PHILIPS

Data handbook

Electronic components and materials

Components and materials

Part 13 December 1979

Fixed resistors

COMPONENTS AND MATERIALS

PART 13 - DECEMBER 1979

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 three series of handbooks each comprising several parts.

ELECTRON TUBES	BLUE
SEMICONDUCTORS AND INTEGRATED CIRCUITS	RED
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.

October 1977

ELECTRON TUBES (BLUE SERIES)

Part 1a	**December 1975**	**ET1a 12-75**	**Transmitting tubes for communication, tubes for r.f. heating** Types PE05/25 to TBW15/25
Part 1b	**August 1977**	**ET1b 08-77**	**Transmitting tubes for communication, tubes for r.f. heating, amplifier circuit assemblies**
Part 2a	**November 1977**	**ET2a 11-77**	**Microwave tubes** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, diodes, triodes T-R switches
Part 2b	**May 1978**	**ET2b 05-78**	**Microwave semiconductors and components** Gunn, Impatt and noise diodes, mixer and detector diodes, backward diodes, varactor diodes, Gunn oscillators, sub-assemblies, circulators and isolators
Part 3	**January 1975**	**ET3 01-75**	**Special Quality tubes, miscellaneous devices**
Part 4	**March 1975**	**ET4 03-75**	**Receiving tubes**
Part 5a	**October 1979**	**ET5a 10-79**	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
Part 5b	**December 1978**	**ET5b 12-78**	**Camera tubes and accessories, image intensifiers**
Part 6	**January 1977**	**ET6 01-77**	**Products for nuclear technology** Channel electron multipliers, neutron tubes, Geiger-Müller tubes
Part 7a	**March 1977**	**ET7a 03-77**	**Gas-filled tubes** Thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes
Part 7b	**May 1979**	**ET7b 05-79**	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units
Part 8	**July 1979**	**ET8 07-79**	**Picture tubes and components** Colour TV picture tubes, black and white TV picture tubes, monitor tubes, components for colour television, components for black and white television.
Part 9	**March 1978**	**ET9 03-78**	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

Part 1a	**August 1978**	**SC1a 08-78**	**Rectifier diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), transient suppressor diodes, rectifier stacks, thyristors, triacs
Part 1b	**December 1979**	**SC1b 12-79**	**Diodes** Small signal germanium diodes, small signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
Part 2	**November 1977**	**SC2 11-77**	**Low-frequency and dual transistors***
Part 2	**June 1979**	**SC2 06-79**	**Low-frequency power transistors**
Part 3	**January 1978**	**SC3 01-78**	**High-frequency, switching and field-effect transistors**
Part 4a	**December 1978**	**SC4a 12-78**	**Transmitting transistors and modules**
Part 4b	**September 1978**	**SC4b 09-78**	**Devices for optoelectronics** Photosensitive diodes and transistors, light emitting diodes, photocouplers, infrared sensitive devices, photoconductive devices
Part 4c	**July 1978**	**SC4c 07-78**	**Discrete semiconductors for hybrid thick and thin-film circuits**
Part 5a	**November 1978**	**SC5a 11-76**	**Professional analogue integrated circuits**
Part 5b	**March 1977**	**SC5b 03-77**	**Consumer integrated circuits** Radio-audio, television
Part 6	**October 1977**	**SC6 10-77**	**Digital integrated circuits** LOCMOS HE4000B family
Part 6b	**August 1979**	**SC6b 08-79**	**ICs for digital systems in radio and television receivers**
Signetics integrated circuits 1978			Bipolar and MOS memories Bipolar and MOS microprocessors Analogue circuits Logic - TTL

* Low-frequency general purpose transistors will be transferred to SC3 later in 1979. The old book SC2 11-77 should be kept until then.

COMPONENTS AND MATERIALS (GREEN SERIES)

Part 1	**July 1979**	**CM1 07-79**	**Assemblies for industrial use** PLC modules, high noise immunity logic FZ/30-series, NORbits 60-series, 61-series, 90-series, input devices, hybrid integrated circuits, peripheral devices
Part 2b	**February 1978**	**CM2b 02-78**	**Capacitors** Electrolytic and solid capacitors, film capacitors, ceramic capacitors, variable capacitors
Part 3a	**September 1978**	**CM3a 09-78**	**FM tuners, television tuners, surface acoustic wave filters**
Part 3b	**October 1978**	**CM3b 10-78**	**Loudspeakers**
Part 4a	**November 1978**	**CM4a 11-78**	**Soft ferrites** Ferrites for radio, audio and television, beads and chokes, Ferroxcube potcores and square cores, Ferroxcube transformer cores
Part 4b	**February 1979**	**CM4b 02-79**	**Piezoelectric ceramics, permanent magnet materials**
Part 6	**April 1977**	**CM6 04-77**	**Electric motors and accessories** Small synchronous motors, stepper motors, miniature direct current motors
Part 7	**September 1971**	**CM7 09-71**	**Circuit blocks** Circuit blocks 100 kHz-series, circuit blocks 1-series, circuit blocks 10-series, circuit blocks for ferrite core memory drive
Part 7a	**January 1979**	**CM7a 01-79**	**Assemblies** Circuit blocks 40-series and CSA70 (L), counter modules 50-series, input/output devices
Part 8	**June 1979**	**CM8 06-79**	**Variable mains transformers**
Part 9	**August 1979**	**CM9 08-79**	**Piezoelectric quartz devices** Quartz crystal units, temperature compensated crystal oscillators
Part 10	**April 1978**	**CM10 04-78**	**Connectors**
Part 11	**December 1979**	**CM11 12-79**	**Non-linear resistors** Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)
Part 12	**November 1979**	**CM12 11-79**	**Variable resistors and test switches**
Part 13	**December 1979**	**CM13 12-79**	**Fixed resistors**

FIXED RESISTORS

SURVEY

resistor type	resistance range	tolerance %	dissipation at °C	dissipation W	type number or basic catalogue number	page
Carbon film	1 Ω to 10 MΩ	5; 10	70	0,2	CR16	
				0,33	CR25	
				0,5	CR37	
		5		0,67	CR52	
				1,15	CR68	
				2	CR93	7
Standard film	1 Ω to 1 MΩ	5	70	0,33	SFR25	19
Non-flammable	1 Ω to 15 kΩ	5	70	0,33	NFR25	27
Metal film	51 Ω to 100 kΩ	1; 2	70	0,25	MR16	35
Metal film, CECC 40101	1 Ω to 1 MΩ	0,5; 1; 2	70	0,4	MR25	
				0,5	MR30	
				1	MR52	43
Metal film, MIL-R-10509F	10 Ω to 1 MΩ	0,1; 0,25; 0,5; 1	125	0,1	MR24E; MR24C	
				0,125	MR34E; MR34C	
				0,25	MR54E; MR54C	
				0,5	MR74E; MR74C	
			70	0,125	MR24D	
				0,25	MR34D	
				0,5	MR54D	
				0,75	MR74D	53
High voltage	220 kΩ to 22 MΩ	5; 10	70	0,25	VR25	59
High voltage	100 kΩ to 68 MΩ	1; 5	70	0,5	VR37	
				1	VR68	67
Power metal film	10 Ω to 10 kΩ	5	70	1,6	PR37	75
Power metal film	10 Ω to 27 kΩ	5	70	2,5	PR52	81
Cemented wirewound	0,1 Ω to 33 kΩ	5; 10	40	4	AC04	
				5	AC05	
				7	AC07	
				10	AC10	
				15	AC15	
				20	AC20	87
Cemented wirewound	0,1 Ω to 12 kΩ	5; 10	70	1	ACL01	
				2	ACL02	
				3	ACL03	97
Cemented wirewound	5,6 Ω to 16 kΩ	5	70	4	WR0617	
				7	WR0825	
				9,5	WR0842	
				15	WR0865	105

resistor type	resistance range	tolerance %	dissipation at °C	dissipation W	type number or basic catalogue number	page
Enamelled wirewound	4,7 Ω to 100 kΩ	5	70	4	WR0617E	
				7	WR0825E	
				11	WR0842E	
				17	WR0865E	115
Rectangular wirewound	0,15 Ω to 22 kΩ	5; 10	70	4	EH04	
				5	EH05	
				7	EH07	
				9	EH09	
				17	EH17	123
Wirewound with side terminations	1 Ω to 120 kΩ	5; 10	40	8 to 100	2322 321	
				8 to 250	2322 323	129
Adjustable wirewound	1,2 Ω to 47 kΩ	5; 10	40	10 to 100	2322 322	
				10 to 250	2322 324	133
Low-ohmic wirewound	0,1 Ω to 10 Ω	10	70	2	2322 326	137
Low-ohmic glass-sealed	0,1 Ω to 6,8 Ω	10	40	1	2322 327	141
Pin-head carbon	33 Ω to 180 kΩ	10	70	0,05	2322 120	143

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

INTRODUCTION

Two basic versions of film resistors are available, namely carbon film resistors and metal film resistors.
Carbon film resistors are used if moderate demands are made on stability, temperature coefficient and tolerance. To meet higher demands on one or more of these parameters metal-film resistors are used.
The specification of these resistors is based primarily on I.E.C. publication 115, "Recommendations for fixed non-wire-wound resistors type 1 for use in electronic equipment".
A different way of specifying power ratings has been adopted, however, to give the circuit designer better guidance in selecting the proper resistor for a given application.
Before going into detail on this point some remarks have to be made about the basic behaviour of film resistors.

BASIC BEHAVIOUR

Power dissipation in a resistor causes the temperature of the resistor body to increase. The temperature rise is determined by the laws of heat conduction, convection and radiation and will be maximum at the so-called hot spot (usually the middle of the resistor body).
Theoretically in the temperature range where radiation plays only a minor part - and this is the normal temperature range of film resistors - the maximum temperature rise ΔT is proportional to the power dissipated: $\Delta T = A.P.$; experiments confirm this.
The proportionality constant A gives the temperature rise at the hot spot per watt of dissipated power and can be interpreted as a heat resistance with dimensions deg C/W. This heat 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 increase and the ambient temperature T_{amb} is the maximum temperature (hot spot temperature) of the resistor.

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

The stability of a film resistor under endurance tests is mainly determined by the hot spot temperature and the resistance value. The lower the resistance value with the other conditions kept constant the higher the stability due to the greater film thickness for these lower resistance values.

The above relations can be summarised schematically in the following way:

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

WAY OF SPECIFYING THE PERFORMANCE

Formerly a resistor was characterised by a wattage rating hardly any attention being paid to the above mentioned relations apart from giving a derating line.
In the adopted system the relation between the several variables is given for a certain heat resistance, or, in other words, for certain resistor dimensions; the materials used and the test mounting are in general the same for different resistor types. The resistor is thus characterised by its dimensions.
The dissipation is given as a function of the hot spot temperature with the ambient temperature as a parameter.

From $\Delta T = A.P.$ 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 hrs, 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.1. The intersection of the dash line with the horizontal axis gives the hot spot temperature under chosen conditions.

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 dashed 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.

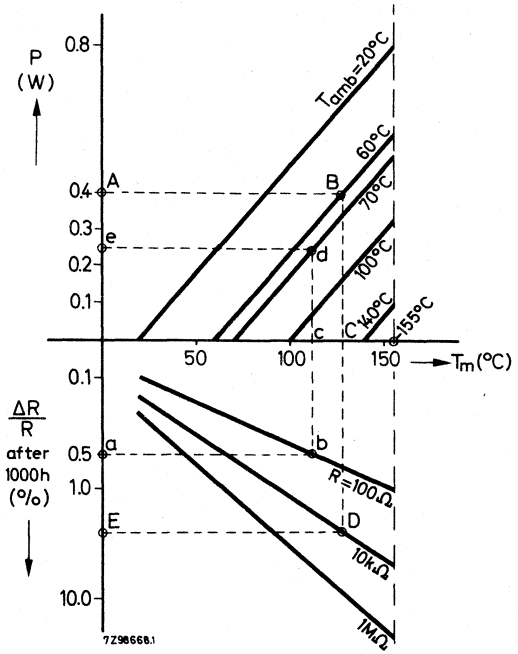


Fig.1. Performance nomogram (for a fictitious resistor) illustrating the new way of specifying the performance of film resistors.

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.

CARBON FILM RESISTORS

QUICK REFERENCE DATA

Resistance ranges	1 Ω to 10 MΩ; E12 or E24 series
Resistance tolerance	5 and 10%
Abs. max. dissipation at T_{amb} = 70 °C*	CR16 = 0,2 W, CR52 = 0,67 W CR25 = 0,33 W, CR68 = 1,15 W CR37 = 0,5 W, CR93 = 2 W
Basic specification	IEC publication 115-1, 115-2
Climatic category	55/155/56
Stability after	
load	see nomogram (Fig. 2)
climatic tests	ΔR max. 1,5% for R ≤ 220 kΩ ΔR max. 3 % for R > 220 kΩ
soldering	ΔR max. 0,5% or 0,5 Ω
short time overload	ΔR max. 1 %

APPLICATION

In a great variety of electronic circuits, from hearing aids to computers, from telecommunication equipment to portable radios.

DESCRIPTION

A homogeneous film of pure carbon is deposited on a high grade ceramic body by pyrolysis of a hydrocarbon gas. Resistors with resistance values lower than 10 ohms have an electroless-deposited nickel film instead of a carbon film. The further processing, however, is the same. Contact caps of special alloy are pressed onto the ends of the resistor body, and tinned electrolytic copper connecting wires are welded to these caps.

As a rule the required resistance value is not obtained by pyrolysis only; helixing, that is, cutting a helical groove in the carbon film, is necessary in which the desired resistance value is arrived at by regulating the pitch of the helix. The thinner the carbon layer and the finer the pitch of the helix, the higher the resistance value.

Finally the resistors are coated with three or more layers of a tan lacquer for electrical and climatical protection.

* 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.

MECHANICAL DATA

Dimensions in mm

Outlines

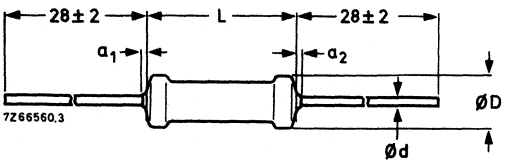


Fig. 1a.

style	D_{max}	L_{max}	d	$a_1 + a_2$	l
CR16	1,6	4,0	0,5	⩽1	28 ± 2
CR25	2,5	6,5	0,6	⩽1	28 ± 2
CR37	3,7	10	0,7	⩽1	28 ± 2
CR52	5,2	16,5	0,8	⩽2	28 ± 2
CR68	6,8	18	0,8	⩽2	28 ± 2
CR93	9,0	31,7	0,8	⩽2	36 ± 2

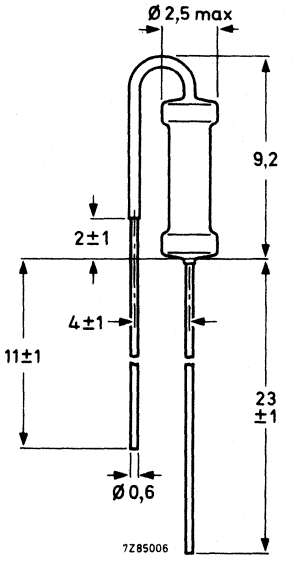


Fig. 1b Style CR25A.

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

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).

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 items)

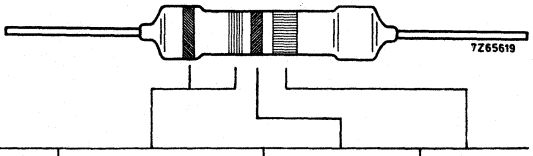
CR16	8 g	CR52	96 g
CR25	23 g	CR68	148 g
CR37	42 g	CR93	552 g

Mounting

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

Marking

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



colour	significant figures	multiplier	tolerance
black	0	1 x	
brown	1	10 x	
red	2	100 x	
orange	3	1 000 x	
yellow	4	10 000 x	
green	5	100 000 x	
blue	6	1 000 000 x	
violet	7		
grey	8		
white	9		
silver			± 10%
gold		0,1 x	± 5%

ELECTRICAL DATA

style	limiting voltage* V (r.m.s.)	resistance range	tolerance (± %)	series**	catalogue number
CR16	150	10 Ω - 220 kΩ	5	E24	2322 210 13...
		270 kΩ - 1 MΩ	10	E12	2322 210 12...
CR16 on reel		10 Ω - 220 kΩ	5	E24	2322 210 23...
		270 kΩ - 1 MΩ	10	E12	2322 210 22...
CR25	250	1 Ω - 1 MΩ	5	E24	2322 211 13...
		1,2 MΩ - 10 MΩ	10	E12	2322 211 12...
CR25 on reel		1 Ω - 1 MΩ	5	E24	2322 211 23...
		1,2 MΩ - 10 MΩ	10	E12	2322 211 22...
CR25A	250	1 Ω - 1 MΩ	5	E24	2322 106 33...
		1,2 MΩ - 10 MΩ	10	E12	2322 106 32...
CR37	350	1 Ω - 1 MΩ	5	E24	2322 212 13...
		1,2 MΩ - 10 MΩ	10	E12	2322 212 12...
CR37 on reel		1 Ω - 1 MΩ	5	E24	2322 212 23...
		1,2 MΩ - 10 MΩ	10	E12	2322 212 22...
CR52▲	500	1 Ω - 1 MΩ	5	E24	2322 213 13...
CR68▲	750	1 Ω - 1 MΩ	5	E24	2322 214 13...
CR93▲	1000	10 Ω - 1 MΩ	5	E24	2322 215 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 - 9,1 MΩ	5
1 - 9,1 kΩ	2	10 MΩ	6

Note
For CR25 and CR37, all resistor values above 1 MΩ will become obsolescent and can be replaced by corresponding types of VR25 range.

* Limiting voltage (element and insulation). This is the maximum voltage that may be applied continuously to the resistor element (see IEC publication 115-1 and 115-2). This voltage is also the maximum voltage that may be applied continuously to the insulation of the resistor.

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

▲ For resistance values higher than 1 MΩ, those from the VR37/VR68 series are recommended, see Fig. 3 of the relevant specification.

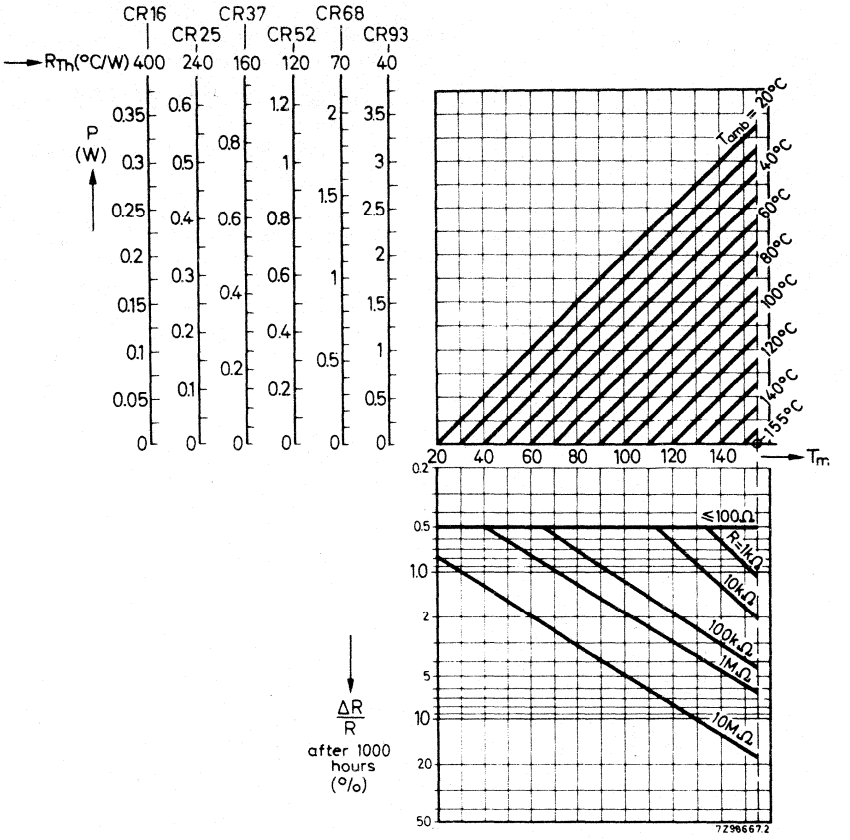


Fig. 2.

Performance nomogram for different styles of resistor showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature T_m, 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 ($\Delta R/R$ after x h) = ($\Delta R/R$ after 1000 h). $(t_x/1000)^{\frac{1}{2}}$.

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. 3 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. 3 replace the rated dissipation.

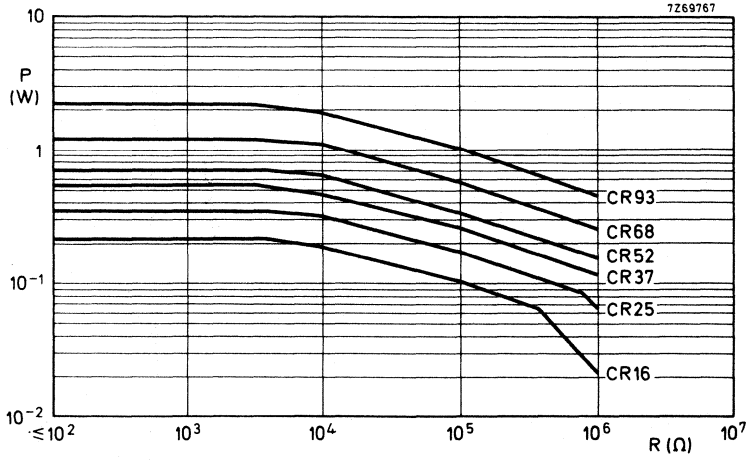


Fig. 3 Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance value for a resistance drift of 1,5% after 1000 hours or for a maximum temperature of 155 °C without reaching the resistance drift of 1,5%, limiting voltage being taken into account.

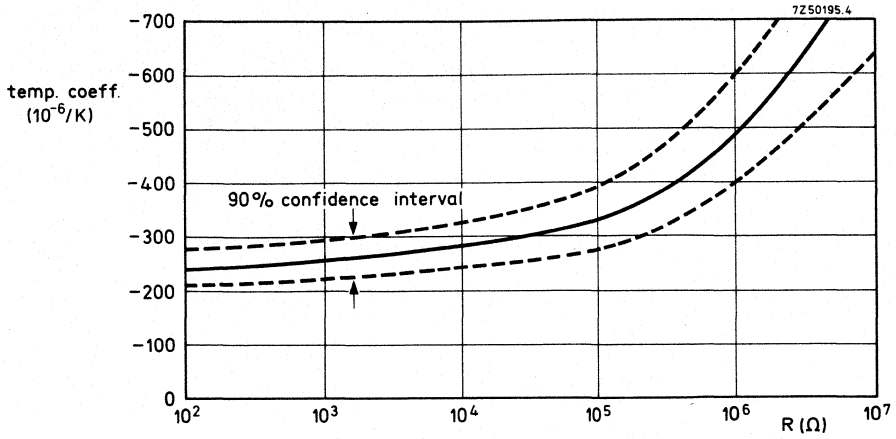


Fig. 4 Temperature coefficient as a function of the resistance value, applicable to all resistor styles. For values $< 10\ \Omega$ the temperature coefficient is $\leqslant + 200.10^{-6}/K$.

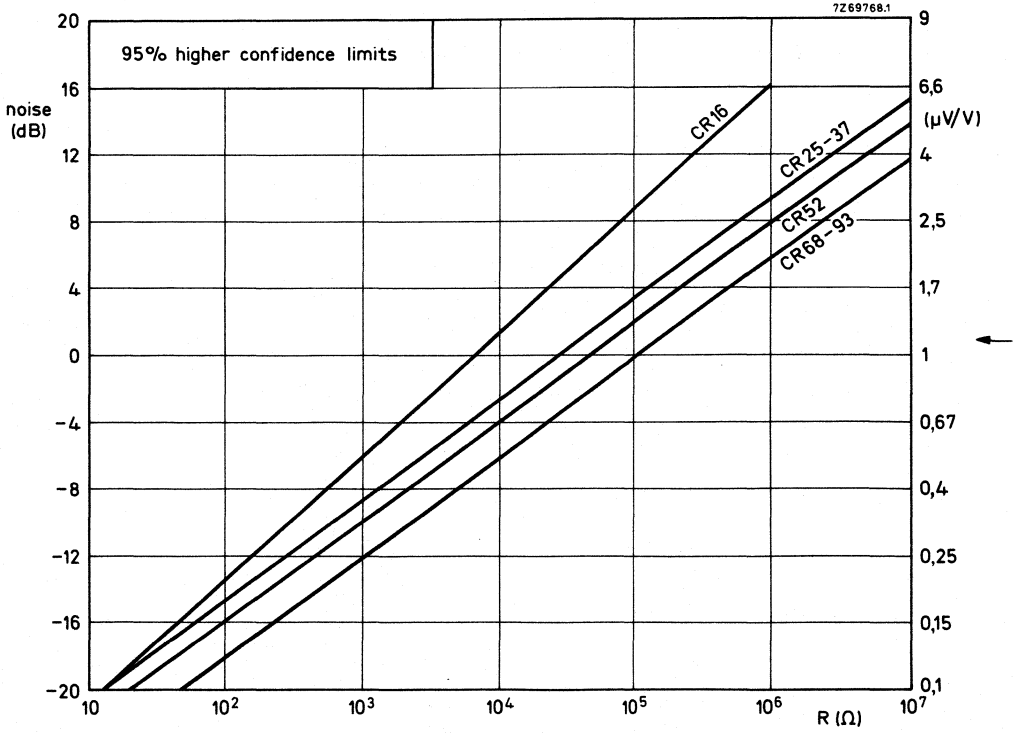


Fig. 5 Noise as a function of the resistance value. 0 dB = 1 μV/V.

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		CR93	
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	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o
10	3,47	70	2,97	70	2,35	61	2,26	61	2,46	63	3,95	71
22	1,72	52	1,61	51	1,43	45	1,40	46	1,37	43	2,42	60
56	1,11	31	1,07	28	1,02	26	1,08	27	1,07	25	1,54	34
100	1,03	23	1,02	22	1,02	17	1,01	18	1,09	20	1,40	32
220	0,99	10	0,99	9	1	6	0,98	4	1	4	0,98	5
560	0,98	0	0,97	−5	0,94	−16	0,97	−5	0,90	−18	0,83	−31
1000	0,96	−9	0,92	−15	0,88	−25	0,86	−24	0,79	−31	0,48	−56
2200	0,84	−32	0,82	−35	0,69	−47	0,64	−50	0,49	−59	0,25	−71
5600	0,50	−60	0,41	−66	0,35	−69	0,31	−72	0,22	−77	0,10	−83

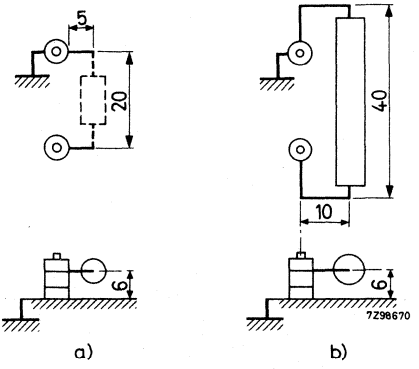


Fig. 6 Measuring arrangement: (a) for CR16 to CR68, (b) for CR93.

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 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	
	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% or 0,5 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% or 0,5 Ω
20	Na	Rapid change of temperature	½ h - 55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,5% or 0,5 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10 g, three directions; total 6 h	no damage ΔR max. 0,5% or 0,5 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR max. 0,5% or 0,5 Ω

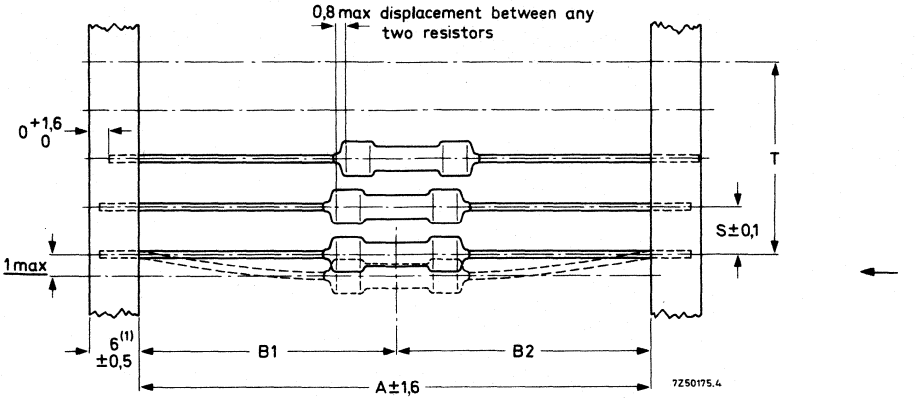
IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 hours 155 °C	
23.3	D	Damp heat (accel)		
		1st cycle	24 hours; 55 °C; 95 - 100% R.H.	
23.4	Aa	Cold	2 hours; −55 °C	
23.5	M	Low air pressure	1 hour; 85 mbar; 15 - 35 °C	
23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95 - 100% R.H.	R_{ins} = min. 1000 MΩ ΔR max. 1,5% for R ⩽ 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. 3.	R_{ins}: min. 1000 MΩ ΔR max.: 1,5% for R ⩽ 220 kΩ; 3% for R > 220 kΩ
26.2	–	Endurance	1000 hours; 70 °C; dissipation taken from Fig. 3	ΔR max.: 1,5%
11	–	Temperature coefficient	between −55 °C and + 155 °C	see Fig. 4
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. 5
9	–	Insulation resistance	–	min. 10^4 MΩ
15	–	Short time overload	room temperature, dissipation 6,25 x value taken from Fig. 3, (voltage not more than 2 x limiting voltage), 10 cycles, 5 s on, 45 s off	ΔR max. 1%
13	–	Voltage coefficient	–	< 5 ppm

STANDARD PACKAGING

style	number per box		
	bandolier	bulk	bandolier reeled
CR16	1000		5000
CR25	1000		5000
CR25A		1000	
CR37	1000		5000
CR52	500		
CR68	500		
CR93	250		

Configuration of bandolier

Dimensions in mm



(1) For styles CR52 and CR68: 5 mm.

Fig. 7.

style	A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
CR16	52,4	1,2	5	2 mm per 10 spacings 1,5 mm per 5 spacings
CR25	52,4	1,2	5	
CR37	52,4	1,2	5	
CR52	66,7	1,2	10	
CR68	66,7	1,2	10	
CR93	92*	1,2	10	

* Tolerance ± 2 mm.

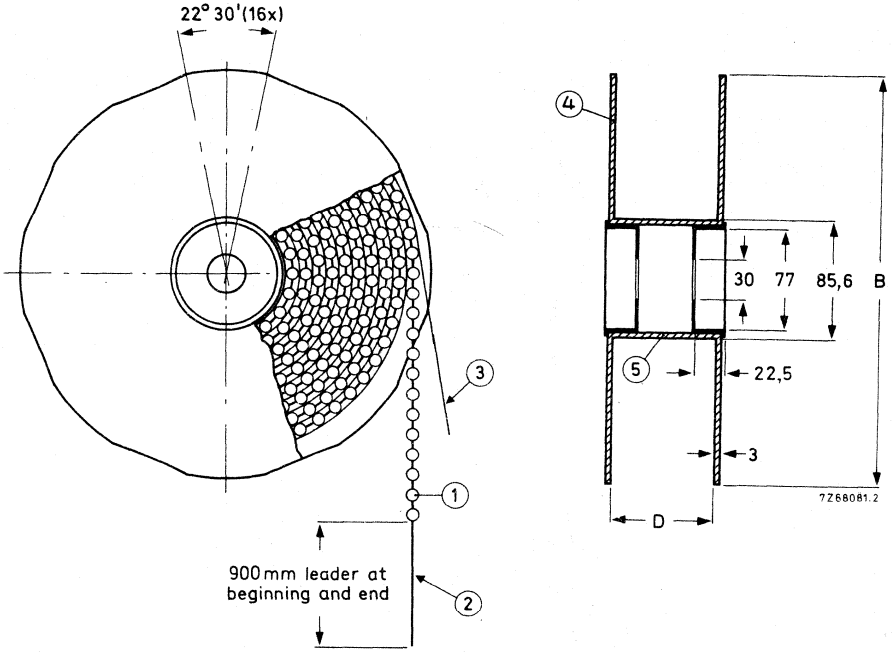


Fig. 8 Reel dimensions (mm).

(1) resistor
(2) bandolier
(3) paper
(4) flange
(5) cylinder

style	B	D
CR16	305	75
CR25	305	75
CR37	356	75

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range	from 1 Ω to 1 MΩ **E24** series
Resistance tolerance	± 5%
Temperature coefficient	$\leqslant 250 \cdot 10^{-6}$/K
Abs. max. dissipation at T_{amb} = 70 °C*	0,33 W
Noise	$\leqslant 0{,}1\ \mu V/V$
Basic specification	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

APPLICATION

These resistors have been developed for applications in all kinds of electronic circuits.

DESCRIPTION

A homogeneous film of nickel-chromium is deposited on a high grade ceramic body. The lower part of the resistance range has an electroless-deposited nickel-phosphor film instead of nickel-chromium, the further processing, however, is the same. After a helical groove is cut in the resistive layer, connecting wires of electrolytic copper with lead-tin are welded to the end-caps.

As a rule the required resistance value is not obtained by deposition of a film only, cutting a helical groove (helixing) in the metal film is also necessary. The thinner the metal film layer and the finer the pitch of the helix, the higher the resistance value.

Finally the resistor is coated with a light-green lacquer, for electrical, mechanical and climatological protection. The encapsulation is resistant to all commonly used cleaning solvents for printed wiring boards.

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

MECHANICAL DATA

Dimensions in mm

Outlines

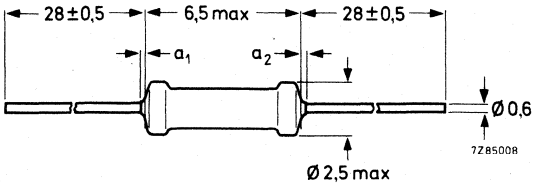


Fig. 1 Standard version. $a_1 + a_2 \leqslant 1$ mm.

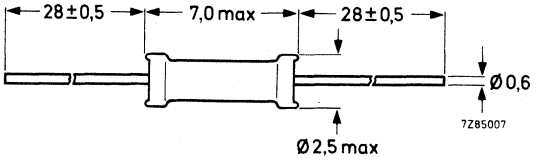


Fig. 2 Clean lead version.

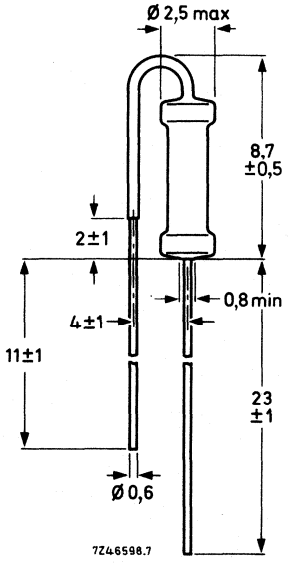


Fig. 3 Stand-up version, style SFR25A.

The bent lead is partly covered with an insulating lacquer having a breakdown voltage of at least 50 V (d.c.).

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).

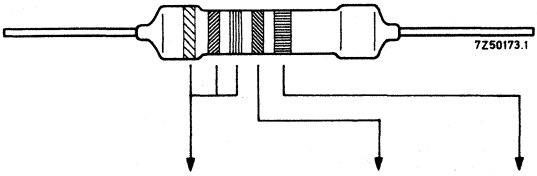
Mass (per 100 items): 25 g

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. Thanks to its maximum clean lead to clean lead dimension of 7,0 mm, the clean lead version (see Fig. 2) can even be automatically inserted at a 4e pitch (10,16 mm). Furthermore the resistors can be mounted without any problem directly against double-sided printed circuit boards. The stand-up version can be inserted at a pitch of 1e.

Marking

The nominal resistance value and the tolerance are marked on these resistors by means of four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors" (see also IEC publication 115-1 clause 4.5).



colour	significant figures	multiplier	tolerance
black	0	1 x	
brown	1	10 x	
red	2	100 x	
orange	3	1 000 x	
yellow	4	10 000 x	
green	5	100 000 x	
blue	6	1 000 000 x	
violet	7	–	
grey	8	–	
white	9	–	
silver		–	
gold		0,1 x	± 5%

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 ± 5%, and ranges from 1 Ω to 1 MΩ. The values of these series are given in the table "Standard series of values in a decade" at the back of this book.

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

Composition of the catalogue number

2322 181.. ...

packing:

- 13 for standard version, 1000 items on bandolier
- 23 for standard version, 5000 items taped, on reel
- 33 for stand-up version (SFR25A), 1000 items loose per box
- 53 for clean lead version, 1000 items on bandolier
- 63 for clean lead version, 5000 items taped, on reel

Resistance value code: first two figures of the resistance value (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 91 kΩ
- 4 for R of 100 to 910 kΩ
- 5 for R of 1 MΩ

Example

The catalogue number of a resistor SFR25 of 5600 Ω clean lead version, taped on a bandolier of 1000 items and supplied in a box is 2322 181 53562.

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 specification were necessary for our method of specifying.

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 350° 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 10 g, three directions; total 6 h	no damage ΔR max. 0,25% + 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40 g	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 mbar; 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	$\leqslant 250 \cdot 10^{-6}$/K
10	–	Voltage proof on insulation	standard and stand-up version 700 V_{rms}, 1 minute clean lead version: 500 V_{rms}, 1 min	no breakdown
14	–	Noise	IEC publication 195	$\leqslant 0{,}1\ \mu V/V$
9	–	Insulation resistance		min. 10^4 MΩ
		Short time overload	Room temperature, dissipation $6{,}25P_n$ (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0,25% + 0,05 Ω

STANDARD PACKAGING

Straight wire versions: bandoliered, 1000 items per box, 5000 per reel per box.
Stand-up version: 1000 items, loose per box.

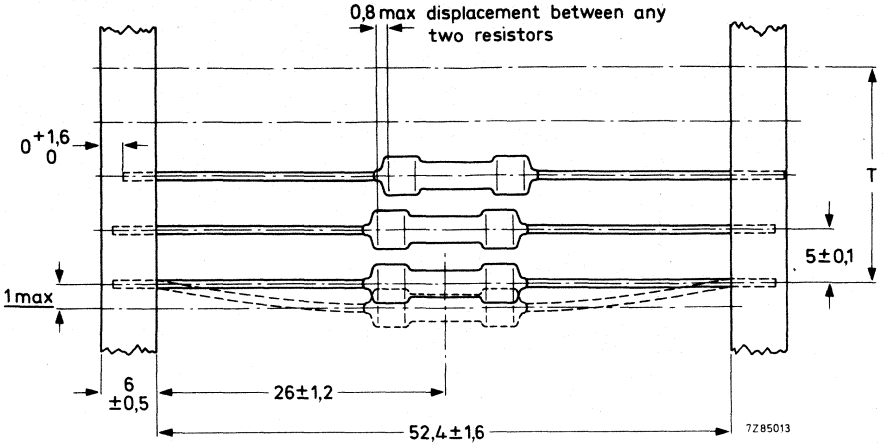
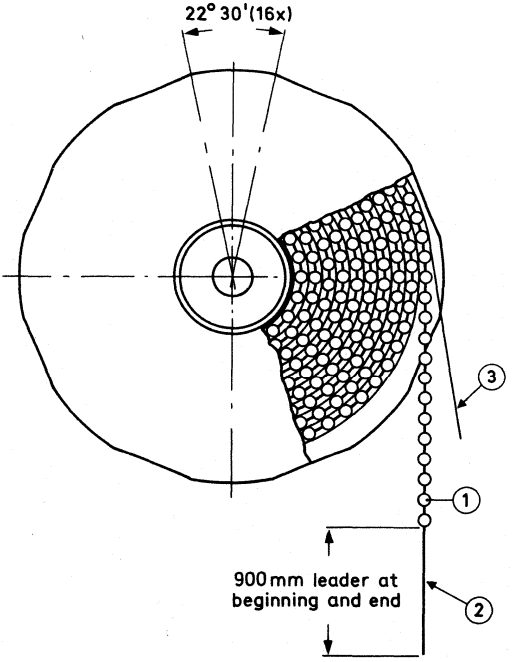


Fig. 4 Configuration of bandolier (dimensions in mm).

T = max. deviation of pitch; T = 2 mm per 10 spacings, 1,5 mm per 5 spacings.



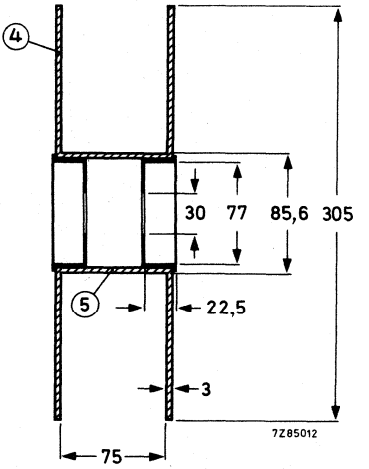


Fig. 5 Reel dimensions (in mm).

(1) resistor
(2) bandolier
(3) paper
(4) flange
(5) cylinder

NON-FLAMMABLE RESISTORS
metal film

QUICK REFERENCE DATA

Resistance range	1 Ω to 15 kΩ E24 series
Resistance tolerance	5%
Temperature coefficient	$\leqslant 250.10^{-6}$/K
Abs. max. dissipation at T_{amb} = 70 °C *	0,33 W
Basic specifications	IEC 115-1, 115-2
Climatic category (IEC 68)	55/155/56
Stability after:	
endurance test	ΔR/R max. 1%
climatic tests	ΔR/R max. 1%
soldering	ΔR/R max. 0,25% + 0,05 Ω
short time overload	ΔR/R max. 0,25% + 0,05 Ω

APPLICATION

These resistors have been specially 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 to 4).

DESCRIPTION

A homogenous metal film is deposited on a high grade ceramic body. (The metal is electroless nickel for values from 1 Ω to 15 Ω and nickel-chromium for values from 16 Ω to 15 kΩ.) Steel contact caps are pressed onto the ends of the resistor body. Tinned electrolytic copper connecting wires are welded to these caps.

The required resistance value is obtained by cutting a helical groove through the metal film. The resistors are coated with grey flame retardant insulating lacquer. The lacquer is resistant against commonly used cleaning solvents.

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

MECHANICAL DATA

Dimensions in mm

Outlines

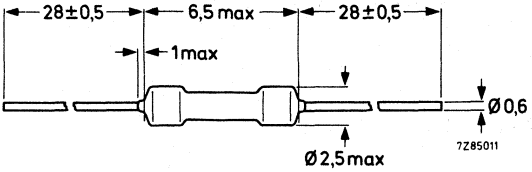


Fig. 1.

Maximum lacquer run-off on the wire is 1 mm. Total lacquer run-off on both leads together is also max. 1 mm (clean lead to clean lead, max. 7,5 mm). 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: 25 g.

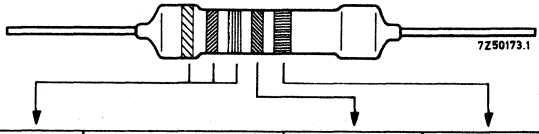
Mounting

The resistors are suitable for processing in automatic insertion machines and cut and bend 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 value and the tolerance are marked on these resistors by means of four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors" (see also IEC publication 115-1 clause 4. 5).



colour	significant figures	multiplier	tolerance
black	0	1 x	
brown	1	10 x	
red	2	100 x	
orange	3	1000 x	
yellow	4	–	
green	5	–	
blue	6	–	
violet	7	–	
grey	8	–	
white	9	–	
silver		–	
gold		0,1 x	± 5%

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 ± 5%, and ranges from 1 Ω to 15 kΩ. The values of this series are given in the table "Standard series of values in a decade" at the back of this book.

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

Composition of the catalogue number

2322 205 .....

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

Resistance value code: first two figures of the resistance value (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 with a tolerance of 5%, taped on a bandolier of 1000 items and supplied in a box is 2322 205 13562.

Uninflammability

Cheese-cloth tube, diameter 3x that of the resistor, mounted around the resistor should not ignite at any overload up to 1000x rated dissipation (with a maximum of 2x limiting voltage). (Test method according to U.L. spec. 492.2.).

D.C. overload steps: 4, 6,5, 10, 20, 60, 80, 100, 150, 300, 500 and 1000 times rated dissipation.

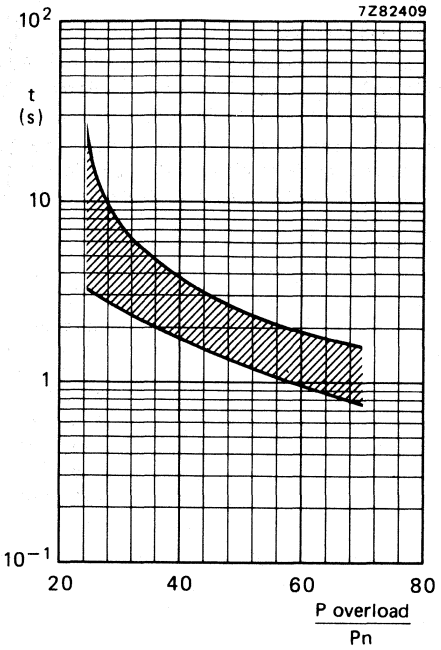


Fig. 2 Time to interruption (t) in S as a function of the overload $\frac{P_{overload}}{P_n}$ for $R > 100\ \Omega$.

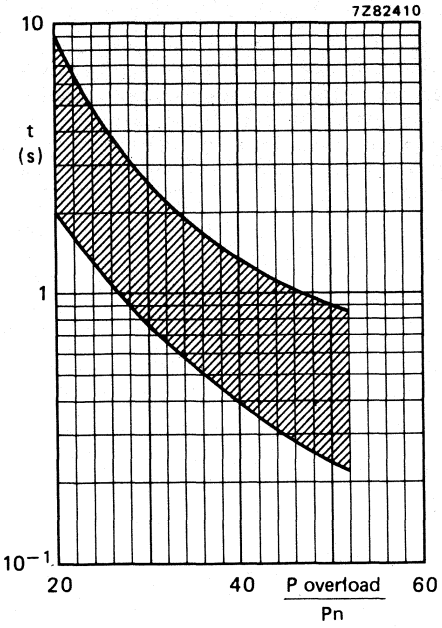


Fig. 3.

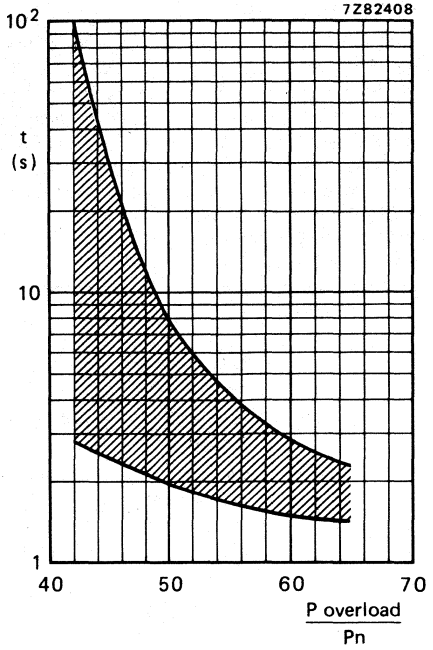


Fig. 4.

Time to interruption (t) in s as a function of the overload $\frac{P_{overload}}{P_n}$ for $R \leqslant 15\ \Omega$ (Fig. 3) and $15\ \Omega < R < 15\ k\Omega$ (Fig. 4). $P_n = 0{,}33$ W.

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 specification were necessary for our method of specifying. For inflammability requirements reference is made to U.L. publication 492.2 and to CECC draft 156E (sec.).

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°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,25% or 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% or 0,05 Ω
20	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,25% or 0,05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10 g, three directions; total 6 h	no damage ΔR max. 0,25% or 0,05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR max. 0,25% or 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 mbar; 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%
11	–	Temperature coefficient	between −55 °C and + 155 °C	$\leqslant 250.10^{-6}$/K for R > 15 Ω $\leqslant 100.10^{-6}$/K for R ⩽ 15 Ω
10	–	Voltage proof on insulation	500 V_{rms} 1 minute	no breakdown
14	–	Noise	IEC publication 195	< 0,1 μV/V
9	–	Insulation resistance		min. 10^4 MΩ
		Short time overload	Room temperature, dissipation $6{,}25P_n$ (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0,25% + 0,05 Ω

STANDARD PACKAGING

Bandoliered 1000 items per box, 5000 items per reel.

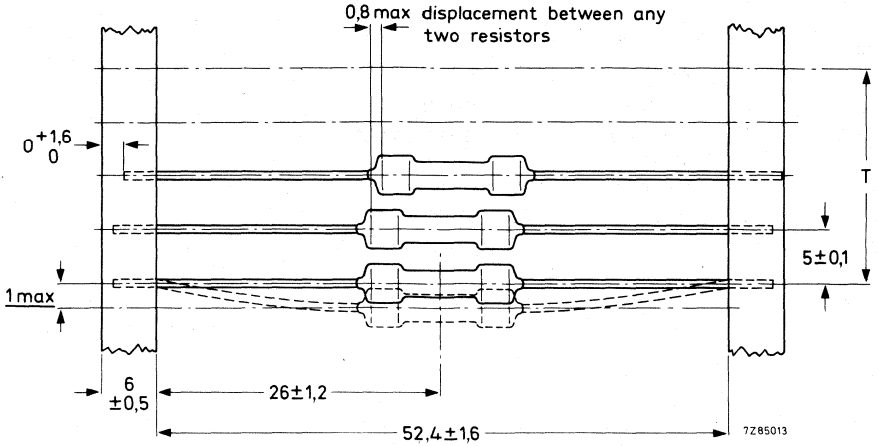
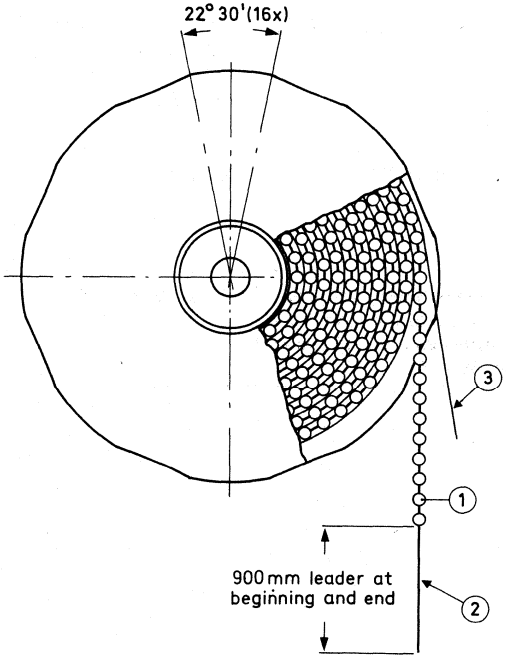


Fig. 5 Configuration of bandolier (dimensions in mm).

T = max. deviation of pitch; T = 2 mm per 10 spacings, 1,5 mm per 5 spacings.



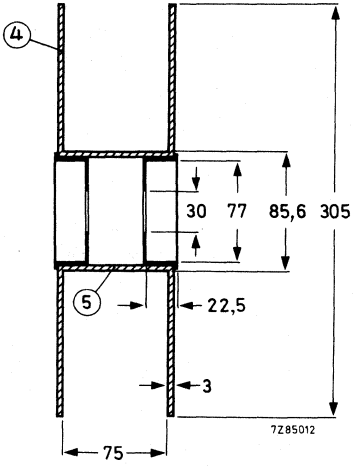


Fig. 6 Reel dimensions (in mm)

(1) resistor
(2) bandolier
(3) paper
(4) flange
(5) cylinder

METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range	51 Ω to 100 kΩ E24 and E96 series
Resistance tolerance	±1, ±2
Temperature coefficient	±50, ±100 · 10^{-6}/K
Abs. max. dissipation at T_{amb} = 70 °C*	0,25 W
Basic specification	IEC 115-1
Climatic category (IEC68)	55/155/56
Stability after:	
load	to be established
climatic tests	Δ R/R max. 0,5% +0,05 Ω
soldering	Δ R/R max. 0,1%
short time overload	Δ R/R max. 0,25% +0,05 Ω

* This is the dissipation at T_{amb} = 70 °C which causes the max. permissible hot-spot temperature of 175 °C to occur, irrespective of the resistance drift provoked by this condition.

APPLICATION

These resistors have been developed for applications in which precision, stability, and a low temperature coefficient are required, e.g. in computers, telecommunication equipment, measuring apparatus, etc.

DESCRIPTION

A homogeneous film of nickel-chromium is vacuum-deposited on a high grade ceramic body. Contact caps of special alloy are then pressed onto the ends of the resistor body, and the tinned electrolytic copper connecting wires are welded to the caps.

As a rule the required resistance value is not obtained directly by deposition of the film: helixing, that is, cutting a helical groove in the metal film, is also needed.

The resistors are protected by four or more layers of a green lacquer that are resistant against the commonly used cleaning solvents.

MECHANICAL DATA

Dimensions in mm

Outlines

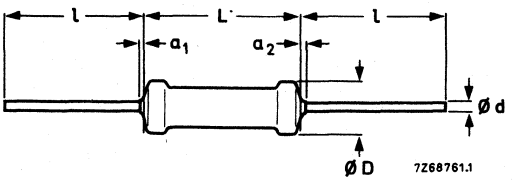


Fig. 1.

Table 1

D_{max}	L_{max}	$a_1 + a_2$	1	d
1,6	4,0	⩽1	28 ± 2	0,5

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.)

Diameter of hole in gauge plate 0,8 mm.

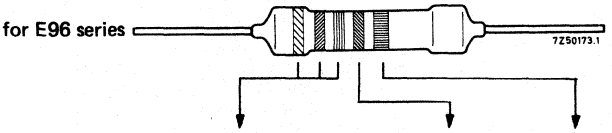
Mass (per 100 pieces) 8 g

Mounting

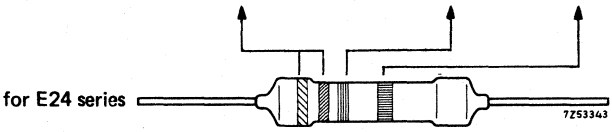
→ The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. Furthermore the resistors can be mounted without any problem directly against double-sided printed circuit boards.

Marking

The nominal resistance value and the tolerance are marked on these resistors by means of four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors" (see also IEC publication 115-1 clause 4.5).



colour	significant figures	multiplier	tolerance
black	0	1 x	
brown	1	10 x	± 1%
red	2	100 x	± 2%
orange	3	1000 x	
yellow	4	10 000 x	
green	5		
blue	6		
violet	7		
grey	8		
white	9		
silver			
gold		0,1 x	



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 ±1% and 2%, and from the E96 series for resistors with a tolerance of ±1%. The values of the E24 and E96 series are given in the table "Standard series of values in a decade" at the back of the handbook.

Table 2, standard range

style	resistance range	tol. ±%	series	temperature coefficient $\cdot 10^{-6}$/K	limiting voltage (r.m.s.) V *	cat. number 2322 followed by
MR16	51,1 Ω – 100 kΩ	1	E24/E96	50	150	150 5....
	51 Ω – 100 kΩ	2	E24	100	150	150 4....
MR16 on reel	51,1 Ω – 100 kΩ	1	E24/E96	50	150	150 2....
	51 Ω – 100 kΩ	2	E24	100	150	150 1....

Composition of the catalogue number

2322 . . . . . .

style code see Table 2

tolerance code
2 or 5 for ± 1%
1 or 4 for ± 2%

resistance value code: first three significant figures of the resistance value followed by

9 for R of 51 to 97,6 Ω
1 for R of 100 to 976 Ω
2 for R of 1 to 9,76 kΩ
3 for R of 10 to 97,6 kΩ
4 for R of 100 kΩ

* Limiting voltage (element and insulation). This is the maximum voltage that may be applied continuously to the resistor element (see IEC publication 115-1). This voltage is also the maximum voltage that may be applied continuously to the insulation of the resistor.

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 3 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 specifications 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 5 N, 10 s	number of failures < 10 ppm
	Ub	Bending half number of samples	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% or 0,1 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. 0,1%
20	Na	Rapid change of temperature	3 h − 55 °C/ 3 h + 155 °C, 5 cycles	ΔR max. 0,1% or 0,1 Ω
22	Fc	Vibration	frequency 10-500 Hz displacement 1,5 mm or acceleration 10 g, three directions; total 6 h	no damage ΔR max. 0,1% or 0,1 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR max. 0,1% or 0,1 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	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
24.2	Ca	Damp heat (long term exposure)	56 days; 40 °C; 90-95% R.H. dissipation ⩽ 1,25 mW	R_{ins} min. 1000 MΩ ΔR max. 1,0% + 0,05 Ω
26.2	–	Endurance	1000 h; 70 °C; dissipation 0,125 W	ΔR max.: 0,5%
11	–	Temperature coefficient	between −55 °C and +155 °C	⩽ 50, ⩽ 100 · 10^{-6}/K see Table 2
13	–	Voltage proof	2 x limiting voltage (a.c.)	no breakdown
14	–	Noise	IEC publication 195	to be established
9	–	Insulation resistance		min. 10^4 MΩ

STANDARD PACKAGING

number per box

bandolier	bandolier reeled
1000	5000

Configuration of bandolier

Dimensions in mm

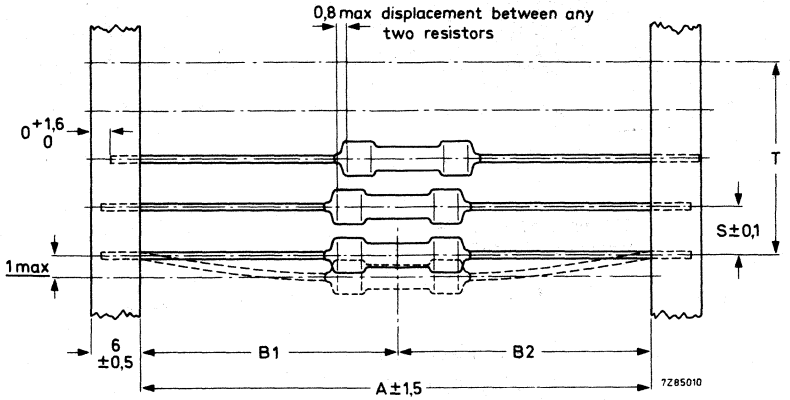
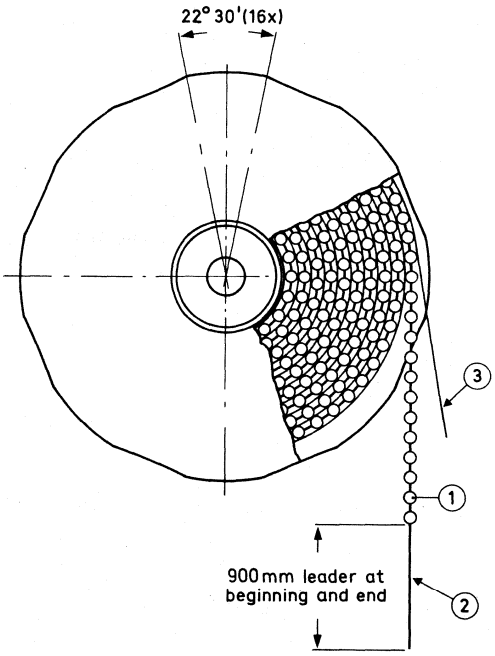
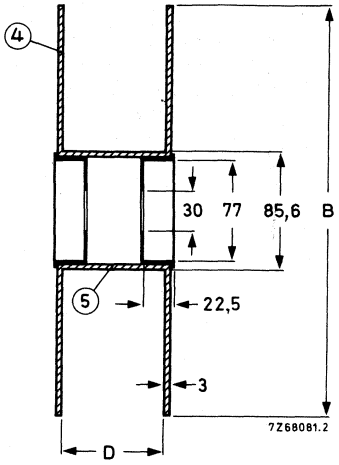


Fig. 2.

Table 4

A	B1 – B2 ± max.	S (spacing)	T (max. deviation of spacing)
52,4	1,2	5	2 mm for 10 spacings 1,5 mm for 5 spacings





(1) resistor
(2) bandolier
(3) paper
(4) flange
(5) cylinder

Fig. 3 Reel dimensions (mm).
B = 305; D = 75.

METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range	1 Ω to 1 MΩ E24, E96 and E192 series
Resistance tolerance	± 0,5, ± 1, ± 2%
Temperature coefficient	± 50, ± 100 · 10^{-6}/K
Abs. max. dissipation at T_{amb} = 70 °C *	MR25 0,4 W MR30 0,5 W MR52 1 W
Basic specification	IEC 115-1
Climatic category (IEC 68)	55/155/56
Approval	CECC 40101
Stability after:	
load	see nomogram
climatic tests	Δ R/R max. 0,5% + 0,05 Ω
soldering	Δ R/R max. 0,1%
short time overload	Δ R/R max. 0,25% + 0,05 Ω

APPLICATION

These resistors have been developed for applications in which precision, stability, and a low temperature coefficient are required, e.g. in computers, telecommunication equipment, measuring apparatus, etc.

DESCRIPTION

A homogeneous film of nickel-chromium is vacuum-deposited on a high grade ceramic body (resistors with the lowest resistance values may have an electroless-deposited nickel film instead of a vacuum-deposited nickel-chromium film). Contact caps of special alloy are then pressed onto the ends of the resistor body, and the tinned electrolytic copper connecting wires are welded to the caps.

As a rule the required resistance value is not obtained directly by deposition of the film; helixing, that is, cutting a helical groove in the metal film, is also needed.

The resistors are protected by four or more layers of a green lacquer that is resistant against the commonly used cleaning solvents.

* This is the dissipation at T_{amb} = 70 °C which causes the max. permissible hot-spot temperature of 175 °C to occur, irrespective of the resistance drift provoked by this condition.

MECHANICAL DATA

Dimensions in mm

Outlines

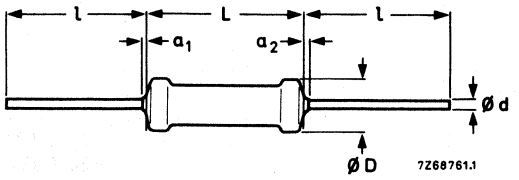


Fig. 1.

Table 1

style	D_{max}	L_{max}	$a_1 + a_2$	l	d
MR25	2,5	6,5	$\leqslant 1$	28 ± 2	0,6
MR30	3,0	10,0	$\leqslant 1$	28 ± 2	0,6
MR52	5,2	16,5	$\leqslant 1$	38 ± 3	0,6

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.)

Diameter of hole in gauge plate 1,0 mm

Mass (per 100 pieces)

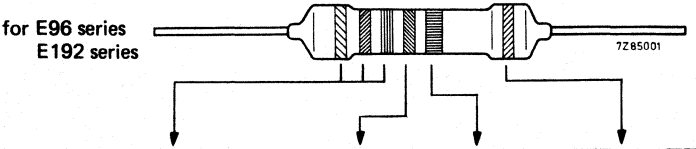
MR25 25 g
MR30 32 g
MR52 92 g

Mounting

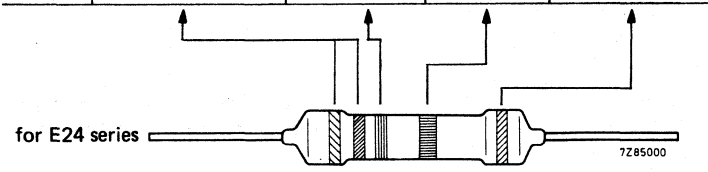
The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. Furthermore the resistors can be mounted without any problem directly against double-sided printed circuit boards.

Marking

The nominal resistance value and the tolerance are marked on these resistors by means of four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors" (see also IEC publication 115-1 clause 4.5).



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



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 ±1% and 2%, from the E96 series for resistors with a tolerance of ±1% and from the E192 series for resistors with a tolerance of ±0,5%. The values of these series are given in the table "Standard series of values in a decade" at the back of this book.

Table 2

style	resistance range	tol. ±%	series	temperature coefficient ± · 10^{-6}/K	limiting voltage (r.m.s.) V **	cat. number 2322 followed by
MR25	1 Ω – 1 MΩ	0,5	E192	50 *	250	151 7....
	1 Ω – 1 MΩ	1	E24/E96	50 *	250	151 5....
	1 Ω – 1 MΩ	2	E24	100	250	151 4....
MR 25	1 Ω – 1 MΩ	1	E24/E96	50 *	250	151 2....
on reel	1 Ω – 1 MΩ	2	E24	100	250	151 1....
MR 30	1 Ω – 1 MΩ	0,5	E192	50 *	350	152 7....
	1 Ω – 1 MΩ	1	E24/E96	50 *	350	152 5....
	1 Ω – 1 MΩ	2	E24	100	350	152 4....
MR 30	1 Ω – 1 MΩ	1	E24/E96	50 *	350	152 2....
on reel	1 Ω – 1 MΩ	2	E24	100	350	152 1....
MR 52	4,99 Ω – 1 MΩ	1	E96	100	500	153 5....

Composition of the catalogue number

2322 ... .

style code
see Table 2

tolerance code
2 or 5 for ±1%
1 or 4 for ±2%
7 for ±0,5%

resistance value code: first three figures of the resistance value (in Ω) followed by
8 for R of 1 to 9,76 Ω
9 for R of 10 to 97,6 Ω (see note next page)
1 for R of 100 to 976 Ω
2 for R of 1 to 9,76 kΩ
3 for R of 10 to 97,6 kΩ
4 for R of 100 to 976 kΩ
5 for R of 1 MΩ

Example

The catalogue number of a resistor MR30 of 3650 Ω with a tolerance of 1% is 2322 152 53652.

* For resistance values lower than 49,9 Ω: 100 · 10^{-6}/K

** Limiting voltage (element and insulation). This is the maximum voltage that may be applied continuously to the resistor element (see IEC publication 115-1). This voltage is also the maximum voltage that may be applied continuously to the insulation of the resistor.

Note

For the resistance value 49,9 Ω, 1% and 0,5% the "Composition of the catalogue number" is not applicable. The relevant catalogue numbers are stated in full below:

MR25, 0,5%	2322 151 90444
MR25, 1%	2322 151 90144
MR25 on reel	2322 151 90544
MR30	2322 152 90144
MR30 on reel	2322 152 90544
MR52	2322 153 90144

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. 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 $\Delta R/R$, 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.

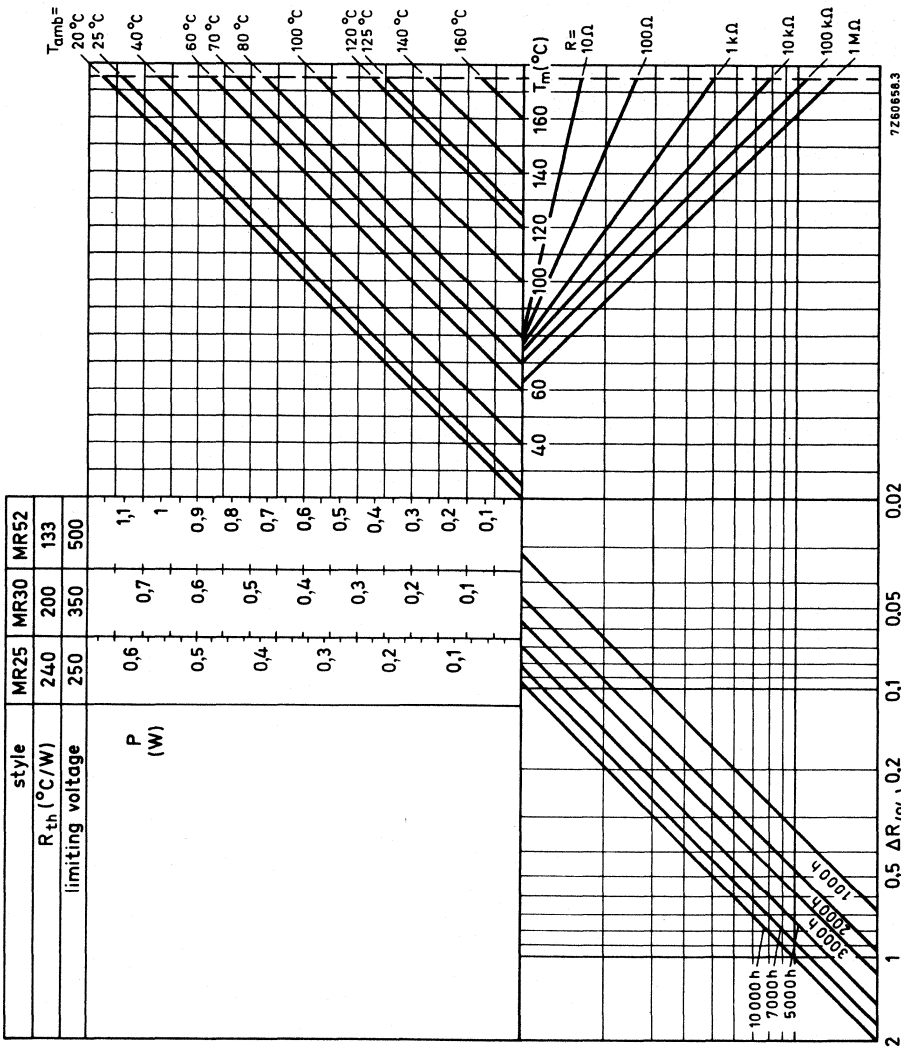


Fig. 2 Performance nomogram for different styles of resistor, showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature (T_m) and max. resistance drift $\Delta R/R$ after 1000 to 10 000 hours of operation.

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°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,1% or 0,1 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% or 0,1 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10 g, three directions; total 6 h	no damage ΔR max . 0,1% or 0,1 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR max. 0,1% or 0,1 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: MR25: ⩽ 2,5 mW MR30: ⩽ 3 mW MR52: ⩽ 5 mW	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
26.2	–	Endurance	1000 h: 70 °C: dissipation: MR25: 0,25 W MR30: 0,3 W MR52: 0,45 W	ΔR max.: 0,5%
11	–	Temperature coefficient	between −55 °C and +155 °C	⩽ 50, ⩽ 100 · 10^{-6}/K see Table 2
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	⩽ 0,25 μV/V for R ⩽ 100 kΩ ⩽ 0,50 μV/V for R > 100 kΩ
9	–	Insulation resistance		min. 10^4 MΩ

STANDARD PACKAGING

style	number per box	
	bandolier	bandolier reeled
MR25	1000	5000
MR30	1000	5000
MR52	1000	

Configuration of bandolier

Dimensions in mm

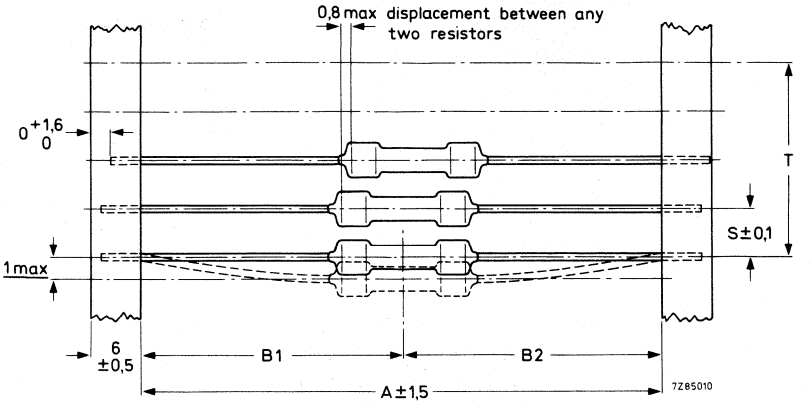
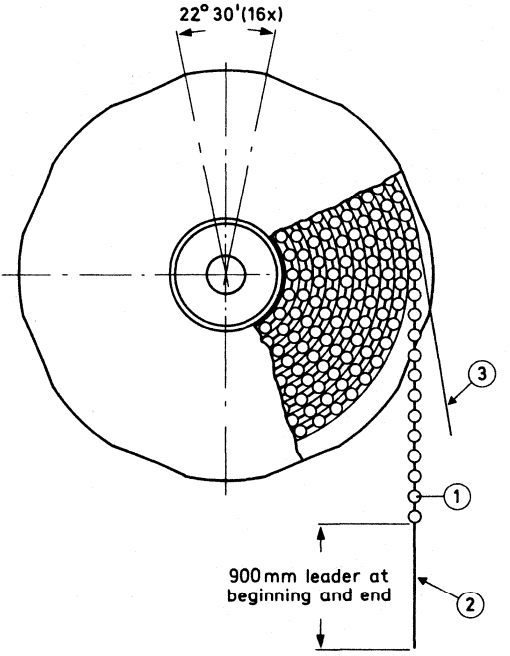


Fig. 3.

style	A	B1 – B2 ± max.	S (spacing)	T (max. deviation of spacing)
MR25	52,4	1,2	5	2 mm for 10 spacings 1,5 mm for 5 spacings
MR30	52,4	1,2	5	
MR52	66,7	1,2	10	



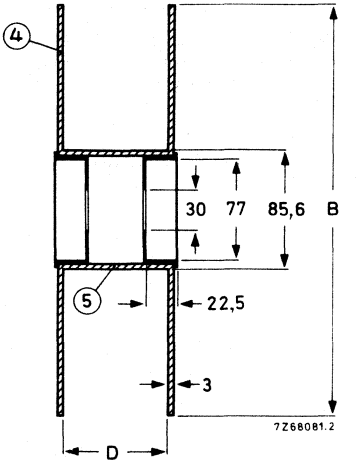


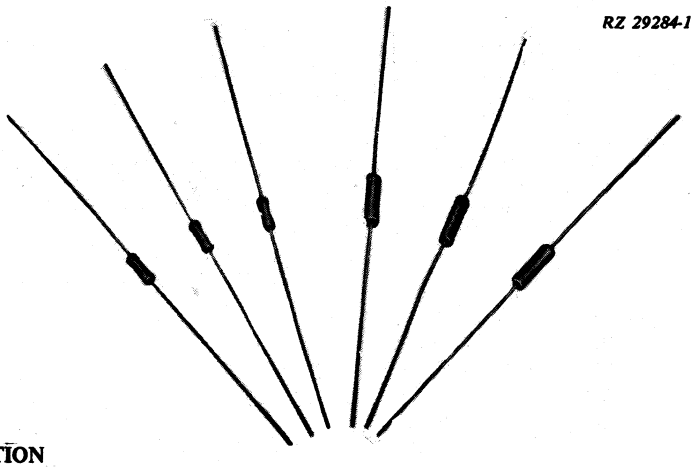
Fig. 4 Reel dimensions (mm).

(1) resistor
(2) bandolier
(3) paper
(4) flange
(5) cylinder

style	B	D
MR25	305	75
MR30	356	75

LACQUERED METAL FILM RESISTORS
according to MIL-R-10509F

QUICK REFERENCE DATA	
Resistance ranges	from 10 Ω to 1 MΩ, E96, E192 series
Resistance tolerance	0.1, 0.25, 0.5, 1 %
Rated dissipation at T_{amb} = 125 °C	MR 24E/C 0.1 W
	MR 34E/C 0.125 W
	MR 54E/C 0.25 W
	MR 74E/C 0.5 W
at T_{amb} = 70 °C	MR 24D 0.125 W
	MR 34D 0.25 W
	MR 54D 0.5 W
	MR74D 0.75 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

These resistors have been developed for applications in which precision, stability, and a low temperature coefficient are required, e.g. in computers, telecommunication equipment, measuring apparatus, etc.

DESCRIPTION

A homogeneous film of nickel-chromium * is vacuum deposited on a high grade ceramic body. Contact caps of special alloy are then pressed onto the ends of the resistor body, and next the tinned electrolytic copper connecting wires are welded to the caps.
As a rule the required resistance value is not obtained directly by deposition of the film; helixing, that is, cutting a helical groove in the metal film, is also needed.
The resistors are protected by four or more layers of a green lacquer being resistant against the commonly used cleaning solvents.

MECHANICAL DATA

Dimensions in mm

Outlines

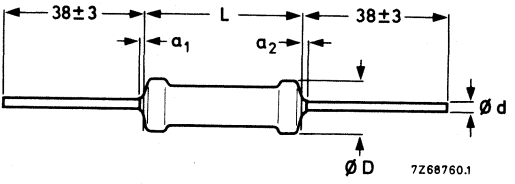


Table I

style	D_{max}	L_{max}	a_1, a_2 / $a_1 + a_2$	d
MR24 E/C/D	2,5	6,5	≤ 1	0,6
MR34 E/C/D	3,1	10,5	≤ 1	0,6
MR54 E/C/D	5,2	16,5	≤ 1	0,6
MR74 E/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).

nominal lead diameter (mm)	width of hole in gauge plate (mm)
0,6	1,0
0,8	1,2

Mass (per 100 pieces)

MR24 E/C/D	25 g
MR34 E/C/D	32 g
MR54 E/C/D	92 g
MR74 E/C/D	200 g

* Resistors with the lowest resistance values may have an electroless nickel film instead of a vacuum deposited nickel-chromium film. The further processing, however, is the same.

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 in a table at the back of this book.

Standard range

Table II

style	rated dissipation (W)	maximum temperature coefficient (ppm/degC)	resistance range and tolerance	max. voltage (V rms)	MIL style	style code *)
	at 125°C	±	0.1/0.25/0.5% E192 series 1% E96 series			
MR24E	0.1	25	49.9 Ω—100 kΩ	200	RN55E	160
MR24C	0.1	50	49.9 Ω—100 kΩ	200	RN55C	161
MR34E	0.125	25	49.9 Ω—499 kΩ	250	RN60E	163
MR34C	0.125	50	49.9 Ω—499 kΩ	250	RN60C	164
MR54E	0.25	25	49.9 Ω— 1MΩ	300	RN65E	166
MR54C	0.25	50	49.9 Ω— 1MΩ	300	RN65C	167
MR74E	0.5	25	24.9 Ω— 1MΩ	350	RN70E	169
MR74C	0.5	50	24.9 Ω— 1MΩ	350	RN70C	170
	at 70 °C	±	1% E96 series			
MR24D	0.125	100	10 Ω—301 kΩ	200	RN55D	162
MR34D	0.25	100	10 Ω— 1MΩ	300	RN60D	165
MR54D	0.5	100	10 Ω— 1MΩ	350	RN65D	168
MR74D	0.75	100	10 Ω— 1MΩ	500	RN70D	171

Composition of the catalogue number

2322 ... .

Style code
see table II

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 the following table the "Composition of the catalogue number" is not applicable. In this table the last 5 digits of the catalogue number are stated in full.

*) See composition of the catalogue number

Table III

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 IV

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

PACKING

Bulk packing, 100 pcs per box

*) Though our resistors with a temperature coefficient of 100 ppm/°C correspond with characteristic D resistors of MIL-R-10509F, they meet the more severe test requirements of characteristic C and E resistors.

2322 241

HIGH-VOLTAGE RESISTORS

QUICK REFERENCE DATA

Resistance range	220 kΩ to 10 MΩ, E24 series 12 MΩ to 22 MΩ, E12 series
Resistance tolerance	± 5% (E24), ± 10% (E12)
Max. body temperature (hot spot)	155 °C
Temperature coefficient	± 200 · 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 have been developed for applications in which high resistance values, high stability and reliability are required at high voltages. The resistors meet the safety requirements of IEC 65.

DESCRIPTION

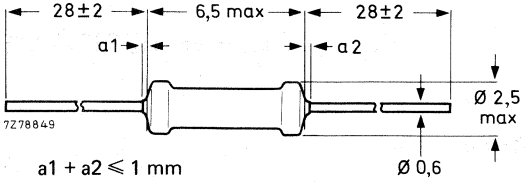
A metal-glazed film is deposited on a high grade ceramic body. Contact caps of special alloy are then pressed onto the ends of the resistor body, and the tinned electrolytic copper connecting wires are welded to the caps. The resistors are coated with a light-blue insulating lacquer which also provides protection against environmental effects.

MECHANICAL DATA

Dimensions in mm

Outlines

Fig. 1.



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).

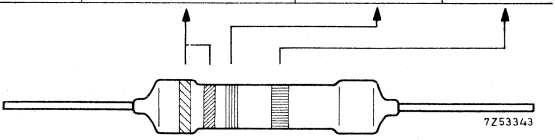
Diameter of hole in gauge plate 1,0 mm.

Mass (100 pieces) 23 g

Marking

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

colour	significant figures	multiplier	tolerance
black	0	–	
brown	1	–	
red	2	–	
orange	3	–	
yellow	4	10 000x	± 5%*
green	5	100 000x	
blue	6	1 000 000x	
violet	7	–	
grey	8	–	± 10%*
white	9	–	



* Yellow and grey instead of gold and silver because metal particles in the lacquer have bad influence on high voltage properties.

Mounting

The resistors should be used in a dust free environment and are suitable for processing on automatic insertion equipment and cutting and bending machines.

ELECTRICAL DATA

Resistance range	220 kΩ to 10 MΩ, E24 series 12 MΩ to 22 MΩ, E12 series
Resistance tolerance	± 5% (E24), ± 10% (E12)
Max. 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 115-1
Climatic category (IEC 68)	55/155/56
Stability after:	
1000 h max. load	$\Delta R/R \leqslant 3\%$
accelerated damp heat test (6 days)	$\Delta R/R \leqslant 3\%$
long term damp heat test (56 days)	$\Delta R/R \leqslant 3\%$
Noise	max. 5 μV/V

Composition of the catalogue number

2322 241 . . . . .

- 12 in box / 22 on reel: 10% tolerance
- 13 in box / 23 on reel: 5% tolerance
- 4 for R of 220 kΩ to 910 kΩ
- 5 for R of 1 MΩ to 9,1 MΩ
- 6 for R of 10 MΩ to 22 MΩ
- first two digits of the resistance value

See under Standard packaging

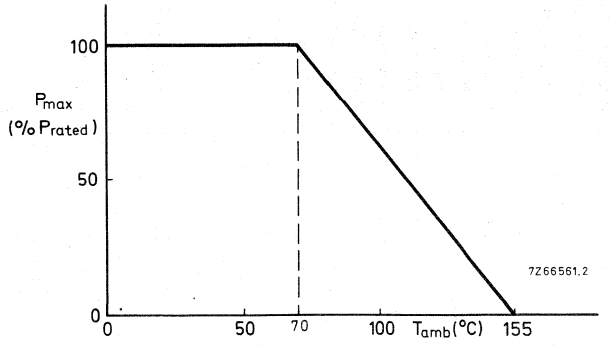


Fig. 2 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

TEST AND REQUIREMENTS

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
		Robustness of terminations		
18	Ua	Tensile all samples	load 10 N (1 kg); 10 s	
	Ub	Bending half number of samples	load 5 N (0,5 kg); 4 x 90°	no damage ΔR max. 0,5%
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	
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%
20	Na	Rapid change of temperature	½ h – 55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,5%
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%
21	–	Bump	3 x 1500 bumps in three directions; 40g	no damage ΔR max 0,5%

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, 85 mbar, 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. The dissipation should not exceed: 1% of 0,25 W (25 mW)	R_{ins} min 1000 MΩ ΔR max. 3%

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
26.2	–	Endurance	1000 hours; 70 °C; dissipation 0,25 W or limiting voltage	ΔR max. 3%
11	–	Temperature coefficient	between –55 °C and + 155 °C	$\pm 200 \cdot 10^{-6}/K$
10	–	Voltage proof	700 V r.m.s., 1 minute	no breakdown
14	–	Noise	IEC publication 195	max. 5 $\mu V/V$
9	–	Insulation Resistance		min. $10^4 M\Omega$

STANDARD PACKAGING

The resistors are supplied on bandolier, 1000 pieces per box or 5000 pieces on reel.

Configuration of bandolier

Dimensions in mm

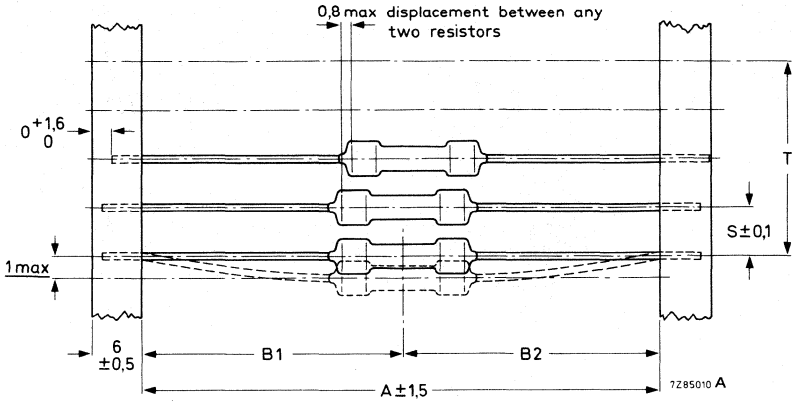
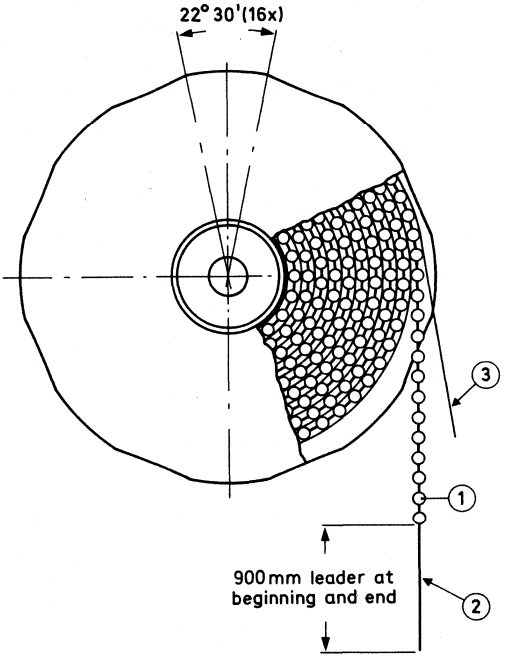
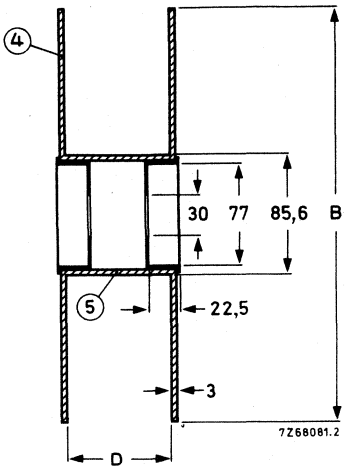


Fig. 3.

A	B1 – B2 ± max.	S (spacing)	T (max. deviation of spacing)
52,4	1,2	5	2 mm per 10 spacings 1,5 mm per 5 spacings

Reel dimensions (mm)





B = 305 mm
D = 75 mm

(1) resistor
(2) bandolier
(3) paper
(4) flange
(5) cylinder

HIGH-VOLTAGE RESISTORS

QUICK REFERENCE DATA

Resistance range, VR37	220 kΩ to 33 MΩ } E24 and
VR68	100 kΩ to 68 MΩ } E96 series
Resistance tolerance	±5% (E24), ±1% (E96)
Max. body temperature (hot spot)	155 °C
Temperature coefficient	$\pm 200 \cdot 10^{-6}$/K
Rated dissipation at T_{amb} = 70 °C, VR37	0,5 W
VR68	1,0 W
Limiting voltage, VR37	3500 V (d.c.) or 2500 V (r.m.s.)
VR68	10 000 V (d.c.) or 7000 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:	typical value VR37	VR68
1000 h max. load	ΔR 0,5%	ΔR 1%
accelerated damp heat test (6 days)	ΔR 0,5%	ΔR 1%
long-term damp heat test (56 days)	ΔR 0,5%	ΔR 1%
Noise	0,5 μV/V	0,5 μV/V

APPLICATION

These resistors have been developed for applications in which high resistance values, high stability and reliability, and a more or a less close tolerance 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. Contact caps of special alloy are then pressed onto the ends of the resistor body, and the tinned electrolytic copper connecting wires are welded to the caps.

The resistors are coated with a light-blue insulating lacquer which also provides protection against environmental effects.

MECHANICAL DATA

Dimensions in mm

Outlines

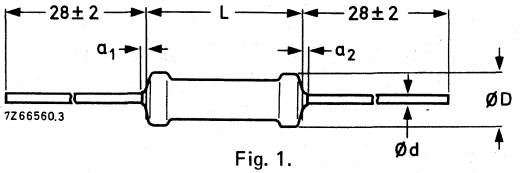


Fig. 1.

style	L_{max}	D_{max}	$a_1 + a_2$	d
VR37	10	3,7	1,0	0,7
VR68	18	6,8	1,2	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.)

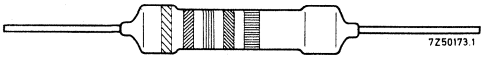
Diameter of hole in gauge plate 1,0 mm for d = 0,7 mm; 1,2 mm for d = 0,8 mm.

Mass (100 pieces) VR37: 42 g VR68: 148 g

Marking

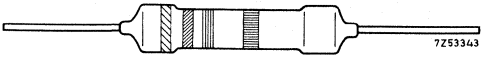
The nominal resistance value and the tolerance are marked on these resistors by means of four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors".

E96-series, tol. 1%



colour	significant figures	multiplier	tolerance
black	0	–	
brown	1	–	±1%
red	2	–	
orange	3	–	
yellow	4	–	±5% *
green	5	100 000 x	
blue	6	1 000 000 x	
violet	7	–	
grey	8	–	
white	9	–	

E24-series, tol. 5%



* Yellow instead of gold, because metal particles in gold lacquer have bad influence on high voltage properties.

Mounting

The resistors should be used in a dust free environment and are suitable for processing on automatic insertion equipment and cutting and bending machines. Furthermore the resistors can be mounted without any problem directly against double sided printed circuit boards.

ELECTRICAL DATA

Resistance range, VR37	220 kΩ to 33 MΩ } E24 and
VR68	100 kΩ to 68 MΩ } E96 series
Resistance tolerance	±5% (E24), ±1% (E96)
Max. body temperature (hot spot)	155 °C
Temperature coefficient	$\pm 200 \cdot 10^{-6}$/K
Rated dissipation at T_{amb} = 70 °C, VR37	0,5 W
VR68	1,0 W
Limiting voltage, VR37	3500 V d.c. or 2500 V r.m.s.
VR68	10 000 V d.c. or 7000 V r.m.s.
Dielectric withstanding voltage of the insulation for 1 minute	min. 700 V r.m.s.
Basic specification	IEC 115-1
Climatic category (IEC 68)	55/155/56

Stability after:	IEC requirement	typical value VR37	VR68
1000 h max. load	ΔR ⩽ 3%	ΔR 0,5%	ΔR 1%
accelerated damp heat test (6 days)	ΔR ⩽ 3%	ΔR 0,5%	ΔR 1%
long term damp heat test (56 days)	ΔR ⩽ 3%	ΔR 0,5%	ΔR 1%
Noise	2,5 μV/V	0,5 μV/V	0,5 μV/V

Composition of the catalogue number

E96-series, tol. 1% 2322 ... 8....

style code
242 for VR37
244 for VR68

4 for R of 100 kΩ to 976 kΩ
5 for R of 1 MΩ to 9,76 MΩ
6 for R of 10 MΩ to 68 MΩ

first three digits of the resistance value

E24-series, tol. 5% 2322 ... 13...

style code
242 for VR37
244 for VR68

4 for R of 100 kΩ to 910 kΩ
5 for R of 1 MΩ to 9,1 MΩ
6 for R of 10 MΩ to 68 MΩ

first two digits of the resistance value

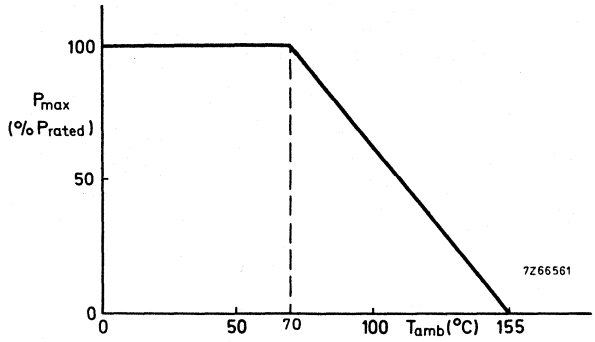


Fig. 2 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

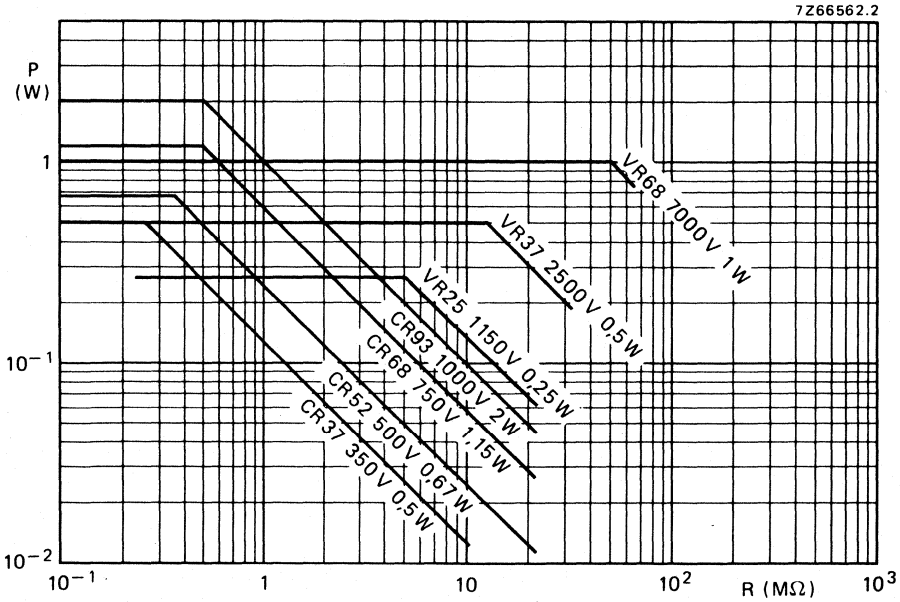


Fig. 3 Power versus resistance value of carbon and high voltage resistors at T_{amb} = 70 °C.

TESTS AND REQUIREMENTS

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
		Robustness of terminations		
18	Ua	Tensile all samples	load 10 N (1 kg) ; 10 s	
	Ub	Bending half number of samples	load 5 N (0,5 kg) ; 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,5%
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%
20	Na	Rapid change of temperature	½ h – 55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,5%
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%
21	-	Bump	3 x 1500 bumps in three directions ; 40g	no damage ΔR max. 0,5%

TESTS AND REQUIREMENTS (continued)

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
23		Climatic sequence		
23.1	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, 85 mbar, 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	Ca	Damp heat (steady state)	56 days, 40 °C, 90 - 95% R.H. The dissipation should not exceed: 1% of 0,5 W (5 mW) for VR37, or 1% of 1 W (10 mW) for VR68	R_{ins} min. 1000 MΩ ΔR max. 3%

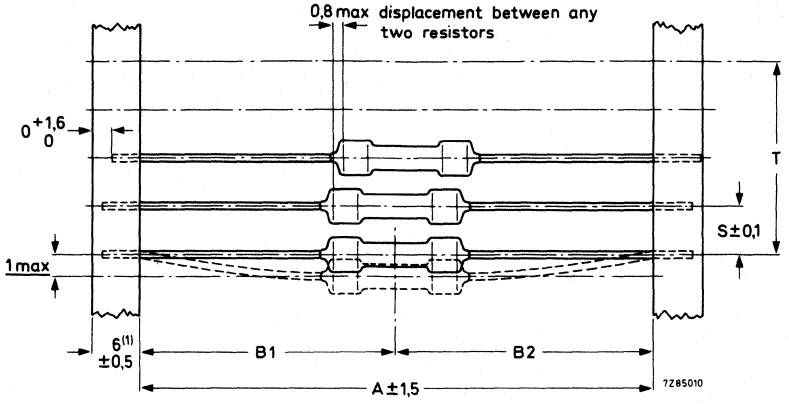
TESTS AND REQUIREMENTS (continued)

IEC 115-1 clause	IEC 68 test method	Test	Procedure	Requirements
26.2	-	Endurance	1000 hours ; 70 °C ; dissipation 0,5 W (VR37) 1,0 W (VR68) or limiting voltage	ΔR max. 3%
11	-	Temperature coefficient	between −55 °C and + 155 °C	± 200 ppm/°C
13	-	Voltage proof	700 V r.m.s.	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, VR37 1000 items per box, VR68 500 items per box.

Configuration of bandolier Dimensions in mm



(1) For style VR68: 5 ± 0,5 mm.

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

POWER METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range	10 Ω to 10 kΩ, E24 series	
Resistance tolerance	± 5%	
Max. body temperature (hot spot)	300 °C	
Rated dissipation at T_{amb} = 70 °C	1,6 W	
Basic specification	MIL-R-11804/2B, char. G	
Climatic category (IEC 68)	55/200/56	
Stability after:	requirement	typical value
1000 h max. load	$\Delta R \leqslant 5\%$	ΔR 2,5%
climatic tests	$\Delta R \leqslant 3\%$	ΔR 0,5%
soldering	$\Delta R \leqslant 1\%$	ΔR 0,1%
short time overload	$\Delta R \leqslant 2\%$	ΔR 0,2%

DESCRIPTION

The resistive element consists of a chromium-nickel film deposited on a ceramic body and adjusted to value by spiralling. Contact caps with tinned copper-clad iron connecting wires are force-fitted onto the ends of the ceramic body.

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.

MECHANICAL DATA

Dimensions in mm

Outlines

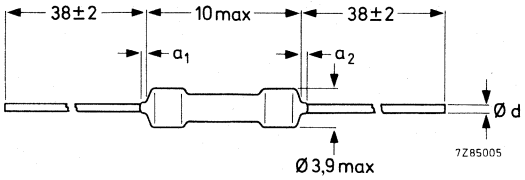


Fig. 1 Version with straight leads. d = 0,6 or 0,8 mm; $a_1 + a_2 \leqslant 1$ mm.

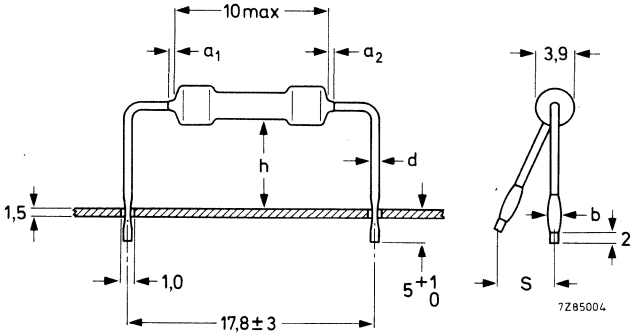


Fig. 2 Version with cropped and formed leads, pitch = 7e.

$a_1 + a_2$	b	d	h	S max.
$\leqslant 1$	1,1 + 0,1	0,6	8 + 2	3
$\leqslant 1$	1,1 + 0,1	0,6	15 + 2	3
$\leqslant 1$	1,3 + 0,1	0,8	8 + 2	2
$\leqslant 1$	1,3 + 0,1	0,8	15 + 2	2

Mass (per 100 items): 40 g

Mounting

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

Marking

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

Example: 27 R 5%

ELECTRICAL DATA

version			catalogue number
Fig.	d	h	
1	0,6		2322 191 3..0.
	0,8		2322 191 5..0.
2	0,6	8	2322 191 4..0.
		15	2322 191 4..1.
	0,8	8	2322 191 6..0.
		15	2322 191 6..1.

Resistance range	10 Ω to 10 kΩ, E24 series *
Resistance tolerance	± 5%
Temperature coefficient	max. ± 250.10^{-6}/K
Maximum body temperature (hot spot)	300 °C
Rated dissipation at T_{amb} = 70 °C	1,6 W
Dielectric withstanding r.m.s. voltage of the insulation for 1 min	min. 500 V
Basic specification	MIL-R-11804/2B, char. G
Climatic category (IEC 68)	55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation	see Figs 3 and 4
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering place) as parameter	see Figs 5 and 6

Composition of the catalogue number

2322 191 . . . . .

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

9 for R of 10 to 91 Ω
1 for R of 100 to 910 Ω
2 for R of 1000 to 9100 Ω
3 for R of 10000 Ω

mounting height (h)
0 = 8) cropped and formed
1 = 15) version
0 = straight lead version

first two digits of the resistance value (E24 series)

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

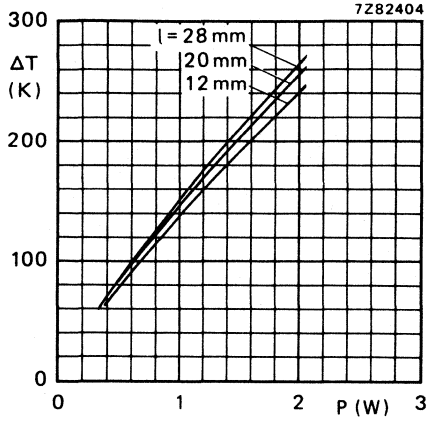


Fig. 3 Hot-spot temperature rise (ΔT) versus dissipated power (P) at different lead lengths (l), leads ϕ = 0,6 mm.

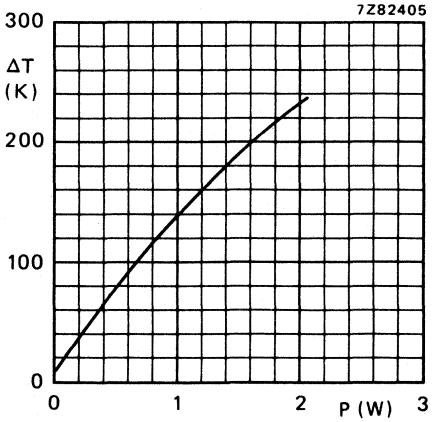


Fig. 4 Hot-spot temperature rise (ΔT) versus dissipated power (P), leads ϕ = 0,8 mm.

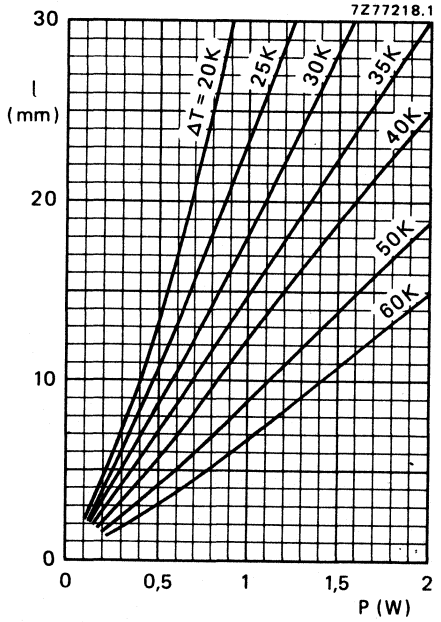


Fig. 5 Lead length l versus dissipated power with ΔT as a parameter, leads ϕ = 0,6 mm.

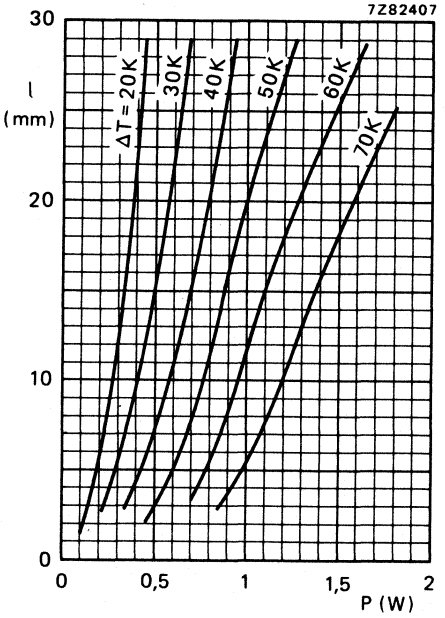


Fig. 6 Lead length l versus dissipated power with ΔT as a parameter, leads ϕ = 0,8 mm.

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. 3
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	Resistance versus temperature	3. 17	$\leqslant 250\ 10^{-6}/K$
4. 6. 14	108	Load life	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		$\Delta R \leqslant 3\%$

STANDARD PACKAGING

The resistors with straight leads are supplied on bandolier, 1000 items per box.
The resistors with cropped and formed leads are supplied loose, 1000 items per box.

Configuration of bandolier Dimensions in mm

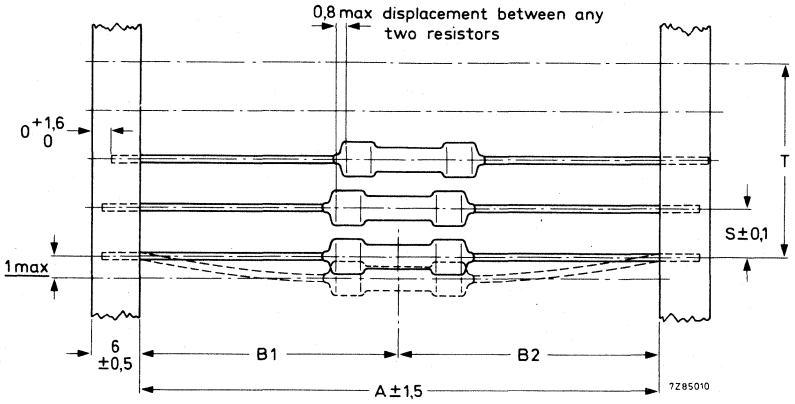


Fig. 7.

style	A	B1 – B2 ± max.	S (spacing)	T (max. deviation of spacing)
PR37	73 ± 1,5	1,2	5	2 mm per 10 spacings 1,5 mm per 5 spacings

POWER METAL FILM RESISTORS

QUICK REFERENCE DATA		
Resistance range	10 Ω to 27 kΩ, E4 series	
Resistance tolerance	± 5%	
Max. body temperature (hot spot)	300 °C	
Rated dissipation at T_{amb} = 70 °C	2,5 W	
Basic specification	MIL-R-11804/2B, 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

The resistive element consists of a chromium-nickel film deposited on a ceramic body and adjusted to value by spiralling. Contact caps with tinned copper-clad iron connecting wires are force-fitted onto the ends of the ceramic body.
The resistor has a red non-inflammable coating of a protective silicon lacquer. It can withstand 500 V (r.m.s.) and is resistant against most of the commonly used cleaning solvents.

MECHANICAL DATA Dimensions in mm

Outlines

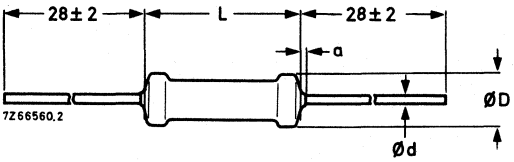


Fig. 1

L_{max}	D_{max}	a_{max}	d
16,7	5,2	1,2	0,6

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).

Width of hole in gauge plate 1,0 mm

Mass (per 100 items) 92 g

Mounting

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

Marking

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

Example: 27 R 5%

ELECTRICAL DATA

Resistance range	10 Ω to 27 kΩ, E24 series *
Resistance tolerance	± 5%
Temperature coefficient	max. 500.10^{-6}/K
Maximum body temperature (hot spot)	300 °C
Rated dissipation at T_{amb} = 70 °C	2,5 W
Dielectric withstanding r.m.s. voltage of the insulation for 1 min	min. 500 V
Basic specification	MIL-R-11804/2B, char.G
Climatic category (IEC 68)	55/200/56

Composition of the catalogue number

2322 192 3..0.

Tolerance code
3 for 5%

9 for R of 10 to 91 Ω
1 for R of 100 to 910 Ω
2 for R of 1000 to 9100 Ω
3 for R of 10000 to 27000 Ω

First two digits of the resistance value (E24 series)

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

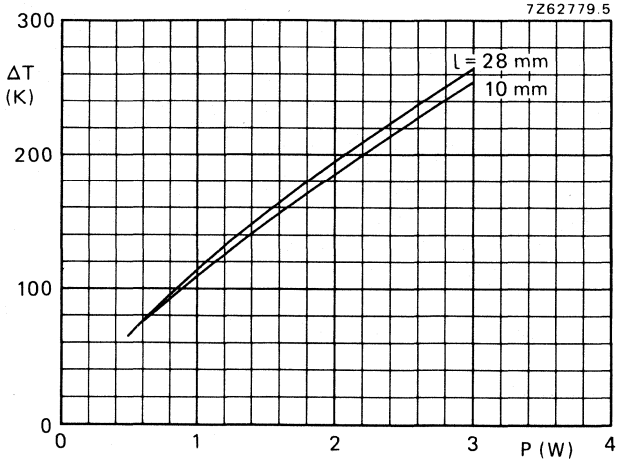


Fig. 2 Hot spot temperature rise (ΔT) versus dissipated power (P) at different lead lengths (l).

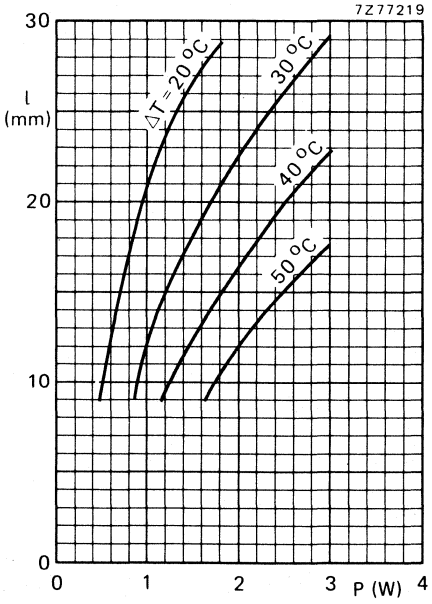


Fig. 3 Lead length l versus dissipated power with ΔT of solder joint as a parameter.

TESTS AND REQUIREMENTS

All tests are carried out according to the schedule of MIL-R-11804E. In the table below the tests and requirements are listed with reference to the relevant paragraphs of this specification.

MIL test			requirement	
R-11804E paragraph	STD 202D method	procedure	MIL-R-11804 E 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	$\Delta R \leq 2\%$
4.6.6		Hot spot	3.10	see Fig. 2
4.6.7		Thermal shock	3.11	$\Delta R \leq 2\%$, no damage
4.6.8		Momentary overload	3.12	$\Delta R \leq 2\%$, no damage
4.6.9	106	Moisture resistance [1]	3.13	$\Delta R \leq 3\%$
4.6.11	211	Terminal strength	3.15	$\Delta R \leq 1\%$, no damage
4.6.12	208	Lead solderability	3.16	95% covered
4.6.13	304	Resistance versus temperature	3.17	$\leq 500\ 10^{-6}/K$
4.6.14	108	Load life [1]	3.18	$\Delta R \leq 5\%$, no damage
4.6.15	205	Shock	3.19	$\Delta R \leq 0,5\% \pm 0,05\ \Omega$
4.6.16	204	Vibration (high frequency)	3.20	$\Delta R \leq 0,5\% \pm 0,05\ \Omega$ no damage
IEC115	IEC68	Damp heat		$\Delta R \leq 3\%$

[1]) To dissipate the maximum wattage, the voltage shall not be exceeded

STANDARD PACKAGING

The resistors are supplied on bandolier 500 items per box.

Configuration of bandolier (dimensions in mm)

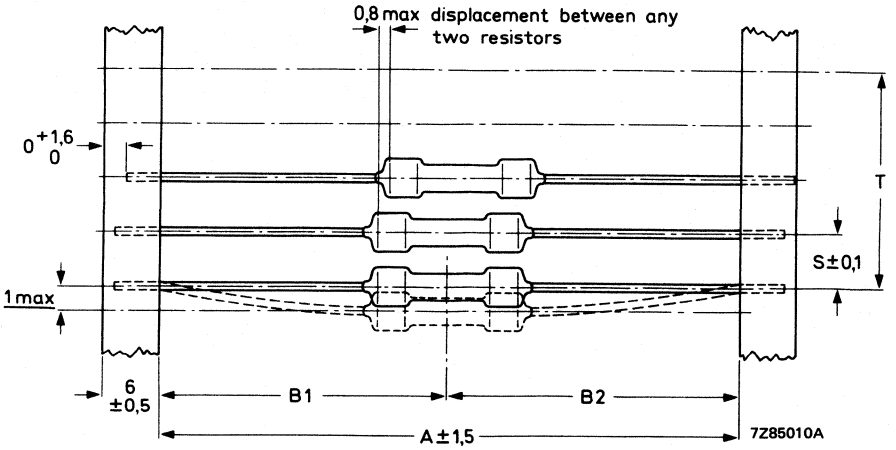


Fig. 4.

A	B1 − B2 ± max.	S (spacing)	T (max. deviation of spacing)
66,7	1,2	10	2 mm per 10 spacings 1,5 mm per 5 spacings

CEMENTED WIREWOUND RESISTORS

QUICK REFERENCE DATA	
Resistance range	from 0,1 Ω to 33 kΩ, E24 series
Resistance tolerance	± 5% or ± 10%
Maximum body temperature	350 °C
Rated dissipation at T_{amb} = 40 °C	AC04 4 W, AC10 10 W AC05 5 W, AC15 15 W AC07 7 W, AC20 20 W
Basic specification	IEC publication 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 wirewound resistors are specially 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 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

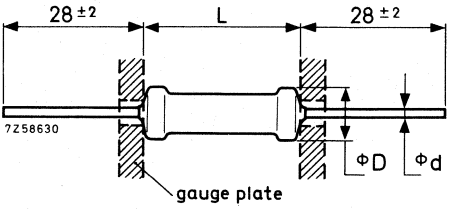


Fig. 1

Table 1

style	D_{max}	L_{max}	d
AC04	6	19	0,6
AC05	8	19	0,8
AC07	8	27	0,8
AC10	8	44	0,8
AC15	10	51	0,8
AC20	10	67	0,8

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: Measurement of the dimensions of a cylindrical component having two axial terminations).

nominal lead diameter	dia. of hole in gauge plate
0,6 mm	1,0 mm
0,8 mm	1,2 mm

Mass (per 100 pieces)

AC04	100 g
AC05	175 g
AC07	225 g
AC10	530 g
AC15	840 g
AC20	1090 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. 2 and 3.

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} = 40 °C

Example: 27R 5%
4W

ELECTRICAL DATA

Table 2, standard range

style	rated dissipation (W) T_{amb} = 40 °C	rated dissipation (W) T_{amb} = 70 °C	resistance range Ω	tol. %	catalogue number
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 - 10000	5	2322 329 07...
AC10	10	8,4	0,68 - 8,2	10	2322 329 40...
			10 - 15000	5	2322 329 10...
AC15	15	12,5	0,82 - 8,2	10	2322 329 45...
			10 - 22000	5	2322 329 15...
AC20	20	16	1,2 - 8,2	10	2322 329 50...
			10 - 33000	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 (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	-	0,82 Ω	: 7
1	-	8,2 Ω	: 8
10	-	91 Ω	: 9
100	-	910 Ω	: 1
1 000	-	9 100 Ω	: 2
10 000	-	33 000 Ω	: 3

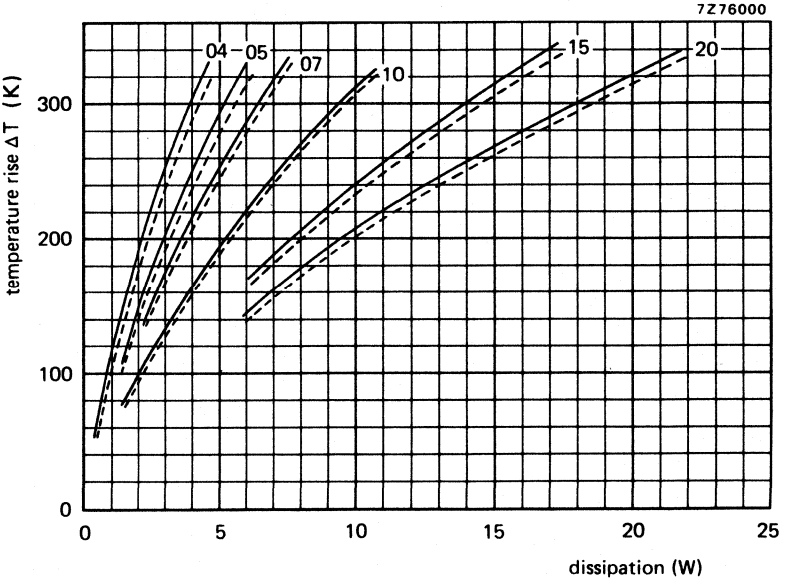
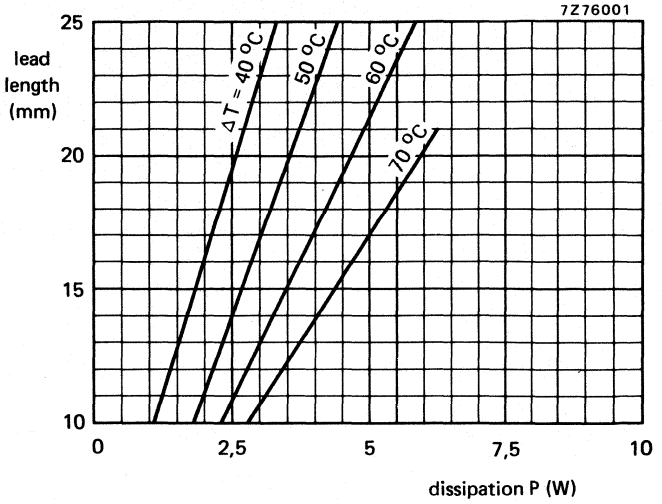


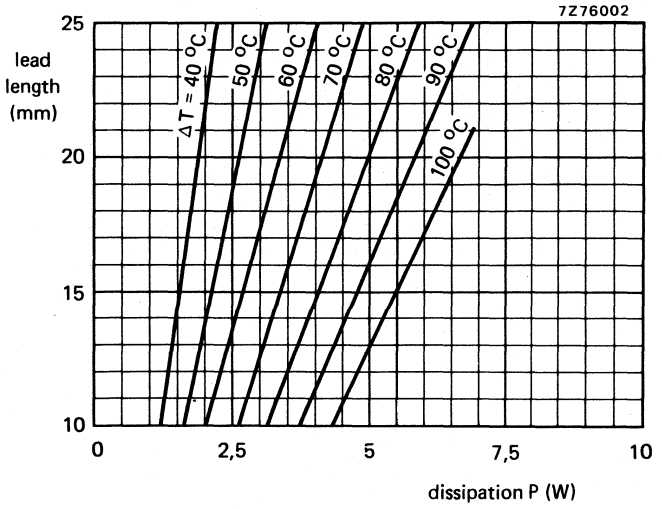
Fig. 2. Temperature rise of the resistor body as a function of the dissipation.

——— for lead length of 25 mm
– – – for lead length of 10 mm



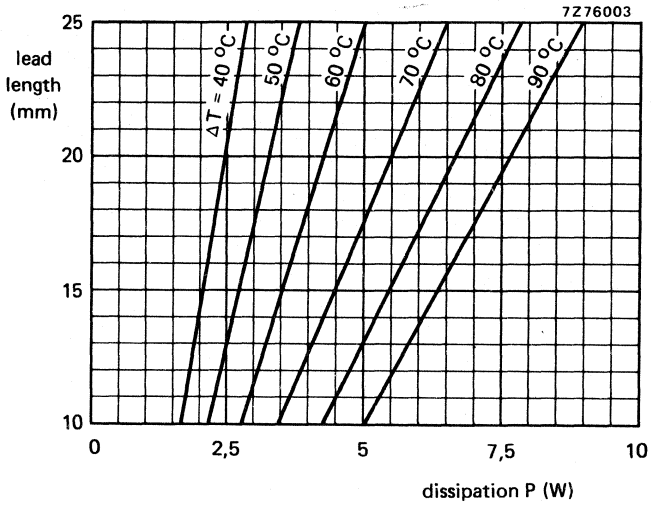
AC04

Fig. 3a. 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.



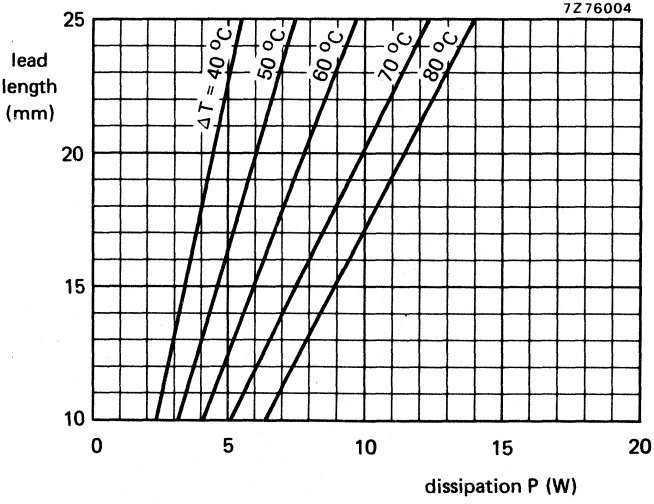
AC05

Fig. 3b. 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.



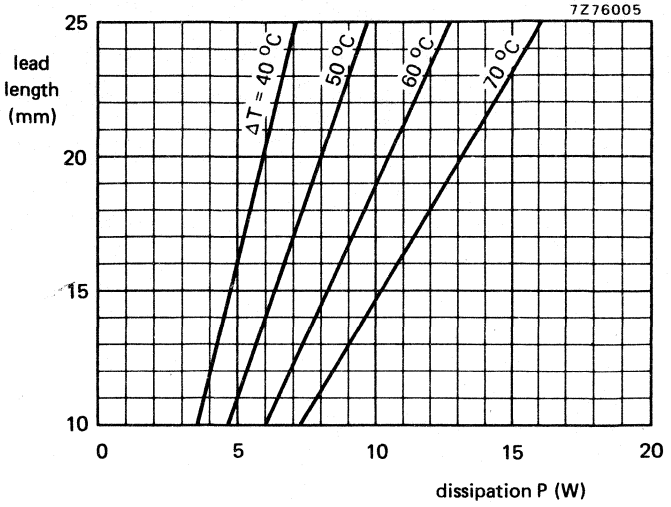
AC07

Fig. 3c. 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.



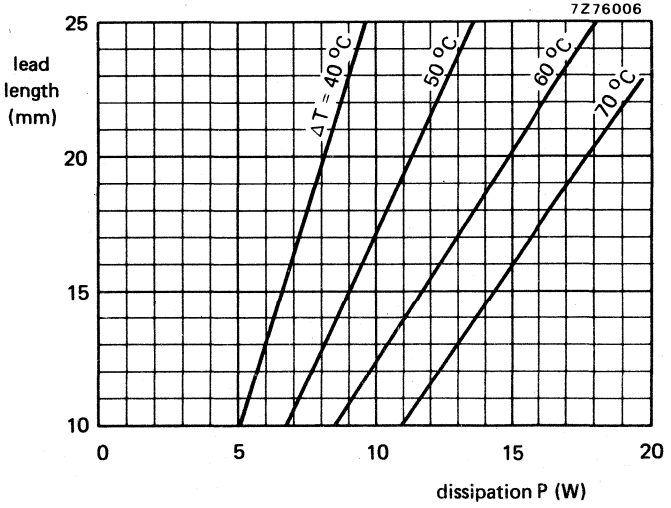
AC10

Fig. 3d. 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.



AC15

Fig. 3e. 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.

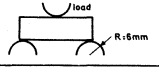


AC20

Fig. 3f. 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.

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

Table 3

IEC 266 clause	IEC 68 test method	test	procedure	requirements
14		robustness of resistor body	 load 200 ± 10 N	no visible damage $\Delta R \leq 0,5\%$ or $0,05\ \Omega$
15	U Ua Ub Uc	robustness of terminations: tensile, all samples bending, half number of samples torsion, other half number of samples	 load 10 N, 10 s load 5 N, 4 x 90° 2 x 180° in opposite directions	 no visible damage $\Delta R \leq 0,5\%$ or $0,05\ \Omega$
16	T	soldering: solderability thermal shock	 2 s 230 °C, flux 600 3 s 350 °C, 2,5 mm from body	 good tinning, no damage no damage, $\Delta R \leq 0,5\%$ or $0,05\ \Omega$
17	Na	rapid change of temperature	$\frac{1}{2}$ h −40 °C/$\frac{1}{2}$ h +200 °C, 5 cycles	no visible damage $\Delta R \leq 1\%$
18	Fc	vibration	10 – 500 Hz, 0,75 mm or 10 g, whichever is the less, for 6 h	no visible damage $\Delta R \leq 0,5\%$ or $0,05\ \Omega$
19	Eb	bumping	390 m/s^2, 4000 ± 10 bumps	no visible damage $\Delta R \leq 0,5\%$ or $0,05\ \Omega$

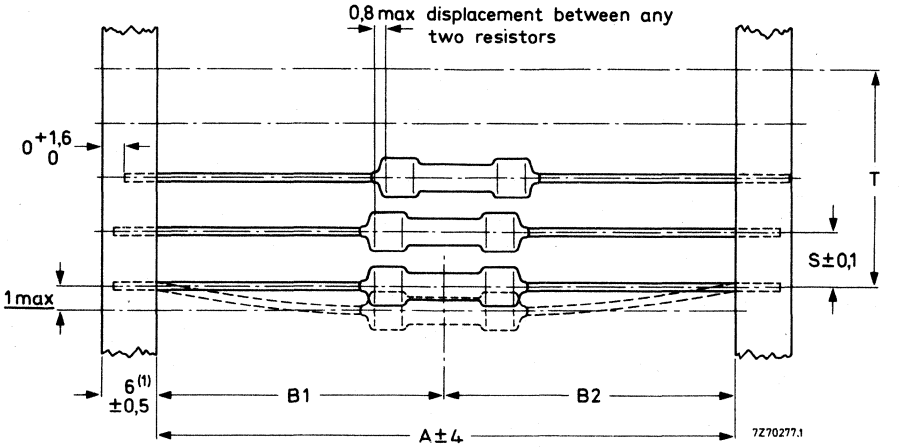
IEC 266 clause	IEC 68 test method	test	procedure	requirements
20		climatic sequence:		final measurements
20.2	Ba	dry heat	16 h 200 °C	
20.3		damp heat (accelerated)		
		1st cycle	1 day 55 °C, 95-100% R.H.	
20.4	Aa	cold	2 h −40 °C	
20.5	M	low air pressure	1 h 8,5 kN/m^2, 15-35 °C	
20.6	D	damp heat (accelerated)		
		remaining cycles	5 days 55 °C, 95-100% R.H.	after 24 h at rated diss. $\Delta R \leq 5\%$
21	Ca	damp heat long term	56 days 40 °C, 90-95% R.H., 0,01 P_{rated}	$\Delta R \leq 5\%$, after 24 h at rated diss. $\Delta R \leq 5\%$
13.6		overload	10 times rated dissipation, 5 s	$\Delta R \leq 2\%$
22		endurance	1000 h at room temperature	$\Delta R \leq 5\%$
23		endurance	1000 h at upper category temperature	$\Delta R \leq 5\%$

STANDARD PACKAGING

style	number per box	
	bandolier	singles
AC04	500	
AC05	500	
AC07	500	
AC10		100
AC15		100
AC20		100

Configuration of bandolier

Dimensions in mm



(1) Style AC04 will be supplied with a tape width of 5 or 6 mm.

Fig. 4.

style	A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
AC04	66	1,2	10	2 mm per 10 spacings
AC05	66	1,2	10	1,5 mm per 5 spacings
AC07	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%

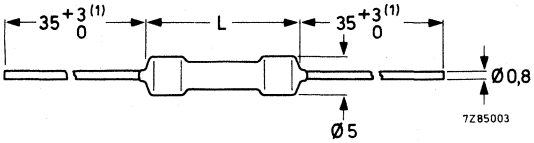
DESCRIPTION

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: 28 ± 2 mm.

Fig. 1 Standard version with straight leads.

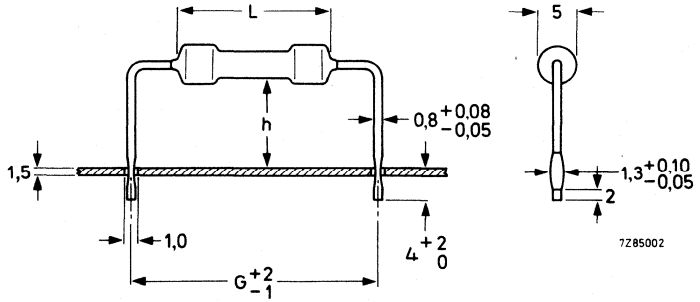


Fig. 2 Special version with cropped and formed leads, available on special request.

Table 1

style	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

style	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

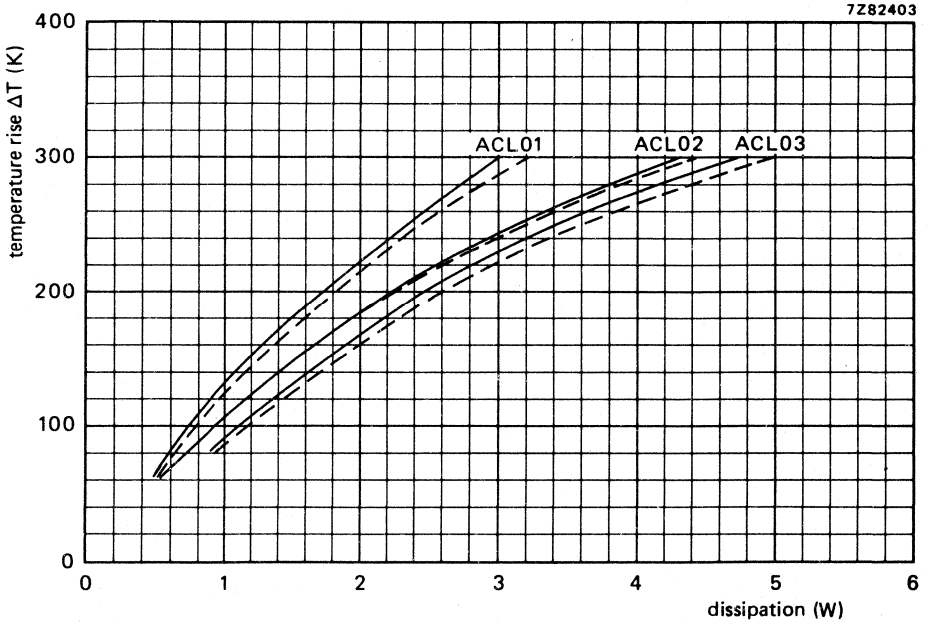


Fig. 3 Temperature rise of the resistor body as a function of the dissipation.
—— for lead length of 18 mm
– – – for lead length of 10 mm.

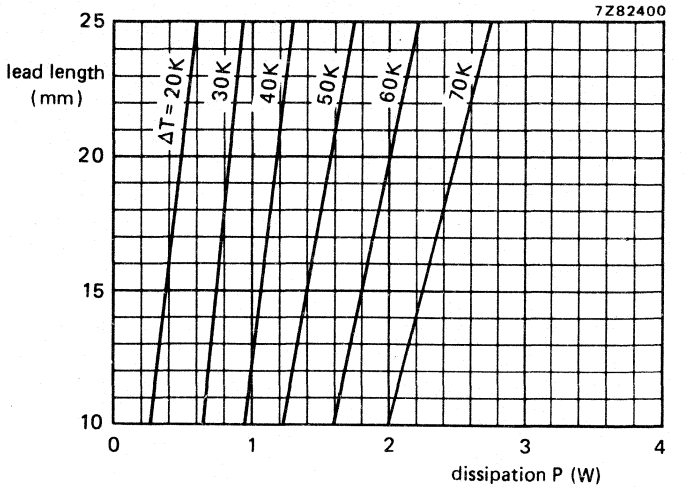


Fig. 4 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style ACL01.

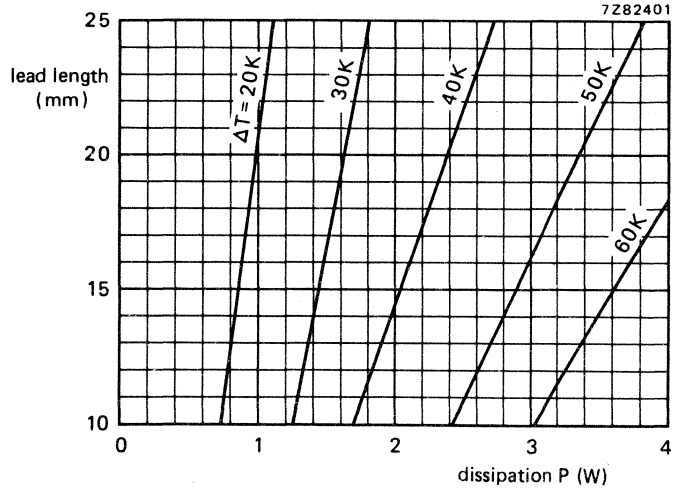


Fig. 5 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style ACL02.

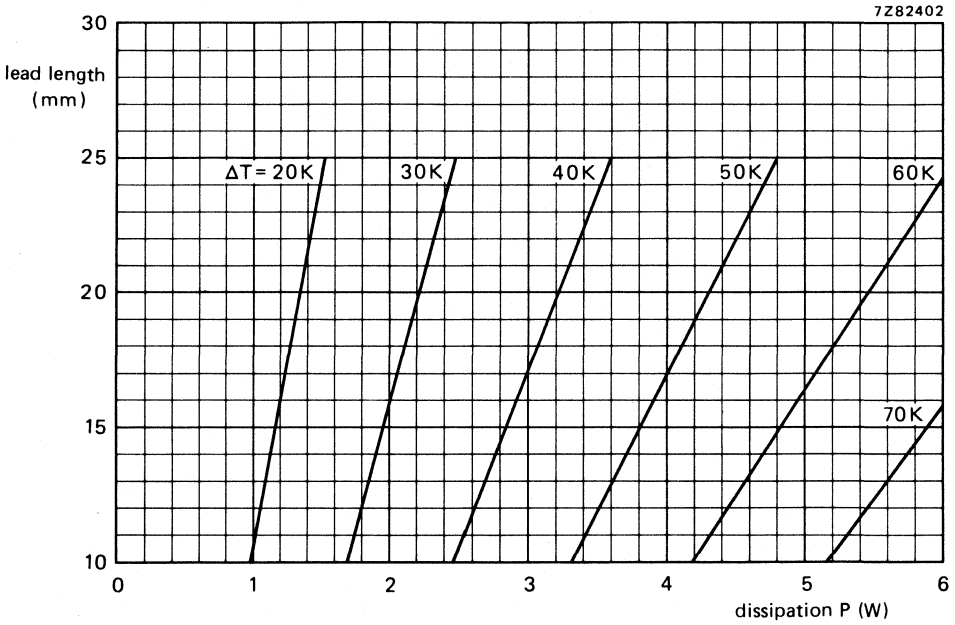


Fig. 6 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style ACL03.

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 $\Delta R \leqslant 0{,}5\%$ or 0,05 Ω
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 $\Delta R \leqslant 0{,}5\%$ or 0,05 Ω
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, $\Delta R \leqslant 0{,}5\%$ or 0,05 Ω
17	Na	rapid change of temperature	3 h –40 °C/3 h +200 °C, 5 cycles	no visible damage $\Delta R \leqslant 1\%$ or 0,05 Ω
18	Fc	vibration	10 – 500 Hz, 0,75 mm or 10g, whichever is the less, for 6 h	no visible damage $\Delta R \leqslant 0{,}5\%$ or 0,05 Ω
19	Eb	bumping	390 m/s², 4000 ± 10 bumps	no visible damage $\Delta R \leqslant 0{,}5\%$ or 0,05 Ω
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 Dimensions in mm

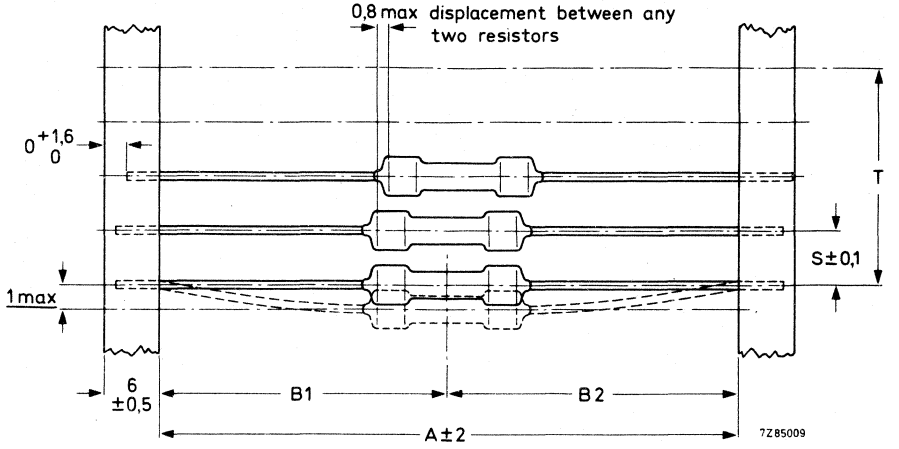


Fig. 7.

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

CEMENTED WIREWOUND RESISTORS

QUICK REFERENCE DATA

Resistance ranges	from 5,6 Ω to 16 kΩ, E24 series
Resistance tolerance	5%
Maximum body temperature	400 °C
Rated dissipation at T_{amb} = 70 °C	WR0617 4 W WR0825 7 W WR0842 9,5 W WR0865 15 W
Basic specification	IEC publication 266
Climatic category (IEC 68)	40/200/21 or 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 wirewound load resistors are specifically designed to dissipate high loads in a small volume.

DESCRIPTION

On a ceramic rod with metal caps pressed over the ends a resistor element is wound in a single layer. The ends of the resistance wire and the leads are connected to the caps by welding. Tinned copperclad leads with a low heat conductivity are employed permitting the use of relatively short leads to obtain stable mounting.
The resistor is coated with a green-coloured cement which is noninflammable and cannot drip even at very high overloads.
The resistor is not electrically insulated.

MECHANICAL DATA

Dimensions in mm

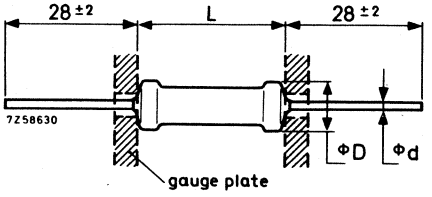


Fig.1

Table I

Style	Dmax	Lmax	d
WR0617	6	19	0.6
WR0825	8	27	0.8
WR0842	8	44	0.8
WR0865	8	67	0.8

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 I.E.C. publication 294: Measurement of the dimensions of a cylindrical component having two axial terminations).

nominal lead diameter 0.6 mm	dia of hole in gauge plate 1.0 mm
0.8 mm	1.2 mm

Weight (per 100 pcs)

WR0617	100 g
WR0825	225 g
WR0842	530 g
WR0865	730 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 2, 3a, 3b, 3c and 3d.

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 ± %
- style

ELECTRICAL DATA

Table II, standard range

style	rated dissipation at T_{amb} = 70 °C (W)	resistance range (Ω)	series [1]	catalogue number
WR0617	4	5,6 - 4700	E24	2322 325 37...
WR0825	7	6,8 - 10000	E24	2322 325 27...
WR0842	9,5	10 - 10000	E24	2322 325 17...
WR0865	15	16 - 16000	E24	2322 325 07...

Resistance tolerance	± 5%
Maximum permissible body temperature	400 °C
Ambient temperature range	−40 to +200 °C
Temperature coefficient	−50 to + 140 ppm/°C except for: WR0617, 10 Ω - 16 Ω and WR0825, 15 Ω - 33 Ω
Climatic category according to IEC 68	
for resistors withstanding 21 days damp heat test (Table III)	40/200/21
for resistors withstanding 56 days damp heat test (Table III)	40/200/56

Table III

style	resistance range	
	21 days damp heat test	56 days damp heat test
WR0617	160 - 4700 Ω	5,6 - 150 Ω
WR0825	430 - 10000 Ω	6,8 - 390 Ω
WR0842	620 - 15000 Ω	10 - 560 Ω
WR0865	910 - 16000 Ω	16 - 820 Ω

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:

5,6	-	9,1 Ω	: 8
10	-	91 Ω	: 9
100	-	910 Ω	: 1
1000	-	9100 Ω	: 2
10000	-	16000 Ω	: 3

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

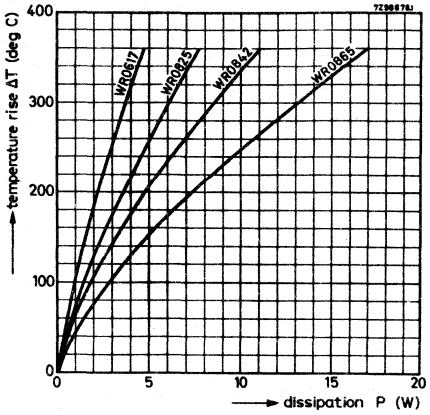


Fig. 2. Temperature rise of the resistor body as a function of the dissipation.

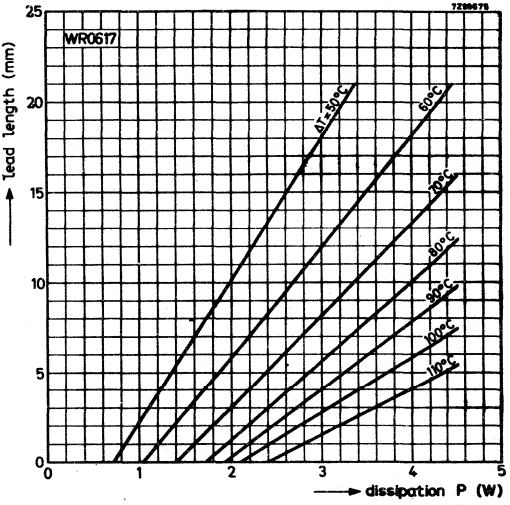


Fig. 3a. Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style WR0617.

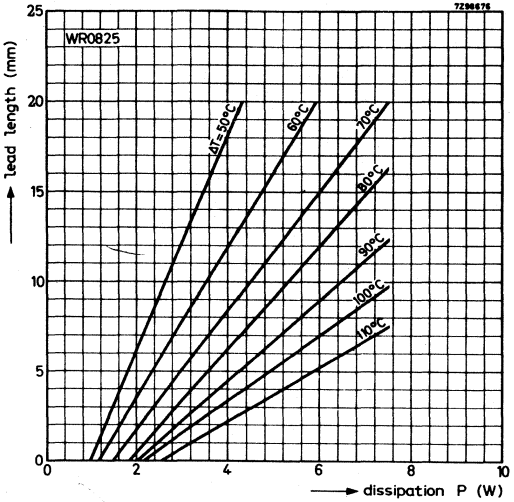


Fig. 3b. Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style WR0825.

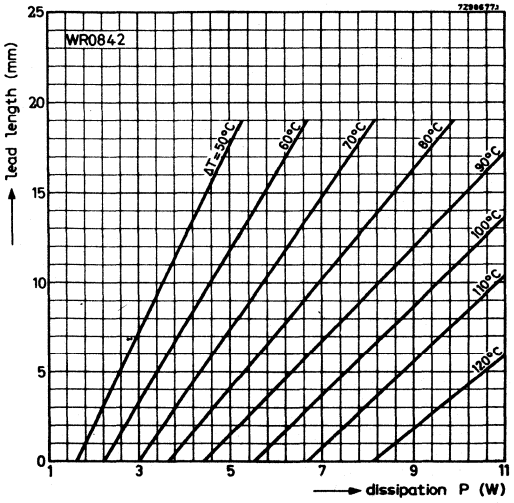


Fig. 3c. Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style WR0842.

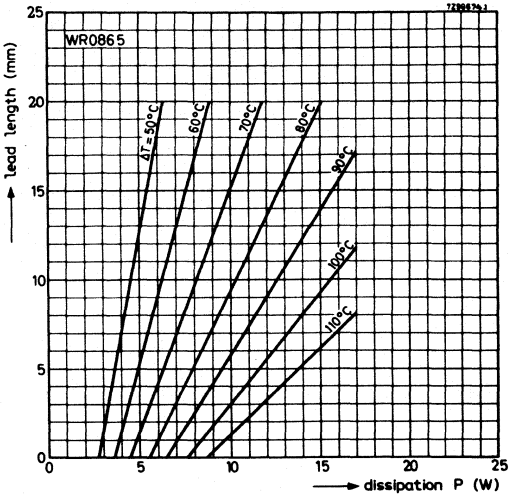
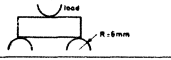


Fig. 3d. Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style WR0865.

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

Table IV

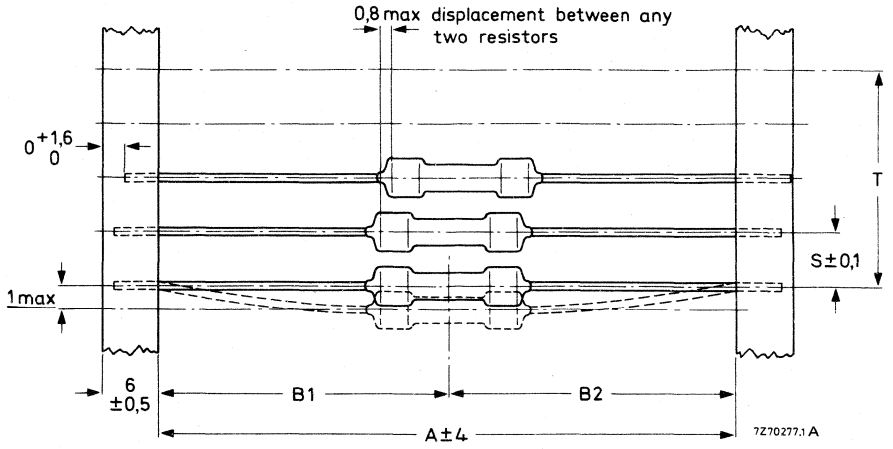
IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
14		robustness of resistor body	 load 200 ± 10 N	no visible damage ΔR ≤ 0,5% or 0,05 Ω
15	U Ua Ub Uc	robustness of terminations: tensile, all samples bending, half number of samples torsion, other half number of samples	 load 10 N, 10 s load 5 N, 4 x 90° 2 x 180° in opposite directions	 no visible damage ΔR ≤ 0,5% or 0,05 Ω
16	T	soldering: solderability thermal shock	 2s 230 °C, flux 600 3s 350 °C, 2.5 mm from body	 good tinning, no damage no damage, ΔR ≤ 0,5% or 0,05 Ω
17	Na	rapid change of temperature	½ h −40 °C/½ h + 200 °C, 5 cycles	no visible damage ΔR ≤ 1%
18	Fc	vibration	10 − 500 Hz, 0,75 mm or 10g, whichever is the less, for 6 h	no visible damage ΔR ≤ 0,5% or 0,05 Ω
19	Eb	bumping	390 m/s², 4000 ± 10 bumps	no visible damage ΔR ≤ 0,5% or 0,05 Ω
20 20.2 20.3 20.4 20.5 20.6	 Ba Aa M D	climatic sequence: dry heat damp heat (accelerated) 1st cycle cold low air pressure damp heat (accelerated) remaining cycles	 16 h 200 °C 1 day 55 °C, 95-100% R.H. 2 h −40 °C 1 h 8,5 kN/m², 15-35 °C 5 days 55 °C, 95-100% R.H.	final measurements: ΔR ≤ 5%, category -/-/21 after 24 h at rated diss. ΔR ≤ 5%
21	Ca	damp heat long term	21 or 56 days (see Table III) 40 °C, 90-95% R.H., 0,01 Prated	ΔR ≤ 5%, after 24 h at rated diss. R ≤ 5%
13.6 22 23		overload endurance endurance	10 times rated dissipation, 5 s 1000 h at room temperature 1000 h at upper category temperature	ΔR ≤ 2% ΔR ≤ 5% ΔR ≤ 5%

STANDARD PACKAGING

style	number per box	
	bandolier	singles
WR0617	500	
WR0825	500	
WR0842		50
WR0865		50

Configuration of bandolier

Dimensions in mm



style	A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
WR0617	66	1,2	10	2 mm per 10 spacings
WR0825	74	1,2	10	1,5 mm per 5 spacings

ENAMELLED WIREWOUND RESISTORS

QUICK REFERENCE DATA		
Resistance ranges		from 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,	WR 0617 E	4 W
	WR 0825 E	7 W
	WR 0842 E	11 W
	WR 0865 E	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 % or 0,1 Ω

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

Dimensions in mm

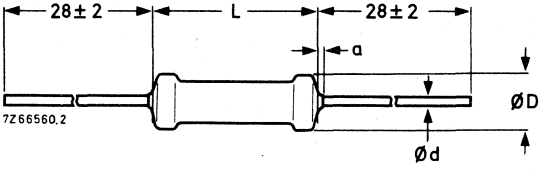


Fig. 1

Style	D_{max}	L_{max}	d
WR0617E	6	19	0,7
WR0825E	8	27	0,8
WR0842E	8	44	0,8
WR0865E	8	67	0,8

a = max 3 mm

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: Measurement of the dimensions of a cylindrical component having two axial terminations).

Diameter of hole in gauge plate 1,0 mm

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

style	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

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:

4.7	-	9.1 Ω:	8
10	-	91 Ω:	9
100	-	910 Ω:	1
1 000	-	9 100 Ω:	2
10 000	-	91 000 Ω:	3
		100 000 Ω:	4

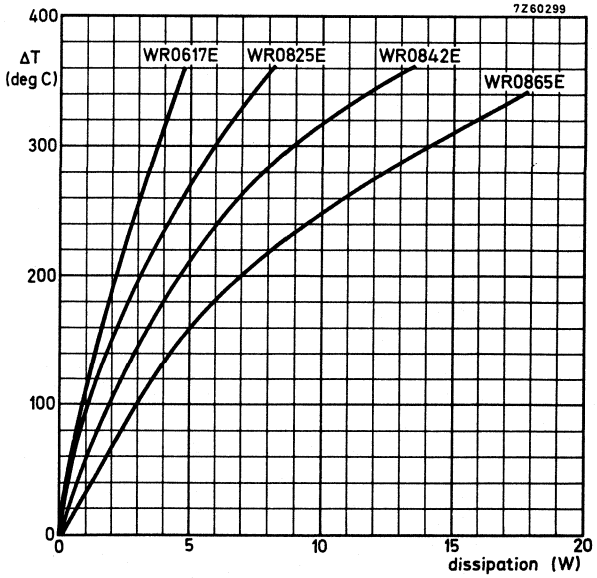
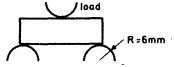


Fig. 2 Temperature rise (ΔT) of the resistor body as a function of the dissipation. Distance between cap and solder joint is 10 mm.

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

IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
14		robustness of resistor body	 load 200 ± 10 N	no visible damage $\Delta R \leq 0,5\%$ or $0,05\,\Omega$
15	U Ua Ub Uc	robustness of terminations: tensile, all samples bending, half number of samples torsion, other half number of samples	 load 10 N, 10 s load 5 N, 4 x 90° 2 x 180° in opposite directions	 no visible damage $\Delta R \leq 0,5\%$ or $0,05\,\Omega$
16	T	soldering: solderability thermal shock	 2 s 230 °C, flux 600 3 s 350 °C, 6 mm from body	 good tinning, no damage no damage, $\Delta R \leq 0,5\%$ or $0,05\,\Omega$
17	Na	rapid change of temperature	$\frac{1}{2}$ h −55 °C/$\frac{1}{2}$ h + 200 °C, 5 cycles	no visible damage $\Delta R \leq 1\%$
18	Fc	vibration	10 - 500 Hz, 0,75 mm or 10 g, whichever is the less, for 6 h	no visible damage $\Delta R \leq 0,5\%$ or $0,1\,\Omega$
19	Eb	bumping	390 m/s^2, 4000 ± 10 bumps	no visible damage $\Delta R \leq 0,5\%$ or $0,1\,\Omega$

TESTS AND REQUIREMENTS, continued

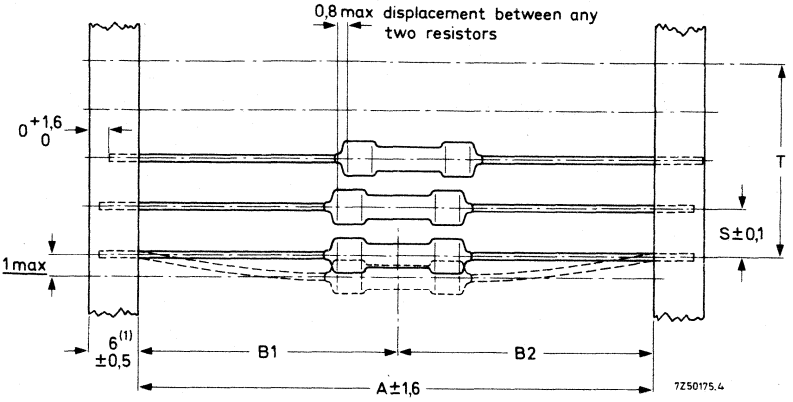
IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
20		climatic sequence:		final measurements:
20.2	Ba	dry heat	16 h 200 °C	
20.3		damp heat (accelerated) 1st cycle	1 day 55 °C, 95-100% R.H.	
20.4	Aa	cold	2 h −55 °C	
20.5	M	low air pressure	1 h 8.5 kN/m^2, 15-35 °C	$\Delta R \leq 5\%$, category -/-/21
20.6	D	damp heat (accelerated) remaining cycles	5 days 55 °C, 95-100% R.H.	after 24 h at rated diss. $\Delta R \leq 5\%$
21	Ca	damp heat long term	21 or 56 days (see Table III) 40 °C, 90-95% R.H., 0.01 P_{rated}	$\Delta R \leq 1\%$, after 24 h at rated diss. $\Delta R \leq 1\%$
13.6		overload	2 times rated dissipation, 10 min 10 times rated dissipation, 5 s	$\Delta R \leq 2\%$
22		endurance	1000 h at 70 °C	$\Delta R \leq 5\%$
23		endurance	1000 h at upper category temperature	$\Delta R \leq 5\%$

STANDARD PACKAGING

style	number per box	
	bandolier	singles
WR0617E	500	
WR0825E	500	
WR0842E		50
WR0865E		50

Configuration of bandolier

Dimensions in mm



(1) Style WR0617E 5 mm.

style	A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
WR0617E	66,7	1,2	10	2 mm per 10 spacings
WR0825E	74	1,2	10	1,5 mm per 5 spacings

RECTANGULAR WIREWOUND RESISTORS

QUICK REFERENCE DATA		
Resistance ranges		from 0,15 Ω to 22 kΩ E24 or E12 series
Resistance tolerance		± 5% or ± 10%
Max. body temperature (hot spot)		350 °C
Rated dissipation at T_{amb} = 70 °C,	2306 335 (EH04)	4 W
	2306 330 (EH05)	5 W
	2306 331 (EH07)	7 W
	2306 332 (EH09)	9 W
	2306 333 (EH17)	17 W
Basic specification		IEC publication 266
Climatic category (IEC 68)		40/200/56
Stability after:		
1000 h rated dissipation		ΔR/R max. 5 %
climatic tests		ΔR/R max. 3 %
short time overload		ΔR/R max. 2 %

APPLICATION

These resistors have been designed for high dissipation in a small volume. Their rectangular shape facilities mounting against a flat surface.

DESCRIPTION

The resistor element is wound in a single layer on a flass 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, sand-filled, ceramic case. The ends of the body are impregnated with a protective silicon resin. The resistors are resistant against agressive solvents.

MECHANICAL DATA

Dimensions (mm)

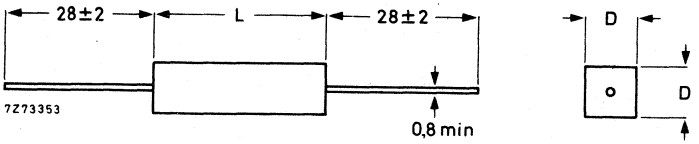


Fig. 1

	D max	L max
2306 335	7, 2	20
2306 330	7, 2	26
2306 331	7, 2	36
2306 332	7, 2	46
2306 333	10, 2	62

Mass (per 100 items)

2306 335	295 g
2306 330	319 g
2306 331	400 g
2306 332	510 g
2306 333	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.

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: 27R 5%
9 W

ELECTRICAL DATA

Standard range

rated dissipation (W) at T_{amb} = 70 °C W	resistance range Ω	tolerance ± %	series *	catalogue number
	0,1 - 8,2	10 **	E12	2306 335 02...
	10 - 3900	5	E24	2306 335 03...
5	0,15 - 8,2	10 **	E12	2306 330 02...
	10 - 6800	5	E24	2306 330 03...
7	0,27 - 8,2	10 **	E12	2306 331 02...
	10 - 12000	5	E24	2306 331 03...
9	0,33 - 8,2	10 **	E12	2306 332 02...
	10 - 15000	5	E24	2306 332 03...
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	350 °C
Ambient temperature range	-40 to +200 °C
Temperature coefficient 0,15 - 5,1 Ω	≤ +600 . 10^{-6}/K
5,6 - 22000 Ω	-50 to +140 . 10^{-6}/K
Climatic category (IEC 68)	40/200/56

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:

0,1	-	0,82	Ω : 7
1	-	8,2	Ω : 8
10	-	91	Ω : 9
100	-	910	Ω : 1
1000	-	9100	Ω : 2
10000	-	22000	Ω : 3

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

** Tolerance of 5% on request.

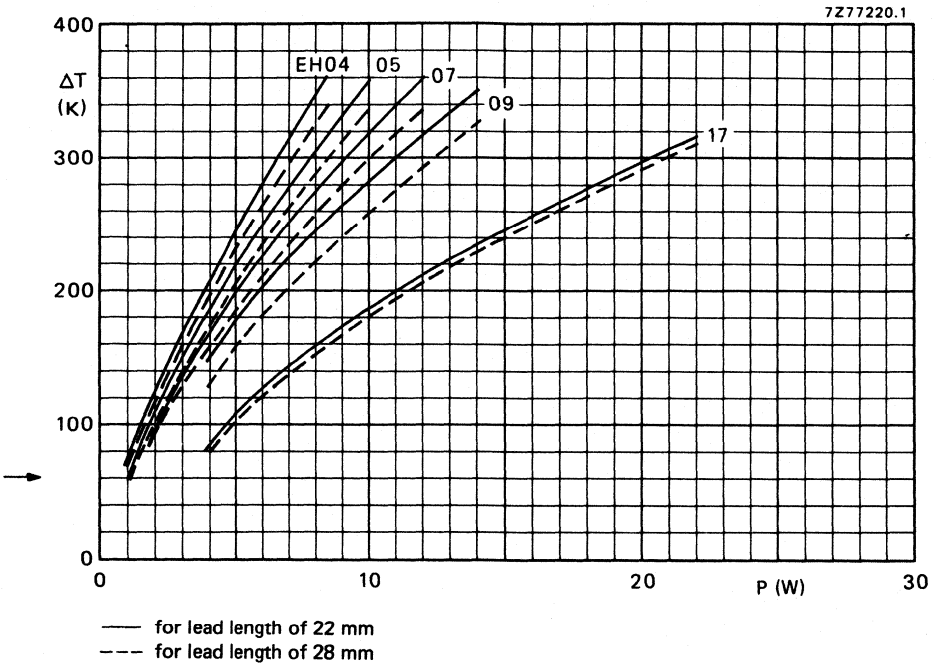
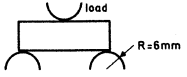


Fig.2. Hot spot temperature rise (ΔT) as a function of the dissipation (P) at two lead lengths.

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

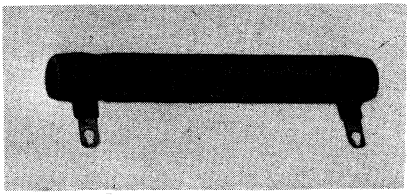
IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
14		robustness of resistor body	 load 200 ±10 N	no visible damage $\Delta R \leq 0,5\%$ or 0,05 Ω
15	U	robustness of terminations:		
	Ua	tensile, all samples	load 10 N, 10 s	
	Ub	bending, half number of samples	load 5 N, 4 x 90°	
	Uc	torsion, other half number of samples	2 x 180° in opposite directions	no visible damage $\Delta R \leq 0,5\%$ or 0,05 Ω
16	T	soldering: solderability thermal shock	2s 230 °C, flux 600 3s 350 °C, 2,5 mm from body	good tinning, no damage no damage, $\Delta R \leq 0,5\%$ or 0,05 Ω
17	Na	rapid change of temperature	$\frac{1}{2}$ h – 40 °C/$\frac{1}{2}$ h +200 °C, 5 cycles	no visible damage $\Delta R \leq 1\%$
18	Fc	vibration	10 - 500 Hz, 0,75 mm or 10g, whichever is the less, for 6 h	no visible damage $\Delta R \leq 0,5\%$ or 0,05 Ω
19	Eb	bumping	390m/s^2, 4000 ± 10 bumps	no visible damage $\Delta R \leq 0,5\%$ or 0,05 Ω

TESTS AND REQUIREMENTS, continued

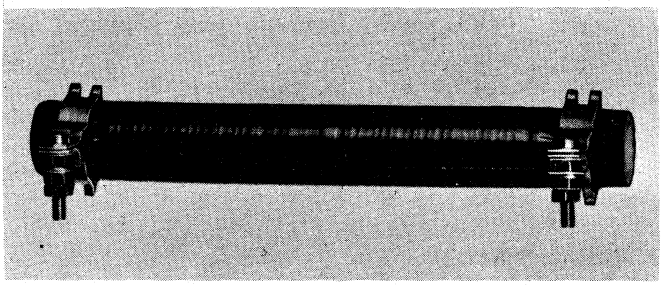
IEC 266 clause	IEC 68 test method	Test	Procedure	Requirements
20		climatic sequence:		final measurements:
20.2	Ba	dry heat	16 h 200 °C	
20.3		damp heat (accelerated)		
		1st cycle	1 day 55 °C, 95-100% R.H.	$\Delta R \leq 3\%$
20.4	Aa	cold	2 h – 40 °C	
20.5	M	low air pressure	1 h 85 mbar, 15-35 °C	
20.6	D	damp heat (accelerated)		
		remaining cycles	5 days 55 °C, 95-100% R.H.	after 24 h at rated diss. $\Delta R \leq 3\%$
21	Ca	damp heat long term	56 days 40 °C, 90-95% R.H., 0,01 P_{rated}	$\Delta R \leq 3\%$, after 24 h at rated diss. $\Delta R \leq 3\%$
13.6		overload	10 times rated dissipation, 5 s	$\Delta R \leq 2\%$
22		endurance	1000 h at 70 °C, rated dissipation	$\Delta R \leq 5\%$
23			1000 h at upper category temperature	$\Delta R \leq 5\%$

WIRE-WOUND RESISTORS WITH SIDE TERMINATIONS

≤ 40 W



≥ 60 W



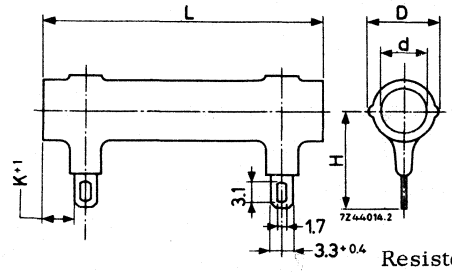
RZ 14250

	cemented	enamelled
Max. dissipation at 40 °C (P_{nom})	8 - 250 W	8 - 100 W
Resistance values	1 Ω - 11 kΩ	160 Ω - 120 kΩ
Tolerance	±5 % (±10 %)	±5 %

CONSTRUCTION

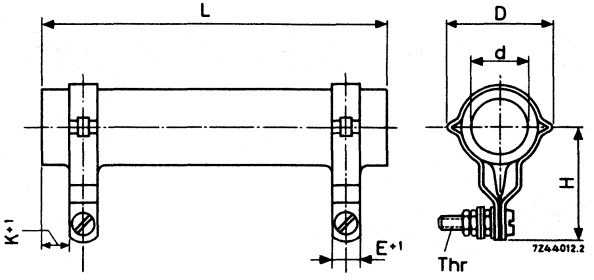
The resistors consist of one layer of resistance wire on a ceramic cylinder with side terminations. The 323-resistors are coated with cement, the 321-resistors with enamel for mechanical protection.

Dimensions in mm



P_{nom} (W)	D_{max}	d_{min}	K	L	H
8	11.5	5	2.5	26^{-2}	14
10	11.5	5	4	41^{-2}	14
16	11.5	5	4	62.5^{-2}	14
25	16	8	4	64^{-2}	20
40	16	8	4	103^{-5}	20

Resistors with $P_{nom} \leq 40$ W

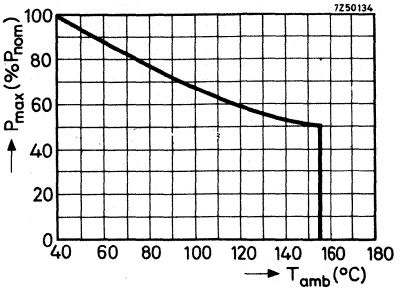


Resistors with $P_{nom} \geq 60$ W

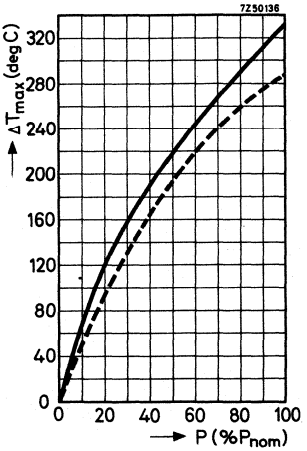
P_{nom} (W)	D_{max} (mm)	d_{min} (mm)	E (mm)	H (mm)	K (mm)	L (mm)	Thr (mm)
60	32	12.5	8.5	33	6	103^{-5}	M4
100	32	12.5	8.5	33	6	165^{-8}	M4
160	44	20	10	40	8	165^{-8}	M5
250	44	20	10	40	8	256^{-10}	M5

TECHNICAL PERFORMANCE

Max. dissipation at 40 °C (= P_{nom})	see Schedule
at > 40 °C	see relevant graph
Max. dissipation, mounted, with a bolt through the cylinder, against a metal plate	1.2 x max. dissipations given above
Max. overload at 40 °C	2 P_{nom} during 10 minutes, 10 P_{nom} during 5 seconds
Resistance values (see Schedule)	measured at P = 0.1 P_{nom}
Tolerance	±5 % (±10 %)
Temperature coefficient	(−50 to +140) 10^{-6}/deg C
Change in resistance after load tests	< 5 %
after climatic tests	<3 %
Insulation	the coating is non-insulating
Ambient temperature range	−55 to +155 °C
Climatic robustness	category 55/155/56 (IEC 68)



Max. dissipation as a function of the ambient temperature. With a bolt through the resistor, mounted against a metal plate, P_{max} can be multiplied by 1.2.



Max. temperature rise as a function of the dissipation. The broken line applies to mounting with bolt and plate.

SCHEDULE

coating	P_{nom} (W)	resistance values			D_{max} x L_{max} (mm x mm)	catalog number: 2322 followed by
		tol. (±..%)	min. (Ω)	max. (Ω)		
cement	8	10	1	100	11.5 x 26	323 14...
		5	110	150		323 34...
enamel		5	160	6 800		321 34...
cement	10	10	1.2	27	11.5 x 41	323 12...
		5	30	300		323 32...
enamel		5	330	12 000		321 32...
cement	16	10	1.5	2.7	11.5 x 62.5	323 10...
		5	3	620		323 30...
enamel		5	680	24 000		321 30...
cement	25	10	2.7	15	16 x 64	323 08...
		5	16	820		323 28...
enamel		5	1 000	39 000		321 28...
cement	40	5	4.7	1 600	16 x 103	323 26...
enamel		5	1 800	75 000		321 26...
cement	60	5	3	2 200	32 x 103	323 24...
enamel		5	2400	68 000		321 24...
cement	100	5	6.8	4 300	32 x 165	323 23...
enamel		5	4 700	120 000		321 23...
cement	160	5	10	6 800	44 x 165	323 22...
cement	250	5	16	11 000	44 x 256	323 21...

Standard resistance values within the given range can be chosen from the E12 series. Resistance values of the E24 series (tol. ± 5%) are available on request. (See Table at the back of this handbook)

Composition of the catalog number, for ordering

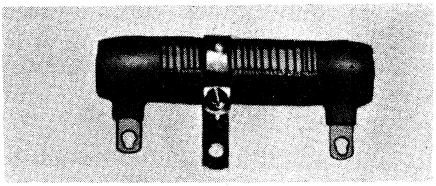
2322 . . . . . .

See table ←

The first two digits of the resistance value, neglecting a decimal point. ←

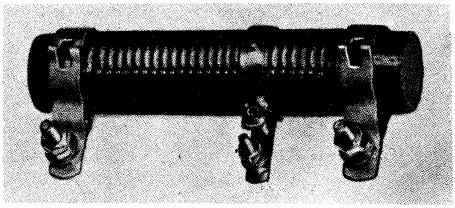
→ 8 for R of 1 to 8,2 Ω
9 for R of 10 to 82 Ω
1 for R of 100 to 820 Ω
2 for R of 1 to 8,2 kΩ
3 for R of 10 to 82 kΩ
4 for R of 100 to 120 kΩ

ADJUSTABLE WIRE-WOUND RESISTORS



RZ 14250-1C

≤ 40 W



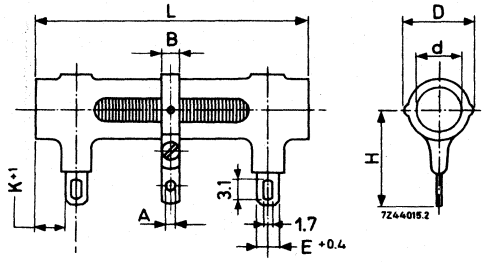
≥ 60 W

	cemented	enamelled
Max. dissipation at 40 °C (P_{nom})	10 - 250 W	10 - 100 W
Resistance values	1.2 Ω - 11 kΩ	330 Ω - 47 kΩ
Tolerance	±5 % (10%)	±5 %

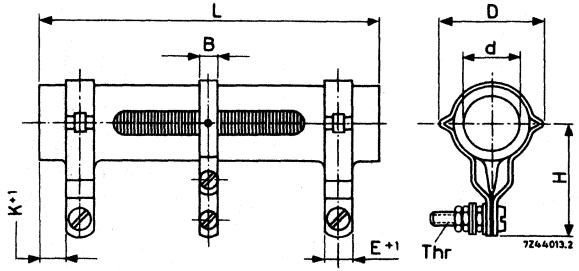
CONSTRUCTION

The resistors consist of one layer of resistance wire on a ceramic cylinder with side terminations. A strap, fitted with a silver contact, may be adjusted to any point along an uncoated strip of the resistor. The 324-resistors are coated with cement, the 322-resistors with enamel for mechanical protection.

Dimensions in mm



Resistors with $P_{nom} \leq 40$ W



Resistors with $P_{nom} \geq 60$ W

P_{nom} (W)	dimensions in mm								
	D_{max}	d_{min}	H	K	E	L	B	A	Thr
10	11.5	4.2	14	4	3.3	41^{-2}	5	2.8	-
16	11.5	4.2	14	4	3.3	62.5^{-2}	5	2.8	-
25	16	7.2	20	4	3.3	64^{-2}	6	3.2	-
40	16	7.2	20	4	3.3	103^{-5}	6	3.2	-
60	32	12.5	33	6	8.5	103^{-5}	6	-	M4
100	32	12.5	33	6	8.5	165^{-8}	6	-	M4
160	44	20	40	8	10	165^{-8}	8	-	M5
250	44	20	40	8	10	256^{-10}	8	-	M5

TECHNICAL PERFORMANCE

Identical to that of the non-adjustable wire-wound resistors with side terminations, see 323 and 321 series.

SCHEDULE

coating	P_{nom} [1] (W)	resistance values (R_{nom}) [1] tol. (±..%)	min. (Ω)	max. (Ω)	short circuit [1] (% R_{nom})	D_{max} x L_{max} (mm x mm)	cat.number 2322 followed by
cement	10	10	1.2	27	9	11.5 x 41	324 12...
		5	30	300			324 32...
enamel		5	330	3 300			322 32...
cement	16	10	1.5	2.7	5	11.5 x 62.5	324 10...
		5	3	620			324 30...
enamel		5	680	6 800			322 30...
cement	25	10	2.7	15	4	16 x 64	324 08...
		5	16	820			324 28...
enamel		5	1 000	9 100			322 28...
cement	40	5	4.7	1 600	2.5	16 x 103	324 26...
enamel		5	1 800	18 000			322 26...
cement	60	5	3	2 200	3	32 x 103	324 24...
enamel		5	2400	24 000			322 24...
cement	100	5	6.8	4 300	1.5	32 x 165	324 23...
enamel		5	4 700	47 000			322 23...
cement	160	5	10	6 800	1.5	44 x 165	324 22...
cement	250	5	16	11 000	1	44 x 256	324 21...

Standard resistance values within the given range can be chosen from the E12 series: Resistance values of the E24 series (tol. ±5%) are available on request. (See Table at the back of this handbook)

→ Composition of the catalog number, for ordering

2322 ... .

See table ←

The first two digits of the nominal resistance value, neglecting a decimal point. ←

→ 8 for R of 1,2 to 8,2 Ω
9 for R of 10 to 82 Ω
1 for R of 100 to 820 Ω
2 for R of 1 to 8,2 kΩ
3 for R of 10 to 47 kΩ

[1] The adjustable contact short-circuits a number of windings. The maximum resistance loss has been given as a percentage of the nominal resistance. Nominal dissipation and nominal resistance values apply if no contact strap were connected.

LOW-OHMIC WIREWOUND RESISTORS

QUICK REFERENCE DATA	
Resistance range	0,1 to 10 Ω, E24 series
Resistance tolerance	± 10%
Rated dissipation at T_{amb} = 70 °C	2 W

APPLICATION

In transistor circuits

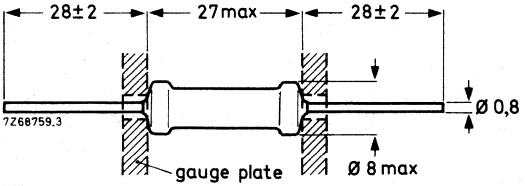
DESCRIPTION

The resistors consist of a layer of resistance wire on a ceramic bar and two caps with tinned leads. The body is coated with a green cement.

MECHANICAL DATA

Dimensions in mm

Outlines



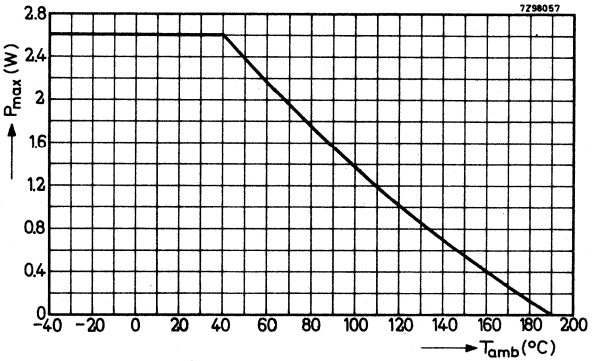
Marking

Each resistor is marked with:
- resistance value (R for Ω, K for kΩ)
- tolerance on resistance in %
- rated dissipation at T_{amb} = 70 °C (2 W)

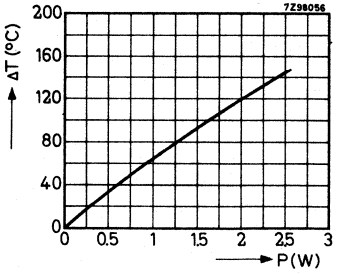
e.g. 6R8 10%
2 W

ELECTRICAL DATA

Max. dissipation at T_{amb} = 40 °C	2,6 W
at other temperatures	see relevant graph
Operating body temperature	−40 to + 190 °C
Resistance values, measured	
at P ≤ 0,2 W	0,1 to 10 Ω, E24 series
Resistance tolerance	± 10%
Temperature coefficient	
for 0,1 to 1 Ω resistors	(0 to + 600) ppm/°C
for 1,1 to 10 Ω resistors	(−50 to + 25) ppm/°C
Change in resistance remaining after load tests and after climatic tests	≤ 1,5%
Climatic category conforming to NT-14-2-4	505



Maximum dissipation as a function of the ambient temperature



Rise of body temperature as a function of the dissipation

COMPOSITION OF THE CATALOGUE NUMBER

2322 326 51...

└ resistance code

The resistance code consists of the two significant figures of the resistance value (in Ω) followed by a figure for the multiplier, the multiplier code being:

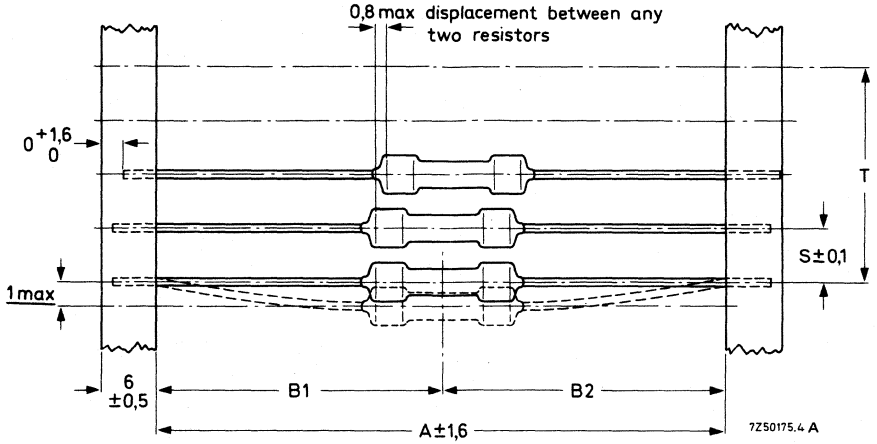
x 0,01 = 7
x 0,1 = 8
x 1 = 9

Examples: 107 for 0,1 Ω; 917 for 0,91 Ω; 438 for 4,3 Ω; 109 for 10 Ω

STANDARD PACKAGING

The resistors are supplied on bandolier, 500 pieces per box.

Configuration of bandolier (dimensions in mm)



A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
74	1,2	10	2 mm per 10 spacings 1,5 mm per 5 spacings

LOW-OHMIC GLASS-SEALED WIRE RESISTORS

Maximum dissipation at 40 °C	1 W
Resistance values	0,1 to 6,8 Ω, E12 series
Tolerance	±10 %

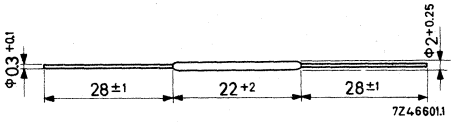
APPLICATION

In transistor circuits

CONSTRUCTION

The resistors consist of a glass-sealed resistance wire provided with tinned leads.

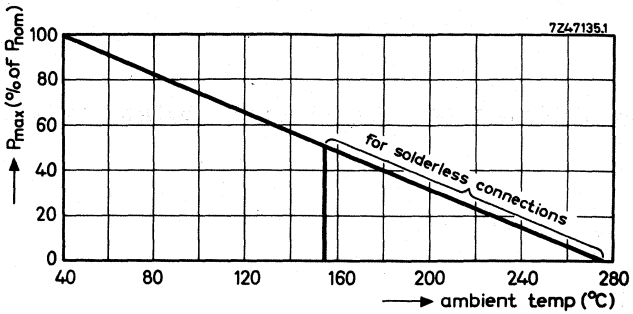
Dimensions in mm



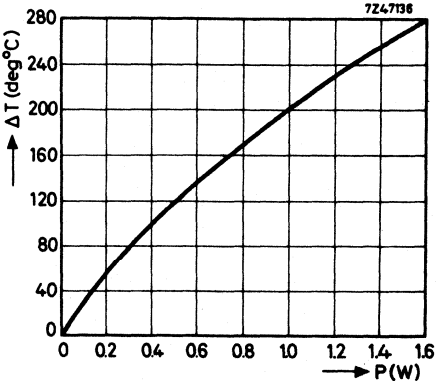
TECHNICAL PERFORMANCE

The resistances (nominal value and tolerance) are measured at P = 0,1 W and between points 30 mm apart.

Tolerance	±10 %
Resistance change remaining after climatic tests.	< 5 %
Temperature coefficient	(−50 to +150) 10^{-6}/K
Operating body temperature	−25 to +275 °C
Max. dissipation at 40 °C (P_{nom})	1 W
Climatic robustness	category 25/155/56 (IEC 68)



Maximum dissipation as a function of the ambient temperature



Rise of body temperature as a function of the dissipation

SCHEDULE

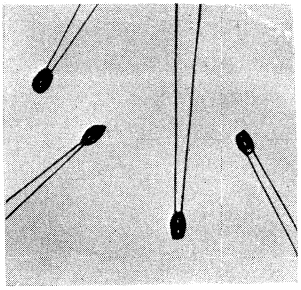
Composition of the catalog number, for ordering:

2322 327 61...
└→ resistance code, see table

resistance (Ω)	resistance code	resistance (Ω)	resistance code
0.1	107	1	108
0.12	127	1.2	128
0.15	157	1.5	158
0.18	187	1.8	188
0.22	227	2.2	228
0.27	277	2.7	278
0.33	337	3.3	338
0.39	397	3.9	398
0.47	477	4.7	478
0.56	567	5.6	568
0.68	687	6.8	688
0.82	827		

INSULATED PIN-HEAD CARBON RESISTORS

QUICK REFERENCE DATA	
Max. dissipation at T_{amb} = 70 °C	0,05 W
Resistance range	33 Ω to 180 kΩ, E12 series
Resistance tolerance	± 10%
Noise	< 10 μV/V



RZ 15568-5

APPLICATION

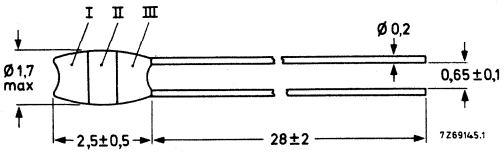
In hearing aids, short-distance communication sets, weather radio probes.

DESCRIPTION

The resistors consist of a pellet of carbon composition between the parallel connection leads. The pellet is coated with synthetic resin.

MECHANICAL DATA

Dimensions in mm



Soldering

- Do not solder or bend the leads less than 0,5 mm from the resistor body.
- The resistor is not suitable for wave soldering.

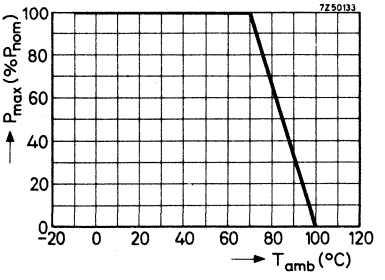
Colour code, for resistance values in Ω;

colour	band I, first digit	band II, second digit	band III, multiplier
black	-	0	x 1
brown	1	1	x 10
red	2	2	x 100
orange	3	3	x 1000
yellow	4	4	x 10 000
green	5	5	
blue	6	6	
violet	7	7	
grey	8	8	
white	9	9	

ELECTRICAL DATA

For tests and measuring methods see IEC publications 109 and 115

Max. dissipation at 70 °C (=P_{nom})	0,05 W
at other temperatures	see respective graph
Limiting voltage, peak value	50 V
Resistance values, measured at $P \leqslant 0{,}1\ P_{nom}$	33 Ω to 180 kΩ, E12 series
Tolerance	± 10%
Temperature coefficient (from +25 to +70 °C)	+1000 to −2000 ppm/°C
Voltage dependence $\frac{\Delta R}{R} = f(V)$	< 0,3%/V
Ambient temperature range	−10 to +100 °C
Noise	< 10 μV/V
Change in resistance after:	
- mechanical force of 1 N (100 g) along axis of connection	< 1%
- mechanical force of 0,2 N normal to axis of connection	< 1%
- damp-heat test C, 21 days (IEC68)	< 20%
- endurance test, P_{nom} at 70 °C	< 10%
- 10 000 h storage	< 5%



COMPOSITION OF THE CATALOGUE NUMBER

2322 120 22 . . .

└── resistance code:
first two figures of the resistance value followed by:
9 for R of 33 to 82 Ω
1 for R of 100 to 820 Ω
2 for R of 1 to 8,2 kΩ
3 for R of 10 to 82 kΩ
4 for R of 100 to 180 kΩ

e.g. the catalogue number of a resistor of 3300 Ω is 2322 120 22332.

INDEX OF CATALOGUE NUMBERS

See also Survey on pages 2 and 3.

STANDARD SERIES OF VALUES IN A DECADE
for resistances and capacitances

according to I E C publication 63

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

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