OPERATION MANUAL

Precision High
Capacity Resistances
Model 1282

Valid from: 15.11.2022

Manufacturer:
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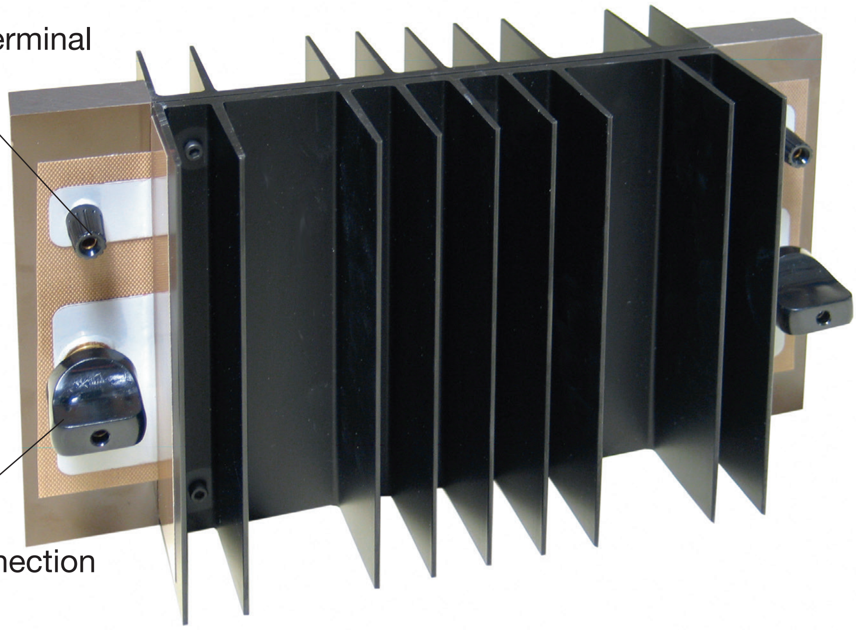
Precision High Capacity Resistors

The test certificate is your assurance that the resistor you have received meets your resistance and tolerance requirements.



Application

In connection with very precise digital voltmeters the model 1282 resistors are used as measuring resistors for accurate registration of direct and alternating currents up to 200 A.

The compact construction supports universal application. The exceptional low temperature coefficient extends the scope of application a second time.

A typical application is the wide range of quality and reliability testing. Regular measurements give a reliable information of the quality level of parts, instruments and systems.

Typical values:

- Rated load 20 W
- Manufactured in range 1 mΩ ... 100mΩ
- Standard values 1mΩ, 10 mΩ, 100 mΩ
- Uses 4 wire technology
- Error tolerance 0.02 %
- Suitable for technical frequency of 50 Hz

Description

Technologies already approved with our precision and calibration resistors - which especially guarantee a secure conduction of the dissipation heat - have been transferred to the precision high capacity resistors.

Those are designed on four-wire measurement principle. The voltage path is equalized to the customized value and to an accuracy of 0.02 %, (with reference temperature = 23 °C).

At maximum load a temperature increase within the resistor occurs. This temperature increase is compensated by a large surface area of the cooling body.

The heat resistance of the resistors described is 1 K/W: The temperature of the resistor rises 1 K per Watt of supplied energy. All power and limiting values of the diagrams overleaf refer to the resistor material MANGANIN®.

Unfavorable installation with insufficient possibility of ventilation and cooling have to be taken into consideration accordingly.

Factors resulting in damage or destruction

The resistor as measurement standard is a vital link in the measurement chain.

Its reliability depends on how it is used.

Careful handling is essential and any actions or conditions that might damage the resistor must be avoided.

The following factors will result in irreparable damage:

a) Measurement currents > 200 A (200 A is the limit used for the electromechanical design, e.g. of the current terminals).

b) Surface temperatures below 0°C or above 85°C

The surface temperature (of the cooling fins) largely equals the temperature of the resistor material. A temperature outside the specified range will damage (modify) the resistor material and result in a permanent change to the nominal value.
The surface temperature depends on the ambient temperature and the load.

c) Temperature shocks are also undesirable. Even if temperatures are kept with the limits specified above, it is essential to avoid rapid rises or drops in temperature. This is because the resultant rapid expansion or contraction would cause a change in the resistor material.

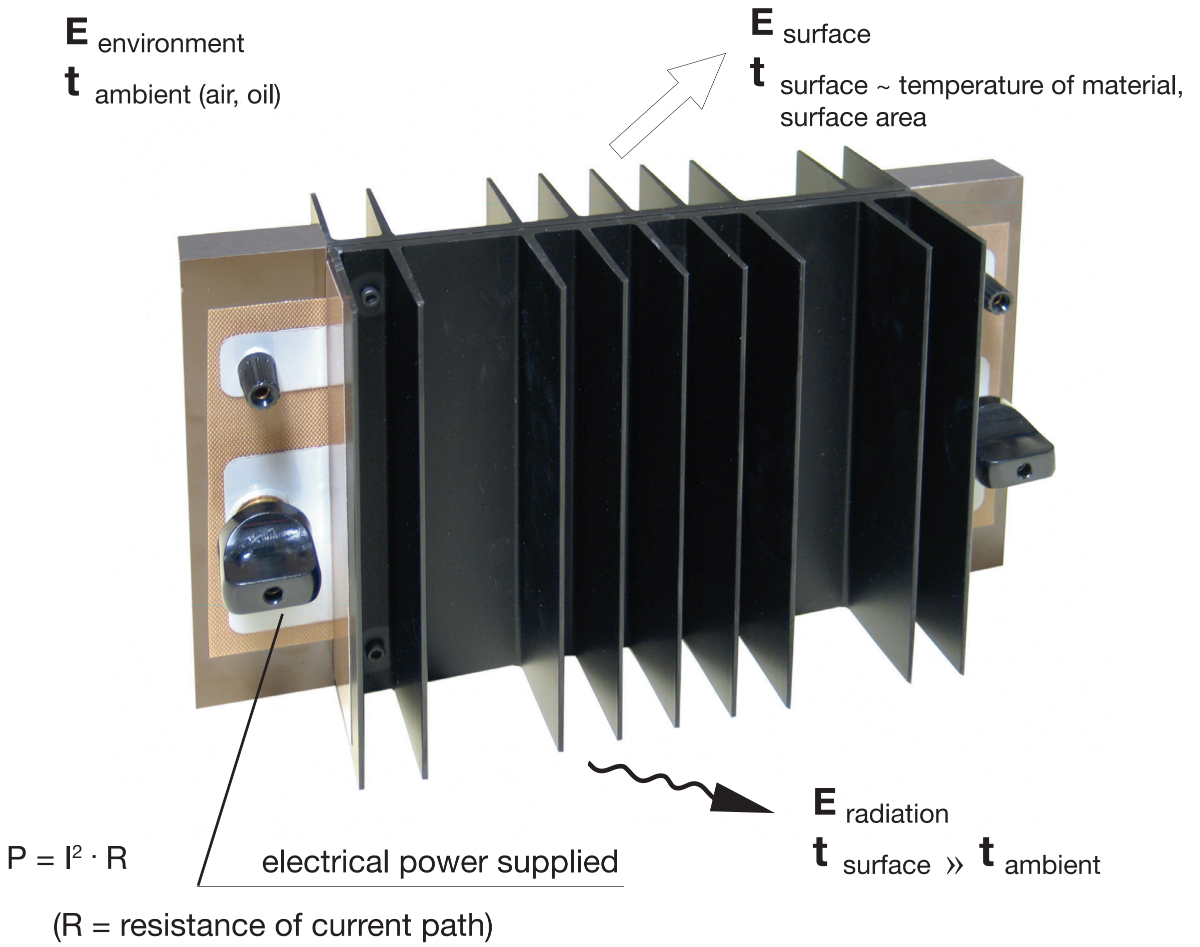
d) Mechanical shocks such as knocks or vibrations have an equally unwelcome impact. Careful handling will prevent such faults.

Operating conditions

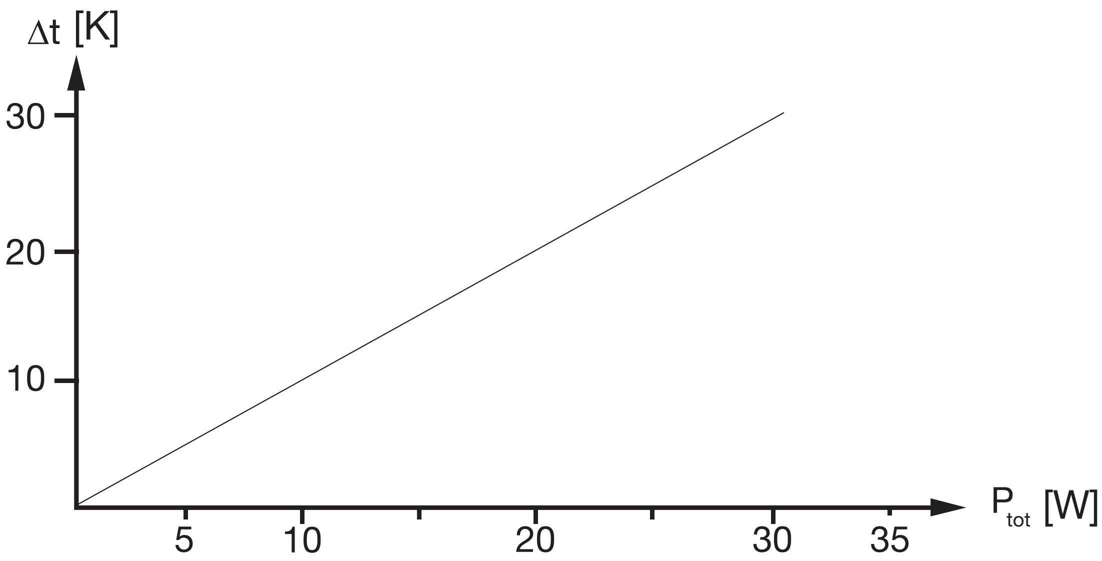
The certified value including relevant figures for the measurement uncertainty is referred to the specified environmental conditions (reference conditions) that prevailed during the measurements.
Energy and time are the main influencing factors.

Whilst the "energy" factor can be reproduced readily by suitable means (e.g. climate-controlled locations, selecting the same measurement current etc.), this is not possible for the "time" factor. "You cannot turn back the clock" - more on this later.

Energy, the environmental factor

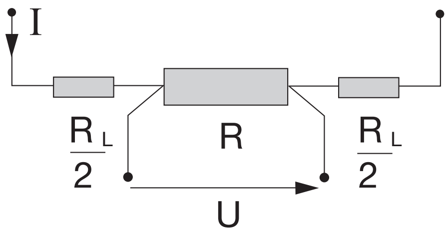


Characteristic curve of temperature rise



Heat-sink temperature = ambient temperature + temperature rise

P_{tot} = power dissipation
t_u = ambient temperature
Δt = temperature rise through dissipation



at R = 1 mΩ → R_L ≤ 6 mΩ
at R = 10 mΩ → R_L ≤ 8 mΩ
at R = 100 mΩ → R_L ≤ 12 mΩ

(R_L= resistance of current path)

The precision resistor is part of the "environmental system" and is affected by the temperature of its surroundings i.e. its surface temperature tracks any change in the ambient temperature at a rate given by its time constant, or if used in a temperature-regulated environment, e.g. in an oil bath, assumes this regulated temperature.

If electrical energy (power) is now supplied to this resistor, this will perturb the temperature equilibrium. The electrical power is converted into heat, resulting in a rise in temperature of the surface with respect to the ambient temperature.

Heat transfer occurs according to the surrounding medium, the surface finish and the temperature.

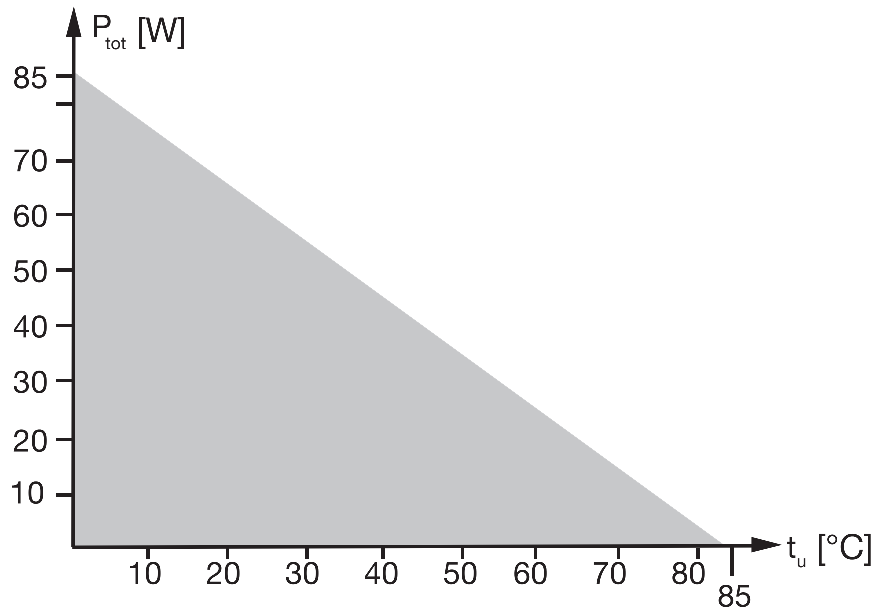
At very high surface temperatures, energy is also emitted by radiation.

The heat dissipation with respect to air - the thermal resistance Rth - for the 1282 precision resistor is 1 K/W, i.e. per Watt of supplied power, the surface temperature rises by 1 K with respect to the ambient temperature.

Maximum load curve

This relationship can be used to illustrate the requirement mentioned in the introduction of keeping within the temperature limits.

The maximum load curve shows the relationship between the maximum amount of electrical power that can be input and the ambient temperature.



At an ambient temperature of 85 °C, no more than "0 W" is allowed to be input (in theory).

At an ambient temperature of 0 °C, 85 W can be input.

$$P_{tot} \cdot R_{th} \leqslant 85\ °C$$

$$85\ W \cdot 1\ K/W = 85\ °C$$

In order to make full use of the available power range, it is therefore recommended to use the resistor at the lowest possible ambient temperatures. The installation position should be chosen carefully, e.g. not close to equipment that generates heat.

Unimpeded air circulation e.g. through natural thermal convection is essential. The most reliable medium for use is air, with a suitable load and constant ambient temperature.

It is also possible to operate the resistor in an oil bath, however. The non-metallic parts (reinforced hard fiber) are suitable for this use.

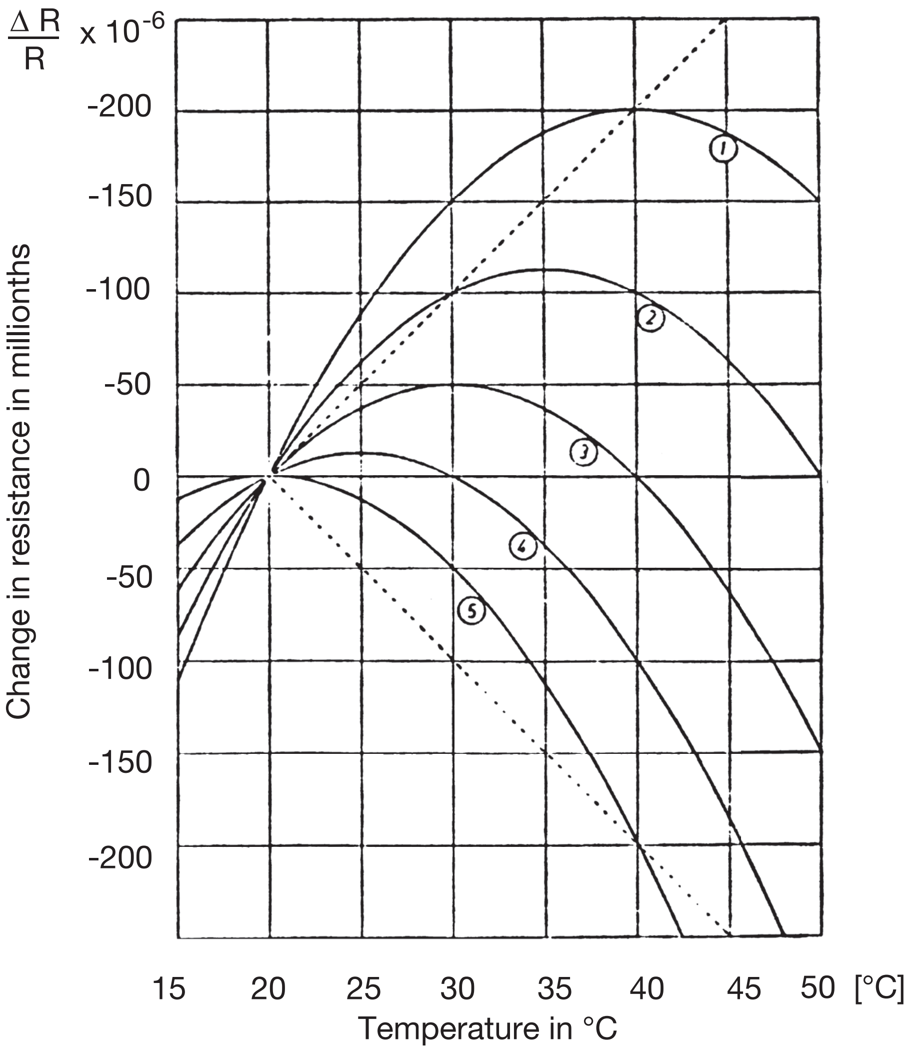
There is also the option to use the resistor in water, although less-corrosive water should be used. A long-term effect on the metal parts (CU terminals/Al heat sink) cannot be ruled out in this case, however. Furthermore, it is also not possible to rule out a change in the nominal value resulting from a reaction with the medium (water/oil).

Tolerance

The maximum load curve shows the maximum possible power that a resistor can be subjected to at a known ambient temperature [P_{tot} = f (tu)], where to is the ambient temperature. It does not, however, given any indication of the extent to which the tolerance in the resistance value is affected by the temperature.

The temperature dependence of the resistance value is minimized by the choice of MANGANIN®, as the material.

MANGANIN® is an alloy that the special features of low temperature dependence and good long-term stability.
The following curves shows the change in resistance as a function of temperature.



The differences 1 ... 5 in the curves are caused by different production batches for the material (small changes in the alloy composition or its treatment e.g. different rates of cooling).

The curve (parabola) $R_{(t)}$ = f (t) can be expressed as

$$\mathbf{R_t = R_{20} [1 + \alpha_{20} (t - 20) + \beta (t - 20)^2]}$$

where

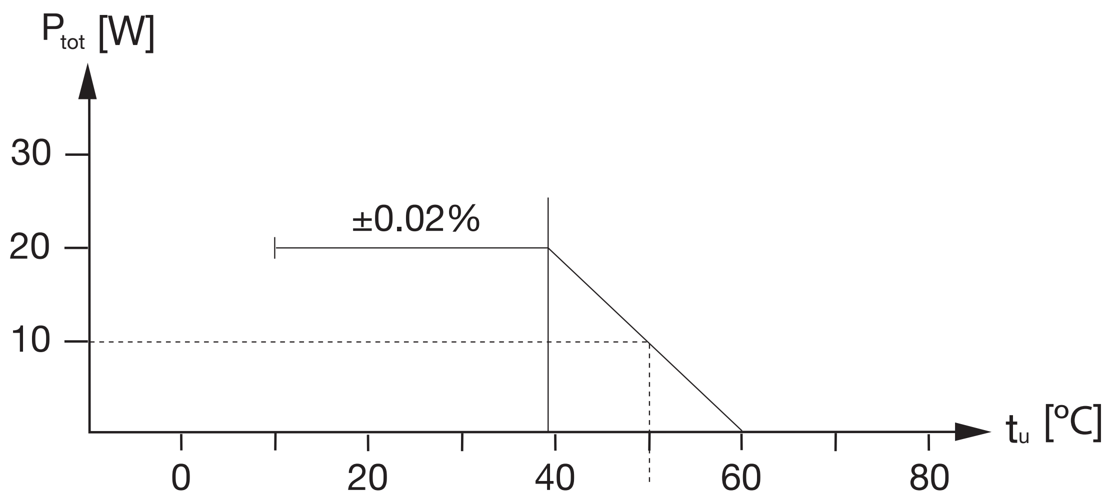
R_t = resistance value at temperature t
R_{20} = resistance value at 20 °C

$$\alpha_{20} = 0 \ldots 20 \cdot 10^{-6} \ \ 1/K; \ \beta = - 0{,}59 \cdot 10^{-6} \ \ 1/K^2$$

depending on the different curves.

Specifying the accuracy rating and the temperature dependence (even if small) narrows the region of use further (see maximum load curve).
Any deviation from the reference conditions t ambient, I measurement) given in the test certificate will result in a different resistance temperature and therefore a result that differs from the measured value.
To stay within the defined tolerance, any power that causes a temperature rise (P_{tot}, t ambient), must remain within specified limits.

This results in the **load reduction curve.**



The load reduction curve can be used to find the maximum load that can be applied for different ambient temperatures for a given acceptable error arising from a load-induced rise. Example: t_u max. 50 °C, acceptable temperature-related ΔR = 0.02 %, gives a maximum permitted load of 10 W.

This curve is obtained from the equation:

Equation 1: $\mathbf{R_t = R_{20} [1 + \alpha_{20} (t_x - 20) + \beta (t_x - 20)^2]}$

curve for MANGANIN®

Equation 2: $$\frac{KI}{100} = \frac{R_t}{R_{20}} - 1$$

R_t = resistance value at temperature t
R_{20} = resistance value at temperature 20 °C
KI = ± 0.02
α_{20} = 0 ... 20 · 10^{-6} 1/K
β = - 0,59 · 10^{-6} 1/K^2

Substituting equation 2 in equation 1 and solving for temperature t gives equation 3:

$$t\,1/2 = \frac{1}{\beta}\left[\frac{\alpha_{20}}{-2} \pm \sqrt{\left(\frac{\alpha_{20}}{2}\right)^2 + \beta\left(\underbrace{\frac{R_t}{R_{20}}-1}_{\pm KI}\right)}\right] + 2$$

The resistance with accuracy rating 0.02 % has the following temperature limits:

t1 = + 11.9 °C; t2 = + 61.9 °C

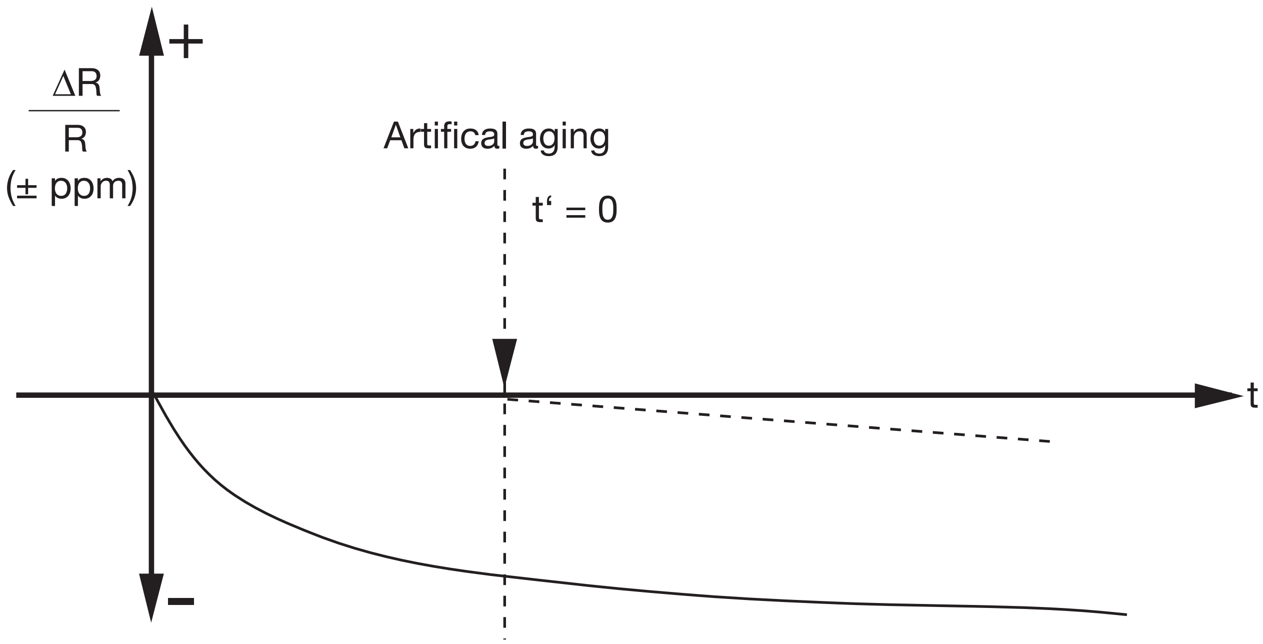
The load reduction curve takes account of the relationship between temperature and accuracy rating, with the temperature expressed as a function of the power supplied (y-coordinate) and ambient temperature (x-coordinate).

The time factor

A resistance calibrated at a given point in time will vary from its original value as a result of various factors (long-term stability).
The major factors here are the material, mechanical properties, aging and external influence (operation).

MANGANIN® as the source material has excellent long-term stability. Thanks to a good mechanical design, the resistance plates are held under no stress internally, which also helps stability. The initial calibration is followed by artificial aging, which takes the resistor past the steep section of the curve of resistance change over time. The final value (which appears in the test certificate) is not measured until after this aging process. Now the point on the curve lies in a region with a lower gradient.
The long-term stability is < 0.01 % over years.

Period measurement can be used to predict the long-term behavior as a smooth curve within limits.
We recommend that these periodic measurements are carried our with DKD/DAkkS calibration certificate in our calibration laboratory.



DKD/DAkkS calibration certificate

The D-K-15141-01-00 calibration laboratory at burster präzisionsmesstechnik gmbh & co kg is accredited and monitored to ISO 17025 by DAkkS (the German accreditation body).
Its status is evidenced by an accreditation certificate, and the laboratory is authorized to issue calibration certificates showing the DAkkS logo and the DKD logo (from the German calibration service).
The information presented on the calibration certificate meets DAkkS specifications. These calibration certificates are recognized internationally by multilateral agreements.
The precision high resistors of type 1282 can be supplied with a DKD/DAkkS calibration certificate.
The best-case measurement uncertainty equals $\pm 1 \cdot 10^{-5}$ of the measured value.

Factory calibration certificate

A factory calibration certificate can also be provided for the calibration resistors. This contains documentary proof of traceability to national measurement standards, and full documentation of all measured values and their tolerances.

Technical Data

Resistance ranges:	1 mΩ - 100 mΩ, any resistance value within this range is available
Resistance tolerance:	0.02 %
Calibration temperature:	23 °C
Resistance material:	MANGANIN®
Temperature coefficient:	< 20 ppm/K
Temperature dependence:	$R_t = R_{20}\,[(1 + \alpha_{20}\,(t - 20) + \beta\,(t - 20)^2)]$ $\alpha_{20} = 0 \ldots 20 \cdot 10^{-6}$ $\beta = -0.59 \cdot 10^{-6}$
Long-term stability:	< 0.01 % over years
Long-term load:	20 W
Short-time over load:	approx. 90 W < 1 min
Ultimate load:	60 W at 25 °C environmental temperature
Current limit (at 1 mΩ):	200 A
Surface temperature:	max. 85 °C, results from heat resistance + ambient temperature
Thermal resistance:	1 K/W

Construction:

Resistance element is made of a MANGANIN® sheet with four terminal connection. It is installed free of mechanical tension between two cooling bodies, current junction is realized via screw terminals, potential tap is made via brass terminals.

Capacity C_R:	< 4 nF, resistance element to cooling body
Electrical strength:	test voltage 1950 V_{DC}
Max. potential:	42 V against cooling body, insulated mounting required for higher voltages
Isolation resistance R_{IS}:	> 100 MΩ, cooling body against resistance element
Specifications:	according DIN EN 60477
Dimensions (W x H x D):	265 x 100 x 150 [mm]
Weight:	approx. 2.3 kg