

Formula 1

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Formula 2

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Formula 3

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Detailed Explanation

Microreactor scale-up presents unique challenges distinct from traditional batch reactor scale-up due to the dominance of laminar flow, high surface-to-volume ratios, and precise control over transport phenomena. Unlike empirical 'scale-up factors', this decision tree emphasizes first-principles reasoning: it begins with reaction classification (e.g., fast exothermic, slow mass-transfer-limited, photochemical) and progressively evaluates critical dimensionless numbers (e.g., Graetz, Damköhler, Péclet), thermal stability criteria, and mixing fidelity requirements. Each decision node prompts engineering judgments—such as whether to number-up (replicate identical units) versus scale-out (increase channel dimensions)—while flagging risks like hot-spot formation, byproduct accumulation, or residence time broadening. The interactive PDF format supports real-time annotation, embedded calculators for key parameters (e.g., required heat transfer area, pressure drop estimation), and hyperlinked references to design standards (e.g., ISO 8504-2 for flow uniformity) and case studies. Crucially, it bridges theoretical chemical reaction engineering with practical implementation constraints—including materials compatibility (e.g., corrosion resistance of Hastelloy vs. silicon carbide), regulatory documentation needs (e.g., ICH Q5 for biocatalytic processes), and digital twin integration readiness—making it both an educational tool and a deployable engineering workflow artifact.

Key Components

#	Component
1	Reaction Classification Module
2	Transport Limitation Assessment Engine
3	Scale-Up Strategy Selector (Number-up vs. Scale-out vs. Hybrid)

Applications

#	Application
1	Pharmaceutical API synthesis under Quality-by-Design (QbD) frameworks
2	High-throughput screening of catalytic reaction conditions
3	Safe scale-up of nitration or ozonolysis reactions with narrow thermal runaway margins

Related Concepts

#	Concept
1	Continuous Flow Chemistry
2	Dimensionless Number Analysis
3	Residence Time Distribution (RTD)

Tags

chemical-engineering, flow-chemistry, process-safety

Microreactor Scale-Up Decision Tree (Interactive PDF)