Thermic Fluid Film Temperature (Dittus–Boelter)

Film (tube wall) temperature of a thermic fluid in a fired heater coil from bulk temperature, heat flux, tube size, velocity and fluid properties (Dittus–Boelter).

Method: Dittus–Boelter correlation (Dittus and Boelter 1930, as given by McAdams)

Input parameters

Unit system: SI

Parameter	Value	Unit
Bulk fluid temperature	290.00	°C
Heat flux at the tube inside wall	40.000	kW/m²
Tube inside diameter	50.000	mm
Fluid velocity in the tube	2.5000	m/s
Thermic fluid	Enter the properties below	
Density of the fluid	760.00	kg/m³
Specific heat of the fluid	2.6000	kJ/(kg·K)
Thermal conductivity of the fluid	0.10000	W/(m·K)
Kinematic viscosity of the fluid	0.60000	cSt

Calculated results

Parameter	Value	Unit
Film (inside wall) temperature	307.98	°C
Film temperature rise above bulk	17.977	K
Film heat transfer coefficient	2,225.1	W/(m²·K)
Reynolds number	208,333	
Prandtl number	11.856	
Nusselt number	1,112.5	

Notes for this case

- Compare the film temperature with the fluid maker's maximum film temperature.

Formula and method

$$Re = \frac{v\, d_i}{\nu} \qquad Pr = \frac{\rho\, \nu\, c_p}{k} \qquad Nu = 0.023\, Re^{0.8}\, Pr^{0.4} \qquad h = \frac{Nu\, k}{d_i}$$

$$\Delta T_f = \frac{q''}{h} \qquad T_f = T_b + \Delta T_f$$

Variables

T_b	bulk fluid temperature	K
q''	heat flux at the inside wall	W/m²
d_i	tube inside diameter	m
v	fluid velocity	m/s
fluid	fluid chosen, or properties entered	–
ρ	density	kg/m³
c_p	specific heat	J/(kg·K)
k	thermal conductivity	W/(m·K)

ν	kinematic viscosity	m²/s
T_f	film temperature	K
ΔT_f	film rise above bulk	K
h	film coefficient	W/(m²·K)
Re	Reynolds number	–
Pr	Prandtl number	–
Nu	Nusselt number	–

Method and standards

Dittus–Boelter correlation for fully developed turbulent flow in smooth tubes, with the Prandtl exponent 0.4 for a fluid being heated; fluid properties at the bulk temperature. Fluid properties: either typed in, or taken from the makers' published liquid tables for Therminol 55 (Eastman bulletin TF8994), Therminol VP-1 (Eastman bulletin TF9141), DOWTHERM A (Dow technical data sheet; no kinematic viscosity tabulated) and Therminol 66 (Eastman bulletin SFE-HTF-19853), interpolated linearly between the published points (viscosity linearly in its logarithm) and never extrapolated. More fluids will be added as their makers' tables are captured. With a tabulated fluid, the film temperature is checked against the maker's maximum film temperature (Therminol 55: 335 °C; Therminol VP-1: 430 °C; Therminol 66: 375 °C).

Assumptions and limits

- Turbulent flow (Re above about 10 000), 0.6 < Pr < 160; uniform flux; properties at bulk temperature with no wall-viscosity correction (a source of error for viscous oils at high flux).
- Below Re 10 000 no film temperature is shown, because Dittus–Boelter would under-predict it.
- DOWTHERM A is not offered here because the maker publishes no viscosity table for it; choose "enter the properties" and type its viscosity.

References

- Dittus–Boelter correlation (Dittus and Boelter 1930, as given by McAdams)

Report details

Report reference	FCC-4D05-P0VS (the same inputs always give the same reference)
Generated	17 November 2026, 19:37 UTC
Calculator	Thermic Fluid Film Temperature (Dittus–Boelter)
Method last reviewed	11 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	5 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

https://calc.firecad.com/boilers-power-plant/thermic-fluid-heaters/thermic-fluid-film-temperature

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Reopens the calculator with the inputs of this report.