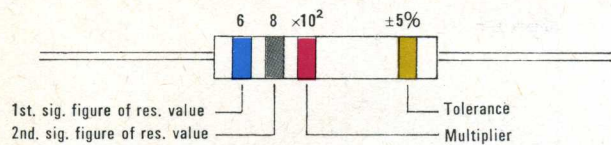


# Resistance Value Coding

## COLOUR BAND MARKING

Colour	1st, 2nd & 3rd Figures	Multiplying factor	Tolerance
Brown	1	10	±1%
Red	2	10 <sup>2</sup>	±2%
Orange	3	10 <sup>3</sup>	—
Yellow	4	10 <sup>4</sup>	—
Green	5	10 <sup>5</sup>	—
Blue	6	10 <sup>6</sup>	—
Mauve	7	10 <sup>7</sup>	—
Grey	8	10 <sup>8</sup>	—
White	9	10 <sup>9</sup>	—
Black	0	1	—
Gold	—	10 <sup>-1</sup>	±5%
Silver	—	10 <sup>-2</sup>	±10%

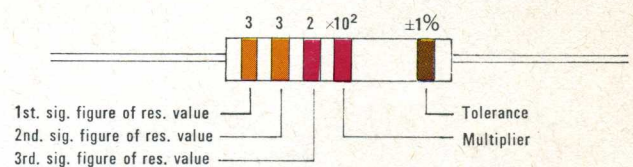
### E24 Series



**E24 6K8±5%**

### EXAMPLES

### E48/96 Series



**E96 33K2±1%**

## I.E.C. LEGEND MARKING (Marking by means of letters and digits).

In line with the recommendations of I.E.C., Welwyn have introduced the international system of legend marking for resistance values as detailed in the I.E.C. Publication 62 and also by British Standard B.S.1852.

### RESISTANCE VALUE

The I.E.C. code consists of two figures and a letter or three figures and a letter, where the code letter appropriate to the multiplier used replaces the decimal point.

CODES	LETTER	MULTIPLIER	NOTES
	R	1	Replaces decimal point and indicates Ohms.
	K	10 <sup>3</sup>	Also replaces decimal point and indicates Kilohms.
	M	10 <sup>6</sup>	" " " " " " Megohms.
	G	10 <sup>9</sup>	" " " " " " Gigaohms.
	T	10 <sup>12</sup>	" " " " " " Teraohms.

Where there are two significant figures only (e.g. E6, E12 and E24 series) the coding has three characters (except in the decade 100 999) for any given multiplier, e.g. 100K Ω is coded 100K. Where there are three significant figures, a four character code is used.

R (Ohms)		K (Kilo)		M (Mega)		G (Giga)		T (Tera)	
1		10 <sup>3</sup>		10 <sup>6</sup>		10 <sup>9</sup>		10 <sup>12</sup>	
Value	Code	Value	Code	Value	Code	Value	Code	Value	Code
0.1 Ω	R10								
0.55 Ω	R55								
0.999 Ω	R999								
1 Ω	1R0	1K Ω	1K0	1M Ω	1M0	1KM Ω	1G0	1MM Ω	1T0
5.5 Ω	5R5	5.5K Ω	5K5	5.5M Ω	5M5	5.5KM Ω	5G5	5.5MM Ω	5T5
9.99 Ω	9R99	9.99K Ω	9K99	9.99M Ω	9M99	9.99KM Ω	9G99	9.99MM Ω	9T99
10 Ω	10R	10K Ω	10K	10M Ω	10M	10KM Ω	10G		
55 Ω	55R	55K Ω	55K	55M Ω	55M	55KM Ω	55G		
99.9 Ω	99R9	99.9K Ω	99K9	99.9M Ω	99M9	99.9KM Ω	99G9		
100 Ω	100R	100K Ω	100K	100M Ω	100M	100KM Ω	100G		
550 Ω	550R	550K Ω	550K	550M Ω	550M	550KM Ω	550G		
999 Ω	999R	999K Ω	999K	999M Ω	999M	999KM Ω	999G		

## TEMPERATURE COEFFICIENT

B.S. Code letters are as follows

Temperature Coefficient	Code Letters
250	X
150	G
100	Z
50	C
25	D
15	Y

**RESISTANCE TOLERANCE** Welwyn are not adopting the specification recommendations for tolerance as this is found to be restrictive for many of our precision products.

**NOTE** This I.E.C. System of Nomenclature is also used on all Welwyn Documents where Resistance Value is expressed.





# Resistor Preferred Ohmic Values

Decimal multiples or sub-multiples also apply

E6	E12	E24	E48	E96	E192	
10	10	10	10.0	10.0	10.0 10.1	
			10.2	10.2	10.4	
			10.5	10.5	10.6	
		11	11.0	11.0	11.0 11.1	
			11.3	11.3	11.4	
			11.5	11.5	11.7	
	12	12	12.1	12.1	12.1 12.3	
			12.4	12.4	12.6	
			12.7	12.7	12.9	
		13	13.0	13.0	13.0 13.2	
			13.3	13.3	13.5	
			13.7	13.7	13.8	
14	14	14.0	14.0	14.0 14.2		
		14.3	14.3	14.5		
		14.7	14.7	14.9		
	15	15	15	15.0	15.0	15.0 15.2
				15.4	15.4	15.6
				15.8	15.8	16.0
16			16.2	16.2	16.2 16.4	
			16.5	16.5	16.7	
			16.9	16.9	17.2	
17		17	17.4	17.4	17.4 17.6	
			17.8	17.8	18.0	
			18.2	18.2	18.4	
		18	18.7	18.7	18.7 18.9	
			19.1	19.1	19.3	
			19.6	19.6	19.8	
20	20	20.0	20.0	20.0 20.3		
		20.5	20.5	20.8		
	21.0	21.0	21.3			
	21.5	21.5	21.8			

E6	E12	E24	E48	E96	E192
22	22	22	22.1	22.1	22.1 22.3
			22.6	22.6	22.9
			23.2	23.2	23.4
		23	23.7	23.7	23.7 24.0
			24.3	24.3	24.6
			24.9	24.9	25.2
	24	24	25.5	25.5	25.8
			26.1	26.1	26.4
			26.7	26.7	27.1
		27	27.4	27.4	27.4 27.7
			28.0	28.0	28.4
			28.7	28.7	29.1
30	30	29.4	29.4	29.8	
		30.1	30.1	30.5	
		30.9	30.9	31.2	
	31	31.6	31.6	31.6 32.0	
		32.4	32.4	32.8	
		33.2	33.2	33.6	
33	33	33	34.0	34.0	34.0 33.4
			34.8	34.8	35.2
			35.7	35.7	36.1
		36	36.5	36.5	36.5 37.0
			37.4	37.4	37.9
			38.3	38.3	38.8
	39	39	39.2	39.2	39.2 39.7
			40.2	40.2	40.7
			41.2	41.2	41.7
		42	42.2	42.2	42.2 42.7
			43.2	43.2	43.7
			44.2	44.2	44.8
43	43	45.3	45.3	45.9	
		46.4	46.4	47.0	

E6	E12	E24	E48	E96	E192
47	47	47	47.5	47.5	47.5 48.1
			48.7	48.7	49.3
			49.9	49.9	50.5
		51	51.1	51.1	51.1 51.7
			52.3	52.3	53.0
			53.6	53.6	54.2
	56	56	54.9	54.9	55.6
			56.2	56.2	56.9
			57.6	57.6	58.3
		59	59.0	59.0	59.0 59.7
			60.4	60.4	61.2
			61.9	61.9	62.6
62	62	63.4	63.4	64.2	
		64.9	64.9	65.7	
		66.5	66.5	67.3	
	68	68	68.1	68.1	68.1 69.0
			69.8	69.8	70.6
			71.5	71.5	72.3
73		73.2	73.2	74.1	
		75.0	75.0	75.9	
		76.8	76.8	77.7	
78	78	78.7	78.7	78.7 79.6	
		80.6	80.6	81.6	
		82.5	82.5	83.5	
	84	84.5	84.5	85.6	
		86.6	86.6	87.6	
		88.7	88.7	89.8	
91	91	90.9	90.9	90.9 92.0	
		93.1	93.1	94.2	
	95.3	95.3	96.5		
	97.6	97.6	98.8		

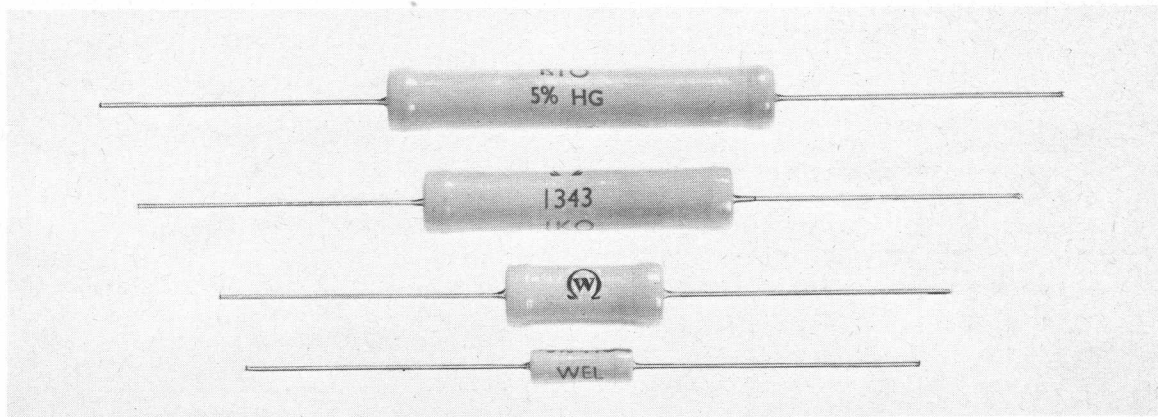
Note: The above values are in accordance with I.E.C. Publication 63 (1963) and B.S.2488.





# Precision Power Wirewound Resistors

## Series 13-40



Wire element – withstands high electrical shock load  
 Temperature coefficient of resistance typically  $<20$  ppM/°C

Power dissipation up to 8 watts

High stability – typically 1%

Rugged construction – welded connections

Selection tolerances down to  $\pm 1\%$

### GENERAL DESCRIPTION

The precision power wirewound Series 13–40 is a range of medium power resistors suitable for applications requiring high stability, low temperature coefficient and dissipation up to 8 watts.

The nickel alloy wire element is wound on a high quality ceramic rod and welded to the cap assembly. Protection is provided to the wire by several coats of high temperature lacquer.

**Welwyn** Electric Limited

BEDLINGTON NORTHUMBERLAND NE22 7AA ENGLAND

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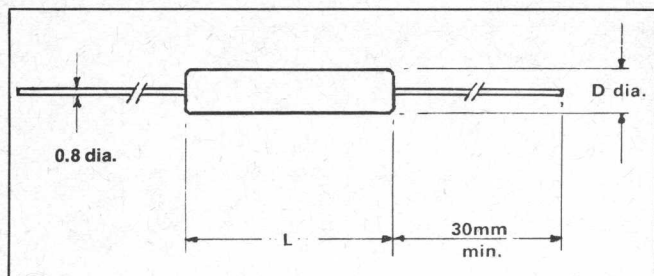
Telex: 53514



BS 9000  
 approval number  
 1023/M



**MECHANICAL DATA**



**Terminations** Material: Solder coated copper wire. Pull strength: 1kg. Solderability: The terminations adequately meet the requirements of BS2011, Part 2T, Method 1 (Solder bath).

**Marking** Legend marked with type reference, value, tolerance and date code.

**Maximum dimensions (millimetres)**

Type ref.	D max.	L max.	Approx. weight (gm)
1341	5.4	14	1.1
1342	10.0	22	3.7
1343	10.0	42	6.6
1344	10.0	52	8.0

**Solvent resistance** The coating and marking are resistant to all industrial cleaning solvents suitable for printed circuits.

**Flammability** The lacquer protection meets the requirements of BS2011, Test Pa, Flammability.

**ELECTRICAL DATA**

Type ref.	Resistance range (ohms)	Rated dissipation (watts) at ambient temperature	
		20°C	70°C
1341	0.1 to 2k	2	1.6
1342	0.1 to 4.7k	4	3.1
1343	0.1 to 13k	6	4.7
1344	0.1 to 18k	8	6.3

**Manufactured values:** Available in any resistance value within the stated range.

**Standard selection tolerances:**  $\pm 5\%$ ,  $\pm 2\%$ ,  $\pm 1\%$ . Values below 1 $\Omega$ :  $\pm 5\%$ .

**Derating:** Derate linearly from rated dissipation at 70°C to zero at 250°C.

**Thermal impedance**

Type ref.	1341	1342	1343	1344
Thermal impedance (°C/watt)	115	57	38	29

**Temperature coefficient:** typically <20 ppM/°C for resistance values above 1 $\Omega$ .

**Isolation voltage:** 560 volts d.c. or a.c. peak

**Insulation resistance:** >10<sup>9</sup> $\Omega$  at 500 volts d.c.

**ENVIRONMENTAL DATA**

**Endurance:** 1000 hours at rated dissipation in 70°C ambient:  $\Delta R$  typically 1%.

**Shelf stability, 12 months:**  $\Delta R$  typically better than 0.1%.

**Change due to soldering:**  $\Delta R$  better than 0.1%.

**Climatic category:** 55/200/56.

**Climatic sequence:**  $\Delta R$  typically 1%.

**Temperature rapid change:**  $\Delta R$  typically 0.2%.

**APPLICATION NOTES**

The axial terminations should not be bent closer than 1.5 mm from the body, and the recommended minimum bend radius is 1 mm. If

the resistors are to dissipate full rated power, it is recommended that the terminations should not be soldered closer than 4 mm from the body.

**ORDERING PROCEDURE**

Specify type reference, value and tolerance using the I.E.C. resistance code to identify the value. E.g. 1342/2KO  $\pm 1\%$ .

**Welwyn Electric Limited**

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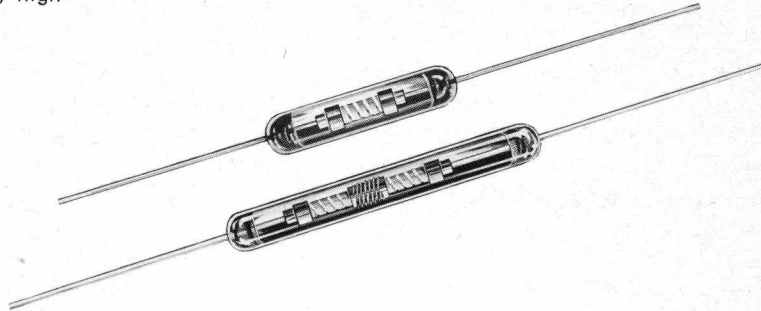
# Welmegox<sup>®</sup> High Value Resistors

SERIES  
**38-10**

S026 Nov. '75

## FEATURES

- Highest available values at close tolerance.
- Welwyn Cermetox resistive film.
- Stability 1%.
- Suitable for use in radiation monitoring equipment, electrometers, low current measurements, high impedance amplifiers.

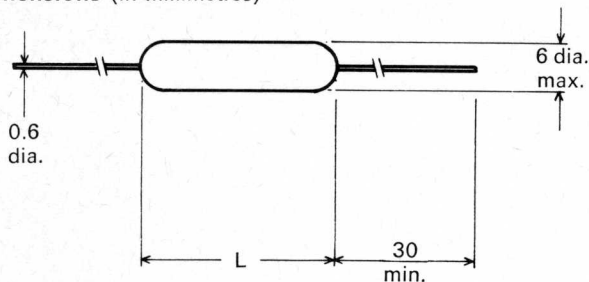


## MECHANICAL DATA

### Construction

The resistive film is fired on to a high purity ceramic substrate; brass end caps are force fitted to the substrate which is then adjusted to value with a helical cut in the ceramic; the leads are mechanically locked into the end caps and the assembly sealed into the glass envelope. All close tolerance units utilise two substrates connected in series within the glass envelope. High value units, Type 3812, are part filled with silicone oil.

### Dimensions (in millimetres)



### Registered Trade Names

WELMEGOX<sup>®</sup>

CERMETOX<sup>®</sup>

Type	L max. (mm)	Weight gm
3810	25.0	1.5
3811	42.9	2.2
3812	48.0	2.5

## TERMINATIONS

### Material

Solder coated dumet wire.

### Strength

Pull strength 3 kg.

### Solderability

The terminations adequately meet the requirements of BS9110, Clause 1.2.6.2.

### Marking

Resistance value, tolerance and serial number. The value is marked in accordance with IEC62. E.g. 1G0 is  $10^9$  ohms, and 1T5 is  $1.5 \times 10^{12}$  ohms.

### Solvent Resistance

The glass envelope is coated with silicone and should not be subjected to solvents or their vapours. (See application notes.)

### Flammability

All materials used are inherently non-flammable.

### Packaging

Each resistor is individually packed in a polythene envelope together with a card carrying measurement details and serial number.

WELWYN ELECTRIC LIMITED

BEDLINGTON • NORTHUMBERLAND • NE22 7AA • ENGLAND

Telephone: Bedlington (0670) 822181 Telex: 53514



BS 9000  
approved number  
1023/M



## ELECTRICAL DATA

Type ref.	Resistance range in ohms (1T = 10 <sup>12</sup> )	Selection tolerances	Limiting element voltage (Volts d.c. or a.c. r.m.s.)
3810	100M - 1T	± 20%, ± 10%	500
3811	100M - 1T	± 10%, ± 5%, ± 2%, ± 1%	1000
3812	1T - 100T	± 10%, ± 5%	1000
3812	1T - 10T	± 2%	1000

### Manufactured Values

Available in any value within the specified range.

### Standard Selection Tolerances

As defined in the table above.

### Capacitance

3810 0.4 pF approx.

3811 and 3812 0.2 pF approx.

### Operating Temperature Range

-40° to +100°C.

### Temperature Coefficient

Typically -0.15%/°C. } over the full resistance range.  
Maximum -0.2%/°C. }

### Voltage Coefficient

V.C. is constant with applied voltage: it varies with resistance value and is negative. Typical values are given in the table below.

Type	3810	3811, 3812
10 <sup>8</sup> ( $\Omega$ )	-0.01%/V	-0.005%/V
10 <sup>12</sup> ( $\Omega$ )	-0.04%/V	-0.02%/V
10 <sup>14</sup> ( $\Omega$ )	—	-0.04%/V

## ENVIRONMENTAL DATA

### Endurance

1000 hours at 20°C:  $\Delta R$  typically 1%.

### Shelf Stability, 12 Months

$\Delta R$  typically 0.5%.

### Change due to Soldering

$\Delta R < 0.1\%$ .

### Relevant Specification

Conforms to U.K.A.E.A. Specification AESS (R) 10390.

## APPLICATION NOTES

Each resistor is given a serial number. The card packed with each resistor carries that number; details of the measured resistance value  $\pm 1\%$ ; the applied voltage at which that measurement was made; the date of measurement.

Welwyn record against the serial number details of resistance value at room temperature and at 60°C; room temperature; temperature coefficient; voltage coefficient calculated from measurements made with 10V and 100V applied.

Although the glass envelope is an excellent insulant and would be adequate in a dry atmosphere, the condensation which occurs in a normal atmosphere will provide a shunt resistance which will modify the very high resistance value. To minimise this effect all units are coated with silicone, and it is essential that this coating is not damaged; any handling should be by the terminations. For the same reason solvents must not be used.

The resistors should not be used in a damp atmosphere. If moisture develops on the body the resistor should be dried for 30 minutes at 70°C. and allowed to cool for a further 30 minutes in a dry atmosphere.

To avoid damage to the seal between terminations and glass the leads must be fully supported inside the point of bending during any preforming operation.

## ORDERING PROCEDURE

State type reference, resistance value and tolerance. E.g. 3811, 150G $\Omega$   $\pm 2\%$ .





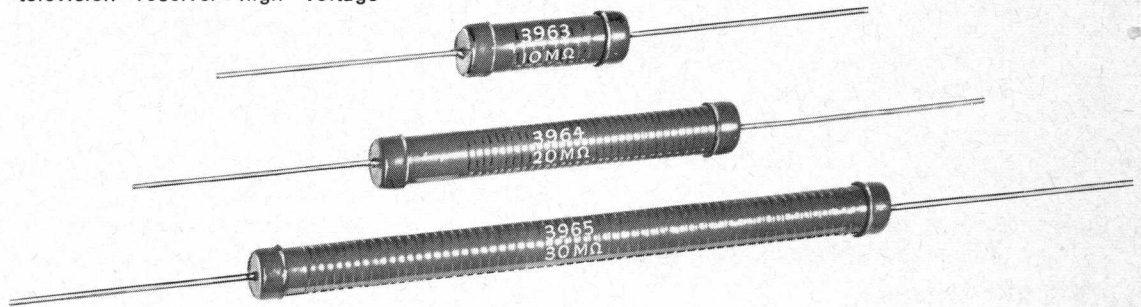
# Cermetox High Voltage Resistors

SERIES  
**39-60**

S061 OCT. '74

## FEATURES

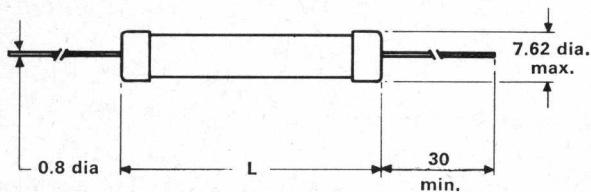
- Single units suitable for voltages up to 20 kV.
- Resistance values up to 200M $\Omega$ .
- Stability: better than 4%.
- High reliability Cermetox resistive film.
- Suitable for use in television receiver high voltage circuits.



## MECHANICAL DATA

### Construction

The Cermetox sintered oxide film is fired on to a high purity ceramic rod to which is fitted brass end caps and welded terminations. The resistive film is adjusted to value with a helical cut and, finally, several coats of special lacquer provide protection to the resistive element.



### Maximum Dimensions (in millimetres)

Type	Length (L)	Weight (gms)
3963	22.8	2.0
3964	48.3	3.6
3965	84.2	5.7

Registered Trade Name  
**CERMETOX**

### TERMINATIONS

#### Material

Solder-coated copper wire.

#### Strength

Pull strength 1kg.

#### Solderability

The terminations adequately meet the requirements of BS2011, Part 2T, Method 1 (Solder bath).

### Marking

Legend marked with type reference, resistance value, tolerance and date code.

### Solvent Resistance

The protective coating of the body provides excellent resistance to all normal industrial cleaning solvents.

### Flammability

The resistors are non-flammable and meet the requirements of BS2011, Test Pa, Flammability.

**WELWYN ELECTRIC LIMITED**

BEDLINGTON • NORTHUMBERLAND • NE22 7AA • ENGLAND  
Telephone: Bedlington (0670) 822181 Telex: 53514



BS 9000  
approval number  
1023/M



# SERIES 39-60 Cermetox High Voltage Resistors

## ELECTRICAL DATA

Type	Resistance range (M $\Omega$ )	Rated dissipation at 20°C (watts)	Limiting element voltage (d.c. or a.c. r.m.s.)
3963	2 to 33	0.7	4kV
3964	2 to 100	1.3	10kV
3965	10 to 200	2.6	20kV

### Manufactured Values

Available in any value within the specified range.

### Selection Tolerance

$\pm 10\%$  is standard.  
 $\pm 5\%$  available to special order.

### Derating

Derate linearly from rated dissipation at 20°C to zero at 100°C.

### Thermal Impedance

Type reference	3963	3964	3965
Thermal impedance (°C/watt)	52	37	28

### Temperature Characteristic of Resistance

Over the range  $-40^{\circ}$  to  $+70^{\circ}$ C T.C.R. is substantially linear.

### Temperature Coefficient

The coefficient is typically between  $-1500$  ppm to  $-2000$  ppm/°C.

### Voltage Coefficient

The combined effect of voltage and self-heating is negative and accurately retraceable. The effect is dependent upon resistance value and will be within the range  $-7\%$  to  $-13\%$  when the limiting element voltage is applied. Lower voltages will have a proportionately reduced effect.

### Insulation Resistance

This series is not insulated. (See Application Notes.)

## ENVIRONMENTAL DATA

### Endurance

1000 hours at rated dissipation in 20°C ambient:  
 $\Delta R$  typically  $<4\%$ .

### Shelf Stability, 12 Months

$\Delta R$  typically 1%.

## APPLICATION NOTES

The wire terminations should not be bent closer than 1.5 mm from the body and the recommended minimum bend radius is 1 mm.

It is often appropriate in high voltage equipments to immerse the components in oil to avoid effects of corona and tracking. These resistors are suitable for immersion in transformer oil of the type Shell Diallyl B. If it is

required to use other types of oil, tests should be made to establish compatibility with the lacquer coating.

Because of the high voltage which can appear between the end cap and any adjacent metal part, it is recommended that these resistors be mounted at an adequate distance from other conducting parts.

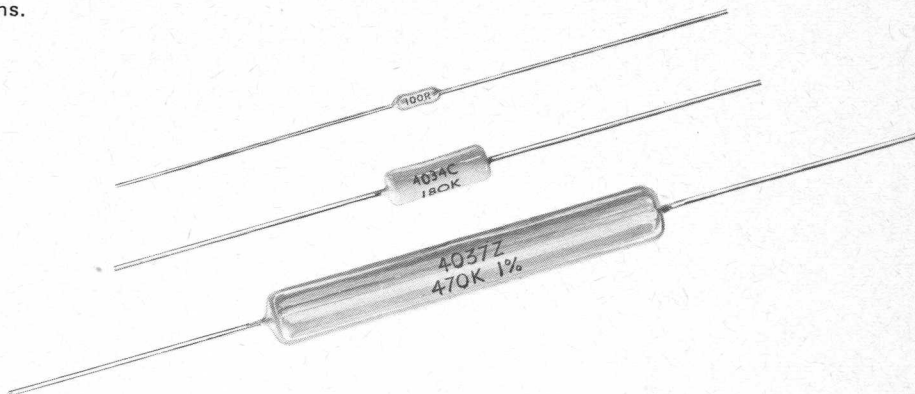
## ORDERING PROCEDURE

Specify type reference, resistance value and tolerance, e.g. 3964, 50M $\Omega$   $\pm 10\%$ , should be ordered using the IEC resistance code, thus : 3964-50M $\pm 10\%$ .



## FEATURES

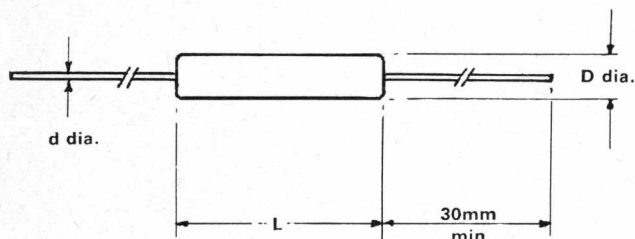
- Wide range of values and standard selection tolerances.
- Selected for temperature coefficient down to  $\pm 25$  ppm/ $^{\circ}$ C.
- Five sizes,  $\frac{1}{8}$  to 2 watts.
- Three sizes approved to BS9111 N016.
- Ceramic body and welded leads for mechanical strength.
- Suitable for high stability applications.



## MECHANICAL DATA

### Construction

A metal film is deposited on to a high purity ceramic former. Pressed caps are force fitted to the former, providing noise free electrical contact between film and cap. The resistor is trimmed to value with a helical cut in the film, termination wires are welded to the caps and, finally, the body is coated with a blue protection system to give complete immunity from the effects of moisture.



### Dimensions

Type	L mm max.	D mm max.	d mm nom.	Weight gms.	Minimum mounting centres INCHES*	
					length	width
4032	5.6	2.2	0.6	0.3	0.40	0.10
4033	8.9	3.2	0.8	0.6	0.50	0.15
4034	14.5	5.1	0.8	1.1	0.70	0.20
4036	27.0	9.1	0.8	3.5	1.20	0.40
4037	57.2	9.1	0.8	6.2	2.40	0.40

\*For maximum packing density, with adequate clearance, use this table of dimensions which is based on the 0.05" grid.

### TERMINATIONS

#### Material

Solder coated copper wire.

#### Strength

The terminations withstand all appropriate tests defined by BS9111 N016.

#### Solderability

The leads adequately meet the requirements of BS2011, Part 2T, Method 1 (Solder bath), Components for Normal Applications. This requires "... good tinning, with wetting of the terminations to within 2 mm of the point of emergence from the resistor body, at a solder bath temperature of 230 $^{\circ}$ C".

### Marking

Legend marked with resistance value, tolerance and temperature coefficient code. On the larger sizes, where space is available, the type reference and manufacturing date code are included.

Temperature coefficient is described by a suffix letter added to the type reference. Z denotes 100 ppm, C denotes 50 ppm and D denotes 25 ppm/ $^{\circ}$ C.

### Solvent Resistance

The body protection and marking are resistant to all industrial cleaning solvents suitable for printed circuits.

### Flammability

The self-extinguishing coating meets the requirements of BS2011, Test Pa, Flammability.

WELWYN ELECTRIC LIMITED

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BS 9000  
approval number  
1023/M



# SERIES 40-30

## ELECTRICAL DATA

Type	BS9111 N016 style	Rated dissipation at 70°C (watts)	Selection tolerance (See note 2)	Resistance range (ohms)			Limiting element voltage (Volts, d.c. or a.c. r.m.s.)	Isolation voltage (Volts, d.c. or a.c. peak)
				± 100 ppm/°C Code Z	± 50 ppm/°C Code C	± 25 ppm/°C Code D		
4032	JZ - 100ppM/°C	0.125 (See note 1)	± 1.0% 0.5 0.25	10 - 510k 20 - 510k 40 - 240k (See note 4.)	10 - 320k 20 - 320k 40 - 240k	50 - 120k	200	210
	JC - 50ppM/°C							
4033	KZ - 100ppM/°C	0.25 (See note 1)	± 1.0% 0.5 0.25 0.1	1 - 1.5M 10 - 1.5M 20 - 500k 40 - 250k	10 - 1.0M 10 - 1.0M 20 - 500k 40 - 250k	50 - 250k	250	280
	KC - 50ppM/°C							
4034	LZ - 100ppM/°C	0.5 (See note 1)	± 1.0% 0.5 0.25 0.1	1 - 5.0M 10 - 5.0M 20 - 2.0M 40 - 1.0M	10 - 3M 10 - 3M 20 - 2M 40 - 1M	50 - 1M	300	350
	LC - 50ppM/°C							
4036	—	0.65	± 1.0% 0.5 0.25 0.1	1 - 20M 10 - 15M 20 - 5.0M 40 - 2.5M	10 - 7.5M 10 - 7.5M 20 - 5.0M 40 - 2.5M	50 - 2.5M	500 (See note 3)	700
4037	—	1.3	± 1.0% 0.5 0.25 0.1	5 - 80M 10 - 40M 20 - 10M 40 - 5M	30 - 15M 30 - 15M 30 - 10M 40 - 5M	50 - 5M	1000 (See note 3)	1400

### Notes

- For details of stability performance at higher dissipations, see "Application Notes"
- It is recommended that resistors required at ± 0.1% tolerance should be confined to ± 25 ppm/°C. Similarly, ± 0.2% selection tolerance should not be ordered with a T.C. wider than ± 50 ppm/°C.
- At rated dissipation the applied voltage must not exceed limiting element voltage. At up to 50% of rated dissipation the applied voltage can be increased, depending on resistance value, to a maximum of 1500 volts on 4036 and 3000 volts on 4037.
- 4032Z is available below 10Ω and down to 5Ω at ± 2%; below 5Ω and down to 2Ω at ± 5%.
- Measurement of resistance is made at a point on the terminations 6mm from the body in accordance with BS E9110.

### Manufactured Values

The standard range is the E24 and E96 Series of preferred values.  
Values outside of these Series may be specially negotiated, depending on quantity.

### Derating

Derate linearly from rated dissipation at 70° to zero at 125°C. (See Application Notes.)

### Thermal Impedance

Type reference	4032	4033	4034	4036	4037
Thermal impedance (°C/watt)	144	92	70	77	46

### Insulation Resistance

>10<sup>11</sup> Ω at 500 volts d.c.

### Temperature Coefficient

± 100, ± 50 or ± 25 ppm/°C.

See table above for resistance range applicable to each T.C.

### Thermo-electric Effect

The e.m.f. generated due to differential temperature across the resistor is <2μV/°C.

### Voltage Coefficient

The effect of applied voltage is negligible.

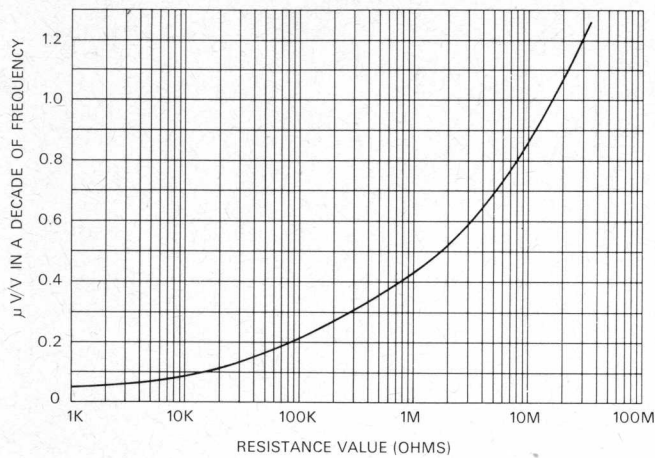
## INDUCTANCE AND CAPACITANCE

Resistance type	Residual capacitance in pF	Residual inductance in μH						
		10Ω	100Ω	1kΩ	10kΩ	100kΩ	1MΩ	10MΩ
4032	0.22	0.007	0.014	0.025	0.035	0.058	—	—
4033	0.25	0.010	0.021	0.045	0.054	0.070	0.070	—
4034	0.32	0.012	0.025	0.068	0.100	0.125	0.135	—
4036	0.41	0.018	0.090	0.450	0.830	1.020	1.100	1.400
4037	0.59	0.020	0.170	0.630	0.970	1.400	2.600	2.800



## NOISE

Graph 1



### Approved Resistance Range (BS9111 N016)

4032 - JZ	100ppM/°C	2Ω to 510kΩ
4033 - KZ	100ppM/°C	1Ω to 1.5MΩ
4034 - LZ	100ppM/°C	1Ω to 3.0MΩ
4032 - JC	50ppM/°C	10Ω to 240kΩ
4033 - KC	50ppM/°C	10Ω to 1.0MΩ
4034 - LC	50ppM/°C	10Ω to 3.0MΩ

## ENVIRONMENTAL DATA

### Endurance

1000 hours at full recommended dissipation in 70°C ambient:-

$\Delta R$  typically 0.2%, but can increase to a maximum of 0.5% for the highest resistance values in each size. See Graph 2.

### Shelf Stability, 12 Months

$\Delta R$  typically 0.1%.  $\Delta R$  can increase to a maximum of 0.25% for the highest resistance values in each size.

### Short Term Overload

After 6.25 times rated dissipation for 5 secs.:  
 $\Delta R$  typically 0.1%.

### Change due to Soldering

$\Delta R < 0.05\%$ .

### Climatic Category

55/125/21.

### Climatic Sequence

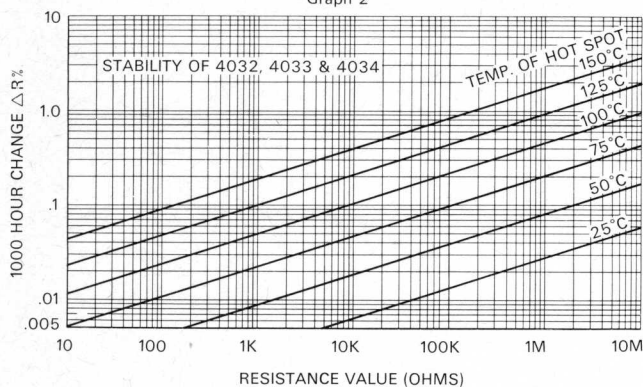
$\Delta R < 1\%$ .

### Temperature Rapid Change

$\Delta R < 0.1\%$ .

## APPLICATION NOTES

Graph 2



The stability of a film resistor is dependent on the power it dissipates, its resistance value and the ambient temperature. It follows that a resistor may be used at different levels of dissipation, according to the ambient conditions and the stability required for the application.

Graph No. 2 shows the relationship between stability and resistance values at different resistor hot spot temperatures. The hot spot temperature will result from the combined effect of ambient temperature and resistor dissipation.

Limiting element voltage will restrict permitted dissipation in the upper end of the resistance range. (But see also note 3 to table under "Electrical Data".)

The terminations should not be bent closer than 1.5 mm from the body, and the recommended minimum bend radius is 1 mm.

## ORDERING PROCEDURE

Specify type reference, resistance value, tolerance and temperature coefficient, e.g. 4033D, 6.8kΩ, ±1%. should be ordered using the IEC resistance code, thus: 4033D-6K8±1%.

The letter D signifies a T.C.R. of ± 25 ppm/°C  
(Use C for 50 ppm/°C and Z for 100 ppm/°C.)

If release is required specify also "Released to BS9111 N016" and the appropriate style reference. Certified test records (C.T.R.'s) are available for inspection by customers purchasing released products.





# Power Metox Resistors

**SERIES  
F**

S039 OCT. '74

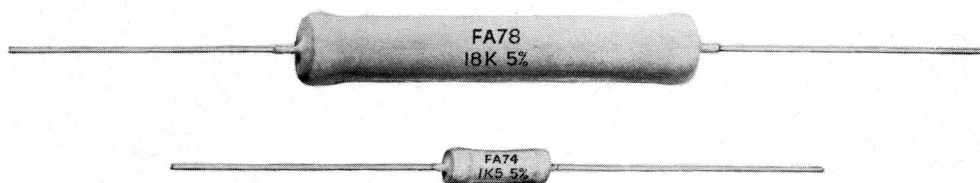
## FEATURES

- Four different mounting styles.
- Rugged construction for high reliability.
- Very wide resistance range.
- Suitable for domestic appliances and general purpose power applications.
- FA style approved to BS9111 FO11. Suitable for Post Office equipment.

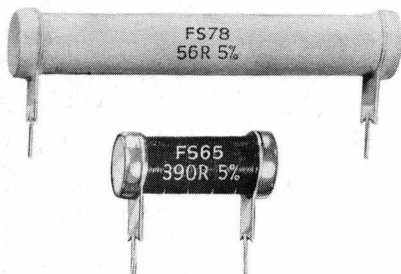
## GENERAL DESCRIPTION

The Welwyn range of Power Metox resistors offers four mounting styles, and can be supplied with cement or lacquer protection.

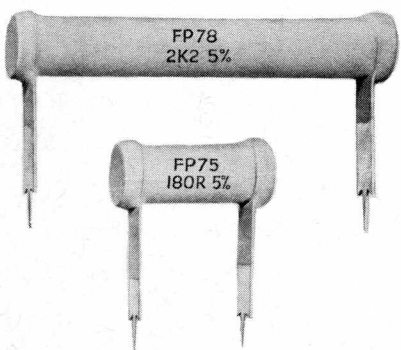
**FA70 style, cement protected, 5 sizes**



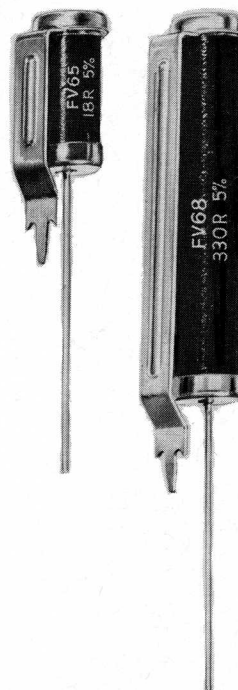
**FS60 style, lacquer protected  
FS70 style, cement protected  
5mm stand off, 4 sizes**



**FP60 style, lacquer protected  
FP70 style, cement protected  
15mm stand off, 4 sizes**



**FV60 style, lacquer protected  
FV70 style, cement protected  
4 sizes**



**WELWYN ELECTRIC LIMITED**

BEDLINGTON • NORTHUMBERLAND • NE22 7AA • ENGLAND  
Telephone: Bedlington (0670) 822181 Telex: 53514



BS 9000  
approval number  
1023/M

# SERIES F

## MECHANICAL DATA

### Construction

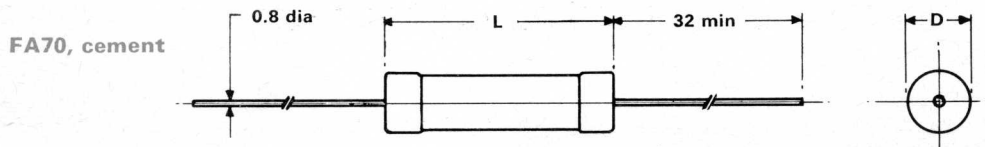
Oxide film range: The oxide film is deposited on to a high purity ceramic rod. End caps are force fitted and terminations either welded to the caps or formed integrally with them, according to style. The resistive film is trimmed to value by a helical cut in the resistor body. Axial termination styles are protected with grey cement, whilst vertical and horizontal mounting styles are protected either with cement or with high temperature lacquer. The design of the lugs of both vertical and horizontal mounting styles ensures that the

resistor will remain positively located after insertion into the printed circuit board during flow soldering.

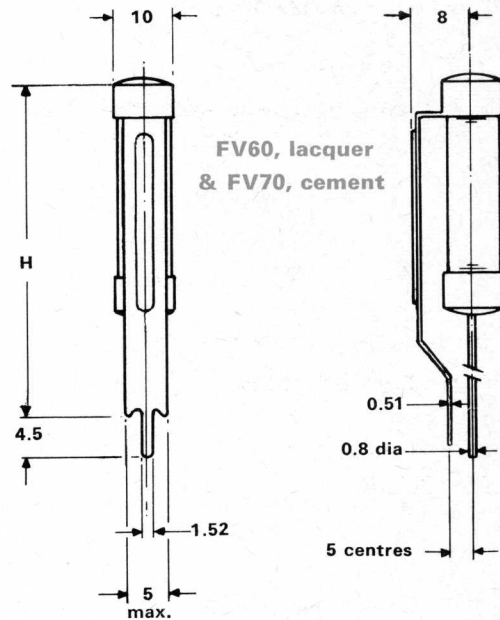
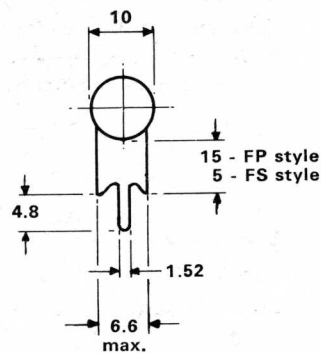
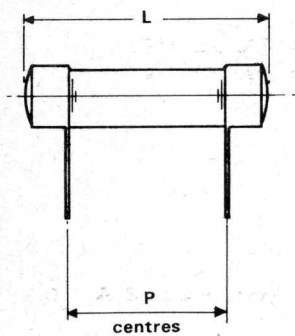
Wirewound range: The value range of the oxide resistors is extended down to  $0.1\Omega$  by the inclusion of a wirewound version. The resistive wire is welded at each end to the caps; terminal fitting and protection are the same as for the oxide film range, and operating characteristics are similar or better. Protection is with grey cement.

### Maximum Dimensions (in millimetres)

Size ref. *	Style reference						Approx. weight (gms)
	FA7*		L	FP6*, FP7* FS6*, FS7*		FV7* FV6*	
	oxide	wirewound		L	P	H	
4	5.1	5.4	14	—	—	—	1.1
5	9.2	10.0	22	22	15.2	30	3.7
6	9.2	10.0	32	32	25.4	40	5.2
7	9.2	10.0	42	42	35.6	50	6.6
8	9.2	10.0	52	52	45.7	60	8.0



FS60, lacquer & FS70, cement short lug.  
FP60, lacquer & FP70, cement long lug.



### TERMINATIONS

#### Material

Solder coated copper wire or solder coated brass lugs.

#### Strength (wire)

Pull strength 1 kg.

#### Solderability

The terminations adequately meet the requirements of BS2011, Part 2T, Method 1 (Solder bath).

### Marking

Legend marked with type reference, value, tolerance.

### Flammability

Both types of protection are flame retardent and meet the requirements of BS2011, Test Pa, Flammability.





**ELECTRICAL DATA**

Type reference	Resistance range (ohms)			Rated dissipation at 40°C (watts)	Limiting element voltage (volts d.c.)	BS9111 F011 Applicable only to axial (FA) style	
	Min. at ±10%	Min. at ±5%	Max. at ±5%			Proof voltage (volts a.c. peak)	Max. rating at 70°C (watts)
FA 74	0.1	0.5	40k	2.0	350	—	—
FA, FP, FS 75	0.1	0.5	60k	3.7	450	400	3.0
FA, FP, FS 76	0.1	0.5	65k	5.9	500	400	5.0
FA, FP, FS 77	0.1	0.75	70k	7.0	650	400	6.0
FA, FP, FS 78	0.2	1.0	80k	8.2	650	400	7.0
FP, FS, FV 65. FV 75	20 to 60k			3.7	450	400	3.0
FP, FS, FV 66. FV 76	20 to 65k			5.9	500	400	5.0
FV 67, 77	40 to 70k			7.0	650	400	6.0
FV 68, 78	50 to 80k			8.2	650	400	7.0

\* Lacquered resistors (FP, FS, FV 60) are not insulated.

Resistors with the following resistance range are wirewound.

Size reference	4	5	6	7	8
Resistance values below	20Ω	20Ω	20Ω	40Ω	50Ω

**Manufactured Values**

The standard values are defined by the E24 Series. Other values can be obtained by negotiation, subject to a requirement for suitable quantities.

**Standard Selection Tolerances**

± 10%, ±5%.

**Derating**

Derate linearly from rated dissipation at 40°C to zero at 235°C. See also Application Notes concerning mounting on p.c. boards.

**Thermal Impedance**

Size reference	4	5	6	7	8
Thermal impedance (°C/watt)	65	44	40	30	26

Note that the thermal impedance will not be significantly affected by the type of termination. Thus the FA77 will have a very similar impedance to the FV77. See Application Notes.

**Temperature Coefficient**

Oxide film: not greater than ± 500 ppm/°C.  
Wirewound: not greater than + 100 ppm/°C.

**ENVIRONMENTAL DATA**

**Endurance**

1000 hours at full load in 40°C ambient: ΔR <3%.

**Shelf Stability, 12 Months**

ΔR <2%.

**Change due to Soldering**

ΔR <0.5%.

**Climatic Category**

40/125/56.

**Climatic Sequence (BS2011, Procedure 3 of Z/ABDM)**

ΔR typically 1%.

**Temperature Rapid Change**

ΔR <0.5%.

**Approved Resistance Range (BS9111 F011)**

Type reference	FA75	FA76	FA77	FA78
Resistance range	51Ω to 11kΩ	51Ω to 8.2kΩ	51Ω to 6.8kΩ	51Ω to 5.6kΩ



**APPLICATION NOTES**

The axial terminations should not be bent closer than 1.5 mm from the body, and the recommended minimum bend radius is 1 mm. If the resistors are to dissipate full rated power, it is recommended that the terminations should not be soldered closer than 4 mm from the body.

The protective coating should not be subjected to industrial solvents.

Due to limitations imposed by some p.c.b. materials, derating may be necessary. In general, the lower the cost of the basic material the lower will be its maximum operating

temperature. To ensure that this temperature is not exceeded, derating must be applied as indicated in the table below. The power ratings shown in the table have been recommended on the evidence of worst case conditions, but some relaxation may be possible in certain cases. The board hot spot will occur at the junction of board and resistor termination, but the temperature rise of the board will not exceed that specified in BS415, for the stated materials, providing that the recommended deratings are adhered to.

Type ref.	Ambient Temperature	P.C. board material and BS415 recommended max. operating temperatures		
		Resin impregnated paper 105°C	Phenolic resins, cellulose fillers 130°C	Epoxy resins and glass fibre 155°C
		Max. dissipation for worst condition mounting (watts)		
FS65 FS75	20°C	3.7	3.7	3.7
	40°C	2.8	3.7	3.7
	70°C	1.3	3.0	3.0
FS66 FS76	20°C	5.3	5.9	5.9
	40°C	3.5	5.0	5.9
	70°C	1.4	3.0	5.0
FS67 FS77	20°C	5.5	7.0	7.0
	40°C	3.5	6.0	7.0
	70°C	1.5	3.5	6.0
FS68 FS78	20°C	8.2	8.2	8.2
	40°C	5.5	8.2	8.2
	70°C	2.5	5.0	7.0
FP65, 75 FV65, 75	20°C	3.7	3.7	3.7
	40°C	3.5	3.7	3.7
	70°C	2.0	3.0	3.0
FP66, 76 FV66, 76	20°C	5.9	5.9	5.9
	40°C	4.5	5.5	5.9
	70°C	2.5	4.0	5.0
FP67, 77 FV67, 77	20°C	7.0	7.0	7.0
	40°C	7.0	7.0	7.0
	70°C	3.0	6.0	6.0
FP68, 78 FV68, 78	20°C	8.2	8.2	8.2
	40°C	8.2	8.2	8.2
	70°C	4.5	7.0	7.0

Silicone resins, polyimide, PTFE and other high grade materials which can withstand temperatures in excess of 155°C will not require derating of resistors.

FA style resistors, when mounted directly on a p.c. board, will impart a similar temperature rise to the board as is experienced by the resistor. See table "Thermal Impedance".

**ORDERING PROCEDURE**

Specify type reference, value and tolerance, e.g. FV77, 10kΩ ±10%, should be ordered using the IEC resistance code, thus: FV77-10K±10%.





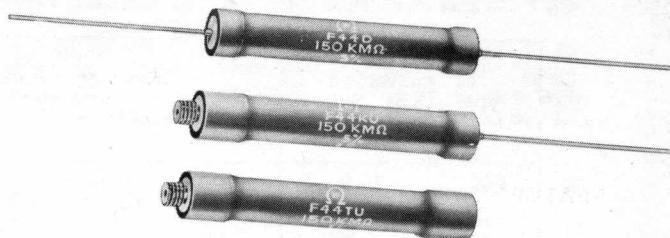
# High Voltage Resistors

**SERIES  
F40**

S028 OCT. '74

## FEATURES

- Continuous d.c. voltage up to 14kV.
- Pulse voltage up to 50kV.
- Resistance values up to 150GΩ.
- Stability 1%.
- Resistors can be matched and assembled into multiple units, e.g. for precision high voltage dividers.

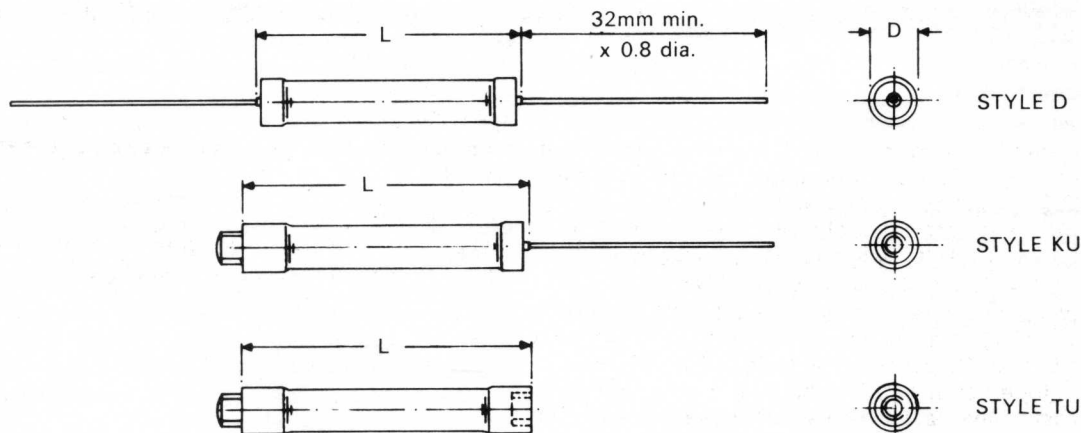


## MECHANICAL DATA

### Construction

The resistive film (Cermetox oxide film) is deposited on to a high purity ceramic rod. Turned brass caps are force fitted and the resistive film adjusted to value with a helical cut in the ceramic. An irradiated polyolefin sleeve provides mechanical protection and insulation.

Three styles of termination are offered: these permit single resistors to be used as axial wired components (style D); or assemblies of resistors may be screwed together, using a combination of Styles TU and KU, to provide a termination wire at each end for electrical connections.



### Maximum Dimensions (in millimetres)

Type	Length (L)	Diameter (D)	Weight (gms)
F43D	25.4	8.4	2.7
F44D	50.8	8.4	4.9
F43KU	30.2	8.5	3.5
F44KU	53.2	8.5	6.4
F43TU	32.6	8.5	5.3
F44TU	55.6	8.5	8.4

### Marking

Legend marked with type reference, ohmic value and tolerance.

### Solvent Resistance

The polyolefin sleeve provides excellent resistance to all normal industrial cleaning solvents.

### Flammability

The polyolefin sleeve is flame retardant within the terms of DEF5011, Test No. 7, Fire Risk.

## TERMINATIONS

### Styles D and KU

Material: Solder coated copper wire.

Strength: Pull strength 1kg.

Solderability: The terminations adequately meet the requirements of BS9110, Clause 1.2.6.2.

### Styles KU and TU

All caps are tapped UNF-10 x 4.2 mm deep (full depth thread).

UNF-10 is 32TPI, 60° thread angle, 4.72 ± 0.07 mm outside diameter, 3.83 mm core diameter.

All style KU and TU resistors are supplied with a single 8 mm long screwed coupling stud.

**WELWYN ELECTRIC LIMITED**

BEDLINGTON • NORTHUMBERLAND • NE22 7AA • ENGLAND

Telephone: Bedlington (0670) 822181 Telex: 53514



BS 9000  
APPROVED FACTORY  
1023/M

## ELECTRICAL DATA

Type	Rating at 20°C. (watts)	Resistance Ranges in standard selection tolerances	Limiting Element Voltage (kV d.c. or a.c. r.m.s.)	Isolation Voltage (kV d.c. or a.c. peak)
F43	0.7	2MΩ to 100GΩ at ±10%, ±5% 2MΩ to 3GΩ at ±2%	4	6
F44	1.3	2MΩ to 150GΩ at ±10%, ±5% 2MΩ to 10GΩ at ±2%	14	14

### Manufactured Values

Available in any value within the specified range.

### Standard Selection Tolerances

±10% ±5%, ±2%.

### Derating

Derate linearly from full load at 20°C. to zero at 100°C.

### Temperature Characteristic

Over the range -40° to +100°C., the characteristic is substantially linear.

### Temperature Coefficient

The coefficient is typically within the range -1500 ppm to -2000 ppm/°C.

### Voltage Coefficient

The combined effect of voltage and self-heating is negative and accurately retraceable. The effect is dependent upon resistance value and will be within the range -5% to -9% when the limiting element voltage is applied. Lower voltages will have a proportionately reduced effect.

### Noise

The voltage noise has been measured in accordance with I.E.C. 195, with applied voltages up to 250V. Noise is typically less than 2μV/volt per decade of frequency.

### Insulation Resistance

Greater than 10<sup>13</sup>Ω at 500V d.c.

## ENVIRONMENTAL DATA

### Endurance

1000 hours at full load in 20°C. ambient  
ΔR typically better than 1%.

### Shelf Stability, 12 Months

ΔR typically 0.5%

### Climatic Category

40/100/21. Due to the possibility of surface condensation it is recommended that these resistors are not used in conditions of high humidity with applied high voltage.

## APPLICATION NOTES

It is often appropriate in high voltage equipments to assemble the components in oil to avoid effects of corona and tracking. When it is required to use these resistors in oil they can be supplied with a lacquer protection suitable for transformer oil of the type Shell Diallyl B. This type is designated by the suffix H after the type reference. E.g. F44DH. If it is required to use other types of oil, tests should be made to establish compatibility with the lacquer coating.

Because of the high voltage which can appear between the end cap and any adjacent metal part, it is recommended that these resistors should be mounted at an adequate distance from other conducting parts.

The wire terminations should not be bent closer than 1.5 mm from the body, and the recommended minimum bend radius is 1 mm.

Care should be taken to prevent the resistor markings from being abraded whilst cleaning solvents or their vapour is present.

### Matched Sets

The performance of the F40 Series resistors makes them ideal for use in high voltage divider chains: the ratio stability will be <2% after 1000 hours on full load. Voltage dividers can be supplied as custom built sets with a ratio accuracy of 1%, alternatively of 2%.

The following details should be provided to initiate a custom built design:—

- Maximum working voltage of chain.
- Range of working voltage variation during operation.
- Voltage ratio and accuracy over stated range of operating voltage.
- Operating ambient temperature range.
- Operating environment of divider chain.
- Physical mounting and assembly details.
- Quantity required.

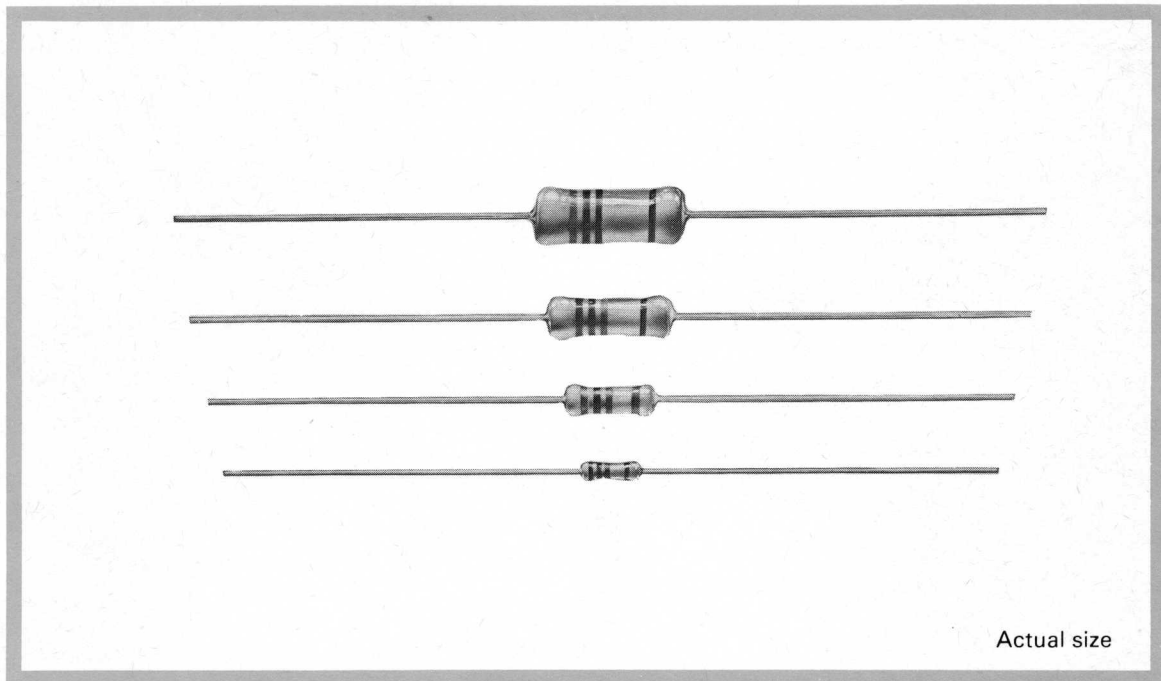
## ORDERING PROCEDURE

Specify type reference, resistance value and tolerance, e.g. F44KU, 100MΩ ±5%, should be ordered using the IEC resistance code, thus: F44KU-100M±5%.





# Miniature Metox<sup>®</sup> Resistors Series MR



**\*Fully approved to BS9111 N002 – 10Ω to 1MΩ**

\*Multiple rating – predictable stability for any combination of load and ambient temperature.

\*High reliability – assessed from 230 million unit test hours.

\*Proven load life stability –  $\Delta R$  1.5% median after 70,000 hours.

\*High mechanical strength – ceramic body and welded cap-to-termination wire assembly.

\*Legible colour code – light grey body colour.

**\*MR4 and MR5 are STOCK ITEMS, 10Ω and above**

**Welwyn** Electric Limited

BEDLINGTON NORTHUMBERLAND NE22 7AA ENGLAND

Telephone: Bedlington (0670) 822181

Telex: 53514



BS 9000  
approval number  
1023/M

# Miniature Metox Resistors

## MECHANICAL DATA

### CONSTRUCTION

The resistive film is deposited on to a high purity ceramic former. Pressed caps are force fitted to the former, providing excellent electrical contact between film and cap. The resistor is trimmed to value with a helical cut in the film, termination wires are welded to the cap and, finally, the body is conformally coated with cement and solvent proof lacquer to give complete protection against moisture.

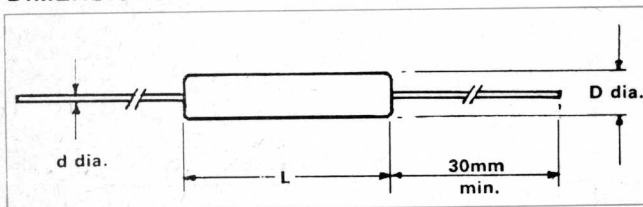
### SOLVENT RESISTANCE

The body protection and marking are resistant to all industrial cleaning solvents suitable for printed circuits.

### FLAMMABILITY

The self-extinguishing coating meets the requirements of BS2011, Test Pa, Flammability.

### DIMENSIONS



Type	L mm max.	D mm max.	d mm mon.	Weight gms.	Minimum mounting centres INCHES*	
					Length	Width
MR4	7.0	2.3	0.6	0.3	0.45	0.10
MR5	10.0	3.2	0.8	0.6	0.55	0.15
MR6	14.5	5.1	0.8	1.1	0.75	0.20
MR8	17.3	7.5	0.8	1.7	0.85	0.30

\*For maximum packing density, with adequate clearance, use this table of dimensions (based on the 0.05" grid) to establish printed circuit board drill centres. See also information on back page concerning preforming.

### APPROVED RESISTANCE RANGE TO BS9111 N002

Type	MR4	MR5	MR6	MR8	Certified test records (C.T.R.'s) are available for inspection by customers who purchase released products.
Resistance ( $\Omega$ )	10 to 150k	10 to 1M	10 to 1M	10 to 10k	

## ELECTRICAL DATA

Type	Resistance range (ohms)	Rating	Limiting element voltage (volts d.c. or a.c. r.m.s.)	BS9111 N002			
				B.S. style	B.S. max. rating (watts) for stability of		
					3%	2%	1%
MR4	10 to 150k	Refer	250	FX	0.25	0.125	0.063
MR5	1 to 1M	to	350	EX	0.5	0.25	0.125
MR6	1 to 1M	stability	500	DX	1.0	0.5	0.25
MR8	10 to 47k	data	700	CX	2.0	1.0	0.5

### Manufactured Values

Standard values: E24 Series down to 10 $\Omega$  } See "Stock items" on back page.  
E12 Series below 10 $\Omega$   
Also 140 $\Omega$  and 600 $\Omega$

Non-standard values, if suitable for colour coding, will be manufactured when the quantity is sufficiently large.

### Selection Tolerances

1 $\Omega$  to 2.2 $\Omega$ :  $\pm 10\%$   
2.7 $\Omega$  to 9.1 $\Omega$ :  $\pm 10\%$ ,  $\pm 5\%$   
10 $\Omega$  and above:  $\pm 5\%$ ,  $\pm 2\%$ ,  $\pm 1\%$

### INDUCTANCE AND CAPACITANCE

Type	Residual capacitance in pF (all values)	Residual inductance — $\mu$ H					
		10 $\Omega$	100 $\Omega$	1k $\Omega$	10k $\Omega$	100k $\Omega$	1M $\Omega$
MR4	0.13	0.003	0.005	0.008	0.009	0.009	—
MR5	0.19	0.005	0.009	0.021	0.036	0.042	0.042
MR6	0.26	0.006	0.010	0.035	0.053	0.065	0.073
MR8	0.50	0.016	0.030	0.124	0.187	0.200	—

**Derating** Refer to Stability Data

**Voltage Coefficient** Negligible

**Insulation Resistance**  $> 10^{10}\Omega$  at 500 V d.c.

### Thermal Impedance

Type reference	MR4	MR5	MR6	MR8
Thermal impedance ( $^{\circ}$ C/watt)	140	90	70	50

### Temperature Coefficient

Not greater than  $\pm 250$  ppm/ $^{\circ}$ C.

Note that over the full resistance range, T.C. will be within  $\pm 150$  ppm/ $^{\circ}$ C to a confidence level of 75%



## STABILITY AND ENVIRONMENTAL DATA

The stability of a film resistor is dependent on power dissipation, ambient temperature and resistance value. It follows that a given size of resistor may be used at different dissipation levels, according to the stability required in its application.

The Multiple Rating concept of Miniature Metox resistors was introduced for this reason. As guidance to the user in the selection of the appropriate resistor size for a given application, the relationship between stability, dissipation and ambient temperature for MR4, MR5 and MR6 is shown in Graphs Nos. 1, 2 and 3. The stability figures are representative of the performance of resistors at the "critical resistance value", i.e. that value for which the limiting element voltage is applied to achieve the specified dissipation. Resistance values either side of "the critical value" will tend to provide greater stability.

Graph No. 4 shows the relationship between stability and resistance value for MR4, MR5 and MR6 when the resistor is loaded (combination of dissipation and ambient temperature) to give an element temperature of 100°C.

When the user has determined the stability, resistance value, dissipation and ambient temperature appropriate to the application, he can select the smallest suitable resistor by reference to the two sets of graphs.

It is recommended that Miniature Metox resistors should not be used with an element temperature exceeding 155°C.

**Shelf Stability, 12 Months**  $\Delta R$  typically 0.1%

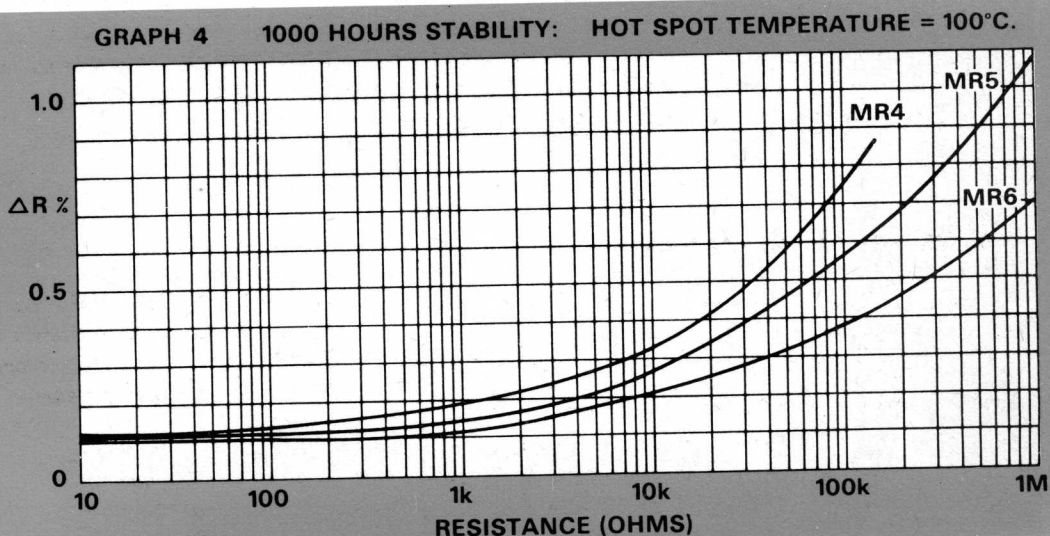
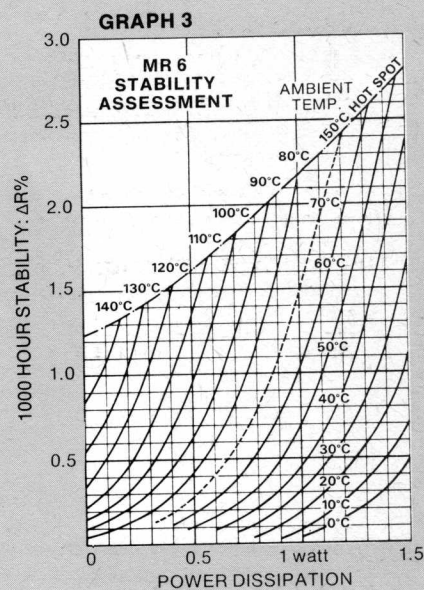
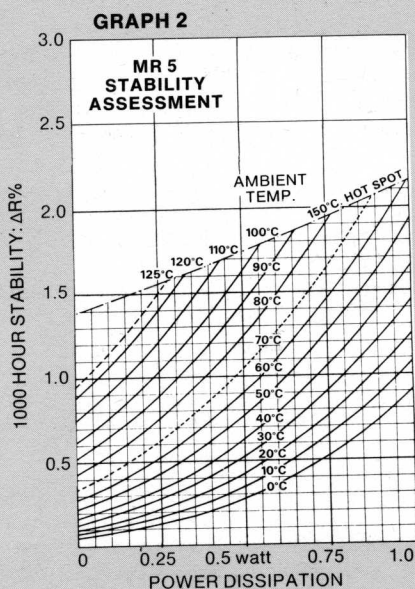
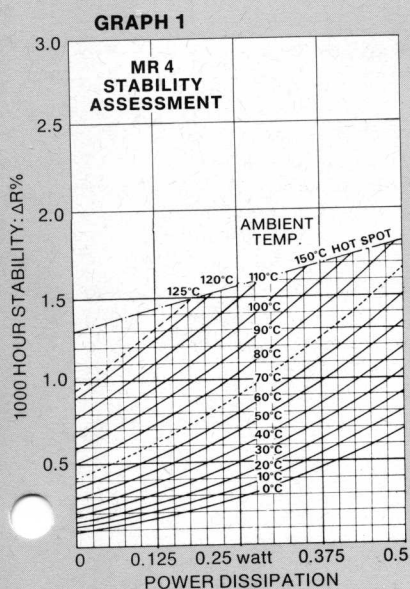
**Short term Overload** After 5 secs. at 6.25 times B.S. max. rated dissipation for 3% stability:  $\Delta R$  typically 0.1%.

**Resistance to Soldering Heat**  $\Delta R < 0.1\%$  (B.S. limit  $< 0.15\%$ ).

**Climatic Category** 55/125/56.

**Climatic Sequence**  $\Delta R 0.5\%$  (B.S. limit 1% max.).

**Temperature Rapid Change**  $\Delta R < 0.25\%$  (B.S. limit 0.5% max.).



## RELIABILITY

Assessed as the result of 230,000,000 unit hours at B.S. rated dissipation in ambient of 50°C when there were two failures. (Criterion of failure:  $\Delta R$

>5%). The mean time between failures (m.t.b.f.) is  $7.40 \times 10^7$  hours and the failure rate is 0.0014% per 1000 hours at 60% confidence level.

## APPLICATION NOTES

The terminations should not be bent closer than 1.5mm from the body, and the recommended minimum bend radius is equal to the wire diameter.

Limiting element voltage will restrict the permitted dissipation of resistance values in the upper end of the resistance range.

## ORDERING PROCEDURE

Specify type reference, resistance value and tolerance. E.g. MR4, 6.8k $\Omega$   $\pm 2\%$ , and should be ordered using the I.E.C. resistance code, thus: MR4-6K8 $\pm 2\%$ .

If release is required specify this, also the appropriate style reference, e.g. Release to BS9111 N002-FX.

## STOCK ITEMS

MR4 & MR5 are normally available ex-stock in the whole of the E24 preferred value range (10 $\Omega$  and

above), and in each of the three tolerances.

## MEASUREMENT OF RESISTOR LENGTH

Welwyn use the method of measurement recommended in BS9110 to check resistor length. See figure 1. The slight chamfer on the cheek inside face is to accommodate the radius formed by the body coating.

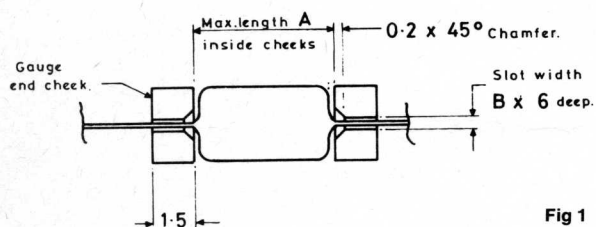


Fig 1

Slot B extends 6mm down the cheek to ensure that the full diameter of the resistor body is embraced in this test method.

The "clean-wire" length of termination at least must commence at the point where the wire emerges outside the cheek when the resistor body is pushed up against that cheek; first at one end and then at the opposite end.

Max. dimensions - millimetres

	MR4	MR5	MR6	MR8
A	7.0	10.0	14.5	17.3
B	1.0	1.2	1.2	1.2

## RESISTOR TERMINATION WIRE PREFORMING

Termination wires can be preformed and cropped, ready for semi-automatic component insertion equipment, alternatively to reduce labour content in component assembly costs.

Precise details of the preformed components must be supplied, using the nomenclature of figure 2.

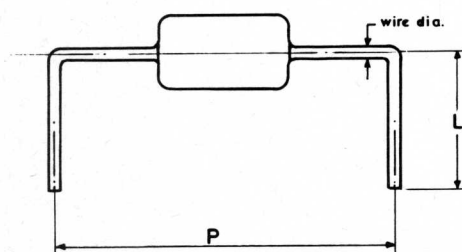


Fig 2

P - pitch of formed wires. See table below for minimum dimension.

L - effective length of formed wire, measured from resistor axis.

Minimum Pitch P

	MR4	MR5	MR6	MR8
Preferred	10.8	13.8	18.3	21.1
By negotiation	9.8	12.8	17.3	20.1

All dimensions should be stated in millimetres, giving tolerances where applicable.

Due consideration must be given to the resistor body maximum dimensions as defined in this data sheet.

# Welwyn Electric Limited

BEDLINGTON NORTHUMBERLAND NE22 7AA ENGLAND

Telephone: Bedlington (0670) 822181

Telex: 53514



BS 9000  
approval number  
1023/M



Miniature Metox Resistors  
**NATO STOCK NUMBERS**  
 BS 9111 N002 Fixed non-wirewound insulated resistors

**SERIES**  
**MR**

S060 OCT. '74

**TYPE MR4 Style FX ±1%**

**TYPE MR4 Style FX ±2%**

± 1% SELECTION TOLERANCE						± 2% SELECTION TOLERANCE					
Nominal Ohms	NOMINAL OHMS MULTIPLIER					Nominal Ohms	NOMINAL OHMS MULTIPLIER				
	× 1 10Ω to 91Ω 5905-99-	× 10 100Ω to 910Ω 5905-99-	× 10 <sup>2</sup> 1KΩ to 9.1KΩ 5905-99-	× 10 <sup>3</sup> 10KΩ to 91KΩ 5905-99-	× 10 <sup>4</sup> 100KΩ to 910KΩ 5905-99-		× 1 10Ω to 91Ω 5905-99-	× 10 100Ω to 910Ω 5905-99-	× 10 <sup>2</sup> 1KΩ to 9.1KΩ 5905-99-	× 10 <sup>3</sup> 10KΩ to 91KΩ 5905-99-	× 10 <sup>4</sup> 100KΩ to 910KΩ 5905-99-
10	013-6189	013-6213	013-6237	013-6261	013-6285	10	013-6290	013-6314	013-6338	013-6362	013-6386
11	013-6190	013-6214	013-6238	013-6262	013-6286	11	013-6291	013-6315	013-6339	013-6363	013-6387
12	013-6191	013-6215	013-6239	013-6263	013-6287	12	013-6292	013-6316	013-6340	013-6364	013-6388
13	013-6192	013-6216	013-6240	013-6264	013-6288	13	013-6293	013-6317	013-6341	013-6365	013-6389
15	013-6193	013-6217	013-6241	013-6265	013-6289	15	013-6294	013-6318	013-6342	013-6366	013-6390
16	013-6194	013-6218	013-6242	013-6266		16	013-6295	013-6319	013-6343	013-6367	
18	013-6195	013-6219	013-6243	013-6267		18	013-6296	013-6320	013-6344	013-6368	
20	013-6196	013-6220	013-6244	013-6268		20	013-6297	013-6321	013-6345	013-6369	
22	013-6197	013-6221	013-6245	013-6269		22	013-6298	013-6322	013-6346	013-6370	
24	013-6198	013-6222	013-6246	013-6270		24	013-6299	013-6323	013-6347	013-6371	
27	013-6199	013-6223	013-6247	013-6271		27	013-6300	013-6324	013-6348	013-6372	
30	013-6200	013-6224	013-6248	013-6272		30	013-6301	013-6325	013-6349	013-6373	
33	013-6201	013-6225	013-6249	013-6273		33	013-6302	013-6326	013-6350	013-6374	
36	013-6202	013-6226	013-6250	013-6274		36	013-6303	013-6327	013-6351	013-6375	
39	013-6203	013-6227	013-6251	013-6275		39	013-6304	013-6328	013-6352	013-6376	
43	013-6204	013-6228	013-6252	013-6276		43	013-6305	013-6329	013-6353	013-6377	
47	013-6205	013-6229	013-6253	013-6277		47	013-6306	013-6330	013-6354	013-6378	
51	013-6206	013-6230	013-6254	013-6278		51	013-6307	013-6331	013-6355	013-6379	
56	013-6207	013-6231	013-6255	013-6279		56	013-6308	013-6332	013-6356	013-6380	
62	013-6208	013-6232	013-6256	013-6280		62	013-6309	013-6333	013-6357	013-6381	
68	013-6209	013-6233	013-6257	013-6281		68	013-6310	013-6334	013-6358	013-6382	
75	013-6210	013-6234	013-6258	013-6282		75	013-6311	013-6335	013-6359	013-6383	
82	013-6211	013-6235	013-6259	013-6283		82	013-6312	013-6336	013-6360	013-6384	
91	013-6212	013-6236	013-6260	013-6284		91	013-6313	013-6337	013-6361	013-6385	

**TYPE MR4 Style FX ±5%**

± 5% SELECTION TOLERANCE					
Nominal Ohms	NOMINAL OHMS MULTIPLIER				
	× 1 10Ω to 91Ω 5905-99-	× 10 100Ω to 910Ω 5905-99-	× 10 <sup>2</sup> 1KΩ to 9.1KΩ 5905-99-	× 10 <sup>3</sup> 10KΩ to 91KΩ 5905-99-	× 10 <sup>4</sup> 100KΩ to 910KΩ 5905-99-
10	013-6391	013-6415	013-6439	013-6463	013-6487
11	013-6392	013-6416	013-6440	013-6464	013-6488
12	013-6393	013-6417	013-6441	013-6465	013-6489
13	013-6394	013-6418	013-6442	013-6466	013-6490
15	013-6395	013-6419	013-6443	013-6467	013-6491
16	013-6396	013-6420	013-6444	013-6468	
18	013-6397	013-6421	013-6445	013-6469	
20	013-6398	013-6422	013-6446	013-6470	
22	013-6399	013-6423	013-6447	013-6471	
24	013-6400	013-6424	013-6448	013-6472	
27	013-6401	013-6425	013-6449	013-6473	
30	013-6402	013-6426	013-6450	013-6474	
33	013-6403	013-6427	013-6451	013-6475	
36	013-6404	013-6428	013-6452	013-6476	
39	013-6405	013-6429	013-6453	013-6477	
43	013-6406	013-6430	013-6454	013-6478	
47	013-6407	013-6431	013-6455	013-6479	
51	013-6408	013-6432	013-6456	013-6480	
56	013-6409	013-6433	013-6457	013-6481	
62	013-6410	013-6434	013-6458	013-6482	
68	013-6411	013-6435	013-6459	013-6483	
75	013-6412	013-6436	013-6460	013-6484	
82	013-6413	013-6437	013-6461	013-6485	
91	013-6414	013-6438	013-6462	013-6486	

**APPROVED RANGE**  
 10 Ω to 150 k Ω

*Note:* The range of approvals may be extended, so reference to Welwyn Electric Limited should be made for requirements not shown.

**WELWYN ELECTRIC LIMITED**

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BS9000  
 (FORWARD NUMBER)  
 1023/M

**TYPE MR5 Style EX ±1%**

**TYPE MR5 Style EX ±2%**

± 1% SELECTION TOLERANCE

Nominal Ohms	NOMINAL OHMS MULTIPLIER				
	× 1 10Ω to 91Ω	× 10 100Ω to 910Ω	× 10 <sup>2</sup> 1KΩ to 9.1KΩ	× 10 <sup>3</sup> 10KΩ to 91KΩ	× 10 <sup>4</sup> 100KΩ to 910KΩ
	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-
10	013-5826	013-5850	013-5874	013-5898	013-5922
11	013-5827	013-5851	013-5875	013-5899	013-5923
12	013-5828	013-5852	013-5876	013-5900	013-5924
13	013-5829	013-5853	013-5877	013-5901	013-5925
15	013-5830	013-5854	013-5878	013-5902	013-5926
16	013-5831	013-5855	013-5879	013-5903	013-5927
18	013-5832	013-5856	013-5880	013-5904	013-5928
20	013-5833	013-5857	013-5881	013-5905	013-5929
22	013-5834	013-5858	013-5882	013-5906	013-5930
24	013-5835	013-5859	013-5883	013-5907	013-5931
27	013-5836	013-5860	013-5884	013-5908	013-5932
30	013-5837	013-5861	013-5885	013-5909	013-5933
33	013-5838	013-5862	013-5886	013-5910	013-5934
36	013-5839	013-5863	013-5887	013-5911	013-5935
39	013-5840	013-5864	013-5888	013-5912	013-5936
43	013-5841	013-5865	013-5889	013-5913	013-5937
47	013-5842	013-5866	013-5890	013-5914	013-5938
51	013-5843	013-5867	013-5891	013-5915	013-5939
56	013-5844	013-5868	013-5892	013-5916	013-5940
62	013-5845	013-5869	013-5893	013-5917	013-5941
68	013-5846	013-5870	013-5894	013-5918	013-5942
75	013-5847	013-5871	013-5895	013-5919	013-5943
82	013-5848	013-5872	013-5896	013-5920	013-5944
91	013-5849	013-5873	013-5897	013-5921	013-5945

(013-5946 1MΩ)

± 2% SELECTION TOLERANCE

Nominal Ohms	NOMINAL OHMS MULTIPLIER				
	× 1 10Ω to 91Ω	× 10 100Ω to 910Ω	× 10 <sup>2</sup> 1KΩ to 9.1KΩ	× 10 <sup>3</sup> 10KΩ to 91KΩ	× 10 <sup>4</sup> 100KΩ to 910KΩ
	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-
10	013-5947	013-5971	013-5995	013-6019	013-6043
11	013-5948	013-5972	013-5996	013-6020	013-6044
12	013-5949	013-5973	013-5997	013-6021	013-6045
13	013-5950	013-5974	013-5998	013-6022	013-6046
15	013-5951	013-5975	013-5999	013-6023	013-6047
16	013-5952	013-5976	013-6000	013-6024	013-6048
18	013-5953	013-5977	013-6001	013-6025	013-6049
20	013-5954	013-5978	013-6002	013-6026	013-6050
22	013-5955	013-5979	013-6003	013-6027	013-6051
24	013-5956	013-5980	013-6004	013-6028	013-6052
27	013-5957	013-5981	013-6005	013-6029	013-6053
30	013-5958	013-5982	013-6006	013-6030	013-6054
33	012-5959	013-5983	013-6007	013-6031	013-6055
36	013-5960	013-5984	013-6008	013-6032	013-6056
39	013-5961	013-5985	013-6009	013-6033	013-6057
43	013-5962	013-5986	013-6010	013-6034	013-6058
47	013-5963	013-5987	013-6011	013-6035	013-6059
51	013-5964	013-5988	013-6012	013-6036	013-6060
56	013-5965	013-5989	013-6013	013-6037	013-6061
62	013-5966	013-5990	013-6014	013-6038	013-6062
68	013-5967	013-5991	013-6015	013-6039	013-6063
75	013-5968	013-5992	013-6016	013-6040	013-6064
82	013-5969	013-5993	013-6017	013-6041	013-6065
91	013-5970	013-5994	013-6018	013-6042	013-6066

(013-6067 1MΩ)

**TYPE MR5 Style EX ±5%**

± 5% SELECTION TOLERANCE

Nominal Ohms	NOMINAL OHMS MULTIPLIER				
	× 1 10Ω to 91Ω	× 10 100Ω to 910Ω	× 10 <sup>2</sup> 1KΩ to 9.1KΩ	× 10 <sup>3</sup> 10KΩ to 91KΩ	× 10 <sup>4</sup> 100KΩ to 910KΩ
	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-
10	013-6068	013-6092	013-6116	013-6140	013-6164
11	013-6069	013-6093	013-6117	013-6141	013-6165
12	013-6070	013-6094	013-6118	013-6142	013-6166
13	013-6071	013-6095	013-6119	013-6143	013-6167
15	013-6072	013-6096	013-6120	013-6144	013-6168
16	013-6073	013-6097	013-6121	013-6145	013-6169
18	013-6074	013-6098	013-6122	013-6146	013-6170
20	013-6075	013-6099	013-6123	013-6147	013-6171
22	013-6076	013-6100	013-6124	013-6148	013-6172
24	013-6077	013-6101	013-6125	013-6149	013-6173
27	013-6078	013-6102	013-6126	013-6150	013-6174
30	013-6079	013-6103	013-6127	013-6151	013-6175
33	013-6080	013-6104	013-6128	013-6152	013-6176
36	013-6081	013-6105	013-6129	013-6153	013-6177
39	013-6082	013-6106	013-6130	013-6154	013-6178
43	013-6083	013-6107	013-6131	013-6155	013-6179
47	013-6084	013-6108	013-6132	013-6156	013-6180
51	013-6085	013-6109	013-6133	013-6157	013-6181
56	013-6086	013-6110	013-6134	013-6158	013-6182
62	013-6087	013-6111	013-6135	013-6159	013-6183
68	013-6088	013-6112	013-6136	013-6160	013-6184
75	013-6089	013-6113	013-6137	013-6161	013-6185
82	013-6090	013-6114	013-6138	013-6162	013-6186
91	013-6091	013-6115	013-6139	013-6163	013-6187

(013-6188 1MΩ)

**APPROVED RANGE**  
**10 Ω to 1 M Ω**  
*Note:* The range of approvals may be extended, so reference to Welwyn Electric Limited should be made for requirements not shown.





Miniature Metox Resistors  
**NATO STOCK NUMBERS**  
 BS 9111 N002 Fixed non-wirewound insulated resistors

**SERIES**  
**MR**

**TYPE MR6 Style DX ±1%**

**TYPE MR6 Style DX ±2%**

±1% SELECTION TOLERANCE							±2% SELECTION TOLERANCE						
Nominal Ohms	NOMINAL OHMS MULTIPLIER						Nominal Ohms	NOMINAL OHMS MULTIPLIER					
	× 1 10Ω to 91Ω	× 10 100Ω to 910Ω	× 10 <sup>2</sup> 1KΩ to 9.1KΩ	× 10 <sup>3</sup> 10KΩ to 91KΩ	× 10 <sup>4</sup> 100KΩ to 910KΩ	× 10 <sup>5</sup> 1MΩ to 9.1MΩ		× 1 10Ω to 91Ω	× 10 100Ω to 910Ω	× 10 <sup>2</sup> 1KΩ to 9.1KΩ	× 10 <sup>3</sup> 10KΩ to 91KΩ	× 10 <sup>4</sup> 100KΩ to 910KΩ	× 10 <sup>5</sup> 1MΩ to 9.1MΩ
	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	
10	013-5442	013-5466	013-5490	013-5514	013-5538	013-5562	10	013-5570	013-5594	013-5618	013-5642	013-5666	
11	013-5443	013-5467	013-5491	013-5515	013-5539	013-5563	11	013-5571	013-5595	013-5619	013-5643	013-5667	
12	013-5444	013-5468	013-5492	013-5516	013-5540	013-5564	12	013-5572	013-5596	013-5620	013-5644	013-5668	
13	013-5445	013-5469	013-5493	013-5517	013-5541	013-5565	13	013-5573	013-5597	013-5621	013-5645	013-5669	
15	013-5446	013-5470	013-5494	013-5518	013-5542	013-5566	15	013-5574	013-5598	013-5622	013-5646	013-5670	
16	013-5447	013-5471	013-5495	013-5519	013-5543	013-5567	16	013-5575	013-5599	013-5623	013-5647	013-5671	
18	013-5448	013-5472	013-5496	013-5520	013-5544	013-5568	18	013-5576	013-5600	013-5624	013-5648	013-5672	
20	013-5449	013-5473	013-5497	013-5521	013-5545	013-5569	20	013-5577	013-5601	013-5625	013-5649	013-5673	
22	013-5450	013-5474	013-5498	013-5522	013-5546		22	013-5578	013-5602	013-5626	013-5650	013-5674	
24	013-5451	013-5475	013-5499	013-5523	013-5547		24	013-5579	013-5603	013-5627	013-5651	013-5675	
27	013-5452	013-5476	013-5500	013-5524	013-5548		27	013-5580	013-5604	013-5628	013-5652	013-5676	
30	013-5453	013-5477	013-5501	013-5525	013-5549		30	013-5581	013-5605	013-5629	013-5653	013-5677	
33	013-5454	013-5478	013-5502	013-5526	013-5550		33	013-5582	013-5606	013-5630	013-5654	013-5678	
36	013-5455	013-5479	013-5503	013-5527	013-5551		36	013-5583	013-5607	013-5631	013-5655	013-5679	
39	013-5456	013-5480	013-5504	013-5528	013-5552		39	013-5584	013-5608	013-5632	013-5656	013-5680	
43	013-5457	013-5481	013-5505	013-5529	013-5553		43	013-5585	013-5609	013-5633	013-5657	013-5681	
47	013-5458	013-5482	013-5506	013-5530	013-5554		47	013-5586	013-5610	013-5634	013-5658	013-5682	
51	013-5459	013-5483	013-5507	013-5531	013-5555		51	013-5587	013-5611	013-5635	013-5659	013-5683	
56	013-5460	013-5484	013-5508	013-5532	013-5556		56	013-5588	013-5612	013-5636	013-5660	013-5684	
62	013-5461	013-5485	013-5509	013-5533	013-5557		62	013-5589	013-5613	013-5637	013-5661	013-5685	
68	013-5462	013-5486	013-5510	013-5534	013-5558		68	013-5590	013-5614	013-5638	013-5662	013-5686	
75	013-5463	013-5487	013-5511	013-5535	013-5559		75	013-5591	013-5615	013-5639	013-5663	013-5687	
82	013-5464	013-5488	013-5512	013-5536	013-5560		82	013-5592	013-5616	013-5640	013-5664	013-5688	
91	013-5465	013-5489	013-5513	013-5537	013-5561		91	013-5593	013-5617	013-5641	013-5665	013-5689	

**TYPE MR6 Style DX ±5%**

±5% SELECTION TOLERANCE						
Nominal Ohms	NOMINAL OHMS MULTIPLIER					
	× 1 10Ω to 91Ω	× 10 100Ω to 910Ω	× 10 <sup>2</sup> 1KΩ to 9.1KΩ	× 10 <sup>3</sup> 10KΩ to 91KΩ	× 10 <sup>4</sup> 100KΩ to 910KΩ	× 10 <sup>5</sup> 1MΩ to 9.1MΩ
	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-
10	013-5698	013-5722	013-5746	013-5770	013-5794	013-5818
11	013-5699	013-5723	013-5747	013-5771	013-5795	013-5819
12	013-5700	013-5724	013-5748	013-5772	013-5796	013-5820
13	013-5701	013-5725	013-5749	013-5773	013-5797	013-5821
15	013-5702	013-5726	013-5750	013-5774	013-5798	013-5822
16	013-5703	013-5727	013-5751	013-5775	013-5799	013-5823
18	013-5704	013-5728	013-5752	013-5776	013-5800	013-5824
20	013-5705	013-5729	013-5753	013-5777	013-5801	
22	013-5706	013-5730	013-5754	013-5778	013-5802	
24	013-5707	013-5731	013-5755	013-5779	013-5803	
27	013-5708	013-5732	013-5756	013-5780	013-5804	
30	013-5709	013-5733	013-5757	013-5781	013-5805	
33	013-5710	013-5734	013-5758	013-5782	013-5806	
36	013-5711	013-5735	013-5759	013-5783	013-5807	
39	013-5712	013-5736	013-5760	013-5784	013-5808	
43	013-5713	013-5737	013-5761	013-5785	013-5809	
47	013-5714	013-5738	013-5762	013-5786	013-5810	
51	013-5715	013-5739	013-5763	013-5787	013-5811	
56	013-5716	013-5740	013-5764	013-5788	013-5812	
62	013-5717	013-5741	013-5765	013-5789	013-5813	
68	013-5718	013-5742	013-5766	013-5790	013-5814	
75	013-5719	013-5743	013-5767	013-5791	013-5815	
82	013-5720	013-5744	013-5768	013-5792	013-5816	
91	013-5721	013-5745	013-5769	013-5793	013-5817	

**APPROVED RANGE**  
**10Ω to 1 MΩ**  
 Note: The range of approvals may be extended, so reference to Welwyn Electric Limited should be made for requirements not shown.



**TYPE MR8 Style CX ±1%**

± 1% SELECTION TOLERANCE

Nominal Ohms	NOMINAL OHMS MULTIPLIER					
	× 1 10Ω to 91Ω	× 10 100Ω to 1KΩ	× 10 <sup>2</sup> 1KΩ to 10KΩ	× 10 <sup>3</sup> 10KΩ to 100KΩ	× 10 <sup>4</sup> 100KΩ to 1MΩ	× 10 <sup>5</sup> 1MΩ to 2.7MΩ
	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-
10	013-5049	013-5073	013-5097	013-5121	013-5145	013-5169
11	013-5050	013-5074	013-5098	013-5122	013-5146	013-5170
12	013-5051	013-5075	013-5099	013-5123	013-5147	013-5171
13	013-5052	013-5076	013-5100	013-5124	013-5148	013-5172
15	013-5053	013-5077	013-5101	013-5125	013-5149	013-5173
16	013-5054	013-5078	013-5102	013-5126	013-5150	013-5174
18	013-5055	013-5079	013-5103	013-5127	013-5151	013-5175
20	013-5056	013-5080	013-5104	013-5128	013-5152	013-5176
22	013-5057	013-5081	013-5105	013-5129	013-5153	013-5177
24	013-5058	013-5082	013-5106	013-5130	013-5154	013-5178
27	013-5059	013-5083	013-5107	013-5131	013-5155	013-5179
30	013-5060	013-5084	013-5108	013-5132	013-5156	
33	013-5061	013-5085	013-5109	013-5133	013-5157	
36	013-5062	013-5086	013-5110	013-5134	013-5158	
39	013-5063	013-5087	013-5111	013-5135	013-5159	
43	013-5064	013-5088	013-5112	013-5136	013-5160	
47	013-5065	013-5089	013-5113	013-5137	013-5161	
51	013-5066	013-5090	013-5114	013-5138	013-5162	
56	013-5067	013-5091	013-5115	013-5139	013-5163	
62	013-5068	013-5092	013-5116	013-5140	013-5164	
68	013-5069	013-5093	013-5117	013-5141	013-5165	
75	013-5070	013-5094	013-5118	013-5142	013-5166	
82	013-5071	013-5095	013-5119	013-5143	013-5167	
91	013-5072	013-5096	013-5120	013-5144	013-5168	

**TYPE MR8 Style CX ±2%**

± 2% SELECTION TOLERANCE

Nominal Ohms	NOMINAL OHMS MULTIPLIER					
	× 1 10Ω to 91Ω	× 10 100Ω to 1KΩ	× 10 <sup>2</sup> 1KΩ to 10KΩ	× 10 <sup>3</sup> 10KΩ to 100KΩ	× 10 <sup>4</sup> 100KΩ to 1MΩ	× 10 <sup>5</sup> 1MΩ to 2.7MΩ
	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-
10	013-5180	013-5204	013-5228	013-5252	013-5276	013-5300
11	013-5181	013-5205	013-5229	013-5253	013-5277	013-5301
12	013-5182	013-5206	013-5230	013-5254	013-5278	013-5302
13	013-5183	013-5207	013-5231	013-5255	013-5279	013-5303
15	013-5184	013-5208	013-5232	013-5256	013-5280	013-5304
16	013-5185	013-5209	013-5233	013-5257	013-5281	013-5305
18	013-5186	013-5210	013-5234	013-5258	013-5282	013-5306
20	013-5187	013-5211	013-5235	013-5259	013-5283	013-5307
22	013-5188	013-5212	013-5236	013-5260	013-5284	013-5308
24	013-5189	013-5213	013-5237	013-5261	013-5285	013-5309
27	013-5190	013-5214	013-5238	013-5262	013-5286	013-5310
30	013-5191	013-5215	013-5239	013-5263	013-5287	
33	013-5192	013-5216	013-5240	013-5264	013-5288	
36	013-5193	013-5217	013-5241	013-5265	013-5289	
39	013-5194	013-5218	013-5242	013-5266	013-5290	
43	013-5195	013-5219	013-5243	013-5267	013-5291	
47	013-5196	013-5220	013-5244	013-5268	013-5292	
51	013-5197	013-5221	013-5245	013-5269	013-5293	
56	013-5198	013-5222	013-5246	013-5270	013-5294	
62	013-5199	013-5223	013-5247	013-5271	013-5295	
68	013-5200	013-5224	013-5248	013-5272	013-5296	
75	013-5201	013-5225	013-5249	013-5273	013-5297	
82	013-5202	013-5226	013-5250	013-5274	013-5298	
91	013-5203	013-5227	013-5251	013-5275	013-5299	

**TYPE MR8 Style CX ±5%**

± 5% SELECTION TOLERANCE

Nominal Ohms	NOMINAL OHMS MULTIPLIER					
	× 1 10Ω to 91Ω	× 10 100Ω to 1KΩ	× 10 <sup>2</sup> 1KΩ to 10KΩ	× 10 <sup>3</sup> 10KΩ to 100KΩ	× 10 <sup>4</sup> 100KΩ to 1MΩ	× 10 <sup>5</sup> 1MΩ to 2.7MΩ
	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-	5905-99-
10	013-5311	013-5335	013-5359	013-5383	013-5407	013-5431
11	013-5312	013-5336	013-5360	013-5384	013-5408	013-5432
12	013-5313	013-5337	013-5361	013-5385	013-5409	013-5433
13	013-5314	013-5338	013-5362	013-5386	013-5410	013-5434
15	013-5315	013-5339	013-5363	013-5387	013-5411	013-5435
16	013-5316	013-5340	013-5364	013-5388	013-5412	013-5436
18	013-5317	013-5341	013-5365	013-5389	013-5413	013-5437
20	013-5318	013-5342	013-5366	013-5390	013-5414	013-5438
22	013-5319	013-5343	013-5367	013-5391	013-5415	013-5439
24	013-5320	013-5344	013-5368	013-5392	013-5416	013-5440
27	013-5321	013-5345	013-5369	013-5393	013-5417	013-5441
30	013-5322	013-5346	013-5370	013-5394	013-5418	
33	013-5323	013-5347	013-5371	013-5395	013-5419	
36	013-5324	013-5348	013-5372	013-5396	013-5420	
39	013-5325	013-5349	013-5373	013-5397	013-5421	
43	013-5326	013-5350	013-5374	013-5398	013-5422	
47	013-5327	013-5351	013-5375	013-5399	013-5423	
51	013-5328	013-5352	013-5376	013-5400	013-5424	
56	013-5329	013-5353	013-5377	013-5401	013-5425	
62	013-5330	013-5354	013-5378	013-5402	013-5426	
68	013-5331	013-5355	013-5379	013-5403	013-5427	
75	013-5332	013-5356	013-5380	013-5404	013-5428	
82	013-5333	013-5357	013-5381	013-5405	013-5429	
91	013-5334	013-5358	013-5382	013-5406	013-5430	

**APPROVED RANGE**  
**10Ω to 10 kΩ**  
*Note:* The range of approvals may be extended, so reference to Welwyn Electric Limited should be made for requirements not shown.

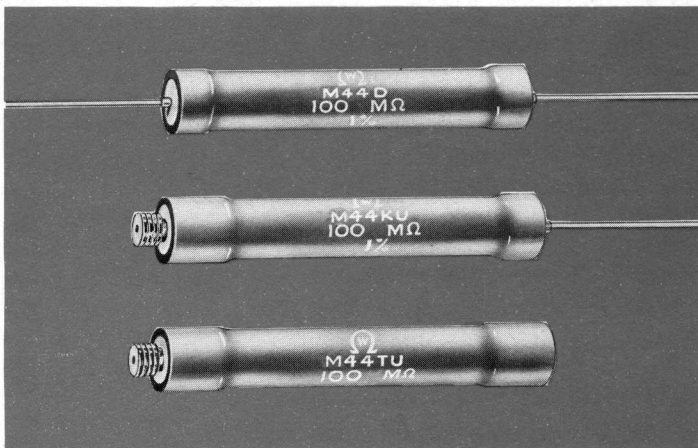




# SERIES M40 HIGH VOLTAGE RESISTORS

## FEATURES

- ★ Continuous d.c. voltage up to 10kV.
- ★ Lacquer coated version available for oil immersion.
- ★ Resistance values up to 100MΩ
- ★ Stability better than 1%
- ★ Sets of resistors for multiple units can be matched for T.C.R. or resistance ratio.
- ★ Suitable for precision high voltage dividers, feedback chains, etc.
- ★ Enquiries welcomed for non-standard resistor lengths, operating voltages or resistance values outside of the catalogued range.

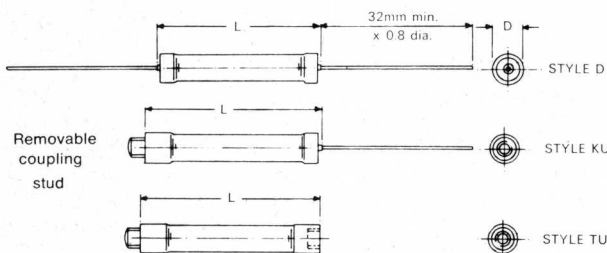


## MECHANICAL DATA

### Construction

The resistive film is deposited on to a high purity ceramic former. Turned brass caps are force fitted and the resistor adjusted to value with a helical cut through the film. A red protective sleeve provides mechanical protection and electrical insulation. Alternatively, for oil immersion, a lacquer protection is applied.

Three styles of termination are offered: Style D permits single resistors to be used as axial wired components; Styles TU and KU permit assemblies of resistors to be screwed together in a series chain, the end members of which can have axial wires for ease of electrical connection.



### Maximum dimensions (millimetres)

Type	Length (L)	Diameter (D)	Weight (g)
M43D	25.4	8.4	3.4
M44D	50.8	8.4	5.8
M43KU	30.2	8.5	4.0
M44KU	53.2	8.5	6.7
M43TU	32.6	8.5	5.8
M44TU	55.6	8.5	8.4

### Marking

Legend marking with type reference, resistance value, tolerance and date code.

### Solvent resistance

The protective sleeve provides excellent resistance to all normal industrial cleaning solvents.

## TERMINATIONS

### Styles D and KU

*Material:* Solder coated copper wire.

*Strength:* Pull strength 1kg.

*Solderability:* The terminations adequately meet the requirements of IEC68-2-20, Part 2, Test T, 3.2. Solder bath method (270°C).

### Styles KU and TU

All caps are tapped UNF-10 x 4.2mm deep (full depth thread).

UNF-10 is 32TPI, 60° thread angle, 4.72 ± 0.07mm outside diameter, 3.83mm core diameter.

All styles KU and TU are supplied with a single 8mm long screwed coupling stud.



**Welwyn Electric Limited**

BEDLINGTON NORTHUMBERLAND NE22 7AA ENGLAND

Telephone: Bedlington (0670) 822181

Telex: 53514



BS 9000  
approval number  
1023/M

**ELECTRICAL DATA**

Type ref.	Maximum dissipation at 20°C (watts)	Resistance range	Limiting element voltage d.c. or a.c. r.m.s. (kV)	*Isolation voltage d.c. or a.c. peak (kV)
M43	0.7	5Ω to 30MΩ	4	6
M44	1.3	10Ω to 100MΩ	10	10

\***Isolation voltage.** These high voltage insulated resistors are assessed by applying a test voltage between the resistor element and a band of aluminium foil wrapped centrally around the body of the resistor. The width of the foil is 6mm, irrespective of resistor length, and the quoted isolation voltage is the maximum recommended value in air.

**Manufactured values**

Supplied in any ordered value within the specified range.

**Standard selection tolerances**

±5%, ±2%, ±1%

**Derating**

Derate linearly from recommended dissipation at 20°C to zero at 100°C.

**Temperature coefficient of Resistance**

The T.C.R. is less than ±150 ppM/°C over the full resistance range. Over a restricted range resistors can be supplied with a T.C.R. not exceeding ±100, ±50 or ±25 ppM/°C.

**Voltage coefficient**

The effect on the measured resistance value when voltage is applied is typically better than 1 ppM per volt. For most applications voltage coefficient can be considered to be negligible.

**Noise**

The noise voltage has been measured in accordance with I.E.C.95 with applied voltages up to 250V. Noise is typically less than 1µV/volt per decade of frequency.

**Insulation resistance**

Greater than 10<sup>13</sup>Ω at 500V d.c.

**ENVIRONMENTAL DATA**

**Endurance**

1000 hours at recommended dissipation in 20°C ambient: ΔR typically better than 1%.

**Shelf stability, 12 months**

ΔR typically 0.5%.

**Climatic category**

Upper temperature category is 100°C; lower temperature category is -55°C. Due to the possibility of surface condensation it is recommended that high voltages are not applied to resistors in conditions of high humidity.

**ORDERING PROCEDURE**

Specify type reference, resistance value, tolerance and temperature coefficient, e.g. M44KU, 100MΩ ±5°, 100 ppM/°C should be ordered using the IEC resistance code, thus M44KU/100M ±5°/100 ppM/°C. Lacquered version, without sleeve, for oil immersion is denoted by suffix 'H'. Thus an M44KU for oil immersion becomes M44KUH.

**APPLICATION NOTES**

For some high voltage applications it is required to immerse the components in oil or gas to reduce the effects of corona and surface tracking. A special lacquer protected version of the resistor is suitable for immersion in transformer oil or SF<sub>6</sub>.

The maximum continuous voltage which may be applied to resistance values in the low end of the range will be limited by maximum permitted dissipation. Limiting element voltage will restrict dissipation in resistors with values above critical.

$$R_{crit} = \frac{(\text{Limiting element voltage})^2}{\text{Recommended max. dissipation}}$$

The wire terminations should not be bent closer than 1.5mm from the body, and the recommended minimum bend radius is 1mm.

Care should be taken to prevent the resistor markings from being abraded while cleaning solvents or their vapours are present.

Because of the high voltage which can appear between the end cap and any adjacent metal part, it is recommended that these resistors should be mounted at an adequate distance from other conducting parts.

An appropriate number of resistors may be screwed together as a stick to provide an assembly which will be capable of withstanding any desired voltage, providing only that no individual resistor is subjected to a greater stress or dissipation than is recommended in this data sheet.

**Matched sets**

The performance of the Series M40 resistors makes them ideal for use in precision high voltage divider chains; the ratio stability will be within 1% after 1000 hours at rated dissipation. Dividers can be supplied as custom built sets with a ratio accuracy of 1%, alternatively 2%. The temperature coefficient of individual resistors in a set can be matched within the absolute band ±150 ppM/°C, with all resistors in the set within 150, 100 or 50 ppM/°C of each other. Alternatively the same matching of T.C.R. can be applied more simply to the two sections of a voltage divider chain.

**Special applications**

For special applications the following details should be provided with any enquiry to enable us to offer the most suitable and cost effective solution:-

- Maximum working voltage of chain.
- Range of working voltage variation during operation.
- Voltage ratio and accuracy, over stated range of operating voltage.
- Absolute temperature coefficient of resistance.
- Differential temperature coefficient of resistance.
- Operating ambient temperature range.
- Environment proposed for resistors.
- Physical mounting and assembly details.
- Quantity of sets required.

In pulse applications the following information is also necessary:-

- Peak voltage.
- Pulse width and shape.
- Pulse repetition frequency.

Enquiries are welcomed for special resistors and sets where resistor length, operating voltages or resistance values are outside of the catalogued range.

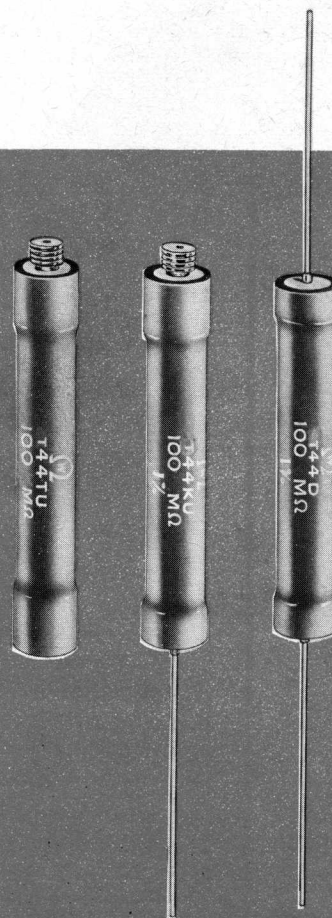




# SERIES T40 HIGH VOLTAGE RESISTORS

## FEATURES

- Withstands up to 21kV d.c. continuously in air and up to 50kV d.c. continuously in oil.
- Resistance range: 500k $\Omega$  to 2G $\Omega$ . Stability better than 1%.
- Suitable for transmission line test equipment, electron microscope feedback circuits, electron beam welders, metal deposition equipment.
- Sets of resistors can be matched for precision high voltage dividers, precision feedback chains.
- Low inductance version available.



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BS 9000  
approval number  
1023/M

# MECHANICAL DATA

## Construction

The Invarox<sup>®</sup> resistive film is deposited on to an alumina former to which are force-fitted turned brass endcaps. The resistor is adjusted to value with a helical cut through the film, and finally a protective sleeve is fitted to provide mechanical protection and electrical insulation. Where the resistor is required for oil immersion, it can be ordered with a lacquer protection and omission of the sleeve. There is available also a low inductance version.

Three styles of termination are offered:

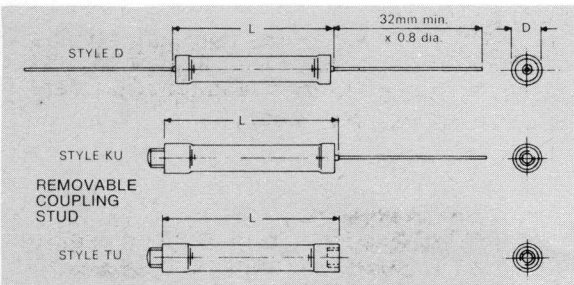
Style D permits single resistors to be used as axial wired components; Styles TU and KU permit assemblies of resistors to be screwed together in a series chain, the end members of which can have axial wires for ease of electrical connection.

## Marking

Legend marked with type reference, ohmic value, tolerance, and date code.

## Solvent resistance

The protective sleeve provides excellent resistance to all normal industrial cleaning solvents.



## Flammability

The protective sleeve is flame retardant within the terms of DEF5011, Test No. 7, Fire Risk.

## TERMINATIONS

### Styles D and KU

**Material:** Solder coated copper wire.

**Strength:** Pull strength 1kg.

**Solderability:** The terminations adequately meet the requirements of IEC 68-2-20, Part 2, Test T, 3.2., Solder bath method (270°C).

### Styles KU and Tu

All caps are tapped UNF-10 x 4.2mm deep (full depth thread).

UNF-10 is 32TPI, 60° thread angle, 4.72 ± 0.07mm outside diameter, 3.83mm core diameter.

All style KU and TU resistors are supplied with a single 8mm long screwed coupling stud.

## Maximum Dimensions (millimetres)

Type	Length (L)	Diameter (D)	Weight (gm)
T43D	25.4	8.4	3.1
T44D	50.8	8.4	5.6
T43KU	30.2	8.5	3.9
T44KU	53.2	8.5	7.4
T43TU	32.6	8.5	5.8
T44TU	55.6	8.5	8.2

# ELECTRICAL DATA

Type ref.	Rated dissipation at 20°C (watts)	Resistance range	Limiting element voltage dc or ac rms (kV)	Isolation voltage dc or ac peak (kV) See note 1.
T43	1.5	500kΩ to 600MΩ	4	6
T44	3.5	1MΩ to 2GΩ	14 (See note 2)	10

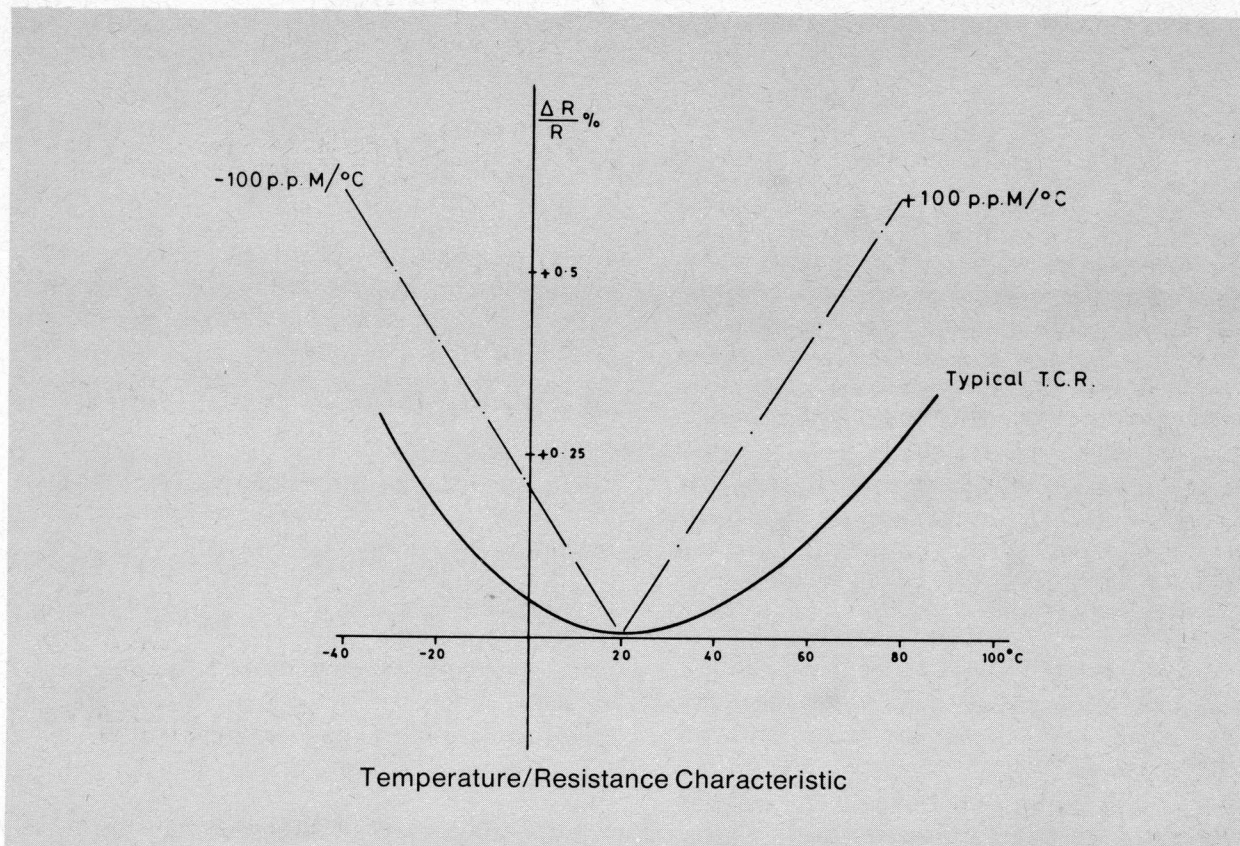
### Note 1:

Isolation voltage. These high voltage insulated resistors are assessed by applying a 1 minute test voltage between the resistor element and a band of aluminium foil wrapped centrally around the body of the resistor. The foil width is 6mm, irrespective of resistor length, and the quoted isolation voltage is the maximum recommended value in air.

### Note 2:

At rated dissipation the applied voltage must not exceed limiting element voltage. If dissipation is limited to a maximum of 50% of rated dissipation, the applied voltage may be increased to a maximum of 21kV dc, subject to resistance value being sufficiently high.





**Manufactured values:**

Supplied in any ordered value within the specified range.

**Standard selection tolerances:**

±1%, ±2%, ±5% over the full resistance range. Closer tolerances can be supplied by special arrangement.

**Derating:**

Derate linearly from rated dissipation at 20°C to zero at 150°C.

**Temperature coefficient of resistance (-10° to +70°C):**

The T.C.R. will not exceed ±100 ppM/°C over the full resistance range. ±50 or ±25 ppM/°C can be supplied. (See graph).

**Voltage coefficient:**

The effect on the measured resistance value when voltage is applied is less than 1ppM per volt. For most applications voltage coefficient can be considered to be negligible.

**Low inductance version:**

For those applications requiring minimum inductance, a specially adjusted version is available; it is denoted in the type reference by the addition of the suffix 'L', e.g. T44DL.

**Insulation resistance:**

Greater than  $10^{13}\Omega$  at 500 volts d.c.

## ENVIRONMENTAL DATA

**Endurance:**

1000 hours at rated dissipation in 20°C ambient:  
 $\Delta R$  typically better than 1%.

**Shelf stability, 12 months:**

$\Delta R$  typically 0.5%

**Temperature Category:**

Lower temperature category is -55°C; upper temperature category is 150°C. Due to the possibility of surface condensation it is recommended that high voltages are not applied to resistors in conditions of high humidity.

## ORDERING PROCEDURE

Specify type reference, resistance value, tolerance and temperature coefficient, e.g. T44KU, 100MΩ ±5%, 100ppM/°C should be ordered using the I.E.C. resistance code, thus: T44KU/100M ±5%/100ppM/°C.

Lacquered version, without sleeve, for oil immersion denoted by suffix 'H'. Low inductance version denoted by suffix 'L'. Thus, a T44KU for oil immersion and with low inductance becomes T44KUHL.

## APPLICATION NOTES

For some high voltage applications it is required to immerse the components in oil or gas to reduce the effects of corona and surface tracking. A special lacquer protected version of the resistor is available, which is suitable for immersion in transformer oil or SF<sub>6</sub>.

The maximum continuous voltage which may be applied to resistance values in the low end of the range will be limited by maximum permitted dissipation. Limiting element voltage will restrict dissipation in resistors with values above critical.

$$R_{\text{crit}} = \frac{(\text{Limiting element voltage})^2}{\text{Recommended max. dissipation}}$$

The wire terminations should not be bent closer than 1.5mm from the body, and the recommended minimum bend radius is 1mm.

Care should be taken to prevent the resistor markings from being abraded while cleaning solvents or their vapours are present.

Because of the high voltage which can appear between the endcap and any adjacent metal part, it is recommended that these resistors should be mounted at an adequate distance from other conducting parts.

An appropriate number of resistors may be screwed together as a stick to provide an assembly which will be capable of withstanding any desired voltage, providing only that no individual resistor is subjected to a greater stress or dissipation than is recommended in this data sheet.

The ratio stability will be within 1% after 1000 hours at rated dissipation. Dividers can be supplied as custom-built sets with a ratio accuracy of 1%. The temperature coefficient of individual resistors in a set can be matched

within the absolute band  $\pm 100$  ppM/ $^{\circ}$ C, with all resistors in the set within 100, 50 or 25 ppM/ $^{\circ}$ C of each other. Alternatively the same matching of T.C.R. can be applied more simply to the two sections of a voltage divider chain.

### Special applications

Where appropriate, a matched set of resistors for divider or network application may include lower values supplied from Welwyn's M40 range of high voltage metal film resistors.

For special applications the following details should be provided with any enquiry to enable us to offer the most suitable and cost effective solution:-

Maximum working voltage of chain.

Range of working voltage variation during operation.

Voltage ratio and accuracy, over stated range of operating voltage.

Absolute temperature coefficient of resistance.

Differential temperature coefficient of resistance.

Operating ambient temperature range.

Environment proposed for resistors.

Physical mounting and assembly details.

Quantity of sets required.

In pulse applications the following information is also necessary:-

Peak voltage.

Pulse width and shape.

Pulse repetition frequency.

Enquiries are welcomed for special resistors and sets where resistor length, operating voltages or resistance values are outside of the catalogued range.



**Welwyn Electric Limited**

BEDLINGTON NORTHUMBERLAND NE22 7AA ENGLAND

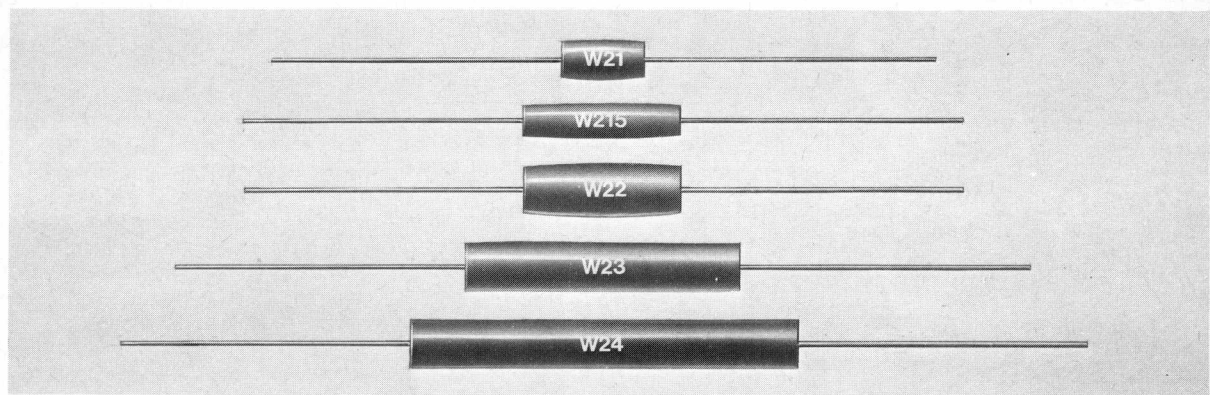
Telephone: Bedlington (0670) 822181 Telex: 53514



BS 9000  
approval number  
1023/M



# Vitreous Enamelled Wirewound Resistors Series W



Accepted for military and British Post Office applications

Highest dissipation, size for size, of any type

Rugged construction; all electrical connections are welded

Suitable for harsh environments

Approved to BS9114 N001 over the resistance range:-	W21	W22	W23	W24
	1Ω to 10kΩ	1Ω to 20kΩ	1Ω to 56kΩ	1Ω to 100kΩ

## GENERAL DESCRIPTION

Vitreous enamelled wirewound resistors are capable of higher dissipation, size for size, than any other type; this is because they can withstand a much higher temperature. The table above defines the resistance range

which is approved to BS9114 N001, but the performance information provided in this leaflet applies to the entire resistance range of each resistor size, as defined in the Electrical Data on the next page.

**Welwyn** Electric Limited

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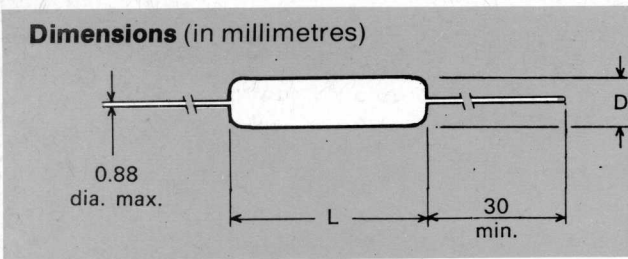
BS 9000  
approval number  
1023/M



## MECHANICAL DATA

**Construction** A high purity ceramic substrate is assembled with force fit end caps to which are welded the terminal wires. The resistive element is

wound on to the substrate and the ends welded to the caps. The body is then vitreous enamelled to give a protective coating which is impervious to moisture.



Type	L Max.	D Max. for values of 1Ω and above	D Max. for values <1Ω	Weight (gms)
W21	12.7	5.6	6.1	1
W215	22.2	6.5	7.0	2
W22	22.2	8.0	8.9	2
W23	38.1	8.0	8.9	3.5
W24	53.5	8.0	8.9	5

### TERMINATIONS

**Material** Manganese nickel wire, eutectic solder coated.

**Strength** The terminations withstand all appropriate tests defined by BS9114 N001.

**Solderability** The leads adequately meet the requirements of BS2011, Part 2T, Method 1 (Solder bath), components for normal applications. This requires "good tinning, with wetting of the terminations to within 6 mm of the point of emergence from the body, at a solder bath test

temperature of 270°C."

**Marking** The bodies are legend marked with the type reference, ohmic value, tolerance and, with the exception of W21, date code.

**Solvent Resistance** The vitreous coating and marking are solvent resistant to all accepted industrial cleaning fluids.

**Flammability** All materials used are inorganic and inherently non-burning.

## ELECTRICAL DATA

Type	BS9114 N001 Style	Resistance Range (ohms)					Rated Dissipation at 70°C (watts)	Limiting Element Voltage (d.c. or a.c. r.m.s.)
		Min. at ±10%	Min. at ±5%	Min. at ±2%	Min. at ±1%	Max. at all tolerances		
W21	J	0.1	0.3	0.5	1	10k	2.5	100
W215	-	0.15	0.3	0.5	1	15k	4	140
W22	K	0.1	0.3	0.5	1	20k	6	200
W23	L	0.15	0.5	1	1	60k	9	500
W24	M	0.2	0.5	1	1	100k	12	750

**Manufactured Values** Available in any value within the specified range. E24 Series is the preferred range of values.

**Selection Tolerances** ±10%, ±5%, ±2% and ±1%.

**Inductance** Inductance is dependant upon ohmic value, and the following information is intended as a guide. More detailed information for specific applications is available upon request.

W21 up to 200Ω  
W215 up to 180Ω  
W22 up to 150Ω

W23 up to 75Ω  
W24 up to 50Ω

Inductance is typically <2μH

**Derating** Derate linearly from full load to 70°C to zero at 350°C. Also, see Application Note and graph below.

**Temperature Rise** (see graph below)

**Temperature Coefficient** Typically <75 ppM/°C. Maximum 120 ppM/°C

**Voltage Coefficient** Negligible.

**Noise** Current noise is zero.

**Insulation Resistance** See application notes.

Fig. 1 Temperature Rise

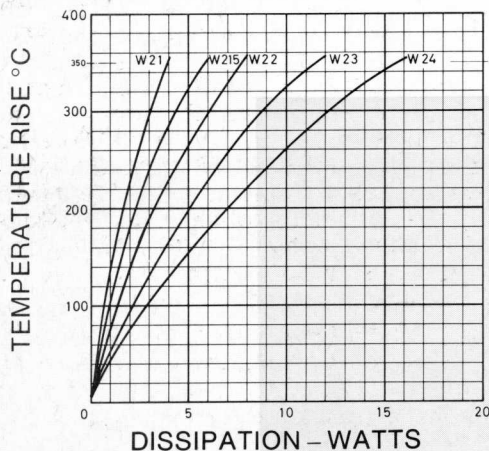
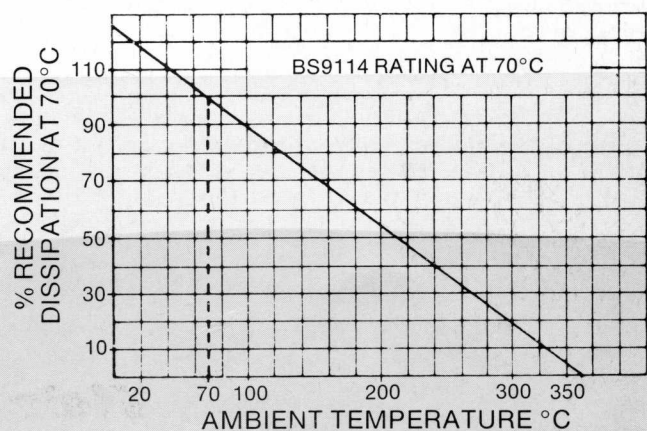


Fig. 2 Derating



## ENVIRONMENTAL DATA

**Endurance** 1000 hours at full load in 70°C ambient:  
 $\Delta R$  typically <2%.

**Shelf Stability, 12 Months**  $\Delta R$  typically <0.1%

**Change due to Soldering**  $\Delta R$  <0.1%.

**Climatic Category** 55/200/56.

**Climatic Sequence**  $\Delta R$  typically <1%.

**Temperature Rapid Change**  $\Delta R$  typically <0.2%.

**Reliability** A series of tests, simulating typical operating conditions, has been carried out over a period extending to 30,000 hours and totalling 5.4 million unit test hours.

Using the criterion of failure  $\Delta R \geq 10\%$ , there were no failures. The reliability can be stated as a failure rate of 0.0165% per 1000 hours, at 60% confidence level, or as a mean time between failures of  $6 \times 10^6$  hours.

## APPLICATION NOTES

The terminations should not be bent closer than 1.5 mm from the body, and the recommended minimum bend radius is 1 mm. If the resistors are to dissipate the full rated power, it is recommended that the terminations should not be soldered closer than 6 mm from the body.

If the resistors are to be operated in an ambient of 20°C, the permissible dissipation is approximately 20% greater than the 70°C rating and the same performance will be achieved. Refer to Fig. 2. for permitted dissipations at intermediate ratings.

If some degradation of stability is acceptable, the resistors may be permitted to dissipate a higher power, providing always that a surface temperature of 400°C. is not exceeded.

When cold, vitreous enamel has excellent insulation resistance. In common with all insulants the specific resistance of the enamel decreases with increase in temperature: therefore, if operated at any temperature approaching the maximum, the resistor cannot be classed as an insulated type and should not be used in contact with any conducting material.

Due care must be taken when determining mounting arrangements in particular, the clearance between the resistor body and the printed circuit board and the distance from the body to the point at which the termination wires are soldered. If the resistor is in contact with the p.c.b. the maximum dissipation to avoid damage to the p.c.b. may be ascertained by reference to Fig. 1.

## ORDERING PROCEDURE

Specify type reference, resistance value and tolerance, e.g. W21, 20k $\Omega$   $\pm 5\%$ , should be ordered using the IEC resistance code, thus W21 - 20K $\pm 5\%$ .

If release is required specify also "Release to

BS9114 N001" and appropriate style reference.

Certified Test Records (C.T.R.'s) are available for inspection by customers who purchase released products.

## EQUIVALENCE OF RESISTOR STYLES IN INTER SERVICES SPECIFICATIONS

W Series resistors can be supplied with the appropriate release for use in Armed Services equipment which calls for any style detailed in the table below. Resistors approved to BS9114 N001 are suitable for **all** applications which originally specified

RCS11, DEF5111-1, DEF5115-2 or BS9114 F001 or N002.

The W Series can also be supplied with appropriate release for use in Post Office equipment; the table includes all equivalent Resistor Coil Numbers.

Welwyn type reference	DEF5111-1 Style	DEF5115-2 Style	BS9114 F001 BS9114 N002 Style	BS9114 N001 Style	Post Office Resistor Coil No.			
					$\pm 10\%$	$\pm 5\%$	$\pm 2\%$	$\pm 1\%$
W21	RWV3-J	RFH3-2.5	2E-56-2.5	J	35	35A	35B	-
W22	RWV4-J	RFH3-6	2E-56-6	K	-	40	40A	40B
W23	RWV4-K	RFH3-9	2E-56-9	L	-	36	-	-
W24	RWV4-L	RFH3-12	2E-56-12	M	-	50	-	-

## NATO STOCK NUMBERS

Originally, the U.K. Armed Services employed a codification system which gave each part a number, prefixed by a letter. For resistors the full code was the letter Z followed by six digits. Later it became necessary to incorporate the system into a wider scheme suitable for use by the NATO countries. The codes were called NATO Stock Numbers and were formed by a four digit code to identify the NATO supply classification, followed by two digits which specified the country of origin (U.K. was 99), and followed by a further seven digits which was the Z number with Z replaced by a zero.

E.g. 5905-99-011-9472 replaced Z119472.

These original NATO numbers are shown in brackets in the table overleaf. At a later stage the NATO numbers were revised and it is these new numbers which are in current use and shown in bold type.



# NATO STOCK NUMBERS

## BS 9114 N001 Fixed wirewound non-insulated resistor

(See Equivalence of Resistor Styles on previous page)

### TYPE W21 Style J

Nominal Ohms.	NOMINAL OHMS MULTIPLIER				
	$\times 10^{-1}$ 1Ω to 9.1Ω	$\times 1.0$ 10Ω to 91Ω	$\times 10$ 100Ω to 910Ω	$\times 10^2$ 1kΩ to 9.1kΩ	$\times 10^3$ 10kΩ
	5905-99	5905-99	5905-99	5905-99	5905-99
10	014-0489 (011-3195*)	014-0513 (011-3207)	014-0537 (011-3231)	014-0561 (011-3255)	014-0585
11	014-0490	014-0514 (011-3208)	014-0538 (011-3232)	014-0562 (011-3256)	
12	014-0491 (011-3196*)	014-0515 (011-3209)	014-0539 (011-3233)	014-0563 (011-3257)	
13	014-0492	014-0516 (011-3210)	014-0540 (011-3234)	014-0564 (011-3258)	
15	014-0493 (011-3197*)	014-0517 (011-3211)	014-0541 (011-3235)	014-0565 (011-3259)	
16	014-0494	014-0518 (011-3212)	014-0542 (011-3236)	014-0566 (011-3260)	
18	014-0495 (011-3198*)	014-0519 (011-3213)	014-0543 (011-3237)	014-0567 (011-3261)	
20	014-0496	014-0520 (011-3214)	014-0544 (011-3238)	014-0568 (011-3262)	
22	014-0497 (011-3199*)	014-0521 (011-3215)	014-0545 (011-3239)	014-0569 (011-3263)	
24	014-0498	014-0522 (011-3216)	014-0546 (011-3240)	014-0570 (011-3264)	
27	014-0499 (011-3200*)	014-0523 (011-3217)	014-0547 (011-3241)	014-0571 (011-3265)	
30	014-0500	014-0524 (011-3218)	014-0548 (011-3242)	014-0572 (011-3266)	
33	014-0501 (011-3201*)	014-0525 (011-3219)	014-0549 (011-3243)	014-0573 (011-3267)	
36	014-0502	014-0526 (011-3220)	014-0550 (011-3244)	014-0574 (011-3268)	
39	014-0503 (011-3202*)	014-0527 (011-3221)	014-0551 (011-3245)	014-0575 (011-3269)	
43	014-0504	014-0528 (011-3222)	014-0552 (011-3246)	014-0576 (011-3270)	
47	014-0505 (011-3203*)	014-0529 (011-3223)	014-0553 (011-3247)	014-0577 (011-3271)	
51	014-0506	014-0530 (011-3224)	014-0554 (011-3248)	014-0578 (011-3272)	
56	014-0507 (011-3204*)	014-0531 (011-3225)	014-0555 (011-3249)	014-0579 (011-3273)	
62	014-0508	014-0532 (011-3226)	014-0556 (011-3250)	014-0580 (011-3274)	
68	014-0509 (011-3205*)	014-0533 (011-3227)	014-0557 (011-3251)	014-0581 (011-3275)	
75	014-0510	014-0534 (011-3228)	014-0558 (011-3252)	014-0582 (011-3276)	
82	014-0511 (011-3206*)	014-0535 (011-3229)	014-0559 (011-3253)	014-0583 (011-3277)	
91	014-0512	014-0536 (011-3230)	014-0560 (011-3254)	014-0584 (011-3278)	

### TYPE W22 Style K

Nominal Ohms.	NOMINAL OHMS MULTIPLIER				
	$\times 10^{-1}$ 1Ω to 9.1Ω	$\times 1.0$ 10Ω to 91Ω	$\times 10$ 100Ω to 910Ω	$\times 10^2$ 1kΩ to 9.1kΩ	$\times 10^3$ 10kΩ to 20kΩ
	5905-99	5905-99	5905-99	5905-99	5905-99
10	014-0385 (011-9770)	014-0409 (011-3272)	014-0433 (011-3296)	014-0457 (011-3320)	014-0481
11	014-0386	014-0410 (011-3273)	014-0434 (011-3297)	014-0458 (011-3321)	014-0482
12	014-0387 (011-9771)	014-0411 (011-3274)	014-0435 (011-3298)	014-0459 (011-3322)	014-0483
13	014-0388	014-0412 (011-3275)	014-0436 (011-3299)	014-0460 (011-3323)	014-0484
15	014-0389 (011-9772)	014-0413 (011-3276)	014-0437 (011-3300)	014-0461 (011-3324)	014-0485
16	014-0390	014-0414 (011-3277)	014-0438 (011-3301)	014-0462 (011-3325)	014-0486
18	014-0391 (011-9773)	014-0415 (011-3278)	014-0439 (011-3302)	014-0463 (011-3326)	014-0487
20	014-0392	014-0416 (011-3279)	014-0440 (011-3303)	014-0464 (011-3327)	014-0488
22	014-0393 (011-9774)	014-0417 (011-3280)	014-0441 (011-3304)	014-0465 (011-3328)	
24	014-0394	014-0418 (011-3281)	014-0442 (011-3305)	014-0466 (011-3329)	
27	014-0395 (011-9775)	014-0419 (011-3282)	014-0443 (011-3306)	014-0467 (011-3330)	
30	014-0396	014-0420 (011-3283)	014-0444 (011-3307)	014-0468 (011-3331)	
33	014-0397 (011-9776)	014-0421 (011-3284)	014-0445 (011-3308)	014-0469 (011-3332)	
36	014-0398	014-0422 (011-3285)	014-0446 (011-3309)	014-0470 (011-3333)	
39	014-0399 (011-9777)	014-0423 (011-3286)	014-0447 (011-3310)	014-0471 (011-3334)	
43	014-0400	014-0424 (011-3287)	014-0448 (011-3311)	014-0472 (011-3335)	
47	014-0401 (011-9778)	014-0425 (011-3288)	014-0449 (011-3312)	014-0473 (011-3336)	
51	014-0402	014-0426 (011-3289)	014-0450 (011-3313)	014-0474 (011-3337)	
56	014-0403 (011-9779)	014-0427 (011-3290)	014-0451 (011-3314)	014-0475 (011-3338)	
62	014-0404	014-0428 (011-3291)	014-0452 (011-3315)	014-0476 (011-3339)	
68	014-0405 (011-9780)	014-0429 (011-3292)	014-0453 (011-3316)	014-0477 (011-3340)	
75	014-0406	014-0430 (011-3293)	014-0454 (011-3317)	014-0478 (011-3341)	
82	014-0407 (011-9781)	014-0431 (011-3294)	014-0455 (011-3318)	014-0479 (011-3342)	
91	014-0408	014-0432 (011-3295)	014-0456 (011-3319)	014-0480 (011-3343)	

### TYPE W23 Style L

Nominal Ohms.	NOMINAL OHMS MULTIPLIER				
	$\times 10^{-1}$ 1Ω to 9.1Ω	$\times 1.0$ 10Ω to 91Ω	$\times 10$ 100Ω to 910Ω	$\times 10^2$ 1kΩ to 9.1kΩ	$\times 10^3$ 10kΩ to 56kΩ
	5905-99	5905-99	5905-99	5905-99	5905-99
10	014-0267 (011-9782)	014-0292 (011-3463)	014-0316 (011-3487)	014-0340 (011-3511)	014-0364
11	014-0268	014-0293 (011-3464)	014-0317 (011-3488)	014-0341 (011-3512)	014-0365
12	014-0269 (011-9783)	014-0294 (011-3465)	014-0318 (011-3489)	014-0342 (011-3513)	014-0366
13	014-0270	014-0295 (011-3466)	014-0319 (011-3490)	014-0343 (011-3514)	014-0367
15	014-0271 (011-9784)	014-0296 (011-3467)	014-0320 (011-3491)	014-0344 (011-3515)	014-0368
16	014-0272	014-0297 (011-3468)	014-0321 (011-3492)	014-0345 (011-3516)	014-0369
18	014-0273 (011-9785)	014-0298 (011-3469)	014-0322 (011-3493)	014-0346 (011-3517)	014-0370
20	014-0274	014-0299 (011-3470)	014-0323 (011-3494)	014-0347 (011-3518)	014-0371
22	014-0275 (011-9786)	014-0300 (011-3471)	014-0324 (011-3495)	014-0348 (011-3519)	014-0372
24	014-0276	014-0301 (011-3472)	014-0325 (011-3496)	014-0349 (011-3520)	014-0373
27	014-0277 (011-9787)	014-0302 (011-3473)	014-0326 (011-3497)	014-0350 (011-3521)	014-0374
30	014-0278	014-0303 (011-3474)	014-0327 (011-3498)	014-0351 (011-3522)	014-0375
33	014-0279 (011-9788)	014-0304 (011-3475)	014-0328 (011-3499)	014-0352 (011-3523)	014-0376
36	014-0280	014-0305 (011-3476)	014-0329 (011-3500)	014-0353 (011-3524)	014-0377
39	014-0281 (011-9789)	014-0306 (011-3477)	014-0330 (011-3501)	014-0354 (011-3525)	014-0378
43	014-0282	014-0307 (011-3478)	014-0331 (011-3502)	014-0355 (011-3526)	014-0379
47	014-0283 (011-9790)	014-0308 (011-3479)	014-0332 (011-3503)	014-0356 (011-3527)	014-0380
51	014-0284	014-0309 (011-3480)	014-0333 (011-3504)	014-0357 (011-3528)	014-0381
56	014-0285 (011-9791)	014-0310 (011-3481)	014-0334 (011-3505)	014-0358 (011-3529)	014-0382
62	014-0286	014-0311 (011-3482)	014-0335 (011-3506)	014-0359 (011-3530)	014-0383
68	014-0287 (011-9792)	014-0312 (011-3483)	014-0336 (011-3507)	014-0360 (011-3531)	014-0384
75	014-0288	014-0313 (011-3484)	014-0337 (011-3508)	014-0361 (011-3532)	014-0385
82	014-0289 (011-9793)	014-0314 (011-3485)	014-0338 (011-3509)	014-0362 (011-3533)	014-0386
91	014-0291	014-0315 (011-3486)	014-0339 (011-3510)	014-0363 (011-3534)	014-0387

### TYPE W24 Style M

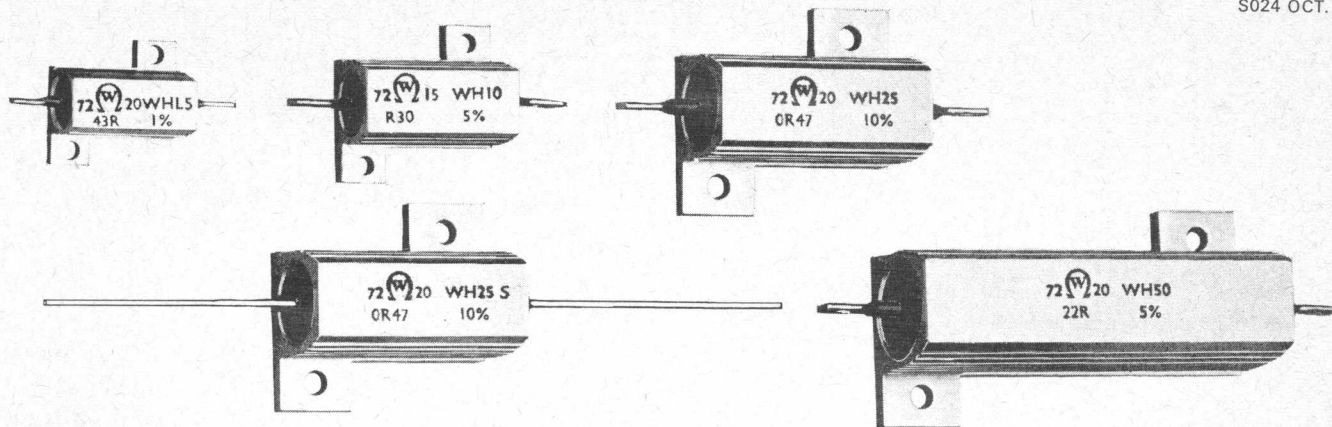
Nominal Ohms.	NOMINAL OHMS MULTIPLIER				
	$\times 10^{-1}$ 1Ω to 9.1Ω	$\times 1.0$ 10Ω to 91Ω	$\times 10$ 100Ω to 910Ω	$\times 10^2$ 1kΩ to 9.1kΩ	$\times 10^3$ 10kΩ to 100kΩ
	5905-99	5905-99	5905-99	5905-99	5905-99
10	014-0146 (011-9794)	014-0170 (011-3349)	014-0194 (011-3373)	014-0218 (011-3397)	014-0242 (011-3421)
11	014-0147	014-0171 (011-3350)	014-0195 (011-3374)	014-0219 (011-3398)	014-0243 (011-3422)
12	014-0148 (011-9795)	014-0172 (011-3351)	014-0196 (011-3375)	014-0220 (011-3399)	014-0244 (011-3423)
13	014-0149	014-0173 (011-3352)	014-0197 (011-3376)	014-0221 (011-3400)	014-0245 (011-3424)
15	014-0150 (011-9796)	014-0174 (011-3353)	014-0198 (011-3377)	014-0222 (011-3401)	014-0246 (011-3425)
16	014-0151	014-0175 (011-3354)	014-0199 (011-3378)	014-0223 (011-3402)	014-0247 (011-3426)
18	014-0152 (011-9797)	014-0176 (011-3355)	014-0200 (011-3379)	014-0224 (011-3403)	014-0248 (011-3427)
20	014-0153	014-0177 (011-3356)	014-0201 (011-3380)	014-0225 (011-3404)	014-0249 (011-3428)
22	014-0154 (011-9798)	014-0178 (011-3357)	014-0202 (011-3381)	014-0226 (011-3405)	014-0250 (011-3429)
25	014-0155	014-0179 (011-3358)	014-0203 (011-3382)	014-0227 (011-3406)	014-0251 (011-3430)
27	014-0156 (011-9799)	014-0180 (011-3359)	014-0204 (011-3383)	014-0228 (011-3407)	014-0252 (011-3431)
30	014-0157	014-0181 (011-3360)	014-0205 (011-3384)	014-0229 (011-3408)	014-0253 (011-3432)
33	014-0158 (011-9800)	014-0182 (011-3361)	014-0206 (011-3385)	014-0230 (011-3409)	014-0254 (011-3433)
36	014-0159	014-0183 (011-3362)	014-0207 (011-3386)	014-0231 (011-3410)	014-0255 (011-3434)
39	014-0160 (011-9801)	014-0184 (011-3363)	014-0208 (011-3387)	014-0232 (011-3411)	014-0256 (011-3435)
43	014-0161	014-0185 (011-3364)	014-0209 (011-3388)	014-0233 (011-3412)	014-0257 (011-3436)
47	014-0162 (011-9802)	014-0186 (011-3365)	014-0210 (011-3389)	014-0234 (011-3413)	014-0258 (011-3437)
5					



# Chassis Mounted Resistors

**SERIES  
WH**

S024 OCT. '74



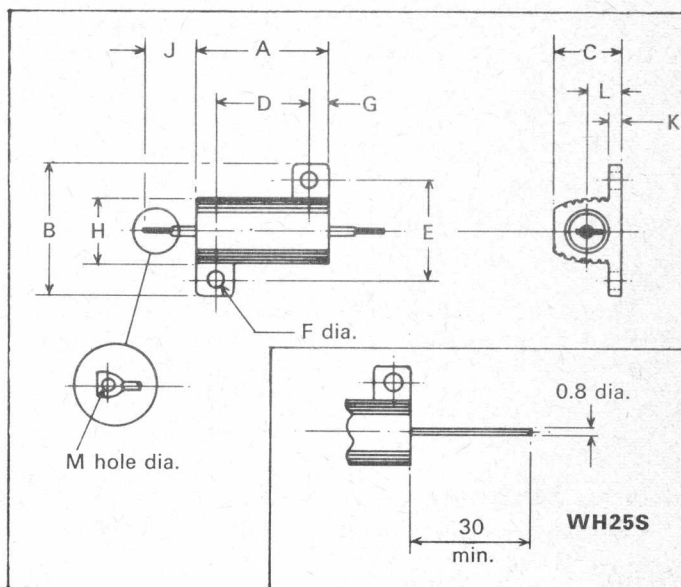
## FEATURES

- Extruded aluminium housing for high heat transfer.\*
- Dissipation: 10 to 50 watts at 20°C.
- Resistance range: 0.05Ω to 39KΩ.
- Climatic category: 55/200/56.
- Dimensions conform to MIL-R 18546C.
- Designed for high wattage dissipation where component can be mounted on heat sink, e.g. chassis.

## MECHANICAL DATA

### Construction

The wire element is wound on a high purity ceramic former and welded to the end caps to which also are welded heavy copper terminal posts. The basic resistor is then encapsulated within a gold anodised aluminium housing.



### Dimensions (in millimetres)

TYPE	A	B	C	D	E	F	G	H	J	K	L	M	Weight (gms.)
WH5	±0.1	±0.2	Max.	±0.1	±0.1	±0.10	±0.2	±1.0	±0.3	±0.3	±1.0	±0.13	3.2
WH10	16.6	16.4	8.8	11.3	12.5	2.40	2.5	8.9	6.3	1.6	4.3	1.27	3.2
WH10	20.5	20.6	10.9	14.3	15.9	2.40	2.9	11.2	7.4	2.4	5.4	2.16	6.3
WH25S	26.9	26.9	14.9	18.3	19.9	3.50	4.4	11.9	—	2.0	7.4	—	11.5
WH25	28.4	27.6	14.9	18.3	19.9	3.24	4.9	14.0	10.4	2.4	7.4	2.16	15
WH50	50.5	29.4	16.4	39.7	21.5	3.24	5.3	15.5	10.4	2.4	8.2	2.16	31

## TERMINATIONS

### Material

Solder dipped copper wire.

### Strength

WH5, WH10 and WH25S - Pull strength 2.5 kg.

WH25 and WH50 - Pull strength 4 kg.

### Solderability

The terminations adequately meet the requirements of BS2011 part 2T, method 1 (Solder bath).

### Marking

The top face of the body is marked with type reference, ohmic value, tolerance and manufacturing date code.

### Solvent Resistance

Body protection and marking are solvent resistant to all accepted industrial cleaning fluids.

### Flammability

Encapsulant is inherently non-burning.



**WELWYN ELECTRIC LIMITED**

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BS 9000  
approval number  
1023/M

# SERIES WH

## ELECTRICAL DATA

Type	WH5	WH10	WH25S	WH25	WH50
Resistance Range (ohms)	0.05 to 3.4K	0.05 to 6.0K	0.05 to 18K	0.05 to 18K	0.05 to 39K
Rating at 20°C On chassis (watts)	10	15	20	25	50
Rating at 20°C No chassis (watts)	5.5	8.0	8.75	12.5	20.0
Limiting Element Voltage (volts d.c.)	160	265	550	550	1250
Isolation Voltage (volts d.c.)	700	700	1760	1760	1760
Proof Voltage (volts a.c. peak)	1000	1000	2500	2500	2500

Ratings applicable when resistors are mounted on a chassis:-

- 101 x 152 x 51 mms deep x 1 mm aluminium for the two smaller sizes. Total area is 412 sq. cms.
  - 127 x 178 x 51 mms deep x 1 mm aluminium for the three larger sizes. Total area is 537 sq. cms.
- See Application notes.

### Manufactured Values

Available in any value within the specified range. E24 Series is the preferred range of values.

### Standard Selection Tolerances

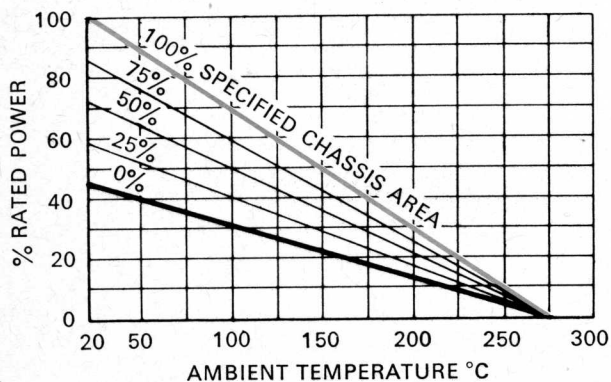
±10%, ±5%, ±2%, ±1% and ±0.5%.

### Low Value Limits

± 10%	± 5%	± 2%	± 1%	± 0.5%
0.05Ω	0.1Ω	1Ω	10Ω	50Ω

### Low Inductance

Low inductance versions are available in a restricted range of values.



### Derating

- Derate linearly from full load at 20°C ambient to zero at 275°C. (See Graph)
- If heat sink area is less than that specified in the table above further derating must be applied. See Application Notes.

### Temperature Rise

TYPE REF.	WH5	WH10	WH25S	WH25	WH50
No chassis: °C/watt	22.2	19.4	16.8	13.3	9.5
On specified chassis: °C/watt	5.8	5.1	5.0	4.2	3.0

### Temperature Coefficient

±50 ppm/°C over the range -55°C to +150°C.  
±100 ppm/°C above 150°C.

### Insulation Resistance

>10<sup>10</sup>Ω

## ENVIRONMENTAL DATA

### Endurance

1000 hours at full load in 20°C ambient: ΔR <1%.

### Short Term Overload

After 5 secs. at 5 times rated power: ΔR <0.5% or 0.05Ω whichever is the greater.

### Change due to Soldering

ΔR negligible.

### Climatic Category

55/200/56

### Climatic Sequence

ΔR <1% or <0.05Ω whichever is the greater.

### Temperature Rapid Change

ΔR <0.5% or <0.05Ω whichever is the greater.

## APPLICATION NOTES

Note that the specified chassis are four-sided trays. To obtain the specified performance the base of the resistor should be coated with silicone grease before mounting. This improves thermal conductivity to the heat sink.

In applications where the chassis area available as a heat sink is less than that specified, reference should be made to the derating graph to establish the correct rating. The graph should be used also to obtain the reduced rating applicable to ambient temperatures above 20°C.

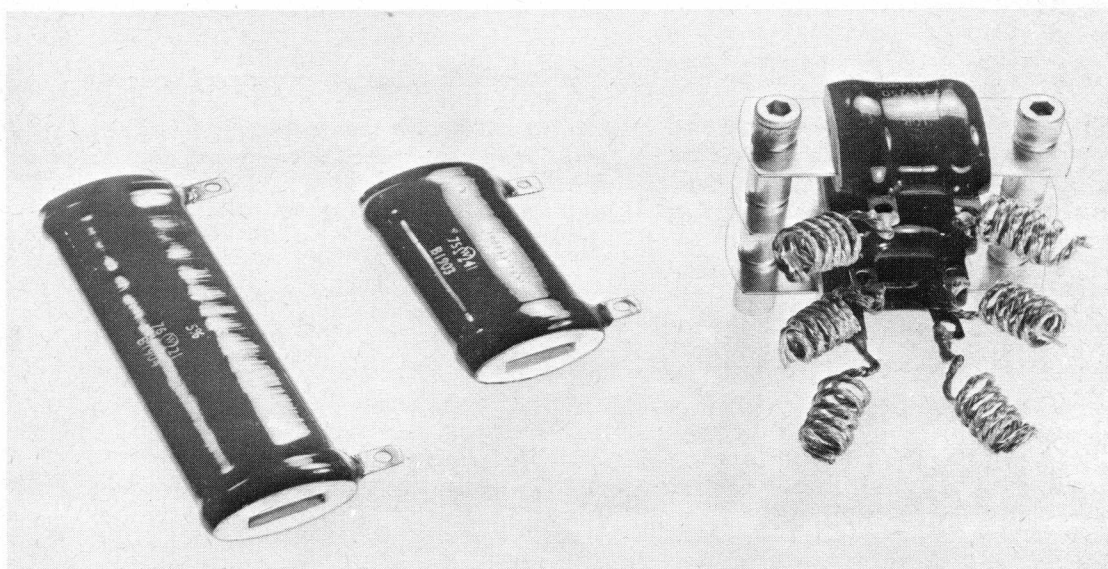
Limiting element voltage will restrict the permitted dissipation of resistance values at the upper end of the range.

## ORDERING PROCEDURE

Specify type reference, resistance value and tolerance, e.g. WH25, 3.7kΩ ±5%, should be ordered using the IEC resistance code, thus: WH25-3K7±5%.



# Elliptical Vitreous Enamelled Wirewound Resistors



- \* High power-to-size ratio
- \* Fixed or tapped versions
- \* Pigtail, lug or wire terminations
- \* Mounting devices suitable for stacking of resistors
- \* Withstands high mechanical shock loads
- \* Suitable for pulse applications

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approval number  
1023/M



# Elliptical Vitreous Enamelled Wirewound Resistors

**Vitreous enamelled wirewound resistors** are capable of withstanding a higher dissipation, size for size, than any other protected type; this is attributable to the higher operating temperature which the wire and enamel can withstand. The vitreous enamel provides exceptionally good protection to the wire element, and the resistors can safely be used in a wide range of harsh environmental conditions.

**The elliptical shape** of the former makes the 1900 Series suitable for positions with limited head clearance. The mounting bracket, which inserts into the tube bore and is in intimate contact with the ceramic, removes heat to the mounting plate while the aerofoil shape assists the passage of cooling air over the resistor surface.

**The Welwyn elliptical range** is based on five sizes of tube, each having a recommended maximum dissipation which will limit operating surface temperature to 375°C maximum.

Resistors can be supplied with fixed windings, or they may be tapped, and each is available with lug or wire terminations for soldered connections, or pigtails for flexible connections. Suitable screws, nuts and spring washers can be supplied for the lugs.

**Adjustable resistors** are practicable, over a reduced resistance range, and enquiries for economic quantities will be considered upon request. Similarly, special requirements for values, tolerances and terminations not described in this brochure will be examined upon receipt of details.

**Mounting devices** are available which permit resistors to be stacked to provide a higher packing density.

**The stability and high reliability** of Welwyn elliptical vitreous resistors is a direct result of the best quality materials being used in their construction. High purity ceramic tubes have been matched to nickel iron alloy bands and specially formulated enamel to ensure that the resistors can withstand repeated heat cycling without damage. Connections between the resistance element and end bands are welded; terminations are brazed.

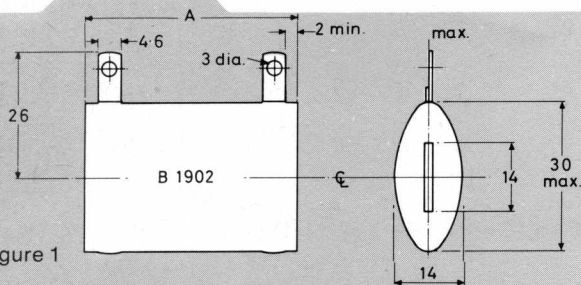


Figure 1

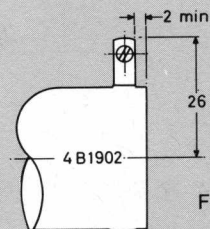


Figure 2

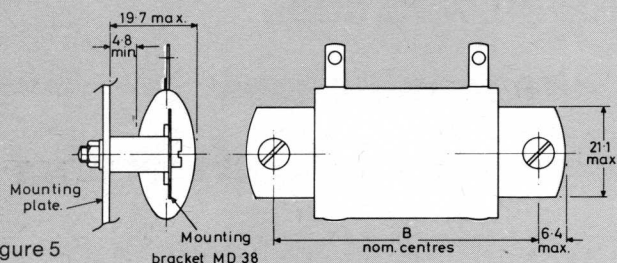


Figure 5

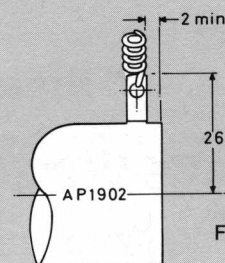


Figure 3

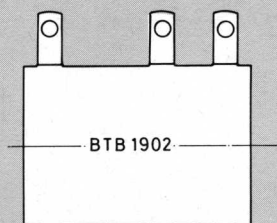


Figure 6

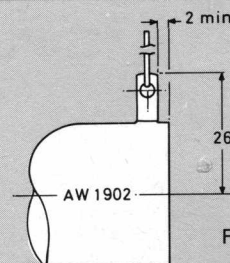


Figure 4

## MECHANICAL DATA

**Terminations:** Lugs (Figure 1) – 60/40 solder coated nickel iron. Denoted by prefix 'B' to size reference, thus: B1902.

Lugs with screws, nuts and washers (Figure 2) – Screws and nuts are brass, nickel plated. Denoted by prefix '4B', thus: 4B1902.

Pigtails (Figure 3) – 14/193 mm tinned copper, 160 mm minimum length. Denoted by prefix 'AP', thus: AP1902.

Rigid wires (Figure 4) – 1.2 mm diameter solder coated copper, 32 mm minimum length. Denoted by prefix 'AW', thus: AW1902.

**Manufactured Values:** Available in any value within the specified resistance range.

**Standard Selection Tolerances:**  $\pm 10\%$ ,  $\pm 5\%$ ,  $\pm 2\%$ ,  $\pm 1\%$ .

**Temperature Coefficient of Resistance:** Typically  $+50$  ppM/ $^{\circ}\text{C}$  and will not exceed  $+120$  ppM/ $^{\circ}\text{C}$ .

**Insulation Resistance:** See Application Notes on page 4.

**Voltage Coefficient:** Negligible.

**Noise:** Current noise is zero.

**Table 1** – Dimensions in millimetres. See Figures 1 and 5.

Size ref.	Resistor length A max.	Fixing centres B nom.
1900	26.5	45
1901	32.5	51
1902	43.0	61
1903	52.0	70
1904	89.5	108

Any termination style, B, 4B, AP or AW is available in each of the five sizes.

## ELECTRICAL DATA

**Table 2**

Size ref.	*Dissipation (watts) to produce operating hotspot temperature of				Resistance range (ohms)				Limiting element voltage	
	ambient = 20°C			ambient = 70°C 375°C	Min. resistance at					Max. value
	200°C	300°C	375°C		$\pm 10\%$	$\pm 5\%$	$\pm 2\%$	$\pm 1\%$		
1900	8.5	16	23	18.5	1	4	20	40	2.8k	140
1901	9.5	18	26	21	1	6	40	70	4.8k	250
1902	11	21	30	24	2	10	60	70	8.3k	400
1903	12	24	35	27	2	14	60	100	11.5k	530
1904	20	40	56	43	4	30	60	100	24.4k	1100

\*The stated dissipation applies to single resistors mounted as shown in Figure 5. See also graph of temperature rise/dissipation. See Application Notes for derating information concerning other mounting arrangements and for stacked resistors.

## ENVIRONMENTAL DATA

**Endurance:** When operated at the recommended maximum dissipation, which will limit the hotspot temperature to 375°C, the change in resistance after 1,000 hours operation will not exceed  $\pm 5\%$ . A lower hotspot temperature will give improved stability.

**Shelf Stability, 12 months:** The change in resistance will be less than 1%.

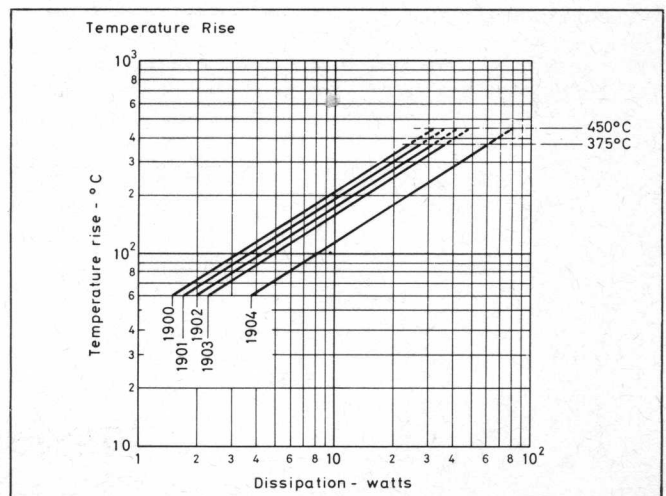
**Performance under humid conditions:** After 56 days in 40°C ambient and 90% to 95% relative humidity, the change in resistance will be less than 2%.

### ORDERING PROCEDURE

Specify full type reference, resistance value and tolerance, using IEC resistance code. E.g. B1902/10R  $\pm 5\%$  is a resistor of size 1902 with B style lugs, 10 $\Omega$   $\pm 5\%$ .

Mounting devices are fully described on page 4.

See that section for ordering procedure, also Fig. 5.





## TAPPED RESISTORS

Resistors can be supplied with tapping points. (See Figure 6). The addition of an extra terminal restricts the available winding length, hence the maximum total resistance is less than offered for a two terminal resistor of the same size. The reduction will be proportional to the number of taps and Table 3 is intended as a guide.

For any section the minimum resistance is 1Ω and the standard selection tolerance  $\pm 10\%$ .

\*Maximum total dissipation assumes that this will be evenly spread over the total element length, and will produce a hotspot temperature of 375°C in 20°C ambient.

Table 3

Size ref.	*Maximum total dissipation (watts) with single tap	Maximum total resistance with single tap (ohms)	Maximum number of taps
1902	21	5.8k	1
1903	27	9.0k	1
1904	50	22.0k	2

Enquiries for tapped resistors should state the following details:

- Resistance per section. Maximum dissipation per section.**
- Maximum operating ambient temperature. Maximum permissible dimensions, if important.**
- Type of terminations required.**
- Proposed method of mounting: vertical or horizontal axis; flat or on edge.**
- Details of stacking, where applicable.**

## MOUNTING DEVICES

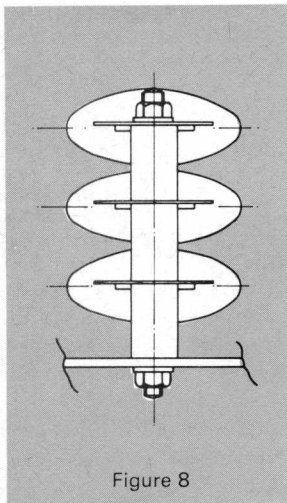


Figure 8

The specially designed mounting device incorporates a formed ear which forces the support plate against the inside of the ceramic former. This materially assists the removal of heat to the mounting platform or chassis. The spacing bush is rivetted to the support plate.

When mounted in the recommended manner, the resistors will withstand high mechanical shock. See Figure 5 and Table 1, page 2.

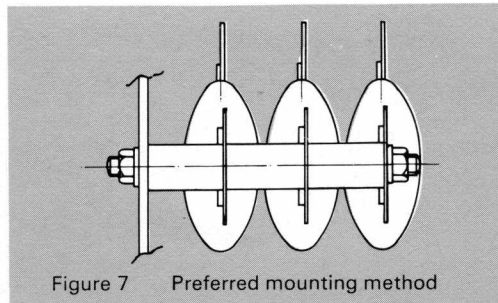


Figure 7 Preferred mounting method

### ORDERING PROCEDURE

Mounting brackets should be ordered in pairs and specify type reference MD38.

## APPLICATION NOTES

When cold, vitreous enamel has excellent insulation resistance. In common with all insulants the specific resistance of the enamel decreases with increased temperature; therefore, if operated at any temperature approaching the maximum, the resistors cannot be classed as an insulated type and should not be used in contact with any conducting material.

The recommended dissipation for each of the listed resistor hotspot temperatures applies to resistors when mounted singly and as shown in Figure 5. If

the resistors are mounted horizontally, or stacked, derating should be applied as recommended in Table 4.

For improved stability the resistors should be operated at a lower hotspot temperature. This may be achieved by

- a) Mounting singly, as in Figure 5.
- b) Forced cooling.
- c) Reduced dissipation.

Resistors mounted singly will benefit most from the heat sink effect of the mounting plate.

Appreciable reduction of hotspot temperature can be achieved by arranging that resistors are subjected to some measure of forced draught. In general, it is most efficient to extract air from the top of the resistor enclosure and arrange that the air inlet is adjacent to the bottom of the resistors.

If soft soldered connections are used, resistors should be derated, where applicable, to limit the hotspot temperature to 300°C.

Mounting method		No. of resistors in stack		
		1	2	3 and more
% derating for each resistor when mounted as in	Fig. 7	0	30%	45%
	Fig. 8	10%	40%	55%

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1023/M



**Welwyn**



## About the Company

The Company was founded in 1937 at Welwyn Garden City, Hertfordshire, from whence it derived its name. The declared policy then was that it would produce components of the best obtainable quality. Throughout, this policy has been rigorously pursued and has established for Welwyn an international reputation for the highest quality products.

**Resistors:** With a diversity of product range probably greater than any other European resistor manufacturer, it is possible to purchase from Welwyn, resistors suitable for almost any application. Resistive elements range over wirewound, metal oxide film and metal film (this last type of element available in several forms from general purpose to ultra-precision) which provide components suitable for a vast range of applications. Special types have been developed for use as RF dummy loads, co-axial assemblies and high voltage assemblies.

An agreement with Vishay inter-technology Inc., in the U.S.A., permits the exclusive manufacture and sales in the U.K. of the Vishay-Welwyn Ultra-Precision range of bulk metal film resistors, renowned for stability, low temperature coefficient and suitability for high frequency applications.

Stemming from discrete resistor production, many types of attenuator, including thick film, are manufactured for Post Office telecommunications equipment; also precision high value types for instrument inputs.

Welwyn have a measurements laboratory which is fully B.C.S. approved for the most precise measurements of d.c. resistance available in U.K. Calibration and certification of, all d.c. resistance standards is in increasing demand. As a natural progression from this precision measuring facility, Welwyn manufacture and market a range of resistance transfer standards and laboratory resistance standards covering the range  $1 \Omega$  to  $1T \Omega$ .

**Potentiometers:** A very wide range of potentiometers is available from Welwyn. Many of these are made at Bedlington, and in addition we have a factoring agreement with Clarostat in America.

During 1973 Welwyn acquired **Colvern Limited**, Romford, for many years pre-eminent in potentiometer production. Their range of wirewound and cermet potentiometers makes a notable addition to the range of products which can now be offered.

This most powerful combination enables us to offer potentiometers and trimmers for most applications. All types of element are available in a wide variety of mounting arrangements and ratings, testimony to the Company's determination to maintain and enhance its reputation as a leader in the professional potentiometer field.

**Hybrid Integrated Circuits:** In 1965 Welwyn entered the thick film circuit field. A solid foundation of design and production experience has been accumulated and Welwyn can justly claim to have the most advanced capability in U.K. for the design and manufacture of thick film hybrid integrated circuits.

A complete service is offered from design to functional and environmental testing. A large team of experienced engineers is employed to convert conventional circuit designs into equivalent thick film circuits, in the most economical manner compatible with the required performance criteria. Rigid quality control and detailed records are maintained at all production stages: certified release is available to all of the chief U.K. inspection authorities.

**Printed Circuits and Flexible Interconnections:** From 1969, when a licensing agreement was made with Sanders Associates Inc. of America, a highly sophisticated production facility has been built up for the manufacture in quantity of precision printed circuit

## CONTENTS

<b>Introduction</b>	<b>page 3</b>
<b>Mechanical data</b>	<b>4</b>
<b>Electrical data</b>	<b>6</b>
<b>Low inductance windings</b>	<b>7</b>
<b>Adjustable resistors</b>	<b>8</b>
<b>Tapped resistors</b>	<b>9</b>
<b>Mounting devices</b>	<b>10</b>
<b>Application notes</b>	<b>11</b>

boards, double-sided and multilayer; single and multilayer flexible printed wiring. Welwyn Intersystem provides complete interconnection systems using combinations of rigid and flexible circuits. A comprehensive application service is offered.

In 1974 **Welwyn Electric GmbH** was formed. Welwyn management recognises the vital importance of a healthy export market and the offices in Reutlingen, staffed by German Nationals, extends the large volume of business taken in Germany.

**Welwyn Strain Measurement Ltd** was formed as a company in 1974, after eight years operation as a separate division of Welwyn Electric. The company is the sole agent and distributor in the U.K. for products manufactured by Vishay Intertechnology Inc. of America, and operates from a factory at Basingstoke, Hampshire.

Two other Welwyn subsidiary companies also are wholly concerned with various aspects of strain measurement: **Strainstall Ltd.**, Isle of Wight and **Stress Engineering Services Ltd.**, Somerset.



# Welwyn Electric Limited

BEDLINGTON NORTHUMBERLAND NE22 7AA ENGLAND

Telephone: Bedlington (0670) 822181 Telex: 53514 Telegrams: Resistor Bedlington

# Tubular Vitreous Enamelled Wirewound Resistors

- Fixed, adjustable, tapped and low inductance types
- Range of terminations
- High dissipation
- Rugged construction for harsh environments
- Range of mounting styles and fittings
- Suitable for pulse applications

## Introduction

Vitreous enamelled wirewound resistors are capable of withstanding a higher dissipation, size for size, than any other protected type; this is attributable to the higher operating temperature which the wire and enamel can withstand. Vitreous enamel provides exceptionally good protection to the wire element and is essentially impervious to moisture. The resistors can safely be used in harsh environmental conditions.

The Welwyn range is based on thirteen sizes of tube, each of which has a recommended maximum dissipation which limits operating surface temperature to a maximum of 375 °C.

Resistors can be supplied with fixed, adjustable, tapped or low inductance winding; each of these winding styles is available with the following choice of terminations.

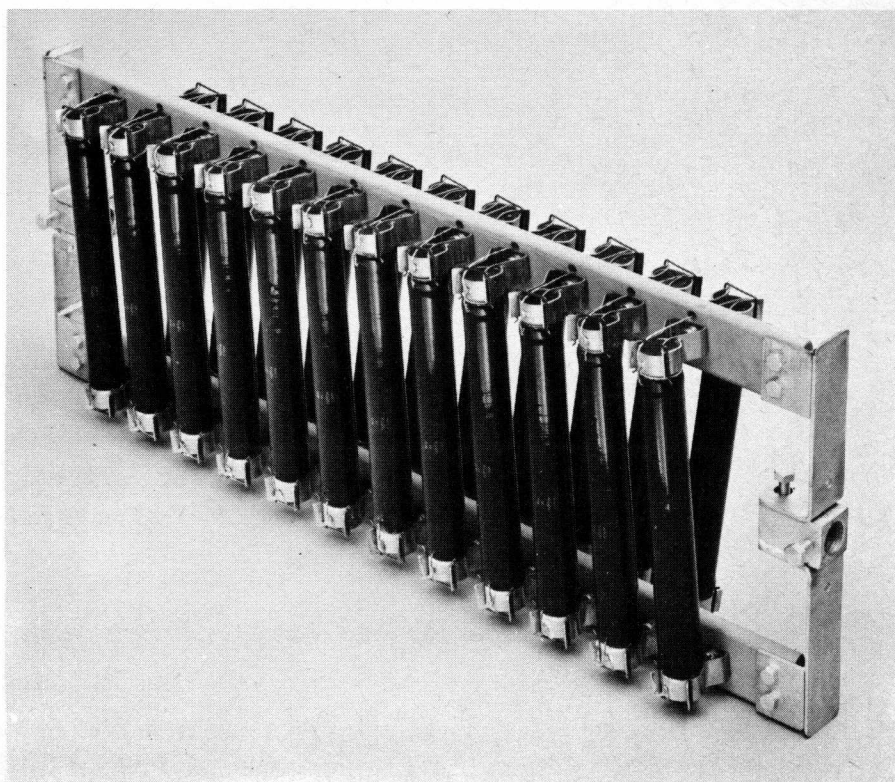
- Lugs for soldered connections.
- Pigtails for flexible connections.
- Ferrules, permitting connection via spring mounting devices.
- Rigid wires (single strand).
- Screws, nuts and spring washers.

See pages 4 & 5.

Mounting devices are available which permit resistors to be mounted by both ends or by one end. Single ended mounting is recommended for applications which do not subject the resistor to shock or vibration. All mounting devices are described on pages 10 and 11.

The stability and high reliability of Welwyn tubular vitreous resistors is a direct result of the best quality materials being used in their construction. High purity ceramic tubes have been matched with nickel chromium resistance alloy wires and specially formulated enamel to ensure that the resistors can withstand repeated heat cycling without damage. Connections between the resistance element and end terminations are welded; other connections are brazed. Ferrules and the F type mounting plug are anchored into the tubes with high temperature cement.

**Special requirements, for types or styles not described in this brochure, will be considered for economic quantities.**



*A Welwyn array of large tubular vitreous resistors specially designed for use with high voltage dust precipitation equipment. These arrays have been recommended by Electrical Research Association for use in C.E.G.B. power stations.*



## Mechanical Data

### TERMINATIONS

**Lugs (Figure 1)** – 60/40 solder coated nickel iron. Denoted by prefix 'B' to size reference, thus: B1602.

**Pigtails (Figure 2)** – 14/.193 mm copper, 150 mm minimum length. Denoted by prefix 'AP', thus: AP1602.

**Rigid wires (Figure 3)** – 1.2 mm diameter tinned copper, 32 mm minimum length. Denoted by prefix 'AW', thus: AW1602.

**Lugs with screws, nuts and washers (Figure 4)** – screws and nuts brass

nickel plated. Denoted by prefix '4B', thus: 4B1602.

**Ferrule, electrically live (Figure 5)** – Nickel plated brass. Denoted by prefix 'C', thus: C1602.

**Ferrule, electrically isolated (Figure 6)** – Connection to resistor via 60/40 solder coated nickel iron lugs. Denoted by prefix 'CB', thus: CB1602.

**Ferrule, electrically isolated (Figure 7)** – Connection to resistor via pigtails of 14/.193 mm copper, 150 mm minimum length. Denoted by prefix 'CP', thus: CP1602.

**Marking:** The resistors are legend marked with type reference, resistance value, tolerance and manufacturing date code.

**Ordering Procedure:** Specify full type reference, resistance value and tolerance, using IEC resistance code. For example, C1602/10R  $\pm$  5% is a resistor of size 1602 with electrically live ferrules, 10 $\Omega$   $\pm$  5%. Mounting devices are fully described on pages 10 and 11. See that section for ordering procedure.

**Table 1. Dimensions in millimetres**

Size ref.	A max.	B max.	C nom.	D nom.	E max.	F max.	G nom.	H $\pm$ 0.15	J	K max.
1601	33.0	17.5	8.2	4.5	5.0	19.5	15	3.2	M3	59
1905	56.1	14.5	6.5	4.5	5.0	17.5	10	3.2	M3	–
1600	61.5	14.5	6.5	4.5	5.0	17.5	10	3.2	M3	–
1602	51.0	17.5	8.2	4.5	5.0	19.5	15	3.2	M3	77
1906	64.3	17.5	8.2	4.5	5.0	19.5	15	3.2	M3	90
1603	74.5	17.5	8.2	4.5	5.0	19.5	15	3.2	M3	101
1604	102	17.5	8.2	4.5	5.0	19.5	15	3.2	M3	128
1605	89.5	24.0	13.2	5.7	6.8	26.5	17	4.2	M4	122
1908	102	24.0	13.2	5.7	6.8	26.5	17	4.2	M4	134
1607	102	32.0	19.2	7.0	9.8	32.0	22	6.5	M6	134
1606	166	24.0	13.2	5.7	6.8	26.5	17	4.2	M4	198
1608	152	32.0	19.2	7.0	9.8	32.0	22	6.5	M6	184
1609	216	32.0	19.2	7.0	9.8	32.0	22	6.5	M6	248

Termination styles B, 4B, AP and AW are available in all 13 tube sizes.

Termination styles C, CB and CP are available in sizes 1601 to 1609 inclusive and 1906 and 1908.

Figure 1

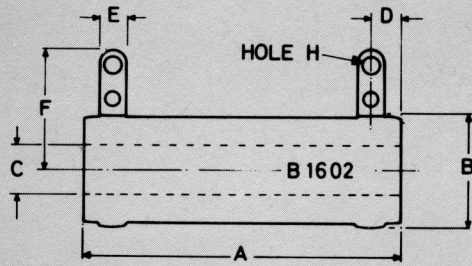


Figure 2

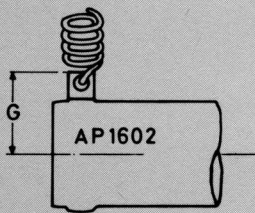


Figure 3

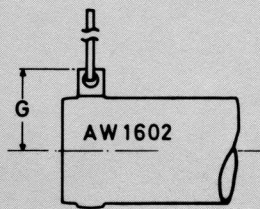


Figure 4

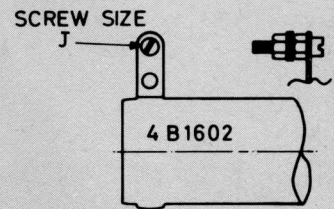


Figure 5

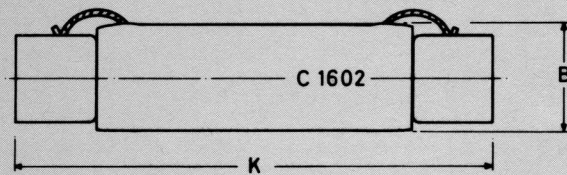


Figure 6

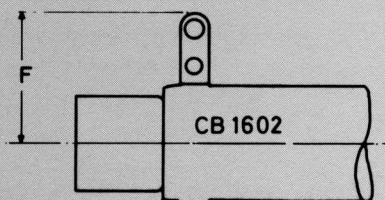
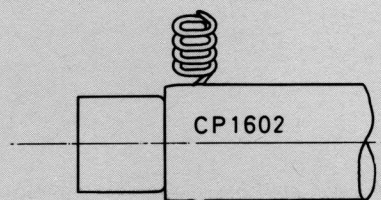


Figure 7





## Electrical Data

**Table 2.**

Size ref.	*Dissipation (watts) to produce operating hotspot temperature of				Resistance range (ohms)				Limiting element voltage		Low inductance winding resistance range (ohms)		
	200 °C	300 °C	375 °C	375 °C	Minimum resistance at			Max. at any tolerance	Termination style		Min. res. at		Max. at either tolerance
	Ambient = 20 °C			Ambient = 70 °C	± 5%	± 2%	± 1%		C	All others	± 10%	± 5%	
1601	5	10	14	11	1	15	25	15k	250	150	10	50	1.3k
1905	7	14.5	20	16	1	15	30	30k	—	450	10	50	3.5k
1600	7.5	15	21	16.5	1	15	30	56k	—	600	10	50	5.0k
1602	8	15.5	22	17	1	20	25	43k	500	350	10	50	4.0k
1906	9.5	19	28	22	1	20	30	50k	700	550	10	50	5.5k
1603	11	22	32	25	1	20	30	83k	850	750	10	50	7.5k
1604	15.5	31	45	35	1	20	60	100k	1300	1000	15	50	11.5k
1605	21	41	59	47	1	30	40	100k	1100	900	15	50	14k
1908	24	47	68	54	1	30	40	100k	1200	1000	10	50	16k
1607	34	66	95	76	1	30	50	100k	1300	900	15	50	22k
1606	41	80	115	91	1	30	40	160k	2100	1900	15	50	32k
1608	52	101	145	115	1	30	50	180k	2100	1800	20	50	38k
1609	74	145	208	165	1	35	50	250k	3000	2500	30	100	58k

\* The stated dissipation applies to resistors mounted horizontally with unobstructed bore.

**Manufactured values:** Available in any value within the specified resistance range.

**Standard selection tolerances:**  
Standard winding ± 5%, ± 2%, ± 1%.  
Low inductance winding ± 10%, ± 5%.

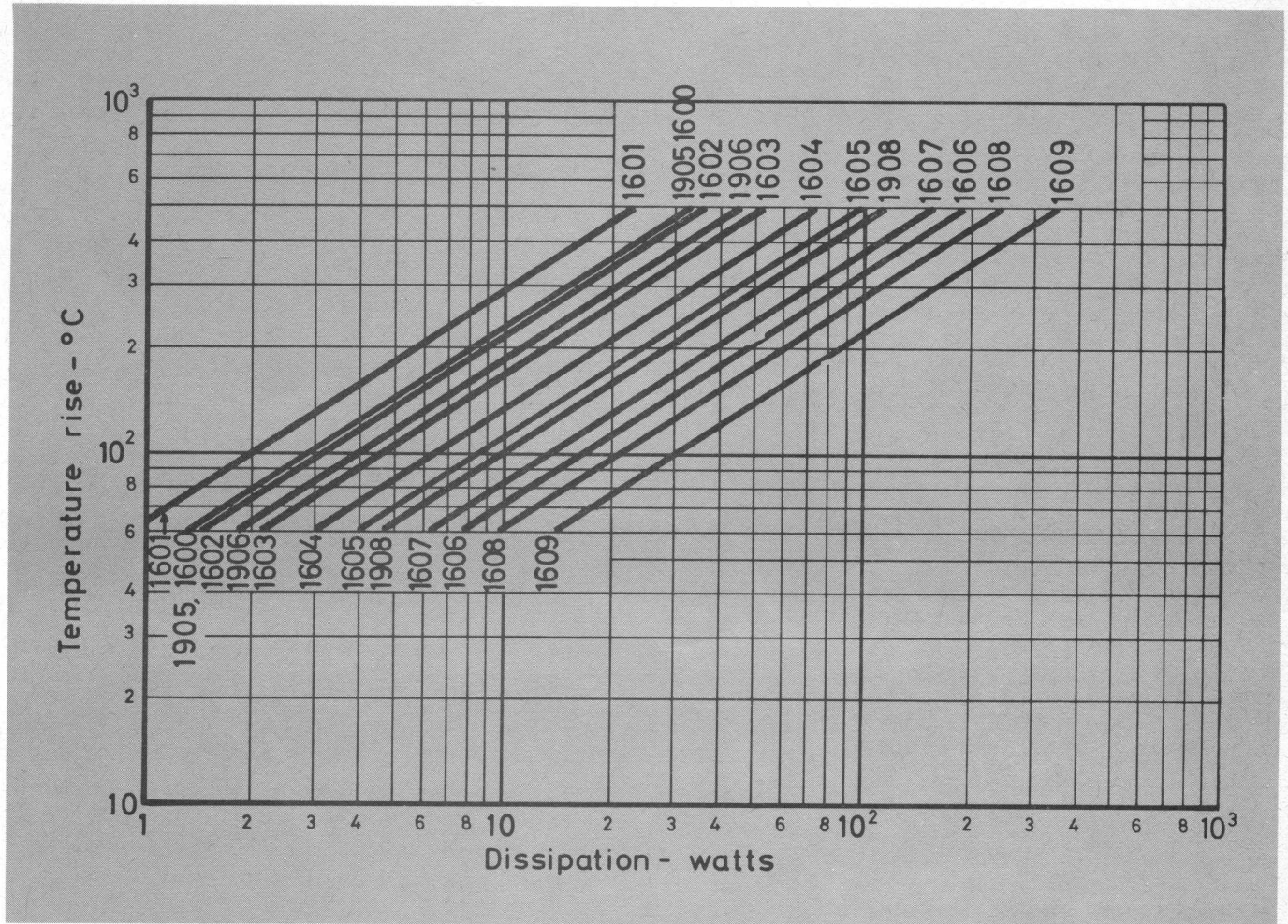
**Temperature coefficient of resistance:** T.C.R. is typically +75 ppm/°C and will not exceed +120 ppm/°C.

**Insulation resistance:** See Application Notes on page 11.

**Voltage coefficient:** Negligible.

**Noise:** Current noise is zero.

## Temperature Rise



### Low Inductance Windings

Ayrton-Perry wound elements are supplied for low inductance applications. This winding style has a maximum permissible hot spot temperature of 300 °C. The maximum dissipation is defined in Table 2

under the heading Operating hot spot temperature of 300 °C, and resistance ranges are defined in the three right-hand columns of this table.

**Ordering Procedure:** Specify the full type reference, resistance value

and tolerance, using IEC code references. The addition of 'L' to the prefix describing terminal configuration indicates Ayrton-Perry winding. E.g. BL1602/10R ± 5%.

### Environmental Data

**Endurance:** When operated at the recommended maximum dissipation, which will limit the hot spot temperature to 375 °C, the change in resistance after 1000 hours operation will not exceed

±5%. Lower hot spot temperatures will give improved stability.

**Shelf stability, 12 months:** The change in resistance will be less than 1%.

**Performance under humid conditions:** After 56 days in 40 °C ambient and 90% to 95% relative humidity the change in resistance will be less than 2%



## Adjustable Resistors

Adjustable resistors use the same basic construction as fixed resistors already described, and have a window in the vitreous enamel through which contact is made to the resistive element by a sliding contact band. The band is fitted with a clamping screw and nut to retain it firmly in position and the contact (or wiper) can be similarly locked in position to make positive electrical connection with the element.

The adjustable winding style has a maximum permissible hot spot temperature of 300 °C and the maximum dissipation, for an ambient temperature of 20 °C, is specified in Table 4. The partial open winding necessitates a reduced maximum resistance, when compared with fixed resistors, and the resistance range is also defined in Table 4.

More than one adjusting band can be fitted, up to the maximum number specified in Table 3.

Adjustable resistors are available in termination styles B, 4B, AP, C, CB and CP, in sizes 1602 to 1609 inclusive and 1906 and 1908.

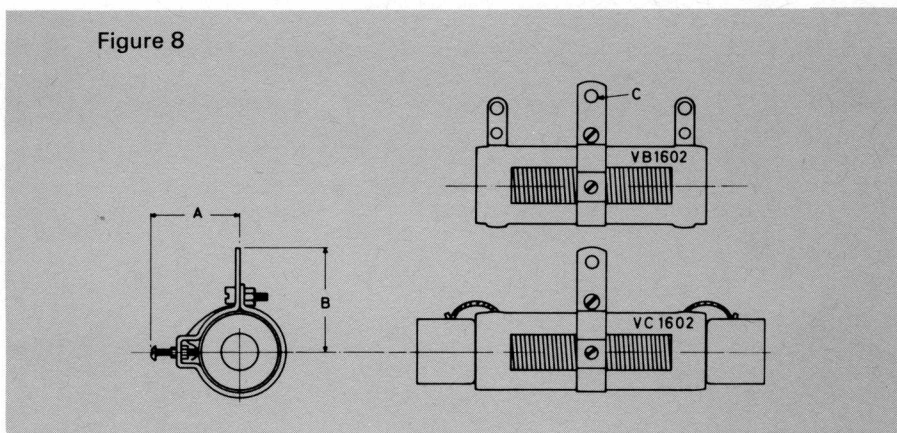


Table 3

Size references	A mm max.	B mm max.	Hole C dia. mm	Max. No. of adjusting bands
1602, 1603, 1906	20	25	3	1
1604	20	25	3	3
1605, 1908	25	30	4	2
1606	25	30	4	4
1607	30	35	4	2
1608	30	35	4	3
1609	30	35	4	5

All other dimensions are as for fixed resistors. (See pages 4 and 5).

Table 4

**Manufactured values:** Available in any value within the specified resistance range.

**Standard selection tolerance:**  $\pm 10\%$ .

All other details of the electrical and environmental performance of adjustable resistors is the same as for fixed resistors, described on Page 7.

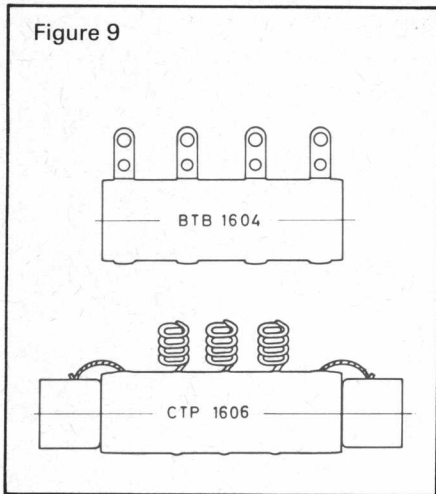
**Ordering Procedure:** Specify full type reference, resistance value and tolerance, using IEC resistance code. The addition of 'V' to the prefix describing terminal configuration indicates an adjustable resistor. E.g. VCP1602/60R  $\pm 10\%$  is a 60 $\Omega$  adjustable resistor with ferrules and pigtail terminations.

Type ref.	Max. dissipation in 20 °C ambient (watts)		Resistance range (ohms)	
	200 °C hot spot	300 °C hot spot	Min.	Max.
1602	8	15.5	2	1.6k
1906	9.5	19	3	2.5k
1603	11	22	4	3k
1604	16	31	5	5.3k
1605	21	41	5	4.5k
1908	24	47	10	7.5k
1607	34	66	10	8.1k
1606	41	80	15	13.2k
1608	52	101	15	15.4k
1609	74	145	15	24.5k

## Tapped Resistors

Fixed resistors can be supplied with taps to special order. Because of the reduced winding length, the total resistance of a tapped resistor will be less than can be offered on a fixed resistor of the same size. The reduction is proportional to the number of taps and Table 5 is intended as a guide.

The minimum resistance per section on all sizes is  $1\Omega$  and the standard selection tolerance for any section is  $\pm 10\%$ .



**Table 5**

Size ref.	*Maximum total dissipation in 20 °C ambient (watts) with single tap	Max. total resistance with single tap (ohms)	Max. number of taps
1905	14.5	9k	1
1600	15.0	12k	1
1602	15.5	9k	1
1906	19.0	13k	1
1603	22	18k	1
1604	31	29k	2
1605	41	34k	2
1908	47	38k	2
1607	66	53k	2
1606	80	78k	4
1608	101	93k	4
1609	145	140k	4

\* Maximum total dissipation assumes that this will be evenly spread over the total element length.

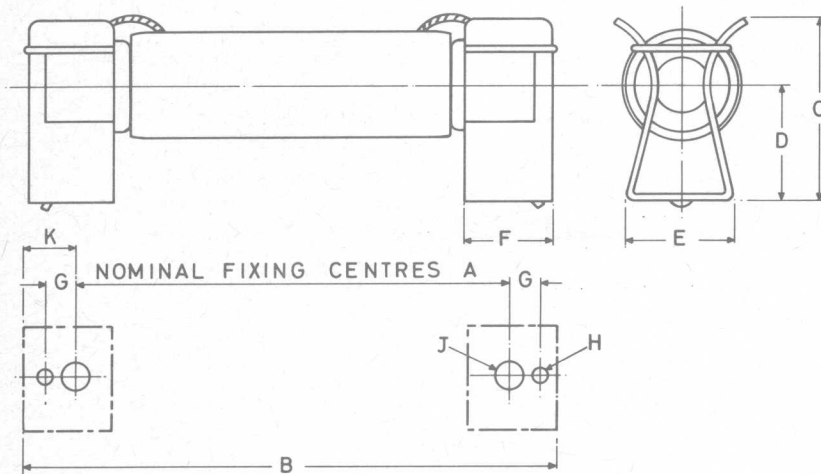
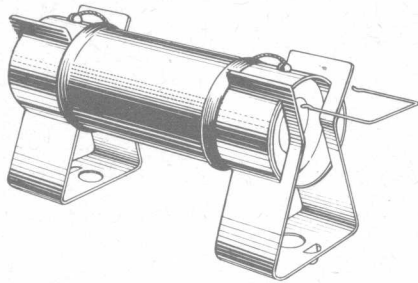
Enquiries for tapped resistors must state the following details:

- Resistance per section
- Maximum dissipation per section
- Maximum operating ambient temperature
- Maximum permissible dimensions, if important
- Type of terminations required
- Resistor style or proposed method of mounting



## Mounting devices

Figure 10



These mounting clips are suitable for termination styles C, CB and CP. MD4, 5 and 6 have an ear formed in the bottom surface of the bracket to prevent rotation on the mounting plate.

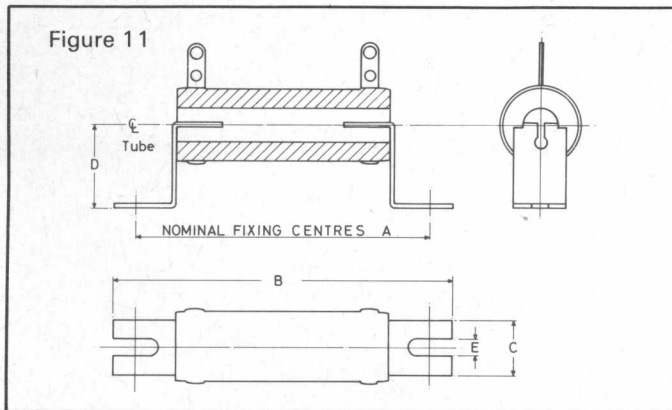
The auxiliary locking springs ensure positive retention of the tube under severe mechanical shock conditions.

See Figure 10.

**Ordering Procedure:** Mounting clips (and auxiliary locking springs, when required) should be ordered in pairs and specify the type reference.

**Table 6** Mounting Clip Dimensions (mm)

Clip type reference	Tube sizes	A nom.	B max.	C nom.	D max.	E max.	F max.	G $\pm 0.2$	H dia.	J dia.	K nom.	Auxiliary locking spring ref.
MD1 MD4	1601 1602 1603 1604 1906	52 70 90 121 83	68 86 106 137 99	29	19	17.5	14.5	4.8	4.0	3.9	7.2	MD16
MD2 MD5	1605 1606 1908	108 187 121	128 207 142	35	22	25.5	17.5	5.6	4.0	4.7	8.7	MD17
MD3 MD6	1607 1608 1609	125 176 240	146 197 261	49	33	32.0	19.0	6.4	4.0	6.3	9.52	MD18



**Table 7** Mounting Bracket Dimensions (mm). See Fig. 11.

Type ref.	Tube sizes	A nom.	B nom.	C max.	D max.	E nom.
MD40	1600	78	92	10	20	4.2
	1905	73	87			
MD41	1601	50	64	13	20	4.2
	1602	68	82			
	1603	91	105			
	1604	119	133			
	1906	81	95			
MD42	1605	106	120	20	25	5.2
	1606	183	197			
	1908	119	133			
MD43	1607	121	143	28	30	5.2
	1608	171	193			
	1609	235	257			

\*These brackets are suitable for termination styles B, 4B, AP & AW.

**Ordering Procedure:** Mounting brackets should be ordered in pairs and specify the type reference.

## Application Notes

When cold, vitreous enamel has excellent insulation resistance. In common with all insulants the specific resistance of the enamel decreases with increased temperature; therefore, if operated at any temperature approaching the maximum, the resistor cannot be classed as an insulated type and should not be used in contact with any conducting material.

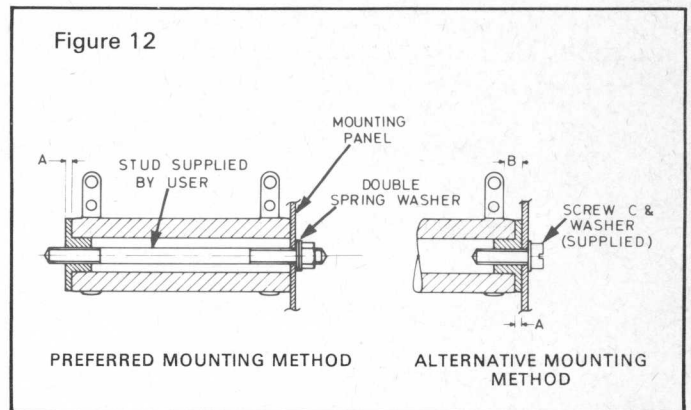
The recommended dissipation for each of the resistor hot spot temperatures applies to resistors

mounted horizontally. If the bore is completely blocked a 15% derating is recommended. However, wherever possible, resistors should be mounted vertically with unobstructed bore. This makes best use of the chimney effect of the heated tube and will encourage a cooling stream of air through the bore.

Allowance must be made, when tubular resistors are mounted in banks, for the effects produced by radiation between tubes.

Appreciable reduction of hot spot temperature can be achieved by arranging that resistors are subjected to some measure of forced draught. In general, it is most efficient to extract air from the resistor enclosure and arrange that the air inlet is adjacent to the bottom of the tubes.

If soft soldered connections are used, the resistors should be derated, where applicable, to limit the hot spot temperature to 300°C.



**Table 8** Mounting Plug Dimensions (mm). See Fig. 12.

Tube sizes	A	B		C
		Min.	Max.	
1601 1602 1603 1604 1906	1.6	3.7	5.3	M4
1605 1606 1908	1.6	3.7	5.3	M5
1607 1608 1609	3.2	5.2	6.8	M6

F type bushes are suitable for termination styles B, 4B, AP and AW.

**Ordering Procedure:** Mounting plugs are denoted by the prefix 'F' added to the size reference; e.g. BF1602 and APLF1602.



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Miniature vitreous wirewound	W	Cermetox® high voltage (professional range)	F40
Chassis-mounting, aluminium housed	WH	Welmet® high voltage (precision range)	M40
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