# MSMPR Crystalliser: Dominant Size and Nucleation

Dominant crystal size, nuclei population density, nucleation rate and crystal number in a mixed-suspension mixed-product-removal crystalliser (Perry's Eq. 18-34).

**Method:** Perry's Chemical Engineers' Handbook; 9th ed. (McGraw-Hill, 2019); ...

## Input parameters

Unit system: SI

| Parameter | Value | Unit |
|---|---|---|
| Crystal growth rate<br>Enter in m/s; 1 µm/min = 1.67 × $10^{-8}$ m/s. | 1.0000e-08 | m/s |
| Drawdown (residence) time | 3.3800 | h |
| Slurry density (crystals per volume) | 450.00 | g/L |
| Crystal density | 1,335.0 | kg/m³ |
| Volume shape factor | 1.0000 | |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Dominant (mass) size | 0.36504 | mm |
| Nuclei population density (number per m³ per m of size, 1/m⁴) | 2.5627e+14 | |
| Nucleation rate (number per m³ per second) | 2,562,732 | Hz |
| Crystals per m³ of slurry (number per m³) | 3.1183e+10 | |

**Notes for this case**

- n⁰ is in number per m³ per m of size; B⁰ in number per m³ per second.

## Formula and method

$$n = n^0 e^{-L/G\tau}, \quad L_D = 3G\tau, \quad M_T = 6k_v\rho_c n^0 (G\tau)^4, \quad B^0 = n^0 G$$

### Variables

| | | |
|---|---|---|
| $G$ | Crystal growth rate | m/s |
| $\mathcal{T}$ | Drawdown (residence) time | s |
| $M_T$ | Slurry density (crystals per volume) | kg/m³ |
| $\rho_c$ | Crystal density | kg/m³ |
| $k_v$ | Volume shape factor | - |
| $L_D$ | Dominant (mass) size | m |
| $n^0$ | Nuclei population density (number per m³ per m of size) | 1/m⁴ |
| $B^0$ | Nucleation rate (number per m³ per second) | 1/(m³·s) |
| $N_T$ | Crystals per m³ of slurry (number per m³) | 1/m³ |

### Method and standards

MSMPR population balance (Randolph and Larson).

### Assumptions and limits

- Ideal MSMPR; size-independent growth; no breakage.
- n⁰, B⁰ and N_T are shown as plain numbers in SI: n⁰ per m³ per m of size, B⁰ per m³ per second, N_T per m³.

### References

- Perry's Chemical Engineers' Handbook
- 9th ed. (McGraw-Hill, 2019)
- sec. 18 (crystallisation): population balance n = n⁰ exp(−L/Gτ)

- Eq. (18-34)
- and Example 18-4

## Report details

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|---|---|
| Report reference | FCC-PKCW-7X17 (the same inputs always give the same reference) |
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| Calculator | MSMPR Crystalliser: Dominant Size and Nucleation |
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| Software release | FireCAD Calc, release of 17 November 2026 |
| Release checks | 2 reference cases of this calculator, computed independently, are checked on every release |

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

### This calculator online

https://calc.firecad.com/chemical/unit-operations/msmpr-crystal-size

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.