Shell-and-Tube Tube-Side Pressure Drop with Return and Nozzle Losses

Tube-side friction, entrance, exit and return losses by the velocity-head allowances, and nozzle losses, for regular or U-tube shell-and-tube exchangers.

Input parameters

Unit system: SI

Parameter	Value	Unit
Tube-side mass flow	216,000	kg/h
Tube inside diameter	15.700	mm
Number of tubes	400.00	
Number of tube passes	2.0000	
Tube length	6.0000	m
Density	995.00	kg/m³
Viscosity	0.75000	mPa·s
Viscosity ratio bulk to wall	1.1000	
Tube type	U-tubes	
Nozzle inside diameter	200.00	mm
Shells in series	1.0000	

Calculated results

Parameter	Value	Unit
Tube-side Reynolds number	32,439	
Tube velocity	1.5574	m/s
Tube-side mass flux	1,549.6	kg/(m²·s)
Darcy friction factor	0.028221	
Friction loss in the tubes	25.685	kPa
Velocity heads for entrance, exit and return losses	1.7000	
Entrance, exit and return losses	2.0514	kPa
Nozzle Reynolds number	509,296	
Nozzle losses (all shells)	2.7494	kPa
Total tube-side pressure drop	30.485	kPa

Notes for this case

- The allowances: turbulent 2n_p − 1.5 velocity heads (U-tubes 1.6n_p − 1.5); laminar with Re ≥ 500, 3.25n_p − 1.5 (U-tubes 2.38n_p − 1.5). Nozzles: 0.75 G_n²/ρ per shell turbulent, 1.5 G_n²/ρ laminar.

Formula and method

$$\Delta P_f = \frac{f n_p L G^2}{2 \rho D_i \phi}, \quad f = 0.4137 Re^{-0.2585}$$

$$\Delta P_r = \alpha_r \frac{G^2}{2\rho}, \quad \alpha_r = 2n_p - 1.5 \ (\text{turbulent}), \quad \Delta P_n = 0.75 N_s \frac{G_n^2}{\rho}$$

Variables

$\dot{m}$	Tube-side mass flow	kg/s
D_i	Tube inside diameter	m
n_t	Number of tubes	-
n_p	Number of tube passes	-
L	Tube length	m
ρ	Density	kg/m³
μ	Viscosity	Pa·s
μ/μ_w	Viscosity ratio bulk to wall	-
tubes	Tube type	-
D_n	Nozzle inside diameter	m
N_s	Shells in series	-
Re	Tube-side Reynolds number	-
V	Tube velocity	m/s
G	Tube-side mass flux	kg/(m²·s)
f	Darcy friction factor	-
ΔP_f	Friction loss in the tubes	Pa
α_r	Velocity heads for entrance, exit and return losses	-
ΔP_r	Entrance, exit and return losses	Pa
Re_n	Nozzle Reynolds number	-
ΔP_n	Nozzle losses (all shells)	Pa
ΔP_i	Total tube-side pressure drop	Pa

Method and standards

Darcy friction in the tubes plus velocity-head allowances for headers and nozzles.

Assumptions and limits

- Single-phase flow; viscosity correction (μ/μ_w)^0.14 turbulent, ^0.25 laminar.

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

https://calc.firecad.com/chemical/process-heat-exchangers/shell-tube-tube-side-pressure-drop

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.