Power distribution

Rated currents of busbars E-Cu (DIN 43 671)

DIN 43 671 specifies the continuous currents for busbars at an ambient temperature of 35°C and an average busbar temperature of 65°C. With the aid of a correction factor (k_2), the continuous currents specified in the following table may be adjusted to alternative operating temperatures.

For safe operation with thermal reserve, it is advisable to limit the busbar temperature to a maximum of 85°C. However, the decisive factor is the lowest permissible continuous temperature of the components which directly contact the busbar system (fuse bases, outgoing cables etc.). The ambient air temperature of the busbars or busbar system should not exceed 40°C; an average of 35°C maximum is recommended.

For the continuous temperatures specified in the table, an emission level of 0.4 applies, equivalent to an oxidating copper bar. In modern busbar systems – built into enclosures with a protection category of IP 54 and above – a more favourable emission level can be assumed. The lower emission level facilitates an additional increase in continuous currents compared with the figures in DIN 43 671, irrespective of the specified air and busbar temperature. Experience indicates an increase in the continuous current of 6 – 10% compared with the table figures for uncoated copper bars, and 60% for surface-oxidised copper bars.

Example:
For a Cu bar 30 x 10 mm (E-Cu F30), DIN 43 671 specifies a constant current of I_{N65} = 573 A.
The correction factor diagram indicates a correction factor of k_2 = 1.29 for square cross-sections at 35°C air temperature and 85°C bar temperature. Thanks to the more favourable emission level, the continuous current is increased by a further 6 – 10%. In this example, a mean value of 8% is used. Compared with the table figure from DIN 43 671, the Rittal rated current specification for a Cu bar 30 x 10 mm is:

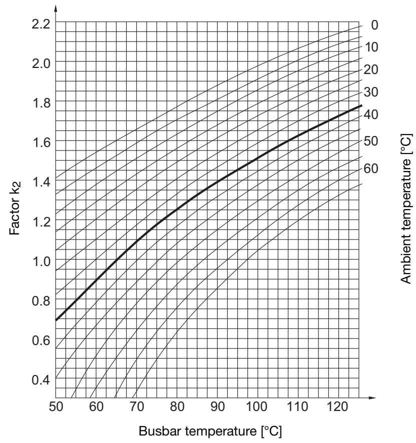
$$\mathbf{I_{N85} = I_{N65} \cdot k_2 + 8\%}$$
$$\mathbf{= 573\ A \cdot 1.29 \cdot 1.08}$$
$$\mathbf{I_{N85} = 800\ A}$$

Continuous currents for busbars
Made from E-Cu with square cross-section in indoor locations at 35°C air temperature and 65°C bar temperature, vertical position or horizontal position of the bar width.

Width x thickness mm	Cross section mm²	Weight[1]	Material[2]	Continuous current in A			
				AC current up to 60 Hz		DC current + AC current 16 Hz	
				Bare bar	Coated bar	Bare bar	Coated bar
12 x 2	23.5	0.209		108	123	108	123
15 x 2	29.5	0.262		128	148	128	148
15 x 3	44.5	0.396		162	187	162	187
20 x 2	39.5	0.351		162	189	162	189
20 x 3	59.5	0.529		204	237	204	237
20 x 5	99.1	0.882		274	319	274	320
20 x 10	199.0	1.770		427	497	428	499
25 x 3	74.5	0.663		245	287	245	287
25 x 5	124.0	1.110		327	384	327	384
30 x 3	89.5	0.796		285	337	286	337
30 x 5	149.0	1.330		379	447	380	448
30 x 10	299.0	2.660	E-Cu F30	573	676	579	683
40 x 3	119.0	1.060		366	435	367	436
40 x 5	199.0	1.770		482	573	484	576
40 x 10	399.0	3.550		715	850	728	865
50 x 5	249.0	2.220		583	697	588	703
50 x 10	499.0	4.440		852	1020	875	1050
60 x 5	299.0	2.660		688	826	696	836
60 x 10	599.0	5.330		985	1180	1020	1230
80 x 5	399.0	3.550		885	1070	902	1090
80 x 10	799.0	7.110		1240	1500	1310	1590
100 x 10	999.0	8.890		1490	1810	1600	1940

[1] Calculated with a density of 8.9 kg/dm³
[2] Reference basis for the continuous current levels (figures taken from DIN 43 671)

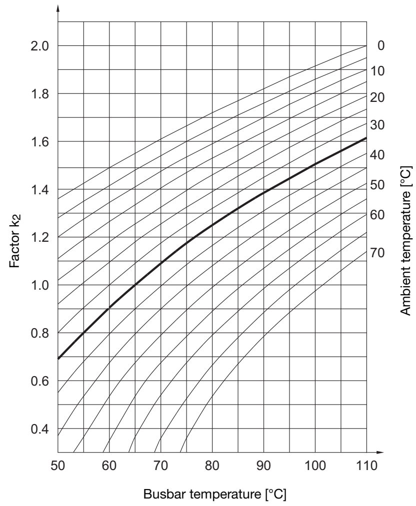
Correction factor diagram to DIN 43 671



Rittal PLS current load
According to DIN 43 671, the correction factor k_2 (correction factor diagram) is used to correct the basic rated current with reference to the existing temperatures of the ambient air and the busbar. In accordance with DIN 43 671, the load figures of the Rittal PLS special bars have been determined on the basis of measurement trials, as follows:

PLS special busbars	Rated current AC 50/60 Hz	
	for 35/75°C	for 35/65°C (basic value)
PLS 800	800 A	684 A
PLS 1600	1600 A	1368 A

Correction factor diagram for PLS



Rated currents of busbars E-Cu (DIN 43 671)

In addition to the rated currents for copper busbars to DIN 43 671, the following table lists additional values for rated currents of Flat-PLS busbar systems with bare copper bars for AC currents up to 60 Hz.

These values were determined on Flat-PLS busbars fitted in enclosures with various protection categories, as well as with and without forced ventilation. Depending on the busbar system and protection category, two figures are given, representing the rated current at an overtemperature of 30 K and 70 K. In contrast to the rated currents to DIN 43 671, the temperature outside the enclosure is measured as the ambient temperature here.

The benefit of this approach is that the enclosure housing, which may exert a major influence on the busbar system, is taken into account in the ratings data for the busbar system. Designing a busbar system to DIN 43 671 without consideration of the enclosure housing may lead to thermal problems in the enclosure interior, particularly with higher currents.

Although IEC 61 439-1 permits higher overtemperature limits than 70 K, the absolute busbar temperature at an ambient temperature of 35°C and 70 K overtemperature limit is 105°C. This figure of 105°C is high, but significantly below the thermal softening of copper material, and therefore acceptable.

Example:
If a rated current is used at an overtemperature of 30 K, this means that the temperature of the busbars is 30 K above the ambient temperature of the enclosure. Expressed in absolute figures, therefore, at an ambient temperature of 35°C around the enclosure housing, this produces a maximum absolute busbar temperature of 65°C.

Rated AC currents of Flat-PLS busbar system up to 60 Hz for bare copper bars (E-Cu F30) in A

Design of Flat-PLS busbar system	Protection category of enclosure										
	Ri4Power DIN 43 671	IP 2X with forced ventilation[1)]		IP 2X		IP 43		IP 54 with forced ventilation[2)]		IP 54	
	ΔT = 30 K	ΔT = 30 K	ΔT = 70 K	ΔT = 30 K	ΔT = 70 K	ΔT = 30 K	ΔT = 70 K	ΔT = 30 K	ΔT = 70 K	ΔT = 30 K	ΔT = 70 K
2 x 40 x 10 mm	1290	1780	2640	1180	1900	1080	1720	1680	2440	1040	1640
3 x 40 x 10 mm	1770	2240	3320	1420	2320	1280	2040	1980	2960	1200	1920
4 x 40 x 10 mm	2280	2300	3340	1460	2380	1320	2100	2080	3020	1260	2000
2 x 50 x 10 mm	1510	2200	3260	1340	2140	1200	1920	1980	2920	1140	1800
3 x 50 x 10 mm	2040	2660	3900	1580	2540	1400	2240	2320	3440	1320	2100
4 x 50 x 10 mm	2600	2700	4040	1640	2660	1440	2340	2360	3500	1380	2220
2 x 60 x 10 mm	1720	2220	3340	1440	2300	1280	2060	2020	2940	1200	1920
3 x 60 x 10 mm	2300	2700	4120	1720	2780	1540	2440	2400	3520	1440	2260
4 x 60 x 10 mm	2900	2740	4220	1740	2840	1580	2540	2420	3580	1460	2360
2 x 80 x 10 mm	2110	2760	4160	1740	2840	1600	2560	2540	3720	1480	2360
3 x 80 x 10 mm	2790	3300	5060	2000	3260	1840	2960	3060	4520	1680	2700
4 x 80 x 10 mm	3450	3680	5300	2060	3440	1900	3060	3220	4880	1780	2820
2 x 100 x 10 mm	2480	3240	4840	1920	3200	1800	2880	2900	4340	1660	2660
3 x 100 x 10 mm	3260	3580	5400	2200	3720	1980	3240	3320	4880	1920	2980
4 x 100 x 10 mm	3980	3820	5500	2320	3820	2000	3400	3380	4900	1960	3120

1) For I_N < = 2000 A using fan-and-filter unit SK 3243.100,
for I_N > 2000 A using fan-and-filter unit SK 3244.100
2) For I_N < = 2000 A using fan-and-filter unit SK 3243.100 and outlet filter SK 3243.200,
for I_N > = 2000 A using fan-and-filter unit SK 3244.100 and outlet filter SK 3243.200

For calculating rated currents at temperatures between the overtemperature limits of Flat-PLS busbar systems, the correction factor diagram may be used. If data is available regarding the maximum ambient temperature and the maximum bar temperature, a correction factor k_2 may be calculated using the correction factor diagram. With a correction factor k_2 and a specified rated current at 30 K overtemperature limit, the new rated current is calculated.

Example:
Flat-PLS 100 busbar system
with 4 x 100 x 10 mm

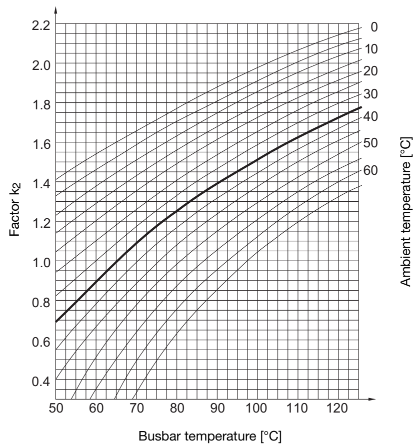
I_{N30} at IP 2X = 2320 A
Ambient temperature = 35°C
Busbar temperature = 85°C

From the diagram, this produces a factor k_2 = 1.29

The new rated current under these conditions is then calculated as follows:

$$\mathbf{I_N = I_{N30} \cdot k_2 = 2320\ A \cdot 1.29 = 2992\ A}$$

Correction factor diagram



Calculation of heat loss in busbars

The heat loss of busbars can be calculated using the following equation, provided the AC current resistance is known:

$$P_v = \frac{I_B^2 \cdot r \cdot l}{1000}$$

P_v [W] heat loss

I_B [A] operating current

r [mΩ/m] AC or DC current resistance of busbar

l [m] length of busbar which I_B flows through

In order to calculate the heat loss in accordance with the above formula, in individual cases it can be assumed that the rated current of a circuit and/or the "operating currents" of the busbar sections and the corresponding length of the conductor system in the installation or distributor are known. By contrast, the resistance of conductor systems – particularly the AC current resistance of busbar arrangements – cannot simply be taken from a document or determined yourself.

For this reason, and in order to obtain comparable results when determining heat losses, the table shows the resistance values in mΩ/m for the most common cross-sections of copper busbars.

AC current resistance of busbars made from E-Cu 57

Dimensions[1]	Resistance per 1 m of busbar system in mΩ/m[2]							
	I 1 main conductor		III 3 main conductors		II II II 3 x 2 main conductors		III III III 3 x 3 main conductors	
mm	**r**$_{GS}$[1] (65°C)	**r**$_{WS}$[2] (65°C)	**r**$_{GS}$[1] (65°C)	**r**$_{WS}$[2] (65°C)	**r**$_{GS}$[1] (65°C)	**r**$_{WS}$[2] (65°C)	**r**$_{GS}$[1] (65°C)	**r**$_{WS}$[2] (65°C)
1	2	3	4	5	6	7	8	9
12 x 2	0.871	0.871	2.613	2.613				
15 x 2	0.697	0.697	2.091	2.091				
15 x 3	0.464	0.464	1.392	1.392				
20 x 2	0.523	0.523	1.569	1.569				
20 x 3	0.348	0.348	1.044	1.044				
20 x 5	0.209	0.209	0.627	0.627				
20 x 10	0.105	0.106	0.315	0.318	0.158	0.160		
25 x 3	0.279	0.279	0.837	0.837	0.419	0.419		
25 x 5	0.167	0.167	0.501	0.501	0.251	0.254		
30 x 3	0.348	0.348	1.044	1.044	0.522	0.527		
30 x 5	0.139	0.140	0.417	0.421	0.209	0.211		
30 x 10	0.070	0.071	0.210	0.214	0.105	0.109		
40 x 3	0.174	0.174	0.522	0.522	0.261	0.266		
40 x 5	0.105	0.106	0.315	0.318	0.158	0.163		
40 x 10	0.052	0.054	0.156	0.162	0.078	0.084	0.052	0.061
50 x 5	0.084	0.086	0.252	0.257	0.126	0.132	0.084	0.092
60 x 5	0.070	0.071	0.210	0.214	0.105	0.112	0.070	0.079
60 x 10	0.035	0.037	0.105	0.112	0.053	0.062	0.035	0.047
80 x 5	0.052	0.054	0.156	0.162	0.078	0.087	0.052	0.062
80 x 10	0.026	0.029	0.078	0.087	0.039	0.049	0.026	0.039
100 x 5	0.042	0.045	0.126	0.134	0.063	0.072	0.042	0.053
100 x 10	0.021	0.024	0.063	0.072	0.032	0.042	0.021	0.033
120 x 10	0.017	0.020	0.051	0.060	0.026	0.036	0.017	0.028

[1] **r**$_{GS}$ DC current resistance of busbar system in mΩ/m
[2] **r**$_{WS}$ AC current resistance of busbar system in mΩ/m

The resistance values shown in the table are based on an assumed average busbar temperature of 65°C (ambient temperature + self-heating) and therefore on a specific resistance of

$$\rho\ (65°C) = 20.9 \left[\frac{m\Omega \cdot mm^2}{m}\right]$$

Example: r$_{GS}$ for 1 main conductor 12 x 2 mm

$$r_{GS} = \frac{\rho\ (65°C) \cdot l}{A} = \frac{20.9 \left[\frac{m\Omega \cdot mm^2}{m}\right] \cdot 1\ m}{24\ mm^2} = 0.871\ m\Omega$$

For busbar temperatures other than 65°C, the resistance may be calculated as follows:

Positive temperature deviation
$r_{(x)} = r_{(65°C)} \cdot (1 + \alpha \cdot \Delta\theta)$

Negative temperature deviation
$r_{(x)} = r_{(65°C)} \cdot (1 - \alpha \cdot \Delta\theta)$

$r_{(x)}$ [mΩ/m] resistance at any chosen temperature

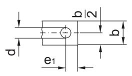
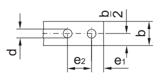
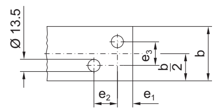
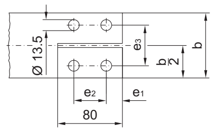
α $\left[\frac{1}{K}\right]$ Temperature coefficient (for Cu = $0.004 \frac{1}{K}$)

Δθ [K] Temperature difference in relation to the resistance value at 65°C

ρ $\left[\frac{m\Omega \cdot mm^2}{m}\right]$ Specific resistance

Busbar screw connections to DIN 43 673

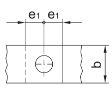
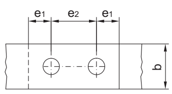
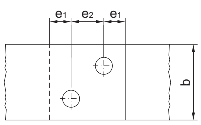
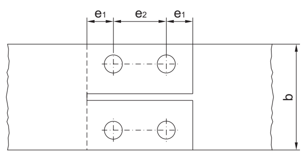
Drilling patterns and drilled holes

Busbar widths mm		12 to 50		25 to 60			60			80 to 100		
Form[1]		1		2			3			4		
Drilled holes in the bar ends (drilling pattern)												
	Nominal width b	d	e_1	d	e_1	e_2	e_1	e_2	e_3	e_1	e_2	e_3
Hole size	**12**	5.5	6	–	–	–	–	–	–	–	–	–
	15	6.6	7.5	–	–	–	–	–	–	–	–	–
	20	9.0	10	–	–	–	–	–	–	–	–	–
	25	11	12.5	11	12.5	30	–	–	–	–	–	–
	30	11	15	11	15	30	–	–	–	–	–	–
	40	13.5	20	13.5	20	40	–	–	–	–	–	–
	50	13.5	25	13.5	20	40	–	–	–	–	–	–
	60	–	–	13.5	20	40	17	26	26	–	–	–
	80	–	–	–	–	–	–	–	–	20	40	40
	100	–	–	–	–	–	–	–	–	20	40	50
Permissible deviations for hole-centre distances ± 0.3 mm												

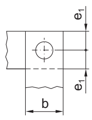
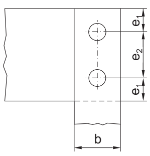
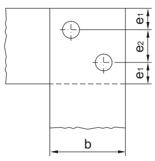
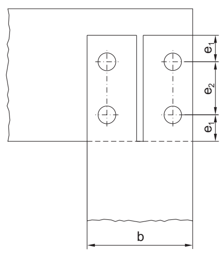
[1] Shape designations 1 – 4 match DIN 46 206, part 2 – Flat-type screw terminal

Examples of busbar screw connections

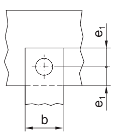
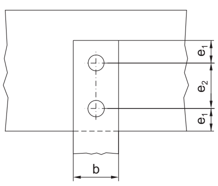
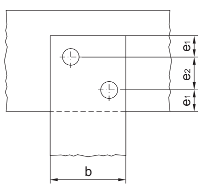
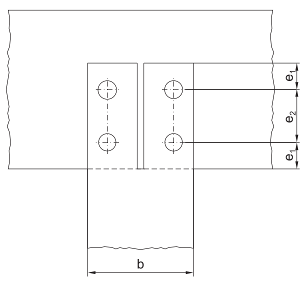
Longitudinal connections

Angular connections

T-connections

Note:
- For dimensions b, d, e_1 and e_2, refer to table "Drilling patterns and drilled holes"
- Slots are permissible at one end of the bar or at the end of a bar stack