The Institute for Interconnecting and Packaging Electronic Circuits
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IPC-TM-650
TEST METHODS MANUAL

Number **2.6.9.2**	
Subject **Test to Determine Sensitivity of Electronic Components to Ultrasonic Energy**	
Date **1/95**	Revision
Originating Task Group **Ultrasonic Cleaning Task Group (5-31e)**	

1.0 Scope The purpose of this test method is to provide a consistent procedure to test the sensitivity of electronic components to ultrasonic energy. There has been reluctance in the electronics industry to use ultrasonic energy for printed board assembly cleaning because of the possibility of damage to wire bonds in active, hermetically sealed components or other damage that might cause latent failures.

Recent work has shown that electronic components have a low potential for damage from ultrasonics (References 1-7) under conditions seen in most cleaning processes. In addition, MIL-STD-2000 Rev. A and J-STD-001 now allow for the use of ultrasonic cleaning, as does the proposal for IEC TC91 International Standards based on an updated revision of the J-STD-001.

1.1 Definitions

Ultrasound: All sound in frequencies above the range of human hearing. For the purpose of ultrasonic cleaning, frequencies between 18-800 KHz are in commercial use. In the lower frequency ranges, fluid cavitation is the primary agitation method. In the higher frequency ranges, microstreaming (i.e., fluid pumping) is believed to be the form of mechanical agitation.

Frequency: The number of periodic oscillations, vibrations of waves per unit of time, usually expressed in cycles per second (Hertz).

Generator: An electronic system which converts the 50 or 60 Hz power line electricity into an ultrasonic frequency drive signal which powers the transducers in their resonant frequency range.

Transducers: Convert electrical energy from the generator into mechanical (vibratory) energy, producing high intensity sound waves in a liquid and causing cavitation of microstreaming. Transducers are primarily of two types, piezoelectric and magnetostrictive.

Piezoelectric: Piezoelectric ceramics, which change dimensions in the presence of an electric field. Thickness varies in response to an applied voltage. Conversion efficiency = 70-90%.

Magnetostrictive: Made of nickel or its alloys, it changes length when placed in a magnetic field. Conversion efficiency = 20-50%.

Cavitation: The rapid formation and oscillation or violent collapse of microscopic bubbles or cavities in a liquid, produced by introducing high frequency (ultrasonic) sound waves into a liquid. The agitation from countless implosions of these bubbles create a highly effective scrubbing of both exposed and hidden surfaces of parts immersed in the cleaning solution.

Degas: The act of removing entrained gas from cleaning fluid. Gas bubbles tend to absorb ultrasonic energy, thereby decreasing the amount of energy available for cleaning.

Power Density: Average output power of ultrasonic generator divided by total volume of liquid being sonified.

2.0 Applicable Documents

2.1 Institute for Interconnecting and Packaging Electronic Circuits (IPC)

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Assemblies

IPC-CH-65 Guidelines for Cleaning of Printed Boards and Assemblies.

2.2 Joint Industry Standards

J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

2.3 Military

MIL-STD-2000 Rev. A Standard Requirements for Soldered Electrical and Electronic Assemblies

2.4 Other Publications

IEC-TC-91 Proposed International Standard (based on J-STD-001) International Requirements for Soldered Electrical and Electronic Assemblies using Surface Mount and Related Assembly Technologies.

3.0 Test Specimens The components to be tested should be the exact type and package style the tester intends to use in production. A statistically valid number of each type and package style of interest should be tested.

4.0 Apparatus

4.1 Tank Testing shall be done in an ultrasonic tank, preferably in the equipment to be used in production. Water is to be used as the ultrasonic transmission testing fluid, regardless of the cleaning agent to be used in the production process. Water will degas, transmit ultrasonics, and cavitate more easily than most new cleaning agents and is, therefore, considered a ''worst case'' ultrasonic testing fluid. Care must be taken to maintain water level during testing. Water temperatures should be maintained at 60°C ±5°C (140°F ± 10°F).

It is recommended that testing equipment operate near 40Khz or higher and have a power output in the range listed in the chart below. Power is measured as the output from the generator to the transducers. Note in the chart that the amount of power necessary is scaled for various tank sizes.

Tank Size liters (gallons)	Power Density watts/liter (watts/gallon)	
	Magnetostrictive	Piezoelectric
19 (5)	66-76 (250-290)	33-38 (125-145)
38 (10)	53-68 (200-220)	26.5-29 (100-110)
95 and greater (25 and greater)	21-32 (80-120)	10.5-16 (40-60)

If frequencies other than 40 KHz range or power densities or frequencies differing from the ranges listed above are to be used in production, they should be used in testing as well, and noted on the Ultrasonic Test Data Record.

4.2 Basket Loose components will be placed randomly in a basket or in a beaker (pyrex or stainless steel) for testing. If a basket is used, it should be made of stainless steel and preferably have a solid bottom for optimal ultrasonic transmission. Tight mesh should always be avoided. If a beaker is chosen, plastic is not acceptable as it will dampen ultrasonic transmission.

5.1 Procedure

Note: Standard ESD handling methods should be used in handling and assembly so as not to have ESD damage misinterpreted as damage by ultrasonic exposure.

5.1.1 Perform functional electrical tests on components to be subjected to ultrasonic energy. All components should go though standard prescreening tests to eliminate infant mortality. Note any anomalies and ignore any malfunctions in further testing.

5.1.2 Fill the test tank with de-ionized water. Turn on ultrasonics and allow a minimum of 15 minutes for the water to degas. Evidence of cavitation should be obtained by placing a piece of aluminum foil in the water for one minute and inspecting for an erosion pattern (evidence of cavitational activity). If the surface of the foil is not disrupted, continue to degas until the foil confirms ultrasonic activity.

Test components in the equipment described above. Place components randomly in basket or in a beaker. Baskets should be suspended off the bottom of the tank or contain stand off legs to keep it from setting directly on the bottom of the tank. If a beaker is to be used, it should be filled with deionized water and degassed as described in the above paragraph. The beaker should be suspended in the water-filled tank and not placed on the tank bottom.

Subject specimens to ultrasonics for a time period 10 times longer than the expected exposure anticipated under normal cleaning conditions or thirty minutes, whichever is longer.

5.1.3 (Optional) Conduct any environmental stressing test(s) as specified by the reliability requirement of the product line in concern.

5.2 Evaluation Method

5.2.1 Repeat the functional electrical test in 5.1.1. Any failures should be analyzed for cause of failure. Any failure, excluding those noted in 5.1.1 or attributable to a documented defect will also be considered caused by the ultrasonics.

5.2.2 Any defect which is not assignable to a previously documented defect will also be considered caused by ultrasonics.

5.2.3 Any component exhibiting no failures or 100% reliability after ultrasonic testing will be considered safely resistant to ultrasonics under the conditions tested. Any component with less than 100% reliability will be suspect unless subsequent testing can demonstrate that it is 100% reliable. Unless classified or proprietary, please report test results to the Ultrasonic Energy Task Group through the IPC for compilation in the attached list.

It is important that the IPC receives as much data as possible, whether it be to support previously submitted data, add new data, or provide conflicting data for certain components. All information received will be entered into a database for all IPC members to access. The data will prove more useful as the volume of data increases.

6.0 Notes Contact IPC for a list of test components.

6.1 References

6.1.1 William Vuono and Ayche McClung, ''An Update on an Assessment of Ultrasonic Cleaning Techniques for Military Printed Wiring Boards,'' presented at IPC Fall Meeting, 1990.

6.1.2 B.P. Richards, P. Burton and P.K. Footner, ''Does Ultrasonic Cleaning of PCBs Cause Component Problems; An Appraisal,'' IPC Technical Review, June 1990.

6.1.3 B.P. Richards, P. Burton and P.K. Footner, ''The Effects of Ultrasonic Cleaning on Device Degradation,'' Circuit World, Vol.16, No. 3.

6.1.4 B.P. Richards, P. Burton and P.K. Footner, ''The Effects of Ultrasonic Cleaning on Device Degradation - An Update,'' Circuit World, Vol. 17, No. 4.

6.1.5 B.P. Richards, P. Burton, and P.K. Footner, ''The Effects of Ultrasonic Cleaning on Device Degradation - Quartz Crystal Devices,'' Circuit World, Vol. 18, No. 4.

6.1.6 B.P. Richards, P.K. Footner and P. Burton, ''A Study of the Effect of Ultrasonic Cleaning on Component Quality - Hybrid Devices,'' Circuit World, Vol. 19, No. 1.

6.1.7 Fritz Ehorn, ''Final Report on the Structural Dynamic Analysis of Selected PWB Components under the 400 Khz Ultrasonic Cleaning Environment,'' MEL Ref. MS7507, March 6, 1991.

6.1.8 William Puskas and Gary Ferrell, ''Process Control Ultrasonic Cleaning,'' presented at Nepcon West, 1988.

6.1.9 Kenneth S. Suslick, ''The Chemical Effects of Ultrasound,'' Scientific American, February, 1989.

6.1.10 Ismail Kashkoush, Ahmed Busnaina, Frederick Kern, Jr. and Robert Kunesh, ''Particle Removal Using Ultrasonic Cleaning,'' Institute of Environmental Sciences, 1990 Proceedings.

Ultrasonic Test Data Record

Name of tester ______________________ Date ____________

Company ______________________

Address ______________________

Phone ______________________ Fax ______________________

Make and model of equipment ______________________

Tank size (liters) ____________ Dimensions (cm x cm x cm) ____________

Generator output power (watts) ____________ Frequency (KHz) ____________

No. of boards tested per trial ____________ Substrate ____________

Exposure time (minutes) ______________________

Other stress testing (pre- or post-) ______________________

Describe ______________________

Component tested Type Mfgr Part #	No. tested	Passed	Failed	Comments

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