CREATING IMPACT FROM SCIENCE

NPL
National Physical Laboratory

Introduction to the National Physical Laboratory

September 27, 2023

NPL

About NPL

UK's National Metrology Institute founded in 1900

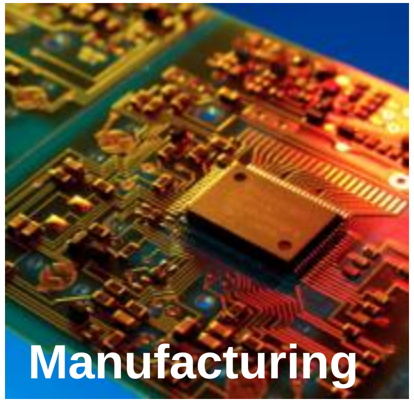
A public corporation owned by the Department for Science, Innovation and Technology (DSIT)

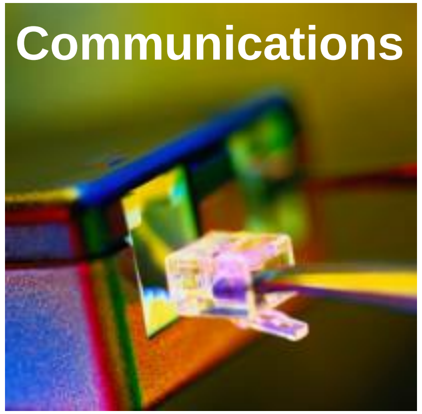
Based in Teddington (London) with locations in Strathclyde, Surrey, Cambridge, Huddersfield and Solihull

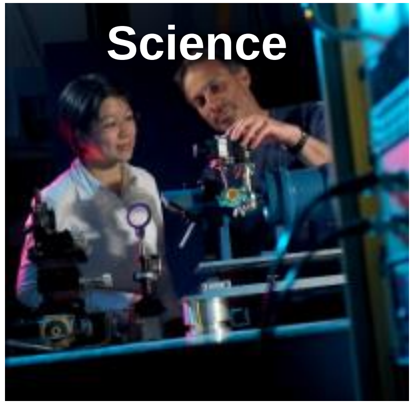
Strategic partners DSIT, the University of Surrey and The University of Strathclyde

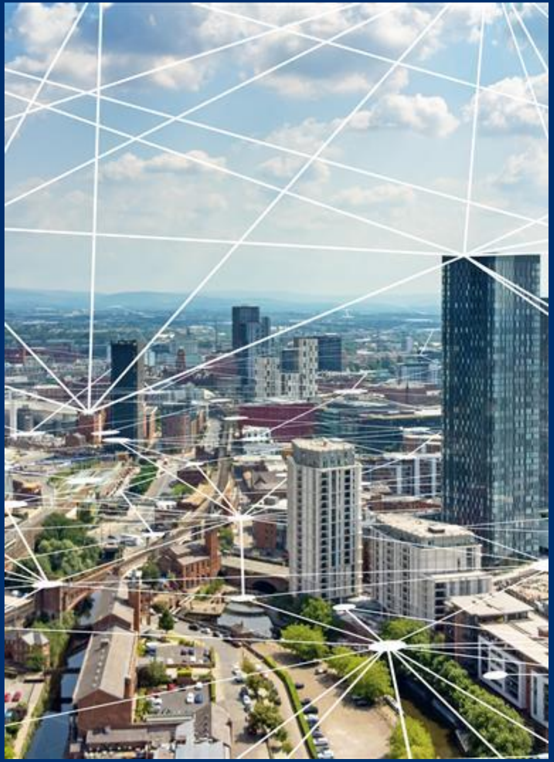
800 scientists with a breadth and depth of metrology expertise.

The growing demand for better measurements









National challenges

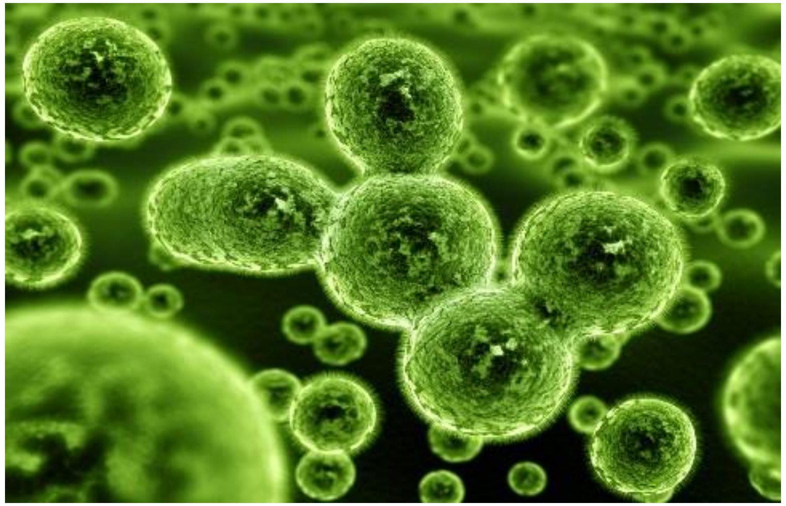
Metrology improves the effectiveness and efficiency of science and trust in its outcomes, which in turn unlocks the potential of innovation, allowing faster routes to market. Evidence-based policy, regulation and decision making are heavily reliant on measurements and data, and NPL is key in providing and digitising that measurement infrastructure.

Our focus areas

Digital

Environment & Energy

Life Sciences & Medical



Advanced Manufacturing & Materials

We contribute to more than 160 national and international standardisation committees

NPL

- International Standards Organisations
- Regional Standards Organisations
- National Standards Organisations

A standard is a …

'document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context'

(ISO/IEC Guide 21-1:2005, 3.1)

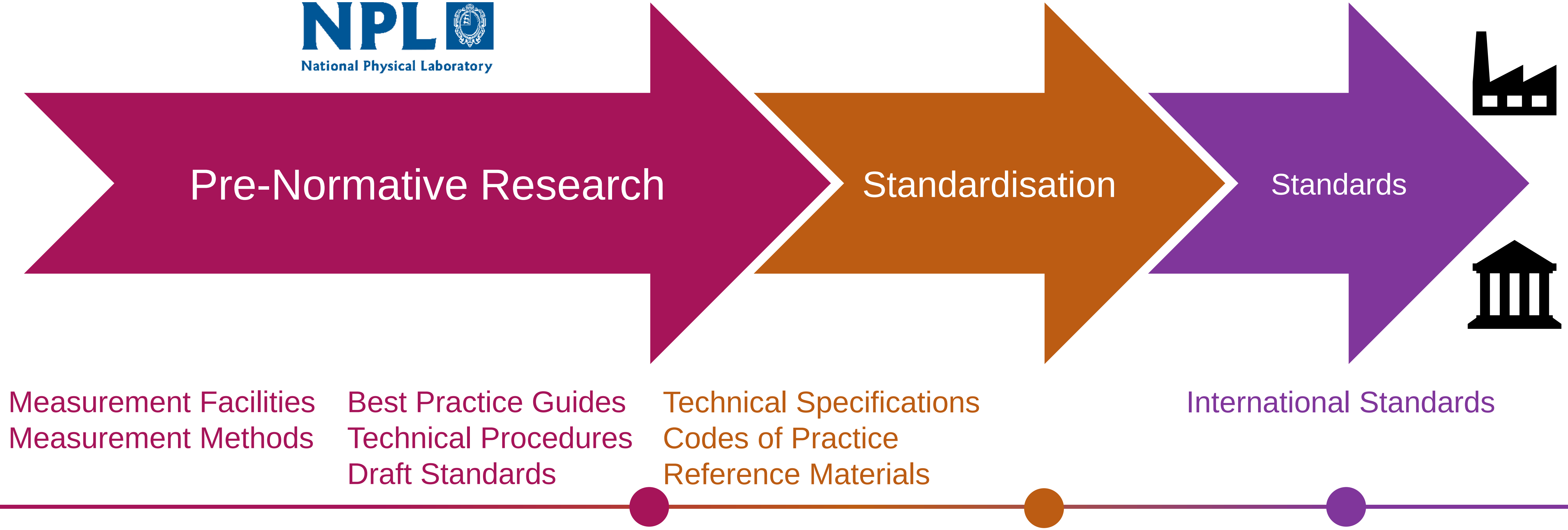
Materials metrology

The performance of materials and how it is affected by the environment products operate in, is of paramount importance for fit-for-purpose and sustainable design

Materials metrology is the science of measurement as applied to materials, involving a rigorous approach to the measurement of materials properties, improving understanding of the sources of variability, thereby resulting in the development of improved and validated measurement techniques which, through the provision of international standards, enabling acquisition of assured materials data of appropriate quality and reliability

Our role

World leading experts in materials metrology, evidenced through leadership in standards committees (ISO, ASTM), leadership and participation of international inter-comparisons for materials precision data



Good Practice Guide

NPL Good Practice Guide No. 52 – Determination of Residual Stresses by X-ray Diffraction.

Authored by experts from the Open University, MMSC, QinetiQ, Stresstech and NPL, with steer from the XRD focus group established as part of this project.

Scope - The recommendations are meant for stress analysis where only the peak shift is determined. If a full triaxial analysis of stress is performed, using a stress-free reference, then the absolute peak location has to be determined. However, such an analysis is beyond the scope of this Guide, which assumes that measurements are made with the assumption that the stress normal to the surface is zero i.e. plane stress conditions, and so a full triaxial analysis is not required.

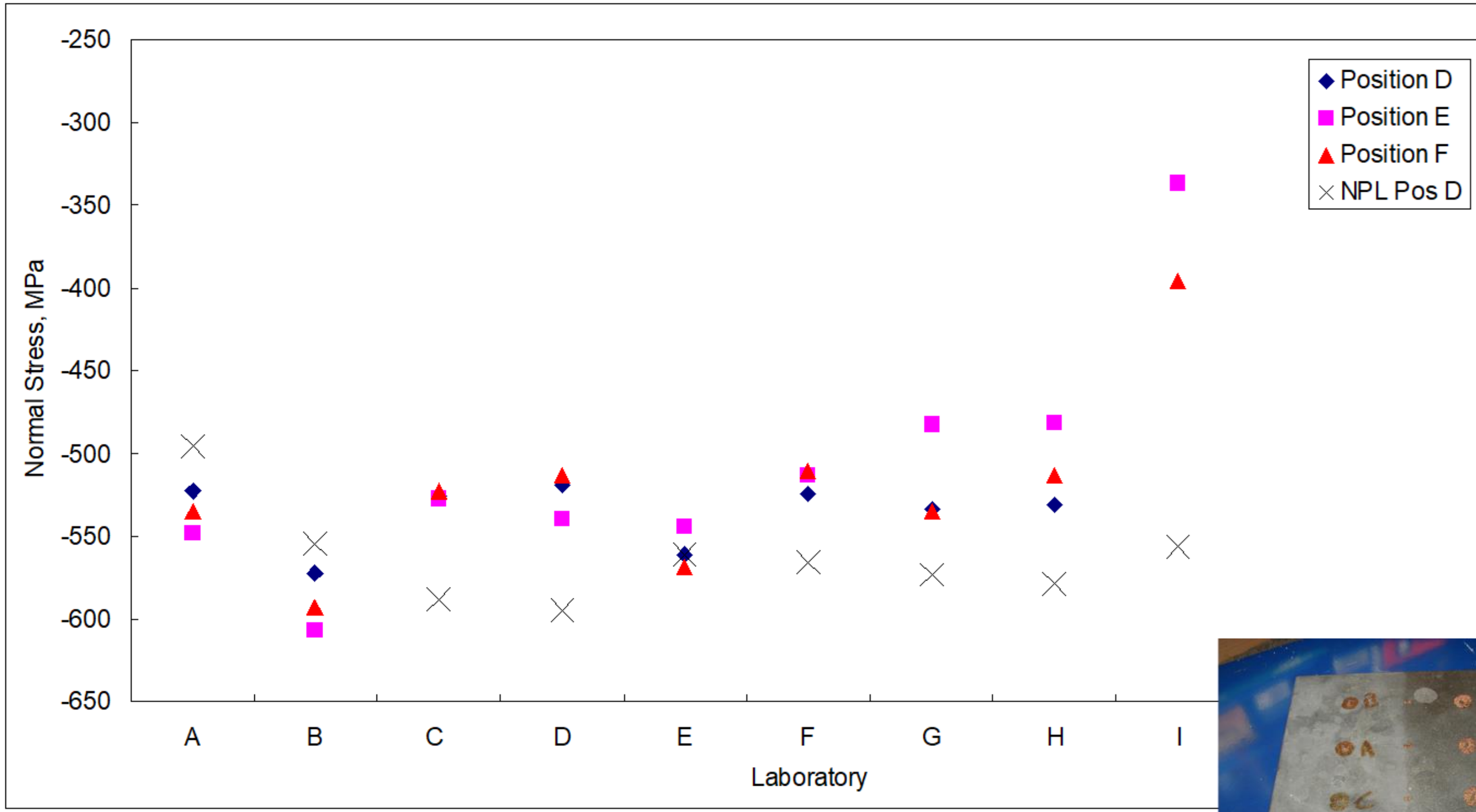
Future Version

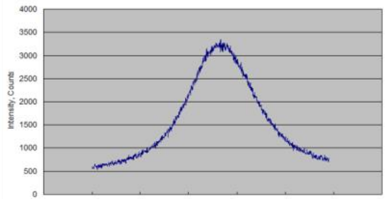
The GPG is an evolving document which will continue to be updated as and when best practice and/or the measurement procedure changes.

For example, the introduction and increased use of portable diffractometers. In most cases the GPG covers the measurement technique, but it does not include the Cos α method, and so we are planning an update to elaborate on the use of portable system.

Round Robin – Uncertainty Evaluation

- Review identified 2 techniques, hole drilling and X-ray diffraction.
- Round robin conducted using each technique.
- Material – Shot peened spring steel.
- 7 different machine types.
- 3 different detector types.
- The majority of participants used CrKa, although some did use CuKa.
- 5 different peak fitting techniques.





Round Robins – Why do them?

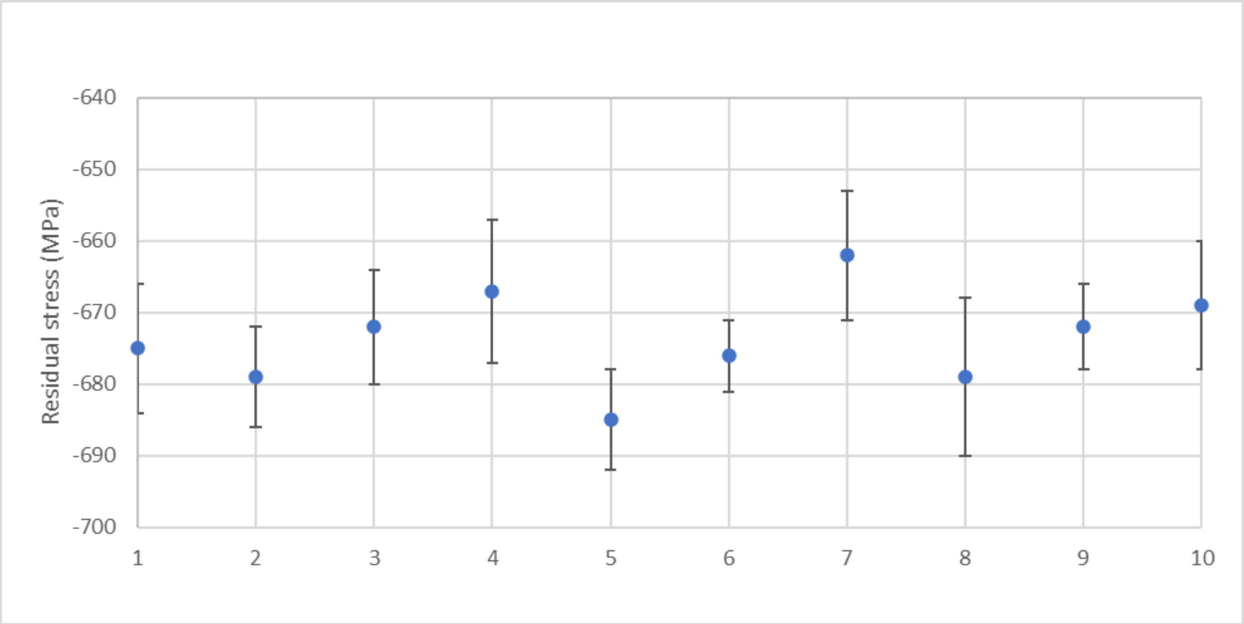
- Compare different operating procedures and methods
- Verification checks
- Proficiency checks
- Sample a range of equipment
- Comply with ISO 17025 for accreditation
- Validate standards (e.g. VAMAS)

Repeatability of µx360 (Cos α method)

- Used a shot peened spring steel sample.
- Note this was a different sample to the one shown previously, so not directly comparable.
- Repeatability – 10 repeat measurements without removing the sample.
- Reproducibility – 2 users conducting 5 measurements, removing the sample each time.

Results - Repeatability

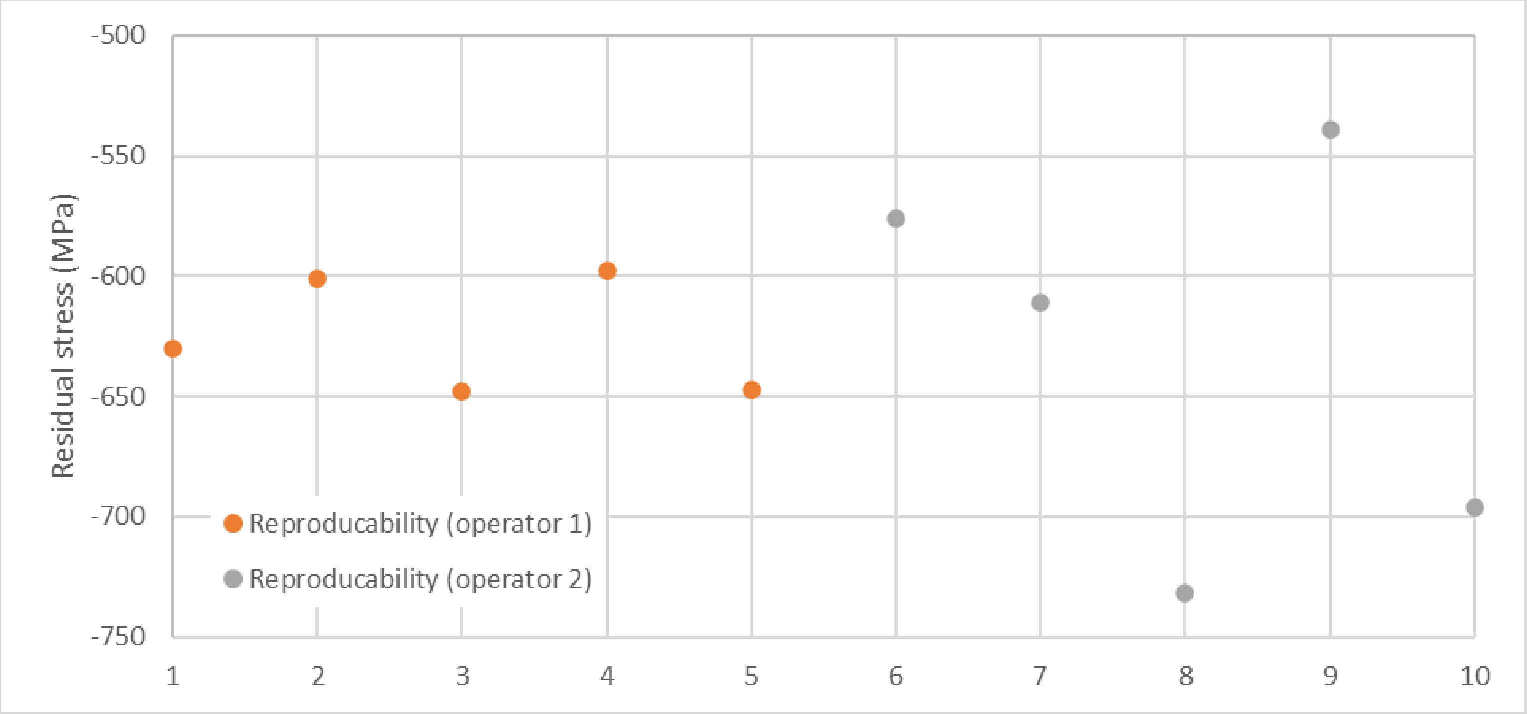
	Residual stress, (MPa)	Std. dev. (MPa)
Non-shot-peened steel (material bulk)	29	17
Shotpeened steel (90 deg check)	-657	13
Shotpeened steel (repeatability 1)	-675	9
Shotpeened steel (repeatability 2)	-679	7
Shotpeened steel (repeatability 3)	-672	8
Shotpeened steel (repeatability 4)	-667	10
Shotpeened steel (repeatability 5)	-685	7
Shotpeened steel (repeatability 6)	-676	5
Shotpeened steel (repeatability 7)	-662	9
Shotpeened steel (repeatability 8)	-679	11
Shotpeened steel (repeatability 9)	-672	6
Shotpeened steel (repeatability 10)	-669	9
Average	-674	8



The estimated residual stress value in the above example is, therefore, -674 +/- 40 MPa.
The above reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, which corresponds to a level of confidence of approximately 95 percent.

Results - Reproducibility

	Residual stress (MPa)
Shotpeened steel (reproducability 1)	-630
Shotpeened steel (reproducability 2)	-601
Shotpeened steel (reproducability 3)	-648
Shotpeened steel (reproducability 4)	-598
Shotpeened steel (reproducability 5)	-647
Average	-625
Shotpeened steel (reproducability 1)	-576
Shotpeened steel (reproducability 2)	-611
Shotpeened steel (reproducability 3)	-732
Shotpeened steel (reproducability 4)	-539
Shotpeened steel (reproducability 5)	-696
Average	-631



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