THE AUSTRALIAN METROLOGIST

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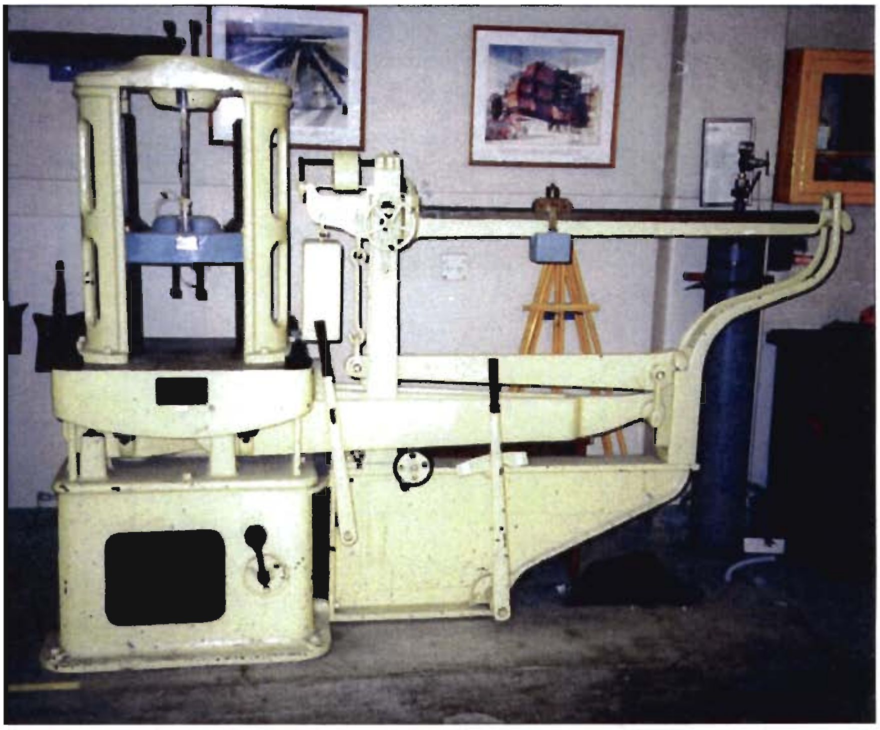

Riehlé Testing Machine – Metrology in Retrospect

The Australian Metrologist
is published four times per year by the Metrology Society of Australia Inc., an Association representing the interests of metrologists of all disciplines throughout Australia.

Normal dates of publication are mid-month in February, May, August and November.

All editorial copy should be sent to the editor by the middle of the month prior to publication.

Further information regarding the Metrology Society of Australia may be found on the Information Page.

From the Editor

February does not seem to be a good time to schedule TAM, and I was not in a position to compile this edition until over a month after the closing date for contributions. Technical difficulties then plagued preparation - unfortunately an excellent article by Bob Frenkel had to be held over to the next issue.

However, I'm sure you will find some good reading inside - from Jeff Tapping's article on assessing conformance to specification to Julian Holland's new Metrology in Retrospect article on a testing machine installed in Adelaide.

I'm sure you will enjoy the latest deep thoughts from a shallow(?) mind!

Please send plenty of contributions for the next issue as soon as possible to allow me to get the TAM schedule back on track.

Letters to the Editor are always welcome.

- *Maurie Hooper*

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MSA 2001 Gold Coast Oct 2nd-4th

EVERYDAY METROLOGY

Progress Report and Second Call for Papers

Planning is well under way for the MSA 2001 Conference "Everyday Metrology - A Vital Cog in the Wheels of Industry" and we thought we could give you an update on the progress. First of all, let us remind you that, in addition to showcasing the Society at its major biennial event, we have tried to achieve two extra aims : establishing a better base in Queensland and giving members the opportunity to combine attendance at the conference with a family holiday on the Gold Coast.

Conference Format

The conference venue is the Grand Mercure Hotel, Broadbeach.

Tuesday October 2nd

10 am Welcoming Address

First Plenary Lecture Sessions

6 pm Welcoming Function

Wednesday October 3rd

9 am Second Plenary Lecture Sessions

7 pm Conference Dinner

Thursday October 4th

9 am Start

Workshops and Sessions

5.30 pm Conference Closure

In addition, the NML Melbourne Branch staff will be presenting a one-day course on Uncertainty on Monday October 1st at the same venue but as a separate event. On Friday, October 5th, the Queensland members will host a golf day on one of the fantastic Gold Coast courses which will be a splendid way to round off the week for any standard of golfer.

Conference Content

The conference will consist of plenary lectures, oral and poster presentations, trade displays and the following workshops :

Calibration - the Basics
ISO 9000 Calibration Requirements
What to Calibrate
Calibration Service Providers
Report Interpretation
Uncertainty - the Basics
TAM Instrument Adjustment
Auditing
Open Forum

Conference Fees

Full Registration : Members $200, Non-members $300

One Day Registration Members $100, Non-members $150

Full registration includes the cost of morning and afternoon teas, a copy of the conference proceedings, attendance at the dinner and welcoming function on the first evening. It does **not** include lunch. Extra dinner tickets will be available at a cost of $50 per person.

Venue

The conference venue is The Grand Mercure Hotel, Broadbeach. It is centrally located in Broadbeach, a short walk to the beach and connected to Jupiters' Casino by monorail. Accommodation includes free undercover parking, use of the tennis courts, health and fitness centre, swimming pools, spa and sauna. The Oasis Shopping Centre is located at the rear and under the hotel and offers a large choice of restaurants.

Accommodation

The Grand Mercure is offering accommodation at $135 per room per night, single, double or twin share. This does not include breakfast. There are many apartments within walking distance (less than 1500m) of the hotel. These include :

Victoria Square Apartments	07 5592 1794
King Tide	07 5531 7124
La Grande	07 5592 5350
Cascade Gardens	07 5592 0567

San Mateo	07 5561 0444
Old Burleigh Court	07 5570 2211

The Grand Mercure will be providing a registration form for delegates and they will be handling the accommodation. It will be the responsibility of delegates to arrange their own accommodation.

Air Travel

Ansett Australia will be the official carrier for the conference. They have offered us a terrific deal: a 50% discount off the full adult economy class airfare or, alternatively, the "Best Fare of the Day". To avail yourself of this offer, phone Ansett Sales **1313 00** and quote the Masterfile No. **MC01388**.

Sydney-Gold Coast Return	$321	+Tax	+GST
Melbourne-Gold Coast Return	$466	"	"
Adelaide-Gold Coast Return	$491	"	"
Perth-Gold Coast Return	$761	"	"

Sponsorship

Letters have gone out to several potential sponsors for the conference, detailing the various ways that they might be involved. We would welcome suggestions for others whom you think it would be worthwhile approaching.

Format of Papers

We will employ the same format for papers as used in the preceding MSA conferences viz. 5 page limit, two columns on A4, 10-point Times New Roman font or equivalent. Electronic versions are encouraged; alternatively, 3 hard copies will be required.

Oral and poster sessions will be finalised after papers are submitted and reviewed. We hope to have submissions on all the topics and issues that have been covered in previous conferences :

Traceability, innovation, environment, medicine, legal aspects, chemical standards, instrumentation, international developments.

Submission

Abstracts for papers and posters are to be submitted to Tony Collings by April 1st and papers by May 30th. Authors will be notified of acceptance as soon as possible and provided with complete details of format.

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Shane Brann	Shane@vms.net.au	07 3344 1866

The Brazilian Metrology Society

The MSA has signed an Agreement of Cooperation with The Brazilian Metrology Society. The text of the Agreement is as follows:

The undersigned organizations understand and strongly believe that it would be of great benefit to both organizations to have a more active membership. Giving to all members an opportunity to be kept more informed of events in international metrology and related activities through this Agreement of Cooperation will aid this objective.

Both organizations shall act to share information by having members of similar subcommittees of their respective organisations set up regular lines of communication. Each shall include the partner organisation on its mailing lists for members' bulletins. In its regular publications each organization shall offer and provide space for publishing current activities of the partner organization.

Both organizations shall seek to identify potential areas of cooperation, including the following:

* *Exploring the possibility of presenting papers at each other's conferences and promoting these conferences in all available newsletters.*
* *Making joint submissions to such international bodies as IMEKO.*
* *Identifying issues of national importance in which metrology is a critical factor and promoting joint activity between their national economies at a governmental level on such issues.*
* *Facilitating visits by each Society's members to the partner's country for technical interaction.*

Unless otherwise stated, each partner shall cover its own costs of participation in any cooperative activity.

This Agreement of Cooperation is the appropriate instrument under which joint projects, studies and other cooperation can be established, with the understanding that each action shall be individually stated and approved by both partners before its execution. Until further notice, as a formal means of communication, the undersigned members will serve as Liaison Delegates to interact on behalf of their organizations with the partner organization.

The Agreement was signed in very formal proceedings (and magnificent surroundings in the State of Sao Paulo's equivalent of Government House) during the Opening Ceremony of Metrologia-2000, a major metrology conference held in Sao Paulo, Brazil in the first week of December. The MSA's Honorary Secretary, Laurie Besley, represented the MSA and the Brazilian Society was represented by its President, Prof. Mauricio Frota, and the President of its Council, Mr Ozires Silva.

Laurie was attending the Congress on behalf of the National Measurement Laboratory but had initiated contact with the Brazilian Society of Metrology (BSM), who were the organisers of the Congress. The BSM had immediately suggested a formal agreement that might facilitate cooperation between the two Societies and the MSA Executive had agreed. The MSA now has a plaque embossed in natural Brazilian gemstones commemorating the occasion.

The BSM clearly has a major presence on the Brazilian scientific scene. It is Brazil's representative at the International Measurement Confederation, IMEKO. Its patrons include very senior representatives from many of Brazil's major industrial companies. The BSM was the major organiser of this Congress, which was attended by some 1700 registrants. In addition the Society managed to attract the attention of the Brazilian Minister for Science. He hosted a special two-hour discussion between on the one hand, the science and technology ministers from many of the states of the Brazilian federation, and on the other, a number of the foreign delegates to the Congress, on the importance of metrology to a modern national economy

The MSA feels that association with such a group can only be beneficial to us. Watch this space for the results of the cooperation.

MSA South Australia

A meeting was held in November with the informal-talk format that has proved to be popular recently. First Les Felix told the group of some of the error components in calibrating manometer pressure meters. Next, Richard Duncan gave us a run-down on the mode of operation of the ISO committees of which he is a member. It seems that there is no fixed method, but generally it is an incremental progression from a list of topics though a series of circulated drafts. Richard described ISO as having been a massive paper-production machine, but recently he attended a meeting for final approvals where all documents were circulated in software form, and all final amendments done on a lap-top connected to a projection screen. Delegates were offered amended versions on floppy disk. One delegate did not even bother to bring his lap-top because he read all the stuff in advance and knew he could get the final versions over the Internet. It looks like we could actually be moving towards a paperless society.

The Metrology Society of India (MSI)

The MSI has sent to the MSA the July 2000 edition of their Society journal MAPAN, which contains articles on the following:

* *"Impact of New Schedule VII-Heading B on Consumers and Manufacturers of Weighing Instruments with Dial as Indicating Device."*

* *"Development of International Temperature Scales and ITS-90."*

* *"Standardisation in Electrical Steel Sheets and Strips."*

* *"R&D File: Cutting Road Noise."*

I will happily provide to members copies of any of these MAPAN papers on request.

Laurie Besley

Hon. Secretary, MSA

DEEP THOUGHTS FROM A SHALLOW MIND

I was sitting in my shed the other day trying to daydream, but my mind kept wandering. I was thinking about my friend Jeff Tapping and the problems he has been raising about the ISO Guide to the Expression of Uncertainty in Measurement. I thought I'd see what all the fuss was about, so lacking a copy of this esteemed publication, I jumped on my bike and made for our local second hand bookshop. When I got there, the sign on the door said "Open 24 hours", but the owner, a nice little old lady, was locking up. I said, "Hey, the sign says you're open 24 hours". She said, "Yes, but not in a row".

I eventually talked my way in and found dozens of copies of the Guide, all stacked on the Mystery shelves. According to the NLOL, the Guides were brought in by a strange assortment of misfits and eccentrics with glazed and confused looks on their faces, calling themselves Metrologists. These Metrologists had given up trying to understand the Guide and had traded their copies in for lighter reading, generally mathematical texts like "A Gardeners Handbook for the Extraction of Roots", "Dental Care for Decaying Exponentials", and "The Laplace Transform - Before and After".

I happened to have a copy of a mathematics book I wrote a few years ago, "How i Solved my Imaginary Problems", in my saddlebag, so I traded it for a copy of the Guide. Riding back to the shed, I went through a stop sign and a policeman pulled me over. He said, "Didn't you see the stop sign?" I replied, "Yes, but I don't believe everything I read".

Eventually, I got back to the shed and began to read the Guide. It's not that difficult. This guy ISO is writing about a student who goes round distributing tea. The student is probably in the Salvation Army or Meals on Wheels, and he's giving the tea to the poor and needy. Perhaps ISO is a friend of the student and helps him give out the tea.

The normal distribution had me worried for a while. Initially I believed that ISO was upset with the number of boring and dull people in the world, who he called Type B people. Several times, he proposed quite a rude course of action, using a uniquely Australian term, for some of the squares in the population, and my expectation was that ISO was proposing to distribute normals, or Type A people, to create a happier world. I was wrong. I soon discovered that ISO used normal distribution and bell distribution interchangeably, and then I understood. ISO and the student were also giving out bells to the poor, probably to ring them to attract attention to their plight.

So, the ISO Guide is actually a political manifesto. ISO and the student are redistributing tea and bells from the rich to the poor, and the amount they distribute depends on the degree of freedom of the society, calculated by these two other guys, Welch and Satterthwaite. I must admit that I am a little puzzled as to what the needy will do with the rectangles and triangles.

Having solved the ISO Guide conundrum, I leave you with some more important questions:

1. Who wrote "Das Kapital"?

A: Lenin B: Stalin

C: Trotsky D: Marx

2. What was the pen name of the author Eric Blair?

A: George Eliot B: George Bernard Shaw

C: George Orwell D: Georges Simenon

3. What kind of bridge is the Golden Gate Bridge?

A: Cantilever B: Bascule

C: Suspension D: Steel Arch

4. What was the name of the first US space shuttle?

A: Discovery B: Columbia

C: Challenger D: Atlantis

5. Why is the third hand on a watch is called the second hand?

6 Are part-time band leaders called semi-conductors?

Oops, I better go. Out the window of the shed, I see a tramp walking by carrying a cup of tea, two rectangles, a triangle and ringing a bell. I think that bell is tolling for me!

- J R Miles

(Answers on page 16)

A New Perspective on Assessing Conformance to Specification

Jeffrey Tapping

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"Of course the conviction of 'the truth' of geometrical propositions ... is founded exclusively on rather incomplete experience. At a later stage ... we will see that this 'truth' is limited."

- Albert Einstein in Special Theory of Relativity, 1905

When a measured quantity is needed to be of a particular magnitude the requirement is usually given as a specification that the quantity be in a stated range. This practice is applied to a broad range of situations, for example height of recruits, voltage of electricity supply, size of a manufactured component, the error in a measuring instrument and weight of product in a packet. Until recently a test for conformance to a specification was on the basis of a simple measurement of the quantity without an associated uncertainty, with acceptance if the result was within the range and rejection if it did not. With the advent of uncertainties the situation became less clear-cut. The result of a measurement was then a range of values rather than a single value, so the test for conformance involved superimposing one range on another. If all of values in the range representing the result met the specification, or none of them did, the position was clear, the result met or failed the specification respectively. But if the range of the specification and the range representing the result overlapped a dilemma arose as to whether there was conformance or not: the outcome was seen as ambiguous.

Initially there was confusion, with some just ignoring the uncertainty and using the old criterion, and some requiring that conformance be clear (that is, an overlap was a failure). One directive was that the two parties involved (say the manufacturer and the client), should just come to an agreement on how to interpret the overlap situation. The subject now seems to be stumbling on, with a general feeling of unease surrounding it and no satisfactory solution emerging. Reference 1 describes the problem in detail, mentions some approaches taken, and makes a plea for more discussion. Reference 2 gives a method for making a decision, while Reference 3 shows some potential adverse outcomes of using this method. Reference 4 laments the complexity of using uncertainties and makes a plea for something that sees the problem from an engineer's perspective.

Reference 2 assumes a situation where one party, say a manufacturer, is trying to demonstrate a claim to another party, say a customer. But it equally can be used by a customer trying to demonstrate non-conformance to a manufacturer. It directs that the overlap region counts against the claimant, that is the party attempting to demonstrate conformance or non-conformance. This system leads to the situation where the same result could give a different decision depending who the measurement was commissioned by. An unscrupulous vendor could wrongfully pass results in the overlap region knowing that such a result will be a "pass" if a challenge is made by someone else, so the system could be seen as an encouragement for dishonesty.

All of these methods are fundamentally the same, and all lead to some curious outcomes for results in the vicinity of the criterion limits. The most important is that the outcome can depend on the measurement process, specifically the uncertainty of the result. None of the existing methods give any information on how well a measurement matches up against the criteria. In the systems using uncertainty bands, the results will be affected by the level of confidence used (95% say, or 99%), and in fact the old system which ignored uncertainty was just using a sort of 50% confidence level.

And this leads to another interesting fact. For a symmetrical uncertainty band based on a 95% level of confidence there is a 2.5% probability that the true result is above the band, and 2.5% that it is below. So if a measurement is in the conformance region with one limit of the uncertainty band on the conformance limit, then it has actually passed on the basis of a 97.5% level of confidence. To get conformance to 95% confidence the uncertainty band should actually have been calculated using a 90% confidence. For a normal distribution of uncertainty this actually makes very little difference because of the non-linear shape of the wings of the distribution, but it does suggest that the method has been constructed without thought of what was actually going on. The difference may be small but for high-value products the cost could be significant.

The use of 95% confidence in calibration and measurement is an arbitrary choice. A couple of decades ago in Australia we used 99%, and changed only to conform with the weight of international practice. The arbitrariness is not important in measurement and calibration, provided we use a uniform level so that there is no confusion. Any person with a little knowledge can mentally convert from an uncertainty of one standard deviation (68%) to two (95%) to three (99.7%) or back. But in the case of conformance the choice is crucial, and the level used should be appropriate for the particular application. Further, results based on a pass/fail criterion give no information that would allow conversion analogous to that described for uncertainties. Those seeking conformance results should not be constrained in this way.

The most significant symptom suggesting absence of systematic analysis in the conformance system is that once an uncertainty band is applied to a measurement it is treated as if it is an absolute boundary. This shows the lack of appreciation of the crucial point that the result of a measurement with an uncertainty estimate is actually a probability distribution [see Reference 5], with the result indicating the centre of the distribution and the uncertainty limits enclosing a specified high proportion of the probable locations of the true value. There will therefore always be a finite probability that the actual result is outside of the uncertainty band.

A probability distribution, sometimes called a frequency distribution, is a graph of the relative probability of a quantity having particular values. The important properties of probability distributions for this discussion are, 1) the area under a section of the curve (that is, the area enclosed by two vertical lines, the curve and the horizontal axis), is proportional to the probability of the quantity having a value in the range defined by the two vertical lines; and 2) the total curve covers all occurrences, so the area under the whole curve is 1 (100%). Consult Reference 5 Clause 4, or better still a basic statistical textbook for more details. Discussion below on Figure 1 also expands on this subject.

Probability distributions can of course have a variety of shapes, but most measurement results have a distribution which approximates the normal distribution. This occurs because, according to the Central Limit Theorem [Ref. 5], the convolution (combination), of a number of distributions tends towards a normal distribution regardless of the shapes of the individual distributions. The combination is closer to normal if the components approximate normal distributions, and most components to measurement uncertainties have distributions with near-normal shapes around the mean value, even if they do not in the regions further away from the mean. Now convolution is just what we do when we combine a number of contributions of uncertainty to a measurement result, so in most cases the probability distribution of the result of a measurement will be a good approximation to a normal distribution.

So in reality, when testing for conformance to a specification, we actually have a normal distribution (or something close to it), superimposed on the conformance band, not a band on top of a band. If the test is viewed this way, there is no ambiguity region. The test is simply whether a specified portion of the probable values of the result fall within the conformance band or not. The principle can be illustrated using Figure 1, which is a graph of a normal distribution of probable values of a measured quantity. On the upper horizontal axis, M is the mean of the readings (the "most probable value" of the measured quantity), and S is one standard deviation of the distribution. The lower axis shows the area under the curve going from left to right. If the vertical dashed line is the lower limit of a specification, then the shaded area represents the probability that the actual result is within the specified band. Conversely if the line is the upper limit of a specified band then the area of the unshaded region is the probability of the result being within the band. In this figure the dashed line is 1.8 standard deviations from M, and it can be seen that in this example there is about a 3.6% chance of the true value being higher than the line and about a 96.4% chance of it being below.

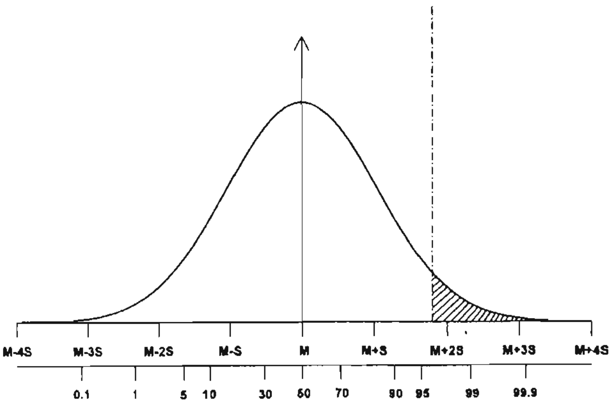

Figure 1: Normal distribution with scales of standard deviations and percentage area.

The question which arises from this is, how can we calculate the probability that the true value is within the conformance region for a particular measurement? The old method involved simple arithmetic, but calculations of probability distributions are much more complicated. The answer is that all of the tools you need are in your spreadsheet program, in the functions that generate the normal distribution. In Excel the required function is NORMDIST, and in Lotus 1-2-3 it is @NORMAL. The use of the Excel function is discussed in Appendix 1, and an example of a calculation is given in Appendix 2. As mentioned in Appendix 1, degrees of freedom of measurement results can be taken into account by using other functions, with some added complications in their application.

For the reasons given above most distributions can be considered to be normal, at least in the region around the peak, but if a distribution is believed to approximate a geometrical shape, for example a rectangular or triangular distribution, then the calculations are just simple geometrical formulae which can be easily derived. Actually any shape of distribution could be accommodated by look-up tables or curve fitting as an alternative to using a spreadsheet, even a normal distribution.

The procedure for testing for conformance is then as follows.

1. Measure the parameter to produce an estimate of the true value.
2. Compute the standard uncertainty of the estimate. This then defines the spread of the distribution of probable true values.
3. Using a spreadsheet or another calculation process, compute the proportion of the probability distribution which is within the conformance zone. This gives the probability that the true value conforms to the specification, expressed as a fraction between 0 and 1 or as a percentage.
4. Compare the probability of conformance with the required probability.

The method suggested so far already gives much more information than is available by the present methods. In addition to a pass/fail decision it shows the position of the result with respect to the conformance band: whether it is well in, marginal or well out. For the purposes of discussion here I will call the quantity derived in step 3 the Conformance Factor. This information could be used for quality control, or for reviewing marginal passes or failures. But there is an additional piece of information that could be useful.

The quality of the measurement process will affect the standard error of the result, which in turn affects the conformance factor: if the standard error of the measurement is larger, a higher proportion of false results will occur (that is, passes that should be failures and vice versa). So it would be useful to have in a report some indication of how good the measurement process was, particularly when deciding if improvements to the process, or a better process are worth looking at.

The standard uncertainty is a raw form of measure, but the most useful form of indication is a dimensionless number which relates the measurement uncertainty to the requirement. I propose that for specifications which require that the result is in certain bounds, that a number be given which is the ratio of the semi-width of the bounds (that is, x if the specification is $\pm x$), to the standard uncertainty of the measurement. I propose the term Resolution Coefficient. If the resolution coefficient is small, a high proportion of the probability distribution will spill outside of the conformance band, regardless of where the mean of the measurement is. If the resolution coefficient is large then most of the probability distribution of the measurement will easily fit in the bounds of the specification and the resolution is good. So for a resolution coefficient of one, a result which falls in the middle of the conformance band (that is, right on specification), has a 68% probability that the quantity conforms and 32% that it does not (16% that it is above the band, and 16% that it is below). This measurement process is then unsatisfactory for testing for conformance. The same result with a resolution coefficient of three would have a 99.7% probability of conformance, so this measurement process was clearly far more appropriate for the test.

A higher resolution coefficient means that fewer results deemed to fail should actually be passed. For this reason a resolution factor should be included as part of many specifications, in addition to the specification limits.

The system presented here is based on a simple symmetrical specification and a normal distribution in the measurement results, conditions that fit most requirements, but it can be easily adapted to other conditions if required. It can also be utilised as a simple yes/no system through to a comprehensive report on the statistical spread of measurements. In the discussion above the fact has been ignored that for a normal distribution superimposed on a band there is a finite (but possibly very small), probability that the true result could be either above or below the band, but this is covered in Appendix 2.

The proposed scheme has the advantage that the measurement process remains the same as in the current methods, and it is a change in the way of looking at and analysing the results rather than a different measurement approach. No scheme can compensate for an inadequate measurement uncertainty, but it is desirable that the outcome of measurements be seen realistically so that appropriate remedial action can be planned for failures. The scheme also prevents confusion and possible deception created by choosing conformance criteria that make a result looks better than it is. It also allows an incremental change from the present system towards full implementation of the proposal. Some may find it uncomfortable because it reveals the fact that there is always some chance that a measurement that seems to pass in fact fails, and vice-versa. But hiding from uncomfortable facts is not a recipe for good outcomes.

With this system many options open up for tailoring specifications to suit individual needs. One for instance is to have a conformance factor which varies according to the resolution coefficient of the measurement to reduce the risk of results which appear to pass actually being significant failures. By having a realistic picture of what outcomes actually are, those in specialist areas are best able to take the system and use it in a way that suits their requirements.

In conclusion, a system has been presented for judging conformance to specifications which is superior to existing systems. It is more realistic and more flexible than those currently used, and gives much more useful information where needed. It necessarily involves more calculations, but these can easily be done with a spreadsheet or a custom-made calculation program. It is a move away from uncertainties (which many find confusing), towards probabilities which are part of every-day life for all of us and are therefore more easily understood.

Appendix 1: The Spreadsheet Function

The Excel function we will use has the following form:

NORMDIST(X, M, S, T)

where

X is the value of the specification limit,
M is the measured mean of the distribution,
S is the standard deviation of the distribution,
T is a flag indicating which of two possible forms of the function we require. For our application the value "true" is entered.

The function calculates the fraction of the total area under the distribution which lies to the left of the value X, and so the result varies between zero and one. If the fraction to the right of X is required, the result is simply subtracted from one.

The function which takes into account degrees of freedom of the measurement result is TDIST in Excel, and in Lotus 1-2-3 is @TDIST. The use of these functions is more complicated for two reasons. First they refer to the Student's t Distribution curve (see Reference 5), which has a central value of zero and horizontal-axis units of standard deviations, so some arithmetic is necessary to get units and zero's to correspond. Secondly they can only cover half the distribution curve (they are intended for quite a different purpose), and some logical and arithmetic steps are needed to take account of all circumstances. But I have worked out a procedure and it is available to anyone who would like it.

Appendix 2: Calculation Procedure

For this example we will consider a case in which the diameter of a rod is measured, with the following outcome:

M is the measured diameter,
S is the standard uncertainty of the measure ment (that is, the standard deviation of the prob ability distribution of the measurement result),
D is the required diameter,
±T is the specified tolerance,
L is the lower limit of the tolerance band, equal to (D-T),
U is the upper limit of the tolerance band, equal to (D+T).

Figure 2 illustrates a probability distribution of such a measurement superimposed on the tolerance band. This figure is similar to Figure 1, but with the lower limit of a conformance band at the dashed line labelled L, and the upper limit labelled U. The fraction of the area under the curve which is below the lower limit is given by:

NORMDIST(L, M, S, TRUE)

And the fraction of area which is above the upper limit is given by:

1 - NORMDIST(U, M, S, TRUE)

It can be seen that in the example in Figure 2 the proportion of the distribution below the lower limit is negligible. In most real cases one tail or the other will be negligible but may not be if the standard uncertainty S is comparable to the width of the band (that is, the resolution coefficient is low).

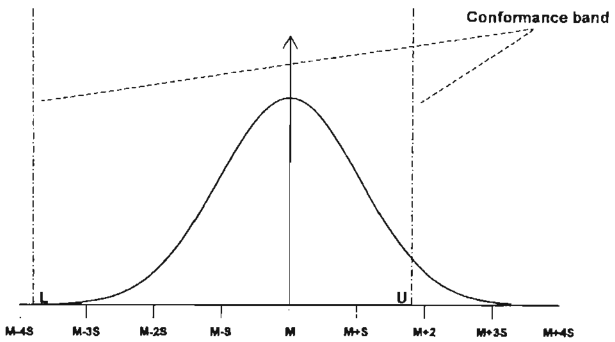

Figure 2: Probability distribution superimposed on a tolerance band.

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4. Parrish, C.J., "Engineering Measurement Uncertainty: a plea for simplicity", Quality Today, April 2000, page 10.

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Metrology in Retrospect

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A Testing Machine for Adelaide

In February 1901, Robert Chapman wrote to the finance committee of the University of Adelaide for permission to order a testing machine for the new engineering department.[1] The University of Adelaide was founded in 1874, a generation after the universities in Sydney and Melbourne. Engineering was established a little later in Adelaide than at the older universities. Chapman had not long graduated from the University of Melbourne (B.A. 1886, M.A. and B.E. 1888) when he became an assistant lecturer in mathematics and physics at Adelaide.

In preparing for an independant engineering course - he became the lecturer in engineering in 1901 - Chapman sought to equip an engineering laboratory. He had consulted various colleagues including Professor W.H. Warren at the University of Sydney. Although Sydney had acquired an English testing machine on Kirkaldy's pattern[2] Chapman looked to purchase a different sort of machine. 'I have decided upon the type of testing machine apparently most suited to our requirements', Chapman informed the finance committee. This was a 'U.S. Standard 100,000 lbs. Testing

Machine, Automatic and fitted with G. Henning's autographic recorder - complete with battery, countershaft and tools for tensile, transverse and compressive strains', manufactured by the Riehlé Brothers Testing Machine Co. of Philadelphia. This for £380 (£402.10s with various accessories) was considerably cheaper than the £600 Sydney had paid for its Kirkaldy machine 15 years before.

The firm which became Riehlé Brothers seems to have begun in Philadelphia in 1825, presumably as one of the antecedent firms, Abbott & Co. or Banks, Dinmore & Co. According to the earliest catalogue I have seen the Philadelphia Scale Works as such was established in 1846 but it seems to have been quite some years later that the brothers Riehlé took over the business. At all events it was a well-established manufacturer of a wide variety of scales when the firm was approached in 1866 by a man with a problem. The firm was engaged in manufacturing a relatively new development, platform scales. With expanding agriculture and technology, the market for cattle and hay scales, railway track scales, furnace charging scales and so on, was keeping the Philadelphia Scale Works busy.[3]

For some reason Mr Fulton of S. Fulton & Co. of Conshohocken, Pennsylvania, thought the Scale Works could solve his problem. His company manufactured cast-iron pipe that was being supplied to a contractor installing the pipe for the City of Boston. Unfortunately many of the pipes were getting broken during shipping and installation, or failed after a short time. As a result Boston was withholding substantial payment. Fulton and the contractor were suing the City for their money.

What Fulton wanted from the Scale Works was a machine to test the quality of his cast iron. In the quagmire of opinions this was the only way to get some cast-iron facts, as it were. The firm took up the challenge, apparently reluctantly, and before long had devised a substantial machine that could break samples of the metal and measure the force required to do this. The machine consisted of four very solid timber pillars on which were mounted crosspieces. From a "Justice" hydraulic jack secured at the top of the frame was suspended a crane beam scale to which the upper grip for holding the specimen was attached. The lower grip for securing the specimen was attached to the lower crosspiece. With the small specimen of iron mounted between the grips a "Justice" hand pump began to work the jack while weights were adjusted to maintain the scale beam horizontal. In due course the specimen broke and a certificate was issued. The result was apparently a vindication of the quality of Mr Fulton's iron as he bought the machine as evidence - for $350 - and before long he and the contractor had won their suit with the City of Boston.[4]

In fact this was not the first testing machine to be built and used in Philadelphia. In the early 1830s the United States Treasury had approached the Franklin Institute of Pennsylvania to investigate explosions in boilers. For this a machine was constructed of heavy oak timbers on which hundreds of careful tests were made.[5]

The Franklin Institute machine was a one-off. Mr Fulton's machine was the beginning of an industry. With the publicity of the legal case, other pipe manufacturers soon wanted testing machines for themselves. The Scale Works found itself repeating and modifying the original machine, 'and in time [according to Tatnall's account] every single pipe works in the United States had been supplied'. In 1870 the Supervising Inspector of Steam Engineering in the United States invited Riehlé to build ten boiler-plate testing machines. Up to that point Riehlé had followed the prototype in making machines with substantial wooden frames. The new contract called for the machines to be 'all metal'. After several years of experimenting with the use of these machines, the government in 1877 made it compulsory to test samples of all plate used in wrought iron boilers. The market for testing machines began to expand rapidly.

Riehlé Brothers exhibited their testing machines along with their other manufactures at that showcase of American and foreign industry, the Centennial Exposition held in Philadelphia in 1876. About the same time the firm was developing a universal testing machine to be pitched to the expanding iron and steel industry. The great new machine was launched in 1880 and the industry centred on Pittsburgh proved receptive. Reportedly, 'every mill but one in that vast and crowded region ordered a testing machine'.

The principal designer of Riehlé's testing machines during the 1870s was the firm's superintendent, Tinius Olsen. It is a measure of the strength of the market for testing machines that Olsen set up his own testing machine business in 1880 which within a decade rivalled Riehlé Brothers. Other firms in the United States were also beginning to manufacture testing machines about that time. With the growing emphasis on testing machine manufacture, the opportunity arose for Riehlé Brothers to sell the scale side of the business. The firm became Riehlé Brothers Testing Machine Co. in the early 1890s.

It was under this name that the firm mounted an extensive display at the World's Columbian Exposition held in Chicago in 1893. This no doubt only aided the international recognition the firm had already gained. In 1891 it was reported, for example, that Riehlé's Latest Improved Power Tortional Testing Machine had been supplied to the Russian and Brazilian governments as well as various American firms.[6] (Riehlé had begun to apply electric motors to their machines in 1890.)

In addition to firms and governments, universities were also an increasing market for testing machines. As Tatnall remarks, 'Riehlé had had a large exhibit at the Centennial Exposition in Philadelphia in 1876 which had first shown testing machines to the world in general and to the Universities in particular'. By the 1880s universities were increasingly equipping engineering laboratories, for which testing machines were an essential component. Both the State College of Pennsylvania and Worcester University in Massachusetts had purchased the tortional testing machine mentioned above. So by 1900 when Robert Chapmen was looking to equip an engineering laboratory at the University of Adelaide, Riehlé Brothers Testing Machine Co. had an established track record.

In November 1900 Chapman had received a quotation from Wm Adams & Co. Ltd in Clarence Street, Sydney, for the supply of a Riehlé testing machine and accessories.[7] This was the basis of his request to the finance committee. In September 1901 the Registrar of the University received a letter from Clarke Padley & Co. in Melbourne. They had heard that the University intended to obtain a materials testing machine and wished 'to bring under your notice the "Schencks" Machines which have a high character'. They would be glad to send an illustrated catalogue and quote prices.[8] They were far too late in the running as the order had been placed in May![9] Adams & Co. wrote in October informing Chapman that the testing machine and accesories were in the SS *Redhill*, expected to arrive about the end of November.[10]

In his letter to the finance committee, Chapman had noted that 'The machine is apparently liable to Customs duty, but I will make an effort to get it in free'. With the machine arrived in December, the Registrar wrote to the Collector of Customs about the matter of duty. In January 1902 the Registrar received a discouraging reply: 'Referring to your letter dated the 20th ult[im]o, I beg to inform you that the motor [*sic*] in question is not a scientific instrument and cannot therefore be admitted as such. It is classed as machinery liable to a duty of 25%'.[11] W.H. Bragg, the professor of mathematics and physics (and in due course a Nobel Prize-winner and President of the Royal Society of London) wrote late in January to reassure the Registrar:[12]

My dear Registrar

I think that you can sign without hesitation the declaration asked for by the Customs authorities. The testing machine and motor are "intended for scientific purposes" and "were specially imported for teaching purposes".

It is recognised all over the world that it is one of the functions of a University to make scientific tests demanding skill and accuracy: to be a court of appeal in such matters. If Mr Chapman carries out, with the aid of the new instrument, a test for the Government or any one else, the fact that you have signed this declaration will not prevent the acceptance of a fee by the University as a recompense for the expenditure of time and skilled labour by one of its officers. If it did, neither the University nor any of its officers could ever accept a fee for a chemical analysis, or a specific gravity test, or an electrical or bacteriological or any other sort of test; since in all these cases apparatus must be used, and the testing machine does not differ in any characteristic from such apparatus, in spite of its being called a machine. It is not a machine at all, in the ordinary sense of the word, as it has nothing to do with the manufacture or transportation of goods: it is only a measuring instrument, and should be classed with balances, burettes, reading microscopes, potentiometers and the like.

Faithfully yours

WH Bragg

Bragg's argument had the desired effect. The Collector of Customs wrote to the Registrar in early February: 'Referring to your further letter dated 29th January last ... I beg to inform you that I am now satisfied that this ~~motor~~ testing machine is undoubtedly a scientific instrument, and as it is to be used for teaching purposes only, I am prepared to allow it to come in duty free'.[13] It only remained for the testing machine to be set up and put to work!

Robert Chapman went on to play a prominent role in the engineering community in Australia. He was appointed professor of engineering in 1907, a post he held - with a break as professor of mathematics and mechanics, 1910-1919 - until his retirement in 1937. Not only was he a foundation member and president of the South Australian Institute of Engineers (founded 1913), but later served as president of the Institution of Engineers, Australia. He played an active part in setting up a standards laboratory in South Australia and was a member of the Australian Commonwealth Engineering Standards Association. He was knighted on his retirement.[14]

Acknowledgments

I am pleased to acknowledge the assistance I have received from several people in the preparation of this paper. In Adelaide, Kylie Percival, Archivist of the University of Adelaide, and the staff of Special Collections have been generous in guiding me through the University's rich documentation on several research visits to Adelaide. John Patterson, Curator of the Physics Museum, and Dr Kenneth Moxham of the Department of Civil Engineering also provided information. Steven Turner and William E. Worthington, Jr, both of the National Museum of American History, Washington, kindly gave me access to the trade literature collection and the files of the Specialist Section of Heavy Machinery & Civil Engineering respectively. Valerie Havyatt made a number of helpful suggestions on the first draft.

References

[1] R.W. Chapman to Finance Committee, 21 February 1901, University of Adelaide Archives (UAA), Docket 215/1901

[2] See Julian Holland, 'Facts Not Opinions', *The Australian Metrologist*, No. 17, June 1999, pp. 9-12

[3] The following account of the origins of the Riehlé Brothers testing machine manufacture is drawn from Francis G. Tatnall, *Evolution of the Testing Machine*, published by Riehlé Brothers Testing Machine Co, Philadelphia [1925?]

[4] No doubt an examination of original records would reveal a more complex sequence of events.

[5] Chester H. Gibbons, *Materials Testing Machines, an account of their development, with special reference to the tension-compression-transverse group* (Pittsburgh, 1935), pp. 16-18

[6] *The Manufacturer and Builder*, 23/1 January 1891, p. 6

[7] Adams & Co. to Chapman, 12 November 1900; photocopy provided by Dr Kenneth Moxon and forwarded to me by John Patterson. The firm begun by William John Adams in Sydney in 1884 was an important agent for numerous overseas engineering firms for a century and actively engaged in business throughout Australia; *The Bell-Wether, William Adams - an Australian company from foundation to takeover - 1884 to 1984* (Melbourne, 1984)

[8] Clarke Padley & Co. to Registrar, 6 September 1901; UAA, 961/1901

[9] Adams & Co. to Registrar, 6 May 1901; UAA, 486/1901

[10] Adams & Co. to Chapman, 28 October 1901; UAA, 1197/1901

[11] Collector of Customs to Registrar, 2 January 1902; UAA, 7/1902

[12] W.H. Bragg to Registrar, 25 January 1902; UAA, 77/1902

[13] Collector of Customs to Registrar, 5 February 1902; UAA, 108/1902

[14] R.J. Bridgland, 'Chapman, Sir Robert William', *Australian Dictionary of Biography*, vol. 7 (Melbourne, 1979), pp. 613-15

NEWS FROM AUSTRALIA'S NATIONAL MEASUREMENT LABORATORY - A RETROSPECTIVE OF THE YEAR 2000

The CSIRO National Measurement Laboratory (NML) National Facility is the holder of Australia's physical standards of measurement and the source of traceability for calibration, testing and measurement services in Australia. NML's review of the year 2000 shows a busy program, balancing international and national responsibilities.

Representing Australia's measurement system in the international sphere continues to be a significant part of NML's role, with highlights as follows.

Appointment of the Director of NML to the CIPM

Dr Barry Inglis, Director of the National Measurement Laboratory, CSIRO, was elected to the International Committee for Weights and Measures (CIPM) in July 2000. The CIPM is a committee of eminent scientists and metrologists elected under the Convention of the Metre to oversee the activities of the International Bureau for Weights and Measures (BIPM), and it plays a central role in setting the directions of international metrology. Over the 125 year history of the Convention, only around 135 people have served on the CIPM and appointees have included such notable scientists such as G Ferraris, D Mendeleyev , A A Michelson, P Zeeman , C Fabry, and L de Broglie. Dr Inglis is the fourth Australian to be appointed, so Australia has had an excellent record of representation at CIPM. While the appointment is personal and reflects the merits of the individual appointee, it is also a reflection on the standing that Australian metrology maintains in the international community.

NML - Australia's representative in International Metrology activities

As part of NML's ongoing commitment to providing an effective international interface for Australia's measurement activities, NML scientists represent Australia at peak international meetings in the various specialist metrology disciplines. Over the year 2000 senior scientists from the National Measurement Laboratory have represented Australia at meetings (including Working Group Meetings) of the CIPM Consultative Committees (CCs) for:

* Amount of Substance

* Electricity and Magnetism

* Length

* Photometry and Radiometry

* Temperature

(NML experts also represent Australia on the CCs for Acoustics, Ultrasound & Vibration; Mass; and Time & Frequency, although these Committees did not meet in 2000.)

These meetings provide regular opportunities for experts from the major National Metrology Institutes (NMIs) around the world to join with the International Bureau of Weights and Measures (BIPM) to discuss relevant technical activities in each specialist metrology area.

In addition, NML provides representation, through its Director, at the annual Meeting of Directors of NMIs convened by the Director of the BIPM in Paris, held in February 2000, and the annual General Conference on Weights and Measures (CGPM), held in October 2000.

NML scientists regularly provide their expertise at international technical meetings. Those held during 2000 include working group meetings of the International Electrotechnical Committee (IEC), the International Conference on Large High Voltage Electric Systems (CIGRE), and the International Special Committee on Radio Interference (CISPR), among others.

NML signs Global MRA

The National Measurement Laboratory joined 37 other National Metrology Institutes (NMIs) in signing a global Mutual Recognition Arrangement (MRA) in measurement, the 'Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes' in October 1999 at the BIPM in Paris. Having formally established the document, over the year 2000 the BIPM and NMIs including NML have been actively involved in the next important phase of establishing the integrity of the data that provide the technical basis for the MRA. NML is playing a key role in this process for the Asia-Pacific region, with the Director of NML, Dr Barry Inglis, having been unanimously elected by the APMP membership as the Chairman of the 'APMP MRA Advisory Committee'. In this capacity, he attends meetings of the Joint Committee of Regional Metrology Organisations and the BIPM (JCRB) to evaluate submissions of technical data to support participation by NMIs in the global MRA. The JCRB met in February 2000 in Washington and in October 2000 in Paris.

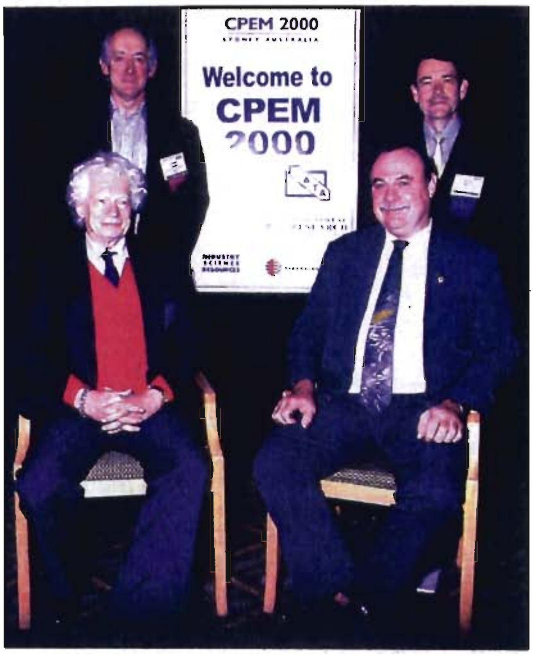
The National Measurement Laboratory proudly hosts CPEM 2000, 14-19 May, 2000

The National Measurement Laboratory, CSIRO, hosted the Conference on Precision Electromagnetic Measurements (CPEM) in Sydney from 14-19 May 2000, jointly organised with the Measurement Standards Laboratory (MSL), New Zealand. CPEM is the foremost international conference series in electrical metrology and fundamental constants, and CPEM 2000 was the 21st conference in the CPEM series. This was only the second CPEM conference to be held outside North America and Europe and reflects recognition of the growing importance of the Asia Pacific region to world metrology.

CPEM 2000 was officially opened by the Hon. Warren Entsch, Parliamentary Secretary to the Minister for Industry, Science and Resources (ISR) of the Australian Government. NML, MSL and the Department of Industry, Science & Resources were Principal Sponsors of the conference, and NATA and Standards Australia were Major Sponsors. Australian sponsors also included: the Metrology Society of Australia; the Joint Accreditation System of Australia and New Zealand (JAS-ANZ); the National Standards Commission; TransGrid, Australia; Bellinger Instruments, Australia; the Fluke Corporation, Australia; Oxford Instruments, Australia; and Texas Instruments, Australia. The conference included a comprehensive trade exhibition showing the latest in technology, techniques and trade publications.

The conference attracted 430 delegates from 43 countries. Of these, 67 were from Australia. In all, 329 technical papers were presented, covering progress in quantum effect devices and applications, and research advances in the more traditional fields of electrical and electromagnetic measurement from dc to millimetre wave, automated instrumentation, calibration systems, electromagnetic compatibility, lasers and optoelectronics, optical metrology, and a large number of papers on time and frequency. There were also reports on fundamental constants and on developments in the atomic based kilogram and other basic activities. International keynote speakers presented plenary papers on basic advances in physics, metrology in astronomy and developments in national standards and international comparisons.

CPEM 2000 coincided almost to the day with the 125th anniversary of the signing of the Convention du Mètre, which is the foundation for the harmonisation of international metrology. To commemorate this occasion, Dr Terry Quinn, the Director of the BIPM, was invited to present a plenary paper on the history and future of the Convention du Mètre and the BIPM. Members of



At the Opening of CPEM 2000: (background, L-to-R) Dr Terry Quinn, Director, BIPM; Dr Barry Inglis, Chairman, CPEM 2000, and Director, NML, CSIRO, Australia; (foreground, L-to-R) Prof Jean Kovalevsky, President, CIPM; the Hon Warren Entsch, Parliamentary Secretary to the Minister for Industry, Science and Resources (ISR), Australia.

Attendees at the 16th APMP General Assembly, held in Thailand in November 2000. Seated on the central sofa, from L to R, are the inaugural recipients of the APMP Award, Dr Jong-Chul Park of KRISS, Korea, Mr Trebor Jones of NML, Australia, and Dr Barry Inglis of NML, Australia.

the CIPM held a meeting on the anniversary day, 20 May, at Sydney Observatory and a number of CPEM 2000 delegates joined them for a luncheon to mark the occasion. Henceforth, 20 May will be known as "World Metrology Day".

With the ever-increasing emphasis on global trading and international trade agreements, the need for mutual acceptance of national standards between economies and measurement traceability within economies has never been greater. The global MRA was established to address this situation. However, its success depends on the development of more accurate and more stable standards accessible either directly or indirectly by all economies. This represents a special challenge for NMIs and was reflected in CPEM 2000 through a special provision for 'key comparisons' and a special category of support for participation by representatives of developing economies, as well as the scheduling of a special evening discussion session on participation by NMIs in the global MRA.

(See photo previous page.)

Asia-Pacific Activities

Within the region, NML has played a strong role in the Asia-Pacific Metrology Programme (APMP). Until November 1999, NML provided the Office of the Chairman and Secretariat for APMP, with Dr Barry Inglis, Director of NML, being the APMP Chairman for the period 1994-1999. Since November 1999, Dr Inglis has been the Chairman of the APMP MRA Advisory Committee, established to assist regional NMIs participate in the global MRA. NML experts chair APMP Technical Committees on Length (until November 2000) and Photometry & Radiometry.

At the 16th APMP General Assembly in Bangkok in early November 2000, Mr Trebor Jones (retired from NML, CSIRO) and Dr Barry Inglis each received an APMP Award recognising their "prominent and long-term contributions" to regional and international metrology. Mr Jones was the inaugural Regional Coordinator of APMP in 1980.

NML continued a number of bi- and multilateral projects with partner NMIs from the Asia-Pacific region over the year 2000, to assist in the development of their national standards of measurement. These projects involved the National Metrology Institutes of: Malaysia, the Philippines, Thailand, Vietnam, and Indonesia. Funding was generously provided by the Australian government's Department of Industry, Science and Resources (ISR), the Australian Agency for International Development (AusAID), the World Bank and the Asia-Pacific Economic Cooperation (APEC). The projects involve training attachments for staff from recipient laboratories at NML and training visits by NML staff, as well as bi- and multi-lateral measurement comparisons to evaluate capabilities.

In early December 2000, a 4-day workshop for quality managers of NMIs was run by NATA and NML in Singapore. The workshop was funded by APEC and hospitality was generously provided by the Singapore Productivity and Standards Board.

(See photo previous page)

Review of South African Standards and Conformance Infrastructure

Over the period March-December 2000, with NATA as the primary coordinator, an Australian consortium involving NML, NATA, and Standards Australia, joined with South African consultants (Bentley West) to undertake a review of the standards and conformance infrastructure in South Africa.

Multi-lateral CMM Project with PTB, Germany, and NRLM, Japan

Through a project funded by the Ministry of International Trade and Industry (MITI), Japan, NRLM (Japan), PTB (Germany) and NML (Australia) are collaborating in a project to develop a method for calibration of Coordinate Measuring Machines (CMM). The project builds on earlier work by PTB and NPL (UK), and aims to build a software simulation (Virtual CMM) for calculation of uncertainties in CMM measurements. In order to produce the simulation, many parameters of CMM performance will need to be established by physical measurement as well as theoretical analysis. The project spans the period from 1999 to 2002, and the output will be the basis for an international documentary standard to be promulgated through ISO/TC 213.

Time and Frequency Measurement in the Asia-Pacific

The installation of NML-developed international time comparison systems was completed at five national standards laboratories in SE Asia (Thailand, Indonesia, the Philippines, Malaysia and Vietnam). The project was funded by AusAID. The systems consist of an OEM Global Positioning System (GPS) receiver, a PC running the LINUX operating system, and some additional timing hardware. The major innovation of the system lies in the software, and its ability to be maintained and diagnosed remotely by NML. Ten systems are presently in operation in the Australia/Asia-Pacific region.

Reference Gas Mixtures

NML has received funding from ISR to establish a gravimetric and analytical facility for the production of reference gas mixtures for Australia's natural gas industry. The first phase of this project was completed in mid-2000 with the purchase of a suite of equipment for this purpose. In the second phase, the facility has been made operational and the first reference mixtures will be produced before the middle of 2001. The project is scheduled for completion in mid-2002. The outcome for Australia will be the ability to provide legal traceability to national standards for all measurements of the composition of natural gas. This will provide a firm basis for both custody transfer of gas within Australia and gas exports overseas. It is planned that the facility's ability to produce reference gas mixtures will be extended to other areas in the future, including standards for vehicle exhaust emissions, Greenhouse gases and air quality monitoring.

Accreditation of NML's Calibration Services

NML delivers its calibration services through 11 metrology discipline oriented 'projects' and the Melbourne Branch. The discipline oriented projects are based in Lindfield, Sydney. They are Standards for Mass & Related Quantities, Optical Radiometry, Temperature, Length, Power Systems Technology, Time & Frequency, Resistance, Acoustics & Vibration, Low Frequency, Radio Frequency & Microwave and Impedance. The Melbourne Branch based at Clayton, Victoria delivers services in the metrology areas of Pressure, Dimensional & Engineering metrology, Electrical (DC), Time & Frequency and Electrical (Impedance).

At present seven NML projects at Sydney, and two areas of the Melbourne Branch have been accredited by NATA to ISO Guide 25/ ISO 17025. In addition the Acoustics & Vibration and the Low Frequency projects, and the Time & Frequency and Electrical (DC) areas of Melbourne Branch have been assessed and recommended for accreditation subject to a few conditions being satisfied. The technical assessors for these assessments were drawn from the national metrology or equivalent laboratories of Canada, France, Germany, Indonesia, Japan, New Zealand, Singapore, South Africa, Chinese Taipei, USA, Switzerland, Sweden and Korea. It is anticipated that the accreditation of NML's calibration services will be completed by mid-2001.

Calibration Services for Australian industry

Within Australia, NML continued to provide a range of services to the Australian measurement community. Calibration services are provided to NATA-accredited calibration laboratories, and directly to industry in cases where services are unavailable through NATA-accredited laboratories. [Year 2001 details are available from Ms Darien Northcote (ph: (02) 9413 7180)].

Measurement Uncertainty Courses were run throughout Australia to provide training and assistance in interpreting the ISO Guide to the Expression of Uncertainty in Measurement. Both one day and three day courses are available. [Year 2001 details are available from Ms Jan Brett (ph: (03) 9545 29650]

NML's Temperature Measurement Course, 9-11 October 2000

The biennial NML Temperature Measurement Course was held from 9-11 October 2000 at the National Measurement Laboratory. The course attracted 60 participants from Industry and the two major distributors of temperature measuring instrumentation as exhibitors. The course provides an opportunity to gain knowledge about general principles of measurement as well as specific techniques in thermometry and is of value to technicians, engineers, scientists and others involved in or responsible for, work in which the measurement of temperature is important.

NML to offer Measurement Training Courses to Australia's science and technology community

The National Measurement Laboratory is in the process of formalising technical training courses in various areas of metrology to meet the needs of Australian industry, research organisations and other interested members of the science and technology community. NML's highly successful biennial Temperature Measurement Course and Measurement Uncertainty Course will be part of a suite of courses to be offered, both domestically and within the Asia-Pacific region.

At this time, NML is seeking expressions of interest in order to assist in the planning of relevant courses. Please indicate whether you would be interested in courses in any of the following areas and fax a copy of this sheet to Mr Robin Bentley, Fax: +61 2 9413 7474.

Temperature ( )
Uncertainty of Measurement ( )
Electrical Measurements: Voltage, Resistance, Impedance, etc ( )
High Voltage ( )
EMC and RF Quantities ( )
AC/DC Transfer ( )
Determination of Uncertainty in CMM Measurements ( )
Length & Dimensional Metrology ( )
Time & Frequency ( )
Mass, Force, Pressure, Density, etc ( )
Photometry & Radiometry ( )
Acoustics and Vibration ( )
Ultrasound ( )
Other (please indicate below) ( )

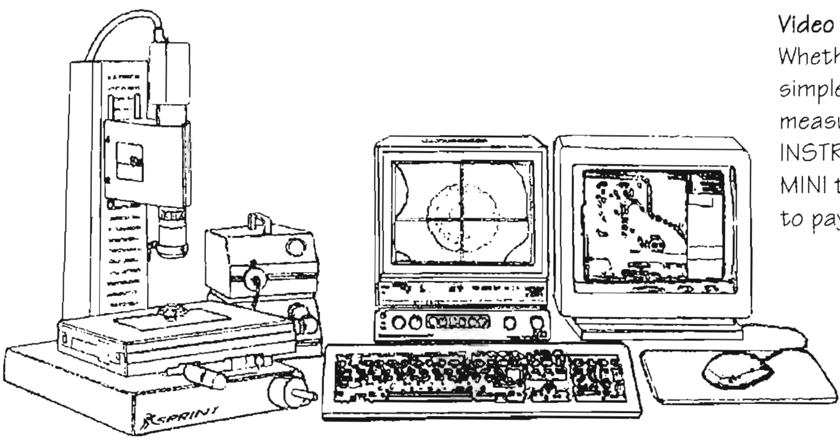
Please attach details of specific requirements and/or other comments.

For more information, please contact Mr Robin Bentley (Ph: +61 2 9413 7764; Fax: +61 2 9413 7474; E-mail: robin@tip.csiro.au).

For more information about the National Measurement Laboratory, please contact Mrs Maggie Goodwin, Fax: +61 2 9413 7383, E-mail: mgoodwin@tip.csiro.au.

Answers to DEEP THOUGHTS (from page 5)

1. D
2. C
3. C
4. B
5. ?
6. ?



METROLOGY SOCIETY OF AUSTRALIA AWARD 2001

The Metrology Society of Australia Award recognises achievement and excellence in Australian metrology and the contribution metrologists make to the Australian community. Metrology is the science of measurement. Membership of the MSA includes scientists, engineers and technicians working in government and industry from all fields of measurement in Australia and overseas.

The MSA Award is presented biennially at the MSA conference dinner. In 2001 this will take place in Broadbeach, Qld, 3rd October.

Nominations are now invited for this award. Only members of the Metrology Society of Australia are eligible. Members may self nominate or nominate another member.

The award is for work completed, or that has gained scientific or industrial recognition, in the past five years and which has contributed to the Australian economy. The work must fall into one or more of the following categories:

Basic research: Original research directed towards the significant improvement of fundamental measurements, the accuracy of derived units or fundamental constants. Solutions to difficult measurement problems, work that has fundamental importance to the development of measurement, the application of new or existing science and mathematics to new measurement applications, including the development of new instruments, techniques or methods for reducing uncertainty.

Development: The development of new instruments, measuring techniques or systems for Australian industry, including the design of prototypes, testing, characterisation and product manufacturing. For example, the development of a new thermometer or an in-line automatic inspection system.

Application to industry: The use of new or improved measurement science and technology in Australian industry to increase quality, productivity and competitiveness. For example, the use of new sensors to control production processes or the application of statistics for scheduling recalibration systems.

Selection Process

The Award judges will be a sub-committee of the MSA National Management Committee. The judges will use criteria such as; degree of innovation, significance of the work, potential or real cost savings, stage of development, potential for application in other fields or industries; quality of the supporting material and testimonial evidence supplied.

The Award judges are bound by confidentiality agreements, ensuring complete confidentiality of submitted material.

The Metrology Society of Australia Award 2001

To nominate, please fill in the entry form below and send it and the submission to:

The Secretary
Metrology Society of Australia
PO Box 218
Lindfield NSW 2070

The closing date for entries is **1 September 2001**

Nominee: ....

Address: ....

Telephone: ....

Fax: ....

Email: ....

Concise description of work on which the nomination is based:

....

....

....

....

Nominated by: ....

If not self nomination, please provide contact information below.

....

....

Signed:

Date:

Do you wish the submitted material to remain confidential? Y/N

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The Secretary, Metrology Society of Australia
c/o CSIRO National Measurement Laboratory
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The Editor welcomes all material relevant to the practice of Metrology. Non-original material submitted must identify the source and contact details of the author and publisher. The editor reserves the right to refuse material that may compromise the Metrology Society of Australia. Contributors may be contacted regarding verification of material.

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