Thermic Fluid System Heat-Up Time

Time to heat a thermic fluid system's fluid and steel from cold to operating temperature with a given heater output and heat loss, and the heat stored.

Method: Lumped energy balance with loss proportional to temperature rise (definitions)

Input parameters

Unit system: SI

Parameter	Value	Unit
Fluid volume in the system	12.000	m³
Mean fluid density	850.00	kg/m³
Mean fluid specific heat	2.3000	kJ/(kg·K)
Mass of steel heated (heater, pipes, vessels)	18.000	t
Steel specific heat	0.50000	kJ/(kg·K)
Start temperature	30.000	°C
Operating temperature	280.00	°C
Heater output	1,200.0	kW
Heat loss at operating temperature	40.000	kW
Maximum allowed heating rate	50.000	°C/h

Calculated results

Parameter	Value	Unit
Heat stored	2,254.2	kWh
Time limited by heater output	1.9105	h
Time limited by heating rate	5.0000	h
Heat-up time	5.0000	h

Notes for this case

- Heat loss taken proportional to temperature rise above the start. Fluid makers limit the rate (often 30–50 K/h) and require holding at about 100–120 °C to drive off moisture before going higher.

Formula and method

$$C = V_f \rho c_p + m_s c_s, \quad t_Q = \frac{C(T_2 - T_1)}{Q_l} \ln \frac{Q_h}{Q_h - Q_l}, \quad t_r = \frac{T_2 - T_1}{r_{max}}$$

Variables

V_f	Fluid volume in the system	m³
ρ	Mean fluid density	kg/m³
c_p	Mean fluid specific heat	J/(kg·K)
m_s	Mass of steel heated (heater, pipes, vessels)	kg
c_s	Steel specific heat	J/(kg·K)
T_1	Start temperature	K
T_2	Operating temperature	K
Q_h	Heater output	W
Q_l	Heat loss at operating temperature	W
r_{max}	Maximum allowed heating rate	K/s
E	Heat stored	J

t_Q	Time limited by heater output	s
t_r	Time limited by heating rate	s
t	Heat-up time	s

Method and standards

Lumped heat balance.

Assumptions and limits

- Uniform temperature; constant heater output.
- The heat loss is zero at the start temperature and rises in proportion to the temperature rise, reaching Q_l at the operating temperature. Starting from a warm system (above ambient) the losses are underestimated.

References

• Lumped energy balance with loss proportional to temperature rise (definitions)

Report details

Report reference	FCC-Z1KX-GGQ0 (the same inputs always give the same reference)
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Release checks	2 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-system-heat-up

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.