Resistance Heating Element: Wire Length and Surface Load

Hot and cold resistance, wire length, surface loading and mass of a resistance heating element for a power and voltage, from wire diameter and resistivity.

Method: Resistance and surface loading of heating elements

Input parameters

Unit system: SI

Parameter	Value	Unit
Element power	2.0000	kW
Supply voltage	230.00	V
Wire diameter	0.60000	mm
Resistivity at 20 °C	1.0900	Ω·mm²/m
Hot/cold resistance factor at operating temperature	1.0400	
Wire density	8,400.0	kg/m³

Calculated results

Parameter	Value	Unit
Resistance at operating temperature	26.450	Ω
Resistance at 20 °C	25.433	Ω
Wire length	6.5972	m
Surface loading	16.083	W/cm²
Wire mass	15.669	g
Current	8.6957	A

Notes for this case

• The element must have R = V²/P at its working temperature. Its cold resistance is that divided by the alloy's temperature factor C_t (about 1.02–1.07 for NiCr 80/20 at 600–1,000 °C, larger for FeCrAl and much larger for pure metals), and the length follows from R = ρL/A. Surface loading P/(πdL) decides the wire temperature and life: a few W/cm² for open coils in still air, 10–20 W/cm² in forced air or sheathed elements, more for immersion. A thicker wire gives a longer element and lower surface loading.

Formula and method

$$R_{hot} = \frac{V^2}{P}, \quad L = \frac{R_{hot}}{C_t}\frac{\pi d^2}{4\rho_{20}}, \quad q = \frac{P}{\pi d L}$$

Variables

P	Element power	W
V	Supply voltage	V
d	Wire diameter	m
ρ_{20}	Resistivity at 20 °C	Ω·m
C_t	Hot/cold resistance factor at operating temperature	-
ρ_m	Wire density	kg/m³
R_{hot}	Resistance at operating temperature	Ω
R_{20}	Resistance at 20 °C	Ω
L	Wire length	m
q	Surface loading	W/m²
m	Wire mass	kg

I	Current	A

Method and standards

Heater wire.

Assumptions and limits

- Uniform wire; steady operating temperature.

References

Resistance and surface loading of heating elements

Report details

Report reference	FCC-X1RG-N5MW (the same inputs always give the same reference)
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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

https://calc.firecad.com/electrical/circuits/heating-element-wire-length

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.