DuPont Series 17 Resistors

HIGH RELIABILITY HYBRID MICROCIRCUITS AND PRECISION RESISTOR NETWORK 10Ω - 1MΩ/SQ SILVER ALLOY TERMINATIONS

Technical Data Sheet

Product Description

DuPont Series 1700 Resistor Compositions have been developed as part of a materials system for use in the manufacture of high reliability hybrid circuits requiring high stability, low TCR, and low process sensitivity.

Product Benefits

- Post laser trim stability of less than 0.5% average ∆R under all standard testing conditions.
- TCRs of less than 100 ppm/°C, even with blends.
- Low sensitivity to variations in firing temperature, time at peak and resistor geometry.

Processing

Substrates

Reported properties are based on tests on 96% alumina substrates. Substrates of other compositions and from various manufacturers may result in variations in performance properties.

Termination

Unless otherwise stated, reported properties are based on tests with 9308 silver/palladium conductor composition, prefired at 850°C. Excellent results have also been obtained using other silver/palladium conductor compositions. The precious metal alloy compositions are prefired at 850°C.

Composition Properties

Test	Properties
Viscosity (Pa.s) (UC & #14 Spindle, 10 rpm, 25°C ± 1°C)	145-210
Thinner	DuPont 4036
Coverage (cm²/g) (in²/g)	80 - 110 12.5 - 15

This table shows anticipated typical physical properties for DuPont 1700 series based on specific controlled experiments in our labs and are not intended to represent the product specifications, details of which are available upon request.

Resistor Geometry

Series 1700 compositions are Quality Assurance tested using a 1.5 mm x 1.5 mm resistor with prefired silver/palladium DuPont 9308 terminations. Variations in resistor geometry will result in slight variations in resistivity and TCR, as shown in Figures 4 and 6, respectively. These data are based on tests of 1 mm and 1.5 mm wide resistors varying in length from 0.5–5 mm.

Printing Conditions

Specified properties are based on resistors printed to 25 ± 3 μm dried print thickness. This is readily achieved using 200-mesh stainless steel screens with 15 ± 3 μm emulsion thickness. Nylon or polyester screens may be used in some applications although a lower mesh count of 150–175 will usually be required to achieve equivalent print thickness.

Table 2
Typical Fired Resistor Properties

Series 17	1711	1713	1721	1729	1731	1739	1749	1759
Resitivity[2], Ω/sq, % 1M ± 10%	10 ± 10%	30 ± 10%	100 ± 10%	1 k ± 10%	1 k ± 10%	10 k ± 10%	100k	± 10%
Temperature Coefficient of Resistance (TCR)[2], ppm/°C	0 ± 100	0 ± 50	0 ± 50	0 ± 100	0 ± 50	0 ± 100	0 ± 100	0 ± 100
Vintage Coefficient of Resistance (TCR)[3], ppm/°C –90	—	—	—	—	—	—	–30	–40
Short Term Overload Voltage[4], V/mm	8	5	21	70	60	200	280	370
Standard Working Voltage[5], V/mm	3	2	8	28	25	80	110	150
Maximum Rated Power Dissipation[6], mW/mm^2	900	135	600	784	625	426	120	22
Quan Tech Noise[7], dB	<-30	<-30	–19	—	–15	–6	2	—
Blendable Series	A	A	A	B	A	B	B	B

[1] Typical resistor properties based on laboratory tests using recommended processing conditions: terminations—DuPont Palladium/Silver Conductor Composition 9308 prefired at 850°C (1562°F); substrate—96% alumina; printing—200-mesh stainless steel screen (18 µm emulsion thickness) to a dried thickness of 25 ± 3 µm; firing—60-min cycle to peak temperature of 850°C (1562°F) for 10 minutes.

[2]Shipping specifications. Resistor geometry—1.5 mm x 1.5 mm. Temperature Coefficient of Resistance –55+25°C and +25 +125°C

[3] Voltage coefficient of Resistance. Resistor geometry 1 mm x 1 mm laser trimmed with P-cut to 1.5x average fired value. VCR measured from 5–50 VDC.

[4] Short Term Overload Voltage—required (5 sec duration) to induce a resistance change of 0.25% in a 1 mm x 1 mm resistor at 25°C.

[5] Standard working voltage—0.4x Short Term Overload Voltage.

[6] Maximum Rated Power Dissipation— $\frac{(\text{Standard Working Voltage}^2)}{\text{Resistance}}$

[7] Resistor geometry—1 mm x 1 mm; Firing cycle—60-minute cycle to peak temperature of 850°C for 10 minutes.

Drying
Prints should be allowed to level 5–10 min at room temperature and then dried 10–15 min at 150°C (302°F).

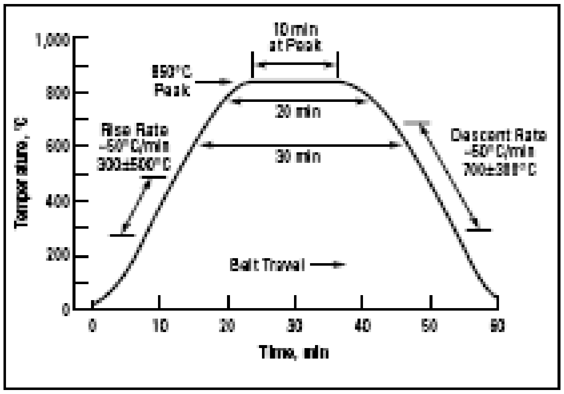
Effect of Variations in Thickness
Figure 3 and 5 illustrate the effect of print thickness variations on resistivity and TCR, respectively. Print thickness outside the 20–30 µm range may result in compromised TCR and/or stability characteristics.

Firing
DuPont Series 1700 resistivity and TCR specifications are based on a 60-min firing cycle with a 10-min peak at 850°C, 20 min above 800°C and 30 min above 600ºC (see figure 1).

Refire Sensitivity
The effects of multiple firings at 850°C on resistivity and TCR are illustrated in Figures 11 and 12. These data are based on tests of 1 mm x 1 mm resistors terminated with silver/palladium 9308. 10 kΩ/sq or lower resistors change very slightly on refiring. The 100k and 1MΩ/sq resistors show significant increases in resistivity on refiring; however, TCR's remain well within the ±100 ppm/°C limits.

Encapsulation
In general, glass encapsulation is not required. However, in applications which require mechanical protection or protection from extreme environments such as high temperature nitrogen or forming gas, DuPont QQ550 encapsulant fired at 500°C (932°F) is recommended. Glass encapsulation of 1 mm x 1 mm resistors terminated with silver/palladium DuPont 9308 shifts the resistivity of DuPont Series 1700 resistors by less than 1%.

Figure 1. Recommended Firing Profile 60-Min Cycle



30-Min Firing

Series 1700 can be fired using a 30-min cycle as shown in **Figure 2**. However, slight negative resistivity shifts and positive TCR shifts should be expected.

Figure 2. 30-Min Cycle

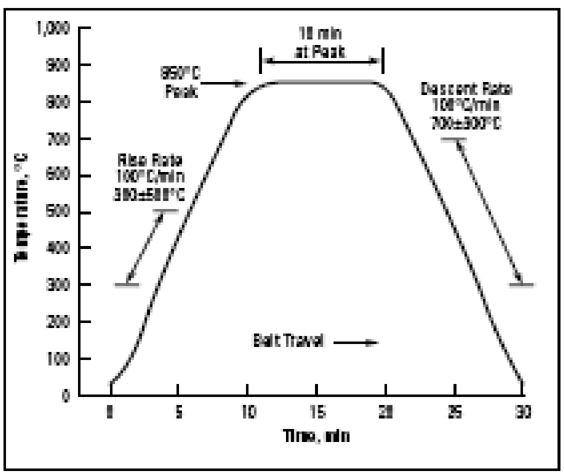


Figure 3. Effect of Print Thickness on Resistivity

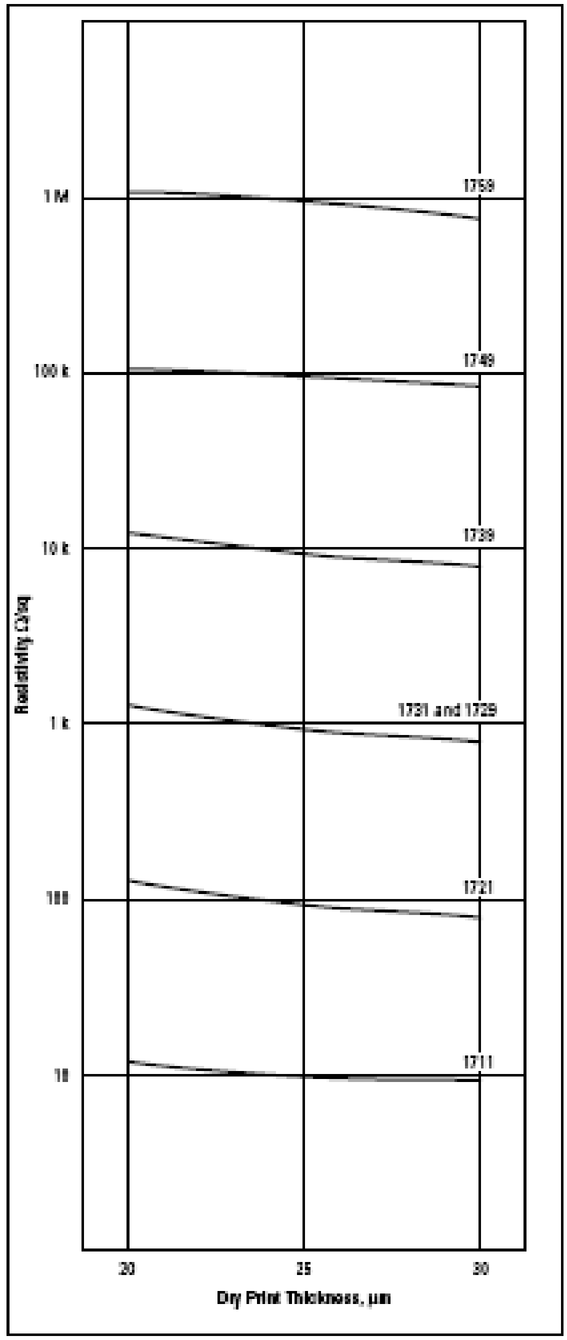


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Figure 5. Effect of Print Thickness on TCR

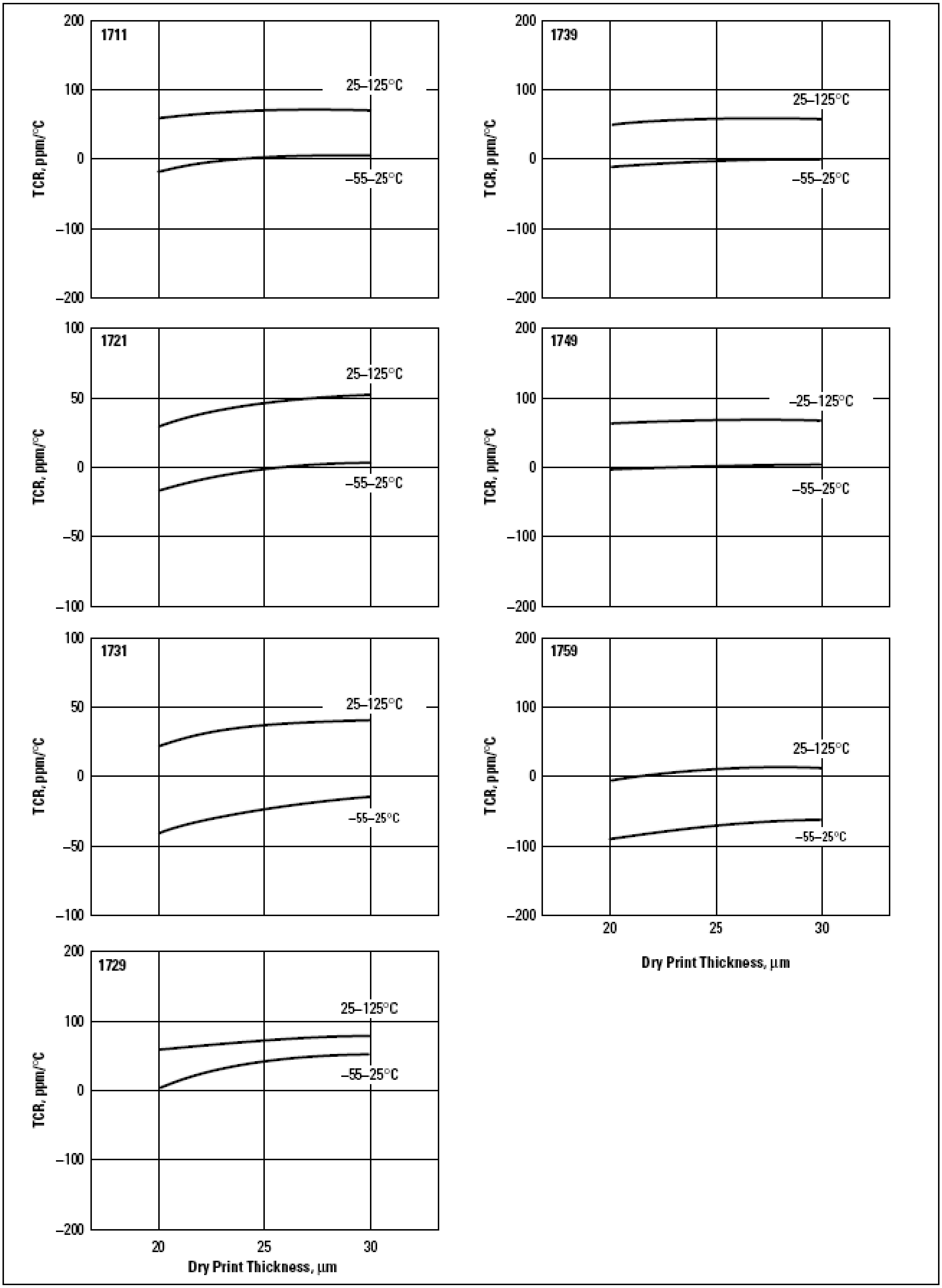
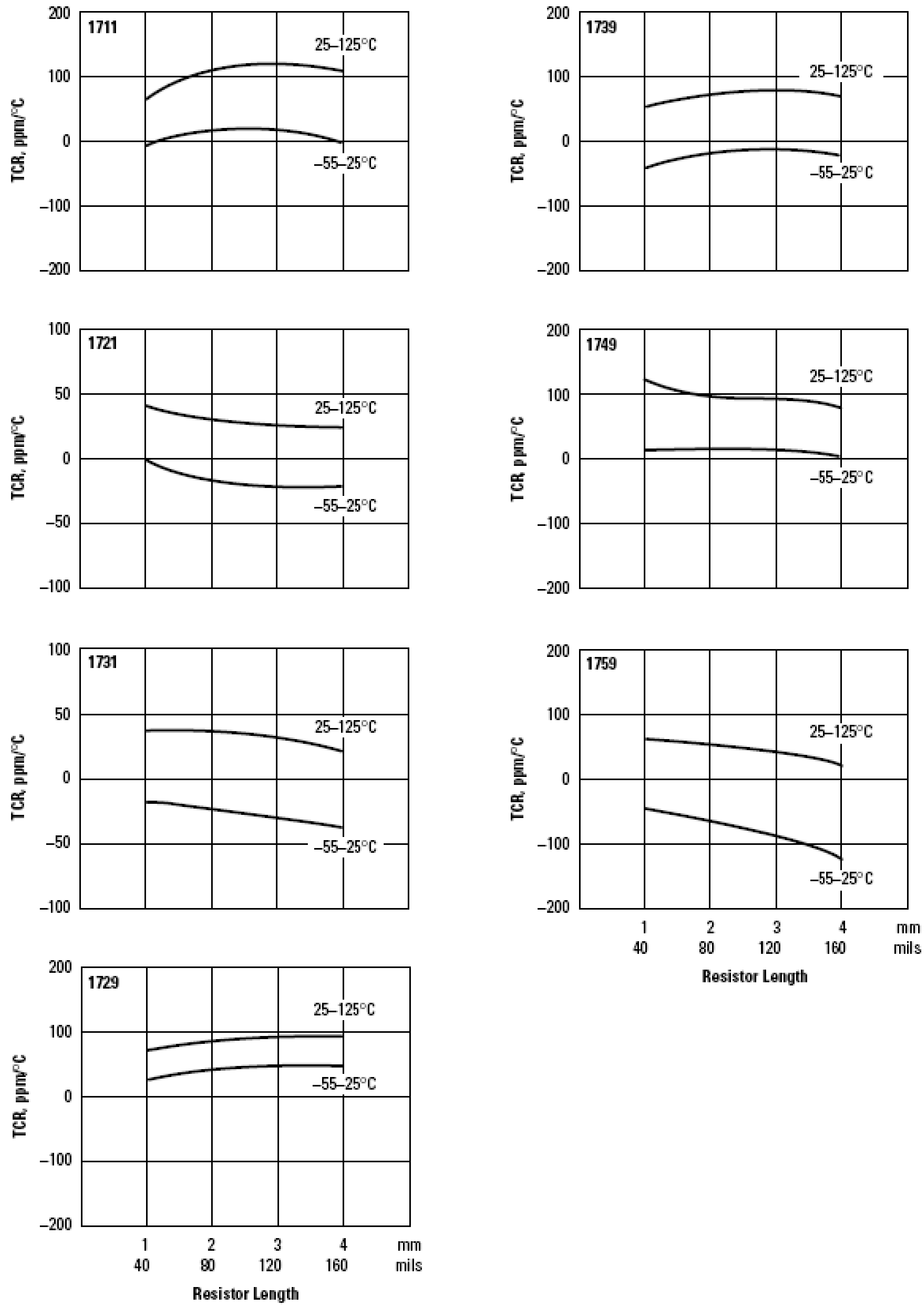


Figure 6. Effect of Resistor Length on TCR



Resistance values and TCRs will vary with variations in peak firing temperature and time at peak temperature.

Figures 7 and **9** illustrate the effect of variations in peak temperature in the 825°C (1517°F) and 875°C (1607°F) range on resistivity and TCR, respectively. Increases in peak temperature yield resistivity changes well below 1%/°C for resistivities of 10 Ω–10 kΩ/sq, +2%/°C at 100 kΩ/sq, and +3%/°C at 1 MΩ/sq.

The effects of variations in peak firing time in the 5–15 min range on resistivity and TCR are illustrated in **Figures 8** and **10**, respectively.

Stability of Series 1700 After Laser Trimming

Series 1700 was developed to give optimum stability of laser trimmed resistors from the time immediately after completion of the laser trim, through the further process and storage steps required in the production of a hybrid circuit or resistor network and on to the power loaded functional use of the resistor.

All stability data were produced using 1 mm x 1 mm (40 mil x 40 mil) resistors terminated with Palladium Silver Conductor Composition 9308 prefired at 850°C (1562°F) unless otherwise stated. The resistors were fired using a 60-min cycle with 10 min at a peak temperature of 850°C (1562°F) and laser trimmed 1.5–2x their fired value with a plunge cut using a production-type YAG laser trimming system. It is recommended that such a system should be operated at a speed of 1–2.5 cm/s (0.4–1 in/s), a frequency of 2–5 kHz and an average power of 0.8–1.5 W. Initial measurements were taken 15–50 ms after completion of the laser trim.

Load Life Stability

Figure 13 shows resistance changes of 1 mm x 1 mm resistors stored at 70°C (158°F) ambient and under electrical load. Duty cycle was 1.5 hr on, 0.5 hr off. Resistance changes shown are after 2,000 hr for 1721 and 1731, and after 1,000 hr for 1711, 1739, 1749, and 1759.

Figure 7. Effect of Peak Firing Temperature on Resistivity

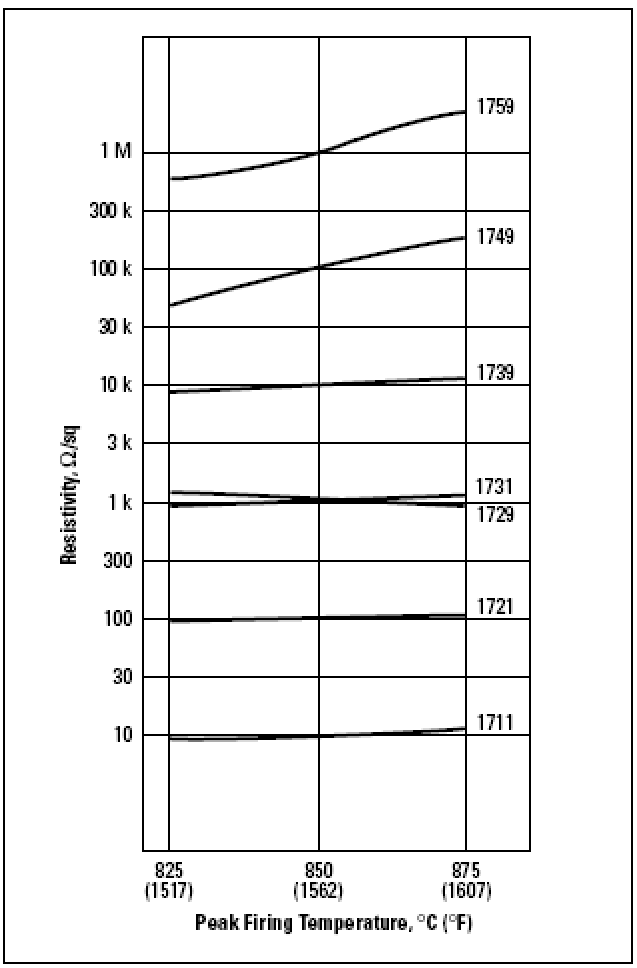
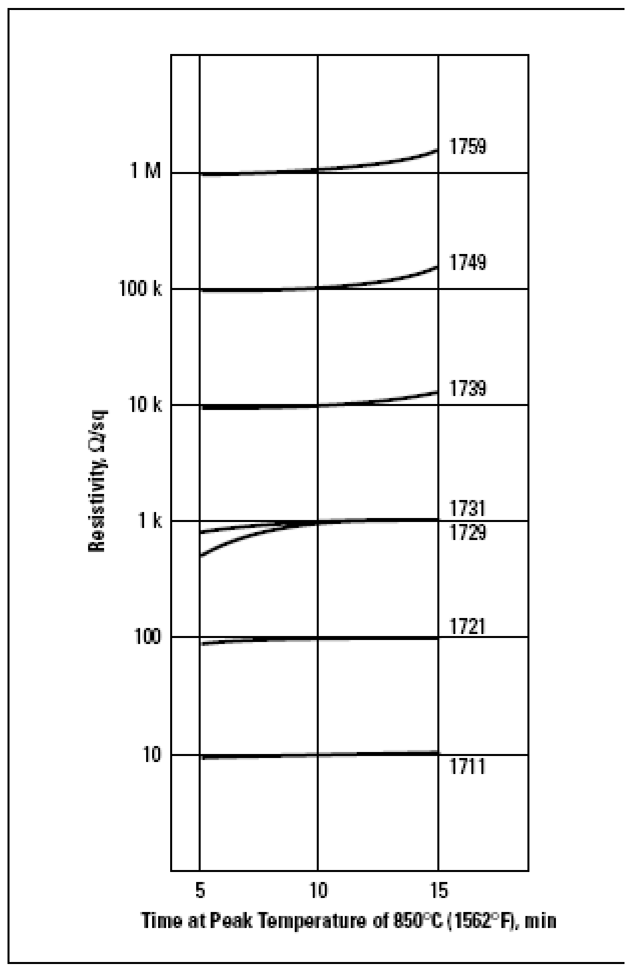


Figure 8. Effect of Time at Peak Temperature on Resistivity



igure 9.   Effect of Peak Firing Temperature on TCR

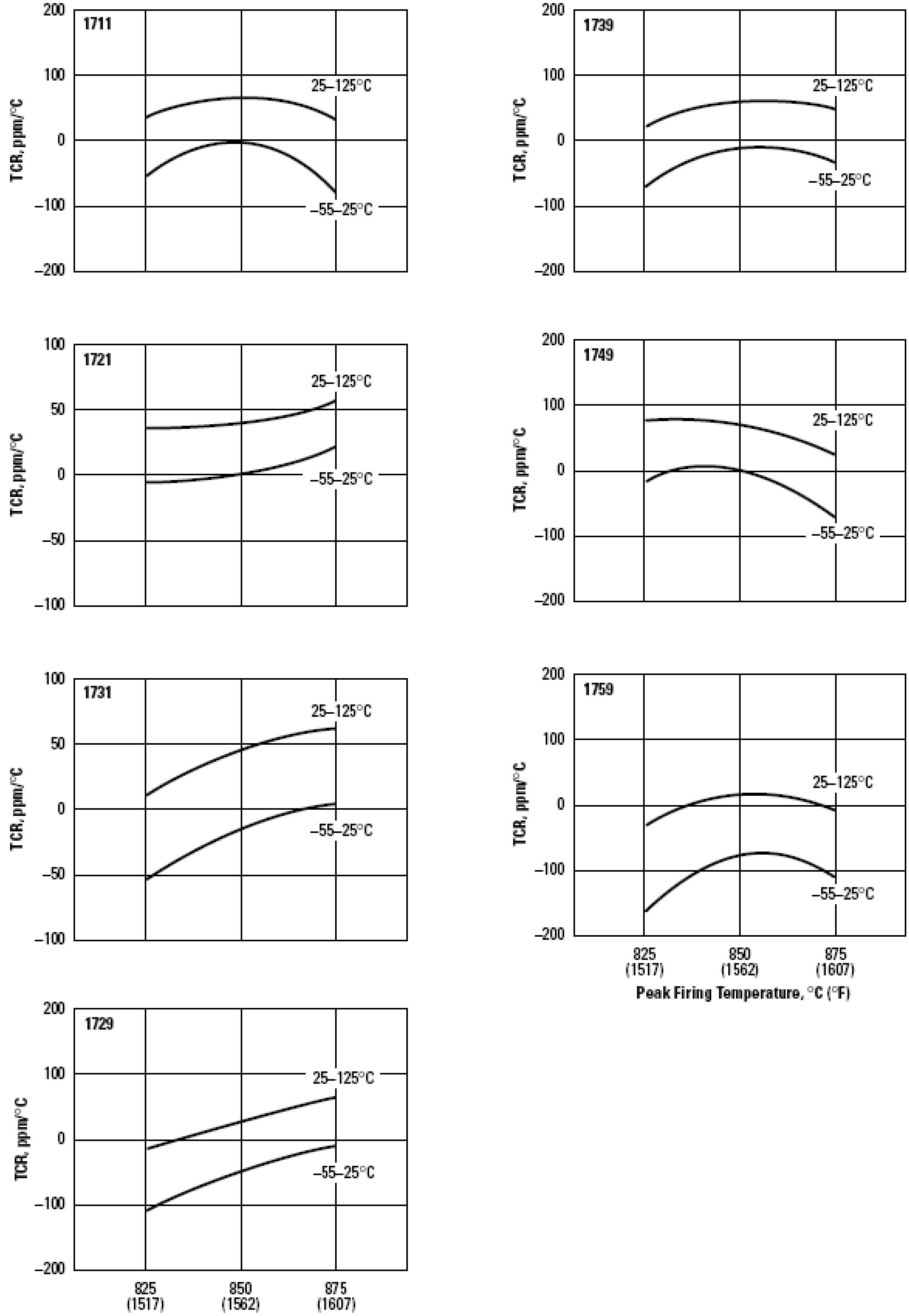


Figure 9. Effect of Peak Firing Temperature on TCR

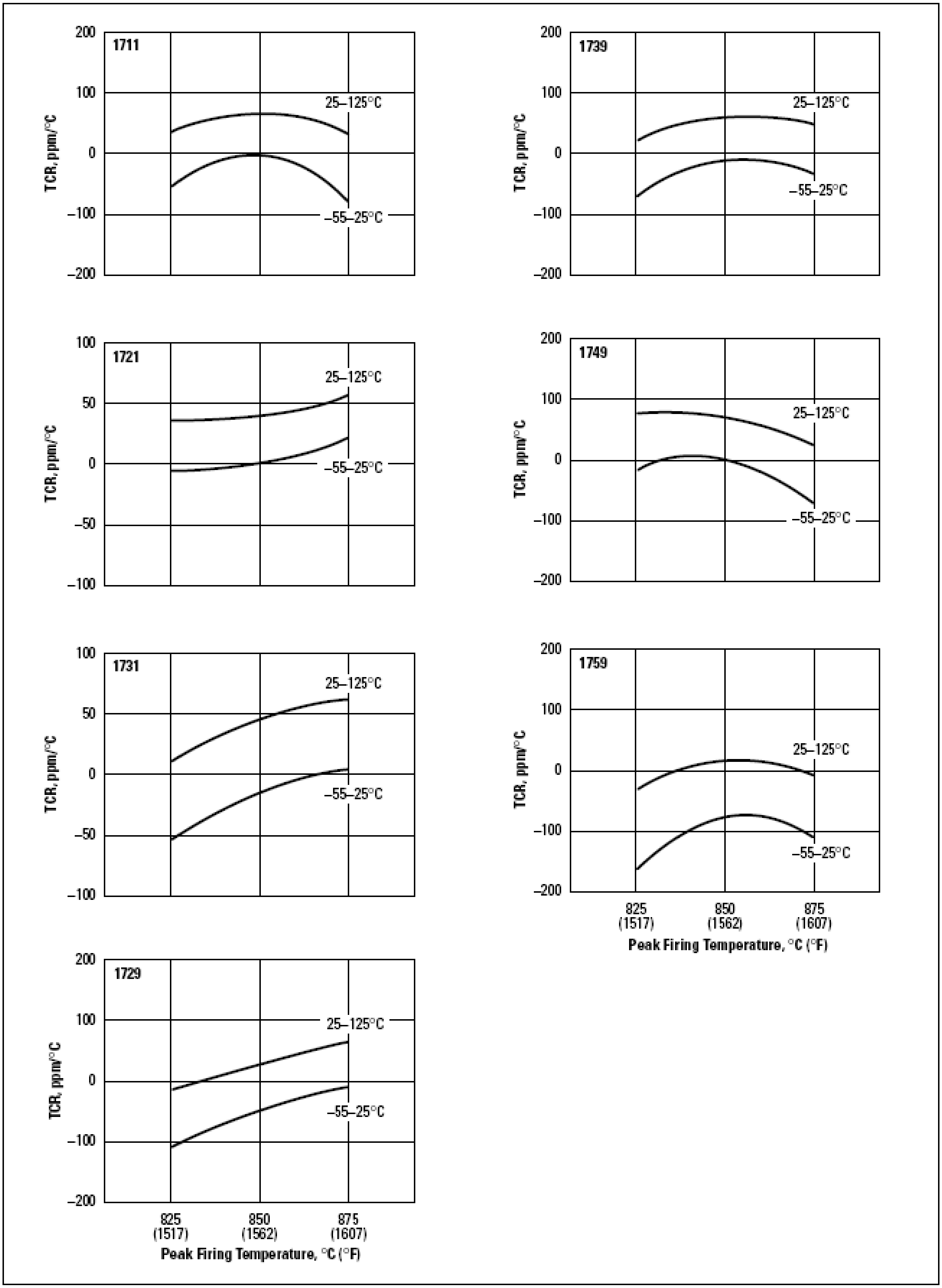


Figure 10. Effect of Time at Peak Temperature on TCR

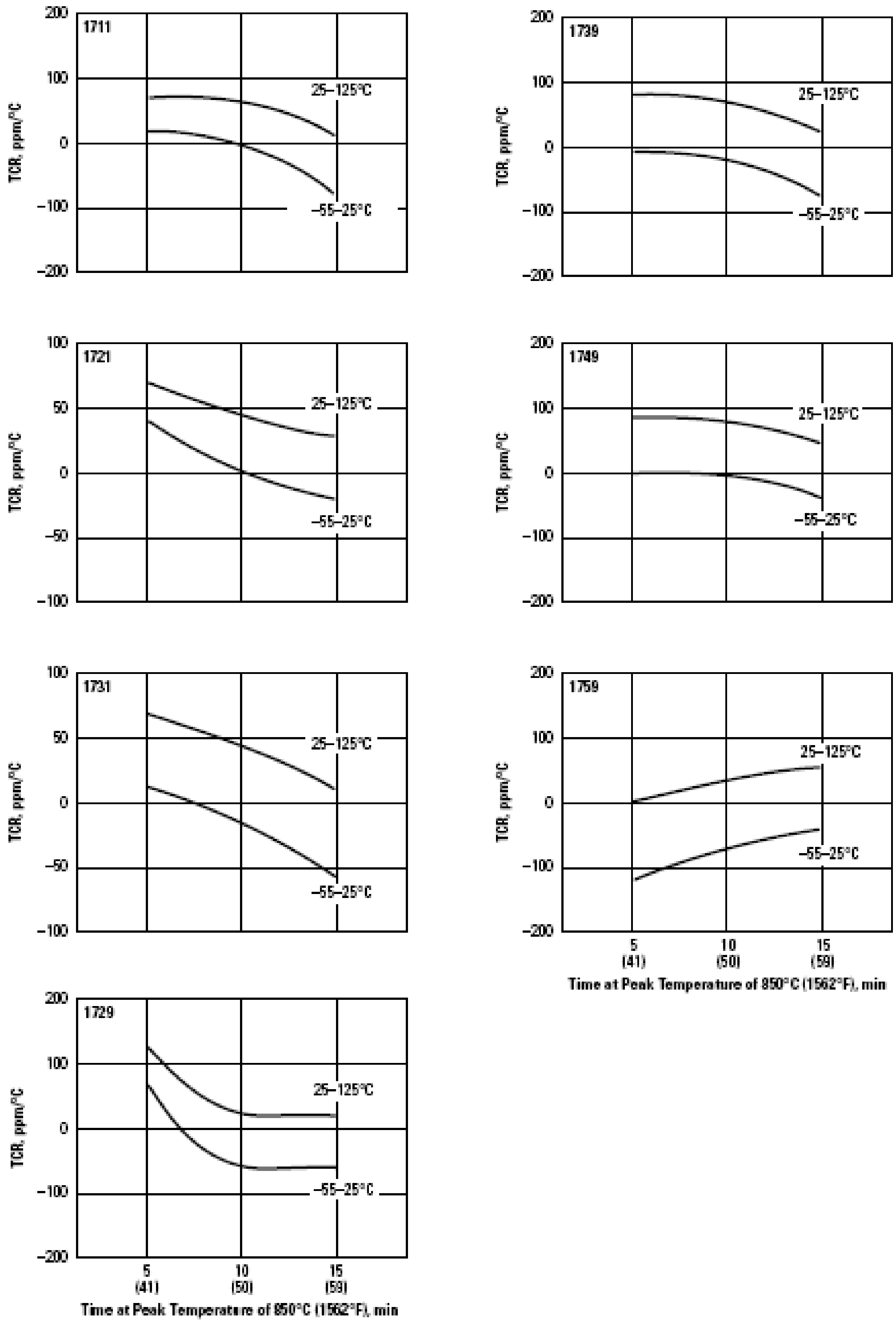
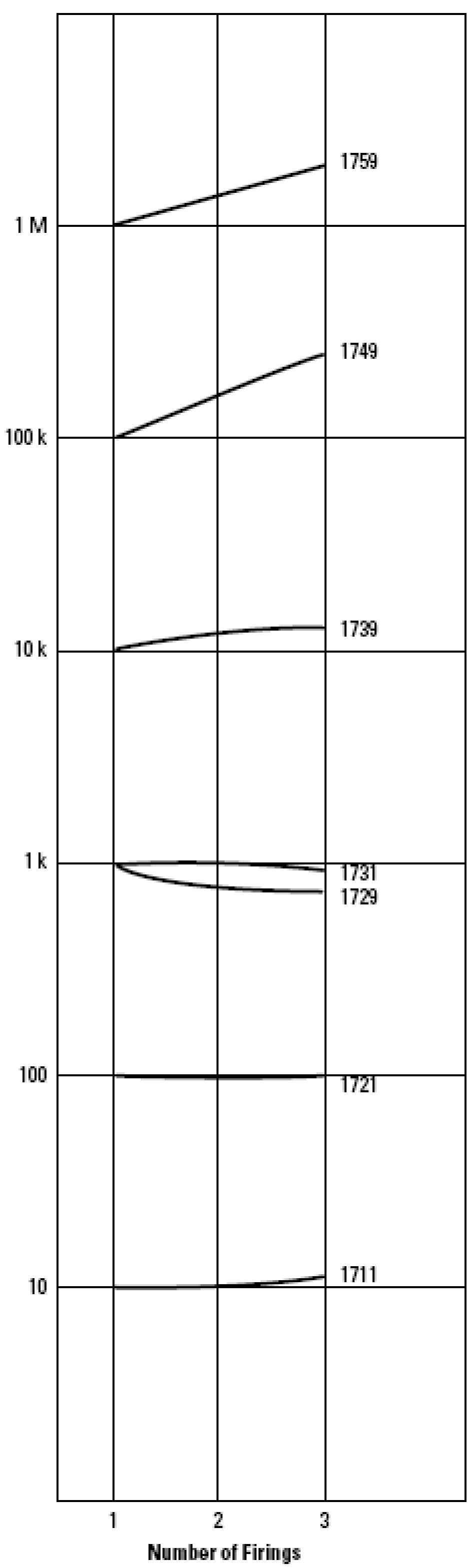


Figure 11. Effect of Refiring on Resistivity



Resistance value and TCRs will vary with refiring.

Figures 11 and **12** illustrate the effect of a second and third firing on resistivity and TCR, respectively.

Solder Dipping Stability

The results of tests made to determine the effects of dipping Series 1700 resistors into molten solder are shown in Figure 13 The parts were dipped for 5 sec in 62Sn/36Pb/2Ag solder and the flux used was Alpha 611.

Stability after Thermal Shock

Series 1700 resistors were subjected to a thermal shock test which consisted of 5 cycles with 5 min at –65°C (–85°F), transfer within 10 sec to 150°C (302°F) and a dwell of 5 min before transfer back to –65°C (–85°F). Figure 13 shows the results.

Figure 12. Effect of Refiring on TCR

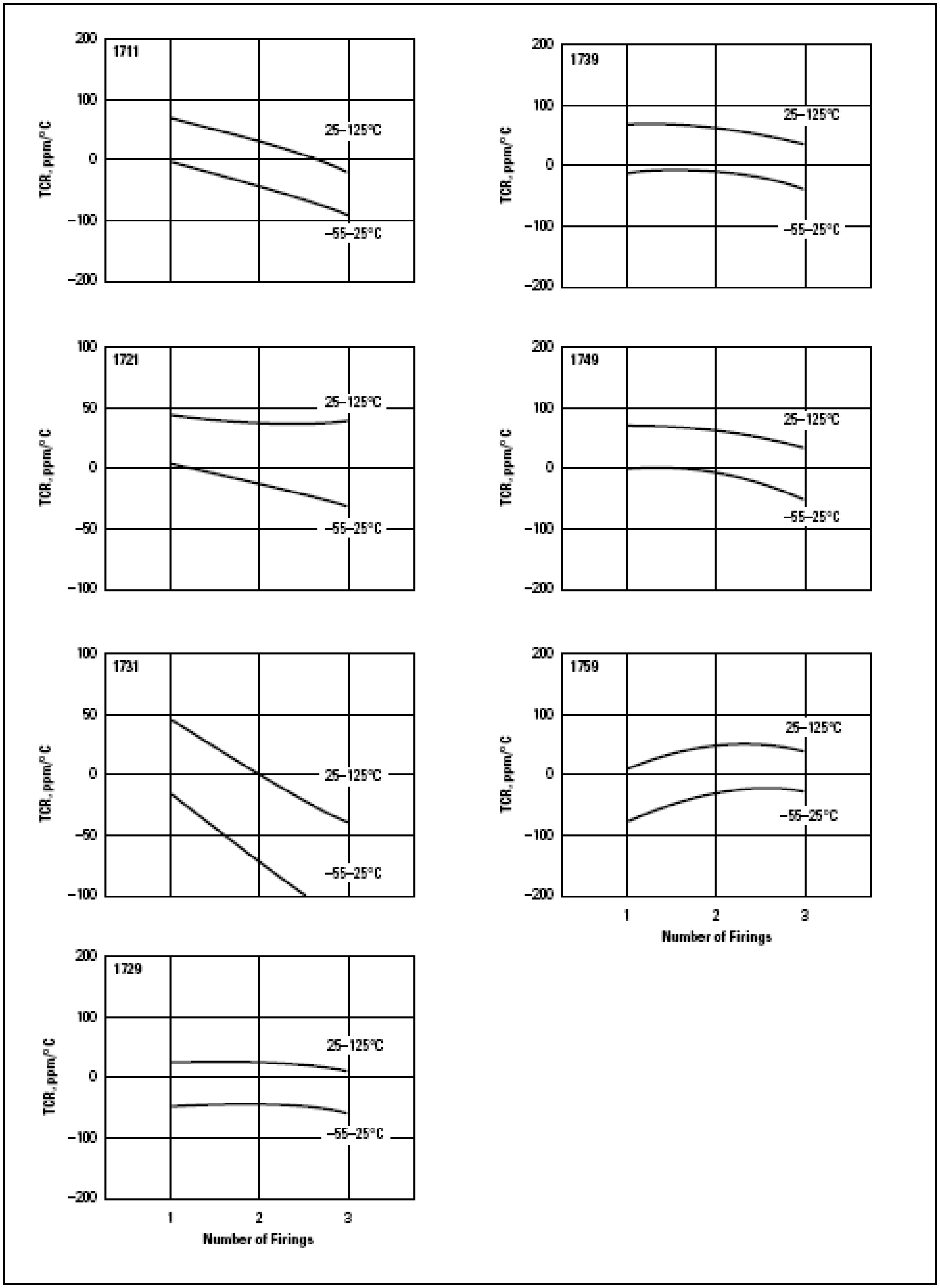
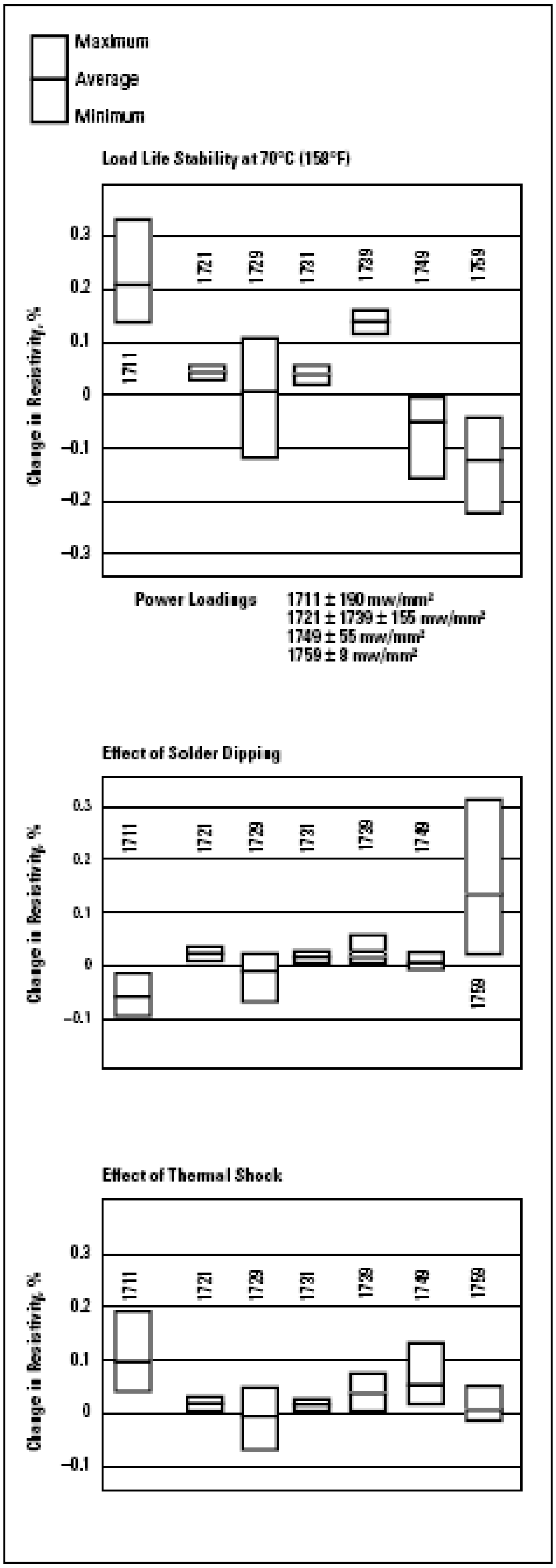


Figure 13. Series 1700 Stability after Laser Trimming



No Load Stability

Figure 14 illustrates the excellent stability under a variety of environmental conditions, of Series 1700 resistors after laser trimming. The data shown are based on tests of 1 mm x 1 mm resistors trimmed by plunge cut and 2 mm x 1 mm resistors trimmed by L-cut. Storage conditions include 25°C (77°F)—no load, 150°C (302°F)—no load, and 40°C (104°F)—90% relative humidity.

Resistor stability is dependent on many factors including termination material, substrate, processing conditions, and laser trim parameters. Under controlled conditions, Series 1700 compositions are capable of 0.25% end of life tolerances.

Blending Characteristics

Series 1700 consists of two blendable subseries:

- 10 Ω/sq through 1 kΩ/sq —Adjacent members of the group of compositions including 1711, 1721, and 1731 are blendable with respect to resistivity and TCR.
- 1 kΩ/sq through 1 MΩ/sq —Adjacent members of the group of compositions including 1729, 1739, 1749, and 1759 are blendable with respect to resistivity and TCR.

Blend curves for Series 1700 compositions are shown in **Figure 15**. The data represented in these curves were generated using 1.5 mm x 1.5 mm resistors terminated with pre-fired Pd/Ag 9308.

Resistivities and TCRs blend smoothly and predictably for all blend ratios.

Figure 14. Series 1700 Resistor Compositions Environmental Stability after Laser Trimming

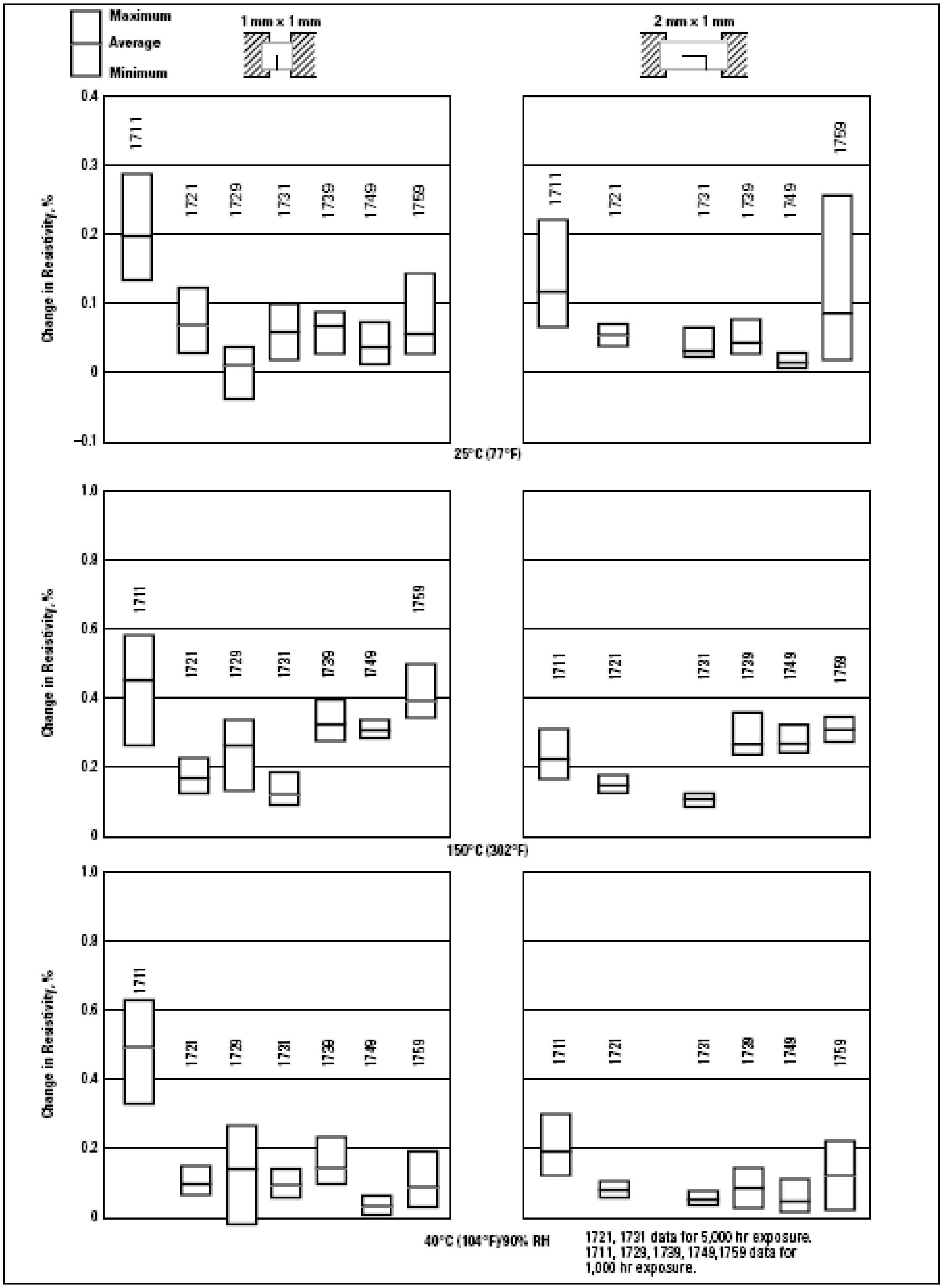
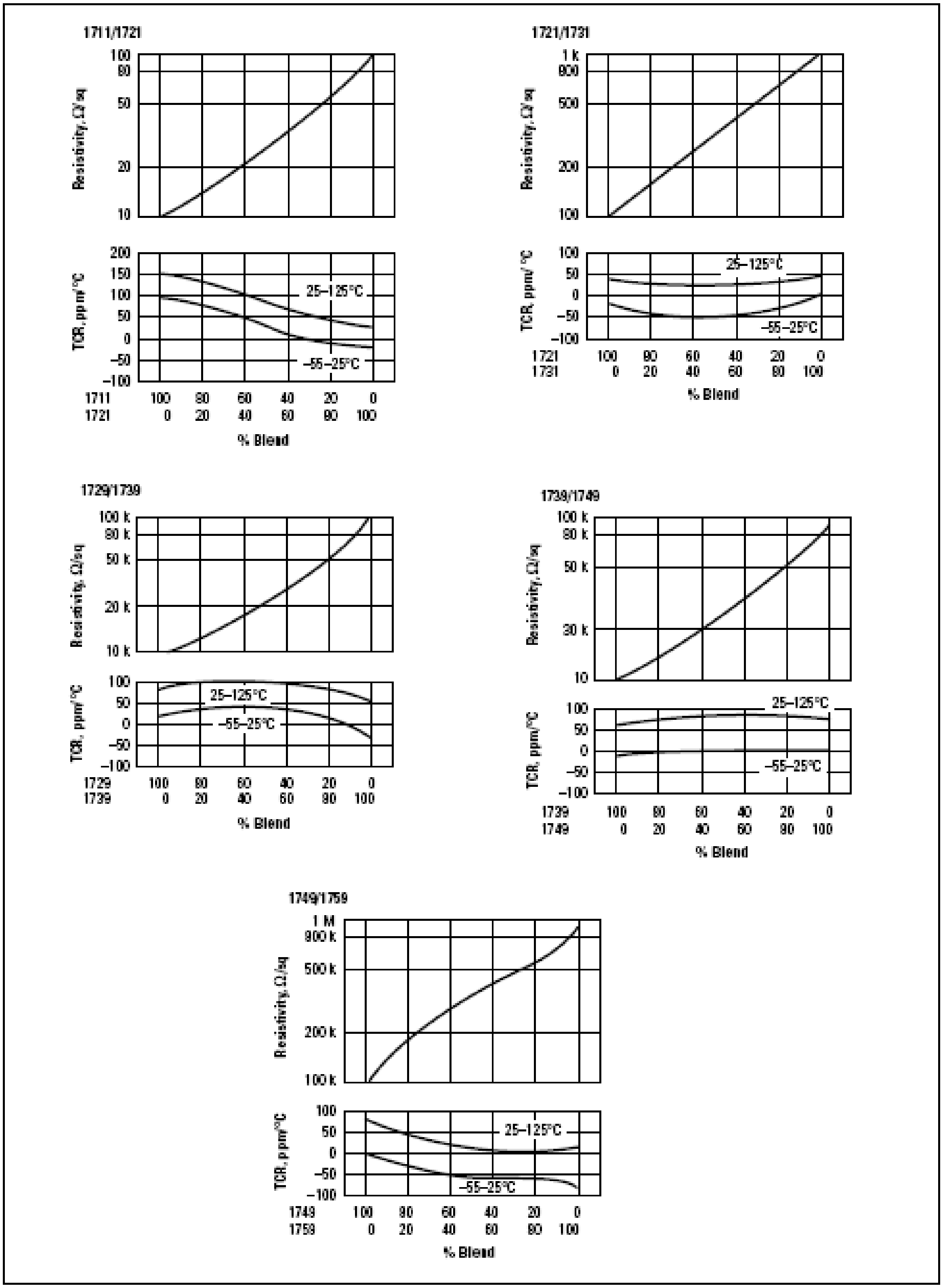


Figure 15. Series 1700 Blend Curves



Storage and Shelf Life

Containers should be stored, tightly sealed, in a clean, stable environment at room temperature (<25°C). Shelf life of material in unopened containers is six months from date of shipment. Some settling of solids may occur and compositions should be thoroughly mixed prior to use.

Safety and Handling

For Safety and Handling information pertaining to this product, read the Material Safety Data Sheet (MSDS).

Caution: Do not use in medical applications involving implantation in the human body or contact with internal body fluids or tissue unless the product is provided by DuPont under a formal written contract consistent with the DuPont Policy Regarding Medical Applications of DuPont Materials H-50103-2 ("Medical Applications Policy") and which expressly acknowledges the contemplated use. For additional information, please request a copy of DuPont Medical Caution Statement H-50102-2 and the DuPont Medical Applications Policy.

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For more information on DuPont 1700 series or other DuPont Microcircuit Materials products, please contact your local representative:

Americas
DuPont Microcircuit Materials
14 T.W. Alexander Drive
Research Triangle Park, NC 27709
Tel.: 800-284-3382

Europe
Du Pont (U.K.) Limited
Coldharbour Lane
Bristol BS16 1QD
U.K.
Tel.: 44-117-931-3191

Asia
DuPont Kabushiki Kaisha
DuPont Electronic Center
KSP R&D B213, 2-1, Sakado 3-chome, Takatsu-ku,
Kawasaki-shi, Kanagawa, 213-0012, Japan

Tel: +81-44-820-7575

DuPont Taiwan Ltd
45, Hsing-Pont Road,
Taoyuan, Taiwan 330
Tel.: 886-3-377-3616

DuPont China Holding Co. Ltd
Bldg 11, 399 Keyuan Rd., Zhangji Hi-Tech Park,
Pudong New District, Shanghai 201203, China
Tel.: 86-21-6386-6366 ext.2202

DuPont Korea Inc.
3~5th Floor, Asia tower #726,
Yeoksam-dong, Gangnam-gu
Seoul 135-719, Korea
Tel.: 82-10-6385-5399

E. I. DuPont India Private Limited
7th Floor, Tower C, DLF Cyber Greens,
Sector-25A, DLF City, Phase-III,
Gurgaon 122 002 Haryana, India
Tel.: 91-124-4091818

Du Pont Company (Singapore) Pte Ltd
1 HarbourFront Place, #11-01
HarbourFrong Tower One,
Singapore 098633
Tel.: 65-6586-3022

http://mcm.dupont.com