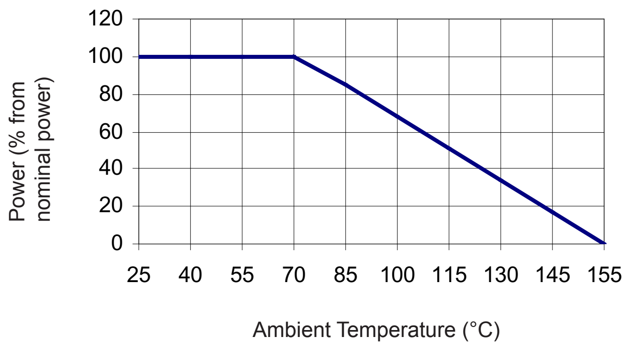
TECHNICAL DATA REGARDING POWER AND HEAT SINK DIMENSIONING

In our data sheets the nominal power dissipation is mentioned for all resistors.
The data are mentioned for a free standing assembly i.e. SMD assembled on a PCB. The ambient temperature is always 70°C. This means that the inherent temperature of the resistance element will reach without an additional cooling the limiting temperature.

The inherent temperature is the sum of the ambient temperature and the temperature through the power dissipation. If the ambient temperature is higher than 70°C the power dissipation must be reduced to secure that the resistance element will not exceed the limiting temperature. Otherwise the element will might be damaged. This necessary reduction of the power dissipation is denoted as ‘derating’. In the data sheets a ‘derating curve’ (Picture 5) is always mentioned. The value of the specific power dissipation depends on the ambient temperature in % of the nominal power dissipation.

Picture 5 - Derating-Curve of a free standing resistor series USR/USN, UNR, UHR, UPW without additional cooling



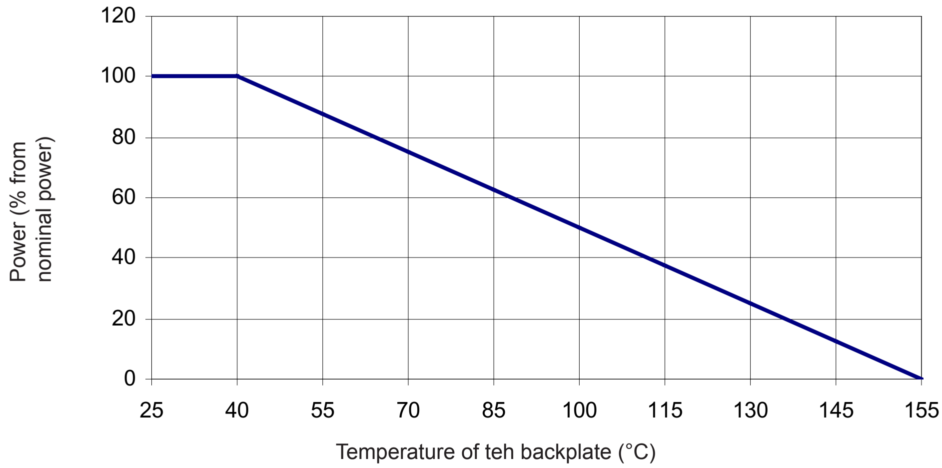
If the ambient temperature reaches the limiting temperature of the element, it is not possible to electrically stress the element. If the ambient temperature is below 70°C, it is possible to stress the element with a higher power than mentioned in the data.
A supplementary increase of the power dissipation is possible, if an additional cooling system is attached (i.e. heat-sink, forced air blast).
The most effective method is a forced air blast with a ventilating fan. With this additional cooling the heat convection of the resistor can be higher: In general, a forced air blast of 3 m/s and an optimal placed construction, it is possible to double the power dissipation.

Another possibility is the use of a heatsink. With a heatsink the surface of the resistor is larger, resulting in higher convection.
For all resistor series we have constructed elements with a possibility to use a heatsink (i.e. housings like TO 220 and TO 218).
In the data sheets the nominal power dissipation in use with a heatsink is mentioned. The specifications belong to these conditions:

- Assembled on a heatsink with optimal fixed mounting (pressurized and use of a heat conduction paste)
- Temperature of the heatsink 25°C (for power resistors 40°C)

If the resistor is installed on a heatsink, the derating curve looks different from the freestanding assembly. The power dissipation depends on the temperature of the case bottom plate (picture 6).

Picture 6 - Derating-Curve of a resistor (optimal assembling on a heatsink)



The max. allowed power dissipation depends on the temperature of the heatsink, because the inherent temperature is the sum of the heat from the power dissipation (regarding the heatsink temperature) and the heatsink temperature itself.

For the max. allowed power dissipation this condition is valid: $T_{resistor} = dT_R + T_{KK} = T_{limit}$.

The temperature of the heatsink results in the over-temperature of the heatsink itself (dTKK) and the ambient temperature of the whole application.
Valid is: $T_{limit} = dT_R + dT_{KK} + T_{ambient}$

In protection to the electrical technology we obtain the factor of proportionality between the power dissipation and the over-temperature: the thermal resistance $R_{th} = dT / P$

For the resistor and the used heatsink the following condition is valid: $R_{thR} = dT_R / P$ or $R_{thKK} = dT_{KK} / P$

In order to calculate the max. power we have to use following equation which results from the former equations:

$$P_{max} = (T_{limit} - T_{ambient}) / (R_{thR} + R_{thKK}) \; ; (R_{thR} = R_{thAppl} + R_{thj-c})$$

For all heatsink mounting resistors the mentioned data for the thermal resistance are for an optimal assemblage. The thermal resistance for the heatsink must be optained from the manufacturer of the heatsink.

Example 1:

We are assembling a USR 2-T220 on a heatsink with a thermal resistance of 7 K/W. We want to know the maximal power dissipation (ambient temperature 25°C) ?

Solution:
$P_{max} = (155°C - 25°C) / (13\ K/W + 7\ K/W) = 6.5\ W$
In a freestanding application the maximal power dissipation is 2.3 W.

Another application for heatsink mounted resistors is the possibility to reduce the change of the resistor value (through the temperature change) and to increase the stability. The inherent temperature will be constant at the same power dissipation.

In order to calculate the inherent temperature (the power dissipation is fixed) we need the following equation:

$$T_{resistor} = P * (R_{thR} + R_{thKK}) + T_{ambient}$$

In order to calculate the thermal resistance of a heatsink (application is fixed) we have this equation:

$$R_{thKK} = (T_{resistor} - T_{ambient}) / P - R_{thR}$$

Example 2:

The temperature change of an 2.5Ohm measuring resistor must be lower than 40ppm if there is a stress current of 1A. To reach this we are using a resistor of the series USR with TCR 1. The maximal inherent temperature of this resistor is 60°C. The ambient temperature in the application (i.e. Measurement Equipment) is 35°C. The question is which resistor type and which heatsink do we have to use?

Solution:
The power dissipation is $P = R * I^2 = 2.5$ W.
The first resistor we are choosing is the USR 4-T220
The thermal resistance of the heatsink we have to use results in the following equation
$R_{thkk} \leq (60°C - 35°C) / 2.5 W - 13 K/W = - 3 K/W$.
A heatsink with this thermal resistance is not possible.

One solution is to use a water cooled heatsink to reduce the temperature below the ambient temperature. This solution is very expensive and for normal applications not possible.

It is better to use the resistor type UNR4-4020 TK1. The thermal resistance is 2.7 K/W. The thermal resistance of the heatsink we have to use with this resistor is ≤ 7.3 K/W.