Number 2.6.26	
Subject **DC Current Induced Thermal Cycling Test**	
Date **11/99**	Revision **Proposal**
Originating Committee: Test Methods Subcommittee (7-11)	

IPC-TM-650
Test Methods Manual

1.0 Scope This test measures changes in resistance of plated-through hole barrels and internal layer connections as holes are subjected to thermal cycling. Thermal cycling is produced by the application of a current through a specific coupon configuration.

In this technique, the test coupon is resistance heated by passing DC current through the internal layer connection to the barrel for 3 minutes to bring the temperature of the copper to a designated temperature (slightly above the Tg of the laminate in the sample.) Switching the current on and off, creates thermal cycles between room temperature and the designated temperature within the sample. This thermal cycling induces cyclic fatigue strain in the plated-through hole barrels and internal layer interconnects and accelerates any infant mortality or latent defects.

The number of cycles achieved permits a quantitative assessment of the performance of the entire interconnect.

Detailed information regarding the test is found in the NOTES 6.0 section.

2.0 Applicable Documents

2.1 IPC-TM-650, Method 2.1.1, Microsectioning

2.2 IPC-TM-650, Method 2.1.1.2,Microsectioning - Semi or Automatic Technique

3.0 Test Specimens Daisy chain test coupon per Figure 1. See Note 6.2.1.

4.0 Apparatus or Material

4.1 Interconnect Stress Test System (IST) See Note 6.1

4.2 Two (2) Four pin, 2.54mm (0.1 inch) pitch male connectors (MOLEX 2241-4042 or equivalent)

4.3 Sn60Pb40 or Sn63Pb37 Solder

4.4 Solder Flux

4.5 Soldering Iron

4.6 Multimeter - optional

4.7 Thermal Imaging equipment - optional

5.0 Procedure

5.1 Sample preparation

5.1.1 Solder two 4 pin male connectors in the 0.040 inch holes at left and right edges of side 1. A solder fillet must be apparent on both sides of the coupon.

5.1.2 Allow coupons to come to room temperature (approximately 10 minutes), prior to installation onto IST system.

5.2 IST Procedure

5.2.1 Position coupons at each test head by attaching male to female connectors.

5.2.2 Provide system software with specific test conditions. The available ranges and typical conditions are as follows:

Conditions	IST Range	Typical
No. of samples	1-6	6
Test Temp	50°C to 250°C	150°C
	(122°F to 422°F)	(302°F)
Max. Res. Chng	1-100%	10%
Max No. Cycles	1-4000	250 (1 day)
Data Coll. Freq.	1-100 cycles	10 cycles
Cooling Ratio	0.5-2X heat time	0.66
Table Selection	system/custom	system

5.2.3 Enter a data file name and begin the pre-cycle test sequence. When the pre-cycle sequence is complete, the IST system begins the thermal cycling of the coupons. Enter a file name and begin test. The IST system continuously monitors the coupons and records the relative changes in resistance of both the barrel and the internal layer connections. Data is compiled for each coupon's performance throughout IST stress testing. The system software provides a download file to graph the coupon's performance. Data is compiled to create graphs of each coupon's performance throughout IST stress testing.

5.3 Microsection Evaluation - Optional If detailed failure analysis is desired to determine exact location of separations and/or cracks. A multimeter or a thermal imaging system can aid in identifying the failure location. Microsection of failed coupons shall be performed in accordance with IPC-TM-650, Method 2.1.1 or 2.1.1.2.

6.0 Notes

6.1 IST SYSTEM DETAILS
This equipment is available from:
PWB Interconnect Solutions Inc.
195 Stafford Rd W Unit 105
Nepean, Ontario Canada K2H 9C1
(613)-596-4244
URL: www.pwbcorp.com

6.2 IST Coupon. Certain design rules must be applied to achieve thermal uniformity. Electronic design files for coupon construction are available from the IPC office. The coupon resistance should measure between 150 milliohms and 1.5 ohms when measured at room temperature. Two resistance values (voltage drops) for each coupon are monitored independently, using a four wire measurement technique.

The test coupon(s) is incorporated on the panel to monitor or qualify design, materials or processes and provide risk assessment of product and/or reliability assurance.

6.3 Detailed Description of Steps

6.3.1 Pre Cycling Test Sequence.
The following paragraphs detail the sequence for a single coupon, however this sequence is done at all test heads simultaneously. The ambient resistance, target temperature resistance, rejection resistance and current is calculated for each coupon and displayed on the PC monitor.
CAUTION: Handling the coupons will raise the temperature of the coupon and may affect the ambient resistance calculation during the precycling sequence. If the ambient temperature of the coupons is in question, cool the coupons with the fans on the IST equipment for 1 - 2 minutes.

6.3.1.1 Ambient Resistance The auto ranging multimeter measures the ambient resistance (voltage drop) of the coupon. This is the circuit that heats the coupon with DC current.

6.3.1.2 Target Temperature Resistance The system software calculates and displays the required "target" resistance (temperature). The available stress testing range is from 50°C - 250°C (122°F - 422°F). The equation used to calculate the target resistance is as follows:

$$\text{Target Resistance} = R_{rm}(1 + \alpha_T[T_h - T_{rm}])$$

where:
α_T = Estimated thermal coefficient of resistance for the interconnect
R_{rm} = Resistance of coupon at room temp (approximately 25C)
T_h = Specified temperature to be achieved.
T_{rm} = Room Temperature

6.3.1.3 Rejection Resistance The rejection resistance is calculated and displayed. This is adjustable from 1 - 100% increase. If 10% is selected, 10% of the target resistance is calculated and added to the original resistance to establish the rejection criteria.

6.3.1.4 Current The system selects an initial current based on the ambient resistance of the coupon and the current table. The current tables are derived from software libraries on the IST equipment. During the precycling sequence, the initial current is adjusted for each coupon to assure the test temperature resistance is achieved in 3 minutes $\pm$ 3 seconds (see paragraph 6.3.1.5*)*

NOTE: Additional equations/algorithms used by IST that establish the initial current selection for pre-cycling, relative to the relationship of coupon interconnect resistance α_T , coupon construction and stress test temperature to be achieved are considered proprietary at this time.

6.3.1.5 Pre-cycling is initiated by the application of the selected current to the coupon, the computer monitors and records the coupon's performance throughout this first cycle. If at the end of the 1st pre-cycle, the coupon achieves the specified resistance level in 3 minutes $\pm$ 3 seconds, it will be accepted for subsequent stress testing. If the resistance level was not achieved in this time frame, the coupon will automatically be pre-cycled again with a revised or compensated current. The system will re-test using revised conditions until all coupons are accepted or rejected for stress testing.

NOTE: The equation/algorithms used by IST to compensate the DC current is considered proprietary at this time.

6.3.1.6 Forced air cooling is commenced after each pre-cycle to cool the coupons. (Requires 3.0 minutes)

6.3.1.8 The system automatically records and saves all information regarding conditions for subsequent stress testing.

6.3.2 Stress Cycle Test Sequence
6.3.2.1 The stress test is initiated by re-applying the same DC current level established for each individual coupon during the pre-cycle operation. Three minutes of heating is followed by two to three minutes of cooling. Cooling time is a function of overall thickness and construction of the coupon.

6.3.2.2 Individual coupons are continually recycled using their customized heating and cooling conditions until one of the rejection criteria is achieved or the maximum number of cycles is completed.

6.3.2.3 The coupon's resistance "delta" (variance from initial calculated resistance) increases (positively) as failure inception occurs. The rate of change in the delta is indicative of the mechanical change (failure) within the interconnects.

6.3.2.4 When each coupon delta reaches the maximum resistance rejection criteria, IST stress testing is stopped. The rejection criteria prevents thermal runaway (burnout) plus allows for early intervention for failure analysis to be completed effectively.

6.3.3 Graphing and Data Analysis
6.3.3.1 The IST system continuously monitors the two independent circuits of each coupon, recording multiple points of each cycle until the coupon exceeds one of the rejection criteria. The data is compiled to create graphs of each or all coupon's performance throughout IST stress testing.   Figure 2, 3 and 4 are typical graphs.
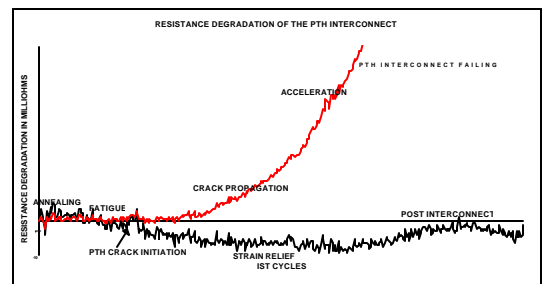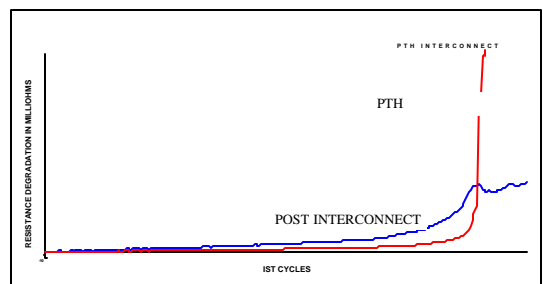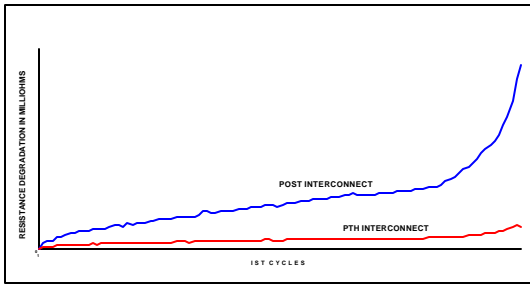

Figure 2

Figure 3

Figure 4.

6.4 The Test Methods Subcommittee is aware of other test systems that operate on principles similar to those used by IST. The subcommittee encourages their submission along with relevant test data. This test method will be revised as necessary to include these test systems as this information becomes available.

Figure 1 IST Test coupon