

Example # 2 Size Distribution of Particles Sampled with Cascade Impactor

Given

24 hr 6 stage Cascade impactor particle data measured in atmospheric air near an industrial plant. Cascade Impactor samples at air flow of 1.0 cfm for 24 hr. Air Volume sampled = 1440 cubic ft air
 % Particle Weight Increment = (100)(wt particles collected downstream of jet stage)/(total particle wt)
 Cumulative % Particle Wt less than 30 microns = 100 - Jet Stage 1 % Weight Increment

EPA Particle Size Distribution Module <http://www.epa.gov/eogapt1/module3/distribu/distribu.htm>

Cascade Impactor Jet Stage	Impactor Aero Cut Diameter (da ₅₀ , microns)	Wt Particles Collected (mg)	(g)	% Weight Increment	Cumulative % Particle Wt Less than da ₅₀
1	30	1.0	.0010	6.667	93.333
2	23	2.0	.0020	13.333	80.000
3	13	4.0	.0040	26.667	53.333
4	8	4.5	.0045	30.000	23.333
5	4	2.0	.0020	13.333	10.000
6	1	1.0	.0010	6.667	3.333
Filter		0.5	.0005		
	Total Wt of Particles	15.0 mg	.015 gm		

a.) Total particle mass concentration provided by cascade impactor sampler

$$\text{VolAirSampled} := (1 \cdot \text{ft}^3 \cdot \text{min}^{-1}) \cdot (24 \cdot \text{hr})$$

$$\text{VolAirSampled} = 40.776 \text{ m}^3$$

$$i := 0..6$$

$$\mu\text{m} := 10^{-6} \cdot \text{m}$$

$$\mu\text{g} := 10^{-6} \cdot \text{gm}$$

$$\text{MassConc} := \frac{15.0 \cdot \text{mg}}{1440 \cdot \text{ft}^3}$$

$$\text{MassConc} = 367.861 \frac{\mu\text{g}}{\text{m}^3}$$

$$\text{da}_{50} := \begin{pmatrix} 30 \\ 23 \\ 13 \\ 8 \\ 4 \\ 1 \\ .01 \end{pmatrix}$$

$$\text{Wt} := \begin{pmatrix} 1 \\ 2 \\ 4 \\ 4.5 \\ 2 \\ 1 \\ .5 \end{pmatrix} \cdot \text{mg}$$

b) Calculate the % particle mass less than cascade impactor cut diameter da₅₀ for each cascade impactor jet stage and put calculated results in the table above.

$$\text{Wt}\%_i := \frac{100 \cdot \text{Wt}_i}{15 \cdot \text{mg}}$$

$$\text{Wt}\% = \begin{pmatrix} 6.667 \\ 13.333 \\ 26.667 \\ 30 \\ 13.333 \\ 6.667 \\ 3.333 \end{pmatrix}$$

$$\text{Cum} := \begin{pmatrix} 93.33 \\ 80 \\ 53.333 \\ 23.333 \\ 10 \\ 3.333 \end{pmatrix}$$

$$\text{Cum1} := 100 - \text{Wt}\%_0$$

$$\text{Cum1} = 93.333$$

$$\text{Cum2} := \text{Cum1} - \text{Wt}\%_1$$

$$\text{Cum2} = 80$$

$$\text{Cum3} := \text{Cum2} - \text{Wt}\%_2$$

$$\text{Cum3} = 53.333$$

$$\text{Cum4} := \text{Cum3} - \text{Wt}\%_3$$

$$\text{Cum4} = 23.333$$

$$\text{Cum5} := \text{Cum4} - \text{Wt}\%_4$$

$$\text{Cum5} = 10$$

$$\text{Cum6} := \text{Cum5} - \text{Wt}\%_5$$

$$\text{Cum6} = 3.333$$

$$\text{TotalWt}\% := \sum_i \text{Wt}\%_i$$

$$\text{TotalWt}\% = 100$$

$$\text{TotalWt} := \sum_i \text{Wt}_i$$

$$\text{TotalWt} = 15 \text{ mg}$$

c) Plot the % particle weight less than the cascade impactor jet stage cut diameter on the horizontal axis versus the particle aerodynamic diameter (microns) on the vertical axis using the log probability graph

d) What is the particle size distribution mass median diameter (from graph) 12.5 microns

From graph mass median diameter = about 12.5 microns

e) What is the Geometric Standard Deviation σ_g of the Impactor Particle Size Distribution

From graph d_{84} = about 25 microns

From graph $d_{15.8}$ = about 6.5 microns

$$\sigma_{\text{large}} := \frac{25}{12.5}$$

$$\sigma_{\text{large}} = 2$$

$$\sigma_{\text{small}} := \frac{12.5}{6.5}$$

$$\sigma_{\text{small}} = 1.923$$

Note that the size distribution curve is not straight so σ_g magnitude of the large particles differs from the σ_g of the small particles.

$$\sigma_g := \left(\frac{25}{6.5} \right)^{0.5}$$

$$\sigma_g = 1.961$$

f) What is the PM10 particle mass concentration provided by the Cascade Impactor?

$$\text{PM10Conc} := (0.35) \cdot \text{MassConc}$$

Looking at the graph it appears that about 35% of the particle mass is less than 10 microns aerodynamic diameter. So 35% of the impactor total particle mass conc. = PM10 mass conc.

$$\text{PM10Conc} = 128.751 \frac{\mu\text{g}}{\text{m}^3}$$

g) What is the 24 hr average PM2.5 Particle Mass Concentration provided by the cascade impactor?

$$\text{PM25Conc} := (0.06) \cdot \text{MassConc}$$

Looking at the graph it appears that about 6% of the particle mass is less than 2.5 microns aerodynamic diameter. So 6% of the impactor total particle mass conc. = PM2.5 mass conc.

$$\text{PM25Conc} = 22.072 \frac{\mu\text{g}}{\text{m}^3}$$

h) Compare the 24 hr average PM2.5 particle concentration with the PM2.5 NAAQS?

PM 2.5 NAAQS = 35 micrograms/cubic meter so the PM2.5 conc. of 22.072 micrograms/cubic meter is less than the PM2.5 NAAQS.

