PHILIPS

Data handbook

Electronic components and materials

Components and materials

Part 13 February 1984

Fixed resistors

COMPONENTS AND MATERIALS

PART 13 - FEBRUARY 1984

FIXED RESISTORS

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, sub-assemblies and materials; it is made up of four series of handbooks each comprising several parts.

ELECTRON TUBES	BLUE
SEMICONDUCTORS	RED
INTEGRATED CIRCUITS	PURPLE
COMPONENTS AND MATERIALS	GREEN

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

Where ratings or specifications differ from those published in the preceding edition they are pointed out by arrows. Where application information is given it is advisory and does not form part of the product specification.

If you need confirmation that the published data about any of our products are the latest available, please contact our representative. He is at your service and will be glad to answer your inquiries.

ELECTRON TUBES (BLUE SERIES)

The blue series of data handbooks is comprised of the following parts:

T1 **Tubes for r.f. heating**

T2a **Transmitting tubes for communications, glass types**

T2b **Transmitting tubes for communications, ceramic types**

T3 **Klystrons, travelling-wave tubes, microwave diodes**

ET3 **Special Quality tubes, miscellaneous devices** (will not be reprinted)

T4 **Magnetrons**

T5 **Cathode-ray tubes**
Instrument tubes, monitor and display tubes, C.R. tubes for special applications

T6 **Geiger-Müller tubes**

T7 **Gas-filled tubes**
Segment indicator tubes, indicator tubes, dry reed contact units, thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes, associated accessories

T8 **Picture tubes and components**
Colour TV picture tubes, black and white TV picture tubes, colour monitor tubes for data graphic display, monochrome monitor tubes for data graphic display, components for colour television, components for black and white television and monochrome data graphic display

T9 **Photo and electron multipliers**
Photomultiplier tubes, phototubes, single channel electron multipliers, channel electron multiplier plates

T10 **Camera tubes and accessories, image intensifiers**

T11 **Microwave semiconductors and components**

SEMICONDUCTORS (RED SERIES)

The red series of data handbooks is comprised of the following parts:

S1 **Diodes**
Small-signal germanium diodes, small-signal silicon diodes, voltage regulator diodes($< 1{,}5$ W), voltage reference diodes, tuner diodes, rectifier diodes

S2 **Power diodes, thyristors, triacs**
Rectifier diodes, voltage regulator diodes ($> 1{,}5$ W), rectifier stacks, thyristors, triacs

S3 **Small-signal transistors**

S4a **Low-frequency power transistors and hybrid modules**

S4b **High-voltage and switching power transistors**

S5 **Field-effect transistors**

S6 **R.F. power transistors and modules**

S7 **Microminiature semiconductors for hybrid circuits**

S8 **Devices for optoelectronics**
Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.

S9 **Power MOS transistors**

S10 **Wideband transistors and wideband hybrid IC modules**

INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks is comprised of the following parts:

IC1 **Bipolar ICs for radio and audio equipment**

IC2 **Bipolar ICs for video equipment**

IC3 **ICs for digital systems in radio, audio and video equipment**

IC4 **Digital integrated circuits**
CMOS HE4000B family

IC5 **Digital integrated circuits – ECL**
ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs

IC6 **Professional analogue ICs**

IC7 **Signetics bipolar memories**

IC8 **Signetics analogue ICs**

IC9 **Signetics TTL logic**

IC10 **Signetics Integrated Fuse Logic (IFL)**

IC11 **Microprocessors, microcomputers and peripheral circuitry**

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks is comprised of the following parts:

C1 **Assemblies for industrial use**
PLC modules, PC20 modules, HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices, hybrid ICs

C2 **Television tuners, video modulators, surface acoustic wave filters**

C3 **Loudspeakers**

C4 **Ferroxcube potcores, square cores and cross cores**

C5 **Ferroxcube for power, audio/video and accelerators**

C6 **Synchronous motors and gearboxes**

C7 **Variable capacitors**

C8 **Variable mains transformers**

C9 **Piezoelectric quartz devices**
Quartz crystal units, temperature compensated crystal oscillators, compact integrated oscillators, quartz crystal cuts for temperature measurements

C10 **Connectors**

C11 **Non-linear resistors**
Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)

C12 **Variable resistors and test switches**

C13 **Fixed resistors**

C14 **Electrolytic and solid capacitors**

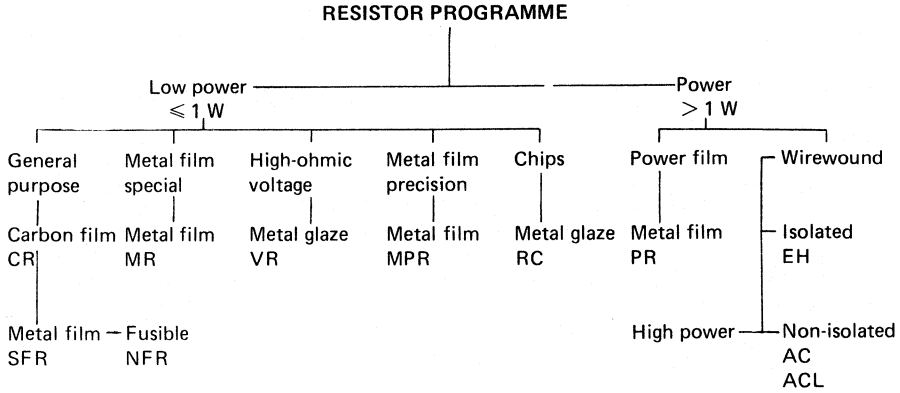
C15 **Film capacitors, ceramic capacitors**

C16 **Permanent magnet materials**

C17 **Stepping motors and electronics**

C18 **D.C. motors**

C19 **Piezoelectric ceramics**



For easy reference, type numbers (such as MR16) are at the top of each page. Orders should, however, always state the 12-figure catalogue number.

The resistor programme is divided into two parts: low power resistors (≤ 1 W) and power resistors (> 1 W). The index of catalogue numbers is at the back of this book and lists the relevant page numbers.

All dimensions on drawings are in mm unless otherwise indicated. According to the S.I. units the symbol K (Kelvin) is used instead of °C in combinations such as K/W. Also ΔT is in K. Atmospheric pressure is given in kPa instead of millibars, mm Hg, etc. 1000 mbar = 100 kPa.

Some devices are labelled **"Maintenance Type"**. The relevant resistors are available for equipment maintenance only and are no longer recommended for equipment production.

SEE ALSO SURVEY ON PAGE 16
AND INDEX ON PAGE 173

GENERAL

INTRODUCTION

The data are presented - whenever possible - according to a "format", in which the following items are stated:

Title
QUICK REFERENCE DATA
APPLICATION
DESCRIPTION
MECHANICAL DATA
Mass
Mounting
Marking
ELECTRICAL DATA
PULSE LOAD BEHAVIOUR
COMPOSITION OF THE TYPE NUMBER
TESTS AND REQUIREMENTS
STANDARD PACKAGING

DESCRIPTION

Almost all types have a cylindrical ceramic body, either rod or tube. The resistive element is either a carbon film, a metal film or a wound wire element. The film types have been trimmed to the required ohmic resistance by cutting a helical groove in the resistive layer. This process is completely computer controlled and yields a high reliability. The terminations are usually iron end caps to which tinned connecting wires of electrolytic copper are welded. Some of the high power wirewound resistors are provided with solder tags or bolts.
All resistor bodies are coated with a coloured lacquer or enamel for protection. Dependent on the types this lacquer provides electrical, mechanical and/or climatic protection – also against soldering flux and cleaning solvents, according to MIL-STD-202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

A dimensional sketch and, if applicable, a table of dimensions are given. The lead length of axial types is usually not stated if the resistors are only available on tape.

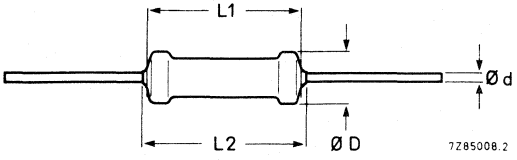


Fig. 1.

The sketch does include, however, length (L), and diameter of the body (D) and the lead diameter (d). For certain types, the length is stated as L1 and L2; L1 is the body length, L2 is the body length plus lacquer on the leads. In other cases the maximum area on the leads which may be covered by lacquer is stated (a1 and a2; usually a1 + a2 $\leqslant$ 1 mm). By specifying L1/L2 or L and a1/a2 the dimensional "clean lead to clean lead" properties can be determined.

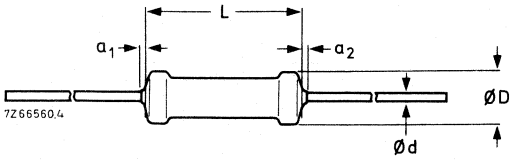


Fig. 2.

For so called "bare bottom" types no lacquer is allowed on the leads at all. The length of the cylindrical body (L or L1) is measured by inserting the leads into the holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294).

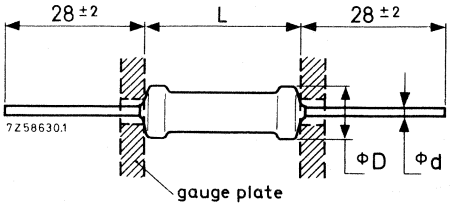


Fig. 3.

The relationship between the diameter of the leads and the diameter of the holes in gauge plate is as follows:

d	hole diameter
0,5	0,8
0,6	1,0
0,7	1,0
0,8	1,2

This method, of course, does not apply to rectangular resistors, "stand-up" types and wirewound resistors with side terminations.

Some resistors (CR25A, SFR25A, VR25A) are available as "stand-up" types. The bent lead is partially covered with insulating lacquer with a breakdown voltage of at least 50 V (d.c.)

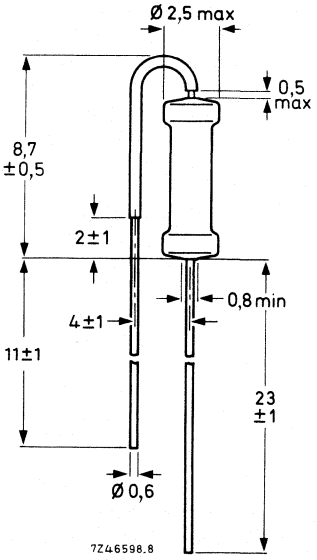


Fig. 4.

Mass

The mass (weight) is given per 100 resistors.

Mounting

Most types with straight axial leads, as well as most resistors in the "stand-up" version (radial leads), are suitable for processing on automatic insertion equipment and cutting and bending machines. Chip resistors are suitable for handling by automatic chip placement systems.

Marking

The resistors are either colour coded or provided with an identification stamp. The colour code consists of a number of coloured bands according to IEC publication 62: "Colour code for fixed resistors". See also IEC 115-1 clause 4.5. The coloured bands indicate the *nominal resistance*, the *tolerance* on the resistance and, if applicable, the *temperature coefficient*. A maximum of bands may be used, but in some instances there are fewer, e.g. if the products are too small. The *resistance code* consists of either 3 or 4 bands and is followed by a distinctly wider band representing the *tolerance*. The temperature coefficient is to the right of the tolerance band and usually positioned on the cap (MR types), as a wide band.

The *resistance code* includes the first two or three *significant figures* of the resistance value (in ohms), followed by a *multiplier*. This is a factor by which the significant-figure value must be multiplied to find the relevant resistance value. Whether two or three significant figures are represented depends on the tolerance: ± 2% and higher requires two bands; ± 1% and lower requires three bands.

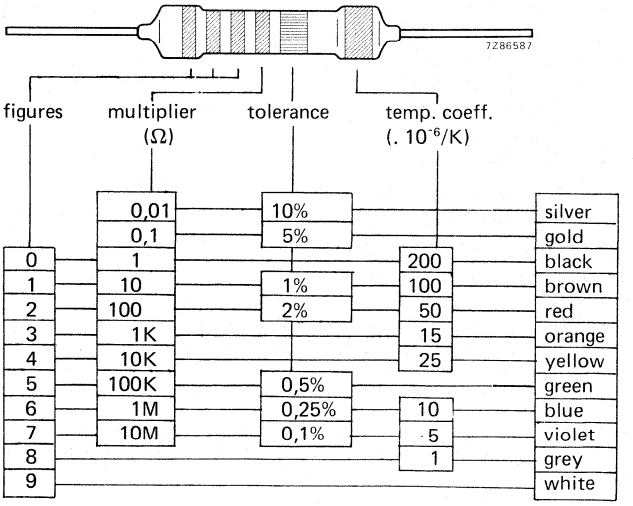


Fig. 5.

The "figures" refer to the first two or three digits of the resistance value of the standard series of values in a decade, according to IEC publication 63 and as indicated in the relevant data sheet and printed at the back of this book.

Body colours The resistor bodies are lacquered in different colours to simplify identification:

tan	CR16, CR25, CR37, CR52, CR68
light green	SFR16, SFR25, SFR30
grey	NFR25, NFR30
green	MR16, MR25, MR30, MR52 MR24E/C/D, MR34E/C/D, MR54E/C/D, MR74E/C/D MPR24, MPR34 AC04, AC05, AC07, AC10, AC15, AC20 ACL01, ACL02, ACL03
light blue	VR25, VR37, VR68
red	PR37, PR52
brown	WR0167E, WR0842E, WR0825E, WR0865E

Certain resistors are not coded by colour bands but by a stamp giving pertinent data (alphanumeric marking). This is adopted with MIL types MR24E/C/D, MR34E/C/D, MR54E/C/D, MR74E/C/D as well as PR37 and PR52. Resistors outside the standard IEC 63 series of types MPR24 and MPR34 are stamped. All wirewound resistors are likewise stamped. Chip resistors are unmarked but the relevant marking is given on the package.

ELECTRICAL DATA

The electrical data include: nominal resistance range and tolerance, limiting voltage, temperature coefficient, absolute maximum dissipation, climatic category and stability.
The *limiting voltage* (r.m.s.) for resistor element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation, see IEC publications 115-1 and 115-2.
Where applicable, *derating details* and performance *nomograms* are given, showing the relationship between power dissipation, ambient temperature, hot-spot temperature and maximum resistance drift after prolonged operation. For power resistors graphs indicate the relationship between temperature rise and dissipation with lead-length or heatsinks as parameters.
The temperature rise in a resistor due to power dissipation is determined by laws of heat conduction, convection and radiation. The maximum body temperature usually occurs in the middle of the resistor and is called the *hot-spot* temperature.

Heat conducted by the leads – which can be considerable in power types – must not reach the melting point of the solder at the joints. This may call for the use of heatsinks and/or longer leads.

In the normal operating temperature range of film resistors the temperature rise at the hot-spot, ΔT, is proportional to the power dissipated: $\Delta T = A \times P$. The proportionally constant A gives the temperature rise per watt of dissipated power and can be interpreted as a thermal resistance in K/W. This thermal resistance is a function of the dimensions of the resistor, the heat conductivity of the materials used and, to a lesser degree, of the way of mounting. The sum of the temperature rise and the ambient temperature is:

$$T_m = T_{amb} + \Delta T.$$

The stability of a film resistor during endurance tests is mainly determined by the hot-spot temperature and the resistance. The lower the resistance – other conditions kept constant – the higher the stability due to the greater film thickness.

Summarizing:

dimensions determine		heat resistance
heat resistance x dissipation	=	temperature rise
temperature rise + ambient temperature	=	hot-spot temperature
hot-spot temperature and resistance value determine		stability

Performance

When specifying the performance of a resistor, the dissipation is given as a function of the hot-spot temperature, with the ambient temperature as a parameter.

From $\Delta T = A \times P$ and $T_m = T_{amb} + \Delta T$ it follows that:

$$P = \frac{T_m - T_{amb}}{A}$$

If P is plotted against T_m for a constant value of A, parallel straight lines are obtained for different values of the ambient temperature. The slope of these lines,

$\frac{dP}{dT_m} = \frac{1}{A}$, is the reciprocal of the heat resistance and is characteristic for the resistor.

The stability $\frac{\Delta R}{R}$ can be determined experimentally, for instance after 1000 h, as a function of the hot-spot temperature with the resistance value as a parameter. It has been found that the resistance changes exponentially with temperature, giving a straight line when log $\frac{\Delta R}{R}$ is plotted against T_m.

A combination of the graphs of P and $\frac{\Delta R}{R}$ against T_m gives a nomogram from which the values of several variables can be determined for a resistor of a given size under different working conditions. An example of such a nomogram with fictitious values is given in Fig. 6. The intersection of the broken line with the horizontal axis gives the hot-spot temperature under chosen conditions.

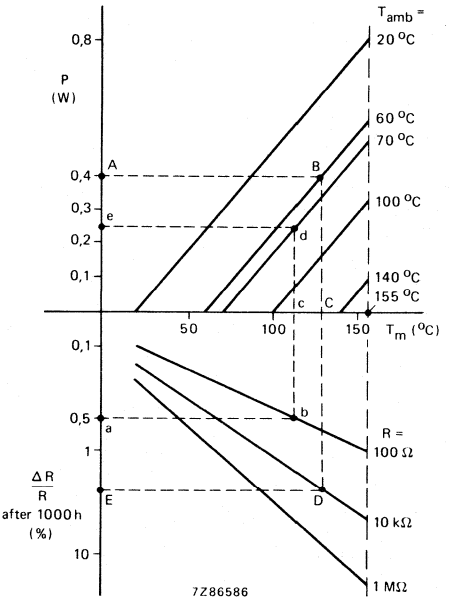


Fig. 6 Peformance nomogram (for a fictitious resistor) illustrating the way of specifying the performance of film resistors.

Example 1

Assume that a 10 kΩ resistor whose characteristics are described by the nomogram is to be operated at a power dissipation of 0,4 W and an ambient temperature of 60 °C. To find out whether this dissipation is allowable at this ambient temperature and, if so, what the expected stability of the resistor will be, draw in the upper half of the nomogram a horizontal line through A (power dissipation of 0,4 W). This line intersects the 60 °C ambient temperature line at point B, corresponding to a hot-spot temperature of 128 °C (point C). This is safely below the maximum indicated by the broken line at 155 °C; therefore a dissipation of 0,4 W at an ambient temperature of 60 °C is well within the allowable limit.

Extend line BC into the lower half of the nomogram until it intersects the 10 kΩ line at point D. This means that at a hot-spot temperature of 128 °C a resistance change of about 2,5% (point E) can be expected after 1000 hours of operation.

Example 2

Assume that a 100 Ω resistor, whose characteristics are described by the nomogram, is to be operated at an ambient temperature of 70 °C with a required stability after 1000 h of 0,5%. It is desired to find the maximum permissible power dissipation. In the lower half of the nomogram, a line that corresponds to a stability of 0,5% intersects the 100 Ω resistance line at point b, corresponding to a hot-spot temperature of 112 °C (point c).

Extending the line b-c into the upper half of the nomogram, it intersects the line indicating an ambient temperature of 70 °C at point d, corresponding to a maximum permissible power dissipation of 0,25 W (point e).
If the power to be dissipated exceeds the value found, a bigger type of resistor should be used.

The temperature coefficient

The temperature coefficient of resistance is a ratio which indicates the rate of increase (decrease) of resistance per °C increase (decrease) of temperature within a specified range, and is expressed in parts per million per °C (. 10^{-6}/K).

Example: If the temperature coefficient of a resistor of R_{nom} = 1 MΩ between −55 °C and +155 °C is ± 100 . 10^{-6}/K its resistance will be:

at 25 °C: 1 000 000 Ω (nominal = rated value)
at +155 °C: 1 000 000 Ω + (130 . 100 . 10^{-6}) x 1 000 000 Ω = 1 013 000 Ω
at −55 °C: 1 000 000 Ω − (80 . 100 . 10^{-6}) x 1 000 000 Ω = 992 000 Ω

If the temperature coefficient is specified as ⩽ 100 . 10^{-6}/K the resistance will be within the shaded area.

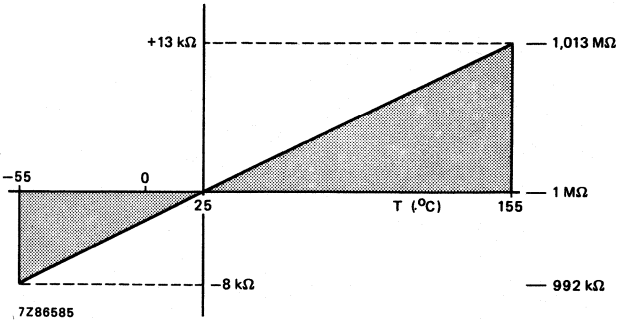


Fig. 7.

PULSE-LOAD BEHAVIOUR

In future, information on pulse-load behaviour is to be included in all new or revised data; pending revision, same data will continue to be published without such information.

Knowing the thermal characteristics of a resistor, it is possible to calculate the load due to a single pulse which will cause a resistor to fail by going open circuit. This theoretical maximum can be expressed in terms of peak pulse power, $\hat{P}$, and pulse duration, t_i, the straight line in Fig. 1 is a typical example for a film resistor. In practice, however, owing to variations in the resistance film, substrate, or spiralling, resistors fail at loads less than this theoretical maximum; the dashed line in Fig. 1 shows the observed maximum for a resistor under single-pulse loading.

The magnitude of a single pulse at which failure occurs is of little practical value. More usually, the resistor must withstand a continuous train of pulses of repetition time t_p during which only a small resistance change is acceptable. This resistance change $\Delta R/R$ is equal to the change permissible under continuous load conditions. The continuous pulse train and small permissible resistance change both reduce the maximum pulse handling capability.

Using a computer program which takes account of all factors affecting resistor behaviour under pulse loads, curves similar to those of Fig. 1 are being produced for all our resistor ranges.

Measurements have shown that the calculated value is accurate to within 10% of the true value.

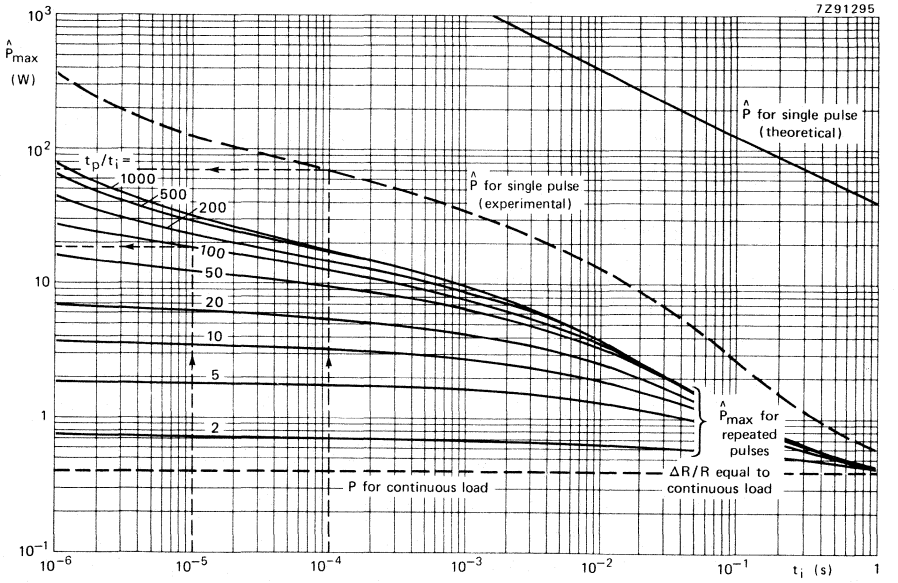


Fig. 1 Max. permissible peak pulse power ($\hat{P}_{max}$) versus pulse duration (t_i) for a typical resistor.

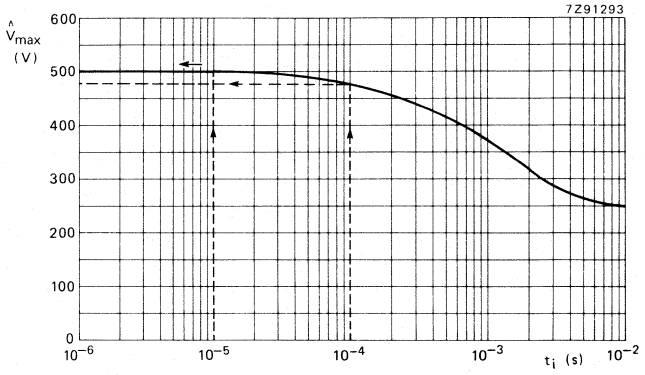


Fig. 2 Max. permissible peak pulse voltage ($\hat{V}_{max}$) versus pulse duration (t_i) for a typical resistor.

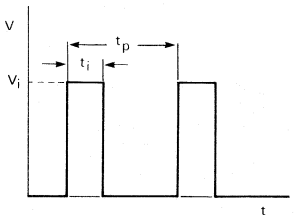


Fig. 3 Rectangular pulses.

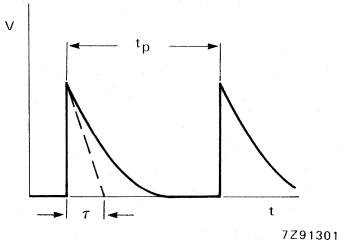


Fig. 4 Exponential pulses.

$\hat{P}$	= applied peak pulse power
$\hat{P}_{max}$	= max. permissible peak pulse power (see Fig. 1)
$\hat{V}_i$	= applied peak pulse voltage (Figs 3 and 4)
$\hat{V}_{max}$	= max. permissible peak pulse voltage (Fig. 2)
R	= nominal resistance value
t_i	= pulse duration (rectangular pulses)
t_p	= pulse repetition time
τ	= time constant (exponential pulses)
T_{amb}	= ambient temperature
T_{hsp}	= max. hot spot temperature of the resistor

Pulse-load behaviour of metal film resistors ($R > 10\ \Omega$)

Definitions

Single Pulse. The resistor is considered to be operating under single pulse conditions if, during its life, it is loaded with a limited number (approx. 1500) of pulses at long time intervals (greater than one hour).

Repetitive Pulse. The resistor is operating under repetitive pulse conditions when it is loaded by a continuous train of pulses of similar power.

Determination of pulse loading

The graphs of Figs 1 and 2 may be used to determine the maximum pulse loading for a resistor. The calculations assume:

- $T_{amb} = 70\ ^{o}C$
- T_{hsp} is the maximum permissible hot spot temperature for the relevant resistor family;
- $\Delta R/R$ equal to the permitted value for 1000 hours at continuous level.

- *For repetitive rectangular pulses:*
  - $\frac{\hat{V}_i^2}{R}$ must be lower than the value of $\hat{P}_{max}$ given by the solid lines of Fig. 1 for the applicable value of t_i and duty cycle t_p/t_i.
  - $\hat{V}_i$ must be lower than the value of $\hat{V}_{max}$ given in Fig. 2 for the applicable value of t_i.

- *For repetitive exponential pulses:*
  - As for rectangular pulses, except that $t_i = 0{,}5\ \tau$.

- *For single rectangular pulses:*
  - $\frac{\hat{V}_i^2}{R}$ must be lower than the value of $\hat{P}_{max}$ given by the dashed line of Fig. 1 for the applicable of t_i.
  - $\hat{V}_i$ must be lower than the value of $\hat{V}_{max}$ given in Fig. 2 for the applicable value of t_i.

Examples

Determine the stability of a typical resistor for operation under the following pulse-load conditions.

1. Continuous pulse train

A 100 Ω resistor is required to operate under the following conditions:

$\hat{V}_i = 40$ V; $t_i = 10^{-5}$ s; $t_p = 10^{-3}$ s.

Therefore:

$$P = \frac{40^2}{100} = 16 \text{ W} \quad \text{and} \quad \frac{t_p}{t_i} = \frac{10^{-3}}{10^{-5}} = 100.$$

For

$$t_i = 10^{-5} \text{ s} \quad \text{and} \quad \frac{t_p}{t_i} = 100,$$

Fig. 1 gives $\hat{P}_{max} = 19$ W and Fig. 2 gives $\hat{V}_{max} = 500$ V. As the operating conditions $\hat{P} = 16$ W and $\hat{V}_i = 40$ V are lower than these limiting values, this resistor can safely be used.

2. Single pulse

A 1000 Ω resistor is required to operate under the following conditions:

$\hat{V}_i = 200$ V; $t_i = 10^{-4}$ s.

Therefore:

$$\hat{P}_{max} = \frac{200^2}{1000} = 40 \text{ W}.$$

The dashed curve of Fig. 1 shows that at $t_i = 10^{-4}$ s, the permissible $\hat{P}_{max} = 70$ W and Fig. 2 shows a permissible $\hat{V}_{max}$ of 480 V, so again this resistor may be used.

COMPOSITION OF THE CATALOGUE NUMBER

Resistors are ordered by their *catalogue number*, a 12-digit number. The packaging method is an integral part of this number, and so is the resistance code.

TESTS AND REQUIREMENTS

Essentially all tests on resistors are carried out according to the schedule of IEC publication 115-1 in the specified climatic category and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In some instances deviations from the IEC recommendation are made.

STANDARD PACKAGING

Most types can be processed automatically. They are supplied on tape for this purpose, i.e. a bandolier which fits most commonly used automatic mounting machine. Not all bandolier configurations are identical, the deviating parameters are given in Figs 8 and 9.

Axial leads

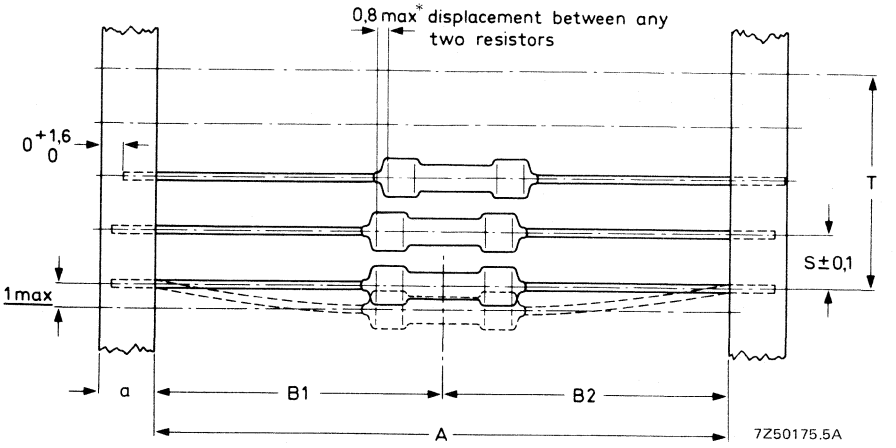


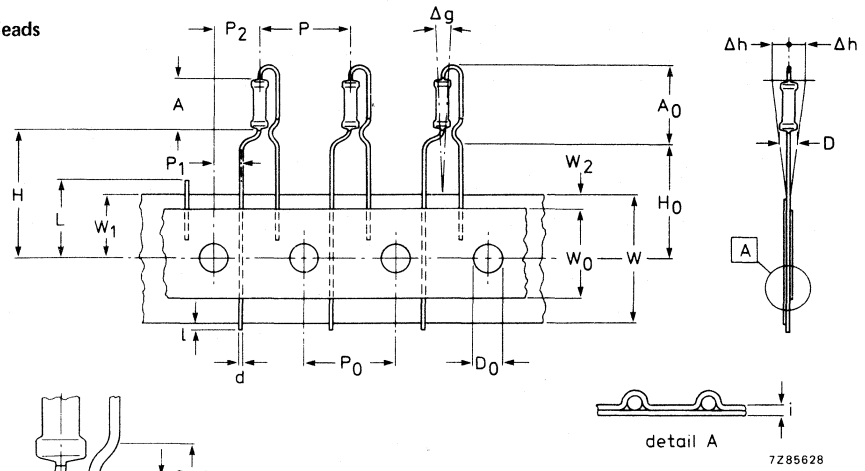
Fig. 8.

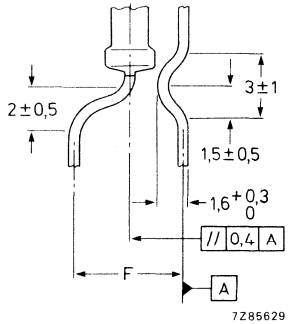
S = spacing
T = maximum deviation of spacing: 1 mm per 10 spacings or
0,5 mm per 5 spacings

a = tape width
A = tape distance
B1 – B2 = centricity

* 0,5 max. for type SFR16T.

Radial leads





Bandolier for types with radial leads.

Fig. 9.

Body diameter	D
Body length	A
Mounting height	A_0
Lead wire diameter	d
Pitch of components	P
Feed hole pitch	P_0
Maximum deviation of spacing	T
Feed hole centre to lead	P_1
Feed hole centre to body	P_2
Lead to lead distance	F
Component alignment	Δh
Component alignment	Δg
Tape width	W
Hold down tape width	W_0
Hole position	W_1
Hold down tape position	W_2
Distance component to tape centre	H
Lead wire clinch height	H_0
Lead wire protrusion	I
Feed hole diameter	D_0
Total tape thickness	i
Length of snipped lead	L

Extraction force for components in the tape plane, vertically to the direction of unreeling: $\geqslant$ 5N.

Bandoliers can be reeled; dimensions A and B differ per type.

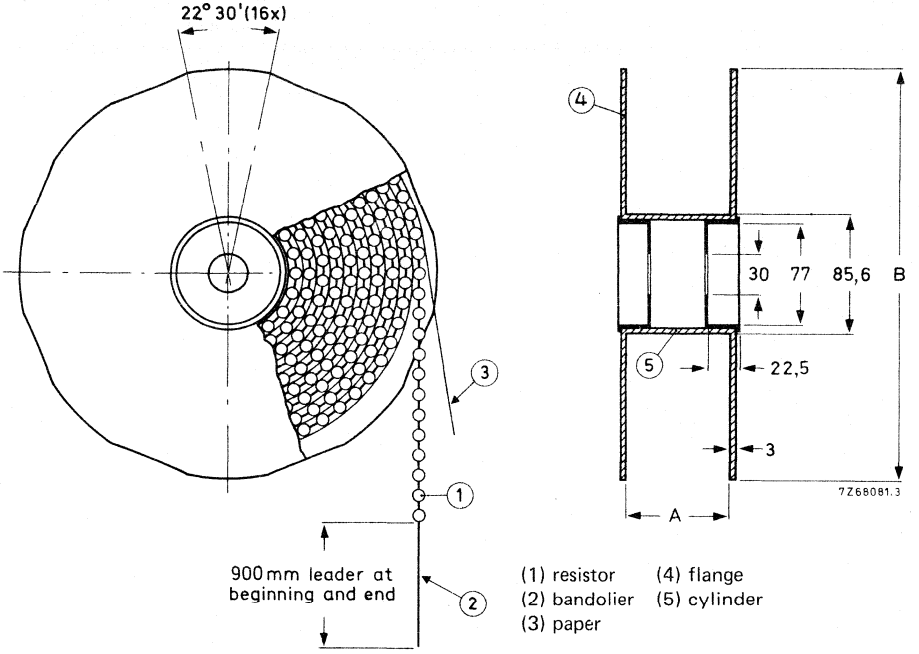


Fig. 10.

Bandoliers may also be supplied concertinaed in a cardboard box ("ammopack").

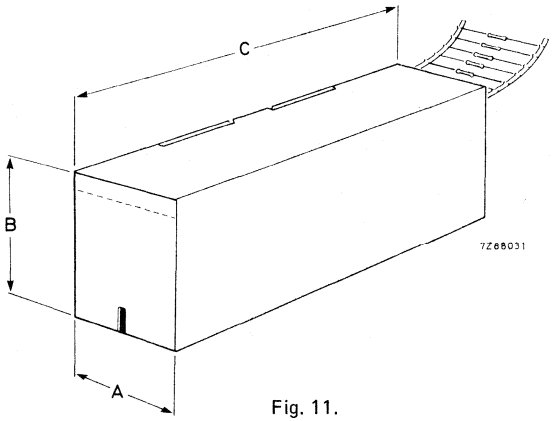


Fig. 11.

"Ammopack" is an abbreviation of "ammunition packing". The dimensions A-B-C vary per type and quantity.

SURVEY

resistor type	resistance range	tolerance %	dissipation at °C	dissipation W	type number or basic catalogue number	page
Carbon film	1 Ω to 1 MΩ	5; 10	70	0,2	CR16	21
				0,33	CR25	21
				0,5	CR37	21
				0,67	CR52	21
				1,15	CR68	21
Standard film	10 Ω to 1 MΩ	5	70	0,20	SFR16	35
				0,50	SFR16T	41
	1 Ω to 10 MΩ	5; 2		0,4	SFR25	47
				0,50	SFR25H	57
				0,50	SFR30	65
Fusible	1 Ω to 15 kΩ	5	70	0,33	NFR25	71
				0,50	NFR30	71
Metal film	10 Ω to 100 kΩ	2; 1	70	0,25	MR16	81
	1 Ω to 1 MΩ	0,5; 1; 2		0,4	MR25	81
				0,5	MR30	81
	4,99 Ω to 1 MΩ	1		1	MR52	81
MIL film	10 Ω to 1 MΩ	0,1; 0,25; 0,5; 1	70	0,125	MR24D	89
				0,25	MR34D	89
				0,5	MR54D	89
				0,75	MR74D	89
	49,9 Ω to 1 MΩ		125	0,1	MR24E/C	89
				0,125	MR34E/C	89
				0,25	MR54E/C	89
	24,9 Ω to 1 MΩ			0,5	MR74E/C	89
Metal film, precision	24 Ω to 100 kΩ	0,05; 0,02; 0,01	70	0,125	MPR24	93
				0,250	MPR34	93
	4,99 Ω to 1 MΩ	0,5; 0,25; 0,1		0,250	MPR24	93
				0,40	MPR34	93
High voltage	220 kΩ to 22 MΩ	1; 5; 10	70	0,25	VR25	105
	220 kΩ to 33 MΩ	1; 5		0,5	VR37	115
	100 kΩ to 68 MΩ			1,0	VR68	115
Power metal film	2,2 Ω to 1 MΩ	5	70	1,6	PR37	123
	2,2 Ω to 51 kΩ			2,5	PR52	123

resistor type	resistance range	tolerance %	dissipation at °C	dissipation W	type number or basic catalogue number	page
Cemented wirewound	0,1 Ω to 33 kΩ	5; 10	40	3	AC03	131
				4	AC04	131
				5	AC05	131
				7	AC07	131
				10	AC10	131
				15	AC15	131
				20	AC20	131
Cemented wirewound	0,1 Ω to 12 kΩ	5; 10	70	1	ACL01	141
				2	ACL02	141
				3	ACL03	141
Enamelled wirewound	4,7 Ω to 100 kΩ	5; 10	70	4	WR0617E	151
				7	WR0825E	151
		5		11	WR0842E	151
				17	WR0865E	151
Rectangular wirewound	0,15 Ω to 22 kΩ	5; 10	70	4	EH04	157
				5	EH05	157
				7	EH07	157
				9	EH09	157
				17	EH17	157
Chip	1 Ω to 10 MΩ	5; 10; 20	70	0,125	RC01	165

See also index of catalogue numbers at the back of the book.

CARBON FILM - CR

CARBON FILM RESISTORS

QUICK REFERENCE DATA

Resistance ranges			1 Ω to 1 MΩ; E12 or E24 series
Resistance tolerance			± 5 and ± 10%
Absolute maximum dissipation at T_{amb} = 70 °C*			CR16 = 0,2 W; CR25 = 0,33 W; CR37 = 0,5 W; CR52 = 0,67 W; CR68 = 1,15 W
Basic specification			IEC 115-1 and 115-2
Climatic category			55/155/56
Stability after			
load			see nomogram (Fig. 3)
climatic tests	R ≤ 220 kΩ	ΔR/R	max. 1,5%
	R > 220 kΩ	ΔR/R	max. 3%
soldering		ΔR/R	max. 0,5% or 0,5 Ω
short time overload		ΔR/R	max. 1%

DESCRIPTION

Resistors of 10 Ω to 1 MΩ have a homogeneous film of pure carbon deposited on a high grade ceramic body. Resistors R < 10 Ω have an electroless-deposited nickel film, and resistors R > 1 MΩ have a homogeneous film of metal alloy. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with a tan lacquer which provides electrical, mechanical and climatological protection. The encapsulation is resistant to all cleaning solvents commonly used for printed-wiring boards.

MECHANICAL DATA

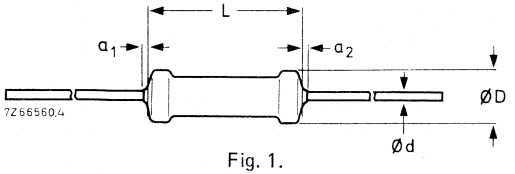


Fig. 1.

type	D_{max}	L_{max}	d	$a_1 + a_2$
CR16	1,6	4,0	0,5	≤ 1
CR25	2,5	6,5	0,6	≤ 1
CR37	3,7	10	0,7	≤ 1
CR52	5,2	16,5	0,8	≤ 2
CR68	6,8	18	0,8	≤ 2

* Dissipation at T_{amb} = 70 °C which causes the maximum permissible hot-spot temperature of 155 °C to occur, irrespective of the resistance drift provoked by this condition.

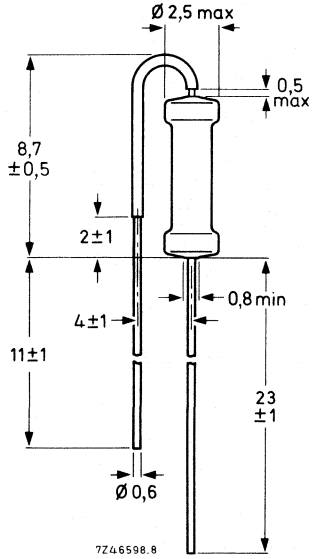


Fig. 2 "Stand-up" type, CR25A, for vertical mounting.

The bent lead is partially covered with an insulating lacquer with a break-down voltage of at least 50 V (d.c.)

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294).

nominal lead diameter (mm)	dia. of hole in gauge plate (mm)
0,5	0,8
0,6/0,7	1,0
0,8	1,2

Mass (per 100 resistors)

CR16	8 g	CR52	96 g
CR25	23 g	CR68	148 g
CR37	42 g		

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. Type CR25A can be inserted at a pitch of 1 e.

Marking

The nominal resistance and the tolerance are marked on the resistors by means of four coloured bands according to IEC publication 62: "Colour code for fixed resistors". See General Section. The code on type CR25A should be read downwards from the bent lead.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E12 - E24 series within the range 1 Ω to 1 MΩ. These values are given in the table "Standard series of values in a decade" at the back of the handbook.
The tolerance on the rated voltage is either ± 10 or ± 5%.
The limiting voltage (r.m.s.) for resistor element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation, see IEC publication 115-1 and 115-2.

Table

type	packing	quantity	resistance range	limiting voltage V r.m.s.	tolerance %	series	catalogue number
CR16	in box	1000	10 Ω – 220 kΩ	150	5	E24	2322 210 13...
			270 kΩ – 1 MΩ		10	E12	2322 210 12...
	on reel	5000	10 Ω – 220 kΩ		5	E24	2322 210 23...
			270 kΩ – 1 MΩ		10	E12	2322 210 22...
CR25	in box	1000	1 Ω – 1 MΩ	250	5	E24	2322 211 13...
	on reel	5000	1 Ω – 1 MΩ		5	E24	2322 211 23...
	in box	5000	1 Ω – 1 MΩ		5	E24	2322 211 73...
CR25, 26 mm	in box	2000	1 Ω – 1 MΩ		5	E24	2322 211 43...
CR25A	in box	1000	1 Ω – 1 MΩ	250	5	E24	2322 106 33...
CR37	in box	1000	1 Ω – 1 MΩ	350	5	E24	2322 212 13...
	on reel	5000	1 Ω – 1 MΩ		5	E24	2322 212 23...
CR52*	in box	500	1 Ω – 1 MΩ	500	5	E24	2322 213 13...
CR68*	in box	500	1 Ω – 1 MΩ	750	5	E24	2322 214 13...

Composition of the catalogue number

In the above-mentioned catalogue number, replace the first two dots by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

1 - 9,1 Ω	8	10 - 91 kΩ	3
10 - 91 Ω	9	100 - 910 kΩ	4
100 - 910 Ω	1	1 MΩ	5
1 - 9,1 kΩ	2		

* For resistance values higher than 1 MΩ, those from the VR37/VR68 series are recommended, see Fig. 4 of the relevant specification.

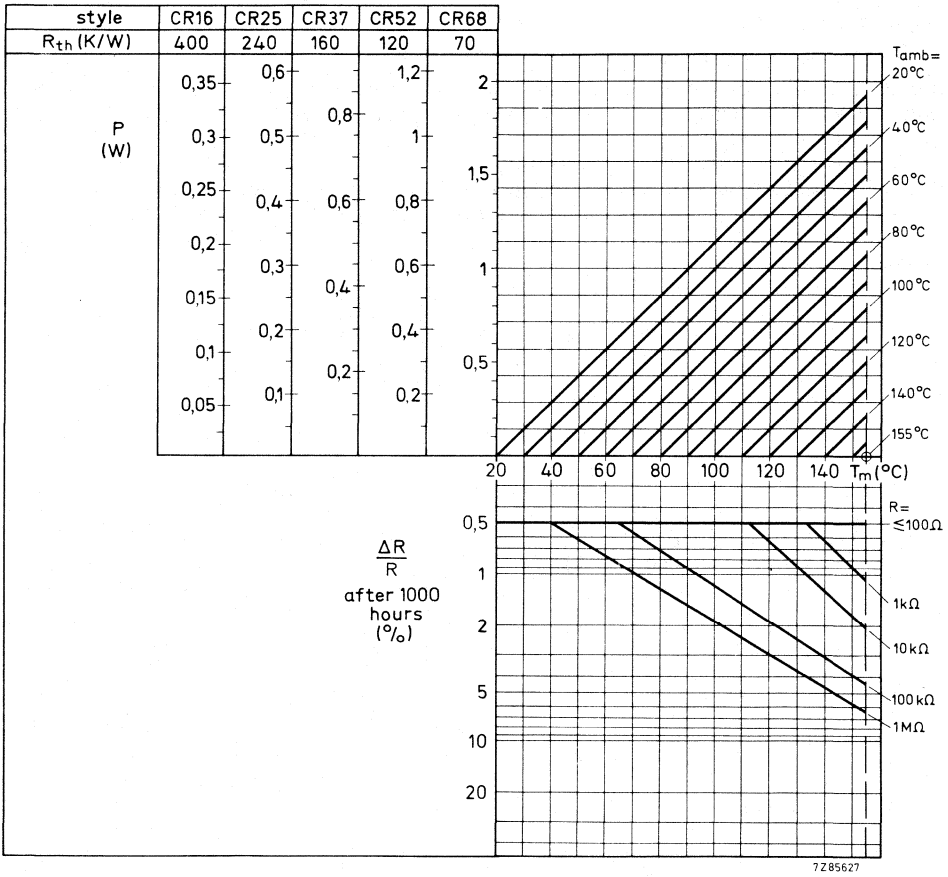


Fig. 3.

Performance nomogram for different styles of resistor showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature T_m, resistance value R, and maximum resistance drift $\Delta R/R$ after 1000 h of operation.

For continuous operation longer or shorter than 1000 h, t_x, the stability can be approximated by multiplying the drift $\Delta R/R$ after 1000 h with the square root of the time ratio, so:

$$(\Delta R/R \text{ after x h}) = (\Delta R/R \text{ after 1000 h}) \cdot (t_x/1000)^{1/2}$$

See also following notes.

Notes on nomogram

1. The nomogram should not be extended beyond the maximum permissible hot-spot temperature of 155 °C.
2. The resistance change given by the nomogram for P = 0 at a particular ambient temperature is indicative of the shelf life stability of a resistor at that temperature.
3. The stability lines do not give exact values for $\Delta R/R$, but represent a probability of 95% that the real values will be smaller than those obtained from the nomogram.
4. In the nomogram the limiting voltage of the resistors has not been taken into consideration.
5. IEC publication 115-1 is still based on the conventional method of rating resistors by a fixed "rated dissipation" at 70 °C requiring at that dissipation a fixed maximum permissible drift. In our specification, however, the rated dissipation is no longer specified and also the guaranteed resistance drift is made dependent on the working conditions. To bridge the gap between the system of IEC 115-1 and our system, Fig. 4 is added. In this figure the permissible dissipation at 70 °C for a resistance drift of max. 1,5% after 1000 hours is given, taking into consideration that the hot-spot temperature should not rise above 155 °C (horizontal part of the curves). In our specification the curves of Fig. 4 replace the rated dissipation.

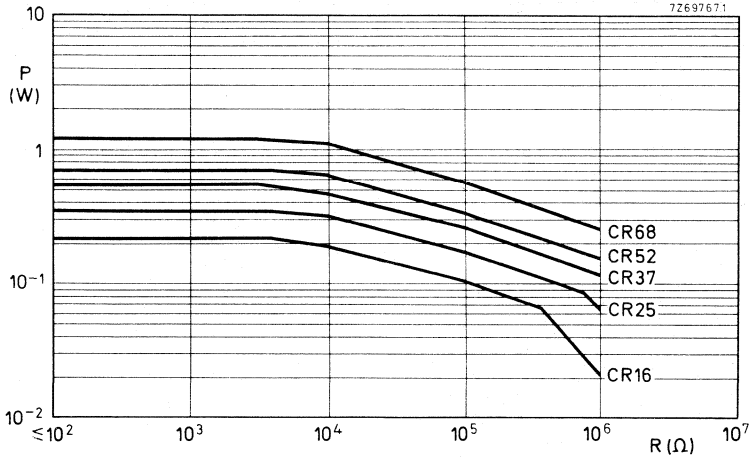


Fig. 4 Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance value for a resistance drift of 1,5% after 1000 hours or for a maximum temperature of 155 °C without reaching the resistance drift of 1,5%, limiting voltage being taken into account.

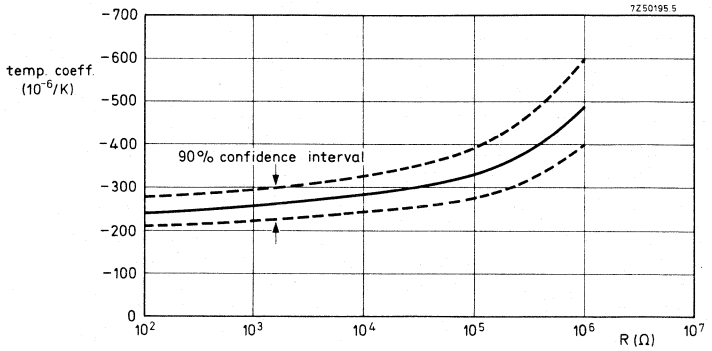


Fig. 5 Temperature coefficient as a function of the resistance value, applicable to all CR types. For values $< 10\ \Omega$ the temperature coefficient is $\leqslant + 200.10^{-6}/K$.

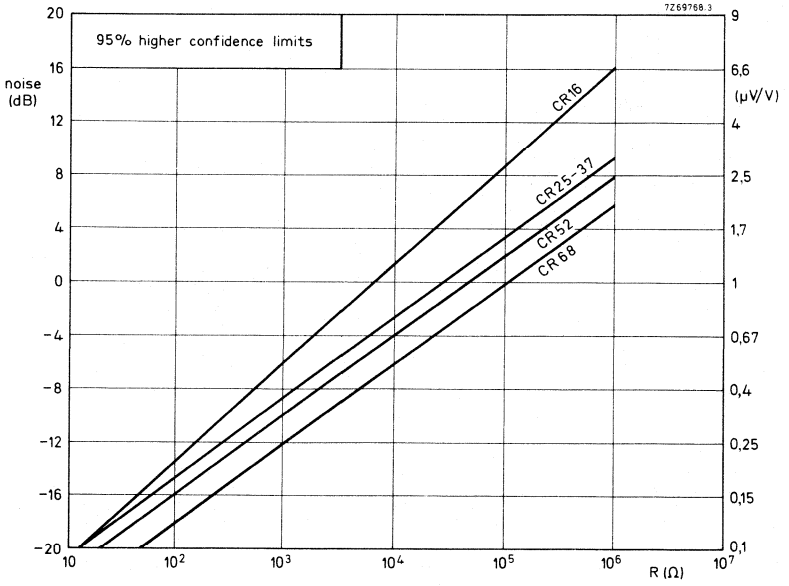


Fig. 6 Noise as a function of the resistance value. 0 dB = 1 μV/V.

High-frequency behaviour

The behaviour of a resistor at high frequencies is influenced not only by its construction but also by external factors such as length of leads, environmental stray capacitances and the measuring apparatus. Thus these factors have to be considered when measuring. The following table gives typical values under test conditions at 250 MHz using the measuring arrangement shown below. An RX-meter type 250 A of Boonton Radio Corporation is used.

Frequency: 250 MHz

	CR16		CR25		CR37		CR52		CR68	
R_{nom} (Ω)	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o
10	3,47	70	2,97	70	2,35	61	2,26	61	2,46	63
22	1,72	52	1,61	51	1,43	45	1,40	46	1,37	43
56	1,11	31	1,07	28	1,02	26	1,08	27	1,07	25
100	1,03	23	1,02	22	1,02	17	1,01	18	1,09	20
220	0,99	10	0,99	9	1	6	0,98	4	1	4
560	0,98	0	0,97	−5	0,94	−16	0,97	−5	0,90	−18
1000	0,96	−9	0,92	−15	0,88	−25	0,86	−24	0,79	−31
2200	0,84	−32	0,82	−35	0,69	−47	0,64	−50	0,49	−59
5600	0,50	−60	0,41	−66	0,35	−69	0,31	−72	0,22	−77

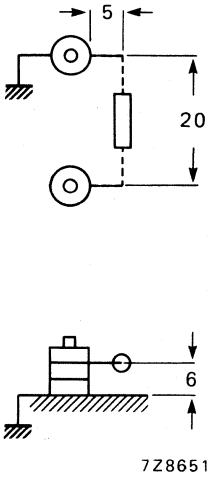


Fig. 7 Measuring arrangement.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) are carried and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC specification were necessary for our method of specifying.

Table

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	ϕ 0,5 mm: load 5 N; 10 s ϕ 0,6 - 0,7 - 0,8 mm: load 10 N; 10 s	number of failures $< 10.10^{-6}$
	Ub	Bending half number of samples	ϕ 0,5 mm: load 2,5 N; 4 x 90° ϕ 0,6 - 0,7 - 0,8 mm: load 5 N; 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,5% + 0,05 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage ΔR max. 0,5% + 0,05 Ω
20	Na	Rapid change of temperature	½ h - 55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,5% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h	no damage ΔR max. 0,5% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,5% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 hours 155 °C	
23.3	D	Damp heat (accel)		
		1st cycle	24 hours; 55 °C; 95 - 100% R.H.	
23.4	Aa	Cold	2 hours; −55 °C	
23.5	M	Low air pressure	1 hour; 8,5 kPa; 15 - 35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95 - 100% R.H.	R_{ins} = min. 1000 MΩ ΔR max. 1,5% for $R \leqslant 220$ kΩ max. 3% for $R > 220$ kΩ
24.2	Ca	Damp heat (steady state)	56 days; 40 °C; 90 - 95% R.H. The dissipation should not exceed 1% of the value indicated by Fig. 4.	R_{ins}: min. 1000 MΩ ΔR max.: 1,5% for $R \leqslant 220$ kΩ; 3% for $R > 220$ kΩ
26.2	–	Endurance	1000 hours; 70 °C; dissipation taken from Fig. 4	ΔR max.: 1,5%
11	–	Temperature coefficient	between −55 °C and + 155 °C	see Fig. 5
10	–	Voltage proof on insulation	CR16: 250 V CR25: 500 V CR37: 700 V CR52: 700 V CR68: 1000 V CR93: 1000 V r.m.s. 1 minute	no breakdown
14	–	Noise	IEC publication 195	see Fig. 6
9	–	Insulation resistance	–	min. 10^4 MΩ
15	–	Short time overload	room temperature, dissipation 6,25 x value taken from Fig. 4, (voltage not more than 2 x limiting voltage), 10 cycles, 5 s on, 45 s off	ΔR max. 1%
13	–	Voltage coefficient	–	$< 5.10^{-6}$

STANDARD PACKAGING

type	quantity per box		
	bandolier	bulk	bandolier reeled
CR16	1000		5000
CR25	1000/2000/5000		5000
CR25A		1000	
CR37	1000		5000
CR52	500		
CR68	500		

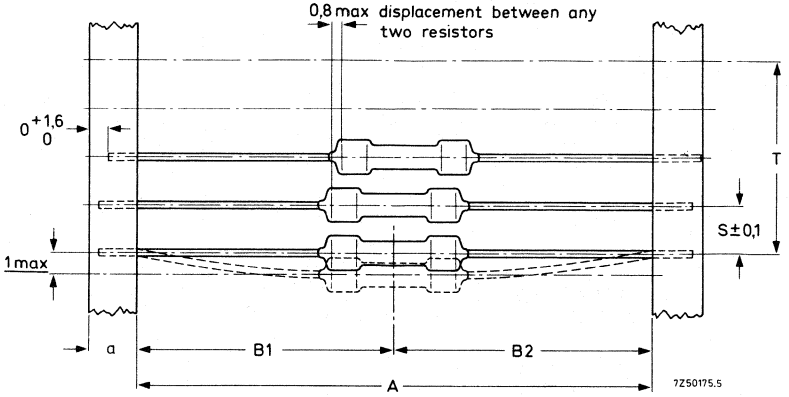


Fig. 8.

type	a ± 0,5	A ± 1,6	B1 – B2 ± max	S (spacing)	T (max. deviation of spacing)
CR16	6	52,4	1,2	5	1 mm per 10 spacings 0,5 mm per 5 spacings
CR25	6	52,4	1,2	5	
CR25	6	26 + 1,5 – 0	1,0	5	
CR37	6	52,4	1,2	5	
CR52	5	66,7	1,2	10	
CR68	5	66,7	1,2	10	

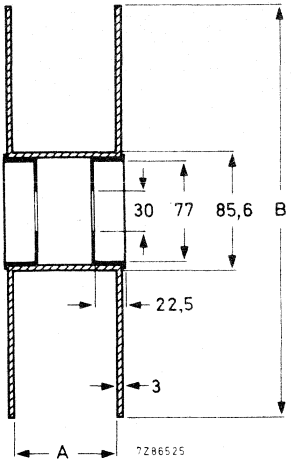


Fig. 9 Reel dimensions.

type	A	B
CR16	75	305
CR25	75	305
CR37	75	305

Leader (without resistors): 900 mm at beginning and end of reeled bandolier.

STANDARD FILM - SFR, NFR

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			10 Ω to 1 MΩ, E24 series		
Resistance tolerance			± 5%		
Temperature coefficient					
$R \leqslant 100$ kΩ			$\leqslant 100 . 10^{-6}$/K		
$R > 100$ kΩ			$\leqslant 250 . 10^{-6}$/K		
Absolute maximum dissipation					
at $T_{amb} = 70$ °C *			0,20 W		
Noise					
$R \leqslant 68$ kΩ		max.	0,1 μV/V		
68 kΩ $< R \leqslant 100$ kΩ		max.	0,5 μV/V		
$R > 100$ kΩ		max.	1,5 μV/V		
Basic specifications			IEC 115-1 and 115-2		
Climatic category (IEC 68)			55/155/56		
Stability after			$R \leqslant 100$ kΩ		$R > 100$ kΩ
load	ΔR/R	max.	1% + 0,05 Ω	max.	2% + 0,1 Ω
climatic tests	ΔR/R	max.	1% + 0,05 Ω	max.	2% + 0,1 Ω
soldering	ΔR/R	max.	0,25% + 0,05 Ω	max.	0,25% + 0,05 Ω
short time overload	ΔR/R	max.	0,25% + 0,05 Ω	max.	0,5% + 0,05 Ω

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with a light-green lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents commonly used for printed wiring boards.

MECHANICAL DATA

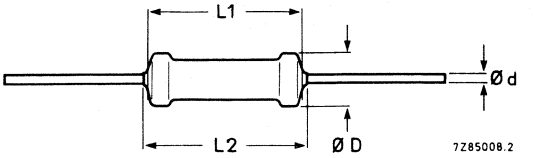


Fig. 1 This standard version is specially made to obtain a minimum "clean lead to clean lead" dimension L2.

Dmax = 1,6 mm; L1 max = 3,7 mm; L2 max = 4,0 mm; d = 0,5 mm.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,5 mm diameter, the diameter of the holes in the gauge plates is 0,8 mm.

* Dissipation at $T_{amb} = 70$ °C which causes the maximum permissible hot-spot temperature of 155 °C to occur, irrespective of the resistance drift provoked by this condition.

Mass 8 g per 100 resistors

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for this type is 3e (7,6 mm).

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 10 Ω to 1 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 5%.

The limiting voltage (r.m.s.) for resistor element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation. See IEC publications 115-1 and 115-2. This voltage is 150 V.

COMPOSITION OF THE CATALOGUE NUMBER

2322 180 . 3 . . .

1 = 1000 resistors on bandolier in ammopack
2 = 5000 resistors on bandolier on reel

code for resistance:
first two figures of the resistance (in Ω)
followed by:

9	for R =	10 to 91	Ω
1	for R =	100 to 910	Ω
2	for R =	1 to 9,1	kΩ
3	for R =	10 to 91	kΩ
4	for R =	100 to 910	kΩ
5	for R =	1	MΩ

Example

The catalogue number of a resistor SFR16 of 5600 Ω, taped on a bandolier of 1000 items, supplied in ammopack, is 2322 180 13562.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to +155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	ϕ 0,5 mm; load 5N; 10 s	number of failures: < 10 ppm
	Ub	Bending half number of samples	ϕ 0,5 mm; load 2,5N; 4 x 90°	number of failures: < 10 ppm
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,25% + 0,05 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage ΔR max. 0,25% + 0,05 Ω
20	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,25% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,25% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,25% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h, 155 °C	
23.3	D	Damp heat (accel)		
		1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; –55 °C	
23.5	M	Low air pressure	2 h; 8,5 kPa 15-35 °C	
23.6	D	Damp heat (accel) re-maining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ R ⩽ 100 kΩ: ΔR max. 1,0% + 0,05 Ω R > 100 kΩ: ΔR max. 2% + 0,1 Ω
24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_n	R_{ins} min. 1000 MΩ R ⩽ 100 kΩ: ΔR max. 1,0% + 0,05 Ω R > 100 kΩ: ΔR max. 2% + 0,1 Ω
26.2	–	Endurance	1000 hours; 70 °C; nominal dissipation or V_{max}	R ⩽ 100 kΩ: ΔR max. 1,0% + 0,05 Ω R > 100 kΩ: ΔR max. 2% + 0,1 Ω
11	–	Temperature coefficient	between –55 °C and +155 °C	R ⩽ 100 kΩ: ⩽ 100.10^{-6}/K R > 100 kΩ: ⩽ 200.10^{-6}/K
10	–	Voltage proof on insulation	300 V (r.m.s.) 1 minute	no breakdown
14	–	Noise	IEC publication 195	R ⩽ 68 kΩ: max. 0,1 μV/V 68 kΩ < R ⩽ 100 kΩ: max. 0,5 μV/V R > 100 kΩ: max. 1,5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ
15	–	Short time overload	Room temperature, dissipation 6,25 x 0,125 W (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	R ⩽ 100 kΩ: ΔR max. 0,25% + 0,05 Ω R > 100 kΩ: ΔR max. 0,5% + 0,05 Ω

PACKAGING

The resistors are supplied on bandolier; either 1000 resistors in ammopack or 5000 resistors on reel.

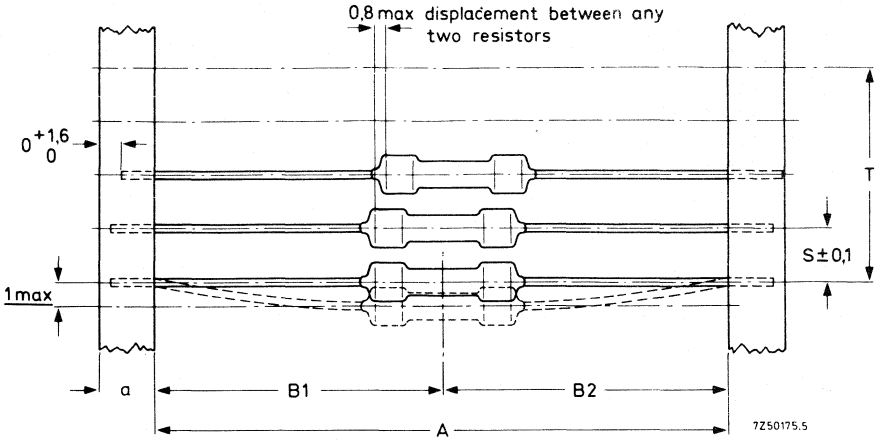


Fig. 2.

type	a ± 0,5	A ± 1,5	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
SFR16	6	52,5	1,2	5	1 mm per 10 spacings, 0,5 mm per 5 spacings

Reel dimensions

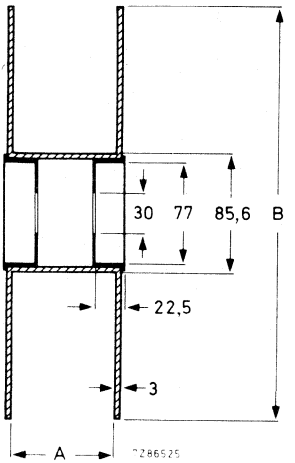


Fig. 3 Length of leader at beginning and end (bandolier without resistors) is 300 mm.

type	quantity	A	B
SFR16	5000	75	305

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			10 Ω to 1 MΩ, E24 series	
Resistance tolerance			± 5%	
Temperature coefficient				
$R \leqslant 100$ kΩ			$\leqslant \pm 100.10^{-6}$/K	
$R > 100$ kΩ			$\leqslant \pm 250.10^{-6}$/K	
Nominal dissipation, P_n at $T_{amb} = 70$ °C*			0,50 W	
Thermal resistance, R_{th}			170 K/W	
Noise				
$R \leqslant 68$ kΩ		max.	0,1 μV/V	
$R > 68$ kΩ $\leqslant 100$ kΩ		max.	0,5 μV/V	
$R > 100$ kΩ		max.	1,5 μV/V	
Basic specifications			IEC 115-1 and 115-2	
Climatic category (IEC 68)			55/155/56	
Stability after			$R \leqslant 100$ kΩ	$R > 100$ kΩ
load	ΔR/R	max.	1% + 0,05 Ω	2% + 0,1 Ω
climatic tests	ΔR/R	max.	1% + 0,05 Ω	2% + 0,1 Ω
soldering	ΔR/R	max.	0,25% + 0,05 Ω	0,25% + 0,05 Ω
short time overload	ΔR/R	max.	0,25% + 0,05 Ω	0,5 % + 0,05 Ω

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with a light-green lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents commonly used for printed wiring boards.

MECHANICAL DATA

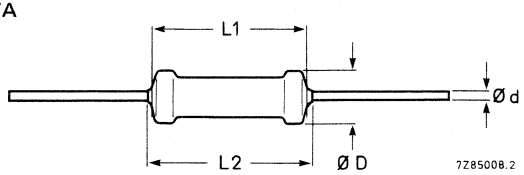


Fig. 1 Standard version, specially made to obtain a minimum "clean lead to clean lead" dimension L2 (bare bottom). For lead length see Fig. 5.

type and style	D	L1	L2 max	d
SFR16T	$1,7^{+0,2}_{-0,1}$	$3,5^{+0,2}_{-0,1}$	3,7	$0,5^{+0,01}_{-0,03}$

* The maximum permissible hot-spot temperature is 155 °C.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,5 mm diameter, the diameter of the holes in the gauge plates is 0,8 mm.

Mass 12,5 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch is 2e (5 mm).

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors".

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 10 Ω to 1 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 5%.

The limiting voltage (r.m.s.) for resistor element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation. See IEC publications 115-1 and 115-2. This voltage is 200 V.

type	bandolier width	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR16T	26 mm	ammopack	2000	10 Ω to 1 MΩ	5	2322 180 63 . . .
	52 mm	ammopack	1000	10 Ω to 1 MΩ	5	2322 180 73 . . .
	52 mm	on reel	5000	10 Ω to 1 MΩ	5	2322 180 83 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω) followed by:

9 for R =	10 to 91	Ω
1 for R =	100 to 910	Ω
2 for R =	1 to 9,1	kΩ
3 for R =	10 to 91	kΩ
4 for R =	100 to 910	kΩ
5 for R =	1	MΩ

Example

The catalogue number of a resistor SFR16T of 5600 Ω ±5%, on a 52 mm bandolier of 1000 items, supplied in ammopack, is 2322 180 73562.

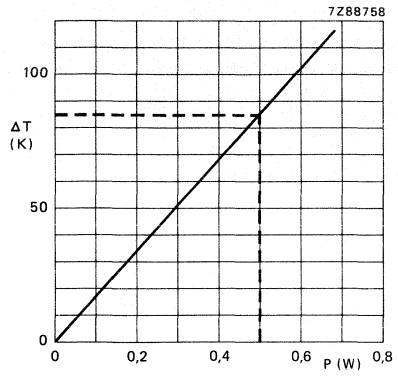


Fig. 2 Hot-spot temperature rise (ΔT) versus dissipated power.

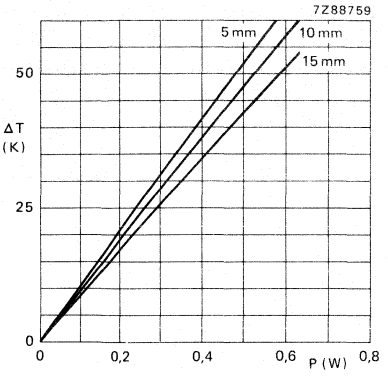


Fig. 3 Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

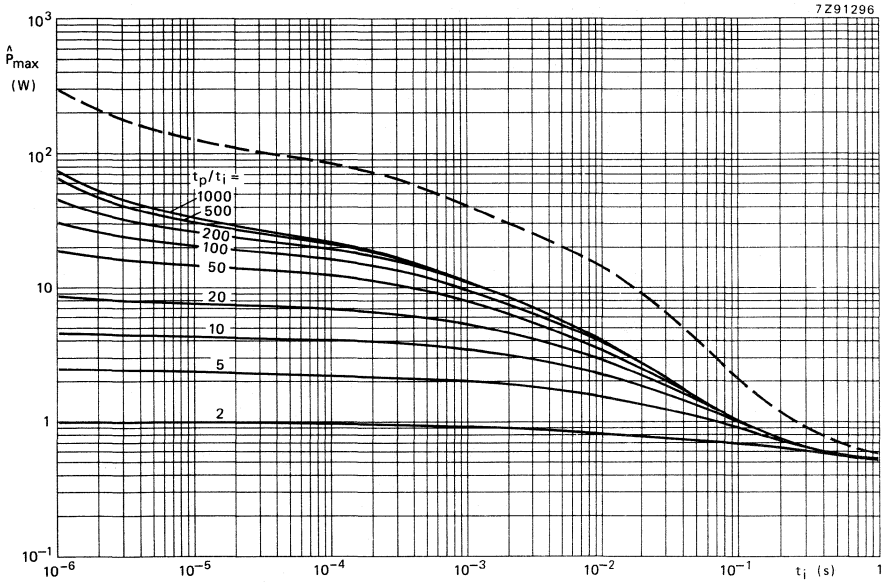


Fig. 4 Max. permissible peak pulse power ($\hat{P}_{max}$) versus pulse duration (t_i).

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	ϕ 0,5 mm; load 5 N; 10 s	number of failures < 10 ppm
	Ub	Bending half number of samples	ϕ 0,5 mm; load 2,5 N; 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,25% + 0,05 Ω
19	T	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
			thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0,25% + 0,05 Ω
20	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,25% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,25% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,25% + 0,05 Ω

IEC115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h, 155 °C	
23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; −55 °C	
23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ R ⩽ 100 kΩ ΔR max. 1% + 0,05 Ω R > 100 kΩ ΔR max. 2% + 0,1 Ω
24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_n	R_{ins} min. 1000 MΩ R ⩽ 100 kΩ ΔR max. 1% + 0,05 Ω R > 100 kΩ ΔR max. 2% + 0,1 Ω
26.2	–	Endurance	1000 hours; 70 °C; P_n or V_{max}	R ⩽ 100 kΩ ΔR max. 1% + 0,05 Ω R > 100 kΩ ΔR max. 2% + 0,1 Ω
11	–	Temperature coefficient	between −55 °C and + 155 °C	R ⩽100 kΩ: ⩽ ±100.10^{-6}/K R >100 kΩ: ⩽ ±250.10^{-6}/K
10	–	Voltage proof on insulation	400 V (r.m.s.) during 1 minute	no breakdown
14	–	Noise	IEC publication 195	R ⩽ 68 kΩ: max. 0,1 μV/V 68 kΩ < R ⩽ 100 kΩ: max. 0,5 μV/V R > 100 kΩ: max. 1,5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ
15	–	Short time overload	Room temperature, dissipation 6,25 P_n (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	R ⩽ 100 kΩ: ΔR max. 0,25% + 0,05 Ω R > 100 kΩ: ΔR max. 0,5% + 0,05 Ω
		Intermittent overload acc. to JIS-C5205 5.8	16 x 0,16 W; 1 S on −25 S off; 10 000 ± 200 cycles V max. 600 V	ΔR max. 0,75% + 0,05 Ω

PACKAGING

The resistors are supplied on bandolier in ammopack or on reel.

type	quantity per box		
	in ammopack on bandolier 52 mm	26 mm	52 mm bandolier on reel
SFR16T	1000	2000	5000

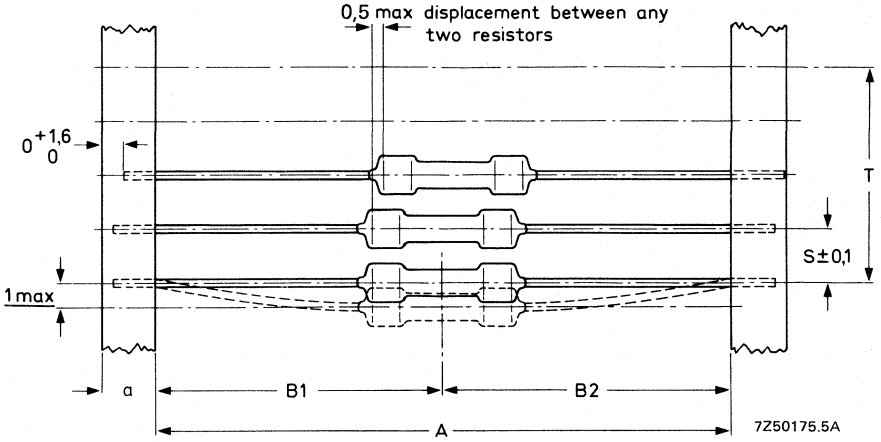


Fig. 5 Bandolier for SFR16T.

	a ± 0,5	A	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
	6	52,5 ± 1,5	0,5	5	1 mm per 10 spacings
	6	26 + 1,5 − 0	0,5	5	0,5 mm per 5 spacings

See handbook for details on reel dimensions and ammopack.

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 10 MΩ, E24 series
Resistance tolerance			± 5% and ± 2%
Temperature coefficient			
$R \leqslant 1$ MΩ			$\leqslant 100 . 10^{-6}$/K
$R > 1$ MΩ			$\leqslant 250 . 10^{-6}$/K
Absolute maximum dissipation at $T_{amb} = 70$ °C *			0,4 W
Noise			
$R \leqslant 1$ MΩ		max.	0,1 μV/V
$R > 1$ MΩ		max.	1,5 μV/V
Basic specifications			IEC 115-1 and 115-2
Climatic category (IEC 68)			55/155/56
Stability after			
load	ΔR/R	max.	1% + 0,05 Ω
climatic tests	ΔR/R	max.	1% + 0,05 Ω
soldering	ΔR/R	max.	0,25% + 0,05 Ω
short time overload	ΔR/R	max.	0,25% + 0,05 Ω

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with a light-green lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents commonly used for printed wiring boards.

MECHANICAL DATA

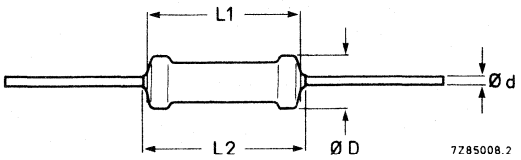


Fig. 1 Standard version, style 1 and 2. Style 2 is specially made to obtain a minimum "clean lead to clean lead" dimension L2 (bare bottom).

type and style	D_{max}	L1 max	L2 max	d
SFR25, style 1	2,5	6,5	7,5	0,6
SFR25, style 2	2,5	6,5	7,0	0,6

* This is the dissipation at $T_{amb} = 70$ °C which causes the maximum permissible hot-spot temperature of 155 °C to occur, irrespective of the resistance drift provoked by this condition.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,6 mm diameter, the diameter of the holes in the gauge plates is 1,0 mm.

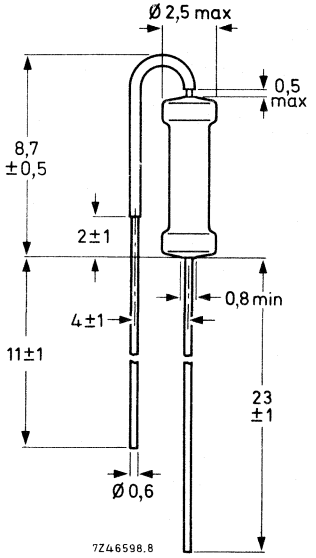


Fig. 2 "Stand-up" type SFR25A, for vertical mounting. The bent lead is partially covered with an insulating lacquer with a breakdown voltage of at least 50 V (d.c.).

Mass 25 g per 100 resistors.

Mounting

Styles 1 and 2 are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for style 1 is 5e (12,7 mm) and for style 2, 4e (10,2 mm). The "stand-up" type, SFR25A, can be inserted into holes with a pitch of 1e.

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 10 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is either ± 5% or ± 2%.

The limiting voltage (r.m.s.) for resistor element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation. See IEC publications 115-1 and 115-2. This voltage is 250 V.

type	style	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR25	1	ammopack	1000	1 Ω to 1 MΩ	5	2322 181 13 . . .
			5000			2322 181 73 . . .
		on reel	5000			2322 181 23 . . .
SFR25 "bare-bottom"	2	ammopack	1000	1 Ω to 10 MΩ	5	2322 181 53 . . .
			5000			2322 181 43 . . .
			1000	1 Ω to 1 MΩ	2	2322 181 54 . . .
		on reel	5000	1 Ω to 10 MΩ	5	2322 181 63 . . .
			5000	1 Ω to 1 MΩ	2	2322 181 64 . . .
SFR25 CECC approved 40101	2	ammopack	1000	1 Ω to 1 MΩ	5	2322 183 13 . . .
			1000		2	2322 183 14 . . .
			5000		5	2322 183 43 . . .
			5000		2	2322 183 44 . . .
		on reel	5000		5	2322 183 63 . . .
			5000		2	2322 183 64 . . .
SFR25 26 mm bandolier	2	ammopack	2000	1 Ω to 10 MΩ	5	2322 181 03 . . .
SFR25A "stand-up"	2	in box (loose)	1000	1 Ω to 10 MΩ	5	2322 181 33 . . .
SFR25AS radial taped	2	on reel	4000	1 Ω to 10 MΩ	5	2322 184 43 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω) followed by:

8 for R = 1 to 9,1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9,1 kΩ
3 for R = 10 to 91 kΩ
4 for R = 100 to 910 kΩ
5 for R = 1 to 9,1 MΩ
6 for R = 10 MΩ

Example

The catalogue number of a resistor SFR25 of 5600 Ω ±5%, bare-bottom version, taped on a bandolier of 1000 items, supplied in ammopack, is 2322 181 53562.

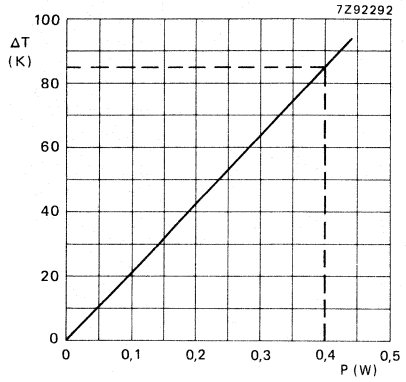


Fig. 3 Hot-spot temperature rise (ΔT) versus dissipated power.

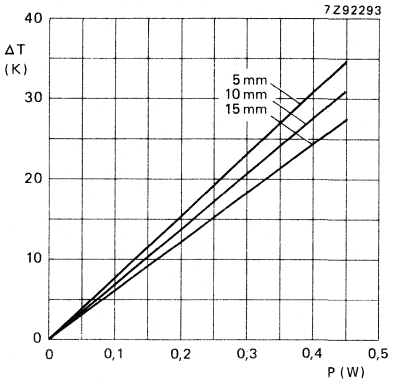


Fig. 4 Temperature rise (ΔT) at the end of the lead (soldering point) versus dissipated power, at various lead lengths after mounting.

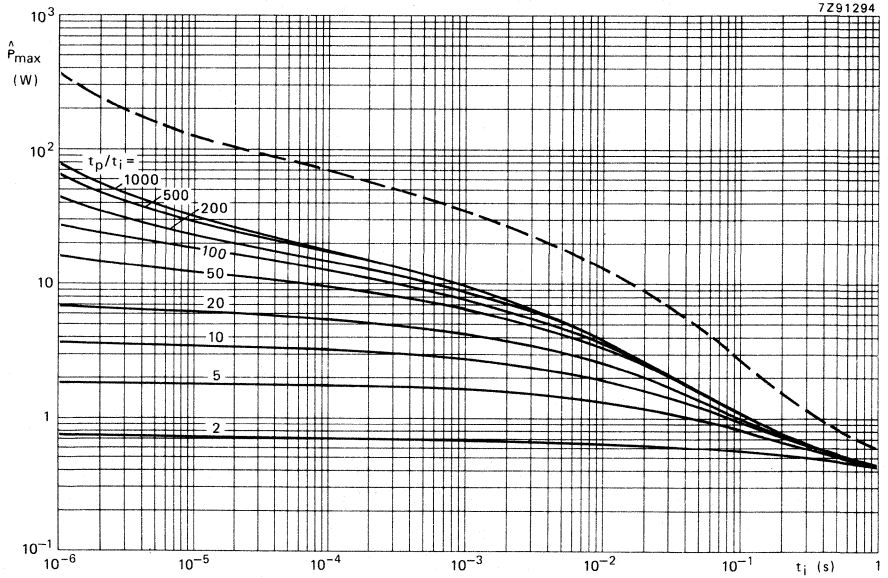


Fig. 5 Maximum permissible peak pulse power versus pulse duration.

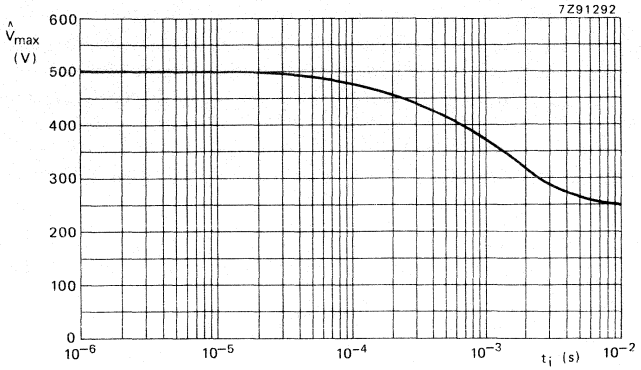


Fig. 6 Maximum permissible peak pulse voltage versus pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range –55 to +155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	ϕ 0,6 mm; load 10N; 10 s	number of failures < 10 ppm
	Ub	Bending half number of samples	ϕ 0,6 mm; load 5N; 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,25% + 0,05 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage ΔR max. 0,25% + 0,05 Ω
→ 20	Na	Rapid change of temperature	½ h –55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,25% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h 3 x 2 h)	no damage ΔR max. 0,25% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,25% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h, 155 °C	
23.3	D	Damp heat (accel)		
		1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; −55 °C	
23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 1% + 0,05 Ω ←
24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_n	R_{ins} min. 1000 MΩ ΔR max. 1% + 0,05 Ω ←
26.2	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	ΔR max. 1% + 0,05 Ω ←
11	–	Temperature coefficient	between −55 °C and + 155 °C	$R \leqslant 1$ MΩ: $\leqslant 100.10^{-6}$/K $R > 1$ MΩ: $\leqslant 250.10^{-6}$/K
10	–	Voltage proof on insulation	SFR25, style 1 700 V (r.m.s.) SFR25, style 2 600 V (r.m.s.) SFR25A 600 V (r.m.s.) 1 minute	no breakdown ←
14	–	Noise	IEC publication 195	$R \leqslant 1$ MΩ: max. 0,1 μV/V $R > 1$ MΩ: max. 1,5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ
–	–	Short time overload	Room temperature, dissipation 6,25 P_n (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0,25% + 0,05 Ω

PACKAGING

Resistors with axial leads are supplied on bandolier in ammopack or on reel; those with radial leads are either loose in a cardboard box or, with bent leads, on a bandolier in ammopack.

type and style	quantity per box		
	on bandolier ammopack	bulk loose	bandolier on reel
SFR25, style 1	1000/5000	–	5000
SFR25, style 2	1000/2000/5000	–	5000
SFR25A	–	1000	–
→ SFR25AS		–	4000

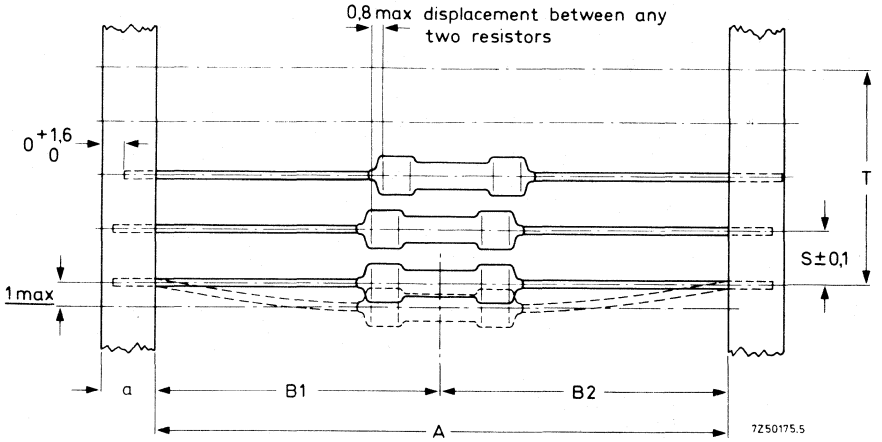


Fig. 3 Bandolier for SFR25, style 1 and 2.

type and style	a ± 0,5	A	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
SFR25, style 1	6	52,5 ± 1,5	1,2	5	1 mm per 10 spacings
SFR25, style 2	6	26 + 1,5 – 0	1,0	5	0,5 mm per 5 spacings
SFR25, style 2	6	52,5 ± 1,5	1,2	5	

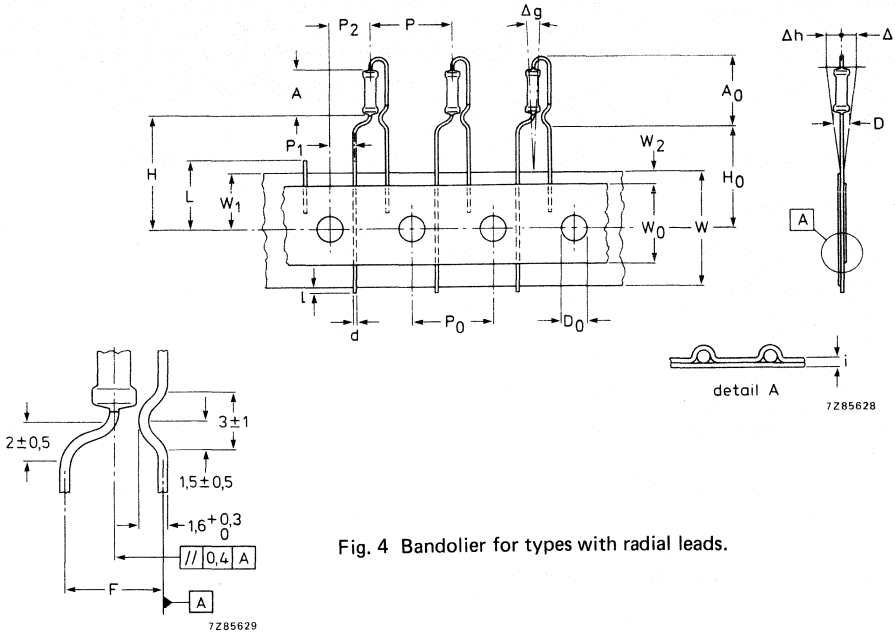


Fig. 4 Bandolier for types with radial leads.

Body diameter	D	max.	2,50
Body length	A	max.	7,00
Mounting height	A_0	max.	12,50
Lead wire diameter	d		0,60 ± 0,06
Pitch of components	P		12,7 ± 1,0
Feed hole pitch	P_0		12,7 ± 0,3
Maximum deviation of spacing	T		1,0 per 20 spacings 0,5 per 4 spacings
Feed hole centre to lead	P_1		3,85 ± 0,5
Feed hole centre to body	P_2		6,35 ± 0,4
Lead to lead distance	F		5,08 + 0,6 −0,2
Component alignment	Δh		0 ± 2 mm
Component alignment	Δg		0 ± 3°
Tape width	W		18,0 + 1 −0,8
Hold down tape width	W_0	min.	12,5 or 6 mm
Hole position	W_1		9,0 ± 0,5
Hold down tape position	W_2		2 + 0 −1,5
Distance component to tape centre	H		19,0 ± 1
Lead wire clinch height	H_0		16,5 ± 0,5
Lead wire protrusion	l	max.	0
Feed hole diameter	D_0		4,0 ± 0,2
Total tape thickness	i	max.	0,7
Length of snipped lead	L	max.	11,0

Extraction force for components in the tape plane, vertically to the direction of unreeling: ⩾ 5N.

Reel dimensions

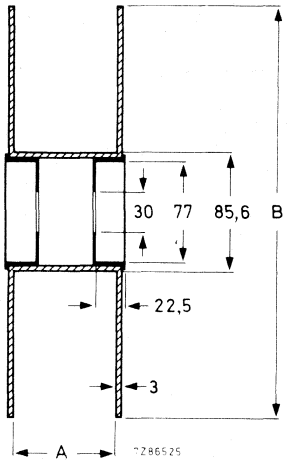


Fig. 5 Length of leader at beginning and end (bandolier without resistors) is 300 mm.

type	quantity	A	B
SFR25	5000	75	305
SFR25AS	4000	40	356

STANDARD FILM RESISTORS
metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 10 MΩ, E24 series	
Resistance tolerance			± 5% and ± 2%	
Temperature coefficient				
$R \leqslant 1$ MΩ			$\leqslant 100 \cdot 10^{-6}$/K	
$R > 1$ MΩ			$\leqslant 250 \cdot 10^{-6}$/K	
Nominal dissipation			0,50 W	
Thermal resistance			120 K/W	
Noise				
$R \leqslant 1$ MΩ		max.	0,1 μV/V	
$R > 1$ MΩ		max.	1,5 μV/V	
Basic specifications			IEC 115-1 and 115-2	
Climatic category (IEC 68)			55/155/56	
Stability after			$R \leqslant 1$ MΩ	$R > 1$ MΩ
load	ΔR/R	max.	1% + 0,05 Ω	2% + 0,1 Ω
climatic tests	ΔR/R	max.	1% + 0,05 Ω	2% + 0,1 Ω
soldering	ΔR/R	max.	0,25% + 0,05 Ω	0,25% + 0,05 Ω
short time overload	ΔR/R	max.	1% + 0,05 Ω	1% + 0,05 Ω

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with a red-brown lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents according to MIL-STD-202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

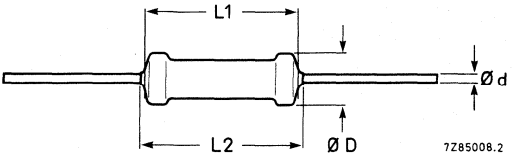


Fig. 1.

type	D_{max}	L1 max.	L2 max.	d
SFR25H	2,5	6,5	7,5	0,6

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,6 mm diameter, the diameter of the holes in the gauge plates is 1,0 mm.

Mass 25 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for this type is 5e (12,7 mm).

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 10 MΩ. E24 series of values is given in the table "Standard series of values in a decade" according to IEC publication 63. The tolerance on the rated resistance is either ± 5% or ± 2%.

The limiting voltage (r.m.s.) for resistor element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation. See IEC publications 115-1 and 115-2. This voltage is 350 V.

Table 1

type	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR25H	ammopack	1000	1 Ω to 10 MΩ	5	2322 186 13 ...
		1000	1 Ω to 1 MΩ	2	2322 186 14 ...
		5000	1 Ω to 10 MΩ	5	2322 186 73 ...
		5000	1 Ω to 1 MΩ	2	2322 186 74 ...

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω) followed by:

8 for R = 1 to 9,1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9,1 kΩ
3 for R = 10 to 91 kΩ
4 for R = 100 to 910 kΩ
5 for R = 1 to 9,1 MΩ
6 for R = 10 MΩ

Example

The catalogue number of a resistor SFR25H of 5600 Ω ± 5% on a bandolier of 1000 items, supplied in ammopack, is 2322 186 13562.

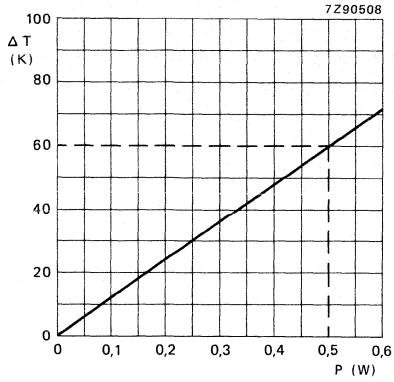


Fig. 2 Hot-spot temperature rise (ΔT) versus dissipated power

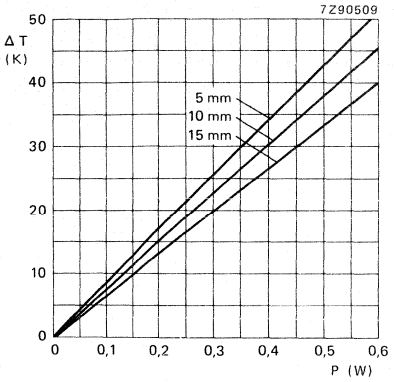


Fig. 3 Temperature rise (ΔT) at the end of the lead (soldering point) versus dissipated power, at various lead lengths after mounting.

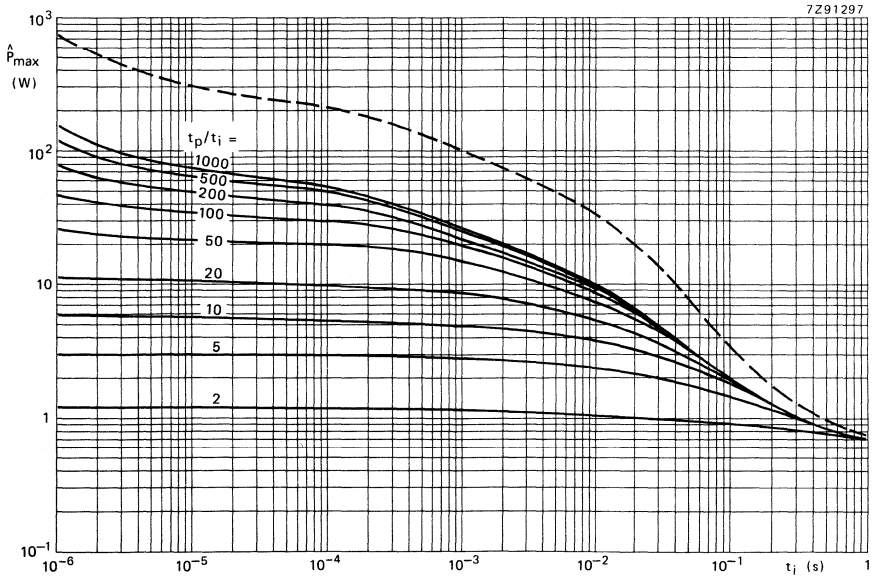


Fig. 4 Max. permissible peak pulse power ($\hat{P}_{max}$) versus pulse duration (t_i).

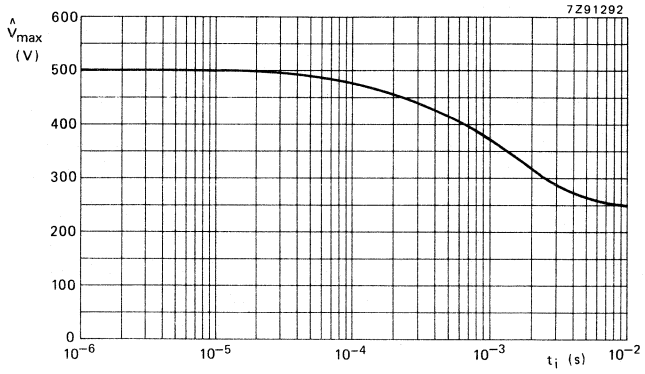


Fig. 5 Max. permissible peak pulse voltage ($\hat{V}_{max}$) versus pulse duration (t_i).

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 2

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	ϕ 0,7 mm; load 10N; 10 s	number of failures < 10 ppm
	Ub	Bending half number of samples	ϕ 0,7 mm; load 5N; 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,25% + 0,05 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning no damage ΔR max. 0,25% + 0,05 Ω
20	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C 5 cycles	$R \leqslant 1$ MΩ: ΔR max. 0,25% + 0,05 Ω $R > 1$ MΩ: ΔR max. 0,5% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,25% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,25% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h, 155 °C	
23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; −55 °C	
23.5	M	Low air pressure	2 h; 85 kPa; 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ R ⩽ 1 MΩ: ΔR max. 1% + 0,05 Ω R > 1 MΩ: ΔR max. 2% + 0,1 Ω
24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_n	R_{ins} min. 1000 MΩ R ⩽ 1 MΩ: ΔR max. 1% + 0,05 Ω R > 1 MΩ: ΔR max. 2% + 0,1 Ω
26.2	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	R ⩽ 1 MΩ: ΔR max. 1% + 0,05 Ω R > 1 MΩ: ΔR max. 2% + 0,1 Ω
11	–	Temperature coefficient	between −55 °C and + 155 °C	R ⩽ 1 MΩ: ⩽ 100.10^{-6}/K R > 1 MΩ: ⩽ 250.10^{-6}/K
10	–	Voltage proof on insulation	700 V (r.m.s.) 1 minute	no breakdown
14	–	Noise	IEC publication 195	R ⩽ 1 MΩ: max. 0,1 μV/V R > 1 MΩ: max. 1,5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ
15	–	Short time overload	Room temperature, dissipation 6,25 P_n (voltage not more than 2 x limiting voltage). 10 cycles 5 s on, 45 s off.	ΔR max. 1% + 0,05 Ω

PACKAGING

The resistors are supplied on bandolier, either 1000 or 5000 resistors in ammopack.

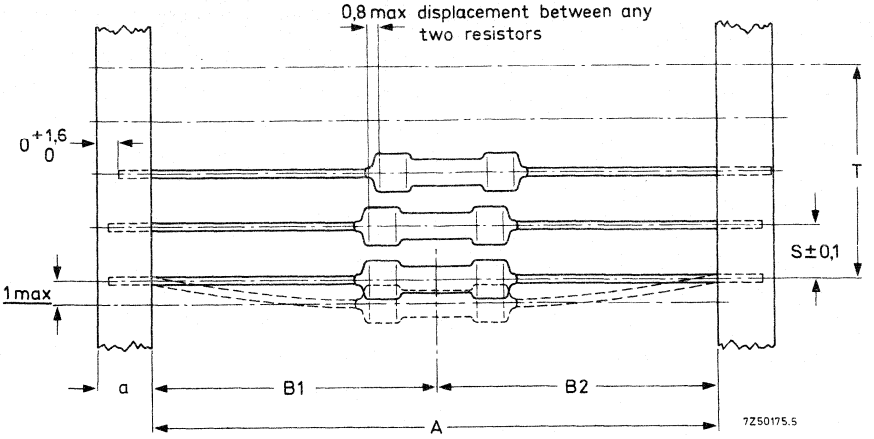


Fig. 6.

type	a ± 0,5	A ± 1,5	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
SFR25H	6	52,5	1,2	5	1 mm per 10 spacings 0,5 mm per 5 spacings

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 10 MΩ, E24 series	
Resistance tolerance			± 5 and ± 2%	
Temperature coefficient				
$R \leqslant 1$ MΩ			$\leqslant 100 . 10^{-6}$/k	
$R > 1$ MΩ			$\leqslant 250 . 10^{-6}$/k	
Absolute maximum dissipation				
at T_{amb} = 70 °C *			0,50 W	
Noise				
$R \leqslant 1$ MΩ		max.	0,1 μV/V	
$R > 1$ MΩ		max.	1,5 μV/V	
Basic specifications			IEC 115-1 and 115-2	
Climatic category (IEC 68)			55/155/56	
Stability after			$R \leqslant 1$ MΩ	$R > 1$ MΩ
load	ΔR/R	max.	1% + 0,05 Ω	2% + 0,1 Ω
climatic tests	ΔR/R	max.	1% + 0,05 Ω	2% + 0,1 Ω
soldering	ΔR/R	max.	0,25% + 0,05 Ω	0,25% + 0,05 Ω
short time overload	ΔR/R	max.	1% + 0,05 Ω	1% + 0,05 Ω

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with a light-green lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents commonly used for printed wiring boards.

MECHANICAL DATA

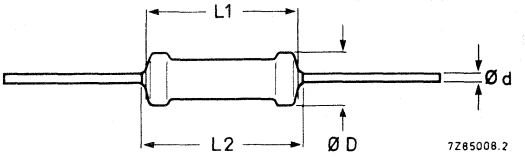


Fig. 1 Dmax = 3,0 mm; L1 max = 8,5 mm; L2 max = 9,5 mm; d = 0,7 mm.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor is clamped without deformation (IEC publication 294). For leads of 0,7 mm diameter, the diameter of the holes in the gauge plates is 1,0 mm

* This is the dissipation at T_{amb} = 70 °C which causes the maximum permissible hot-spot temperature of 155 °C to occur, irrespective of the resistance drift provoked by this condition.

Mass 33 g per 100 resistors

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for this type is 5e (12,7 mm).

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 10 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is either ± 5% or ± 2%.

The limiting voltage (r.m.s.) for resistor element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation, see IEC publication 115-1 and 115-2. This voltage is 350 V.

type	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR30	ammopack	1000	1 Ω to 10 MΩ	5	2322 182 13 . . .
		5000	1 Ω to 10 MΩ	5	2322 182 73 . . .
		1000	1 Ω to 1 MΩ	2	2322 182 14 . . .
	on reel	5000	1 Ω to 10 MΩ	5	2322 182 23 . . .
		5000	1 Ω to 1 MΩ	2	2322 182 24 . . .
SFR30 CECC approved 40101	ammopack	1000	1 Ω to 1 MΩ	5	2322 185 13 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω), followed by:

8 for R = 1 to 9,1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9,1 kΩ
3 for R = 10 to 91 kΩ
4 for R = 100 to 910 kΩ
5 for R = 1 to 9,1 MΩ
6 for R = 10 MΩ

Example

The catalogue number of a resistor SFR30 of 5600 Ω ± 5%, on a bandolier of 1000 items, supplied in ammopack, is 2322 182 13562.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range –55 to +155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	ϕ 0,7 mm; load 10N; 10 s	number of failures < 10 ppm
	Ub	Bending half number of samples	ϕ 0,7 mm; load 5N; 4 x 90°	number of failures < 10 ppm
	Uc	Torsion other half number of samples	3 x 360 ° in opposite directions	no damage ΔR max. 0,25% + 0,05 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning no damage ΔR max. 0,25% + 0,05 Ω
20	Na	Rapid change of temperature	½ h –55 °C/½ h + 155 °C, 5 cycles	$R \leqslant 1$ MΩ: ΔR max. 0,25% + 0,05 Ω $R > 1$ MΩ: ΔR max. 0,5% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,25% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,25% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h, 155 °C	
23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; –55 °C	
23.5	M	Low air pressure	2 h; 85 kPa; 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ R ⩽ 1 MΩ: ΔR max. 1% + 0,05 Ω R > 1 MΩ: ΔR max. 2% + 0,1 Ω
24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_n	R_{ins} min. 1000 MΩ R ⩽ 1 MΩ: ΔR max. 1% + 0,05 Ω R > 1 MΩ: ΔR max. 2% + 0,1 Ω
26.2	–	Endurance	1000 hours; 70 °C; nominal dissipation or V_{max}	R ⩽ 1 MΩ: ΔR max. 1% + 0,05 Ω R > 1 MΩ: ΔR max. 2% + 0,1 Ω
11	–	Temperature coefficient	between –55 °C and + 155 °C	R ⩽ 1 MΩ: ⩽ 100.10^{-6}/K R > 1 MΩ: ⩽ 250.10^{-6}/K
10	–	Voltage proof on insulation	700 V (r.m.s.) 1 minute	no breakdown
14	–	Noise	IEC publication 195	R ⩽ 1 MΩ: max. 0,1 μV/V R > 1 MΩ: max. 1,5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ
15	–	Short time overload	Room temperature, dissipation 6,25 P_n (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 1% + 0,05 Ω

PACKAGING

The resistors are supplied on bandolier; either 1000 resistors in ammopack or 5000 resistors on reel.

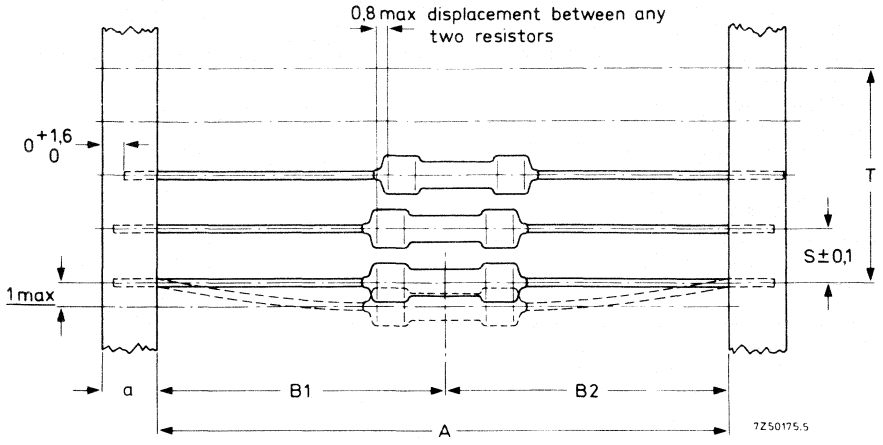
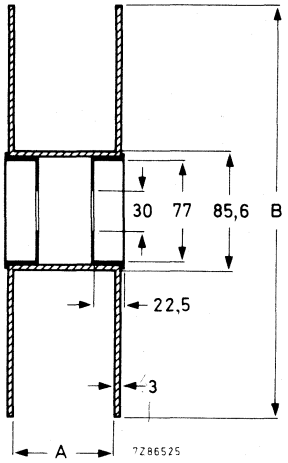


Fig. 2.

type	a ± 0,5	A ± 1,5	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
SFR30	6	52,5	1,2	5	1 mm per 10 spacings 0,5 mm per 5 spacings

Reel dimensions



type	quantity	A	B
SFR30	5000	75	356

Fig. 3 Length of leader at beginning and end (bandolier without resistors) is 300 mm.

FUSIBLE RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range		1 Ω to 15 kΩ, E24 series	
Resistance tolerance		± 5%	
Temperature coefficient		⩽ 100.10^{-6}/K	
Absolute maximum dissipation at T_{amb} = 70 °C*	NFR25 NFR30	0,33 W 0,50 W	
Basic specifications		IEC 115-1 and 115-2	
Climatic category (IEC 68)		55/155/56	
Stability after		NFR25	NFR30
endurance test	ΔR/R max.	1% + 0,05 Ω	1% + 0,05 Ω
climatic tests	ΔR/R max.	1% + 0,05 Ω	1% + 0,05 Ω
soldering	ΔR/R max.	0,25% + 0,05 Ω	0,25% + 0,05 Ω

APPLICATION

These resistors have been designed to meet the safety requirements in audio and video applications, in circuits where protection against overloads is needed, e.g. in power supply circuits. The resistors will become open circuited within a certain range of overload, without the risk of fire (see Figs 2 and 5).

DESCRIPTION

A homogenous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with a grey flame retardant lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents commonly used for printed-wiring boards.

MECHANICAL DATA

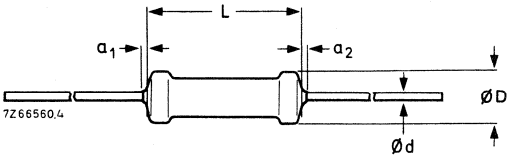


Fig. 1.

type	D_{max}	L_{max}	d	$a_1 + a_2$
NFR25	2,5	6,5	0,6	⩽ 1
NFR30	3,0	8,5	0,7	⩽ 1

* This is the dissipation at T_{amb} = 70 °C which causes the maximum permissible hot-spot temperature of 155 °C to occur, irrespective of the resistance drift provoked by this condition.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,6 and 0,7 mm diameter of the holes in the gauge plate is 1,0 mm.

Mass

NFR25	25 g per 100
NFR30	33 g per 100

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines.

Since these resistors are used in applications where overloads can occur, it is not advisable to mount the resistors against other components or against printed circuit boards.

Marking

The nominal resistance and the tolerance are marked on these resistors by means of four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 15 kΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of this book. The tolerance on the rated resistance is ± 5%.

The limiting voltage (r.m.s.) for element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation. See IEC publications 115-1 and 115-2. This voltage is 250 V for NFR25 and 350 V for NFR30.

Composition of the catalogue number

2322 20 . . . . .

style
5 = NFR25
6 = NFR30

packing:
13 for 1000 items on bandolier
23 for 5000 items on reel

resistance code: first two figures of the resistance (in Ω) followed by
8 for R of 1 to 9,1 Ω
9 for R of 10 to 91 Ω
1 for R of 100 to 910 Ω
2 for R of 1 to 9,1 kΩ
3 for R of 10 to 15 kΩ

Example

The catalogue number of a resistor NFR25 of 5600 Ω, taped on a bandolier of 1000 items, supplied in ammopack, is 2322 205 13562.

Time to interruption as a function of overload

"Interruption" means that the nominal resistance has increased at least 10 times.

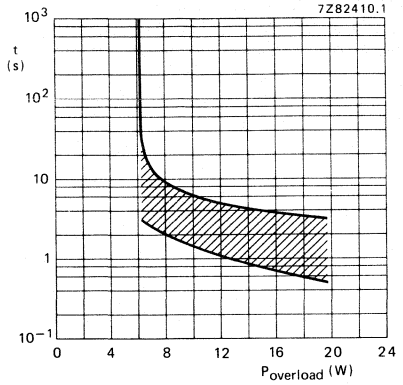


Fig. 2 NFR25; $R \leqslant 15\ \Omega$.

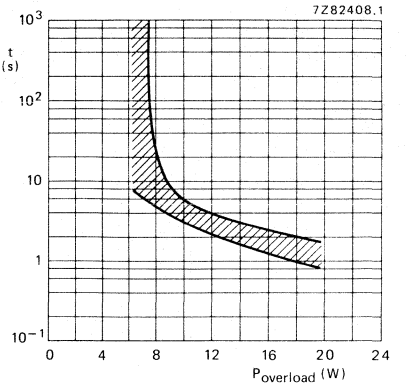


Fig. 3 NFR25; $15\ \Omega < R \leqslant 100\ \Omega$.

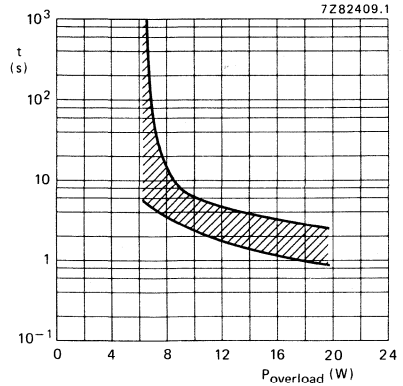


Fig. 4 NFR25; $R > 100$.

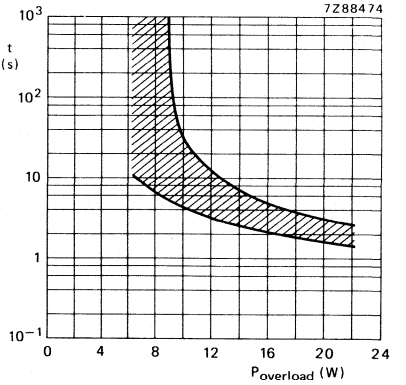


Fig. 5 NFR30.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range –55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying. For inflammability requirements reference is made to U.L. publication 1412 and to CECC.

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	load 10 N, 10 s	number of failures < 10 ppm
	Ub	Bending half number of samples	load 5 N, 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,25% + 0,05 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning no damage ΔR max. 0,25% + 0,05 Ω
20	Na	Rapid change of temperature	½ h –55 °C/½ h + 155 °C 5 cycles	ΔR max. 0,25% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,25% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,25% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h; 155 °C	
23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; –55 °C	
23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 1,0% + 0,05 Ω
24.2	Ca	Damp heat (steady state)	56 days; 40 °C; 90-95% R.H. dissipation $0{,}01P_n$	R_{ins} min. 1000 MΩ ΔR max. 1,0% + 0,05 Ω
26.2	–	Endurance	1000 hours; 70 °C; nominal dissipation or V_{max}	ΔR max. 1,0% + 0,05 Ω
11	–	Temperature coefficient	between –55 °C and + 155 °C	$\leqslant 100.10^{-6}$/K
10	–	Voltage proof on insulation	700 V (r.m.s.) 1 minute	no breakdown
14	–	Noise	IEC publication 195	$< 0{,}1\ \mu V/V$
9	–	Insulation resistance		min. 10^4 MΩ

PACKAGING

The resistors are supplied on bandolier; either 1000 resistors in ammopack or 5000 resistors on reel.

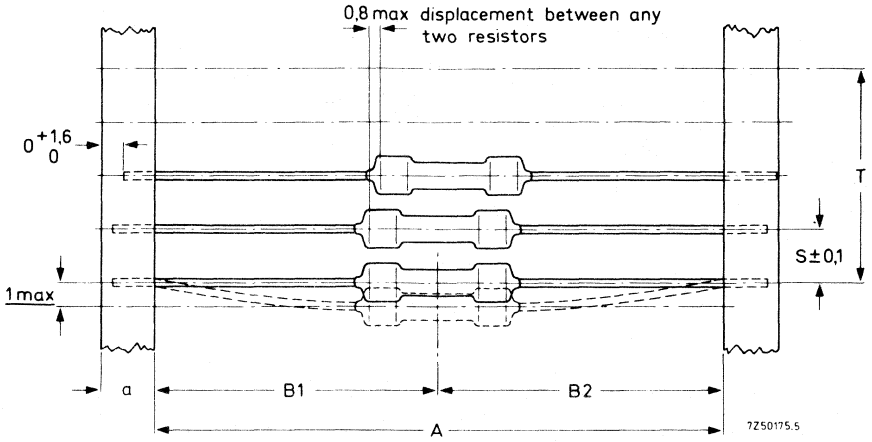


Fig. 6.

type	a ± 0,5	A ± 1,5	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
NFR25	6	52,5	1,2	5	1 mm per 10 spacings, 0,5 mm per 5 spacings
NFR30	6	52,5	1,2	5	

Reel dimensions

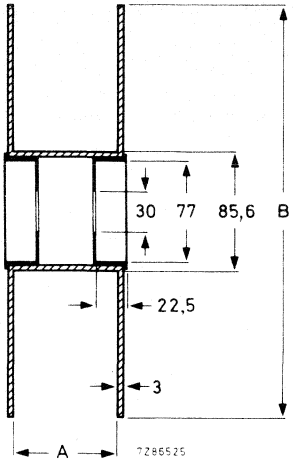


Fig. 7.

type	quantity	A	B
NFR25	5000	75	305
NFR30	5000	75	356

METAL FILM — MR, MPR

METAL FILM RESISTORS

QUICK REFERENCE DATA

Type	MR16	MR25	MR30	MR52
Resistance range	10 Ω to 100 kΩ	1 Ω to 1 MΩ	1 Ω to 1 MΩ	4,99 Ω to 1 MΩ
Series	E24; E96	E192; E24; E96	E24; E96	E96
Resistance tolerance	± 1%; ± 2%	± 0,5%; ± 1%; ± 2%	± 0,5%; ± 1%; ± 2%	± 1%
Temperature coefficient	± 50.10^{-6}/K	± 50.10^{-6}/K	± 50.10^{-6}/K	± 100.10^{-6}/K
Absolute max. dissipation at T_{amb} = 70 °C	0,25 W	0,4 W	0,5 W	1 W
Basic specification		IEC 115-1		
Climatic category (IEC 68)		55/155/56		
Approval		CECC 40101		
Stability after				
load		ΔR/R see nomogram		
climatic tests		ΔR/R max. 0,5% + 0,05 Ω		
soldering		ΔR/R max. 0,1% + 0,01 Ω		
short time overload		ΔR/R max. 0,25% + 0,05 Ω		

APPLICATION

For use in professional equipment: computers, telecom, measuring, etc.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with layers of green lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents commonly used for printed-wiring boards.

MECHANICAL DATA

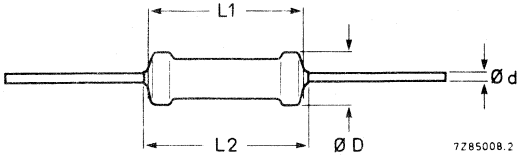


Fig. 1 This standard version is specially made to obtain a minimum "clean lead to clean lead" dimension L2.

Table 1

type	D_{max}	$L1_{max}$	$L2_{max}$	d
MR16	1,6	4,0	5,0	0,5
MR25	2,5	6,5	7,5	0,6
MR30	3,0	10,0	11,0	0,6
MR52	5,2	16,5	17,5	0,6

* Dissipation at T_{mab} = 70 °C which causes the maximum permissible hot-spot temperature of 175 °C to occur, irrespective of the resistance drift provoked by this condition.

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,5 mm dia the diameter of the holes in the gauge plate is 0,8 mm and for leads of 0,6 mm dia these holes are 1,0 mm dia.

Mass

type MR16 : 8 g per 100
MR25 : 25 g per 100
MR30 : 32 g per 100
MR52 : 92 g per 100

Mounting

The resistors are suitable for processing an automatic insertion equipment and cutting and bending machines.

→ **Marking**

The nominal resistance and tolerance are marked on the resistors by four or six coloured bands according to IEC publication 62 "Colour code for fixed resistors". Four bands are used for resistors with a 2% tolerance: 2 for the resistance value, 1 for multiplier and 1 red for tolerance.

Six bands are used for resistors with either 1% or 0,5% tolerance: 3 for resistance value, 1 for multiplier, 1 for tolerance and 1 for the temperature coefficient.

See General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series for resistors with a tolerance of ± 2%, from E24/E96 series for ± 1% and from the E192 series for ± 0,5%. The values of these series are given in the table "Standard series of values in a decade" at the back of the handbook. The limiting voltage (r.m.s.) for resistor element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation. See IEC publication 115-1 and 115-2.

Table 2

type	packing	quantity	resistance range	tol. %	series	temp. coefficient $.10^{-6}/K$	limiting voltage V	catalogue number 2322 followed by:
MR16	ammopack	1000	10 Ω to 100 kΩ	1	E24/96	50	150	150 5....
				2	E24			150 4....
	reel	5000		1	E24/96			150 2....
				2	E24			150 1....
MR25	ammopack	1000	1 Ω to 1 MΩ	0,5	E192	50*	250	151 7....
				1	E24/96			151 5....
				2	E24			151 4....
		5000		1	E24/96			151 8....
				2	E24			154 1....
	(26 mm)	2000		1	E24/96			154 0....
	reel	5000		1	E24/96			151 2....
				2	E24			151 1....
MR30	ammopack	1000	1 Ω to 1 MΩ	0,5	E192	50*	350	152 7....
				1	E24/96			152 5....
				2	E24			152 4....
	reel	5000		1	E24/96			152 2....
				2	E24			152 1....
MR52	ammopack	1000	4,99 Ω to 1 MΩ	1	E96	100	500	153 5....

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first three figures of the resistance in Ω followed by

8 for R = 1 to 9,76 Ω
9 for R = 10 to 97,6 Ω (see note)
1 for R = 100 to 976 Ω
2 for R = 1 to 9,76 kΩ
3 for R = 10 to 97,6 kΩ
4 for R = 100 to 976 kΩ
5 for R = 1 MΩ

Example: the catalogue number of a resistor MR25 of 3650 Ω ± 1% in ammopack of 1000 is 2322 151 53652

Note
The composition of catalogue number is not applicable for R = 49,9 Ω the relevant catalogue numbers will be indicated on request.

* For R < 4,99 Ω : $100.10^{-6}/K$.

DISSIPATION AND STABILITY

The stability as a function of dissipation and ambient temperature is indicated in the performance nomogram of Fig. 2.

Notes on nomogram

1. It cannot be used for MR16.
2. It should not be extended beyond the maximum permissible hot-spot temperature of 175 °C.
3. The change in resistance for P = 0 at a particular ambient temperature is indicative for the shelf-life stability of a resistor at that temperature.
4. The stability lines do not give exact values of $\Delta R/R$ but represent a probability of 95% that the actual values will be smaller than those obtained from the nomogram.
5. The limiting voltage has not been taken into consideration.

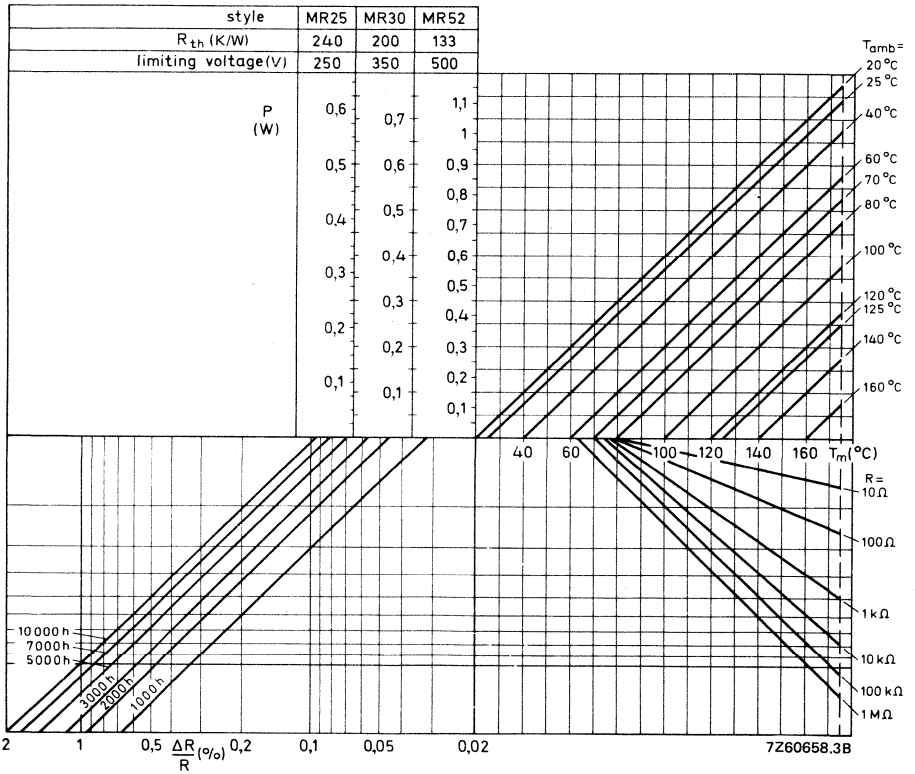


Fig. 2 Performance nomogram for different styles of resistor, showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature (T_m) and max. resistance drift $\Delta R/R$ after 1000 to 10 000 hours of operation.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C, damp heat, long term, 56 days) are carried out along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC specification were necessary for our method of specifying.

Table 3

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	load 10 N, 10 s	
	Ub	Bending half number of samples	load 5 N, 4 x 90° (MR16: load 2,5 N, 4 x 90°)	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,1% + 0,01 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600	good tinning no damage
			thermal shock: 3 s. 350 °C, 6 mm from body	ΔR max. 0,1%
20	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,1% + 0,01 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h	no damage ΔR max. 0,1% + 0,01 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,1% + 0,01 Ω MR16, for R ⩽ 100 Ω: ΔR max. 0,5% + 0,05 Ω

Table 3 (continued)

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	B	Dry heat	16 h; 155 °C	
23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; –55 °C	
23.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
24	Ca	Damp heat (long-term exposure)	56 days; 40 °C; 90-95% R.H. dissipation: MR16: ⩽ 1,25 mW MR25: ⩽ 2,5 mW MR30: ⩽ 3 mW MR52: ⩽ 5 mW	R_{ins} min. 1000 MΩ ΔR max. 1,0% + 0,05 Ω } ΔR max. 0,5% + 0,05 Ω
26.2	–	Endurance	1000 h: 70 °C: dissipation: MR16: 0,125 W MR25: 0,25 W MR30: 0,3 W MR52: 0,45 W } or V_{max}	ΔR max. 0,5% + 0,05 Ω
11	–	Temperature coefficient	between –55 °C and + 155 °C	⩽ 50.10^{-6}/K MR52: ⩽ 100.10^{-6}/K
13	–	Voltage proof	2 x limiting voltage (a.c.) with a maximum of 750 V (r.m.s.)	no breakdown
14	–	Noise	IEC publication 195 MR16: R ⩽ 68 kΩ R > 68 kΩ MR25, MR30, MR52: R ⩽ 100 kΩ MR25, MR30, MR52: R > 100 kΩ	 max. 0,1 μV/V max. 0,5 μV/V max. 0,25 μV/V max. 0,5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ
15	–	Short-time overload	T_{amb} = 25 °C dissipation 6,25 x P_{nom} voltage ⩽ 2 x limiting voltage 10 cycles: 5 s on - 45 s off	ΔR max. 0,25% + 0,05 Ω

PACKAGING

The resistors are supplied on bandolier; either in ammopack or on reel, see Table 2.

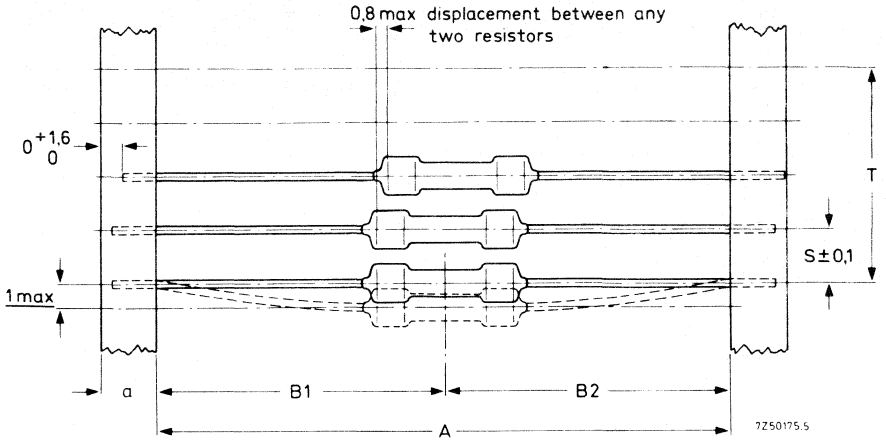
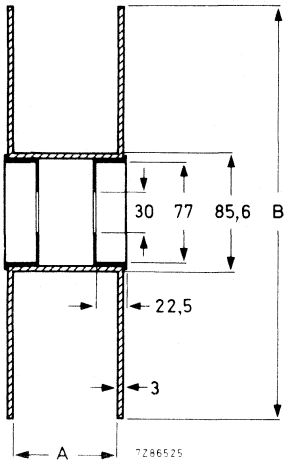


Table 3

type	a	A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
MR16	6 ± 0,5	52,4 ± 1,5	1,2	5	1 mm per 10 spacings, 0,5 mm per 5 spacings
MR25	6 ± 0,5	52,4 ± 1,5	1,2	5	
MR25 on 26 mm bandolier	6 ± 0,5	26,0 ± 1,5	1,0	5	
MR30	6 ± 0,5	52,4 ± 1,5	1,2	5	
MR52	6 ± 0,5	66,7 ± 1,5	1,2	10	

Reel dimensions



type	quantity	A	B
MR16	5000	75	305
MR25	5000	75	305
MR30	5000	75	365
MR52	–	–	–

Length of leader at beginning and end (bandolier without resistors): 300 mm.

LACQUERED METAL FILM RESISTORS

according to MIL-R-10509F

QUICK REFERENCE DATA

Resistance range		10 Ω to 1 MΩ, E96 and E192 series
Resistance tolerance		± 0,1; 0,25; 0,5; 1%
Rated dissipation at		
T_{amb} = 70 °C	MR24D	0,125 W
	MR34D	0,25 W
	MR54D	0,5 W
	MR74D	0,75 W
T_{amb} = 125 °C	MR24E/C	0,1 W
	MR34E/C	0,125 W
	MR54E/C	0,25 W
	MR74E/C	0,5 W
Basic specification		MIL-R-10509F
Stability after		
load	ΔR/R	max. 0,5% +0,05 Ω
climatic tests	ΔR/R	max. 0,5% +0,05 Ω
soldering	ΔR/R	max. 0,1% +0,05 Ω
short-time overload	ΔR/R	max. 0,25% +0,05 Ω

APPLICATION

For use in professional equipment: computers, telecom, measuring, etc.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with layers of green lacquer which provide electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents commonly used for printed wiring boards.

MECHANICAL DATA

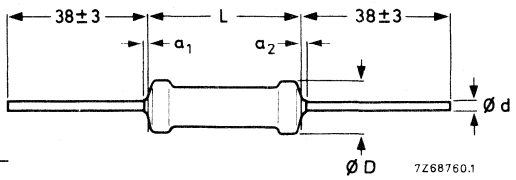


Fig. 1.

Table 1

type	D_{max}	L_{max}	a_1, a_2 $a_1 + a_2$	d
MR24E/C/D	2,4	6,5	≤ 1	0,6
MR34E/C/D	3,1	10,5	≤ 1	0,6
MR54E/C/D	5,2	16,5	≤ 1	0,6
MR74E/C/D	6,8	20,5	≤ 1	0,8

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294). For leads of 0,6 mm diameter the diameter of the holes in the gauge plate is 1,0 mm and for leads of 0,8 mm these holes are 1,2 mm diameter.

Mass

MR24E/C/D	25 g per 100
MR34E/C/D	32 g per 100
MR54E/C/D	92 g per 100
MR74E/C/D	200 g per 100

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

Marking

The resistors are marked according to the MIL specification MIL-R-10509F. This means that the following information is printed on the resistor:

MIL style
Value and tolerance in MIL code
Manufacturers' identification symbol.

In the MIL code for value and tolerance the value is indicated by four figures and a letter: first the three significant figures according to the E192 or E96 series, a fourth figure indicating the number of zeros to follow and then a letter indicating the tolerance as follows:

B = ± 0,1%; C = ± 0,25%; D = ± 0,5% and F = ± 1%.

Example: 22,1 kΩ ± 1% is written as 2212 F.
This code should not be used for ordering. Please use the catalogue number (see next page) for this purpose.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E96 series for resistors with a tolerance of ± 1%, from the E192 series for resistors with a tolerance of ± 0,5%, ± 0,25% or ± 0,1% (MIL-R-10509F para 1.2.1.3). Resistors with a tolerance of ± 0,1% and ± 0,25% may also be requested with resistance values deviating from the E192 series, provided the value can be indicated with no more than three significant figures. The values of the E96 and E192 series are given at the back of this book.

Table 2

style	rated dissipation W	maximum temperature coefficient . 10^{-6}/K	resistance range and tolerance	max. voltage V rms	MIL style	catalogue number 2322 followed by
	at 125 °C	±	0,1/0,25/0,5% E192 series 1% E96 series			
MR24E	0,1	25	49,9 Ω to 1 MΩ	200	RN55E	160 . . . . .
MR24C	0,1	50	49,9 Ω to 1 MΩ	200	RN55C	161 . . . . .
MR34E	0,125	25	49,9 Ω to 1 MΩ	250	RN60E	163 . . . . .
MR34C	0,125	50	49,9 Ω to 1 MΩ	250	RN60C	164 . . . . .
MR54E	0,25	25	49,9 Ω to 1 MΩ	300	RN65E	166 . . . . .
MR54C	0,25	50	49,9 Ω to 1 MΩ	300	RN65C	167 . . . . .
MR74E	0,5	25	24,9 Ω to 1 MΩ	350	RN70E	169 . . . . .
MR74C	0,5	50	24,9 Ω to 1 MΩ	350	RN70C	170 . . . . .
	at 70 °C	±	1% E96 series			
MR24D	0,125	100	10 Ω to 1 MΩ	200	RN55D	162 . . . . .
MR34D	0,25	100	10 Ω to 1 MΩ	300	RN60D	165 . . . . .
MR54D	0,5	100	10 Ω to 1 MΩ	350	RN65D	168 . . . . .
MR74D	0,75	100	10 Ω to 1 MΩ	500	RN70D	171 . . . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the tolerance and resistance code:

2322 . . . . . .

style code see Table 2

tolerance code
1 for ± 1%
2 for ± 0,5%
3 for ±0,25%
4 for ± 0,1%

resistance value code: first three significant figures of the resistance value (in Ω) followed by
9 for R of 10 to 98,8 Ω
1 for R of 100 to 988 Ω
2 for R of 1 to 9,88 kΩ
3 for R of 10 to 98,8 kΩ
4 for R of 100 to 988 kΩ
5 for R of 1 MΩ

For the resistance values mentioned in Table 3 the "Composition of the catalogue number" is not applicable. In this table the last 5 digits of the catalogue number are stated in full.

Table 3

resistance value Ω	last 5 digits of the catalogue number			
	0,1%	0,25%	0,5%	1%
29,9	92102	92122		
39,9	92103	92123		
49,9	92104	92124	92134	92144
59,9	92105	92125		
69,9	92106	92126		
79,9	92107	92127		
89,9	92108	92128		
99,9	92109	92129		

TESTS AND REQUIREMENTS

All tests are carried out according to the schedule of MIL-R-10509F para 4.4.2. In the table below the tests and requirements are listed with reference to the relevant paragraphs of this specification.

Table 4

MIL method			requirement	
R 10509F paragraph	STD 202 method	procedure	MIL-R-10509F paragraph	requirement*
4.6.4	102	Temperature cycling	3.9	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.5	–	Low-temperature operation	3.10	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.6	–	Short-time overload	3.11	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.7	211	Terminal strength	3.12	$\Delta R \leqslant 0{,}2\% + 0{,}05\ \Omega$
4.6.8	301/105	Dielectric withstanding voltage	3.13	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.9	302	Insulation resistance	3.14	$R_{ins} \geqslant 10\,000\ M\Omega$
4.6.10	210	Resistance to soldering heat	3.15	$\Delta R \leqslant 0{,}1\% + 0{,}05\ \Omega$
4.6.11	106	Moisture resistance	3.16	$\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$ $R_{ins} \geqslant 100\ M\Omega$
4.6.13	108	Life	3.18	$\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
4.6.15	205	Shock, medium impact	3.20	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.16	204	Vibration	3.21	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$

PACKAGING

Bulk packing, 100 per box.

* Although resistors with a temperature coefficient of $100.10^{-6}/K$ correspond with characteristic D resistors of MIL-R-10509F, they meet the more severe test requirements of characteristic C and E resistors.

METAL FILM PRECISION RESISTORS

QUICK REFERENCE DATA

Resistance range		24 Ω to 100 kΩ	4,99 Ω to 1 MΩ
Resistance tolerance		± 0,05; 0,02; 0,01%	± 0,5; 0,25; 0,1%
Category		25/125/56	55/155/56
Failure level		S	R
Absolute maximum dissipation at T_{amb} = 70 °C	MPR24	0,125 W	0,250 W
	MPR34	0,25 W	0,40 W
Specification based on		CECC 40300 MIL-R-10509 MIL-R-55182 DIN 44061 IEC 115-5	
Temperature characteristic between + 20 and + 70 °C		ΔR/R max. ± 0,0025% (TC 25) ΔR/R max. ± 0,0015% (TC 15) ΔR/R max. ± 0,0010% (TC 10) ΔR/R max. ± 0,0005% (TC 5)	
Vibration test		10 Hz to 500 Hz; 0,75 mm or 98 m/s²	
Air pressure (lower limit)		8,5 kN/m²	
Stability after			
load		ΔR/R max. 0,05% + 0,01 Ω	
climatic tests		ΔR/R max. 0,05% + 0,01 Ω	
soldering test		ΔR/R max. 0,01% + 0,01 Ω	
short overload		ΔR/R max. 0,01% + 0,01 Ω	

APPLICATION

These resistors have been developed for highly professional applications such as computers, test and telecommunication equipment, where high stability and low temperature coefficient are essential.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with layers of green lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents commonly used for printed-wiring boards.

Resistors ⩽ 200 Ω with tolerances of 0,05, 0,02 and 0,01% have a low inductance.

MECHANICAL DATA

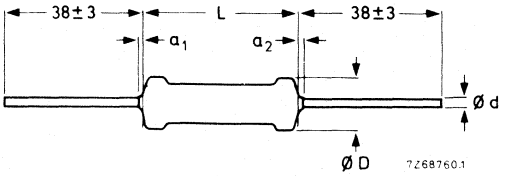


Fig. 1.

Table 1

type	D_{max}	L_{max}	$a_1 + a_2$	d
MPR24	2,5	6,5	⩽1	0,6
MPR34	3,0	10,0	⩽1	0,6

The lead length (38 ± 3 mm) only applies to untaped resistors, i.e. those packed in a cassette. See Standard Packaging.

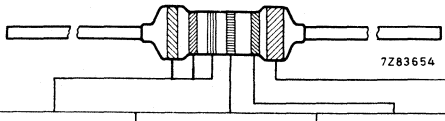
The length of the body is measured by inserting the leads into the 1 mm diameter holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294).

Mass (per 100 items): MPR24 – 25g
MPR34 – 30g

Coding

The resistors are either colour-coded or marked. Any value within the range can be supplied colour-coded, provided the resistance can be expressed in 3 coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section. All other resistors, including those in cassette packing, are marked.

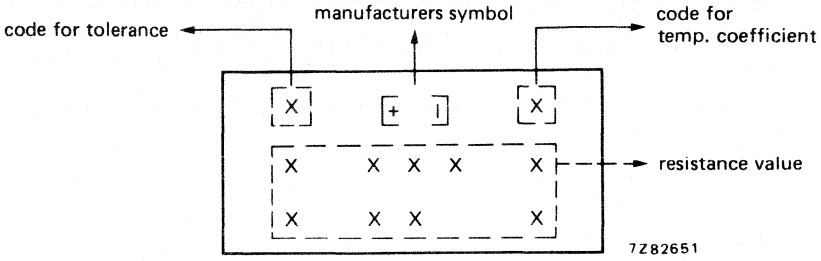
Colour coding



colour	significant figures	multiplier	tol. %	TC . 10^{-6}/K
black	0	1 x		
brown	1	10 x		
red	2	100 x		50
orange	3	1 000 x		15
yellow	4	10 000 x		25
green	5	100 000 x	± 0,5	
blue	6	1 000 000 x	± 0,25	10
violet	7		± 0,1	5
grey	8			
white	9			
silver	–	0,01 x		
gold	–	0,1 x		

Marking

When marked, the following details are printed on the resistors:



Tolerance: (acc IEC62).

± 0,5 % = D
± 0,25% = C
± 0,1 % = B
± 0,05% = W
± 0,02% = P
± 0,01% = L

Temperature coefficient:

TC 25 = 1
TC 15 = 2
TC 10 = 3
TC 5 = 4

Resistors with other temperature coefficients are available on request.

Resistance value:

Nine positions are available for the resistance value according to IEC62.
Example: 4R99 = 4,99 Ω
K2751 = 275,1 Ω
27R83 = 27,83 Ω

ELECTRICAL DATA

Maximum permissible voltage: 250 V (d.c.). Insulation voltage: 500 V (d.c.)

Resistance range		24 Ω to 100 kΩ	4,99 Ω to 1 MΩ
Resistance tolerance		± 0,05; 0,02; 0,01%	± 0,5; 0,25; 0,1%
Climatic category (IEC68)		25/125/56	55/155/56
Failure level		S	R
Absolute maximum dissipation at T_{amb} = 70 °C	MPR24	0,125 W	0,250 W
	MPR34	0,25 W	0,40 W
Temperature coefficient		5,10,15,25 · 10^{-6}/K	5,10,15,25 · 10^{-6}/K

Resistors in the range 24 Ω to 200 Ω, tolerance < 0,1%, are of low inductance.

Derating at temperatures above 70 °C

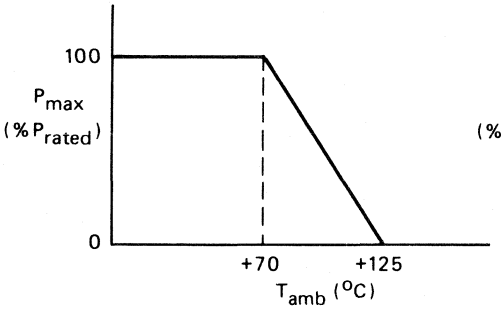


Fig. 2a Maximum dissipation (P_{max}) as a function of T_{amb} for R tolerances of 0,05, 0,02 and 0,01%.

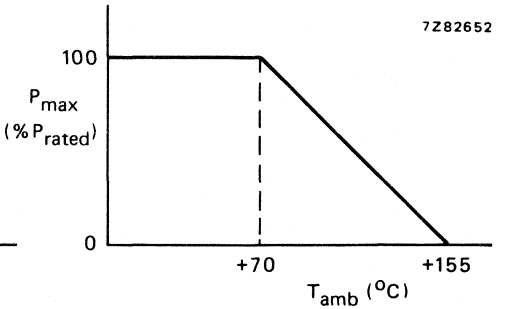


Fig. 2b Maximum dissipation (P_{max}) as a function of T_{amb} for R tolerances of 0,5, 0,25 and 0,1%.

Dissipation and stability

The stability as a function of dissipation and ambient temperature is indicated in the performance nomogram of Fig. 3 for resistors with R tolerance ≥ 0,1%.

Notes on nomogram

1. The nomogram should not be extended beyond the maximum permissible hot-spot temperature of 175 °C.
2. The resistance change given by the nomogram for P = 0 at a particular ambient temperature is indicative of the shelf-life stability of a resistor at that temperature.
3. The stability lines do not give exact values ΔR/R, but represent a probability of 95% that the real values will be smaller than those obtained from the nomogram.
4. In the nomogram the limiting voltage of the resistors has not been taken into consideration.

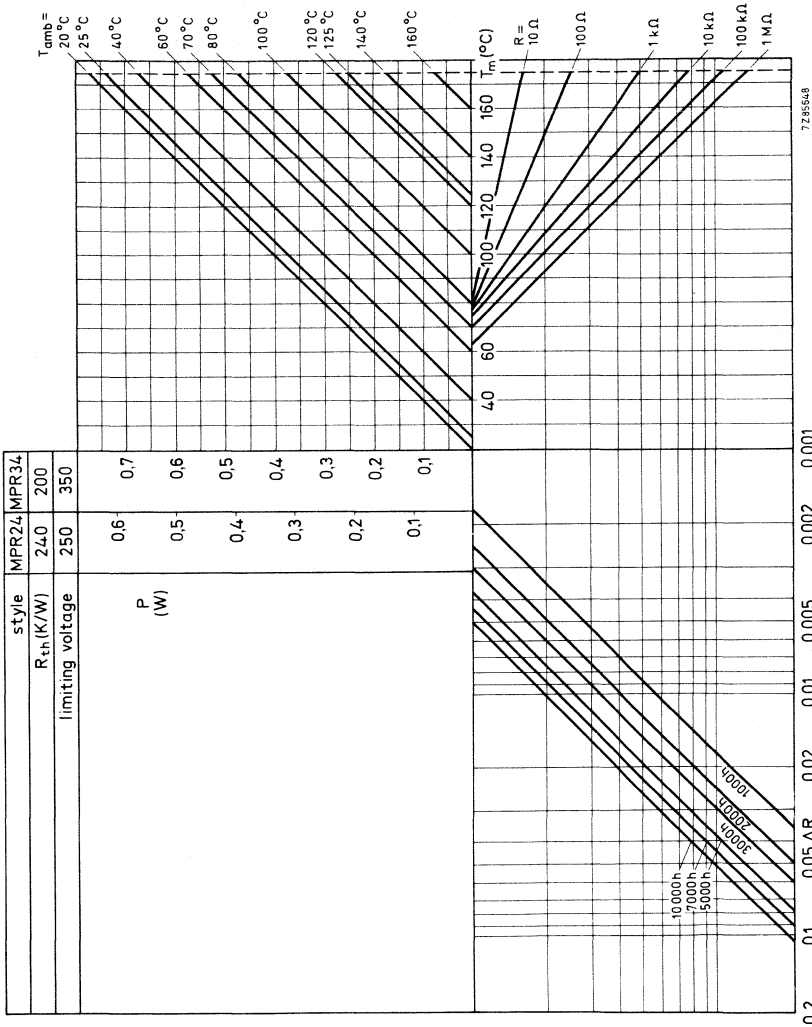


Fig. 3 Performance nomogram for different styles of resistor, showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature (T_m) and max. resistance drift $\Delta R/R$ after 1000 to 10 000 hours of operation.

COMPOSITION OF THE CATALOGUE NUMBER

a. For tolerances ± 0,05; ± 0,02 and ± 0,01%

2322 14X XXXXX

style
MPR24 = 1
MPR34 = 2

tolerance
± 0,05% = 6
± 0,02% = 7
± 0,01% = 8

temperature coefficient
25 • 10^{-6}/K = 0
15 • 10^{-6}/K = 1
10 • 10^{-6}/K = 2
5 • 10^{-6}/K = 3

Resistance code, fixed by supplier. Any value in the range 24 Ω to 100 kΩ. The resistors are marked and packed in cassettes of 20.

resistance range	T.C.	standard packing	± 0,05%	± 0,02%	± 0,01%
			MARKED		
			8th and 9th digit of the catalogue number		
24 Ω to 100 kΩ	25	20	60xxx	70xxx	80xxx
	15	20	61xxx	71xxx	81xxx
	10	20	62xxx	72xxx	82xxx
	5	20	63xxx	73xxx	83xxx

b. For tolerances ± 0,5; ± 0,25 and ± 0,1%

2322 14X XXXXX

style
MPR24 = 1
MPR34 = 2

tolerance & packing
0,5% 100 = 0
1000 = 1
0,25% 100 = 2
1000 = 3
0,1% 100 = 4
1000 = 5

temperature coefficient & coding
25 • 10^{-6}/K, colour coded = 0
15 • 10^{-6}/K, colour coded = 1
10 • 10^{-6}/K, colour coded = 2
5 • 10^{-6}/K, colour coded = 3
25 • 10^{-6}/K, marked = 4
15 • 10^{-6}/K, marked = 5
10 • 10^{-6}/K, marked = 6
5 • 10^{-6}/K, marked = 7

Resistance code, fixed by supplier. Any value in the range 4,99 Ω to 1 MΩ, temperature coefficient 25 or 15 • 10^{-6}/K, or any value in the range 4,99 Ω to 100 kΩ, temperature coefficient 10 or 5 • 10^{-6}/K.

The resistors are supplied on bandoliers of either 100 or 1000.

resistance range	T.C.	standard packing	± 0,5%		± 0,25%		± 0,1%	
			colour coded	marked	colour coded	marked	colour coded	marked
			8th and 9th digit of the catalogue number					
4,99 Ω to 1 MΩ	25	100	00xxx	04xxx	20xxx	24xxx	40xxx	44xxx
		1000	10xxx	14xxx	30xxx	34xxx	50xxx	54xxx
	15	100	01xxx	05xxx	21xxx	25xxx	41xxx	45xxx
		1000	11xxx	15xxx	31xxx	35xxx	51xxx	55xxx
4,99 Ω to 100 kΩ	10	100	02xxx	06xxx	22xxx	26xxx	42xxx	46xxx
		1000	12xxx	16xxx	32xxx	36xxx	52xxx	56xxx
	5	100	03xxx	07xxx	23xxx	27xxx	43xxx	47xxx
		1000	13xxx	17xxx	33xxx	37xxx	53xxx	57xxx

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of the CECC publication 40.300 category 55/155/56 (for the 0,5%, 0,25% and 0,1% tolerance classes) and category 25/125/56 (for the 0,05%, 0,02% and 0,01% tolerance classes) along the lines of CECC 40.000, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".
In the following table the tests are listed with reference to the relevant clauses of CECC publication 40.000 and IEC publication 68; a short description is also given on the test procedure and requirements. In some instances deviations from the CECC were necessary for our method of specifying.

Table 2

CECC 40.000 test method	IEC 68 test method	test	procedure	requirements
4.5		Insulation resistance	after 1 min with 500 V d.c.	min. 10^4 MΩ
4.6		Voltage proof	2 x limiting voltage (a.c.) with a maximum of 750 V (r.m.s.) during 1 min.	no breakdown
4.7		Temperature coefficient	(a) between + 20 °C and + 70 °C (b) between −55 °C and + 155 °C *	⩽ 25, ⩽ 15, ⩽ 10, ⩽ 5 • 10^{-6}/K ⩽ 25, 10^{-6}/K
4.10		Noise	IEC publication 195	⩽ 0,25 μV/V for R ⩽ 100 KΩ ⩽ 0,50 μV/V for R ⩽ 100 KΩ
4.11		Overload	5 s, 6,25 x P_{nom} or 2 x limiting voltage (whichever the less)	ΔR_{max} ⩽ 0,01% + 0,01 Ω
4.14		Robustness of terminations		
	Ua	Tensile all samples	load 10N, 10 S	
	Ub	Bending half number of samples	load 5N, 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR_{max} ⩽ 0,01% + 0,01 Ω
4.15	T	Soldering	solderability: 2 S 230 °C flux 600 Thermal shock: 3 S 350 °C 6 mm from body	good timing no damage ΔR_{max} ⩽ 0,01% + 0,01 Ω
4.16	Na	Rapid change of temperature	(a) ½ h −25 °C/½ h + 125 °C 5 cycles (b) ½ h −55 °C/½ h + 155 °C 5 cycles *	ΔR_{max} ⩽ 0,01% + 0,01 Ω ΔR_{max} ⩽ 0,01% + 0,01 Ω
4.17	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR_{max} ⩽ 0,01% + 0,01 Ω

* (a) and (b) refer to the tolerance groups mentioned in Composition of the Catalogue Number.

CECC 40.000 test method	IEC 68 test method	test	procedure	requirements
4.19	Fc	Vibration	frequency 10 - 500 Hz, displacing 1,5 mm or deceleration 10 g, three directions; total 6 h	no damage $\Delta R_{max} \leqslant 0{,}01\% + 0{,}01\ \Omega$
4.20		Climatic sequence		
4.20.2	B	Dry heat	(a) 16 h; 125 °C (b) 16 h; 155 °C *	
4.20.3	D	Damp heat (accel.) 1st cycle	24 h; 95 - 100% R.H.	
4.20.4	Aa	Cold	(a) 2 h; –25 °C (b) 2 h; –55 °C *	
4.20.5	M	Low air pressure	1 h; 8,5 kPa; 15 - 35 °C	
4.20.6	D	Damp heat (accel.) remaining cycles	5 days; 95 - 100% R.H.	R_{ins} min. 100 MΩ $\Delta R_{max} \leqslant 0{,}05\% + 0{,}01\ \Omega$
4.21	Ca	Damp heat, Steady state (long term exposure)	56 days 40 °C; 90 - 95% R.H. dissipation $\leqslant$ 1,25 mW	R_{ins} min. 100 M $\Delta R_{max} \leqslant 0{,}05\% + 0{,}01\ \Omega$
4.24		Endurance 1½ h on/½ h off	2000 h 70 °C dissipation P_{nom}	R_{ins} min. 100 MΩ $\Delta R_{max} \leqslant 0{,}05\% + 0{,}01\ \Omega$

→ * (a) and (b) refer to the tolerance groups mentioned in Composition of the Catalogue Number.

STANDARD PACKAGING

100 resistors on bandolier in a cardboard box; 1000 resistors on bandolier in ammopack, or 20 resistors in cassette, including list with individual measuring details.

Configuration of bandolier

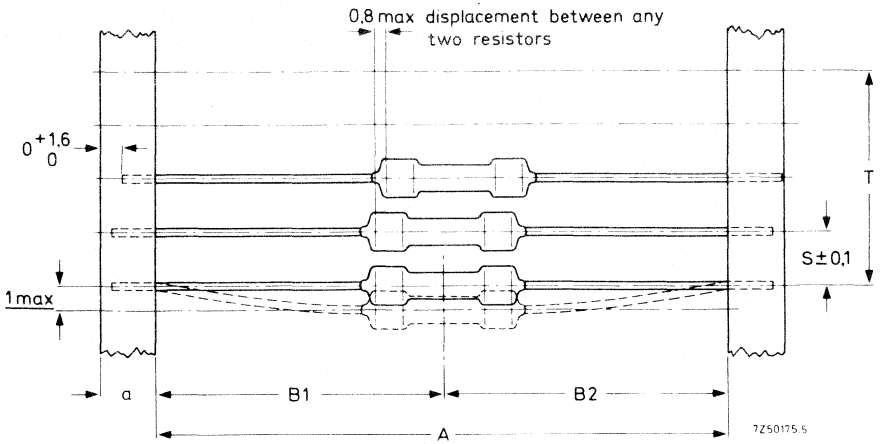


Fig. 4.

type	a ± 0,5	A ± 1,5	B1 - B2 ± max.	S spacing	T max. deviation of spacing
MPR24	6	63,5	1,2	5	1 mm per 10 spacings
MPR34	6	63,5	1,2	5	0,5 mm per 5 spacings

HIGH VOLTAGE — VR

HIGH-OHMIC/HIGH-VOLTAGE RESISTORS

QUICK REFERENCE DATA

Resistance range	220 kΩ to 15 MΩ, E24/E96 series 220 kΩ to 10 MΩ, E24 series 12 MΩ to 22 MΩ, E12 series
Resistance tolerance	± 1% (E24/E96), ± 5% (E24), ± 10% (E12)
Max. permissible body temperature (hot spot)	155 °C
Temperature coefficient	$\pm 200 \cdot 10^{-6}$/K
Rated dissipation at T_{amb} = 70 °C	0,25 W
Limiting voltage	1600 V (d.c.) or 1150 V (r.m.s.)
Dielectric withstanding voltage of the insulation for 1 minute	min. 700 V (r.m.s.)
Basic specification	IEC 115, type 1B
Climatic category (IEC 68)	55/155/56
Stability after:	
1000 h max. load	ΔR/R max. 3%
accelerated damp heat test (6 days)	ΔR/R max. 3%
long-term damp heat test (56 days)	ΔR/R max. 3%
Noise	max. 5 μV/V

APPLICATION

These resistors are for applications in which high resistance, high stability and reliability are required at high voltages. The resistors meet the safety requirements of IEC 65.

DESCRIPTION

A metal-glazed film is deposited on a high grade ceramic body; tinned electrolytic copper connecting wires are welded to the end caps. The resistors are coated with a light-blue insulating lacquer which also provides protection against environmental effects.

MECHANICAL DATA

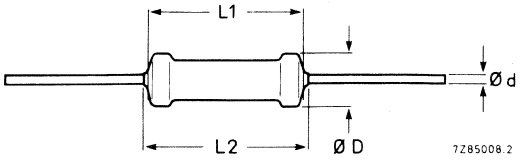


Fig. 1 Axial leads.

Table 1

type	D_{max}	$L_{1\,max}$	$L_{2\,max}$	d
VR25	2,5	6,5	7,5	0,6

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,6 mm diameter, the diameter of the holes in the gauge plates is 1,0 mm.

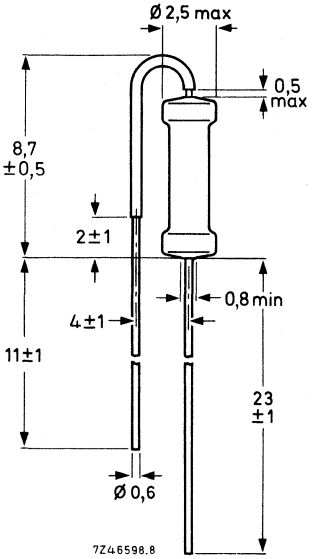


Fig. 2 "Stand-up" type VR25A, for vertical mounting. The bent lead is partially covered with an insulating lacquer with a breakdown voltage of at least 50 V (d.c.).

Mass 23 g per 100 resistors

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for the type with axial leads is 5 e (12,7 mm). The "stand-up" type, VR25A, can be inserted into holes with a pitch of 1 e.

Marking

The nominal resistance and the tolerance are marked on these resistors by four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors". See General Section.

Yellow and grey are used instead of gold and silver because metal particles in the lacquer could affect high-voltage properties.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the
E12 series within the range 12 MΩ to 22 MΩ for R ± 10%,
E24 series within the range 220 kΩ to 10 MΩ for R ± 5% and
E24/E96 series within the range 220 kΩ to 15 MΩ for R ± 1%
See the table "Standard series of values in a decade" at the back of the book.
The limiting voltage for resistor element and insulation is the maximum voltage that may be applied continuoulsy to the resistor element or the insulation, see IEC publications 115-1 and 115-2. This voltage is 1600 V (d.c.) or 1150 V (r.m.s.).

Table 2

type	packing	quantity	resistance range	tolerance ± %	series	catalogue number 2322 followed by:
VR25	ammopack	1000	220 kΩ to 15 MΩ	1	E24/E96	241 8....
			220 kΩ to 10 MΩ	5	E24	241 13...
			12 MΩ to 22 MΩ	10	E12	241 12...
		5000	220 kΩ to 10 MΩ	5	E24	241 53...
			12 MΩ to 22 MΩ	10	E12	241 52...
	on reel	5000	220 kΩ to 10 MΩ	5	E24	241 23...
			12 MΩ to 22 MΩ	10	E12	241 22...
VR25	ammopack	2000	220 kΩ to 10 MΩ	5	E24	241 43...
		2000	12 MΩ to 22 MΩ	10	E12	241 42...
26 mm bandolier						
VR25A "stand-up"	in box (loose)	1000	220 kΩ to 10 MΩ	5	E24	241 33...
			12 MΩ to 22 MΩ	10	E12	241 32...
VR25AS radial taped	ammopack	2000	220 kΩ to 10 MΩ	5	E24	243 13...
			12 MΩ to 22 MΩ	10	E12	243 12...
	on reel	4000	220 kΩ to 10 MΩ	5	E24	243 33...
			12 MΩ to 22 MΩ	10	E12	243 32...

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures (for 1% tolerance first three figures) of the resistance, followed by:

4 for R = 280 to 910 kΩ
5 for R = 1 to 9,1 MΩ
6 for R > 10 MΩ

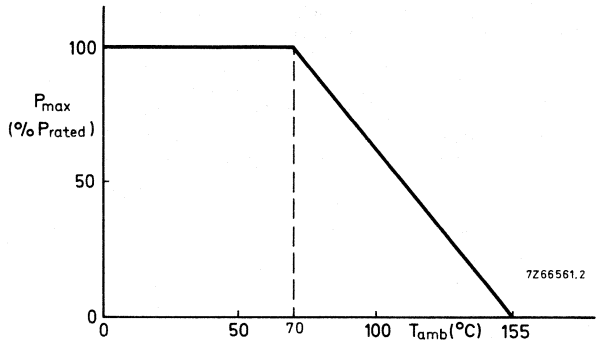


Fig. 3 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

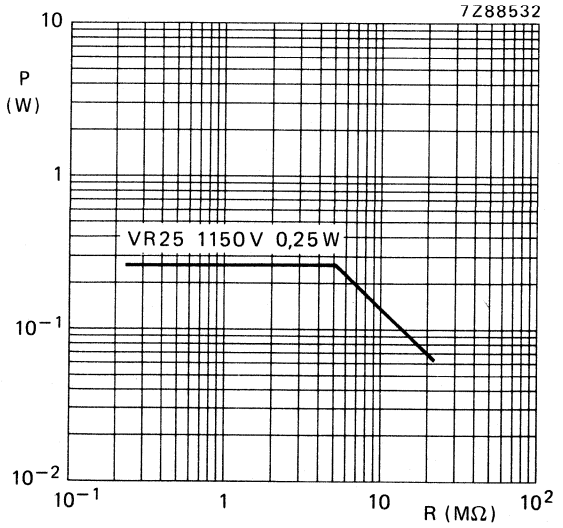


Fig. 4 Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range –55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	load 10N; 10 s	number of failures: < 10 ppm
	Ub	Bending half number of samples	load 5N; 4 x 90°	number of failures: < 10 ppm
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,5% + 0,05 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage ΔR max. 0,5% + 0,05 Ω
20	Na	Rapid change of temperature	½ h –55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,5% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,5% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,5% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h, 155 °C	
23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; −55 °C	
23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 3%
24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation ≤ 0,01 P_n limiting voltage 16 V (d.c.)	R_{ins} min. 1000 MΩ ΔR max. 3%
26.2	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	ΔR max. 3%
11	–	Temperature coefficient	between −55 °C and + 155 °C	± 200.10^{-6}/K
10	–	Voltage proof on insulation	700 V (r.m.s.), 1 minute	no breakdown
14	–	Noise	IEC publication 195	max. 5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ
–	–	Short time overload	Room temperature, dissipation 6,25 P_n (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0,5% + 0,05 Ω

PACKAGING

Resistors with axial leads are supplied on bandolier in ammopack or on reel; those with radial leads are either loose in a cardboard box or – with bent leads – on a bandolier in ammopack.

type	quantity per box		
	bandolier ammopack	bulk loose	bandolier on reel
VR25	1000/2000/5000	–	5000
VR25A	–	1000	–
VR25AS	2000	–	4000

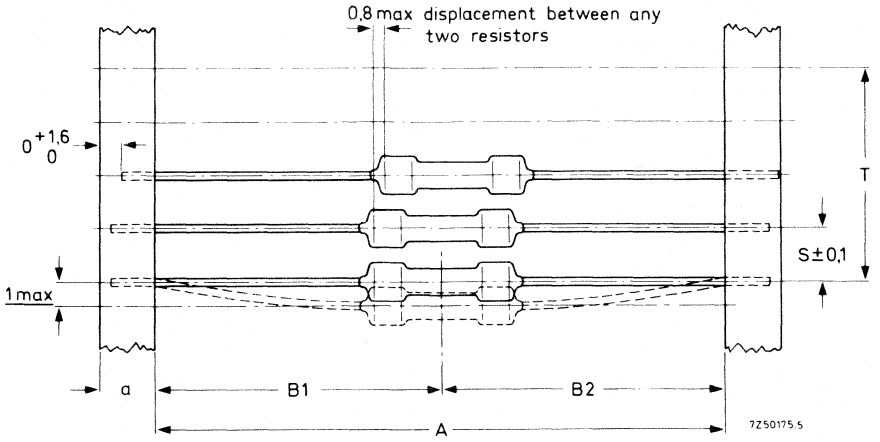


Fig. 5 Bandolier for VR25, axial types.

type	a ± 0,5	A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
VR25	6	52,5 ± 1,5	1,2	5	1 mm per 10 spacings
VR25	6	26 + 1,5 – 0	1,0	5	0,5 mm per 5 spacings

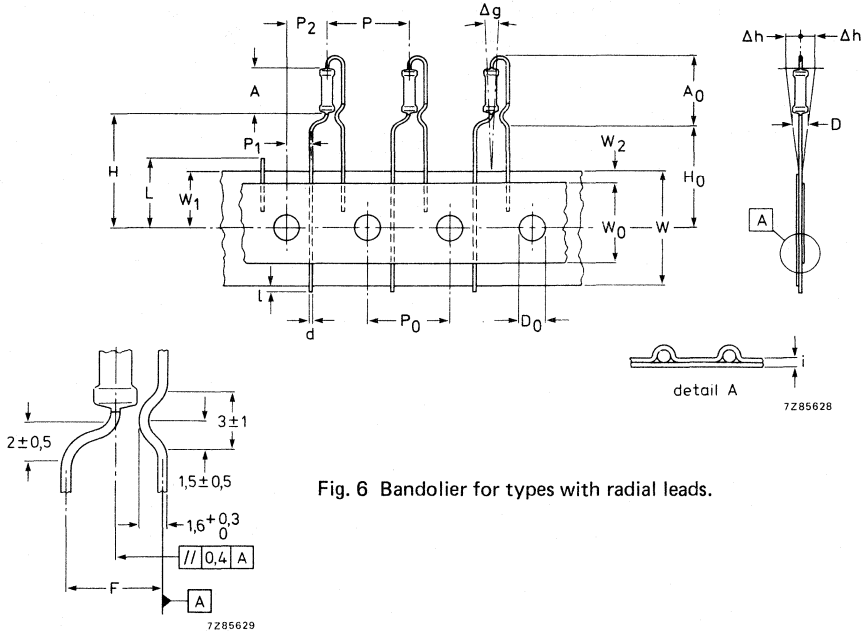
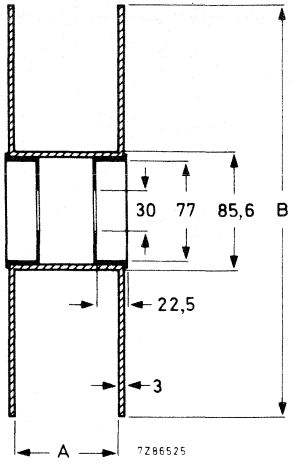


Fig. 6 Bandolier for types with radial leads.

Body diameter	D	max.	2,50
Body length	A	max.	7,00
Mounting height	A_0	max.	12,50
Lead wire diameter	d		0,60 ± 0,06
Pitch of components	P		12,7 ± 1,0
Feed hole pitch	P_0		12,7 ± 0,3
Maximum deviation of spacing	T		1,0 per 20 spacings
Feed hole centre to lead	P_1		3,85 ± 0,7
Feed hole centre to body	P_2		6,35 ± 1,0
Lead to lead distance	F		5,0 + 0,8 – 0,2
Component alignment	Δh		0 ± 2 mm
Component alignment	Δg		0 ± 3°
Tape width	W		18,0 + 1 – 0,8
Hold down tape width	W_0		6,5 or 12,5
Hole position	W_1		9,0 ± 0,5
Hold down tape position	W_2		2 + 0 – 1,5
Distance component to tape centre	H		19,0 ± 1
Lead wire clinch height	H_0		16,0 ± 0,5
Lead wire protrusion	ℓ	max.	0
Feed hole diameter	D_0		4,0 ± 0,3
Total tape thickness	i	max.	0,9
Length of cropped lead	L	max.	11,0

Extraction force for components in the tape plane, vertically to the direction of unreeling: ⩾ 5N.

Reel dimensions



type	quantity	A	B
VR25	5000	75	305
VR25AS	4000	40	356

Length of leader at beginning and end (bandolier without resistors): 300 mm

HIGH-OHMIC/HIGH-VOLTAGE RESISTORS

QUICK REFERENCE DATA

Type			VR37	VR68
Resistance range				
	E24 series		220 kΩ to 33 MΩ	100 kΩ to 68 MΩ
	E24/E96 series		220 kΩ to 33 MΩ	100 kΩ to 68 MΩ
Resistance tolerance				
	E24 series		± 5%	± 5%
	E24/E96 series		± 1%	± 1%
Max. permissible body temperature (hot spot)			155 °C	155 °C
Temperature coefficient			± 200.10^{-6}/K	± 200.10^{-6}/K
Rated dissipation at T_{amb} = 70 °C			0,5 W	1,0 W
Limiting voltage				
d.c.			3,5 kV	10 kV
r.m.s.			2,5 kV	7 kV
Dielectric withstanding voltage of the insulation for 1 minute		min.	700 V	700 V
Basic specification			IEC 115-1B	IEC 115-1B
Climatic category (IEC 68)			55/155/56	55/155/56
Stability after:				
1000 h max. load	ΔR/R	max. (req.: 1,5%)	typ. 0,5%	typ. 1%
6 days damp-heat test	ΔR/R	max. (req.: 1,5%)	typ. 0,5%	typ. 1%
56 days damp-heat test	ΔR/R	max. (req.: 0,5%)	typ. 0,5%	typ. 0,5%
Noise		max. (req.: 2,5 μV/V)	typ. 0,5 μV/V	typ. 0,5 μV/V

APPLICATION

Where high resistance, high stability and high reliability at high voltage are required. The resistors meet the safety requirements of IEC 65, 4th edition; NFC 92.130; BS415; VDE 0860.

DESCRIPTION

A metal-glazed film is deposited on a high grade ceramic body; tinned electrolytic copper wires are welded to the end caps. The resistors are coated with a light blue insulating lacquer which also provides protection against environmental effects.

MECHANICAL DATA

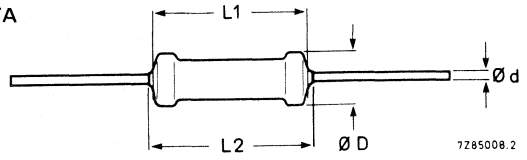


Fig. 1 Axial leads.

Table 1

type	D_{max}	$L_{1\,max}$	$L_{2\,max}$	d
VR37	3,7	9,0	10,0	0,7
VR68	6,8	16,5	19,0	0,8

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving those plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,7 mm diameter, the diameter of the holes in the gauge plates is 1,0 mm; for leads of 0,8 mm diameter, the holes are 1,2 mm.

Mass (per 100) VR37: 42g; VR68: 148g

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines.

Marking

The nominal resistance and the tolerance are marked on these resistors by four (E24 series) or five (E96 + E24) coloured bands according to IEC publication 62 "Colour code for fixed resistors". See General Section.
Yellow and grey are used instead of gold and silver, because metal particles in the lacquer could affect high-voltage properties.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24/E96 series (tolerance ± 1%) and E24 series (tolerance ± 5%) within the range 220 kΩ to 33 MΩ for type VR37 and 100 kΩ to 68 MΩ for type VR68. Values up to 220 MΩ are available on request. See the table "Standard series of values in a decade" at the back of the book.

The limiting voltage for resistor element and insulation is the maximum voltage that may be supplied continuously to the resistor element or the insulation, see IEC publications 115-1 and 115-2. This voltage is 3500 V (d.c.) or 2500 V (r.m.s.) for type VR37 and 10 kV (d.c.) or 7 kV (r.m.s.) for type VR68.

Table 2

type	packing	quantity	resistance range	tolerance ± %	series	catalogue number 2322 followed by:
VR37	ammopack	1000	220 kΩ to 33 MΩ	1	E24/E96	242 8 . . . .
				5	E24	242 13 . . .
	on reel	5000	220 kΩ to 33 MΩ	1	E24/E96	242 7 . . . .
		5000		5	E24	242 23 . . .
VR68	ammopack	500	100 kΩ to 68 MΩ	1	E24/E96	244 8 . . . .
				5	E24	244 13 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures (E24 series) resp. first three figures (E24/E96) of the resistance (in Ω) followed by:
4 for R = 100 kΩ to 976 kΩ
5 for R = 1 MΩ to 9,76 MΩ
6 for R = 10 MΩ to 68 MΩ

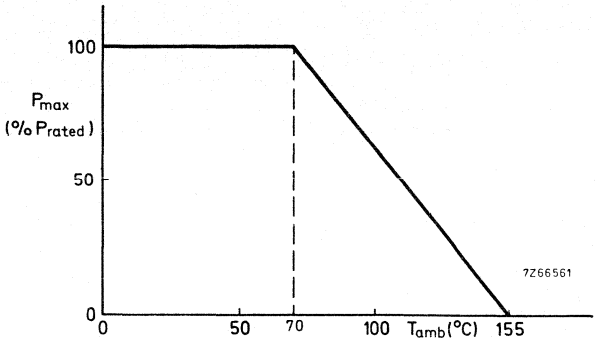


Fig. 2 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

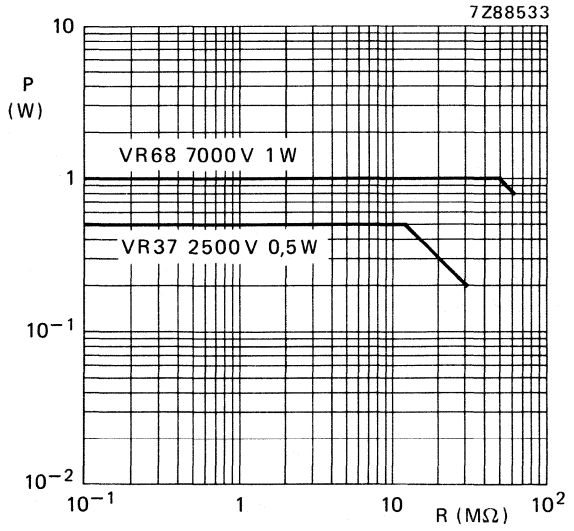


Fig. 3 Power versus resistance value of high-voltage resistors at T_{amb} = 70 °C.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range –55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	load 10N; 10 s	number of failures: < 10 ppm
	Ub	Bending half number of samples	load 5N; 4 x 90°	number of failures: < 10 ppm
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,5% + 0,05 Ω
19	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage ΔR max. 0,5% + 0,05 Ω
20	Na	Rapid change of temperature	½ h –55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,5% + 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,5% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,5% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h, 155 °C	
23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; −55 °C	
23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
23.6	D	Damp heat (accel) re-maining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 1,5%
24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation $\leqslant 0{,}01\ P_n$ limiting voltage 16 V (d.c.)	R_{ins} min. 1000 MΩ ΔR max. 1,5%
26.2	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	ΔR max. 1,5%
11	–	Temperature coefficient	between −55 °C and + 155 °C	$\pm\ 200.10^{-6}$/K
10	–	Voltage proof on insulation	700 V (r.m.s.), 1 minute	no breakdown
14	–	Noise	IEC publication 195	max. 2,5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ

STANDARD PACKAGING

The resistors are supplied on bandolier in ammopack or on reel.

type	quantity per box	
	bandolier ammopack	bandolier on reel
VR37	1000	5000
VR68	500	

Configuration of bandolier

Dimensions in mm

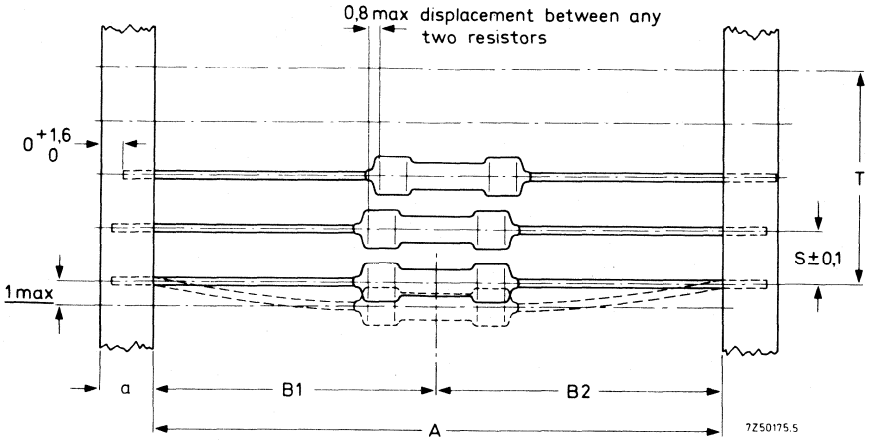


Fig. 4.

type	a ± 0,5	A ± 1,5	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
VR37	6	52,4	1,2	5	1 mm per 10 spacings
VR68	5	66,7	1,2	10	0,5 mm per 5 spacings

POWER FILM — PR

POWER METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range	PR37	2,2 Ω to 1 MΩ, E24 series*
	PR52	2,2 Ω to 51 kΩ, E24 series *
Resistance tolerance		± 5%
Max. body temperature (hot spot)		300 °C
Rated dissipation at T_{amb} = 70 °C	PR37	1,6 W
	PR52	2,5 W
Basic specification		IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)		55/200/56

Stability after	requirement	typical value
1000 h max. load	ΔR ⩽ 5%	ΔR 2,5%
climatic tests	ΔR ⩽ 3%	ΔR 0,5%
soldering	ΔR ⩽ 1%	ΔR 0,1%
short time overload	ΔR ⩽ 2%	ΔR 0,2%

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps.

The resistor has a red non-inflammable coating of a protective silicon lacquer which can withstand 500 V (r.m.s.) and is resistant against most of the commonly used cleaning solvents according to MIL-STD-202E, method 215 and IEC 68-2-45.

COMPOSITION OF THE CATALOGUE NUMBER

2322 19. . . . .

type
PR37 = 1
PR52 = 2

style code
3 = straight copper-clad iron leads, ϕ 0,6
4 = cropped and formed copper-clad iron leads ϕ 0,6
5 = straight copper leads, ϕ 0,8
6 = cropped and formed copper leads, ϕ 0,8

	8 for R =	2,2	to	9,1 Ω
	9 for R =	10	to	91 Ω
	1 for R =	100	to	910 Ω
	2 for R =	1 000	to	9 100 Ω
PR52	3 for R =	10 000	to	51 000 Ω
PR37	3 for R =	10 000	to	91 000 Ω
PR37	4 for R =	100 000	to	910 000 Ω
PR37	5 for R =	1000 000 Ω		

mounting height (h), Fig. 2
0 = 8 | cropped and formed
1 = 15 | version
0 = straight lead version
first two digits of the resistance value (E24 series)

* Values 1 to 2 Ω can be delivered on request.

MECHANICAL DATA

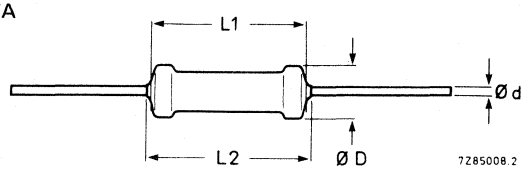


Fig. 1 Version with straight leads, see Table 1.

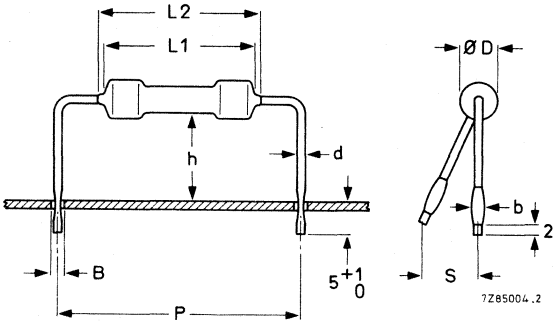


Fig. 2 Version with cropped and formed leads.

Table 1

type	leads	D_{max}	L_{1max}	L_{2max}	d	b +0,1	h +2	S_{max}	P ± 3	B ϕ_{max}
PR37	copper-clad	3,9	10	11	0,6	1,1	8	2	17,8	1,0
	iron	3,9	10	11	0,6	1,1	15	3	17,8	1,0
	copper	3,9	10	11	0,8	1,3	8	2	17,8	1,2
		3,9	10	11	0,8	1,3	15	3	17,8	1,2
PR52	copper-clad	5,2	16,7	17,9	0,6	1,1	8	2	25,4	1
	iron	5,2	16,7	17,9	0,6	1,1	15	3	25,4	1
	copper	5,2	16,7	17,9	0,8	1,3	8	2	25,4	1,2
		5,2	16,7	17,9	0,8	1,3	15	3	25,4	1,2

Mass (per 100) PR37: 40 g; PR52: 92 g.

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range. The mounting pitch of version with cropped and formed leads is 7 e for PR37 and 10 e for PR52.

Marking

Each resistor is marked with:
– resistance value (R for Ω, K for kΩ)
– tolerance on resistance in %.

Example: 27 R ± 5%

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 2,2 Ω to 27 kΩ (type PR37) and 2,2 Ω to 51 kΩ (type PR52).* E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 5%.

Table 2

type	leads			mounting height (h, Fig. 2)	resistance range	catalogue number 2322 followed by
	style	dia. mm	material			
PR37	straight	0,6	copper-clad; iron	–	2,2 Ω to 27 kΩ	191 3 . . 0 .
		0,8	copper	–		191 5 . . 0 .
	cropped and formed	0,6	copper-clad; iron	8		191 4 . . 0 .
		0,8	copper	8		191 6 . . 0 .
		0,6	copper-clad; iron	15		191 4 . . 1 .
		0,8	copper	15		191 6 . . 1 .
PR52	straight	0,6	copper-clad iron	–	2,2 Ω to 51 kΩ	192 3 . . 0 .
		0,8	copper	–		192 5 . . 0 .
	cropped and formed	0,6	copper-clad; iron	8		192 4 . . 0 .
		0,8	copper	8		192 6 . . 0 .
		0,6	copper-clad; iron	15		192 4 . . 1 .
		0,8	copper	15		192 6 . . 1 .

To complete the catalogue number, see Composition of the Catalogue Number. For quantities and packing see Standard packaging.

Temperature coefficient		
$R \geqslant 10\ \Omega$		max. $\pm 250.10^{-6}$/K
$R < 10\ \Omega$		max. $\pm 350.10^{-6}$/K
Maximum body temperature (hot spot)		300 °C
Rated dissipation at T_{amb} = 70 °C	PR37	1,6 W
	PR52	2,5 W
Dielectric withstanding r.m.s. voltage of the insulation for 1 min		min. 500 V
Basic specification		MIL-R-11804/E, char. G
Climatic category (IEC 68)		55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation		see Figs 3, 4, 7, 8
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering place) as parameter		see Figs 5, 6, 9, 10

* Resistors of 1 to 2 Ω can be supplied on request.

TESTS AND REQUIREMENTS (in accordance with MIL-R-11804E or IEC 115-2)

MIL test			requirement	
R-11804E paragraph	STD-202D method	procedure	MIL-R-11804E paragraph	
4. 6. 1		Visual and mechanical examination	3. 1; 3. 3 to 3. 4. 3 3. 21 to 3. 22. 1	
4. 6. 2	303	D.C. resistance		within tolerance
4. 6. 3		Temperature	3. 7	$\Delta R \leqslant 2\%$
4. 6. 6		Hot spot	3. 10	see Fig. 2, 4, 7, 8
4. 6. 7		Thermal shock	3. 11	$\Delta R \leqslant 2\%$, no damage
4. 6. 8		Momentary overload	3. 12	$\Delta R \leqslant 2\%$, no damage
4. 6. 9	106	Moisture resistance	3. 13	$\Delta R \leqslant 3\%$
4. 6. 11	211	Terminal strength	3. 15	$\Delta R \leqslant 1\%$, no damage
4. 6. 12	208	Lead solderability	3. 16	95% covered
4. 6. 13	304	Temperature coefficient	3. 17	$R \geqslant 10\ \Omega$: $\leqslant 250.10^{-6}/K$ $R < 10\ \Omega$: $\leqslant 350.10^{-6}/K$
4. 6. 14	108	Load lfe	3. 18	$\Delta R \leqslant 5\%$, no damage
4. 6. 15	205	Shock	3. 19	$\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
4. 6. 16	204	Vibration (high frequency)	3. 20	$\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$ no damage
IEC 115	IEC 68	Damp heat		$\Delta R \leqslant 3\%$

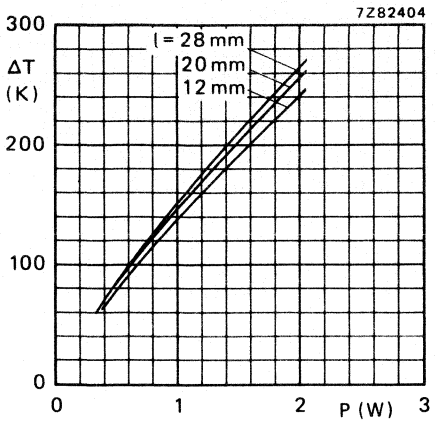


Fig. 3 PR37. Hot-spot temperature rise (ΔT) versus dissipated power (P) at different lead lengths (l), copper-clad iron leads ϕ = 0,6 mm.

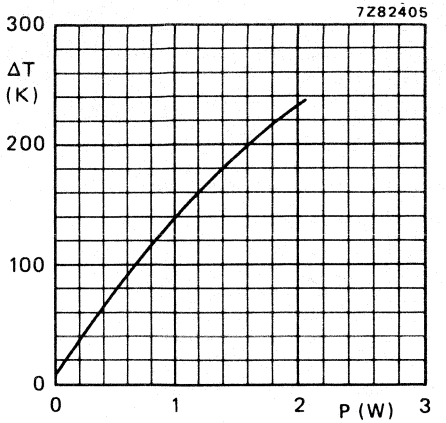


Fig. 4 PR37. Hot-spot temperature rise (ΔT) versus dissipated power (P), copper leads ϕ = 0,8 mm.

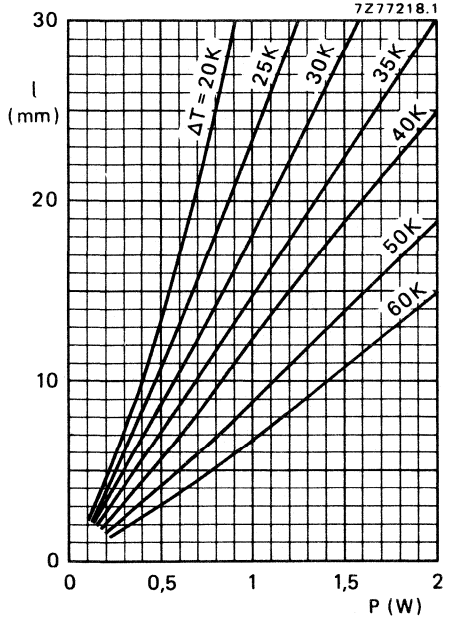


Fig. 5 PR37. Lead length l versus dissipated power with ΔT as a parameter, copper-clad iron leads ϕ = 0,6 mm.

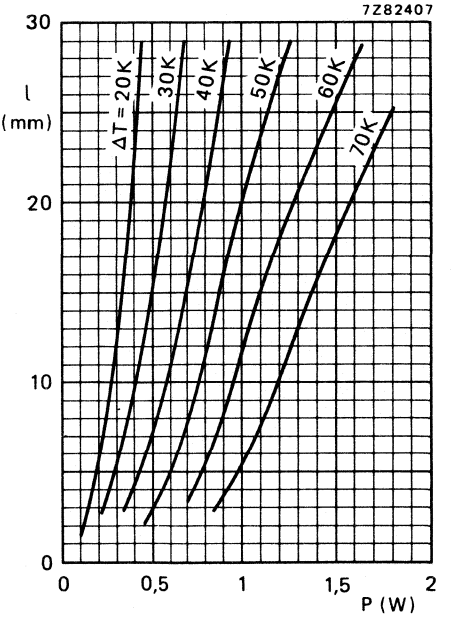


Fig. 6 PR37. Lead length l versus dissipated power with ΔT as a parameter, copper leads ϕ = 0,8 mm.

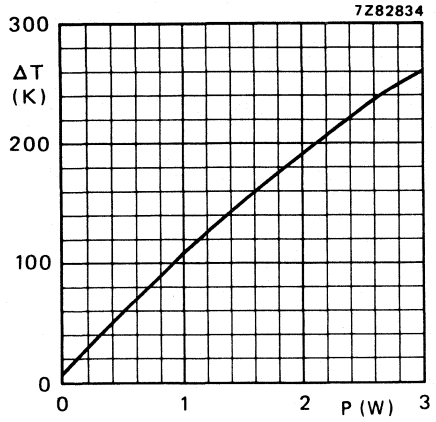


Fig. 7 PR52. Hot-spot temperature rise (ΔT) versus dissipated power (P) copper-clad iron leads ϕ = 0,6 mm.

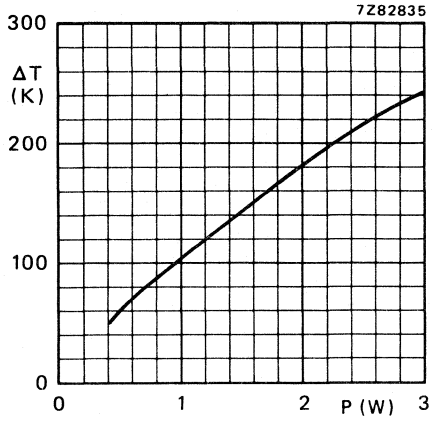


Fig. 8 PR52. Hot-spot temperature rise (ΔT) versus dissipated power (P), copper leads ϕ = 0,8 mm.

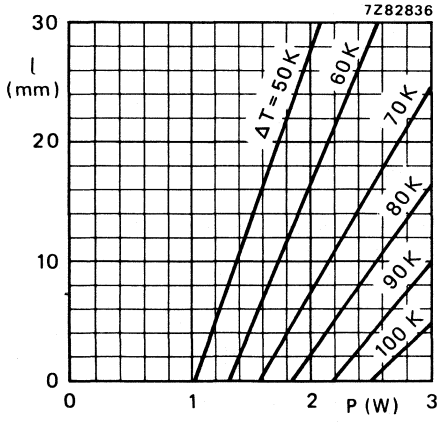


Fig. 9 PR52. Lead length l versus dissipated power with ΔT as a parameter, copper-clad iron leads ϕ = 0,6 mm.

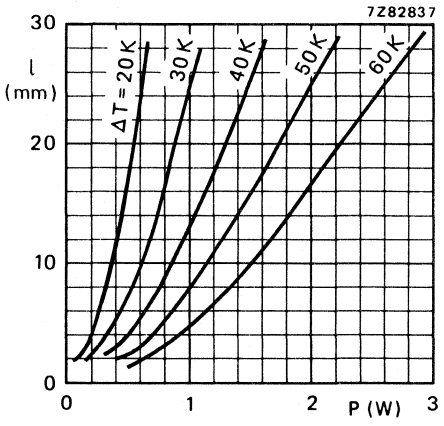


Fig. 10 PR52. Lead length l versus dissipated power with ΔT as a parameter, copper leads ϕ = 0,8 mm.

STANDARD PACKAGING

type and style	quantity per box	
	on bandolier ammopack	bulk loose
PR37, straight leads	1000	
PR52, straight leads	500	
PR37 cropped and formed leads, h = 8 mm		1000
h = 15 mm		500
PR52 cropped and formed leads, h = 8 mm		500
h = 15 mm		250

Configuration of bandolier

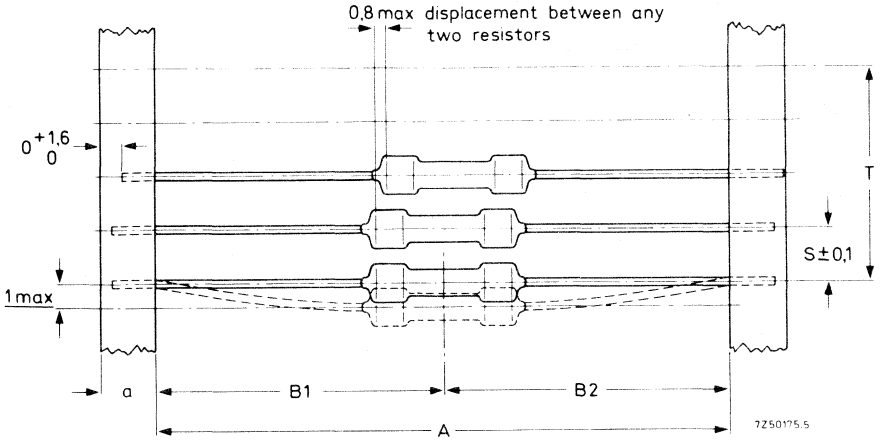


Fig. 11.

type	a ± 0,5	A ± 1,5	B1 – B2 ± max.	S (spacing)	T (max. deviation of spacing)
PR37	6	73	1,2	5	1 mm per 10 spacings
PR52	6	80	1,2	10	0,5 mm per 5 spacings

CEMENTED WIREWOUND RESISTORS

QUICK REFERENCE DATA

Resistance range	0,1 Ω to 33 kΩ, E24 series
Resistance tolerance	± 5% or ± 10%
Max. permissible body temperature (hot spot)	350 °C
Rated dissipation at T_{amb} = 40 °C	AC03: 3 W AC04: 4 W, AC10 = 10 W AC05: 5 W, AC15 = 15 W AC07: 7 W, AC20 = 20 W
Basic specification	IEC 266
Climatic category (IEC 68)	40/200/56
Stability after	
load	ΔR/R max. 5%
climatic tests	ΔR/R max. 5%
short time overload	ΔR/R max. 2%

APPLICATION

These resistors have been designed to dissipate high powers in a small volume.

DESCRIPTION

The resistor element is wound in a single layer on a ceramic rod. Metal caps are pressed over the ends of the rod. The ends of the resistance wire and the leads are connected to the caps by welding. Tinned copper-clad iron leads with poor heat conductivity are employed permitting the use of relativity short leads to obtain stable mounting. The resistor is coated with a green silicon cement which is non-inflammable and cannot drip even at high overloads, and is resistant to most commonly used cleaning solvents, according to MIL-STD-202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

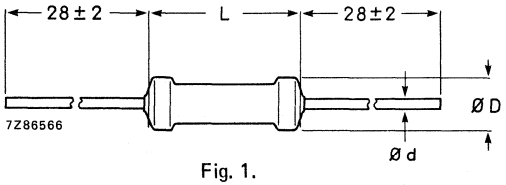


Fig. 1.

Table 1

type	D_{max}	L_{max}	d
AC03	5,5	13	0,8
AC04	5,5	17	0,6
AC05	7,5	17	0,8
AC07	7,5	25	0,8
AC10	8	44	0,8
AC15	10	51	0,8
AC20	10	67	0,8

Note: The lead length (28 ± 2 mm) only applies to untaped resistors, i.e. types AC10, AC15 and AC20.

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,6 mm diameter, the diameter of the holes is 1,0 mm; for leads of 0,8 mm diameter the holes are 1,2 mm.

Mass (per 100)

AC03	80 g
AC04	100 g
AC05	175 g
AC07	225 g
AC10	530 g
AC15	840 g
AC20	1090 g

Mounting

The resistors AC03, AC04, AC05 and AC07 are suitable for processing on cutting and bending machines. Care should be taken that the temperature rise of the resistor body does not affect nearby components or materials by conducted or convected heat. The temperature rise of the resistor body and of leads of different lengths is given as a function of the dissipation in Figs 2 and 3.

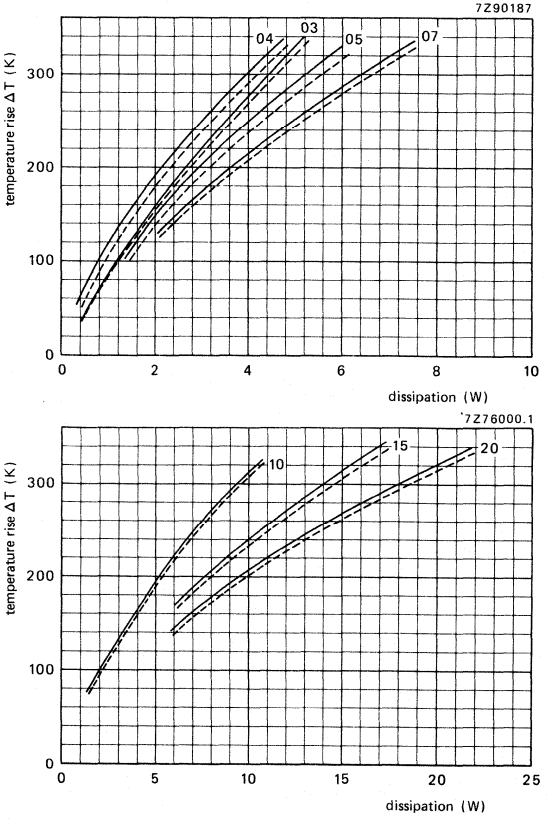


Fig. 2 Temperature rise of the resistor body as a function of the dissipation.
——— for lead length of 25 mm
– – – for lead length of 10 mm

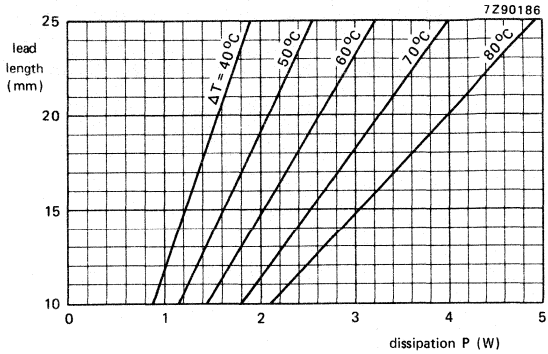


Fig. 3 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC03.

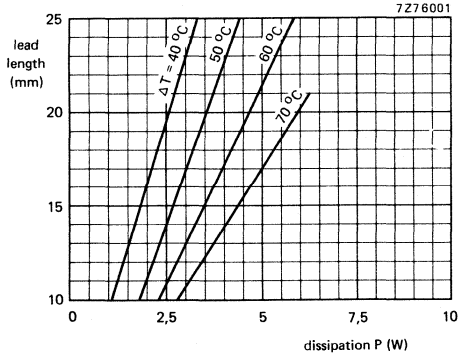


Fig. 4 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC04.

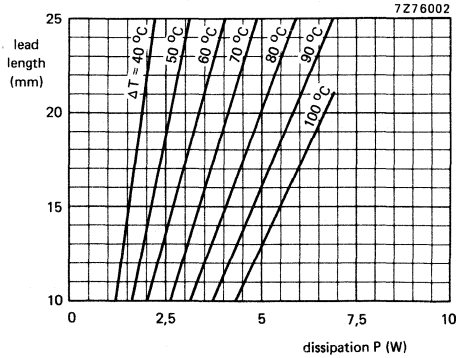


Fig. 5 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC05.

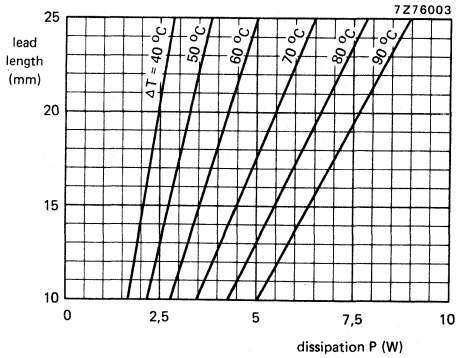


Fig. 6 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC07.

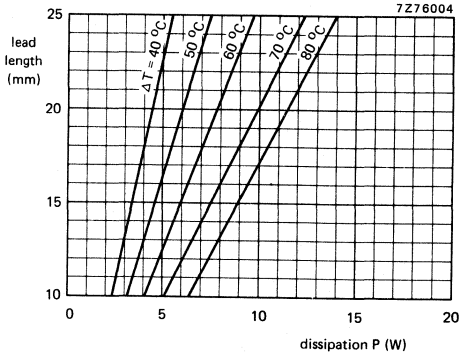


Fig. 7 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC10.

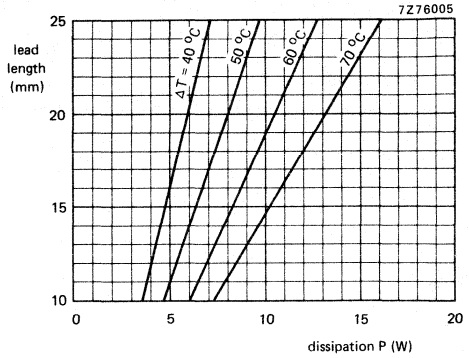


Fig. 8 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC15.

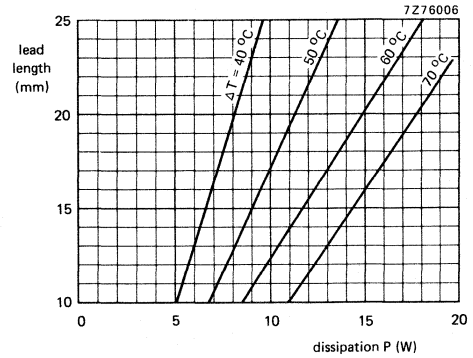


Fig. 9 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC20.

Marking

The nominal resistance (R for Ω, K for kΩ), the tolerance on the resistance and the rated dissipation at T_{amb} = 40 °C are printed on the resistor body, e.g. 27 R 5% 4 W.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series, tolerance ± 5% or ± 10% within the range 0,1 Ω to 33 kΩ as per **Table 2**. See the table "Standard series of values in a decade" at the back of the Handbook.

Table 2

type	rated dissipation (W) T_{amb} = 40 °C	rated dissipation (W) T_{amb} = 70 °C	resistance range Ω	tol. %	catalogue number
AC03	3	2,5	0,3 - 3000	10	2322 329 33 . . .
			12 - 3000	5	2322 329 03 . . .
AC04	4	3,5	0,10 - 8,2	10	2322 329 34 . . .
			10 - 4700	5	2322 329 04 . . .
AC05	5	4,7	0,10 - 8,2	10	2322 329 35 . . .
			10 - 5600	5	2322 329 05 . . .
AC07	7	5,8	0,10 - 8,2	10	2322 329 37 . . .
			10 - 10 000	5	2322 329 07 . . .
AC10	10	8,4	0,68 - 8,2	10	2322 329 40 . . .
			10 - 15 000	5	2322 329 10 . . .
AC15	15	12,5	0,82 - 8,2	10	2322 329 45 . . .
			10 - 22 000	5	2322 329 15 . . .
AC20	20	16	1,2 - 8,2	10	2322 329 50 . . .
			10 - 33 000	5	2322 329 20 . . .

Maximum permissible body temperature	350 °C
Ambient temperature range	−40 to + 200 °C
Temperature coefficient	−80 to + 140 · 10^{-6}/K
Values < 10 Ω	+600 · 10^{-6}/K
Climatic category (IEC68)	40/200/56

COMPOSITION OF THE CATALOGUE NUMBER

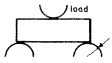
The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance followed by:

7 for R = 0,1 to 0,82 Ω
8 for R = 1 to 8,2 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9,1 kΩ
3 for R = 10 to 33 kΩ

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publications 266 and 266A category 40/200/56 (rated temperature range −40 to + 200 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68. "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 266, 266A and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 266 clause	IEC 68 test method	test	procedure	requirements
14		Robustness of resistor body	 load 200 ± 10 N	no visible damage $\Delta R \leq 0{,}5\% + 0{,}05\ \Omega$
15	U	Robustness of terminations:		
	Ua	Tensile all samples	load 10 N; 10 s	
	Ub	Bending half number of samples	load 5 N; 4 x 90°	
	Uc	Torsion other half number of samples	2 x 180° in opposite directions	no visible damage ΔR max. 0,5% + 0,05 Ω
16	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 2,5 mm from body	good tinning, no damage ΔR max. 0,5% + 0,05 Ω
17	Na	Rapid change of temperature	½ h −40 °C/½ h + 200 °C, 5 cycles	no visible damage ΔR max. 1% + 0,05 Ω
18	Fc	Vibration	frequency 10-500 Hz, displacement 0,75 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no visible damage ΔR max. 0,5% + 0,05 Ω
19	Eb	Bump	4000 ± 10 bumps 390 m/s²	no visible damage ΔR max. 0,5% + 0,05 Ω

IEC 266 clause	IEC 68 test method	test	procedure	requirements
20		Climatic sequence		
20.2	Ba	Dry heat	16 h, 200 °C	
20.3		Damp heat (accel)		
		1st cycle	24 h; 55 °C; 95-100% R.H.	
20.4	Aa	Cold	2 h; −40 °C	
20.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
20.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	after 24 h at P_n ΔR max. 1% + 0,05 Ω
21	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation $\leqslant 0{,}01\ P_n$	ΔR max. 1% + 0,05 Ω
22	–	Endurance	1000 h at 70 °C	ΔR max. 5%
23			1000 h at 200 °C	ΔR max. 5%
13.6		Overload	10 x P_n, 5 s	ΔR max. 2%

STANDARD PACKAGING

type	quantity per box	
	bandolier	bulk
AC03	500	
AC04	500	
AC05	500	
AC07	500	
AC10		100
AC15		100
AC20		100

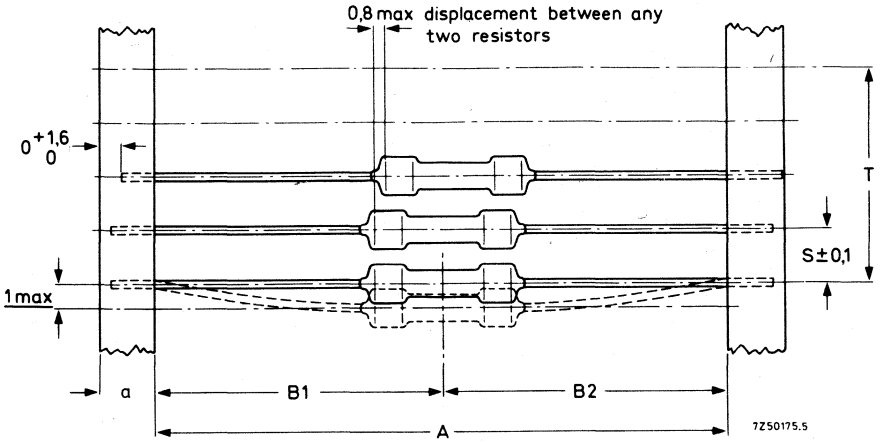


Fig. 4.

type	a ± 0,5	A ± 4	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
AC03	5	66	1,2	10	1 mm per 10 spacings 0,5 mm per 5 spacings
AC04	5 or 6	66	1,2	10	
AC05	6	66	1,2	10	
AC07	6	74	1,2	10	

CEMENTED WIREWOUND RESISTORS

These wirewound resistors are specially designed to dissipate high powers in a small volume.

QUICK REFERENCE DATA

Resistance range		from 0,1 Ω to 12 kΩ, E24 or E12 series
Resistance tolerance		± 5% or ±10%
Maximum body temperature		350 °C
Rated dissipation at T_{amb} = 70 °C	ACL01	1 W
	ACL02	2 W
	ACL03	3 W
Basic specification		IEC publication 266
Climatic category (IEC 68, DIN 40 045)		40/200/56
Stability after:		
load, 1000 h		ΔR/R max. 3%
climatic tests		ΔR/R max. 5%
short time overload		ΔR/R max. 2%

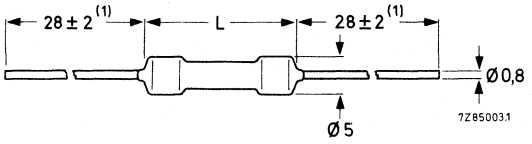
DESCRIPTION

The resistor element is wound in a single layer on a glass-fibre rod. Metal caps are pressed over the ends of the rod. The ends of the resistance wire and the leads are connected to the caps by welding. Tinned copper-clad iron leads with poor heat conductivity are employed permitting the use of relatively short leads to obtain stable mounting. The resistor is coated with a green silicon cement which is non-inflammable and cannot drip even at high overloads.

MECHANICAL DATA

Dimensions in mm

Outlines



(1) If taped: 35 mm.

Fig. 1 Standard version with straight leads.

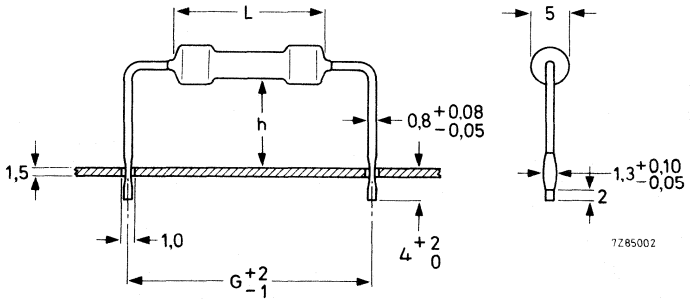


Fig. 2 Special version with cropped and formed leads, available on special request.

Table 1

type	L_{max}	G	h
ACL01	16	20	8 or 15
ACL02	24	27,5	8 or 15
ACL03	34	–	8 or 15

Mass (per 100 pieces)

ACL01	66 g
ACL02	79 g
ACL03	96 g

Mounting

The resistors must be mounted in such a way that:

- no stress is exerted on the leads so as to allow thermal expansion over the wide permissible temperature range.
- nearby components and materials are not affected by the dissipated heat.
- the temperature at the soldering spots of the leads does not reach the melting point of the solder.

The temperature rise of the resistor body and of the leads at various distances from the body is given as a function of the dissipation for the different resistor styles in Figs 3 to 5.

Marking

Each resistor is marked with:

- resistance value (R for Ω, K for kΩ)
  e.g. 27 Ω = 27R
  15 kΩ = 15K
- tolerance on resistance in %
- rated dissipation at T_{amb} = 70 °C

Example: 10R 5%
1W

ELECTRICAL DATA

Table 2, standard range

type	rated dissipation (W) T_{amb} = 70 °C	resistance range Ω	tol. %	series	catalogue number
ACL01	1,0	0,10 – 8,2	10	E12	2306 300 02...
		10 – 3900	5	E24	2306 300 03...
ACL02	2,0	0,18 – 8,2	10	E12	2306 301 02...
		10 – 8200	5	E24	2306 301 03...
ACL03	3,0	0,27 – 8,2	10	E12	2306 302 02...
		10 – 12 000	5	E24	2306 302 03...

Maximum permissible body temperature	350 °C
Ambient temperature range	−40 to +200 °C
Temperature coefficient	−50 to +140 · 10^{-6}/K
Values < 10 Ω	+600 · 10^{-6}/K
Climatic category (IEC 68)	40/200/56

Composition of the catalogue number

In the catalogue number (Table 2) replace the first two dots by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

0,1	–	0,91	Ω : 7
1	–	9,1	Ω : 8
10	–	91	Ω : 9
100	–	910	Ω : 1
1 000	–	9 100	Ω : 2
10 000	–	22 000	Ω : 3

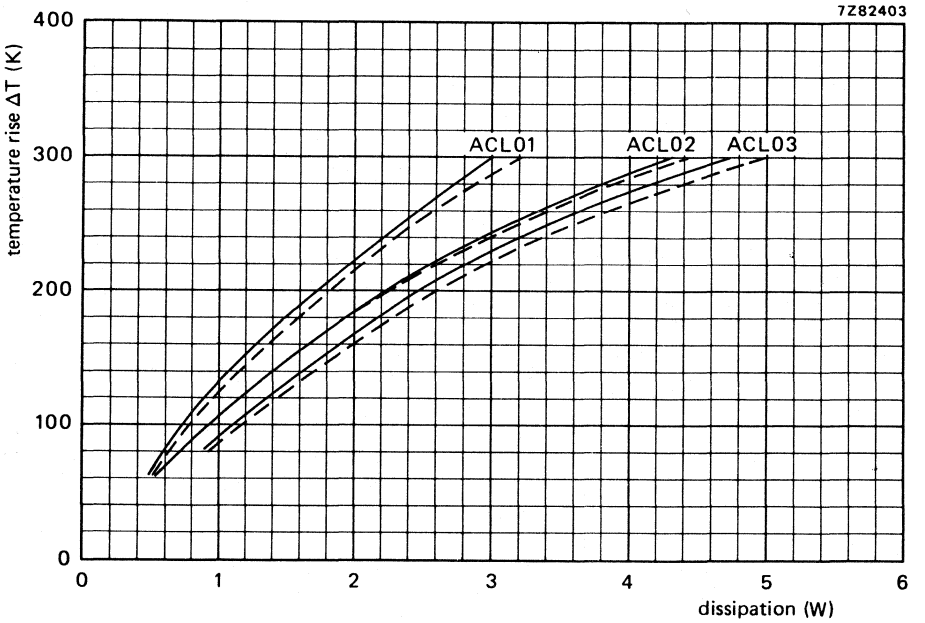


Fig. 3 Temperature rise of the resistor body as a function of the dissipation.
—— for lead length of 18 mm
– – – for lead length of 10 mm.

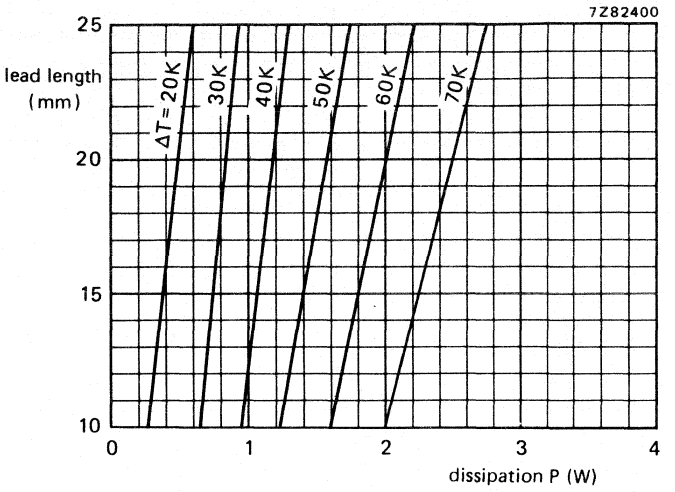


Fig. 4 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style ACL01.

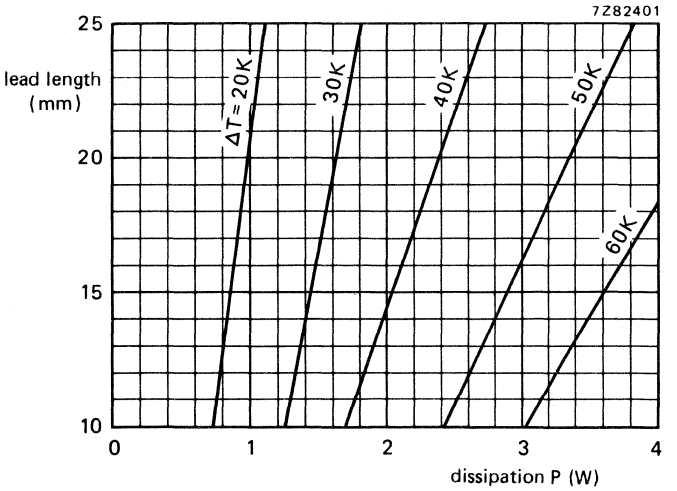


Fig. 5 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style ACL02.

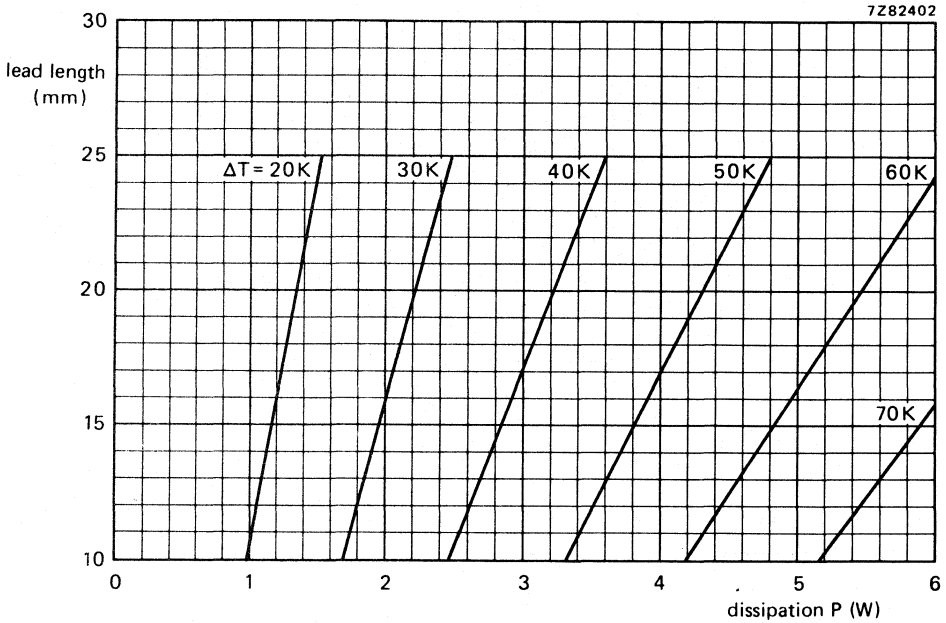


Fig. 6 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style ACL03.

TESTS AND REQUIREMENTS (in accordance with IEC publication 266 and 266 A)

IEC 266 clause	IEC 68 test method	test	procedure	requirements
14		robustness of resistor body	load 200 ± 10 N	no visible damage $\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
15	U	robustness of terminations:		
	Ua	tensile, all samples	load 10 N, 10 s	
	Ub	bending, half number of samples	load 5 N, 4 x 90°	
	Uc	torsion, other half number of samples	2 x 180° in opposite directions	no visible damage $\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
16	T	soldering:		
		solderability	2 s 230 °C, flux 600	good tinning, no damage
		thermal shock	3 s 350 °C, 2,5 mm from body	no damage, $\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
17	Na	rapid change of temperature	3 h −40 °C/3 h +200 °C, 5 cycles	no visible damage $\Delta R \leqslant 1\% + 0{,}05\ \Omega$
18	Fc	vibration	10 – 500 Hz, 0,75 mm or 10g, whichever is the less, for 6 h	no visible damage $\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
19	Eb	bumping	390 m/s², 4000 ± 10 bumps	no visible damage $\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
20		climatic sequence:		final measurements
20.2	Ba	dry heat	16 h 200 °C	
20.3		damp heat (acc) 1st cycle	1 day 55 °C, 95-100% R.H.	
20.4	Aa	cold	2 h −40 °C	
20.5	M	low air pressure	1 h 8,5 kN/m², 15-35 °C	
20.6	D	damp heat (acc) remaining cycles	5 days 55 °C, 95-100% R.H.	after 24 h at rated diss. $\Delta R \leqslant 5\%$
21	Ca	damp heat long term	56 days 40 °C, 90-95% R.H., 0,01 P_{rated}	$\Delta R \leqslant 5\%$, after 24 h at rated diss. $\Delta R \leqslant 5\%$
13.6		overload	10 times rated dissipation, 5 s	$\Delta R \leqslant 2\%$
22		endurance	1000 h at room temperature	$\Delta R \leqslant 3\%$
23		endurance	1000 h at upper category temp.	$\Delta R \leqslant 3\%$

STANDARD PACKAGING

Loose: 500 pieces per box

On bandolier: on special request only.

Configuration of bandolier

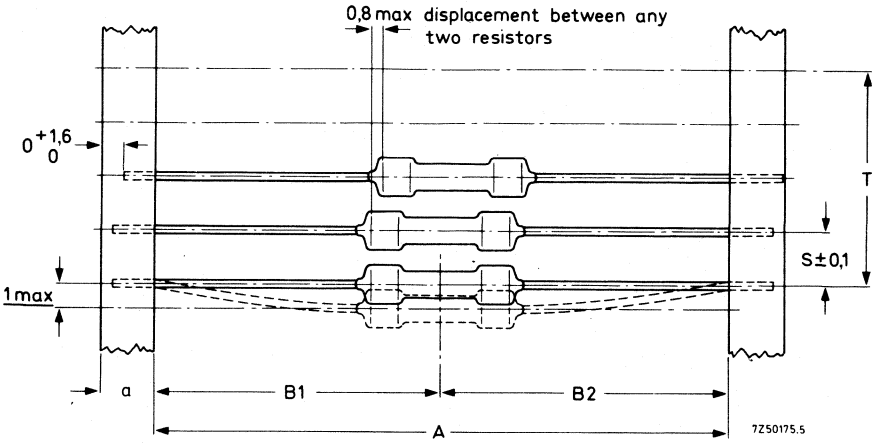


Fig. 7.

type	a ± 0,5	A	B1 – B2 ± max.	S (spacing)	T (maximum deviation of spacing)
ACL01	6	81 ± 2	1,2	10	1 mm per 10 spacings 0,5 mm for 5 spacings
ACL02	6	87 ± 2	1,2	10	
ACL03	6	97 ± 2	1,2	10	

WIREWOUND - WW

ENAMELLED WIREWOUND RESISTORS

QUICK REFERENCE DATA

Resistance ranges		4,7 Ω to 100 kΩ, E24 or E12 series
Resistance tolerance		±5% or ±10%
Max. body temperature (hot spot)		400 °C
Rated dissipation at T_{amb} = 70 °C	WR0617E	4 W
	WR0825E	7 W
	WR0842E	11 W
	WR0865E	17 W
Basic specification		IEC publication 266, type 2
Climatic category (IEC 68)		55/200/56
Stability after:		
1000 h max. load		ΔR/R max. 5%
climatic tests		ΔR/R max. 1%
dip-soldering test		ΔR/R max. 0,5%
short time overload		ΔR/R max. 2%

APPLICATION

As power resistors in electrical and electronic circuitry.

DESCRIPTION

These resistors have a single layer of resistance wire wound on a ceramic body. Leads of solder-coated copper-clad wire are secured to caps which are force-fitted on to the ends of the ceramic body. The resistor is coated with brown enamel.

MECHANICAL DATA

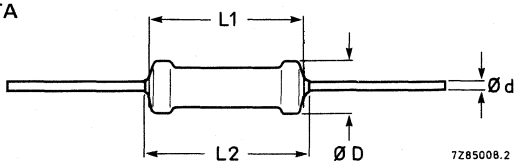


Fig. 1.

Table 1

type	D_{max}	L1 max	L2 max	a_{max}
WR0617E	6	19	25	3
WR0825E	8	27	33	3
WR0842E	8	44	50	3
WR0865E	8	67	73	3

Note
The lead length (28 ± 2 mm) only applies to untaped resistors, i.e. types WR0842E and WR0865E.

The length of the resistor body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294). The diameter of the holes in the gauge plate is 1,0 mm.

Mass

WR0617E
WR0825E
WR0842E
WR0865E

Mounting

The resistors must be mounted in such a way that:

– no stress is exerted on the leads so as to allow thermal expansion over the wide temperature range.
– nearby components and materials are not affected by the dissipated heat.

Marking

Each resistor is marked with:

– resistance value (R for Ω, K for kΩ)
e.g. 27 Ω = 27R
27 kΩ = 27K
– tolerance on resistance in %
– rated dissipation at T_{amb} = 70 °C

Example: 27R 10%
4W

ELECTRICAL DATA

Table 2

type	rated dissipation at T_{amb} = 70 °C W	resistance range Ω	tol. %	series *	catalogue number
WR0617E	4	4,7 – 4700	5	E24	2322 330 22 . . .
		4,7 – 47	10	E12	2322 330 21 . . .
WR0825E	7	6,8 – 27 000	5	E24	2322 330 32 . . .
		6,8 – 27	10	E12	2322 330 31 . . .
WR0842E	11	10 – 56 000	5	E24	2322 330 42 . . .
WR0865E	17	15 – 100 000	5	E24	2322 330 52 . . .

Maximum body temperature (hot spot)	400 °C
Ambient temperature range	–55 to +200 °C
Temperature coefficient	–80 to +140 $.10^{-6}$/K
Climatic category (IEC 68)	55/200/56

* See the table "Standard series of values in a decade" at the back of this book.

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in Table 2 is completed by inserting the resistance code: the first two significant figures of the resistance value (in Ω) followed by:

8 for R of 4,7 to 9,1 Ω
9 for R of 10 to 91 Ω
1 for R of 100 to 910 Ω
2 for R of 1 to 9,1 kΩ
3 for R of 10 to 91 kΩ
4 for R of 100 kΩ

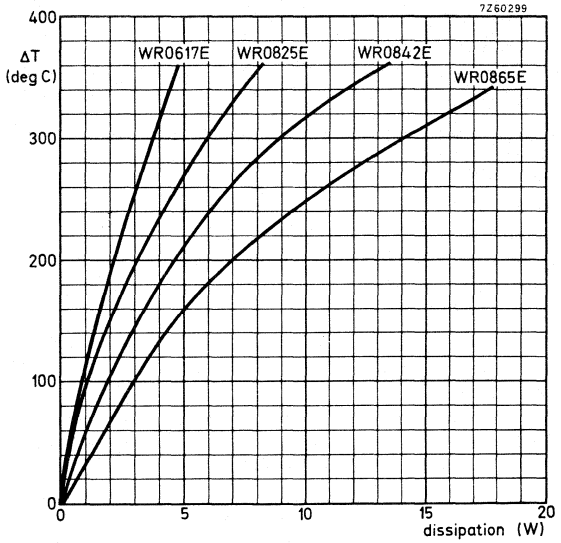
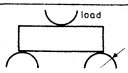


Fig. 2 Temperature rise (ΔT) of the resistor body as a function of the dissipation. Distance between cap and solder joint is 10 mm.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publications 266 and 266A, category 55/200/56 (rated temperature range –55 °C to +200 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 266, 266A and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 3

IEC 266 clause	IEC 68 test method	test	procedure	requirements
14		Robustness of resistor body	 load 200 ± 10N	no visible damage $\Delta R \leqslant 0{,}5\%$ or 0,05 Ω
15	U	Robustness of terminations		
	Ua	Tensile all samples	load 10N; 10 s	
	Ub	Bending half number of samples	load 5N; 4 x 90°	
	Uc	Torsion other half number of samples	2 x 180° in opposite directions	no visible damage ΔR max. 0,5% + 0,05 Ω
16	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage ΔR max. 0,5% + 0,05 Ω
17	Na	Rapid change of temperature	½ h –55 °C/½ h + 200 °C, 5 cycles	no visible damage ΔR max. 1%
18	Fc	Vibration	frequency 10-500 Hz, displacement 0,75 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no visible damage ΔR max. 0,5% + 0,05 Ω
19	Eb	Bump	4000 ± 10 bumps 390 m/s²	no visible damage ΔR max. 0,5% + 0,05 Ω

IEC 266 clause	IEC 68 test method	test	procedure	requirements
20		Climatic sequence		
20.2	Ba	Dry heat	16 h, 200 °C	
20.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
20.4	Aa	Cold	2 h; −55 °C	
20.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
20.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	after 24 h at P_n ΔR max. 5%
21	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation $\leqslant$ 0,01 P_n	after 24 h at P_n ΔR max. 1%
22	—	Endurance	1000 h at 70 °C	ΔR max. 5%
23			1000 h at 200 °C	ΔR max. 5%
13.6	—	Overload	10 x P_n, 5 s 2 x P_n, 10 min.	ΔR max. 2%

STANDARD PACKAGING

type	number per box
	bandolier
WR0617E	500
WR0825E	500
WR0842E	100
WR0865E	100

Configuration of bandolier

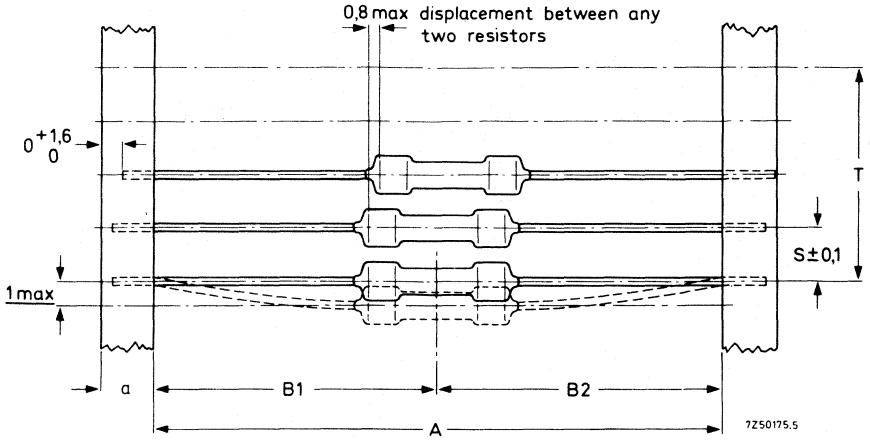


Fig. 3.

type	a ± 0,5	A ± 1,6	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
WR0617E	5	66,7	1,2	10	1 mm per 10 spacings 0,5 mm per 5 spacings
WR0825E	6	74	1,2	10	
WR0842E	6	88	1,2	10	
WR0865E	6	110	1,2	10	

RECTANGULAR WIREWOUND RESISTORS

QUICK REFERENCE DATA

Resistance range		0,15 to 22 kΩ, E24/E12 series
Resistance tolerance		± 5% or ± 10%
Max. permissible body temperature (hot spot)		350 °C
Rated dissipation of T_{amb} = 70 °C		EH04: 4 W; EH05: 5 W; EH07: 7 W; EH09: 9 W; EH17: 17 W
Basic specification		IEC 266
Climatic category (IEC 68)		40/200/56
Stability after		
load	ΔR/R max.	5%
climatic tests	ΔR/R max.	3%
short time overload	ΔR/R max.	2%

APPLICATION

The resistors are for high dissipation in a small volume. The rectangular shape facilitates mounting against a flat surface.

DESCRIPTION

The resistor element is wound in a single layer on a glass fibre rod. Metal caps are pressed over the ends of rod and wire. Tinned copper leads are welded to the caps. The resistor is mounted in a rectangular, sandfilled ceramic case. The ends of the body are impregnated with a protective silicon resin. The resistors are resistant against aggressive solvents.

MECHANICAL DATA

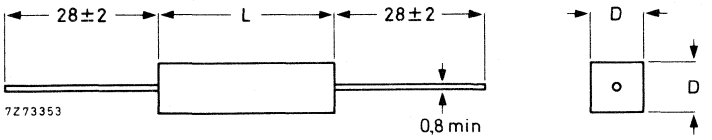


Fig. 1.

Table 1

type	D_{max}	L_{max}
EH04	7,2	20
EH05	7,2	26
EH07	7,2	36
EH09	7,2	46
EH17	10,7	62

Mass (per 100)

EH04: 295 g; EH05: 319 g; EH07: 400 g
EH09: 510 g; EH17: 1400 g

Mounting

The resistors must be mounted in such a way that:
- no stress is exerted on the leads so as to allow thermal expansion over the wide permissible temperature range.
- nearby components and materials are not affected by the dissipated heat.
- the temperature at the soldering spots of the leads does not reach the melting point of the solder.

The temperature rise of the resistor body and of leads of different lengths is given as a function of the dissipation in Fig. 2.

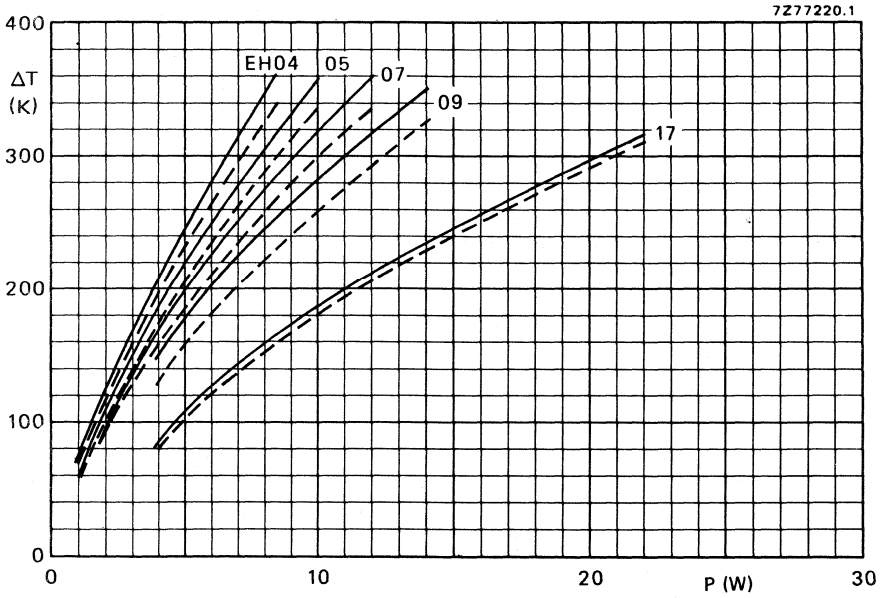


Fig. 2 Hot spot temperature rise (ΔT) as a function of the dissipation (P) at two lead lengths.
——— for lead length of 22 mm
– – – – – for lead length of 28 mm

Marking

The nominal resistance (R for Ω, k for kΩ), the tolerance on the resistance and the rated dissipation at T_{amb} = 70 °C are printed on the resistor body, e.g. 27R 5% 9 W.

ELECTRICAL DATA

Standard values of rated resistance

Standard values of rated resistance (nominal resistance) are taken from the E24 series, tolerance ± 5% and E12 series, tolerance ± 10%, within the range of 0,1 Ω to 22 kΩ as per Table 2. See the table "Standard series of values in a decade" at the back of the Handbook.

Table 2

type	rated dissipation (W) at T_{amb} = 70 °C W	resistance range Ω	tolerance %	series	catalogue number
EH04	4	0,1 – 8,2	10 *	E12	2306 335 02...
		10 – 3900	5	E24	2306 335 03...
EH05	5	0,15 – 8,2	10 *	E12	2306 330 02...
		10 – 6800	5	E24	2306 330 03...
EH07	7	0,27 – 8,2	10 *	E12	2306 331 02...
		10 – 12000	5	E24	2306 331 03...
EH09	9	0,33 – 8,2	10 *	E12	2306 332 02...
		10 – 15000	5	E24	2306 332 03...
EH17	17	0,47 – 8,2	10 *	E12	2306 333 02...
		10 – 22000	5	E24	2306 333 03...

Breakdown r.m.s. voltage of encapsulation	min. 2000 V
Max. permissible body temperature (hot spot)	350 °C
Ambient temperature range	−40 to + 200 °C
Temperature coefficient 0,1 – 5,1 Ω	$\leqslant +600 \cdot 10^{-6}$/K
5,6 – 22000 Ω	−50 to + 140 . 10^{-6}/K
Climatic category (IEC66)	40/200/56

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in Table 2 is completed by inserting the resistance code: the first two figures of the resistance followed by:

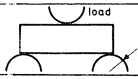
7 for R = 0,1 to 0,82 Ω	9 for R = 10 to 91 Ω	2 for R = 1 to 9,1 kΩ
8 for R = 1 to 8,2 Ω	1 for R = 100 to 910 Ω	3 for R = 10 to 22 kΩ

* Tolerance of ± 5% on request.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publications 266 and 266A category 40/200/56 (rated temperature range –40 to +200 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68. "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 266, 266A and 68, a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 3

IEC 266 clause	IEC 68 test method	test	procedure	requirements
14		Robustness of resistor body	 load 200 ± 10 N	no visible damage $\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
15	U	Robustness of terminations.		
	Ua	Tensile all samples.	load 10N; 10 s	
	Ub	Bending half number of samples	load 5N; 4 x 90°	
	Uc	Torsion other half number of samples	2 x 180° in opposite directions	no visiable damage ΔR max. 0,5% + 0,05 Ω
16	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 2,5 mm from body	good tinning, no damage ΔR max. 0,5% + 0,05 Ω
17	Na	Rapid change of temperature	½ h –40 °C/½ h + 200 °C, 5 cycles	no visible damage ΔR max. 1%
18	Fc	Vibration	frequency 10-500 Hz, displacement 0,75 mm or acceleration 10 g three directions; total 6 h (3 x 2 h)	no visible damage ΔR max. 0,5% + 0,05 Ω
19	Eb	Bump	4000 ± 10 bumps 390 m/s²	no visible damage ΔR max. 0,5% + 0,05 Ω
20		Climatic sequence		
20.2	Ba	Dry heat	16 h, 200 °C	
20.3	D	Damp heat (accel.) 1st cycle	24 h; 55 °C; 95-100% R.H.	
20.4	Aa	Cold	2 h; –40 °C	
20.5	M	Low air pressure	1 h; 8,5 x Pa; 15-35 °C	
20.6	D	Damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	after 24 h at P_n ΔR max. 3%

IEC 266 clause	IEC 68 test method	test	procedure	requirements
21	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation: $\leqslant 0{,}01\ P_n$	ΔR max. 3%
22	—	Endurance	1000 h at 70 °C	ΔR max. 5%
23			1000 h at 200 °C	ΔR max. 5%
13.6		Overload	$10 \times P_n$, 5 s	ΔR max. 2%

RESISTOR CHIP

QUICK REFERENCE DATA

Resistance range	1 Ω to 10 MΩ and jumper (0 Ω)
	E24, E12 and E6 series
Resistance tolerance	± 5, ± 10, ± 20%
Temperature coefficient	$< \pm 200.\ 10^{-6}$/K
Abs. max. dissipation at T_{amb} = 70 °C	0,125 W
Maximum permissible voltage	200 V (r.m.s.)
Climatic category (IEC 68)	55/155/56
Basic specification	IEC 115-1
Stability after:	
load, 1000 h at T_{amb} = 70 °C	ΔR/R max. 1,5% + 0,2 Ω
climatic tests	ΔR/R max. 1,5% + 0,2 Ω
soldering	ΔR/R max. 1% + 0,05 Ω
short time overload, max. 400 V	ΔR/R max. 2% + 0,2 Ω

APPLICATION

Resistor chips are used in a wide scale of equipment. Important considerations for using chip resistors are:

- decrease of size and mass of equipment
- reduction of assembly costs of equipment
- specific electrical requirements (such as h.f. characteristics).

The main application areas for resistor chips are:
TV (tuner), radio (hi-fi slim-line and portable), radio recorders, watches, video cameras, shavers, pocket calculators, instruments, telecommunication, medical equipment, military equipment and automotive industry.

DESCRIPTION

On a high grade ceramic body (aluminium oxide) a metal glaze layer is screened. Depending on the composition of the metal glaze different resistance values can be obtained. On both ends a contact is made in such a way that optimum solderability is guaranteed. This is achieved by applying three layers. The resistive layer is covered with a protective coat.

MECHANICAL DATA

Outlines

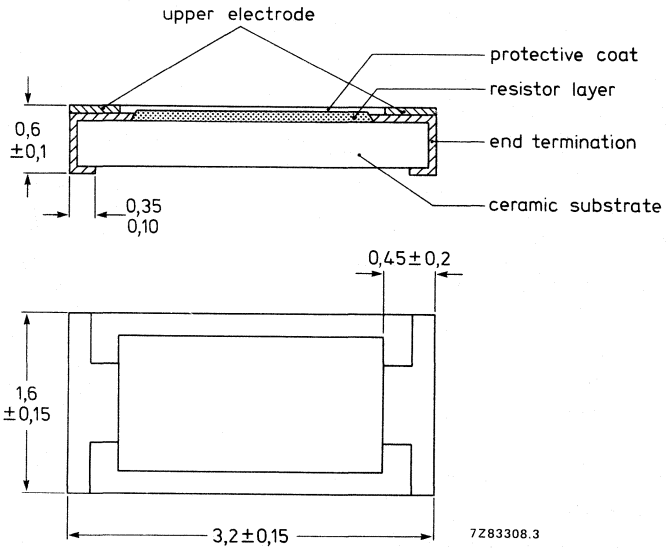


Fig. 1.

Mass (per 100): 1,0 g

Mounting

This resistor chip is most suitable to be handled by automatic chip placement systems, due to its rectangular shape and the small tolerances on the dimensions. Chip placement can be done on ceramic substrates and printed circuit boards. The electrical connection to the circuit can be made by wave-soldering or reflow soldering. The electrodes guarantee a reliable contact. The protective coatings enable "face-down" mounting. Thanks to its robust construction the resistor chip can be immersed completely in a solder bath of 255 °C for one minute. By doing so it is possible to mount chip resistors on one side of a printed circuit board and other discrete components the other side.

Marking

The chips will not be marked. The marking is done on the packing. The marking includes resistance value, tolerance, code number, style, quantity, production period and an origin source code.

Soldering

Limiting conditions min. 230 °C, 2 s
max. 250 °C, 60 s

Maximum permitted solder conditions:

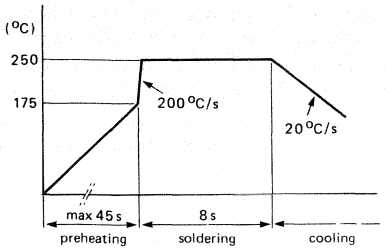
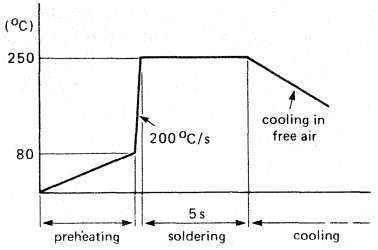


Fig. 2 Reflow soldering.



7Z89653

Fig. 3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

ELECTRICAL DATA

Standard values of resistance and tolerance

Standard values of nominal resistance are taken from the E6 series for resistors with a tolerance of ± 20%; from the E12 series for resistors with a tolerance of ± 10% and from the E24 series for resistors with a tolerance of ± 5% and ± 10%. The values of these series are given at the back of the Data Handbook and are according to IEC publication 63.

The limiting voltage (r.m.s.) for element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation. See IEC publications 115-1 and 115-2. This voltage is 200 V.

The temperature coefficient is $< \pm 200 \cdot 10^{-6}$/K.

Table 1

resistance range	tol. ± %	series	catalogue number 2322 followed by				
			cardboard tape		blister tape		bulk
			4000	10 000	4000	10 000	1000
10 Ω to 1 MΩ	5	E24	711 20 . . .	711 50 . . .	712 30 . . .	712 70 . . .	715 50 . . .
1 Ω to 10 Ω	10	E24	711 10 . . .	–	712 40 . . .	712 80 . . .	715 40 . . .
10 Ω to 1 MΩ	10	E12					
1 MΩ to 10 MΩ	10	E24					
1 Ω to 10 MΩ	20	E6	711 00 . . .	–	–	–	715 30 . . .

The jumper has a maximum resistance R_{max} = 50 mΩ at a rated current I_r = 2 A. They are supplied 4000 on reel, catalogue number 2322 711 90001 or 1000 per bag, catalogue number 2322 715 90004.

COMPOSITION OF THE CATALOGUE NUMBER

In the above-mentioned catalogue number, replace the first two dots by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

1 to 9,1 Ω: 8	10 to 91 kΩ: 3
10 to 91 Ω: 9	100 to 910 kΩ: 4
100 to 910 Ω: 1	1 to 9,1 MΩ: 5
1 to 9,1 kΩ: 2	10 MΩ: 6

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1. This means: rated temperature range −55 to + 155 °C; damp heat (long term) 56 days (see IEC publication 115-2 clause 4.1). The tests are carried out along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

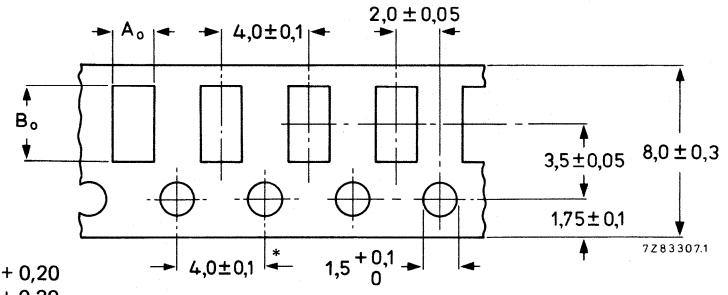
Table 2

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
19	T	soldering	unmounted chips completely immersed for 4 ± 1 s in a solder bath of 230 ± 10 °C	good tinning no damage ΔR max. 1% + 0,05 Ω
20	Na	Rapid change of temp.	½ h −55 °C/½ h + 155 °C 5 cycles	ΔR max. 1,5% + 0,2 Ω
22	Fc	Vibration	frequency: 10-500 Hz; displacement 1,5 mm or acceleration 10g, three directions; total 6 h	no damage ΔR max. 0,5% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions; 40g	no damage, ΔR max. 0,5% + 0,05 Ω
23		Climatic sequence		
23.2	Ba	Dry heat	16 h; 155 °C	
23.3	D	Damp heat (accel.)		
		1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; −55 °C	
23.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
23.6	D	Damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR max. 1,5% + 0,2 Ω
24.2	Ca	Damp heat (steady state)	56 days; 40 °C; 90-95% R.H. dissipation ⩽ 1,25 mW	R_{ins} min. 1000 MΩ ΔR max. 1,5% + 0,2 Ω
26.2	–	Endurance	1000 h; 70 °C; nominal dissipation	ΔR max. 1,5% + 0,2 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
9	–	insulation resistance	–	min. 10^4 MΩ
15	–	short time overload	room temp. dissipation 6,25 x 0,125 W (voltage not more than 2 x limiting voltage) 10 cycles 5 s on, 45 s off	ΔR max. 2% + 0,2 Ω
11	–	temperature coefficient	between –40 °C and + 125 °C	$< \pm 200 \cdot 10^{-6}$/K

STANDARD PACKAGING

1. Cardboard tape, on reel; quantity 4000 per reel; reel diameter 180 mm (see Figs 4, 6).
2. Cardboard tape, on reel; quantity 10 000 per reel; reel diameter 250 mm (see Figs 4, 6).
3. Blister tape, on reel; quantity 4000 per reel; reel diameter 180 mm (see Figs 5, 6).
4. Blister tape, on reel; quantity 10 000 per reel; reel diameter 250 mm (see Figs 5, 6).
5. Bulk, in bag, quantity 1000.



A_o = 1,85 + 0,20
B_o = 3,45 + 0,20

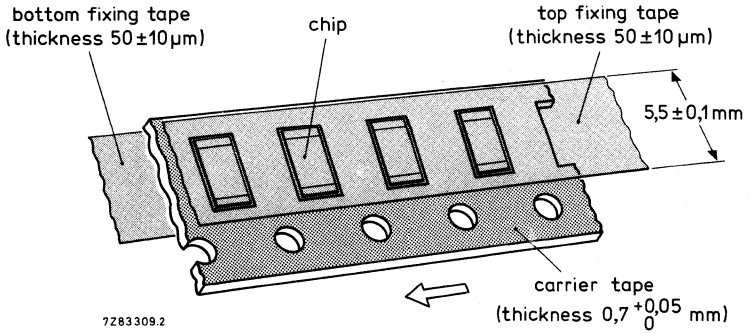
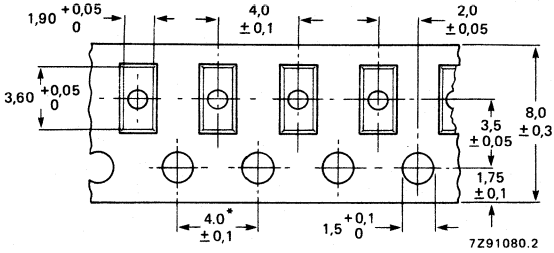


Fig. 4 Cardboard tape.

* Cumulative tolerance over 10 holes: ± 0,2 mm.



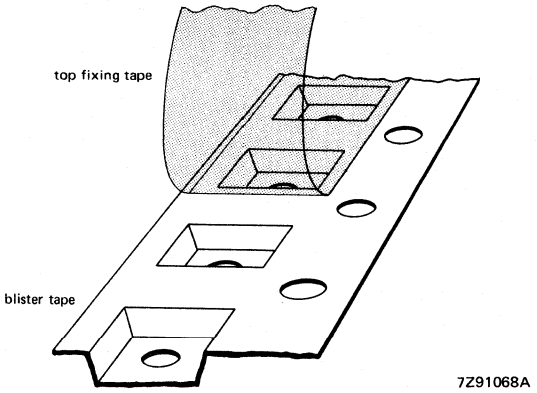


Fig. 5 Blister tape.

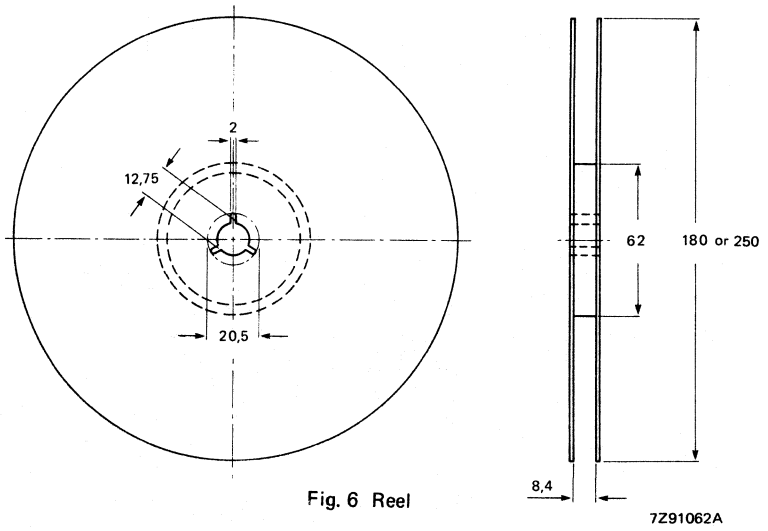


Fig. 6 Reel

* Cumulative tolerance over 10 holes: ± 0,2 mm.

INDEX OF CATALOGUE NUMBERS

NOTES

FIXED RESISTORS

Argentina: PHILIPS ARGENTINA S.A., Div. Elcoma, Vedia 3892, 1430 BUENOS AIRES, Tel. 541-7141/7242/7343/7444/7545.
Australia: PHILIPS INDUSTRIES HOLDINGS LTD., Elcoma Division, 67 Mars Road, LANE COVE, 2066, N.S.W., Tel. 427 0888.
Austria: ÖSTERREICHISCHE PHILIPS BAUELEMENTE Industrie G.m.b.H., Triester Str. 64, A-1101 WIEN, Tel. 629111.
Belgium: N.V. PHILIPS & MBLE ASSOCIATED, 9 rue du Pavillon, B-1030 BRUXELLES, Tel. (02) 242 7400.
Brazil: IBRAPE, Caixa Postal 7383, Av. Brigadeiro Faria Lima, 1735 SÃO PAULO, SP, Tel. (011) 211-2600.
Canada: PHILIPS ELECTRONICS LTD., Electron Devices Div., 601 Milner Ave., SCARBOROUGH, Ontario, M1B 1M8, Tel. 292-5161.
Chile: PHILIPS CHILENA S.A., Av. Santa Maria 0760, SANTIAGO, Tel. 39-4001.
Colombia: SADAPE S.A., P.O. Box 9805, Calle 13, No.51 + 39, BOGOTA D.E. 1., Tel. 600600.
Denmark: MINIWATT A/S, Strandlodsvej 2, P.O. Box 1919, DK 2300 COPENHAGEN S, Tel. (01) 541133.
Finland: OY PHILIPS AB, Elcoma Division, Kaivokatu 8, SF-00100 HELSINKI 10, Tel. 17271.
France: R.T.C. LA RADIOTECHNIQUE-COMPELEC, 130 Avenue Ledru Rollin, F-75540 PARIS 11, Tel. 355-44-99.
Germany: VALVO, UB Bauelemente der Philips G.m.b.H., Valvo Haus, Burchardstrasse 19, D-2 HAMBURG 1, Tel. (040) 3296-0.
Greece: PHILIPS S.A. HELLENIQUE, Elcoma Division, 52, Av. Syngrou, ATHENS, Tel. 9215111.
Hong Kong: PHILIPS HONG KONG LTD., Elcoma Div., 15/F Philips Ind. Bldg., 24-28 Kung Yip St., KWAI CHUNG, Tel. (0)-245121.
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STANDARD SERIES OF VALUES IN A DECADE

for resistances and capacitances

according to IEC publication 63

E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48
100	100	100	169	169	169	287	287	287	487	487	487	825	825	825
101			172			291			493			835		
102	102		174	174		294	294		499	499		845	845	
104			176			298			505			856		
105	105	105	178	178	178	301	301	301	511	511	511	866	866	866
106			180			305			517			876		
107	107		182	182		309	309		523	523		887	887	
109			184			312			530			898		
110	110	110	187	187	187	316	316	316	536	536	536	909	909	909
111			189			320			542			920		
113	113		191	191		324	324		549	549		931	931	
114			193			328			556			942		
115	115	115	196	196	196	332	332	332	562	562	562	953	953	953
117			198			336			569			965		
118	118		200	200		340	340		576	576		976	976	
120			203			344			583			988		
121	121	121	205	205	205	348	348	348	590	590	590			
123			208			352			597					
124	124		210	210		357	357		604	604		E24	E12	E6	E3
126			213			361			612						
127	127	127	215	215	215	365	365	365	619	619	619	10	10	10	10
129			218			370			626			11			
130	130		221	221		374	374		634	634		12	12		
132			223			379			642			13			
133	133	133	226	226	226	383	383	383	649	649	649	15	15	15	
135			229			388			657			16			
137	137		232	232		392	392		665	665		18	18		
138			234			397			673			20			
140	140	140	237	237	237	402	402	402	681	681	681	22	22	22	22
142			240			407			690			24			
143	143		243	243		412	412		698	698		27	27		
145			246			417			706			30			
147	147	147	249	249	249	422	422	422	715	715	715	33	33	33	
149			252			427			723			36			
150	150		255	255		432	432		732	732		39	39		
152			258			437			741			43			
154	154	154	261	261	261	442	442	442	750	750	750	47	47	47	47
156			264			448			759			51			
158	158		267	267		453	453		768	768		56	56		
160			271			459			777			62			
162	162	162	274	274	274	464	464	464	787	787	787	68	68	68	
164			277			470			796			75			
165	165		280	280		475	475		806	806		82	82		
167			284			481			816			91			