Preliminary Study Report of APEC Capacity Building Workshop on Understanding Conformity Requirements for Software Controlled Weight and Measuring Instruments for Sustainable Trade

APEC Workshop on Software Conformance for Measuring Instruments

10 – 12th May 2022

1.0 EXECUTIVE SUMMARY

A three-day workshop on Understanding Conformity Requirements for Software Controlled Weight and Measuring Instruments for Sustainable Trade will be conducted fully online in May 2022. Before the respondents join the workshop, this program begins by conducting a preliminary study. This study is essential to measure the APEC economies' knowledge and experience in performing software testing for measuring instruments. This is to prevent the vulnerability of software measuring instruments from software tampering and illegal activities. Hence, this study aims to measure the level of awareness and readiness on software conformance for measuring instruments among APEC member economies. Their early knowledge is obtained regarding (a) standards pertaining to software for measuring instruments, (b) software testing techniques and methods, and (c) approach to construct a good software for measuring instruments. The implementation of this study is based on the educational training Kirkpatrick model which is useful as a reference guide that emphasizes the achievement of learning objectives as well as considers the short-term of the study. An online survey method was used in which questionnaires were distributed to 30 policymakers and regulators from APEC economies. Data collected were analyzed using the Statistical Package for the Social Sciences (SPSS) version 21.0 to obtain the mean values and percentages. Results were presented in the form of description analysis with respondents' demographic and respondents' level of awareness and readiness of software conformity for measuring instruments.

2.0 DESKTOP STUDY

A desk-based study has been conducted using a systematic literature review (SLR). SLR will help a researcher to retrieve and analyze relevant research from past studies in a comprehensively and transparently.

2.1 Software Conformance for Measuring Instruments

Most consumers are unaware of legal metrology control in measuring instruments applied in their daily activities, such as buying groceries, refueling the car, or paying for utility bills. Legal metrology control is meant for ensuring that trade and business transactions are fairly conducted and profitable. This control not only covers end-user transactions but also involves various levels of business transactions, such as planting, harvesting, and manufacturing. Therefore, measuring and weighing instruments should undergo a process known as “pattern approval” or “type approval.”

The International Vocabulary of Terms in Legal Metrology defines pattern approval as a “*decision of legal relevance, based on the review of the type evaluation report, that the type of a measuring instrument complies with the relevant statutory requirements and results in the issuance of the type approval certificate* (OIML, 2013).”

Laws compliant with national certification bodies such as the National Metrology Institute, notified bodies, and/or pattern approver agencies are responsible for evaluating and issuing the pattern approval certificate (Said, Shukur, & Ibrahim, 2017). The instrument evaluation process for pattern approval, namely, pattern approval evaluation, is defined in the same document as a “*conformity assessment procedure on one or more specimens of an identified type (pattern) of measuring instruments which results in an evaluation report and/or an evaluation certificate* (OIML, 2013).”

Pattern approval evaluation comprises the following:

1. Evaluation and assessment of the documents (test certificate and results) of the measuring instrument;
2. Assessment of the measuring instrument against legal standard requirements, such as those from the International Organization of Legal Metrology (OIML);
3. Test and evaluation of the measuring instrument against maximum permissible error (MPE) as stated in the legal standards.

An instrument that uses software to control its operation is called a software-based device, which is defined as a “device used to compute and processes using software” (NIST, 2014). An advanced and precise measuring instrument, such as an electronic weighing scale in a market or small shop, relies on its software for measuring purposes (Ma, Lu, Mao & Shen, 2012). Therefore, the software has become a critical element that must be evaluated in the pattern approval process to ensure the reliability of instruments.

Studies show that traders tend to manipulate and cheat on measuring and weighing instruments. Mechanical methods were previously used to manipulate the readings of measuring and weighing instruments to gain additional profit. However, the software has become the most vulnerable element to be manipulated in measuring instruments (Al-Wosabi, Shukur, Ibrahim, 2015). Numerous cases have been reported in Malaysia (Ibrahim, Shukur, Zainal & Al Wosabi, 2015).

Evaluation, verification, and assessment of software during pattern approval are critical for ensuring a credible and smooth operation related to weighing and measuring instruments and systems. The penalty for using fraudulent measuring instruments is stated in the Weight and Measures Act 1972 Section 17 (International Law Book Services, 2009) is as follows: *Whoever is in possession of any weight or measure or instrument for weighing or measuring which he knows to be false and intending that the same may be fraudulently used or having fraudulently used such weight or measure or instrument for weighing or measuring shall be guilty of an offence and shall, on conviction, be liable to a fine not exceeding five thousand ringgit or to imprisonment for a term not exceeding four years or to both. Any weight or measure or instrument for weighing or measuring used or in any person’s possession for use in contravention of this section shall be liable to be forfeited*.

Therefore, software for measuring instrument shall also be checked and verified to ensure that the measuring instrument system work as intended within the specified standards and tolerances.

2.2 Issues of Software Conformance and Measuring Instruments

In the digital era, everything now relies on software. Software plays an important part in banking, trades, medical, production, entertainment and education. Software vulnerability leads to software piracies, code stealing and software tampering. This does not only affect the software industries, but can cause more troubles such as in economic and legal situations, where people nowadays tend to tamper or manipulate software in the favour of their purposes in every sector. This includes manipulation and illegal deception on measuring instruments and scales that happen previously for mechanical methods, but involve software vulnerability in a modern nowadays.

There are numbers of real-life cases where software tampering could be a serious threat to the community. The recent case was reported to have occurred in Rompin, Pahang in 2021 where computer confiscation of vehicle weighing equipment for palm weighing equipment was carried out by KPDNHEP. The computer system for this tool is believed to have been manipulated to reap excessive profits (N. Yusof 2021). Also, several cases have been reported in several other places in Malaysia by Ibrahim et al. (2015). In 2013, a scam identified by the authorities took place at a petrol station in Silibin, Ipoh. A similar case was also found to occur in India in 2008 (Abdo et al. 2015).

Several cases were reported in Thailand involving software fraud on vehicle scales for agricultural use (APEC 2009). The United States is also no exception, as early as 1999 as reported by Tasić (2012) where the software for the calculation of oil prices was modified and was only accurate to the value of a coefficient of 5 gallons. Other than that, the price is higher than it should be. This is because the tool for oil verification in the US is 5 gallons in size. Brazil has also been reported to have suffered a loss of USD 300 million over a five-year period as a result of metrological fraud (Soratto et al. 2018).

Most recently in 2019, a house was found in Sibu Sarawak already found modifying the electric meter. Authorities were able to detect this theft because the bill differences were too significant compared to previous usage (DayakDaily 2019).

At the same time, countries in the Asia-Pacific Economic Cooperation (APEC) have also raised concerns about the functionality and use of software in measuring instruments such as oil pumps and electronic scales. Some of the 24 concerns are

related to the accuracy and security of software embedded in generating measurement values (MCS 2010).

All these situations occur due to regulation software on measuring instruments is still not controlled, moreover, this software becomes most vulnerable to being manipulated.

2.3 Awareness and Knowledge of Software Conformance

Software used on weighing and measuring equipment (WMI) is one of the most essential parts of the measuring instrument and should obtain software compliance approval before it is allowed for use in trading. As devices related to weight and measuring instruments are widely used for trades among APEC economies (i.e. digital scales, weighbridges, electricity meters); attracting attackers to exploit the device's software as well as the embedded code to gain revenue illegally. However, there are difficulties faced in checking software for measuring instruments. Among them are a lack of knowledge and experience to perform software tests, no procedures and standards developed to be adhered to, as well as inadequate facilities (Muhammad Azwan Ibrahim et. al 2018). Insufficient knowledge becomes a major challenge as it opens up the possibility of manipulated instruments (the 25th Asia Pacific Law Metrology Forum and Working Group Meeting).

Furthermore, the APEC member economies should be educated about the risks and hazards associated with fraudulent software measuring instruments. Research by Waly, Tassabehji & Kamala (2012) identified that awareness training programs can provide employees with initial knowledge that is the key to reducing the number of security breaches. Awareness is an effective tool to decrease illegal software activities. That is, APEC economies should be aware of the potential threats to the software fraudulent and the consequences of their actions (Lacey 2010). It is necessary to develop an adequate level of awareness on software conformance for measuring instruments among the members as a means of protecting information assets (Eminagaoglu, Ucar & Eren 2009). According to (Veiga & Eloff 2007), user awareness, education, and training are critical components of software for measuring instruments.

2.4 Educational Training Kirkpatrick Model

To ensure that the respondents' knowledge level information is obtained coherently, this study reviews the appropriate training evaluation model used to measure the level of user awareness. These models have specific approaches to educational evaluation such as goal-based, goal-free, responsive, systems-based, professional review and quasi-legal approaches. Yet only goal-based models and systems -based approaches are often used in assessment for training (Eseryel 2002). Among the most influential models and capable of producing a lot of work' is the Kirkpatrick model. This model uses a goal-based assessment approach and has four levels of assessment, namely reaction, learning, behavior, and results. While the system-based model consists of CIPP, IPO and TVS models.

The difference between the Kirkpatrick model and other models is that Kirkpatrick helps practitioners think about the purpose of the assessment, as opposed to a system-based model that focuses on the overall context and situation. In addition, the Kirkpatrick model emphasizes the purpose (continuing education) of continuing education and training, hence the strength of this model is to focus on the behavioral outcomes of the respondents. While the CIPP, IPO and TVS models make evaluations in general and do not provide a dynamic interaction between the design stage and training evaluation. The involvement of each person (collaborative aspect) during the assessment is not emphasized (Eseryel 2002).

This study uses the Kirkpatrick model as a basic guide to meet the objectives of the study in measuring the level of knowledge and awareness of workshop participants. The selection of this model is appropriate because it considers the short period of the study, as well as taking into account the attitudes of respondents covering all levels/levels in the organization. (Schurmann et al. 2019).

2.5 Research Framework of Preliminary Study

Research framework refers to the overall program process that begins with the program objective and output of the preliminary study.

The intended outcome of this program is to improve respondents' knowledge of (a) standards pertaining to software for measuring instruments; (b)software testing techniques and methods; and (c)approach to construct a good software for measuring

instruments. To measure their understanding, a preliminary study has been conducted before the implementation of the workshop. The specific objective of this study is to obtain the level of awareness and readiness on software conformance for measuring instruments. There are two main parts to this study namely a desk-based study and a pre-workshop survey. The desk-based study is a research activity that includes identifying, reviewing, and analyzing the relevant sources such as peer-reviewed journal articles, proceedings, books, and related materials to meet the objective of the preliminary study. Figure 1 shows the research framework of the preliminary study for the APEC Capacity Building Workshop.

The desk-based study is conducted using the systematic literature review (SLR) method. In this study, SLR is a review method that applied systematic searching to acquire the extent of the level of awareness and readiness on software conformance for measuring instruments among APEC economies. SLR is used to identify issues in software conformance and measure instrument issues in general as well as awareness of the related matters. This study analyzes peer-reviewed articles related to software conformance, measuring instruments, and awareness of software conformance aspects. This article is retrieved from several established sources such as the Institute of Electrical and Electronics Engineers (IEEE Xplore), Google Scholar, and APEC Project Database (PDB). There are specific research keywords used to identify relevant articles that focus on a discussion of the knowledge and awareness of APEC member economies on software conformance for measuring instruments. This search was set to a 10-year time limit to incorporate only recent studies.

Next, the online survey is conducted basis on the educational training Kirkpatrick model which is useful as a reference guide that emphasizes the achievement of learning objectives as well as considers the short-term of the study. This survey involved 30 policymakers and regulators from APEC member economies as respondents, which give priority to women respondents. This survey used a set of questionnaires with the format of multiple choice and close-ended (4-point Likert Scale). It consists of five sections namely demographic, awareness of software conformance, knowledge of software conformity for measuring instruments, readiness on software conformance, and importance of software conformity.

Finally, the output of this study will be a preliminary study report that describes the processes of the development of a framework, preparation of the pre-workshop survey questions, the dissemination of the questions, pre-workshop survey results, and the overall discussion.

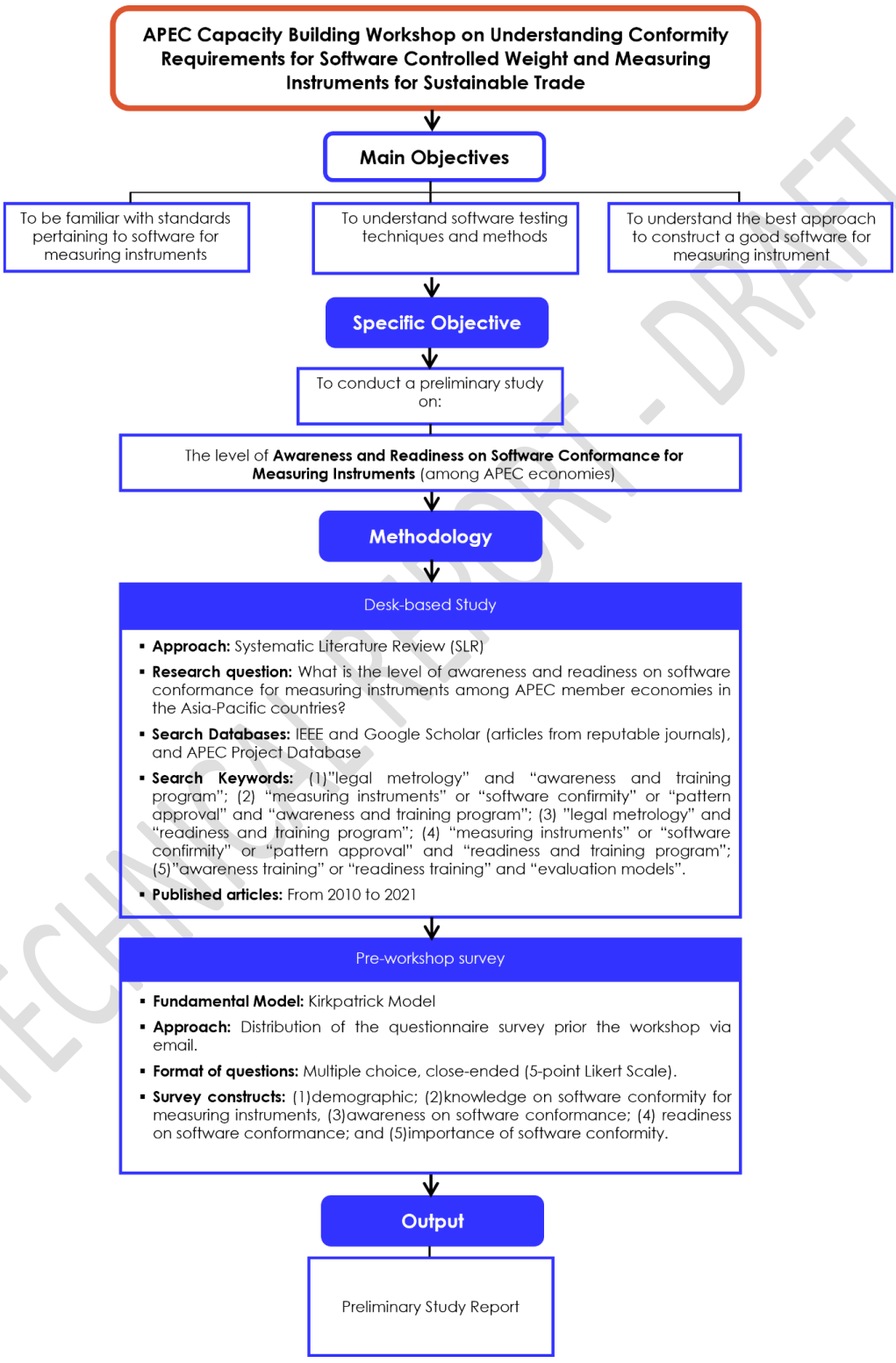

Figure 1 Research framework of preliminary study for APEC Capacity Building Workshop

3.0 METHODOLOGY

This study has been conducted to obtain the level of awareness and readiness on software conformance for measuring instruments. The objective of this study is to improve respondents' knowledge of (a) Standards pertaining to the software for measuring instrument; (b) Software testing techniques and methods; and (c) Approach to construct a good software documentation.

The formation of research criteria consists of variables determined based on previous studies and discussions with project overseers from UKM and NMIM. The four main variables of this study are awareness, knowledge, readiness, and software conformity.

- Awareness refers to the state or ability to perceive, feel, or be conscious of events, objects, or sensory patterns. More broadly, it is the state or quality of being aware of something. Awareness in this study refers to respondents' general awareness of the software conformance for measuring instruments.

- Knowledge is the state or fact of knowing; understanding or information about a subject that you get from experience or study. Knowledge in this study refers to respondents' knowledge of software standards and requirements.

- Readiness is the state of being prepared for something and willing to do something. In this study, readiness refers to the respondents' country's readiness on adopting/apply the software conformance for measuring instruments.

- Software conformity refers to an instrument evaluation process for pattern approval, namely, pattern approval evaluation towards software for measuring instruments.

This study uses a purposive sampling technique to select specific respondents such as policymakers and regulators from APEC economies who work on policies related to legal metrology.

An online survey was distributed to respondents via email using a questionnaire. The questionnaire was constructed based on five sections namely Section A

Demographic (15 items), Section B Awareness (7 items), Section C Knowledge (8 items), Section D Readiness (5 items), and Section E Software Conformity (6 items).

Data collected from respondents were analyzed using statistical software called Statistical Package for Social Sciences (SPSS). SPSS is a comprehensive user-friendly system that can take data from almost any type of file and use it to generate tabulated reports, charts, trends and descriptive statistics. For this study, descriptive statistics (mean and percentage) were used to analyze the survey data.

4.0 ANALYSIS AND RESULTS

Of the 30 surveys distributed via email, a total of 15 responses received from respondents were compiled and analyzed to examine the level of awareness and readiness of software conformance for measuring instruments.

The demographic information of the respondents consists of seven factors, namely gender, country, organization, position category, years of experience, highest qualification and field of educational background. Figures 2 and 8 show the percentage of respondents that participate in the survey. From the result, most of the respondents are male (87%, n=13) and the rest are female (13%, n=2).

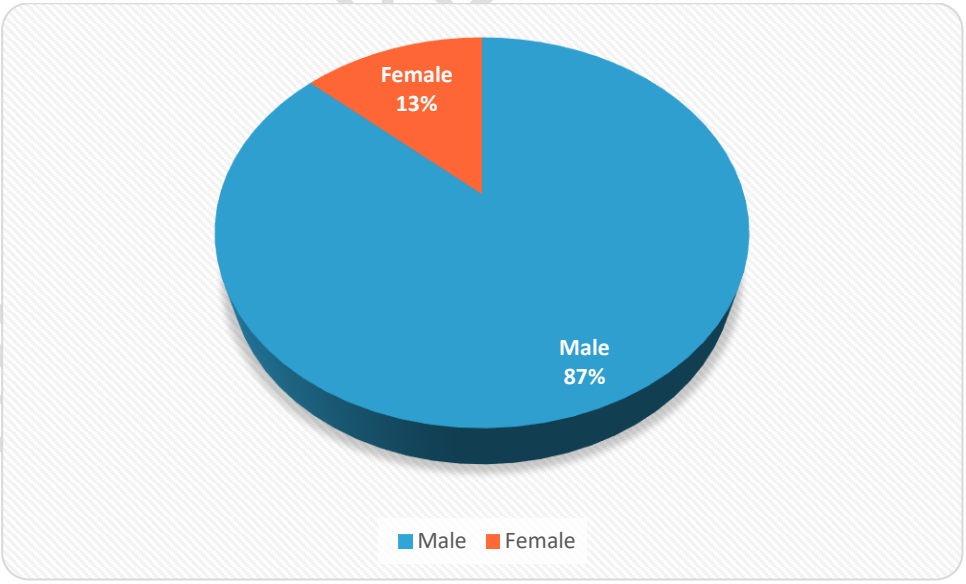

Figure 2 Gender

Next, Figure 3 shows that the majority of respondents were from Canada (26.7%, n=4), followed by respondents from Australia, Chinese-Taipei, Philippines and

Vietnam (13.3%, n=2), and the remaining from Brunei, Papua New Guinea and Peru (6.7%, n=1) respectively.

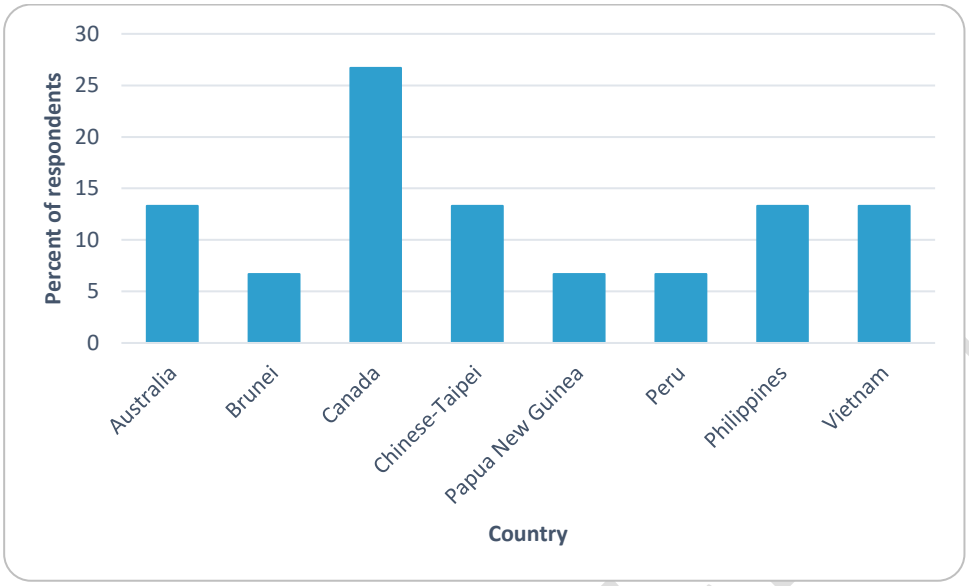

Figure 3 Country

From the result, 26.7%(n=4) respondents have worked at Measurement Canada, 13.3%(n=2) respondents have worked at National Measurement Institute, Australia and Industrial Technology Development Institute, Philippines, and 6.7%(n=1) respondents have worked at other institutes as shown in Figure 4.

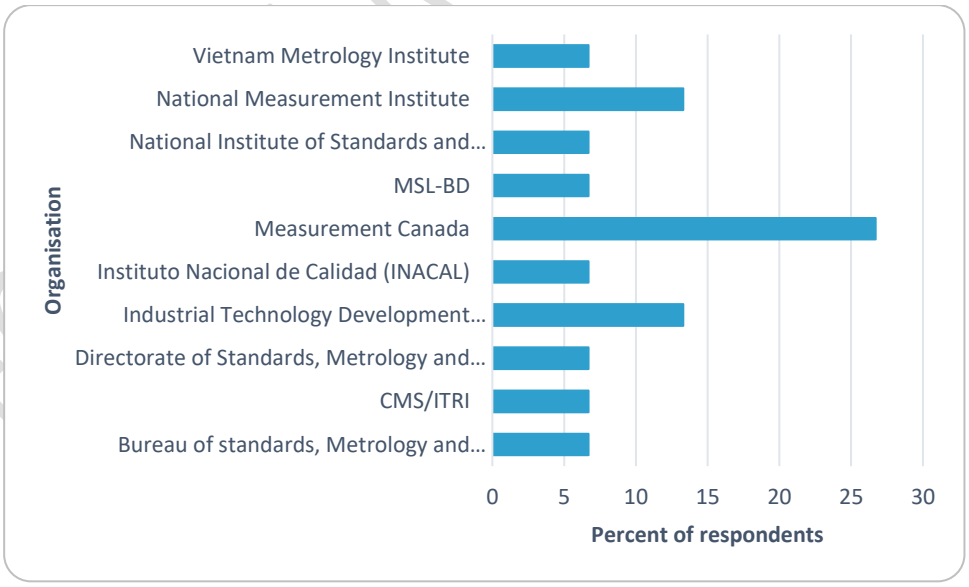

Figure 4 Name of the organization

Moreover, most of the respondents (40%, n=6) were from a technical professional category, 20%(n=3) of them were from technical, 13.3%(n=2) were

from management and technical management, and 6.7%(n=1) were from top management and other categories.

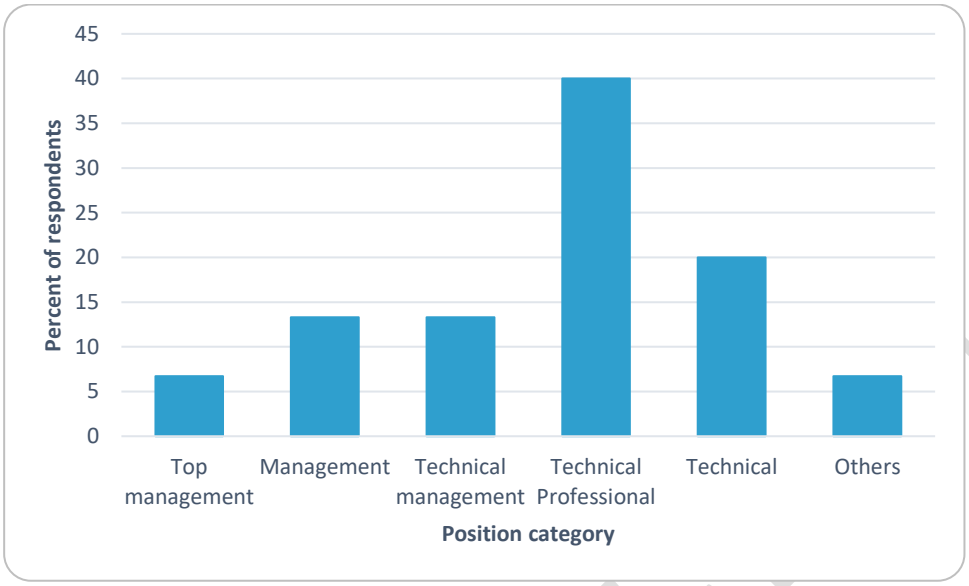

Figure 5 Position category

From Figure 6, it shows that 40%(n=6) of respondents have 6-10 years of experience, followed by 33.3%(n=5) who have 10-20 years of experience, and the rest 13.3%(n=2) have respectively below than 5 years and above 20 years experience in the related industry.

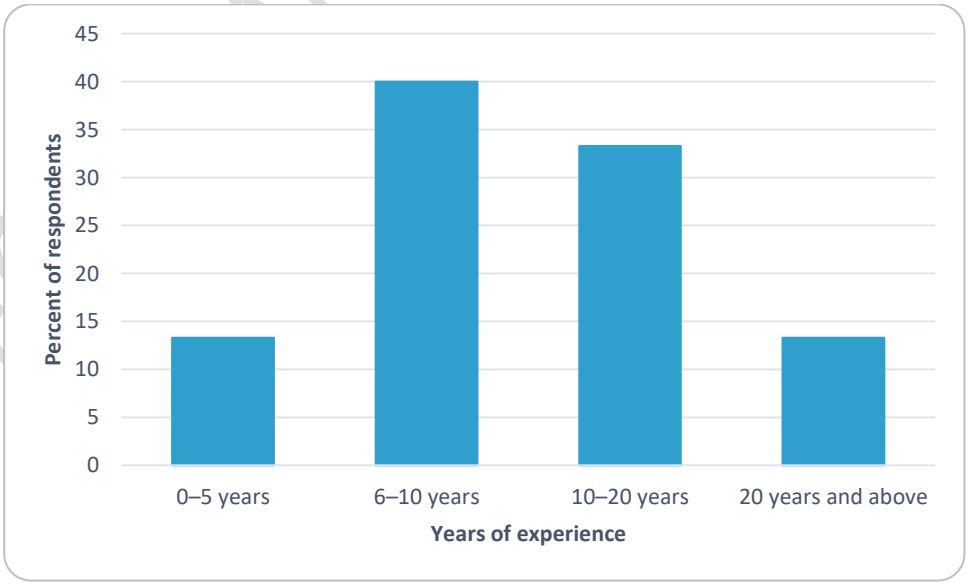

Figure 6 Years of experience in the related industry

About 40%(n=6) of the respondents have a bachelor's degree, 26.7%(n=4) have a Master's degree, 20%(n=3) have a Diploma, and 13.3%(n=2) have a Ph.D. degree.

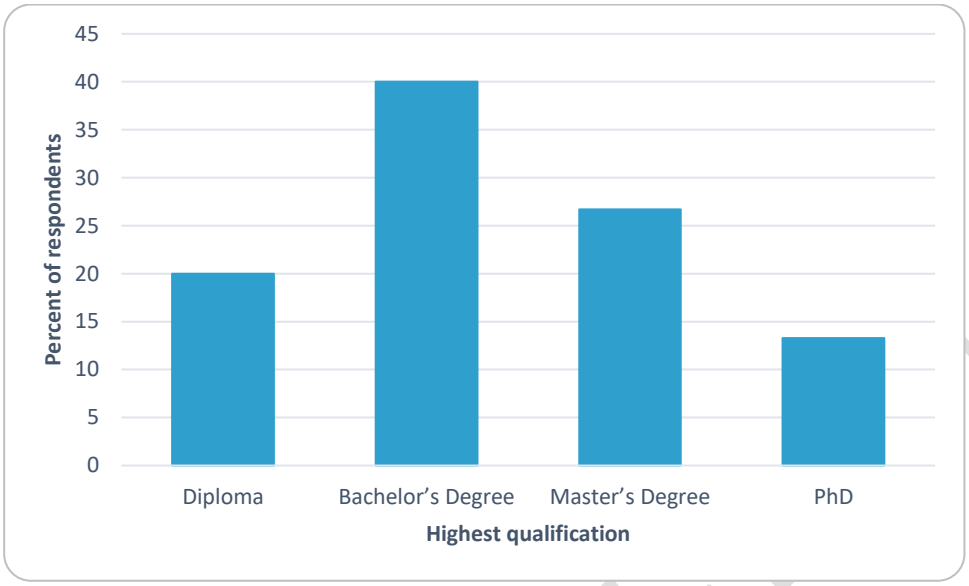

Figure 7 Highest qualification

Finally, the majority of them have an educational background field in Engineering (60%, n=9), followed by field in Physics (20%, n=3), other background fields (13.3%, n=2), and Chemistry field (6.7%, n=1).

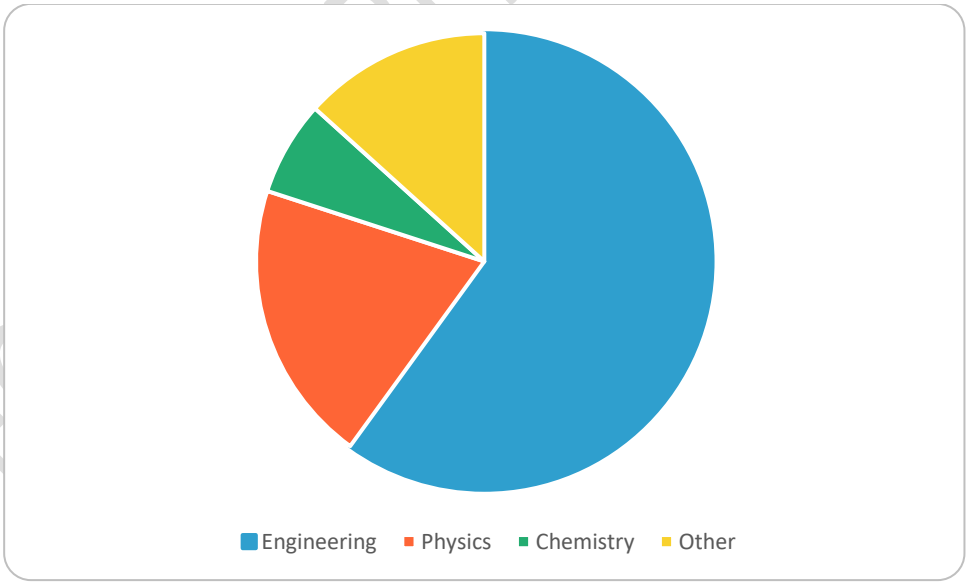

Figure 8 Field of educational background

4.1 Country profile analysis

The survey on country profiles was conceptualized to obtain the knowledge, and to measure the level of awareness and the country's readiness or preparedness

towards the implementation of software conformity for measuring instruments. There are seven multiple-choice questions related to the country's profile in this study.

From the result, 93.3% of the country has regulations for measuring instruments used for trade. Apart from that, only 13.3% or two countries have regulations covering the software part. This low percentage affects the other related questions which are software that goes through the examination process for pattern approval (20%), followed by software that is examined during the market surveillance (13.3%), and OIML/WELMEC documents being adopted in the country (26.7%). Nevertheless, 86.7% of the countries become a member of the OIML organization. From the percentage, 46.7% of countries have joined as member states, while the remaining 40% have joined as corresponding members (see Figure 10).

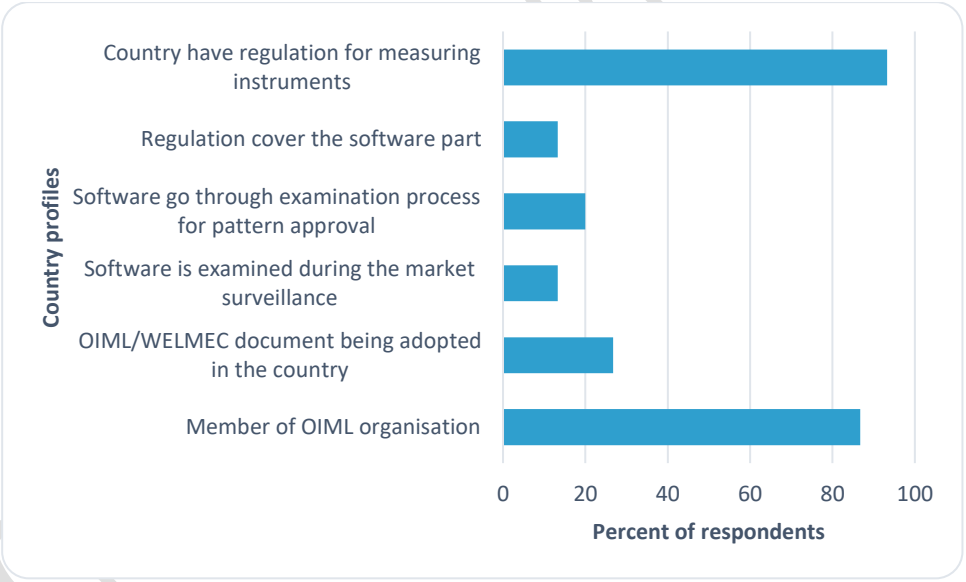

Figure 9 Country profiles

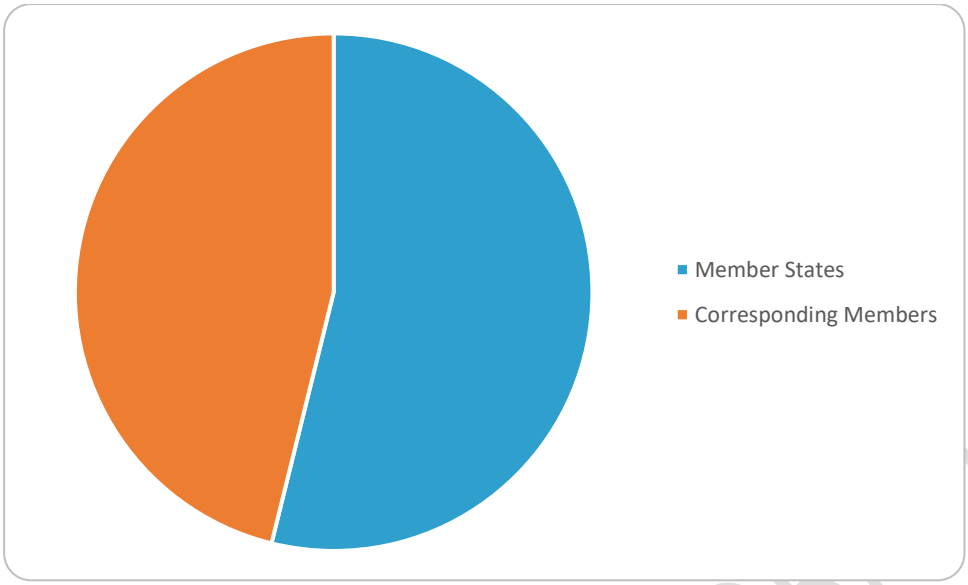

Figure 10 Type of member

4.2 Variable analysis

Furthermore, a mean score was used to obtain the level of awareness, and readiness of software conformity for measuring instruments. Each item from four variables namely awareness, knowledge, readiness and software conformity were computed. These values were then compared with a mean score level to facilitate the interpretation of the findings. The mean score levels are determined by dividing the mean range (1 to 4) into three categories namely low, moderate, and high (Tengku Siti Meriam et al. 2019; Kosnin & Lee 2008) (Table 3).

Table 3 Mean score level

The range for each category	Level
1.00 – 1.33	Low
1.34 – 2.66	Moderate
2.67 – 4.00	High

Based on Table 4 under the Awareness variable, most of the respondents have a high awareness of the software conformance for measuring instruments for items 1 and 6, while the respondents have a moderate level of awareness for item 7 (mean = 2.54) for the appropriate approaches in preparing good software documentation.

Table 4 Awareness

No.	**Item**	**Mean**	**Level**
1.	The OIML/WELMEC are international organisations in legal metrology.	3.85	High
2.	The status of the implementation of software conformity for measuring instruments in my country.	2.77	High
3.	Certain economies had already implemented software conformity for measuring instruments.	3.00	High

4.	The role of software examination in type/pattern approval.	3.15	High
5.	The software for measuring instruments is prone to tampering.	3.46	High
6.	Proper techniques that can be used in software examination.	2.77	High
7.	The appropriate approaches in preparing good software documentation.	2.54	Moderate

Next, Table 5 under the Knowledge variable indicate that the respondents have a high level of knowledge for item 1, 2 and 4, while the remaining (item 3, 5,6,7,8) show that the respondents have moderate knowledge of software standards and requirements.

Table 5 Knowledge

No.	Item	Mean	Level
1.	The relevant OIML document that specifically contains requirements for the software.	2.75	High
2.	OIML D and OIML R document.	2.92	High
3.	The difference between OIML D and OIML R document.	2.62	Moderate
4.	The relevant WELMEC document that specifically contains requirements for the software.	2.77	High
5.	The basic category of requirements for software in WELMEC document.	2.46	Moderate
6.	General process flow of approval in the software examination.	2.15	Moderate
7.	How to perform software examinations using correct software testing techniques.	1.92	Moderate
8.	The difference between a good or bad software documentation.	1.85	Moderate

Results from Table 6 under the Readiness variable indicate that most of the respondents have agreed with each item that their country has moderate readiness on applying the software conformance for measuring instruments.

Table 6 Readiness

No.	Item	Mean	Level
1.	Ready in terms of relevant expertise.	2.23	Moderate
2.	Ready in terms of sufficient facilities and capabilities.	2.18	Moderate
3.	Ready in terms of required legislation.	1.85	Moderate
4.	Ready in terms of industries (industrial readiness).	1.92	Moderate
5.	Ready to recognise software examination reports from other APEC economies.	2.00	Moderate

Lastly, Table 7 shows that most of the respondents have agreed with the perception of the importance of software conformity for each item under the Software Conformity variable.

Table 7 Software conformity

No.	Item	Mean	Level
1.	Software conformity is an important exercise to prevent or reduce the event of illegal use of the software for measuring instruments.	3.62	High
2.	Software conformity exercise can help the government increase losses of revenue in tax.	3.08	High
3.	Implementing software conformity can protect consumers from fraudulent transactions.	3.52	High
4.	Implementing software conformity can increase consumers confident in trades.	3.62	High
5.	Implementing software conformity can promote fair trades.	3.77	High
6.	Having specific legislation on software for measuring instruments can ensure that trade and business transactions can be conducted fairly and profitably.	3.69	High

5.0 DISCUSSION AND CONCLUSION

The findings show that the majority of the respondents are male respondents who have a background in Engineering, as well as have more than six years of experience in the related industry.

The overall mean level of awareness and readiness in this study includes moderate and high levels as respondents consist of APEC software practitioners as well as APEC officials who work in the area of software measuring instruments.

Moreover, findings show that most respondents have a high level of awareness (mean value exceeds 3.0) of software conformance for measuring instruments. This can be seen in the item the OIML/WELMEC are international organizations in legal metrology which recorded the highest mean value of 3.85. This is because most respondents are from member countries of OIML (86.7%). However, the item on the appropriate approaches to preparing good software documentation only obtained a mean value of 2.54, which is a moderate level and can be improved through the current emphasis in the workshop later.

Meanwhile, respondents' level of knowledge was high for items the relevant OIML document that specifically contains requirements for the software, items related to OIML D and OIML R document, as well as items for the relevant WELMEC

document that specifically contains requirements for the software. However, they have a moderate level of knowledge regarding the differences between OIML D and OIML R, the basic category of requirements for software in the WELMEC document, the general process flow of approval in the software examination, how to perform software examinations using the correct software testing techniques, and also the difference between good or bad software documentation. This moderate result is because most respondents do not know the process during the software examination. After all, they have never been involved in software testing techniques.

Furthermore, the findings found that all respondents agreed that the level of readiness of their countries to adopt the software conformance for measuring instruments is still at a moderate level. This is because most respondent countries do not have regulations covering the software part, as well as their software for measuring instruments does not go through pattern approval checks and is not checked during market surveillance. This exposes their software to vulnerability to tampering.

Finally, the results show a high level of respondents' perception of the importance of software conformity with a mean value exceeding 3.0 for each item. This proves that most respondents have high perception and awareness in terms of understanding the importance of applying software conformity, but can not be practiced due to their country’s lack of readiness in the implementation of software conformity for measuring instruments.

Overall findings include the level of awareness and readiness of respondents on software conformity for measuring instruments to determine their understanding of standards pertaining to software for measuring instruments, software testing techniques and methods, and also the best approach to construct a good software documentation. This in turn achieves the objective of the implementation of the preliminary study.

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