APLAC

Asia Pacific Laboratory Accreditation Cooperation

APLAC T063 Safety Test for Creepage and Clearance Distance Proficiency Testing Program

Final Report

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APPENDIXES

1. Introduction

This report summarizes the results of APLAC T063 Safety Test for Creepage and Clearance Distance Proficiency Testing Program involving testing laboratories for the Asia Pacific Laboratory Accreditation Cooperation (APLAC), European co-operation for Accreditation (EA) and International Laboratory Accreditation Cooperation (ILAC).

The design for the shape of the merchandises have the trend toward light and compact nowadays, so for the safety test of all electrical products has become more and more important in the measuring of insulation distance, such as creepage and clearance distances measurement. The objective of this proficiency testing program is to evaluate the competence of laboratories for the safety test of the insulation distance measurement for the designated Printed Circuit Board, such as creepage and clearance distances.

2. Program Feature

(a) APLAC, EA and ILAC members were invited to participate. There were in total 36 laboratory participants nominated by 18 accreditation bodies (ABs) in this program. All samples were sent to the ABs and transferred to the participating laboratories.

Table 1 Summary of Economies and Participants

Economy	No. of Participants
Australia	1
Canada	4
Germany	1
HK, SAR	3
India	3
Japan	3
Korea	2
Latvia	1
New Zealand	3
People's Republic of China	3
Philippines	3
Poland	1
Portugal	1
Sweden	1
Taiwan	3
Thailand	3
Total	36

(b) Participating laboratories were supplied one square Printed Circuit Board. The size of the sample is 6x6 cm^2 with TAF logo on the front.

(c) Each participating laboratory is required to obtain the measurement of insulation distances, such as creepage and clearance distances.

(d) Laboratories were requested to perform the tests according to their copy of the Instructions to Participants and to record their results on the accompanying Results Sheet, both of which were distributed to participants with the samples. (Appendix C)

(e) Each laboratory was randomly allocated a unique code number for the program to enable confidentiality of results. Its code number makes reference to each laboratory in this report.

3. Content of Appendices

APPENDIX A contains:

(a) The results of samples reported by participants and the calculated Z-Score result for each test on each sample.

(b) A table of robust statistics for each test, such as number of results, median, normalized IQR, robust CV, minimum, maximum and range.

(c) Z-Scores and ordered Z-Score charts calculated for laboratories for each test.

(d) Test methods are reported for each laboratory.

APPENDIX B contains the details of sample preparation and homogeneity testing.

APPENDIX C contains a copy of the *Instructions to Participants* and the *Results Sheet*, as supplied to participants.

APPENDIX D contains details of statistical procedures, calculations and formula.

4. Statistical design of the program

One identical type of test piece was used in this program. Robust statistical procedures were used to generate the Z-scores and summary statistics for the sample - number of results, median, normalized interquartile range, minimum, maximum and range.

For each laboratory, a single robust Z-score was calculated for each returned result.

For each item, we can use the Z-score of each laboratory to understand the degree that the result of that laboratory deviates from the population. If $|Z-\text{Score}|\geq 3$ it represents that the testing result is an outlier and we will denote it by "※". For the testing result that $|Z-\text{Score}|\geq 3$ one should make further assessment.
It should be noted that when calculating the Z-scores of between-lab for Item 2, Item 3 and Item 9, since the calculated normalized interquartile range are all zeros and this will result in the situation that the formulae of these robust Z-scores are divided by zeros. So, instead of the robust Z-scores, the performance of each participant was evaluated by means of a performance index, Z-score, which is calculated as (refer to ISO 13528):

$$Z=\frac{\text{result}-X}{\hat{\sigma}},$$

where X is the mean of the sample and $\hat{\sigma}$ is the corresponding standard deviation.

5. Outlier Results

The outliers of feedback results are shown as below, the detail information please refers to the Summary of Results in Appendix A.

Table 2 List of Outliers

$\lvert Z-\text{Score}\rvert \geq 3$	Lab Code	Proportion (%)
Item 1	20, 33	5.56%
Item 2	N/A	
Item 3	N/A	
Item 4	3, 24	5.56%
Item 5	34	2.78%
Item 6	17, 19	5.56%
Item 7	N/A	
Item 8	N/A	
Item 9	N/A	
Item 10	3, 17, 24	8.33%
Item 11	N/A	
Item 12	N/A	

6. Technical Comments

General Comments

The program was intended to check the laboratories how to determine the Clearance and Creepage by way of a sample resembling a printed circuit board.

In addition to the above, the laboratories was also reference to the IEC 60664-1 to selection and measurement of the correct clearance and creepage pathways, it makes sure the measurement of the pathway deemed to be the shortest.

After collecting the measuring data from attending laboratory and analyzing them by statistic method, for the result of the program, we find the result of test Item1(the creepage distance between F1 and F2) and Item4 (the creepage distance between R1 and R2) are divided into two groups because the attending laboratory measuring the width of groove between F1 and F2 have different result (＞1mm and ＜1mm). After discussing, we decide to make separately statistic analysis for test Item1 and Item4. (The statistic results please referring Appendix A)

Besides, because of the vague definition of the sample's groove design and pollution degree on this program, the result of the program leads to unavoidable doubt. We will make fully consideration for next improvement.

Comments for Participants

By analyzing and evaluating laboratories related to Z-Score>3, possible abnormal causes occur as follows:

1. Clearance measurement: measuring the shortest clearance is not in compliance with the requirement of the standard.
2. Creepage distance measurement:
   - The shortest distance is not found in the measurement so that the values of measured data are oversized.
   - The determination of position in consideration of measurement path is incorrect so that the values of measured data are higher than average values.
   - The calculation during the measurement of creepage-distance generates errors in the summation.

For laboratories with abnormal causes, the determination ability in measuring creepage-distance and clearance must be re-enhanced, and the requirements and definitions corresponding to safety standards during the measurement must be also understood practically, so as to actually promote technical abilities of safety in the laboratories.

Appendix A

Summary of Results

Information of Test

Table 3 Summaries of Results

Item 1	Creepage Distance Measurement F1 and F2 Gap >1mm		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1			N/A
2			N/A
3	6	0.54	± 0.07 mm
4	5.8	-0.54	0.1mm
6			N/A
7			N/A
8			N/A
9	5.8	-0.54	0.023/0.06
10			N/A
11			N/A
12			N/A
13	6.4	2.70	± 0.14mm
14			N/A
15			N/A
16	5.8	-0.54	0.02mm
17			N/A
18	5.9	0.00	0.2mm
19			N/A
20	5	-4.856※	1.28
21			N/A
22			N/A
23	6.3	2.16	0.024
24	6.1	1.08	0.01
25	5.9	0.00	0.03mm
26			N/A
27			N/A
28			N/A
29	5.9	0.00	5.90±0.02
32			N/A
33	6.6	3.777※	±15μm
34	5.9	0.00	0.05949
35	6.1	1.08	0.3mm
36			N/A
38			N/A
39	5.9	0.00	± 0.11
40			N/A

No. of result	15
Median	5.9
Normalized IQR	0.185
Robust CV (%)	3.14
Maximum	6.6
Minimum	5.0
Range	1.6

Item 2	Creepage Distance Measurement F1 and F2 Gap<1mm		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	3.9	0.00	0.39mm
2	4	0.69	0.1414
3			N/A
4			N/A
6	3.8	-1.38	± 0.0266
7	3.9	0.00	0.032mm
8	3.9	0.00	0.1
9			N/A
10	4.1	2.76	± 0.03
11	3.9	0.00	± 0.01
12	3.9	0.00	0.03mm, 95%
13			N/A
14	3.9	0.00	0.14mm
15	3.8	-1.38	± 0.07mm
16			N/A
17	3.9	0.00	± 0.031
18			N/A
19	3.9	0.00	N/A
20			N/A
21	3.9	0.00	0.038mm
22	3.8	-1.38	0.118
23			N/A
24			N/A
25			N/A
26	3.9	0.00	± 0.07mm
27	3.9	0.00	0.01mm
28	3.9	0.00	0.019mm
29			N/A
32	4	1.38	0.06mm
33			N/A
34			N/A
35			N/A
36	4	1.38	± 88µm
38	3.8	-1.38	0.253
39			N/A
40	3.9	-0.69	122

No. of result	21
Median	3.9
Mean	3.9
Standard Deviation	0.07
Maximum	4.1
Minimum	3.8
Range	0.3

Item 3	Creepage Distance Measurement F2 and F3		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	10	0.00	0.39
2	10	0.00	0
3	10.1	1.19	± 0.07 mm
4	10.1	1.19	0.2mm
6	9.8	-2.38	± 0.0266
7	9.9	-1.19	0.032mm
8	10	0.00	0.009
9	10	0.00	0.016/0.06
10	10.2	2.38	± 0.03
11	10	0.00	± 0.01
12	10	0.00	0.03mm, 95%
13	10	0.00	± 0.01mm
14	10	0.00	0.14mm
15	9.9	-1.19	± 0.07mm
16	10	0.00	0.02mm
17	9.9	-1.19	± 0.031
18	10	0.00	0.1mm
19	10	0.00	N/A
20	10	0.00	0.03
21	10	0.00	0.050mm
22	10	0.00	0.118
23	10	0.00	0.024
24	10	0.00	0.007
25	10.2	2.50	0.03mm
26	10	0.00	± 0.07mm
27	10.1	1.19	0.01mm
28	10	0.00	0.019mm
29	10	0.00	10.000±0.002
32	10	0.00	0.06mm
33	10	0.00	±15µm
34	10	0.00	0.26199
35	10.1	1.19	0.2mm
36	10	0.00	± 88µm
38	9.8	-2.38	0.654
39	9.9	-1.19	± 0.08
40	10	-0.60	122

No. of result	36
Median	10.0
Mean	10.0
Standard Deviation	0.08
Maximum	10.2
Minimum	9.8
Range	0.4

Item 4	Creepage Distance Measurement R1 and F3		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	7.4	0.26	0.39
2	7.35	0.13	0.1414
3	8.7	3.597※	± 0.07 mm
4	7.7	1.03	0.1mm
6	8.3	2.57	± 0.0266
7	7.1	-0.51	0.040mm
8	7.3	0.00	0.1
9	6.8	-1.29	0.021/0.06
10	7	-0.77	± 0.07
11	7.2	-0.26	± 0.07
12	7.6	0.77	0.03mm, 95%
13	7.1	-0.51	± 0.14mm
14	7.1	-0.51	0.14mm
15	7.2	-0.26	± 0.07mm
16	7.1	-0.51	0.02mm
17	8.4	2.83	± 0.031
18	7	-0.77	0.1mm
19	8.1	2.06	N/A
20	7.5	0.51	1.28
21	7.1	-0.51	0.256mm
22	7	-0.77	0.236
23	7.3	0.00	0.024
24	8.6	3.34※	0.023
25	6.9	-1.03	0.038
26	7.3	0.00	± 0.07mm
27	6.8	-1.29	0.04mm
28	7.5	0.51	0.01mm
29	7	-0.77	7.000±0.007
32	7.6	0.77	0.1mm
33	8	1.80	±15μm
34	6.9	-1.03	0.11286
35	8	1.80	0.3mm
36	7.5	0.51	± 88μm
38	7.2	-0.26	0.48
39	7.6	0.77	± 0.14
40	8	1.80	122

No. of result	36
Median	7.3
Normalized IQR	0.389
Robust CV (%)	5.33
Maximum	8.7
Minimum	6.8
Range	1.9

Item 5	Creepage Distance Measurement R1 and R2 Gap >1mm		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1			N/A
2			N/A
3	31.8	1.16	± 0.07 mm
4	32.2	2.70	0.2mm
6			N/A
7			N/A
8			N/A
9	31.4	-0.39	0.022/0.06
10			N/A
11			N/A
12			N/A
13	31.6	0.39	± 0.14mm
14			N/A
15			N/A
16	32	1.93	0.1mm
17			N/A
18	31.4	-0.39	0.1mm
19			N/A
20	31.4	-0.39	1.28
21			N/A
22			N/A
23	31.8	1.16	0.024
24	31.7	0.77	0.01
25	31.6	0.39	0.03
26			N/A
27			N/A
28			N/A
29	31.5	0.00	31.5±0.04
32			N/A
33	31.4	-0.39	±15μm
34	29.1	-9.25※	0.22231
35	31.3	-0.77	0.3mm
36			N/A
38			N/A
39	31.3	-0.77	± 0.11
40			N/A

No. of result	15
Median	31.5
Normalized IQR	0.259
Robust CV (%)	0.82
Maximum	32.2
Minimum	29.1
Range	3.1

Item 6	Creepage Distance Measurement R1 and R2 Gap <1mm		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	21.6	-1.01	0.39
2	22.1	0.67	0.4243
3			N/A
4			N/A
6	21.7	-0.67	± 0.0266
7	22	0.34	0.040mm
8	21.7	-0.67	0.1
9			N/A
10	22	0.34	± 0.04
11	22	0.34	± 0.02
12	21.5	-1.35	0.03mm, 95%
13			N/A
14	21.9	0.00	0.14mm
15	21.8	-0.34	± 0.07mm
16			N/A
17	25	10.455※	± 0.031
18			N/A
19	23	3.71※	N/A
20			N/A
21	22	0.34	0.127mm
22	21.5	-1.35	0.236
23			N/A
24			N/A
25			N/A
26	21.5	-1.35	± 0.07mm
27	21.7	-0.67	0.01mm
28	21.2	-2.36	0.01mm
29			N/A
32	22	0.34	0.1mm
33			N/A
34			N/A
35			N/A
36	22	0.34	± 33µm
38	21.6	-1.01	1.44
39			N/A
40	22.2	1.01	122

No. of result	21
Median	21.9
Normalized IQR	0.297
Robust CV (%)	1.35
Maximum	25.0
Minimum	21.2
Range	3.8

Item 7	Creepage Distance Measurement R1 and R3		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	25.8	0.00	0.39
2	25.8	0.00	0.2828
3	25.9	0.19	± 0.07 mm
4	26.4	1.16	0.2mm
6	25.5	-0.58	± 0.0266
7	25.3	-0.96	0.040mm
8	25.3	-0.96	0.1
9	25.7	-0.19	0.045/0.07
10	26.1	0.58	± 0.04
11	26	0.39	± 0.02
12	25.4	-0.77	0.03mm, 95%
13	26.4	1.16	± 0.14mm
14	25.2	-1.16	0.14mm
15	26.1	0.58	± 0.07mm
16	25.6	-0.39	0.02mm
17	26.6	1.54	± 0.031
18	25.9	0.19	0.2mm
19	26.2	0.77	N/A
20	25.6	-0.39	1.28
21	26	0.39	0.126mm
22	25.4	-0.77	0.206
23	26	0.39	0.024
24	25.4	-0.77	0.01
25	26.3	0.96	0.038
26	25	-1.54	± 0.07mm
27	25.4	-0.77	0.04mm
28	25.6	-0.39	0.01mm
29	25.1	-1.35	25.1±0.2
32	25.8	0.00	0.1mm
33	26.4	1.16	±15µm
34	26.4	1.16	0.68344
35	25.6	-0.39	0.3mm
36	26.1	0.58	± 33µm
38	25.9	0.19	1.726
39	25.3	-0.96	± 0.11
40	25.6	-0.39	122

No. of result	36
Median	25.8
Normalized IQR	0.519
Robust CV (%)	2.01
Maximum	26.6
Minimum	25.0
Range	1.6

Item 8	Clearance Distance Measurement F1 and F2		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	3.9	0.00	0.39
2	4	1.35	0.1414
3	3.8	-1.35	± 0.07 mm
4	3.8	-1.35	0.1mm
6	3.8	-1.35	± 0.0266
7	3.9	0.00	0.032mm
8	3.9	0.00	0.1
9	4	1.35	0.016/0.06
10	4.1	2.70	± 0.03
11	3.9	0.00	± 0.01
12	3.9	0.00	0.03mm, 95%
13	4	1.35	± 0.015mm
14	3.9	0.00	0.14mm
15	3.8	-1.35	± 0.07mm
16	3.8	-1.35	0.02mm
17	3.9	0.00	± 0.031
18	3.9	0.00	0.1mm
19	3.9	0.00	N/A
20	4	1.35	0.03
21	3.9	0.00	0.038mm
22	3.8	-1.35	0.118
23	3.9	0.00	0.024
24	3.9	0.00	0.007
25	4	1.35	0.03mm
26	3.9	0.00	± 0.07mm
27	3.9	0.00	0.01mm
28	3.9	0.00	0.019mm
29	3.9	0.00	3.900±0.005
32	4	1.35	0.06mm
33	3.8	-1.35	±15µm
34	3.8	-1.35	0.01032
35	3.9	0.00	0.2mm
36	4	1.35	± 88µm
38	3.8	-1.35	0.253
39	3.8	-1.35	± 0.08
40	3.9	0.00	122

No. of result	36
Median	3.9
Normalized IQR	0.074
Robust CV (%)	1.90
Maximum	4.1
Minimum	3.8
Range	0.3

Item 9	Clearance Distance Measurement F2 and F3		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	10	0.00	0.39
2	10	0.00	0
3	10.1	1.22	± 0.07 mm
4	10.1	1.22	0.2mm
6	9.8	-2.44	± 0.0266
7	9.9	-1.22	0.032mm
8	10	0.00	0.009
9	10	0.00	0.016/0.06
10	10.2	2.44	± 0.03
11	10	0.00	± 0.01
12	10	0.00	0.03mm, 95%
13	10	0.00	± 0.01mm
14	10	0.00	0.14mm
15	9.9	-1.22	± 0.07mm
16	10	0.00	0.02mm
17	9.9	-1.22	± 0.031
18	10	0.00	0.1mm
19	10	0.00	N/A
20	10	0.00	0.03
21	10	0.00	0.050mm
22	10	0.00	0.118
23	10	0.00	0.024
24	10	0.00	0.007
25	10.2	2.56	0.03
26	10	0.00	± 0.07mm
27	10.1	1.22	0.01mm
28	10	0.00	0.019mm
29	10	0.00	10.0000±0.002
32	10	0.00	0.06mm
33	10	0.00	±15μm
34	10	0.00	0.26199
35	10	0.00	0.2mm
36	10	0.00	± 88μm
38	9.8	-2.44	0.654
39	9.9	-1.22	± 0.08
40	10	-0.61	122

No. of result	36
Median	10.0
Mean	10.0
Standard Deviation	0.08
Maximum	10.2
Minimum	9.8
Range	0.4

Item 10	Clearance Distance Measurement R1 and F3		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	7.4	0.26	0.39
2	7.4	0.26	0.1414
3	8.7	3.597※	± 0.07 mm
4	7.7	1.03	0.1mm
6	8.3	2.57	± 0.0266
7	7.1	-0.51	0.040mm
8	7.3	0.00	0.1
9	6.8	-1.29	0.016/0.06
10	7	-0.77	± 0.07
11	7.2	-0.26	± 0.07
12	7.6	0.77	0.03mm, 95%
13	7.1	-0.51	± 0.14mm
14	7.1	-0.51	0.14mm
15	7.2	-0.26	± 0.07mm
16	7.1	-0.51	0.02mm
17	5.2	-5.396※	± 0.031
18	7	-0.77	0.1mm
19	8.2	2.31	N/A
20	7.5	0.51	1.28
21	7.1	-0.51	0.256mm
22	7	-0.77	0.236
23	7.3	0.00	0.024
24	8.6	3.34※	0.023
25	6.9	-1.03	0.036
26	7.3	0.00	± 0.07mm
27	6.8	-1.29	0.04mm
28	7.5	0.51	0.01mm
29	7	-0.77	7.000±0.007
32	7.6	0.77	0.1mm
33	8.3	2.57	±15µm
34	6.9	-1.03	0.11586
35	8	1.80	0.3mm
36	7.5	0.51	± 88µm
38	7.2	-0.26	0.48
39	7.6	0.77	± 0.14
40	8	1.80	122

No. of result	36
Median	7.3
Normalized IQR	0.389
Robust CV (%)	5.33
Maximum	8.7
Minimum	5.2
Range	3.5

Item 11	Clearance Distance Measurement R1 and R2		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	17.9	0.67	0.39
2	17.9	0.67	0.2828
3	17.8	0.00	± 0.07 mm
4	17.8	0.00	0.2mm
6	17.6	-1.35	± 0.0266
7	17.6	-1.35	0.040mm
8	17.8	0.00	0.1
9	17.7	-0.67	0.016/0.06
10	17.8	0.00	± 0.03
11	17.8	0.00	± 0.01
12	17.8	0.00	0.03mm, 95%
13	18	1.35	± 0.01mm
14	17.7	-0.67	0.14mm
15	17.6	-1.35	± 0.07mm
16	17.8	0.00	0.02mm
17	17.9	0.67	± 0.031
18	17.7	-0.67	0.1mm
19	17.8	0.00	N/A
20	17.5	-2.02	1.28
21	17.9	0.67	0.151mm
22	17.9	0.67	0.118
23	17.8	0.00	0.024
24	17.8	0.00	0.007
25	17.8	0.00	0.03
26	17.9	0.67	± 0.07mm
27	17.8	0.00	0.04mm
28	18	1.35	0.01mm
29	17.8	0.00	17.8±0.07
32	17.6	-1.35	0.06mm
33	17.7	-0.67	±15µm
34	18	1.35	0.20618
35	17.7	-0.67	0.2mm
36	17.8	0.00	± 88µm
38	17.9	0.67	1.186
39	17.9	0.67	± 0.08
40	17.8	0.00	122

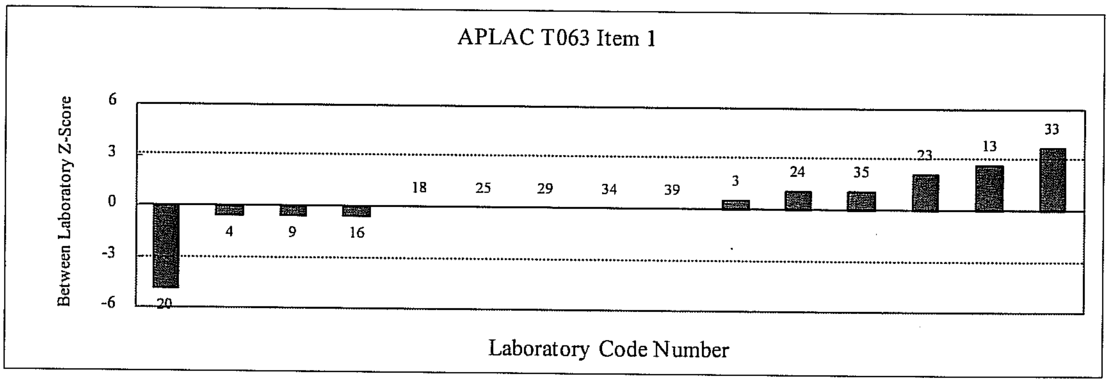
No. of result	36
Median	17.8
Normalized IQR	0.148
Robust CV (%)	0.83
Maximum	18.0
Minimum	17.5
Range	0.5

Item 12	Clearance Distance Measurement R1 and R3		
Lab Code	Result (mm)	Z-Score	Expanded Uncertainty
1	23	1.35	0.39
2	23.1	2.70	0.2828
3	23	1.35	± 0.07 mm
4	22.8	-1.35	0.2mm
6	22.8	-1.35	± 0.0266
7	22.9	0.00	0.040mm
8	23	1.35	0.007
9	22.9	0.00	0.016/0.06
10	23	1.35	± 0.03
11	23	1.35	± 0.01
12	23	1.35	0.03mm, 95%
13	23	1.35	± 0.14mm
14	22.9	0.00	0.14mm
15	22.8	-1.35	± 0.07mm
16	22.8	-1.35	0.1mm
17	23	1.35	± 0.031
18	22.9	0.00	0.1mm
19	23	1.35	N/A
20	22.8	-1.35	0.03
21	23	1.35	0.071mm
22	22.9	0.00	0.118
23	22.9	0.00	0.024
24	22.8	-1.35	0.007
25	23	1.35	0.038
26	23	1.35	± 0.07mm
27	22.9	0.00	0.04mm
28	22.9	0.00	0.01mm
29	22.9	0.00	22.90±0.02
32	22.8	-1.35	0.06mm
33	22.9	0.00	±15μm
34	23.1	2.70	0.02782
35	23	1.35	0.2mm
36	23	1.35	± 33μm
38	22.9	0.00	1.526
39	23	1.35	± 0.08
40	22.8	-1.35	122

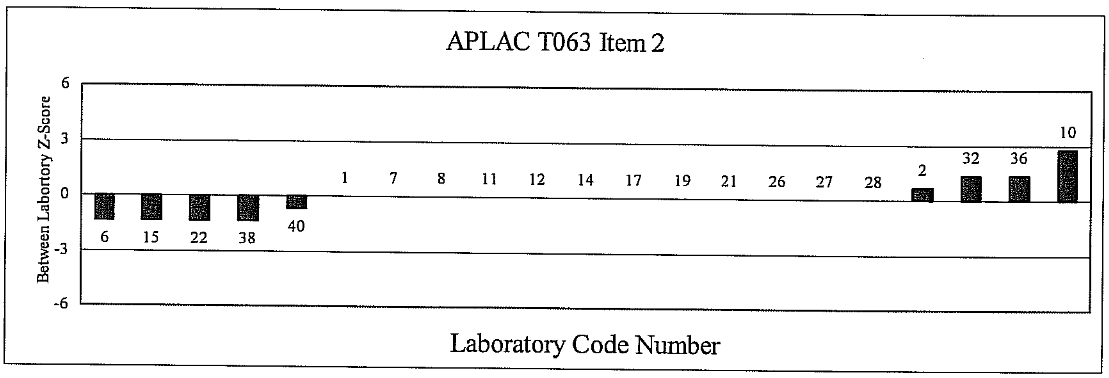
No. of result	36
Median	22.9
Normalized IQR	0.074
Robust CV (%)	0.32
Maximum	23.1
Minimum	22.8
Range	0.3

Figure 1 Histogram of Z-Score

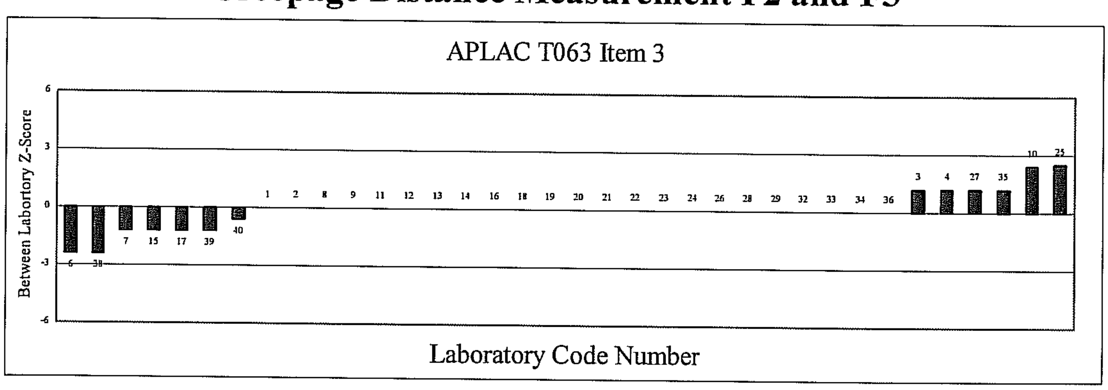
Creepage Distance Measurement F1 and F2 >1mm



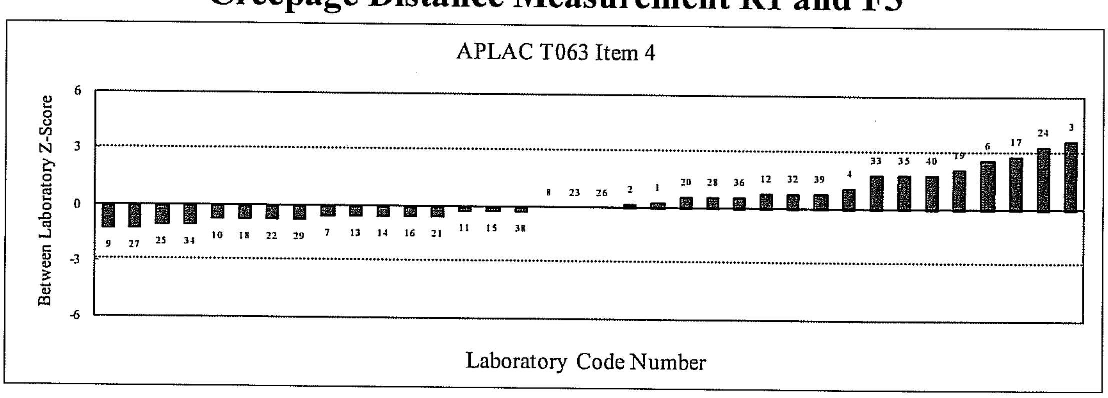
Creepage Distance Measurement F1 and F2 <1mm



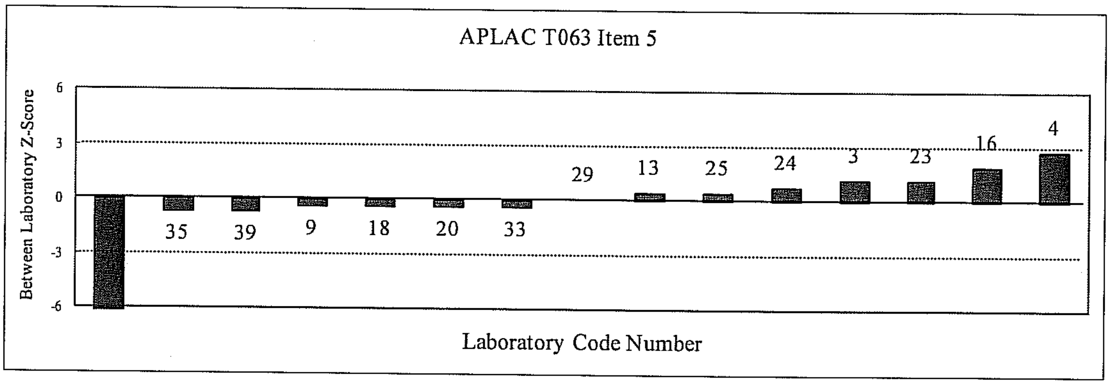
Creepage Distance Measurement F2 and F3



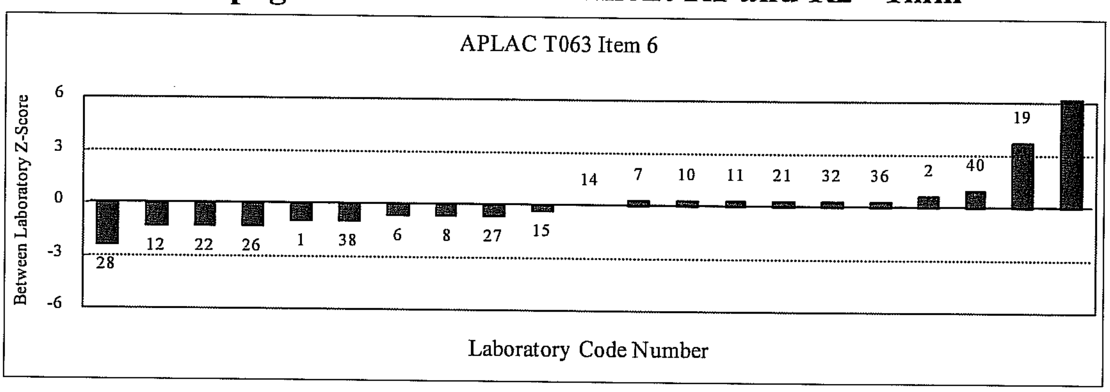
Creepage Distance Measurement R1 and F3



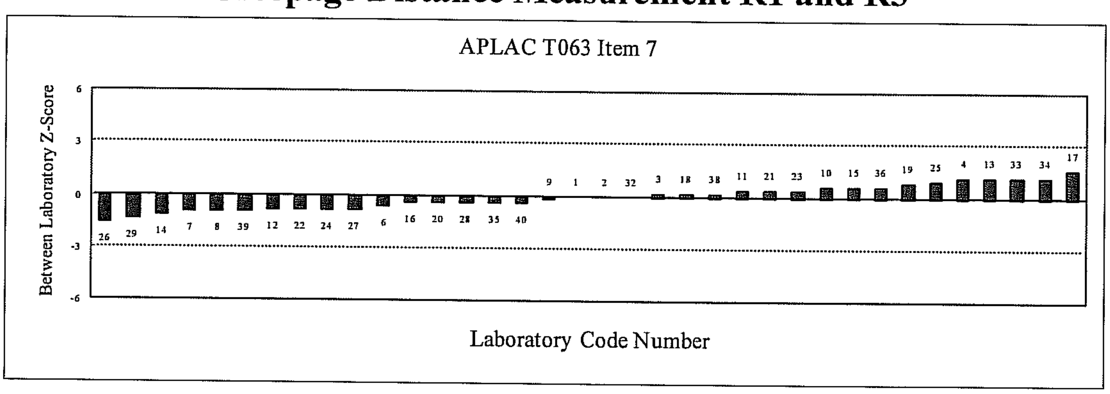
Creepage Distance Measurement R1 and R2 >1mm



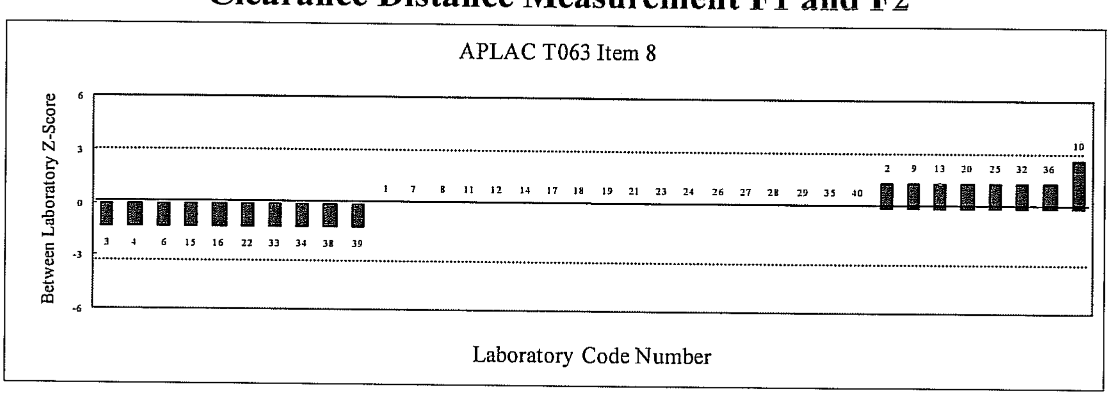
Creepage Distance Measurement R1 and R2 <1mm



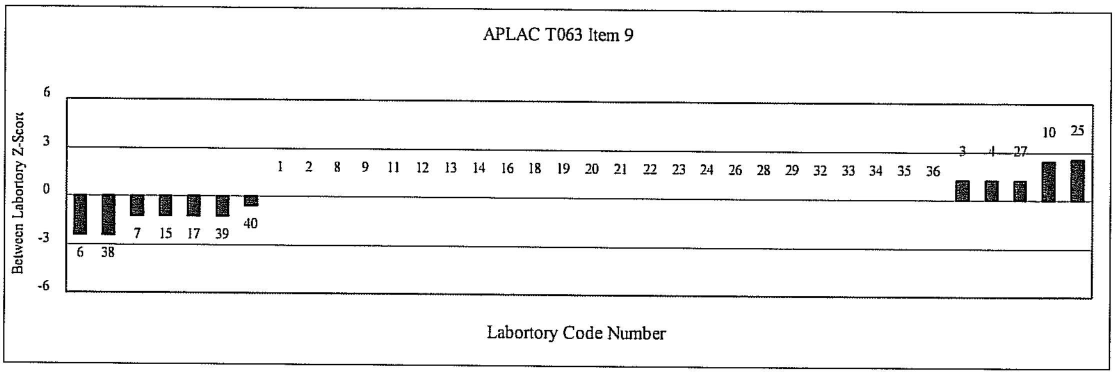
Creepage Distance Measurement R1 and R3



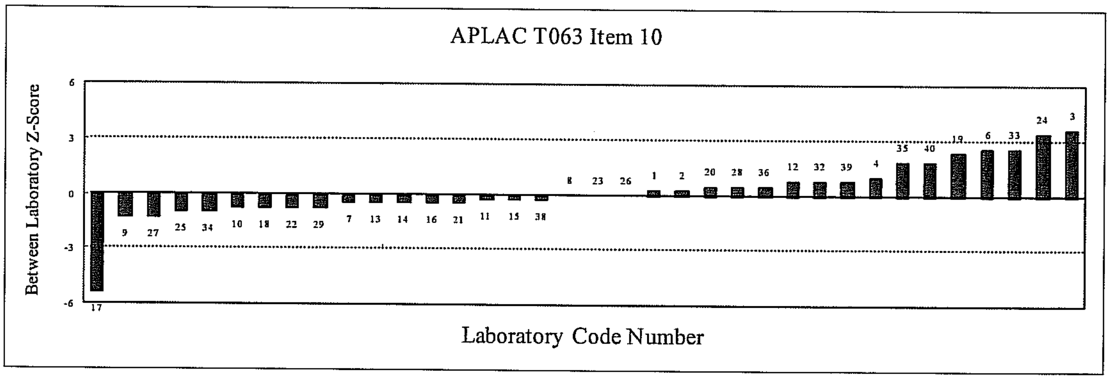
Clearance Distance Measurement F1 and F2



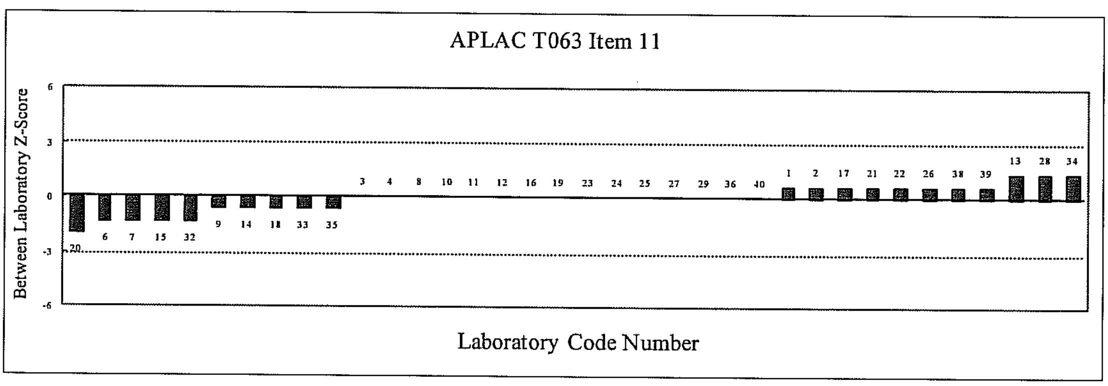
Clearance Distance Measurement F2 and F3



Clearance Distance Measurement R1 and F3



Clearance Distance Measurement R1 and R2



Clearance Distance Measurement R1 and R3

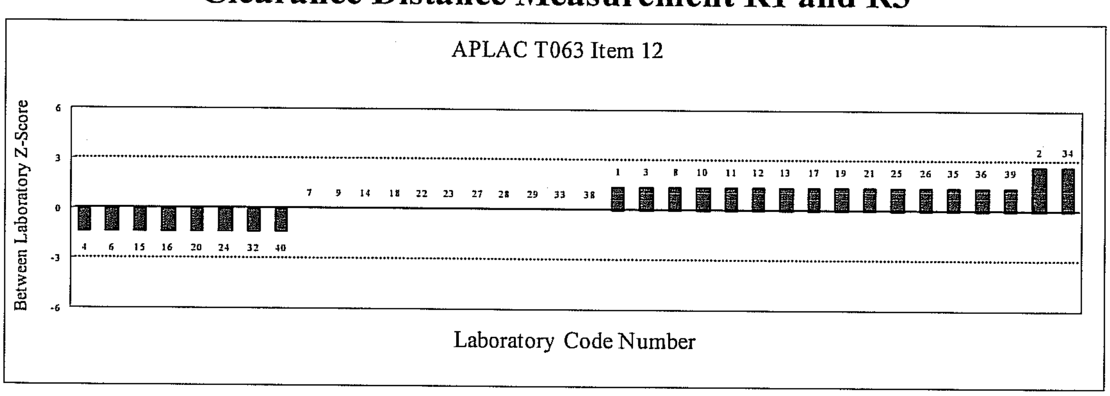


Table 4 Information of Test

Lab Code	Temperature (℃)	RH (%)	Instrument	Method
1	23.3	65	C	NIL
2	23	56	G (QPS1250)/ Digital Caliper (QPS610)	NIL
3	26	64	I: Vernier Calliper	IEC60664-4:2002 Clause 4.2 Pollution Degree 2, CTL Decision sheet 590
4	22	35	Stereo Microscope Wild Type 327615	NIL
6	24.3	57.6	C	IEC60664-4:2002 clause 4.2 (Refer to CTL decision sheet 590)
7	21.7	50.5	G, I: Vernier Callipers	NIL
8	25.6	45.2	D	NIL
9	23	60	H, I: Microscope with integrated micrometers	Direct measurement for thickness and trigero-metric calculations
10	24.7	38	I: reading microscope & separate vernier callipers	NIL
11	21	41	I and C	NIL
12	25	59	D	NIL
13	22.4	54	C and I	NIL
14	24.9	37.4	C	NIL
15	22.3	54.6	C	NIL
16	25	50	C	NIL
17	26	62	C	NIL
18	22±1	52±3	I: Microscope with separate microruler	NIL
19	26	65	NIL	NIL

Lab Code	Temperature (℃)	RH (%)	Instrument	Method
20	23	50	C 1.hand lens, M3-469 cal due date:14/12/2008 2.Caliper, M3-688 cal due date:23/09/2008	IEC60664-4:2002 clause 4.2 , CTL DSH 590
21	22	54	D	NIL
22	25	63	I: viewed and measured with verier calipers, and radius gauge.	NIL
23	26	52	C	NIL
24	20	55	I: Microscope J: Microscope and vernier callipers	IEC 60664-1:2002
25	23	60	B & D	NIL
26	21	51	C	NIL
27	22	50	C and G	NIL
28	21.3	29	H & C	NIL
29	23	52	H: 0~25mm, 0.001mm I: Microscope STM6-F10-3, 0.001mm/0.5±μm	IEC 60664-1, and the Pollution degree is 2
32	20	48	C I: tested with feeler gauges	NIL
33	23	35	C: digital calliper	IEC60664-4:2002 clause 4.2
34	24.8	43.5	I: viewed and measured with integrated microscope	IEC60664-4:2002 clause 4.2. And CTL decision sheet 590, Pollution degree 2 was considered.
35	21	38	Viewed with loupe, measured with separated digimatic caliper.	IEC 60950-1; 2005, Annex F
36	26	58	C: Vernier caliper with least count of 0.02mm G: Peak scale type 7x, Graduated Eyepiece with least count of 0.1mm	IEC 60950-1; 2001, Annex F

Lab Code	Temperature (℃)	RH (%)	Instrument	Method
38	25	50	C	NIL
39	NIL	NIL	D	IEC 60950-1
40	25	60	C	NIL

Appendix B

Preparation of the samples

Homogeneity testing

SAMPLE PREPARATION

The samples used in this program were originally supplied by DongYing microelectronics CORP, Taiwan. The sample-Printed Circuit Board size is 6x6 cm2 with TAF logo on the front. Printed Circuit Board is discussed and designed. This was not made known to the participants at the time of testing. It use same material for safety test. Since the purpose is to compare the safety test of technological ability of the laboratories. It is therefore imperative that the samples of supply are carefully selected and samples supplied to the laboratories.15 samples were used for testing homogeneity.

HOMOGENEITY TESTING

To allow suitable and reliable proficiency testing, homogeneity tests will be conducted on randomly selected samples before test samples are distributed to participants.

For the homogeneity check, at least 15 samples prepared in their final package will be selected in random. For the 15 test samples, measurement results for each of tests will be obtained under repeatability conditions.

For the samples to be accepted as suitable for use, the results of this testing and any applicable statistical analysis (i.e. Robust CV or ANOVA) of the results must indicate that no significant variability existed. Thus any outlier results subsequently identified in a program will not be attributable to sample variability.

Reference to the results of homogeneity has find the distance between F1 and F2 was not homogenous. We consider that the main cause is due to the measurement distance between F1 and F2 is too short to meet the homogenous. Because the factors of the sample design, it may cause measuring judgment variation, then affect the measurement result. For the distance between F1 and F2 measuring point is too small, it may have big error effect. If using the data for validation, the result must be not convergent since F1 and F2 are not suitable as a basis for proficiency test.

After meeting discussion, because the sample groove design is 1cm, it would affect the test result on F1, F2 and R1, R2 and cause the judgment difference of the participants' pollution level, and then affect the measurement result.

If not considering that pollution might affect the measurement result and it might cause the big difference on data analysis when sample design; we find the result of the creepage distance between F1 and F2 and the creepage distance between R1 and R2 are divided into two groups because the attending laboratories measuring the width of groove between F1 and F2 have different result (＞1mm and ＜1mm). Classify the F1, F2 and R1, R2 creepage distance data that was replied from participants, and re-do the data analysis using F1, F2 and R1, R2 groove measurement data upon the condition greater than 1mm and shorter than 1mm. Analysis result, the laboratory shrinks for the difference of the data.

Table 5 ANOVA TABLE (One-Way ANOVA)

Sources	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio
Between	SSB	$K-1$	MSB	$F=\dfrac{MSB}{MSE}$
Within	SSW	$N-K$	MSW	
Total	SSTO	$N-1$		

$$\mathrm{SSTO}=\sum_{i=1}^{k}\sum_{j=1}^{n_i}(X_{ij}-\overline{X}_{\cdot\cdot})^2=\sum_{i=1}^{k}\sum_{j=1}^{n_i}X_{ij}^{\ 2}-\frac{X_{\cdot\cdot}^2}{N}$$

$$\mathrm{SSB}=\sum_{i=1}^{k}\sum_{j=1}^{n_i}(\overline{X}_{i\cdot}-\overline{X}_{\cdot\cdot})^2=\sum_{i=1}^{k}\frac{X_{i\cdot}^2}{n_i}-\frac{X_{\cdot\cdot}^2}{N}$$

$$\mathrm{SSW}=\sum_{i=1}^{k}\sum_{j=1}^{n_i}(X_{ij}-\overline{X}_{i\cdot})^2$$

where K is the number of treatments, n_j is the number of observations in the jth treatment and $N=n_1+n_2+\cdots+n_K$.

Table 6 Homogeneity Testing Results

TAF-CNLA-CE15F TEST REPORT

IEC 60664-1:2002 AND CTL decision sheet 590

Report Reference No.:	
Compiled by (+ signature):	Eric Lai Project Engineer
Approved by (+ signature):	Jason Chuang Director
Date of Start:	April 3, 2008
Date of Issue:	April 30, 2008
Number pages:	7
Testing laboratory	**Sporton International Inc.**
Address:	14Fl.-2, No. 186, Jianyi Rd., Junghe City, Taipei Hsien
Testing location:	Taiwan
TAF Certificate Form No.:	1151
BSMI Laboratory No:	SL2-IN/VA-T-0106
Applicant:	**Taiwan Accreditation Foundation**
Address:	8F, No.20, Nan-Hai Road, Taipei, Taiwan 100-74, R.O.C
Standard:	IEC 60664-1:2002 及 CTL decision sheet 590
Possible test case verdicts:	Complied
Type of test object:	Printed Circuit Board size is 6x6 cm^2
Model/type reference:	
Manufacturer:	DongYing microelectronics CORP, Taiwan
Address:	
Rating:	

Homogeneity Testing Results

Clearances mesurement (mm)															
Location \ Sample No.	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
F1 and F2	3.66	3.72	3.73	3.70	3.77	3.79	3.70	3.71	3.80	3.83	3.67	3.66	3.79	3.73	3.70
	3.62	3.66	3.73	3.70	3.77	3.79	3.70	3.71	3.85	3.80	3.65	3.63	3.79	3.73	3.69
	3.66	3.73	3.73	3.70	3.76	3.79	3.70	3.71	3.80	3.83	3.66	3.66	3.79	3.72	3.70
	3.62	3.66	3.72	3.70	3.77	3.79	3.70	3.70	3.85	3.80	3.65	3.63	3.79	3.73	3.69
	3.66	3.72	3.73	3.71	3.77	3.78	3.70	3.71	3.81	3.83	3.67	3.65	3.79	3.73	3.70
	3.61	3.66	3.73	3.70	3.77	3.79	3.70	3.71	3.85	3.80	3.65	3.63	3.79	3.72	3.69
	3.66	3.72	3.73	3.70	3.76	3.79	3.71	3.71	3.80	3.83	3.67	3.66	3.78	3.73	3.69
	3.62	3.66	3.73	3.70	3.77	3.79	3.70	3.71	3.85	3.81	3.65	3.63	3.79	3.73	3.69
	3.66	3.73	3.73	3.71	3.77	3.79	3.70	3.71	3.80	3.83	3.67	3.66	3.78	3.72	3.70
	3.62	3.66	3.72	3.70	3.77	3.78	3.70	3.71	3.86	3.80	3.64	3.63	3.79	3.73	3.69
Combined Standard Uncertainty (um)	35	45	21	21	21	21	21	21	40	27	27	27	21	21	21
Expanded (k=2) (um)	70	90	42	42	42	42	42	42	80	53	53	53	42	42	42

Clearances mesurement (F1 and F2)

Source	*SS*	*D.F.*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.3416	14	0.0244	7.23956	4.76E-11	1.765688
Within	0.455	135	0.00337			
Total	0.7966	149				

Creepage mesurement (mm)															
Sample No. / Location	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
F1 and F2	3.66	3.72	3.73	3.70	3.77	3.75	3.70	3.71	3.84	3.82	3.67	3.66	3.79	3.73	3.70
	3.62	3.66	3.73	3.70	3.77	3.75	3.70	3.71	3.83	3.82	3.65	3.63	3.79	3.73	3.69
	3.65	3.72	3.72	3.71	3.77	3.75	3.71	3.71	3.84	3.82	3.67	3.66	3.79	3.73	3.69
	3.62	3.66	3.73	3.70	3.77	3.75	3.70	3.70	3.84	3.82	3.65	3.64	3.79	3.73	3.69
	3.66	3.66	3.73	3.70	3.76	3.75	3.70	3.71	3.84	3.82	3.66	3.65	3.79	3.73	3.70
	3.62	3.72	3.73	3.70	3.77	3.74	3.70	3.71	3.83	3.82	3.65	3.63	3.79	3.72	3.69
	3.66	3.73	3.73	3.71	3.77	3.75	3.70	3.71	3.84	3.82	3.67	3.66	3.78	3.73	3.70
	3.62	3.66	3.73	3.70	3.77	3.75	3.71	3.71	3.83	3.81	3.64	3.63	3.79	3.73	3.70
	3.66	3.72	3.72	3.70	3.76	3.75	3.70	3.71	3.83	3.82	3.67	3.66	3.79	3.73	3.70
	3.63	3.65	3.73	3.70	3.77	3.75	3.70	3.71	3.83	3.82	3.65	3.63	3.79	3.73	3.69
Combined Standard Uncertainty (um)	31	50	21	21	21	21	21	21	21	21	27	27	21	21	21
Expanded (k=2) (um)	61	101	42	42	42	42	42	42	42	42	53	53	42	42	42

Creepage mesurement (F1 and F2)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.135733	14	0.009695	1.959367	0.025477	1.765688
Within	0.668	135	0.004948			
Total	0.803733	149				

Clearances mesurement (mm)

Location \ Sample No.	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
F2 and F3	9.9	10.0	10.0	10.0	10.0	9.9	9.9	10.0	10.0	9.9	10.0	9.9	10.0	9.9	10.0
	10.0	10.0	10.0	9.9	9.9	10.0	10.0	9.9	10.0	9.9	9.9	9.9	10.0	10.0	9.9
	10.0	9.9	10.0	10.0	9.9	10.0	9.9	9.9	10.0	9.9	9.9	9.9	10.0	9.9	10.0
	9.9	10.0	9.9	10.0	10.0	9.9	10.0	10.0	9.9	10.0	9.9	10.0	9.9	9.9	10.0
	9.9	10.0	9.9	10.0	10.0	9.9	10.0	9.9	10.0	9.9	10.0	10.0	10.0	10.0	9.9
	10.0	9.9	10.0	9.9	10.0	10.0	9.9	9.9	10.0	9.9	10.0	10.0	10.0	9.9	10.0
	9.9	10.0	9.9	10.0	9.9	10.0	10.0	9.9	10.0	10.0	9.9	10.0	9.9	10.0	9.9
	10.0	9.9	10.0	10.0	10.0	9.9	9.9	10.0	10.0	9.9	10.0	9.9	10.0	9.9	10.0
	9.9	10.0	9.9	10.0	9.9	10.0	9.9	10.0	10.0	10.0	9.9	9.9	10.0	10.0	9.9
	9.9	10.0	9.9	10.0	10.0	9.9	10.0	10.0	9.9	10.0	9.9	10.0	9.9	9.9	10.0
Combined Standard Uncertainty (um)	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61
Expanded (k=2) (um)	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122

Clearances mesurement (F2 and F3)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.027733	14	0.001981	0.779675	0.689514	1.765688
Within	0.343	135	0.002541			
Total	0.370733	149				

Creepage mesurement (mm)															
Sample No. / Location	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
F2 and F3	9.9	10.0	9.9	10.0	10.0	9.9	9.9	10.0	9.9	10.0	9.9	10.0	9.9	10.0	9.9
	9.9	9.9	9.9	9.9	10.0	10.0	9.9	10.0	9.9	10.0	10.0	10.0	9.9	10.0	10.0
	9.9	9.9	9.9	9.9	10.0	9.9	10.0	10.0	10.0	9.9	10.0	10.0	10.0	10.0	9.9
	9.9	10.0	9.9	10.0	9.9	9.9	10.0	10.0	10.0	9.9	10.0	10.0	10.0	9.9	9.9
	10.0	9.9	10.0	10.0	10.0	9.9	10.0	9.9	10.0	9.9	10.0	10.0	9.9	10.0	9.9
	9.9	9.9	10.0	10.0	9.9	10.0	10.0	10.0	9.9	10.0	9.9	10.0	10.0	9.9	10.0
	10.0	10.0	9.9	10.0	10.0	10.0	9.9	9.9	9.9	10.0	10.0	10.0	9.9	10.0	9.9
	10.0	9.9	9.9	10.0	10.0	9.9	10.0	9.9	9.9	10.0	9.9	10.0	10.0	9.9	10.0
	9.9	10.0	10.0	9.9	9.9	9.9	10.0	9.9	10.0	10.0	10.0	10.0	10.0	10.0	9.9
	9.9	9.9	9.9	10.0	9.9	10.0	10.0	10.0	10.0	9.9	10.0	9.9	10.0	9.9	10.0
Combined Standard Uncertainty (um)	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61
Expanded (k=2) (um)	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122

Creepage mesurement (F2 and F3)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.039733	14	0.002838	1.157531	0.315114	1.765688
Within	0.331	135	0.002452			
Total	0.370733	149				

Clearances mesurement (mm)															
Sample No. / Location	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
R1 and R3	22.8	22.7	22.7	22.7	22.8	22.7	22.8	22.7	22.8	22.7	22.7	22.8	22.7	22.8	22.7
	22.7	22.7	22.8	22.8	22.7	22.8	22.7	22.8	22.7	22.8	22.8	22.7	22.8	22.8	22.8
	22.8	22.7	22.8	22.8	22.7	22.7	22.8	22.7	22.6	22.7	22.7	22.8	22.8	22.7	22.7
	22.7	22.8	22.6	22.8	22.7	22.7	22.7	22.8	22.8	22.8	22.8	22.7	22.7	22.7	22.8
	22.7	22.8	22.8	22.7	22.8	22.7	22.7	22.8	22.7	22.8	22.7	22.8	22.8	22.6	22.8
	22.8	22.7	22.7	22.7	22.8	22.8	22.7	22.7	22.8	22.8	22.8	22.6	22.7	22.8	22.7
	22.7	22.8	22.7	22.7	22.7	22.7	22.8	22.7	22.8	22.8	22.8	22.7	22.8	22.8	22.8
	22.7	22.7	22.8	22.7	22.8	22.6	22.8	22.7	22.7	22.8	22.8	22.7	22.8	22.7	22.8
	22.8	22.8	22.7	22.8	22.7	22.8	22.7	22.7	22.8	22.7	22.7	22.7	22.8	22.8	22.8
	22.8	22.7	22.8	22.8	22.8	22.8	22.7	22.7	22.7	22.8	22.7	22.7	22.7	22.7	22.7
Combined Standard Uncertainty (um)	61	61	117	61	61	117	61	61	117	61	61	117	61	117	61
Expanded (k=2) (um)	122	122	234	122	122	234	122	122	234	122	122	234	122	234	122

Clearances mesurement (R1 and R3)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.023733	14	0.001695	0.511985	0.922949	1.765688
Within	0.447	135	0.003311			
Total	0.470733	149				

Creepage mesurement (mm)															
Sample No. / Location	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
R1 and R3	25.6	25.8	25.6	25.9	25.8	25.9	25.9	25.7	25.9	25.6	25.9	25.9	25.9	25.7	25.6
	25.7	25.8	25.7	25.9	25.6	25.8	25.6	25.6	25.6	25.6	25.8	25.6	25.9	25.8	25.6
	25.6	25.6	25.8	25.6	25.6	25.8	25.7	25.7	25.7	25.8	25.8	25.7	25.9	25.6	25.6
	25.7	25.7	25.8	25.7	25.6	25.8	25.8	25.9	25.9	25.9	25.6	25.6	25.6	25.9	25.9
	25.9	25.9	25.9	25.9	25.9	25.6	25.8	25.6	25.9	25.7	25.6	25.6	25.6	25.6	25.9
	25.6	25.9	25.7	25.6	25.9	25.7	25.8	25.9	25.8	25.9	25.6	25.8	25.8	25.9	25.8
	25.6	25.9	25.8	25.6	25.9	25.9	25.9	25.9	25.6	25.6	25.6	25.8	25.8	25.9	25.6
	25.7	25.7	25.8	25.6	25.8	25.6	25.9	25.6	25.9	25.6	25.6	25.9	25.8	25.8	25.7
	25.6	25.7	25.8	25.6	25.9	25.7	25.9	25.6	25.6	25.7	25.6	25.6	25.9	25.6	25.6
	25.7	25.9	25.9	25.6	25.9	25.6	25.6	25.8	25.7	25.9	25.9	25.7	25.6	25.8	25.6
Combined Standard Uncertainty (um)	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174
Expanded (k=2) (um)	349	349	349	349	349	349	349	349	349	349	349	349	349	349	349

Creepage mesurement (R1 and R3)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.2264	14	0.016171	1.040087	0.418068	1.765688
Within	2.099	135	0.015548			
Total	2.3254	149				

Clearances mesurement (mm)															
Sample No. / Location	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
R1 and F3	8.3	8.4	8.3	8.3	8.4	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.4	8.3	8.3
	8.4	8.3	8.4	8.3	8.4	8.4	8.4	8.3	8.4	8.4	8.3	8.4	8.3	8.4	8.4
	8.3	8.3	8.3	8.3	8.3	8.4	8.3	8.3	8.4	8.4	8.3	8.4	8.3	8.4	8.3
	8.4	8.4	8.3	8.3	8.4	8.3	8.3	8.3	8.4	8.3	8.4	8.4	8.3	8.3	8.4
	8.4	8.3	8.4	8.3	8.4	8.4	8.3	8.4	8.3	8.3	8.4	8.3	8.3	8.3	8.4
	8.3	8.3	8.4	8.3	8.3	8.4	8.3	8.3	8.3	8.3	8.3	8.4	8.3	8.3	8.4
	8.4	8.4	8.4	8.3	8.4	8.3	8.4	8.3	8.4	8.4	8.3	8.4	8.4	8.3	8.4
	8.3	8.4	8.3	8.4	8.4	8.3	8.3	8.4	8.4	8.3	8.3	8.4	8.3	8.4	8.3
	8.3	8.3	8.3	8.4	8.3	8.4	8.3	8.4	8.3	8.3	8.4	8.3	8.4	8.4	8.4
	8.4	8.4	8.3	8.3	8.3	8.4	8.4	8.3	8.4	8.4	8.4	8.3	8.3	8.4	8.3
Combined Standard Uncertainty (um)	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61
Expanded (k=2) (um)	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122

Clearances mesurement (R1 and F3)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.025733	14	0.001838	0.717176	0.754215	1.765688
Within	0.346	135	0.002563			
Total	0.371733	149				

Creepage mesurement (mm)															
Sample No. / Location	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
R1 and F3	8.3	8.4	8.3	8.3	8.3	8.3	8.4	8.4	8.3	8.4	8.3	8.3	8.3	8.4	8.3
	8.4	8.3	8.3	8.3	8.4	8.4	8.4	8.3	8.3	8.4	8.4	8.4	8.4	8.4	8.3
	8.3	8.3	8.3	8.3	8.4	8.4	8.4	8.4	8.3	8.3	8.4	8.4	8.4	8.3	8.4
	8.4	8.4	8.3	8.3	8.3	8.4	8.4	8.3	8.3	8.3	8.4	8.3	8.3	8.3	8.4
	8.4	8.3	8.3	8.3	8.3	8.4	8.3	8.4	8.3	8.3	8.4	8.3	8.4	8.4	8.3
	8.3	8.4	8.3	8.3	8.4	8.3	8.3	8.4	8.3	8.4	8.4	8.3	8.4	8.3	8.4
	8.4	8.3	8.4	8.4	8.3	8.3	8.3	8.4	8.3	8.3	8.3	8.3	8.3	8.3	8.4
	8.4	8.3	8.3	8.4	8.3	8.3	8.3	8.3	8.3	8.4	8.3	8.3	8.4	8.4	8.3
	8.3	8.4	8.3	8.4	8.4	8.4	8.3	8.4	8.3	8.3	8.4	8.3	8.4	8.3	8.3
	8.3	8.4	8.4	8.3	8.4	8.3	8.4	8.4	8.3	8.4	8.4	8.4	8.3	8.4	8.3
Combined Standard Uncertainty (um)	61	61	61	61	61	61	61	61	20	61	61	61	61	61	61
Expanded (k=2) (um)	122	122	122	122	122	122	122	122	40	122	122	122	122	122	122

Creepage mesurement (R1 and F3)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.047733	14	0.00341	1.425033	0.149626	1.765688
Within	0.323	135	0.002393			
Total	0.370733	149				

Clearances mesurement (mm)															
Sample No / Location	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
R1 and R2	17.7	17.9	17.9	17.8	17.9	17.9	17.7	17.8	17.7	17.8	17.8	17.8	17.8	17.7	17.8
	17.8	17.8	17.8	17.7	17.8	17.8	17.8	17.8	17.9	17.8	17.8	17.8	17.9	17.8	17.8
	17.7	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.7	17.8	17.8	17.8	17.8	17.9	17.8
	17.9	17.8	17.8	17.9	17.8	17.7	17.8	17.8	17.8	17.8	17.7	17.7	17.7	17.8	17.7
	17.8	17.7	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.7	17.9	17.9
	17.8	17.8	17.8	17.7	17.8	17.9	17.8	17.8	17.7	17.8	17.9	17.9	17.8	17.8	17.7
	17.9	17.9	17.8	17.8	17.8	17.7	17.8	17.8	17.7	17.8	17.8	17.7	17.8	17.8	17.8
	17.8	17.8	17.8	17.9	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.7	17.8	17.8
	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.7	17.9	17.8	17.8	17.8	17.8	17.8	17.7
	17.9	17.9	17.9	17.8	17.8	17.7	17.8	17.8	17.8	17.7	17.8	17.8	17.8	17.8	17.7
Combined Standard Uncertainty (um)	117	117	61	117	61	117	61	61	117	61	117	117	117	117	117
Expanded (k=2) (um)	234	234	122	234	122	234	122	122	234	122	234	234	234	234	234

Clearances mesurement (R1 and R2)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.031333	14	0.002238	0.691402	0.779688	1.765688
Within	0.437	135	0.003237			
Total	0.468333	149				

Creepage mesurement (mm)															
Sample No. / Location	1 (79)	2 (263)	3 (198)	4 (257)	5 (176)	6 (44)	7 (217)	8 (229)	9 (272)	10 (280)	11 (139)	12 (230)	13 (298)	14 (74)	15 (125)
R1 and R2	31.7	31.9	31.9	31.7	31.7	31.8	31.7	31.7	31.8	31.7	31.8	31.8	31.8	31.7	31.9
	31.7	31.8	31.8	31.9	31.9	31.8	31.9	31.7	31.8	31.7	31.9	31.8	31.9	31.9	31.9
	31.7	31.9	31.9	31.7	31.8	31.9	31.7	31.8	31.9	31.7	31.9	31.9	31.9	31.8	31.7
	31.9	31.9	31.9	31.7	31.9	31.7	31.8	31.8	31.7	31.7	31.9	31.9	31.8	31.7	31.9
	31.8	31.8	31.7	31.8	31.8	31.7	31.9	31.9	31.7	31.9	31.9	31.9	31.9	31.7	31.8
	31.7	31.9	31.7	31.9	31.8	31.8	31.8	31.7	31.9	31.8	31.8	31.7	31.7	31.8	31.9
	31.9	31.7	31.8	31.7	31.9	31.9	31.9	31.7	31.8	31.7	31.8	31.9	31.9	31.7	31.9
	31.7	31.8	31.9	31.8	31.7	31.8	31.7	31.8	31.9	31.9	31.7	31.7	31.8	31.9	31.8
	31.7	31.9	31.9	31.7	31.7	31.9	31.7	31.8	31.8	31.7	31.9	31.7	31.8	31.7	31.9
	31.9	31.7	31.9	31.7	31.9	31.9	31.8	31.9	31.9	31.7	31.7	31.9	31.9	31.8	31.7
Combined Standard Uncertainty (um)	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117
Expanded (k=2) (um)	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234

Creepage mesurement (R1 and R2)

Source	*SS*	*D.F*	*MS*	*F-Ratio*	*P-value*	*Critical value*
Between	0.139733	14	0.009981	1.422839	0.150615	1.765688
Within	0.947	135	0.007015			
Total	1.086733	149				

Appendix C

Instructions to Accreditation Body

Instructions to Participants

Results Sheet

Asia Pacific Laboratory Accreditation Cooperation

APLAC T063 Safety Test for Creepage and Clearance Distance Proficiency Testing Program

Instruction to Accreditation Bodies

1. ORGNAIZATION

Taiwan Accreditation Foundation (TAF) organizes APLAC T063 Safety Test for Creepage and Clearance Distance Proficiency Testing Program, which is under the auspices of Asia Pacific Laboratory Accreditation Cooperation (APLAC). The objective of this proficiency testing program is to evaluate the competence of laboratories for the safety test of the insulation distance measurement for the designated Printed Circuit Board, such as creepage and clearance distances.

2. SAMPLE

Accreditation bodies (AB) will receive samples, the Instructions to Accreditation Bodies and Receipt Form (hard copy and soft copy) from the organizers. Each participating laboratory is supplied with one Printed Circuit Board. Upon receipt, AB should carefully check the samples (number of samples and physical conditions, etc.) and shall promptly acknowledge the TAF by returning the Receipt Form (for Accreditation Bodies) through **E-mail and facsimile**.

Please E-mail and Fax to：
Taiwan Accreditation Foundation (TAF)
Ms. Jean Yang
FAX: +886-3-5726308
E-mail: jeanyang@taftw.org.tw

AB is recommended to promptly distribute the samples, together with the Instructions to Participating Laboratories and Result Sheet (hard and soft copy) to their respective participating laboratories.

AB shall remind their respective participating laboratories to carefully check the sample upon receipt and promptly acknowledge the TAF by returning the Receipt Form (for Participating Laboratories) through **E-mail and facsimile**.

Each participating accreditation body must be responsible for the shipping fees.

3. TESTS TO BE CARRIED OUT

Please refer to Instructions to Participating Laboratories enclosed. The Instructions to Participating Laboratories documents are master copies. The AB should make copies for distribution to the participating laboratories. Instructions could be e-mailed on request. If necessary, these documents should be translated into the appropriate language by the accreditation body.

4. DISTRIBUTION SCHEME

Before the beginning of the distribution scheme, homogeneity tests will be performed by the reference laboratory:

Junghe Safety Laboratory of Sporton International Inc.

It is the responsibility of the accreditation body to make sure that the test samples are dispatched to the participating laboratories in their own economy.

5. DOCUMENTS TO BE SUBMITTED

Within one week of the completion of the testing, participating laboratories are required to both facsimile and e-mail to their accreditation body the Result Sheet requested in the Instructions to Participating Laboratories. No other documentation is required. The accreditation body should provide details of any problems that their laboratories had.

The accreditation body should collect the documentation of the results from the participating laboratories, and then **E-mail/Facsimile** **Before 30 June 2008** to TAF.

On receipt of the information for this APLAC Proficiency Testing Program, **TAF** will prepare an interim report on each laboratory then sent back to the participating accreditation body. A final report will be issued at the end of the program with each laboratory only identified by a **confidential** code number.

6. GENERAL INFORMATION

For general queries, please contact:

Taiwan Accreditation Foundation (TAF)
Ms. Jean Yang
FAX: +886-3-5726308
E-mail: jeanyang@taftw.org.tw

Asia Pacific Laboratory Accreditation Cooperation

APLAC T063 Safety Test for Creepage and Clearance Distance Proficiency Testing Program

Receipt Form

In order to monitor the progress of the Proficiency Testing Program, we kindly ask each accreditation body, on receipt of the artifacts, to fill in this **Receipt Form** and E-mail/facsimile it to:

Taiwan Accreditation Foundation (TAF)
Ms. Jean Yang
FAX: +886-3-5726308
E-mail: jeanyang@taftw.org.tw

Thank you in advance for your cooperation.

1. The APLAC T063 artifacts were received on: ______________ (date).
2. After inspection, are the contents of the package damaged:
   ☐ Yes ☐ No, if yes, is it still suitable for use? ☐ Yes ☐ No
3. Is there a Declaration to Customs Officials and Shipping Agents enclosed in the plastic envelope and attached to the outside of the case? ☐ Yes ☐ No

Remarks: ____

____

____

Name of Accreditation Body: ______________________________

Contact Person: ________________

Fax: ________________________

E-mail: ______________________

Asia Pacific Laboratory Accreditation Cooperation

APLAC T063 Safety Test for Creepage and Clearance Distance Proficiency Testing Program

Instruction to Participating Laboratories

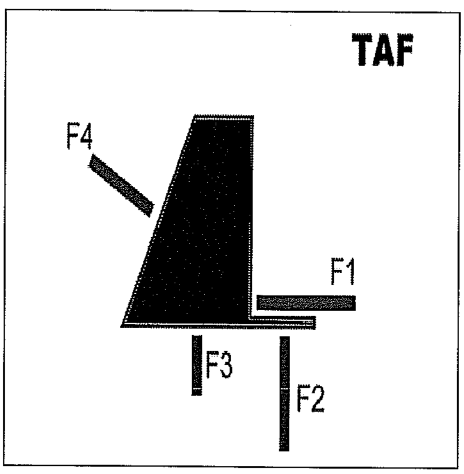
To ensure that results from this program can be analyzed properly, participants are asked to adhere carefully to the following instructions.

1. **SAMPLE**

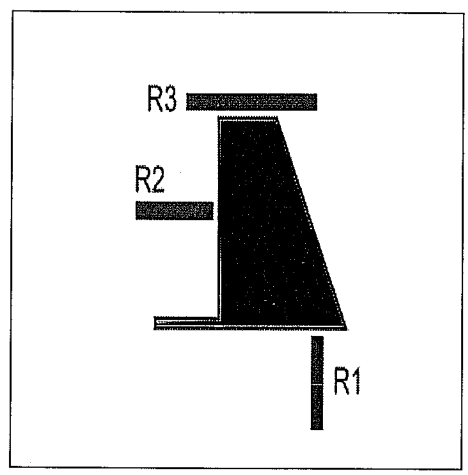
The participating laboratory will obtain one square Printed Circuit Board. On receipt of the artifacts, unpack and inspect them for any defects. Please contact with your accreditation body if the sample is damaged.

2. **TESTS TO BE PERFORMED**

Sample Information: The sample-Printed Circuit Board size is 6x6 cm^2 with TAF logo on the front. Please refer to the following figures:



Frontage of the Sample



Back of the Sample

Blue: Track on the front of sample with the logo of TAF

Green: Track on the back of sample

Black: Trapezoid cut out of sample

Testing Period: Test should be finished **within one week** after receiving the sample.

Test Method: The standard of applying for creepage and clearance distance determinations are **IEC60664-1: 2002 clause 4.2.** In addition, the participants are requested to refer to **CTL decision sheet 590**. (Please see the attachment file.)

Test Items: Measure Creepage and Clearance distances. The testing points details refer to Result Sheet (1), the each position should be measured 2 times, and then record the data and the average value in the Result Sheet (1). The data of creepage and clearance distances measurement unit should be millimeter (mm) to in one decimal place, which are recorded in the Result Sheet (1). However, there is no any restriction for the participants during the testing.

In the description blank, please describe the creepage and clearance distances path illustration of the chosen measurement points, and then show the measurement calculating method, in addition, to fill the data in the Result Sheet (2) and (3).

Where possible, uncertainties should be calculated using the method in the ISO Guide to the Expression of Uncertainty in Measurements.

3. DOCUMENTS TO BE SUBMITTED

Within one week of the completion of the tests, participating laboratories are required to send the Result Sheet(s) to their accreditation body (AB).

Submit the results electronically to the TAF on or before **30 June 2008** to jeanyang@taftw.org.tw using the soft copy of the Result Sheet(s) provided.

No other documents are required. Laboratories should make a copy of all documents and worksheets for their own records and keep these on file for an adequate period of time (at least until a final report has been issued).

An interim report draft with all the received data tabulated in a well-formatted table and the consensus values of each test will be sent out to all participating AB, then kindly request the participating AB distributes the interim report draft to the participating laboratories. Any clarification or correction of results should be made within 2 weeks after receipt of the interim report draft.

A final report will be issued at the end of the program with each participant only identified by a **confidential** code number.

4. CONFIDENTIALITY

For this program your laboratory has been allocated the code number shown on the interim report draft. All reference to your laboratory in reports associated with this program will be with this code number, thus ensuring confidentiality of results.

5. GENERAL INFORMATION

For general queries, please contact with your accreditation body, additional information may be obtained from:

Taiwan Accreditation Foundation (TAF)

Ms. Jean Yang

TEL：+886-3-5714848 Ext 224

FAX：+886-3-5726308

E-mail: jeanyang@taftw.org.tw

APLAC T063 Safety Test for Creepage and Clearance Distance

Result Sheet (1)

Lab Code: ____

Accreditation Body: ______________________

Lab Name: ______________________

Test Ambient:_____℃; _____% R.H. **Test Date:**______________ (day/month/year)

Creepage Distance Measurement (in one decimal place) **Sample No.:**______

No.	Locations between	1st (mm)	2nd (mm)	Average (mm)	Instrument Type (*)	Exp. Uncertainty
1	F1 and F2					
2	F2 and F3					
3	R1 and F3					
4	R1 and R2					
5	R1 and R3					

Clearance Distance Measurement (in one decimal place)

No.	Locations between	1st (mm)	2nd (mm)	Average (mm)	Instrument Type (*)	Exp. Uncertainty
1	F1 and F2					
2	F2 and F3					
3	R1 and F3					
4	R1 and R2					
5	R1 and R3					

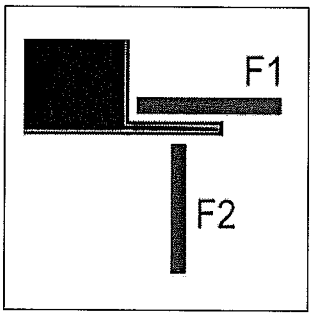
***Please tick the Instrument Type that you use in this program, and then fill in the table above.**

- ☐ A: viewed with hand lens, measured with separate ruler
- ☐ B: viewed with loupe, measured with separate ruler
- ☐ C: viewed with hand lens, measured with separate vernier callipers
- ☐ D: viewed with loupe, measured with separate vernier callipers
- ☐ E: viewed with hand lens, measured with separate micrometer
- ☐ F: viewed with loupe, measured with separate micrometer
- ☐ G: viewed and measured with integrated lens/reticule
- ☐ H: viewed and measured with integrated micrometer
- ☐ I: other, ______________________

APLAC T063 Safety Test for Creepage and Clearance Distance

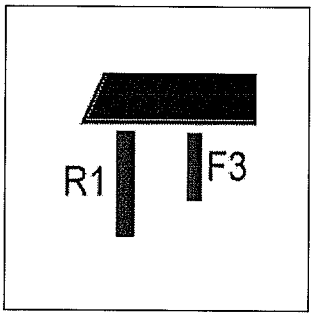
Result Sheet (2)

1. Please describe the creepage distance of F1 and F2.



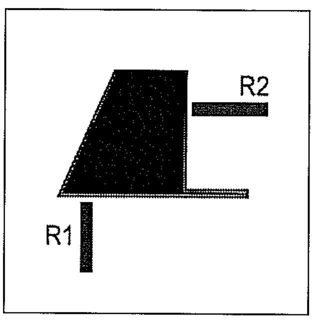
Description:

2. Please describe the creepage distance of R1 and F3.



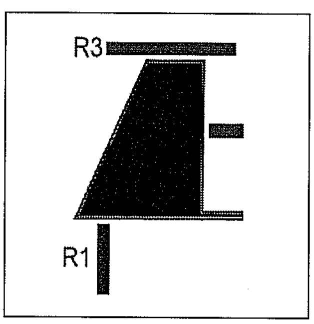
Description:

3. Please describe the creepage distance of R1 and R2.



Description:

4. Please describe the creepage distance of R1 and R3.



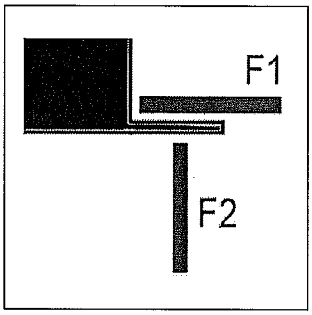
Description:

Signature: ______________________ Date: ______________________

APLAC T063 Safety Test for Creepage and Clearance Distance

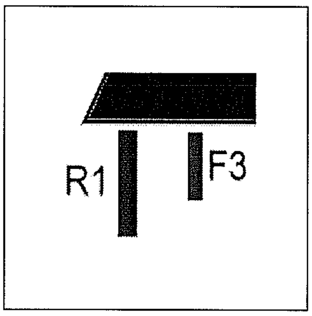
Result Sheet (3)

1. Please describe the clearance distance of F1 and F2.



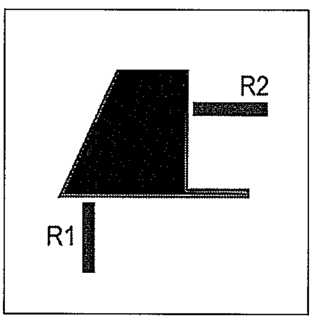
Description:

2. Please describe the clearance distance of R1 and F3.



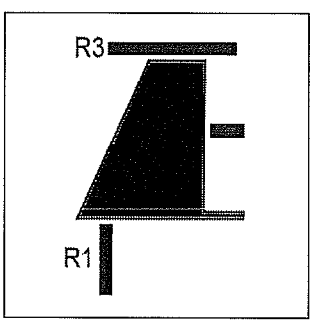
Description:

3. Please describe the clearance distance of R1 and R2.



Description:

4. Please describe the clearance distance of R1 and R3.



Description:

Signature: ______________________ Date: ______________________

Measurement Uncertainty Budget

Items	Factors of Uncertainty x_i	Type A / Type B	Probability Distribution	Standard Uncertainty $u(x_i)$	Coverage Factor(κ)
Combined Standard Uncertainty $u_c(Y)$:					
Expanded Uncertainty (95% confidence interval) $U_{exp} = \kappa \times u_c(y)$:					

Please make copies of this form if there is no enough blank.

Signature: ____________________ Date: ____________________

INSTRUCTIONS – MEASUREMENT UNCERTAINTY

Part (1) Background information & justification for this change

ISO/IEC 17025 requires that, except under specified conditions, the uncertainty of measurement associated with the results of tests and measurements must be estimated.

What is uncertainty of measurement?

Uncertainty of measurement is defined as a "parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand" (the measurand is the particular quantity subject to measurement).

The result of a test or measurement is our best estimate of the true value of the measurand. The result is imperfect. The true value of the measurand is contained within a range of values about the measurement result and the "uncertainty of measurement" is an estimate of the magnitude of that range expressed at a given level of confidence (confidence interval). Uncertainty of measurement is usually given as a 95% confidence interval and would normally be expressed in the appropriate SI units (ie. mm, °C, g/l, MPa etc).

For example, the result of a measurement might be 5.1 mg/l with an uncertainty of ±0.2 mg/l at a 95% level of confidence. This means that there is an estimated 95% probability that the true value is in the range 4.9 mg/l to 5.3 mg/l. The 95% probability means that there is an estimated one in twenty chance that the true value is outside that range.

Uncertainty of measurement may also be expressed as a percentage where appropriate.

To assist laboratories to comply with the requirements of ISO/IEC 17025 for estimating uncertainty and to promote a uniform methodology in its estimation, information packages for APLAC PT testing program participants now include general guidance relating to estimating uncertainties for the specific testing involved, and final program reports will now include relevant worked examples. All program participants are required to report their estimates of uncertainty to their accreditation bodies along with their results unless the Technical Adviser to the program specifically waives any requirement to estimate uncertainties. The estimates of uncertainty provided by participants will be incorporated into the final program reports enabling direct comparison of uncertainty estimates across the program participants. The uncertainty estimates will not be used in the evaluation of the results on the primary samples.

How is uncertainty of measurement to be estimated?

APLAC expects that program participants' uncertainties of measurement would be estimated in accordance with the requirements of the respective member accreditation bodies. There are different approaches and methodologies available. Worked examples provided in APLAC PT program reports will generally be based on ISO GUM but will recognise other methodologies in accordance with 5.4.6.3 NOTE 3 in ISO 17025.

Estimates of uncertainty of measurement provided by program participants are required to be given at the 95% level of confidence.

ISO GUM methodology

An estimate of uncertainty of measurement would usually be based on the combination of a number of influencing parameters (components of uncertainty) such as errors in reference values, instrument errors, repeatability, thermal effects, weighing errors, inhomogeneity etc. ISO GUM methodology requires that the influence of each component of uncertainty on the measurement result be quantified and expressed numerically as a standard deviation. These values are then combined according to the rules of the propagation of uncertainty to produce a combined standard deviation (combined standard uncertainty) and the combined standard uncertainty is multiplied by a coverage factor to produce an expanded uncertainty at the required level of confidence. Detailed descriptions and information on the implementation of this methodology have been published by ISO2, UKAS3 and Eurachem/CITAC4 and made available over the internet[7].

Uncertainty of measurement is best estimated within the individual laboratory environment. All factors which will have a significant influence on the test or measurement result must be included in the estimation process. There must be suitable programs utilising reference standards, instruments and materials to ensure on-going and adequate quality control and repeatability and reproducibility of methods and equipment over time. In many instances, it will be possible to utilise quality control data in assessing uncertainty components such as precision. Where these data are not available, it may be necessary to carry out precision studies or to rely on published information about the method or portions of it until the laboratory can obtain its own estimates.

APLAC is aware of the general need for better estimates of uncertainty, and estimates that are obtained under similar conditions in all laboratories. PT programs are useful mechanisms for spreading awareness of uncertainty of measurement and the effects of different ways of estimating it. We anticipate that the information made available through PT programs will help focus discussions on uncertainty of measurement.

APLAC Technical Committees will interpret the information and report on current practices. They will also make recommendations for improving the collection of uncertainty data, the estimation of uncertainties and incorporating data and information on uncertainty of measurement into PT program reports. Therefore we anticipate an evolution in the mechanisms for collecting and reporting uncertainty data and associated information over the next few years.

Participation in APLAC PT programs should assist laboratories to develop appropriate estimates of uncertainty, help to guide accreditation bodies to adopting common and consistent approaches leading to enhanced understanding and international comparability of measurements among the member nations.

APLAC will consider the use of estimates of uncertainty of measurement in the evaluation of its PT testing program results after it is satisfied that participating laboratories are estimating uncertainties of measurement in an appropriate and consistent manner.

Here are a few important terms:

Standard uncertainty (*u(xi)*) is an input component of uncertainty *xi* expressed as a standard deviation. It should be expressed in the units of the influencing parameter, but may be expressed as a percentage where convenient.

Type A evaluation estimates of standard uncertainty are evaluated by applying statistical techniques to a series of repeatability or curve fitting data. For example, a standard uncertainty estimated from the repeatability of measurements on replicate samples is a Type A evaluation.

Type B evaluation estimates of standard uncertainty are based on assumed probability distributions, experience, laboratory records, or other information. For example, a standard uncertainty estimated using data provided on a calibration certificate is a Type B evaluation.

Sensitivity coefficient (*ci*) is the mathematical relationship between an influencing parameter and its effect on the result of a measurement. In many instances it is unity. That is, there is a one to one relationship between the value of the influence and its effect on the measurement result. For example, when weighing a sample of material, any uncertainty due to errors in the balance reading will have a one to one effect on the measurement result. On the other hand, if we are considering the influence of temperature on the length of a metal bar then the sensitivity coefficient is equal to the coefficient of linear thermal expansion for the metal bar multiplied by the length of the bar. It is important to note that a sensitivity coefficient has units. It is also important to note that the calculation methodology used by Eurachem/CITAC4 incorporates sensitivity coefficients in a manner that does not require their specific evaluation.

Combined standard uncertainty (*uc(y)*) is the final estimate of uncertainty for the test or measurement result *y* expressed as a standard deviation. It is calculated by multiplying the standard uncertainty *u(xi)* for each input component *(xi)* with its respective sensitivity coefficient *ci* to produce *ciu(xi)* and then combining those values by taking the square root of the sum of their squares. Note that the products $c_i u(x_i)$ must each be expressed in the same units as those required for expressing the combined estimate $u_c(y)$.

Expanded uncertainty (U) is the final result of our estimate of uncertainty expressed as a confidence interval. It is calculated by multiplying the combined standard uncertainty by a coverage factor to produce the desired level of confidence (usually 95%).

Coverage factor (k) is a multiplier used to expand the combined standard uncertainty $u_c(y)$ to an interval that is estimated to contain the true value of the measurand at a given level of confidence ($U = k.u_c(y)$). The coverage factor then represents the number of standard deviations in the expanded uncertainty and is determined according to the Student-t distribution. A coverage factor of 2 is commonly used to approximate the expanded uncertainty to the 95% confidence level.

References

1. ISO-IEC 17025:1999. General requirements for the competence of testing and calibration laboratories. ISO, Geneva (1999)
2. Guide to the Expression of Uncertainty in Measurement. ISO, Geneva (1993)
3. UKAS LAB 12: The Expression of Uncertainty in Testing. UKAS, London (2000)
4. Eurachem / CITAC Guide QUAM: 2000.P1. Quantifying Uncertainty in Analytical Measurement, 2nd Edition (2000)
5. ISO/DTS 21748:2002 Guide for the use of repeatability, reproducibility, and trueness estimates in measurement uncertainty estimation.
6. APLAC TC 005, Interpretation and Guidance on the Estimation of Uncertainty of Measurement in Testing
7. www.A2LA.org / (for A2LA policies, links to guidance documents, including the UKAS Guide, and the Eurachem/CITAC Guide, at no cost), www.measurementuncertainty.org / (Eurachem/CITAC Guide), www.fasor.com/iso25 / (general information, links, and discussion of ISO-IEC 17025)

Appendix D

Statistical Procedures

Calculations and Formulae

STATISTICAL PROCEDURES

The procedures are based on robust statistics and use z-score to assess performance of participant. Z-score are normalized value that gives a score to each result, relative to the other numbers in the group, so a z-score value close to zero means that result agrees well with those from the other laboratories.

Robust statistics are statistics that are not highly influenced by the presence of extreme results. In a mathematical environment robustness is the ability of a statistical method center of a database, the mean (average), is not robust. A robust alternative to the mean is the median (the middle value). The difference between these two is best illustrated by the following example.

The statistical procedures use z-score to identify outlier results. An outlier will be any result(s), which has an absolute z-score value greater than three. Outliers are identified in the table by a marker (※) next to the relevant z-scores.

The calculation of the z-score depends on the statistical design of the program. Related samples can be identical (uniform pair) or similar (split pair). Occasionally it may be the case that a program can only be designed to have a single result on a single sample.

A very high between-laboratories z-score indicates that one or both of a laboratory's results is significantly higher than the consensus value (median). Similarly, a very low (i.e. negative) between-laboratories z-score shows that a laboratory's result(s) is lower than expected.

Summary of Statistics

The list of summary statistics appears at the bottom of the table of results and consists of:

1. The number of results for that test/sample (*No. of Results*);
2. The median of laboratory's results - i.e. the middle value (*Median*);
3. The normalized interquartile range of the results (*Normalized IQR*) – the interquartile range times 0.7413;
4. The robust coefficient of variation, expressed as a percentage (*Robust CV*) - i.e.

   $100\times$ *Normalized IQR* $\div$ *Median*;
5. The minimum and maximum laboratory results; and
6. The range (*Maximum* - *Minimum*).

Ordered Z-Score Charts

Ordered between laboratories z-score bar charts and ordered within laboratory z-score bar charts are also used to illustrate the data. Each laboratory z-score is drawn on a chart and identified by their code number. The z-score limits of $\pm$ 3 are also drawn which makes it easy to identify any bars extending past this point which would be outliers.

These charts contain solid lines at +3 and –3, so the outliers are clearly identifiable as the laboratories whose "bar" extends beyond these cut-off lines. The y-axis has been limited to range from –6 to +6, so in some cases very large or small (negative) Z-scores appear as extending beyond the limit of the chart.

STATISTICAL CALCULATIONS AND FORMULAE

Robust Z-Scores are calculated by replacing the mean and standard deviation in the "classical" Z-Score by the median and normalized IQR, respectively - i.e. the Z-Score for a result is the result minus the median (all) divided by the normalized IQR.

$$\text{Z-Score} = \frac{result - Median}{NormalizedIQR}$$

The median is the middle value of the group, i.e. half of the results are higher than it and half are lower. It is calculated from the sorted values (from lowest to highest). If N is an odd number, the median is the singular central value. If N is even, it is the average of the two central values.

The interquartile range (IQR) is the difference between the lower and upper quartiles. The lower quartile (Q1) is the value below that a quarter of the results laid. Similarly, the upper quartile (Q3) is the value above that a quarter of the results laid. The quartiles are calculated analogously to the median and IQR=Q3-Q1. The "Normalized IQR" equals IQR×0.7413. The factor 0.7413 comes from the standard normal distribution, which has a mean of zero and a standard deviation equal to one. The width of the interquartile range of such a distribution is 1.34898 and 1/1.34898 = 0.7413.

Multiplying the IQR by this factor makes it comparable to a standard deviation. The "Robust CV" is a coefficient of variation and is equal to the normalized IQR divided by the median, expressed as a percentage (i.e. multiplied by 100). The minimum, maximum and range are the lowest value, the highest value and the difference between them (respectively).