NPL
National Physical Laboratory

Environmental *Measures*

A National Measurement Newsletter

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Improving the efficiency of the UK Chemical Process Industry

NPL have developed a new calibration method for Quadrupole Mass Spectrometry (QMS) that could save the UK Chemical Process Industry an estimated £2.4m per year.

Monitoring the many chemicals involved in an industrial process on-line and in real-time often enables significant efficiency savings and associated environmental benefits. For example, ethylene (a component of paints, plastics and produce ripener) is produced in petrochemical plants from natural gas. This process can at times deviate from peak efficiency resulting in the wastage of natural gas, a finite resource. Real-time monitoring would enable operators to make immediate corrections for any drifting of the process away from optimal yield.

The adoption of real-time monitoring technology such as QMS would enable each plant to save on costs as well as saving natural resources. In the past the QMS technique, had limited use in industry due to an inherent drift that can invalidate calibrations over short timescales.

The Analytical Science Team at NPL have developed a calibration transfer strategy that addresses this issue and has been shown to compensate for the instrumental drift in laboratory tests. Consequently, quantification errors typically seen after two weeks are only observed after 11 months of operation. The strategy works by: recording multi-component calibration spectra at the start of the year, measuring an internal standard daily to track instrument changes, then adjusting the calibration spectra accordingly.

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dti
National Measurement System

Stacking the odds

A 'virtual chimney' developed by NPL has helped improve the accuracy of pollution measurement.

Regulators and people near factories rely on accurate data from operators to ensure pollution is kept within safe levels.

Emissions vary according to changes in factory operations. This can make it difficult to test the proficiency of the people doing the monitoring.

NPL's 'virtual chimney' or stack simulator overcomes this problem. It allows monitoring teams to test their procedures and proficiency under controlled conditions.

In a recent test, measurements made by monitoring teams of the same gases and using the same equipment varied by as much as 20%, says NPL air quality scientist Rod Robinson.

"This highlights the importance of proficiency testing and calibration which enable accurate measurements," Robinson says.

The measurements can vary due to problems with the gas mixtures used for equipment calibration. NPL can supply traceable gas mixtures for calibration.

The variation can also be a result of human error.

NPL is working with the Source Testing Association, a regulatory body, to develop and operate proficiency testing schemes. The schemes are open to all UK stack emissions monitoring teams and aim to improve the reliability and accuracy of emissions monitoring in the UK.

The stack simulator developed by NPL enhances its existing proficiency testing scheme.

The simulator can also be used for instrument development. It allows manufacturers of new continuous emission monitors to test their equipment over a range of operating conditions.

The simulator can generate a wide range of gas mixtures, including typical combustion gases containing O_2, CO, NO and SO_2 with moisture present.

For more information on NPL stack emissions monitoring, or the proficiency testing schemes, contact Melanie Williams 020 8943 6121 melanie.williams@npl.co.uk

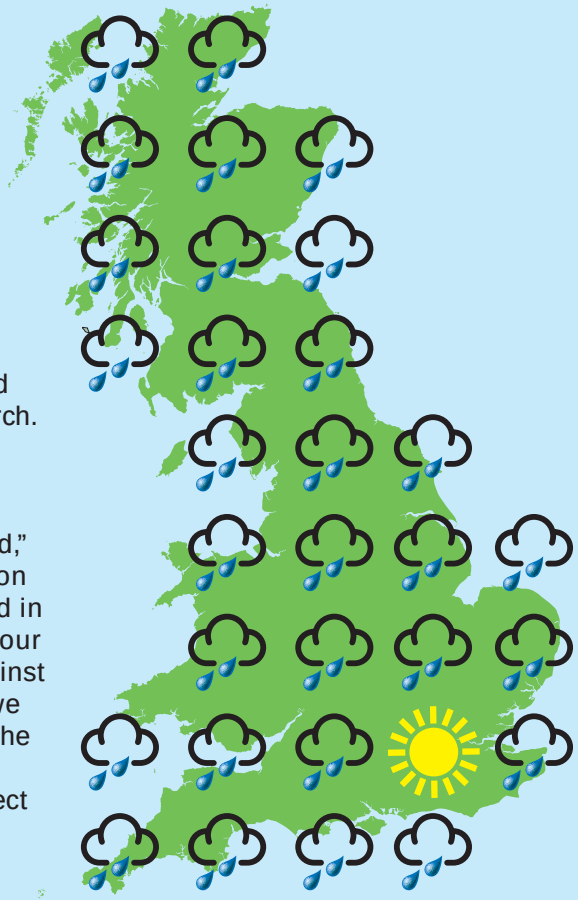
Meteorology or metrology? The weathermen visit NPL

The Royal Meteorological Society and NPL held a one-day meeting on the role of measurement standards and traceability within meteorological observation networks. Forty delegates from the meteorological community attended to hear presentations and toured NPL's laboratories for environmental and climate measurement.

The lab tours featured:

- Development of a novel Airborne Differential Absorption Lidar System
- Demonstration of the potential use of the Trace Water Vapour Facility to investigate the role of water vapour (present in the upper troposphere and lower stratosphere) in the climate system
- Details of the TRUTHS project and the spectral radiance and irradiance primary scales (SRIPS)

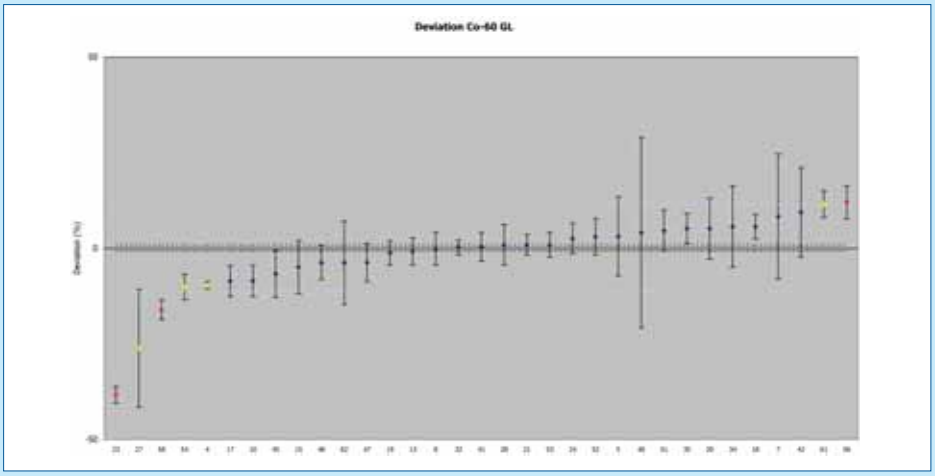
Jonathan Shanklin from NERC's British Antarctic Survey summed up the importance of NPL research. "I did not realise the full extent and variety of work carried out at the NPL, despite having read about some of it in Physics World," Shanklin said. "Our solar radiation measurement programme ended in the mid 80s, and at that time all our instruments were calibrated against the Met Office standard. Today we are planning to restart some of the measurements, and so the talks and demonstrations were of direct relevance."



NPL Environmental Radioactivity Comparison Exercise 2005

Radioactivity in the environment is monitored in the UK by a network of analytical laboratories to check that radioactivity in the foodchain is within acceptable limits. Given the public concern over radioactivity, NPL has a key role in helping the laboratories to demonstrate that their measurements are accurate, consistent and independent of the nuclear industry.

NPL has recently completed a proficiency test exercise for these laboratories; the exercise included preparing more than 130 radioactive samples and distributing them to 30 laboratories in the UK and, in addition, to 20 overseas organisations. These were based on primary radioactivity standards developed by NPL over the last few years. Five different sample types were offered: a mixture of seven alpha and beta emitters at two concentration levels, a mixture of ten gamma emitters at two concentration levels and a mixture of three pure beta emitters. The results were discussed at a workshop held at NPL at the end of February 2006; 75% of the results returned by the laboratories were in good agreement but problems were highlighted with assaying radionuclides with complex decay schemes.



Deviation of Cobalt -60: one of the 130 samples tested.

NPL have produced a report on the 2005 Comparison Exercise. This report can be downloaded at: www.npl.co.uk/ionrad/publications/

The next environmental radioactivity proficiency test exercise is planned for early 2007.

If you would like to take part in the 2007 exercise, contact
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Reducing our exposure to Ozone

In the year 2000 an estimated 20,000 premature deaths in the EU were attributed to ground-level ozone. Later this year a European comparison exercise, led by NPL, will measure 30 of the hydrocarbon species that are believed to be responsible for the production of this ozone.

The presence of ozone in the stratosphere has always been beneficial to the earth and its inhabitants due to it's ability to block out potentially damaging ultraviolet radiation from the Sun. However, at ground level in Europe, ozone has been identified as the most damaging gaseous air pollutant. It is a known irritant, causing inflammation of the respiratory tract, and has been proven to have a negative impact on human health, vegetation and many materials.

Ozone is not emitted directly, but is formed within the atmosphere as the result of photochemical reactions between sunlight, nitrogen oxides (mainly arising from combustion processes), and hydrocarbons - most of which are man-made. Though low in concentration, about a few parts per billion, the presence of these hydrocarbon species is often the crucial factor in ozone production. Accurate measurements of these molecules are a very high priority and current EU legislation has made the measurement of these molecules mandatory for all EU member states. During the comparison, each species will be measured at concentrations similar to their occurrence in the atmosphere. The measurements will help to refine current models of the chemical processes, and gauge the effectiveness of steps being taken to deal with the problem.

The comparison is being organised through EUROMET and the European Joint Research Centre at Ispra.

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Climate modelling with confidence

NPL is moving one step closer to providing climate scientists with accurate, traceable field measurements for monitoring the global climate. NPL's Optical Radiation Measurement Team in conjunction with the Natural Environmental Research Council Field Spectroscopy Facility (NERC FSF) is developing a new field instrument to support unequivocal calibration of various satellite sensors operating in the optical region and the validation of their data.

The only feasible method of obtaining global-scale data on the state of the planet is by satellite sensors that can measure the solar energy reflected from the Earth's atmosphere and surface. The accuracy and reliability of satellite sensors' data is of great importance, and much effort goes into characterising such instruments before launch.

GRASS constructed in front of the Chilbolton Advanced Meteorological Radar (CAMRa) at the CCLRC Chilbolton Observatory and AERONET site, during the NCAVEO Field Experiment.

However, the stress of launch and the extreme environment of space affect the calibration of sensors, introducing uncertainty into the data, especially the long time-series data necessary to investigate and monitor climate change. Once in orbit, post-launch calibration is vital to validate the instruments' performance. This is often achieved by using field instruments that measure the light reflected from 'calibration sites' – such as deserts or grassland – which can be viewed by satellite sensors. NPL's new field instrument GRASS (Gonio RAdiometric Spectrometer System) is intended to provide quasi-simultaneous, multi-angle, multi-spectral measurements of reflected sunlight from the Earth's surface. Field instruments, such as GRASS, provide the in-situ data to validate the satellite measurements.

Due to their macro- and microphysical construction, natural targets reflect light with different intensities in different directions. Depending on the viewing angle the surface can appear brighter or darker – as seen for example on a mown lawn or a forest canopy. Every surface on Earth has a specific Bi-Directional Reflectance Distribution Function (BRDF) property that describes the relationship between the reflected radiance from the surface and the directions of irradiance and the viewing angle.

A crucial parameter required to calculate the Earth's Radiation budget is the surface albedo, which is defined as the directional integration, over all sun-view geometries, of the fraction of incident radiation that is reflected by a surface. Satellite instruments do not directly measure surface albedo. It must be inferred through a series of manipulations of the raw data. If the BRDF is not considered it can lead to large errors in the retrieved albedo. Since albedo is used in climate models, it is vital to reduce these errors by developing our understanding of the angular reflectance of terrestrial surfaces. The solution is a field goniometer, such as GRASS, which can measure angularly resolved reflectance and therefore provide data for the development and validation of models. This is essential to improve our understanding of the planet, not only for climate change but also more immediate activities such as agriculture, pollution and disaster mitigation.

The GRASS instrument will provide the structure and optics to collect the radiation, which will then connect to a variety of spectroradiometers. GRASS is being designed to measure the Earth's reflected sunlight over half a hemisphere at 30-degree intervals i.e. 0^{o}, 30^{o}, 60^{o}, 90^{o}, 120^{o}, 150^{o}, 180^{o}, on a series of seven arms. GRASS will have 36 cameras (figure 1), (five on each arm and

Figure 1. Picture of the nadir entrance optic in radiance orientation

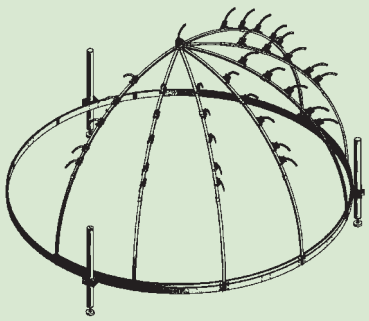

Figure 2. Schematic diagram of the Gonio RAdiometric Spectrometer System

one at nadir) each consisting of an entrance optic and an optical fibre (figure 2.). The fibres feed to a set of multiplexers, which give one optical output that can be coupled to a spectrometer and thus give traceability to SI units through NPL.

GRASS has several advantageous design features. The hemispherical structure is designed with a set of legs that are adjustable, so for example a spectral measurement can be taken of the top of a vegetation canopy. The angular sampling is also programmable, meaning a predefined set of measurements can be taken in the field and a smaller sample of measurements at a few angles can be taken without moving the instrument. Another design feature is that the lenses on the fibres can be replaced with a cosine diffuser, giving GRASS the ability to measure both radiance and irradiance at multiple angles.

Grass was first deployed in June 2006 (see box below). In the future, the GRASS instrument will be used by UK researchers to provide data for comparison with satellite information to develop a better understanding of the anisotropy of natural targets.

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Figure 3. GRASS being used during the NCAVEO Field Experiment

GRASS is on the move ...

The GRASS instrument was first deployed by the ORM team in June 2006 (figure 3.), as part of an experiment organized by Network for the Calibration and Validation of Earth Observation data (NCAVEO) at Chilbolton, Hampshire. The ORM team joined 54 other people, 4 aircraft, and 5 satellites to validate and intercompare data from a range of airborne and satellite sensors. GRASS although not completely built, performed very well. Additional, all of the field instruments used during the field experiment were calibrated against an NPL standard, a Transfer Standard Absolute Radiance Source (TSARS). In the longer term the GRASS instrument will be used by UK researchers to provide data for comparison with satellite information to develop a better understanding of the anisotropy of natural targets.

Blue Skies

NPL have teamed up with Expedia who sent their blue sky explorer Anya Hohnbaum, to define and quantify the 'best blue sky' in the world.

Anya made measurements of the sky in some 25 locations, which will be categorised according to the internationally accredited colour system initially established by NPL/Imperial College back in the 1920s. NPL provided the portable equipment needed to make the measurements and will process the data produced to determine the winner of the competition. And the winner is....

For further details on the competition (and to find out who won) please visit www.npl.co.uk/blueskies

ORM helicopter's a go!

The ORM team from NPL are working in collaboration with members of the Waldegrave School Science Club in Twickenham to build and fly a remote controlled helicopter.

The helicopter will take spectral measurements of the Earth's surface that will support satellite Earth Observation missions. The project aims to improve children's awareness and interest in environmental issues such as climate change – engaging tomorrow's scientists in today's challenges.

For more information, please visit www.npl.co.uk/ormhelicopter or contact Nigel Fox 020 8943 6825 nigel.fox@npl.co.uk

A breath of fresh air

Under European legislation the presence of certain heavy metals in the environment has to be accurately measured to determine the extent of their toxicological effects on public heath and the environment. These metals, released into the air as fine particle aerosols, are produced by manmade activities such as industrialisation and fossil fuel combustion. To help reduce the concentration of one such heavy metal, cadmium, NPL is leading research into possible substitutes in neutron detectors.

How NPL determines airborne metal concentrations

The UK Heavy Metals Network is managed by NPL on behalf of DEFRA. Through this network of 17 sites across the UK (figure 1), NPL measures and monitors the UK's air quality. The ambient species that are monitored, as required by the European Commission's First and Fourth Air Quality Daughter Directives (DDs), include: Lead, Arsenic, Cadmium, Nickel, Mercury and Polycyclic aromatic hydrocarbons (PAHs).

At each site, Partisol 2000 instruments collect weekly samples of ambient PM10 particulate matter onto air filters which are then sent to NPL for analysis. These are analysed using microwave-assisted digestion of the filters in a strongly acidic solution. The total metals content is determined using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) on the resultant digest. NPL's measurement procedure is UKAS accredited and fully compliant with the European standard for the measurement of metals in the PM10 fraction of ambient air, which was approved by European Member States last year.

SITE	DESIGNATION
London (Brent)	Roadside
London (Cromwell Road)	Roadside
London (Horseferry Road)	Urban Background
Avonmouth	Industrial Background
Avonmouth 2	Background
Cardiff	Roadside
Swansea	Industrial Background
Walsall	Industrial Background
Walsall 2	Industrial Background
Runcorn	Background
Manchester	Roadside
Leeds	Urban Background
Sheffield	Industrial Background
Newcastle	Industrial Background
Eskdalemuir	Rural
Motherwell	Urban Background
Glasgow	Urban Background

Figure 1. UK heavy metals network sites

A cadmium alternative

Cadmium is commonly used as a thermal neutron absorber in neutron detecting instrumentation because a relatively thin layer, of about 1 mm, absorbs all thermal neutrons whilst having a negligible effect on higher energy neutrons. For this reason, it has applications in instruments designed to measure thermal neutron fluence, and in radiation protection where its presence improves the dose equivalent response. However, cadmium is highly toxic, being linked to kidney dysfunction, respiratory problems, bone disease and human carcinogenesis. The use and disposal of cadmium and its compounds is therefore strictly controlled by law.

Many companies are reluctant to include cadmium in their products since a disposal route must be in place to ensure that its discharge to water is controlled. A safer alternative would be desirable.

A Joint Industry Project between NPL, the University of Lancaster and several industrial firms is investigating a suitable alternative to cadmium. The project is not yet completed but evidence indicates that no alternative with the ideal nuclear absorption characteristics exhibited by cadmium exists. Nevertheless, there are materials, gadolinium and boron being two, which are reasonable alternatives in some applications. These can be used in dosemeters and survey instruments where allowance can be made for the fact that their absorption properties are not ideal. In instruments designed to provide accurate measurements of thermal neutron fluence, however, cadmium appears to be superior to all other materials and it will probably continue to be used but with much greater care being taken in handling and disposal.

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The Neutron Group's research contact
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NPL: Leading the revolution

The advent of nanotechnology has revolutionised the monitoring of airborne particles and has highlighted their potential impact on public health and the environment. NPL's brand new Nanoparticle Experimental Facility (NEF), will make possible the measurement of gas-borne nanoparticles at the lab.

This centre of excellence will support our well-established environmental monitoring activities and rigorously examine nanoparticles in a range of situations under controlled conditions. Partnered with our new Field Instrument Evaluation and Demonstration (FIELD) suite, NEF will enable us to carry out comprehensive evaluations and comparisons of various particle instruments all on one site.

This work is supported by the DTI's Valid Analytical Measurement programme.

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The Nanoparticle Experimental Facility

Building a better future

Under the Kyoto agreement, the UK agreed to cut their CO_2 emissions by 12.5% of 1990 levels by 2012. In order to reach this target we must cut our energy consumption and become more energy efficient. NPL is working toward this goal by helping the UK building industry comply with new standards.

There is often a perception that transportation and industrial processes are the largest producers of CO_2. However it is now estimated that about 40% of energy consumption in the UK is spent in space heating and cooling of buildings. Following the EC's Energy Performance of Buildings Directive (2003), the UK government introduced new amendments to part L of the UK Building Regulations earlier this year.

Under the new regulations, energy efficiency standards for both new build and renovated buildings will have to be dramatically improved. To achieve this goal all building materials and components such as roof and cavity wall insulation, double-glazed windows and doors will have to meet new thermal performance standards.

The NPL Thermophysical Properties group have been carrying out thermal performance measurements on building materials since 1978. NPL is one of the few organisations in the UK accredited to carry out many of the tests according to the EU measurement methods and works with industry regulators to assist the implementation of the new regulations.

NPL have recently set up a measurement facility to enable the U-values of Industrial doors to be measured to a new EU Product Standard and have also worked with window manufacturers and their trade associations to quantify the improvement in thermal properties achieved by changing the spacing bar design in double-glazed window units. At present, NPL is actively involved in working groups preparing CEN and ISO standards for the measuring the thermal transmission through building components. These measurements allow suppliers to certify their products and builders to build more energy efficient factories, offices and homes according to the new building regulations. This should lead to a reduction in energy that will benefit businesses, homeowners and the environment.

Photo Courtesy: LRT Surveys Limited

St. Paul's Cathedral thermal map

NPL Thermal Performance Facilities

- A validated hot box, capable of measuring the U value of structures up to 300 mm thick (e.g. curtain walls & roof panels), at all orientations, with a target uncertainty of ± 6%.
- A range of national standard Guarded Hot-Plate facilities for measuring the thermal conductivity or thermal resistance of a wide range of building materials and insulation products for EN 12664:2001, EN 12667:2001 and EN 12939:2000.

The Thermal Metrology Programme and research at NPL is underpinned by the DTI's National Measurement System (NMS).

For further information on NPL's Thermal Programme and research contact Ray Williams
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If you would like further information on any aspect of **Environmental Measures,** *please contact:*
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Are you the voice of innovation?

NPL have begun formulation for the NMS Materials Programme 2007+. This program aims to support sustainability and reduce the impact that materials have on the environment, in the following ways:

- The role of materials in efficient energy production
- Recycling, reusing, and improved materials processing
- Better design and technology e.g. lightweight materials for transport

In order for the programme to be tailored to meet the needs of industry and academia, we need your views. The consultation process has been improved to enable continuous feedback into present and future programmes.

To get involved and have your say, visit the formulation website: www.npl.co.uk/formulation/materials/2007plus or contact the Programme Formulator: Bill Nimmo 020 8943 7141 MP2007@npl.co.uk

We look forward to hearing from you!

Exclusive Event: Underwater Acoustics 2006

4 – 8 September at NPL

NPL is pleased to host these popular annual Seiche courses. Underwater Acoustics 2006 consists of three courses:

Basic Underwater Acoustics, Advanced Underwater Acoustics and Acoustic Monitoring of Marine Wildlife. Lectures will be given by experts in this field including a 2 hour session on Environmental Impact Assessment.

For further details and to register, please download the brochure/application form at: www.npl.co.uk/acoustics/underwater_acoustics_2006/

Forthcoming events

www.npl.co.uk/events

Joint Time & Frequency Club and Location and Timing KTN Meeting

14 September 2006
NPL, Teddington

The Advancement of Technical Competence of Staff in Upcoming Laboratories in Humidity

19 - 21 September 2006
NPL, Teddington

Optical Frequency Combs for Space (OFCS)

2 – 3 October 2006
NPL, Teddington

Humidity Measurement in Industrial Gases

11 October 2006
NPL, Teddington

Neutron Measurement Workshop: The (un) reliability of neutron measurements

26 October 2006
NPL, Teddington

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