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CARD-EDGE CONNECTOR RELIABILITY†

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This paper considers the results of using tin or T/A platings as a substitute for gold in card-edge connectors.

Measurements have been made on mated systems before and after various environmental tests. It has been shown that gold-gold contacts still provide the best reliability even if some of the gold platings have become worn through due to constant withdrawal and insertion.

The escalating price of gold in recent years has caused a trend in industry towards the reduction of gold plating thickness for permanent interconnection systems. Furthermore, there has been an increasing interest in identifying the reliability consequences of substituting tin or tin alloy platings for the gold. This paper considers the reliability of various combinations.

1. TEST ITEMS

It has been considered fundamental to the experimental philosophy that the evaluation should be based on commercially available card-edge connectors and industrially manufactured PCB's. No test material has been manufactured or plated using laboratory equipment. In this way it should be possible directly to transfer the results of the evaluation to practical industrial applications.

This evaluation of card-edge connectors has included products from at least two different manufacturers for each type of tested contact plating combinations (see Table I), viz.

10 combinations of gold-gold contact platings
6 combinations of tin-tin contact platings
2 combinations of gold-tin contact platings.

2. TEST PLAN

The evaluation falls into three main parts.

A. A technological test programme to show the withdrawal force of the PCB's from the card-edge connectors and the quality of the platings.

B. A full environmental test programme consisting of contact resistance measurements before and after a number of environmental exposures. Before all environmental exposures all test variants were exposed to both 1 and 20 matings. The purpose of this part of the project was to simulate a normal industrial application in hot indoor, tropical or corrosive outdoor environments (see Figure 1).

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TABLE I
Survey of results relevant to normal professional application.

Variant No.	Connector code	PCB code	Connector plating (approx)	PCB plating (approx)	Connector plating quality	Withdrawal force (N/pin)	Damp heat	Dry heat	Industrial atmosphere
1	A standard	PCB thin	Min. 0.5 μm gold	0.5 μm gold	Fine	Not measured	+	+	0
2	A standard	PCB standard	Min. 0.5 μm gold	1.4 μm gold	Fine	0.7	+	+	+
3	B standard	PCB thin	Min. 0.25 μm gold	0.5 μm gold	Fine	Not measured	–	+	0
4	B standard	PCB standard	Min. 0.25 μm gold	1.4 μm gold	Fine	1.5	+	+	0
8	B heavy	PCB thin	Min. 2.5 μm gold	0.5 μm gold	Fine	Not measured	+	+	–
9	B heavy	PCB standard	Min. 2.5 μm gold	1.4 μm gold	Fine	1.8	+	+	0
10	B heavy	PCB heavy	Min. 2.5 μm gold	2.5 μm gold	Fine	Not measured	+	+	+
11	A heavy	PCB tin	Min. 2.5 μm gold	Fused tin/lead	Fine	Not measured	–	–	–
12	B heavy	PCB tin	Min. 2.5 μm gold	Fused tin/lead	Fine	Not measured	–	–	–
13	A tin†	PCB tin	Tin	Fused tin/lead	Fine	0.8	–	–	–
14	A tin†	PCB tin, lubr.	Tin	Fused tin/lead	Fine	0.5	–	–	–
15	C tin	PCB tin	Tin	Fused tin/lead	Fine	1.8	–	–	–
16	C tin	PCB tin, lubr.	Tin	Fused tin/lead	Fine	1.1	0	–	–
17	D tin	PCB tin	Tin	Fused tin/lead	Fine	1.7	–	–	+
18	D tin	PCB tin, lubr.	Tin	Fused tin/lead	Fine	1.5	0	–	–

†: The manufacturer of the "A tin" type connector specifies min. 15 μm tin/lead plating on the PCB edge contacts. Tin/lead plating was actually found to about 9 μm on many of the contact.

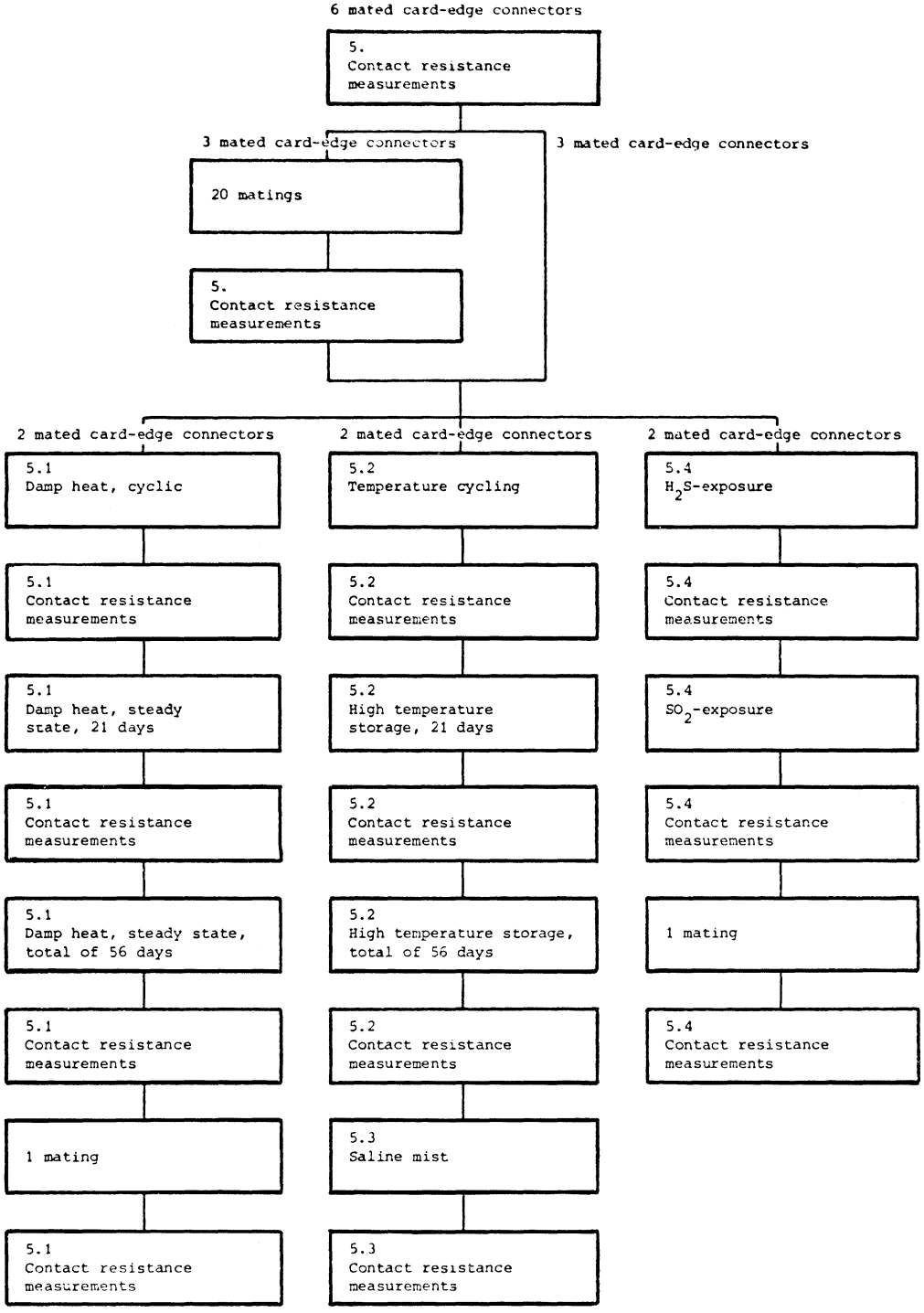

FIGURE 1 Test plan for full environmental test programme.

C. Endurance testing to show the effect of excessive initial wear on the long term contact reliability in damp heat environments.

3. SURVEY RESULTS

In the survey the following three quality grades have been used:

+: Means perfect

No increase in contact resistance has been measured during environmental exposures.

0: Means normally acceptable

Small increase of contact resistance has been measured.

–: Inferior

All the other cases not covered by "+" or "0".

A survey of results from most environmental exposures and technological tests is presented in Table I. Only results which are judged to be significant for the prediction of reliability in most professional applications are shown in Table I. Therefore, the results from salt mist exposure and endurance testing, which are only relevant for very few applications, are omitted from the survey.

TABLE II
Survey of results for permanently mated gold plated contacts.

Variant No.	Connector Code	PCB Code	Damp heat	Dry heat	Industrial atmosphere	Saline mist
1	A standard	PCB thin	+	+	+	0
2	A standard	PCB thin	+	+	+	–
3	B standard	PCB thin	+	+	+	+
4	B standard	PCB standard	+	+	+	+
8	B heavy	PCB thin	+	+	+	+
9	B heavy	PCB standard	+	+	+	+
10	B heavy	PCB heavy	+	+	+	+

4. DISCUSSION AND CONCLUSIONS

Each of the contact plating combinations has fundamentally different environmental characteristics and will therefore be discussed separately.

Gold-Gold Contact Plating Combinations:

The evaluation has revealed that the permanently mated gold contacts maintain excellent contact reliability in all normally found environments, despite a large number of pinholes or worn-through areas in the gold platings (see three first columns of Table II). There is decreasing contact reliability after saline mist exposure for one type of card-edge connector (see last column of Table II). However, saline mist exposure is an unrealistic test for

most industrial applications, and these results should therefore be disregarded, unless the card-edge connectors are intended for use in environments where direct contamination by sea water may occur.

However, just one unmating/mating cycle after prolonged environmental exposures, may result in decreasing contact reliability (compare the corresponding columns of Tables II and III). This shows that servicing after a long time of application or storage in tropical or industrially polluted environments may very well create a number of contact failures in defiance of the fact that no contact problems existed before the servicing. Furthermore such contact failures may be intermittent and therefore hard to recognize.

It appears from the test results (see Tables III and IV) that the gold plating thickness of the card-edge connectors has only a little effect on the contact reliability. Contrary to this, the contact reliability in "corrosive" environments will be very sensitive to the gold plating thickness of the PCB edge contacts.

TABLE III

Survey of results for gold plated contacts with one mating after environmental exposures.

Variant No.	Connector Code	PCB Code	Damp heat	Industrial atmosphere
1	A standard	PCB thin	+	0
2	A standard	PCB standard	+	+
3	B standard	PCB thin	–	0
4	B standard	PCB standard	+	0
8	B heavy	PCB thin	+	–
9	B heavy	PCB standard	+	0
10	B heavy	PCB heavy	+	+

Tin-Tin Contact Plating Combinations:

Tin plated card-edge connector contact systems will only be a realistic alternative to gold if a complete environmental test programme can prove the contact performance of the actual connectors. The three types of tin plated connectors tested in this evaluation did not appear to have acceptable contact reliability (see Table I). Lubrication of tin plated card-edge connector contact systems will increase contact reliability, but will not ensure a perfect contact performance if the contact reliability of the unlubricated contacts is very low.

Gold-Tin Contact Plating Combinations:

Combinations of gold plated card-edge connectors with tin/lead plated PCB edge contacts will probably have the lowest contact performance compared with gold-gold and tin-tin contact plating combinations. Tin/lead plated PCB edge contacts should only be inserted in gold plated card-edge connectors, if a complete environmental test programme has proved the contact performance.

TABLE IV

Reliability in corrosive or damp heat environments in dependence on number of initial matings.

Variant No.	Connector Code	PCB Code	Damp heat						Industrial atmosphere	
			1 initial mating	10 initial matings	20 initial matings	25 initial matings	50 initial matings	100 initial matings	1 initial mating	20 initial matings
1	A standard	PCB thin	+	+	+	+	+	+	0	0
2	A standard	PCB standard	+	+	+	+	+	+	+	+
3	B standard	PCB thin	+	+	–	–	+	+	0	0
4	B standard	PCB standard	+	+	+	+	+	0	0	0
8	B heavy	PCB thin	+	+	+	+	+	+	0	–
9	B heavy	PCB standard	+	+	+	+	+	+	+	0
10	B heavy	PCB heavy	+	+	+	+	+	+	+	+