

International Proficiency Testing Scheme for the Estimation of Shooting Distance by Chemographical Coloring

In cooperation with the ENFSI Expert Working Group Firearms/GSR

Scheme Description



Expert Working Group
Firearms / GSR



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*QUALITY & STATISTICS!

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List of abbreviations

Abbreviation	Meaning
DAkKS	Deutsche Akkreditierungsstelle GmbH
ENFSI	European Network of Forensic Science Institutes
FMJ	Full Metal Jacket
ILAC	International Laboratory Accreditation Cooperation
PT	Proficiency Testing
QC	Quality Control
SDD	Shooting Distance Determination

1 Introduction

1.1 Quality standards

Proficiency testing (PT) is defined by DIN EN ISO/IEC 17043:2010 [1] as the use of interlaboratory comparisons for the determination of the performance of individual laboratories in specific tests or measurements and for the monitoring of the laboratories' long-term performance.

When carried out within the context of a comprehensive quality assurance program, proficiency testing is an independent means of assessing the quality of test and calibration results, as described by DIN EN ISO/IEC 17025:2018 [2].

The SDD PT scheme for the “Estimation of Shooting Distance by Chemographic Methods” provided by quo data Gesellschaft für Qualitätsmanagement und Statistik mbH (hereafter referred to as QuoData GmbH) is operated in accordance with DIN ISO/IEC 17043:2010 [1] and ILAC G13:2007 [3] as well as with the ENFSI Guidance document [4].

QuoData GmbH is a PT provider accredited by DAkkS according to DIN EN ISO/IEC 17043:2010 [1] since 2022 for the international proficiency testing scheme for the detection and classification of gunshot residues by SEM/EDS.

1.2 Aims of the SDD PT scheme

The aim of the SDD PT scheme is to enable laboratories to perform forensic examinations using chemographic coloring methods to monitor and to improve the quality of their shooting distance estimations. The SDD scheme enables laboratories to demonstrate the quality of their measurements to accreditation bodies and other appropriate authorities.

The SDD PT scheme will involve screen-printed samples (using a patented procedure) which will allow an assessment of the participants' competence in staining/coloring the lead-containing GSR pattern and interpreting findings.

This PT scheme will be available in two different formats:

- with screen-printed samples for both the case shot and the test shot series,
- with a screen-printed sample for the case shot, but digital photos for the test shot series

This PT scheme was developed on the basis of three preparatory PT rounds carried out within the framework of the ENFSI Working Group “Firearms/GSR” and through the financial support of the European Union (see e.g. EU-Project Numbers *I/25-5793-2019-41* and *Home/2011/ISEC/AG/4000002489*). These three PT rounds were conducted in 2015, 2020, and 2021. As a result of this preparatory phase, the samples are optimized for chemographic methods. Moreover, the screen-printing technique makes it possible to send *identical* samples to the participants. A more detailed description of the PTs can be found in [5].

Between 30 and 100 participants are expected per SDD PT round.

2 SDD PT scheme: Organisation and management

2.1 Announcement

A SDD PT scheme description will be available on the website of QuoData GmbH (as given in Section 2.2) along with information on the current PT round and upcoming PT rounds, including information about the test materials, and all relevant dates and deadlines. Participants of previous SDD PT rounds will receive an email with the announcement of the current PT round. New participants are invited to complete an application form on the PT portal provided by QuoData GmbH. State-registered forensic science laboratories and all members of the European Network of Forensic Science Institutes (ENFSI) are welcome to participate. However, the final decision about participation is the responsibility of the Advisory Board.

Additionally, the current PT round will be announced in proficiency testing scheme databases (e.g. EPTIS) on the internet.

2.2 Website and notification

All deadlines will be published on the non-restricted website of the QuoData GmbH:

<https://quodata.de/de/ringversuche/sdd-quality-scheme>

All important changes in the timeline will be announced by email as well as on the website.

2.3 SDD PT portal

Since 2023, the SDD PT scheme is managed via the PT portal available at

<https://forensics-pt.quodata.de>

Each participant has an individual account, where the reported data, the final reports of results as well as the individual certificates of the respective participant's institution are made available. Access to the documents is possible at any time – for all PT rounds participated in from 2023 onwards.

The enrollment for a SDD PT round is also done via the PT portal.

The initial registration for the PT portal is possible via an online application form provided here:

https://forensics-pt.quodata.de/pt-participant/lab_applicant/add

2.4 Establishment of the Advisory Board

The SDD PT scheme is organized, conducted and evaluated by QuoData GmbH. Technical direction and advice is provided by the Advisory Board, consisting of at least two representatives of the ENFSI Expert Working Group Firearms/GSR.

The current members of the Advisory Board are

- Ludwig Niewöhner, PhD
Forensic Science Institute, BKA, 65193 Wiesbaden, Germany.
- Glenn R.C. Roepnarain, B.Sc.
Netherlands Forensic Institute, NFI, 2490 AA The Hague, Netherlands.

The Advisory Board may seek advice from other organizations/individuals with specific expertise on an ad hoc basis. The membership of the Advisory Board is reviewed on a regular basis.

QuoData GmbH is responsible for the planning and coordination of the SDD PT scheme, the evaluation of performance, and the authorization of the final report, according to DIN EN ISO/IEC 17043:2010 [1]. In addition, QuoData GmbH manages also the day-to-day operation of the PT rounds, including sample purchase and preparation, dispatch, data processing, reporting of the results in a final report, and providing individual certificates. The terms of reference (TOR) of the Advisory Board are:

- To consider the scope and direction in which the SDD PT scheme should develop.
- To represent the views of the ENFSI Expert Working Group Firearms/GSR.
- To provide specialist advice to the SDD PT scheme organizers on technical and other matters to contribute to a smooth performance of the SDD PT scheme.
- To assess the results obtained in the SDD PT scheme and examine the implications they have for the progress of the SDD PT scheme.
- To consider the nature and timing of PT rounds and to decide on the test materials to be used.
- To assist in the revision of the SDD PT scheme description.
- To advise on the promotion and publicity of the SDD PT scheme.
- To provide, when requested, expert advice to participants on specific analytical difficulties encountered in the SDD PT scheme.
- To discuss technical comments on each round for inclusion in the report.

The Advisory Board will meet when necessary to ensure progression of the SDD PT scheme, but at least once a year.

2.5 Timeline

The SDD PT scheme will be offered once a year. Test materials are distributed to participants, with distribution dates published on the website of the QuoData GmbH¹. Samples are dispatched no later than the announced dates specified on the website. After the dispatch of the samples, laboratories have approximately four weeks to process the samples, determine shooting distance and report their results.

Dates of the reporting deadlines are also available on the website of the QuoData GmbH¹. The structure within a PT round is as follows:

- Announcement of the PT round.
- Procurement, preparation and quality control testing of test materials.
- Dispatch of test materials and instructions to participants.
- Request to participants to process test materials and report results to QuoData GmbH as instructed and within the specified deadline.
- Data preparation and plausibility check by QuoData GmbH.
- Analysis of results and comparison of performance of laboratories using appropriate techniques, such as z scores.
- Distribution of final report of results and individual certificates to participants.
- Review of PT round and identification of requirements for subsequent PT rounds.
- Start of the subsequent PT round.

For each PT round, the final report of results will be made available to participants within 4-6 weeks of the submission deadline.

All important changes in the timeline will be announced by email as well as on the website of QuoData GmbH¹.

¹ <https://quodata.de/de/ringversuche/sdd-quality-scheme>

2.6 Frequency of participation

As part of a comprehensive quality assurance program, and to gain most benefit from trend analysis, regular/annual participation in the SDD PT scheme is recommended.

2.7 Confidentiality

In order to ensure confidentiality, a unique laboratory reference number (lab ID) is allocated to each participant in all PT rounds, with changing lab-IDs from round to round. All participants are named in the reports with their anonymized lab code only, and data of individual participants may only be passed on with the prior consent of the participant. However, the participants agree that the proficiency testing provider or the Advisory Board may publish the results in anonymized form.

In cases where anonymity could not be preserved, laboratory reference numbers may be changed at the request of the participating laboratory, at the discretion of QuoData GmbH.

The final reports of results and all results pertaining to the specific proficiency test rounds must be treated as confidential unless they are presented and discussed at the annual meeting of the ENFSI Expert Working Group Firearms/GSR and/or published by the Advisory Board. The use of final reports of results is permitted to the participants exclusively for internal purposes and within the framework of legal requirements.

If participating laboratories intend to disclose their laboratory code for some PT rounds or to reproduce a final report of results, even in part, the approval of the proficiency testing provider and the Advisory Board must be obtained.

2.8 Subcontracting services

Various aspects of the SDD PT scheme can be subcontracted as needed. When subcontracting occurs, it is placed with a competent subcontractor and the proficiency testing provider is responsible for this work.

2.9 SDD PT scheme development

QuoData GmbH is continually striving to improve the SDD PT scheme and to introduce new recommendations where appropriate. This will be accomplished in close collaboration with the Advisory Board.

2.10 Potential major sources of errors

The potential major sources of errors are shown in Table 1.

Table 1: Potential major sources of errors in the SDD PT scheme

No.	Phase	Label	Potential error in each phase
1	Preparation of samples	a	error in screen-printing process
2	Dispatch of test samples to the participants	a	defect or damage of the test samples during the transport
3	Measurement errors at the participant's site	a	error during chemographic procedure
		b	error during comparisons with test shot series
4	Submission of data by the participants	a	submission of incomplete data sets
5	Data preparation and plausibility check	a	errors in the data submission process by the participants
6	Generation of the final report of results	a	wrong transfer of the data (tables, graphics) into the final report of results
7	Generation of the individual certificates	a	wrong transfer of the laboratory specific results into their certificates

3 Test material

3.1 Preparation of test material

Wherever practical, test materials should be as similar as possible to those routinely tested by participating laboratories. However, in some cases, in order to achieve the required degree of homogeneity and stability, test materials may be in the form of simulated samples.

In this SDD PT scheme, participants receive pieces of cotton cloth with characteristic GSR patterns. Homogeneity testing will be performed for each PT round.

The sample material is designed according to the requirements of the Advisory Board and produced by the INM (Leibniz Institute for New Materials) in Saarbrücken, Germany, using a patented screen-printing method, developed by the Bundeskriminalamt (BKA), Germany [6].

The sample set consists of:

- One or more case shots (i.e. the sample for which shooting distance must be determined),
- A series of test shots (i.e. characteristic patterns for a series of distances, which the pattern on the case shot is compared to).

Case shot

Each participant will receive at least one piece of cotton cloth (approx. 20 cm x 20 cm in size) with a screen-printed latent lead pattern that mimics the lead distribution pattern of a shooting incident. The cloth sample will display an intensely colored lead pattern when treated by chemographic methods according to the participants' SOPs. The bullet hole is marked by a white circle located in the middle of the sample. The sample has a serial number.

Test shot series

The series typically consists of 10-12 screen-printed shots. The corresponding shooting distance is indicated at the bottom of each printed shot. Alternatively, a defined number of photos of chemographically coloured shots will be delivered. The screen-printed test shots (or photo sets) will differ for users of the filterpaper method and the users of the photopaper method.

Screen-printing procedure

The sieves for the screen prints were produced via real shots from a Glock 19 semi-automatic pistol using Geco cal. 9 mm x 19 FMJ ammunition. Other weapon/ammunition combinations may be chosen if requested. For each shooting distance, the most representative pattern out of five shots was selected and used as a template for the prints. In this manner, "outliers" were excluded in the production of the sieves.

3.2 Quality control

Test samples are, as far as possible, prepared using a well-controlled process, which has been verified to produce homogeneous material. Quality control will be performed on behalf of the ENFSI Expert Working Group Firearms/GSR by a DIN EN ISO/IEC 17025:2018 [2] accredited laboratory or by members of the Advisory Board. If, in the opinion of QuoData GmbH / the Advisory Board, any material does not meet homogeneity requirements, replacement material will be dispatched. For each PT round, details regarding the performed tests, the results and the acceptability criteria will be provided in the final report of results.

3.3 Distribution

The test material is shipped in an appropriate packaging and under conditions determined in such a way as to ensure the samples are adequately protected during transit.

Participants are asked to check the contents of packages immediately after reception and to contact QuoData GmbH if any problems with the condition of the test materials or accompanying documents are observed.

3.4 Metrological traceability

Metrological traceability in the narrow sense is not applicable since there are no reference standards for gun shot patterns against which other standards are calibrated. Nonetheless, it should be noted that the sample preparation procedure can be considered to be based on reference standards (namely, the sieves used in the screen-printing procedure) and that the determination of shooting distance can be considered to consist in a manner of calibration against the test shot series.

4 Analysis and reporting of results by the participants

4.1 Methods of analysis

Participants are asked to treat the PT sample in the same way as a routine sample. This means that the examination of the sample should be performed analogously to real-life GSR-containing cloth samples in accordance with the standard laboratory operating procedure (SOP) for chemographic investigations of gunshot residues on cloth (see e.g. [7] and [8]).

The participants are asked to process the samples for the visualization of lead patterns and to determine the shooting distance for the case shot using the test shot series.

Participants are also requested to report:

- Analytical result 1: the actual shooting distance estimate, expressed in terms of one of the shooting distance categories resulting from the test shot series.

- Lower and upper limit (analytical result 2). This corresponds to the form in which testimony is presented by expert witness in court, and reflects the forensic expert's experience and assessment of between-shot variability and the quality of his/her own chemographical coloring. For certain participants, the interval between lower and upper limit may be quite large, reflecting their own routine procedure. If the interval is too large (e.g. greater than 4 categories) then the corresponding z score is only provided for information, and the assessment of laboratory performance is based solely on the z score corresponding to analytical result 1 (unless the actual distance of the case shot lies outside the interval submitted by the participant).
- A photograph/digital scan of the chemographical coloring of the case shot.
- Information as to whether photo paper or filter paper is used (this information must be provided prior to the start of the given PT round).
- Answers to questions regarding the participants' SOP (optional).
- The wording in reports sent to the court (optional).

4.2 Data reporting

Results are reported to QuoData GmbH via a web-based online data entry form, which is available on the PT portal (<https://forensics-pt.quodata.de>).

In this online data entry form, the classes regarding analytical results 1 and 2 as well as information regarding the analytical procedure are submitted. Results received after the deadline for any particular PT round will only be included under exceptional circumstances and in agreement with QuoData GmbH and the Advisory Board.

It is recommended that results are checked thoroughly before reporting. Once submitted and received, results may only be amended at the discretion of the SDD PT scheme coordinator.

4.3 Late submission of results

Participants are asked to submit their results before the deadline to ensure that their results are included in the statistical analysis and in the final report of results. Results received after the closure date may be excluded from the overall assessment and disregarded in the final report of results. An individual certificate will however still be issued.

5 Performance assessment

5.1 Statistical analysis

5.1.1 Assignment of classes

In order to guarantee a statistically reliable evaluation of the analytical results for the best allocation to a shooting distance class (analytical result 1), the analytical results are assigned to so-called classes obtained from the test shot series, as illustrated by the following table.

Assigned class	Case shot was ranked between ...
1	... 2 and 5 cm
2	... 5 and 10 cm
3	... 10 and 15 cm
4	... 15 and 20 cm
5	... 20 and 30 cm
6	... 30 and 40 cm
7	... 40 and 60 cm
8	... 60 and 80 cm
9	... 80 and 100 cm
10	... 100 and 150 cm
11	... 150 and 200 cm

The analytical results of the estimated range of the case shot distance (analytical result 2) are assessed by taking into account both the lower limit (minimum shooting distance) and the upper limit (maximum shooting distance). Both limits are assigned to classes, as illustrated in the following table.

Assigned class	Shooting distance of test shot
0	0 cm
1	2 cm
2	5 cm
3	10 cm
4	15 cm
5	20 cm
6	30 cm
7	40 cm
8	60 cm
9	80 cm
10	100 cm
11	150 cm

5.1.2 Assessment by means of z scores

In order to guarantee a statistically reliable evaluation, the assessment is not based on the absolute values of the submitted shooting ranges but on the assigned classes. The assessment is performed using the software package PROLab Plus [9], which is widely used for the assessment of method performance (in collaborative studies) and of laboratory performance (in proficiency tests).

The participating laboratories' performance is assessed by means of z scores, following ISO 13528:2022 [10] and EURACHEM [11].

In general, z scores describe the standardized deviation of the laboratory's result x_i (i.e. the assigned class) from the assigned value x_{pt} in terms of the acceptable spread of results or standard deviation for proficiency assessment σ_{pt} , calculated by the formula

$$z = \frac{x_i - x_{pt}}{\sigma_{pt}}$$

For the best allocation to a shooting distance class (analytical result 1), the assigned value x_{pt} is defined as the correct class.

For the estimated range of the case shot distance, the assigned value x_{pt} for the lower limit is defined as the highest case shot class below the nominal distance, and the assigned value x_{pt} for the upper limit is defined as the lowest case shot class above the nominal distance.

The standard deviation for proficiency assessment σ_{pt} is set to the reproducibility standard deviation σ_R by the robust statistical Q method according to ISO 13528:2022 ([10], [12]). The robust method was selected in order to take into account the discrete nature of the assigned classes and to minimize the effect of potential outliers.

Here, the reproducibility standard deviation characterizes the variability of the data under reproducibility conditions, i.e. test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment.

A summary of the assigned values x_{pt} and the standard deviations for proficiency assessment σ_{pt} is provided in the final report of results, separately for each case shot (sample) and response (analytical result 1 and 2).

For the best allocation to a shooting distance class (analytical result 1), a laboratory's result is:

- **satisfactory** if $|z| \leq 2.0$;
- **questionable** if $2.0 < |z| < 3.0$;
- **unsatisfactory** if $|z| \geq 3.0$.

For the estimated range of the case shot distance (analytical result 2) the same interpretation of z scores applies, with the addition of the following rules (corresponding to the case that the estimated range does not include the case shot): a laboratory result for the lower limit is assessed as unsatisfactory if it

exceeds the shooting distance of the case shot, and a laboratory result for the upper limit is assessed as unsatisfactory if it lies below the shooting distance of the case shot.

Accordingly, for the lower limit, a laboratory's result is:

- **satisfactory** if $-2.0 \leq z \leq 0.0$;
- **questionable** if $-3.0 < z < -2.0$;
- **unsatisfactory** if $z \leq -3.0$ or $z > 0.0$.

And for the upper limit a laboratory's result is:

- **satisfactory** if $0.0 \leq z \leq 2.0$;
- **questionable** if $2.0 < z < 3.0$;
- **unsatisfactory** if $z \geq 3.0$ or $z < 0.0$.

5.2 Final report of results and individual certificates

The final report of results and the individual certificates will be made available to participants within 4-6 weeks of the submission deadline.

Participant results will only be identified by the lab ID.

Individual certificates for each participant including the obtained z scores are provided with the final report of results.

5.3 Complaints

Any complaints will be fully investigated according to our quality management system to determine the underlying cause and to decide upon a course of action. This course of action together with results of any investigations carried out will be communicated to the participant.

If there are any concerns regarding to the correct conduct or evaluation of the PT round or about the assessment of the participant's proficiency, an appeal can be submitted within four weeks after the publication date of the final report of results by contacting forensics-pt@quodata.de.

6 References and sources of information

- [1] DIN EN ISO/IEC 17043:2010: 'Conformity assessment — General requirements for proficiency testing'; <https://www.iso.org/standard/29366.html> .
- [2] DIN EN ISO/IEC 17025:2018: '*General requirements for the competence of testing and calibration laboratories*'; <https://www.iso.org/standard/66912.html> .
- [3] ILAC (International Laboratory Accreditation Cooperation) G13:2007: '*Guideline for the Requirements for the Competence of Providers of Proficiency Testing Schemes*'.
- [4] ENFSI Standing Committee for Quality and Competence (QCC): '*Guidance on the Conduct of Proficiency Tests and Collaborative Exercises Within ENFSI*'; 27-06-2014; https://enfsi.eu/wp-content/uploads/2021/05/2021-05-03_FINAL-PT-Guidance-Draft_AM-format.pdf .
- [5] Niewöhner, L., Barth, M., Neimke, D., Latzel, S., Stamouli, A., Nys, B., Gunaratnam, L., Fries, K., Uhlig, S., Baldauf, H.: '*Development, design, and realization of a proficiency test for the Forensic Determination of Shooting Distances – FDSD 2015*'; Forensic Chemistry (2016); No. 1; 22 – 30; doi: <http://dx.doi.org/10.1016/j.forc.2016.06.002> .
- [6] Niewöhner, L., Neimke, D., Barth, M. (inventors), Bundeskriminalamt (assignee): '*Verfahren zur Herstellung identischer latenter Partikel-Verteilungen auf Oberflächen*'; Patent No. DE 10 2004 027 770; <https://register.dpma.de/DPMAregister/pat/register?AKZ=1020040277702> .
- [7] Lichtenberg, W.: '*Methods for the Determination of Shooting Distance*'; Forensic Science Review (1990); Vol 2(1); p. 38 ff.
- [8] Suchenwirth, H.: '*Ein einfaches spezifisches Abdruckverfahren zum Erfassen und Beurteilen von Schmauchbildern*'; Archiv für Kriminologie (1972); Vol. 150; p. 152 ff.
- [9] Software PROLab Plus; QuoData GmbH; Dresden, Germany.
- [10] ISO 13528:2022: '*Statistical methods for use in proficiency testing by interlaboratory comparison*'; <https://www.iso.org/standard/78879.html> .
- [11] EURACHEM Guide on "Selection, Use and Interpretation of Proficiency Testing (PT) Schemes by Laboratories"; Second Edition 2011; http://www.eurachem.org/images/stories/Guides/pdf/Eurachem_PT_Guide_2011.pdf.
- [12] Rousseeuw P.J.; '*Tutorial to Robust Statistics*'; Journal of Chemometrics 5; pp.1-20; 1991.