



AEROSPACE STANDARD

AS6171™/7

Issued 2016-10
Reaffirmed 2022-06

Techniques for Suspect/Counterfeit EEE Parts Detection by Electrical Test Methods

RATIONALE

This document provides guidance and requirements on the electrical test procedures to be employed by the Test Laboratory (Lab) for electrical, electronic and electro-mechanical (EEE) parts for suspect counterfeit (SC) part detection. The level of testing should be derived by the User Organization working in conjunction with the Test Lab, taking into consideration the risk level as defined in the SC part detection test sequence specified herein. It shall be the responsibility of the Test Lab to conduct the electrical test following the sequence of test and inspections for a given risk level specified herein. Reporting procedures shall be defined on how to handle anomalous or failed parts and the reporting protocol on how to detect counterfeit parts. The creation of this document is a step in addressing the ever-increasing global problem of EEE parts counterfeiting.

AS6171/7 has been reaffirmed to comply with the SAE Five-Year Review policy.

INTRODUCTION

The electrical test serves as an important part of the procedure to ascertain whether a device is SC or not. Typically, electrical testing is one of the last steps performed in the verification process, following less expensive steps such as visual inspection, resistance to solvents and radiographic examination. Full electrical testing, if performed to the published datasheet, ensures that the Customer will receive devices that operate in accordance with the manufacturer's device specifications. However, parts passing electrical testing may still be counterfeit devices. Other tests may be needed to be performed, other than electrical testing, so as to assure that the parts are not suspect counterfeit. Electrical testing for the purposes of detecting SC electronic devices is most often justified for the following reasons:

1. Electrical test is one of the best ways to determine if a device is still functional and operational. Electrical test can verify that the device is meeting the rated operating parameters at the specified temperatures per the device electrical test specification.
2. Electrical testing is a very efficient and comprehensive way to non-destructively screen 100% of a component.
3. When there is evidence within a lot that some SC parts or rejects have been mixed in and there is no visual way to separate the SC parts from the good ones, electrical test may distinguish between SC parts and authentic parts depending upon the coverage of the electrical test being applied.
4. Electrical testing can identify components with different performance levels, physical structure or revision levels that cannot be accurately determined with other inspection methods.
5. If parts are damaged from handling, extended storage or environmental issues, testing can determine what percentages of the units are failures. A high rate of failed units can indicate systemic problems with an entire lot received.
6. Electrical testing is an effective method in which to detect electrically defective units, such as manufacturing rejects.

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7. Electrical testing is more critical for applications that have a high risk factor and have the potential for causing life threatening or significant monetary/mission critical damages.
8. When all visual and non-electrical testing has been completed without reasonable certainty of verification, and the part source is not from an OCM or an authorized OCM distributor, then electrical testing may be the only remaining non-destructive testing method to complete the determination.
9. Electrical test may be useful to diagnose actual system failures when no obvious cause of the failures can be found.
10. When part marking does not indicate grade (e.g., speed, power, temperature, quality) of the product and the parts have to be a specific grade for the application, electrical test is the best option. The potential of counterfeiting in such a case comes when it is suspected that the parts were counterfeited by an unapproved third party supplier and falsely marked with the original manufacturer's logo, part number and other markings on the device.
11. For all other instances where documentation or external markings have been expertly altered or falsified, electrical testing may be the best confirmation of part verification.

Counterfeiters are continuing to improve their techniques and their abilities to clone, substitute and forge EEE components. Often the goal of the counterfeiter is to avoid quick detection by visual and mechanical means. Changing of electrical parameters is not easy to do; hence, counterfeiters rarely perform processes to change such electrical characteristics of the devices. Thus, it is critical that a robust electrical test be performed to aid in the assurance of SC detection.

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1. SCOPE

1.1 Scope of Electrical Test Document

The scope of this document is to:

1. Specify techniques to detect SC parts using electrical testing.
2. Provide various levels of electrical testing that can be used by the User to define test plans for detecting SC parts.
3. Provide minimum requirements for testing laboratories so that User/Requester can determine which test houses have the necessary capabilities. (For example: technical knowledge, equipment, procedures and protocols for performing electrical testing for verification analysis.) Note: User/Requester is defined in AS6171 General Requirements
4. Specify Burn-In and environmental tests. The environmental tests include Temperature Cycling for Active Devices and Thermal Shock for Passive Devices. Seal Tests are described and recommended for hermetic devices.

The following terminology is used throughout this document:

- a. Shall = is mandatory;
- b. Should = is recommended; and
- c. Will = is planned (is considered to be part of a standard process).

If AS6171/7 is invoked in the contract, the base document, AS6171 General Requirements shall also apply.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

The requirements of this document are intended to supplement the requirements of a higher level quality standard (e.g., AS9100, ISO17025) and other quality management system documents. They are not intended to stand alone, supersede, or cancel requirements found in other quality management system documents, requirements imposed by contracting authorities, or applicable laws and regulations unless an authorized exemption/variance has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS6171	Test Method Standard, General Requirements, Suspect/Counterfeit, Electrical, Electronic, and Electromechanical Parts
AS9003	Inspection and Test Quality Systems, Requirements for Aviation, Space, and Defense Organizations
ARP9009	Aerospace Contract Clauses
AS9100	Quality Management Systems - Requirements for Aviation, Space and Defense Organizations
AS9120	Quality Management Systems - Requirements for Aviation, Space and Defense Distributors

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

ANSI/ESD S20.20	ESD Control Program Standard
ANSI/ISO IEC 17025	General Requirements for the Competence of Testing and Calibration Laboratories
ISO 9000	Quality Management Systems-Fundamentals and Vocabulary
ISO 9001	Quality Management Systems-Requirements
IDEA-STD-1010	Acceptability of Electronic Components Distributed in the Open Market
JESD-625	Requirements for Handling Electrostatic Discharge Sensitive Devices
MIL-PRF-19500	Semiconductor Devices, General Specification for
MIL-PRF-38534	Hybrid Microcircuits, General Specification for
MIL-PRF-38535	Integrated Circuits (Microcircuits) Manufacturing, General Specification for
MIL-STD-202	Test Method Standard for Electronic and Electrical Component Parts
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Method Standard-Microcircuits
MIL-HDBK-103	List of Microcircuit Drawings (FSC 5962)

2.3 Terms and Definitions

See 2.2 of AS6171.

2.4 Acronyms

See 2.3 of AS6171.

3. MATERIAL CONTROL/ESD HANDLING/TEST HANDLING

3.1 Material Control/ESD Handling

The handling requirements of this document will meet the minimum requirements of 3.9.5 of the AS6171 General Requirements.

Test Labs and their authorized sub-contractors shall implement handling and storage procedures and processes to prevent part and material degradation and apply the Electrostatic Discharge (ESD) controls as prescribed in this document. The handling and storage procedures shall be maintained from receipt of parts through testing, inspections, storage, packaging and shipment back to User/Requester. These processes and procedures shall include as a minimum the following:

1. Unique containers and packaging markings to identify the parts as received.
2. Control and limit personnel access to the parts during inspection and storage.

3. Provide for interim storage of parts as required.
4. Protective cushioning for storage and transportation.
5. ESD Protective bench surfaces where parts are handled during tests, inspections and for other similar processes where parts are being handled
6. Ensure that appropriate material handling practices are followed keeping in mind the ESD prevention protocols as mentioned above.

3.2 Test Equipment

Test equipment is used to create signals and capture responses from a device under test (DUT). Just as component types are unique in their construction and purposes, so also is the equipment used to test them. Test equipment is generally designed and optimized to be effective for specific device functions. As new device technologies are introduced often new test equipment is needed. Test Equipment can be put into two primary categories: Bench Equipment and Automated Test Equipment (ATE). Generally, bench equipment is used for more specialized and unique measurements while ATEs are consistently used for repetitive testing that requires multiple testing interactions. A well-equipped testing laboratory will often have both a complement of bench equipment and ATE.

NOTE: The test fixtures and test equipment required to perform the Burn-In and Environmental Tests specified in 4.3 herein are described in the reference documents that are cited in that section.

1. Basic Bench Equipment

- a. Bench equipment is generally used to perform more basic measurements of voltage, current and circuits under test. These are self-contained measurement devices with preset measurement functions, that have defined and specific user-interface controls that select specific hardware defined measurement tasks.

2. Basic bench equipment should include:

- a. Ammeter
- b. Inductance bridge
- c. Ohmmeter
- d. Waveform generator
- e. Voltmeter
- f. Pulse generator
- g. DC power supply
- h. Oscilloscope
- i. Curve tracer
- j. LCR meter
- k. Insulation resistance equipment

3. RF testing requires more focused bench equipment including:

- a. Spectrum analyzer
- b. RF power meter
- c. Noise analyzer/noise source
- d. Network analyzer
- e. RF sources
- f. Waveform generators

4. Automated Test Equipment (ATE)

ATE can be defined as a combination of hardware (test fixture or apparatus) and software (routine or test script) that performs electrical tests on a device (Device Under Test - DUT), using computer controlled automation for the purpose of performing measurements and evaluating test data that are consistent in terms of accuracy, repeatability and resolution. ATE equipment is used to conduct repetitive measurement tasks that would usually require multiple interactions of the operator and/or test conditions to be changed manually for each measurement. ATE systems are also designed to reduce the amount of test time needed to verify that a device works properly and/or to diagnose defects.

More complex devices require ATE based testing. Such devices include, but not limited to:

- a. FPGAs/Processors/ASIC (High pin count/High Frequency digital ATE)
- b. Memories (High Frequency Digital Testers with pattern generation capabilities)
- c. Digital-to-Analog-Converter (DAC)/Analog-to-Digital-Converter (ADC)/Mixed Signal (Digital Testers with high precision analog source and capture)
- d. Integrated Radio Frequency (RF) Devices (Testers with Digital, Analog and RF testing resources)

4. REQUIREMENTS

This section provides Test Laboratories the minimum requirement to perform electrical testing for SC mitigation.

Electrical testing, when used in association with other SC mitigation steps, forms an integral part of the SC verification plan. Electrical testing should be used to check for both device verification and handling and storage related damage. In some cases, for certain devices types, Direct Current (DC) electrical test are frequently used as a low cost SC detection technique while for some other devices, more extensive functional and Alternating Current (AC) tests are most likely to reveal suspect devices and establish circuit functionality. The type of electrical test will be defined by the risk level and commodity type as detailed in the AS6171 General Requirements.

The proper selection of electrical tests needed to verify a component's individual operation and functionality shall be based on the overall User's applications and needs and the risk levels. Additional considerations include test equipment and fixturing costs, time required to perform the test, and degree of component complexity.

Appendix B also shows required Test Lab procedures expected from Test Labs.

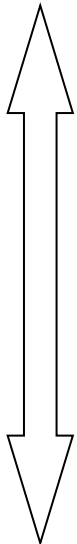
4.1 Sampling Plan

The sampling plan shall be in accordance with AS6171 General Requirements Electrical Test Levels Examples

For risk level definition and sequence of tests based on risk levels, see AS6171 General Requirements. DC Test at ambient temperature is defined in the device datasheet or as the parameters tested in MIL-STD-883, Method 5005, Group A, subgroup 1 for a comparable or equivalent Standard Microcircuit Drawings (SMD) defined microcircuit. For Active or Passive Devices, the DC test shall include the same parameters defined in the datasheet or for a comparable or equivalent MIL-PRF defined part. Once the total risk has been determined, the appropriate risk mitigation procedures specified in the AS6171 General Requirements should be implemented. For the Electrical Test Method, there are several test level examples as outlined in the Table 1 Electrical Test Level Examples Matrix. Some data sheets or equivalent may list typical values for certain key parameters, such as propagation delays or AC parameters with no specified limits. Such typical values are not tested for SC screening purposes. However, for certain SC investigations, it may be advantageous to measure these parameters, at the discretion of the User/Requester if the risk is high and conclusion is not clear from all the testing done to authenticate the product.

The DC test should be performed for Active Devices, and value measurements for Passive Devices, as shown in Table 2. All testing is performed at ambient temperature (+25 °C) unless otherwise specified in Table 1

Table 1 - Electrical test level examples (see Note 1)

Test Level	Test Parameter Outline
	High Test Coverage Electrical Test - Active Devices - DC, key AC/Switching parameters, and full Functional Test over temperature, Temperature Cycling/Pre and Post-Test Electricals, Burn-In (240 hours for Space Grade Microelectronic products; for other products and applications, Burn-In time may vary) and Pre and Post Electricals may include limits and delta limits - Passive Devices - Key Electrical Parameters Test over temperature. Thermal Shock with Pre- and Post-Test Electricals. Burn-In with Pre and Post Electricals (Burn-In time to be specified by Components Engineer for Space Grade Microelectronic products, for other products and applications Burn-In time may vary)
	Electrical Test - Active Devices - DC, key AC/Switching parameters, and full Functional Test over temperature. - Passive Devices - Key Electrical Parameters Test over temperature.
	Electrical Test - Active Devices - DC, key AC/Switching parameters and key Functional, at ambient temperature. - Passive Devices-Key Electrical Parameters Test at ambient temperature.
	Electrical Test - Active Devices - DC Test at ambient temperature - Passive Devices - Value measurement at ambient temperature
	Low Test Coverage Electrical Test - Active Devices - Curve Trace at ambient temperature - Passive Devices - Value measurement at ambient temperature.

Note 1: Seal Test should be performed on hermetic devices when specified in the Test Requirements as part of the SOW or Purchase Order.

Table 2 - Minimum basic level test

Component	Minimum Basic Level Test
Microcircuits and Semiconductor Devices	Curve Trace (See Note)
Microcircuits and Semiconductor Devices	DC Electrical Test
Resistors (includes heaters, thermistors, and fuses)	DC resistance
Capacitors (includes filters)	Capacitance, dissipation, and insulation resistance. Additional Tests for Tantalum Capacitors, DC leakage current and equivalent series resistance (ESR)
Inductors	Coil inductance or coil resistance
Transformers	Winding-to-winding isolation, winding continuity, winding inductance, turns or voltage ratio
Connectors	Pin-to-pin and pin-to-case isolation, contact resistance
Relays	Input coil inductance, contact resistance, and coil voltage to contact control transfer
Crystals	Frequency and equivalent resistance

NOTE: Curve Trace is a measurement of voltage versus current to obtain parameters such as a diode's forward voltage and current, reverse leakage current, and reverse breakdown voltage.

The SMD documents are cited here as an example in Appendix C but other equivalent documents can be referenced in a similar manner. The DC Test performed at +25 °C is a test called out in numerous DLA Land and Maritime Standard Microcircuit Drawings (SMD) or comparable/equivalent documents. The use of the SMD or equivalent documents takes the uncertainty out of deciding which test is to be performed, as it is well defined and not subject to interpretation. In this manner, all Test Laboratories will bid on, and perform identical tests.

The DC Test at +25 °C is defined in MIL-STD-883, Method 5005, Group A, as Subgroup 1. The SMD or equivalent documents utilize this information in setting up all its tests to add uniformity and consistency to the specified testing.

4.2 Electrical Testing Requirements

Electrical testing shall be performed using appropriate requirements as specified in Customer supplied requirement documents and/or related SMDs, MIL-PRFs, manufacturer datasheets or customer supplied documents. Taking into consideration other evidence already collected by non-electrical means, such as external and internal visual examination and radiographic inspection, the subject parts shall be electrically tested per the specified sampling plan.

Test requirements should be developed by individuals with the appropriate technical background, experience and competence due to the potentially complex nature of SC detection. This test documentation should become a part of a Statement of Work (SOW) in the event the testing is done by an outside test facility or to document the test requirements if done in-house. Table 2 in this document shows the minimum required level of electrical testing, the DC Electrical test for Active Devices or value measurements for Passive Devices. At the minimum level the tests shall be performed at ambient temperature, which is defined as +25 °C.

The extent of electrical testing shall be determined by the User/Requester Cognizant Engineer by selecting the pertinent key electrical parameters from the appropriate specifications as follows:

1. Military parts: DLA Standard Microcircuit Drawing (SMD) for microcircuits (MIL-PRF-38534, MIL-PRF-38535), MIL-PRF-19500 for semi-conductor devices, and the appropriate MIL-PRFs for Passive devices.
2. Commercial-Off-the Shelf (COTS) parts: DLA Vendor Item Drawing (VID) for microcircuits or the component manufacturer's datasheet.
3. Customer supplied parts: Customer generated specifications (e.g., SOW - Statement of Work; CID - Commercial Item Drawing; VID - Vendor Item Drawing or SCD - Source Control Drawing).



Examples of key electrical parameters are shown in Appendix C and D, for Active and Passive Devices, respectively.

The part's thermal characteristics should be considered while selecting key electrical parameters. Certain applications may require such additional tests as Thermal Impedance for Semiconductor Devices and Temperature Rise for Passive Devices. The importance of the use of the MIL documentation for generating the test procedures cannot be overstated, since all the key parameter limits and test conditions are defined.

4.3 Burn-In and Environmental Tests

4.3.1 Burn-In Tests

Burn-In of Active Devices such as microcircuits and semiconductors involves the stressing of semiconductor junctions to eliminate defective devices, those with inherent defects, or those devices that were not designed to perform over the stressful conditions that are required in space and military applications. The process of counterfeiting may degrade part quality, so subjecting components to the Burn-In process may purge suspect counterfeit components. When used in conjunction with pre and post Burn-In Electricals, it may also detect commercial devices that are remarked as full military parts. This testing is recommended at highest risk level as shown in Table 1.

The User/Requester Cognizant Engineer shall specify the Burn-In test conditions and the pre and post Burn-In electrical parameter limits and delta limits. The Burn-In scheme should not violate the maximum junction temperature as specified by the manufacturer.

Unless specified by the Cognizant Engineer's test procedure or the device specification, Burn-In shall be performed in accordance with the following methods outlined in Table 3.

Table 3 - Burn-in test methods

Device	Test Method
Microcircuits	MIL-STD-883, METHOD 1015
Semiconductor Devices	
Diodes and Rectifiers	MIL-STD-750, METHOD 1038
Transistors	MIL-STD-750, METHOD 1039
Thyristors (controlled rectifiers)	MIL-STD-750, METHOD 1040
Power MOSFETs or IGBT	MIL-STD-750, METHOD 1042
Passive Devices	Refer to applicable MIL-PRF for this device type

NOTE: IGBT-Insulated Gate Bipolar Transistor

A Burn-In test should be performed on Active Devices whose Risk Level is ranked as Critical Risk. The test should be performed at the component's maximum junction temperature limit. The Cognizant Engineer shall specify the Burn-In test conditions; including Burn-In time duration and the pre- and post-Burn-In electrical parameter and delta limits. Unless specified by the Cognizant Engineer's test procedure or the device specification, the Burn-In test for Passive Devices should be performed in accordance with the equivalent life test methods for required burn-in outlined in the comparable device MIL-PRFs specification. Examples of these device specifications are shown in Appendix C for Active Part types or Appendix D for Passive Part types.

4.3.2 Techniques for SC EEE Parts Detection by Selected Environmental Test Methods

Environmental Testing can be used to detect some of the anomalies associated with counterfeit parts due to characteristics such as sub-standard materials of construction, poor quality packaging, or defects in used parts approaching their end-of-life. The technique involves stressing the devices and then inspecting them for changes in both Physical and Electrical Characteristics. The tests consist of Temperature Cycling for Active Devices (microcircuits and semiconductor devices), Thermal Shock for Passive Devices and Seal Tests for hermetic devices. The Environmental Tests for Active and Passive Devices are accompanied by pre and post electrical testing. The challenge for the Test Laboratory and User/Requester personnel is in the Interpretation of Test Results of whether the failure is a Counterfeit or a Quality/Reliability issue. These tests detect both counterfeit parts and also reliability/quality issues. While mishandling or storage in hostile environments may not necessarily be a counterfeit part anomaly, it may be an indicator of some types of counterfeiting, particularly for used parts sold as new. Environmental screening may also provide a means of counterfeiting for some cases of lower grade parts being misrepresented as higher grade parts.