BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
institute of building testing

ilac-MRA

Z 7008

FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Testing of Finished Construction Layer Treatments
ZHU 2025/1

Brno University of Technology
Proficiency testing provider at the SZK FAST
Veveří 95, Brno 602 00
Czech Republic

www.szk.fce.vutbr.cz
www.ptprovider.cz

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1 Introduction and Important Contacts

At the beginning of 2025, the Proficiency Testing Provider at SZK FAST (PoZZ) launched a Proficiency Testing Programme (PrZZ), designated ZHU 2025/1, to verify and assess the consistency of finished treatments of structural layers test results. The assessment of the results of the proficiency testing programme was carried out by a committee consisting of the following PT Provider employees:

Head of the PT Provider, PTP coordinator

Assoc. Prof. Tomáš Vymazal, Ph.D.
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The subjects of proficiency testing were the following testing procedures:

1. ČSN 73 6175, Art. 8 Measurement of longitudinal and transverse pavement surface evenness using a straightedge [1],
2. ČSN 73 6175, Art. 9 Measurement of longitudinal pavement surface evenness using a planograph [1],
3. EN 12697-36 Bituminous mixtures – Test methods – Part 36: Determination of the thickness of bituminous pavement [2],
4. EN 13036-1 Road and airfield surface characteristics – Test methods – Part 1: Measurement of pavement surface macrotexture depth using a volumetric patch technique [3],
5. EN 13036-4 Road and airfield surface characteristics – Test methods – Part 4: Method for measurement of slip/skid resistance of a surface – The pendulum test (PTV) [4],
6. EN 13036-7 Road and airfield surface characteristics – Test methods – Part 7: Irregularities in pavement surface levels – Longitudinal profile by direct measurement [5].

Test procedures 4, 5 and 6 were not opened due to low interest of participants.

The supplier, SQZ, s. r. o., was responsible for the preparation of testing samples for the PTP. The supplier is responsible for homogeneity and stability of testing samples.

The test results from individual PTP participants were compared via a method involving the statistical analysis of all their results in a manner complying with ISO 5725-2 [6] and with EN ISO/IEC 17043 [7]. The outcome is the present final report summarizing the results of the interlaboratory comparison, including statistical evaluation.

19 laboratories took part in PTP. In order to maintain the anonymity of the PTP, each laboratory was given an identification number that will be used henceforth in this document. An integral part of the present final report is a Certificate of Participation in the Proficiency Testing Program. It is unique for each participant and includes the participant's ID used in this report. The following chart shows the participation of laboratories in individual parts of the PTP.

Table 1: Participation of individual laboratories in the PTP

ID/Method	1	2	3	4	5	6
9969d5	X	X	X	-	-	-
758124	-	X	-	-	-	-
81698a	X	-	-	-	-	-

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ID/Method	1	2	3	4	5	6
922aa9	-	-	X	-	-	-
95b8b8	X	X	-	-	-	-
c77498	X	-	X	-	-	-
eeaf07	X	-	X	-	-	-
a0bec7	X	-	-	-	-	-
b4f908	-	X	-	-	-	-
886ba3	X	X	-	-	-	-
18e48c	X	X	X	-	-	-
87072b	X	-	-	-	-	-
724d7e	-	-	X	-	-	-
2ffb83	-	-	X	-	-	-
1c3bf1	-	-	X	-	-	-
3b5d16	-	-	X	-	-	-
bc587d	X	X	X	-	-	-
ad374e	X	X	X	-	-	-
aa02d6	-	X	-	-	-	-

Table 2: List of participants (laboratories) – the order in the table does not correspond to the identification number in previous table

Laboratory	Address	Accreditation number
CONTROL-VHS-SK, s.r.o.	Priemyselná 6, 82109 Bratislava, Slovenská republika	437/S-317
Centrum dopravního výzkumu, v.v.i.	Líšeňská 33a, Brno, 63600, Česká republika	1506
DSP a.s.	Kostěnice 111, Kostěnice, 530 02, Česká republika	1782
LABORATORIUM DROGOWE SZCZECIN	Tama Pomorzańska 13L, Szczecin, 70-030, 9552380666	AB1806
QCONTROL s.r.o., odštěpný závod	Lesní 693, Bílovice nad Svitavou, 66401, Česká republika	1737
Skanska a.s.	Křižíkova 682/34a, Praha 8- Karlín, 186 00, Česká republika	1355
TESScontrol, s. r. o. Oblastné Laboratórium Bratislava, Laboratórium Bratislava	Ľubochnianska 1/A, 831 04 Bratislava, Bratislava, 831 04, Slovenská republika	S-375
TESScontrol, s. r. o. Oblastné Laboratórium Zvolen, Laboratórium Zvolen	Hronská 1, 960 93 Zvolen, Zvolen, 960 93, Slovenská republika	S-375
TESScontrol, s. r. o. Oblastné Laboratórium Žilina, Laboratórium Žilina	Štrková 17, 010 01 Žilina Slovenská republika	S-375
TESScontrol, s. r. o., organizačná zloška, TESScontrol - Zkušební laboratoř Znojmo	Brněnská 3797/29„ Znojmo, 669 02, Česká republika	L-1793

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Laboratory	Address	Accreditation number
TPA ČR s.r.o.	Vrbenská 1821/31, České Budějovice, 37006, Česká republika	1181
TPA ČR, s.r.o. - Brno	Vrbenská 1821/31, České Budějovice, 37006, Česká republika	1181
VIALAB CZ s.r.o. - Hradec Králové	U Michelského lesa 1581/2, Praha 4, 14000, Česká republika	1112
VIALAB CZ s.r.o. - Laboratoř Morava, pracoviště LM1-Zlín	PO BOX 207, Praha 6, 16041, Česká republika	1170
VIALAB CZ s.r.o. - Laboratoř Morava, pracoviště LM3-Brno	PO BOX 207, Praha 6, 16041, Česká republika	1170
VIALAB CZ s.r.o. - Laboratoř Morava, pracoviště LM4-Ostrava	PO BOX 207, Praha 6, 16041, Česká republika	1170
VIALAB CZ s.r.o. - Praha	U Michelského lesa 1581/2, Praha 4, 14000, Česká republika	1112
Ředitelství silnic a dálnic s. p.	Čerčanská 2023/12, Praha 4 - Krč, 140 00, Česká republika	1072
Ředitelství silnic a dálnic s. p., Samostatné oddělení zkušebnictví Praha, Laboratoř Praha	Na Pankráci 546/56, Praha, 140 00, Česká republika	1734

2 Procedures used in the Statistical Analysis of Laboratory Results

2.1 Test Procedure No. 1 – Measurement of Longitudinal and Transverse Road Surface Evenness Using a Straightedge

The statistical analysis is based on the following steps:

1. Evaluation of intralaboratory variabilities by Cochran's C test: If 5% or 1% critical value is exceeded, the effect of the individual observations is first considered. If the results indicate that high participant variability is caused by a single observation, this value is excluded from the experiment, but the participant is not excluded as outlying. By overcoming 1% of the critical value, the participant's results can be marked as outlying and excluded from the experiment (symbol **X**).
2. The numerical critical evaluation of the test results using Grubbs' test: By overcoming 1% critical value, the participant's results can be marked as outlying and excluded from the experiment (symbol **X**).
3. Graphical determination of the consistency of laboratories (Mandel's statistics): The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies.
4. Evaluation of descriptive statistics and, if possible, taking into account the number of observations, the repeatability and reproducibility.
5. Evaluation of the assigned value.
6. The performance evaluation: The most significant outcome of the PT Program is the so-called z-score and ζ-score (zeta-score). These characteristics assess the performance of individual participants by comparing it with the assigned value and measurement uncertainties. z-score and ζ-score are compared with limit values. The resulting ζ-score values are not taken into account during the final evaluation of the performance of participants as they are to a considerable degree dependent on

the values of the measurement uncertainties of the assessed institutions. The following scales are applied for the z-score values:

- $|z\text{-score}| < 2 \Rightarrow$ shows that the laboratory performance is **satisfactory** and generates no signal – ✓.
- $2 \leq |z\text{-score}| < 3 \Rightarrow$ shows that the laboratory performance is **questionable** and generates an action signal – ?.
- $|z\text{-score}| \geq 3 \Rightarrow$ shows that the laboratory performance is **unsatisfactory** and generates an action signal – !.

Procedures used in the statistical analysis of proficiency testing programs can be found here: http://ptprovider.cz/?lang=en.

3 Conclusions of the Statistical Analysis

The submitted report summarizes the results of the proficiency testing program ZHU 2025/1 (PrZZ) organized by the Proficiency Testing Provider at the SZK FAST. A total of 19 laboratories participated in the PrZZ. The program focused on common standardized tests of finished pavement layers. The test results are evaluated separately for each test procedure under review. The evaluated statistical characteristics, test results, and graphical representations are included in the appendix of this report. The designation of the test procedures is given in Section 1 of this report.

For test procedures 1 and 2, it was not possible to carry out a full statistical analysis. The evaluation approach is described in Sections 3.1 and 3.2.

The overall assessment of participants' performance is provided in Section 3.4.

3.1 Test procedure No. 1 – Measurement of longitudinal and transverse pavement surface evenness using a straightedge

The measurement of longitudinal unevenness was carried out by the participants at the same time on a test section 100 m long, on which the organizer marked points at 2 m intervals. Measurements were therefore made at 25 stations. The last station was not evaluated within the experiment, as the majority of participants did not provide results for it. The stations were labelled from 1 to 24.

Considering the accuracy of the test method according to ČSN 73 6175, Art. 8 [1] (1 mm), it was not possible to perform a complete statistical evaluation. The results of this test were therefore assessed within the conformity experiment by comparing the measured values of individual participants at each station separately.

Outliers were identified according to the criterion of 1.5 times the interquartile range (IQR) using a box plot (see Appendix 1.1). Subsequently, the data were assessed as a multi-level experiment and an analysis of participants' results across all stations was performed.

The criterion for unsatisfactory performance was set at 20%. Thus, if a participant had outlying results at more than 20% of stations, their overall performance was evaluated as unsatisfactory. Based on this analysis, the performance of all participants can be declared as **satisfactory**.

The measurement of transverse unevenness was carried out by the participants on the same test section, at pre-marked points at 20 m intervals. Measurements were therefore made at five stations labelled A to E.

Since the results of the participants differed only by very small multiples of rounding error, it was not possible to perform a complete statistical evaluation. Appendix 1.2 therefore contains only the test results together with basic descriptive statistics. The final assessment of performance was made by expert judgement, which showed that the participants' results do not differ statistically significantly. The performance of all participants can therefore be declared as **satisfactory**.

3.2 Test procedure No. 2 – Measurement of longitudinal pavement surface unevenness using a planograph

In the first phase, the participants were asked to report the numbers of irregularities greater than 4 mm and 8 mm. However, due to the character of the test section, no values above 4 mm were recorded. Based on this finding, the assessment criteria were revised and set to three intervals: 0 to 1 mm, 1 to 2 mm, and greater than 2 mm.

Participants then submitted to the organizer the complete measurement record in XLSX format. The frequency of recorded values differed among participants. To ensure uniform evaluation, all data were therefore converted into a common structure – the measured section was divided into 200 one-meter intervals, and for each interval the maximum measured unevenness value was determined.

Based on these maxima, each interval was assigned to one of the three categories listed above. For each dataset, the counts of occurrences in individual categories and their relative proportions with respect to the total of 200 intervals were determined. These percentages formed the basis for the statistical evaluation of the results.

The appendix includes both the graphs from the original participant records and the graphs of recalculated one-meter maxima, enabling a direct comparison of the original data with the uniformly processed results. Furthermore, the data are presented in the form of cumulative bar charts, in which the proportions of individual categories are shown for all IDs sorted in ascending order according to the proportion of intervals with unevenness ≤ 1 mm.

The statistical evaluation was then performed on the values of the percentage representation of unevenness in the three mentioned intervals. This evaluation is presented in Sections 2.4 to 2.6 of the appendix.

Based on this analysis, the performance of all participants can be declared as **satisfactory**.

3.3 Test procedure No. 3 – Determination of the thickness of bituminous pavement

This test procedure was evaluated as a multi-level experiment. A participant's results were assessed as outlying, questionable, or unsatisfactory if the critical values were exceeded at least at two levels of the experiment. Based on this analysis, the performance of all participants can be declared as **satisfactory**.

3.4 Overall summary

Table 4: Evaluation of participants' performance and outliers.
✓ – satisfactory performance; ? – questionable performance; ! – unsatisfactory performance; X – outlying result

ID / Test	1	2	3	4	5	6
9969d5	✓	✓	✓	-	-	-
758124	-	✓	-	-	-	-
81698a	✓	-	-	-	-	-
922aa9	-	-	✓	-	-	-
95b8b8	✓	✓	-	-	-	-
c77498	✓	-	✓	-	-	-
eeaf07	✓	-	✓	-	-	-
a0bec7	✓	-	-	-	-	-
b4f908	-	✓	-	-	-	-
886ba3	✓	✓	-	-	-	-
18e48c	✓	✓	✓	-	-	-
87072b	✓	-	-	-	-	-
724d7e	-	-	✓	-	-	-
2ffb83	-	-	✓	-	-	-
1c3bf1	-	-	✓	-	-	-
3b5d16	-	-	✓	-	-	-
bc587d	✓	✓	✓	-	-	-
ad374e	✓	✓	✓	-	-	-
aa02d6	-	✓	-	-	-	-

References

[1] ČSN 73 6175. *Measurement and evaluation of road surface roughness*. 2009.

[2] EN 12697-36. *Bituminous mixtures - Test methods for hot mix asphalt - Part 36: Indentation using cube or cylindrical specimens*. 2012.

[3] EN 13036-1. *Road and airfield surface characteristics - Test methods - Part 1: Measurement of pavement surface macrotexture depth using a volumetric patch technique*. 2010.

[4] EN 13036-4. *Road and airfield surface characteristics - Test methods - Part 4: Method for measurement of slip/skid resistance of a surface: The pendulum test*. 2011.

[5] EN 13036-7. *Road and airfield surface characteristics - Test methods - Part 7: Determination of pavement surface macrotexture depth using a volumetric patch technique*. 2008.

[6] ISO 5725-2. *Accuracy (trueness and precision) of measurement methods and results - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*. 2019.

[7] EN ISO/IEC 17043. *Conformity assessment - General requirements for proficiency testing*. 2010.

1 Appendix – ČSN 73 6175, Art. 8 Measurement of longitudinal and transverse pavement surface evenness using a straightedge

1.1 Determination of longitudinal unevenness

1.1.1 Test results

Table 4: Test results – Outliers are marked in red. Stations are labelled from 1 to 24.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
9969d5	0	0	1	0	1	0	1	1	2	0	5	0	2	1	0	0	0	2	2	2	3	1	0	0
81698a	1	1	1	2	0	1	2	2	2	1	4	0	2	1	1	0	0	2	2	1	2	0	1	0
95b8b8	1	1	1	0	1	1	1	2	1	1	3	0	2	1	0	0	0	1	2	1	2	0	1	1
c77498	0	1	0	1	0	0	1	2	2	4	1	2	1	1	0	0	1	2	1	2	0	1	0	0
eeaf07	0	1	0	1	0	0	1	2	2	4	1	2	1	1	0	0	1	2	1	2	0	1	0	0
a0bec7	0	1	0	1	0	0	1	2	2	4	1	2	1	1	0	0	1	2	1	2	0	1	0	0
886ba3	1	1	0	1	0	2	1	2	2	1	4	1	2	1	1	1	1	1	2	2	2	1	1	0
18e48c	0	1	0	1	0	0	1	1	2	0	1	0	3	0	0	1	0	1	2	1	2	0	0	0
87072b	1	1	1	1	1	1	1	2	2	2	5	2	2	1	1	1	1	1	2	3	4	1	3	1
bc587d	1	0	1	1	1	2	1	1	2	2	1	1	2	1	0	1	1	1	0	1	1	2	2	1
ad374e	1	1	0	0	0	1	1	1	2	0	4	0	2	0	0	0	0	1	1	1	2	0	0	0

1.1.2 Graphical representation

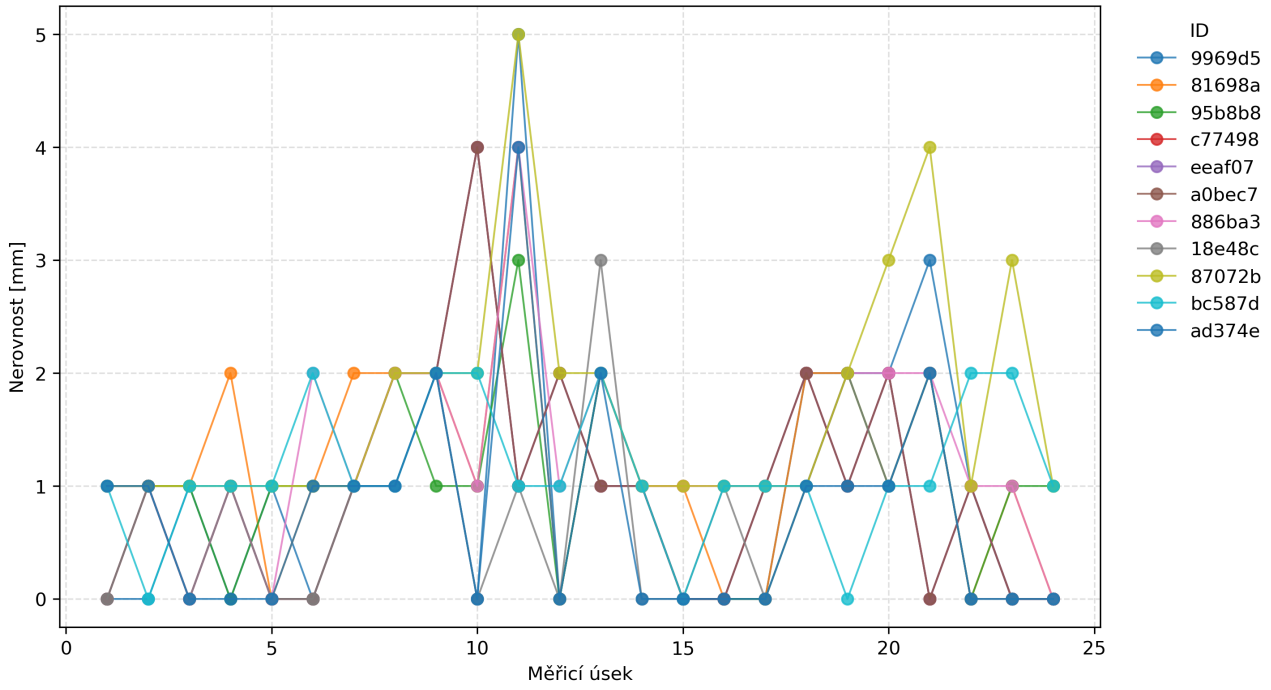

Figure 1: Graphical representation of the test results

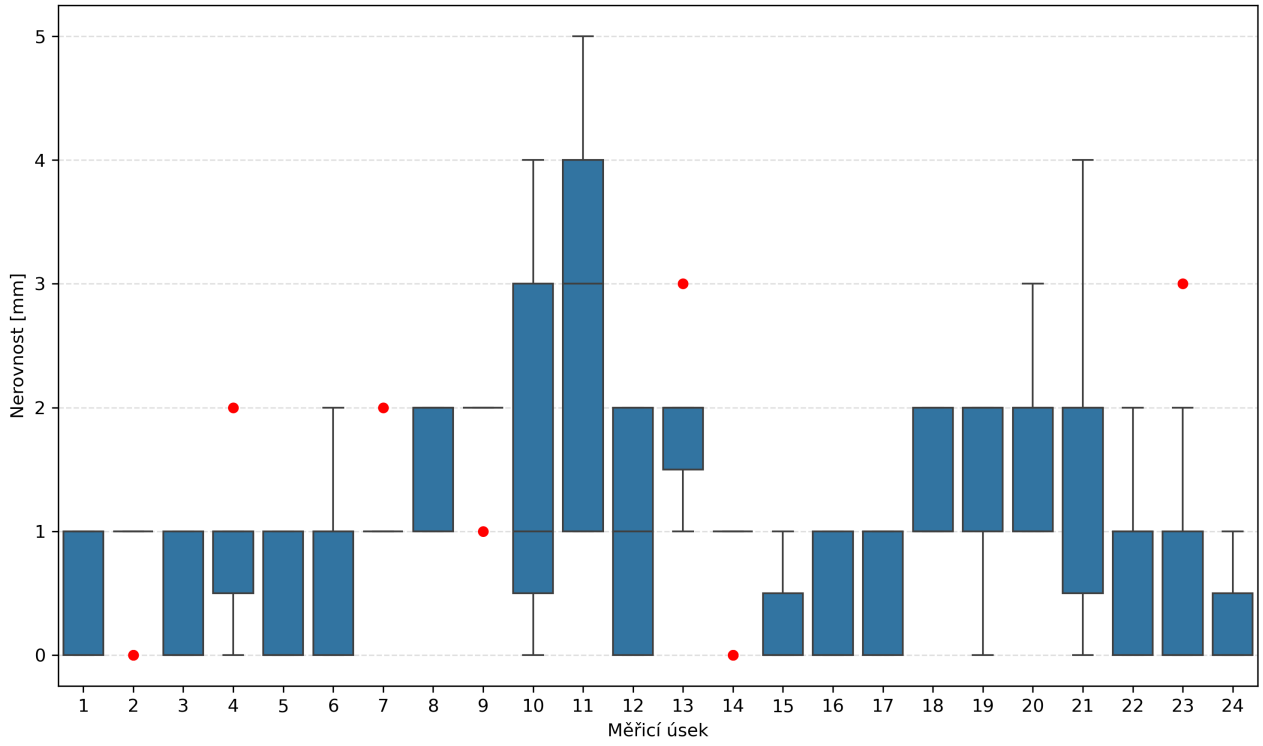

Figure 2: Boxplot of test results including identification of outliers.

1.2 Determination of transverse unevenness

1.2.1 Test results – Station A

Table 5: Test results – sorted by mean value. Outliers are marked in red. u_X – participant's expanded uncertainty; $\bar{x}$ – arithmetic mean; s_0 – sample standard deviation; V_X – coefficient of variation

ID Participant	Test results [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
9969d5	0	0	0	-	0	0	0
81698a	0	1	0	-	0	0.6	173.21
95b8b8	0	1	0	-	0	0.6	173.21
18e48c	0	1	0	-	0	0.6	173.21
bc587d	1	0	0	-	0	0.6	173.21
ad374e	0	1	0	-	0	0.6	173.21
c77498	1	0	2	-	1	1	100
eeaf07	1	0	2	-	1	1	100
a0bec7	1	0	2	-	1	1	100
87072b	1	1	1	-	1	0	0
886ba3	2	-	-	-	2	0	0

1.2.2 Test results – Station B

Table 6: Test results – sorted by mean value. Outliers are marked in red. u_X – participant's expanded uncertainty; $\bar{x}$ – arithmetic mean; s_0 – sample standard deviation; V_X – coefficient of variation

ID Participant	Test results [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
9969d5	0	0	0	-	0	0	0
95b8b8	0	0	0	-	0	0	0
c77498	0	0	0	-	0	0	0
eeaf07	0	0	0	-	0	0	0
a0bec7	0	0	0	-	0	0	0
18e48c	0	0	0	-	0	0	0
ad374e	0	0	0	-	0	0	0
81698a	1	0	0	-	0	0.6	173.21
bc587d	1	1	0	-	1	0.6	86.6
886ba3	1	-	-	-	1	0	0
87072b	1	1	1	-	1	0	0

1.2.3 Test results – Station C

Table 7: Test results – sorted by mean value. Outliers are marked in red. u_X – participant's expanded uncertainty; $\bar{x}$ – arithmetic mean; s_0 – sample standard deviation; V_X – coefficient of variation

ID Participant	Test results [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
9969d5	0	0	0	-	0	0	0
81698a	0	0	0	-	0	0	0
95b8b8	0	0	0	-	0	0	0
c77498	0	0	0	-	0	0	0
eeaf07	0	0	0	-	0	0	0
a0bec7	0	0	0	-	0	0	0
886ba3	0	-	-	-	0	0	0
18e48c	0	0	0	-	0	0	0
ad374e	0	0	0	-	0	0	0
bc587d	0	0	1	-	0	0.6	173.21
87072b	1	1	1	-	1	0	0

1.2.4 Test results – Station D

Table 8: Test results – sorted by mean value. Outliers are marked in red. u_X – participant's expanded uncertainty; $\bar{x}$ – arithmetic mean; s_0 – sample standard deviation; V_X – coefficient of variation

ID Participant	Test results [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
9969d5	0	0	0	-	0	0	0
81698a	0	0	0	-	0	0	0
95b8b8	0	0	0	-	0	0	0
18e48c	0	0	0	-	0	0	0
ad374e	0	0	0	-	0	0	0
bc587d	0	1	0	-	0	0.6	173.21
c77498	0	2	0	-	1	1.2	173.21
eeaf07	0	2	0	-	1	1.2	173.21
a0bec7	0	2	0	-	1	1.2	173.21
886ba3	1	-	-	-	1	0	0
87072b	1	1	1	-	1	0	0

1.2.5 Test results – Station E

Table 9: Test results – sorted by mean value. Outliers are marked in red. u_X – participant's expanded uncertainty; $\bar{x}$ – arithmetic mean; s_0 – sample standard deviation; V_X – coefficient of variation

ID Participant	Test results [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
9969d5	0	0	0	-	0	0	0
81698a	0	0	0	-	0	0	0
95b8b8	0	0	0	-	0	0	0
c77498	0	0	0	-	0	0	0
eeaf07	0	0	0	-	0	0	0
a0bec7	0	0	0	-	0	0	0
18e48c	0	0	0	-	0	0	0
ad374e	0	0	0	-	0	0	0
bc587d	0	1	1	-	1	0.6	86.6
886ba3	1	-	-	-	1	0	0
87072b	1	1	1	-	1	0	0

2 Appendix – ČSN 73 6175, Art. 9 Measurement of longitudinal pavement surface unevenness using a planograph

2.1 Planograph measurement results

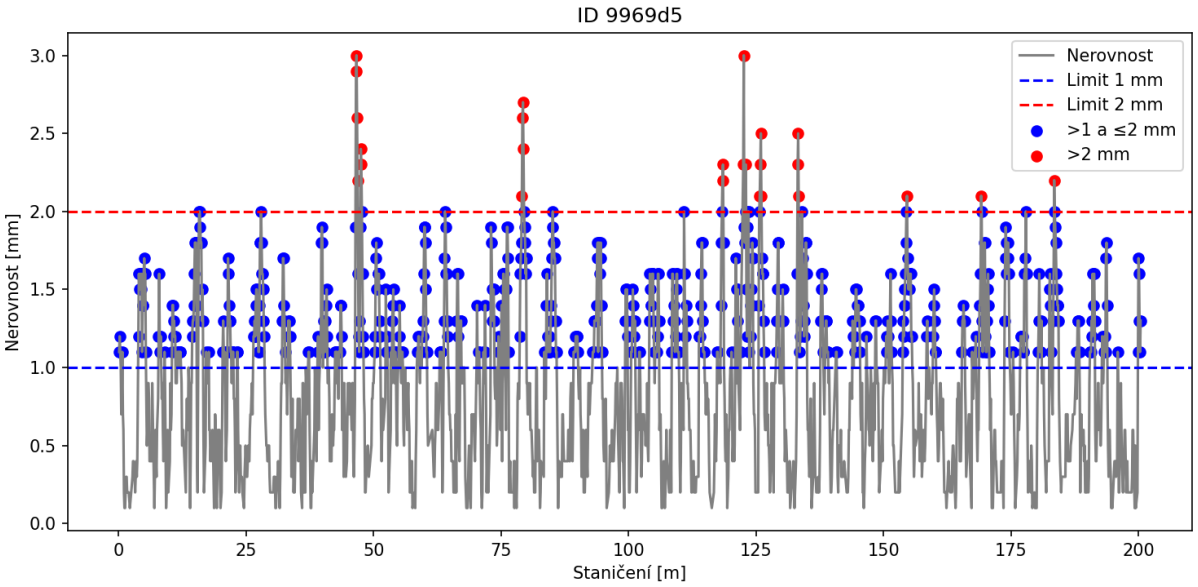

Figure 3: Submitted data – ID 9969d5

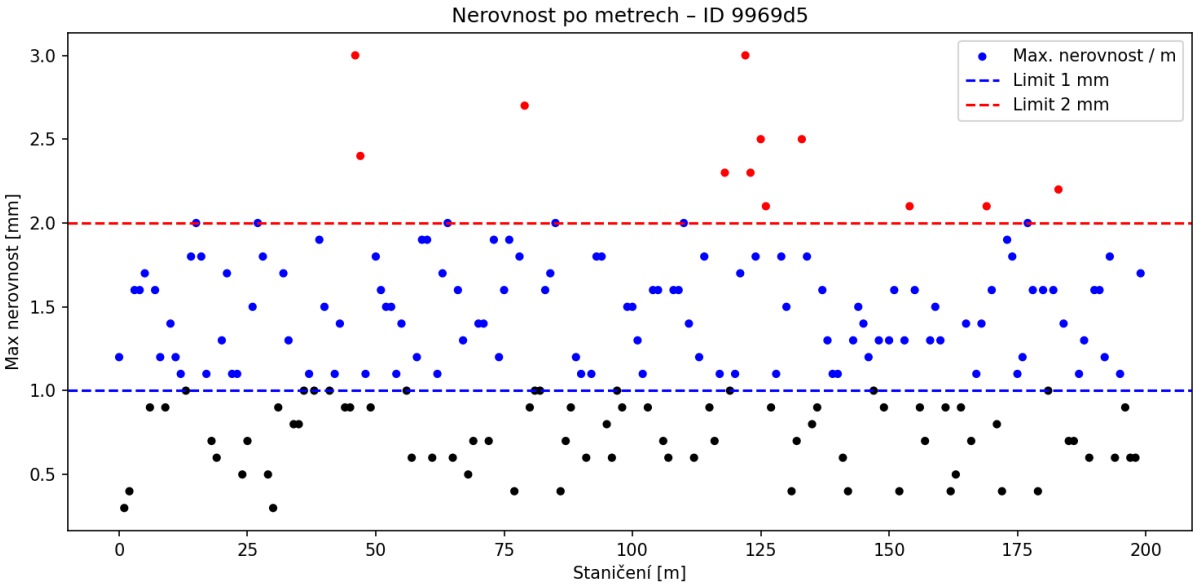

Figure 4: Maximum values per meter – ID 9969d5

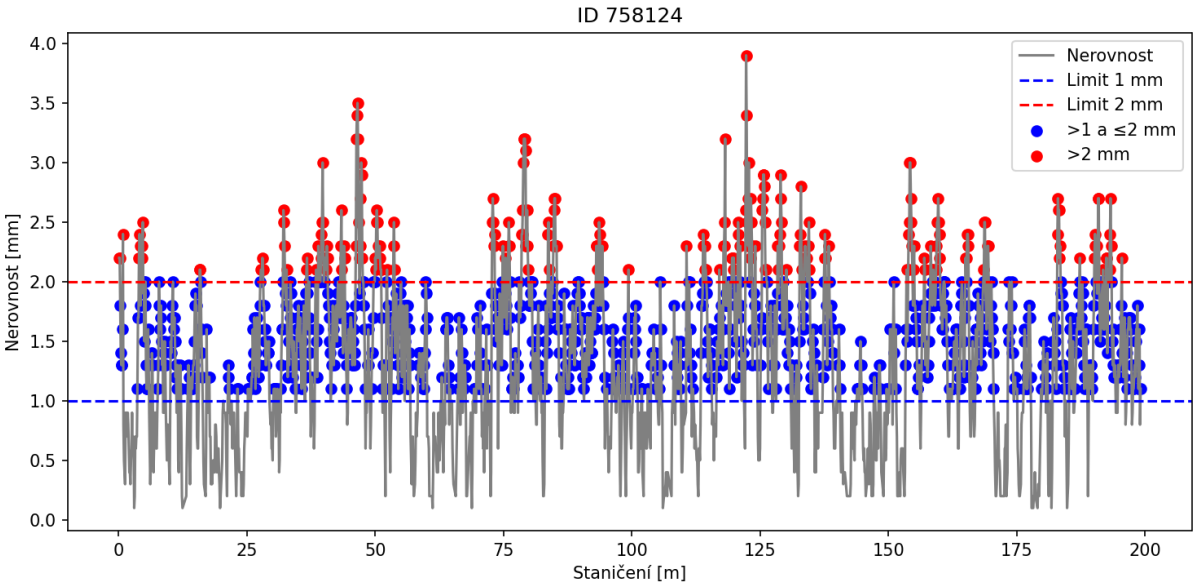

Figure 5: Submitted data – ID 758124

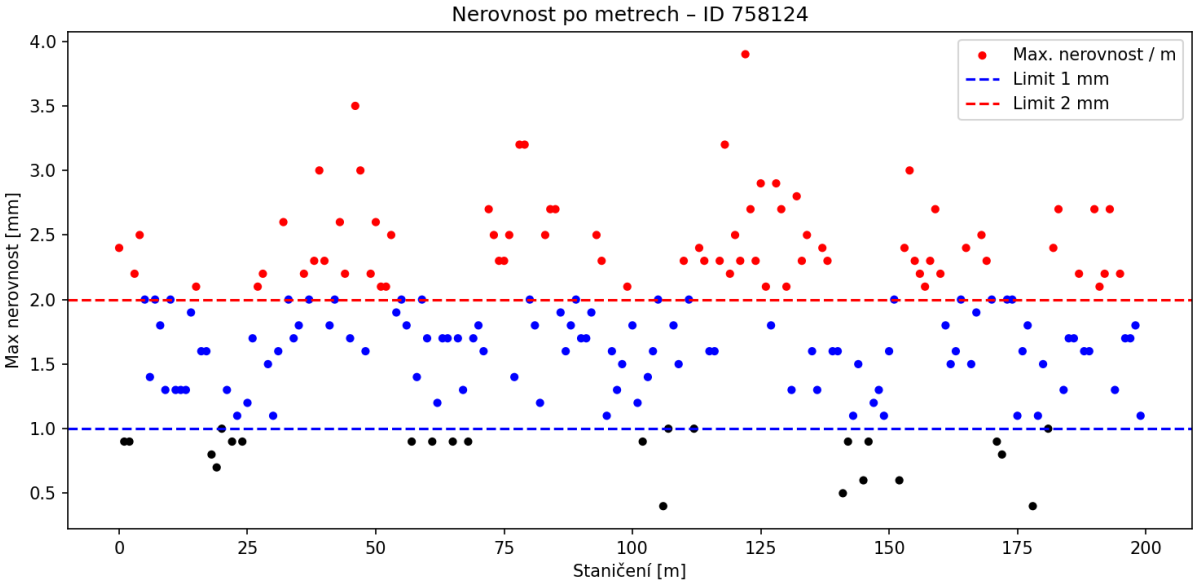

Figure 6: Maximum values per meter – ID 758124

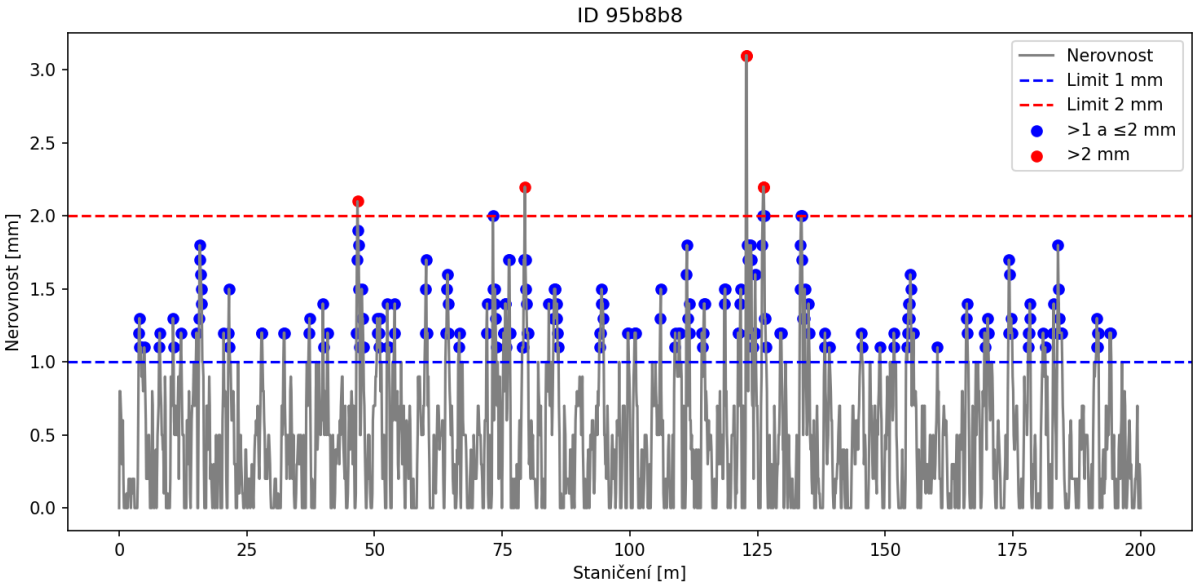

Figure 7: Submitted data – ID 95b8b8

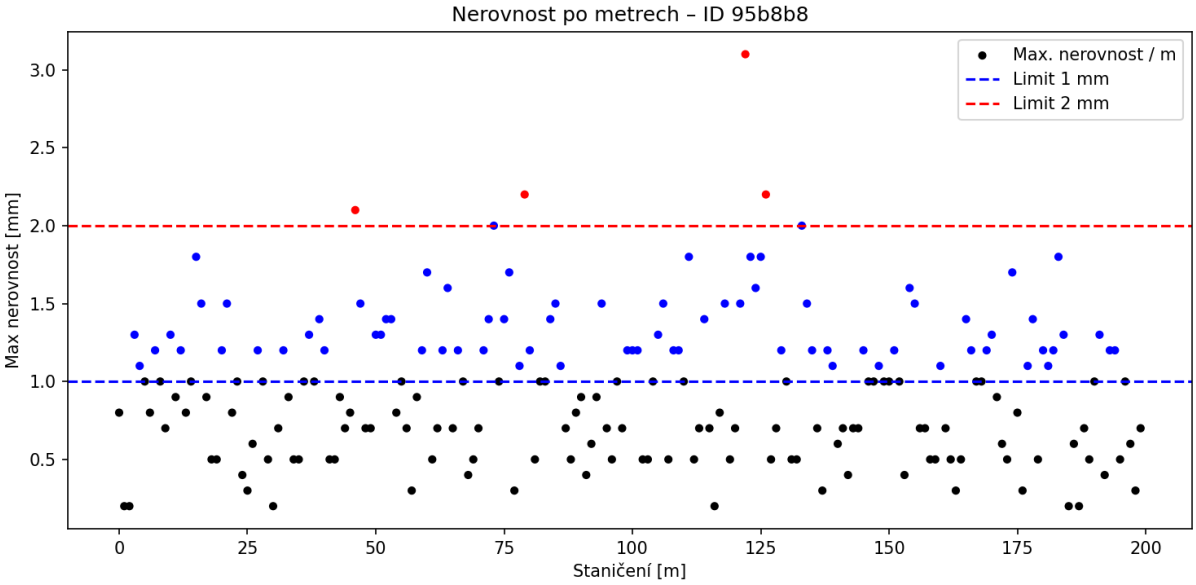

Figure 8: Maximum values per meter – ID 95b8b8

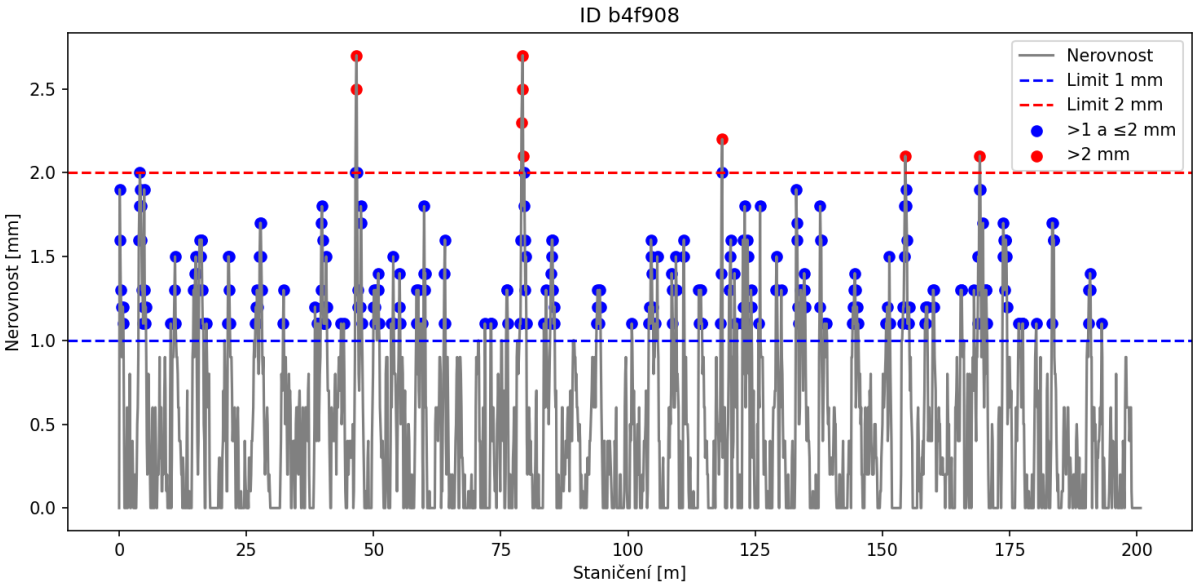

Figure 9: Submitted data – ID b4f908

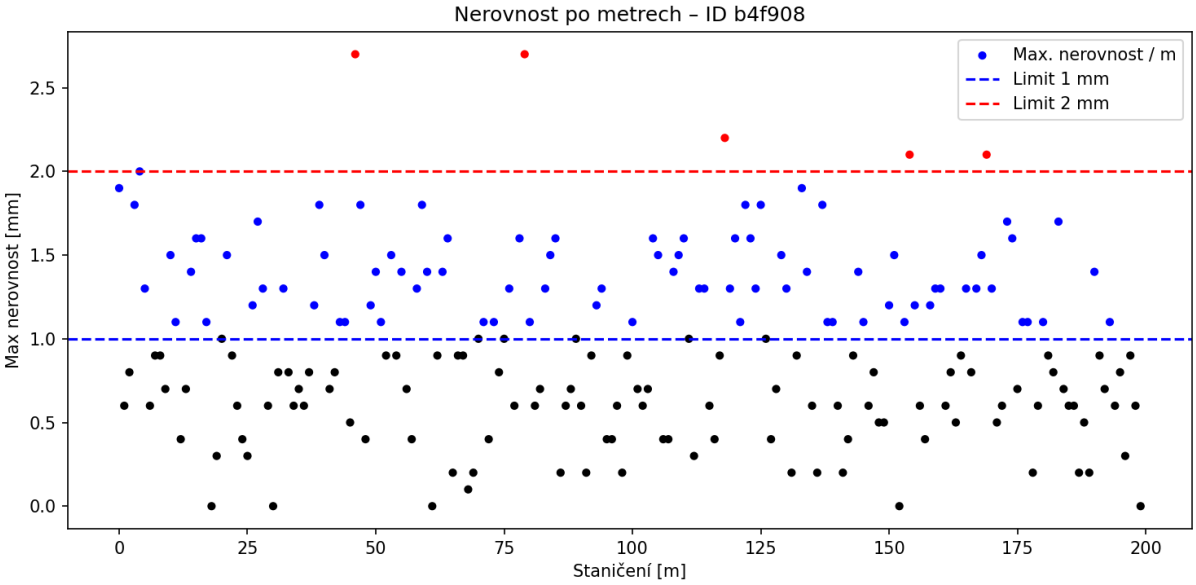

Figure 10: Maximum values per meter – ID b4f908

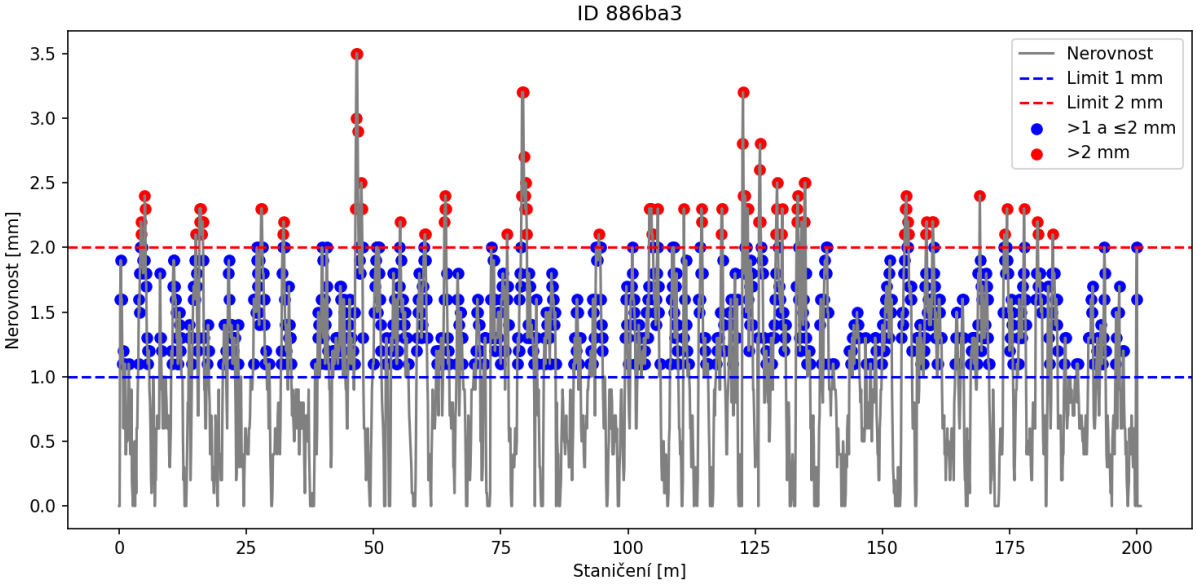

Figure 11: Submitted data – ID 886ba3

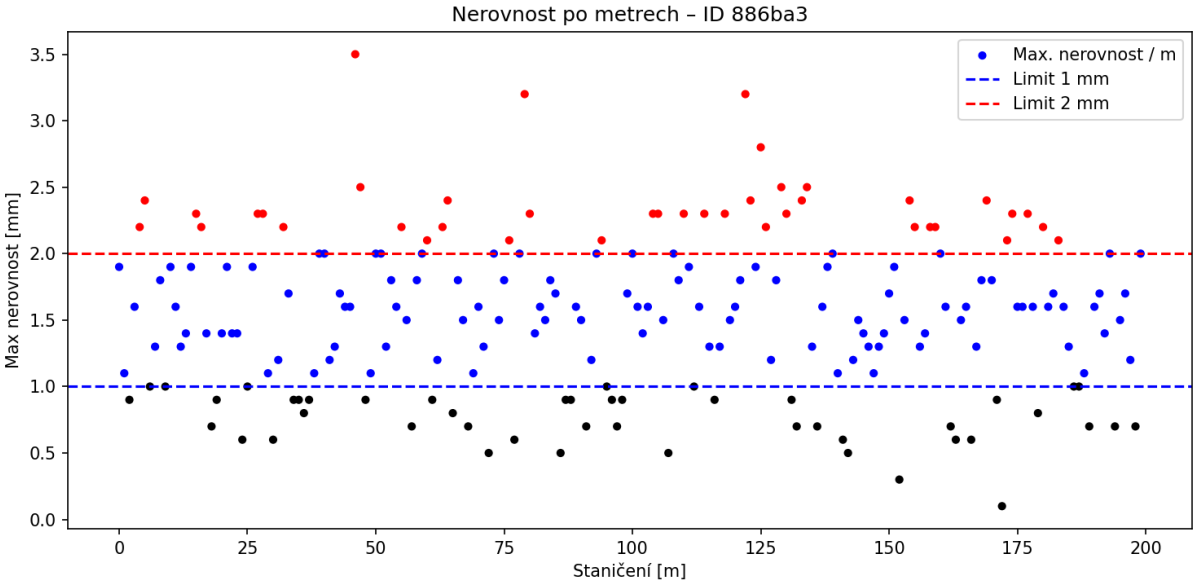

Figure 12: Maximum values per meter – ID 886ba3

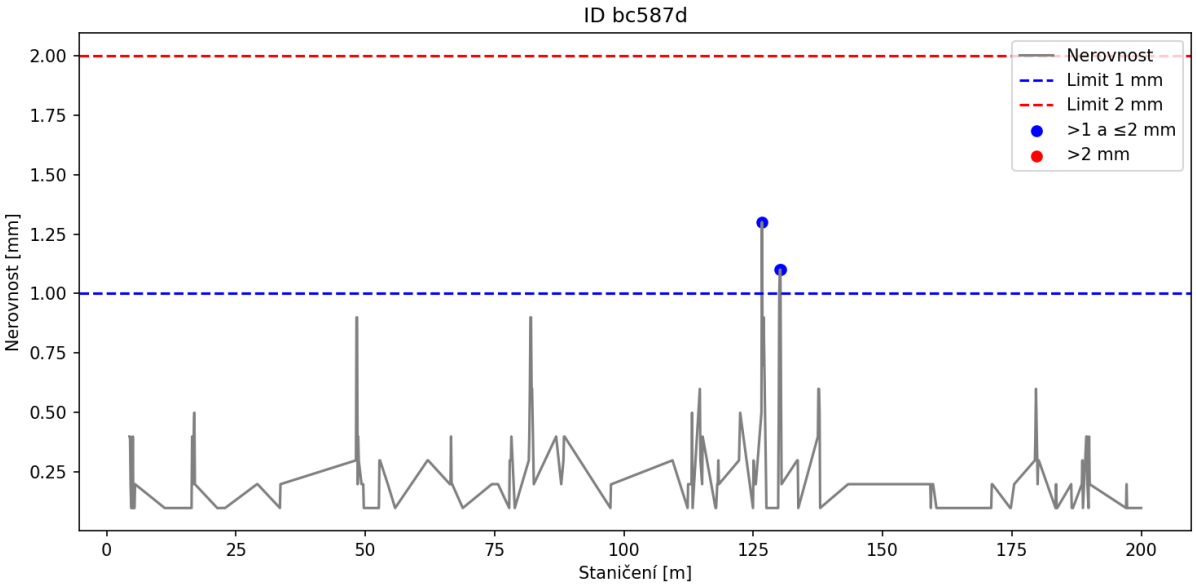

Figure 13: Submitted data – ID bc587d

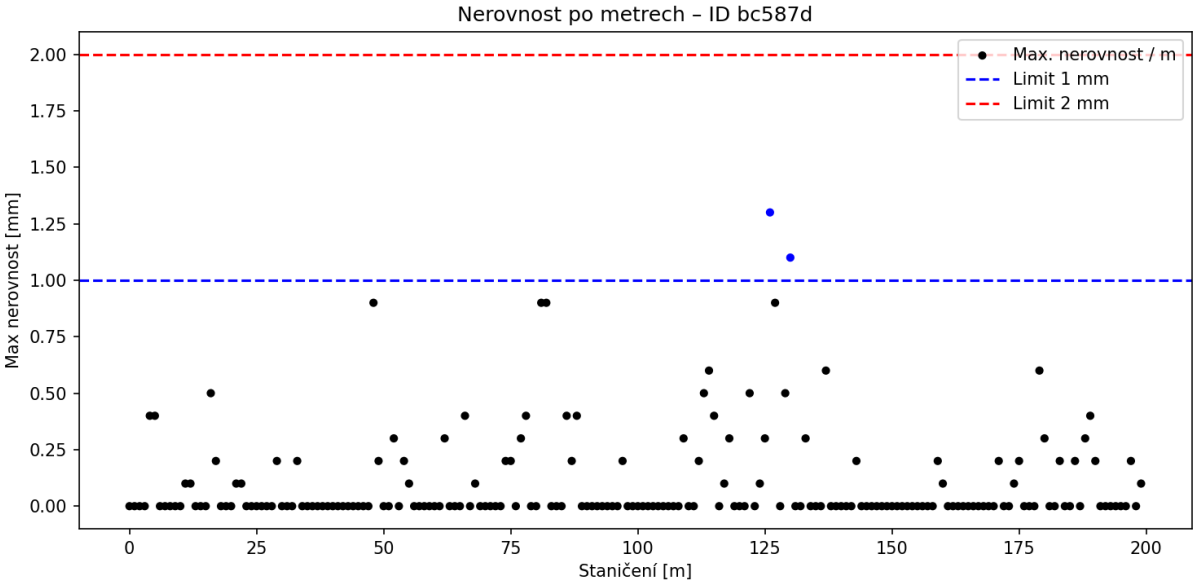

Figure 14: Maximum values per meter – ID bc587d

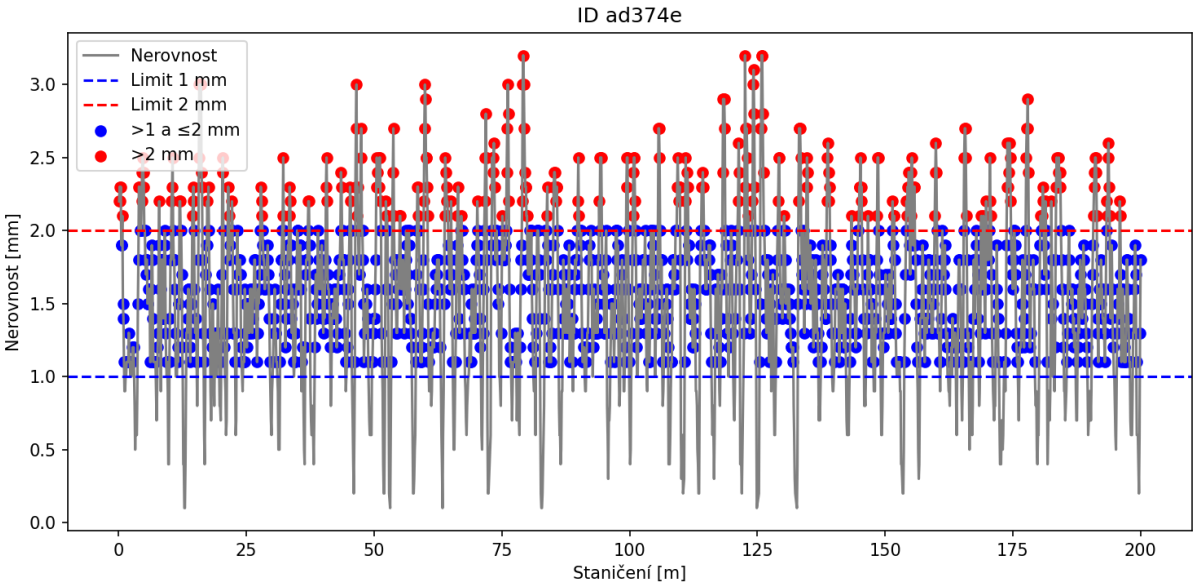

Figure 15: Submitted data – ID ad374e

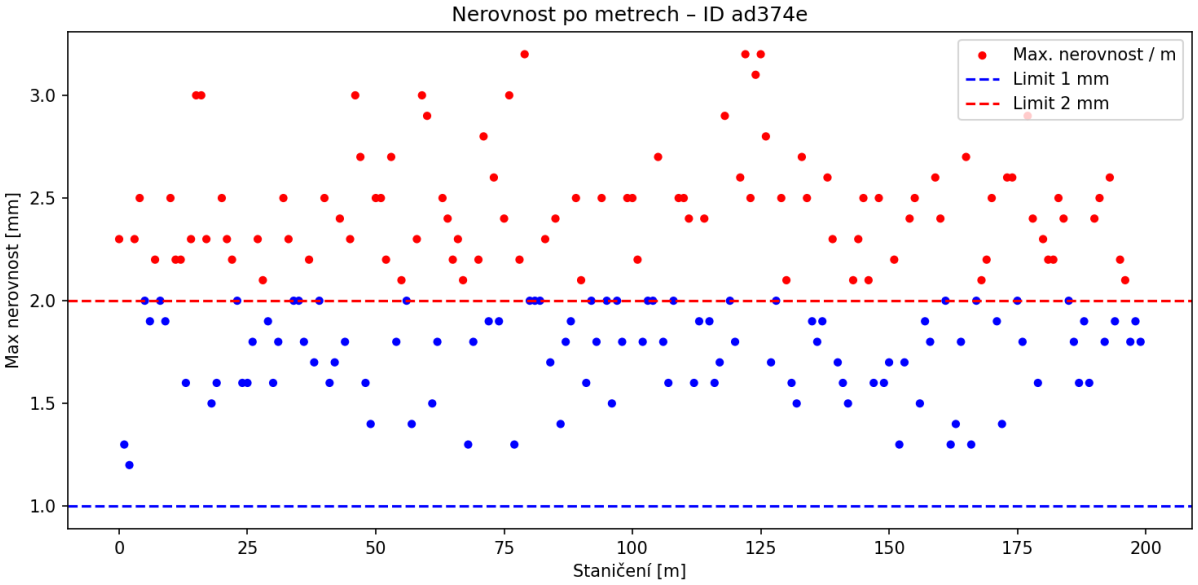

Figure 16: Maximum values per meter – ID ad374e

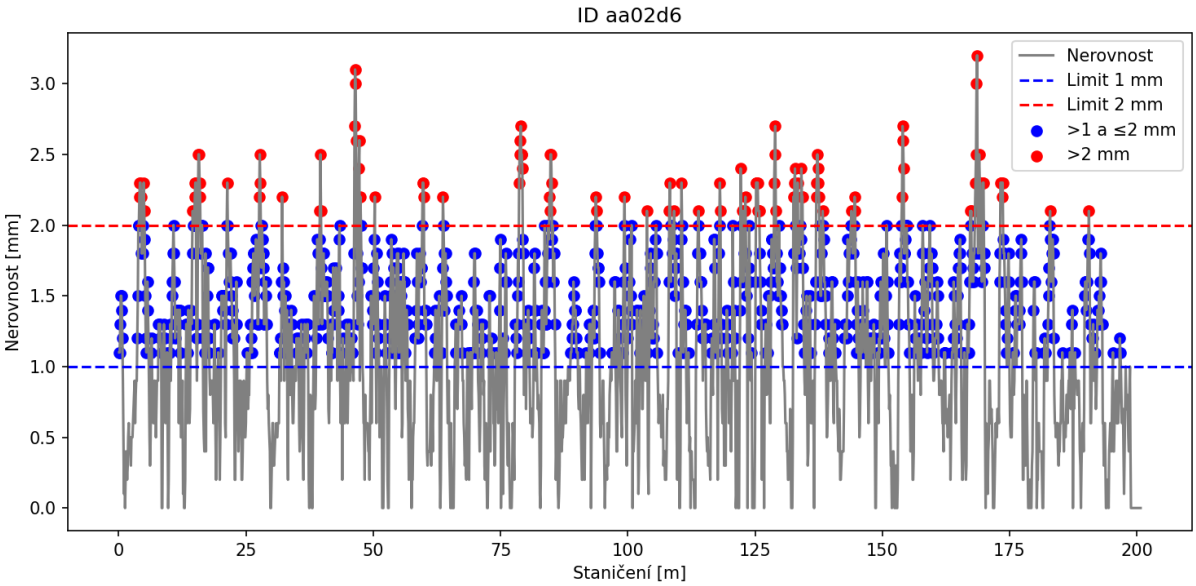

Figure 17: Submitted data – ID aa02d6

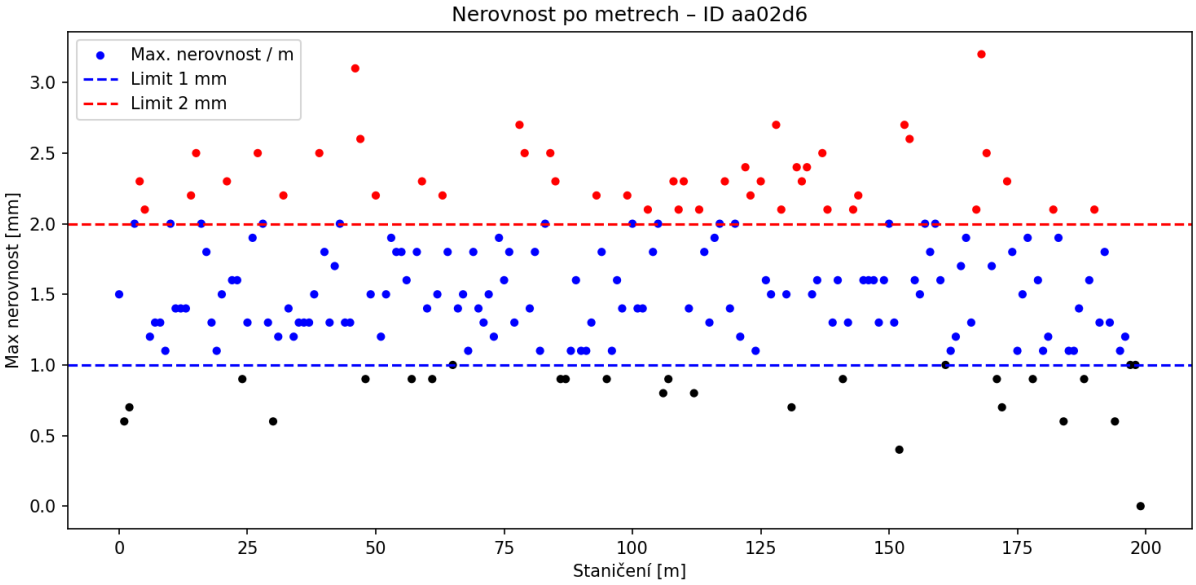

Figure 18: Maximum values per meter – ID aa02d6

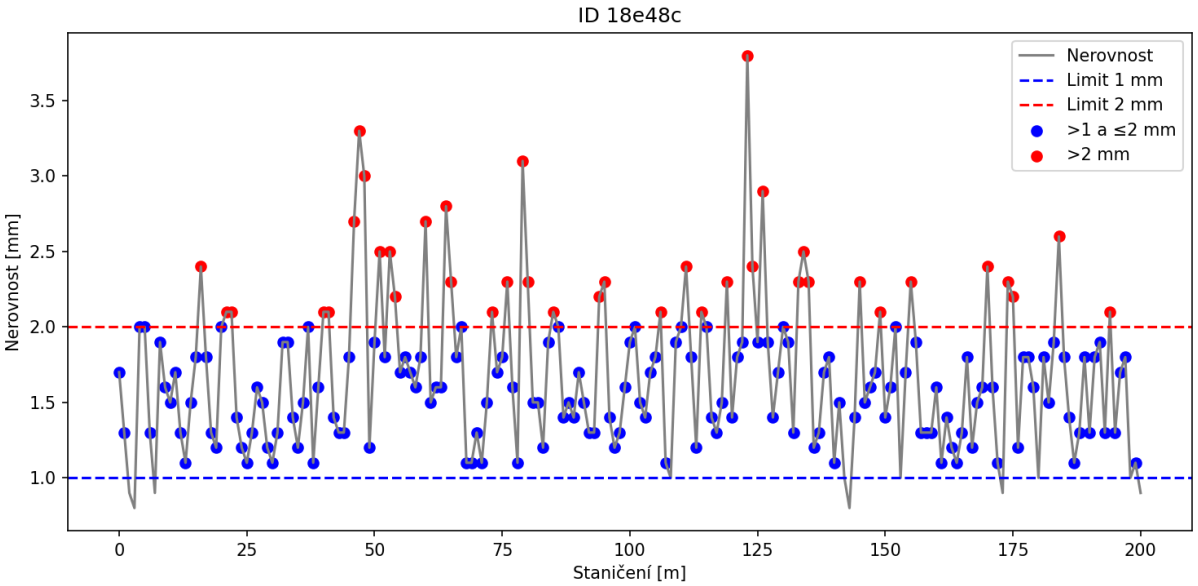

Figure 19: Submitted data – ID 18e48c

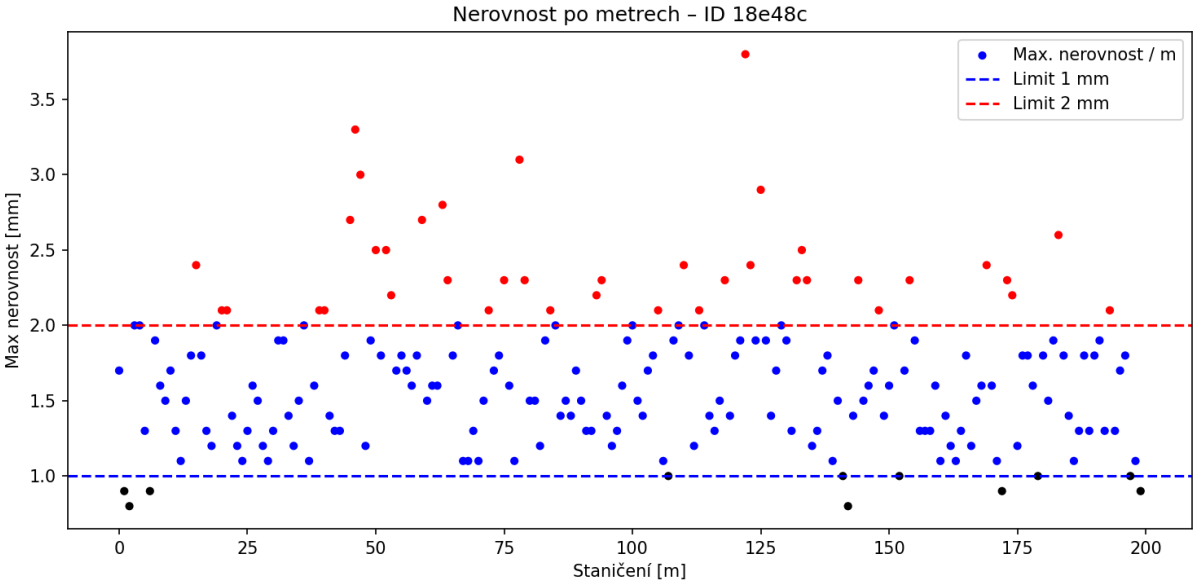

Figure 20: Maximum values per meter – ID 18e48c

2.2 Overview of points above limits – Submitted data

Table 10: Overview of points according to limits

ID	n	≤1 mm (count)	≤1 mm (%)	>1 and ≤2 mm (count)	>1 and ≤2 mm (%)	>2 mm (count)	>2 mm (%)
18e48c	201	11	5.5	151	75.1	39	19.4
ad374e	1895	370	19.5	1232	65.0	293	15.5
758124	1844	623	33.8	989	53.6	232	12.6
aa02d6	1919	952	49.6	852	44.4	115	6.0
886ba3	1920	986	51.4	835	43.5	99	5.2
9969d5	1718	1116	65.0	577	33.6	25	1.5
b4f908	1920	1621	84.4	290	15.1	9	0.5
95b8b8	1917	1682	87.7	229	11.9	6	0.3
bc587d	160	157	98.1	3	1.9	0	0.0

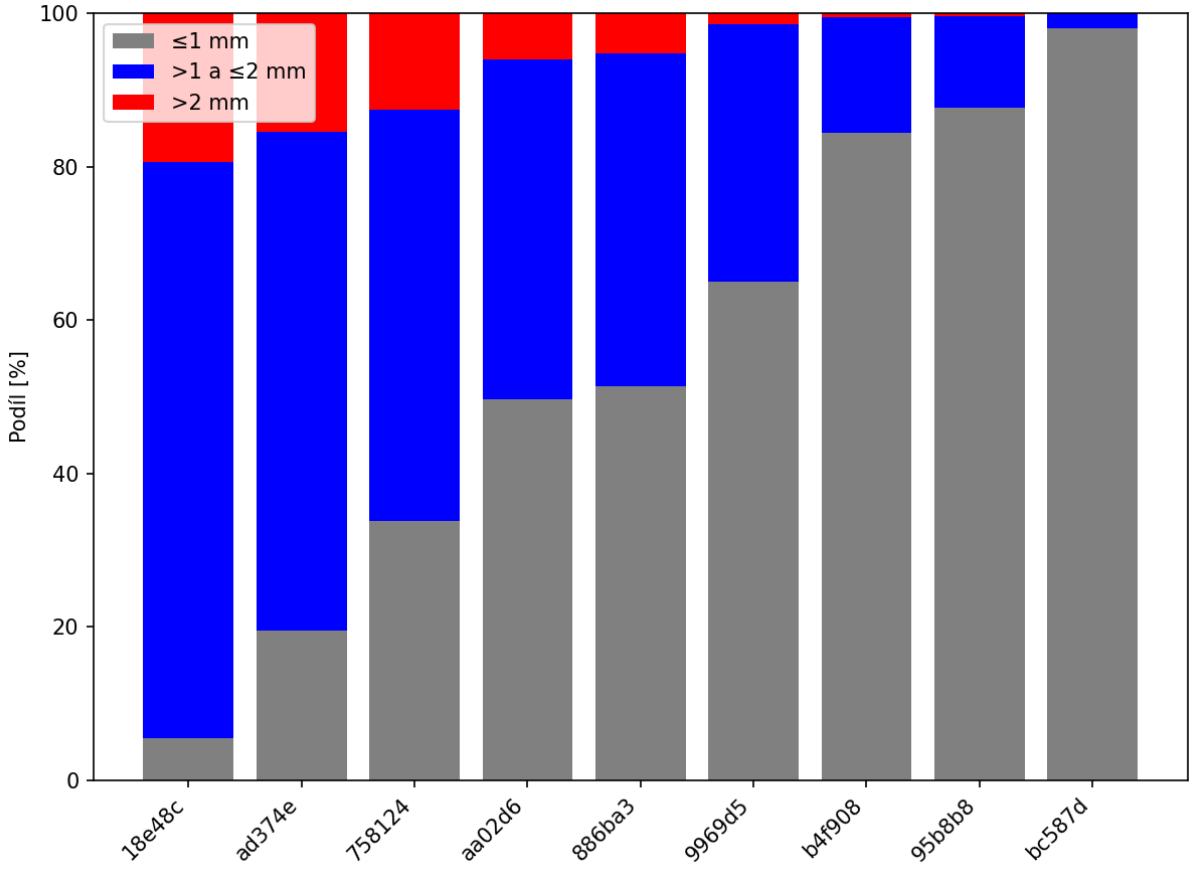

Figure 21: Cumulative bar chart of percentage shares according to the specified limits.

2.3 Overview of points above limits – Maximum values per meter (1 m)

Table 11: Overview of points according to limits (maxima per 1 m)

ID	n	≤1 mm (count)	≤1 mm (%)	>1 and ≤2 mm (count)	>1 and ≤2 mm (%)	>2 mm (count)	>2 mm (%)
ad374e	200	0	0.0	102	51.0	98	49.0
18e48c	200	11	5.5	150	75.0	39	19.5
758124	200	24	12.0	103	51.5	73	36.5
aa02d6	200	27	13.5	128	64.0	45	22.5
886ba3	200	47	23.5	113	56.5	40	20.0
9969d5	200	74	37.0	114	57.0	12	6.0
b4f908	200	111	55.5	84	42.0	5	2.5
95b8b8	200	120	60.0	76	38.0	4	2.0
bc587d	200	198	99.0	2	1.0	0	0.0

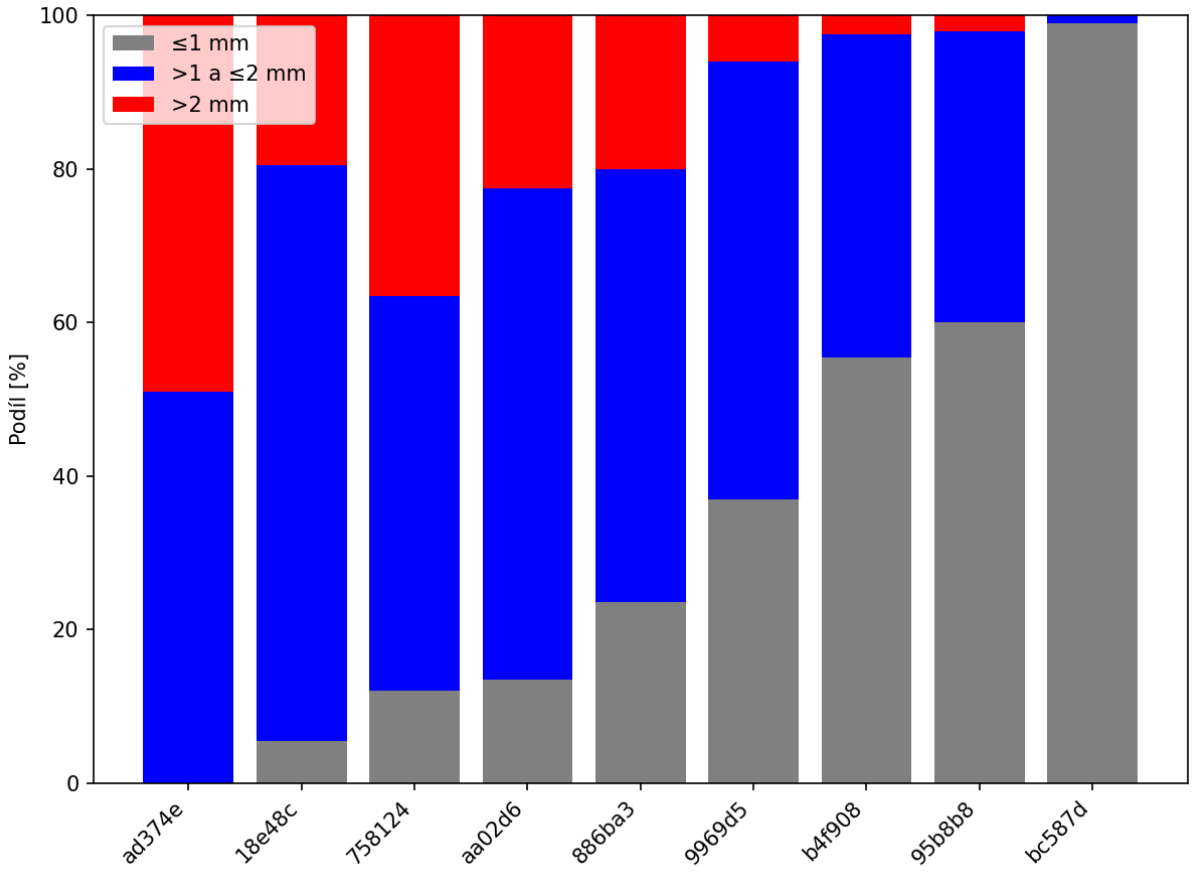

Figure 22: Cumulative bar chart of percentage shares of maximum unevenness per meter according to the specified limits.

2.4 Percentage of unevenness ≤ 1 mm

2.4.1 Test results

Table 12: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [%]	u_X [%]
ad374e	0.0	-
18e48c	5.5	-
758124	12.0	-
aa02d6	13.5	-
886ba3	23.5	-
9969d5	37.0	-
b4f908	55.5	-
95b8b8	60.0	-
bc587d	99.0	-

2.4.2 The Numerical Procedure for Determining Outliers

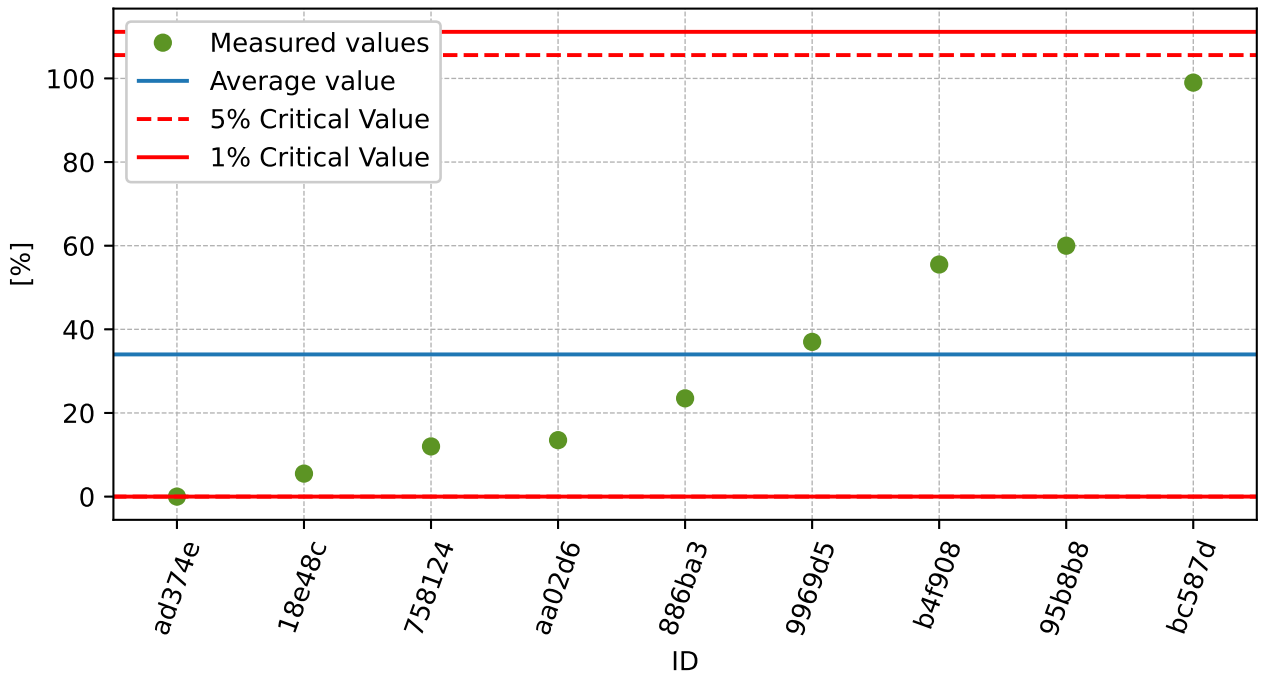

Figure 23: **Grubbs' test** - average values

2.4.3 Mandel's Statistics

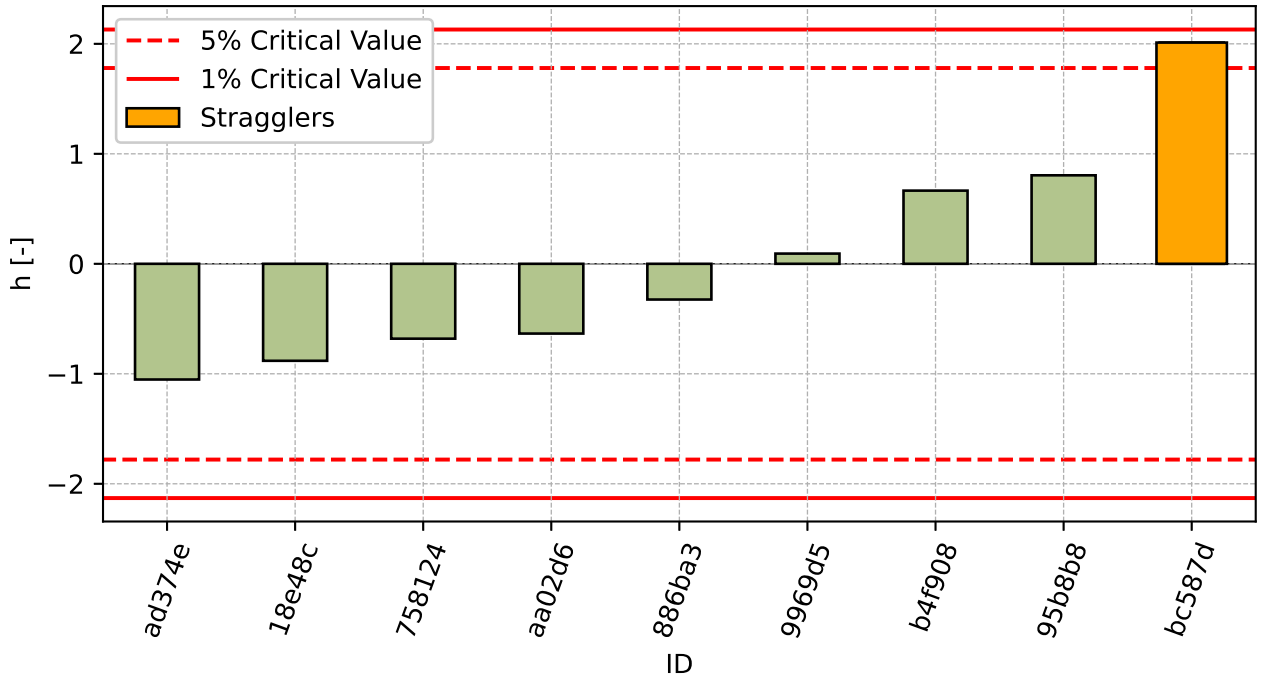

Figure 24: Interlaboratory Consistency Statistic

2.4.4 Descriptive statistics

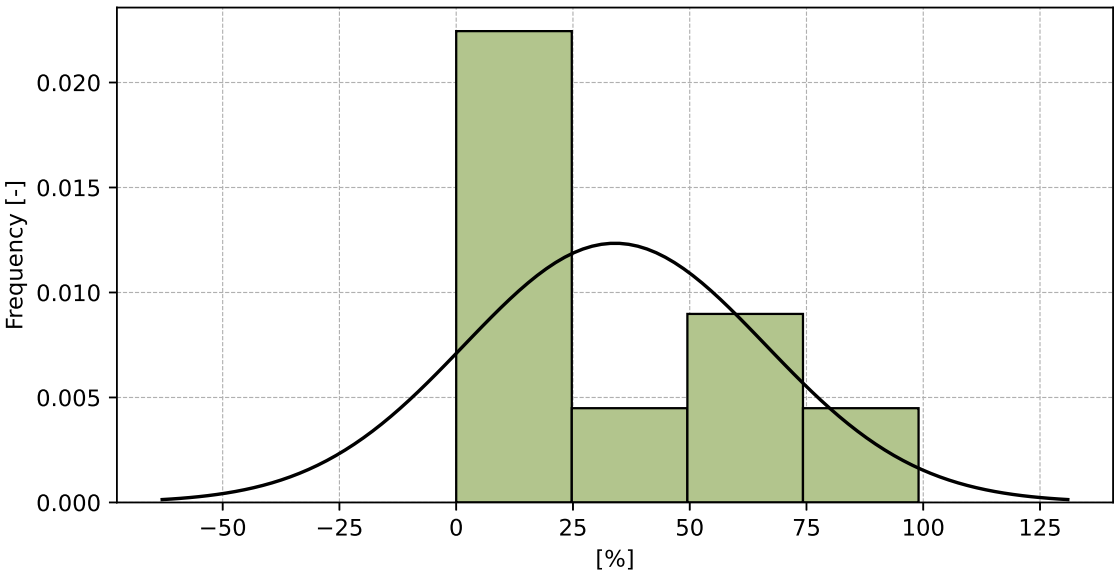

Figure 25: Histogram of all test results

Table 13: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	34.0
Sample standard deviation – s	32.32
Asigned value – x^*	34.0
Robust standard deviation – s^*	34.55
Measurement uncertainty of asigned value – u_X	14.4
p-value of normality test	0.263 [-]

2.4.5 Evaluation of Performance Statistics

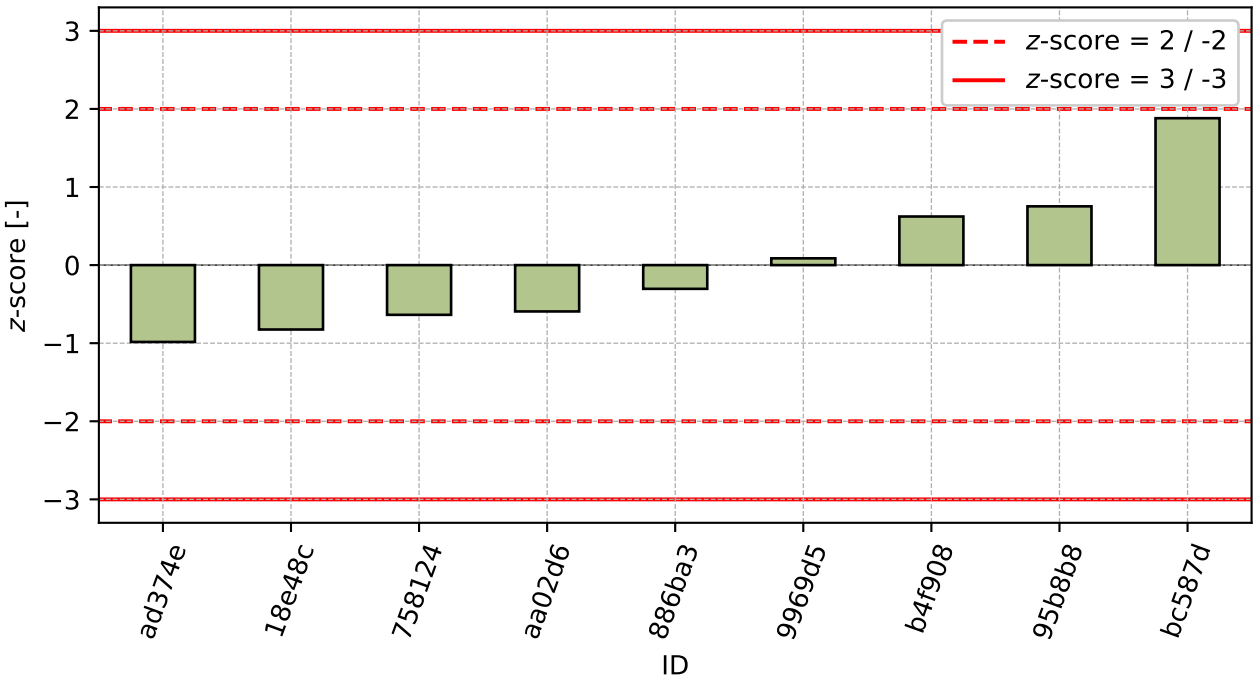

Figure 26: z-score

Table 14: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ad374e	-0.98	-
18e48c	-0.82	-
758124	-0.64	-
aa02d6	-0.59	-
886ba3	-0.30	-
9969d5	0.09	-
b4f908	0.62	-
95b8b8	0.75	-

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ID	z-score [-]	ζ-score [-]
bc587d	1.88	-

2.5 Percentage of unevenness > 1 mm and ≤ 2 mm

2.5.1 Test results

Table 15: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [%]	u_X [%]
bc587d	1.0	-
95b8b8	38.0	-
b4f908	42.0	-
ad374e	51.0	-
758124	51.5	-
886ba3	56.5	-
9969d5	57.0	-
aa02d6	64.0	-
18e48c	75.0	-

2.5.2 The Numerical Procedure for Determining Outliers

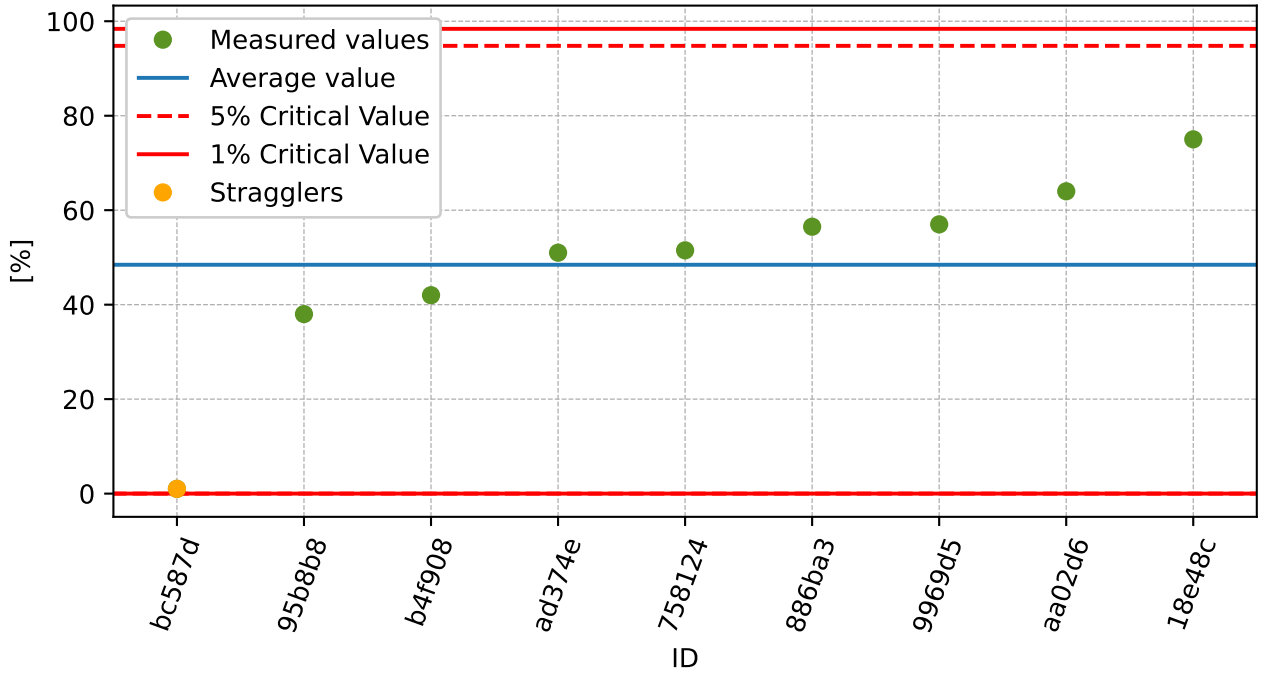

Figure 27: **Grubbs' test** - average values

2.5.3 Mandel's Statistics

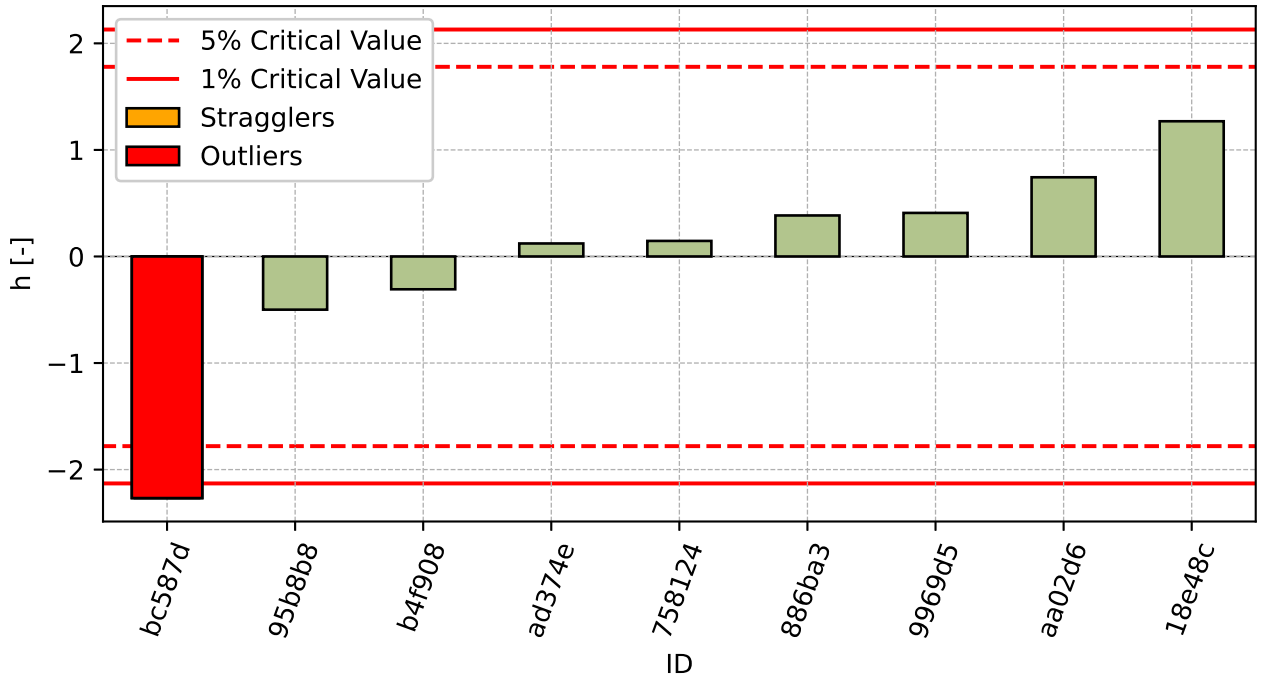

Figure 28: Interlaboratory Consistency Statistic

2.5.4 Descriptive statistics

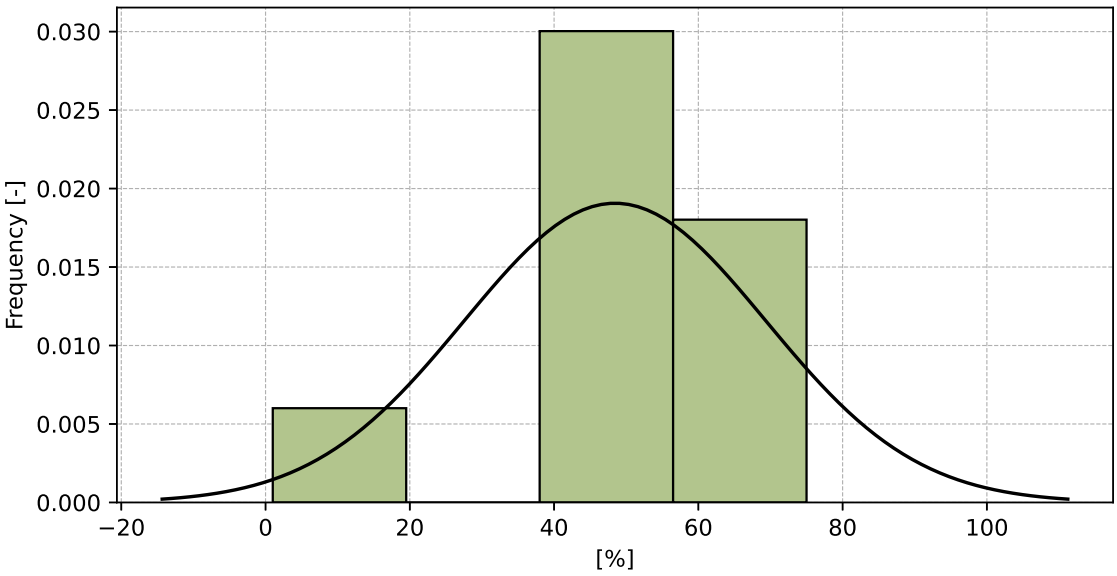

Figure 29: Histogram of all test results

Table 16: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	48.4
Sample standard deviation – s	20.92
Asigned value – x^*	51.7
Robust standard deviation – s^*	14.56
Measurement uncertainty of asigned value – u_X	6.06
p-value of normality test	0.153 [-]

2.5.5 Evaluation of Performance Statistics

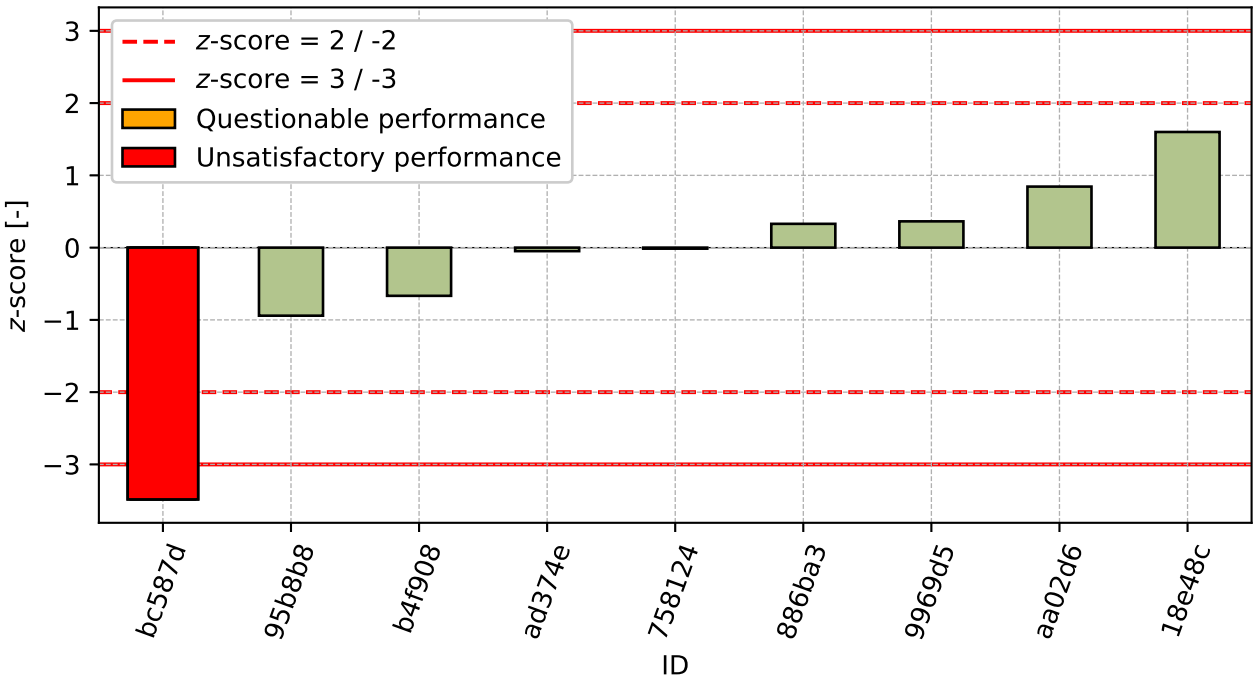

Figure 30: z-score

Table 17: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
bc587d	-3.48	-
95b8b8	-0.94	-
b4f908	-0.67	-
ad374e	-0.05	-
758124	-0.01	-
886ba3	0.33	-
9969d5	0.36	-
aa02d6	0.84	-

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ID	z-score [-]	ζ-score [-]
18e48c	1.60	-

2.6 Percentage of unevenness > 2 mm

2.6.1 Test results

Table 18: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [%]	u_X [%]
bc587d	0.0	-
95b8b8	2.0	-
b4f908	2.5	-
9969d5	6.0	-
18e48c	19.5	-
886ba3	20.0	-
aa02d6	22.5	-
758124	36.5	-
ad374e	49.0	-

2.6.2 The Numerical Procedure for Determining Outliers

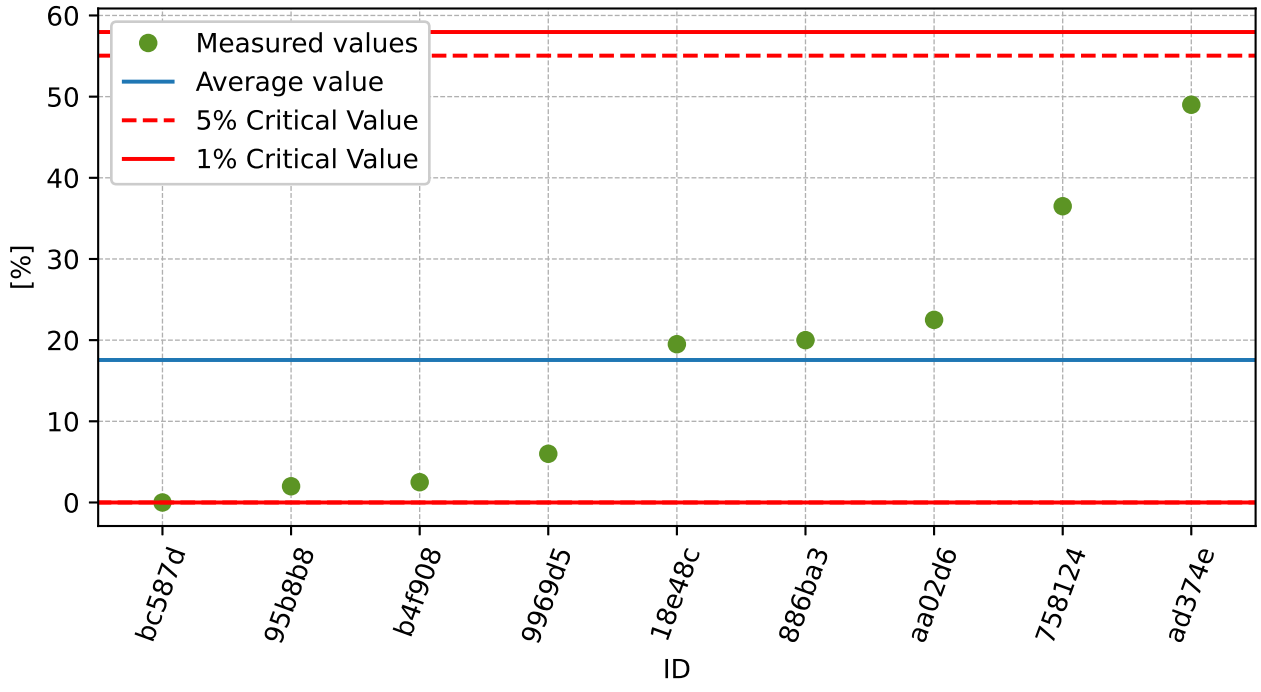

Figure 31: **Grubbs' test** - average values

2.6.3 Mandel's Statistics

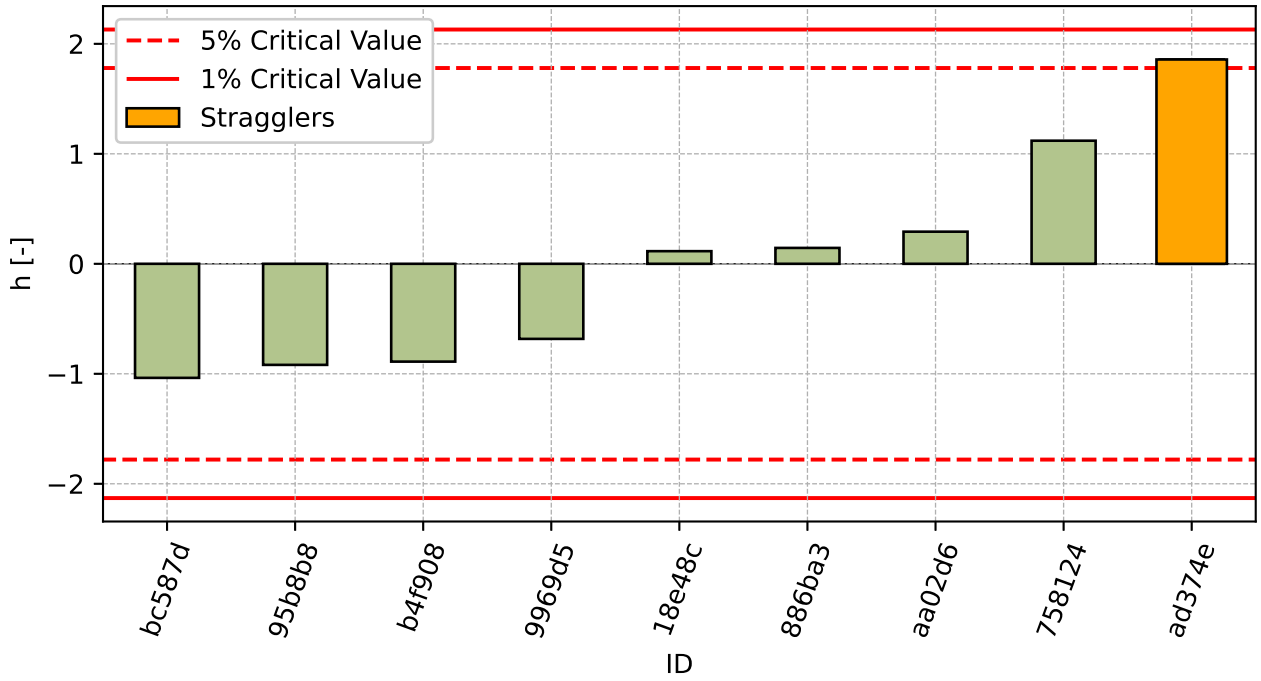

Figure 32: Interlaboratory Consistency Statistic

2.6.4 Descriptive statistics

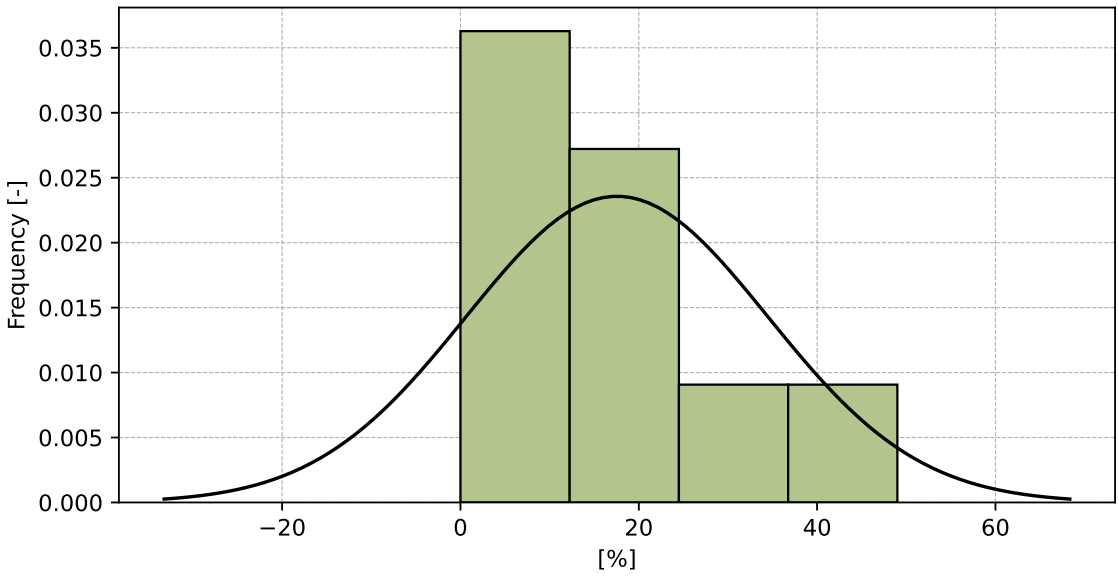

Figure 33: Histogram of all test results

Table 19: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	17.6
Sample standard deviation – s	16.93
Asigned value – x^*	17.6
Robust standard deviation – s^*	18.1
Measurement uncertainty of asigned value – u_X	7.54
p-value of normality test	0.231 [-]

2.6.5 Evaluation of Performance Statistics

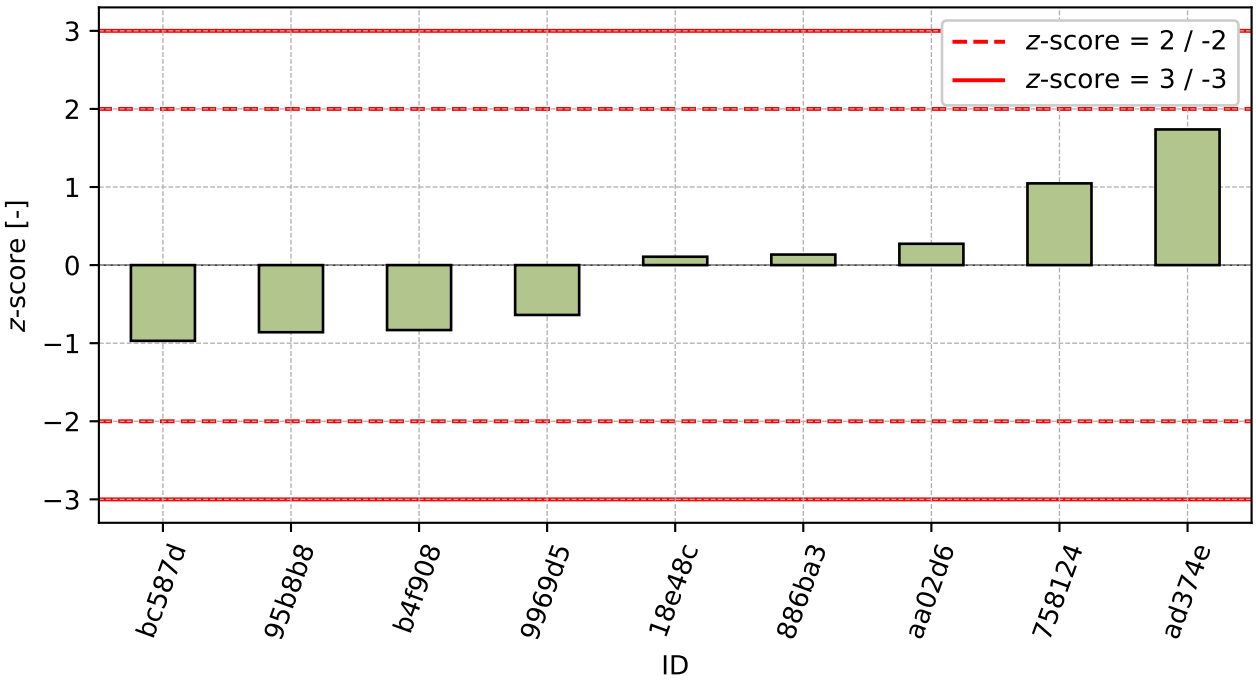

Figure 34: z-score

Table 20: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
bc587d	-0.97	-
95b8b8	-0.86	-
b4f908	-0.83	-
9969d5	-0.64	-
18e48c	0.11	-
886ba3	0.14	-
aa02d6	0.27	-
758124	1.05	-

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ID	z-score [-]	ζ-score [-]
ad374e	1.74	-

3 Appendix – EN 12697-36 Bituminous mixtures: Test methods – Part 36: Determination of the thickness of bituminous pavement

3.1 Wearing course

3.1.1 Test results

Table 21: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [mm]				u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
724d7e	33	34	34	35	2	34	0.8	2.4
18e48c	35	35	34	34	-	34	0.6	1.67
3b5d16	35	32	35	36	-	34	1.7	52
9969d5	34	35	36	34	1	35	1	2.76
2ffb83	35	35	36	33	-	35	1.3	3.62
ad374e	36	35	35	34	-	35	0.8	2.33
1c3bf1	38	33	34	36	-	35	2.2	6.29
bc587d	36	37	33	36	-	36	1.7	4.88
922aa9	35	36	36	37	-	36	0.8	2.27
c77498	36	35	37	38	-	36	1.3	3.54
eeaf07	36	35	36	39	-	36	1.7	4.75

3.1.2 The Numerical Procedure for Determining Outliers

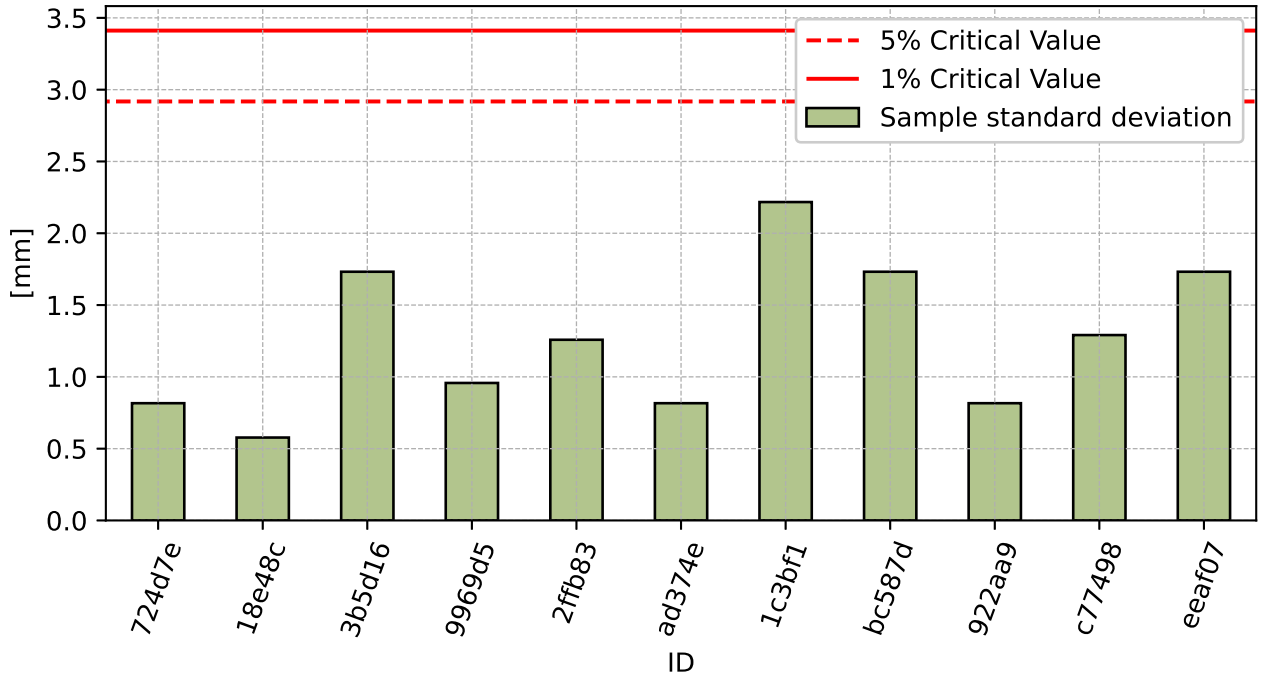

Figure 35: **Cochran's test** - sample standard deviations

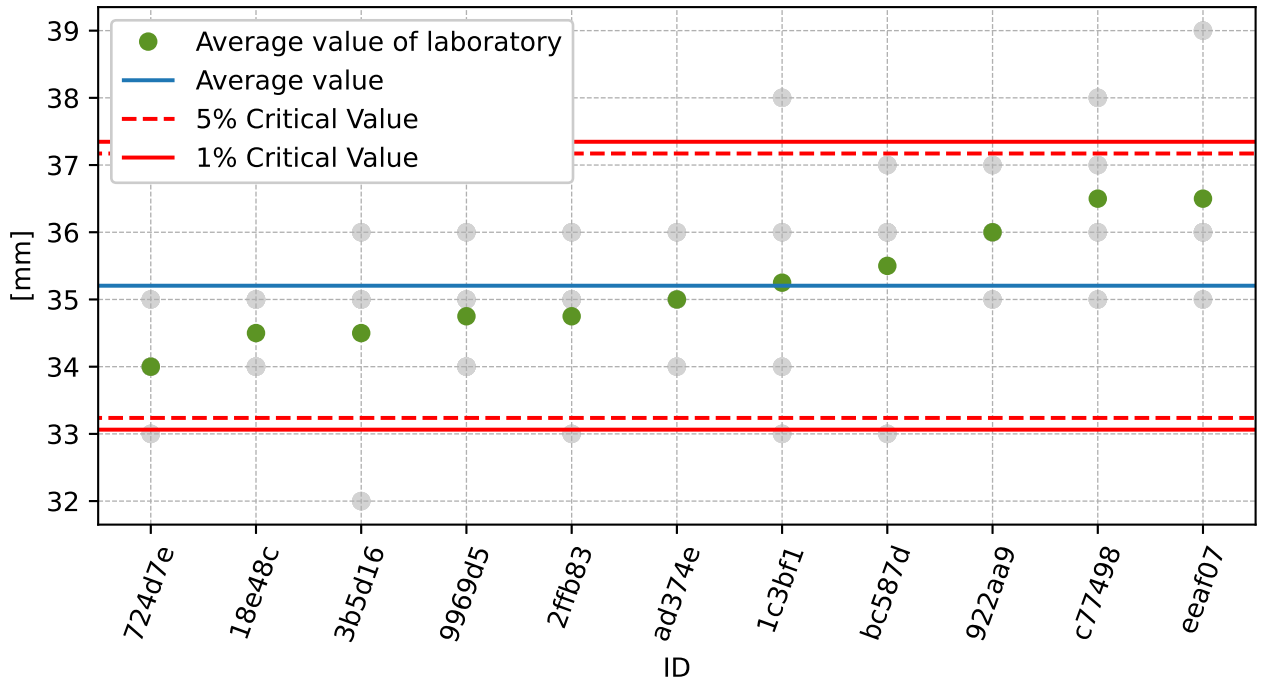

Figure 36: **Grubbs' test** - average values

3.1.3 Mandel's Statistics

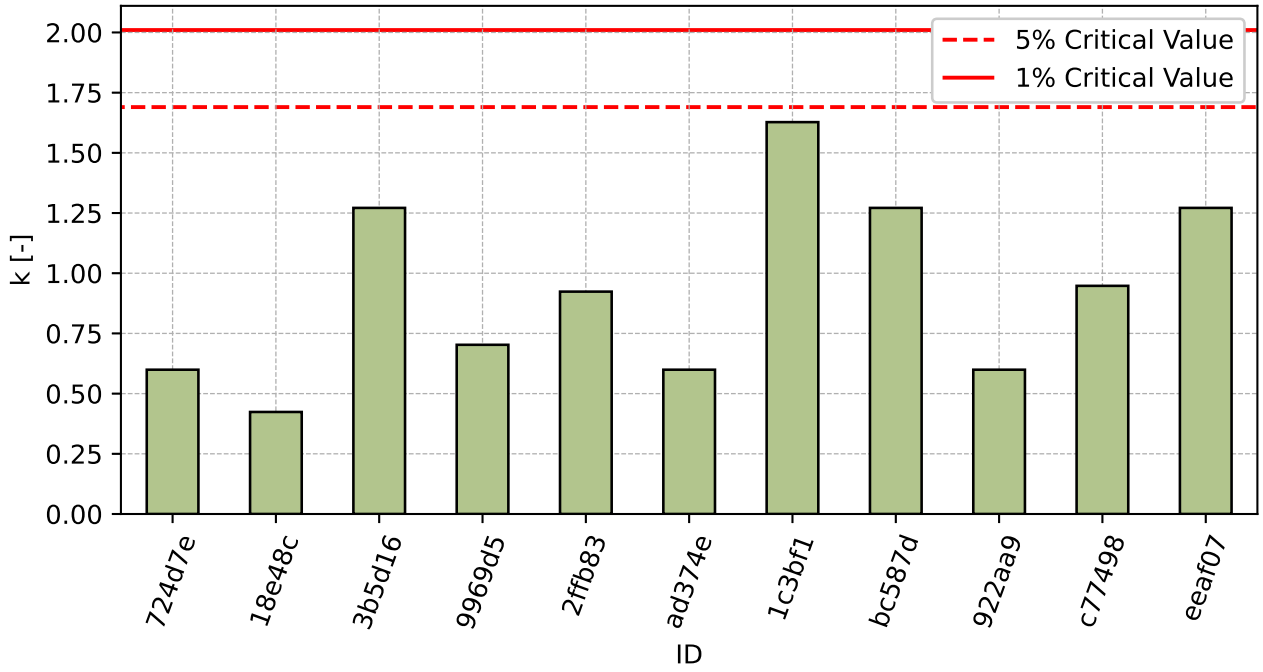

Figure 37: Intralaboratory Consistency Statistic

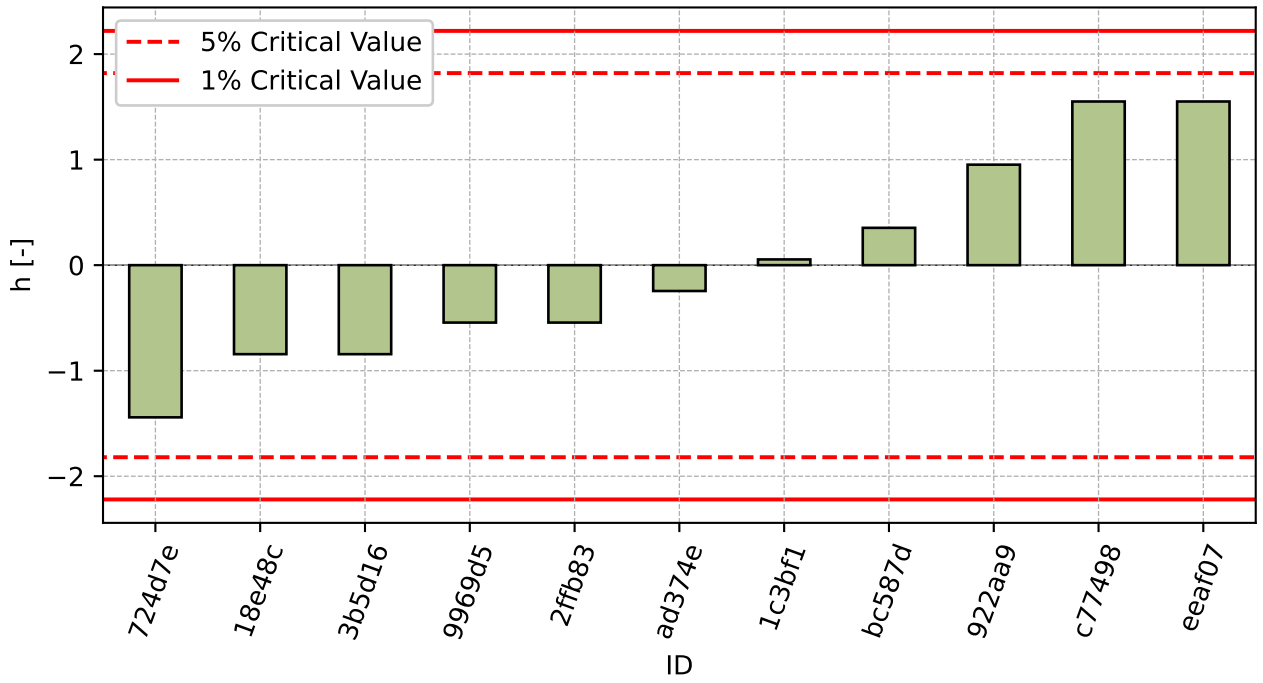

Figure 38: Interlaboratory Consistency Statistic

3.1.4 Descriptive statistics

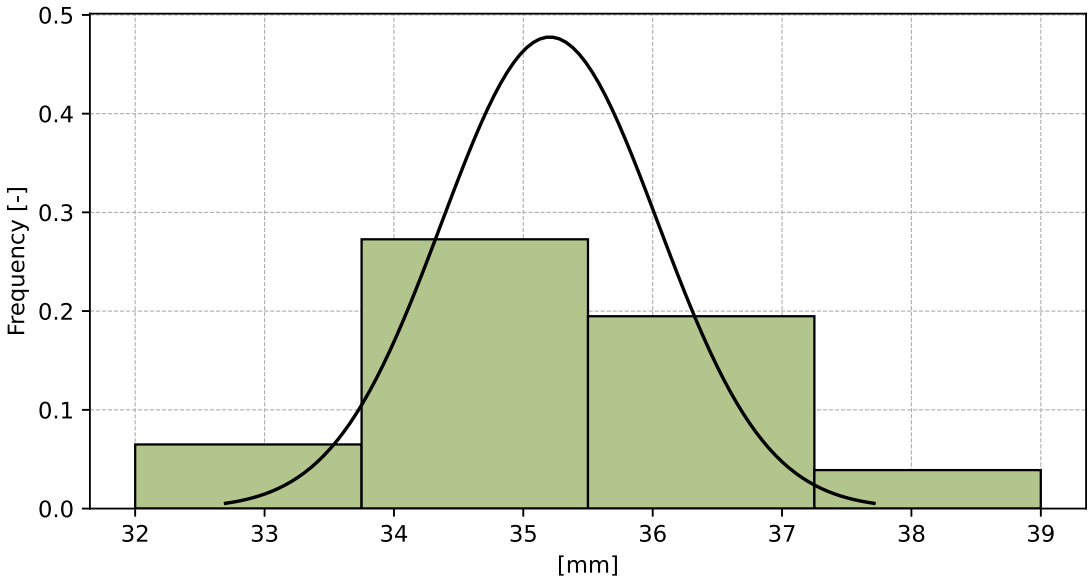

Figure 39: Histogram of all test results

Table 22: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	35
Sample standard deviation – s	0.8
Asigned value – x^*	35
Robust standard deviation – s^*	0.8
Measurement uncertainty of asigned value – u_X	0.3
p-value of normality test	0.065 [-]
Interlaboratory standard deviation – s_L	0.5
Repeatability standard deviation – s_r	1.4
Reproducibility standard deviation – s_R	1.4
Repeatability – r	4
Reproducibility – R	4

3.1.5 Evaluation of Performance Statistics

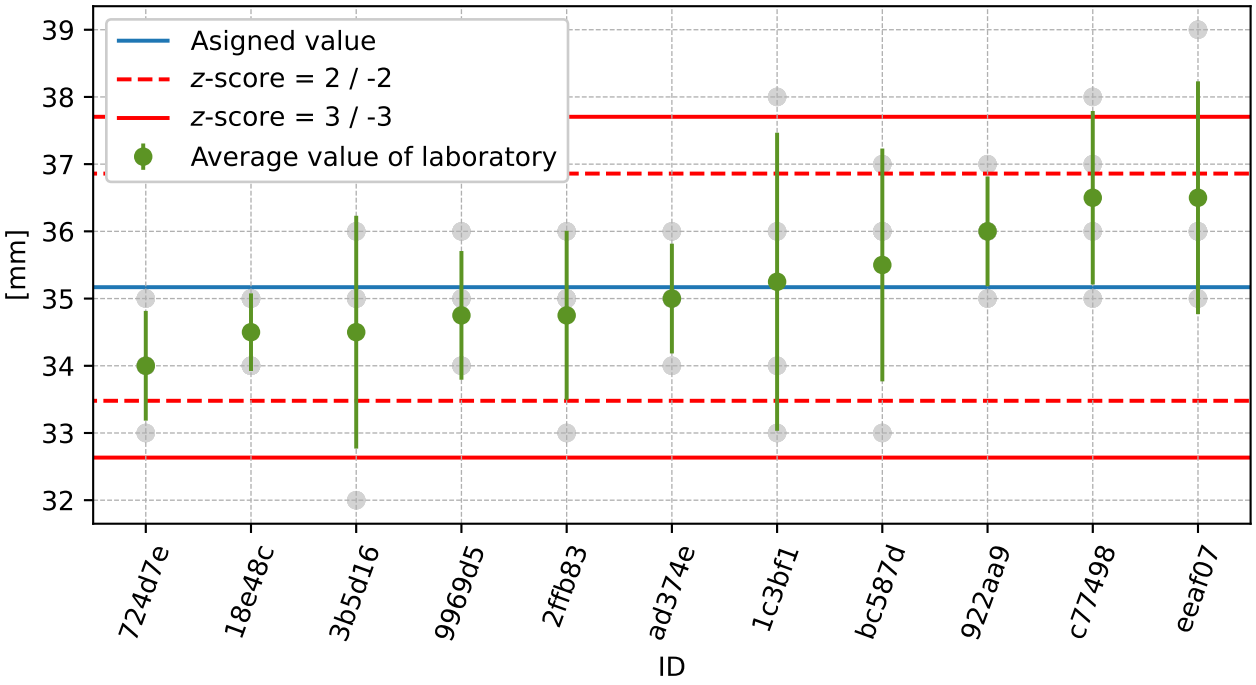

Figure 40: Average values and sample standard deviations

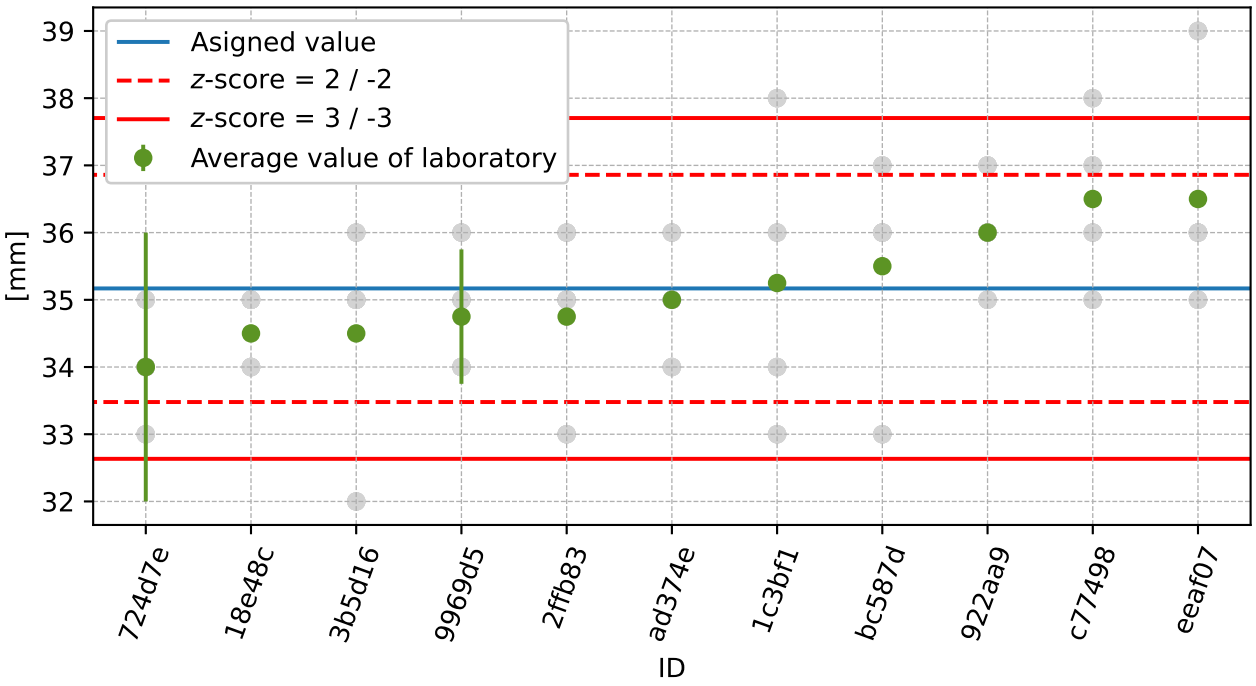

Figure 41: Average values and extended uncertainties of measurement

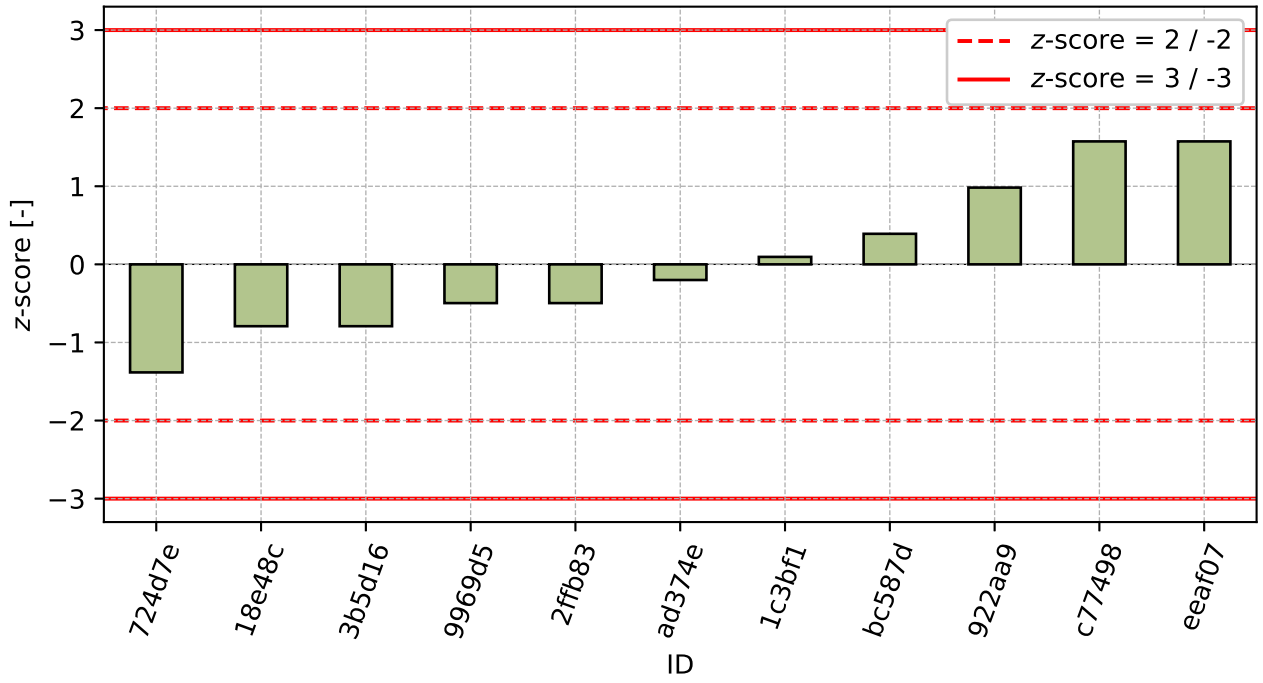

Figure 42: z-score

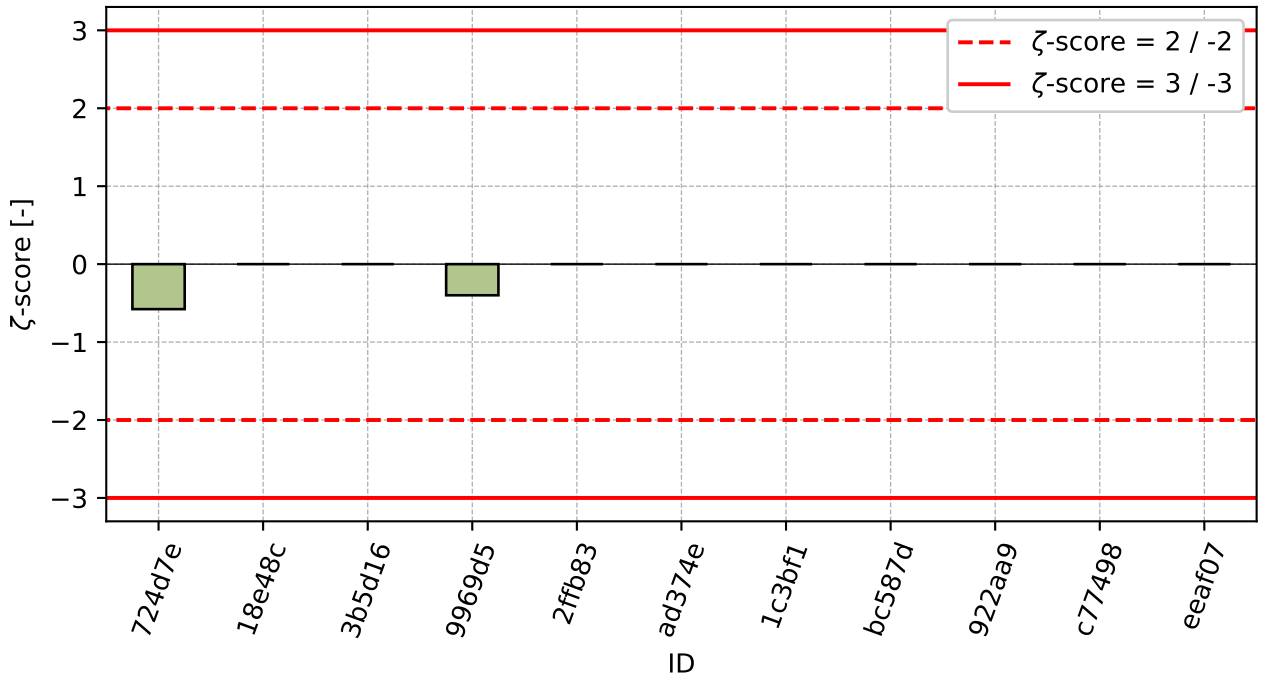

Figure 43: ζ-score

Table 23: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
724d7e	-1.38	-0.58
18e48c	-0.79	-
3b5d16	-0.79	-
9969d5	-0.50	-0.40
2ffb83	-0.50	-
ad374e	-0.20	-
1c3bf1	0.10	-
bc587d	0.39	-
922aa9	0.98	-
c77498	1.57	-
eeaf07	1.57	-

3.2 Binder course

3.2.1 Test results

Table 24: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [mm]				u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
1c3bf1	47	51	46	46	-	48	2.4	51
c77498	50	46	47	48	-	48	1.7	3.58
eeaf07	50	46	47	48	-	48	1.7	3.58
2ffb83	46	46	48	51	-	48	2.4	4.95
922aa9	47	48	49	48	-	48	0.8	1.7
3b5d16	52	48	46	48	-	48	2.5	5.19
9969d5	49	49	50	48	1	49	0.8	1.67
18e48c	50	49	50	50	-	50	0.5	11
ad374e	49	50	49	51	-	50	1	1.92
bc587d	50	54	48	49	-	50	2.6	5.23
724d7e	50	51	49	52	2	50	1.3	2.56

3.2.2 The Numerical Procedure for Determining Outliers

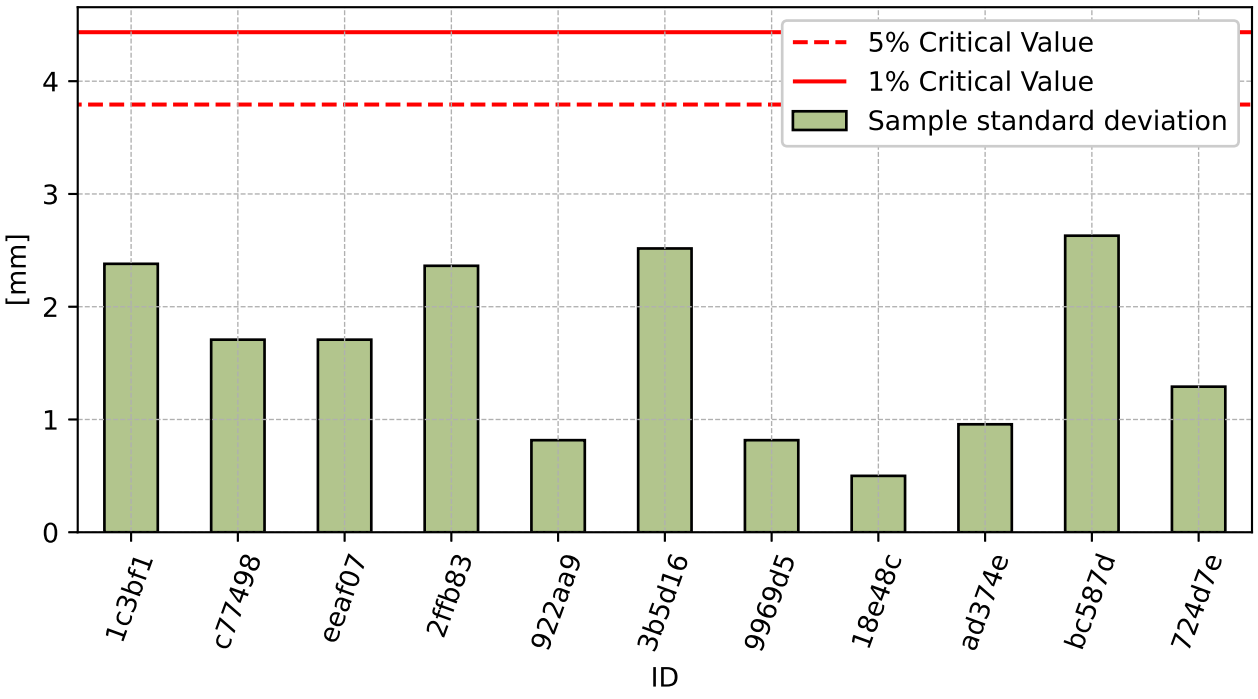

Figure 44: **Cochran's test** - sample standard deviations

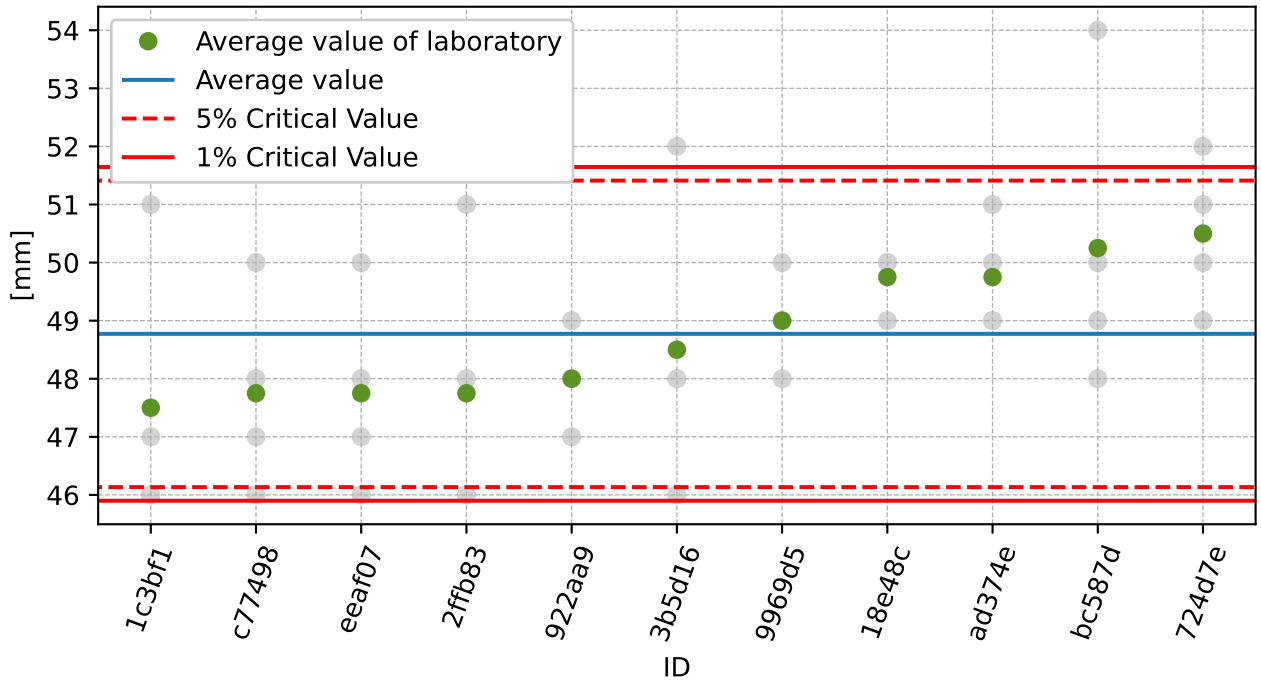

Figure 45: **Grubbs' test** - average values

3.2.3 Mandel's Statistics

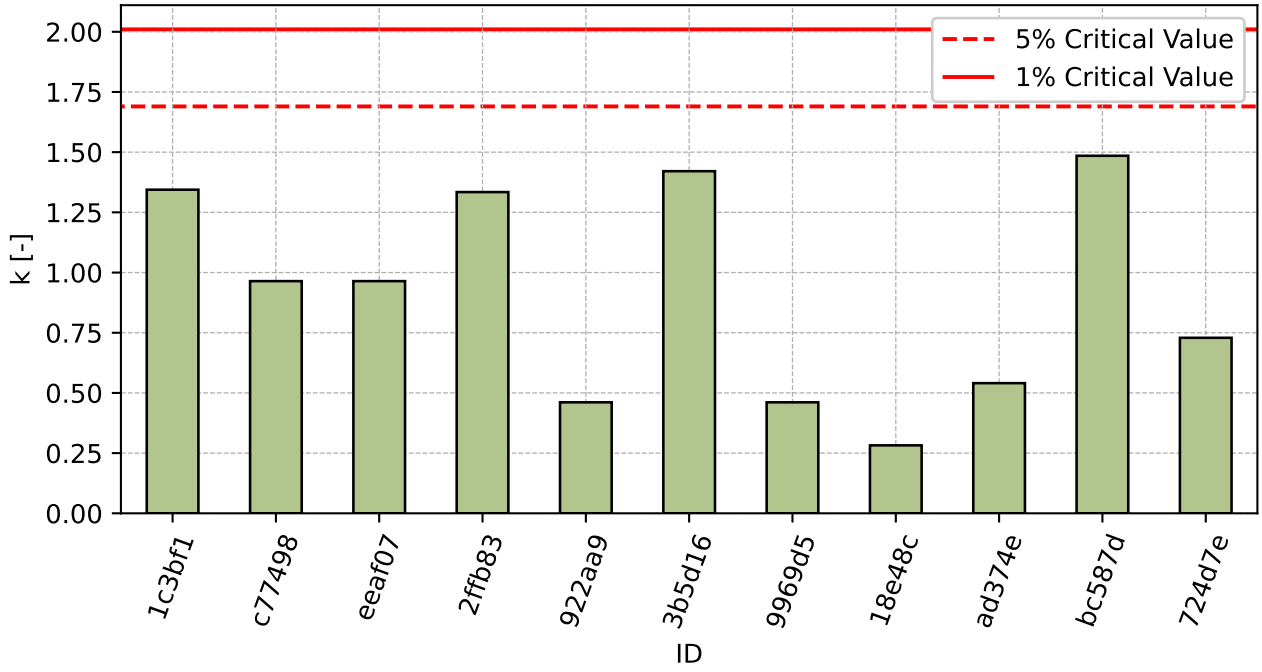

Figure 46: Intralaboratory Consistency Statistic

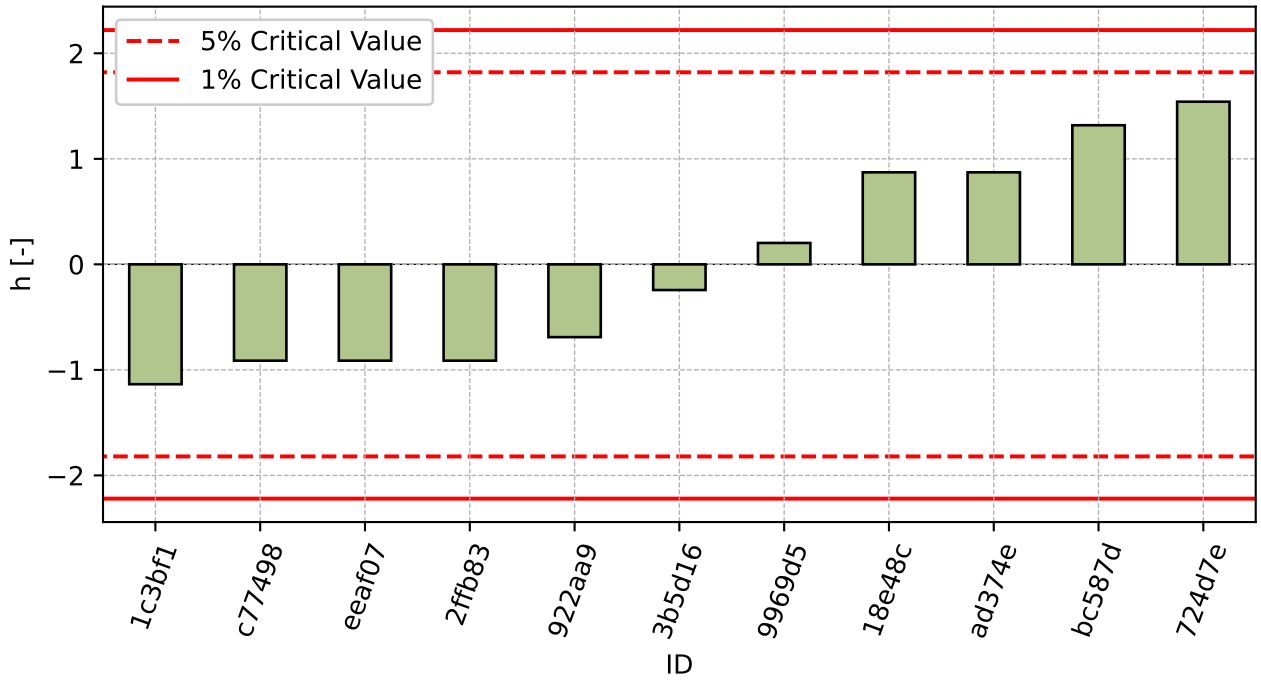

Figure 47: Interlaboratory Consistency Statistic

3.2.4 Descriptive statistics

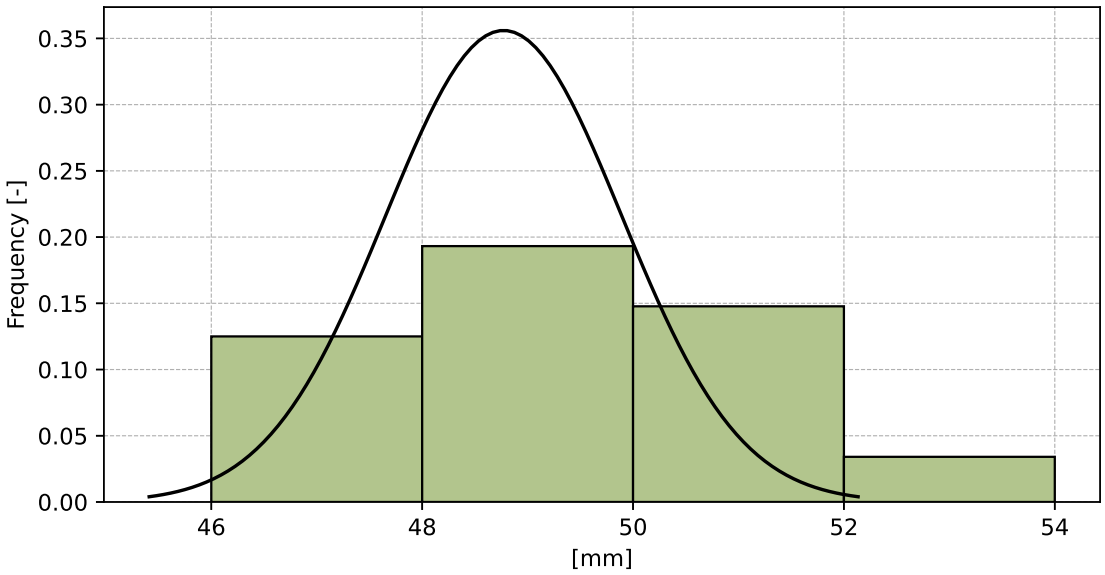

Figure 48: Histogram of all test results

Table 25: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	49
Sample standard deviation – s	1.1
Asigned value – x^*	49
Robust standard deviation – s^*	1.2
Measurement uncertainty of asigned value – u_X	0.5
p-value of normality test	0.04 [-]
Interlaboratory standard deviation – s_L	0.7
Repeatability standard deviation – s_r	1.8
Reproducibility standard deviation – s_R	1.9
Repeatability – r	5
Reproducibility – R	5

3.2.5 Evaluation of Performance Statistics

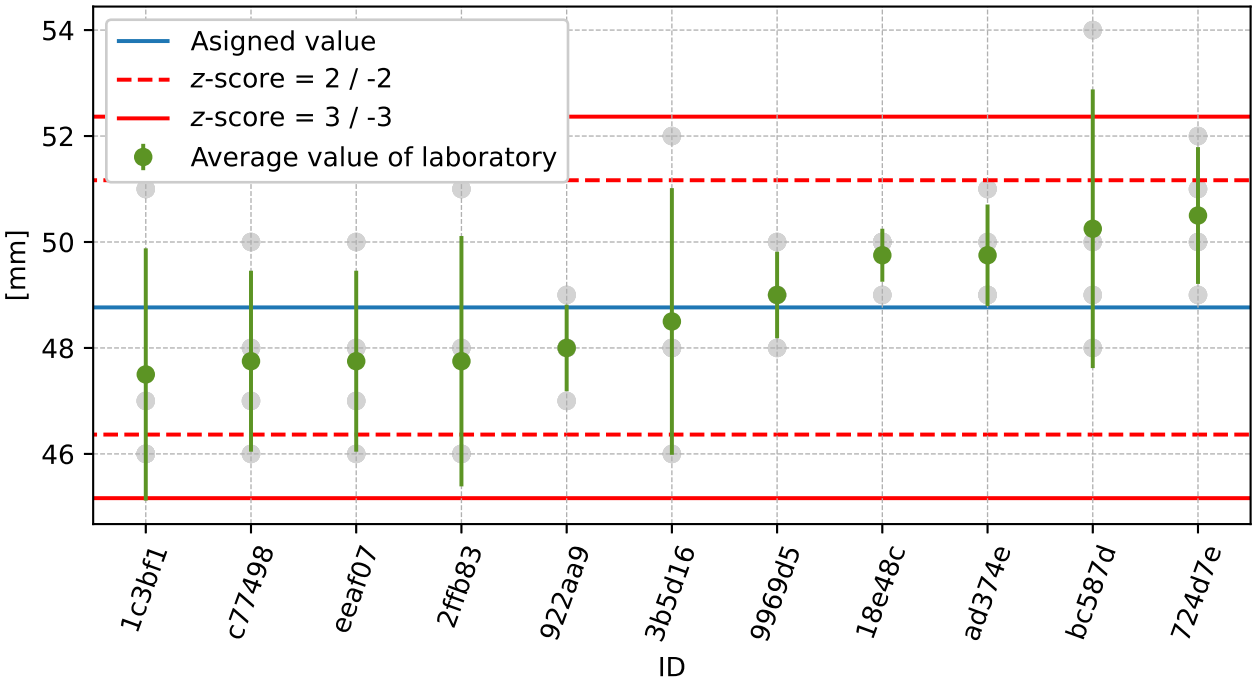

Figure 49: Average values and sample standard deviations

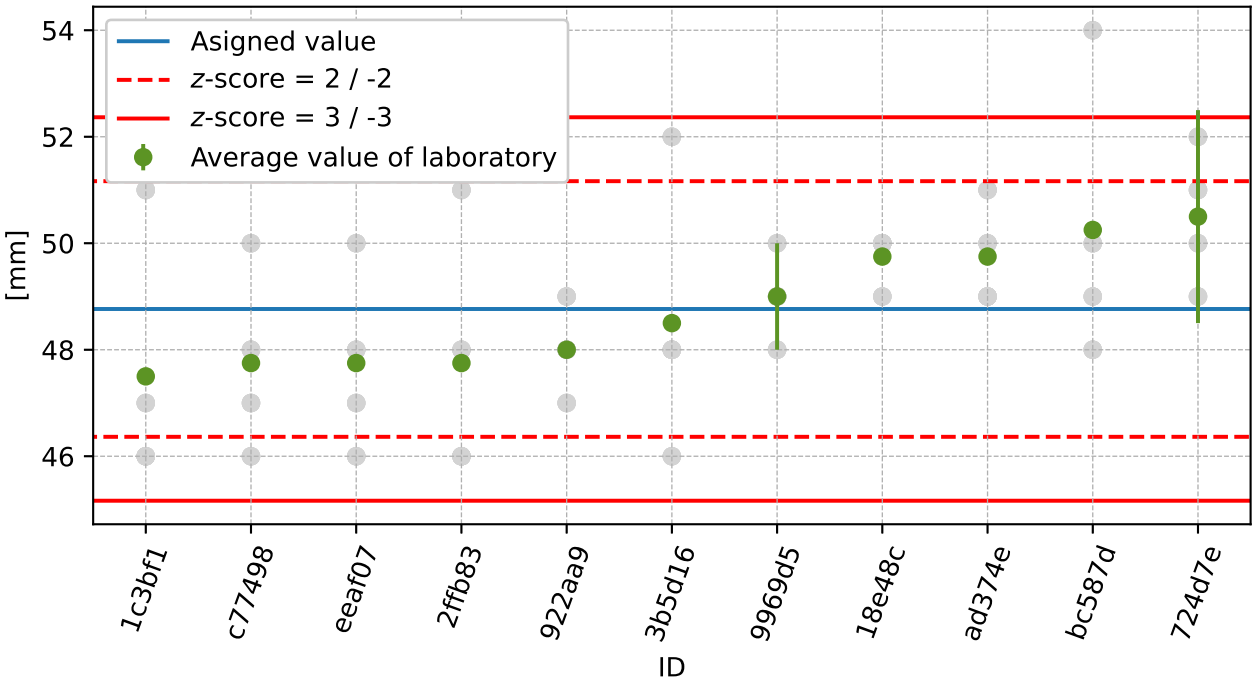

Figure 50: Average values and extended uncertainties of measurement

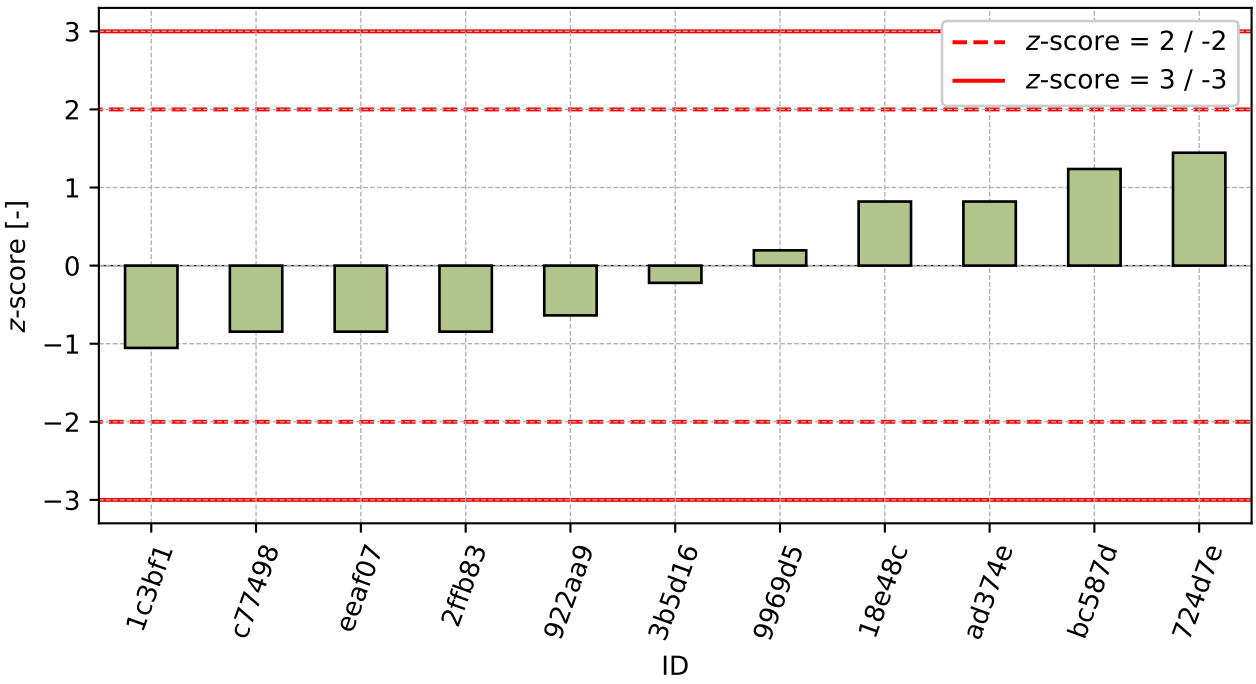

Figure 51: z-score

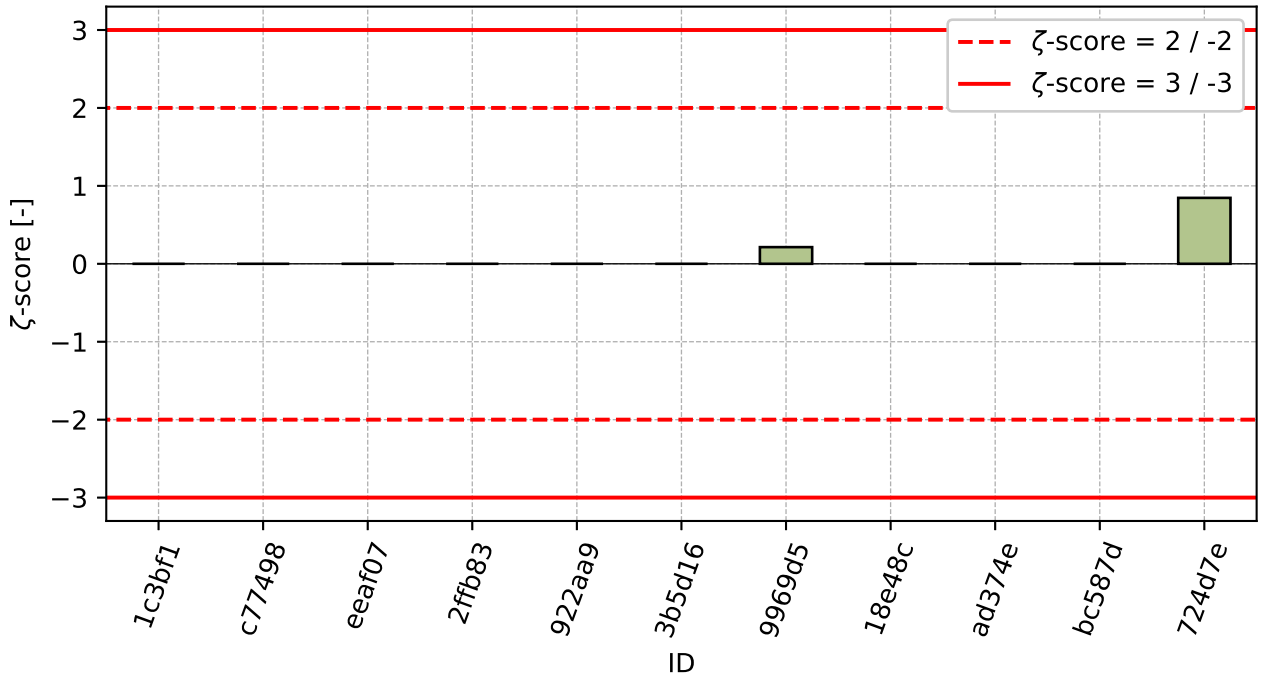

Figure 52: ζ-score

Table 26: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
1c3bf1	-1.05	-
c77498	-0.85	-
eeaf07	-0.85	-
2ffb83	-0.85	-
922aa9	-0.64	-
3b5d16	-0.22	-
9969d5	0.20	0.21
18e48c	0.82	-
ad374e	0.82	-
bc587d	1.24	-
724d7e	1.45	0.85

3.3 Base layer I

3.3.1 Test results

Table 27: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [mm]				u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
18e48c	63	65	64	66	-	64	1.3	2
ad374e	64	64	66	65	-	65	1	1.48
922aa9	65	65	64	66	-	65	0.8	1.26
3b5d16	63	69	68	65	-	66	2.8	4.16
724d7e	67	65	68	67	2	67	1.3	1.89
9969d5	67	67	65	69	1	67	1.6	2.44
1c3bf1	65	66	70	67	-	67	2.2	3.22
c77498	70	70	64	65	-	67	3.2	4.76
eeaf07	70	70	64	66	-	68	3	4.44
2ffb83	70	69	63	68	-	68	3.1	4.61
bc587d	70	69	67	71	-	69	1.7	2.47

3.3.2 The Numerical Procedure for Determining Outliers

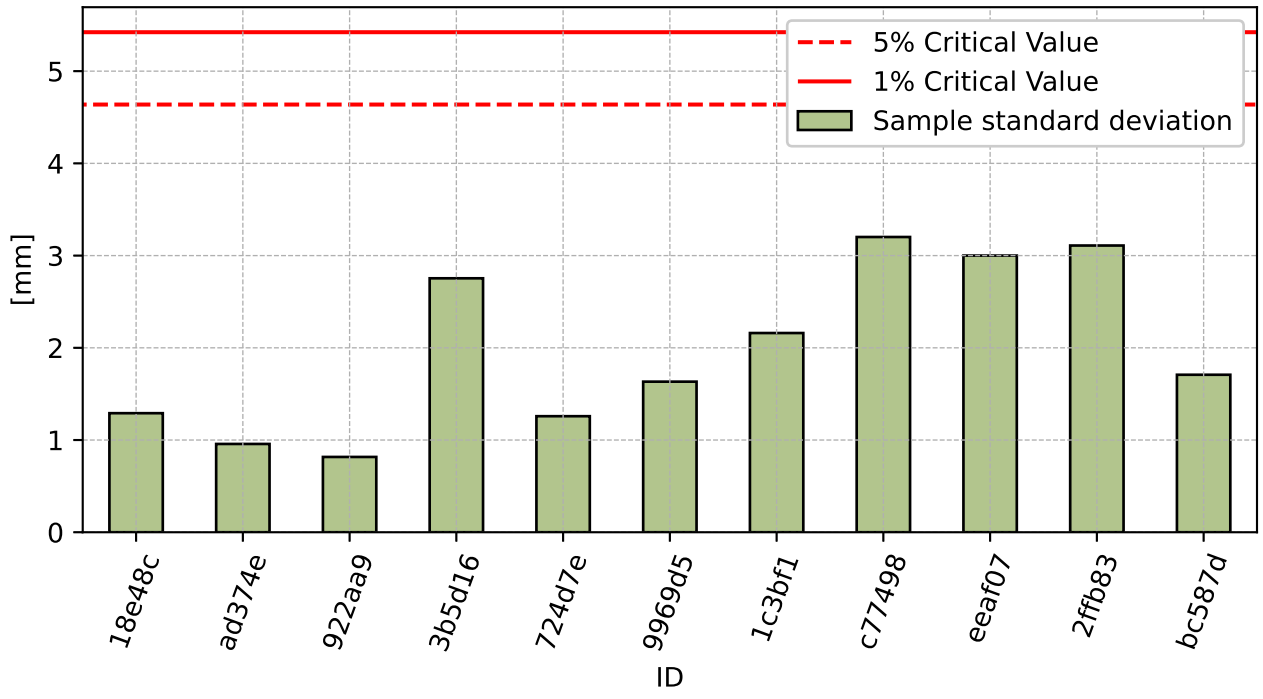

Figure 53: **Cochran's test** - sample standard deviations

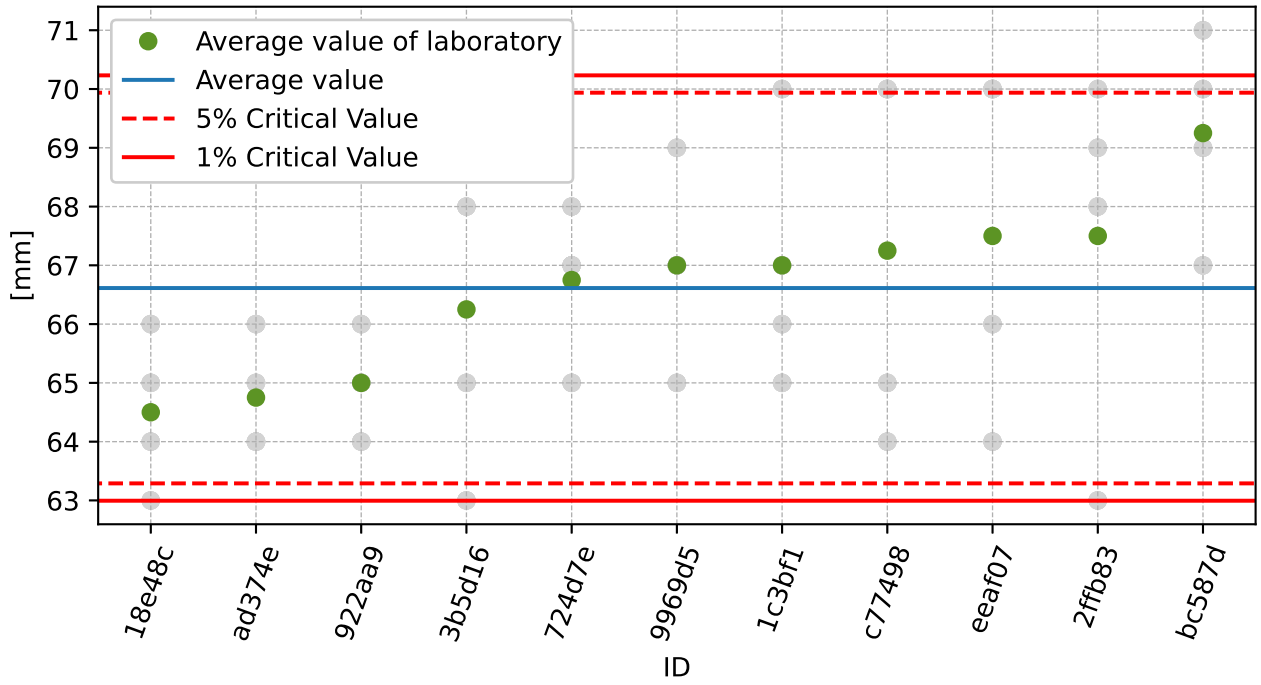

Figure 54: **Grubbs' test** - average values

3.3.3 Mandel's Statistics

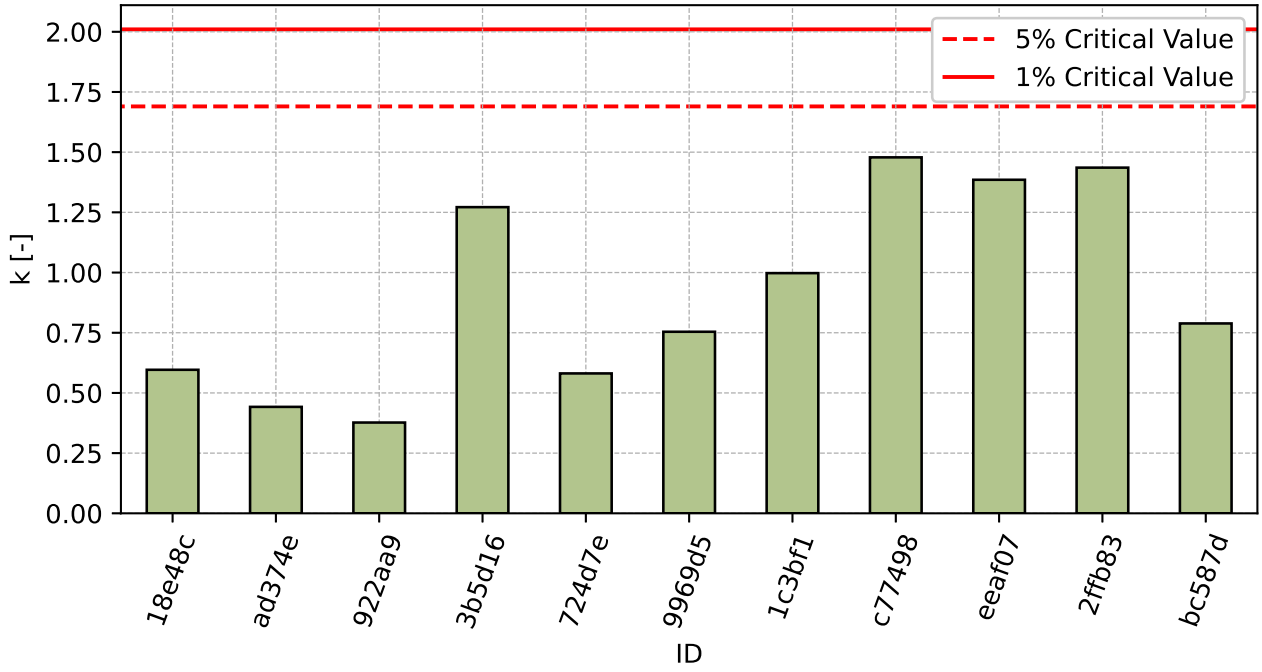

Figure 55: Intralaboratory Consistency Statistic

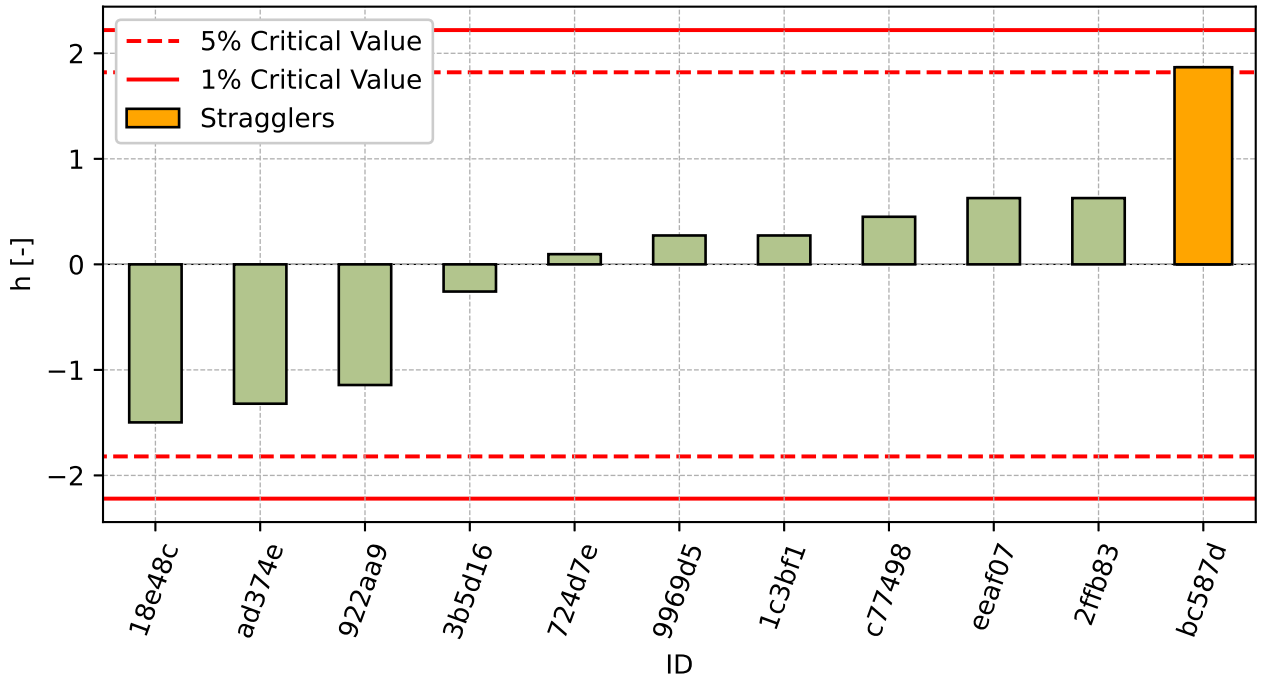

Figure 56: Interlaboratory Consistency Statistic

3.3.4 Descriptive statistics

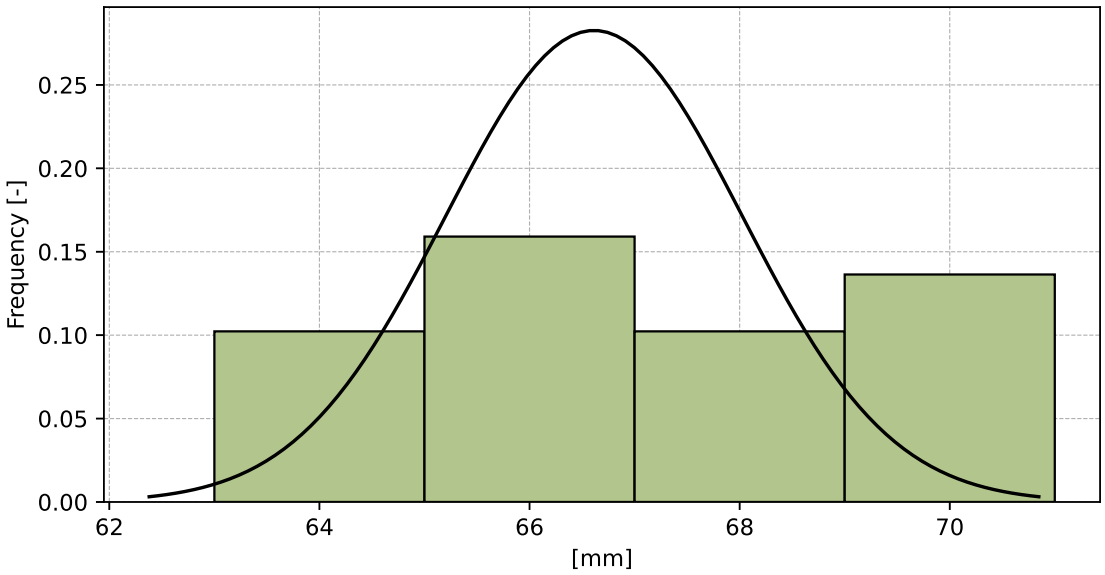

Figure 57: Histogram of all test results

Table 28: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	67
Sample standard deviation – s	1.4
Asigned value – x^*	67
Robust standard deviation – s^*	1.2
Measurement uncertainty of asigned value – u_X	0.4
p-value of normality test	0.008 [-]
Interlaboratory standard deviation – s_L	0.9
Repeatability standard deviation – s_r	2.2
Reproducibility standard deviation – s_R	2.3
Repeatability – r	6
Reproducibility – R	7

3.3.5 Evaluation of Performance Statistics

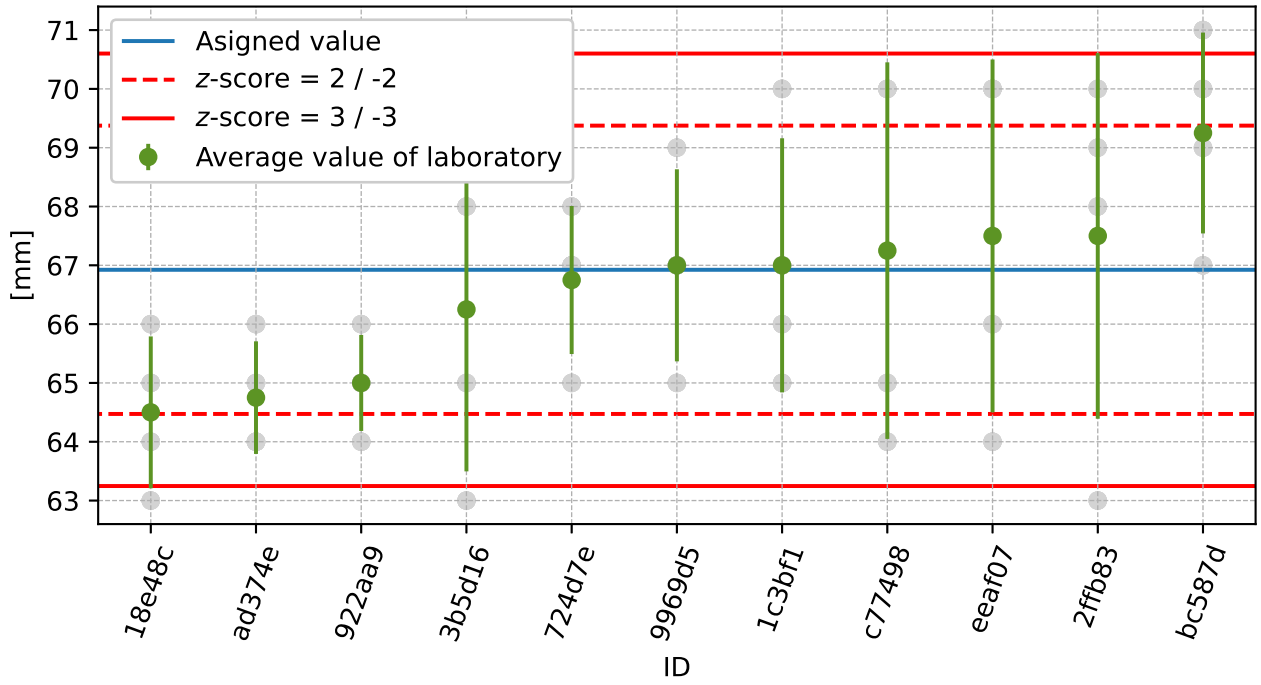

Figure 58: Average values and sample standard deviations

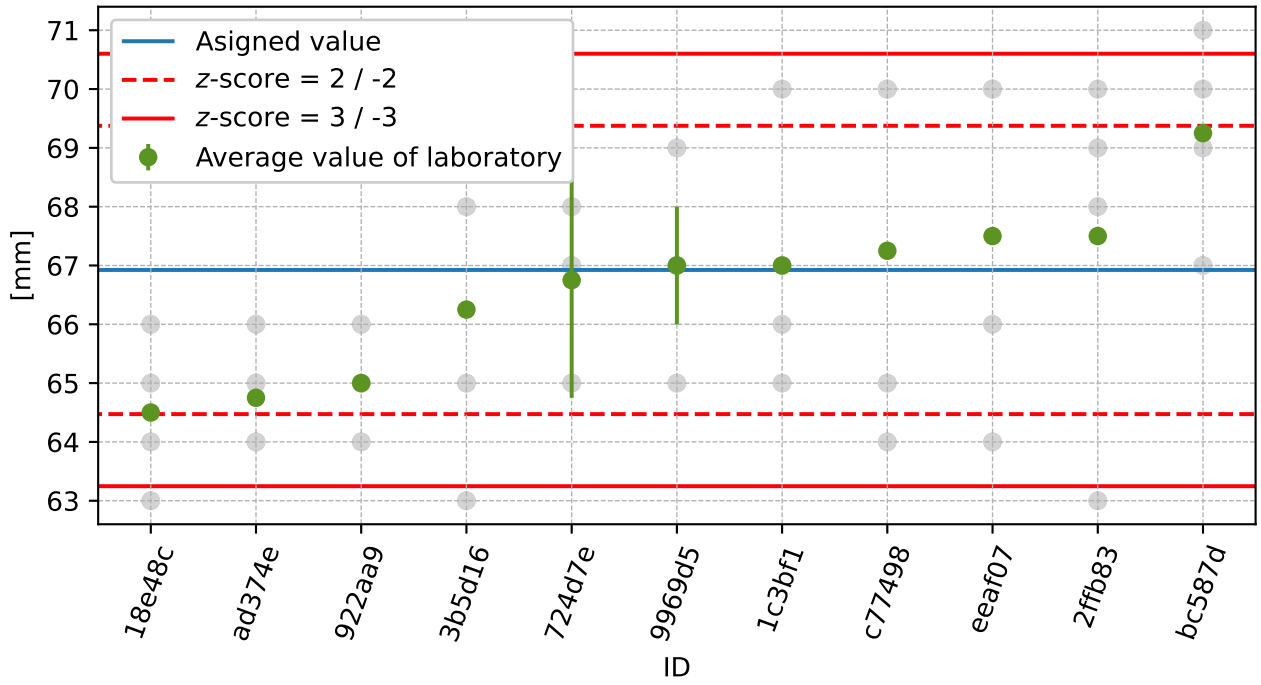

Figure 59: Average values and extended uncertainties of measurement

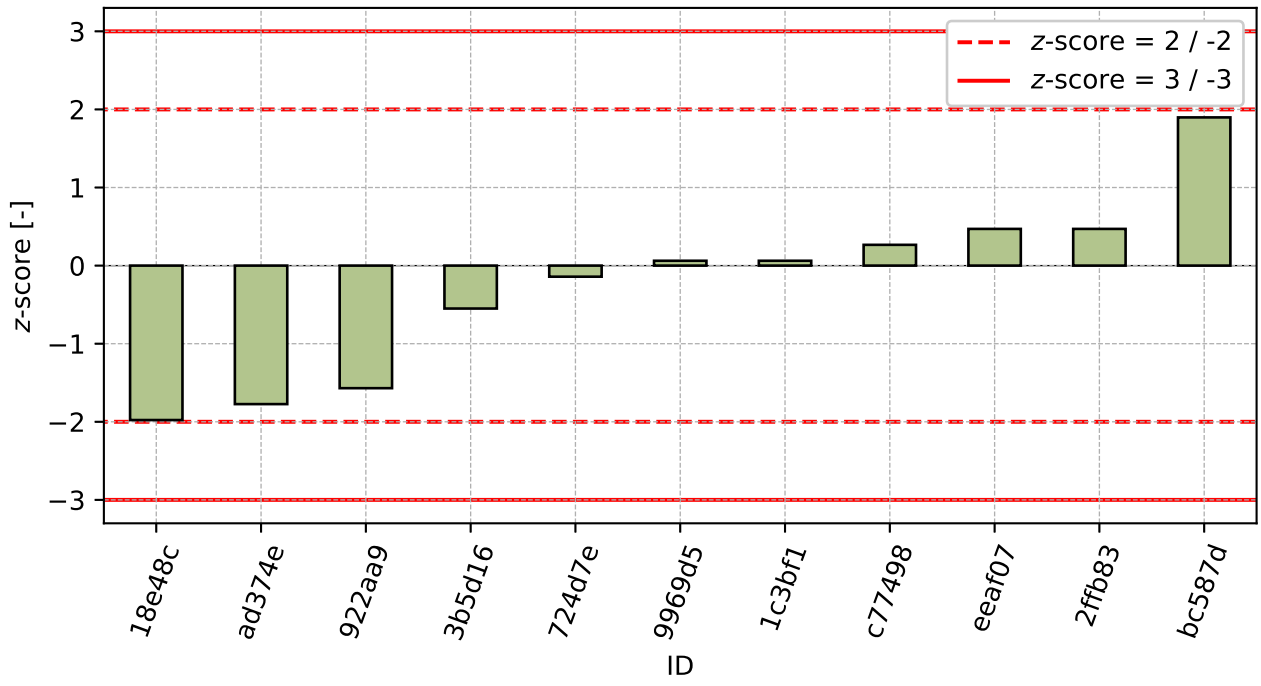

Figure 60: z-score

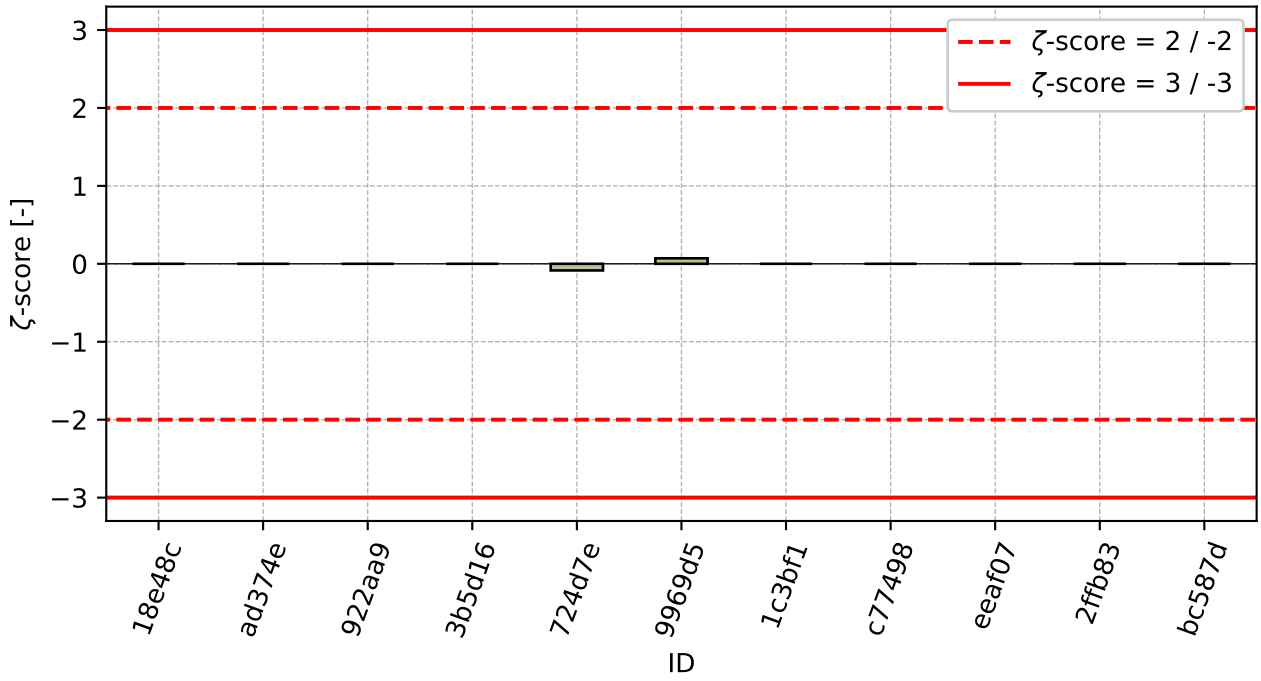

Figure 61: ζ-score

Table 29: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
18e48c	-1.98	-
ad374e	-1.77	-
922aa9	-1.57	-
3b5d16	-0.55	-
724d7e	-0.14	-0.09
9969d5	0.06	0.07
1c3bf1	0.06	-
c77498	0.27	-
eeaf07	0.47	-
2ffb83	0.47	-
bc587d	1.90	-

3.4 Base layer II

3.4.1 Test results

Table 30: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [mm]				u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
9969d5	231	231	229	230	1	230	1	0.42
eeaf07	231	232	231	234	-	232	1.4	0.61
18e48c	233	231	232	232	-	232	0.8	0.35
1c3bf1	231	230	234	234	-	232	2.1	0.89
922aa9	234	231	232	234	-	233	1.5	0.64
c77498	232	233	232	234	-	233	1	0.41
ad374e	232	234	233	232	-	233	1	0.41
2ffb83	234	235	234	229	-	233	2.7	1.16
3b5d16	232	235	232	233	-	233	1.4	0.61
bc587d	240	234	235	238	-	237	2.8	1.16
724d7e	241	242	241	240	2	241	0.8	0.34

3.4.2 The Numerical Procedure for Determining Outliers

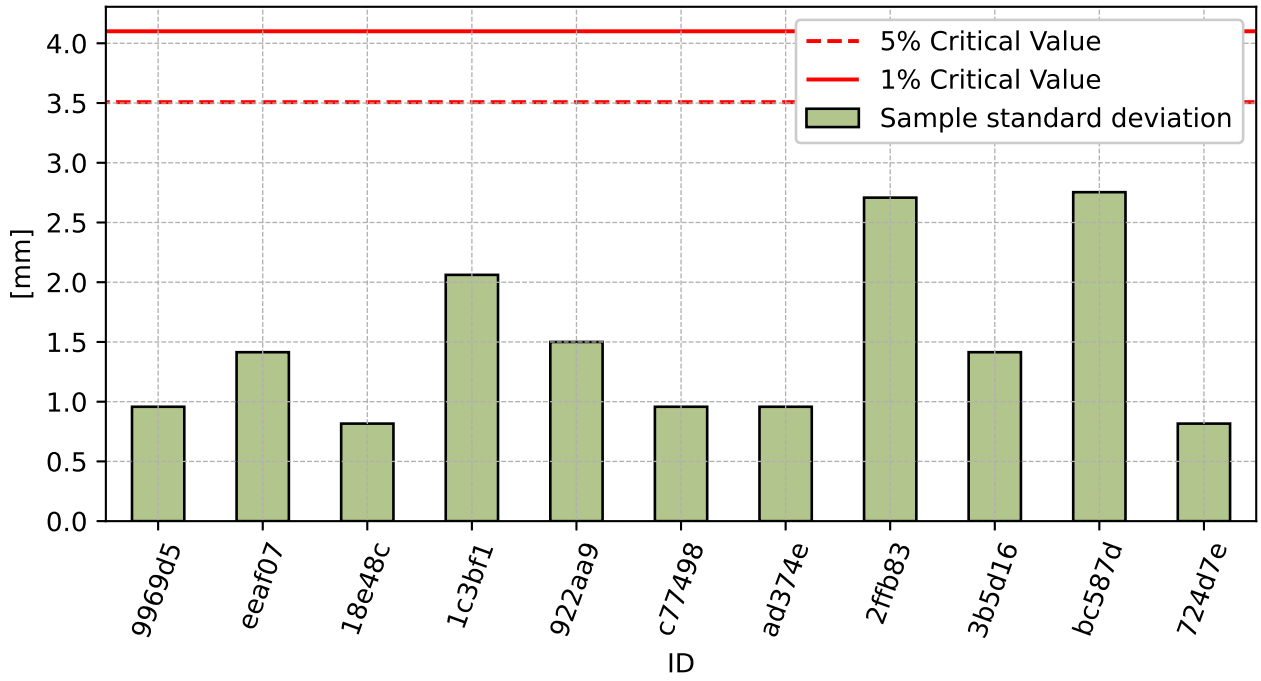

Figure 62: **Cochran's test** - sample standard deviations

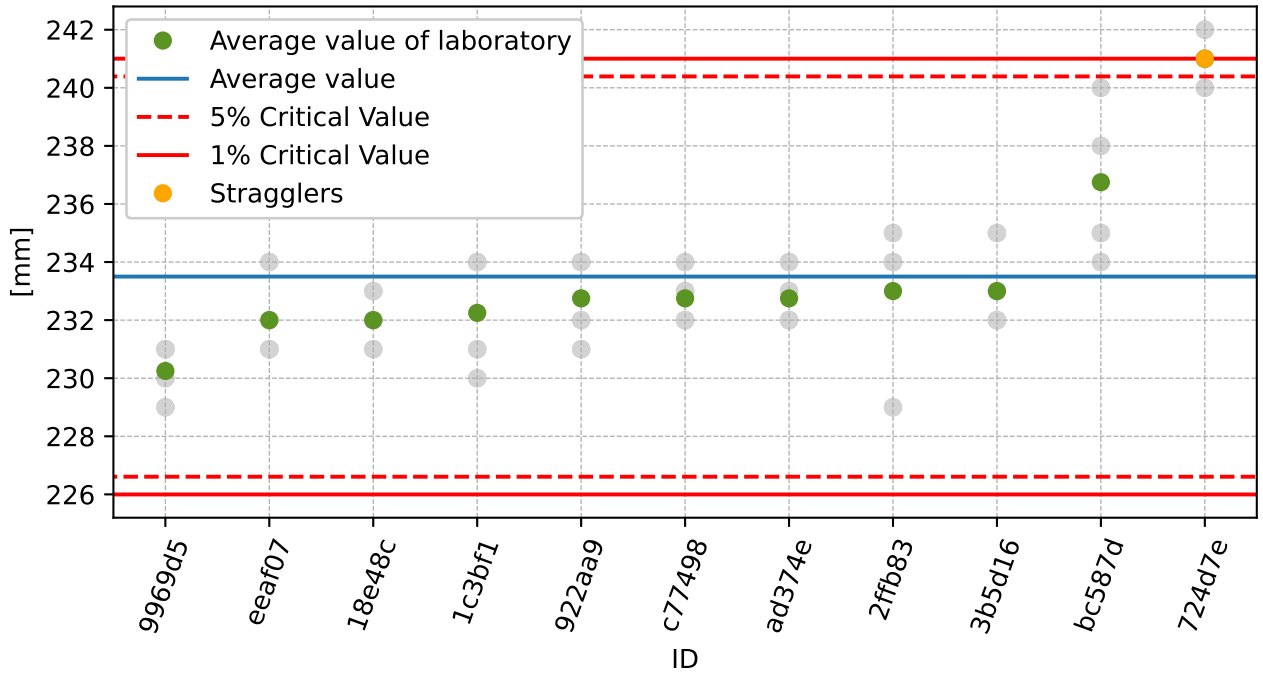

Figure 63: **Grubbs' test** - average values

3.4.3 Mandel's Statistics

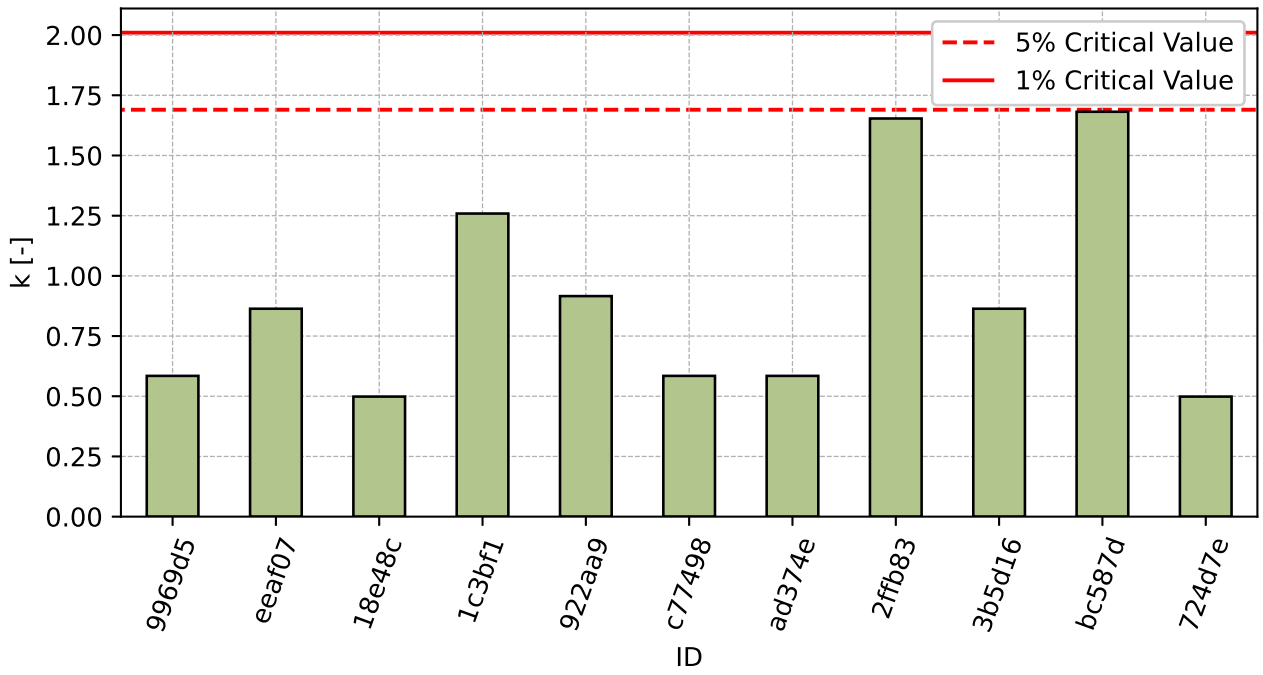

Figure 64: Intralaboratory Consistency Statistic

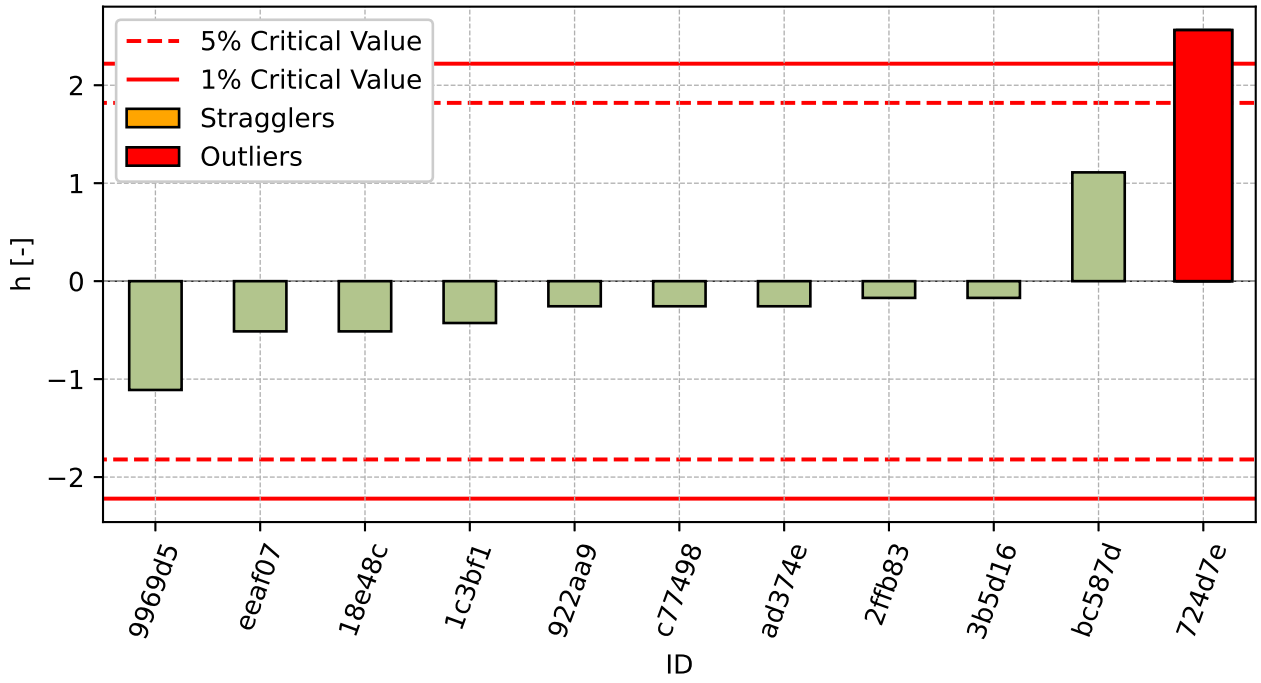

Figure 65: Interlaboratory Consistency Statistic

3.4.4 Descriptive statistics

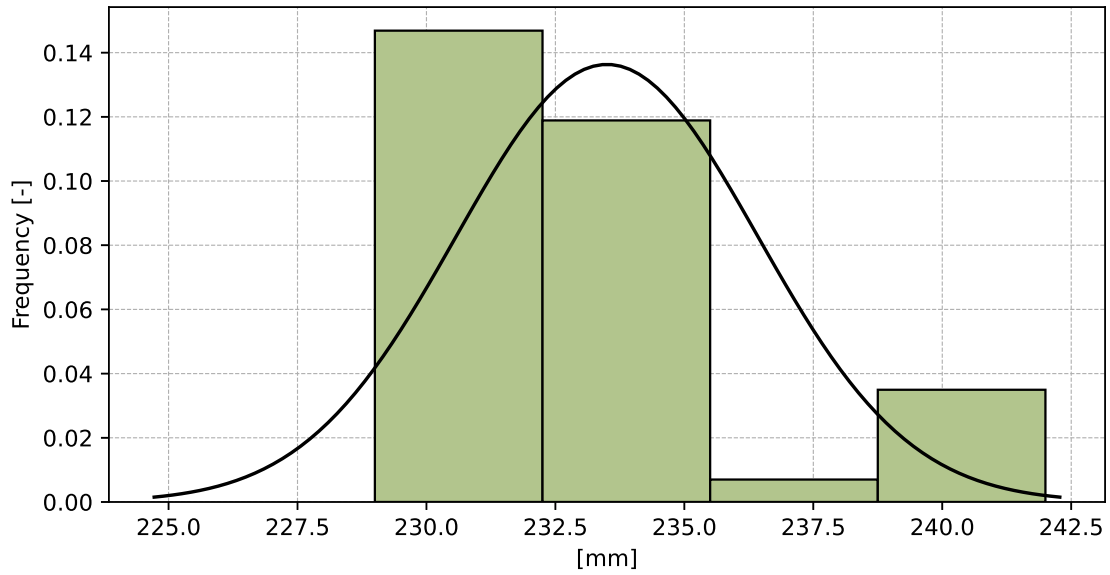

Figure 66: Histogram of all test results

Table 31: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	234
Sample standard deviation – s	2.9
Asigned value – x^*	233
Robust standard deviation – s^*	2.8
Measurement uncertainty of asigned value – u_X	1.1
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	2.8
Repeatability standard deviation – s_r	1.6
Reproducibility standard deviation – s_R	3.3
Repeatability – r	5
Reproducibility – R	9

3.4.5 Evaluation of Performance Statistics

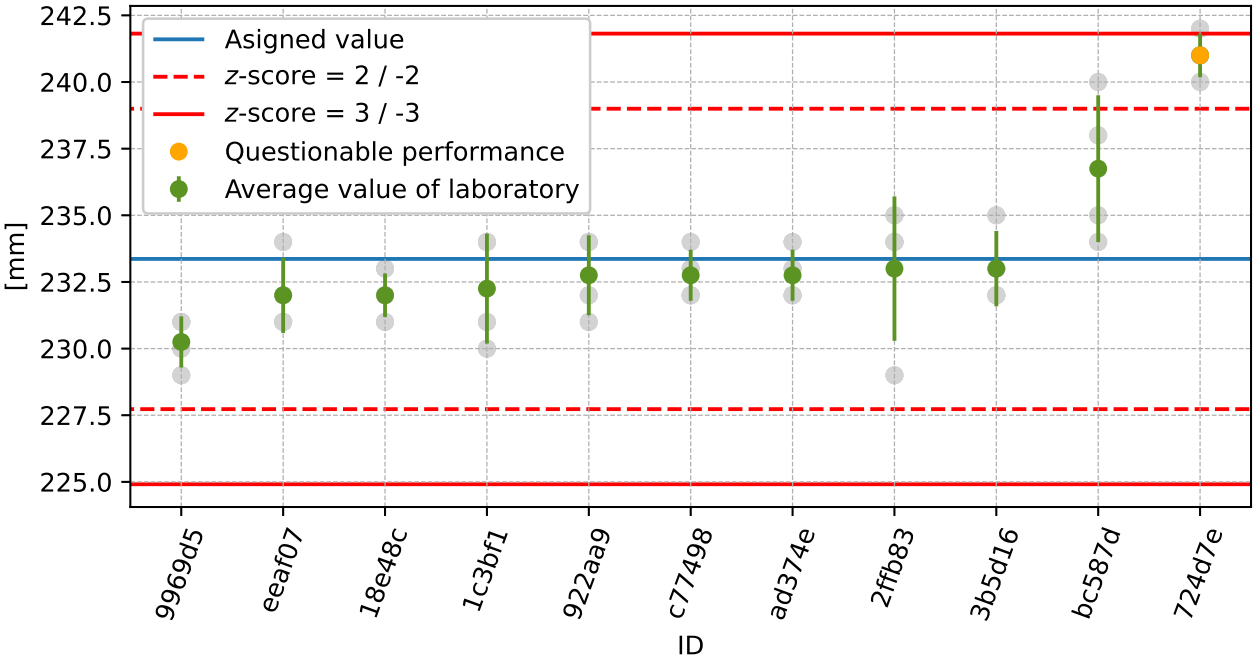

Figure 67: Average values and sample standard deviations

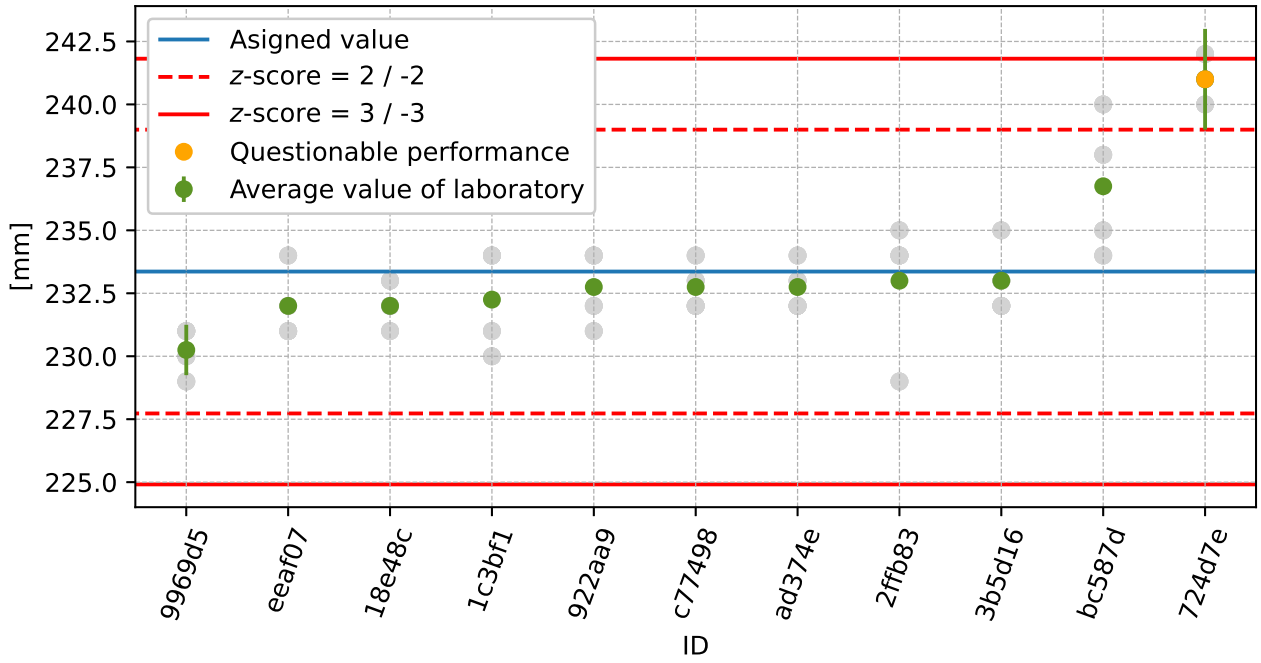

Figure 68: Average values and extended uncertainties of measurement

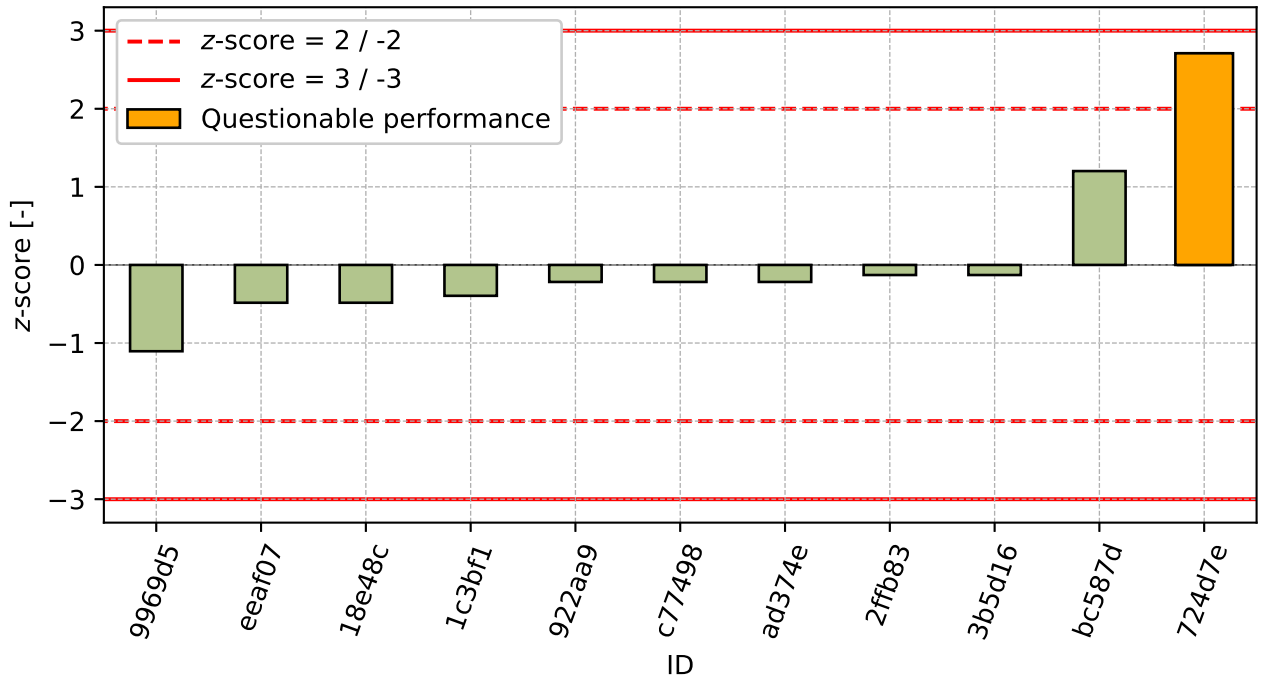

Figure 69: z-score

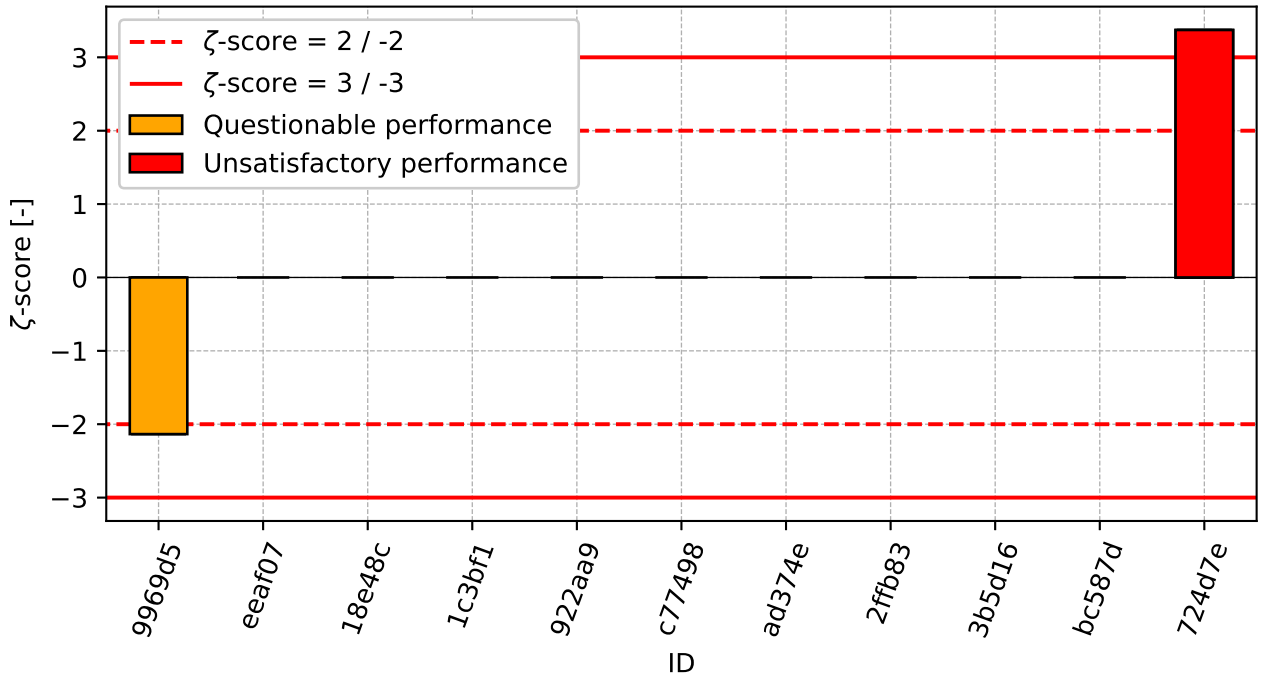

Figure 70: ζ-score

Table 32: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
9969d5	-1.11	-2.13
eeaf07	-0.48	-
18e48c	-0.48	-
1c3bf1	-0.40	-
922aa9	-0.22	-
c77498	-0.22	-
ad374e	-0.22	-
2ffb83	-0.13	-
3b5d16	-0.13	-
bc587d	1.20	-
724d7e	2.71	3.37

4 Appendix – EN 13036-1 Road and airfield surface characteristics: Test methods – Part 1: Measurement of pavement surface macrotexture depth using a volumetric patch technique

Test was not conducted due to low participant interest.

5 Appendix – EN 13036-4 Road and airfield surface characteristics: Test methods – Part 4: Method for measurement of slip/skid resistance of a surface – The pendulum test (PTV)

Test was not conducted due to low participant interest.

6 Appendix – EN 13036-7 Road and airfield surface characteristics: Test methods – Part 7: Irregularities in pavement surface levels – Longitudinal profile by direct measurement

Test was not conducted due to low participant interest.