LEAK DETECTION - FLUE PASSAGES
- HIGH UTILITY BILLS
- INDOOR AIR QUALITY
- HUMIDITY PROBLEMS
- DRAFTS
- REFRIGERANT SYSTEM DIAGNOSTICS

INDOOR AIR / ENVIRONMENTAL QUALITY

DESIGNING FOR ACCEPTABLE IAQ / IEQ
- UNDERSTANDING VENTILATION AND ACCEPTABLE IAQ
- UNDERSTANDING FILTRATION SYSTEMS

INSTALLING IAQ / IEQ SYSTEMS
- PREVENTING RE-ENTRAINMENT & CROSS-CONTAMINATION

OPERATING & MAINTAINING IAQ / IEQ SYSTEMS
- FILTRATION SYSTEMS
- RECOVERY VENTILATORS
- ULTRAVIOLET C (UVC)
- EXHAUST/VENTILATION FANS

IAQ / IEQ CONTROL STRATEGIES
- POLLUTANT PATHWAYS
- SOURCE CONTROL - REMOVE / CONTAIN
- FILTRATION
- DILUTION AIR
- LOCAL EXHAUST
- WHOLE HOUSE VENTILATION
- POWERED ATTIC VENTILATORS

$\frac{CFM_n}{CFM_o} = \frac{RPM_n}{RPM_o}$ *o* = old, *n* = new CFM and RPM are interchangeable.

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

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

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

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

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

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

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

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

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

1 IWC = 0.0360 PSI
1 PSI= 27.72 IWC

Pressure 1 x Volume 1 = Pressure 2 x Volume 2

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

$Area = 1t \times radius^2$

$A^2 + B^2 = C$

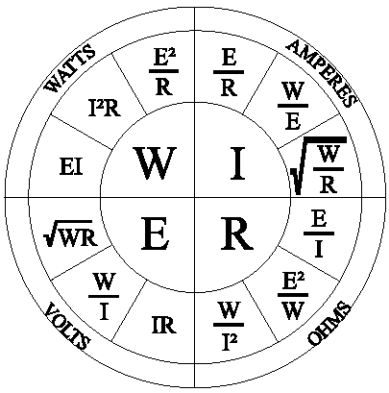
Round Duct Area (ft2) = $\frac{1t \times diameter}{576}$

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

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

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

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



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

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

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

TEMPERATURE PRESSURE CHART-atsealevel

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

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

CONTINUED

TEMPERATURE PRESSURE CHART-atsealevel

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

TEMP.		REFRIGERANT						
•f	0C	22	134a	404A	407C	410A	4220	507
32	0.0	57.5	27.8	72.4	52.1	101.2	55.2	75.8
33	0.6	58.8	28.6	73.9	53.4	103.3	56.5	77.4
34	1.1	60.2	29.5	75.5	54.8	105.4	57.9	79.0
35	1.7	61.5	30.4	77.1	56.1	107.5	59.3	80.7
36	2.2	62.9	31.3	78.7	57.5	109.7	60.6	82.3
37	2.8	64.3	32.2	80.3	58.9	111.9	62.0	84.0
38	3.3	65.7	33.1	82.0	60.3	114.1	63.5	85.7
39	3.9	67.1	34.1	83.7	61.7	116.3	64.9	87.5
40	4.4	68.6	35.0	85.4	63.2	118.6	66.4	89.2
42	5.6	71.5	37.0	88.8	66.1	123.2	69.4	92.8
44	6.7	74.5	39.0	92.4	69.2	127.9	72.5	96.4
46	7.8	77.6	41.1	96.0	72.3	132.8	75.6	100.2
48	8.9	80.8	43.2	99.8	75.5	137.8	78.9	104.0
50	10.0	84.1	45.4	103.6	78.8	142.9	82.2	108.0
52	11.1	87.4	47.7	1092	101.7	148.1	96.1	112.0
54	12.2	90.8	50.0	1133	105.6	153.5	998	116.1
56	13.3	94.4	52.4	117.4	109.6	159.0	103.6	120.4
58	14.4	98.0	54.9	121.7	113.7	164.7	107.4	124.7
60	15.6	101.6	57.4	126.0	117.9	170.4	111.4	129.1
62	16.7	105.4	60.0	1305	122.3	176.3	1154	133.7
64	17.8	109.3	62.7	1350	126.7	182.4	1195	138.3
66	18.9	113.2	65.4	139.7	131.2	188.6	123.8	143.1
68	20.0	117.3	68.2	144.4	135.8	194.9	128.1	147.9
70	21.1	121.4	71.1	149.3	140.5	201.4	132.5	152.9
72	22.2	125.7	74.1	154.3	145.4	208.0	137.1	158.0
74	23.3	130.0	77.1	1594	150.3	214.8	1417	163.2
76	24.4	134.5	80.2	164.6	155.4	221.8	146.5	168.5
78	25.6	139.0	83.4	169.9	160.5	228.9	151.3	174.0
80	26.7	143.6	86.7	175.4	185.8	236.1	156.3	179.5
82	27.8	148.4	90.0	181.0	171.2	243.6	161.3	185.2
84	28.9	153.2	93.5	1867	176.8	251.2	1665	191.0
86	30.0	158.2	97.0	1925	182.4	258.9	1718	197.0
88	31.1	163.2	100.6	198.4	188.2	266.8	177.2	203.0
90	32.2	168.4	104.3	204.5	194.1	274.9	182.7	209.2
92	33.3	173.7	108.1	210.7	200.1	283.2	188.4	215.5
94	34.4	179.1	112.0	2170	206.3	291.6	1941	222.0
96	35.6	184.6	115.9	2234	212.5	300.3	2000	228.6
98	36.7	190.2	120.0	230.0	219.0	309.1	206.0	235.3
100	37.8	195.9	124.2	236.8	225.5	318.1	212.1	242.2
102	38.9	201.8	128.4	243.6	232.2	327.2	218.4	249.2
104	40.0	207.7	132.7	250.8	239.0	336.6	224.8	256.3
106	41.1	213.8	137.2	2578	245.9	346.2	2313	263.7
108	42.2	220.0	141.7	265.1	253.0	355.9	237.9	271.1
110	43.3	226.4	146.4	272.5	260.3	365.9	244.7	278.7
112	44.4	232.8	151.1	280.1	287.6	376.1	251.6	286.5
114	45.6	239.4	156.0	287.9	275.1	386.4	258.8	294.4
116	46.7	246.1	160.9	2958	282.8	397.0	2658	302.4
118	47.8	253.0	166.0	3038	290.6	407.8	2732	310.7
120	48.9	260.0	171.2	312.1	298.6	418.8	280.6	319.1
125	51.7	278.0	184.6	333.3	319.2	447.4	299.9	340.8
130	54.4	296.9	198.7	355.6	340.7	477.4	320.2	363.6