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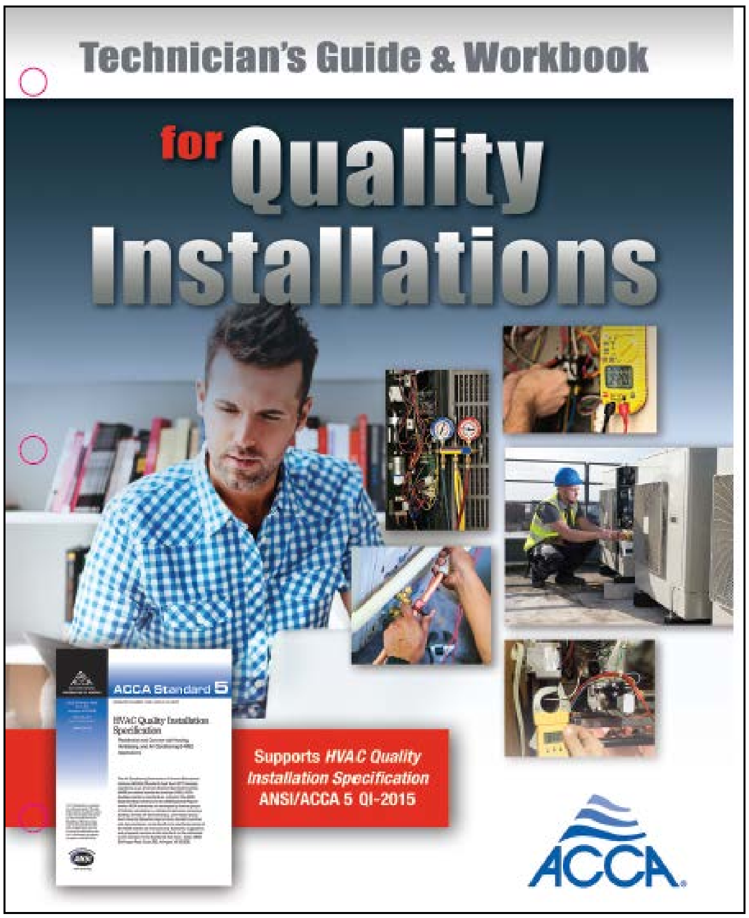
INSTRUCTOR'S LESSON PLAN For the: TECHNICIAN'S GUIDE & WORKBOOK for QUALITY INSTALLATIONS



Instructors may customize the material to augment existing curriculum.
Contains the real world training materials that Technicians need to excel in the field.

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ISBN

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Part 1: Curriculum Outline for *Technician's Guide & Workbook for Quality Installations*

This course was inspired by HVAC contractors who requested more training material on the basics needed to complete a quality installation in the field. Their participation in editing and adding material have made this course unique in its execution. The curriculum outline is intended for use by HVAC instructors at vocational-technical schools, HVACR training centers, and community colleges for introducing their students to industry-accepted installation measurement and documentation procedures. It has been designed for use with the *Technician's Guide & Workbook for Quality Installations*, a "how-to" compendium for the ANSI/ACCA Standard 5-2015 HVAC Quality Installation Specification. It may be used during the final semester to cement theory taught, by showing how it is applied in the field.

Course material covers many of the areas that are commonly taught in HVACR programs from a field application perspective. Individual sections may be modified and used to fit into existing programs as an additional resource material. The full course is designed for a 16 week semester, and contains thirteen power point presentations designed for 60 minute classes. The power point slides address the basics of installing, measuring, and documenting HVAC installations. For the 16 week course, each of the first 11 Power Point sections is followed by two hands on labs. The instructor may select hands on exercises from recommended options in each section, or substitute for the hands on exercises with class discussions based on questions designed to encourage class participation.

The outline format allows the instructor to expand the actual lesson plan to suit the needs of their students, and augment their available materials, or pre-existing lesson plans. At the end of the 11 basic lessons, a student will understand the basic minimum requirements for installing, measuring, and documenting an HVAC installation. Additionally, there are five modules that may be used for math review. The math modules focus directly on techniques for solving field math problems specific to the curriculum. One technique is to use the math modules in conjunction with the hands on class where and when the specific math is needed. Finally, the Guide & Workbook contain many appendices designed to be used in the field as reference materials. For example altitude/temperature charts for air correction factors.

Course Materials

- Student Text Book: *Technician's Guide & Workbook for Quality Installations*

Instructor's Resources

- 13 Power Point modules designed for 60 minute lectures (597 slides available through ACCA)

  Includes, 5 power point math reviews specifically designed to show students how to easily get answers for all of the math problems found in the *Technician's Guide & Workbook for Quality Installations*.
- A 28 page Teacher's Answer Addenda and Guide for questions in the Guide & Work book and recommendations for spicing up the hands on field testing (pages 6-33)
- Sample final exam answer sheet and exam listed in order of book sections so it may be cut in half for a mid-semester and final exam (pages 34-47)

Review Copies and Power Point Modules for the *Technician's Guide & Workbook for Quality Installations* available upon Request. Contact Don Prather at donald.prather@acca.org or by phone at 703-824-8867

See also, Part 4 of this volume.

Power Point 1 for Day 1 – Design Aspects (60 minutes presentation 1)
Introduction and up to page 4 ending at Section 4.1.1 page 4

Class content:

- Background information & Purpose:
  - Explanation why the QI procedures are important to do
  - The general layout of the material is explained
- Scope:
  - Equipment Types
  - Exceptions
- Design Aspects (basic definitions):
  - Ventilation
  - Building Heat Gain/Loss
  - Sizing HVAC equipment
  - Matching HVAC equipment
- Equipment Installation Aspects:
  - Static Pressure (SP) in ducts explained
  - Basic SP tools and usage described

Homework: Reading: Pages 1-25 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 2 for Day 2 – Airflow Across The Indoor Heat Exchanger (60 minutes presentation 2)
Pre-class reading: (see homework above)

Class content:

- Acceptable Procedures:
  - List of acceptable procedures
  - Instrument calibration note
  - Zones and equipment setup
  - SP Drop Method (with Test Your Knowledge Study Questions p.9-10 and possible Lab/field exercises)
  - Traversing (with Test Your Knowledge Study Questions p.15-16 and possible Lab/field exercises)
  - Flow Grid (with Test Your Knowledge Study Questions p.19 and possible Lab/field exercises)
  - Pressure Matching (with Test Your Knowledge Study Questions p.22 and possible Lab/field exercises)
  - Temperature Rise Method (with Test Your Knowledge Study Questions p.23 and possible Lab/field exercises)

Field Exercises for Days 3 & 4 – Lab Exercises on Airflow Across The Indoor Heat Exchanger
(Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 26-35 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 3 for Day 5 – Water flow Through The Indoor Heat Exchanger (60 minutes presentation 3) Pre-class reading: (see homework above)

Class content:

- Acceptable Procedures:
  - Background
  - List of acceptable procedures
  - Water Pressure Drop Method
  - Water Temperature Change Method
  - Other OEM Approved Methods

Field Exercises for Days 6 & 7 – Lab Exercises on Water flow Through The Indoor Heat Exchanger (Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 36-42 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 4 for Day 8 – Refrigerant Charge (60 minutes presentation 4)
Pre-class reading: (see homework above)

Class content:

- Acceptable Procedures:
  - Superheat Test
  - Subcooling Test
  - Other OEM Approved Methods

Field Exercises for Days 9 & 10 – Lab Exercises Refrigerant Charge (Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 43-45 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 5 for Day 11 – Electrical Requirements (60 minutes presentation 5)
Pre-class reading: (see homework above)

Class content:

- Background
- Electrical Testing
- Electrical Documentation

Field Exercises for Days 12 & 13 – Lab Exercises Electrical Requirements (Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 48-53 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 6 for Day 14 – On Rate for Fuel-Fired Equipment and Combustion Venting Systems (60 minutes presentation 6) Pre-class reading: (see homework above)

Class content:

- Acceptable Procedures:
  - Combustion Testing Gas
  - Combustion Testing Oil
- Combustion Venting Systems
  - Appliance vent categories
  - Draft Hoods
  - Vent sizing & lengths

Field Exercises for Days 15 & 16 – Lab Exercises Combustion Appliance Requirements (Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 54-56 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 7 For Day 17 – System Controls (60 minutes presentation 7)
Pre-class reading: (see homework above)

Class content:

- Confirmation of control/safety selection
- OEM supported control options selected
- Verification of proper equipment cycling

Days 18 & 19 – Lab Exercises Combustion Appliance Requirements (Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 57-63 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 8 For Day 20 – Distribution Aspects/ Duct Leakage (60 minutes presentation 8)
Pre-class reading: (see homework above)

Class content:

- Acceptable Procedures:
  - Airflow Comparison Method
  - Duct pressurization test
  - ANSI/SMACNA and AHJ Methods

Days 21 & 22 – Lab Exercises Combustion Appliance Requirements (Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 64-73 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 9 For Day 23 – Airflow Balance (60 minutes presentation 9)
Pre-class reading: (see homework above)

Class content:

- Background
- Airflow measurement devices
- Traversing
- Diffuser area K
- Proportional balance

Days 24 & 25 – Lab Exercises Combustion Appliance Requirements (Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 74-80 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 10 For Day 26 – Hydronic (Water Flow) Balance (60 minutes presentation 10)
Pre-class reading: (see homework above)

Class content:

- Background
- Water flow measurement devices
- System set up
- Pressure drop method
- Doppler method

Days 27 & 28 – Lab Exercises Combustion Appliance Requirements (Selected from the Hands on Lab Exercises sections by instructor based on available tools and equipment. It is recommended where there are no tools or equipment available that the additional time is used doing the Test Your Knowledge Study Questions as a Class)

Homework: Reading assignment pages 81-89 (Instructor selects Test Your Knowledge Study Questions based on class and lab exercises selected by the school's program)

Power Point 11 For Day 29 – System Documentation & Owner education (60 minutes presentation 12) Pre-class reading: (see homework above)

Class content:

- Required documentation
- Required owner education

In securing a better understanding of the material or for the creation of a lesson plan, ACCA offers the following additional resources for instructors:

- ACCA's QI Guide & Workbook Online Video Training Course
- Residential HVAC Design for Quality Installation (online, in-person, host classes)

Part 2: Answer Addenda for QI Blue & Green Highlighted Sections

HVAC is evolving and tommorrow's technicians will need far better documentation and technical skills than past generations of technicians. The HVAC industry is poised to make a technological leap, and many technicians will not be trained or equiped to follow. By covering the information in this Workbook in detail you are preparing your students for the future. Further, they will be in demand and have many opportunities throughout their careers because they will have the basic understanding and skill set to be successful in the evolving high-tech HVACR industry. This course is designed to provide technicians with the foundation they need to become experts in HVAC installation practices and requirements. The points that are repeated, are the ones that cause technicians the most confusion, and are often done wrong in the field.

The ANSI/ACCA 5 QI-2015 HVAC (Quality Installation Specification) was first completed and published in 2007 as the minimum standard for properly designing, installing, testing and docmentating HVAC installations for residential and light commercial applications. The Standard was updated in 2010 and again in 2015. The *QI Guide & Workbook* was designed as a compendium to the standard for the installation technicians. The design requirements are coverd in courses on Manuals J, D, and S. Some of the questions provided in the Workbook's blue sections are designed to encourage class discussion so the instructor can dispell HVAC myths and rules of thumb. The vast majority of the questions are designed to drive home specific important points or to make sure the students can do the required calculations, find and identify the necessary data etc. Everything in the Guide & Workbook is part of a usefull knowledge base that is needed in the field today. By taking the students through the field exercises in the green sections, students will quickly learn what they missed or didn't fully understand as they try to apply the principles.

Answers provided in this Teacher's Guide are designed to aid instructions when they cover the material in class. In some cases, additional correct responses may not be fully covered because there are many possabilities that your creative students may come up with.

One final thing, ACCA wrote this Guide & Workbook so it could become a tool to be used to create a fun learning experience, so relax, go with the flow and have some fun with it!

Figure 11 (from Guide & Workbook): ESP Sample Measurement

Example:

Based on the ESP measurement locations shown in Figure 11, and the table values from Figure 12, the CFM of the Fan at .40 inches of water column (IWC) on medium fan speed toggle setting is 750 CFM.

External Static Pressure		Air Volume and Motor Watts at Specific Blower Taps								
		Low Speed			Medium Speed			High Speed		
In. wg	Pa	Cfm	L/s	Watts	Cfm	L/s	Watts	Cfm	L/s	Watts
.00	0	700	330	245	895	420	310	1030	485	375
.05	10	690	325	240	875	415	305	1010	475	370
.10	25	680	320	235	865	410	300	990	470	365
.15	35	665	315	230	850	400	290	970	460	355
.20	50	655	310	225	830	390	285	955	450	350
.25	60	640	300	220	810	385	280	925	440	345
.30	75	625	295	215	795	375	270	900	425	335
.40	100	595	280	210	**750**	355	255	850	400	320
.50	125	555	260	195	700	330	240	800	380	305
.60	150	510	240	185	640	300	225	725	340	290
.70	175	395	185	165	-----	-----	-----	620	295	265
.75	185	-----	-----	-----	-----	-----	-----	570	270	255

Note: All Model X9 air data is measured external to unit with air filter in place. Electric heaters have no appreciable air resistance

Figure 12 (from Guide & Workbook): Typical OEM ESP / Fanspeed / Airflow in CFM Chart

Test Your Knowledge Study Questions Pages 9 & 10 in Workbook

1. Based on the ESP values from Figure 12: if the fan speed was set on high and the ESP was 0.25 IWC, what would the CFM be using the sample table in Figure12?
   Down the left column to .25 and right across the row to high speed = 925 Cfm
2. Based on the ESP values from Figure 12: if the fan speed was low and the ESP was .70 IWC what would the CFM be using the sample table Figure 12?
   Down the left column to .70 and right across the row to low speed = 395 Cfm.
3. Based on the ESP values from Figure 12: if the fan speed was on medium and the ESP was 0.70 IWC what would the CFM be using the sample table Figure 12?
   Down the left column to .70 and right across the row to low speed = ----- Cfm. Thus, you would anticipate it is below 640 Cfm: however, since it is not listed it is not listed on the fan curve for that unit and there is a problem that needs to be resolved.
4. An HVAC system was designed to provide 1600 CFM with an ESP of 0.50 IWC in the cooling mode. Field measurements found the ESP to be 0.40 and the airflow to be 1775. Do these measurements comply with the *QI Standard* requirements?
   The fan at full speed must be within 85 and 115% of design. Thus since the unit is operating at a higher CFM 1.15 X 1600 = 1840: thus, 1775 complies for the CFM portion of the question;
   Since the ESP is less than the design amount it is compliant. Note: the lower ESP will always result in operational savings and reflects the supply and return duct system having

less resistance to flow than the design. (Larger duct, shorter runs, better grade of 90s than used for calculations etc.)

5. An HVAC system was designed to provide 1600 CFM with an ESP of 0.50 IWC in the cooling mode. Field measurements found the ESP to be 0.60 and the airflow to be 1350. Do these measurements comply with the *QI Standard* requirements?

   The fan at full speed must be within 85 and 115% of design. The unit is operating at a lower CFM .85 X 1600 = 1360: thus, 1360 does not comply with the CFM portion of the question;

   The ESP is 0.10 greater than the design amount and is compliant. Note: the higher ESP will always result in increased operational costs.

   Here you could ask the students what they would do to get a higher airflow to get some participation.

   In this example there is a problem that must be addressed. Ways to fix the problem include: replacing a dirty filter, increasing the fan speed, install larger duct to some areas, use a better grade of 90s, or increase the filter area. In this example, 10 CFM could be gained by one relatively minor fix.

6. Provide a reasons why airflow may be different in heating and cooling modes.

   This one can be a good one for class discussion. The basic idea here is there may be different BTU and airflow requirements for heating and cooling that result in different total airflow requirements. The point to make clear here is when balancing the system it needs to be in the higher airflow setting and after balancing they need to check and see if the system works in the other mode. Once in a while, zoning may be needed if the airflows are too different and it is good to identify rooms where there is a potential for trouble maintain the desired temperature during start up.

7. Explain the difference between ESP and TSP.

   ESP = External Static Pressure: for most HVAC applications that is defined the difference between the entering SP and the SP exiting the OEM's box/piece of equipment. TSP = Total Static Pressure for the system is sum of the supply and return duct measurements. Note: some engineers will use the outside of the building static pressure for TSP when outside air is being brought into a system. The main point is to know when an engineer or OEM uses one of these terms, they need to define it.

8. Contractors must prove what two separate airflow requirements have been met as evidence of acceptable airflow values across gas-fired or oil-fired heat exchanger applications:

   1st like in the first 5 questions above they must establish the unit meets the design requirements. Then as a safety check they need to make sure it meets the OEM's minimum airflow requirements across the heat exchanger. If it does not, there is a design problem that need to be noted and addressed

9. Explain the difference between laminar and turbulent airflow.

   Laminar is smooth linear airflow and turbulent airflow moves in a circular or unsmooth pattern.

10. A Technician completed his evaluation of the ESP based on the OEM charts and filled out all of the required information required. Two years later a second Technician making the measurements does not get the same result. What could some of the causes for the differences be?

    This is a great question with many answers from dirty coils or filters to shut down supply diffusers or returns blocked by furniture. One time I even found a fan squirrel cage put on backwards when a blower motor was replaced. This question was put here for fun everyone should have an answer that works.

Hands on Lab or Field Exercises

1) **Identify the test port locations, and then measure the ESP on an HVAC Unit with a wet coil and with a dry coil.**
   This can be done on any piece of ac equipment, ACCA recommends using different type of tools for measuring SP and comparing the results. Every student should get a hands on chance when possible.
2) **Based on the ESP measurements, and the fan tap setting, use the OEM chart to evaluate the CFM the HVAC unit is providing.**
   This can be done on any piece of equipment, Again, ACCA recommends using different type of tools for measuring SP and comparing the results. Every student should get a hands on chance when possible.
3) **Based on the OEM minimum and maximum airflow requirements, show that the system is operating within an acceptable CFM range.**
   Students should compare field measured values with both the OEM data and QI requirements

Test Your Knowledge Study Questions Pages 15 & 16 in Workbook

Note: To calculate round duct the area used for CFM calculations (in sq. ft.), π or 3.14 is multiplied by the area of the duct in square inches and then divided by 144 to translate the measurement into square feet. The duct area is then multiplied by 4,005, and again multiplied by the square root of the average VP measurement value to get CFM.

1. Once again laminar flow comes into play. Explain how a Technician can know when the velocity pressure measurements cannot be used for a traverse.
   Whenever a negative number is measured on the measuring tool there is enough turbulence at the testing location to cause some of the air to flow backwards. Because the measurement is a reflection of the value on the imaginary plane inside of the duct that represents the total area: having air going both ways across it makes the measurement data inaccurate.
2. VP measurement were read using a pressure differential gauge like the one pictured in Figure 16 in a 4 inch round duct. The ten VP readings of 0.25, 0.35, 0.33, 0.28, 0.34, 0.29, 0.30, 0.26, 0.29, and 0.27 were made at a 100ft of elevation and the air temperature in the duct was measured at 70^{O}F. What was the CFM in the 4 inch round duct?
   Since the altitude is 100ft, and the air temperature is 70^{O}F, no temperature or altitude adjustment is required. Step 1: The average of the 10 measurements is calculated (0.296). Step 2: the square root of the average VP is calculated (0.544). Step 3: The square root of the VP is multiplied by 4005 and the area of the duct in square feet. 4005 X 0.554 x 0.0873 = 194 CFM
   Note: area of 4" round in square feet = 0.0873
3. Based on correction table in Appendix 3 what would the correction factor be if the traverse was done at 9,000 ft. and the air in the duct had a temperature of 150^{O}F?
   The correction factor from the table (0.62) is multiplied by the CFM calculated in Question 2 above. Thus, the CFM = 0.62 X 194 = 120 CFM
4. When traversing with a hot wire anemometer what can cause the total VP measurement to be wrong?
   When using a hot wire anemometer if there is airflow going in the wrong direction due to turbulence it will not read the temperature difference as a negative number. So, there could be a false airflow measurement due to not identifying the turbulence. When there is a long straight duct run with laminar flow the hot wire anemometer will provide accurate data points for a traverse.

5. Provide directions for holding a Pitot tube when doing a traverse.
   It is important that the probe is held perpendicular, level and still and the total pressure hole must be pointed directly into the airflow to obtain accurate measurements.
6. What does it mean if a traverse is being done and the velocity pressure measurements are negative on a manometer?
   If all of the velocity pressure measurements are negative the hoses on the Pitot tube are hooked up backwards; if only one or more are negative there is turbulence present, it is not a good location and the measurements cannot be used.
7. Explain how to connect a Pitot tube to a manometer for reading velocity pressure.
   The total pressure connection at the bottom of the probe is connected to the plus or high side of the meter and the SP connection (90's out of the probe) is connected to the minus or low side of the meter.
8. Where can traverse lay-out directions and or charts for different sizes and shapes of duct be located and who are the approved providers in the *QI Standard*?
   Travers charts may be found in Appendix 2 of the Technician's Guide & Workbook for Quality Installations. Approved traverse directions from the following groups are accepted for a QI job: AABC, ACCA, ASTM, NEBB, SMACNA, TABB and ASHRAE.
9. What are the plusses and minuses of using the Traverse method in the field?
   There is no answer to this question given in the Workbook, this question was designed to invoke class discussion and thought about traversing in general. Students with or without experience generally can come up with plusses and minuses. Some answers that should be expected are: Minuses; Takes a long time to do, have to drill a bunch of holes in the duct and then reseal it, no place which will work for a traverse due to duct installation designs, etc. Plusses; provides an accurate measurement, is recognized by QI for measuring airflow, etc. Since the answer is an opinion, there is no wrong answers for this question.
10. Explain why a different number of access holes are needed in the duct for the Equal Spacing and Tchebycheff traversing methods.
    They use different formulas for calculating the hole locations.

Hands on Lab or Field Exercises

1) **Measure the supply duct and the return duct on an HVAC system and develop a traverse lay out by the Tchebycheff method. Then do a traverse and calculate the CFM.**
   This exercise can be done on a duct or on a white board. Obviously, a hands on traverse where the students can do hands on measurements and compare results is the best option. Running through the process on a white board can also be beneficial in making sure they know how to do the math.
2) **Measure the supply duct and the return duct on an HVAC system and develop a traverse lay out by the equal spacing traverse layout method. Then do a traverse and calculate the CFM.**
   See answer to number 1 above
3) **Compare the two traverse measurements with the OEM ESP chart value (if available).**
   This is a great exercise because it provides feedback on the accuracy of the measurements that the students can wrap their heads around. It lays the groundwork for explaining why numerous measurement methods may need to be used in the field to prove an airflow measurement is correct.

Test Your Knowledge Study Questions Page 19 in Workbook

Reminder: For flow grids the area used for CFM calculations equals the flow grid manufacturer's area value based on the size of grid selected in square feet. That number is then multiplied by square root of the VP and then multiplied by 4,005 to get a CFM value. That value is then adjusted for altitude and air temperature if required. Finally, the resistance of the flow grid is generally higher than the resistance of the filter it replaced so, there is an additional correction factor used based on the static pressure difference in the supply duct between the system with the filter in and the system with the flow grid in.

1. Does laminar airflow comes into play with a flow grid application?
   This question was designed to generate conversation. The general answer is no because the flow grids that slide into a unit will have a single direction the airflow travels in due to the pressure difference across it. However, there may be a turbulent area where a flow grid that attaches to a pole can't be used. Thus, for that type of application it could not be ruled out.
2. Explain how two SP measurements are taken and combined when the flow grid method is used.
   Static pressure is the measure difference between the pressure in the room and the pressure in the duct. Flow grids measure the total pressure and the static pressure which if divided into two steps could be done as two static pressure measurements and then added together. When the static pressure is subtracted from the higher static pressure measurement called the total static pressure: the pressure exerted in all directions is subtracted from the pressure caused by the airflow movement. That sum is called the velocity pressure is used to calculate the airflow.
3. What documentation is required for the Flow Grid method that is not required for the Traverse method?
   The flow grid requires a correction factor based on the supply duct SP before it is inserted and the SP during the measurement. This is used to calculate a correction factor for the measured value for the difference in resistance between the normal filter and the flow grid.
4. Provide directions for making sure the flow grid does not have any airflow leaking by.
   This is another question for discussion since it is not covered in the text but will be encountered in the field. Generally, tape, inserts and spacers provided by the flow grid OEM or any other answer is acceptable. The main point is for the students to know it can't be put in loosely with air leaking around it and work properly.
5. What are the advantages and disadvantages of using the flow grid method?
   It is accurate, and fairly quick to use for most residential systems, disadvantages include the possibility of leaking by, and needing to measure SP on the supply trunk (One more SP reading and ESP could be used with OEM data.).

Hands on Lab or Field Exercises

1) **Set up a filter box type of flow grid, and utilizing the OEM directions and correction values determine the airflow through an HVAC system.**
   This could be done by a few groups of students and the results could then be compared to prove the repeatability of the process for verification purposes in the field.
2) **Compare the flow grid measurements with the OEM ESP chart value (if available).**
   This would show the accuracy of airflow measurements in the field and the differences in values would show why measuring more than one way may be required on some jobs where the airflow is suspected to be too high or too low.

Test Your Knowledge Study Questions page 22 in Workbook

1. Does laminar airflow come into play when setting up the pressure matching method?
   No, the calibrated fan creates the flow across the orifice.
2. What documentation is required for the pressure matching method that is not required for the Flow Grid method?
   Notes on test locations supply duct SP, and set up methods
3. Provide directions making sure the pressure matching method does not have any airflow leaking between the HVAC equipment and the calibrated fan unit.
   This is another class discussion type of question designed to drive home the point that if air is leaking by or out of the test equipment set up the measurements will not be accurate.
4. When would it make the most sense to use the pressure matching method?
   This can be done when there is going to be a duct leakage test because the equipment is on site and set up.
5. What are the limitations based on fan sizing to the pressure matching method?
   Generally, the fan sizing is ok for use in residential systems and all systems that can be measured utilizing the tool OEM's directions and tables. Systems with large blowers may exceed the table values for some of these blowers. Thus, for light commercial applications this tool may not be large enough to provide an accurate answer.

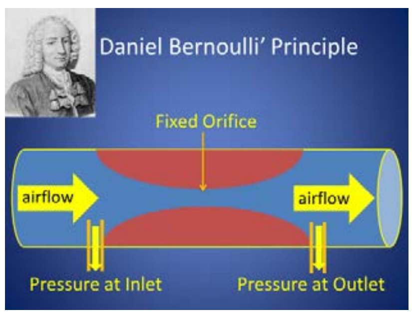


Figure 19 (from Guide & Workbook): Brenoulli Principle

Note: Calibrated fans and many other tools are based on the Bernoulli's principle (see Figure 19): if you know the pressure on both sides of a fixed orifice you can then calculate the flow through that orifice.

6. Without the Brenoulli principle many of the test tools used for airflow and water flow would not exist. When using test instruments to measure the pressure in and the pressure out what cautions should be taken to ensure the equipment is measuring the correct pressure?
   This question is a reminder on how the SP probes, hoses and meters need to be set up from page 7 in the text. It introduces the idea of water flow being calculated using the same methods. Air is considered a fluid in physics so this question reinforces that idea and gives students another way of remembering it.

Hands on Lab or Field Exercises

1) **Set up a calibrated blower fan designed for pressure matching and utilizing the OEM directions and correction values determine the airflow through an HVAC system.**
   This can be done by groups and the answers compared for accuracy and repeatability. If there is a chance for you to slip in some blockage or turn down a damper between tests without being noticed, it is a good diagnostic lesson for the students to work out too.

2) **Compare the calibrated fan measurements with the OEM ESP chart value (if available).**
   This can be done by groups and the answers compared for accuracy and repeatability.

Test Your Knowledge Study Questions page 25 in Workbook

1. How does laminar airflow come into play when using the temperature rise method?
   If the airflow is not laminar it will result in low airflow and the temperature rise will be too high. In worst case scenarios it will result in system short cycling due to the heat exchanger overheating and tripping the high temperature safety.
2. Explain why the equipment must be operating in the maximum heating position to perform the temperature rise test.
   The OEM CFM charts are based on full load conditions.
3. Explain why the fuel or electrical measurements must be verified in the maximum heating position to perform the temperature rise test.
   The OEM charts depend on the heating elements to be functioning correctly. Thus, the combustion must be operating correctly for a fuel fired unit, and the voltage and amperage must be correct for an electric furnace.
4. Provide directions to make sure the temperature probe is measuring the average temperature in the duct.
   It is critical that the temperature probes are long enough to sense the average temperature in the duct, and properly placed in the supply duct and in the return duct. This is especially true if there is make-up air present. The probes have to measure the average temperature accurately for the table to work.
5. What are the advantages and disadvantages of using the temperature rise method?
   This is a list of reasons there is not a single correct or wrong response. One main advantage is it is easy to do after the combustion system is set up properly and is included in many OEM combustion startup procedures (same for electrical resistance heating). One main disadvantage is the difficulty in getting accurate average temperature measurements.
6. Describe stratification in airflow.
   Stratification is when there are layers of air flowing that are different temperatures. For example when an outside air/makeup air stream meets a return air stream, they will try to remain separate. Many duct systems will install something to cause some turbulence and mix the two before they enter the return filter and the heat exchanger.

Hands on Lab or Field Exercises

1) **Utilizing OEM directions use the temperature rise method to measure airflow across the heat exchanger.**
   Obviously, this is not a good test to shut off air on between groups!
2) **Compare the temperature rise method with the OEM ESP chart value or another airflow measurement type.**
   At this point the values and their accuracy for the various types of measurements done by the students can be compared for accuracy. This type of comparison and knowledge will help them in the analysis of field measurements in the field. Hopefully, it will save them from submitting obviously flawed or bogus numbers third party evaluators too often find when checking existing work on failed jobs.

Test Your Knowledge Study Questions page 29 in Workbook

1. Name 3 items that are found on the OEM chart for pressure drop across the coil?
   Common correct answers include: GPM, water pressure drop, water temperature, coil model number, coil manufacturer's name, and for this guide, type of coil.
2. Explain why the hydronic loop pump must be operating and the air must be removed before making a pressure difference measurement.
   The pressure measurements needed are dependent on laminar flow of water. Thus, if there is air in the system the pressures will not be correct and in a worst case the gages needles will be bouncing and not settle on a point.
3. Explain why the expansion tank should be properly set up before hydronic measurements are taken.
   The expansion tank allows for the expansion of water in the system. When doing a water pressure test for calculating pressure drop, the pressures must remain stable and must reflect the final operating conditions. When an expansion tank is adjusted, it may change the flow by changing the operating pressures. Thus, requiring another check of the flow at the new pressures.
4. Why may a Doppler meter provide incorrect measurements on existing pipe systems?
   The Doppler method is dependent on the pipes being in new condition. If there is scale on the inside of the pipes the inside area is smaller and the calculations will not take that into account resulting in a higher than actually present water flow reading.
5. What are the advantages and disadvantages of using the temperature rise method?
   The main advantage is how easy and quick it is to take this measurement. One disadvantage is it requires access to the water for measuring the temperature. (Note: this should have said pressure rise same answers)

Water Pressure Drop (in Feet @ 180ºF)			
GPM	**Coil A**	**Coil B**	**Coil C**
2	**0.4**	**0.4**	**0.5**
4	**1.4**	**1.6**	**1.7**
6	**3.0**	**3.3**	**3.7**
8	**5.2**	**5.7**	**6.3**
10	**7.9**	**8.7**	**9.6**

Figure 25(from Guide & Workbook): Sample OEM Coil Pressure Chart

6. When measuring pressure drop across the coil in the field a Technician found the pressure drop on a coil type B (use sample OEM chart above) to be 2.2 in a system where the water temperature was 180ºF. How many gallons per minute would be going through that coil? (To find a value interpolation is needed see math review section if required).
   2.2 would obviously be between 6 and 4 GPM. Interpolation:

   Step 1: 3.3 – 1.6 = 1.7; Step 2: 3.3 – 2.2 = 1.1 ; Step 3: 1.1 ÷ 1.7 = 0.647; Step 4: 6 – 4 = 2; Step 5: 0.647 X 2 = 1.284; Step 6: 6 – 1.284 = 4.716 GPM or about 4.7 GPM

Hands on Lab or Field Exercises

Measure the pressure drop across the heat exchanger and evaluate the water flow based on the OEM Chart.
This test should get the same results for everyone doing it. It is a great place for teaching interpolation because the students will see the need to learn it so they can get answers in the field.

Test Your Knowledge Study Questions page 32 in Workbook

1. A Technician found there was a flow of 1.5 GPM using the temperature rise method in a system operating at 60ºF and with 50% Propylene Glycol added for freeze protection. What would the actual GPM be when corrected for the antifreeze's effect on the measured value?
   This is a trick question because the flow rate is 1.5 GPM. The actual equivalent GPM that would be used for calculating the load in BTUs would be a slightly smaller number. Thus, in some cases it is important to know how much work the water can actually do when it has been derated by the addition of antifreeze. The Figure 28 table correction factor for -60 Propylene Glycol is 1.045 and for -26 it is 1.041. First interpolate for the correction factor (1.04425). Then divide the 1.5 GPM by the factor to get the equivalent GPM for water without the antifreeze: 1.5 ÷ 1.04425 = 1.44 GPM. Thus, if 1.5 GPM was required, 96% of the required water flow would be present. Note: The main point is some efficiency will be lost when antifreeze is required for safe cold weather operation and when adding it a precise measurement of the percentage used is important to do.
2. Explain why many Technicians may do both the pressure drop method and the temperature rise method and compare results when balancing a system.
   When there are test ports for both, and the OEM provides both values it only takes a minute or so to evaluate flow using both methods. Thus, they can double check their numbers easily. It is always a best practice to test using two methods when balancing a system in order to double check the results.
3. Why is it important to measure the temperatures using a bulb well or a specialized type of temperature probe like a Pete's plug (see Figure 29 below) needle tip temperature gauge to get the temperature of the water?
   The measurement's accuracy depends on the measurement probe being in the water stream or at least not losing temperature to heat transferred by the slight difference between the pipe's surface temperature and the internal water temperature.
4. What are the advantages and disadvantages of using the temperature rise method?
   Here many answers correct, the main points to get would be: The temperature rise method is an easy quick method for evaluating heat transfer. The main disadvantage is the possibility of errors due to the accuracy of the temperature measurement tools. Additionally, OEM tables are for new equipment startups and the measured values may not be accurate for use in verification of water flow after a few years of operation.
5. List the items required for documenting water flow using the temperature rise method.
   Name of Technician; Job location; Date of readings or measurements; field calculations and temperatures measured; OEM chart; Equipment location.

Figure 29 (from Guide & Workbook): Pet's Plugs™ (left) and Temperature/Pressure Probe Designed For Direct Water Stream Insetion (right)

Hands on Lab or Field Exercises

Measure the water flow based on the water temperature rise method and compare to the water flow using a water flow meter or another water flow measuring method.
This is a good exercise because it can be used to quantify errors caused by temperature measurement errors in the field.

Test Your Knowledge Study Questions page 35 in Workbook

1. How are the pressure drop measurements across an orifice converted into GPM?
   The answer here includes some explanation or calling out of the Bernoulli Principle.
2. Explain why the equipment must be operating in the maximum heating position to perform the pressure drop test.
   The maximum flow rates may only be achieved in the maximum heating position for variable speed systems. It is a good practice to test and balance at maximum flow values and under a maximum load when possible. This is a trick question designed to stimulate conversation in a class because the flow can be measured by the pressure drop accurately for the design range of the balancing valve.
3. Explain how the flow rate in GPM will affect the velocity of water through an orifice.
   The greater the flow rate the greater the velocity. It should be noted that this is true within the design limits of the measuring valve.
4. Explain how the PSI increase across a flow measuring valve will affect the GPM.
   The greater the PSI is the higher the GPM value will be. It should be noted that this is true within the design limits of the measuring valve.
5. Explain how the Bernoulli Principal applies to water flow measurements.
   In actuality, it probably should be explained why it applies to air because it is based on fluid flow. This question was designed to reinforce how the Bernoulli Principal works.

Hands on Lab or Field Exercises

Measure the water flow based on the pressure difference in a water flow measuring / balancing valve using the OEM directions and the valve chart.
This can be used to evaluate other field measurement values since it will generally be the most accurate value. Be sure to point out the GPM measured is within the OPEM chart values. A common error found in the field is Technicians trying to use oversized valves to get values when the measured values are not on the charts. They need to be confident they can tell the engineer the valves need to be replaced before balancing can be done.

Test Your Knowledge Study Questions page 39 in Workbook

1. Name the type of expansion devices that identify the need to verify refrigerant charge using the superheat test.
   Fixed orifice; piston metering device; cap-tube
2. Explain what step is required if the superheat value is lower than the OEM's required value.
   The system is overcharged and refrigerant needs to be removed.
3. Explain what step is required if the superheat value is higher than the OEM's required value.
   If the reading is greater than the specified value: a few ounces of refrigerant will need to be removed and placed in a new recovery cylinder or one with the same type of refrigerant in it. Wait 15 minutes and test again. Continue this process until the measured superheat is within the specified range.
4. Provide directions to make sure the temperature probe is measuring the correct temperature for the suction line temperature measurement.
   The temperature probe should then be strapped or clamped mechanically to the top of the pipe, completely insulated, and taped so that the temperature is as close to the refrigerant temperature in the pipe as possible.
5. How will refrigerant gauge calibration and accuracy affect superheat calculations?
   This is another trick question for class discussions. Generally, the gage will not read inaccurately when it is used to subtract and get a superheat value. Thus, if the total is wrong by the same amount for both measurements it should not make the superheat difference an incorrect value.

Hands on Lab or Field Exercises

1. **Check the refrigerant charge using the superheat method.**
   This is a good class exercise and all of the measured values can be put together and displayed. Any differences can be discussed. For example, where some different due to the room cooling down, how did this affect the super heat readings etc.
2. **Remove or add refrigerant and weigh in the OEM charge and compare results with the superheat method.**
   This is a good exercise and you can add a step by adjusting the refrigerant first by superheat, then removing it and weighing it to see if it matches the OEM weight. Thus, some can adjust the charge first and weigh the charge after it is removed. Others can weigh in a charge and then check the superheat. Giving the students practical experience in removing and adding a charge. Remember to properly vacuum the system between charging to show students how that process works as well.

Test Your Knowledge Study Questions page 42 in Workbook

1. Explain why refrigerant gauge calibration (see Figure 37 below) is important for refrigerant charge testing?
   Again a trick question, for class discussion. To accurately know the temperatures the pressures need to be accurate however, when the test is based on a pressure difference the meter must accurately measure the difference not the exact pressures.
2. Explain what step is required if the subcooling value is higher than the OEM's required value.
   When the reading is greater than the specified value: a few ounces of refrigerant will need to be removed and placed in a new recovery cylinder or one with the same type of refrigerant in it. Wait 15 minutes and test again. Continue this process until the measured subcooling is within the specified subcooling range.
3. Explain what step is required if the subcooling value is lower than the OEM's required value.

   When the reading is less than the specified value: add a few ounces of refrigerant and wait 15 minutes and test again. Continue this process until the measured subcooling is within the specified subcooling range.
4. Provide directions to make sure the temperature probe is measuring the correct temperature for the suction line temperature measurement.
   The temperature probe should be located as close to the liquid line connection at the condenser as possible. Subcooling requires an accurate temperature measurement of the liquid line (sometimes referred to as high-side line). It is important to ensure that the pipe has been cleaned or lightly sanded down if necessary, and the temperature probe is securely attached because good clean contact is required for accurate readings. The probe should be wrapped with insulation and taped so the temperature measured is as close to the temperature of the pipe as possible (generally on top of the pipe).
5. Using the chart in Figure 36 for an OEM subcooling value of 10 determine the subcooling value for 163 psig.
   78
6. How will refrigerant gauge calibration and accuracy affect subcooling calculations?
   This is another trick question for class discussions. Generally, the gage will not read inaccurately when it is used to subtract and get a superheat value. Thus, if the total is wrong by the same amount for both measurements it should not make the superheat difference an incorrect value.

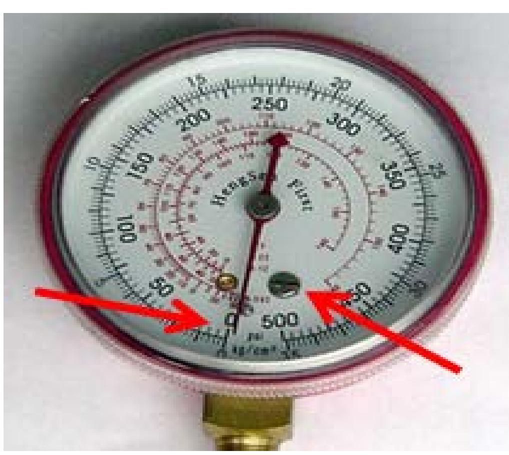


Figure 37 (from Guide & Workbook): Gauge Calibration Needle Zero Adjustment Screw

Hands on Lab or Field Exercises

1. **Check the refrigerant charge using the subcooling method.**
   This is a good class exercise and again the various measurements taken by students can be compared.
2. **Check gauges for calibration.**
   Changing gauge calibration during a break can add some spice to the discussions and the measurement procedures and reinforce how to calibrate a gauge.

Test Your Knowledge Study Questions Pages 46 & 47 in Workbook

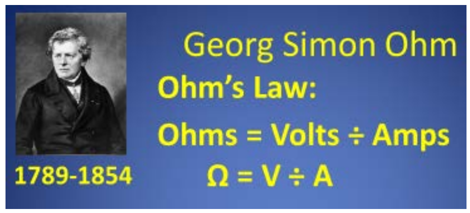


Figure 43 (from Guide & Workbook): Ohms Law (resistance in ohms = volts divided by Amps)

1. A Technician found there was 120 Volts on a circuit that measure 9 amps what would the resistance in ohms be?
   120V ÷ 9 A = 13.33 Ω
2. Explain how to make a voltage and amperage measurement on an HVAC system.
   This question was meant to be used to get class discussion going. In some cases you may not be able to measure the voltage and amperage for a whole system with one set of measurements. Students could also interpret this question as how to use the tools.
3. Name 2 items that can be found on OEM data plates and can be measured in the field.
   The standard answer would be volts and amps, there could be hertz, horsepower, etc.
4. What code is followed for wire sizing?
   National Electrical Code (NEC)

Figure 44: Wire Type Markings Figure 45: Sample Marked Wires

(From Guide & Workbook)

5. Figure 44 on the left above shows wire types in the abbreviations placed on the wire. Figure 45 on the right shows a THHN wire. If it is a stranded wire explain where that wire might be used in a correctly wired HVAC system.
   This again is a class discussion question, and anywhere but outside where there are contaminants in the air that can cause oxidation is a correct answer. A leading question might be: would you use stranded wire for condenser wiring in an ocean front application?

Hands on Lab or Field Exercises

1. **Measure evaporator Fan Amperage and voltage.**
   Compare student measurements using different meters.
2. **Measure Condenser amperage and voltage.**
   Compare student measurements using different meters.
3. **Measure control amperage and voltage.**
   Compare student measurements using different meters.
4. **Compare results of all of the readings above to the OEM's maximum and minimum voltage and amperage name plate listings.**
   This is to reinforce the idea that there are acceptable ranges they should be looking at when measuring amperage and voltage.

Test Your Knowledge Study Questions page 50 in Workbook

1. Explain why the pressure of the fuel needs to be within the OEM specified range in order to do a combustion analysis?
   When the pressure of the fuel is low the proper amount of fuel is not supplied. Thus, the combustion would tend to run lean. Why waste time doing a combustion test to show that result before adjusting the pressure.
2. Explain why the oil nozzle selected is an important factor for proper combustion in an oil fired furnace.
   Proper flame size is critical for the heat exchangers proper operation. When the wrong nozzle is selected it will not provide the proper BTU. In worst case scenarios, oversizing or the wrong angle selection, could cause oil to hit the sides of the heat exchanger and build up. Thus, decreasing airflow and causing more buildup.
3. Why would properly trained Technicians verify the airflow across a heat exchanger is correct before starting a combustion analysis test on a furnace?
   It is a good practice to verify that heat can be removed via the airflow before applying the heat (turning on the furnace or boiler (same for water flow through the heat exchanger).
4. Using the sample data sheet in Figure 49 name the model number, pump GPM, nozzle sizing, and input rating needed to provide an output of 112,000BTU.
   O23V Unit -140; nozzle size 0.85 GPH-80^{O} B; pump psig 140; input rating 140,000; output rating 112,000; Note pump GPM can be calculated based on 0.85 GPH ÷ 60 Min = .0141666 (the point of that part of the question was to point out GPH is in hours.
5. For a gas furnace explain why it is important that the furnace be within the manufacturers firing range.
   Safety when firing is dependent on all of the OEM directions being followed for all fossil fuel appliances.

Hands on Lab or Field Exercises

1. **Using meter and HVAC equipment manufacturer's directions do a combustion analysis on a fuel fired furnace or a boiler.**
   Good class exercise can compare answers to make sure they understand how to operate the meter and the accuracy thy may expect in the field. Can move the pressure adjustments during a break (so they don't catch you) to vary the results.

Test Your Knowledge Study Questions page 53 in Workbook

DC96VC & DM96VC Direct Vent (2 - Pipe) and Non-Direct Vent (1- Pipe)										
Maximum Allowable Length of Vent/Flue Pipe & Combustion Air Pipe (ft)										
Unit Input (Btu)	Pipe Size (in.)	Number of Elbows								
		0	1	2	3	4	5	6	7	8
45,000	2 or 2 1/2	220	215	210	205	200	195	190	185	180
70,000	2 or 2 1/2	200	195	190	185	180	175	170	165	160
90,000	2 or 2 1/2	30	25	20	15	10	NA			
90,000	3	105	98	91	84	77	70	63	56	49
115,000	3	119	112	105	98	91	84	77	70	63

1) Maximum allowable limits listed on individual lengths for inlet and flue and NOT a combination.

2) Minimum requirement for each vent pipe is five (5) feet in length and one elbow/tee.

Figure 53 (from Guide & Workbook): Typical OEM vent pipe design requirements

1. Using the chart shown in Figure 53 above, what is the maximum number of elbows that can be installed for a 90,000 BTU unit?
   The answer is: 8 for 3" pipe and 4 for 2" or 2.5" pipe.
2. Explain why combustion venting design must meet the furnace or boiler equipment manufacturers design requirements.
   For safe operation all of the code and OEM installation requirements must be met. Improper venting may cause serious safety concerns.
3. Explain why a manufacturer's required slope for venting might be important on a category IV venting system.
   A condensing furnace needs to drain and anywhere drainage is designed into a system you will find a slope to ensure the condensation can be moved to where it is designed to be captured and removed.
4. Explain why the vent pipe diameters selected in the chart above change the number of elbows and total length of the vent system.
   The larger pipe will handle a larger input BTU value and the additional resistance to flow caused by adding 90s is proportionally smaller.
5. Figure 52 shows a typical OEM start up sheet for a boiler. Why would an OEM want the startup sheet properly filled out before an equipment warranty was approved?
   Obviously, to make sure it was installed properly!

Hands on Lab or Field Exercises

Use OEM venting requirements to evaluate the venting on a boiler and/or a furnace.

This can be done using lab equipment and the OEM directions to evaluate the equipment's installation. A good question is ask what the maximum vent piping length could be if a number of 90s were added to reinforce the OEM sizing limits.

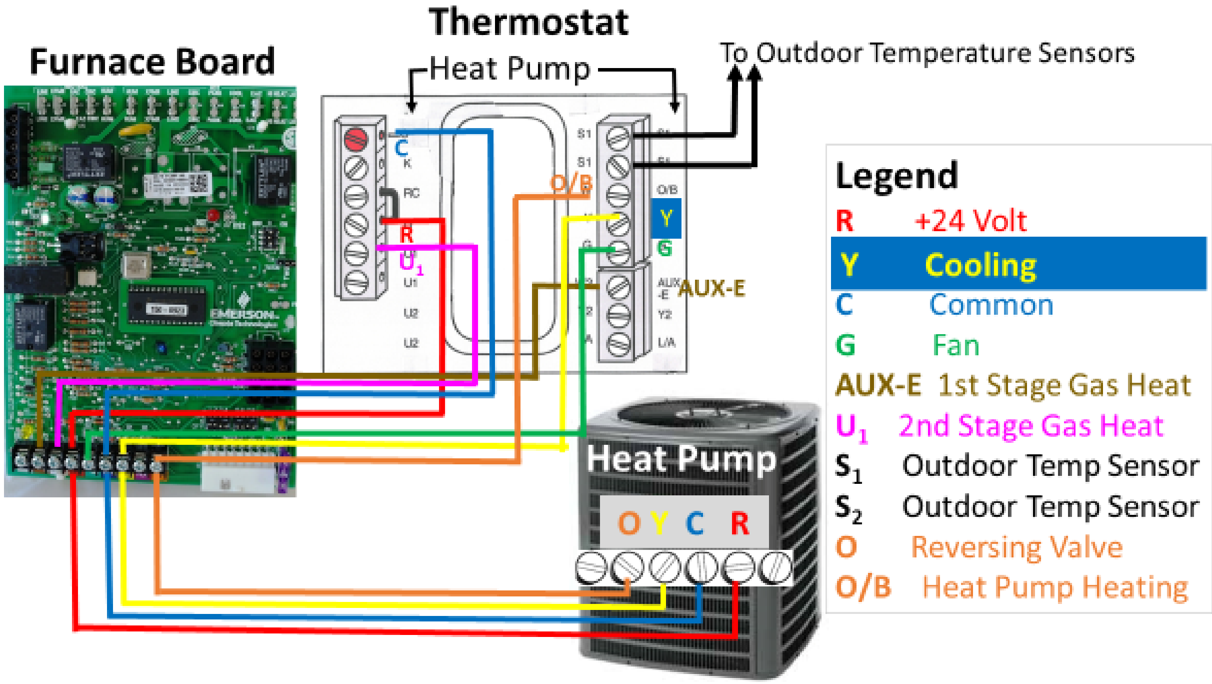


Figure 56 (from Guide & Workbook): Typical Digital HVAC Sequence Controller

Test Your Knowledge Study Questions pages 55 &56 in Workbook

1. In Figure 56, according to the legend, what color wire is used by the OEM for the reversing valve control?
   Orange
2. Explain why "as built" set points need to be recorded in the equipment documentation.
   Often the out of the box factory set points are not correct for the application. Thus, it is always a good practice to record all "as built" measurements and set points for future reference and proof that the system was operating and installed properly.
3. In your experience where would you locate calibration information for a thermostat?
   This can be answered in many ways: from an OEM web page or app, from the documentation in the box, from the inside lid of the thermostat etc.
4. Where would a Technician find information on testing and calibrating a safety device?
   This too can be answered in many ways: from an OEM web page or app, from the documentation in the safety device's box, etc.

5. Explain why many safety devices are wired in series with the low voltage power supply?
   It is cheaper to make them for low voltage applications, controlling for safety in the low voltage circuit make sense, again many correct answers are possible and this question was meant to get class discussion going. Most students should have a workable answer to this question.

Figure 57 (in text) shows Ohm's Law, explain what can cause a fuse to blow and why that may indicate a problem in the protected system or the supply voltage.
Fuses generally "blow" when their amperage and/or voltage limitations are exceeded.

6. The picture below also shows a blown fuse in the top right corner. What will the Ohm meter read if that fuse is measured?
   As pictured the meter is reading a resistance in ohms so the white fuse is good. If the fuse in the top right corner was measured, the meter would read no resistance because it would see an open circuit.

Figure 57 (from Guide & Workbook): Verifying a Fuse is Good (Shows Ohms Resistance on the Meter (left) Typical Blown Fuse (top right)

Hands on Lab or Field Exercises

1. **Verify the calibration of the thermostat.**
   This can be a fun exercise if numerous types of thermostats are checked and some are good and some are bad.
2. **Determine if the control wiring is in compliance with the OEM drawings.**
   This can be done as a diagnostic exercise where something is wrong and it is not working. Leaving a wire connected that has had the cover removed can be interesting for students to find. All in compliance but not working….where to look next?
3. **Verify that the equipment will operate safely in heating and cooling modes.**
   Too often in the field, startup Technicians only check the system for the season they are starting it up in.

Test Your Knowledge Study Questions page 59 in Workbook

1. For a new installation, a Technician found there was a 155 CFM leakage rate during testing on a two-ton system designed to operate at 800 CFM. Does this system's duct system pass or fail?
   This system fails and the ducts need sealing it is above 10%: 155 ÷ 800 X 100 = 19.375%

2. For an existing installation, a Technician found there was a 155 CFM leakage rate during testing on a two-ton system designed to operate at 800 CFM. Does this system's duct system pass or fail?
   This existing system passes it is below 20%: 155 ÷ 800 X 100 = 19.375%
3. Why is it important to seal off all of the outlets when measuring duct leakage using the duct pressurization method?
   If the outlets leak it will make the resulting leakage look higher than it is.
4. What are the advantages and disadvantages of using the duct pressurization method?
   There are numerous answers to this question main points for using the method are: provides accurate results that can be compared to the required values. Point against: Takes time to set up, need a calibrated blower and a meter to do the measurement.
5. List the items required for documenting airflow using the duct pressurization method.
   Technician's Name; Test date; Location; Supply air temperature; Data on the test equipment including models and serial numbers; Copies of airflow measurement data sheets and calculations; Copies of test instrument manufacturer's data sheets or tables, if available.

Hands on Lab or Field Exercises

1. **Set up and run a duct leakage test using the duct pressurization method following the test equipment OEM's directions.**
   Students can each do the setup and measurements and results can be compared. Here, during a break between student setups a damper can be opened or some tape removed to change the leakage rate. It is an interesting lesson on how much air leaks out of a few small holes.

Test Your Knowledge Study Questions page 61 in Workbook

1. What are the advantages and disadvantages in using the Airflow comparison method for evaluating duct leakage?
   Many correct answers are possible, the two main points are: ease of measurement with a common air balancing tool is a plus and lack of accuracy and the possibility of a math error in adding up the totals are minuses.
2. For homes or buildings in compliance with ASHRAE 62.2 and 62.1 requirements, explain why the outside air supply duct would need to be sealed in order to use this method of testing?
   Obviously, duct leakage cannot be tested with an opening to the outside left open. Note: this question is here because the mistake has been made when testing commercial systems for leakage.
3. When doing the airflow comparison method, could a flow grid be used for measuring the return airflow in a system without return ducting?
   The answer is yes. Any method that would verify the return airflow at the filter could be used.
4. Explain why a fan powered AMD does not need a correction factor for measuring airflow through a diffuser or grille.
   The fan powered AMD has a built in orifice and a calibrated fan. Thus, the meter will display the actual FPM. Loop-hole alert: there may be meters that do not adjust for altitude and temperature, in that case the premise of this question is wrong.
5. List the items required for documenting airflow using the airflow comparison method. Will the items listed vary depending on the return airflow method selected?
   Starting with the second part of the question the items listed will vary when tools other than the AMD hood type of tool is used. The basic list is: Name of Technician; Test date;

Location; Supply air temperature; Data on the test equipment including models and serial numbers; Copies of airflow measurement data sheets, and calculations, will be submitted as the acceptable documentation for §5.1.3 for this test; If the customer refuses to approve the cost of repairs to the duct, documentation of the customer's notification and refusal is required.

Hands on Lab or Field Exercises

1. **Measure airflow leakage using the airflow comparison method.**
   This is a good class exercise, be sure to reinforce double checking the addition: generally errors will be made when students add long columns of numbers. They need to know why it is important to double check their math in the field. It could save them a lot of duct sealing!
2. **Compare results to a test done using the duct pressurization method following the test equipment OEM's directions.**
   Comparing the two methods will provide the students with reinforcement on the methods and the accuracy of each.

Test Your Knowledge Study Questions page 63 in Workbook

1. Explain when a Technician would use the ANSI/SMACNA HVAC Air Duct Leakage Test Manual method.
   Generally, this method could be used any time. However, it is much more likely to be required on a larger commercial balancing job.
2. Explain why the 25 Pa testing pressure may not be adequate for testing duct designed to operate at high pressures.
   Testing at higher Pascal testing pressures will provide duct pressures closer to the higher operating pressures in some commercial systems and better reflect the leakage at those higher pressures.
3. Explain why calculating duct area in square feet to use with the SMACNA commercial duct leakage formulas might add unnecessary extra steps for a residential duct system's leakage analysis.
   Residential systems tend to be smaller thus, total leakage without regard to the duct's area has been deemed as accurate enough for low pressure designs. Since the large commercial buildings have computerized engineer sized duct drawings that include sizing, the duct leakage testing by sections can be more easily laid out by the design engineer. This duct leakage testing process is generally specified for hospitals, labs, buildings with variable air volume systems, and industrial facilities.

Hands on Lab or Field Exercises

1. **Visit a building like a hospital or an office building with Variable air volume ducting systems designed to operate at high velocity above the pressure of iwc and study the sealing practices.**
   Many students have never seen high end commercial systems. A field trip to the local hospital or an office building with VAV systems is good for all of them and may encourage a few to consider
2. **Use the SMACNA Manual's directions to perform a duct leakage test.**
   This is a good exercise if your training facility's focus is on technicians who will be employed in the commercial and industrial sector.

Test Your Knowledge Study Questions page 65 in Workbook

The formula used for the balancing shortcut above $(CFM_{beginning} \div CFM_{final})^2 = (SP_{beginning} \div SP_{final})$ is Fan Law 2 there are two other fan laws used in testing and balancing work: Fan law 1 shows the relationship between CFM and revolutions per minute of the fan (operating within the fan curve). Fan law 3 compares CFM to the horsepower required to move that amount of air. Fan laws 1 is: $(CFM_{beginning} \div CFM_{final}) = (RPM_{beginning} \div RPM_{final})$ and Fan law 3 is: $(CFM_{beginning} \div CFM_{final})^3 = (BHP_{beginning} \div BHP_{final})$ where BHP = Break horsepower. From those formulas it can be seen that a small increase in CFM will result in a larger change in static pressure and a much larger change in the horsepower requirements. For more information on using these formulas in calculations see the Fan Laws in Appendix 1 Quick Math Review.

1. Explain why is it important to check airflow balancing with the doors open and closed?
   Airflow follows the path of least resistance. Thus, simply opening or closing a door can change how many CFM are entering (and then leaving) a room. The only way to make sure the return paths work is to shut and open the doors during testing.
2. Explain why it is important that the design airflow is verified before attempting to balance a system.
   Partially closing balancing dampers to adjust to the proper airflow adds resistance to the system. Thus, balancing by its nature will generally slightly decrease the total airflow. The best practice is to measure the airflow before starting to balance and when possible it should be set between 100% and 110% of the designed airflow to allow for a slight loss due to the added resistance.
3. Explain why balancing the airflow into each room is important?
   Airflow = BTU and each room has a BTU requirement for heating and cooling. When the airflow is low or high the BTUs into that space are also low or high. When there are more or less BTU provided to a room it will be warmer or cooler than it was designed to be when the system is operating.
4. Explain why the duct dampers should each be in the open position before starting a balancing procedure?
   Before balancing, the dampers need to be placed in the open position so the airflow is maximized and the total duct system resistance is minimized.
5. Explain why a small increase in airflow may cause a large increase in the horse power required?
   Fan law 3 states: $(CFM_{beginning} \div CFM_{final})^3 = (BHP_{beginning} \div BHP_{final})$ thus: for a sample problem where the original BHP was 0.25 and the CFM was 1200, if the CFM is increased by 10% to 1320 the BHP would be increased by
   $(1200 \div 1320)^3 = (0.25 \div BHP_{final})$…….$0.7513148 = 0.25 \div BHP_{final}$ Thus $BHP_{final} = 0.25 \div 0.7513148 = 0.33275$. In this case, a 10% increase in airflow resulted in a 33.1% increase in the BHP.
6. On a job with a multi speed fan operating in low speed, the first measured CFM (from a traverse in the duct) was 856 CFM and the first measured static pressure in the supply duct two feet down the main branch and before the first take off by another 2 feet (the traverse location) was 0.56 inches of water column (IWC). The Technician changed to medium fan speed and the static pressure changed to 0.61 IWC. What would the new CFM be based on Fan Law 2?
   Fan Law 2: $(CFM_{beginning} \div CFM_{final})^2 = (SP_{beginning} \div SP_{final})$; Thus plugging in the numbers results in:
   $(856\ CFM \div CFM_{final})^2 = (0.56 \div 0.61) = 0.918$
   In algebra we can take the square root of both sides of an equation and it does not change the final result so in this case we can remove the square by taking the square root on the left

side and simply make that equal to the square root of 0.918: $856 \div CFM_{final} = 0.918^{0.5} = 0.958$ & $CFM_{final} = 856 \div 0.958 = 894$ CFM

Hands on Lab or Field Exercises

1. **Measure airflow through a duct and the SP of the duct. Adjust the airflow using only a SP measurement and a damper adjustment and verify the airflow change is correct.**
   This is a good exercise that once mastered and learned can save Technicians time when balancing large systems in the field.

Test Your Knowledge Study Questions page 68 in Workbook

1. A Technician using an AMD measured an airflow of 100 CFM from a bedroom diffuser. Based on an earlier traverse done on the duct trunk feeding the diffuser the airflow was actually 110 CFM. What would the Technician use as a correction factor for diffusers that were the same type and size?
   Since the actual measured airflow based on the traverse was 110 the correction factor for AMD hood readings for that type of diffuser would be 10%. Thus the measured value would be multiplied by 1.1.
2. Explain why two supply registers that were near to each other might not provide the correct CFM measurements when a non-fan powered AMD is used.
   The resistance of the hood on the AMD may result in pushing more air than normal to the other open diffuser causing the measured diffuser to have a low measurement.
3. AMDs are a great tool for measuring airflow and have made measurements quick and easy after correction factors are calculated (if required). Why would the air temperature need to be recorded as a requirement in the documentation section?
   Many AMD will not correct for air temperature, when balancing hot air, it is important to take the temperature into consideration. Most balancing is done on cold air where the temperature will not result in a percentage of error worth noting. Note: The correction chart on page 110 of the Guide & Workbook shows airflow as being 3% higher at 55F and 3% lower at 90F. Thus, recording the air temperature provides a baseline for how accurate the measurements are and for using the correction factor when recording the final CFM results on a balancing report.
4. Explain why it might take longer to measure airflow using an analog AMD where there are both vertical and horizontal diffusers in every room.
   Hood type analog AMD need to be calibrated for horizontal and vertical measurements.
5. What are some of the advantages and disadvantages of measuring airflow using an AMD?
   Many answers are possible, main points include: Advantages will include is a fast tool for getting measurements that can be used for proportional balancing, disadvantages will include has questionable accuracy on round diffusers and there needs to be a correction factor established when they are used for balancing (with the exception of the fan powered AMD)

Hands on Lab or Field Exercises

1. **Using a traverse or a flow station value check for a correction factor on a specific diffuser type for balancing with an AMD.**
   It is always good to have the students operate the tools and to get real measurements that can be compared to measurements done by others. Using the traverse or a flow station will reinforce double checking the measured value the AMD hood spits out like gospel.

Test Your Knowledge Study Questions page 73 in Workbook

1. Why might the average airflow in a traverse when measured with a hot wire anemometer be suspect if there is turbulence in the duct where the measurement was taken?
   The hot wire anemometer does not distinguish which way the air is going only the temperature difference caused by the flow itself.
2. Where would a Technician go to find traversing directions?
   Hopefully, they answer in the Guide & Workbook. Also: ACCA Manual B, AABC, ASHRAE, NEBB, and TABB
3. When using the Ak method for measuring the average airflow coming out of a grille or diffuser what correction factors might be needed?
   Many answers are OK here including: temperature, altitude, and the meter's mechanical error
4. When balancing why is it a good practice to balance within 5% of the design airflow value?
   Balancing should always be done as accurately as possible. By balancing within 5% the correct BTU in each room is provided. When other tools are used to verify that a building is balanced correctly being within 5% provide less of an opportunity for other tools to measure airflows more than the 20% allowable within the standard's requirements. The reason the 20% was allowed was for verification due to the different errors in tools, not for what would be considered a reasonable way to balance a system.
5. List the items required for documenting airflow on a balancing report.
   Technicians name; Test date; Location; A document that indicates the room names and diffuser/return register readings, and area k value and/or correction factors for AMD; Meter / model and serial number, correction factors (if needed); Location/AHU unit number; Supply air temperature; Design value and % of design for final readings.

Hands on Lab or Field Exercises

1. **Measure airflow using the AK value for a diffuser, OEM directions and an anemometer.**
   This is a good math exercise, and the students can compare answers. By doing these as individuals and comparing them to others, especially if different tools are used, the students may come to appreciate why balancing within 5% is a good idea (especially if their work may be verified).
2. **Verify airflow value measured by another acceptable method.**
   It is always good to support the practice of verifying measured values through the use of another tool.

Test Your Knowledge Study Questions page 76 in Workbook

As with the fan laws there are two other Pump laws that are used in balancing. They are: Pump law 1 shows the relationship between CFM and revolutions per minute of the fan (operating within the fan curve). Fan law 3 compares CFM to the horsepower required to move that amount of air. Fan laws 1 is: $(GPM_{beginning} \div GPM_{final}) = (RPM_{beginning} \div RPM_{final})$ and Pump law 3 is: $(GPM_{beginning} \div GPM_{final})^3 = (BHP_{beginning} \div BHP_{final})$ where BHP = Break horsepower. From those formulas it can be seen that a small increase in GPM will result in a larger change in pressure drop and a much larger change in the horsepower requirements. For more information on using these formulas in calculations see the Pump Laws in Appendix 1Quick Math Review.

1. On a job, where the boiler required a minimum flow of 4 GPM, a Technician measured 3 GPM flowing through the boiler. If the 2 BHP pump is operating at 100% and at 1200 RPM.

What would the required BHP and RPM be for a pump that would supply the required 4GPM?

$(GPM_{beginning} \div GPM_{final})^3 = (BHP_{beginning} \div BHP_{final})$: $(3 \div 4)^3 = (2 \div BHP_{final})$

Thus; $BHP_{final} = 2 \div 0.421875 = 4.74$ BHP

$(GPM_{beginning} \div GPM_{final}) = (RPM_{beginning} \div RPM_{final})$; $(3 \div 4) = (1200 \div RPM_{final})$

Thus; $RPM_{final} = 1200 \div 0.75 = 1600$ RPM

2. Explain why it would be important to have the air out of a system before balancing is started.
   Air in a hydronic system may cause pump cavitation, and in a worst case coils and portions to be bypassed by the water flow or the pump could quit pumping due to its being filled with air.
3. A boiler is changed out on an existing home where the homeowner has been complaining about hot and cold rooms. Explain why the Technician might do a system balance evaluation.
   The radiators or heat exchanger in each room require a designed water flow in GPM. The GPM = the required BTU for the design. When the designed flow is not balanced properly the GPM can be high or low.
4. Explain why a hydronic balance is important to do?
   Completing a hydronic balance is the only way to make sure the water flow through the home is working as designed. It also is required to make sure the minimum and maximum water flow through equipment is not exceeded.
5. After looking at Figures 19 and 72, explain how the flow control valve works.
   The answers will be varied but should be based on the Bernoulli Principle.

Hands on Lab or Field Exercises

1. **Follow OEM directions for pressurizing an expansion tank for the system and the location.**
   Most technicians in the field have little knowledge of expansion tanks. Since Hydronic systems cannot operate properly unless the expansion tanks are properly installed and set to operate at the proper pressure. Thus it is the first step to be done before balancing a system.

Test Your Knowledge Study Questions page 78 in Workbook

Water Pressure Drop (in feet @ 180°F)			
GPM	COIL A	COIL B	COIL C
2	0.4	0.4	0.5
4	1.4	1.6	1.7
6	3.0	3.3	3.7
8	5.2	5.7	6.3
10	7.9	8.7	9.6

Figure 74 (from Guide & Workbook)): Sample Coil Pressure Drop vs GPM Chart

1. Based on The sample coil chart above in Figure 74: What would the flow in GPM be for a Type C coil that measured a 1.7 ft. pressure drop (water @ 180°F)?

4 GPM

2. Based on The sample coil chart above: What would the flow in GPM be for a Type A coil that measured a 1.7 ft. pressure drop (water @ 180^{O}F)? Note: see Appendix 1 for Interpolation instructions if needed)
   4.375 GPM
3. Explain why water temperature would be important to know when taking pressure measurements.
   Water pressure drop on the chart is dependent on temperature. Thus, as with air, water temperature may change the GPM measured significantly. If the system is designed to operate at 180F it should be balanced when it is operating at 180F. If that is not possible, a correction factor for the valve based on water temperature needs to be used.
4. What are the plusses and minuses of using a manometer for measuring water pressure differences?
   There are many possible answers here two to look for are manometers are easy to use have a wide scale that is accurate, for the positive side, and there must be balancing valves and access ports for the negative side.
5. Explain why care should be taken in the storage and transportation of pressure gauges used for measuring water pressure differences.
   Many pressure gauges do not stay calibrated when they have been bounced around in the back of a truck or in a tool kit. Calibration tools always need to be treated with special care.
6. Explain why a pressure gauge with a scale of 0 PSI to 500PSI might not be the most accurate tool for measuring a 0.5 PSI pressure difference for a hydronic measurement.
   Since the percentage of error is based on the range of the gauge, a small number like 0.5 PSI cannot be accurately read on a 0-500 gauge. The general rule is: the pressure being measured should be in the center area for the range of the gauge selected. Thus, to measure 0.5 PSI: a 0 to 1 PSI Gauge would work well.

Hands on Lab or Field Exercises

1. **Using the pressure drop method, verify that the water flow through the heat exchanger is within the OEM specified ranges and meets the design requirements.**
   When the water can be heated it is a good lesson to check it cold and at a few intermediate temperatures as the system warms up.

Test Your Knowledge Study Questions page 80 in Workbook

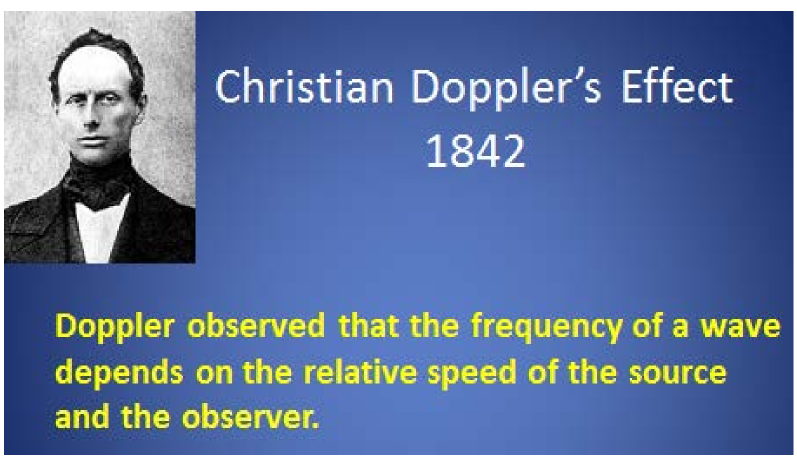


Figure 77 (from Guide & Workbook): Doppler Effect

1. Name a few items that could keep a Doppler (see Figure 77above) meter from providing the actual water flow.
   Entering the wrong pipe type or diameter, a buildup of calcium calcimate or other contaminants on the inside walls of the pipe, and chemicals in the water such as antifreeze, are typical answers the class will come up with.
2. What are the plusses and minuses of using a Doppler flow meter to measure water flow?
   The main minus is accuracy on older piping systems since the pipe's internal cleanliness may not be able to be determined. The main plus is it can be used on piping without access ports or balancing valves.
3. Why would the *QI Standard* require the measurements and the information on how they were obtained left with the equipment on the job site?
   Additionally, it is a great day when that information is found on an existing job because diagnostics can be based on existing conditions when the equipment was last balanced. The home or building owner has paid for the service and should have a record of the work.
4. Explain why it would be impossible to use a Doppler meter to measure water flow in a system containing soft deionized water.
   The meter measures the speed of the particles in the water and there are none in deionized water.
5. Since the Doppler meter is dependent on the water's specific gravity, would the Meter manufacturer's literature need to be checked for a correction factor if antifreeze was added to the hydronic system?
   The answer is yes, there would need to be a correction made.

Hands on Lab or Field Exercises

Using a Doppler meter, verify that the water flow through the heat exchanger is within the OEM specified ranges and meets the design requirements.
This is a good assignment since the students will see all of the factors that must be taken into account to make an accurate measurement.

Test Your Knowledge Study Questions page 89 in Workbook

1. How could explaining the required maintenance procedures for HVAC equipment to the home owner or building operator benefit an HVAC contractor?
   This again can have many answers some to look for: decrease call backs, increase the likelihood maintenance will be done or that they will get called to do it.
2. Explain why having operating sequences left with the equipment might help future Technicians.
   Walking into an equipment room with a wall full of controls can be intimidating. Having operating sequences helps the technician diagnose the problem even when it is on a basic furnace or heat pump system.
3. List 6 items that would be found on a pump test and balance report?
   See page 108 in the Guide & Workbook for a sample report and what could be included in this response.
4. What is the difference between architectural drawings and as built red line drawings?
   Architectural drawing are the plan, the red line drawings indicate changes in the as built/installed building and equipment.
5. What would be some differences between maintenance instructions and operating instructions?

Numerous answers are available here too. Two main points are operating instructions are for basically for how to operate the thermostatic controls on HVAC systems. Maintenance includes filter and other routine maintenance requirements that may be needed to keep the warranty valid.

6. Explain why documentation for an HVAC installation that meets the *QI Standard's* requirements cannot be found on a single form.
   The QI Standard requirements are based on the equipment being installed. There is no one form fall all installed equipment available….even if there was who would want to fill out that encyclopedia?
7. Explain why information on who to contact for warranty questions is often left attached to HVAC systems when they are installed?
   This is required so the building/home owner knows who to contact. Most HVACR companies have a service department and require their Technicians to put these tags on equipment.

Hands on Lab or Field Exercises

1. **Make a list of the owner documentation required for an HVAC system and gather the needed data plate information for the selected unit.**
   From the measurements made in the previous hands on lab sections put together marked versions of the OEM data with the as found measurements highlighted on copies of the OEM charts.
   This can be done as homework where the students look at the equipment in their homes and gather the required information from the OEM/internet and elsewhere and mark it based on the equipment installed.

Part 3: Sample Test and Answer Sheet

Questions in this test cover every section in the Guide& Workbook. Questions from the blue sections in the Guide & Workbook for the areas covered can be used the midterm exam if one is required. They may also be used for the final exam and augmented by the multiple choice sample test. The weighting for the final grading is up to the instructor, the original multiple choice test was designed to be pass-fail with a 70% cut off for passing. Because the multiple choice test touches on all of the sections, the results from the multiple choice questions could be used to determine where more time or emphasis is needed for future classes. Answers for sample multiple choice test which is shown in its entirety starting on the next page:

1. E
2. B
3. D
4. C
5. E
6. E
7. A
8. D
9. B
10. D
11. C
12. E
13. C
14. D
15. A
16. D
17. D
18. D
19. D
20. E
21. D
22. D
23. D
24. C
25. C
26. B
27. A
28. D
29. C
30. C
31. C
32. E
33. A
34. C
35. D
36. E
37. C
38. C
39. A
40. E
41. D
42. E
43. D
44. D
45. D
46. D
47. E
48. B
49. A
50. E

1. Which statement on Static Pressure measurement probes is false?
   a. Static pressure probes have the tip closed
   b. Static pressure probes are inserted with the tip facing into the airflow
   c. Static pressure probes often have a magnet in their base
   d. Pitot tubes can be used as Static pressure tubes
   e. Static pressure probes measure pressure in the center of the duct

2. Which of the following indicates a blockage in the duct is between the reading port and the blower?
   a. a higher Static pressure measurement
   b. a lower Static pressure measurement
   c. a neutral Static pressure measurement
   d. b and c above
   e. a and c above

3. When the CFM is increased the Static Pressure is:
   a. Changed to velocity pressure
   b. decreased
   c. not changed
   d. increased
   e. Changed to total pressure

4. Which formula is not used for calculating airflow velocity in a duct?
   a. CFM = Area $(ft)^2$ x 4005 x $VP^{½}$
   b. VP + SP = TP
   c. SP + TP = VP
   d. Average value = Total ÷ Number of measurements
   e. A = 3.14 x R^2

5. When measuring air velocity in a duct which tool is not appropriate from the list below?
   a. Veined anemometer
   b. Pitot Tube and manometer
   c. Vel-Probe and manometer
   d. Hot wire anemometer
   e. Velometer

6. When Traversing Duct the pattern lay out for access holes can be calculated based on the following:
    a. ASHRAE Standard 111 guidance
    b. ACCA Quality Installation guidance
    c. NEBB Guidance
    d. TABB Guidance
    e. BPI Guidance

7. Which one of the following is not an approved QI method for verifying airflow across the heat exchanger?
    a. Distribution Comparison Method
    b. Traversing Duct
    c. Flow Grid Method
    d. Pressure Matching Method
    e. Temperature Rise Method

8. Provided the figure of 40 CFM per BTU/H what would the BTU/H total be for a room with two diffusers providing 100 CFM each?
    a. 8000 BTU
    b. 4000 BTU
    c. 150 BTUH
    d. 300 BTUH
    e. None of the above

9. When measuring airflow through an AMD hood type of device which type of correction factor is not required?
    a. Hood airflow resistance
    b. humidity
    c. air temperature
    d. air altitude
    e. diffuser

10. A supply diffuser had four measured airflow readings as follows: 903, 862, 934, and 869. If the area K value is 0.22 what is the CFM being provided to the room (rounded to 1 CFM)?
    a. 193
    b. 194
    c. 195
    d. 196
    e. 197

11. Before starting a proportional airflow balance the following must be verified as within the QI Standard 5's accepted range:
    a. Airflow direction
    b. Airflow velocity
    c. Duct Leakage
    d. Duct Total Pressure
    e. Duct Velocity Pressure

12. Supply and return diffusers, grilles, and registers for five HVAC QI 5 residential balances were found to be within the following ranges, which one did not meet the minimum QI-5 requirement?
    a. Individual Airflows are within the greater of ±15% of design, or 25 CFM
    b. Individual Airflows are within the greater of ±10% of design, or 10 CFM
    c. Individual Airflows are within the greater of ±20% of design, or 20 CFM
    d. Individual Airflows are within the greater of ± 5% of design, or 25 CFM
    e. Individual Airflows are within the greater of ±10% of design, or 30 CFM

13. Which equation below is Fan Law 2?
    a. $(CFM_{beginning} \div CFM_{final})^2 = (RPM_{beginning} \div RPM_{final})$
    b. $(CFM_{beginning} \div CFM_{final})^2 = (RPM_{beginning} \div RPM_{final})$
    c. $(CFM_{beginning} \div CFM_{final})^2 = (SP_{beginning} \div SP_{final})$
    d. $(CFM_{beginning} \div CFM_{final}) = (SP_{beginning} \div SP_{final})^2$
    e. $(CFM_{beginning} \div CFM_{final}) = (BHP_{beginning} \div BHP_{final})$

14. Which one of the following is not an approved QI TAB method in for verifying airflow for compliance with ASHRAE 62.2 airflow measurement?
    a. AMD/flow hood
    b. Traversing Duct
    c. Flow Grid Method
    d. Centerline Velocity/Pressure Table method
    e. Area K

15. Which of the following is the correct formula for determine GPM in a hydronic loop?
    a. GPM = Btuh ÷ (ΔT x 500)
    b. GPM = Btuh x (ΔT x 500)
    c. GPM = ΔT ÷ (Btuh x 500)
    d. GPM = ΔT x (Btuh x 500)
    e. GPM = ΔT ÷ (Btuh x 50)

16. Water Flow Pressure drop Method
    Which of the following is never found on an OEM temperature rise chart?
    a. Coil Identification
    b. GPM
    c. Ft of Head
    d. Service Factor
    e. ∆T

17. Which of the following is never found on an OEM temperature rise chart?
    a. Coil Identification
    b. GPM
    c. Ft of Head
    d. Pipe Diameter
    e. ∆T

18. Which Statement is not true concerning water measurement using the Bernoulli' Principal?
    a. A fixed orifice is needed
    b. A pressure inlet port is needed (low side port)
    c. A pressure outlet port is needed (high side port)
    d. A pressure center port is needed (neutral port)
    e. Water flows through the fixed orifice

19. A Technician measured 140 CFM on a return grille designed for 160 CFM what was the actual percentage of design?
    a. 114.30%
    b. 87%
    c. 114.23%
    d. 87.50%
    e. 87.23%

20. Which equation below is Pump Law 3?
    a. $(GPM_{beginning} \div GPM_{final})^3 = (RPM_{beginning} \div RPM_{final})$
    b. $(GPM_{beginning} \div GPM_{final}) = (RPM_{beginning} \div RPM_{final})^3$
    c. $(GPM_{beginning} \div GPM_{final})^3 = (SP_{beginning} \div SP_{final})$
    d. $(GPM_{beginning} \div GPM_{final}) = (SP_{beginning} \div SP_{final})^3$
    e. $(GPM_{beginning} \div GPM_{final})^3 = (BHP_{beginning} \div BHP_{final})$

21. Which is not included in a hydronic system check before balancing is done?
    a. Water strainers clean
    b. Pump running
    c. Valves open or set
    d. Automatic air vents capped off
    e. Air removed, system filled

22. Which of the following is never found on an OEM temperature rise chart?
    a. Coil Identification
    b. GPM
    c. Ft of Head
    d. Service Factor
    e. ΔT

23. Which of the following is never found on an OEM temperature rise chart?
    a. Coil Identification
    b. GPM
    c. Ft of Head
    d. Pipe Diameter
    e. ΔT

24. Which of the following is not a sign an expansion tank is not operating properly
    a. As temperature in the system rises the loop pressure increases
    b. When tapping on the expansion tank it sounds full of water (no hollow tank ring)
    c. Pump head decreases as loop temperature rises
    d. Boiler shuts off on high pressure safety
    e. Safety valve opens when operating in heating mode

25. Which tool is used to measure water pressure?
    a. Anemometer
    b. Velprobe
    c. Manometer
    d. Ohm meter
    e. Water meter

26. Which of the definitions below is the best definition of a BTU?
    a. British Temperature Unit
    b. The amount of energy required to raise one pound of water 1 degree Fahrenheit
    c. Melting 1000 pounds of ice in an hour equals one BTU
    d. 956 Joules equals one BTU
    e. None of the above

27. Which is the most correct description of Doppler's observation on waves??
    a. Doppler observed that the frequency of a wave depends on the relative speed of the source and the observer.
    b. Doppler observed that the power of a wave depends on the relative speed of the wave
    c. Doppler observed that the frequency of a wave depends on the relative size of the source relative to the observer.
    d. Doppler observed that the power of a wave depends on the relative size of the wave
    e. Doppler observed that the size of a wave depends on the relative speed of the wave relative to the observer.

28. Which of the following answers type(s) of heat exchanger must have the water flow verified for a QI installation?
    a. Refrigerant to water
    b. Water to water
    c. Water to air
    d. a, b, and c above
    e. b and c above

29. Using Pump law 2 if the GPM is increased from 10 GPM to 15 GPM and the original ΔP was 8 psig, what will the new ΔP be?
    a. 16 PSIG
    b. 17 PSIG
    c. 18PSIG
    d. 19 PSIG
    e. None of the above

30. Identify the item below not required on a test and balance report
    a) Technician's Name
    b) Job Address
    c) Customer's Name
    d) Air Temperature/Altitude
    e) Tool Used

31. Which of the following would never be needed for checking refrigerant charge?
    a. Refrigerant Gauge Set
    b. Sand paper or sanding block
    c. Vacuum pump
    d. Wet bulb temperature measurement instrument
    e. Refrigerant scale

32. Superheat Refrigerant Charge
    For which type(s) of system metering device is charging done by the subcooling method?
    a. Piston metering device
    b. TXV
    c. Fixed orifice
    d. Cap tube
    e. a, c and d above

33. Which of the following is not included in the data for weighing in a charge?
    a. OEM target value
    b. Weight of the charge
    c. Length and size of refrigerant piping included in the weight of the refrigerant
    d. Type of refrigerant
    e. OEM model number

34. Which of the following is not found inside of an AC motor?
    a. Rotor
    b. Stator
    c. Stimulator
    d. Wire coil
    e. Fan blades

35. Which of the following is not a voltage measurement recorded for HVAC applications?
    a. Condenser Voltage
    b. Voltage to Ground
    c. Compressor Voltage
    d. Service Factor Voltage
    e. Fan motor voltage

36. Which of the following components is not designed for a specific amperage range?
    a. Fuse
    b. Transformer
    c. Motor
    d. Compressor
    e. None of the above

37. Which of the following is not a true statement?
    a. Fuses can be checked for continuity with an ohmmeter when the power is off.
    b. Control boards have minimum and maximum voltage ratings
    c. Fuses can be tested for the rated voltage limits with a magnetometer
    d. For a QI job the correct safety devices/systems of controls must be verified per OEM specifications.
    e. For a QI job the correct cycling/operational sequences of controls must be verified per OEM specifications.

38. Which statement about wire used for HVAC applications is not correct?
    a. UF-B wire would be rated for use outside
    b. As the wire gage number decreases the wire size decreases
    c. As the wire gauge number increases the wire size decreases
    d. The lettering found on the wire designates the wire coating for usage and the gage.
    e. Wire for HVAC applications can be stranded or solid.

39. For Gas appliances which of the following is listed in QI as the requirement for meeting the on-rate requirement?
    a. Clocking the meter, and temperature rise or combustion analysis per OEM directions.
    b. Locking the meter, and measuring the temperature rise and doing a combustion analysis per OEM directions.
    c. Recording the amount of time a furnace or boiler is on and the cost in BTU/H.
    d. Recording the cost in BTU/H for each hour a combustion appliance operates.
    e. Recording the cost in BTU/H for each hour a combustion appliance operates and the amount of time it operates.

40. Which is of the following statements is true when measuring gas pressure at the taps on a gas valve?
    a. All pressure taps are threaded in the UNC category as per the Unified Thread Standard (UTS).
    b. All pressure taps are threaded in the M category as per the Unified Thread Standard (UTS).
    c. All pressure taps are threaded in the P category as per the Unified Thread Standard (UTS).
    d. One side of the manometer hose is connected to the pressure tap and the other side is closed to atmosphere
    e. One side of the manometer hose is connected to the pressure tap and the other side is left open to atmosphere.

41. Which of the following is not stamped on an oil burner nozzle?
    a. Gallons per hour
    b. Spray angle
    c. Spray pattern
    d. Spray length
    e. None of the above

42. Which of the following statements on gas vents is not true?
    a. Category I is for residential and is most common it includes gravity fed and plus 80 furnace models
    b. Category II may be required for some residential boilers and wall vented water heaters
    c. Category III tank-less water heaters SS duct
    d. Category IV high efficiency with plastic pipe
    e. Category V high efficiency with galvanized double walled vent pipe

43. Which of the following is not required on an equipment start up sheet for an oil furnace for a QI installation?
    a. Nozzle pressure
    b. Oil pump pressure
    c. Temperature rise
    d. CAZ test for combustion airflow
    e. Oil type

44. Which of the following is not a QI approved Duct Leakage testing method?
    a. Duct Pressurization Test @ 25 Pascal
    b. Airflow Comparison Method
    c. ANSI/SMACNA Air Duct Leakage Test Manual
    d. Pressure Pan Test

45. How much duct leakage is allowed on a QI for existing duct in a retrofit job?
    a. There can be no more than 20% total duct leakage (airflow in CFM duct pressure 30 Pascals)
    b. There can be no more than 25% total duct leakage (airflow in CFM duct pressure 20 Pascals)
    c. There can be no more than 20% total duct leakage (airflow in CFM duct pressure 15 Pascals)
    d. There can be no more than 20% total duct leakage (airflow in CFM duct pressure 25 Pascals)
    e. There can be no more than 25% total duct leakage (airflow in CFM duct pressure 20 Pascals)

46. Which of the following tools cannot be used to measure airflow for the airflow comparison method in a QI job?
    a. Flow hood
    b. Flow Grid
    c. Anemometer
    d. Manometer and static pressure probe
    e. Manometer and Pitot tube

47. Which of the following items for a QI standard compliant duct leakage test is not a documentation requirement?
    a. Job Name/Address
    b. Name of Technician
    c. Job Date
    d. Meter(s) used
    e. None of the above

48. Which of the following is not listed as a QI reporting requirement?
    a. Flow Grid number/Pa/CFM/meter
    b. Pump cavitation Sone value
    c. Pressure matching fan CFM
    d. CFM & temperature Rise vs External Static Pressure chart.
    e. Traverse Readings/Measurements

49. Which of the following measurements is not required for either superheat or subcooling documentation?
    a. Wet bulb entering condenser air temperature measurement.
    b. Suction Line temperature
    c. Wet bulb return air temperature at the inside unit return
    d. Liquid line temperature
    e. Liquid line pressure

50. Which one of the following is not an approved option for supplying outside air in a residential application?
    a. HRV or ERV
    b. Exhaust Only System
    c. Exhaust fan + Outside air duct connected to the return plenum
    d. Outside supply fan + Outside exhaust fan
    e. Temperature Rise Method

Part 4: Other Educational Offerings

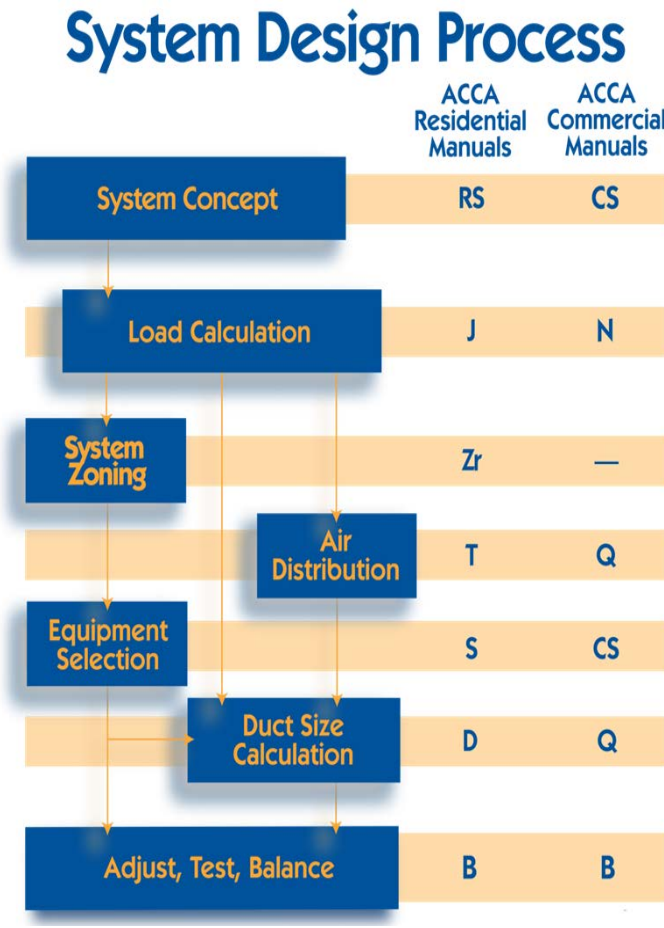
<u>OVERVIEW: *ACCA Training Offerings*</u>

ACCA's Educational Offerings for an Evolving Marketplace

Updated 15 September 2015

As a supplier of educational programs in the HVACR industry for well over 50 years, three factors serve as driving forces within ACCA. First and foremost is to make sure ACCA educational programs and services are of the highest quality; second is to stay a step ahead of the emerging industry needs and trends so that ACCA can offer contractors what they need when they need it, and finally be cost effective in developing and delivering educational programs and services to contractors. ACCA's Standards have been widely recognized and accepted by all sectors of the HVAC industry and several have become code requirements. The chart on the right provides a snapshot view of how ACCA Manuals combine to cover the Design Process.

In advancing its training mission, ACCA avails itself to a number of approaches, from face-to-face training, to video/CD training solutions, to the online certificate program, to webinars, to ensuring its manuals/standards/guides are on the cutting edge of industry good practices, to develop educational plot forms for A) Contractors, B) Technicians, C) Consumers, D) Instructors, and E) Code Officials [see attached sheets for specifics on each].



<u>FACE-TO-FACE TECHNICAL EDUCATION (‘Classroom Setting’)</u>

(For more information, contact www.acca.org, or call 703-575-4477)

- **Residential Design For Quality Installations (RDQI):** A journeyman or higher level, three-day course covering Residential Design for Quality Installations includes: Manual J8® (Load Calculations), Manual D® (Duct Design), and the ANSI/ACCA 5-QI-2014 (HVAC Quality Installation Specification). Also included are: Manual T® (Air Distribution Basics), Manual S® (Equipment Selection), and ACCA's Duct Slide Rule, that provides the students with all of the tools needed to properly design and supervise the installation of an HVAC system to meet code as well as Energy Star® requirements.
- **Educational Program Instructor Certification (EPIC):** Residential EPIC is a master or expert level course that covers the residential design process in depth and requires the use of a Windows-based lap top computer. Material provided and covered includes the following: Manual J8® (load Calculations), Manual S® (Equipment Selection), Manual D® (Duct Design), Manual H® (Heat Pump Systems), Manual P® (Psychrometrics), Manual T® (Air Distribution Basics), Manual TT-102® Understanding the Friction Chart), and Manual 4® (Perimeter Heating and Cooling). Commercial EPIC parallels the residential EPIC course covering ACCA's commercial design materials: Manual CS® (Commercial Applications, Systems and Equipment), Manual N® (Commercial Load Calculation), Manual H® (Heat Pump

Systems), Manual P® (Psychrometrics), Manual T® (Air Distribution Basics), and Manual Q® (Commercial Low Pressure, Low Velocity, Duct System Design)

- **Seminars at ACCA meetings, conferences, and councils:** ACCA's continues to evolve its seminar classroom opportunities that are made available in conjunction with various meetings and other events. These draw a large number of people where it is cost-effective to offer multiple learning modules:
  - ACCA Conference and IE3 Indoor Air EXPO.
  - Building Performance Forum (a two-day learning experience for contractors co-sponsored by ACCA and BPI).
  - National HVACR Service Managers Forum (a two-day learning experience exclusively for service managers in contracting businesses).
  - Commercial Contracting Roundtable (the leading educational and networking experience for commercial HVACR contractors).
  - Numerous sessions provided at monthly local ACCA chapter meetings.

INDIVIDUALIZED STUDY

Embracing what ACCA sees as an important part in the education of the future, ACCA has developed individualized training so it can be used when and where the user wants. Individualized study materials are available in several formats designed to meet individual needs: CDs, Videos, recorded webinars, and Manuals/Guides. ACCA's material provides high quality training and reusable training materials at an affordable price so contractors can train employees when it is convenient.

- **Quality Assurance Accreditation Programs:** ACCA now offers an online training course with testing that allow contractors to receive accreditation for the Energy Star New Homes program (QA), ACCA's Existing Homes –Residential Service & Installation (RSI), and the RSI Verifier Program.

- **Energy and Home Performance Programs:** ACCA offers online training courses with testing that allow contractors to become program members. The programs include the Quality Assured (QA) program and the Residential Service & Installation (RSI) program.

- **Webinars for ACCA Members:** ACCA provides members with access to the latest business practices and technology implementations through webinars. Webinars are seen as a hybrid methodology that allows those who want to participate to have access to very specific topics when it is more convenient for them.
- **Qtech Online Training (CEU) Programs:** ACCA offers online two 6 hour video QI and QH training courses with a pdf copy of the selected guide & workbook and online testing and a 3hour Manual D basics course that allows a technician to receive a certificate that is recognized for CEUs by BPI, ESCO, NATE, RESNET, and RSES.

INDUSTRY TRAINING COLLABORATIONS

- **North America Technician Excellence (NATE):** ACCA is committed to NATE certification as a mark of distinction and a way for consumers and contractors to gain a true comfort level with the professionalism of HVAC technicians.

- **Instructor Workshops:** ACCA has been working with the Council of Air Conditioning and Refrigeration Educators (CARE), and to develop and disseminate the information HVACR instructors want and need.

- **Building Performance Forum:** ACCA forum for HVAC contractors and raters involved in the home performance industry held in conjunction with the Building Performance Institute, Inc. (BPI).

ACCA values collaborative partnerships with business entities and allied associations to advance the goal of quality education in a cost effective manner.

CONTRACTOR: *ACCA Training Offerings*

ACCA's Educational Offerings for an Evolving Marketplace

Updated 16 February, 2016

Contractor To Contractor

For access to member benefits:

http://members.acca.org/home

- ACCA Conference
- Mixed Groups
- Code of Professional Conduct
- ACCA Blogs
  - Federal Affairs
  - State Affairs
  - Conference & Expo
  - Industry News & Opinion
  - Service Managers Forum
  - Building Performance

QA & RSI Training

Access to all contractors:

http://www.acca.org/qa/resources

- QA Contractor Elements
- Participation Requirements
- Outdoor Load Calculation Design Conditions
- QA Sample Policy Template
- ENERGY STAR Checklists
- RSI HVAC Verifiers

Free To Members Video Training

Watch: http://members.acca.org/acca/watch

1. Performance Reviews For Success
2. Stress in Service Contracting
3. 10 Easy Steps to Handling the Poor Performer

Plus, ACCA has an additional 133 additional Videos covering contracting management and employee relationship issues.

Safety Downloads

Risk Management Library:

http://www.acca.org/members/downloads

- A SIR Program – It's Just the Ticket!
- Who Are You Insuring?
- Who Pays for Errors?
- Conduct a "Safety" Interview
- Don't Risk a Lot to Save a Little
- Distracted Driving: At What Cost?
- First Impressions Work Both Ways
- Set Driving Expectations
- Workers' Compensation Fraud
- How Much Is a Good Name Worth?
- Two to Hire, Two to Fire!
- Preparing for a Flu Pandemic
- Concentrate On Safety
- Real Value or Paper Value?
  - Winter Driving Woes
  - Battling Mother Nature
  - Business Interruption
  - Add TLC to Workers' Comp
  - Back to Back Safety

Free Member Downloads

Keeping contractors up to date:
http://members.acca.org/home

- Residential HVAC Design for Quality Installation (Jack Rise Course)
- Technical Bulletins
- Customizable Brochures
- Comfor Tools (to be customized for distribution to customers)
- Q&A Section
- Forms and Templates
- ACCA Annual Report
- Hurricane Last Minute Essentials Guide
- Sample Emergency Management Plan
- Open for Business Planning Package

Contractor Focused CD's & DVDs

Training Library
http://www.hvacessentials.com

- Contractor Soft Skills DVD
- Convert Phone Calls into More Sales DVD
- LEED, Follow or Get Out of the Way (Book and/or CD)

Forums & Annual Meeting

Live Training & Information:
http://members.acca.org/home

- ACCA Conference & IE3 Expo
- Service Manager Forum
- Building Performance Forum
- Radiant & Hydronic Forum

Free To Members Audio Training

Listen: http://members.acca.org/acca/listen/

- The Price Is Right! How To Properly Price Commercial Services
- The Next Generation of HVAC
- Private Label Products: Are They Worth It?

Plus, 30 Additional Audio Programs addressing business related issues.

Political Action Committee

Legislation Tracking, Grassroots Action Center and Federal affairs updates on the following items brings the latest information on in following areas of interest to contractors:
http://www.capwiz.com/acca/home/

- Tax Legislation
- Regional standards
- Copper & Metal Theft
- Healthcare
- Labor
- Commercial Energy Efficiency Incentives
- Residential Energy Efficiency Incentives
- Refrigerants
- Regional Standards
- Regulatory reform
- Small Business Capital Investment
- Transportation

Breaking News

IE3 Media: http://www.ie3media.com/

- IE3
- Insider Emails
- Special Interest Council News Letters:
  - Building Performance
  - Radiant and Hydronics

ACCA Town Hall

Town hall discussions and issues discussed.
http://www.acca.org/members/videos

Why Join ACCA?

To become part of the leading edge in the HVACR industry and grow your business.

Learn what ACCA has to offer Contractors:
http://www.acca.org/join/

- Free Training
- Free Technical & Legal Support
- Free Downloads
- Connect with:
  - Customers

- Contractors
- Job Seakers

TECHNICIAN: *ACCA Training Offerings*

ACCA's Educational Offerings for an Evolving Marketplace

Updated 16 February, 2016

Video and CD Training

ACCA on line store: **www.acca.org/store**

HVAC Essentials

- Understanding Manual J: Heat Gain & Heat Loss in the Real World
- Understanding Manual D: Airflow & Duct Design in the Real World
- Understanding Section 608: refrigerant Handling in the Real World
- Understanding Manual N: Commercial Load Calculation in the Real World
- Understanding Quality Installation
- Understanding Electricity
- Understanding Manual Q: Low Pressure, Low Velocity Duct Design in the Real World
- Understanding Manual Zr
- HVAC Essentials Understanding 608
- Tips for Residential HVAC Installation CD
- Control System Basics for HVAC Technicians CD
- Refrigeration and Air Conditioning 7th Edition CD set

Nate Training CDs

- Mastering Core Service CD
- Mastering Heat Pump Service CD
- Mastering Core Installation CD
- Mastering Air Conditioning Inst. CD
- NATE Air Conditioning and Heat Pumps CD
- NATE Air Distribution CD
- NATE Gas and Oil Heating CD
- NATE Hydronics CD

Mobile App

https://www.calcunow.com

DuctWheel for iPad

Qtech Online Course Providing CEU's

Available at: **www.acca.org**

- Quality Installation
- Quality Home Evaluations and Performance Improvements
- Manual D Basics
- NATE Essentials
- Understanding Section 608
- Technician's Guide & Workbook for Quality installations
- Technician's Guide & Workbook for Home Performance Improvements

Training Books and Materials

ACCA on line store: **www.acca.org/store**

- Technician's Guide & Workbook for Quality Installations
- Technician's Guide and Workbook for Home Evaluations and Performance Improvements
- Study Guide for EPA Section 608 (English, Spanish, and Italian)
- Training Manual for EPA Section 608 (English, and Spanish)
- Section 608 Refresher Manual (English, and Spanish)
- EPA 609 Certification and Training Manual
- Calculator/Pocket Card Set
- Careers In the HVAC Industry
- Control System Basics for HVAC Technicians
- Customer Service Handbook For HVACR Technicians
- Airflow In Ducts
- Blueprints and Plans For HVAC

- Commercial System Quick Reference (CSQR)
- Digital Controls for HVAC Technicians
- Duct Calculation Slide Rule
- Energy Efficiency Manual
- Fans and V-Belt Drives
- Geothermal HVAC: Green Heating and Cooling
- Good HVAC Practices for Residential and Commercial Buildings (ACCA)
- Green Guide
- HVAC Equations, Data, and Rules of thumb, 2nd Edition
- HVAC Licensing Study Guide
- HVAC Spanish
- Math for the Technician
- Refrigeration and Air Conditioning 7th Edition
- Modern Refrigeration and Air Conditioning, 19th Edition
- Refrigeration for HVAC Technicians How Refrigeration Works
- Troubleshooting HVAC-R Equipment
- Building Science Principles Reference Guide
- Geothermal Heat Pump Training Manual
- Tech to Tech
- How Come?
- Modern Hydronic Heating
- Pumping Away, and other really cool piping options for hydronic system
- Residential Hydronic Heating, Installation and Design
- The Lost Art of Steam Heating
- Refrigeration for HVAC Technicians
- Bob's House
- Duct Diagnostics and Repair

- HVAC Installation Procedures Handbook
- HVAC Maintenance Procedures Handbook
- HVAC Service Procedures Handbook
- Layout for Duct Fittings
- Manual 4 Inst. Techniques for Perimeter heating and Cooling
- Tips for Residential HVAC Installation
- HVAC Servicing Procedures Handbook
- HVAC Installation Procedures Handbook
- HVAC Maintenance Procedures Handbook
- Installing Residential Forced Air Furnaces
- Layout For Duct Fittings

NATE Training Manuals

ACCA on line store: **www.acca.org/store**

- NATE A/C & Heat Pumps Manual
- NATE Air Distribution
- NATE Essentials Manual
- NATE Gas and Oil Heating
- NATE Hydronics
- Mastering Air Distribution Service
- Mastering Hydronics – Gas Service
- Mastering Gas Furnace installation
- Mastering Gas Furnace Service
- NATE Core Essentials
- NATE Air Conditioning and Heat Pumps
- NATE Air Distribution
- NATE Gas and Oil Heating
- NATE Hydronics

Course Related Text and Work Books

ACCA online store: **www.acca.org/store**

- Technician's Guide for Quality Installations
- Manual B Balancing and Testing Air and Hydronic Systems
- Manual H Heat Pump Systems and Applications

- Controls – Level 1 Fundamentals
- Life Cycle Costing for HVAC Systems
- Principles of Mechanical Refrigeration

Consumer: *ACCA Training Offerings*

ACCA's Educational Offerings for an Evolving Marketplace

Updated 16 February, 2016

ACCA develops innovative consumer education materials for light commercial and residential customers. Tools are designed to help consumers locate and evaluate HVACR contractors. They help consumers recognize contractors who have differentiated themselves by offering standards-based quality installation services. Extensive web information on how to:

1. Find a contractor
2. Select a contractor
3. What questions to ask a contractor
4. What the QI is
5. Contractor proposal evaluation checklists
6. Commonly asked questions and answers
7. Texts that explain basic HVAC design and installation principles in non technical language

Consumer Videos

Animated Videos:

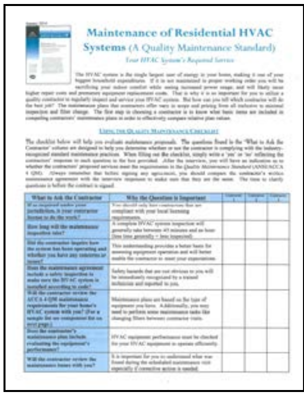
- *Comfort Health Safety* **http://www.acca.org/homes/**
- *When Is The Best Time To Ask These Questions?* **http://www.acca.org/homes/**

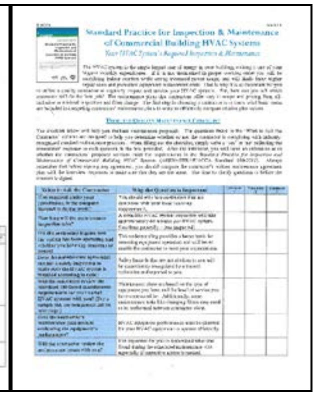
Videos:

- *A Guide For Home Heating and Air Conditioning* **http://www.acca.org/homes/**
- *A Guide For Business Heating AND Air Conditioning Services* **http://www.acca.org/buildings/**

Consumer Checklists

Quality Installation Checklist (*English & Spanish)* *http://www.acca.org/homes/*
Quality Maintenance Checklist (*Residential and Commercial Versions)* *http://www.acca.org/homes/*





Frequently Asked Questions & The Right Questions To Ask

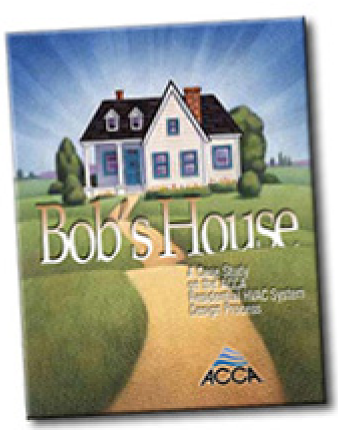
Found at: **http://www.acca.org/homes/**

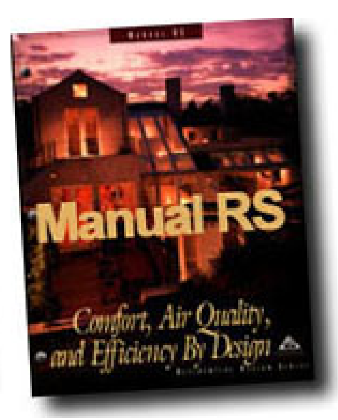
- **Are your technicians NATE certified?** NATE certification is the industry's standard for technician excellence. You should never accept anything less.
- **Do you offer continuing education to your employees?** This industry changes rapidly. Ask the contractor to describe their training program.
- **Can you provide local references?** Get the names of neighbors who have used the company's services, and then follow up with them.
- **Do you offer a service agreement plan?** Well-maintained equipment runs more efficiently and lasts longer.
- **Are you properly licensed?** Unfortunately, every state, city, or county could have different contractor licensing rules. Ask for proof!
- **Do you follow the industry standards?** Make sure your contractor knows what "Manual J" and "Quality Installation" are, just for a start. Scroll down on this page to find out what these standards are and why they are important to you!

Texts Designed For End Users

Found at: http://www.acca.org/store/

Bob's House, a case study for understanding the residential HVAC design process and Manual RS-Comfort, Air Quality, & Efficiency by Design are designed to be used by those who want a basic understanding of HVAC design practices.





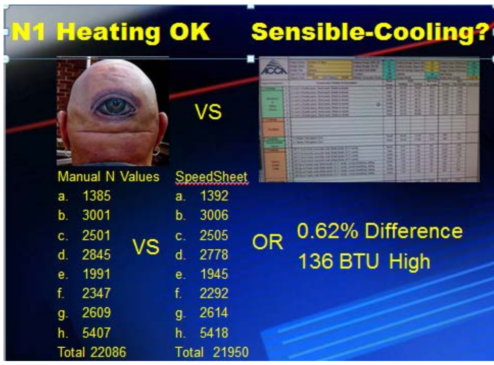
INSTRUCTOR: *ACCA Training Offerings*

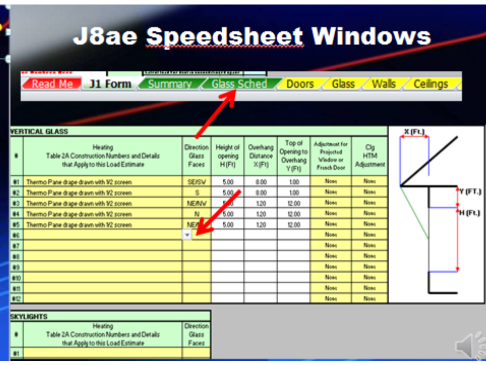
ACCA's Educational Offerings for an Evolving Marketplace

Updated 16 February, 2016

ACCA participates in HVACR Instructor Work Shops and develops education materials for light commercial and residential training. ACCA helps instructors provide the training that contractors need today's technicians to have. The net result of using ACCA's HVACR training materials is to provide students with market place skills based on the HVACR industry's good practices and procedures.

Free Downloads From The ACCA Website





Manual N Speedsheet video Manual Jae Speedsheet video QI Standards

Speedsheet Videos available at: www.acca.org/speedsheet

Other Supporting Resource Materials Available as Free Downloads:

Standards available at: www.acca.org/standards/quality/:

- HVAC Quality Installation Specification (English)
- HVAC Quality Installation Specification (Spanish)
- Home Performance Evaluation & Improvement
- HVAC Quality Installation Protocols
- Quality Maintenance of Residential HVAC Systems
- HVAC System Cleanliness & Restoration
- Manual J8 Long House Speedsheets and Training videos

ACCA Instructor's Lesson Plans

ACCA has lesson plans for Instructors available on the educator's page on the website. Lesson plans are available for:

- EDU 1-9/2015 Instructor's Lesson Plan for Manuals J, D, and S.
- EDU 2-9/2015 Instructor's Lesson Plan for *Technician's Guide & Workbook for Quality Installations*
- EDU 3-9/2015 Instructor's Lesson Plan for *Technician's Guide & Workbook for Home Performance Improvement*
- EDU 4-2/2016 Instructor's Lesson Plan for *Manual D Basics*

Instructor's Training Certification Manual

ACCA has a Geothermal Heat Pump Training Certification Instructor Manual available for those who wish to teach the basics of Geothermal Heat Pump design and installations. Available at: www.acca.org/store

Instructor Power Point Presentations on CD's

Cd's developed for Instructor Use In the Classroom

Power points available at: www.acca.org/store

- Controls – Level 1 Fundamentals
- Life Cycle Costing for HVAC Systems
- Principles of Mechanical Refrigeration
- Simutech–Simuair-Air Conditioning Simulator Training System
- Water Piping and Heat Pumps- Instructor
- Residential Design Instructor Power point
- Commercial design Instructor Power Point
- 608 Certification Program (Refrigerant Transition and recovery Certification Instructor Manual includes lesson plans and *overhead* masters) Procter Sign Up: http://www.acca.org/for-contractors/
- Understanding Section 608

North American Technical Excellence Instructor's CDs

NATE CDs available at: http://www.nateessentials.com

- NATE A/C & Heat Pumps Manual
- NATE Air Distribution
- NATE Essentials Manual
- NATE Gas and Oil Heating
- NATE Hydronics

ACCA's Educational Program Instructor Certification (EPIC)

ACCA's Educational Program Instructor Certification (EPIC) is a 4 day course designed for those instructors with a master's level experience in HVAC systems. Participants must supply their own windows-based computer system. The following Manuals and materials are provided by ACCA:

- Manual D (Duct Design)
- Manual J (Load Calculation)
- Manual H (Heat Pump Systems)
- Manual P (Psychrometrics)
- Manual S (Equipment Selection)
- Manual T (Air Distribution Basics)
- Manual 4 (Perimeter Heating & Cooling)
- Manual TT-102 (Understanding the Friction Chart.

Residential EPIC available at: www.acca.org/education/epic/

Apprenticeship Program

ACCA developed a training series of Manuals designed to teach what contractors need entry level technicians to know. Designed to be a two or four year program, the books are available with an Instructor's Guide CD. The following Courses are designed to build upon one another:

- HVACR 101 Book and Instructor's Guide on CD
- HVACR 201 Book and Instructor's Guide on CD
- HVACR 301 Book and Instructor's Guide on CD
- HVACR 401 Book and Instructor's Guide on CD

Available at: www.acca.org/store

CODE OFFICIALS: *ACCA Training & Resources*

ACCA's Educational Offerings for an Evolving Marketplace

Updated 16 February, 2016

ACCA develops education materials for light commercial and residential Code Officials. Tools are designed to help them understand the basic requirements for HVACR designs. Additionally, ACCA is available as a trusted unbiased HVACR industry expert to answer Code Official's questions one on one when they call in.

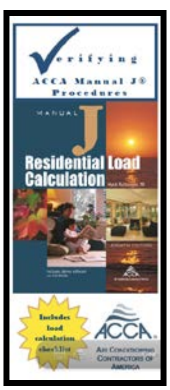
Building Code Requirements for ACCA Manuals

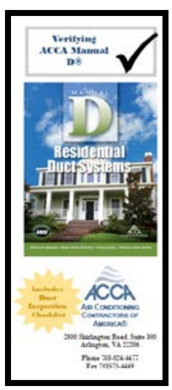
The following national codes make reference to specific ACCA procedures in order to comply. Jurisdictions that adopt these codes require the use of ACCA procedures as outlined in our technical manuals.

- The **IAPMO's Uniform Mechanical Code** requires the use of Manual J (Residential Load Calculation), Manual N (Commercial Load Calculation), Manual D (Residential Duct Systems), and Manual Q (Commercial Duct Systems).
- The **ICC's International Mechanical Code** requires the use of Manual D (Residential Duct Systems).
- The **ICC's International Residential Code** requires the use of Manual J (Residential Load Calculation) and Manual S (Residential Equipment Selection), Manual D (Residential Duct Systems).
- The **ICC's International Energy Conservation Code** requires the use of Manual J (Residential Load Calculation) and Manual S (Residential Equipment Selection).

Codes Verification Brochure's for Manuals J, D, and S

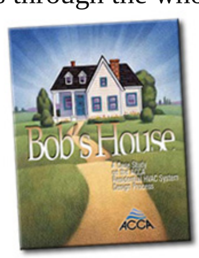
Available at: http://www.acca.org/standards/codes/





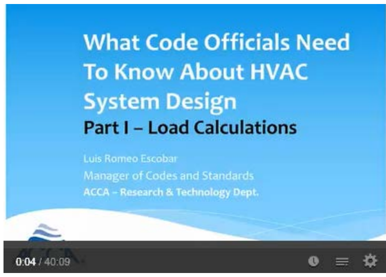
Bob's House

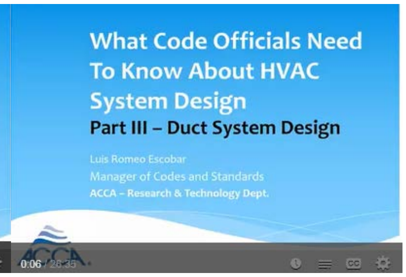
A Manual designed to walk Code Officials through the whole design process on a typical home.



Videos for Code Officials + Continuing Education Units from ICC

Available at: https://www.acca.org/codes/





ACCA has produced a three-part video series entitled, *What Code Officials Need to Know About HVAC System Design*. The three videos cover load calculations, equipment selection, and duct sizing per ACCA Manual J, Manual S, and Manual D, respectively. As a member of the ICC Preferred Provider Program, ACCA has also developed an evaluation for code officials wishing to earn CEUs from ICC to help maintain their certifications. The evaluation consists of a pdf of the presentation slides for note-taking, as well as a 30 question exam.

Residential System Design Review Forms

Available at: https://www.acca.org/standards/codes/

Illustrated examples and review form downloads are made available for free to Code Officials

- ICC Residential System Review Form
- UMC Residential System Review Form
- Understanding & Using the System Review Form



Guidance on Approved Software Meeting Code Requirements

A brochure designed to provide guidance on approved software providers.
http://www.acca.org/standards/software/