



APLAC T017

SAR

PROFICIENCY TESTING PROGRAM

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1. **FOREWORD**

Mobile (or cellular) telephony has developed rapidly over the past ten years. It is now part of the basic equipment of modern life and over 1.3 billion phones are in use worldwide. Concerns about health effects caused by exposure to the low level RF radiation emitted by mobile telephones and base stations have increased over the last few years becoming a major societal issue in some countries, or at least among part of the population.

This report summarises the results of APLAC T017 SAR proficiency testing program involving testing laboratories for the Asia Pacific Laboratory Accreditation Cooperation (APLAC). This program covered testing of Specific Absorption Rate (SAR) on Mobile Phones.

The exercise was conducted by the CNLA/ TAF(Taiwan Accreditation Foundation). The aim of the program was to assess laboratories' ability to competently perform the tests examined.

2. **FEATURES OF THE PROGRAM**

- a) A total of 16 laboratories participated in the program. Seven APLAC members were invited to participate. The following economies had laboratories participating in this [program](#):

Economy	No. of Labs	Economy	No. of Labs
Australia	1	Singapore	1
China	3	Taiwan	6
Hong Kong, China	1	USA	1
Korea	3		

- b) Participating laboratories were supplied two mobile phone samples labelled APLAC T017 Sample A and Sample B. These test samples had been circulated between laboratories and each laboratory received the same testing samples.
- c) The SAR on Mobile Phones will be tested to IEEE Std 1528-2003 Recommended Practice for Determining the Peak Spatial – Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.
- d) Prior to distribution the samples were analysed for stability. Based on the results of this preliminary testing it was concluded that the samples were sufficiently stability, therefore any results later identified as outliers could not be attributed to any significant sample variability. (Appendix B)
- e) 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", two samples were circulated to participants. (Appendix C)
- f) Each laboratory was randomly allocated a unique code number for the program to enable confidentiality of results. Reference to each laboratory in this report is made by its code number.

3. **FORMAT OF APPENDICIES**

APPENDIX A [contains](#):

- (i) The results reported by laboratories for the tests on the samples.
- (ii) A table of robust statistics for each test - number of results, median, normalised IQR, robust CV, minimum, maximum and range.
- (iii) Z-scores and z-score charts calculated for between laboratories and within laboratory for each test.
- (iv) A Youden diagram for each test.
- (v) Test methods and testing equipment reported for each lab.

APPENDIX B contains details of sample preparation and stability testing data.

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 formulae.

APPENDIX E APLAC PT Committee comments.

4. **STATISTICAL DESIGN OF THE PROGRAM**

The samples labelled APLAC sample A and sample B were identical, for the detailed description of samples refer to Appendix B.

Robust statistical procedures were used to generate the z-scores and summary statistics for the sample - number of results, median, normalised interquartile range, minimum, maximum and range.

For each laboratory, the between-laboratories z-score was calculated for the APLAC sample A and sample B. This was based on the (standardised) sum of the calculated mean of the results reported for each sample. The within laboratory z-score was based on the (standardised) difference between the mean of the APLAC sample A and sample B results reported from each participants.

TABLE A - SUMMARY STATISTICS

Item	Test Frequency		Phantom Position	Phone Position	SAR _{1g} (mW/g)		
	Frequency (MHz)	Channel			Summary Statistic	APLAC Sample A	APLAC Sample B
1	1710.2	512	Left Head	Cheek	No. of Results	16	16
					Median	0.460	0.406
					Normalized IQR	0.029	0.034

2	1747.8	698	Left Head	Cheek	No. of Results	16	16
					Median	0.405	0.418
					Normalized IQR	0.029	0.037
3	1784.8	885	Left Head	Cheek	No. of Results	16	16
					Median	0.316	0.334
					Normalized IQR	0.016	0.028
4	1710.2	512	Left Head	Tilted 15°	No. of Results	16	16
					Median	0.460	0.414
					Normalized IQR	0.069	0.046
5	1747.8	698	Left Head	Tilted 15°	No. of Results	16	16
					Median	0.422	0.471
					Normalized IQR	0.056	0.050
6	1784.8	885	Left Head	Tilted 15°	No. of Results	16	16
					Median	0.331	0.355
					Normalized IQR	0.017	0.023
7	1710.2	512	Right Head	Cheek	No. of Results	16	16
					Median	0.503	0.425
					Normalized IQR	0.040	0.058
8	1747.8	698	Right Head	Cheek	No. of Results	16	16
					Median	0.415	0.423
					Normalized IQR	0.060	0.076
9	1784.8	885	Right Head	Cheek	No. of Results	16	16
					Median	0.330	0.320
					Normalized IQR	0.042	0.041
10	1710.2	512	Right Head	Tilted 15°	No. of Results	16	16
					Median	0.337	0.312
					Normalized IQR	0.051	0.036
11	1747.8	698	Right Head	Tilted 15°	No. of Results	16	16
					Median	0.298	0.331
					Normalized IQR	0.027	0.063
12	1784.8	885	Right Head	Tilted 15°	No. of Results	16	16
					Median	0.237	0.267
					Normalized IQR	0.025	0.036

5. OUTLIER RESULTS

In order to achieve the program's aim of assessing laboratories' testing performance, a robust statistical approach, which uses z-scores to assess participants performance has been utilised. The z-score is a measure of how far the result(s) is from the consensus value - a normalized value which gives a "score" to each result relative to the other results in the group. Therefore a z-score close to zero means that the result agrees well with those from other laboratories. An outlier will be any result(s) which has an absolute z-score value greater than three.

Refer to Appendix D for calculation of z-scores.

TABLE B
OUTLIER RESULTS
(Between-Laboratories and Within-Laboratory)

Item	Test Frequency		Phantom Position	Phone Position	Between-Laboratories Z-Score	Within-Laboratory Z-Score
	Frequency (MHz)	Channel				
1	1710.2	512	Left Head	Cheek	6, 8	5
2	1747.8	698	Left Head	Cheek	8	3, 5
3	1784.8	885	Left Head	Cheek	N/A	3, 5
4	1710.2	512	Left Head	Tilted 15°	3, 8, 14	5, 6
5	1747.8	698	Left Head	Tilted 15°	3, 8	5, 6, 10
6	1784.8	885	Left Head	Tilted 15°	3, 8, 14	3, 5, 6, 10, 14
7	1710.2	512	Right Head	Cheek	8	5
8	1747.8	698	Right Head	Cheek	8	5
9	1784.8	885	Right Head	Cheek	6, 8	N/A
10	1710.2	512	Right Head	Tilted 15°	N/A	5, 8, 13, 14

11	1747.8	698	Right Head	Tilted 15°	N/A	13
12	1784.8	885	Right Head	Tilted 15°	N/A	5

Of the 16 participating laboratories, the total of 8 laboratories has been identified as having reported one or more extreme results. Of the 192 results returned, the total of 40 results has been identified as extreme results (20.8%).

The following parameters in Table C are used to calculate the z-score values.

TABLE C: Z-Score Values

Item	Test Frequency		Phantom Position	Phone Position	Standardized Sum		Standardized difference	
	Frequency (MHz)	Channel			Median	Norm IQR	Median	Norm IQR
1	1710.2	512	Left Head	Cheek	0.599	0.031	0.041	0.023
2	1747.8	698	Left Head	Cheek	0.572	0.051	0.013	0.010
3	1784.8	885	Left Head	Cheek	0.460	0.039	0.013	0.014
4	1710.2	512	Left Head	Tilted 15°	0.625	0.067	0.032	0.021
5	1747.8	698	Left Head	Tilted 15°	0.638	0.078	0.030	0.014
6	1784.8	885	Left Head	Tilted 15°	0.484	0.037	0.017	0.006
7	1710.2	512	Right Head	Cheek	0.656	0.042	0.057	0.028
8	1747.8	698	Right Head	Cheek	0.590	0.060	0.003	0.037
9	1784.8	885	Right Head	Cheek	0.452	0.035	0.000	0.031
10	1710.2	512	Right Head	Tilted 15°	0.471	0.055	0.022	0.010

11	1747.8	698	Right Head	Tilted 15°	0.443	0.076	0.025	0.022
12	1784.8	885	Right Head	Tilted 15°	0.357	0.042	0.019	0.012

Refer to Appendix D for calculation of standardised sum and standardised difference.

6. TECHNICAL COMMENTS

6.1 Measured maximum SAR_{1g} (mW/g) is list respectively from APLAC Sample A and Sample B of all participating Lab.(LAB. CODE NUMBER 1~16) :

LAB. CODE NUMBER	SAMPLE A			SAMPLE B			Dosimetric measurement system
	Maximum SAR _{1g} (mW/g)	Test		Maximum SAR _{1g} (mW/g)	Test		
		Item	Channel		Item	Channel	
1	0.513	1	512	0.472	5	698	DASY
2	0.612	7	512	0.559	5	698	DASY
3	0.465	1	512	0.351	2	698	INDEXSAR
	0.465	7	512	0.351	8	698	
4	0.513	7	512	0.469	5	698	DASY
5	0.423	4	512	0.601	5	698	DASY
6	0.599	7	512	0.502	8	698	DASY
7	0.511	7	512i	0.435	7	512	DASY
8	0.353	1	512	0.331	1	512	DASY
9	0.488	7	512	0.467	7	512	DASY
10	0.48	7	512	0.41	1	512	Aprél
11	0.504	4	512	0.484	5	698	DASY
12	0.467	4	512	0.432	5	698	DASY
13	0.519	7	512	0.472	5	698	DASY
14	0.709	4	512	0.646	4	512	INDEXSAR
15	0.564	7	512	0.497	5	698	DASY
16	0.499	7	512	0.48	5	698	DASY

For the data list above, the result can be summarised as follows :

- It appear likely the maximum SAR_{1g} (mW/g) from APLAC sample A are measured at frequency Channel 512 of all participant; for measurement phantom position, 75% of participants at Cheek position; 25% of participants at Tilted-15° position, respectively.
- For APLAC sample B, 68.8% of participants measured maximum SAR_{1g} (mW/g) at frequency Channel 698 and 31.2 % at Channel 512; for measurement phantom position, 37.5 % of participants at Cheek position; 62.5% of participants at Tilted-15° position, respectively.

6.2 The table shows below are list of Youden Plot and Z-score from APLAC Sample A and Sample B of every test Item (Channel) of all precipitants.

- Test Item 1(Channel 512) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 8 、 5 、 3 、 6
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 8 、 1 、 6
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : 8 、 6
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 5 、 3
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 5

b. Test Item 2(Channel 698) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 8 、 3 、 5
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 8 、 5
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : 8
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 3 、 8 、 5
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 3 、 5

c. Test Item 3(Channel 885) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 5 、 3
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : None
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : None
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 3 、 11 、 5
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 3 、 5

d. Test Item 4(Channel 512) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 8 、 3 、 6 、 5 、 14
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 3 、 8 、 14
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : 3 、 8 、 14
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 5 、 6 、 8
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 5 、 6

e. Test Item 5(Channel 698) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 3 、 8 、 10 、 6 、 5 、 14
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 3 、 8 、 10 、 14
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : 3 、 8
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 10 、 6 、 5
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 10 、 6 、 5

f. Test Item 6(Channel 885) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 3 、 8 、 6 、 5 、 10 、 2 、 14
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 3 、 8 、 2 、 14
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : 3 、 8 、 14
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 10 、 3 、 14 、 6 、 5
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 10 、 3 、 14 、 6 、 5

g. Test Item 7(Channel 512) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 8 、 5 、 3 、 14 、 6 、 2
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 8 、 3 、 2 、 6
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : 8
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 14 、 5
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 5

h. Test Item 8(Channel 698) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 8 、 5 、 14 、 2 、 6
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 8 、 6 、 2
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : 8
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 14 、 5
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 5

i. Test Item 9(Channel 885) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 8 、 6 、 14
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 8 、 2 、 15 、 6
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : 8 、 6
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 14
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : None

j. Test Item 10(Channel 512) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 8 、 5 、 13 、 11 、 14
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 8
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : None
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 14 、 11 、 13 、 8 、 5
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 14 、 13 、 8 、 5

k. Test Item 11(Channel 698) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 13 、 2
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 2
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : None
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 13
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 13

l. Test Item 12(Channel 885) :

Lab. beyond range of Youden Plot ellipse	LAB. CODE NUMBER : 3 、 5 、 13 、 2
Lab. beyond range -2~+2 of ZB-score	LAB. CODE NUMBER : 3 、 2
Lab. beyond range -3~+3 of ZB-score	LAB. CODE NUMBER : None
Lab. beyond range -2~+2 of ZW-score	LAB. CODE NUMBER : 13 、 5
Lab. beyond range -3~+3 of ZW-score	LAB. CODE NUMBER : 5

6.3 General Comments

- Lab 3 which reported conductivity σ (1.7 S/m) of SAR measurements was beyond the tolerance range of IEEE 1528 (σ :1.33~1.47 S/m for head-tissue at 1800MHz) and the date of calibration for Dosimetric E-Field Probe should be confirmed. Parameters above will be having possibility of increases measurement uncertainty value.
- Lab 1 and 14 laboratories which report environment temperature during SAR measurement was 25.5°C and 20°C, receptivity. According to IEEE 1528 specifying tolerance range $\pm 2^\circ\text{C}$ for both environmental temperature and liquid temperature (18~25°C), the laboratories must consider the above tolerance range and temperature conformity between environment and liquid each other in order to reduce the [measurement](#) uncertainty.
- The date of calibration for Dosimetric E-Field Probe of Lab 13 was overdue, which might increase possibility of measurement uncertainty.
- [From test datas of measured maximum SAR_{1g} \(mW/g\) by every Lab.: Lab 8 got the lowest maximum SAR_{1g} \(mW/g\) for SAMPLE A and SAMPLE B; Lab 14 got the highest maximum SAR_{1g} \(mW/g\) for SAMPLE A and SAMPLE B.](#)
- [According to analyses of the above 6.2 for measurements from SAMPLE A and SAMPLE B by LAB. 1~16, laboratories with integrated SAR measurement results beyond Youden Plot limit at every Test Item\(Channel\) are shown as follows:](#)

LAB. CODE	Test items which outside Youden Plot limit
5	Test Items : 1,2,3,4,5,6,7,8,10,12,etc. Total item:10
8	Test Items : 1,2,4,5,6,7,8,9,10,etc. Total item:9
3	Test Items : 1,2,3,4,5,6,7,12,etc. Total item:8
6	Test Items : 1,4,5,6,7,8,9,ect. Total item:7
14	Test Items : 4,5,6,7,8,10,etc. Total item:6
2	Test Items : 6,7,8,11,12,etc. Total item:5
13	Test Items : 10,11,12,etc. Total item:3
10	Test Items : 5,6,etc. Total item:2
11	Test Items : 10. Total item:1

- As a general rule from the analytic results of Z-score, the related Lab.s with a Z-score outside the range -2~+2 are suggested to check the factors of uncertainties of their measurement system; the related Lab.s with a Z-score outside the range -3~+3 are encouraged to review the factors of uncertainties and even investigate “Quality Management” and “Technical Requirements” of whole system.