MAINTENANCE, CALIBRATION, AND OPERATION OF ISOKINETIC SOURCE-SAMPLING EQUIPMENT

by

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CONTENTS

Page

LIST OF FIGURES

MAINTENANCE, CALIBRATION, AND OPERATION OF ISOKINETIC SOURCE-SAMPLING EQUIPMENT

INTRODUCTION

The purpose of this publication is to explain the maintenance, calibration, and operation of the isokinetic source-sampling equipment described in Construction Details of Isokinetic Source-Sampling Equipment[1] as performed by the Emission Testing Branch of the Office of Air Programs, Environmental Protection Agency. This procedure has been used satisfactorily and is presented as a guide to assist interested personnel in using the equipment.

The sampling train has four major components: (1) the pitobe assembly, which includes the probe nozzle, a heated glass probe, and a pitot tube for monitoring gas velocity during sampling; (2) the meter box assembly, which consists of a system of manometers, an orifice meter, a vacuum pump, a dry gas meter, and electrical controls for sampling; (3) the sample box assembly, which contains the glassware; and (4) the umbilical cord, which connects the sample box with the meter box. A representation of the sampling train is shown in Figure 1. The maintenance and calibration procedure described for each of the components should be followed in the shop or laboratory in preparation for each sampling test.

459-345 O - 72 - 2

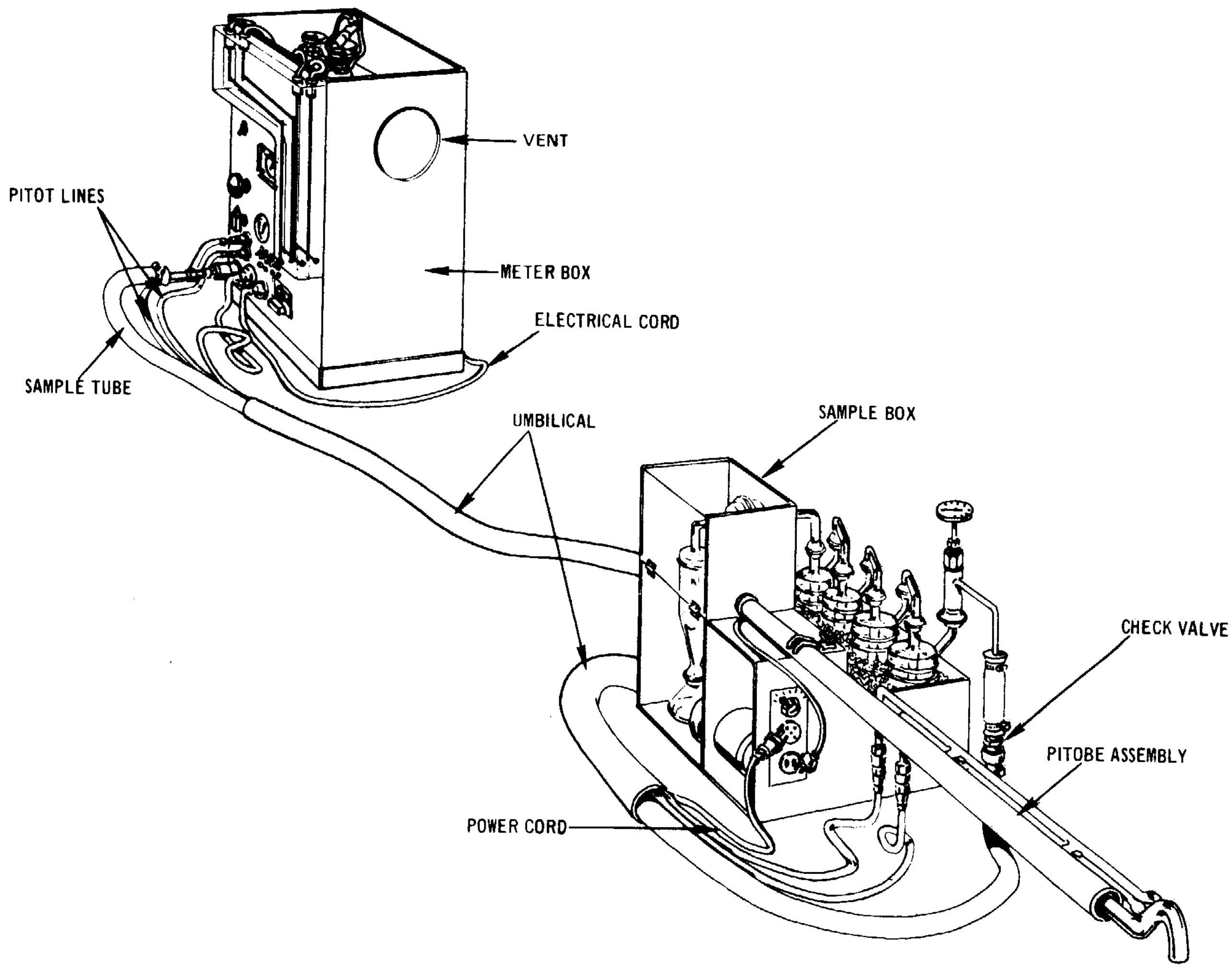


Figure 1. Sampling train.

MAINTENANCE

PITOBE ASSEMBLY

Preliminary Disassembly

To disassemble the pitobe, first remove the Swagelok* union (parts 2 through 7) except for the welded nut (8) as shown in Figure 2. The nozzle (1) is usually removed in the field and carried separately. Check for broken glass chips.

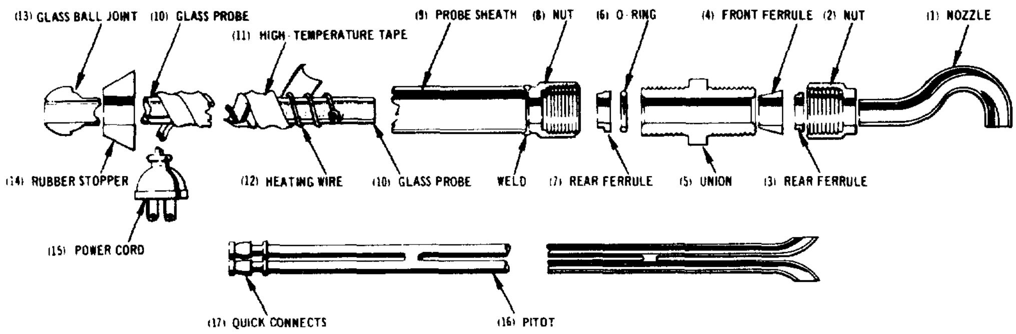


Figure 2. Pitobe assembly.

Probe

Remove the glass probe (10) from the sheath (9) and check visually for broken or fractured sections. The most common area of broken or fractured sections is within 1-1/2 inches from the front and approximately 3 inches from the rear. Some fractures on the back end are hard to see because of the tape (11) and rubber stopper (14). One way of checking is to gently twist the glass probe and listen for grating sounds. Inspect the electrical system of the probe for visible shorts or burned spots shown by uniform darkening of the high-temperature insulation tape (11), and the power cord connection (15). Then plug the power cord into a variable transformer and set the power rating at about 55 volts. The probe should become warm to the touch over its entire length in a few minutes. If the probe does not heat, check the variable transformer for proper voltage and for loose connections in the plug (15) and Nichrome wire. Shorts are indicated by partial heating in

*Mention of a specific company or product name does not constitute endorsement by the Environmental Protection Agency.

the rear portion of the probe. Breaks in the Nichrome wire can be checked with an ohmmeter or a battery-light system.

If the probe is in good order, proceed with the cleaning process. Wipe the grease from the ball joint. Clean the probe internally by brushing, first using tap water, then distilled, deionized water followed by acetone. Rinse the probe with acetone and allow it to dry in the air. Inspect visually for cleanliness and repeat the procedure if necessary.

Pitot-Probe Sheath

Remove the quick connects (17) from the pitot tube (16) and wipe them clean. A drop of penetrating oil helps keep them in good working condition.

Use compressed air to blow out the pitot tube. Both the pitot tube and sheath should be wiped or washed clean with water and air dried. Inspect the pitot tube openings for damage and misalignment, and, if necessary, repair and recalibrate the tube according to the procedure given in the Calibration section of this report.

Swagelok Union

Clean the stainless steel union (5), nut (2), ferrules (3, 4, 7), and rubber O-ring (6) by scrubbing. Rinse with distilled, deionized water, and then with acetone; air dry.

Assembly

After the parts are cleaned and inspected, assemble the pitobe component except the nozzle. Insert the probe into the sheath, making sure that the rubber stopper seats properly onto the sheath. The front end of the glass probe should be about flush with the front end of the welded union nut (8). This prevents the union (5) from pushing against the probe and chipping the end or unseating the rubber stopper. Replace the Swagelok union (2-7), making sure that the rear ferrule (7) is on backwards. Asbestos cord should be substituted for the O-ring when stack temperatures in excess of 500^{o} F are expected. The union (5) should be only finger tight. The use of a wrench can cause cracks within the first 1/2 inch of the probe or, if the nut (8) was not welded square with the sheath, cracks about 1-1/2 inches from the front.

Cover the open ends of the probe with serum caps or similar covers to avoid contamination.

A sample check list is shown in Figure 3. There should be at least two sets of pitobes of the desired length for each sample box with each pitobe identified.

Date ____________________ Probe No. ____________

Probe

- Glass probe ____________
- Rubber stopper ____________
- Insulation tape ____________
- Power cord extension ____________
- Heating system ____________
- Clean ____________

Pitot-probe sheath

- Quick connects ____________
- Pitot tube ____________
- Sheath and welded nut ____________
- Clean ____________
- Calibration (pitot tube) ____________

Swagelok union

- Probe side
  - Rear ss ferrule (backwards) ____________
  - Rubber O-ring ____________
  - Asbestos cord ____________
- Union ____________
- Nozzle side
  - Front ss ferrule ____________
  - Rear ss ferrule ____________
- Clean ____________
- General remarks: ____________

Note: 25-foot Nichrome wire on particulate probes.

Initial each item when checked and write in any remarks.

Figure 3. Suggested pitobe assembly check list.

NOZZLES

Inspect the knife edge of the nozzle for damage. If damaged, repair and recalibrate the nozzle according to the procedure in the Calibration section. Clean the nozzle by scrubbing and rinse with distilled, deionized water, and then with acetone; air dry. Cover the open ends with serum caps or similar covers to avoid contamination or damage to the knife edge.

There should be a selection of nozzles ranging from 1/8 to 1/2 inch in diameter in 1/16-inch increments with two or three sets of each size. The exact diameters should be etched on the shank of each of the nozzles and all the nozzles kept in a separate box.

METER BOX ASSEMBLY

Casing

Remove the meter box casing, check the general condition, and make necessary repairs.

Pump Oil and Filter

Change the pump lubricating oil (28), if dirty; fill to mark; and clean the pump filter (27). The parts are identified in Figure 4.

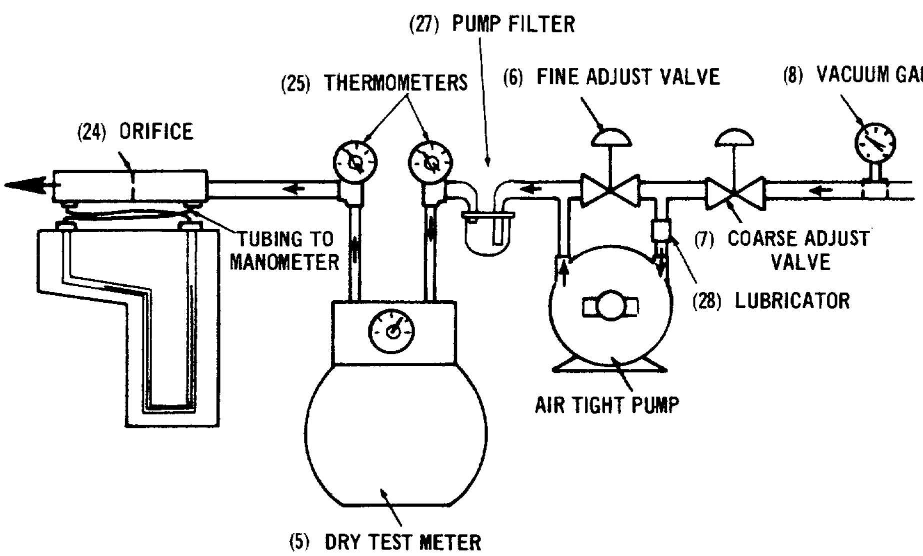


Figure 4. Pump-meter assembly.

Thermometers

Check the dry-gas-meter thermometers (25). The temperature should check against room temperature using a mercury-in-glass thermometer as the standard.

Quick Connects

Wipe the quick connects (9) clean (Figure 5). A drop of penetrating oil helps keep them in good working condition.

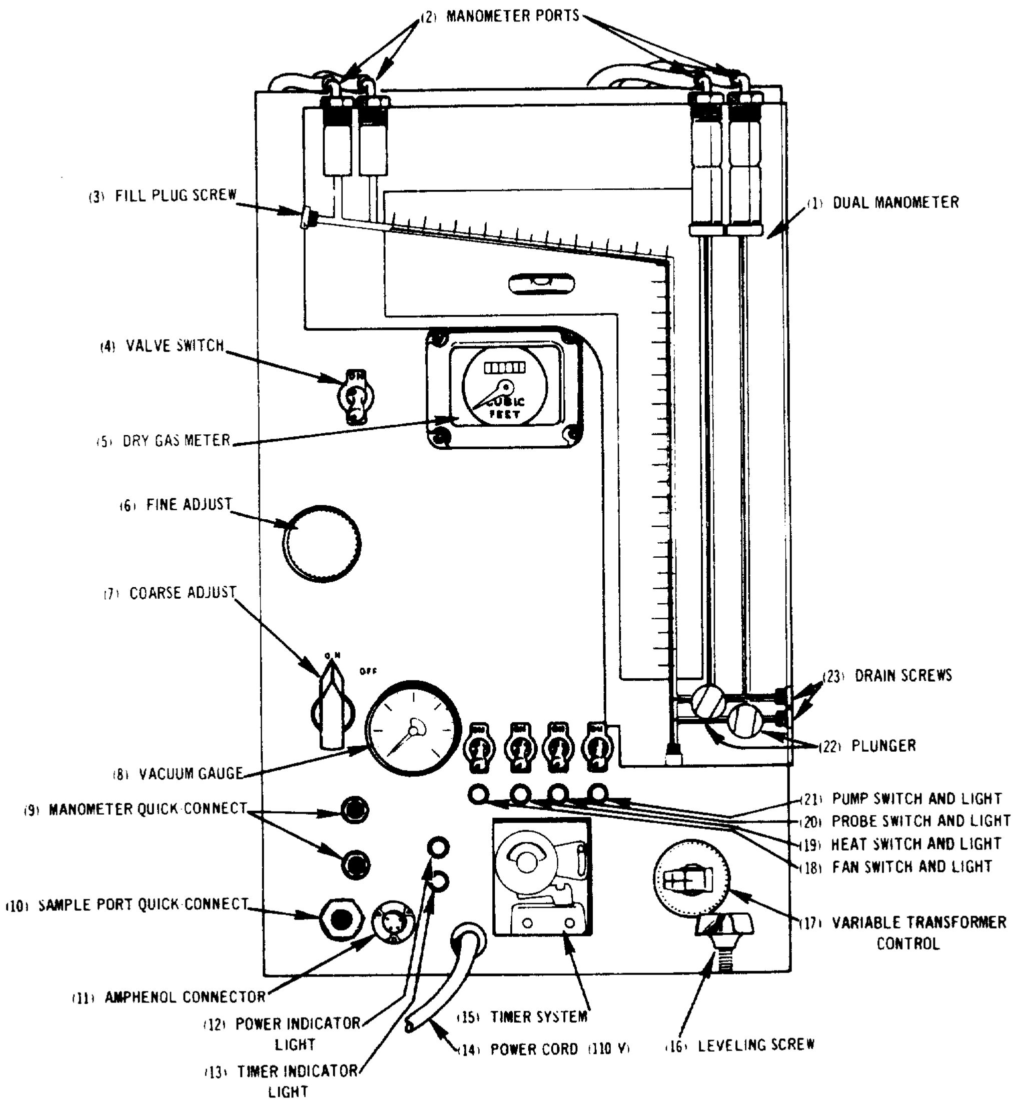


Figure 5. Front panel of meter box.

Dual Manometer

Visually check the pitot and orifice manometer lines. They should be free of fluid. Check for leaks, especially around the fluid-level plunger (22) and drain screws (23) shown in Figure 5. Replace the fluid-level plunger or O-rings, if necessary. Wipe the dual manometer (1) clean. The back can be cleaned with compressed air or the device can be removed from the box and wiped clean. If the dual manometer is unusually dirty, clean as recommended by the manufacturer. Replace the red manometer fluid, if it is faded. Manometer fluids are color-coded: red is used for the pitot tube manometer and yellow for the orifice manometer (or a similar combination) for ease of reading in the field.

After making sure that the manometer ports (2) are open and the manometer lines connected, level the manometer and check the fluid level. The manometer can be filled with fluid by removing the screw (3) on the left side. When the manometer is zeroed, the fluid-level plunger should have about 1/4- to 1/2-inch travel inward.

Pitot-Tube Lines

Blow through the pitot-tube quick connects (9) to check for obstructions. The sealing balls in these quick connects should be removed to allow for free movement of air. The pitot-tube manometer should respond.

Solenoid Valve

Plug the meter-box power cord into a 110-volt outlet. The power indicator light (12) should go on and a click should be heard. The click is the sound of the solenoid valves moving into the position shown in Figure 6. If the clicking sound does not occur, check the power source, plug, power cord and connections, bulb, and solenoid valve.

The valve switch (4), shown in Figure 5, operates the solenoid valve assembly, which contains three 2-way solenoid valves (Figure 6). Two are usually open and one is closed. When the valve switch is turned on, the two open valves close and the flow into the manometer is blocked and the closed solenoid valve opens to allow the pressure to equalize. This allows the manometer to be zeroed while the pump is running.

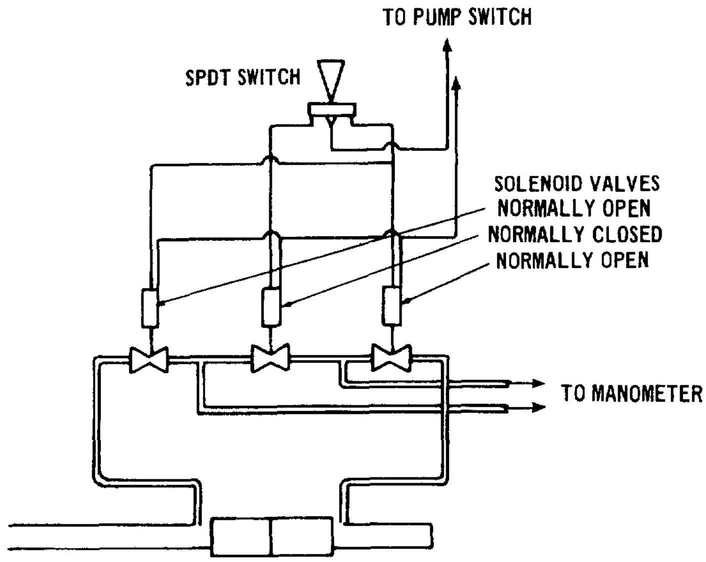


Figure 6. Solenoid assembly diagram.

The solenoid assembly operates only on the orifice manometer. To zero the pitot tube manometer, the pitot tube lines can be disconnected at the quick connects on the meter box.

Lights and Switches

Turn the coarse-adjust valve (7) to the <u>off</u> position and open fully the fine-adjust valve (6). Turn on all switches (18 through 21) to check the lights. The heater light should not go on until the fan switch is also on. If any of the lights do not function, check for defective parts, including switches, lights, fuses, and wiring.

Orifice Meter Lines

Turn off all switches except the pump switch (21). Turn on the valve switch (4) and carefully adjust the coarse-adjust and fine-adjust valves. The orifice meter manometer should respond to valve controls. If no movement is observed, check the solenoid valves or the orifice meter system.

Timer

Leaving the pump on, check the timer system (15), which should operate only when the pump is on. Malfunction of the timer can be caused by decreased voltage supply or a worn synchronous motor. The timer has different cams for various time periods or cycles, but the most commonly used is 5 minutes. Check the

459-345 O - 72 - 3

timing for at least two cycles. The buzzer and timer light (13) should go on at the end of the specified cycle. The duration of the buzz can be regulated by adjusting the notch on the timer. Turn the pump off.

Amphenol Outlet and Variable Transformer

Check the Amphenol outlet with a voltmeter or check light by connecting the leads to the different terminals (Figure 7). When connected across the variable transformer, the voltage meter or check light should respond correspondingly.

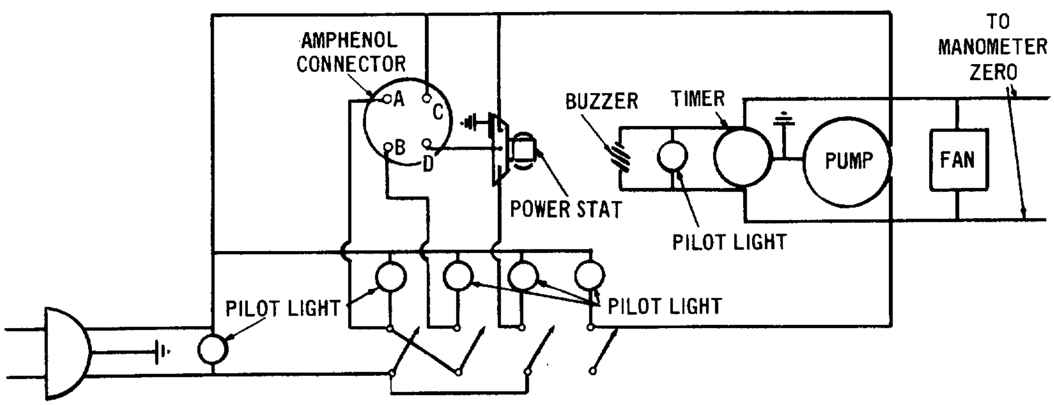


Figure 7. Meter box wiring diagram.

Vacuum System

Insert a plugged male quick connect into the sample port (10), shown in Figure 5. Make sure that the valve switch (4) is off and then activate the pump. Turn the coarse-adjust valve to the on position and close fully the fine-adjust valve. The vacuum gauge (8) should read about 27 inches of mercury for a barometric pressure of 30 inches of mercury. Check the leakage rate using the reading on the dry gas meter (5) and a watch. If leakage exceeds 0.02 cubic foot per minute, find and correct the leak or leaks. Parts to check are the pump, vacuum gauge, metering valves, and pipes.

Calibration

After all systems are functioning properly, calibrate the dry gas meter (5) shown in Figure 5 and the orifice meter (24) shown in Figure 4 according to the procedure in the Calibration section.

A sample check list and a calibration and calculation sheet are shown in Figures 8 and 9. For recording purposes, the meter box should be numbered.

Date ______________ Box No. ______________ Dry gas meter No. ______________

Pump oil and filter ______________

Quick connects ______________

Dry-gas meter thermometers ______________

Dual manometer system ______________

Pitot-tube lines ______________

Solenoid valve ______________

Lights and switches ______________

Orifice-meter lines ______________

Timer ______________

Amphenol outlet ______________

Variable transformer ______________

Vacuum system

Metering valve ______________

Vacuum gauge ______________

Leak check at ______ inches of mercury - leakage = ______________

Calibration (orifice and meter) ______________

General remarks ______________

____

____

Initial each item when checked and write in any remarks.

Figure 8. Suggested meter box assembly check list.

SAMPLE BOX ASSEMBLY

Ice Bath

Fill the ice bath (4) with water and check for leaks (Figure 10).

Electrical System

Using an Amphenol adapter (Figure 11), plug into a 110-volt source. The fan and heater should go on. Failure to operate may be caused by a faulty electrical source, a poor connection, a defective fan, or a defective heating element. The

Date ____________________ Box No. ____________

Barometric pressure, P_b = ___in. Hg Dry gas meter No. ____________

Orifice manometer setting, ΔH, in. H_2O	Gas volume wet test meter V_w, ft^3	Gas volume dry gas meter V_d, ft^3	Temperature: Wet test: Meter t_w, °F	Temperature: Dry gas meter: Inlet t_{di}, °F	Temperature: Dry gas meter: Outlet t_{do}, °F	Temperature: Dry gas meter: Average t_d, °F	Time θ, min	γ	ΔH@
0.5	5								
1.0	5								
2.0	10								
4.0	10								
6.0	10								
8.0	10								
						Average			

Calculations

ΔH	$\frac{\Delta H}{13.6}$	γ: $\frac{V_w P_b (t_d + 460)}{V_d\left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$	ΔH@: $\frac{0.0317\ \Delta H}{P_b\ (t_d + 460)}\left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737		
2.0	0.147		
4.0	0.294		
6.0	0.431		
8.0	0.588		

γ = Ratio of accuracy of wet test meter to dry test meter. Tolerance = ± 0.01

ΔH@ = Orifice pressure differential that gives 0.75 cfm of air at 70° F and 29.92 inches of mercury, in. H_2O. Tolerance - ± 0.15

Figure 9. Suggested orifice and dry gas meter calibration and calculation form.

wiring diagram is shown in Figure 12. Check thermostat operation by inserting a dial thermometer in the heated section of the box. The temperature will generally fluctuate 20 to 30° about the average after it stabilizes. The usual setting is 250° F, but the thermostat can be adjusted to the setting desired.

Check the probe heater plug with a voltmeter or with a 110-volt check light.

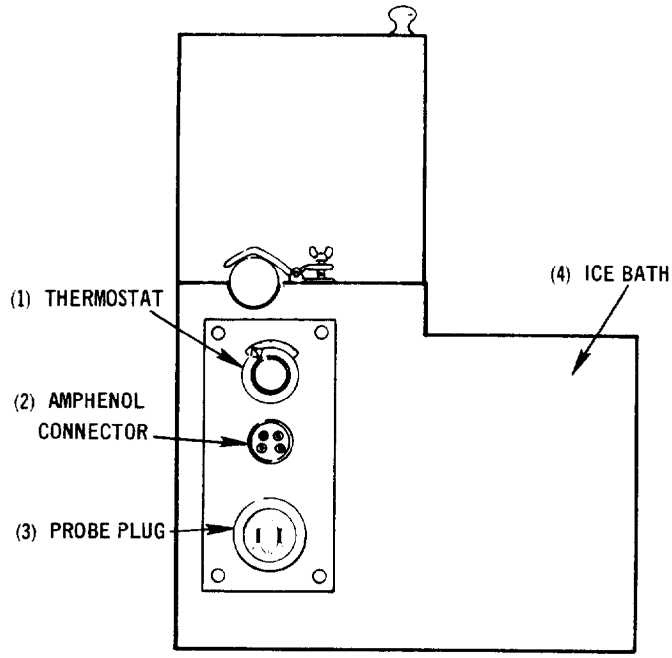


Figure 10. Sample box.

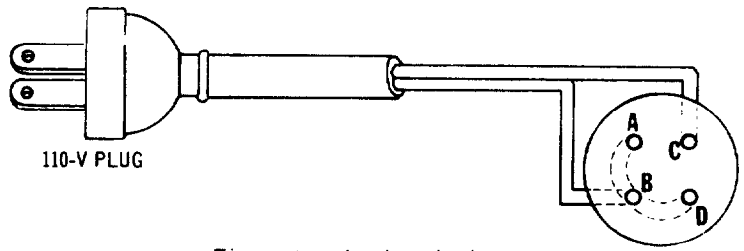


Figure 11. Amphenol adaptor.

A sample check list is shown in Figure 13. Again, for recording purposes, the box should be numbered. At least two sets of the sample-box assembly, including the glassware for each meter box, should be on hand for a stack test and preferably more, depending on the number of runs required in a day. The availability of several sets increases efficiency during the test since the sample train can be cleaned while the second run is being made or the trains can be cleaned after all runs have been completed.

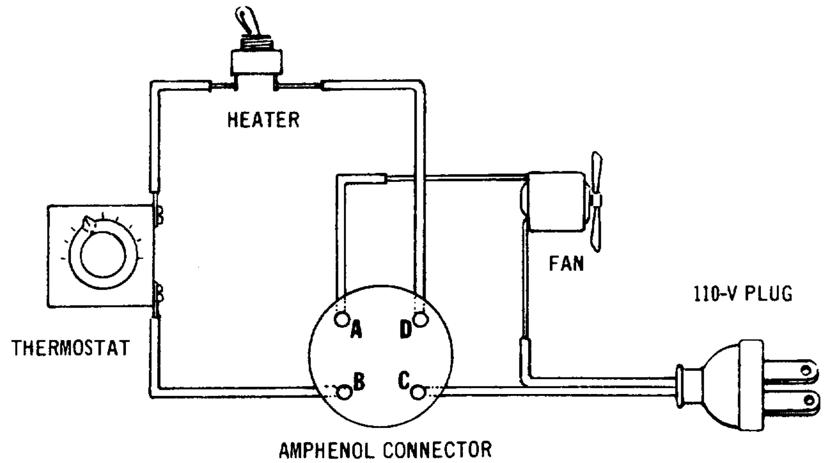


Figure 12. Amphenol wiring diagram.

Date ______________________ Box No. ______________________

Ice bath ______________________

Electrical system

Heater ______________________

Blower ______________________

Probe receptacle ______________________

Thermostat ______________________

Setting for average temperature of ___ °F

Temperature variation ___°F ± ___°F

General remarks ______________________

____

____

Initial each item when checked and write in any remarks.

Figure 13. Suggested sample box check list.

POLLUTANT COLLECTOR

Glass Parts

Wipe the grease from the joints of the cyclone (1) and flask (2), filter holder (4), glass connectors (5), and impingers (3), shown in Figure 14. Wash with glass cleaning detergent. For hard-to-clean parts use dichromate sulfuric acid cleaning solution. Rinse with distilled, deionized water, and then acetone; air dry. Reassemble the impinger portions using a thin coat of acetone-insoluble silicone stopcock grease on the upper half of the taper joints (Figure 15). Cover all exposed openings to avoid contamination.

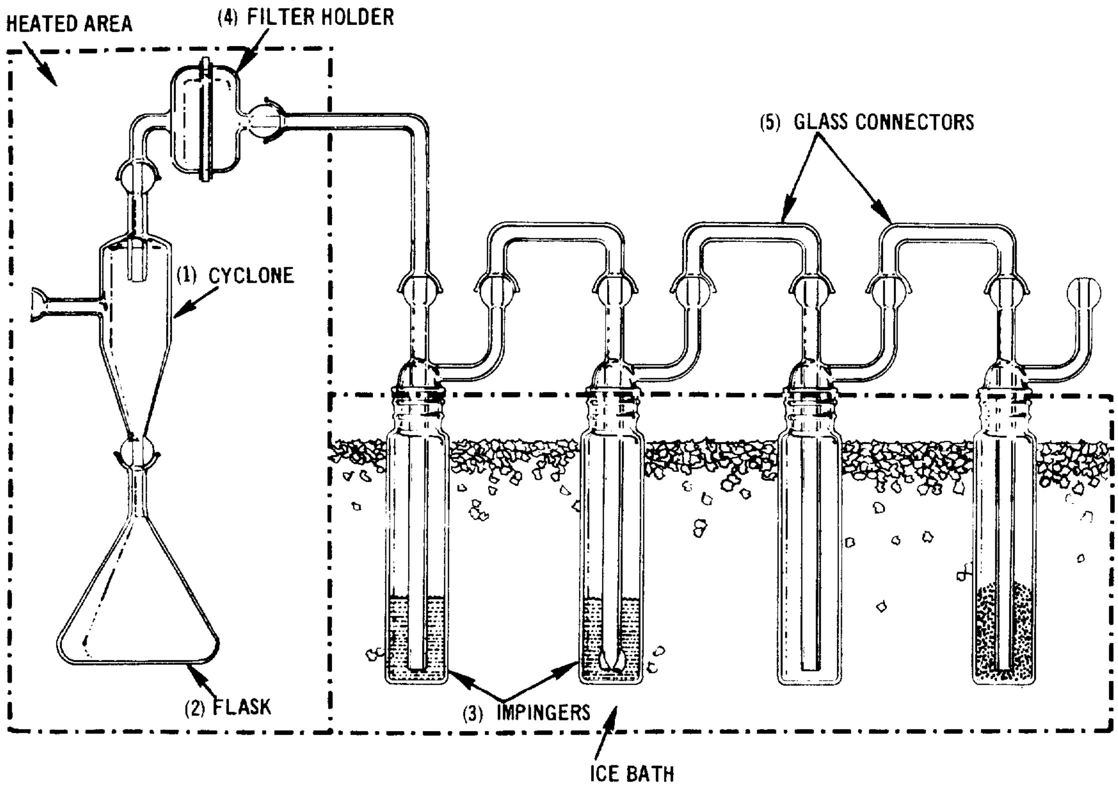


Figure 14. Sample box glassware assembly.

Glass Frit

If the glass frit (7), shown in Figure 16, is dirty, place it in boiling, concentrated HCl for 0.5 hour. Rinse with distilled, deionized water, and then acetone; air dry. If the frit still does not appear clean, boil for 2 hours in concentrated H_2SO_4 plus a few drops of sodium or potassium nitrate. Rinse well with distilled,

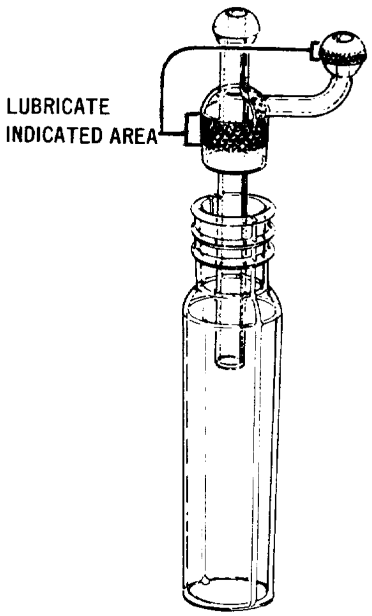


Figure 15. Impinger.

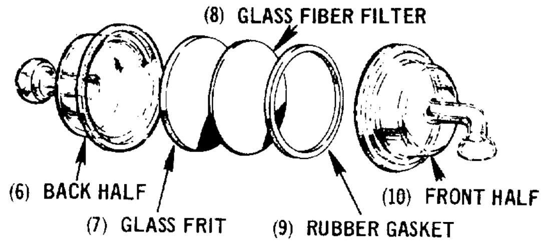


Figure 16. Glass filter holder assembly.

deionized water, and then acetone; air dry. This procedure should also be followed with new frits. The filter-holder assembly is shown in Figure 16.

Assemble the filter holder and components for a pressure-drop check as shown in Figure 17 (see dry gas meter and orifice meter under Calibration). Turn the pump on and adjust flow on the orifice manometer to $\Delta H@$. If the vacuum gauge

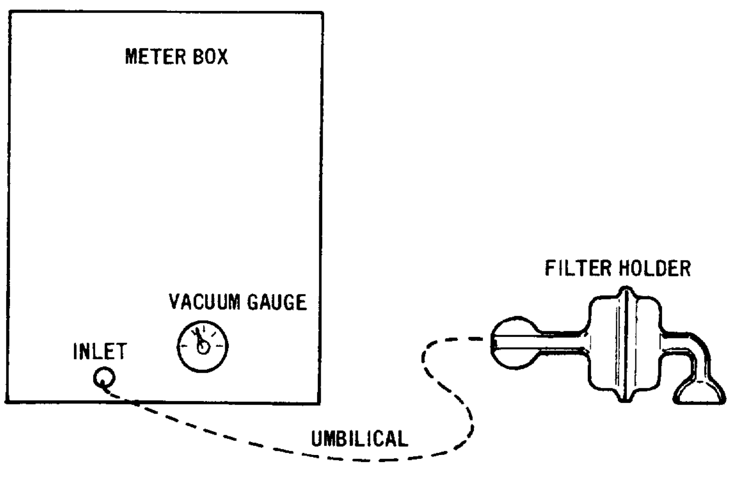


Figure 17. Glass frit pressure drop check.

on the meter box reads higher than 2 inches of mercury, the frit either is too fine and should be replaced or is dirty and should be cleaned and checked again.

Greenburg-Smith Impinger Orifice

Fill the Greenburg-Smith impinger tube with water. If the water does not drain through the orifice in 6 to 8 seconds, it should be replaced. This is only required for new impingers.

Filter-Holder Gasket

Clean the filter-holder gasket by washing. Rinse with distilled, deionized water, and then acetone; air dry.

UMBILICAL CORD

Quick Connects

Wipe the vacuum line and pitot line (1-2) quick connects clean (Figure 18). A drop of penetrating oil on each helps keep them in good working condition.

Thermometer

Check the dial thermometer (4). The temperature should check against room temperature when a mercury-in-glass thermometer is used as the standard.

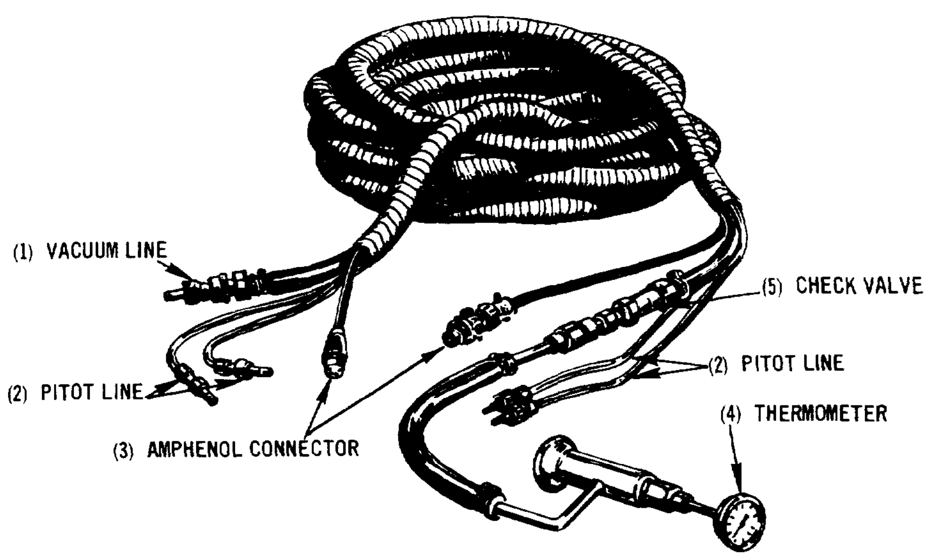


Figure 18. Umbilical cord.

Electrical Lines

Check the electrical lines (3) for continuity using an ohmmeter or a battery-light system. Make sure that the leads are connected to the proper prongs. If there is no continuity in any of the lines, check the Amphenol connections. If this is not the problem, replace the cord.

Check Valve

Disconnect the joint at the check valve (5) and add a drop of lubricating oil on the valve.

Vacuum and Pitot Lines

Test the vacuum line for leaks by blocking the inlet with the plugged ball joint. Connect the line to the meter box and check for leakage as before. If leakage is noted, check all connections first and then, if necessary, check the tubing. If the cause is not readily identified, slightly pressurize the line and check for leaks using soapy water.

Connect one end of the pitot-tube line to a 36-inch U-tube mercury manometer or a similar device. Pull a vacuum of at least 10 inches, seal the tubing at the pump end, and check for leaks by noting the mercury manometer. Do the same for the other side. If leakage is noted, check the tubing the same way as for the vacuum line.

A sample check list is shown in Figure 19. For recording purposes, the umbilical cord should be numbered.

Date ____________________ Umbilical No. ____________________

Quick connects ____________________

Thermometer ____________________

Electrical check ____________________

Check valve ____________________

Leak test

Vacuum line ____________________

Pitot lines ____________________

General remarks ____________________

____

____

____

Initial each item when checked and write in any remarks.

Figure 19. Suggested umbilical cord check list.

CALIBRATION

NOZZLE DIAMETER

Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.001 inch. Make 10 separate measurements using different diameters each time and obtain the average of the measurements. The largest deviation from the average should not exceed 0.002 inch. If the nozzle is satisfactory, polish off the old inscribed value or, if new, etch the value of the inside diameter on the outside of the nozzle.

PITOT TUBE

Measure the velocity pressure, ΔP, at the same point within a cross section of a straight run of ductwork (8 diameters downstream and 2 diameters upstream from any point of disturbance) with a standard pitot tube and the S-type pitot tube for the desired range of gas velocities. The S-type pitot should be calibrated twice, reversing the direction of the legs during the second calibration. Make at least three determinations for each direction. Determine the pitot tube coefficient for each direction as:

$$C_{P(s)} = 0.99\sqrt{\frac{\Delta P\ (\text{standard})}{\Delta P(s)}}$$

Use only those pitot tubes in which the average coefficient, C_P, equals 0.85 ± 0.02 in both directions, since the nomograph used with the sampling train is designed for this number.

DRY GAS METER AND ORIFICE METER

Connect the components as shown in Figure 20. The wet test meter is a 1-cubic-foot-per-revolution meter with $\pm$ 1 percent accuracy. Run the pump for about 15 minutes with the orifice manometer set at about 0.5 inch of water to allow the pump to warm up and to permit the interior surface of the wet test meter to be wetted. Then gather the information as requested on the data sheet in Figure 9. Calculate γ, the ratio of accuracy of the wet test meter to the dry test meter, and $\Delta H_@$. If an average γ of 1.0 ± 0.01 is not obtained, the dry gas meter should be

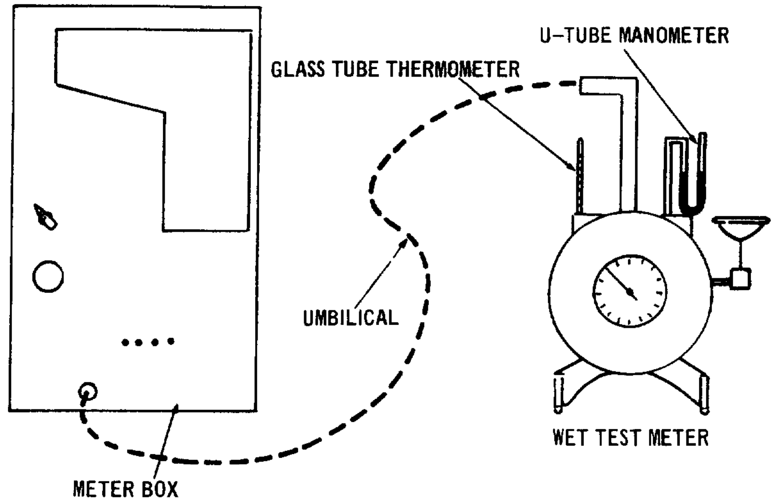


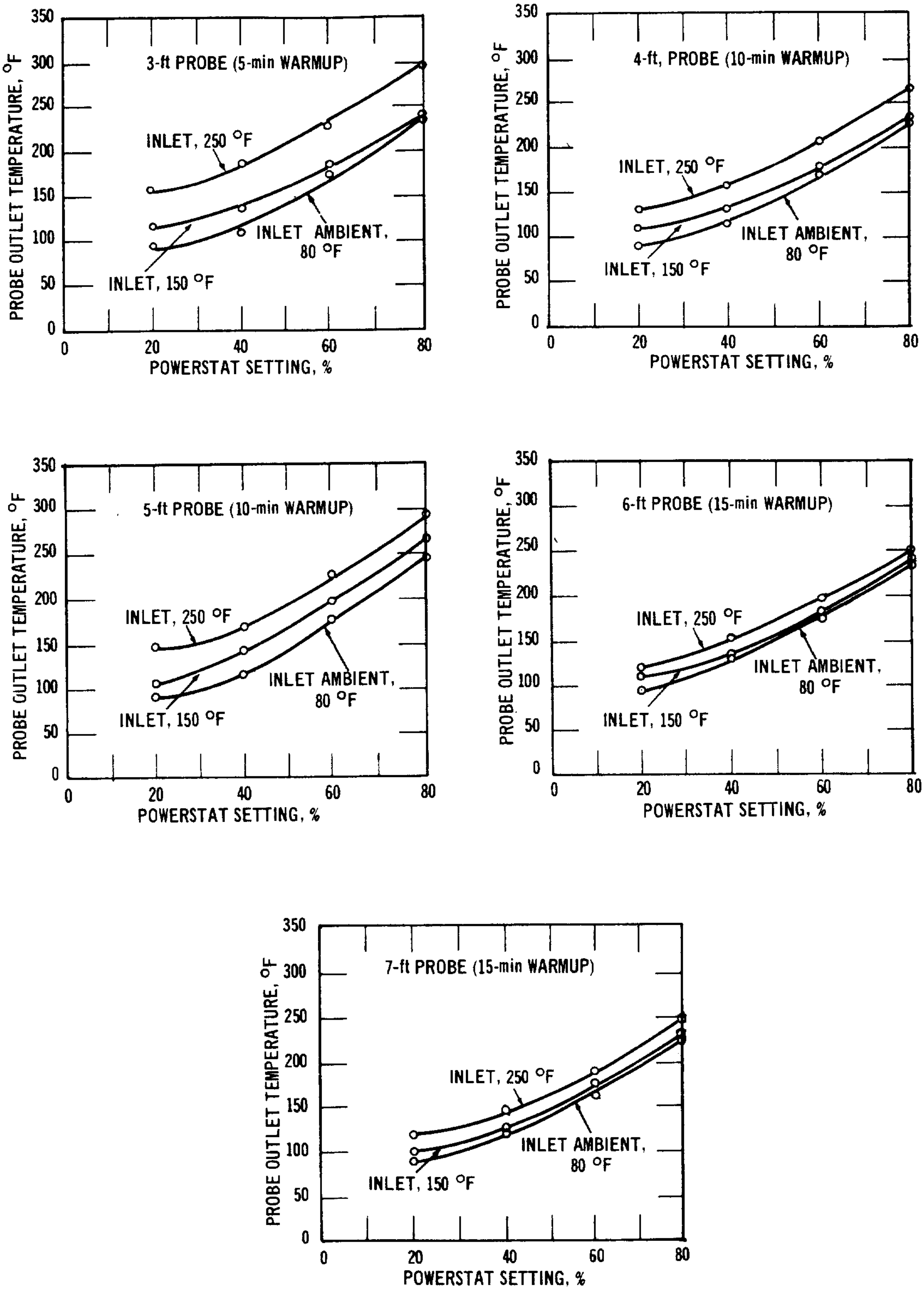
Figure 20. Calibration setup.

adjusted until γ meets the specification. This can be accomplished by removing the plate on top of the gas meter and adjusting the linkages.

Since the nomograph is designed for a $\Delta H_@$ of 1.84 inches of water, a value within 0.25 inch of 1.84 inches of water is desirable. If a value in this range is not obtained, the orifice opening should be adjusted or the orifice replaced. In addition, $\Delta H_@$ should not vary by more than $\pm$ 0.15 over the range of operation of 0.5 to 8 inches of water. If the $\Delta H_@$ is acceptable, record $\Delta H_@$ on the front of the meter box.

HEATING PROBE CALIBRATION

If the probes are constructed as outlined in Reference 1, the graphs in Figure 21 may be used to determine the probe heat setting required. If the probes are not constructed as outlined or a calibration of the probes is required, similar graphs can be constructed by using a heat source and measuring the inlet and outlet temperatures at the various variable transformer settings while passing air through at about 0.75 cubic foot per minute.



NOTE: Flow rate held constant at 0.75; 50% change in flow rate has little effect on probe temperature.

Figure 21. Probe temperatures.

FIELD OPERATION

Preparing the site so that the equipment can be positioned is frequently the most difficult part of sampling. Scaffolding must occasionally be erected when the sample port is not near a catwalk or other structure. The duorail[2] has been found to be a useful tool for sampling small-diameter stacks. At many sites the sampler must use his ingenuity to get the sampling equipment to the sample port.

In selecting the site, the sampler should keep in mind that the distance from the probe to the bottom of the sample box is about 13 inches. Although the equipment was designed to fit into 2-1/2-inch holes, it has been found that 3-inch holes allow easier entrance and removal without nicking the nozzle or picking up deposited dust.

Because sampling approaches vary, the description of the operation of the isokinetic sampling equipment will be confined to the use of the nomographs, assembly of the components, and adjustment of the flow rate to isokinetic conditions once the probe is positioned at the desired sampling point.

NOMOGRAPHS

The correction factor nomograph (Figure 22) and the operating nomograph (Figure 23) have been designed for use with the sampling train as aids for rapid isokinetic sampling rate adjustments and for selection of a convenient nozzle size. To determine the correction factor, C, on the nomograph, the following information is first required:

1. Percent moisture, % H_2O. This may be determined from a previous test or presurvey, or before the sample run.
2. Orifice calibration factor, $\Delta H_@$. This is determined from the laboratory calibration (see section on Calibration).
3. Meter temperature, T_m. Temperature at the meter rises above ambient temperature because of the pump and can easily be estimated with experience. An estimate within 10° F (approximately ± 1 percent error) is all

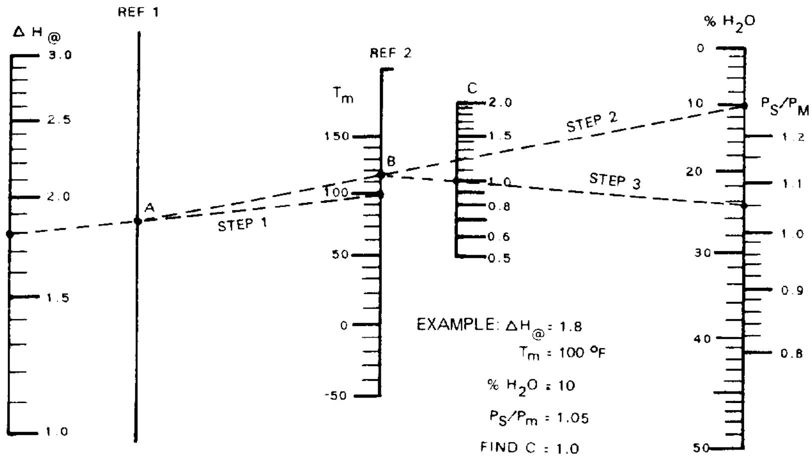


Figure 22. Nomograph for correction factor C.

that is necessary (an initial estimate of about 25° F above ambient temperature has been used).

4. Stack pressure, P_s. This is measured before the sample run; or if the sampling site is near the exit of the stack, atmospheric pressure is used.

5. Meter pressure, P_m. Same as atmospheric pressure.

To obtain correction factor, C (Figure 22):

1. Draw line from $\Delta H_@$ to T_m to obtain point "A" on reference line 1 (REF 1).

2. Draw line from point "A" to % H_2O to obtain point "B" on reference line 2 (REF 2).

3. Draw line from point "B" to the calculated value P_s/P_m to obtain correction factor, C.

To select the nozzle size and to set the K-factor on the operating nomograph, the following information is first required:

1. C factor. This is obtained from the correction-factor nomograph (Figure 22).

2. Stack temperature, T_s. This is determined in °F by a rough temperature traverse to within ± 25° F before the sample run.

3. Average velocity pressure, ΔP. This is determined by a rough preliminary pitot traverse, using the average of minimum and maximum ΔP's in

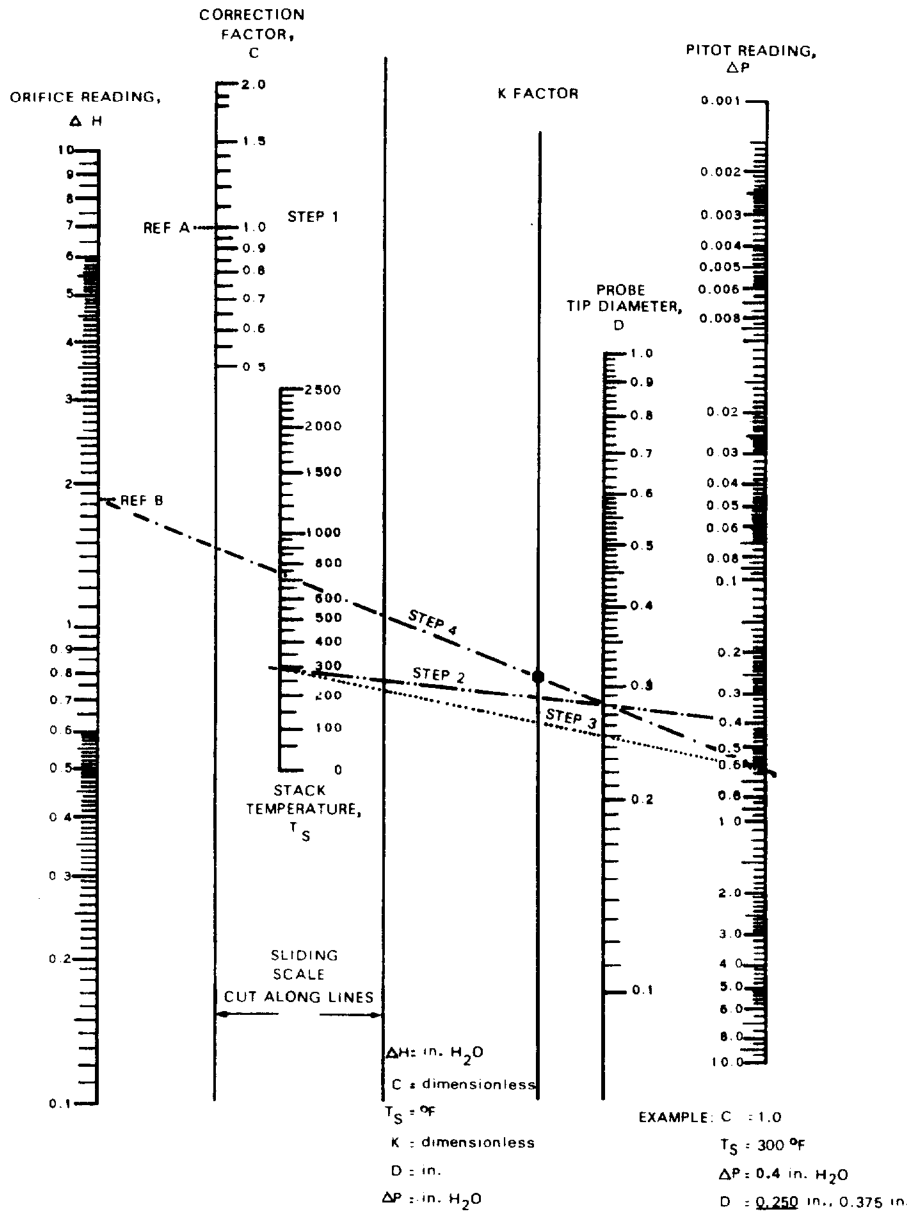


Figure 23. Use of the nomograph in selecting nozzle size and setting K factor.

inches of water.

4. Exact available nozzle sizes, D. This is obtained from calibration of available nozzles.

To select the nozzle size and to set the K-factor pivot point, use the following procedure (Figure 23):

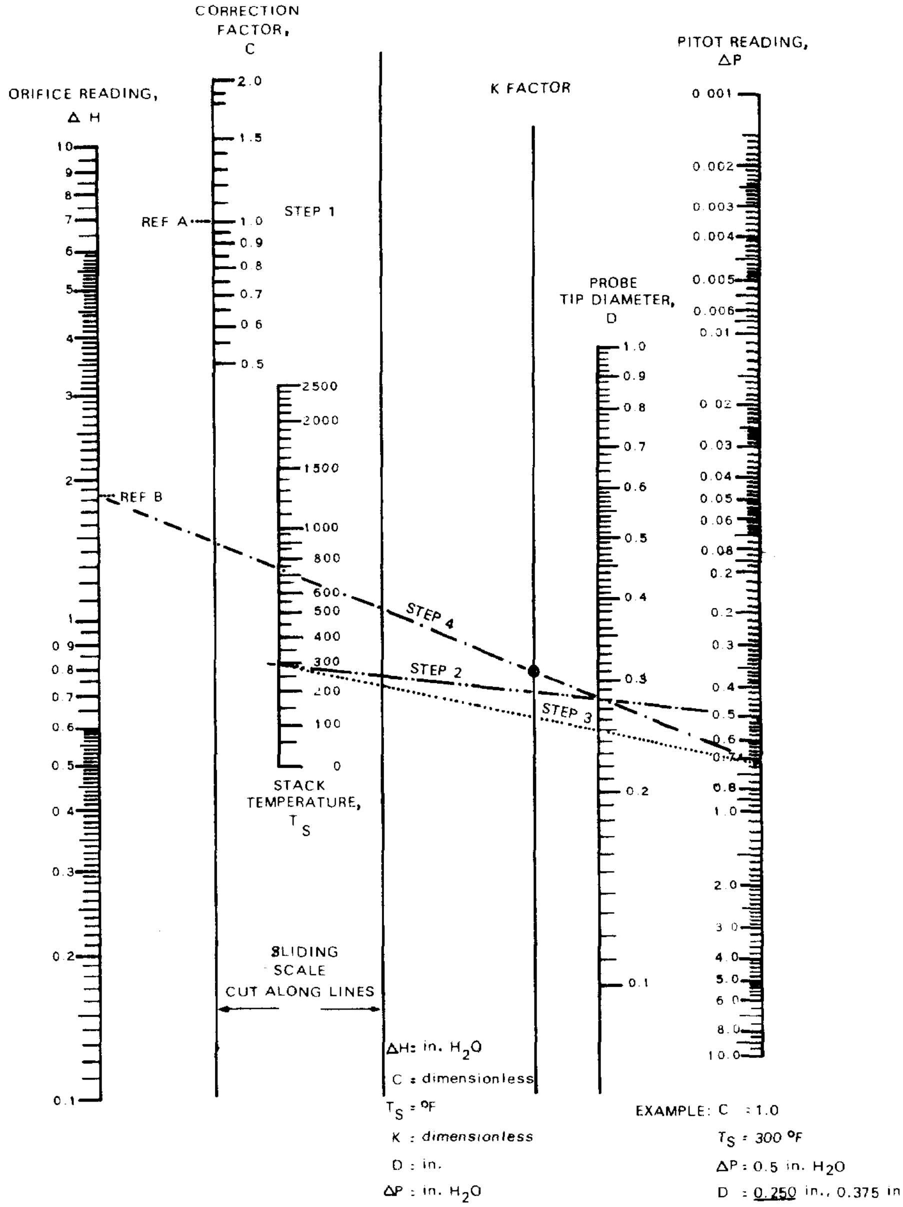


Figure 23. Use of the nomograph in selecting nozzle size and setting K factor.

inches of water.

4. Exact available nozzle sizes, D. This is obtained from calibration of available nozzles.

To select the nozzle size and to set the K-factor pivot point, use the following procedure (Figure 23):

1. Set correction factor, C, on sliding scale to the reference mark, "A."
2. Align T_s with average ΔP, note probe tip diameter on D scale, and select exact nozzle size closest to it.
3. Align T_s with exact nozzle size selected and obtain a value on the ΔP scale.
4. Align the ΔP value with reference mark, "B", on ΔH scale, and set the K-factor pivot point.

To obtain the orifice meter setting, ΔH, for isokinetic conditions after the K-factor pivot point has been set, use the following procedure (Figure 24):

1. Position the pitobe nozzle at the sampling point.
2. Read the pitot tube ΔP.
3. Align the ΔP through the K-factor pivot point.
4. Obtain ΔH and adjust metering valves.

The nomograph assumes the following once the K-factor pivot point is set:

1. T_s does not change more than 25° for $T_s < 1000°$ F or 50° for $T_s > 1000°$ F.
2. D is not changed during the test.
3. T_m was estimated correctly and does not vary more than 10°.
4. Percent H_2O remains constant, within $\pm$ 1.0%.
5. P_s and P_m remain constant, within $\pm$ 1.0%.

SAMPLE COLLECTION ASSEMBLY

Pitobe Assembly

After selecting a suitable probe length, remove the cover from the nozzle side of the stainless steel union on the probe sheath. Ensure that the probe side of the union contains a stainless steel back ferrule inserted backwards and a Viton A O-ring, and that the nozzle side has a stainless steel front and back ferrule (Figure 2). If the stack temperature is above 500° F, replace the Viton A O-ring with asbestos cord.

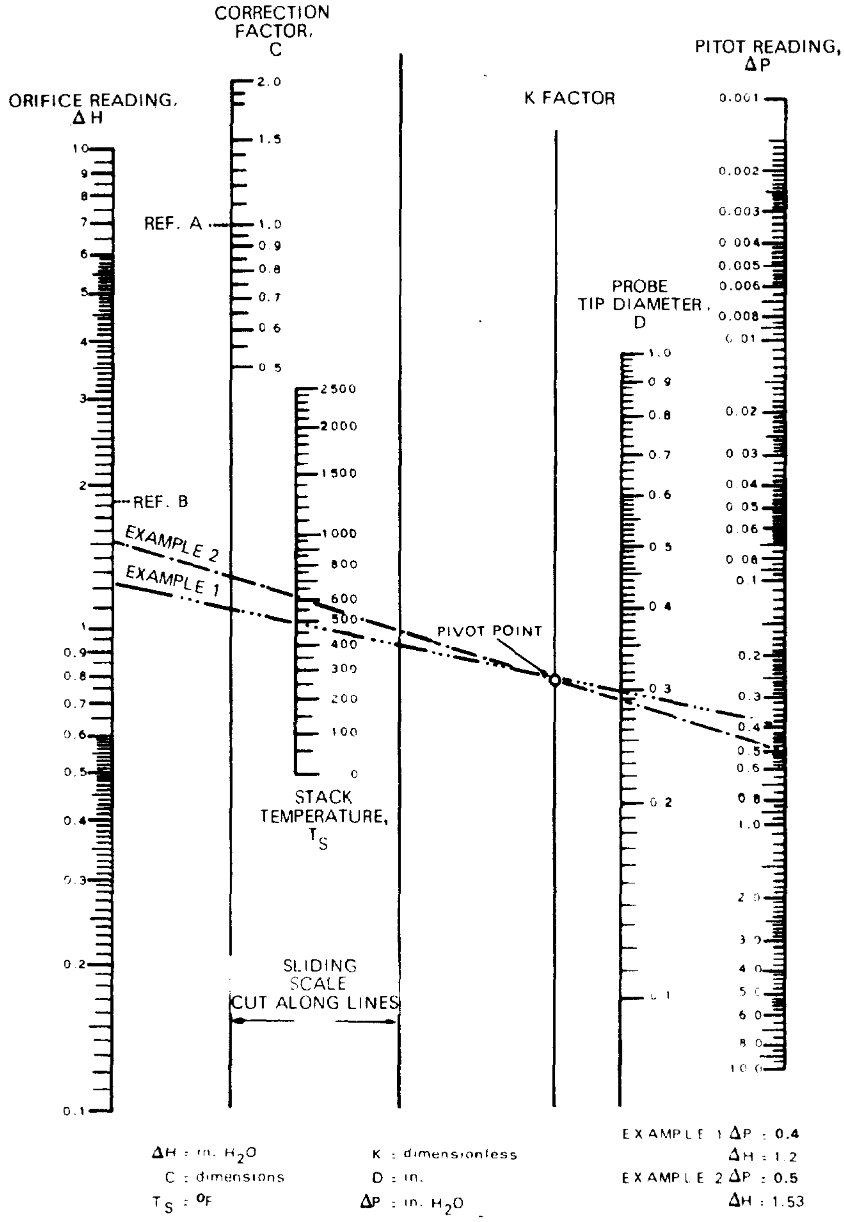


Figure 24. Nomograph operation to obtain desired orifice meter settings.

Remove the cover from the shank end of the selected nozzle (obtained from the nomograph), insert the nozzle in the probe sheath union, and finger tighten the union. Avoid the use of wrenches as this would bind the ferrules to the nozzle shank and could cause the glass probe to crack. Keep the nozzle tip and the ball joint on the glass probe covered until the assembly of the equipment is complete and sampling is about to begin. Mark the probe with heat-resistant tape or by

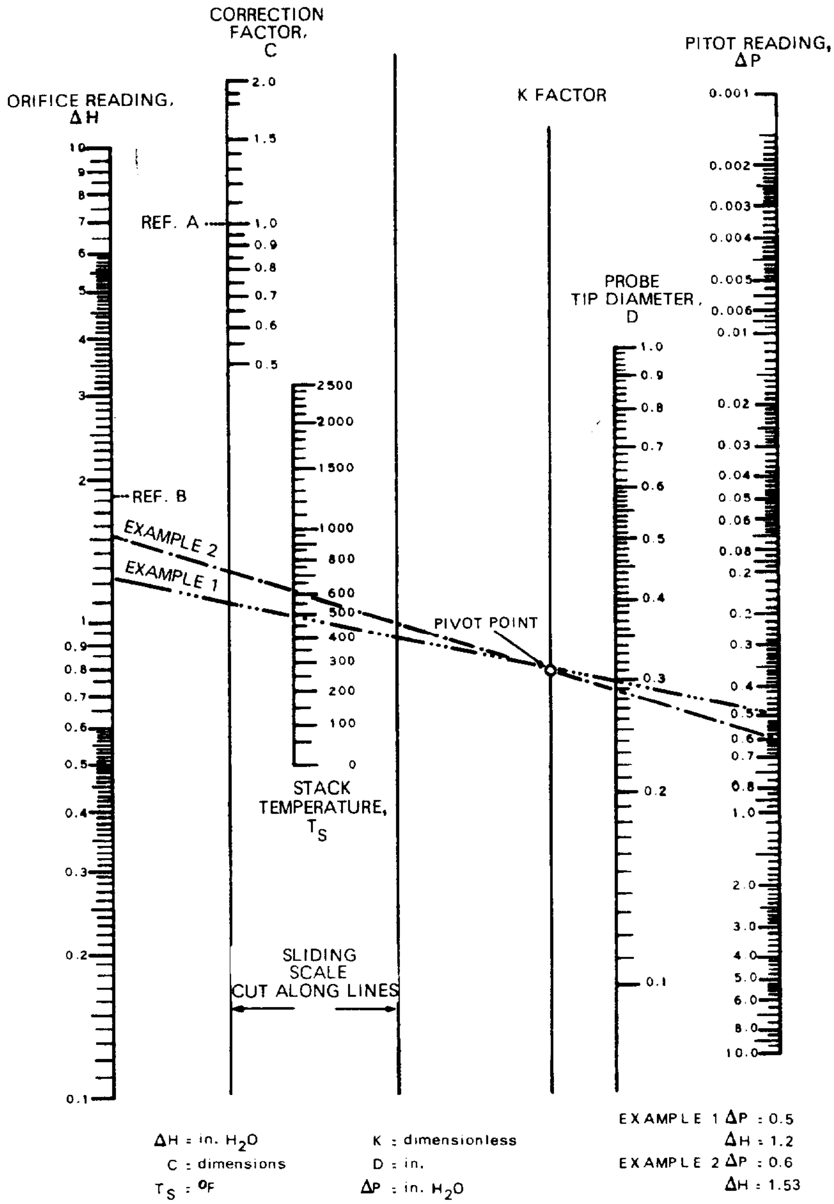


Figure 24. Nomograph operation to obtain desired orifice meter settings.

Remove the cover from the shank end of the selected nozzle (obtained from the nomograph), insert the nozzle in the probe sheath union, and finger tighten the union. Avoid the use of wrenches as this would bind the ferrules to the nozzle shank and could cause the glass probe to crack. Keep the nozzle tip and the ball joint on the glass probe covered until the assembly of the equipment is complete and sampling is about to begin. Mark the probe with heat-resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point.

Attach a temperature probe to the metal sheath of the sampling probe so that the sensor extends beyond the probe tip and does not touch any metal. Its position should be about 1 inch from the pitot tube and probe nozzle to avoid interference with the gas flow.

Sample Box Assembly

Place the tared filter in the filter holder and record the filter number on the data sheet. Tighten the clamps around the filter holder to prevent leakage around the rubber gasket.

Assemble the collection system, as shown in Figure 1 or as dictated by the requirements of the test, using a very light coat of silicone grease (acetone non-reactive) on the lower half of all the male ball joints (Figure 15).

LEAK TEST

Place the meter box in a convenient position up to 200 feet from the test port and connect the vacuum line of the umbilical cord to the inlet of the meter box and the outlet of the last Greenburg-Smith impinger of the sample box. Check the ball joint stopper in the inlet to the cyclone for possible leakage. Turn the coarse-adjust valve on the meter box to the off position and open the fine-adjust valve slowly until fully opened. Partially close the fine-adjust valve until the vacuum gauge reads 10 inches of mercury; then check the dry gas meter for flow. If the flow through the dry gas meter exceeds 0.02 cubic foot per minute at 10 inches of mercury gauge pressure, the leak or leaks must be found and corrected.

When the check is complete, first remove the plug from the inlet to the cyclone, and immediately turn off the vacuum pump. This prevents water from the impingers from being forced backward into the filter and cyclone.

FINAL SAMPLING TRAIN ASSEMBLY

Remove the cover from the ball joint on the probe, lightly grease the lower half of the ball joint with silicone grease (Figure 15), and connect the probe. Make sure that the rubber stopper is snug in the opening in the sample box. Secure the probe by tightening the probe holding clamps.

Make all necessary electrical and pitot-tube line connections. Set the variable transformer on the meter box so that the desired probe temperature is obtained (use Figure 21 as a guide). Set the thermostat on the sample box at 250° F or at the desired temperature. Turn on the heater, blower, and probe switches on the meter box. Allow the sample box and probe to heat for at least 15 minutes before starting the test and make periodic checks and adjustments to assure the desired sample box temperature.

Fill the impinger section of the sample box with ice and a little water. Add ice periodically during testing to maintain the temperature of the gas leaving the last impinger at less than 70° F.

SAMPLE RUN

Record all necessary initial data such as that shown at the top of the sample data sheet in Figure 25, including the initial dry gas meter reading. Turn off the coarse-adjust valve on the meter box, fully open the fine-adjust valve, and set the timer cam to zero. Remove the cover from the nozzle tip and place the pitobe at the first sampling point. Record the clock time, read ΔP on the pitot tube manometer, and determine ΔH from the nomograph as shown previously.

Turn the pump on and set ΔH on the meter box first by adjusting the coarse-adjust valve and then the fine-adjust valve.

The sample run plan should consider the number of traverse points and the sampling time at each point. A good rule of thumb to follow is to collect a weight of particulate matter equal to about 20 percent of the filter weight. The upper limit is usually set by the pressure drop across the filter and the amount of condensate the impingers can hold. Generally the length of sampling time at each traverse point is 5 or 10 minutes.

During the sample traverse the pitobe is moved from point to point without turning the pump off except when changing ports. The ΔP should be monitored and adjustments made on the orifice meter with the aid of the nomograph when necessary. Besides the regular time interval recordings, a set of readings should be recorded when the ΔP changes by more than 20 percent.

Plant ______

Run number ______

Location ______

Date ______

Operator ______

Sample box number ______

Meter box number ______

VERY IMPORTANT - FILL IN ALL BLANKS

Read and record at the start of each test point.

Ambient temperature, °F ______

Barometric pressure, in. Hg ______

Assumed moisture, % ______

Heater box setting, °F ______

Probe tip diameter, in. ______

Probe length, ft. ______

Probe heater setting ______

Point	Clock time	Dry gas meter, ft^3	Pitot, in. H_2O ΔP	Orifice ΔH, in. H_2O		Dry gas temperature, °F		Pump vacuum, in. Hg gauge	Box temp- erature, °F	Impinger temp- erature, °F	Stack pressure, in. Hg	Stack temp- erature, °F
				Desired	Actual	Inlet	Outlet					

Comments:

Figure 25. Suggested particulate field data form.

SHUTDOWN

When testing has been completed, turn off the vacuum pump, remove the pitobe from the stack, and take a final set of readings. Turn off the heater, blower, and probe heat switches and remove the probe from the sampling port. Cover the nozzle tip as soon as it is cool enough in order to avoid contamination or loss of sample. Disconnect the probe from the cyclone inlet and cover both the end of the probe and the inlet to the cyclone. Disconnect the umbilical cord from the sample box and cover the last impinger outlet. The probe and sample box are then ready for cleanup and the analytical procedure.

REFERENCES

1. Martin, Robert M. Construction Details of Isokinetic Source-Sampling Equipment. Air Pollution Control Office, Environmental Protection Agency, Research Triangle Park, N. C. Publication No. APTD-0581. April 1971.

2. Smith, Walter S. et al. Stack Gas Sampling Improved and Simplified with New Equipment. Presented at 60th Annual Meeting of Air Poll. Control Assoc., Cleveland, Ohio. June 11-16, 1967.

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ERRATA FOR APTD-0576

MAINTENANCE, CALIBRATION, AND OPERATION
OF ISOKINETIC SOURCE-SAMPLING EQUIPMENT

1. Page 12, Figure 9. Change second equation under Calculations to

$$\frac{0.0317\ \Delta H}{P_b\ (t_{do} + 460)} \left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$$

2. Replace pages 27 and 29 with attached pages that contain corrections in the ΔP scale of the nomographs in Figures 23 and 24.