INSTRUCTOR'S STUDY GUIDE

Associated Air Balance Council

Forward

The Instructor’s Study Guide Package is divided into seven (7) sections, the same as the Technician’s Package. Each section herein contains the complete study guide, the section examination (which includes the answers) and the Practical Performance Test (Field Evaluation scorecard). This package should be kept in an inaccessible place and is for use only by the Instructor or TAB Engineer only.

The Instructor, or TAB Engineer, should keep the entire Technician's package and distribute only the part needed at any given time. The candidate is not to be given the entire package.

The AABC Technician Training Manual has been incorporated into this study guide and should be used as originally designed with the exception that the individual chapters should be studied in the sequence listed in this study guide. The review questions at the end of each chapter is to be used by the candidate during the study process. The Additional Reference Guide correlates additional Training Manuals and references associated chapters should the technician need a better understanding of each topic. The examinations herein should be administered as you would the final technician's certification examination in order to acclimate the candidate to the examination process.

After successful completion of each section examination, the Field Evaluation scorecard should be administered. These requirements are established to ensure that the candidate receives both the practical training and proper guidance necessary to acquire practical technical skills.

Assuming a 3-year training period after employment for a new certified technician candidate, it is suggested that each section be completed at a maximum of 4-5 months apart. This will allow a few months after completion for final review of previous sections and tests before sitting for the AABC certified technician exam. (The schedule may of course be accelerated depending on the individual candidate's previous experience and knowledge.)

Technician's Completion Status

SECTION 1: AIR BASICS

Study Guide Date:_____________
Examination Date:_____________
Practical Performance Test Date:_____________

SECTION 2: AIR SYSTEMS

Study Guide Date:_____________
Examination Date:_____________
Practical Performance Test Date:_____________

SECTION 3: WATER MEASUREMENTS

Study Guide Date:_____________
Examination Date:_____________
Practical Performance Test Date:

SECTION 4: REFRIGERATION & HEATING

Study Guide Date:_____________
Examination Date:_____________
Practical Performance Test Date:_____________

SECTION 5: TEMPERATURE MEASUREMENTS

Study Guide Date:_____________
Examination Date:_____________
Practical Performance Test Date:_____________

SECTION 6: CONTROLS & SPECIAL SYSTEMS

Study Guide Date:_____________
Examination Date:_____________
Practical Performance Test Date:_____________

SECTION 7: SOUND & VIBRATION

Study Guide Date:_____________
Examination Date:_____________
Practical Performance Test Date:_____________

TECHNICIAN'S NAME:_________________________

Section #1

AIR BASICS

Study Guide

Reference Guide

Black = AABC Technician Training

Manual Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Air Basics Guide

Air Basics Guide

Air Basics Guide

Air Basics Guide

Air Basics Guide

Section #1

AIR BASICS

Technician's Exam

Associated Air Balance Council

AIR BASICS
TEST #1

Chapter 1
TAB Instrumentation

1. Name five instruments that are used to record FPM. **1 POINT**

   a) **Digital Anemometer**
   b) **Velocity Grid**
   c) **Digital Manometer**
   d) **AnalogVelometer**
   e) **Analog Anemometer**

2. What are the two types of tachometers and what is the main difference between them? **Contact and Laser/Strobe. Contact tachometers will come into contact with the fan or motor shaft. Strobes or laser tachometers will use a light source and/or a reflector attached to the fan or motor shaft to record rotational speed.** **1 POINT**

3. Fill in the blank:

   a. **Tachometers** are the instruments that are used to record **fan** or **motor** speeds, and can be two types; **Contact** or **Laser / Strobe** . **1 POINT**

   b. **Anemometers** & **Velometers** are used strictly for recording air velocities. The **anemometer** utilizes a **rotating vane** for collecting actual air velocities. **1 POINT**

   c. **Capture Hoods** measure air volume directly. The instrument is designed so the **hood skirt** will encase or **capture** an entire air device. **1 POINT**

   d. **Differential Pressure Meters** are used for measurements across devices such as **pumps** , **coils** , venturis, **heat** exchangers and refrigeration **machines (Chillers)** . **1 POINT**

4. Provide the typical range of values and tolerances for each of the following temperature measurements. **1 POINT**

		Typical Range	Recording Tolerance
a.	Airside DB	**-20°F to 120°F**	**Nearest 0.10°F**
b.	Airside WB	**-20°F to 90°F**	**Nearest 0.10°F**
c.	Chilled Water	**38°F to 56°F**	**Nearest 0.10°F**
d.	Heating Water	**120°F to 180°F**	**Nearest 0.10°F**
e.	Humidity	**10% to 90%**	**Nearest 1%**
f.	Dewpoint	**30°F to 60°F**	**Nearest 0.10°F**

Chapter 2
Air Pressure

1. Name several instruments used for measuring air pressures.

   a) **Manometer**
   b) **Inclined Manometer**
   c) **Inclined-Vertical Manometer**
   d) **U-tube Manometer**
   e) **Micro-Manometer**
   f) **Magnehelic Gauge**

2. There are three types of air pressures measured in ducts. Name them.

   a) **Total Pressure**
   b) **Static Pressure** **1 POINT**
   c) **Velocity Pressure**

3. a) A duct is 24"x 20". What is its equivalent duct diameter? **24.73"** **1 POINT**

   b) Another duct is 12" x 10". What is its equivalent duct diameter? **12.36"** **1 POINT**

4. Indicate the number of velocity pressure readings that should be recorded when performing a traverse in the following ducts:

   a) 8" Round duct **6**
   b) 16" Round duct **10** **2 POINTS**
   c) 32"x16" duct (Log-Tchebycheff method) **30**
   d) 64"x10" duct (Log-Tchebycheff method) **21**

5. The minimum number of velocity pressure readings using the Log-Tchebycheff method for a rectangular duct is: **9** **1 POINT**

6. Convert the following velocity pressures to FPM.

   a) 0.15 **1551** b) 0.19 **1746** **2 POINTS**
   c) 1.10 **4200** d) 0.34 **2335**

7. A duct is 28"x 24". The average velocity is 1,625 FPM. What is the quantity of air flow in cubic feet per minute through the duct? **7583** **1 POINT**

8. An oval duct is 29" x 26". The average velocity is 1,625 FPM. What is the quantity of air flow in cubic feet per minute through the duct? **6872** **1 POINT**

9. Write the equation to calculate air density:

   1 POINT

$$D = 1.325 \times \frac{P_b}{Ta}$$

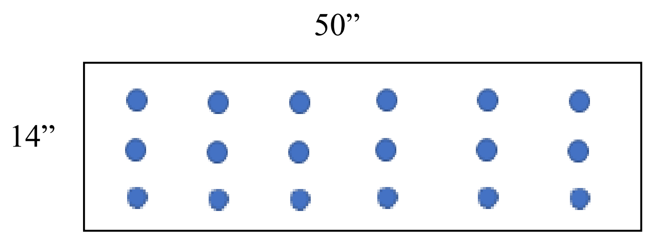
10. Resistance to air flow produces__**friction**____losses that vary with air velocity, duct size, length, and interior surface roughness. **1 POINT**

11. Total pressure is equal to__**static**____pressure plus___**velocity**_____pressure.
1 POINT

12. What is the correction factor with barometric pressure equal to 23.0 in. Hg. and a temperature of 150º F?___**1.22**_____ **1 POINT**

13. What is the correction factor with barometric pressure equal to 23.0 in. Hg. and a temperature of 200º F?___**1.27**_____ **1 POINT**

14. a) Diagram where to drill holes when traversing (Log Tchebycheff method) a 50” x 14” duct with 1” of internal insulation and show center to center measurements for the 50” and 14” sides.



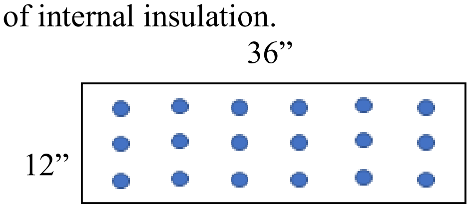
On the 50" side the test holes could be drilled at the following locations. Starting at the side of the duct:

3.9" 12.3" 22" 28" 37.7" 46.1"
2 POINTS

On the 14" side the test holes could be drilled at the following locations. Starting at the side of the duct:

1.8" 7" 12.2" **1 POINT**

b) Diagram where to drill holes when traversing (Log Tchebycheff method) a 36” x 12” duct with 1" of internal insulation.



On the 36" side the test holes could be drilled at the following locations. Starting at the side of the duct:

3.1" 9" 15.9" 20.1" 27" 32.9" **2 POINTS**

On the 12" side the test holes could be drilled at the following locations. Starting at the side of the duct:

1.6" 6" 10.4" **1 POINT**

Chapter 3
Measuring Rotational Speed

1. The RPM of a fan is 950 and the motor RPM is 1,735. The air flow is 8,500 CFM.
   a) The CFM needs to be increased to 9,000. What fan RPM is needed? **1006**
   b) The CFM needs to be increased to 9,500. What fan RPM is needed? **1062**
   c) The CFM needs to be reduced to 8,000. What fan RPM is needed? **894**

   3 POINTS

2. A strobe light is a type of (a) contact tachometer or (b) non-contact tachometer. **b**

   1 POINT

3. The pitch diameter of a sheave is (a) approximately where the middle of the V-belt rides in the sheave groove or (b) the same as outside diameter. **a**

   1 POINT

4. Increasing the size of a fixed-pitch motor sheave or adjusting the belts to ride higher in a variable-pitch sheave, will result in (a) an increase or (b) a decrease in fan speed.
   a **1 POINT**

5. A fan is delivering 2,500 CFM. The fan sheave is 10.6" Pd. It has been decided that the output of the fan should be reduced to 2,350 CFM. The motor's speed is 1,725 RPM and it has a variable-pitch sheave. The belt is riding at a pitch diameter of 4.75".

   a) New pitch diameter of the motor sheave = **4.47"** **1 POINT**

   b) New pitch diameter for fan = **11.28"** **1 POINT**

6. Both the motor and the fan have fixed sheaves. The motor sheave is 7.0" Pd and the fan sheave is 13.0" Pd. The air flow of the fan needs to be increased to 20,150 CFM from 18,600 CFM. It is decided to change the fan sheave in order to increase the fan CFM.

   a) Find the size of the new fan sheave. **12"**

   $$\frac{20{,}150\text{ CFM}}{18{,}600\text{ CFM}} = 1.083 \qquad \frac{1}{1.083} = 0.923 \qquad 0.923 \times 13 = 12$$

   3 POINTS

   b) How else can it be done?

   $$\frac{18{,}600\text{ CFM}}{20{,}150\text{ CFM}} = 0.923 \qquad 0.923 \times 13 = 12$$

   1 POINT

7. a) A motor sheave has a pitch diameter of 5”. The fan-sheave pitch diameter is 10”. The distance between the shaft centers is 20”. Find the belt length required.__**64"**__

1 POINTS

b) A motor sheave has a pitch diameter of 8”. The fan sheave pitch diameter is 14”. The distance between the shaft centers is 18”. Find the belt length required.__**71.04"**__

$$\mathbf{L=2C + 1.57(D+d) + (D-d)^2/4C}$$

1 POINT

8. Generally, motor shaft diameters are in increments of__**1/8**__ inches and fan shaft diameters are in increments of__**1/16**__inches. **1 POINT**

9. When installing or removing belts, never__**force**__ the belts over the sheaves. Instead, loosen the motor, which is usually mounted on an adjustable base, and slide the motor up for easy removal of the belts. For installation of belts, put the belts on the sheaves and move the motor back to adjust the belts for proper tension. Secure the motor. **1 POINT**

10. All belt drives shall be adjusted for proper belt tension. The correct operating tension is the__**lowest tension**__at which the belts will not slip under peak load conditions. **1 POINT**

Chapter 4
Electrical Components and Measurements

1. A volt is a measure of__**electric force**__or__**potential**__. **1 POINT**

2. Amps are a measure of__**electric flow rate**__. **1 POINT**

3. When measuring voltage and amperage on a three-phase circuit (a) only one phase needs to be measured or (b) all phases need to be measured.__**b**__

   Why? **To verify each leg and to obtain a true average.**

   1 POINT

4. To reverse the rotation of a three-phase motor, change (a) any power lead (b) any two power leads or (c) all power leads.__**b**__ **1 POINT**

5. It is a generally accepted practice to leave a motor operating in the service factor area.

   a) True or b) False __**b**__ **1 POINT**

6. A 25-horsepower, dual-voltage motor is rated at 230/460 volts. For 230 volts the rated amps are 68. The rated amps for 460 volts are__**34**__. **1 POINT**

7. Find brake horsepower for motor listed above with the following operating conditions:

   a) average amps = 54
      average volts = 235
      average power factor = 0.87
      motor efficiency = 0.83

      __**21.27**__ BHP

      1 POINT

   b) average amps = 45
      average volts = 220
      average power factor = 0.78
      motor efficiency = 0.83

      __**14.8**__ BHP

      1 POINT

8. If a motor becomes overloaded or one phase of a three-phase circuit fails (single phasing), there will be an increase in current through the motor. If this increased current draw through the motor lasts for any appreciable time and is greatly in excess of the full-load current rating, the windings will overheat and damage may occur to the insulation, resulting in a burned-out motor. To prevent motors from overheating,

   __**thermal**__ __**overload**__ __**devices**__ must be installed.

   1 POINT

9. A fan is delivering 30,000 CFM. The fan motor is operating at 22 BHP. The fan needs to deliver 32,000 CFM.
   a) Calculate the new BHP. **26.7** **1 POINT**

   b) Calculate the new BHP if the fan needs to deliver 36,000 CFM. **38.0** **1 POINT**

10. A pump is operating at 2,000 GPM with the discharge valve full open. The operating brake horsepower is 62. To decrease the GPM to 1,850 a new impeller will be installed.

    Calculate the new BHP. **49.07** **1 POINT**

11. Calculate the approximate BHP using the following data.
    a) Nameplate HP = 25
       Nameplate Voltage = 460
       Nameplate Amps = 27
       Running Amps = 23 / 24 / 23
       Running Volts = 465 / 465 / 465

       21.69 BHP **1 POINT**

    b) Calculate FLE_{ff} x PF **0.87**
       1 POINT

       $$\frac{25 \times 746}{1.732 \times 27 \times 460}$$

    c) Calculate % Load **73%**
       1 POINT

       $$\frac{23.33 - (0.5 \times 27)}{(0.5 \times 27)} \times \frac{465}{460}$$

    d) From Table 4.1 "L" factor is 0.98 (for 75% load and 25 NPHP)

       Calculate actual BHP **21.47**
       1 POINT

       $$\frac{1.732 \times 23.33 \times 465 \times (0.87) \times 0.98}{746}$$

Chapter 5
Air Distribution Devices and Terminals

1. The smallest area of an air stream leaving an orifice is called the **vena contracta.**
1 POINT

2. When an outlet is mounted so that it discharges into free space, the air stream entrains air on both its upper and lower surfaces. However, air entrainment takes place only along one surface when the outlet is mounted so that the air stream is moving adjacent to or in contact with a wall or ceiling, as is the case with flush-mounted ceiling diffusers. This results in a low-pressure area immediately adjacent to the wall or ceiling. Some of the room air is diverted into this low-pressure area with the result that the mixed-air stream tends to follow along in contact with the surface. This is known as **surface effect**. **1 POINT**

3. K-factors or AK factors apply not only to a specific type and size of grille or diffuser but also to a **specific** air-measuring instrument and the correct positioning of that instrument. **1 POINT**

4. If a flow factor is not available or if it is producing an unsatisfactory result, a flow factor can be field determined if it is possible to make an accurate **pitot-tube traverse** in the supply duct for the outlet in question. **1 POINT**

5. Name several types of ceiling diffusers.

   a) **Round**
   b) **Square**
   c) **Rectangular**
   d) **Perforated Face**
   e) **Linear Slot**
   f) **Light Troffer**

   2 POINTS

6. The adjustable bars on the face of a grille are used to control **air pattern**. (**direction**, **throw**, **spread**). **1 POINT**

7. Name two of the functions of a terminal box.

   a) **Regulate the air flow to the space**
   b) **Supply air at the proper temperature**

   1 POINT

8. Name several classifications of terminal boxes.

a) **Single duct**

b) **Dual Duct**

c) **Induction**

d) **Pressure Dependent**

e) **Pressure Independent**

f) **Constant Volume**

g) **Variable Air Volume**

1 POINT

9. Opposed-blade dampers are generally recommended for **volume control**.

1 POINT

10. Single-blade or opposed-blade volume dampers immediately behind diffusers and grilles should not be used for balancing because when throttled, they

a) **Create noise at the outlet** and

b) **Change the effective area of the outlet**

1 POINT

11. a) What is the Ak of a 20" x 24" grille with a traverse of 1,475 CFM and an average face velocity of 500 FPM? **2.95** **1 POINT**

b) What is the Ak of this grille if it has an average face velocity of 1000 FPM?
1.475 **1 POINT**

12. What part of a 24" x 12" grille actually measures 24" and 12"? **c**

a) Outer edge of frame.
b) Inside edge of frame.
c) Duct size.
d) None of above.

1 POINT

Chapter 6
Fans

1. a) A fan is operating at the speed of 935 RPM. The fan discharge static pressure is 2.5 in. WC. Find the new static pressure if the fan speed is increased to 1,020 RPM. **2.98"** WC **1 POINT**

   b) Find the new static pressure if the fan speed is increased to 1200 RPM. **4.12"** WC
   1 POINT

2. A fan is operating at 755 RPM. The fan discharge static pressure is 3.0 in. WC. Find the new static pressure if the fan speed is decreased to 675 RPM. **2.40"** WC
   1 POINT

3. A fan is operating at 0.95 in. WC static pressure is 580 RPM. Find the RPM needed to increase the static pressure to 1.25 in. WC. ***665*** RPM
   1 POINT

4. A fan is operating at 35,000 CFM with a discharge static pressure of 4.25 in. WC. The air volume is reduced to 31,250 CFM. Find the new static pressure. **3.39"** WC
   1 POINT

5. A Pitot-tube traverse of the main duct identifies the total air flow in the system to be 2,200 CFM. The static pressure at the traverse point is 1.3 in. WC. The total CFM in the system needs to be increased to 2,500. Find the new static pressure at the traverse point.
   1.68" WC **1 POINT**

6. A fan is operating at 35,450 CFM and 3.8 in. WC static pressure. Find the new CFM if the static pressure is decreased to 3.5 in. WC. **34,022** CFM
   1 POINT

7. A fan is operating at 10,000 CFM at 1.3 in. WC at standard conditions. Find the new static pressure if the density is increased to 0.17 lbs/cu.ft. **2.95"** WC
   1 POINT

8. A fan is operating at a speed of 735 RPM. The motor is operating at 11.0 brake horsepower. Find the new brake horsepower if the fan speed is decreased to 700 RPM.
   9.48 BHP **1 POINT**

9. A fan is operating at 655 RPM. The motor is operating at 25 brake horsepower. Find the new brake horsepower if the fan speed is increased to 725 RPM. __**33.90**__BHP.

1 POINT

10. A fan is operating at 820 RPM and 28,000 CFM. The fan speed needs to be increased as much as possible to get maximum air volume. The motor is rated at 25 horsepower and is operating at 19 brake horsepower. Find the a) maximum RPM and b) maximum air volume at which the fan can rotate without exceeding rated horsepower.

a) __**899**__RPM **1 POINT** b) __**30,682**__CFM

11. A fan is operating at 5,000 CFM at 3 brake horsepower. Find the new brake horsepower if the air volume is increased by 10%.__**3.99** BHP__

1 POINT

12. A fan is operating at 15,000 CFM at 9.2 BHP. The density of the air is 0.062 lbs. per cubic foot. Find the new brake horsepower at standard conditions.__**11.13**__ BHP

1 POINT

13. A system curve is a __**plot of the pressure required to move air through the system**__ and is plotted using the following equation: **1 POINT**

$$\frac{SP_2}{SP_1} = \left[\frac{CFM_2}{CFM_1} \right]^2$$

14. The operating point is the intersection of the __**fan performance curve**__ and the__**system curve**__. **1 POINT**

15. The three most common causes of poor fan performance are:

a) **Improper outlet connections**

b) **Non-uniform inlet flow** **1 POINT**

c) **Swirl or spin at the fan inlet**

16. Two fans, each handling 10,000 CFM at 2.5 in. WC SP are selected to operate in parallel. The combined curve will have the fans operating at __**20,000**__CFM at __**2.5**__ in. WC SP. **1 POINT**

17. Name the four general classifications of centrifugal fans.

a) **Forward Curve**

b) **Airfoil**

c) **Backward Curve / Inclined**

d) **Radial**

1 POINT

18. The most efficient of the centrifugal fans is the **airfoil**. **1 POINT**

19. Name the three general classifications of axial fans.

a) **Propeller**

b) **Tube axial**

c) **Vane axial**

1 POINT

20. For an axial fan, as total pressure increases, the horsepower **a** .

a) increases or b) decreases **1 POINT**

21. A fan is selected to deliver 40,000 CFM at 1.5 in. WC SP at standard density. The power required is 7.4 BHP. If the air density is 0.060 lbs./cu. ft., what is the actual static pressure and brake horsepower at which the fan will operate (if the fan speed remains unchanged)?

a) **1.2** WC SP

b) **5.92** BHP

1 POINT

22. A fan is selected to deliver 10,500 CFM at 3.5 in. WC SP and 20 BHP at standard air conditions. The fan speed is 450 RPM. The actual operating density is 0.082 lbs./cu. ft. Find the operating static pressure and brake horsepower.

a) **3.83** WC SP

b) **21.87** BHP

1 POINT

23. A fan is tested in an air density of 0.057 lbs./cu. ft. The tested brake horsepower is 14.8. What will the rated brake horsepower be when corrected for standard air?

19.47 BHP **1 POINT**

100 POSSIBLE TOTAL POINTS **85% REQUIRED TO PASS** **MAX. TIME = 3 Hrs.**

AIR BASICS - FIELD EVALUATION

Employee: ____

Evaluator: ____

The purpose of this evaluation is to accurately determine the field ability of the technician in conjunction with the written examination of the AIR BASICS section of the AABC training curriculum. Each line item below has been observed by the Evaluator and will be scored in one of three different categories. The "AVERAGE" category pertains to that of the average performance expected by an employee of this firm. Anything less than that will be marked as "POOR" and anything greater than that will marked as "GOOD".

		POOR	AVRG	GOOD
		3	2	1
1	Familiar with Electronic Air meter and all functions			
2	Familiar with Water meters (Use of, prep, draining, venting)			
3	Familiar with Flow Hood (Prep, Tear Down, Use of, etc.)			
4	Fills in data on sheets properly and neatly			
5	Obtains all required data needed (or asked for)			
6	Attention to detail for paperwork in field			
7	Able to set up a rectangular duct traverse sheet			
8	Able to set up a round duct traverse sheet			
9	Understands theory behind a duct traverse and how to mark holes			
10	Understands duct pressures (Total vs. Static)			
11	Can calculate RPM by manual count of fan sheave vs. motor sheave			
12	Sheave adjustments			
13	Well orientated with project by contract drawings			
14	Shows self-initiative in performing all the above listed items			

Field technician should have a maximum score of 29 to consist of no more than 3 marks under the "POOR" category. If the total score is more than 29 or more than 3 marks are under the "POOR" category, the technician will be considered as unqualified for completion of the AIR BASICS section of testing. Any technician failing to complete any section of testing will be required to improve within the given time frame at which time the evaluation will be given again.

Field technician________qualifies for completion of the AIR BASICS section of testing upon verification of written examination.

________ does NOT qualify for completion of the AIR BASICS section of testing.

If the field technician did not qualify for completion of the AIR BASICS section, he/she will be re-evaluated on or around__________________only after verification that the written examination has been passed.

Evaluator signature:_________________________ Employee signature: ____________________________

Date:__________________ Date: __________________

Section #2

AIR SYSTEMS

Study Guide

Reference Guide

Black = AABC Technician Training Manual

Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Air Systems Guide

Air Systems Guide

Air Systems Guide

Air Systems Guide

Air Systems Guide

Section #2

AIR SYSTEMS

Technician's Exam

Associated Air Balance Council

AIR SYSTEMS
TEST #2

Chapter 7
Air Balance Preparation

1. Name the project documents to be reviewed in becoming familiar with the systems to be balanced. **3 POINTS**
   a) **Contract Documents**
   b) **Drawings**
   c) **Specifications**
   d) **Submittal Data**
   e) **Shop Drawings**
   f) **Temperature Control Drawings**

2. List the items to be checked during the site inspection.
   a) The building (list three): **3 POINTS**
      1) **Doors Installed**
      2) **Windows Installed**
      3) **Outside Walls Sealed Tight**

      Walls and Partitions Installed

      Ceilings and Tiles Installed

   b) The fan and duct system (list ten): **5 POINTS**
      1) **Fan housings properly sealed**
      2) **Fan plenums installed as per drawings and specifications**
      3) **Vortex dampers operational**
      4) **Speed drives operational**
      5) **Flexible connections properly installed**
      6) **Fan wheel aligned properly**
      7) **Fan bearings lubricated**
      8) **Ductwork installed as per drawings and specifications**
      9) **Ductwork intact**
      10) **End-caps installed**

      - **Access doors secured**
      - **No missing inlets or outlets**
      - **Ductwork is free of debris**
      - **All duct dampers, including fire and smoke dampers installed and accessible**
      - **Automatic control dampers installed and operational**
      - **All terminal boxes, reheat coils, electric coils, etc. installed and accessible**
      - **Terminal boxes operational**
      - **Un-obstructed return air path from each conditioned space back to the unit**

   c) The filters and coils (list four): **3 POINTS**
      1) **Filters clean**
      2) **Correct filters installed**
      3) **Filter frame properly installed and airtight**
      4) **Coil clean and properly installed**

d) The drives and components (list four):

1) **Drive components installed**
2) **Sheaves properly aligned and tight on their shafts**
3) **Belts adjusted for the correct tension**
4) **Belt guard properly installed**

2 POINTS

e) The motor and electrical equipment (list five):

1) **Motor wired and energized**
2) **Proper starter and overload protection installed**
3) **Correct fuses installed**
4) **Motor secured on its frame**
5) **Motor bearings lubricated**

3 POINTS

f) The controls (list two):

1) **Controls complete**
2) **Controls operational**

2 POINTS

Chapter 8
Basic Balance Procedures - Air Systems

1. List the damper and the diverter settings for balancing a system.

   1) Outside dampers: Where separate minimum and maximum outside air dampers are used, set the minimum damper to **100** % open. When a single outside air damper is used for both minimum and economizer, the minimum outside air is 500 CFM and the maximum outside air is 2000 CFM, open the damper to **25** % to approximate minimum outside air. **1 POINT**

   2) Return air dampers: Return-air dampers should be **100** % open. **1 POINT**

   3) Exhaust air dampers: Exhaust-air /relief air dampers should be **0** % open. **1 POINT**

   4) Face and bypass dampers: Face and bypass dampers should be set for **100** % flow through the coil. The exception is if the coil has a diversity (the coil is sized for less CFM than supplied by the fan). If this is the case, the bypass damper should be opened to an amount equal to the excess fan CFM so that the total CFM will not be restricted. **1 POINT**

   5) Multizone mixing dampers: Mixing dampers should be set for **100** % flow through the cooling coil except if the coil has a diversity, in which case the dampers would be set for the required flow through the cooling coil and the remaining air through the heating coil. **1 POINT**

   6) Manual volume dampers: All volume dampers should be **100** % open. **1 POINT**

   7) Splitter dampers, extractors: All splitter dampers should be open to a **neutral** position so that they are not restricting the air flow to either duct. All extractors should be set in the **wide-open** position. **1 POINT**

   8) Backdraft dampers: All backdraft dampers should be **operational** & **non - binding**. **1 POINT**

   9) Fire and smoke dampers: Generally, fire and smoke dampers will be set in the **full** **open** position. However, in more complex systems a variety of configurations may be used, especially in systems that have multiple fans and sequences of operation. **1 POINT**

2. Momentarily starting and stopping a fan is called **bumping** and is done to check the **rotation**. **1 POINT**

3. A fan supplies 10,500 CFM. The outside air is to be set at 1,575 CFM. The outside air is 91° F and the return air is 76° F. Find the mixed-air temperature that corresponds to the correct amount of outside air. **1 POINT**

   __**78.25**__ °F

4. Do a __**static - pressure**__ profile of the economizer damper operation to confirm that the automatic dampers operate simultaneously to close the return air as the outside air is opening and vice versa. **1 POINT**

5. Write the procedure for proportional balancing of a low-pressure distribution system.

   1) Branch balancing:

      From the Pitot-tube traverses or reading of the outlets, determine which branches are over on design CFM and which are under. Investigate and correct for any blockages. Start with the highest branch and adjust the branch damper until the air flow is within 10% of the desired amount. After the highest branch is adjusted to within 10% of desired flow, go to the next highest and adjust accordingly. After all the branches have been adjusted, go back and recheck each branch and make readjustments if necessary. After all branches are adjusted to within 10% of desired airflow, proceed with balancing the terminals (outlets or inlets).

      10 POINTS

   2) Outlet Balancing:

      Measure flow at the terminal nearest the supply fan. Reduce excessive flow by dampering. Move to the next terminal on the same desired flow. Continue balancing outward by branches until all the terminals have been adjusted. Make one or more passes until an acceptable balance is obtained. After all the terminals have been adjusted, make any necessary adjustments at the branch dampers in order to achieve the system balance.

      10 POINTS

Chapter 9

Balancing Procedure for Constant Volume Supply & Exhaust Systems

1. At the completion of balancing of a multizone system:
   a) At least__**one**___outlet balancing damper will be fully_**open**_on_**every**___zone.
   b) At least__**one**____zone balancing damper will be fully__**open**___.
   c) Reset the system to__**normal**_____operating conditions. **3 POINTS**

2. For single-duct terminal box, constant-volume systems balance the branches starting with the__**highest**____branch and adjust the branch damper until the airflow is within ____**10%**___of the desired amount. Use the total of the outlets on the branch or balance using static pressures and Fan Law__**2A**__________. **2 POINTS**

3. For dual-duct terminal box systems take measurements at the end of the system to determine if the__**static**_____pressure is at or above the minimum required for terminal mixing box operation. Increase or decrease__**fan**___speed as needed. Check the___**static**______________pressure drop across the terminal. Consult the terminal __**manufacturer**______ for pressure drop requirements. Generally, 0.75 in. WC or more is required. Record__**static**__pressure in the___**inlet**_________duct to each end-run terminal. The static pressure should be at least at_**minimum**_required static but should not be excessive. If the system serves multiple floors, record the pressure at each floor takeoff and each end run for future reference. Check that the terminals ___**mixing**_________dampers are operating correctly with minimal_**leakage** and verify that all terminals are controlled by the proper__**space thermostat**_. **5 POINTS**

4. For induction terminal box systems check the side of the induction terminal box for a __**CFM versus static pressure**_________chart. If the total fan capacity is less than **95%** of design or the static pressure is not adequate, notify the __**appropriate responsible person**_before proceeding with the balancing. Read the primary air pressure at a typical nozzle in the _**first**_ and__**last**___induction terminal on each riser/branch. Use Fan Law 2A to convert static pressures to CFM. Determine the air flow being delivered but_**do not**_ adjust these terminals. After all the risers/branches have been read in the above manner, determine which risers/branches/ have the highest pressures/air flow. Reduce the airflow to the risers/branches with high pressures and continue the balance until all risers/branches are close to being equal. Adjust the __**fan speed**___, if needed, so that the static pressure to the riser/branch with the lowest pressure is adequate but not excessive. Starting with the induction terminals closest to the fan adjust each terminal to within___**10%**___of design air flow. _**Two**_or_**three**__ adjusting passes are normally needed to balance the induction system.

6 POINTS

Chapter 10
<u>Balancing Procedures for Variable Air Volume Systems</u>

1. List the five types of fan volume control typically used in variable air volume systems:
   a) **Variable Frequency Drive**
   b) **Fan Vortex Dampers**
   c) **Supply / Return Air Dump Dampers** **5 POINTS**
   d) **Supply Fan Discharge Damper**
   e) **System Bypass Damper**

2. The general balancing procedure for balancing variable-air-volume systems is to set space **thermostat** to either full **heating** or full **cooling** as required to satisfy the design **diversity** factor. Select **thermostats** to simulate as near as practical the manner in which the system will respond to the building's cooling load shift. With proper **diversity** established, adjust the **static** **pressure** control device for the supply fan to provide design total. **2 POINTS**

3. Pressure **dependent** terminal boxes do not have an automatic volume controller to regulate air flow as the inlet static pressure changes. The air flow delivered by the box is solely **dependent** on the inlet static pressure, and therefore changes as the inlet static pressure changes. **2 POINTS**

4. Pressure **independent** VAV boxes have the ability to maintain air flow at any point between maximum and minimum, regardless of the box inlet static pressure, as long as the pressure is within the design operating range. **1 POINT**

5. List the 14-step balancing procedure for a single-duct, pressure-independent system.
   1) **Operate all associated fans noted in pre-setting procedures.**
   2) **Set the individual terminal box to be tested on full cooling (100% demand).**
   3) **Allow the terminal box to control to the maximum CFM setting. Verify that the primary damper for the terminal box being balanced is in control, and not open 100%.**
   4) **Proportionally balance the supply diffusers downstream of the terminal box being tested.**
   5) **Record final airflow and all applicable data at maximum airflow.**
   6) **Command the terminal box being testing to the minimum/heating airflow setpoint. During this procedure the heating source for terminal box can be verified for performance.**

7) **Allow the terminal box to control to the reduced air volume setting and record final airflow and all applicable data at minimum airflow. During this procedure the fan performance and heating source for the terminal box can be verified for air volume and heating performance.**

8) **Continue this procedure for all terminal boxes located on the respective air handling system.**

9) **Command all terminal boxes of a respective air handling unit system to maximum CFM airflow setpoints, and perform Pitot tube traverses of the total system and compare them to the total of the terminal boxes to determine duct leakage and required instrument correction factors if applicable.**

10) **Record final measurements in the 100% cooling mode.**

11) **After the system is balanced according to the contract documents, return to the unit and reset the min outside air dampers to design quantity. Determine the amount of outside air. Record final static pressures, fan RPM, and motor amps**

12) **Verify the operation of the system in the maximum outside air mode, if applicable.**

13) **Return the system back into a logical non-modulating balancing mode and record the following final conditions/data: Amps, voltage, fan speed, motor speed, and static pressures. Coil temperatures can be recorded if the design air conditions, required water temps and flow are available.**

    Mark the dampers for resetting in case of tampering or accidental movement. Walk the system checking for drafts and noise.

14) **Review the field report to be sure that no information has been omitted, all data has been recorded correctly and accurately and that all notes regarding problems, deficiencies, and other abnormal conditions are completely explained. When the balancing procedures are complete for a system with constant volume terminals, the following should be true:**

    • At least one supply outlet balancing damper is fully open on every terminal box.

    • At least one return air balancing damper is fully open (if applicable).

    Reset the system to normal operating conditions.

10 POINTS

Chapter 11 **1 POINT**

Underfloor Air Distribution

1. List the three basic approaches to underfloor air distribution (UFAD) systems:
   a) **Pressurized underfloor plenum with a central air handler delivering air through the plenum.**
   b) **Neutral pressure plenum with air delivered into the conditioned space through local fan-powered (active) supply outlets in combination with the central air handler.**
   c) **Ducted air supply through the plenum to terminal devices and supply outlets.**

2. In a pressurized UFAD system, the underfloor plenum is under a positive static pressure produced by a central AHU that delivers the air along the plenum and up through the passive grilles/diffusers. What is this typical pressure range?

   0.05”w.c. to 0.20”w.c. **1 POINT**

3. Category 1 leakage may allow air to travel to the __**return**__ plenum above or to the floor below. Additionally, the air leakage could travel directly to the __**outside**__ of the building or __**outside**__ the confines of the underfloor system. This additional leakage may __**increase**__ fan brake horsepower requirements and cooling loads.

   2 POINTS

4. List five areas that Category 1 leakage may occur from: **1 POINT**
   a) **Plenum walls**
   b) **Joints through cavities**
   c) **Columns**
   d) **Construction defects**
   e) **Any metal wall stud penetration**

5. Category 2 leakage from the plenum through a raised floor and into an __**occupied**__ space is not always detrimental to a system. In some cases, minimal leakage may __**aid**__ in system performance and comfort conditions. If the air leakage is __**extreme**__ or in the wrong locations, such as too close to occupants, comfort problems may result. **2 POINTS**

6. List five areas that Category 2 leakage may occur from: **2 POINTS**
   a) **Gaps in floor panels**
   b) **Electrical/Communication/data outlets**
   c) **Joints at edge of the floor and vertical walls**
   d) **Air diffuser installation**
   e) **Columns**

1 POINT

7. Where can the TAB technician locate the design floor pressures/leakage requirements? **Mechanical specifications** **1 POINT**

8. Name three advantages of an underfloor air distribution system (UFAD)

    a) **Reduced calculated building thermal loads and reduced energy usage**

    b) **Temperature stratification occurs in the upper level, away from occupants**

    c) **Constant temperatures can allow for extended periods of economizer mode**

1 POINT

100 TOTAL POSSIBLE POINTS **85% REQUIRED TO PASS** **MAX. TIME = 1.5 Hrs**

AIR SYSTEMS - FIELD EVALUATION

Employee: ______________________________________

Evaluator: ______________________________________

The purpose of this evaluation is to accurately determine the field ability of the technician in conjunction with the written examination of the AIR SYSTEMS section of the AABC training curriculum. Each line item below has been observed by the Evaluator and will be scored in one of three different categories. The "AVERAGE" category pertains to that of the average performance expected by an employee of this firm. Anything less than that will be marked as "POOR" and anything greater than that will marked as "GOOD".

		POOR	AVRG	GOOD
		3	2	1
1	Fills in data on sheets properly and neatly			
2	Obtains all required data needed (or asked for)			
3	Attention to detail for paperwork in field			
4	Can set up, drill and perform a rectangular traverse			
5	Can set up, drill and perform a round traverse			
6	Can calculate a K-Factor for the flow hood based on measured data			
7	Can continue onward with next task when field leader isn't present			
8	Fully understands data taken and what it means			
9	Well orientated with project by contract drawings			
10	Shows self-initiative in performing all the above listed items			

Field technician should have a maximum score of 21 to consist of no more than 2 marks under the "POOR" category. If the total score is more than 21 or more than 2 marks are under the "POOR" category, the technician will be considered as unqualified for completion of the AIR SYSTEMS section of testing. Any technician failing to complete any section of testing will be required to improve within the given time frame at which time the evaluation will be given again.

Field technician________qualifies for completion of the AIR SYSTEMS section of testing upon verification of written examination.

_______ does NOT qualify for completion of the AIR SYSTEMS section of testing.

If the field technician did not qualify for completion of the AIR SYTEMS section, he/she will be re-evaluated on or around__________________only after verification that the written examination has been passed.

Evaluator signature:_________________________ Employee signature: ____________________________

Date:____________________ Date: _________________

Section #3

WATER MEASUREMENTS

Study Guide

Reference Guide

Black = AABC Technician Training Manual

Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Water Measurements Guide

Water Measurements Guide

Water Measurements Guide

Water Measurements Guide

Water Measurements Guide

Water Measurements Guide

Section #3

WATER MEASUREMENTS

Technician's Exam

Associated Air Balance Council

WATER MEASUREMENTS
TEST #3

Chapter 12
Hydronic Flow Measurements

1. Vacuum gauges measure pressures__**below**__atmospheric. The readings are in inches of__**mercury**______. **1 POINT**

2. A compound gauge at sea level reads 5 in. Hg. Find the absolute pressure.

   __**17.15**_PSIA **1 POINT**

3. Differential pressure gauges can be used to measure the pressure drop across flow meters, terminals, and__**heat exchangers**__. **1 POINT**

4. Name four types of flow meters: **4 POINTS**

   a) **Orifice plates** c) **Annular** • **Turbine**

   b) **Venturis** d) **Ultrasonic flow meters**

5. Which flow meter is also a balancing valve?_**Calibrated balancing valve**____ **1 POINT**

6. Which type of flow meter has a multi-ported flow sensor?_**Annular flow meter**__ **1 POINT**

7. One advantage of flow meters is that they can be installed adjacent to elbows, valves and other pipe fittings and still provide accurate, reliable readings? __**b**___ **1 POINT**

   a) True b) False

8. To be able to use the pressure drop across a coil for flow measurements the coil must:

   a) **Be a new coil or in like-new condition**

   b) **Have certified date from the equipment manufacturer indicating actual tested water flow and pressure drop at rated flow.**

   c) **Have properly installed and located pressure taps for measuring differential pressure** **3 POINTS**

9. The entering water pressure of a new heat exchanger is 15 psig. The leaving pressure is 11 psig. The heat exchanger is rated at a pressure drop of 6 psig @ 150 GPM. Find the actual GPM.__**122.5 GPM**________ **1 POINT**

10. The heating coil in an air-handling unit has a measured entering temperature of 182° F. The leaving temperature is 164°. If the heat transfer rate is 198,000 Btuh, find the GPM flow rate. **22 GPM** **1 POINT**

11. The manufacturer's pressure drop across a coil for a given GPM can be used for balancing only when**:** **3 POINTS**

    a) The coil is new or new-like condition.

    b) Have certified data from equipment manufacturer indicating actual tested water flow and pressure drop at rated flow.

    c) Have properly installed and loaded pressure taps for measuring differential pressure.

Chapter 13
Pumps

1. If the pressure at the inlet to the pump impeller is reduced below the vapor pressure of the water, the pump will begin to______**cavitate**______________. This results in __________**reduced**______________ pump life. **1 POINT**

2. To eliminate_**cavitation**___problems, it is necessary to maintain a minimum suction pressure at the pump inlet. This minimum pressure is called_**net positive suction** ___**pressure**__. **1 POINT**

3. The head-capacity curves for pumps are referenced to___**impeller**___size. **1 POINT**

4. Find the brake horsepower of a pump that is operating at 540 GPM and 90 feet of head. The pump efficiency is 78 percent.

   _**15.73**_BHP **1 POINT**

5. Calculate the efficiency of a pump if it is operating at 1260 GPM, 142 feet of head and 60 BHP.

   _**75**__ % **1 POINT**

6. List the steps to verify impeller size. **8 POINTS**

   a) **Obtain the correct pump curve.**

   b) **Turn the pump off.**

   c) **Close the discharge valve. Verify that the suction valve is full open.**

   d) **Turn the pump on.**

   e) **Read the pressure on the suction and discharge sides of the pump.**

   f) **Calculate the PSI rise across the pump by subtracting the suction pressure from the discharge pressure. If the suction is in a vacuum, convert the reading to psig and add the result to the discharge pressure.**

   g) **Multiply the pump psi rise by 2.31 feet/psi to obtain rise in feet of water.**

   h) **Plot the rise on the vertical axis of the pump curve at zero flow. This is the shut-off head.**

7. Readings are taken on a pump to determine impeller size. The discharge pressure is 87 psig. The suction pressure is 8 psig. Use the pump curve in your text to determine the impeller size.

 __**13**__ Inches **1 POINT**

8. Using the same pump curve in your text, determine the flow rate if the discharge pressure is 97 psig. The suction pressure is 10 psig. The impeller size is 14 inches.

 __**615**__ GPM **1 POINT**

9. A pump is operating at the following conditions: 800 GPM, 105 feet of water and 25 brake horsepower. The impeller size is 10". Calculate the new operating conditions if the impeller is decreased to 9".

 a) **720 GPM** **3 POINTS**

 b) **85 feet of head**

 c) **18.23 BHP**

10. Name 3 ways of reducing pump GPM which would be in the owner's best interest.

 a) **Trim impeller** **3 POINTS**

 b) **Reduce RPM**

 c) **Replace pump**

Chapter 14
<u>Hydronic Devices</u>

1 POINT

1. The amount of "safety" generally added to the pressure setting on the PRV is__**5**__psi.

2. ___**Gate**___valves should be used for tight shutoff and not for throttling. **1 POINT**

3. Although__**globe**_____valves can be used for throttling, they have high pressure drops and are not recommended for balancing work. **1 POINT**

4. A valve that is a combination of a balancing valve, a check valve, and a shutoff valve is called a___**combination**_____, **multi-purpose**_____or__**triple-duty**_____valve. **1 POINT**

5. Automatic control valves are designated as either **two** way or__**three**____way. **1 POINT**

6. ___**Three**___-way valves are classified as mixing or __**diverting**___ . This refers to the internal construction of the valve and not it's __**application**___ . **1 POINT**

7. Which type of valve has 2 "in" ports and 1 "out" port?___**Mixing**_____ **1 POINT**

8. ACV must be installed so that they seat__**against**____flow. **1 POINT**

9. Name five types of manual valves used for balancing.

   a) **Plug**
   b) **Ball**
   c) **Butterfly**
   d) **Calibrated Balancing**
   e) **Combination**

   5 POINTS

10. For the most efficient heat transfer, coils should be piped__**counter**__flow. Why?

    Uniform temperature difference through coil **1 POINT**

Chapter 15
Basic Hydronic Piping Systems

1. Return piping systems may be piped direct return or_**reverse**_return. Which system is self-balancing?_**Neither**_ **1 POINT**

2. A three-pipe system has one_**return**_main and two_**supply**_mains. **1 POINT**

3. A pumping system that has a pump to provide flow around the mains and then several smaller pumps to provide flow to the terminals is called a_**primary - secondary**_ system. These types of systems_**reduce**_pumping horse-power. **1 POINT**

4. If a system has pumps installed in parallel, the maximum horsepower for an individual pump will occur when: **Only one pump is operating** **1 POINT**

5. When pumps operate in series the_**horsepower**_and the_**head**_increase while the_**GPM**_remains constant. **1 POINT**

6. When two identical pumps operate in parallel, the _**head**_ remains constant and the _**GPM**_ doubles. **1 POINT**

7. When the head pressure is higher than design, what are five issues the technician should look for?

   a) **Closed valves or valves installed in the incorrect direction**

   b) **Poor inlet or discharge fittings**

   c) **Clogged strainers**

   d) **Debris between the strainer basket and the pump inlet**

   e) **Improper strainer screen size (construction strainers)**

5 POINTS

Chapter 16
Water Balance Preparation

1. Name the project documents to be reviewed to become familiar with the systems to be balanced.
   a) **Contract documents including drawings, specifications, addenda.**
   b) **Submittal data, including pump curves and equipment performance data.**
   c) **Shop drawings.** **4 POINTS**
   d) **Temperature control drawings.**

2. List the items to be checked during the site inspection.

   a) System installation and condition:

      1) **Piping, pumps and equipment installed according to the drawings and specifications.**
      2) **No valves, flow meters, or temperature/pressure taps missing.**
      3) **System cleaned and flushed.**
      4) **Construction strainer screens replaced with permanent screens, strainers cleaned.**
      5) **System filled to the proper level and the PRB set.**
      6) **Air vents properly installed and operational and all air purged from the system.**
      7) **Water in the expansion tanks at the proper level.**

   2 POINTS

   b) Piping and distribution system:

      1) **Piping intact and free of leaks.**
      2) **Piping free of debris.**
      3) **Valves, flow meters and temperature/pressure taps accessible.**
      4) **Valves, including pressure-reducing valves operational.**
      5) **Valves, piped correctly, terminal coils installed correctly and accessible, terminals piped correctly.**

   2 POINTS

c) Pumps: **1 POINT**

1) **Pumps properly aligned, grouted and anchored.**
2) **Bearings lubricated.**
3) **Vibration isolators properly installed and adjusted.**
4) **Flexible connections installed properly.**

d) Motor and electrical: **2 POINTS**

1) **Pump motors properly wired and energized.**
2) **Proper starter and overload protection installed.**
3) **Correct fuses installed.**
4) **Motors properly secured on their frames.**
5) **Motor bearings lubricated.**

e) Controls and start-up for boiler: **1 POINT**

1) **Control complete and operational.**
2) **Boiler start-up tests complete.**
3) **Boiler firing correctly.**
4) **Boiler's operational and safety settings for temperature pressure correct.**
5) **Pressure relief valve installed and operating properly.**
6) **Refrigeration equipment start-up tests complete.**

f) Controls and start-up for chiller: **1 POINT**

1) **Controls complete and operational.**
2) **Chiller and compressor operating correctly.**
3) **Operational and safety settings for temperature and pressure correct for the chiller.**

g) Controls and start-up for cooling tower: **1 POINT**

1) **Controls complete and operational**
2) **Cooling tower or air-cooled condensers fans and motors installed and operating correctly.**

Chapter 17
Basic Water System Balance Procedures **2 POINTS**

1. The procedure, where applicable, for balancing the water system will be to adjust the main's balancing valve to about__**110**__ % of design. Next, adjust the headers starting with the header with the_**highest** flow. Set this header's balancing valve until the water flow is within__**10**__ % of the desired amount. Then read the other headers and set their balancing valves to achieve plus or minus__**10**__% of design. After finishing with the headers go to the_**highest** riser and adjust it accordingly. Continue adjusting each riser from the_**highest**_ to the__**lowest**______. After finishing with the risers go to the highest__**branch**___and adjust it accordingly. Continue adjusting each____**branch**_______from the___**highest**___to the____**lowest**_____. After all of the **branches** have been adjusted go back and recheck. Some readjustment of the **banches** may be necessary. It will usually take **two** to **three** passes of adjusting valves before all the **branches** are correct.

2. When several valves are throttled, there will be an_**increase**_in static head at the discharge of the pump and a reduction in __**total**____ ___**flow**____. This is why in the presetting stage it is good practice, if possible, to set the pump at__**110**_ % of design. Even with this cushion it still may be necessary to__**open**_____the discharge valve or _**increase**_ the impeller size when the balancing is finished to bring the water flow to__**design**__ conditions. **1 POINT**

3. To balance the terminals, begin by measuring flow at the terminal ___**nearest**_____ the pump. Reduce excessive flow by closing the valve. Move to the next **terminal** on the___**same**___ branch and adjust the valve as needed to bring the water flow within __**10**_ % of desired flow. Continue balancing_**outward**_ by branches until all the terminals have been adjusted. Make one or more passes until an acceptable_**balance** is obtained. **1 POINT**

4. After all the terminals have been adjusted it may be necessary to make slight adjustments at the branch valves in order to achieve the system balance. Since all the terminals have been___**proportionally**____balanced to each other by branch, an adjustment at the branch valve will increase or decrease all the terminals on that branch proportionally. **1 POINT**

Chapter 18
Domestic Hot Water Balance Procedures

1. A typical domestic water system may include the following equipment: **5 POINTS**
   a) **Hot Water Heater/Boiler**
   b) **Hot Water Return Circulation Pump**
   c) **Cold Water Domestic Pressure Booster Skid**
   d) **Storage Tanks**
   e) **Thermal Mixing Valves**
   - **Pressure Reducing Valves**
   - **Return Loop Balancing Stations**

2. Return balancing stations are installed at __**each**__ location where the design engineer expects to maintain hot water availability in a specific time frame. **1 POINT**

3. The domestic cold, hot and return loop water piping systems will be located in the __**plumbing section**__ of the contract plans. **1 POINT**

4. The __**installing**__ __**contractor**__ with the TAB technician should walk the entire domestic water system and verify that all __**isolation**__ and __**balancing**__ __**valves**__ in the system are open and installed in the plan indicated locations. **1 POINT**

5. The __**instrument**__ and all __**components**__ should be sterilized __**before**__ and __**after**__ each use and properly stored to maintain their cleanliness. **1 POINT**

6. At a minimum, the testing instrumentation should be cleaned by the following method: **5 POINTS**
   a) **Chlorine bleach Solution concentration should be between 20% and 40%.**
   b) **isolation valves open and the chlorine solution poured through the meter**
   c) **allow solution to flow through the testing hoses**
   d) **Connect the insertion plugs (Pete's plugs) to the hoses and the hoses to the meter.**
   e) **Connect the meter to the domestic system and fill**

7. It is very important during balancing activities that the domestic system __**not**__ __**be**__ in use. **1 POINT**

8. The temperature verification of the domestic hot water balance can be performed by either: **1 POINT**
   a) **Recording an actual temperature at the balancing station**
   b) **Recording temperatures at the point-of-use locations and verifying the time it takes to obtain hot water**

9. All balancing activities and temperature verification should be documented on the __**approved AABC report**__ forms. **1 POINT**

100 POSSIBLE TOTAL POINTS **85% REQUIRED TO PASS** **MAX. TIME = 2.5 Hrs.**

WATER MEASUREMENTS - FIELD EVALUATION

Employee: ____

Evaluator: ____

The purpose of this evaluation is to accurately determine the field ability of the technician in conjunction with the written examination of the WATER section of the AABC training curriculum. Each line item below has been observed by the Evaluator and will be scored in one of three different categories. The "AVERAGE" category pertains to that of the average performance expected by an employee of this firm. Anything less than that will be marked as "POOR" and anything greater than that will marked as "GOOD".

		POOR	AVRG	GOOD
		3	2	1
1	Fills in data on sheets properly and neatly			
2	Obtains all required data needed (or asked for)			
3	Attention to detail for paperwork in field			
4	Can locate and identify all water system components in field			
5	Converting PSI to Feet/Inches			
6	Gauge set up and tear down (bleeding, draining, etc.)			
7	Understands different balancing valve configurations and usage			
8	Understands two/three way and bypass set up			
9	Understands diversity and proportion balancing methods			
10	Pump set up, pressures and relations between the two			
11	Fully understands data taken and what it means			
12	Well orientated with project by contract drawings			
13	Shows self-initiative in performing all the above listed items			

Field technician should have a maximum score of 27 to consist of no more than 3 marks under the "POOR" category. If the total score is more than 27 or more than 3 marks are under the "POOR" category, the technician will be considered as unqualified for completion of the WATER section of testing. Any technician failing to complete any section of testing will be required to improve within the given time frame at which time the evaluation will be given again.

Field technician________qualifies for completion of the WATER section of testing upon verification of written examination.

________ does NOT qualify for completion of the WATER section of testing.

If the field technician did not qualify for completion of the WATER section, he/she will be re-evaluated on or around__________________only after verification that the written examination has been passed.

Evaluator signature:_________________________ Employee signature: ___________________________

Date:____________________ Date: __________________

Section #4

REFRIGERATION & HEATING

Study Guide

Reference Guide

Black = AABC Technician Training Manual

Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Refrigeration & Heating Guide

Refrigeration & Heating Guide

Section #4

REFRIGERATION & HEATING

Technician's Exam

Associated Air Balance Council

REFRIGERATION & HEATING
TEST #4

Chapter 19
HVAC Refrigeration

1. Name the four stages in the vapor-compression cycle.
   a) **Evaporation** **4 POINTS**
   b) **Compression**
   c) **Condensation**
   d) **Expansion**

2. Heat that causes a change of state without a change in temperature is called **latent** heat. **1 POINT**

3. The ratio of the amount of heat required to raise the temperature of one pound of substance 1° F as compared to the amount required to raise one pound of water 1° F is the **specific heat** of a substance. **2 POINTS**

4. A fluid that absorbs heat through the process of vaporization and releases heat through condensation is called a **refrigerant** **1 POINT** .

5. The boiling point of a liquid changes in the **same** direction as the pressure to which the liquid is subjected. **1 POINT**

6. A compressor has two main functions. Name them. **2 POINTS**
   a) **Pump refrigerant vapor from the evaporator to the condenser.**
   b) **Compress the refrigerant vapor from a lower pressure to a higher pressure.**

7. The metering device is part of the **expansion** stage in the vapor-compression cycle. **1 POINT**

8. The evaporation stage is where unwanted heat is removed and absorbed into the **refrigerant**. **1 POINT**

9. In an air-cooled condenser, the condensation stage is where unwanted heat from the system is rejected into the **air**. **1 POINT**

10. Unloaders are used on **reciprocating** compressors for **capacity** control. **2 POINTS**

Chapter 20
Water Chillers and Other Heat Exchangers

1. In a **centrifugal** compressor the refrigerant vapor is drawn from the evaporator into the eye of the impeller through inlet vanes. **1 POINT**

2. Calculate the estimated condenser load for an open-type compressor if the operating capacity of the compressor is 8 tons and the brake horsepower is 7.2.

   Btuh = **114,324** **5 POINTS**

3. Determine the total heat rejection at the condenser with a hermetic compressor if the operating capacity of the compressor is 4.5 tons and the power input is 5.3 Kw.

   Btuh = **72,089** **5 POINTS**

4. The design air flow through an air-cooled condenser is 5,000 CFM. The leaving air temperature is 97° F. The entering air temperature is 82° F. Find heat rejected in Btuh and tons of refrigeration.

   Btuh = **81,000** **10 POINTS**

   Tons = **6.75**

5. Determine the water flow needed to remove 580,000 Btuh if the temperature difference through a water-cooled condenser is to be maintained at 10°.

   GPM = **116** **5 POINTS**

6. A condenser has a capacity of 50 tons. Find the leaving water temperature if entering water temperature is 85° F and the flow rate through the condenser is 120 GPM.

   °F = **95** **5 POINTS**

7. The decrease in temperature as the water passes through the tower is called the tower **range** . The difference in temperature between the leaving water temperature (LWT) and the entering air wet bulb temperature (EWB) is called the tower **approach**
   2 POINTS

8. The following measurements are made on a cooling tower:

   Entering water temperature: 94.5° F
   Leaving water temperature: 85° F
   Entering air temperature, wb: 70° F
   GPM: 350

   Find the tower range, load, and approach.

   tower range = **9.5°**

   tower load = **1,662,500 Btuh** **15 POINTS**

   tower approach = **15°**

Chapter 21
Cooling Towers

1. When the temperature of the cold water leaving the tower is taken at a throttle valve on the discharge side of the circulating pump, the water temperature must be adjusted for the ___**heat increase created by the pump**___. **1 POINT**

2. Define and explain LWTF.

LWTF is the final temperature of the water leaving the tower at test conditions. It is the tested leaving water temperature (LWTT) corrected or adjusted for temperature increase created by the pump, and for temperature increase created by the make-up water. **2 POINTS**

3. Write the equation to calculate fan motor brake horsepower.

$$\mathbf{BHP_C = \frac{Kw \times EFF_M}{0.746}}$$

3 POINTS

4. Calculate the cooling tower percent capability if the adjusted test flow is 2,000 GPM and the predicted flow is 2,258 GPM.

___**88.57**___ % **5 POINTS**

Chapter 22
Boilers and Steam System Components

1. Dry-back and wet-back are two kinds of **fire-tube** boilers. **1 POINT**

2. A **two** or **four** pass boiler has a stack at the front, while a **three** pass boiler has a stack at the back. **2 POINTS**

3. The maximum efficiency attainable for both natural gas and oil-fired boilers is about **80** %. **1 POINT**

4. The difference between the boiler room temperature and the stack temperature is called the **net stack temperature** **1 POINT**

5. The boiler stack temperature should be no more than **150** ° above the steam or water temperature. If it is, the boiler is not working efficiently. The rule of thumb for stack temperatures is that for each **100** ° that the stack temperature is lowered, there is a **2.5** % increase in efficiency. **2 POINT**

6. The amount of excess air needed for complete combustion, plus some extra for a safety factor, should not exceed **10** %. **1 POINT**

7. The stack tested oxygen level should be at least **1** % but should not exceed **2** %. **1 POINT**

8. A rule of thumb says that there is approximately **5** % excess air for each **1** % of oxygen in the flue gas. **1 POINT**

9. The amount of carbon dioxide should be **high** as possible. For maximum efficiency in natural gas boilers this will be about **10** % while oil-fired boilers should have about **13** to **14** % carbon dioxide. **2 POINTS**

10. A test should also be made for the presence of carbon monoxide (CO). The amount of CO present should be **zero** **1 POINT**

11. Steam traps should be installed at the following locations: **3 POINTS**

a) **at risers and expansion loops**

b) **all low points**

- **ahead of pumps**

c) **ahead of valves**

- **at ends of mains**
- **below heat exchangers and coils**
- **at intervals along horizontal pipe runs**

12. Name 3 types of steam traps: **3 POINTS**

a) **Mechanical (density operated)**

b) **Thermostatic (temperature operated)**

c) **Thermodynamic (kinetic energy operated)**

13. List 5 potential steam trap failures: **5 POINTS**

a) **Abnormally warm boiler room**

b) **Condensate receiver venting steam**

c) **Condensate pump water seal failing prematurely**

Inlet and outlet lines to trap nearly the same temperature

d) **Overheating or under-heating in conditioned space**

e) **Boiler operating pressure difficult to maintain**

Vacuum in return lines difficult to maintain

Water hammer in steam lines

Steam in condensate return lines

14. A **condensate** **receiver** is an open vessel consisting of a tank, level sight-glass and typically integrated pumps. **1 POINT**

100 POSSIBLE TOTAL POINTS **85% REQUIRED TO PASS** **MAX. TIME = 2 Hrs.**

REFRIGERATION & HEATING - FIELD EVALUATION

Employee: ____

Evaluator: ____

The purpose of this evaluation is to accurately determine the field ability of the technician in conjunction with the written examination of the REF & HTG section of the AABC training curriculum. Each line item below has been observed by the Evaluator and will be scored in one of three different categories. The "AVERAGE" category pertains to that of the average performance expected by an employee of this firm. Anything less than that will be marked as "POOR" and anything greater than that will marked as "GOOD".

		POOR	AVRG	GOOD
		3	2	1
1	Fills in data on sheets properly and neatly			
2	Obtains all required data needed (or asked for)			
3	Attention to detail for paperwork in field			
4	Can locate and identify all refrigeration components in field			
5	Can locate and identify all heating components in field			
6	Can identify different system types in field (HP loop, VAV reheat, etc.)			
7	Identifying cooling and heating related problems in field			
8	Fully understands data taken and what it means			
9	Well orientated with project by contract drawings			
10	Shows self-initiative in performing all the above listed items			

Field technician should have a maximum score of 21 to consist of no more than 2 marks under the "POOR" category. If the total score is more than 21 or more than 2 marks are under the "POOR" category, the technician will be considered as unqualified for completion of the REF & HTG section of testing. Any technician failing to complete any section of testing will be required to improve within the given time frame at which time the evaluation will be given again.

Field technician________qualifies for completion of the REF & HTG section of testing upon verification of written examination.

________ does NOT qualify for completion of the REF & HTG section of testing.

If the field technician did not qualify for completion of the REF & HTG section, he/she will be re-evaluated on or around__________________only after verification that the written examination has been passed.

Evaluator signature:________________________ Employee signature: ____________________________

Date:__________________ Date: ______________

Section #5

TEMPERATURE MEASUREMENTS

Study Guide

Reference Guide

Black = AABC Technician Training Manual

Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Temperature Measurements Guide

Temperature Measurements Guide

Section #5

TEMPERATURE MEASUREMENTS

Technician's Exam

Associated Air Balance Council

TEMPERATURE MEASUREMENTS
TEST #5

Chapter 23
Psychometrics

1. Air entering a cooling coil is at 80 db and 65 wb. The air leaving the coil is 57 db and 90% RH. The airflow across the coil is 55,000 CFM. Find:

a) EAT DP	**56.5º F**	
b) LAT DP	**54º F**	
c) EAT gr/lb. of moisture	**68.29 gr/lb.**	
d) LAT gr/lb. of moisture	**62.33 gr/lb.**	
e) Delta gr/lb. of moisture removed	**7.54 gr/lb.**	**28 POINTS**
f) SHF	**0.86**	
g) EAT RH	**44%**	
h) LAT wb	**55.2º F**	
i) EAT h	**30.06 Btu/lb.**	
j) LAT h	**23.35 Btu/lb.**	
k) Btuht removed	**1,663,200 Btuh**	
l) Btuhs removed	**1,368,428 Btuh**	
m) Btuhl removed	**294,772**	
n) Tons of refrigeration required	**138.6 Tons**	

Write the formulas used, then substitute above data in to show calculations:

Btuht removed

5 POINTS

Btuht = cfm x 4.5 x delta ht

1,663,200 = 55,000 x 4.5 x 6.72 (30.06 Btu/lb. – 23.34 btu/lb.)

Btuhs removed

5 POINTS

Btuhs = cfm x 1.08 x delta T
1,366,200 = 55,000 x 1.08 x 23(80-57)
***Btuhs = cfm x 4.5 x delta hs**
1,368,428 = 55,000 x 4.5 x 5.529(19.221 Btu/lb. – 13.692 Btu/lb.)

Btuhl removed

5 POINTS

Btuhl = Btuht – Btuhs
294,772 = 1,663,200 – 1,368,428
***Btuhl = cfm x 4.5 x delta hl**
294,772 = 55,000 x 4.5 x 1.191 (10.839 Btu/lb. – 9.648 Btu/lb.)
Btuhl = cfm x 0.68 x delta gr/lb.

5 POINTS

281,996 = 55,000 x 0.68 x 7.54(69.77 gr/lb. – 62.23 gr/lb.)

Tons of Refrigeration

***Btuht/12,000 Btu per ton**
1,663,200/12,000 = 138.6 tons

Chapter 24
Equipment and System Performance Verification

1. The responsibility of the test-and-balance agency is to verify the system __**operation**__ as specified in the __**contract documents**__ and report any installation problems observed. The verification process will consist of confirming operational performance of all HVAC equipment and subsystems, to include:

   a) **Air**

   b) **Water**

   c) **Refrigeration**

   d) **Fans**

   e) **Pumps**

   f) **Chillers**

   g) **Cooling Towerd**

   h) **Interconnecting ducting and piping**

10 POINTS

2. Physical changes to the HVAC system such as adjusting, relocating, or repairing components, etc., is the responsibility of the __**contractor(s)**__ and should __**not**__ be done by the technician unless specifically authorized by the __**test & balance engineer**__. The technician will also need to make arrangements with the appropriate responsible person for __**opposite**__ season inspection and testing to prove the capability of the system(s) to match capacity with varying load conditions. Each system will be tested in its __**normal**__ operating mode.

2 POINTS

3. The air and water through a heating coil have been balanced. Verify the performance of the coil by comparing heat transfer. The measured temperatures and flows are:

   Air flow is 20,000 CFM.
   Entering air temperature: 60.2° F
   Leaving air temperature: 76.4° F
   Entering water temperature: 180° F
   Leaving water temperature: 160° F
   GPM at the flow meter: 35 GPM

   Btuh (Air) = __**349,920**__

   Btuh (Water) = __**350,000**__

20 POINTS

4. The air and water through a cooling coil have been balanced. Verify the performance of the coil by comparing heat transfer. The measured temperatures and flows are:

   The air flow is 30,000 CFM.
   Entering air temperature - 77° FDB/64° FWB
   Leaving air temperature - 59° FDB/59° FWB
   Entering water temperature - 44° F
   Leaving water temperature - 54° F
   GPM at the flow meter - 95 GPM
   From page 240: 64° FWB = 29.31 Btu and 59º FWB = 25.78 Btu

   Btuh (Air) = **476,550**

   Btuh (Water) = **475,000**

20 POINTS

100 POSSIBLE POINTS **MAX. TIME = 1.50 Hrs**

85% REQUIRED TO PASS

TEMPERATURE MEASUREMENTS - FIELD EVALUATION

Employee: ____

Evaluator: ____

The purpose of this evaluation is to accurately determine the field ability of the technician in conjunction with the written examination of the TEMPERATURE section of the AABC training curriculum. Each line item below has been observed by the Evaluator and will be scored in one of three different categories. The "AVERAGE" category pertains to that of the average performance expected by an employee of this firm. Anything less than that will be marked as "POOR" and anything greater than that will marked as "GOOD".

		POOR	AVRG	GOOD
		3	2	1
1	Fills in data on sheets properly and neatly			
2	Obtains all required data needed (or asked for)			
3	Attention to detail for paperwork in field			
4	Accuracy in placement and time frame of temperature measurements			
5	Understands Glass stem thermometers and usage			
6	Understands Shortridge digital probes and usage			
7	Understands Dataloggers and usage (programing, etc.)			
8	Fully understands data taken and what it means			
9	Well orientated with project by contract drawings			
10	Shows self-initiative in performing all the above listed items			

Field technician should have a maximum score of 21 to consist of no more than 2 marks under the "POOR" category. If the total score is more than 21 or more than 2 marks are under the "POOR" category, the technician will be considered as unqualified for completion of the TEMPERATURE section of testing. Any technician failing to complete any section of testing will be required to improve within the given time frame at which time the evaluation will be given again.

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Evaluator signature:________________________ Employee signature: ____________________________

Date:________________ Date: ________________

Section #6

CONTROLS & SPECIAL SYSTEMS

Study Guide

Reference Guide

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Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Controls & Special Systems Guide

Controls & Special Systems Guide

Controls & Special Systems Guide

Controls & Special Systems Guide

Controls & Special Systems Guide

Section #6

CONTROLS & SPECIAL SYSTEMS

Technician's Exam

Associated Air Balance Council

CONTROLS & SPECIAL SYSTEMS
TEST #6

Chapter 25
Controllers and Controlled Devices

1. State the purpose of an HVAC automatic control system. **2 POINTS**
   The purpose of an HVAC automatic control system is to start, stop, or regulate the flow of air, water, or steam and to provide stable system operation by maintaining desired temperature, humidity and pressure.

2. The normal system pressure to the controllers in a single-pressure pneumatic air system is **18** to **24** psi. **1 POINT**

3. Two-pipe thermostats have two connections (**branch** and **main**) and receive 20 PSIG of main air directly from the supply system. **1 POINT**

4. Reverse-acting thermostats respond to a rise in temperature, pressure, or humidity by causing a **decrease** in branch pressure output. **1 POINT**

5. Pneumatic valves and actuators use **air pressure** , **springs** and an **air bladder** to modulate the valve stem open and closed. **1 POINT**

6. Define normally open and normally closed for pneumatic controlled devices.
   a) Normally closed is: **1 POINT**

      The position of a controlled device when the power source is removed. A controlled device the moves toward the closed position as the branch line pressure decreases is normally closed.

   b) Normally open is: **1 POINT**

      The position of a controlled device when the power source is removed. A controlled device that moves toward the open position as the branch line pressure decreases is normally open.

7. Name the first three components of a pneumatic system.
   a) **Relief valve** **3 POINTS**
   b) **Refrigerated air dryer**
   c) **Oil removal filter**

8. List 5 types of analog input points: **3 POINTS**
   a) **Room Temperature**
   b) **Room Humidity**
   c) **Return/Mixed Air Temperature**
   d) **Discharge Air Temperature**
   e) **Supply Static Pressure**

- **Chilled Water Return Temperature**
- **Chilled Water Supply Temperature**
- **Heating Water Supply Temperature**
- **Heating Water Return Temperature**
- **Chilled and Heating Water Differential Pressure**

9. The **BACnet** protocol, an ASHRAE standard, provides mechanisms by which computerized building automation devices can exchange information, regardless of the particular building service they perform or manufacturer who supplies them. **1 POINT**

10. A set of automated controls and software that will monitor and optimize the use of energy in commercial buildings is called the **Energy Management System (EMS)** system. **1 POINT**

11. A digital computer is often used to control HVAC devices such as valves via microprocessors using software to perform the control logic. This automated control of a condition or process is called the **Direct Digital Control (DDC)** system.
1 POINT

Chapter 26
Calibration & Control Sequence Verification

1. Control verification means: **2 POINTS**

   a) **Setting control to a proper fixed mode to prevent any changes during balancing.**

   b) **Verifying proper operation.**

2. The motor thermal overload protection is __**normally**__ __**closed**______ **1 POINT**

3. Even if the supply fan is off the return fan can be started by placing the return fan selector switch to H. ____**b**___ **1 POINT**

   a) True b) False

4. If the chilled water pump is on automatic the pump will start when the outside air temperature is__**above**___setpoint. **1 POINT**

5. If the chilled water flow switch is__**closed**__and the chilled-water temperature is_**above**_ set point the refrigerant solenoid valve should_**open**_. **2 POINTS**

Chapter 27
Special Systems

1. The **lower** the class rating, the cleaner the room. **1 POINT**

2. What class of clean room should have a particle count not to exceed 1 particle per cubic foot of a size 0.5 micron and larger, with no particle exceeding 5.0 micron, with airflow between 70 and 90 FPM, air change rates between 360 and 540 ACH and ceiling HEPA diffuser coverage between 60% and 100%? **a** **1 POINT**

   a) Class 1 b) Class 10 c) Class 100

3. When performing clean room testing, the **supply** airflow should not be adjusted to satisfy room pressures. The **supply** airflow has been designed to provide the required airflow **velocity** through HEPA filters, if applicable and across equipment and work surfaces. **2 POINTS**

4. **Active** chilled beams, also known as induction diffusers or ceiling mounted induction terminals, consist of a **primary** air duct connection, a series of induction nozzles, a heating/cooling coil, a supply outlet(s) and an inlet section. **2 POINTS**

5. Active chilled beams are able to induce and condition **three** to **six** times as much room air as fresh (primary) air being supplied to the beam. **1 POINT**

6. The primary air in an active chilled beam **cannot** be measured with a flow hood without also measuring the secondary air quantity. Therefore, capture hoods should a) be used or b) not be used to determine primary airflow for active chilled beams. **b** **1 POINT**

7. Duct leakage is affected by:

   a) **Static pressure**
   b) **System size**
   c) **Openings in the duct**
   d) **Joints**
   e) **Seams**
   f) **Access doors**
   g) **Rod penetrations**
   h) **Workmanship**

   4 POINTS

8. Perform a leakage analysis for the following system:

   50,000 CFM, 2” wg
   1,000 linear feet of sealed round duct (12,900 sf of duct)
   Average distribution is 3.88 CFM/sf (50,000/12,900sf).

   a. The leakage class is **12**.
   b. The leakage rate is **18.5** CFM/100 sf.
   c. The allowable leakage rate for the system is **2,387** CFM.
   d. The percentage of allowable leakage for the system is **4.77** %.

   4 POINT

9. What are the four procedures for testing a unit for casing leakage: **2 POINTS**

   a. **Verify all openings and panels are properly sealed by the manufacturer**

   b. **Install the duct leakage test apparatus to one of the unit blank-off panels that will be removed for final ductwork connections.**

   c. **Energize the pressure test apparatus and pressurize the unit to the specified static pressure.**

   d. **Measure and document the airflow leakage rate as indicated by the specific orifice plate reference airflow chart which is part of the test apparatus.**

10. A box-like structure, generally mounted on a bench or table, which encloses a source of air contaminants is called a ____**laboratory fume hood**____. **1 POINT**

11. Generally, __**100**__ FPM is satisfactory for most lab fume hood applications. **1 POINT**

12. Describe how the bypass lab fume hood works: **1 POINT**

The bypass hood is a variation of the constant volume fume hood. It has a vertically moveable sash. The construction of the hood is similar to the conventional hood with the addition of the bypass to allow for a constant volume of air through the fume hood as the sash is closed. As the sash is pulled down, the air volume through the hood face is reduced. At the same time the sash is being closed, the bypass is being opened, and more air is then drawn through the bypass. This keeps air flow through the hood and the face velocities relatively constant.

Questions 13 – 16 pertain to fume hood testing:

13. The room ventilating systems should be in __**normal / full**__ operation. If the hood has a horizontally moving sash, position the sash to obtain the __**maximum**__ face opening or the "as used" position. Position the baffles to give __**full**__ airflow across the work surface. **1 POINT**

14. Traverse the hood face and determine the average face velocity. Set up a grid pattern by dividing the vertical and horizontal dimensions to attain equal areas over the cross section of the sash opening. The maximum distance between the center points should not be greater than __**6**__ inches. The readings closest to the hood walls should be taken at __**1/2**__ this distance. **1 POINT**

15. Make a complete traverse of the hood face with smoke to determine whether positive air flow is entering the hood over the entire hood face. All smoke must be carried directly to the back of the hood and exhausted. No __**reverse**__ air flows or __**dead**__ air spaces are permitted. If visible smoke flows out the front of the hood, the hood the test. **1 POINT**

16. Place a pan of hot water in the center of the working area. Add enough chunks of **dry ice** to the hot water to form a large volume of heavy white smoke. **1 POINT**

17. What are the three types of tests performed by a 3rd party agency in the ASHRAE 110 Hood verification procedure: **3 POINTS**

    a. **Face velocity measurements**

    b. **Smoke capture visualization**

    c. **Tracer gas containment**

18. What type of hood classification, per IMC requirements, shall be installed where the cooling appliances produce grease or smoke? __**Type I or Class 1**__ **1 POINT**

19. What type of hood classification, per IMC requirements, shall be installed over cooking or dishwashing appliances that produce heat, steam, or products of combustion that do not produce grease or smoke? __**Type II**__ or __**Class 2**__ **1 POINT**

20. Face discharge is make-up air being supplied through the __**front**__ of the exhaust hood, normally through perforated stainless steel panels. Make-up air is delivered into the room at relatively __**low**__ velocity so this type of distribution may allow up to __**80**__% - __**85**__ % of make-up air to exhaust depending on design. **2 POINTS**

21. Downward discharge is make-up air being supplied at the __**front**__ of the front of the exhaust hood, normally through registers or perforated panels. As the discharge area is relatively small, __**higher**__ velocities are common, which may __**decrease**__ the volume of make-up air able to be delivered without upsetting the plume rising off the cooking appliances. **2 POINTS**

22. Provide two methods used for determining exhaust airflow during kitchen hood testing:

    a. **Pitot tube traverse**

    b. **K-factor model**

    2 POINTS

23. If welded exhaust ductwork is drilled for a traverse, in all cases, the test holes must be __**welded**__ __**closed**__ by the installing contractor. **1 POINT**

24. Provide seven possible reasons that the kitchen hood may not be performing as designed:

    a. **Supply air drafts from the HVAC system**

    b. **Inconsistent make-up velocities**

    c. **Cold make-up air**

    d. **Position of cooking equipment**

    e. **Air migration through the kitchen**

    f. **Unusual personnel movements**

    g. **Canopy height**

    4 POINTS

25. Provide the six procedures, prior to beginning the stairwell pressurization verification, to verify the performance of the supply air fan: **3 POINTS**

   a. **The supply air fan should be initially enabled with the stairwell doors open to prevent damage due to over-pressurization. If controlled by a VFD, set to a speed of 60 Hz.**

   b. **Proportion of the individual supply air grilles can be performed with the stairwell doors open.**

   c. **Once the supply grilles are proportioned, the final supply fan performance should be verified with the stairwell doors closed.**

   d. **If there is sufficient ductwork between the fan and elevator shaft, a Pitot tube traverse should be performed.**

   e. **As an alternative, the fan total static pressure should be plotted on the manufacturer's fan curve.**

   f. **Once the performance of the fan has been confirmed, the pressure testing of the stairwell can be performed.**

26. Provide two procedures if the minimum stairwell static pressure cannot be achieved:

   a. **Confirm the fan is operating at design airflow** **1 POINT**

   b. **Visually inspect the stairwell for any openings in the construction of the stairwell or excessive flow leakage around the doors.**

27. Provide three procedures if the stairwell static pressure ranges exceed the maximum allowable by code:

   a. **If the fan has a VFD, the fan speed can be reduced.**

   b. **If the stairwell has barometric dampers, inspect the dampers for limiting weights. These weights can be adjusted to allow for the dampers to open further and allow additional airflow to be relieved from the stairwell and reduce static pressure.**

   c. **If the stairwell has automatic dampers controlled by the BMS the signal to the actuators can be increased to open the dampers and reduce the static pressure in the stairwell.**

28. Elevator shaft pressurization is described as a means of __**smoke**__ __**control**__ in tall buildings. The basic idea is that a fan system __**floods**__ the shaft with ambient air during a fire, thereby __**preventing**__ smoke from entering the elevator shaft by creating __**positive**__ pressure differences across all elevator doors. **2 POINTS**

Chapter 28

Variable Frequency Drives

1. Insulated gate bipolar transistors (IGBT) are very fast-switching power transistors that generate a variable voltage, variable frequency __**wave**__ __**form**__ that changes the speed of the motor. **1 POINT**

2. Name three key features of a VFD: **3 POINTS**

   a. **Energy savings**

   b. **No inrush current**

   c. **Current limiting**

3. The IGBT changes the characteristics of waveforms applied to a motor due to the speed at which the transistor cycles on and off. As the pulse width changes, the __**applied**__ __**frequency**__ __**changes**__, thus __**motor**__ __**speed**__ changes. **2 POINTS**

4. What information should be recorded from the display of the VFD? **3 POINTS**

   The operating volts, amps, and Hz

5. Synchronous speed is a direct function of __**applied**__ __**frequency**__ and number of __**motor**__ __**poles**__. **2 POINTS**

6. What actual data should be verified and recorded in the final report? **3 POINTS**

   The actual motor, fan or pump RPM

Chapter 29
Air Infiltration

1. In order to have a leak two things must be present. An **opening** and a **pressure** differential across it. **1 POINT**

2. 0.20" wc. is equal to **49.8** Pascal. **1 POINT**

3. A door fan testing system consists of three main components. A **door panel**, a **calibrated two channel pressure gauge**, and a calibrated **fan assembly**. **3 POINTS**

4. All considered forms of bias pressure, **wind** HVAC pressure, and Stack Effect must all be accounted for during infiltration testing. **1 POINT**

5. In warm climates, Stack Effect is **reversed**. **1 POINT**

6. Increased energy costs, decreased comfort, and the introduction of **moisture** which can lead to mold or structural damage are direct impacts of building infiltration. **1 POINT**

7. All **exterior** openings in the air barrier must be sealed prior to infiltration testing. **1 POINT**

8. Also referred to as the envelope, the **square footage** is used with the actual measured leakage at a given pressure to determine leakage in CFM per square foot, or equivalent leakage area in square feet. **1 POINT**

9. To minimize the effects of bias pressures, and obtain the most accurate test results, testing should be done at **higher** pressures and in both pressurized and depressurized tests. **1 POINT**

10. In addition to measuring air infiltration, door fans are also used to enhance leak detection when using theatrical smoke, or **infrared thermography** to locate air barrier leaks. **1 POINT**

100 POSSIBLE POINTS **85% REQUIRED TO PASS** **MAX. TIME = 3.0 Hrs**

CONTROLS & SPECIAL SYSTEMS - FIELD EVALUATION

Employee: ____

Evaluator: ____

The purpose of this evaluation is to accurately determine the field ability of the technician in conjunction with the written examination of the CONTROLS section of the AABC training curriculum. Each line item below has been observed by the Evaluator and will be scored in one of three different categories. The "AVERAGE" category pertains to that of the average performance expected by an employee of this firm. Any thing less than that will be marked as "POOR" and anything greater than that will marked as "GOOD".

		POOR	AVRG	GOOD
		3	2	1
1	Fills in data on sheets properly and neatly			
2	Obtains all required data needed (or asked for)			
3	Can locate and identify different types of control systems			
4	Troubleshooting different control systems			
5	Calculating duct linear footage in field			
6	Running DALT test and understanding concept			
7	Fume hood testing			
8	Pressurization Testing (room to room, stairwell, inside to outside)			
9	Fully understands data taken and what it means			
10	Shows self-initiative in performing all the above listed items			

Field technician should have a maximum score of 21 to consist of no more than 2 marks under the "POOR" category. If the total score is more than 21 or more than 2 marks are under the "POOR" category, the technician will be considered as unqualified for completion of the CONTROLS section of testing. Any technician failing to complete any section of testing will be required to improve within the given time frame at which time the evaluation will be given again.

Field technician________qualifies for completion of the CONTROLS section of testing upon verification of written examination.

________ does NOT qualify for completion of the CONTROLS section of testing.

If the field technician did not qualify for completion of the CONTROLS section, he/she will be re-evaluated on or around__________________only after verification that the written examination has been passed.

Evaluator signature:________________________ Employee signature: ____________________________

Date:__________________ Date: ___________________

Section #7

SOUND & VIBRATION

Study Guide

Reference Guide

Black = AABC Technician Training Manual

Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Sound and Vibration Guide

Sound and Vibration Guide

Section #7

SOUND & VIBRATION

Technician's Exam

Associated Air Balance Council

SOUND & VIBRATION
TEST #7

Chapter 30
Sound and Vibration — **9 POINTS Each**

(Enter letter best describing statement)

1. A range of frequencies from 20 Hz to 20 kHz. **b) band**
2. A curve representing how the human ear hears. **c) noise criteria**
3. The unit of measurement for sound pressure. **l) decibel**
4. The number of pressure variations per second. **a) frequency**
5. A frequency band where the highest frequency is twice the lowest frequency. **e) octave**
6. Any pressure vibration that the human ear can hear. **i) sound**
7. An instrument designed to respond to sound in approximately the same way as the human ear. **h) sound-level meter**
8. The total acoustical power radiated from the source. **g) sound power level**
9. The reading indicated on a sound-level meter. **f) sound-pressure level**
10. Threshold of hearing. **j) zero decibels**
11. Threshold of pain. **k) 130 decibels**
12. Noise. **d) unwanted sound**

a) frequency
b) band
c) noise criteria
d) unwanted sound
e) octave
f) sound-pressure level
g) sound power level
h) sound-level meter
i) sound
j) zero decibels
k) 130 decibels
l) decibel

96 POSSIBLE POINTS **85% REQUIRED TO PASS** **MAX. TIME = 30 MIN.**

SOUND AND VIBRATION - FIELD EVALUATION

Employee: ____

Evaluator: ____

The purpose of this evaluation is to accurately determine the field ability of the technician in conjunction with the written examination of the SOUND/VIB section of the AABC training curriculum. Each line item below has been observed by the Evaluator and will be scored in one of three different categories. The "AVERAGE" category pertains to that of the average performance expected by an employee of this firm. Anything less than that will be marked as "POOR" and anything greater than that will marked as "GOOD".

		POOR	AVRG	GOOD
		3	2	1
1	Fills in data on sheets properly and neatly			
2	Obtains all required data needed (or asked for)			
3	Understands building requirements for an accurate sound test			
4	Fully understands the sound meter and all functions			
5	Accuracy in measurements (sound)			
6	Charting NC level from measured data			
7	Fully understands data taken and what it means			
8	Shows self-initiative in performing all the above listed items			

Field technician should have a maximum score of 17 to consist of no more than 1 marks under the "POOR" category. If the total score is more than 17 or more than 1 marks are under the "POOR" category, the technician will be considered as unqualified for completion of the SOUND/VIB section of testing. Any technician failing to complete any section of testing will be required to improve within the given time frame at which time the evaluation will be given again.

Field technician________qualifies for completion of the SOUND/VIB section of testing upon verification of written examination.

________ does NOT qualify for completion of the SOUND/VIB section of testing.

If the field technician did not qualify for completion of the SOUND/VIB section, he/she will be re-evaluated on or around__________________only after verification that the written examination has been passed.

Evaluator signature:________________________ Employee signature: ____________________________

Date:_________________ Date: __________________