CALIBRATION AND TRACEABILITY: A METROLOGY REQUIREMENT THAT MUST BE REALIZED THROUGHOUT SAUDI ARABIA

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ABSTRACT

All test and measuring instruments must be calibrated both at the time of manufacturing and at regular intervals during use to assure the accuracy and confidence in the measurements. Precise and accurate measurements are not only needed to improve production, product quality and research & development, but also needed for any preventive or corrective measure to be taken by law enforcement bodies. For a country of the size of Saudi Arabia, which is utilizing all available resources to enhance its technological capabilities throughout its different regions, it is a basic requirement to introduce and develop a calibration and traceability system that is capable of unifying and harmonizing the measurements throughout the kingdom, irrespective of place, person or time. This paper highlights the real needs for such an effective national calibration system and present some suggestions towards the strategy of establishing several accredited laboratories throughout the Kingdom to implement this important task.

Keywords: *Metrology, Calibration. Measurement, Accuracy, Traceability, Acriditation, Primary and Secondary Laboratory.*

الملخص

من المهم معايرة جميع أجهزة القياس والمعايرة عند تصنيعها وعلى فترات منتظمة أثناء الاستخدام لضمان دقة و وثوقية القياسات . فالحاجة لضباطه ودقة القياسات ليست مطلوبة فقط لتحسين الإنتاج وجودة المنتجات والبحث والتطوير بل إن ذلك أيضاً مطلباً ضرورياً عند اتخاذ إجراءات وقائية أو تصحيحية من قبل الهيئات المسئولة عن تطبيق القوانين . وفي بلد بحجم المملكة العربية السعودية التي سخرت جميع مواردها المتاحة لدعم قدراتها التقنية في المناطق المختلفة فإنه من المتطلبات الأساسية إيجاد وتطوير نظام للمعايرة والتسلسلية يكون قادر على توحد وتوافق نتائج القياسات في أنحاء المملكة بغض النظر عن المكان أو الشخص أو الوقت . وتسلط هذه الورقة الضوء على الاحتياج الحقيقي لنظام وطني فعال للمعايرة وتقدم بعض الاقتراحات نحو استراتيجية تأسيس عدة مختبرات معتمدة في مختلف مناطق المملكة لتطبيق هذا المطلب الهام .

1. INTRODUCTION

Metrology is the field of knowledge concerned with all theoretical and practical aspects of measurement regardless of the accuracy level or field of science or technology where they might occur [ISO, 1984]. For example, it covers measurement theory, units, standards, instruments, methods, laboratory, personnel, etc. It plays an important role in a wide range of our every day activities, such as trade, science, technology, industry, agriculture, health, safety, etc. Consequently, it is an essential part of the infrastructure of any country to ensure harmonization of measurement within the country and with respect to the international community, especially after the removal of trade barriers between the World Trade Organization WTO countries which are implementing quality and environmental standards systems such as ISO 9000 and ISO 14000 [Kind and Quinn, 1995]. The most important elements of Metrological infrastructure in any country are laws and regulations, organization and management, specification standards, measurement standards, calibration facilities, personnel, information, awareness and education.

In Saudi Arabia, calibration and measurement activities were not formulated until 1383 H (1964). This is because priorities were given to the services of the Holy places, health, education, regulation and laws, defense and public security. The infrastructure of the country was significantly improved after the rise of oil prices in 1973. As a result unprecedented development and expansion throughout Saudi Arabia in all various fields was carried out in a grand scale fashion. This included of course the important area of measurement and calibration, a task implemented today by the Saudi Arabian Standards Organization (SASO), which is working to enhance its capabilities towards the fulfillment of all metrological requirements of Saudi Arabia.

Test Laboratories and centers through out Saudi Arabia are performing measurements and tests independently of each others. In other words the results obtained by various centers for the same measured quantity may not be compatible among themselves. This is because no national calibration and traceability system exists at present to ensure uniformity of measurements irrespective of place, time, or person. This paper highlights the needs for such calibration systems, review the present situation and present some suggestions towards establishing several accredited laboratories throughout the kingdom to implement the important task of calibration and traceability.

2. IMPORTANCE OF CALIBRATION AND TRACEABILITY

Calibration and traceability are important elements of Metrology. Calibration is defined by international standards as "the set of operations which establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system, or values represented by a material measure, and the corresponding known values of a measurand" [ISO, 1984]. It must be said that calibration provides two major benefits. First, it allows you to use your instruments with confidence by minimizing the uncertainties associated with your

instruments. Second it fulfills the requirements for traceability to national standards demanded so frequently today. Similarly, Traceability is defined as "The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national, through an unbroken chain of comparison all have stated uncertainty" [ISO, 1984].

In production and quality control, one of the most significant factors is the reliability of measurements. This reliability can only be achieved by calibrating the measuring devices, e.g. determining the magnitude of its measurement error with a better, more accurate, instruments. However, this more accurate instruments, also needs to be calibrated and in the way a chain is established. Via that chain all measurements are connected to the 7 base SI units; the Meter (m), Kilogram (kg), Second (s), Ampere (A), Kelvin (K), Candela (Cd) and Mole (m) as defined by BIPM (Bureau International des Poids et Measures) the international center of metrology. This process is known as calibration and traceability, which is important element of metrology. Figure 1 shows the output response of an instrument before and after calibration namely, one year specification, As Found and 24 hours specification, As Left for 100 mV, 1V and 10 V [Fluke, 1996]. This reflects the importance of periodic calibration of all the various measuring devices and/or systems.

For a country of the size of Saudi Arabia with an area of about 2 millions Square Kilometers, which is utilizing all available resources to enhance its technological capabilities throughout its different regions, it is a basic requirement to introduce and develop a calibration and traceability system that is capable of unifying and harmonizing the measurements in the various fields and activities of life. Precise and accurate measurements are not only needed to improve production, product quality and research and development, but also needed for any preventive or corrective measures to be taken by law enforcement bodies. Precise and accurate measurements are particularly important in areas like:

1. Extraction and utilization of natural resources.
2. Activities related to the state defense and public security.
3. Testing and quality certification of products.
4. Environmental and meteorological activities and control.
5. Safety related matters.
6. Scientific research.
7. Sales and service transactions.
8. Treatment and diagnostics in medicine.
9. Registration of national and international sport records.
10. Repair, calibration and verification of measuring equipments.

The needs for an effective calibration and traceability system are increasing day by day [Coleman and Waters, 1997]. To illustrate this further, consider, for example, the release by human and industrial activities of toxic and harmful wastes to the atmosphere in the gas, liquid and solid forms, which ends as suspended particulate matter in the air. In order to

control and monitor their amount and effect by environmental regulation bodies, these effluents have to be accurately measured [Verma, 1997].

Since these wastes are produced in various cities and places, the measurement made, say at Dammam, Riyadh and Jeddah must be compatible among themselves. This means that test instruments at the three places should give the same results within specified limits. This can be achieved when all measurements are made with reference to an accepted national or international standard of measurement. In other words, the measurement must be made in terms of SI units, which are realized in national and international laboratories [Coleman and Waters, 1997].

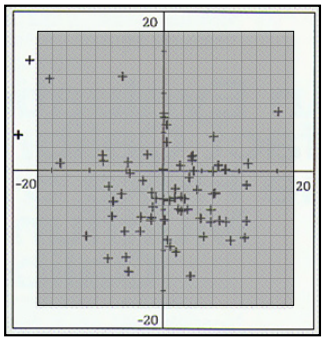
3. PRESENT SITUATION OF METROLOGY IN SAUDI ARABIA.

There are different objectives for Metrology such as legal, industrial, military, research and development and medical metrologies [Al-Muhaisini, 1994], which are well established on an independent basis throughout Saudi Arabia. However, Legal metrology in Saudi Arabia traces back to the early days of Islam, where many activities in Islamic religion state the importance of accurate measurement either through fare trading or through Islamic duties; in fact, four of the Islam main fundamentals, Prayer, Zakatt, Fasting and Hajj, rely on accurate measurement. For example accurate determination of time is required for prayer, Fasting and Hajj; accurate determination of weight is required for Zakat.

Now a days Saudi Arabian Standards Organization SASO is the national authority for weights and measures since 1392 (1972). As part of its main objectives, SASO has established in 1406 H (1986) the national measurement and calibration laboratory (NMCL), which houses the primary standards of the country in the various fields of measurements which are traceable to international standards. At present SASO is upgrading the NMCL to coincide with the completion of the new laboratory building at SASO new premises. In addition, a survey conducted by SASO in 1994 showed that many public and private calibration laboratories exist throughout the country [SASO, 1994]. Among those are:

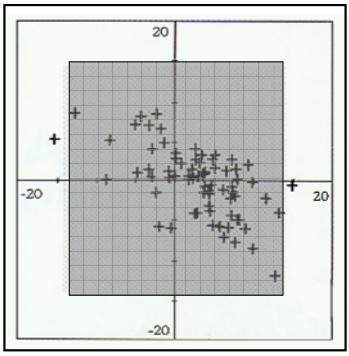
1. A number of calibration laboratory in different sectors of Military.
2. A number of calibration laboratories are available in some universities and research organizations. For example, King Fahad University for petroleum and minerals (KFUPM) has a well-equipped laboratory, King Abdulaziz City for Science and Technology (KACST) is in the process of establishing its own calibration laboratory.
3. There are a number of private laboratories, which provide their services to the factory or the company where they belong and do not offer calibration services to outside customers.
4. Some private calibration laboratories provide services to customers on business basis. Few of them are accredited by SASO.
5. SASO is running an accreditation system for both calibration and testing laboratories according to the international standards (ISO – 25).

Correlation Analysis-As Found 100 mV



+100 mV

Correlation Analysis-As Left 100 mV



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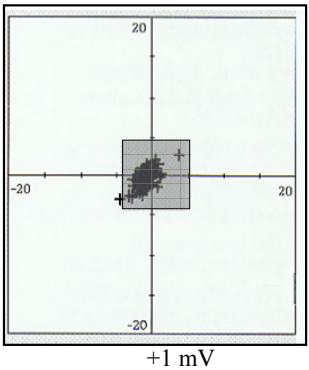
Correlation Analysis-As Found 1 mV



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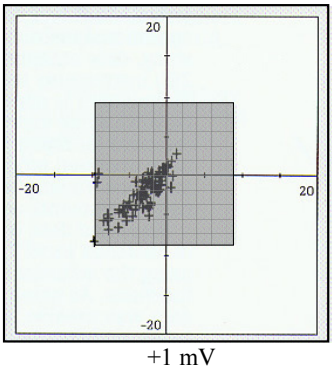
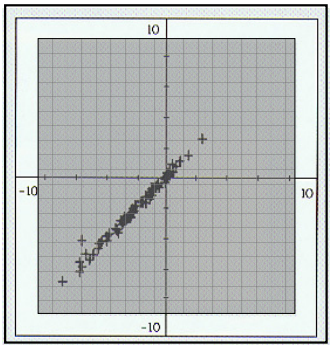


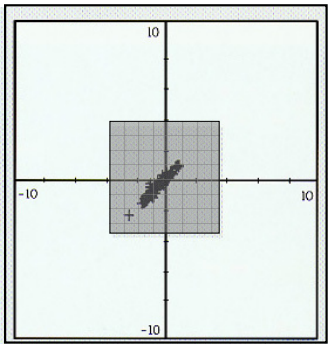
+1 mV

Correlation Analysis-As Found 10 mV



+10 mV

Correlation Analysis-As Left 10 mV



+10 mV

Figure 1: Comparison of an instrument response before and after calibration. Shaded boxes show one-year specification, as found and 24-hour specification, as left.

4. SUGGESTED IMPROVEMENT STRATEGY.

4.1 Legal Requirements

The awareness of the importance of measurement and calibration was stated in royal decree no 29, which was issued about 35 years ago. It states that the metric system is the official system of units, which have to be used throughout the kingdom. However the harmonization of calibration activities in Saudi Arabia is not only a national requirement but also an international requirement. The regional grouping is required for mutual recognition of test results which is a prerequisite for free trade and an effective mean of minimizing trade barriers. Accordingly, without a harmonized national calibration system, the benefit of the participation in a regional grouping will be highly down graded. Therefore, there is an urgent need to either revise the above mentioned law to cover all aspects of measurement activities in Saudi Arabia such as laws and regulations, laboratory accreditation, calibration and traceability etc, or a new law on uniformity of measurements may be drafted. These legal requirements will enable the national authority to implement an effective national policies in the field of metrology.

4.2 Calibration and Traceability system

In addition to the responsibilities of (SASO) as briefly mentioned earlier, other responsibilities associated with calibration and traceability must be added. Some of these new responsibilities may include:

1. The implementation of the new law on guarantee of uniformity of measurements.
2. The assessment and accreditation of the measurement laboratories performing calibration, testing or sampling and of laboratories that certify products, personnel and quality systems in the various regions of the kingdom.
3. The supervision of training courses on verification, calibration and traceability of mass, electricity, volume and capacity, temperature and pressure measurement instruments.

However, SASO cannot provide all the kingdom requirements of traceable measurements directly. This is due to various reasons that includes:

1. The large area of the Kingdom of Saudi Arabia.
2. The responsibility of maintaining the primary standards and realizing and maintaining transfer standards.
3. The huge technical tasks involved in the various calibration and traceability requirements from test centers upto national and international levels of an unbroken chain of comparisons with stated uncertainties.

Instead, a network of external laboratories is needed to enable the dissemination of the standards to the ultimate users of measuring instruments. Such laboratories must be accredited by SASO through its system of accreditation. Since the capital cost of such specialized laboratories is highly dependent on the required accuracy level, it is envisaged that such a network will involve various classes of laboratories based on different levels of accuracies.

For the size of the country of Saudi Arabia, a minimum of five secondary standard laboratories are required to provide adequate calibration and traceability services that will cover East, West, North, South and center provinces of the kingdom as shown in Figure 2. They are called secondary because they come next (interms of accuracy) to the national primary standard laboratories of SASO. The routine calibration of these secondary standards laboratories should be performed at the national primary standard laboratories of SASO either directly or indirectly through its own transfer standards.

Figure 2: The five regions for secondary standard laboratories around the kingdom.

Under each of the five regional secondary standards laboratories, a sub network of working standards laboratories must be established to provide services for the various test centers in the relevant province as shown in Figure 3. The secondary and working standards laboratories must be accredited and monitored by SASO. It must be mentioned that accreditation is defined as "a formal recognition that a laboratory is competent to carry out specific calibrations, tests or specific types of calibrations or tests" [NAMAS, 1989]. The accreditation procedures and requirements are very much involved and out of the scope of this paper. However, confidence in the ability of the accredited laboratories (in the system) to carry out these calibrations in a technically competent manner is essential.

In the above suggested national calibration and traceability system or any similar system that may be used, confidence in each stage of the chain of comparisons linking the calibration of an instrument to the primary standards of the country must be established through reliable measurements and procedures. Of course, each comparison in the chain will inevitably increase the uncertainty of the measurement results but the total uncertainty of the instrument calibration must be known with respect to national standards. This will allow the ultimate user to have confidence in his ability to make measurements to the required degree of accuracy. And this is what traceability means in the real world measurements.

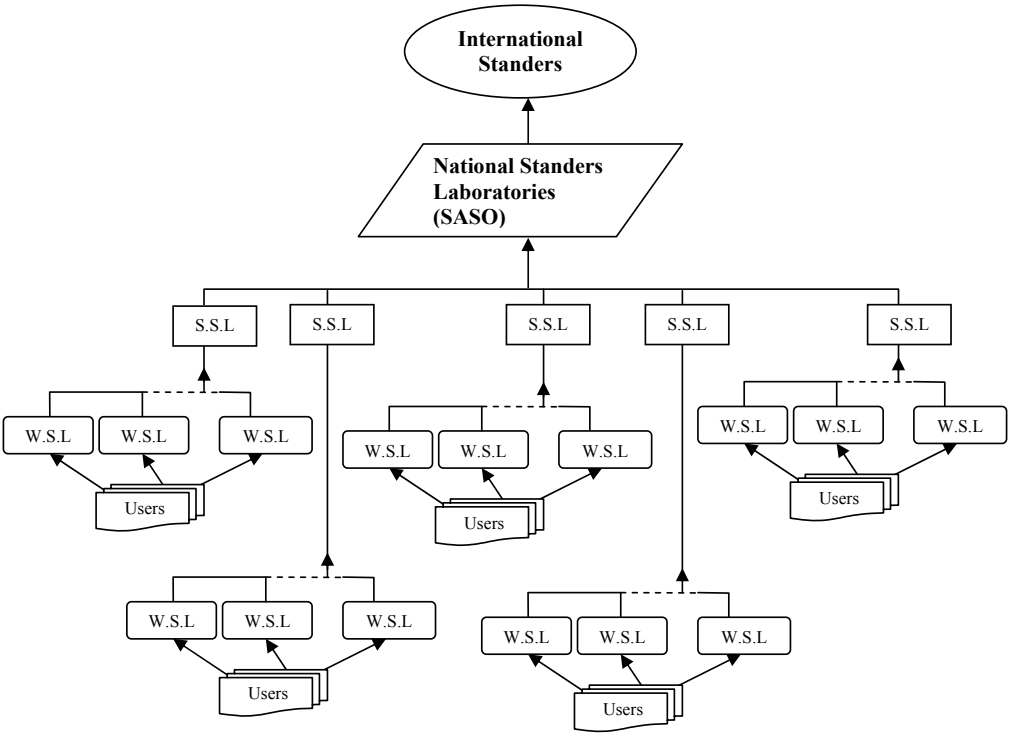


Figure 3: The suggested structure for national calibration and traceability system.

Implementation of a national measurement system of this kind will definitely result in enhanced and reliable measurement, which will positively effect a very wide range of activities throughout the kingdom. The responsibility of implementing such system is that of the national authority as entrusted by the new or modified laws as discussed earlier. However the funding of such program must make use of the available infrastructure, both in the public and the private sectors. In other words, this network system of calibration laboratories at all levels could be totally or partially funded either by public or private sectors.

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5. CONCLUSIONS

The needs for organizing and developing the kingdom measurement infrastructure is not only a national requirement but also is essential for international trade. Implementation of a national measurement system as briefly outlined in this paper or any similar effective system will result in harmonized and reliable measurements which underpin a very wide range of activities from research, manufacturing, healthcare and environmental monitoring and control through to consumer protection. The effort presented in this work is only meant to draw attention to this important field which directly affect our daily lives. Therefore, further detailed studies are needed to cover all aspects of this important subject.

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