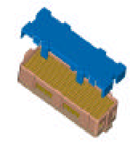
MEG-Array®
Solder Joint Reliability Testing Results Summary
IPC-SM-785

TELECOM - Central Office Environment



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MEG-Array®
Product Engineer

Report Date: 06/02/01

SUBJECT:
MEG-Array® Solder Joint Reliability Testing per the TELECOM Central Office requirements of IPC-SM-785. All testing was performed at an independent test facility.

PURPOSE:
Predict solder joint *"end-of-life"* of the MEG-Array® Connector System

CONCLUSION:
Per the IPC-SM-785 *"end-of-life"* calculation method, the MEG-Array® 400 Position, 14mm Stack Connector System has the following solder joint *"end-of-life"* value:

MEG-ArrayÒ Solder Joint "End-of-Life" = 22.1years

PRODUCT TESTED:
Meg-Array® 400 Position – 14mm PCB-to-PCB Stack System
- *Plug Assembly P/N 84520-102 – 400 Position, 6mm*
- *Receptacle Assembly P/N 74390-101 – 400 Position, 8mm*

TESTING PERFORMED:

Thermal Cycling Parameters per IPC-SM-785:

Temperature Range:	0°C to 100°C
Dwell Time at each Extreme:	15 minutes
Ramp-Rate:	10°C/minute
Total time for 1 Cycle:	50 minutes
Number of Cycles per 24 hrs:	28.8 cycles
Electrical Event Detection:	100Ω Event (above initial R) for a 200 nanosecond duration or longer.
PCB Layout:	All 400 connector positions of each individual connector sample are “daisy-chained” to yield an individual sample resistance R.
Test Failure Rate Criteria:	Stop test when a minimum of 63.2% sample failure rate is achieved.
Failure Criteria:	Fifteen 100Ω-200ns events within 100 thermal cycles of one another. The Final R was recorded after the 15th electrical event for all failed samples.
Number of Samples Tested:	30 MEG-Array® Assemblies in the Mated Condition using mechanical PCB “edge-rails” to prevent Z-Axis movement of the test PCB’s (See Photos 1, 2, & 3 on Page 4 for PCB Edge-Rail depiction).

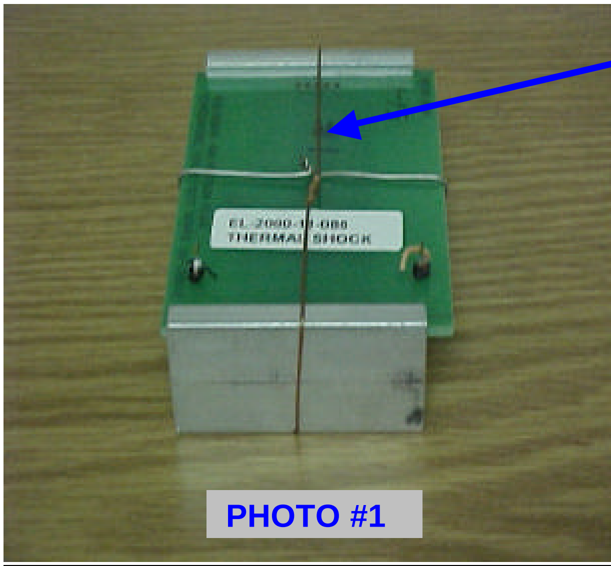
TEST DATA:

TABLE 1 – THERMAL CYCLE DATA

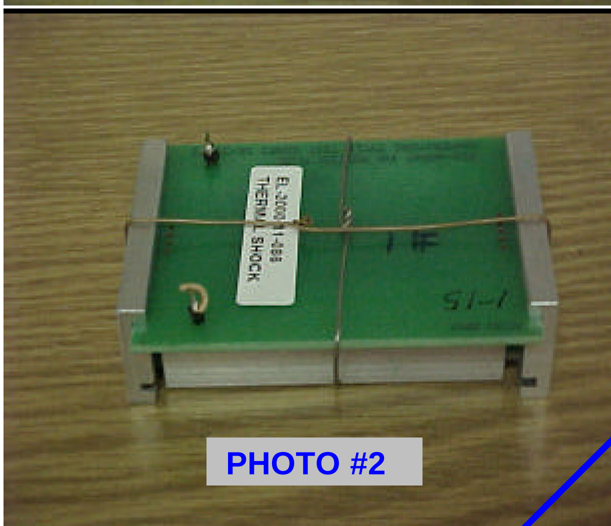
Failure Number (Sequential)	Sample Number	Number of Thermal Cycles Completed	Initial Resistance R (W)	Final Resistance R (W)
1	1-7	928	9.925	∞
2	1-10	997	9.958	∞
3	1-20	1046	9.878	24.118
4	1-11	1194	9.875	78.997
5	1-5	1277	9.951	35.529
6	1-25	1547	9.993	28.431
7	1-13	1638	9.978	34.126
8	1-6	1659	9.996	51.584
9	1-9	1660	9.961	118.016
10	1-18	1662	9.994	∞
11	1-17	1664	9.968	24.689
12	1-12	1681	9.925	34.353
13	1-1	1741	9.932	73.470
14	1-4	1744	9.962	21.928
15	1-21	1941	9.905	17.659
16	1-27	1942	10.006	17.466
17	1-14	2050	9.903	11.083
18	1-18	2054	9.946	41.865
19	1-15	2072	9.922	15.258
20	1-16	2242	9.915	14.804
21	1-23	2303	9.915	44.219
22	1-28	2503	9.989	12.535
23	1-22	2514	9.975	12.456
24	1-2	2588	9.999	14.355
25	1-3	*	9.952	*
26	1-19	*	9.989	*
27	1-24	*	10.001	*
28	1-26	*	9.943	*
29	1-29	*	10.017	*
30	1-30	*	9.996	*

*Sample had not failed after 2588 Thermal Cycles (after 80% Failure-Rate was achieved and test was stopped)

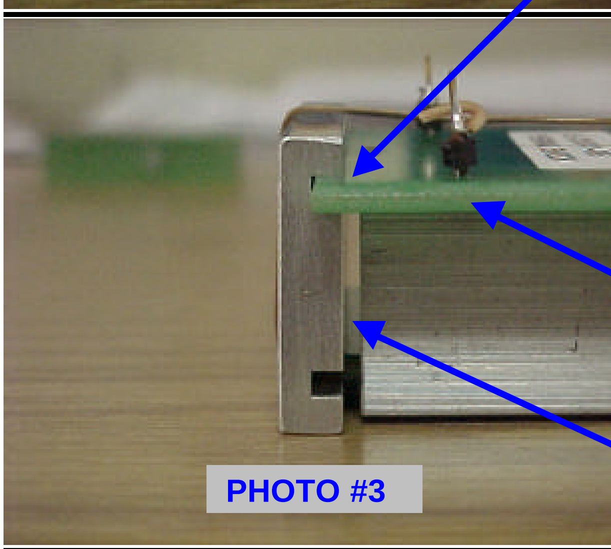
TEST VEHICLE PHOTOS (TYPICAL)



Wire used to secure mated system together



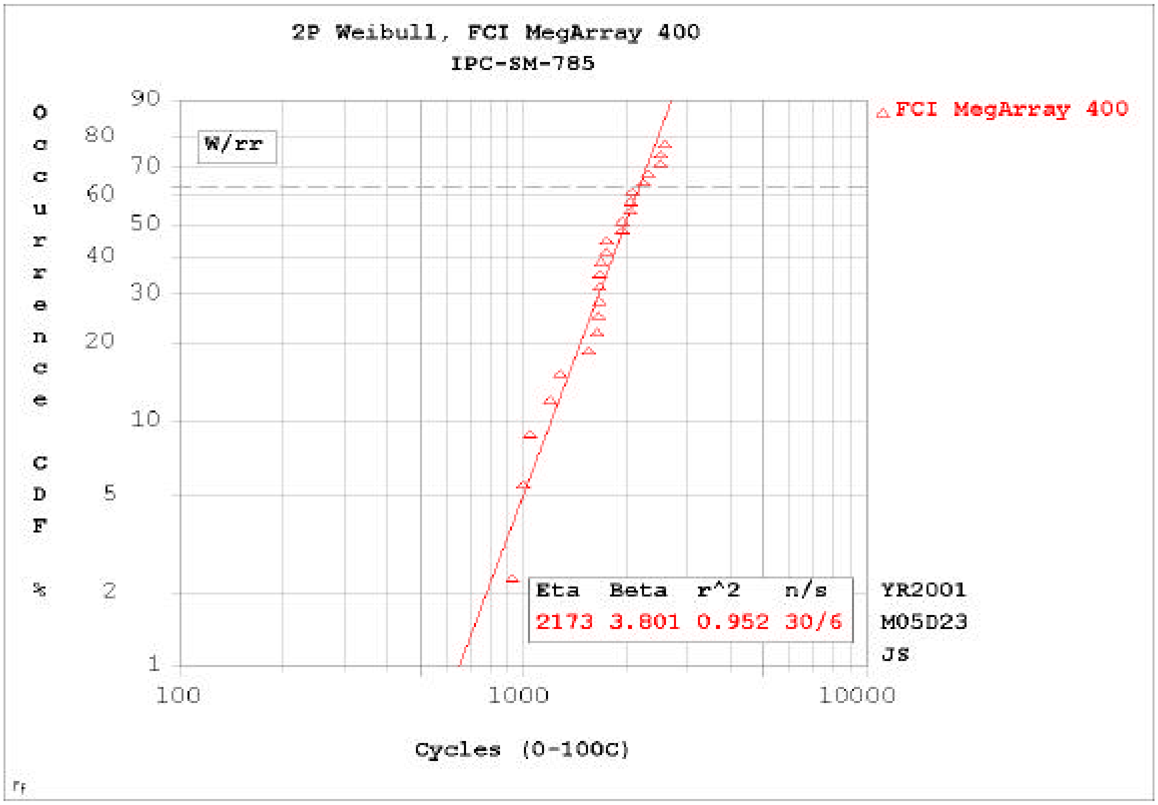
PCB "edge-rails" to prevent Z-Axis movement of PCB's during testing (typical on both ends of both test PCB's)



<u>Single Layer Test PCB's</u>
- PCB Thickness = .093" Nominal (Typ)
- No Internal Ground Planes

Edge-Rail Material: Aluminum

2 Parameter Weibull Distribution of Test Data:



Distribution Analysis (Regression)

Weibull [t0 = None ... 2 Parameter]
Correlation(r)=.9757049 r^2=.952 ccc^2=.9121 r^2-ccc^2= .0399 (Okay)
Characteristic Value=2173 Weibull Slope=3.801 Method=rr

Weibull [t0 = 632.5634 ... 3 Parameter] [Scale Not As Recorded]
Correlation(r)=.9813256 r^2=.963 ccc^2=.9577 r^2-ccc^2= .0053 (Okay)
Characteristic Value=1580 Weibull Slope=2.112 Method=rr/t0^

LogNorm [t0 = None ... 2 Parameter]
Correlation(r)=.9813256 r^2=.963 ccc^2=.9284 r^2-ccc^2= .0346 (Okay)
Log-Mean Antilog=1945 Std. Dev. Factor=1.465 Method=rr

Normal+ [t0 = None ... 2 Parameter]
Correlation(r)=.9767292 r^2=.954 ccc^2=.9284 r^2-ccc^2= .0256 (Okay)
Mean=1985 Std. Deviation=622.5 Method=rr

Optimum Distribution: Weibull [t0 = None ... 2 Parameter]

Note: Wiebull Distribution was third party generated using the testing data shown in TABLE 1

END-OF-LIFE CALCULATION:

Per IPC-SM-785, the following Modified Coffin-Manson (Norris-Landsberg) Equation (EQ 1) is used to calculate the Acceleration Factor (AF) for product features that are purely “creep” dominated such as solder joints:

EQ 1: $$AF = [\Delta T_L / \Delta T_F]^{1.9} \; [F_F / F_L]^{1/3} \; e^{(1414\{1/Tmax_F - 1/Tmax_L\})}$$

Where:

AF = Calculated Acceleration Factor (Cyclic Basis)
ΔT = Package/Board Temperature Difference Between T_{OFF} & T_{ON} (°K)
T_{MAX} = Maximum Solder Joint Temperature
F = Cyclic Frequency (in cycles per 24 hour period)
F, L Subscripts = Denotes Field and Lab (i.e. ATC) Conditions, Respectively

Values used in Modified Coffin-Manson to Calculate AF:

ΔT_L = 100°K (Testing Temperature Range: 0°C to 100°C)
ΔT_F = 15°K (Use 15°K for Central Office; Use 35°K for Outdoor)
$T_{MAX\,L}$ = 373°K (100°C Test Temperature Extreme)
$T_{MAX\,F}$ = 318°K (Use 45°C for both Central Office & Outdoor)
F_L = 28.8 Cycles/24 Hours (Based on 50 minute test cycle)
F_F = 6 Cyles/24 Hours (Use 6 for TELECOM which is considered 1 Cycle/Day)

$$AF = [100°K / 15°K]^{1.9} \; [6 \text{ cycles/day} / 28.8 \text{ cycles/day}]^{1/3} \; e^{(1414\{1/318K - 1/373K\})}$$

$$AF = 41.98499$$

For End-of-Life (Estimated Field Life):

EQ 2: $$N_F = AF \times N_L$$

Where:

N_F = Cyclic Failure Life in the Field
N_L = Cyclic Failure Life in the Lab (i.e. ATC)
AF = Acceleration Factor from Modified Coffin-Manson Equation

The Cumulative Weibull Probability Function is as follows:

EQ 3 : $$Fw(t) = 1 – e^{-(t/\alpha)\,^\wedge\,\beta}$$

Where :
Fw(t) = Cumulative Probability Function (Input = Allowable Failure Rate)
(t) = Cyclic Failure Life (in Cycles)
α = Eta = Time Constant/Characteristic from 2P Weibull Distribution (in Cycles)
β = Weibull Exponent Constant from 2P Weibull Distribution

EQ 4: $$t = N_L = \text{Cyclic Failure Life}$$

Solving the EQ 3 for the cyclic failure life t yields EQ 5:

$$Fw(t) = 1 – e^{-(t/\alpha)\,^\wedge\,\beta}$$

$$Fw(t) - 1 = – e^{-(t/\alpha)\,^\wedge\,\beta}$$

$$1- Fw(t) = e^{-(t/\alpha)\,^\wedge\,\beta}$$

$$\ln[1- Fw(t)] = -(t/\alpha)^{\beta}$$

$$\{-\ln[1- Fw(t)]\}^{1/\beta} = t/\alpha$$

EQ 5 : $t = \alpha \{-\ln[1- Fw(t)]\}^{1/\beta}$

Substituting a .01% Failure Rate into EQ 5 for Fw(t) yields the following (.01% Failure Rate = 100 ppm Failure Rate):

$$t = \alpha \{-\ln[1- Fw(t)]\}^{1/\beta}$$

Where :

Fw(t) = .0001 Failure Rate
α = Eta = 2173 (Time Constant/Characteristic from 2P Weibull Distribution)
β = 3.801 (Weibull Exponent Constant from 2P Weibull Distribution)

$$t = 2173 \text{ Cycles } \{-\ln[1- Fw(.0001)]\}^{1/3.801} = 192.636 \text{ Cycles}$$

Per EQ 4 :

$$N_L = t = 192.639 \text{ Cycles}$$

Substituting N_L into EQ 2 yields :

$$N_F = AF \times N_L$$

$$N_F = 41.98499 \times 192.639 \text{ Cycles}$$

$$N_F = 8087.94 \text{ Cycles (Cyclic Field End-of Life)}$$

TELECOM = 1 Cycle/Day

[8087.94 Cycles] / [365 Cycles/Year) = 22.158 years

END-OF-LIFE = 22.1 Years

TEST EQUIPMENT LIST

Equipment	*Manufacturer*	*Model#*	*Lab#*	*Last Cal*	*Next Cal*
Digital Multimeter	Hewlett Packard	3441A	TL567	02/05/00	02/05/01
Harness	Trace Laboratories	N/A	N/A	Verified as used	
Chart Recorder	Honeywell	DR4500	TL542	07/16/00	07/16/01
Temp Cycling Chamber	BLUE M	OV520-2	TL576	Verified as used	
Event Detector	Analysis Tech	STD256	TL492	04/13/00	04/13/01
Data Logger	Fluke	2635A TL543		07/02/00	07/02/01
Holding Fixture	Trace Labs	N/A	N/A	Verified as used	