

On the Modification of the Low Flow-Rate PM₁₀ Dichotomous Sampler Inlet

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A popular flat-topped inlet used for the collection of atmospheric particulate matter was modified to reduce water intrusion during rain and snow events. Simple alterations in the intake region of this inlet were made, including a larger drain hole, a one piece top plate, and louvers. Wind tunnel tests were performed at 24 km/h for fine particle aspiration and at 2, 8, and 24 km/h for coarse particle sampling characteristics of the modified design. The laboratory evaluations of this inlet for fine (PM_{2.5}) and coarse (PM₁₀) particle sampling demonstrated that the aspiration characteristics of this inlet were identical to those of the original inlet. This inlet should greatly reduce, if not totally prevent, the intrusion of precipitation. Further, sampling effectiveness test results suggest that the modified inlet could be substituted for the original inlet where the original inlet is part of a designated reference or equivalent method sampler for PM₁₀.

INTRODUCTION

The function of the inlet on an aerosol collection device is to extract an air sample containing the aerosol from the atmosphere in an unbiased manner in both calm and windy conditions. An inlet often includes an integral particle size separator to remove particles of sizes greater than the size range to be collected by the sampler. Current inlets in use for sampling particulate matter with aerodynamic diameters $<10 \mu\text{m}$ (PM₁₀) employ impactors (Liu and Pui 1981; McFarland and Ortiz 1982; Kim et al. 1998) or cyclones (Wedding et al. 1982) to limit particle collection to the PM₁₀ size range. The Federal Reference Method (FRM) for fine particulate matter (PM_{2.5}), as it was originally proposed (U.S. EPA 1996), specified a particular flat-topped inlet with an internal impactor (see Figure 1) that aspirates particulate matter sample air from the atmosphere at 16.7 l/min (MacFarland and Ortiz 1982). In this application, the impactor serves to remove the bulk of large particles ($>10 \mu\text{m}$) from the extracted

sample to reduce particulate matter loading in the subsequent (PM_{2.5}) size separation unit. Selection of this inlet was based upon its satisfactory sampling characteristics at elevated wind speeds, low design flow rate, many years of use and wide acceptance, and incorporation in several EPA designated reference and equivalent methods for PM₁₀ (e.g., Sierra Andersen Models SA241 and SA241M; Sierra Andersen Model FH621-N Beta Monitor; Met One Models BAM1020, GBAM1020, BAM1020-1, and GBAM1020-1; Rupprecht and Patashnick TEOM Series 1400/1400a PM₁₀ monitor; and Rupprecht and Patashnick Partisol Model 2000 Air Sampler). User experience and results from several studies indicated that under some atmospheric conditions, this inlet can fail to reject precipitation, allowing moisture to pass through to subsequent components of the sampler.

A modified version of the originally proposed inlet, designed to correct this flaw, is currently specified as part of the recently promulgated FRM for PM_{2.5} (U.S. EPA 1997). This modification was carefully designed to greatly improve precipitation rejection while retaining its favorable PM_{2.5} aspiration characteristics as well as its first-stage large particle size separation function. Various proposed modifications of the inlet were tested for PM_{2.5} aspiration efficiency in the EPA Aerosol/Wind Tunnel Test Facility, and the selection of the final modification design was based on the results of these tests. The goals of the modified inlet design were to minimize rain intrusion, produce a simpler, low cost design, and if possible retain aspiration and entry characteristics suitable for both PM_{2.5} and PM₁₀ samplers.

This paper seeks to determine if this modified inlet can replace the original inlet in those EPA-designated PM₁₀ samplers that use the original inlet to take advantage of the improved design. To allow the modified PM₁₀ inlet to replace the original inlet, the modified inlet, with its integral particle size separator, must meet the performance requirements specified in EPA regulations (1998, Subpart D). This requires determining the particle size sampling effectiveness characteristics and 50% cutpoint at three specified wind speeds, as set forth in Subpart D. Sampling

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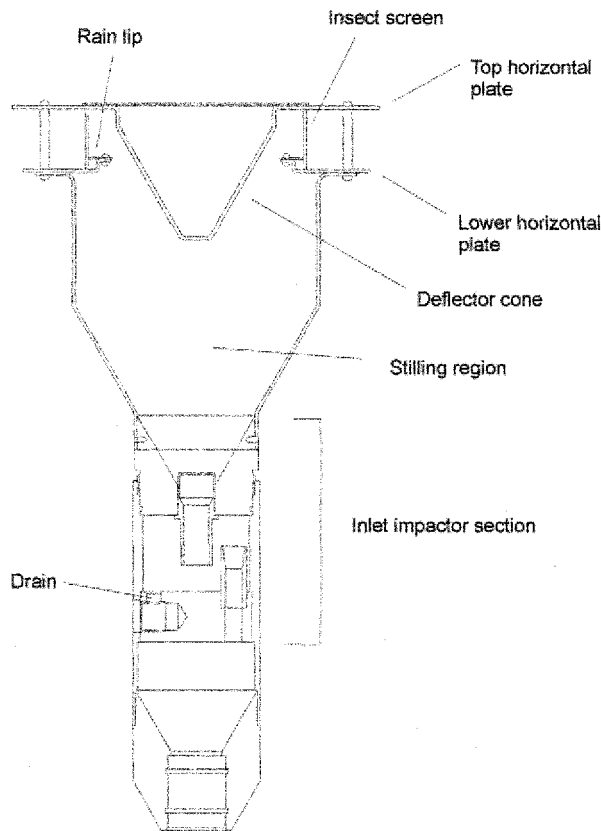


Figure 1. Popular flat-top inlet often used for PM_{10} sampling.

effectiveness data for the modified inlet was collected in the EPA Aerosol/Wind Tunnel Test Facility at Research Triangle Park, NC.

This paper presents results of the collection efficiency of the modified inlet for collecting PM_{10} , while minimizing the intrusion of water into the inlet. The modified inlet results are compared to the original inlet and to the IMPROVE inlet (Cahill et al. 1990), which is expected to have good rain rejection characteristics. Insight into critical inlet design parameters are also presented.

DESIGN APPROACHES

The major source of intrusion of water into the inlet occurs during precipitation events. These phenomena are observed to be sporadic in nature. On one occasion, the authors observed water intrusion into the sampling components downstream of the inlet section for only one out of six collocated samplers. A factor that influences the tendency for intrusion of rain droplets to occur appears to be large droplet heavy downpours with gusty winds. The nature of this type of problem makes it difficult to approach quantitatively. Therefore a qualitative engineering approach was taken to prevent water from entering the inlet and to remove it more efficiently if it enters.

The first approach to reduce precipitation intrusion involved simple alterations in the flat-top intake geometry to eliminate

direct pathways, similar to that used on the Sierra Andersen Model 1200. The final design shown in Figure 2 is the result of the many alterations and iterations (described below) of the inlet design. Included in this figure are the dimensions that were modified during testing. These were comprised of the top plate diameter, D , the louver taper angle, θ , and the length of the louver, L . A number of experimental configurations were tested, with and without the deflector cone present. In all cases, the original insect screen was present. Two features of this design are noteworthy in addition to the modification of the intake region itself. The first is that the deflector cone is now a part of the top plate, instead of being attached to the top plate, preventing water invasion into the cone itself. The second is that the drain hole has been expanded to improve drainage. The original drain hole did not function properly due to the surface tension of water creating a meniscus that impeded flow at the drain opening.

The second approach involved a more aggressive alteration in the size of the intake region of the inlet. The benefits of this approach include not only the prevention of intrusion of rain and snow into the sampler but also the elimination of the need for expensive spun components as well as reduction in the size of the inlet, thus improving its durability and transportability. As an initial test, the similar IMPROVE inlet (Cahill et al. 1990) was tested at a lower flow rate (16.7 l/min) than its intended design flow rate (23 l/min).

Figure 3 displays a schematic view of a second scaled down version of the original inlet. The diameter of this Reduced Volume Inlet (RVI) ($D = 7.5$ cm) was slightly larger than the inlet impactor external housing diameter and was reduced from the

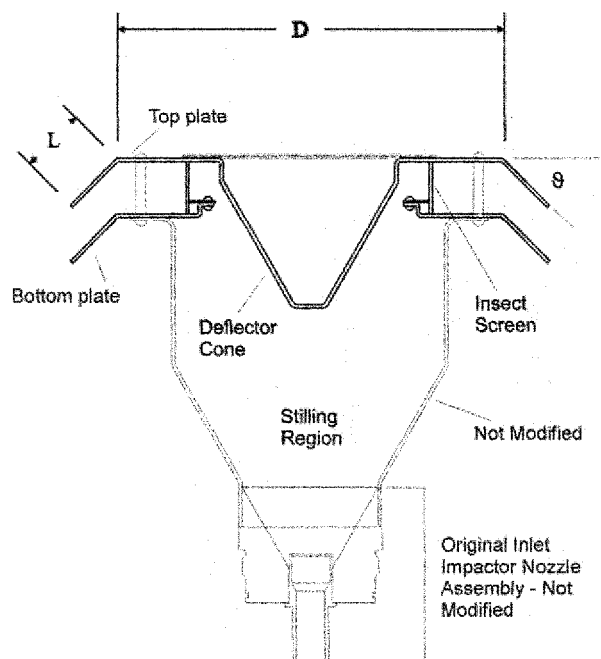


Figure 2. Modified inlet currently in use for the FRM for sampling $PM_{2.5}$. $D = 18.4$ cm, $L = 4$ cm, and $\theta = 45^\circ$.

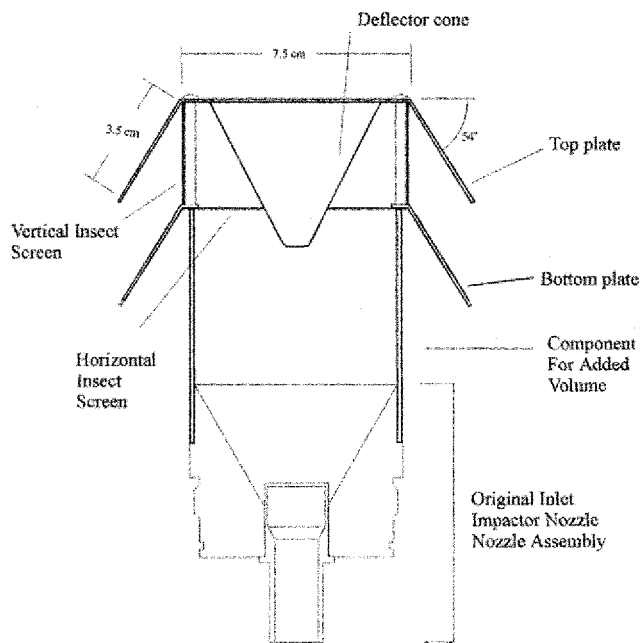


Figure 3. RVI schematic as described in the text.

original design diameter ($D = 21$ cm). A single taper angle of 54° on both the upper and lower horizontal plates was used for all tests of this inlet. Tests were conducted with an insect screen present in a horizontal and vertical configuration (Figure 3). Tests were also conducted without this insect screen present. Finally, additional tests were conducted with the deflector cone present and with an added volume component to serve as a stilling region.

In addition to the modification of the intake geometry, the impactor nozzle section was machined with dimensions to yield a smaller 50% cutpoint than the original unit. The purpose of this modification was to reduce loading of the $PM_{2.5}$ separator. The diameter of the original nozzle was reduced to a width of 0.63 cm, which gives a Reynolds number of 3700, a stream velocity of 8.80 m/s, and a theoretical 50% cutpoint of $5 \mu\text{m}$ (Marple and Willeke 1976a, 1976b, 1979).

EXPERIMENTAL APPROACHES

The EPA Aerosol Test Facility has been described previously (Ranade et al. 1990) and will only be briefly accounted here. The flow in the tunnel is counter-clockwise. There are few flow obstructions, and a number of access doors are provided to allow all sections of the wind tunnel to be cleaned. The test aerosol was generated on top of the wind tunnel. A distributor is used for tests taken at high wind speeds. The test section of the wind tunnel is 1.22 m high by 1.52 m wide. The blower fan is capable of moving air at 50 km/h through the test section.

Before testing, the wind speed in the tunnel was set to the desired value. The nominal wind speed was determined to be uniform across the test area if the coefficient of variation of the individually measured wind speeds was $<10\%$. The test area

is defined as a rectangular area having a horizontal dimension of not less than 1.2 times the width of the test inlet at its inlet opening and a vertical dimension not less than three times the height of the test inlet opening. The wind speed was measured using a hot-wire probe anemometer at fifteen traverse points throughout the test area.

A vibrating orifice aerosol generator (VOAG) (Berglund and Liu 1973) was used to generate monodisperse aerosol. The droplet diameter, D_d , generated is given by

$$D_d = \sqrt[3]{\frac{Q}{10\pi F}} \times 10^4, \quad [1]$$

where Q is the flow rate of the liquid and F is the frequency of vibration of the orifice. The volatile portion of the droplets evaporates, leaving nonvolatile liquid droplets. These liquid droplets consisted of oleic acid and uranine, which were dissolved in the vaporizable dry ethanol. The concentrations of the uranine and oleic acid were varied to obtain aerosols of various sizes according to

$$D_p = \sqrt[3]{\frac{C}{10^6}} \times D_d, \quad [2]$$

where D_p is the physical particle size and C is the concentration of both the uranine and oleic acid combined in parts per million. Since the density of the particle was known, the aerodynamic diameter was readily calculated. The typical operating parameters for the VOAG were a feed rate of 0.3 ml/min, a vibrating frequency of 70 kHz, and an orifice size of $20 \mu\text{m}$. Particle size was determined using a microscope slide impactor. The microscope slides were coated with an oleophobic coating, for which the flattening coefficient is known (Olan-Figeroa et al. 1983), and sized using a calibrated microscope. The challenge aerosols that were generated for the second test (described below) are summarized in Table 1. It should be noted that solid aerosol particles

Table 1

Particle sizes and wind speed for sampling effectiveness and 50% cutpoint tests

Particle size (μm) ^a	Wind speed	Wind speed	Wind speed
	(km/h)	(km/h)	(km/h)
	2	8	24
3 ± 0.5	liquid	liquid	liquid
5 ± 0.5	liquid	liquid	liquid
7 ± 0.5	liquid	liquid	liquid
9 ± 0.5	liquid	liquid	liquid
10 ± 0.5	liquid	liquid	liquid
11 ± 0.5	liquid	liquid	liquid
13 ± 1.0	liquid	liquid	liquid
15 ± 1.0	liquid	liquid	liquid
20 ± 1.0	liquid	liquid	liquid
25 ± 1.0	liquid/solid	liquid/solid	liquid/solid

^aMass median aerodynamic diameter.

were generated using the VOAG with a solution of fluorescein and sodium hydroxide (Vanderpool and Rubow 1988; Ranade et al. 1990).

The challenge aerosol was introduced into the top of the wind tunnel and neutralized using a Kr-85 source. The uniformity of the particulate matter was determined using an array of five samplers (rake) placed within the sampling zone (Woods et al. 1986). This test was done before each testing day. In order to sample the aerosol in an isokinetic manner at different wind speeds, the rake samplers were operated with different nozzle diameters and flow rates. The flow rate through each sampler was determined using calibrated dry gas test meters. Each nozzle contained a 47 mm diameter glass fiber filter where the aerosol was collected. Background checks of aerosol contamination were accomplished by running the rake without the generation of aerosol.

Challenge aerosol concentrations in the wind tunnel were determined using fluorometric analysis. After a suitable sampling period, the filters were collected. These filters were placed into clean polypropylene containers and extracted in an ultrasonic bath for 10 min in 20 ml of 0.01 N NaOH solution. It should be noted that the 20 ml of NaOH solution was first used to rinse the inside of the nozzle so that the total uranine content could be determined. Disposable pipettes were used to transfer 2 ml aliquots to cuvettes. The cuvettes were spun in a centrifuge for 10 min to eliminate glass fibers which might interfere with the fluorometric analysis (Tolocka et al. 2001). The fluorometric content of the extract was determined using a calibrated fluorometer. Again, a test procedure was considered valid if the spatial variation in aerosol concentration throughout the test section was <10% for that testing day.

PM₁₀ Inlet Testing

This set of tests was used to determine if the sampling effectiveness of the modified inlet could meet the specifications for a PM₁₀ inlet as described in Subpart D of Part 53 of the Code of Federal Regulations (1998). These tests were conducted using the challenge aerosols described in Table D-2 of Subpart D. The sampling effectiveness is defined as

$$E = \frac{m_{\text{sampler}}}{m_{\text{iso}}} \times 100\%, \quad [3]$$

where m_{sampler} and m_{iso} are the masses collected from each inlet sampler and isokinetic sampler (including the nozzle wash), respectively, for identical sampling periods.

The original and modified inlets were installed onto a cart and tested simultaneously in the test section of the wind tunnel. The flow controllers for the modified and reference inlets were calibrated and operated at 16.7 l/min. The positions of the two inlets were switched periodically to reduce the impact of bias due to spatial inhomogeneity in the wind tunnel test section.

A high-volume isokinetic sampler was also installed on the cart, positioned between the two test samplers. Because the isokinetic sampler meets the criteria for representative sampling

(Davies 1968; Belayaev and Levin 1970, 1974; Davies and Subari 1982), it provided the basis for determining the collection efficiency of the impactors. A high-volume pump and transformer on the cart were used to control the flow rate (0.019 m³/s) of the isokinetic sampler. The velocity of the isokinetic sample air was matched to the various wind velocities by changing the square orifice inlet of the sampler. After each individual test, the filters from all samplers were analyzed. Comparisons were performed in triplicate to ensure accuracy. Furthermore, comparisons of the concentrations obtained with the high volume isokinetic and the Rake samplers were also made. Typically they agreed to within 5%.

PM_{2.5} Particle Testing

The tests used to determine if the fine particle (PM_{2.5}) sampling characteristics were maintained in the modified inlet were conducted at a wind speed of 24 km/h with monodisperse 3.0 and 3.5 μm liquid challenge aerosols. Upon the successful completion of the fluorometric analysis of the filters, the penetration ratio (P) of the various modified inlets to the original inlet was calculated:

$$P = \frac{m_m}{m_r} \times 100\%, \quad [4]$$

where m_m and m_r are the masses collected by the modified and original inlets, respectively.

RESULTS AND DISCUSSION

PM_{2.5} results

Table 2 presents the results of wind tunnel testing of the original inlet and alternative inlets with various intake geometry modifications at a wind speed of 24 km/h with a monodisperse $d_p = 3.5$ μm challenge aerosol. Initially, two identical original reference design inlets with no modifications were shown to have a penetration ratio (P) = 100%, thereby indicating that testing the inlets simultaneously was a valid approach. Next, the aspiration ratio for an open tube was measured to be 64%, clearly demonstrating the need for some type of specialized inlet geometry to ensure adequate aspiration of fine particles at elevated wind speeds.

A configuration having an intake louver angle (θ) of 30° with $D = 0.215$ m and $L = 0.065$ m added to both the top and bottom horizontal plates had a measured penetration ratio of 100%. The penetration ratio was reduced to 95% with a 90° bend of the top plate only. While both of these configurations presented an intake geometry that would qualitatively improve inlet performance during rain and snow events, they seemed to be awkward, bulky, and over-designed solutions to the problem. The configuration with an intake taper angle of 45° was tested with the following combination of configurations:

1. with and without the bottom plate,
2. with and without the deflector cone in place.

Table 2

Aspiration ratios determined for the original inlet with modifications to the intake geometry at 24 km/h with a 3.5 μm liquid challenge aerosol

Intake geometry description	Deflector cone present	D (cm) ²	L (cm) ²	Aspiration ratio (%)
Original inlet	Y	21	0	100
Open tube	N	NA ¹	NA	64
30° taper on top and bottom plates	Y	21.5	6.5	100
90° bend on top plate	Y	28	14.5	95
45° taper on top plate	N	18.5	4	82
45° taper on top plate	Y	18.5	4	89
45° taper on top and bottom plates	N	18.5	4	83
45° taper on top and bottom plates	Y	18.5	4	103

¹Not applicable.

²See Figure 2.

Without the deflector cone present, $P = 82\%$ with the top plate only and $P = 83\%$ with both plates in place. The addition of the deflector cone served to increase the penetration ratio to 89% with the top plate only and 103% with both the top and bottom tapered elements.

A tuft wand (a 0.6 cm diameter, 2 m wooden dowel with an 8 cm piece of yarn attached to one end) was used for flow visualization of both the reference and modified inlets and provided some qualitative insight into the airflow dynamics of the test configurations. First, the insect screen seems to do little to alter the airflow. Conversely, the deflector cone presents a major alteration in the flow patterns observed in the intake region. Without the deflector cone, the air passes rapidly through the top of the inlet and out the other side with little change in velocity. This may explain why aspiration ratios for this configuration are low and are starting to approach the values of the open tube. When inserted, the deflector cone presents a bluff body to the incoming air on the windward side of the inlet causing the flow to deflect into the stilling region. This presents a second route of entry for the aerosol. Furthermore, a wake zone is created at the leeward side of the deflector cone. Finally, the presence of two tapered parallel plates facing the wind provides a scooping action that encourages the air to smoothly transition into the windward side of the inlet. From these observations and the quantitative measurements above, the critical elements of this intake geometry at this elevated wind speed seem to be the presence of the deflector

Table 3

Results of testing the modified inlet as specified in Subpart F, the wind tunnel aspiration test

Run number	Measured concentration original inlet (ng/m ³)	Measured concentration modified inlet (ng/m ³)	Aspiration ratio, ¹ %
1	15.1	14.6	98.6
2	14.5	14.8	101.5
3	14.6	14.5	98.4
4	14.8		

¹As defined in the Federal Register as $A = m_c / ((m_{ref}(i) + m_{ref}(i + 1))/2)$, where m_c is the mass collected by the candidate sampler and m_{ref} is the mass collected by the reference method for the i th and $i + 1$ iteration.

cone to aid the particles into the stilling region and the scooping action promoted by two parallel plates facing the wind.

The RVI was tested in a variety of configurations in an empirical attempt to understand the phenomena of fine particle aspiration (3 and 3.5 μm). With the redesigned 5 μm inlet impactor section, the penetration ratio was 80% with the insect screen oriented horizontally and 86% without the screen present. The inlet impactor nozzle section was returned to its original geometry for the balance of the tests. The measured penetration ratio with no screen present was 101%, demonstrating that a smaller inlet could indeed have sampling characteristics similar to those of a larger inlet.

Returning the insect screen to the unit caused the penetration ratio to drop to 67% with the screen in the vertical position and 82% in the horizontal position. It is thought that a complex combination of local air streamlines and aerosol trajectories plays a critical role in the deposition of fine particulate matter onto the screen. This demonstrates that an insect screen, if desired, must be an integral part of the inlet design. Adding a deflector cone with the screen in the vertical position increased the penetration ratio to 84%. Inclusion of an added volume component to the stilling region had little effect ($P = 85\%$).

Based upon the fine particle, high wind speed tests performed, a recommended design approach was to use minor modifications of the original inlet intake geometry, with the 45° louver on both the upper and lower plates. This configuration was then tested exactly as specified in Subpart F, Section 53.63 of Part 53 of the Code of Federal Regulations (1998). The results are summarized in Table 3. The aspiration ratios measured are well within the acceptance criteria. Qualitative testing and field data confirmed that this design also greatly improved the rejection of precipitation into the inlet.

PM₁₀ Results

The results of testing the modified inlet for sampling effectiveness for PM₁₀ sampling are shown in Figures 4–6. The curves

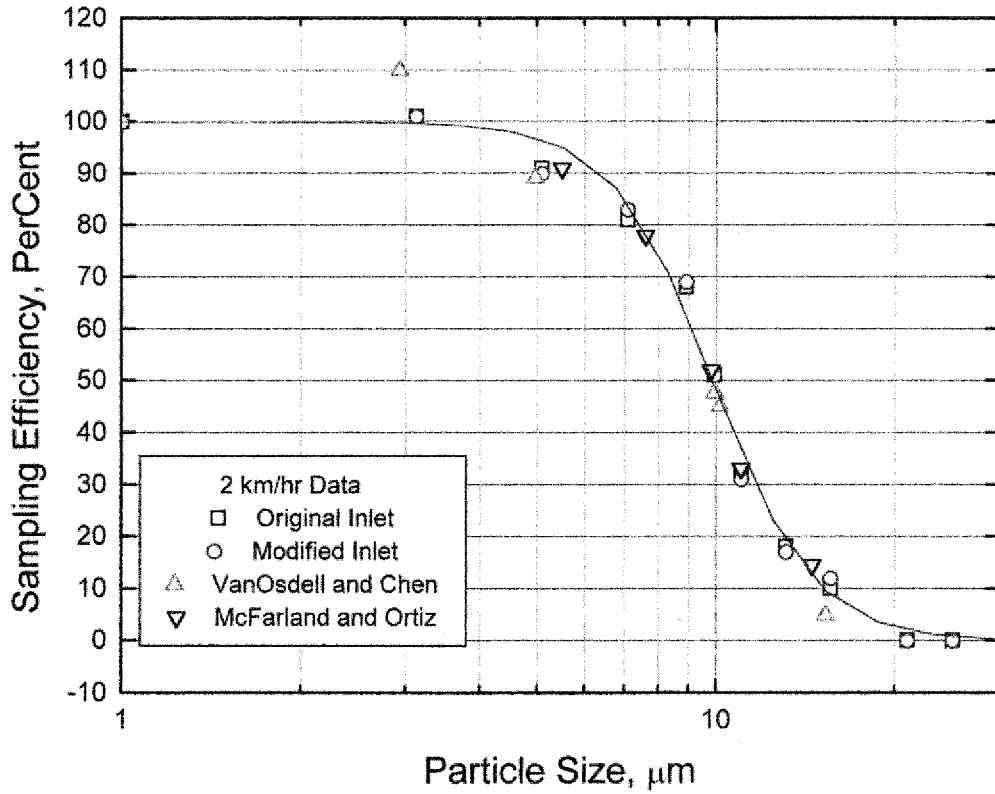


Figure 4. Test results for the modified and original inlet at 2 km/h. Solid line indicates a logistical fit to all of the data sets.

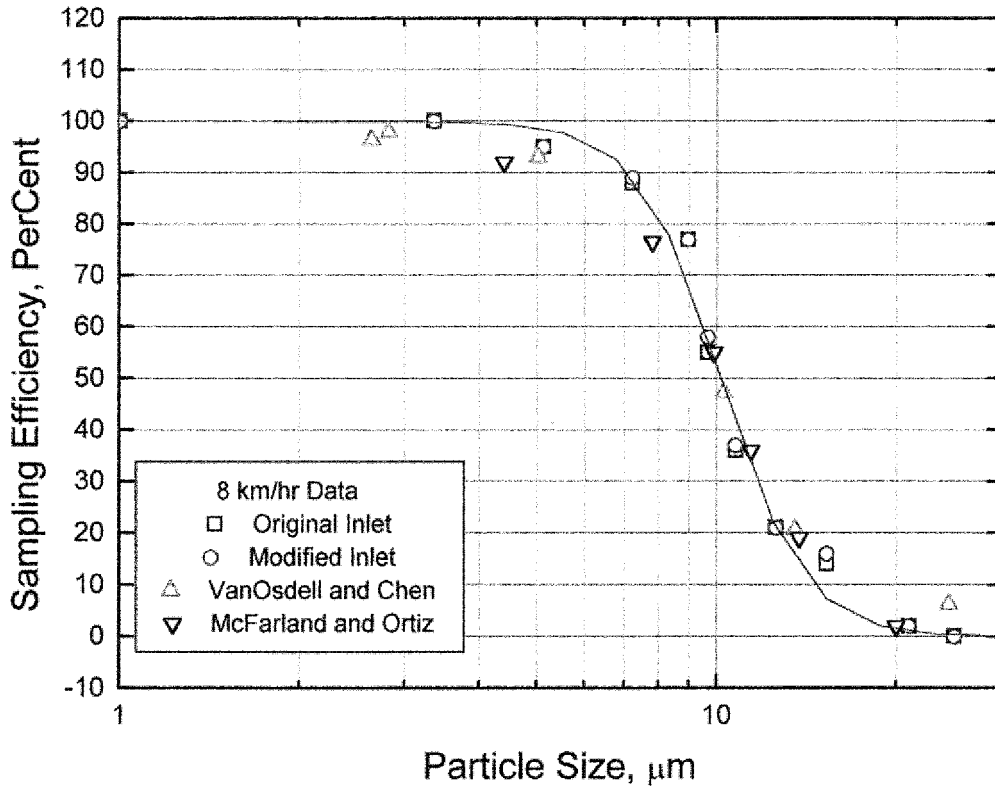


Figure 5. Test results for the modified and original inlet at 8 km/h. Solid line indicates a logistical fit to all of the data sets.

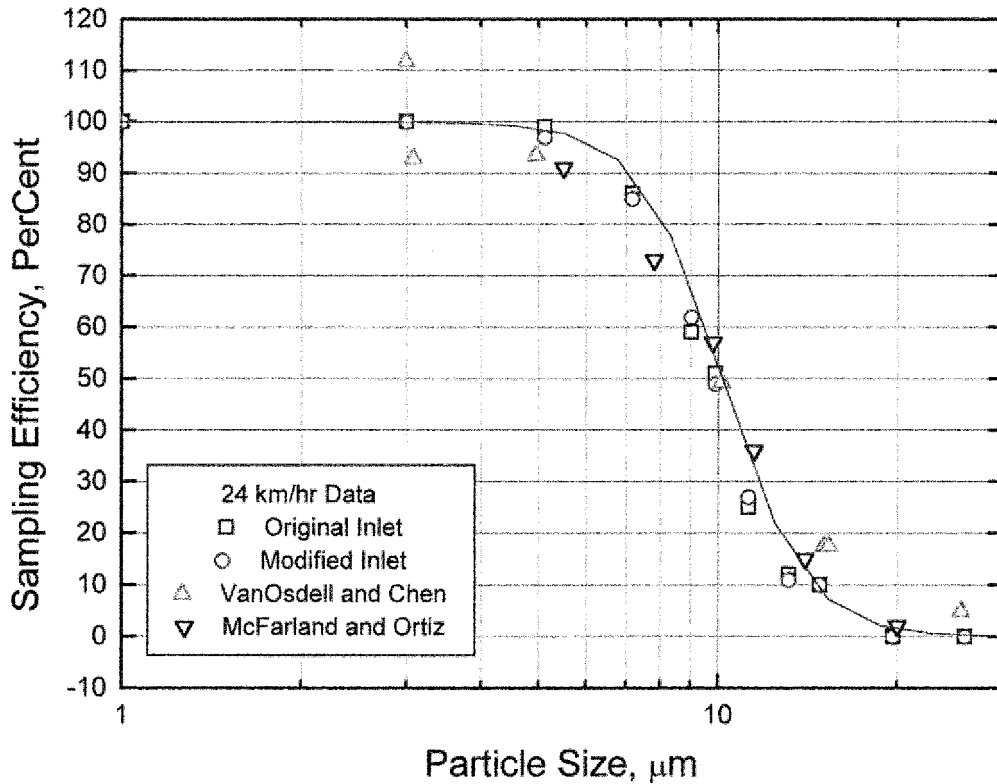


Figure 6. Test results for the modified and original inlet at 24 km/h. Solid line indicates a logistical fit to all of the data sets.

that describe the data in these figures have been fit using a sigmoidal function of the form

$$y = \frac{A - B}{1 + \left(\frac{x}{x_0}\right)^p} + B \quad [7]$$

in logarithmic space using a least squares procedure. *A* and *B* are the initial and final values of the function and were held fixed at 100% and 0% for 1 and 50 μm particles, respectively. The 50% cutpoint, *x*₀, and the exponential, *p*, were allowed to vary to fit the efficiency values (*y*). It should be noted that the data have not been corrected for multiplets (Ranade et al. 1990; VanOsdell and Chen 1990). Data obtained for the original inlet are also shown in these figures for comparison.

The data at each wind speed are also directly compared to data taken by VanOsdell and Chen (1990), as well as measurements made by McFarland and Ortiz (1984) on the identical original inlet. As can be seen, neither the oversampling for the 3 μm particles at 2 km/h observed by VanOsdell and Chen (1990) nor the oversampling at 24 km/h found by Wedding et al. (1985) is evident in the data presented here. The calculated 50% cutpoints at each wind speed of the modified inlet are in excellent agreement with the previous data. Furthermore, the cutpoints for the modified inlet appear to be identical to the cutpoints obtained for the original inlet in this study.

Table 4
Performance of the original and modified inlets

Inlet tested	Wind speed (km/h)	50% cutpoint (μm)	Predicted mass collection ratio, ¹ %
Original inlet (this study)	2	9.9	102.9
	8	10.1	104.3
	24	9.7	100.8
Modified inlet (this study)	2	9.9	102.9
	8	10.3	104.9
	24	9.7	100.9
Original inlet (VanOsdell and Chen)	2	9.8	99.7
	8	10.1	100.6
	24	10.0	105.9
Original inlet (McFarland and Ortiz)	2	9.9	99.2
	8	10.2	102.7
	24	10.0	100.9
Original inlet (Ranade et al.)	2	10.7	110.2
	8	10.5	112.0
	24	NA ²	NA

¹This ratio is the expected mass collected by the test sampler (from integrating the effectiveness curve against a specified aerosol size distribution) compared to the expected mass predicted for an “ideal” sampler using the aerosol size distribution in 40 CFR Part 53.

²Not available.

Table 5
25 μm solid particle test results

	Sampling effectiveness, %, at each wind speed (km/h)		
	2	8	24
Original inlet	0.09	0.2	1.8
Modified inlet	0.10	0.2	1.7

The performance curves for each sampler given by the equation above can predict the amount of mass that would be collected by each sampler, compared to an ideal inlet (Woods et al. 1986) as described in Subpart D of 40 Code of Federal Regulations (1998). Table 4 summarizes the results of this analysis for the modified inlet, and again this inlet shows nearly identical performance to that of the original inlet. Last, Table 5 shows the results of the solid particle tests. Particle bounce, breakup, or deagglomeration for either inlet does not appear to be problematic (John et al. 1991) as less than 2% of the 25 μm solid particles are observed to penetrate the inlet, even at 24 km/h. These results suggest that the modified inlet could be substituted for the original inlet where it is part of a designated reference or equivalent method sampler for PM_{10} .

CONCLUSIONS

The inlet originally proposed in the FRM for $\text{PM}_{2.5}$ was modified to reduce water intrusion during rain and snow events. The approach taken was to make simple alterations in the intake region of the original inlet that includes a larger drain hole, a onepiece top plate, and louvers. Wind tunnel tests were performed at 24 km/h for fine particle aspiration and at 2, 8, and 24 km/h for coarser particle sampling characteristics of the modified design. These tests were done to ensure that the aspiration of fine particulate matter would not be compromised by the design modifications.

The selected configuration used currently for the FRM for $\text{PM}_{2.5}$ was developed as a modification to the intake geometry of the original inlet so that the top and bottom horizontal plates are angled at 45°. The laboratory evaluations of this inlet for fine ($\text{PM}_{2.5}$) and coarse (PM_{10}) particle sampling demonstrated that the aspiration of this inlet was identical to the original inlet. Qualitatively, this inlet should reduce, if not totally prevent, the intrusion of rain and snow. Further, sampling effectiveness test results suggest that the modified inlet could be substituted for the original inlet where the original inlet is part of a designated reference or equivalent method sampler for PM_{10} .

Two additional observations can be made upon conclusion of the tests presented here. The first is that the proper operation of an inlet at elevated wind speeds must be confirmed to ensure accurate aerosol collection. The second is that even minor modifications to this inlet can cause reductions in particle aspiration. For the modification to the intake region of the original inlet,

the factors that appear critical to the preservation of the original performance characteristics are as follows:

1. The presence of a deflector cone which provides a bluff body before the air is introduced into the stilling region of the inlet, and
2. the presence of a louver on both the top and bottom plates to encourage the incoming air to be scooped smoothly into the interior region of the inlet.

The testing of the RVI demonstrated the feasibility of a smaller inlet; however, more work is needed to identify the exact geometry that would allow it to be used as an equivalent inlet for PM_{10} or $\text{PM}_{2.5}$ sampling.

DISCLAIMER

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication. Mention of trade names or commercial products does not constitute endorsement or recommendation by the Agency.

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