3 Qualification Tests for Components and Assemblies

Components, materials, and assemblies have a great impact on the quality and reliability of the equipment and systems in which they are used. Their selection and qualification has to be considered with care by new technologies or important redesigns, on a case-by-case basis. Besides cost and availability on the market, important selection criteria are intended application, technology, quality, long-term behavior of relevant parameters, and reliability. A qualification test includes characterization at different stresses (for instance, electrical and thermal for electronic components), environmental tests, reliability tests, and failure analysis. After some considerations about selection criteria for electronic components (Section 3.1), this chapter deals with qualification tests for complex integrated circuits (Section 3.2) and electronic assemblies (Section 3.4), and discusses basic aspects of failure modes, mechanisms, and analysis of electronic components (Section 3.3). Procedures given in this chapter can be extended to nonelectronic components and materials as well. Reliability related basic technological properties of electronic components are summarized in Appendix A10. Statistical tests are in Chapter 7, test and screening strategies in Chapter 8, design guidelines in Chapter 5.

3.1 Basic Selection Criteria for Electronic Components

As given in Section 2.2 (Eq. (2.18)), the failure rate of equipment and systems without redundancy is the sum of the failure rates of their elements. Thus, for large equipment or systems without redundancy, high reliability can only be achieved by selecting components and materials with sufficiently low failure rates. Useful information for such a selection are:

1. Intended application, in particular required function, environmental conditions, as well as reliability and safety targets.
2. Specific properties of the component or material considered, in particular technological limits, useful life, long term behavior of relevant parameters.

A. Birolini, Reliability Engineering, 6th ed., DOI 10.1007/978-3-642-14952-8_3,
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3. Possibility for accelerated tests.
4. Results of qualification tests on similar components or materials.
5. Experience from field operation.
6. Influence of derating, influence of screening
7. Potential design problems, in particular sensitivity of performance parameters, interface problems, EMC.
8. Limitations due to standardization or logistic aspects.
9. Potential production problems (assembling, testing, handling, storing, etc.).

As many of the above requirements are conflicting, component selection often results in a compromise. The following is a brief discussion of the most important aspects in selecting electronic components.

3.1.1 Environment

Environmental conditions have a major impact on the functionality and reliability of electronic components, equipment, and systems. They are defined in international standards [3.8]. Such standards specify stress limits and test conditions, among others for

- heat (steady-state, rate of temperature change), cold, humidity, precipitation (rain, snow, hail), radiation (solar, heat, ionizing), salt, sand, dust, noise, vibration (sinusoidal, random), shock, fall, acceleration.

Several combinations of stresses have also been defined, for instance,

- temperature and humidity, temperature and vibration, humidity and vibration.

Not all stress combinations are relevant and by combining stresses, or in defining sequences of stresses, care must be taken to avoid the activation of failure mechanisms which would not appear in the field.

Environmental conditions at equipment and system level are given by the application. They can range from severe, as in aerospace and defense fields (with extreme low and high ambient temperatures, 100% relative humidity, rapid thermal changes, vibration, shock, and high electromagnetic interference), to favorable, as in computer rooms (with forced cooling at constant temperature and no mechanical stress). International standards can be used to fix representative environmental conditions for many applications, e.g. IEC 60721 [3.8]. Table 3.1 gives examples for environmental test conditions for electronic/electromechanical equipment and systems. The stress conditions given in Table 3.1 have indicative purpose and have to be refined according to the specific application, to be cost and time effective.