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THE AUSTRALIAN METROLOGIST

From the Editor

Our regular contributors in Jeff Tapping and Ron Cook have again been busy, allowing this issue to emerge about the end of the year! I am desperately seeking more people to provide articles, book reviews, letters etc to allow TAM to be produced more frequently.

As Australia endures a long dry winter leading into a summer with severe water shortages, it is hard to keep this sentiment out of the writings. We continue our two popular series - Jeff Tapping's *Quantification* and Ron Cook's - *Riverbank Reflections*. Jeff has been busy and has provided two book reviews. It is good to see a book on the subject of measurement uncertainty - written by two of our members, Les Kirkup and Bob Frenkel. You will find an insert in TAM from the publisher offering a discount for members wishing to purchase this book.

In addition there is a reprint from the MSA 2005 Conference Proceedings of the paper on Improving the performance of an Air Lubricated Piston Gauge by Neville Owen of NMI.

- Maurie Hooper

The Australian Metrologist

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Editor: Maurie Hooper

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President's Report - December 2006

This I suspect will be a shorter article than usual. At this time of the year you probably have little more time to read this than I appear to have to write it.

Another year appears to have flashed by and Christmas and a New Year approach. It has however been a good year with some really great thing to celebrate. At the most recent meeting of the National Committee we noted that for the first time ever every state including Northern Territory has a state coordinator. This is great news for me personally as for me, as I see the states and the state activities to be the life blood of the society. As such I would like to formally welcome, Duane Mullis (NT) and Glenn Reece (Tas) to the ranks of state coordinators. Equally my gratitude goes to Les Felix in SA, Daniel Burke in NSW, David Pack in WA, Brian Phillips in Queensland and John Widdowson in Victoria for their commitment and hard work throughout the year.

It has been delightful to see the Victorian Group emerging from the wilderness. This is not a criticism, simply an observation of where that group has been the past few years. I would implore you all to support John and his team in their efforts. It is the intention next year to have the state activities more widely advertised and notified earlier so that interstate visitors can join their colleagues in other states. NSW recently undertook an ambitious event, holding a hypothetical on uncertainty in Chemistry, with a particular focus on including non-members. This was a great success and we are hoping it might become a "travelling show".

Each of your state coordinators needs your support, as they put in a lot of work to organise events that will be both enjoyable and interesting. I have heard some people saying that "Oh I won't go to that one - it's not really in my field." Stop for one minute and think about what you are saying. We are a measurement society; all measurement is "your field". Experience has shown me that it doesn't matter what the topic is I always come away from visits or seminars in other fields with at least one good new idea. Isn't that worth it!

We recently had another breakthrough at the AGM, thanks to Neville Owen. He organised simultaneous meetings in four states with video and teleconferencing. While as always the technology won the day (the video conference failed) it was great to achieve that level of unity across the states. It was a privilege and challenge for me giving a talk simultaneously to four states. Especially remembering to tell the other states which slide we were on; but I gather it was received well in all quarters. We are thinking of using this as a method of including some of the smaller states in special activities as way of supporting them. I think this has great potential.

I promised a short article and a short article you will get. I would like to thank Keith Fordham and Rick Laslett for joining the National Committee this year. To those who have decided to stick it out for another year my deepest gratitude.

To close I wish you and yours all the joy, peace and hope of Christmas. May it be a time of good friends and refreshment and an exciting and happy New Year.

- Dr Jane Warne

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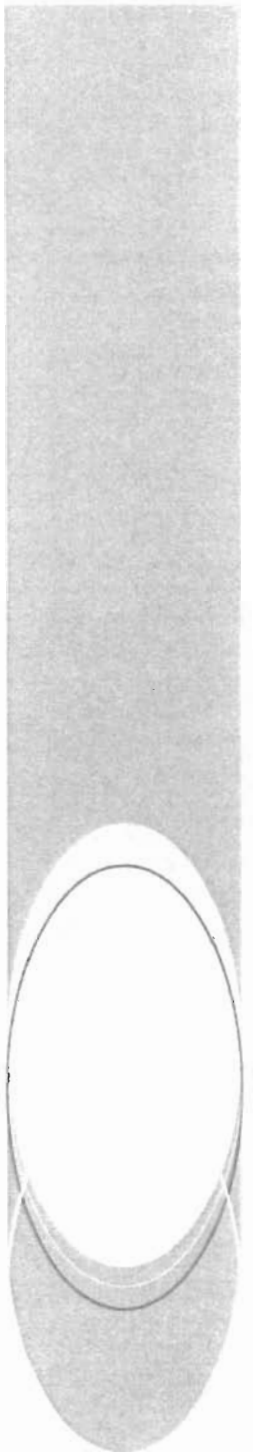

I hope that you have not been kept awake at night wondering about the list of measurement units I gave you in the last edition. If you were, you can stop taking the tablets and relax as the answers are revealed to you.

16mo

This is an abbreviation of sextodecimo, and refers to folding or cutting a sheet of paper four times to form sixteen pages. It is actually one of a series: *4to* for quarto, *8to* for octavo and *16mo* for sextodecimo. The actual size of the final sheet then depends on the size of the original, so a quarto page could be anything from 7¼ x 6¼ inches (184 mm x 165 mm) if cut from a Pot sheet, to 17 x 13 inches (432 mm x 330 mm) from an Atlas sheet. The names of these larger sheets came originally from the watermarks that were place on them. The terms *4to* et cetera were often used to specify the sizes of books, but for them the finished size would be a little smaller due to trimming. So you can see that these size specifications are quite rubbery. They have now been superseded (except in some less enlightened regions), by ISO paper sizes.

Tola

The *tola* was a small unit of weight used in India, and it was equal to the weight of a rupee coin. The name derives from the old Sanskrit word tula meaning a suspension balance, and it seems that the general idea of a close relationship between weights and quantities of coins made from precious metals was widespread. The Chinese once had a weight called the tael (or tahil), which was also the weight of a coin. In ancient Israel and Greece it was the talent, a unit of weight mostly used to measure precious metals. The Shekel, now a currency unit in Israel, began millennia ago as a weight, and you may recall that pound as a unit of currency began as a weight of silver. And so was the idea of using coins as weights spread by international traders, or just an obvious concept that arose independently in different places? We will never know for sure.

CHU

This sounds like a unit for loud sneezes, but isn't. These are the initials of Centigrade Heat Unit, a mongrel unit defined as the heat required to raise 1 pound water by 1 degree Celsius. It goes back to the days when physicists had one foot in the metric camp and the other in the imperial camp. It was also known as the pound-calorie, by analogy with the true calorie (also known as the gram calorie), which was the heat required to raise one gram of water by 1°C. The *CHU* has a value of approximately 1898.5 Joules.

International unit

You were probably not tricked by this one. The term is used in medicine for a quantity, usually a dose of a medicinal substance such as drugs and vitamins, and will appear on the labels of stuff in your home. The interesting thing is that it is an arbitrary mass of the substance arrived at by consensus to be approximately one dose, and it is from this consensus that the title "international" comes. How to define "dose" in each case is part of the arbitrary judgement. Some examples for vitamins are:

A	0.6 micrograms
B	10 mg
C	0.05 mg
D	1 mg

International candle

The international candle was the meat in the sandwich between the *Standard Candle* and the *Candela*, which were successive units of luminous intensity. Obviously the light from actual candles will vary according to how they were made, so again the prefix International derived from an agreement on what that candle should actually be. The concept of luminous intensity, which is the subjective effect of illumination on a human visual system, is an interesting anomaly amid the objective measurements forming the rest of our official system of units. We might come back to it in a future issue.

Line

When is a line not a line? When it is a length! In fact there have been a number of different uses of the name *line* for a length. The first seems to have been an old French unit called the *ligne* (which just means line in French), equal to about 2.26 mm. This became a rarely used British length called a *line* equal to one twelfth of an inch, or 6 points (2.117 mm). It may have been used in printing, but I have no confirmation of that. Another *line* was used as a measurement of the thickness of buttons and watch movements, in this case equal to one fortieth of an inch, or 0.635 mm. The *ligne* seems also to have been passed to the Russians as the *liniya*, equal to one tenth of an inch (2.54 mm).

Kienböck unit

Robert Kienböck was an Austrian radiologist of some note, and this unit was named in his honour. It denotes one tenth of the amount of irradiation by X-rays that just produces a slight reddening of the skin, and which would therefore be considered to be a safe dose from the point of view of skin damage. I picture Mr Kienböck as a caring and conservative therapist, suitable for naming such a unit after. I wonder if he was?

Dollar and Cents

Well yes, these are units of currency, but that is not the answer I wanted. They are also a pair from of a collection of units I have, that have been invented by scientists when they have not had a person to name something after, and they have run out of Greek or Latin inspiration. In this case they were coined (pardon the pun), by nuclear researchers for units of nuclear reactivity, with 100 Cents = 1 Dollar. This must surely have resulted in some misunderstandings around the laboratory.

Gowpen

I had to pick this one out of the bunch because not only does it have a funny-sounding name, but an interesting meaning. A *gowpen* is the amount of a liquid or divided material (such as a powder or grain), that can be held in a pair of cupped hands. Its origin is Scandinavian, but its sole use now is as part of a Scottish dialect. That's a pity - it seems like a useful quantity to me, so perhaps we can set up a campaign to revive it. I encourage you all to use it at every opportunity.

rH

When looking at this you may have wondered if I really meant Rh, which refers to blood types, but no I did not. Then you may have wondered if it was related in any way to pH, and you would have hit the target if you did. pH is a measure of acidity, and is equal to the negative logarithm of the hydrogen ion concentration in a solution, measured in gram atoms per litre. In *rH* the H again refers to hydrogen, but this time in terms of its power as a reducing agent. So *rH* is like pH, but is an oxidation-reduction scale rather than an alkalinity-acidity scale.

Golden number

It's funny what an effect metallic gold has had on people for millennia, just because it has a striking colour and a low reaction potential. It has been glorified to the extent that the word itself has come to signify magnificence, greatness and importance. So you might guess that a Golden Number signifies something seen as important. It is in fact a number used in calculating the date of Easter in a particular year, which you probably know is dependent on phases of the moon. The name comes from the fact that in mediaeval times the number was printed in gold on calendars.

But the tortuous story of this term begins with something called the Metonic Cycle. This is a period of nineteen years after which the phases of the moon appear on the same days of the year. The Golden Number is the position in that cycle of a particular year, found by adding one to the year, then dividing by nineteen. The Golden Number is the remainder after the division, numbered from one to nineteen, with a remainder of zero taken as nineteen. Are you with me, because there is more work to be done before we reach Easter? Next we calculate the Sunday letter for our year. For the current century we get this as follows:

- Divide the year by 4 and discard the remainder,
- add the result to the year,
- add 6,
- divide by 7

- the remainders from zero to 6 are then used to get the Sunday Letter, with zero = A, then 1 = G, 2 = F, down to 6 = B.
- Finally we get the date of Easter Sunday from a 19 by 7 table of dates (too bulky to reproduce here).

I don't know about you, but I think I would rather wait for next year's diary to come out to find out when Easter is next year, and after that I don't care.

You might wonder why Easter is set to the dates that it is, and it is an interesting story but perhaps a bit too far away from measurement so I will leave you to ferret out that for yourself. But if you really want to hear it from me then let me know.

IQ

So you know what IQ is do you? It's a measure of intelligence, isn't it? But what is intelligence? Well, it is the score a person gets in an IQ test. Now that is a rather circular argument that gets us very little distance. OK then, you get one point for knowing that IQ stands for Intelligence Quotient, but no extra for knowing that a quotient is the outcome of dividing one number by another. The real points come for knowing what is divided by what to get IQ. Well then I will tell you the story. IQ was originally developed to measure how well children were going at school, so that they could be put into an appropriate class, and was developed out of concern that retarded children should get an appropriate education. Children were submitted to a series of tests, and the average score determined for each age. The quotient for a child was obtained by dividing the age corresponding to their score by their actual age, then multiplying by 100. So if a child of 10 obtained a score equal to the average score for 12 year olds, their IQ was 120. If their score was the average for 8 year olds, their IQ was 80. Now this is a quite reasonable process, and appropriate for the intended application. But problems arise when the idea is extended to adults. You no longer have stages of continuous development to give you numbers, and the population is no longer a uniform one. People with different backgrounds have different sorts of knowledge, so how can you compile questions that legitimately compare one with the other? The answer is that you can't, but the idea of IQ was so appealing that psychologists went ahead anyway, and made up tests giving numbers that indicated relative abilities in a range of types of activities, but with no real measurement units. Now if these test were used only to compare people with exactly the same background there would be an argument for saying that the results were meaningful, but we know that often they are not. And we have not even touched on the problem of the uncertainty that should be associated with an individual score. So next time someone mentions IQ to you, give them a chuckle and tell them you prefer to believe in Santa Claus.

Errata

I know that at least one person reads what I write, and his name is Max Purss. Max has pointed out that the ton mile is not the cost per mile of transporting one ton of freight between two locations as I stated, but just a unit used to get that cost. I was tempted to say, as a high school maths teacher of mine did, that this was actually a deliberate mistake inserted to see if you were paying attention, but my conscience would not let me.

Next issue

This Quantification has blown out a bit, so I have held over until the next issue the topics poncelet, pud and funte. So the topics for the next issue are:

Poncelet

Pud and funte

Dollar as currency, pesos and pieces of eight

Tear factor

Glug

Gnathic index

Last

How long is a pik?

What is the Saros cycle, and why is it so named?

Richter scale

- *Jeffrey Tapping*

(comments and criticisms are welcome at jtapping@bigbutton.com.au)

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Riverbank Reflections 7

Ron Cook

This month talk-back radio in Melbourne has been dominated by talk of rain or lack of it to be more accurate. I'm walking along Scotsman's Creek, which once was a real creek if not a rivulet. The first member of my branch of the Cook clan to set foot in Australia worked on a selection that had the creek as part of its boundary. The Scotsman after whom the creek was named was the overseer and taught my ancestor to ride a horse and round-up cattle like the locals. The ancestor taught himself to drink like the locals.

Today, although the banks are clothed in native vegetation and there is always some water in the creek, the creek is really a glorified open storm-water drain with some settling ponds with reed beds to filter out some of the less palatable stuff that washes into the little valley. Back in the 1840's you could be speared by a local, shot by a villain or bitten by a snake while wandering along the creek, but the water was sweet and supported a small community. Today you are more likely to be run down by a high speed cyclist on the shared path that meanders along the bank or mauled by a large dog. Oh and the water isn't potable, although there is a small but steady flow today.

Given the paucity of rain I wonder where the water in the creek is coming from. It is probably better that I don't know. The water hen, ducks, heron and occasional swan seem to thrive and although there are some frogs about they and any small fish must struggle to reach maturity let alone old age. There have recently been strong suggestions that we should gather up all the run-off, such as goes into this creek, and recycle it. Forget the modeling and measurement uncertainties, sustainability of streams and cost benefit studies, if you see some water, dam it.

To me that's probably something to be left alone until we can come to terms as a community with drinking recycled water. Our politicians have been spooked by public bias against recycling water for drinking and any hint of recycling is hushed up. ("I am their leader, I must follow them" said Jim Hackett). Perth is pressing ahead with a desalination plant and "looking" at recycling water, Sydney has quietly dropped its plan for desalination as an alternative to recycling – or is desalination back on the agenda? Should the scientific community try to point out that after treatment, urine is perfectly safe to drink? After all we have measurements to prove this.

Further, one million people in Adelaide thrive on water part of which been through several kidneys on its journey to their glass. If you hadn't realized this just think what flows into the Murray and its tributaries such as the Darling and Murrumbidgee, all upstream of the pumping station for Adelaide primary water source. Similar sized cities in the USA and elsewhere have been drinking and bathing in recycled water for more than half a century, perhaps longer. We have varying degrees on recycled water in the drinking supplies of many other towns and cities in Australia.

In spite of these facts, a recent survey, by CSIRO shows that although there is very high acceptance for using recycled water for watering public parks and flushing toilets, 46% thought drinking recycled water was unacceptable or highly unacceptable. The use of recycled water for uses such as agriculture had good support but the closer the recycled water got to body contact the lower the acceptance.

I think there are issues here for metrologists. Firstly is the drought an aberration? Can we ride it out and continue on as before? Although inaccuracies in measuring "the weather" are no longer being used to justify ignoring the changes we now see; the argument is now whether the change is temporary or not. Based on historical evidence (measurement records) it seems Australia is indeed a land of drought and floods. It is a land where "average rainfall" has a dubious meaning. In an earlier column I mentioned the running 30 year average used for "average" values of precipitation and so forth. As such it is an interesting measurand, a moving target albeit a slowly moving one.

I remember a talk by Dr Jane Warne from the Bureau of Meteorology, yes none other than our current MSA President. She showed with great clarity the difficulty of making environmental measurements outside of the laboratory. Metrologists mostly measure the environmental conditions in the laboratory to make estimates of additional uncertainties in our measurements. But when the environmental conditions are the measurand, then their measurement must be approached more carefully.

As a lay meteorologist I would expect measured precipitation to correlate well with the water that reaches the surface. This includes all rain, the stuff that pelts vertically down, that which is almost horizontal in strong winds, the gentler drizzles and mist condensing on grasses and bushes and of course snow and hail. A simple gauge will work on most of these with varying degrees of error. The errors would matter less if the instrumentation were uniform and invariant as although there would be uncorrected systematic errors, these would remain constant. Changes in instrumentation may result in the removal of some of the systematic errors but this runs the risk of destroying the continuity of results to some extent. And this of course has happened over time, particularly with the introduction of automated remote weather recording stations and improved sensing systems in weather balloon payloads. The meteorologist of course tries to account for such changes when found, but sometimes it might be more practical to note the change and carry on.

While the changes we see are far larger than those produced by changes in the instrumentation, I still ponder how many other fields of measurement have had instrument related changes in their long term measurement records.

There are many stories that can be told where using a better measuring instrument has resulted in different results. A decade or so ago in a large Australian scientific research organization there were some researchers who relied on a set of mercury-in-glass thermometers fitted to digesters. These vessels contained a pulpy substance and operated under pressure at raised temperatures while the contents were agitated by a semi-rotary motion like a washing machine. The experimental process had to be stopped frequently so that the thermometers could be read and the readings recorded. Then along came a physicist. He fitted a set of slip-rings and resistance thermometers so that all the digesters could be read without interrupting the process.

A useful advance? No. His scheme was rejected because there was a 3 °C difference between the old and the new and the new just had to be wrong. I helped check the calibration of the two systems. The old thermometers were indeed in error by 3 °C. Not surprising considering their age and operating conditions. Initially they were probably quite accurate but they had never been subject to recalibration because it wasn't as easy as for the conventional LIG thermometer, and anyway what could possible go wrong with such a simple instrument. (!!!).

I brashly suggested that this 3 °C error was a partial explanation of why this group had had such trouble scaling up their processes. The effect of such a temperature shift has a huge effect on the rate of chemical reactions. My intention was to show the new data as being something positive, but it wasn't seen in that light.

I wasn't asked to help again.

But I have digressed. I expect that the doubters might be right and the drought is not a permanent change. However it may be several seasons before it recedes and it's unlikely the climate will return to the 1950's average. Climatologists point to warmer, dryer and stormier weather on average for the future. One might ask have the current models got the right trend line. Well they are based on good measurements, and we are given, in effect the expected values and what I take as the uncertainty limits. As the predicted changes are bigger than the uncertainties I'd trust them much more than predictions based on say studying ant behavior, not that there's anything wrong with studying ants.

The long term trend aspect seems to be lost from sight for most at the moment anyway as farmers and others call for immediate action on equitable sharing of water and its conservation.

So our area of the world is slowly drying out and although not everyone is convinced of the cause most accept the principle if not the numbers. There is work still to be done there.

A more difficult issue is convincing the community of the acceptability of recycled water for all domestic usage. In new housing estates separate pipelines can be installed so drinking and bathing water has the minimum of recycled water in it. A new estate in Cranbourne boasts of this feature. This does reduce primary water demand but avoids the issue.

Another avoidance tactic involves industry recycling all its water. As 90% of the water used in Melbourne (and probably most large cities) is used by industry this could be the most productive route, but it would be at a cost. On-site processing might be possible and there are examples of this around, but it might be more practical to reprocess at a central position. If this water was returned to industry that would reduce consumption and also avoid the issue of drinking recycled water. A whole new reticulation system would be required and this would be expensive. The taxpayer almost certainly would have to cover the cost.

The more affordable option, taking the treated effluent and diverting it from ocean outfall into a holding reservoir for wider distribution is the one that people are recoiling from. Could an education campaign backed by reliable measurements change the public perception?

Unlikely. While there are alternatives (someone else can fix it) and there is hope it will rain heavily soon and it doesn't directly impact on the hip pocket or ability to enjoy the current lifestyle the present prejudices will endure. We may need level 4 or 5 water restrictions on individuals and industries before logic starts to bite. Better measurements alone won't convince Joe Public. Of course good measurements will be crucial to maintaining the quality and safety of our reticulated water systems, but rows of numbers very rarely sway opinions.

At the next MSA Conference in Adelaide I'll raise a glass of partly recycled water to all present and together we'll enjoy our drink.

Well I've reached a fence across the creek with a sign "Private Property, Keep Out" so its time to turn heel and walk back.

† "Predicting Community Behaviour in Relation to Waste Water Reuse, What Drives Decisions to Accept or Reject?", Po, Nancarrow, Leviston, Porter, Syme and Kaercher, CSIRO May 2005, cited by Engineers Australia Vol 78, No 9 Sept. 2006.

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BOOK REVIEW

An Introduction to Uncertainty in Measurement
by Les Kirkup and Bob Frenkel
Cambridge University Press, Cambridge 2006 (hardcover
ISBN 0-521-84428-2)

As we know, the Guide to the Expression of Uncertainty in Measurement (GUM) is now all-pervasive in the fields of measurement standards and calibration, but there are many sectors of science and engineering that still use the old traditional mish-mash of statistical methods and terminology when dealing with measurements. The prime purpose of this book is to attack the problem at its source: the tertiary institutions that are training the measurers of tomorrow. The blurb on the back cover says that it "...introduces measurement and uncertainty to second- and third-year students of science and engineering.", and "This book is also useful to professionals in industry ...". It would be a great pity if metrologists without a tertiary degree took this to mean that it was not appropriate for them, because although it has plenty of equations and some discussions of complex issues, it is a remarkably readable text. I wish that the textbooks that I was required to buy at university were half as understandable. If you start at the beginning with a Granny Smith apple and a cup of tea, you will probably find that the cup is empty and apple core brown before you put this book down.

The first chapter is a gentle introduction to the place and significance of measurement in our technological society, with discussion of where high accuracies are needed for particular purposes. The next chapter describes the SI system, units of measurement, and significant figures in numbers, then Chapter 3 moves on to terms used in measurement. All of these topics are presented in a gentle conversational style with plenty of everyday examples to help you to grasp the concepts.

In Chapter 4 you will finally come to uncertainty, but it is ten pages into the chapter before you encounter an equation, and even then it is just the definition of standard deviation.

The titles of the following chapters tell you how the full story is unfolded:

5. Some statistical concepts.
6. Systematic errors.
7. Calculation of uncertainties.
8. Probability density, the Gaussian distribution and central limit theorem.
9. Sampling a Gaussian distribution.
10. The *t*-distribution and Welch-Satterthwaite formula.
11. Case studies in measurement uncertainty.

Bearing in mind that this book is intended as a tertiary textbook, it is to be expected that there is some maths in these chapters, but if you are not maths-literate and think there is nothing in them for you, you are wrong. I will give an example that shows why. In Chapter 9, there is an equation which expresses overall degrees of freedom (dof) from the individual dof from two components combined together. The discussion below it points out that if the two components have quite different dof values, the overall dof will be closer to the smaller value than to the larger. What this means in practice is that if you have a component with a small dof, there is little point in churning out a large number of values to try to reduce the uncertainty. You do not have to understand much maths to carry this around in your head and use it as a quick check on whether it is worth doing more work. A rule of thumb that minimises your work it not to be sneered at. All through the book the mathematics is accompanied by explanations and examples that assist in understanding of concepts. There is also quite a bit of discussion of systematic errors with examples, a topic vital to every measurement person.

The book is sprinkled with small calculation exercises, and at the back there are answers to these so that you check if you were correct. The final chapter has five case studies in which uncertainties are worked out step by step with full explanation. All of this means that you do not have to use the book for passive input, but can actually apply the principles and test your knowledge along the way.

I had some small reservations about reviewing a book co-written by a friend and former colleague, but my conscience is clear. I find that I can truthfully recommend this book to anyone with a serious interest in measurement and uncertainties, whether they are beginner or an old hand.

- *Jeffrey Tapping*

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Exhibit at the

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The courses cover the basic estimation process from specification of the measurement model through to evaluation of the final figure of measurement uncertainty. The course material is based on physical measurements and is regularly updated with new examples. Course notes, a text and a certificate are provided to all attendees. The three day course incorporates a written test and those who achieve a pass mark receive a Certificate of Completion. It therefore

WHAT DOES MTI AIM TO DO?

We take measurement uncertainty seriously. It seems to us that there is an ongoing need for training courses in uncertainty of measurement. Further a course that presents an overview of the ISO "Guide to the Expression of Uncertainty in Measurement" and provides a practical approach to calculation of measurement uncertainty is surely more useful than just a set of lectures. Until "hands -on" experience in calculations and uncertainty estimation has been gained the topic remains shrouded in mystery for many metrologists.

By using problems and examples drawn from a range of physical measurements we believe we can bridge the gap between reading the GUM and doing the estimates. We provide one day and three day courses as these seem to best match the needs of the measurement community.

Course accessibility is important so we take the courses to each of the main State Capitals at least once per year. MTI specializes in in-house courses using worked examples based on the client's activities and we welcome enquiries.

Courses are normally run at graduate level, but are presented in a manner so that attendees with experience and a good understanding of at least one field of testing and basic skills in algebra and numerical calculation will be able to complete the course.

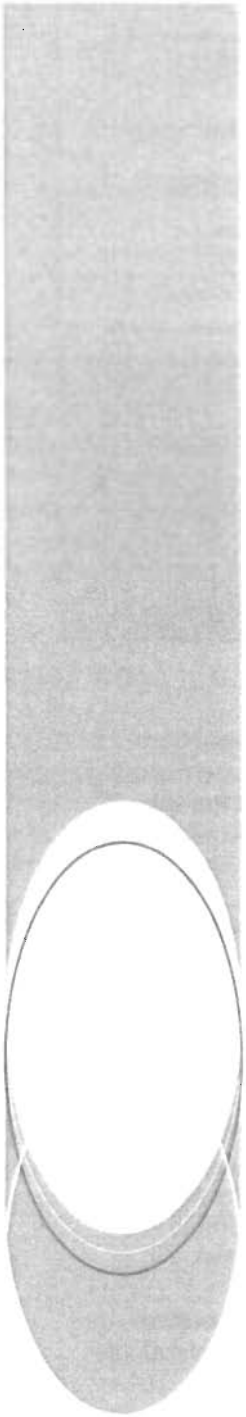
Fluke is one of only a few companies who can offer a complete calibration solution to our customers. Our products include calibrators, standards, software, procedures, training, service and support – everything that the calibration customer needs to do his or her job, plus the support he or she needs, before and after the sale. These elements offer significant value to our customers, helping them to increase throughput, control their measurement assets, and maximize their investments in hardware and software.

Ultimately, we aim to provide customers with the *confidence* that they are making the best measurements possible when using Fluke calibration products and services. This confidence is earned in many ways:

- Products that are the most accurate in their class, designed and supported by world class engineers, scientists, and metrologists working in the fields of temperature, precision dc/lf analog and rf design.
- Software that allows customers to automate the calibration process and perform consistent, efficient calibrations.
- Global support of both hardware and software products that includes Fluke experts talking directly with customers.
- A global presence that includes nine primary standards laboratories around the globe, with maintained uncertainties comparable to those found in national labs. Fluke laboratories in the United States and Germany house two of only 35 Josephson dc voltage arrays in the world found outside a national laboratory.
- A strong, supportive presence in the global calibration community – including a calibration textbook, an average of 10 papers per year submitted to metrology conferences, membership in national and global calibration organizations.
- A staff of associates that includes hundreds of person-years of experience in calibration. Fluke has been in the business of calibration for more than 50 years.

BOOK REVIEW

Jeffrey Tapping



Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences

U.S. Climate Change Science Program, Synthesis and Assessment Product 1.1

You might ask what this title refers to. Well, the topic is the extent to which climate modelling can be relied on to predict the effects of influences such as carbon dioxide emissions on climate change. Then you might ask why a book on this subject is being reviewed in a metrologists' publication. Of course climate change is something of concern to us all, but the simple answer is that most of it is discussion on measurement and uncertainties. And if you think that you have some problems with uncertainties, then read this book and you will realise how well off you are.

The book is the first in a series to be compiled for presentation to the U.S. Congress, and so whether or not it is valid and persuasive will affect future policy not just in the U.S., but around the world. The authors are more than forty experts in climate modelling and data analysis, and they took on a very daunting task: to present an extremely complex topic in a way that non-experts could get some grasp of the validity of the conclusions. Some quotations from the Abstract will be useful to let you know where the discussion ends up, and they might be handy for quoting to your sceptical acquaintances.

"Previously reported discrepancies between the amount of warming near the surface and higher in the atmosphere have been used to challenge the reliability of climate models and the reality of human-induced global warming. ... This significant discrepancy no longer exists because errors in the satellite and radiosonde data have been identified and corrected."

These few words are simple enough, but the full story is an extensive description of how these conclusions came about. An interesting point is that although more data have been collected in recent times, the biggest factor has been the re-examination of the old data, and in particular a better appreciation of the uncertainties of measurements that have been made and of the climate models. A point that is put strongly is that in the past there has been a tendency to consider noise in data without taking into account other uncertainty factors. The book often uses different terminology to us, but what they are saying in our language is that previously changes in the character of data sources, and the uncertainty in the knowledge of systematic errors, have not been adequately considered. As a result error bars have been underestimated, and so outcomes have been labelled as disagreeing when in truth the error bars overlap quite a bit.

It is worth just briefly explaining some background. It is obvious that modelling something as complex and extensive as our atmosphere is bound to produce large uncertainties in the temperatures of particular locations or regions. But the objective is not to predict exactly what the rainfall will be in Sydney or Alice Springs, but to say whether the general temperature rises in recent decades are due to solar variation, or atmospheric dust or carbon dioxide emissions, or methane, or what. The term the modellers use is "fingerprinting", that is, whether a recorded change in a "forcing factor" (what we would call an influence), produces the same pattern in the models as has been measured in the atmosphere. A good example is whether the models predict what actually happened after the volcano Mount Pinutabo injected immense amounts of dust into the sky, and the answer is that they do.

Consider one example of problems the modellers have. What do you think it would be like if you were measuring a particular parameter, and each successive reading came from a different meter from a dozen different types of instrument, all calibrated by different people in different places at different times? That is what it is like for climate modellers, who take temperature data from land, sea, the atmosphere, the stratosphere, from

different countries and from the equator to the poles. Readings are taken by fixed land stations, balloon-borne instruments and satellites. In each case some condition of the measurement may have been changed over the years, either deliberately or inadvertently. On top of that they have to contend with solar variations, the El Niño effect, the ozone hole, variable cloud cover and volcano eruptions. What a tangle to try to unravel!

The crucial data that contributed to the previous apparent discrepancies came from measurements of upper atmosphere temperature using satellite observations. First, these are quite indirect measurements which require some assumptions about the relationship between radiation measurements made in space, and the temperatures in various layers of the atmosphere. Second, the atmospheric conditions might change by some unknown amount, for example a volcano or forest fire will put an unknown amount of sulfur dioxide into the stratosphere. Third, the orbit of a satellite degrades over time (that is, its altitude decreases due to atmospheric drag). Fourth, the calibration of a detector may change over time and there is no way to recalibrate it. These are some of the problems the modellers have been working on, correcting data where they could and evaluating remaining uncertainties.

While these problems may seem to have little relevance to your work, some aspects of the way they are tackled come closer to home. For instance I found the discussion on least-squares fitting to trend data covered many of the traps I learned about over the years. I will not go into detail here, but there are plenty of bits and pieces that will be useful to many of you.

For me this publication gives an opportunity to make an important point. My impression is that most metrologists see estimating uncertainties as something unpleasant that they are required to do, rather like filling in you tax return. But a better analogy is the financial accounts in a business. The accounts show where effort is going and to what effect; where more attention is required and where less. An uncertainty budget is an analysis of your measurement, and tells you where your efforts need to increase or decrease. The bottom line is important, but how you get there is no less important. But to use the information in your uncertainty budget effectively you need to have a feel for the general topic, not just the arithmetic in your calculations. And a good way to do that is to look outside of your little box, by reading more on uncertainties in other areas of measurement where the structure of the problem is different to yours. And I will guarantee that the difficulties of the climate modellers will be very different to yours.

Getting back to the main topic of the book, it became clear to me that what the modellers do have on their side is some very clever people, and nineteen different models including one from CSIRO and one from our Bureau of Meteorology. These people are now firmly convinced that human activity is the only plausible explanation for global temperature rises. After reading this report I am also convinced that in spite of all the difficulties they face, their conclusions are correct.

(Information about the Climate Change Science Program can be found at *www.climatescience.gov*, and the book can be ordered at the web site for the Global Change Research Information Office, *www.gerio.org/orders*)

- Jeffrey Tapping

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Improving performance in an Air Lubricated Piston Gauge

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Reprinted from the MSA 2005 Conference "Smart Measurements - Metrologists Advancing Industry"

Abstract

The highest quality air lubricated piston gauges operate with very small mechanical clearances, typically less than 1 μm. This is necessary when operating at higher pressure with low uncertainty to reduce the fall rate due to gas flow past the piston and to more closely define the actual area of the piston gauge. Unfortunately very low clearance piston gauges often suffer from poor sensitivity due to interference between the piston and cylinder walls., particularly at the lower end of the pressure range This paper discusses this issue and describes an operating procedure that significantly reduces this effect, improving the performance of the piston gauge.

Keywords: piston gauge; air lubricated; sensitivity.

Introduction

The purpose of this paper is to propose a method by which an operator can confidently and reliably achieve the best sensitivity when cross floating air lubricated piston gauges. This method can also help identify when a high quality piston gauge actually requires disassembly and cleaning.

Piston Gauge Tested

The equipment subject to method trials reported in this paper is a pneumatic Ruska' model 2465 high range (7000 kPa) 8.4 mm² piston. The piston and cylinder are tungsten carbide with a specified [1] sensitivity threshold of < 1ppm at full scale and a specified maximum fall rate of 4 mm per minute.

Expected Sensitivity

When this piston gauge is operated with care, it is possible for an operator to discriminate a difference in fall rate with a change in mass of 1 ppm when loaded with the mass-carrying bell and one ring weight, providing approximately 1.5 kg load. This is equivalent to 15 μN or 1.8 Pa sensitivity.

When a piston gauge does not perform well, as exhibited by short spin times or a tendency to stop abruptly, the first action is to assume the piston requires cleaning and to proceed with dismantling. This can be very time consuming and every maintenance operation runs the risk of damage or wear. Hence unnecessary cleaning should be minimised.

Performance

When admitting nitrogen gas to the high range piston gauge it is very common to experience poor performance, exhibited as anything from shortened spin times to the piston stalling quite abruptly. It is thought that this effect is due to interference between the walls of the piston and cylinder. Under these circumstances the piston gauge is unusable and action must be taken to rectify the situation. The practice recommended by the manufacturer [1] is to admit nitrogen slowly and to coax the piston gauge to spin. This can be unsuccessful on occasions, resulting in dismantling and further cleaning until satisfactory performance is exhibited.

Possible Causes

A number of possible causes for this poor performance have been identified for investigation. Some of these are ruled out here with the remaining possible causes left for further investigation.

When gas is pressurised it heats up until the excess energy of compression can be dissipated. If this excess energy were taken up exclusively in the piston it would be necessary for the piston to increase by at least 10°C to cause interference in a 0.1 μm gap. In practice, typical temperature rises in the range 0.1-0.3°C are experienced and

these dissipate within a few minutes. Hence temperature change by compressed gas is an unlikely to cause of sticky performance

At the pressures involved (not more than 7 MPa), the distortion coefficient provides a maximum movement of 0.004 μm. Regardless of the direction of movement this is not sufficient for piston or cylinder elastic distortion to cause interference.

Tungsten carbide is a ceramic material with tungsten carbide micro crystallites bonded with cobalt to form a continuous phase. In normal use, a piston and cylinder are expected to suffer rubbing contact until gas lubrication is fully established. This will lead to a small amount of abrasion wear resulting in free particles in the piston cylinder gap, leading to the requirement for regular cleaning. This build up of particles is expected to occur slowly and is unlikely to cause a distinct grabbing or stalling of a recently cleaned piston gauge.

Decreasing the pressure in a gas space can result in dissolved liquids condensing out. If the nitrogen gas being used has some dissolved liquid content this may contaminate the piston surface while depressurising the space under the piston. To reduce the likelihood of this problem the nitrogen used is 99.999 % clean, with liquid contaminants limited to less than 1 ppm. The impact of this contamination is likely to be small but cannot be ruled out. In combination with the abrasion wear noted above, this may cause a sticky effect over time.

Although not normally attributed to curved surfaces, the very finely manufactured and finished surfaces of the piston and cylinder may exhibit a static friction effect like wringing. This situation could persist and could intermittently be re-established until a fully developed flow of lubricating gas was established in the piston gauge.

These speculations on possible causes have been conducted to better understand and minimise those causes which can be mitigated. No stand out cause has currently been identified. However a method has been successfully trialled which minimises the impact.

An Operating Caution

There is no substitute for a clean piston gauge. Before relying on the methods in this paper it is essential that an operator is absolutely sure that the piston gauge is truly clean. This may mean training in proper cleaning methods, reference to manufacturers and other documented cleaning techniques and microscopic inspection. A dirty or contaminated piston or cylinder can be irreparably damaged by following these methods without proper care.

A condition that occurs commonly enough is when a piston gauge has been cleaned and carefully reassembled but performs poorly by giving short spin times or lacks sensitivity by appearing to spin adequately but not falling in response to the addition of incremental weights. Where an operator is certain that cleaning was effective these methods can be considered before conducting a second clean.

Avoiding the Problem

The common method of loading a piston gauge and bringing it into balance is to simply load the weight stack and slowly apply pressure to float the piston.

The method suggested in this paper is to hold the piston up against the top stop while applying pressure. It is recommended that masses be progressively added to reduce the upward force on the top stop while applying pressure. The incremental load applied for the Ruska model 2465 was 1 kg. This load can be easily accommodated by the integral piston stop mechanism.

When pressurised in this manner, a clean piston gauge is typically well behaved, with long spin times, often in excess of 1 hour, when the weights are floated. There is no need to coax the piston to achieve long spin times.

This method can be used with quite high gas pressurising rates; for example taking the high range tester of the Ruska model 2465 from atmospheric pressure up to 7 MPa in less than a

minute (actually 5 quick jumps with mass loading in between) causes no undue problems when the piston is floated at full load.

Conclusion

When pressurised in the conventional manner, gas operated piston gauges often experience poor performance, as measured by short spin times and stalling behaviour, particularly if the pressurising rate is high (greater than 700 kPa/min). Using the method described in this paper results in excellent performance, even for high pressurising rates.

By implementing this alternate method, it is possible to maintain very high sensitivity with a clean piston gauge without going through an often redundant and time-consuming cleaning process.

The reasons for the success of this method are unknown and are currently being investigated.

References

[1] Ruska Instrument Corporation*, "Gas Lubricated Piston Pressure Gauge Model 2465-754 User's Manual"

** Note: Any mention of commercial product names in this paper does not constitute endorsement of these products*

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MSA Victorian Section

Meeting report
31 August 2006
Meeting held at Mettler Toledo

The meeting started at 6:00pm with refreshments and general discussion. 11 MSA members attended and it was an informal affair.

John Widdowson thanked Keith Fordham and Mettler Toledo for providing their premises as the meeting place.

John advised that the next meeting of the Victorian section will be after the AGM, probably on the 18 October at NATA, North Melbourne. After the conclusion of the AGM, Paul McMullan (NATA) will give a short talk on the changes to NATA's Applied Physics, Metrology and Electrical fields of testing. When this meeting is finished, there will be a dinner at a nearby hotel.

The final meeting for the year will be a laboratory tour of the Bureau of Meteorology (BOM) laboratories. The date for this visit is the 7 December. Numbers to this event will be limited.

The meeting then discussed ideas for venues, topics and site visits.

The speaker for the meeting, Jane Warne, gave a talk on the work she is engaged in with the measurement of tsunamis. Jane's talk included concepts including:

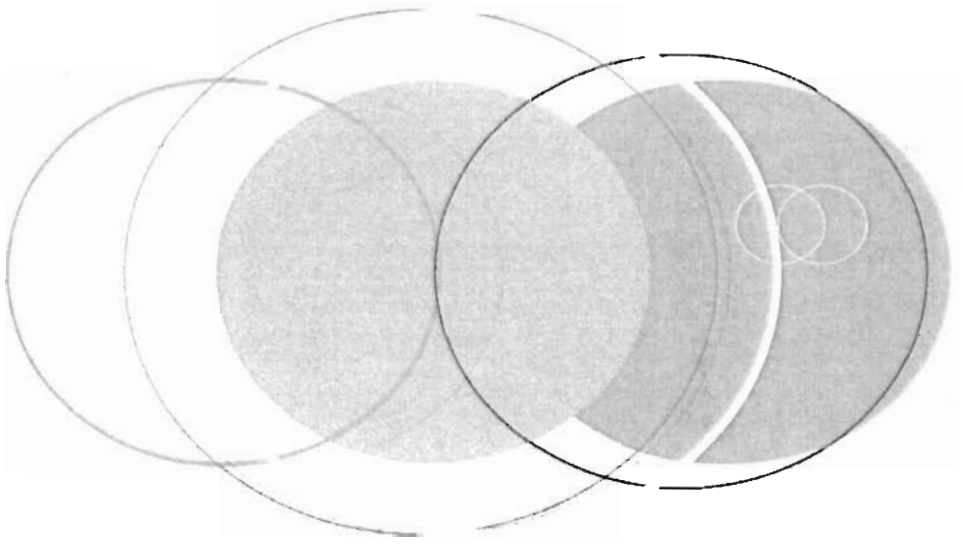
- What do we want to measure;
- How do we measure it;
- Are we measuring the right thing;
- My measurement are better than you measurement;
- What do you mean, are these results traceable?;

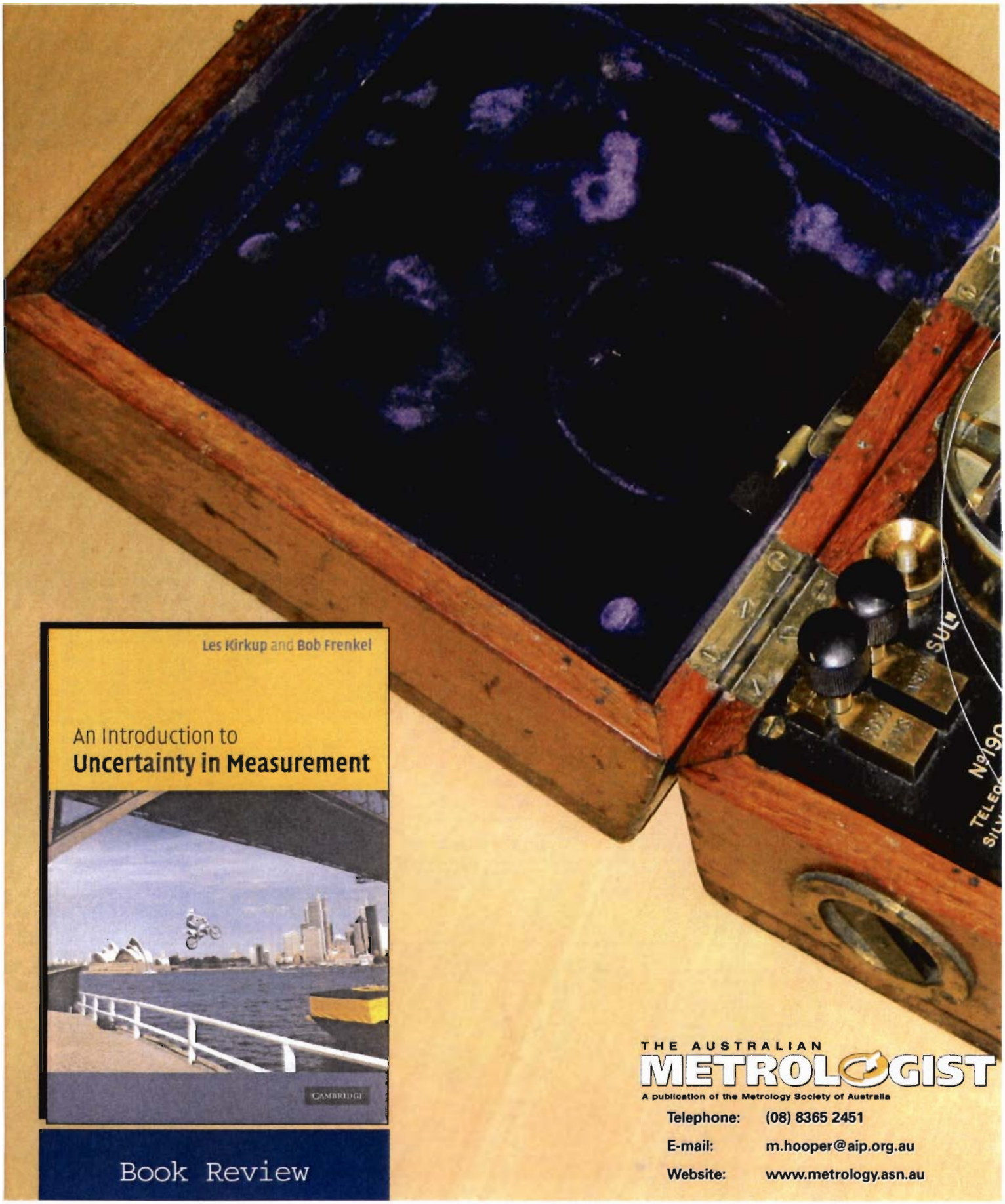
Jane showed how tsunamis are born, propagated and how Australia could be affected. The BOM is conducting routine measurements to try to predict tsunamis and save lives. All this comes at a cost, but although the cost is high, the cost in life is higher if nothing is done.

The meeting closed at 8:00pm.

John Widdowson

Victorian Section Coordinator.





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