

REPORT

Study of Improved Methods for Absolute Colorimetry

Third Report Recommendations

National Measurement System
Programme for Optical Radiation
Metrology
Project 7
Reference MPU 8/36.3

J F Verrill, P C Knee and
A R Hanson

February 1997

NPL REPORT QM 130

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Third Report

Recommendations

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INTRODUCTION

NMSPU contracted NPL to carry out a study into improved methods for absolute colorimetry. The first report issued was:

Review of Existing Services, Artifacts, Instrumentation and Dissemination Methods for Colorimetric Measurements, NPL Report QMS 108, April 1996.

Following this a detailed survey was carried out to establish industrial needs, including those of SMEs, for colorimetric measurements. The survey was divided into two parts, the first a survey of NPL customers carried out by NPL staff, the second a survey of companies selected from marketing databases and carried out by PE Research. The second report was presented in two parts,

Study of Industrial Requirements for Colorimetric Measurements
Part 1, NPL Report QM 128 December 1996
Part 2, PE Research Report October 1996

The third report provides recommendations for making necessary improvements in the UK capability for absolute measurements for colorimetry with particular reference to current problems and future needs. Five recommendations are made. These cover education, accuracy, transfer standards, specification standards and measurement of appearance. Where statistical data from the second report are quoted, the first number is from the NPL results and the second from the PE results.

Data on industrial sectors, problems and future needs are summarised in the Annex.

1. EDUCATION

Argument

(20%, 3%) of respondents to the survey said that the greatest requirement is for better training and education. The more informed group (NPL customers) had a much better awareness of the need for education. A major reason for the large number of disagreements between and within companies, said to be the biggest problem by (25%, 36%) of respondents lies in the lack of understanding of accuracy. (48%, 33%) of respondents said they did not know what accuracy they achieved. Of those stating an accuracy achieved, (35%, 59%) claimed to achieve the highest accuracy of 0-0.5 CIELAB units. These claims are strongly at variance with the results of the *NPL Spectrophotometry and Colorimetry Club Intercomparison of Colour Measurements*, which showed that such accuracy is achieved only by a very small number of companies using the best quality instruments in pristine condition. The difference is probably due to widespread misinterpretation of the technical specifications of the instruments which do not give figures for accuracy. Instead they quote figures for repeatability and inter-instrument agreement, for instruments of the same make and model leaving the factory gate. Many users may take these figures to mean accuracy. Several courses on colour measurement are available including a course on *Measurement Techniques for Colorimetry and Spectrophotometry* run by NPL. However, there is no course dedicated specifically to absolute accuracy and how this might be determined and improved by traceability through the use of calibrated colour standards for industrial colour measurements.

Recommendation 1

A specialist course should be held periodically, on accuracy in colour measurements using calibrated colour standards for traceability, maintenance of instruments and diagnosis of instrumental errors. In addition NPL should publish notes on the use of colour standards for these purposes.

NMSPU should continue to support the NPL Spectrophotometry and Colorimetry Club which holds Technology Transfer meetings 2-3 times a year and organizes working parties with industry on best practice in measurements.

2. ACCURACY

Argument

Accuracy lies at the heart of many difficulties encountered by respondents. The limitation in the accuracy of currently available commercial instruments is, in turn, limited by the accuracies achieved by national laboratories. If left unaddressed, this issue will cause significant errors in communication between customers and suppliers as more companies use numerical data in preference to material samples as purchasing standards. The European intercomparison of surface colour measurements, coordinated by NPL and published in 1993 showed that only 50% of measurements made by the four national laboratories agreed to within 0.5 CIELAB units, which is approximately the limit of discrimination of the human eye. Differences up to 2 CIELAB units occurred. The recent NPL Spectrophotometry and Colorimetry intercomparison of industrial colour measurements (*NPL Report QU113*) showed that approximately the same level of accuracy was achieved by only the best quality available commercial instruments with other instruments giving larger inaccuracies.

Recommendation 2

NMSPU should continue to support research into the reduction of uncertainty of measurements. The aim should be to reduce NPL uncertainties from the present 0.6 CIELAB units to 0.3 CIELAB units at the 95% confidence level. At the same time methods should be developed for the determination and correction of errors in industrial colour measuring spectrophotometers through the use of calibrated artefacts and corrections applied through software to achieve an agreement with NPL to within 0.5 CIELAB units.

3. TRANSFER STANDARDS

Argument

Several organisations have requested transfer standards with lower thermochromism. A possible route for achieving this is now open to research following the observation by NPL of anomalously low coefficients of thermochromism in strong colours.

Some organisations, including the *Society of Dyers and Colourists* have requested the development of stable fluorescent transfer standards.

Recommendation 3

NMSPU should consider funding research into the development of red, orange, yellow and green colour standards with coefficients of thermochromism of not greater than 0.03 CIELAB units per °C. (This has already been achieved for cyan blue colour standards).

NMSPU should consider funding research into the development of stable white, red, orange and yellow fluorescent surface colour standards.

4. SPECIFICATION STANDARDS

Argument

Inadequate standardisation of methods of measurement was listed as the major problem by (6%, 7%) of respondents. The *British Standards Institution* and the *Society of Dyers and Colourists* both stressed the need for a standard daylight source for colorimetry. This is needed for colour matching booths and for the spectrophotometric measurement of fluorescent colours.

Recommendation 4

NMSPU should continue to support representation on standards committees at national and international levels.

Particular emphasis should be placed on a recommendation for a standard daylight source(s) through CIE TC1-44 *Practical Daylight Sources for Colorimetry*. This support should extend to an experimental programme on the evaluation of currently available daylight sources.

NMSPU should also support an experimental investigation of geometric tolerances for colorimetry with the aim of improving inter-instrument agreement. The results should be forwarded to CIE TC2-39, *Geometrical Tolerances for Colorimetry* for inclusion in any preparation of a new recommendation by the CIE.

5. MEASUREMENT OF APPEARANCE

Argument

In the past the majority of measurements of colour have been made on uniform materials. The situation is changing with (13%, 18%) of respondents to the survey giving their major problem as the measurement of textured or patterned surfaces or materials with complex optical properties. These include the novel colour effects produced by metallic and pearlescent paints or thin film coatings where the appearance changes with angle of view, as well as translucent materials such as plastics, cosmetics and food.

The surveys show a major future requirement is for equipment to meet new measurement situations (40%, 37%). Instrumentation based on TV cameras and CCD arrays is now being developed for measurement of patterned or textured surfaces both on and off line. Instrumentation is now available for the measurement of metallic surface colours. At present there are no standards or calibration services for either novel colour effect materials, translucent materials or systems for the measurement of textured or patterned surfaces.

The current methods measure only the colour specification of the sample itself but do not take account of the effects of the surround which influence perceived colour. This may in part account for the large number of disagreements between visual assessments and instrumental measurements, given as the biggest problem by (6%, 13%) of respondents. Colour appearance is a particular problem in graphic design and desk top publishing where designs are transferred from self luminous visual displays to reflective media. Several colour appearance models varying in complexity have been developed. The CIE intends to recommend a model for industrial use in 1999.

Recommendation 5

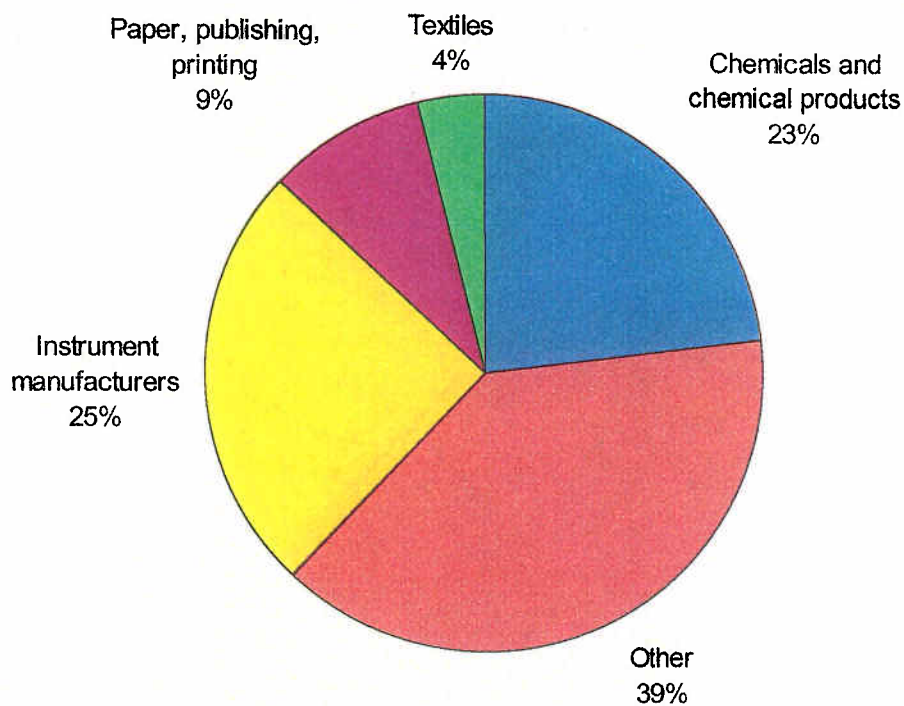
NMSPU should consider funding the development of measurement standards for appearance including patterned and textured surfaces, special effect materials such as metallic paints and translucent materials. These are required for the textile, paint, automotive, plastics and food/drink industries.

A small paper study should be carried out into the impact of a recommended colour appearance model on industrial colour measurements.

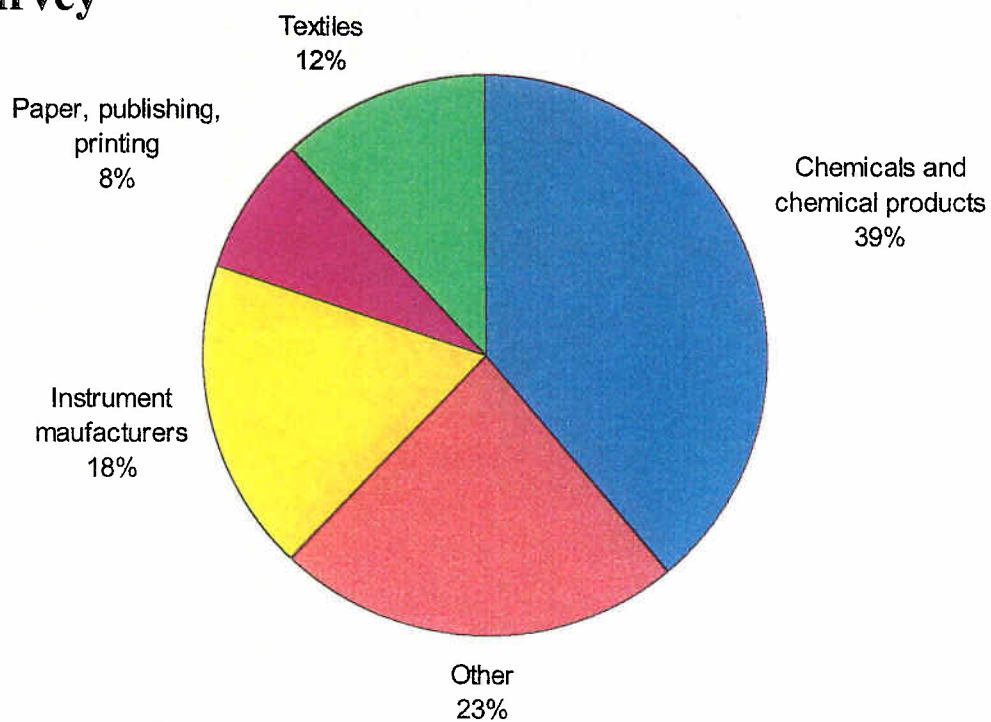
Annex

Industrial Sectors

NPL Survey



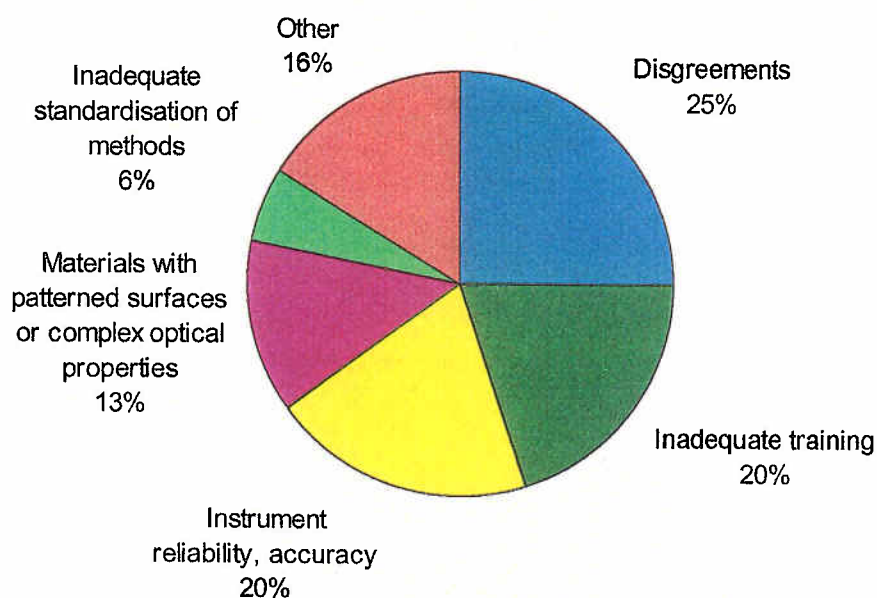
PE Survey



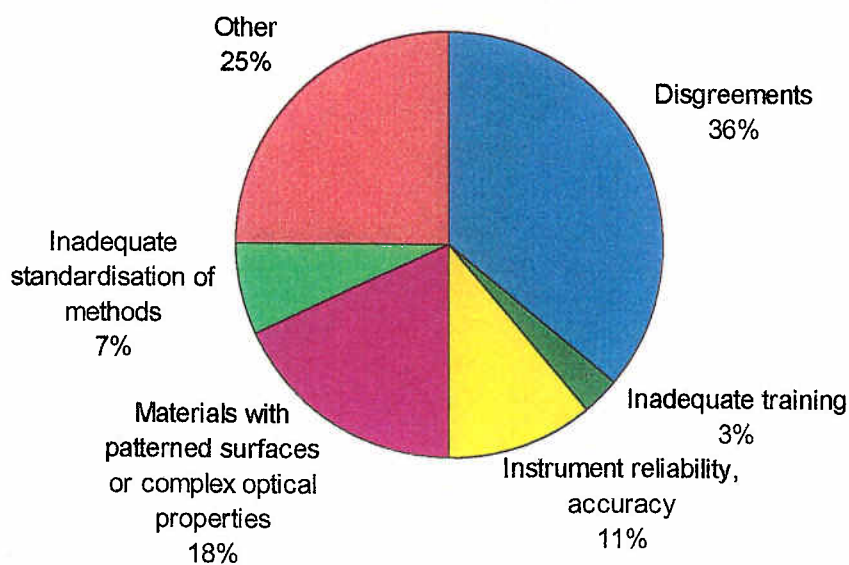
Full details are given in the Second Report, Part 1, Page 2 and Part 2, Page 11

PROBLEMS

NPL Survey



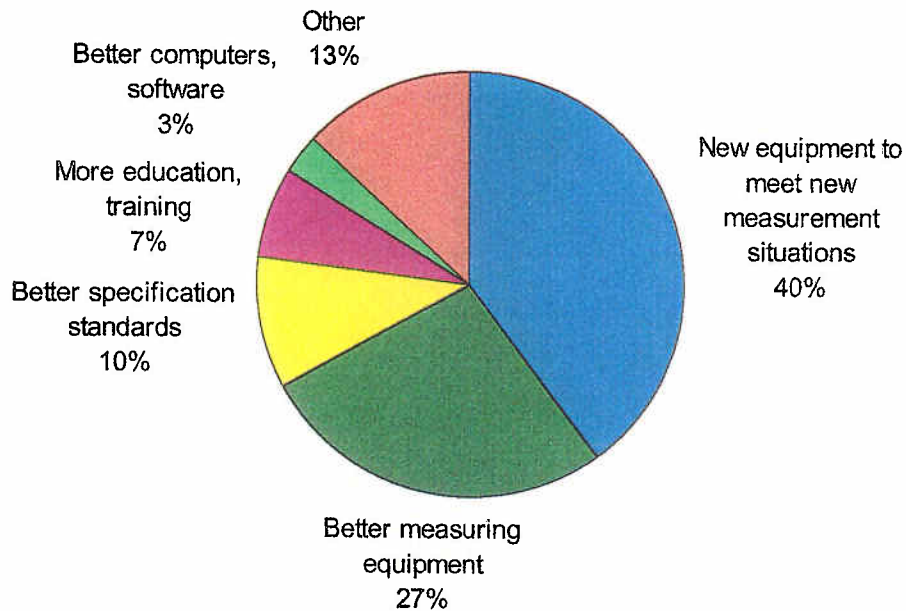
PE Survey



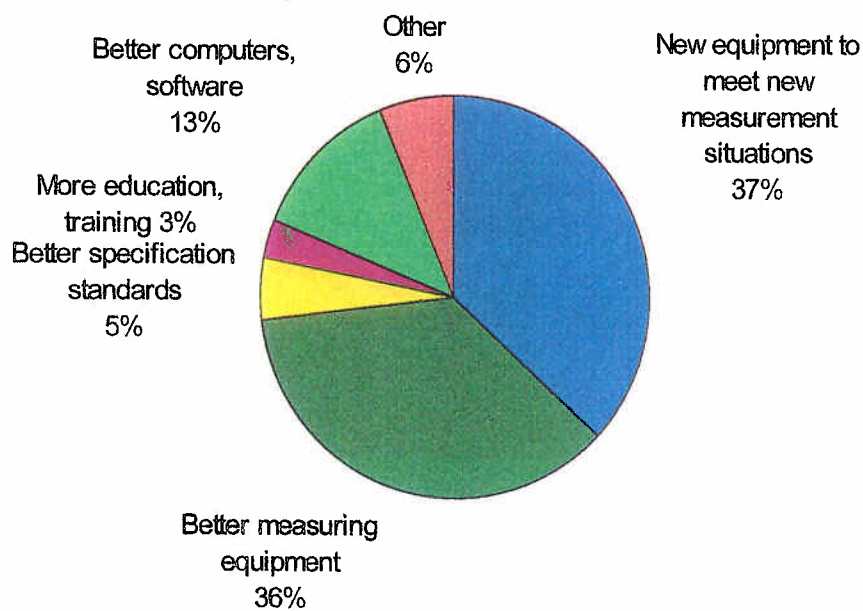
Full details are given in the Second Report, Part 1, Page 5 and Part 2, Page 22

FUTURE NEEDS

NPL Survey



PE Survey



Full details are given in Second Report, Part 1, Page 6 and Part 2, Page 23