



## ESL ELECTROSCIENCE

CERAMIC TAPES &  
THICK-FILM MATERIALS

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## CERMET RESISTOR SYSTEM

## 2700-G Series

### Ruthenium Resistor • Cadmium-free

ESL 2700-G Series is a cadmium-free family of ruthenium based materials providing stable performance under high voltage stresses. The 2700-G Series are suitable for TV focus controls, lightning surge arrestors, and high voltage applications. Resistivities are available in seven contiguous ranges for 10  $\Omega$ /sq. to 10 M $\Omega$ /sq. Adjacent resistivities are blendable. ESL 2700-GD Series is available for use over 4913-G.

The 2700-G Series exhibits tight resistance distributions, low surface contact resistance for high resistivities, and small shifts in resistance after the application of very high voltages. These low cost compositions have found use in TV focus controls, high voltage dividers, and bleeder resistors. They are easy to process, are stable, laser trimable, and find use in many industrial and commercial applications.

Extremely high short-time power levels may be used for special pulsing or high voltage surge applications. ESL 2714-G is suggested for use in lightning arrestor circuits, and in some instances, 2-3 mm long resistors have been subjected to many thousands of 1 kV capacitor discharges with good performance. High voltage stress changes are about twice as good for the gold terminated resistors, as compared to palladium silver terminations.

Characteristics of the 2700-G Series are:

- Wide range of resistivities: 10  $\Omega$ /sq. to 10 M $\Omega$ /sq.
- Tight resistance distribution
- High Voltage insensitivity
- TCR's of  $\pm 100$  ppm
- Good Heat Stability: < 0.3% DR in the mid-ranges, 150°C for 1000 hours, no load
- Low contact resistance in the high ranges

ESL Europe 2700-G Series 1004-A

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See Caution and Disclaimer on other side.

## PASTE DATA

<b>Blending:</b>	Adjacent decade values of the seven contiguous ranges are blendable with each other
<b>Viscosity:</b> (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
<b>Shelf Life (20 - 25 °C):</b>	6 months

## PROCESSING

<b>Screen Mesh, Emulsion:</b>	200 S/S, 12.5 µm
<b>Levelling Time (at 20°C):</b>	5 - 10 min
<b>Drying Time (at 125°C):</b>	10 - 15 min
<b>Firing Temperature Range:</b>	850°C
	Time at peak:
<b>Total Cycle Time:</b>	45 min
<b>Substrate for Calibration:</b>	96% alumina
<b>Recommended Termination:</b>	9695
<b>Thinner:</b>	ESL 401

## TYPICAL PROPERTIES

<b>Dried Print Thickness:</b> (on 96% alumina)	22.5 ± 2.5 µm
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### Stabilization:

Overglazes or post-fire stabilizations are not normally required for resistors 1 kΩ/sq. or higher. If desired, however, ESL 4771-P (500°C-540°C) may be used. ESL 242-SB Yellow may be used with curing at 150°C. Thermal stabilizations for high power applications may typically be performed between 300°C for 50 hours to 450°C for 2 hours (before final laser trimming). Voltage short time overloads of about twice rated voltage for 5 to 10 seconds may additionally be used for stabilization. Heat stabilization conditions should take into consideration any possible effects on the solderability or wire bondability of the conductor used.

Overglaze protection is required for 2711-G and 2712-G due to their higher concentrations of the conductive phase, which results in a porous film structure.

ESL Europe 2700-G Series 1004-A

**CAUTION:** Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

**DISCLAIMER:** The product information and recommendations contained herein are based on data obtained by tests we believe to be accurate, but the accuracy and completeness thereof is not guaranteed. No warranty is expressed or implied regarding the accuracy of these data, the results obtained from the use hereof, or that any such use will not infringe any patent. ElectroScience assumes no liability for any injury, loss, or damage, direct or consequential, arising out of its use by others. This information is furnished upon the condition that the person receiving it shall make his own tests to determine the suitability thereof for his particular use, before using it. User assumes all risk and liability whatsoever in connection with his intended use. ElectroScience's only obligation shall be to replace such quantity of the product proved defective.

## Power Rating:

The 2700-G Series resistors are rated for power at a level of 0.16 Watts/mm<sup>2</sup> (100 Ω/sq. inch). A hot spot maximum of 150°C is recommended.

## Notes:

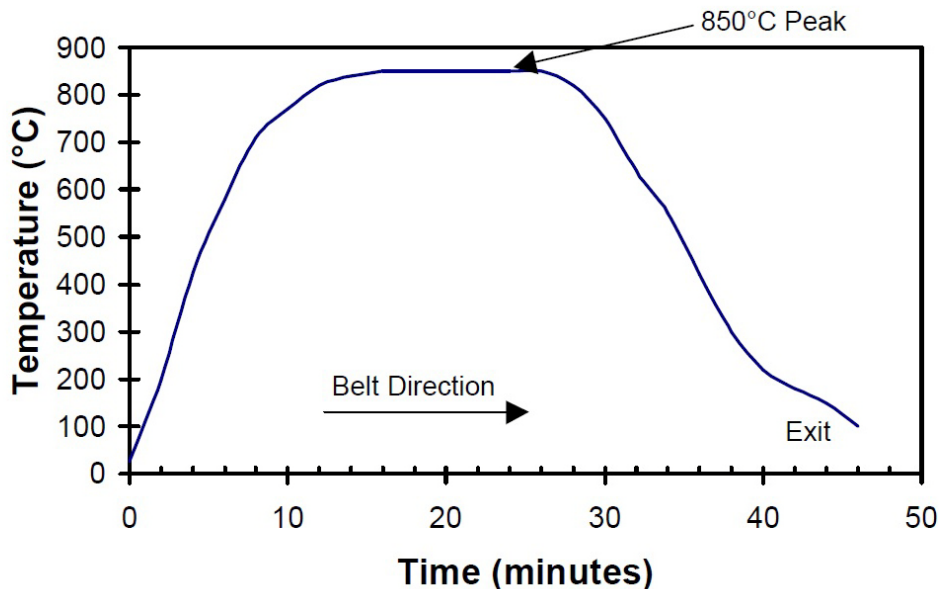
a - Drying in an inadequately air vented furnace is not recommended and can shift resistivities.

b - The 2700-G Series has low sensitivity to firing times. Changes in resistivity of  $\pm 20\%$  may be expected by varying the firing cycle time by  $\pm 15$  minutes. For mid-range and high resistivities, lowering peak firing temperatures will raise resistivity. Increasing peak temperatures will have very little effect on resistivity over a 10°C range.

c - Small shifts in resistivity may occur with 99% alumina substrates or substrates containing substantial amounts of calcium or barium silicates.

d - The 2700-G Series resistors are calibrated to give as-fired resistivities of  $\pm 10\%$  in the mid-ranges and  $\pm 20\%$  in the end ranges, measured on 1.25 mm x 1.25 mm resistors. Most other ESL silver, palladium silver, platinum-silver, or gold terminations may be used. Higher silver content terminations other than 9635-B give slightly lower resistivities, more positive TCR's, and somewhat larger geometry effects for small sized resistors. Gold terminations usually give higher resistivities, more negative TCR's and smaller geometry effects. Upon refiring, the resistivities of the high values of the 2700-G Series will drop by 10%-20% using gold terminations and by 30%-50% with silver bearing terminations.

## Typical 850°C Firing Profile



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COMPOSITION	2711-G	2712-G	2713-G	2714-G	2715-G	2716-G	2717-G
VISCOSITY Pa-s	225±25	225±25	225±25	225±25	225±25	225±25	225±25
DRIED THICKNESS (µm)	22.5±2.5	22.5±2.5	22.5±2.5	22.5±2.5	22.5±2.5	22.5±2.5	22.5±2.5
FIRED THICKNESS (µm)	12.5±2.5	12.5±2.5	12.5±2.5	12.5±2.5	12.5±2.5	12.5±2.5	12.5±2.5
RESISTIVITY (Ω/sq.)	10	100	1 k	10 k	100 k	1 M	10 M
TOLERANCE (%)	±20	±10	±10	±10	±10	±20	±20
TCR (-55°C to +125°C)	±100	±100	±100	±100	±100	-100±100	-250±100
Noise (Quan Tech) (dB)	N/A	≤ -20	≤ -5	≤ 0	≤ +5	≤ +20	≤ +35
VCR (ppm/V/cm)	N/A	N/A	N/A	≥ -15	-20	≤ -30	≤ -50
HEAT STABILITY (%ΔR, 150°C, 1000 hours)	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0
EFFECT OF OVERGLAZE (%) (530°C, 10-12 min. @ PEAK)	±2.5	±2.5	±2.5	±2.5	±2.5	±2.5	±2.5
REFIRE (at 850°C) (%)	±20	±20	≥ -40	±40	-40	≥ -40	-50
STOL (2.5 x Rated Voltage, 5 sec.)(%)	0.25	0.25	0.25	0.25	-	-	-
LASER TRIM (125°C, 24 hours) (%)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PULSING (20 Pulses @ 1250 V) (%)	±5	±5	±5	±5	±5	±5	±5
FIRING SENSITIVITY (Fire at 825°C or 875°C) (%)	N/A	±30	±30	±30	±30	±30	±30
SOLDER DIP (220°C, 5 sec.)							
BARE RESISTORS (%)	3.00	0.30	0.20	0.20	0.20	0.50	0.50
OVERGLAZED (%)	0.30	0.10	0.10	0.10	0.10	0.20	0.30

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