

Cemented Wirewound Resistors with Ferrules



The ZWK series, with completely welded construction, is the perfect choice for high continuous power dissipation up to 150 W with the option for a non-inductive type (ZWK Ni). With their extremely high pulse power capability, they are the ideal choice as inrush current limiters. Typical applications include but are not limited to drive systems, power supplies, frequency inverters, AC and DC filters, and as snubber resistors. Specific application requirements (ohmic value, rated power, peak voltage, pulse shape, pulse duration, termination style, and environmental conditions) can be submitted to Vishay for a recommendation of the most suitable product.

FEATURES

- Excellent pulse load capability
- High operating voltage up to 7350 V
- Non inductive type (Ni) available
- Different caps options:
 - GDK style with different inner threads
 - GZK made from drawn brass, nickel plated
- Easy to change when mounted with spring clips
- Non-flammable according to UL 94-V0
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



RoHS
COMPLIANT
HALOGEN
FREE
GREEN
(5-2008)

APPLICATIONS

- Inrush current limiter
- Capacitor charge / discharge
- Snubber resistor
- Brake resistor
- Filter resistor

TECHNICAL SPECIFICATION

TYPE / VARIANT	RATED DISSIPATION P_{40}	RESISTANCE RANGE ⁽¹⁾ TCR -10 ppm/K to -80 ppm/K WM50	RESISTANCE RANGE ⁽¹⁾ TCR +100 ppm/K to +180 ppm/K WM110	RESISTANCE TOLERANCE	OPERATING VOLTAGE U_{max}
ZWK 10	10 W	0.47 Ω to 8.2 k Ω	1.5 Ω to 22 k Ω	± 10 %	$\sqrt{P \times R}$
		0.51 Ω to 8.2 k Ω	1.5 Ω to 22 k Ω	± 5 %	
		5.1 Ω to 8.2 k Ω	-	± 2 %	
ZWK 10 Ni	10 W	0.24 Ω to 1.5 k Ω	0.56 Ω to 3.9 k Ω	± 10 %	
		1.0 Ω to 1.5 k Ω	1.0 Ω to 3.9 k Ω	± 5 %	
		-	-	± 2 %	
ZWK 15	15 W	0.47 Ω to 12 k Ω	1.1 Ω to 33 k Ω	± 10 %	
		0.51 Ω to 12 k Ω	1.2 Ω to 33 k Ω	± 5 %	
		5.1 Ω to 12 k Ω	-	± 2 %	
ZWK 15 Ni	15 W	0.36 Ω to 2.2 k Ω	0.82 Ω to 5.6 k Ω	± 10 %	
		0.75 Ω to 2.2 k Ω	1.0 Ω to 5.6 k Ω	± 5 %	
		-	-	± 2 %	
ZWK 20	20 W	0.75 Ω to 20 k Ω	1.6 Ω to 51 k Ω	± 10 %, ± 5 %	
		2.0 Ω to 20 k Ω	-	± 2 %	
		-	-	± 10 %, ± 5 %	
ZWK 20 Ni	20 W	0.56 Ω to 3.3 k Ω	1.3 Ω to 9.1 k Ω	± 10 %, ± 5 %	
		1.5 Ω to 36 k Ω	3.3 Ω to 100 k Ω	± 10 %, ± 5 %	
		2.2 Ω to 20 k Ω	-	± 2 %	
ZWK 40	40 W	1.1 Ω to 6.8 k Ω	2.7 Ω to 18 k Ω	± 10 %, ± 5 %	
		1.8 Ω to 47 k Ω	4.3 Ω to 130 k Ω	± 10 %, ± 5 %	
		2.0 Ω to 47 k Ω	-	± 2 %	
ZWK 40 Ni	40 W	1.5 Ω to 8.2 k Ω	3.3 Ω to 24 k Ω	± 10 %, ± 5 %	
		2.7 Ω to 75 k Ω	6.2 Ω to 200 k Ω	± 10 %, ± 5 %	
		2.7 Ω to 75 k Ω	-	± 2 %	
ZWK 60	60 W	2.2 Ω to 13 k Ω	5.1 Ω to 36 k Ω	± 10 %, ± 5 %	
		4.7 Ω to 130 k Ω	11 Ω to 360 k Ω	± 10 %, ± 5 %	
		4.7 Ω to 130 k Ω	-	± 2 %	
ZWK 60 Ni	60 W	3.9 Ω to 24 k Ω	9.1 Ω to 62 k Ω	± 10 %, ± 5 %	
		-	-	± 10 %, ± 5 %	
		-	-	± 2 %	
ZWK 90	90 W	-	-	± 2 %	
		-	-	± 2 %	
		-	-	± 2 %	
ZWK 90 Ni	90 W	-	-	± 2 %	
		-	-	± 2 %	
		-	-	± 2 %	
ZWK 150	150 W	-	-	± 2 %	
		-	-	± 2 %	
		-	-	± 2 %	
ZWK 150 Ni	150 W	-	-	± 2 %	
		-	-	± 2 %	
		-	-	± 2 %	

Notes

- The operating temperature range for these resistors is from -55 °C up to 250 °C
- (1) Resistance values are to be selected for ± 10 % from the E12 series, and for ± 5 % and ± 2 % from the E24 series

**PACKAGING**

TYPE	PACKAGING CODE	QUANTITY	FORMAT	DIMENSION OF PACKAGE
All	LX	Variable	Bulk, separately packed with paper	Box size selection according to quantity and product size

GLOBAL PART NUMBER INFORMATION

Part Numbering: ZWK010J11000KLX000

Z	W	K	0	1	0	J	1	1	0	0	0	K	L	X	0	0	0
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TYPE	VARIANT / TERMINAL	TCR / MATERIAL	RESISTANCE	TOLERANCE	PACKAGING	SPECIAL
ZWK010 = ZWK 10 ZWK015 = ZWK 15 ZWK020 = ZWK 20 ZWK040 = ZWK 40 ZWK060 = ZWK 60 ZWK090 = ZWK 90 ZWK150 = ZWK 150	I = GZK J = GDK (also known as GDR and M4)	1 = WM 50 -10 ppm/K to -80 ppm/K 3 = WM 110 +100 ppm/K to +180 ppm/K	3 digit value 1 digit multiplier MULTIPLIER 7 = $\cdot 10^{-3}$ 8 = $\cdot 10^{-2}$ 9 = $\cdot 10^{-1}$ 0 = $\cdot 10^0$ 1 = $\cdot 10^1$ 2 = $\cdot 10^2$ 3 = $\cdot 10^3$	G = $\pm 2.0\%$ J = $\pm 5.0\%$ K = $\pm 10.0\%$	LX = loose pack, without quantity	000 = standard 3 digit code = customized version ⁽¹⁾

Product Description: ZWK 10 1 GDK 100R 10 %

ZWK 10	1	GDK	100R	10 %
TYPE	TCR / MATERIAL	VARIANT / TERMINAL	RESISTANCE	TOLERANCE

Notes

- The products can be ordered using either the PRODUCT DESCRIPTION or the PART NUMBER.
- ⁽¹⁾ For special variants, special windings, or the non inductive (ZWK Ni) versions, please contact: ww1resistors@vishay.com.



DESCRIPTION

The rugged design of cemented wirewound resistors enables them to withstand extreme high pulses and makes them well suited for use in high power / high current applications. Production is strictly controlled and follows an extensive set of instructions established for reproducibility. The winding is done with specific materials on a specially developed fine ceramic body (Al_2O_3). With different diameters and turn spacings, a large ohmic value range can be offered. The ceramic used meets the highest requirements against mechanical resistance, thermal shock, dielectric strength, and insulation resistance at high temperatures. The cement coating is fired layer by layer several times at high temperatures. The resulting cement coating is resistant to the cleaning solvents specified in IEC 60115-1 ⁽¹⁾.

The resistors are marked with type, resistance, tolerance and winding material.

Product quality is verified by testing procedures, performed on all individual resistors.

The ZWK series meet single lot / date code packaging requirements.

MATERIALS

Vishay acknowledges the following systems for the regulation of hazardous substances:

- IEC 62474, Material Declaration for Products of and for the Electrotechnical Industry, with the list of declarable substances given therein ⁽²⁾
- The Global Automotive Declarable Substance List (GADSL) ⁽³⁾
- The REACH regulation (1907/2006/EC) and the related list of substances with very high concern (SVHC) ⁽⁴⁾ for its supply chain

The products do not contain any of the banned substances as per IEC 62474, GADSL, or the SVHC list, see www.vishay.com/how/leadfree.

Hence the products fully comply with the following directives:

- 2000/53/EC End-of-Life Vehicle Directive (ELV) and Annex II (ELV II)
- 2011/65/EU Restriction of the Use of Hazardous Substances Directive (RoHS) with amendment 2015/863/EU
- 2012/19/EU Waste Electrical and Electronic Equipment Directive (WEEE)

Vishay pursues the elimination of conflict minerals from its supply chain, see the Conflict Minerals Policy at www.vishay.com/doc?49037.

Notes

- ⁽¹⁾ Other cleaning solvents with aggressive chemicals should be evaluated in actual cleaning process for their suitability.
- ⁽²⁾ The IEC 62474 list of declarable substances is maintained in a dedicated database, which is available at <http://std.iec.ch/iec62474>.
- ⁽³⁾ The Global Automotive Declarable Substance List (GADSL) is maintained by the American Chemistry Council, and available at www.gadsl.org.
- ⁽⁴⁾ The SVHC list is maintained by the European Chemical Agency (ECHA) and available at <http://echa.europa.eu/candidate-list-table>.

ASSEMBLY

The resistors are available with two different termination styles.

The GDK style has machined caps made from brass material CW608N which is plated with nickel. The standard internal thread size is M4 acc. to DIN 13-1. For custom inner thread sizes, contact: ww1resistors@vishay.com.

The GZK style has termination caps made from drawn brass plated with nickel.

It is easy to install / replace these components with either termination style if they are mounted with spring clips. For details about mounting accessories offered, see the datasheet: www.vishay.com/doc?21015.

For special windings or non-inductive (GWK Ni) versions, please contact: ww1resistors@vishay.com.

3D-Models are available upon request, please contact: ww1resistors@vishay.com.

APPLICATION INFORMATION

The power dissipation of the resistor generates a temperature rise with respect to the ambient. The permissible dissipation is derated for temperatures above 40 °C, as shown in the derating diagram, in order to avoid overheating of the resistor. The heat dissipated from the resistor may affect adjacent components, therefore proper clearance is required in order to avoid overheating.

All materials used are non-flammable and inorganic according to UL 94-V0.

These resistors do not feature a limited lifetime when operated within the permissible limits. However, resistance value drift increasing over operating time may result in exceeding a limit acceptable to the specific application, thereby establishing a functional lifetime.

RELATED PRODUCTS

In higher continuous power applications and more demanding environmental conditions, a vitreous coated alternative like the GWK series might be suitable. See the datasheet:

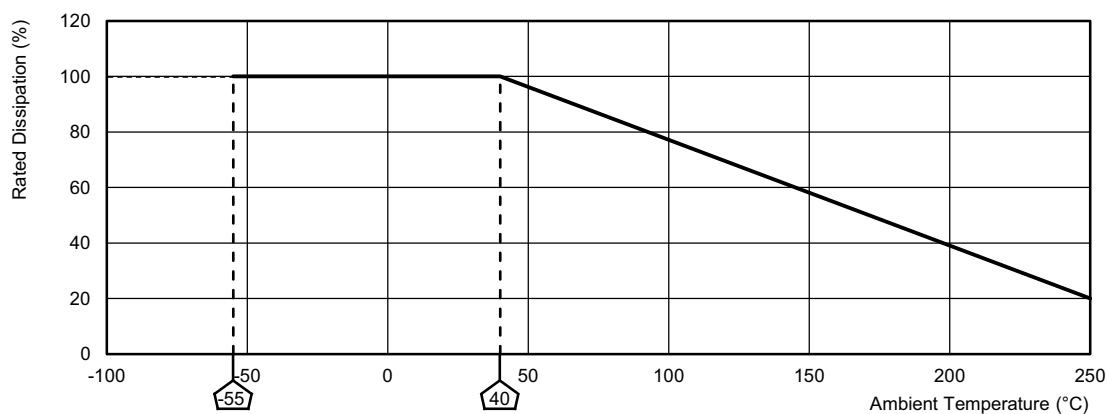
"Vitreous Wirewound Resistors with Ferrules"
www.vishay.com/doc?21006

For low ohmic values and rated dissipation up to 500 W, there is the cemented coated ZBS series. See the datasheet:

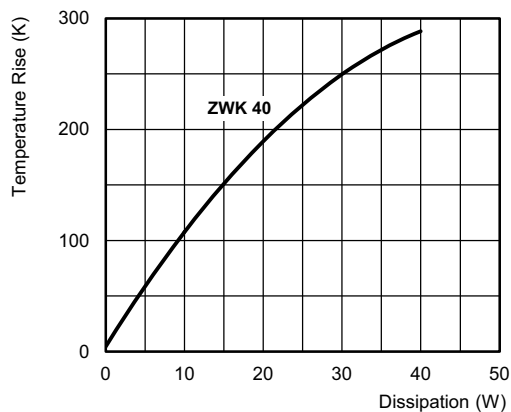
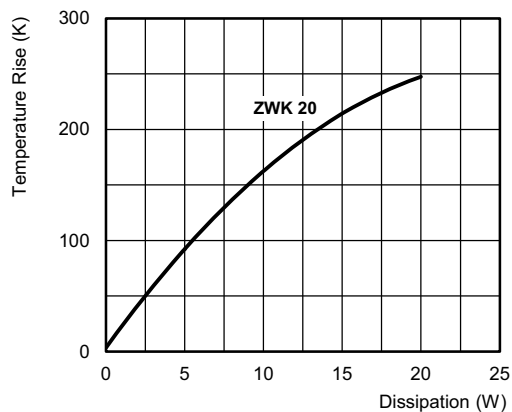
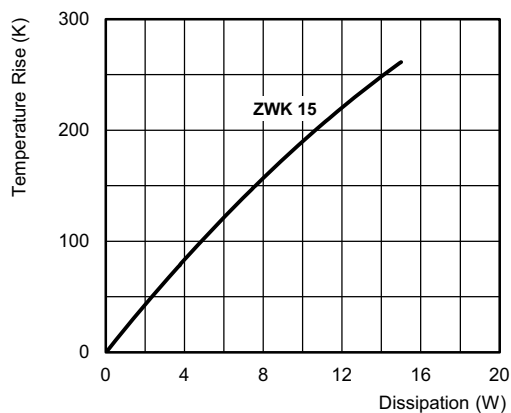
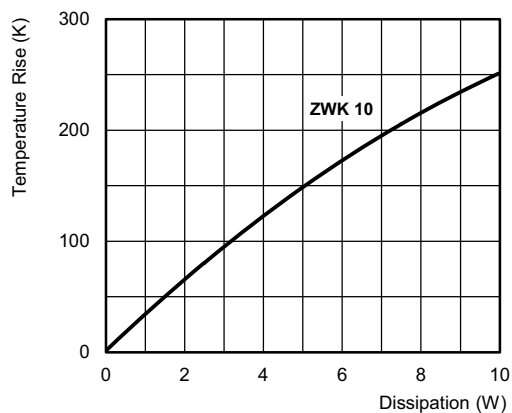
"Cemented Wirewound Resistors with Corrugated Ribbon"
www.vishay.com/doc?21011



DERATING

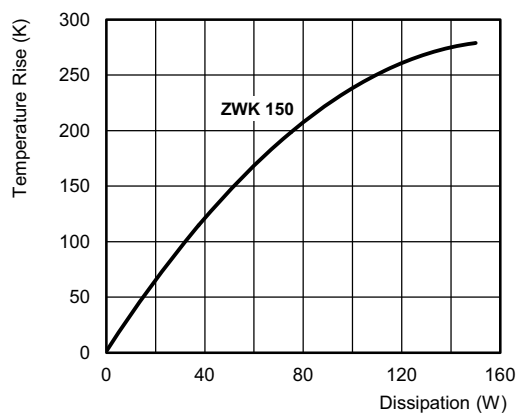
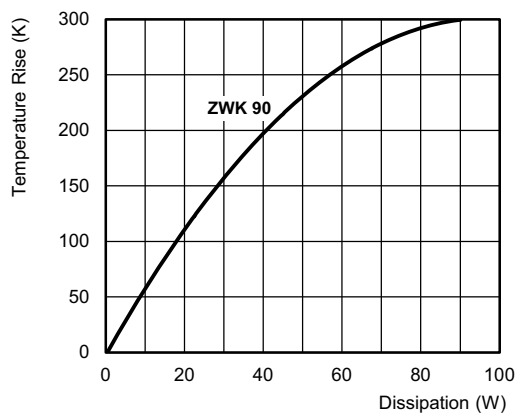
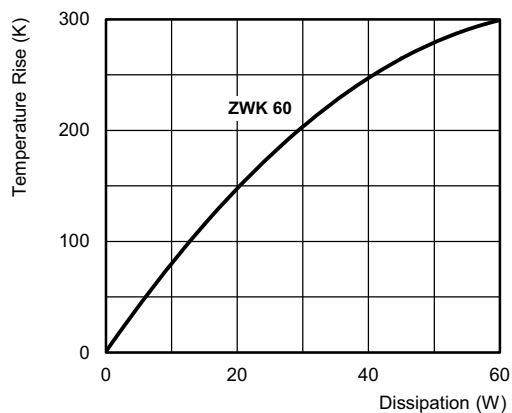


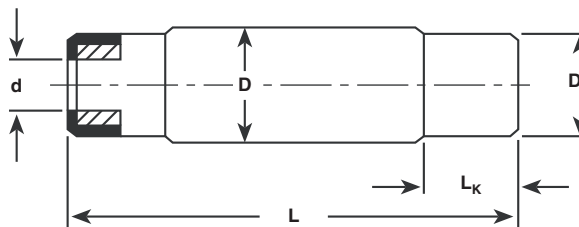
TEMPERATURE RISE



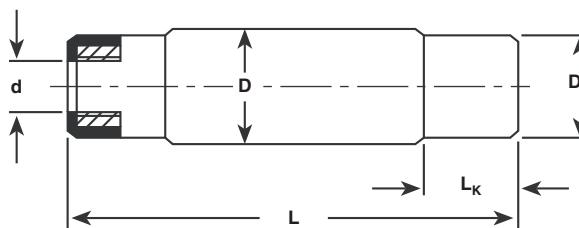


TEMPERATURE RISE



DIMENSIONS AND MASS
**GZK
TERMINATION**

ZWK 10 to ZWK 150 with GZK termination (caps made from drawn brass, nickel plated)

TYPE / VARIANT	D (mm)	L (mm)	D _K (mm)	L _K (mm)	d (mm)	MASS ⁽¹⁾ (g)
ZWK 10 ZWK 10 Ni	12.0 ± 0.8	51.0 ± 1.3	11.0	10.0	4.5	10
ZWK 15 ZWK 15 Ni	15.0 ± 0.8	61.0 ± 1.5	14.0	13.0	5.5	20
ZWK 20 ZWK 20 Ni	15.0 ± 0.8	81.0 ± 2.0	14.0	13.0	5.5	35
ZWK 40 ZWK 40 Ni	22.0 ± 1.0	101.0 ± 2.5	21.0	16.0	10.0	65
ZWK 60 ZWK 60 Ni	22.0 ± 1.0	121.0 ± 3.0	21.0	16.0	10.0	75
ZWK 90 ZWK 90 Ni	22.0 ± 1.0	166.5 ± 4.2	21.0	16.0	10.0	105
ZWK 150 ZWK 150 Ni	22.0 ± 1.0	266.5 ± 6.7	21.0	16.0	10.0	170

**GDK
TERMINATION**

ZWK 10 to ZWK 150 for GDK termination (machined caps with inner thread)

TYPE / VARIANT	D (mm)	L (mm)	D _K (mm)	L _K (mm)	d ⁽²⁾ (mm)	MASS ⁽¹⁾ (g)
ZWK 10 ZWK 10 Ni	12.0 ± 1.0	56.0 ± 1.0	11.0	10.0	M4	15
ZWK 15 ZWK 15 Ni	15.0 ± 1.0	66.0 ± 1.5	14.0	13.0	M4	25
ZWK 20 ZWK 20 Ni	15.0 ± 1.0	86.0 ± 2.0	14.0	13.0	M4	40
ZWK 40 ZWK 40 Ni	22.0 ± 1.0	108.0 ± 2.5	21.5	18.0	M4	70
ZWK 60 ZWK 60 Ni	22.0 ± 1.0	128.0 ± 3.0	21.5	18.0	M4	80
ZWK 90 ZWK 90 Ni	22.0 ± 1.0	173.0 ± 4.2	21.5	18.0	M4	110
ZWK 150 ZWK 150 Ni	22.0 ± 1.0	273.0 ± 6.7	21.5	18.0	M4	175

Notes

- (1) Standard gauge, actually mass is depending on resistance value.
(2) For special inner threads, please contact: ww1resistors@vishay.com.

**PULSE HANDLING FOR SHORT PULSES**

For single pulses up to 100 ms duration the following energy resistance chart can be used to calculate the energy a resistor can handle. Look to the resistance value or the next higher value of the model you need and follow this row to the energy per ohm column to the left. The energy per ohm value multiplied by the resistance value is the energy the resistor can handle for pulses less than or equal to 100 ms. This energy divided by 0.1 s is the power the resistor can handle for 100 ms. For the power the resistor can handle for 10 ms divide the energy by 0.01 s. The maximum pulse power is limited at 625 x rated power.

Do not use this chart for ZWK Ni styles. For more information and assistance please contact ww1resistors@vishay.com.

ENERGY RESISTANCE CHART for Class 1; WM 50 (-10 ppm/K to -80 ppm/K)													
ZWK10		ZWK 15		ZWK 20		ZWK 40		ZWK 60		ZWK 90		ZWK 150	
Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)
1.51E - 03	8.2K	1.51E - 03	12K	1.51E - 03	20K	1.51E - 03	36.0K	1.50E - 03	47K	1.50E - 03	75K	1.50E - 03	130K
1.51E - 03	6.8K	1.51E - 03	10K	1.51E - 03	16K	1.51E - 03	30.0K	1.50E - 03	39K	1.50E - 03	62K	1.50E - 03	110K
1.52E - 03	5.6K	1.51E - 03	8.2K	1.51E - 03	13K	2.79E - 03	24.0K	1.51E - 03	33K	1.50E - 03	51K	1.50E - 03	91K
2.80E - 03	4.7K	2.80E - 03	6.8K	2.79E - 03	11K	2.79E - 03	20.0K	2.79E - 03	27K	2.79E - 03	43K	2.79E - 03	75K
2.81E - 03	3.9K	2.80E - 03	5.6K	2.80E - 03	9.1K	4.76E - 03	16.0K	2.79E - 03	22K	2.79E - 03	36K	2.79E - 03	62K
4.79E - 03	3.3K	4.78E - 03	4.7K	4.77E - 03	7.5K	4.77E - 03	13.0K	4.76E - 03	18K	4.76E - 03	30K	4.76E - 03	51K
4.80E - 03	2.7K	4.79E - 03	3.9K	4.78E - 03	6.2K	7.65E - 03	11.0K	4.76E - 03	15K	4.76E - 03	24K	4.76E - 03	43K
7.71E - 03	2.2K	7.68E - 03	3.3K	7.67E - 03	5.1K	7.65E - 03	9.1K	7.65E - 03	12K	7.64E - 03	20K	7.64E - 03	36K
1.17E - 02	1.8K	1.17E - 02	2.7K	1.16E - 02	4.3K	1.16E - 02	7.5K	1.16E - 02	10K	1.16E - 02	16K	7.64E - 03	30K
1.17E - 02	1.5K	1.17E - 02	2.2K	1.16E - 02	3.6K	1.70E - 02	6.2K	1.16E - 02	8.2K	1.16E - 02	13K	1.16E - 02	24K
1.72E - 02	1.2K	1.71E - 02	1.8K	1.70E - 02	3.0K	1.70E - 02	5.1K	1.70E - 02	6.8K	1.70E - 02	11K	1.70E - 02	20K
2.44E - 02	1.0K	2.43E - 02	1.5K	2.42E - 02	2.4K	2.42E - 02	4.3K	2.42E - 02	5.6K	2.42E - 02	9.1K	2.41E - 02	16K
3.34E - 02	820	3.33E - 02	1.2K	2.43E - 02	2.0K	3.31E - 02	3.6K	3.31E - 02	4.7K	3.31E - 02	7.5K	3.30E - 02	13K
3.35E - 02	680	3.34E - 02	1.0K	3.32E - 02	1.6K	4.49E - 02	3.0K	4.48E - 02	3.9K	3.31E - 02	6.2K	3.30E - 02	11K
4.54E - 02	560	4.52E - 02	820	4.50E - 02	1.3K	4.49E - 02	2.4K	4.48E - 02	3.3K	4.48E - 02	5.1K	4.48E - 02	9.1K
4.56E - 02	470	4.53E - 02	680	4.51E - 02	1.1K	7.63E - 02	2.0K	4.49E - 02	2.7K	4.48E - 02	4.3K	4.48E - 02	7.5K
7.74E - 02	390	7.70E - 02	560	7.67E - 02	910	7.64E - 02	1.6K	7.63E - 02	2.2K	7.62E - 02	3.6K	7.62E - 02	6.2K
7.76E - 02	330	7.72E - 02	470	7.68E - 02	750	1.22E - 01	1.3K	1.22E - 01	1.8K	7.63E - 02	3.0K	7.62E - 02	5.1K
1.24E - 01	270	1.23E - 01	390	1.23E - 01	620	1.22E - 01	1.1K	1.22E - 01	1.5K	1.22E - 01	2.4K	1.22E - 01	4.3K
1.89E - 01	220	1.88E - 01	330	1.87E - 01	510	1.86E - 01	910	1.86E - 01	1.2K	1.86E - 01	2.0K	1.86E - 01	3.6K
1.90E - 01	180	1.88E - 01	270	1.87E - 01	430	2.73E - 01	750	2.72E - 01	1.0K	1.86E - 01	1.6K	1.86E - 01	3.0K
2.78E - 01	150	2.76E - 01	220	2.74E - 01	360	2.73E - 01	620	2.73E - 01	820	2.72E - 01	1.3K	2.72E - 01	2.4K
3.96E - 01	120	3.93E - 01	180	3.90E - 01	300	3.89E - 01	510	3.88E - 01	680	3.87E - 01	1.1K	3.87E - 01	2.0K
5.43E - 01	100	5.39E - 01	150	5.35E - 01	240	5.33E - 01	430	5.32E - 01	560	5.31E - 01	910	5.30E - 01	1.6K
7.33E - 01	82	7.27E - 01	120	5.36E - 01	200	7.18E - 01	360	7.17E - 01	470	7.16E - 01	750	7.15E - 01	1.3K
9.65E - 01	68	9.57E - 01	100	9.50E - 01	160	9.45E - 01	300	9.43E - 01	390	7.16E - 01	620	7.15E - 01	1.1K
1.25E + 00	56	1.24E + 00	82	1.23E + 00	130	1.22E + 00	240	1.22E + 00	330	1.22E + 00	510	9.41E - 01	910
1.60E + 00	47	1.58E + 00	68	1.57E + 00	110	1.56E + 00	200	1.56E + 00	270	1.22E + 00	430	1.22E + 00	750
2.01E + 00	39	1.99E + 00	56	1.97E + 00	91	1.96E + 00	160	1.95E + 00	220	1.56E + 00	360	1.94E + 00	620
2.02E + 00	33	1.99E + 00	47	1.97E + 00	75	3.00E + 00	130	1.95E + 00	180	1.95E + 00	300	1.94E + 00	510
3.09E + 00	27	3.06E + 00	39	3.02E + 00	62	3.00E + 00	110	2.99E + 00	150	2.99E + 00	240	2.98E + 00	430
3.12E + 00	22	3.07E + 00	33	4.42E + 00	51	4.38E + 00	91	4.37E + 00	120	2.99E + 00	200	2.98E + 00	360
4.56E + 00	18	4.48E + 00	27	4.43E + 00	43	4.39E + 00	75	4.38E + 00	100	4.36E + 00	160	4.35E + 00	300
4.60E + 00	15	4.52E + 00	22	4.45E + 00	36	7.33E + 00	62	7.31E + 00	82	7.29E + 00	130	4.36E + 00	240
7.67E + 00	12	7.53E + 00	18	7.42E + 00	30	7.35E + 00	51	7.33E + 00	68	7.30E + 00	110	7.28E + 00	200
1.20E + 01	10	1.18E + 01	15	1.17E + 01	24	1.15E + 01	43	1.15E + 01	56	1.15E + 01	91	1.14E + 01	160
1.59E + 01	8.2	1.56E + 01	12	1.54E + 01	20	1.52E + 01	36	1.52E + 01	47	1.51E + 01	75	1.51E + 01	130
2.07E + 01	6.8	2.03E + 01	10	2.00E + 01	16	1.97E + 01	30	1.97E + 01	39	1.96E + 01	62	1.95E + 01	110
2.09E + 01	5.6	2.05E + 01	8.2	2.01E + 01	13	2.83E + 01	24	1.97E + 01	33	1.96E + 01	51	1.96E + 01	91
2.99E + 01	4.7	2.93E + 01	6.8	2.87E + 01	11	2.83E + 01	20	2.82E + 01	27	2.81E + 01	43	2.80E + 01	75



ENERGY RESISTANCE CHART for Class 1; WM 50 (-10 ppm/K to -80 ppm/K)													
ZWK10		ZWK 15		ZWK 20		ZWK 40		ZWK 60		ZWK 90		ZWK 150	
Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)
4.17E + 01	3.9	4.08E + 01	5.6	4.00E + 01	9.1	4.84E + 01	16	3.92E + 01	22	3.90E + 01	36	3.89E + 01	62
5.15E + 01	3.3	5.03E + 01	4.7	4.93E + 01	7.5	4.86E + 01	13	4.83E + 01	18	4.80E + 01	30	4.78E + 01	51
5.23E + 01	2.7	5.09E + 01	3.9	4.96E + 01	6.2	7.78E + 01	11	7.74E + 01	15	4.81E + 01	24	4.79E + 01	43
8.38E + 01	2.2	8.13E + 01	3.3	7.95E + 01	5.1	7.81E + 01	9.1	7.77E + 01	12	7.72E + 01	20	7.68E + 01	36
1.27E + 02	1.8	1.23E + 02	2.7	1.21E + 02	4.3	1.19E + 02	7.5	1.18E + 02	10	1.17E + 02	16	7.69E + 01	30
1.29E + 02	1.5	1.25E + 02	2.2	1.22E + 02	3.6	1.74E + 02	6.2	1.73E + 02	8.2	1.17E + 02	13	1.17E + 02	24
1.90E + 02	1.2	1.83E + 02	1.8	1.78E + 02	3	1.74E + 02	5.1	1.73E + 02	6.8	1.72E + 02	11	1.71E + 02	20
2.70E + 02	1.0	2.61E + 02	1.5	2.53E + 02	2.4	2.48E + 02	4.3	2.46E + 02	5.6	2.44E + 02	9.1	2.43E + 02	16
3.72E + 02	0.82	3.58E + 02	1.2	3.47E + 02	2.0	3.40E + 02	3.6	3.37E + 02	4.7	3.35E + 02	7.5	3.33E + 02	13
5.05E + 02	0.68	4.87E + 02	1.0	4.72E + 02	1.6	4.60E + 02	3.0	4.57E + 02	3.9	4.54E + 02	6.2	3.33E + 02	11
8.44E + 02	0.62	6.41E + 02	0.82	6.21E + 02	1.3	6.05E + 02	2.4	6.00E + 02	3.3	4.55E + 02	5.1	4.52E + 02	9.1
8.53E + 02	0.56	8.37E + 02	0.68	8.08E + 02	1.1	7.87E + 02	2.0	7.80E + 02	2.7	5.97E + 02	4.3	5.92E + 02	7.5
8.71E + 02	0.47	8.71E + 02	0.47	8.18E + 02	0.91	1.60E + 00	1.6	7.84E + 02	2.2	7.75E + 02	3.6	7.69E + 02	6.2
				8.30E + 02	0.75	8.30E + 02	0.75	7.90E + 02	1.8	7.78E + 02	3.0	7.71E + 02	5.1
										7.80E + 02	2.7	7.72E + 02	4.7

ENERGY RESISTANCE CHART for Class 3; WM 110 (+100 ppm/K to +180 ppm/K)													
ZWK10		ZWK 15		ZWK 20		ZWK 40		ZWK 60		ZWK 90		ZWK 150	
Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)
4.67E - 04	22K	4.66E - 04	33K	4.66E - 04	51K	4.65E - 04	100K	4.65E - 04	130K	4.65E - 04	200K	4.65E - 04	360K
4.68E - 04	20K	4.67E - 04	27K	4.66E - 04	43K	4.65E - 04	82K	4.65E - 04	110K	4.65E - 04	160K	4.65E - 04	300K
7.97E - 04	15K	7.96E - 04	22K	7.94E - 04	36K	7.93E - 04	68K	7.93E - 04	91K	7.93E - 04	130K	7.92E - 04	240K
7.98E - 04	12K	1.27E - 03	18K	7.94E - 04	30K	7.93E - 04	56K	7.93E - 04	75K	7.93E - 04	110K	7.92E - 04	200K
1.28E - 03	10K	1.28E - 03	15K	1.27E - 03	24K	1.27E - 03	47K	1.27E - 03	62K	1.27E - 03	91K	1.27E - 03	160K
1.28E - 03	8.2K	1.94E - 03	12K	1.94E - 03	20K	1.27E - 03	39K	1.27E - 03	51K	1.27E - 03	75K	1.27E - 03	130K
1.95E - 03	6.8K	1.94E - 03	10K	1.94E - 03	16K	1.94E - 03	33K	1.93E - 03	43K	1.93E - 03	62K	1.93E - 03	110K
3.11E - 03	5.6K	3.10E - 03	8.2K	3.10E - 03	13K	1.94E - 03	27K	1.94E - 03	36K	3.09E - 03	51K	1.93E - 03	91K
3.11E - 03	4.7K	4.75E - 03	6.8K	3.10E - 03	11K	3.09E - 03	22K	3.09E - 03	30K	3.09E - 03	43K	3.09E - 03	75K
4.76E - 03	3.9K	4.75E - 03	5.6K	4.74E - 03	9.1K	4.73E - 03	18K	4.73E - 03	24K	4.72E - 03	36K	4.72E - 03	62K
4.78E - 03	3.3K	7.47E - 03	4.7K	7.45E - 03	7.5K	4.73E - 03	15K	4.73E - 03	20K	4.73E - 03	30K	4.72E - 03	51K
7.50E - 03	2.7K	7.48E - 03	3.9K	7.45E - 03	6.2K	7.44E - 03	12K	7.43E - 03	16K	7.43E - 03	24K	7.42E - 03	43K
7.52E - 03	2.2K	1.20E - 02	3.3K	1.20E - 02	5.1K	7.44E - 03	10K	7.44E - 03	13K	7.43E - 03	20K	7.42E - 03	36K
1.21E - 02	1.8K	1.20E - 02	2.7K	1.20E - 02	4.3K	1.19E - 02	8.2K	1.19E - 02	11K	1.19E - 02	16K	1.19E - 02	30K
1.21E - 02	1.5K	1.94E - 02	2.2K	1.93E - 02	3.6K	1.20E - 02	6.8K	1.19E - 02	9.1K	1.93E - 02	13K	1.19E - 02	24K
1.95E - 02	1.2K	1.94E - 02	1.8K	1.93E - 02	3.0K	1.93E - 02	5.6K	1.93E - 02	7.5K	1.93E - 02	11K	1.92E - 02	20K
3.13E - 02	1.0K	3.12E - 02	1.5K	3.11E - 02	2.4K	1.93E - 02	4.7K	3.09E - 02	6.2K	3.09E - 02	9.1K	3.09E - 02	16K
3.14E - 02	820	5.02E - 02	1.2K	3.11E - 02	2.0K	3.10E - 02	3.9K	3.10E - 02	5.1K	3.09E - 02	7.5K	3.09E - 02	13K
5.06E - 02	680	5.03E - 02	1.0K	5.01E - 02	1.6K	3.10E - 02	3.3K	4.98E - 02	4.3K	4.98E - 02	6.2K	4.97E - 02	11K
5.07E - 02	560	7.65E - 02	820	7.62E - 02	1.3K	4.99E - 02	2.7K	4.98E - 02	3.6K	4.98E - 02	5.1K	4.97E - 02	9.1K
7.72E - 02	470	7.67E - 02	680	7.63E - 02	1.1K	7.60E - 02	2.2K	7.59E - 02	3.0K	7.58E - 02	4.3K	7.57E - 02	7.5K
7.75E - 02	390	1.20E - 01	560	1.19E - 01	910	7.60E - 02	1.8K	7.59E - 02	2.4K	7.58E - 02	3.6K	7.58E - 02	6.2K
1.21E - 01	330	1.20E - 01	470	1.20E - 01	750	1.19E - 01	1.5K	1.19E - 01	2.0K	1.19E - 01	3.0K	1.19E - 01	5.1K
1.22E - 01	270	1.88E - 01	390	1.87E - 01	620	1.86E - 01	1.2K	1.86E - 01	1.6K	1.85E - 01	2.4K	1.19E - 01	4.3K
1.90E - 01	220	1.88E - 01	330	1.87E - 01	510	1.86E - 01	1.0K	1.86E - 01	1.3K	1.85E - 01	2.0K	1.85E - 01	3.6K
2.97E - 01	180	2.95E - 01	270	2.93E - 01	430	2.91E - 01	820	2.91E - 01	1.1K	2.90E - 01	1.6K	2.90E - 01	3.0K
2.99E - 01	150	2.96E - 01	220	2.93E - 01	360	2.92E - 01	680	2.91E - 01	910	2.91E - 01	1.3K	2.90E - 01	2.4K



ENERGY RESISTANCE CHART for Class 3; WM 110 (+100 ppm/K to +180 ppm/K)													
ZWK10		ZWK 15		ZWK 20		ZWK 40		ZWK 60		ZWK 90		ZWK 150	
Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)	Energy/ Ω (Ws/ Ω)	R (Ω)
5.11E - 01	120	5.06E - 01	180	5.01E - 01	300	4.98E - 01	560	4.98E - 01	750	4.97E - 01	1.1K	4.96E - 01	2.0K
5.14E - 01	100	8.10E - 01	150	5.03E - 01	240	4.99E - 01	470	4.98E - 01	620	4.97E - 01	910	4.96E - 01	1.6K
8.23E - 01	82	8.14E - 01	120	8.06E - 01	200	8.00E - 01	390	7.99E - 01	510	7.97E - 01	750	7.96E - 01	1.3K
8.29E - 01	68	1.24E + 00	100	1.23E + 00	160	8.01E - 01	330	7.99E - 01	430	7.98E - 01	620	7.96E - 01	1.1K
1.26E + 00	56	1.25E + 00	82	1.23E + 00	130	1.22E + 00	270	1.22E + 00	360	1.22E + 00	510	1.21E + 00	910
1.27E + 00	47	1.95E + 00	68	1.93E + 00	110	1.22E + 00	220	1.22E + 00	300	1.22E + 00	430	1.21E + 00	750
1.99E + 00	39	3.04E + 00	56	1.94E + 00	91	1.92E + 00	180	1.91E + 00	240	1.91E + 00	360	1.90E + 00	620
3.09E + 00	33	3.05E + 00	47	3.01E + 00	75	2.98E + 00	150	2.98E + 00	200	2.97E + 00	300	2.96E + 00	510
3.12E + 00	27	4.79E + 00	39	3.03E + 00	62	2.99E + 00	120	2.98E + 00	160	2.97E + 00	240	2.96E + 00	430
4.91E + 00	22	4.82E + 00	33	4.76E + 00	51	4.70E + 00	100	4.69E + 00	130	4.68E + 00	200	4.66E + 00	360
4.97E + 00	18	7.72E + 00	27	7.62E + 00	43	4.72E + 00	82	4.70E + 00	110	4.68E + 00	160	4.67E + 00	300
7.94E + 00	15	7.79E + 00	22	7.66E + 00	36	7.56E + 00	68	7.53E + 00	91	7.51E + 00	130	7.48E + 00	240
8.07E + 00	12	1.25E + 01	18	1.23E + 01	30	7.58E + 00	56	7.55E + 00	75	7.52E + 00	110	7.49E + 00	200
1.29E + 01	10	1.26E + 01	15	1.24E + 01	24	1.22E + 01	47	1.22E + 01	62	1.21E + 01	91	1.21E + 01	160
2.08E + 01	8.2	2.03E + 01	12	1.99E + 01	20	1.22E + 01	39	1.95E + 01	51	1.21E + 01	75	1.94E + 01	130
2.11E + 01	6.8	2.05E + 01	10	2.01E + 01	16	1.97E + 01	33	1.96E + 01	43	1.95E + 01	62	1.94E + 01	110
3.35E + 01	5.6	3.27E + 01	8.2	3.20E + 01	13	1.98E + 01	27	3.13E + 01	36	3.11E + 01	51	3.10E + 01	91
3.40E + 01	4.7	4.99E + 01	6.8	4.89E + 01	11	3.15E + 01	22	3.13E + 01	30	3.12E + 01	43	3.10E + 01	75
5.20E + 01	3.9	5.05E + 01	5.6	4.92E + 01	9.1	4.82E + 01	18	4.80E + 01	24	4.77E + 01	36	4.75E + 01	62
5.28E + 01	3.3	7.91E + 01	4.7	7.72E + 01	7.5	4.84E + 01	15	4.81E + 01	20	4.78E + 01	30	4.76E + 01	51
8.28E + 01	2.7	8.01E + 01	3.9	7.79E + 01	6.2	7.61E + 01	12	7.56E + 01	16	7.51E + 01	24	7.47E + 01	43
1.32E + 02	2.2	1.28E + 02	3.3	1.25E + 02	5.1	7.65E + 01	10	1.21E + 02	13	7.53E + 01	20	7.48E + 01	36
1.35E + 02	1.8	1.30E + 02	2.7	1.26E + 02	4.3	1.23E + 02	8.2	1.22E + 02	11	1.21E + 02	16	1.20E + 02	30
1.39E + 02	1.5	2.58E + 02	2.2	2.03E + 02	3.6	1.98E + 02	6.8	1.96E + 02	9.1	1.95E + 02	13	1.20E + 02	24
		3.35E + 02	1.8	2.53E + 02	3	2.46E + 02	5.6	2.44E + 02	7.5	2.43E + 02	11	2.41E + 02	20
		3.40E + 02	1.5	3.28E + 02	2.4	3.19E + 02	4.7	3.16E + 02	6.2	3.14E + 02	9.1	3.12E + 02	16
		3.48E + 02	1.2	3.32E + 02	2.0	3.21E + 02	3.9	3.18E + 02	5.1	3.15E + 02	7.5	3.12E + 02	13
						3.23E + 02	3.3	3.20E + 02	4.3	3.16E + 02	6.2	3.13E + 02	11



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