DESIGN OF A GLASS CASEWORK DATABASE INHERITING QUALITY ASSURANCE ASPECTS

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ABSTRACT: Based on the results of a proficiency test carried by 11 German federal state labs and one Swiss crime lab using different measurement protocols and equipment a project group was founded in 1999 aimed at working on the harmonisation of refractive index measurements. This group outlined minimum criteria for case working ("eleven laws" of refractive index measurement), taking into account existing documents like ASTM E 1967-98.

In co-operation with the glass manufacturer SCHOTT a glass standard with controlled refractive index $\pm 7 \times 10^{-6}$ was obtained. This BKA-K5 standard was distributed to all German forensic state laboratories. This glass should be used as an external standard in order to ensure quality control charts.
A database has been designed for scene of crime and suspect glass material. The database will include information on: refractive index, standard deviation, number of measurements, annealing, origin, colour, thickness, glass type, type of crime, date of measurement.

The aim of this centralised database is to enhance the evidential value of a given case regarding the frequency of occurrence and further relevant questions. Statistical calculations (t-test) and grouping algorithms are also integrated into this software.

KEY WORDS: Database; External standard; Forensic glass interpretation; Refractive index; Quality assurance.

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INTRODUCTION

In 1999 a proficiency test including 11 German federal state labs and a Swiss lab was carried out by the forensic science institute of the Bundeskriminalamt (BKA).

The aim of the proficiency test was the differentiation of 4 glasses (2 pairs of glass samples with similar refractive indices).

The results were:

- two labs dropped out (no return of results),
- two labs determined only match point temperature (no calibration of the GRIM),
- two labs showed extraordinary high/low refractive index measurements,
- refractive index of remaining 6 labs & 2 BKA results exhibited rsd of smaller than 5×10^{-5},
- no full differentiation of the glasses without annealing,
- only three labs were able to distinguish between all samples.

Two main results which could be drawn by the proficiency test were the importance of the annealing procedure and the need for harmonisation in making refractive index measurements.

Based on the results of the proficiency test several factors that act as drawbacks in the every day working of forensic glass cases were postulated:

1. The lack of harmonised operating procedures for GRIM including sample preparation.
2. The lack of common quality assurance steps including a common and unified external standard.
3. The need for a central database for the collection of case work GRIM data in order to interpret the results.

PROJECT GROUP GRIM

Triggered by the discussions followed by the outcome of this proficiency test a project group was founded in 1999 aimed at working on the above tasks. Project members are delegates from 5 federal state crime labs Landeskriminalamt (LKA) Hesse, LKA Saxony-Anhalt, LKA Schleswig-Holstein, LKA Saxony, LKA Baden-Württemberg, and the BKA. The co-ordination of the project group GRIM is carried out by the BKA.

Hence, the main objectives of this project group are the harmonisation of refractive index measurements including quality management (QM) steps, and the build up of a central refractive index database which also deals with grouping problems (see Figure 1).

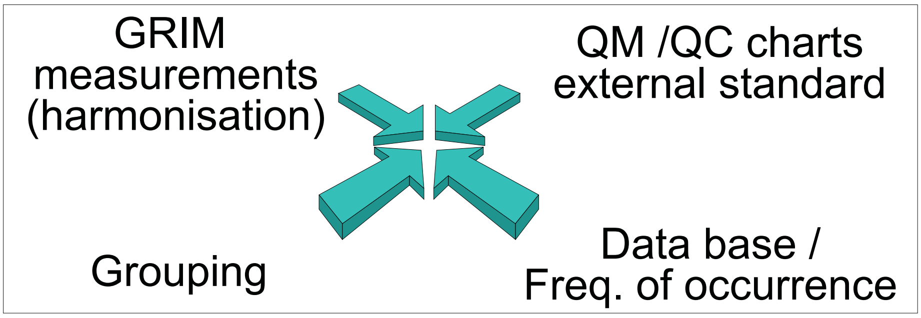

Fig. 1. Main objectives of the project group GRIM.

This group outlined minimum criteria for case working, taking into account existing documents like ASTM E 1967-98. Important features of the ASTM E 1967-98 [1] are:

– calibration of GRIM (min of 3 glasses/oil),
– measurement at Na D line, filter at 589 ± 5 nm,
– measurement of an external standard differing from the calibration standards,
– control with an external standard (control charts),
– precision/standard deviation of reference material: 0.00002 n_d during a period of 5 h, 0.00003 n_d during a period of 5 days.

After thorough discussions the project group stated 11 requirements ("11 laws") of refractive index measurement (Table I).

TABLE I. SUMMARY OF THE "11 LAWS" OF REFRACTIVE INDEX MEASUREMENT

"Law"		Activity
I	Sample preparation	P
II	Measurements of freshly produced edges	P
III	Measurement window	P
IV	Phase contrast	C
V	Heating rate	P
VI	External BKA-K5-standard	C
VII	Qualitiy control charts	C
VIII	Interference filter	C
IX	Calibration	C
X	Outliner test	C
XI	Number of measurements	C

(P – proposed action, C – compulsory action for the use of a refractive index case work database).

"11 LAWS" OF REFRACTIVE INDEX MEASUREMENT

1. Glass fragments should be cleaned before further embedding. Ethanol or acetone are proper cleaning agents. In case of strong contamination the glass fragments could be treated with concentrated nitric acid. H_2O_2 is sufficient to remove blood stains.
2. Fresh edges should be selected for measurement if possible.
3. The measurement should be carried out close the optical axis of the microscope.
4. The phase contrast should be controlled and adjusted before every measurement.
5. The heating rate of the hot-stage should be set to 4°C/min.
6. An external standard should be measured every day. 4 edges of the external standard BKA-K5 should be measured.
7. Implementation of quality control (QC) charts. Quality control charts of the external standard glass BKA-K5 should be used to detect trends and drifts. Annotation: A drift could result from a reduction of illumination caused by wall deposition in the halogen lamp. To prevent this deposition the lamp current should be at least 80% of the operating voltage.
8. Use of an interference filter with a wavelength of 589 nm ± 5 nm and a maximal half width of 10 nm. Due to discrepancies between factory information and real values and due to degradation of the filter, interference filters should be measured by microspectrophotometry.
9. Calibration of the B range glass set with a minimum of 7 calibration glasses with match temperatures between 35°C and 85°C.
10. Calculation of outliner tests (Grubbs t-test) with the results of suspect and control samples (minimum of 5 results are needed for statistical calculations).
11. Number of measurements: glass fragments from the control material should be measured on 10 different edges (not taking into account the number of embeddings). For the recovered material no general statement of the minimum of edges to be measured can be given.

It should be stated that these "11 laws" do not substitute the ASTM guideline, they should be regarded as additional guidelines. These eleven laws for refractive index measurements are the preconditions for a harmonisation of refractive index measurements and the construction of a case work database inheriting refractive index values.

The claim of the ASTM to use an external calibration glass different from the calibration standards (the Locke B3 is often used) in combination with the aim of using quality control charts (7th law) have led to the production of a new external standard BKA-K5. In co-operation with the glass manufacturer Schott Glaswerke (Mainz/Germany) a glass standard with an optical homogeneity of $\Delta n \pm 7.4 \times 10^{-7}$ was obtained. This BKA-K5 standard has been distributed to all German forensic state laboratories using GRIM. This optical crown glass should be used as an external standard in order to ensure quality control charts. The optical homogeneity of $\Delta n \pm 7.4 \times 10^{-7}$ and the spatial deviation of the refractive index is documented in the interferogram measured by Schott Glass (see Figure 2).

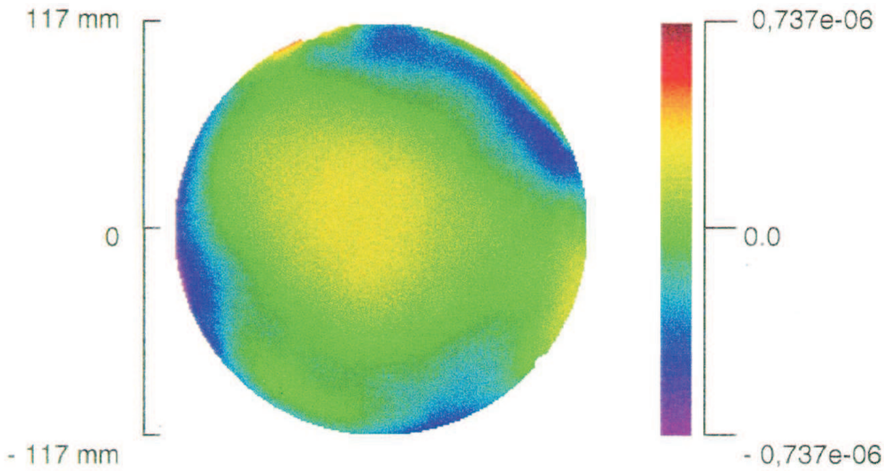

Fig. 2. Interferogram of a cross-section of the BKA-K5 standard glass (left scale geometrical dimension, right scale variation of refractive index measured on $\lambda = 632.8$ nm; measurements by Schott Glaswerke, Germany).

In addition to these steps towards harmonisation of refractive index measurements, the installation of a central glass database is ongoing. The aim of this database is the central collection of refractive indices observed in German case work to be able to calculate the frequency of occurrence of glass with a certain refractive index. This would greatly increase the evidential value of refractive index measurements.

DATABASE LAYOUT

The database has been designed for two separate data sets for scene of crime glass material and suspect glass material.

The database (programmed in Microsoft Access 97) will include information on:

– refractive index,
– standard deviation,

– number of measurements,
– sampling area,
– annealing information,
– sender, federal state,
– case number,
– colour,
– thickness,
– glass type,
– origin of glass
– type of crime,
– date of measurement,
– further remarks.

Each refractive index from a case work sample will be connected by the date of measurement with the corresponding refractive index of the external standard BKA-K5. Therefore it will be possible to calculate refractive index ratios which will further reduce system specific deviations.

The aim of this centralised database is to enhance the evidential value within a given case regarding the frequency of occurrence of the glass involved and to help answer further relevant questions. Statistical calculations (t-test) and grouping algorithms are also integrated into a module attached to this software.

GROUPING PROBLEM

An important feature of case interpretation is the decision weather several glasses belong to one specific group or not. When examining a sample of glass fragments recovered from a suspect in a forensic case, the question arises whether the fragments may come from several different sources.This grouping problem has been addressed by several statisticians [4].

Well know grouping algorithms are:
– EL 1 – Evett Lambert 1 [3],
– ELM 1 – Evett Lambert Modification 1.
– SKM 2 – Scott Knott Modification 2[5]

Based on recent publications [2] we decided to use the Scott Knott Modification 2 and incorporated this grouping algorithm into a module attached to our database software.

SUMMARY

After the establishment of a German project group GRIM in 1999, eleven requirements ("11 laws") of refractive index measurement were postulated. Furthermore a new glass standard BKA-K5 was introduced into case work as an important part of the quality management system.

Great progress has been made thanks to a joint effort of all project group members with outstanding contribution (programming) from Mr. Weise (LKA Baden-Württemberg). Nevertheless the case work database is still under development.

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