Steam Coil Area to Heat a Tank in a Given Time

Steam coil or jacket area needed to heat a batch of liquid from one temperature to another in a set time, with steam used and the peak steam flow.

Method: IAPWS-IF97; Batch heating with constant U (Kern)

Input parameters

Unit system: SI

Parameter	Value	Unit
Liquid in the tank	10.000	t
Specific heat of the liquid	4.1800	kJ/(kg·K)
Starting temperature	20.000	°C
Final temperature	80.000	°C
Heat-up time wanted	2.0000	h
Overall heat transfer coefficient of the coil	800.00	W/(m²·K)
Steam pressure in the coil (absolute, saturated)	4.0000	bar

Calculated results

Parameter	Value	Unit
Coil area needed	4.8211	m²
Steam used for the batch	1,175.6	kg
Average steam flow	587.81	kg/h
Peak steam flow at the start	804.53	kg/h
Steam saturation temperature	143.61	°C

Notes for this case

- Tank heat losses and the tank's own steel are not included; add a margin, and size the steam supply and trap for the peak flow.

Formula and method

$$A = \frac{m\,c_p}{U\,t}\ln\frac{T_s - T_0}{T_s - T_1} \qquad m_s = \frac{m\,c_p(T_1 - T_0)}{h_{fg}} \qquad \dot{m}_{s,0} = \frac{UA(T_s - T_0)}{h_{fg}}$$

Variables

m	liquid mass	kg
c_p	liquid specific heat	J/(kg·K)
T_0	start temperature	K
T_1	final temperature	K
t	heat-up time	s
U	overall coefficient	W/(m²·K)
p_s	steam pressure	Pa
A	coil area	m²
m_s	steam for the batch	kg
$\dot{m}_s$	average steam flow	kg/s
$\dot{m}_{s,0}$	peak steam flow	kg/s
T_s	steam saturation temperature	K
h_{fg}	latent heat	J/kg

Method and standards

Unsteady batch heating with a condensing medium at constant temperature and constant U, integrated exactly; steam properties from IAPWS-IF97.

Assumptions and limits

- Well-mixed liquid; condensate leaves saturated; no losses.
- The coil is at the steam pressure entered. A control valve ahead of the coil lowers the pressure and the steam temperature in the coil: enter the pressure in the coil, not the supply pressure.

References

- IAPWS-IF97
- Batch heating with constant U (Kern)

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/boilers-power-plant/steam/tank-heating-coil

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.