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METROLOGIST

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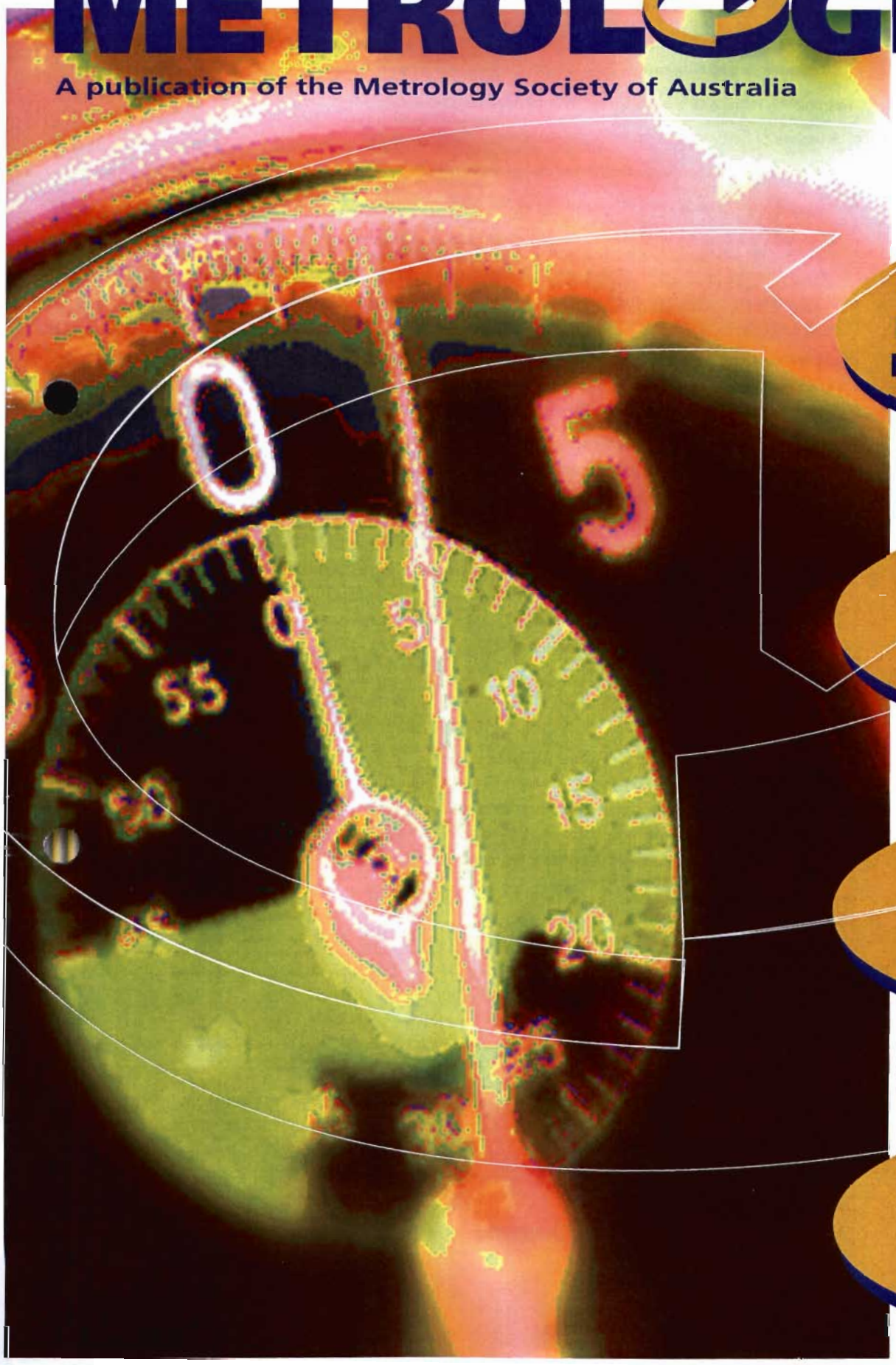

Vehicle Speed Measurement. How accurate?

New MOU for NATA & SA

The Church and Early Measurement

Metrology in 2020 from the NSC

From the Editor

As noted in Jane Warne's report, this is more than just a face-lift in the design of TAM. We are aiming at a more consistent publication, with a more predictable mix of articles.

We hope the magazine will also fulfil several needs we have identified:

- A means of communication between members and about events
- Industry news, as well as key updates from national bodies
- Research news about what is happening at the leading edges of our field
- To provide a forum for discussion, dialogue and debate on metrology issues

I'm sure there will be different views on these changes across the membership. We invite you to tell us what you like, and what you don't like, about the new TAM. It is your magazine – the primary contact that MSA has with most of its members.

Of course much of the content must come from you, the members – which is a good reason to make every effort to recruit new members. Application forms may be obtained by sending an e-mail to our Secretary, if you wish, me. (Letters and phones are also still acceptable forms of communication.)

This year we will be making every endeavour to achieve as close to a three-month publication frequency as we can. To this end, if you have contributions for the next issue, please send them by the end of April (or an indication that you are preparing something).

Maurie Hooper

The Australian Metrologist

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. Please check with the editor regarding preferred layout (font, size, etc) and any included diagrams or photos.

Contributions

Articles, news, papers and letters, either via e-mail, disk or hard copy, should be sent to:

The Editor
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The deadline for the next issue is 30th April 2003.

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Need a Position?

Write or e-mail the Editor with your details including years of experience and qualifications. This service is offered free of charge.

Need a Metrologist?

If you have a position vacant, write or e-mail the Editor with the details. A charge of $20 for up to 10 lines applies. (The circulation may be small but it is well targeted.)

The deadline for positions wanted/vacant is as above.

Letters to the Editor

Letters should normally be limited to about 200 words. Writers will be contacted if significant editorial changes are considered necessary.

Editorial Policy

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.

Editor: Maurie Hooper

2002/03 Adversiting Rates for The Australian Metrologist

Space A4 page	One issue	Two issues	Three/Four issues
Full page	$400	$750	$1050
1/2 page	$225	$425	$600
1/3 page	$150	$130	$400
1/4page	$115	$215	$290
1/8 page	$60	$110	$150
Colour			
Full page	$800	$1500	$2100

Closing date for copy to be received for TAM is the 16th of the month preceding publications.

Contact the TAM editor for further details.

Please Note: Camera ready artwork is to be supplied. Size and specifications are available from the editor. If extra typesetting etc is required an extra charge will apply. MSA members receive a 10% discount when they place advertisements in TAM.

MSA Membership Enquiries

Membership is available to all appropriately qualified and experienced individuals. Associate membership is also available.

Contact either your State Coordinators or the Secretary, Dr. Ilya Budovsky on (02) 9413 7201 or fax (02) 9413 7202, e-mail address ilya.Budovsky@csiro.au or write to:

The Secretary, Metrology Society of Australia
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Members	$40 Joining Fee
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Associates	$35 Joining Fee
	$35 Annual Subscription

Presidents Report 2003-02-07

I hope this new edition of TAM finds you all happy and rested after the festive season and not too overcome by the hassles and doomsday that appears to be the flavour of 2003. I saw a cartoon in one of the papers early in the New Year. It showed a door with 2002 written above it and a crowd of people trying to get through. Above the door was loud speaker saying "You all did so badly at 2002 it has been decided you need to go back and do it all again." Well I for one am hoping that is not the case. This year holds great promise for the Metrology Society I believe, even if it does not for the world in general.

The New Look TAM

As you will notice this edition of TAM has given the magazine a major face-lift. We hope you find the new format more attractive to read, easier to navigate and relevant, with specific regular and feature items in predictable places. You will see in our editor's column a more detailed description of what we are trying to achieve. We are aiming to express a broad and I think dynamic vision for the future of the magazine and the committee and I hope you will catch hold of this idea as enthusiastically as we have. For the dreams to come true however we need your, thoughts, ideas and contribution. This magazine should be a must read for all metrologist and it is your input that makes it that way.

Web – Mentoring

As part of a recent National Committee Meeting that the State Coordinators participated in; there was a suggestion, from a Queensland member, that they would like access to the names and skills of members. The intention was that when a member had a problem they could contact a member with the appropriate expertise. The committee generally thought that this was a very good idea and fitted well with the current plans for a member's only page on the MSA web pages. However it is recognised that given the current changes in the Privacy Act that it is not a straightforward exercise to put this information on the Web. Apart from the privacy issues there are questions about the type and amount of personal information that should be available. For example: Should you include company contacts, or just personal contact information? Is inclusion of company information and services free advertising or endorsement? If it is, do we mind? Is it worth operating a chat room or bulletin board? If so, are there people around who would be prepared to moderate such a facility to ensure queries were answered?

We therefore felt it was of value to open up the debate to the members and see how interested you are in having such facilities or to suggest other solutions. We would really be interested in your feed back on this issue. Please direct your responses to The Editor, The Australian Metrologist, 11 Richland Road Newton SA 5074 or tameditor@metrology.asn.au, or myself via president@metrology.asn.au.

MSA 2004

Plans for the next MSA conference in Melbourne are well underway. A venue for the conference has been identified and it is intended that the conference will take place in early March 2004 around the time of the Grand Prix for the petrol heads or Moomba for the fun loving. The format will be similar to previous ones with a 3-day conference and we hope to include a workshop, trade show and the mandatory social entertainments. We are however looking for people to help on the committee, and before you run for cover, this does not have to mean a particularly onerous commitment of time or energy. Over the next few months we will be gearing up to producing leaflets, selecting social venues (Always a popular activity!), wooing sponsors, marketing, and getting papers submitted and reviewed. There is room for anyone to contribute, large or small. So far the committee has really enjoyed the work and we would love to have more to share the work and fun. So please contact me (Jane Warne via president@metrology.asn.au.) if you are interested and we will see if we can squeeze you in.

Enjoy this edition of the new look TAM, have a go at the crossword, but don't get too cross with the author. And I look forward to your contributions in the next edition.

Dr Jane Warne

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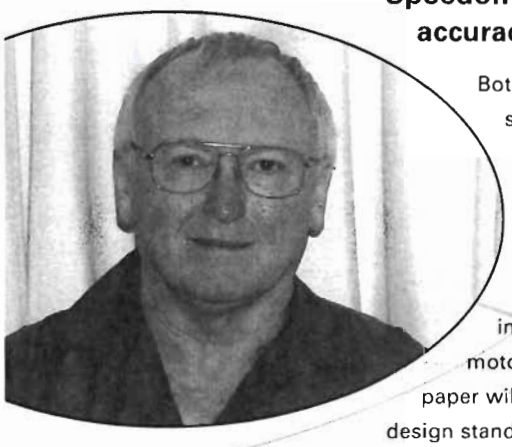

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Speedometer testing; Speedometer accuracy; Speedometer uncertainty

Both federal and state legislation set standards for the accuracy of speedometers installed in motor vehicles. Unless these legislative provisions are compatible, and prosecution policies recognise the accuracy achievable by speedometers installed in vehicles, there is danger that motorists could offend unwittingly. This paper will discuss the interaction of the federal design standard, individual state prosecution policies and the performance of speedometers and associated testing equipment.

The Australian Motor Vehicle Standards Act, (known as the Australian Design Rules, or ADR [1]) sets requirements for speedometers installed in vehicles to be used on the road throughout Australia as:

> *"indicate the actual speed, for all speeds above 40 km/h, to an accuracy of ± 10 percent."*

State Legislatures have also set their own minimum requirement. For example New South Wales Traffic Law [2] requires that speedometers:

> *"indicate, when the vehicle is travelling at a speed in excess of 50 km/h, a speed that is not more than 10% less than actual speed".*

The individual State requirements are all worded differently and may impose different constraints on the performance of speedometers. However none change the "*10% less*" requirement, which is a main contributing factor to the system failure. This accuracy guide method has severe limitations and is only used by persons with a lack of understanding of measurement.

Uncertainties are an integral part of regulations administered by the National Standards Commission, such as those concerning the weighing of products in commerce. Since there is a trend to base the level of fines on exactly how much the speed limit is exceeded, the policy should recognise the effect of uncertainty of measurement and fall into line with other measurements with financial implications. The ADR [1] should take account of the requirements of the ISO Guide to the Expression of Uncertainty in Measurement [3]. This reference to uncertainty is an integral part of weight measurement and is found in Australia's adoption of "Organisation Internationale De Métrologie Légale Recommendation R111" [4].

There is a system that would enable drivers to reliably determine if they are travelling within the posted speeds limits. This paper will endeavour t prove the accuracy and safety aspects of a test system that once used, will enable the public to travel within the posted speed and furthermore be **expected** to do so.

Monash University Research Notes:

The Monash University Accident Research Centre published research notes with the heading "Accuracy of vehicle speedometer readings with respect to speed enforcement tolerances" [5]. Table 1 gives a compilations of statistics summarised in the notes.

The University used some collated results from other sources and whilst the test methodology was not described these results indicate either a failure by manufactures to meet the minimum requirement of the relevant ADR [1], or that other mechanical factors are affecting the results.

Rolling Road Testing

The speed indication in vehicles is tested by either measuring the time to travel a known distance, or on an apparatus consisting of rollers with known circumference and measurable rotational velocity (a "rolling road"). Some instrument repair companies merely "check" odometers over a distance and conclude the speedometer accuracy from this data. Some have recently used GPS units. All require conducting tests on public roads.

Actual speed relationship to indicated speed. in km/h										
actual	20	40	50	60	70	80	90	100	110	120
max indicated	24	43	58	64	77	83	97	108	117	130
min indicated	15	27	41	48	62	71	80	84	98	105

Table 1: Summary of tests on speedometers carried out by Monash University Accident Research Centre and others between 1982 and 2001

Testing of speedometers should ideally be conducted throughout the usable range as this eliminates the need for extrapolation. There are obvious safety implications if speedometers installed in vehicles are tested throughout their range on public roads. However using a rolling road for such tests, reduces the safety issues and the latest computerised rolling road machines provide a printout of the parameters tested.

The author undertook experiments to relate the difference between true and indicated vehicle speed with varying tyre wear and tyre fill pressures. These tests were conducted on a rolling road machine. This machine held a current NATA accredited certificate of accuracy. During these experiments it was found that tyre growth under the influence of centrifugal force was only significant when the tyres were under-inflated and at speeds of more than 120 km/h. Steel banded type tyres did not expand significantly beyond this speed.

The tyre inflation pressures referred to in these tests were hot pressures and should not be confused with cold pressures settings recommended by the manufacturers. Variation in pressure will occur as the tyre pressure increases with heating during use. This pressure increase through expansion, is much as 30 kPa. The tyres of the test vehicles were initially inflated to 160 kPa, once the tyre had reached operating temperature. The first run at 160 kPa was followed by tests in increments of 30 kPa to a maximum tyre pressure of 280 kPa. One of the tests was conducted with a standard tyre pressure of 190 kPa and the equivalent weight of four adult males in the car (recommended 210 kPa high load), all the other test in this series were with one adult male only. The deviations from true speed occurring at indicated speeds of 30, 60, 80 and 120 km/h were recorded. (Table 2 and Chart 1). Three readings were made at each speed and pressure, and mean of the readings was calculated.

The change in the tread depth of a Dunlop Monza 205/65R15 tyre, from new through to the wear indicator bars, was measured to be 7 mm. The change in effective circumference during its life for this particular tyre, was calculated to be 1.07% while stationary (static) and 1.09% while rotating (dynamic). The static test was a measure of the distance travelled through one revolution of the tyre whilst under standard load, whereas the dynamic test was derived mathematically from data collected during the entire test program (some of these tests are not described in this paper). The tyre wear factor is discussed later in the "Discussion" section. Changes such as under-inflation or tyre wear will cause the indicated speed to be greater than the actual speed. Tyre pressures change with temperature can result in a 30 kPa pressure change between a hot tyre and one at ambient temperature as previously mentioned. An increase in tyre temperature will cause a lower indicated speed than actual speed as the results in Table 2 indicate.

On the face of it, the circumference of a tyre is constant whatever the tyre pressure. However tyres compress as the tyre surface changes shape when it meets the road surface squeezing and then stretching each portion of tread during a cycle so that the distance travelled per revolution of the wheel changes.

Experiments showed that a Dunlop Monza 205/65R15 tyre fitted to a rim had an undistorted radius of 320 mm at a pressure of 220 kPa, a compressed radius of 295 mm and, at a pressure of 190 kPa a compressed radius of 290 mm. The calculated circumferences for the three radii were

Actual	tyre pressure (kPa)					
Speed (km/h)	280	250	220	190	160	190 + load
30	28.5	28.6	28.6	27.7	27.4	27.2
60	58.1	58.4	58.2	57.7	56.4	56.2
80	78.2	78.4	77.7	77.4	76.7	76.3
120	116.6	116.4	116.6	115.9	115.2	114.9

Table 2: Indicated speed versus actual speed for various tyre pressure

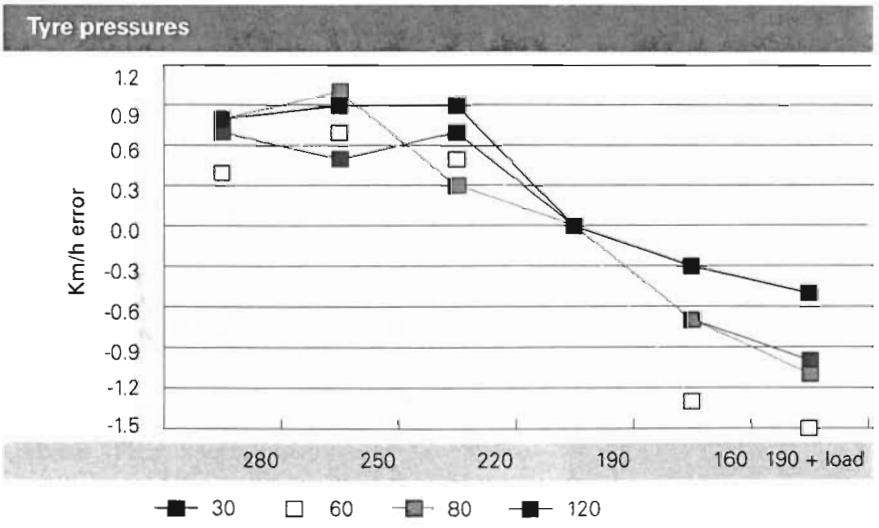

Figure 1: Data in Table 2 presented graphically

2011 mm, 1854 mm and 1822 mm respectively. The distance travelled in one rotation, for the compressed tyres was measured to be 1966.5 mm at 220 kPa and 1908.0 mm at 190 kPa. The difference in the measured distances travelled was 0.7% yet the radii differed by 1.7%. Further clarification of this phenomenon would require test throughout the pressure range for a number of combinations of vehicle and tyres. This will be the subject of a future investigation.

When speed is measured using rollers the compressed diameter of the tyre varies from the compressed diameter of the same tyre on the road surface. This is due to the rollers creating two curved surfaces rather than one flat surface on the tyre (load surface area).

The effective circumference of a tyre on the road can differ with brand, ply rating, belt type (steel or nylon) and tread depth. This circumference should then be duplicated when the vehicle is on the rollers by increasing the tyre pressure. The increase in tyre pressure required will be depending on tyre type, but early test results indicate it would be in the region of 30 kPa. Tyre pressure should be returned to recommended value before the vehicle is returned to the road.

Tyre slippage for a sedan on the roller was measured at a range of speeds using a strobe light and was found to be minimal. Great care was given to minimise slippage during the tests, and the measured slippage was less than 100 mm over the test distance of three kilometres. The total effect of slippage on speed accuracy was not deemed as significant in *no load* testing.

Another machine that utilises rollers is the dynamometer and can be used to test speedometers. Its primary function is to create load by converting test vehicle wheel energy to a controllable load and measures force developed by the drive wheels. Care should be taken when using a dynamometer that slippage is not induced by the machine's load generation. Some operators use the load generation to minimise hunting (the failure to maintain a constant speed due to engine behaviour). Load generation should be minimised as should tie-down pressures. It is normal practice to chain or strap the vehicle under heavy load conditions for measuring engine torque to avoid the vehicle climbing up and out of the roller valley. In these tests, lateral restraining of the vehicle was used instead of tie down, since vertical restraining caused tyre distortion, which can lead to an error in the region of 2 km/h.

Instrument Errors

Systematic errors that are not eliminated during calibration or applied as a correction, will contribute with opposite sign to the results of speed measurement by a police pursuit vehicle. For example, consider a police car tested at 100 km/h with a reported error of +1.5 km/h with new tyres (that is, the true speed is 1.5 km/h less than the indicated speed) now has tyres at half wear equating to 1km/h (100 km/h displayed , actual 97.5 km/h). Another vehicle is then perceived to be travelling at 2.5 km/h faster than actual by a pursuit vehicle. If the motorist has a speedometer error of -1.5 km/h and is travelling at an indicated speed of 100 km/h and has an actual speed of 101.5 km/h, we can see that it has been measured to exceed the speed by 4 km/h, enough to be considered a breach of traffic rules. These errors created by, (a) tyre wear, (b) not applying calibration corrections, and/or (c) from the roller-to-road anomaly, are critical to the overall picture, since the accumulative affect can be as much as 4 km/h. These three items were intentionally not calculated in this first view of the uncertainty assessments (subject discussion to follow) since the errors may or may not be deemed as uncertainty components.

To calculate the uncertainty associated with a driver's knowledge of the true speed of his or her vehicle, a review of the components of uncertainty arising from interpretation of speedometer indication, vehicle load, engine power management and tyre behaviour was undertaken by the author. (Discussed further in this chapter).

The driver's ability to accurately determine the vehicle speed using an ordinary speedometer is affected by:

> *The intrinsic accuracy of the instrument (the systematic error).*
>
> *Parallax error.*
>
> *Size of minor graduations (normally 5 or 10 km/h).*
>
> *Readability (usually one fifth of one minor graduation).*

Based on these factors uncertainty (expressed as 95% confidence intervals) for a speedometer (in pursuit conditions) read to 2 km/h was

60 km/h is ±8 km/h

80 km/h is ±10 km/h

110 km/h is ±13 km/h.

A calibrated speedometer read to 2 km/h and tested with certified speedometer testing reaches a higher accuracy than the ADR18.5.1.2, that is the ±10% rule is no longer the limiting factor but the accumulated uncertainty describe in this paper, yielded results of ±4.9 km/h at 110 km/h for a single vehicle, without any account for tyre wear and roller to road anomaly. This assumes that the speedometer was either adjusted to read true or the calibration correction was applied. Failing this, the uncertainty must be calculated with an uncertainty component due to the known systematic error.

The needle in an analogue speedometer will be about 2 mm from the gauge face. This results in a parallax error, which will depend on the position of the driver's dominant eye. The maximum error derived from experimentation was less than 2 km/h. With the advent of liquid crystal displays with either synthesized analogue or numerical readout, parallax problems are not an issue. On the other hand rounding of the displayed speed may create errors but these would be less than 1 km/h.

Analogue instruments display information by indicating with a needle or a pointer. The graduations on the display face limit the precision of the instrument readability. With a minimum division of 5 km/h and a needle width of the equivalent of 1 km/h, resolution to a fifth of a division or 1 km/h can be expected. Examples of the application of this convention can be found in Australian Standard AS1349 [6]

Since infringements can occur in just a few metres, we investigated other sources of speed control and measurement and found one overriding problem with smaller vehicles. Tests with an air-conditioned four-cylinder vehicle showed a 5 km/h variation in speed with the compressor cycling. This variation is created by the driver compensation for power fluctuations by his efforts to maintain constant speed. Policy makers may wish to include this in the big picture.

Calibration of the testing machine

The measurement of the roller diameters and rotational speed creates a standard deviation of less than 0.1 to 0.3 km/h between the speeds of 30 and 180 km/h. The stability of performance of all the roller machines tested throughout Australia over the last six years has been in the region of ± 0.2 km/h. Plotted roller wear on the Adelaide based unit was less than 0.01% over six years.

Police tolerances for speed infringements

The inconsistency between Australian States in their tolerance of small infringement of speed limits means that there is no single system in use. The most widely used system is the decade method. The posted speed limit can be exceeded by 9 km/h eg 69 in a 60 km/h zone (89 in 80 km/h zone etc) and incurs a fine if 70 km/h is detected. This method was introduced to compensate for the ADR 18.5.1.2 speedometer error of ±10%.

One State has recently introduced a 3 km/h tolerance, since their detecting equipment carried an uncertainty in the region of ±2 km/h. This system works on the premise that the drivers must not exceed the speed limit and the onus is upon the driver to ensure that they comply with the law irrespective of accuracy of their speedometer.

Discussion

Achievable aims:

The statistics collated by the Monash University, the police departments, the Royal Automobile Association and myself, indicate that a high proportion of speedometers are offset 3 km/h low and this offset is to compensate for drift. There has been no response from manufacturers confirming this practice. The application of this understating speed by 3 km/h for the allowance of drift is not supported by test figures and the accuracy of speedometers is not enhanced by purposely inflicted errors. The latest manufactured vehicles have an accuracy of 3% or better, of reading with one brand offering an adjustable version correct to within 2% of full scale. In the first instance, the use of "3%" is an archaic method of describing accuracy and creates a distorted view of the errors expected. Statistics have shown that ADR [1] should be amended to read "an accuracy of ±(0.65% of full scale + 1.75% of reading) or ±(1.5 km/h + 1.75% of reading) thus ensuring that the tolerance does not limit the lower values to impossible accuracies or the upper value becoming vague.

Acknowledgements:

I would like to thank the following people and companies for their assistance in producing this paper.

Royal Automobile Association of South Australia for the use of testing equipment.

R Laslett of S.A. Police Traffic Technical Support for encouragement and guidance.

J Lipman Traffic Technical Support NSW Police, for duplicate testing to expose systematic errors.

Injection Perfection, for duplicate testing to expose systematic errors.

J Tapping for his editorial assistance.

References:

1. The Australian Motor Vehicle Standards Act 1989, Design Regulation 18.5.1.2
2. New South Wales Traffic Law, Ninth Edition, Road Transport Regulation 1998 Section 41.
3. ISO Guide to the Expression of Uncertainty in Measurement. International Organisation for Standardisation, Geneva, 1993 ISBN 92-67-10188-9
4. Organisation Internationale De Métrologie Légale" Recommendation R111 titled Weights of classes E1, E2, F1, F2, M1, M1-2, M2-3 and M3
5. Monash University Accident Research Centre, "Accuracy of Vehicle Speedometer readings with respect to speed enforcement tolerances".
6. Australian Standard AS1349-1986, Bourdon tube pressure and vacuum gauges, Section 1.3 (Definitions), 1.3.4 (Scales and scale markings).
7. Australian Standard ISO/IEC17025-1999, "General requirements for the competence of testing and calibration laboratories."

Tyre behaviour

The tests the author conducted did not set out to measure individual effects of tyre behaviour on speed but was a measure of an overall effect. My "lumping" of the tyre behaviour was purely to extract a reason for variation in speed measurement. Tyre wear and low fill pressure just resulted in a higher indicated speed. Of concern were the tyre pressure variations from cold to hot tyres that gave a lower indication compared to actual speed.

Improved method

With the adoption of the suggested changes to the design rules, and with roller anomaly taken into account, we can then address the policy of dealing with the error caused by tyre wear, so that the uncertainty can be calculated considering all significant components. The author suggest taking measurements for the tyre wear at the half wear point since a tread depth at time of test can be obtained and results of the speedometer test mathematically corrected to the half wear point.. The tyre wear can then be included in the uncertainty to reflect results by tyres wear being other than half worn. The combined uncertainty components mentioned earlier and these latest additions were calculated to be ±6.7 km/h for a Dunlop Monza 205/65R15 tyre at 110 km/h.

No mans land

In some Australian States road works and children's crossing zones are automatically classed as 25 km/h zones. As the wording of the design rules (ADR 18.5.1.2) does not call for any accuracy for speeds below 40 km/h, the driver has no assurance of the vehicle's true speed in these zones.

Driver's responsibly

Other errors that have been attributed to outside interference (for example incorrect tyre size fitted, or differential ratio altered), or a deviation from manufacturers specifications are a separate issue. With vehicles made to the suggested amended ADR (as noted in paragraph "Achievable aims") the un-calibrated speedometer would have a lower calculated uncertainty of speed measurement and can be expected to perform within a lesser infringement tolerance.

Breach of natural justice

The calculation of uncertainty associated with speeds up to 120km/h shows that the decade method used by police forces allows infringement notices to be issued to drivers travelling within the region of uncertainty. The issuing of infringement notices using the 3 km/h tolerance system can be even unfair to drivers who use a speed-measuring instrument conforming to Australian design rules.

A temporary measure

A suggested policing policy is to allow 7 km/h at speeds of up to 50 km/h and an additional 1 km/h for every 10 km/h of speed up to 110 km/h speed. This policy will prevent infringements notices being issued for the region of uncertainty and therefore should not be legally challengeable. This policy of expanded tolerances would only be an interim measure to correct the present situation, prior to public testing facilities being introduced.

The solution

I believe that this paper lays the groundwork to give the Federal Government, State Governments, State Police Forces and motorists the tools to operate motor vehicle speed control measures correctly and fairly. If all recommendations are accepted, a policing fixed tolerance of 7 km/h (or a sliding scale of tighter constraint but more cumbersome to apply) can be used without compromising the motorists and afford them their right to an accurate form of speed measurement. However this policy assumes the application of calibration offsets to correct the speed value. The process of testing and calibration of rolling road testers that is traceable to a national standard must be made publicly available. A series of approved testing stations should be available so that motorists can confirm their speedometer accuracy and drive accordingly.

The tests conducted by the author as described in this paper are traceable to an Australian National Standard and have adhered to the requirements of AS17025 [7].

media release

14 February 2003

Commonwealth Government reaffirms commitment to peak standards and laboratory accreditation authorities

The Australian Government today signed revised Memoranda of Understanding (MoUs) with both the National Association of Testing Authorities, Australia (NATA), and with Standards Australia International Ltd (Standards Australia), reaffirming their key roles in supporting Australia's national technical infrastructure.

The MoUs, which were signed by the Parliamentary Secretary, Mr Warren Entsch (representing the Minister for Industry, Tourism and Resources) and representatives of NATA and Standards Australia, recognise these organisations as the peak bodies in their respective fields.

In signing the MoUs on behalf of the Commonwealth, Mr Entsch said today that: "Standards Australia and NATA are two vital components of Australia's standards and conformance infrastructure, and the signing of these new MoUs is an indication of the on-going importance the Government places on its good relationship with both organisations."

> *"The activities of both organisations contribute significantly to Australia's export success, and I congratulate both Standards Australia and NATA for your outstanding achievements," said Mr Entsch.*

The MoUs were last reaffirmed in 1998 and are reviewed at regular intervals to ensure they continue to reflect the changing needs of Australian business and industry.

According to the Chief Executive of Standards Australia, Mr Ross Wraight: "The MoU with Standards Australia recognises both our role as the peak non-government standards development body, as well as the valuable work we undertake in shaping the development and implementation of standards and related services both in Australia and internationally." NATA's Chief Executive, Mr Anthony Russell, said: "NATA's MoU with the Commonwealth recognises our continuing role as Australia's national accreditor of testing and calibration laboratories and emphasises the importance of the relationship between the Commonwealth and the technical infrastructure bodies."

Both MoUs also recognise the leading role played by Standards Australia and NATA in regional and international standards and laboratory accreditation.

NATA is Australia's signatory to a number of international mutual recognition agreements that facilitate the recognition and acceptance of Australian test data from accredited laboratories in foreign markets.

Standards Australia is the nation's leading Standards setting body and is a major participant in international Standards development through its membership of the International Organisation for Standardization (ISO) and the International Electro-technical Commission (IEC). With its head quarters in Sydney, Australia, it has more than 100 technical experts serving more than 2000 on-line committees developing both Australian and International Standards for Australian industry. It was the first national standards body in the world to develop on-line delivery of technical documents.

Since its formation in 1922 Standards Australia has developed and maintained more than 6000 Australian Standards and given input into some 14 000 international Standards. Through its consensus based Standards development process, which sees agreement reached between more than 9000 representatives from industry bodies, trade associations, government and consumer groups, it continues to provide high-level technical knowledge to the Australian community.

Media Inquiries

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Editors Notes

NATA was created over 50 years ago to evaluate and recognise the technical competence of testing and measurement facilities in Australia. It has since developed into the world's largest national laboratory accreditation system, with over 2,500 accredited laboratories. These laboratories operate in areas such as medical testing, construction materials, engineering, applied physics, biological testing, metrology and many other technologies. It has also expanded its activities to include inspection services accreditation, proficiency testing, training and other services specifically for the laboratory and inspection sectors.

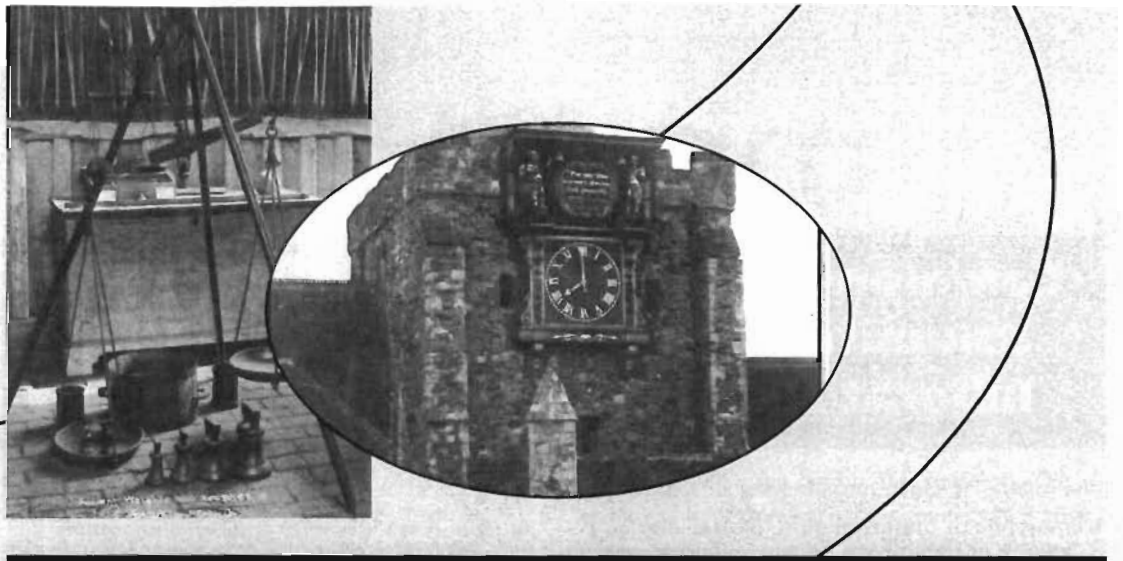

Figure 1:
Elaborate tower clock on St Mary's Church, Rye, Sussex, from a cabinet card photograph, c. 1890. The clock face and the 'Quarter-Boys' above – they strike the quarters but not the hours – date from 1760 but the clock itself was constructed in 1561-62 and is said to be the oldest functioning church turret clock in England. The inscription between the Quarter-Boys reads 'For our time is a very shadow that passeth away', a quotation from Ch. 2, V. 5 of The Wisedome of Solomon, a book of the Apocrypha in the King James Bible.

Figure 2:
Weights and Measures at St Augustine's Church, Brookland, Kent, from an old postcard, c.1910. Brookland is a few kilometres to the north east of Rye.

Churches and Measurement

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Churches are about time and eternity. They have from time immemorial been concerned with the cycles of life and season as well as matters that are beyond time. The church calendar is marked by numerous recurrent events, most obviously Christmas and Easter. Christmas was celebrated in Rome by the middle of the fourth century, the date subsuming and displacing the pagan festival of *natalis solis invicti* – the birthday of the unconquered sun – or the passing of the winter solstice as we would more prosaically regard it.

Easter is more interesting from a metrological point of view as it depends on the lunar calendar and therefore does not fall on a regular date in the solar calendar. Indeed the name *Easter* is possibly derived from the Phoenician *Astarte*, goddess of the moon and of the measurement of time. Words cognate with *moon* occur throughout the Indo-European group of languages and seem to be derived from the Sanskrit *mâ*, to measure. Modern city dwellers can pass weeks or months without catching sight of the moon or giving it a moment's thought, but to our ancestors the phases and revolutions of the moon were a reliable way of counting out the passage of the days over the course of the year, providing the rhythm for planting and harvest. The cycle of phases of the moon, or 'mooneth', provides our *month* of 28 days which could conveniently be divided into quarters or weeks.

Easter is celebrated on the Sunday following the first full moon after the northern spring equinox (or rather after March 20 which was the equinox date in 325 when the system was codified). There are some calendrical complexities to this which have resulted in the discrepancy between Orthodox and Western Christian celebrations. However the calculation is derived, it is important because of other events in the church calendar which are tied to the date of Easter.

The division of time within the day owes something to the rise of monasticism. Traditionally it was convenient to divide the daylight into 12 hours and similarly the darkness, so the length of an hour varied with the seasons. The establishment of monastic communities required a system for canonical hours. There were seven of these regulating the cycle of prayers throughout the day – matins, prime, tierce, sext, none, vespers and compline. The day began with early morning prayers – matins – before sun-up. The activities of the day were then punctuated at the first, third, sixth and ninth hours, followed by the last two prayer vigils after dark. Curiously the ninth hour – none – which originally fell between midday and dusk migrated to an earlier time, eventually settling down as noon. This was perhaps the result of fasting which could not be broken until the ninth hour, a greater trial the further north one was on long summer days in Europe.[1]

King Alfred the Great in late ninth-century England developed the means of dividing the day into 24 equal hours. As his biographer Asser records, Alfred 'had promised to render to God ... one half of his mental and bodily effort both by day and night'. But there was a problem with this. Alfred had no means for accurately marking the passage of the hours at night. And even in the daytime, the frequent occurrence of rain and cloud made the passing hours uncertain. So Alfred 'began to reflect on how he might be able (sustained by God's mercy) to preserve the substance of his vow unfailingly until he died, by means of some enduring principle, without any kind of uncertainty'.

> *When he had thought about these things for some time, he at last hit upon a useful and intelligent solution. He instructed his chaplains to produce an ample quantity of wax, and, when they had brought it, he*

told them to weigh it against the weight of pennies on a two-pound balance. When a sufficient amount of wax, equivalent in weight to seventy-two pennies, had been measured out, he told the chaplains to make six candles out of it, each of equal size, so that each candle would be twelve inches long and would have the inches marked on it. Accordingly, once this plan had been devised, the six candles were lit so as to burn without interruption through the twenty-four hours of each day and night in the presence of the holy relics of a number of God's chosen saints which the king always had with him everywhere.

One can only imagine that a great deal of trial and error went into this, to produce candles of just the right thickness (and consistency of wax and so on) that the six candles would burn in succession for the twenty-four hours at the rate of three inches an hour. It is also interesting to note this association of mass and length with time. And it seems Alfred would have understood very well that operations which work in the laboratory don't necessarily work in the field. (One might suspect that Alfred famously burnt the cakes while attempting to develop an oven timer.) Asser's account continues:

But because of the extreme violence of the wind, which sometimes blew day and night without stopping through the doors of the churches or through the numerous cracks in the windows, walls, wall-panels and partitions, and likewise through the thin material of the tents, the candles on occasion could not continue burning through an entire day and night up to the same hour that they had been lighted the evening before.

How long did it take Alfred and his chaplains to realise that the draught made the candles burn faster 'so that they had finished their course before their appointed hour'? He overcame the problem with an 'ingeniously and cleverly devised' plan – to make a lantern out of wood and ox-horn. The thinly shaved ox-horn was translucent so the candle's light could be seen (and the candle replaced when necessary) while remaining protected from the draught.[2]

Churches, as the focus of communal life by the middle ages, regulated people's days in many ways. When for most people it was sufficient to estimate the time of day from the position of the sun, churches sometimes provided a more codified system of time keeping. A number of late Anglo-Saxon sundials survive in churches in Yorkshire in the north of England. The best preserved of these is built over the south doorway of St. Gregory's Minster in the remote valley of Kirkdale on the edge of the North York Moors. The sundial is engraved on the vertical face of a large stone slab 236 cm long and 51 cm high and bears an inscription in Old English stating 'This is the day's sun-marker at every hour'. Another inscription on the stone indicates that St. Gregory's was built about 1060, replacing an earlier church that 'was completely ruined and collapsed'.[3]

The development of the mechanical clock two centuries or so later began a marked shift in society. The fourteenth century saw the equal hours of the mechanical clock supersede the seasonally variable hours that had previously predominated. When the first mechanical clock was developed, with an escapement to regulate the falling weight which drove it, cannot be precisely determined. But churches and churchmen were prominent in the erection of clocks. These were large mechanical devices with no hands or clockface, but tolled the hours by the chiming of bells. (Indeed, 'clock' is related to the French *cloche* and German *Glocke*, meaning 'bell'.).

In the 1320s Roger Stoke built an astronomical tower clock for Norwich Cathedral, and a little later Richard of Wallingford built a tower clock for the abbey of St Alban's, of which he was abbot. These clocks no longer survive but two turret clocks from later in the fourteenth century have been preserved. It is thought that the Salisbury Cathedral clock was constructed in 1386 and installed in a thirteenth-century bell tower. In the eighteenth century it was removed to the Cathedral tower where it worked until 1884. In the 1950s it was conserved and has since been on display in the Cathedral nave. The Wells Cathedral clock dates from 1392 and, with various modifications, remained in use at Wells until 1835. It subsequently moved to London and is now in the Science Museum there.[4] In time it became commonplace for church towers, as the dominant building of towns and villages, to have a mechanical clock by which the community could regulate its comings and goings (Figure 1).

Time has its place within churches also. Sermons were given by the hour-glass. These seem to have come into use in English churches in the sixteenth century and have been widespread by the middle of the following century. There is a record from the accounts of Christ Church, St. Catherine's, Aldgate in London for the year 1564: 'Paid for an hour-glass that hangeth by the pulpitt when the preacher doth make a sermon that he may know how the hour passeth away'.[5]

The hour-glass was hardly an expensive item. We find another entry – 'Payde for an houre-glass for the pulpit, 4*d*' – in churchwardens' accounts from Abingdon, near Oxford. Yet it was a very useful one. A rector in the Gloucestershire village of Bibury, we are told,

> *used to preach two hours, regularly turning the glass. After the text, the esquire of the parish withdrew, smoaked his pipe, and returned to the blessing.*

As the author of the 1853 article from which these accounts are quoted comments: 'One advantage presented by this ancient and precise practice [the use of hour-glasses] was, that the squire of the parish knew exactly when it was time to put out his pipe and return for the blessing, which he cannot ascertain under the present uncertain and indefinite mode of preaching'.[6]

The use of hour-glasses continued into the eighteenth century, but by then watches were becoming more readily available and hour-glasses increasingly redundant. In 1811, or perhaps earlier, the large silver hour-glass formerly used in St. Dunstan's, Fleet Street, London, was melted down to make two staff heads for the parish beadles.[7] By the middle of the nineteenth century, they were purely of antiquarian interest.

Apart from time, churches have sometimes been associated with other types of measurement. Jakob Köbel, in his *Geometrei* published in Frankfurt in 1535, has a delightful illustration showing the method of constructing a rod measure. Sixteen men in their Sunday best – including soft leather shoes which they leave on – are lined up heel to toe as they emerge from church.[8]

Churches could also house more permanent indications of linear measure. At some time towards the end of the twelfth century, as the building of London's St Paul's Cathedral was well advanced – building had been going on for about 100 years although it was not finished until 1310 – a charter referred to '57 feet by the foot of Algar which is sculptured on the base of a column in the church of St. Paul'.[9] Algar is thought to have been a prebendary in the early twelfth century and was perhaps responsible for incorporation of this useful feature in a convenient public location. It was more generally referred to as the foot of St. Paul's and seems to have been identical with the royal standard foot of twelve inches. As with ensuring the consistency of weights and measures in trade, this public 'foot of St. Paul's' seems to have been particularly relevant in land transactions. References to the foot of St. Paul's continue with diminishing frequency up to the end of the fifteen century and by the time the cathedral was destroyed in the Great Fire of 1666 the inscribed column was perhaps considered no more than its neighbouring columns. Still, such a public standard of measure was a novel innovation. A number of public standards of length were erected on buildings in Victorian Britain, such as the one that can still be seen by the entrance to the old Royal Observatory at Greenwich in London.

'A false balance is abomination to the Lord but a just weight is his delight.' These words look down on the shoppers browsing through tee-shirts and cheap jewellery in the market hall in Greenwich, just down the hill from the old Royal Observatory. Originally they looked down on bakers and butchers supplying more fundamental needs to the local people. The sentence is the first verse of chapter XI of Proverbs in Noah Webster's 1833 edition of the Bible.

Churches have played some role in maintaining just weights. The photograph in Figure 2 is from an old postcard captioned "Ancient Weights and Measures in Brookland Church". Brookland is a little village lying between Romney Marsh and Walland Marsh, Kent. Edward Hasted described Brookland at the end of the eighteenth century:[10]

> *The village is neat and rather pleasant, considering the situation, and the houses, as well as inhabitants, are of a better sort than are usually seen in the Marsh. The church stands in the middle of it.*

The Church of St Augustine was built in the mid thirteenth century. The feature which first strikes the visitor is the detached wooden belfry to the left of the porch. On entering one is immediately drawn to the twelfth century lead font which bears the signs

Footnotes

1. Alfred W. Crosby, *The Measure of Reality – Quantification and Western Society*, 1250-1600 (Cambridge, 1997), pp. 33-34. As a child, watching the matinee movie on TV in the afternoon was a puzzle I have still not solved!
2. Asser's *Life of King Alfred*, sections 103-104, in *Alfred the Great*, translated by Simon Keynes and Michael Lapidge (Penguin Classics, 1983), pp. 107-09.
3. Richard Fletcher, *St. Gregory's Minster, Kirkdale* (1990).
4. F.A.B. Ward, *Time Measurement* (London, 1966), pp. 31-32.
5. Quoted by A.W.S., 'On the use of the hour-glass in pulpits', *Notes and Queries*, Vol. 7 (18 June 1853), p. 590.
6. *Ibid.*
7. *Notes and Queries*, Vol. 8 (23 July 1853), p. 83
8. This is illustrated in R.D. Connor, *The Weights and Measures of England* (London: 1987), fig. 21; see p. 44 for discussion.
9. Quoted by Connor, *op. cit.*, p. 85
10. Edward Hasted, *The History and Topographical Survey of the County of Kent*, vol. 8 (1799), p. 382.
11. Anne Roper, *The Church of St. Augustine Brookland*, Thirteenth Edition (1997), pp. 11-12.
12. Hasted, *op. cit.*, pp. 385-86.

of the zodiac and occupations of the months, a feature of medieval calendars. Turning to the right, to the west end of the church, the ancient weights and measures are still to be seen, now secured behind glass. These were made by Vincent of London Bridge in 1795 for the Hundred of Aloesbridge which includes the parish of Brookland. The iron-banded wooden corn measures, liquid measures and brass ell are overshadowed by the great beam scales. This is said to be the only set in existence in a church in Kent and the oldest Hundred set that remains."

Whether these weights and measures were specifically related to tithes as the guide book suggests, I am not so sure. They may have been, like the foot of St. Paul's, intended to provide consistent and reliable measures for commercial transactions in the district. Hasted recorded that 'A fair is held here yearly on the feast of St. Peter ad Vincula, or Lammas-day, being August 1, for toys and pedlary'. Coming at the end of summer, this was a harvest celebration with traders coming to buy produce as well as those selling 'toys and pedlary', meaning small manufactured goods such as metal tools and woven cloth that could not be produced locally. This was probably the chief occasion when the weights and measures of the Hundred of Aloesbridge were at their most active. Hasted tells us that.

> *The lands towards the south [of the parish of Brookland] are by far the most fertile, for towards Snargate they are very poor and wet, and much covered with rushes and thistles. It consists in general of marsh-land, there not being above thirty acres of land ploughed throughout the parish, which altogether contains about 1730 acres of land.*

The tithe regulations dating back to the fourteenth century indicate the variety of produce of such a marsh-bound community: 'hay, calves, chicken, lambs, pigs, geese, hens, eggs, ducks, pigeons, bees, honey, wax, swans, wool, milkmeats [cheese], pasture, flax, hemp, garden-herbs, apples, vetches, merchandises, fishings, foulings, and all other manner of small tithes arising from all things whatsoever'.

So as you sit down to your next feast, give a thought for those who have feasted before you, what it was they were celebrating, and how, in a world before supermarkets, the feast marked the cycles of the seasons and of people's lives.

What Will Legal Metrology be in the Year 2020?

Judith Bennett
Executive Director NSC

On 26th and 27th September 2002, the International Bureau of Legal Metrology held a seminar in Saint Jean de Luz, France entitled "What Will Legal Metrology be in the Year 2020?" Speakers from 12 different countries presented a total of 23 papers on various aspects of this topic. The presentations were divided into sections according to subject matter:

- Globalisation
- National and regional activities and mutual recognition
- Scope and organisation of legal metrology
- Impact of new technologies.

The major papers will be published in the next few issues of the OIML Bulletin and will also be available on the OIML website: www.oiml.org. The October edition contains a paper on "Pattern Approval and Pattern Compliance in an Age of Globalisation" by Judith Bennett and Adrian Caster of the National Standards Commission. This paper presented a model for mutual recognition and international data-sharing, and stimulated a lively debate.

Overall, the following strong themes emerged from the presentations:

- Legal metrology will need to adapt to an environment characterised by globalisation of trade and deregulation of markets.
- The immediate challenges for OIML are, firstly to establish mutual acceptance arrangements for pattern approval test reports, and secondly to achieve closer integration with the Metre Convention and ILAC in order to deliver a global measurement system.
- The role of governments will be to write legislation, set standards and pursue global cooperation. The testing, certification and accreditation functions will increasingly be carried out by the private sector, and this trend has already started in Europe.
- Legal measuring systems of the future will consist of smart sensors, which will be remotely operated, calibrated and inspected through wireless communication, via the Internet and other computer networks. The traditional approach to legal metrology will not be suitable for such systems. The legal metrologist will need to be involved in the design of software, rather than the testing of hardware. The challenges will be electronic sealing, protection of communications and proof of transactions.
- There will be a shift of focus from pattern approval to international conformity assurance and national market surveillance. In-field surveillance of instruments will be increasingly carried out using remote diagnostic software.
- In the past, the OIML has had a strong focus on trade measurement. The scope of legal metrology must broaden to include environmental, health and safety measurements, and product quality measurements. The development of global systems in these areas will involve modernisation of legislation in most countries, and the resolution of jurisdictional issues between legal metrology agencies and government regulatory agencies in each of these areas.
- The needs of developing countries must be recognised and accommodated. This will best be achieved through a 'regional' approach, particularly in Africa. The role of OIML is not to provide aid, but to develop a closer relationship with the World Bank and other aid agencies, to build their understanding of the importance of legal metrology in national development, and to advise them on the best ways to integrate metrology infrastructure into their assistance programs.

The National Standards Commission has already recognised many of these trends, and has adopted strategies to ensure that the Australian national measurement system keeps pace with global changes. In the year 2000, the Commission entered into its first mutual recognition arrangements and established a national pattern compliance program – ahead of the rest of the world. NSC has also been working with the Australian grain and wine industries on product quality measurement, and has recently gained support for a new OIML technical committee on "Instruments for Quality Analysis of Agricultural Products", for which Australia will provide the secretariat.

The inclusion of regulatory measurements under the legal metrology 'umbrella' presents major legal and technical challenges. NSC and NARL are working together on issues of traceability of chemical measurements, and are establishing stakeholder networks to identify needs and develop appropriate solutions.

Events such as the OIML Seminar provide a timely reminder that we live in a time of rapid change, and must ensure that we constantly develop the knowledge, strategies and capabilities to survive and prosper in the 21st Century.

News from the National Measurement Laboratory (NML)

The Asia-Pacific Metrology Programme (APMP)

A Commonwealth Science Council initiative in 1977 heralded the formation of the Asia-Pacific Metrology Programme (APMP), which began in 1980 with the aim of improving the measurement standards and capabilities of, primarily, the developing economies of the region. From the 1990s the focus expanded to include the attainment of international equivalence in measurement standards.

The collaboration between member national standards laboratories, in sharing expertise and technical services, has helped to build mutual confidence in measurement capabilities. Participation in international comparisons and comparisons within the region has assisted in gaining international recognition of the measurement capabilities of the member laboratories.

The CSIRO National Measurement Laboratory continues to play an active part in this organisation. At the 18th APMP General Assembly, held in November, in Hanoi, Vietnam, NML's Director, Dr Barry Inglis, presented a paper entitled "The Final Target of the Global MRA". Another five staff members attended Technical Committee (TC) meetings as well as the General Assembly. Dr Noel Bignell was elected chairman of the TC for Mass, while Dr Rohana Ediriweera continued in his role as chairman of the TC on Quality Systems. Dr Brian Ricketts, Dr Nick Brown and Dr Angela Samuel attended TC meetings on Electricity & Magnetism, Length and Developing Economies, respectively.

Training for the Asia-Pacific Region

NML regularly conducting training courses, from a few days to a few weeks in duration, both at home and overseas. In November, NML played host, for a week, to visitors from the National Institute of Metrology, Thailand. Mr Virat Plangsangmas and Mr Channarong Thangchotika received training in the field of Acoustics.

International Assessments and Comparisons

As reported in TAM, September 2002, a global Mutual Recognition Agreement has been established between 48 national metrology institutes around the world, including NML.

Under the MRA, national measurement institutes must demonstrate competence by participating in international comparisons and in peer assessments.

NML has provided peer assessors for many evaluations over the last three years, with the most recent being undertaken in October.

Staff members visited the Korean Research Institute of Standards and Science (KRISS) for two technical reviews:

- Dr Nick Brown, in the company of scientists from the National Research Council, Canada and the National Measurement Institute, Japan (NMIJ) carried out a technical assessment for length standards; and
- Mr John Peters reviewed the RF and Microwave areas.

Two reviews were also conducted at the National Measurement Institute, Japan:

- Mr Bruce Meldrum assessed the Acoustics and Vibration Project; and
- Dr Mark Ballico reviewed the temperature standards area.

NML participates regularly in intercomparisons, both bilaterally and multi-laterally, within the Asia-Pacific region and around the world. One of the more recent comparisons involved a three-month stay in Germany by Dr Yi Li, who was working at Physikalisch Technische Bundesanstalt (PTB) in the high voltage area. The very favourable results of this intercomparison of resistive dividers up to 100 kV DC highlighted NML's capabilities in this area.

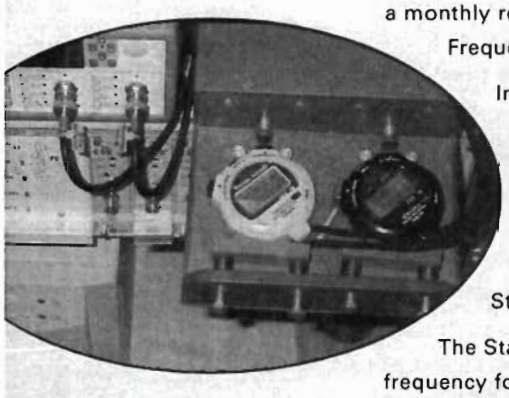
Time Transfer Systems

The demand for the expertise of NML's Time and Frequency project, headed by Dr Peter Fisk, continues, with the installation of time transfer systems across the world. Most recently, systems have been installed in Fiji and Taiwan, with the system delivered last May, to the Communications Research Laboratory, Tokyo, set to become Japan's primary time link to UTC (universal coordinated time) early in 2003.

Mr Steve Quigg (front centre) with staff from the various labs around Fiji. Mr Joeli Kini (front left) is the head of the Suva Lab.

NML's Web Site

The web site maintained by NML continues to expand. You can now find information on publications, facilities and training courses being offered, as well as staff details and areas of research being undertaken. Please visit the updated site: www.nml.csiro.au.



System for stopwatch calibration: Counter and stopwatches along top, with Rubidium standard (left side), buffer amplifiers and GPS receiver underneath. (Stopwatch calibrator is not visible.)

The installation in Fiji was the culmination of several years' collaboration. In late 1998 NML built, supplied and installed a GPS common-view Time Transfer System for the Standards Laboratory maintained by the Ministry of Commerce, Business Development and Investment in Suva, Fiji. This system provided traceability of their Rubidium Frequency Standard to the Australian National Frequency Standard. Operation was computer based, with NML issuing a monthly report on the performance of the Frequency Standard.

In January of this year, the system was recommissioned by NML, the equipment having been relocated to a new building. NML staff member Steve Quigg visited Fiji, bringing an improved Rubidium Frequency Standard to upgrade the system.

The Standard presently provides a reference frequency for a stopwatch calibrator. After recommissioning, staff from various regional laboratories visited the Suva laboratory to become familiar with the system and the use of the stopwatch calibrator. (A universal counter timer that was an integral part of the original Time Transfer System is now redundant and is available for general frequency and time interval measurements.).

Australian Global Navigation Satellite System

Dr Fisk was chairman of the Policy Development Working Group of the Coordination Committee for the Australian Global Navigation Satellite System, which developed a policy entitled "Positioning for the Future". This strategic policy was launched in August 2002 and following this Dr Fisk was appointed chair of the associated Policy Implementation Working Group. Members of this group come from government agencies and private industry. The purpose of the group is to oversee the implementation of the strategies contained in the policy and to advise the AGCC on ways to promote and facilitate implementation of the policy by other organisations as well as advise on issues arising from the adoption of the policy. The AGCCPIWG falls within the jurisdiction of the Department of Transport and Regional Services.

Australia's Measurement, Standards and Conformance Infrastructure

The main part of the seminar programme was as follows:

Welcome	Mr Tim Mackey, Deputy Secretary, Department of Industry, Tourism and Resources.
Industry Minister's Remarks:	The Hon Warren Entsch MP, Parliamentary Secretary to the Minister for Industry, Tourism and Resources.
Keynote Presentation:	Mr David Ellyard - overview of nature and work of agencies in the MS&C Infrastructure, and the benefits they provide to clients.
Industry Response:	Mr Chris Whitworth, Executive General Manager Special Projects, Alstom Power – the need for a secure and efficient measurement, standards and conformance infrastructure.
Science Minister's Remarks:	The Hon Peter McGauran MP, Minister for Science.

This was followed by case studies presented by industry representatives highlighting their interactions with, and the importance of, the various agencies of the infrastructure.
The industry case studies were given by;
Mr Brian Casey, Chief Executive Officer, Victorian Meat Authority,
Mr Philip Doddridge, Technical Manager, Southcorp Wines,
Mr James Galloway, Executive Director, Australian Electrical and Electronic Manufacturers Association,
Dr Mike Manton, Chief, Bureau of Meteorology Research Centre,
Patrick Callioni, Chief General Manager, National Office of Information Economy, and
Mr Norm Crothers, General Manager Content, Australian Consumer's Association.

The seminar concluded with a panel session where the chief executives of all the agencies making u the Measurement, Standards and Conformance Infrastructure answered questions from the audience.

An essential part of the foundation on which Australia's business productivity and trade competitiveness is built, is the Measurement, Standards and Conformance Infrastructure. In spite of its basic importance, this infrastructure is often not visible and is not fully appreciated.

To address this issue, a seminar was held at Parliament House in Canberra on 29 August 2002, where the range of support activities and services provided by this infrastructure, and the resulting benefits to trade, industry and business were presented. Approximately 80 people attended the seminar, including government ministers, advisers, government officials and industry representatives.

The overview by Mr David Ellyard and the industry response by Mr Chris Whitworth in the following pages.

David Ellyard's Presentation

Minister McGauran, Parliamentary Secretary Entsch, ladies and gentlemen. I'm David Ellyard, and it is my privilege to be your guide through the next two or so hours.

As Mr Entsch has explained, the purpose of today is to explore the vital issue of technical standards, what they are, why they are important, how we come to have them.

Again as Mr Enstch has pointed out, these technical standards underpin, much, if not most, of what we do as consumers, as employees, as business people, as citizens, day by day.

As you cook your breakfast bacon, you can ponder the fact that, thanks to our system of standards you can believe that the 500 gm pack of bacon did in fact contain 500 grams, that it was acceptably free of any microbiological contamination, while the grain in your breakfast cereal did not contain an unsafe level of pesticide residues and water in the tap was not likely to make you sick from algal contamination.

As you drive to work, you can be confident that the seat belts that protect you from injury have been built and tested to a prescribed standard, and you can make a call on your mobile phone (hands free of course) thanks to the technical standards that underpin the operation of the cell phone network. When you stop for petrol, you can believe what the pump says about the amount of fuel you bought.

And since you have the top down, you can reach for the sun block, confident that it really is SP30+.

When you reach your place of work, you can note that what we might call the modern economy really began with the setting and applying of standards and with ways of being sure those standards were being applied.

Mass production, the manufacture of complex objects from interchangeable parts, what was called in the 19th century the American System, was only possible with the invention of micrometers and vernier callipers and other precision instruments to ensure the pieces were the same size, and, backing that, a set of rigorous standards of size and weight and time and other dimensions.

Today the economy depends crucially on telecommunications and information technology, and that too is fundamentally a matter of standards, including precision about the frequencies of radio and infrared and optical signals, and the various standards of practice such as the protocols which enable computers to talk to each other.

There is a still bigger picture, since the economy is increasingly global. Both trade and investment depend crucially on confidence, and that confidence is based very much on being able to rely on the quality of goods and services, and on the accuracy of measurement and on standards being adhered to.

Of course, In our blasé way most of us would think this now to be all routine stuff, not at all remarkable, not likely to make the front page of the daily paper.

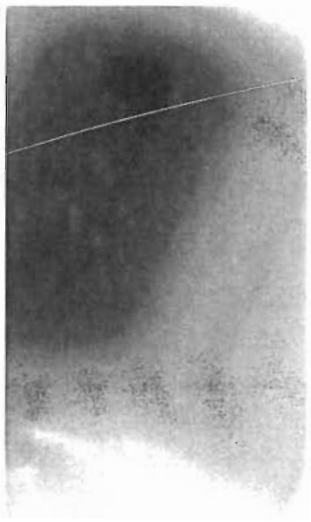
Yet without a system of standards there would not be a front page, or even a daily paper. Complex machines such as printing presses could not be built or maintained, the printers could not rely on the quality of the ink or paper or the plastic wrap. The phones would not operate, let alone the Internet. We could not even be sure that the hot meals in the staff canteen were safe to eat.

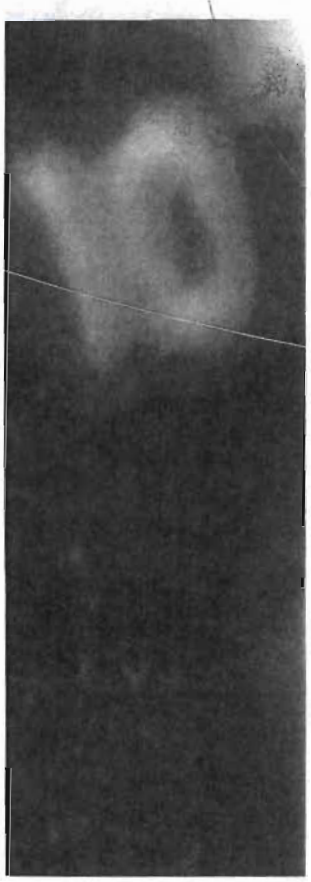
That things do work, and that we can feel acceptably safe and confident, is largely the result of the efforts of the six agencies who are in a sense your hosts here this morning. Their names are listed on our banner; the National Standards Commission, the National Measurement Laboratory, the Australian Government Analytical Laboratory, the National Association of Testing Authorities and Standards Australia, and the Joint Accreditation System of Australia and New Zealand.

And to those we can add the Commonwealth Department of Industry, Tourism and Resources, which helps to link them together, and has also made most of the arrangements which has made this morning happen.

Together these make up a network, a technical infrastructure, underpinning and supporting so much of what we do day by day. The full title of this grouping, the Measurement, Standards and Conformance Infrastructure, is impressive, and so it should be, given the importance of their contributions, individually and collectively. You will I think know much more about those contributions by the time we are through the morning.

But we can say at once that these are world-ranked operations, leading the field in many ways. NATA is the oldest and largest grouping of accredited testing laboratories in the world. Standards Australia was the first such organization anywhere





to have its products available via the Internet. The other agencies can make similar claims. Certainly all have strong international links and make their mark in global forums and organisations

It seems to me that three basic points can be made about the operation of this infrastructure and the agencies that comprise it. I think these points will be emphasised as we go through the morning, and you hear from some of the clients of these agencies, and about the benefits that have been secured.

Firstly what they do is generate confidence in the systems and procedures in which our lives are embedded, from dawn to dusk, from cradle to grave, all the things I have talked about earlier.

We need to be able to trust the quality and reliability of the goods and services we use. Setting standards, and then ensuring that those standards are met... that is the "conformance" bit... is one way to give that confidence.

The second point is that so much of what these organisations do goes unheeded and unheralded, however vital it may be. These measurement, standards and conformance agencies are genuinely "quiet achievers". Hence the importance of today which gives them a chance to wave the flag and shout a bit about the roles they play, so that you and your colleagues will know that you need them, and will want to make better use of their services.

It is worth saying that the ambit of these agencies covers all the portfolios of government, and that they are well placed to deliver on the three "I" words which are so important to this government, namely innovation, investment and international competitiveness.

Thirdly I would say that their value can be determined by the benefits they deliver, by the money or time or injury or even lives they help to save, from the fiscal bottom lines or the environmental quality they help enhance, from the things they make possible, or even easy, which could not be done at all without a process that sets the standards and maintains them, and provides procedures to ensure that they are adhered to.

But enough from me. It is time to hear from someone who knows the contributions these agencies make from first hand experience. I welcome to the microphone Mr Chris Whitworth, General Manager of Alstom Power, to give a user's perspective.

Chris Whitworth's Presentation

Minister, Mr. Entsch, Ladies and Gentlemen,

Preamble

My willingness to participate in this presentation today, is driven not so much by my role as Chairman of the Industry Advisory Committee which serves the CSIRO's Measurement Standards Sector, but rather by my professional concern for the need of a secure and efficient measurement standards infrastructure on which Australia's industries can depend, as they face the challenges and opportunities of free trade in an increasingly global environment. In fact, it is this concern that has led to my involvement with the CSIRO.

Introduction

I am a senior engineering executive of Alstom Power and have spent most of my career in the power and resource development industries. My experience working overseas and in dealing with foreign associates has given me an enduring admiration for Australian competence but the highly competitive world in which we work today requires attention to maximising not only the effectiveness of our direct efforts but also to maximising the effectiveness of the underlying infrastructure of our business environment. Measurement standards are a vital part of that infrastructure and Australia's industries require that its security be assured while they maintain their focus on the tactics of global and local endeavours.

The importance of the measurement standards and conformance infrastructure.

Unfortunately, 'measurement standards and conformance infrastructure' is not the kind of activity that attracts public attention. We all know where the announcement of a discovery in maintaining frequency standards would be reported if it coincided with the discovery of a scandal in a sporting club, but measurement standards do matter, and they affect our daily lives.

Simplistically:

- Where would we be if a 'millimetre' or a 'micrometre' used in making an Australian product didn't coincide with the millimetre or micrometre expected by a foreign client?

- How about an "Australian" tonne of wheat being lighter than the tonne a foreign purchaser thought he was getting?

Simple though it might seem, trade and commerce need the maintenance and traceability of standards, globally - and who is to do this? Left up to industry, it is likely that a "seller's" tonne would become rather light and a "purchaser's" tonne would become somewhat heavier.

The activities of a viable measurement standards and conformance infrastructure go beyond simply caring for fundamental standards. There is an ongoing need to seek simplicity and uniformity, to devise standards for new technologies and to actively participate in the development of such infrastructure internationally.

Importance of standards to the power boiler industry

In my principal field of operation, steam boilers for the power industry, standards have played an important role for over a century. The frequency and consequences of boiler explosions led to the development and ongoing maintenance of documented standards to control the integrity of design, materials, fabrication and operation. These documented standards have become international and it is their availability and control that enables Alstom Power, here in Australia, to design and supply power plant equipment to projects in USA, Canada, Thailand, Vietnam, Malaysia and New Caledonia.

Quality, measurement and analytical standards are important to this industry in many ways. For example:

- **Quality:** Australia's adoption of internationally recognised quality standards provided entry for our industry to international markets, but adoption alone was not enough for ongoing business. The maintenance of our reputation as a supplier of quality products and services requires constant attention to the management, accreditation and certification of Australia's technical infrastructure as well as constant attention to our company's quality systems.
- **Plant Performance**: Competition has resulted in modern plant being designed less conservatively than previously. With financial consequences of under-performance now swamping the slender profit margins of such plant, the techniques and accuracy of performance measurement have become crucial to survival in this business. Accreditation and traceability of measurement standards and instrument calibration is essential to the fair and equitable assessment of plant performance, especially when working internationally.
- **Greenhouse Gas Emissions**: Australia is more reliant on cheap electricity from fossil-fuelled power stations than any other country in the developed world. As such, it has the most to lose under the imposition of a carbon tax. Already, a trade in renewable energy certificates has been established, to encourage the installation of renewable forms of electricity generation. This trade is the precursor to international carbon trading based on GHG mitigation, yet the measurement of GHG emission is far from accurate. This is an area in which the CSIRO could contribute greatly with its wide range of research expertise, to devise better means for the accurate measurement of GHG and so avoid unfair imposts on the cost of boilers and the cost of generating electricity in Australia. This is of even greater concern to Victoria, with its reliance on the cheap but less efficient fossil fuel resource of brown coal.
- **Environmental Monitoring**: Modern power stations are expected and required to prevent degradation of the environment. Putting aside the matter of GHG, other fluid releases must be controlled also. The matter of standards is extremely important in this regard as it is not sufficient for a specification to simply require, for example, that only "pure" water can be released - after all, how pure is "pure". Clearly, analysis, measurement and standards activities are essential, and AGAL has this expertise.

The on-going need

When attuned to the relevance of metrology and standards to our society, many examples will emerge to the thoughtful person. Without standards, conformance and quality, our soldiers might face a situation where ammunition from an ally won't fit into their weapons. Our sailors might run aground if the calibration of their navigation equipment is incorrect. Our airmen might be shot down if their "friendly" signals aren't recognised. Our defense equipment manufacturers might not win contracts if they cannot provide traceability of their instrument calibrations to international standards.

The agencies making up the infrastructure are as follows:

- National Standards Commission (NSC)
- National Measurement Laboratory (NML)
- Australian Government Analytical Laboratories (AGAL)
- Standards Australia International (SAI)
- National Association of Testing Authorities (NATA)
- Joint Accreditation System of Australia and New Zealand (JAS-ANZ).

Hospital patients might die if medication standards are not properly maintained.

As Australian industries enter higher technologies that entail work at molecular levels, the need for a secure measurement standards infrastructure is even more important. The outlook is ever more demanding standards of measurement.

It is vital that our measurement standards and conformance infrastructure is secure, efficient and readily available to serve the needs of all sectors of Australia's industries.

The benefits of a national measurement institute

In conclusion I would like to comment on a current proposal to amalgamate the NSC, AGAL and the National Measurement Laboratory into a single National Measurement Institute.

From an industry standpoint, government services are often obscured by the location and lack of overt presence of their agencies. This situation combined with industry's natural aversion to the trappings of bureaucracy, frequently results in Australian companies failing to take advantage of the expertise and benefits available from these sources. The CSIRO appears to have recognised this problem and is investigating ways of connecting with industry more effectively.

The availability of a "one-stop-shop" for services in metrology, analysis and standards would greatly assist industry when faced with a need for assistance in these areas.

As a taxpayer, I personally find the formation of a single National Measurements Institute very appealing - on the basis of better utilisation of government resources and reduced overheads.

The National Measurement Laboratory's magnificent facility at West Lindfield would seem to be an excellent location for a consolidated NMI. Present cost/benefit results would surely be improved by its use for this purpose, especially as this somewhat under-utilised facility has been so purpose-built as to be just about useless for alternative, ordinary commercial use. If it were to be blindly "rationalised" and lost to the service of metrology, Australia's needs and international image in this area would suffer greatly.

TAM Profiles

Our profiled metrologist this edition is Graham Cox, who until recently was a Senior Chemist with Pasminco, a large Australian owned mining, smelting and refining company in Port Pirie, South Australia. Graham recently completed the IRIS Graduate Certificate of Engineering (Metrology & Quality), and he reports some personal notes on his experience of the course. He says: Quite a bit of the course was directly applicable to my daily work as a Certified Practising Chemist working in the mining and base metal smelting and refining industry. The "Experimental Analysis" was excellent as was the detailed feedback. The SPC, DOE and other topics have helped me in my work in which I am mainly responsible for the supervision of laboratory staff, and the operation of a very large geochemical/metallurgical laboratory performing over one million analyses per year.

Through the course mentor (Dennis Sexton) who recommended me, I became a member of the American Society for Quality (ASQ), an excellent move in giving me the opportunity to take advantage of the knowledge and learning opportunities offered to members of that Society.

The "Calibration, Documentation & Laboratory Management" course was also really useful as our company is ISO 9000 Certified and my lab is ISO 17025 Accredited. By studying this subject I had the opportunity to really get familiar and understand these standards and how they apply to my work. I believe my invitation to become a NATA assessor recently, was greatly assisted by me undertaking formal studies of Quality Management Systems and Laboratory Management via the course.

The "Measurement Systems" course helped to broaden my understanding of the wider field of metrology in general.

South Australian member of the MSA, Jeffrey Tapping, actually introduced me to the Society and the IRIS course back in 1999, for which I am indeed grateful. I attended the Biennial MSA Conference in Broadbeach last October and really enjoyed participating and making contact with other members of MSA and fellow IRIS course students.

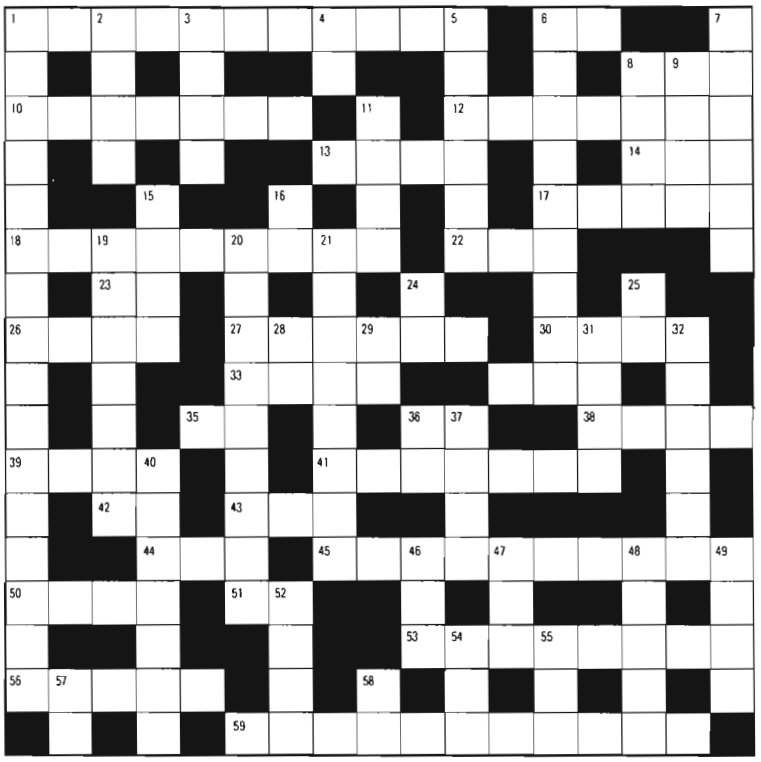
After working at Pasminco for the last 16 years, Graham has just accepted a new position with General Electric (GE) as a Technical Specialist and will be working in a consultancy role at the BHPBilliton managed Boodarie Iron, a new $2.5B Direct Reduced Iron plant at Port Hedland, WA, which produces almost two million tonnes of iron briquettes per annum for electric arc furnace production of steel in China, Japan and South Korea.

Crossword

Book Competition!

This crossword from Jane Warne gives TAM readers and MSA memebers an opportunity to win a prize! You can use the ordinary or the cryptic clues (for the crossword buffs out there).

Send your entry to "TAM Crossword" c/o The Editor, The Australian Metrologist, 11 Richland Road, Newton SA 5074 before the 30th of April 2003. The first correct and neat entry will win the book "The Measure of All Things", reviewed by Jane in this issue. Get a team effort going around the lunch table and win the book for the company!



Down Clues

1 An early agricultural pump
2 Singularity
3 Meteorological element measured in the units of length
4 The ratio of the circumference of a circle to its diameter
5 A man of learning, a distinguished scientist
6 The instrument invented in 1643 by Italian physicist Evangelista Torricelli
7 An instrument for separating particles by size
8 American standards laboratory
9 Indian measure of weight or volume, approximately equivalent to 2lb or 1 lt
11 Inventor of the Arc Light, Safety Lamp, Sodium and Potassium
15 Accurately conforming
16 An isotope of this metal commonly used in radio-therapy
19 Stretching strength
20 Father of lease square fitting
21 A mathematician whose primary field of study is the shape and area of the earth
24 Transition metal used to harden steel
25 alpha particles
28 The second last element
29 a thousandth of a second
31 Electrical potential
32 Being under age; minority; immature
36 Abbreviation for a unit of light intensity
37 The prefix for a million, million, millionth
40 A French mathematician
46 Defined atmosphere
47 Standards Laboratory
48 Egyptian measure of length
49 A measure of the asymmetry of a distribution
52 This is integral to the definition of both the Julian and Gregorian calendars
54 Abbreviation for External
55 Defence Laboratories
57 Inert gas
58 Turbulence factor

Down Cryptic Clues

1 Ancient Greek bath fastener
2 One on the lee side
3 A wet king's
4 An irrational dessert
5 A learned servant
6 Meter out under pressure
7 The cretinous sentinel at the cinema scrambled the first half of our tickets.
8 No mist
9 The profit of foresight
11 V day
15 To rue oxygen
16 Co-operative Company
19 Ten scrambled lies
20 The French green doctor
21 No tea in desert geography
24 Molly be dumb
25 The male element
28 Nobel's short prize
29 Millie ran a close second
31 Sporting an electrical pole
32 None of age
36 A short bar of soap
37 At to by 10 -18 it is a very small number
40 The French place
46 A short sexually transmitted disease
47 Enamel
48 Four arms
49 Distorted Kews
52 English lunatic without bugs
54 Short without eternal scrambling
55 One rearranged dais
57 Ardour without dour resolve.
58 Rescue the actor by eliminating the cues

Across Cryptic Clues

1 7000 grains of weight
6 Our Queensland National rep
8 First letters to a native sweethearts consul
10 See us sell the scrambled scale
12 I err in Venn diagrams.
13 Protectors of Laboratory law
14 Marine watch
17 A mixed up meter
18 The non-weather science
22 A tiger without grrrh!
23 Common market
26 The pleasurable eating experience
27 On gnome
30 Short evening
33 Not a roads
34 Electric black bird
35 First of a giants call
36 So, Fa, Te, Do
38 It lends itself to catching light and a dose of Zs.
39 Nil for I but some for you
41 Sex to an ant
42 seat without a street
43 Murdered cast
44 Part without tea
45 Resistance it's useless to Borgs on board.
50 An eel's spinning revelry
51 Confused me
53 The lamb re
56 Chat was singularly scrambled in time
59 A cause of great consternation

Across Clues

1 English system of weights and measures
6 One of the points that defined a temperature scale
8 The legal arm of metrology
10 The Swedish astronomer who defined the decimal temperature scale with 0 as the boiling point of water and 100 as the freezing point
12 A common dimensional measurement method which uses a duel scale
13 Laboratory accreditation body
14 Observation
17 What was intended to be 1 10 millionth of the distance from pole to equator
18 The science of weights and measures
22 Union
23 A lanthanide
26 Unit of force
27 Pillar or rod used to measure time by its shadow on a marked surface
30 Balanced
33 A unit of both length and volume
34 a device that can measure wave forms
35 Key constituent of steel
36 Lanthanum
38 Law related to induced electromagnetic force
39 Balance point of a current meter
41 An instrument to aid in navigation by measuring the height of the sun
42 each
43 Precision cast
44 Equality
45 Oscillation of a system
50 A device for winding line or cable
51 Unit of measuring the amount of printing matter in line
53 One of the French scientist who defined the metre
56 A device for measuring time
59 A key definer of a measurand

Annual Financial Report 01 - '02

Metrology Society of Australia (ABN 802 123 257 48)

Balance Sheet as of June 30, 2002

Assets	2001-2002	2000-2001
Assets Current Assets		
Cash management	16,043.36	15,430.35
MSA Conference	5,832.82	5,826.24
MSA No.1	25,719.68	9,490.75
Term Deposit 1	18,038.85	17,532.76
Term Deposit 2	11,431.04	10,890.85
Total Assets	**77,065.75**	**59,170.95**
Liabilities & Equity		
Equity		
Opening Bal Equity	35,150.46	35,150.46
Retained Earnings	24,052.49	22,883.64
Net Income	17,862.80	1,136.85
Total Liabilities & Equity	**77,065.75**	**59,170.95**

Statement of Receipts and Expenditure for year ended 30 June 2002

Income	2001-2002	2000-2001
CMM Activities		8,223.72
Fees		
Annual	12,630.00	11,640.00
Nominating	785.00	665.00
Total Fees	13,415.00	12,305.00
Interest	1,704.72	2,130.75
MSA 2001 income	37,272.00	
TAM income		
Advertising TAM	360.60	290.00
Subscriptions TAM	30.00	0.00
Total TAM income	390.60	290.00
Total Income	**52,782.32**	**23,174.17**
Expense		
MSA 2001	22,286.78	7,986.01
Society General		
Bank Fees	193.03	252.12
Disbursements to states	819.43	1,283.04
IMEKO Fees	1,722.29	2,500.00
Meetings	2,414.28	475.77
Office	270.00	1,108.99
Web	511.50	
Other	679.95	1,934.91
Total Society General	6,610.48	7,554.83
TAM	6,022.26	6,496.48
Total Expense	**34,919.52**	**22,037.32**
Net Surplus or (Deficit)	**17,862.80**	**1,136.85**

Treasurer's Report

This financial report represents a period of 12 months from July 1, 2001 to June 30, 2002. The Balance Sheet reflects a healthy financial state showing the society has assets of $77,065.75. The Statement of Receipts and Expenditure for the period shows a surplus of $17,862.80. The large size of the surplus is due to the fact that most of the income for the MSA 2001 conference is reflected in this period. The overall surplus for the MSA 2001 conference was around $7,000.

Subscription fees increased slightly from the previous year. This is a common trend in a conference year TAM costs are down but we are not managing to produce 4 issues each year. This trend needs to be addressed. I believe we have reached a critical stage in the societies development. Members need to be vocal about what they expect from the society in order to ensure it continues to grow and mature while serving the needs of its members. While many great ideas were put forward at the last annual general meeting there are insufficient people willing to implement these ideas. Without willing workers who make a sustained effort to develop the MSA the society will not survive.

IMEKO continues to be a concern. The committee has undertaken to work to ensure this membership is useful to the society. Despite th commitment to IMEKO there does not appear to be anyone available to coordinate our involvement and ensure we get value from our membership.

I would like to thank the MSA executive committee for their support and especially Ilya Budovsky who as secretary has worked especially hard to ensure the reporting between the membership database and the treasurer is perfect. Special thanks to our honorary auditor Bryce Thornton, who is guiding the development of sound financial reporting systems that will stand the Society in good stead as it grows in strength. Next year I will have completed six years as Treasurer of MSA. This is a good time for someone new to consider taking on this role.

Book Review

The Measure of All Things

Ken Alder

Publisher: Little, Brown (an imprint of Time Warner Books UK) 2002. ISBN 0-316-85989-3

Last year I was cruising a bookshop looking for that ever-elusive Christmas present for my husband, when I noticed this book. Normally I would have walked straight past as my reading taste tend to run to the escapist - murder mysteries, thrillers and, of course, science fiction. However, despite my lowbrow tastes, the subtitle "The seven year odyssey that transformed the world" caught my imagination. While I consider myself a metrology enthusiast, I had never thought of a single event in metrology transforming the world. I also realised that this was an area of metrology I knew very little about – how the metric system came into being.

I was in primary school when Australia adopted the metric system. I remember learning feet and inches, acres, fathoms, stones, pounds, ounces, pints, and miles per hour. I confess to still think in some of these units from time to time. The height or weight of people or the temperature on particularly hot days; why? As a child I got out of school if it reached 100°F, 38°C does not have the same memories associated with it. Conversely in other areas of life I cannot think in anything but metric, miles and pounds per square inch have no meaning, and ironically I only relate to temperatures below about 80°F in the Celsius scale.

This may seem a strange introduction to a review on the history of meter however it is this quirky nature of human beings that is at the heart of this tale. While being a very good history of the metric system, it is also a fascinating study of the relationship between science and the scientist and how a drive for truth can create or break a man. It is a study of the interactions and relationships between, politics, economics, science and society and how people on mass and as individuals respond and adapt to change.

In 1790 the King of France and the National Assembly authorised the Academy of Sciences, as a matter of high priority, to design a system of uniform measures. "They (the Academy) vowed to choose a set of measures which would 'encompass nothing that was arbitrary, nor to the particular advantage of any people on the planet' ." (pp29) The meridian expedition was the outcome of this vision, a system of measurement based on size of the earth. The metre would form the basis of this system and would be equal to 1 10 millionth of the distance from the pole to the equator. The metre was to be determined to within 0.005% or 0.005mm, the equivalent of 50m in the distance from pole to equator; phenomenal precision given the instrumentation of the day.

The story starts in 1792 on the eve of the French Revolutionary with two savants Jean-Baptiste-Joesph Delambre and Pierre-Francois-André Méchain starting out on an expedition to measure the length of the meridian from Dunkerque to Barcelona. With a couple of assistants each, they set off in opposite directions, Delambre to measure from Dunkerque to Rodex and Méchain to measure from Barcelona to Rodex. This expedition was planned to take one year and ended up taking seven years and changed the face of society, economics and science. While these may seem to be extreme claims, Ken Alder tells a compelling story and argues a strong case for exactly that.

Above all this book is a fascinating study of how people deal with challengers and their own limitations. Delambre and Méchain become real people in a complicated time who are dedicated to the completion of their mission regardless of the personal cost. Méchain did not see his children, wife nor his co-worker Delambre for the duration of the seven-year journey. They continued working through several changes of government and the dissolution and reformation of the body that commissioned the mission. When hyper-inflation meant their funding did not come near paying for the expedition, they used their personal funds to ensure the work continued. Delambre and Méchain faced incredible trials from being captured and threatened with death by revolutionary forces as spies for the King, to being trapped on the wrong side of the French – Spanish boarder during the revolutionary war between France and Spain. They worked month after month, in war zones, extreme weather and through epidemics.

With a supporting cast of people such as Lalande, Legendre, Lavoisier, Laplace, Gauss, Jefferson and of course Napoleon peppered throughout, the story provides an interesting view of France and Paris during this period. I found the book fascinating, compelling and in no way a dry history. While to some the fact that the metre is in fact short by 0.2mm would indicate that this mammoth undertaking was a failure. Ken Alder is persuasive in his argument that this was indeed a turning point in the history of the world, both scientifically and economically. It marks the transition from savant to scientist, from philosophy to modern science, and from feudal economics to globalisation. The book is well written, compelling and highly recommended.

Reviewed by Jane Warne.