Asia Pacific Laboratory Accreditation Cooperation
Proficiency Testing Programme
APLAC T101
Winding temperature-rise test (resistance method)

FINAL REPORT

Organized by

China National Accreditation Service for Conformity Assessment (CNAS)

Technical Center for Mechanical and Electrical Product Inspection and Testing of SHCIQ (SMEC)

ACKNOWLEDGEMENTS:

Contributions from all accreditation bodies and participants to this programme are gratefully noted.

Special thanks are extended to APLAC PT Committee, and their support to the programme.

May, 2017

Content

Summary

1. The APLAC T101 Proficiency Testing Programme “Winding temperature-rise test (resistance method)” (hereafter referred to as APLAC T101) was organized by China National Accreditation Service for Conformity Assessment (CNAS) in collaboration with Technical Center for Mechanical and Electrical Product Inspection and Testing of SHCIQ (SMEC), under the auspices of Asia-Pacific Laboratory Accreditation Cooperation (APLAC).

2. APLAC members as well as other non-APLAC accreditation bodies were invited to participate in the programme. Each accreditation body of APLAC members was invited to nominate up to a maximum of 2 laboratories from its economy to participate. Non-APLAC members were invited to nominate up to a maximum of 1 laboratory to participate. Therefore, total of **40** laboratories from 25 economies registered for the programme. **39** laboratories submitted their results on time, 1 lab withdrawn from the programme (see Table 1).

3. Assigned values and standard deviations are determined by the robust analysis according to Algorithm A, in Annex C of ISO 13528: 2015, after the removal of some data based on technical rationale.

Summary Statistics of Participants’ Results

Statistical Item	Temperature-rise of winding（K）
Number of results included in statistics	31
x_{pt}	62.4
s*	4.1
CV%	6.6%
Max	69.5
Min	5.1
Range	64.4

4. The z-scores were used as the numerical indicator to evaluate individual participant’s performance in the programme.

1. Introduction

1.1 This report summarizes the results of the APLAC T101 proficiency testing programme. The programme was organized by China National Accreditation Service for Conformity Assessment (CNAS) in collaboration with Technical Center for Mechanical and Electrical Product Inspection and Testing of SHCIQ (SMEC), under the auspices of Asia-Pacific Laboratory Accreditation Cooperation (APLAC). SMEC has been accredited by CNAS against ISO/IEC 17043 (Accreditation No. CNAS PT0030) for the scope of this PT program.

1.2 Windings are used extensively in electrical and electronic products as a magnetoelectric conversion component. The safety of winding is an essential part of electronic product safety. Over heat of the windings could cause severe thermal burn injury of the human body. Winding temperature test encompasses a wide range of products, such as audio/video devices, information technology equipment, house-hold appliances, motors, power tools, transformers, etc.

Most economies have laboratories capable of testing electrical products safety for regulatory compliance purposes. To prevent people suffer from thermal burn injury, winding temperature-rise test is one of the essential tests of electrical safety testing. Resistance method is the most commonly used method to measure the winding temperature-rise.

1.3 Table 1 shows the geographical distribution of participants.

Table 1 Geographical Distribution of Participants

Economy	Number of Participants Registered	Number of Participants Submitted
Australia	2	2
Botswana *	1	1
China	4	4
France *	1	1
Hong Kong	2	2
India	3	3
Indonesia	2	2
Italy *	1	1
Japan	3	3
Jordan *	1	1
Korea	1	1
Lithuania *	1	1
Mongolia	1	1
Morocco *	1	1
Netherlands *	1	1
Philippines	2	2

Economy	Number of Participants Registered	Number of Participants Submitted
Portugal *	1	1
Russia	1	1
Singapore	2	2
Thailand	2	2
Tunisia *	1	1
UAE	1	1
Ukraine *	1	1
USA	2	1
Vietnam	2	2
Total	40	39

Note: "*" represents non-APLAC economies.

1.4 Each participant was confidentially assigned with a unique laboratory code (001 to 038 and 042 to 043) which is used throughout the programme.

1.5 The programme was carried out as the schedule shown in Table 2.

Table 2 Programme Schedule

Event	Period	Responsible
Invitation of participants	Jan. – June. 2016	CNAS
Preparation and evaluation of PTIs	Mar. – Sept. 2016	SMEC
Dispatch of PTIs	Sept. 2016	SMEC
Testing and collecting of results	Oct. 2016	Participants
Interim report	Dec. 2016	CNAS/ SMEC
Feedback	Dec. 2016 –Jan. 2017	Participants
Draft Final report	Feb. 2017	CNAS/ SMEC
Final report	April 2017	CNAS/ SMEC

2. Objective

This program is intended to help participants to demonstrate their testing capabilities of the laboratories in different economies, understand the difference between the different laboratories, make improvement, and try to establish a common understanding of the test for further improvement in different economies.

3. Proficiency Testing Items (PTIs)

3.1 Each participant was provided with ONE patented electrical box, demonstrated by Figure 1. Each box contains a copper winding and an electronic circuit to simulate the windings in various electrical and electronic appliances, such as audio/video devices, information technology equipment, house-hold appliances, motors, power tools.

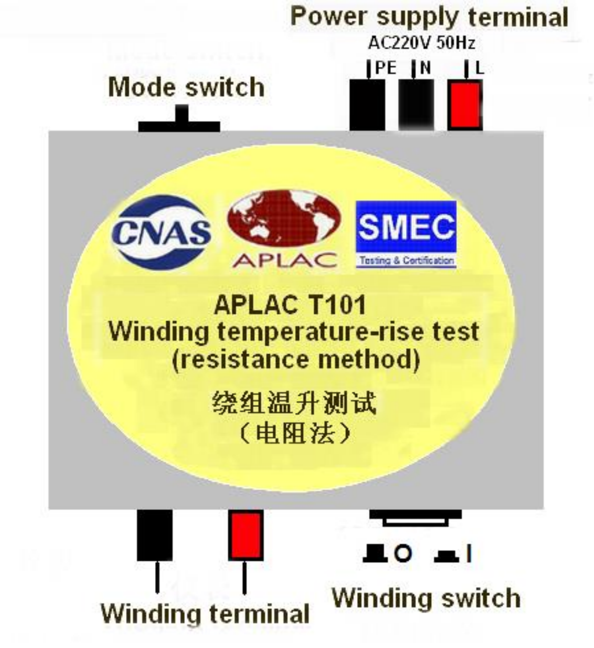

Figure 1 Structure Diagram of PTI

Power supply terminals and mode switches are set on the rear side of the sample while winding terminals and winding switch are set on the front side. The PT label is placed on the top side. Voltage of AC220V 50Hz is applied through power supply terminals. There are two output modes: mode 1 and mode 2. Winding terminals are used to connected ohmmeter (alligator clips and banana plugs are recommended) when the sample power off. When the winding switch is "ON" with blue light, it indicates the winding is powering. And "OFF" without blue light indicates the resistance of the winding is not powering, which hot resistance can be measured.

3.2 The homogeneity study and stability study of the test samples were carried out by SMEC in accordance with the procedures stipulated in ANNEX B. A well-defined manufacturing process is used to guarantee the quality of the PTIs. After that, a preliminary screening procedure is used to ensure the precision accuracy of the sample. Finally, EACH sample is tested in duplicate for determining the homogeneity. Ten samples were picked randomly for monitoring the stability of the samples before dispatch and after submission of results. The results indicated that the test samples were considered to be sufficient homogeneity and stability for the proficiency testing programme. Refer to ANNEX B for further information.

3.3 The PTIs were distributed by express delivery in September 2016. Relevant documents were also provided via e-mail simultaneously (see ANNEX C).

3.4 Upon receipt of the PTIs, participants were required to immediately check the physical conditions and promptly acknowledge SMEC by returning the Sample Receipt Form via the e-mail box of the contact.

4. Test Requirement of the Winding Temperature-Rise

The participants were required to report the temperature-rise of copper winding upon the parameters recorded according to the formula, as stipulated in *Instructions For Participating Laboratories* in Annex C.

$$\Delta t=[(R2-R1)/R1]\times(k+t1)+t1-t2$$

Where,

Δt: the calculated temperature-rise of copper winding, K;

R1: the resistance of the winding at temperature t1 (cold), Ω;

R2: the resistance of the winding at the end of the thermal test t2, Ω;

t1: the temperature (℃) of the winding (cold) at the moment of the initial resistance measurement, ℃;

t2: the temperature (℃) of the winding at the end of the thermal test, ℃;

k: the reciprocal of the temperature coefficient of resistance at 0℃ of the conductor material, for copper winding, k=234.5.

If applicable, the backward induction is used to ascertain the value of R2 at the instant of switching off. Result Sheet and Questionnaire need to be finished.

Besides, all the participants were requested to complete the Result Form according to the instructions, including the result sheet and the questionnaire (see ANNEX C):

a) Report calculated temperature-rise of the winding;

b) Report reference standards information;

c) Report all the measured parameters as well as the calculated result;

d) Report the fitting curves used in calculation;

e) Provide detailed information of the environmental conditions and test conditions applied in this scheme;

f) Report the Expanded uncertainty of the test result and measurement uncertainties as possible as they can. It is the responsibility of participating laboratories to avoid collusion or falsification of results.

5. Statistical Design

5.1 The reported result of the winding temperature-rise is used for the evaluation of performance of participants.

5.2 Part of the participants' results were excluded from statistical analysis due to technical reasons, which are as follows.

1) 015, the pretreatment time was too short (2hrs) to meet the requirements of the instruction (4hrs).

2) 016, the pretreatment time was too short (3hrs) to meet the requirements of the instruction (4hrs).

3) 019, fluctuation of resistance value was reported and after the replacement of samples, the problem still exists.

4) 030, time interval between power off and the first measurement was 5790s, which is against the requirement (<60s) of measuring the resistance at the instant of disconnecting the power supply.

5) 034, incorrect calculation of temperature-rise.

6) 038, highest ambient temperature during the test is 26.1℃, which went out of the required range of the instruction (20±5)℃.

5.3 After the removal based on technical analysis, the robust statistical technique of Algorithm A in C.3 of ISO 13528:2015 *"Statistical methods for use in proficiency testing by inter laboratory comparisons"* were used to obtain σ_{pt}(=s*) and x_{pt}. Summary of participants' statistical results are as shown in Table 3.

Table 3 Summary Statistics of Participants' Results

Statistical Item	Temperature-rise of winding（K）
Number of results included in statistics	31
x_{pt}	62.4
s*	4.1
CV%	6.6%
Max	69.5
Min	5.1
Range	64.4

Note: Each sample has two output modes, one of which is designed as a disturbance value against collusion. So the value of Mode 2 for sample No.1~35 and the value of Mode 1 for sample No.36~70 are not included in the statistical analysis. ONLY the value of Mode 1 for sample No.1~35 and the value of Mode 2 for sample No.36~70 are included in the statistical analysis.

5.4 Participants' performance was evaluated via a numeric indicator, z-score, which is calculated as follows:

$$z_i = \frac{(x_{i-}x_{pt})}{\sigma_{pt}}$$

where

x_i is the reported result of the participant;

x_{pt} is the assigned value;

σ_{pt} is the standard deviation for proficiency assessment.

Summary of the z-scores of the participants are as shown in Table 4.

Table 4 Summary Statistics of Z-Scores

Z-Score	Performance	Number of Results (Percentage)
∣z∣≤2.0	Satisfactory	27(69.2%)
2.0<∣z∣<3.0	Questionable	2(5.1%)
∣z∣≥3.0	Unsatisfactory*	10(25.6%)

Total	39(100%)

Note: "*" represents the 6 removees which are included in the "unsatisfactory" performance.

Participants with the action signal should thoroughly investigate their results and find the possible root cause. Participants with the warning signal are encouraged to review their results.

In addition to tables of the results, z-scores, and summary statistics, the ordered z-score histograms are included in the report (see Figure 2). On these charts each laboratory's z-score is shown in ascending order, and the labs with | z | ≥ 3.0 were marked with their lab codes on the graph. From these charts each laboratory can readily compare its performance relative to other laboratories.

5.5 Uncertainty of assigned value

Because assigned values which are derived from the participant results are not traceable to an international measurement standard, the uncertainty of assigned value is estimated from the participant results. According to ISO 13528:2015, the standard uncertainty of assigned value is calculated as the following formula:

$$\mathrm{u}(x_{pt}) = 1.25 \times \frac{s^*}{\sqrt{p}} = 0.21s^* = 0.86K < 0.3\sigma_{pt} = 1.23K$$

It shows that the uncertainties of the assigned values are small enough compared with the 0.3s*.

6. Evaluations of Participants' Performance on the Winding Temperature-Rise Test

6.1 Participants' results

6.1.1 An overview of participants' performance is summarized in Table 5.

Table 5 Summary of Participants' Performance

Z-Score	Performance	Lab Code
| z | ≤2.0	Satisfactory	002, 003, 004, 007, 008, 009, 010, 011, 012, 014, 017, 018, 020, 022, 023, 024, 025, 026, 027, 028, 029, 032, 033, 036, 037, 042, 043
2.0< | z | <3.0	Questionable	005, 006
| z | ≥3.0	Unsatisfactory*	001, 013, 015*, 016*, 019*, 021, 030*, 034*, 035, 038*

Note: "*" represents the 6 removees which are included in the "unsatisfactory" performance.

6.1.2 Participants' results and performance are presented in ANNEX A.

6.2 Graphical analysis of participants' results

6.2.1 The ranked participants' results for winding temperature-rise are shown graphically in Figure 2~5.

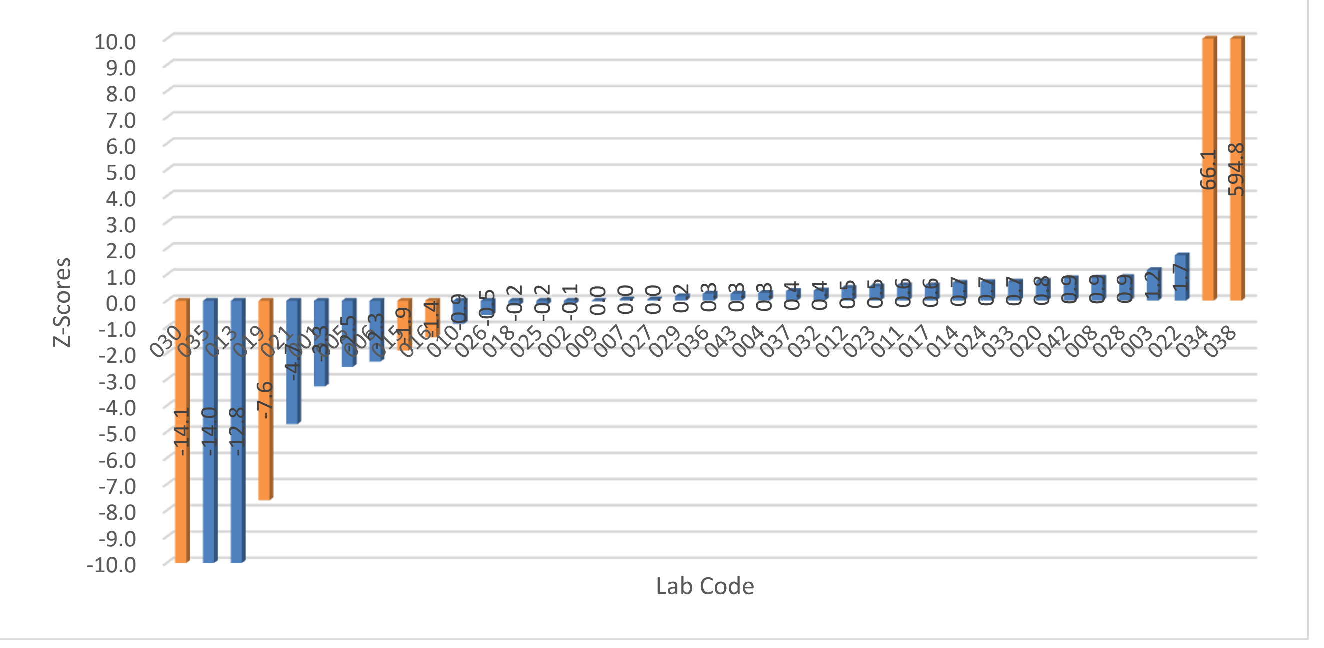

Figure 2　Ranked Participant Z-Scores for Winding Temperature-Rise

Note: Brown bars ONLY indicate the “statistical position” of the participants’ values excluded from statistical analysis, NOT their testing competence.

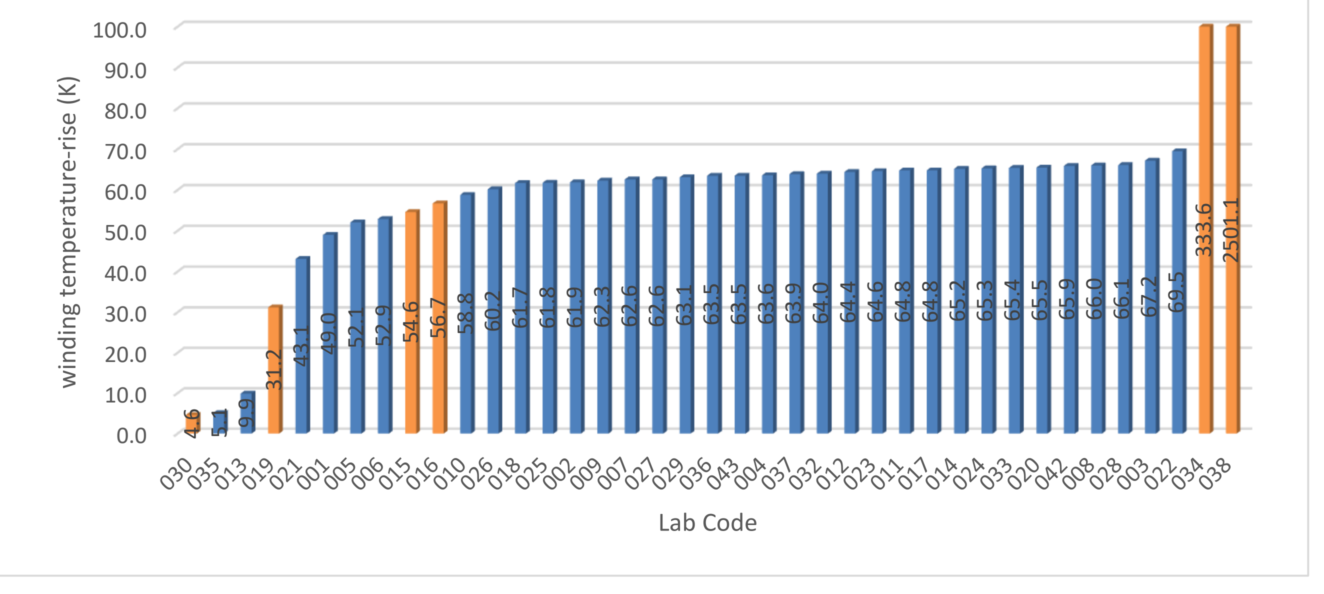

Figure 3　Ranked Participant Results for Winding Temperature-Rise

Note: Brown bars ONLY indicate the “statistical position” of the participants’ values excluded from statistical analysis, NOT their testing competence.

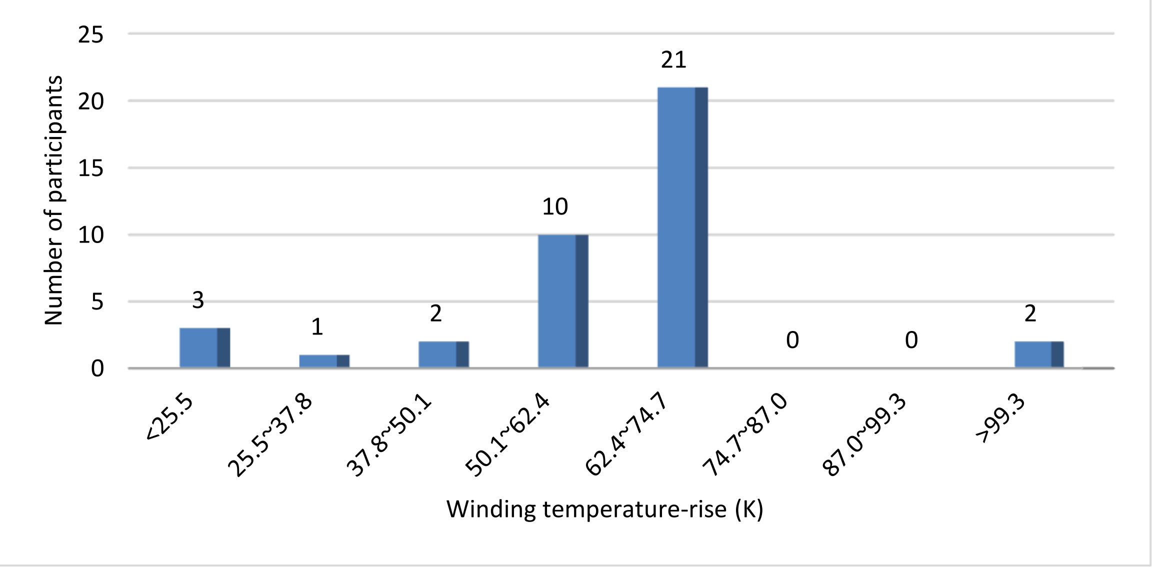

Figure 4 Histogram of Participant Results

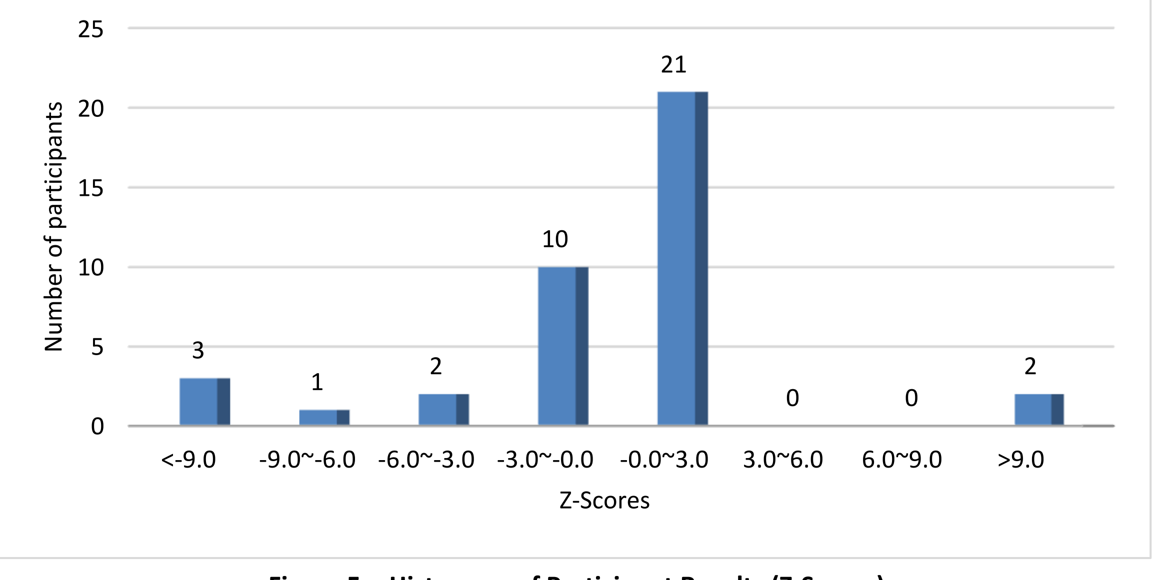

Figure 5 Histogram of Participant Results (Z-Scores)

6.3 Further information from participants

6.3.1 According to the information from results sheet, the valuable information related to testing (e.g. accreditation status, reference standards, testing methods, time interval, and temperature measuring instrument) are summarized in Table A.2 of ANNEX A.

6.3.2 From the information kindly offered by participants, it can be concluded that IEC 60335 standard is the prevailing method that participants used. Other methods may be traced back to it (e.g. EN 60335-1, LST EN 60335-1:2012+AC:2014, NM EN 60335-1, SNI IEC 60335-1:2009). Overview of reference standards used by participants is summarized in Table 6.

Table 6 Summary of Reference Standards

No.	Standard	Number of Lab	Percentage
1	IEC 60335-1	30	76.9%
2	IEC 60745-1	5	12.8%
3	IEC 62841-1	4	10.3%
4	IEC 60034-1	4	10.3%
5	IEC 60950-1	2	5.1%
6	IEC 61558-1	2	5.1%
7	IEC 60598-1	1	2.6%
8	IEC 60065	1	2.6%
9	IEC 61347-1	1	2.6%
10	IEC 61010-1	1	2.6%
11	IEC 60947-1	1	2.6%
12	IEC 60068-2-1 IEC 60068-2-2 IEC 60068-2-6 IEC 60068-2-14 IEC 60068-2-27 IEC 60068-2-64	1	2.6%
13	IEC 60601-1	1	2.6%
14	EN 60335-1	1	2.6%
15	HP3458A	1	2.6%
16	JIS C6065 JIS C6950-1	1	2.6%
17	LST EN 60335-1:2012+AC:2014 (EN 60335-1:2012+AC:2014)	1	2.6%
18	NM EN 60335-1 NM EN 60598-1	1	2.6%
19	SNI IEC 60335-1:2009	1	2.6%

Note: Some participants referred to several testing standards at the same time.

6.4 Measurement uncertainty

6.4.1 Although the measurement uncertainties reported by participants were not requested to be used in evaluating the participants' performance, it was one of the important part of testing competence.

6.4.2 Some participants didn't report measurement uncertainties. The number of participants reporting expanded measurement uncertainties of the test result is given in Table 7. And factors influencing measurement uncertainties submitted by the participants are analyzed in Table 8.

Table 7 Summary of Expanded Uncertainty Number

Status	Number of Labs	Percentage
Reported (in the required format)	24	61.5%
Reported	11	28.2%

Status	Number of Labs	Percentage
(in other format)		
Unreported	4	10.3%

Table 8 Summary of Factors influencing Measurement Uncertainties

Item	Factor	Number of Labs	Percentage
a	Power supply	9	23.1%
b	Electric parameter measuring instruments	13	33.3%
c	Temperature measuring instrument	27	69.2%
d	Environmental temperature	16	41.0%
e	Ohmmeter	30	76.9%
f	Time interval measured after switching off	12	30.8%
g	Other	5	12.8%

7. Comments

7.1 Influence of Methods

7.1.1 Testing standards used by participants are summarized in Table 6. Different methods and corresponding number of unsatisfactory results are summarized according to items respectively. Detailed information is summarized in Table 9.

Table 9 Summary of Reference Standards used by Participants with Unsatisfactory Results

Reference Standard	Number of Labs
IEC 60335-1 IEC 60745-1 IEC 62841-1	7
IEC 60947-1	1
Other	2

7.1.2 Backward induction method is not specific requirement in all the standards. The number of labs using this method is summarized in Table 10.

Table 10 Summary of Backward Induction Method used by Participants

Status	Number of Labs	Percentage
Used	20	51.3%
Unused	19	48.7%

7.2 Analyzing of measurement uncertainty

In respect of the evaluation of measurement uncertainty, further capacity improvements are recommended for participants who did not report measurement uncertainty or reported an improper value (either underestimated or overestimated). Following §9.8.4 of ISO 13528, it is unlikely that any participant's reported standard uncertainty is larger than 1.5 times the robust standard deviation of participants (1.5s*=6.15), called u_{max}. u_{max}[1] is used to identify aberrant uncertainties. The participants with standard uncertainty larger than 1.5s* are encouraged to follow *GUM (Guide to the Expression of Uncertainty in Measurement)*, in quantifying measurement uncertainty in analytical measurements. According to the expanded measurement uncertainty reported by participants, no result is out of the limit. However, 11 labs reported improper form of uncertainty. 5 labs did not report measurement uncertainty. Detailed information is summarized in Table A.1.

7.3 Influence of measuring apparatus

From the information kindly offered by participants, it can be concluded that thermocouple is the prevailing measuring instrument that participants used. Overview of apparatus used by participants is summarized in Table 11. Different measuring instruments and corresponding number of unsatisfactory results are summarized according to items respectively. Detailed information is summarized in Table 12.

Table 11 Summary of Measuring Instruments

No.	Measuring Instruments	Number of Lab	Percentage
1	Thermocouple K	13	33.3%
2	Thermocouple T	9	23.1%
3	Thermocouple J	2	5.1%
4	Thermometer	13	33.3%
5	Other	4	10.3%

Table 12 Summary of Measuring Instruments used by Participants with Unsatisfactory Results

Reference Standard	Number of Labs
Thermocouple K	2
Thermocouple T	2
Thermometer	5
Other	1

7.4 Influence of the distance between the temperature measuring point and center of the sample

Overview of the horizontal and vertical distance values kindly offered by participants is summarized in Table 13. It shows that the temperature measuring point is mostly placed within a distance of 50cm. Different distance values and corresponding number of unsatisfactory results are summarized according to items respectively. Detailed information is summarized in Table 14.

[1] a reported uncertainty, u(xi), can be valid even if it is larger than u_{max}; and when this occurs participants and any interested parties should check the result or the uncertainty estimate. Similarly, a reported uncertainty can be smaller than u_{max}, and still not be valid. These are informative indicators only.

Table 13 Summary of distances between the temperature measuring point and center of the sample

No.	Horizontal distance (cm)	Number of Lab	Percentage
1	≤50	28	71.8%
2	>50, ≤100	7	17.9%
3	>100	4	10.3%
No.	**Vertical distance (cm)**	**Number of Lab**	**Percentage**
1	≤50	37	94.9%
2	>50, ≤100	1	2.6%
3	>100	1	2.6%

Table 14 Summary of distances between the temperature measuring point and center of the sample with Unsatisfactory Results

Horizontal distance (cm)	Number of Labs
≤50	6
>50, ≤100	3
>100	1
Vertical distance (cm)	**Number of Labs**
≤50	9
>50, ≤100	1
>100	0

The temperature measuring point is recommended to be placed in the same plane with the center of the sample and as close as possible while not affected by its emitting heat.

7.5 Understanding of the instruction

Some situations as reported by the participants occurred due to a different understanding of the instruction. For example, it was mentioned in the instruction that the winding switch should be off for R1 measurement and R2 measurement could be done in the same manner both for mode 1 and mode 2. And the winding switch was in "ON" position with blue light when powering, while "OFF" without blue light was for resistance measuring. However, some labs measured R2 with the winding switch in ON position and cut off the power supply directly. The issue lies in the on or off position of the winding switch which is actually the power button of the sample. That leads to a change of the resistance value.

Most labs understand the instruction the same way as the PT provider. And for the evaluation of the participants' performance, it was based on the initial submitted result. Outlier value due to this reason may not come down to the lab's incapability. Attention needs to be paid on the wording of the instruction in the future to avoid such misunderstandings.

7.6 Due to miscommunication, the 042, 043 labs did not received their PTIs until January 2017. After consulting the APLAC PT Committee and the corresponding AB, the results of the 042, 043 labs did not include in the statistical calculation of the assigned value. But their performances were still evaluated according to the same criteria.

7.7 For the sample delivery issue reported by lab 019, a new PTI was sent to the lab after its reporting fluctuation of resistance value. However, the problem still exists after the replacement of samples. Since the samples were not required to send back, no conclusion could be made.

8. Remarks

8.1 If the participants have any queries about this report, please contact the coordinator of this proficiency testing programme as follows:

Coordinator of the organizing accreditation body CNAS:
Name: He Ping (Mr.) (Chairman of APLAC PT Committee)
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Coordinator of the proficiency testing provider in SMEC:
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Add.: No.1208, Minsheng Road, Pudong New Area, Shanghai 200135, China
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Tel: +86 21 38620831

8.2 Use of the report other than the demonstration of the performance shall only be allowed with the written permission from APLAC.

9. References

[1] ISO/IEC 17043:2010, Conformity assessment–General requirements for proficiency testing
[2] ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories
[3] ISO 13528: 2015, "Statistical methods for use in proficiency testing by inter-laboratory comparisons"

ANNEX A Results and Statistical Analysis

Table A.1 Results of winding temperature-rise test

Lab code	Temperature-rise of winding(K)	Z-Score	Expanded Uncertainty k=2	Measurement uncertainties
001	49.0	-3.3	1.3 K	c/e/f
002	61.9	-0.1	1.6 K	c /e /f
003	67.2	1.2	1.19951 K	b /c /d /e/f
004	63.6	0.3	3.5 K	g
005	52.1	-2.5	0.52% *	a/b/c/d/e/f
006	52.9	-2.3	2.3 Deg C *	b
007	62.6	0.0	0.46 K	b/ c/ d/ e/ f
008	66	0.9	2.5 K	c/ d/ e
009	62.3	0.0	±0.04% *	e
010	58.8	-0.9	±3.31 K	b/c/d/e/f
011	64.8	0.6	--	--
012	64.4	0.5	0.0135 K	a/b/e
013	9.9	-12.8	0.07 ohm *	e
014	65.2	0.7	0.246 K	c/e
015	54.6	/	0.61 K	c/e
016	56.7	/	a. 0.5% * b. 0.5% * c. 1.14 °C * d. 1.14 °C * e. 1.03% * f. 1.0% *	a/b/c/d/e/f
017	64.8	0.6	±1.55% *	b/c/e
018	61.7	-0.2	0.37% *	--
019	31.2	/	3 Degree *	c/d/e
020	65.5	0.8	1 K	a/c/d/e
021	43.1	-4.7	0.54 K	b/c/e
022	69.5	1.7	1.74 K	a/b/c/d/e/f
023	64.6	0.5	1.2%rdg *	a/b/c/d/e/f
024	65.3	0.7	4.8 K	a/b/c/d/e/f
025	61.8	-0.2	0.619 K	a/c/d/e/f
026	60.2	-0.5	0.401 K	a/c/e
027	62.6	0.0	5.6 K	c/d/e
028	66.1	0.9	--	a/b/c/d/e
029	63.1	0.2	--	--
030	4.6	/	15.6mOhm, 0.03degC, 430.7mV, 1.6%RH, 0.084mA *	c/e
031	--	--	--	--
032	64	0.4	3.9 K	b/c/d/e
033	65.4	0.7	0.7654 K	c/e
034	333.6	/	0.24 K	c/e
035	5.1	-14.0	1.90 ohm *	c/e/f
036	63.5	0.3	5.2 K	c/e
037	63.9	0.4	1.96 K	--
038	2501.1	/	--	a/b/c/d/e/f
042	65.9	0.9	6.8 K	c/d/e

Lab code	Temperature-rise of winding(K)	Z-Score	Expanded Uncertainty k=2	Measurement uncertainties
043	63.5	0.3	3.59 K	b/c/d/e/f

Note1: "--" the uncertainty information was not provided.

Note2: Red color means "Unsatisfactory" while orange means "Questionable".

Note3: "*" represents expanded uncertainty value reported in different measurement unit as required.

Table A.2 Review of Test Methods

Lab code	Test Standard	Backward induction used or not	Time Interval (s)	Temperature measuring instrument
001	IEC 60745-1 IEC 60335-1 IEC 62841-1	yes	10	Thermocouple K
002	IEC 60335-1 IEC 60034-1 IEC 60745-1	yes	0.4	Thermocouple K
003	IEC 60335-1 IEC 60745-1 IEC 62841-1	no	5	Thermocouple T
004	IEC 60335-1 IEC 60950-1 IEC 61558-1 IEC 61010-1	yes	5	Thermocouple K
005	IEC 60034-1	yes	25.5	Thermocouple T
006	IEC 60335-1	yes	15	Thermocouple K
007	IEC 60335-1	yes	5	Thermocouple T
008	JIS C6065 JIS C6950-1	yes	1	Thermocouple J Hybrid Recorder
009	IEC-60335-1	no	5.09	Hygrometer testo 174H
010	IEC 60335-1	yes	5	Thermocouple T
011	IEC 60335-1	yes	1	Thermocouple T
012	IEC 60335-1	no	<1	Thermometer
013	IEC 60335-1	no	1	Thermocouple T
014	IEC 60335-1	no	6.8	Thermometer
015	IEC 60335-1	no	2	Thermometer
016	IEC 60947-1	Yes	10	Thermocouple T
017	LST EN 60335-1:2012+AC:2014 (EN 60335-1:2012+AC:2014)	no	2.8	Thermometer
018	IEC 60068-2-1 IEC 60068-2-2 IEC 60068-2-6 IEC 60068-2-14 IEC 60068-2-27 IEC 60068-2-64	no	3	Thermocouple
019	IEC 60335-1	no	10	Thermocouple K
020	IEC 60335	no	2.6	Thermometer
021	NM EN 60335-1 NM EN 60598-1	no	15	Thermometer
022	IEC 60335-1	no	5	Thermometer

Lab code	Test Standard	Backward induction used or not	Time Interval (s)	Temperature measuring instrument
	IEC 60034-1 IEC 60745-1 IEC 62841-1			
023	IEC 60335-1	yes	5	Thermocouple J
024	IEC 60335-1	yes	2	Thermocouple T
025	IEC 60335-1	yes	10	digital thermohigrometer
026	SNI IEC 60335-1:2009	no	3	Thermometer Thermocouple K
027	IEC 60601-1	yes	2.5	Thermocouple K
028	IEC 60335-1 IEC 60745-1	yes	10	Thermocouple K
029	IEC 60335-1	no	4.8	temperature meter
030	IEC/EN 60335-1	no	5790	Thermometer
031	--	--	--	--
032	IEC 60335-1	no	0.5	Thermocouple K
033	IEC 60335-1 IEC 60034-1 IEC 62841-1	no	1.3	Thermocouple K
034	HP3458A	no	30	Thermometer
035	IEC 60335-1	yes	2	Thermometer
036	IEC 60335-1	yes	1	Thermocouple T
037	IEC 60335-1	no	30	Thermocouple K
038	IEC 60335-1	yes	10	Ambient temperature measuring sensor in the hot winding ohmmeter
042	IEC 60335 IEC 61558 IEC 60598 IEC 60065 IEC 61347 IEC 60950	yes	1	Thermocouple K
043	IEC 60335-1	yes	1	Thermocouple K

Note: “--”Results or information were not provided.

ANNEX B Sample preparation and homogeneity study

1. Sample preparation

The Proficiency Test Item(PTIs) for this program are patented electrical boxes to simulate the windings in various electrical and electronic appliances, such as audio, video devices, information technology equipment, house-hold appliances, motors, power tools. Normative electrical components are utilized, including, high-accuracy COPPER windings, accurate resistances, and PCBs. They are installed in an enclosed electrical box to ensure the sample's integrity during the transportation process. PTIs are designed by SMEC and manufactured by qualified production unit.

All copper wingdings with enameled wire of high quality are produced by the same worker on a same machine. They are welded on PCB boards and fastened with screw after a well-defined manufacturing process. Silica gel is used to captivate the nut.

Power supply terminals and mode switch are set on the rear side of the sample while winding terminals and winding switch are set on the front side. And its top side is labeled. Voltage of AC220V 50Hz is applied through power supply terminals. Whether PE terminal is used to connect grounding conductor or not is acceptable. There are two output modes: mode 1 and mode 2. Each sample has two output modes, one of which is designed as a disturbance value against collusion. So the value of Mode 2 for sample No.1~35 and the value of Mode 1 for sample No.36~70 are not included in the statistical analysis. ONLY the value of Mode 1 for sample No.1~35 and the value of Mode 2 for sample No.36~70 are included in the statistical analysis. Winding terminals are used to connected ohmmeter (alligator clips and banana plugs are recommended) when the sample is not powering. When the winding switch is "ON" with blue light, it indicates the winding is powering. And "OFF" without blue light indicates the resistance of the winding is not powering, which hot resistance can be measured. Metal boxes against water and shock are chosen to protect PTIs.

Environmental temperature is controlled strictly within the range prescribed in the standards during the whole production process. All the components went through thermal stability test and electrical aging treatment and considered to be stable within the operating cycle. PTIs are sealed against disassembling.

2. Homogeneity test

2.1 Preliminary Screening

All the samples were tested twice under the repeatability conditions and the average value of each sample was studied against general average. The data are given in the Table B.1. 50 proficiency test samples with first approximation are extracted.

The procedure in Annex B of ISO 13528:2015 is followed, resulting in the summary statistics listed. The between-sample standard deviation S_s is calculated and compared with the standard deviation for proficiency assessment σ_{pt}. Refer to the σ_{pt} of *CNAS T0380*[2] *Proficiency Testing Programme* "Winding temperature-rise test (resistance method)" as the permissible error of preliminary screening. The *CNAS T0380* σ_{pt} is 1.5938K. The estimate of sample variability is checked against (general average ±

[2] CNAS T0380 Proficiency Testing Programme "Winding temperature-rise test (resistance method)" is a PT Programme held by CNAS in 2008, using the same testing methods as APLAC T101.

$0.3\sigma_{pt(\mathrm{T0380})}$) .

20 out of 70 samples were removed against the permissible error of preliminary screening. 50 were kept for Homogeneity check as shown in Table B.1.

Table B.1 Homogeneity data for proficiency test items

Sample No.	Temperature-rise of winding for mode 1, 1st test (K)	Temperature-rise of winding for mode 1, 2nd test (K)	Sample No.	Temperature-rise of winding for mode 2, 1st test (K)	Temperature-rise of winding for mode 2, 2nd test (K)
001	65.00	65.01	036	64.98	65.38
002	65.62	65.48	037	64.27	64.95
003	65.46	65.40	038	66.01	66.60
004	64.19	64.12	039	65.22	64.26
005	65.09	65.09	040	64.17	65.01
006	65.33	65.14	041	64.63	65.44
007	64.93	64.89	042	63.43	63.93
008	64.05	64.05	043	64.22	64.76
009	65.04	64.65	044	65.30	64.73
010	65.76	65.84	045	63.75	63.75
011	64.50	64.28	046	64.18	65.55
012	65.40	65.09	047	63.52	63.92
013	65.29	65.29	048	63.84	65.04
014	64.80	64.27	049	64.46	65.15
015	64.57	64.79	050	64.52	65.26
016	65.61	64.88	051	64.56	65.23
017	65.83	65.07	052	64.11	64.72
018	65.60	65.29	053	66.69	65.61
019	64.58	64.11	054	63.97	63.95
020	64.75	64.75	055	64.01	64.25
021	64.29	64.84	056	65.08	64.82
022	64.66	64.92	057	65.96	64.90
023	63.10	64.46	058	64.14	64.20
024	65.04	65.76	059	63.42	62.36
025	64.57	64.30	060	65.06	64.98
026	64.69	65.55	061	65.64	65.06
027	65.61	65.16	062	66.32	66.33
028	64.83	64.62	063	63.62	63.88
029	64.85	65.64	064	63.40	64.58
030	64.82	65.74	065	64.21	64.19
031	63.04	63.53	066	64.43	64.70
032	64.28	65.56	067	63.94	64.06
033	64.67	65.17	068	64.32	65.24
034	64.02	64.24	069	63.21	63.21
035	65.75	65.52	070	64.02	64.94

Note: Red color represents the removal data and samples.

2.2 Statistical Results

After removal of the samples out of the permissible error, the statistical results of homogeneity check is listed in Table B.2.

Table B.2 Homogeneity results for proficiency test items

Measurands	Result
General average	64.79K
Test times	100
S_S1	14.35K
S_S2	8.85K
f1	49
f2	50
MS1	0.29K
MS2	0.18K
S_s	0.24K

2.3. Evaluation of homogeneity

S_s is less than the check values($0.3*\sigma_{pt}=0.3*4.1K=1.23K$), so homogeneity is sufficient. Therefore it was concluded that any outlier results subsequently identified could not be attributed to sample variability.

3. Stability test

3.1 Stability check

The procedure in Annex B of ISO 13528:2015 is followed to evaluate stability. 10 PTIs are randomly selected for stability check. Since the testing samples were not required to be sent back, their stability test should be carried out within the period from sample receipt to dispatching. The time interval was one month (Aug. 18th ~ Sep. 19th, 2016). All the results were listed in Table B.3. Their average values are studied (see Table B.4).

Table B.3 Stability data for proficiency test items

Sample No.	Temperature-rise of winding for mode 1, 1st test (K)	Temperature-rise of winding for mode 1, 2nd test (K)	Temperature-rise of winding for mode 1, 3rd test (K)	Temperature-rise of winding for mode 1, 4th test (K)
007	64.93	64.89	64.50	64.35
015	64.57	64.79	64.73	64.25
022	64.66	64.92	64.45	64.23
029	64.85	65.64	65.43	64.99
033	64.67	65.17	64.95	64.63
044	65.30	64.73	65.09	64.75

Sample No.	Temperature-rise of winding for mode 1, 1st test (K)	Temperature-rise of winding for mode 1, 2nd test (K)	Temperature-rise of winding for mode 1, 3rd test (K)	Temperature-rise of winding for mode 1, 4th test (K)
050	64.52	65.26	64.59	64.12
058	64.14	64.20	64.33	64.06
066	64.43	64.70	64.32	64.25
068	64.32	65.24	64.39	64.24

3.2 Statistical Results

Table B.4 Stability results for proficiency test items

Measurands	Result (K)
Average of 1st and 2nd test	64.80
Average of 3rd and 4th test	64.53
Absolute value of difference	0.27
Check value ($0.3\sigma_{pt}$)	1.23

3.3 Evaluation of stability

Compare the general average of the measurements obtained in the homogeneity check with the general average of the results obtained in the stability check. As the absolute value of difference between average of homogeneity and average of stability is less than the check value($0.3*\sigma_{pt}$), so the samples are considered to be adequately stable.

ANNEX C Relevant documents

APLAC T101 Proficiency Testing Programme -
Winding temperature-rise test (resistance method)

Nomination Form for Accreditation Bodies

Please complete the details below and make sure all the information are fully completed. Please **email** to jiangyingzhou@163.com jiangyz@shciq.gov.cn mailto:liuch@iqtc.cnand cc to heping@cnas.org.cn **no later than June 1st, 2016.**

Accreditation Body Information

Name: ______________________________

Contact Person: ______________________________

Shipping Address: ______________________________

Country/Economy: ______________________________

Phone: ______________ Fax: ______________

E-mail: ______________

Nomination Priority: 1

Laboratory Name:	______________________________
Contact Person:	______________________________
Physical Address:	______________________________
Country/Economy:	______________________________
Phone:	______________ Fax: ______________
E-mail:	______________
Accredited for test:	

Nomination Priority: 2

Laboratory Name:	______________________________
Contact Person:	______________________________
Physical Address:	______________________________
Country/Economy:	______________________________
Phone:	______________ Fax: ______________
E-mail:	______________
Accredited for test:	

Sample Receipt Form
(Participating Laboratories)

Institute/ Laboratory: ______________________________

Postal address: ______________________________

Lab Code: ______________________________

Contact person: __________ __________ __________

Title	Given name	Surname

E-mail: ______________________________

Print name / Signature: ______________________________

Date: ______________________________

Confirmation of Package Contents

I hereby acknowledge the receipt of package of APLAC proficiency testing programme (APLAC T101).

☐ Were the result form and instruction present? ☐Yes ☐No

☐ The sample is *Intact & Sealed / Broken / Missing** and should be *Suitable / Not Suitable** for analysis (* Please delete as appropriate).

Other comments: ______________________________

Upon receipt of the sample, please complete this form and return it to the co-ordinator of the proficiency testing programme (E-mail: jiangyz@shciq.gov.cn; jiangyingzhou@163.com; shciqsmec@163.com).

Instructions For Participating Laboratories

1. Objective

The APLAC proficiency testing programme "Winding temperature-rise test (resistance method) (APLAC T101)" is organized by China National Accreditation Service for Conformity Assessment (CNAS), with Technical Center for Mechanical and Electrical Product Inspection and Testing of SHCIQ (SMEC) as the collaborator, under the auspices of Asia Pacific Laboratory Accreditation Cooperation (APLAC).

This program is intended to assist participants in demonstrating their testing capacity of using resistance method on the measurement of temperature-rise, understand the difference between different laboratories, and to identify problems and opportunities for self-improvement.

2. Analysis Of The Proficiency Test Sample

(1) Sample Description

Each participating laboratory will be provided with ONE patented electrical box, shown in Figure 1, to simulate the windings in various electrical and electronic appliances, each containing a

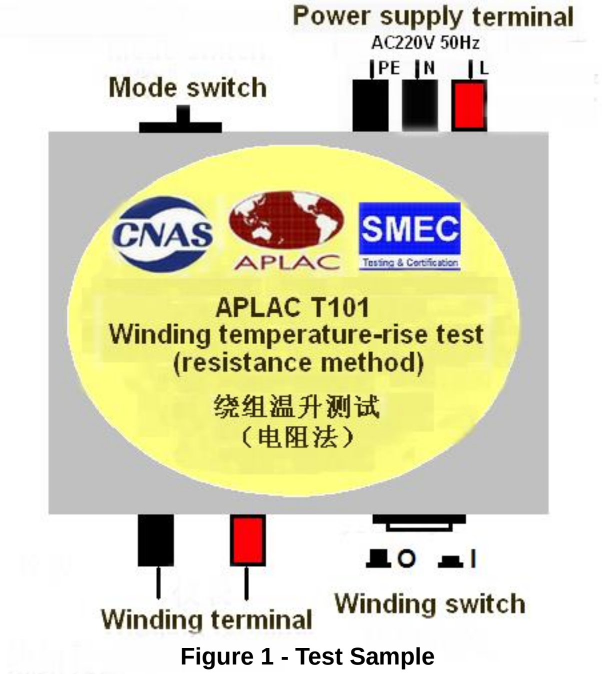

Figure 1 - Test Sample

copper winding and an electronic circuit. Power supply terminals and mode switch are set on the rear side of the sample while winding terminals and winding switch are set on the front side. And its top side is labeled. Voltage of AC220V 50Hz is applied through power supply terminals. Whether PE terminal is used to connect grounding conductor or not is acceptable. There are two output modes: mode 1 and mode 2. Winding terminals are used to connected ohmmeter (alligator clips and banana plugs are recommended) when the sample is not powering. When the winding switch is "ON" with blue light, it indicates the winding is powering. And "OFF" without blue light indicates the resistance of the winding is not powering, which hot resistance can be measured.

Upon receipt of the sample, please complete the Sample Receipt Form (Participating Laboratories) and return it to the coordinator of the proficiency testing programme (E-mail to: jiangyz@shciq.gov.cn, jiangyingzhou@163.com and shciqsmec@163.com at the same time). Replacement of a new sample will be arranged if the proficiency test sample is identified to be not suitable for testing (e.g., no current or without blue light when powering, etc.).

(2) Reference Standards and Applicable Standards

Participants should treat the proficiency test sample in the same manner as the majority of routine samples. They are expected to use the test method described in relevant end-product standards of their choice, which should be consistent with their routine procedures.

Applicable standards are:

IEC 60335-1 Household and similar electrical appliances – Safety - Part 1: General requirements

IEC 60034-1 Rotating electrical machines – Part 1: Rating and performance

IEC 60745-1 Hand-held motor-operated electric tools –Safety –Part 1: General requirements

IEC 62841-1 Electric motor-operated hand-held tools, transportable tools and lawn and garden machinery – Safety – Part 1: General requirements

Please fill the reference standards information in the Result Sheet correspondingly.

(3) Test Environment

During the whole process, the testing condition should be remained at temperature (20±5)℃, relative humidity (60±15)% without forced convection. And the sample should be stored in this environment for at least 4 hours before the test.

(4) Thermocouple Locations

Temperature and humidity meter is used to monitor the environmental condition during the whole testing process. The ambient temperature is measured at such a distance from the sample so as not to influence the temperature reading. At this point, the ambient temperature shall not vary by more than 10℃ during the test. The vertical distance and horizontal distance to the center of the sample are recorded and filled in the Questionnaire correspondingly. Temperature measuring point should be arranged as shown in Figure 2.

(5) Sample Mounting

The proficiency testing sample is placed on a dull black painted plywood support with the side labeled facing up. The support has dimensions which are at least 300mm in excess of those of the orthogonal projection of the specimen on the support. The sample is then connected to the power supply and instruments.

(6) Sample Testing

Before testing, the value of R1 is measured on the winding terminals using ohmmeter while the winding switch is off and t1 should be recorded. Then voltage is applied, which is 220V and frequency is 50Hz. The mode switch is turned to mode 1 and the winding switch is on. Testing

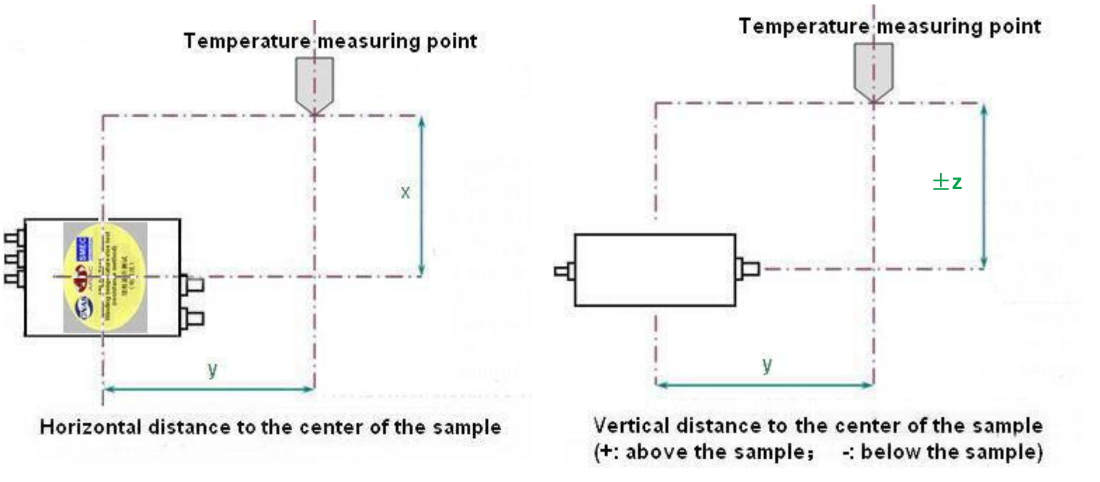

Figure 2 - Measuring Point Layout

voltage and current need to be monitored through instruments and recorded. When the sample is powering, ohmmeter shall not be connected to it except for online resistance meter. The sample is powered for 2hr continuously. After that, the value of R2 is measured on the winding terminals at the instant of disconnecting the power supply and t2 is recorded.

After fully cooling down, the mode switch is turned to mode 2, and the test shall be repeated.

The instruments and facilities used in the test are listed in Table 1.

Table 1 - Testing Specifications

No.	Instruments and facilities	Measurand
1	AC Power supply	220V， 50Hz
2	Ohmmeter	the resistance of the winding at the beginning and the end of the test (R1, R2) for mode 1 and mode 2
3	Ammeter	the input current in the circuit for mode 1 and mode 2, optional
4	Voltmeter	the input voltage of the sample for mode 1 and

No.	Instruments and facilities	Measurand
		mode 2
5	Thermometer	ambient temperature at the beginning and the end of the test(t1, t2) for mode 1 and mode 2
6	Humidity meter	ambient humidity for mode 1 and mode 2
7	Chronograph	the time the sample is powered, 2hr

(7) Calculation

After the test, the participants should calculate the temperature-rise of copper winding upon the parameters recorded according to the formula.

$$\Delta t=[(R2-R1)/R1]\times(k+t1)+t1-t2$$

Where,

Δt: the calculated temperature-rise of copper winding, K;

R1: the resistance of the winding at temperature t1 (cold), Ω;

R2: the resistance of the winding at the end of the thermal test t2, Ω;

t1: the temperature (℃) of the winding (cold) at the moment of the initial resistance measurement, ℃;

t2: the temperature (℃) of the winding at the end of the thermal test, ℃;

k: the reciprocal of the temperature coefficient of resistance at 0℃ of the conductor material, for copper winding, k=234.5.

If applicable, the backward induction is used to ascertain the value of R2 at the instant of switching off. Result Sheet and Questionnaire need to be finished.

3. Reporting & Submitting Results

AB shall remind the nominated laboratories to complete the Result Sheet, Questionnaire and Satisfaction Survey and submit them via email to the coordinator of the proficiency testing programme (E-mail to: jiangyz@shciq.gov.cn, jiangyingzhou@163.com and shciqsmec@163.com at the same time) no later than the deadline 20th October 2016. Results submitted after the deadline will not be accepted.

The testing parameter to be measured is the winding temperature-rise of the sample tested and calculated using resistance method. Participants are required to provide information about the factors in the process for mode 1 and mode 2, such as the resistance, temperature, time interval since switching off to first measurement etc.. Participants are also asked to provide photos of test set-ups and encouraged to report their uncertainties of measurement.

Participants should be aware that any submitted results are considered final and accordingly such results and units should be thoroughly checked before submission. Participants are reminded that the ability to report results in the specified unit and within the given time scale are part of the proficiency test.

4. Important Notes

FOR SAFETY, THE PROFICIENCY TEST SAMPLE SHOULD BE HANDLED WITH CARE TO PREVENT THERMAL INJURY AND ELECTRIC SHOCK.

The test sample shall not be opened, otherwise the test result is invalid.

Under no condition should the sample be powered by 240V or above.

Photos of test set-ups need to provide a clear snapshot of the connection between the sample and power supply as well as instruments.

Preparation and processing of the samples is sublet to subcontractor.

For this proficiency testing programme, return of the proficiency test sample is not necessary.

5. Contact

AB may wish to contact the coordinator of the proficiency testing programme for any inquires.

The contact details are given below:
Coordinator of organizing accreditation body CNAS:

Name: He Ping (Mr.)
Add.: No.8 Nanhuashi, Dongcheng District, Beijing, 100062, China
E-mail: heping@cnas.org.cn
Tel: +8610 6710 5290

Coordinator of the proficiency testing provider in SMEC:

Name: Jiang Yingzhou (Mr.)
Add.: No.1208, Minsheng Road, Pudong New Area, Shanghai 200135, China
E-mail: jiangyz@shciq.gov.cn, jiangyingzhou@163.com , shciqsmec@163.com
Tel: +86 21 38620831

APLAC T101 Proficiency Testing Programme
"Winding temperature-rise test (resistance method)"

APLAC T101 Proficiency Testing Programme
"Winding temperature-rise test (resistance method)"
Result Sheet

Laboratory Information

1	Name of the laboratory			
	Note: If the laboratory is accredited, please fill in the column with the name on the accreditation certificate.			
2	Address of the laboratory			
3	Reference standards			
4	Accreditation certificate No.		Note: for reference standards within the accredited scope	
5	Name of accreditation body			
6	Laboratory Code.			
7	Sample No.			
8	Country/Economy:			

Test result

		Mode 1	Mode 2	
7	R1 at the beginning of the test (Ω)			two decimals reserved
8	R2 at the end of the test (Ω)			two decimals reserved
9	t1 at the beginning of the test (℃)			one decimal reserved
10	t2 at the end of the test (℃)			one decimal reserved
11	Calculated temperature-rise of the winding (K)			one decimal reserved
12	Time interval since switching off to first measurement (s)			one decimal reserved
13	Whether backward induction is used to ascertain the value of R2 at the instant of switching off?			a. yes / b. no
14	Equation of the plotted curve by backward induction (if the answer of 13 is a)			
15	Expanded uncertainty of the test result (K) k=2			
16	Measurement uncertainties	/ / / multiple choice e.g.: a/b/c	a. power supply b. electric parameter measuring instruments c. temperature measuring instrument d. environmental temperature e. ohmmeter f. time interval measured after switching off g. other (full description)	

Plotted curve of resistance against time

Photos of test set-ups

APLAC T101 Proficiency Testing Programme
"Winding temperature-rise test (resistance method)"

APLAC T101 Proficiency Testing Programme
"Winding temperature-rise test (resistance method)"
Questionnaire

Preconditioning

1	Pretreatment of temperautre range (℃)		
2	Pretreatment of humidity range (%)		
3	Pretreatment time (h) :		

Environmental condition

4	Highest temperautre during the test (℃)		one decimal reserved
5	Lowest temperautre during the test (℃)		one decimal reserved
6	Temperature measuring instrument (single choice) :		a. thermometer b. thermocouple c. other (full description)
7	Horizontal distance x between the temperature measuring point and center of the sample (cm)		
8	Horizontal distance y between the temperature measuring point and center of the sample (cm)		
9	Vertical distance z between the temperature measuring point and center of the sample (cm) ("-"indicates lower than the sample; "+" indicates higher than the sample)		
10	Test condition (single choice) :		a. operational test chamber b. non-operational test chamber c. laboratory with temperature controlled d. laboratory without temperature controlled e. other (full description)

Test condition

		Mode 1	Mode 2
10	Voltage at the beginning of the test (V)		
11	Voltage at the end of the test (V)		
12	Frequency of power supply (Hz)		
13	Current at the beginning of the test (A)		
14	Current at the end of the test (A)		

15	Power supply	a. model		
		b. manufacturer		
		c. measuring range		
		d. measuring accuracy		
		e. stabilizing method of power supply (single choice)		a. auto b. manual c. other (full description)
16	Thermocouple (if the answer of 6 is b)	a. type		(e.g.: J or K or T)
17	Thermometer or other (if the answer of 6 is a or c)	a. type		(e.g.: digital or other type)
		b. model		
		c. manufacturer		
		d. measuring range		
		e. measuring accuracy		
		f. next calibration date		YYYY-MM-DD
18	Ohmmeter	a. type		(e.g.: digital or pointer-type)
		b. model		
		c. manufacturer		
		d. measuring range		
		e. measuring accuracy		%
		f. next calibration date		YYYY-MM-DD
20	Electric parameter measuring instruments	a. type		(e.g.: digital or pointer-type)
		b. model		
		c. manufacturer		
		d. measuring range		
		e. measuring accuracy		
		f. next calibration date		YYYY-MM-DD
21	Chronograph	a. type		(e.g.: digital or pointer-type)
		b. model		
		c. manufacturer		
		d. measuring range		
		e. measuring accuracy		
		f. next calibration date		YYYY-MM-DD

Other information

22	Testing date		YYYY-MM-DD
23	Beginning time of the test		hh:mm
24	Ending time of the test		hh:mm
25	Is there any deviation from this instruction during testing?		a. none b. yes, fill in the column below
26	Other necessary comments:		

APLAC T101 Proficiency Testing Programme
"Winding temperature-rise test (resistance method)"

Satisfaction Survey

Dear honored friend, thank you for enrolling into APLAC T101 Winding temperature-rise proficiency test. And also thank you for taking time out to fill in this table to help us improve our work. Your opinion is very important for us. Really thank you for your support!

Please add ticks "√" where appropriate.

		A. Satisfied	B. somewhat satisfied	C. normal	D. dissatisfied
1	Are you satisfied with the overall implementation process of this programme?				
2	Are you satisfied with the convienence of registration and connection?				
3	Are you satisfied with punctuality of sample delivery?				
4	Are you satisfied with comprehensiveness of this instruction?				
5	Are you satisfied with validity of the information provided?				
6	Are you satisfied with impartiality and confidentialityof this programme ?				
7	Are you willing to enroll in the programme if possible ?		a. yes / b. no		
8	Is there anything that makes you dissatisfactory and needs to be improved?				
9	Do you have any other idea or requirement in the programme?				

End of Report