Aerosol Formulae

Properties of Air at STP and constants:
λ = mean free path of gas molecules, air = 0.066 µm
μ = viscosity of gas, air = 1.81×10^{-4} g/cm·s
ρ_g = density of gas, air = 1.2×10^{-3} g/cm^3
g = acceleration of gravity, 980 cm/s^2
ρ_p = density of particle, unit density = 1 g/cm^3

Definition of Symbols:
C_c = Cunningham (slip) correction factor
d = diameter of particle, cm
D_j = diameter of jet, cm
N = number of particles
v = velocity of particle, cm/s
U = air velocity, cm/s

Mass of spherical particles:
$$M = \pi d^3 \rho_p N / 6$$

Surface area of spherical particles:
$$SA = \pi d^2 N$$

Volume of spherical particles:
$$V = \pi d^3 N / 6$$

Median Diameter:
$$xMD = d_{50\%}$$
x = M for mass, C for count, or S for surface area

Geometric Standard Deviation:
$$GSD = d_{84\%} / d_{50\%}$$

Hatch-Choate Conversion:
$$MMD = CMD \exp(3 \ln^2 GSD)$$

Stokes' Law Drag Force Equation:
$$F_D = 3 \pi d v \mu / C_c$$

Reynolds Number:
$$Re = (d v \rho_g) / \mu$$
Re = 6.6 v[cm/s] d[cm], for air at STP

Terminal Settling Velocity (Re < 1):
$$V_{TS} = (C_c d^2 \rho_p g) / 18 \mu$$
V_{TS}[cm/s] = 0.003 d[µm]^2, unit density sphere in air, 1µm < d < 100µm

Cunningham Slip Correction Factor (dimensionless):
$$Cc = 1 + \lambda/d [2.514 + 0.8 \exp(-0.55 d/\lambda)]$$
$$Cc = 1 + (0.167 / d[\mu m]),\text{ air approx.}$$

Terminal Settling Velocity (Re > 1):
$$V_{TS} = [(4 d \rho_p g) / (3 C_D \rho_g)]^{1/2}$$

Calculate V_{TS} when d known
1. $C_D Re^2 = (4 d^3 \rho_p \rho_g g) / (3 \mu^2)$
2. Look up Re on chart
3. Calculate $V_{TS} = Re \mu / (\rho_g d)$

Calculate d when V_{TS} given
1. $C_D/Re = (4 \rho_p \mu g) / (3 \rho_g^2 v^3)$
2. Look up Re on chart
3. Calculate $d = Re \mu / (\rho_g V_{TS})$

Aerodynamic Diameter:
the diameter of the spherical particle with unit density that has the same settling velocity as the particle

Relaxation time:
$$\tau = (d^2 \rho_p C_c) / (18 \mu_g)$$

Stopping Distance:
$$S = v_i \tau$$

Stokes number (Stk):
$$Stk = S / d_c = \tau U / d_c$$

Efficiency of Impactors, Critical Stokes Number
$$Stk_{50\%} = [(d^2 \rho_p C_c) / (18 \mu_g) U] / (D_j / 2)$$
= 0.22 for round jets
= 0.47 for rectangular jets