METROLOGY SOCIETY OF AUSTRALIA

MEASUREMENT

MADE

SIMPLE

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First Edition

Everyone makes measurements, but a little knowledge and application of formal metrological methods, can make the difference between a poor quality result, or a competent and defensible one. Metrology is the science of measurement. It is the "invisible" bedrock of all measurements performed by everyone, everywhere, anytime. Behind these measurements stand the units defined and continuously developed and refined over time by nations who are signatories to the International Treaty of the Metre, operating through the International Committee on Weights and Measures (CIPM) and the International Bureau of Weights and Measures (BIPM), headquartered in Paris, as well as the National Measurement Institutes of each country and the commercial, industrial and institutional metrology laboratories who disseminate the units, within Quality Systems and formal accreditation infrastructures.

To illustrate the basic concepts in metrology consider a simple example; the diameter of a round hole in a metal part which is required to be 15.230 mm with a tolerance of ± 0.01 mm, and which is measured and reported as 15.234 mm. Two questions immediately arise: (1) What is the uncertainty of the measurement, and (2) Does the piece comply with the specification?

A measuring system which is METROLOGICAL ensures measurements are fit for purpose, valid, and sufficiently accurate:

1. To be FIT FOR PURPOSE, it is critically important that the level of uncertainty appropriate to the purpose of the measurement be considered in the context of its cost, not only the level of sophistication of the instrumentation and the test methodology, but just as importantly the level of expertise of the personnel performing the measurements. A measurement which is unnecessarily accurate (and expensive) is ultimately uncompetitive, just exactly the same as a measurement which is not accurate enough to fulfil its intended purpose. The very low uncertainty for the diameter of the hole in our example may be needed if the part is manufactured for a critical part.

2. A VALID result means that it is technically correct using the correct instruments in the correct manner, within the known and understood limitations of performance – and doing so in a demonstrable manner. It also means that measurements of the same measurand (the well defined physical quantity whose value is to be determined, e.g the diameter of a hole in a metal part in our example) taken by different people, at different times, in different places are consistent. This begins by ensuring that the measurements have the property of traceability – that is that they are truly related to the SI unit for that physical quantity. In our example, if the diameter of a hole in a metal part is reported as 15.234 mm, this means exactly, that the value of the diameter is 0.015234 times the value of the SI unit of length, the

metre. It means there is a documented chain of physical tests and calibrations which link the SI unit to the final measurement taken by the end-user in the field.

3. The colloquial concept of accuracy is expressed by the MEASUREMENT UNCERTAINTY which is formally associated with the measurement value. It is only through the value for uncertainty (for example, the uncertainty associated with the diameter measurement of our example may be ± 0.004 mm), that the result has sufficient meaning. Evaluation of the uncertainty involves a clear understanding and specification of what physical quantity we are measuring, that is, specification of the measurand, and is often associated with the context or purpose of the measurand. It requires a measurement model to be developed which includes all the relevant input and influence quantities and parameters, usually mathematically in the form of an equation, but sometimes in the form of empirical relationships between the input and output variables. It requires determining and assigning the correct values and appropriate statistical descriptors and parameters to each of the input quantities, and finally, combining the uncertainties of each of the input quantities into a single result. Then a properly metrological result might be expressed something like:

   The diameter of the circular hole in the part, at a temperature of 25 °C, is 15.234 mm ± 0.004 mm at the 95% level of confidence, with a coverage factor of 2.3 (or equivalently, with 8 degrees of freedom).

   This statement tells us clearly what we are measuring and under what conditions (the measurand), its value and uncertainty, the probabilistic level of confidence associated with the uncertainty interval, and the “statistical strength” of the estimated uncertainty in the form of the degrees of freedom, or the coverage factor. Without all this information, the statement is incomplete. Only on the basis of this information, is it possible to make a rigorously valid statement about whether the actual piece measured complies or does not comply with the stated specification.

If you still need to know more about whether the measurements you are making are fit for purpose, you may like to talk to a metrologist. If so, contact the secretary of the Metrology Society of Australia who will advise your options. The Metrology Society of Australia is an association of professional metrologists, engineers, scientists, technicians and measurement experts throughout Australia, who measure, evaluate, calibrate, maintain, educate and train, design, sell, invent and develop measurement technologies and the Science and Art of Metrology. The Society hold a bi-ennial conference, and holds talks, evenings and social events to promote the professional development of its members and to promote the practice and interests of good measurement practice.