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Processes for Application-Specific Qualification of Electrical, Electronic,
and Electromechanical Parts and Sub-Assemblies for
Use in Aerospace, Defense, and High Performance Systems

RATIONALE

The Aerospace, Defense, and High Performance (ADHP) industries are increasingly dependent on commercial-off-the-shelf (COTS) parts and sub-assemblies (hereinafter referred to as items). The qualification tests and methods typically used by the COTS item manufacturers are based on the needs of target markets other than ADHP markets, and therefore may not be adequate for ADHP applications. It is therefore critical for those who integrate COTS items into ADHP systems to assure that those items are qualified for the specific ADHP application.

INTRODUCTION

This Aerospace Recommended Practice describes an application-specific qualification process for electrical, electronic, and electromechanical (EEE) parts and sub-assemblies in aerospace, defense, and high performance (ADHP) systems. The ADHP industries are increasingly dependent on commercial-off-the-shelf (COTS) parts and sub-assemblies (hereinafter referred to as items, or COTS items). The qualification tests and methods typically used by COTS item manufacturers are based on the needs of target markets which, typically, are markets other than ADHP markets; and therefore may not be adequate for ADHP applications. It is critical for those who integrate COTS items into ADHP systems to assure that those items are qualified for the specific ADHP application.

This document distinguishes between generic qualification, and application-specific qualification. Generic qualification usually consists of a standardized set of tests and methods, to provide confidence that the qualified item will perform its intended function(s) reliably in the targeted generic application(s)¹. In most instances, the generic qualification methods, processes, and tests are defined by the item manufacturers; although in some cases (most notably that of the automotive industry), the customers interact with the item manufacturers to define the qualification tests and methods.

References 1 through 10 are industry standard generic qualification documents published by the JEDEC® Solid State Technology Association, for use in qualification of solid-state electronic components. Likewise, References 11 through 45 have been prepared for use in generic qualification of components for automotive applications. They contain much useful information, but are not specific to applications of ADHP systems. Additionally, a number of military qualification documents (not listed here) have been prepared for a variety of generic military applications, but are not application-specific. Additionally, most EEE part and sub-assembly manufacturers have their own generic qualification processes, which are published, with test results, on their websites or other product literature. Generic qualification data and results may be useful as a baseline for application-specific qualification; but they are generally not sufficient for ADHP applications without additional application-specific data and results.

In contrast to generic qualification, application-specific qualification is typically performed by the ADHP user of the item, employing a set of tests and methods that are customized for the application, to provide assurance that the qualified item will perform its intended function(s) reliably in the specific ADHP application.

¹ Examples of targeted applications are computers, telecommunications, automotive, consumer electronics, etc. The market segment of items targeted for ADHP applications is miniscule, and the costs of ADHP-targeted items cannot be justified in the majority of ADHP applications.

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It is rarely the case that any generic qualification test conditions will match the application-specific in-service conditions exactly; and it is important to understand and use appropriate acceleration models to convert test results to estimates of the behavior of the item in service. That process is therefore integral to the overall process described here.

1. SCOPE

This document describes a process for use by ADHP integrators of EEE parts and sub-assemblies (items) that have been targeted for other applications².

This document does not describe specific tests to be conducted, sample sizes to be used, nor results to be obtained; instead, it describes a process to define and accomplish application-specific qualification; that provides confidence to both the ADHP integrators, and the integrators' customers, that the item will perform its function(s) reliably in the ADHP application.

2. REFERENCES

2.1 For dated references, only the revision cited applies. For undated references, the latest revision of the referenced document (including any amendments) applies. Since compliance to any of the listed references is not required by this document, the user is encouraged to use later revisions than those listed, provided that the later revisions do not include substantial variations from the listed revisions.

1. JESD94B, Application Specific Qualification Using Knowledge Based Test Methodology, JEDEC® Solid State Technology Association, September 2011
2. JESD47I, Stress-Test-Driven Qualification of Integrated Circuits, JEDEC® Solid State Technology Association, April 2011
3. JEP143C, Solid-State Reliability Assessment and Qualification Methodologies, JEDEC® Solid State Technology Association, June 2008
4. JEP150.01, Stress-Test-Driven Qualification of and Failure Mechanisms Associated with Assembled Solid-State Surface-Mount Components, JEDEC® Solid State Technology Association, June 2011
5. JESD237, Reliability Qualification of Power Amplifier Modules, JEDEC® Solid State Technology Association, March 2014
6. JEP122G, Failure Mechanisms and Models for Semiconductor Devices, JEDEC® Solid State Technology Association, November 2010
7. JESD91A, Method for Developing Acceleration Models for Electronic Component Failure Mechanisms, JEDEC® Solid State Technology Association, January 2011
8. JESD85, Method for Calculating Failure Rates in Units of FITS, JEDEC® Solid State Technology Association, January 2014
9. JESD74A, Early Life Failure Rate Calculation Procedure for Semiconductor Components, April 2000
10. JESD22, Series of Test Method Documents, JEDEC® Solid State Technology Association
11. AEC-Q100, Failure Mechanism Based Stress Test Qualification for Integrated Circuits (References 2 through 11 are subordinate documents to this reference. Specific revisions to References 1 through 11 are not shown here.)
12. AEC-Q100-001, Wire Bond Shear Test

² This document does not include "shall" statements, and in that sense it is not a requirements document; however, it is written in a manner that it can be used as a requirement in a contract by stating that the processes described herein shall be followed.

13. AEC-Q100-002, Human Body Model Electrostatic Discharge Test
14. AEC-Q100-004, IC Latchup Test
15. AEC-Q100-005, Non-Volatile Memory Program/Erase Endurance, Data Retention, and Operational Life Test
16. AEC-Q-100-007, Fault Simulation and Test Grading
17. AEC-Q100-008, Early Life Failure Rate (ELFR)
18. AEC-Q100-009, Electrical Distribution Assessment
19. AEC-Q100-010, Solder Ball Shear Test
20. AEC-Q100-011, Charged Device Model (CDM) Electrostatic Discharge Test
21. AEC-Q100-012, Short Circuit Reliability Characterization of Smart power Devices for 12V Systems
22. AEC-Q101, Failure Mechanism Based Stress Test Qualification for Discrete Semiconductors
23. AEC-Q101-001, Rev. A, Human Body Model (HBM) Electrostatic Discharge Test
24. AEC-Q101-003, Rev. A, Wire Bond Shear Test
25. AEC-Q101-004, Miscellaneous Test Methods
26. AEC-Q101-005, Charged Device Model (CDM) Electrostatic Discharge Test
27. AEC-Q101-006, Short Circuit Reliability Characterization of Smart Power Devices for 12V Systems
28. AEC-Q200, Stress Test Qualification for Passive Components
29. AEC-Q200, Rev. D, Base: Stress Test Qualification for Passive Components (base document)
30. AEC-Q200-001, Rev. B, Flame Retardance Test
31. AEC-Q200-002, Rev. B, Human Body Model (HBM) Electrostatic Discharge Test
32. AEC-Q200-003, Rev. B, Beam Load (Break Strength) Test
33. AEC-Q200-004, Rev. A, Measurement Procedures for Resettable Fuses
34. AEC-Q200-005, Rev. A, Board Flex/Terminal Bond Strength Test
35. AEC-Q200-006, Rev. A, Terminal Strength (SMD)/Shear Stress Test
36. AEC-Q200-007, Rev. A, Voltage Surge Test
37. AEC-Q001, Rev. D, Guidelines for Part Average Testing (provides guidelines for using statistical techniques and extended operating conditions to establish part test limits; this approach could be used to provide "Known Good Die.")
38. AEC-Q002, Rev. B, Guidelines for Statistical Yield Analysis (provides guidelines for using statistical techniques to detect and remove abnormal lots of integrated circuits)
39. AEC-Q003, Rev. A, Guidelines for Characterizing the Electrical Performance of Integrated Circuit Products

40. AEC-Q004, Proposed Draft, Zero Defects Guideline (describes a set of tools and processes which suppliers and users of integrated circuits can use to approach or achieve the goal of zero defects during a product's lifetime)
41. AEC-Q005, Rev. A, Pb-Free Test Requirements (Contains a set of tests and defines the minimum requirements for qualification of lead free (Pb-free) metallurgy for components to be used in any automotive electronics application)
42. AEC-Q006, Qualification Requirements for Components Using Copper (Cu) Wire Interconnects.
43. AEC-CDC, Certificate of Design, Construction and Qualification (as published in AEC-Q100 Rev. H)
44. AEC-QTP, Qualification Test Plan (as published in AEC-Q100, Rev. H)
45. MIL-STD-810G, Environmental Engineering Considerations and Laboratory Tests, April 15, 2014
46. EIA-STD-4899B, Requirements for an Electronic Components Management Plan, SAE International, February 1, 2015
47. EIA-933B, Requirements for a COTS Assembly Management Plan, SAE International, March 1, 2015
48. ARP5890, Guidelines for Preparing Reliability Assessment Plans for Electronic Engine Controls, SAE International, February 1, 2011
49. SAE J2816, Guide for Reliability Analysis Using a Physics-of-Failure Process, December 1, 2009

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2.2 Definitions

ACCELERATION MODEL: An equation, or set of equations, used to transform the data obtained from testing or use at one set of conditions, to data that can be used to estimate behavior at another set of conditions.

APPLICATION-SPECIFIC QUALIFICATION: A qualification process that is typically performed by the user of an item, employing a set of tests and methods that are customized for the application, to provide assurance that the qualified item will perform its intended function(s) reliably in the specific application.

GENERIC QUALIFICATION: A qualification process that is typically performed by the producer of an item, employing a standardized set of tests and methods, to provide confidence that the qualified item will perform its intended function(s) reliably in the targeted generic application.

3. APPLICATION-SPECIFIC QUALIFICATION PROCESS

The process for application-specific qualification of items for use in ADHP applications includes the steps described in 3.1 to 3.7, and illustrated in the flow charts of Appendices A and B. Paragraph 3.7 describes documentation of the results of steps 3.1 through 3.6.

3.1 Document the Application-Specific Requirements

Document the requirements to be satisfied by the item in the ADHP application in which the item is intended for use, including environmental conditions, and design and operating requirements. Typically, the requirements are found in the specifications, contracts, and design documents for the application.