Heat Loss Through a Spherical Shell

Heat flow and surface temperature of an insulated spherical vessel from radii, conductivity and inside and outside coefficients, with the critical radius.

Method: Radial conduction in a sphere; R = (1/r_1 − 1/r_2)/(4πk) (Incropera, DeWitt, Bergman and Lavine, Fundamentals of Heat and Mass Transfer, ch. 3)

Input parameters

Unit system: SI

Parameter	Value	Unit
Inside temperature	150.00	°C
Ambient temperature	25.000	°C
Inner radius of the insulation	1.0000	m
Outer radius of the insulation	1.1000	m
Insulation conductivity	0.050000	W/(m·K)
Inside coefficient	500.00	W/(m²·K)
Outside coefficient	10.000	W/(m²·K)

Calculated results

Parameter	Value	Unit
Heat flow	825.51	W
Outer surface temperature	30.429	°C
Critical radius 2k/h_o	10.000	mm

Formula and method

$$\dot{Q} = \frac{T_i - T_a}{\frac{1}{4\pi r_1^2 h_i} + \frac{1/r_1 - 1/r_2}{4\pi k} + \frac{1}{4\pi r_2^2 h_o}}, \quad T_s = T_a + \frac{\dot{Q}}{4\pi r_2^2 h_o}, \quad r_{cr} = \frac{2k}{h_o}$$

Variables

T_i	Inside temperature	K
T_a	Ambient temperature	K
r_1	Inner radius of the insulation	m
r_2	Outer radius of the insulation	m
k	Insulation conductivity	W/(m·K)
h_i	Inside coefficient	W/(m²·K)
h_o	Outside coefficient	W/(m²·K)
$\dot{Q}$	Heat flow	W
T_s	Outer surface temperature	K
r_{cr}	Critical radius 2k/h_o	m

Method and standards

Steady radial conduction.

Assumptions and limits

- Steady, uniform insulation.
- The critical radius is compared with r_1 and r_2: below it, more insulation increases the loss, and the page warns (this matters only for small spheres or poor insulation).

References

- Radial conduction in a sphere
- $R = (1/r_1 - 1/r_2)/(4\pi k)$ (Incropera, DeWitt, Bergman and Lavine, Fundamentals of Heat and Mass Transfer, ch. 3)

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/mechanical/heat-transfer/sphere-conduction

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Reopens the calculator with the inputs of this report.