

DuPont Microcircuit Materials

THICK FILM COMPOSITION

2000 Resistor Series

10Ω/sq - 10MΩ/sq

Product Description

The Series 2000 resistor compositions are intended to be applied to ceramic substrates by screen printing and fired in air to form resistors in hybrid microcircuits.

The series offers versatility to the designer with improved TCR tracking between resistors of different size and value, and a choice of termination materials. Stability is outstanding either with or without encapsulation. To the manufacturer, series 2000 offers broad processing latitude.

Product Benefits

- Excellent laser post-trim stability, encapsulated or unencapsulated
- HTCR's less than 50 ppm
- Small length and thickness effects on resistivity and TCR
- Small shifts of resistivity and TCR on refiring
- Compatible with Ag/Pt or Ag/Pd terminations
- Excellent noise characteristics

Design Notes:

Termination

The reported properties are based on tests using 7484 Ag/Pd conductor compositions as the termination material, prefired at 850°C. Use of different terminating material may cause a shift of resistance and TCR values from those stated.

Blending

Two parallel low ends to Series 2000 are offered. These cannot be interchanged.

Composition Properties

Viscosity (Pa.s) (Brookfield HAT, UC&SP [SC4-14/6RI], 10 rpm, 25°C ± 0.2°C)	140-220
Thinner	4553
Shelf Life [months]	6

Therefore the following members are bendable together A) 2004R/ 2009/ 2019/ 2031/ 2041/ 2051/ 2061/ 2071 or B) 2004/ 2011/ 2015/ 2021/2031 2041/ 2051/ 2061. Only adjacent members are bendable.

Encapsulation

In applications which require mechanical protection from extreme environments, low temperature encapsulant QQ550 or LF161 are recommended to be screen printed over the resistor and fired, prior to laser trimming.

Laser Trimming

To ensure long term stability of the resistors and to achieve maximum trimming accuracy, it is necessary to optimize resistor geometry, cut geometry and trimming parameters. Parameters should be selected that achieve a clean laser cut (kerf). The preferred range of laser trim parameters are as follows: bite size 0.10 to 0.30 mils, power 1 - 3.0W at a frequency of 5Hz.

Typical Fired Resistor Properties

Test	2004R	2009	2004	2019	2011	2015	2021	2031	2041	2051	2061	2071
Sheet Resistivity, (Ω/sq) ¹	4	10		100	10	50	100	1K	10K	100K	1M	10M
Shipping Specification	±10%	±10%	±10%	±10%	±10%	±10%	±10%	±10%	±10%	±10%	±10%	±20%
HTCR (ppm/°C)	0 to 50	≤50	0 to 50	≤50	≤50	≤50	≤50	≤50	≤50	≤50	≤50	≤125
CTCR (ppm/°C)	≥-100	≤100	≥-100	≤75	≤100	≤75	≤75	≤75	≤75	≤75	≤75	≤100
Quan Tech Noise, (dB) ³	-24	-32	-25	-32	-35	-35	-31	-20	-17	-9	9	-
STOL (V/mm) ⁴	3	7.5	5	25	6	17	28	80	165	370	350	275
SWV,(V/.mm) ⁵	1.2	3.0	2	10	2.4	6.8	11	32	66	148	140	110
MRPD, (m/W/mm ²) ⁶	241	600	573	650	430	660	870	570	240	150	9	0.9
ESD (% Δ R after 1x5Kv pulse ⁷)	<0.1	<0.2	<0.1	<0.1	<0.5	<0.1	<0.1	<2	<0.5	<0.1	<0.5	<0.1

Typical Fired Resistor Properties

Wet to dry Shrinkage (%)	50	50	50	51	49	52	45	55	48	53	47	50
Dry to fired Shrinkage (%)	25	21	35	32	39	40	40	39	38	39	42	39
Coverage (cm ² /g)	120	124	125	131	128	139	136	145	130	141	137	132
Blend Series	A	A	B	A	B	B	B	A+B	A+B	A+B	A+B	A+B

¹ Product release specifications (Resistivity and Temperature Coefficient of Resistance are routinely tested for Q.A. release). Test conditions described below in footnote 1. Sheet resistance values are normalized to 20 μm dried thickness

² TCR measured in the ranges -55°C to $+25^{\circ}\text{C}$, $+25^{\circ}\text{C}$ to $+125^{\circ}\text{C}$

³ Quan-Tech noise measured on untrimmed resistors

⁴ Short term overload voltage: voltage required in a 5 second duration to induce a resistance change at 25°C of 0.25% in a 1mm x 1mm resistor trimmed to 1.5x fired value with a single plunge cut

⁵ Standard working voltage = 0.4 x short term overload voltage

⁶ Maximum rated power dissipation = (standard working voltage)²/resistance

⁷ ESD measured on 1 mm x 1 mm resistor trimmed to 1.5x fired value with a single plunge cut



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Processing Conditions

Substrates

Properties are based on tests on 96% alumina substrates. Substrates of other compositions and from various manufacturers may result in variations in performance properties, as may different lots of substrates, and any subsequent processing of substrates (e.g. laser scribing or drilling) prior to printing. It is the responsibility of users to determine the effects of any of the above available in their particular situations.

Printing

325 mesh stainless steel screen with 10-15 μm emulsion. Print speeds of 10-20 cm/s may be used. Control and reproducibility of print thickness are essential to obtain predictable, reproducible fired resistor properties.

The composition should be thoroughly mixed before use. This is best achieved by slow, gently, hand stirring with a clean burr-free spatula (flexible plastic) for 0.5 - 1 minute. Care must be taken to avoid air entrapment.

Printing should be performed in a clean and well ventilated area.

Note: the optimum printing characteristics are generally achieved in the room temperature range of 20°C-23°C.

Drying

Allow prints to level at room temperature, then dry at 150 - 170°C for 10-15 minutes in a well ventilated oven or conveyor dryer.

Firing (See figure 1)

Fire in a well ventilated belt, conveyor furnace. Air flows and extraction rates should be optimized to ensure that oxidizing conditions exist within the muffle, and that no exhaust gases enter the room. Variation in the peak firing temperature and or time at the peak temperature may result in variations in the final fired properties.

Resistors compositions must be fired in clean dry air. Insufficient airflow or pollution of the air in the furnace may result in shifts in resistivity and TCR.

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

The following precautions should be exercised when handling 2000 Series:

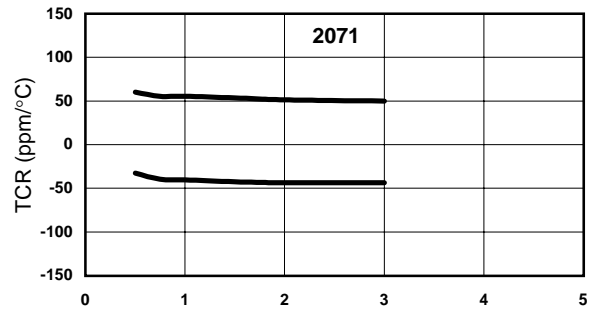
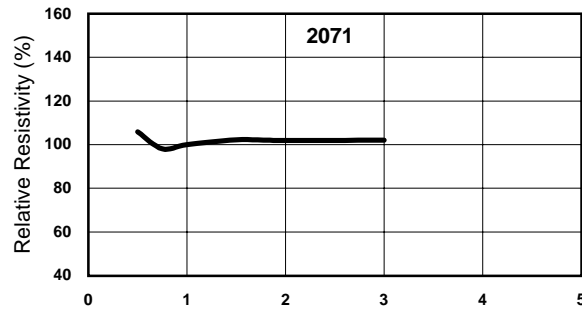
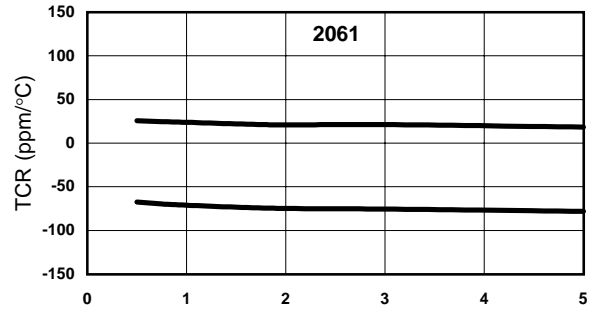
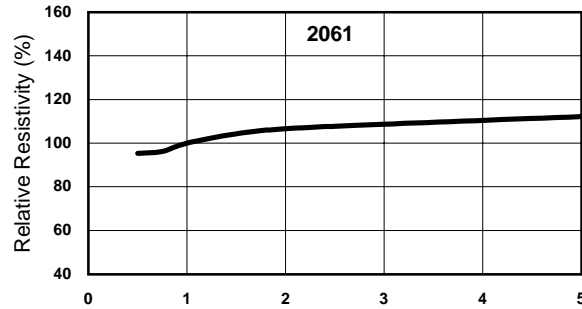
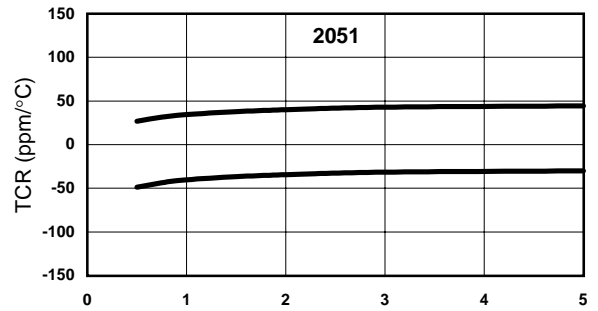
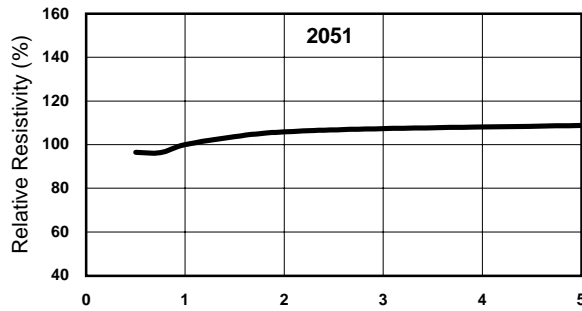
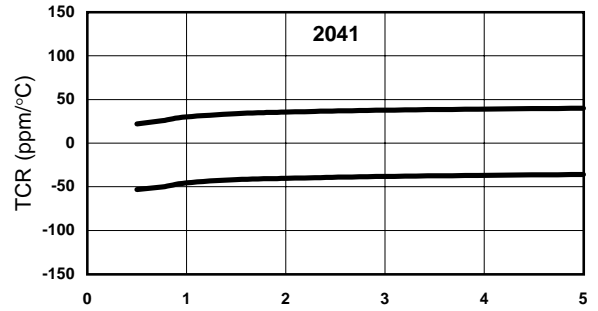
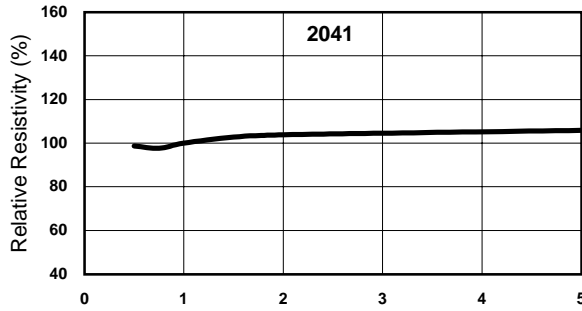
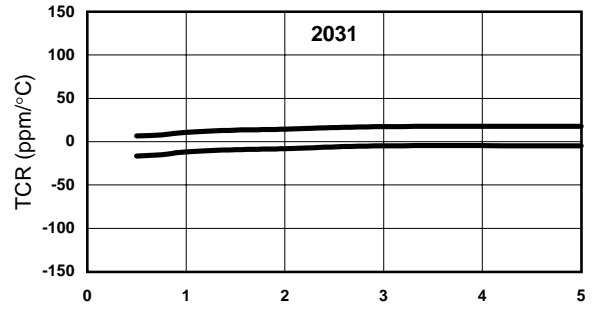
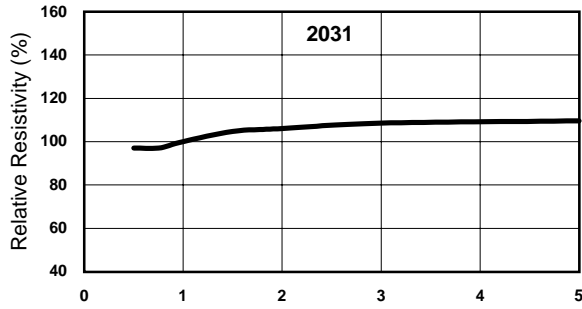
- Use with adequate ventilation
- Avoid prolonged contact with skin
- If contact with skin occurs, wash affected area immediately with soap and water
- Avoid prolonged breathing of vapor
- Dangerous if swallowed - DO NOT CONSUME
- Refer to MSDS for more details



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Series 2000 Length Effect Curves

Data based on resistors of 1.0mm width with 3:1 AgPd terminations.

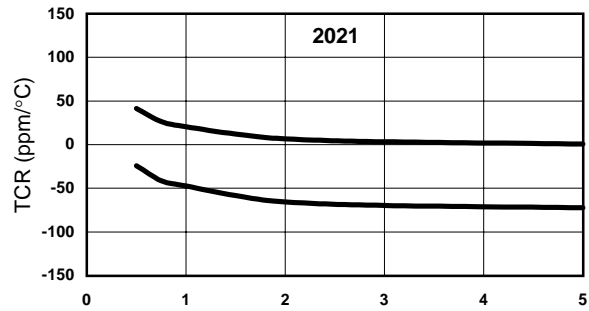
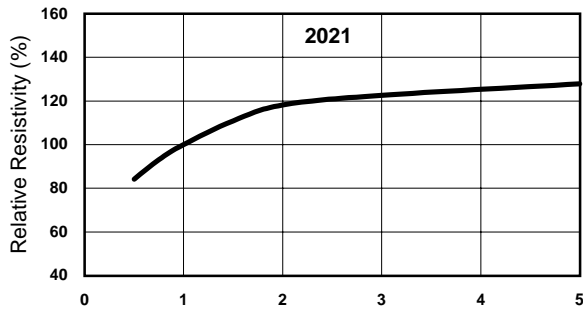
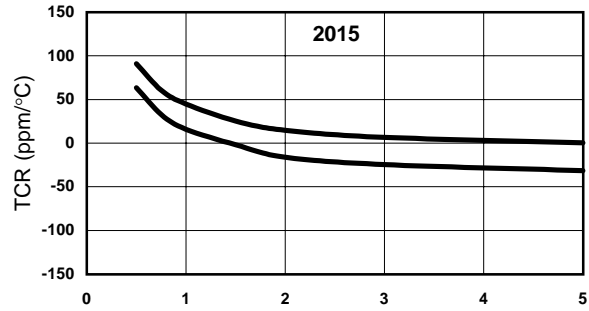
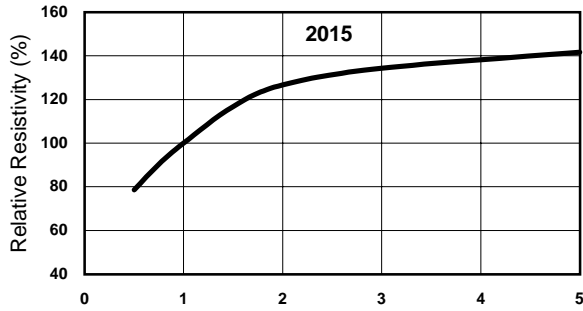
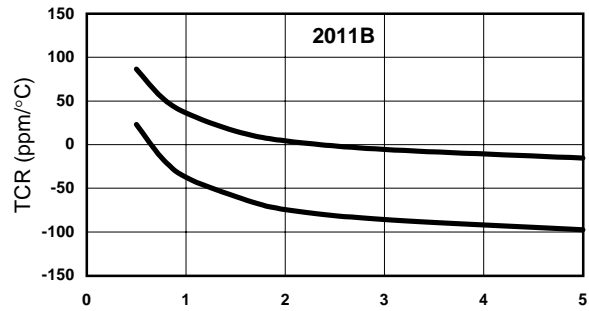
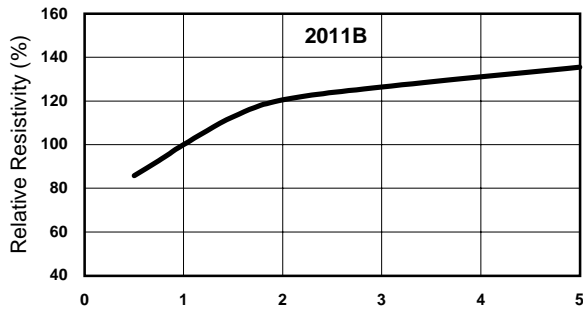
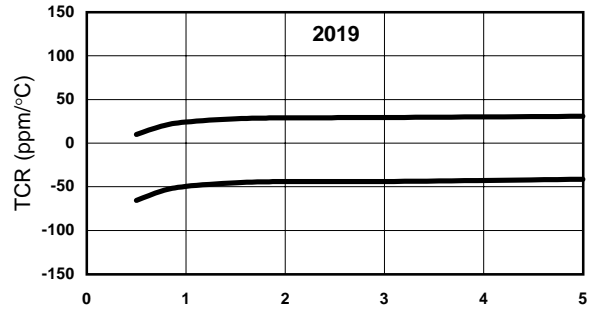
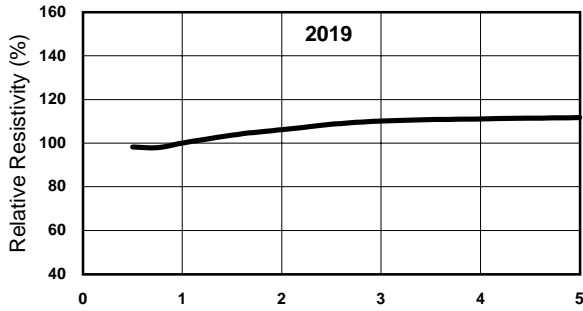
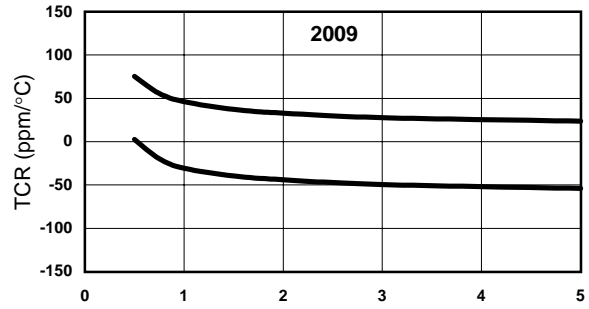
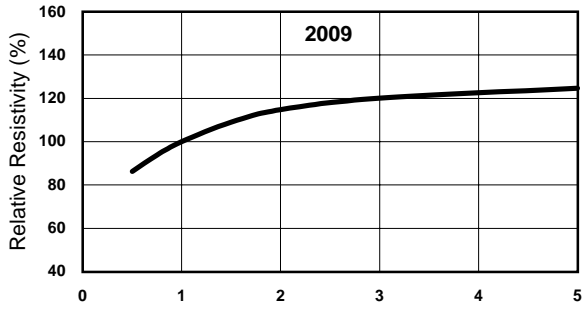


Resistor Length (mm)

Resistor Length (mm)

Series 2000 Length Effect Curves

Data based on resistors of 1.0mm width with 3:1 AgPd terminations.

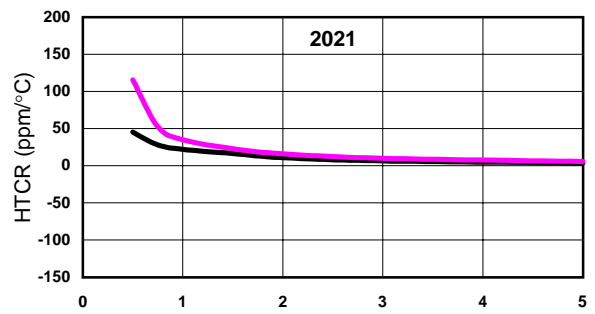
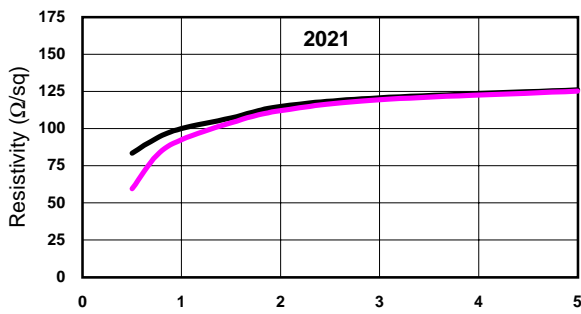
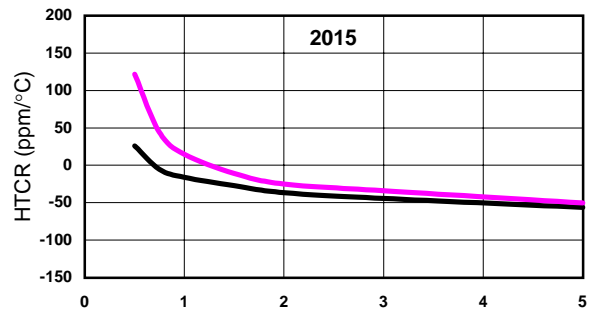
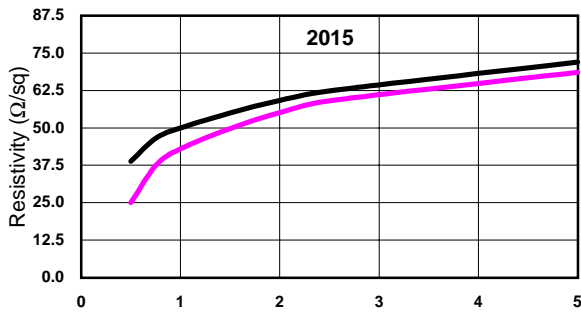
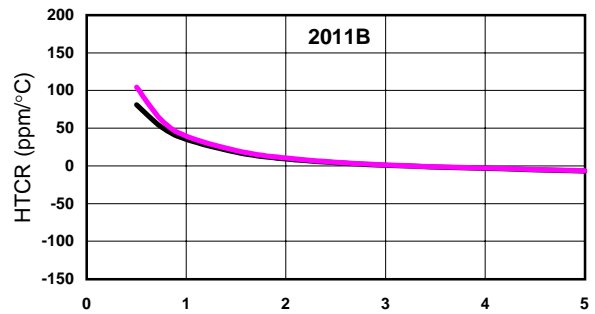
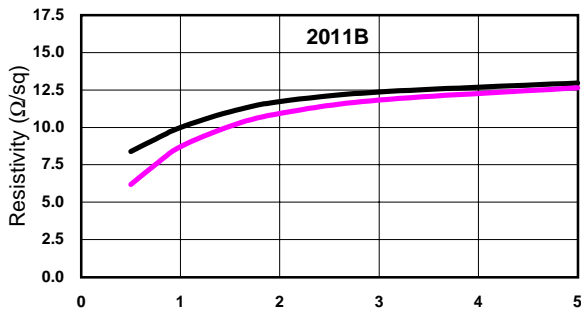
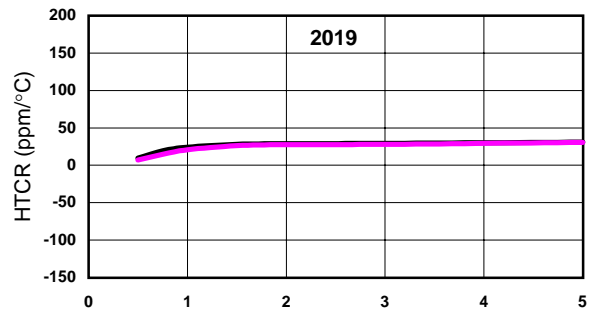
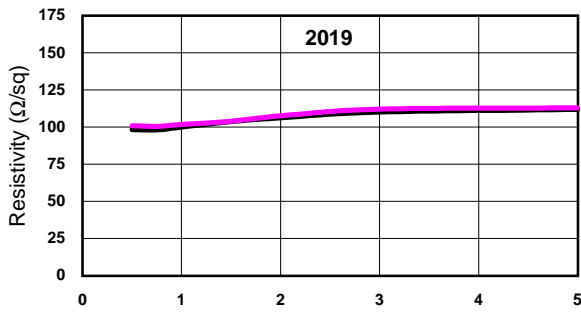
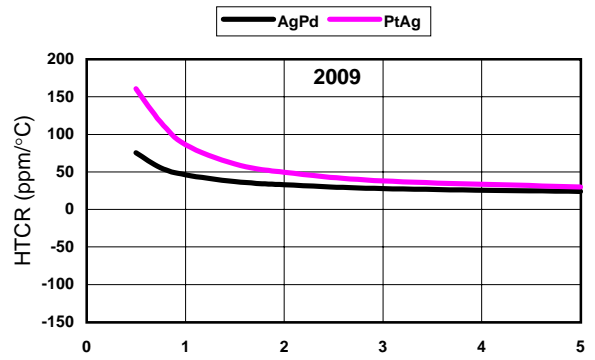
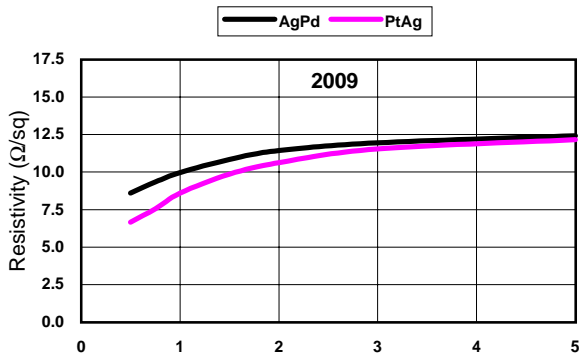


Resistor Length (mm)

Resistor Length (mm)

Series 2000 Termination Dependence (Length Effect Curves)

Data based on resistors of 1.0mm width with 3:1 AgPd and 1% PtAg terminations.

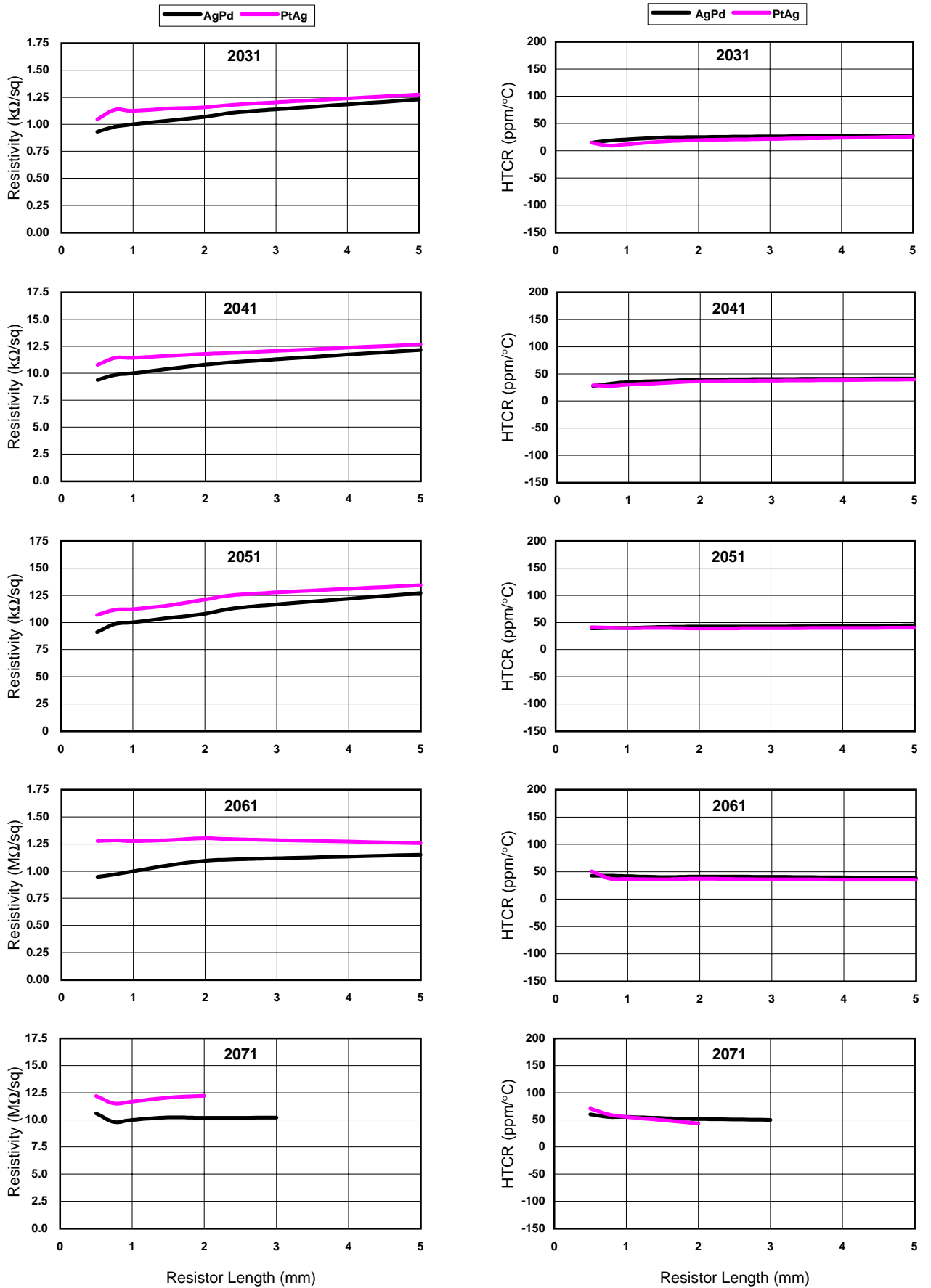


Resistor Length (mm)

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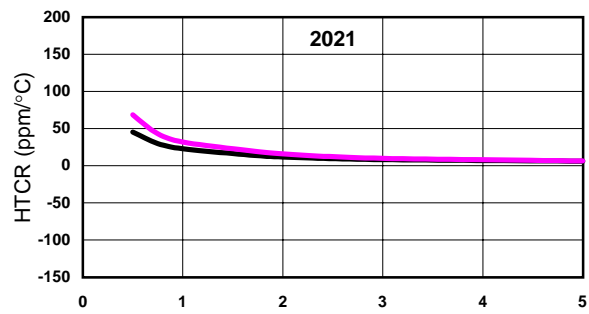
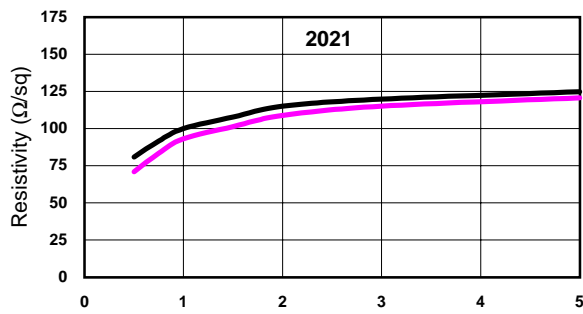
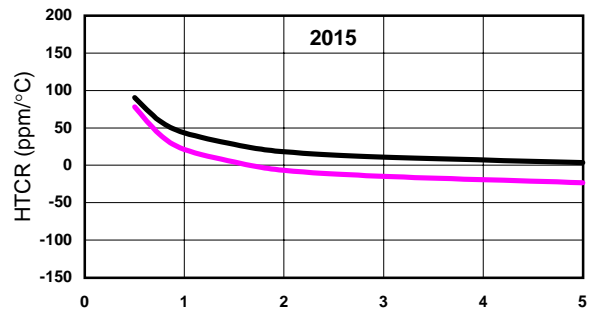
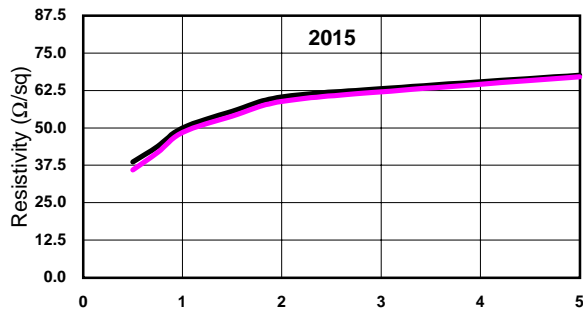
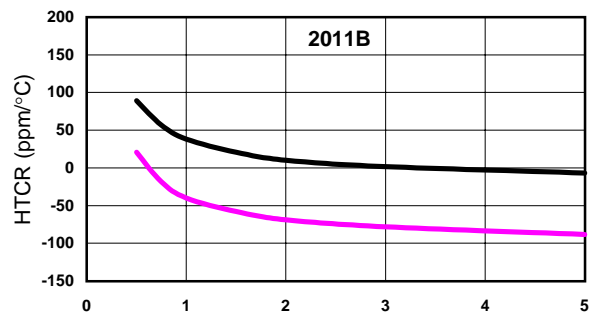
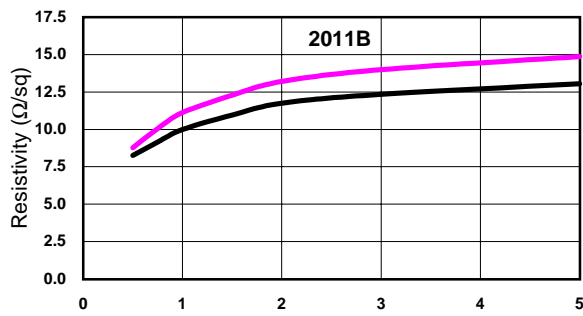
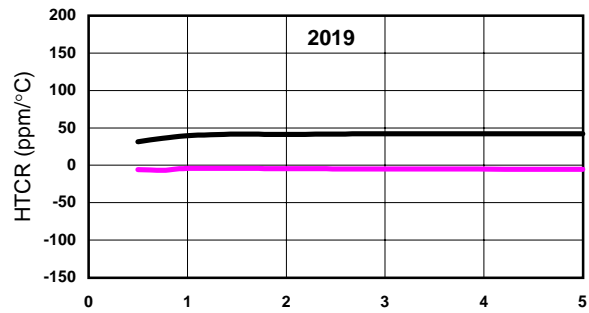
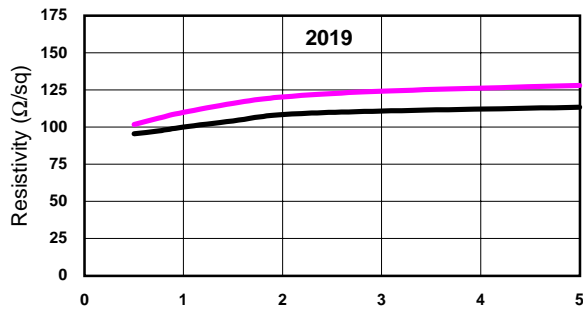
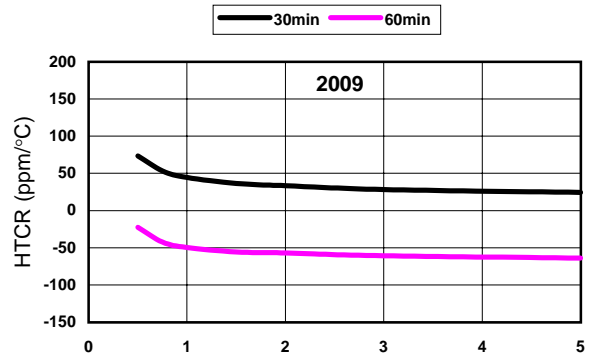
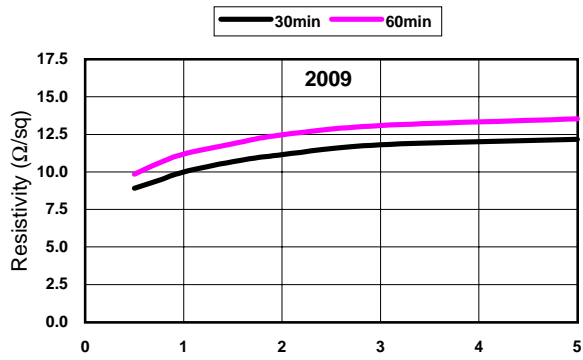
Series 2000 Termination Dependence (Length Effect Curves)

Data based on resistors of 1.0mm width with 3:1 AgPd and 1% PtAg terminations.



Series 2000 Firing Behaviour 850°Cx60min (Length Effect Curves)

Data based on resistors of 1.0mm width with 3:1 AgPd terminations.

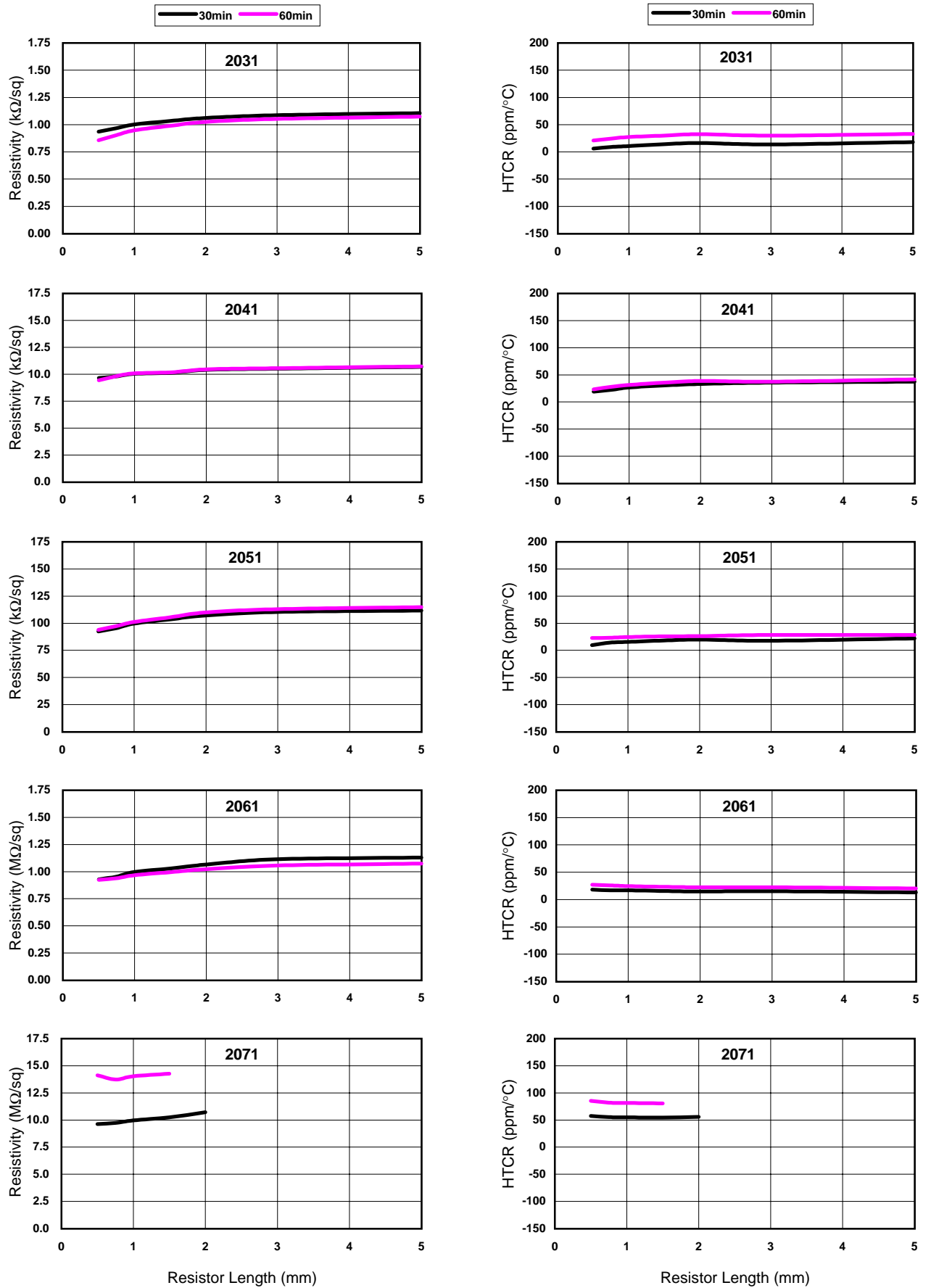


Resistor Length (mm)

Resistor Length (mm)

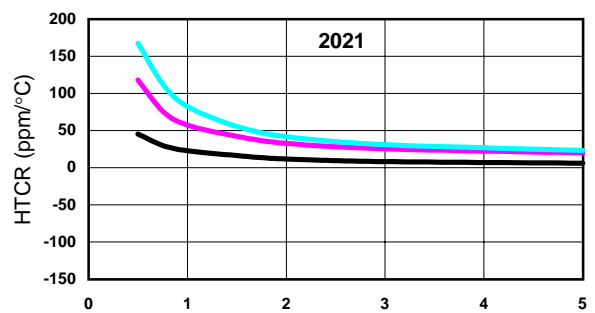
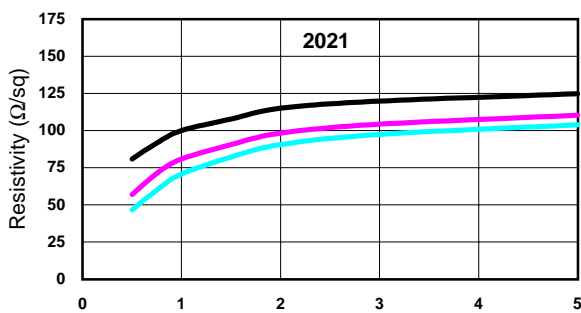
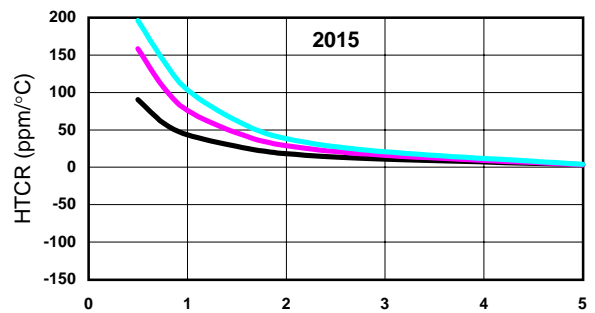
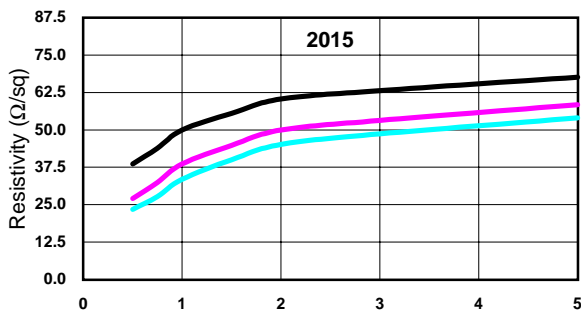
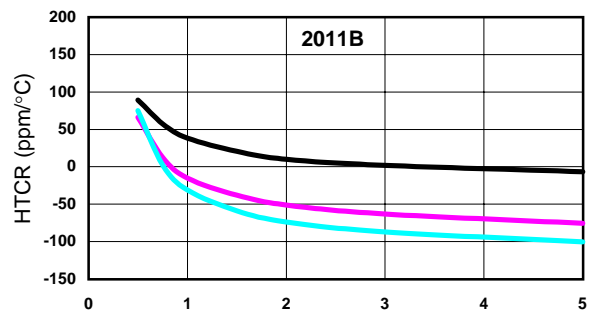
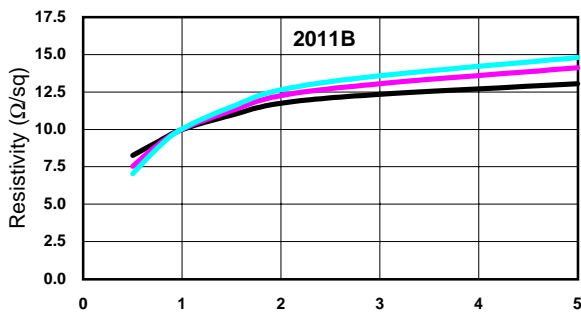
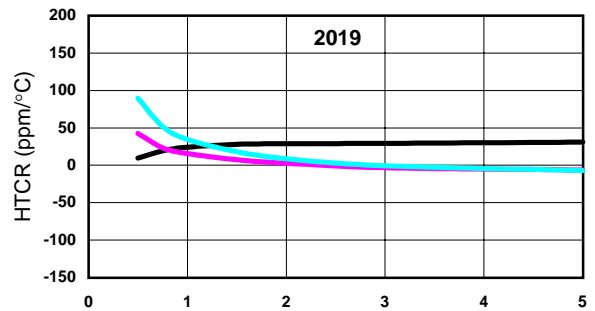
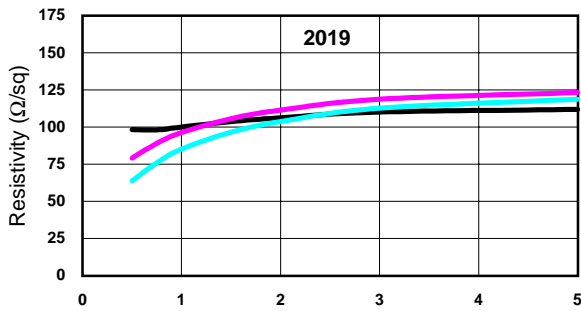
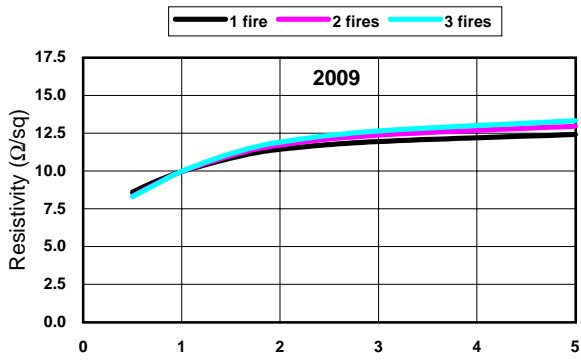
Series 2000 Firing Behaviour 850°Cx60min (Length Effect Curves)

Data based on resistors of 1.0mm width with 3:1 AgPd terminations.



Series 2000 Refiring Behaviour (Length Effect Curves)

Data based on resistors of 1.0mm width with 3:1 AgPd terminations.

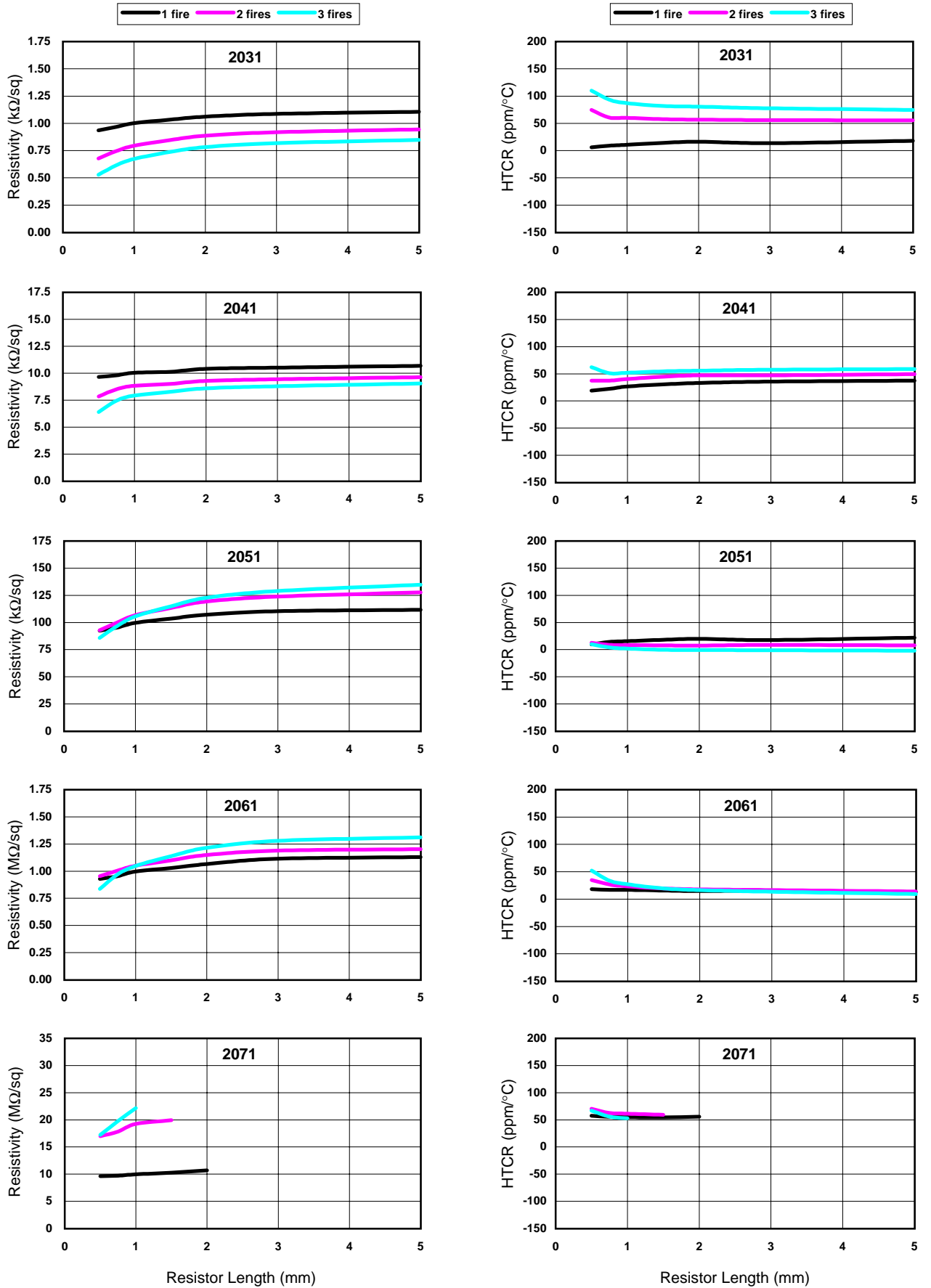


Resistor Length (mm)

Resistor Length (mm)

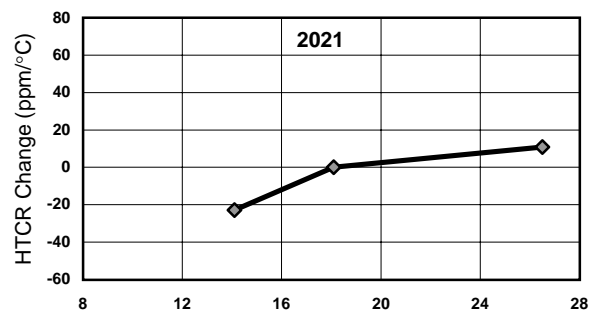
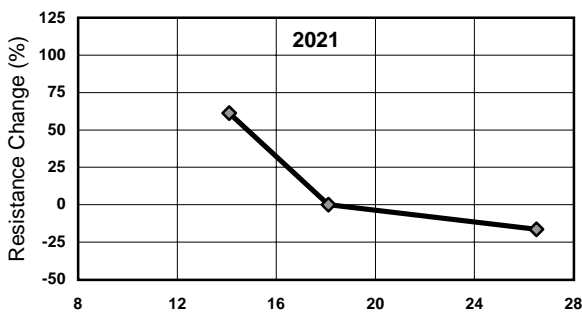
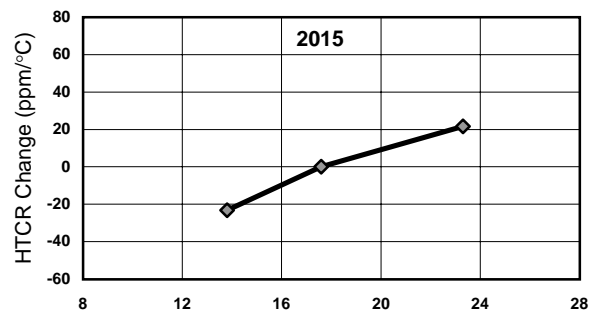
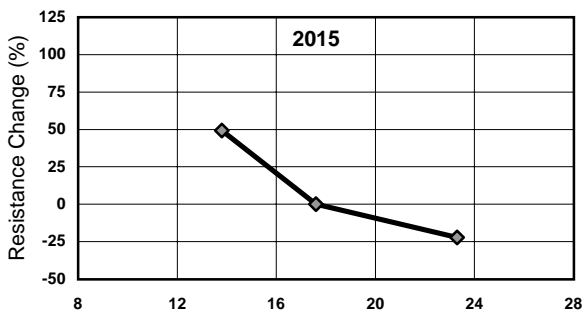
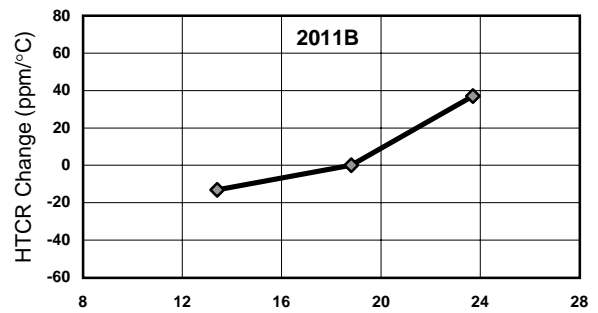
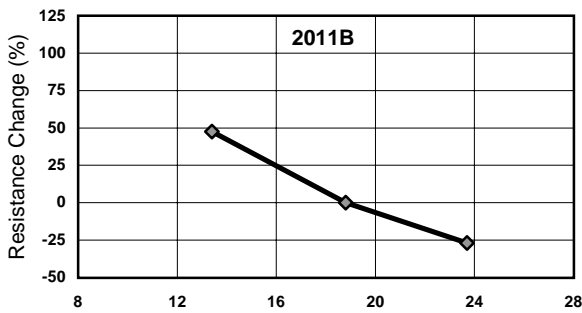
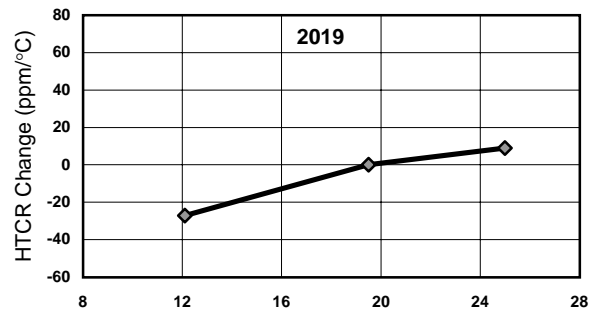
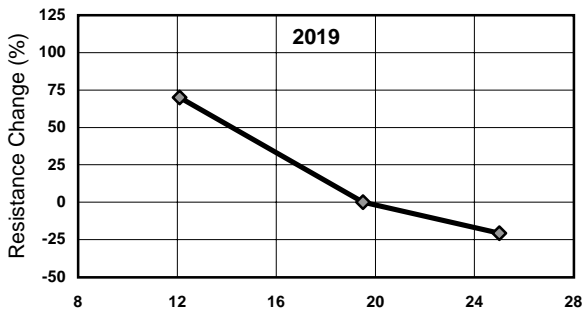
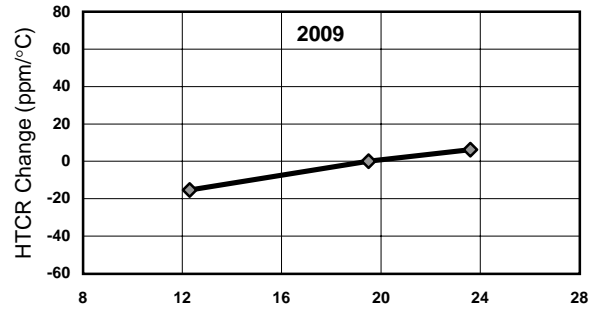
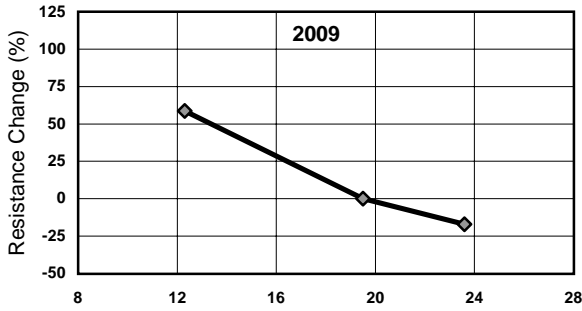
Series 2000 Refiring Behaviour (Length Effect Curves)

Data based on resistors of 1.0mm width with 3:1 AgPd terminations.



Series 2000 Thickness Behaviour

Data based on 1.5x1.5mm resistors with 1% PtAg terminations.

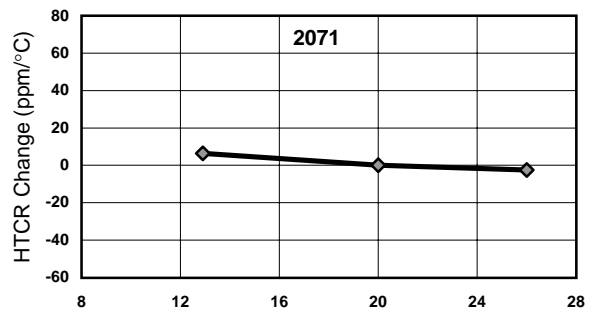
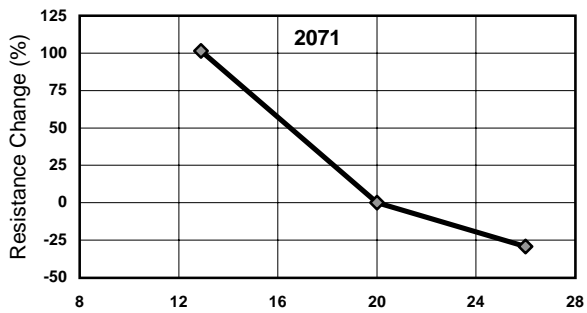
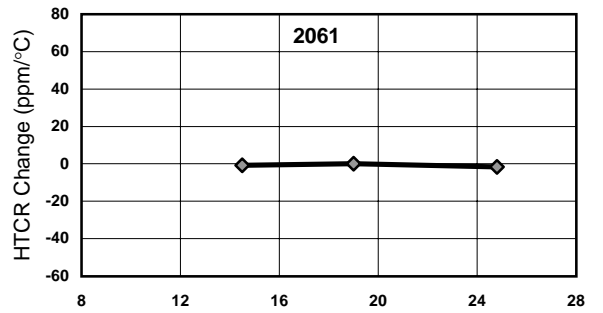
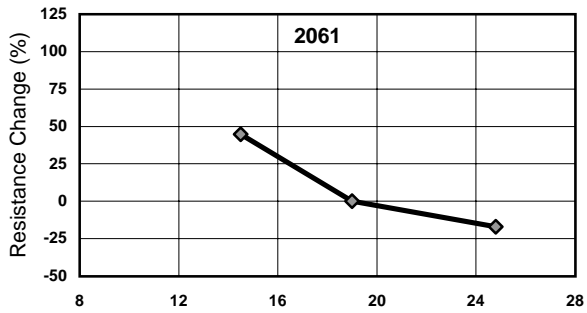
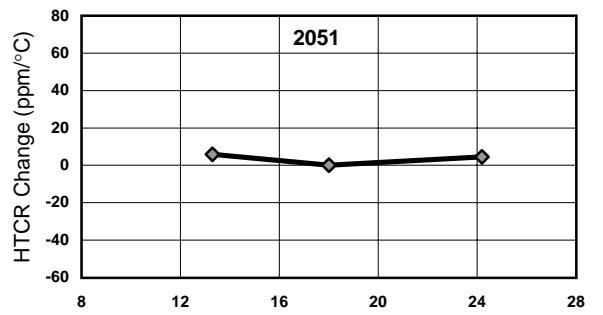
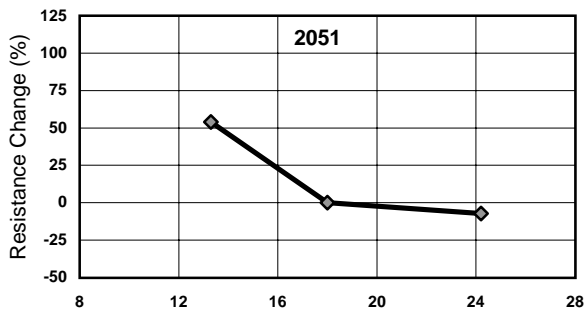
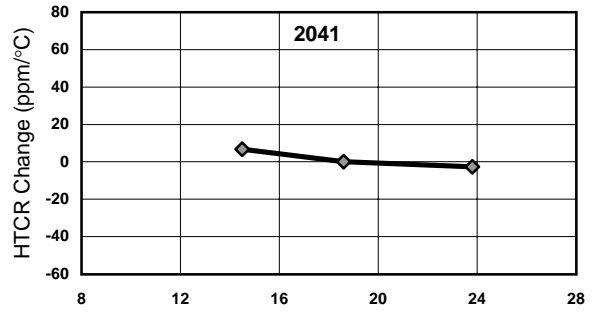
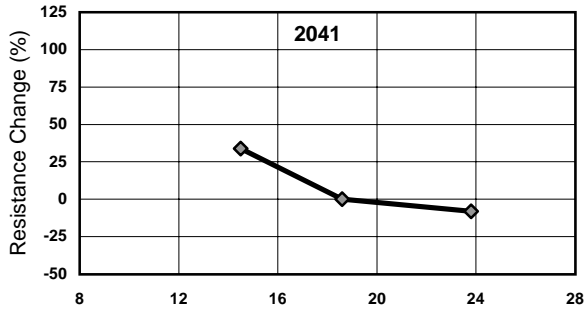
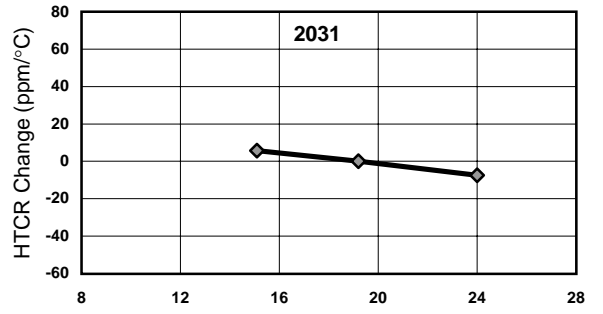
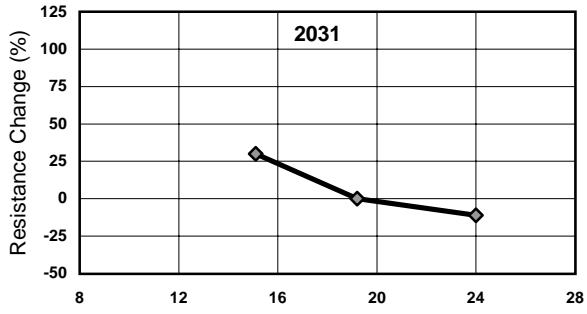


Dried Thickness (µm)

Dried Thickness (µm)

Series 2000 Thickness Behaviour

Data based on 1.5x1.5mm resistors with 1% PtAg terminations.

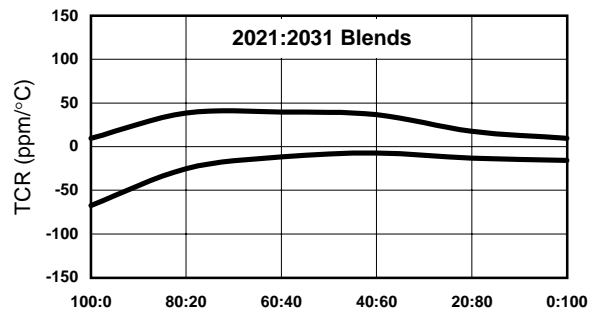
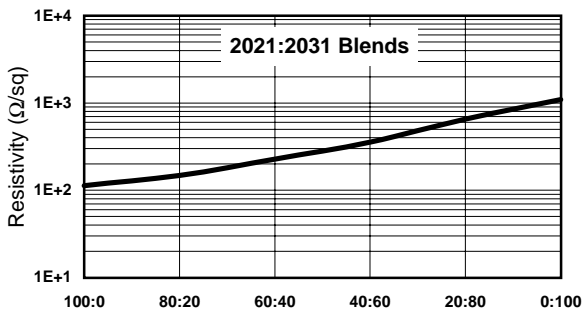
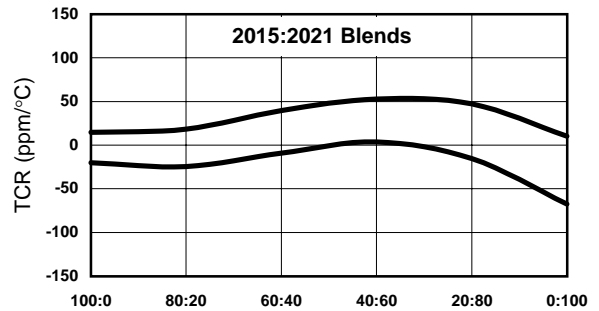
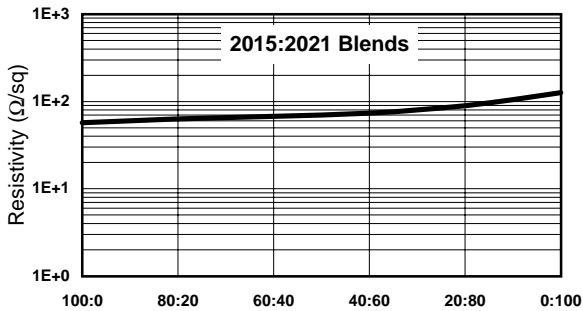
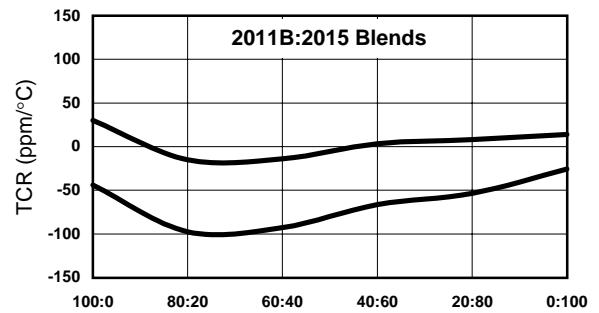
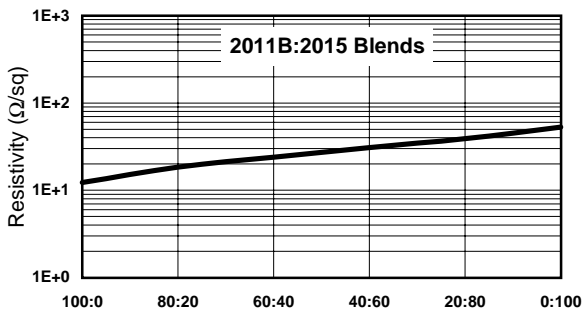
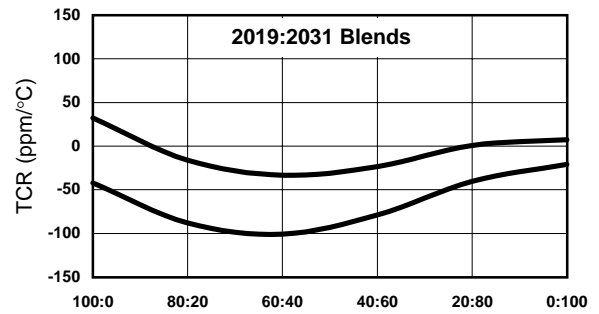
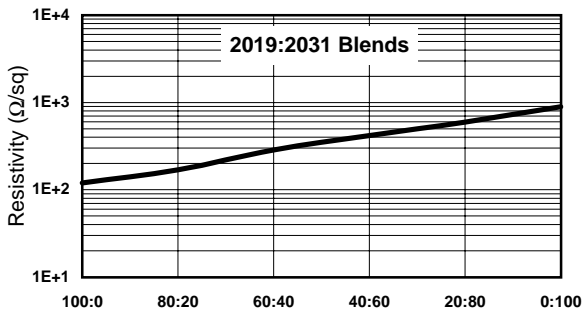
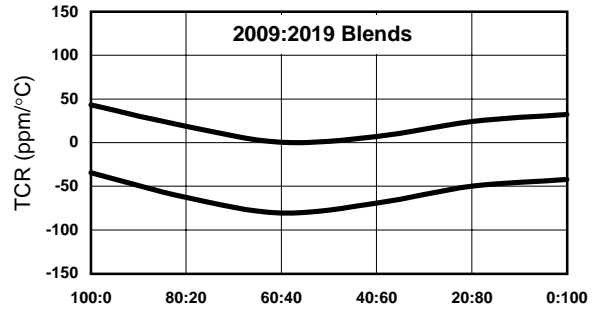
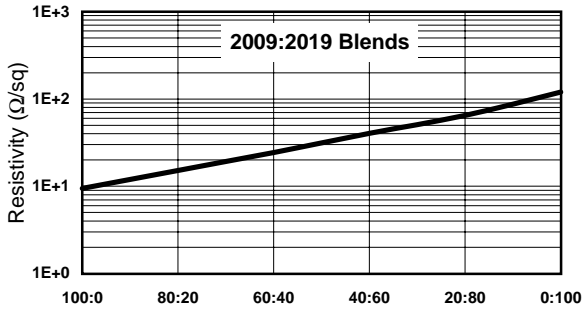


Dried Thickness (µm)

Dried Thickness (µm)

Series 2000 Blend Behaviour

Data based on 1.5x1.5mm resistors with PtAg terminations.

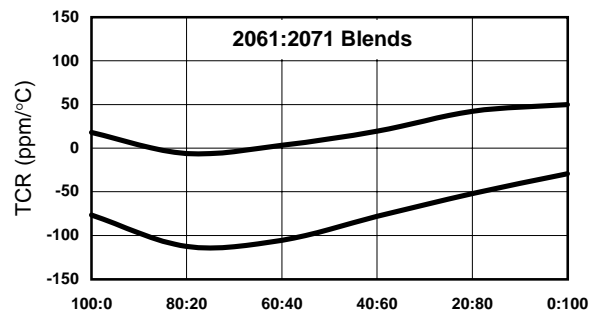
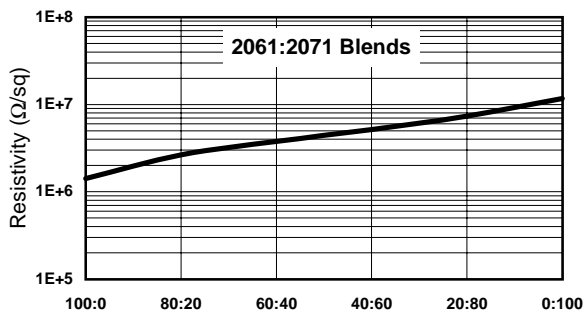
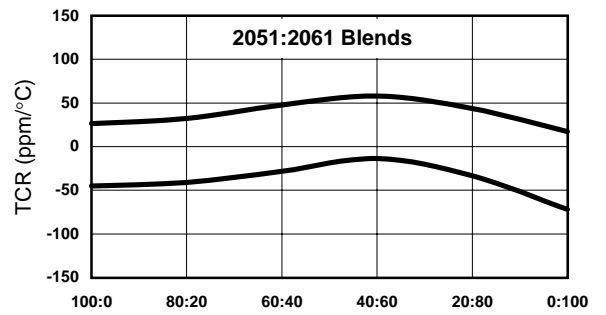
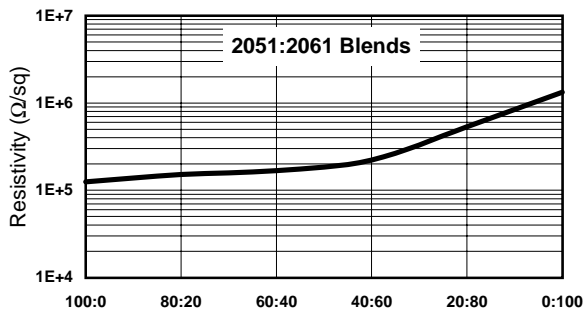
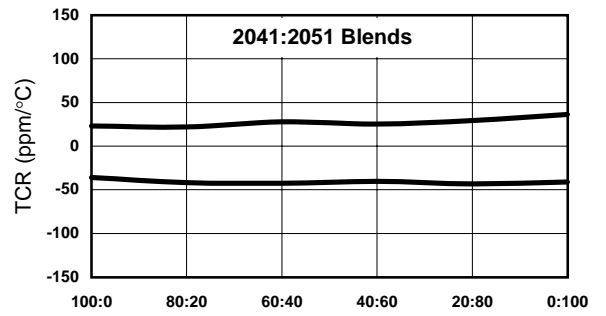
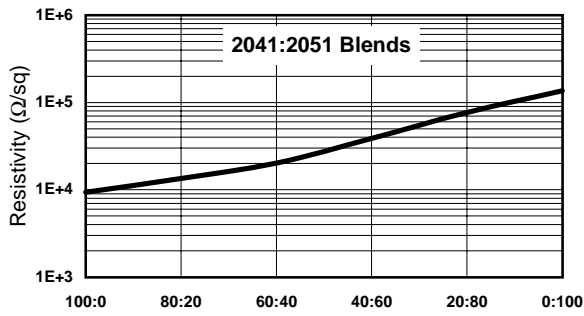
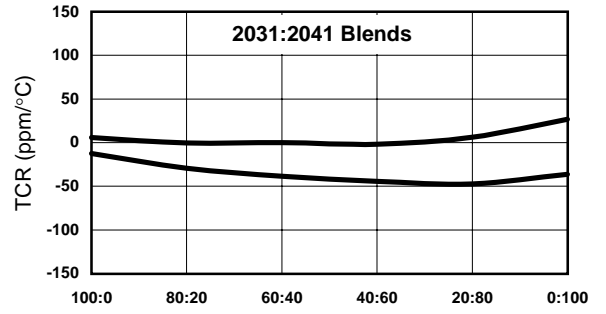
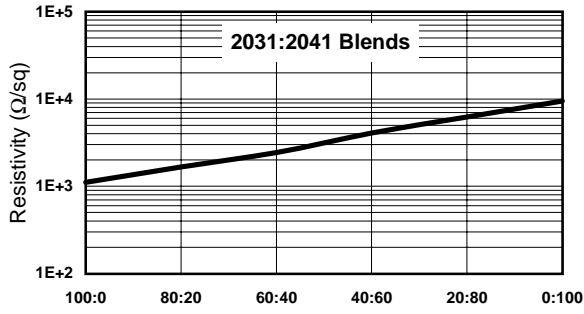


Blend Ratio (%)

Blend Ratio (%)

Series 2000 Blend Behaviour

Data based on 1.5x1.5mm resistors with PtAg terminations.

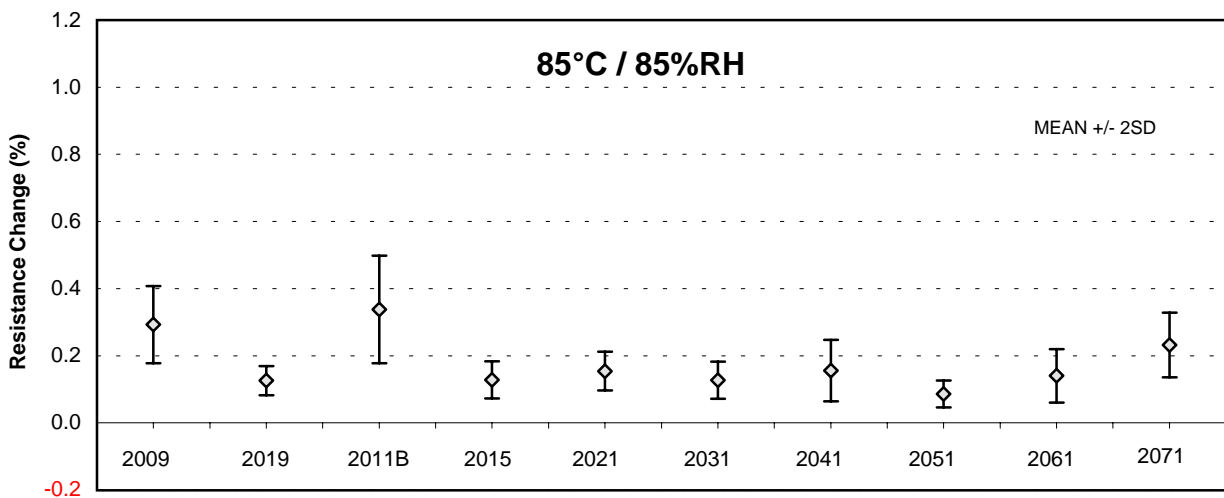
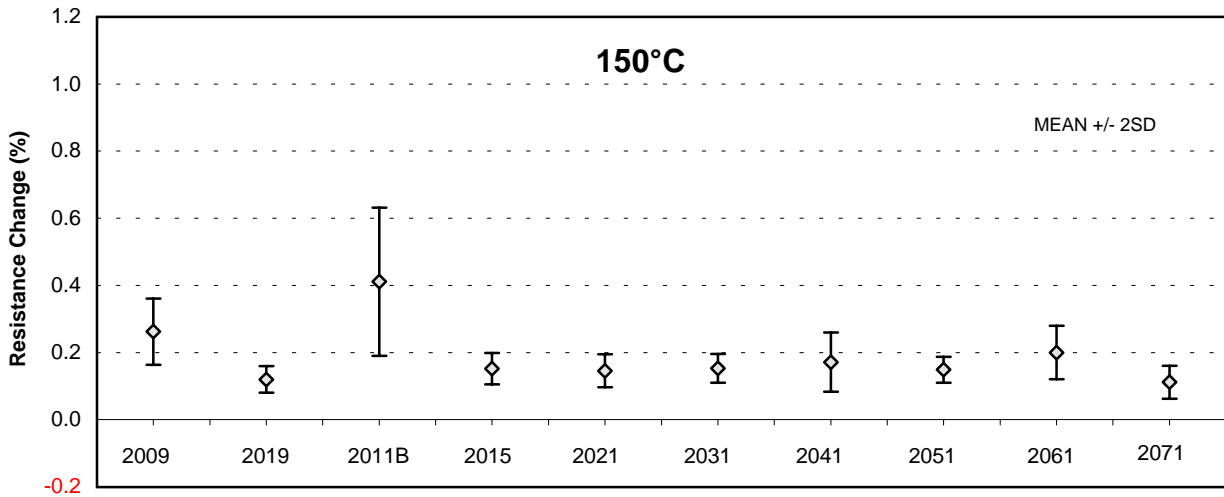
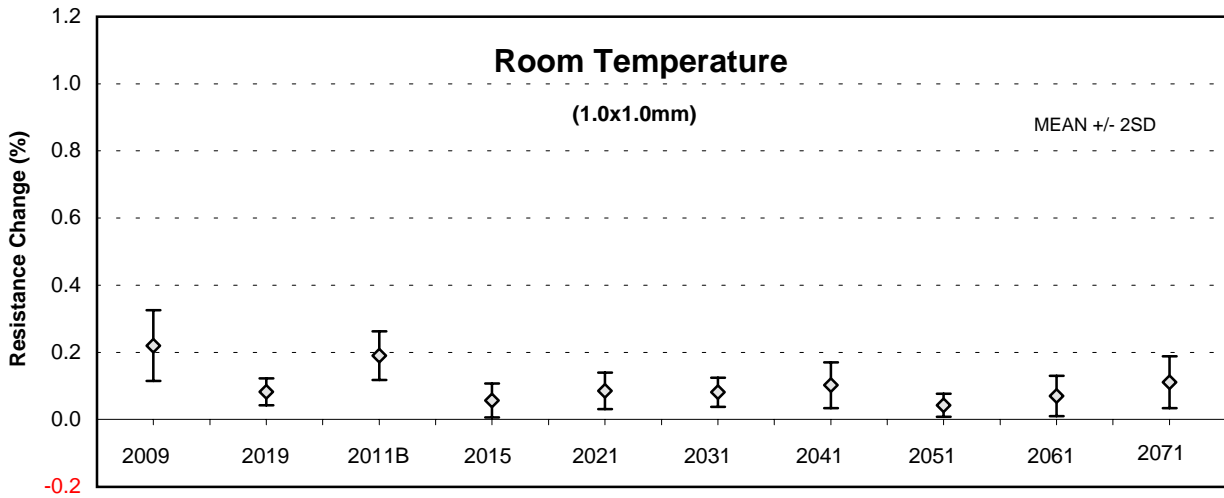


Blend Ratio (%)

Blend Ratio (%)

Series 2000 1,000hr Laser Trim Stability (Unglazed)

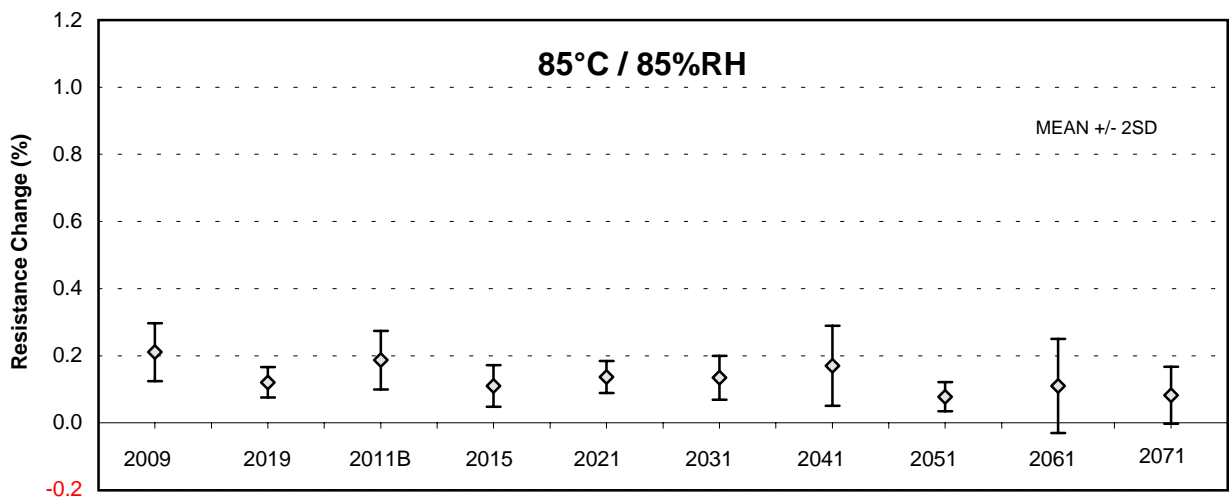
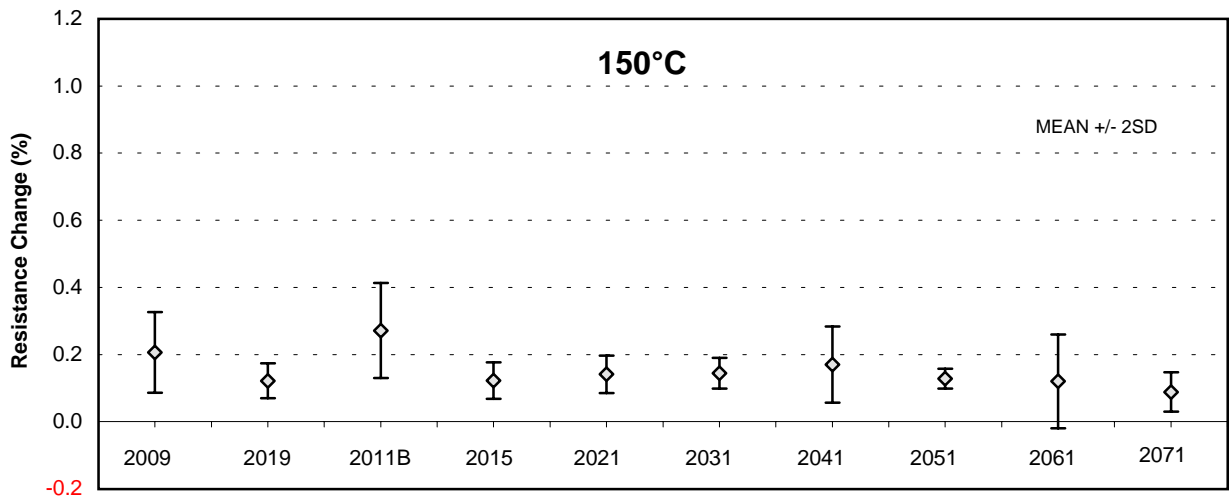
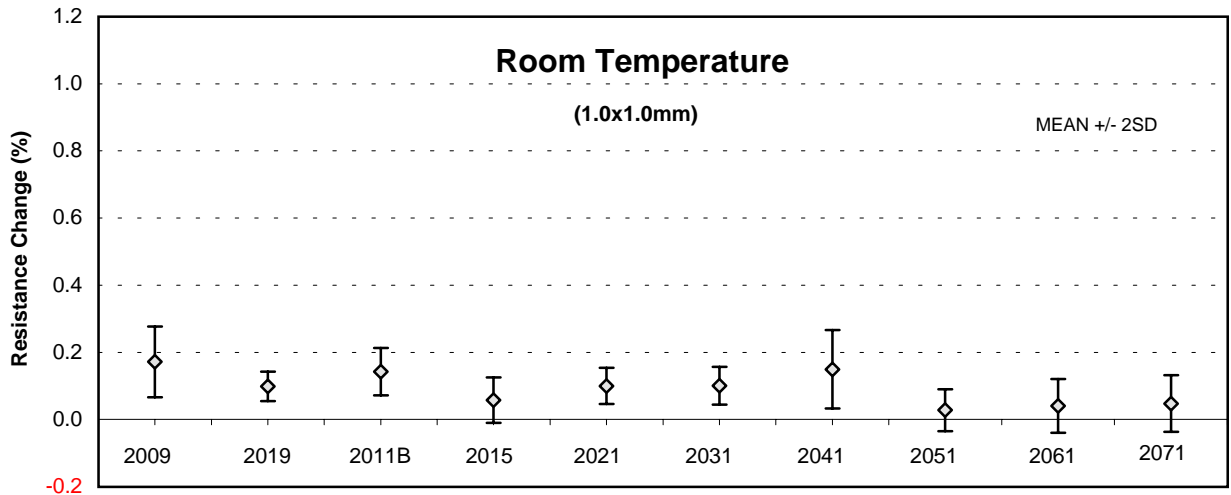
1.0x1.0mm resistors trimmed to 1.5x mean fired value using a single plunge trim.



All data is with respect to the value measured immediately after trimming.

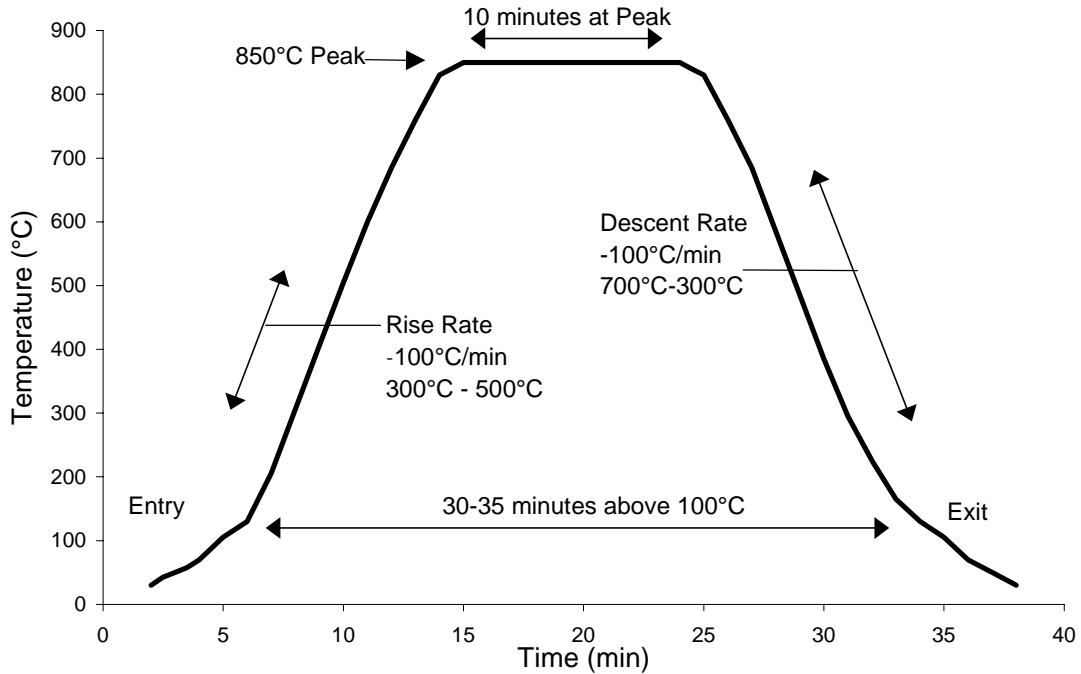
Series 2000 1,000hr Laser Trim Stability (+QQ550 Overglaze)

1.0x1.0mm resistors trimmed to 1.5x mean fired value using a single plunge trim.



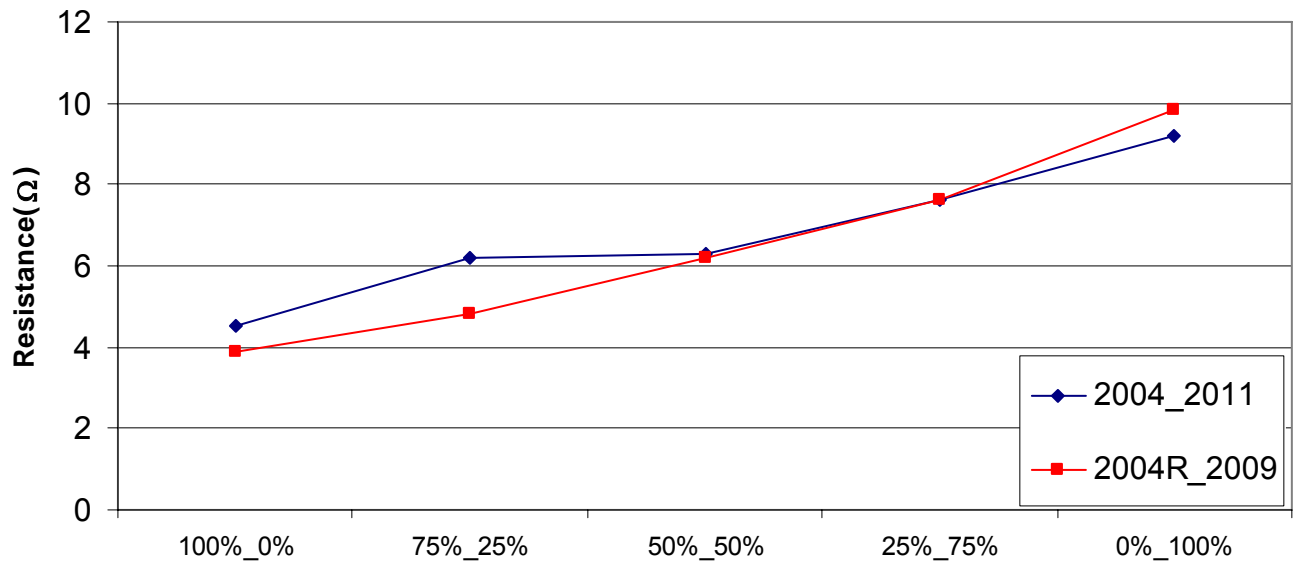
All data is with respect to the value measured immediately after trimming

Typical 850°C 30 Minute Firing Profile

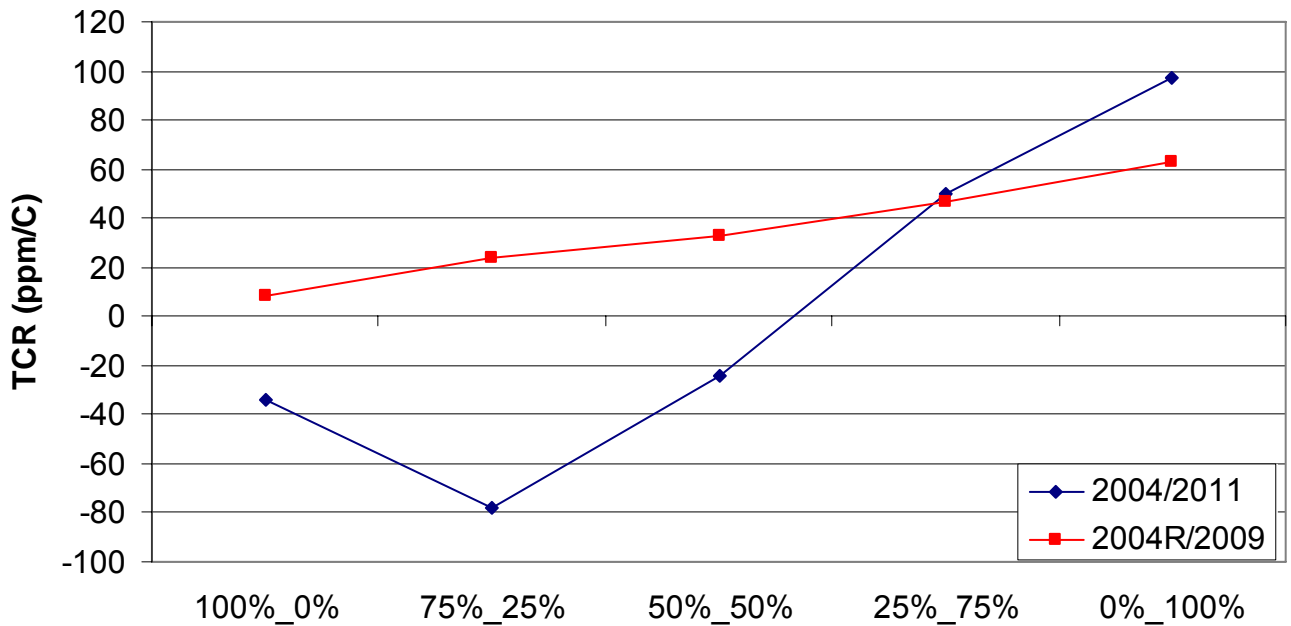


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Resistance Blend Curve



Hot TCR Blend Curve



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