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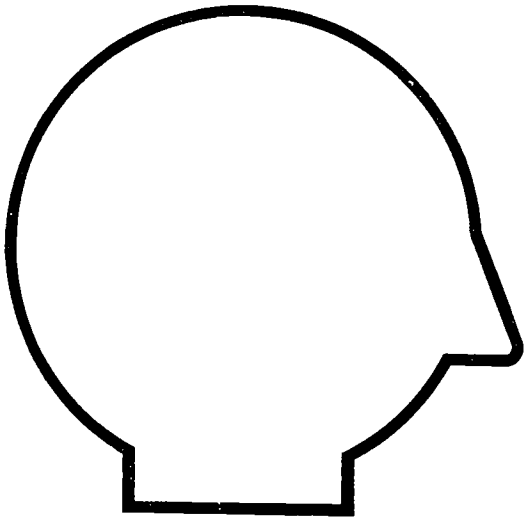
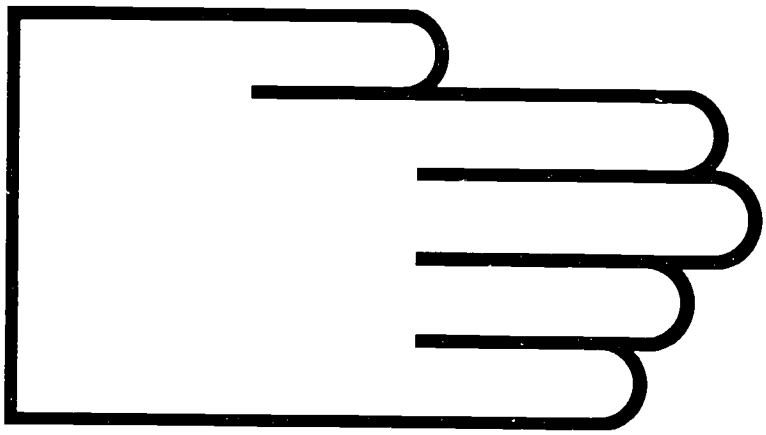
ABSTRACT

This module, one of 25 on vocational education training for careers in environmental health occupations, contains self-instructional materials on using a swinging vane anemometer to measure airflow. Following guidelines for students and instructors and an introduction that explains what the student will learn are three lessons: (1) naming each part of the swinging vane anemometer and describing its function: (2) assembling the anemometer and checking its operation, and (3) measuring airflow at air supply and exhaust vents using the swinging vane anemomenter and its attachments. 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. Performance tests cover the subject matter of each lesson. (CT)



Using a Swinging Vane Anemometer to Measure Airflow



Module 14

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 A SWINGING VANE ANEMOMETER TO MEASURE AIRFLOW 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-INSTRUCTION MATERIALS

This self-instruction learning package or module is designed to allow both students and instructor 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 working 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 do all or most of the items in this test, ask your instructor to obtain the necessary equipment and supplies. Although you do not need special preparation in mathematics or physics to do this module, you should have some working knowledge of science. You do not have to have specialized skills to enter training in this module. This module will help you learn how to take airflow readings but not how to interpret those readings.

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 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.

Take the Performance Test as a posttest.	Finally, after you have mastered all of the exercises in each lesson, ask your instructor to watch you do each item in the Performance Test. The items in the Performance Test are intended for use as a posttest to evaluate the quality of your performance. Turn now to the Performance Test to test your skills prior to training.

GUIDELINES FOR INSTRUCTORS

Approach	The approach of these materials is to provide the student with the skills to operate a swinging vane anemometer, using its attachments. You may find that the instrument presented in this module differs because of the type of instrument that is available. If that is the case, you may need to write supplementary instructions to point out the equipment differences. However, the skills tested in the Performance Test are designed for use with any make and model of instrumentation.
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 may allow students greater access to your assistance, especially in watching them perform the pre- and posttest portions 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

Advise students about the limitations of using a mechanical swinging vane anemometer. Refer them to the instrument operating manual. Inform them that the instrument cannot be used in excessively corrosive or dusty environments. Also explain that correction factors must be applied to readings for different types of supply and exhaust openings, for air temperatures that exceed 70+30° F, and for altitudes greater than 1,000 feet above sea level. These correction factors may be found in the references cited at the end of the module.

If students using this module will eventually be required to interpret the measurements they make, they should also be provided instructions on the basic theories, principles, and practices of industrial ventilation. This module does not present instructions for performing airflow calculations.

Arrange for the students to practice the exercises in Lesson Three using supply and exhaust ventilation grills.

BACKGROUND

Evaluating the performance of an airflow system is a necessary part of industrial air quality surveys. There are several reasons for evaluating airflow. Airflow is measured to assure:

- that the design of a system or any of its components is adequate to control the specific occupational hazards
- that the performance of a system is maintained
- that compliance with ventilation requirements established by Federal or State regulatory agencies is met.

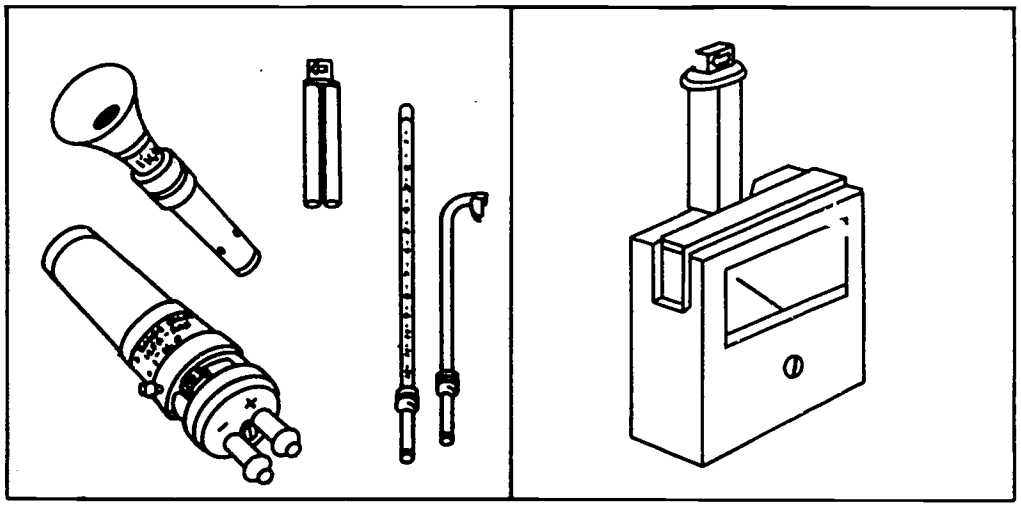
Among the instruments presently in use to determine airflow are the standard Pitot tube, the thermoanemometer, and swinging vane anemometer (velometer). Of these instruments, the standard Pitot tube is considered the standard meter for measuring air velocity pressure. It consists of two metal concentric tubes with no moving parts; the device is shaped somewhat like the letter "S". The Pitot tube is considered to be rugged, and provides accurate velocity pressure readings without having to be calibrated if constructed properly. Its chief limitation is its lack of accuracy when used to measure velocities below 800 feet per minute (fpm). The thermoanemometer is a portable, battery-powered, electronic device that is convenient to use and provides accurate measurements as low as 10 fpm. However, the instrument requires frequent adjustments during use and frequent calibration between uses. The probe on most of these types of units is fragile and very susceptible to clogging.

The swinging vane anemometer is a mechanical device that indicates air velocity as a function of the pressure of an air stream against a spring-loaded swinging vane. The swinging vane anemometer is primarily used for measuring air velocities in exhaust or supply openings. Although more rugged and less susceptible to clogging than thermoanemometers, the swinging vane anemometer has several limitations. For example, it is not able to take readings below 100 fpm at the face of exhaust openings of less than 3 square feet; when high velocities are being measured, the instrument tends to read low on the blowing side of the fan and high on the suction side; and correction factors must be used when exhaust volumes are calculated. In spite of these problems, the swinging vane anemometer was selected for presentation in this module because of its widespread use and general availability. When using the instrument, have the manufacturer's operating manual close by.

You may be required to take air velocity measurements in ventilation systems used for a variety of purposes. But the primary function of airflow developed by an industrial ventilation system is the control of airborne contaminants. It will be your task to use the swinging vane anemometer in a manner that results in valid and reliable assessments of airflow systems.

WHAT YOU WILL LEARN

When you finish working through the steps and exercises in this module, you will be able to use a swinging vane anemometer (Alnor Velometer) to measure airflow.



You will learn these aspects about the swinging vane anemometer in three lessons:

- o Lesson One

  You will be able to name each part of the swinging vane anemometer and describe its function.

- o Lesson Two

  You will be able to assemble the swinging vane anemometer and check its operation.

- o Lesson Three

  You will be able to measure airflow at air supply and exhaust vents using the swinging vane anemometer and its attachments.

LESSON ONE

OBJECTIVE

You will be able to name each part of the swinging vane anemometer and describe its function.

WHERE AND HOW TO PRACTICE

You should practice doing this lesson on a table or desk where there is room to spread out parts and also this book. Read each step before attempting to do it, and make sure you can perform the step as well as described in "How Well You Must Do." Practice labeling parts by using the diagrams in "Exercises."

HOW WELL YOU MUST DO

You must be able to name all the parts of the swinging vane anemometer and describe in your own words how the anemometer and its parts function.

THINGS YOU NEED

You will need a swinging vane anemometer and various probes and range selectors, as well as the instrument operating manual. The Alnor anemometer P-6000 is used as a model because it is similar to other types of swinging vane anemometers.*

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

*Presentation of information in this module on any type or model of equipment should not be construed as an endorsement of the equipment by the U.S. Department of Education.

GETTING THERE--STEPS

STEP 1

Place the velometer and its accessories in front of you. Look at the scales on the meter face. Different scales are used with different probes.

The two lowest scales on the meter face are used with the static pressure probe (1):

- o 0-1 inch of H_2O
- o 0-10 inches of H_2O

The next scale is used with the low-flow probe (2):

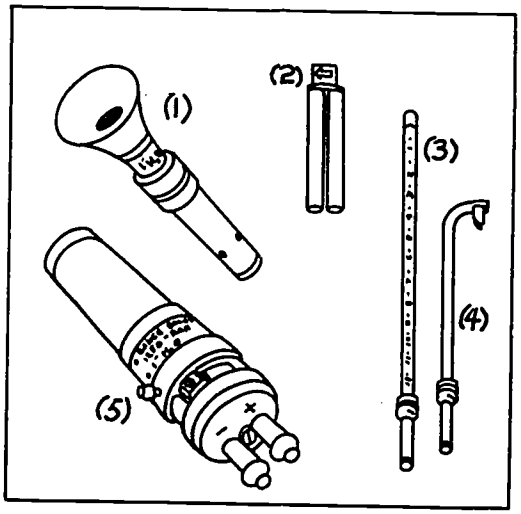
- o 0-300 feet/minute airflow

The next four scales are used with the Pitot (3) and diffuser (4) probes:

- o 0-1,500 feet/minute airflow
- o 0-2,500 feet/minute airflow
- o 0-5,000 feet/minute airflow
- o 0-10,000 feet/minute airflow

Probes (1), (3), and (4) are used with a range selector (5). Although the scales start at zero, that does not mean they register accurately at zero. For example, the 0-300 scale will not register airflow until 50 fpm is reached.

KEY POINT 1

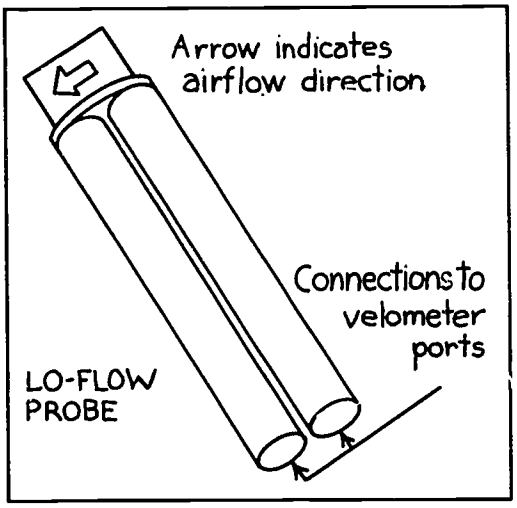


Different scales are used with different probes.

STEP 2

The low-flow probe is used in the effective velocity measuring range of 50-300 fpm, and is particularly suited for the direct measurement of drafts in rooms or open spaces and to measure face velocities at ventilating hoods, spray booths, or similar applications. The low-flow probe connects directly to the velometer ports. Inside the probe is a filter to protect the velometer from particulate matter that may be in the air stream.

KEY POINT 2

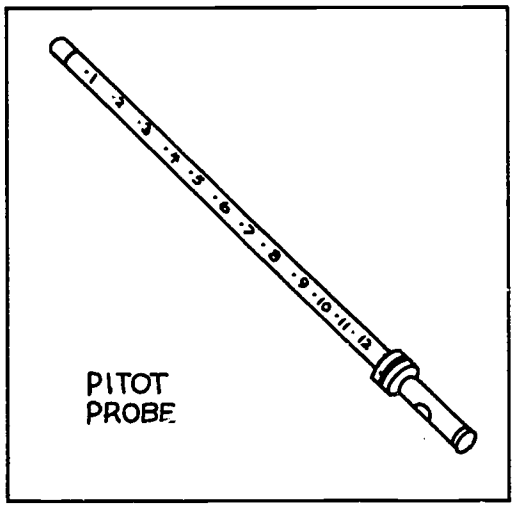


Low flows of 0-300 fpm are measured by the low-flow probe.

STEP 3

The Pitot probe is a general purpose velocity pressure measuring probe primarily suitable for making measurements at supply openings, return openings, and within ducts. It must be used with one of the range selectors.

KEY POINT 3

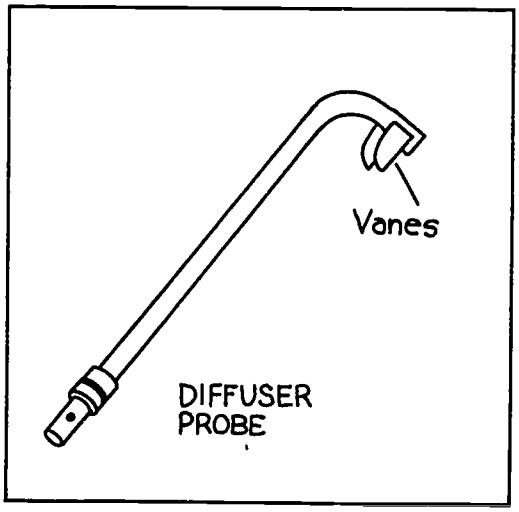


The Pitot probe is a general-purpose measuring probe.

STEP 4

The diffuser probe is primarily designed for measuring the air velocity flowing through diffuser vent grills on air supply ducts. Vanes on the probe head assist in orienting it to the airflow direction. It must be used with a range selector. A correction factor must be applied to the measurements you make in order to report accurate airflow data. The correction factor is usually supplied by the manufacturer.

KEY POINT 4

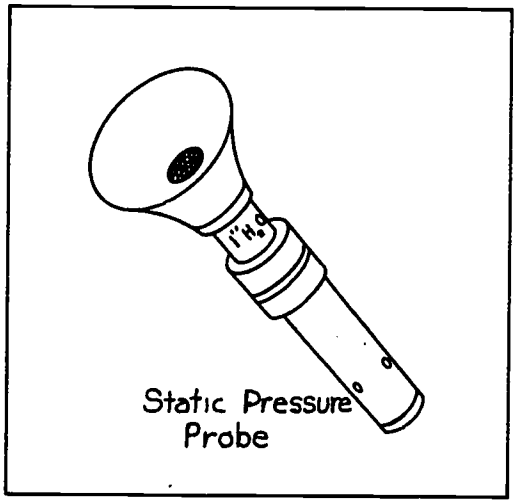


Measure air flowing through diffuser vent grills, using a diffuser probe.

STEP 5

Pick up the static pressure probe and note the rubber cup on the probe head. Press the cup down on a tabletop and quickly pull it up. The pop you hear is the release of the positive seal that is formed. The probe is placed over a small hole on the flat or gently curved surface of a duct. Results are expressed as pressure in inches of water. It must be used with a range selector.

KEY POINT 5



Obtain a positive seal by pressing the rubber cup against a flat surface.

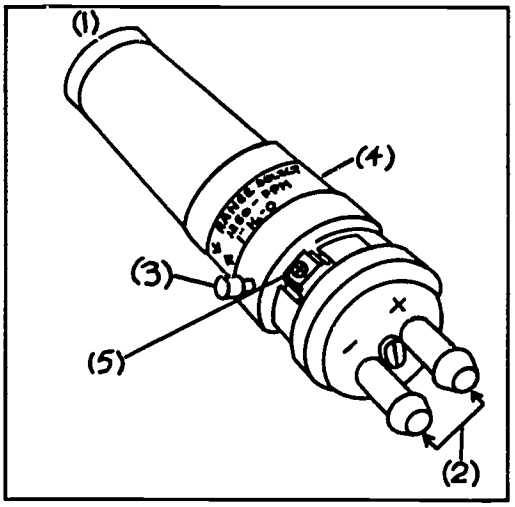
STEP 6

Pick up the range selector. On one end, note the plug-in port (1) that accept the probes described in previous steps. On the other end are the fittings (2) that connect the range selector to the rubber connection hoses. Find the air vent button (3). Depress it for use with the diffuser and static pressure probes, and release it when the Pitot tube is used. Find the range (4) in feet per minute printed on the side of the selector. If the range selector is the same as shown in Key Point 6, slide the range selector switch (5) to the left for 1,250 fpm and to the right for 2,500 fpm.

STEP 7

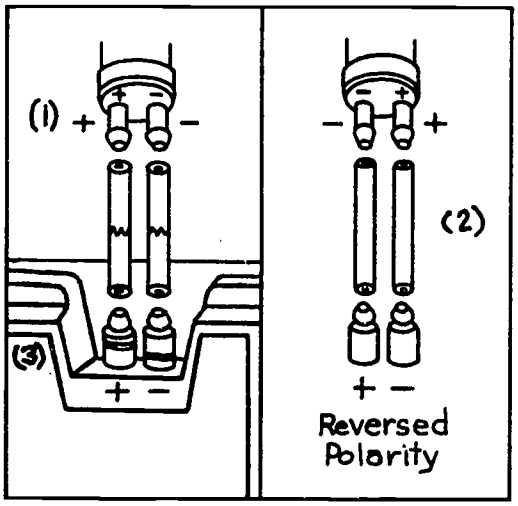
Pick up the connection hoses, the range selector, and the velometer. Push one end of each hose onto the range selector fittings (1). Note the "+" and "-" markings. For many air velocity measurements, the hoses must be connected as shown in Key Point 7. For static pressure measurements, the hoses must be reversed (2) when attached to the velometer: "+" to "-" and "-" to "+". Push the free ends of the hoses all the way onto the velometer fittings (3).

KEY POINT 6



Slide the range selector switch to the desired range, and either release or depress the air vent button.

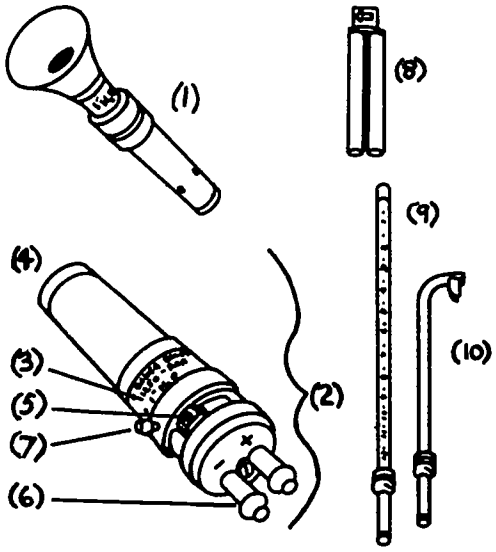
KEY POINT 7



Insert connection hoses, using the proper polarity ("+" or "-").

EXERCISES

Instruction 1: With the swinging vane anemometer and its accessory parts in front of you, practice naming each part and its function. Then label the following drawings to test your knowledge.



(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

(6) _____

(7) _____

(8) _____

(9) _____

(10) _____

Instruction 2: When you have correctly labeled each drawing and can tell what each part does, begin work on Lesson Two.

LESSON TWO

OBJECTIVE

You will be able to assemble the swinging vane anemometer and check its operation.

WHERE AND HOW TO PRACTICE

Continue using the area you selected for practicing Lesson One. Carefully read each step. If you have any question about how to perform any step in this lesson, request help from your instructor.

HOW WELL YOU MUST DO

You must be able to determine if the velometer needs to be recalibrated, to check the meter zeroing, to check the accessories for wear, and be able to attach all accessories so the instrument works within the accuracy stated in the manufacturer's operating instructions. These procedures should take less than 5 minutes.

THINGS YOU NEED

You need the same equipment as in Lesson One.

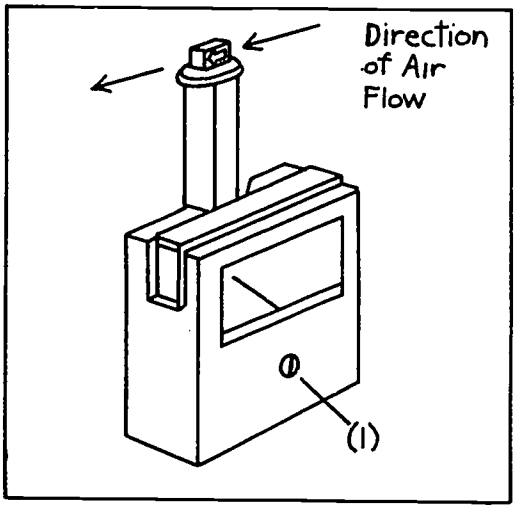
Instructions: Now turn to the next page and begin work on Lesson Two, "Getting There--Steps."

GETTING THERE--STEPS

STEP 1

Check the internal calibration of the velometer. Remove the range selector if you did not do it in Lesson One. Cap or tape the inlet and outlet ports. Lay the velometer down so the meter scales face upward. Turn the zero adjust (1) so that the meter reads slightly upscale from zero. Raise the velometer so that the meter is vertical and observe any change in the reading. If the needle moves over one-fourth of an inch, the unit needs recalibration. Remove the tape from the ports. Blow very gently into the larger air ("+") intake orifice, moving the pointer to full scale. Watch for any sticking of the pointer as it returns downscale to zero. If the air intake port becomes clogged while making measurements, use a rounded toothpick to pick loose any accumulation of dirt or dust.

KEY POINT 1



Check the velometer for calibration and free needle movement.

STEP 2

Place the velometer in a vertical position in front of you. Recap or tape the two ports. Check the zero. The needle should rest exactly on the zero points of the scale. If the needle is not in this position, turn the zero adjustment screw on the front of the case until the pointer is on zero.

KEY POINT 2

The two velometer ports should be <u>closed</u> while zeroing the instrument.

STEP 3

Pick up the low-flow tube. The low-flow probe fits only one way onto the velometer; that is, with the arrow on the probe head pointing to the left when viewing the velometer from the front. Push the low flow tube completely onto the port fittings in the velometer.

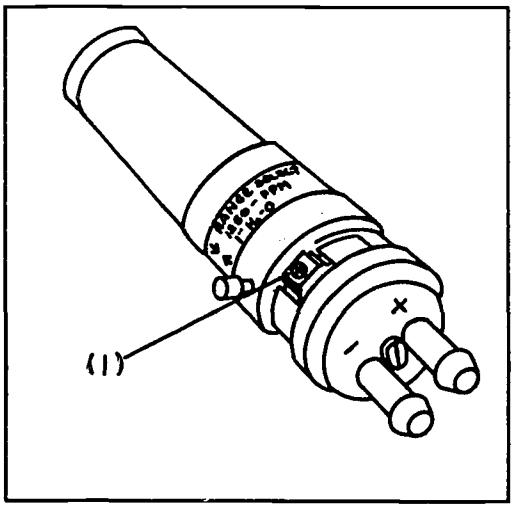
KEY POINT 3

Since no other attachments are necessary, the velometer can now be used to make airflow measurements between 50 and 300 fpm.

STEP 4

Remove the low-flow probe. Pick up the range selector. Check the tightness of the switch plate. If it is loose, tighten the "takeup" adjustment screw (1) located between the two base fittings on the switch housing assembly. When there is a noticeable effort to slide the range selector switch back and forth, the switch plate will be tight enough.

KEY POINT 4

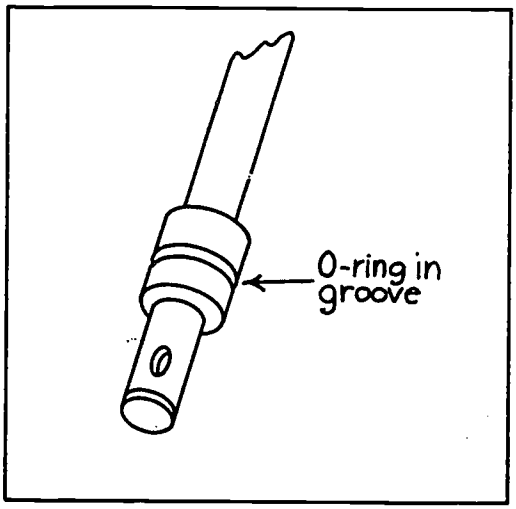


A noticeable effort to change ranges indicates the switch plate is properly tightened.

STEP 5

Pick up the Pitot probe and locate the rubber O-ring near the base. Look for cracks, determine if it fits snugly against the fitting, and check the roundness. If it needs replacement, slip the old O-ring off and lubricate the fitting with silicone grease. Slide the new O-ring on, making sure it is the correct size. The ring should fit snugly with little or no play from side to side.

KEY POINT 5

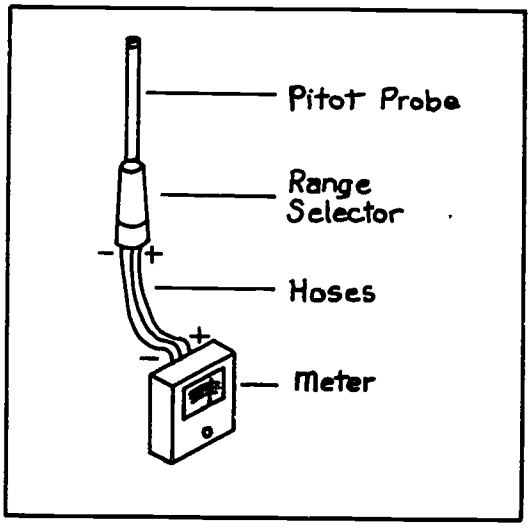


The O-ring should fit snugly, be round, and be free of cracks.

STEP 6

Insert the Pitot probe into the range selector. Push the probe down firmly until the collar of the probe rests against the face of the range selector. Attach the hoses as you did in Step 7 of Lesson One. Make sure the air vent switch is released. The velometer with Pitot tube and range selector is now ready for use.

KEY POINT 6



Release the range selector air vent switch when using the Pitot tube.

EXERCISES

Instruction 1: Practice setting up the velometer using the diffuser probe and range selector. (Repeat Steps 5 and 6.) Plug the diffuser probe into the range selector. Push the air vent switch button in and latch it down. The diffuser probe is now ready for use.

Instruction 2: Locate the static pressure probe, range selector, attachment hose, and velometer. (Repeat Steps 5 and 6.) Assemble these parts following the steps observed in assembling the Pitot probe and diffuser probe, except reverse the polarity of connecting tubes.

Instruction 3: Practice setting up the various combinations of probes and range selectors until you become proficient at making any combination of probes and selectors (with selector in appropriate mode for the probe). Checking the components and assembling each set of attachments should take less than 5 minutes.

LESSON THREE

OBJECTIVE

You will be able to measure airflow at air supply and exhaust vents using the swinging vane anemometer and its attachments.

WHERE AND HOW TO PRACTICE

Perform the steps and exercises in a room in which there are supply and exhaust air vents and returns. Practice making measurements of air flowing from or into the air vents and returns with each type of probe (except the static pressure probe used for ducts).

HOW WELL YOU MUST DO

To take measurements that are within the accuracy of the anemometer you use, you must be able to orient each probe so the air enters the probe head orifice in a direct line and not at an angle.

THINGS YOU NEED

In addition to the equipment you used in the previous lessons, you will need:

- measuring tape, at least 20 feet long
- floor fan, multispeed.

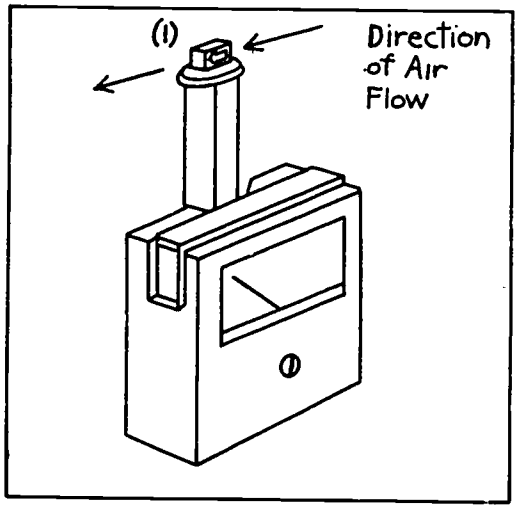
Instructions: Now turn to the next page and begin work on Lesson Three, "Getting There--Steps."

GETTING THERE--STEPS

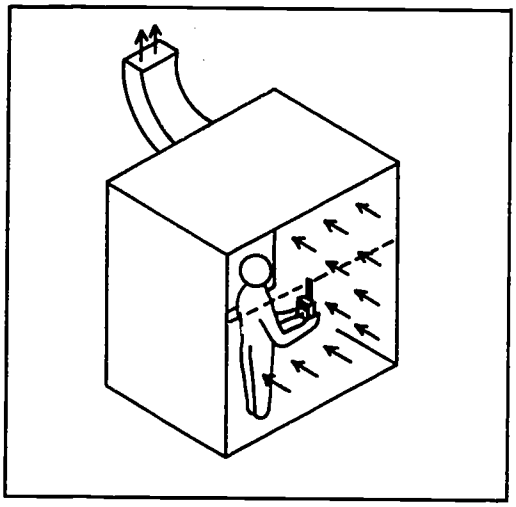
STEP 1

Zero the velometer using the technique presented in Lesson Two. Attach the low-flow probe to the velometer. Do not stand between the meter and the air suction source; stand perpendicular to the flow of air while holding the meter out away from your body. You would hold the meter this way in a paint spray booth or a laboratory hood where the opening of the hood face is greater than 3 square feet. There is a pointer on the head of the probe (1). Standing 10 feet in front of the floor fan, orient the instrument so that the pointer points in the same direction as the air to be measured is flowing. If the direction of airflow is difficult to find, turn the probe slowly until the maximum reading is obtained. Also, hold the instrument vertically in a line perpendicular to the ground. Read the 0-300 fpm scale when using the low-flow probe.

KEY POINT 1



Stand perpendicular to the airflow in a paint spray booth; hold the meter the same way inside a laboratory hood.



Do not tilt the velometer; face the probe in the direction of airflow.

STEP 2

Place the floor fan in a room where it is possible to take air velocity measurements 15 feet in front of or behind the fan. Measure 15 feet in front of the fan. Turn the fan on and set the fan speed switch at the highest position. Pick up the meter and low-flow probe and stand 15 feet in front of the fan, orienting the meter and probe as described in Step 1. Take a measurement and record the reading in feet per minute (fpm) here: _____ fpm.

Take an air velocity measurement at a point 1/2 foot behind the fan. Record your reading here: _____ fpm.

Turn off the fan.

KEY POINT 2

Take an air velocity measurement with the low-flow probe using a fan as an airflow source.

STEP 3

Locate the diffuser probe, the range selector from 1,250-2,500 fpm, and connecting hoses. Check the zeroing of the velometer as you did in Step 1.

KEY POINT 3

Check the operation of the velometer before using.

STEP 4

Attach one end of the connecting hoses to the velometer, making sure they are pushed all the way onto the ports. Connect the other end of the hose running from the "+" port to the "+" fitting on the range selector. Connect the other hose. Make sure that all hose connections are tight. Insert the diffuser probe into the range selector.

KEY POINT 4

Make sure the connecting hoses run from "+" to "+" and "-" to "-" when using the diffuser probe.

STEP 5

Depress and latch the air vent knob. Slide the range switch to the 2,500 fpm position. Always start your measurements in the highest range first. This will ensure you do not damage the velometer by subjecting it to an airflow that is too large for the scale to handle. If the initial reading on the velometer is within the range of the lower scale setting, move to the lower range to improve the accuracy of the measurement. As a general rule, always start measurements with the highest possible range and make the final measurements with the lowest possible range.

KEY POINT 5

Select the highest range first to keep from damaging the instrument.

STEP 6

Find a rectangular or square air supply vent where you can easily make airflow measurements. For this lesson, take nine airflow measurements evenly spaced over the face of the vent. Make sure the vanes on the diffuser probe are perpendicular to the direction of the flow, and that the meter is held in a vertical position. Record the readings in feet per minute here:

1) _____ 6) _____

2) _____ 7) _____

3) _____ 8) _____

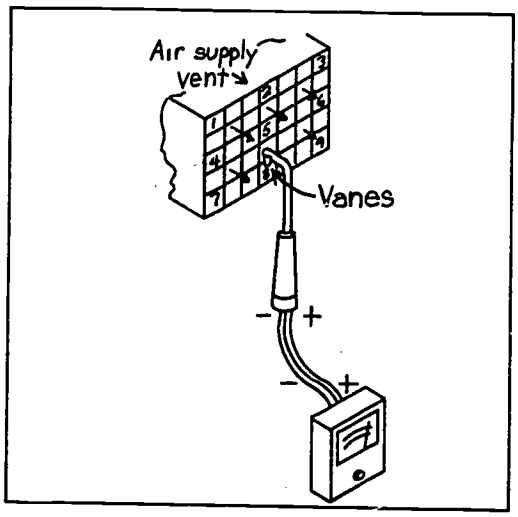
4) _____ 9) _____

5) _____

Average the readings to obtain a single flow value for the vent.

Record the average here:
_____ fpm.

KEY POINT 6



Hold the diffuser probe so the vanes are at a 90° angle to the direction of flow, and take several readings.

EXERCISES

Instruction 1. Compare the readings you recorded in Step 2. What did you observe?

The relationship between the blowing power and the suction power of the fan is 30:1 or, stated another way, the blowing power of a fan is 30 times that of its suction power. Do your readings indicate that?

Instruction 2. Make measurements with the diffuser probe at an exhaust vent grill using the techniques described in Steps 3 through 6. How does the average air velocity value compare with that in Step 6?

Instructions: Check your skill level or progress by working through each of the items in this test. If you can perform each item as well as required, place a check in the space provided. When all of the items are checked, you are ready to demonstrate your skills to your instructor. You may use the following list if needed. You will be considered trained in a skill after your instructor approves your performance on each of the following items.

CHECKING THE OPERATION OF THE SWINGING VANE ANEMOMETER WHILE ASSEMBLING IT

No. 1	_____	Check the internal calibration of the velometer.
No. 2	_____	Zero the velometer meter needle so it rests exactly on the zero points of the scales.
No. 3	_____	Push the low-flow tube completely onto the velometer port fittings.
No. 4	_____	Tighten the switch plate on the range selector until there is a noticeable effort to change ranges.
No. 5	_____	Check the condition and fit of the O-ring on the Pitot, diffuser, and static pressure probes.
No. 6	_____	Attach the connecting hoses with the correct polarity (+ or -) for each probe, making sure the connections are tight.
No. 7	_____	Depress the air vent knob when using the diffuser and static pressure probes, and release it when using the Pitot probe.
No. 8	_____	Slide the range selector switch to the appropriate range for the airflow to be measured.
No. 9	_____	Check and assemble each set of attachments in less than 5 minutes.

FOR FURTHER STUDY

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

No. 1
Lesson Two, Step 1

No. 2
Lesson Two, Step 2

No. 3
Lesson Two, Step 3

No. 4
Lesson Two, Step 4

No. 5
Lesson Two, Step 5

No. 6
Lesson One, Step 8

No. 7
Lesson One, Step 7; Lesson Two, Step 6

No. 8
Lesson One, Step 7

No. 9
Lesson Two, Exercises, Instruction 3

MAKING AIRFLOW MEASUREMENTS USING A SWINGING VANE ANEMOMETER

No. 1 _____ Use the low-flow probe for making airflow measurements by facing the probe in the direction of airflow and holding the instrument vertically in a line perpendicular to the ground.

No. 2 _____ Make measurements at an air supply vent using the diffuser probe; hold the probe so the diffuser vanes are perpendicular to the airflow. Make at least nine measurements at an air supply grill or at an air exhaust vent.

FOR FURTHER STUDY

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

No. 1
Lesson 3, Step 1

No. 2
Lesson 3, Steps 2 through 6

REFERENCES

American Conference of Governmental Industrial Hygienists. Industrial Ventilation, A Manual of Recommended Practice, 16th ed., 1980.

Operating Instructions for the Alnor Velometer, Alnor Instrument Company, Niles, Illinois. (no date)

U.S. Department of Health, Education, and Welfare, National Institute for Occupational Safety and Health. The Industrial Environment--Its Evaluation and Control, Chapter 40, 1973.

U.S. Department of Labor, Occupational Safety and Health Administration. Industrial Hygiene Field Operations Manual, Section 8 (OSHA Instruction CPL 2-2.20), April 1979.