Design Guide for Use of Precision Resistors

Load Life Stability Under Different Conditions of Precision Resistors

Load life stability, expressed in % (or parts per million, ppm) of relative resistance change (R.R.C), defines how stable a resistor is when subjected to its nominal power rating. In order to give this definition an exact meaning, the conditions of the test leading to the establishment of load life stability data must be specified.

1. The nominal load (power rating) must be referenced to a specific ambient temperature. Indeed, different standards define different ambient temperatures of reference, and some specify more than one rating – different ratings for different temperatures.
2. The duration of the load life stability test should be specified as the R.R.C. is a function of time.
3. A test method recommended by standards for precision resistors is usually chosen. It should be strictly followed.

The two parameters usually mentioned together, power rating and ambient temperature, can be joined into one single parameter for a given style of resistors. If the steady state temperature rise can be established, it can be added to the ambient temperature, and the sum will represent the combined (load induced + ambient) temperature. For instance, the Vishay S102C resistor has a temperature rise of 9 ºC per 0.1 W of applied power. It leads to the following sample calculations:

Power Applied (Watts)	Ambient Temperature (ºC)	Combined Temperature (ºC)
0.3	125	3 x 9 + 125 = 152
0.5	80	5 x 9 + 80 = 125
0.3	80	3 x 9 + 80 = 107

Figure 1 shows for a given duration of load life stability test, how the R.R.C. grows with the level of the applied combined temperature. As explained above, the combined temperature comprises the effect of power induced temperature rise and the ambient temperature. The curve shows maximum R.R.C.

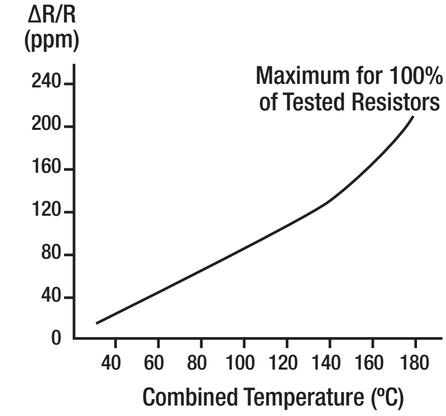

Figure 1. Maximum resistance shifts after 2000 hours of load life test under different thermal stresses – combined temperature, ambient and temperature rise due to applied power.

Figure 2 represents the time relationship: a curve is drawn for a given combined temperature of the R.R.C. as a function of time.

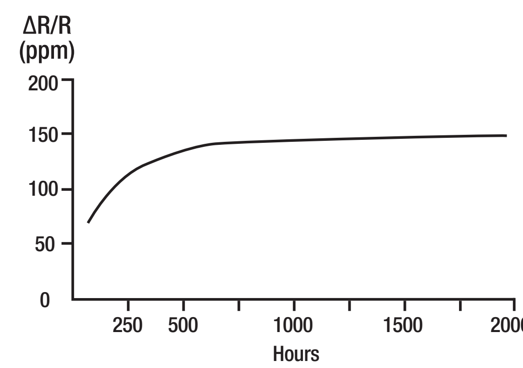

Figure 2. Relative Resistance change (ΔR/R) as function of time, for a given combined temperature (125 °C ambient and 0.3 W load, giving 125 + 0.3 x 9 = 152 °C.)

Design Guide for Use of Precision Resistors

Based on the curves of Figures 1 and 2, Figures 3 through 9 were prepared for designers' use showing the maximum R.R.C. as a function of time for different conditions of load and ambient temperature.

Figures 3, 4, and 5 plot the data for 125 ºC, 80 ºC, and 25 ºC ambient, respectively. On each figure a set of curves represents loads of 0.5 W, 0.3 W, 0.2 W, 0.1 W, and 0.05 W.

Figures 6, 7, 8, and 9 illustrate the curve produced for 0.5 W, 0.3 W, 0.2 W, and 0.1 W, respectively. On each figure a set of curves represents ambient temperature of 125 ºC, 80 ºC, and 25 ºC.

Using these figures, the designer can easily find the maximum expected relative resistance change for any combination of load applied, ambient temperature, and duration of exposure.

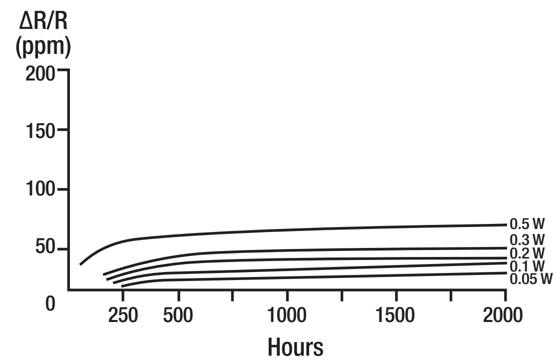

Figure 5. ΔR/R = f (time), 25 °C ambient, loads 0.05 to 0.5 W.

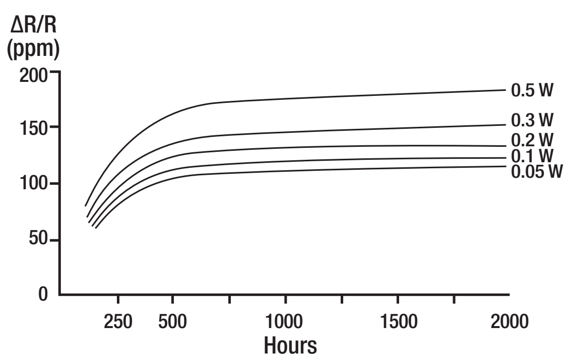

Figure 3. ΔR/R = f (time), 125 °C ambient, loads 0.05 to 0.5 W.

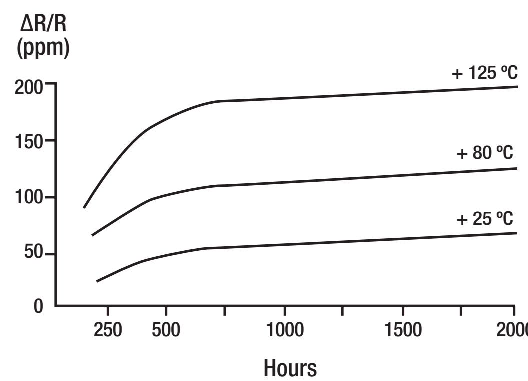

Figure 6. ΔR/R = f (time), load 0.5 W, different ambient temperature.

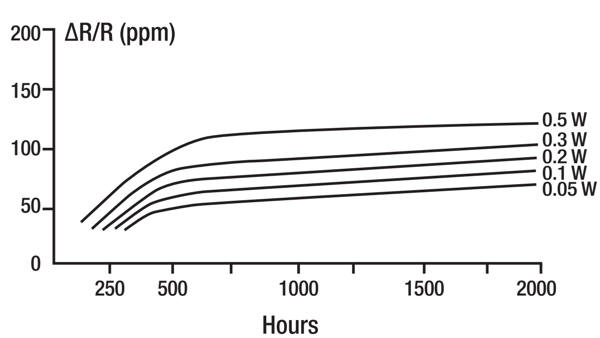

Figure 4. ΔR/R = f (time), 80 °C ambient, loads 0.05 to 0.5 W.

Example 1

Condition: 0.2 watts: + 125 ºC ambient; 2,000 hours

Solution: Combined temperature is:
(2 x 9) + 125 = 143 ºC

Figure 1 gives a ΔR/R of 135 ppm

Example 2

Condition: 0.1 watts: + 80 ºC ambient; 2,000 hours

Solution: Combined temperature is:
(1 x 9) + 80 = 89 ºC

Figure 1 gives a ΔR/R of 70 ppm

Design Guide for Use of Precision Resistors

Example 3

Condition: 0.3 watts: + 80 ºC ambient; 500 hours and 2,000 hours

Solution: Combined temperature is:
(3 x 9) + 80 = 107 ºC

Figure 4 gives a ΔR/R of 80 ppm for 500 hours and 90 ppm for 2,000 hours

Figure 1 also gives 90 ppm for 2,000 hours

Example 4

Condition: 0.2 watts: what is the ΔR/R shift for an exposure of 2,000 hours at 25 ºC, 80 ºC, and 125 ºC?

Solution: Figure 8 gives for 25 ºC ΔR/R = 25 ppm; for 80 ºC ΔR/R = 83 ppm; and for 125 ºC ΔR/R = 135 ppm

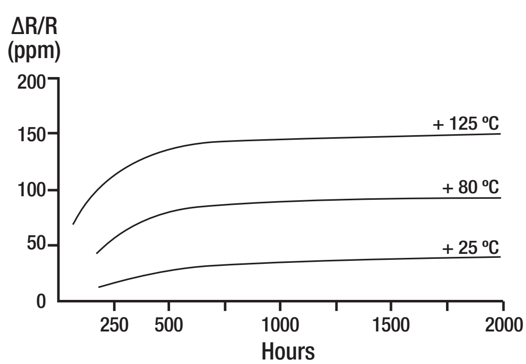

Figure 7. ΔR/R = f (time), load 0.3 W, different ambient temperature.

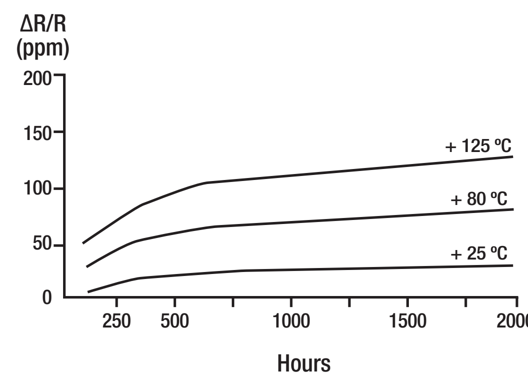

Figure 8. ΔR/R = f (time), load 0.2 W, different ambient temperature.

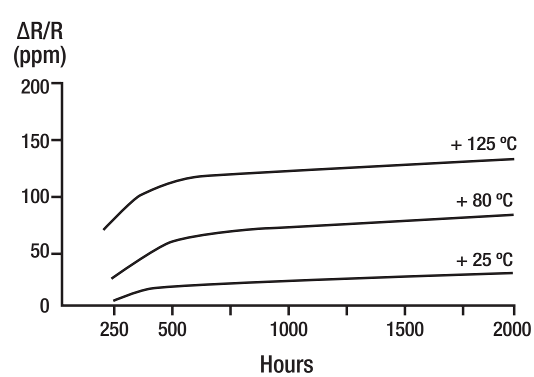

Figure 9. ΔR/R = f (time), load 0.1 W, different ambient temperature.

TECH NOTE

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ISRAEL
FOILSALES.ISRAEL@VISHAY.COM