Metrology Lab

The National Metrology Institute (NMI).

(Traditionally referred to as 'the national laboratory').

Metrology - The science of measurement.

Lord Kelvin, the renowned scientist, had the following to say about metrology:-

"When you can measure what you are speaking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind".

Measurements have been carried out by humans for as long as civilization has existed. From the primitive population who lived in caves to modern man, the need has always been there to measure and know. Of course, all these measurements were approximate. With the development of civilization the need for more acceptable measurement grew. This led to the evolution of the standards of measures. For example, the standard of length evolved from the foot of the "King", to the Egyptian cubit, to the metallic metre and finally to the monochromatic, highly stabilized light source. Interestingly enough, even though we can now measure with much greater precision, the measurements are still "approximate" and will always have an element of "uncertainty".

Today, reliable measurements are required over a much wider range of activities. As industry undergoes major new developments with new materials, techniques and the miniaturization of products, measurements become more critical. The increasing trend to sub-contract assembly or sub-systems means that each location needs to have the same measurement system; otherwise the various parts would not fit together. New areas in metrology, such as nanotechnology, optical techniques, material sciences, and metrology in chemistry, healthcare, food safety and testing have developed rapidly. And today the requirements of law enforcement, fraud, forensics and environmental sciences also need accurate and traceable measurements to be able to function properly.

The further globalization of trade needs traceable, comparable and mutually acceptable measurements across the world, not only in the trade of manufactured products and raw materials but in all aspects of international trade. Society now demands that it can have confidence in the results of measurements. Decisions based on the data that comes from measurements are increasingly seen to have a direct influence on the economy, human safety and welfare. The only way for this to be assured is for measurements in all areas of science to be made in terms of a well defined system of units and verified measurement procedures.

The SI (Systeme International d'Unites) is a globally agreed system of units based on the metric system. There are seven base measurement units from which all other measurement units are derived. These base units are the metre (length), the second (time), the mole (amount of substance), the candela (light intensity), the ampere (current), the kelvin (thermodynamic temperature), and the kilogram (mass).

Measurement science is vital for trade and commerce and is the basis of modern science and technology. (See references made in the Accreditation section to the World Trade Organisation (WTO) and technical barriers to trade (TBTs)). Reliable and traceable measurements are required by every country to ensure that they remain a player in the world market, whether they are selling goods and services or buying them. It is the responsibility of all the countries of the world to ensure they have a practical system to provide their markets with the appropriate levels of traceable metrology to underpin their trade activities. This does not mean that they need to be able to realise the base units of the SI system. What they need is to be able to provide a practical traceable solution, one level higher than the industry is generally operating at.

Several countries have fallen into the trap of planning a national laboratory at the highest level and then finding that they are unable to provide for the requirements of their own industry and academia. The correct way to establish the appropriate level for the national laboratory is to survey the industry and to cater for the general requirements. There will always be one customer who needs an above-average traceable calibration but these should be treated as special and sent to another laboratory that can provide the service, even if it is in another country.

To cater for the demands of its country, the national laboratory also needs to evaluate the cost-effectiveness of maintaining the required level in each discipline of metrology. In Europe, the various countries have recognised that, even in their environment, not every national laboratory can be everything to everybody and they have agreed to have different areas of speciality while maintaining the general requirements for their industry. In some developing counties, the national laboratory is no more than a "post office" which co-ordinates the flow of work to suitable, accredited laboratories in other countries or even economies. The national laboratory also ensures that the work being performed is what is required by their customers and is recognised by the various regulating bodies of their country.

The biggest challenge that faces all metrology laboratories is the availability of suitably qualified staff. It is often said that the head of a national laboratory should at least have a PhD but this is clearly not correct. The staff level needs to be such that they can provide consistently good measurement results and be competent to know what is required to achieve this. So, if the country only has a "post office", it does not need much more than a clerical person with a good understanding of how the international traceability and accredited facilities work. On the other hand, if the organisation is of national research institute level, it will need to have people with suitable qualifications to manage the complicated mathematics and system requirements.

Similarly, if the workload at the national laboratory is such that it does not require specialist staff for every discipline, it is quite easy to combine several of the disciplines under one or two fields. Many high level laboratories group the electro-magnetic and mechanical fields simply as two sections with appropriate cross-trained staff in each group.

Three factors of great importance to metrology laboratories are environmental control, work and storage space, and electrical power supply. Good care must be given to these as the best equipment in the world will not function correctly at the required uncertainties if these are not correctly maintained.

Environmental control is not difficult if it is correctly planned and installed but is a nightmare to fix if you try to patch it up after the main installation is complete. Most of the laboratories will require a temperature control of 23 °C ± 2 °C for high level work and ± 5 °C for general purpose work. Traditionally, the dimensional laboratories have worked at 20 °C and sometimes require a tighter spec of ± 1 °C. It is, however, better to have a good stable temperature than the ideal set point. What is of equal importance is the temperature profile of the whole laboratory. The correct use of diffusers will spread the conditioned air evenly around the laboratory so that there are no direct draughts over any specific work space. Humidity control is of less importance but needs to be maintained at around 45% ± 10% RH.

Normally, environmental control requires two stages with an interlocked system to maintain these conditions well. The first stage is that the general building air conditioning provides a comfortable working environment, and the second is that the laboratory is controlled within that zone. This means that the laboratory conditioning unit only has to contend with the small variances of the building environmental system and not the full fluctuations of the external weather conditions. In this case it generally not necessary to have an airlock between the general building and the laboratory. The laboratory should also have a small amount of positive pressure (through a dust filter system) to keep the outside air and dust out of the laboratory.

Having the correct workspace makes the job much easier. Care must be given to having stable, non-static and deep work surfaces at a convenient level above the floor (this varies depending on the country and the average height of the staff). The metrologists will frequently need to stand and sit, so the right chairs or stools are also required. It is very useful to have the external work brought into the laboratory on a trolley that is at the same height as the work surface so that the work can be left on the trolley while being calibrated. This is obviously not possible in all cases but, where it is, it can save a great deal of time and physical effort.

The pre-calibration storage area needs to be at the same temperature as the laboratory and preferably have power available on the storage racks so that equipment due to be calibrated is allowed to soak at the laboratory temperature under power.

The electrical supply and lighting is frequently overlooked when establishing a laboratory. The lighting in the laboratory needs to be >500 Lux over the work surfaces and about 300 Lux in the storage areas. Some laboratories like to have a combination of fluorescent and incandescent lights so that, if they are doing an electrical noise sensitive measurement, they can turn off the fluorescent lights (they generate a great deal of electrical noise).

The power must be checked to ensure that all the plug points per workstation are fed from the same phase of the electrical supply. Various phases can cause earth loops, which will result in erratic readings and are difficult to find. The mains voltage should be at the normal supply level (e.g. 230 Vac) ± 10% and have sufficient power available to supply all the equipment without causing any voltage drops. Care must also be taken to keep items such as air conditioners and other heavy equipment on a different circuit from the laboratory equipment. It is also essential to test and confirm the earth bonding of the laboratory supply and, if it is not sufficient, then an additional "earth" system must be installed. This is particularly so in high-level electrical and temperature laboratories.

There are several books on the market which relate to all sorts of general laboratory requirements and procedures. It would be well worth the expense of getting some of these books before you finalise the plans for the laboratory. Two that are commonly used are a) Calibration: Philosophy in Practice - ISBN 0-9638650-0-5 b) The Metrology Handbook - ISBN 978-0-87389-620-7

So, the real industry requirements need to be established in each discipline of metrology and then people, equipment and facilities chosen that can cater appropriately to industry. As the industry grows in competence, the national laboratory may need to upgrade its facilities to cater for the new demands, but this is generally not an overnight requirement. **The most important issue is that the national laboratory is capable of producing traceable calibration with competence and efficiency at the level required by its market.** Establishing a national facility with the highest level of accuracy and then being unable to calibrate basic products will mean that industry will lose faith in the national laboratory and seek traceable calibrations from another source.