
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: _____
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SECTION 4: REFRIGERATION & HEATING

Study Guide	Date: _____
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SECTION 5: TEMPERATURE MEASUREMENTS

Study Guide	Date: _____
Examination	Date: _____
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SECTION 6: CONTROLS & SPECIAL SYSTEMS

Study Guide	Date: _____
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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

1 TAB Instrumentation: AABC Tech. Training Manual

- 2 Airflow Instrumentation
- 5 Air & Water Temperature Instrumentation
- 6 Hydronic Instrumentation
- 7 Rotational Speed Instrumentation
- 8 Electrical Instrumentation
- 10 Chapter 1 Review

2 [Instrumentation: AABC National Standards](#)

- [2.3 Temperature Measuring Instruments](#)
- [2.4 Air Measuring Instruments](#)

2 Air Pressure: AABC Tech. Training Manual

- 11 The Atmosphere
- 11 Gravity and Atmospheric Pressure
- 11 Barometric Pressure
- 14 Gauge Pressures and Absolute Pressures
- 14 Measuring Air Pressures in Ducts
- 16 Measuring Static Pressure (SP)
- 16 Total Pressure (TP)
- 17 Velocity Pressure (VP)
- 18 Other Instruments
- 19 Using Air Pressure to Analyze Air Conditioning Systems
- 20 Duct Traverses
- 25 Velocity Pressure Readings
- 25 Anemometer Coil Traverse
- 26 Determining Air Volume
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- 29 Flow Meters
- 30 Pressure Changes in Duct Systems
- 30 Friction Losses
- 31 Dynamic Losses
- 32 Static Pressure Drop Across Components
- 33 Static Pressure Losses in Ducts
- 34 System Static Pressure Losses
- 35 Balancing
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Air Basics Guide

1 Air Fundamentals: Kahoe Manual

- 1.1 Formulas
- 1.2 Air Constant
- 1.3 Correcting for Altitude and Temperature other than Standard
- 1.3 Air Density Correction
- 1.4 Correction Factors
- 1.5 Equivalent Standard Air (Correcting from Altitude to Fan Curve)
- 1.7 System Total Pressure
- 1.7 Duct Pressure Analysis
- 1.8 Air Flow Through Terminals

2 Air Measurement: Kahoe Manual

- 2.1 Formulas
- 2.2 Determining Volume
- 2.2 Pitot Tube
- 2.6 Determining "a" (Area in ft²)
- 2.6 Determining Air Volume with an Orifice
- 2.7 Duct Leakage Testing and the Orifice
- 2.7 Instruments Used for Air Flow Measurements
- 2.7 Velometer
- 2.8 Shortridge Data Meters
- 2.8 Flow Hoods
- 2.10 Rotating Vane Anemometers
- 2.11 Hot Wire Instruments

2 Instrumentation: AABC National Standards

- 2.4 Velocity Measuring Instruments
- 2.4.9 Capture Hoods

3 Airside Volume Measurements: AABC National Standards

- 3.1 Overview
- 3.2 Pitot Tube Traverses
- 3.3 Density Correction
- 3.4 Anemometer Coil Traverse
- 3.5 Correction Factors for Airflow Measuring Devices
- 3.6 Airflow Measuring Stations
- 3.7 Measured System Static Pressure
- 3.8 Fan Curves
- 3.9 System Effect
- 3.10 Diversity

Air Basics Guide

3 Measuring Rotational Speed: AABC Tech. Training Manual

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2 Instrumentation: AABC National Standards

2.7 Rotational Speed Measuring Instruments

4 Basic Measurements: AABC National Standards

- 4.1 Overview
- 4.2 Rotational Measurements

8 Drive Changes: Kahoe Manual

- 8.1 Formulas
- 8.1 Drive Change Calculations
- 8.1 Speed and Volume Change Calculations
- 8.2 Static Pressure Calculations
- 8.2 Brake Horsepower Calculations
- 8.5 New Drive Calculations
- 8.5 Heater Selection Calculation
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4 Electrical Components & Measurement: AABC Tech. Training Manual

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Air Basics Guide

2 Instrumentation: AABC National Standards

2.6 Electrical Measuring Devices

4 Basic Measurements: AABC National Standards

4.3 Electrical Measurements

4.5 Electric Duct Heaters

6 Electrical Measurements: Kahoe Manual

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6.2 Motor Nameplate Information and It's Meaning

6.3 Determining Approximate BHP from field Testing

6.3 Procedure for Determining Approximate BHP

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85 Pressure-Dependent VAV Boxes

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3 Fan Laws: Kahoe Manual

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3.4	Fan Critical Speed Calculations
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3.13	System Effect and Other Devices
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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) **Analog Velometer**
 - 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	<u>-20°F to 120°F</u>	<u>Nearest 0.10°F</u>
b. Airside WB	<u>-20°F to 90°F</u>	<u>Nearest 0.10°F</u>
c. Chilled Water	<u>38°F to 56°F</u>	<u>Nearest 0.10°F</u>
d. Heating Water	<u>120°F to 180°F</u>	<u>Nearest 0.10°F</u>
e. Humidity	<u>10% to 90%</u>	<u>Nearest 1%</u>
f. Dewpoint	<u>30°F to 60°F</u>	<u>Nearest 0.10°F</u>

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:

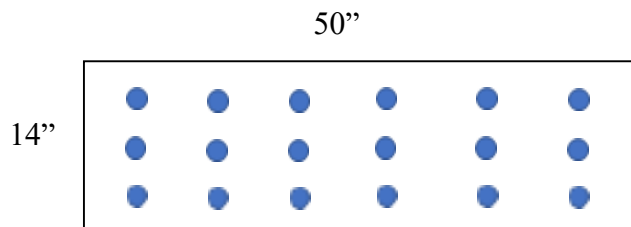
a) 8" Round duct	<u>6</u>	
b) 16" Round duct	<u>10</u>	2 POINTS
c) 32"x16" duct (Log-Tchebycheff method)	<u>30</u>	
d) 64"x10" duct (Log-Tchebycheff method)	<u>21</u>	
5. The minimum number of velocity pressure readings using the Log-Tchebycheff method for a rectangular duct is: 9 **1 POINT**
6. Convert the following velocity pressures to FPM.

a) 0.15 <u>1551</u>	b) 0.19 <u>1746</u>	2 POINTS
c) 1.10 <u>4200</u>	d) 0.34 <u>2335</u>	
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

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

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 150° F? 1.22 **1 POINT**
13. What is the correction factor with barometric pressure equal to 23.0 in. Hg. and a temperature of 200° 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.



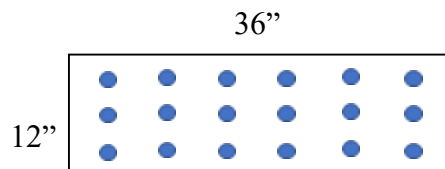
On the 50" side the test holes could be drilled at the following locations. Starting at the side of the duct:

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"

$$L=2C + 1.57(D+d) + (D-d)^2/4C$$

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 $FLE_{ff} \times PF$ 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	d) Perforated Face
b) Square	e) Linear Slot
c) Rectangular	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 | e) Pressure Independent |
| b) Dual Duct | f) Constant Volume |
| c) Induction | g) Variable Air Volume |
| d) Pressure Dependent | |

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

1 POINT

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

a) Forward Curve c) Backward Curve / Inclined

b) Airfoil d) Radial

1 POINT

19. Name the three general classifications of axial fans.

a) **Propeller**

b) **Tube axial**

c) **Vane axial**

1 POINT

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

a) 1.2 WC SP **1 POINT**

b) 5.92 BHP

a) 3.83 WC SP **1 POINT**

b) 21.87 BHP

19.47 BHP 1 POINT

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 be 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

- 7 Air Balance Preparation: AABC Tech. Training Manual
 - 125 Review Documents and Set Up Primary Data Sheets
 - 125 Balancing Specifications
 - 126 Overall Specifications
 - 126 Submittals
 - 126 Plans
 - 128 Data Sheets
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- 8 Basic Balance Procedures - Air Systems: AABC Tech. Training Manual
 - 132 Presetting the System
 - 133 Fans
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 - 135 Proportional Balancing
 - 136 Branch Balancing
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 - 140 Final Data
 - 142 Economizers
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- 6 The Foundation of Basic System Balancing: AABC National Standards
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 - 6.2 Document Review
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 - 6.4 System Components
 - 6.5 Developing the Data Sheets
 - 6.6 Contractor's Responsibilities Prior to Balancing
 - 6.7 Pre-Balance Review
 - 6.8 Economizer Cycle Testing

Air Systems Guide

4 Fan Curves: Kahoe Manual

- 4.1 Fan Types
- 4.1 Centrifugal Fans
- 4.2 Forward Curves (FC) Centrifugal Fan
- 4.3 Backward Inclined (BI) Centrifugal Fan
- 4.4 Air Foil (AF) Centrifugal Fan
- 4.5 Radial Blade Centrifugal Fan
- 4.6 Tubular Centrifugal Fan
- 4.7 Plug Fan
- 4.8 Centrifugal Power Roof Ventilator
- 4.9 Axial Fans
- 4.10 Brake Horsepower Characteristics: Axial vs. Centrifugal
- 4.11 Propeller
- 4.12 Tubeaxial
- 4.13 Vaneaxial
- 4.14 Unstable Flow
- 4.14 System Surge
- 4.14 Fan Surge
- 4.15 Paralleling
- 4.16 Air Volume Change
- 4.16 Change the System
- 4.17 Change of Speed
- 4.17 Change the Fan Inlet Vane Position
- 4.18 Variable Volume Control

5 Fan Systems: Kahoe Manual

- 5.1 Air Systems and Variations
- 5.2 Systems and Control of Fresh Air
- 5.2 Fixed Minimum Fresh Air
- 5.3 Economizer Control
- 5.3 No Exhaust or Relief
- 5.4 Positive Relief
- 5.5 Positive Exhaust
- 5.6 Exhaust Return
- 5.7 Multi-Zone
- 5.8 Reheat
- 5.9 Low Velocity Double Duct
- 5.10 High Velocity Double Duct Constant Volume
- 5.11 Variable Volume
- 5.13 VAV Reheat
- 5.14 VAV Fan Powered Reheat
- 5.16 Induction Unit System

Air Systems Guide

7 Air Balance

- 7.1 Formulas
- 7.2 Balance Procedure for Low Pressure Systems
- 7.4 Balance Procedure for Variable Volume Systems
- 7.6 Balance Procedure for Multi-Zone Systems
- 7.7 Multi-Zones: A General Discussion
- 7.8 Tests to Determine Mixing Damper Leakage
- 7.8 Setting of Minimum Outdoor Air

9 Balancing Procedure for Constant Volume Supply & Exhaust Systems: AABC Tech. Training Manual

- 145 Dampers
- 146 Unit with a multi-zone configuration
- 147 Single-zone Systems
- 149 Multi-Zone Systems
- 153 Terminal Boxes
- 153 Single-Duct Terminal Box Constant-Volume Systems
- 156 Dual-Duct Constant-Volume Terminal Box Systems
- 160 Induction Units
- 163 Single-Duct Constant Primary/Variable Secondary (Bypass) Terminal Box System
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10 Balancing Procedures for Variable Air Volume Systems: AABC Tech. Training Manual

- 167 Presetting Variable Volume Systems
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- 173 Single-Duct Pressure-Independent Systems
- 176 Single Duct, Fan-Powered, Pressure-Independent Systems
- 178 Dual-Duct, Pressure-Independent Systems
- 180 Single-Duct, Fan-Powered, Variable Primary/Constant Secondary, Pressure-Independent Systems
- 181 Single-Duct, Variable Primary/Induction, Secondary Pressure-Independent Systems
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7 Constant Volume Systems: AABC National Standards

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- 7.2 Incremental and Stand-Alone Components
- 7.3 Basic Fan System
- 7.4 Constant Volume Air Handling Units
- 7.5 Multi-Zone Units
- 7.6 Constant Volume Single Duct Systems
- 7.7 Dual Duct Constant Volume System
- 7.8 High-Pressure System with Induction Units

8 Terminal Boxes for Constant Volume and Variable Systems: AABC National Standards

- 8.1 Overview
- 8.2 Single Duct Constant Primary, Constant Secondary
- 8.3 Single Duct Variable Primary, Variable Secondary
- 8.4 Single Duct Constant Primary, Variable Secondary Bypass Systems
- 8.5 Single Duct Variable Primary, Constant Secondary Induction Systems
- 8.6 Single Duct Variable Primary/Constant Secondary Fan Powered Series Terminal boxes
- 8.7 Variable Primary/Variable Secondary Fan Powered Parallel Terminal Box
- 8.8 Dual Duct Terminal boxes

9 Variable Volume: AABC National Standards

- 9.1 Overview
- 9.2 Single Duct Air Valve with Variable Primary, Variable Secondary
- 9.3 Bypass Air Valve Constant Primary, Variable Secondary Bypass Systems
- 9.4 Variable Primary/Constant Secondary Fan Powered Series Terminal Boxes
- 9.5 Variable Primary/Variable Secondary Fan Powered Parallel Terminal Box
- 9.6 Dual Duct Variable Volume
- 9.7 Fan Wall Systems
- 9.8 Underfloor Air Distribution Systems

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10 Fan Systems: Supply / Return / Relief / Exhaust: AABC National Standards

- 10.1 Overview
- 10.2 Air Handling Unit Systems
- 10.3 Utility Vent Sets
- 10.4 Tubular Centrifugal Fan
- 10.5 Power Roof Ventilators
- 10.6 Propeller Fan
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- 10.8 Variable Flow
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11 Underfloor Air Distribution: AABC Tech. Training Manual

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- 185 Pressurized UFAD
- 186 Neutral UFAD
- 186 Diffuser Types
- 187 Floor Plenums
- 188 Leakage Testing
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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 | d) Submittal Data |
| b) Drawings | e) Shop Drawings |
| c) Specifications | 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 | Walls and Partitions Installed |
| 2) Windows Installed | Ceilings and Tiles Installed |
| 3) Outside Walls Sealed Tight | |

- b) The fan and duct system (list ten): **5 POINTS**

- | | |
|--|---|
| 1) Fan housings properly sealed | 6) Fan wheel aligned properly |
| 2) Fan plenums installed as per drawings and specifications | 7) Fan bearings lubricated |
| 3) Vortex dampers operational | 8) Ductwork installed as per drawings and specifications |
| 4) Speed drives operational | 9) Ductwork intact |
| 5) Flexible connections properly installed | 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 | 3) Belts adjusted for the correct tension |
| 2) Sheaves properly aligned and tight on their shafts | 4) Belt guard properly installed |

2 POINTS

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

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

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

Balancing Procedures for Variable Air Volume Systems

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

Underfloor Air Distribution

1 POINT

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:

- a) **Plenum walls**
- b) **Joints through cavities**
- c) **Columns**
- d) **Construction defects**
- e) **Any metal wall stud penetration**

1 POINT

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 be 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.

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_____ 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

1 TAB Instrumentation: AABC Tech. Training Manual

6 Hydronic Instrumentation

12 Hydronic Flow Measurement: AABC Tech. Training Manual

- 191 Pressure Gauges
- 192 Bourdon-Tube Gauges
- 193 Differential-Pressure Meters
- 193 Combination Digital Differential Pressure Meters/Gauges
- 193 Flow Meters
- 193 Orifice Plate
- 194 Venturi
- 195 Annular Flow Meters
- 196 Turbine Flow Meters
- 196 Ultrasonic Flow Meters
- 197 Calibrated Balancing Valves
- 198 Location of Flow Meters
- 198 Flow Measurement Using Differential Pressure
- 201 Flow Measurement Using Differential Temperature
- 201 Temperature Measurement
- 201 Thermometers
- 201 Installed Thermometers
- 201 Surface Temperature Measurement
- 144 Chapter 12 Review

11 Water Measurements: Kahoe Manual

- 11.1 General
- 11.1 Gauges
- 11.2 Flow Metering Devices
- 11.3 Doppler Flow Meter
- 11.3 Temperature Readings

Water Measurements Guide

13 Pumps: AABC Tech. Training Manual

- 205 Terminology
- 206 Types of Pumps
- 206 Types of Centrifugal Pumps
- 206 Positive-Displacement Pumps
- 207 Centrifugal Pumps
- 209 Operation
- 209 Types of Centrifugal Pumps
- 210 Impeller design
- 211 Inlet
- 212 Number of Stages
- 212 Method of driving
- 212 Construction Materials
- 212 Pump Seals
- 213 Pump Bearings
- 214 Pump Couplings and Alignment
- 215 Centrifugal Pump Performance
- 215 Net Positive Suction Head (NPSH)
- 217 Pump Performance Curves
- 218 Establishing Brake Horsepower
- 219 Non-Overloading Pumps
- 219 Pump Tests
- 220 Determining Pump Flow
- 221 Permanent Gauge Locations
- 222 Pump Laws
- 223 Multiple Pumps
- 225 Combination Series and Parallel Operation
- 162 Chapter 13 Review

13 Hydronic Pumps and Pumping Circuits: AABC National Standards

- 13.1 Overview
- 13.2 Pump Head Measurement
- 13.3 Verification of Impeller Size
- 13.4 Determine Pump Flow
- 13.5 Piping Circuits
- 13.6 Pump Circuits

Water Measurements Guide

10 Water Fundamentals: Kahoe Manual

- 10.1 Formulas
- 10.2 Fundamentals of Water Balance
- 10.2 Compressibility
- 10.2 Pressure
- 10.3 Centrifugal Pumps
- 10.3 Viscosity
- 10.3 Pumping
- 10.3 Volume
- 10.3 System Head
- 10.4 Suction Lift
- 10.4 Total Discharge Head (Hd or TDH)
- 10.4 Velocity Head (H_v)
- 10.4 Total System Head (H)
- 10.5 Specific Gravity (sp.gr.)
- 10.6 Net Positive Suction Head and Cavitation
- 10.6 Temperature Transfer Formula
- 10.7 Sensible Heat Transfer
- 10.7 Cooling Sensible Heat Transfer
- 10.7 Pressure Drop vs. Flow Formula
- 10.8 C_v Calculations
- 10.8 Conversions and Equivalents

12 Pumps: Kahoe Manual

- 12.2 Pump Laws
- 12.5 Pumps
- 12.5 Positive Displacement Pumps
- 12.5 Piston Pumps
- 12.5 Rotary Pumps
- 12.5 Screw Pumps
- 12.6 Centrifugal Pumps
- 12.7 Pump Types
- 12.8 Impeller Types
- 12.9 Inlet Types
- 12.9 Stages
- 12.10 Pump Curves
- 12.12 Gathering Pump Information
- 12.12 Field Test

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14 Hydronic Devices: AABC Tech. Training Manual

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- 227 Pressure Control
- 232 Air Control
- 233 Air Vents
- 234 Contamination Control
- 235 Valves
- 235 Manual Valves
- 235 Gate Valves
- 239 Autoflow Valves
- 242 Heat Transfer Devices
- 248 Miscellaneous Components
- 250 Chapter 14 Review

14 [Hydronic Devices: AABC National Standards](#)

- [14.1 Hydronic Devices](#)
- [14.2 Hydronic Flow Measuring](#)

15 Basic Hydronic Piping Systems: AABC Tech. Training Manual

- 251 Water Circulation
- 252 Relationship to Atmospheric Air
- 253 Service
- 253 Piping Arrangements
- 254 One-Pipe Main
- 255 Two-Pipe Direction Return
- 256 Two-Pipe Reverse Return
- 256 Combination Piping Arrangement
- 256 Three-Pipe Main
- 257 Four-Pipe Main
- 258 Pump Circuits
- 259 System Curves
- 268 Chapter 15 Review

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13 Water Systems: Kahoe Manual

- 13.1 Temperature
- 13.1 Flow Generation
- 13.1 Pressurization
- 13.1 Piping Arrangement
- 13.2 Series Loop system
- 13.2 One-Pipe System
- 13.3 Two-Pipe System
- 13.3 Two-Pipe Reverse Return System
- 13.4 Three-Pipe Systems
- 13.4 Four-Pipe Systems
- 13.5 Pump Circuit Arrangement
- 13.5 Primary Pump Circuit
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16 Water Balance Preparation: AABC Tech. Training Manual

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- 269 Balancing Specifications
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- 272 Hydronic Balancing Site Inspection
- 274 Terminology
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17 Basic Water System Balance Procedures: AABC Tech. Training Manual

- 277 Presetting the System
- 278 Pumps
- 279 Multiple Pumps
- 279 Proportional Balancing
- 282 Balancing According to Type of System
- 285 Chapter 17 Review

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- 15 [Hydronic Procedures: AABC National Standards](#)
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 - 15.2 Hydronic System Readiness
 - 15.3 Constant Volume Water Balancing Procedure (Two-Pipe System, Direct or Reverse Return)
 - 15.4 Variable Volume Water Balancing Procedure
 - 15.5 Heating Terminal Temperature Balance
 - 15.6 Steam
 - 15.7 Capacity Testing
- 18 [Domestic Hot Water Balance Procedures: AABC Tech. Training Manual](#)
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 - 293 Instrumentation
 - 293 Sterilization Procedures
 - 293 Balancing Procedures
 - 295 Chapter 18 Review
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 - 19.1 Overview
 - 19.2 Document Review
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 - 19.5 Domestic Hot Water Test Plan
 - 19.6 Instrumentation
 - 19.7 Testing Procedure for Domestic Hot Water Systems
- 14 [Water Balance: Kahoe Manual](#)
 - 14.1 Water Balance Procedure
 - 14.1 General
 - 14.1 Balance Procedure for Primary and Secondary Circuits
 - 14.2 Balance Water Terminals
 - 14.4 Caution on Balancing Three-Way Valve Bypass Balance
 - 14.4 Caution when Balancing Two-Way Valve Systems
 - 14.5 GPM Established through Coils
 - 14.6 Balancing Elements with No Latent Transfer
 - 14.7 Heating coils
 - 14.9 Centrifugal Pumps
 - 14.10 Information to be Included in the Balance Report

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**
 - b) **Venturis**
 - c) **Annular**
 - d) **Ultrasonic flow meters**
 - **Turbine**
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
Hydronic Devices

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

2 POINTS

b) Piping and distribution system:

- | | |
|---|--|
| 1) Piping intact and free of leaks. | 4) Valves, including pressure-reducing valves operational. |
| 2) Piping free of debris. | |
| 3) Valves, flow meters and temperature/pressure taps accessible. | 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. | 3) Vibration isolators properly installed and adjusted. |
| 2) Bearings lubricated. | 4) Flexible connections installed properly. |

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

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

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

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

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

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

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 branches 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**

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 be 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

19 HVAC Refrigeration: AABC Tech. Training Manual

- 297 Terminology
- 298 Fundamentals of Refrigeration
- 300 Refrigerants
- 300 Pressure-Temperature Relationship
- 301 Vapor Compression Refrigeration Cycle
- 304 Compressors
- 313 Compressor Performance
- 314 Troubleshooting
- 314 Common Problems of HVAC Systems
- 317 Wiring Diagrams
- 319 Measuring Refrigeration Temperatures and Pressures
- 321 Chapter 19 Review

20 Water Chillers and Other Heat Exchangers: AABC Tech. Training Manual

- 323 Water Chillers
- 323 Centrifugal Chillers
- 329 Chiller Startup and Shutdown
- 330 Safety Controls
- 330 Absorption Chillers
- 331 Terminology
- 334 Heat Exchangers
- 338 Cooling Towers
- 341 Evaporative Condensers
- 342 Condenser- Capacity Controls
- 343 Condenser Bypass
- 345 Evaporative Coolers
- 346 Chapter 20 Review

16 Chiller Testing: AABC National Standards

- 16.1 Overview
- 16.2 Basic Test
- 16.3 Field Performance Testing of Chillers

21 Cooling Towers: AABC Tech. Training Manual

- 347 Terminology
- 349 Cooling Towers
- 349 Test Instruments
- 350 Test Data
- 350 Design Data
- 351 Test Procedures
- 364 Chapter 21 Review

Refrigeration & Heating Guide

17 Cooling Tower Testing: AABC National Standards

- 17.1 Overview
- 17.2 Basic Test
- 17.3 Performance Test Parameters
- 17.4 AABC Performance Test
- 17.5 CTI Performance Test

22 Boilers and Steam System Components: AABC Tech. Training Manual

- 365 Principals of Combustion
- 366 Boilers
- 371 Testing Boiler Efficiency - Flue-gas Analysis
- 373 Boiler Startup and Inspection
- 376 Fundamentals of Steam Systems
- 376 Testing and Balancing Steam Systems
- 377 Steam Traps
- 380 Condensate Receivers
- 381 Chapter 22 Review

18 Boiler Testing: AABC National Standards

- 18.1 Overview
- 18.2 Basic Test for Hot Water Boilers
- 18.3 Boiler Performance Calculations
- 18.4 Efficiency Tests
- 18.5 Boiler Testing Procedures

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

tower approach = 15°

15 POINTS

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.

$$\text{BHP}_C = \frac{\text{KW} \times \text{EFF}_M}{0.746} \quad \textbf{3 POINTS}$$

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**
 - d) **Overheating or under-heating in conditioned space**
 - e) **Boiler operating pressure difficult to maintain**
- Vacuum in return lines difficult to maintain**
- Inlet and outlet lines to trap nearly the same temperature**
- 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: _____

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		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.

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Section #5

TEMPERATURE MEASUREMENTS

Study Guide

Reference Guide

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Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Temperature Measurements Guide

23 Psychometrics: AABC Tech. Training Manual

- 383 Terminology
- 384 Psychometric Chart
- 386 Air Conditioning Processes
- 387 Air Conditioning Calculations
- 389 Heating and Cooling Calculations
- 390 Moisture Calculations
- 392 Latent Heat Calculations
- 394 Total Heat Calculations
- 395 Sensible Heat Factor Calculations
- 396 Using Psychometric Charts
- 412 Chapter 23 Review

9 Psychometrics: Kahoe Manual

- 9.1 Formulas
- 9.3 Psychometrics
- 9.4 Dry Bulb Temperature (DBT)
- 9.4 Wet Bulb Temperature (WBT)
- 9.4 Relative Humidity (RH or O)
- 9.5 Dew Point Temperature (DPT)
- 9.5 Humidity Ratio (W or HR)
- 9.5 Dry Bulb Scale
- 9.6 Enthalpy
- 9.6 Alignment Circle
- 9.6 Moisture
- 9.7 Sensible Heat Factor (SHF)
- 9.7 Specific Volume (v)
- 9.8 Other Psychometric Terminology
- 9.9 Sample Water Volume Calculations
- 9.9 Sample Total & Sensible Heat Removal Calculations
- 9.11 Heat of Compression

Temperature Measurements Guide

24 Equipment and System Performance Verification: AABC Tech. Training Manual

- 413 Overview
- 414 Air and water temperatures for Air Handling Units
- 415 System Information
- 421 Air Distribution - Temperature Verification
- 421 Heating and Cooling Coil Performance Verification
- 421 Heat transfer equations – Air
- 422 Heat Transfer Equation—Water
- 423 Chapter 24 Review

2 Instrumentation: AABC National Standards

2.3 Temperature Measuring Instruments

4 Basic Measurements

4.4 Temperature Measurements

1 Air Fundamentals: Kahoe Manual

- 1.3 Correcting Field Velocity Measurements taken at
Non-Standard Altitude and Temperature

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	56.5° F	
b) LAT DP	54° 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	55.2° F	
i) EAT h	30.06 Btu/lb.	
j) LAT h	23.35 Btu/lb.	
k) Btuht removed	1,663,200 Btuht	
l) Btuhs removed	1,368,428 Btuhs	
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	Btuht = cfm x 4.5 x delta ht
5 POINTS	1,663,200 = 55,000 x 4.5 x 6.72 (30.06 Btu/lb. – 23.34 btu/lb.)
Btuhs removed	Btuhs = cfm x 1.08 x delta T
5 POINTS	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	Btuhl = Btuht – Btuhs
5 POINTS	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.)
5 POINTS	Btuhl = cfm x 0.68 x delta gr/lb.
	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

20 POINTS

Btuh (Water) = 350,000

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 59° FWB = 25.78 Btu

Btuh (Air) = 476,550

20 POINTS

Btuh (Water) = 475,000

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 be 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.

Field technician _____ qualifies for completion of the TEMPERATURE section of testing upon verification of written examination.
_____ does NOT qualify for completion of the TEMPERATURE section of testing.

If the field technician did not qualify for completion of the TEMPERATURE 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 #6

CONTROLS & SPECIAL SYSTEMS

Study Guide

Reference Guide

Black = AABC Technician Training Manual

Blue = AABC National Standards

Red = Kahoe Test & Balance Field Manual

Controls & Special Systems Guide

25 Controllers and Controlled Devices: AABC Tech. Training Manual

- 425 Pneumatic Systems
- 426 Main Air
- 427 Single-Pressure Air System
- 427 Two Pipe Thermostat
- 429 Controllers
- 431 Valves
- 431 Actuators
- 433 DDC Systems
- 443 Chapter 25 Review

26 Calibration & Control Sequence Verification: AABC Tech. Training Manual

- 445 Overview
- 446 Terminology
- 450 Air Handling Unit
- 453 Preliminary Control System Performance Procedure
- 453 Control System Verification
- 453 Single-Zone Air Handling Unit
- 456 Point to Point Control System Verification
- 457 Chapter 26 Review

12 Temperature Control Systems: AABC National Standards

- 12.1 Overview
- 12.2 Basic Verification of Controls
- 12.3 Verification and Documentation

Controls & Special Systems Guide

27 Special Systems: AABC Tech. Training Manual

459	Overview
459	Clean Rooms
461	Clean Room Testing
459	Clean Room Terminology
462	Balancing Active and Passive Chilled Beams
463	Balancing Procedures
464	Duct Air Leakage Testing (DALT)
465	Responsibilities
465	Test Equipment
466	Test Parameters
467	Testing Procedures
468	Report Data
468	AHU Pressure Testing
468	Casing Leakage Testing
468	Casing Deflection Testing
469	Leakage Testing a Duct System in Multiple Sections
471	System Leakage Classification Analysis
473	Laboratory Fume Hoods and Bio-Safety Cabinets
473	Fume Hood Terminology
475	General
475	Toxicity Levels
476	Types of Laboratory Fume Hoods
478	Test Overview
479	Airflow Velocity Tests
479	Test Conditions
480	Velocity Test Procedure
482	Hood Performance Test Procedures
483	Auxiliary Air Supply
484	Bio-Safety Cabinets
484	ASHRAE 110 Hood Verification
485	Kitchen Hoods
486	Make-Up Air
489	Exhaust Air Testing for the Kitchen Hood
489	Stairwell Pressurization
490	Simple Stairwell Pressurization
491	Over-pressure Relief
491	Supply Fan Bypass
492	VFD Controlled Supply Fans
492	Acceptance Testing
494	Hoistway Pressurization Systems
496	Chapter 27 Review

Controls & Special Systems Guide

5 Duct Leakage Testing: AABC National Standards

- 5.1 Overview
- 5.2 Test Equipment
- 5.3 Test Parameters
- 5.4 Testing Procedures
- 5.5 Report Data

11 Energy Recovery Systems / Panels / Chilled Beams: AABC National Standards

- 11.1 Overview
- 11.2 Rotating Wheel and Rotating Desiccant Wheel
- 11.3 Air-to-Air Plate Heat Recovery Units
- 11.5 Run Around Coil
- 11.4 Thermosiphon Heat Exchangers
- 11.6 Panels Used for Sensible Heating and Cooling
- 11.7 Chilled Beams

20 Kitchen Systems: AABC National Standards

- 20.1 Overview
- 20.2 The Heating, Cooling and Ventilating Systems
- 20.3 Kitchen Hoods
- 20.4 Hoods with Make-Up Air Provisions
- 20.5 Final Balance Procedures

21 Laboratory Systems (Constant Volume & Variable Volume): AABC National Standards

- 21.1 Overview
- 21.2 Terminology
- 21.3 Testing the Lab Exhaust
- 21.4 Testing the Lab Supply
- 21.5 Pressurization
- 21.6 Testing Exhaust Systems
- 21.7 Testing Supply Systems
- 21.8 Stack Velocity
- 21.9 Tracking the Systems and Certifying
- 21.10 Biosafety Cabinets

Controls & Special Systems Guide

24 Smoke Control Testing: AABC National Standards

- 24.1 Overview
- 24.2 Basic Testing
- 24.3 Smoke Control Acceptance Testing
- 24.4 Testing Procedures for Smoke Control Systems
- 24.5 Atriums

25 Testing and Balancing Health Care Facilities: AABC National Standards

- 25.1 Overview
- 25.2 Pressurization
- 25.3 Procedures for Measuring Room Pressures
- 25.4 Smoke Testing for Direction of Airflow
- 25.5 Reporting Procedures for ORs, All Rooms and PE Rooms
- 25.6 Heating
- 25.7 Outdoor Air Intakes and Exhaust Discharge
- 25.8 Filtration

16 Safety: Kahoe Manual

- 16.1 Safety Commitment
- 16.1 Safety Equipment
- 16.1 Safety Statement
- 16.2 Safety
- 16.2 Testing Related Injuries
- 16.2 General Injuries
- 16.2 Burns
- 16.2 Excessive Pressure Hazards
- 16.2 Electrical Hazards
- 16.3 General Injuries
- 16.3 Climbing
- 16.4 Ladder Safety Checklist
- 16.4 Rotating Equipment
- 16.4 Lockout Procedure
- 16.4 Eye Protection
- 16.4 Fume Hood Safety
- 16.5 Site Regulation
- 16.5 Hazard Notification form
- 16.6 Site Safety Inspection Form

Controls & Special Systems Guide

28 Variable Frequency Drives: AABC Tech. Training Manual

- 499 Overview
- 499 Systems
- 500 AC Motor
- 500 Drive Controller
- 504 Chapter 28 Review

29 Air Infiltration: AABC Tech. Training Manual

- 505 Overview
- 505 Sources of pressure that cause air leakage
- 509 Where Buildings Leak
- 510 Effects of Air Infiltration
- 512 Air Infiltration Measurement
- 514 Types of Building Air Infiltration Tests
- 520 Standards for Air Leakage in Residential to
Large Commercial Buildings
- 521 Finding Air Leaks
- 521 Testing Procedures
- 522 Ducted HVAC Systems
- 522 Summary
- 504 Chapter 29 Review

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
 - b) Refrigerated air dryer
 - c) Oil removal filter**3 POINTS**

8. List 5 types of analog input points: **3 POINTS**

- | | |
|--|--|
| a) Room Temperature | • Chilled Water Return Temperature |
| b) Room Humidity | • Chilled Water Supply Temperature |
| c) Return/Mixed Air Temperature | • Heating Water Supply Temperature |
| d) Discharge Air Temperature | • Heating Water Return Temperature |
| e) Supply Static Pressure | • 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** f) **Access doors**
b) **System size** g) **Rod penetrations**
c) **Openings in the duct** h) **Workmanship**
d) **Joints** **4 POINTS**
e) **Seams**
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. **4 POINT**
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 %.

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**
- Face velocity measurements**
 - Smoke capture visualization**
 - 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:
- Pitot tube traverse**
 - K-factor model**
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:
- Supply air drafts from the HVAC system**
 - Inconsistent make-up velocities**
 - Cold make-up air**
 - Position of cooking equipment**
 - Air migration through the kitchen**
 - Unusual personnel movements**
 - 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 be 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

30 Sound and Vibration: AABC Tech. Training Manual

- 525 Sound Terminology
- 529 Fundamentals of Sound
- 529 Sound Pressure Levels (SPL)
- 530 Sound Measurements
- 530 Sound Measuring Procedure
- 531 Sound Measurement Tests
- 532 Sound Measurement Tests with Background Noise
- 533 Sound Measurement Tests Combining Sound Levels
- 533 Sound Measurement Report
- 534 Fundamentals of Vibration
- 534 Vibration Terminology
- 535 Vibration Measurements
- 535 Vibration Measuring Procedure
- 535 Vibration Measurement Tests
- 539 Chapter 30 Review

22 Sound: AABC National Standards

- 22.1 Overview
- 22.2 Sound Measuring Instruments
- 22.3 Sound Rating Methods
- 22.4 Acceptable Noise
- 22.5 Testing Procedures for Measuring Sound Levels

23 Vibration Testing: AABC National Standards

- 23.1 Overview
- 23.2 Vibration Meters
- 23.3 Test Points
- 23.4 Testing Procedures for Vibration Measurements

Sound and Vibration Guide

15 Field Measurements of Sound and Vibration – Kahoe Manual

15.1 Sound Basics

15.1 Decibel

15.2 Frequency

15.2 Noise Criteria (NC) Curves

15.3 Octave Bands

15.6 Sound Measurements Procedure

15.7 Sound Analysis

15.8 Example

15.9 Octave Band Analysis

15.10 Example

15.19 Vibration

15.20 B & K Instrument Procedures

15.21 Measurement of the Drill Press Motor only (no belt)

15.22 Vibration Analysis Form

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