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Air Pollution Training Institute
MD 20
Environmental Research Center
Research Triangle Park NC 27711

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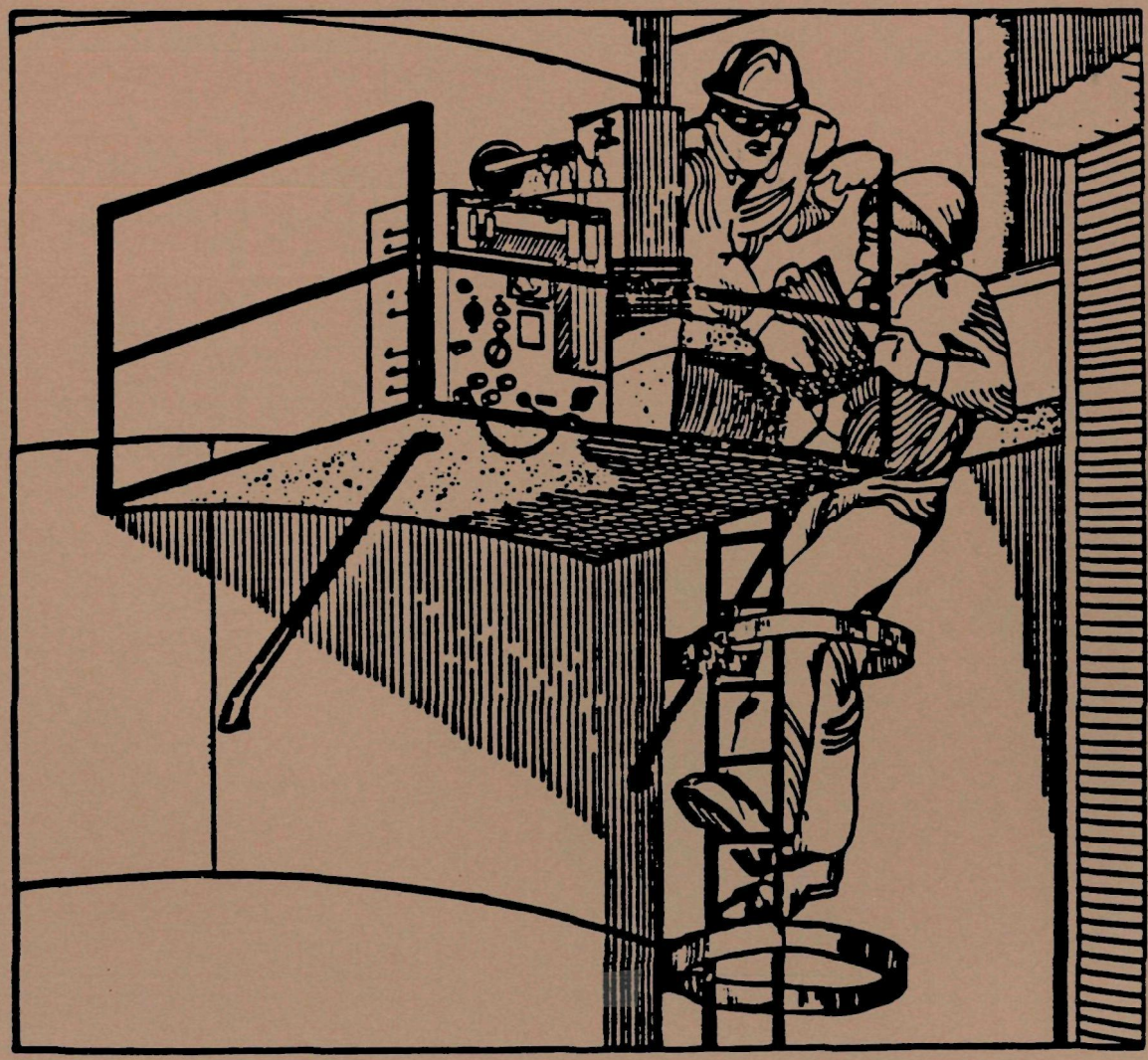
EPA

APTI Course SI:445

Introduction to Baseline Source Inspection Techniques

Self-instructional Guidebook



APTI SI. 445

CORRESPONDENCE COURSE
BASELINE INSPECTION TECHNIQUE FOR AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE EVALUATION

GUIDEBOOK

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Under Contract No.
68-01-6312
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Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Notice

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Availability

This document is issued by the Manpower and Technical Information Branch, Control Programs Development Division, Office of Air Quality Planning and Standards, USEPA. It was developed for use in training courses presented by the EPA Air Pollution Training Institute and others receiving contractual or grant support from the Institute. Other organizations are welcome to use the document.

This publication is available, free of charge, to schools or governmental air pollution control agencies intending to conduct a training course on the subject covered. Submit a written request to the Air Pollution Training Institute, USEPA, MD 20, Research Triangle Park, NC 27711.

Others may obtain copies, for a fee, from the National Technical Information Service (NTIS), 5825 Port Royal Road, Springfield, VA 22161.

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COURSE INTRODUCTION

Course Description

This training course is an 88-hour correspondence course dealing with inspection techniques for evaluating air pollution control equipment performance. This course presents the general concept of the baseline inspection technique, use and calibration of portable instrumentation, general considerations during inspections such as safety procedures and legal and administrative aspects, and specific evaluation procedures for the types of air pollution control equipment listed below:

- o fabric filters
- o electrostatic precipitators
- o wet scrubbers
- o mechanical collectors
- o carbon bed adsorbers

Course Goal

The goal of this course is to introduce air pollution inspection personnel to the principles of the baseline inspection technique and to demonstrate the application of the technique in evaluating the performance of specific types of air pollution control equipment. It is also intended to present general considerations for all facility inspections including use of portable instrumentation, safety procedures, and legal and administrative aspects.

Course Objectives

Upon completion of this course, you should be able to:

1. Explain the baseline inspection technique and the principles upon which it is based.

2. Utilize the baseline inspection technique in evaluating air pollution control equipment performance.

3. List and explain the use of portable field inspection instrumentation and equipment for evaluating air pollution control equipment.

4. Describe the administrative and legal considerations involved in conducting a field inspection.

5. Recall safety considerations for field inspections.

Sequence, Lesson Titles, and Trainee Involvement Time

Section Number	Lesson Title	Trainee Involvement Time (hours)
Lesson 1	Principles of the Baseline Inspection Technique	2
Lesson 2	Use of Portable Instrumentation	8
Lesson 3	Inspection and Evaluation of Fabric Filters	16
Quiz 1	Covering Lessons 1 through 3	2
Lesson 4	Inspection and Evaluation of Electrostatic Precipitators	20
Lesson 5	Inspection and Evaluation of Wet Scrubbers	20
Lesson 6	Inspection and Evaluation of Mechanical Collectors	3
Quiz 2	Covering Lessons 4 through 6	2
Lesson 7	Inspection and Evaluation of Carbon Bed Adsorbers	3
Lesson 8	Inspection Safety	4
Lesson 9	Visible Emission Evaluation	2
Lesson 10	Administrative and Legal Aspects of Plant Inspections	3
Final Exam	Covering Lessons 1 through 10	3

Requirements for Successful Completion of this Course

In order to receive Continuing Education Units (CEUs) and a certificate of course completion you must:

- take two self-graded quizzes and a supervised final examination.
- achieve a final course grade of at least 70% (out of 100%) on the final examination.

Reading Materials

- APTI Correspondence Course Baseline Inspection Technique for Air Pollution Control Equipment Performance Evaluation EPA 450/ .
- Baseline Techniques for Air Pollution Control Equipment Performance Evaluation, report prepared by Engineering-Science for the U.S. Environmental Protection Agency under Contract No. 68-01-6312, Work Assignment No. 30, February 1983, (referred to as the Baseline Manual).
- Field Inspection Notebook, report prepared by Engineering-Science for the U.S. Environmental Protection Agency under Contract No. 68-01-6312, Work Assignment Nos. 62 and 99, Revised Draft October 1983, (referred to as the Field Inspection Notebook).
- The use of Portable Instruments for Evaluation of Air Pollution Control Systems, draft report prepared by Engineering-Science for the U.S. Environmental Work Assignment 60, June 1982, (referred to as the Portable Instruments Paper).
- EPA 340/1-83-011. September 1983. Wet Scrubber Performance Evaluation, (referred to as the Wet Scrubber Manual).

Additional Suggested Readings

The following publications are not included with the course materials and are not necessary for successful completion of this course. However, they are informative and are, therefore, recommended supplemental readings. You should obtain a copy from your State or local air pollution agency files. Should these materials not be available through your agency, contact the Air Pollution Training Institute for assistance.

- Control Techniques for Particulate Emissions from Stationary Sources Volume I, U.S. Environmental Protection Agency Publication EPA-450/3-81-005a, September 1982.
- Industrial Ventilation, Sixteenth Edition. Published by the American Conference of Governmental Industrial Hygienists, Lansing Michigan. 1980.
- Calvert, S., J. Goldschmid, D., Leith, and D. Mehta. Wet Scrubber System Study, Volume I: Scrubber Handbook. U.S. Environmental Protection Agency; Research Triangle Park, N.C. Publication EPA-R2-72-118a, August 1972.
- Mappes, T. E., and R. D. Tems. PEDCo Environmental. An Investigation of Corrosion in Particulate Control Equipment. U.S. Environmental Protection Agency Publication EPA-340/1-81-002, February 1981.
- Yung, S., Calvert and H. F. Barbarika. A.P.T. Inc. Venturi Scrubber Performance Model. U.S. Environmental Protection Agency Publication No. EPA-600/2-77-172, August 177.

- Katz, J. The Art of Electrostatic Precipitation, S&S Printing Company, Pittsburgh, Pennsylvania, 1979.

- White, H. Electrostatic Precipitation of Fly Ash, APCA Reprint Series, Air Pollution Control Association, 1977.

- McDonald, J. R., and Dean, A. H., Southern Research Institute. A Manual for the Use of Electrostatic Precipitators to Collect Fly Ash Particles. U.S. Environmental Protection Agency Publication EPA-600/8-80-025, May 1980.

Use of the Guidebook

This guidebook directs your progress through the course. This section introduces the rest of the course material and how to use it. The instructional sections, Lessons 1 through 10, are self-paced and guide you through the reading materials. Each contain the following subsections:

- reading assignment
- reading assignment topics
- learning goal and objectives
- reading guidance
- review exercise
- review exercise answers and reading information

If supplementary reading material is available, it will be recommended in the appropriate lesson, but this material is not required for successful completion of the course.

It is suggested that after reading the assigned materials and reading guidance, the student complete each review exercise by noting the answers to the multiple choice questions on a separate sheet of paper. (Note: Review questions may have more than one correct answer.) A listing of answers and reading information for each question follows the review exercise. When you are unsure about a question or answer, review the lesson section preceding the exercise. The guidebook includes two additional sections containing two quizzes, Quiz 1 and Quiz 2. They are each located in the guidebook at the appropriate place in the course and should be taken at that time. These quizzes are self-graded with the answers following each quiz. Both are indicative of the type of question that will appear on the final.

Instructions for Completing the Final Examination

- You should have received, along with this guidebook, a separate sealed envelope containing a final examination.

- You must arrange to have someone serve as your test supervisor.

- You must give the sealed envelope containing the final examination to your test supervisor.

- At the end of the course, under the supervision of your test supervisor, complete the final exam.

- After you have completed the final exam, your test supervisor must sign a statement on the exam answer sheet certifying that it was administered in accordance with the specified test instructions.

- After signing the exam answer sheet, your test supervisor must mail the exam and its answer sheet to the following address:

  Air Pollution Training Institute
  Environmental Research Center
  MD-20
  Research Triangle Park, NC 27711

- Exam and course grade results will be mailed to you.

If you have questions, contact:

Air Pollution Training Institute
Environmental Research Center
MD-20
Research Triangle Park, NC 27711

Telephone numbers:
Commercial: (919) 541-2401
FTS: 629-2401

LESSON 1

Principles of the Baseline Inspection Technique

Reading Assignments

Baseline Manual, Chapter 1.

Field Inspection Notebook, page 1.

Reading Assignment Topics

- Need for comparison of present air pollution control device operating parameters with site-specific baseline data.
- Steps and procedures in the "counterflow" manner of the baseline inspection technique.
- Underlying principles of the baseline inspection technique.

Learning Goal and Objectives

Learning Goal

To familiarize you with the concept of the baseline inspection technique and to explain its underlying principles.

Learning Objectives

When you have completed this lesson, you should be able to:

1. Describe the baseline inspection technique.
2. Explain what the "counterflow" method of inspection is and what the advantages of using it are.
3. List and describe the five underlying principles of the baseline inspection technique.

Reading Guidance

- When you have finished the reading assignment, complete the review exercise for Lesson 1. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to Lesson 2 of this guidebook.

Review Exercise

1. The baseline inspection technique provides _____.

   a. an accurate and complete compliance determination
   b. a general evaluation of control system performance
   c. a detailed evaluation of plant maintenance practices
   d. all of the above

2. The baseline technique is the _____.

   a. is the official inspection technique of the U.S. EPA
   b. is the official inspection technique of Regions III and V of the U.S. EPA
   c. is the official inspection technique adopted by the States of North Carolina and Pennsylvania
   d. none of the above

3. Approaching a control system from the stack through to the process ("counterflow" method) is usually advantageous because_____.

   a. it avoids unnecessary handling of process oriented confidential data
   b. it may be done without the operator becoming aware
   c. it avoids time consuming process equipment inspection which is often unnecessary
   d. operating data of the control system is easier to obtain and to evaluate
   e. most air pollution regulations apply directly to stack emissions and control system operation
   f. all of the above

4. The use of portable inspection instruments is often recommended because _____.

   a. many on-site permanent monitors are inoperative a significant portion of the time
   b. many control systems do not have the necessary instruments
   c. highly complex analyses must be performed and it is usually not possible to complete these without additional data
   d. many operators set on-site instruments to give an incorrect indication of control system performance

5. The baseline inspection technique involves detailed internal inspections of the control systems.

   a. true
   b. false

6. Control systems designed by the same manufacturer and operated under similar conditions can be assumed to operate in a similar manner.

   a. true
   b. false

7. The baseline inspection technique utilizes _____.

   a. one key operating parameter
   b. a set of symptoms of performance
   c. comparison of operating parameters at a given site against similar units at plants known to be in compliance
   d. none of the above

8. A symptom used in baseline analyses means _____.

   a. a significant difference between an operating parameter at a given plant as compared against industry norms
   b. a significant difference between an operating parameter measured during the inspection as compared against the value during the baseline period
   c. neither

9. As part of the baseline inspection, an inspector should conduct surveillance around the plant at least an hour prior to announcing his or her presence.

   a. true
   b. false

10. A baseline inspection should be terminated or altered whenever _____.

   a. the inspector does not have the proper safety equipment
   b. it is apparent that the control system is probably in compliance
   c. it is apparent that the control system is not operating
   d. conditions make it potentially unsafe to continue
   e. none of the above
   f. all of the above

11. The baseline inspection technique can prove particularly advantageous to regulatory agency personnel because _____.

   a. it yields data which is often very consistent with state and local regulations
   b. it often allows the inspector to abbreviate inspections when compliance is highly probable
   c. it stresses a thorough inspection of the process equipment
   d. all of the above

12. Portable instrumentation is sometimes used to confirm the operational status of the onsite gauges.

   a. true
   b. false

13. In the baseline technique as much readily obtainable information as possible is used to evaluate performance.

   a. true
   b. false

14. The baseline inspection technique uses detailed checklists of informations which must be obtained at every source.

    a. true
    b. false

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Baseline Manual
1. b	1-1
2. d	1-1
3. a,c,d,e	1-2, 1-3
4. a,b	1-4
5. b	1-4
6. b	1-3, 1-4
7. b	1-4
8. b	1-3 to 1-5
9. b	1-2, 1-3
10. a,b,d	1-3, 1-5
11. a,b	1-3
12. a	1-4
13. a	1-3, 1-4
14. b	1-1 to 1-5

LESSON 2

Use of Portable Instrumentation

Reading Assignments

Portable Instruments Paper, pages 1-36.

Field Inspection Notebook, pages 65-76.

Reading Assignment Topics

- Selection of appropriate measurement ports.
- Instrument calibration procedures.
- Instrument selection.
- Measurement port sealing techniques.
- Identifying measurment errors.
- Instrument static grounding procedures.
- Safety procedures for using instruments.
- Legal and policy restraints in use of instrumentation.

Learning Goal and Objectives

Learning Goal

To familiarize you with the common portable field instruments used to evaluate the performance of air pollution control equipment. This includes knowing when to use the instrumentation, when to accept data from on-site gauges, and how to use the instrumentation safely.

Learning Objectives

When you have completed this lesson, you should:

1. Understand the calibration procedures for portable instruments such as differential pressure gauges, thermocouples, O_2 and CO_2 analyzers, pH meters and other instruments.

2. Understand how to use the instrument so that an accurate measurement can be obtained without any errors induced by an incompletely sealed measurement port.

3. Understand to use the proper probe assembly so that there is no risk of loss of the probe or port seal into the duct.

4. Recognize ports which should not be used due to potential for fumigation from pollutants, due to improper access, or due to potential hazards.

Reading Guidance

- The introduction to the Portable Instruments Paper is very important. This section describes some of the important limitations of the use of the portable instruments. It is also important to read the general guidelines stated on page 65 of the Field Inspection Notebook.

- For more information on the hood static pressure method of making a qualitative estimate of the total gas flow rate, see the Industrial Ventilation Manual (see Supplemental Reference Number 2).

- It is important to fully understand the concept of positive and negative pressure. Before opening a measurement port or even approaching a control device the inspector must know whether the pollutant laden gas stream will tend to escape into the air immediately around the equipment or whether ambient air will leak into the collector. Pages 3-5 of the Portable Instruments Paper address the algebraic sign of the static pressure reading.

- Sealing up the measurement port is an important step in all types of measurements. A useful means to seal a large (greater than 2 inch diameter) port is shown on page 4-11 of the Wet Scrubber Manual (see Supplemental Reference Number 1).

- It is important to ground any metallic probe prior to the start of the measurement. One means to ground the probe is illustrated on page 68 of the Field Inspection Notebook.

- The material concerning the pitot traverses has been excerpted from EPA Methods 1 and 2. However, the equation shown on page 72 of the Field Inspection Notebook is strictly for air or for gas streams having a molecular weight very close to air. Actually this is a very common situation since most combustion gases have a molecular weight very similar to air. The equation shown on page 72 is usually adequate for field inspectors. The full equation is shown on page 20 of the Portable Instruments Paper.

- The information concerning single point gas flow measurements is intended only for situations where an approximate gas flow rate is acceptable. This should not be used for compliance tests. The material is presented since a single point measurement can be made in much less time than a full traverse and the field inspector often needs to know only whether there has been a major increase or decrease in the flow rate since the last inspection or test.

- Information is presented concerning fan speed measurements on pages 31 through 32 of the Portable Instruments Paper. It should be noted that it is rarely necessary to make this measurement. Also, an inspector should understand and respect all potential safety hazards in the vicinity of the fan.

- When you have finished the reading assignment, complete the review exercise for Lesson 2. It begins on the following page.

- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to Lesson 3 of this guidebook.

Supplemental References

1. Richards, J. and R. Segall. Wet Scrubber Performance Evaluation. U.S. Environmental Protection Agency Publication EPA-340/1-83-022, September 1982.

2. Industrial Ventilation, Sixteenth Edition. Published by the American Conference of Governmental Industrial Hygienists, Lansing Michigan. 1980.

Review Exercise

1. If the necessary access ports are not available, the inspector should _____.

   a. demand that these be installed immediately
   b. conclude that the plant is not performing adequate maintenance and prepare a notice of violation
   c. request that these be installed the next time the system is down for maintenance
   d. offer to drill a 1/4" hole to facilitate the present inspection, and request a permanent port for future inspection

2. Static electricity is especially likely following _____ _____.

   a. a wet scrubber with a high static pressure drop
   b. an electrostatic precipitator
   c. a fabric filter handling high resistivity dust
   d. none of the above

3. When calibrating the Fyrite® analyzer, the ambient oxygen concentration is usually _____.

   a. 21.9% in the winter, 21.5% in the summer
   b. 20.9% in the winter, 20.9% in the summer
   c. 19.9% throughout the Northeast
   d. 19.9% everywhere, all the time

4. The static pressure drop across a control system is best measured by _____.

   a. connecting both sides of a differential pressure gauge to taps before and after the collector
   b. measuring the static pressures at both taps separately and then substracting the outlet from the inlet

5. The best type of Pitot tube to use during an inspection is a _____ _____.

   a. type S tube
   b. type B tube
   c. type F (modified) tube
   d. standard tube

6. Failure to saturate the gas stream prior to calibrating the Fyrite® O_2 meter will cause _____.

   a. measured values 1 to 2% O_2 greater than actual
   b. measured values 1 to 2% O_2 less than actual
   c. only minor errors

7. Prior to measuring the static pressure, an inspector should _____.

   a. clean out the tap
   b. ground the probe, if necessary
   c. evaluate potential gas fumigation
   d. calibrate the gauges
   e. check for pressure transducers
   f. adjust the gauge zero
   g. evaluate potential safety conditions
   h. all of the above

8. Water impaction on a thermocouple in an unsaturated gas stream should tend to give _____.

   a. a higher than actual reading due to the exchange of the heat of vaporization
   b. a lower than actual reading
   c. a wet bulb reading
   d. none of the above

9. As a general guidelines, measurement ports on systems with positive pressure should not have a diameter exceeding _____.

   a. 1/4 inch
   b. 1/2 inch
   c. 1 inch
   d. 2 inches
   e. 4 inches
   f. none of the above

10. The major problem resulting from the use of incompletely sealed positive pressure measurment ports is _____.

    a. aspiration effect
    b. sample dilution
    c. instrument instability
    d. exposure to pollutants
    e. all of the above
    f. none of the above

11. During an evaluation of a coal-fired boiler, the inspector measures an oxygen concentration of 9% and a carbon dioxide concentration of 15%. Are the measurements acceptable?

    a. yes
    b. no
    c. there is not enough information

12. There is a 4 inch measurement port on a duct at negative 5 inches of water pressure. What could be used to seal the port during measurements of static pressure, gas temperature and gas O_2/CO_2 concentrations?

    a. a hand
    b. a glove
    c. a piece of cloth
    d. a rubber stopper having a maximum diameter greater than 4 inches
    e. a sanding disk having a maximum diameter greater than 4 inches
    f. nothing is necessary

13. If, during a calibration of a Minihelic® or Magnehelic® gauge, it is noticed that the gauge is no longer giving a linear response and in part of the operating range the gauge is more than 10% in error. The following should be done:

    a. the meter should be disassembled and recalibrated
    b. the meter should be stomped into the dirt
    c. the degree to which the meter floats in a quiet lake should be evaluated
    d. the meter should be used in the next softball pratice
    e. the meter should be properly discarded
    f. the inspector should wring hands and gnash teeth
    g. the inspector should get a new meter

14. Prior to using the Fyrite® analyzer, the following should be done:

    a. a properly sized port in a safe location should be selected
    b. the port should be rodded out
    c. the probe assembly should be leak tested
    d. the probe should be grounded
    e. all of the above
    f. none of the above

15. Some of the problems associated with the use of a slack tube manometer for the measurement static pressure include the following:

    a. it is difficult to measure static pressures greater than 40 inches of water
    b. the liquid may leak out while going to the measurement site
    c. the liquid may freeze in very cold weather
    d. the instrument is bulky
    e. the instrument must be regularly calibrated against a Magnahelic® differential pressure gauge
    f. all of the above

16. pH paper has an accuracy which is usually _____.

    a. plus or minus 0.1 pH units
    b. plus or minus 0.5 pH units
    c. plus or minus 1.0 pH units
    d. plus or minus 5.0 pH units

17. pH paper is usually adequate for evaluation of particulate scrubber liquor except under these conditions:

    a. the liquor contains some strong oxidizing agents which will attack the dyes on the pH paper
    b. the liquor contains some strong alkalies
    c. the liquor is highly colored
    d. the liquor contains a lot of colloidal material

18. During a measurement of the effluent gas from a #6 oil fired burner, the O_2 value was 7% and CO_2 value was 11.5%. Should these measurements be rejected as being obviously in error?

    a. yes
    b. no
    c. there is not sufficient information

19. One simple way to calibrate the Fyrite® CO_2 Analyzer is to _____ _____.

    a. use ambient air which has an ambient concentration of 360 ppm
    b. use a baking soda solution to generate a CO_2 stream
    c. use an automobile exhaust
    d. use your breath
    e. the instrument is a Primary Standard which does not need to be calibrated
    f. all of the above

20. An air pollution control system consists of a hood, 125 feet of carbon steel ductwork which leads to the fabric filter, a 15 foot section of ductwork leading to a fan, and a 23 foot stack. During the inspection the following static pressures are measured: Fan intake +9 inches, filter inlet +3.5 inches, hood exit +0.5 inches, filter outlet +8.5 inches. Is there enough information to calculate the pressure drop across the fabric filter?

    a. yes
    b. no, the measurements were taken at the wrong locations
    c. no, the measurements are obviously incorrect
    d. no, velocity pressure measurements are also necessary

21. A thermocouple should be calibrated using _____.

a. a precision dial-type thermometer
b. a Wheatstone bridge
c. an NBS traceable thermocouple
d. an ice bath and a boiling solution
e. a mercury thermometer

22. A thermister is usually limited to a maximum temperature of _____.

a. 1000°F
b. 500°F
c. 400°F
d. 350°F
e. 300°F
f. 250°F
g. 200°F
h. 150°F
i. 100°F
j. 50°F
k. 0°F
l. none of the above

23. A dial type thermometer usually reads low relative to a thermocouple in measurement of air pollutant laded gas streams because _____.

a. the dial type can often not reach a representative location
b. heat transfer to the dial type thermometer stem is too slow
c. heat transfer up the stem to the outer gauge
d. none of the above
e. all of the above

24. What should be done prior to making a pitot traverse of a duct?

a. make sure that it is necessary to know the gas flow rate
b. make sure that the measurement port is safe
c. make sure that the measurement port can be opened
d. ground the pitot tube
e. make sure that there is no turbulent flow
f. make sure that there is no cyclonic flow
g. make sure that the gas velocity is less than 3200 feet per minute

25. Prior to making a complete pitot traverse using EPA Reference Method 2, the inspector should _____.

a. determine if a centerpoint value could be used to determine the average velocity pressure
b. perform fan calculations to get an estimate of the flow rate
c. select the appropriate nozzle for the pitot tube
d. calibrate an inclined manometer
e. wring hands and gnash teeth

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Portable Instruments Paper	Page(s) in Field Inspection Notebook	Page(s) in Supplemental References
1. c	1-2	65	
2. b,c	2	68	
3. b	14	74	
4. b	3-4		#1 4-12
5. a	18	72	
6. b	14		
7. h	1-9	65-68	#1 4-7 to 4-13
8. b,c	17		
9. c	9	68	
10. d	9	66-67	#1 4-9 to 4-11
11. b		75	
12. d,e	9	65-68	#1 4-9 to 4-11
13. e,g	7		
14. e	1-2, 13	65-66, 74	
15. a,b,c,d	6-9		
16. c	33		
17. a,c,d	34		
18. b		75-76	
19. d	14	74	
20. c	3 & 5		

Question Number and Answer	Page(s) in Portable Instruments Paper	Page(s) in Field Inspection Notebook	Page(s) in Supplemental References
21. c	16-17		
22. e	16		
23. a, c	16		
24. a,b,c,d,f	1-2, 18-19	65-72	
25. a	24		

LESSON 3

Inspection and Evaluation of Fabric Filters

Reading Assignments

Baseline Manual, Chapter 3.

Field Inspection Notebook, pages 1-20.

Reading Assignment Topics

- Components of fabric filter systems.
- The major categories of fabric filters.
- Inspection points and operating parameters of interest for each category of fabric filter.
- Common operating problems for each type of fabric filter.
- Application of the baseline inspection technique to fabric filters.
- General fabric characteristics and capabilities.
- Qualitative field test to determine fabric integrity.
- Diagnostic procedures which can be used if there are symptoms of operating problems.

Learning Goal and Objectives

Learning Goal

The primary goal of this lesson is to illustrate that each of the categories of fabric filters is subject to different operating problems and is inspected in a different manner. You should become familiar with the inspection points which are most important for each type of system.

Learning Objectives

When you have completed this lesson, you should be able to:

1. Recognize the two basic types of pulse jet collector; namely the top clean side access design and the side access design.
2. Understand how a pulse jet bag is cleaned and the typical ranges in the compressed air pressures and cleaning frequency.
3. Understand commonly observed problems with the pulse jet cleaning system components.

4. Understand the factors which can influence the pressure drop in pulse jet type, reverse air type, and shaker type fabric filters.

5. Understand the operating problems which can lead to dust seepage and to fabric holes and tears.

6. Understand how a reverse air type bag is cleaned and the typical operation of the cleaning system.

7. Understand how a shaker type bag is cleaned and the typical operation of the cleaning system.

8. Understand the importance of tension in both reverse air and shaker type fabric filters.

9. Understand ways to evaluate air infiltration in all types of fabric filters.

10. Understand the usefulness of charting bag failure location and frequency.

Reading Guidance

- o *It is important to recognize that there are four major types of* fabric filters. They each have different operating characteristics, modes of failure, and inspection procedures.

- o Although not discussed explicitly in the Field Inspection Notebook, a reverse air (outside-to-inside flow) type fabric filter is inspected in a manner similar to the pulse jet fabric filter. The major difference is that the reverse air (outside-to-inside) unit has a reverse air fan and air delivery system instead of the pulse jet's compressed air supply and delivery system.

- o When you have finished the reading assignment, complete the review exercise for Lesson 3. It begins on the following page.

- o After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- o For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- o After you have reviewed your incorrect answers (if any), proceed to Quiz 1 and then Lesson 4 of this guidebook.

Review Exercise

1. The type of fabric generally used in a pulse jet fabric filter is _____.

   a. woven fabric
   b. felted fabric

2. Pulse jet bags are normally mounted in the following manner inside a baghouse:

   a. hung from "J" hooks
   b. mounted to the tube sheet using snap rings sewn into the bags
   c. mounted on anti-collaspe rings
   d. mounted on cages which hang from the tube sheet

3. The dust cake forms on the _____ surface of the pulse jet bag.

   a. inside
   b. outside

4. The typical air-to-cloth ratio for a pulse jet fabric filter is _____.

   a. 0 to 4
   b. 4 to 8
   c. 8 to 12
   d. 12 to 16
   e. 16 to 20

5. The typical compressed air pressures used on pulse jet collectors is _____.

   a. 10 to 50 inches of water
   b. 100 to 200 inches of water
   c. 10 to 60 psig
   d. 60 to 120 psig
   e. 10 to 70 kilopascals
   f. 70 to 140 kilopascals

6. The components of the pulse jet cleaning system include the following _____.

   a. the diaphragm valve
   b. the rotary discharge valve
   c. the solenoid (or "pilot") valve
   d. the blow tube
   e. the compressed air header
   f. all of the above

7. The proper units of the Air-to-Cloth Ratio are:

   a. Ft/Min
   b. $(Ft/Min)/Ft^2$
   c. $(Ft^3/Min)/Ft^2$
   d. (M^2/Min)
   e. $(M^3/Min)/M^2$

8. Short term puffs from a pulse jet collector are normally indicative of _____.

   a. fabric blinding
   b. seepage due to overcleaning
   c. normal operation
   d. none of the above

9. High pressure drop in a pulse jet collector is often due to the following:

   a. holes and tears
   b. high gas flow rates
   c. inadequate cleaning intensity or frequency
   d. cage misalignment
   e. partial blinding of the fabric
   f. excessive cleaning intensity or frequency
   g. cage abrasion

10. Cleaning in a pulse jet collector is done _____.

    a. bag by bag
    b. row by row
    c. compartment by compartment
    d. none of the above

11. If the diaphragm valves are not working on a pulse jet collector, the following conditions will develop shortly:

    a. the bags will balloon outward away from the support cage
    b. a substantial dust cake will build up on the bags not being cleaned
    c. the opacity will increase
    d. the gas flow rate to the collector will decrease
    e. the pressure drop across the collector will increase
    f. there will be fugitive emissions from the process hood

12. If the compresed air pressure is too high, _____.

    a. there will be momentary seepage of dust immediately following cleaning of each row
    b. the diaphragm will not operate
    c. the cage will become deformed
    d. the efficiency of the collector will improve
    e. no adverse effects will occur

13. Leakage of compressed air from the header or the valve may cause the following conditions:

    a. inadequate cleaning
    b. inoperative solenoid valves
    c. inoperative rotary discharge valves

14. The static pressure drop across a pulse jet collector is a sensitive indicator of holes and tears.

    a. true
    b. false

15. A blast plate is sometimes used to _____.

    a. reduce the risk of dust explosions
    b. reduce erosion of bags near the inlet ducts
    c. reduce the necessary pressure drop
    d. prevent solids discharge problems
    e. all of the above

16. An access hatch may be opened when _____.

    a. it is necessary to observe the clean side deposits and/or the baghouse components
    b. the static pressure inside exceeds 5 inches
    c. there is no differential pressure across the hatch
    d. there is no differential pressure across the hatch and the operator has completed all lockout procedures
    e. there is no differential pressure across the hatch, the operator has completed all lockout procedures, and there are at least two individuals present
    f. there is no differential pressure across the hatch, the operator has completed all lockout procedures, there are at least two individuals present both of whom have the appropriate personal protective equipment

17. A snap ring assembly is usually used on a _____.

    a. pulse jet collector
    b. shaker collector
    c. compressed air dryer
    d. reverse air collector
    e. all of the above

18. The tube sheet in a pulse jet collector is normally _____.

    a. near the bottom of the baghouse
    b. near the top of the baghouse
    c. between compartments
    d. not used

19. Gas flow in a shaker type fabric filter is _____.

    a. from the outside to the inside of the bag
    b. from the inside to the outside of the bag

20. Bag tension in a reverse air (inside to outside filtering) type collector is _____.

    a. critical
    b. mildly important
    c. unimportant

21. Bags in a reverse air (inside to outside filtering) are cleaned in the following manner:

    a. bag by bag basis
    b. row by row
    c. compartment by compartment

22. The static pressure drop across the compartment of a shaker type baghouse during cleaning should be in the following range:

    a. -2 to -4 inches
    b. 0 to -2 inches
    c. 0
    d. 0 to 2 inches
    e. 2 to 4 inches

23. The static pressure drop across a compartment of a reverse air (inside to outside filtering) should be zero.

    a. true
    b. false

24. The maximum rated temperature for a fiberglass fabric is _____.

    a. 300°F
    b. 400°F
    c. 500°F
    d. 600°F
    e. 1000°F

25. Operation on a continuous basis should be at approximately _____ below the maximum rated temperature.

    a. 10°F
    b. 25°F
    c. 50°F
    d. 75°F
    e. 100°F
    f. 0°F

26. The typical air-to-cloth ratios for shaker type and reverse air fabric filters is _____.

    a. 60 to 180 feet per minute
    b. 0.25 to 1.0 meters per minute
    c. 1 to 3 feet squared per minute
    d. 4 to 8 feet squared per minute
    e. 8 to 12 feet per minute squared
    f. 1 to 3 feet per minute
    g. 4 to 8 feet per minute
    h. none of the above

27. The clean side deposits in shaker type and reverse air fabric filters should not be _____.

    a. more than a trace
    b. > 1/4"
    c. > 1"
    d. > 3"
    e. > 6"
    f. >12"
    g. >24"

28. If one failed bag which was recently removed from the collector could not be ripped easily, even near the location of the hole, the most probable cause of the hole includes the following:

    a. high temperature excursions
    b. chemical attack
    c. abrasion
    d. flex failure
    e. installation damage
    f. embers
    g. all of the above

29. Useful means to evaluate air infiltration include the following:

    a. inlet and outlet gas stream temperatures
    b. inlet and outlet O_2 and CO_2 measurements
    c. listening for the audible sound of air infiltration
    d. checking for obvious holes in ductwork or the collector
    e. checking for missing solids discharge valves
    f. all of the above

30. Problems with baghouses are often indicated when the stack opacity is in the following range:

    a. 1 to 10%
    b. 10 to 20%
    c. 20 to 40%
    d. 40 to 60%

31. The maximum recommended operating temperature of Nomex fabric is _____F.

a. 100°
b. 200°
c. 300°
d. 400°
e. 500°

32. Fabrics which are generally considered flex and abrasion resistant include the following:

a. cotton
b. nylon
c. polypropylene
d. polyester
e. fiberglass

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook
1. b	3-3	3
2. d	3-1	2 to 3
3. b	3-1	3
4. b	3-3	4
5. d	3-6	3
6. a,c,d,e	3-1 to 3-3	2 to 3
7. a,c,e		4
8. a,b	3-6	7
9. b,c,e	3-6	8
10. b	3-3	3
11. b,d,e,f	3-5	6 to 7
12. a,d		7
13. a	3-5	7
14. b	3-8	4
15. b		3
16. a,f	3-7	8
17. b,d	3-4,3-9	13
18. b		2
19. b	3-5	13
20. a	3-5	13
21. c	3-4	13
22. c		18
23. b		18

Question Number and Answer	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook
24. c		15
25. c		14
26. b,f	3-5	14
27. a	3-9	19
28. c,d,e,f		20
29. f	3-6,3-8	18
30. a		5,17
31. d		15
32. b,c,d		15

QUIZ 1

This self-administered and self-graded quiz covers the material presented in Lessons 1 through 3. It introduces the type of questions and problems which will appear on the final and is open book. The final, however, will only allow use of the Field Inspection Notebook. Access to a calculator for both the quiz and final will be helpful.

The quiz consists of 25 multiple choice questions and problems. There may be more than one correct answer for each question. You should use a separate sheet of paper to record your answers and scratch paper to work the problems. The answers can be found on the page following the last question.

1. A symptom used in baseline analyses means _____.

   a. a significant difference between an operating parameter at a given plant as compared against industry norms
   b. a significant difference between an operating parameter measured during the inspection as compared against the value during the baseline period
   c. neither

2. During the measurement of the static pressure in a duct ahead of a fabric filter it is suspected that there is some slight air leakage around the probe and into the duct. If the observed static pressure is -18 inches of water, the true static pressure would probably be _____.

   a. -15 inches of water
   b. -20 inches of water
   c. -25 inches of water
   d. +18 inches of water
   e. either b or c

3. A bonding wire is used for the following:

   a. to prevent loss of the probe into the duct
   b. to connect the probe to the instrument
   c. for dissipation of static electricity
   d. to prevent magnetic interference

4. Calculate the average stack gas velocity using the following pitot traverse data and the equation:

$$v_s = 2.9\ C_p\ (\sqrt{\Delta p})_{avg}\ \sqrt{(T_s)_{avg}}$$

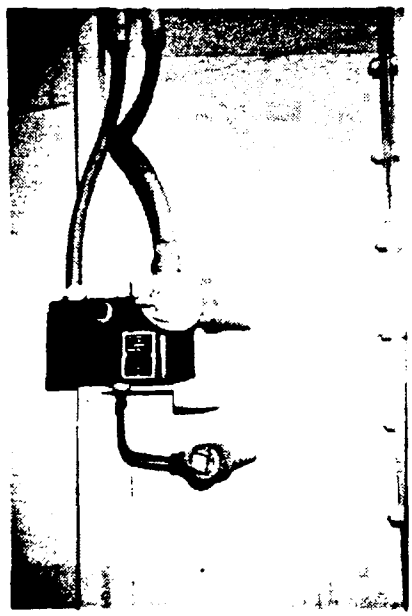
where: v_s = average stack gas velocity (ft/sec),
C_p = pitot tube coefficient (dimensionless, usually varies between 0.83 and 0.87),
Δp = velocity head (manometer reading) of stack gas (in. H_2O), and
T_s = absolute stack temperature (460° + stack gas temp. in °F).

Traverse Point No.	Velocity Head, Inches	Stack Temperature, ° F
1	0.42	314
2	0.46	316
3	0.58	321
4	0.76	325
5	0.83	323
6	0.47	320
7	0.42	315
8	0.38	314

   a. 31.4 feet per second
   b. 31.8 feet per second
   c. 49.2 feet per second
   d. 49.7 feet per second

5. It is necessary to make a static pressure measurement on the duct ahead of the collector. The location shown in the photograph below has safe and convenient access. How should the measurement be made?

   a. by removing the 2 inch plug
   b. by removing the 2 inch plug and using a port seal
   c. by reading the signal off the D/P Transmitter
   d. at another location which will not affect the D/P Transmitter



6. If the inside diameter of the duct is 30 inches and the measured average velocity is 56 feet per second, what is the gas flow rate in ACFM?

   a. 16,493
   b. 275
   c. 3,299
   d. 65,972

7. Portable inspection instruments are sometimes necessary because ____ _____.

   a. some on-site permanent monitors are inoperative a significant portion of the time
   b. many control systems do not have the necessary instruments
   c. highly complex analyses must be performed and it is usually not possible to complete these without additional data
   d. many operators set on-site instruments to give an incorrect indication of control system performance

8. During the inspection of a reverse air collector (inside-to-outside filtering) it is noted that there is a trace of dust (see photograph below) on the clean side of the tube sheet. What does this indicate?

   a. a trace of dust is inevitable and the compartment appears to be in good shape
   b. the compartment contains a number of broken bags
   c. some bleeding of dust may be occurring during the shake cycle
   d. none of the above

9. While evaluating a fabric filter on a spreader stoker boiler, the following measurements were made using the Fyrite analyzers: Inlet to collector, O_2=12.6% and CO_2=11.6%; Outlet of collector, O_2=9.6%, CO_2=11.2%. What can be concluded from these measurements?

   a. the boiler is operating at undesirable excess air rates
   b. there is substantial air infiltration into the fabric filter
   c. the measurement made at the outlet port is incorrect
   d. the measurement made at the inlet port is incorrect
   e. more data is necessary to make any conclusions

10. On a square duct, the length is 50 inches and the width is 20 inches. What is the equivalent diameter?

   a. 35.0 inches
   b. 28.6 inches
   c. 40.1 inches
   d. 18.6 inches

11. What should be done prior to conducting a point-by-point pitot traverse to determine the average gas stream velocity?

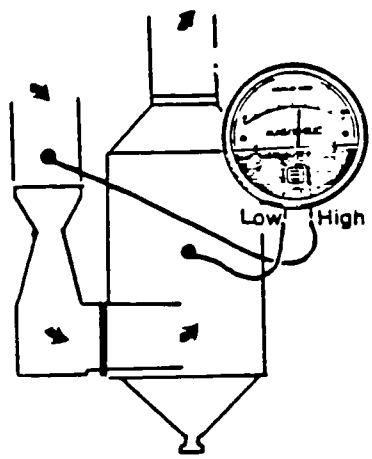
    a. attach the grounding/bonding line to the pitot tube if there is even a remote possibility of static electricity build-up
    b. check for cyclonic flow
    c. determine the number of traverse points necessary
    d. ensure that the measurement port area is structurally secure
    e. ensure that toxic gases and/or steam accidentally released from plant equipment cannot engulf the measurement port location
    f. calibrate the inclined manometer
    g. confirm that it is actually necesary to know the gas stream velocity during the inspection
    h. measure the diameter of the stack at the port location
    i. all of the above

12. Measurement ports on negative pressure ducts must be well sealed during the measurements in order to prevent the following:

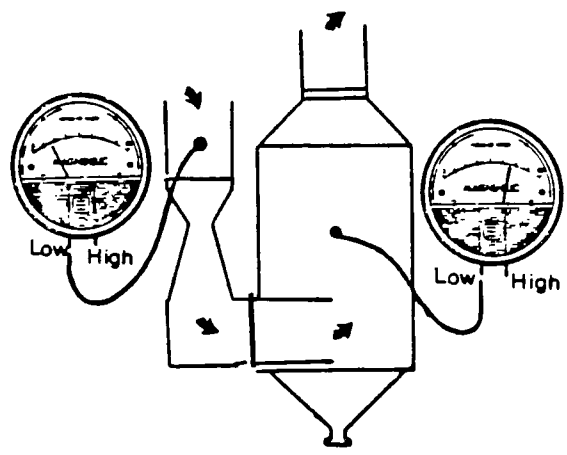
    a. ambient air infiltration into the Fyrite® probe
    b. the build-up of static electricity
    c. fumigation of the inspector as pollutant laden gas flows out of the measurement port
    d. aspiration effect error
    e. cooling of the temperature sensor
    f. lower than actual O_2 and CO_2 measurement

13. The preferred method for measuring the pressure drop across a collector is shown in figure ___.

    a. A
    b. B
    c. neither



A



B

14. During the inspection of a fabric filter, it is noted that the pressure drop has decreased substantially since the baseline period and the opacity has dropped from 10% to almost 0%. There is some minor corrosion on the collector shell and some very audible air infiltration across the top access hatches. The rotary valves and the screw conveyors seem to be performing adequately. Is it necessary to continue the inspection or should the unit be considered in compliance?

    a. stop the inspection, the unit is in compliance
    b. continue the inspection because the data clearly indicates that the bags are being overcleaned
    c. continue the inspection because it is quite possible that there are substantial fugitive emissions from the process hoods
    d. stop the inspection because any problems which may exist are not causing the unit to operate out of compliance

15. During the inspection, the operator of a fabric filter serving a cupola states that the previous bag failure problem has been corrected by using a new bag hanger design and by modifying the tube sheet thimble. He suggests that you follow him into the fabric filter to confirm that this has been done properly. What should the inspector do?

    a. check all six compartments to ensure that the same modifications were made in each
    b. just check one or two compartments
    c. limit the inspection to what can be seen from the access hatch without going inside the compartments
    d. review the drawings and do not waste time on the equipment inspection

16. A pulse jet fabric filter serving a lime unloading (truck) station has an opacity of 0%. The pressure drop has increased from a baseline value of 4 inches of water to a present value of 9 inches. What can be concluded from this data?

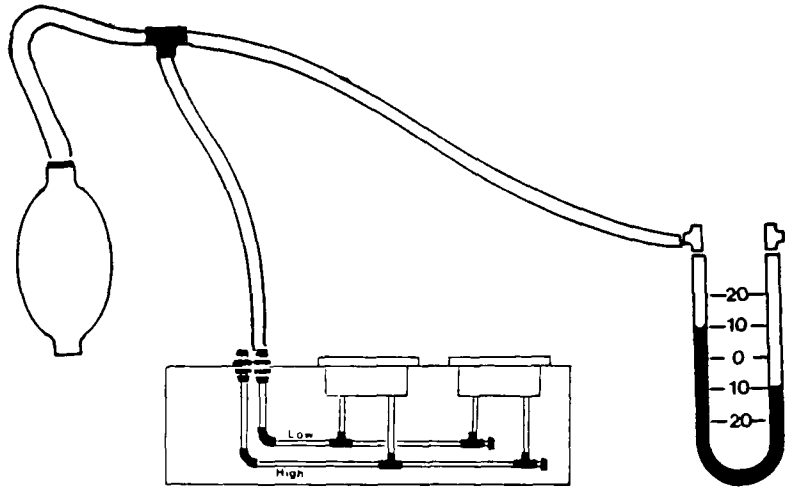
    a. since the baghouse opacity is 0%, the baghouse is in compliance with visible emission regulations
    b. since the pressure drop has increased, the collection efficiency has probably increased since the baseline period
    c. the cleaning system should be inspected carefully
    d. the rotary valves and screw conveyor should be inspected carefully
    e. the potential for fugitive emissions from the unloading shed should be evaluated

17. The baseline inspection technique involves detailed internal inspections of the control systems.

    a. true
    b. false

18. The static pressure indicated on the slack tube manometer shown below is _____.

a. 60 inches
b. 40 inches
c. 20 inches
d. 0 inches



19. The temperature recorder on the outlet of a reverse air fabric filter indicated that there was a temperature excursion to 485°F for a period of 1 hour. What types of fabric would be able to tolerate this condition?

a. cotton
b. Nomex
c. fiberglass with silicon-graphite coating
d. Ryton
e. Dacron

20. During the inspection of a shaker type fabric filter, it is noted that the shake duration is 5 minutes and the frequency is approximately 4 cycles per second. What should the innspector be concerned about?

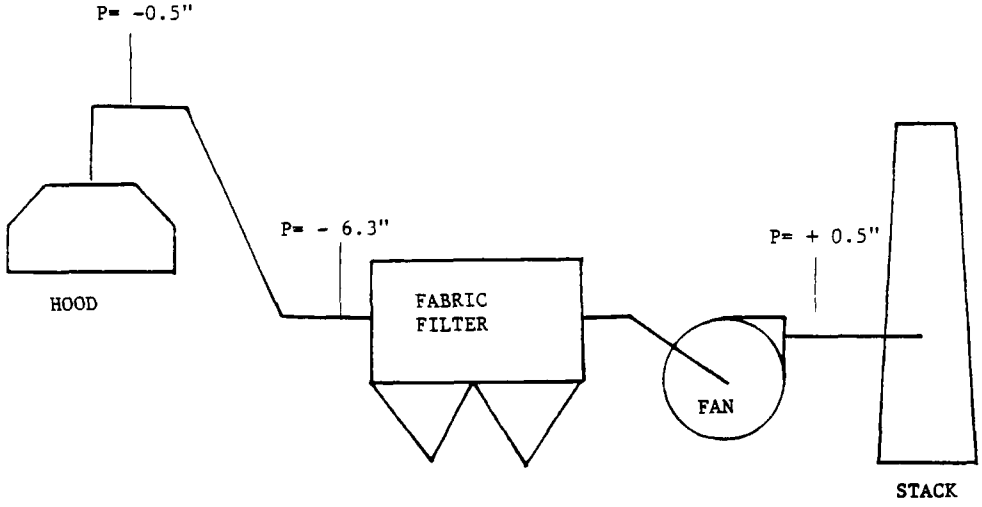
a. overcleaning with premature bag failures
b. bag blinding conditions possibly accompanied by fugitive emissions from the source
c. hopper overflow problems
d. nothing

21. Control systems designed by the same manufacturer and operated under similar conditions can be assumed to operate in a similar manner.

a. true
b. false

22. Static pressure measurement data on a given air pollution control system are shown in the figure below. What is the pressure drop across the collector?

a. 6.8 inches
b. 1.0 inches
c. 5.8 inches
d. 6.1 inches
e. it cannot be determined
f. the measurements are obviously in error

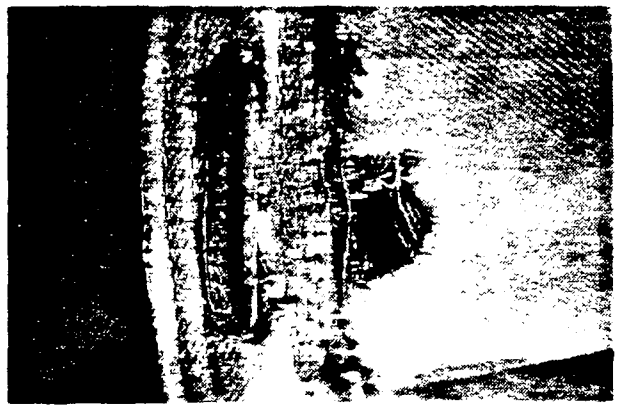


23. Water and oil in the compressed air lines of pulse jet fabric filters can lead to which of the following problems?

a. seepage
b. blinding
c. freezing of the diaphragm valves
d. freezing of thr rotary valves
e. fires in the bags
f. cage erosion

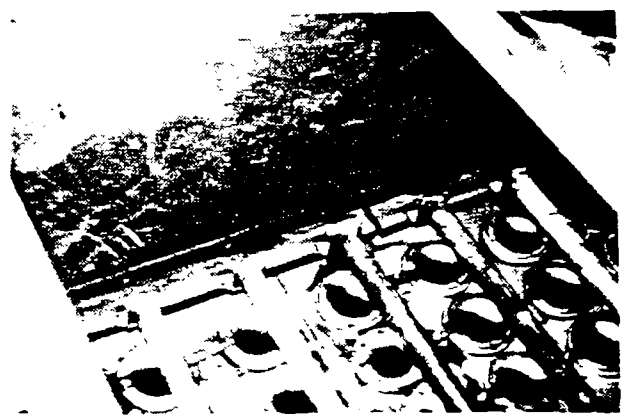
24. The bag shown in the photograph below has recently been removed from a fabric filter with a long history of operating problems. The operator states that the problem occurred due to a temperature excursion and that the cause has been corrected. What should the inspector do?

a. accept this explanation and reschedule an inspection in six months
b. attempt a rip test in the vicinity of the hole to evaluate the overall fabric strength
c. determine if there are any signs of flex failure and or mechanical damage
d. determine if there are any signs of embers



25. The conditions shown in the photograph below were observed in the clean side plenum of a fabric filter. The unit is presently off-line, however, it normally operates with an opacity of zero and no apparent fugitive emissions from the process. Is there a need to continue the inspection of the unit?

a. no, the unit is probably in compliance
b. yes, the pressure drop should be measured when the unit is on-line
c. yes, the potential for air infiltration should be carefully checked when the unit comes back on-line



LESSON 4

Inspection and Evaluation of Electrostatic Precipitators

Reading Assignments

Baseline Manual, Chapter 2.

Field Inspection Notebook, pages 21 to 31.

Reading Assignment Topics

- The functions of components of an electrostatic precipitator control system.
- The importance of determining the layout of Transformer-Rectifier sets on the precipitator prior to starting the data evaluation.
- Procedure for plotting the Transformer-Rectifier set electrical data in order to determine whether the precipitator is presently handling high, moderate, or low resistivity particulate matter.
- Procedure for evaluating the voltages and currents of each field.
- Procedure for estimating the power input for each chamber of the precipitator when the resistivity is either moderate or high.
- Useful inspection points when used with the stack opacity or the electrical data suggests that precipitator performance has decreased since the baseline period.

Learning Goals and Objectives

Learning Goal

To familiarize you with the general operating principles of an electrostatic precipitator and with the parameters of most use in evaluating precipitator performance.

Learning Objectives

When you have completed this lesson, you should:

1. Understand how to plot the Transformer-Rectifier set data (voltages, currents, and spark rates) in order to make a general assessment of the particulate resistivity.
2. Understand how to review the electrical set data plots to determine if there probably are internal problems in one or more fields.
3. Understand how to analyze the present opacity levels and electrical set data to determine if there has been a significant shift since the baseline period.

4. Understand when it is useful to calculate the precipitator power input and when this value can be misleading.

5. Understand some of the mechanical problems which can lead to low voltages and high currents in specific fields, including but not limited to: air infiltration, insulator tracking, electrode warpage, internal clearance problems, electrode sway, and hopper overflow. Understand what external symptoms can be checked to narrow the list of potential problems so that the source operator's corrective action(s) can be reviewed.

6. Understand the most common modes of failure of electrostatic precipitator systems.

7. Understand how the interaction of two or more failures at the same time can lead to a confusing and sometimes very difficult to interpret set of data.

Reading Guidance

- Prior to reading about the inspection procedures for electrostatic precipitators, it is very important to develop a good understanding of the precipitator components and the operating principles. Useful information is presented in the Baseline Manual on pages 2-1 to 2-8 and in the Field Inspection Notebook on Pages 21 to 24. These two references are meant to provide only a quick overview of the salient operating principles. It is recommended that a supplemental reference also be read before continuing with this lesson. Very good information is presented in Katz (see Supplemental References) on pages 6 to 52 and pages 60 to 70.

- One of the most important concepts in electrostatic precipitation is the particle resistivity. The general range of the resistivity (low, moderate, or high) must be identified during the inspection so that the inspection can focus on the problems most likely to be causing any emissions problems. More information on resistivity is presented in the supplemental references: White, pages 38 to 61; Southern Research Institute, pages 323 to 411; and Katz, pages 60 to 75.

- In both the Baseline Manual and the Field Inspection Notebook, the term resistivity means the average resistivity of the particulate entrained in the inlet gas stream. Actually, the resistivity varies from side-to-side of the inlet and varies from the front to the back of the precipitator. Also, most commercial precipitators will have some temporal variation in the resistivity conditions. It is important to recognize that the resistivity is not a constant.

- It is important to recognize that there often is a complex interaction between some of the precipitator operating problems. It is often difficult, for an inspector with limited time and using only the opacity strip charts (and stack observation) and the electrical set data, to diagnose the specific operating problem. It is important to respect the complexity of the device.

- Typical secondary voltages, secondary currents, and spark rates are plotted on page 28 of the Field Inspection Noteboook. In many cases, the baseline data and operating data is not as linear as shown. All three plots should be used together to attempt to identify the general range of the resistivity. The plots shown are typical of moderate resistivity. A low resistivity set of plots would usually have very high secondary currents in all fields and spark rates near to or at zero in all fields. The secondary voltages in low resistivity would drop in all fields. The secondary voltages in low resistivity would drop in all fields relative to the baseline values. In high resistivity, the secondary currents would be low in all fields and the spark rates would usually be high in all the fields. The plots may look different if the unit is undersized or is suffering from internal problems in many of the fields. For these reasons, the plots should not be considered as absolutely reliable for determining the general resistivity range. There will be isolated cases where they do not yield a clear picture of the precipitator operating conditions.

- It is important to realize that the power input should only be used to evaluate emissions if the resistivity is in the high or moderate ranges. In these ranges, the particulate emissions from the precipitator are roughly proportional to the power input. In the low resistivity range, the emissions can increase as the power input goes up.

- When you have finished the reading assignment, complete the review exercise for Lesson 4. It begins on the following page.

- After you have answered the review exercise questions, check your answers. The corect answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to Lesson 5 of this guidebook.

Supplemental References

1. Katz, J. The Art of Electrostatic Precipitation, S&S Printing Company, Pittsburgh, Pennsylvania, 1979.

2. White, H. Electrostatic Precipitation of Fly Ash, APCA Reprint Series, Air Pollution Control Association, 1977.

3. McDonald J.R., and Dean, A.H., Southern Research Institute. A Manual for the Use of Electrostatic Precipitators to Collect Fly Ash Particles. U.S. Environmental Protection Agency Publication EPA-600/8-80-025, May 1980.

Review Exercise

1. The two most important types of data used to evaluate an electrostatic precipitator are the following:

   a. the gas flow rate and the stack opacity
   b. the gas inlet temperature and the gas flow rate
   c. the T-R set electrical data and the opacity
   d. the rapper intensities and rapper frequencies
   e. the T-R set electrical data and the gas flow rate

2. The typical electrostatic precipitator has the following layout of T-R sets:

   a. one or two fields in series
   b. two to ten fields in series
   c. three to fifteen fields in series
   d. four to twenty fields in series
   e. five to forty fields in series
   f. fields are not oriented in series

3. During the charging and particle migration process, dust accumulates on the following:

   a. the collection plate only
   b. the collection plate and the distribution screens only
   c. the discharge electrodes only
   d. the collection plate, discharge electrodes, and the distribution screens
   e. none of the above

4. The voltage on the discharge electrode is the _____.

   a. primary voltage
   b. secondary voltage
   c. none of the above

5. The primary side of the Transformer-Rectifier set operates as _____.

   a. alternating current
   b. direct current
   c. none of the above

6. The secondary side of the Transformer-Rectifier set operates as _____.

   a. alternating current
   b. direct current
   c. none of the above

7. The typical secondary voltages of electrostatic precipitators is between _____.

   a. 1,000 and 5,000 volts
   b. 15 and 50 kilovolts
   c. 5 and 10 kilovolts
   d. 1,000 and 5,000 kilovolts
   e. none of the above

8. If the particulate resistivity is low, the secondary currents are usually _____.

   a. very low in all of the fields
   b. very high in all of the fields
   c. secondary current is set at the T-R set and is unaffected by the resistivity

9. If the particulate resistivity is high, the secondary currents are usually _____.

   a. very low in all fields
   b. very high in all fields
   c. secondary current is set at the T-R set and is unaffected by the resistivity

10. Corona power is calculated by _____.

    a. multiplying the primary current times the primary voltage
    b. multiplying the primary current times the primary voltage times the load factor
    c. multiplying the secondary current times the secondary voltage
    d. multiplying the secondary current times the secondary voltage times the power factor
    e. multiplying the primary voltage times the primary current times the power factor

11. The corona power is a general indicator of performance only when _____.

    a. the resistivity is moderate or low
    b. the resistivity is moderate or high
    c. the resistivity is low or high

12. The primary voltage in an electrostatic precipitator is usually in the range of _____.

    a. 0 to 1000 volts, A.C.
    b. 0 to 1000 volts, D.C.
    c. 0 to 480 volts, A.C.
    d. 0 to 480 kilovolts, D.C.

13. The secondary voltage necessary to establish a corona discharge is usually _____ .

    a. 1000 to 2000 volts
    b. 1 to 3 kilovolts
    c. 15,000 to 25,000 kilovolts
    d. 10 to 20 kilovolts

14. The collection efficiency of an electrostatic precipitator is _____.

    a. strongly affected by the secondary voltage
    b. not related to the secondary voltage, only to the primary voltage

15. The gas velocity through an electrostatic precipitator is usually _____.

    a. 1 to 3 feet per second
    b. 180 to 480 feet per minute
    c. 10 to 25 feet per minute
    d. 3.5 to 12 feet per minute
    e. 3 to 8 feet per second
    f. 30 to 50 feet per minute
    g. 50 to 75 feet per second

16. While observing the stack of an electrostatic precipitator system, the following information is useful in evaluating the present conditions:

    a. the average opacity
    b. the peak opacity during puffs
    c. the duration and timing of the puffs
    d. the presence or absence of detached plumes
    e. all of the above
    f. none of the above

17. Method(s) for evaluating the spark rates in the various fields are _____.

    a. divide the primary current by the primary voltage
    b. count the fluctuations of the primary voltage meter
    c. check the spark rate meter (if present) on each of the electrical cabinets
    d. it is not necessary to know the spark rate

18. If the unit has suffered frequent wire breakage, the inspector may wish to do the following:

    a. evaluate the wire failure location records
    b. examine the wires to evaluate the general type of failure which has occurred
    c. evaluate the power input to each chamber to determine if the loss of fields due to wire failure has in fact caused a significant decrease in the chamber total power input

19. The corona power levels should be evaluated _____.

    a. when the resistivity is in the low to moderate range
    b. on a chamber by chamber basis
    c. for the entire precipitator system by summing up all chambers
    d. when the resistivity is in the moderate to high range
    e. when the opacity is above baseline levels and the resistivity is in the moderate to high range
    f. when the opacity is above baseline levels and the resistivity is in the moderate to low range

20. When the resistivity is in the moderate range, the spark rate tends to _____ from the inlet to the outlet field of a given chamber.

    a. increase
    b. decrease
    c. remain unchanged

21. If the particulate resistivity is low, the dust layer on the collection plate is _____.

    a. held strongly
    b. held only weakly

22. Factors which can aggravate reentrainment emissions from a precipitator collecting low resistivity dust can include the following:

    a. excessive rapping intensity
    b. poor gas distribution
    c. insulator tracking
    d. high gas velocities
    e. excessive rapping frequencies
    f. all of the above

23. At low temperatures, the dissipation of charge from collected particles occurs by _____.

    a. surface conduction
    b. bulk conduction
    c. magic
    d. not at all

24. Surface conduction occurs due to the presence of the following:

    a. elemental nitrogen
    b. adsorbed water molecules
    c. adsorbed sulfur trioxide molecules
    d. elemental calcium
    e. all of the above

25. Each field removes _____% of the particulate matter entering that field.

    a. 0 to 25%
    b. 25 to 40%
    c. 40 to 70%
    d. 70 to 85%
    e. 85 to 95%
    f. 95 to 99%

26. The secondary currents in electrostatic precipitator fields are usually in the range of _____.

    a. 0 to 400 amps, D.C
    b. 0 to 1500 amps, A.C.
    c. 0 to 100 amps, D.C
    d. 0 to 1000 amps, A.C.
    e. 0 to 2 amps, D.C.
    f. 0 to 1 amps, A.C.
    g. 0 to 2000 milliamps, D.C.
    h. 0 to 1000 milliamps, A.C.
    i. 0 to 5000 microamps, A.C.

27. The resistivity of the particulate matter is affected by _____.

    a. the gas temperature
    b. the concentrations of water vapor and sulfur trioxide
    c. the composition of the particulate matter
    d. the secondary voltage
    e. the secondary current

28. For a specific electrostatic precipitator, the particulate matter resistivity is _____.

    a. a constant
    b. not constant

29. If only one field or several fields exhibit shifts from baseline conditions, the most likely cause(s) of the failure would include the following:

    a. resistivity shifts
    b. rapper failure
    c. insulator leakage or failure
    d. misalignment
    e. hopper overflow
    f. localized air inleakage
    g. poor gas distribution
    h. all of the above

30. The electrical set data should be recorded in the following order:

a. the order is not important
b. in numerical order
c. starting with the inlet and proceeding to the outlet
d. in a counterflow direction, starting with the outlet field and proceeding to the inlet

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook	Page(s) in Supplemental References
1. c	2-1	25	
2. b	2-2		#1 32
3. d	2-2 to 2-3	21	
4. b	2-4		
5. a	2-2, 2-9	25	
6. b	2-2, 2-9	25	
7. b	2-2	28	
8. b	2-10	29	
9. a	2-10	29	#1 60 to 75
10. c,e	2-5 to 2-8	31	#1 34 to 36
11. b	2-5 to 2-8	30	
12. c	2-2	25	
13. d	2-4 to 2-5		
14. a	2-4	25	
15. b,e	2-1	21	#1 30 to 31 #2 19
16. e	2-8	25,26	
17. b,c		25	
18. a,b,c		31	
19. b,d,e	2-5 to 2-8 2-10	26	
20. b		26,28	#1 60 to 75
21. b		23	
22. a,b,d,e		23	

Question Number and Answer	Page(s) in Baseline Inspection Manual	Page(s) in Field Inspection Notebook	Page(s) in Supplemental References
23. a		23-24	#1 60-63, #2 39-61 #3 340-356
24. b,c		23-24	#1 60-63, #2 39-61
25. d		21	
26. e,g	2-9	25,28	
27. a,b,c		23	#1 60-63
28. b		23-24	
29. b,c,d,e,f	2-12	30	
30. c	2-8 to 2-10	26	#1 134

LESSON 5

Inspection and Evaluation of Particulate Wet Scrubbers

Reading Assignments

Baseline Manual, Chapter 4.

Field Inspection Notebook, pages 40 to 64.

Wet Scrubber Manual, pages 1-1 to 1-2, 2-1 to 2-41, 3-1 to 3-8, and 4-1 to 4-19.

Reading Assignment Topics

- o General types of wet scrubbers and the differing performance capabilities of these types.
- o Components of wet scrubber systems.
- o The relationship between static pressure drop and the energy utilization within the scrubber.
- o The effect of surface tension on performance.
- o The importance of scrubber liquor pH.
- o The relationship between the liquid-to-gas ratio, the pressure drop, and the scrubber efficiency.
- o The importance of particle size on scrubber performance.
- o The performance parameters used to evaluate scrubber performance.
- o The types of instruments often used to evaluate scrubber performance.
- o The baseline evaluation technique as applied to wet scrubbers.
- o The importance of process operating conditions on the performance of a wet scrubber system.

Learning Goal and Objectives

Learning Goal

To familiarize you with the important wet scrubber performance parameters and with a general methodology for evaluating the present operating condition of the overall wet scrubber system.

Learning Objectives

When you have completed this lesson, you should:

1. Understand the basic design features of the major classes of wet scrubbers.

2. Understand the relationship between the pressure drop, the gas density, and the scrubber efficiency.

3. Understand the factors which can affect scrubber performance without causing any observable change in the pressure drop or the gas density.

4. Understand when the portable instruments should be used and when they are not necessary or are undesirable.

5. Respect all potential safety hazards which can be encountered during an inspection of a wet scrubber.

6. Understand the locations in a scrubber system where corrosion and erosion are most common.

7. Understand the importance of demister performance in preventing liquor reentrainment.

8. Understand the importance of site specific performance evaluations.

Reading Guidance

- If you do not understand the differences between static pressure, velocity pressure, and total pressure, refer to the Industrial Ventilation Manual published by the American Conference of Governmental Industrial Hygienists (see Supplemental Reference list).

- Pages 2-20 to 2-34 of the Wet Scrubber Manual should be read very carefully, since this section presents information demonstrating that performance correlations should be based on the value of pressure drop divided by the gas density. Previously published literature suggested that the correlation could be based on the value of the pressure drop alone. This section presents information demonstrating that pressure drop alone is not adequate.

- The importance of particle size is discussed in Section 2.2 of the Wet Scrubber Manual. The importance of particle size cannot be overstated. Unfortunately, there is very little particle size data for commercial units.

- Section 2.2.3.2 of the Wet Scrubber Manual presents a brief discussion of the evaporative release mechanism for release of "new" aerosols into the gas stream. There is very little published literature available on this topic, possibly because many have failed to recognize the importance of this very undesirable operating condition. A large number of equipment operators have independently discovered that the use of relatively clean liquor in the presaturators and quench towers has a very beneficial impact on the overall scrubber performance.

- Section 2.2.3.1 of the Wet Scrubber Manual presents a brief discussion of the possible ways in which a change in the process equipment operating conditions could effect the scrubber efficiency. Additional information on this very important topic is presented in Section 4.3 of the same manual. It is a subject area in which much more needs to be known. The variability of particle size between different scrubbers on apparently similar process units is one of the major reasons that the site specific baseline approach is so important.

- In reviewing published manuals and articles concerning wet scrubbers, the reader will frequently encounter the terms "efficiency", "penetration", and "transfer units". These three terms actually refer to the same basic concept, namely the extent to which pollutants entering a system are removed. Information to facilitate converting from one term to another are presented in Appendix A of the Wet Scrubber Manual.

- The Field Inspection Notebook, pages 40 to 64 should be read after completing all of the assigned readings in the Wet Scrubber Manual. The notebook section serves as a concise review of the material presented in the Scrubber Manual.

- The effect of liquor surface tension on the performance of a wet scrubber system has not been studied extensively. More work is necessary, especially concerning the effect of the surface tension on the distribution of droplets across the throat of a venturi scrubber and concerning the effect of surface tension on the collection efficiency for fine particles. Refer to Section 2.6 of the Wet Scrubber Manual.

- One of the main tasks in the evaluation of any wet scrubber system is measurement of the pressure drop. Section 4.1.5 of the Wet Scrubber Manual presents some instructions for measuring the pressure drop which are not available elsewhere. This section should be reviewed several times, and the following topics should be clearly understood:

    a. The need for carefully sealing the measurement port to prevent aspiration error.
    b. The need to ensure that the measurement port remains open during the measurement.
    c. The need to use an electrical grounding cable on all measurements at the inlet to wet scrubbers to prevent static electrically initiated explosions.
    d. The need to fully document the measurement port locations so that the implications of the pressure drop value can be determined.

- Gas densities as a function of gas temperature and pressure are shown in Figure C-1 of Appendix C of the Wet Scrubber Manual. This chart demonstrates that the static pressure has a significant impact on the gas density, therefore, gas density will change substantially while passing through the scrubber, even if the temperature remains constant.

- When you have finished the reading assignment, complete the review exercise for Lesson 5. It begins on the page following the Supplemental Reference listing.

- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to Lesson 6 of this guidebook.

Supplemental References

1. Calvert, S., J. Goldschmid, D., Leith, and D. Mehta. Wet Scrubber System Study, Volume I: Scrubber Handbook. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Publication EPA-2-72-118a, August 1972.

2. Richards, J., and R. Segall. Engineering-Science. "The Use of Portable Instruments for Evaluation of Air Pollution Control Systems" Draft Report to the U.S. Environmental Protection Agency, Contract 68-01-6312, June 1982.

3. Mappes, T.E., and R.D. Tems. PEDCo Environmental. An Investigation of Corrosion in Particulate Control Equipment. U.S. Environmental Protection Agency Publication EPA-340/1-81-002, February 1981.

4. Conkle, H.N., H.S. Rosenberg, and S.T. DiNovo. Battelle Columbus Laboratories. Guidelines for the Design of Mist Eliminators for Lime/Limestone Scrubbing Systems. Electric Power Research Institute Publication EPRI FP-327, December 1976.

5. Emission Standards and Engineering Division, OAQPS, U.S. EPA. Control Techniques for Particulate Emissions from Stationary Sources - Volume I. U.S. Environmental Protection Agency Publication EPA-450/3-81-005a, September 1982.

6. Yung. S., S. Calvert, and H.F. Barbarika. A.P.T. Inc. Venturi Scrubber Performance Model. U.S. Environmental Protection Agency Publication No. EPA-600/2-77-172, August 1977.

Review Exercise

1. The particle range which is most difficult to collect in a wet scrubber is _____.

   a. 0.01 to 0.1 microns
   b. 0.1 to 0.2 microns
   c. 0.2 to 0.5 microns
   d. 0.5 to 1.0 microns
   e. 1.0 to 2.0 microns

2. The dominant collection mechanisms in wet scrubbers include _____.

   a. Brownian diffusion
   b. electrostatic attraction
   c. sieving
   d. impaction

3. Corrosion in wet scrubbers fabricated of carbon steel occurs rapidly when the pH is in the range of _____.

   a. 4 to 8
   b. 0 to 6
   c. 7 to 14
   d. 14 to 28

4. The liquor flow rate in the recirculation line is usually measured by the following portable gauges during an inspection:

   a. inductance ammeter
   b. thermocouples
   c. pitot tube
   d. none of the above

5. Demister pluggage is usually caused by _____.

   a. inadequate cleaning of the demister
   b. excessive gas velocity through the demister
   c. high suspended solids in the recirculation liquor
   d. low pH
   e. high pH

6. Typical gas velocities through a demister are _____.

   a. 1 to 5 feet per second
   b. 5 to 20 feet per second
   c. 20 to 40 feet per second
   d. greater than 40 feet per second

7. Scaling in a wet scrubber is frequently caused by _____

   a. rusting of the carbon steel shell
   b. low pH
   c. pH levels above 11

8. The compliance status of a wet scrubber can be determined based on _____.

   a. the opacity
   b. the contact power level
   c. the Method 5 mass emission rate
   d. the pressure drop
   e. all of the above

9. Evaporation of atomized liquor droplets in the inlet of a venturi scrubber could lead to _____.

   a. particle agglomeration
   b. particle regeneration
   c. increased mass emissions from the system
   d. increased suspended solids levels in the recirculation liquor

10. Pressure drop in a venturi scrubber occurs because _____.

    a. acceleration of the liquor injected into the throat
    b. acceleration of the gas in the throat
    c. wall friction
    d. impaction of the particles into the droplets

11. Outlet static pressure of a venturi scrubber should be evaluated at the _____.

    a. a point directly downstream of the throat
    b. a point approximately halfway down the diverging section of the venturi
    c. a point near the elbow leading to the cyclonic separator
    d. a point following the demister
    e. none of the above

12. A make-up stream is necessary to _____.

    a. replace water lost due to evaporation
    b. replace liquor in the recirculation line
    c. replace liquor used in the demister flush system
    d. replace liquor lost in the purge stream

13. The use of liquor with high levels of suspended and dissolved solids in the presaturator could potentially lead to _____.

    a. particle agglomeration
    b. scaling in the presaturator
    c. particle regeneration
    d. demister pluggage

14. Alkaline additives are used in wet scrubbers to _____.

    a. reduce scaling potential
    b. increase the pH
    c. reduce corrosion
    d. none of the above

15. Nozzle pluggage in spray tower scrubbers is often due to _____ _____.

    a. scale from corroded pipes
    b. high suspended solids in the recirculation line
    c. operation at low pH
    d. none of the above

16. The collection efficiency of particles which form from the condensation of vapors in the throat of a venturi scrubber is usually _____.

    a. low
    b. high

17. The overall penetration through a scrubber with a collection efficiency of 98% is _____.

    a. 0.01
    b. 0.02
    c. 1
    d. 2
    e. 0.98
    f. none of the above

18. Most venturi scrubbers for particulate control operate at a liquid-to-gas ratio of _____.

    a. 0 to 2 gallons per 1000 ACF
    b. 2 to 5 gallons per 1000 ACF
    c. 5 to 20 gallons per 1000 ACF
    d. 20 to 50 gallons per 1000 ACF

19. Packed tower scrubbers are used primarily for _____.

    a. removal of particles in the 1 to 5 micron size range
    b. absorption of gases
    c. humidification
    d. removal of particles in the 0.1 to 1.0 micron size range

20. The liquor recirculation rate can sometimes be qualitatively evaluated by _____.

    a. observing the length of the steam plume
    b. observing the rate of discharge from the sump to the recirculation tank
    c. measuring the pump R.P.M.
    d. none of the above

21. Most particle impaction occurs in _____ of a venturi scrubber.

    a. the converging section
    b. the throat
    c. the diverging section
    d. the cyclonic separator
    e. the demister

22. A flooded elbow in a venturi scrubber is used primarily to _____.

    a. minimize the potential of sump overflow
    b. minimize erosion at the bottom of the venturi
    c. improve particle collection efficiency in the cyclonic separator
    d. none of the above

23. Collection efficiency of a venturi scrubber can usually be improved by _____.

    a. increasing the liquid-to-gas ratio
    b. increasing the length of the venturi throat
    c. increasing the gas velocity through the venturi throat
    d. all of the above
    e. none of the above

24. Corrosion of scrubbers may be minimized by _____.

    a. using alkaline additives
    b. maintaining the pH at low levels
    c. use of protective liners
    d. none of the above

25. Corrosion of scrubbers is accelerated by _____.

a. potassium in the scrubbing liquor
b. chlorides in the scrubbing liquor
c. sodium in the scrubbing liquor
d. iron in the scrubbing liquor
e. all of the above

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Wet Scrubber Manual	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook	Page(s) in Supplemental References
1. c	2-12 to 2-13	4-1	40 to 41	#1 Sections 4.3.3 and 5.3
2. a,d	2-10 to 2-11	4-1	41 to 41	#1 Sections 4.3.3 and 5.3
3. b	3-3	4-12	47	#3 7 to 40
4. d			43 to 46 61 to 64	#2 All
5. a,c,e	4-7	4-11,4-7	46,64	#4 xv to xix
6. b				#4 All
7. c				
8. a,c		1-1		
9. b,c	2-15 to 2-16	4-12		#5 4.5-37
10. a,b,c	2-17			#6 36 to 40
11. d	4-8			
12. a,d	2-6			
13. c	2-15 to 2-16	4-12		
14. b,c	2-7			
15. a,b	4-22			
16. a	2-17			
17. b	A-1 to A-5			
18. c	2-38			
19. b,c	4-23	4-4	59	
20. d			45,63	

Question Number and Answer	Page(s) in Wet Scrubber Manual	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook	Page(s) in Supplemental References
21. b	4-29	4-5	41	#6 61 to 110
22. b	4-35			
23. b,c	2-10 to 2-12 2-37 to 2-38			#6 61 to 110
24. a,c	3-3	4-12	47,54,64	#3 34 to 39
25. b				#3 34

LESSON 6

Inspection and Evaluation of Mechanical Collectors

Reading Assignments

Baseline Manual, Chapter 5.

Field Inspection Notebook, pages 32 to 39.

Reading Assignment Topics

- The components and operating principles of cyclones and multiple cyclone collectors.
- The importance of particle size on the collection efficiency of mechanical collectors.
- The importance of gas flow rate on the collection efficiency of mechanical collectors.
- Technique for correcting measured pressure drop back to standard conditions in order to evaluate shifts from baseline operating conditions.
- Techniques for evaluating air infiltration into mechanical collectors.
- General inspection points for mechanical collectors.

Learning Goal and Objectives

Learning Goal

To familiarize you with the basic operating principles of cyclone and of multiple cyclone type mechanical collectors, and to familiarize you with an effective methodology for inspecting these devices.

Learning Objectives

When you have completed this lesson, you should:

1. Know what the inspection data is necessary to complete a detailed evaluation of a mechanical collector.
2. Understand what portable instruments are needed and when they should be used.
3. Understand how to correct the observed pressure drop for the present gas density and gas flow rate.

4. Understand how to recognize the common operating problems of mechanical collectors.

5. Understand the major factors which influence the collection efficiency of mechanical collectors.

Reading Guidance

- Only cyclones and multiple cyclone type collectors are addressed in this lesson. For information concerning other types of mechanical collectors refer to the Particulate Control Techniques Document, Second Edition, Section 4.2 (see Supplemental References).

- The inspection procedures and the evaluation techniques rely on measurements of the static pressures, gas temperatures, and gas stream oxygen concentrations. A large number of existing units do not have measurement ports which can be used to obtain this data. Many also do not have an operating differential pressure gauge. Without these measurement ports and instruments the inspection is limited simply to the stack opacity. This, unfortunately, can be misleading since on many sources the mass emissions may be high while the opacity is in the moderate to low range.

- Some mechanical collectors do have measurements ports before and after the collector, however, they are located in areas where there is poor access and a potential for burns. For example, there are some mechanical collectors which are located just above the steam drum area of a stoker fired boiler. In these dimly lit and limited access areas, it is sometimes risky to attempt to measure the collector operating parameters. Unless there is safe and convenient access to the measurement ports, the measurements should not be made.

- It is important to correct all static pressure drop measurements back to a standard temperature and gas flow rate. The procedure for making the necessary corrections should be read carefully.

- When you have finished the reading assignment, complete the review exercise for Lesson 6. It begins on the page following the Supplemental References.

- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to Quiz 2 and then Lesson 7 of this guidebook.

Supplemental References

1. Control Techniques for Particulate Emissions from Stationary Sources - Volume I, U.S. Environmental Protection Agency Publication EPA-450/3-81-005a, September 1982.

2. Industrial Ventilation, Sixteenth Edition. Published by the American Conference of Governmental Industrial Hygienists, Lansing Michigan. 1980.

Review Exercise

1. The principal mechanism used to separate particles from the gas stream in a mechanical collector is _____.

   a. Brownian diffusion
   b. inertia
   c. diffusiophoresis
   d. thermophoresis
   e. all of the above

2. The typical tube diameters of cyclone tubes in multi-cylcone collectors ranges from _____ to _____ inches.

   a. 1 to 12
   b. 3 to 36
   c. 3 to 12
   d. 12 to 36
   e. none of the above

3. As the gas flow rate decreases from design levels, the particulate matter collection efficiency increases (assume all other factors remain constant).

   a. true
   b. false

4. In multiple cyclone type collectors the vortex in the individual tubes is created by _____.

   a. by the tangential inlets
   b. by the axial inlets and spinner vanes
   c. by the rotary discharge valve

5. When large diameter cyclones are operated at gas flow rates above the design level, the collection efficiency usually _____.

   a. usually decreases due to increased turbulence within the cylindrical section of the cyclone tube
   b. remains at approximately the same efficiency as when the gas flow rate is at the design flow rate
   c. usually increases due to enhanced inertial separation

6. Some of the operating problems common to multiple cyclone type collectors include the following:

   a. air infiltration
   b. inlet vane pluggage
   c. dust discharge tube pluggage
   d. outlet tube pluggage
   e. maldistribution of gas
   f. hopper recirculation
   g. corrosion
   h. poppet valve failure
   i. outlet tube erosion
   j. all of the above

7. The static pressure drop across a cyclone tube is proportional to the _____ of the gas flow rate.

   a. cube
   b. square
   c. square root
   d. log
   e. none of the above

8. In order to evaluate the pressure drop across a multiple cyclone type collector the following data is necessary:

   a. the gas temperature
   b. the gas stream O_2 content
   c. the inlet static pressure
   d. the outlet static pressure
   e. the gas flow rate
   f. the inlet mass concentration
   g. all of the above

9. Possible ways to estimate the present gas flow rate through a mechanical collector serving a coal-fired boiler include the following:

   a. pitot tube
   b. Fyrite® analyzer
   c. estimate using the boiler steam rate
   d. all of the above

10. If the corrected pressure drop value is higher than the corrected baseline pressure drop, the following conditions are possible:

    a. pluggage of the inlet vanes
    b. erosion of the outlet tube extension
    c. weld failure on the clean side tube sheet
    d. pluggage of the outlet tube
    e. pluggage of the solids discharge hole
    f. air infiltration

11. Techniques to evaluate air infiltration on mechanical collectors serving boilers includes the following:

    a. listen for audible leaks
    b. look for cracks or weld gaps in the shell
    c. look for missing solids discharge valves
    d. evaluate inlet and outlet O_2 concentrations

12. Opacity spikes at the exit of a mechanical collector usually suggest the following:

    a. excessive rapping intensities
    b. vibration of the spinner vanes
    c. intermittant process related conditions
    d. all of the above

13. Deformation of the hopper walls on a multiple cyclone type collector often suggests _____.

    a. solids discharge problems
    b. previous hopper fires
    c. aggressive maintenance personnel
    d. frustrated maintenance personnel
    e. all of the above

14. Internal inspections of multiple cyclone collectors should be done _____.

    a. by inspectors whenever the corrected pressure drop suggests pluggage problems
    b. by inspectors whenever the O_2 levels increase by more than 1% going from the inlet to the outlet
    c. by operators whenever there are symptoms of major operating problems and the proper lockout procedures have been followed
    d. by operators on at least an annual basis

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook	Page(s) in Supplemental References
1. b	5-1	33	#1 Section 4.2.1
2. c	5-3	33	
3. b	5-2	33	#1 4.2-25
4. b	5-3	32	
5. a	5-2		
6. a,b,c,d e,f,g,i	5-3 to 5-4	37 to 39	#1 4.2-31 to 4.2-33
7. b	5-4	37	#2 6-14
8. a,c,d,e	5-4	37	
9. a,c		37	
10. a,d		39	
11. a,b,c,d	5-4	37 to 38	
12. c		36	
13. e		38	
14. c,d	5-5	38 to 39	

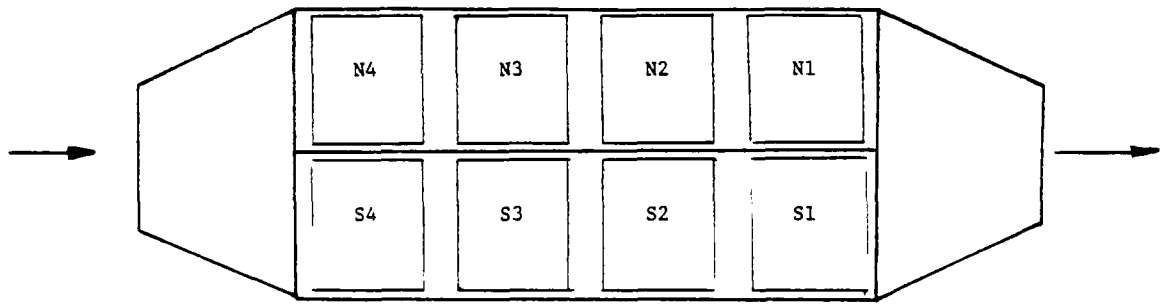
QUIZ 2

The self-administered and self-graded quiz covers the material presented in Lessons 4 through 6. It introduces the type of questions and problems which will appear on the final and is open book. The final, however, will only allow use of the Field Inspection Notebook. Access to a calculator for both the quiz and final will be helpful.

The quiz consists of 25 multiple choice questions and problems. There may be more than one correct answer for each question. You should use a separate sheet of paper to record your answers and scratch paper to work the problems. The answers can be found on the page following the last question.

1. There is a two chamber electrostatic precipitator having four fields in series. The Transformer-Rectifier set numbering system is shown on the sketch provided below. In what order should the electrical data be recorded on the inspection notes?

   a. the way the cabinets are laid out in the control room or substation
   b. S1, S2, S3, S4, N1, N2, N3, N4
   c. S4, S3, S2, S1, N4, N3, N2, N1
   d. N1, S1, N2, S2, N3, S3, N4, S4
   e. none of the above



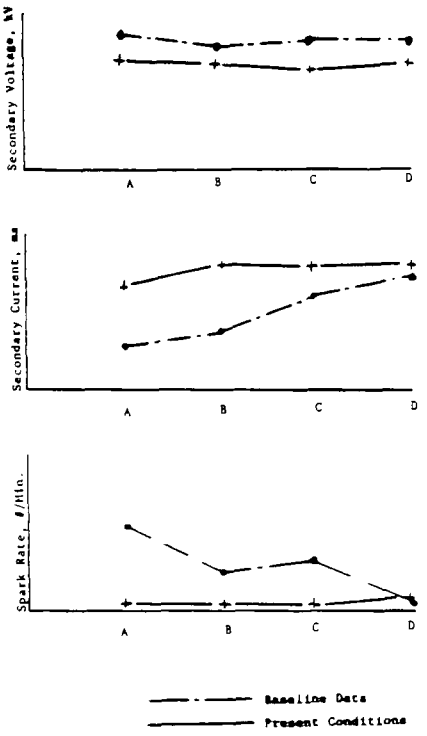
2. The following electrical data was recorded during an inspection. What is the total power input to this one chamber unit? (Use a spark rate of 35 in each field, a power factor of 0.75, a gas temperature of 350°F, gas stream flow rate of 250,000 ACFM, if necessary to complete the calculations.)

   a. 484 watts/1000 ACFM
   b. 2417 watts/1000 ACFM
   c. 2860 watts/1000 ACFM
   d. 3813 watts/1000 ACFM

Field	Primary Voltage, Volts, A.C.	Primary Current, Amps, A.C.	Secondary Current, Milliamps, D.C.
1	259	128	730
2	298	228	1370
3	260	232	1370

3. The electrical data from a one chamber electrostatic precipitator has been plotted below. What does the data suggest?

   a. the rappers are obviously not operating properly
   b. the dust resistivity has increased since the baseline period
   c. the boiler load has decreased
   d. one or more fields has serious malalignment problems
   e. the dust resistivity has decreased since the baseline period



4. Rappers are often used on which of the following components of an electrostatic precipitator system?

   a. collection plates
   b. discharge electrodes
   c. insulators
   d. gas distribution plates
   e. transformer-rectifier sets

5. The gas flow through an electrostatic precipitator is 275,000 ACFM and the unit has the following dimensions: length 50 feet, height 36 feet and width 25 feet. What is the superficial veloci through the treatment zone (velocity across the face of the ESP)?

   a. 3.67 feet per second
   b. 5.09 feet per second
   c. 2.55 feet per second
   d. none of the above
   e. it cannot be calculated using only the data given

6. One field of an electrostatic precipitator had the following operating conditions: secondary voltage 43 KV, secondary current 520 milliamps, spark rate 10 per minute. What is the power input from this one field? (Use the following data if necessary to complete the calculations: power factor 0.75, gas temperature 320°F.)

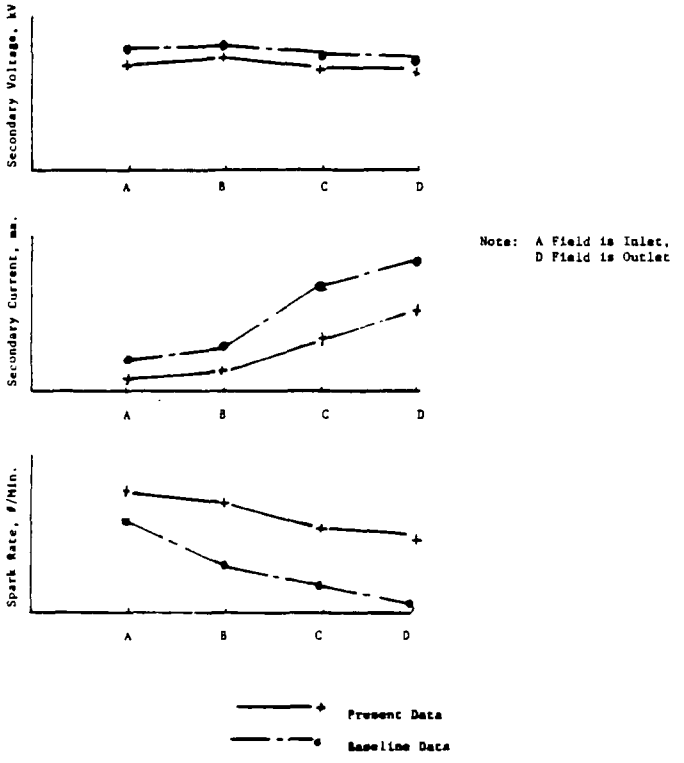
   a. 16,770 watts
   b. 16.8 kilowatts
   c. 22,360 watts
   d. 2.24 kilowatts

7. The power input is a useful parameter to evaluate the operating conditions of the electrostatic precipitator only when the following are true:

   a. the resistivity is in the low to moderate range
   b. the resistivity is in the moderate to high range
   c. the gas velocity is below 3 feet per second
   d. the gas velocity is between 3 and 8 feet per second
   e. the gas velocity is above 8 feet per second

8. During an inspection the electrical data from an electrostatic precipitator was plotted as shown below. What would be suspected from this data?

   a. the fuel sulfur content has decreased substantially
   b. the dust resistivity has increased since the baseline period
   c. the collection plate rappers are not working properly
   d. the gas velocity has increased substantially



9. When the dust resistivity is low there is increased potential for the following:

   a. hopper overflow
   b. rapping reentrainment
   c. hopper boilover
   d. reduced secondary currents
   e. increased spark rate

10. The secondary voltage is the voltage on the _____.

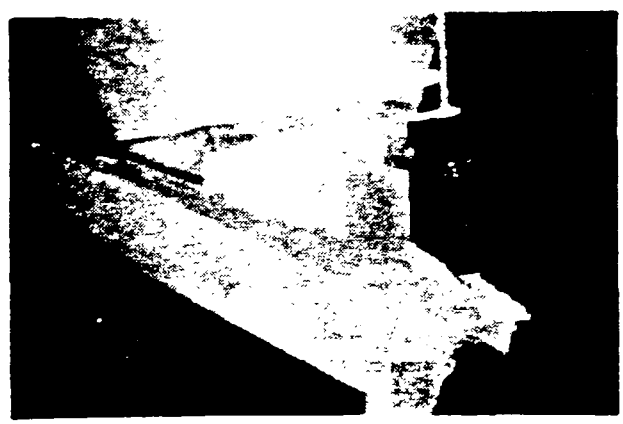
   a. collection plate
   b. discharge electrode
   c. rapper
   d. linear reactor

11. During the inspection of an electrostatic precipitator, it is noticed that there is a 40% opacity puff every five minutes. What should the inspector check?

   a. the rapping frequency
   b. the rapping intensities
   c. the general range of the dust resistivity
   d. the purge air blowers for the insulators
   e. air infiltration through the hopper hatches

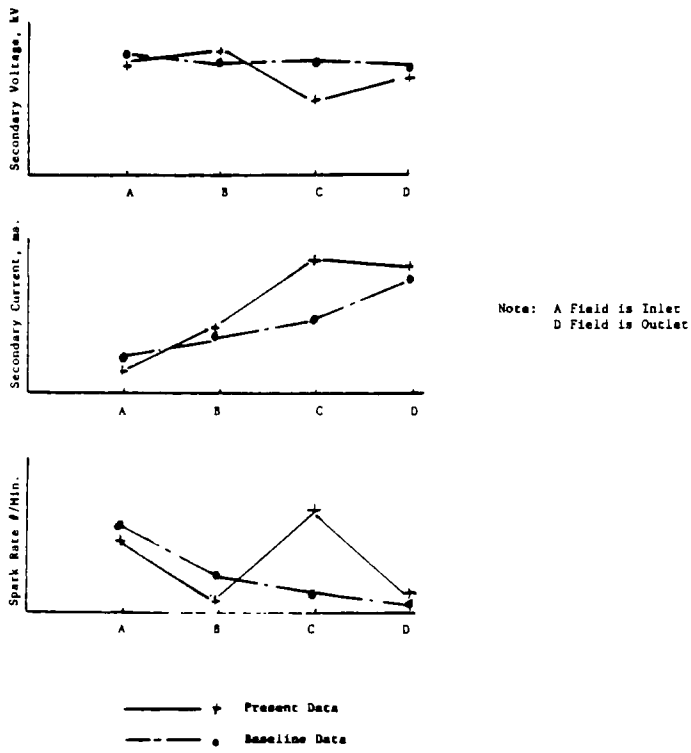
12. The photograph below shows the bottom section of a hopper on an electrostatic precipitator. This unit serves a municipal incinerator. The fan for the system is downstream of the precipitator, therefore, there is a slight negative pressure on the precipitator. There is no dust discharge valve on the hopper and the screw conveyor. What problems, if any, could this cause?

   a. increased dust resistivity in the part of the precipitator directly above this hopper
   b. dust discharge problems caused by the inrushing ambient air
   c. corrosion of the collection plates and discharge electrodes due to the condensation of vaporous material directly above this hopper
   d. deposits on the high voltage insulators
   e. corrosion of the Transformer-Rectifier sets



13. During an inspection of an electrostatic precipitator, the following plots of the electrical data were prepared. What is the most likely explanation of the conditions shown?

a. an increase in the dust resistivity
b. a decrease in the dust resistivity
c. an internal problem in field 3
d. an advanced voltage controller in field 3
e. none of the above



14. An internal inspection of an electrostatic precipitator should be conducted by an agency inspector when _____.

a. there are indications of misaligned plates and wires based on the secondary voltages and currents
b. there are indications of poor gas distribution and the source is making major modifications to the precipitator inlet
c. there are symptoms of rapping reentrainment
d. the operator has reported severe corrosion problems
e. when hell freezes over

15. What would be the expected pressure drop during the inspection assuming that the condition of the mechanical collector was identical to that during the baseline stack test? (Assume a flue gas moisture content of 0.1 pounds per pound of dry air.)

    a. 1.45" of water
    b. 2.40" of water
    c. 3.80" of water
    d. 4.00" of water

16. During the inspection of a mechanical collector serving a spreader stoker type boiler, the following data is obtained: Inlet Static Pressure -2.1 inches, Inlet O_2 12.6%, Inlet CO_2 6.5%, Inlet Temperature 380°F, Outlet Static Pressure -5.6 inches, Outlet O_2 13.2%, Outlet CO_2 6.2%, Outlet Temperature 366°F. What should be the main focus of the inspection based on this data?

    a. the measurements should be repeated since the data is obviously in error
    b. checks should be made to locate where the ambient air is infiltrating into the mechanical collector
    c. the boiler should be inspected to determine why the excess air rate is so high
    d. an internal inspectionn of the mechanical collector should be conducted

17. Erosion of the outlet tube extensions on a multiple cyclone type collector would cause which of the following problems:

    a. increased static pressure drop
    b. air infiltration
    c. reduced static pressure drop
    d. increased opacity
    e. decreased opacity

18. A packed tower wet scrubber is generally used for _____.

    a. collection of submicron particulate matter
    b. collection of particulate matter in sources with high mass concentrations
    c. gas pollutant absorption
    d. collection of sticky aerosols

19. The most useful parameter for correlating scrubber particulate removal efficiency is the following:

    a. pressure drop divided by the gas temperature (average of inlet and outlet)
    b. pressure drop
    c. pressure drop divided by the gas density (average of inlet and outlet)
    d. pressure drop divided by the gas velocity (average of inlet and outlet)
    e. relative motion of the stars and planets

20. The primary physical mechanism used to collect particles in wet scrubbers is the following:

    a. gravity settling
    b. interception
    c. impaction
    d. electrostatic attraction
    e. diffusiophoresis
    f. thermophoresis

21. During an inspection of a wet scrubber system, it is noticed that the I.D. fan is vibrating severely. What should the inspector do?

    a. first, evaluate conditions which could lead to build up of material on the fan, such as poor demister operation
    b. carefully measure the fan R.P.M. and motor current
    c. check the outlet damper position
    d. leave the area immediiately
    e. leave the area immediately and notify a responsible plant official of the fan condition

22. Specify the two conditions which must exist in order for there to be regeneration of aerosols in a particulate wet scrubber.

    a. low pressure drop and low liquor flows
    b. erosion of the pump impeller and high pressure spray nozzles
    c. high liquor total solids and evaporation of some droplets to dryness
    d. precipitation of solids out of solution of a low pH

23. An inspection of a multiple cyclone type collector serving a coal-fired boiler yielded the following data. The baseline data came from a stack test conducted several years before the inspection. Based on the data, what conclusions can be made without making any calculations (assume gas flow rate is proportional to steam rate).

Inspection Data		Baseline Data	
Inlet Static Pressure:	-2.8"	Pressure Drop:	4.0 inches
Outlet Static Pressure:	-6.6		
Inlet Gas temperature:	412°F	Inlet Gas Temperature:	Not measured
Outlet Gas Temperature:	403°F	Stack Temperature:	426°F
Inlet O_2:	7.4%	Inlet O_2:	Not recorded
Outlet O_2:	8.0%	Stack O_2:	8.2%
Inlet CO_2:	12.3%	Inlet CO_2:	Not recorded
Outlet CO_2:	12.0%	Stack CO_2:	11.3%
Boiler Steam Flow:	60,000 Lbs/hr	Boiler Steam Flow:	100,000 Lbs/hr

    a. the resistance to gas flow is substantially higher, therefore, there may be some pluggage of the spinner vanes or the outlet tube
    b. the resistance to gas flow is substantially lower, therefore, there may be some erosion of the outlet tube extensions
    c. there are signs of severe air infiltration
    d. no conclusions can be reached since the baseline data set is incomplete

24. Alkaline material is often injected into wet scrubber systems for the following reason _____.

    a. to reduce corrosion
    b. to provide a convenient disposal means for unwanted waste materials
    c. to prevent erosion of spray nozzles
    d. none of the above

25. The pH measured in the scrubber sump was 4.2. If the scrubber is made of carbon steel is there reason for concern?

    a. no
    b. yes

LESSON 7

Inspection and Evaluation of Carbon Bed Adsorbers

Reading Assignment

Baseline Manual, Chapter 6.

Reading Assignment Topics

- o Basic operating principles of carbon bed adsorbers.
- o Basic configuration of carbon bed systems.
- o Carbon bed system modes of failure.
- o Methods of evaluating adsorption efficiency.
- o Visual inspection techniques.

Learning Goal and Objectives

Learning Goal

To familiarize you with the basic operation of a carbon bed adsorption system and with several readily available techniques which may be used to evaluate the effectiveness of operating systems.

Learning Objectives

When you have completed this lesson, you should be able to:

1. Draw a schematic of a typical carbon adsorption system and explain its basic operation.
2. Explain what "breakthrough" is.
3. Discuss how carbon adsoprtion systems are controlled.
4. Describe three methods to evaluate the current efficiency of an operating carbon adsorption system.
5. Enumerate several visual inspection points for carbon bed adsorbers.

Reading Guidance

- o The carbon bed adsorption system inspection techniques presented in the reading are indications of present system efficiency; they are not strict tests of compliance with regulations.

- In evaluating a carbon bed adsorber, the agency inspector should always be accompanied by one or more plant representatives (ideally including the system operator) to assist in locating system components, explaining current process parameters, and identifying safety hazards.

- When you have finished the reading assignment, complete the review exercise for Lesson 7. It begins on the following page.

- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading asssignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to Lesson 8 of this guidebook.

Review Exercise

1. Carbon adsorption is a technique used for the removal of particulate matter and organic vapors from a gas stream.

   a. true
   b. false

2. The adsorption process is made possible by the following properties of the carbon adsorbant:

   a. porosity
   b. capillary action
   c. secondary bonding to organics
   d. high ratio of surface area to volume
   e. all of the above
   f. none of the above

3. Breakthrough control of carbon bed regeneration/adsorption cycles uses an operator set time period for the adsorption cycle.

   a. true
   b. false

4. In the regeneration process, the organics are desorbed from the carbon by passing steam or hot gases through the bed countercurrent to the flow of gases during adsorption.

   a. true
   b. false

5. Regulatory agency personnel can generally detect the following failure modes in carbon bed adsorption systems:

   a. insufficient steam flow compared to design value
   b. improper setting of system controls
   c. loss of carbon activity
   d. poor steam distribution
   e. probable decrease in efficiency compared to original efficiency

6. It is important that an overall system material balance be taken over a time period long enough to smooth out variability in solvent and material usage and solvent recovery.

   a. true
   b. false

7. Corrosion in the steam exhaust piping of an adsorber can be caused by _____.

   a. superheated steam
   b. acid formed by the combination of steam and organics
   c. abrasive particulate in the exhaust gas stream
   d. additives at the condensor

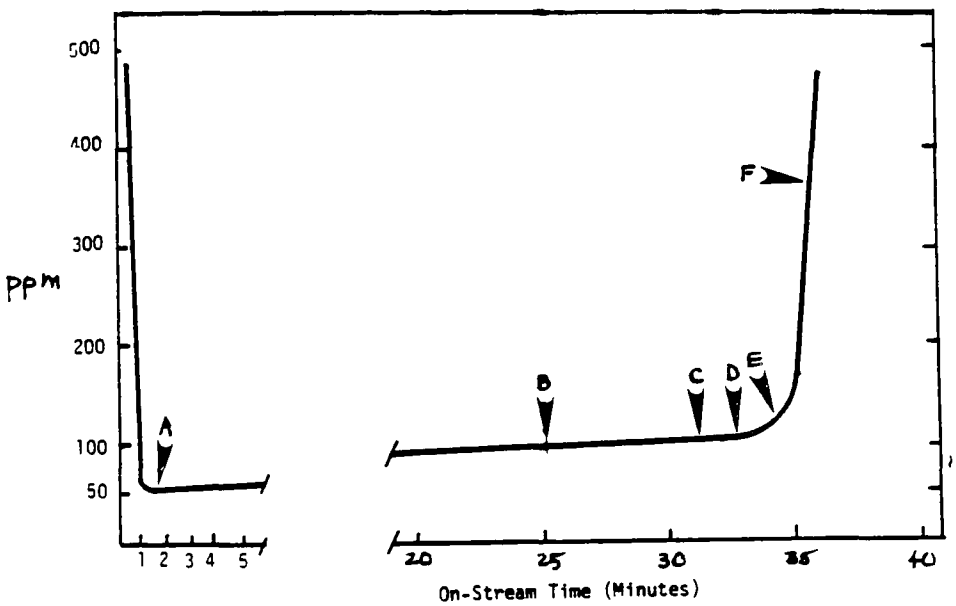
8. During an inspection of a carbon bed adsorption system, plant personnel informed the inspector that 500 lbs. of solvent were recovered for every 2,000 # of steam used. When the system was first installed it was recovering 350 lbs. for every 1,000 # of steam. If the inspector assumes a constant solvent input into the system and constant adsorption cycles he would conclude that _____ _____.

   a. there has been an increase in collection efficiency
   b. there has been a decrease in collection efficiency
   c. there has been no change in collection efficiency

9. An operator should consider readjusting adsorption/regeneration cycle times _____.

   a. if breakthrough is detected
   b. when a visit from the agency inspector is expected
   c. when there is a change in plant operating conditions
   d. only if the system utilizes breakthrough control

The figure below shows the discharge concentration vs. time for a carbon bed. Refer to it to answer Questions 10 through 12.



10. Breakthrough occurs at the point labeled _____.

    a. A
    b. B
    c. C
    d. D
    e. E
    f. F

11. A reasonable adsorption cycle time for this bed in a system with set cycle automatic control would be _____.

    a. 15 minutes
    b. 25 minutes
    c. 30 minutes
    d. 35 minutes
    e. all of the above
    f. none of the above

12. An instrument to be used to detect organics in the discharge gas stream for this system should measure accurately in the _____.

    a. 0-20 ppm range
    b. 0-50 ppm range
    c. 0-200 ppm range
    d. 200-1000 ppm range

Klean Coaters is able to provide the following process and solvent recovery data for one line in its plant controlled by a carbon bed system.

solvent A: purchased is 400 lbs./month
coating b: contains 40% solvent
purchased is 200 gals/month
density is 6 lbs./gal
solvents recovered: 1,613 lbs./month
recovered solvent sold: 813 lbs./month

13. Using an overall system material balance an estimate of Klean Coaters carbon system efficiency is:

    a. 90%
    b. 92%
    c. 96%
    d. 98%

14. Klean Coaters recycles approximately ____ percent of the solvents from their recovery system.

    a. 35%
    b. 50%
    c. 75%
    d. none of the above

Refer to the schematic of a typical carbon bed adsorption system (on the following page) to answer Questions 15 through 17.

15. Because this system is under _____ pressure, the inspector _____ be concerned with gas leakage from sampling ports and/or ductwork.

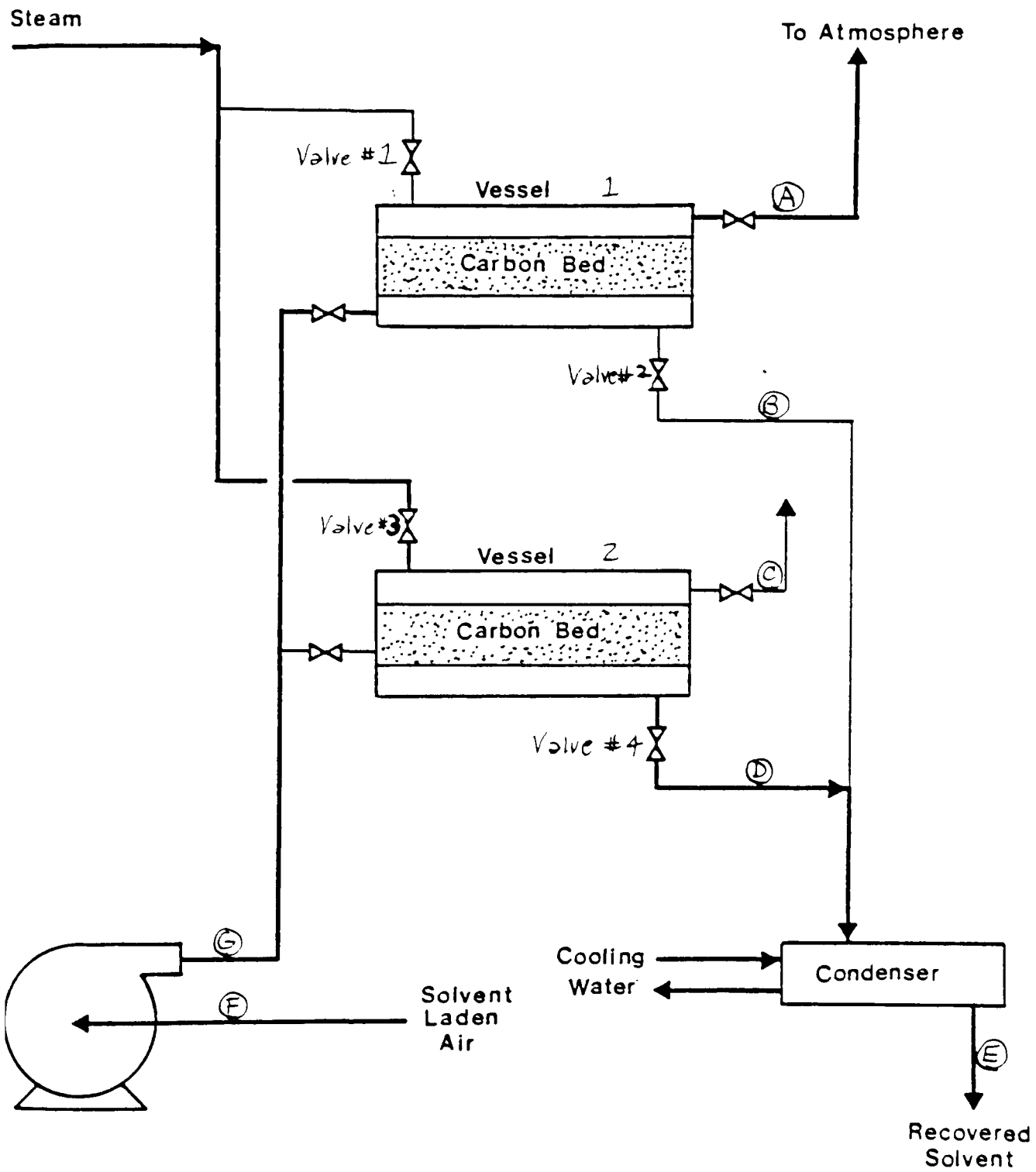
    a. negative, should not
    b. negative, should
    c. positive, should not
    d. positive, should

16. Discharge monitoring would most likely be accomplished at _____.

    a. point A
    b. point B
    c. point C
    d. point D
    e. point E
    f. points A and C
    g. points B and D
    h. none of the above

17. If valves #1 and #2 are open then Vessel 2 must be _____.

    a. in the cooling and drying cycle
    b. in the adsorption cycle
    c. in the regeneration cycle
    d. off-line


Steam
To Atmosphere
Valve #1
Vessel 1
Carbon Bed
A
Valve #2
B
Valve #3
Vessel 2
Carbon Bed
C
Valve #4
D
G
F
Solvent Laden Air
Cooling Water
Condenser
E
Recovered Solvent

Revciew Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Baseline Manual
1. b	6-1
2. e	6-1
3. b	6-4
4. ~~c~~	~~6-1 to 6-4~~
5. a, b, e	6-4 to 6-~~8~~
6. ~~b~~	6-~~7~~
7. d	~~6-7~~
8. ~~a, c~~	6-7
9. ~~d~~	~~6-1,~~
10. ~~c~~	6-1 ~~to~~ 6-4
11. ~~f~~	6-1 to 6-4
12. ~~c~~	~~6-~~
13. c	~~6-6~~
14. d	~~6-6~~
15. d	general
16. f	6-5
17. b	6-1 to 6-4
~~18. a~~	~~6-1~~
~~19. a~~	~~6-5~~

LESSON 8

Inspection Safety

Reading Assignments

Baseline Manual, Chapter 11, Appendix D, and Appendix E.

Field Inspection Notebook, inside front and back covers and page 68.

Reading Assignments Topics

- Potential hazards of inspecting air pollution control equipment.
- Recognition of and dealing with potential hazards.
- Personal protective equipment.
- Confined and partially confined area entry.
- Relationship between agency safety procedures and plant safety requirements.

Learning Goal and Objectives

Learning Goal

To familiarize you with the potential safety hazards encountered in inspecting industrial plants and the procedures required to properly minimize these hazards.

Learning Objectives

When you have completed this lesson, you should be able to:

1. Describe the hazards involved in moving from one place to another in an industrial plant.
2. List at least ten nonspecific symptoms of exposure to air contaminants.
3. Recognize the importance of personal protection equipment for a variety of inspection situations.
4. Explain considerations in the selection and use of respiratory protection.
5. Discuss the hazards involved in confined and partially confined area entry, particularly as related to air pollution control equipment.

6. Explain the significance of using probe grounding techniques in sampling process gas streams.

7. Briefly describe the consequences of heat and cold stress.

8. Explain the safety considerations for working near nuclear type detectors.

Reading Guidance

- The reading assignments for this lesson were written for both regulatory agency and plant maintenance personnel. Regulatory agency personnel should be aware that some procedures are not recommended for them such as confined area entry and have been presented only as guidance for maintenance personnel.

- It is not possible in these reading assignments to cover every possible hazard in an industrial plant, rather the information has been developed to aid inspection and maintenance personnel in considering and handling the possibilities. Every plant situation is different and warrants separate considertion.

- One point that cannot be overemphasized is that, in the process of evaluating air pollution control equipment performance, inspection and maintenance personnel must constanting be alert to their surroundings and current situation in order to recognize potential or imminent hazards.

- It is also important to stress the observation of all plant safety rules, knowledge of plant emergency procedures, and, for inspection personnel, having a plant official accompanying you on the inspection to aid in forseeing hazards and to assist in an emergency.

- When you have finished the reading assignment, complete the review exercise for Lesson 8. It begins on the following page.

- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to Lesson 9 of this guidebook.

Review Exercise

1. The following symptoms may indicate exposure to air contaminants:

   a. headache
   b. drowsiness
   c. shortness of breath
   d. nausea
   e. loss of coordination
   f. eye irritation
   g. all of the above
   h. none of the above

2. Static electricity is especially likely following _____.

   a. a wet scrubber
   b. a fabric filter collection dry dust
   c. electrostatic precipitation
   d. mechanical collection
   e. all of the above

3. Hearing protection is necessary whenever normal conversation cannot he heard at a distance of _____ feet.

   a. 1
   b. 2 or 3
   c. 5
   d. 10

4. Most types of hearing protection reduce noise intensity in the 1000 Hz to 4000 Hz range by _____.

   a. 5 to 10 dB
   b. 10 to 25 dB
   c. 30 to 50 dB
   d. 50 to 75 dB

5. Fan disintegration can be caused by _____.

   a. operating at excessive tip speeds
   b. operating out of balance due to build-up of material or erosion of the fan wheel
   c. operating at high gas temperatures

6. At high concentrations hydrogen sulfide has _____ odor.

   a. a rotten egg
   b. a sewer
   c. a fragant
   d. no

7. If an inspector experiences the nonspecific symptoms of exposure to gases and vapors, he or she should _____.

   a. discuss the potential exposure with plant personnel
   b. continue with the inspection until more definite symptoms develop
   c. leave the area immediately and reevaluate the conditions
   d. all of the above

8. Cartridge type respirators are usually rated at _____.

   a. concentrations twice on PEL
   b. concentrations five times the PEL
   c. concentrations ten times the PEL
   d. concentrations fifty times the PEL

9. When climbing ladders, inspectors should keep their hands on the _____.

   a. side rails
   b. foot rails
   c. either

10. The use of hearing protection in high noise areas hinders normal communication.

    a. true
    b. false

11. Common "partially" confined areas include _____.

    a. walkways between large control systems
    b. weather enclosures around hoppers
    c. weather enclosures around precipitator roofs
    d. pump houses
    e. fan houses
    f. mountings for continuous emission monitors
    g. all of the above

12. "Partially" confined areas are particularly dangerous when _____.

    a. the ducts or control equipment operate at positive pressure
    b. the gas streams contain asphyxiants and toxic agents
    c. the gas streams contain dusts and fumes
    d. all of the above

13. Before inserting a probe into a gas stream it is important to check _____.

    a. that the grounding cable is in good physical condition
    b. that the ground clamp does not interfere with the probe
    c. that the clamp has penetrated any paint or corrosion layer on the grounding point
    d. all of the above

14. Ionizing radiation may be a problem around _____.

    a. electrostatic precipitator rappers
    b. continuous emission monitors
    c. damaged hopper level monitors
    d. electrostatic precipitator electrical cabinets

15. Falls may be caused by _____.

    a. slippery surfaces around wet scrubbers
    b. climbing ice covered ladders
    c. crossing roofs with heavy accumulations of snow or solids
    d. protruding equipment in dimly lit areas
    e. all of the above

16. Prior to using a respirator, an inspector should _____.

    a. be trained in the selection and use of respirators
    b. be trained in the maintenance of respirators
    c. have a physical examination
    d. all of the above

17. When selecting what personal safety equipment is necessary during an inspection, an inspector should be guided by _____.

    a. what the plant representative and other plant personnel are using
    b. plant policies
    c. agency policies
    d. common sense

18. Exposure to particulate and gaseous contaminants often may result from _____.

    a. downwash of effluent from short stacks
    b. fugitive leaks from ducts and hatches into partially confined areas
    c. fugitive leaks through open static pressure taps
    d. fugitive leaks around process equipment
    e. all of the above

19. Safety shoes should be worn _____.

    a. only when required by plant policies
    b. only when required by agency policies
    c. for all plant inspections
    d. when specifically required for plant entry

20. An inspector should not work alone during an inspection, unless _____.

a. plant personnel are too busy to accompany the inspector
b. the inspector is very familiar with the plant
c. no entry into partially confined or confined areas is anticipated
d. the inspector has all the necessary personal protection equipment
e. none of the above

21. Burns may be caused by _____.

a. contact with hot gas ducts
b. contact with measurement probes, such as pitot tubes
c. radiation from process equipment
d. high pressure steam leaks

22. High noise levels are frequently found near _____.

a. fans
b. pulse jet fabric filters
c. electrostatic precipitator rappers
d. process equipment such as compressors and grinding mills
e. rotary discharge valves

23. The suspension of the hard hat needs to be checked at least _____.

a. once a day
b. once a week
c. once a month
d. once a year
e. never

24. Most gaseous contaminants have good "warning properties" therefore the inspector is usually aware that they are present.

a. true
b. false

25. A self-contained rebreather is necessary whenever work is required around areas which _____.

a. have less than 19.5 % oxygen
b. have gaseous concentrations that exceed the safe limit of the cartridge and canister type respirators
c. have less than 16% oxygen
d. have less than 12% oxygen
e. have high carbon monoxide levels

26. The most common routes of entry of toxic compounds include _____ _____.

a. the eyes
b. the respiratory system
c. the skin
d. ingestion
e. all of the above

27. Hazards of opening access hatches include:

a. asphyxiation due to free flowing solids found in hoppers
b. positive pressure systems creating force on the interior of hatch
c. control device fires
d. burns from hot solids
e. hand injuries from "breaking the seal" of the hatch in a negative pressure system

28. Eye protection used during an inspection should conform with plant requirements. It is generally recommended that the inspector carry and use _____.

a. prescription glasses
b. safety glasses
c. flexible goggles
d. prescription or nonprescription safety glasses with side shields

29. Contact lenses should not be worn during inspections.

a. true
b. false

30. Respirator or gas mask cartridges and canister air purifying capabilities are identified by both worded labels and a color code.

a. true
b. false

31. The use of a respirator exposes a worker to additional stress.

a. true
b. false

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook
1. g	11-5 to 11-11	front cover
2. b,c	11-1, 11-15, 11-16	front cover
3. b	11-2, 11-3	front cover
4. c	11-2, 11-3	
5. a,b,d	11-2	
6. d	11-9	
7. c	11-2, 11-3	front cover
8. c	E-12	
9. b	11-12	front cover
10. b	11-12, 11-13	
11. g	11-17 to 11-21	front cover
12. d	11-17 to 11-21	front cover
13. c	11-15 to 121-17	
14. c	11-17, 11-18	back cover
15. e	11-6, 11-12	back cover
16. d	11-5 to 11-11 and D-1 to D-10	
17. b,c,d	11-1 to 11-21	back cover
18. e	11-1 to 11-21	
19. c	11-14	front cover
20. e		back cover
21. a,b,c,d	11-1, 11-2	
22. a,b,c,d	11-12	
23. c	11-13	
24. b	11-5 to 11-11	

Question Number and Answer	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook
25. a,b,c,d,e	11-5, 11-6, 11-18	
26. e	11-1, to 11-21	
27. a,b,c	11-2, 11-19	
28. c,d	11-13, 11-14	
29. a	11-14	front cover
30. a	D-8	
31. a	11-21	

LESSON 9

Visible Emission Observation

Reading Assignments

Baseline Manual, Chapter 10 and Appendix C.

Field Inspection Notebook, pages 77 and 78.

Reading Assignment Topics

- Opacity readings as a diagnostic tool.
- Effect of the angle of observation on the observed opacity.
- Factors which can interfere with opacity readings such as water vapor plumes, fugitive emissions, or detached plumes.
- Opacity-mass correlation.
- Effects of particle size.

Learning Goal and Objectives

Learning Goal

To familiarize you with the use of opacity observations as a diagnostic tool including certain procedures for making accurate readings and the limitations of the method.

Learning Objectives

When you have completed this lesson, you should be able to:

1. Explain the use of opacity as a diagnostic tool.
2. Discuss factors which can interfere with or affect opacity observations.
3. Know the general procedures for making opacity observations.
4. Explain the significance of opacity-mass correlations.

Reading Guidance

- The reading assignment focuses on the use of opacity as a diagnostic tool in evaluating control equipment performance and thus, does not cover in detail the procedures for making an opacity observation. It is therefore recommended that the reader who is not familiar with visible emission observation procedures consult Reference 1 of the supplemental references which covers them in detail.

- When you have finished the reading assignment, complete the review exercise for Lesson 9. It begins on the following page.

- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to Lesson 10 of this guidebook.

Review Exercise

1. Opacity is an especially useful indicator of performance for _____, since the particle sizes which are collected least efficiently attenuate light most effectively.

   a. wet scrubbers
   b. multicyclones
   c. fabric filters
   d. electrostatic precipitators

2. When making a visible emission observation the sun should be _____ _____.

   a. within a 90° quadrant of the observer's back
   b. geometrically normal to the direction of plume travel
   c. within a 140° quadrant at the observer's back
   d. within a 140° quadrant at the front of the observer

3. As the angle of observation increases,_____ .

   a. the apparent opacity increases in relation to the actual opacity
   b. the apparent opacity decreases in relation to the actual opacity
   c. the viewing pathlength across the plume increases
   d. the viewing pathlength across the plume decreases

4. Opacity readings can be corrected back to an observation angle of 0° using the following equation:

   a. $O_c = 1 + [(O_{obs}) \ COS\emptyset]$

   b. $O_c = 1 + [(1 - O_{obs}) \ COS\emptyset]$

   c. $O_c = 1 - [(O_{obs}) \ COS\emptyset]$

   d. $O_c = 1 - [(1 - O_{obs}) \ COS\emptyset]$

   where: O_c = corrected opacity

   O_{obs} = observed opacity

   $\emptyset$ = observation angle

5. Opacity can be an excellent early indicator of developing particulate collection problems.

   a. true
   b. false

6. A control device on a particular point source could be emitting a substantially higher mass concentration with almost no change in opacity levels if _____.

   a. the slope of its opacity-mass concentration correlation is close to vertical
   b. the particle size distribution of the emissions has shifted to favor particles greater than 2 microns in diameter
   c. the particle size distribution of the emissions has shifted to favor particles less than 1 micron in diameter
   d. the slope of the opacity-mass concentration correlation is close to horizontal

7. In cases as described above _____.

   a. continuous emission monitors must be installed
   b. inspection/maintenance personnel must utilize other means to routinely evaluate control device performance
   c. only stack testing can be used for evaluation
   d. none of the above

8. If there is some question as to whether or not a steam plume is present, then _____.

   a. the observer can compare the dissipation of steam vent effluent at the plant with the dissipation of the plume of interest to assist in the determination
   b. the observer should make all opacity readings right at the stack exit
   c. the observer can make a determination by analyzing the effluent gas stream and ambient meteorological conditions using a psychrometric chart
   d. all of the above
   e. none of the above

9. Secondary plumes _____.

   a. are composed of condensed aerosols
   b. are sometimes termed detached plumes
   c. imply control device operating problems
   d. can contain volatile or reactive compounds
   e. eventually revaporize
   f. all of the above

Match the following plume colors to the possible combustion parameters listed in questions 10 through 14.

   a. white
   b. black
   c. reddish brown
   d. bluish white
   e. grey

10. Excess combustion air; loss of burner flame in oil-fired furnace.

11. Inadequate air supply or distribution.

12. Lack of air; clogged or dirty burners or insufficient atomizing pressure, improper oil preheat; improper size of coal.

13. Excess furnace temperatures or excess air; burner configuration.

14. High sulfur content in fuel.

15. If the apparent opacity of a plume viewed at an observation angle of 45° is 40%, then the actual opacity is _____.

    a. 40%
    b. 35%
    c. 30%
    d. 25%

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Baseline Manual	Page(s) in Field Inspection Notebook
1. a,d	10-1	
2. c	10-2	
3. a,c	10-2, 10-3	
4. d		77
5. a	10-1	
6. b,d	10-5 to 10-9	
7. b	10-9	
8. a,c	10-4 to 10-5	
9. a,b,c	10-4	
10. a	10-5	
11. e	10-5	
12. b	10-5	
13. c	10-5	
14. d	10-5	
15. c	10-3	77

LESSON 10

Legal and Administrative Aspects of Plant Inspections

Reading Assignment

Baseline Manual, Chapter 12 and Appendix A.

Reading Assignment Topics

- o Preinspection procedures.
- o Procedures for plant entry.
- o Conducting the inspection.
- o Collecting legally admissable evidence.
- o Handling confidential information.
- o Photographic documentation.

Learning Goal and Objectives

Learning Goal

To familiarize you with the legal and administrative aspects which must be considered as part of a complete plant inspection.

Learning Objectives

When you have completed this lesson, you should be able to:

1. List and describe the preinspection procedures involved in preparing for an inspection and in entering the plant.
2. Explain what an inspector must be aware of during an inspection.
3. List and describe post inspection procedures.
4. Outline a set of procedures for handling confidential business information.
5. Explain the uses of, sensitivity of, and procedures for photographic documentation.

Reading Guidance

- A point which is emphasized throughout the reading material, but which might be noted again is that any time the inspector is unsure concerning an administrative or legal matter he should consult his supervisor, agency legal counsel, and/or the office of the State Attorney General for clarification.

- When you have finished the reading assignment, complete the review exercise for Lesson 10. It begins on the following page.

- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise. Note that many of the questions have more than one correct answer.

- For any review exercise questions that you answered incorrectly, review the page of the reading assignment indicated on the answers page.

- After you have reviewed your incorrect answers (if any), proceed to the final exam (see Section O of this guidebook).

Review Exercise

1. It is best to avoid photographing sensitive areas of a facility and to limit photographs to only those that are absolutely necessary.

   a. true
   b. false

2. Confidential business information can include _____.

   a. photographs
   b. propriety information
   c. special process data
   d. privileged information
   e. emissions data

3. The public relations liason part of an inspector's job includes _____.

   a. respecting the normal working schedule of plant personnel
   b. accepting offers of free lunches and dinners
   c. remaining courteous at all times
   d. respecting union-company agreements

4. An inspector may enter plant premises with either the owner's consent or a warrant.

   a. true
   b. false

5. Inspection data gathered prior to the withdrawal of consent (to enter the plant) is not considered admissable in court.

   a. true
   b. false

6. The inspector should only sign a visitor release form or waiver _____.

   a. when the plant official offers him no other choice
   b. with express permission from his employer
   c. after a determination from the State Attorney General
   d. after visiting the plant a number of times previously and not encountering any hazardous situations
   e. none of the above

7. A good "working file" for the inspector's use includes _____.

   a. plant layout drawing and flowsheets
   b. malfunctions reports
   c. chronology of control actions, inspections, and complaints
   d. recent construction and/or operating permits
   e. baseline performance data
   f. CEM excess emissions reports
   g. all of the above

8. A preinspection survey of the areas surrounding the plant _____ _____.

   a. allows time for a quick file review
   b. can reveal obvious vegetation damage near the plant
   c. may confirm odors downwind of the plant
   d. may show significant fugitive emissions near plant boundries
   e. can allow the inspector to better make an unannounced inspection

9. It is appropriate for the inspector to inform plant management of excess visible emissions subsequent to their observation.

   a. true
   b. false

10. An important point to remember in dealing with confidential business data during an inspection is _____.

   a. don't let the plant official know what you are recording until the exit interview
   b. always get as much operational data as possible
   c. avoid taking it unless it is necessary

11. Which of the following points should the inspector's post inspection interview with a plant official cover?

   a. plant safety requirements
   b. confidential data taken
   c. follow-up questions
   d. compliance of inspection points
   e. need for follow-up inspection
   f. all of the above

12. The following items of safety gear should be carried by the inspector at all times:

   a. safety glasses or goggles
   b. hard hat
   c. safety belt
   d. gas mask
   e. safety shoes
   f. dust mask

13. By Federal mandate the handling of confidential information must be the same from agency to agency.

   a. true
   b. false

14. It is suggested that confidential business data be _____.

    a. marked with a "confidential stamp"
    b. only used by agency personnel
    c. kept in a locked file cabinet
    d. not be reproduced
    e. in general, not be included in the inspection report
    f. a, c, d and e
    g. all of the above

15. Photographic documentation is a necessity for most inspections_____.

    a. true
    b. false

16. A(n) _____ warrant is the type most often obtained in the case of plant entry denial.

    a. criminal
    b. civil
    c. administrative

17. The plant has the right to request handling as confidential business information for all kinds of data.

    a. true
    b. false

18. When refused entry to a facility, the inspector should _____.

    a. tactfully discuss the reason for denial
    b. note the name and title of the plant official making the denial
    c. warn the plant official of potential penalties for the denial of entry
    d. contact his supervisor for further instructions if consent to enter is not gained
    e. all of the above

Review Exercise Answers and Reading Information

Question Number and Answer	Page(s) in Baseline Manual
1. a	12-15
2. a,b,c,d	12-13
3. a,c,d	12-10, 12-11
4. a	12-6
5. b	12-7
6. b,c	12-5
7. a,c,d,e	12-1, 12-2, Appendix A
8. b,c,d	12-4
9. a	12-4, 12-5
10. c	12-13
11. b,c,e	12-11
12. a,b,e,f	12-3
13. b	12-12, 12-13
14. f	12-12 to 12-15
15. b	12-15
16. b,c	12-7
17. a	12-12 to 12-15
18. a,b,d	12-16

SELF INSTRUCTIONAL COURSE
ANSWERS

QUIZ 1	QUIZ 2
1. b	1. c
2. a	2. a
3. c	3. e
4. c	4. a,b,d
5. d	5. b
6. a	6. c
7. a,b	7. b
8. a	8. b
9. d,e	9. b
10. b	10. b
11. a,b,c,d,e,g,h	11. a,b,c
12. a,d,e	12. b,c
13. b	13. c
14. c	14. e
15. c	15. a
16. a,c,e	16. c
17. b	17. c,d
18. b	18. c
19. c	19. c
20. a	20. c
21. b	21. e
22. e	22. c
23. b,c	23. a
24. b	24. a
25. a	25. b

SI:445

Edition A

FINAL EXAM

Introduction to Baseline Source Inspection Techniques

Note: Each question has only one correct answer.

1. In scheduling an inspection, agency personnel should _____.

   a. consider normal working hours at the plant
   b. be aware of agency policy on advance announcement
   c. choose a time when plant processes will probably be operating at representative conditions
   d. all of the above

2. During the measurement of the static pressure in a duct ahead of a fabric filter it is suspected that there is some slight air leakage around the probe and into the duct. If the observed static pressure is -20 inches of water, the true static pressure would probably be _____.

   a. -18 inches of water
   b. -25 inches of water
   c. -30 inches of water
   d. +20 inches of water
   e. either b or c

3. Contact lenses should not be worn during inspections.

   a. true
   b. false

4. Rappers are often used on which of the following components of an electrostatic precipitator system?

   a. insulators
   b. gas distribution plates
   c. transformer-rectifier sets
   d. none of the above

5. The most useful parameter for correlating scrubber particulate removal efficiency is the following:

   a. pressure drop divided by the gas density (average of inlet and outlet)
   b. pressure drop divided by the gas velocity (average of inlet and outlet)
   c. pressure drop divided by the gas temperature (average of inlet and outlet)
   d. pressure drop

6. Which of the following circumstances would tend to increase the value of an opacity observation reading?

   a. having to read the plume at a point after steam disippation
   b. an increase in particle size distribution in the plume, with no change in mass emissions
   c. a decrease in the angle of observation
   d. a change in plume color
   e. all of the above
   f. none of the above

7. The primary physical mechanism used to collect particles in wet scrubbers is the following:

   a. gravity settling
   b. diffusophoresis
   c. thermophoresis
   d. interception
   e. impaction
   f. electrostatic attraction

8. In the regeneration process on a carbon bed adsorption system, the organics are desorbed from the carbon by passing steam or hot gases through the bed countercurrent to the flow of gases during adsorption.

   a. true
   b. false

9. Which of the following points should the inspector's preinspection interview with a plant official <u>not</u> cover?

   a. inspector's preferred inspection agenda
   b. applicable regulations
   c. plant safety requirements
   d. photographs
   e. consequences of the plant's noncompliance with regulations
   f. operational status of process and control device points to be evaluated
   g. none of the above

10. The bag tension is important in which of the types of fabric filters listed below:

    a. reverse air (inside-to-outside filtering)
    b. reverse air (outside-to-inside filtering)
    c. shaker
    d. pulse jet
    e. a and b
    f. a and c

Final Exam Page 3

11. When climbing ladders, inspectors should hold on to the_____.

    a. side rails
    b. foot rails
    c. either

12. On a square duct the length is 42 inches and the width is 36 inches. What is the equivalent diameter?

    a. 39.0 inches
    b. 19.1 inches
    c. 38.8 inches
    d. 78.0 inches

13. The baseline inspection technique involves detailed internal inspections of the control systems.

    a. true
    b. false

14. An inspection of a multiple cyclone type collector serving a coal-fired boiler resulted in the inspection data below. The baseline data came from a stack test. Assuming gas flow rate is proportional to steam rate, what conclusions can be made without making any calculations?

Inspection Data		Baseline Data	
Inlet Static Pressure:	-2.8"	Pressure Drop:	4.0"
Outlet Static Pressure:	-6.6"	Inlet Gas Temperature:	not measured
Inlet Gas Temperature:	412°F	Stack Temperature:	426°F
Outlet Gas Temperature:	403°F	Inlet O_2:	not recorded
Inlet O_2:	7.4%	Stack O_2:	8.2%
Outlet O_2:	8.0%	Inlet CO_2:	not recorded
Inlet CO_2:	12.0%	Stack CO_2:	11.3%
Boiler Steam Flow	60,000 Lbs/hr	Boiler Steam Flow:	100,000 Lb/hr

    a. no conclusions can be reached since the baseline data set is incomplete
    b. the resistance to gas flow is substantially higher, therefore, there may be some pluggage of the spinner vanes or the outlet tube
    c. the resistance to gas flow is substantially lower, therefore, there may be some erosion of the outlet tube extensions
    d. there are signs of severe air infiltration

15. What would be the expected pressure drop during the inspection above assuming that the condition of the mechanical collector was identical to that during the baseline stack test? (Assume a flue gas moisture content of 0.1 pounds per pound of dry air.)

    a. 1.45 inches of water
    b. 2.40 inches of water
    c. 3.80 inches of water
    d. 4.00 inches of water

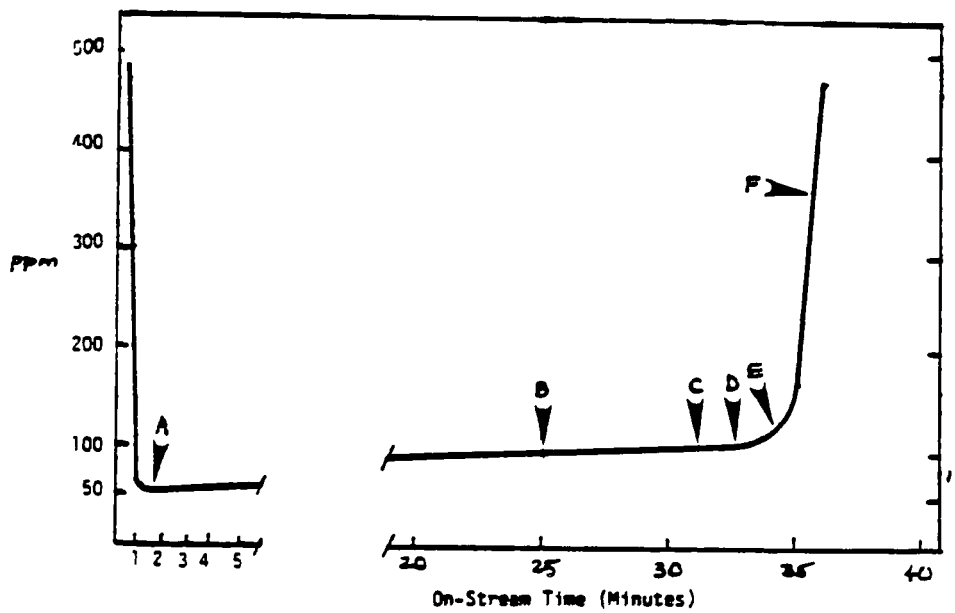
16. A packed tower wet scrubber is generally used for _____.

    a. collection of sticky aerosols
    b. gas pollutant absorption
    c. collection of particulate in sources with high mass concentrations
    d. collection of submicron particulate

17. One field of an electrostatic precipitator had the following operating conditions: secondary voltage 38 KV, secondary current 820 milliamps, spark rate 10 per minute. The power factor is 0.75 and the gas temperature is 320°F. What is the power input from this one field?

    a. 21.5 kilowatts
    b. 31.2 kilowatts
    c. 22,360 watts
    d. 23.4 kilowatts

The figure below shows the discharge concentration vs. time for a carbon bed. Refer to it to answer Questions 18 through 20.



18. Breakthrough occurs at the point labeled _____.

    a. A
    b. B
    c. C
    d. D
    e. E
    f. F

19. A reasonable adsorption cycle time for this bed in a system with set cycle automatic control would be _____.

    a. 15 minutes
    b. 25 minutes
    c. 30 minutes
    d. 35 minutes
    e. all of the above
    f. none of the above

20. An instrument to be used to detect organics in the discharge gas stream for this system should measure accurately in the _____.

    a. 0-20 ppm range
    b. 0-50 ppm range
    c. 0-500 ppm range
    d. 500-1000 ppm range

21. Control system designed by the same manufacturer and operated under similar conditions can be assumed to operate in a similar manner.

    a. true
    b. false

22. The pH measured in the scrubber sump was 3.5. If the scrubber is made of carbon steel is there reason for concern?

    a. no
    b. yes

23. If an inspector experiences the nonspecific symptoms of exposure to gases and vapors, he or she should _____.

    a. continue with the inspection until more definite symptoms develop
    b. discuss the potential exposure with plant personnel
    c. leave the area immediately and reevaluate the conditions
    d. all of the above

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24. An inspector standing 100 feet from a 175 foot stack made 6 minutes of visible emission observations which averaged 32%. If the baseline opacity value (from a continuous emission monitor) for that point source was 18%. Was there a significant shift in opacity?

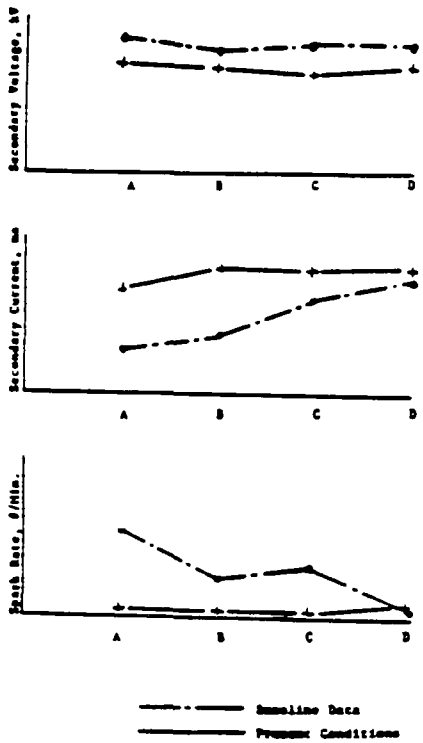
a. yes
b. no

25. If a collector is under negative pressure, there is a tendency for _____.

a. gas to leak out
b. air to leak in

26. The electrical data from a one chamber electrostatic precipitator has been plotted below. What does the data suggest?

a. the rappers are obviously not operating properly
b. the dust resistivity has increased since the baseline period
c. the boiler load has decreased
d. one or more fields have serious malalignment problems
e. the dust resistivity has decreased since the baseline period



27. Water and oil in the compressed air lines of pulse jet fabric filters can lead to which of the following problems?

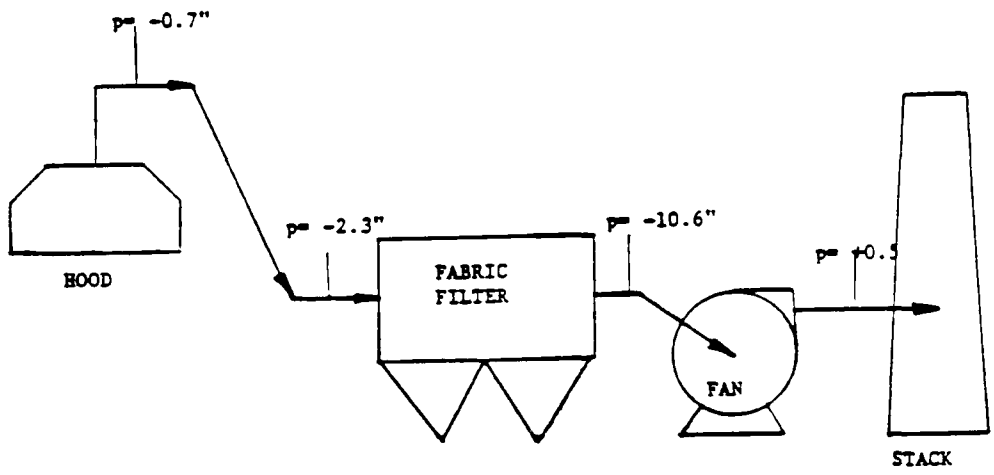
    a. seepage
    b. freezing of the diaphragm valves
    c. freezing of the rotary valves
    d. cage erosion

28. The temperature recorder on the outlet of a reverse air fabric filter indicated that there was a temperature excursion to 385°F for a period of 1 hour. What types of fabric would be able to tolerate this condition?

    a. cotton and Orlon
    b. Nomex and fiberglass
    c. fiberglass only
    d. Ryton and orlon
    e. Dacron and Teflon

29. Static pressure measurement data on a given air pollution control system are shown in the figure below. What is the pressure drop across the collector?

    a. 8.5"
    b. 1.2"
    c. 2.8"
    d. 8.3"
    e. it cannot be determined
    f. the measurements are obviously in error

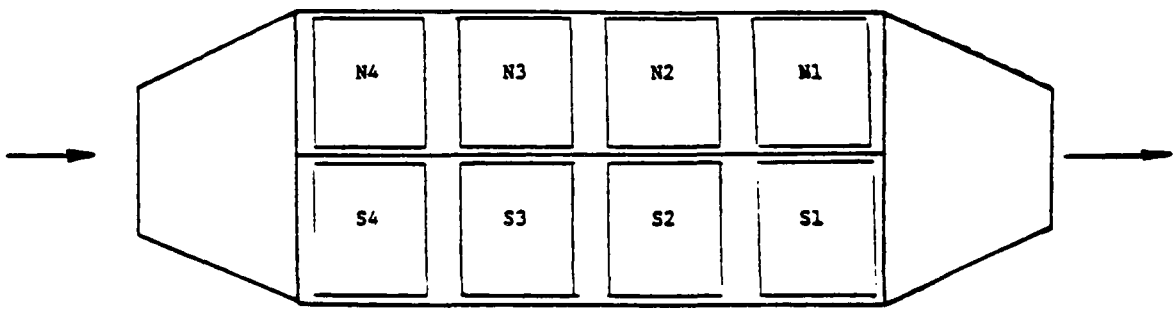


30. During the inspection of a fabric filter, it is noted that the pressure drop has decreased substantially since the baseline period and the opacity has dropped from 10% to almost 0%. The inspector finds some minor corrosion on the collector shell and some very audible air infiltration across the top access hatches. The rotary valves and the screw conveyors seem to be performing adequately. What should the inspector do?

    a. stop the inspection, the unit is in compliance
    b. continue the inspection because the data clearly indicates that the bags are being overcleaned
    c. continue the inspection because it is quite possible that there are substantial fugitive emissions from the process hoods
    d. stop the inspection because any problems which may exist are not causing the unit to operate out of compliance
    e. evaluate start-up procedures which could contribute to corrosion
    f. evaluate the bag failure charts

31. There is a two chamber electrostatic precipitator having four fields in series. The Transformer-Rectifier set numbering system is shown on the sketch provided below. In what order should the electrical data be recorded on the inspection notes?

    a. S4, S3, S2, S1, N4, N3, N2, N1
    b. S1, S2, S3, S4, N1, N2, N3, N4
    c. N1, S1, N2, S2, N3, S3, N4, S4
    d. the way the cabinets are laid out in the control room or substation
    e. none of the above



32. During an inspection of a wet scrubber system, it is noticed that the I.D. fan is vibrating severely. What should the inspector do?

a. evaluate conditions which could lead to build up of material on the fan, such as poor demister operation
b. measure the fan R.P.M. and motor current
c. check the outlet damper position
d. leave the area immediately
e. leave the area immediately and notify a responsible plant official of the fan condition

33. The following electrical data was recorded during the inspection of an electrostatic precipitator. What is the total power input to this one chamber unit? (Use a spark rate of 35 in each field, a power factor of 0.65, a gas temperature of 350°F, gas stream flow rate of 320,000 ACFM, if necessary to complete the calculations.)

a. 328 watts/1000 ACFM
b. 1637 watts/1000 ACFM
c. 1936 watts/1000 ACFM
d. 2582 watts/1000 ACFM

Field	Primary Voltage, Volts, A.C	Primary Current Amps, A.C	Secondary Current Milliamps, D.C.
1	259	128	730
2	298	228	1370
3	260	232	1370

34. A symptom used in baseline analyses means _____.

a. a significant difference between an operating parameter at a given plant as compared against industry norms
b. a significant difference between an operating parameter measured during the inspection as compared against the value during the baseline period
c. neither

35. At high concentrations hydrogen sulfide has _____odor.

a. a rotten eggs
b. a sewer
c. a fragrant
d. no

Name _____
Date _____

Course SI:445

Introduction to Baseline Source Inspection Techniques

Final Examination A

Answer Sheet

1.	a	b	c	d	e	f
2.	a	b	c	d	e	f
3.	a	b	c	d	e	f
4.	a	b	c	d	e	f
5.	a	b	c	d	e	f
6.	a	b	c	d	e	f
7.	a	b	c	d	e	f
	a	b	c	d	e	f
9.	a	b	c	d	e	f
10.	a	b	c	d	e	f
11.	a	b	c	d	e	f
12.	a	b	c	d	e	f
13.	a	b	c	d	e	f
14.	a	b	c	d	e	f
15.	a	b	c	d	e	f
16.	a	b	c	d	e	f
17.	a	b	c	d	e	f
18.	a	b	c	d	e	f
19.	a	b	c	d	e	f
20.	a	b	c	d	e	f
21.	a	b	c	d	e	f
22.	a	b	c	d	e	f
23.	a	b	c	d	e	f
24.	a	b	c	d	e	f
25.	a	b	c	d	e	f
26.	a	b	c	d	e	f
27.	a	b	c	d	e	f
28.	a	b	c	d	e	f
29.	a	b	c	d	e	f
30.	a	b	c	d	e	f
31.	a	b	c	d	e	f
32.	a	b	c	d	e	f
33.	a	b	c	d	e	f
34.	a	b	c	d	e	f
35.	a	b	c	d	e	f

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Quiz Supervisor