THE PM2.5 FEDERAL REFERENCE METHOD (FRM)*

To comprehend the objectives of this study it is necessary and worthwhile to describe the new PM2.5 samplers in generic form. The formal description of the FRM, published by the Environmental Protection Agency (USEPA, 1997), is complicated by legal requirements and is therefore not readily accessible to end-users of the instruments. The PM2.5 FRM is intended to be far more rigorous than any particulate standard previously considered. PM2.5 samplers are broken down into reference samplers, plus three classes of equivalent sampling/measuring devices. The main facets of the method, in logical order, are as follows.

PM 2.5 Definition.

The USEPA defines PM2.5 in two ways. First, as an administrative standard, the FRM states that only measurements made using USEPA-designated instruments (and methods) may be referred to and reported as 'PM2.5'. Measurements made with undesignated instruments may not be accepted into the Federal database as 'PM2.5'. Second, the scientific definition of PM2.5 is based on the particle size-selection characteristics of the Well Impactor Ninety-Six (WINS) Impactor. The impactor must be used downstream of a USEPA-developed first stage inlet (modified PM10 low volume inlet). Originally a proprietary design, complete details of this inlet have been published by USEPA (USEPA, 1997-Part 50, appendix L, Fig. L 1-19, pp. 66-84). Thus, the "PM10" inlet is utilized as a first stage size selector, with the WINS providing the second stage PM2.5 cut.

* Aerosol Science & Technology: The PM 2.5 Federal Reference Method (FRM)." 35(4):339-342.

Design Criteria

Based upon their extensive experience with PM10 measurement, the USEPA decided that the design of PM2.5 instruments was to be rigorously defined. They further determined that in order for any manufacturer to be able to produce instruments having identical sampling performance, the manufacturing drawings of the essential components would be presented in the FRM. These components include the first stage inlet, the second stage separator (WINS), the upper filter holder, the filter cassette and the filter support screen. A typical generic sampler is schematically depicted in Figure 1.

Performance Criteria

The performance segment of the PM2.5 FRM specifies strict guidelines for controls that must be observed, as well as the range of precision and accuracy of those controls. The FRM specifies measurements to be recorded, and how they are to be stored. The flow rate through the instrument is specified as 16.67 $l.min^{-1}$ (1 m^3/hr). This flow must be volumetrically controlled to a precision of 5% and an accuracy of 2% (change to 4% pending). The flow control must be upgraded at least every 30 seconds and recorded (logged) every five minutes. Measurements must also be made, on the same schedule, of barometric pressure, ambient temperature and filter temperature. In the case of filter temperature, it must not exceed the ambient temperature by more than 5° C for more than 30 minutes. This is to minimize any potential effects of solar radiation heating to the particles collected on the filter.

A fan blowing filtered ambient air through the enclosure provides the necessary cooling effect. It is necessary for the entire apparatus to provide accurate performance over a

temperature range of –20 to 40° C. It is also required that the instrument functions down to –30° C. The FRM further specifies an extremely rigorous set of test protocols for a candidate instrument involving environmental test chambers. A 10 day (minimum) field trial is required wherein three candidate instruments are collocated at a field site. A minimum of 10 x 24-hour samples must be collected at concentrations above 10 µg/m^3 PM2.5. The three samplers must achieve a precision of less than 2µg/m^3. No unsuccessful tests are allowed without valid reason.

The supporting run-time (interval) data, which are stored in detailed 5-minute intervals in the sampler's microprocessor, as well as 24-hour integrated performance (filter) data, must be capable of being extracted at the conclusion of a 24-hour run. The FRM mandates the provision of an RS232 port for this purpose. Data may be extracted to a portable computer or data logger. Summary data must also be capable of being recorded by hand from the instrument's display screen. The forms these data take are specified by USEPA and permit the operator to perform a concentration calculation and ensure that the instrument was operating properly during the test cycle. All of these characteristics have been published by USEPA and summarized in Table L-1 (USEPA-1997-Part 50, p 63).

Single and Sequential Filter Samplers

The schematic drawing shown in Figure 1 is of a single filter Reference Method Sampler. The regulations also provide for a sequential filter reference method sampler. The purpose of a sequential sampler is to permit the gathering of data on contiguous run days without the need to locate two samplers at a site and attend to them seven days a week. The sequential samplers designed, designated and permitted for this purpose meet all the criteria of a single

channel sampler, and contain an additional mechanism to automatically change the filter. With each filter change a new data gathering cycle is initiated.

Sampling Protocols

At the present time USEPA regulations require that a filter, on completion of a 24-hour cycle, must be removed from the field within 96 hours after the completion of the run. This means that sequential samplers must be serviced every four days. The filter that is running during the service procedure will be left in place to continue its cycle. The reason for the 96-hour maximum time period is to minimize the presumed potential for mass change in the deposited particulate matter. Operational sampling strategies being considered vary from daily, every third day and every sixth day cycles. The details of the sampling strategy are at present under review.

In other jurisdictions, e.g. Europe, ambient air quality sampling strategies typically utilize automated continuous PM monitors with maintenance carried out at longer intervals (e.g. 16 days). Regulations concerning the measurement of PM2.5 have yet to be implemented in Europe, however systems requiring lower levels of intervention and maintenance are likely to be favored, being most consistent with the existing networks of monitoring stations.

PM2.5 Federal Equivalent Method (FEM) Samplers

The USEPA FRM regulations tabulate the aerodynamic size selection curve of the WINS impactor and require that any 'equivalent' PM2.5 sampling device must have a 50% penetration value (or cut-point) of 2.5 ± 0.2 µm, and sampling bias for PM2.5 concentrations less than ±5%. The sampling bias is calculated numerically for three generalized ambient

aerosol size distributions, designated ‘fine’, ‘typical’ and ‘coarse’, details of which are also given in the regulations. Hence the measured characteristics of any alternative sampling device can be tested against these criteria to determine whether its performance meets the requirements. Further tests are required to establish a) that the candidate sampler continues to meet the standard after loading with dust, and b) gives comparable results to a reference sampler under field conditions. A summary of the performance specifications for equivalent samplers is given in Table F-1, USEPA-1997-Part 53, page 58.

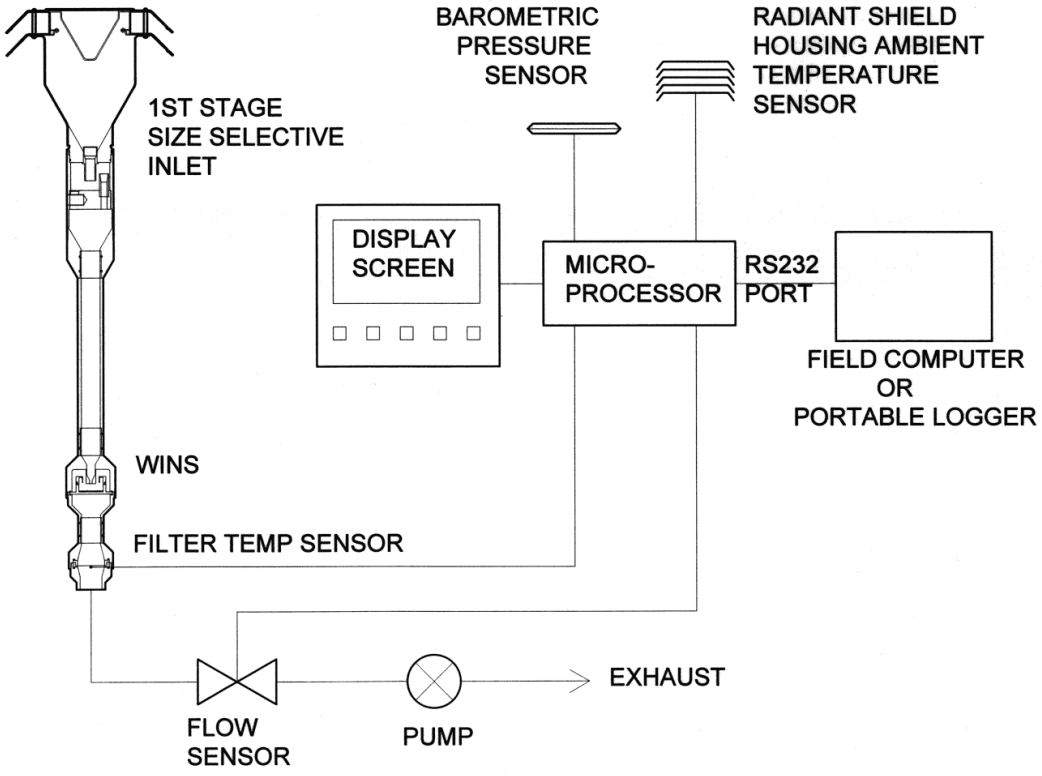

Figure 1. Schematic diagram of a single-channel PM2.5 FRM sampler.