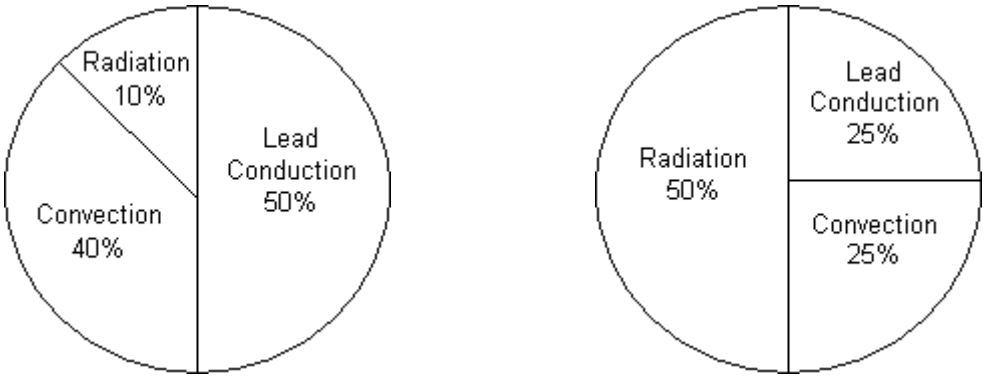
Resistors Failure Mechanisms and Anomalies

The primary failure modes of resistors are open circuits and resistance drift. The relative probability of each depends on the application. For example, a resistor used in an application demanding high precision will naturally be more prone to failure due to

Table 1. Normalized Failure Mode Distributions for Resistors[1]

Resistor Style	Relative Failure Mode Probability			
	Open	Parameter Change	Short	Erratic Output
Fixed, Film	50%	45%	5%	
Network	80%		20%	
Fixed, Wirewound (all styles)	65%	26%	9%	
Variable (all styles)	53%		7%	40%

drift/aging affects. Failure mode also depends on the resistor style. As a rule, film styles are most susceptible to resistance drift while wirewounds usually fail in the open circuit mode. Resistors failing in the short circuit mode are rare and only accounting for 3 to 9% of all resistor failures. A summary of the failure modes of different resistor styles is given in Table 1.



Resistors Above 2 Watts Resistors 2 Watts and Below

Figure 1. Heat Dissipation of Resistors under Room Conditions

The source of resistor failures is generally due to outside environmental factors such as handling damage or external stress. High vibration or shock can also degrade the interface for large mass resistors. Failures seldom occur due to a failure of the resistive element itself. The only exception to this rule is the thin film resistor styles that are susceptible to Electrostatic Discharge (ESD) damage.

The failure modes of variable resistors are substantially different because they have moving parts and are not as well sealed against the outside environment. They fail most commonly in the open circuit mode, and the failure is usually caused by wear of the wiper arm mechanism. Resistance drift and excess noise can also be a problem as the wiper arm ages. The short circuit failure mode is again unlikely for variable resistors.

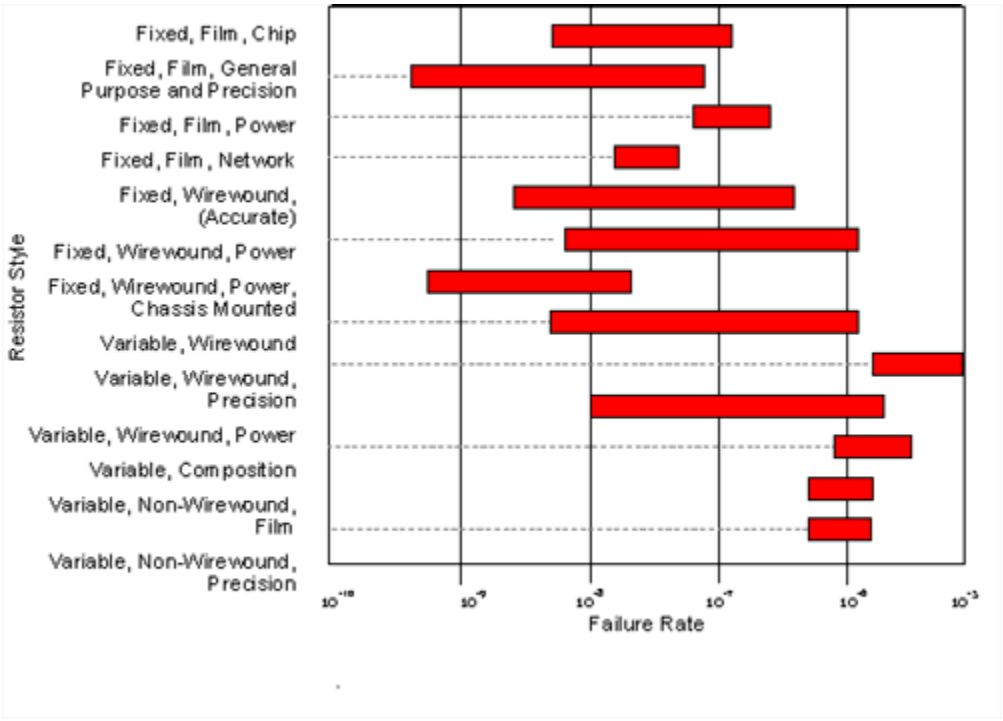


Figure 2. Relative Failure Rates for Resistors

Failures of all resistor styles are most commonly propagated by heat. Therefore, it is important to properly understand resistor heat dissipation properties. The primary heat dissipation mechanism of a low power resistor is by conduction through its component leads, while a high power resistor dissipates heat primarily through radiation. Figure 1 portrays the difference for fixed resistors in free air.

[1] Failure mode data was taken from a combination of resistor manufacturer's recommendations, MIL-HDBK-978, "NASA Parts Application Handbook," 1991; MIL-HDBK-338, "Electronic Reliability Design Handbook," 1994; "Reliability

Toolkit: Commercial Practices Edition," Reliability Analysis Center (RAC), 1998; and "Failure Mode, Effects, and Criticality Analysis (FMECA)," RAC, 1993.