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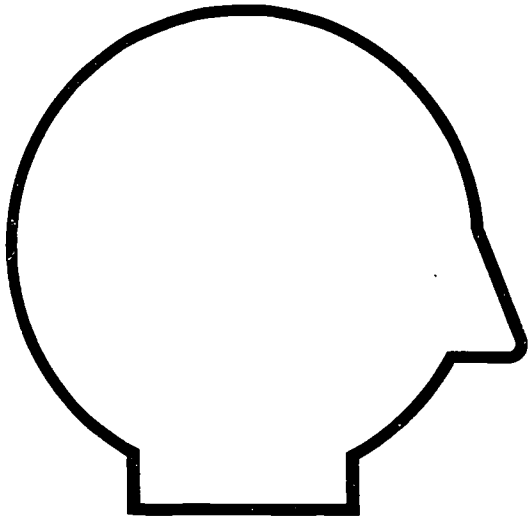
ABSTRACT

This module, one of 25 on vocational education training for careers in environmental health occupations, contains self-instructional materials on using detector tubes and pumps. Following guidelines for students and instructors and an introduction that explains what the student will learn are three lessons: (1) naming the component parts of the sampling pump and detector tube: (2) assembling and using a soapbubble meter for calibrating a detector tube sampling pump: and (3) measuring the amount of carbon monoxide in the air around a fossil-fuel-fired heater, using a detector tube. Each lesson contains objectives, recommended methods and locations for practice, performance criteria, equipment and supplies to perform a task, detailed step-by-step instructions for learning a task, and performance exercises. Two performance tests cover calibrating the sampling pump and measuring concentrations of gases or vapors using detector tubes and pumps. (CT)



Using Detector Tubes and Pumps

Module 4

U.S. DEPARTMENT OF EDUCATION, Office of Vocational and Adult Education

FOREWORD

The Curriculum and Instruction Branch of the Office of Vocational and Adult Education, U.S. Department of Education, identified a need to improve the training opportunities for vocational education students interested in pursuing careers in environmental health. To fulfill that need, Consumer Dynamics, Inc., a Rockville, Maryland, based company, was awarded the contract to develop performance-oriented, competency-based modules in the environmental health sciences.

USING DETECTOR TUBES AND PUMPS is one of the modules in the series, "Vocational Education Training in Environmental Health Sciences." The module content is based on selected materials in the environmental health field. The module is intended to supplement existing course materials.

CONTENTS

USING THESE SELF-INSTRUCTIONAL MATERIALS

This self-instructional learning package or module is designed to allow both students and instructors flexibility of use. Although primarily intended for use in existing training programs, the module can be used by anyone interested in learning new skills or perking up old ones. Therefore, two sets of guidelines are presented--one set addressed to students and the other set addressed to instructors. First, find out how you, the student, should use the materials in this book.

GUIDELINES FOR STUDENTS

Take the Performance Test as a pretest.

When you pick up this book and work through it, your goal will not be a letter grade or a high score on an exam. Instead, you will work to develop skills that you can measure. You will not have to worry about how well someone else is doing. Before you start work on this book, you should, first, find out if you have sufficient skills to start training by reading through the section called PERFORMANCE TEST. If you think you can perform each item as specified, ask your instructor to obtain the necessary equipment and supplies so that you can demonstrate your skill level.

Work on parts you need to practice.

If you do everything well, according to the criteria in the Performance Test guidelines, you will not need to spend time working on this module. If, after taking the Performance Test you discover there are parts of the module you need to practice, follow the key to each item in FOR FURTHER STUDY.

Work straight through each lesson in the order presented.

Should you decide to completely work through this book, begin with the INTRODUCTION and go straight through each of the three lessons. The lesson begins with the OBJECTIVE of the training. Follow the instruction for each part in the order presented. Practice each step in a lesson until you can do it according to the criteria stated for the step. At the end of a lesson, do the EXERCISES. When there are audiovisuals listed at the end of a lesson, ask your instructor for help in obtaining them.

USING THESE SELF-INSTRUCTION MATERIALS

Take the Performance Test as a posttest.

Finally, after you have mastered the exercises, ask your instructor to watch you calibrate and use a sampling pump and detector tubes. The guidelines in the Performance Test can be used as a posttest to evaluate the quality of your performance. Turn now to the Performance Test.

GUIDELINES FOR INSTRUCTORS

Approach

The approach of these materials is to provide the student with (1) the nomenclature and uses of the components of the gas and vapor sampling pump and detector tubes; (2) procedures for calibrating the pump; and (3) procedures for taking a sample using a detector tube. The lessons are sequential in that the information presented in the previous lesson serves as a basis of skill development in a later lesson. Exercises are provided to guide the student's practice of the procedures presented in GETTING THERE--STEPS.

Use of the Performance Test

A Performance Test is provided to serve as a guide to the skill development progress. If a student is able to demonstrate skill development by meeting the criteria for performance given in each test item, further study is not needed. Therefore, the student should be given the option of entering training at any point. To determine at what point to start, the student should take the Performance Test as a pretest. At any time during the course of study, the student should also be allowed to test out of the remaining portions of training.

Also, the student's capability to accurately complete the entire task in a timely manner can be evaluated by using the Performance Test as a posttest. The items listed in the test can serve as a basis for working with other makes and models of sampling pumps and detector tubes.

USING THESE SELF-INSTRUCTION MATERIALS

Independent Study

Students can work independently and at their own pace. Depending on the time frame you set for completing each lesson, you may want to start a group off in each lesson with a demonstration and informal presentation.

As a Laboratory Workbook

Alternatively, you may choose to use this module as a laboratory workbook in a structured laboratory session. With this option, you allow students greater access to your assistance, especially in watching them perform the pre- and posttest portons of the training.

General Instructions

Read through each lesson to anticipate what equipment and supplies you will need to make available for students to use. Also, order any audio-visuals or reading materials you think may present a complementary perspective to the training in this module. Use the items in the Performance Test as the minimum requirements for gauging successful completion of the training.

Specific Instructions

Remind students that the carbon monoxide (CO) samples they take will be affected by the heat of the source. Because the air they sample will probably be in excess of 52° C (125° F), you should show them how to construct a cooling jacket. Use a 1-foot-long, 1/4-inch-diameter copper tube wrapped with a cloth. Short lengths of rubber tubing (I.D.=3/16") can be attached to both ends of the copper tube. One-half of an empty detector tube can be used between the pump and the copper tube. The CO detector tube is inserted into the other end of the copper tube.

BACKGROUND

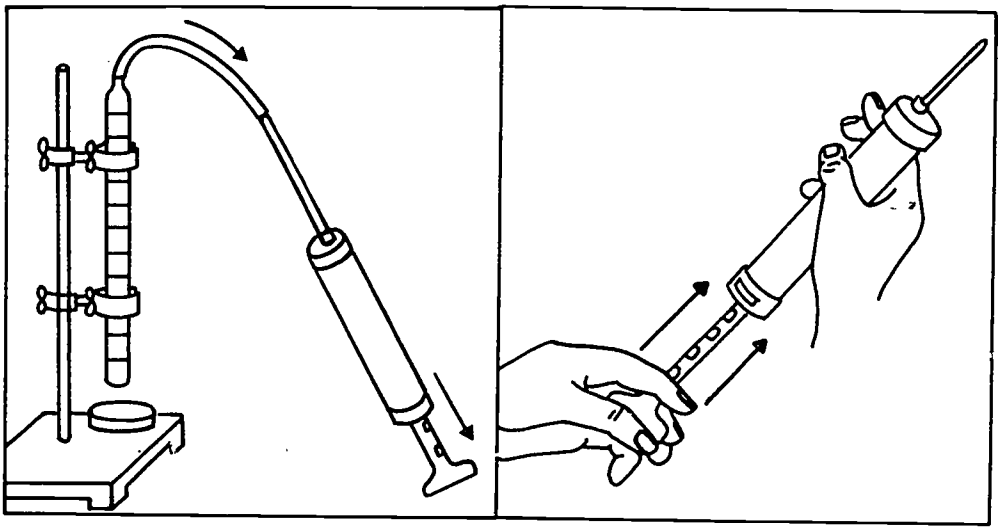
Many industrial processes produce gases and vapors that are released into the air that workers breathe. A safety and health professional such as an industrial hygienist is frequently employed by an industrial firm or a government agency to periodically check on how much of the gases and vapors get into the air. In performing this check, the industrial hygienist or an associate often uses a sampling pump and detector tube to take a quick sample of the air. The detector tube contains a chemical indicator that turns color when exposed to specific substances in the air. If the sampling results indicate that hazardous levels of the substance are present, further testing will be conducted over longer periods.

The main advantage of the detector tube is that it is compact and convenient to use, but its use is limited. Readings can be dangerously misleading unless the detector tube is used under the supervision of an adequately trained industrial hygienist. This individual must see that the tubes are frequently calibrated against known concentrations of the contaminant to be sampled, that paraprofessional staff are informed about interfering substances that may cause false readings, and that paraprofessional staff are told where and when to sample.

Instructions included in this book will enable you to effectively use the sampling pump and detector tubes under the supervision of a trained industrial hygienist. You will be able to calibrate the pump, take readings, and determine the concentration of the gas or vapor. You will not be provided instruction on how to calibrate the detector tube, how to sample in the presence of interfering substances, or where and when to sample.

WHAT YOU WILL LEARN

When you finish working through the steps and exercises in this module, you will be able to calibrate and use a detector tube sampling pump and detector tubes.



You will learn to calibrate and use a detector tube sampling pump in three lessons:

- Lesson One

  You will be able to name the component parts of the sampling pump and detector tube.

- Lesson Two

  You will be able to assemble and use a soapbubble meter for calibrating a detector tube sampling pump.

- Lesson Three

  You will be able to measure the amount of CO in the air around a fossil-fuel-fired heater, using a detector tube.

LESSON ONE

OBJECTIVE

You will be able to name the component parts of the sampling pump and detector tube.

WHERE AND HOW TO PRACTICE

This lesson can be performed in the classroom or area provided with a table or desk on which to place the pump, detector tubes, and this book. Read through a step before doing it, and make sure you can perform the step as well as described in "How Well You Must Do." Practice naming and describing the parts and components. Then label the drawings included in the exercises to test your knowledge.

HOW WELL YOU MUST DO

You must be able to correctly label each diagram in the exercises and to correctly tell how each part works or is used. You should be able to do this in less than 2 minutes.

THINGS YOU NEED

You will need the following equipment to work through this lesson:

- sampling pump, MSA Universal Testing Kit* or equivalent, including Matheson 8014K Toxic Gas Detector Kit
- carbon monoxide detector tubes
- a metric/inch ruler.

Instructions: Now turn to the next page and begin work on Lesson One, "Getting There--Steps."

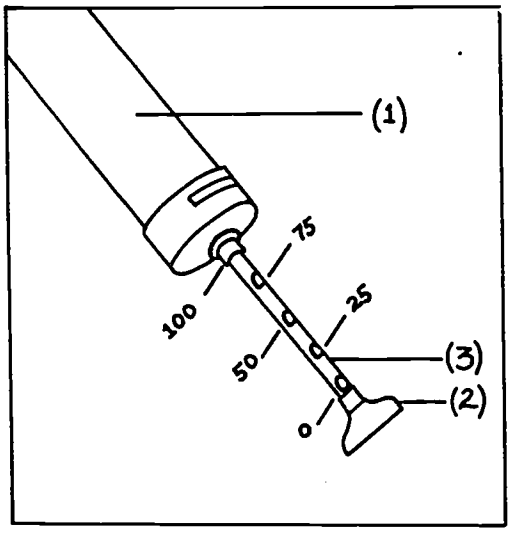
*Presentation of equipment in this module is not intended to be an endorsement of a make or model by the U.S. Department of Education.

GETTING THERE--STEPS

STEP 1

The sampling pump and detector tubes shown in this book are parts of the MSA Universal Testing Kit. Pick up the pump. Holding the pump cylinder (1) in one hand, pull the handle (2) out slowly and note the marks--0, 25, 50, 75, and 100 cc--on the shaft (3). When you reach each of the marks it should click (100 cc=100 ml). Release the handle by turning it a quarter turn. The shaft should return to the "0 cc" position or no more than 6 mm (1/4-inch) out. If it is more than 6 mm, inform your instructor before proceeding through the lessons.

KEY POINT 1

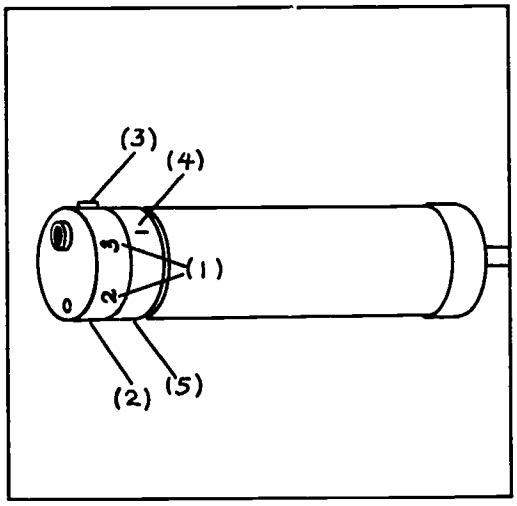


Marks on the shaft indicate air volumes that can be drawn into the pump.

STEP 2

Find the index numbers (1) 1-4 engraved into the edge of the rotating head (2). The numbers refer to the volume of air pulled into the pump: 1--100 ml, 2--75 ml, 3--50 ml, and 4--25 ml. Locate the locking button (3) on the side of the rotating head. Push the button forward while you turn the rotating head to select a number. Select Index 3. Match the index mark (4) on the rotating head with the index mark on the flow control plate (5).

KEY POINT 2

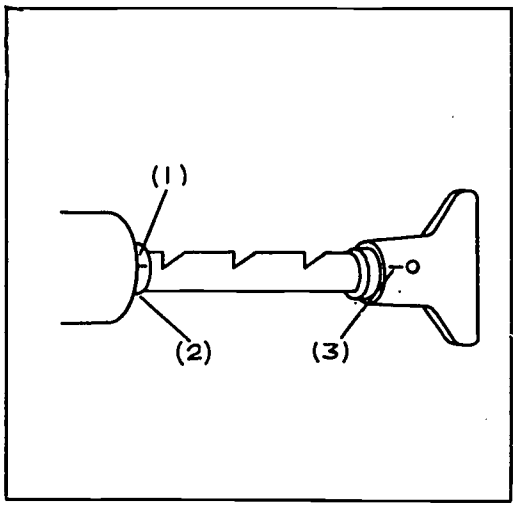


Index numbers on the edge of the rotation head correspond to orifices in the flow control plate.

STEP 3

Line up the index marks (1) on the edge of the back plate (2) with those on the handle (3). Pull the handle out to the 50-cc mark on the shaft. If you were to measure the volume of air the pump is now drawing, it should be 50 ml. Turn the handle a quarter turn to release it. Make sure the handle is as far in as possible to expel any air remaining in the pump. In Lesson Two, the pump will be calibrated to check the actual volume of air being drawn when the rotating head is set at each of the indices.

KEY POINT 3



A volume of 50 ml is drawn into the pump when the rotating head is set at "3" and the handle pulled out to "50 cc."

STEP 4

Pick up a box of detector tubes. The box is marked with this information:

1. the substance the tube is designed to sample

2. the measurable range of the tube in parts per million (ppm)

3. shelf life of the tube or "use by" date

4. the batch or lot number of the tubes.

KEY POINT 4

The detector tube box contains information for the proper selection and use of the tube.

STEP 5

Open the detector tube box. Inside is a set of instructions including: (1) some of the information in Step 4; (2) a list of substances that will "interfere" with the accuracy of measuring the substance the tube is designed to sample; (3) how to use the tube and pump; (4) a color comparison chart for tubes that are not marked with calibration markings; and (5) calibration curves to convert the length of the color stain to concentration in ppm's; (6) the index mark setting to be used; and (7) the steps to make the test.

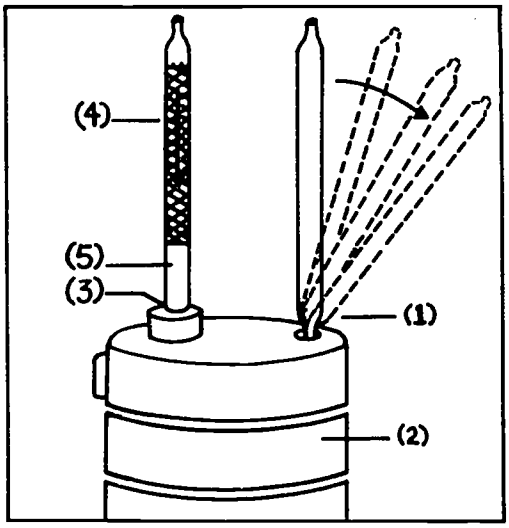
KEY POINT 5

The instructions contain information for interpreting the sampling results.

STEP 6

Take one of the tubes out of the box. Break off the ends by inserting the tips of the tube into the tube breaker hole (1) located in the rotating head (2). When the tips are broken off, look for an arrow on one end of the tube. Insert the tube into the tube holder (3) so the arrow (4) points toward the pump. If there is no arrow on the tube, insert the unfilled end (5) into the tube holder. Once you have seated the tube as far as it will go into the holder, remove the detector tube and set both the tube and pump aside.

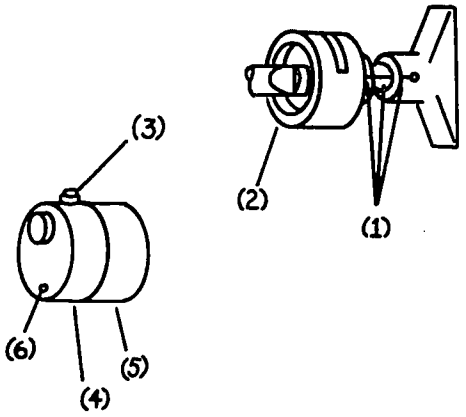
KEY POINT 6



Break off the tips of the detector in the breaker hole. Discard the glass pieces in a waste container.

EXERCISES

Instruction 1: Referring to the equipment and/or drawings in the lesson, label the following drawings. You must be able to name each part in the drawings and describe its function or use.



(1) _____

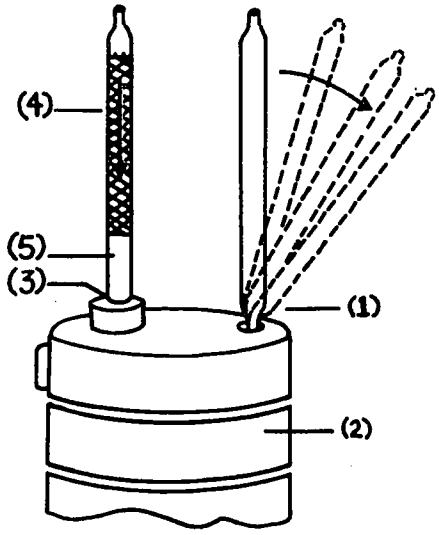
(2) _____

(3) _____

(4) _____

(5) _____

(6) _____



(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

Instruction 2: Practice setting the rotating head and pulling the pump handle back only as far as the volume to be pumped.

Instruction 3: When you are able to do the exercises in this lesson, you are ready to start Lesson Two.

LESSON TWO

OBJECTIVE

You will be able to assemble and use a soapbubble meter for calibrating a detector tube sampling pump.

WHERE AND HOW TO PRACTICE

You can practice the steps in this lesson in a chemistry laboratory or on a table close to a utility sink. Do not calibrate the pump near a sink where food is prepared, since you will be emptying a detector tube that contains corrosive chemicals. Read through each step before trying it. If you have any question about doing a step, ask your instructor for help. Repeat a step until you can do it as well as required in "How Well You Must Do." Work through the exercises for practice in learning how to calibrate a detector tube sampling pump.

HOW WELL YOU MUST DO

To get the soapbubble meter to work, you must be able to get a bubble to rise the entire length of the buret. You must be able to line up the bubble at the starting point before pulling the pump handle to begin calibrating. At each index setting, you must be able to obtain readings that have less than a 5 percent difference; that is, at the "100" setting your result must be between 95 and 105 ml.

THINGS YOU NEED

In addition to the equipment you used in Lesson One, you will need the following:

- buret, 100-ml
- ring stand or buret stand with 2 buret clamps
- petri dish or equivalent
- soapbubble solution
- stopwatch, 0.1-second sweep.

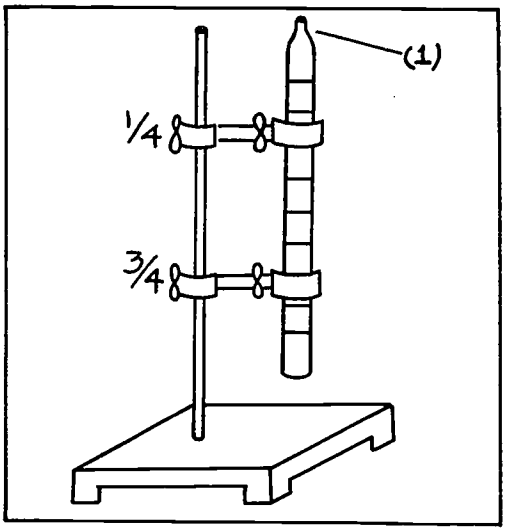
Instructions: Now to the next page and begin work on Lesson Two, "Getting There--Steps."

GETTING THERE--STEPS

STEP 1

Assemble the ring stand for calibrating the detector tube and pump. Attach one buret holder one-fourth the way down the shaft. Attach another buret holder three-fourths the way down the shaft. Place a 100-ml buret, tip up (1) in the holders. Do not fasten the buret too tightly. Open the buret stopcock if there is one.

KEY POINT 1

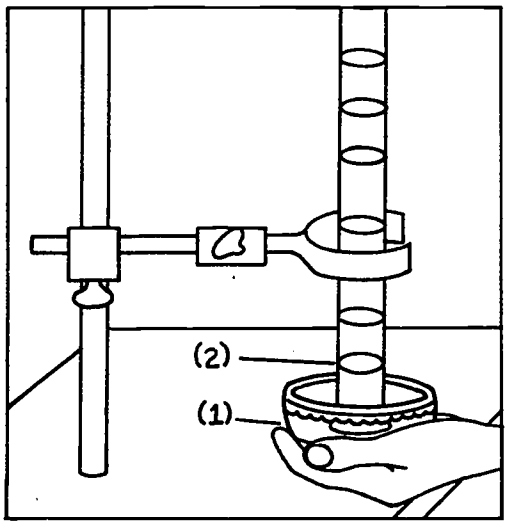


Place the open 100-ml buret upside down. Fasten it securely but not tightly.

STEP 2

Pour soap solution into a flat dish such as a petri dish (1). To calibrate the pump you must get a soapbubble (2) to rise in the buret when the handle is pulled out. To make it easy for the bubble to rise, wet the walls of the buret with soap solution.

KEY POINT 2

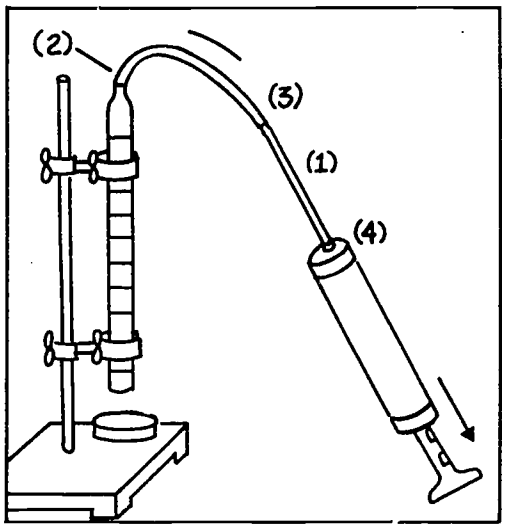


The walls of the buret must be wet with soap solution so that a soapbubble will rise.

STEP 3

Obtain an empty* detector tube (1) from your instructor, or prepare one using the tube you opened in Lesson One. Attach one end of a foot-long piece of rubber tubing to the buret tip (2) and the other end to the detector tube (3). Insert the free end of the detector tube into the tube holder (4) in the pump. Make sure all connections are airtight.

KEY POINT 3



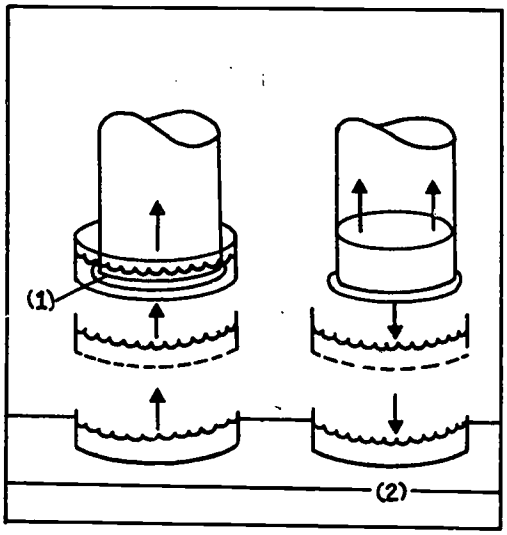
All connections must be tightly fitted.

*The chemical reagents in a detector tube are usually corrosive. If you are emptying the tube you opened in Lesson One, make sure the tube contents are dumped into a noncorrosive container set aside for the disposal of corrosive wastes. Wear protective gloves and laboratory safety glasses with side shields when you handle corrosive materials. Have an organic chemical cartridge, air-purifying respirator available should the detector tube contents produce a gas or vapor when exposed to the air. Do not breathe in such vapors. If you get the material on your skin, wash with copious amounts of water.

STEP 4

Set the pump's rotating head to Index 1. Next, pull the pump handle all the way out to the 100-cc mark. Hold the pump cylinder with one hand. Lift the flat dish containing soap solution so the end (1) of the buret is just under the surface of the solution. As soon as you get a bubble to form, quickly lower (2) the dish. If the bubble breaks before getting to the other end of the buret, remove the buret from the holders. Wet the walls with more soap solution and start another bubble into the unmarked space below the 0-ml mark.

KEY POINT 4

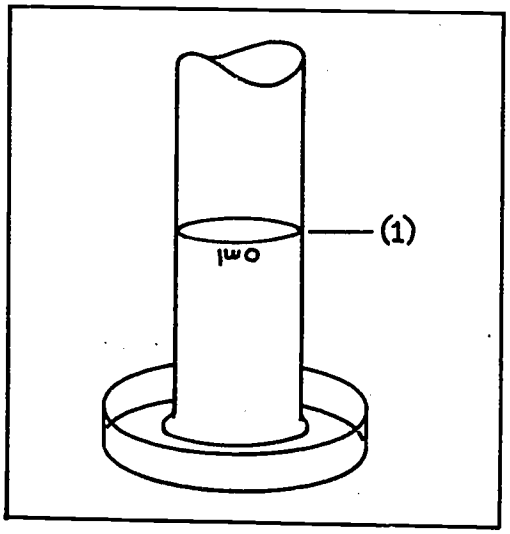


After pulling the handle out, lift the dish to form a bubble; lower it quickly when one has formed.

STEP 5

Disconnect the tubing from the buret tip. Push the pump handle all the way in. Reconnect the tubing. Next, line up a bubble on the 0-ml mark (1). Repeat Step 4 for this. To do this, pull the pump handle out slightly to make the bubble rise slightly. When the bubble is on the 0-ml mark, disconnect the tube again and push the handle slowly back to the starting position to expel the air drawn into the pump. Immediately reconnect the tubing and do not hesitate in going on to Step 6.

KEY POINT 5



Before beginning to calibrate, line up a bubble on the 0-ml mark.

STEP 6

Pull the handle all the way out for a full pump stroke. Wait 1 minute. Note where the soapbubble stops. Record the reading here:

Orifice 1 (100 cc) _____ ml

If the reading is more than 105 ml or less than 95 ml, repeat this step after checking the connections. If your readings are still more than 105 ml or less than 95 ml, have your instructor test the pump. It may need to be repaired.

KEY POINT 6

An error in the pumping volume of ±5 percent is allowable.

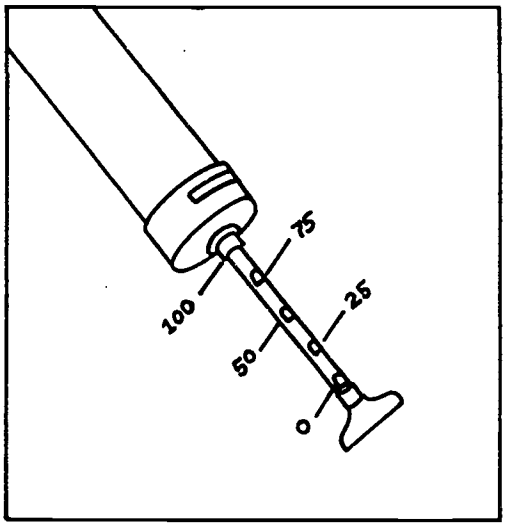
STEP 7

If the reading you got at Orifice 1 was between 95 and 105 ml, repeat Step 6 at the other settings. Remember to pull the handle out only to the 75-cc mark on the shaft when at Orifice 2, to the 50-cc mark at Orifice 3, and to the 25-cc mark at Orifice 4. Record your readings at each orifice setting here:

Orifice 2 (75 cc) _____ ml
Orifice 3 (50 cc) _____ ml
Orifice 4 (25 cc) _____ ml

Routine tests using volumes in this step are not usually performed.

KEY POINT 7



Pull the pump handle out to the mark equal to the volume pulled at each orifice setting.

STEP 8

To test if the orifices are clear, check the flow rate. Repeat Step 5 except that immediately after you pull back the handle (1), start timing (2) how long it takes for the bubble to stop rising. Record your timings here:

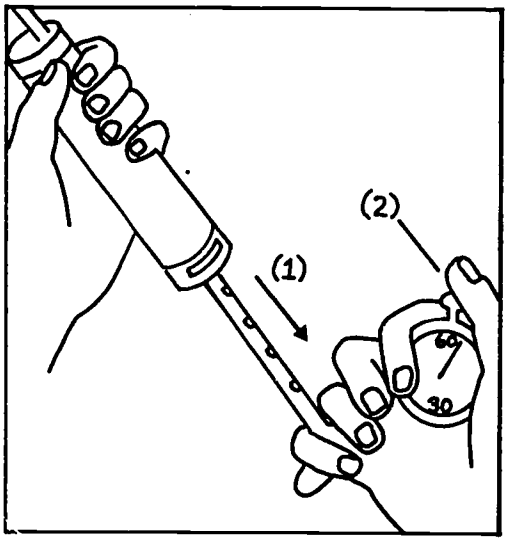
Orifice 1 (100 cc) _____sec
Orifice 2 (75 cc) _____sec
Orifice 3 (50 cc) _____sec
Orifice 4 (25 cc) _____sec

Compare your timings with MSA's recommended periods:

Orifice 1 (100 cc) 46 sec
Orifice 2 (75 cc) 24 sec
Orifice 3 (50 cc) 13 sec
Orifice 4 (25 cc) 2 sec

Your timings for the MSA pump must be within $\pm$0.5 seconds of the above.

KEY POINT 8



By checking the flow rate of the pump, you can test whether the orifices are clear.

EXERCISES

Instructions: Repeat all of the steps in this lesson using a sampling pump and detector tubes from another manufacturer. If pumps are significantly different in design, refer to the manufacturer's instructions on how the different parts function.

LESSON THREE

OBJECTIVE

You will be able to measure the amount of carbon monoxide (CO) in the air around a fossil-fuel-fired heater, using a detector tube.

WHERE AND HOW TO PRACTICE

To see the color change from yellow to brown when using a CO detector tube, you will need to take a sample from a source of CO (a gas) that is usually high in CO. You can use a fossil-fuel-fired heater such as a kerosene stove or lamp, or sample a few inches from the tailpipe of a gasoline-fueled vehicle. CAUTION: When you do take a sample from such a source, make sure that the source is well ventilated, preferably outside.

If the air you are sampling is more than 52° C (125° F), you will need to cool the air before it enters the detector tube. Ask your instructor how to put together a cooling device.

Read and study each step carefully. Ask your instructor for help on any step you do not understand before you attempt to practice a step. Before starting to work through the exercises, make sure you can do each step as well as described in "How Well You Must Do."

HOW WELL YOU MUST DO

You must be able to determine how many pump strokes should be used for sampling in a specific concentration, i.e., parts per million (ppm) or milligrams per liter (mg/l). You must be able to measure the length of stain to the closest millimeter. You must be able to select an appropriate calibration curve and determine ppm of CO.

THINGS YOU NEED

You will not need any of the calibration equipment you used in Lesson Two. In addition to the pump and tubes you used in Lesson One, you will need the following:

- a carbon monoxide source, such as a heater or tailpipe of a running vehicle
- instructions explaining the use of the pump and CO detector tubes.

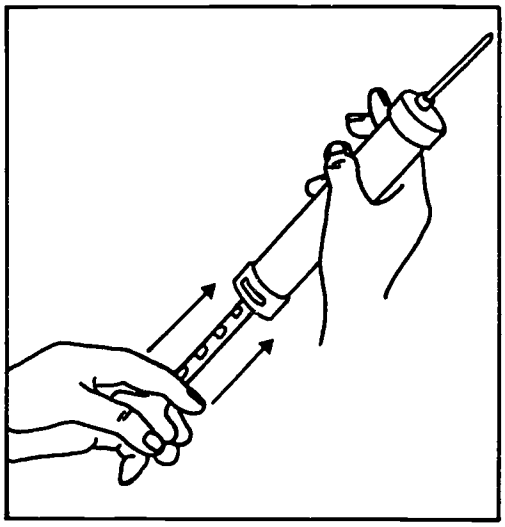
Instructions: Now turn to the next page and begin work on Lesson Three, "Getting There--Steps."

GETTING THERE--STEPS

STEP 1

Even though you may have just calibrated the pump, perform a routine field test to test for leakage from possibly bad seals. First, turn the rotating head several times and set it at Index 4. Insert a fresh, sealed detector tube into the tube holder in the pump. Pull the handle all the way out until it locks. Wait 2 minutes. Release the handle and guide it back to prevent it from springing back. When the handle returns to the starting position, it should be no more than 6 mm (1/4-inch) out. If it is more than 6 mm, the pump must be serviced. Refer to the manufacturer's instruction manual for maintenance directions or return the pump to your instructor or supervisor for repair.

KEY POINT 1



When an unopened tube is inserted in the pump, guide the pump handle back to its starting position to prevent damage to the pump.

STEP 2

Look at detector tube box and at any instructions in the box. Find the measurable range for the type of detector tube you are using. For CO, the range is 10-3,000 ppm. Also, find the number of pump strokes needed to measure CO in this range. Record the numbers here:

_____

_____

KEY POINT 2

To obtain accurate results, use the number of pump strokes recommended for a specific measuring range.

STEP 3

Refer to the instructions. Find and list here the substances or conditions that interfere with sampling:

_____

_____

_____

Determine if any of these substances are in the air you will be sampling. If you are unsure, ask your instructor or supervisor.

KEY POINT 3

Other substances present in the air you sample may interfere with the readings you obtain.

STEP 4

Move to a well-ventilated area and light the campstove or other fossil-fuel-burning heater. Break off the tips of a CO detector tube and insert it so the arrow points toward the pump. Set the orifice index to 1. Because the air immediately around that heater may contain more than 200 ppm CO, pull the pump handle out all the way only one time. Wait 1 minute and release the handle by rotating it a quarter of a turn. Push the handle all the way in to exhaust all of the air in the pump.

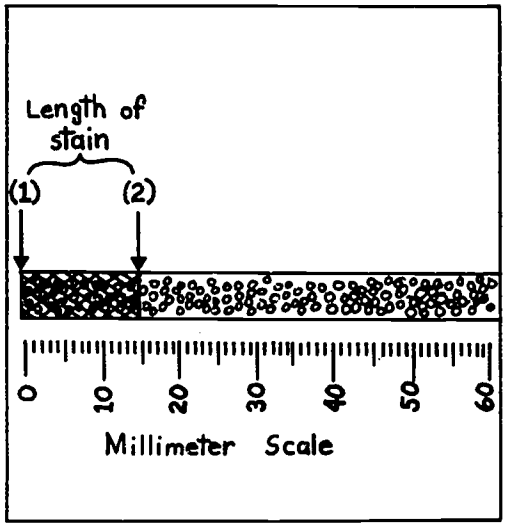
KEY POINT 4

To prevent exposure to CO, take your sample in a well-ventilated area.

STEP 5

If there was 200 ppm CO or greater in the air you sampled, a brown stain will form on the material in the tubes. If a stain is present, remove the tube from the pump. Find the instruction sheet. Lay the tube on the color scale so that the end that was closest to the CO source is at the zero end of the millimeter scale. Line up the beginning (1) of the stain and measure the length (2) of it. Read the millimeter scale to the closest millimeter. Record your result here: _____mm

KEY POINT 5



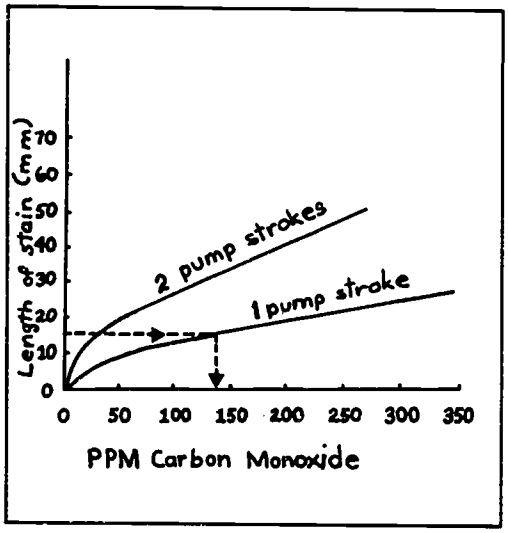
Measure the length of stain using the color-millimeter scale.

*The result you obtain may be more than the allowable ±25% of the true value if the air you sample is more than 52° C (125° F). Heat causes an inaccurate result. To obtain an accurate CO sample from a heated source, the air entering the detector tube must be cooled to 52° C (125° F).

STEP 6

Find the calibration curves on the instruction sheet. Since you used only one pump stroke, select the calibration curve for one pump stroke. Find the concentration of CO in ppm's for the length of stain you recorded in Step 5. Record the concentration here: _____ppm

KEY POINT 6



To determine CO, first select the pump stroke curve. Read the length of stain on the vertical line, move straight to the curve, and straight down to the horizontal line. Read ppm CO.

STEP 7

If a brown stain is not present after one pump stroke, pull the pump handle all the way out and wait 1 minute. Repeat this procedure two more times. If a brown stain develops, repeat Steps 5 and 6.

KEY POINT 7

Use more strokes when color does not develop after the first pump stroke.

EXERCISES

Instruction 1: Repeat Steps 2 through 6 using CO tubes from a very much outdated box. Use the same CO source and same number of pump strokes. Record your results here:

(1) length of stain _____mm

(2) concentration CO _____ppm

Instruction 2: Repeat Steps 2 through 6, using a different CO source. Check the temperature of the air you sample. If it is more than 52° C (125° F), then you will need to use a device to cool the air. Record the data here:

(1) description of CO source _____

(2) number of pump strokes used _____

(3) length of stain _____mm

(4) concentration CO _____ppm

Instruction 3: Repeat Steps 2 through 6, using a different make and model of pump such as that from the Matheson 8014K Toxic Gas Detector Kit. Use the CO tubes. Work through all the necessary steps in this book to learn how to use the pump and tubes, including identifying parts and components and calibration. Use separate paper to record your results.

Instruction 4: With the make and model of sampling pump you used to work through the steps in this book, take different types of samples with the appropriate types of detector tubes.

Instruction 5: When you are able to do the steps and exercises in this book as well as described in each of the "How Well You Must Do" sections, read over the Performance Test. When you are confident you can do each item, request your instructor to watch while you demonstrate how to use and calibrate a sampling pump and detector tubes.

PERFORMANCE TEST

Instruction 1: Read through this test. Check your skill level or progress by working through each of the following items. If you can perform the item as well as required, place a check in the space provided. When you have checked all the items, you are ready to demonstrate your skills to your instructor. You are expected to demonstrate your skills without referring to the items or to the steps in the book. You will be considered trained in these skills after your instructor approves your performance of each item.

(Instructors: You may use this checklist in guiding your evaluation.)

CALIBRATING THE SAMPLING PUMP

No. 1 _____ Check the return action of the pump handle. If it is more than 6 mm from the normal starting position, the pump must be repaired.

No. 2 _____ Release the pump handle and expel all the air from the pump.

No. 3 _____ Set the pump to draw 100 cc of air by turning the rotating head and pulling the pump handle out to the appropriate length.

No. 4 _____ Assemble the calibration apparatus by placing a 100-ml buret upside down, opening the stopcock, and fastening the buret securely but not tightly with buret clamps.

No. 5 _____ Prepare the buret so that a soapbubble will be able to rise easily.

No. 6 _____ Empty a detector tube by breaking the tips and shaking the chemical contents into a proper hazardous waste container.

No. 7 _____ Assemble the calibration train, including the buret, rubber hose, an empty detector tube, and sampling pump. All connections must be airtight.

No. 8 _____ Form a soapbubble, line it up on the 0-ml mark, and get it to rise the entire length of the buret using the sampling pump.

No. 9 _____ Wait sufficient time for the bubble to rise at each index setting and volume.

No. 10 _____ Obtain calibration readings that are within ±5% of the pumping volume.

No. 11 _____ Determine the flow rate at each index setting to within ±0.5 seconds of the manufacturer's specifications.

FOR FURTHER STUDY

If you could not perform one or more of these 11 items above, review and practice the following lesson steps:

No. 1
Lesson One, Step 1

No. 2
Lesson One, Steps 1 and 3

No. 3
Lesson One, Steps 2 and 3

No. 4
Lesson Two, Step 1

No. 5
Lesson Two, Step 2

No. 6
Lesson Two, Step 3

No. 7
Lesson Two, Step 3

No. 8
Lesson Two, Steps 4 and 5

No. 9
Lesson Two, Step 6

No. 10
Lesson Two, Step 6

No. 11
Lesson Two, Step 8

MEASURING CONCENTRATIONS OF GASES OR VAPORS USING DETECTOR TUBES AND PUMPS

No. 1 _____ Check the detector tube box to make sure the tubes are not outdated.

No. 2 _____ Determine the number of pump strokes that must be used for the desired measuring range.

No. 3 _____ Determine what substances or conditions will interfere with sampling results.

No. 4 _____ Using a CO detector tube, take a sample from a CO source.

No. 5 _____ Measure the length of stain to within 1 mm.

No. 6 _____ Use the calibration curves on the box or in the enclosed instructions to determine the concentration of CO in ppm. The proper curve must be selected based on the number of strokes used.

FOR FURTHER STUDY

If you could not perform one or more of these six items above, review and practice the following lesson steps:

No. 1
Lesson One, Step 4

No. 2
Lesson Three, Step 2

No. 3
Lesson Three, Step 2

No. 4
Lesson Three, Step 4

No. 5
Lesson Three, Step 5

No. 6
Lesson Three, Step 6

REFERENCES

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