Table 1: Key Dimensionless Numbers for Reactor Scale-Up

Number (Symbol)	Physical Meaning	Technical Relevance to Scale-Up
Reynolds Number (Re)	Ratio of Inertial to Viscous Forces	**Ensures Hydrodynamic Similarity:** Maintaining the same Re (e.g., turbulent) across scales guarantees that the flow patterns, velocity profiles, and degree of turbulence are identical, which is the foundation for equivalent mixing and transport phenomena. References: empirical correlations and similarity analyses.
Power Number (N_p)	Ratio of Power Input to Inertial Forces	**Ensures Consistent Mixing Energy:** In the turbulent regime, N_p is approximately constant for a given impeller geometry. Use it to scale power consumption and to calculate power per unit volume (P/V) to achieve similar shear and dispersion at larger scales.
Nusselt Number (Nu)	Ratio of Convective to Conductive Heat Transfer	**Guarantees Equivalent Heat Removal:** $Nu = f(Re, Pr)$; keeping Re and Pr similar preserves Nu, and therefore the convective heat transfer coefficient (h). This is critical for removing reaction exotherm and avoiding hot spots during scale-up.
Prandtl Number (Pr)	Ratio of Momentum to Thermal Diffusivity	**Links Fluid Flow to Heat Transfer:** $Pr = \nu/\alpha$ (kinematic viscosity/thermal diffusivity) is a fluid property. It sets the relation between velocity and thermal boundary-layer thickness and enters Nu correlations used for heat transfer design.
Sherwood Number (Sh)	Ratio of Convective to Diffusive Mass Transfer	**Guarantees Equivalent Mass Transfer:** $Sh = f(Re, Sc)$; maintaining Re and Sc preserves Sh, giving similar mass transfer coefficients (k_c). This prevents concentration gradients and helps avoid selectivity changes or undesired side reactions at scale.
Schmidt Number (Sc)	Ratio of Momentum to Mass Diffusivity	**Links Fluid Flow to Mass Transfer:** $Sc = \nu/D$ (kinematic viscosity/mass diffusivity) is a property that relates the velocity boundary layer to the concentration boundary layer and is required in Sherwood correlations.
Damköhler Number (Da)	Ratio of Reaction Rate to Transport Rate	**Defines the Controlling Regime:** $Da = characteristicreactiontimecharacteristictransporttime$. Use separate Da for heat, mass and overall reaction. Matching the relevant Da set keeps the process in the same regime (kinetically controlled vs. transport-controlled) after scale-up.