SAMTEC LABORATORY
TEST PROCEDURES

FIGURE, TABLE AND PARAGRAPH DESIGNATIONS HAVE BEEN MAINTAINED AS IN THE ORIGINAL INDIVIDUAL DOCUMENTS

TLPM-032
CURRENT CARRYING CAPACITY

1. Purpose

1.1. To determine the amount of current the device under test (DUT) can safely carry over the operating temperature range of the DUT.
1.2. Contact loading will also be addressed in this document which will determine how much current can be carried as the number of energized contacts is varied.

2. Definitions

DUT – Device Under Test

3. Reference Documents

3.1. EIA-364-70, *Temperature Rise Versus Current Test Procedure for Electrical Connectors and Sockets*
3.2. Samtec Document; TLSC 0002, *Automated TempRise Software*
3.3. Samtec Document; TLWI 0005, *Thermocouple Calibration Work Instruction*
3.4. Samtec Document; TLOP 0006, *Automated Temperature Rise Versus Current Measurement*
3.5. EIA-364-06 *Contact Resistance*

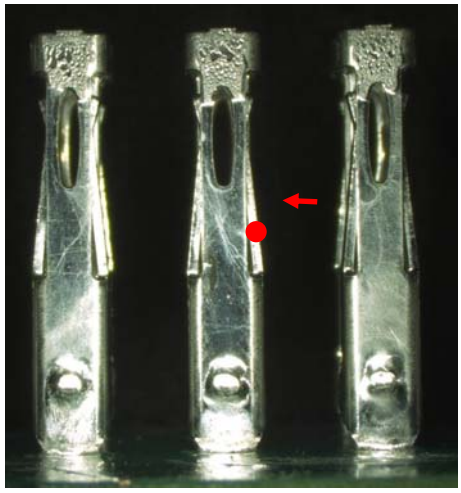
4. Samples

4.1. Three samples shall be tested for each loading configuration. The DUTs shall be configured as follows:
4.2. For single row power connectors the following configurations are to be tested:
  4.2.1. 1 contact energized only
  4.2.2. 2 contacts energized adjacent to each other
  4.2.3. 3 contacts energized adjacent to each other
  4.2.4. 4 contacts energized adjacent to each other
  4.2.5. All contacts energized (list actual number tested)
4.3. For double row power connectors the following configurations are to be tested:
  4.3.1. 2x1 contact energized only
  4.3.2. 2x2 contacts energized adjacent to each other
  4.3.3. 2x3 contacts energized adjacent to each other
  4.3.4. 2x4 contacts energized adjacent to each other
  4.3.5. All contacts energized (list actual number tested)
4.4. The following defines the sample/thermocouple designations and the data acquisition channel connections:
  4.4.1. 1 contact energized: Samples 1 through 3, connected to Channels 1 - 3
  4.4.2. 2 contacts energized: Samples 4 through 6, connected to Channels 4 - 6
  4.4.3. 3 contacts energized: Samples 7 through 9, connected to Channels 7 - 9
  4.4.4. 4 contacts energized: Samples 10 through 12, connected to Channels 10 - 12
  4.4.5. All contacts energized: Samples 13 through 15, connected to Channels 13 – 15
  4.4.6. Ambient temp and Wire temp will be monitored on channels 16 and 17

5. Setup

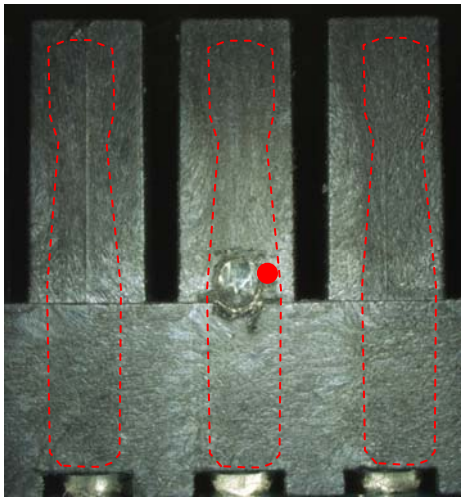
5.1. All test samples shall be wired in a series circuit in accordance with Table 1 and Table 2 below to insure equal current through all samples.
5.2. Five positions on the “100%” samples shall also be wired for Voltage Drop measurements.
5.3. A thermocouple shall be placed as close to the contact interface as possible such as the locations indicated by the red dot and arrow in Figure 1.

Figure 1



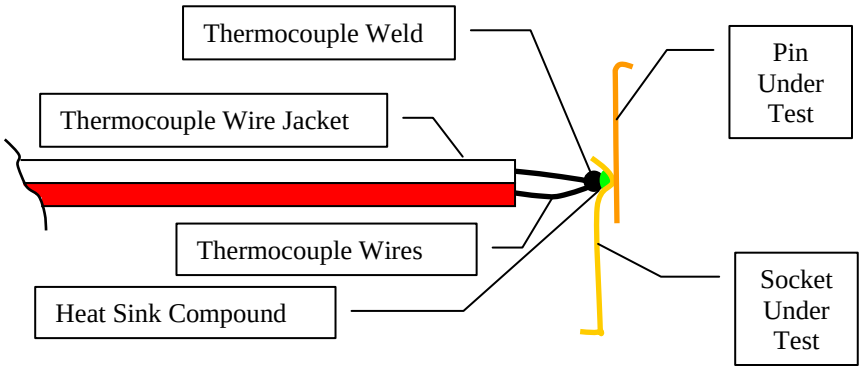
5.4. When necessary, a small hole shall be drilled through the connector body at the proper location to allow a thermocouple to be placed at the contact interface.

Figure 2



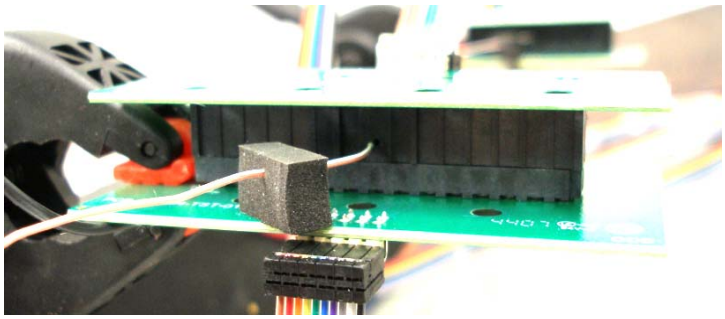
5.5. A small amount of non-silicone, heat sink compound shall be placed at the tip of the thermocouple prior to installation in order to improve the thermal transfer characteristics of the contact/thermocouple interface (indicated below in green).

Figure 3



5.6. Said thermocouple/s shall be mechanically stabilized using small blocks of adhesive foam as illustrated in Figure 4.

Figure 4



5.7. The hole shall be sealed with tape or putty after the thermocouple is installed.
5.8. One thermocouple shall be placed in the ambient environment within the test chamber held in the fixture as specified in EIA-364-70.
5.9. One thermocouple shall be placed on the supply wire/cable or PCB as applicable to insure that the wire/cable/PCB is not influencing to the test data.

5.10. The DUTs shall be placed in one of the test chambers (enclosure) designated to shield against external airflow. Use an appropriate enclosure of sufficient size to accommodate the DUTs as follows:

5.10.1. The DUTS shall be suspended in free air. In the event free air suspension not feasible, a low thermal conduction material (e.g., plastic, wood, glass-epoxy board, etc.) shall be used for support, provided a maximum of 20% of the DUT's surface is in contact with the insulating surface. Samples shall be arranged horizontally and shall meet the following requirements:

5.10.2. DUTs shall be mounted a minimum of 8 inches (20 centimeters) from the walls of the test chamber.

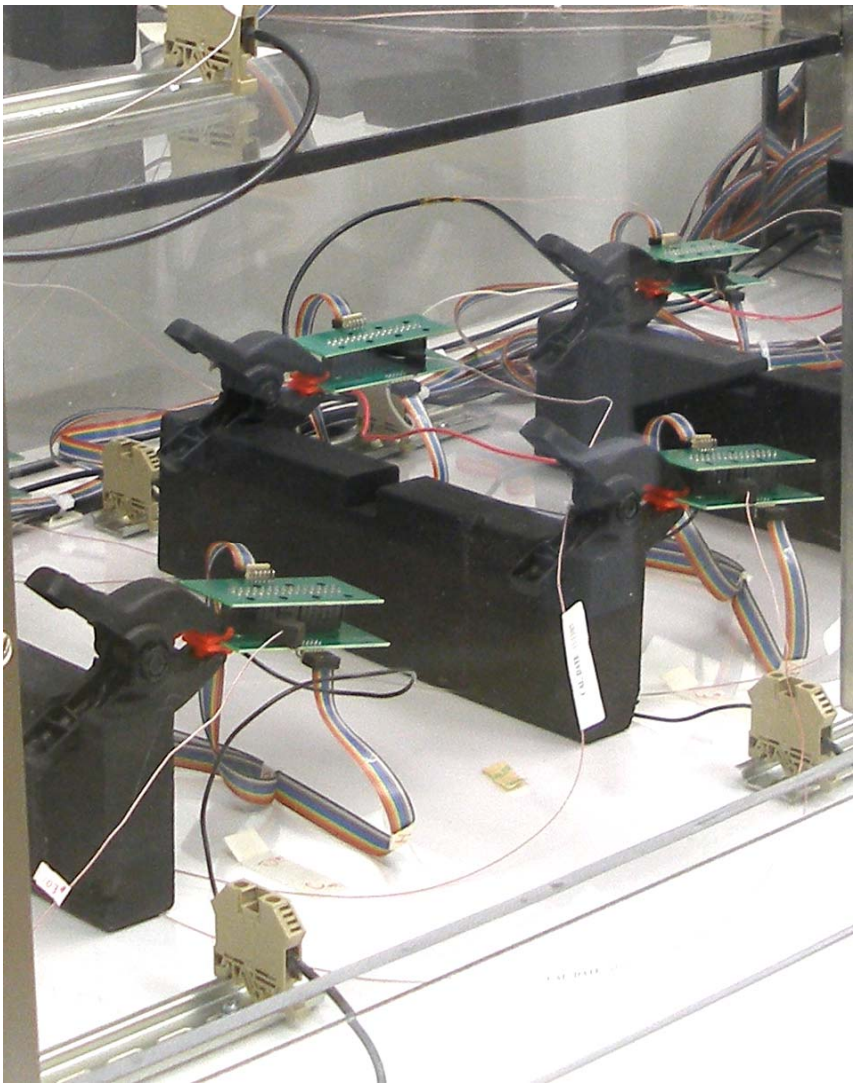
5.10.3. Specimens shall be no closer than 6 inches (15 centimeters) from the top of the enclosure or room.

5.10.4. If free air suspension is used, the specimens shall be a minimum of 2 inches (5 centimeters) above the bottom of the room or enclosure.

5.10.5. See Figures 5 and 6 for typical specimen mounting and wiring layout.

Figure 5

Figure 6



5.11. Printed circuit board components

5.11.1. Any DUT that is meant to be printed circuit board (PCB) mounted in actual use shall be tested on an appropriate PCB as would be used in the final application.

5.11.2. For PCB mounted devices, the current carrying traces shall be capable of carrying the maximum current that is to be applied without contributing to the thermal increase of the DUT being measured. See table 1 below.

5.11.3. Optionally, wires can be attached directly to the terminations of the device.

5.11.4. EIA-364-70 recommends the trace technique not be utilized for test currents greater than 13 amperes. See Table 2 for wire/conductor requirements.

5.12. A digital photograph shall be taken of one test sample prepared for test, with thermocouple installed. This photo shall be stored in the folder with the test data.

6. PRINTED CIRCUIT BOARD AND WIRE SPECIFICATIONS

Table 1

TEST CURRENT	EQUIVALENT WIRE SIZE	TRACE WIDTH		TRACE LENGTH	
Amps	AWG	cm	in	cm	in
0.1	36	0.03	0.01	1.30	0.50
0.5	32	0.06	0.03	2.30	0.90
1.5	28	0.13	0.05	3.00	1.20
2.0	26	0.19	0.08	3.80	1.50
3.0	24	0.25	0.10	4.30	1.70
7.5	20	0.64	0.25	6.90	2.70
13.0	16	1.27	0.50	9.40	3.70

Notes from the EIA:

1. The above trace widths and lengths are based on 1.0 oz copper.
2. The table applies to single sided test boards. Put in the multi-layer and double-sided calcs from the pcb calculator
3. Minimum length is a slight function of temperature rise criteria assumed that is 30°C. For temperature rise criteria less than 30°C, these values are conservative.

Table 2

CONDUCTOR CHARACTERISTICS			
Wire Size	**Test current**	**Minimum Wire Length**	
AWG	**amperes**	**cm**	**in**
36	0.9	4	1.5
34	1.2	5	2.0
32	1.5	5	2.0
30	2.0	8	3.0
28	2.7	9	3.5
26	3.6	11	4.5
24	4.8	14	5.5
22	6.4	16	6.5
20	8.5	20	8.0
18	11	25	10.0
16	15	29	11.5
14	20	36	14.0
12	27	42	16.5
10	35	50	19.5
8	47	57	22.5
6	63	67	26.5
4	84	79	31.0
2	111	93	36.5
0	148	108	42.5
00	171	117	46.0
000	197	126	49.5
0000	227	136	53.5

7. Testing

7.1. The data acquisition system used will measure the Temperature Rise and Voltage Drop of all positions being tested.

7.1.1. Seventeen calibrated thermocouples shall be connected to channels one through seventeen of the acquisition scanner card.

7.1.2. Fifteen pairs of Voltage Drop wires will be connected from samples thirteen through fifteen to channels eighteen through thirty-two.

7.2. The series circuit of test samples shall be connected to an appropriate power supply, capable of the required power levels (see section 9.1).

7.3. Once the above set up and preparations are completed the computer program shall be initialized and the test allowed to run to completion.

7.4. Temperature and Voltage Drop measurements shall be performed in accordance with EIA-364-70B.

7.5. Testing will be performed at five different current levels in order to generate a Current Derating curve via regression analysis.

8. Data Analysis

Data shall be provided in the following formats:

8.1. Temperature Rise (degrees Celsius above ambient).

8.2. Current Derating curve based on the Temp Rise data.

8.3. Voltage Drop (Contact Resistance at Rated Current)

9. Required Equipment

9.1. The power supply used and the test current required will limit the number of contacts that can be tested at one time.

9.1.1. The three factors involved in determining this limit are:

a) Total Resistance of the contact chain including all cables and connections.
b) Test Current to be carried by said system.
c) Maximum Open Circuit Voltage of the power supply

9.1.2. The formula is $V_{oc} \div I_t = R_t$; Where:

a) V_{oc} is the Open Circuit Voltage required
b) I_t is the Test Current
c) R_t is the total resistance of the test circuit

9.1.3. This is also limited by the total power available as specified in the Power Supply manual

9.2. The data acquisition system used to measure the Temperature Rise and Voltage Drop shall be equipped with the following:

9.2.1. Seventeen scanner channels capable of Type-J thermocouple temperature measurements

9.2.2. Fifteen channels capable of measuring Voltage Drop.

TYPE	USE
Keithley Model 7700,20 channel multiplexer	Provide computer controlled switching with thermocouple inputs. Installs into a Keithley Model 2700 Multimeter/Data Acquisition System
Calibrated Thermocouples (2)	For reliable temperature measurements
Keithley Model 2750 Multimeter/Data Acquisition System	Mainframe for 20 channel relay card
HP System Power Supply 6032A	Computer controlled power supply
Thermocouple Radiation Shield # TL-022	To prevent erroneous reference temperature measurements.
IEEE-488 Card	Communications card for PC
PC	To provide interface for IEEE-488 instrumentation and program control.
Keithley Model 580, Micro-Ohmmeter	Measuring instrument

10.Approvals

NAME	DEPARTMENT	DATE
	Quality	
	Engineering	

11.Revisions

REVISION	DESCRIPTION	DATE
00	New	
01	Added TLOP 0009 for Reference Document	10/4/02

TLPM-084
CURRENT CYCLING

1. Purpose

1.1. To determine the performance of the device under test (DUT) when subjected to the power-on/power-off cycling that heats and cools the DUT to simulate normal everyday use.

1.2. All of the contacts (100% loading) will be powered throughout the test.

2. Definitions

DUT – Device Under Test

3. Reference Documents

3.1. EIA-364-70, *Temperature Rise Versus Current Test Procedure for Electrical Connectors and Sockets*
3.2. Samtec Document; TLSC 0002, *Automated TempRise Software*
3.3. Samtec Document; TLWI 0005, *Thermocouple Calibration Work Instruction*
3.4. EIA Publication 364-06 Contact Resistance
3.5. EIA Publication 364-55 Current Cycling

4. Samples

4.1. Eight samples shall be tested in a 100% loading configuration.
4.2. Five positions per DUT shall be tested for Voltage Drop throughout the cycling test.
4.3. One thermocouple shall be installed in each of the eight DUTs.
4.4. One thermocouple shall be placed in the ambient environment within the test chamber held in the fixture as specified in EIA-364-70.
4.5. One thermocouple shall be placed on the supply wire/cable or PCB as applicable to insure that the wire/cable/PCB is not influencing to the test data.
4.6. Two entire test sample groups as defined above can be performed at the same time for a total of sixteen samples.
  4.6.1. An upper chamber shall be used to test one sample set of eight devices.
  4.6.2. A lower chamber shall be used to test one sample set of eight devices.

4.7. The following defines the sample/thermocouple/Voltage Drop designations and data acquisition channel connections:

4.7.1. The Data Acquisition System (DAS) shall be equipped with three scanner cards.

a) Card 1 (20 channels), Lower chamber thermocouples shall be connected to channels one through eight
b) Card 1, Upper chamber thermocouples shall be connected to channels nine through sixteen
c) Card 2 (40 channels), All forty channels shall be connected to the Lower chamber devices under test (5 contacts/device).
d) Card 3 (40 channels), All forty channels shall be connected to the upper chamber devices under test (5 contacts/device).

5. Setup

5.1. All test samples shall be wired in a series circuit in accordance with Table 1 and Table 2 below to insure equal current through all samples.

5.2. All connectors under test shall be wired for five Voltage Drop measurements each.

5.3. When necessary, a small hole shall be drilled through the connector body at the proper location to allow a thermocouple to be place at the contact interface.

5.4. The hole shall be sealed with tape or putty after the thermocouple is installed.

5.5. One thermocouple shall be placed in the ambient environment within the test chamber held in the fixture as specified in EIA-364-70.

5.6. One thermocouple shall be placed on the supply wire/cable or PCB as applicable to insure that the wire/cable/PCB is not influencing to the test data.

5.7. The DUTs shall be placed in one of the test chambers (enclosure) designated to shield against external airflow. Use an appropriate enclosure of sufficient size to accommodate the DUTs as follows:

5.7.1. The DUTS shall be suspended in free air. In the event free air suspension not feasible, a low thermal conduction material (e.g., plastic, wood, glass-epoxy board, etc.) shall be used for support, provided a maximum of 20% of the DUT's surface is in contact with the insulating surface. Samples shall be arranged horizontally and shall meet the following requirements:

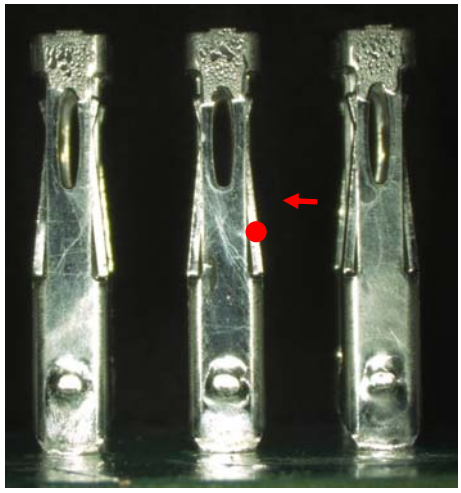
5.7.2. DUTs shall be mounted a minimum of 8 inches (20 centimeters) from the walls of the test chamber.

5.7.3. Specimens shall be no closer than 6 inches (15 centimeters) from the top of the enclosure or room.

5.7.4. If free air suspension is used, the specimens shall be a minimum of 2 inches (5 centimeters) above the bottom of the room or enclosure.

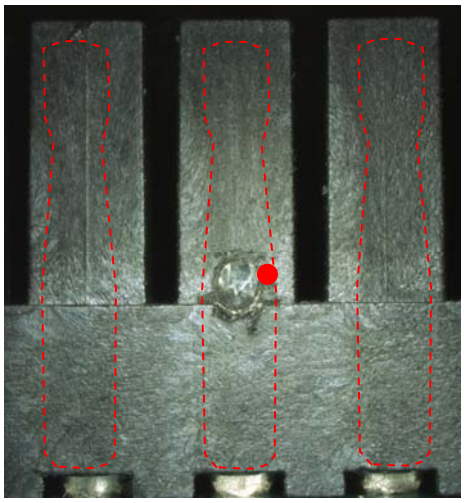
5.7.5. See figure 1 for typical specimen mounting and wiring layout.

Figure 1



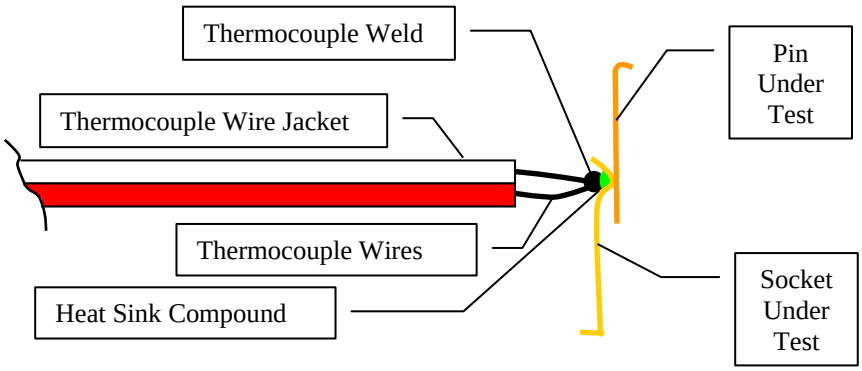
5.8. When necessary, a small hole shall be drilled through the connector body at the proper location to allow a thermocouple to be placed at the contact interface.

Figure 2



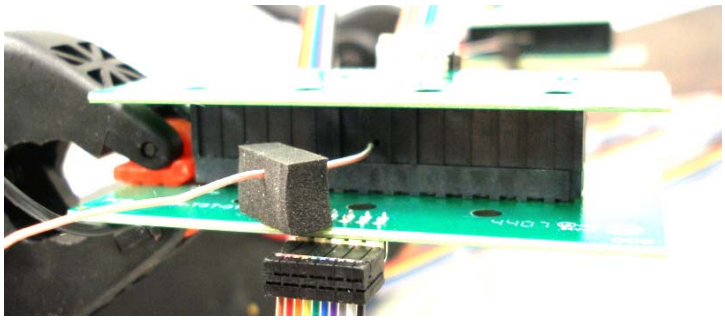
5.9. A small amount of non-silicone, heat sink compound shall be placed at the tip of the thermocouple prior to installation in order to improve the thermal transfer characteristics of the contact/thermocouple interface (indicated below in green).

Figure 3



5.10. Said thermocouple/s shall be mechanically stabilized using small blocks of adhesive foam as illustrated in Figure 4.

Figure 4



5.11. The hole shall be sealed with tape or putty after the thermocouple is installed.
5.12. One thermocouple shall be placed in the ambient environment within the test chamber held in the fixture as specified in EIA-364-70.
5.13. One thermocouple shall be placed on the supply wire/cable or PCB as applicable to insure that the wire/cable/PCB is not influencing to the test data.

5.14. The DUTs shall be placed in one of the test chambers (enclosure) designated to shield against external airflow. Use an appropriate enclosure of sufficient size to accommodate the DUTs as follows:

5.14.1. The DUTS shall be suspended in free air. In the event free air suspension not feasible, a low thermal conduction material (e.g., plastic, wood, glass-epoxy board, etc.) shall be used for support, provided a maximum of 20% of the DUT's surface is in contact with the insulating surface. Samples shall be arranged horizontally and shall meet the following requirements:

5.14.2. DUTs shall be mounted a minimum of 8 inches (20 centimeters) from the walls of the test chamber.

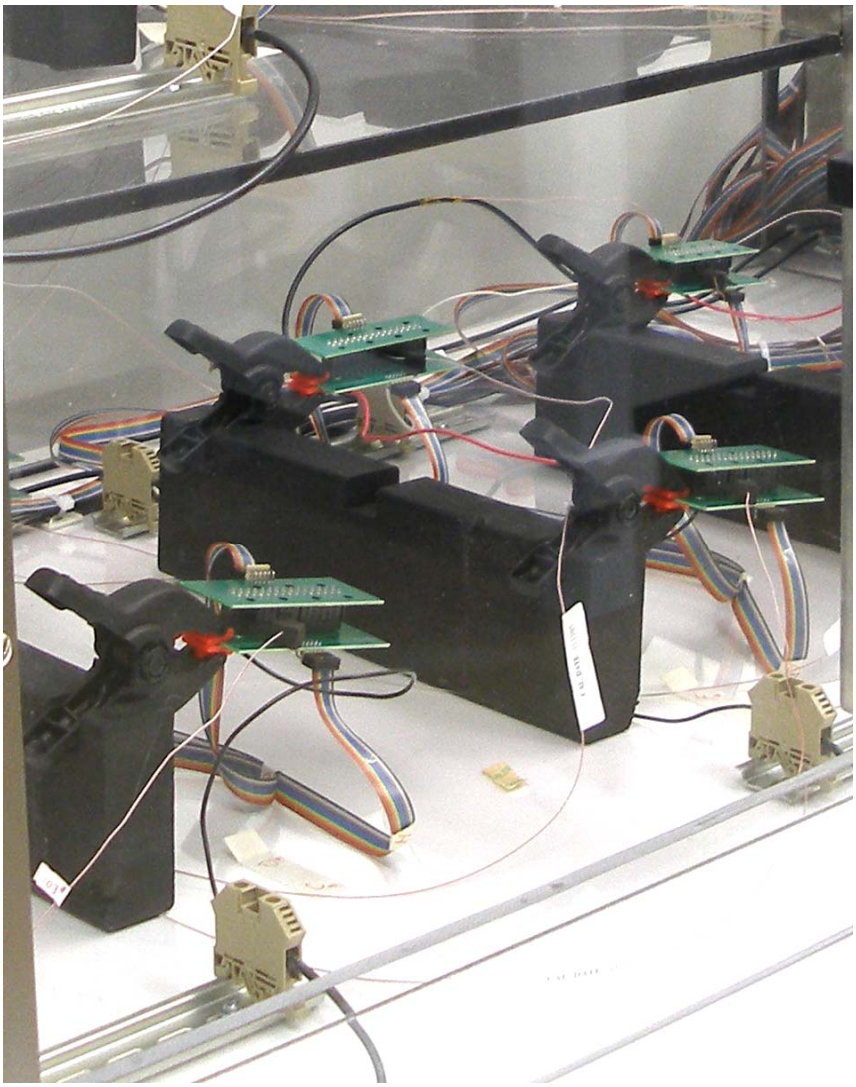
5.14.3. Specimens shall be no closer than 6 inches (15 centimeters) from the top of the enclosure or room.

5.14.4. If free air suspension is used, the specimens shall be a minimum of 2 inches (5 centimeters) above the bottom of the room or enclosure.

5.14.5. See Figures 5 and 6 for typical specimen mounting and wiring layout.

Figure 5

Figure 6



5.15. Printed circuit board components

5.15.1. Any DUT that is meant to be printed circuit board (PCB) mounted in actual use shall be tested on an appropriate PCB as would be used in the final application.

5.15.2. For PCB mounted devices, the current carrying traces shall be capable of carrying the maximum current that is to be applied without contributing to the thermal increase of the DUT being measured. See table 1 below.

5.15.3. Optionally, wires can be attached directly to the terminations of the device.

5.15.4. EIA-364-70 recommends the trace technique not be utilized for test currents greater than 13 amperes. See Table 2 for wire/conductor requirements.

5.16. A digital photograph shall be taken of one test sample prepared for test, with thermocouple installed. This photo shall be stored in the folder with the test data.

6. PRINTED CIRCUIT BOARD AND WIRE SPECIFICATIONS

Table 1

TEST CURRENT	EQUIVALENT WIRE SIZE	TRACE WIDTH		TRACE LENGTH	
Amps	AWG	cm	in	cm	in
0.1	36	0.03	0.01	1.30	0.50
0.5	32	0.06	0.03	2.30	0.90
1.5	28	0.13	0.05	3.00	1.20
2.0	26	0.19	0.08	3.80	1.50
3.0	24	0.25	0.10	4.30	1.70
7.5	20	0.64	0.25	6.90	2.70
13.0	16	1.27	0.50	9.40	3.70

Notes from the EIA:

4. The above trace widths and lengths are based on 1.0 oz copper.
5. The table applies to single sided test boards. Put in the multi-layer and double-sided calcs from the pcb calculator
6. Minimum length is a slight function of temperature rise criteria assumed that is 30°C. For temperature rise criteria less than 30°C, these values are conservative.

Table 2

CONDUCTOR CHARACTERISTICS			
Wire Size	**Test current**	**Minimum Wire Length**	
AWG	**amperes**	**cm**	**in**
36	0.9	4	1.5
34	1.2	5	2.0
32	1.5	5	2.0
30	2.0	8	3.0
28	2.7	9	3.5
26	3.6	11	4.5
24	4.8	14	5.5
22	6.4	16	6.5
20	8.5	20	8.0
18	11	25	10.0
16	15	29	11.5
14	20	36	14.0
12	27	42	16.5
10	35	50	19.5
8	47	57	22.5
6	63	67	26.5
4	84	79	31.0
2	111	93	36.5
0	148	108	42.5
00	171	117	46.0
000	197	126	49.5
0000	227	136	53.5

7. Testing

7.1. The data acquisition system used will measure the Temperature Rise and Voltage Drop of all positions being tested.

7.1.1. Twenty calibrated thermocouples shall be connected to channels one through twenty of the acquisition scanner card 1.

7.1.2. Forty pairs of Voltage Drop wires will be connected from the lower chamber test samples to the DAS card 2.

7.1.3. Forty pairs of Voltage Drop wires will be connected from the upper chamber test samples to the DAS card 3.

7.2. The series circuit of test samples shall be connected to an appropriate power supply, capable of the required power levels (see section 9.1).

7.3. Once the above set up and preparations are completed the computer program shall be initialized and the test allowed to run to completion.

7.4. Temperature and Voltage Drop measurements shall be performed in accordance with EIA-364-70B.

7.5. Testing will be performed at five different current levels in order to generate a Current Derating curve via regression analysis.

8. Data Analysis Data shall be provided in the following formats:
8.1. Temperature Rise (degrees Celsius above ambient).
8.2. Current Derating curve based on the Temp Rise data.
8.3. Voltage Drop (Contact Resistance at Rated Current)

9. Required Equipment

9.1. The power supply used and the test current required will limit the number of contacts that can be tested at one time.

9.1.1. The three factors involved in determining this limit are:
a) Total Resistance of the contact chain including all cables and connections.
b) Test Current to be carried by said system.
c) Maximum Open Circuit Voltage of the power supply

9.1.2. The formula is $V_{oc} \div I_t = R_t$; Where:
a) V_{oc} is the Open Circuit Voltage required
b) I_t is the Test Current
c) R_t is the total resistance of the test circuit

9.1.3. This is also limited by the total power available as specified in the Power Supply manual

9.2. The data acquisition system used to measure the Temperature Rise and Voltage Drop shall be equipped with the scanning cards listed below:

TYPE	USE
Keithley Model 7700,20 channel multiplexer	Provide computer controlled switching with thermocouple inputs. Installs into a Keithley Model 2700 Multimeter/Data Acquisition System
Calibrated Thermocouples (2)	For reliable temperature measurements
Keithley Model 2750 Multimeter/Data Acquisition System	Mainframe for 20 channel relay card
HP System Power Supply 6032A	Computer controlled power supply
Thermocouple Radiation Shield # TL-022	To prevent erroneous reference temperature measurements.
IEEE-488 Card	Communications card for PC
PC	To provide interface for IEEE-488 instrumentation and program control.
Keithley Model 580, Micro-Ohmmeter	Measuring instrument

10.Approvals

NAME	DEPARTMENT	DATE
	Quality	
	Engineering	

11.Revisions

REVISION	DESCRIPTION	DATE
00	New	
01	Added TLOP 0009 for Reference Document	10/4/02