



# TEMPERATURE GRADIENT CONVERSIONS

## Conversions for trench heaters with natural convection FK

The heat output of individual trench heaters is determined by measuring nominal operating (temperature) conditions of 75/65/20 °C ( $t_1/t_2/t_i$ ) in accordance with EN 16430. In accordance with these principle values for trench heaters, further temperature gradients of 65/55/20 °C and 55/45/20 °C were achieved by converting corresponding heat outputs as listed in this catalogue. Where heating units are designed for other thermal conditions, the following conversions will be necessary:

$$1 \quad \Delta t = \frac{(t_1 + t_2)}{2} - t_i$$

$$3 \quad Q = f \cdot Q_n$$

$$2 \quad f = \left( \frac{\Delta t}{50} \right)^n$$

$$4 \quad m = 0.86 \cdot \frac{Q}{t_1 - t_2}$$

|            |        |                                         |
|------------|--------|-----------------------------------------|
| $t_1$      | [°C]   | input water temperature                 |
| $t_2$      | [°C]   | output water temperature                |
| $t_i$      | [°C]   | ambient air temperature                 |
| $\Delta t$ | [K]    | temperature gradient                    |
| $n$        | [-]    | temperature exponent                    |
| $f$        | [-]    | conversion coefficient                  |
| $Q_n$      | [W]    | nominal heat output at 75/65/20 °C      |
| $Q$        | [W]    | heat output at new temperature gradient |
| $m$        | [kg/h] | mass flow rate                          |

## Example

### Values given:

- trench heater FK 200/11/26
- input water temperature  $t_1 = 60$  °C
- nominal output  $Q_n = 618$  W
- output water temperature  $t_2 = 50$  °C
- temperature exponent  $n = 1.4385$
- ambient air temperature  $t_i = 22$  °C

### Solution

To achieve 60/50/22 °C operating conditions, calculate temperature gradient  $\Delta t$  according to formula 1 and conversion coefficient value  $f$  according to formula 2

$$1 \quad \Delta t = \frac{(t_1 + t_2)}{2} - t_i = \frac{(60 + 50)}{2} - 22 = 33 \text{ K}$$

Temperature exponent  $n$  for the required trench heater dimensions can be found in the heat output table. The table also shows coefficient  $f$  for selected temperature gradients.

$$2 \quad f = \left( \frac{\Delta t}{50} \right)^n = \left( \frac{33}{50} \right)^{1.4385} = 0.55$$

Heat output for required temperature gradient is calculated as follows:

$$3 \quad Q = f \cdot Q_n = 0.55 \cdot 618 = 340 \text{ W}$$

## Conversion coefficient $f$ for selected temperature gradients for ambient air temperature of 20 °C

| Depth [mm]                                 | 90/70 °C | 85/75 °C | 70/50 °C | 50/40 °C | 45/35 °C |
|--------------------------------------------|----------|----------|----------|----------|----------|
| KORAFLEX FKT, FKB, FKP, FKO – width 140 mm |          |          |          |          |          |
| 60                                         | 1.2682   | 1.2682   | 0.7477   | 0.4053   | 0.3030   |
| 70                                         | 1.3057   | 1.3057   | 0.7215   | 0.3628   | 0.2617   |
| 90                                         | 1.3205   | 1.3205   | 0.7116   | 0.3476   | 0.2473   |
| 110                                        | 1.3119   | 1.3119   | 0.7173   | 0.3563   | 0.2556   |

|                                       |        |        |        |        |        |
|---------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKB, FKP, FKO – width 140 mm |        |        |        |        |        |
| 130                                   | 1.3352 | 1.3352 | 0.7020 | 0.3332 | 0.2339 |
| 150                                   | 1.3258 | 1.3258 | 0.7081 | 0.3422 | 0.2423 |

|                                            |        |        |        |        |        |
|--------------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKT, FKB, FKP, FKO – width 200 mm |        |        |        |        |        |
| 60                                         | 1.3278 | 1.3278 | 0.7068 | 0.3403 | 0.2405 |
| 70                                         | 1.3047 | 1.3047 | 0.7222 | 0.3638 | 0.2627 |
| 90                                         | 1.3235 | 1.3235 | 0.7096 | 0.3445 | 0.2445 |
| 110                                        | 1.3083 | 1.3083 | 0.7197 | 0.3600 | 0.2591 |

|                                       |        |        |        |        |        |
|---------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKB, FKP, FKO – width 200 mm |        |        |        |        |        |
| 130                                   | 1.3180 | 1.3180 | 0.7133 | 0.3501 | 0.2497 |
| 150                                   | 1.3272 | 1.3272 | 0.7072 | 0.3408 | 0.2410 |
| 190                                   | 1.3209 | 1.3209 | 0.7113 | 0.3471 | 0.2469 |

|                                            |        |        |        |        |        |
|--------------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKT, FKB, FKP, FKO – width 260 mm |        |        |        |        |        |
| 60                                         | 1.3872 | 1.3872 | 0.6699 | 0.2881 | 0.1930 |
| 70                                         | 1.3423 | 1.3423 | 0.6974 | 0.3265 | 0.2277 |
| 90                                         | 1.3300 | 1.3300 | 0.7053 | 0.3381 | 0.2385 |
| 110                                        | 1.2999 | 1.2999 | 0.7254 | 0.3690 | 0.2676 |

|                                       |        |        |        |        |        |
|---------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKB, FKP, FKO – width 260 mm |        |        |        |        |        |
| 130                                   | 1.3406 | 1.3406 | 0.6986 | 0.3281 | 0.2292 |
| 150                                   | 1.3203 | 1.3203 | 0.7117 | 0.3477 | 0.2475 |
| 190                                   | 1.3141 | 1.3141 | 0.7158 | 0.3540 | 0.2534 |
| 300                                   | 1.3102 | 1.3102 | 0.7184 | 0.3580 | 0.2572 |
| 450                                   | 1.3044 | 1.3044 | 0.7224 | 0.3641 | 0.2630 |

|                                            |        |        |        |        |        |
|--------------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKT, FKB, FKP, FKO – width 320 mm |        |        |        |        |        |
| 60                                         | 1.3580 | 1.3580 | 0.6876 | 0.3124 | 0.2148 |
| 70                                         | 1.3278 | 1.3278 | 0.7068 | 0.3403 | 0.2405 |
| 90                                         | 1.3050 | 1.3050 | 0.7220 | 0.3635 | 0.2625 |
| 110                                        | 1.3055 | 1.3055 | 0.7216 | 0.3629 | 0.2619 |

|                                       |        |        |        |        |        |
|---------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKB, FKP, FKO – width 320 mm |        |        |        |        |        |
| 130                                   | 1.3148 | 1.3148 | 0.7154 | 0.3533 | 0.2527 |
| 150                                   | 1.3185 | 1.3185 | 0.7129 | 0.3495 | 0.2492 |
| 190                                   | 1.3213 | 1.3213 | 0.7110 | 0.3467 | 0.2465 |
| 300                                   | 1.3090 | 1.3090 | 0.7192 | 0.3593 | 0.2584 |
| 450                                   | 1.3109 | 1.3109 | 0.7180 | 0.3573 | 0.2565 |

|                                       |        |        |        |        |        |
|---------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKB, FKP, FKO – width 400 mm |        |        |        |        |        |
| 70                                    | 1.3202 | 1.3202 | 0.7118 | 0.3478 | 0.2476 |
| 90                                    | 1.3051 | 1.3051 | 0.7218 | 0.3633 | 0.2623 |
| 110                                   | 1.3042 | 1.3042 | 0.7225 | 0.3643 | 0.2632 |

|                                       |        |        |        |        |        |
|---------------------------------------|--------|--------|--------|--------|--------|
| KORAFLEX FKB, FKP, FKO – width 400 mm |        |        |        |        |        |
| 130                                   | 1.3174 | 1.3174 | 0.7136 | 0.3506 | 0.2502 |
| 150                                   | 1.3216 | 1.3216 | 0.7108 | 0.3464 | 0.2462 |
| 190                                   | 1.3224 | 1.3224 | 0.7103 | 0.3456 | 0.2455 |
| 300                                   | 1.3082 | 1.3082 | 0.7198 | 0.3601 | 0.2592 |
| 450                                   | 1.3077 | 1.3077 | 0.7201 | 0.3607 | 0.2597 |