NPL

Materials Measurement Solutions

Details of the measurement solutions
and testing services provided by
Materials Division of the National Physical Laboratory

Issue 1

NPL's mission is to deliver the highest economic and social benefits as a world-leading National Measurement Institute through excellent responsive science and knowledge services.

Contents

Introducing NPL

Setting the standard

NPL is a world-leading centre for the development of measurement related standards, technology and best practice. Quality of measurement is disseminated to our customers through a variety of means including collaborative research and development, technology transfer, licensing of intellectual property, various forms of consultancy, knowledge networking and through the provision of measurement services. Our capabilities underpin the UK National Measurement System (NMS), ensuring consistency and traceability of measurements in support of UK and overseas customer interests throughout the world.

Delivering service excellence

NPL's reputation relies on the quality of support we provide, both directly and indirectly, to hundreds of thousands of users worldwide for whom maintaining traceable and fit-for-purpose measurement is vital to their business. Our commitment to scientific excellence is coupled with a determination to offer high quality and affordable measurement services that are of the greatest possible technical and commercial benefit to our customers.

Services delivery options:

Calibration, testing and analysis of customer instruments and artefacts at our laboratories in Teddington is just one of the many ways we can deliver measurement service support to your business. In recent years, customers have also benefited from the following alternatives:

- On-site services provided on a one-off or campaign basis, whether in support of inventories of equipment and instrumentation or to solve specific measurement related problems requiring innovative or bespoke solutions.
- The provision of expert manpower support on a visiting or permanent on-site basis if long term support to measurement-critical operations is required.
- Delivery of measurement infrastructure management and maintenance: our work for DEFRA on managing the national Air Quality Network is a good example of this way of working.
- The establishment of 'bedded' out laboratory based measurement capability where a long term on-site presence, working alongside the customer organisation is desirable.
- Independent Product Assessments - NPL can reduce the risk of buying expensive equipment that may not be fit for purpose by providing a thorough pre-service evaluation of new and novel instruments before the final purchasing decision is made.

Calibration, measurement and testing services

NPL continually strives to make its science and technology as valuable, relevant and accessible as possible to our customers. This guide summarises the range of measurement services offered, together with the relevant points of contact who will help you select and specify the services you need, provide quotations and ensure you receive the very best levels of technical and customer service available.

To learn more about Measurement Services please visit at www.npl.co.uk

Working with NPL

We actively encourage our customers to work with us to determine the most suitable means of doing business with NPL. Options include:

- Ad hoc or single orders for customers requiring irregular support. Our Customer Services Executives (CSEs) will help you define your support needs and provide 'immediate response' quotations for particularly urgent jobs.
- Call-off contracts designed to minimise the cost and time spent in managing and processing orders and generating invoices and customer reports. Often the agreement of a pre-authorised 'Limit of Liability' is used to enable customers to place orders quickly and effectively.
- For larger scale or longer term support arrangements, the agreement of a tailored Service Level Agreement (SLA) may offer particular support benefits. Customer-specific service levels can be agreed based upon simple Key Performance Indicators (KPIs).
- Through our established network of preferred suppliers that includes other National Measurement Institutes (NMIs) as well as a range of specialist UKAS accredited laboratories, we are able to offer a 'one stop shop' approach to meeting your high quality measurement requirements.

Scheduling and batching of work:

NPL works with its customers to ensure that the timing of the work carried out is optimised to the needs of the customer's business. Due to the extremely wide range of measurement capabilities at NPL, we encourage our customers to work with us to define the most suitable date for releasing their equipment or standards into the laboratory as it helps minimise equipment downtime.

NPL is able to arrange collection and delivery of equipment to and from our customers' sites. This is particularly beneficial when high value, perhaps fragile, equipment needs to be transported across national boundaries.

Contacting NPL

The NPL Customer Services Team (CSE) provides customers with a single contact point for doing business with NPL. Please contact the CSE at the telephone number or e-mail listed on the relevant page of this brochure for information relating to quotations, placing orders, scheduling of work and progressing orders.

The CSE will be also able to arrange contact with the laboratory expert in the relevant area.

For more general enquiries where it is not clear who best to contact, we provide a Helpline that acts as a gateway to the business, particularly for customers new to NPL.

For all general enquiries please contact:

Helpline: **+44 20 8943 7070**
Fax: **+44 20 8943 6184**
Email: **measurement_services@npl.co.uk**

Degradation & Life Prediction of Materials

The degradation of properties is important for predicting the lifetime of materials and components. Accelerated tests are available to help understand the ageing processes in materials under a variety of conditions.

Services, Instruments and Artefacts:

- Exposure, environmental stress cracking
- Fatigue, thermal cycling, failure analysis
- High temperature degradation, chemical/moisture
- Lifetime assessment and structural health monitoring
- Testing materials in harsh environments - corrosion (e.g. aqueous, H S, steam)
- Ambient and high pressure steam exposure at high temperatures
- Accelerated testing of coatings and TBCs
- Low and high frequency wear testing in steam
- Corrosion in complex atmospheres e.g. simulating fireside conditions
- Low velocity burner exposures
- Thermogravimetric analysis (TGA) in reactive atmospheres

Contact

Customer Service tel: +44 20 8943 8681
Email: materials_enquiries@npl.co.uk

Electrochemical

Measurement techniques are available to support the development and manufacture of new products, improve reliability and predict lifetime of components. Electrochemical measurements include testing of fuel cells and fuel cell components, spatial mapping of photovoltaic conversion efficiency, local scanning electrochemical techniques and standard bulk electrochemical techniques such as cyclic voltammetry and impedance spectroscopy. The teams can offer key support to industry to understand the performance and durability of electrochemical energy conversion materials and devices.

Services, Instruments and Artefacts:

- Fuel cell and fuel cell component testing
- Local/Bulk electrochemical techniques, scanning electrochemical microscopy, cyclic voltammetry, impedance spectroscopy
- Spatial mapping of PV conversion efficiency as a function of specific wavelength and irradiance

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Electronic Interconnection

The Electronics Interconnection Group provides a comprehensive portfolio of test services and bespoke consultancy to the electronics industry based on over 25 years of research experience in the field.

Services:

- Surface Insulation Resistance (SIR) measurement
- CAF measurement
- Solderability Testing
- Evaluation of conformal coating to inhibit tin whisker growth
- Scanning Acoustic Microscopy (SAM)
- Solvent Extract Conductivity (SEC) / Ionic Extraction Testing
- Improving Electronic Reliability – Through Product & Process Qualification at NPL (Webinar series)
- Improving Electronic Reliability – Through Product & Process Qualification Seminar and Tabletop Exhibition
- Characterisation of mechanical property of solder joint
- Solder joint reliability testing
- Shear testing of solder joint
- Mechanical Shock Testing
- Micro-sectioning
- X-Ray Florescence (XRF)
- Scanning Electron Microscopy (SEM)
- Energy Dispersive X-ray Spectra (EDX)
- Surface topography measurements

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Mechanical Testing

The characterisation of all classes of materials, components and materials systems can be carried out over a range of temperatures. Tests may be made on standard macro scale specimens, but increasingly miniaturized tests are being developed which can allow the testing of parts of manufactured components, where properties may vary with position. Techniques and advice on non-destructive testing and structural health monitoring are also available.

Services, Instruments and Artefacts:

- Mechanical testing, static, dynamic, durability, impact
- Composite panel and specimen manufacture
- Digital Image Correlation (DIC) Capability
- Full field strain measurement
- Exposure, environmental stress cracking
- Measurement of strain: extensometers, strain gauges, Fibre Bragg Gratings (FBGs), ESPI
- Non-destructive evaluation (ultrasonic C-scan, microwave, pulse thermography, X-ray)
- Physical property measurements
- Residual stress, XRD and hole drilling
- Miniaturised mechanical tests, ETMT, small punch test
- Hardness, microhardness, nanoindentation, mapping
- Structural health monitoring, (SHM)

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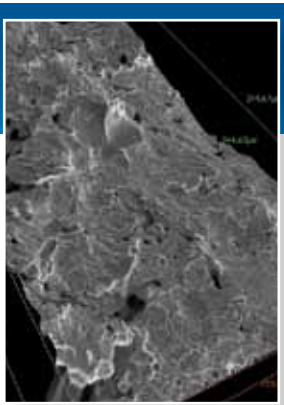
Microstructural Characterisation & Analysis



NPL has an extensive range of advanced metallographic preparation and examination equipment, which underpins our materials testing as well as offering a one stop shop for microstructural characterisation. Sample preparation expertise is available for a wide range of materials ranging from polymer composites to ceramics. Subsequent analysis and characterisation methods to International Standards or in-house procedures are available. NPL actively participates in Standards Committees for the development of new characterisation and microstructural measurement techniques, which are directly traceable to primary standards.

Services, Instruments and Artefacts:

Structure

- property mapping
- local chemistry (EDX, WDX) and composition analysis
- phase identification and quantification (EBSD, optical)
- hardness
- eddy current

- Grain size measurement
- Microstructure imaging (EBSD, optical) including specimen preparation
- Nanoparticle imaging
- Microscopy from 1 nm to 1 m (or 1 mm)
- Optical
- 3D optical SEM including STEM
- Surface structure and wear in 3D on real components up to
- Fractography and Failure Analysis

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Modelling

Finite element and finite difference simulation, structural and thermal modelling, and thermodynamic calculation of phase equilibria can be carried out to support Industry.

Applications of quantum mechanics, molecular dynamics, multi-physics, multi-scale, thermodynamic and FEA computational techniques are used to assess material properties at the molecular, micro and macro scales. Software solutions are also available.

Services:

- Analysis, multi-scale and multi-physics modelling
- CoDA (composites design) – software licences and consultancy
- FEA Software (Abaqus, Ansys, Pafec, LUSAS, Moldflow, Comsol)
- Materials chemistry, thermodynamic and phase equilibrium calculations - consultancy
- MTDATA (thermodynamic and phase diagram modelling) – software licences and courses
- MTDATA thermodynamic databases for metals, oxides, mattes, semiconductors, aqueous solutions, molten salts and gases

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Nanomaterials

NPL nanomaterials effort focuses on the development of reliable and accurate methods to measure the physical properties of nano-objects and the characterisation of transport properties in nanostructured materials.

Services, Instruments and Artefacts:

- Class 100 and 10,000 cleanroom facilities - thermal evaporation, e-beam and sputte desposition, optical lithography
- Nanoparticles characterisation: transmission electron microscopy with electron energy loss spectroscopy
- Surface characterisation on the nanoscale
- Scanning probe metrology of nano-structured materials: scanning Kelvin probe, scanning capacitance, chemical force, adhesion, and magnetic force microscopies

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Piezoelectric, Dielectric & Magnetic

Work is focused in determining functional material properties in piezoelectric materials, magnetic materials, multiferroics, and dielectric and electronic ceramics. Magnetic measurements can be carried out on a wide variety of magnetic materials. The parameters and ranges offered are continuously developed to meet the needs of new applications and measurement standards. Consultancy on the choice of magnetic material and magnetic circuit design, as well as other magnetic related issues, is available.

Services, Instruments and Artefacts:

- AC conductivity standards
- AC measurements of magnetically soft materials: specific total loss, specific apparent power and AC permeability
- AC properties of soft magnetic materials for operational conditions of stress, temperature and electrical waveforms
- DC measurements of magnetically soft materials: normal magnetisation curve, hysteresis loop, remanence and coercivity
- Ferroelectric coefficient measurement
- Functional materials research into functional thin film materials and non-linear properties of piezoelectric materials in harsh environments
- LF electrical characterisation: dielectric properties and impedance characteristics
- Low relative magnetic permeability, feebly magnetic, measurements and reference materials: relative magnetic permeability in the range 1.002 to 1.6
- Magnetic signature measurements using the NPL low magnetic field facility
- Magnetically hard materials: demagnetisation curve, remanence, intrinsic coercivity, maximum energy product
- Modelling of electromagnetic field interactions with materials and metamaterials
- Piezoelectric coefficient measurement
- Piezoelectric displacement measurement
- RF and microwave dielectric measurement services
- RF and microwave dielectric research
- Validation of magnetic measurement systems and calibration of magnetic measurement instrumentation

Contact

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Properties for Process Modelling

A range of measurements are available to provide data on thermal and fluid flow properties from sub-ambient to extremely high temperatures, under controlled atmospheres, for a wide range of materials.

Services, Instruments and Artefacts:

- Density
- Pressure volume temperature (PVT) measurements
- Rheological properties including viscosity
- Thermal analysis of materials - TMA, DSC, DMA, TGA
- Thermal expansion

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Surface Engineering

NPL offers macro to nano-scale measurements of the mechanical and tribological properties of surfaces, coatings and small volumes of material. Tests include surface texture, friction, wear, coating integrity, thickness, adhesion, fracture properties, hardness, elastic modulus and the measurement of residual stress.

Services, Instruments and Artefacts:

Abrasion and Erosion Tests

- ASTM G65 dry sand and rubber wheel abrasion
- ASTM B611 abrasion testing for cemented carbides
- Microscale abrasion
- ASTM G76 low velocity solid particle erosion

Sliding Wear Tests

- ASTM G99pin on disk
- ASTM G133 reciprocating wear
- High temperature reciprocating wear
- High frequency fretting wear

- Atomic Force Microscopy
- Nano-mechanical testing, nano indentation and surface acoustic wave spectroscopy
- Coating adhesion and fracture assessment
- Measurement of mechanical properties of coatings e.g. modulus

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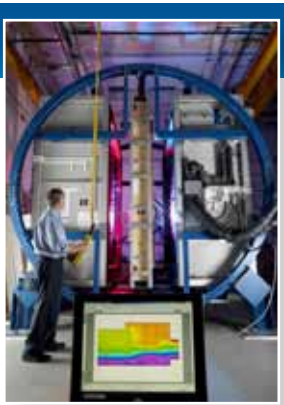
Thermal Performance



NPL provides comprehensive, world class facilities for measuring thermal properties and has UKAS accreditation to ISO Guide 34 for the provision of reference materials and transfer standards used to calibrate commercial measurement apparatus.

We also offer consultancy and a range of measurement services that provide the material data required for modelling industrial applications and the accredited measurements required for certification of construction products.

Services, Instruments and Artefacts:

Thermal Conductivity
- NPL Guarded Hot-Plate - Insulation up to 250 mm thick (5 °C to 40 °C)
- Guarded Heat Flow Meter - Polymers, composites, ceramics and others (-100 °C to 250 °C)
- Thermal Conductivity by Thermal Diffusivity - Metals, ceramics and graphite (25 °C to 1600 °C)
- NPL Low-Temperature Guarded Hot-Plate - Insulation up to 60 mm thickness (-170 °C to 50 °C)
- NPL High-Temperature Guarded Hot-Plate - Insulation and refractories (140 °C to 800 °C)
- NPL Vacuum Guarded Hot-Plate - Construction and engineering materials (-20 °C to 70 °C)
- NPL Axial Heat Flow Meter - Metals and alloys (50 °C to 500 °C)

Thermal Transmittance
- Thermal transmittance using NPL Rotatable Hot Box and NPL Wall Guarded Hot Box
- Windows, skylights, panels, roof sections and walls (up to 450kg)
- Pipe insulation testing up to 250 °C

Thermal Expansion
- Measurements can be made within the temperature range -140 °C to 1400 °C

Thermal Analysis
- Differential Scanning Calorimetry (DSC) within the temperature range -90 °C to 1600 °C
- Dynamic Mechanical Analysis (DMA) within the temperature range -150 °C to 600 °C
- Thermo Mechanical Analysis (TMA) within the temperature range -150 °C to 1000 °C

Reference Standards
- Thermal conductivity reference materials and transfer standards to ISO Guide 34
- Calibrated thermal transmittance panels for Hot Box calibration to EN ISO 12457-1

Contact

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Email: thermal_enquiries@npl.co.uk

Mathematical Modelling

NPL mathematicians offer a range of services including the development of mathematical models and the associated uncertainty evaluations to support all measurement sectors

Services:

- Development and implementation of mathematical models
- Black box testing and validation of the numerical correctness of mathematical models
- Advice and support on the calculation of measurement uncertainties
- Signal and data analysis
- Advice and support on commercial FE/FD modelling software

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NPL Training

NPL has developed a Training Framework designed to up-skill learners in all aspects of measurement and its underpinning principles. In addition, NPL offers bespoke training solutions in line with customers' requirements.

A core understanding of why a measurement process is carried out, rather than just how, can result in:

- Fewer errors and increased productivity in any environment.
- Reduction in the need for expensive technical support.
- Lower waste levels and re-work time.
- Improved quality control, accuracy and repeatability.
- Promotion of decision-making, questioning and planning culture amongst staff.

The primary objective of the training is to provoke the learner in to making a difference within the workplace, giving them the opportunity to generate a return on investment for their employer as well as meet throughput requirements.

NPL is proud to offer the UK the first nationally recognised set of qualifications in metrology. The NPL Training Framework is validated by The National Skills Academy for Manufacturing (NSA-M) and accredited by EAL, a UK Awarding Body.

Measurement Training Needs Analysis Programmes (MTNA)

NPL is also able to offer is a Training Needs Analysis (TNA) of your staff. This is sometimes referred to as the Accreditation of Prior Learning and Experience (APLE) process.

This will involve each member of staff being interviewed by an NPL Accredited Trainer. This is most effective when carried out face to face, rather than on the telephone or online. Once complete, the interview will have given the NPL accredited Trainer all of the necessary information to assess the current competency and skills sets possessed by the learner. Recommendations for appropriate training courses can then be made based on this information and specific outcomes targeted.

NPL Training Framework - Learning Outcomes

The learning outcomes include instilling the following behaviours and attitudes:

- A questioning culture.
- A planning mentality.
- A strategic approach to measurement and calibration.
- A responsible attitude towards measurement and calibration.
- An accomplished, sound and practical understanding for the day-to-day application of metrology in the work place.
- A skilled, motivated and proficient member of staff.

For more information please visit **www.npl.co.uk/training**, email **pete.moors@npl.co.uk** or telephone **+44 20 8943 8672**.

Other types of support offered by NPL:

Measurement Services represent just one way in which our customers can benefit from the wealth of scientific and technical resources at NPL. Other areas of support include:

- Consultancy: ranging from free advice over the telephone to fully or part-funded secondment of NPL experts into customer organisations
- Sale of reference artefacts, samples and measuring equipment
- Licensing of our portfolio of technology Intellectual Property, developed over many years at NPL and now accessible under a variety of exploitation arrangements
- Facility Hire: access to many of NPL's unique laboratory facilities on a pre- booked basis. Customers are able to operate these facilities under the impartial guidance of our technical experts
- Training: our established range of world-renowned measurement-related training products, delivered to meet the specific training and development needs of our customers
- Network Management, including both knowledge network facilitation and measurement infrastructure management
- Modelling of all types, using a wide-range of state-of-the-art techniques and covering the entire breadth of NPL's science and technology base
- Measurements solutions: the development and delivery of bespoke measurement techniques, practices and business solutions, especially at high levels of accuracy or for use in difficult or unusual environments
- Test and measurement instrument design, development, application and impartial evaluation
- Independent measurement, testing and validation of software and systems
- Development of specialist mathematical software for measurement and instrumentation applications.

General business enquiries concerning the above services should be referred to our dedicated Business Development team:

Defence & Security	**Gareth Edwards:**	**+44 20 8943 7046**
Low carbon Energy	**Ray Chegwin:**	**+44 20 8943 6385**
Advanced Manufacturing (Materials)	**Matt Smith:**	**+44 20 8943 7022**
Training	**Pete Moors:**	**+44 20 8943 8672**
Measurement solutions	**Andy Morris**	**+44 20 8943 8749**

NPL's commitment to quality

As the national measurement standards laboratory in the UK, NPL offers services at the highest available levels of accuracy. Customers depend on these to achieve direct traceability to nationally and internationally accepted standards. These services are operated within the most stringent quality and procedural requirements. To demonstrate this formally, it is NPL's policy to seek accreditation, where feasible, for its measurement services.

ISO 9001

NPL's quality management system has been registered for scientific R & D and the provision of internal services by LRQA to ISO 9001: 2000 and where appropriate in accordance with TickIT.

ISO 17025 and ISO Guide 34

Many of NPL's standard calibration, measurement and testing services have been accredited by UKAS. The accredited capability of those services may be found in calibration and testing schedules issued by UKAS.

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CIPM MRA

Many NPL certificates now display the CIPM MRA logo and statement, indicating the mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes.

Customer Satisfaction

At NPL we aspire to provide a world-class service to all of our customers. Your views on our performance are important to us. We would appreciate it if you would tell us how we are doing and suggest areas to us where we could improve our service to you. For more details please visit us at

http://www.npl.co.uk/customer_satisfaction

Terms & Conditions of Business

For detailed information please refer to the Terms & Conditions page on our website:

www.npl.co.uk/terms_conditions

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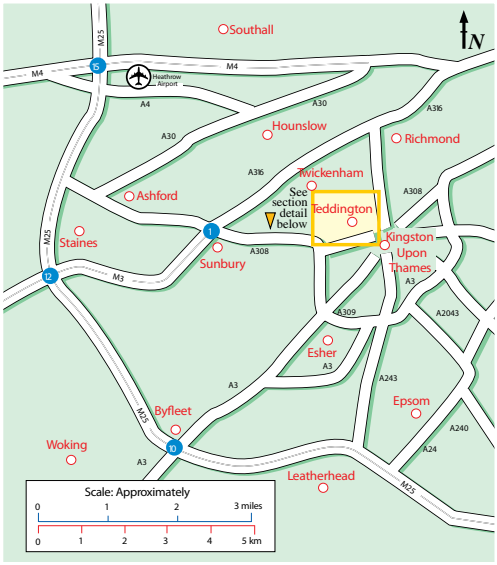

Public Transport

By Rail,
Teddington Station
20 minutes walk to NPL.

Buses.
Teddington is well served by buses from Heathrow, Kingston, Twickenham and Richmond (285, X26, 281, R68 and 33).

By Air
Heathrow Airport
Bus 285 travels to Teddington and stops outside NPL. Bus X26 is faster and stops at Broad Street, a short walk from NPL. Or take a taxi, approximately 30 minutes to Teddington.

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