Two-Phase Friction Multiplier (Lockhart–Martinelli, Chisholm C)

Martinelli parameter and Chisholm two-phase friction multiplier for steam–water from pressure and quality (IF97 properties), and the two-phase pressure drop.

Method: Lockhart and Martinelli; Chem. Eng. Prog. 45 (1949); Chisholm; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Pressure (absolute)	70.000	bar
Steam quality	10.000	%
Chisholm constant: 20 tt, 12 vt, 10 tv, 5 vv (liquid–vapour; t turbulent, v viscous) The form of the Martinelli parameter follows C: 20 turbulent liquid and vapour, 12 viscous liquid and turbulent vapour, 10 turbulent liquid and viscous vapour, 5 both viscous. Other values use the turbulent–turbulent form.	20.000	
Pressure drop of the liquid flowing alone	2.0000	kPa
Total mass flux Total flow over the tube bore area. Used for the Reynolds numbers, which set the X form when C is 12 or 10 and check the regime.	1,000.0	kg/(m²·s)
Tube inside diameter	50.000	mm

Calculated results

Parameter	Value	Unit
Martinelli parameter, in the form set by C	1.8792	
Reynolds number of the liquid flowing alone	493,063	
Reynolds number of the vapour flowing alone	264,697	
Two-phase multiplier	11.926	
Two-phase frictional pressure drop	23.852	kPa

Notes for this case

- Δp_l is the friction drop of the liquid part of the flow, (1 − x)ṁ, flowing alone in the same tube.

Formula and method

$$Re_l = \frac{G(1-x)D}{\mu_l}, \quad Re_v = \frac{GxD}{\mu_v}, \quad f = \frac{16}{Re} \text{ (viscous) or } 0.046\,Re^{-0.2} \text{ (turbulent)}$$

$$X^2 = \frac{f_l}{f_v}\left(\frac{1-x}{x}\right)^2 \frac{\rho_v}{\rho_l}, \quad \phi_l^2 = 1 + \frac{C}{X} + \frac{1}{X^2}, \quad \Delta p_{tp} = \phi_l^2\,\Delta p_l$$

Variables

p	Pressure (absolute)	Pa
x	Steam quality	-
C	Chisholm constant: 20 tt, 12 vt, 10 tv, 5 vv (liquid–vapour; t turbulent, v viscous)	-
G	Total mass flux	kg/(m²·s)
D	Tube inside diameter	m
Δp_l	Pressure drop of the liquid flowing alone	Pa
X	Martinelli parameter, in the form set by C	-

X_{tt}	X with both phases turbulent	-
$Re_l\$, \$Re_v$	Reynolds numbers of the liquid and the vapour flowing alone	-
$f\$, \$f_l\$, \$f_v$	Fanning friction factor; of the liquid and of the vapour flowing alone	-
$\rho_l\$, \$\rho_v$	Saturated liquid and vapour densities (IF97)	kg/m³
$\mu_l\$, \$\mu_v$	Saturated liquid and vapour viscosities (IAPWS 2008)	Pa·s
ϕ_l^2	Two-phase multiplier	-
Δp_{tp}	Two-phase frictional pressure drop	Pa

Method and standards

Lockhart–Martinelli separated-flow model with Chisholm's form of the liquid multiplier. The Martinelli parameter X is the square root of the ratio of the liquid-alone to the vapour-alone friction gradients, each with the viscous (16/Re) or turbulent (0.046 Re^−0.2) friction factor that the chosen C stands for, as Lockhart and Martinelli and Chisholm define it. Saturated-liquid and vapour properties from IAPWS-IF97 and IAPWS 2008. A note appears when the Reynolds numbers (viscous below 1000, turbulent above 2000) do not match the regime of C.

Assumptions and limits

- Separated-flow model.
- The form of X follows C (20, 12, 10 or 5); any other C uses the turbulent–turbulent form.

References

• Lockhart and Martinelli
• Chem. Eng. Prog. 45 (1949); Chisholm
• Int. J. Heat Mass Transfer 10 (1967): φ_l² = 1 + C/X + 1/X²; Collier and Thome
• Convective Boiling and Condensation; X_tt with IAPWS-IF97 densities and IAPWS 2008 viscosities

Report details

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

This calculator online

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