

# Appendix

## Notation

(Dimensions given in terms of mass, M, length, L, time, T, and temperature,  $\theta$ )

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$a$	Exponent
$A$	Area ( $L^2$ ), amplitude (L)
$A_a$	Arithmetic mean of the cake area in a filtering centrifuge ( $L^2$ )
$A_l$	Logarithmic mean of the cake area in a filtering centrifuge ( $L^2$ )
$A_m$	Area of the filter medium in a filtering centrifuge ( $L^2$ )
$b$	Exponent, constant, height of the bowl of a tubular centrifuge (L), isotherm slope
$b_1$	Empirical constant
$B$	Intercept with the y-axis in a plot of a constant-pressure filtration run ( $T/L^3$ ), permeability coefficient
$B_0$	Constant
$B'$	Intercept with the y-axis in a plot of a constant-rate filtration run ( $M/LT^2$ )
$c$	Exponent, capillary viscosity constant, velocity (L/T), velocity of light (L/T)
$c_p$	Specific heat ( $L^2/T^2\theta$ )
$C$	Volume fraction of solids in suspension, gas concentration ( $M/L^3$ )
$C_f$	Volume fraction of solids in the feed
$C_p$	Heat capacity at constant pressure ( $L^2/T^2\theta$ )
$C_u$	Volume fraction of solids in the underflow
$C_v$	Heat capacity at constant volume ( $L^2/T^2\theta$ )
$C_D$	Drag coefficient
$d$	Exponent, diameter of the rod supporting rollers in chain conveyors (L), radius of the product in roller mills (L), diameter of the neck of a hydrometer (L), exponent, depth of a layer (L)
$d_c$	Cell diameter (L)
$D$	Diameter (L), screen aperture (L), dose of microbial inactivation energy
$D_c$	Cyclone and hydrocyclone diameter (L)
$D_f$	Diameter of the feed in roller mills (L)
$D_g$	Gas diffusivity ( $L^2/T$ )

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$D_i$	Inlet diameter of a hydrocyclone (L)
$D_o$	Overflow pipe diameter of a hydrocyclone (L)
$D_p$	Diameter of the product in roller mills (L)
$D_{pc}$	Cut diameter (L)
$D_r$	Diameter of the roll in roller mills (L)
$D_u$	Underflow diameter of a hydrocyclone (L)
$D_{UV}$	Decimal reduction rate in UV treatment
$D_0$	Lethality constant
$D_{10}$	Decimal reduction time, decimal reduction dose
$e$	Exponent
$E$	Energy ( $ML^2/T^2$ ), overall screen efficiency, Young's modulus ( $M/LT^2$ )
$E_a$	Activation energy ( $ML^2/T^2$ )
$E_c$	Electric field intensity threshold value ( $V^a/L$ )
$E_d$	Energy absorbed ( $ML^2/T^2$ )
$E_i$	Bond work index ( $ML^2/T^2$ )
$E_O$	Oversize screen efficiency
$E_p$	Partial efficiency
$E_t$	Total efficiency
$Eu$	Euler number
$E_U$	Undersize screen efficiency
$E_0$	Radiating light hitting the surface of a material
$f$	Frequency (dimensionless), frequency ( $1/T$ ), fanning friction factor
$f_a$	Size fraction of one component of average weight $w_a$
$f(x)$	Frequency or occurrence related to size
$f_L(x)$	Size distribution function by length
$f_M(x)$	Size distribution function by mass (volume)
$f_N(x)$	Size distribution function by number
$f_S(x)$	Size distribution function by surface
$F$	Force ( $ML/T^2$ ), mass flow rate of solids in the feed ( $M/T$ ), cumulative percentage of the coarse fraction in the feed
$F_f$	Cumulative percentage of the fines fraction in the feed
$F_A$	Buoyancy force ( $ML/T^2$ )
$F(x)$	Cumulative frequency
$F_D$	Drag force ( $ML/T^2$ )
$F(x)$	Cumulative percentage oversize of feed solids
$Fr$	Froude number
$g$	Acceleration due to gravity ( $L/T^2$ )
$G_c$	Critical flux ( $M/L^2T$ )
$G(x)$	Grade efficiency
$G'(x)$	Reduced grade efficiency
$h$	Height (L), length of the hydrometer not submerged in the liquid (L), Planck's constant ( $L^2M/T$ )
$H$	Height or depth (L), relative humidity
$I$	Intensity of radiation at a given distance ( $L^2/T^2$ )
$I_0$	Intensity of radiation at the surface of an absorber ( $L^2/T^2$ )
$J$	Rate of diffusion ( $M/T$ )

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$k$	Constant, coordination number
$k_p$	Constant for a family of geometrically similar hydrocyclones
$k_1$	Constant
$k_2$	Constant
$K$	Constant, correlation constant of the power law, slope of the line in a plot of a constant-pressure filtration run ( $T/L^6$ )
$K_c$	Constant depending on the filter medium in air filtration
$K_1$	Cake resistance factor in air filtration
$K'$	Fluid consistency index ( $MT^n/L^2$ ), slope of the line in a plot of a constant-rate filtration run ( $M/L^4T^2$ )
$K''$	Constant in constant-rate filtration
$L$	Length (L)
$m$	Mass (M), weight of a hydrometer (M), constant, moisture content
$m_e$	Moisture content of an isotherm based on a straight-line approximation
$m_f$	Weight of a pycnometer filled with a sample (M)
$m_i$	Initial moisture content
$m_l$	Weight of a pycnometer filled with liquid (M)
$m_s$	Weight of a pycnometer filled with a solid (M)
$m_{sl}$	Weight of a pycnometer filled with liquid and a solid (M)
$m_{LC}$	Weight of a container partially filled with liquid (M)
$m_{LCS}$	Weight of a container with liquid and a submerged solid (M)
$m_0$	Weight of an empty pycnometer (M)
$M$	Mesh size, mass flow rate of solids in suspension (M/T), molar concentration
$M_c$	Mass flow rate of separated solids (M/T), the mass of the solid cake in the bowl of a filtering centrifuge (M)
$M_f$	Mass flow rate of unseparated solids (M/T)
$M_s$	Weight of a specimen (M)
$M_1$	Mixing index
$M_2$	Mixing index
$M_3$	Mixing index
$N$	Rotation speed (1/T), sample size, initial microbial load
$N_c$	Critical rotation speed (1/T)
$N_t$	Microbial load after treatment time $t$
$n$	Exponent, shear index, number of particles in a sample, slope
$n_p$	Constant for a family of geometrically similar hydrocyclones
$n'$	Flow behavior index
$O$	Mass flow rate of solids in the overflow (M/T)
$p$	Proportion by weight of the component within a total sample weight $w$ , agglomerating pressure ( $M/LT^2$ )
$P$	Pressure ( $M/LT^2$ ), power ( $ML^2/T^3$ )
$P_R$	Pressure at reference pressure conditions ( $M/LT^2$ )
$P_0$	Vapor pressure of pure water at a given temperature ( $M/LT^2$ )
$q$	Proportion by weight of a component within a total sample weight $w$
$Q$	Volumetric flow rate ( $L^3/T$ )
$r$	Radius of a particle in roller mills, radius of a feed particle in roller mills (L), radius of a ball in tumbling mills (L), radius (L)

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$R$	Radius (L), radius of the roll in roller mills (L), radius of the drum in tumbling mills (L), radius of rotation (L), universal gas constant
$Re$	Reynolds number
$Re_p$	Particle Reynolds number
$Re_s$	Reynolds number for power-law fluids
$R_f$	Underflow-to-throughput ratio
$R_i$	Neutral zone in a centrifuge (L)
$R_m$	Resistance of the filter medium (1/L)
$R_x$	Outer radii of a stack of discs in a disc-bowl centrifuge (L)
$R_y$	Inner radii of a stack of discs in a disc-bowl centrifuge (L)
$R_A$	Weir radius for the denser phase in a centrifuge (L)
$R_B$	Weir radius for the less dense phase in a centrifuge (L)
$s$	Standard deviation of the analyses of the average value of the fraction of a specific powder, specific surface of a solid ( $L^2$ ), empirical constant, compressibility coefficient
$s_p$	Surface area of a particle ( $L^2$ )
$s_r$	Estimate of the standard deviation of the fraction of a specific powder under complete randomization
$s_0$	Estimate of the standard deviation of the fraction of a specific powder under complete segregation
$S$	Surface ( $L^2$ ), number of discs in the stack in a disc-bowl centrifuge
$SG$	Specific gravity
$Stk_{50}$	Stokes number
$Stk'_{50}$	Stokes number including the reduced cut size
$Stk_{50}^*$	Stokes number for power-law fluids
$Stk_{50}^*(r)$	Stokes number for power-law fluids including the reduced cut size
$t$	Time (T)
$t_c$	Treatment time threshold value in pulsed electric field technology (T)
$T$	Temperature ( $\theta$ ), tensile stress ( $M/LT^2$ )
$TMP$	Transmembrane pressure ( $M/LT^2$ )
$u$	Linear velocity in the vertical direction ( $L/T$ ), fluid-particle relative velocity ( $L/T$ ), settling velocity at concentration $C$ ( $L/T$ )
$u_g$	Terminal settling velocity under gravity ( $L/T$ )
$u_t$	Terminal settling velocity of particles ( $L/T$ ), channel velocity calculated from the cross section ( $L/T$ )
$U$	Mass flow rate of solids in the underflow ( $M/T$ ), volumetric flow rate of the underflow ( $L^3/T$ )
$v$	Linear velocity in the horizontal direction ( $L/T$ )
$v_g$	Terminal settling velocity under gravity ( $L/T$ )
$v_r$	Radial settling velocity ( $L/T$ )
$v_t$	Terminal settling velocity ( $L/T$ )
$v_{tan}$	Tangential velocity ( $L/T$ )
$V$	Volume ( $L^3$ ), compacted volume of solids at a given pressure ( $L^3$ ), linear velocity ( $L/T$ )
$V_f$	Gas superficial velocity through the filter medium in air filtration ( $L/T$ )
$V_p$	Volume of a particle ( $L^3$ )
$V_K$	Volume of a test body ( $L^3$ )
$V_R$	Relation of volumes ( $V/V_s$ )

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$V_s$	Volume of solid material ( $L^3$ )
$V_0$	Sliding velocity at a reference location defined by Eq. 3.16 ( $L/T$ ), initial volume ( $L^3$ ), mean gas velocity ( $L/T$ )
$V'$	Activation volume constant
$w$	Weight of a sample ( $M$ ), mass of solids deposited on the medium per unit volume of filtrate ( $M/L^3$ )
$w_a$	Average weight of a sample ( $M$ )
$W_s$	Weight of dry solids in a package ( $M$ )
WVP	Water vapor permeance ( $T/L$ )
WVTR	Water vapor transmission rate ( $M/L^2T$ )
$x$	Particle size
$x_c$	Cut point ( $L$ )
$x_i$	Every measured value of the fraction of one powder
$x_p$	Diameter of a particle ( $L$ )
$x_{sv}$	Equivalent surface diameter of a particle ( $L$ )
$x_{50}$	Cut size ( $L$ )
$x'_{50}$	Reduced cut size ( $L$ )
$X$	Fraction, distance ( $L$ )
$X_F$	Mass fraction of coarse particles in the feed
$X_O$	Mass fraction of coarse particles in the overflow
$X_U$	Mass fraction of coarse particles in the underflow
$Z(P)$	Pressure increase required to accomplish a one log reduction cycle in $D_{10}$
<i>Greek letters</i>	
$\alpha$	Half the angle of nip in roller mills, angle to the vertical in tumbling mills, surface tension of liquid ( $M/LT^2$ ), specific cake resistance ( $L/M$ )
$\alpha_0$	Empirical constant in Eq. 7.71
$\alpha'_0$	Empirical constant in Eq. 7.71
$\beta$	Empirical constant in Eq. 7.72
$\gamma$	Viscosity coefficient for power-law fluids ( $M/LT^{2-n}$ )
$\dot{\gamma}$	Shear rate ( $1/T$ )
$\delta$	Membrane thickness ( $L$ )
$\Delta P$	Pressure drop ( $M/LT^2$ )
$\Delta m$	Apparent increase in weight ( $M$ )
$\Delta G$	Apparent weight force ( $ML/T^2$ )
$\Delta P_c$	Pressure drop through the powder layer in air filtration ( $M/LT^2$ )
$\Delta P_f$	Pressure drop across the filter medium of an air filter ( $M/LT^2$ )
$-\Delta P$	Total pressure drop across the filter ( $M/LT^2$ )
$-\Delta P_c$	Pressure drop across the cake ( $M/LT^2$ )
$-\Delta P_m$	Pressure drop across the medium ( $M/LT^2$ )
$\Delta V^+$	Activation volume ( $L^3$ )
$\varepsilon$	Porosity or voidage, strain
$\varepsilon_A$	Axial strain
$\varepsilon_L$	Lateral strain
$\eta$	Apparent viscosity ( $M/LT$ )
$\theta$	Angle between the particle and the screen aperture, hydrocyclone cone angle
$\lambda$	Wavelength ( $L$ )
$\mu$	Liquid absolute viscosity ( $M/LT$ ), Poisson's ratio, friction coefficient

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$\mu_g$	Gas viscosity (M/LT)
$\mu_o$	Viscosity of a pure solvent (M/LT)
$\mu'$	Friction coefficient in roller mills
$\nu$	Kinematic viscosity (L <sup>2</sup> /T)
$\pi$	Osmotic pressure (M/LT <sup>2</sup> )
$\rho$	Liquid density (M/L <sup>3</sup> ), frequency
$\rho_b$	Bulk density (M/L <sup>3</sup> )
$\rho_g$	Gas density (M/L <sup>3</sup> )
$\rho_s$	Solids density (M/L <sup>3</sup> )
$\rho_A$	Density of the denser phase in a centrifuge (M/L <sup>3</sup> )
$\rho_B$	Density of the less phase in a centrifuge (M/L <sup>3</sup> )
$\sigma$	Interfacial tension (M/T <sup>2</sup> ), stress (M/LT <sup>2</sup> )
$\sigma_t$	Strength of agglomerates (M/LT <sup>2</sup> )
$\Sigma$	Operator, meaning "algebraic sum of," characteristic geometrical features of a centrifuge equivalent to the area of a gravity settling tank with settling characteristics similar to those of a centrifuge
$\tau$	Shear stress (M/LT <sup>2</sup> )
$\tau_0$	Intercept with the y-axis in plot of shear stress versus shear rate
$\phi$	Volume fraction of spheres in suspension
$\Phi$	Sphericity
$\omega$	Angular velocity (1/T)
$\Omega$	Conical half angle of the discs in a disc-bowl centrifuge

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<sup>a</sup>Volt

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