mind that no test is perfect? The question is pertinent because, depending on the outcome, a player's career could be affected or even ruined. The other side of the coin is that a result could unfairly stand.

Therefore, it is necessary to make a statement about the ***quality*** of the measurement. One consideration is the difficulty of measuring small concentrations. The above limit ***is*** very small as regards accurately determining such concentrations, but an actual concentration that was appreciably greater would be likely to have a performance-enhancing effect. Is therefore 5.2 ng per ml 'appreciably greater' than 2 ng per ml?

Internationally agreed minimum requirements for the competence of laboratories (ISO/IEC 17025, ILAC G8) recognise the difficulties of measurement, stating that a player is positive when the test result is 'significantly above the limit'. The laboratory concerned carries the burden of proof: only when a player is found positive should it report the case for sanctioning.

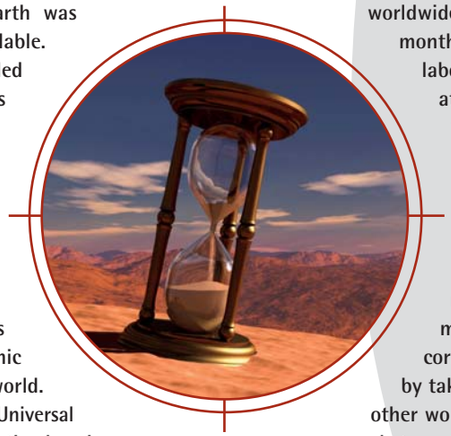
On the basis of repeating and analysing the measurements made and an understanding of the equipment used, the laboratory makes a statement about a ***spread*** of possible test results. The value of 5.2 ng per ml is the laboratory's best estimate of the nandralone concentration, but the uncertainty of the measurement means that the laboratory is only 99% sure the ***true value*** is within a certain range either side of 5.2 ng per ml – where the range spans 0.4 ng per ml to 10.0 ng per ml. An accompanying statement reported that the laboratory was 99% confident that the actual concentration lay in this range. Because the lower endpoint in this spread lay ***below*** the limit, the internationally agreed interpretation is that the result is ***not positive***. Evidently, for a somewhat larger test concentration of, say 7.2 ng per ml, and the same spread about this value, the result ***would*** be positive.

Statements such as the above, where a value is reported with the probability of lying in a stated range, form a major part of modern metrology (measurement science). The statement is known as an expression of uncertainty associated with a measurement, for which the accepted 'bible' is the ***Guide to the Expression of Uncertainty in Measurement*** published by the International Organisation for Standardisation. Clearly, the smaller the uncertainty, the greater the likelihood of obtaining a clear-cut statement of whether an actual concentration lies above or below a limit. The number of borderline cases in which there was genuine doubt would consequently be decreased. Metrologists continually strive to reduce measurement uncertainty and to determine it more reliably for the general benefit of the community.

Dr Adriaan van der Veen of the Dutch Metrology Institute (NMi), who has acted as expert witness in several cases involving the alleged abuse of nandrolone in football, contributed to this article.

Time traceability

Next time you look at your watch, just pause for a moment. Are you really sure it is showing the right time? Perhaps you set it using the six pips on the radio, or to the time shown on breakfast television, but how do you know that these are telling the right time? In fact, just what is meant by the right time?



For centuries, the rotation of Earth was the most accurate timekeeper available. Man-made clocks merely subdivided the day into more convenient units of time. Today, the best clocks, based on the resonances of atoms, are much more stable than the Earth's rotation. A continuous atomic time scale is maintained by the International Bureau of Weights and Measures (BIPM) in Paris, which once a month combines the signals from around 260 atomic clocks in laboratories around the world. This time scale, called Coordinated Universal Time or UTC, provides the basis for timekeeping worldwide. In practice, because UTC is processed monthly and does not exist in real time, national laboratories including NPL maintain local atomic time scales that are kept within 100 nanoseconds (i.e. 100 x 10^{-9} s) of UTC.

Very often, having nanosecond accuracy is less important than simply knowing that you have the correct time. When you are rushing to catch a train, you might only need to know the time to the nearest minute – provided you are sure it is the correct time. Such confidence can be achieved by taking the time from a traceable source, in other words one that can be related, perhaps via several steps, to UTC.

The national time scale underpins the well-established methods of disseminating the time, such as BT's Timeline, and the MSF radio time signal broadcast from Rugby that synchronises many thousands of radio-controlled clocks. These methods will always tell you the correct time to within a known uncertainty. This cannot be said for all public clocks – the time displayed during television programmes has sometimes been off by minutes.

New requirements for time traceability appear frequently. Many of these arise from the rapid growth in e-commerce. In share dealings, for example, prices can change rapidly, and even a difference of a few seconds in the timing of a large transaction might increase the cost by thousands of pounds. Solutions that combine a time stamp from a traceable internet timeserver with a secure audit trail are now being made available to businesses. The police often rely on time traceability to piece together the events around a crime or accident. Mobile phone records might show whether a driver was making a call at the time of a crash, and the time stamp on a CCTV or speed camera photograph can pinpoint a suspect at a particular time.

One thing we can be sure about is that our need to know the correct time will only increase... over time!

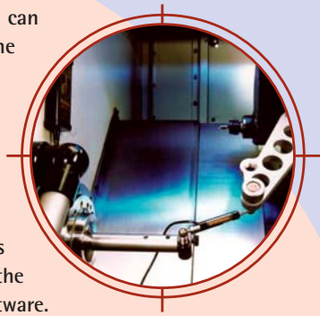
On-Machine Measurement

In the world of engineering manufacture, the advances in quality systems and techniques are developing as rapidly as developments within information and communication technology. Many people own and work with computers and from time to time need to upgrade their hardware, software and personal skills in order to gain full use of the equipment's potential.

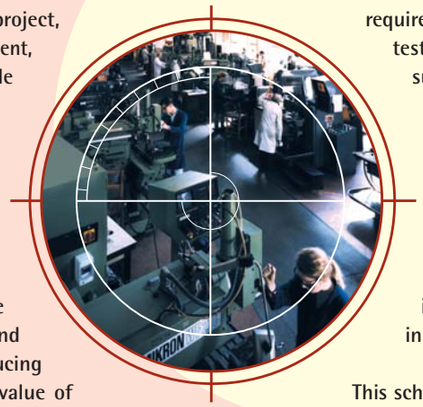
Within engineering manufacturing the same principles apply. Many companies use and benefit from quality management systems and already operate an array of well-calibrated measurement equipment. However, there are some companies where quality control and measurement best practice has fallen behind and it is these companies that find they are at risk of losing existing business and failing to be in a position to develop new business.

In a recent successful pilot project in West Yorkshire, around 30 small to medium engineering companies were encouraged to free trial new process control and measurement equipment. The project, known simply as On-Machine Measurement, was funded by the Department for Trade and Industry, and run by the National Physical Laboratory, The Centre for Precision Technology at the University of Huddersfield, Leeds College of Technology and Kirkdale Industrial Training Services. During the project a wide range of processes were identified that could be improved through the use of advanced measurement technology and techniques. It was successful in reducing machine set-up times and scrap to a value of £200,000 whilst producing new business opportunities to a value of £750,000.

One such piece of technology was the Renishaw Ballbar. This instrument can very quickly evaluate CNC machine tool capabilities. It identifies both electrical and mechanical errors in the machine tool. It uses a linear transducer to monitor the machine's ability to move in a circular pattern. It does this by measuring the change in radius value as the machine moves along a circular path, displaying the result graphically using advanced software.



One company was about to replace a machining centre because it was not producing components to the required specification. By performing a Ballbar test, the errors were identified and with subsequent correction this machine is now producing within specification. This has resulted in a saving of £70,000, the cost of a new machine.



This is just one success story of many that have come from the On-Machine Project, one of the most successful initiatives in manufacturing metrology in recent years.

This scheme will now be rolled out through the UK over the next two years. For more information please contact the NPL Helpline.

International Conference on the Uncertainty of Measurement
St Catherine's College, Oxford, UK: 9 - 10 April 2003

Whether you are a world expert, a complete beginner or someone in between, UNCERT 2003 will provide a forum for the dissemination of the principles of uncertainty in measurement as well as discussion of technical developments and innovation in the area, providing something of interest for all those involved in measurement.

UNCERT 2003 offers a unique opportunity for participants to network with colleagues from both industry and academia.

If you are interested in attending, submitting a paper or sponsoring UNCERT 2003 please contact:
Hannah Edmunds | Tel: 020 8943 6260 | E-mail: hannah.edmunds@npl.co.uk
National Physical Laboratory | Queens Road | Teddington | Middlesex | TW11 0LW

FORTHCOMING EVENTS

6 November 2002 NPL
NMS Air Monitoring Users' Group
Contact: Simon Woods
Tel: 020 8943 6424
E-mail: simon.woods@npl.co.uk

6 - 8 November 2002 NPL
Training Course
'Heat Transfer, Principles and Practice'
Full details of course at www.npl.co.uk/thermal/heattransfer
Contact: Robert Angus
Tel: 020 8943 7110
E-mail: robert.angus@npl.co.uk

12 November 2002 NPL
Humidity Club
Contact: Melanie Williams
Tel: 020 8943 6121
E-mail: melanie.williams@npl.co.uk

12 November 2002 BMW, Hams Hall Plant, Birmingham
DC&LF Club meeting
Contact: Sara Fletcher
Tel: 020 8943 6827
E-mail: dclfclub@npl.co.uk

12 - 13 November 2002 NPL
Obtaining time and frequency traceability using GPS
Contact: Karen Hood
Tel: 020 8943 6582
E-mail: karen.hood@npl.co.uk

19 November 2002 NPL
'Optical Radiation Measurement with Array Detectors'
ORM Club meeting
Contact: Fiona Jones
Tel: 020 8943 6743
E-mail: fiona.jones@npl.co.uk

20 - 21 November 2002
NPL MTDATA Introductory Course
Contact: John Gisby
Tel: 020 8943 7098
E-mail: john.gisby@npl.co.uk
Website: www.npl.co.uk/mtdata/

21 November 2002 NPL
Modulus Measurement Course
Contact: Jerry Lord
Tel: 020 8943 6340
E-mail: jerry.lord@npl.co.uk

22 November 2002 NPL
Title: MTDATA Users' Group Meeting
Contact: John Gisby
Tel: 020 8943 7098
E-mail: john.gisby@npl.co.uk
Website: www.npl.co.uk/mtdata/

26 November 2002, NPL
FOToN UK meeting
Contact: Joan Smith
E-mail: joan.smith@npl.co.uk

28 November 2002 NPL
Electronics Assembly Masterclass
'Solder Joint Reliability: From Tin-Lead to Lead-Free Assemblies'
Contact: Alan Brewin
Tel: 020 8943 6805
E-mail: alan.brewin@npl.co.uk

3 December 2002 NPL
ComNet Meeting,
'RF Safety Hazards'
Contact: Sara Fletcher
Tel: 020 8943 6827
E-mail: comnet@npl.co.uk

13 – 14 January 2003,
BAE SYSTEMS, Warton
ANAMET meeting
Contact: Andrew Morgan
E-mail: andrew.morgan@npl.co.uk

27 - 29 January 2003 NPL
Practical Course in Reference Dosimetry
Contact: Rebecca Nutbrown
Tel: 020 8943 6473
E-mail: rebecca.nutbrown@npl.co.uk

FURTHER INFORMATION

For additional copies of this newsletter, or for more information on any aspect of NPL's work and the range of services available from the Laboratory, call the NPL Helpline:
Tel: 020 8943 6880 | Fax: 020 8943 6458 | Switchboard: 020 8977 3222
E-mail: enquiry@npl.co.uk | Website: www.npl.co.uk
National Physical Laboratory | Queens Road | Teddington | Middlesex | TW11 0LW

4443/AAR/118k/1002

The National Physical Laboratory is operated on behalf of the DTI by NPL Management Limited, a wholly owned subsidiary of Serco Group plc

ISSUE 14 Autumn 2002

NEWS FROM THE
National Physical Laboratory

METROMNIA

GIVE OR TAKE: Dealing With the Uncertainties of Life

Uncertainty of measurement is the doubt that exists about the result of any measurement. We have all heard the expression 'give or take' when it comes to measuring - "the tabletop is three metres long, give or take a centimetre". Uncertainty is an inevitable part of any measurement and becomes an issue when results approach specified limits.

Good measurement practice and traceability ensure that measurements are accurate within their specific uncertainties. Traceability is maintained through comparison to national and international standards with appropriate procedures and measurement uncertainties. With good measurement practice, it should be possible to demonstrate an unbroken chain of comparisons that ends at a national standards body such as NPL.

Understanding uncertainties and traceability has a significant consequence for individual lives as well as corporations. It could mean the success of an athlete's career, a stockbroker making a timely sale or a small company making a profit. With the advancement of technology and the speeding up of transactions, uncertainty and traceability statements will become more important and eventually be the norm in our lives.

Football, doping and uncertainties

Doping tests in sport are commonplace today. Some recent 'nandrolone' cases in football involved high-profile international players who were tested 'positive' after *UEFA Cup* and *Serie A* matches. The outcomes of investigations into doping depend on the presence and (if a threshold is given) on the maximum concentration of a substance. Such thresholds are given if the substance may be present in the body for reasons other than the abuse of drugs.

Suppose that a test indicates a concentration of 5.2 ng per ml for the nandrolone metabolite 19-NA. The limit laid down is 2 ng per ml. It seems that the player has tested 'positive'. But how confident are we in the measurement made, bearing in

NPL
National Physical Laboratory