**RATED RESISTANCE**

Resistance value indicated upon the resistor and the label.

**TOLERANCE**

Permitted variation of the rated resistance value, usually expressed as a percentage of that value.

**RATED DISSIPATION**

Maximum load at a well-defined ambient temperature [Tu], e.g. [Tu] = 70˚C.

**STANDARD POWER RATING (Pw)**

Maximum permitted load at a defined ambient temperature which ensures that resistance stability limit in the relevant specification is not exceeded.

**TEMPERATURE COEFFICIENT**

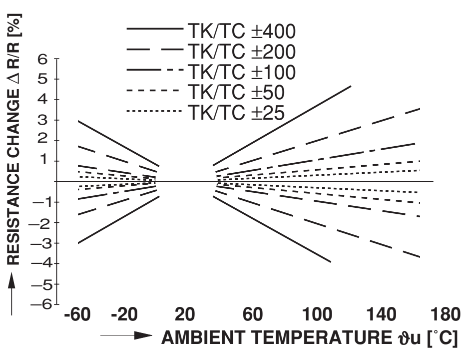
The TC specifies the permissible change of the resistance value depending on temperature and can be described by the following equation:

$$TC\ (10^{-6}/K) = \frac{R - R_{20}}{R_{20} \cdot \Delta\vartheta} . 10^{-6}$$

at which $\Delta\vartheta$ is the difference between 20˚C and the corresponding ambient temperature.

For metal film and metal oxide film resistors, usually the TC is specified as a limiting line at 20˚C and the ambient temperatures (see diagram).

The temperature resistance curves of metal film resistors (MK) show a slight slope, those of metal oxide film resistors (WK) show a larger one. Measured according to DIN specification.




Carbon film resistors have a negative TC depending on the resistance value. See the appropriate data sheets. In film resistors with a high positive TC, the TC must be taken into consideration at the circuit dimensioning with regard to the permissible load $P_{40}$ respective $P_{70}$

The maximum permissible increase of the resistance value by the TC in case of electric load can be determined by way of the maximum permissible temperature of the film temperature.

The change of the resistance value is calculated by:

$$R_{\vartheta max} = R_N\ [(1 + (\vartheta_{smax}, - 20˚C) \cdot TC_{max})]$$

Consequently the maximum permissible current respective the maximum permissible voltage for $P_{40}$ respective $P_{70}$ can be calculated by $R_{\vartheta max.}$

**LIMITING ELEMENT VOLTAGE**

Maximum d.c. or a.c. effective voltage which can be applied continuously to the terminations of a resistor.

**INSULATION VOLTAGE**

Maximum peak voltage which may be applied under continuous operating conditions between the resistor terminations and any conducting mounting surface.

**VOLTAGE PROOF**

Minimum value of a d.c. voltage or peak of an a.c. voltage resulting from performing the voltage test for 1 minute using the V-block method according to IEC60115-1.

**INSULATION RESISTANCE**

Electrical resistance value of the coating measured between the terminations of the resistor and applied V-block according to IEC60115-1.

**THERMAL RESISTANCE**

Quotient of maximum increase of the surface temperature and electric power under well defined test conditions. Under electrical load a film resistor generates heat which increases the film temperature. At the same time heat is dissipated to the environment, so that with constant electrical load and constant convection a thermal balance appears between the heat, generated by the electrical load, and the heat lost by convection.

These proportions are characterized by the thermal resistance. The thermal resistance is defined by the mechanical dimensions of a resistor, the heat dissipation by the wire leads as well as the convection, radiation and the mounting of the resistor.

The thermal resistance $R_{th}$ is defined as follows:

$$R_{th} = \frac{\vartheta s - \vartheta u}{P} = \frac{\vartheta ü}{P}$$

$\vartheta$s [˚C] = film temperature
$\vartheta$u [˚C] = ambient temperature
$\vartheta$ü [˚C] = temperature rise
P [˚C] = load

The thermal resistance measurement is made under defined conditions according to DIN 44 050.
Using this equation the maximum power rating of:

$$Pmax_{.} = \frac{\vartheta s - \vartheta u}{R_{th}}$$ is the result.

Thus the maximum permissible power rating Pmax. is dependent on the maximum permissible film temperature, the ambient temperature $\vartheta$u, and the thermal resistance.

## DERATING

Boundary curve of maximum rated power of the resistor under continuous operation at different ambient temperatures.

## FAILURE RATE

Number of components failed under well defined test conditions, divided by the number of components used and the duration of the test. The failure rate is valid for the total resistance range with a defined confidence level. In operation with lower surface temperatures the failure rate is reduced by several decades

## CATEGORY TEMPERATURE RANGE

Range of ambient temperatures for which the resistor is designed to operate continuously.

## CURRENT NOISE LEVEL

Noise level caused by a d.c. load referred to a frequency decade, expressed in µV/V. The current noise level E1 in µV is that portion of the noise voltage on the terminals of a fixed resistor, that arises from DC current in a resistor in addition to the thermal noise voltage.

The relative noise voltage, expressed in µV/V, is independent of the applied DC voltage U=.

The current noise voltage $E_1$ in µV is that portion of the noise voltage on the terminals of a fixed resistor, that arises from DC current in a resistor in addition to the thermal noise voltage: Normally the thermal noise voltage is negligible.

The relative noise voltage, expressed in µV / V, is independant of the applied DC voltage $U_{=}$.

## NON-LINEARITY

The harmonic index and the voltage coefficient of resistors are criteria for the non-linearity of the current voltage characteristic. Distortion of the applied voltage occurs under AC loading, building up harmonics due to the curvature of the resistance characteristic.

The harmonic index is defined as the logarithm of the ratio of the fundamental $U_1$ to the 3rd harmonic $E_3$.

It is specified in dB:

$$A3 = 20 \cdot \lg \frac{U1}{E_3} \text{ [dB]}$$

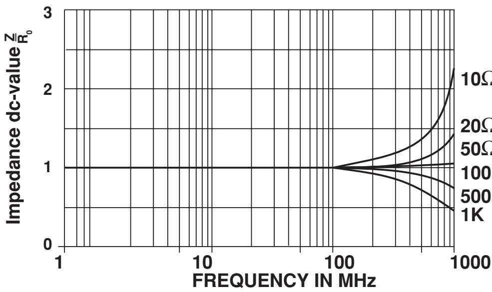
Measurements are according to IEC60440.

## TEMPERATURE RISE

Temperature difference between ambient temperature and maximum surface temperature of the element at a defined load, measured according to DIN 44050.

## HIGH FREQUENCY CHARACTERISTICS

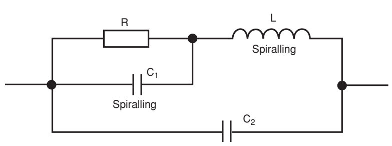
Fixed film resistors show a capacitive and inductive reactance at high frequencies in addition to the pure ohmic resistance because of their structure. The inductive component can be kept low for special styles.




TYPICAL HF-CHARACTERISTICS OF A FIXED FILM RESISTOR

For high frequency applications a special HF-version can be supplied for all cylindrical sizes in the value range from 10Ω to 1KΩ. In HF versions the parasitic reactive components are very small until up to the high megacycles range. Generally as far as HF characteristics on film resistors are concerned, we noted that up to approximately 10MHz they operate as real resistors. By increasing the frequency, more and more reactive components can be produced.

See diagram below:




For resistors with values >1K the capacitive part is already clearly predominant and is increasing more than the inductive part, with higher ohmic values. A measurable improvement by special trimming is not possible here.

Generally, the following classification can be made;

1. Resistors < 100 Ω are all inductive.
2. Resistors between 100 Ω and 470 Ω are "almost real".
3. Resistors > 470 Ω are capacitive.

## PULSE CHARACTERISTICS

Capability of withstanding short duration electrical impulses where the power during the impulse exceeds the rated power of the resistor.

When a film resistor is electrically loaded by impulses the following points have to be observed:

1. The maximum pulse load permissible $\hat{P}$max. depends on the duration ti. The same applies to the maximum pulse voltage permissible Ûmax.
2. The average load P may not exceed the corresponding nominal load. For resistors with resistance values higher than the critical value, the nominal value is determined by the critical value and the maximum operating voltage permissible.

   Required:

   $$P = \frac{1}{tpR} \int_{t_1}^{t_2} U^2(t)dt \leq P_\vartheta$$

   Explanations:

   R = nominal value

   tp = period of time

   U (t) = pulse voltage

   $P_\vartheta$ = nominal load of the resistor for the ambient temp. $\vartheta$.

   $t_2$-$t_1$ = pulse duration $t_i$.
3. It has to be noted if this is a question of an impulse sequence or of single-stop pulses (switching-on proc esses). Approximate values for the load with rectangular pulses for the respective versions are stated in the corresponding chapters of the catalog. All other pulses have to be converted to rectangular pulses which show the same energy content and the same pulse voltage.

   Example: Exponential pulse:

   $$\frac{\tau \hat{U}s^2}{2R} = ti \frac{\hat{U}s^2}{R} \quad \text{e.g. } ti = \frac{\tau}{2}$$

   Explanations:

   $\tau$ = time constant of the exponential pulse

   ti = pulse duration of the rectangular pulse

   Ûs = peak voltage

   R = nominal value of the resistor.

   The maximum pulse voltages permissible U max. are also stated. The permissible pulse loads have been fixed in such a way that the appearing changes in resistance values are comparable to those stated for the electrical long time load according to IEC60115-1

### STABILITY

The change of the resistance values at certain loads and ambient temperatures can be gathered from the stability nomogram which consists of 4 diagrams which can also be used by themselves.

The stability nomograms for the different versions can be seen on the appropriate data sheets. In addition, the limiting values stated in the data sheets, such as maximum load, surface temperature etc. have to be observed.

The following examples show how to use a nomogram:

Example 1.

Known: size D, R = 1KΩ

P = 0.5W, $U_{gr}$ = 350V, t = 5000 h, ϑu = 70˚C

Unknown: Δ R/R after 5000 h

From diagram A: we receive a temperature rise of ϑu = 65˚C for size D at P = 0.5W

From diagram B: a surface temperature of 135˚C can be gained for ϑu = 70˚C

From diagram D: a ΔR/R after 1000 h of 0.13% can be gathered for a surface temperature of 135˚C of a 1-KΩ resistor.

After 5000 h ΔR/R = 0.3% according to diagram C. Please see the solid line in the nomogram.

Example 2.

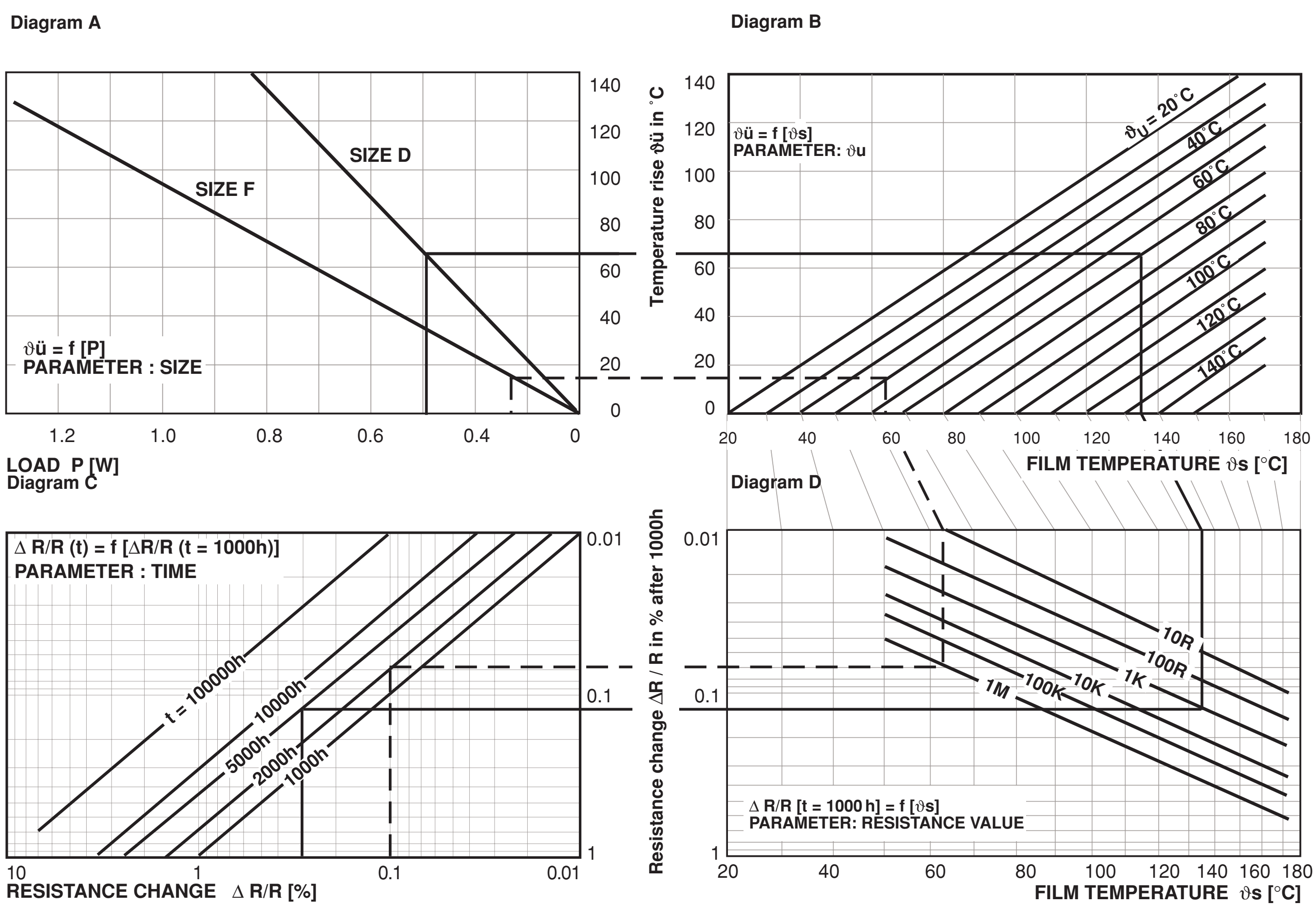
Known: size F,R = 1MΩ

P70 = 1.5W, $U_{gr}$ = 500V, t = 2000 h, ϑu = 50˚C

Unknown: Δ R/R after 2000 h

For R = 1MΩ formula below applies.

$P = \frac{U_{gr}^2}{R}$ = 0.25W as $U = \sqrt{PR} > U_{gr}$




**STABILITY NOMOGRAM TYPICAL VALUES**