

New bounded derivations and verification. NOT a complete reconstruction of Books 22 and 40-58.

Order: definitions and dimensions -> algebraic solutions -> numerical reference checks -> physical assumptions -> material qualification (OPEN).

MF01 / Ideal gas density

$$M \cdot p - R \cdot T \cdot \rho = 0$$

Variants: {"rho": " $M \cdot p / (R \cdot T)$ "}

Units: {"p": "Pa absolute", "rho": "kg/m3", "M": "kg/mol", "R": "J/(mol K)", "T": "K"}

Ideal gas, positive absolute temperature; real-gas deviations not bounded.

Symbolic residual: 0. Reference: BIPM SI; ideal-gas constitutive assumption

MF02 / Ideal gas pressure variant

$$M \cdot p - R \cdot T \cdot \rho = 0$$

Variants: {"p": " $R \cdot T \cdot \rho / M$ "}

Units: {"p": "Pa", "rho": "kg/m3", "M": "kg/mol", "R": "J/(mol K)", "T": "K"}

Same assumptions as MF01.

Symbolic residual: 0. Reference: MF01

MF03 / Hooghoudt spacing

$$-4 \cdot K_a \cdot h^2 - 8 \cdot K_b \cdot d \cdot h + L^2 \cdot q = 0$$

Variants: {"L": " $\sqrt{4 \cdot K_a \cdot h^2 + 8 \cdot K_b \cdot d \cdot h} / \sqrt{q}$ "}

Units: {"L,d,h": "m", "Kb,Ka": "m/day", "q": "m/day"}

Steady-state parallel drainage, equivalent depth supplied; not a transient soil model.

Symbolic residual: 0. Reference:

https://www.fao.org/fileadmin/user_upload/faowater/docs/Guide62Web.pdf

MF04 / Hooghoudt recharge variant

$$-4 \cdot K_a \cdot h^2 - 8 \cdot K_b \cdot d \cdot h + L^2 \cdot q = 0$$

Variants: {"q": " $(4 \cdot K_a \cdot h^2 + 8 \cdot K_b \cdot d \cdot h) / L^2$ "}

Units: {"L,d,h": "m", "Kb,Ka,q": "m/day"}

Same assumptions as MF03.

Symbolic residual: 0. Reference: MF03

MF05 / Hooghoudt positive water-table root

$$-4 \cdot K_a \cdot h^2 - 8 \cdot K_b \cdot d \cdot h + L^2 \cdot q = 0$$

Variants: {"h": " $(-K_b \cdot d + \sqrt{K_a \cdot L^2 \cdot q / 4 + K_b^2 \cdot d^2}) / K_a$ "}

Units: {"h,d,L": "m", "Ka,Kb,q": "m/day"}

$K_a > 0$, positive physical root; cancellation may require stable numerical evaluation.

Symbolic residual: 0. Reference: MF03

MF06 / Circular pipe area

$$A - \pi \cdot D^2 / 4 = 0$$

Variants: {"A": " $\pi \cdot D^2 / 4$ "}

Units: {"A": "m2", "D": "m"}

Circular internal cross-section.

Symbolic residual: 0. Reference: Euclidean geometry

MF07 / Diameter from area

$$A - \pi D^2/4 = 0$$

Variants: {"D": "2*sqrt(A)/sqrt(pi)"}

Units: {"A": "m2", "D": "m"}

Positive diameter only.

Symbolic residual: 0. Reference: MF06

MF08 / Mean flow velocity

$$-A*v + Q = 0$$

Variants: {"v": "Q/A"}

Units: {"Q": "m3/s", "A": "m2", "v": "m/s"}

Area-averaged incompressible flow.

Symbolic residual: 0. Reference: Mass balance

MF09 / Hydraulic pump input power

$$-H*Q*g*rho + P*eta = 0$$

Variants: {"P": "H*Q*g*rho/eta"}

Units: {"P": "W", "eta": "1", "rho": "kg/m3", "g": "m/s2", "Q": "m3/s", "H": "m"}

0 < efficiency <= 1; steady incompressible flow; no transient surge model.

Symbolic residual: 0. Reference: Mechanical energy balance

MF10 / RO feed from permeate

$$-F*Y + Q = 0$$

Variants: {"F": "Q/Y"}

Units: {"Q,F": "m3/s", "Y": "1"}

0 < recovery < 1; mass-flow approximation requires consistent densities.

Symbolic residual: 0. Reference: Mass balance

MF11 / RO brine flow

$$-B + F - Q = 0$$

Variants: {"B": "F - Q"}

Units: {"F,Q,B": "m3/s"}

Volumetric balance with equal-density approximation; salinity balance separate.

Symbolic residual: 0. Reference: Mass balance

MF12 / Static buoyancy mass equivalent

$$-V*(ra - rg) + m = 0$$

Variants: {"m": "V*(ra - rg)"}

Units: {"m": "kg", "ra,rg": "kg/m3", "V": "m3"}

Buoyancy alone; excludes envelope, water and support mass. Negative net lift possible.

Symbolic residual: 0. Reference: Archimedes force balance

NUMERICAL AND SOURCE AUDIT

status: "BOUNDED_MATHEMATICAL_CHECKS_PASSED_NOT_FULL_BOOK_APPROVAL"

source_records_compared: 102597

whitespace_normalized_text_groups: 27126

repeated_text_occurrences: 75471

classification: {"THEOREM_CANDIDATE": 2046, "EXPRESSION_OR_PROSE_CANDIDATE": 94798, "CODE_OR_MIXED_TEXT": 5753}

source_equations_scientifically_approved: 0

symbolic_identities_verified: 12

Hooghoudt_example_m: 64.8074069840786

wet_bulb_cases: 188

wet_bulb_domain_rejections: 1

wet_bulb_max_reference_error_C: 0.04282910523258465

wet_bulb_acceptance_bound_C: 0.15

laminar_distributed_flow_reference: {"exact_m": 1.303536378798166e-07, "computed_m": 1.3035363787981657e-07}

reliability_example: {"target_success_probability": 0.9999, "one_sided_confidence": 0.95, "zero_failure_trials_required": 29956, "assumptions": "Independent identically distributed Bernoulli trials, fixed design and specified mission/conditions; not a blanket feasibility guarantee"}

full_scientific_completeness: false

physical_validation: false

missing_books: ["41", "42"]

Wet-bulb correction: $h_{in} + (w_{sat} - w_{in}) \cdot 4.186 \cdot T_{wet} - h_{sat} = 0$, with enthalpy in kJ/kg dry air. Previous constant-enthalpy approximation omitted incoming liquid-water enthalpy.

Saturation pressure remains approximate. Reference:

<https://github.com/psychrometrics/psychrolib> version 2.5.0.

All source candidates have a comparison record, but none receives mathematical approval just because text repeats, a theorem label occurs, or a source asserts VERIFIED. Exact/normalized text grouping does not establish algebraic equivalence. Unspecified symbols, domains, geometry and material data remain unresolved.

Scientific limits: new theorems require precise hypotheses and proofs; physical impossibilities or absent enabling technology cannot be repaired by assigning a probability. Plant viability, universal manufacturing, BM technology levels, holographic physical resolution, spacecraft readiness and patentability are not established.