HEATED INLET SAMPLE CONDITIONING EFFECTS ON REMOTE DUST MONITORING

APPLICATION NOTE EXPMN-008 (US)

Introduction

Under high ambient humidity conditions, photometric mass measurements have been reported to over-estimate mass concentration readings when compared to a reference method. This is largely attributed to water-uptake, resulting in hygroscopic growth of the aerosol particles. When the aerosol particles increase in size they scatter more light, resulting in higher mass concentration readings by the photometric instrument *(McMurry and Stolzenburg, 1989; Thomas and Gebhart, 1994; Brauer, 1995; Day et al., 2000).*

Certain types of inlet conditioners may substantially improve the correlation between particulate mass concentration derived from real-time particle sizers and filter-based samplers in humid conditions *(Peters, TM, et al, 2008).*

TSI Engineers have developed a Heated Inlet Sample Conditioner for use with the TSI DustTrak™ II and DustTrak DRX Aerosol Monitors to reduce the effect of humidity on photometric mass measurements. This application note summarizes findings from initial field tests demonstrating the effect on DustTrak Aerosol Monitor readings with heated inlet sample conditioning in high-humidity outdoor environments.

Outdoor Urban Pollution Test

Outdoor testing of urban pollution in a warm, high humidity environment was conducted in Singapore using two identical DustTrak DRX Aerosol Monitors (Model 8533) with Autozero Modules inside TSI Environmental Enclosures (Model 8535). See Figure 1 for example of sampling location. One DustTrak monitor was configured with a Heated Inlet Sample Conditioner set to condition incoming sample air to 30% Rh. The other DustTrak Monitor had no sample conditioning. Both instruments were programmed to run side-by-side for identical sample periods. Temperature during the test averaged 28.7°C (range 27.0 to 30.8°C). Relative humidity averaged 79.7%Rh (range 72.9 to 81.4% Rh). The results demonstrate heated inlet sample conditioned photometric readings are lower than non-conditioned photometric readings (see figure 2). The average change between the heated inlet conditioned measurements and the non-conditioned sample measurements was 29.9%.

Figure 1.
Co-located DustTrak Monitors inside Environmental Enclosures (Model 8535) in Singapore

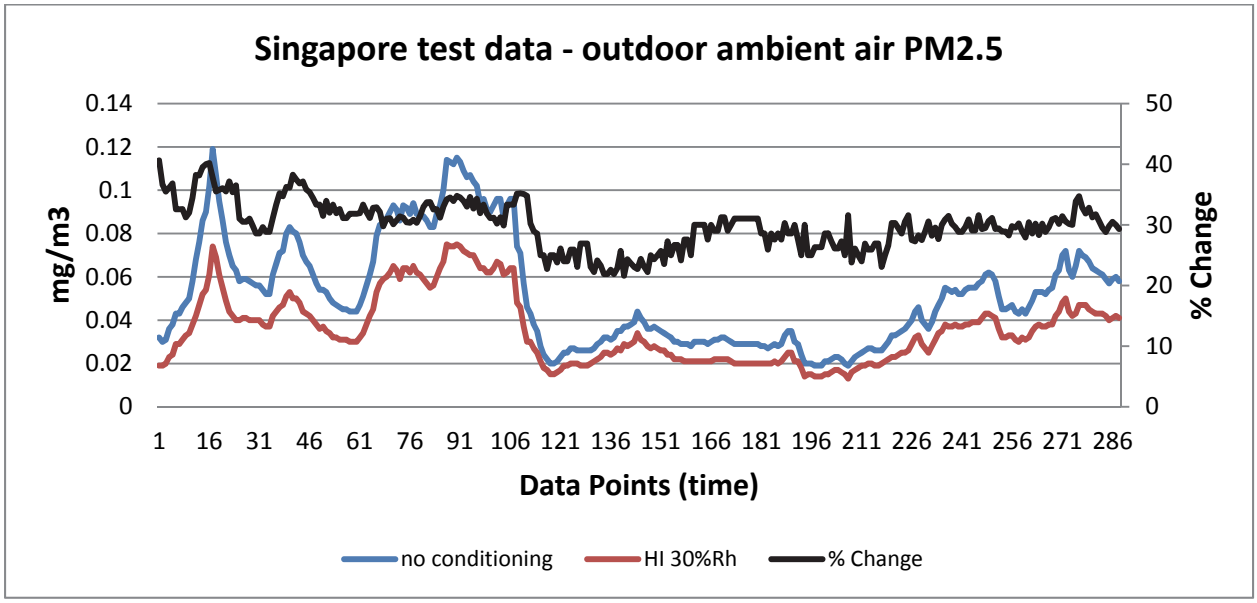

Figure 2. 24-hr test results from PM2.5 sample in outdoor humid environment.
PM2.5 no sample conditioning: Min 0.019mg/m^3, Max 0.119 mg/m^3, Avg 0.052 mg/m^3
PM2.5 with 30%Rh sample conditioning: Min 0.013mg/m^3, Max 0.075 mg/m^3, Avg 0.036 mg/m^3
Average % change between conditioned and non-conditioned: 29.99%

Additional tests were conducted to observe changes in DustTrak Monitor readings with the Heated Inlet Sample Conditioner active and inactive. The intent was to see the difference in measurements between two instruments when one instrument had the Heated Inlet in place and not active, versus in place and active. These tests were run with side-by-side DustTrak DRX Aerosol Monitors with Autozero Modules inside Environmental Enclosures (Model 8535) in high humidity outdoor environments in Singapore. The co-located instruments started logging data with no Heated Inlets in place. After a period of time, the Heated Inlet was added to one of the DustTrak Monitors, but not turned on. Again, after a period of time, the Heated Inlet was turned on. The test continued for equal periods of time with the Heated Inlet turned off then another period of time with the Heated Inlet removed from the flow path. Figure 3 contains data logged during a 10-hr test with the Heated Inlet adjusted every two hours as follows:

Data points 1-24: Heated Inlet not attached to the instrument.
Data points 25-48: Heated Inlet in place, but not turned on.
Data points 49-72: Heated Inlet turned on and active.
Data points 73-96: Heated Inlet turned off, but remained in place atop instrument.
Data points 97-120: Heated Inlet removed from the sample flow path.

The spike at data point 37 occurred when the Heated Inlet was turned on by mistake then turned off after a few minutes. Figure 4 contains data logged during a 5-hr test following the same methodology.

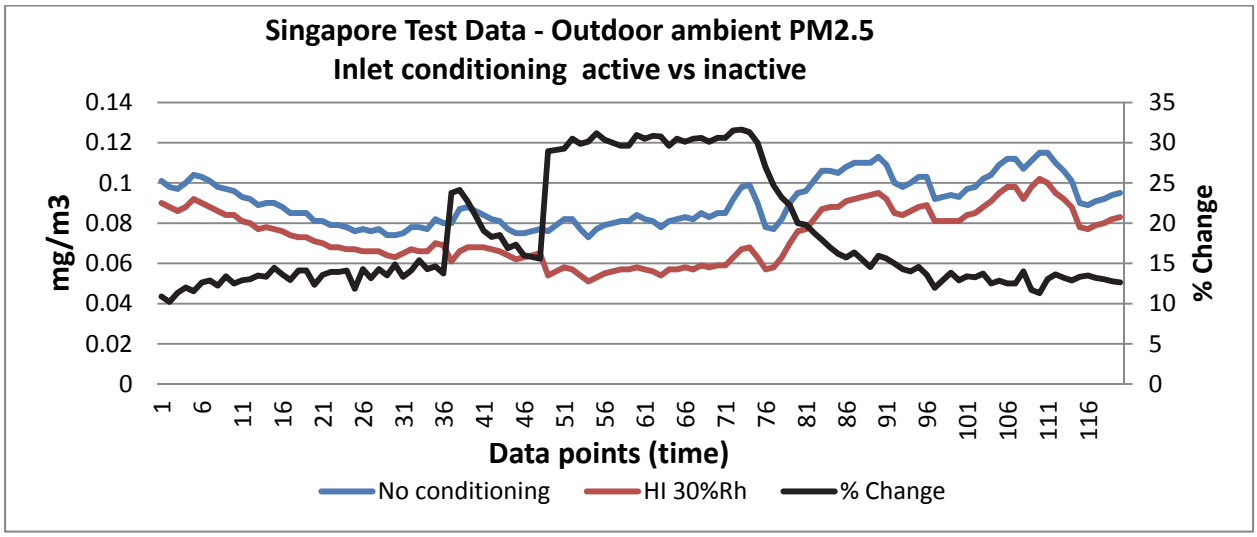

Figure 3. Results from 10-hour test with Heated Inlet in place, removed, active, and inactive
PM2.5 no sample conditioning: Min 0.073mg/m³, Max 0.116 mg/m³, Avg 0.091mg/m³.
PM2.5 with sample conditioning: Min 0.052mg/m³, Max 0.103mg/m³, Avg 0.075mg/m³
Average % change between conditioned and non-conditioned: 30.0% when Heated Inlet is active

Data points 1-24	Heated Inlet not installed	average % change 12.31%
Data points 24-48	Heated Inlet installed, but not active	average % change 16.51%
Data points 49-72	Heated Inlet active	average % change 30.00%
Data points 73-96	Heated Inlet turned off	average % change 19.11%
Data points 97-120	Heated Inlet removed	average % change 12.52%

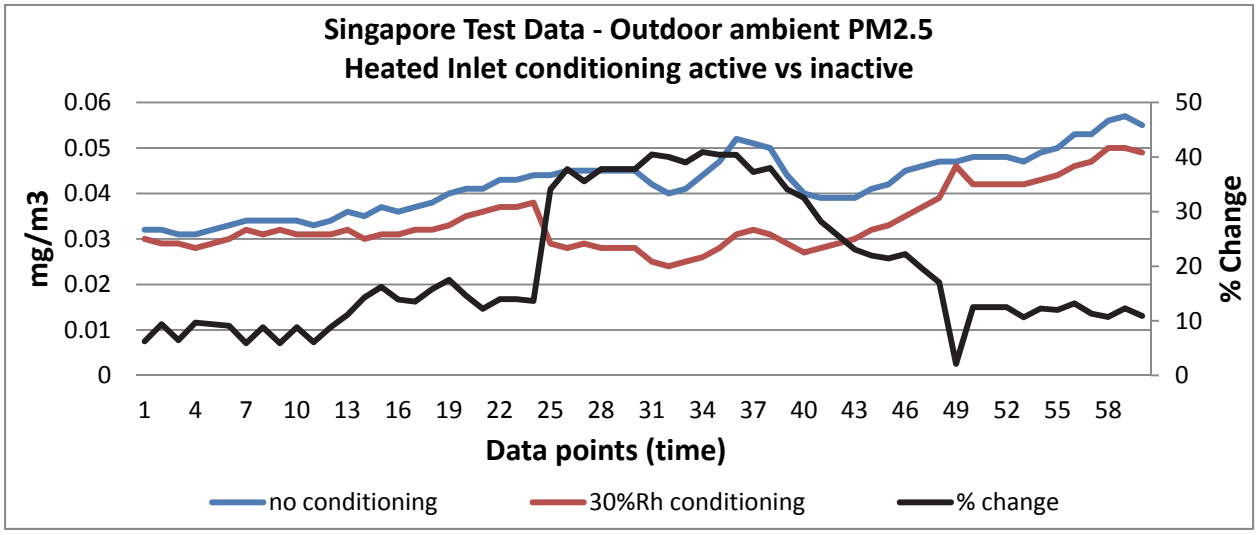

Figure 4. Result from 5-hour test with Heated Inlet in place, removed, active, and inactive.
PM2.5 no sample conditioning: Min 0.031mg/m³, Max 0.057mg/m³, Avg 0.042mg/m³
PM2.5 with sample conditioning: Min 0.024mg/m³, Max 0.05mg/m³, Avg 0.034mg/m.
Average % change between conditioned and non-conditioned: 38.5% when Heated Inlet is active

Data points 1-12	Heated Inlet not installed	average % change 7.88%
Data points 13-24	Heated Inlet installed but not active	average % change 14.22%
Data points 25-36	Heated Inlet active	average % change 38.50%
Data points 37-48	Heated Inlet turned off	average % change 26.75%
Data points 49-60	Heated Inlet removed	average % change 11.08%

A TSI Channel Partner conducted a separate test of outdoor ambient pollution in the warm, humid environment along the coast of Australia. Two identical TSI DustTrak II (Model 8030) Aerosol Monitors were co-located inside Environmental Enclosures (Model 8535). One DustTrak Monitor had the Heated Inlet Sample Conditioner installed and set to condition the sample to 30% Rh. Figure 5 shows the results of the test conducted in Australia.

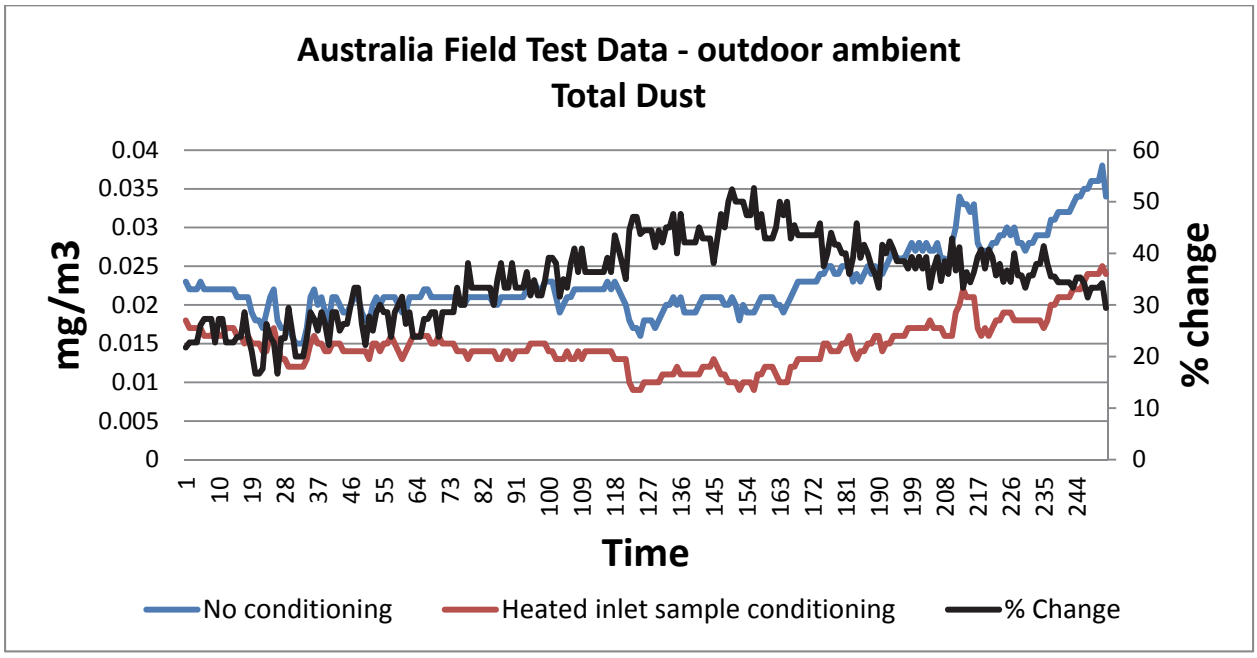

Figure 5. Results from Australia outdoor ambient air testing in marine environment
Average % change between conditioned and non-conditioned: 35%.

Results

These test results indicate the Heated Inlet Sample Conditioner reduces photometric mass measurement compared to an identical photometric instrument without Heated Inlet during side-by-side sampling in outdoor humid environments. A difference of 30% to 35% was observed between data collected with the Heated Inlet active versus inactive with side-by-side identical instruments.

These results have not been validated against federal reference methods and are not expected to be indicative of all aerosols. Different aerosols will be affected by humidity in different ways based on the hygroscopic properties of the aerosol.

Users of the Heated Inlet Sample Conditioner should perform similar side-by-side testing to evaluate the effect on specific aerosols in their sampling locations.

References

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USA	**Tel:** +1 800 874 2811	**India**	**Tel:** +91 80 67877200
UK	**Tel:** +44 149 4 459200	**China**	**Tel:** +86 10 8219 7688
France	**Tel:** +33 4 91 11 87 64	**Singapore**	**Tel:** +65 6595 6388
Germany	**Tel:** +49 241 523030		

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