

Attachment 1

Summary and Rationale for the PM_{10-2.5} FRM

August 22, 2005

Prepared for purposes of the CASAC AAMM September 2005 Peer Review

Summary and Rationale for the PM_{10-2.5} FRM

August 22, 2005

This attachment provides a short summary of salient specifications and provisions of the proposed Federal reference method (FRM) for coarse particulate matter (PM_{10-2.5}). The method would be very similar to the current FRM for PM_{2.5} and incorporates that method's specifications and provisions to a very great extent. Following the summary is a discussion of the rationale supporting the selection of the proposed method.

Summary of the proposed method

The proposed method is based on separate, collocated, concurrent measurements of ambient concentrations of particulate matter in ambient air in the 10 micrometer-and-less size range (PM₁₀) and in the 2.5 micrometer-and-less size range (PM_{2.5}). The measurement of ambient air particulate matter concentration in the 2.5 to 10 micrometer size range (PM_{10-2.5}) is determined as the arithmetic difference between the concurrent PM₁₀ and PM_{2.5} measurements ($PM_{10-2.5} = PM_{10} - PM_{2.5}$). Size ranges are nominal and based on aerodynamic particle diameter. All measurements are 24-hour (± 1 hour) integrated mass concentration values specified in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) based on air volume at actual local conditions of temperature and pressure.

The PM_{2.5} concentration measurements are carried out using a sampler and operational procedures as specified in the FRM for PM_{2.5} in Appendix L of 40 CFR Part 50. PM₁₀ concentration measurements are carried out using a sampler that is identical to the PM_{2.5} sampler except that the PM_{2.5} particle size separator (WINS impactor) is removed and replaced with a specified straight tube adaptor. (Both samplers use a specified PM₁₀ inlet.) Operational procedures for the PM₁₀ sampler are identical to those for the PM_{2.5} sampler except that references to "PM_{2.5}" would be interpreted as "PM_{10c}" and the maintenance procedures pertaining to the PM_{2.5} particle size separator would not be applicable. Note that this PM₁₀ sampler would have to meet more stringent requirements than conventional PM₁₀ reference method samplers as specified in Appendix J of 40 CFR Part 50. Therefore these special PM₁₀ samplers and their associated PM₁₀ measurements should be distinguished from conventional PM₁₀ samplers and measurements by a unique descriptor, which is tentatively "PM_{10c}."

(An associated change proposed to the PM_{2.5} reference method would specify an optional particle size separator – a very sharp cut cyclone (VSCC) – as an alternative to the currently specified WINS impactor for the PM_{2.5} sampler. If adopted, this change would also apply to the PM_{2.5} portion of the PM_{10-2.5} reference method.)

Specific commercially available PM_{10-2.5} sampler pairs and the associated operational procedures would be designated as reference methods for PM_{10-2.5} under proposed amendments to 40 CFR Part 53. PM_{10-2.5} sampler pairs based on a PM_{2.5} sampler model that has been previously designated by EPA as an FRM for PM_{2.5} would be designated as an FRM for PM_{10-2.5} without further testing. Qualifying sampler pairs of dissimilar models, including samplers of multi-filter sequential-sample design, would be designated under Part 53 as Class I equivalent methods, also without further testing if the base PM_{2.5} samplers have been designated as reference or Class I equivalent methods for PM_{2.5}.

Supporting Rationale

The method recommended for promulgation as the FRM for coarse particulate matter (PM_{10-2.5}) in the ambient air is a simple difference method using conventional and well-proven measurement technology. FRMs may be used for multiple air monitoring purposes, and no method can meet all possible objectives well. In selecting a methodology for the PM_{10-2.5} FRM, the primary focus must be on 1) its ability to provide credible and reliable measurements of PM_{10-2.5} for making correct NAAQS attainment decisions, 2) assessing the quality of monitoring data, and 3) providing a credible and practical reference standard of comparison for candidate alternative measurement methods to determine their qualification as equivalent methods (FEMs). Among a variety of potential alternative methods or methodologies considered for the FRM, the proposed method appears to clearly provide the most beneficial and advantageous attributes needed to fulfill the purposes and objectives of a FRM for PM_{10-2.5}, while still serving some other objectives as well. As described below, there is strong and ample justification for this conclusion.

Perhaps the most fundamental requirement for the PM_{10-2.5} FRM is to measure the subject particulate matter with a high degree of fidelity and faithfulness. For purposes of the proposed NAAQS for coarse particulate matter, PM_{10-2.5} is defined as the mass concentration of ambient particles in the coarse-mode fraction of PM₁₀, specifically the (nominal) size range of 2.5 to 10 micrometers. The lower limit of this size range is formally defined by the existing FRM for PM_{2.5} (40 CFR 50, Appendix L), and the upper limit is formally defined by the existing FRM for PM₁₀ (40 CFR 50, Appendix J). In both cases, the particle sizes are defined in terms of aerodynamic size, not physical size. Further, again in both cases, the particle size limits are not step functions but instead are substantially defined by the corresponding FRM-specified measurement methodologies, which have inherent size fractionation curves with characteristic shapes and cutoff sharpness. The proposed PM_{10-2.5} reference method utilizes these same FRM measurement methodologies to determine the PM_{10-2.5} concentration as the difference between separate PM₁₀ and PM_{2.5} measurements, thereby preserving and replicating the same particular PM₁₀ and PM_{2.5} aerodynamic size limit characteristics previously established by the PM₁₀ and PM_{2.5} FRMs.

Also not to be overlooked is that the proposed $PM_{10-2.5}$ FRM utilizes the same fundamentally sound integrated sample, filter-collection, and mass-based gravimetric measurement technology that has been basic to all previous FRMs for the various formal particulate matter indicators. This provides maximum comparability among new or existing $PM_{10-2.5}$, PM_{10} , and $PM_{2.5}$ data sets, and $PM_{2.5}$, PM_{10} , and $PM_{10-2.5}$ calculations can be easily made and interpreted. This measurement technology has an extensive track record from wide use over many years in many government monitoring networks, and its reliability has been well established. No costly studies are needed to assess the impact, affect, or degree of comparability of new or changed measurement technology relative to previously acquired measurement data. Extensive wind tunnel tests have shown that the inlet, used on both the $PM_{2.5}$ and PM_{10} samplers, is capable of aspirating large particles efficiently, even at high wind speeds. And the presence of $PM_{2.5}$ aerosols on the PM_{10} sample collection filter increases the adhesion of larger particles to the filter. This increased adhesion helps to minimize losses of large particles from the PM_{10} filters during handling and transport, which can be a considerable problem with filter samples collected with a virtual impactor-type (dichotomous) sampler where the $PM_{2.5}$ aerosols are not present on the $PM_{10-2.5}$ filter.

An inherent advantage of a difference method is that some (additive) biases may be eliminated or substantially reduced by the subtraction. In the proposed $PM_{10-2.5}$ FRM, both the PM_{10} and $PM_{2.5}$ samplers use the same sample collection filter and operate at the same volumetric flow rate, resulting in identical filter face velocity. In addition, the sample filters for both samplers are maintained at the same temperature and pressure conditions during sample collection as well as during sample retrieval, transport, conditioning, and weighing. Since both filters thus collect the same amount of $PM_{2.5}$ material, volatile losses of $PM_{2.5}$ would presumably be very similar or identical. The effect of these losses is thus cancelled, to a large extent, by the subtraction. Similarly, biases such as might be observed from laboratory or field blanks would tend to be greatly reduced, also. The two $PM_{10-2.5}$ samplers and operational procedures of the method are very closely matched to take maximum advantage of this inherent, error-reducing advantage of a differential method, which helps to compensate for the additional variability resulting from dual measurement systems. Although a difference method could produce negative measurements on occasion, considerable field testing of the method indicates that negative readings are rare, due in substantial part to the excellent precision of the method. Moreover, measured negative $PM_{10-2.5}$ concentrations, if observed, would likely occur only near the detection limit of the method and would thus be unlikely to adversely influence the accuracy of $PM_{10-2.5}$ NAAQS attainment decisions.

The proposed $PM_{10-2.5}$ FRM utilizes commercially available $PM_{2.5}$ samplers that have been extensively evaluated during both laboratory and field studies. Several sampler models have been designated as $PM_{2.5}$ reference method samplers by the EPA under 40 CFR Part 53 and proven in years of routine use in many State monitoring networks. The PM_{10} sampler is identical to the $PM_{2.5}$ sampler, except for removal of the $PM_{2.5}$ particle size separator. Six such samplers have been already designated by the EPA as PM_{10} (PM_{10c}) reference methods. The procedures

for sampler setup, calibration, and operation; filter handling, transport, and conditioning; and sample analysis are identical to those for PM_{2.5} reference methods and are therefore familiar to all monitoring agencies that operate one or more PM_{2.5} samplers. PM_{10-2.5} FRM sampler pairs based on currently designated PM_{2.5} FRM samplers could be quickly designated by EPA as PM_{10-2.5} reference methods, as no additional qualification testing would be required. Existing PM_{2.5} FRM samplers can be easily reconfigured as PM_{10-2.5} FRM sampler pairs by converting some of them to the special PM₁₀ (PM_{10c}) samplers by simply replacing the WINS impactor with the specified straight downtube adaptor. Thus, the PM_{10-2.5} FRM can be rapidly and economically implemented into new or existing monitoring networks to begin collection of PM_{10-2.5} monitoring data expeditiously, with minimal requirements for operator retraining or pilot operation periods. Even if designated automated equivalent methods for PM_{10-2.5} eventually supersede manual FRMs in governmental PM_{10-2.5} monitoring networks, as EPA anticipates, a readily available and field-proven reference method is still vitally important to serve as a reliable, highly credible, and practical reference standard of comparison for qualification of such candidate equivalent methods and for quality assurance of monitoring data.

Another advantageous feature of the proposed FRM is that it provides readily accessible aerosol samples for subsequent chemical analyses. The sampler's design allows use of a wide variety of filter materials including Teflon, quartz, nylon, and polycarbonate. Compared to PM_{2.5}, the chemical composition of coarse-mode aerosols has not yet been extensively evaluated. The ability of the proposed FRM to provide speciated analyses of coarse aerosol samples will be an important tool for the States during development of effective implementation plans.

One possible concern with the proposed FRM is potential losses of volatile components in the PM_{10-2.5} aerosol. In a traditional virtual impactor which uses a flow rate of 1.67 L/min for the coarse channel, the PM_{10-2.5} aerosol is collected with the same size filter but at 1/10 the flow rate, and hence 1/10 the face velocity, of the proposed FRM. If PM_{10-2.5} aerosols are volatile in nature, lower PM_{10-2.5} measurements would be expected with the proposed method than with the virtual impactor. However, recent field test comparisons indicated good agreement between the two methods, providing evidence that substantial PM_{10-2.5} mass is not lost by filtration in the proposed FRM.

The virtual impactor has attributes that make it a prime alternative candidate measurement technology. However, as noted previously, the absence of the PM_{2.5} aerosol component from the PM_{10-2.5} sample filter can make that sample susceptible to losses of large particles during filter handling. Also, large particle carryover to the fine sample filter can significantly bias the PM_{2.5} measurement. Although this may not be a primary concern for the PM_{10-2.5} measurement, an FRM is used for many purposes beyond its primary purpose as a reference standard for compliance measurements and equivalent method qualification. For reasons such as these, as well as the lack of many of the network implementation advantages of the proposed method discussed previously, this potential alternative method is deemed significantly less suitable as a reference method for PM_{10-2.5}.

Other measurement technologies considered for the FRM include a variety of automated methods providing continuous or semi-continuous measurements of $PM_{10-2.5}$. Such methods are particularly desirable for use in $PM_{10-2.5}$ monitoring networks because they offer the potential of substantially lower operational and maintenance costs, hourly averages or other short-term measurements in addition to 24-hour averages, and nearly real-time electronic, remote reporting of measurement data. However, recent field testing of many of these instruments indicated that none can yet achieve performance commensurate to that of the proposed method. The technologies employed by these methods usually represent substantial, if not radical, departure from the well-characterized conventional filter-collection and gravimetric determination, which raises the inevitable questions of representativeness of particle size discrimination, treatment of volatile components, variability with differing site and climatic conditions, and the degree of comparability to conventionally obtained measurements. Also, the EPA anticipates proposing a daily standard for $PM_{10-2.5}$, hence hourly measurements are not required to support such a standard.

Many if not most, of these automated measurement technologies are proprietary. While that alone is not sufficient reason to preclude their consideration for adoption as a FRM, the EPA must be diligent to avoid a situation where monitoring agencies or equivalent method applicants are dependent on a sole entity for obtaining FRM instruments. If a particular manufacturer's technology were specified for the FRM, that manufacturer would enjoy substantial and unfair economic advantages over other manufacturers, who would need to bear licensing, development, testing, and production costs to manufacture the instruments for a limited market where the original manufacturer likely has already established a substantial market presence and reputation for the technology. This reputation could be unintentionally enhanced if the FRM specification were perceived as EPA endorsement of the original manufacturer's technology despite EPA disclaimers to the contrary. These considerations could greatly inhibit the production of the specified technology by other manufacturers. Further, specifying a particular manufacturer's technology by make and model would tend to freeze the design of the instrument, significantly inhibiting further development and innovation. The costs of producing an instrument exactly as specified would always be lower relative to the additional costs of research, development, testing, obtaining EPA approval or designation, and production of a new or improved instrument. Adoption of the proposed FRM along with reasonable qualification requirements for equivalent methods leaves a fair and level playing field for any manufacturer to either produce the specified FRM method samplers or pursue the development and EPA approval of innovative new methods and technologies to strive for competitive marketing advantages.

Nevertheless, many of the current automated technologies for measuring $PM_{10-2.5}$ (and $PM_{2.5}$) are under continuing development and testing, and it is quite likely that some will soon demonstrate adequate performance for use in State and other monitoring networks. Associated with the proposal of the new $PM_{10-2.5}$ FRM, EPA is also proposing testing, standards of comparability, and other requirements for designation of such automated methods as (Class III) equivalent methods for $PM_{10-2.5}$. If such methods can qualify for equivalent method designation,

as EPA anticipates, they would likely be widely deployed in the nation's PM_{10-2.5} monitoring networks in lieu of the proposed FRM. Such a shift to automated equivalent methods would assuage the most common criticisms of the proposed FRM – that it is highly labor-intensive and costly to operate in large monitoring networks and reporting of results is inherently delayed.