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RESPONSE OF THE DUSTTRAK™ DRX TO AEROSOLS OF DIFFERENT MATERIALS

X. L. WANG[a,b], A. Hase[a], G. Olson[a], A. Sreenath[a], J. Agarwal[a]

[a]TSI Incorporated, Shoreview, MN 55126
[b]Desert Research Institute, Reno, NV 89512

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Abstract

The DustTrak DRX (Model 8533/8534) is a real-time monitor for size segregated aerosol mass concentrations. It combines photometry with single particle sizing to measure PM_1, $PM_{2.5}$, PM_4 and PM_{10}. Since this instrument works on the principle of light scattering, its response depends on aerosol properties, such as particle shape, refractive index, size distribution and density. In this poster, we report results from four sets of experiments:

1. DRX photometric response to non-light-absorbing materials;
2. DRX vs. optical particle counter (OPC) for monodispersed oil particles;
3. DRX vs. tapered element oscillating microbalance (TEOM) for lab generated aerosols;
4. DRX for ambient and engine exhaust measurements.

Instrument Principle

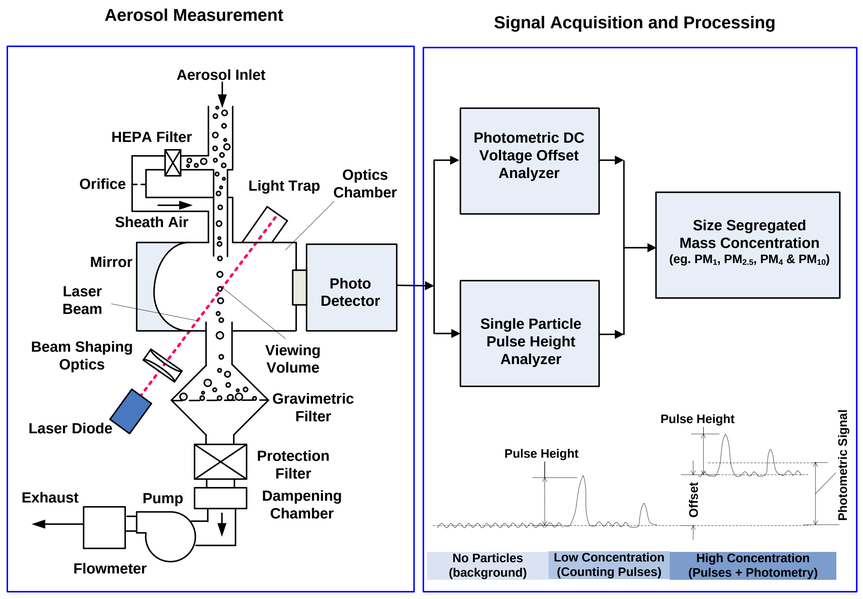

Figure 1. The DRX combines photometric signal (light scattering from all particles) and pulse height (light scattering from individual particles) measurements in one optical device. This information is combined to determine size segregated mass concentrations (patent pending).

Test 1: DRX Photometric Response to Non-light-absorbing Materials

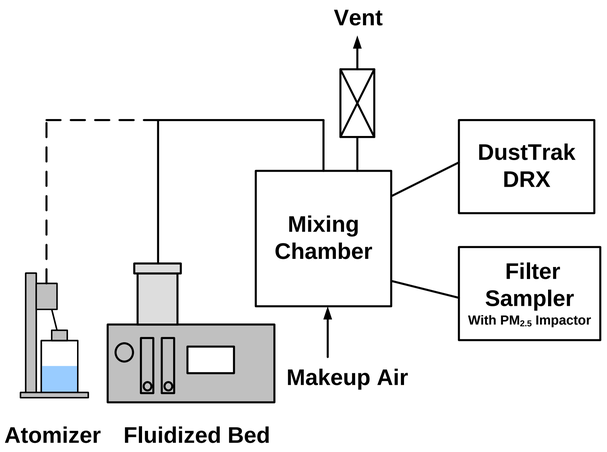

Figure 2. Non-light absorbing aerosols were generated either by an atomizer [$(NH_4)_2SO_4$, NaCl and Emery Oil] or a fluidized bed [Arizona Road Dust or ARD]. A gravimetric filter sampler with a PM2.5 impactor and a DRX without an impactor simultaneously sampled the aerosol from a mixing chamber.

Table 1. Comparison of $PM_{2.5}$ concentrations by gravimetric and DRX. The top row shows the PM2.5 concentrations ratios for various materials. These values are comparable to the density ratio, defined as the density of test material divided by 2.65 g/cm^3 (density of ARD). This agreement indicates when the test aerosol is not light absorbing, its concentration can be estimated by multiplying the DRX $PM_{2.5}$ reading (calibrated by ARD) by the density ratio.

	ARD	$(NH_4)_2SO_4$	NaCl	Emery Oil
Gravimetric/DRX	0.99±0.17	0.61±0.04	0.74±0.10	0.32
ρ_p / ρ_{ARD}	1.00	0.67	0.82	0.33
ρ_p (g/cm^3)	2.65	1.77	2.17	0.87
Refractive Index	1.54	1.534	1.544	1.4645

Test 2: DRX vs. OPC

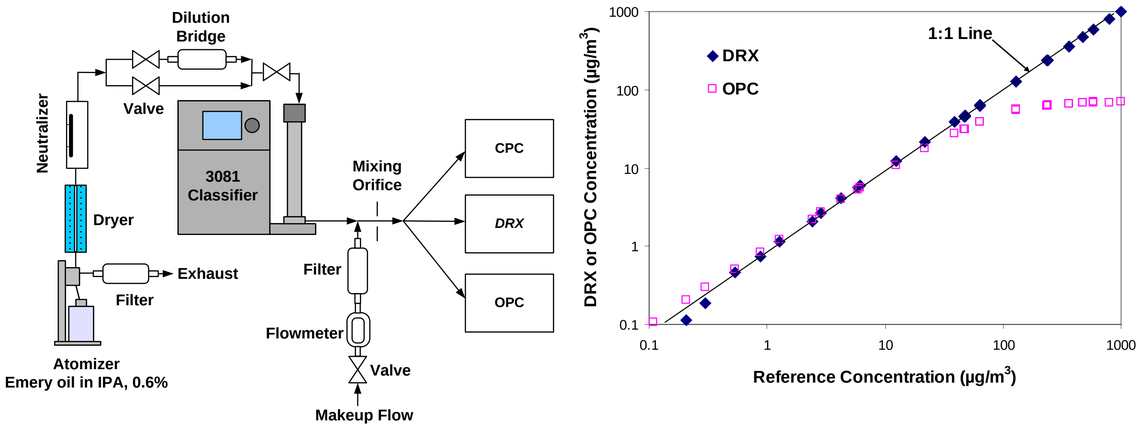

Figure 3. Comparison of 0.5 µm oil particle concentrations measured by a CPC, DRX and OPC. The CPC reading was used as the concentration reference. While the OPC is very accurate at lower concentrations (<10 µg/m^3), it underestimates concentrations at higher concentrations due to coincidence losses. The DRX does not have coincidence error (photometric) and is more accurate than the OPC at higher concentrations.

Test 3: DRX vs. TEOM for A1 Dust and Petroleum Coke

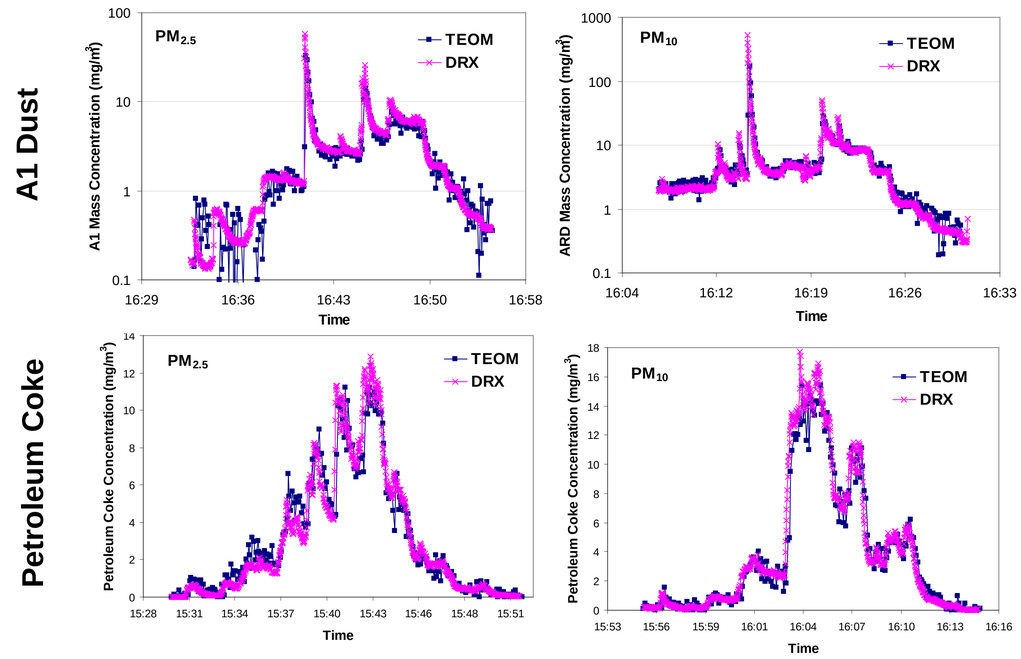

Figure 4. DustTrak DRX and TEOM 1400a comparison for A1 dust and petroleum coke. Test dusts were aerosolized using a fluidized bed and sampled by both instruments. $PM_{2.5}$ or PM_{10} impactors were placed at the inlet of the TEOM during each test. No impactor was used on the DRX. The DRX was calibrated with A1 Dust or petroleum coke, respectively. Note that the DRX has very good agreement with the TEOM for the two very different aerosols in wide concentration ranges.

Test 4: DRX for Ambient and Engine Exhaust Aerosols

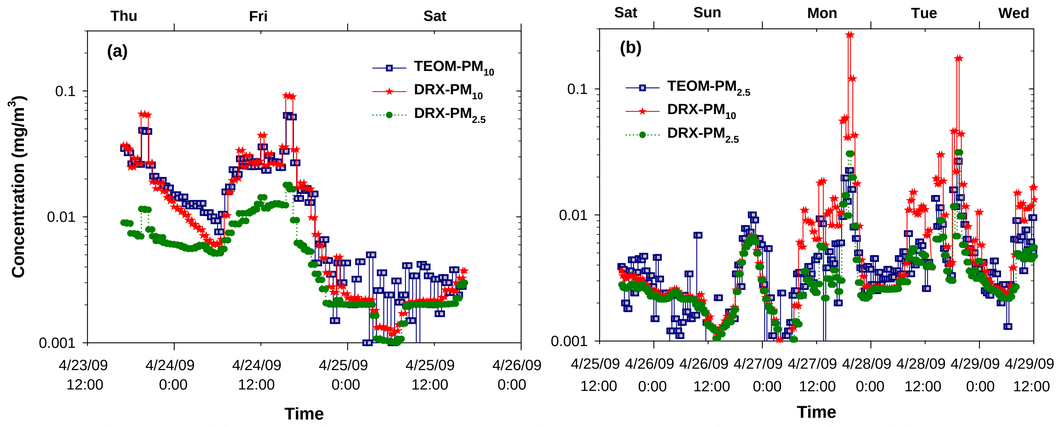

Figure 5. Ambient aerosol concentration measured by DRX and TEOM from a receiving dock in TSI. A PM10 (a) or PM2.5 (b) impactor was installed at the inlet of the TEOM. The DRX did not have a impactor. On weekdays, aerosol concentration started to increase ~8:00 when the first delivery truck arrived. The concentration remained high during the day due to receiving activities. It reached a peak around 19:00 when a janitor swept and vacuumed the floor. The concentration remained low during nights and weekends.

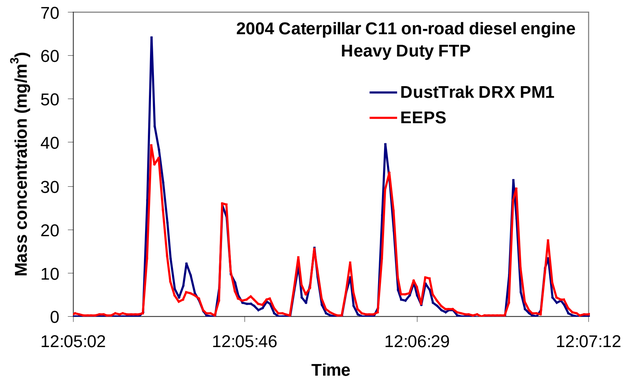

Figure 6. Comparison of the DRX and TSI Engine Exhaust Particle Sizer (EEPS) for diesel engine exhaust as a portion of the Heavy Duty Transient Federal Test Protocol cycle. The two instruments showed good agreement.

Conclusions

- The DRX photometric mass concentration is approximately proportional to particle density when particles are not light-absorbing.
- The DRX is more accurate than an OPC when measuring high concentrations.
- Once calibrated with the aerosol being measured, the DRX agrees with the TEOM within ±15% over a wide concentration range. While the TEOM only gives one mass fraction, the DRX simultaneously reports 5 mass fractions.
- Good agreement between the DRX and TEOM was found for aerosol measured in a receiving dock over a period of a week.
- Good agreement between the DRX and EEPS was found for diesel engine exhaust measurement during a transient cycle.

Reference

X.L. Wang, G. Chancellor, J. Evenstad, J.E. Farnsworth, A. Hase, G.M. Olson, A. Sreenath, and J.K. Agarwal (2009) *A novel instrument for estimating size segregated aerosol mass concentration in real time.* Aerosol Science and Technology, 43:939-950.