Superheater Steam-Side Pressure Drop

Steam-side friction pressure drop of a superheater from steam flow, number of parallel tubes, bore, length and steam conditions (Darcy–Weisbach, IAPWS).

Method: Darcy–Weisbach with Colebrook–White friction factor; IAPWS R7-97 IF97; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam flow through the superheater	50,000	kg/h
Parallel tubes (elements)	60.000	
Tube inside diameter	38.000	mm
Length of one tube (with bends as equivalent length)	45.000	m
Tube roughness	0.046000	mm
Inlet pressure (absolute)	68.000	bar
Steam temperature in	300.00	°C
Steam temperature out	485.00	°C

Calculated results

Parameter	Value	Unit
Friction pressure drop	21.410	kPa
Mean steam velocity	8.2869	m/s
Reynolds number	321,919	
Darcy friction factor	0.021378	
Steam density at the mean temperature	24.630	kg/m³

Formula and method

$$v = \frac{\dot{m}/N}{\rho\,\pi d_i^2/4} \qquad Re = \frac{\rho v d_i}{\mu} \qquad \Delta p = f\,\frac{L}{d_i}\,\frac{\rho v^2}{2}$$

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\varepsilon/d_i}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)\ \text{(turbulent)}, \qquad f = \frac{64}{Re}\ \text{(laminar)}$$

Variables

$\dot{m}$	steam flow	kg/s
N	parallel tubes	–
d_i	tube bore	m
L	tube length	m
ε	roughness	m
p	inlet pressure	Pa
T_1	steam temperature in	K
T_2	steam temperature out	K
Δp	friction pressure drop	Pa
v	mean velocity	m/s
Re	Reynolds number	–
f	Darcy friction factor	–

ρ	steam density at mean temperature	kg/m³
μ	steam viscosity	Pa·s

Method and standards

Darcy–Weisbach with the Colebrook–White friction factor; steam density and viscosity from FireCAD's IAPWS-IF97 and IAPWS 2008 at the inlet pressure and mean temperature.

Assumptions and limits

- Friction only (no acceleration or header losses); properties at the arithmetic mean temperature and inlet pressure. The specific volume of steam is not linear in temperature and falls as the pressure drops, so for long or high-duty superheaters split them into sections.
- The steam entering must be dry saturated or superheated (not more than 1 K below saturation) and the outlet temperature not below the inlet.

References

- Darcy–Weisbach with Colebrook–White friction factor
- IAPWS R7-97 IF97
- IAPWS 2008 viscosity

Report details

Report reference	FCC-ETB2-4R6A (the same inputs always give the same reference)
Generated	17 November 2026, 19:37 UTC
Calculator	Superheater Steam-Side Pressure Drop
Method last reviewed	11 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 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

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Reopens the calculator with the inputs of this report.