Compact Fluorescent Lamp
Check Test Results and Analysis Report

Prepared by

the Global Efficient Lighting Centre

for

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Lamp purchasing and shipping countries
Azerbaijan, Chile, Costa Rica, Dominican Republic, Guinea-Bissau, Lebanon, Panama, Tonga
Tunisia and Uruguay

Contents

Executive Summary

In 2009, the United Nations Environment Programme (UNEP)-Global Environmental Facility (GEF) launched the en.lighten initiative, which aims to accelerate the global market transformation to environmentally sustainable lighting technologies by developing a coordinated global strategy and providing technical support for the phase-out of inefficient lighting.

The "Global Compact Fluorescent Lamps Check Testing" project is one of the activities initiated by UNEP and the Global Efficient Lighting Centre – UNEP Collaborating Centre for Energy Efficient Lighting (GELC) to increase international awareness. The purpose of the project is to improve understanding of lamp quality status and associated technical issues, in participating developing countries. Results of the testing will help decision-makers in developing countries recognize the importance of quality lighting, and will demonstrate the value of strengthening national quality control and testing systems. Long-term, these activities will increase awareness of quality issues in lighting and encourage countries to develop measurement, verification and enforcement (MVE) schemes.

Country representatives purchased a total of 47 models of compact fluorescent lamps (CFLs), in 10 participating countries: Azerbaijan, Chile, Costa Rica, Dominican Republic, Guinea-Bissau, Lebanon, Panama, Tonga, Tunisia and Uruguay. The samples of the models were shipped to GELC and tested by GELC for safety, performance and mercury content.

The test results show the main safety issues for certain models of lamps are: interchangeability; protection against electric shock; and, mechanical strength. Regarding energy performance testing, results of some parameters are good and show a related high compliance rate (power factor and luminous efficacy of lamps with warm colour temperature). However, other results also show the low quality of some key parameters (low luminous efficacy for cool colour temperature lamps, poor lumen maintenance and colour consistency). There is a large deviation in quality among the lamps tested.

The mercury tests show a wide range in the mercury quantity in the lamps and most of the models tested are non-amalgam mercury lamps. The test results also show that the amalgam lamps have a longer life (higher lumen maintenance compliance rate) than the non-amalgam lamps, yet they have much lower mercury content.

The local markets involved in this project have both good quality and poor quality products. This report illustrates the quality situation of these markets to assist countries to better understand how much variation there can be in the quality of lamps. This report is a "snapshot" reference point for countries to consider and begin to plan how they would implement necessary MVE measurements to improve and control lamp product quality.

Glossary

amalgam: an alloy of mercury with another metal that is solid or liquid at room temperature according to the proportion of mercury present

ballast: a device connected between the power supply and one or more discharge lamps which serves mainly to limit the current of the lamp(s) to the required value

chromaticity coordinates: ratio of each of a set of three tristimulus values to their sum

colour rendering index (CRI): measure of the degree to which the psychophysical colour of an object illuminated by the test illuminant conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation

correlated colour temperature (CCT): the temperature of the Planckian radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions; unit: kelvin (K)

efficacy (of a source): quotient of the luminous flux emitted by the power consumed by the source. Unit: $lm \cdot W^{-1}$

fluorescent lamp: a discharge lamp of the low pressure mercury type in which most of the light is emitted by one or several layers of phosphors excited by the ultraviolet radiation from the discharge

general lighting: substantially uniform lighting of an area without provision for special local requirements

initial values: the photometric and electrical characteristics at the end of the 100 hour ageing period

interchangeability: ability of one product, process or service to be used in place of another to fulfil the same requirements. For example, for CFLs, when the lamp screws into the lamp holder, it should not be too loose or too tight, and it should make good contact with the electrical contacts of the socket

lamp: source made in order to produce an optical radiation, usually visible

lamp cap (base): that part of a lamp which provides connection to the electrical supply by means of a lamp holder or lamp connector and, in most cases, also serves to retain the lamp in the lamp holder

lamp holder: a device which holds the lamp in position, usually by having the cap inserted in it, in which case it also provides the means of connecting the lamp to the electric supply

luminous efficacy: see efficacy

luminous flux： quantity derived from radiant flux Φe by evaluating the radiation according to its action upon the CIE standard photometric observer. For photopic vision is the spectral distribution of the radiant flux and V(λ) is the spectral luminous efficiency. Unit: lm

$$\phi_v = K_m \int_0^\infty \frac{d\phi_e(\lambda)}{d\lambda} \bullet V(\lambda) d\lambda \qquad \text{Where} \qquad \frac{d\phi_e(\lambda)}{d\lambda}$$

luminous maintenance (of a lamp): the luminous flux at a given time in the life of a lamp divided by the initial value of the luminous flux of the lamp and expressed as a percentage of the initial luminous flux

maximum mercury content: maximum amount of mercury added to gas discharge lamps to enable their operation.

mechanical strength: the cap shall remain firmly attached to the bulb or that part of the lamp which is used for screwing the lamp in or out when subjected to the torque levels

mercury (Hg): a metallic element, the only one that is liquid at room temperature

power: derivative with respect to time *t* of energy *E* being transferred or transformed

$$P = \frac{dE}{dt}$$

power factor: under periodic conditions, ratio of the absolute value of the active power *P* to the apparent power *S*:

$$\lambda = \frac{|P|}{S}$$

protection against electric shock: provision of measures reducing the risk of electric shock

rated power (of a type of lamp): the value of the power of a given type of lamp declared by the manufacturer or the responsible vendor, the lamp being operated under specified conditions; Unit: W

rated voltage or **rated voltage range:** nominal voltage/range of voltage at which a piece of electrical equipment is designed to operate

resistance to flame and ignition: real part of the impedance to flame and ignition

screw cap (**base):** cap (international designation E) having its shell in the form of a screw thread which engages the lampholder

type: lamps that, independent of the type of cap, are identical in photometric and electrical rating

01 PROJECT BACKGROUND

1. Project Background

The transition to efficient lighting has been recognized worldwide as an effective solution to decrease energy consumption. Efficient lighting can also help developing and emerging countries to reduce their greenhouse gas emissions and address climate change issues.

In 2009, the United Nations Environment Programme (UNEP)-Global Environmental Facility (GEF) launched the en.lighten initiative, which aims to accelerate global market transformation to environmentally sustainable lighting technologies by developing a coordinated global strategy and providing technical support for the phase-out of inefficient lighting.

UNEP-GEF en.lighten initiative assists countries in accelerating market transformation with environmentally sustainable, efficient lighting technologies by:

- Promoting high performance, efficient technologies in developing countries.
- Developing a global policy strategy to phase-out inefficient and obsolete lighting products.
- Assisting countries to develop national and regional efficient lighting strategies, based on an integrated policy approach.

With the support of UNEP/GEF en.lighten initiative, 67 countries participate in the Global Efficient Partnership Programme. These countries aim to phase out inefficient incandescent lamps in their markets by the end of 2016. Many will establish minimum energy performance standards (MEPS) to do so. To be effective, these standards should be reinforced by a monitoring, verification and enforcement (MVE) scheme. The lack of lighting knowledge and quality control measurements is a barrier for those countries seeking to improve access to good quality, efficient lamps in their markets.

02 PROJECT SCOPE

2. Project Scope

2.1 Lamp type

In this project, the selected lamp type is compact fluorescent. Presently they are the most commonly used efficient lighting product in the world. CFLs use up to 75% less energy and typically last six to ten times longer than conventional incandescent lamps. CFLs are the most recognized alternative to replace incandescent lamps. The selected lamps that were tested all had the following characteristics:

Product type: compact fluorescent lamp (CFL)

Lamp type: bare lamp (no cover, no reflector), residential indoor lighting

Rated power: less than 30W (most commonly used for residential/domestic applications)

Lamp cap: single base, E27, B22

Lamp shape: spiral or tube

Power supply: mains

2.2 Lamp purchasing

UNEP-GEF en.lighten initiative recruited 10 countries to participate in this project.

Table 1 Participating countries, by region

Region	Countries
Central America	Costa Rica, Dominican Republic and Panama
South America	Chile and Uruguay
Africa	Guinea-Bissau and Tunisia
West Asia	Azerbaijan and Lebanon
Pacific	Tonga

Participating countries were responsible for sampling the CFL lamps in their local lighting markets. They shipped the samples to GELC for testing. GELC requested that the countries purchase at least six models from each country, and sample the most popular consumer grade lamps. For each model, the lamp samples were selected randomly. However, all the samples of one model are from the same batch, which means the lamps are produced in the same production line on the same day. For sampling requirements and the instructions issued to the samplers, please

refer to Global CFL Quality Sampling Rules (Annex 1), and Global CFL Quality Sampling Sheet (Annex 2).

2.3 Testing items and sample size

Regarding the quality of CFLs, three aspects are considered in this project: safety; performance; and, mercury content. The project budget framework could not cover all of the parameters of a lamp. Therefore, the key parameters and those that fail frequently in the other testing projects conducted by GELC were chosen for this project.

Safety: These mandatory requirements are the basic guarantee against health or economic losses when using the products and are the first concern which needs to be considered for the quality evaluation. In this testing project, the safety items include: interchangeability; protection against electric shock; insulating resistance; electric strength; mechanical strength; and, resistance to flame and ignition.

Performance: These are the key parameters to evaluate the energy efficiency of the lamps as well as their lighting quality, which means the test results clearly indicate if they are actually saving energy. Colour quality tests determine whether the lamps have a similar relative spectral power distribution (compared to daylight). In this project, the lamp performance parameters tested include: power; power factor; initial luminous flux; initial efficacy; colour rendering index (CRI); standard deviation colour match (SDCM); and, luminous maintenance, measured at 2,000 hours.

Mercury content: Along with the high usage of CFL lamps, discussions in the lighting industry and environmental community focus on the mercury content of lamps. In consideration of health and environmental protection during the production and use of CFLs, legislation, standards, criteria and specifications are published at the international and national levels to minimize the mercury content of CFLs. In October 2013, *The Minamata Convention on Mercury,* facilitated by UNEP, was issued. As of October 2014, the Convention has 128 signatories that aim to control and reduce the release of mercury. Noted in the Convention is a maximum mercury content of 5 mg for CFLs for general lighting purposes (wattage no greater than 30W). Therefore, mercury content is another important parameter that needs to be checked in the lamp samples that were purchased from the local markets. Many governments encourage lamp producers to reduce the quantity of mercury and adopt solid mercury (amalgam) to replace liquid mercury (non-amalgam). For example, in China, all of the CFLs in the public procurement list should be amalgam lamps.

Due to the limited project timeframe, not all of the parameters in all national minimum energy performance standards have been tested. For example, the performance test only lasted 2,000 hrs. Nonetheless, for each of the three aspects, the key parameters were included, as listed in Table 2.

Table 2 Testing items and sample size

Safety		
Test Number	Testing Item	Sample Size (number)
1	Interchangeability	8
2	Protection against electric shock	8
3	Insulating resistance	1
4	Electric strength	1
5	Mechanical strength	8
6	Resistance to flame and ignition	1
Performance		
Test Number	Testing Item	Sample Size (number)
1	Power	10
2	Power factor	10
3	Initial luminous flux and initial efficacy	10
4	Colour Rendering Index	10
5	Standard Deviation Colour Matching	10
6	Luminous maintenance at 2,000 hours	10
Mercury		
Test Number	Testing Item	Sample Size (number)
1	Mercury content	5
2	Format of mercury	5

The sample size was determined by synthesizing the relevant data from USA, EU, Australia and China standards. However, in consideration of the project budget, GELC did not require the largest quantity of sample units from those standards. The safety sample size of eight units and one unit (respectively) complies with the China test standard. For the performance test, the sample size of 10 units was based on the requirement in China, U.S. ENERGY STAR and Australia

standard; this is a bit less than EU test requirement. Only the China and Australian test standards specified the mercury test sample size of three units. GELC decided that due to the strong international concerns about mercury content, GELC would require two additional samples (for a total of five units) for testing in this project.

2.4 Reference standards

Since this project involved worldwide lighting markets, all the testing was conducted according to the International Electrotechnical Commission (IEC) testing standards. The IEC standards are the most recognized and adopted by countries. No variations applied to the test methods prescribed in the test standards.

IEC 60968: Self-ballasted lamps for general lighting services—Safety requirements

- Interchangeability
- Protection against electric shock
- Insulating resistance
- Electric strength
- Mechanical strength
- Resistance to flame and ignition

IEC 60969 Self-ballasted lamps for general lighting services—Performance requirements

- Lamp power
- Power factor
- Initial Luminous flux
- Initial efficacy
- Colour Rendering Index
- Standard Deviation Colour Matching
- Luminous maintenance at 2,000 hours

IEC 62554—Sample preparation for measurement of mercury level in fluorescent lamps

- Format of mercury
- Mercury content

03 LAMP SAMPLING AND RECEIVING

3. Lamp Sampling and Receiving

3.1 Lamp sampling

According to the contract between UNEP and participating countries, the countries were responsible for the lamp sampling and shipping. The lamps were requested to be randomly sampled from the local market, based on the country's selection of the most popular models. For each model, 35 lamp units were requested. All the samples of one model should be from the same manufacturing batch.

Before the purchasing started, GELC sent *Global CFL Quality Sampling Procedures* to all the participating countries (Annex 1). Teleconferences were conducted with the appointed samplers from each country to explain in detail the sampling procedures, the shipping instructions and answer all the related questions that the samplers might have regarding the sampling and the shipping. For the specific sampling requirements and rules for the samplers, please refer to the *Global CFL Quality Sampling Rules* (Annex 2). From April to June 2013, the participating countries shipped the sampled lamps to GELC in Beijing, China for testing.

3.2 Lamp receiving

Lamps to be tested were received by GELC from each participating country. GELC had expected to receive 60 sample models per the request to those countries. However, only 50 models were received in total. Among those, 46 models had enough samples to do all the planned testing and the other four models had fewer parameters tested.

Table 3 Lamp models and apparent condition

Country	Lamp models received by GELC (number)	Apparent condition (number of broken lamps)
Costa Rica	4	0
Dominican Republic	4	0
Panama	4	1
Chile	6	0
Uruguay	6	1
Guinea-Bissau	4	0
Tunisia	4	0
Lebanon	6	1
Azerbaijan*	3	2
Tonga**	9	0
Total	**50**	**5**

* There were six models in total from Azerbaijan, however three of them were linear fluorescent lamps, which are not involved in this project test scope, therefore only three models could be tested for this project.

** Four models were sampled by eighteen units, nine units, five units and three units. In this case, for the first three models, only one part of the testing could be arranged according to the sample size required for safety, performance and mercury test; while for the last one, there were not enough samples for any of the three testing aspects.

3.3 Documenting Lamp Samples Tested

All of the useful information for the testing was recorded for each model of lamp, including: the brand, rated power, rated voltage, rated frequency, rated CCT, lamp cap and lamp shape. The lamp information was obtained and recorded first from the lamp (the information marked on the lamp). If some of the information was not marked on the lamp, then the missing information was found on the lamp package.

During the recording of lamp information, GELC found that for some of the lamps, either on the lamp or on the package, there was insufficient information, such as no rated frequency and or lamp cap

shown, or, the rated frequency marked on the lamp was different from the one marked on the package. In these cases, the respective countries were informed and they provided and confirmed the correct information, such as what is their national rated voltage or frequency, and, what lamp caps are used.

Figure 1 Total number of models of spiral shape and tube shape lamps tested

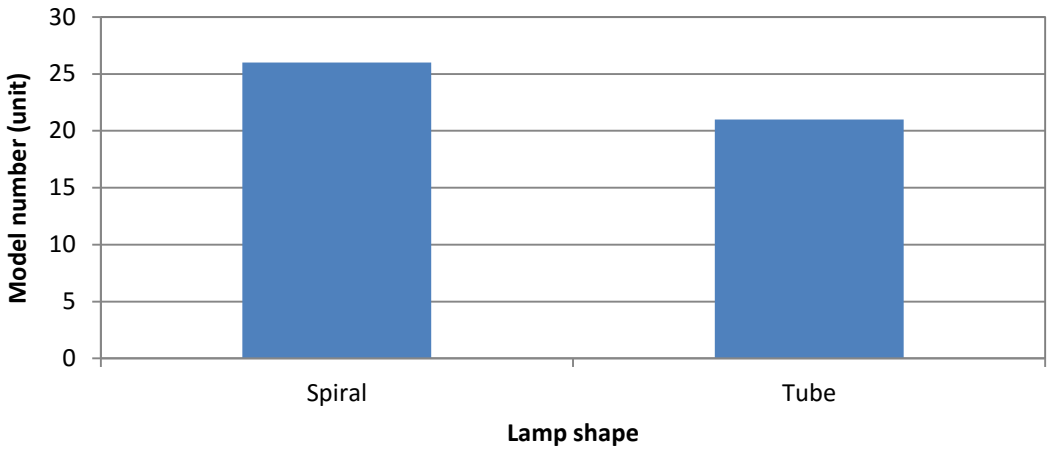
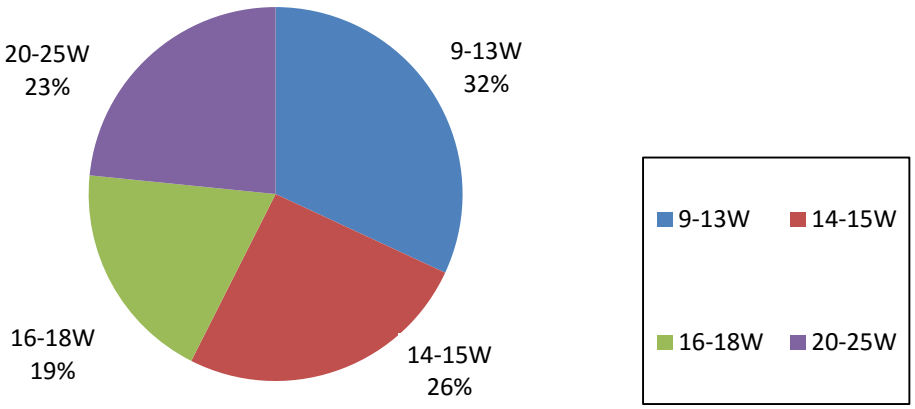


Figure 2 Percentage of each wattage range of total models tested



04 SUMMARY OF TEST RESULTS

4. Summary of Test Results

The test results include three aspects: safety, performance and mercury content (Table 2). The safety and mercury content test was conducted at zero hour. The initial performance tests were conducted at the end of a 100 hour ageing period. The luminous maintenance test was conducted at the end of 2,000 hours operating time.

4.1 Safety test results

The safety test was conducted according to the standard *IEC 60968 Self-ballasted lamps for general lighting services-Safety requirements.* Six safety parameters were tested.

Table 4 Safety test items

Testing items	Test standards
Interchangeability	*IEC 60968 Self-ballasted lamps for general lighting services-Safety requirements*
Mechanical strength	
Insulating resistance	
Electrical strength	
Resistance to flame and ignition	
Protection against electric shock	

A total of 47 models of CFLs were tested for safety. The safety test includes the basic but most important parameters for product quality. In principle, if any lamps tested have safety problems, the products should not be allowed to enter the market. The results of safety testing for the 47 models shows compliance rate of 80.9%, which means that 18.1% of the lamps failed the safety test.

Among the six safety items tested, the failures are all due to three parameters interchangeability, protection against electric shock and mechanical strength. Figure 4 shows that the biggest problem is interchangeability, which accounts for more than half of the failed samples. The second biggest problem is mechanical strength accounting for 36% of the failed samples.

For the other three test items, insulating resistance, electric strength and resistance to flame and ignition, all the samples passed (no failures). Figure 5 shows the compliance rate for the safety test items.

Figure 3 Non-compliance for safety test items

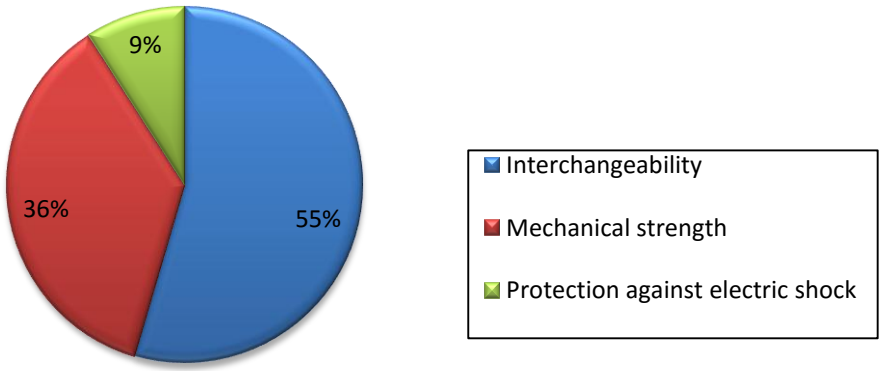
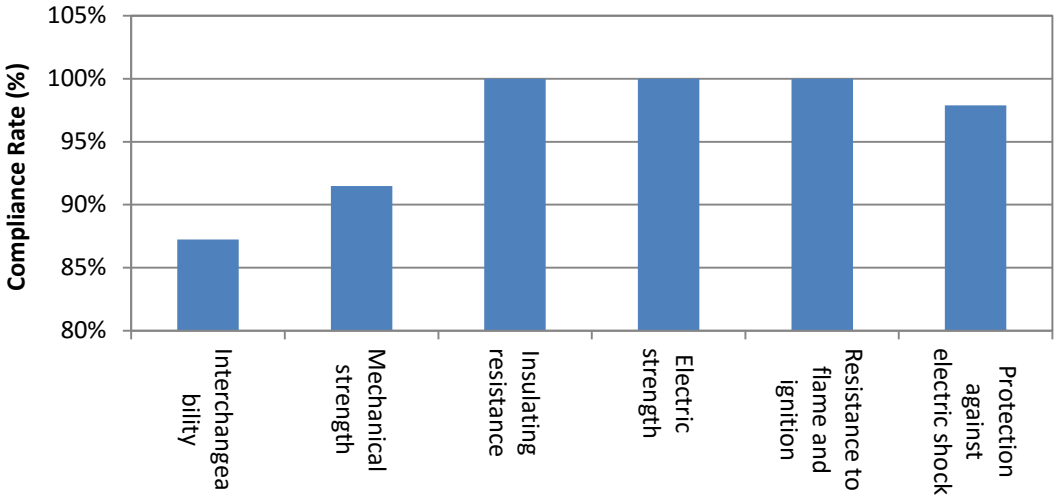


Figure 4 Compliance rate for safety test items



Interchangeability: Refers to the matching degree of the lamp and the lamp holder. When the lamp screws into the lamp holder, it should not be too loose or too tight, which is related to an important technical indicator of safe usage of CFLs. If the lamps have an interchangeability problem, then during installation the lamps cannot screw smoothly into the holder to make firm contact with the electrical contacts, or, there may be too large of a gap between the lamp and the lamp holder, in which cases the lamp would be easily prolapsed or could cause a short circuit within the electronic components. A mismatch of the lamp and the lamp holder may result in arcing or discharge and lead to accidents. The reasons for this quality problem might occur during the assembling process, or, if the manufacturer used lamp caps that do not meet with standard requirements, or, if the manufacturer did not pay good attention to the component quality check of the semi-finished lamps.

Mechanical strength: Mechanical strength mainly assesses if the lamp cap is securely connected. Some manufacturers do not conduct clockwise and counterclockwise torque testing when the lamp and lamp holder are connected; this lack of testing can result in the lamps not meeting the tightening torque requirements of the standard. Therefore some lamp caps may fall off during

the process of installation or removal, which might endanger the end-users and can cause bodily injury.

Electric shock protection: Protection against electric shock refers to the way the lamp screws into the lamp holder (which should be in compliance with the lamp holder standard). The lamp contacts cannot touch the metal parts or any electrical components on the lamp cap, because this metal-to-metal contact would easily lead to dangerous electric shock when users install or remove the lamps. *During this test, GELC found that the structural design of some products do not meet the requirements; these products present a very large safety risk for users.*

4.2 Performance test results

The performance test was conducted according to the standard, *IEC 60969 Self-ballasted lamps for general lighting services - performance requirements.* Seven performance parameters were tested.

Table 5 Performance test items and standards

Testing items	Testing standard	Comparison standard
Lamp power (W)	*IEC 60969 Self-ballasted lamps for general lighting services – Performance requirements*	• *IEC 60969 Self-ballasted lamps for general lighting services – Performance requirements* • *EU Regulation No. 244/2009* • *AS/NZS 4847.2 Self ballasted lamps for general lighting service Part 2: Minimum Energy Performance Standards (MEPS) requirements* • *ENERGY STAR Lamp V1.0 Specification* • *Energy Saving Trust Lamp Specification V7* • *GB/T 17263 Self-ballasted lamps for general lighting service -*
Power factor		
Initial luminous flux (lm)		
Initial efficacy (lm/W)		
Colour Rendering Index (CRI)		
Standard Deviation Colour Matching (SDCM)		
Luminous maintenance (2,000 hours)		

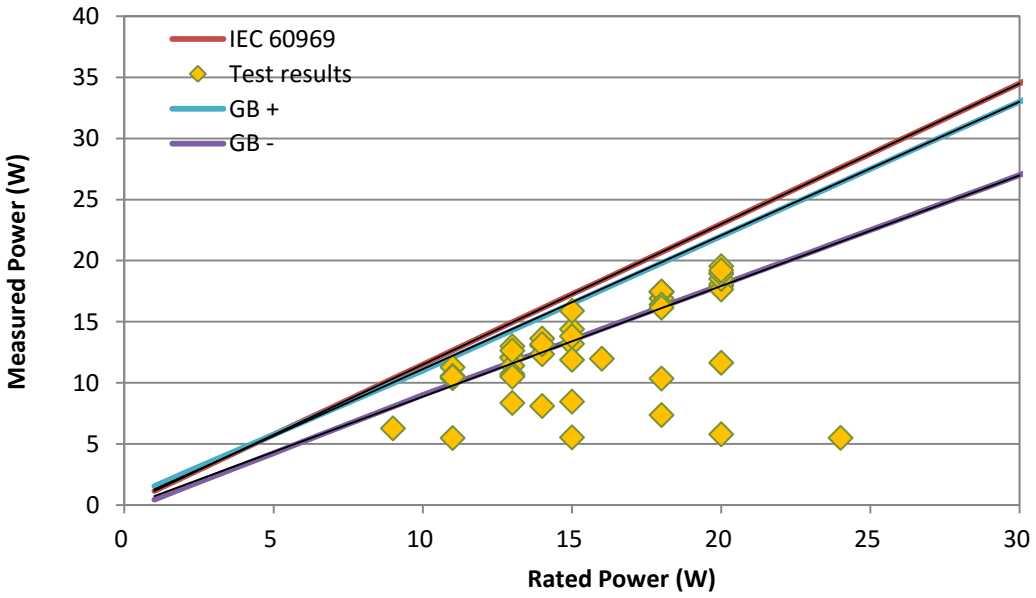
In order to have a better understanding of the lamps' performance quality, six other standards are also referred to in comparing the average test results. However, different standards may differ in some aspects of the test method and sample size and therefore, these other comparison standards only show a general picture of the product quality levels.

IEC 60969 only specifies the maximum requirement for lamp power, therefore the comparisons are mainly used in regional or country standards, as listed in Table 5. All of them have very close requirements for minimum performance.

4.2.1 Lamp input power

Among the listed reference standards above, only two require input power values: *IEC 60969* and *GB/T 17263. IEC 60969* requires that the initial wattage dissipated by the lamp shall not exceed 115% of the rated power. Figure 6 shows that all of the samples are within the maximum power limitation.

Figure 5 Test results for lamp input power



GB/T 17263 requires that when working at the rated voltage and rated frequency, the deviations between actual power consumption and rated power shall not be more than 5%±0.5W for lamps with power less than 10W, and 10% for lamps with power 10W or above, separately. That means for *GB/T 17263,* there is not only a maximum requirement similar to *IEC 60969* (noted as *GB+* in Figure 6), but also a minimum requirement for the lamp power (noted as *GB-* in Figure 6). Figure 6 shows that nearly half of the samples are out of the limits of the allowable tolerance range. This phenomenon appeared on samples from most of the countries; there was no indication that the problem is occurring in any specific country, brand or manufacturers' products.

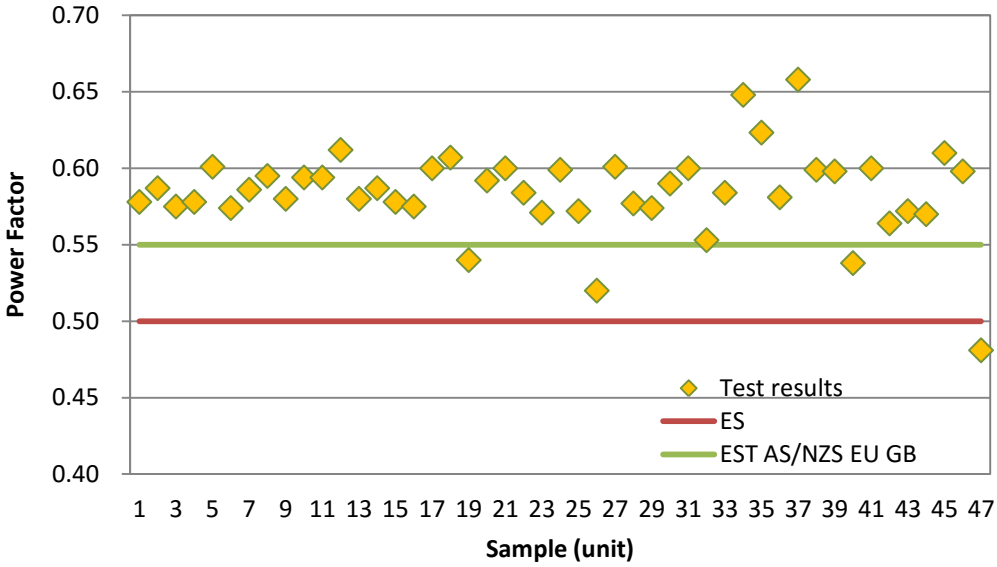
Lamp should operate at or just below its rated power; if the input power demand is much higher or much lower, there is a problem. The potential reason it is much lower may be that the manufacture marks a higher rated power purposely to increase the lamp price; or, it also may be the production controls of the manufacturer does not match its design capability. In any case, products inaccurately rated result in consumer's losses.

4.2.2 Power factor

Almost all the referred standards require that the power factor of the CFLs should be no less than

0.55, except for the *ENERGY STAR Lamp Specification V1.0,* which has a lower requirement of 0.5. Figure 7 shows that only one lamp drops below the minimum requirement of 0.5 from *ENERGY STAR Lamp Specification V1.0,* and if compared with the other standards, another three samples are under the limitation line of 0.55. However, the results show that 91.5% of the samples do meet the power factor requirement.

Figure 6 Test results for power factor



4.2.3 Luminous efficacy

There are different standards providing different requirements for lamp efficacy, within which there are several classifications of lamps. For example, in the EST specification, the minimum efficacy differs with lamp shape; in the GB standard, the minimum efficacy can differ with colour temperatures (even with the same wattage). Therefore, to compare the efficacy data with some standards' specific conditions, the comparison figures must be separated from the reference standards.

4.2.3.1 Efficacy test results compared with *AS/NZS 4847.2*, EU *Regulation No. 244/2009* and *ENERGY STAR Lamp Specification V1.0*

Figure 7 Test results for luminous efficacy

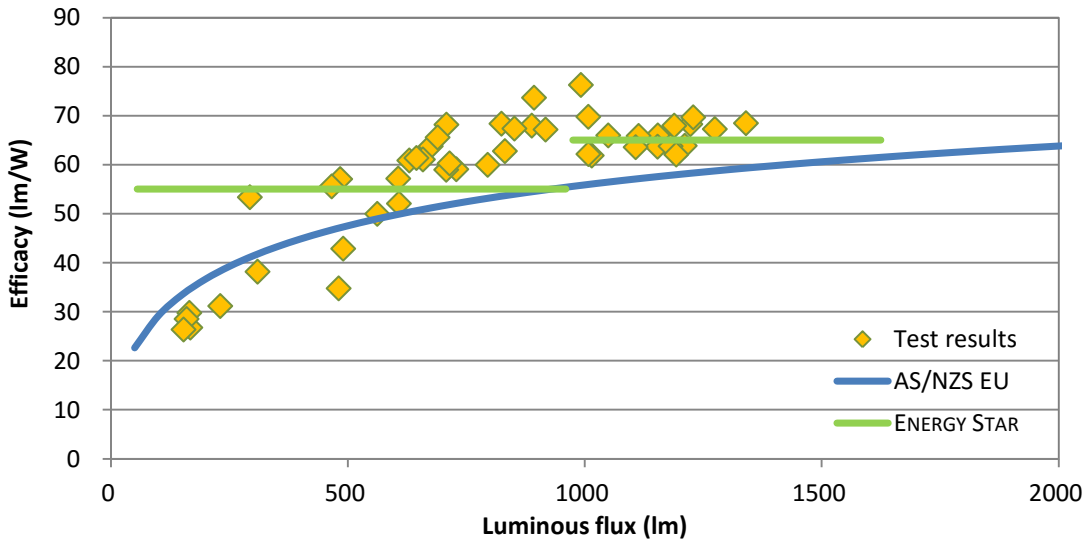


Figure 8 shows the tested efficacy data plotted against the requirements of *AS/NZS 4847.2, EU Regulation No. 244/2009,* and *ENERGY STAR Lamp Specification V1.0*. There are big differences among the test results. Half of the samples did not meet the *ENERGY STAR* requirements, with 20% of the samples having much lower efficacy (for lamp input power between 9W and 25W).

4.2.3.2 Efficacy test results compared with *EST lamp specification V7*

In the EST specification, there are three groups for fluorescent lamps and 17 classes defined for electronic, self-ballasted CFLs. The samples tested belong to Group 1 and Class 1, lamp types without a secondary covering or bulb, all of wattages up to and including 25W. However, for lamps in Group 1 and Class 1 there are two different requirement curves for efficacy, one for stick shape lamps and one for spiral shape lamps.

Figure 8 Test results for luminous efficacy

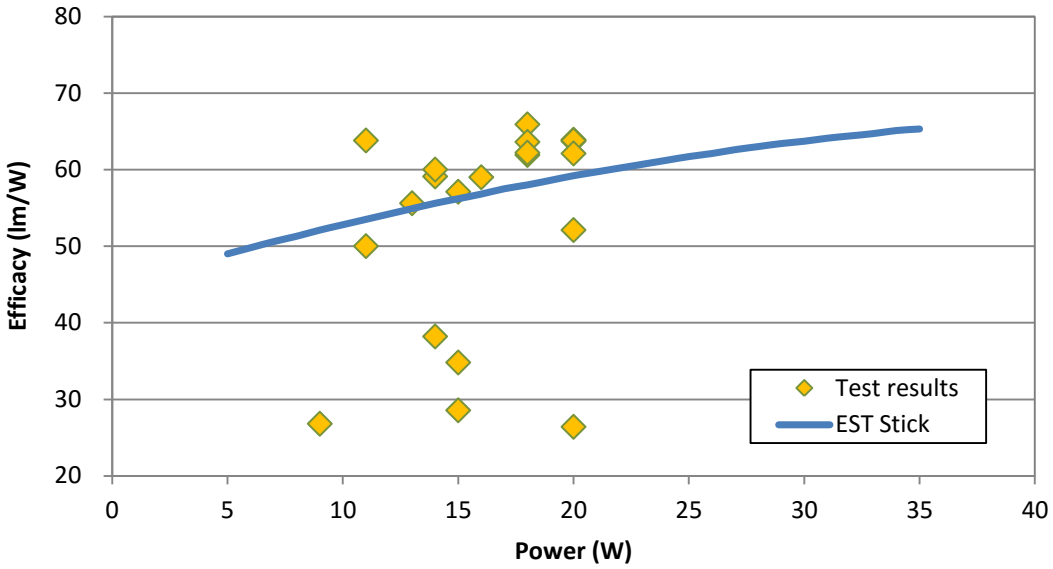


Figure 9 shows the efficacy results for stick lamp' compared with the EST requirement (stick). Only 61% of the lamps meet the EST requirement and there is a large difference between the non-compliant samples and the standard requirement.

Figure 9 Test results for luminous efficacy

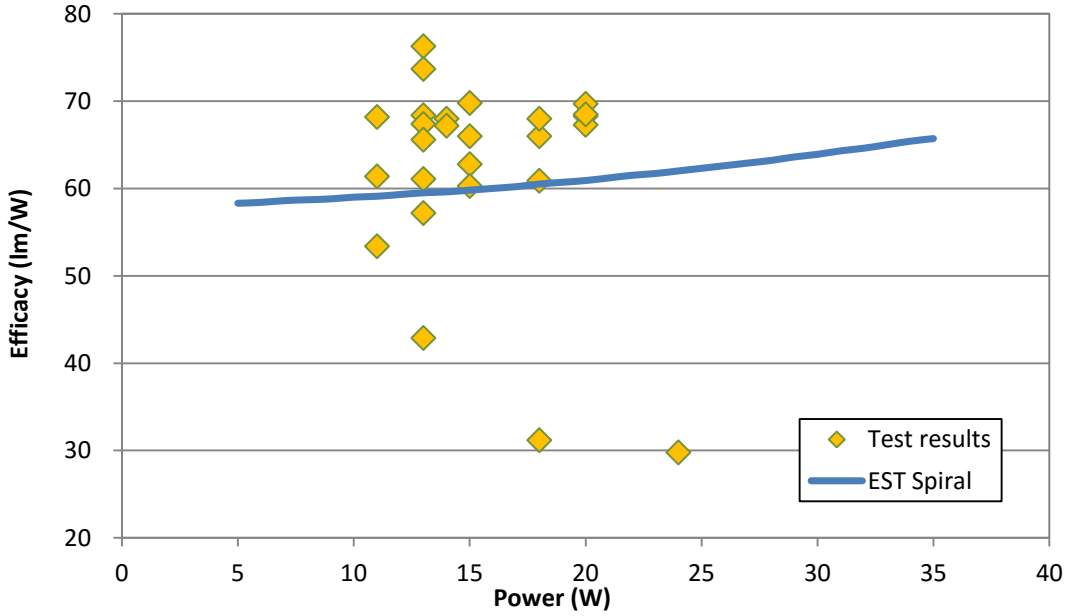


Figure 10 shows the spiral lamps' efficacy results compared with the EST requirement (spiral). Spiral lamps have a higher efficiency requirement than stick yet there is a higher compliance rate for spiral lamps than for the stick lamps. However, there is a big gap between the non-compliant samples and the standard requirement.

4.2.3.3 Efficacy test results compared with *GB/T 17263*

The efficacy requirement in the GB standard, unlike that in the EST standard, has two levels set according to the colour temperature. So, the test samples are divided into two groups: one is cool light with high colour temperature and CCT equal or higher than 4000K; the other is warm light with low colour temperature and CCT less than 4000K. Figure 11 and 12 show the test results compared with the GB standard efficacy requirements.

Figure 10 Test results for luminous efficacy compared to GB/T 17263 (warm light)

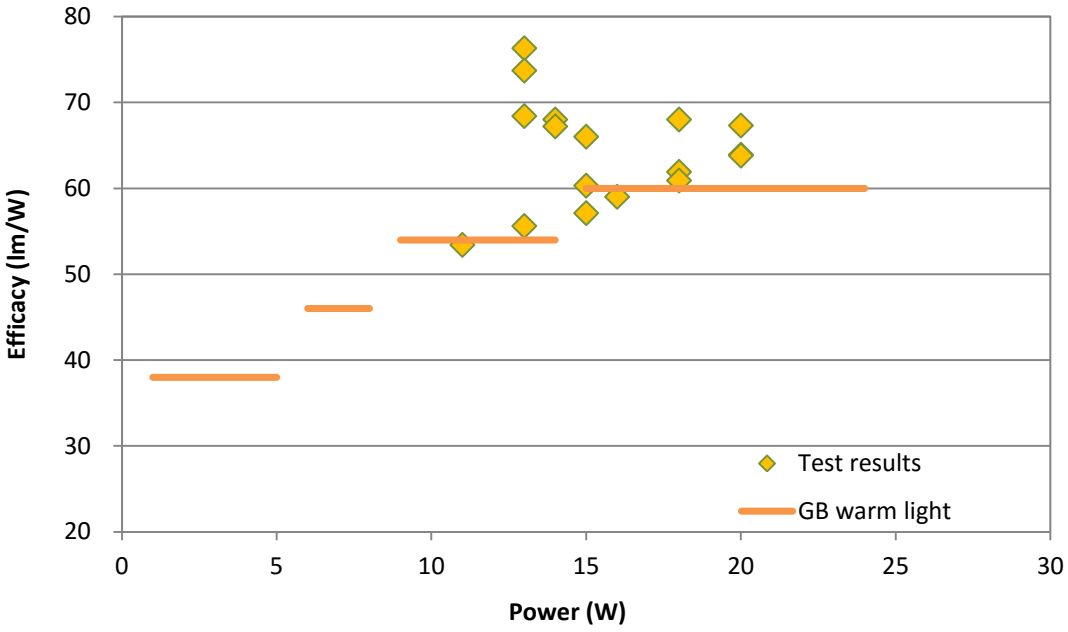


Figure 11 Test results for efficacy compared to GB/T 17263 (cool light)

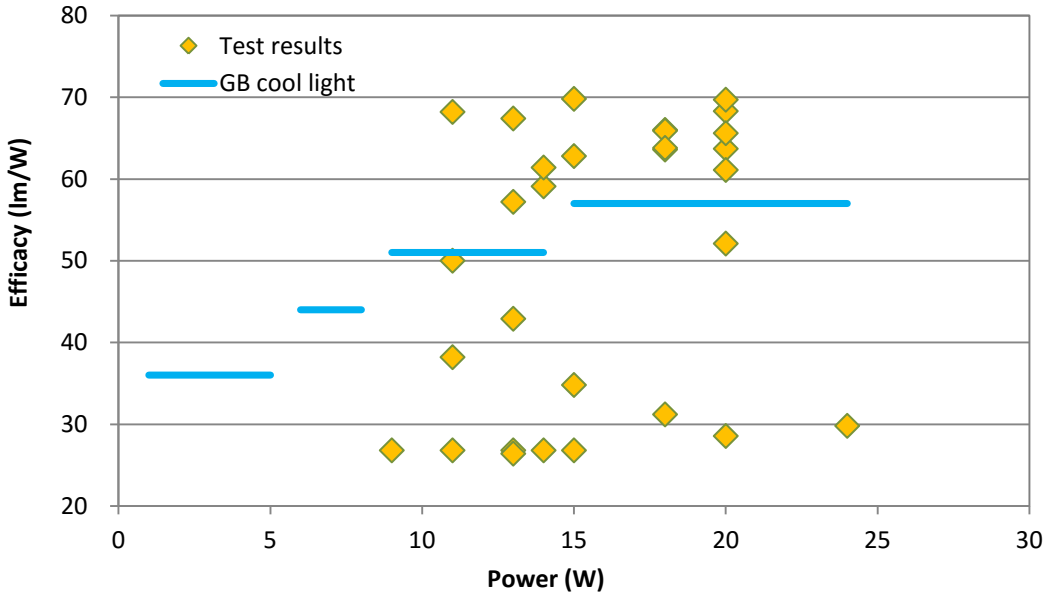


Figure 11 and 12 show that the low temperature (warm light) group of lamps has a higher compliance rate than the high temperature (cool light) group does. In the low temperature group, only individual samples did not meet with the GB standard requirement and the deviations are small. However, most of the non-compliant samples, in the high temperature group, perform much lower than the requirement even though the efficiency requirement is lower. Figure 11 and 12 for the lamps with same wattage also show that there is a difference in results with lamps of the same wattage.

4.2.4 Colour

Colour is an important photometric parameter for lamps. The purity of trichromatic phosphor used in the lamp and the technical level of the manufacturer's production capabilities can be inferred from this colour characteristic. If manufacturers use low quality phosphors and their production techniques are not good, then it would be hard for them to produce lamps with high colour consistency. Two items were evaluated: Colour Rendering Index (CRI) and Standard Deviation Colour Match (SDCM). CRI presents the colour distortion degree of an object when the lamp illuminates the object. SDCM indicates the matching degree between the actual colour and claimed colour of the product. For a lamp with a large SDCM, the actual colour emitted would be different from what the consumers would expect.

4.2.4.1 Colour Rendering Index (CRI)

All of the referred standards require that the CRI should be not less than 80. Figure 13 shows that many of the samples do meet this basic requirement. However, some samples have CRI lower than 80; some are as low as 70. The compliance rate of the samples tested for CRI is 77%.

Figure 12 Test results for CRI

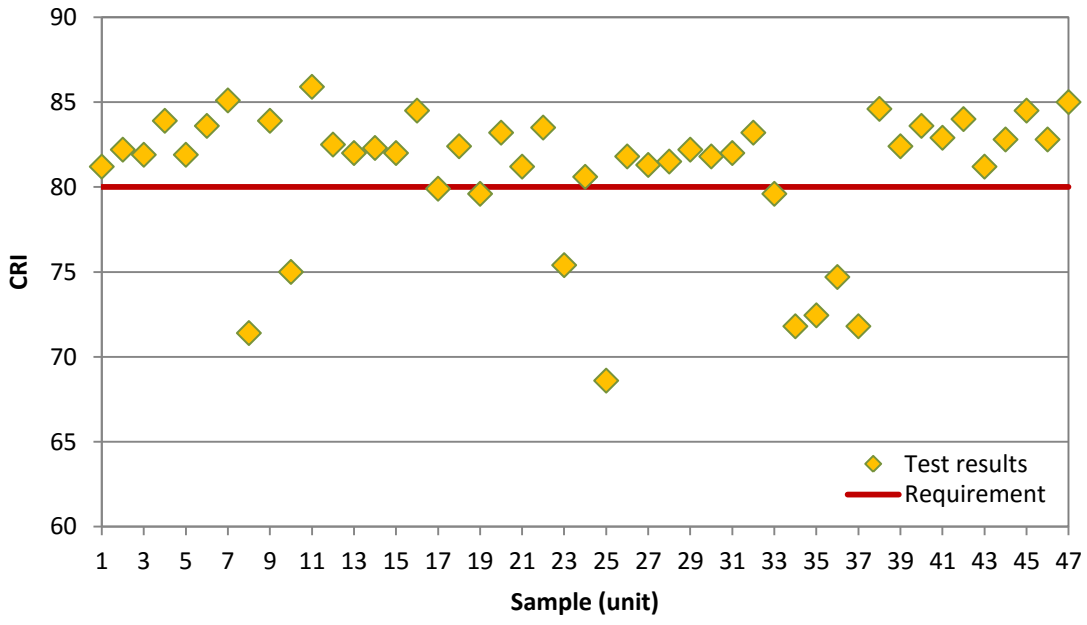
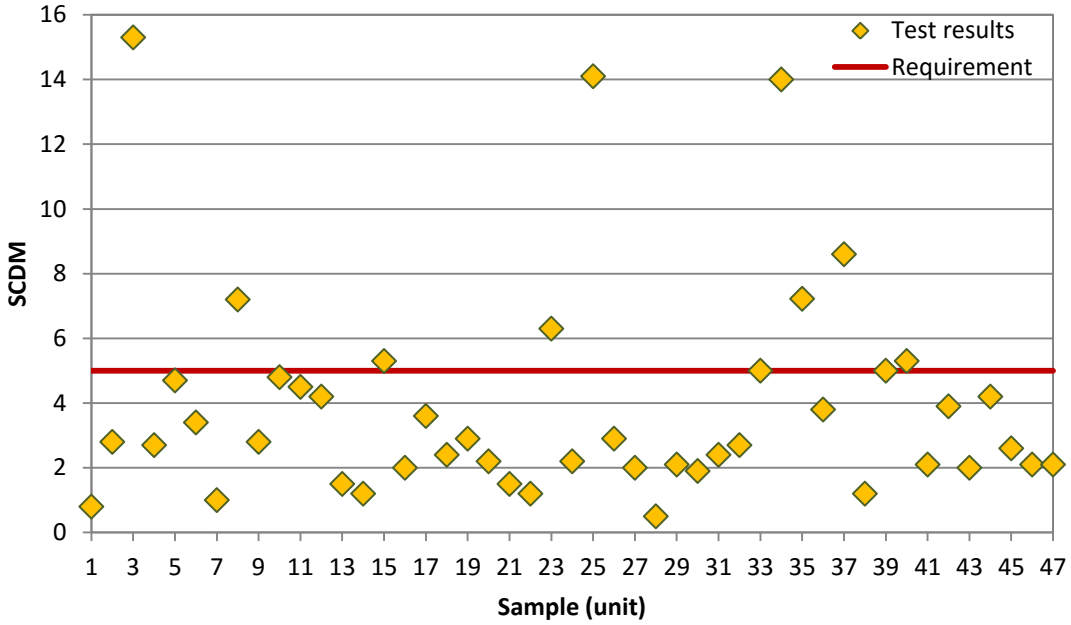


Figure 14 shows SDCM test results. In general, the performance for SDCM should be within five steps. Figure 14 shows that nine batches of samples (19%) have SDCM with more than five steps. Three batches have SDCM over 14 steps—a very unusual result, in GELC's experience.

Figure 13 Test results for SDCM

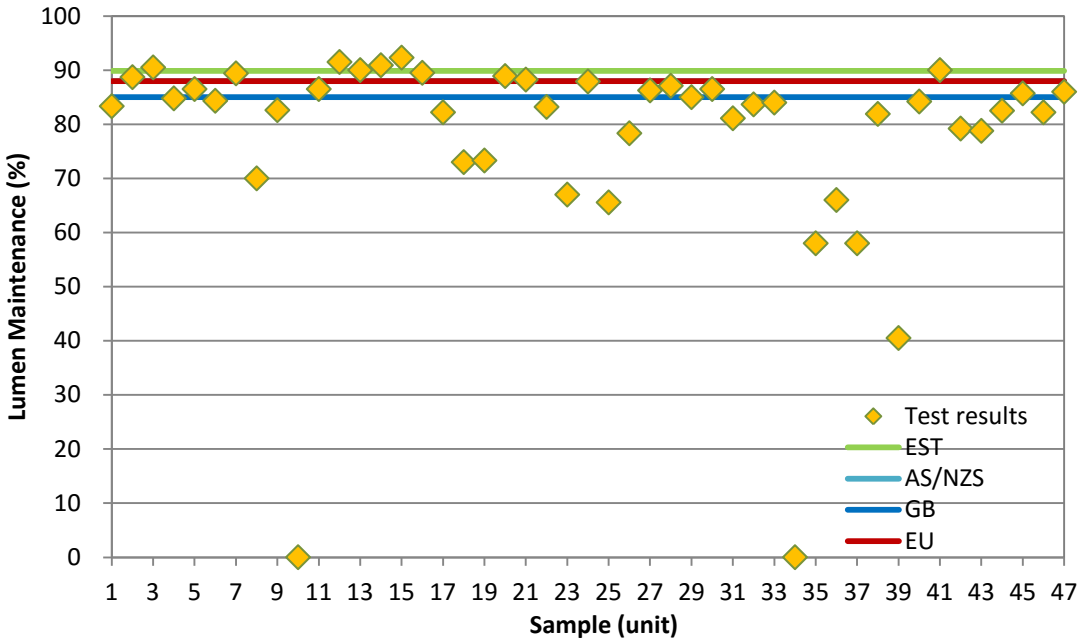


4.2.5 Luminous maintenance at 2,000 hours

As the hours of operation of a lamp increase, the luminous flux of the lamp gradually decays, and the light gets dimmer. Luminous maintenance is defined as the luminous flux at a given time in the life of a lamp divided by the initial value of the luminous flux of the lamp and expressed as a percentage of the initial luminous flux. Luminous maintenance is an important indicator which is related to the life time of the lamp. In this project, the luminous maintenance test was conducted at 2,000 hours.

Figure 15 shows the luminous maintenance results compared with the different reference standards, except for *ENERGY STAR lamp specification V1.0*. For *ENERGY STAR,* there is no requirement for testing luminous maintenance at 2,000 hours; instead, it requires testing at 40% of the rated life time. Figure 15 shows that EST has the highest requirement for luminous maintenance; AS/NZS and EU follow and then the GB standard is the lowest. Figure 15 shows relatively poor results for the luminous maintenance at 2,000 hours. Even for the lowest requirement (GB), nearly half of the samples did not comply. The compliance rate for AS/NZS and EU is less than 30%. For EST the compliance rate is only 13%.

Figure 14 Test results of luminous maintenance at 2,000 hours



4.3 Mercury test results

4.3.1 Mercury format

The element mercury (Hg) is a hazardous and toxic heavy metal, harmful to humans and animals. Mercury is commonly used for discharge lamps as the light emitting substance. At room temperature, the mercury vapor has low pressure which is good for starting the discharge lamps. However, at high temperature, the mercury vapor has higher pressure, which can be helpful for its buffer action. Therefore, in some discharge lamps, mercury plays an irreplaceable role that is more suitable than other elements.

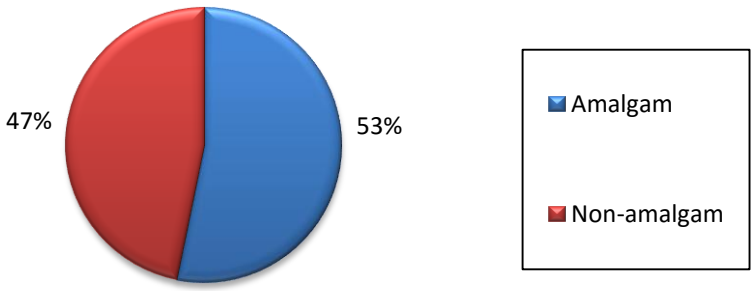
In October 2013, *The Minamata Convention on Mercury,* facilitated by UNEP, was issued. As of October 2014, the Convention has 128 signatories that aim to control and reduce the release of mercury. Noted in the Convention is maximum mercury content of 5 mg for CFLs for general lighting purposes (wattage no greater than 30W).

To reduce mercury pollution and harm to humans and animals, amalgam mercury technology has been developed and adopted by many manufacturers. Amalgam mercury is convenient to control the amount of mercury content injected into CFLs, and can then be more easily recycled at the end of their useful lamp life.

In general, there are two formats of mercury existing in the CFLs, amalgam and non-amalgam. Figure 16 shows the percentage of each mercury format of the CFLs tested. It shows that 53% of the CFLs use the amalgam technology and 47% of the CFLs use the non-amalgam technology. Since nearly half of the lamp models tested use non-amalgam mercury, stakeholders should

consider the environmental and health impacts from these lamps in their markets.

Figure 15 Test results for mercury format (percent of total lamps tested)



4.3.2 Mercury content

Figure 17 shows the average mercury content of each batch of samples. The test results show a huge gap among the testing samples. The better quality lamps have less than 3 mg of mercury, with some having less than 2 mg. However, many lamps have high mercury content. The highest mercury content measured was 14 mg. This raises a very serious issue about why so much mercury content was added to this model. Figure 18 shows the results for amalgam lamps, all containing less than 4 mg of mercury and Figure 19 shows the results for non-amalgam lamps, which have unacceptably high mercury content.

Figure 16 Test results for mercury content

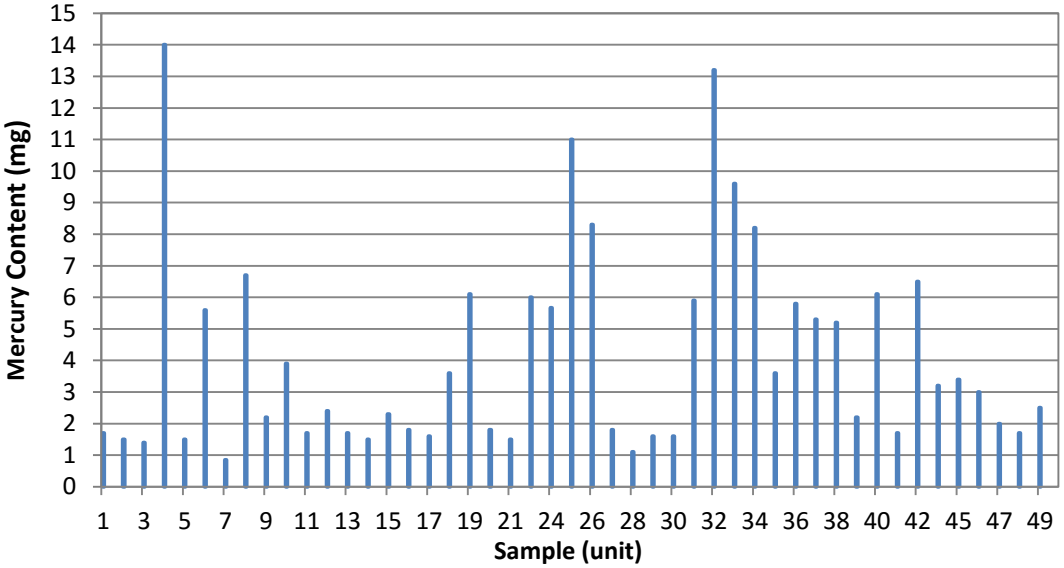


Figure 17 Test results of mercury content, amalgam lamps (each bar represents one lamp)

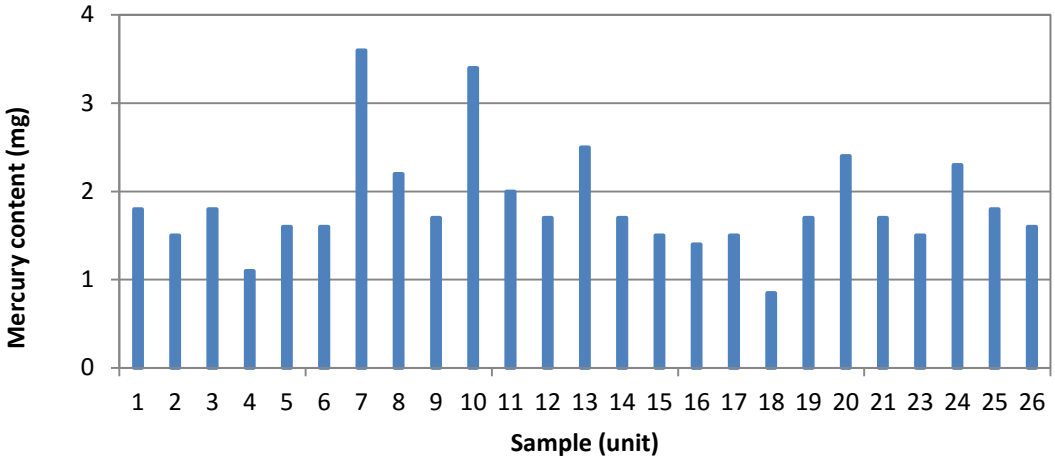


Figure 18 Test results of mercury content, non-amalgam lamp (each bar represents one lamp)

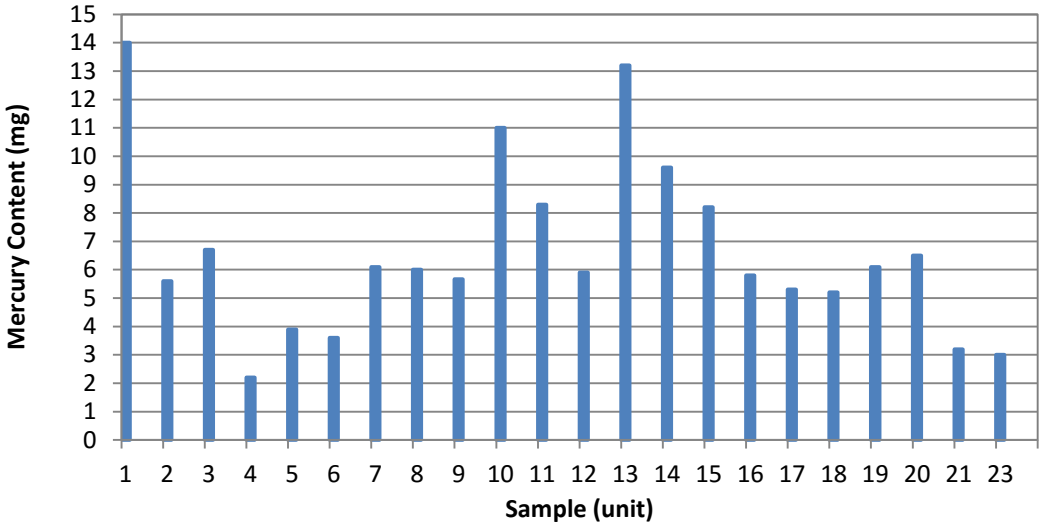


Figure 20 shows the percentage of the total number of lamps containing certain ranges of mercury content. Of all the lamps tested, 36% contain 1.5 to 2.5 mg of mercury, 30% contain 5 to 10 mg. Six percent of the lamps contain over 10 mg of mercury; only 2% contain less than 1 mg of mercury.

Figure 19 Ranges of mercury content, by percent of lamps tested

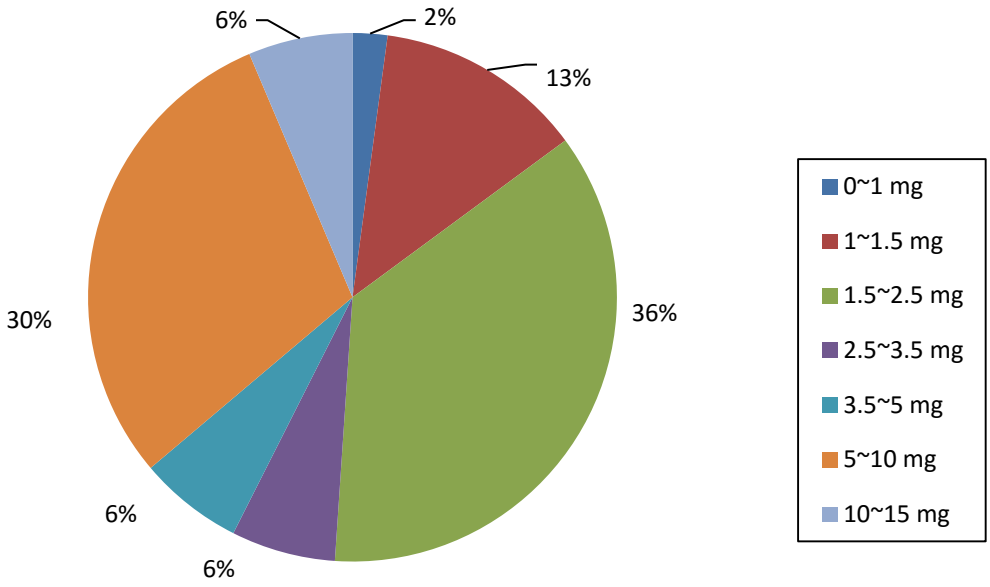


Table 6 shows the maximum mercury content requirements from different reference standards and the corresponding compliance rates of the lamps sampled (from Figure 17-19). More than half of the samples meet the main compliance requirements. These results suggest that in the existing CFL market, stakeholders may need to increase efforts to improve the mercury content of lamps.

Table 6 Mercury content requirements

Reference Standard	Mercury content (maximum allowed)	Compliance rate of lamps tested
Minamata Convention on Mercury	≤5 mg	57%
ENERGY STAR Lamp Specification V1.0	≤2.5mg, for lamp power ≤ 23W ≤3.0mg, for lamp power >23W	51%
EU regulation	≤2.5mg, for lamp power <30W ≤3.5mg, for lamp power between 30W and 50W	51%
AZ/NZS 4847:2010	≤5 mg	57%
GB/T 17263	≤2.5mg, for lamp power ≤ 30W ≤3.5mg, for lamp power >30W	51%
	≤1.5mg, for lamp power ≤ 30W ≤2.5mg, for lamp power >30W	15%
	≤1.0mg, for lamp power ≤ 30W ≤1.5mg, for lamp power >30W	2%

4.4 Mercury content and luminous maintenance

Figure 21 presents the correspondence between mercury content and luminous maintenance. Table 7 lists the luminous maintenance rate in different mercury content rate.

Figure 20 Mercury content and luminous maintenance

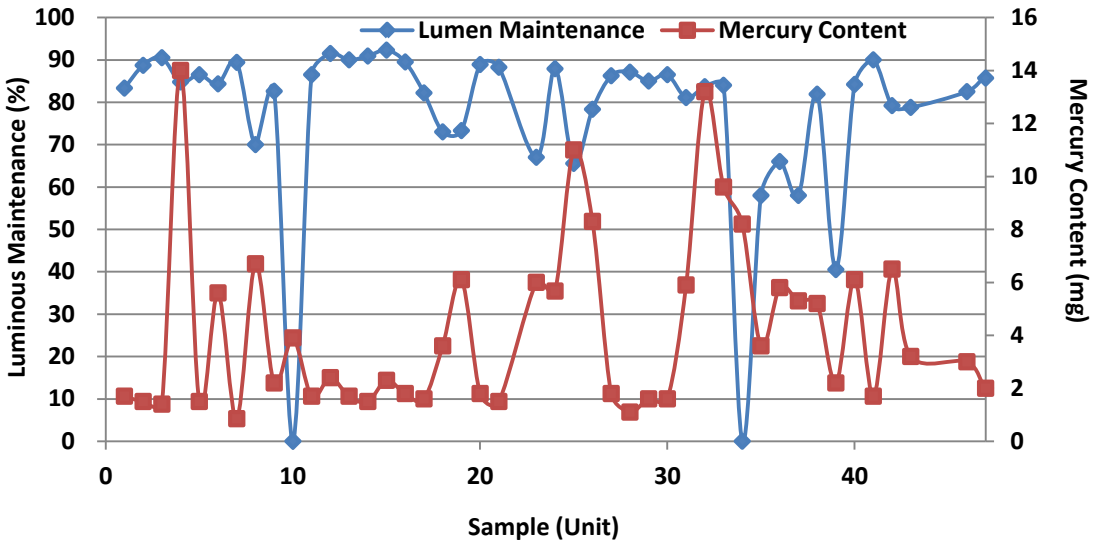


Table 7 Lumen maintenance rate requirements, by ranges of mercury content

Mercury content (mg)	Non-compliance rate (less than 85%)	Compliance rate requirement 85% (GB)	Compliance rate requirement 88% (EU, AS/NZS)	Compliance rate requirement 89.9% (EST)
≤1.0	0	100%	100%	0
≤1.5	0	100%	71%	29%
＞1.5, ≤2	25%	75%	33%	25%
＞2, ≤3	50%	50%	33%	33%
＞3, ≤5	100	0	0	0
＞5	88%	12%	6%	0

With the compared performance standards, the related lowest requirement for lumen maintenance is 85%. Figure 22 and 23 respectively provide the mercury content of the lamps with the lumen maintenance higher and lower than 85%. Figure 22 showed that the majority of lamps that have low mercury content (less than 3mg) meet the lumen maintenance requirement; there are only two

exceptions. Figure 23 shows both low mercury lamps and high mercury lamps: 24% of the lamps contain less than 3 mg of mercury; 40% contain less than 5 mg; and, 60% contain more than 5mg.

Figure 21 Mercury content for the lamps of luminous maintenance higher than 85%

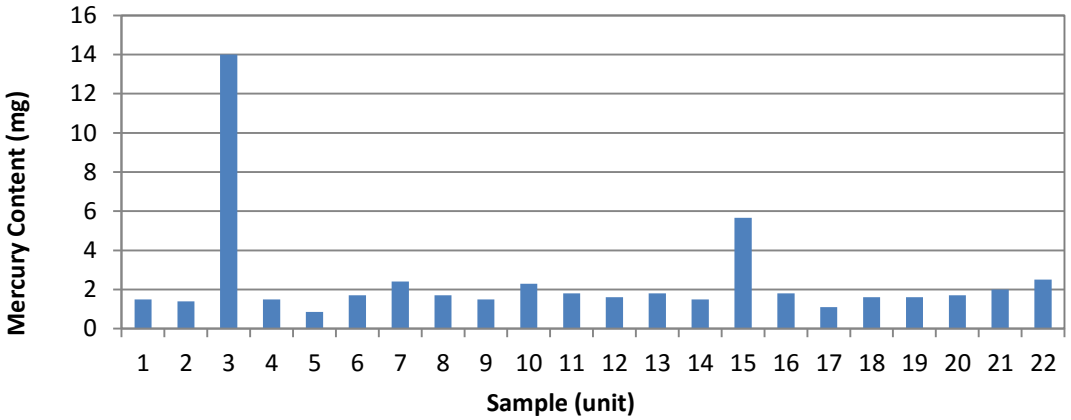


Figure 22 Mercury content for the lamps of luminous maintenance less than 85%

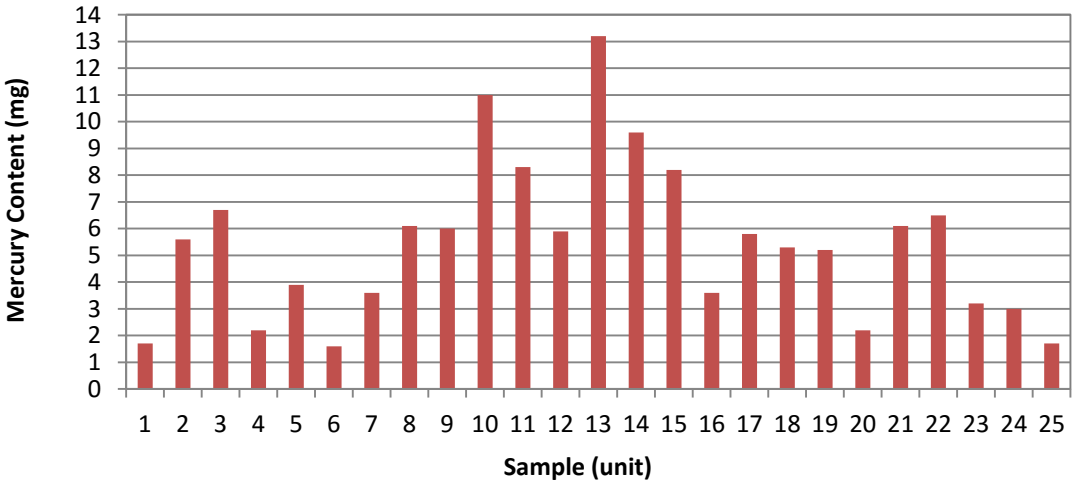


Figure 24 and 25 provide the luminous maintenance of amalgam lamps and non-amalgam lamps. Figure 24 shows that most of lamps have luminous maintenance higher than 80%, with two exceptions. If compared with the lowest requirement of 85%, the compliance rate is 79%. Figure 25 shows that many of the lamps have luminous maintenance lower than 80%. If compared with the lowest requirement of 85%, the compliance rate is only 9%. The results show the non-amalgam lamps have lower luminous maintenance than the amalgam lamps.

Figure 23 Luminous maintenance of the tested amalgam lamps

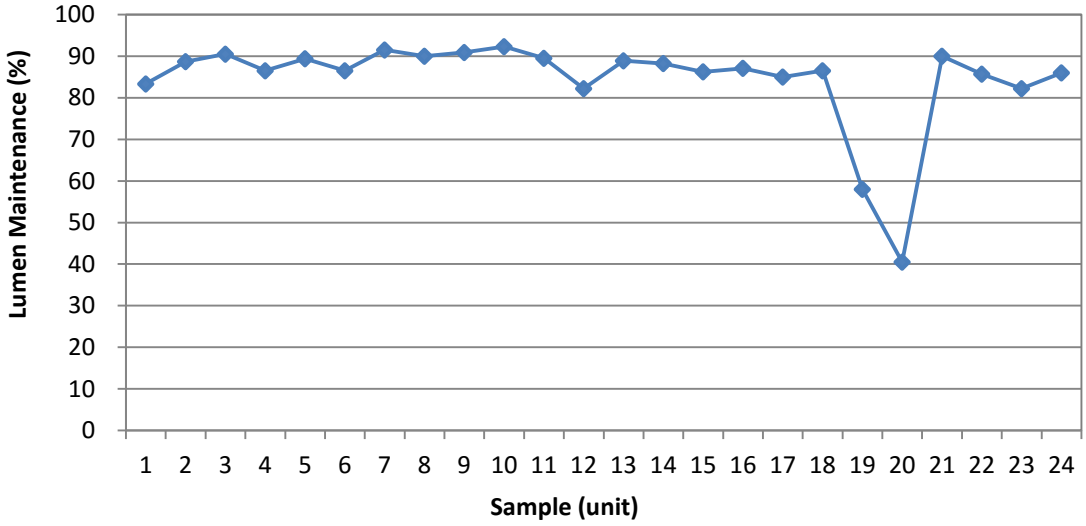
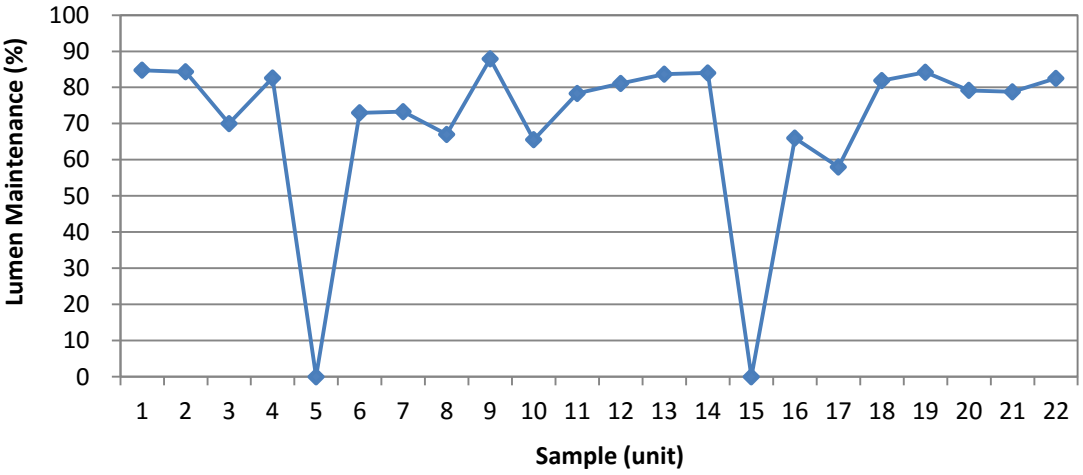


Figure 24 Luminous maintenance of the tested non-amalgam lamps



4.5 Summary

This section summarizes all the test results mentioned above for the comparison with the reference standards. As already mentioned, the test methods adopted by different standards may have some differences, and the sample size may also be different. Therefore, Table 6 does not show the “pass” or “fail” results, but it does present a general overview of performance compared against those standards.

The lamps were randomly sampled from local markets, and therefore reflect the lamp quality situation of the participating country markets. The test results reveal that there are some safety issues for certain lamps. Stakeholders of some of the countries should address these results because the lamps may harm or endanger consumers. Regarding the performance test, some

results are good, showing a related high compliance rate. However, there are some problems for some of the main key parameters, such as large deviations among the lamps. For example, in efficacy, colour, luminous maintenance and other characteristics, some of the lamps could meet the highest requirements, while others do not meet even the most basic requirements. A similar situation is shown by the results of the mercury content test. In the local markets involved in this project, there are good quality products but there are many poor quality products, too. Hopefully, this report will serve as a good reference to those countries stakeholders to better understand the lamp quality in their market. They may consider which MVE measures would be necessary to implement to improve and control lamp product quality, so that consumers are protected and receive the expected benefits from the products, and, the energy savings promised by efficient lighting are delivered.

Table 8 Summary of test results

Testing and Testing items	Reference standards	Standard requirements	Compliance rate of tested lamps
Safety			
Interchangeability	IEC 60968	All testing samples pass	87%
Protection against electric shock	IEC 60968	All testing samples pass	98%
Insulating resistance	IEC 60968	All testing samples pass	100%
Electric strength	IEC 60968	All testing samples pass	100%
Mechanical strength	IEC 60968	All testing samples pass	91%
Resistance to flame and ignition	IEC 60968	All testing samples pass	100%
Performance			
Lamp Power	IEC 60969	The initial wattage dissipated by the lamp shall not exceed 115% of the rated power	100%
	GB/T 17263	When working at the rated voltage and rated frequency, the deviations between actual power consumption and rated power shall not be more than 5%+0.5W for lamps with power less than 10W, and 10% for lamps with power 10W or above, separately	Nearly half

<table>
<tr><th>Testing and Testing items</th><th>Reference standards</th><th>Standard requirements</th><th>Compliance rate of tested lamps</th></tr>
<tr><td rowspan="4">Power factor</td><td>EU Regulation No. 244/2009</td><td>≥ 0,55 if P < 25 W</td><td>91%</td></tr>
<tr><td>AS/NZS 4847.2</td><td>Minimum True Power Factor 0.55</td><td>91%</td></tr>
<tr><td>Energy Saving Trust Lamp Specification V7</td><td>Shall not be less than 0.55</td><td>91%</td></tr>
<tr><td>ENERGY STAR Lamp V1.0 Specification</td><td>Reported value for each lamp model shall have a power factor ≥ 0.5.</td><td>98%</td></tr>
<tr><td>GB/T 17263</td><td>0.55</td><td>91%</td></tr>
<tr><td rowspan="4">Initial luminous flux
/
Initial efficacy</td><td>EU Regulation No. 244/2009</td><td>Maximum rated power (Pmax) for a given rated luminous flux (Φ) (W) 0,24√Φ+0,0103Φ</td><td>57%</td></tr>
<tr><td>AS/NZS 4847.2</td><td>Minimum efficacy in lm/W, 1/(0,24√Φ+0,0103Φ) Where F = initial luminous flux in luminous</td><td>57%</td></tr>
<tr><td>Energy Saving Trust Lamp Specification V7</td><td>See Table 10</td><td>74%</td></tr>
<tr><td>ENERGY STAR Lamp V1.0 Specification</td><td><table><tr><th>Lamp Rated power (watts)</th><th>Minimum Lamp Efficacy (initial lm/W)</th></tr><tr><td><15</td><td>55</td></tr><tr><td>≥15</td><td>65</td></tr></table></td><td>60%</td></tr>
<tr><td>GB/T 17263</td><td><table><tr><th rowspan="2">Power （W）</th><th colspan="2">Efficacy(lm/W)</th></tr><tr><th>Colour RZ/RR</th><th>Colour RL/RB/RN/RD</th></tr><tr><td>≤5</td><td>36</td><td>38</td></tr><tr><td>6～8</td><td>44</td><td>46</td></tr></table></td><td>72%</td></tr>
</table>

Testing and Testing items	Reference standards	Standard requirements	Compliance rate of tested lamps
		9～14 | 51 | 54 15～24 | 57 | 60 ≥25 | 61 | 64	
Standard Deviation Colour Match	AS/NZS 4847.2	Colour co-ordinates of all lamps shall be within the tolerance area on the chromaticity chart as declared by the manufacturer, importer or responsible vendor, but shall in any case be within 5 SDCM from the target values.	85%
	Energy Saving Trust Lamp Specification V7	Within a tolerance limit of 5 MPCD	85%
	GB/T 17263	≤5	85%
Colour Rendering Index	EU Regulation No. 244/2009	≥ 80	83%
	AS/NZS 4847.2	Minimum CRI 80	83%
	Energy Saving Trust Lamp Specification V7	The measured general colour-rendering index (Ra) shall not be less than 80	83%
	ENERGY STAR Lamp V1.0 Specification	Lamp shall have a colour rendering index (Ra) ≥ 80. The average of units tested shall meet the requirements and no more than 3 units shall have Ra < 77. No unit shall have Ra < 75.	81%
	GB/T 17263	80	83%
Luminous maintenance at 2,000 hours	EU Regulation No. 244/2009	At 2,000 hrs: ≥ 88 %	26%
	AS/NZS 4847.2 S	2000 hrs = 0.88	26%

Testing and Testing items	Reference standards	Standard requirements		Compliance rate of tested lamps
	Energy Saving Trust Lamp Specification V7	89.9%		15%
	GB/T 17263	85%		45%
Mercury				
Format of mercury	IEC 62554	Amalgam 53%		NA
	IEC 62554	Non-amalgam 47%		NA
Mercury content	Minamata Convention	Maximum mercury content 5 mg		57%
	EU regulation	≤2.5mg, for lamp power <30W ≤3.5mg, for lamp power between 30W and 50W		51%
	AS/NZS 4847.2	Maximum mercury content 5 mg		57%
	ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 mg mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 mg mercury per lamp		51%
	GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W ≤3.5mg, for lamp power >30W	51%
		Low mercury	≤1.5mg, for lamp power ≤ 30W ≤2.5mg, for lamp power >30W	15%
		Micro mercury	≤1.0mg, for lamp power ≤ 30W ≤1.5mg, for lamp power >30W	2%

Table 9 Values for minimum lumens per watt (package claim) by lamp type and wattage (EST lamp specification V7) – Class 1

Watts	Stick	Spiral
5	49	58.3
6	49.8	58.4
7	50.6	58.6
8	51.3	58.7
9	52.1	58.8
10	52.8	59.0
11	53.5	59.1
12	54.2	59.3
13	54.9	59.5
14	55.6	59.6
15	56.2	59.8
16	56.8	60.0
17	57.5	60.2
18	58	60.5
19	58.6	60.7
20	59.2	60.9
21	59.7	61.2
22	60.2	61.5
23	60.7	61.7
24	61.2	62.0
25	61.7	62.3
26	62.1	62.6
27	62.6	62.9
28	63	63.2
29	63.4	63.6
30	63.7	63.9
31	64.1	64.3
32	64.4	64.6
33	64.7	65.0
34	65.1	65.4
35	65.3	65.7

05 SUMMARY RESULTS FOR EACH COUNTRY

5. Summary Results for Each Country

5.1 Summary results for Azerbaijan

There are six models from Azerbaijan; however among those lamps three models are linear fluorescent lamps, which are not included in this project. Therefore, only three models of CFLs were tested. In this section, the test results are compared with requirements from EU regulation, AS/NZS, ENERGY STAR and GB. The lamp power is also compared with the IEC 60969.

5.1.1 Safety test

Table 10 lists the Pass and Fail results to each test item for Azerbaijan, and from which it can be seen that the all the samples have passed the safety test.

Table 10 Safety test results of Azerbaijan (n=8)

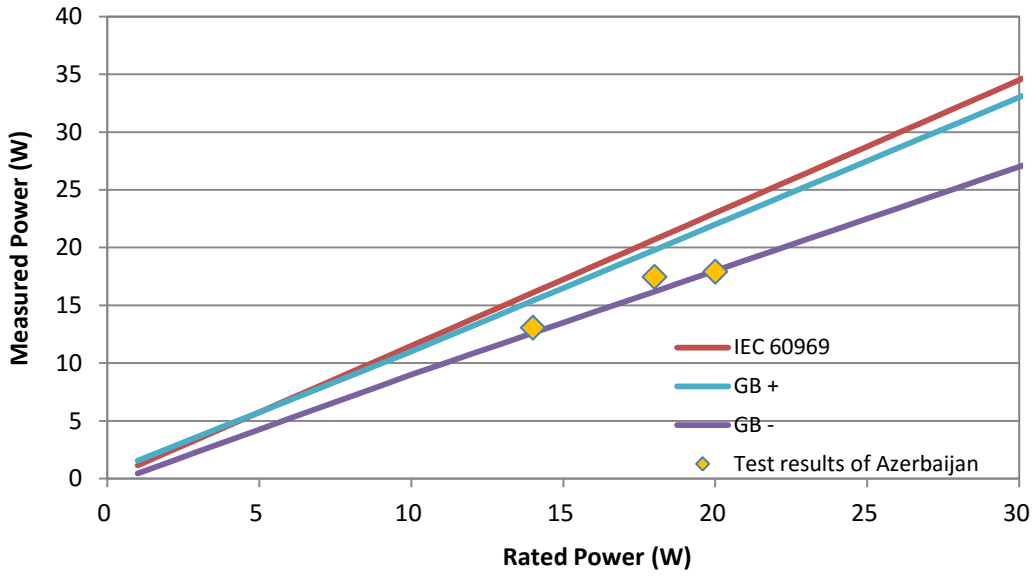
Country	Interchangeability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Azerbaijan	P	P	P	P	P	P

5.1.2 Performance test results

5.1.2.1 Lamp power

The lamp power was compared with IEC 60969 and GB/T 17263. In Figure 26, it can be seen that all of the samples are within requirement of IEC 60969, but not all of the samples meet the requirements of GB/T 17263, as GB/T 17263 limited both maximum and minimum values. It can see that two models of lamps from Azerbaijan met the two standards' requirements; while one model has a slightly lower measured power than the rated power.

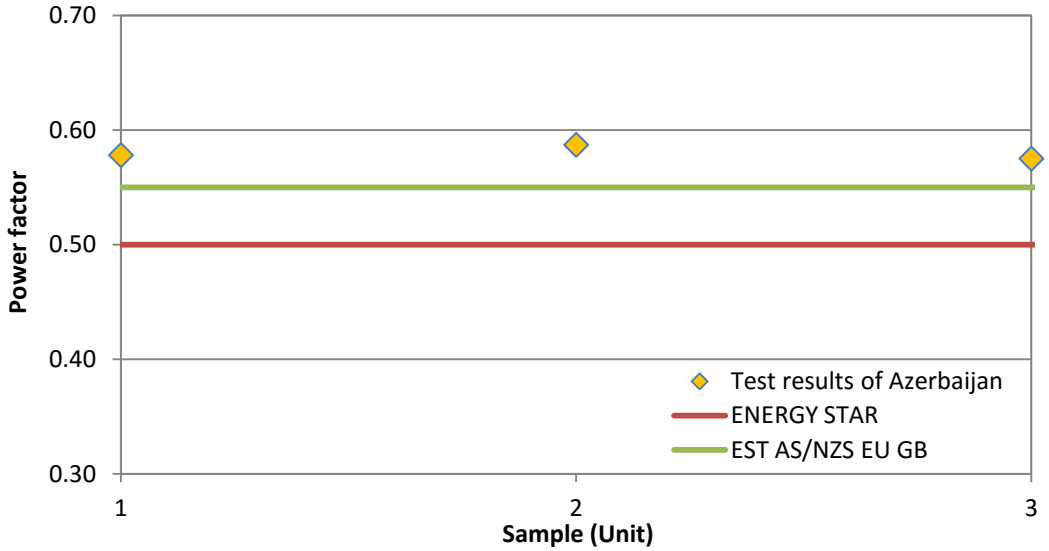
Figure 25 Lamp power test results of Azerbaijan (n=10)



5.1.2.2 Power factor

From figure 27, it can be seen that the power factor of most testing samples over than 0.55 and meet the requirements of all of the reference standards.

Figure 26 Power factor test results of Azerbaijan (n=10)



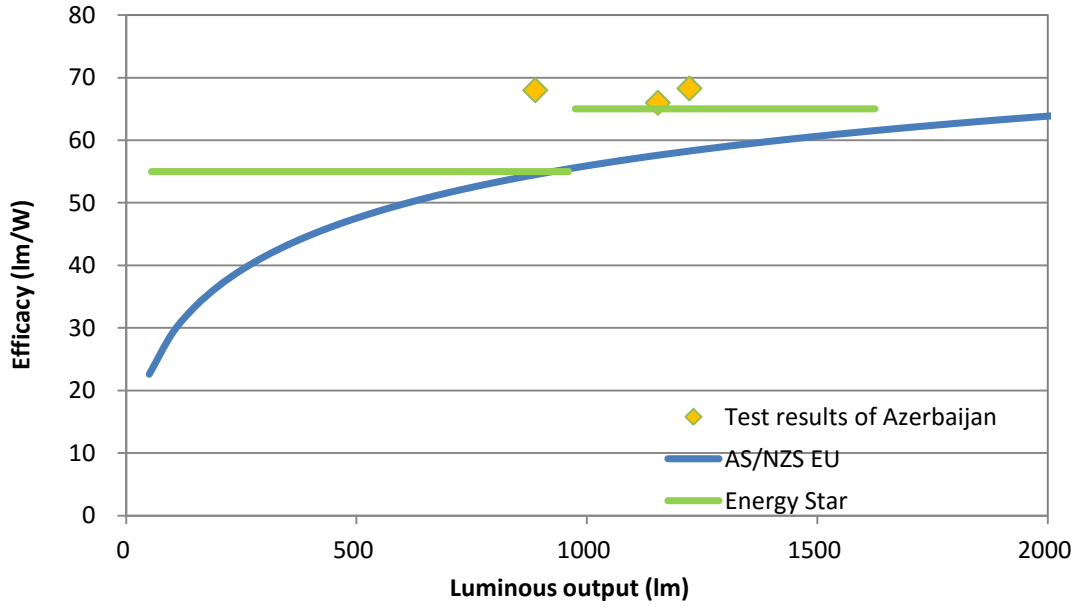
5.1.2.3 Efficacy

a) Compared with EU regulation, AS/NZS 4847.2, and ENERGY STAR lamp specification V1.0

Figure 28 shows the tested efficacy data compared with AS/NZS 4847.2, EU Regulation No.

244/2009 and ENERGY STAR lamp specification V1.0. It can be seen that all the lamps meet the AS/NZS, EU efficacy requirements and ENERGY STAR efficacy requirements.

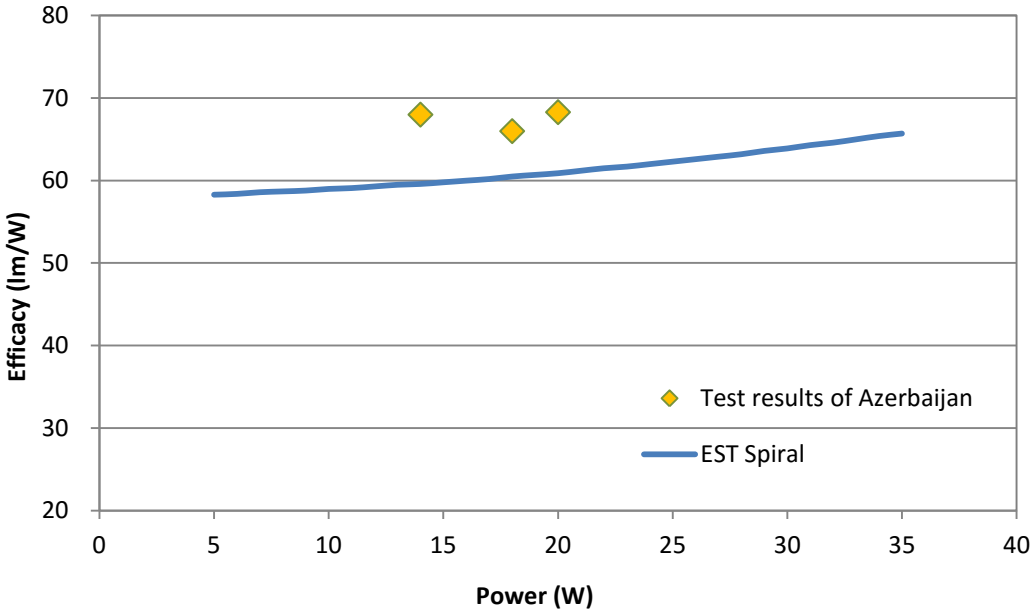
Figure 27 Luminous efficacy test results of Azerbaijan (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes. All of the lamps from Azerbaijan are Spiral shape and the testing results are compared with the corresponding requirements. From figure 29, all the models meet the EST requirements.

Figure 28 Luminous efficacy test results of Azerbaijan (spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for warm light lamps with the CCT equal or higher than 4000K, the other is for cool light lamps with the CCT less than 4000K. One model sample from Azerbaijan has low colour temperature, and the other two are cool light. In Figure 30 and 31, it can be seen that all of them meet the GB requirements.

Figure 29 Luminous efficacy test results of Azerbaijan (warm light) (n=10)

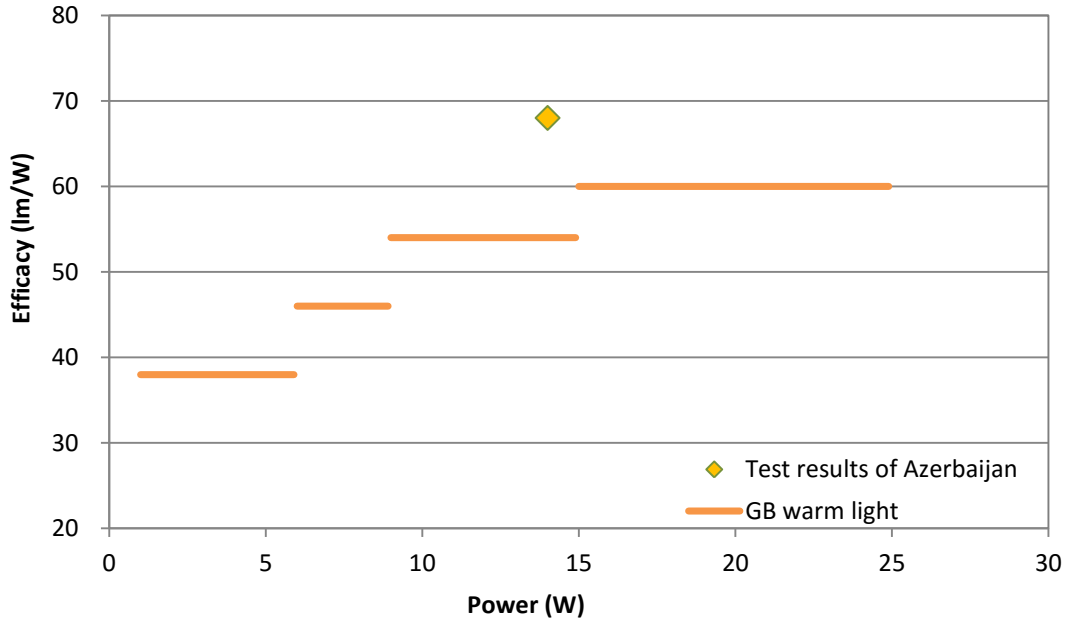
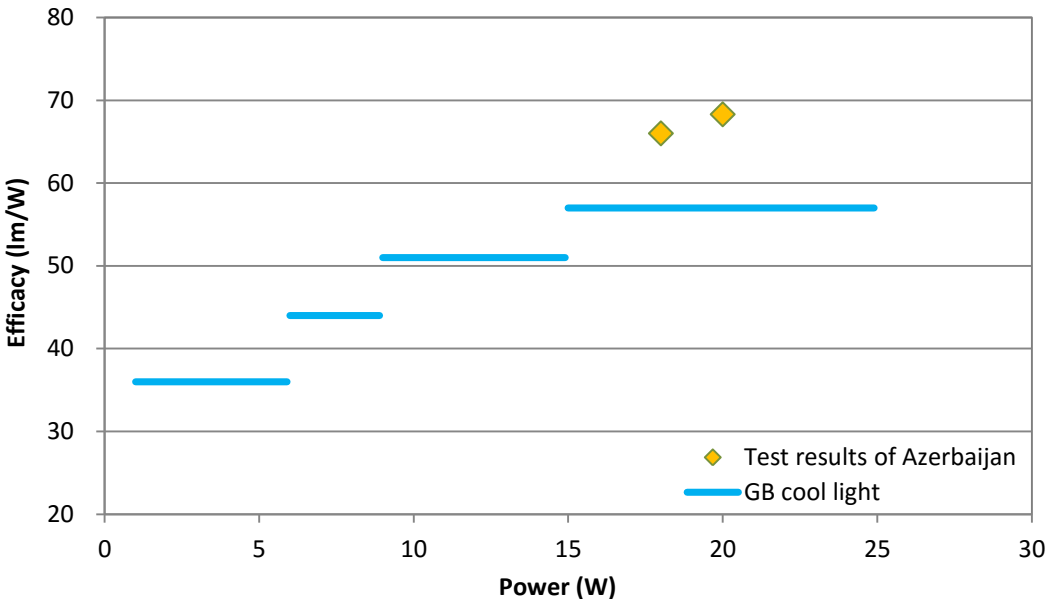


Figure 30 Luminous efficacy test results of Azerbaijan (cool light) (n=10)



5.1.2.4 Colour

Figure 32 and Figure 33 presents the CRI and SDCM test results of the CFLs from Azerbaijan. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a maximum allowance of 5 steps. From Figure 32 and 33, it shows all models of CFLs from Azerbaijan meet the CRI minimum requirement, while one model did not meet the SDCM maximum requirement.

Figure 31 CRI test results of Azerbaijan (n=10)

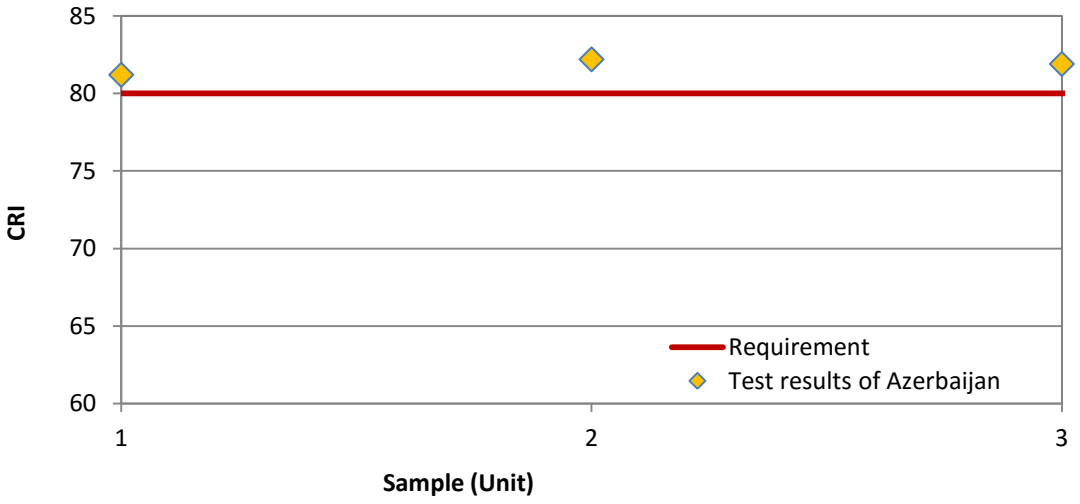
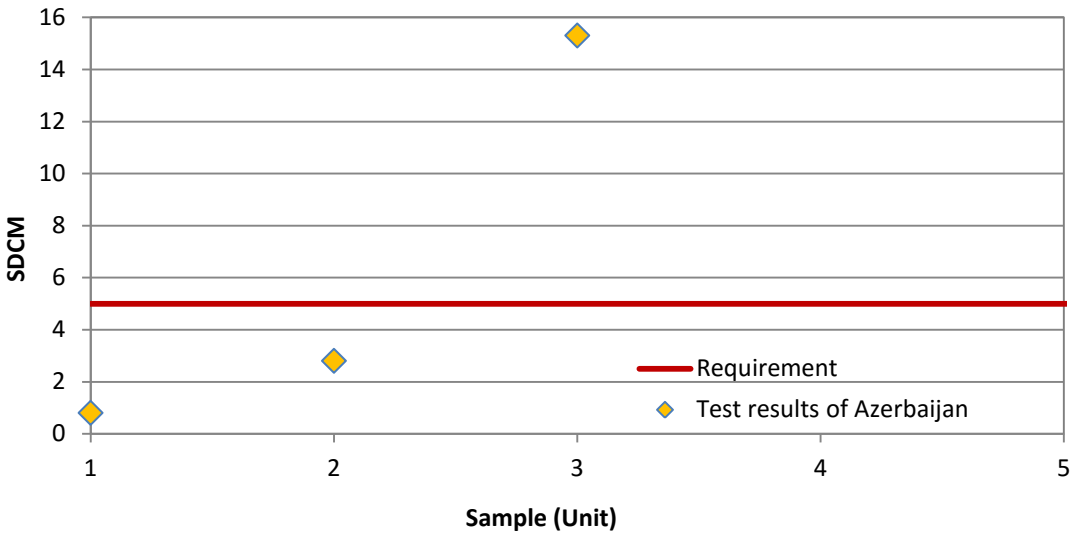


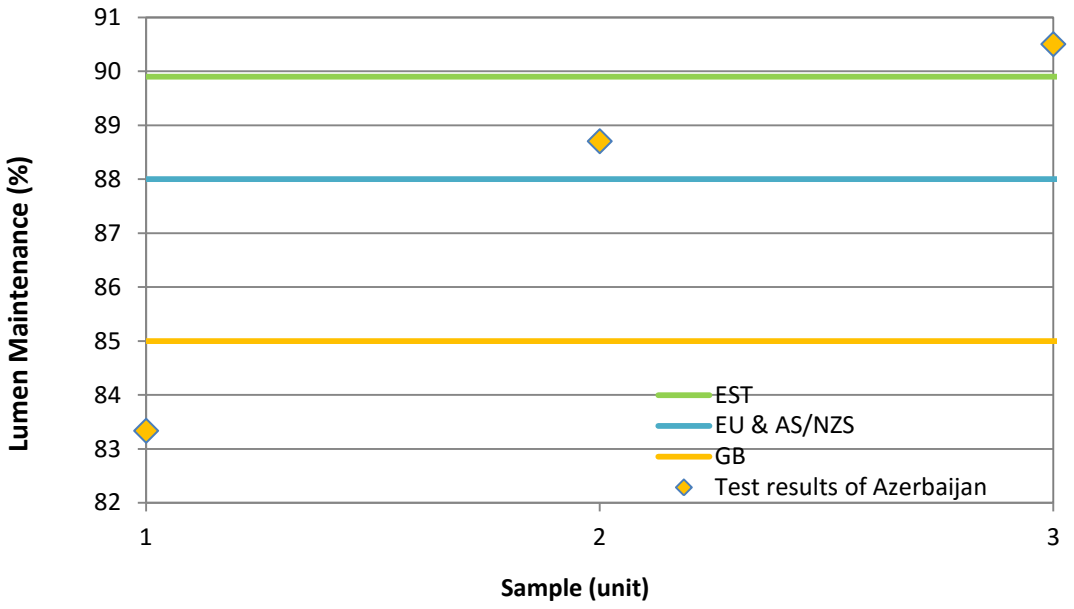
Figure 32 SDCM test results of Azerbaijan (n=10)



5.1.2.5 Luminous maintenance at 2,000 hours

Figure 34 shows the lumen maintenance results compared with the different referred standards. From Figure 34, the lumen maintenance of one model from Azerbaijan is less than 85%, which is the minimum value among all of the compared standards. Two of the models are less than 88%, the second highest line from AS/NZS requirements.

Figure 33 Luminous maintenance test results of Azerbaijan (n=10)

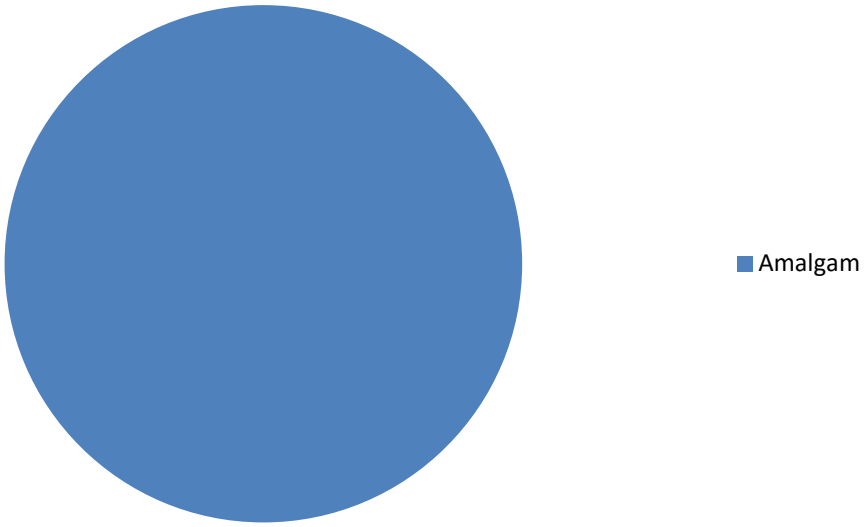


5.1.3 Mercury test results

5.1.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 35 shows all of the samples tested are amalgam lamps.

Figure 34 Format of mercury for the lamps from Azerbaijan



5.1.3.2 Mercury content

Figure 36 shows the average mercury content of each model. We can be seen that amalgam lamps contain stable and small quantities of mercury. All of the models mercury content is less than 2 mg.

Figure 35 Mercury content results for Azerbaijan (n=5)

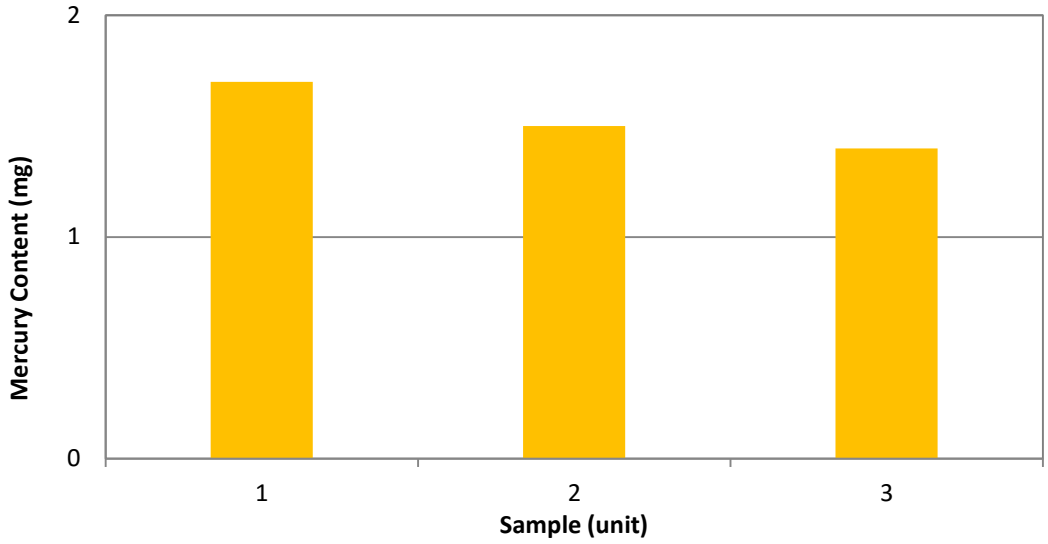


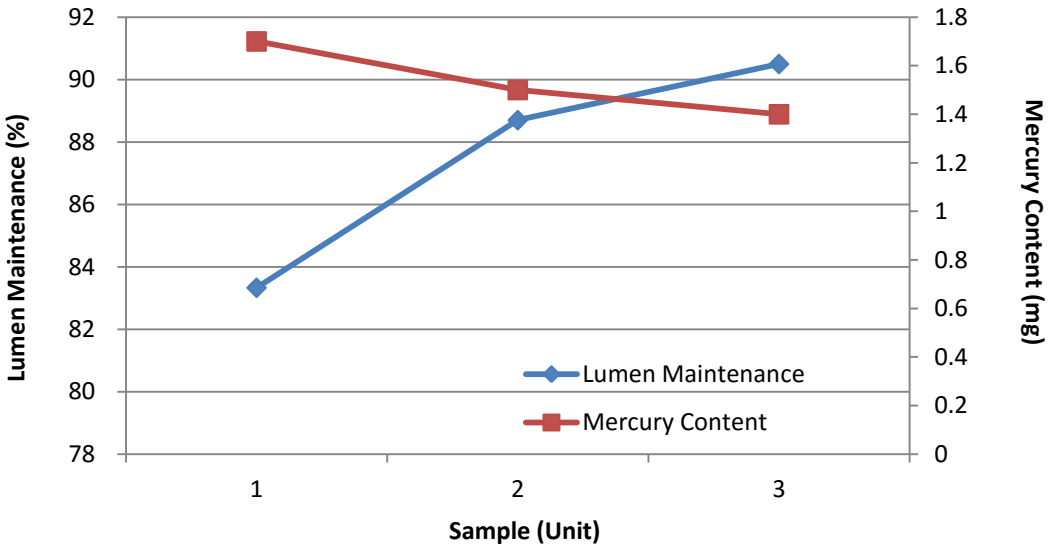
Table 11 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
EU regulation	≤2.5mg, for lamp power <30W;		100%
AS/NZS 4847.2	Maximum mercury content 5mg		100%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		100%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	100%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	67%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0%

5.1.3 Mercury content and lumen maintenance

Figure 37 shows the correspondence of mercury content and lumen maintenance of the lamps from Azerbaijan. All the lamps from Azerbaijan are amalgam lamps. And they show a good lumen maintenance test results, higher than 88%.

Figure 36 Mercury content and lumen maintenance of Azerbaijan



5.1.4 Summary

There are a total six models shipped from Azerbaijan, however among those lamps only three were CFLs which are relevant to this project. Therefore, only three models of CFLs could be tested. From the test results, it can be seen all of the lamps have passed the safety test.

Concerning the performance results, there showed several non-compliances compared with the standards requirements (see Table 12).

Table 12 Non-compliant items

Test items	Compared standards	Results
Lamp power	GB/T 17263	1 model did not meet the requirement
SDCM	EU Regulation/AS/NZS/EST/GB	1 model did not meet the requirement
Lumen maintenance at 2,000 hrs	EU Regulation AS/NZS/ENERGY STAR/ GB	1 model did not meet the requirement;
	EST	2 models did not meet the requirement

Compared with the selected standards, the non-compliance items are lamp power, SDCM and Lumen maintenance at 2,000 hrs. The rest of the testing results are very good.

The measured lamp power of one of the tested samples is too low compared to the rated power. As explained in 4.2.1, the potential reason may be the manufacture marked a higher rated power

in order to increase the lamp price; or it also could be the production capacity of the manufacturer could not match with its design capability. However in the ECOWAS standard there is no requirement for the lamp power.

The most attention needs to be paid to the SDCM and lumen maintenance. SDCM is an important element of the colour characteristic. SDCM indicates the degree of matching between the actual colour and claimed colour of the product. That is, for a lamp with a large SDCM, the actual colour would not be satisfactory for the consumers as it is different from what they expect. The lumen maintenance results indicate that it also needs attention. Within all of the compared standards, only half of models can meet the lowest requirement. The lumen maintenance has a big effect on the lamp life time; the low lumen maintenance results show the luminous flux goes down quickly as the bulb gets older.

5.2 Summary results for Chile

There are six sample models from Chile. Chile has its own MEPS for CFL lamps[1]. As requested by Chile, in this section, apart from those reference standards introduced above, it also compares the test results of the samples with the requirements of Chile MEPS.

5.2.1 Safety test

Table 13 lists the Pass and Fail results to each test item for Chile, and from which we could know that the safety problems of the samples from Chile mainly come from Interchangeability.

Table 13 Safety test results of Chile (n=8)

Country	Interchangeability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Chile	F	P	P	P	P	P

5.2.2 Performance test results

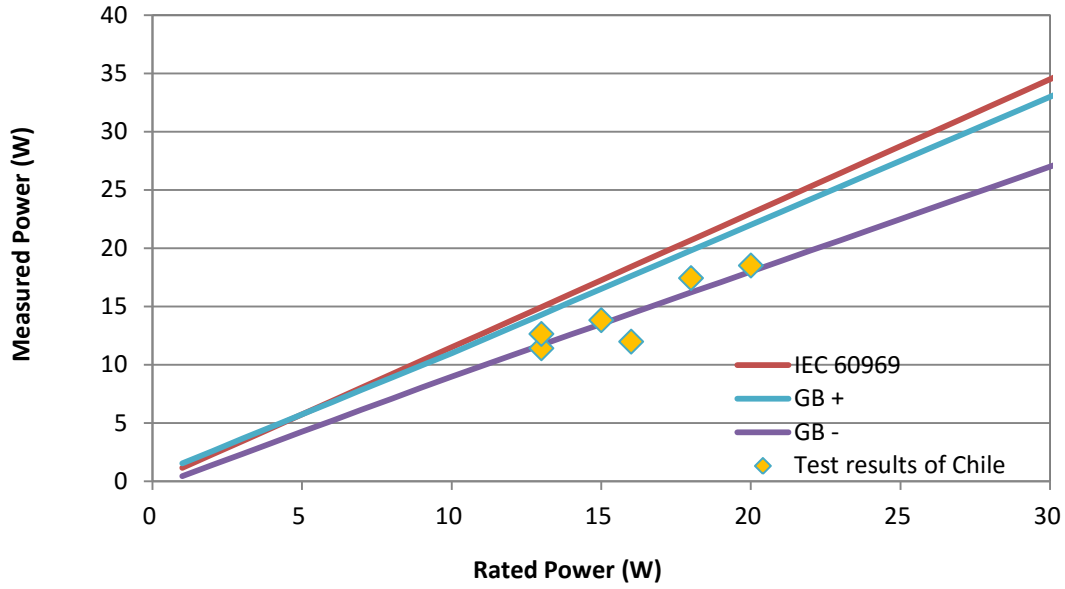
5.2.2.1 Lamp power

There is no Lamp power requirement in the Chile MEPS, therefore the results of lamp power are compared here with IEC 60969 and GB/T 17263.

In Figure 38, it could see that all of the samples are within requirement of IEC 60969, but not all of the samples meet the requirements of GB/T 17263, as GB/T 17263 limits both maximum and minimum values. It can see that most of the lamps from Chile meet the two standards requirements; while a few models of lamps have a slightly lower measured power than the rated power.

[1] *CHILE Anexo 3D Draft Resolución MEPS ampolletas abril_Rev SEC 20130524*

Figure 37 Lamp power test results of Chile (n=10)

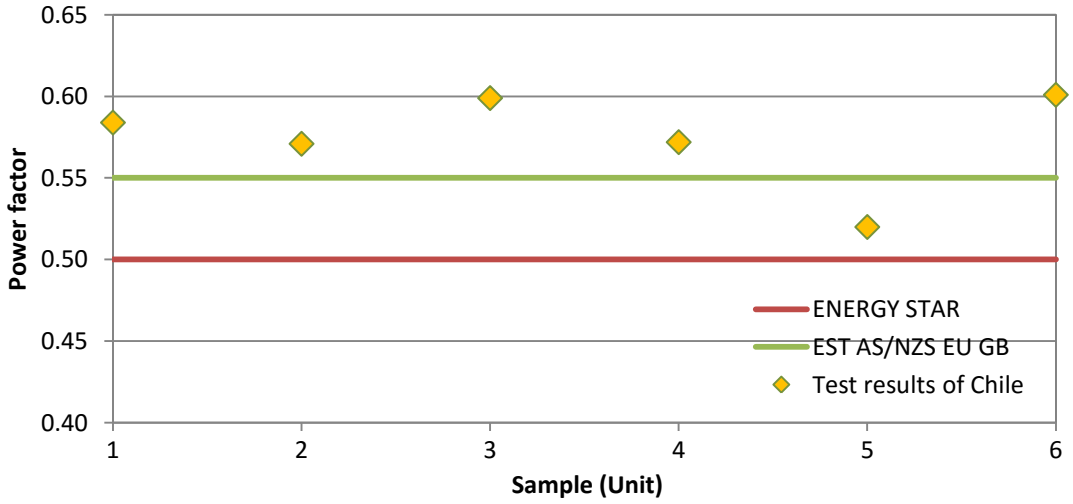


5.2.2.2 Power factor

There is no Power factor requirement in the Chile MEPS, therefore the results of Power factor are compared here with EU regulation, AS/NZS, ENERGY STAR, GB and EST.

From Figure 39, it can be seen that the power factor of most testing samples from Chile are over 0.55 and meet the requirements by all of the comparison standards. There is one model between the lines of ENERGY STAR and EST, AS/NZA, EU and GB.

Figure 38 Power factor test results of Chile (n=10)

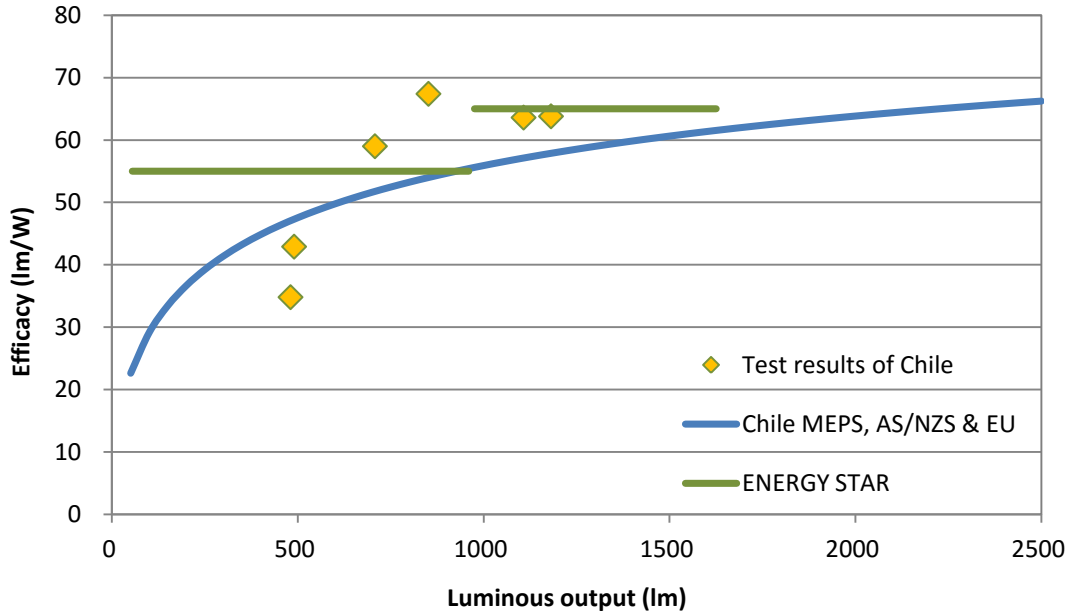


5.2.2.3 Efficacy

a) Compared with Chile MEPS, AS/NZS 4847.2, EU regulation and ENERGY STAR lamp specification V1.0

Figure 40 shows the tested efficacy data compared with Chile MEPS, AS/NZS 4847.2, EU Regulation No. 244/2009 and ENERGY STAR lamp specification V1.0. It can be seen that the lamps with lumen output less than 500 lm could not meet with Chile MEPS and any of other three standards requirements.

Figure 39 Luminous efficacy test results of Chile (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes. And in each group, the testing results are compared with the corresponding requirements. Please see figure 41 and 42.

In Figure 41, three models from Chile meet the EST Stick shape lamp efficacy requirements, and one model from Chile is under the EST minimum requirement.

Figure 42 is the testing results of the spiral shaped lamps compared with EST requirements. One model from Chile meets the EST spiral shape lamp efficacy requirements, and one model from Chile is under the EST minimum requirement.

Figure 40 Luminous efficacy test results of Chile (Stick lamp) (n=10)

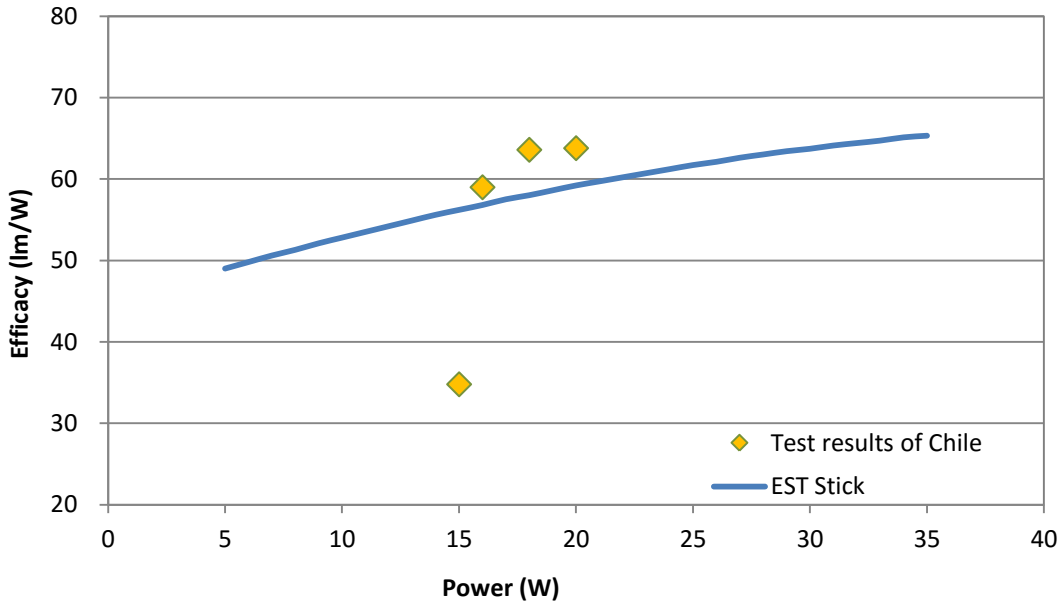
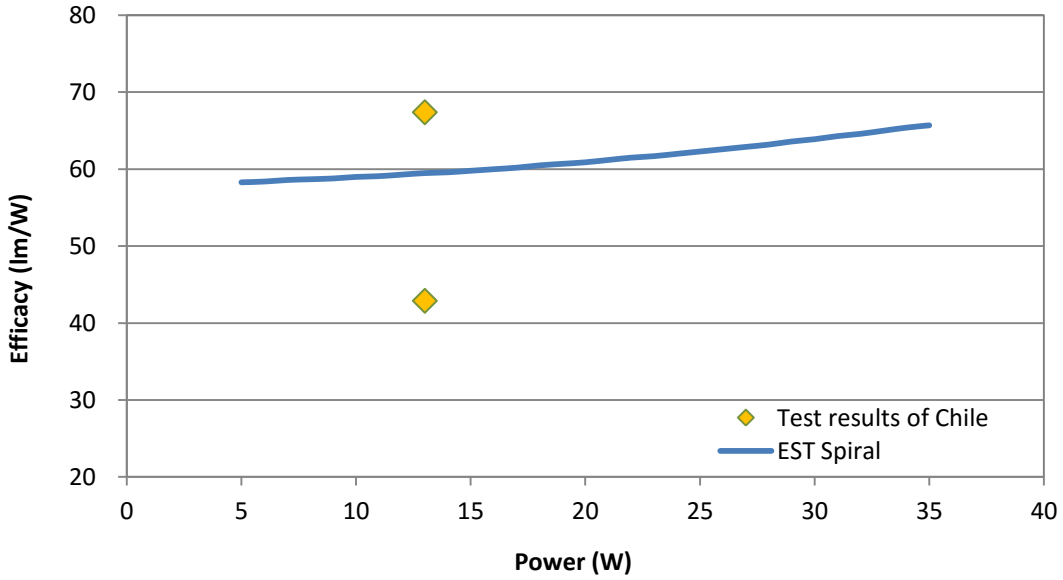


Figure 41 Luminous efficacy test results of Chile (Spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. Therefore, in Figure 43 and 44, the testing samples are separated into cool light group-43 and warm light group- 44. Four models from Chile are coo light, and the other two are warm light, and in total there are three models that fail to meet the GB requirements.

Figure 42 Luminous efficacy test results of Chile (warm light) (n=10)

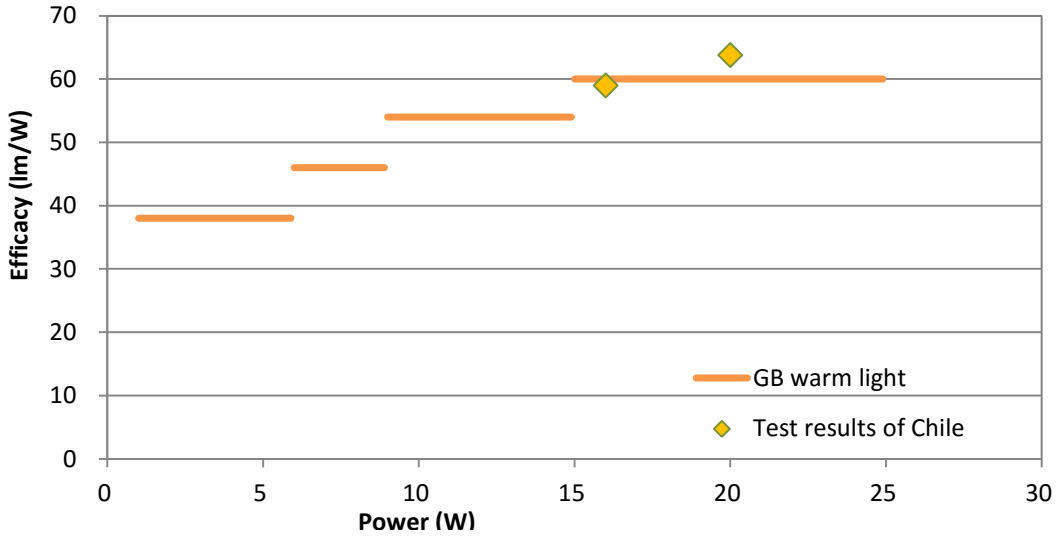
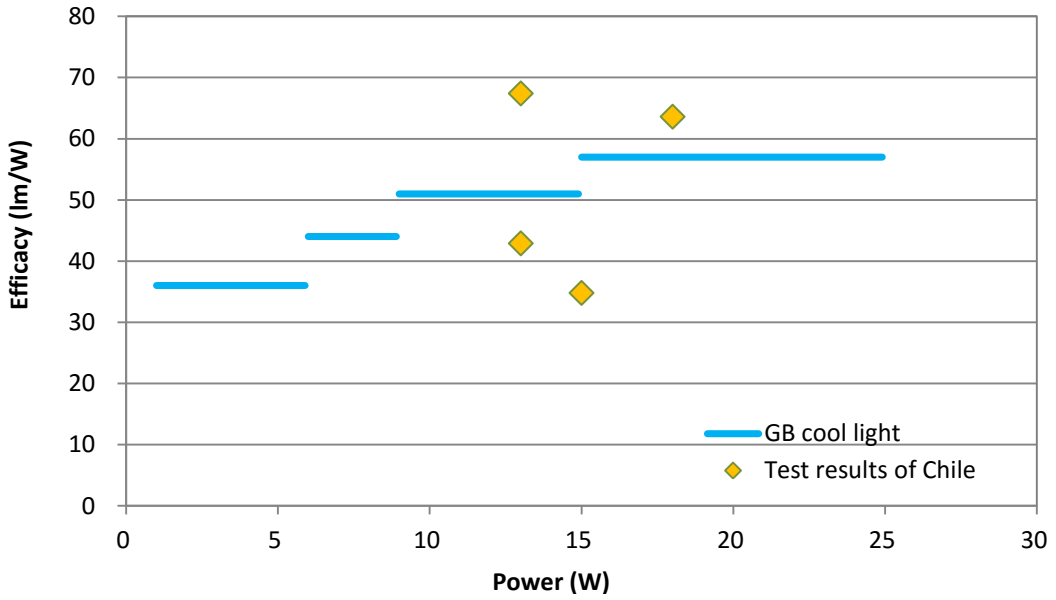


Figure 43 Luminous efficacy test results of Chile (cool light) (n=10)



5.4.2.4 Colour

There is no CRI and SDCM requirement in the Chile MEPS, therefore the results of CRI and SDCM are compared here with EU regulation, AS/NZS, ENERGY STAR, GB and EST.

Figure 45 and Figure 46 present the CRI and SDCM test results of the CFLs from Chile. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a

maximum allowance of 5 steps. Figure 45 and 46 show that two models of CFLs from Chile do not meet this minimum required CRI and maximum requirement of SDCM.

Figure 44 CRI test results of Chile (n=10)

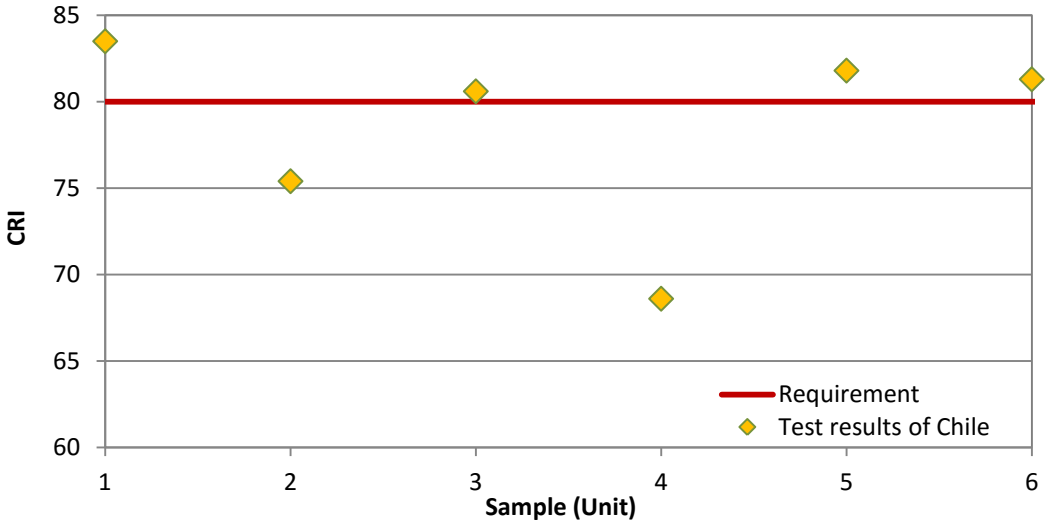
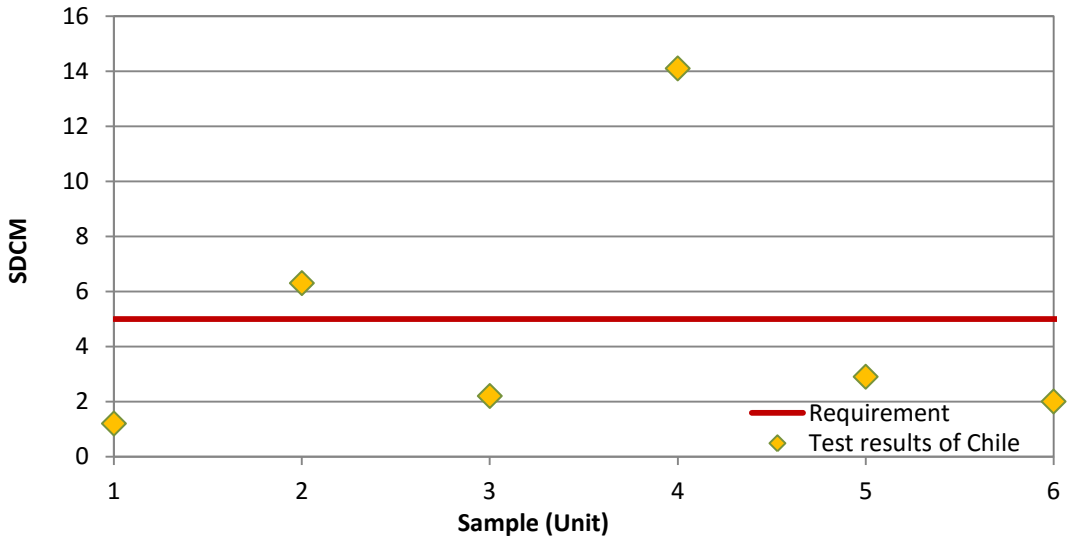


Figure 45 SDCM test results of Chile (n=10)



5.2.2.5 Luminous maintenance at 2,000 hours

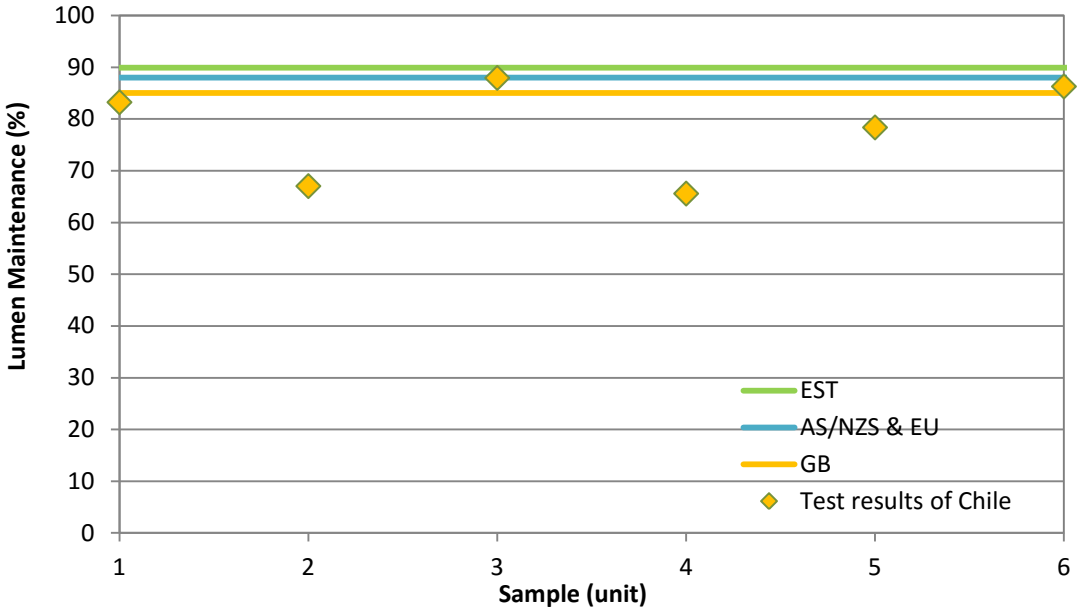
There is no luminous maintenance requirement in the Chile MEPS, therefore the results of lumen maintenance are compared here with EU regulation, AS/NZS, GB and EST.

Figure 47 shows the lumen maintenance results compared with the different referred standards.

From Figure 47, the lumen maintenance of three models from Chile are less than 85%, which is the minimum value among all of the compared standards. There is no model meet the top lumen

maintenance of EST.

Figure 46 Luminous maintenance test results of Chile (n=10)

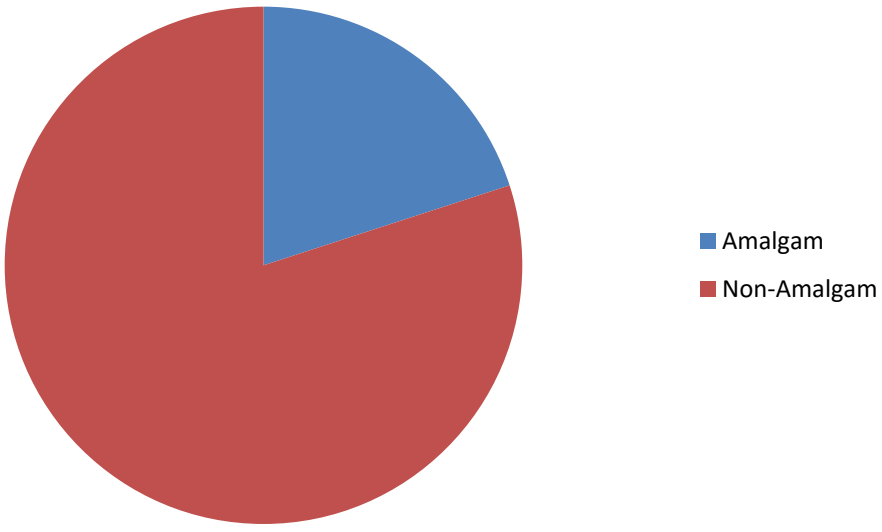


5.2.3 Mercury test results

5.2.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 48 presents the percentage of each mercury format in the CFLs, 20% of the CFLs adopt the amalgam technology and 80% of the CFLs adopt the non-amalgam technology.

Figure 47 Format of mercury for the lamps from Chile



5.2.3.2 Mercury content

There is no mercury content requirement in the Chile MEPS, therefore the results of mercury content are compared with EU regulation, AS/NZS, GB and ENERGY STAR. Figure 49 shows the average mercury content of each model.

Figure 48 Mercury content results for Chile (n=5)

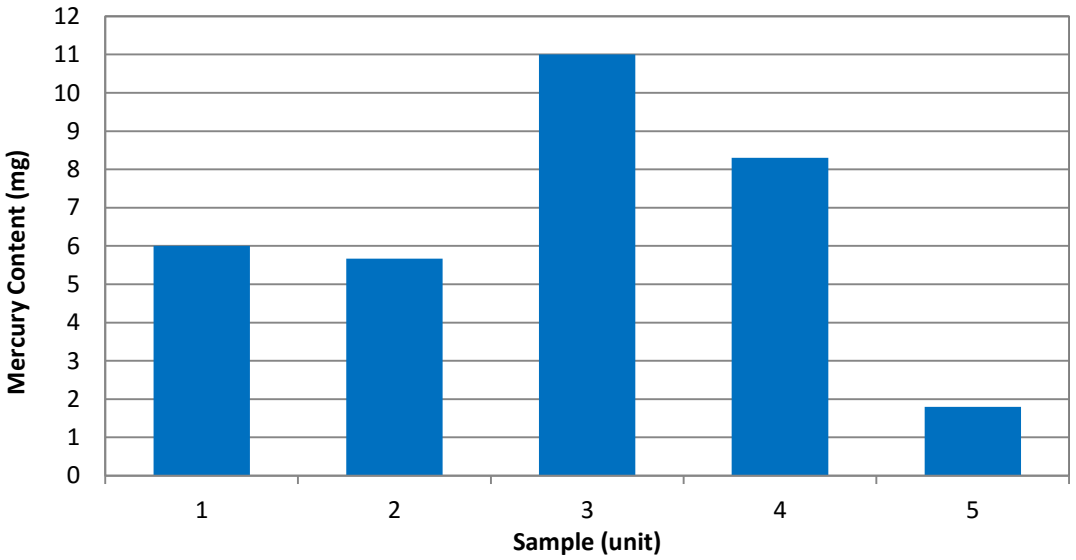


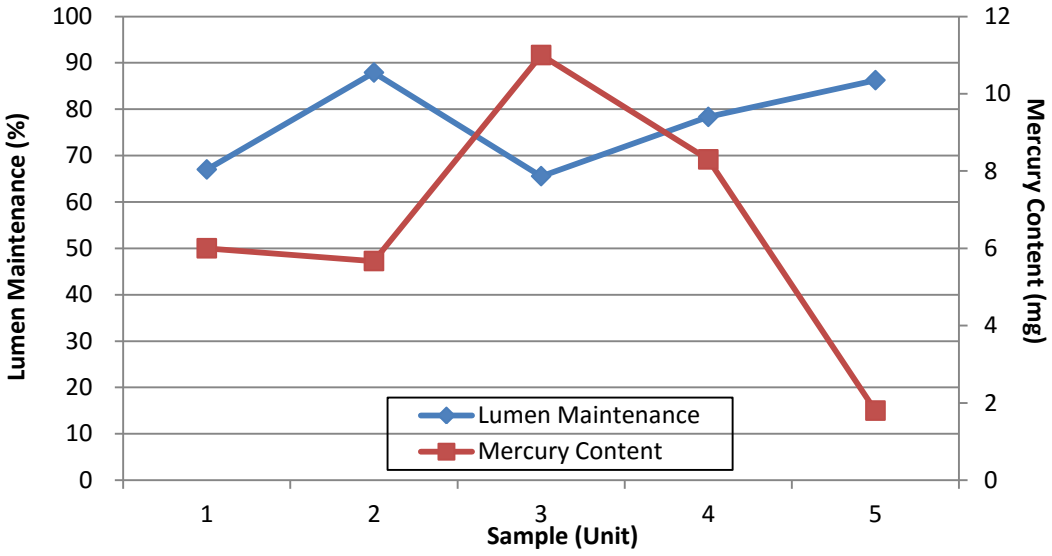
Table 14 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
EU regulation	≤2.5mg, for lamp power <30W;		20%
AS/NZS 4847.2	Maximum mercury content 5mg		20%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		20%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	20%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	0
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0

5.2.3 Mercury content and lumen maintenance

Figure 50 shows the correspondence of mercury content and lumen maintenance of the lamps from Chile. Samples 1 to 4 are non-amalgam lamps. Three of them have the lumen maintenance lower than 80%, however there is one with the lumen maintenance of 88%. Sample 5 is amalgam lamps, which shows a better lumen maintenance result.

Figure 49 Mercury content and lumen maintenance of Chile



5.2.4 Summary

There are six sample models shipped from Chile. From the safety test results, it could see the lamps did not pass the Interchangeability.

Interchangeability: refers to the matching degree of the lamp and lamp hold. Due to the mismatch of the lamp and lamp holder, it may result in arcing or discharge, and lead to accidents. The reason for this quality problem might be during the assembling process, the manufacturers use the lamp caps which do not meet the standard's requirements, or the manufacturers did not take good attention to the component quality check of semi-finished lamps.

For the performance results, it showed all the items did not reach the requirement of the reference standards in Table 15.

Table 15 Non-compliance items

Test items	Compared standards	Results
Lamp power	GB/T 17263	2 models did not meet the requirement
Power factor	AS/NZS/EU Regulation / ENERGY STAR/EST/GB	1 model did not meet the requirement
Efficacy	Chile MEPS/AS/NZS/EU/EST	2 models did not meet the requirement
	ENERGY STAR	4 models did not meet the requirement
	GB	3 models did not meet the requirement
CRI & SDCM	AS/NZS/EU Regulation /ENERGY STAR/EST/GB	2 models did not meet the requirement
Lumen maintenance at 2,000 hours	AS/NZS/EU Regulation	5 models did not meet the requirement;
	EST	6 models did not meet the requirement
	GB	4 models did not meet the requirement
Mercury	AS/NZS /EU/ENERGY STAR/GB	5 models did not meet the requirement

In Chile MEPS, there is only the requirement for efficacy. If compared the test results with them, it was found that 2 sample models did not meet the standard's requirement.

Compared with the other standards, it could see that the non-compliance items are lamp power, power factor, efficacy, CRI, SDCM, Lumen maintenance at 2,000 hrs and mercury content.

5.3 Summary for Costa Rica

The Regional Lighting Efficiency Strategy in Central America has been developed and approved on December 6th 2013[2]. This document establishes the minimum standards for efficiency, quality, safety and environmental impact that all lighting devices must comply with in order to be imported and sold in the countries in the region, including Costa Rica.

There are four sample models from Costa Rica. As requested by the country, the test results of the samples are compared with the minimum energy performance standards (MEPS) requirements of Regional Lighting Efficiency Strategy in Central America. The Central America MEPS defines two levels: one is for minimum requirement, and the other one is named as, "Mesoamerica Award," a higher requirement to encourage the introduction of high efficiency products to the market.

5.3.1 Safety test

Table 16 lists the Pass and Fail results for each test item for Costa Rica. Table 16 shows that all the samples from Costa Rica have passed the safety test.

Table 16 Safety test results of Costa Rica (n=8)

Country	Interchangeability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Costa Rica	P	P	P	P	P	P

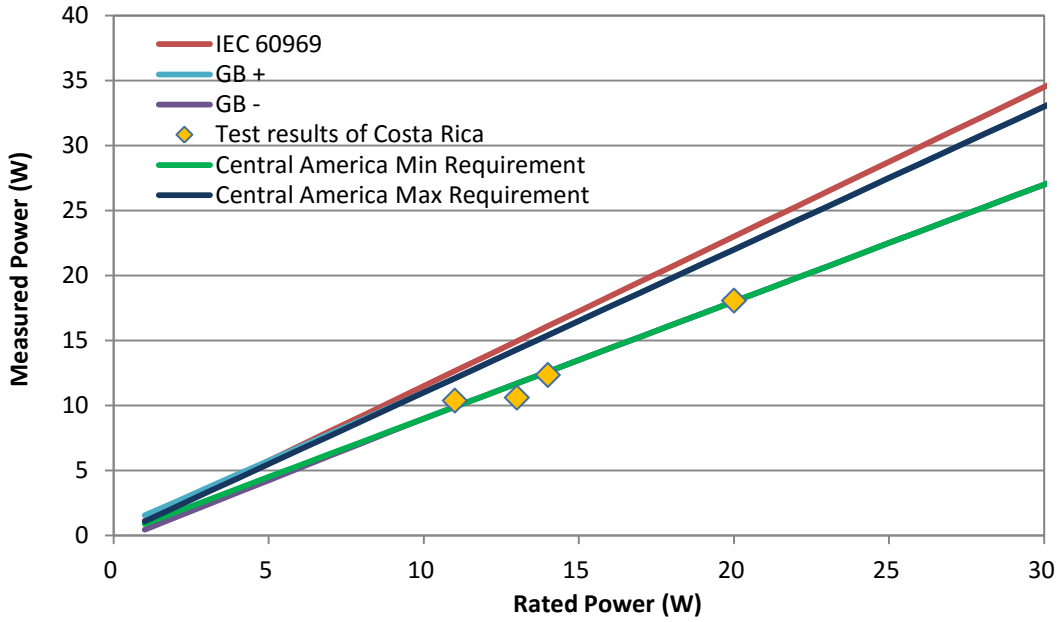
5.3.2 Performance test results

5.3.2.1 Lamp power

Figure 51 shows that all of the samples are within the requirements of IEC 60969, but not all of the samples meet the requirements of Central America MEPS and GB/T 17263, because Central America MEPS and GB/T 17263 limited both maximum and minimum values. Two of the lamps from Costa Rica met both standards' requirements; while there are also two models of lamps with the measured power a bit lower than the required minimum values.

[2] *Regional Lighting Efficiency Strategy in Central America*

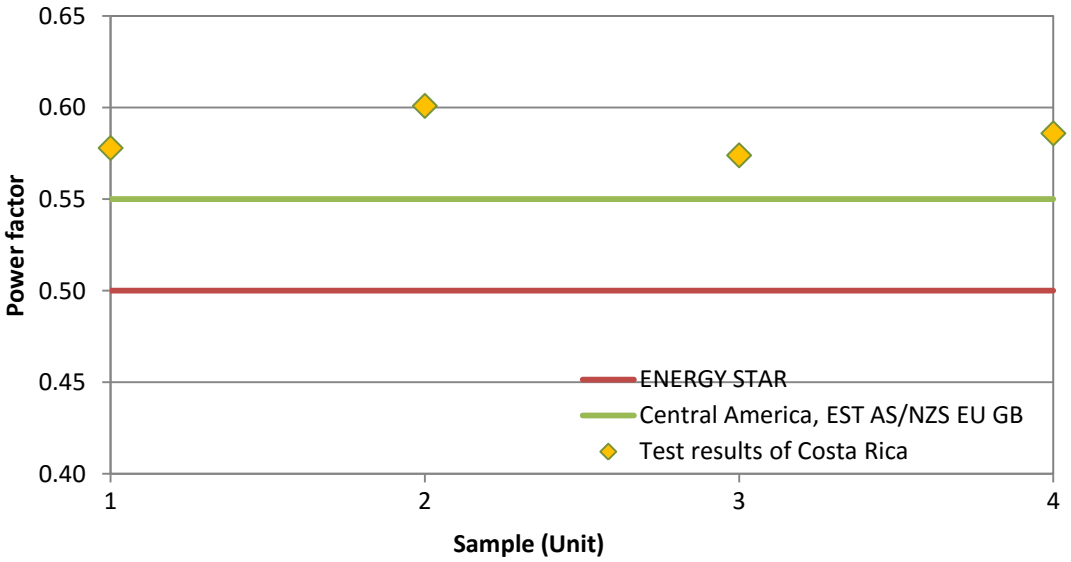
Figure 50 Lamp power test results for Costa Rica (n=10)



5.1.2.2 Power factor

Figure 52 shows that the power factor of the testing samples from Costa Rica all are over 0.55 and meet the requirements of the standards.

Figure 51 Power factor test results of Costa Rica (n=10)

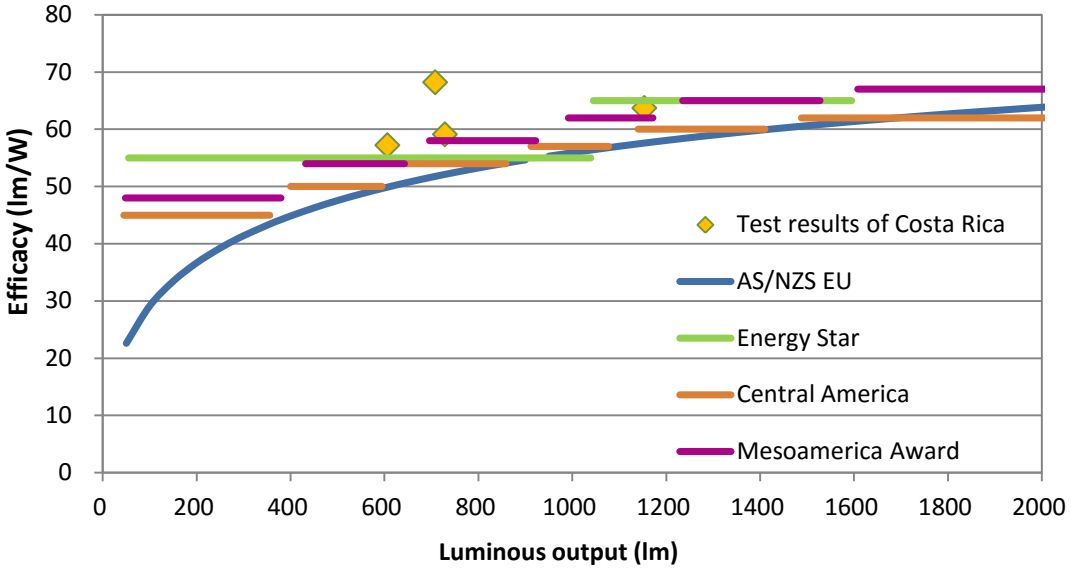


5.3.2.3 Efficacy

a) Compared with Central America MEPS, AS/NZS 4847.2, EU regulation and ENERGY STAR lamp specification V1.0

Figure 53 shows the tested efficacy data compared with the Central America MEPS, AS/NZS 4847.2, EU Regulation No. 244/2009 and ENERGY STAR Lamp Specification V1.0. It can be clearly seen that all of the lamps meet with the Central America MEPS and only one model did not meet with the Mesoamerica Award. Compared with the other standards, there is only one model that just fails to meet the ENERGY STAR requirements.

Figure 52 Luminous efficacy test results of Costa Rica (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes. And in each group, the testing results are compared with the corresponded requirements (Figures 54 and 55).

Figure 53 Luminous efficacy test results of Costa Rica (stick lamp) (n=10)

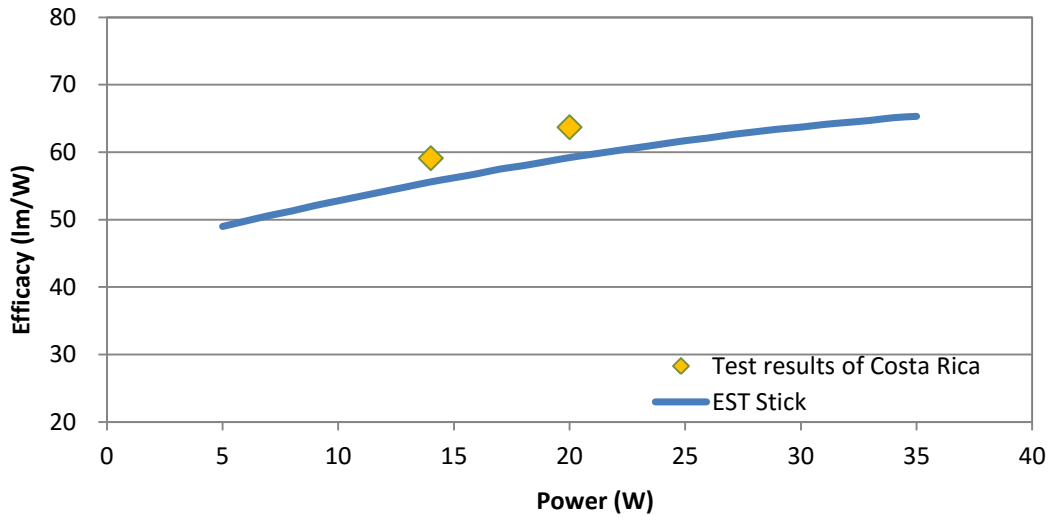
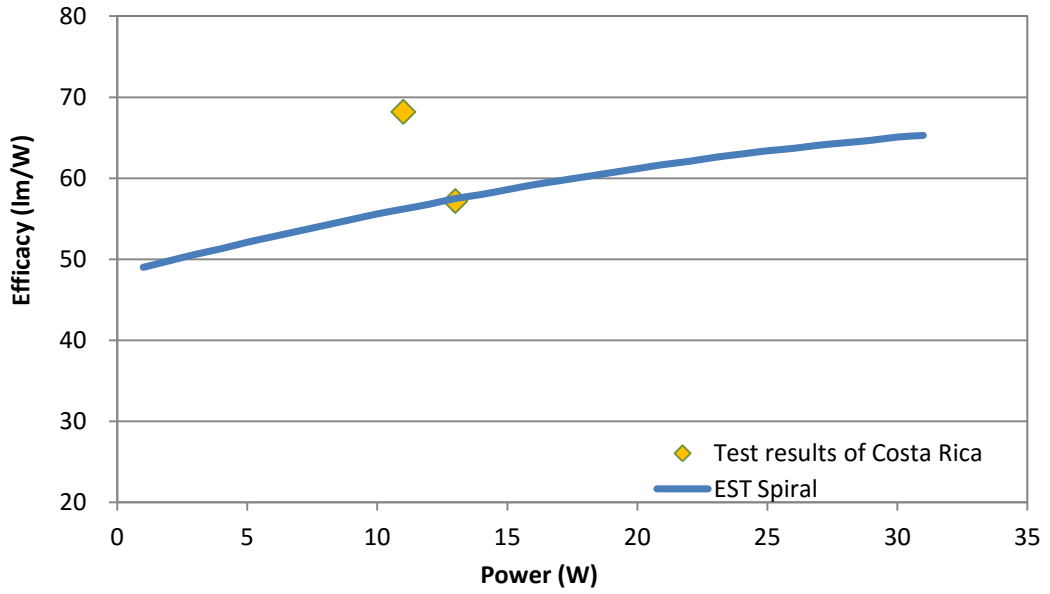


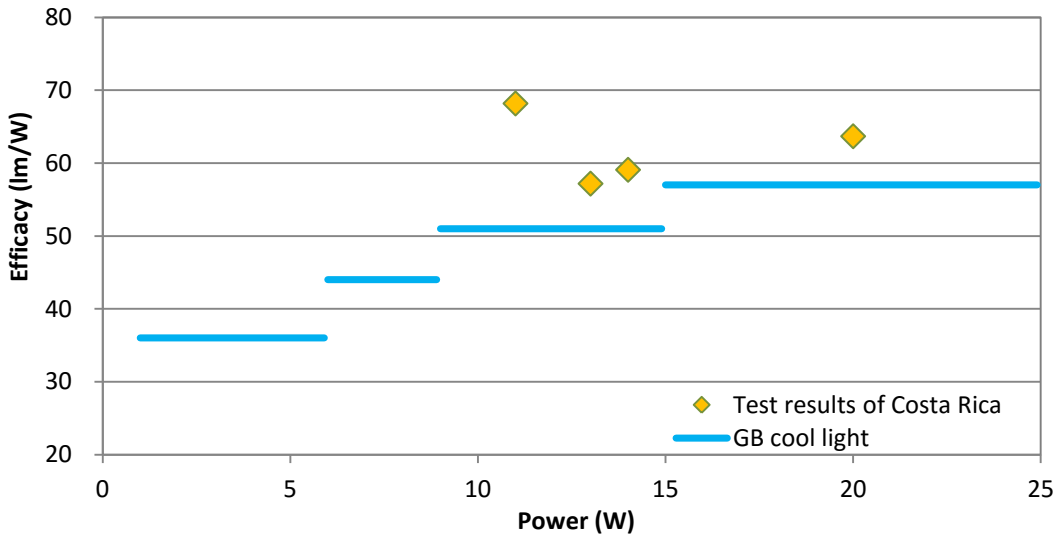
Figure 54 Luminous efficacy test results of Costa Rica (spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. Figure 56 shows results for that the CFLs from Costa Rica (all have cool light).

Figure 55 Luminous efficacy test results of Costa Rica (cool light) (n=10)



5.3.2.4 Colour

Figure 57 and Figure 58 presents the CRI and SDCM test results of the CFLs from Costa Rica. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a maximum allowance of 5 steps. Figure 57 and 58 show that all models of CFLs from Costa Rica meet this minimum requirement.

Figure 56 CRI test results of Costa Rica (n=10)

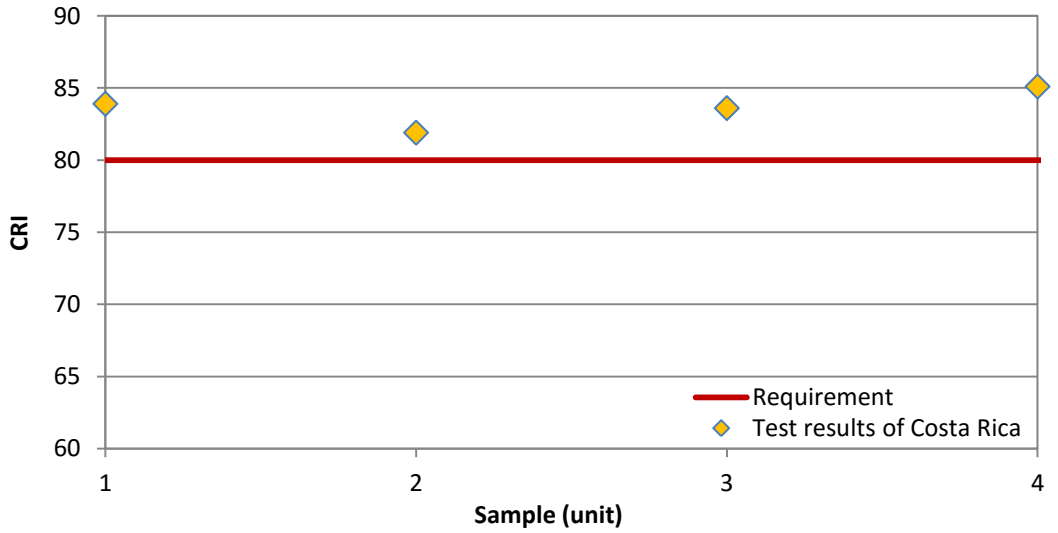
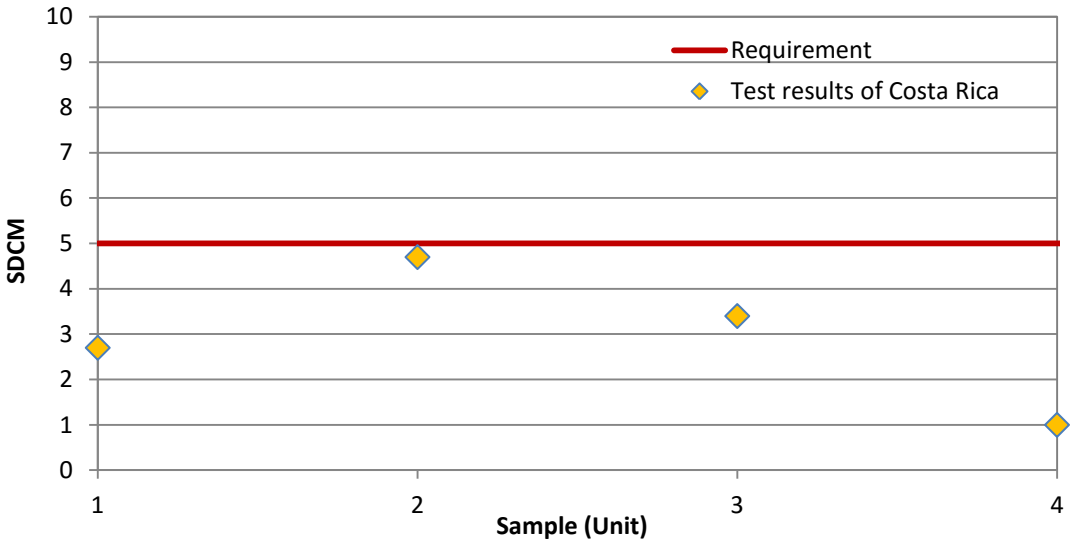


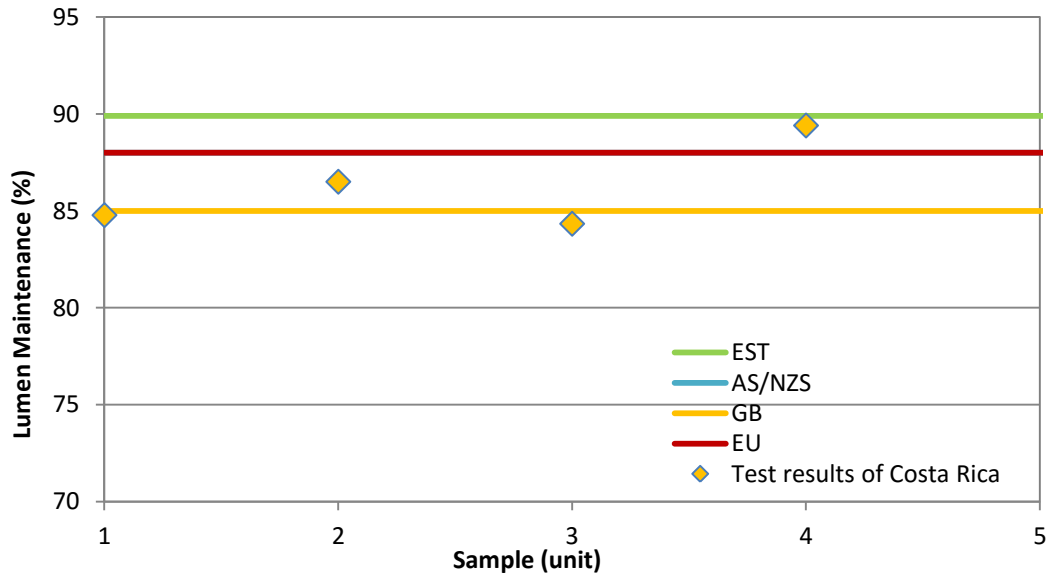
Figure 57 SDCM test results of Costa Rica (n=10)



5.3.2.5 Luminous maintenance at 2,000 hours

The Central America MEPS has no requirement for lumen maintenance at 2,000 hours but Figure 59 shows the lumen maintenance results compared with the other different referred standards.

Figure 58 Luminous maintenance test results of Costa Rica (n=10)



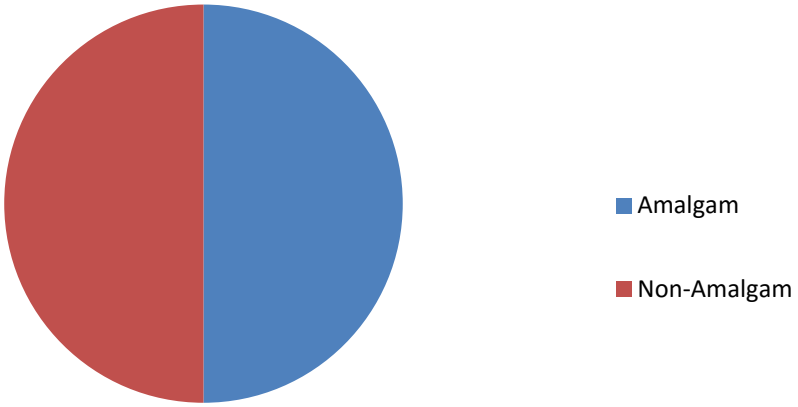
5.3.3 Mercury test results

5.3.3.1 Format of mercury

Figure 60 presents the percentage of each mercury format (amalgam and non-amalgam) of the

CFLs. Half of the CFLs use the amalgam technology and half use the non-amalgam technology.

Figure 59 Format of mercury for the lamps from Costa Rica



5.3.3.2 Mercury content

Figure 61 shows the average mercury content of each model. The average mercury contents of the samples from Costa Rica are quite different; some are up to 14 mg, while some are less than 1.0 mg. The amalgam lamps contain much less mercury than the non-amalgam lamps.

Figure 60 Mercury content results for Costa Rica (n=5)

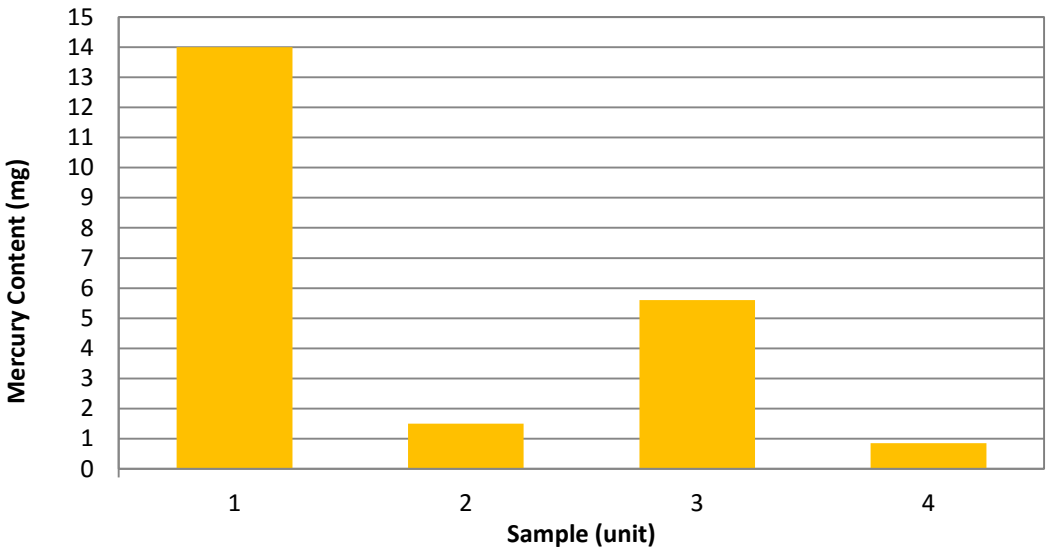


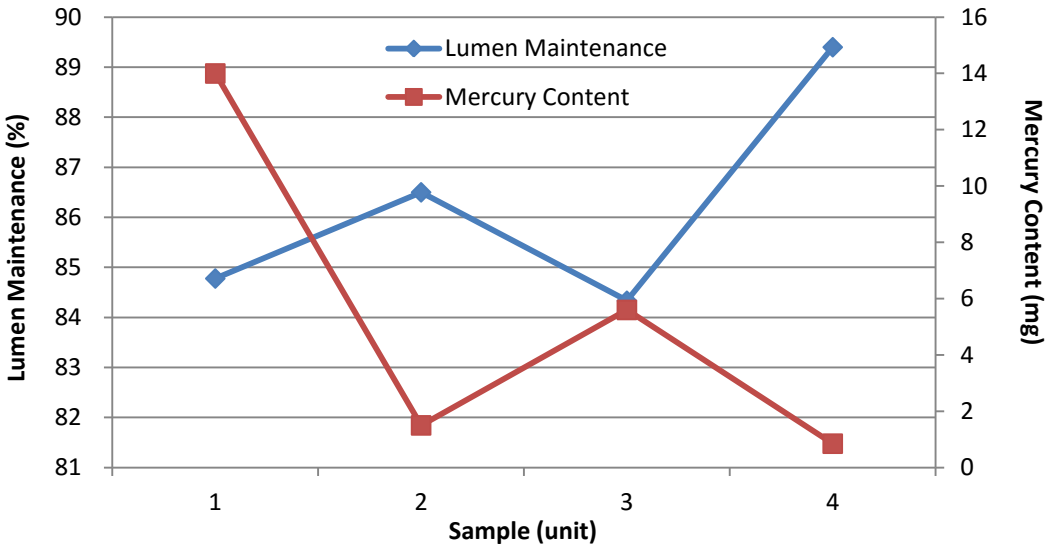
Table 17 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
Regional Lighting Efficiency Strategy in Central America	Less than 3.5mg		50%
Minamata Convention	Maximum mercury content 5 mg		50%
EU regulation	≤2.5mg, for lamp power <30W;		50%
AS/NZS 4847.2	Maximum mercury content 5 mg		50%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		50%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	50%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	50%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	25%

5.3.3 Mercury content and lumen maintenance

Figure 62 shows the correspondence of mercury content and lumen maintenance of the lamps from Costa Rica. Sample 2 and Sample 4 are amalgam lamps, which showed a relatively high lumen maintenance; Sample 1 and Sample 3 are non-amalgam lamps, which showed a lower lumen maintenance.

Figure 61 Mercury content and lumen maintenance of Costa Rica



5.3.4 Summary

All the samples passed the safety test. However for the performance results, some items did not meet the requirement of compared standards, as shown in Table 18.

Table 18 Non-compliance items

Test items	Compared standards	Results
Lamp power	Regional Lighting Efficiency Strategy in Central America	2 models did not meet the requirement
Efficacy	Regional Lighting Efficiency Strategy in Central America (Mesoamerica Award)	1 model did not meet the requirement
	ENERGY STAR	1 model did not meet the requirement
	EST	1 model did not meet the requirement
Lumen maintenance at 2,000 hrs	GB	2 models did not meet the requirement
	EU	3 models did not meet the requirement
	EST	None of the models met the requirement
Mercury	Regional Lighting Efficiency Strategy in Central America	2 models did not meet the requirement

Some of the lamp results show that actual power is lower than the rated power. As explained in

4.2.1, the potential reason may be the manufacture marked a higher rated power to increase the lamp price; or, it also could be that the production capacity of the manufacturer could not meet its design capabilities.

All the models meet the minimum requirements of Central America MEPS; 75% of the models could meet the Mesoamerica Award.

The lumen maintenance results require attention. Within all of the compared standards, only half of models can meet the lowest requirement. Lumen maintenance has a big effect on the lamp life time; the low lumen maintenance results show the luminous flux decreases quickly as the lamps are operated.

Half of the models are non-amalgam lamps, containing more than 5 mg of mercury and as much as 14 mg. This is much higher than the Central America MEPS allows.

5.4 Summary results for Dominican Republic

There are four sample models from the Dominican Republic. The Regional Lighting Efficiency Strategy in Central America has been developed and approved on December 6th 2013[3]. This document establishes the minimum standards for efficiency, quality, safety and environmental impact that all lighting devices must comply with in order to be imported and sold in the countries in the region, including the Dominican Republic.

As requested by the country, the test results of the samples are compared with the minimum energy performance standards (MEPS) requirements of Regional Lighting Efficiency Strategy in Central America. The Central America MEPS defines two levels: one is the minimum requirement, and the other one is named as, "Mesoamerica Award," a higher requirement to encourage the introduction of high efficiency products to the market.

5.4.1 Safety test

Table 19 lists the Pass and Fail results to each test item for Dominican Republic, and from which we know that the samples from Dominican Republic all passed the six safety test items conducted.

Table 19 Safety test results of Dominican Republic (n=8)

Country	Interchangeability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Dominican Republic	P	P	P	P	P	P

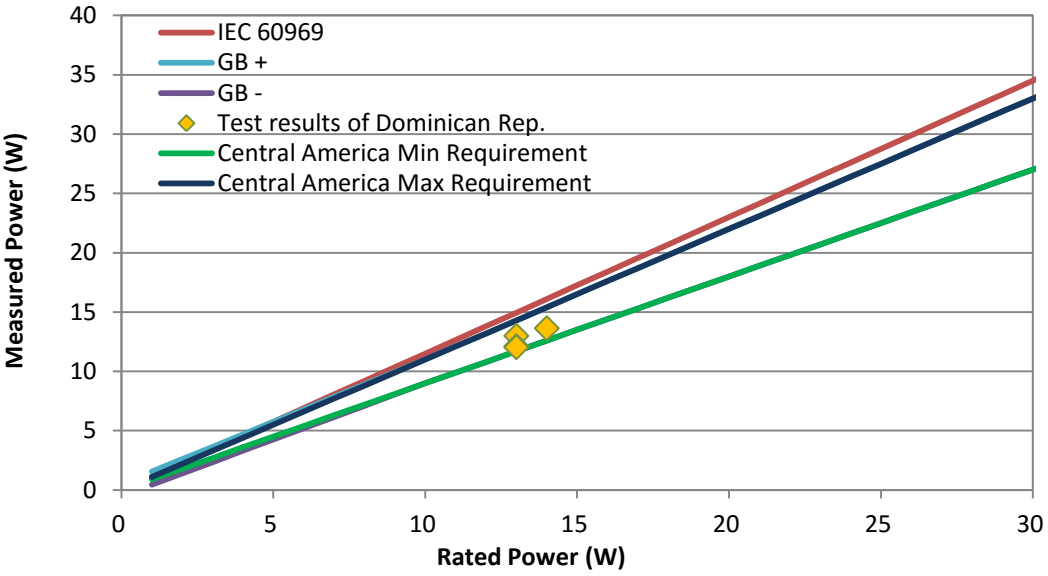
5.4.2 Performance test results

5.4.2.1 Lamp Power

In Figure 63, it can be seen that all of the samples are within requirement of IEC 60969, Central America MEPS and GB/T 17263.

[3] Regional Lighting Efficiency Strategy in Central America

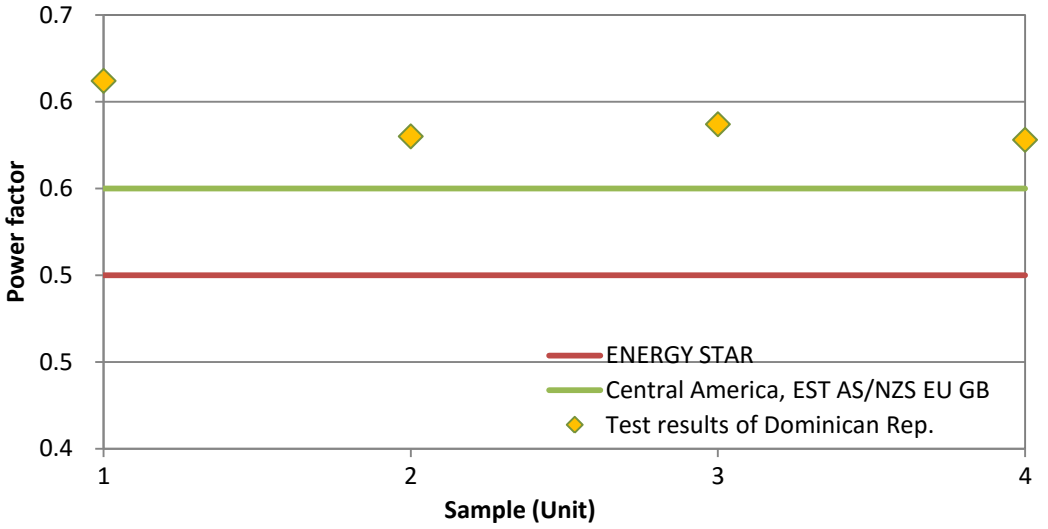
Figure 62 Lamp power test results of Dominican Republic (n=10)



5.4.2.2 Power Factor

From Figure 64, it can be seen that the power factor of the testing samples from Dominican Republic are all over 0.55 and meet the requirements by all of the reference standards.

Figure 63 Power factor test results of Dominican Republic (n=10)



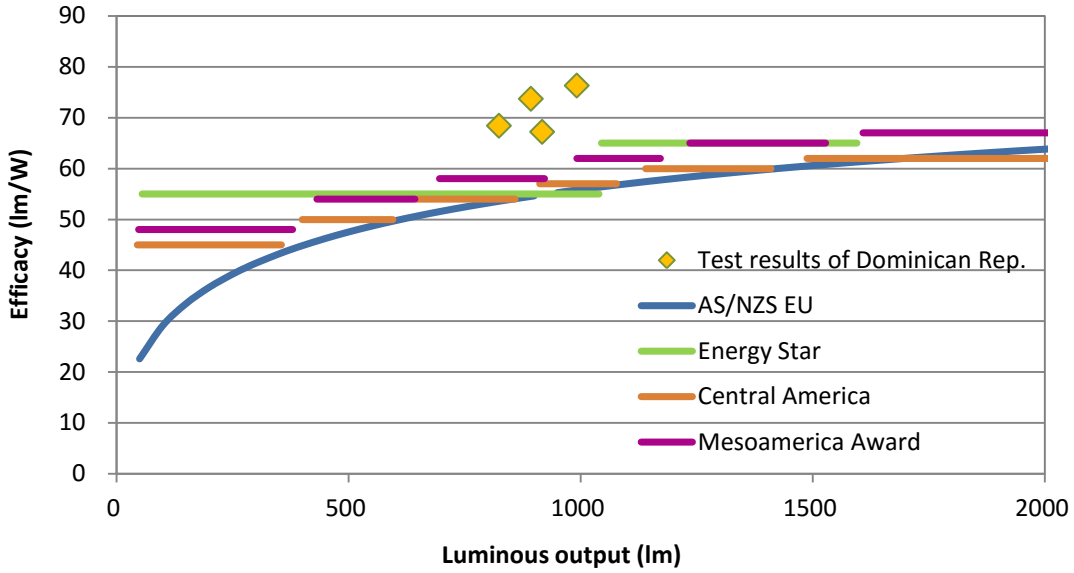
5.4.2.3 Efficacy

a) Compared with Central America MEPS, AS/NZS 4847.2, EU regulation and ENERGY STAR lamp specification V1.0

Figure 65 shows the tested efficacy data compared with Central America MEPS, AS/NZS 4847.2,

EU Regulation No. 244/2009 and ENERGY STAR lamp specification V1.0. It can be seen that all of the models meet all the reference standards.

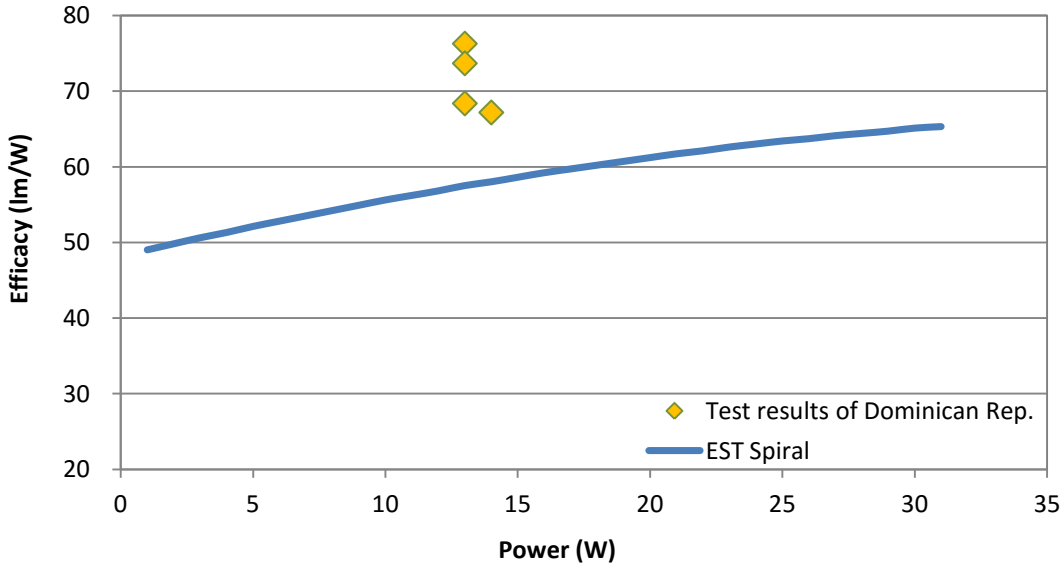
Figure 64 Luminous efficacy test results of Dominican Republic (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes. The samples from Dominican Republic are all spiral. Therefore testing results are compared with the corresponding requirements.

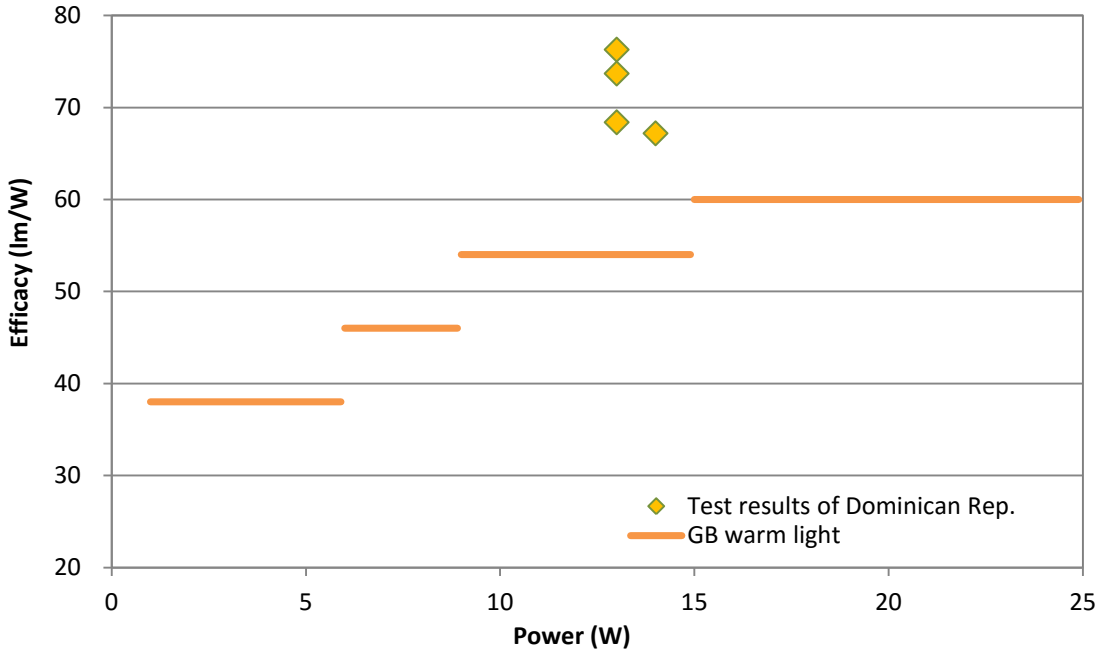
Figure 65 Luminous efficacy test results of Dominican Republic (spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. All the CFLs from Dominican Republic are warm light. Therefore, the testing samples are compared with warm light group. See Figure 67.

Figure 66 Luminous efficacy test results of Dominican Republic (warm light) (n=10)



5.4.2.4 Colour

Figure 68 and Figure 69 present the CRI and SDCM test results of the CFLs from Dominican Republic. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a maximum allowance of 5 steps. From Figure 68, it shows all models of CFLs from Dominican Republic meet with this minimum requirement. And from Figure 69, it can be seen that one model from Dominican Republic is just out of the SDCM maximum scope.

Figure 67 CRI test results of Dominican Republic (n=10)

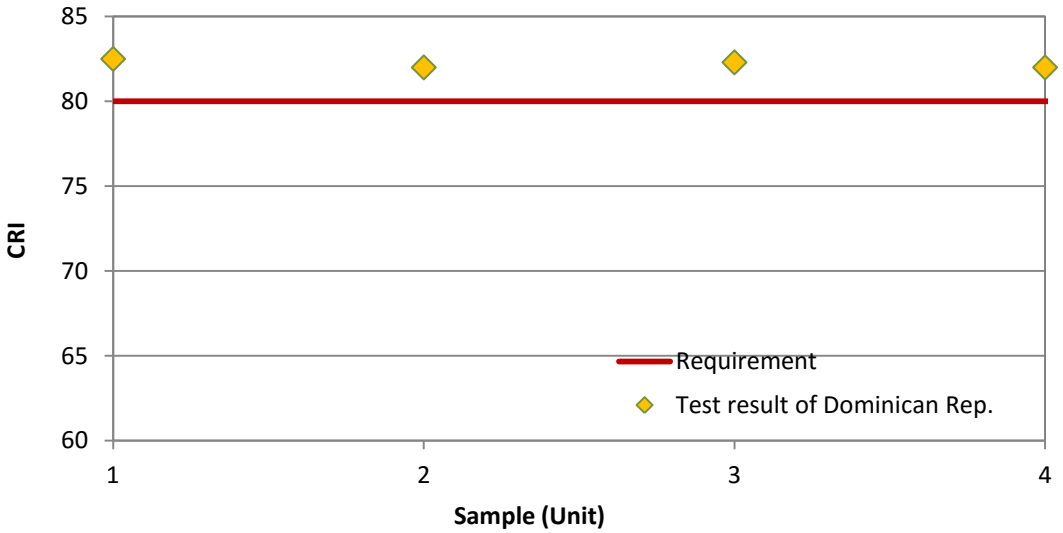
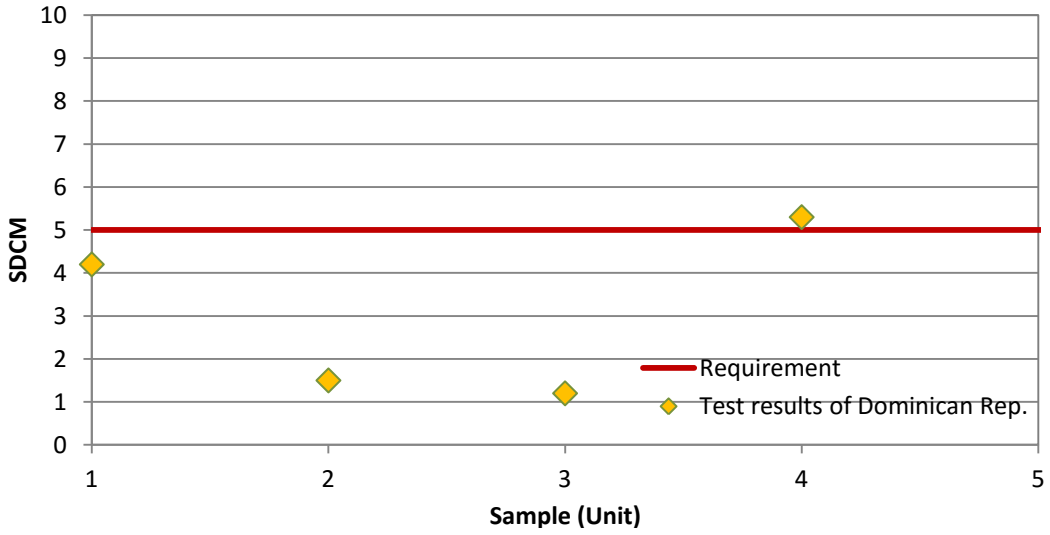


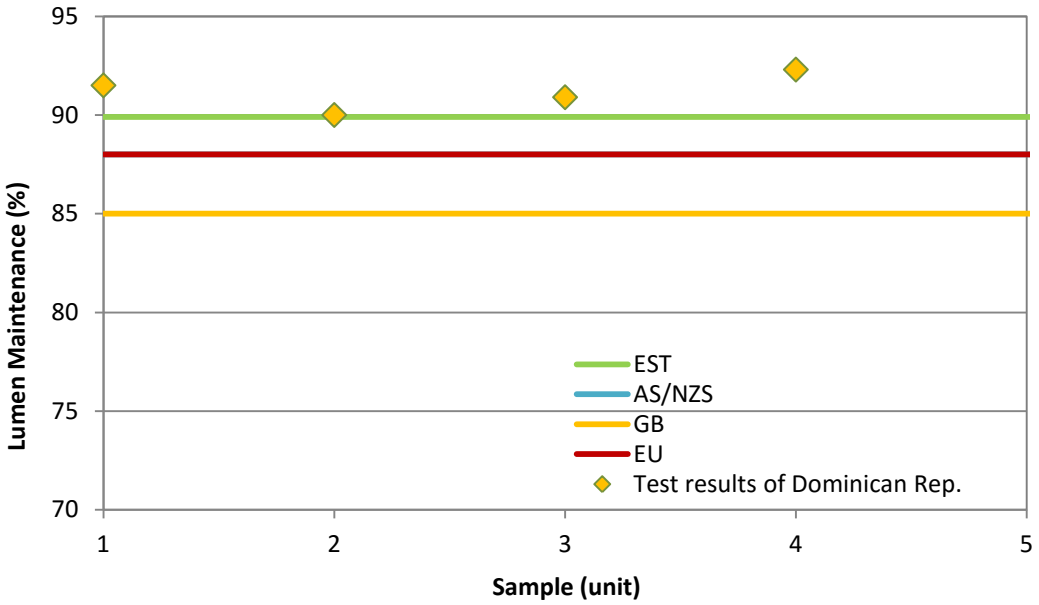
Figure 68 SDCM test results of Dominican Republic (n=10)



5.4.2.5 Luminous maintenance at 2,000 hours

In the Central America MEPS, there is no requirement for lumen maintenance at 2,000 hours; therefore it could not be used for comparing the lumen maintenance results here. Figure 70 shows the lumen maintenance results compared with the different reference standards

Figure 69 Luminous maintenance test results of Dominican Republic (n=10)

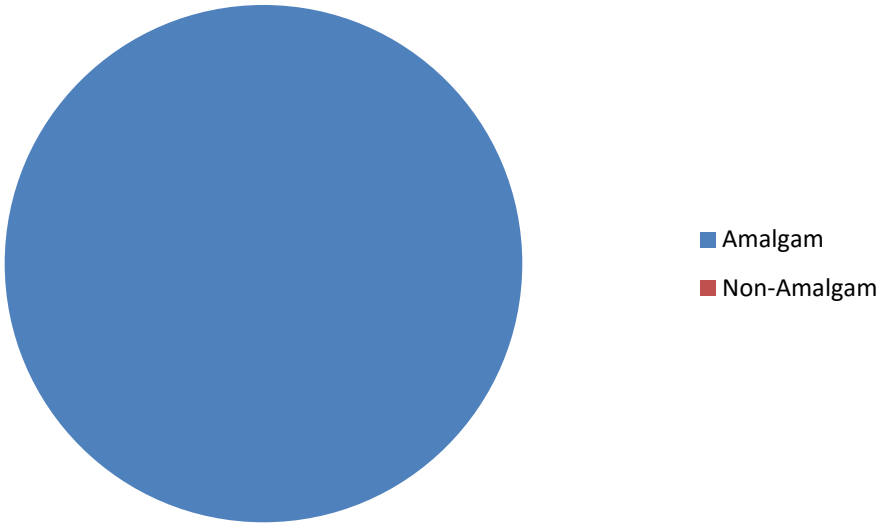


5.4.3 Mercury test results

5.4.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 71 presents the percentage of each mercury format of the CFLs, 100% of the CFLs adopt the amalgam technology.

Figure 70 Format of mercury for the lamps from Dominican Republic



5.4.3.2 Mercury content

Figure 72 shows the average mercury content of each model. We could see the average mercury contents of the samples from Dominican Republic are all less than 3 mg, and some even below 2 mg.

Figure 71 Mercury content results for Dominican Republic (n=5)

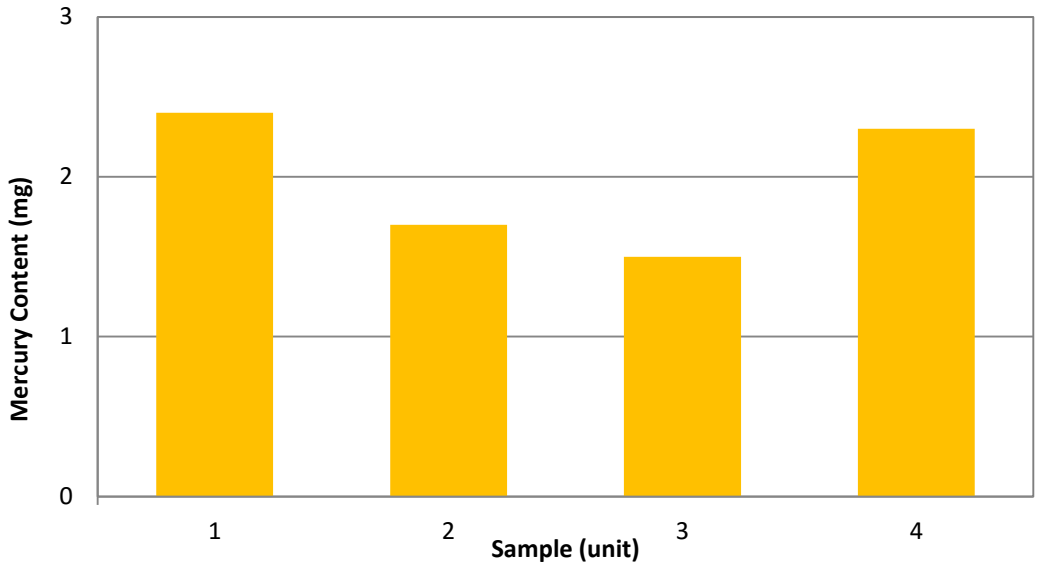


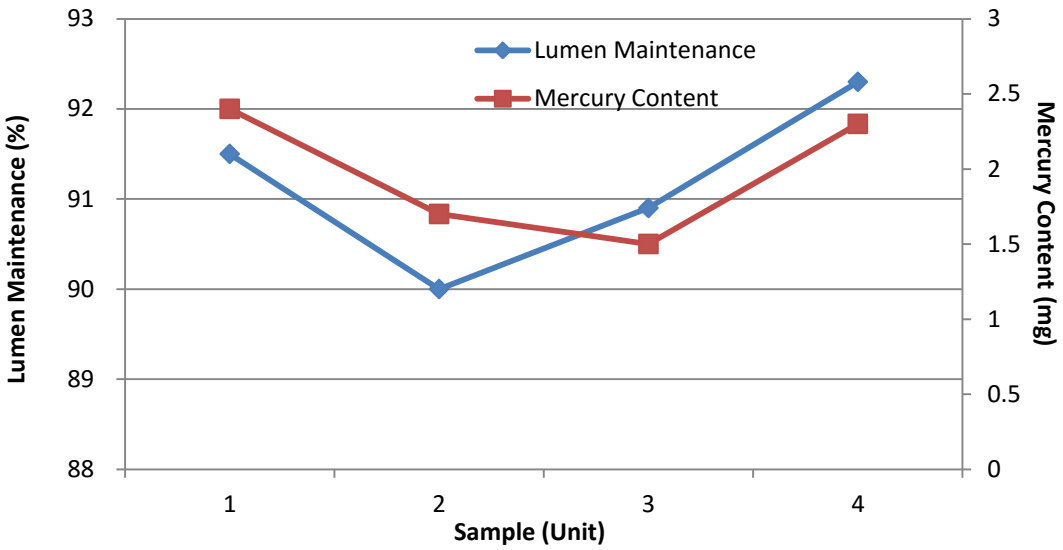
Table 20 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
Regional Lighting Efficiency Strategy in Central America	Less than 3.5mg		100%
Minamata Convention	Maximum mercury content 5mg		100%
EU regulation	≤2.5mg, for lamp power <30W;		100%
AS/NZS 4847.2	Maximum mercury content 5mg		100%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		100%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	100%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	25%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0%

5.4.3 Mercury content and lumen maintenance

Figure 73 shows the correspondence of mercury content and lumen maintenance of the lamps from Dominican Republic. All of the samples are amalgam lamps, which show high lumen maintenance, even over 90%.

Figure 72 Mercury content and lumen maintenance of Dominican Republic



5.4.4 Summary

There are four sample models shipped from Dominican Republic. From the test results, it can be seen all the lamps have passed the safety test.

For the performance results, it showed only one item did not reach to the requirement of the reference standards, see Table 21.

Table 21 Non-compliance items

Test items	Compared standards	Results
SDCM	EU/AS/NZS/ENERGY STAR/EST/GB	1 model did not meet with the requirement

Standard Deviation Colour Match (SDCM) reflects to the lamp colour quality. SDCM indicates the matching degree between the actual colour and claimed colour of the product. That is, for a large SDCM lamp, the actual colour would not be satisfied by the consumers as it is different from what they expect.

The test results showed a good situation for the samples from Dominican Republic. They can meet most of requirements of the reference standards.

5.5 Summary results for Guinea-Bissau

There are four sample models from Guinea-Bissau. As requested by Guinea-Bissau, the Economic Community of West African States (ECOWAS) standard "The Technical Specification for Mains-voltage General Lighting Service Lamps"[4] was used in this section to compare the test results of the samples from Guinea-Bissau. This standard will be implemented by the ECOWAS Member States starting on 31 December 2015. The standard will be mandatory in all ECOWAS countries after a one year grace period.

In this section, the test results are also compared with the other standards: AS/NZS 4847.2, EU regulation, ENERGY STAR lamp specification V1.0, ENERGY STAR and GB/T 17263. The lamp power is also compared with the requirement of IEC 60969.

5.5.1 Safety test

Table 22 lists the Pass and Fail results to each test item for Guinea-Bissau, and from which it can be seen that the safety problems of the samples from Guinea-Bissau mainly come from Interchangeability, Mechanical strength and Protection against electric shock.

Table 22 Safety test results of Guinea-Bissau (n=8)

Country	Interchangeability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Guinea-Bissau	F	F	P	P	P	F

5.5.2 Performance test results

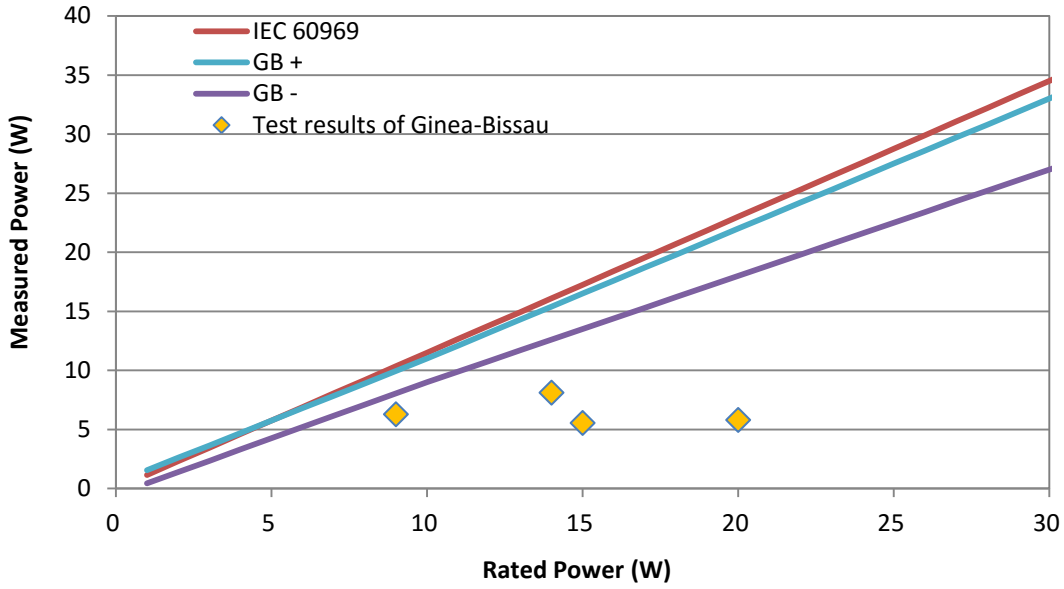
5.5.2.1 Lamp power

There is no requirement in the ECOWAS standard for the lamp power, therefore the lamp power was compared with IEC 60969 and GB/T 17263.

In Figure 74 it can be seen that all of the samples are within the requirement of IEC 60969, but not all of the samples meet the requirements of GB/T 17263, as GB/T 17263 limits both maximum and minimum values. It can see that all of the lamps from Guinea-Bissau are out of the GB requirement scope.

[4] Technical Specification for Mains-voltage General Lighting Service Lamps, First Draft, 2014-04-17

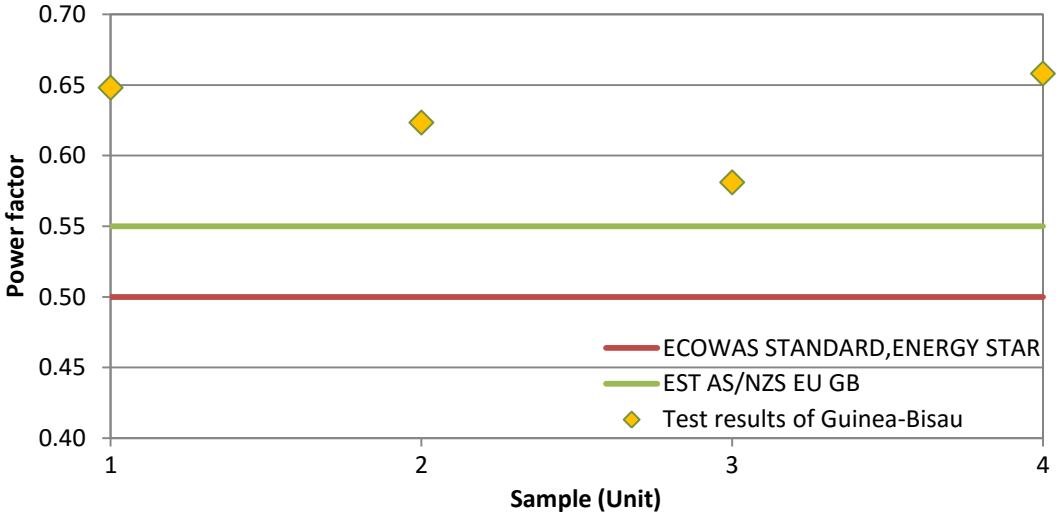
Figure 73 Lamp power test results of Guinea-Bissau (n=10)



5.5.2.2 Power factor

From figure 75, it can be seen that the power factor of all the samples from Guinea-Bissau all over than 0.55 and meet the requirements by all of the reference standards.

Figure 74 Power factor test results of Guinea-Bissau (n=10)

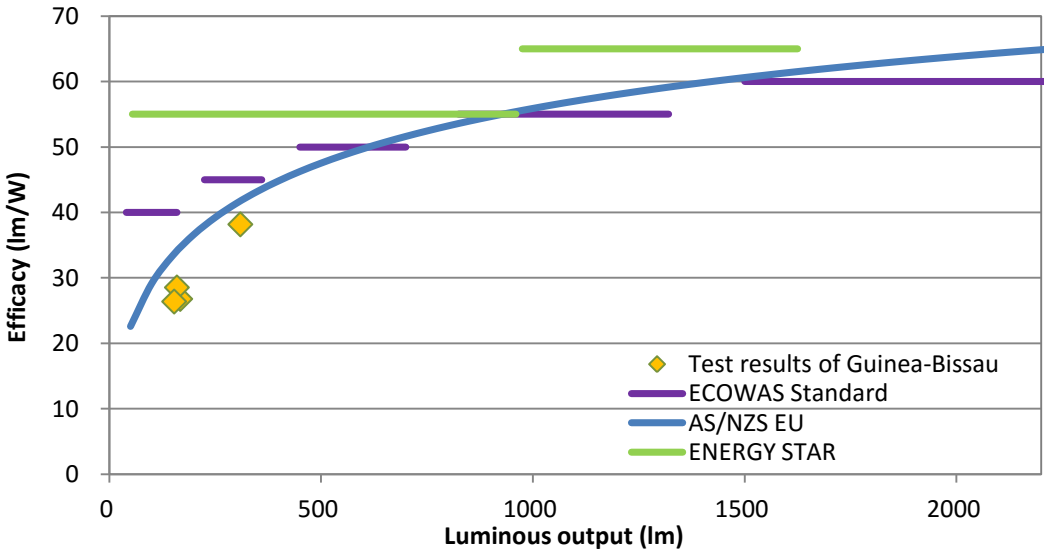


5.5.2.3 Efficacy

a) Compared with ECOWAS MEPS, AS/NZS 4847.2, EU regulation and ENERGY STAR lamp specification V1.0

Figure 76 shows the tested efficacy data compared with ECOWAS MPES, AS/NZS 4847.2, EU Regulation No. 244/2009 and ENERGY STAR lamp specification V1.0. It can be clearly seen that all four models of lamp from Guinea-Bissau did not meet the minimum requirement of the reference standards, including ECOWAS MEPS.

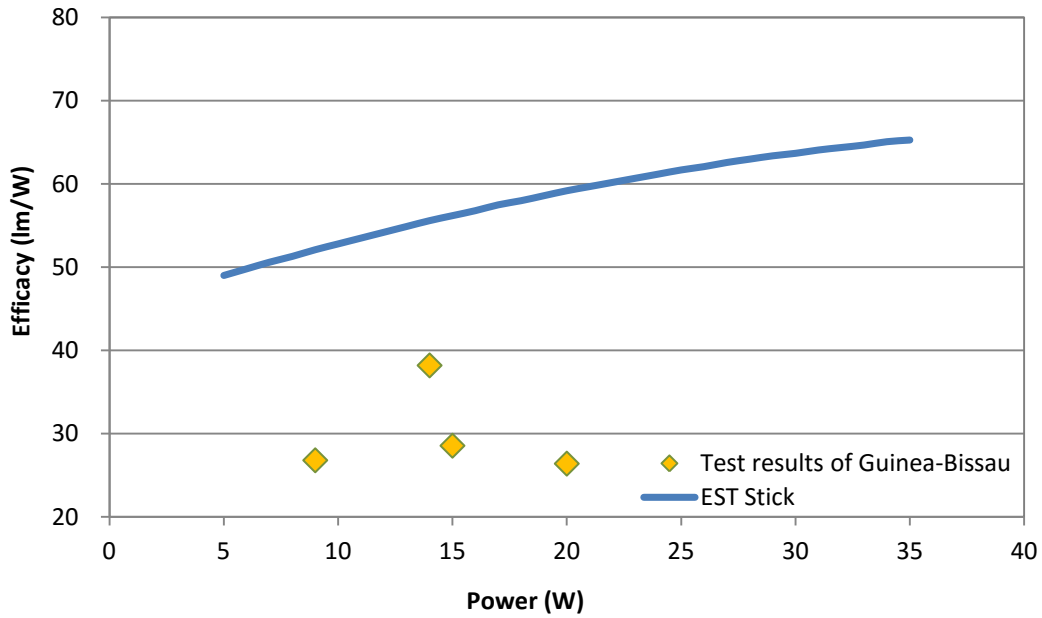
Figure 75 Luminous efficacy test results of Guinea-Bissau (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes. All of models sampled from Guinea-Bissau are stick shape and the testing results are compared with the corresponding requirements. From figure 77, the test results show all of them did not meet the reference standards' requirements.

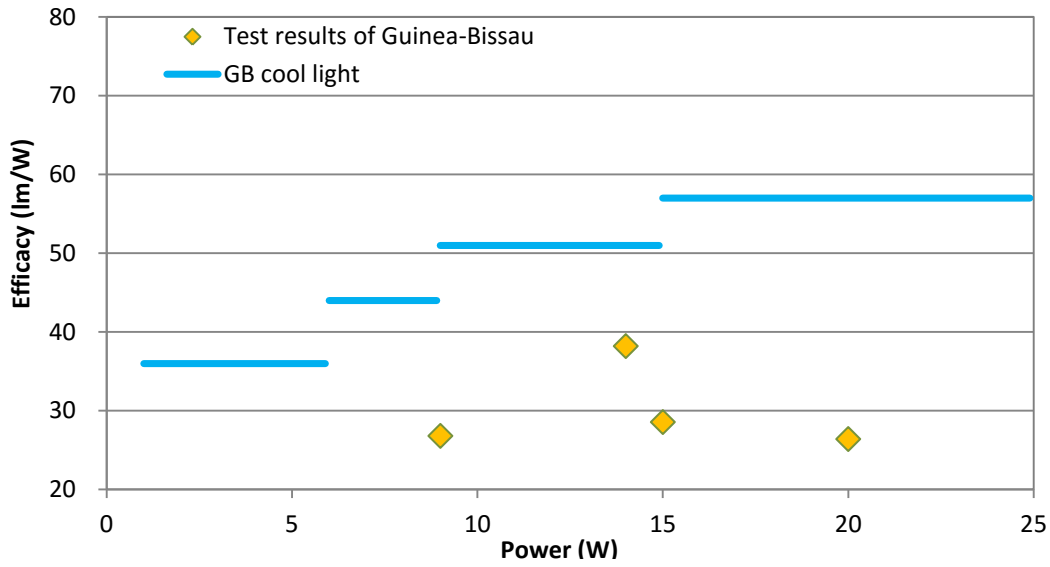
Figure 76 Luminous efficacy test results of Guinea-Bissau (stick lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. All the CFLs from Guinea-Bissau are with the cool light, and the results shows in Figure 78 they failed to meet the GB requirements.

Figure 77 Luminous efficacy test results of Guinea-Bissau (cool light) (n=10)



5.5.2.4 Colour

Figure 79 and Figure 80 presents the CRI and SDCM test results of the CFLs from Guinea-Bissau. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a maximum allowance of 5 steps. From Figure 79, it shows all models of CFLs from Guinea-Bissau could not meet this minimum requirement. And from Figure 80, it can be seen that three models from Guinea-Bissau are out of the SDCM maximum scope.

Figure 78 CRI test results of Guinea-Bissau (n=10)

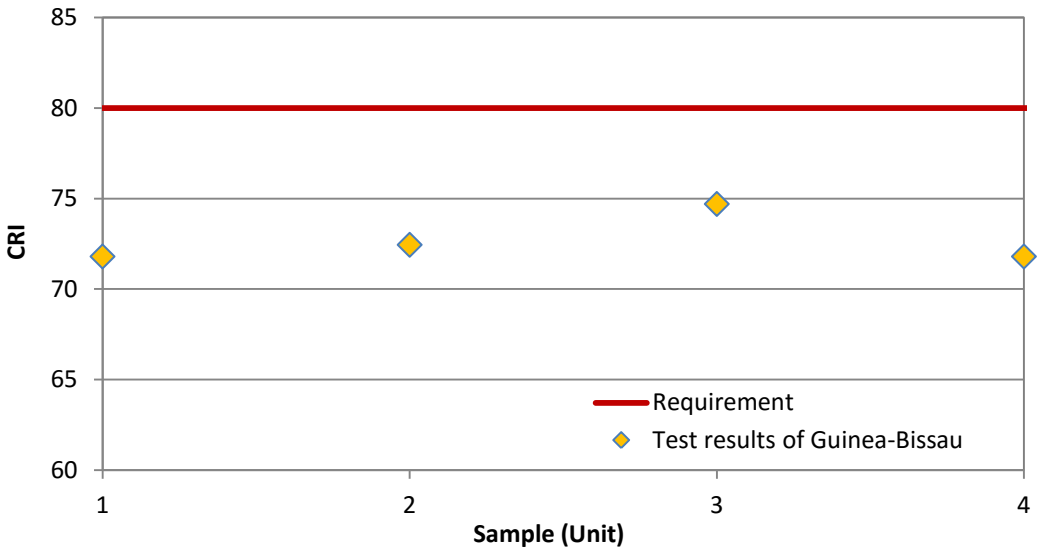
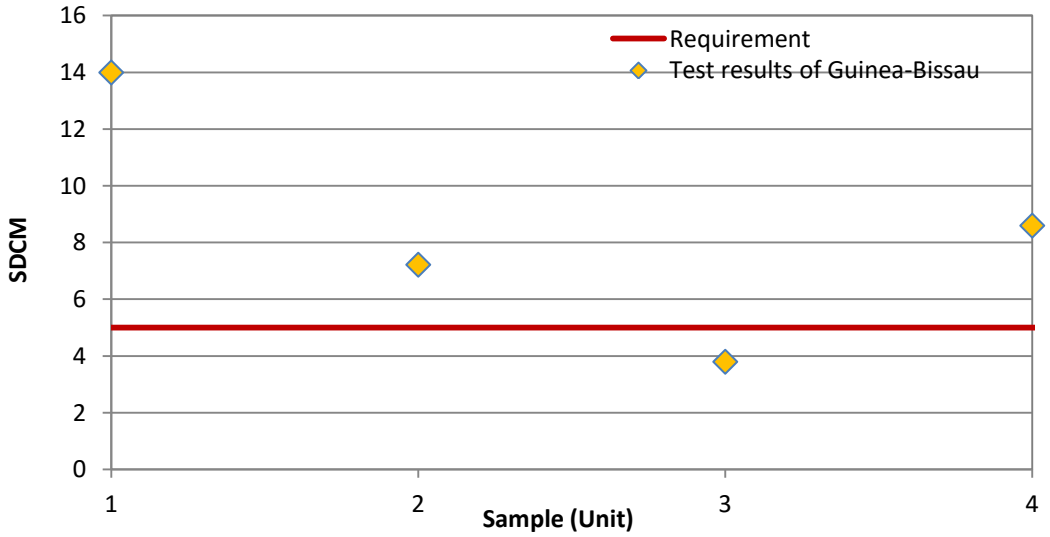


Figure 79 SDCM test results of Guinea-Bissau (n=10)

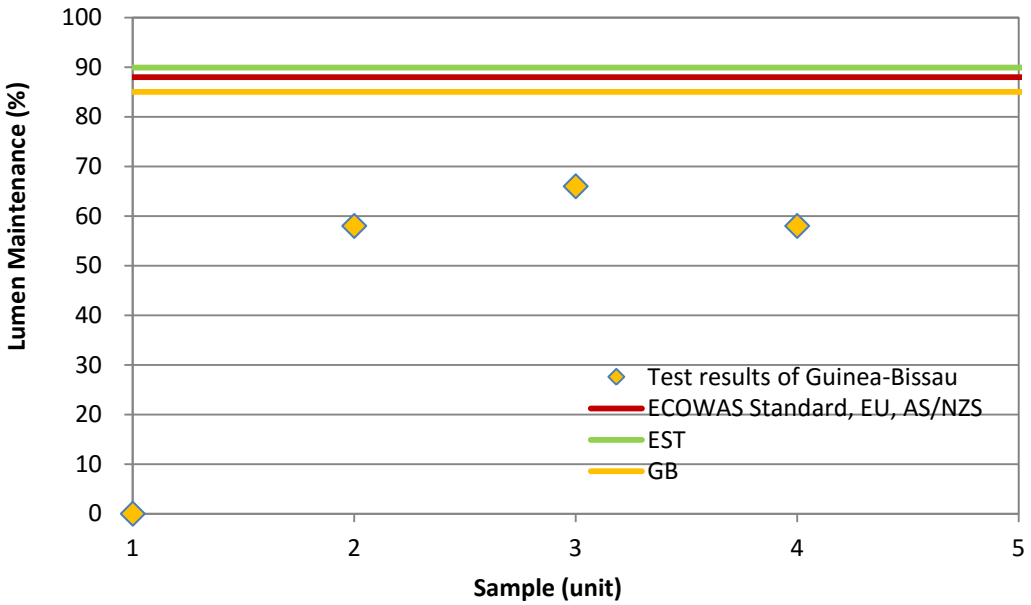


5.5.2.5 Luminous maintenance at 2,000 hours

Figure 81 shows the lumen maintenance results compared with the different reference

standards.

Figure 80 Luminous maintenance test results of Guinea-Bissau (n=10)

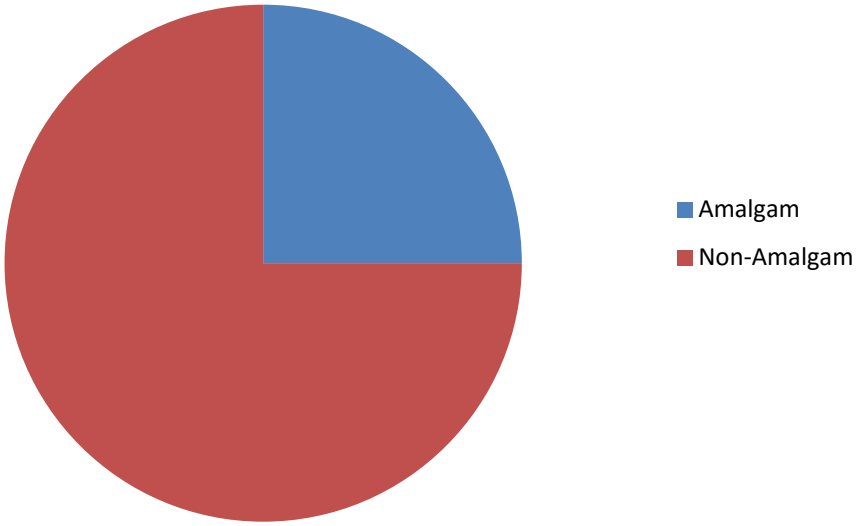


5.5.3 Mercury test results

5.5.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 82 presents the percentage of each mercury format of the CFLs, 25% of the CFLs adopt the amalgam technology and 75% of the CFLs adopt the non-amalgam technology. This is quite a high proportion for the non-amalgam lamps.

Figure 81 Format of mercury for the lamps from Guinea-Bissau



5.5.3.2 Mercury content

Figure 83 shows the average mercury content of each model.

Figure 82 Mercury content results for Guinea-Bissau (n=5)

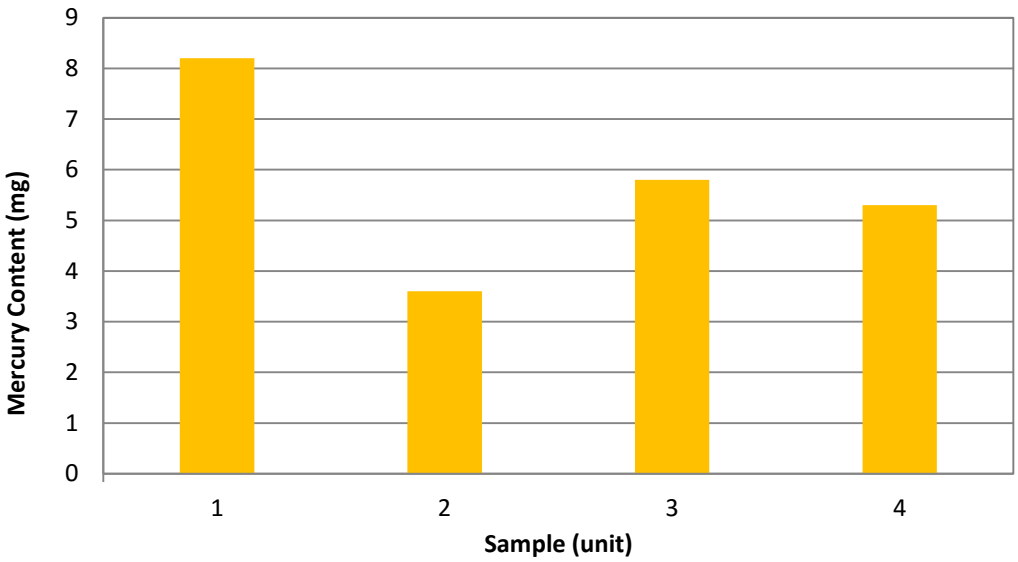


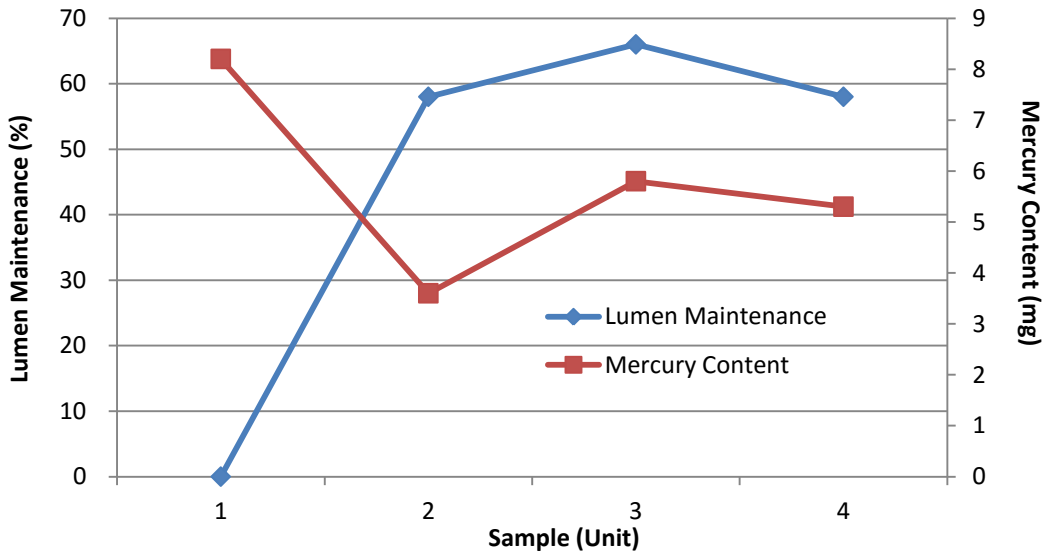
Table 23 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
ECOWAS MEPS	Lamps shall contain no more than 2.5 mg of mercury.		0%
EU regulation	≤2.5mg, for lamp power <30W;		0%
AS/NZS 4847.2	Maximum mercury content 5mg		25%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		0%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	0%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	0%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0%

5.5.3 Mercury content and lumen maintenance

Figure 84 shows the correspondence of mercury content and lumen maintenance of the lamps from Guinea-Bissau. Lumen maintenance results are poor for the four models. Sample 1 failed before 2,000 hours. Sample 2 is an amalgam lamp and the other two are non-amalgam lamp. Samples 2 and 4 have the same lumen maintenance results, however if we also compare the mercury content we find the amalgam lamp, sample 2, is lower.

Figure 83 Mercury content and lumen maintenance of Guinea-Bissau



5.5.4 Summary

There are four sample models shipped from Guinea-Bissau. From the test results, it can be seen the samples failed for Interchangeability, Mechanical Strength, and Electric shock protection.

Interchangeability: refers to the matching degree of the lamp and lamp hold. Due to the mismatch of the lamp and lamp holder, it may result in arcing or discharge, and lead to accidents. The reason for this quality problem might be during the assembling process, the manufacturers use the lamp caps which do not meet the standard's requirements, or the manufacturers did not pay enough attention to the component quality check of semi-finished lamps.

Mechanical strength: Mechanical strength mainly assesses if the lamp cap is securely connected. Some manufacturers do not pay attention to do clockwise and counter clockwise torque testing, when the lamp and lamp holder is connected, which result in the lamps not meeting the tightening torque requirements of the standard. Therefore some lamp caps may easily falling off during the process of installation or removal, which might be dangerous to the end-users and probably result in bodily injury

Electric shock protection: Protection against electric shock means when the lamp screws into the lamp holder (which complies with the lamp holder standard), it cannot touch the metal parts or any electrical components on the lamp cap, because it would be easily to lead to dangerous electric shock when users in the process of installation or removal. During the test, it was also found that the structural design of some products do not meet the requirements, such products have a very large safety risk when in use.

Concerning the performance results, there showed several non-compliances compared with the requirement of standards, see Table 24.

Table 24 Non-compliance items

Test items	Compared standards	Results
Lamp power	IEC 60969 /GB/T 17263	All models did not meet the requirement
Efficacy	ECOWAS standards	All models did not meet the requirement
	ENERGY STAR/EST/GB	All models did not meet the requirement
CRI	EU/AS/NZS/ENERGY STAR/EST/GB	All models did not meet the requirement
SDCM	EU/AS/NZS/ENERGY STAR/EST/GB	3 models did not meet the requirement
Lumen maintenance at 2,000 hrs	ECOWAS standards	1 model failed; 3 models did not meet the requirement;
	EU/AS/NZS/EST/GB	1 model failed; 3 models did not meet the requirement
Mercury	ECOWAS standards	All models did not meet the requirement

Lamp power, Efficacy, CRI, SDCM, Lumen maintenance at 2,000 hrs, and mercury content did not meet the related standards.

The problem with the lamp power is all of the samples measured power is low, which means the actual power is too low compared to the rated power. As explained in 4.2.1, the potential reason may be the manufacture mark a higher rated power in purpose in order to increase the lamp price; or it also could be the production capacity of the manufacturer could not match with its design capability. However in the ECOWAS standard there is no requirement for the lamp power.

The most attention must be paid to the Efficacy, CRI, SDCM and lumen maintenance, as the test results showed almost all of the samples failed, compared against any of the standards. Low efficacy means those lamps are not energy saving and it is hard to achieve the energy saving goals. CRI and SDCEM are the two important elements of the colour characteristic. CRI presents the colour distortion degree of an object when the lamp illuminates the object. SDCM indicates the matching degree between the actual colour and claimed colour of the product. That is, for a large SDCM lamp, the actual colour would not be satisfied by the consumers as it is different from what they expect.

Regarding the mercury test results, it can be seen that 75% of the samples are non-amalgam lamps, and they contained the mercury content higher than 5 mg. As we can see this is much higher than the ECOWAS Standard requirements. It is clear that there should be more effort to make sure the lamps sold in the local market could meet the requirement of ECOWAS Standard.

5.6 Summary results for Lebanon

There are six sample models from Lebanon.
Lebanon established their MEPS in 2006. As requested by Lebanon, the test results are compared against the requirements of Lebanon MEPS. In addition, the test results are also compared against EU regulation, AS/NZS, ENERGY STAR and GB. The lamp power also compared with the IEC 60969.

5.6.1 Safety test

Table 25 lists the Pass and Fail results to each test item for Lebanon, and from which we can be seen that the safety problems of the samples from Lebanon mainly come from Interchangeability.

Table 25 Safety test results of Lebanon (n=8)

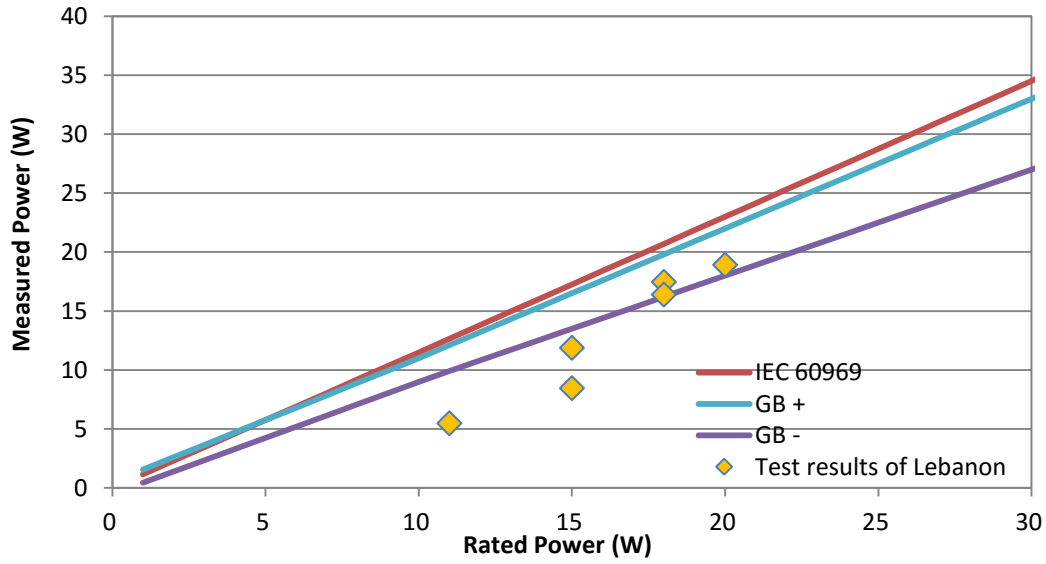
Country	Interchan geability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Lebanon	F	P	P	P	P	P

5.6.2 Performance test results

5.6.2.1 Lamp power

There is no requirement from the Lebanon MEPS for the lamp power, therefore the lamp power was compared with IEC 60969 and GB/T 17263. In Figure 85, it can be seen that all of the samples are within requirement of IEC 60969, but not all of the samples meet the requirements of GB/T 17263, as GB/T 17263 limits both maximum and minimum values. It can see that nearly half of the lamps from Lebanon met the two standards requirements; while the other three models have a slightly lower measured power than the rated power.

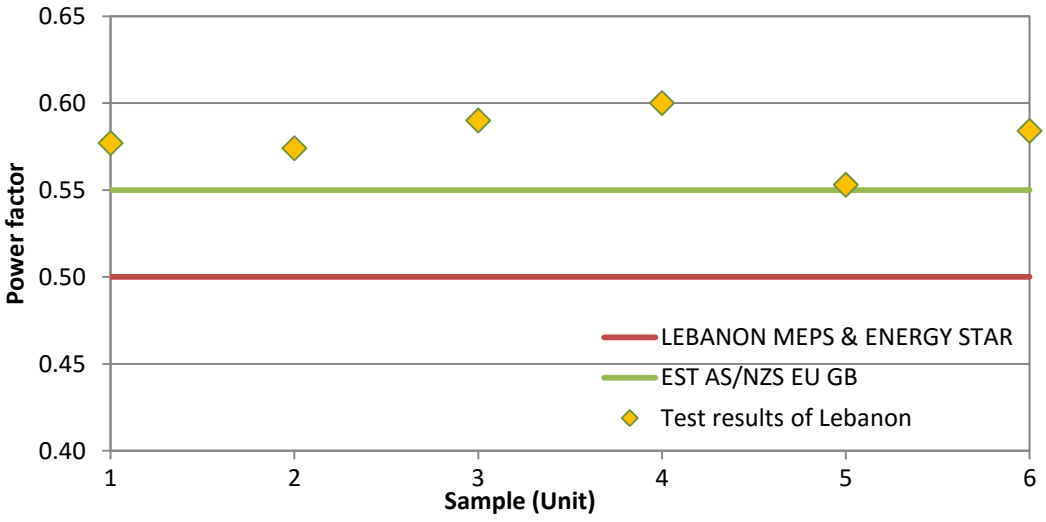
Figure 84 Lamp power test results of Lebanon (n=10)



5.6.2.2 Power factor

From Figure 86, it can be seen that the power factor of the testing samples are not less than 0.55 and meet the requirements by all of the reference standards.

Figure 85 Power factor test results of Lebanon (n=10)



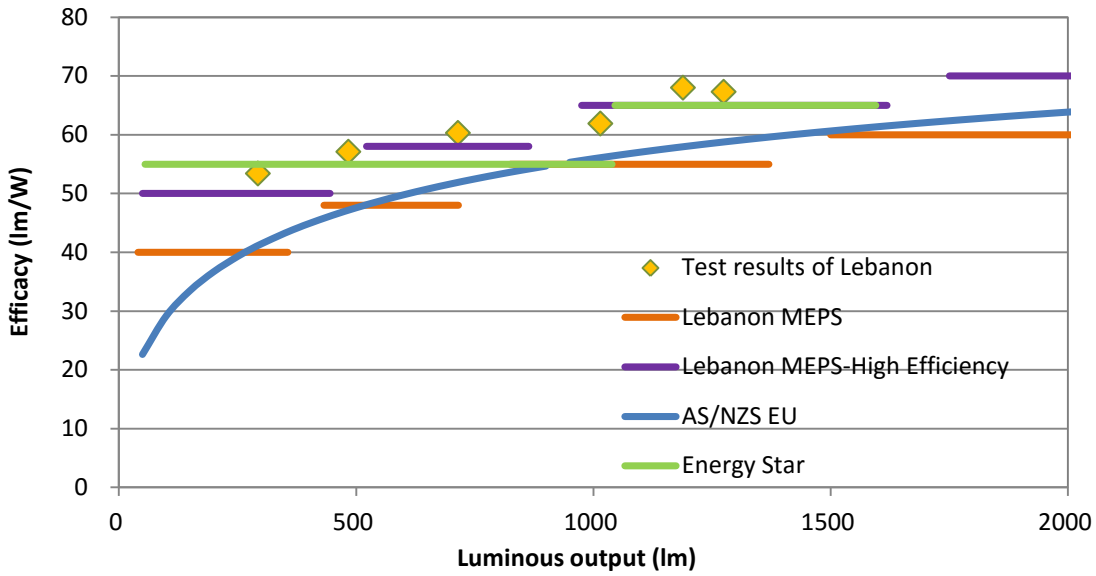
5.6.2.3 Efficacy

a) Compared with Lebanon MEPS, EU regulation, AS/NZS 4847.2, and ENERGY STAR lamp specification V1.0

Figure 87 shows the tested efficacy data compared with Lebanon MEPS, AS/NZS 4847.2, EU Regulation No. 244/2009 and ENERGY STAR lamp specification V1.0. It can be seen that all the lamps meet the Lebanon MEPS, AS/NZS and EU efficacy requirements. However two models do

not quite achieve the ENERGY STAR requirements.

Figure 86 Luminous efficacy test results of Lebanon (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes and in each group, the testing results are compared with the corresponding requirements. Please see Figure 88 and 89.

Figure 88 shows the testing results of the stick shaped lamps compared with EST requirements. Figure 89 is the testing results of the spiral shaped lamps compared with EST requirements. From both figures, it can be seen that one spiral model of the total six did not meet the EST requirements.

Figure 87 Luminous efficacy test results of Lebanon (stick lamp) (n=10)

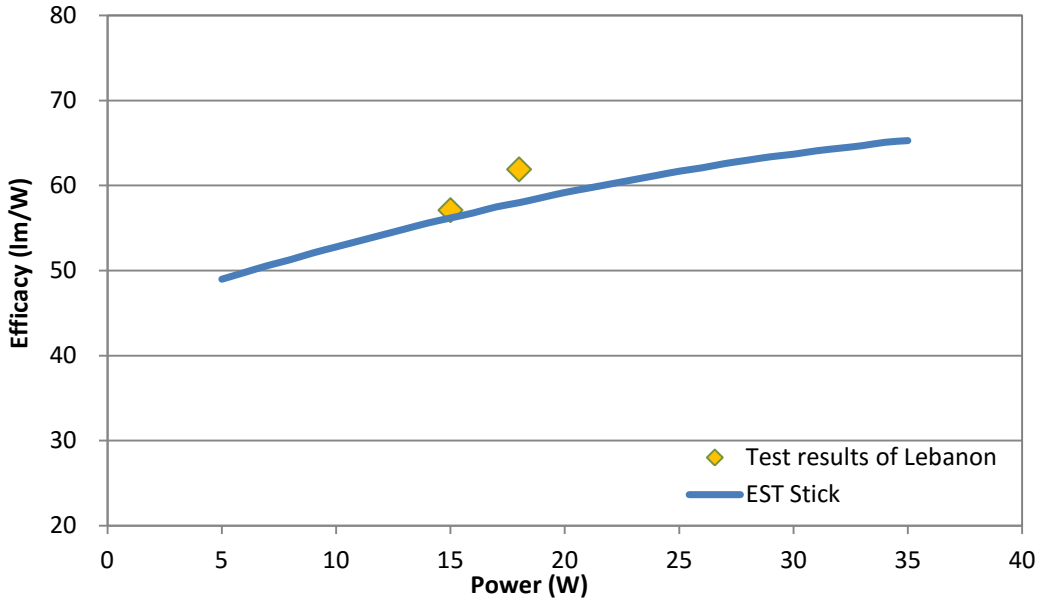
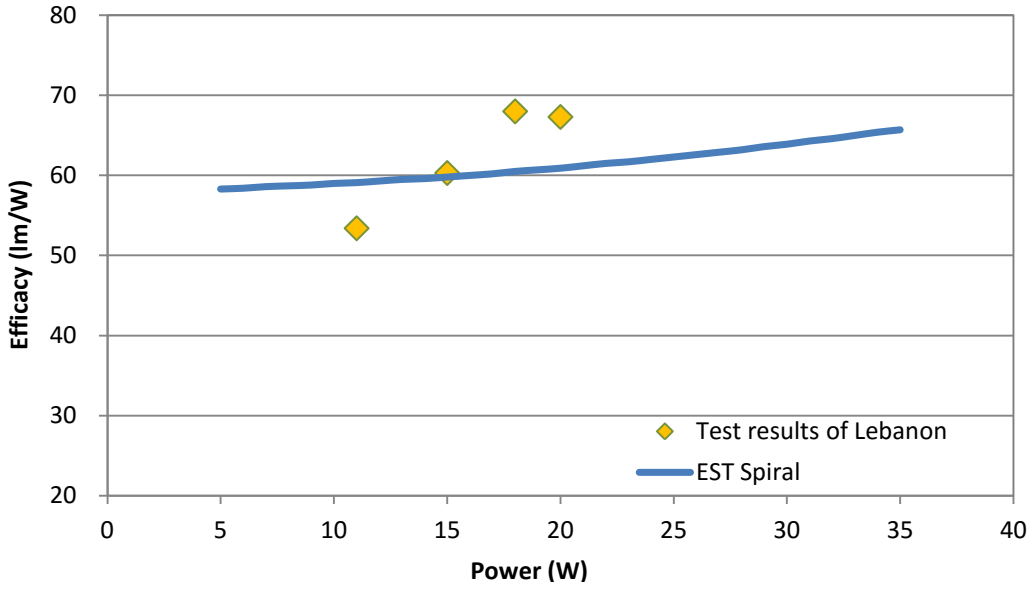


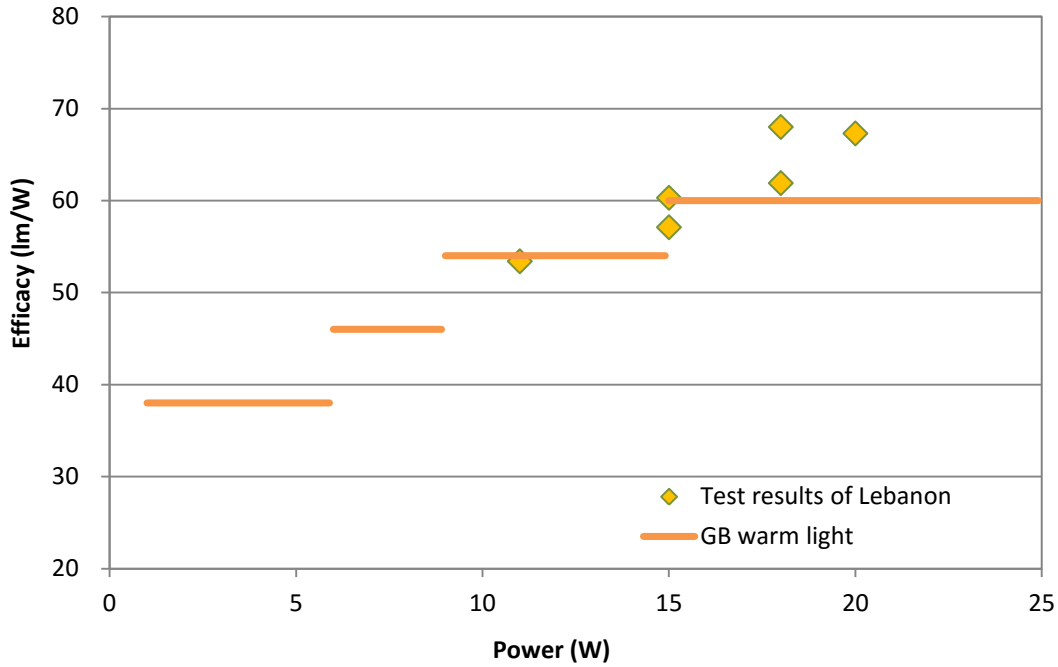
Figure 88 Luminous efficacy test results of Lebanon (spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. All the samples from Lebanon are with warm light, in Figure 90, it can be seen that there are two models whose efficacy is a bit lower than the GB requirements.

Figure 89 Luminous efficacy test results of Lebanon (warm light) (n=10)



5.6.2.4 Colour

Figure 91 and Figure 92 presents the CRI and SDCM test results of the CFLs from Lebanon. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a maximum allowance of 5 steps. From Figure 91 and 92, it shows two models of CFLs from Lebanon all meet this CRI minimum requirement and SDCM maximum requirement.

Figure 90 CRI test results of Lebanon (n=10)

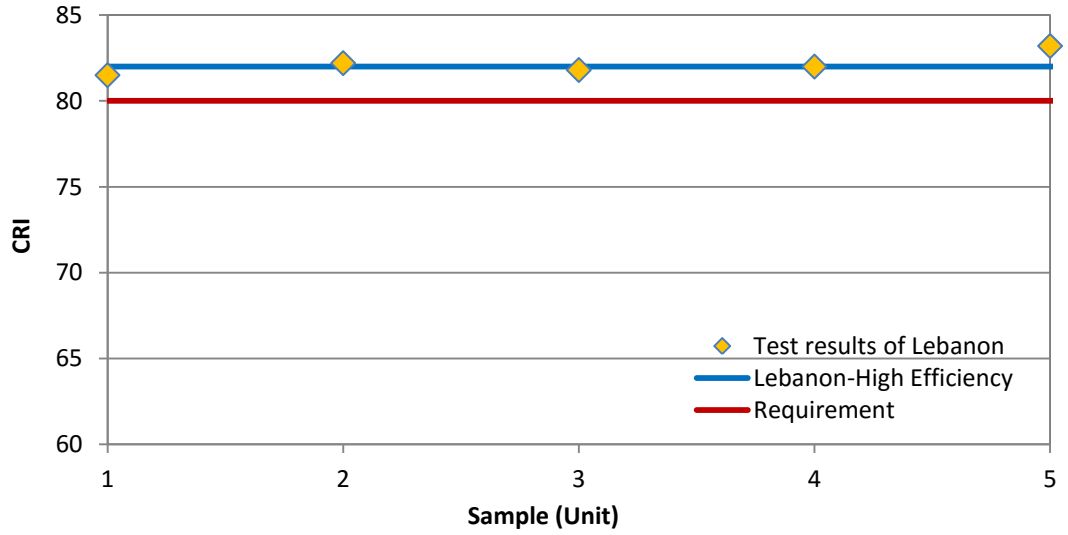
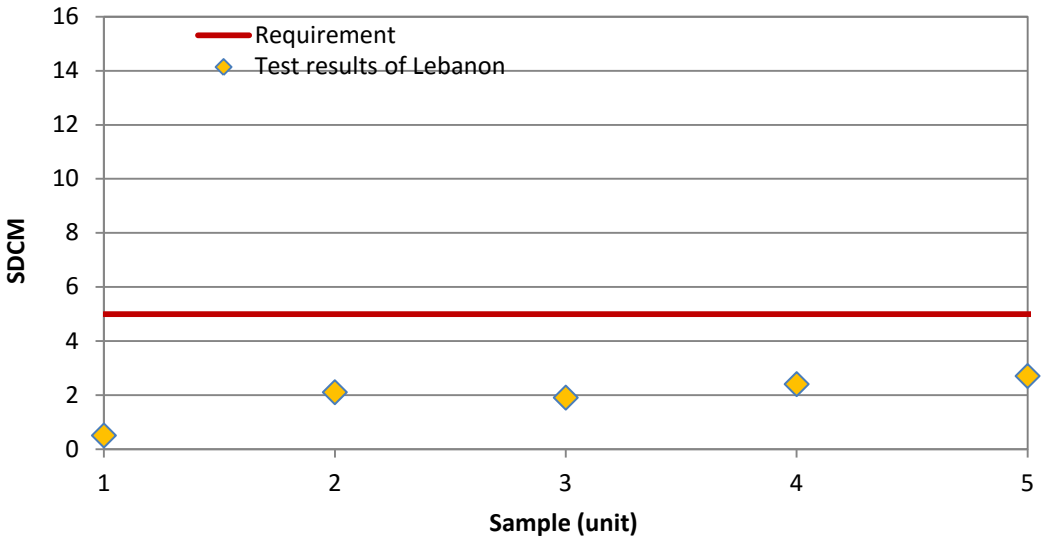


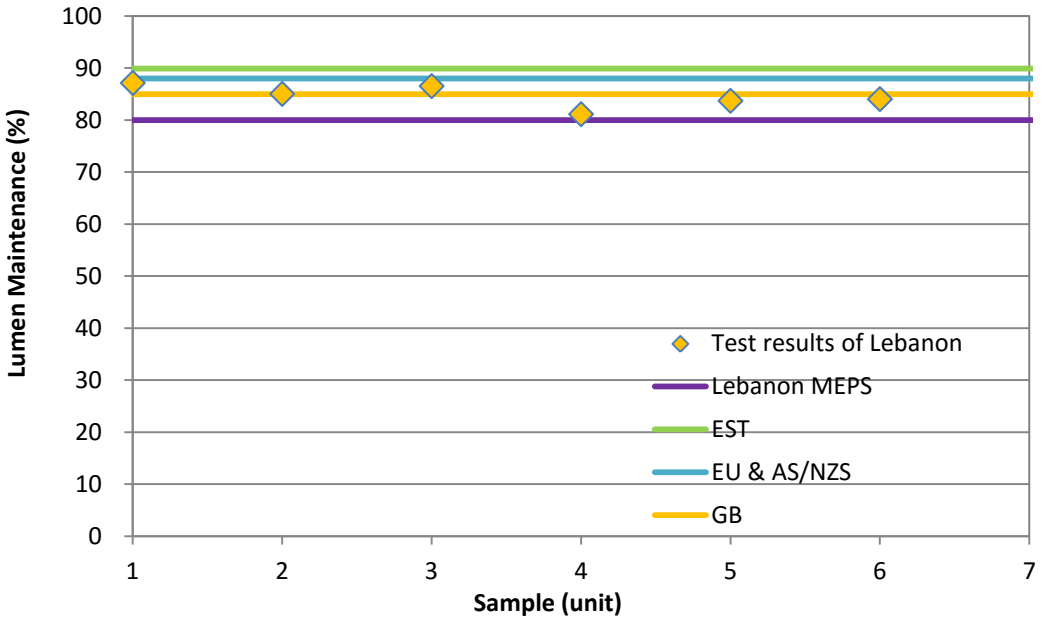
Figure 91 SDCM test results of Lebanon (n=10)



5.6.2.5 Luminous maintenance at 2,000 hours

Figure 93 shows the lumen maintenance results compared with the different reference standards. From Figure 93, the lumen maintenance of three models from Lebanon are less than 85%, which is the minimum value among all of the reference standards. All of them are less than 88%, the second highest line from AS/NZS requirements.

Figure 92 Luminous maintenance test results of Lebanon (n=10)

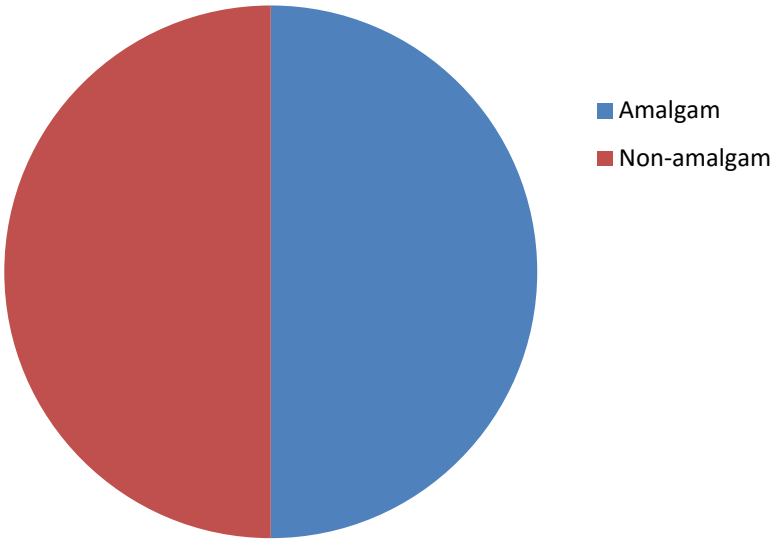


5.6.3 Mercury test results

5.6.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 94 presents the percentage of each mercury format of the CFLs, 50% of the CFLs adopt the amalgam technology and 50% of the CFLs adopt the non-amalgam technology. This is quite a big proportion for the non-amalgam lamps.

Figure 93 Format of mercury for the lamps from Lebanon



5.6.3.2 Mercury content

Figure 95 shows the average mercury content of each model. We can be seen that the mercury contents are very different from the lamps. The amalgam lamps all showed lower mercury content, which are less than 2 mg and the non-amalgam lamps showed higher mercury content, which could be over than 13 mg.

Figure 94 Mercury content results for Lebanon (n=5)

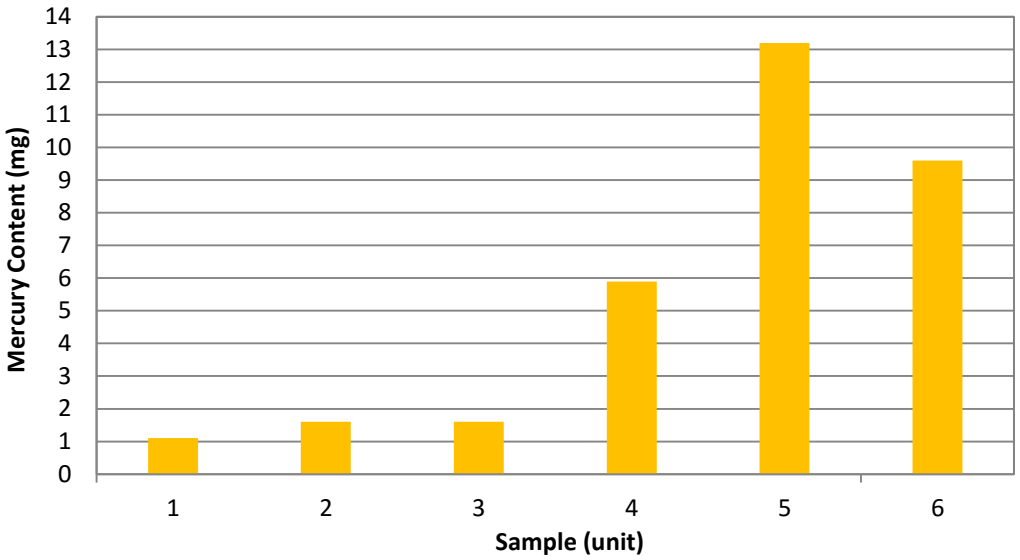


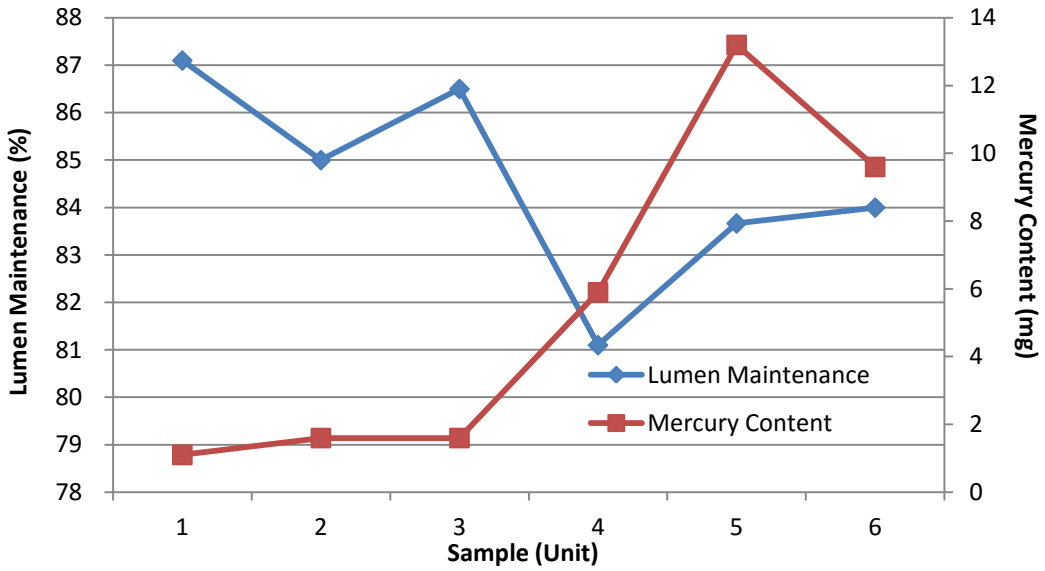
Table 26 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
Lebanon MEPS	5mg per lamp		50%
EU regulation	≤2.5mg, for lamp power <30W;		50%
AS/NZS 4847.2	Maximum mercury content 5mg		50%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		50%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	50%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	17%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0%

5.6.3 Mercury content and lumen maintenance

Figure 96 shows the connection between mercury content and lumen maintenance of the lamps from Lebanon. Samples 1 to 3 are amalgam lamp and have the good lumen maintenance results. Samples 4 to 6 are non-amalgam lamps and have the lower lumen maintenance test results.

Figure 95 Mercury content and lumen maintenance of Lebanon



5.6.4 Summary

There are six sample models shipped from Lebanon. From the test results, it can be seen the lamps did not pass the Interchangeability safety test.

Interchangeability: refers to the matching degree of the lamp and lamp hold. Due to the mismatch of the lamp and lamp holder, it may result in arcing or discharge, and lead to accidents. The reason for this quality problem might be during the assembling process, the manufacturers use the lamp caps which do not meet the standard's requirements, or the manufacturers did not take good attention to the component quality check of semi-finished lamps.

Concerning the performance results, there showed several non-compliances compared with the requirement of standards, see Table 27.

Table 27 Non-compliant items

Test items	Compared standards	Results
Lamp power	GB/T 17263	Half of models did not meet the requirement
Efficacy	Lebanon MEPS (High Efficiency)	2 models did not meet the requirement
	EU Regulation/EST/GB/ENERGY STAR	1 model did not meet the requirement
CRI	Lebanon MEPS (High Efficiency)	1 model did not meet the requirement
Lumen maintenance at 2,000 hours	EU Regulation AS/NZS/ EST	6 models did not meet the requirement;
	GB	3 models did not meet the requirement
Mercury	Lebanon MEPS	3 models did not meet the requirement

Compared with Lebanon MEPS, the efficacy, colour and lumen maintenance results all met the standard's requirements. Those results even met with the High Efficiency requirement in the Lebanon MEPS. Only the item did not meet is mercury, as stated in the standard, it requires the maximum mercury content is 5 mg per lamp. However for the samples tested, the results showed half of them did not meet this requirement.

Compared with the other standards, the non-compliant items are lamp power, efficacy, CRI, Lumen maintenance at 2,000 hrs and mercury.

The problem in the lamp power is all of the samples measured lower than the rated power, which means the actual power is too low compared to the rated power. As explained in 4.2.1, the potential reason may be the manufacture deliberately marks a higher rated power in order to increase the lamp price; or it also could be the production capacity of the manufacturer does not match with its design capability.

The most attention needs to be paid to the Efficacy, CRI, and lumen maintenance. Low efficacy means those lamps are not energy saving and would not achieve the energy saving goals. CRI is the important element of the Colour characteristic. CRI presents the colour distortion degree of an object when the lamp illuminates the object. The lumen maintenance results indicated that it also needs attention. Within all of the compared standards, only half of models can meet the lowest requirement. The lumen maintenance has a big effect on the lamp life time; the low lumen maintenance results show the luminous flux goes down quickly as the bulb gets older.

Regarding the mercury test results, it can be seen that 50% of the samples are non-amalgam lamps, and they contained the mercury content much higher than 5 mg.

5.7 Summary results for Panama

There are four sample models from Panama. The Regional Lighting Efficiency Strategy in Central America has been developed and approved on December 6th 2013[5]. This document establishes the minimum standards for efficiency, quality, safety and environmental impact that all lighting devices must comply with in order to be imported and sold in the countries in the region, including Panama.

As requested by the country, the test results of the samples are compared with the minimum energy performance standards (MEPS) requirements of the Regional Lighting Efficiency Strategy in Central America. The Central America MEPS defines two levels: one is the minimum requirement, and the other one is named as, "Mesoamerica Award," a higher requirement to encourage the introduction of high efficiency products to the market.

5.7.1 Safety test

Table 28 lists the Pass and Fail results to each test item for Panama, and from which we could know that the safety problems of the samples from Panama mainly come from Interchangeability and Mechanical strength.

Table 28 Safety test results of Panama (n=8)

Country	Interchangeability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Panama	F	F	P	P	P	P

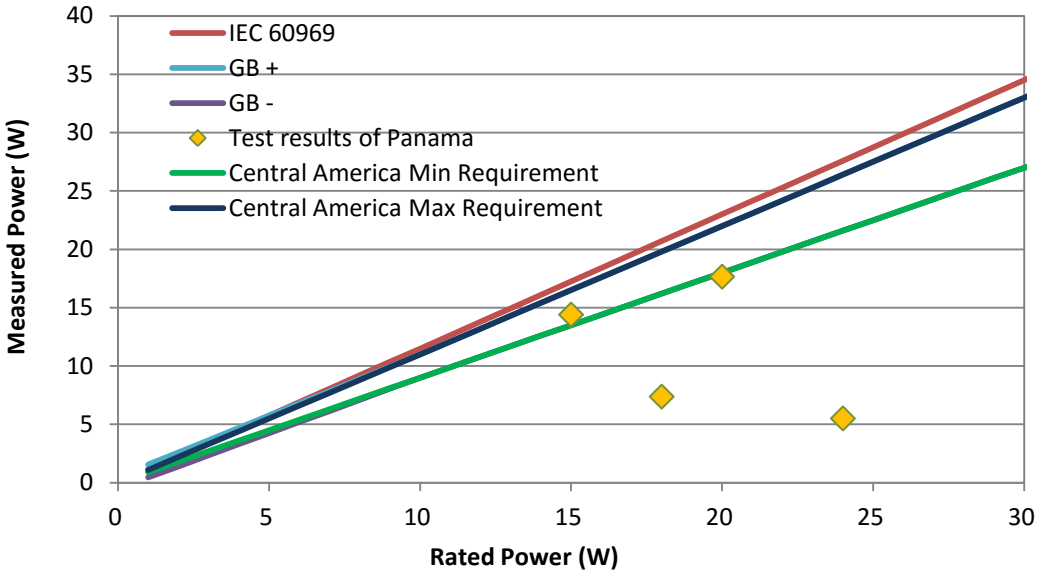
5.7.2 Performance test results

5.7.2.1 Lamp power

In Figure 97, it could see that all of the samples are within requirement of IEC 60969, but not all of the samples meet the requirements of Central America MEPS and GB/T 17263, as Central America MEPS and GB/T 17263 limited both maximum and minimum values. It can see that most of the lamps from these three countries matched the best with the two standards' requirements; while there also two models of lamps have much lower measured power than the rated power.

[5] *Regional Lighting Efficiency Strategy in Central America*

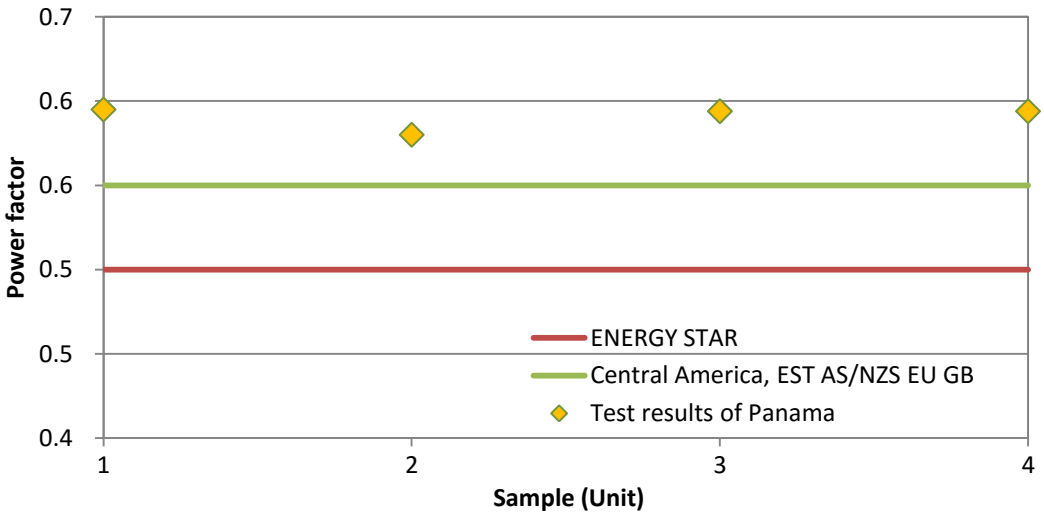
Figure 96 Lamp power test results of Panama (n=10)



5.7.2.2 Power factor

From figure 98, it can be seen that the power factor of the testing samples from Panama are all over than 0.55 and meet the requirements by all of the standards.

Figure 97 Power factor test results of Panama (n=10)



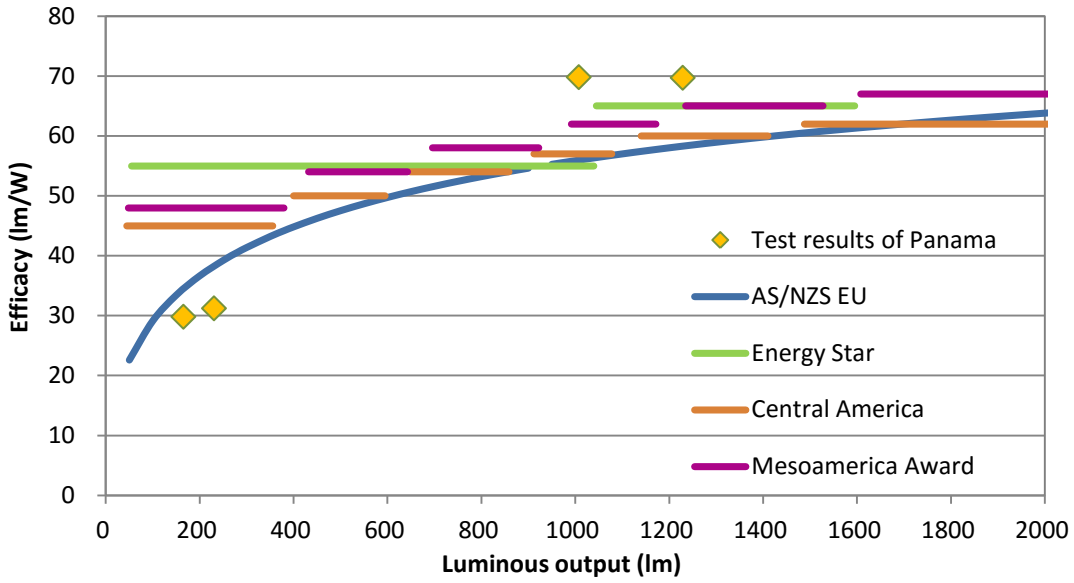
5.7.2.3 Efficacy

a) Compared with Central America MEPS, AS/NZS 4847.2, EU regulation and ENERGY STAR lamp specification V1.0

Figure 99 shows the tested efficacy data compared with Central America MEPS, AS/NZS 4847.2, EU Regulation No. 244/2009 and ENERGY STAR lamp specification V1.0. It can be clearly seen that

the lamps with lumen output less than 500 lm could not meet with any of the standard requirements.

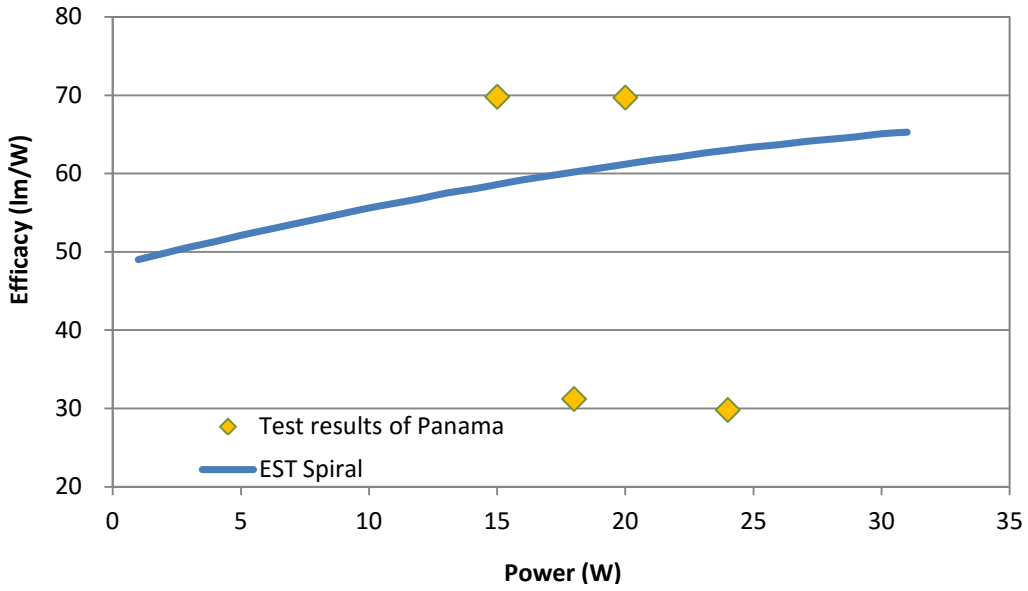
Figure 98 Luminous efficacy test results of Panama (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes. The lamps from Panama are all spiral, therefore, the testing results are compared with the corresponded requirement. Please see figure 100.

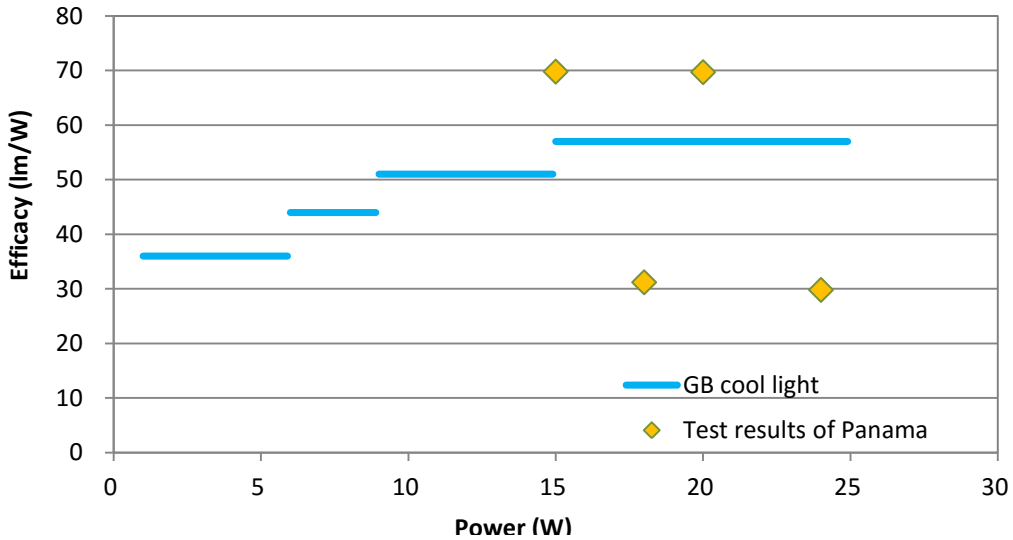
Figure 99 Luminous efficacy test results of Panama (spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. All the CFLs from Panama are with the cool light. And it could see that, two models of CFLs from Panama are failed to meet with the GB requirements.

Figure 100 Efficacy test results of Panama (cool light) (n=10)



5.7.2.4 Colour

Figure 102 and Figure 103 presents the CRI and SDCM test results of the CFLs from Panama. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a

maximum allowance of 5 steps. From Figure 102, it shows two models of CFLs from Panama could not meet this minimum requirement. And from Figure 103, it could see that one model from Panama is out of the SDCM maximum scope.

Figure 101 CRI test results of Panama (n=10)

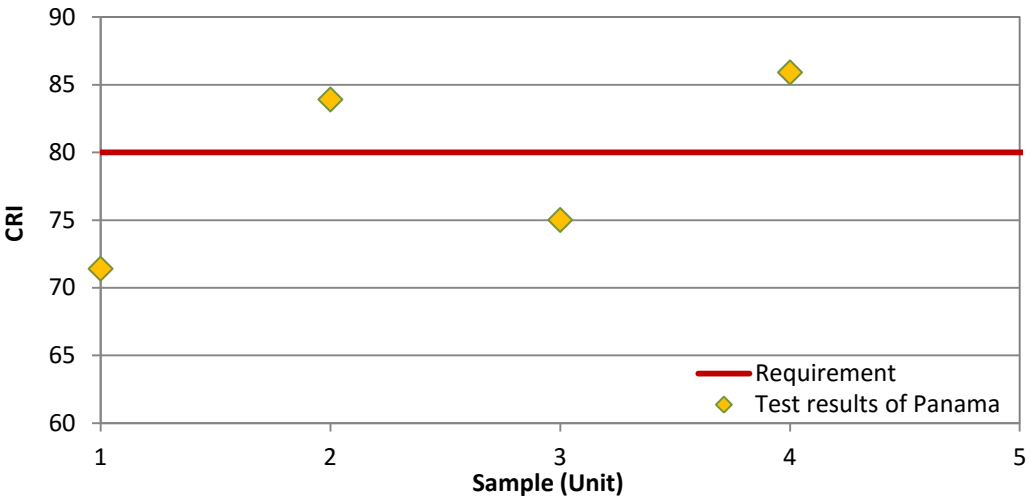
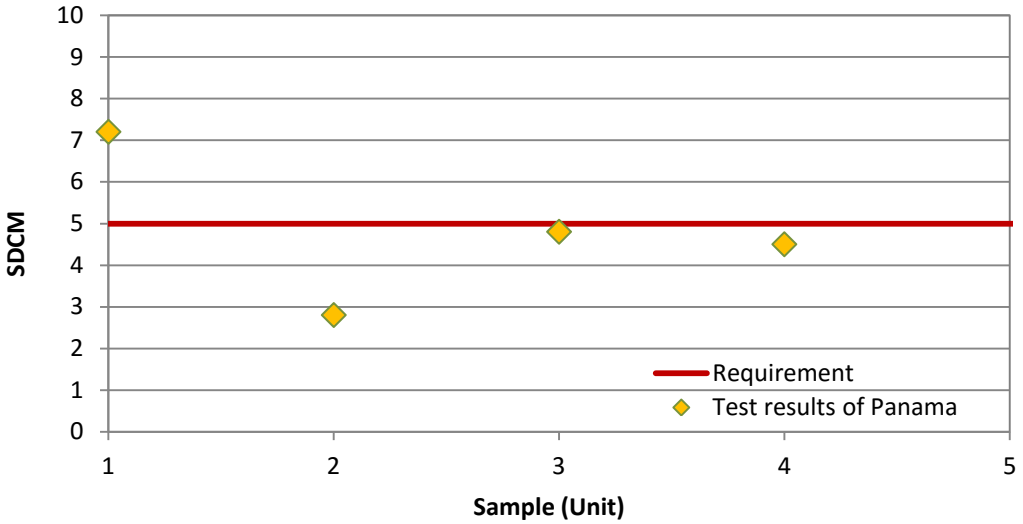


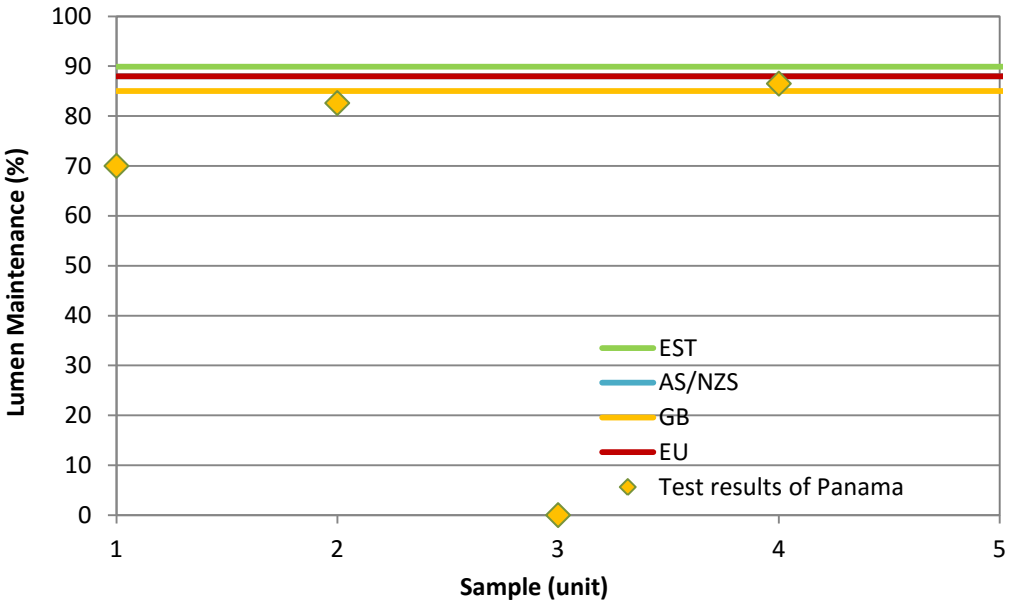
Figure 102 SDCM test results of Panama (n=10)



5.7.2.5 Luminous maintenance at 2,000 hours

In the Central America MEPS, there is no requirement for lumen maintenance at 2,000 hours; therefore it could not be used for comparing the lumen maintenance results here. Figure 104 shows the lumen maintenance results compared with the different reference standards. Only one sample meets one of the reference standards while one sample failed by 2,000 hours.

Figure 103 Luminous maintenance test results of Panama (n=10)

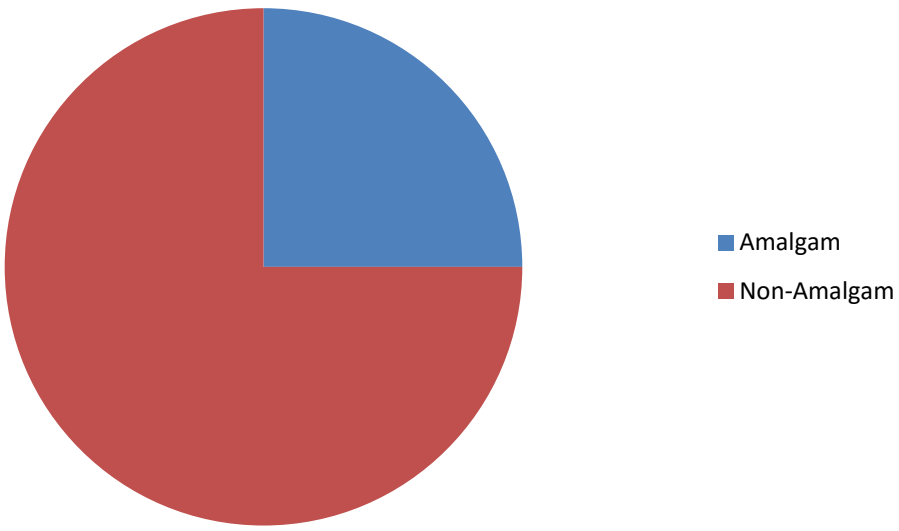


5.7.3 Mercury test results

5.7.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 105 presents the percentage of each mercury format of the CFLs, 25% of the CFLs adopt the amalgam technology and 75% of the CFLs adopt the non-amalgam technology. It is a quite big proportion for the non-amalgam lamps.

Figure 104 Format of mercury for the lamps from Panama



5.7.3.2 Mercury content

Figure 106 shows the average mercury content of each model. We could see there is a large gap among the testing results.

Figure 105 Mercury content results for Panama (n=5)

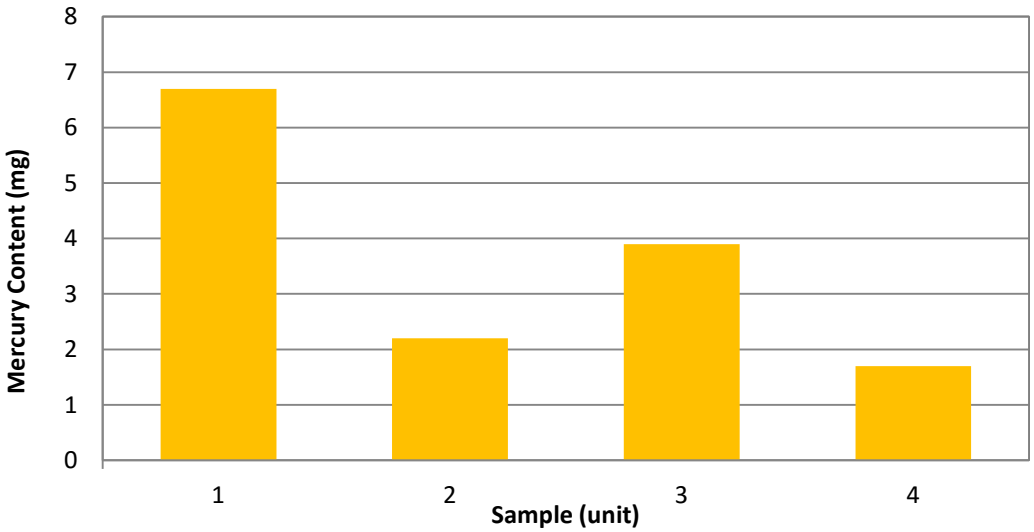


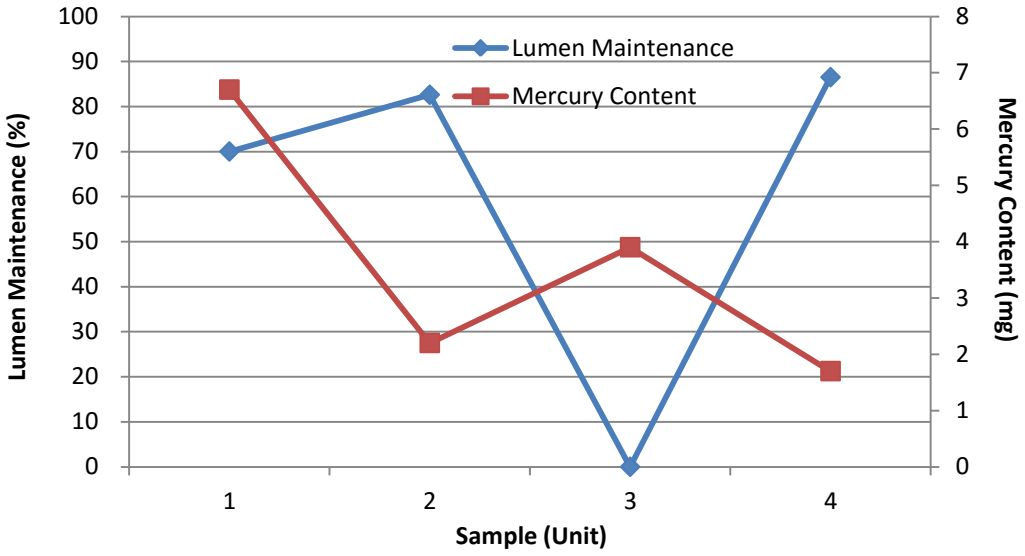
Table 29 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
Regional Lighting Efficiency Strategy in Central America	Less than 3.5mg		50%
Minamata Convention	Maximum mercury content 5mg		75%
EU regulation	≤2.5mg, for lamp power <30W;		50%
AS/NZS 4847.2	Maximum mercury content 5mg		75%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		50%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	50%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	25%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0%

5.7.3 Mercury content and lumen maintenance

Figure 107 shows the correspondence of mercury content and lumen maintenance of the lamps from Panama. Sample 1, 2 and 3 are non-amalgam lamps, which showed a related low lumen maintenance; Sample 3 has failed before 2,000 hours. Sample 4 is the amalgam lamps, which shows the highest lumen maintenance compared to the others.

Figure 106 Mercury content and lumen maintenance of Panama



5.7.4 Summary

There are four sample models shipped from Panama. From the test results, it could see that there are two models of lamp did not pass the safety test, and failed at Interchangeability and Mechanical Strength.

Interchangeability: refers to the matching degree of the lamp and lamp hold. Due to the mismatch of the lamp and lamp holder, it may result in arcing or discharge, and lead to accidents. The reason for this quality problem might be during the assembling process, the manufacturers use the lamp caps which do not meet with the standard's requirements, or the manufacturers did not pay enough attention to the component quality check of semi-finished lamps.

Mechanical strength: Mechanical strength mainly assesses if the lamp cap is securely connected. Some manufacturers do not pay attention to do clockwise and counter clockwise torque testing, when the lamp and lamp holder connected, which results in the lamps not meeting with the tightening torque requirements of the standard. Therefore some lamp caps are easily falling off during the process of installation or removal, which might be dangerous to the end-users and probably result in bodily injury

For the performance results, some items did not meet the requirement of the reference

standards listed in Table 30.

Table 30 Non-compliant items

Test items	Compared standards	Results
Lamp power	Regional Lighting Efficiency Strategy in Central America	3 models did not meet with the requirement
Efficacy	Regional Lighting Efficiency Strategy in Central America	2 model did not meet with the requirement
	ENERGY STAR/EST/GB	2 models did not meet with the requirement
CRI	EU/AS/NZS/ENERGY STAR/EST/GB	2 models did not meet with the requirement
SDCM	EU/AS/NZS/ENERGY STAR/EST/GB	2 models did not meet with the requirement
Lumen maintenance at 2,000 hrs	GB	1 model failed; 2 models did not meet with the requirement;
	EU	1 model failed; 3 models did not meet with the requirement
	EST	1 model failed; all of the models did not meet with the requirement
Mercury	Regional Lighting Efficiency Strategy in Central America;	2 models did not meet with the requirement

Comparing with Central America MEPS, the lamp power, efficacy and mercury content did not meet the required minimum standards.

Comparing with the other standards, the test results showed problems with: lamp power, efficacy, CRI, SDCM, lumen maintenance at 2,000 hrs and mercury content.

The issue with the lamp power is that three models of lamps measured power is lower than the minimum line defined in Central America MEPS, which means the actual power is too low compared to the rated power. As explained in 4.2.1, the potential reason may be the manufacture mark a higher rated power in purpose in order to increase the lamp price; or it also could be the production capacity of the manufacturer could not match with its design capability.

The efficiency tests show that two models have very high efficacy (higher than Mesoamerica Award and EST requirement), however the remaining two are very low and did not meet any of the requirements of the reference standards.

The lumen maintenance results are also very poor. One model failed before 2,000 hours and only 25% of models (1 sample) could meet with the least demanding requirement.

Regarding the mercury test results, it can be seen that 75% the models are non-amalgam lamps;

with maximum mercury content of over 6 mg. Half of them did not meet the regional MEPS.

5.8 Summary results for Tonga

There are nine sample models from Tonga. However, insufficient sample units were received for 4 sample models – 18 units, 9 units, 5 units and 3 units separately. Therefore, it was not possible to carry out all the tests for all the models. According to the total lamp number of each model, the safety test was conducted on six models, the performance test on six models, and the mercury test on seven models.

Tonga does not have its own MEPS, however they requested to compare their test results with Australian MEPS (AS/NZS 4847.2). Apart from the Australian In this section, the test results compared with requirements from EU regulation, AS/NZS, ENERGY STAR and GB. The lamp power also compared with the IEC 60969.

5.8.1 Safety test

Table 31 lists the Pass and Fail results to each test item for Tonga, and from which we can be seen that there are two items did not pass the safety test: Interchangeability and Mechanical strength.

Table 31 Safety test results of Tonga (n=8)

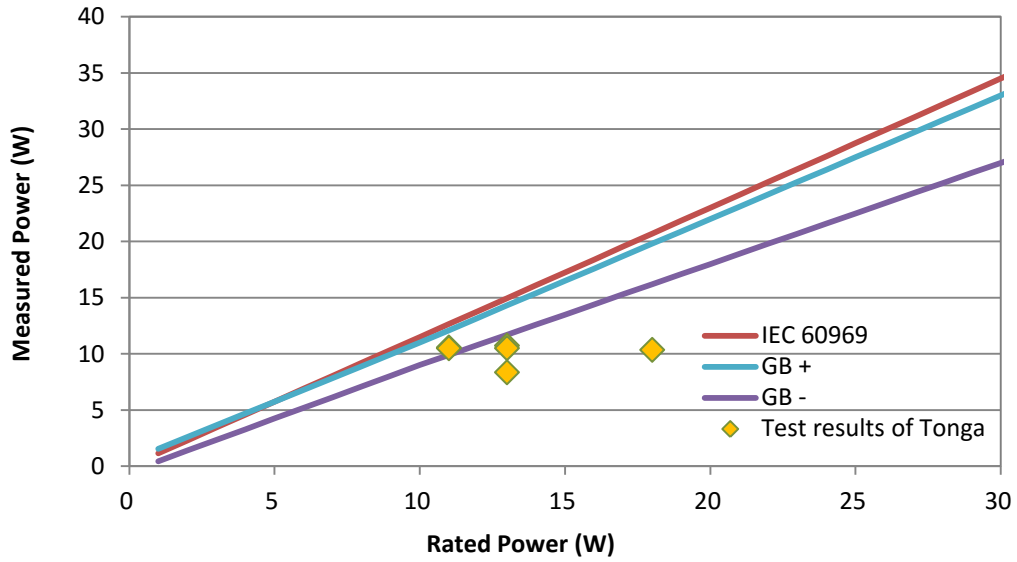
Country	Interchangeability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Tonga	F	F	P	P	P	P

5.8.2 Performance test results

5.8.2.1 Lamp Power

The lamp power was compared with IEC 60969 and GB/T 17263. In Figure 108, it can be seen that all of the samples are within the requirement of IEC 60969, but not all of the samples meet the requirements of GB/T 17263, as GB/T 17263 limits both maximum and minimum values. It can be seen that only one of the models of lamps from Tonga met the two standards' requirements; while the other models had lower measured power than the rated power.

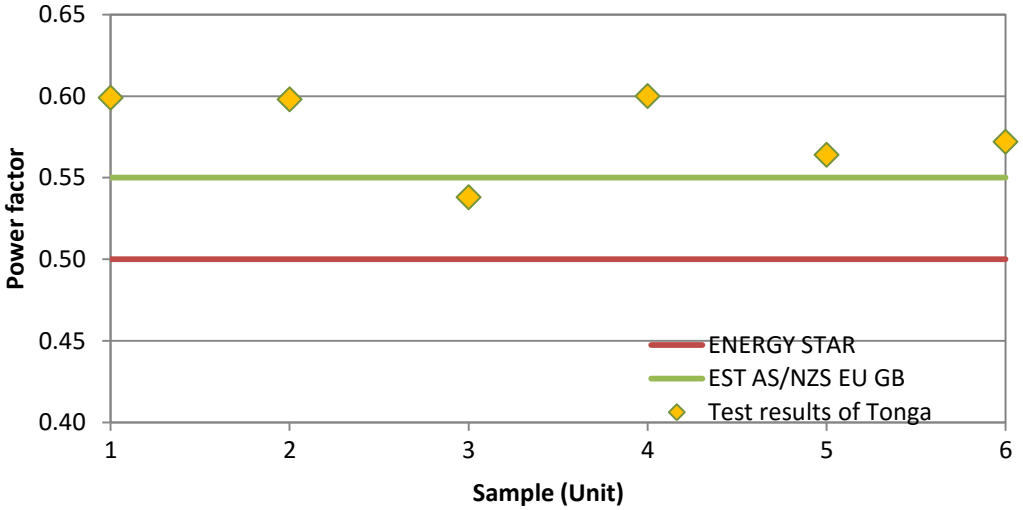
Figure 107 Lamp power test results of Tonga (n=10)



5.8.2.2 Power factor

From Figure 109, it can be seen that the power factor of all samples is over 0.50 and meet the ENERGY STAR requirements. There are five models testing results over 0.55 and meet all of the reference standards.

Figure 108 Power factor test results of Tonga (n=10)



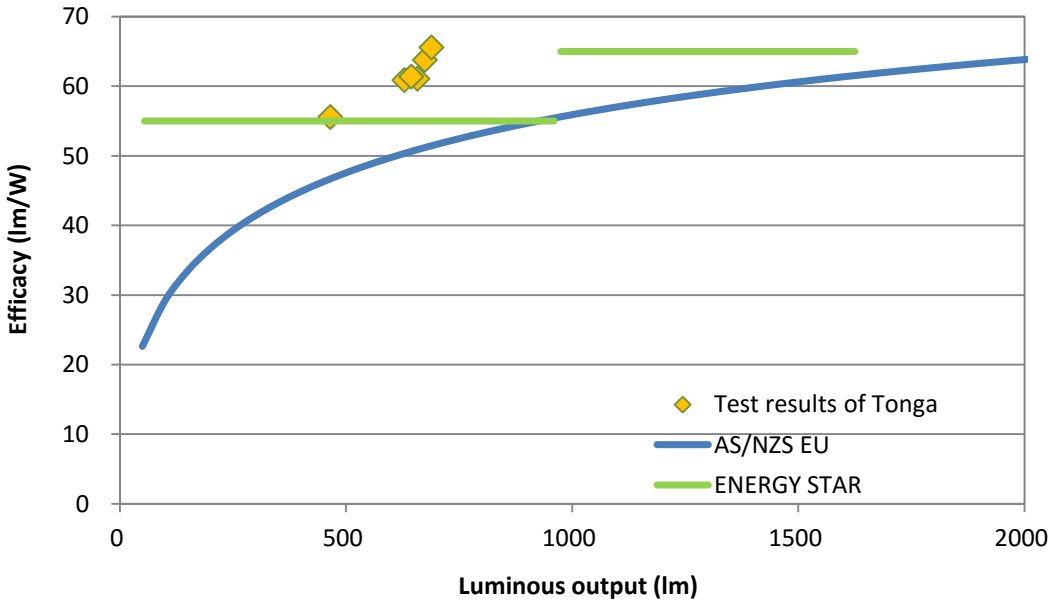
5.8.2.3 Efficacy

a) Compared with AS/NZS 4847.2, EU regulation, and ENERGY STAR lamp specification V1.0

Figure 110 shows the tested efficacy data compared with AS/NZS 4847.2, EU Regulation No. 244/2009 and ENERGY STAR lamp specification V1.0. It can be seen that all the lamps meet all of

the reference standards.

Figure 109 Luminous efficacy test results of Tonga (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes and in each group, the testing results are compared with the corresponding requirements. Please see Figure 111 and 112.

Figure 111 is the testing results of the stick shaped lamps compared with EST requirements. Figure 112 is the testing results of the spiral shaped lamps compared with EST requirements. From Both figure, it can be seen that all of the models meet the EST requirements.

Figure 110 Luminous efficacy test results of Tonga (stick lamp) (n=10)

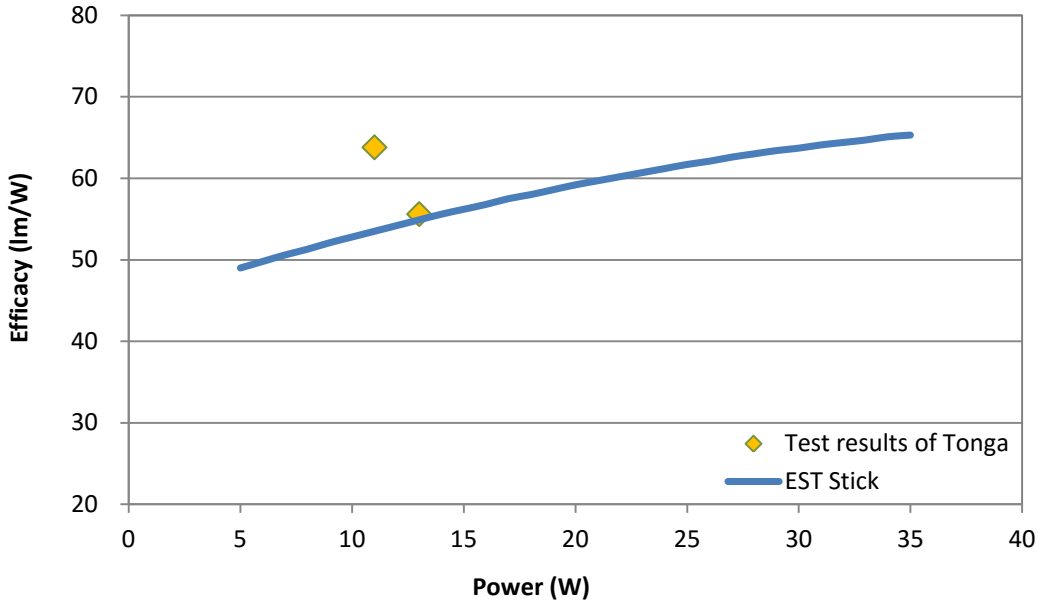
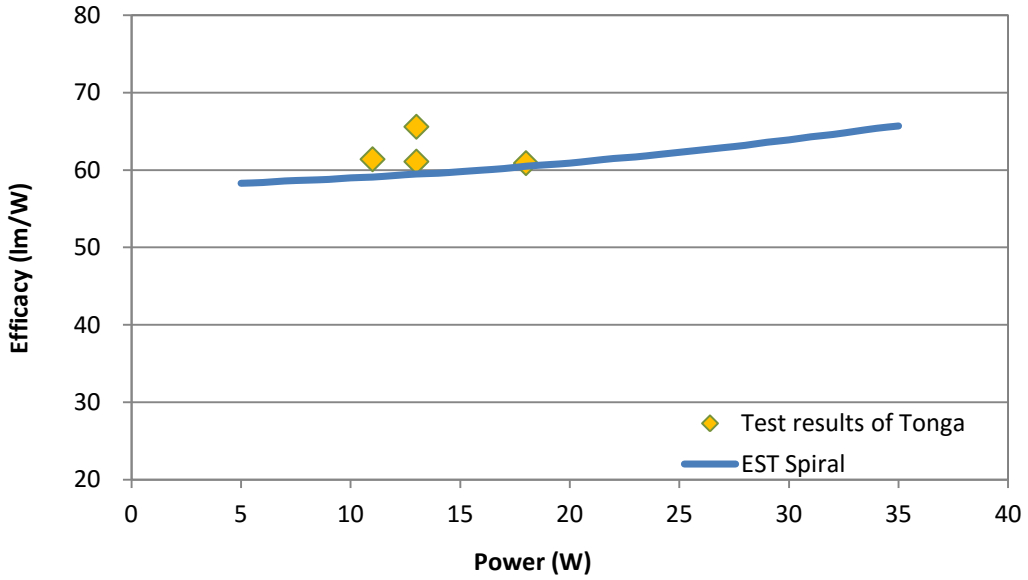


Figure 111 Efficacy test results of Tonga (spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. All the samples from Tonga meet the GB requirements.

Figure 112 Luminous efficacy test results of Tonga (warm light) (n=10)

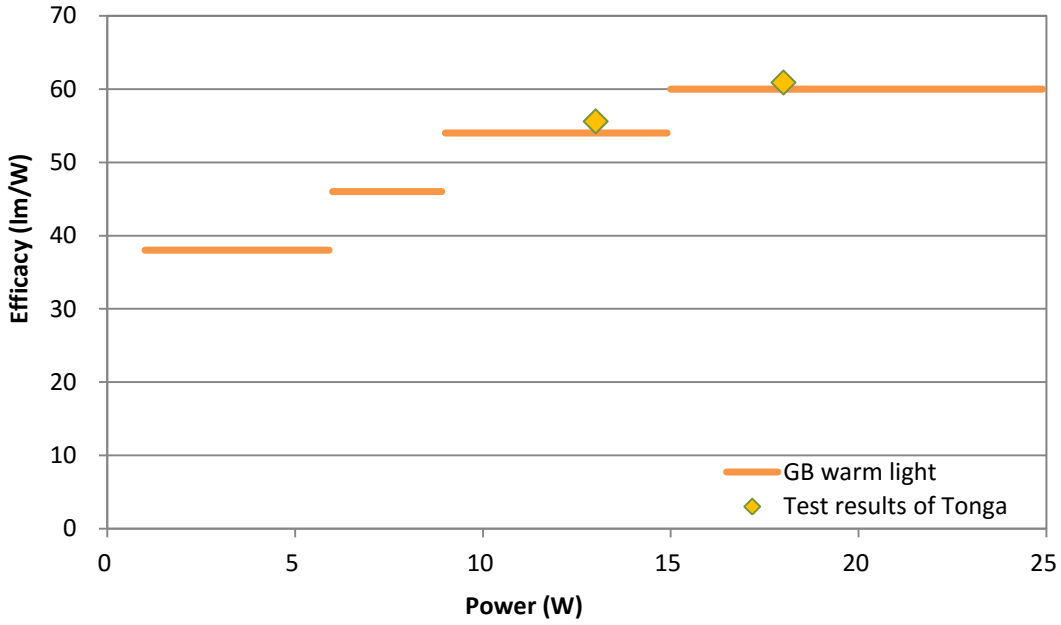
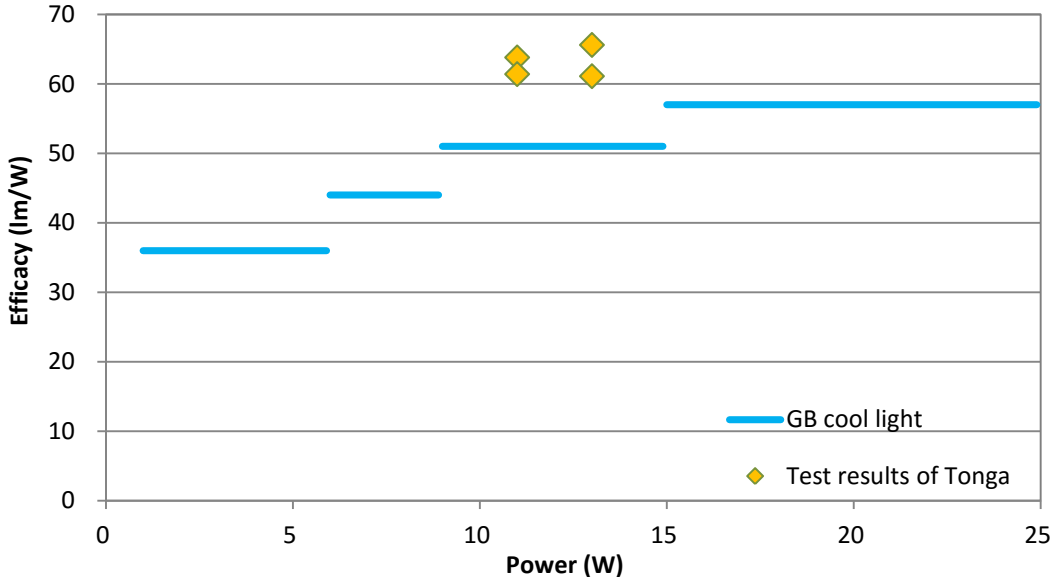


Figure 113 Luminous efficacy test results of Tonga (cool light) (n=10)



5.8.2.4 Colour

Figure 115 and Figure 116 presents the CRI and SDCM test results of the CFLs from Tonga. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a maximum allowance of 5 steps. From Figure 115 and 116, it shows all models of CFLs from Tonga

meet this CRI minimum requirement. However for the SDCM, there is one model that exceeded the maximum allowance.

Figure 114 CRI test results of Tonga (n=10)

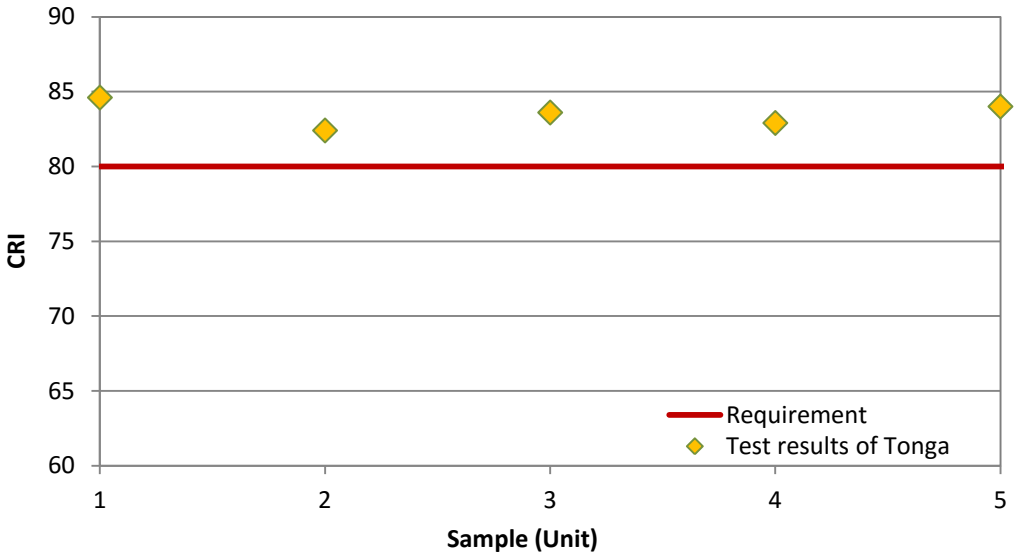
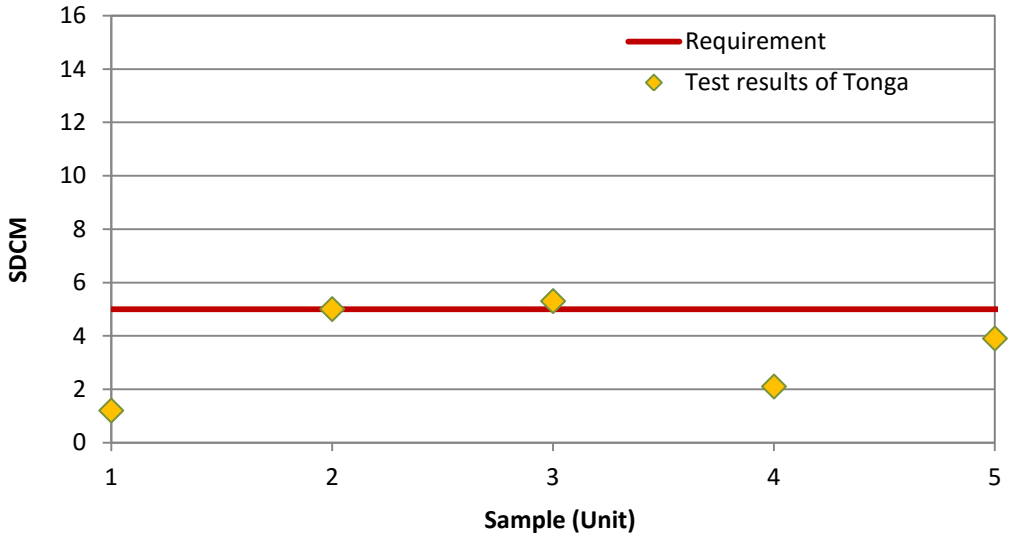


Figure 115 SDCM test results of Tonga (n=10)

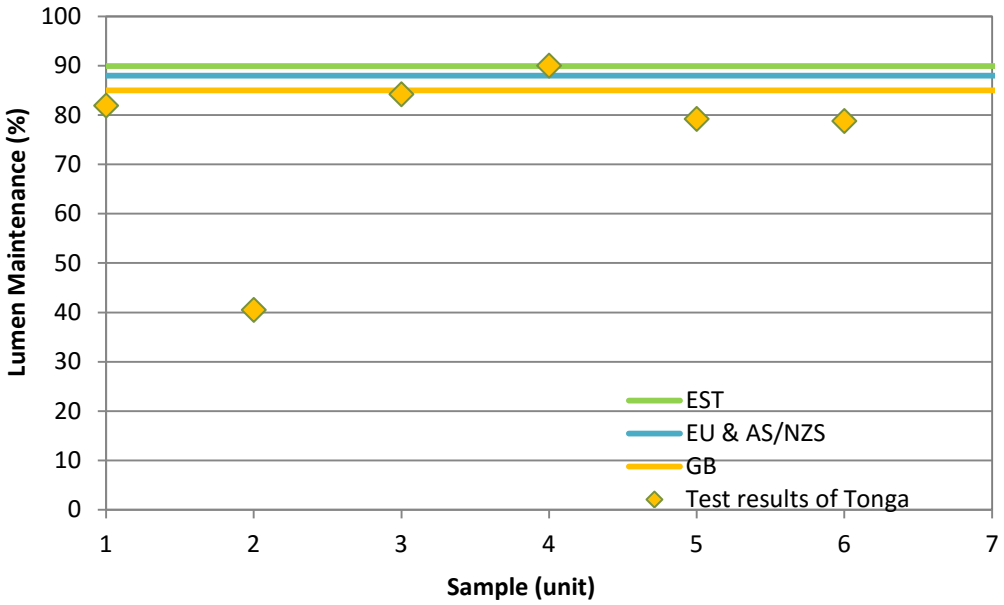


5.8.2.5 Luminous maintenance at 2,000 hours

Figure 117 shows the lumen maintenance results compared with the different reference standards.

From Figure 117, the lumen maintenance of five models from Tonga are less than 85%, which is the minimum value among all of the compared standards. There is one model that meets the highest EST requirement. .

Figure 116 Luminous maintenance test results of Tonga (n=10)

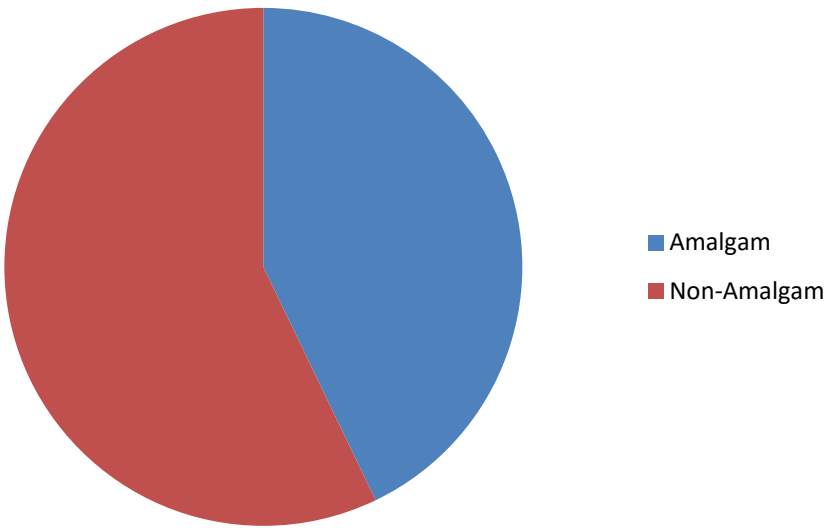


5.8.3 Mercury test results

5.8.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 118 presents the percentage of each mercury format of the CFLs, 43% of the CFLs adopt the amalgam technology and 57% of the CFLs adopt the non-amalgam technology. This is a quite big proportion for the non-amalgam lamps.

Figure 117 Format of mercury for the lamps from Tonga



5.8.3.2 Mercury content

Figure 119 shows the average mercury content of each model. We can be seen there is a big difference between the lamps, due to the use of amalgam and non-amalgam. The amalgam lamps contain stable and lower quantities of mercury, less than 2 mg, while all of the high mercury content lamps are non-amalgam, which may be higher than 6 mg.

Figure 118 Mercury content results for Tonga (n=5)

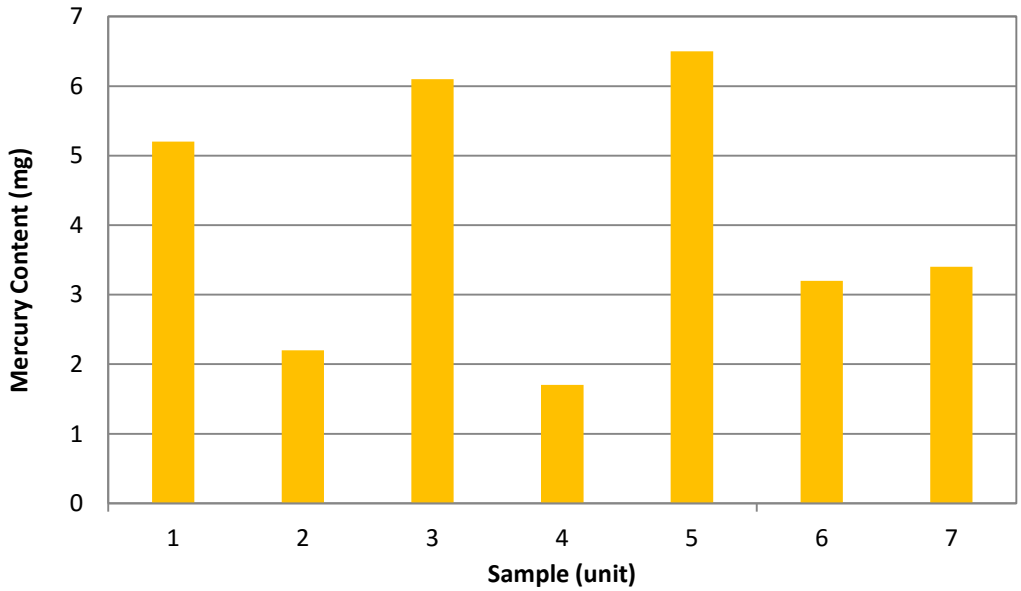


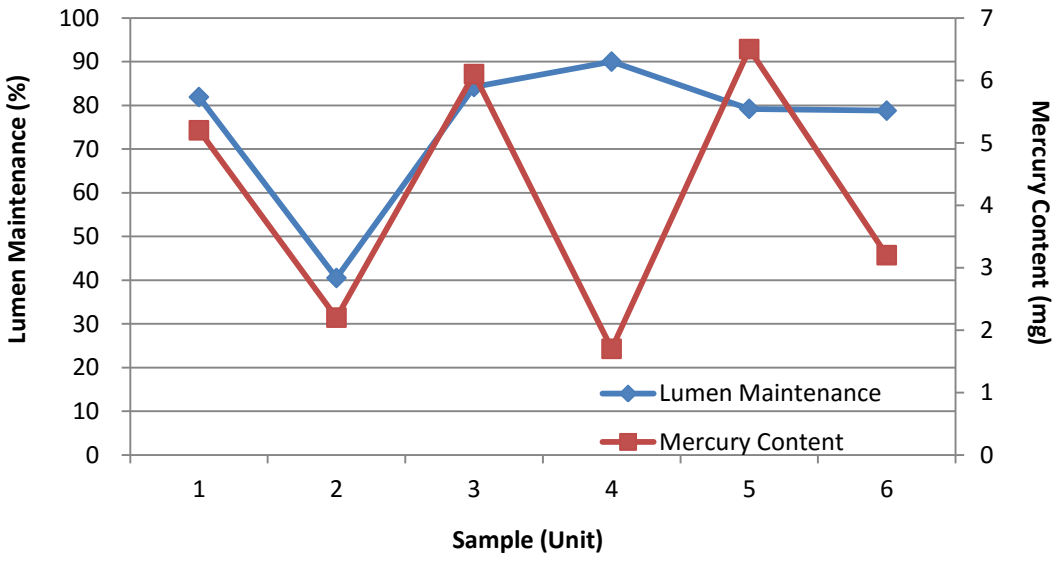
Table 32 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
AS/NZS 4847.2	Maximum mercury content 5mg		57%
EU regulation	≤2.5mg, for lamp power <30W;		29%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		29%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	29%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	0%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0%

5.8.3 Mercury content and lumen maintenance

Figure 120 shows the connection between mercury content and lumen maintenance of the lamps from Tonga. Lamp 2 and 4 are amalgam lamps and the others are non-amalgam lamps. For the amalgam lamps, both of them with the low mercury, however the lumen maintenance are different, one is good (up to 90%), one is bad. None of the non-amalgam lamps meet the minimum lumen maintenance requirement of 85%.

Figure 119 Mercury content and lumen maintenance of Tonga



5.8.4 Summary

There are nine sample models shipped from Tonga. Not all tests could be performed on all the models due to insufficient numbers of sample units. Safety and performance testing was carried out on six samples while the mercury test was carried out on seven samples. In the safety test, some of the lamps failed the interchangeability and mechanical strength tests.

Interchangeability: refers to the matching degree of the lamp and lamp hold. Due to the mismatch of the lamp and lamp holder, it may result in arcing or discharge, and lead to accidents. The reason for this quality problem might be that during the assembling process, the manufacturers use the lamp caps which do not meet the standard's requirements, or the manufacturers did not pay enough attention to the component quality check of semi-finished lamps.

Mechanical strength: Mechanical strength mainly assesses if the lamp cap is securely connected. Some manufacturers do not pay attention to the clockwise and counter clockwise torque testing when the lamp and lamp holder is connected, which results in the lamps not meeting the tightening torque requirements of the standard. Therefore some lamp caps may easily falling off during the process of installation or removal, which might be dangerous to the end-users and probably result in bodily injury

Concerning the performance results, there showed several non-compliances compared with the requirement of standards, see Table 33.

Table 33 Non-compliance rate

Test items	Compared standards	Results
Lamp power	GB/T 17263	Three of models did not meet the requirement
Power factor	AS/NZS/EU Regulation /ENERGY STAR/EST/GB	1 model did not meet the requirement
SDCM	AS/NZS/EU Regulation /ENERGY STAR/EST/GB	1 model did not meet the requirement
Lumen maintenance at 2,000 hours	AS/NZS/EU Regulation /ENERGY STAR/EST/GB	5 models did not meet the requirement;
Mercury	AS/NZS 4847.2	3 models did not meet the requirement

When compared with Australian MEPS, AS/NZS 4847.2, the efficacy and CRI met with the standard requirements. However SDCM, lumen maintenance and mercury content results did not.

Compared with the other standards, the non-compliant items are lamp power, SDCM, lumen maintenance at 2,000 hrs and mercury.

The lamp power problem is the measured power is low, which means the actual power is too low compared to the rated power. As explained in 4.2.1, the potential reason may be the manufacture mark a higher rated power in purpose in order to increase the lamp price; or it also could be the production capacity of the manufacturer does not match with its design capability.

The most attention needs to be paid to the SDCM and lumen maintenance. SDCM is the important element of the Colour characteristic. SDCM indicates the degree of matching between the actual colour and claimed colour of the product. That is, for a lamp with a large SDCM, the actual colour would not be satisfactory to the consumers as it is different from what they expect. The lumen maintenance results indicate that it also needs attention. Within all of the compared standards, only half of models can meet the lowest requirement. The lumen maintenance has a big effect on the lamp life time; the low lumen maintenance results show the luminous flux goes down quickly as the bulb gets older.

Regarding the mercury test results, it can be seen that 57% of the samples are non-amalgam lamps, and they contained the mercury content higher than 5 mg.

5.9 Summary results for Tunisia

There are four sample models from Tunisia.

Tunisia does not have Minimum Energy Performance Standard (MEPS) currently, however it requested to use the European Union's MEPS[6] to compare and see if the samples from Tunisia could meet the requirement. In addition to the EU MEPS, the test results are also compared against three other standards: AS/NZS 4847.2, ENERGY STAR lamp specification V1.0, GB/T 17263. The lamp power also compared against the requirement of IEC 60969.

5.9.1 Safety test

Table 34 lists the Pass and Fail results to each test item for the two countries, and from which we can be seen that all the samples from Tunisia have passed the safety test.

Table 34 Safety test results of Tunisia (n=8)

Country	Interchan geability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Tunisia	P	P	P	P	P	P

5.9.2 Performance test results

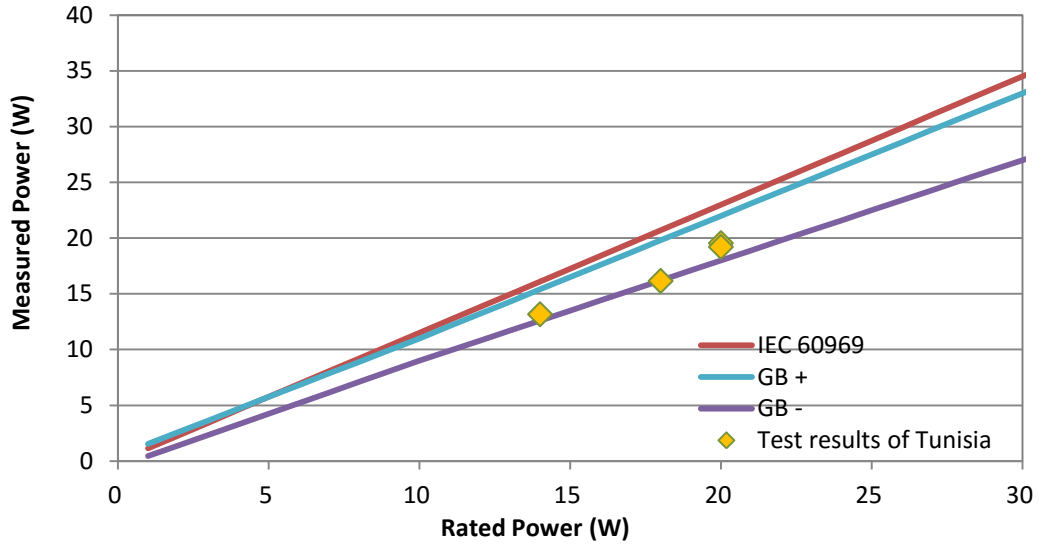
5.9.2.1 Lamp power

There is no requirement from the EU MEPS for the lamp power, therefore the lamp power was compared with IEC 60969 and GB/T 17263.

In Figure 121, it can be seen that most of the lamps from Tunisia matched well with the two standards' requirements.

[6] *COMMISSION REGULATION (EC) No 244/2009*

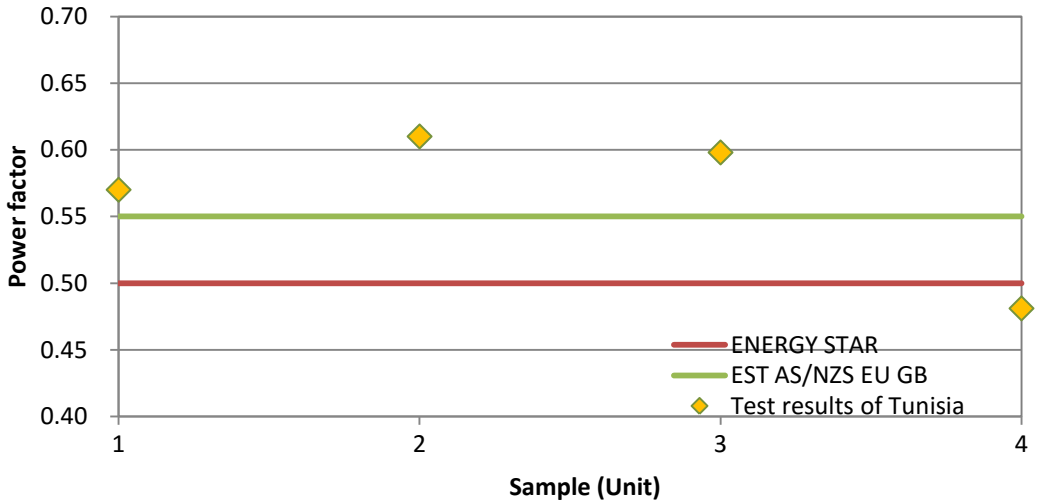
Figure 120 Lamp power test results of Tunisia (n=10)



5.9.2.2 Power factor

From Figure 122, it can be seen that the power factor of most testing samples from Tunisia are over 0.55 and meet the requirements by all of the comparison standards. However, there is one model which is under the minimum line of ENERGY STAR with PF 0.5.

Figure 121 Power factor test results of Tunisia (n=10)



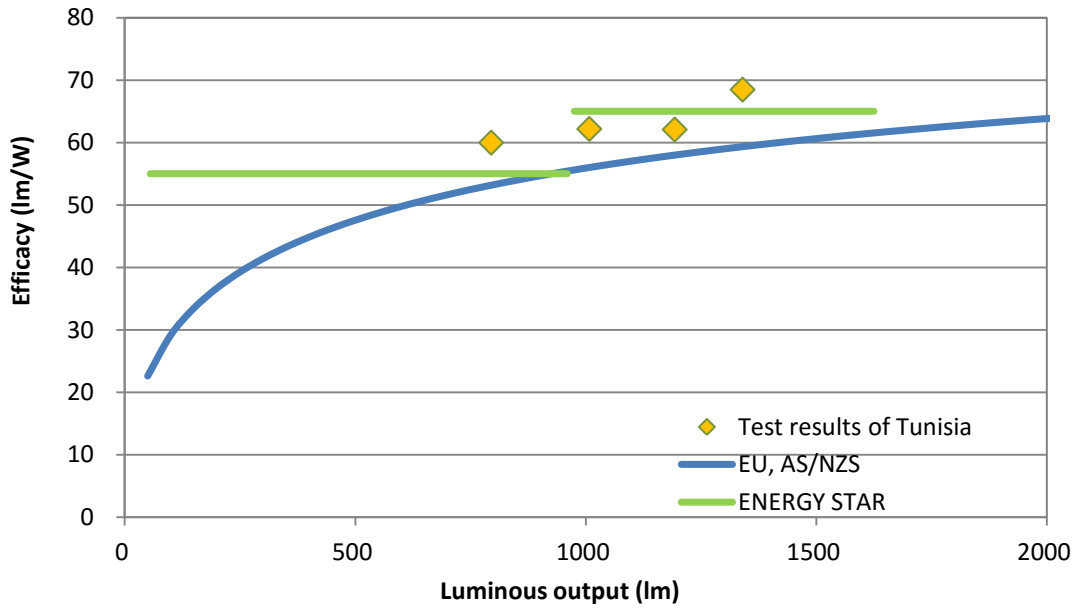
5.9.2.3 Efficacy

a) Compared with EU regulation, AS/NZS 4847.2, and ENERGY STAR lamp specification V1.0

Figure 123 shows the tested efficacy data compared with AS/NZS 4847.2, EU Regulation No. 244/2009 and ENERGY STAR lamp specification V1.0. It can be clearly seen that all four models of

lamps from Tunisia meet these the first two standards requirements, but two models do not meet the ENERGY STAR efficacy requirements.

Figure 122 Efficacy test results of Tunisia (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shapes and in each group, the testing results are compared with the corresponding requirements. Please see Figure 123 and 124.

Three models from Tunisia are stick shape and one is spiral shape. From Figure 123 and 124, it can be seen that the efficacies of all of those models are higher than the standard requirement.

Figure 123 Luminous efficacy test results of Tunisia (stick lamp) (n=10)

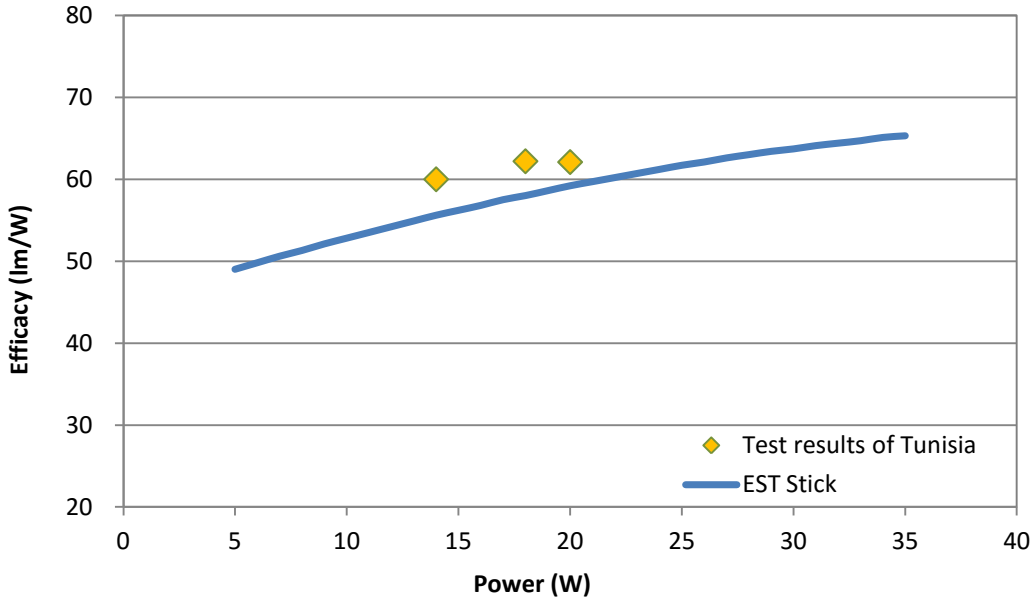
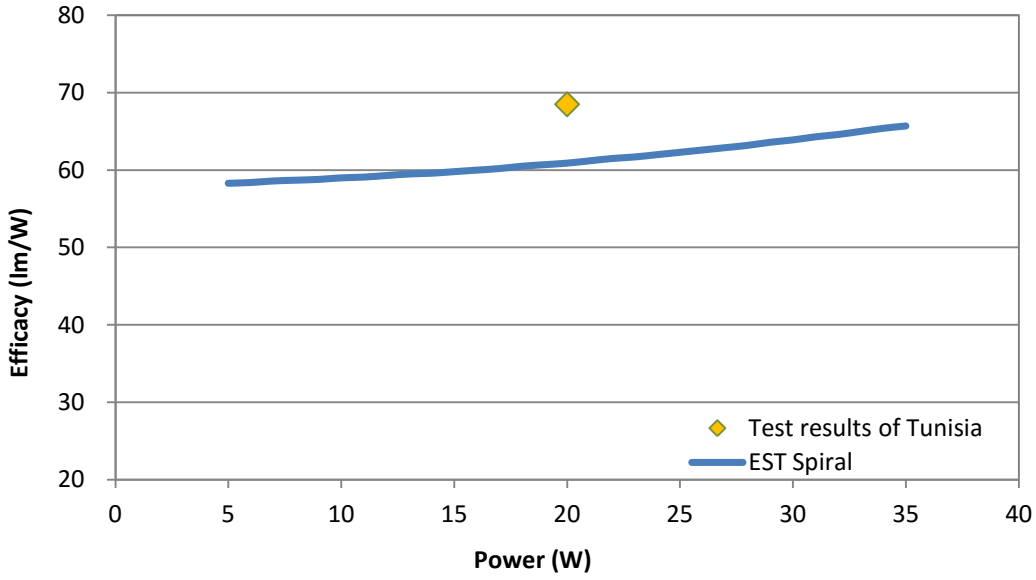


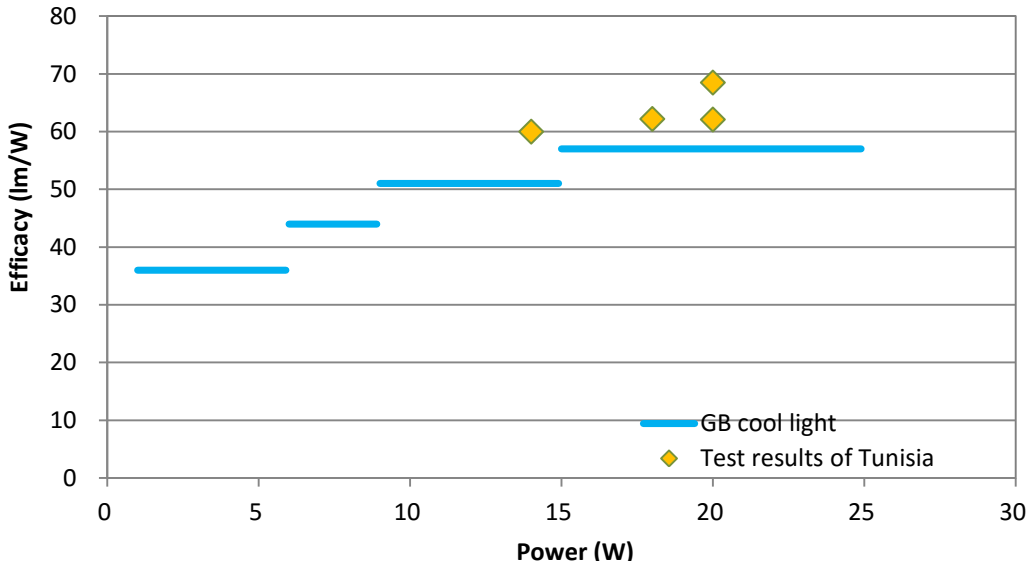
Figure 124 Luminous efficacy test results of Tunisia (spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. All the CFLs Tunisia are with the cool light, and the results shows all of the models from Tunisia are compliance with the GB standard.

Figure 125 Luminous efficacy test results of Tunisia (cool light) (n=10)



5.9.2.4 Colour

Figure 127 and Figure 128 presents the CRI and SDCM test results of the CFLs from Tunisia. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a maximum allowance of 5 steps. From Figure 127 and 128, it shows all models of CFLs from Tunisia meet this minimum requirement.

Figure 126 CRI test results of Tunisia (n=10)

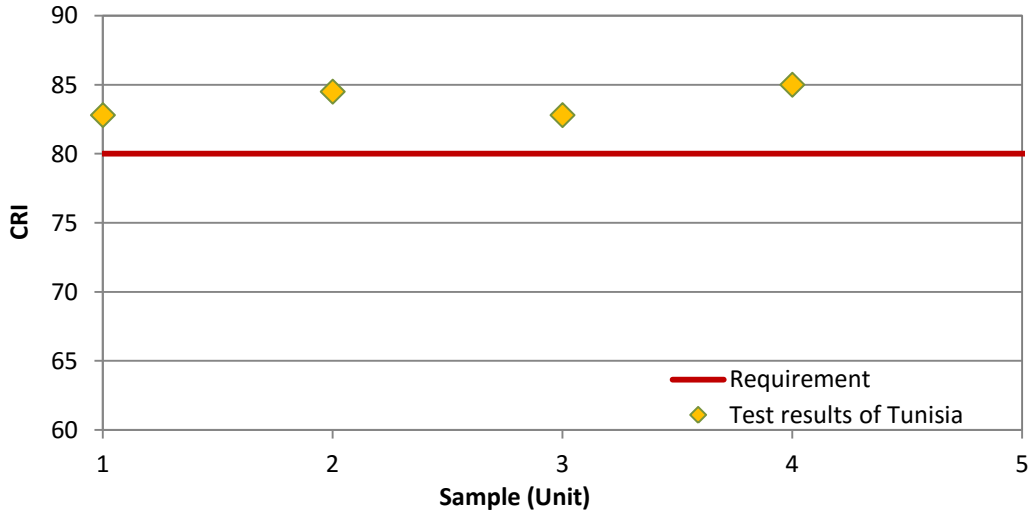
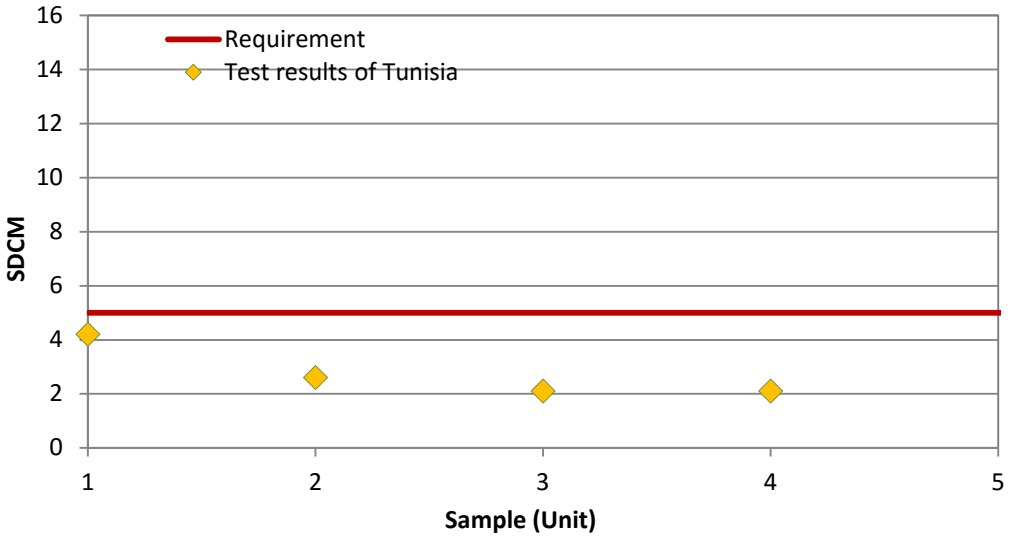


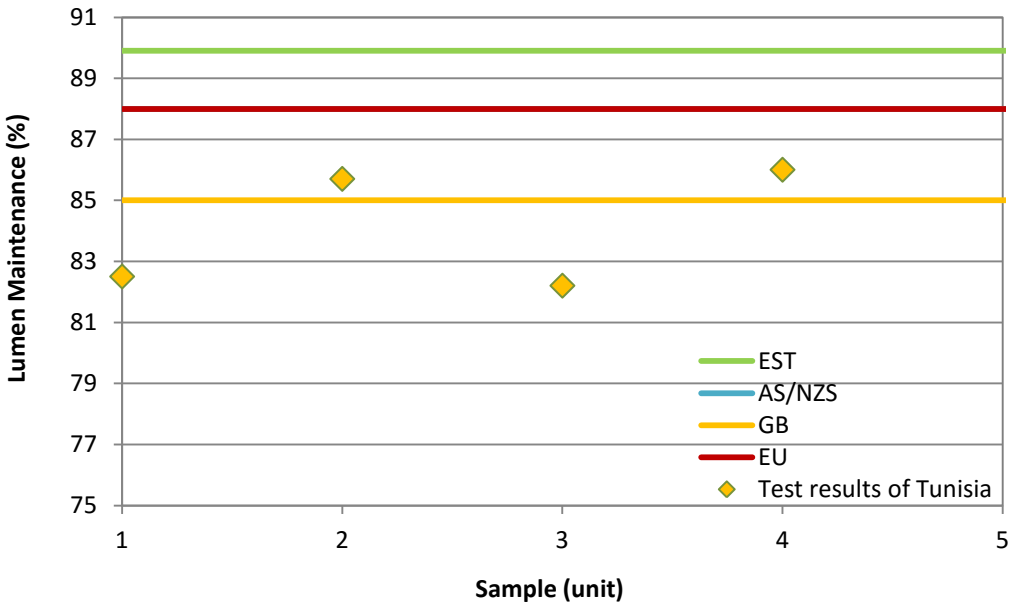
Figure 127 SDCM test results of Tunisia (n=10)



5.9.2.5 Luminous maintenance at 2,000 hours

Figure 129 shows the lumen maintenance results compared with the different reference standards, from Figure 129, only two models of the lamps from Tunisia meet lumen maintenance minimum requirement of 85%, which is all the minimum value among all of the compared standards. No model has the lumen maintenance over than 88%.

Figure 128 Luminous maintenance test results of Tunisia (n=10)

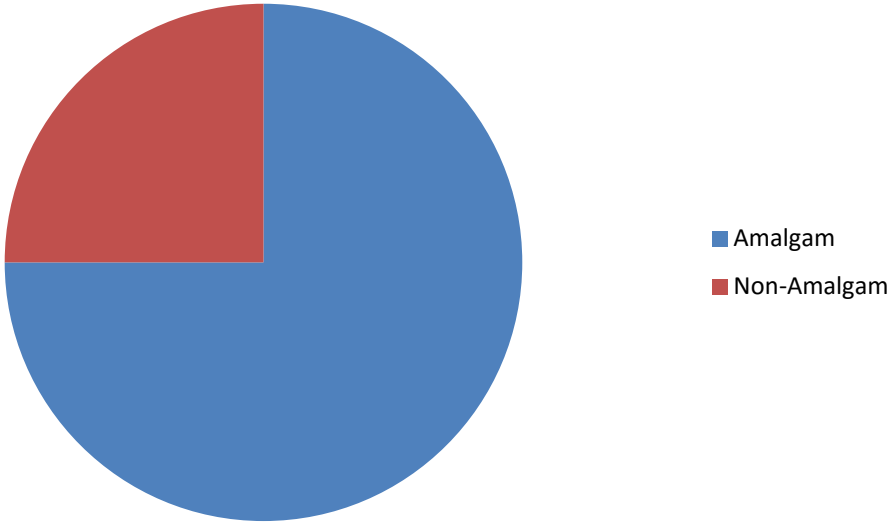


5.9.3 Mercury test results

5.9.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 130 presents the percentage of each mercury format in the CFLs, 75% of the CFLs adopt the amalgam technology and 25% of the CFLs adopt the non-amalgam technology.

Figure 129 Format of mercury for the lamps from Tunisia



5.9.3.2 Mercury content

Figure 131 shows the average mercury content of each model. We can also see the average mercury contents of the samples from Tunisia is less than 3 mg, and two of them are even below 2 mg.

Figure 130 Mercury content results for Tunisia (n=5)

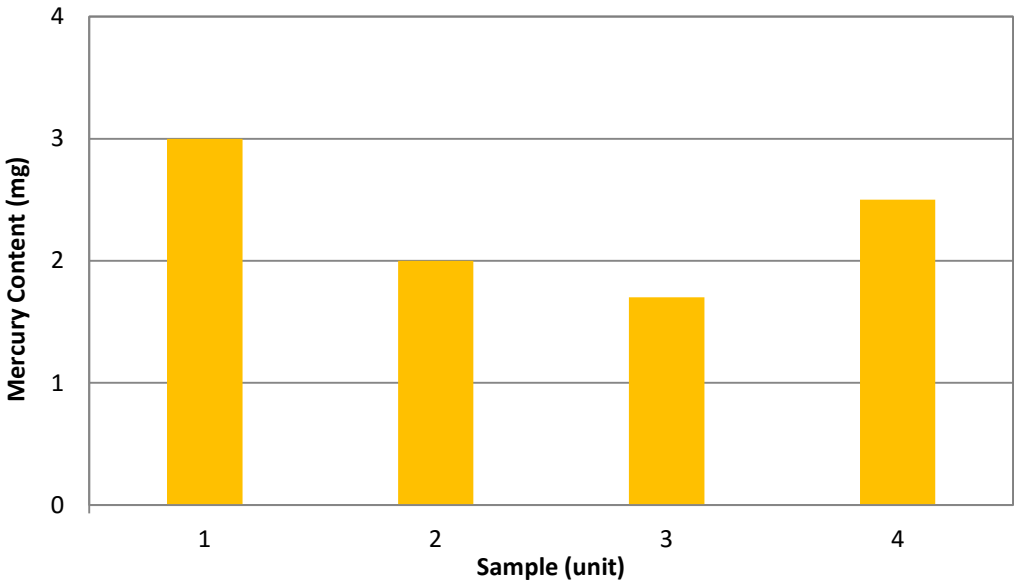


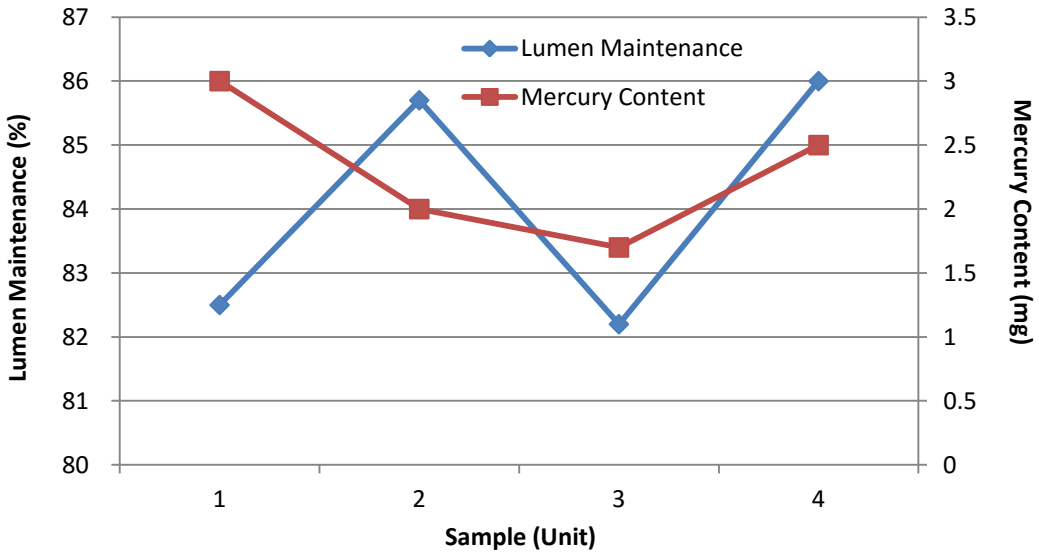
Table 35 Mercury content requirements

Standards/ Specifications	Requirements		Compliance rate
EU regulation	≤2.5mg, for lamp power <30W;		75%
AS/NZS 4847.2	Maximum mercury content 5mg		100%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		75%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	75%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	0%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0%

5.9.3 Mercury content and lumen maintenance

Figure 132 shows the correspondence of mercury content and lumen maintenance of the lamps from Tunisia. Sample 1 is non-amalgam lamp and the others are amalgam lamps. From Figure 132, it can be seen that the non-amalgam lamp and lowest mercury content amalgam lamp have the low lumen maintenance. It might be the mercury content is not sufficient to keep the high lumen output or it appears the lumens depreciation of the mercury.

Figure 131 Mercury content and lumen maintenance of Tunisia



5.8.4 Summary

There are four sample models shipped from Tunisia. From the test results, it can be seen all the lamps have passed the safety test.

Concerning the performance results, there are several non-compliance compared with the requirement of standards, see Table 36.

Table 36 Non-compliant items

Test items	Compared standards	Results
Efficacy	EU Regulation/EST/GB	All models meet the EU MEPS requirement
	ENERGY STAR	2 models did not meet the requirement
Lumen maintenance at 2,000 hours	EU Regulation AS/NZS/ EST	4 models did not meet the requirement;
	GB	2 models did not meet the requirement
Mercury	EU Regulation	1 model did not meet the requirement

Efficacy, Lumen maintenance at 2,000 hours, and mercury content did not meet the related standards.

The most attention should be paid to lumen maintenance, as the test results showed almost all of the samples failed when compared against any of the standards, including EU MEPS. Lumen

maintenance is an important parameter that reflects the life time. Although the efficacy could be very high initially, as the luminous flux attenuates very quickly over time the efficacy falls with it and does not provide a satisfactory economic saving.

Regarding the mercury test results, it can be seen that 25% of the samples are non-amalgam lamps, which is the only model that could not meet EU MEPS requirement. Therefore encouraging amalgam lamps would be good for the country to reduce mercury.

5.10 Summary results for Uruguay

There are six sample models from Uruguay. Uruguay has its own CFL MEPS UNIT 1160:2007 and requested to compare their test results with their CFL MEPS. In this section, the lamp samples are compared with UNIT 1160:2007

In this section, the test results are also compared with the other standards: AS/NZS 4847.2, EU regulation, ENERGY STAR lamp specification V1.0, ENERGY STAR and GB/T 17263. The lamp power is also compared with the requirement of IEC 60969.

5.10.1 Safety test

Table 37 lists the Pass and Fail results to each test item for Uruguay, and from which it can be seen that the samples from Uruguay all passed the safety test.

Table 37 Safety test results of Uruguay (n=8)

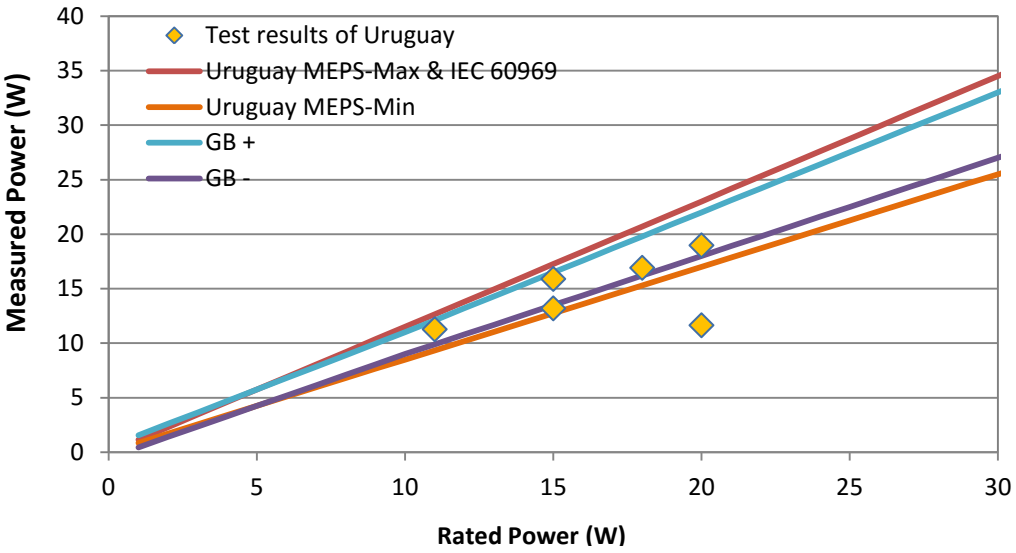
Country	Interchangeability	Mechanical strength	Insulating resistance	Electric strength	Resistance to flame and ignition	Protection against electric shock
Uruguay	P	P	P	P	P	P

5.10.2 Performance test results

5.10.2.1 Lamp power

In Figure 133, it can be seen that all of the samples are within the requirements of IEC 60969, but not all of the samples meet the requirements of Uruguay MEPS and GB/T 17263, as they limit both maximum and minimum values. It can see that most of the lamps from Uruguay matched well with the two standards' requirements but there also some models of lamps which have a slightly lower measured power than the rated power for Uruguay.

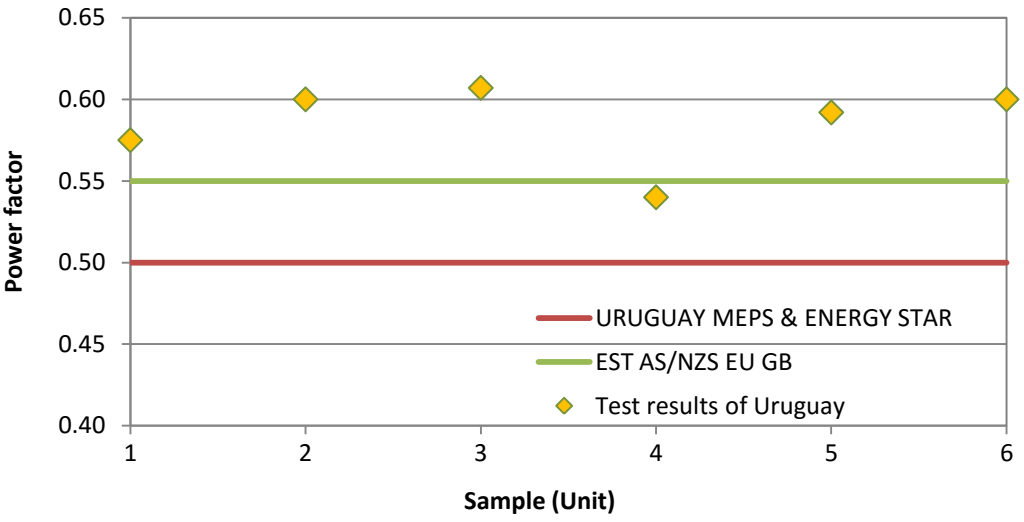
Figure 132 Lamp power test results of Uruguay (n=10)



5.10.2.2 Power factor

From Figure 134, it can be seen that the power factor of most testing samples from Uruguay are over 0.5 and meet the requirements of Uruguay MEPS. There is one model between the lines of ENERGY STAR and EST, AS/NZA, EU and GB.

Figure 133 Power factor test results of Uruguay (n=10)



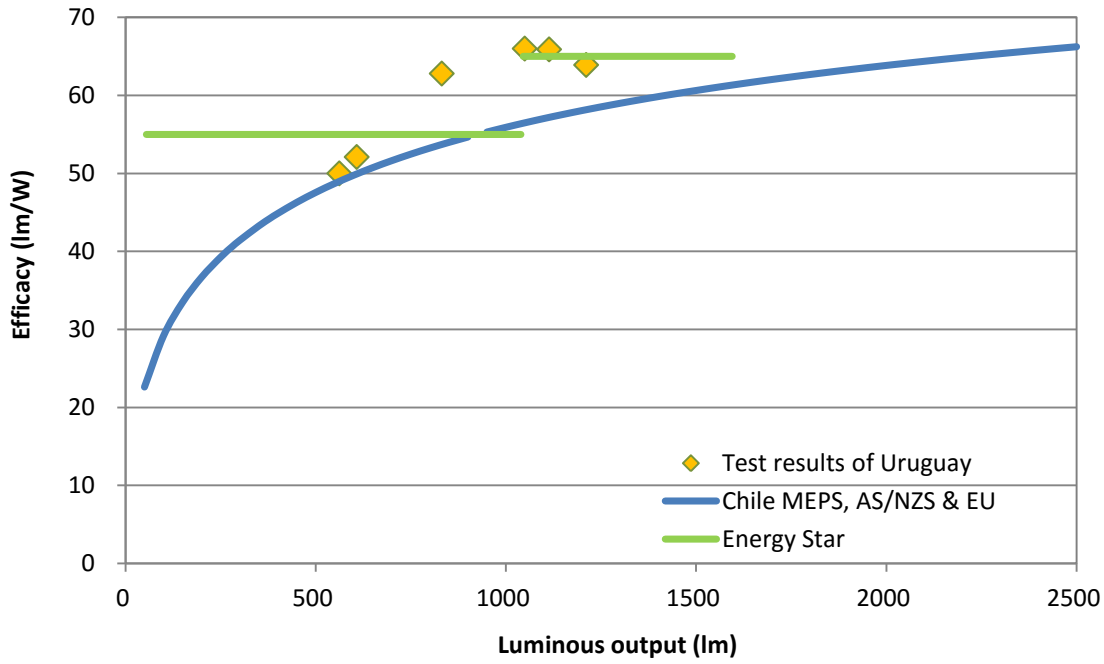
5.10.2.3 Efficacy

a) Compared with Uruguay MEPS, AS/NZS 4847.2, EU regulation and ENERGY STAR lamp specification V1.0

Figure 135 shows the tested efficacy data compared with Uruguay MEPS, AS/NZS 4847.2, EU

Regulation No. 244/2009 and ENERGY STAR lamp specification V1.0. From the results, it can be seen that all of the models meet the requirements of the Uruguay MEPS. However, some lamps did not meet the ENERGY STAR requirements.

Figure 134 Luminous efficacy test results of Uruguay (n=10)



b) Compared with EST lamp specification V7

EST lamps specification V7 defines different efficacy requirements for the stick lamp and spiral lamp. Therefore, the test data are divided into two groups according to their lamp shape, and in each group, the testing results are compared with the corresponding requirements (see Figure 136 and 137).

In Figure 136, one model from Uruguay meets the EST Stick shape lamp efficacy requirements, and two models are under the EST minimum requirement.

Figure 137 shows the testing results of the spiral shaped lamps compared against EST requirements. Both models tested from Uruguay meet the EST spiral shape lamp efficacy requirements.

Figure 135 Luminous efficacy test results of Uruguay (stick lamp) (n=10)

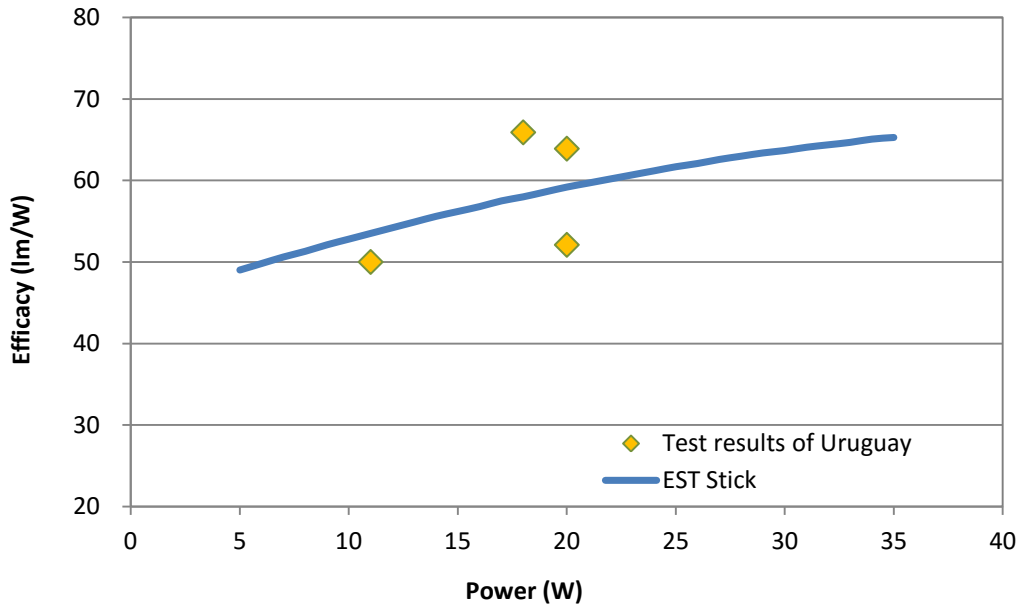
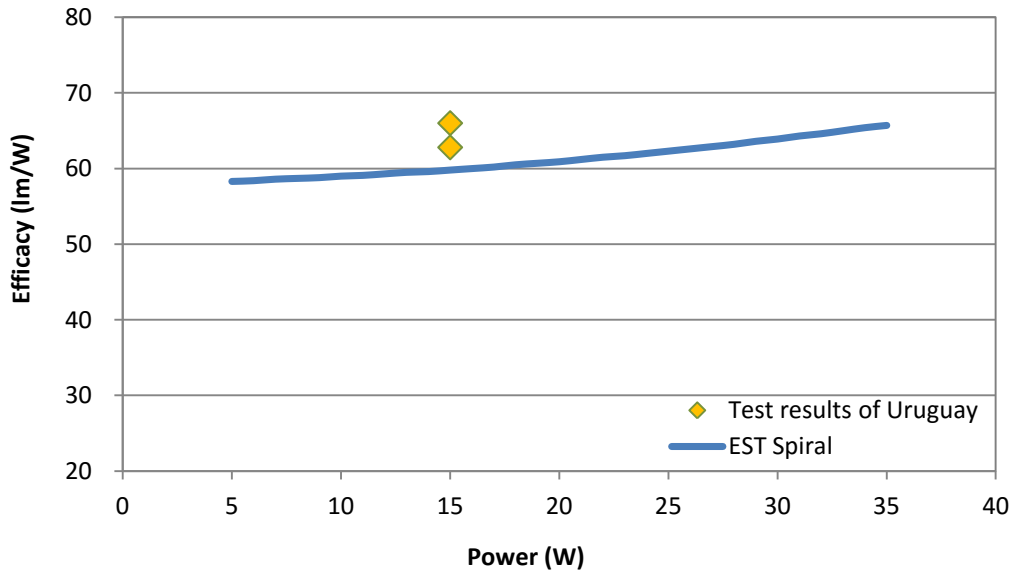


Figure 136 Efficacy test results of Uruguay (spiral lamp) (n=10)



c) Compared with GB/T 17263

GB/T 17263 sets two levels of efficacy for CFLs, one is for cool light lamps with the CCT equal or higher than 4000K, the other is for warm light lamps with the CCT less than 4000K. Therefore, in Figure 138 and 139, the testing samples are separated into cool light group-138 and warm light group- 139. Four models from Uruguay are cool light, and the other two are warm light, the test results show two of them do not meet the GB requirements.

Figure 137 Luminous efficacy test results of Uruguay (warm light) (n=10)

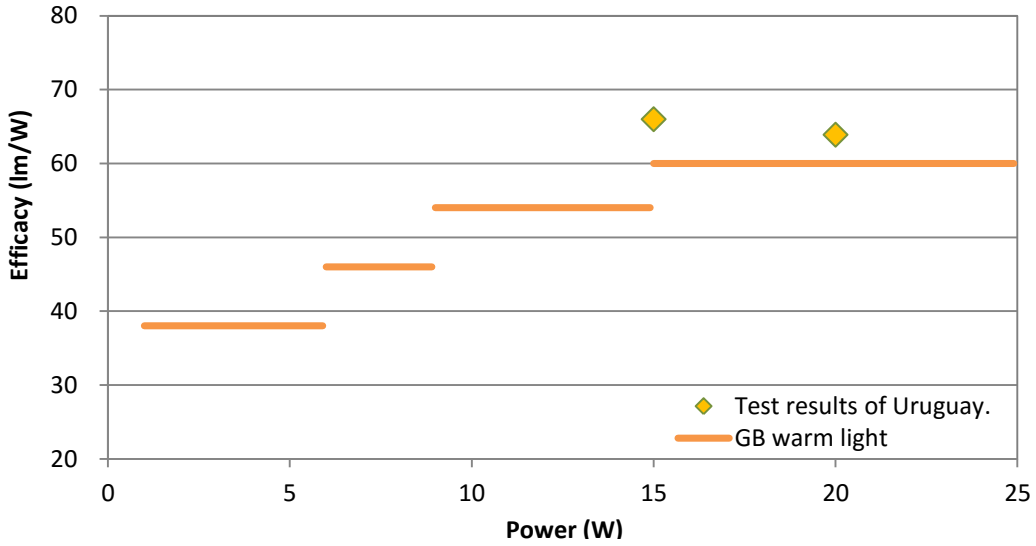
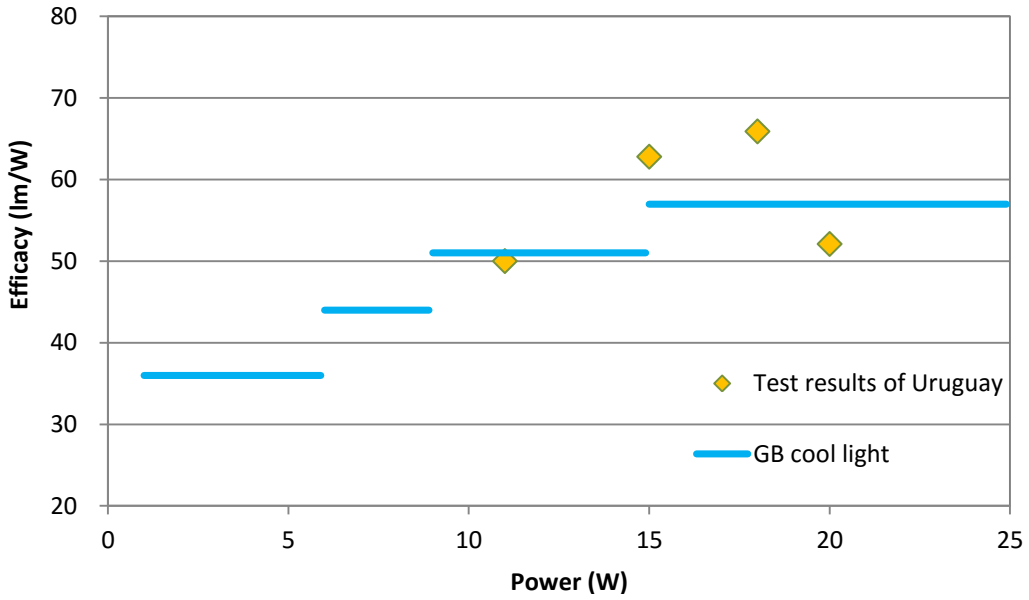


Figure 138 Luminous efficacy test results of Uruguay (cool light) (n=10)



5.10.2.4 Colour

Figure 140 and Figure 141 present the CRI and SDCM test results of the CFLs from Uruguay. The minimum required CRI from all of the referenced standards is 80 and for SDCM there is a maximum allowance of 5 steps. From Figure 140 and 141, it shows all of CFLs from Uruguay meet the minimum required CRI and maximum SDCM.

Figure 139 CRI test results of Uruguay (n=10)

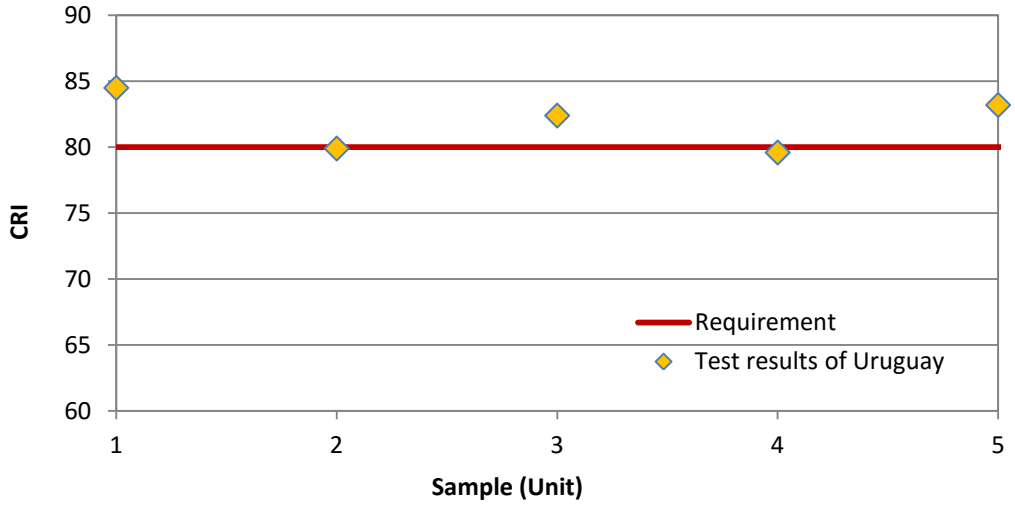
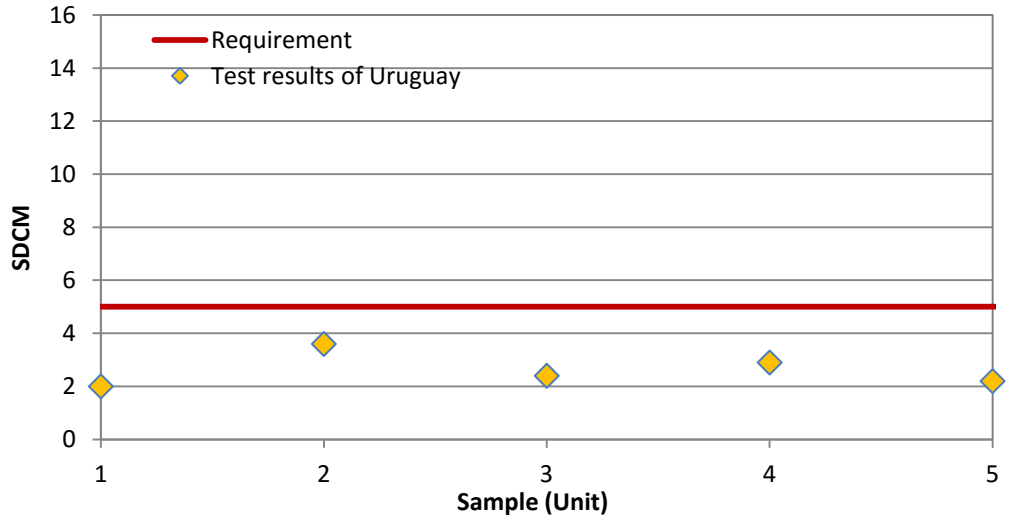


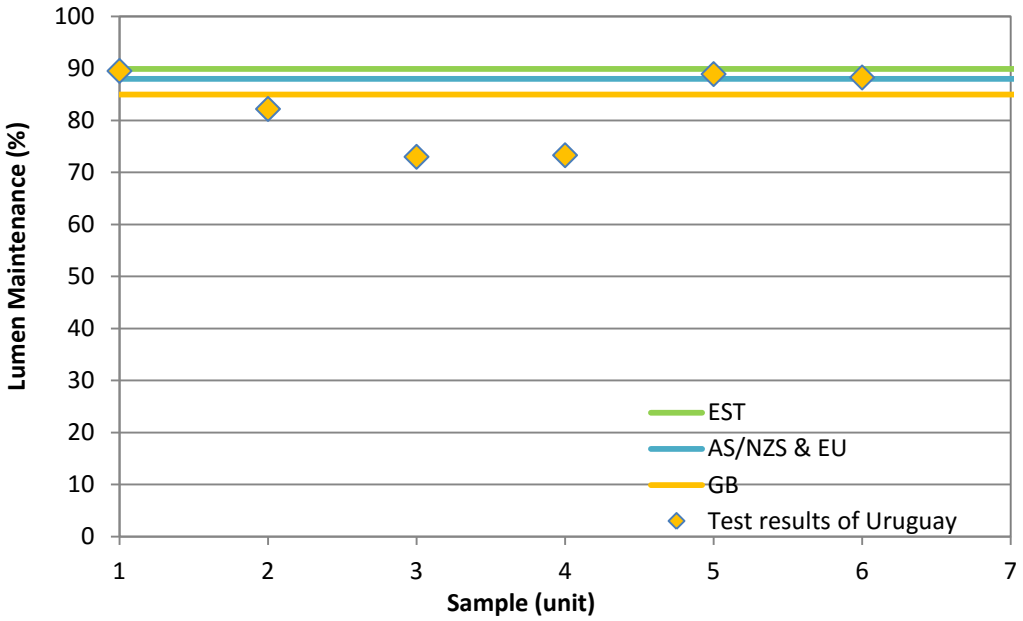
Figure 140 SDCM test results of Uruguay (n=10)



5.10.2.5 Luminous maintenance at 2,000 hours

From Figure 142, the lumen maintenance of three models from Uruguay are less than 85%, which is the minimum value among all of the compared standards. There is no model meeting the top lumen maintenance of EST.

Figure 141 Luminous maintenance test results of Uruguay (n=10)

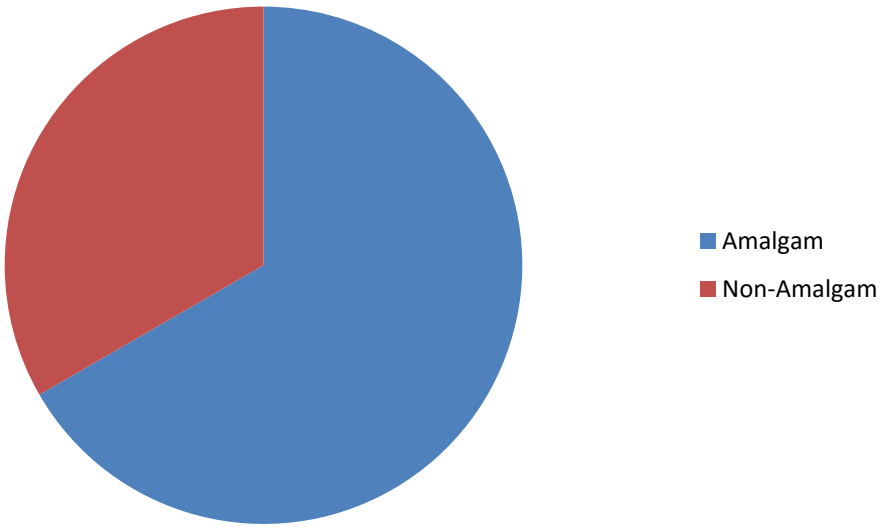


5.10.3 Mercury test results

5.10.3.1 Format of mercury

There are two formats of mercury in CFLs, amalgam and non-amalgam. Figure 143 presents the percentage of each mercury format of the CFLs, 67% of the CFLs use the amalgam technology and 33% of the CFLs use non-amalgam technology.

Figure 142 Format of mercury for the lamps from Uruguay



5.10.3.2 Mercury content

Figure 144 shows the average mercury content of each model.

Figure 143 Mercury content results for Uruguay (n=5)

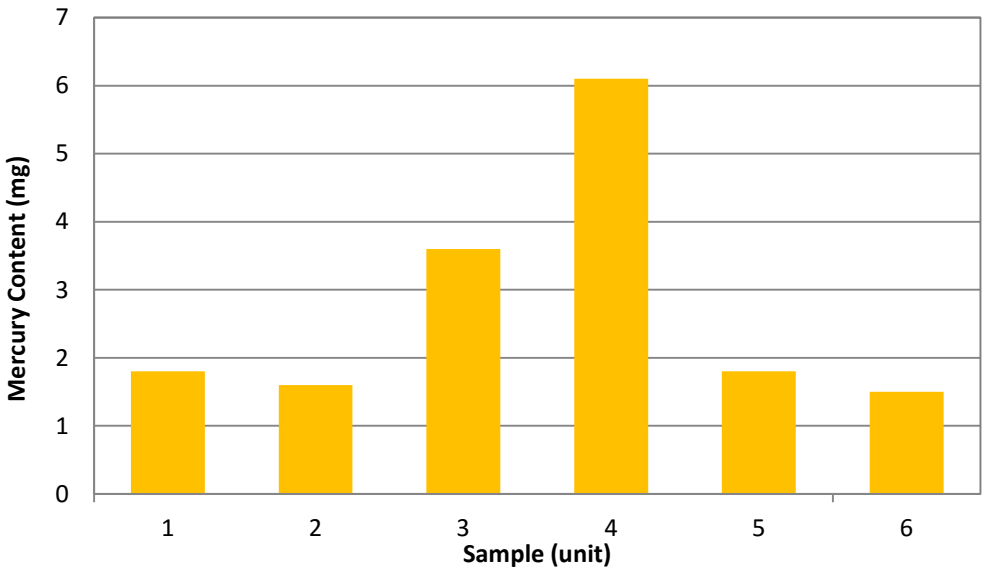


Table 38 Mercury content requirements

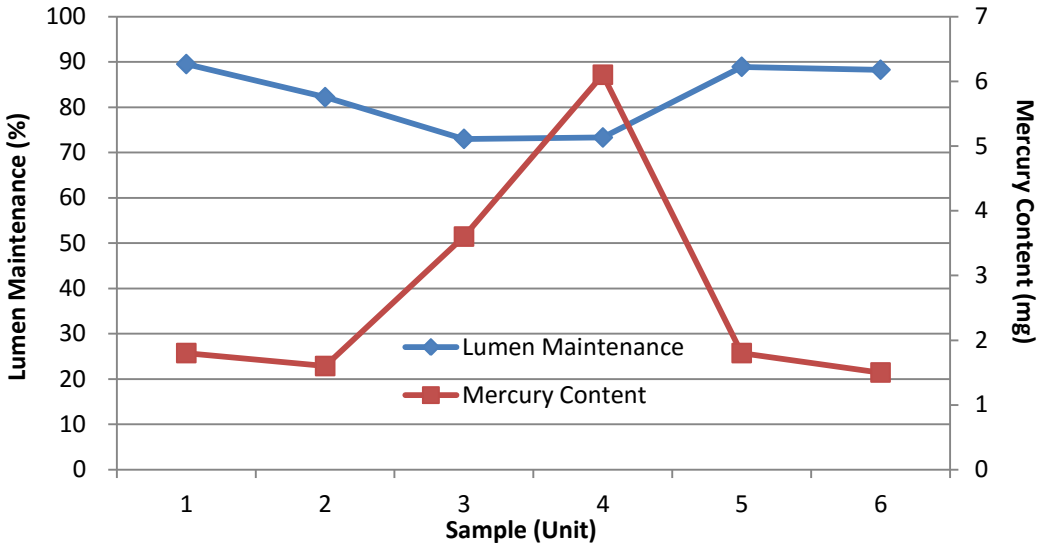
Standards/ Specifications	Requirements		Compliance rate
EU regulation	≤2.5mg, for lamp power <30W;		67%
AS/NZS 4847.2	Maximum mercury content 5mg		83%
ENERGY STAR Lamp V1.0 Specification	Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp Lamps > 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp		67%
GB/T 17263	Compliance	≤2.5mg, for lamp power ≤ 30W;	67%
	Low mercury	≤1.5mg, for lamp power ≤ 30W;	17%
	Micro mercury	≤1.0mg, for lamp power ≤ 30W;	0

5.10.3 Mercury content and lumen maintenance

Figure 145 shows the relationship between mercury content and lumen maintenance of the lamps from Uruguay. Samples 3 and 4 are non-amalgam lamps and have the lowest lumen maintenance among the six models. The rest are amalgam lamps, and three of them have lumen

maintenance results of nearly 90%.

Figure 144 Mercury content and lumen maintenance of Uruguay



5.10.4 Summary

There are six sample models shipped from Uruguay. From the safety test results, it can be seen all the lamps pass the safety test.

For the performance results, it shows there are some items that did not reach the requirements of the reference standards, see Table 39.

Table 39 Non-compliance items

Test items	Compared standards	Results
Lamp power	Uruguay MEPS	1 model did not meet the requirement
	GB/T 17263	2 models did not meet the requirement
Power factor	AS/NZS/EU Regulation /ENERGY STAR/EST/GB	1 model did not meet the requirement
Efficacy	EST/GB	2 models did not meet the requirement
	ENERGY STAR	4 models did not meet the requirement
Lumen maintenance at 2,000 hours	AS/NZS/EU Regulation	4 models did not meet the requirement;
	EST	6 models did not meet the requirement
	GB	3 models did not meet the requirement
Mercury	AS/NZS 4847.2	1 model did not meet the requirement
	EU regulation/ENERGY STAR/GB	4 models did not meet the requirement

Compared with Uruguay MEPS, the efficacy, and power factor met with the standard requirement. However the lamp power results did not.

Compared with the other standards, the non-compliance items are lamp power, power factor, Efficacy, Lumen maintenance at 2,000 hours and mercury content.

06 CONCLUSION

6. Conclusion

47 CFL models were sampled and purchased from 10 countries including Costa Rica, Panama, Dominican Republic, Chile, Uruguay, Guinea-Bissau, Tunisia, Azerbaijan, Lebanon and Tonga. These samples were tested for safety, performance and mercury content.

The test results showed the main safety issues for certain lamps are interchangeability, protection against electric shock and mechanical strength. Regarding the performance tests, some results are good and show a related high compliance rate, for example, power factor and the efficacy of warm white lamps. However, other results showed the low quality performance for some main key parameters, such as cool white lamp efficacy, lumen maintenance and colour. There also is a large quality deviation among the lamps and similar situation with the mercury test. The majority of the lamps tested are non-amalgam. The test results showed the amalgam lamps, containing less mercury, have a higher lumen maintenance compliance rate than the non-amalgam lamps.

The local markets involved in this project have both good quality and bad quality products. This report aims to show real results that reflect the market quality situation, for those countries to enable a better understanding of the lamp quality in the market. This is also a benchmark document for them to consider, plan and implement any necessary monitoring, verification and enforcement measurements in order to improve and control the lamp product quality in their markets.

Table 40 presents the ranks of compliance rates in the three aspects of testing in this project. The numbers from 1 to 10 represent high compliance rate to low compliance rate. Table 40 shows that the Dominican Republic has the highest rate, followed by Tunisia and Azerbaijan.

Table 40 Ranks of compliance rate

Country	Rank for Safety test	Rank for Performance test	Rank for Mercury test	Note
Costa Rica	1	2	5	Have regional MEPS
Panama	3	5	4	Have regional MEPS
Dominican Republic	1	1	1	Have regional MEPS
Chile	2	6	7	Have national MEPS
Uruguay	1	4	3	Have national MEPS
Guinea-Bissau	4	5	8	Have regional MEPS
Tunisia	1	2	2	No regional MEPS; may harmonize with EU
Lebanon	2	3	5	Have national MEPS
Azerbaijan	1	3	1	No regional/national MEPS
Tonga	3	4	6	No regional/national MEPS

Recommendation

1. Establish and Strengthen the Enforcement of Regional and National Lighting Efficiency MEPS

The testing showed some problems with the lamps in each participating country. For those countries that have regional or national MEPS, it would be easier to compare the test results with their own MEPS to see if the lamp quality satisfied their expectation. The MEPS requirement would encourage the lamp producers, importers, distributors to pay more attention to lamp quality. For those countries that do not have regional or national MEPS, or MEPS which only cover a limited range of parameters, the results suggest the need to develop or adopt existing MEPS, based on their own situations. For those countries that already have established lamp MEPS, the results show the need to strengthen the enforcement of the MEPS to deliver benefits and drive the progress of quality in the market.

2. Establish and Strengthen the Quality Supervision System

Due to the special properties of CFLs, it is hard to distinguish the differences—simply by appearance—between the lamps with high and low quality. Therefore, effective lamp market supervision would be very helpful for the countries to control product quality. From the response of the countries, GELC understands that most have not conducted CFL quality check tests previously. Therefore they may need to conduct more test to understand in more detail the quality issues of lamps in their local market. Most of the countries have expressed interests in promoting efficient lighting technologies and improving the quality of products for their consumers.

Market quality control is long term, regular work, so GELC suggests that responsible government ministries and departments cooperate to establish and implement a market supervision system. For any imported lighting products, or lighting products sold in the market, governments should conduct market inspection tests regularly, to supervise and monitor the product quality and ensure that all available products meet MEPS requirements. It could be also helpful to evaluate the product quality improvement over time and revise the MEPS requirements as necessary.

3. Enhance Quality Control Capability

One approach for countries to enhance their quality control capabilities is to increase laboratory testing and professional capabilities so that they can regularly and rapidly check and verify product conformance. For countries that have regional or national lighting test laboratories, collaborative technical activities and trainings can improve their lighting testing capacities and professional development. Testing laboratories whether private or public will support the national or regional quality supervision system by conducting safety, performance and mercury tests for CFL lamps.

4. Encourage importing, purchasing, and using amalgam CFLs

To reduce mercury content and emissions and protect consumers and the environment, GELC recommends that countries import, purchase and use amalgam CFLs, instead of non-amalgam CFLs. As the results in this report show, non-amalgam CFLs perform well with lower mercury levels and higher lumen maintenance levels to deliver the benefits of efficient lighting technology.

5. Increase public awareness

Countries can utilize the publicity capabilities of the media, making best use of press and other media in different areas and departments for the broad promotion of qualified CFLs. Various stakeholder groups (government, private sector and civil society) can take full advantage of each opportunity to popularize the importance of efficient lighting to consumers, raising recognition of energy-saving products and awareness of energy conservation. Outreach campaigns can guide consumers on how to identify and buy good quality CFLs. Messages should encourage the consumer to buy good quality CFLs rather than choosing only the lowest cost products. With regard to product problems, such as the low compliance rate, promotion could be strengthened, so as to attract the stakeholders' attention and support.

6. Increasing the communication between consumer country and lighting industry

In order to have a better understanding of the consumer countries' needs and expectations, and the specific conditions for use of the products, it would be good to increase the communication between consumers and the lighting industry. Better communication can be helpful for the improvement of the lighting industry which in turn can produce the lamps that will satisfy the consumers in the countries.

7. Improve the lighting industry

This testing report focuses on lamp product quality in the participating countries and offers support to them to understand better lamp quality and lamp quality issues. However, to achieve the goals of promoting high efficiency lighting products worldwide, GELC suggests conducting regular lamp evaluation activities based on this project and publishing more analysis reports on lamp quality. The published report would have strong impacts on the whole lighting industry, and drive their improvement of lighting production. Controlling product quality at the source would help consumers to obtain good performing lamps.

Annex 1. Global CFL Quality Sampling Rules

The sampling rules are made to make sure the sampling of CFL goes very well.

1. Requirement of samples

- Mode and number: CFL<60W, 35 per type.
- Requirement of sample: all the samples of one type should be of the same batch and the same mode. All the parameters should be the same.

2. Address and methods

- Address: circulation domain, such as shopping mall, supermarket, shops or small market. **1 or 2 types should be from the shopping mall or the supermarket, 2 or 3 types should be from the shops or small market.**
- Methods: sampling by random, purchasing the samples and pay for it.

3. Sampling person

Organization appointed by the country carries out the sampling tasks. At least 2 persons should be appointed and one of them should be responsible for the sampling.

4. Sampling/arriving time

- Planned sampling time: May and June of 2012.
- All the samples and questionnaires should be sent to the specific organization in two days after finishing samples.

5. Sampling procedures and matters need attention

5.1 Initial investigation for the selling place should be carried out before sampling to avoid not being able to find the right place.

5.2 Please ask whether there is CFL in sell and how many brands and modes before sampling to check whether there is enough numbers (35 per type).

Note: It is allowed to purchase the sample of different manufacturer or purchasing different modes of one manufacturer in one place.

5.3 At least two samplers should be carrying out the samples. Please show the CFL sampling notice and effective person certificate to the sales person and specify the objective of sampling.

5.4 If there are enough products, please ask the sales show more than 35 samples. Samplers should choose the samples of the right number in person.

5.5 Firstly, please check all the samples are from the same batch which means the dates of manufacturing are the same. Secondly, please check all the parameters of every sample are the same including the voltage, power, correlated colour temperature and so on.

Finally, please check the package of product to make sure it is complete.

5.6 Please put the samples in the packing boxes and vibration absorber should be filled in the boxes to make sure that the transportation of samples will not be affected by the vibration.

5.7 At least two samplers and one salesman should witness the sampling and packing process and pictures should be taken to record the sampling process to avoid dispute. It is better for one batch one box to avoid mix up.

5.8 Samplers should paste the sealing tape after the confirmation of the samples. Please sign on the joint point of the sealing tape (signatures of two samplers and the salesman are needed). Protective methods should be taken (please use sticky tape to cover the sealing tape).

5.9 Samplers should fill in the sampling sheet after finishing the sampling. The writing should be clear, easy to recognize and it is not allowed to change or revise casually. Please revise like "~~sample~~" with two bars and confirm with signature by sampler.

5.10 Sampling sheet should be signed by the samplers (at least two persons). Samplers should be responsible for the accuracy and completeness of the sampling sheet. Salesman should sign on the sampling sheet and stamp the seal (if there is any) and check the content of the sampling sheet.

5.11 There are three pages of sampling sheet. The first page and the second page should be sent to the test organization and the third page should be saved by the sampling organization.

5.12 Samplers should take pictures of samples and sampling address to prove the source of samples.

6. Sending requirement

6.1 Please send the samples to the address below after packing:

Company Name: National Lighting Test Center

Address: No. A3 Changpocun, Dabeiyao, Chaoyang District, Beijing

Postcode: 100022

Contact Person: NAME

6.2 Please specify on the outside of packing boxes: the samples are used for global sampling of CFL quality check.

7. Sampling discipline

7.1 Please keep confidentiality to the manufacturer and not notice the manufacturer the sampling address.

7.2 Please keep justness and follow the discipline. It is not allowed to accept any gift or any meal invitation from the manufacturer. It is not allowed to sightseeing during the sampling process.

7.3 Please follow the arrangement of sampling responsible person and not act without permission. Please carry out the sampling process according to the task. It is not allowed to change the objective of work or evade responsibility.

7.4 Please keep record when there is problem and submit it to the organization.

7.5 Please finish the questionnaire during the sampling. Please send the questionnaire and the samples to the test organization.

Annex 2. Global CFL Quality Sampling Sheet

Annex 2: Global CFL Quality Sampling Sheet

Task unit		UNEP	Task type	Sampling
Sampling address	Name		Contact person	
	Address		Telephone	
	Lighting products in sale	☐ CFL, ☐ SSL, ☐ GLS, ☐ Off-grid lighting, other_____		
manufacturer	Name		Post code	
	Address		Telephone	
Product information	☐ EU; ☐ ES; ☐ UL; ☐ other_____			
	Name		Mode	
	Date of manufacture/ batch number		Brand	
	Sampling number		Situation of sealed sample	
	Sampling date		Post address	
Sampling organization	Name		Contact person	
	Address		Telephone	
	Post code		Fax/Email	
Note（matters need to specify）:				
The place of sampling has no objection Signature（Seal）: Date:			Sampler（signature）: Sampling organization (seal) Date	

Note: There are three pages for one sheet.

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