1.0 INTRODUCTION

The purpose of this document is to present practical information that can be used for the selection and application of capacitors. This is part of a series of Reliability Analysis Center (RAC) documents on various component types to assist in their selection and application for reliability. The information provides an awareness of the factors that should be considered when designing circuits containing capacitors, with the ultimate goal of assisting in the achievement of a reliable circuit. The goal of this document is not to provide a tutorial on the construction of, or the physics associated with, capacitors since this has been done extensively in the literature. Rather, it is to present data and information that is not available elsewhere. As such, much of the information contained herein is based on quantitative data from databases developed at the RAC. It is RAC's intent that this document complement existing literature on capacitors.

At the time of this writing, many military specifications and handbooks are being either canceled or transitioned to non-government organizations due to the acquisition reform movement. However, there are several sections in this document that reference military specifications and handbooks. This is done only for cases in which the authors believe that they offer valuable information that is not available elsewhere.

Section 2 of this document presents a discussion of the factors that should be considered when designing reliable circuits containing capacitors. Section 2.1 discusses specific considerations, including derating, corona and partial discharges, voltage breakdown, radiation damage, dielectric absorption, frequency effects, and equivalent series resistance (ESR). Section 2.2 contains a presentation of application information on specific capacitor types.

Section 3 contains quantitative reliability data on various capacitor types. Section 3.1 contains field reliability data that has been collected by RAC from various sources. Section 3.2 contains several reliability prediction models that have been developed for both military (MIL-HDBK-217) and commercial grade components. Appendix B provides additional information on the development of the MIL-HDBK-217 model to provide the reader with insight into the factors which have been shown to influence reliability.

Section 4 contains information that will allow the user to apply capacitors in a manner that insures robustness. One technique that can be used to insure robustness is Worst Case Circuit Analysis (WCCA). Section 4.1 and Appendix D present a description of WCCA and Section 4.2 present data that is necessary to perform a WCCA. Included in Section 4.2 are mathematical relationships that estimate parametric changes of capacitance, Equivalent Series Resistance (ESR), and dissipation factor as a function of time, temperature and voltage. This information, coupled with the WCCA technique, is particularly useful to insure that the circuit is capable of operating reliably with expected parametric changes.

Section 5 presents data that RAC has collected relating to the modes of failure of various capacitor types. This information is useful in quantifying the relative percentage of failure modes. This can be used to support the performance of failure modes and effects analysis, and to identify predominant failure modes.

Section 6 summarizes the sources of data used in Sections 3, 4, and 5. This includes failure rate, failure mode and parameter change data sources.

Section 7 is a summary of Government/Industry Data Exchange Program (GIDEP) alerts on capacitors. This data is presented so that the reader can identify the reasons for reliability or quality problems that have been experienced with capacitors.