EXAMPLES

Tubular element for a flat iron	
Rating, P	1,000 W
Voltage, U	220 V
Final tube diameter	8 mm (0.315 in)
Final tube length	300 mm (11.8 in)

If the terminal length inside the tube is 2 × 25 mm the coil length (L_e) will be
L_e = 300 mm – (2 × 25 mm) = 250 mm (9.8 in).

Hot resistance based on equation [8] and [9]

$$R = \frac{U^2}{P} = \frac{220^2}{1{,}000} = 48.4\ \Omega$$

Tubes surface load based on equation [5]

$$p_{tube} = \frac{P}{A_{tube}} = \frac{P}{0.01 \times \pi d_{tube} \times L_e} =$$

$$\frac{1{,}000}{0.01 \times \pi \times 8 \times 250} = 15.91\ W/cm^2\ (103\ W/in^2)$$

$$p_{wire} = 3 \times p_{tube} \qquad [20]$$

Wire surface load inside tube. Factor 3 is used as a rule of thumb:

$$p_{tube} = \frac{P}{A_{tube}} = \frac{P}{0.01 \times \pi d_{tube} \times L_e} =$$

$$\frac{1{,}000}{0.01 \times \pi \times 8 \times 250} = 15.91\ W/cm^2\ (103\ W/in^2)$$

Wire surface based on equation [5]

$$p_{wire} = 3 \times p_{tube} = 3 \times 15.91 =$$

$$47.74 \approx 48\ W/cm^2\ (309\ W/in^2)$$

Kanthal® D is a sensible choice and an average wire temperature of 700°C (1,290°F) likely. Due to temperature factor of resistance C_t = 1.05 for Kanthal® D.

Resistance at room temperature based on equation [2]

$$R_T = C_t R_{20} \Rightarrow R_{20} = \frac{R_T}{C_t} = \frac{48.4}{1.05} = 46.09 \approx 46.1\ \Omega$$

The ratio between wire surface and resistance is:

$$\eta = \frac{A_c}{R_{20}} = \frac{20.83}{46.1} = 0.452\ cm^2/\Omega\ \ (0.070\ in^2/\Omega)$$

This is corresponding to a wire size of about 0.3 mm (0.012 in).

We assume that a steel tube of initially 9.5 mm (0.37 in) diameter is being used and can then expect a resistance reduction of about 30% upon rolling.

The resistance of the coil should therefore be about 65.3 Ω. The wire surface prior to compression is 7% bigger, or 22.5 cm^2 (3.49 in^2), and the ratio between wire surface and resistance 0.34 cm^2/Ω (0.053 in^2/Ω).

The corresponding wire size is 0.26 mm (0.01 in). Tests with this wire size have to be made in order to check the resistance reduction as a result of compression.

Coil suspended on a Mica-cross, element for a hair dryer

Rating, P	350 W
Voltage, U	55 V
Length of coil, l	250 mm (9.8 in)
Coil outer diameter, D	6 mm (0.236 in)

For this application a surface load, p, of 7 W/cm^2 (45.16 W/in^2) is reasonable.

Wire surface based on equation [5]

$$p = \frac{P}{A_c} \Rightarrow A_c = \frac{P}{p} = \frac{350}{7} = 50\ \mathrm{cm}^2\ (7.75\ \mathrm{in}^2)$$

Assuming a wire temperature of 600°C (1,110°F) and choosing Kanthal D with an C_t value of 1.04.

Hot- and cold resistance based on combining equations [8], [9] and [2]

$$R_T = \frac{U^2}{P} = \frac{55^2}{350} = 8.64\ \Omega$$

$$R_{20} = \frac{R_T}{C_t} = 8.31\ \Omega$$

By calculating the surface area to cold resistance ratio, a suitable wire dimension is found, combining [1'] and [6'], [7']

Wire

$$\frac{A_c}{R_{20}} = \frac{50\ \mathrm{cm}^2}{8.31\ \Omega} = 6.01\ \mathrm{cm}^2/\Omega\ \ (0.93\ \mathrm{in}^2/\Omega$$

According to table for Kanthal D Ø 0.70 mm (0.0276 in) has an surface area to resistance ratio of 6.27 cm^2/Ω (0.97 in^2/Ω).

D/d ratio has to be considered since too low as well as too high values will create problems in the coiling process. Verifying the geometry of the coil, suitable values for the D/d ratio should be between 6 and 12. In this case:

$$\frac{D}{d} = \frac{6\ \mathrm{mm}}{0.7\ \mathrm{mm}} = 8.6$$

Length of wire is calculated as the ratio between resistance needed and resistance per meter (table on page 48, Kanthal D, d = 0.7 mm)

$$R_{20/m} = 3.51\ \Omega/\mathrm{m}$$

Wire length:

$$\ell = \frac{R_{20}}{R_{20/m}} = \frac{8.31\ \Omega}{3.51\ \ \Omega/\mathrm{m}} = 2.367\ \mathrm{m}$$

Coil pitch, s, based on equation [17]

$$s = \frac{\pi(D - d)L_e}{\ell} = \frac{\pi(7 - 0.7) \times 250}{2370} = 2.09\ \mathrm{mm}$$

Relative pitch based on equation [18]

$$r = \frac{s}{d} = \frac{2.09}{0.7} = 2.98$$

Surface load based on [5]

$$p = \frac{P}{A_{C/m}\ell} = \frac{350}{22 \times 2.37} = 6.7\ \mathrm{W/cm}^2$$