

Be amazed!
Science from The National Physical Laboratory



Cover image: An NPL 'Electron Tree', this fern-like structure trapped inside a Perspex block is the result of electrons rushing out through a break in the base of the block.

Find out more at:

www.npl.co.uk/electrontree

where you can read all about them, and watch a video of how they are made.



The Future in our Hands

Since joining NPL as Managing Director in March 2009, I have been amazed by the breadth and depth of the work we undertake and the benefit we give to the UK.

Our mission is to deliver world-leading science that gives the highest economic and social benefits. As the UK has faced unprecedented financial upheavals, we have worked to ensure that our science has the maximum impact to support UK industry - thus independent economists have been able to show that NPL's work for the National Measurement System contributes approximately £2 billion per annum to UK GDP. Although this economic impact is vital, we also take pride in supporting the quality of life of our citizens, e.g. nearly 200,000



people a year are treated using radiotherapy where NPL's work with UK hospitals ensures that the dose is measured and targeted effectively, saving 150 lives annually.

Our principal role remains as the UK's National Measurement Institute (NMI), ensuring consistency and traceability

of measurements in both the UK and for our customers throughout the world. In these areas we have made great strides in the last year to improve the accuracy to which we can measure temperature through a redefinition of the kelvin, and time where we are developing the most accurate clocks in the universe - vital in underpinning modern communication technologies.

However, NPL is so much more than 'just' measurement. We are a National Science & Technology Laboratory for Business and Innovation: building on our core strengths of measurement, we are now delivering contracts in knowledge transfer; advanced manufacturing and applied science (notably materials science, medical physics and bio-science), sustainability (including the development of renewables, carbon metrology and energy efficiency) and the digital world (including data security). In 2009 we worked for over 2,000 companies, including working on over 200 government contracts, and grew our third party work by over 12%.

Collaboration and partnership are key themes for NPL. Our key relationship is with our National Measurement Office colleagues in the Department for Business, Innovation & Skills. We also work very closely with academia. In 2009 we concluded Memoranda of Understanding with the University of Surrey, Imperial College London and the University of Bath for collaboration in research, and we also work closely with Research Councils and the Technology Strategy Board to align our research and hence maximise its impact. Internationally, we are involved with 15 projects in the European Metrology Research Programme, and this year have enhanced our interactions with our sister NMIs in the US, Germany, China, Brazil, India, Korea and elsewhere.

Since joining NPL I have been delighted by the commitment, expertise and passion from our world-class scientists and engineers ably supported by our business teams who safeguard NPL's reputation for the important work we do. You will see some of the individual achievements highlighted within this



report; I am particularly proud of the awards that recognises NPL's safety performance, our commitment to diversity, and our training and development process.

It's also great to see our commitment to helping engender the same passion for science and technology in schools and amongst our broader community. Over 20% of our staff support our educational outreach programmes and over 20,000 people benefited from it in 2009.

In 2010 we will continue all this work as well as strengthening our work supporting government priorities in advanced manufacturing, energy, the environment, life sciences, security, and low carbon metrology.

I hope you enjoy reading this Annual Review and, like me, you are amazed at the work NPL does for the UK.



Dr Brian R Bowsler
Managing Director

Opposite inset images:

This 'Sphere' will be used to measure the Boltzmann constant and re-define the kelvin.

NPL staff at 2009's Water Rocket Challenge, part of our educational outreach programme.

Our Clients

NPL is a unique science organisation that works with businesses, academia and governments offering multidisciplinary R&D and knowledge to anyone that needs it. Here are just a few examples of recent clients:

BAE SYSTEMS

BAE wanted to ensure that every engineer, designer and inspector had a good grasp of metrology to increase productivity by reducing human error. BAE Systems trainers completed the training course to become accredited to deliver the NPL Dimensional Measurement Training Programme to its own staff.

nationalgrid

The power of action.

"The project demonstrates the superiority of the innovative, automated measurement techniques over manual methods of determination. The testing at NPL allowed these new methods to be proved and provided confidence in their accuracy." - Dr Nick Bates, National Grid.



BENTLEY

"Thanks to NPL Training, the measurement associates are now thinking out of the box. We are already seeing a faster turnaround of measurement activities with higher accuracy and increased confidence. NPL is known for its technical expertise in this area, and can provide the highest level validated training. It's added to our professionalism and improved communication with our suppliers." - Mark Imms, Metrology Manager, Bentley Motors.



A new breed of more efficient power stations could be the answer to reducing the environmental impact of burning fossil fuels. But they create an unfamiliar environment for existing materials which could increase the risk of corrosion and premature component failure. Current models can't predict how materials will react to these conditions. This prompted NPL, in partnership with four academic and industrial organisations, to develop new methods for predicting the corrosion behaviour of high temperature materials in coal-fired utility boilers.

FLUKE

"Working together with a member of NPL has helped us understand and demonstrate the potential for a novel measurement technique. The support has saved Fluke between three to six months of internal engineering development work and ~£100,000 in monetary terms. We estimated that if development time savings were on critical path for shorter time-to-market, the wider impact on revenue and profits of NPL's intervention could be £1 million to £10 million" - Paul Roberts, Project Manager, Fluke Precision Measurement Ltd.



NPL managed the call on behalf of EURAMET for the first phase of the European Metrology Research Programme which has brought €21 million from the European Commission together with around €43 million from the participating countries to create a €64.6 million budget. Twenty-one projects are now underway addressing challenges in: fundamental metrology related to redefinition of the SI units; metrology for the health sector; and industrially focused electrical and dimensional metrology. NPL has subsequently been appointed to manage the entire proposed seven-year programme worth €400 million.



"BP Exploration has continued to benefit from NPL's world class corrosion testing and modelling capabilities in 2009, and we intend to cooperate even more closely in 2010 and beyond." - Steve Groves Programme Manager - Inherently Reliable Facilities Flagship BP.



"NPL has helped us greatly to understand our environmental monitoring requirements at our site in Slough whilst remaining compliant with regulatory demands through regular monitoring. They have always delivered an extremely professional, helpful and responsive service, on time and on budget." - Peter Bowman, Senior Project Manager, Scottish & Southern Energy.



The University of Surrey and NPL are to collaborate on the delivery of a £10 million programme to translate the results of research into innovation that makes a real-world difference including areas that cover mobile communications and internet connectivity, next generation materials for space and satellite engineering and nanotechnology supporting the further miniaturisation in the semiconductor industry.



NPL provided consultancy to help GSD understand the sources of the RF emissions from GPS systems in order to find shielding solutions, which would allow the police to use the systems in confidence. GSD Navigation, a producer of GPS systems for commercial use, needed to support the police service to ensure Radio Frequency (RF) emissions from GPS would not interfere with their secure communication systems.



NPL tested the design of a radar system for Thomas Keating which will help understand how clouds affect the Earth's complex climate. Low clouds normally reflect sunlight and lead to global cooling, whereas high clouds act like huge insulating blankets - warming the climate by reducing how much heat is lost into space. The prototype design of the instrument, which will be launched in 2013 as part of the EarthCARE mission, was tested in NPL's anechoic chamber, which has the temperature stability and sensitivity necessary to make these demanding measurements. Dr Richard Wylde, Managing Director, Thomas Keating said "NPL was able to work flexibly with us, taking test results, making changes and coming back to retest. The excellent flexible conditions enabled us to refine the device and provide independent confirmation about its robustness."



As a testament to the partnership between NPL and Agilent, one of the reasons that they recently chose to base their European Service Centre in the UK rather than at the European head office in Germany was the strength of its close relationship with NPL.

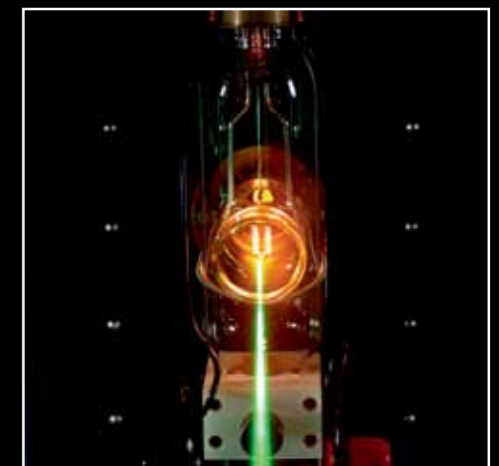


Over the last five years NPL in collaboration with leading UK organisations in energy materials and the Department of Energy and Climate Change (DECC) have been collaborating with the US Department of Energy (DOE) on fossil energy research and development. Advanced materials have been identified as an essential underpinning technology in the development of new and cleaner power generation systems with lower costs, shorter lead-times and less risk. NPL is leading this work in two key areas, steam oxidation and standards & databases. This continuing research is an essential part of helping to achieve any targets set by future energy policy for energy security and climate change.



"NPL has provided us with very valuable services, which have helped ensure that our satellites offer the accuracy needed provide our customers with technology they can trust, and remain ahead of our competitors" - Dr Martin Unwin, Head of GNSS/GPS Team, Surrey Satellite Technology Ltd.

Alignment of a spectral irradiance standard lamp using a laser. Straight view (inset).



The future of gas analysis

NPL has worked with Dolomite (a UK company who specialise in manufacturing micro-structured components) and the University of York to build a miniature gas analyser. The device is constructed on a glass chip the size of a CD, which makes it ideal for applications that require very low power consumption. Its performance in detecting very low concentrations of gases is so good, because of the unique cross-section of the channels etched in the glass, which are very close to being perfectly circular. It will be used in various applications including monitoring trace atmospheric components and detecting toxic vapours.

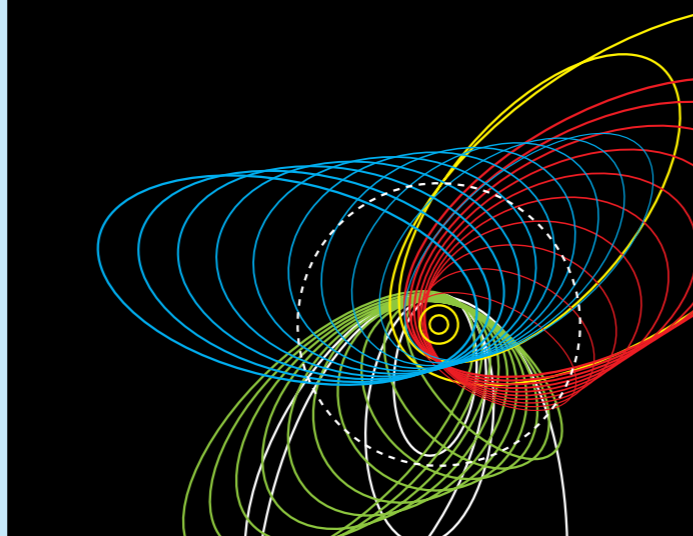


Thinner is stronger

NPL was the first to show that small structures have enhanced strength, not by being small in volume but simply by being thin. In the amazing world of nanotechnology you might expect that smaller would be stronger - but in a dramatic twist in the plot, it is only the smallest dimension in a material that needs to be reduced to obtain improved properties. By demonstrating this "thinness effect" NPL has shown that nano-layers are just as strong as nano-particles and opened the door to the production of much larger volumes of stronger material more easily than previously thought. NPL's work will provide designers with easier routes to exploit length-scale engineering in nanotechnology and create tougher surfaces and microscopic components that are less likely to break.

Quantum mechanics on the cheap

NPL developed a new technique that uses aspects of quantum mechanics to dramatically improve the accuracy and efficiency of how computers model materials. This technique will save companies lots of time and money when they are developing new products or materials, as it gives them a way of seeing how a material really behaves under certain conditions. Using better physical descriptions of quantum phenomena in computer models is a huge challenge. So this advance is great news for developers of next-generation materials for use in biotechnology, nanotechnology and other areas of cutting-edge science.

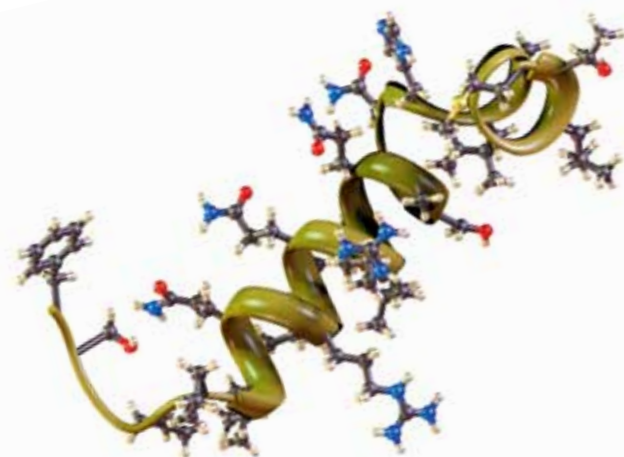


Saving £50 million

Careful planning was critical to the success of third generation (3G) mobile phone networks. An important novel feature of the networks was the use of a new type of variable tilt antenna. The antenna range at NPL delivered better information about how the antennas would behave. Evaluations show that the calibration data improvements supplied by NPL's measurements could result in a 1% one-off saving in network capital costs which equates to a saving of £50 million.

Molecular medicine

NPL has embarked on a major strategic alliance with the University of Edinburgh, Oxford University, IBM Research, the STFC Rutherford Appleton Laboratory and the Diamond Light Source. The aim is to create a research and business development partnership based around emerging technologies related to molecular medicine. The consortium will focus on developing new tools to reveal, in unprecedented detail, the molecular structure of short protein fragments (peptides) the control of which is relevant in a wide variety of biomedical contexts such as the inhibition of viral infections, the reversal of early-stage protein aggregation implicated in neurodegenerative diseases and molecular-scale defence mechanisms against bacterial infections.

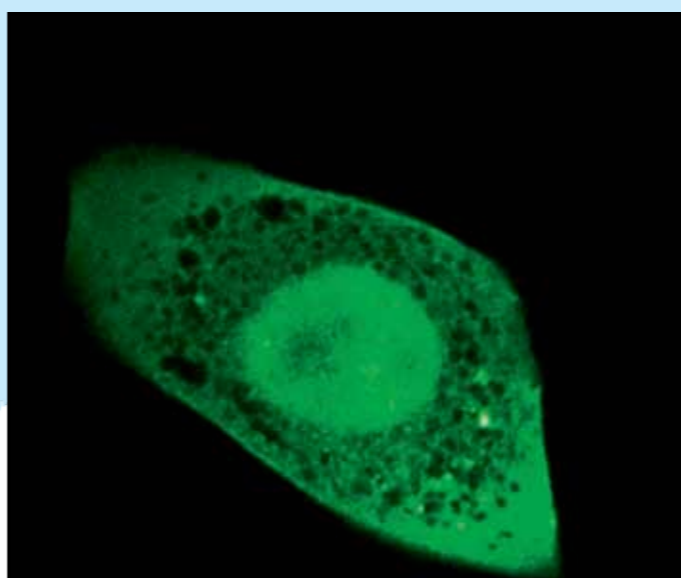


Building an artificial eye

NPL has built an artificial eye that accurately mimics the way human eyes view light. The eye will lead to a better understanding of how new lighting technologies and display systems such as projection TVs and low energy lighting affect eyesight. The eye will allow manufacturers of these products to test and, where necessary, modify their products and so end the debate on the safety of these new light sources. This will help ensure that innovation in this exciting area continues unhindered, and will help ensure that the vision of future generations is safeguarded.

Viral infections watched in real time

NPL has helped develop a technique that makes it possible to watch, in real time, viruses infecting individual cells. It is hoped that by observing how different properties of the cells are affected at different stages of an infection, it will be possible to monitor how effective new anti-viral treatments are. This ground-breaking work, which is a result of NPL collaborating with the University of Edinburgh, is a great example of what can be achieved with NPL's help.



Cool science

NPL is paving the way for highly accurate measurement at the nano-scale and beyond, by developing the world's first tiny microwave-powered room-temperature fridge. Heat makes accurate measurement very difficult. This 'fridge' allows scientists to cool down just the part of a sample they are interested in, rather than wasting huge amounts of energy chilling the entire sample. The fridge will be of great use in applications where high sensitivity measurements are needed, such as bio-analytical screening for viruses.



Our People

NPL's reputation is built on great people and exceptional scientists; here are just a few examples of what NPL staff have recently achieved:

Alan Turnbull



Alan Turnbull's world-leading expertise in corrosion has been further recognised by winning the Willis Rodney Whitney Award from NACE International. Alan was key in NPL becoming one of only two suppliers to a major oil company for their Inherently Reliability Facilities flagship programme.

Graham Machin



Graham Machin, one of the world's top temperature measurement scientists, contributed to and co-edited a major two-volume work entitled 'Radiometric temperature measurement'. Graham has a great passion for his subject and for good measurement practice in general and was recently made a visiting professor at the University of Glamorgan in addition to his visiting professorship at the University of Valladolid, Spain.

Graham Sims



Graham Sims, has recently celebrated his 41st anniversary of working at NPL. During these 41 years, Graham has helped establish NPL as one of the foremost research institutes in the world and is personally recognised internationally for leadership of standardisation for composites material.

Ian Gilmore



Since joining in 1991 Ian Gilmore has helped turn NPL into a world-leading surface and nanoanalysis research group. Ian was recently made a Fellow of the AVS, a large society and symposium in the US, in recognition of his international leadership in surface and nanoanalysis and pioneering research in the analysis of organic molecules at surfaces.

Peter Whibberley



Peter Whibberley, senior research scientist in NPL's Time Group was featured in the UK launch edition of *Wired* magazine in an article on the UK's 'secret power brokers'. The article focused on Peter's role of controlling and disseminating the UK time signal.

Michael de Podesta



Michael de Podesta was made a Member of the Order of the British Empire (MBE) for his outstanding commitment and passion for science communication. Michael was one of the first Science Ambassadors at NPL, going out to schools and the community to bring science to life. Michael is now a key Science Ambassador mentor, giving many NPL staff the confidence to go out to schools and colleges and promote science. Michael's work on the redefinition of the kelvin, through an improved determination of the Boltzmann constant using an acoustic thermometer, was recently featured in *Nature*.

John Pethica



John Pethica, NPL's Chief Scientific Advisor, has become Physical Secretary and Vice-President of the Royal Society, replacing Sir Martin Taylor. The Society is the UK National Academy of Science, and elects Fellows from the UK and the Commonwealth. It is governed by a Council of 21 Fellows, including five Honorary Officers: President, Treasurer, two Secretaries (physical sciences and life sciences) and Foreign Secretary.

Ling Hao



Ling Hao was elected a Fellow of the Institute of Physics. Ling is leading work on applications of nanoscience, superconducting electronics and microwave technology for precision measurements, aimed at single particle measurements and metrology with nanoSQUIDs and nanoelectromechanical system (NEMS) resonators. In addition to this, Ling researches low dimensional carbon, including carbon nanotubes and graphene.

Kamal Hossain



Kamal Hossain, Director of Research & International Co-operation at NPL, was awarded an Order of the British Empire (OBE) for services to industry for his outstanding scientific leadership, increasing NPL's international reputation and his work on improving links between research, standards and innovation, particularly for new technologies.

Rod Robinson



The Times science magazine *Eureka* had a feature on 'the fifteen most pressing problems of our time'. Rod Robinson, principal research scientist in NPL's Environmental Measurements Group, was interviewed for his role in carbon measurement and placing carbon trading on a firm footing.

Richard Leach



Richard Leach has been elected a Fellow of the Institute of Physics. Richard is leading work into the development of measurement and characterisation techniques for micro- to nanoscale features. This work includes the measurement of surface topography, micro co-ordinate metrology and the measurement of low forces. Richard has recently published a textbook in his area of expertise.

Markys Cain



Markys Cain was awarded the Verulam Medal by the Institute of Materials, Minerals & Mining. The award recognised Markys for his distinguished contribution to the field of ceramics and developing NPL's metrology capability to characterise a new generation of piezoelectric and ferroelectric materials and devices. Markys has also been made a visiting professor at Queen Mary, University of London.

Richard Brown



Richard Brown has been elected as a Fellow of the Royal Society of Chemistry (RSC) and was also the winner of the RSC's SAC Silver Medal. As part of this he delivered a lecture entitled 'Environmental analytical measurements: from the laboratory to the field' at Pfizer's European Headquarters for R&D. Richard was also the co-author of 'Establishing SI traceability for measurements of mercury vapour', with NPL's Andrew Brown, that won the CITAC (Cooperation on International Traceability in Analytical Chemistry) Award for the Most Important Paper on Metrology in Chemistry.

Continuous Professional Development Team



NPL was awarded the Institute of Physics (IoP) Best Practice in Professional Development Award. This recognises large organisations that visibly demonstrate best practice in the training of physicists. The IoP cited the excellent work NPL has done, particularly mentioning our mentoring scheme, educational outreach activities, secondment and scientific recognition schemes. The award recognises NPL's commitment to continuing professional development and to engaging, inspiring and supporting all staff to achieve their full potential.

Susan Evans



Susan Evans accepted the Women into Science, Engineering and Construction (WISE) 'Investor in WISE' award on behalf of NPL. The WISE award gives public recognition to companies who have actively addressed the issue of encouraging girls and young women into science, engineering and construction. NPL's submission cited the excellent work done through our educational outreach and diversity programmes.

Corporate Assurance Team



The Corporate Assurance Team has been instrumental in helping NPL win the RoSPA (Royal Society for the Prevention of Accidents) Sector Award for Research and Development, as well as being nominated as a finalist for the country's premier award 'The Sir George Earle Trophy'. NPL was commended for motivated teams and positive leadership.



National Physical Laboratory

NPL is a world-leading centre for the development and exploitation of measurement science, technology, related standards, and best practice in a diverse range of technical areas and market sectors. As the UK's National Measurement Institute, our capabilities underpin the UK National Measurement System (NMS), ensuring consistency and traceability of measurements in support of UK and overseas customer interests. We aim to provide world-class science and engineering with economic, social and environmental benefits to the UK.

Your partner for science & innovation

Our services are built on 110 years' experience in delivering world-class scientific innovation and knowledge for exploitation in industry. Making NPL your science partner gives you access to hundreds of scientists, world-leading science, facilities and knowledge networks.

Research and Development – NPL can complement, or provide, bespoke contract research and development for your organisation and we can also project-manage scientific teams on your behalf.

Consultancy – Whether you are interested in validating performance, improving quality or resource efficiencies, an NPL measurement audit can tailor a solution for your organisation.

Measurement Services – We have over 200 standard calibrations, tests, reference artefacts and training courses, many of which are unique in accuracy and availability.

Technology Exploitation – Our scientific research and development often manifests itself in technology, software or instrumentation IP which can be commissioned to design new instruments for sale or licence.

Knowledge Transfer – NPL specialises in developing methodologies to ensure our research is exploited. We can help organisations to do the same by implementing strategies that might encompass policy support, network management or impact assessment.

Close-up image of compact NPL strontium ion trap showing 1.5 mm diameter ring.

Compact NPL strontium ion trap (inset).



NPL's technical areas of expertise

Acoustics

Sound in Air
Ultrasound
Underwater Acoustics

Advanced Materials

Composites
Electrochemistry
Electronics Interconnect
Innovative Metals Engineering
Multifunctional Materials
Organic Electronics
Performance of Engineered Surfaces
Polymeric Materials
Structural Health Monitoring
Thermal Performance of Materials & Structures
Thermodynamics

Analytical Science

Gas Standards
Trace Analysis & Electrochemistry

Biotechnology

Biodiagnostics
Biophysics
Biomaterials

Electromagnetics

Electromagnetic Materials
Electrical Measurement
Electrical Quantum Standards
RF & Microwave
Terahertz
Wireless Communications

Engineering Measurements

Dimensional
Mass, Force, Pressure
Temperature & Humidity

Environmental Measurement

Air Quality & Airborne Particles
Atmospheric Science, Emission & Security

Ionising Radiation

Dosimetry
Neutron Metrology
Radioactivity

Mathematics & Scientific Computing

Biometrics
Data Security
Measurement Uncertainties
Modelling
Numerical Computation
Signal Processing

Nanoscience

Surface & Nanoanalysis
Nanodimensional
Nanomaterials

Optical Radiation & Photonics

Bio-Medical
Displays
Environment & Climate Change
Few Photon Science
Materials & Appearance
Optical Communications & Data
Photometry & Sources
Radiometry & Detectors

Quantum Phenomena

Nanophysics
Quantum Information Processing
& Communication

Time & Frequency

Microwave Frequency Standards
Optical Frequency Standards & Metrology
Time

Contact us

We help all UK industry, research organisations, institutions and government departments to use our knowledge to support their business. Working with NPL opens the door to hundreds of scientists and world-class facilities.

NPL provides a range of services to solve your problems by applying measurement advice to enhance and complement your skill base. NPL experts give up to two hours of free advice and have many guides and dissemination events available.

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NPL is accredited by UKAS as a calibration laboratory No. 0478 and testing laboratory No. 0002 to ISO 17025:2005 and as a reference material producer No. 4002 to ISO Guide 34:2000.