

# Particle Grade Efficiency Curve Use to Obtain Overall Collection Efficiency

Pilat

Given

*Example Calculation with Mathcad7*

Mathcad7

Table of 9 particle diameter ranges, 9 average diameters  $dp$ , collection efficiency  $\eta_{dp}$  at each average diameter and the problem solution Cascade impactor particle size distribution from Example 4.1 p. 105 Noll Particle mass concentration at device inlet = 2.0 grain/scf (Example 4.2 Page 109 Noll)

$$\text{grain} := \text{lb} \cdot 7000^{-1}$$

$$\mu\text{m} := \text{cm} \cdot 10^{-4}$$

Find:

- % by weight of particles in each size range
- Inlet concentration in each particle diameter range
- Control device outlet particle mass conc in each size range
- Overall particle collection efficiency (fractional)
- Overall particle penetration through device and emitted (fractional)
- Size distribution of particles emitted from control device
- Present graph of size distribution of particles at inlet and outlet of device

$$i := 0..8$$

$$\text{Cinlet} := 2.0 \cdot \frac{\text{grain}}{\text{ft}^3}$$

I calculated the "%Range" matrix numbers shown below "by hand" so I could present them here.

SizeRange :=	$\begin{pmatrix} 0 - 2 \\ 2 - 4 \\ 4 - 6 \\ 6 - 10 \\ 10 - 14 \\ 14 - 20 \\ 20 - 30 \\ 30 - 50 \\ 50 - 70 \end{pmatrix}$	dp :=	$\begin{pmatrix} 1 \\ 3 \\ 5 \\ 8 \\ 12 \\ 17 \\ 25 \\ 40 \\ 60 \end{pmatrix} \cdot \mu\text{m}$	$\eta_{dp} :=$	$\begin{pmatrix} 0.1 \\ 0.3 \\ 0.6 \\ 0.8 \\ 0.9 \\ 0.96 \\ 0.98 \\ 0.99 \\ 0.9999 \end{pmatrix}$	%Lessdp :=	$\begin{pmatrix} 0.5 \\ 10 \\ 30 \\ 67 \\ 86 \\ 96 \\ 99.4 \\ 99.8 \\ 100.0 \end{pmatrix}$	%Range :=	$\begin{pmatrix} 0.5 \\ 9.5 \\ 20 \\ 37 \\ 19 \\ 10 \\ 3.4 \\ 0.4 \\ 0.2 \end{pmatrix}$
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The particle mass concentration in a particle diameter range is the total mass concentration times the fraction of the particle mass in that size range. The fraction of particle mass in the particle diameter range is obtained from the Cumulative size information given in the %Lessdp matrix above (and is shown as %Range in the right hand matrix above).

$$\text{InletConc}_i := \left( \frac{\%Range_i}{100} \right) \cdot (\text{Cinlet})$$

$$\text{OutletConc}_i := (\text{InletConc}_i) \cdot (1.0 - \eta_{dp_i})$$

$$\text{TotalInletConc} := \sum_i \text{InletConc}_i$$

InletConc =	$\begin{pmatrix} 0.01 \\ 0.19 \\ 0.4 \\ 0.74 \\ 0.38 \\ 0.2 \\ 0.068 \\ 0.008 \\ 0.004 \end{pmatrix} \frac{\text{grain}}{\text{ft}^3}$	OutletConc =	$\begin{pmatrix} 0.009 \\ 0.133 \\ 0.16 \\ 0.148 \\ 0.038 \\ 0.008 \\ 0.00136 \\ 0.00008 \\ 0.0000004 \end{pmatrix} \frac{\text{grain}}{\text{ft}^3}$
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$$\text{TotalInletConc} = 2 \frac{\text{grain}}{\text{ft}^3}$$

$$\text{TotalOutletConc} := \sum_i \text{OutletConc}_i$$

$$\text{TotalOutletConc} = 0.4974 \frac{\text{grain}}{\text{ft}^3}$$

**Outlet Conc = 0.4974 grain/cubic ft**

$$\text{Overall}\eta := \frac{(\text{TotalInletConc} - \text{TotalOutletConc})}{\text{TotalInletConc}}$$

$$\text{Overall}\eta = 0.75128$$

**Overall Collection Eff = 75.128%**

Now we need to calculate the size distribution of the particles emitted from the control device. This is done by calculating the particle mass concentration at the device outlet for each particle diameter range (which we have done above), summing up the total outlet concentration, then calculating the % mass in each size range in this outlet concentration.

$$\text{Outlet\%Massdp}_i := \left( \frac{\text{OutletConc}_i}{\text{TotalOutletConc}} \right) \cdot (100)$$

$$\text{Outlet\%Greater}_i := 100 - \sum_{i=0}^i \text{Outlet\%Massdp}_i$$

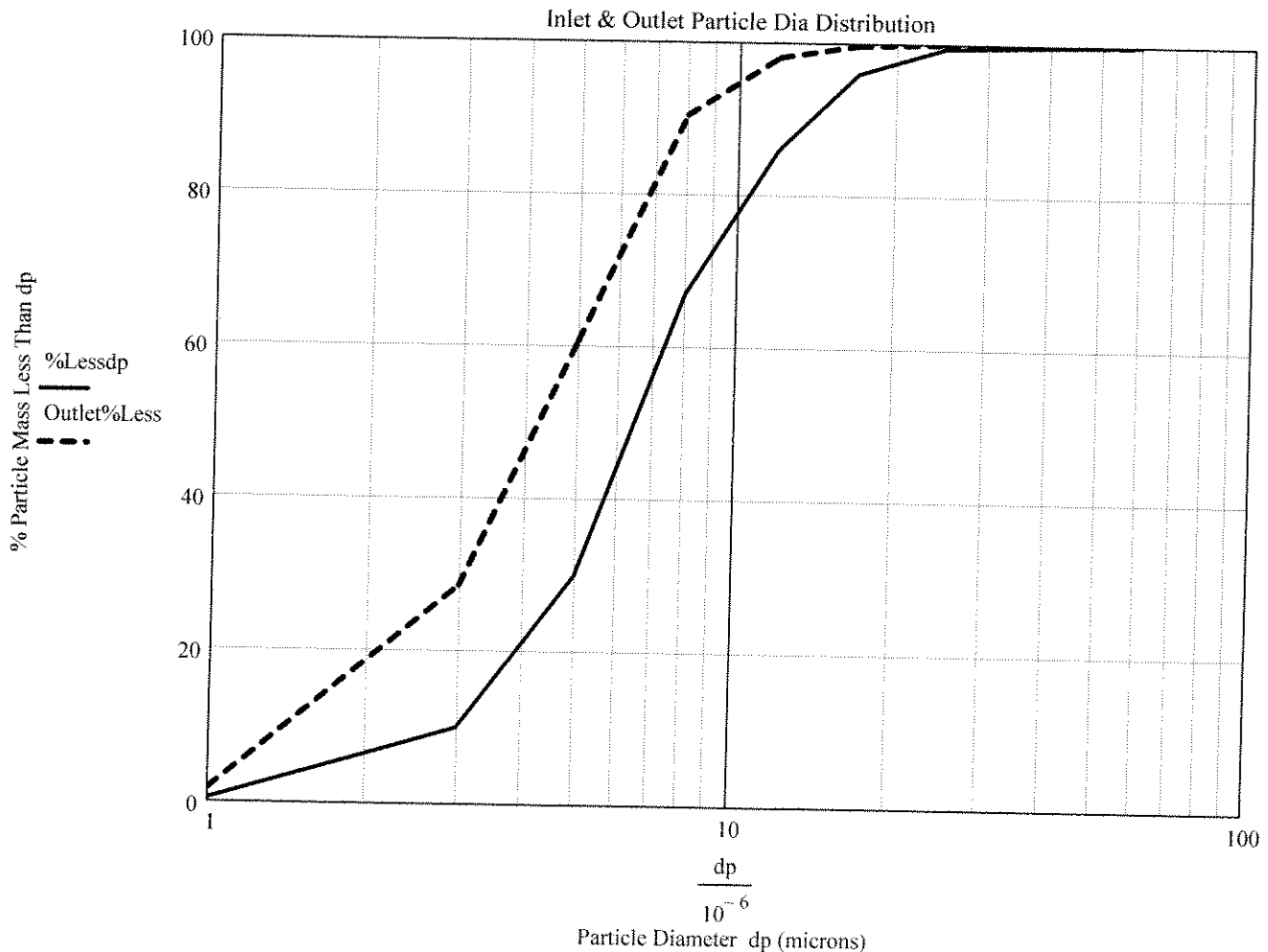
The Outlet%Massdp is the % of particle mass conc in the particle diameter range for which dp is the average diameter

$$\text{Outlet\%Less}_i := 100 - \text{Outlet\%Greater}_i$$

dp =	1	1.809262	1.80926197
	3	26.736871	28.54613337
	5	32.164657	60.71079068
	8	29.752308	90.46309869
12 μm	Outlet%Massdp = 7.639106	Outlet%Less = 98.10220481	
17	1.608233	99.71043767	
25	0.2734	99.98383726	
40	0.016082	99.99991959	
60	0.00008	100	

The %OutletLess calculated and shown to the left is the % of particle mass concentration less than the particle diameters dp (and this is shown in graph below)

The inlet and outlet particle size distributions are plotted in the graph below. Note that the mass median diameter is the particle diameter with 50% of the mass less than this diameter. The inlet mass median diameter is 6.5 and outlet 4.3 microns.



A graph of the "Grade Efficiency Curve" or particle collection efficiency (fractional) versus particle diameter (microns) is shown below.

