

MSCMF: Conditional two-source pipeline theorem and release obligations

Revision 1, 2026-10-05. A derived result under explicit assumptions, not a new physical law or a production approval.

1. Mathematics: definitions and assumptions

Let s in $[0, L]$ denote position along a straight pipe. Total continuous withdrawal Q is positive and uniform: $k=Q/L$ [m²/s]. At the meeting position x , discharge is zero. From source A to x the discharge magnitude is $k(x-s)$; from source B to x it is $k(s-x)$.

L, x, D_A, D_B are in metres. Cross-sections $A_i = \pi D_i^2/4$ [m²]. Source hydraulic heads H_A, H_B are in metres relative to the same datum. Density ρ [kg/m³], gravity g [m/s²], Darcy friction factors f_A, f_B [dimensionless] are positive and constant. There are no branch discontinuities, leaks, storage, local losses or transients. These assumptions must be checked rather than inferred from a book's feasibility claim.

Define $C_i = f_i k^2 / (6 g D_i A_i^2)$, in 1/m².

Integrating Darcy-Weisbach gives head loss $C_i L^3$ over a source-to-meeting distance L :

$\int_0^L [f_i / (2 g D_i)] [k u / A_i]^2 du = C_i L^3$.

The compatibility equation is $F(x) = H_A - H_B - C_A x^3 + C_B (L-x)^3 = 0$.

$F'(x) = -3 C_A x^2 - 3 C_B (L-x)^2 < 0$ for $L > 0$.

Therefore at most one meeting point exists. A meeting point in $[0, L]$ exists if and only if $-C_B L^3 \leq H_A - H_B \leq C_A L^3$. Equality places the meeting at one endpoint; strict inequalities give an interior meeting point.

Proof: continuity, endpoint signs and strict monotonicity. No stochastic convergence assumption is needed.

2. Solutions and numerical certificate

Equal source heads and equal C give $x=L/2$ exactly.

Otherwise bisection on $[0, L]$ converges. After n intervals the midpoint error is bounded by $L/2^{(n+1)}$. To obtain position error $\leq \epsilon_x$, choose $n \geq \lceil \log_2(L/(2 \epsilon_x)) \rceil$ with n nonnegative. This bounds mathematical root location under exact arithmetic; floating-point roundoff and uncertain physical inputs need separate bounds.

For uncertain but bounded source heads and coefficients, evaluate the monotone limiting models and bracket x . A point estimate cannot substitute for missing input ranges.

3. Physics: pressure envelope for flat terrain

For constant elevation z_0 , the meeting head is $H_m = H_A - C_A x^3 = H_B - C_B (L-x)^3$.

$H(s) = H_m + C_A (x-s)^3$ for $s \leq x$, and $H_m + C_B (s-x)^3$ for $s \geq x$.

The minimum gauge pressure is $p_{\min} = \rho g (H_m - z_0)$. The maximum is $\rho g (\max(H_A, H_B) - z_0)$.

For an assumed outlet setpoint p_{set} and an explicitly specified regulator margin Δp , a necessary steady-state condition is $p_{\min} \geq p_{\text{set}} + \Delta p$. A second necessary condition is $p_{\max} \leq$ the qualified pipe-system allowable pressure. Neither establishes constant outlet pressure by itself: regulator flow curves, minimum flows and dynamic interaction remain to be supplied and tested.

The result does not cover varying terrain, fluid properties, Reynolds-dependent friction, discrete withdrawals, pumps switching, cavitation, air pockets, freezing, biofouling, rupture or surge. Those require corresponding models and measured/qualified inputs. A constant friction factor is a scenario assumption, not a universal material constant.

4. Material science and manufacturing gate

Geometry alone cannot supply an allowable stress. Required data include material identity, temperature-dependent strength, creep/fatigue, environmental degradation, defect acceptance, joint performance and manufacturing tolerances.

Material models must be selected after determining actual loads and environments. Homogeneous isotropic elastic-cylinder results cannot be silently applied to composite laminates or

printed anisotropic material.

A computable admissibility condition is $\text{demand}_j \leq \text{allowable}_j$ for every identified failure mode j , with independently justified factors and uncertainty margins. Unknown allowable_j makes the condition undecidable from supplied data; it is not assigned an invented value.

5. Reproducible verification and release sequence

1. Verify dimensions, conservation, algebra and solution uniqueness (the scope proved above).
2. Benchmark the numerical implementation against this closed-form limiting case and an independently implemented hydraulic solver.
3. Replace constant-friction and flat-terrain assumptions with actual site and fluid data; test numerical convergence, uncertainty and transient scenarios.
4. Qualify material, joints, pressure envelope, fatigue, supports, controls and manufacturing process for those loads.
5. Test representative hardware using predefined acceptance limits and traceable instruments; inspect and independently review results.
6. Issue a dated, configuration-specific release only if all applicable conditions and product obligations are met.

A proof of steps 1-2 does not automatically establish steps 3-6. The workflow must stop release when a required condition fails or lacks evidence.

6. Numerical illustration

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{
  "scenario": "ILLUSTRATIVE_NOT_SITE_DATA",
  "L_m": 100000.0,
  "Q_m3_s": 1.0,
  "D_m": 1.2,
  "constant_Darcy_f": 0.02,
  "meeting_m": 50000.0,
  "head_loss_each_side_m": 2.768102003981425,
  "required_equal_source_head_m": 238.52969263947992,
  "outlet_pressure_Pa": 300000.0,
  "assumed_regulator_reserve_Pa": 50000.0,
  "physical_release": false
}
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7. Scope of the requested 99.99 percent

A probability requires a defined event, population, exposure and inference model. It cannot describe all possible products without those definitions. For a fixed Bernoulli success criterion with independent identical trials and zero failures, demonstrating a one-sided 95 percent lower confidence bound of at least 0.9999 requires 29,956 trials. This conditional statistical statement does not establish feasibility of unbuilt hardware or unknown environments.

8. Open source coverage

Book 41 and Book 42 were not found in the supplied roots during inventory. Two PDFs require a password and one DOCX failed decompression; available alternate editions were retained. The 27,126 normalized source-text groups have not all received mathematical or physical approval. No complete scientific reconstruction, EU conformity, patent readiness or fabrication release is claimed by this document.