

**Compendium of Methods
for the Determination of
Inorganic Compounds
in Ambient Air**

Compendium Method IO-1.1

**DETERMINATION OF PM₁₀
IN AMBIENT AIR USING
THE ANDERSEN CONTINUOUS
BETA ATTENUATION MONITOR**

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Method IO-1.1

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Method IO-1.1
Determination of PM₁₀ in Ambient Air
Using the Andersen Continuous Beta
Attenuation Monitor

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Chapter IO-1 CONTINUOUS PM₁₀ ANALYZERS

Method IO-1.1 DETERMINATION OF PM₁₀ IN AMBIENT AIR USING THE ANDERSEN CONTINUOUS BETA ATTENUATION MONITOR

1. Scope

1.1 The area of toxic air pollutants has been the subject of interest and concern for many years. Recently the use of receptor models has enabled U. S. Environmental Protection Agency (EPA) to identify the elemental composition of atmospheric aerosol into components and relate them to specific emission sources. The assessment of human health impacts resulting in major decisions on control actions by federal, state, and local governments is based on these data. Accurate measures of toxic air pollutants at trace levels are essential to proper assessment.

1.2 Suspended particulate matter (SPM) in air generally is a complex, multi-phase system of all airborne solid and low vapor pressure liquid particles having aerodynamic particle sizes from below 0.01 μm to 100 μm and larger. Historically, SPM measurement has concentrated on total suspended particulates (TSP), with no preference to size selection.

1.3 The EPA reference method for TSP is codified at 40 CFR 50, Appendix B. This method uses a high-volume sampler to collect particles with aerodynamic diameters of approximately 100 μm or less. The high-volume samples 40 and 60 ft^3/min of air with the sampling rate held constant over the sampling period. The high-volume design causes the TSP to be deposited uniformly across the surface of a filter located downstream of the sampler inlet. The TSP high volume can be used to determine the average ambient TSP concentration over the sampling period, and the collected material subsequently can be analyzed to determine the identity and quantity of inorganic metals present in the TSP.

1.4 Research on the health effects of TSP in ambient air has focused increasingly on those particles that can be inhaled deeply into the respiratory system, i.e., particles of aerodynamic diameter less than 10 μm . The health community generally recognizes that these particles may cause significant, adverse health effects.

1.5 On July 1, 1987, the EPA promulgated a new size-specific air quality standard for ambient particulate matter. This new primary standard applies only to particles with aerodynamic diameters \leq 10 micrometers (PM₁₀) and replaces the original standard for TSP. To measure concentrations of these particles, the EPA also promulgated a new federal reference method (FRM).

1.6 This method is based on the separation and removal of non-PM₁₀ particles from an air sample followed by filtration and gravimetric analysis of PM₁₀ mass on the filter substrate. These smaller particles are able to reach the lower regions of the human respiratory tract and, thus, are responsible for most of the adverse health effects associated with suspended particulate pollution.

1.7 Monitoring methods for particulate matter (PM) are designated by the EPA as reference or equivalent methods under the provisions of 40 CFR Part 53, which was amended in 1987 to add specific requirements for PM₁₀ methods. Part 53 contains functional specifications and other requirements that reference methods and equivalent method must meet, along with explicit test procedures for candidate methods or samplers. General requirements and provisions for reference and equivalent methods are also given in Part 53, as are the requirements for submitting an application to the EPA for a reference or equivalent method determination.

1.8 Under the Part 53 requirements, *reference methods* for PM₁₀ must use the measurement principle and meet other specifications set forth in 40 CFR 50, Appendix J. They must also include a PM₁₀ sampler that meets the requirements specified in Subpart D of 40 CFR 53. Appendix J specifies a measurement principle based on extracting an air sample from the atmosphere with a powered sampler that incorporates inertial separation of the PM₁₀ size range particles followed by collection of the PM₁₀ particles on a filter over a 24-h period. The average PM₁₀ concentration for the sample period is determined by dividing the net weight gain of the filter over the sample period by the total volume of air sampled. Other specifications are prescribed in Appendix J for flow rate control and measurement, flow rate measurement device calibration, filter media characteristics and performance, filter conditioning before and after sampling, filter weighing, sampler operation, and correction of sample volume to EPA reference temperature and pressure. In addition, sampler performance requirements in Subpart D of Part 53 include sampling effectiveness (the accuracy of the PM₁₀ particle size separation capability) at each of three wind speeds and "50% cutpoint" (the primary measure of 10-micron particle size separation). Field tests for sampling precision and flow rate stability are also specified. In spite of the instrumental nature of the sampler, this method is basically a manual procedure, and all designated reference methods for PM₁₀ are therefore defined as manual methods.

1.9 The operational procedures of a continuous PM₁₀ monitor that directly measures particulate mass at concentrations of 0.005-20,000 µg/m³ on a real-time basis, as illustrated in Figure 1, is described in this method.

1.10 The instrument periodically (averaging ranges from ½ hours to daily) determines total mass accumulation on a filter medium and calculates mass concentration. It uses a continuous filter tape system that reduces the need for frequent manual filter changes.

1.11 With certain specifications, the instrument has been designated as an equivalent method for determining 24-h average PM₁₀ concentration in ambient air by the EPA under Designation No. EQPM-0990-076, effective September 18, 1990 (1). Except as otherwise noted, this protocol addresses the configuration and operation of the instrument as an equivalent method for PM₁₀.

1.12 The methodology detailed in this method is employed by organizations such as the EPA, the Northwest Air Pollution Authority, the Palm Beach County Health Department, and Echo Bay Minerals Company for indoor and outdoor air quality monitoring.

2. Applicable Documents

2.1 ASTM Standards

- D1356 *Definitions of Terms Related to Atmospheric Sampling and Analysis*.

2.2 Other Documents

- U. S. Environmental Protection Agency Technical Assistance Document (2).
- U. S. Environmental Protection Agency Quality Assurance Handbook (3).
- Andersen PM₁₀ Beta Attenuation Monitor Operator Manual (4).

3. Summary of Method

3.1 In operation, suspended particles in ambient air are pulled through the PM₁₀ inlet head at a flow rate of 16.7 L/min. The inlet head consists of a series of impaction plates to segregate particulate matter by size. Because of the design of the inlet, accurate sampling is accomplished independent of wind speed and direction.

3.2 Air is drawn into the inlet and deflected downwards into the acceleration jet of the impact unit. Because of their greater momentum, particles larger than the 10 micron cutpoint impact out and are retained in the middle plenum impaction chamber, as illustrated in Figure 2. The particle fraction smaller than 10 microns is carried upward by the air flow and down the vent tubes to the beta gauge sampler.

3.3 After traversing the inlet configuration, the PM₁₀ particles are deposited on a glass fiber filter tape. A low level of beta radiation is emitted from the source and passes through the filter tape and deposited particles. The increase of particles collected on the tape causes a lower beta-ray measurement in the measuring chamber, as illustrated in Figure 3. This filter-spot position results in a continuous observation of the increasing particulate mass and corresponding concentration. A compensation chamber receives an equal portion of the beta-ray and is used as a reference by comparing the sample measurement in the measuring chamber with transmitted radiation through a compensation chamber foil that exhibits the same absorptivity as clean filter tape.

3.4 As particles collect on the filter, the differential reading changes, and the signal is converted by an on-board computer to PM₁₀ concentrations.

3.5 Changes in temperature, pressure, and humidity affect the PM₁₀ measurement on the filter tape; the measurements made through the compensation foil are affected to the same degree. Thus, the foil measurement supplies baseline information to the internal computer that allows the instrument to compensate for environmental effects.

3.6 By measuring the accumulated mass of particles on the tape and the volumetric flow rate of air through the instrument, the instrument can calculate the mass concentration of particles in the ambient air.

3.7 The unit controls allow the user to define the operating parameters of the instrument by menu-driven routines.

3.8 Output from the monitor maybe in the form of visual display, on-board computer storage, telemetry, printout, or storage in an auxiliary disc. Output can be in digital or analog form.

4. Significance

4.1 SPM in outdoor air presents a complex multiphase system consisting of a spectrum of particle sizes ranging in aerodynamic diameter from below 0.01 μm to greater than 100 μm. Historically, the measurement of suspended particulate matter encompassed all suspended particulates, with no preference to size selection. Research on the health effects of TSP in ambient air has focused increasingly on those particles that can be inhaled into the respiratory system (i.e., PM₁₀). Researchers generally recognize that, except for toxic

materials, this fraction (< 10 µm) of the total particulate loading is of major interest to the EPA associated with health effects.

4.2 Because of the health effects of PM₁₀, this continuous particulate monitor has been developed to allow mass measurement of PM₁₀ concentration on a real-time basis.

4.3 The monitor utilizes a filter-based measuring system for providing real-time mass monitoring capability. With certain specifications, the monitor has been designated by the EPA as an equivalent method for determining the 24-h average ambient concentration of PM₁₀. In addition, the instrument can be operated outside the equivalent method specifications to perform other types of PM sampling programs.

4.4 The particulate sample is retained on the filter tape. The instrument can be equipped with an optional date and time stamper for labeling each sample spot on the filter tape.

5. Definitions

[Note: Terms used in this document are consistent with the definitions found in ASTM D1356. All abbreviations and symbols are defined within this document at the point of first use. Any user-prepared standard operating procedures (SOP) should also conform to the definitions of ASTM D1356.]

5.1 Air Pollution. The presence of unwanted material in the air. The term "unwanted material" here refers to material in sufficient concentrations, present for a sufficient time, and under circumstances to interfere significantly with comfort, health, or welfare of persons or with the full use and enjoyment of property.

5.2 Beta Particle. An elementary particle emitted by radioactive decay, that may cause severe burns.

5.3 Coarse and Fine Particles. Coarse particles are those with diameters (aerodynamic) greater than 2.5 µm that are removed by the sampler's inlet; fine particles are those with diameters (aerodynamic) less than 2.5 µm. These two fractions are usually defined in terms of the separation diameter of a sampler.

5.4 Filter. A porous medium for collecting particulate matter.

5.5 Mass Concentration. Concentration expressed in terms of mass of substance per unit volume of gas.

5.6 Particle. A small discrete mass of solid or liquid matter.

5.7 Particle Concentrations. Concentration expressed in terms of number of particles per unit volume of air or other gas. NOTE: On expressing particle concentration the method of determining the concentration should be stated.

5.8 Sampling. A process consisting of the withdrawal or isolation of a fractional part of a whole. In air or gas analysis, the separation of a portion of an ambient atmosphere with or without the simultaneous isolation of selected components.

5.9 Sampling, Continuous. Sampling without interruptions throughout an operation or for a predetermined time.

6. Interferences

6.1 In high humidity or rainy climates, water may collect on the filter tape, causing artificially high mass readings. In hot, humid environments where the instrument is housed in an air-conditioned shelter, the inlet tube within the shelter should be insulated to avoid condensation. In rainy climates, the instrument's inlet tube heater may be used to ensure that any water drawn into the unit is in vapor phase as it passes through the filter. The heater should be set at the lowest effective temperature to avoid volatilizing any semivolatiles in the PM₁₀. A brief accumulation of water on the filter tape that subsequently evaporates as drier air is pulled through the instrument will cause erroneous short-term readings, but the 24-h average value will not be adversely affected.

6.2 The instrument's primary operating mechanism is the radiometric microbalance system, which relies on changes in the strength of a beta ray beam passing through the filter paper to determine changes in particulate mass collected. Because this mechanism lacks moving parts, the instrument is not sensitive to vibrations (i.e., vacuum pump vibration or mechanical noise) that might hurt the accuracy of some other types of continuous particulate monitors.

6.3 The instrument is also less sensitive to temperature, pressure, and humidity fluctuations than some other types of continuous particulate monitors because of the second beta ray measurement that provides baseline information to the internal computer. Because the instrument compensates for fluctuations in temperature, the ambient air stream does not need to be heated to a particular standard temperature as long as the ambient air is within the operating range (-20 to 40EC). Heating the ambient air stream can eliminate some semivolatile chemicals that would normally be detected by the instrument, leading to inaccuracies in both mass measurements and later chemical analyses. The heating for moisture control is discussed in Section 6.1.

6.4 The instrument's electronic and mechanical parts should be protected against rain, condensation, and rapid temperature fluctuations.

7. Apparatus

The Andersen Beta Attenuation Monitor is comprised of three main components: the PM₁₀ air inlet, the central instrument, and the vacuum pump. In addition, a number of accessories are required. The following sections describe these components.

7.1 Air Inlet

7.1.1 To qualify as an EPA equivalent method for PM₁₀, the instrument must be fitted with a model SA 246b air inlet. When operated at the design flow rate of 1,000 L/h, this air inlet separates particles larger than 10 Fm from the airstream, allowing particles smaller than 10 μm to pass into the measurement device for detection. The manufacturer also offers a TSP and PM_{2.5} inlets.

7.1.2 As illustrated in Figure 4, the air inlet has an upper and lower assembly. The upper assembly comprises a top plate, deflector, acceleration nozzle, insect screen, and lower plate and rain deflector. The lower assembly comprises a particle collector unit, vent tubes, and water collection jar. An inlet tube also is supplied to connect the PM₁₀ inlet to the central instrument.

7.2 Central Instrument

The central instrument is illustrated in Figures 5 and 6 (front and back, respectively). The front of the instrument is sealed with a transparent protective cover, which can be removed by unscrewing the two black knobs on its surface. Removing the cover exposes the measuring chamber, the filter tape advance system, and the operating controls. The controls consist of a liquid crystal display (LCD) and keyboard located in the upper right corner of the front panel. Also located on the front panel is a label indicating that the instrument has been designated by the EPA as an equivalent method for PM₁₀ (if this label is not present, contact the manufacturer). The power switch for the instrument, connection points for power, vacuum tubing, and data input/output devices are located on the back of the instrument. The socket for connecting the inlet tube is located on the top of the instrument. The major components of the central instrument are discussed below.

7.2.1 Filter Tape System. The instrument draws ambient air from the air inlet and inlet tube through glass fiber filter tape, depositing the PM₁₀ on the tape (glass fiber filter tape must be used for designation as an equivalent method for PM₁₀). The filter tape system consists of two filter tape reels: the left reel holds the spool of clean tape and the right reel receives the used tape with deposited PM₁₀. The left reel holds up to 42 meters of tape. The internal computer advances the tape according to preset parameters (e.g., mass accumulation limits, pressure or flow rate changes, and timed intervals). The PM₁₀ mass collected on the filter tape is measured, along with the volume of air that has passed through the tape, to determine the concentration of PM₁₀ in the ambient air.

7.2.2 Measurement System. The main components of the measurement system (radiometric microbalance) are the radiation source and the measurement and compensation chambers. The radiation source is a stainless steel capsule containing Krypton 85 gas. The measurement chamber is situated above the radiation source and is separated from the radiation source by the spot on the filter tape where the PM₁₀ is currently being deposited. The compensation chamber is to the side of the radiation source and is separated from the radiation source by a piece of foil that absorbs approximately the same amount of radiation as clean filter tape. During operation, the radiation source focuses radiation beams towards both the measurement and compensation chambers. The particle-laden filter tape absorbs more radiation than the compensation foil. The difference in measurements indicates the PM₁₀ mass collected on the filter.

7.2.3 Flowmeter and Flow Controller. The flow rate of air through the filter tape is an important parameter in the calculation of the ambient PM₁₀ concentration. To measure this parameter, an orifice-type flowmeter is located inside the cabinet just prior to the connector for the vacuum tubing to the pump. For proper particle size selection at the PM₁₀ inlet, the instrument must maintain a stable flow rate at the design level of 1,000 L/h. To achieve constant flow, the instrument is fitted with an airflow regulator bleed valve interposed in the intake line of the pump. The regulator valve is mounted on the inside of the back of the cabinet with the air intake and air filter on the back panel. The valve servomotor is actuated by thyristors controlled by the internal computer. The system maintains the selected flow rate within a deviation of $\pm 0.5\%$, regardless of changes in temperature, pressure, or pressure drop across the filter (which increases as PM₁₀ accumulates). The flow metering and control system is diagrammed in Figure 7.

7.2.4 Internal Computer. The internal computer calculates and records PM₁₀ measurements reported by the measurement mechanism. Based on the mass of particles collected and the volumetric flow rate of air, the computer calculates ambient concentration. The computer also serves as an interface between the operator and the instrument. The operator can use the computer to set operating parameters, transmit information about monitored air quality, and perform maintenance operations.

7.2.5 Control Keys and LCD. The control keys and LCD allow the operator to view the measured values and to change the settings of the instrument's operational parameters. The controls are based on a

menu system. Above the LCD are a number of small lights that indicate the status of various instrument systems. The keyboard and control system are described more fully in Section 10.1.

7.3 Vacuum Pump

The external vacuum pump is connected to the monitor by a power cord and air hose. When the monitor is in operation, the pump continuously draws 1,000 L/h of ambient air through the monitor. The pump has a rotary vane construction that is known for low maintenance during continuous operation. The pump is fitted with protective filters.

7.4 Accessories

7.4.1 Calibration Kit. Each instrument comes with a set of two calibration foils. During periodic maintenance, these foils are used to recalibrate the instrument. The foils are designed to absorb a certain percentage of the beta ray beam. With the zero foil inserted into the measurement chamber, the instrument is automatically rezeroed. When the span foil is inserted, the calibration "potentiometer" on the control panel is used to adjust the mass reading to the known span foil value. The recalibration procedure is described in Section 11. The calibration foils are included in the EPA's designation of the instrument as an equivalent method for PM₁₀.

7.4.2 Vacuum Tubing. A length of vacuum tubing is supplied to link the central instrument to the vacuum pump.

7.4.3 Power Cord. An unattached power cord is supplied with the instrument. The cord must be attached to the back of the instrument at the appropriate location and plugged into the power supply.

7.4.4 Filter Tape. Two rolls of filter tape are supplied with the instrument. The lifetime of a roll depends on the frequency with which the tape is advanced to a new sampling spot. At 40 meters, each roll has the capacity for about 1,300 sample spots. Normal PM₁₀ operation uses 1 to 2 spots in 24 hrs.

7.4.5 Input/Output Connectors. The instrument can be used with a variety of input and output devices. Consult the Operator Manual or the manufacturer for specifics on the options that are available and the appropriate connection cords.

8. Siting Requirements and Assembly

[Note: When the instrument is used outdoors, protect it from the elements, particularly rain. When the central instrument is installed in the outdoor environmental shelter, be certain the sampler tube leading out of the shelter roof has a watertight fit.]

8.1 Siting Requirements

8.1.1 As with any type of air monitoring study in which sample data are used to draw conclusions about a general population, the validity of the conclusions depends on the representativeness of the sample data. Therefore, the primary goal of a monitoring project is to select a site or sites where the collected particulate mass is representative of the monitored area.

8.1.2 Basic siting criteria for the placement of ambient air samplers are documented in Table 1. This list is not a complete listing of siting requirements; instead, an outline to be used by the operating agency to determine a sampler's optimum location. Complete siting criteria are presented in 40 CFR 58, Appendix E.

8.1.3 Additional factors not specified in the Code of Federal Regulations (CFR) must be considered in determining where the sampler will be deployed. These factors include accessibility under all weather

conditions, availability of adequate electricity, and security of the monitoring personnel and equipment. The sampler must be situated where the operator can reach it safely despite adverse weather conditions. If the sampler is located on a rooftop, care should be taken that the operator's personal safety is not jeopardized by a slippery roof surface during inclement weather. Consideration also should be given to the fact that routine operation (i.e., calibrations, filter installation and recovery, flow checks and audits) involves transporting supplies and equipment to and from the monitoring site.

8.1.4 To ensure that adequate power is available, consult the manufacturer's instruction manual for the sampler's minimum voltage and power requirements. Lack of stable power source can result in the loss of many samples because of power interruptions.

8.1.5 The security of the sampler itself depends mostly on its location. Rooftop sites with locked access and ground-level sites with fences are common. In all cases, the security of the operating personnel as well as the sampler should be considered.

8.2 Assembly

8.2.1 Connection Points. Connection points are numbered on Figures 5 and 6. The following instructions refer to those numbers.

1. Connect the inlet tube to the male connector (1) on the top of the central instrument. Tighten union nut firmly.
2. Connect the pump to the hose socket (26) on the back of the central instrument.
3. Connect the vacuum pump power cord to the back of the central instrument (24).
4. As applicable, connect the selected input and output devices to the appropriate connection points on the back of the central instrument.
5. Connect the power cord to the socket on the back of the central instrument (23) and to a 115 volt (V), 60 Hertz (Hz) power supply.

8.2.2 Startup. After establishing all connections, the device is ready to use and can be turned on with the power switch (22) on the back of the central instrument. The unit automatically starts a filter change and zero. To prevent soiling of the measuring chambers, install the filter tape immediately after switching on the power if the filter tape has not been installed previously.

9. Installing the Filter Tape

[Note: Upon arrival, a new Andersen Beta Gauge Sampler will already be equipped with filter tape. Follow the procedures outlined below to prepare the instrument for operation. Follow these same procedures to replace used filter tape reels.]

9.1 Switch the sampler power on if this has not yet been done.

9.2 Remove the front cover of the sampler.

9.3 Unscrew and remove the nut from the left reel spindle and place a new filter tape reel on the spindle. Place the reel so that it will turn counter clockwise as the tape unwinds.

9.4 Press the BACK key on the keyboard until the LCD reads "Maintenance and Calibration." (Additional information on the operation of the control keys is presented in Section 10.1.)

9.5 Press the YES key and then the NO key to enter interactive maintenance mode.

- 9.6 Press the NEXT key and then the YES key to switch the vacuum pump off.
- 9.7 Press the NEXT key and then the YES key to raise the measuring head.
- 9.8 Unwind about 1 meter of filter tape and thread it around the rollers and through the gap in the dust collection chamber as shown in Figure 5.
- 9.9 Unscrew and remove the nut from the right reel spindle. Place an empty filter tape reel on the spindle. Secure the free end of the filter tape to the empty reel with adhesive tape.
- 9.10 Rotate the empty reel counter-clockwise to remove slack from the filter tape between the reels.
- 9.11 Return the nuts to both spindles.
- 9.12 Initiate the filter change cycle by pressing the FC + Z control key (right key).
- 9.13 The instrument will sense if the feed reel does not turn (i.e., if the feed reel is empty or if the slack has not been taken out of the tape between the reels). Consequently, the pump will not switch on after the filter change. If the pump does not come on, check the filter strip tension and initiate another filter change cycle or switch the pump on with the control keys (see Section 10.1).

10. Operation and Data Storage

[Note: After the filter tape has been installed, the appropriate operating parameters must be set using the control system. The functioning of the control system is explained below in Section 10.1, and the initial settings are discussed in Section 10.2. Additional topics are covered in Sections 10.3 through 10.7. The manufacturer presets all PM₁₀ parameters at the factory except local time, elevation and outputs.]

The instrument can be operated within an ambient temperature range of -20 to +40EC. Storage and transport are possible without damage within a temperature range of -30 to +60EC. The instrument should be protected from rain, condensation, and rapid temperature fluctuation during operation.]

10.1 Control System

10.1.1 The control keyboard and status lights are illustrated in Figure 8. The control menu tree is part of the software in the instrument control system as delineated in the manufacturer's manual. By moving through the menu, the control keys can be used to view measured values on the LCD or to change the operating parameters of the instrument.

10.1.2 Keyboard/Interface Enable.

10.1.2.1 The keyboard and data interface are enabled alternatively. In normal operating mode, the "On line" status light is lit. Under these conditions, the keyboard is disabled. No parameters can be changed and a filter change cannot be initiated manually. The serial and parallel interface are active.

10.1.2.2 When the concentration value is displayed on the LCD, the keyboard can be enabled by the key sequence YES, NO, NEXT (see Figure 8 and Sections 10.1.2 through 10.1.4 for information about the control keys). This sequence enables the keyboard and disables the control via the interfaces. (The keyboard also can be enabled from the first screen under the "Maintenance and Calibration?" parameter group.) The

"On line" status light is switched off. All parameters can be changed with UP and DOWN. Filter change and printout can be initiated with the FC + Z key.

10.1.2.3 If no key is struck for 4 min, the device reverts automatically to normal operating mode. The keyboard is disabled, and interfaces are enabled again. The keyboard can also be disabled from the first screen under the "Maintenance and Calibration?" parameter group.

10.1.3 The two keys on the left have a dual function, depending on the LCD display. Parameters shown on the display can be altered:

DOWN key for lower values,

UP key for higher values.

A question asked on the display can be answered with YES or NO.

10.1.4 The next two keys (BACK and NEXT) are used for interactive and display control. The NEXT key advances to the next dialog text; the BACK key backspaces. Pushing the NEXT key will consecutively call up the following text and displays on the LCD.

- (1) DUST CONCENTRATION: XXX µg/m³
- (2) DUST MASS: XXX µg
- (3) OBSERVING TIME:
- (4) THRESHOLDS?
- (5) DATE/TIME 86-02-19 8:45:23 (EXAMPLE)
- (6) LAST CHANGE 90-08-22 13:12 (EXAMPLE)
- (7) CHANGE FILTERSTRIP?
- (8) CALIBRATION FACTORS AND AIR FLOW RATE?
- (9) OUTPUTS?
- (10) MAINTENANCE AND CALIBRATION?

The first two points above are measured value displays. Lines 3-10 are the beginnings of parameter groups. In Group 10, it is possible to implement all action necessary for maintenance and calibration (e.g., raise measuring head).

When a parameter group heading is being displayed, press the YES key to access the parameter group; press the NEXT key to advance the parameters, displays, or questions within the group; or press the BACK key to reverse the process.

Example: If the LCD reads "Change Filterstrip ?", the following texts will be called up by the key sequence YES, NEXT, NEXT, NEXT, NEXT, NEXT.

CHANGE FILTERSTRIP?		YES
FILTER CHANGE IF MASS	> 2,400 µg	NEXT
CHANGE IF PRESSURE	> 300 kPa	NEXT
CHANGE IF FLOW RATE	< 950 l/h	NEXT
FILTER CHANGE BY CYCLE:	420 min	NEXT
FILTER CHANGE BY TIME:	24:00 h	NEXT
CALIBRATION FACTORS AND AIR FLOW RATE?		

Each displayed parameter can be altered by means of the UP and DOWN keys. When the NEXT key is struck, the edited value is entered. When the BACK key is struck, edited values are not entered.

10.1.5 The right key is labeled "FC + Z/PRINT." The function of this key depends on the status of the interactive system. Pressing this key initiates a filter change and zeroing sequence except when the system is accessing the digital interface; then, depressing this key causes the preset parameters to be printed.

10.2 Initial Settings

After the filter tape has been installed (see Section 9), set the appropriate operating parameters for the instrument. If the instrument was purchased to operate as an EPA equivalent method for PM₁₀, a label should be on the front of the central instrument showing this designation, and the parameter settings should be correct when the instrument is turned on. (If the equivalent method designation label is not present, contact the manufacturer to determine whether the instrument can be operated as an equivalent method.) Follow the instructions below to verify that the operating parameters are set properly and to correct any that are wrong.

[Note: Please refer to the manufacturer's manual for the menu tree as you scroll through the various parameters for instruction.]

10.2.1 Enable Keyboard. Enable the keyboard as discussed in Section 10.1.1. (This action will disable the serial and parallel interfaces.) The "On line" status light will go out when the keyboard is enabled.

10.2.2 Observing Time. After the keyboard has been enabled, press the NEXT key until the LCD displays "OBSERVATION TIME: CON VARIABLE = N CONST = Y." Press the YES key to select a constant observing time. Display shows "EPA - MODE: NO." Press NEXT key, UP and DOWN keys to set observing time at 60 minutes. This is a required setting for equivalent method for PM₁₀. Press the NEXT key to enter this value.

10.2.3 Date/Time. Press the NEXT key until the LCD reads "Date/Time." If the displayed date and time are correct, proceed to Section 10.2.4. If the date and time are not correct, enter this parameter group by pressing the YES key. Set the correct year using the UP and DOWN keys, then press NEXT to advance to "month." Use the UP and DOWN keys to set the correct month and press NEXT to advance to "day." Proceed in this manner until the year, month, day, hour (24-h clock), minute, and second have been set. After the second has been set, press NEXT to enter the new date and time into the instrument.

10.2.4 Automatic Filter Change. Press the NEXT key until the LCD reads "Filter Change?" and press the YES key to enter this parameter group. In this group, the user sets parameters that automatically initiate a filter tape advance. For each parameter, use the UP and DOWN keys to set the desired value and press the NEXT key to enter the selected value and advance to the next parameter (see Table 1 for the sequence of parameters).

10.2.5 Calibration Factor. Press the NEXT key until the LCD reads "Calibration and Air Flow Rate?" and press the YES key to enter this parameter group. The LCD will read "Calibration Factor." Use the UP and DOWN keys to set this parameter at 2400, which is a required setting for the equivalent method for PM₁₀. Press the NEXT key to enter this value.

10.2.6 Standard Volume. When the NEXT key is pressed to enter the required calibration factor, the menu advances to the screen for selecting the terms in which the PM₁₀ concentration will be expressed. Press the NO key to toggle back and forth between EPA standard conditions (298 K, 1013 kilopascals [kPa]) and scientific STP (273 K, 1013 kPa). Press the YES key to select actual operating conditions. When the LCD shows the desired terms (generally EPA standard conditions), press the NEXT key to enter the selection.

10.2.7 Elevation. When the NEXT key is pushed to enter the desired terms for concentration, the menu advances to the screen for entering the "altitude above sea level" (in meters) at which the instrument will be operated. Use the UP and DOWN keys to set this parameter. This value is used by the instrument to calculate the theoretical ambient barometric pressure at the monitor site to determine the flow rate. (The instrument does not directly measure the ambient barometric pressure.) See Section 3.6.1 of the Operator

Manual for the details of the calculation. If desired, the user can calculate the elevation that corresponds to the seasonal average barometric pressure at the site and enter this elevation in place of the actual elevation. When the desired elevation has been set, press the NEXT key to enter the selection.

10.2.8 Air Flow Rate. When the NEXT key is pressed to enter the desired elevation, the LCD will display the current measured value for the flow rate. Press the YES key to advance the menu to the screen where the flow rate can be set; use the UP and DOWN keys to set the **flow rate at 1,000 L/h. (This is a required setting for the equivalent method for PM₁₀.)** Press the NEXT key to enter the required flow rate.

10.2.9 Flow Rate Minimum and Maximum. The EPA sampling guidelines require that the actual flow rate be within $\pm 10\%$ of the nominal flow rate. The next two LCD screens allow the user to set the minimum and maximum acceptable flow rates. If the measured flow rate is outside the acceptable range, the green "Air Flow" status light goes out and the yellow status light comes on. In addition, the electronic output will indicate an "alarm" status for the air flow rate.

When the NEXT key is pressed to enter the required air flow rate (see Section 10.2.8), the menu advances to the screen for entering the minimum acceptable flow rate. Use the UP and DOWN keys to set this parameter to 900 L/min. Press the NEXT key to enter this value and to advance to the menu screen for entering the maximum acceptable flow rate. Use the UP and DOWN keys to set this parameter to 1,100 L/min. Press the NEXT key to enter this value.

10.2.10 Inlet Heater Temperature. When the NEXT key is pressed to enter the maximum acceptable flow rate, the menu advances to the screen for entering the desired inlet tube heater temperature. This heater should be used only as necessary in rainy climates to prevent water from collecting on the filter tape (see Section 6.1). The minimum effective temperature should be used. Use the UP and DOWN keys to set the desired temperature (0E-100EC) and press the NEXT key to enter the selected value. Turn the heater on with the switch in the upper left corner of the front panel (see Figure 5).

10.2.11 Outputs. A variety of output devices (analog or digital) can be used to record measured values and monitor the instrument's operation. The appropriate output settings will depend upon the device(s) used and the data desired. Press the NEXT key until the LCD reads "Outputs" and press the YES key to enter this parameter group. Consult the Operator Manual (see Section 4.1.10) to determine the appropriate settings for each individual instrument setup.

10.2.12 Reset Measuring Cycle Buffer. When beginning operation for the first time or after a significant break in operation, the existing measuring cycle buffer should be deleted so that computed concentrations will reflect only current ambient conditions. Press the NEXT key until the LCD reads "Maintenance and Calibration?" and press the YES key to enter this parameter group. Press the NEXT key five times to reach the "Measuring Cycle" screen. Press the YES key to reset the buffer. The "On" status light will flash for $\frac{1}{2}$ h, then burn constantly. The concentration will not be computed and displayed until 6 min have passed.

10.2.13 Disable Keyboard. Disable the keyboard as discussed in Section 10.1.1. This action will enable the serial and parallel interfaces. The "On line" status light will come on.

10.3 Other Menu Functions

A number of other functions can be carried out using the enabled keyboard. See the Operator Manual (Section 4.1) for details.

10.4 Summary of Instrument Operation

Automatic operation is accomplished in a microprocessor controlled cycle with four phases: filter change, mass zero balance, concentration zero balance, and measurement.

10.4.1 Filter Change. The pump shuts off automatically, and the particle collection chamber lifts off the filter tape. The filter feed advances a fresh, unused section of the filter tape under the particle collection and

measuring chamber (increment 30 mm). This process lasts exactly 30 s. During this phase, the "Filter change" status light blinks rapidly. The integrated filter tape controller ensures that the pump is shut off automatically if the filter tape breaks or the end of the tape is reached.

10.4.2 Mass Zero Balance. The mass readout is zeroed automatically with the particle collection chamber closed and pump switched on. This balance is carried out in a processor-controlled cycle. The ionization chamber amplifier is fed an offset voltage until the amplifier output supplies zero volts. This balancing takes 90 sec. During this phase, the "Filter change" status light blinks slowly.

10.4.3 Concentration Zero Balance. During this phase, the sampling cycle for particle mass values has already started, but no new concentration value is yet computed. The first six measured mass values are used to determine the starting point for the new particle mass/time curve, and the difference between this point and the end point before the filter change is subtracted from the old curve. With this correction, the old measured values (from before the filter change) can continue to be used after the filter change so that the observing time is not altered and continuous concentration readout is possible, even during the period of filter change. This phase constitutes 10% of the observing time, which is 6 min when the instrument is operated as an EPA equivalent method for PM₁₀. The "Filter change" status light is lit continuously during this phase. All output channels display the last computed concentration value from before the filter change during all three filter change phases.

10.4.4 Measurement Phase. After the zero balances, the routine particle collection and measurement process commences. A current particle concentration value is computed 60 times per observing time from the increasing mass. To qualify as an EPA equivalent method, the observing time must be set to 60 min, which results in a particle concentration value being calculated every 1 min. The current particle mass and concentration values pass continuously to the output channels. The measurement phase is terminated by the next filter change. This phase may last from a few minutes to several days depending on which parameters are selected to initiate the filter change cycle (for the PM₁₀ equivalent method, a filter change must be carried out each midnight). The instrument repeats the cycle discussed above when the preset conditions for a filter change are met.

10.5 Data and Measured Value Memory

The instrument manages four measured value files that all take the form of cyclic memories. The memories are only erased if an error has been found in the random access memory (RAM) after connection of power supply. Normally, the last 40 or 60 blocks of data are always stored. The file contents can be displayed on the LCD or output via the serial interface.

10.5.1 Measured Values. The current measured values are always entered in File 1 after execution of the print cycle.

Block structure:

- date/time of day
- concentration
- particle mass
- observing time
- analog 1
- analog 2

In the case of a print cycle time of 0 min, no entry will take place. The measured value file contains 40 blocks.

10.5.2 Half-hour averages (Total of 60 half-hour averages are stored). The half-hour averages of PM₁₀ concentration and of the two analog channels are computed. Totaling for averaging is carried out once per second if the air flow rate is not disturbed, the filter tape has not broken, and the measured value buffer memory is at least half full. Entry in File 2 takes place every half hour.

Block structure:

- date/time of day
- concentration
- analog 1
- analog 2

The half-hour average file contains 60 blocks, with the newest data replacing the oldest.

10.5.3 Daily Averages (Total of 40 daily averages stored, midnight to midnight). The daily averages of concentration and of the two analog channels are obtained from the sum of the half-hour averages divided by their number. Entry in File 3 always takes place at the end of a day at 24:00 h. The date belonging to a data block is entered at the beginning of the day at 00:00 h.

Block structure:

- date
- concentration
- analog 1
- analog 2

The daily average file contains 40 blocks, with newest data replacing oldest.

[Note: analog 2 = air flow [L/hr]]

10.5.4 Histogram Memory. At the end of a day at 24:00 h, the half-hourly averages of the past day are divided into 21 concentration classes. A histogram is formed for dust concentration. The level of the concentration classes is specified by the histogram threshold. A "3" in the first class signifies three half-hourly averages of the day were between 0 $\mu\text{g}/\text{m}^3$ and the threshold value. A "5" in the second class signifies 5½ averages of the day were between 1 and 2 times the value of the histogram threshold (see Operator Manual Section 4.1.9 for information on selecting the histogram threshold value).

Block structure:

- date
- histogram threshold
- 21 concentration classes

The histogram file contains 40 blocks.

10.6 Data Output

The measured values averaged by the instrument are passed to several output channels. The channels are discussed below.

10.6.1 LCD Display. In its basic state, the LCD display will always show the averaged PM₁₀ particle concentration value. Pressing the NEXT key also allows the display of the collected particle dust mass. For test purposes, it is possible to call up all 8 analog channels simultaneously on the display.

10.6.2 Analog Outputs, Chart Recorder. Analog outputs for PM₁₀ concentration and dust mass are available to record the measured value with analog chart recorders. Voltage outputs of 0-10 V as well as potential-free current outputs (0-20 mA, offset 0, 2 or 4 mA) are available. It is possible to choose linear or logarithmic output. The full-scale and zero-point voltages for the output range may also be selected (see Operator Manual Section 4.1.10.1 for information on analog output settings).

10.6.3 Serial Interface, Printer. Data and measured values can be passed to a printer or computer via this interface. Output takes place in 7 bit ASCII code with even parity and 2 stop bits. Commercially available printers with suitable interface can be connected. With the print format selections, the data that will be output may be selected. With the print cycle selections, the printout frequency may be determined (see Operator Manual Section 4.1.10.2 for information on setting the print format and print cycle).

10.7 Remote Control

All control functions for the instrument can be accomplished from a remote location using the serial interface. See Operator Manual (see Section 4.2.1) for information and control codes. Limited remote control functions can be accomplished using the parallel interface (see Section 4.2.2 of the Operator Manual for information).

11. System Calibration

11.1 Particle Mass

The instrument has been factory calibrated with a primary particle generator. The "calibration factor" has been preset to a standard of 2,400 µg (2,400 µg corresponds to + 10V at the amplifier or analog output). Mass readings are compared between the standardized particle generator and the instrument. When factory calibration has been completed, the instrument is checked with a factory set of "mother" foils. Zero and high mass readings are checked to insure good factory agreement, and a factory test certificate is included with the instrument.

11.1.1 Mass Measurement Function Check. A function check should be conducted after starting the instrument, after maintenance activities, or when the measurement system may not be working properly.

11.1.1.1 Remove the test probe from its holder on the face of the instrument and insert the probe into the aperture on the measuring chamber (see Figure 5).

11.1.1.2 After 1 min, the displayed concentration or mass value should rise significantly. This indicates that the measurement system is functioning.

11.1.1.3 After completing the function check, remove the test probe from the measuring chamber! The probe should be stored in the holder provided on the instrument.

11.1.2 Mass Calibration Using Zero/Span Foil Kit. Calibrate the instrument every 2-3 months and after repairs with the calibration foils. **Do not touch the calibration foil sheets; additional oil or dust on the foil may change the mass calibration. The foils must be kept in their original storage box.**

11.1.2.1 Raise the measuring head as directed in Section 9 for installing the filter tape (see Sections 9.1 through 9.7). It is important to turn off the vacuum pump to prevent foil damage.

11.1.2.2 With the chamber raised, remove the filter tape from the dust collection point and insert the guide bar (included in the calibration kit) between top and bottom chamber from the front (inserting the guide bar requires some force; this will not harm the spring-loaded upper chamber).

11.1.2.3 Insert the foil holder with the zero foil.

11.1.2.4 Press the NEXT and YES keys; lower the chamber and initiate zero. To switch to offset and mass display, press the NEXT key again.

11.1.2.5 After completion of zeroing ("Filter change" status light stops blinking and remains on), remove the zero foil and insert the calibration span foil.

11.1.2.6 Wait at least 4 min until the measured value has stabilized (can be read best on a chart recorder). Compare the LCD value to the value inscribed on the span foil.

11.1.2.7 If the LCD value does not agree with the value on the span foil, adjust the instrument using the "Calibration" potentiometer on the front panel of the instrument (note value). Repeat steps 3 through 6.

11.1.2.8 Following adjustment, remove the foil holder and guide bar, raise the measuring head again, re-insert the filter tape, and press FC + Z.

[Note: Be sure to turn on the pump and disable the keyboard to provide data output.]

11.2 Air Flow Rate

The particle size separation characteristics of the Andersen PM₁₀ inlet require that specific volumetric air flow rates be maintained during operation. Particle laden air passing through the inlet is forced to take a sharp turn upon entry. A change in the inlet entrance velocity will result in a change in the nominal particle size collected. For this reason, the air flow rate must be maintained at a constant air flow rate of 16.7 actual L/min (1 m³/hr) ± 10%.

11.2.1 Flow Rate Audit. To insure an accurate measurement of PM₁₀ concentrations, the EPA stipulates air flow rate audit frequencies for all samplers used to report data into the national data base. Please refer to *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume 2, Section 2.10 for basic requirements. The instrument's air flow rate should be checked upon installation, after maintenance activities, and at routine intervals throughout the year (at least once per calendar quarter).

11.2.1.1 Several commercially available air flow rate measurement standard devices are available. The manufacturer recommends a (calibrated) dry gas test meter with a display that is easily read to tenths and preferably hundredths of a liter. A dry gas test meter has a low pressure drop across the meter and is reproducible, rugged, and relatively inexpensive. Other measuring devices may be used; however, the manufacturer does not recommend mass flow meters with high pressure drop across the meter.

11.2.1.2 The SA 247 air flow rate measuring cap is used to replace the SA 246b PM₁₀ inlet to audit the air flow rate. Remove the SA 246b inlet and place the SA 247 cap with hose barb connector on top of the inlet drift tube. An O-ring seal inside the SA 247 air flow measuring cap assures an airtight seal. Attach a leak-free vacuum hose from the hose barb on the cap to the outlet side of the dry gas test meter. Open the inlet side of the dry gas test meter to the atmosphere for no resistance.

11.2.1.3 Set the instrument to measure flow rate in terms of actual operating conditions (see Section 10.2.6). Use the dry gas test meter and a stopwatch to measure the flow rate of the instrument. If the dry gas test meter is calibrated in units of standard volume at EPA reference conditions (298 K, 1013 kPa), use a thermometer and barometer to measure the actual ambient air temperature and pressure so that the measured flow rate in standard units (std L/hr) can be converted to actual units (actual L/hr) using the following equation:

$$Q_a = Q_{std} (P_{std}) / (T_{std}) (T_a / P_a)$$

where:

- Q_a = measured flow rate in actual L/hr.
- Q_{std} = measured flow rate in std L/hr.
- P_{std} = EPA reference pressure (1013 kPa).
- T_{std} = EPA reference temperature (298 K).
- T_a = actual ambient temperature (K).
- P_a = actual barometric pressure (kPa).

11.2.1.4 To insure a good reproducible air flow rate measurement, the time from start to stop of an audit with the dry gas test meter should be 10 min. While the air flow rate audit is being made with the dry gas test meter, monitor the air flow rate indicated by the instrument.

11.2.1.5 Compare the air flow rate measured with the dry gas test meter to the instrument's preset air flow rate (design flow rate of SA 246b inlet = 1,000 actual L/hr) and to the sampler indicated flow rate. If

the audited air flow rate differs from the set or indicated flow rates of the instrument by more than 10%, contact the manufacturer for assistance and service.

11.2.2 Flow Rate Calibration.

11.2.2.1 As discussed in Section 7.2.3, the air flow rate for the instrument is held constant (within $\pm 0.5\%$) using a regulator valve that is adjusted based on input from the instrument's flow rate measurement system.

11.2.2.2 The manufacturer recommends no periodic recalibration by the user. However, the field audit described in Section 11.2.1 is required quarterly for any instrument operating as an EPA equivalent method for PM₁₀.

11.3 Leak Check

The manufacturer has not developed any recommended leak checking procedures. Do not put the system under high positive or negative pressure; damage to the measurement system could result.

12. Method Safety

This instrument uses a radioactive source to measure PM₁₀. Only trained personnel with radiological authorization (e.g., the Andersen Service Division) may work on the source (e.g., cleaning the measuring chambers). The source has been secured with tamper-proof hardware and may not be disassembled without authorization.

13. Maintenance

To ensure proper instrument performance, the following maintenance steps must be consistently followed.

13.1 Vacuum Pump

The vacuum pump is the reliable rotary vane vacuum pump (multi-chamber system) with a dry rotor, which is known for its minimal maintenance during continuous service. The pump is supplied as an external unit and is fitted with protective filters.

13.1.1 Protective filter 1 in the suction line is used to protect the pump inlet. If the pump runs for any length of time with a defective sample filter strip or without any sample filter strip at all, check or replace the pump inlet filter. If a dirty pre-filter in the pump if the carbon vanes are intact and the pump does not reach the necessary air delivery rate may be the cause.

13.1.2 Protective filter 2 is mounted on the vacuum pump exhaust and is used to collect the worn carbon vane dust and act as a noise muffler for the vacuum pump. The cloth filter in the pump exhaust should be removed, soap and water cleaned and dried, and replaced each 6 months of pump operation.

13.1.3 Because the pump normally operates with pre-filtered air, carbon vane wear is very slight. The life of a set of carbon vanes is typically more than 1 yr. For this reason, check the carbon vanes at intervals of 2,000-3,000 operating hours (i.e., 3 months) or change yearly. The rotary pumps should be maintained in accordance with the instructions of the pump manufacturer.

13.2 PM₁₀ Inlet

Andersen recommends removing, cleaning, and checking the O-ring of the Model SA 246b PM₁₀ Inlet six times per year based on sampling every day for a 24-h period. Sampling locations where PM₁₀ levels are in nonattainment may require more frequent maintenance. See Operator Manual, Section 5.3, for detailed maintenance procedures.

13.3 Radioactive Source

As discussed in Section 12, maintenance of the radioactive source may only be carried out by authorized individuals. Contact the manufacturer for more information.

13.4 Air Flow Regulator Bleed Valve

The air inlet for the regulator bleed valve is located on the back panel of the instrument (see Figure 6). The inlet is fitted with a protective filter that must be replaced annually, or more often in very dusty environments. An inexpensive automobile fuel filter is suitable for this purpose.

14. Performance Criteria and Quality Assurance (QA)

Required quality assurance measures and guidance concerning performance criteria that should be activated within each laboratory are summarized in the following sections.

14.1 Standard Operating Procedures (SOPs)

14.1.1 SOPs should be generated by the users to describe and document the following activities in their laboratories:

- Assembly, calibration, leak check, and operation of the specific sampling system and equipment used;
- Preparation, storage, shipment, and handling of the sampler system;
- Purchase, certification, and transport of standard reference materials; and
- All aspects of data recording and processing, including lists of computer hardware and software used.

14.1.2 Specific stepwise instructions should be provided in the SOPs and should be readily available to and understood by the personnel conducting the monitoring work.

14.2 Quality Assurance Program

The user should develop, implement, and maintain a quality assurance program to ensure that the sampling system is operating properly and collecting accurate data. Established calibration, operation, and maintenance procedures should be conducted on a regularly scheduled basis and should be part of the quality assurance program. Calibration verification procedures provided in Section 11, operation procedures in Section 10, and the manufacturer's instruction manual should be followed and included in the QA program. Additional QA measures (e.g., trouble shooting) as well as further guidance in maintaining the sampling system are provided by the manufacturer. For detailed guidance in setting up a quality assurance program, the user is referred to the *Code of Federal Regulations* (4) and the *U. S. EPA Handbook on Quality Assurance* (3).

15. References

1. Equivalent Method Designation, Andersen Instruments Model FH62I-N PM₁₀ Beta Attenuation Monitor, *Federal Register*, Vol. 55, September 18, 1990, p. 38387.
2. Andersen Instruments, Inc., *Operator Manual: FH 62 I-N PM₁₀ Beta Attenuation Monitor*, Atlanta, GA.
4. *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II--Ambient Air Specific Methods (Interim Edition)*, EPA 600/R-94/038b.
5. 40 CFR, part 58, Appendices A and B.

TABLE 1. EXAMPLE OF MINIMUM SAMPLER SITING CRITERIA

Scale	Height above ground, meters	Distance from supporting structure, meters		Other spacing criteria
		Vertical	Horizontal ^a	
Micro	2 to 7	> 2	> 2	<ol style="list-style-type: none"> 1. Should be > 20 meters from trees. 2. Distance from sampler to obstacle, such as buildings, must be twice the height that the obstacle protrudes above the sampler.^a 3. Must have unrestricted airflow 270 degrees around the sampler inlet. 4. No furnace or incineration flues should be nearby.^b 5. Spacing from roads varies with traffic (see 40 CFR 58, Appendix E). 6. Sampler inlet is at least 2 m but not greater than 4 m from any collocated PM₁₀ sampler (see 40 CFR 58, Appendix E).
Middle, neighborhood, urban, and regional scale	2 to 15	> 2	> 2	

^aWhen inlet is located on rooftop, this separation distance is in reference to walls, parapets, or penthouses located on the roof.

^bDistance depends on the height of furnace or incineration flues, type of fuel or waste burned, and quality of fuel (sulfur, ash, or lead content). This is to avoid undue influences from minor pollutant sources. As a precautionary measure, the sampler should be placed at least 5 meters from the furnace or incinerator flue.

TABLE 2. SEQUENCE OF PARAMETERS

Parameter	Value	Comments
Mass	#2,400 Fg	Mass on filter; a higher setting could result in "pegged" readings.
Pressure	User select	Pressure drop across filter; increases with mass loading.
Air Flow	\$900 L/hr	Flow rate through instrument; can drop with mass loading.
Cycle	User select	Minutes since last change; select > 1,440 min to minimize changes.
Time	24:00	Filter change at midnight; required for equivalent method.

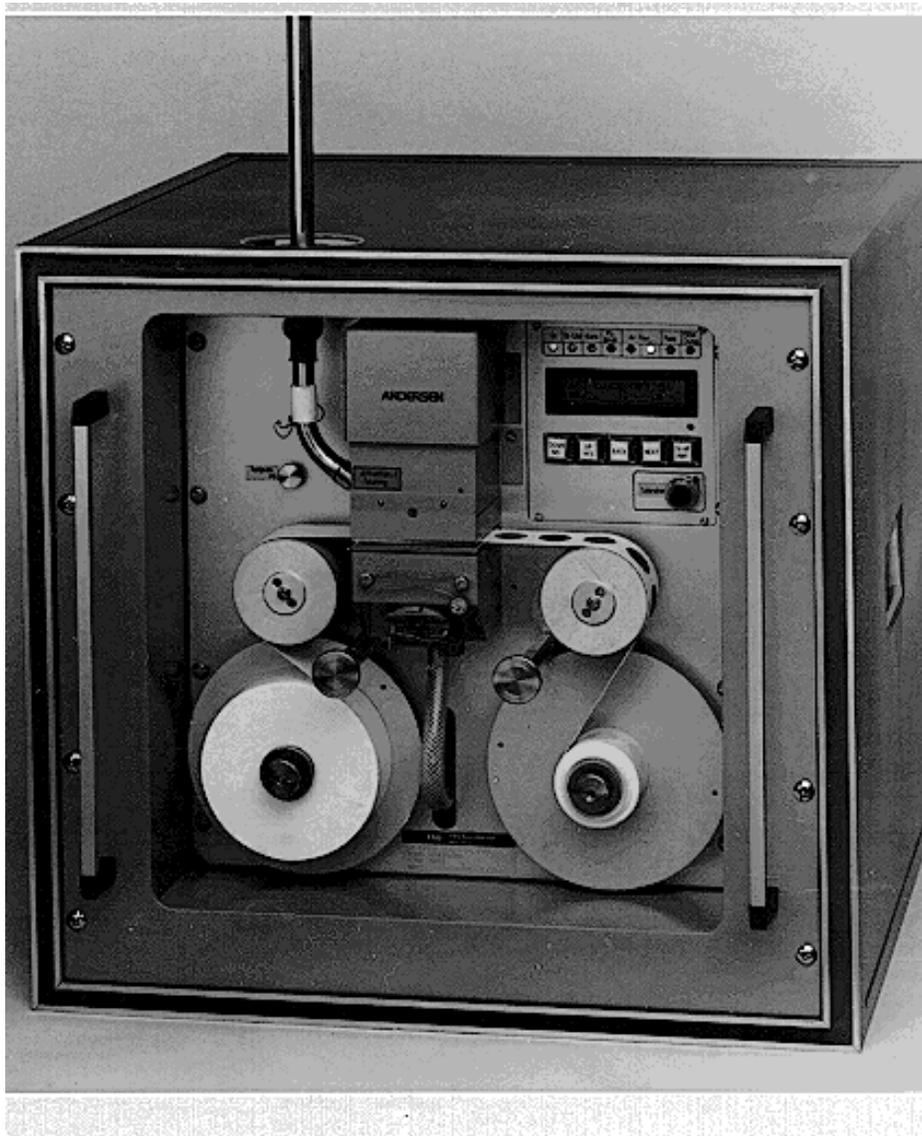
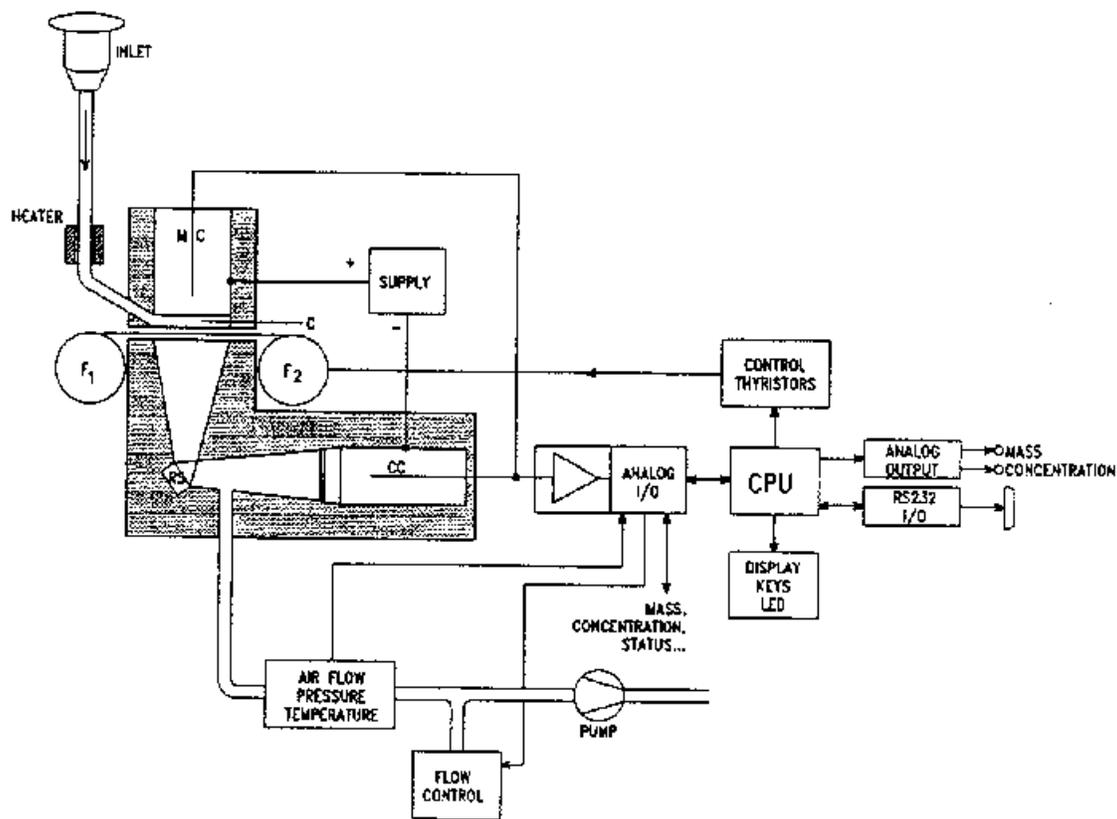


Figure 1. Andersen PM₁₀ Beta gauge monitor.



- WC = MEASURING CHAMBER
- CC = COMPENSATION CHAMBER
- RS = RADIOACTIVE SOURCE
- C = CHAMBER FOR PARTICULATE DEPOSITION AND MEASUREMENT
- RS-C-WC = MEASUREMENT SECTION
- RS-CC = COMPENSATION MEASUREMENT SECTION
- F₁, F₂ = FILTER REELS

Figure 2. Schematic diagram of the Andersen beta gauge monitor.

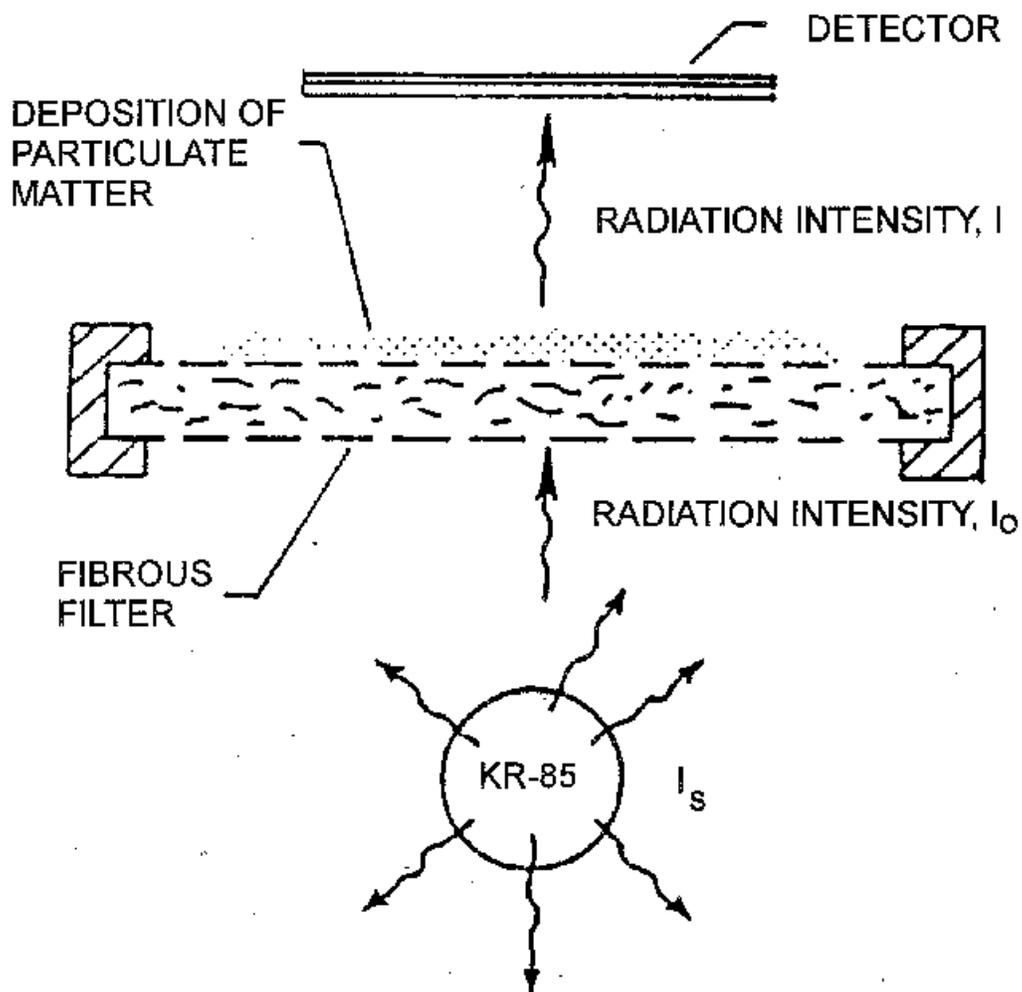


Figure 3. Measurement principle of the Andersen beta gauge monitor.

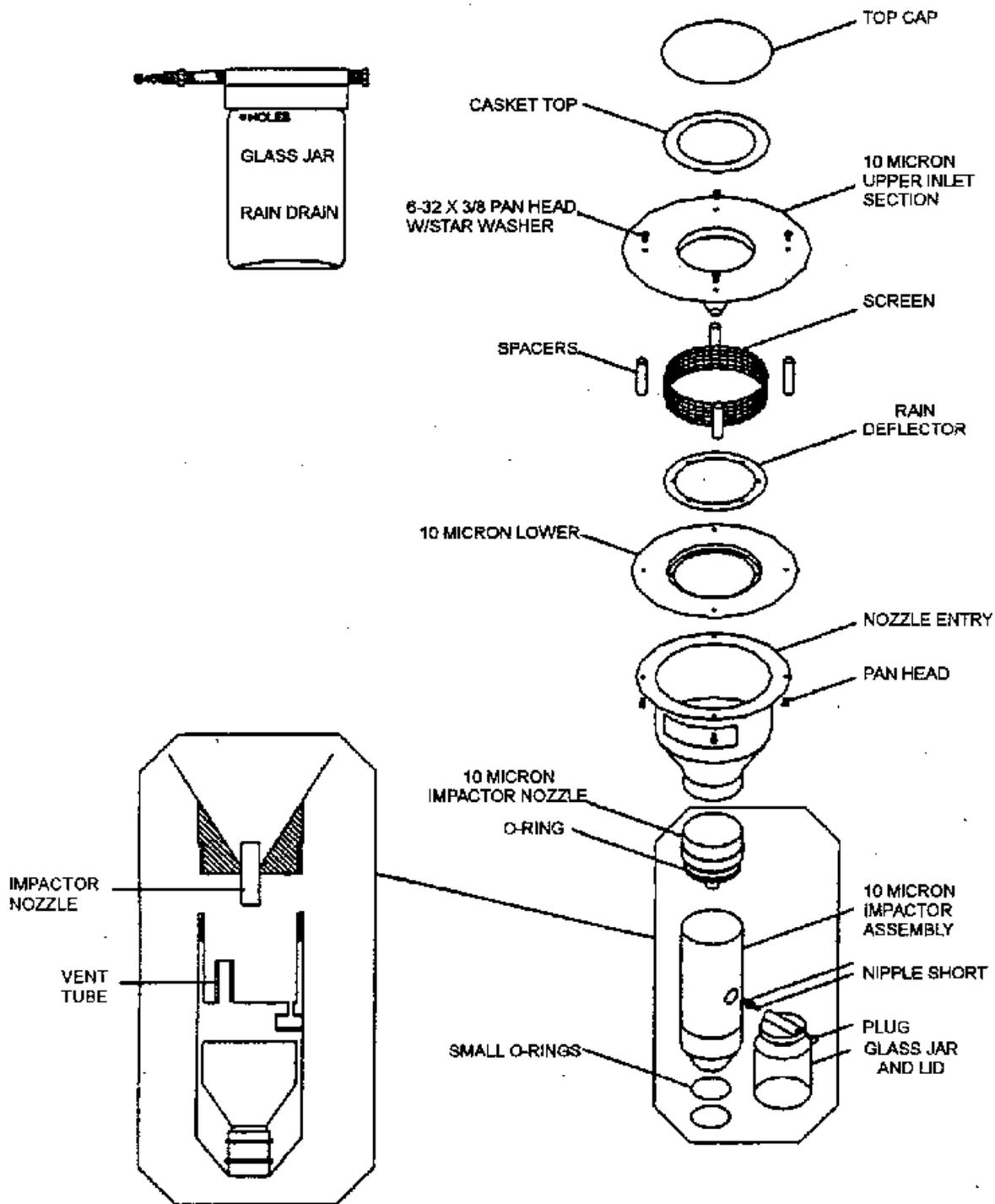
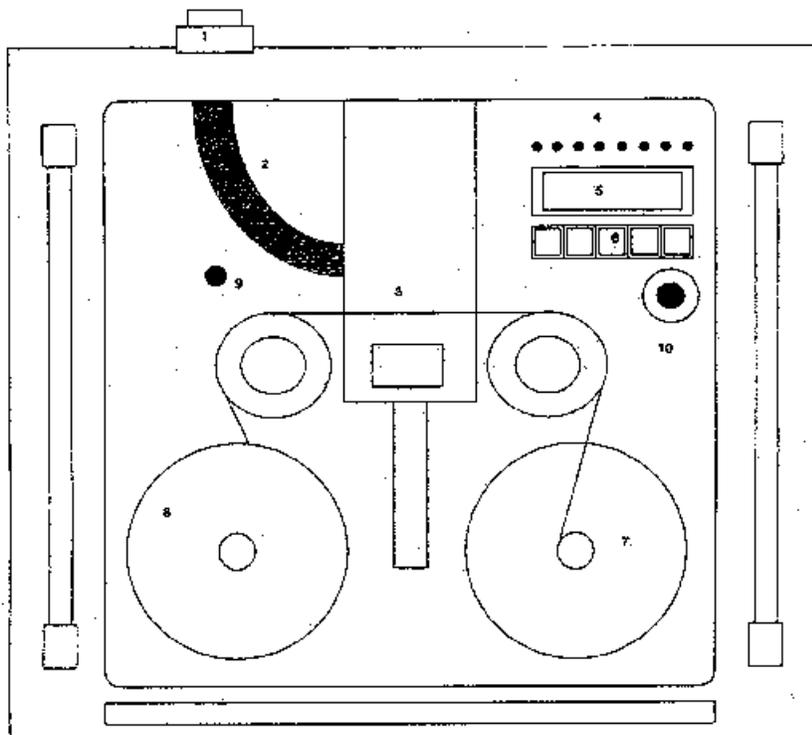
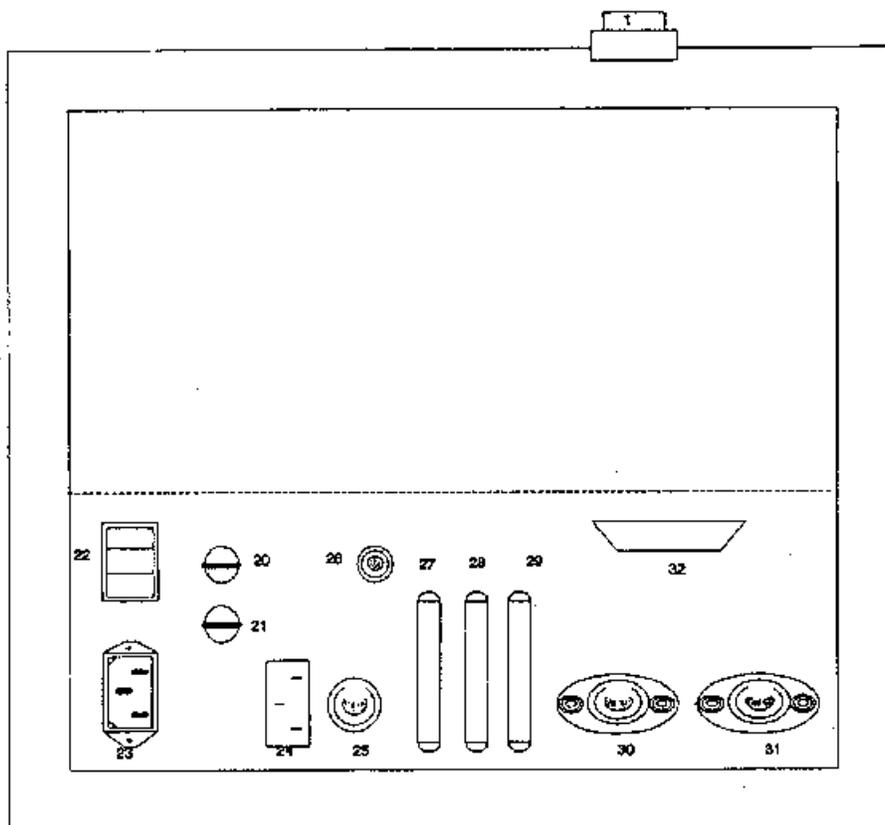


Figure 4. Andersen beta monitor PM-10 inlet.



LEGEND			
1.	Air inlet		
2.	Heated air inlet		
3.	Opening for test probe		
4.	LED's indication operating/error status		
A	"ON"	(green)	Continuously lit power ON, no error
B	"ON LINE"	(green)	Flashing slowly (0.5Hz). measured value buffer contains <30 sample values
C	"Alarm"	(red)	Flashing rapidly (2Hz) zero no longer reached
D	"FS Break"	(yellow)	Auto, On Line, keyboard disabled
E	"Flowrate"	(green)	Concentration alarm Threshold 1 exceeded flashing - Threshold 2 exceeded
F	"Flowrate"	(yellow)	Filter tape feed reel not turning on filter change; end of filter tape or break
G	"Pump"	(green)	Air flow rate OK
H	"Filter change"	(red)	Air flow rate outside limits
			Pump running
			Filter change cycle running 3-phase, flashing see Section 10.4
5.	Display for readout		
6.	Control keys		
7/8.	Filter strip reels		
9.	Test probe		
10.	Calibration potentiometer		

Figure 5. Front of Andersen beta gauge monitor.



- LEGEND**
- 20. 4 amp power fuse for pump/controller
 - 21. 1 amp power fuse for electrical
 - 22. Power switch
 - 23. 115 VAC power
 - 24. Pump connecting socket
 - 25. Air flow rate regulator valve connection socket
 - 26. Pump connection socket
 - 27. Data interface RS 232
 - 28. Relay contacts
 - 29. Analog inputs
 - 30. Concentration output
 - 31. Mass concentration output
 - 32. Network computers output

Figure 6. Rear of Andersen beta gauge monitor.

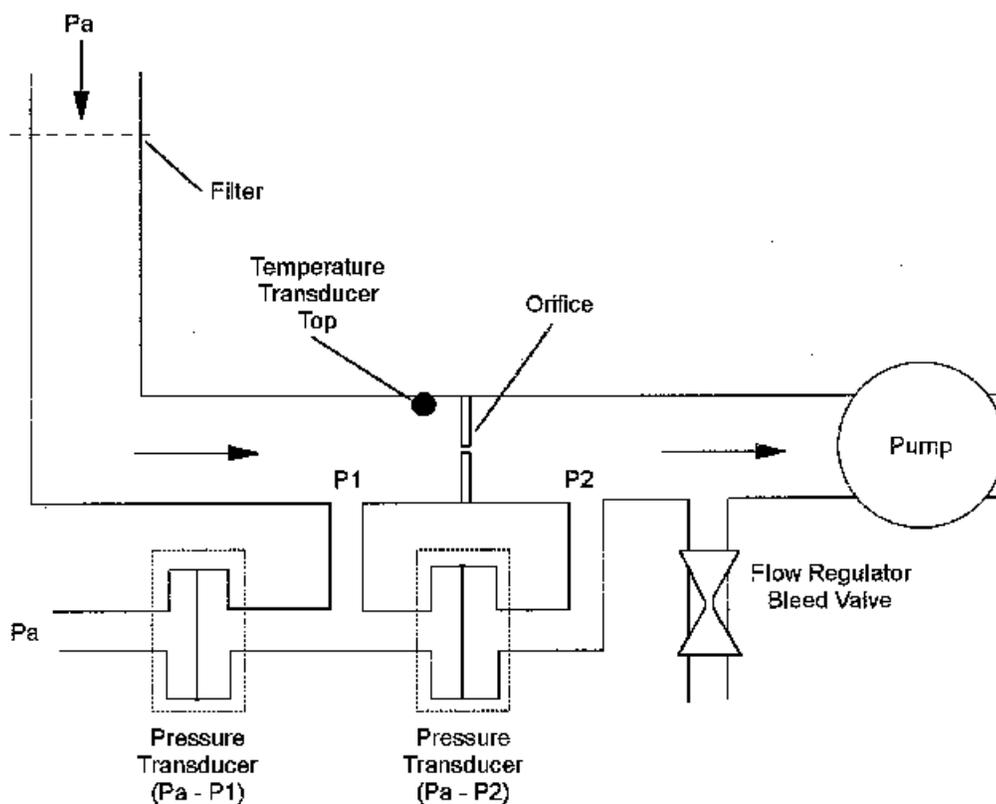


Figure 7. Air flow rate measurement and control for the Andersen beta gauge monitor.

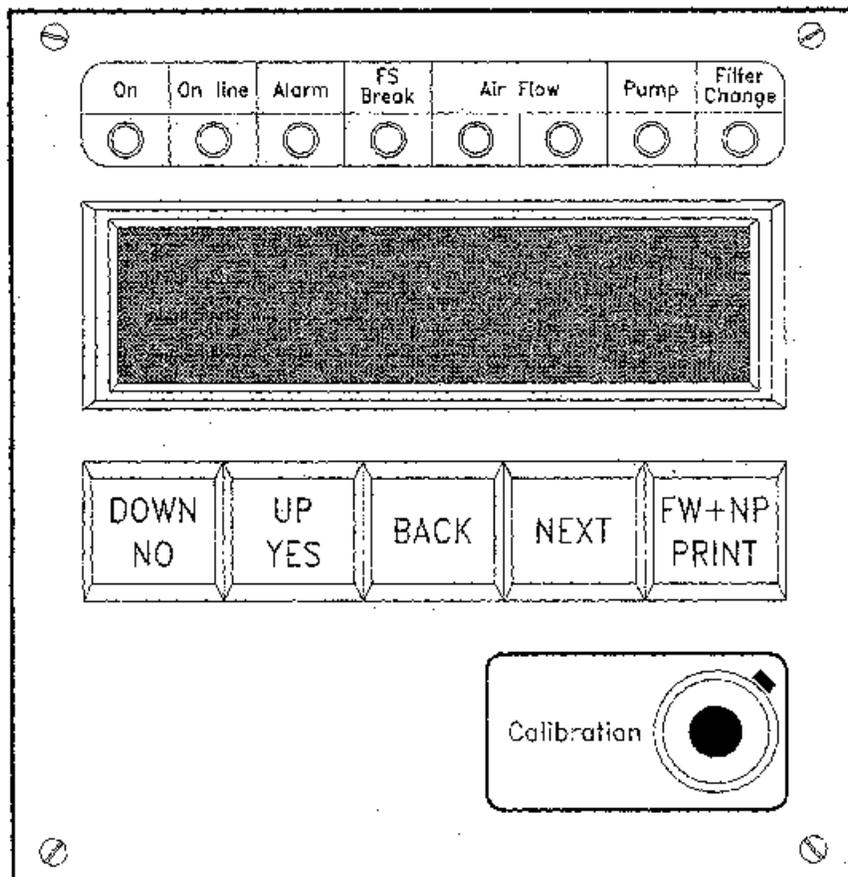


Figure 8. Instrument control system for the Andersen gauge monitor.