



FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program Testing of Finished Construction Layer Treatments ZHU 2026/1

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

Date: August 25, 2026

Assoc. Prof. Ing. Tomáš Vymazal, Ph.D.
Head of the PT Provider, PTP coordinator



Ing. Petr Misák, Ph.D.
Coordinator of PTP results assessment

Contents

1 Introduction and Important Contacts	3
2 Procedures used in the Statistical Analysis of the Precision Experiment	5
3 Conclusions of the Statistical Analysis	6
3.1 Testing procedure No. 1 – Measurement of longitudinal and transverse unevenness of the pavement surface using a straightedge	6
3.2 Testing procedure No. 2 – Measurement of longitudinal unevenness of the pavement surface using a planograph	6
3.3 Testing procedure No. 3 – Determination of the thickness of an asphalt pavement	7
3.4 Overall Summary	7
Standards and Documents Used	9
Appendix	10
1 Appendix – ČSN 73 6175, Art. 8 Measurement of longitudinal and transverse unevenness of the pavement surface using a straightedge	10
1.1 Determination of longitudinal unevenness	10
1.1.1 Test results	10
1.1.2 Graphical representation	10
1.2 Determination of transverse unevenness	12
1.2.1 Test results	12
1.2.2 Graphical representation	12
2 Appendix – ČSN 73 6175, Art. 9 Measurement of longitudinal unevenness of the pavement surface using a planograph	14
2.1 Planograph measurement results	14
2.2 Overview of points above limits – Submitted data	22
2.3 Overview of points above limits – Maximum values per meter (1 m)	23
2.4 Percentage of unevenness ≤ 1 mm	24
2.4.1 Test results	24
2.4.2 The Numerical Procedure for Determining Outliers	24
2.4.3 Mandel's Statistics	25
2.4.4 Descriptive statistics	26
2.4.5 Evaluation of Performance Statistics	27
2.5 Percentage of unevenness >1 and ≤ 2 mm	28
2.5.1 Test results	28
2.5.2 The Numerical Procedure for Determining Outliers	28
2.5.3 Mandel's Statistics	29
2.5.4 Descriptive statistics	29
2.5.5 Evaluation of Performance Statistics	30
2.6 Percentage of unevenness >2 mm	31
2.6.1 Test results	31
2.6.2 The Numerical Procedure for Determining Outliers	31
2.6.3 Mandel's Statistics	32
2.6.4 Descriptive statistics	33
2.6.5 Evaluation of Performance Statistics	34
3 Appendix – EN 12697-36 Determination of the thickness of an asphalt pavement	35
3.1 Wearing course	35
3.1.1 Test results	35
3.1.2 The Numerical Procedure for Determining Outliers	35
3.1.3 Mandel's Statistics	37

3.1.4	Descriptive statistics	38
3.1.5	Evaluation of Performance Statistics	39
3.2	Binder course	42
3.2.1	Test results	42
3.2.2	The Numerical Procedure for Determining Outliers	42
3.2.3	Mandel's Statistics	44
3.2.4	Descriptive statistics	45
3.2.5	Evaluation of Performance Statistics	46
3.3	Base course I	49
3.3.1	Test results	49
3.3.2	The Numerical Procedure for Determining Outliers	49
3.3.3	Mandel's Statistics	50
3.3.4	Descriptive statistics	51
3.3.5	Evaluation of Performance Statistics	52
3.4	Base course II	55
3.4.1	Test results	55
3.4.2	The Numerical Procedure for Determining Outliers	55
3.4.3	Mandel's Statistics	56
3.4.4	Descriptive statistics	57
3.4.5	Evaluation of Performance Statistics	58
4	Appendix – EN 13036-1 Measurement of pavement surface macrotexture depth using a volumetric patch technique	61
4.1	Test results	61
4.2	The Numerical Procedure for Determining Outliers	61
4.3	Mandel's Statistics	62
4.4	Descriptive statistics	62
4.5	Evaluation of Performance Statistics	63
5	Appendix – EN 13036-4 Method for measurement of slip/skid resistance of a surface – The pendulum test (PTV)	66
5.1	Test results	66
5.2	The Numerical Procedure for Determining Outliers	66
5.3	Mandel's Statistics	67
5.4	Descriptive statistics	67
5.5	Evaluation of Performance Statistics	68
6	Appendix – EN 13036-7 Irregularity measurement of pavement courses – The straightedge test	71
6.1	Longitudinal unevenness	71
6.1.1	Test results	71
6.1.2	The Numerical Procedure for Determining Outliers	71
6.1.3	Mandel's Statistics	72
6.1.4	Descriptive statistics	73
6.1.5	Evaluation of Performance Statistics	74
6.2	Transverse unevenness	77
6.2.1	Test results	77
6.2.2	The Numerical Procedure for Determining Outliers	77
6.2.3	Mandel's Statistics	78
6.2.4	Descriptive statistics	79
6.2.5	Evaluation of Performance Statistics	80

1 Introduction and Important Contacts

In 2026, the Proficiency Testing Provider at SZK FAST (PoZZ) launched a proficiency testing programme (PTP) designated ZHU 2026/1, the aim of which was to verify and assess the consistency of the test results of finished construction layer treatments. 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.

Brno University of Technology

Faculty of Civil Engineering

Institute of Building Testing

Veveří 95, Brno 602 00

Czech Republic

Tel.: +420 603 313 337

Email: Tomas.Vymazal@vut.cz

Coordinator of PTP result assessment

Ing. Petr Misák, Ph.D.

Brno University of Technology

Faculty of Civil Engineering

Institute of Building Testing

Veveří 95, Brno 602 00

Czech Republic

Tel.: +420 774 980 255

Email: Petr.Misak@vut.cz

The subjects of proficiency testing were the following testing procedures:

1. ČSN 73 6175, Art. 8 Measurement of longitudinal and transverse unevenness of the pavement surface using a straightedge [1],
2. ČSN 73 6175, Art. 9 Measurement of longitudinal unevenness of the pavement surface using a planograph – reports and raw data to be sent to the organizer [1],
3. EN 12697-36 Determination of the thickness of an asphalt pavement [2],
4. EN 13036-1 Measurement of pavement surface macrotexture depth using a volumetric patch technique [3],
5. EN 13036-4 Method for measurement of slip/skid resistance of a surface – The pendulum test (PTV) [4],
6. EN 13036-7 Irregularity measurement of pavement courses – The straightedge test [5].

The measurement took place at one time and at one location in cooperation with the supplier SQZ, s. r. o.

The test results of the individual PTP participants are compared with each other by the method of statistical analysis of a precision experiment in accordance with ISO 5725-2 [6] and EN ISO/IEC 17043 [7]. The outcome is the present final report, which summarizes the results of the precision experiment, including the statistical evaluation.

14 laboratories took part in the programme in total. In order to maintain the anonymity of the PTP participants, each laboratory was assigned an identification number that will be used henceforth in this document. An integral part of the present final report is the Certificate of Participation in the Proficiency Testing Program, which is unique for each participant and states the participant's ID used in this report. The following table shows the participation of laboratories in the individual parts of the PTP.

Table 1: Participation of individual laboratories in the PTP

ID/Method	1	2	3	4	5	6
07c8f3	X	-	-	-	-	-
8a8a6b	X	X	X	-	-	-
fbd2df	-	X	X	-	-	-
3ce9a9	-	-	-	X	X	X
4bc4e9	X	X	X	-	-	-

Continued on next page

Continued from previous page

ID/Method	1	2	3	4	5	6
3b3783	X	-	-	-	-	-
cced85	X	X	X	-	-	-
66aaab	-	X	-	-	-	-
73d85a	-	-	X	X	X	X
56c28f	-	-	X	-	-	-
688512	X	X	X	X	X	X
511cb0	-	-	-	-	X	X
e23d26	X	X	X	X	X	X
6d40bf	X	X	X	X	-	-

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

Laboratory	Address	Accreditation number
Asphalt Pavement Institute APIAN doo - Beograd	Asfaltna baza 1, Ruma, 22400, Srbija	ATS-01/565
LABORATORIJSKI PUTNI CENTAR DOO	Boska Petrovica 3, Novi Sad, 21000, Serbia	01-531
SQZ, s.r.o. - organizačná zložka Bratislava, pracovisko Banská Bystrica	Mlynské Nivy 68, Bratislava, 82105, Slovensko	S-376
SQZ, s.r.o. - organizačná zložka Bratislava, pracovisko Banská Bystrica	Mlynské Nivy 68, Bratislava, 82105, Slovensko	S-376
SQZ, s.r.o. - organizačná zložka Bratislava, pracovisko Bratislava	Mlynské Nivy 68, Bratislava, 82105, Slovensko	S-376
SQZ, s.r.o. - organizačná zložka Bratislava, pracovisko Žilina	Mlynské Nivy 68, Bratislava, 82105, Slovensko	S-376
Slovenská správa ciest	Dúbravská cesta 3, Bratislava, 841 04, Slovenská republika	S-281
VIALAB CZ s.r.o. - CL07 Hradec Králové	Piletická 498, Hradec Králové, 503 41, Česká republika	L 1112
VIALAB CZ s.r.o. - CL12 Liberec	Piletická 498, Hradec Králové, 503 41, Česká republika	L 1112
VIALAB CZ s.r.o., laboratoř Čechy západ, pracoviště Letkov u Plzně	VIALAB CZ s.r.o., MUCODE 1593, PO Box 207,, Praha 6, 160 41, Česká republika	1524
VIALAB CZ, s.r.o. - Laboratoř Morava, pracoviště LM1 Zlín	U Michelského lesa 1581/2, Praha 4, 14000, Česká republika	1170
VIALAB CZ, s.r.o. - Laboratoř Morava, pracoviště LM3 Brno	U Michelského lesa 1581/2, Praha 4, 14000, Česká republika	1170
VIALAB CZ, s.r.o. - Laboratoř Morava, pracoviště LM4 Ostrava	U Michelského lesa 1581/2, Praha 4, 14000, Česká republika	1170
Ředitelství silnic a dálnic s. p.	Čerčanská 2023/12, Praha 4 - Krč, 140 00, Česká republika	1072

2 Procedures used in the Statistical Analysis of the Precision Experiment

The statistical evaluation of the PT Program consists of the following steps:

1. Evaluation of intralaboratory variabilities by Cochran's C test: If the 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 exceeding the 1% 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 exceeding the 1% critical value, the participant's results are 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 with respect to the number of observations, also of the repeatability and reproducibility.
5. Calculation 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 the measurement uncertainties. The 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. 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 a warning 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 by the Proficiency Testing Provider at SZK FAST can be found in full at <http://ptprovider.cz/?lang=en>.

3 Conclusions of the Statistical Analysis

The present report summarizes the results of the Proficiency Testing Program ZHU 2026/1 (PT Program) organized by the Proficiency Testing Provider at the SZK FAST. A total of 14 laboratories took part in the PT Program. The program focused on ordinary standardized tests of finished pavement surface treatments. The test results are evaluated separately for each testing procedure examined. The evaluated statistical characteristics, the results of the tests performed and the graphical presentations form part of the Appendix to this report. The designation of the testing procedures is given in part 1 of this report.

In the case of testing procedures 1 and 2, a full statistical analysis could not be performed. The method of evaluation is described in parts 3.1 and 3.2. The overall evaluation of the performance of participants is given in part 3.4.

3.1 Testing procedure No. 1 – Measurement of longitudinal and transverse unevenness of the pavement surface using a straightedge

The longitudinal unevenness was measured by the participants at the same time on a single 100 m long test section, on which the organizer marked points at 2 m intervals. The measurement was therefore carried out at 25 chainages. The last chainage was not evaluated within the experiment, because most participants did not submit results for it. The chainages were numbered 1 to 24.

Given the precision of the test method according to ČSN 73 6175, Art. 8 [1] (1 mm), a complete statistical evaluation could not be performed. Within the precision experiment, the results of this test were therefore assessed by comparing the values measured by the individual participants at each chainage separately.

Outlying values were identified using the criterion of 1.5 times the interquartile range (IQR) by means of a box plot (see Appendix 1.1). The data were subsequently assessed as a multi-level experiment and an analysis of the participants' results across all chainages was carried out.

The criterion for an evaluation other than satisfactory was set at 50 %. A participant therefore had to have outlying results at more than half of the chainages for their overall performance to be evaluated as questionable. Such a high threshold reflects the fact that the test method has a precision of 1 mm and that, with a small number of participants, the interquartile range narrows to such an extent that a lower criterion would also flag differences at the level of the rounding error. The highest proportion of outlying results found was 30 % of the chainages, and therefore, on the basis of the analysis carried out in this way, the performance of all participants can be declared **satisfactory**.

The transverse unevenness was measured by the participants on the same test section, at predefined locations spaced 20 m apart. The measurement was therefore carried out at five chainages designated A to E.

As the participants' test results differ only by very small multiples of the rounding error, a complete statistical evaluation could not be performed. Appendix 1.2 therefore presents only the test results obtained, together with the basic descriptive characteristics. The final performance evaluation was carried out by expert judgement, which shows that the participants' results do not differ in a statistically significant manner. The performance of all participants can therefore be declared **satisfactory**.

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

In the first stage, the participants of the experiment were required to submit the numbers of detected irregularities greater than 4 mm and 8 mm. However, given the character of the section under investigation, no participant recorded a value higher than 4 mm. On the basis of this finding, the assessment criteria were modified and set to three intervals: 0 to 1 mm, 1 to 2 mm, and greater than 2 mm.

The participants subsequently sent the organizer the complete measurement record in XLSX or another format. The recording frequency differed between participants. In order to ensure a uniform evaluation, all data were therefore converted to a common structure – the measured section was divided into 200 one-metre intervals and the maximum measured unevenness value was determined for each interval.

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

The Appendix contains both the graphs of the original records submitted by the participants and the graphs of the recalculated maximum values per one metre, which allows a direct comparison of the original data with the uniformly processed results. The data are further presented in the Appendix in the form of stacked bar charts, in which the proportions of the individual categories are shown for all IDs.

The statistical evaluation was subsequently carried out on the percentages of the detected irregularities in the three intervals mentioned. This evaluation is presented in parts 2.4 to 2.6 of the Appendix.

The results of the laboratory designated **fbd2df** were identified as outlying in two of the three intervals. The results of this laboratory were therefore overall marked as **outlying**. The performance of all other laboratories could be declared **satisfactory**.

3.3 Testing procedure No. 3 – Determination of the thickness of an asphalt pavement

This testing procedure was evaluated as a multi-level experiment; the levels are the four layers of the core drill sample. An evaluation other than satisfactory became the overall evaluation of the test only when the critical values were exceeded at at least three of the four levels. This is because the layers differ in both thickness and homogeneity, so a deviation at a single one of them does not indicate anything about the competence of the laboratory as a whole.

On the basis of the analysis carried out in this way, the performance of laboratory **73d85a** is evaluated as **questionable** – its results were outlying at two layers and questionable at one. The performance of all other participants is **satisfactory**.

3.4 Overall Summary

Table 3: Evaluation of participants' performance and outliers.

✓ – satisfactory performance; ? – questionable performance; ! – unsatisfactory performance, X – outlying result

Table 3: Evaluation of participants performance

ID / Method	1	2	3	4	5	6
07c8f3	✓	-	-	-	-	-
3b3783	✓	-	-	-	-	-
3ce9a9	-	-	-	✓	✓	✓
4bc4e9	✓	✓	✓	-	-	-
511cb0	-	-	-	-	✓	✓
56c28f	-	-	✓	-	-	-
66aaab	-	✓	-	-	-	-
688512	-	✓	✓	✓	✓	✓
6d40bf	-	✓	✓	✓	-	-
73d85a	-	-	?	✓	✓	✓

Continued on next page

Continued from previous page

ID / Method	1	2	3	4	5	6
8a8a6b	✓	✓	✓	-	-	-
cced85	✓	✓	✓	-	-	-
e23d26	-	✓	✓	✓	✓	✓
fbd2df	-	X	✓	-	-	-

References

- [1] ČSN 73 6175. *Measurement and evaluation of road surface roughness*. 2009.
- [2] EN 12697-36. *Bituminous mixtures - Test methods - Part 36: Determination of the thickness of bituminous pavement*. 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: Irregularity measurement of pavement courses: the straightedge test*. 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 unevenness of the pavement surface using a straightedge

1.1 Determination of longitudinal unevenness

1.1.1 Test results

Table 4: Test results – Longitudinal unevenness. Outlying values (beyond 1.5 times the interquartile range) are marked in red. Chainage is numbered 1 to 25.

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	25
07c8f3	1	1	2	4	3	2	3	1	1	1	2	2	2	1	2	3	3	2	1	2	1	1	2	3	4
8a8a6b	2	2	4	4	3	2	3	0	0	0	1	1	3	1	3	3	0	2	0	2	0	2	0	3	0
4bc4e9	1	1	2	2	2	0	0	0	0	2	2	2	1	2	2	1	0	2	2	0	0	1	2	3	
3b3783	1	1	2	2	2	0	0	0	0	2	2	2	1	2	2	1	0	2	2	0	0	1	2	3	
cced85	1	1	2	2	2	0	0	0	0	2	2	2	1	2	2	1	0	2	2	0	0	1	2	3	

1.1.2 Graphical representation

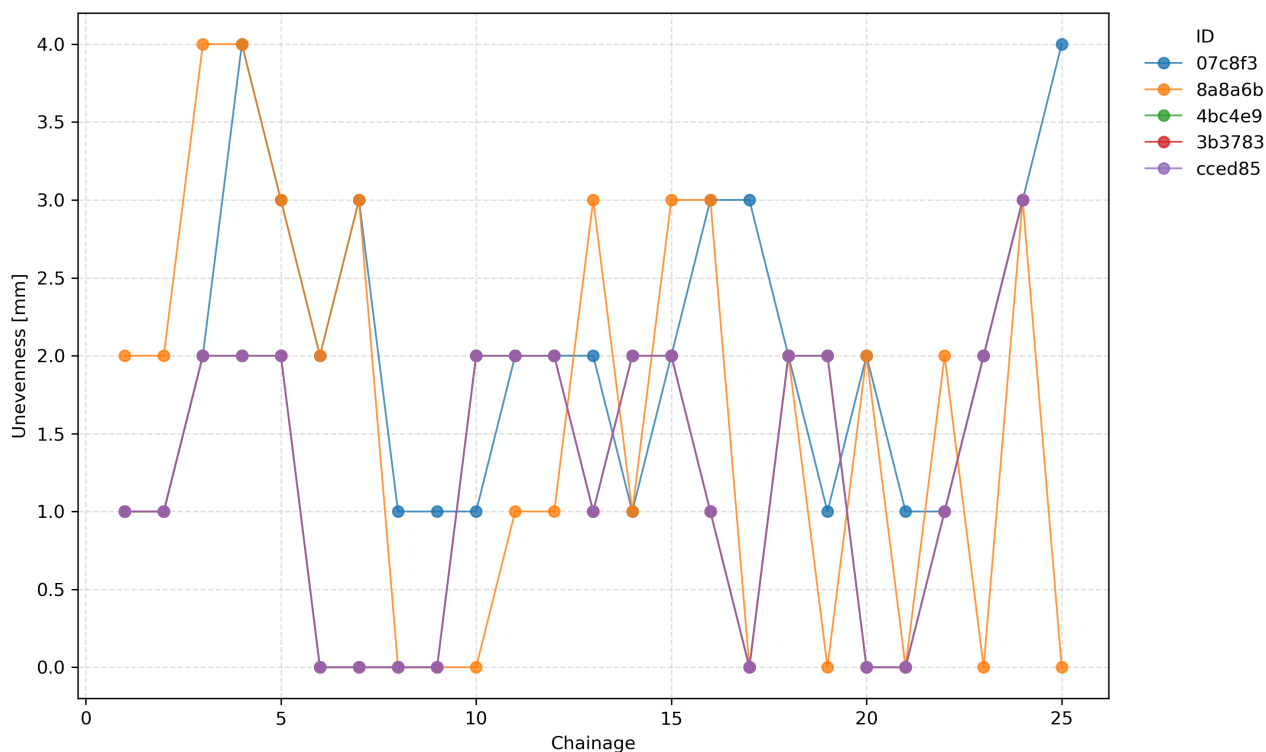


Figure 1: Measured unevenness along the chainage for individual participants.

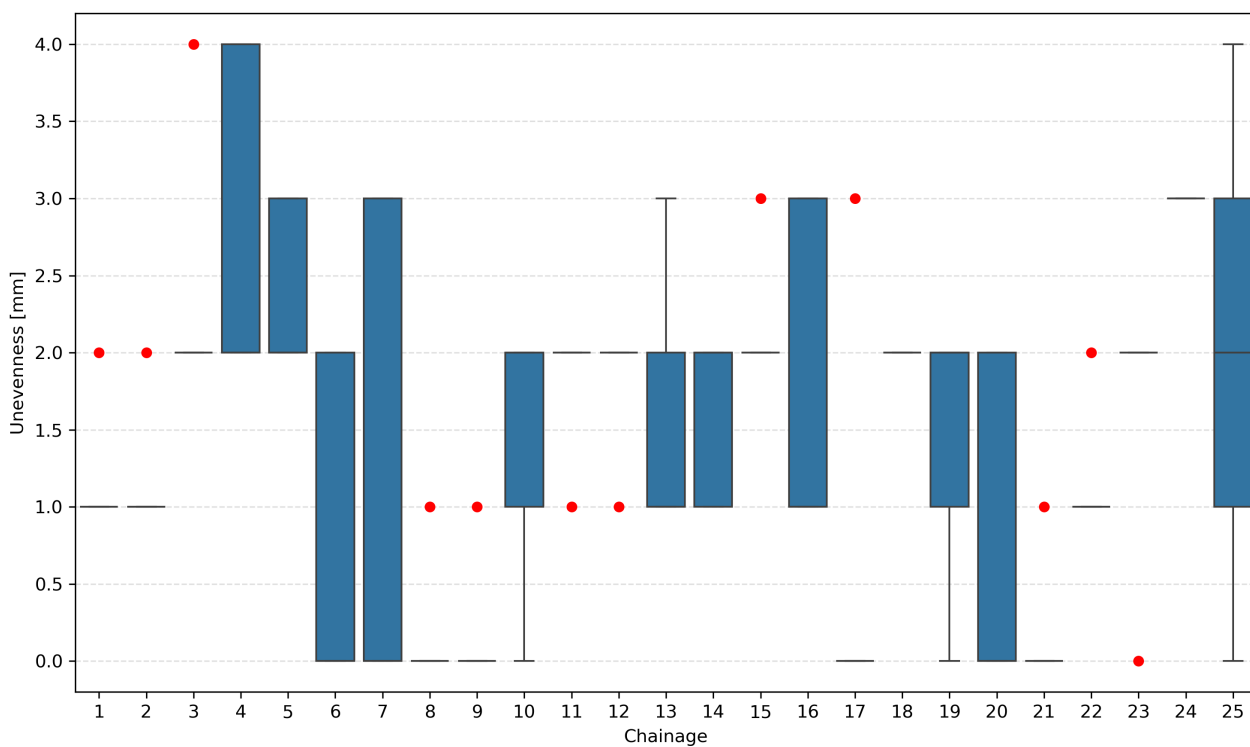


Figure 2: Box plot of test results including identification of outlying values.

1.2 Determination of transverse unevenness

1.2.1 Test results

Table 5: Test results – Transverse unevenness. Outlying values (beyond 1.5 times the interquartile range) are marked in red. Chainage is numbered 1 to 5.

ID	1	2	3	4	5
07c8f3	1	1	1	1	1
8a8a6b	0	1	1	0	0
4bc4e9	3	0	1	1	0
3b3783	3	0	1	1	0
cced85	3	0	1	1	0

1.2.2 Graphical representation

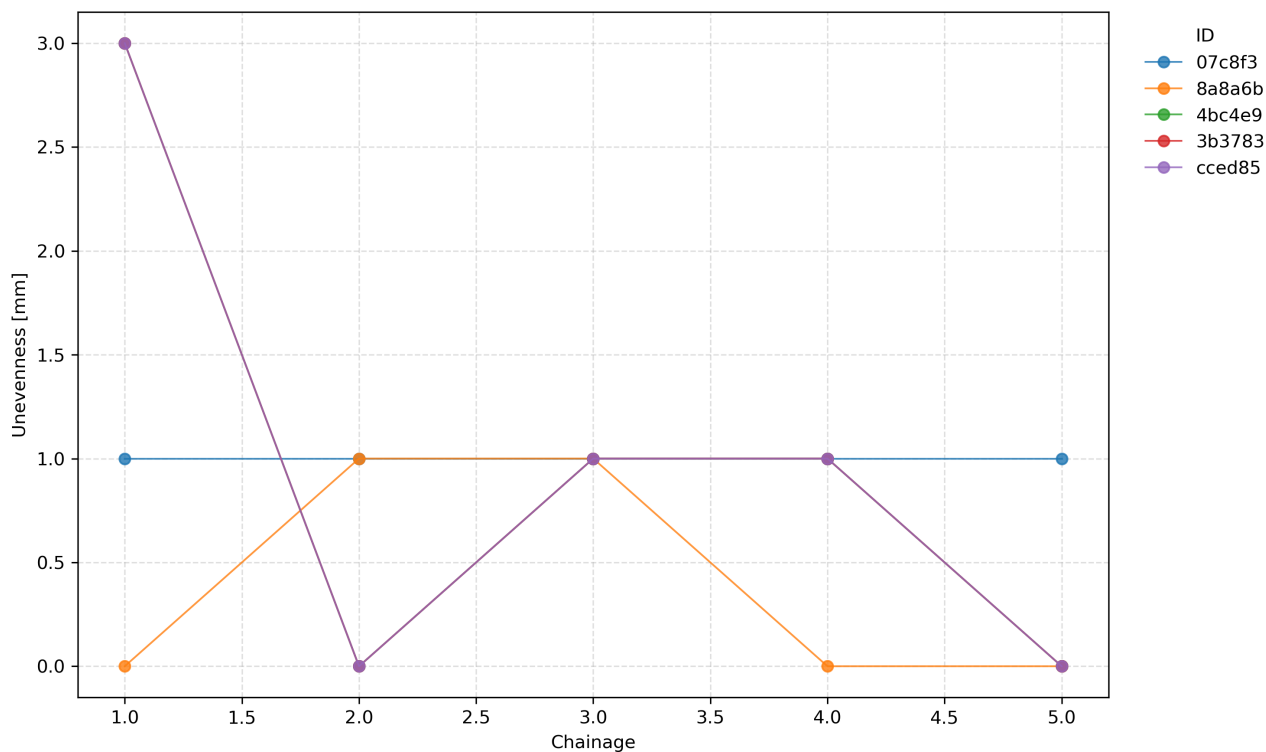


Figure 3: Measured unevenness along the chainage for individual participants.

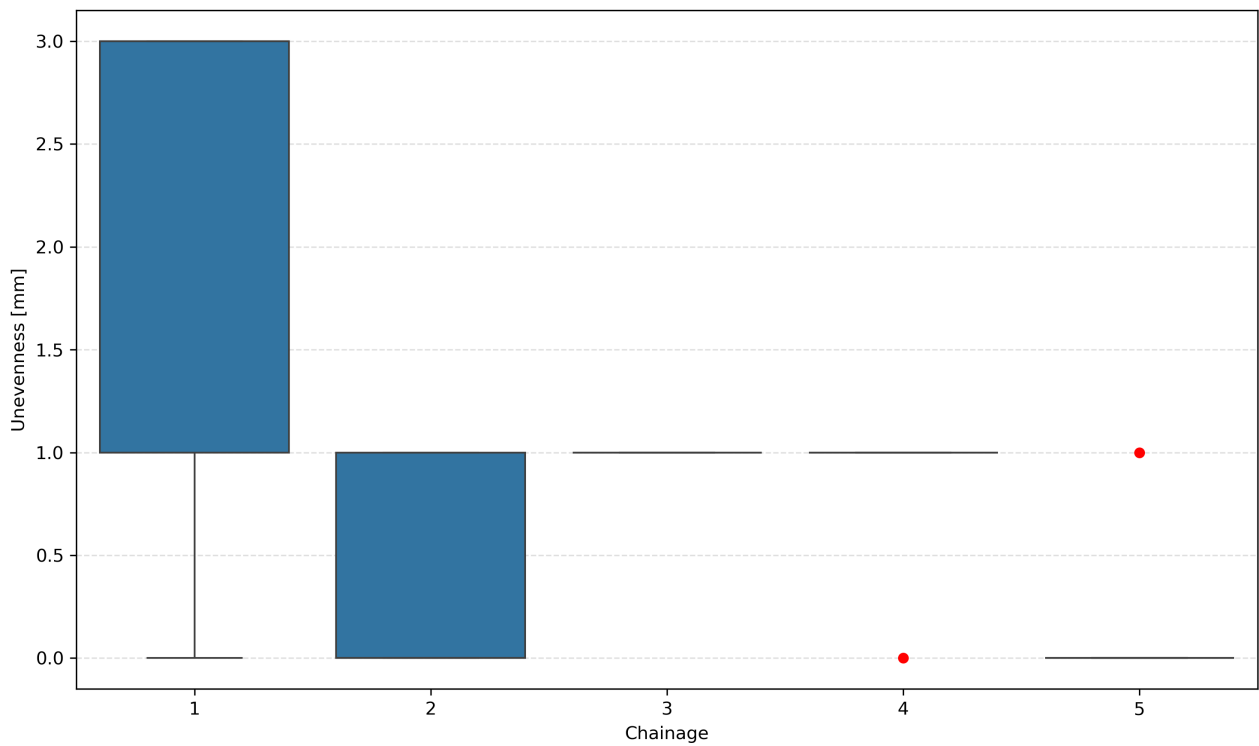


Figure 4: Box plot of test results including identification of outlying values.

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

2.1 Planograph measurement results

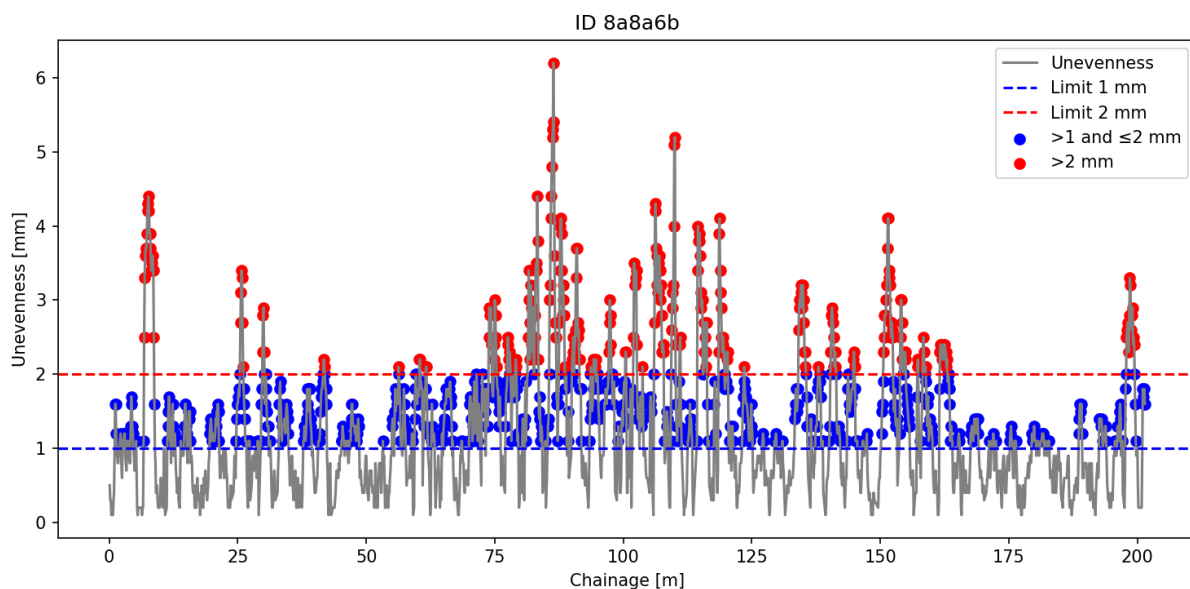


Figure 5: Submitted data – ID 8a8a6b

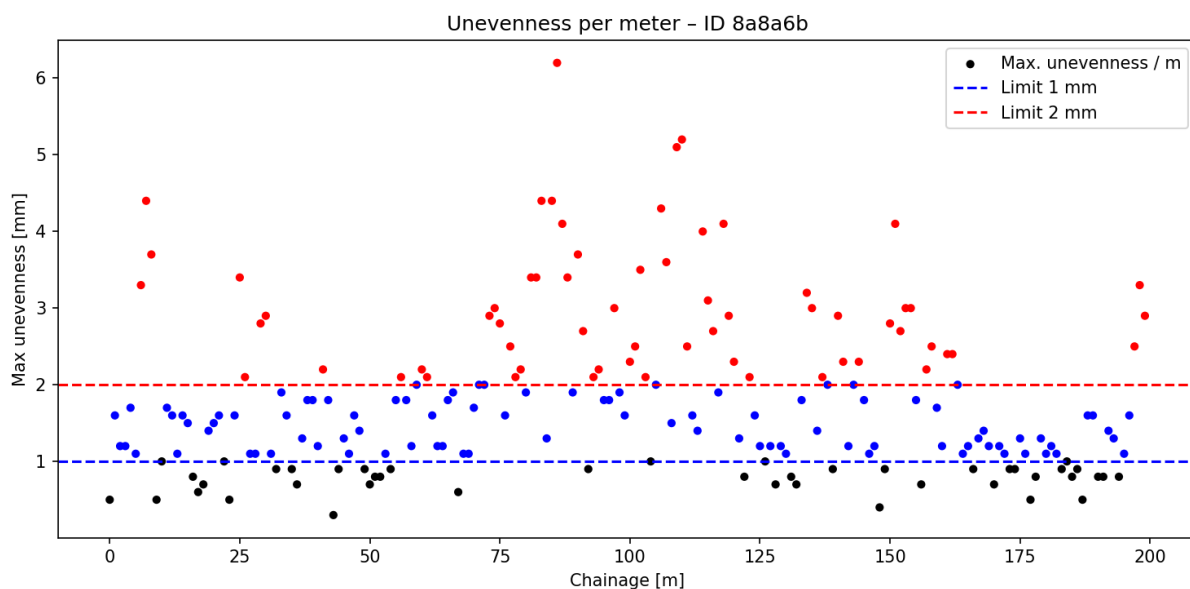


Figure 6: Maximum values per meter – ID 8a8a6b

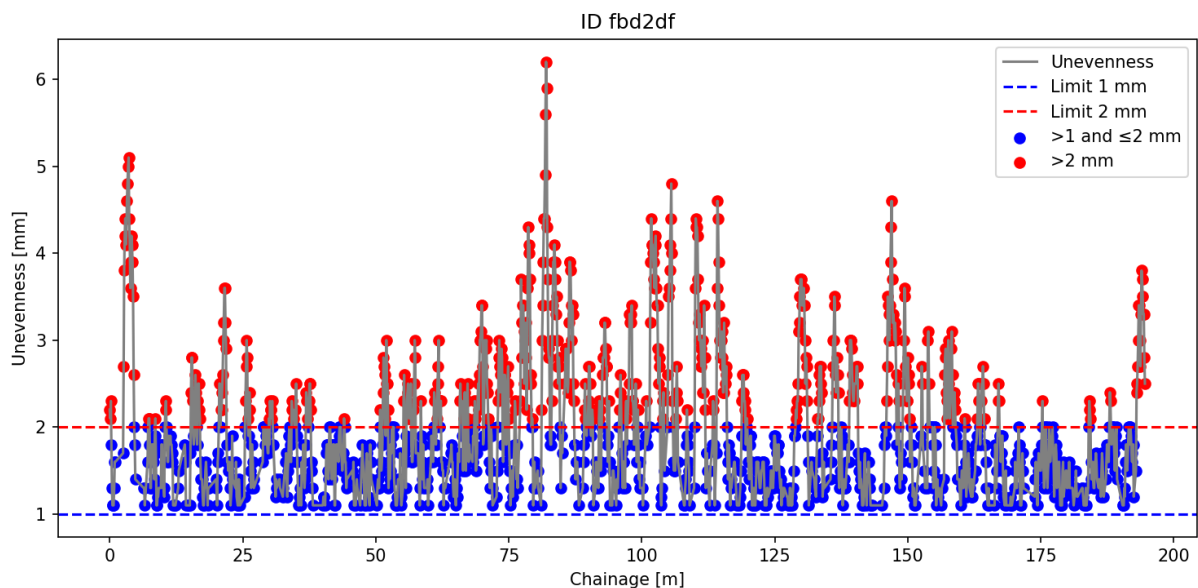


Figure 7: Submitted data – ID fbd2df

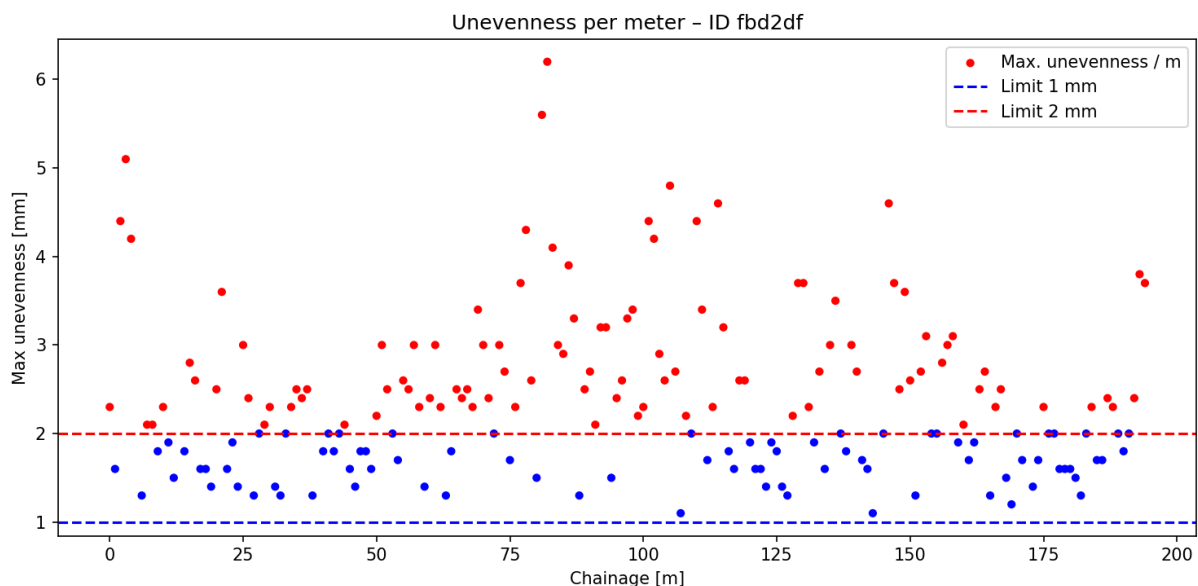


Figure 8: Maximum values per meter – ID fbd2df

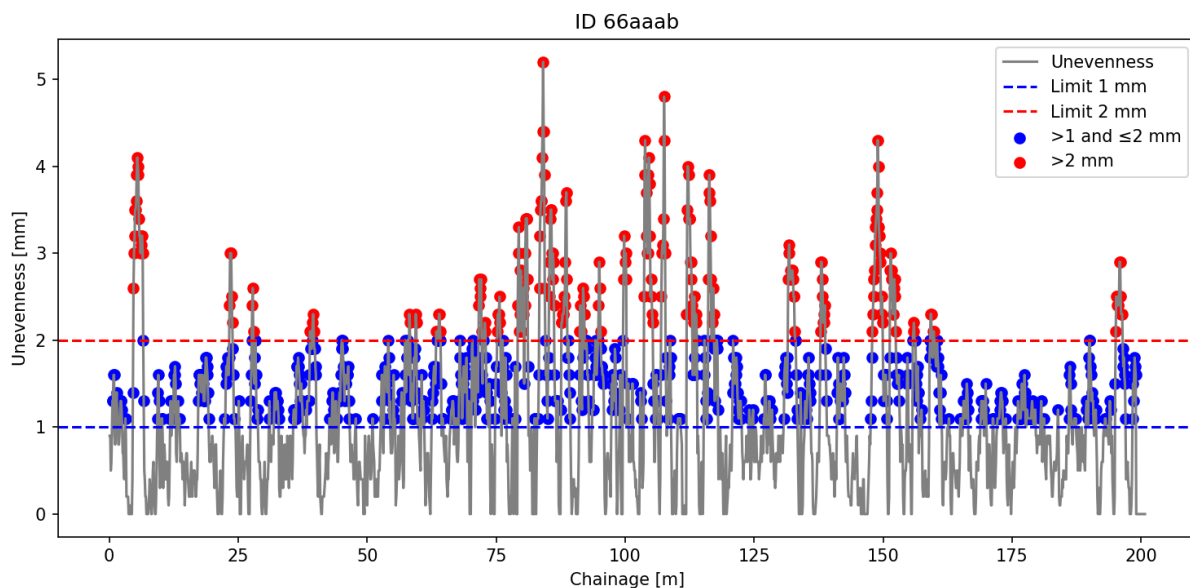


Figure 9: Submitted data – ID 66aaab

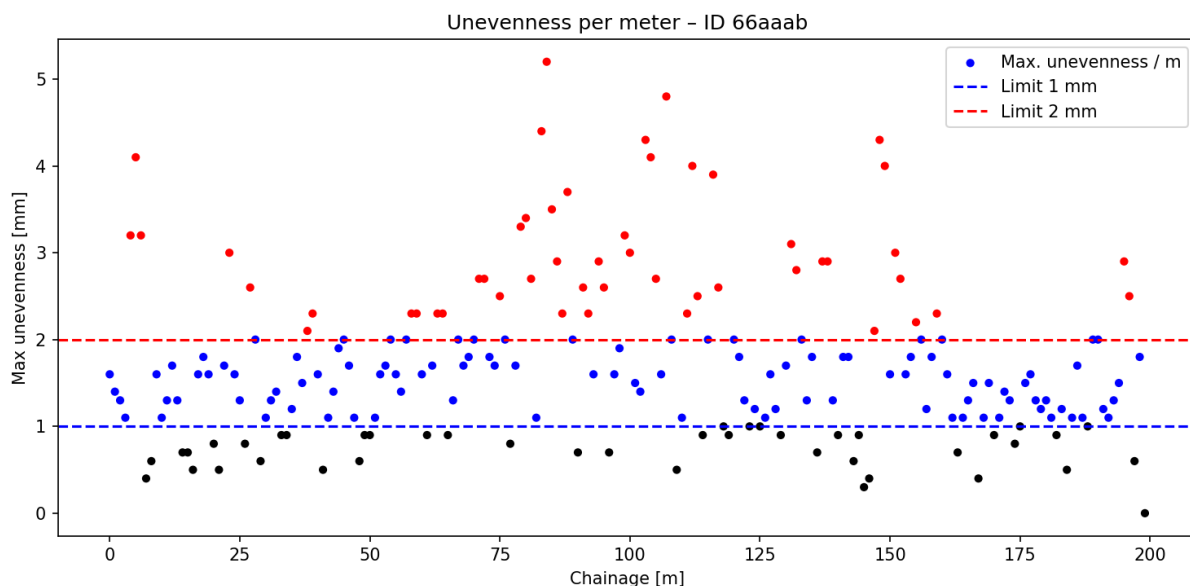


Figure 10: Maximum values per meter – ID 66aaab

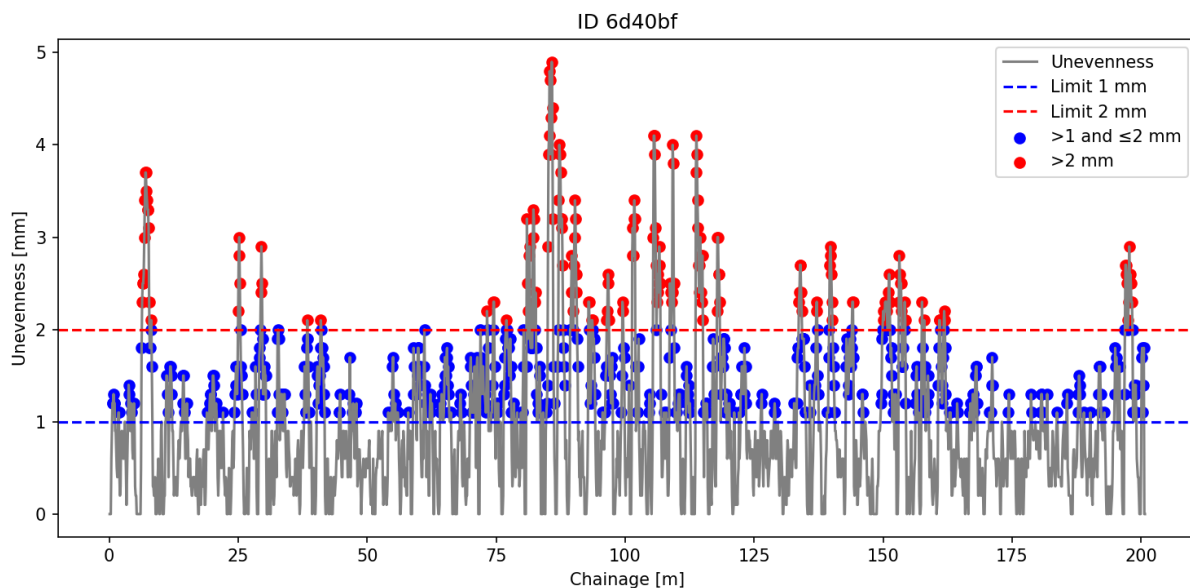


Figure 11: Submitted data – ID 6d40bf

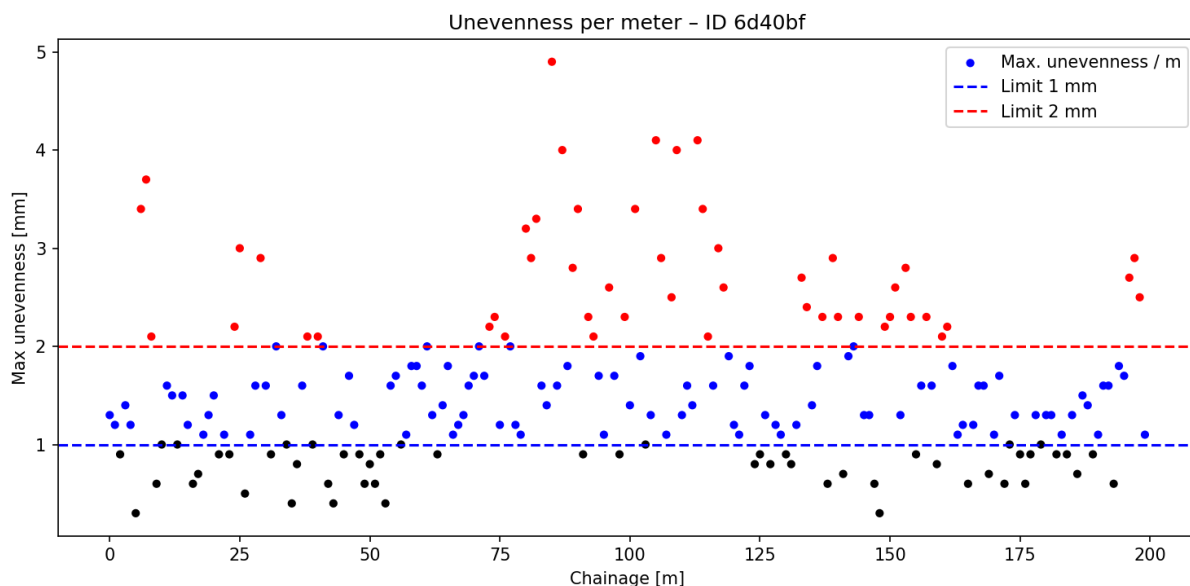


Figure 12: Maximum values per meter – ID 6d40bf

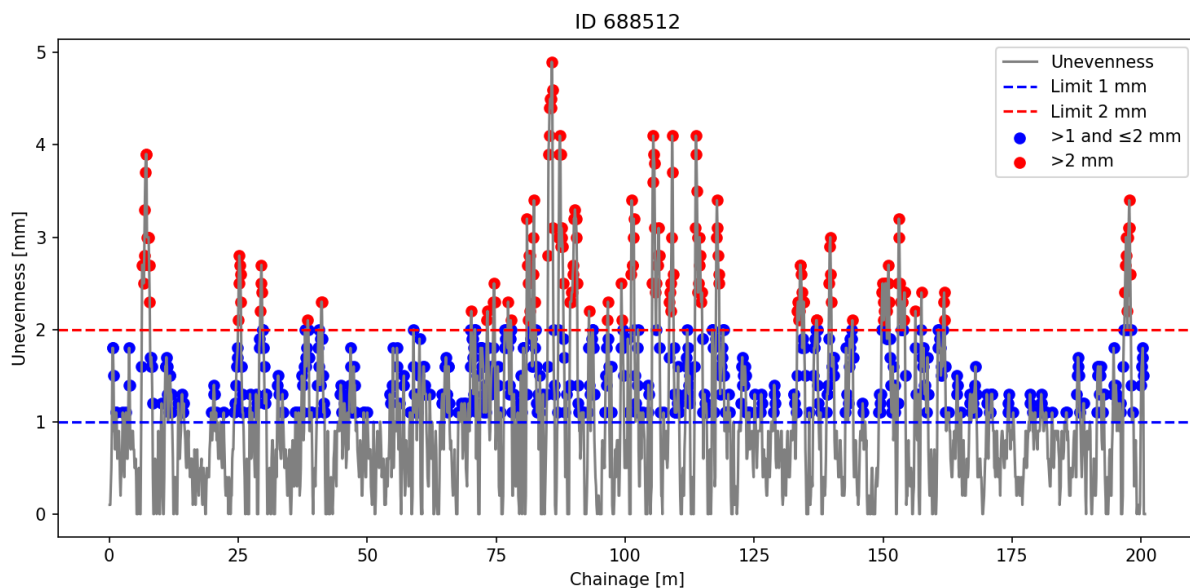


Figure 13: Submitted data – ID 688512

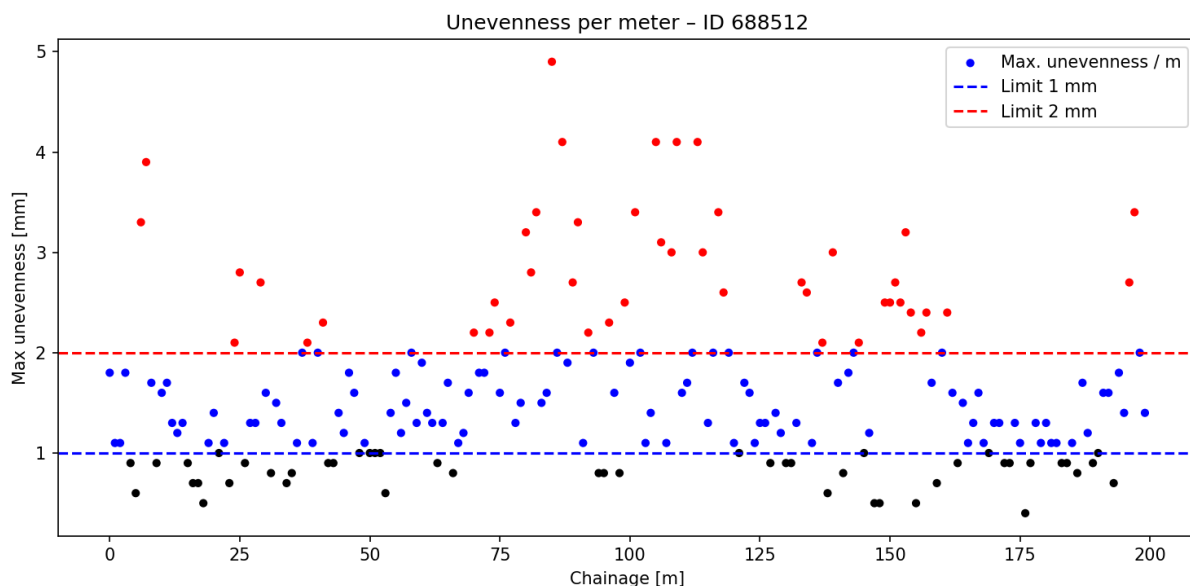


Figure 14: Maximum values per meter – ID 688512

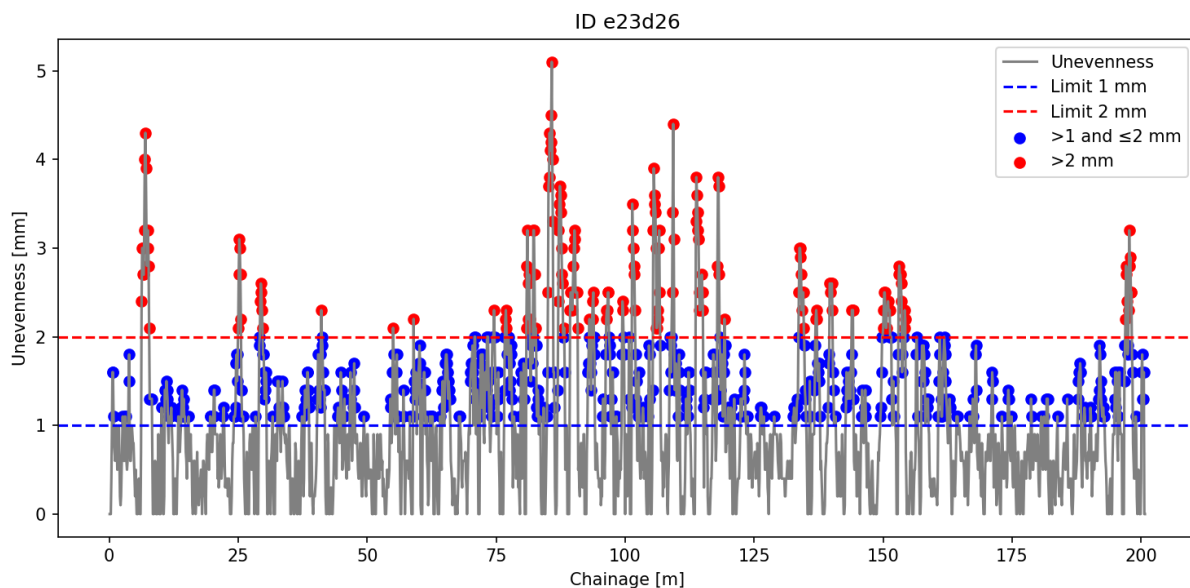


Figure 15: Submitted data – ID e23d26

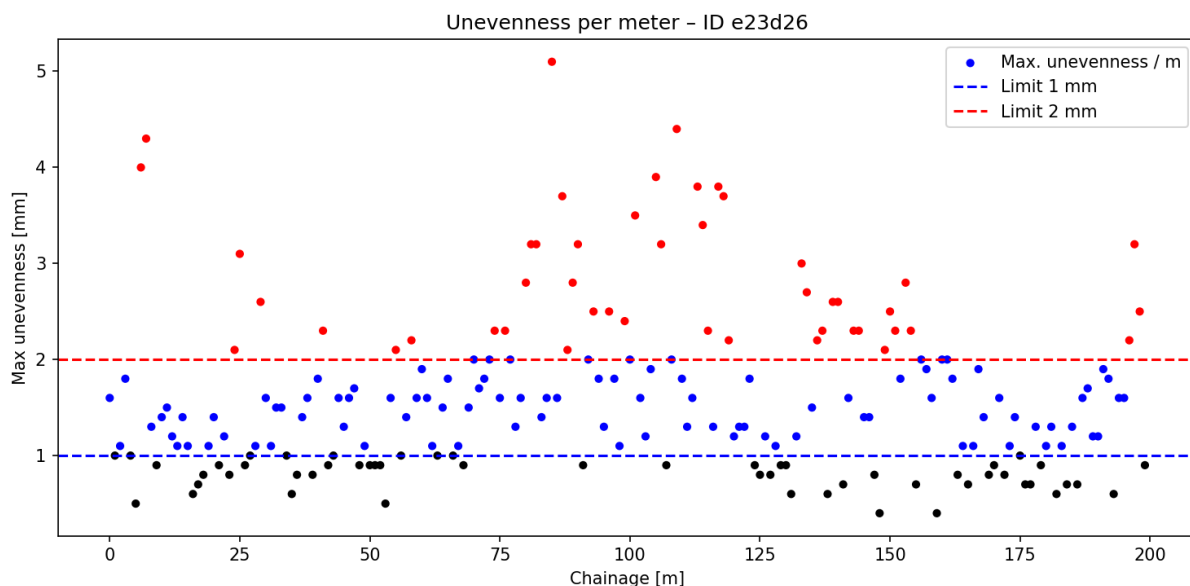


Figure 16: Maximum values per meter – ID e23d26

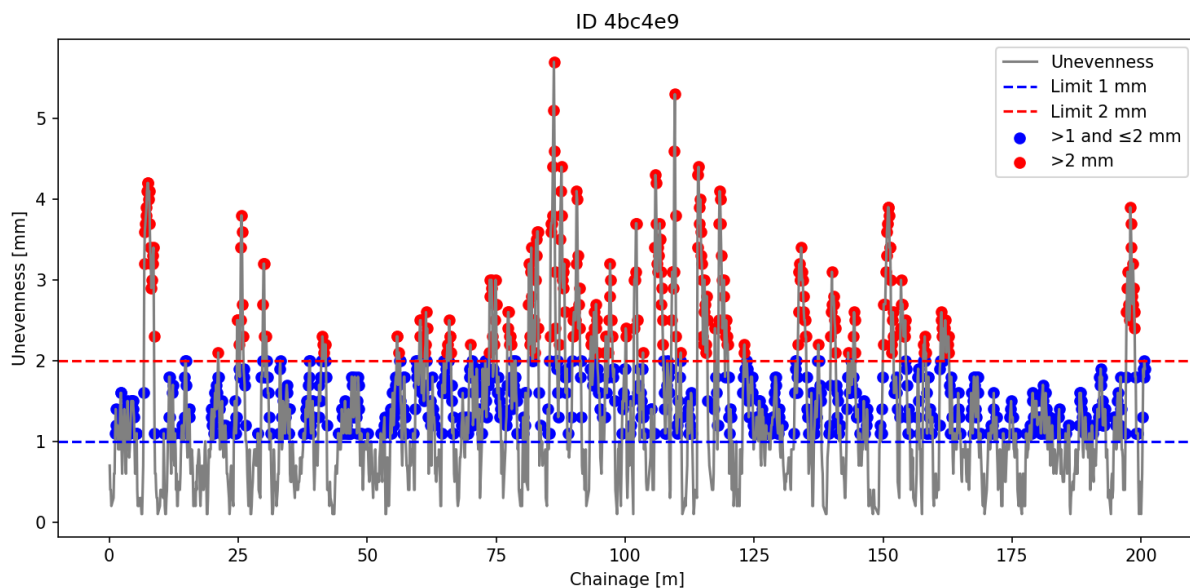


Figure 17: Submitted data – ID 4bc4e9

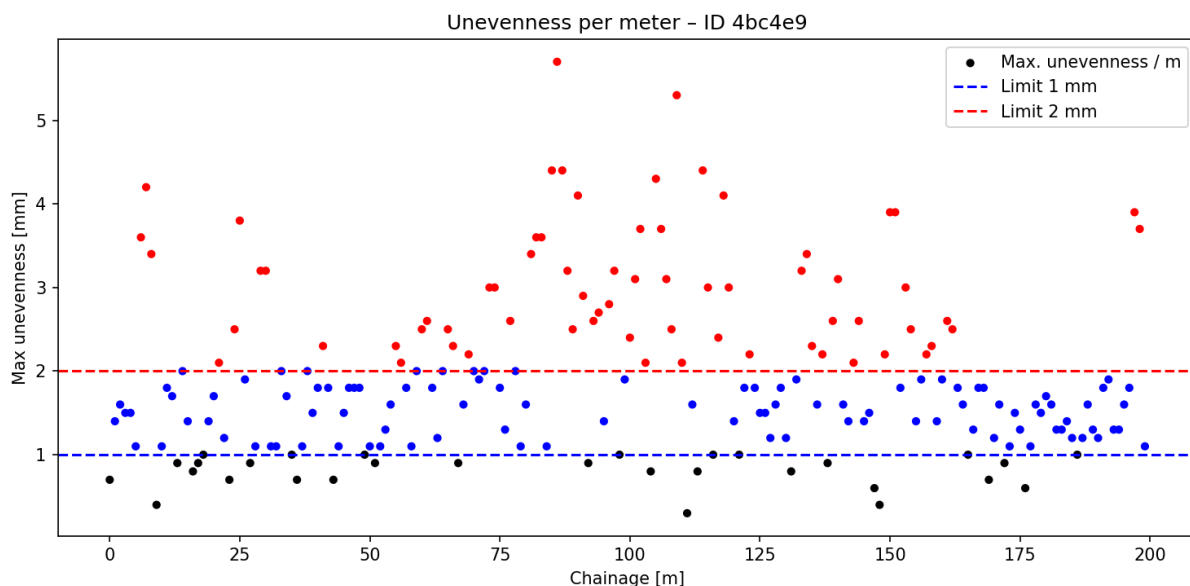


Figure 18: Maximum values per meter – ID 4bc4e9

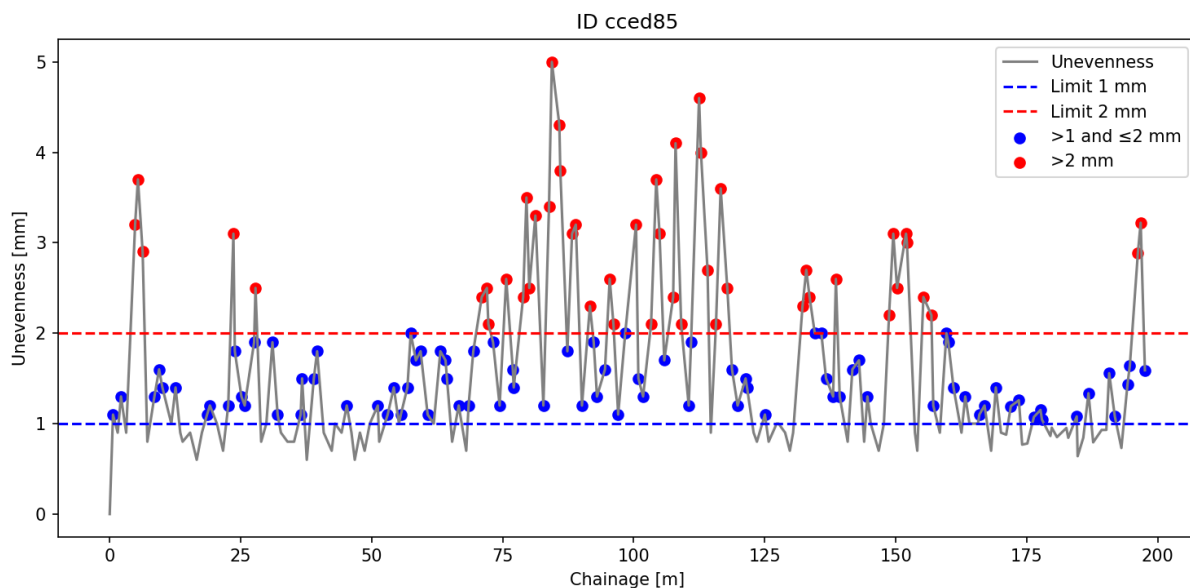


Figure 19: Submitted data – ID cced85

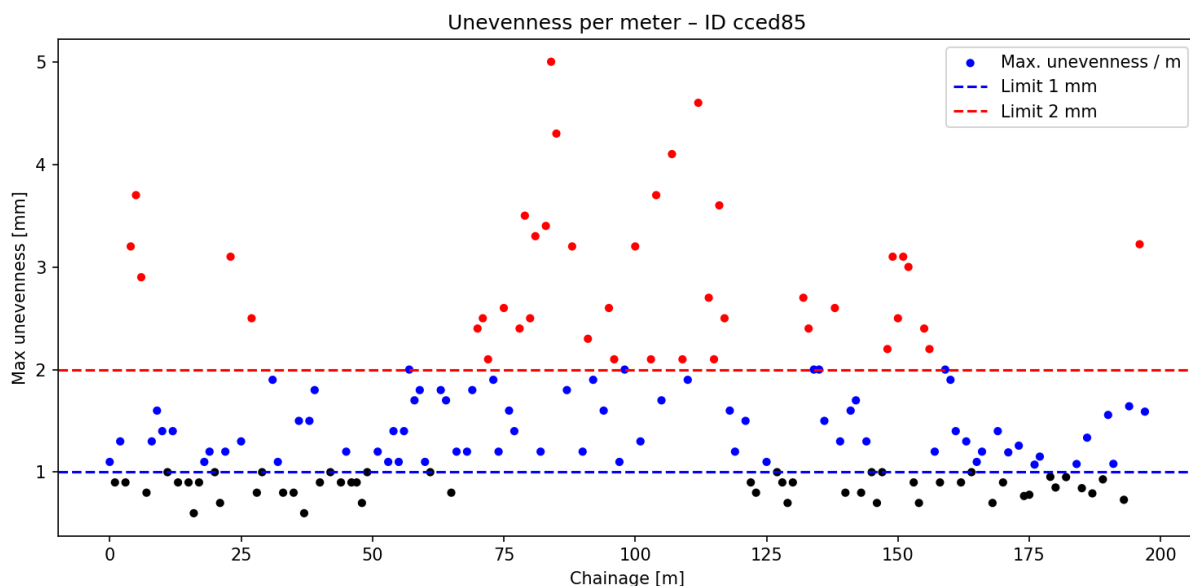


Figure 20: Maximum values per meter – ID cced85

2.2 Overview of points above limits – Submitted data

Table 6: 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 (%)
fb2df	1402	0	0.0	903	64.4	499	35.6
cced85	201	68	33.8	85	42.3	48	23.9
4bc4e9	1818	743	40.9	753	41.4	322	17.7
8a8a6b	1814	869	47.9	665	36.7	280	15.4
66aaab	1919	1039	54.1	636	33.1	244	12.7
688512	1919	1159	60.4	573	29.9	187	9.7
e23d26	1919	1211	63.1	522	27.2	186	9.7
6d40bf	1919	1228	64.0	515	26.8	176	9.2

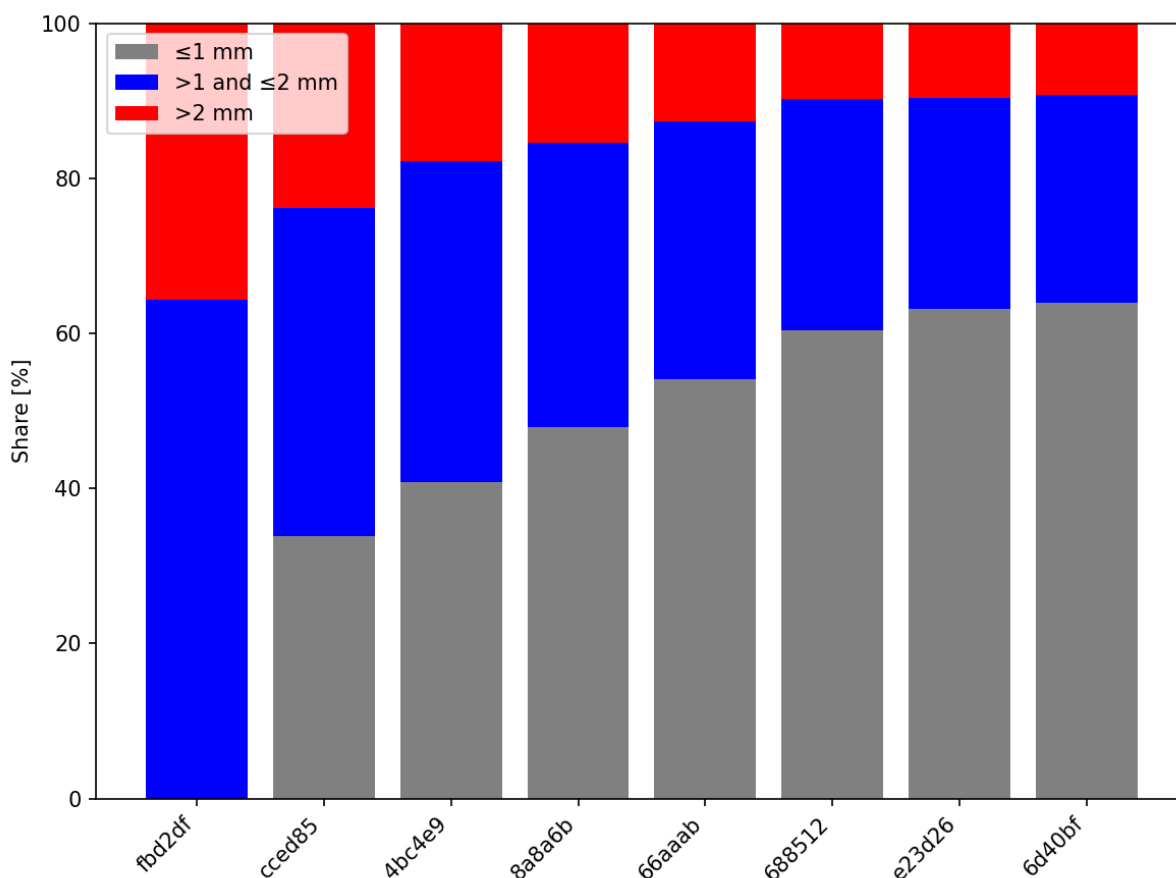


Figure 21: Cumulative bar chart of percentage shares according to the specified limits.

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

Table 7: 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 (%)
fbd2df	190	0	0.0	84	44.2	106	55.8
4bc4e9	200	30	15.0	102	51.0	68	34.0
66aaab	200	43	21.5	106	53.0	51	25.5
8a8a6b	200	44	22.0	93	46.5	63	31.5
688512	200	48	24.0	106	53.0	46	23.0
6d40bf	200	53	26.5	98	49.0	49	24.5
e23d26	200	54	27.0	99	49.5	47	23.5
cced85	165	51	30.9	73	44.2	41	24.8

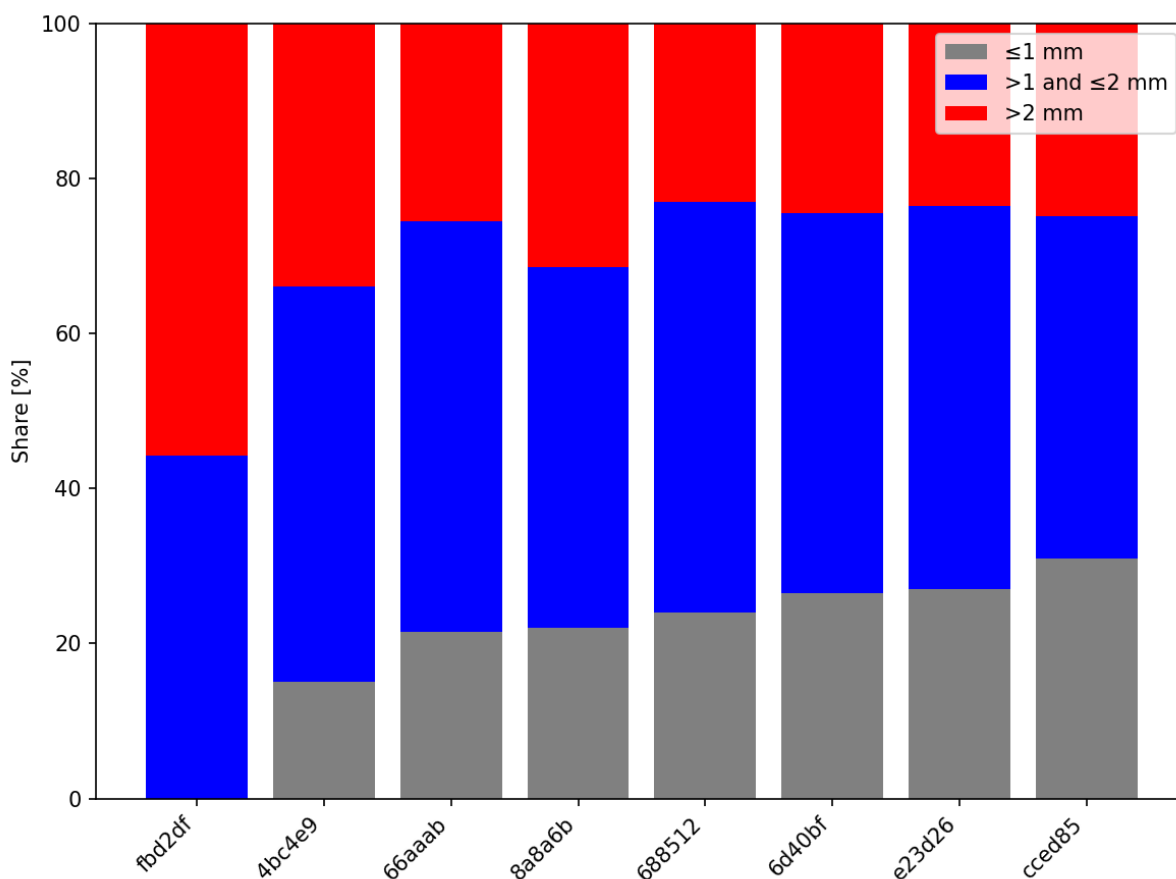


Figure 22: Cumulative bar chart of percentage shares of maximum unevenness per meter according to the specified limits.

2.4 Percentage of unevenness ≤ 1 mm

2.4.1 Test results

Table 8: Test results – ordered by average value. Outliers are marked by red color. u_X – extended uncertainty of measurement.

ID	Result [%]	u_X [%]
fbd2df	0.0	-
66aaab	21.5	-
8a8a6b	22.0	-
688512	24.0	-
6d40bf	26.5	-
e23d26	27.0	-

2.4.2 The Numerical Procedure for Determining Outliers

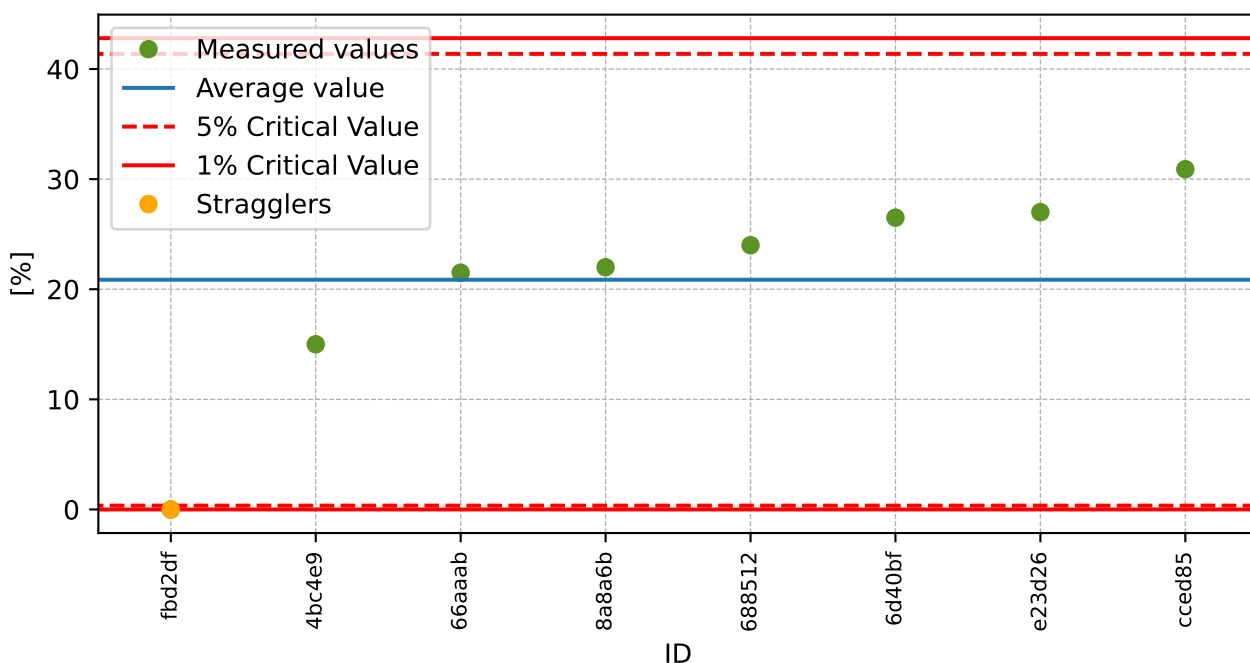


Figure 23: **Grubbs' test** - average values

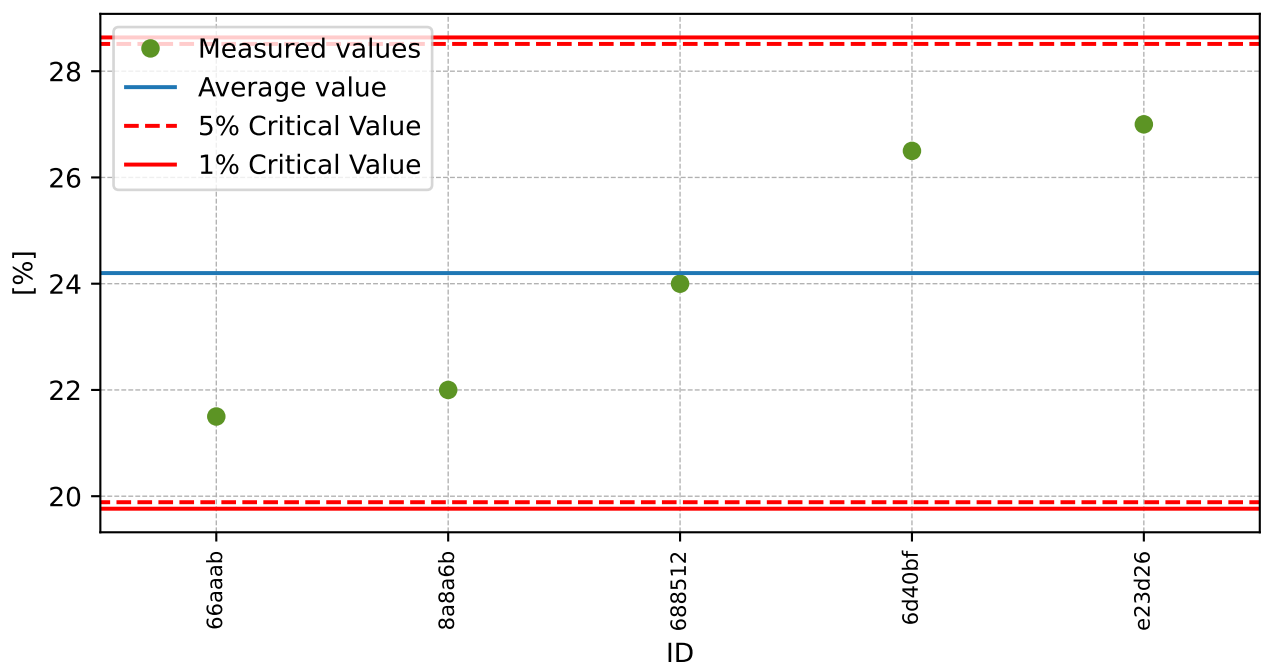


Figure 24: **Grubbs' test** - average values without outliers

2.4.3 Mandel's Statistics

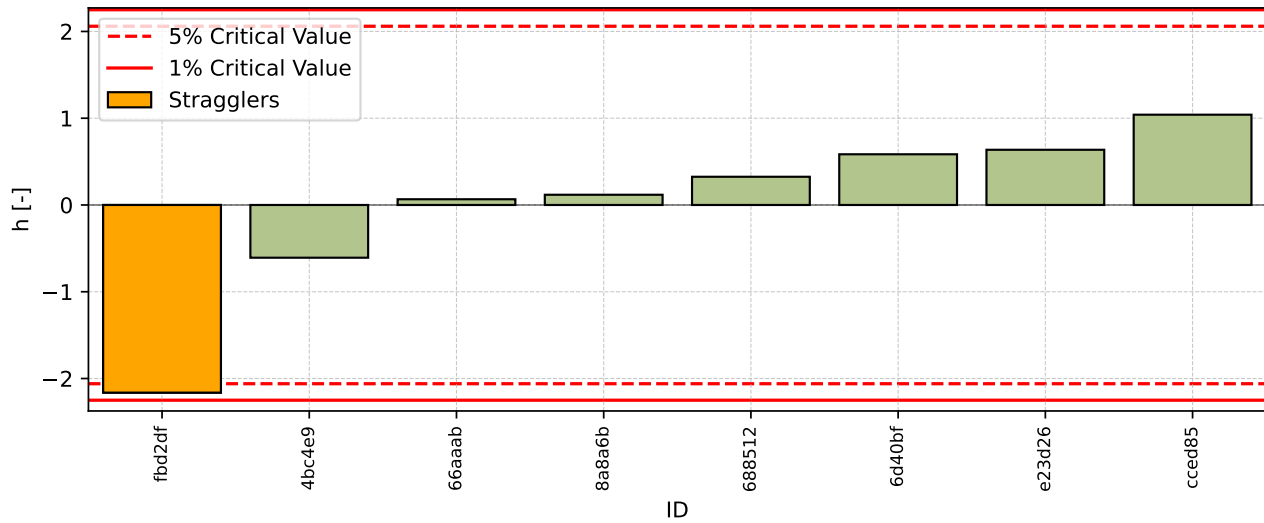


Figure 25: Interlaboratory Consistency Statistic

2.4.4 Descriptive statistics

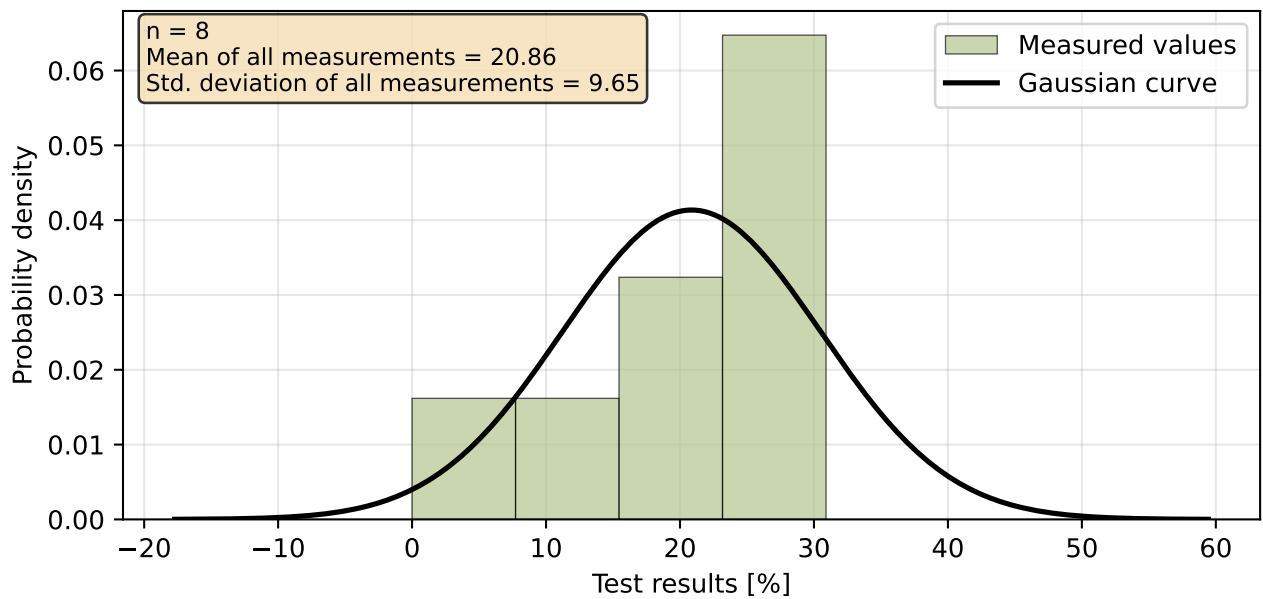


Figure 26: Histogram of all test results

Table 9: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	20.86
Sample standard deviation – s	9.65
Assigned value – x^*	20.86
Robust standard deviation – s^*	9.65
Measurement uncertainty of assigned value – u_X	3.41
p -value of normality test [-]	0.088

2.4.5 Evaluation of Performance Statistics

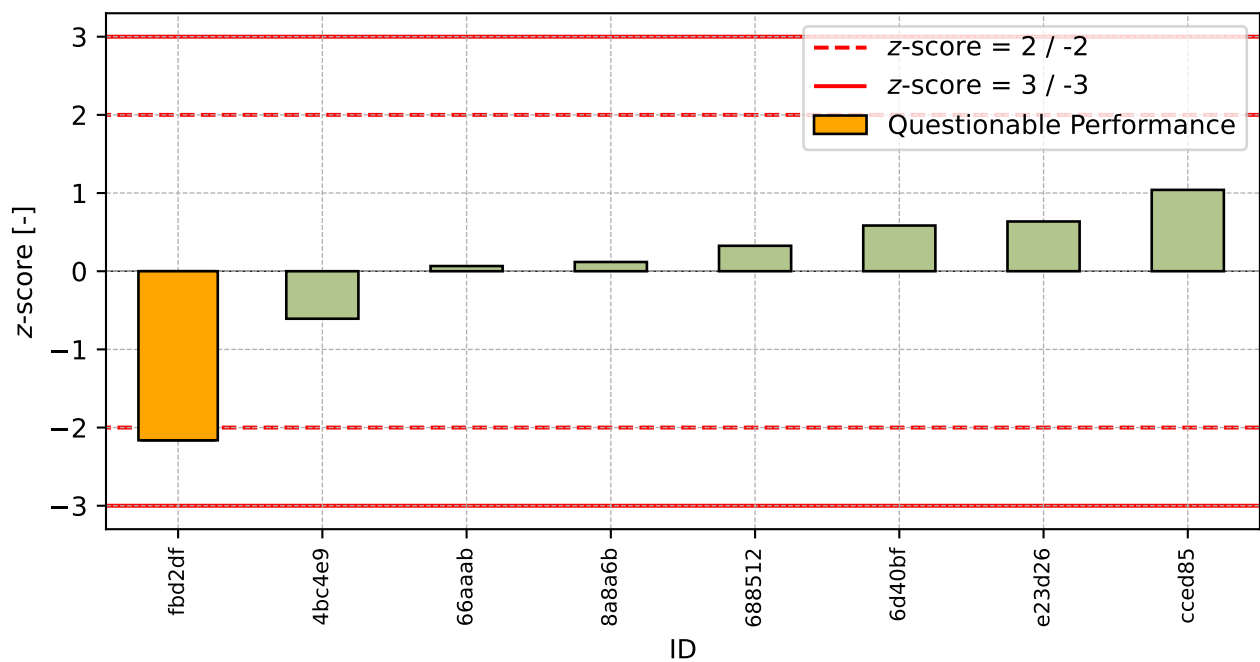


Figure 27: z-score

Table 10: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
fbd2df	-2.16	-
4bc4e9	-0.61	-
66aaab	0.07	-
8a8a6b	0.12	-
688512	0.33	-
6d40bf	0.58	-
e23d26	0.64	-
cced85	1.04	-

2.5 Percentage of unevenness >1 and ≤2 mm

2.5.1 Test results

Table 11: Test results – ordered by average value. Outliers are marked by red color. u_X – extended uncertainty of measurement.

ID	Result [%]	u_X [%]
fbd2df	44.2	-
cced85	44.2	-
8a8a6b	46.5	-
6d40bf	49.0	-
e23d26	49.5	-
4bc4e9	51.0	-
66aaab	53.0	-
688512	53.0	-

2.5.2 The Numerical Procedure for Determining Outliers

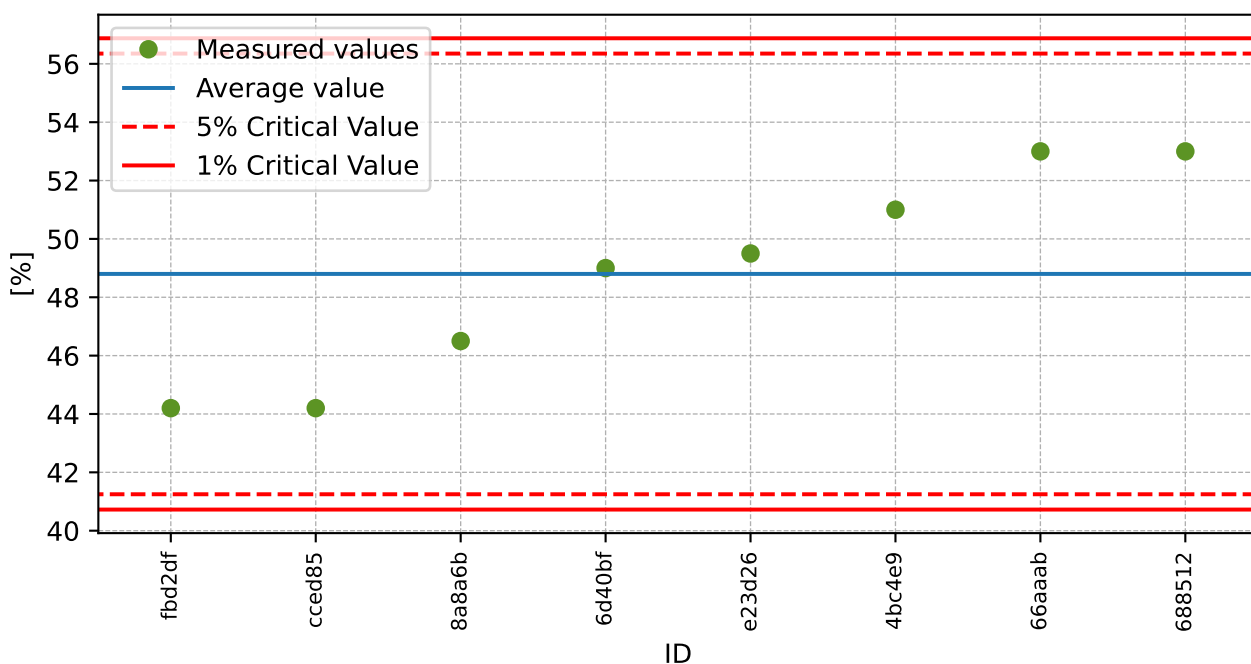


Figure 28: **Grubbs' test** - average values

2.5.3 Mandel’s Statistics

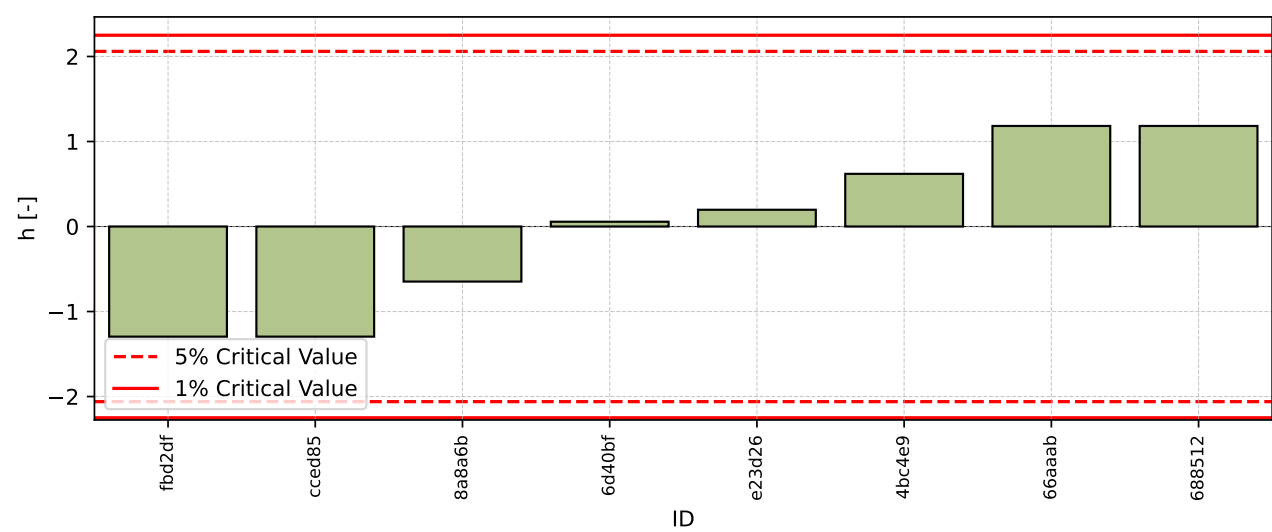


Figure 29: Interlaboratory Consistency Statistic

2.5.4 Descriptive statistics

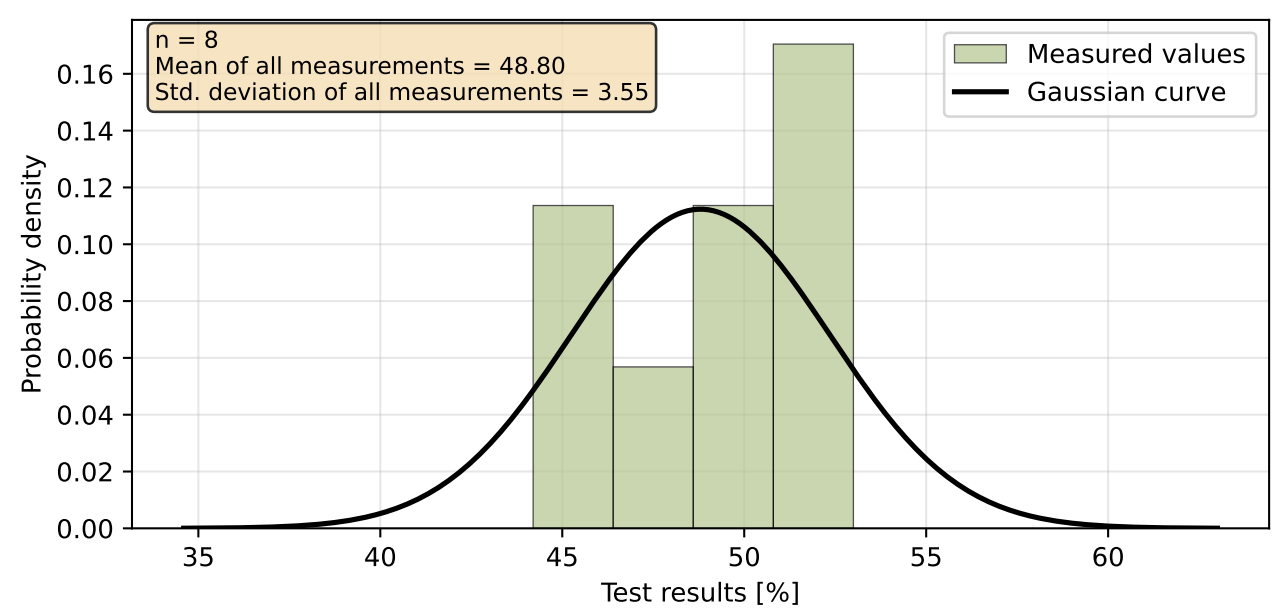


Figure 30: Histogram of all test results

Table 12: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	48.80
Sample standard deviation – s	3.55
Assigned value – x^*	48.80
Robust standard deviation – s^*	3.55
Measurement uncertainty of assigned value – u_X	1.26
p -value of normality test [-]	0.303

2.5.5 Evaluation of Performance Statistics

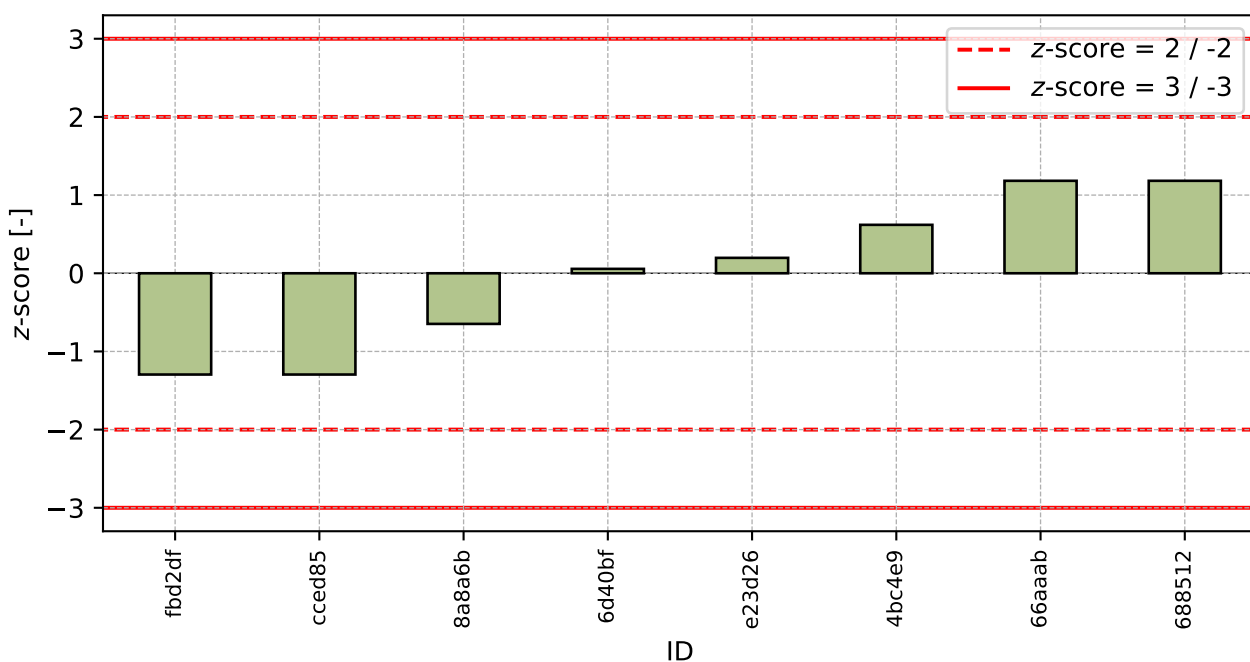


Figure 31: z-score

Table 13: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
fbd2df	-1.30	-
cced85	-1.30	-
8a8a6b	-0.65	-
6d40bf	0.06	-
e23d26	0.20	-
4bc4e9	0.62	-
66aaab	1.18	-
688512	1.18	-

2.6 Percentage of unevenness >2 mm

2.6.1 Test results

Table 14: Test results – ordered by average value. Outliers are marked by red color. u_X – extended uncertainty of measurement.

ID	Result [%]	u_X [%]
688512	23.0	-
e23d26	23.5	-
6d40bf	24.5	-
cced85	24.8	-
66aaab	25.5	-
8a8a6b	31.5	-
4bc4e9	34.0	-
fbd2df	55.8	-

2.6.2 The Numerical Procedure for Determining Outliers

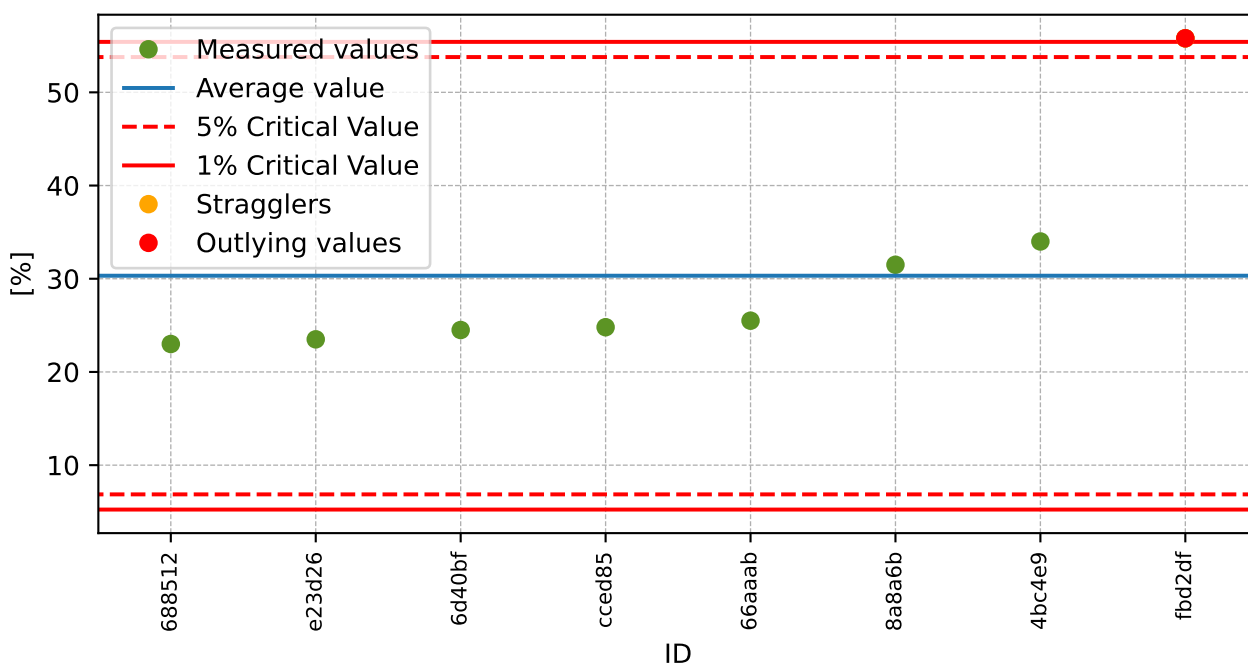


Figure 32: **Grubbs' test** - average values

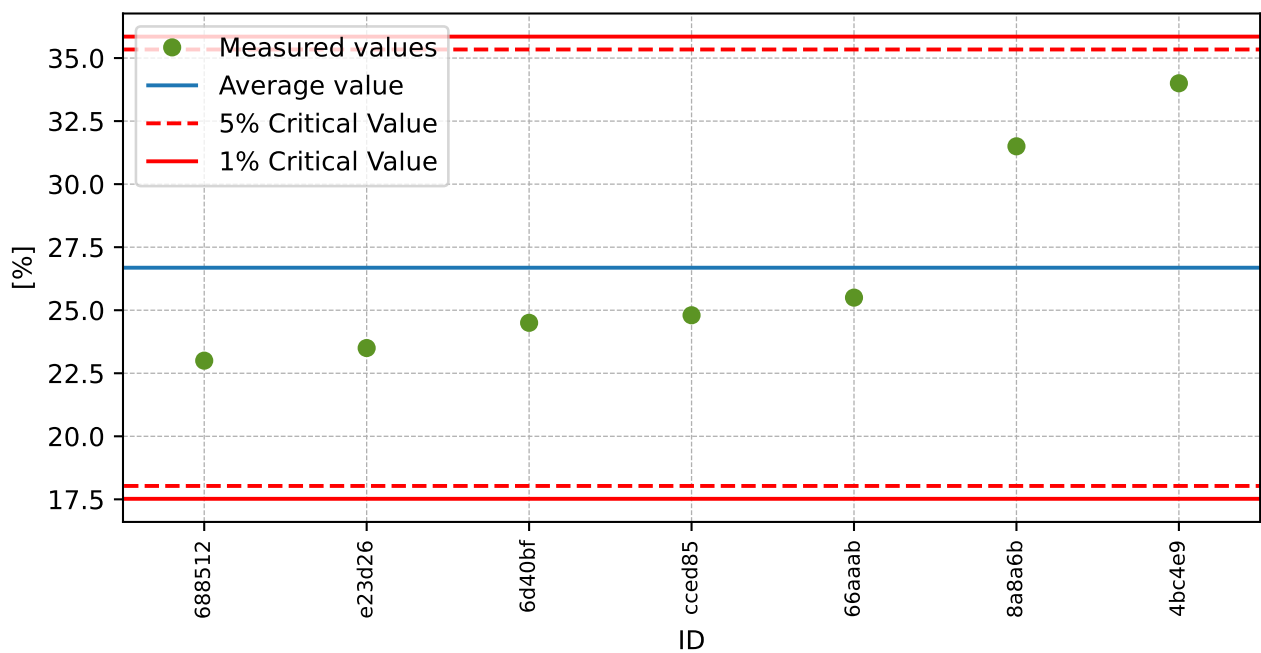


Figure 33: **Grubbs' test** - average values without outliers

2.6.3 Mandel's Statistics

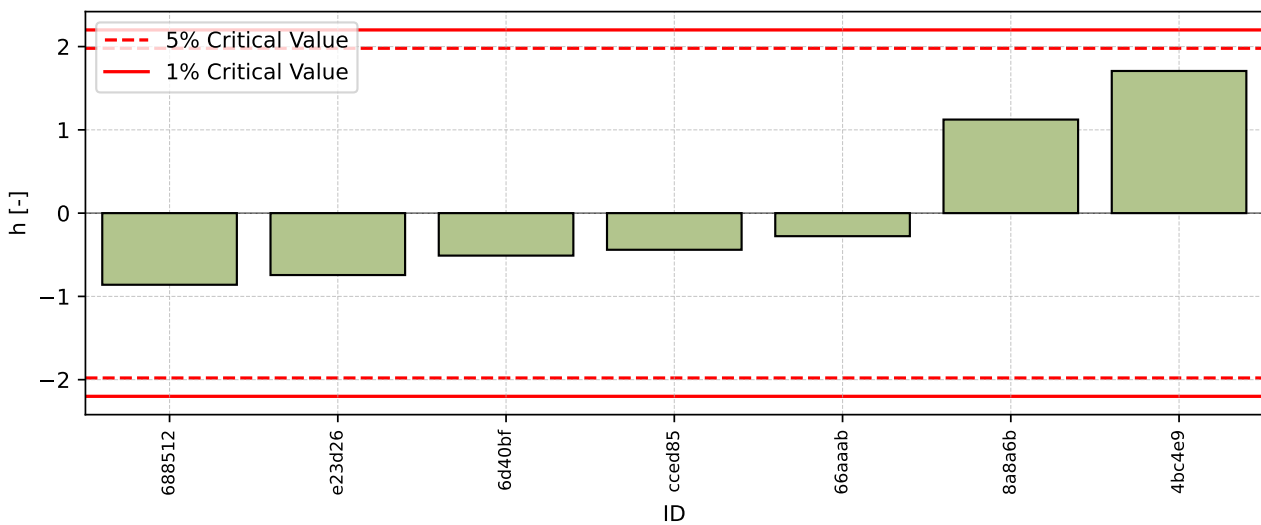


Figure 34: Interlaboratory Consistency Statistic

2.6.4 Descriptive statistics

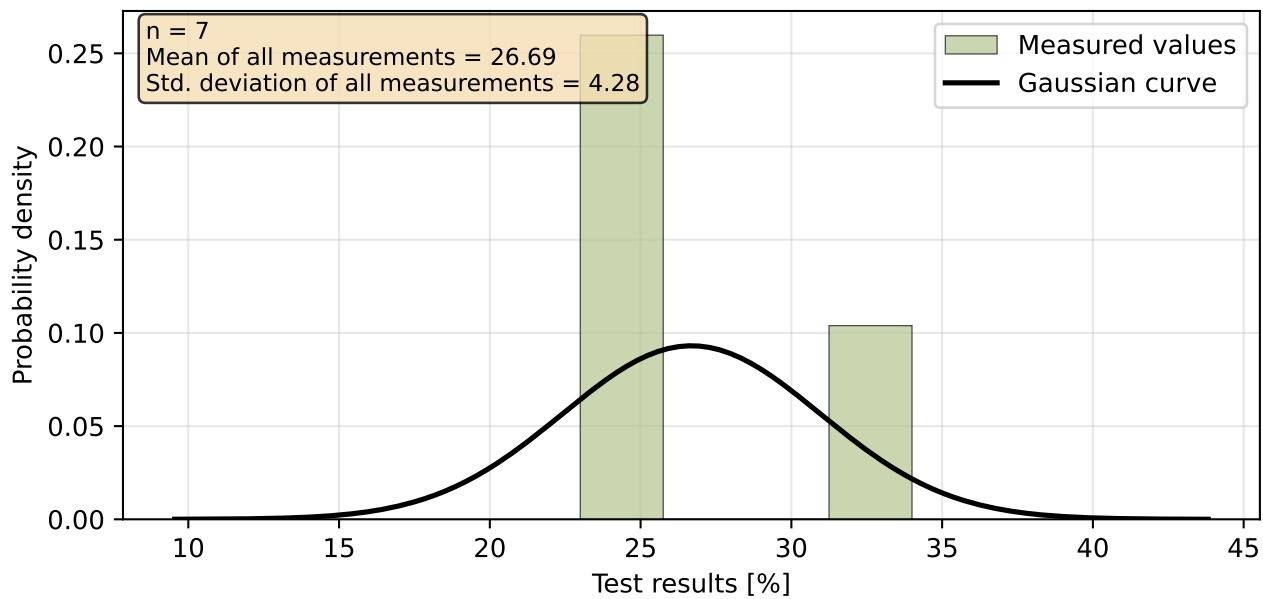


Figure 35: Histogram of all test results

Table 15: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	26.69
Sample standard deviation – s	4.28
Assigned value – x^*	26.69
Robust standard deviation – s^*	4.28
Measurement uncertainty of assigned value – u_X	1.62
p -value of normality test [-]	0.046

2.6.5 Evaluation of Performance Statistics

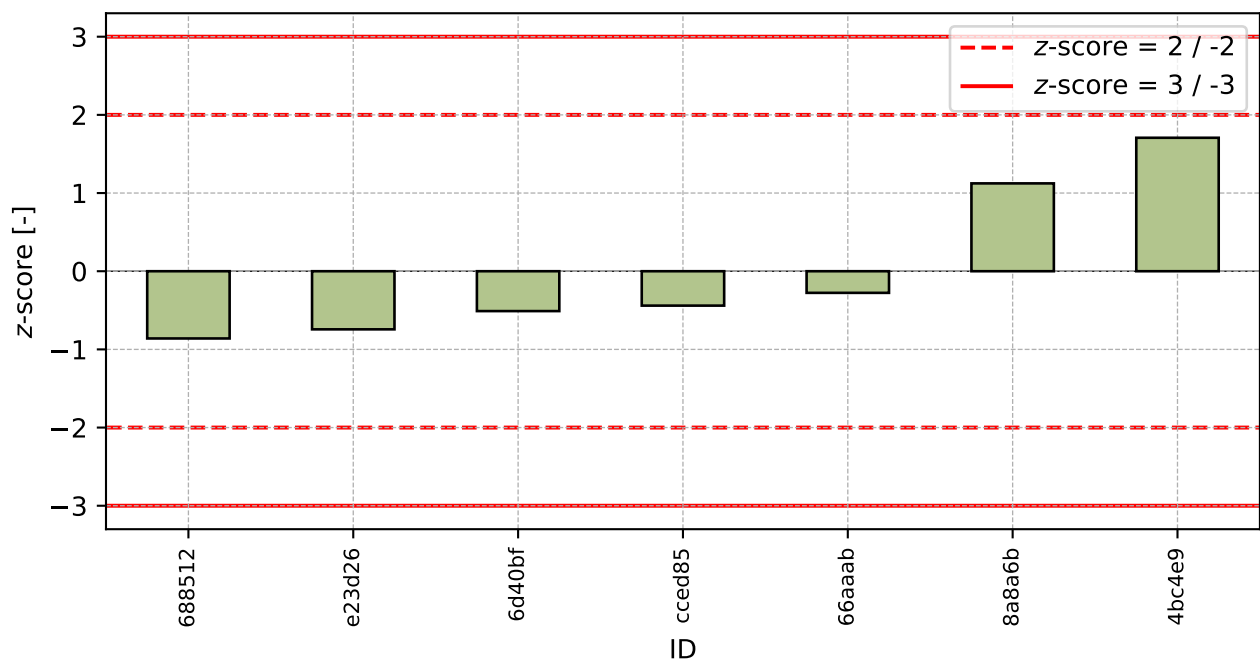


Figure 36: z-score

Table 16: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
688512	-0.86	-
e23d26	-0.74	-
6d40bf	-0.51	-
cced85	-0.44	-
66aaab	-0.28	-
8a8a6b	1.12	-
4bc4e9	1.71	-

3 Appendix – EN 12697-36 Determination of the thickness of an asphalt pavement

3.1 Wearing course

3.1.1 Test results

Table 17: Test results – ordered by average value. Outliers are marked by red color. Columns 1–4 are individual determinations; u_X – extended uncertainty of measurement; $\bar{x}$ – average value; s_0 – sample standard deviation; V_X – variation coefficient

ID	1 [mm]	2 [mm]	3 [mm]	4 [mm]	u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
56c28f	32	33	32	33	2.0	32	0.6	1.78
688512	33	34	34	33	-	34	0.6	1.72
e23d26	34	34	34	33	-	34	0.5	1.48
6d40bf	34	34	34	33	-	34	0.5	1.48
fbd2df	34	35	35	34	0.3	34	0.6	1.67
cced85	35	35	34	34	-	34	0.6	1.67
8a8a6b	34	35	35	35	1.0	35	0.5	1.44
4bc4e9	35	35	34	35	-	35	0.5	1.44
73d85a	46	47	48	46	-	47	1.0	2.05

3.1.2 The Numerical Procedure for Determining Outliers

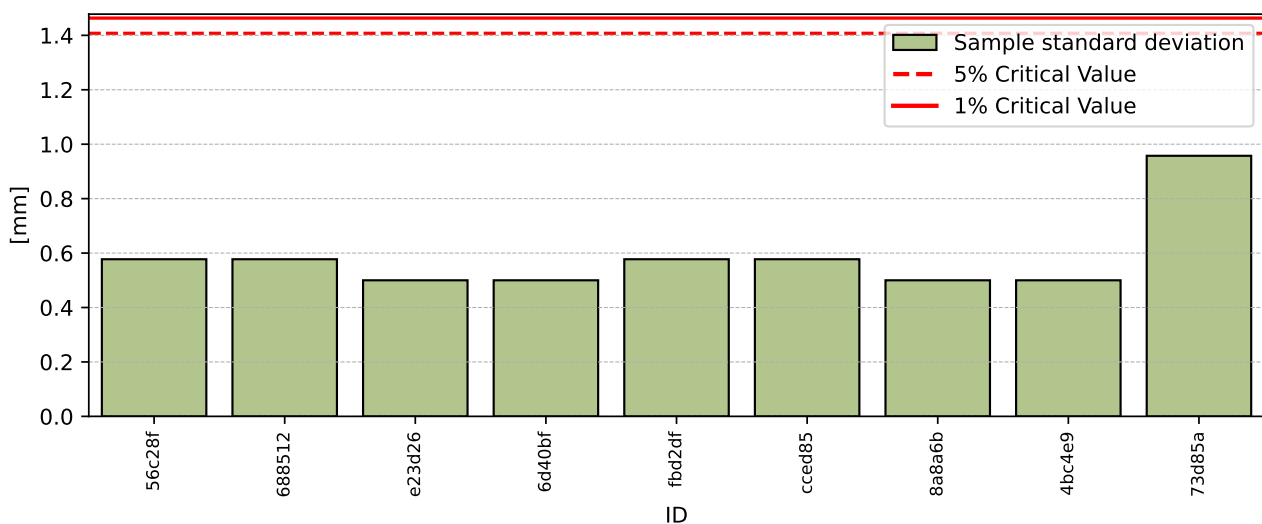


Figure 37: **Cochran's test** - sample standard deviations

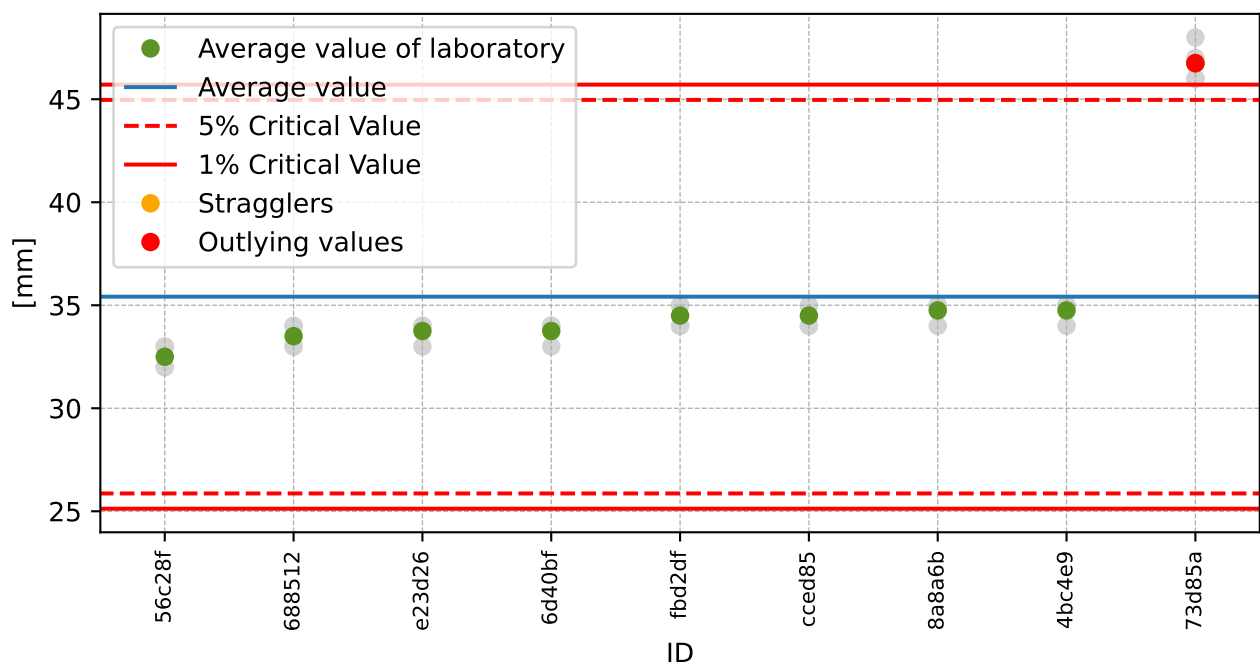


Figure 38: **Grubbs' test** - average values

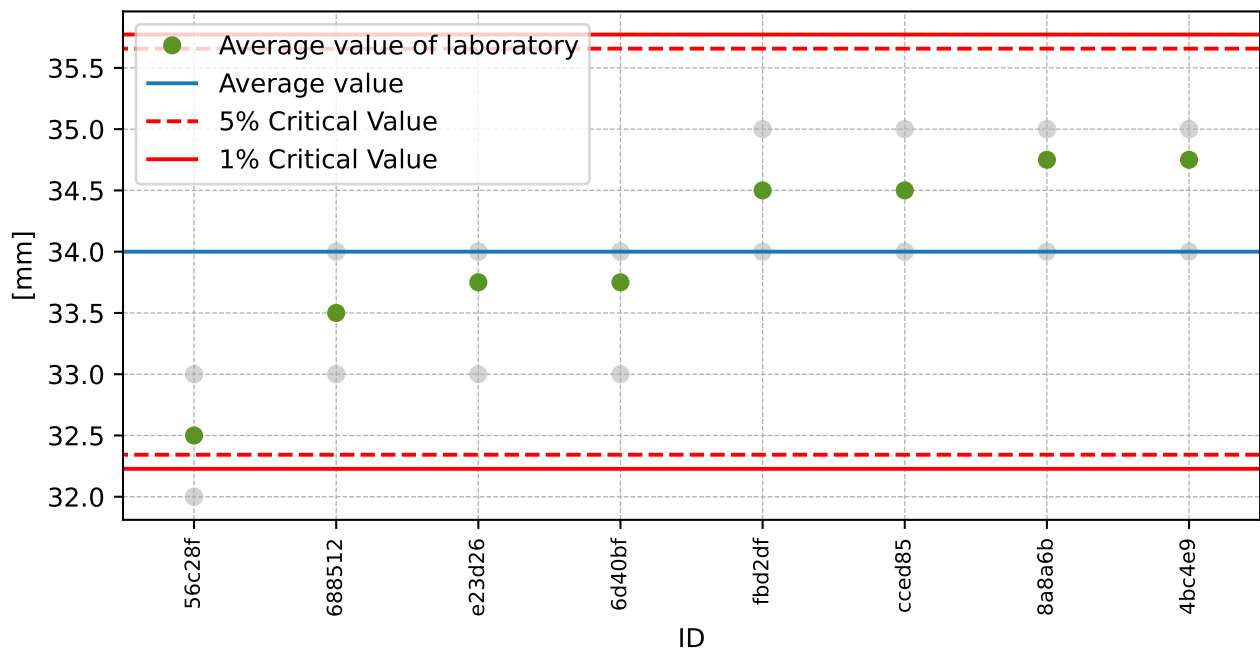


Figure 39: **Grubbs' test** - average values without outliers

3.1.3 Mandel’s Statistics

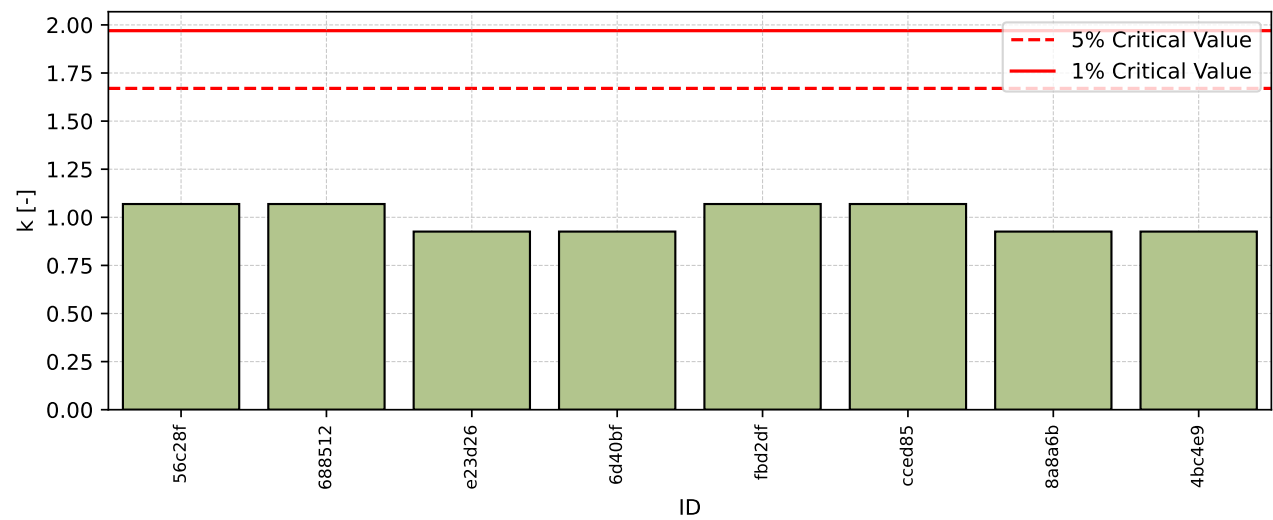


Figure 40: Intralaboratory Consistency Statistic

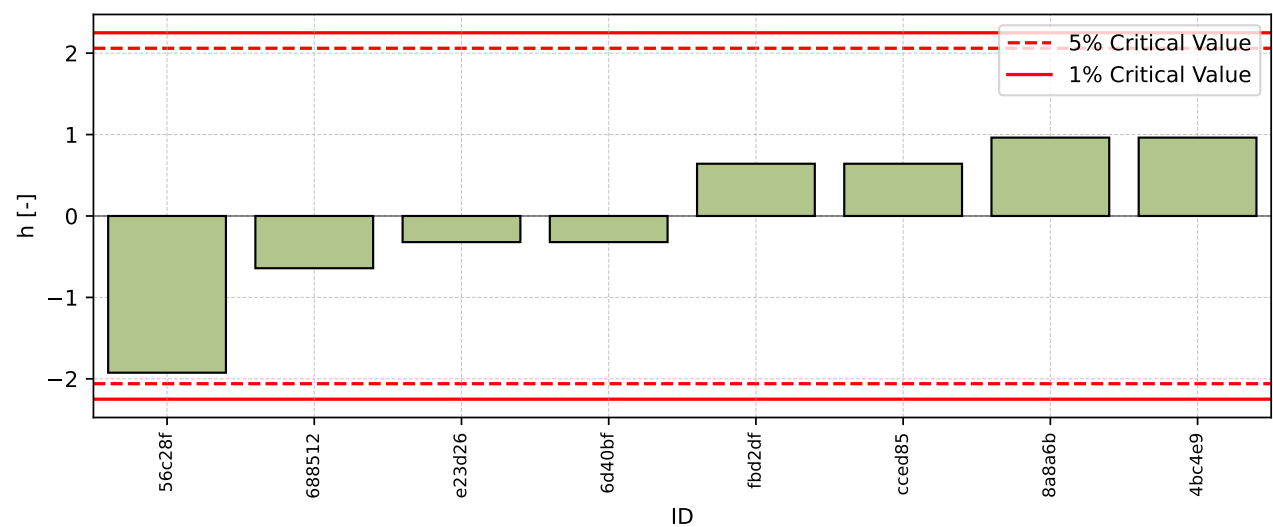


Figure 41: Interlaboratory Consistency Statistic

3.1.4 Descriptive statistics

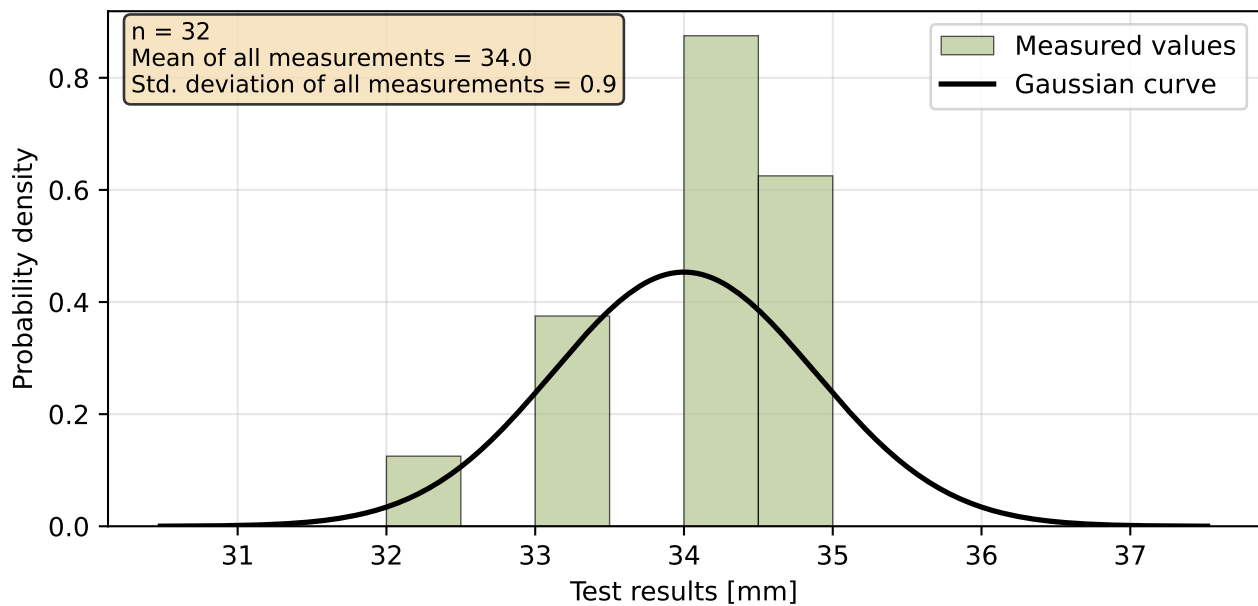


Figure 42: Histogram of all test results

Table 18: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	34.0
Sample standard deviation – s	0.8
Assigned value – x^*	34.0
Robust standard deviation – s^*	0.8
Measurement uncertainty of assigned value – u_X	0.3
p -value of normality test [-]	< 0.001

3.1.5 Evaluation of Performance Statistics

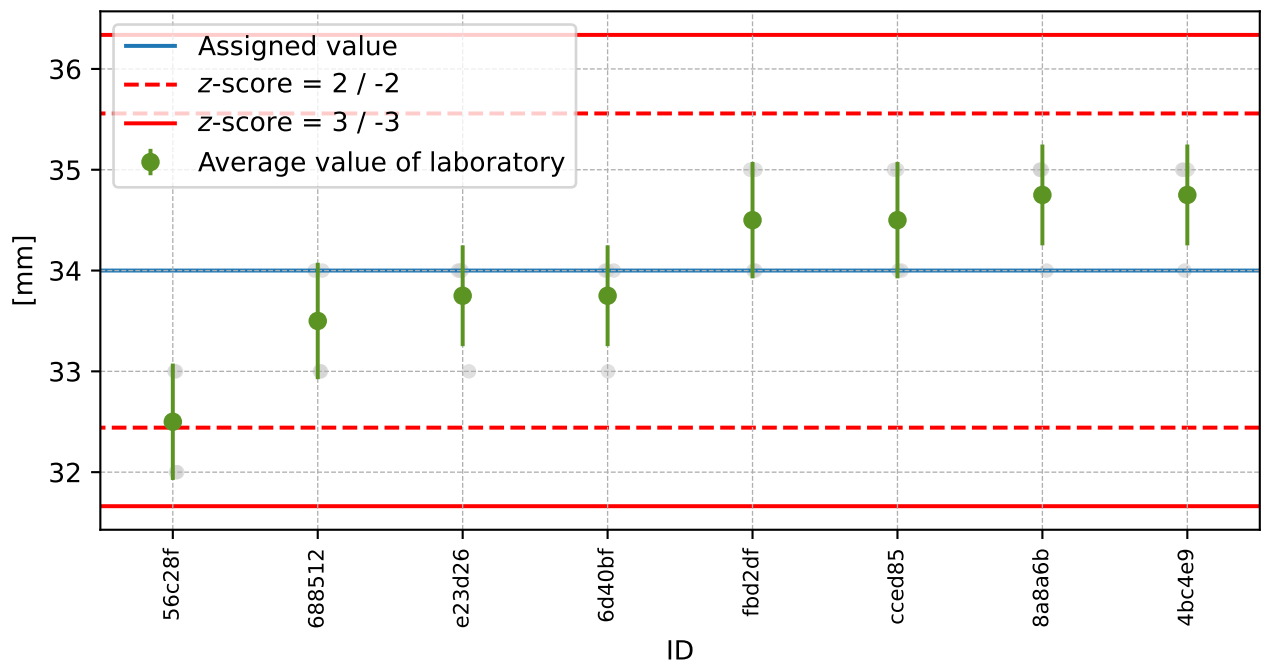


Figure 43: Average values and sample standard deviations

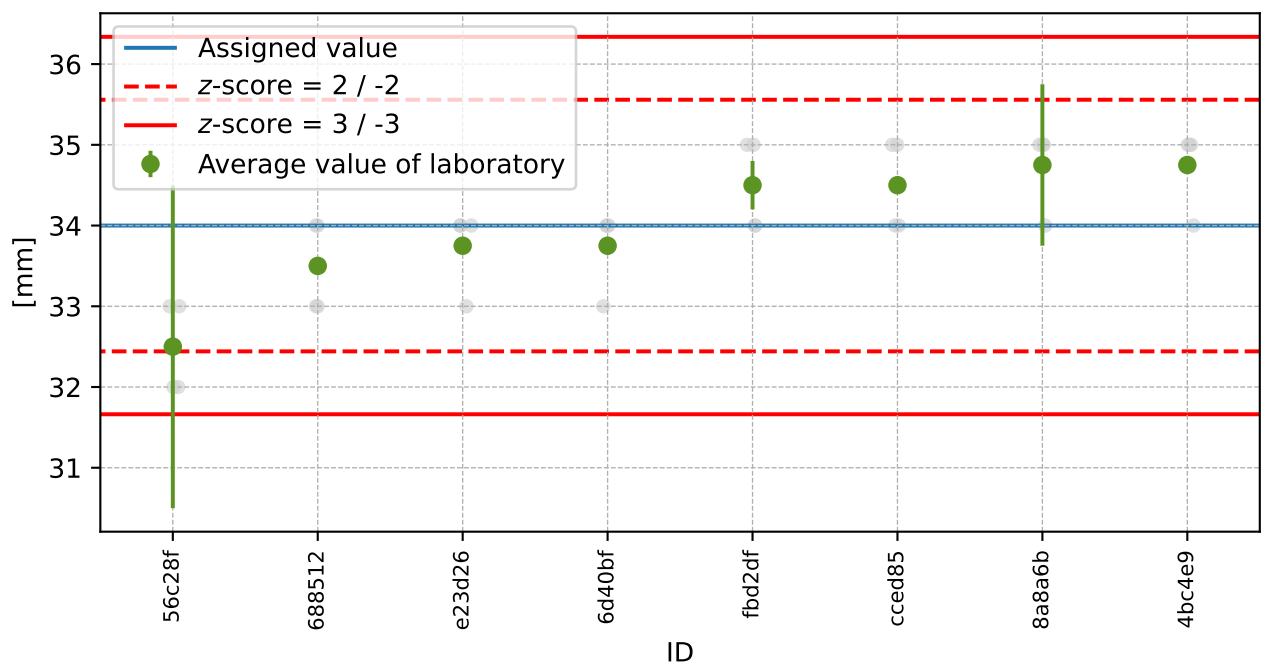


Figure 44: Average values and extended uncertainties of measurement

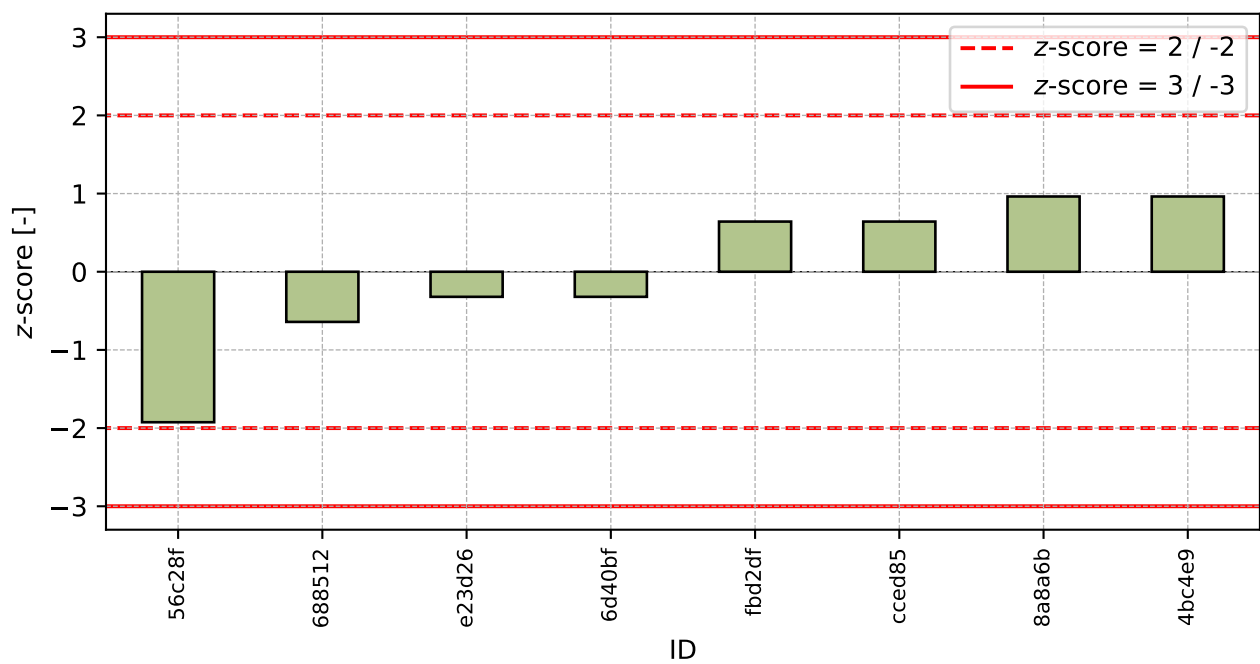


Figure 45: z-score

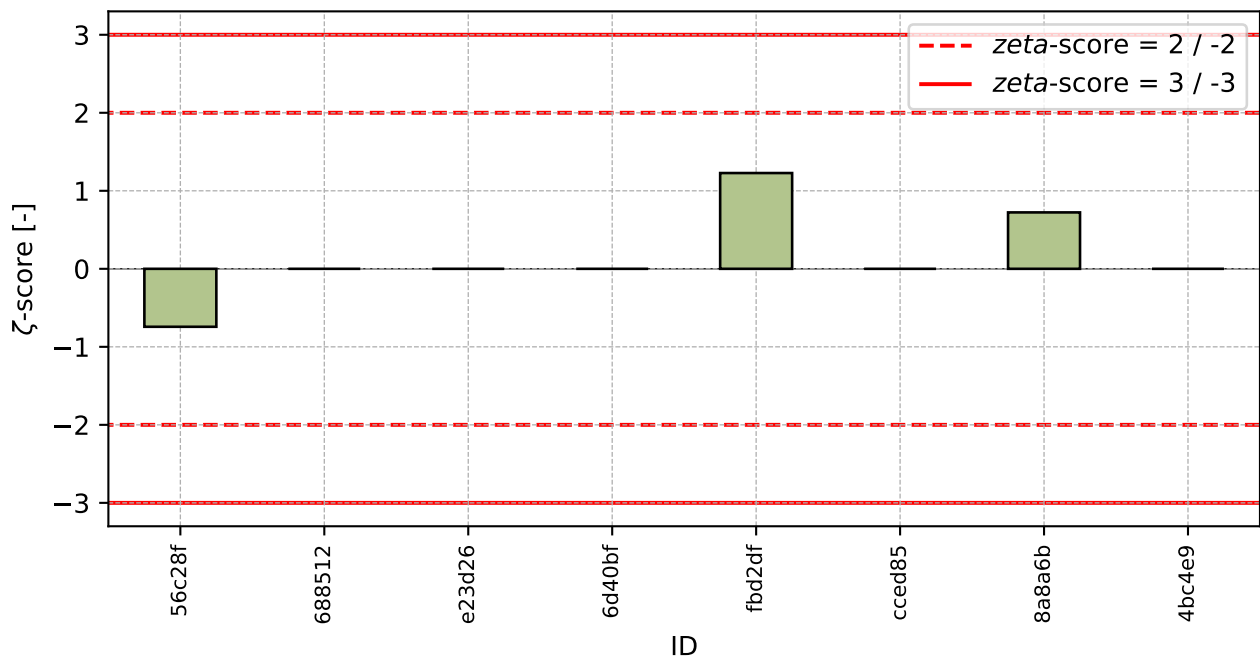


Figure 46: ζ-score

Table 19: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
56c28f	-1.93	-0.74
688512	-0.64	-
e23d26	-0.32	-
6d40bf	-0.32	-
fbf2df	0.64	1.23
cced85	0.64	-
8a8a6b	0.96	0.72
4bc4e9	0.96	-

3.2 Binder course

3.2.1 Test results

Table 20: Test results – ordered by average value. Outliers are marked by red color. Columns 1–4 are individual determinations; u_X – extended uncertainty of measurement; $\bar{x}$ – average value; s_0 – sample standard deviation; V_X – variation coefficient

ID	1 [mm]	2 [mm]	3 [mm]	4 [mm]	u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
73d85a	69	68	68	70	-	69	1.0	1.39
8a8a6b	81	80	80	80	1.0	80	0.5	0.62
56c28f	81	80	81	80	2.0	80	0.6	0.72
688512	80	80	81	81	-	80	0.6	0.72
fb2df	82	81	81	81	0.7	81	0.5	0.62
4bc4e9	81	81	81	82	-	81	0.5	0.62
cced85	81	81	81	82	-	81	0.5	0.62
e23d26	81	81	82	81	-	81	0.5	0.62
6d40bf	81	81	82	81	-	81	0.5	0.62

3.2.2 The Numerical Procedure for Determining Outliers

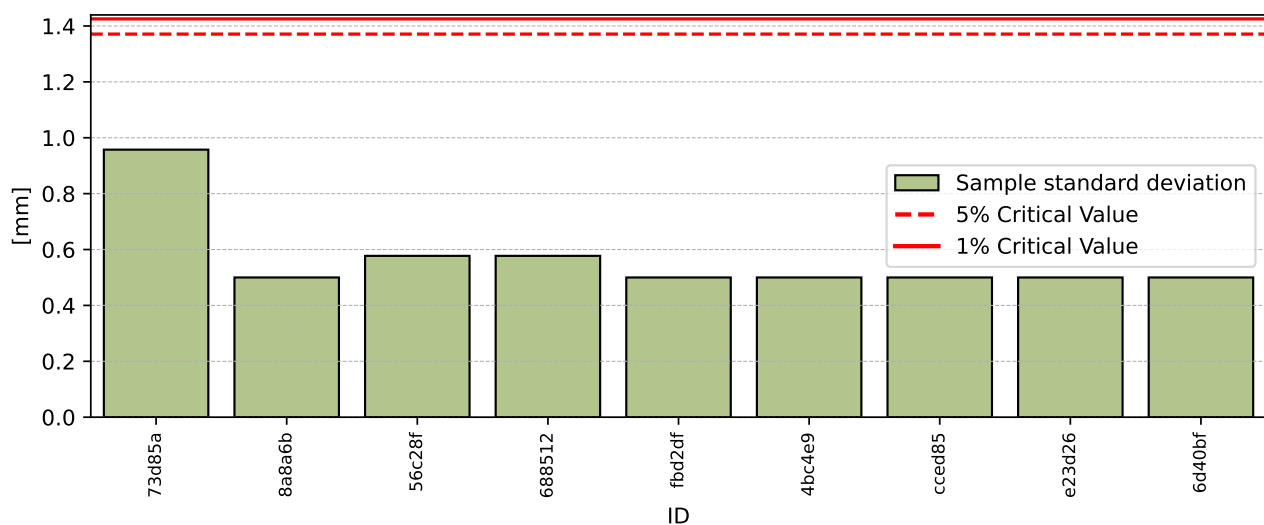


Figure 47: **Cochran's test** - sample standard deviations

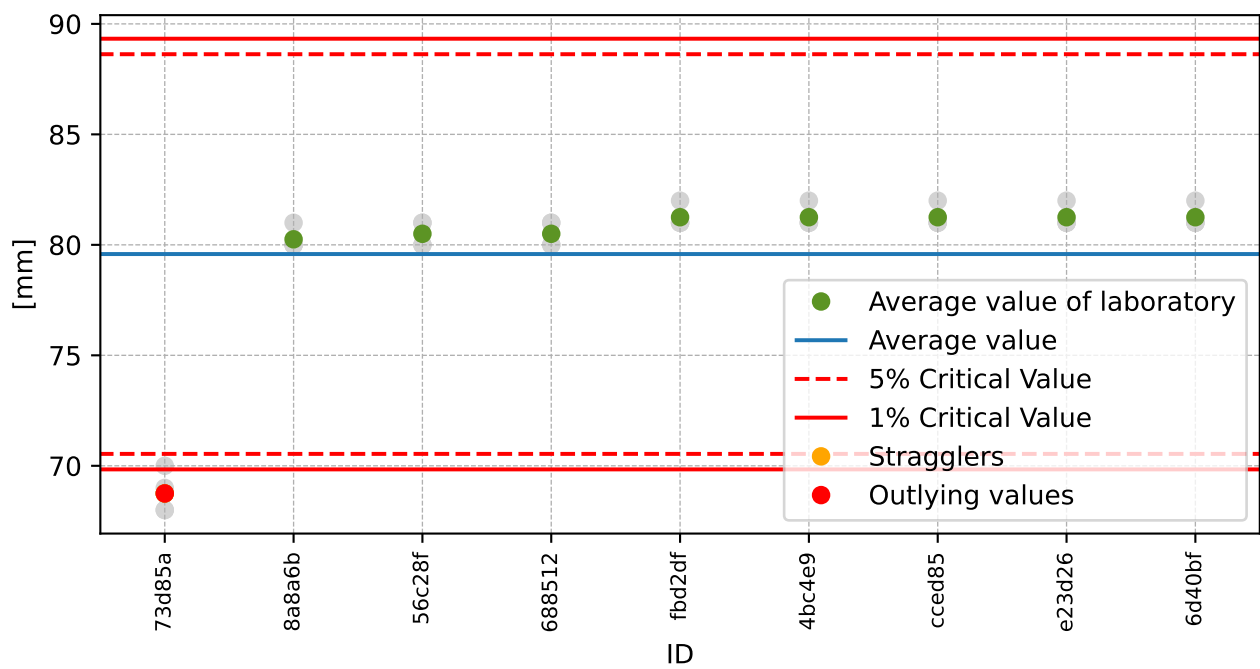


Figure 48: **Grubbs' test** - average values

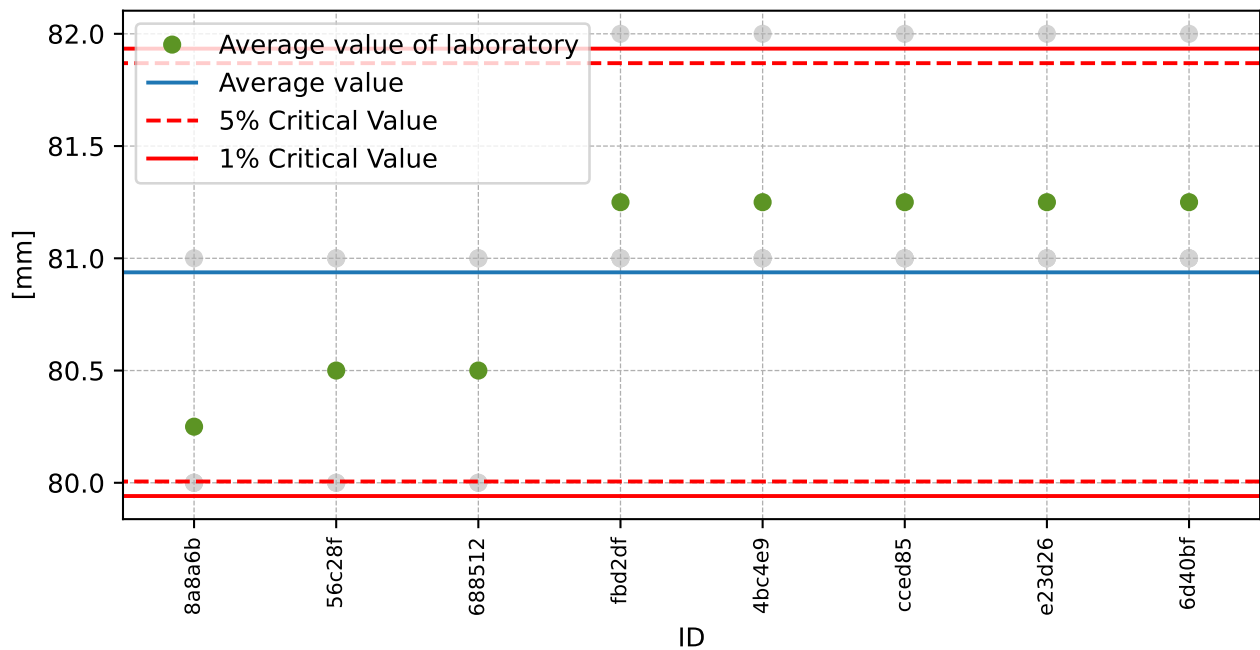


Figure 49: **Grubbs' test** - average values without outliers

3.2.3 Mandel’s Statistics

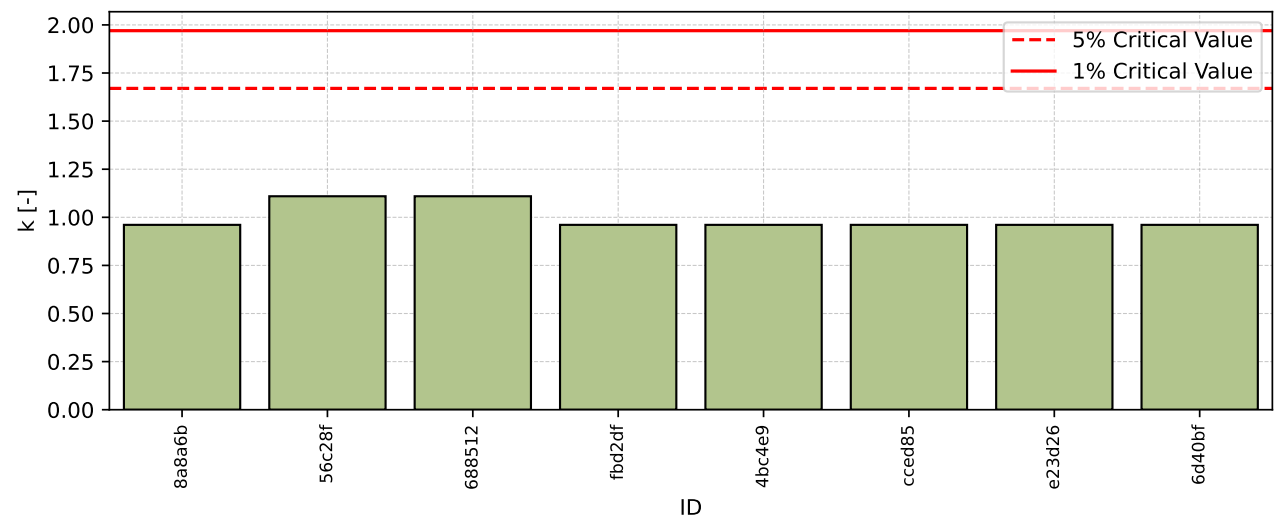


Figure 50: Intralaboratory Consistency Statistic

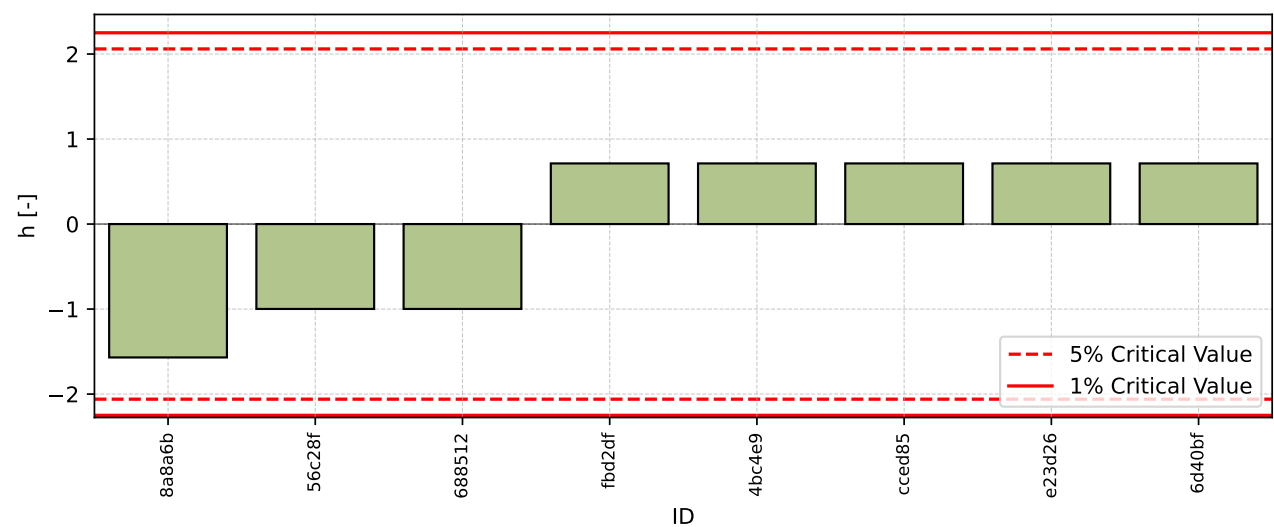


Figure 51: Interlaboratory Consistency Statistic

3.2.4 Descriptive statistics

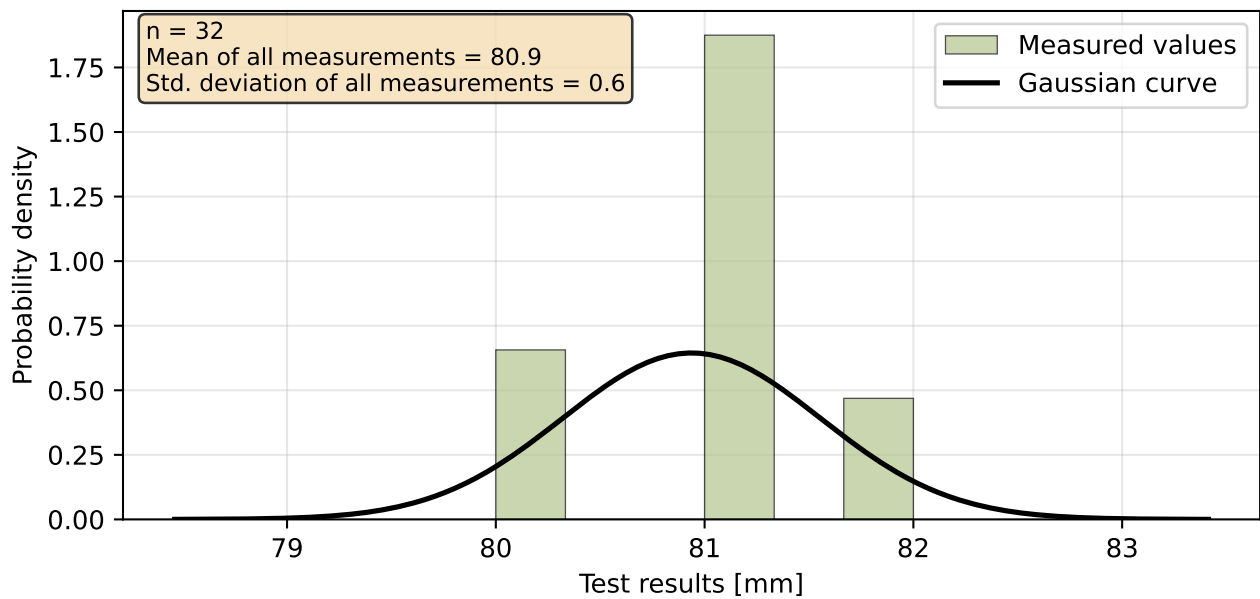


Figure 52: Histogram of all test results

Table 21: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	80.9
Sample standard deviation – s	0.4
Assigned value – x^*	80.9
Robust standard deviation – s^*	0.4
Measurement uncertainty of assigned value – u_X	0.2
p -value of normality test [-]	< 0.001

3.2.5 Evaluation of Performance Statistics

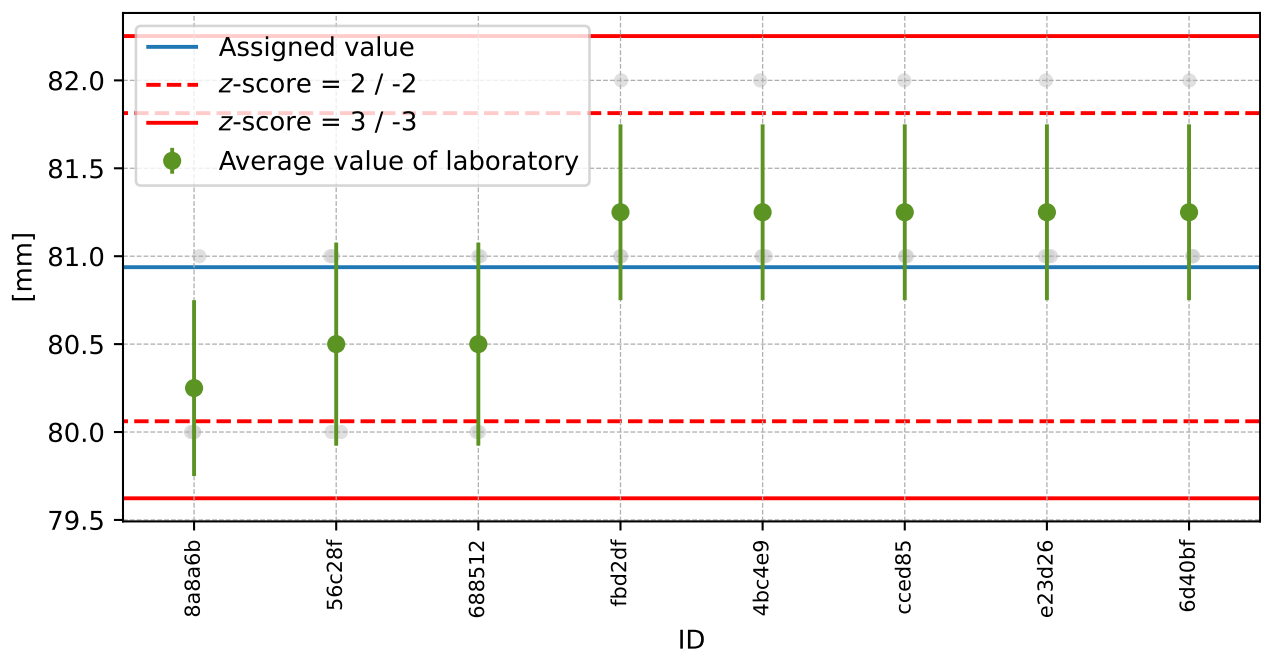


Figure 53: Average values and sample standard deviations

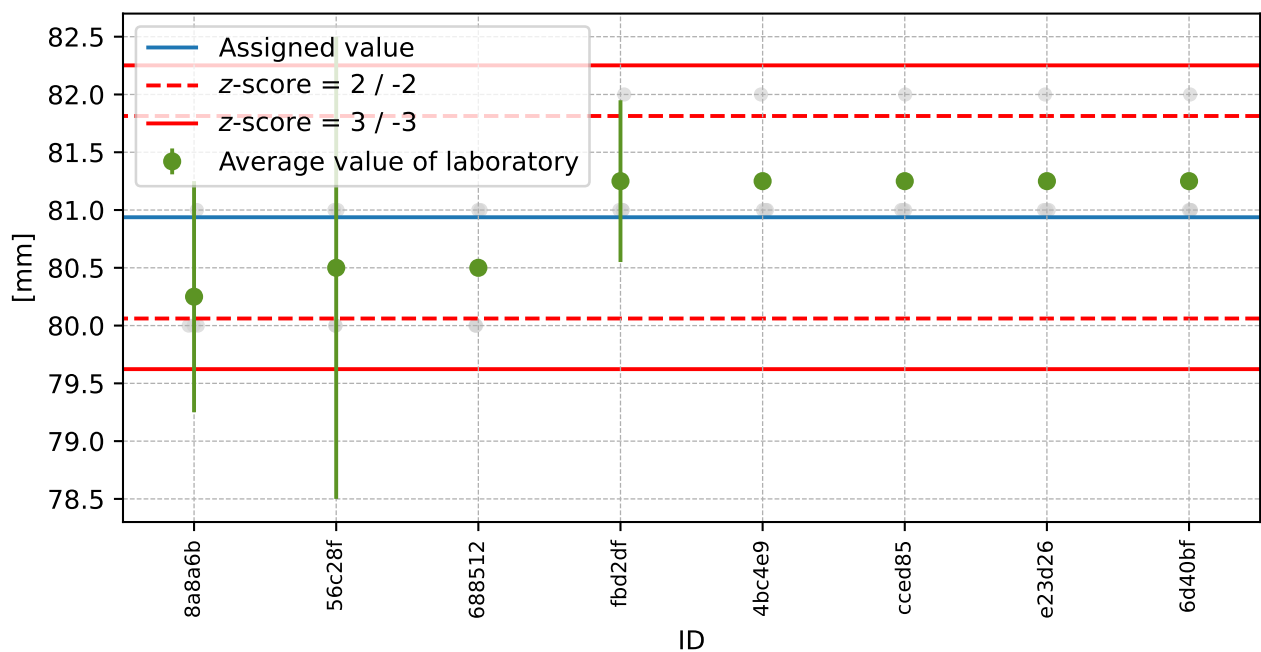


Figure 54: Average values and extended uncertainties of measurement

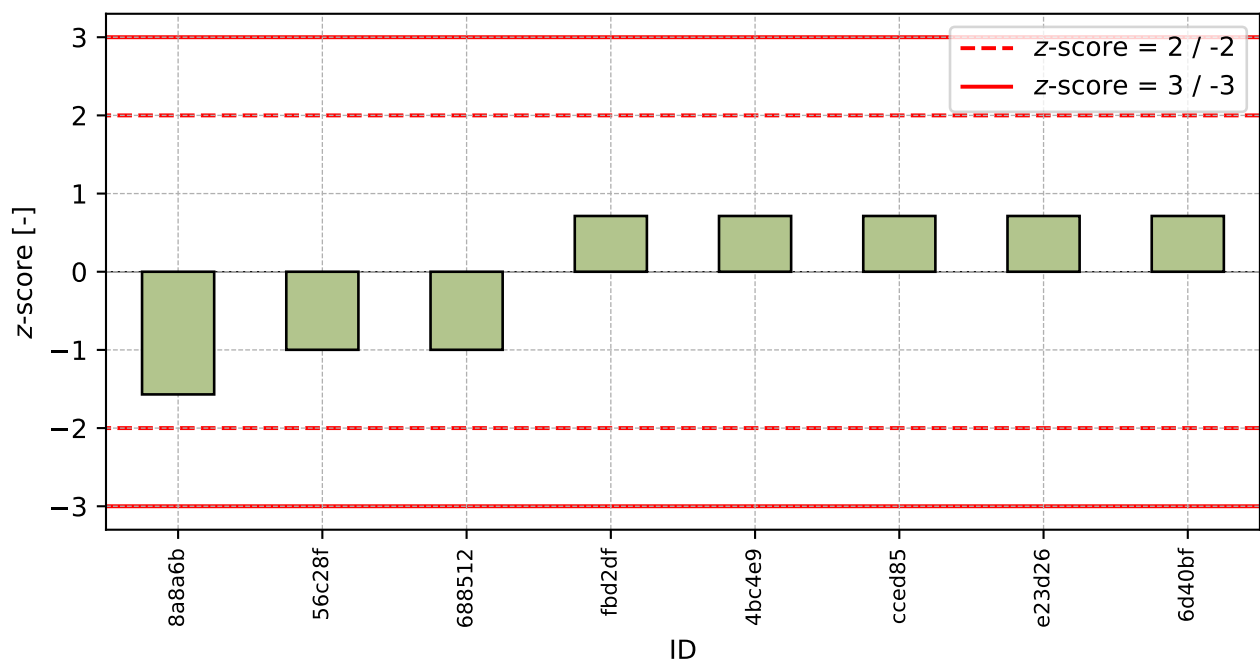


Figure 55: z-score

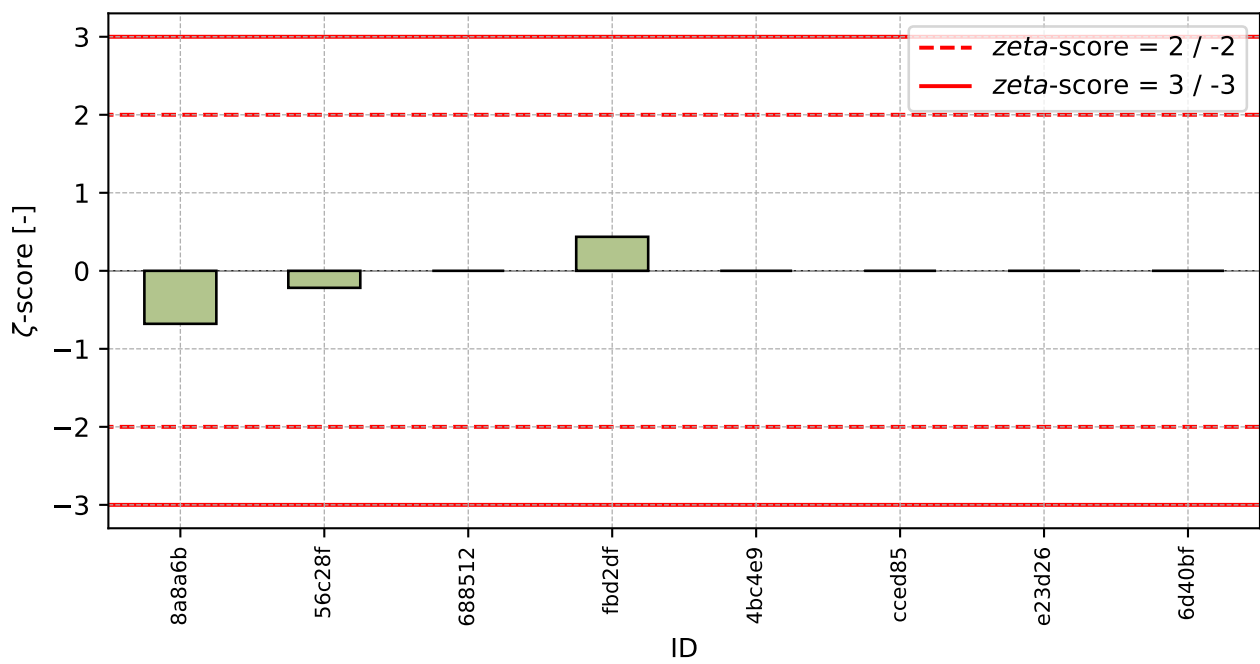


Figure 56: ζ-score

Table 22: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
8a8a6b	-1.57	-0.68
56c28f	-1.00	-0.22
688512	-1.00	-
fbf2df	0.71	0.44
4bc4e9	0.71	-
cced85	0.71	-
e23d26	0.71	-
6d40bf	0.71	-

3.3 Base course I

3.3.1 Test results

Table 23: Test results – ordered by average value. Outliers are marked by red color. Columns 1–4 are individual determinations; u_X – extended uncertainty of measurement; $\bar{x}$ – average value; s_0 – sample standard deviation; V_X – variation coefficient

ID	1 [mm]	2 [mm]	3 [mm]	4 [mm]	u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
688512	67	69	68	69	-	68	1.0	1.40
fbd2df	69	69	70	69	0.6	69	0.5	0.72
73d85a	71	68	69	69	-	69	1.3	1.82
6d40bf	70	69	69	69	-	69	0.5	0.72
4bc4e9	69	69	71	69	-	70	1.0	1.44
cced85	69	69	71	69	-	70	1.0	1.44
56c28f	69	70	70	69	2.0	70	0.6	0.83
8a8a6b	70	70	69	71	1.0	70	0.8	1.17
e23d26	71	70	69	70	-	70	0.8	1.17

3.3.2 The Numerical Procedure for Determining Outliers

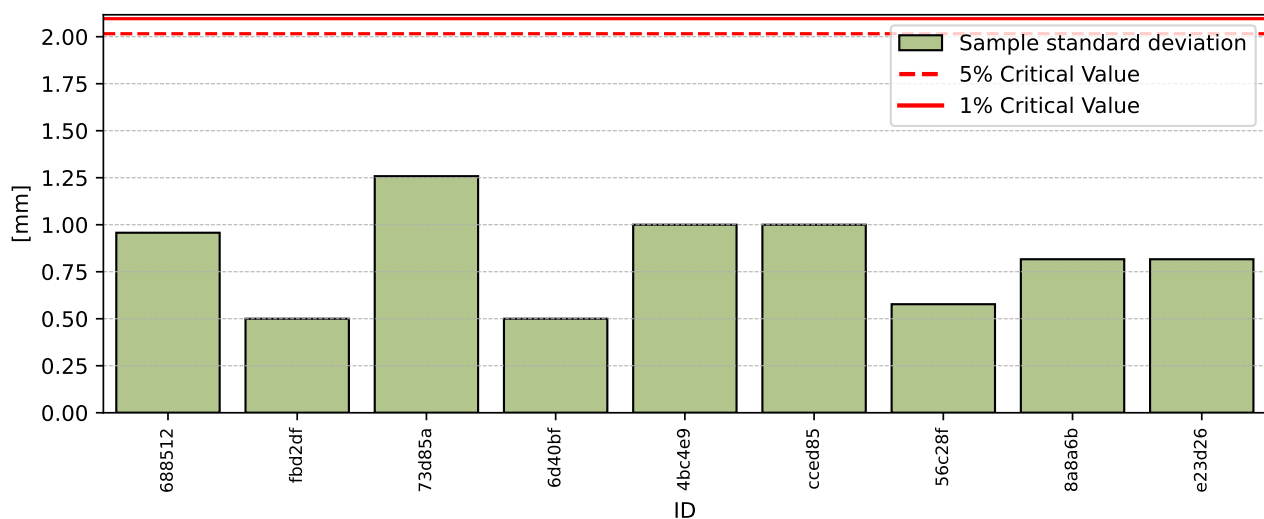
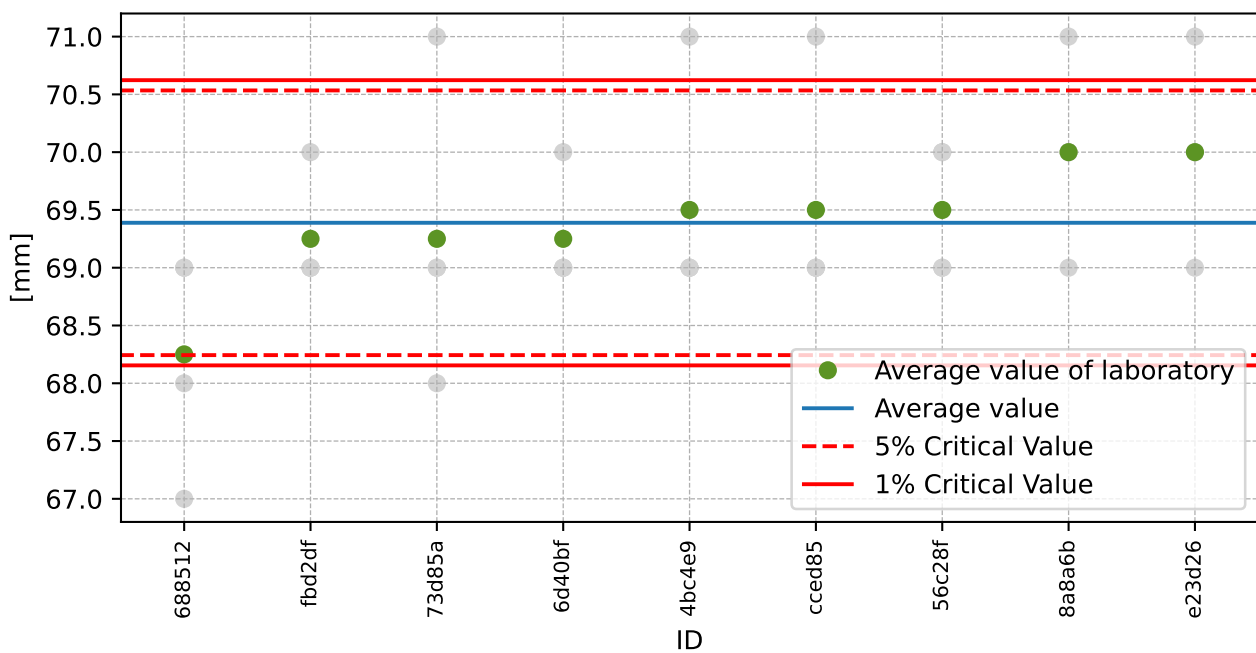


Figure 57: **Cochran's test** - sample standard deviations

Figure 58: **Grubbs' test** - average values

3.3.3 Mandel's Statistics

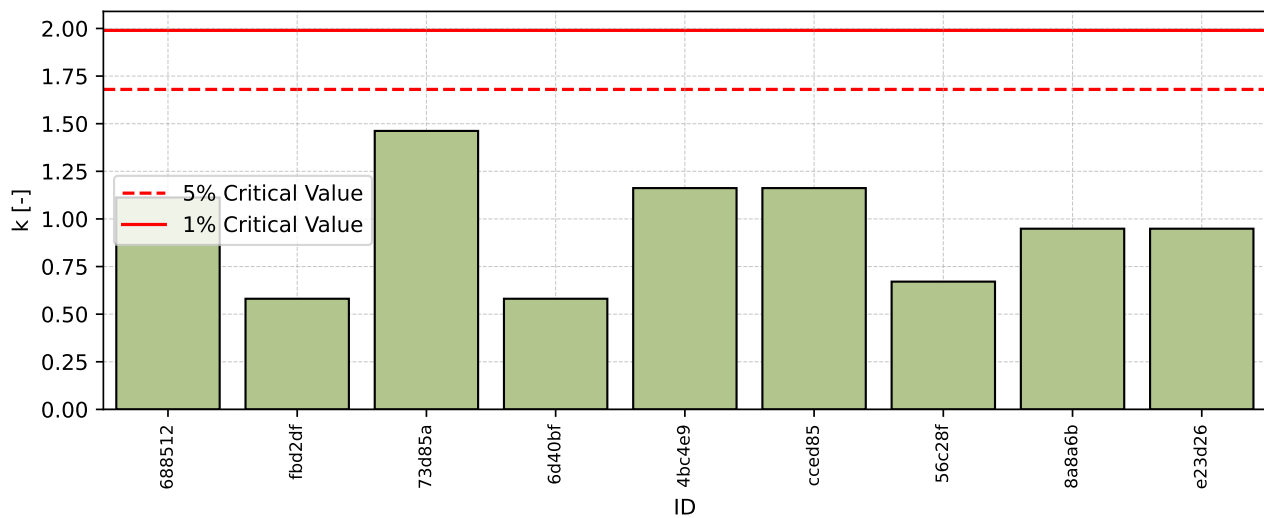


Figure 59: Intralaboratory Consistency Statistic

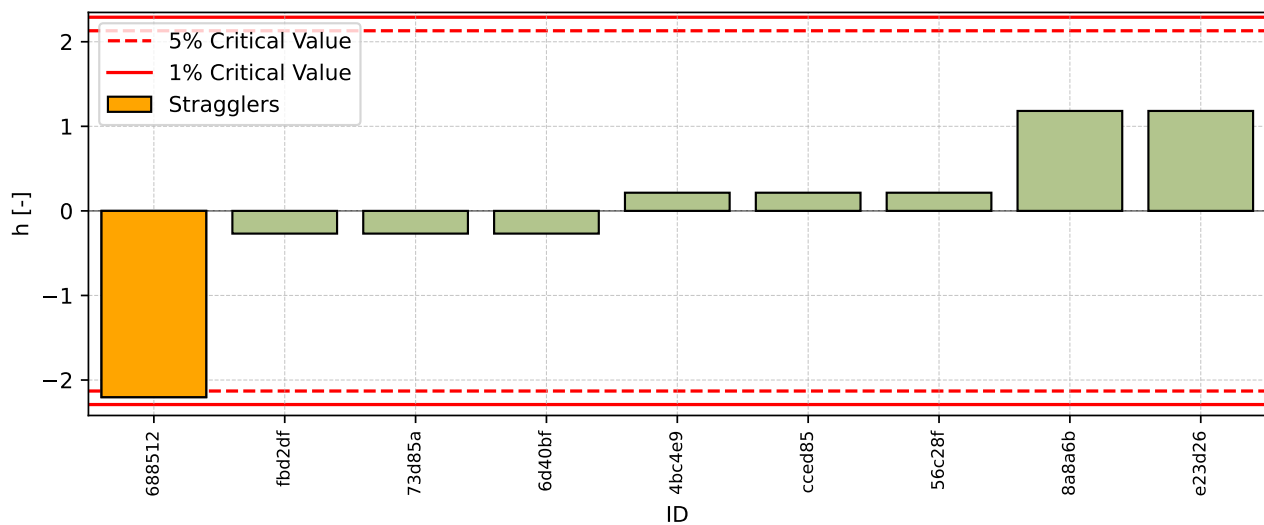


Figure 60: Interlaboratory Consistency Statistic

3.3.4 Descriptive statistics

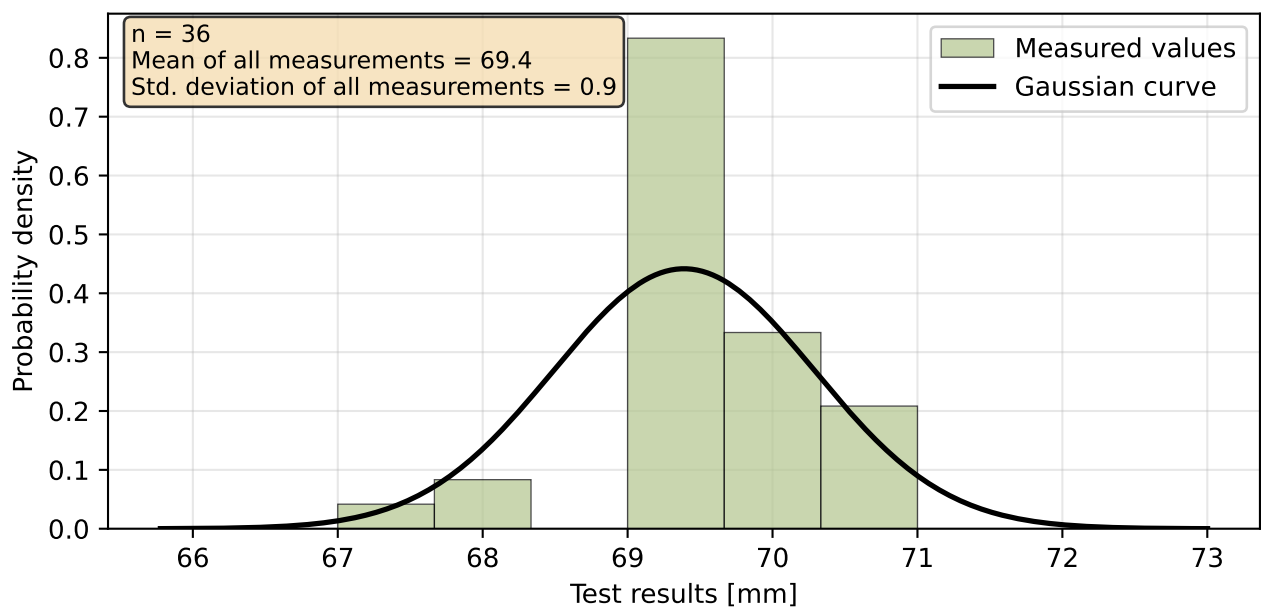


Figure 61: Histogram of all test results

Table 24: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	69.4
Sample standard deviation – s	0.5
Assigned value – x^*	69.4
Robust standard deviation – s^*	0.5
Measurement uncertainty of assigned value – u_X	0.2
p -value of normality test [-]	< 0.001
Interlaboratory standard deviation – s_L	0.3
Repeatability standard deviation – s_r	0.9
Reproducibility standard deviation – s_R	0.9
Repeatability – r	2.4
Reproducibility – R	2.5

3.3.5 Evaluation of Performance Statistics

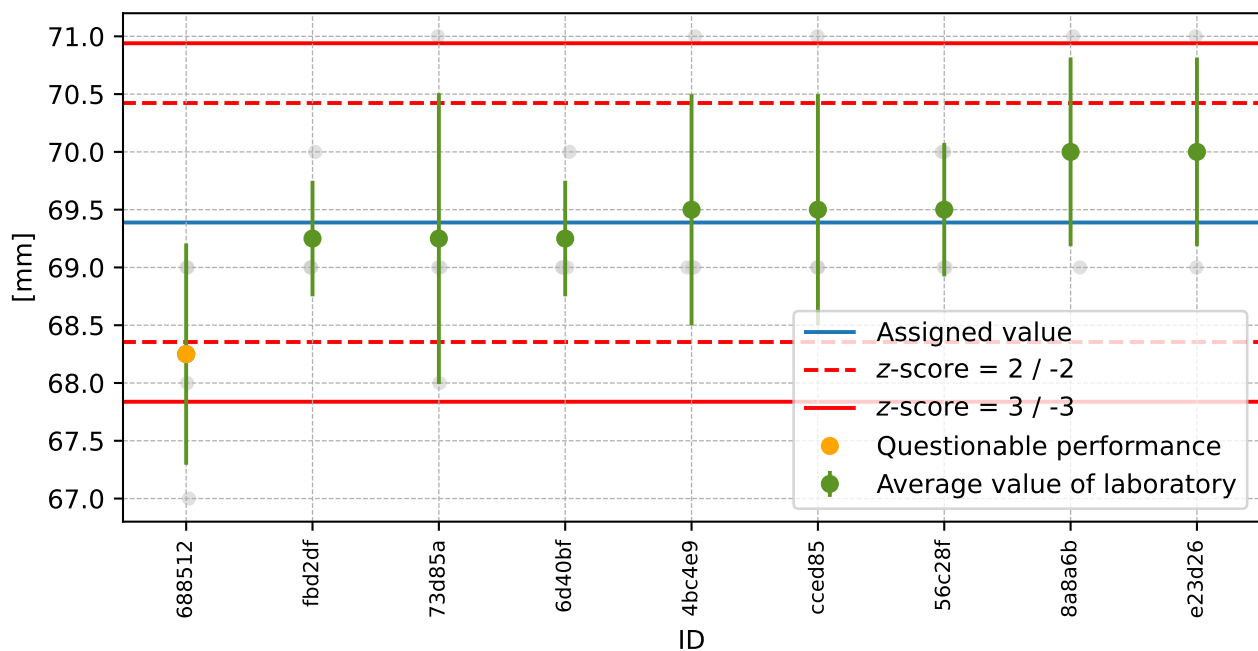


Figure 62: Average values and sample standard deviations

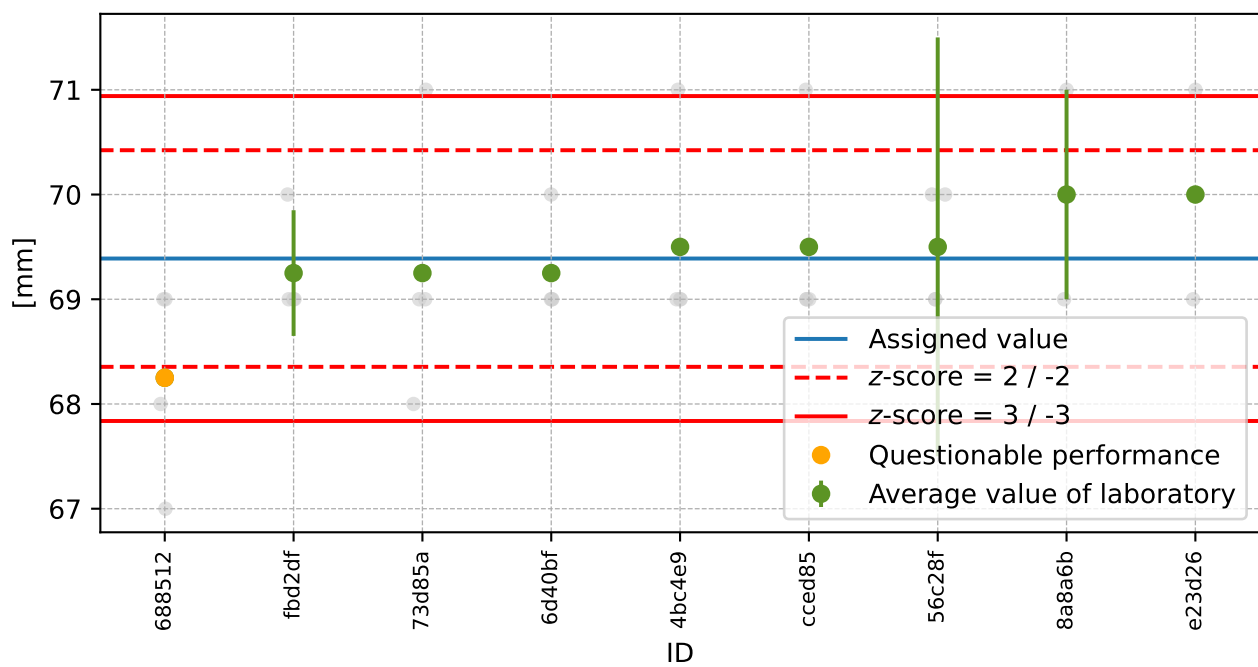


Figure 63: Average values and extended uncertainties of measurement

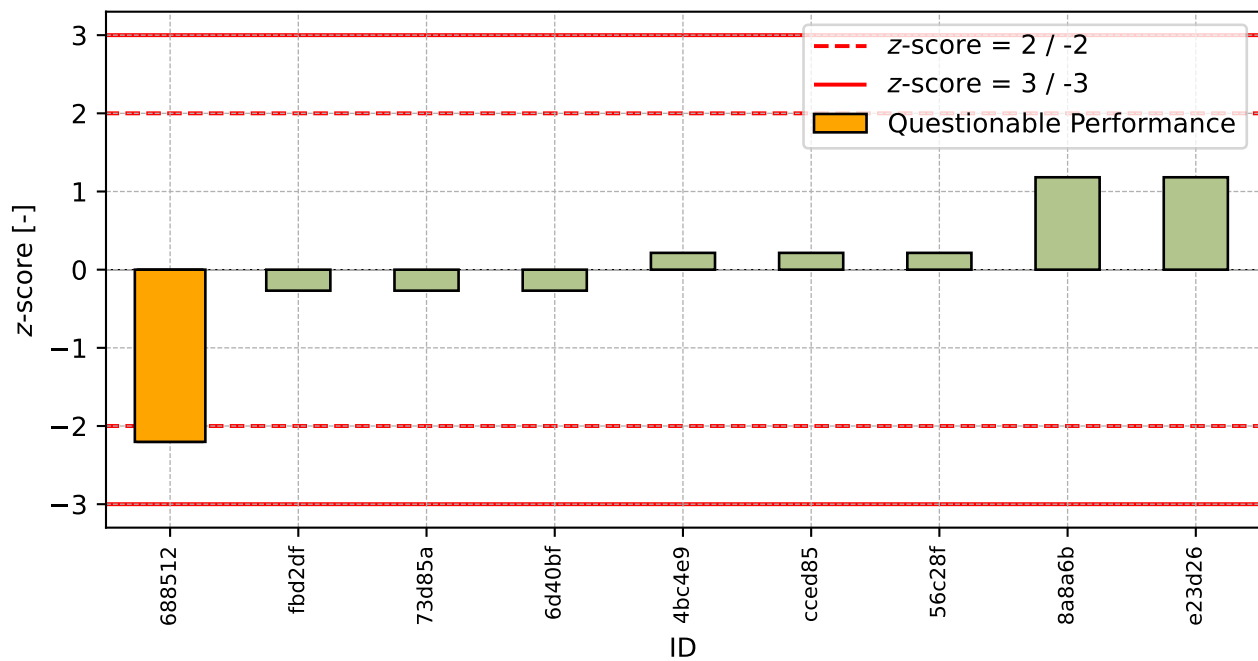
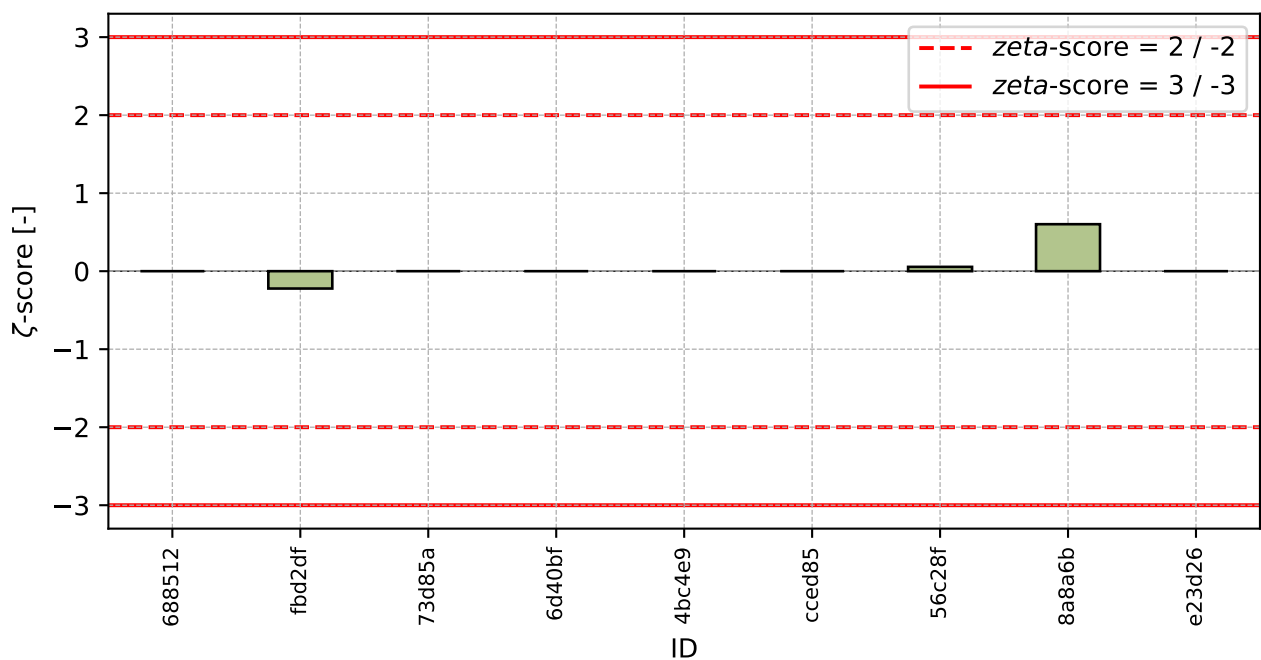


Figure 64: z-score

Figure 65: ζ -scoreTable 25: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
688512	-2.20	-
fbd2df	-0.27	-0.22
73d85a	-0.27	-
6d40bf	-0.27	-
4bc4e9	0.21	-
cced85	0.21	-
56c28f	0.21	0.06
8a8a6b	1.18	0.60
e23d26	1.18	-

3.4 Base course II

3.4.1 Test results

Table 26: Test results – ordered by average value. Outliers are marked by red color. Columns 1–4 are individual determinations; u_X – extended uncertainty of measurement; $\bar{x}$ – average value; s_0 – sample standard deviation; V_X – variation coefficient

ID	1 [mm]	2 [mm]	3 [mm]	4 [mm]	u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
6d40bf	70	69	69	68	-	69	0.8	1.18
688512	70	70	70	67	-	69	1.5	2.17
4bc4e9	70	70	68	70	-	70	1.0	1.44
cced85	70	70	68	70	-	70	1.0	1.44
56c28f	69	70	71	69	2.0	70	1.0	1.37
e23d26	70	69	70	70	-	70	0.5	0.72
fbd2df	70	69	71	70	0.6	70	0.8	1.17
8a8a6b	71	71	72	69	1.0	71	1.3	1.78
73d85a	71	72	71	72	-	72	0.6	0.81

3.4.2 The Numerical Procedure for Determining Outliers

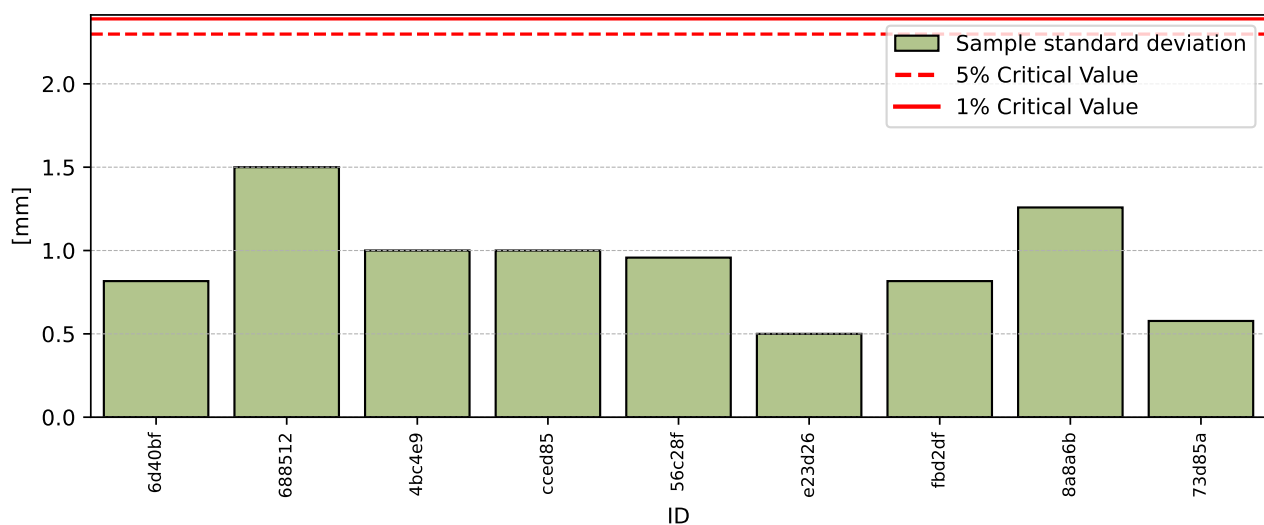


Figure 66: **Cochran's test** - sample standard deviations

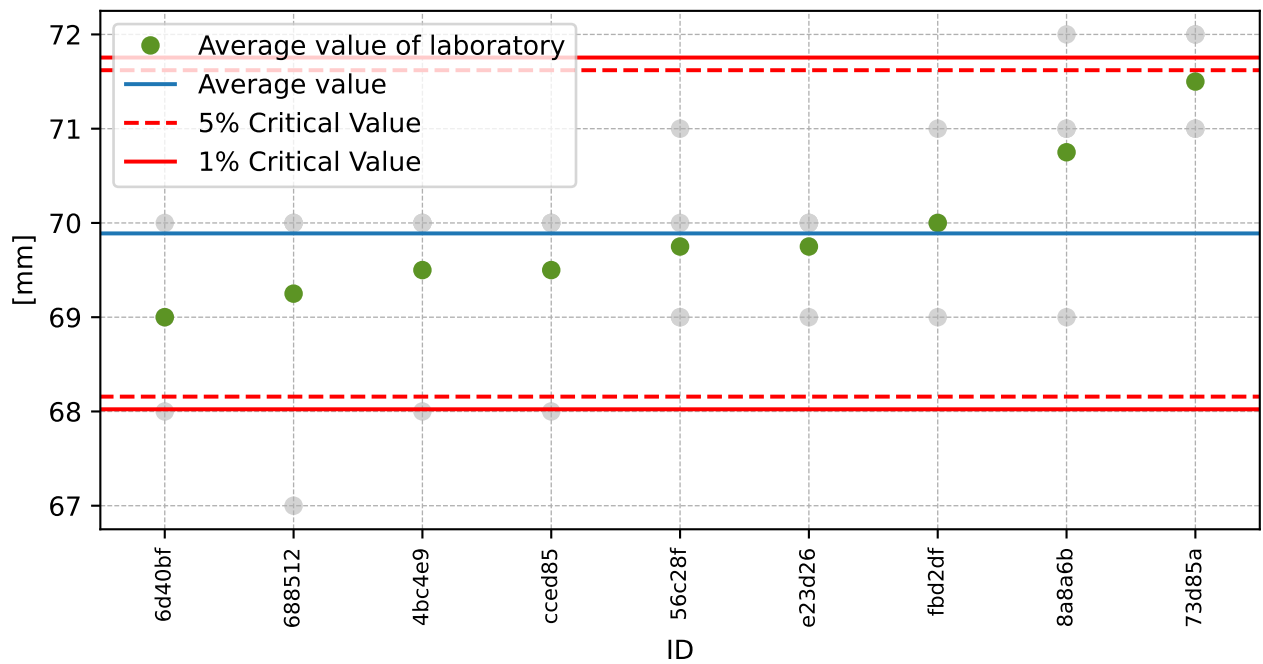


Figure 67: **Grubbs' test** - average values

3.4.3 Mandel's Statistics

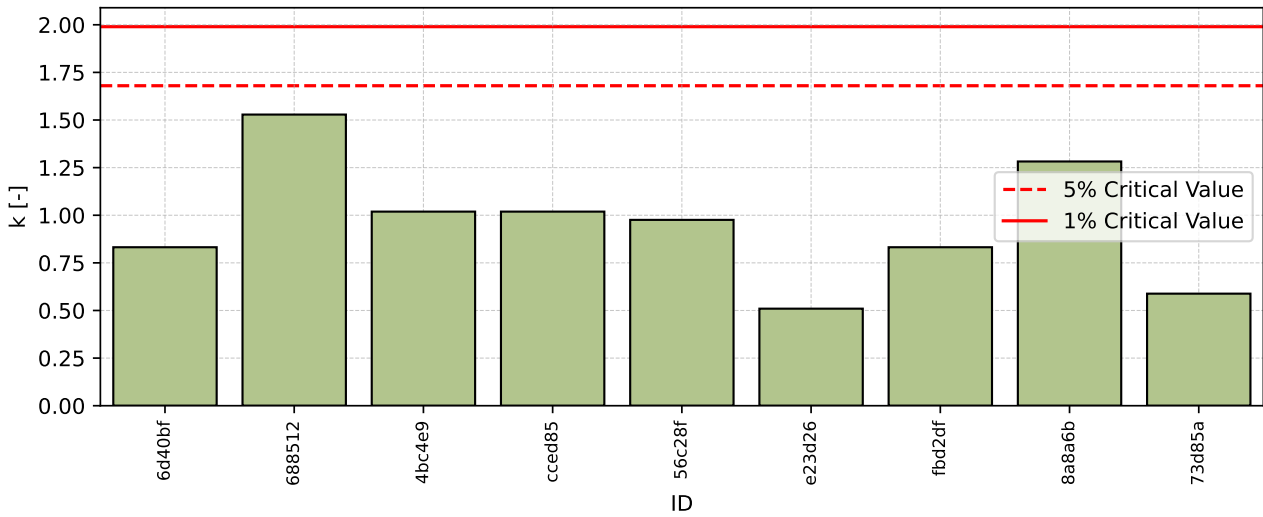


Figure 68: Intralaboratory Consistency Statistic

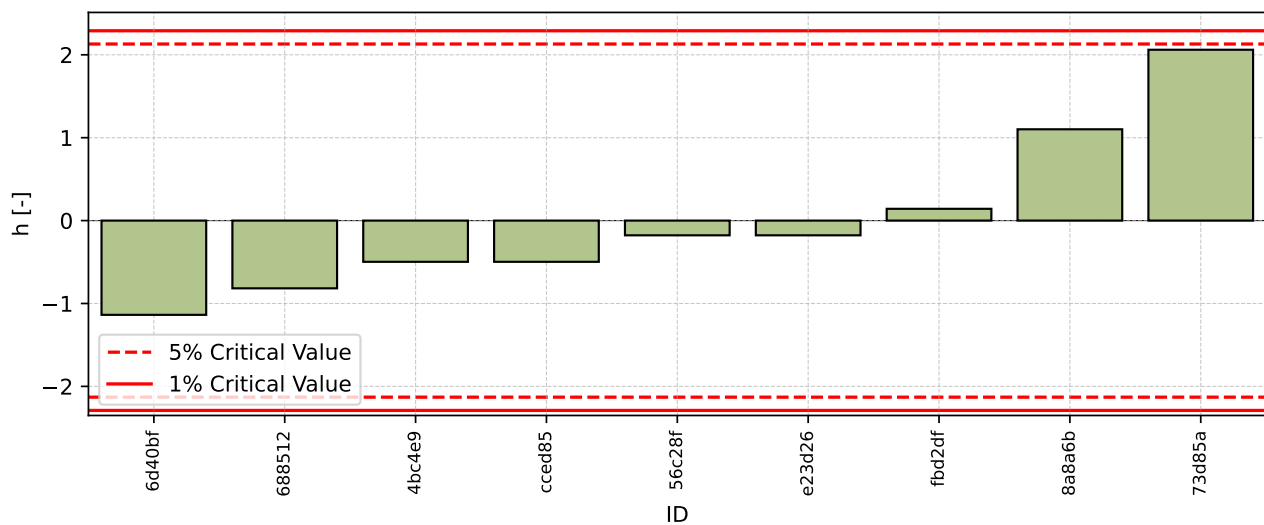


Figure 69: Interlaboratory Consistency Statistic

3.4.4 Descriptive statistics

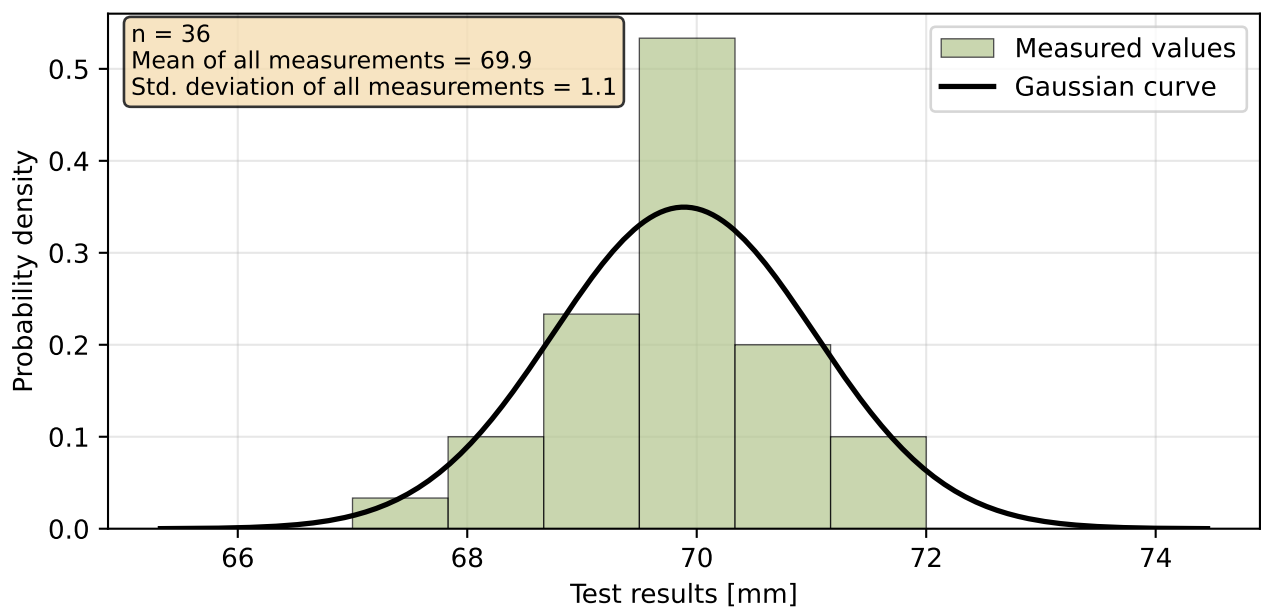


Figure 70: Histogram of all test results

Table 27: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	69.9
Sample standard deviation – s	0.8
Assigned value – x^*	69.9
Robust standard deviation – s^*	0.8
Measurement uncertainty of assigned value – u_X	0.3
p -value of normality test [-]	0.012
Interlaboratory standard deviation – s_L	0.6
Repeatability standard deviation – s_r	1.0
Reproducibility standard deviation – s_R	1.2
Repeatability – r	2.7
Reproducibility – R	3.2

3.4.5 Evaluation of Performance Statistics

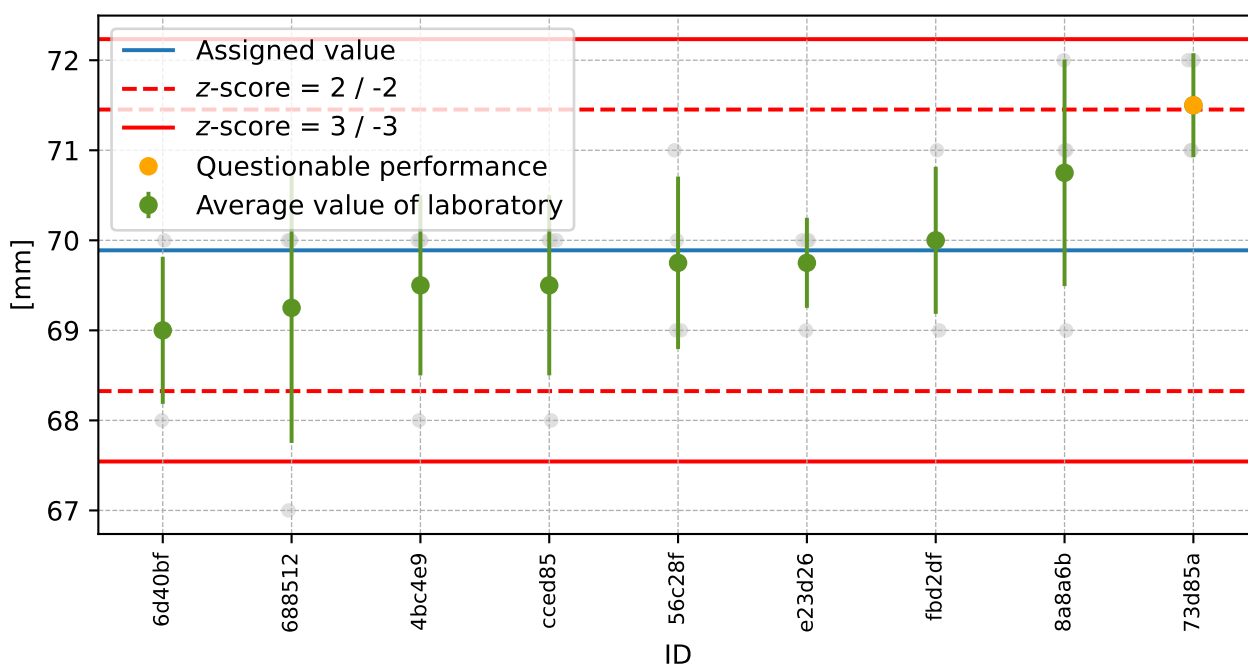


Figure 71: Average values and sample standard deviations

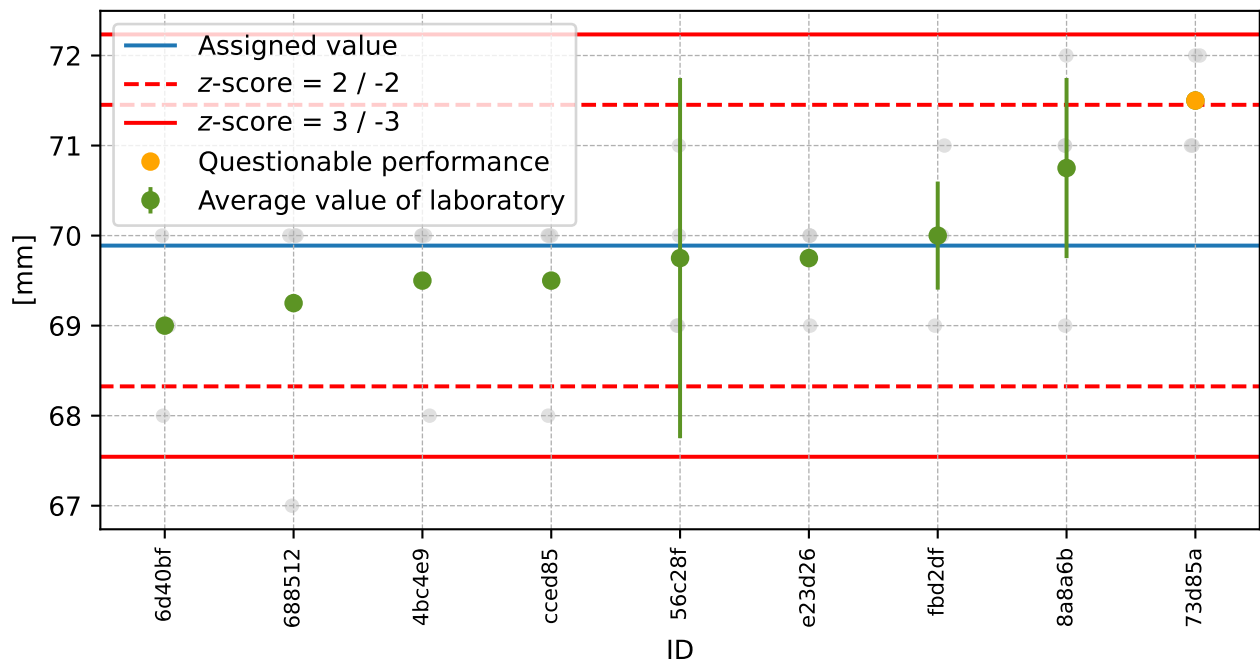


Figure 72: Average values and extended uncertainties of measurement

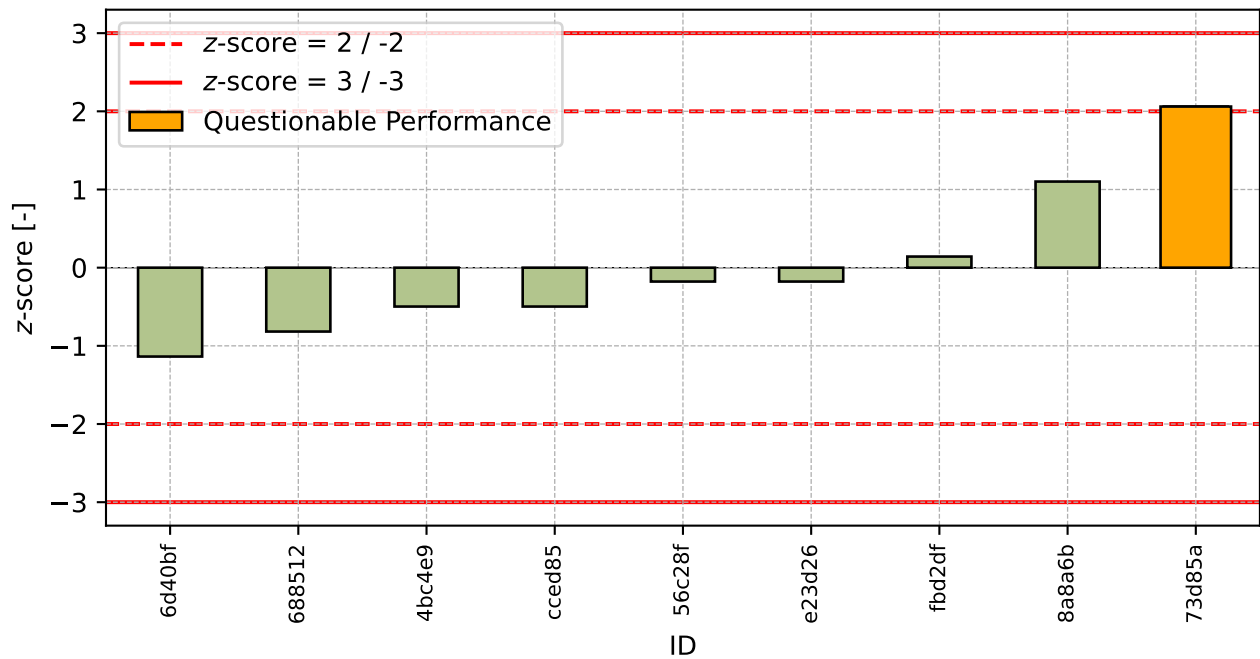
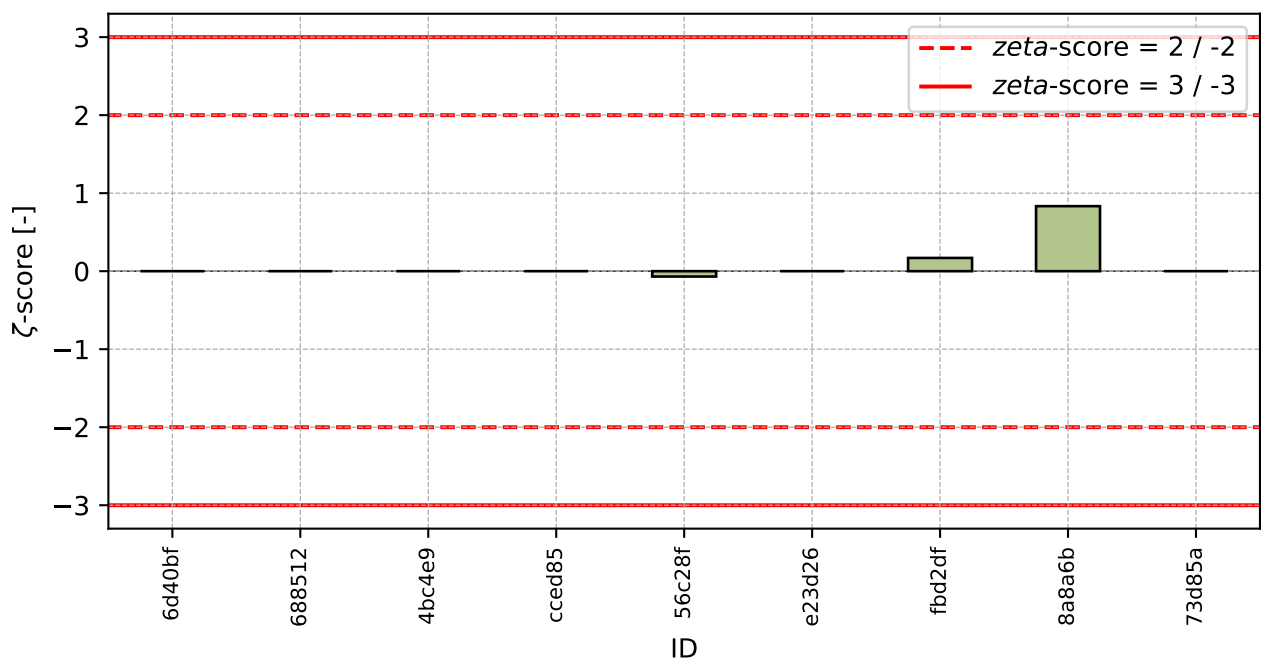


Figure 73: z-score

Figure 74: ζ -scoreTable 28: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
6d40bf	-1.14	-
688512	-0.82	-
4bc4e9	-0.50	-
cced85	-0.50	-
56c28f	-0.18	-0.07
e23d26	-0.18	-
fbd2df	0.14	0.17
8a8a6b	1.10	0.83
73d85a	2.06	-

4 Appendix – EN 13036-1 Measurement of pavement surface macrotexture depth using a volumetric patch technique

4.1 Test results

Table 29: Test results – ordered by average value. Outliers are marked by red color. u_X – extended uncertainty of measurement.

ID	Result [mm]	u_X [mm]
73d85a	0.66	-
3ce9a9	0.67	0.020
6d40bf	0.78	-
e23d26	0.83	-
688512	0.84	-

4.2 The Numerical Procedure for Determining Outliers

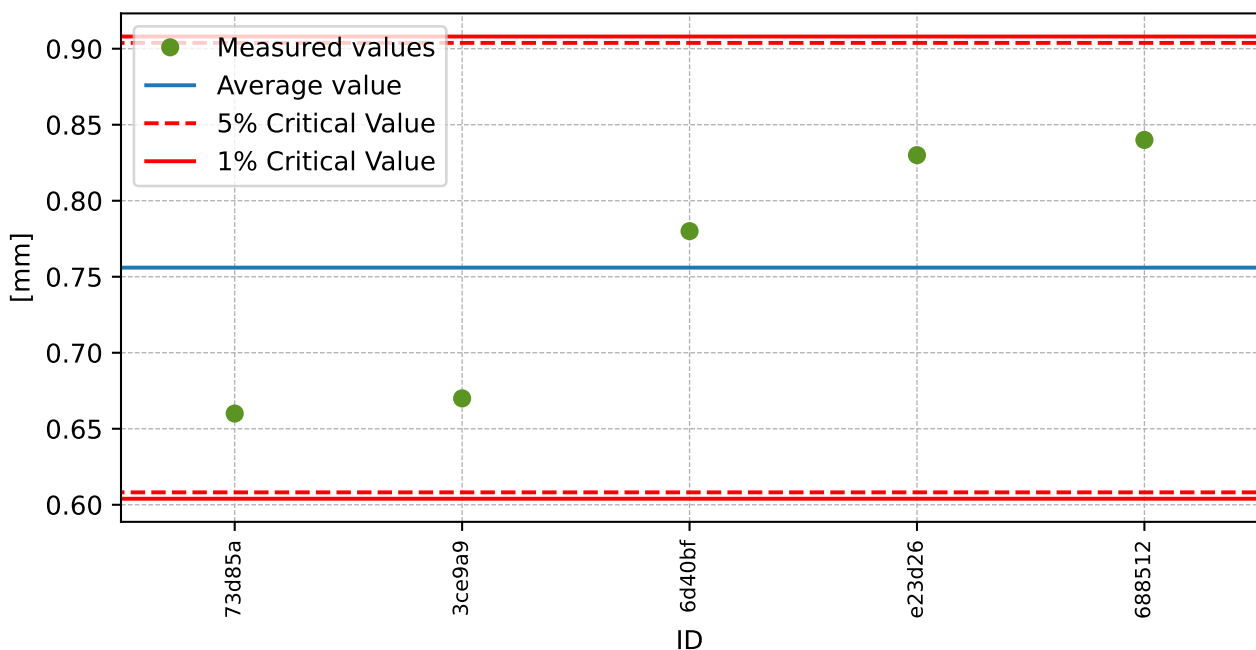


Figure 75: **Grubbs' test** - average values

4.3 Mandel's Statistics

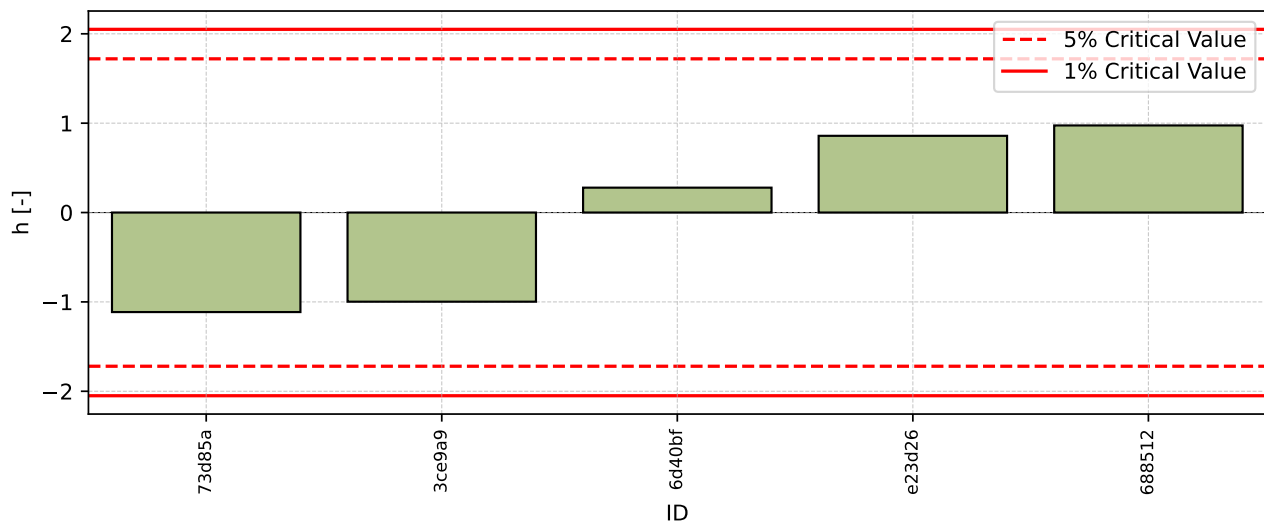


Figure 76: Interlaboratory Consistency Statistic

4.4 Descriptive statistics

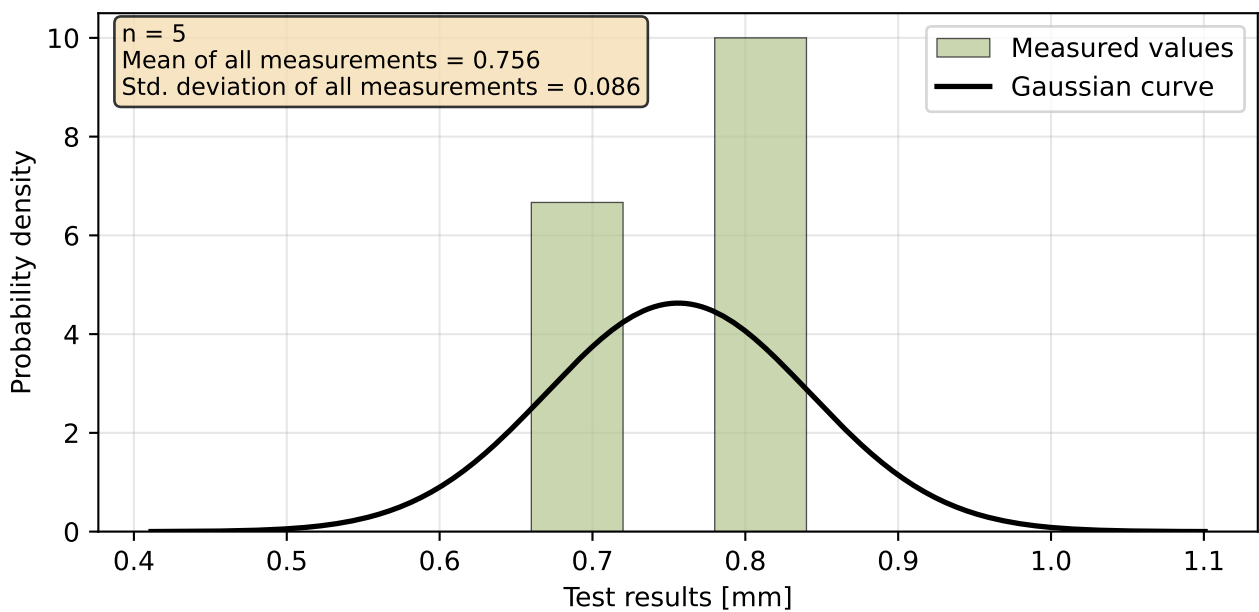


Figure 77: Histogram of all test results

Table 30: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	0.756
Sample standard deviation – s	0.086
Assigned value – x^*	0.756
Robust standard deviation – s^*	0.086
Measurement uncertainty of assigned value – u_X	0.039
p -value of normality test [-]	0.172

4.5 Evaluation of Performance Statistics

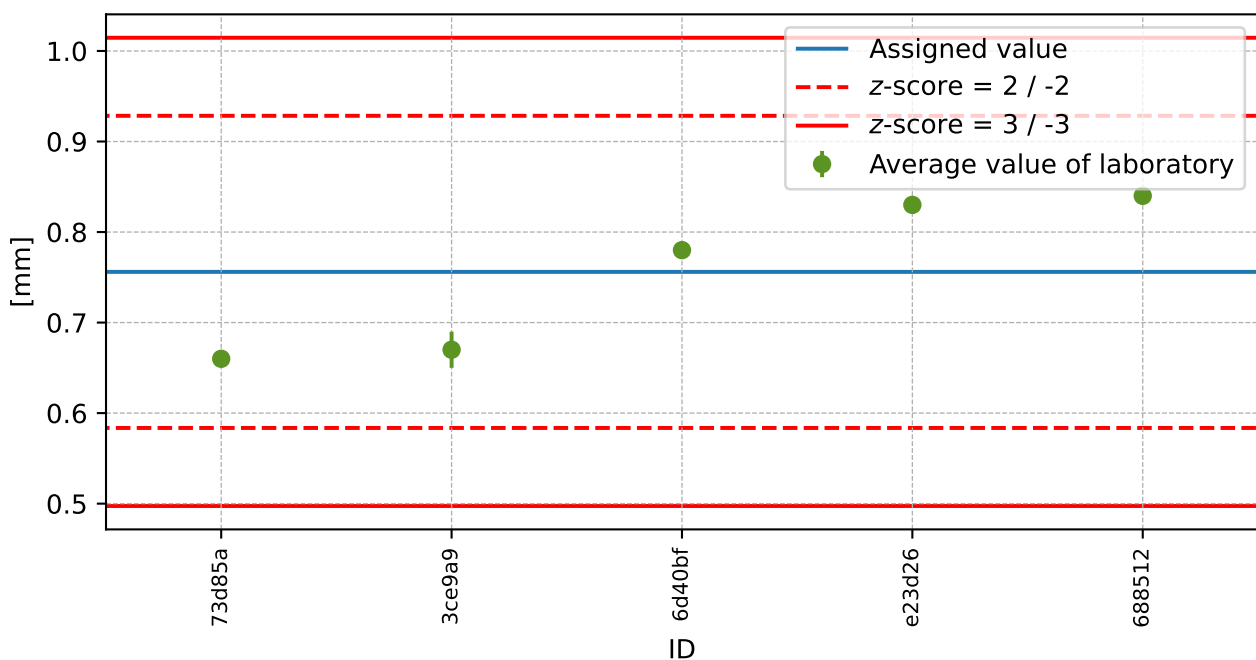


Figure 78: Average values and extended uncertainties of measurement

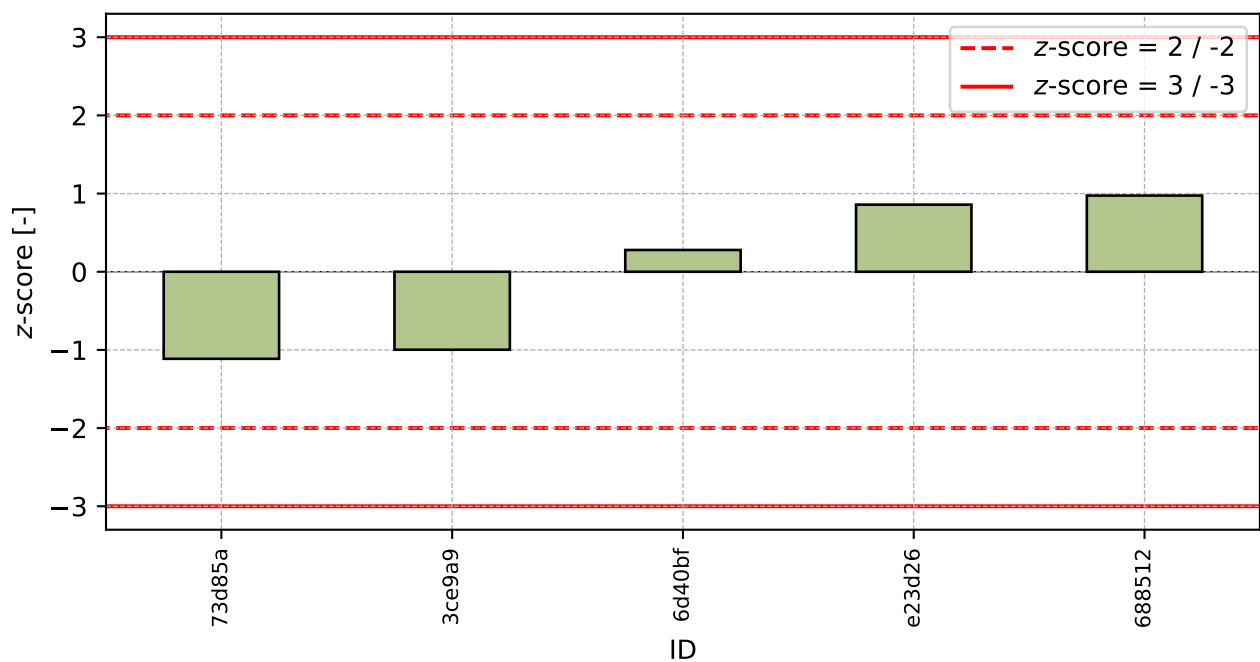


Figure 79: z-score

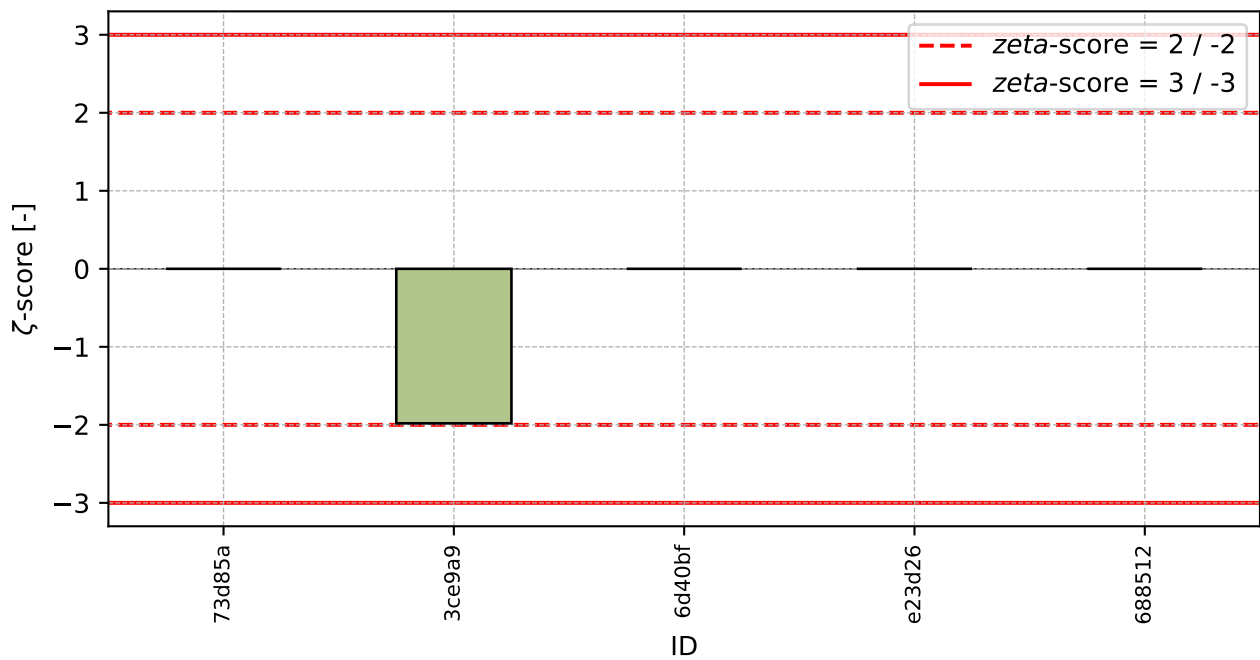


Figure 80: ζ-score

Table 31: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
73d85a	-1.11	-
3ce9a9	-1.00	-1.98
6d40bf	0.28	-
e23d26	0.86	-
688512	0.97	-

5 Appendix – EN 13036-4 Method for measurement of slip/skid resistance of a surface – The pendulum test (PTV)

5.1 Test results

Table 32: Test results – ordered by average value. Outliers are marked by red color. u_X – extended uncertainty of measurement.

ID	Result [-]	u_X [-]
511cb0	66	-
e23d26	68	-
3ce9a9	70	0.9
73d85a	70	-
688512	77	-

5.2 The Numerical Procedure for Determining Outliers

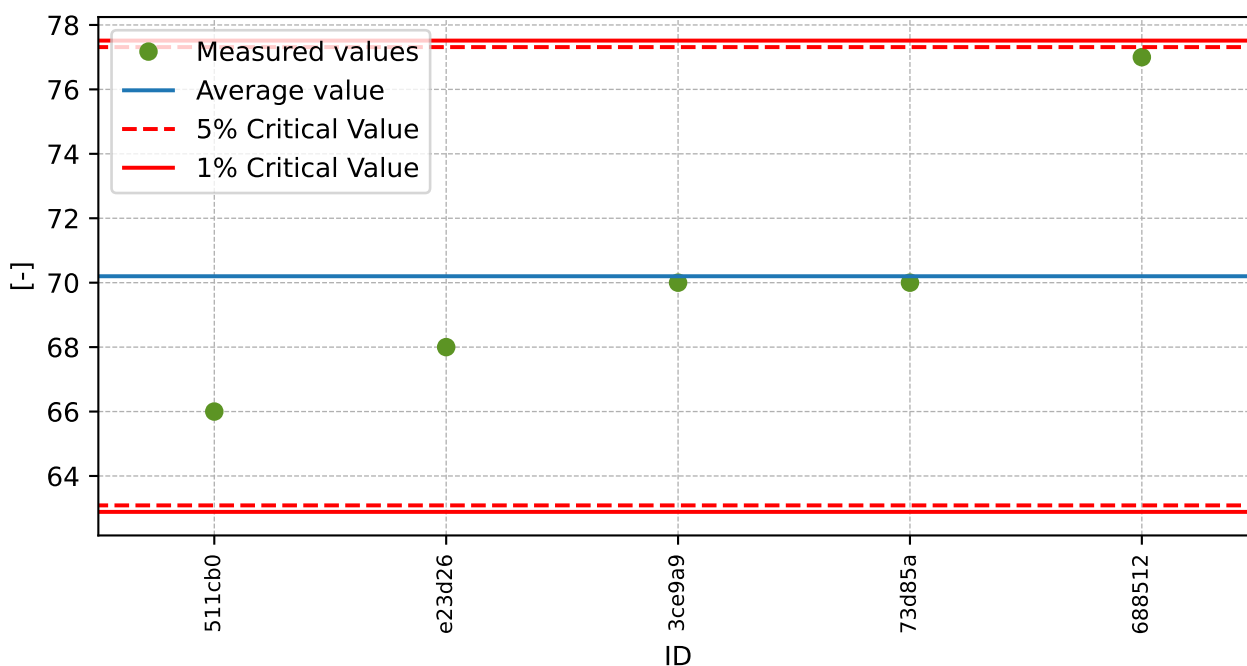


Figure 81: **Grubbs' test** - average values

5.3 Mandel's Statistics

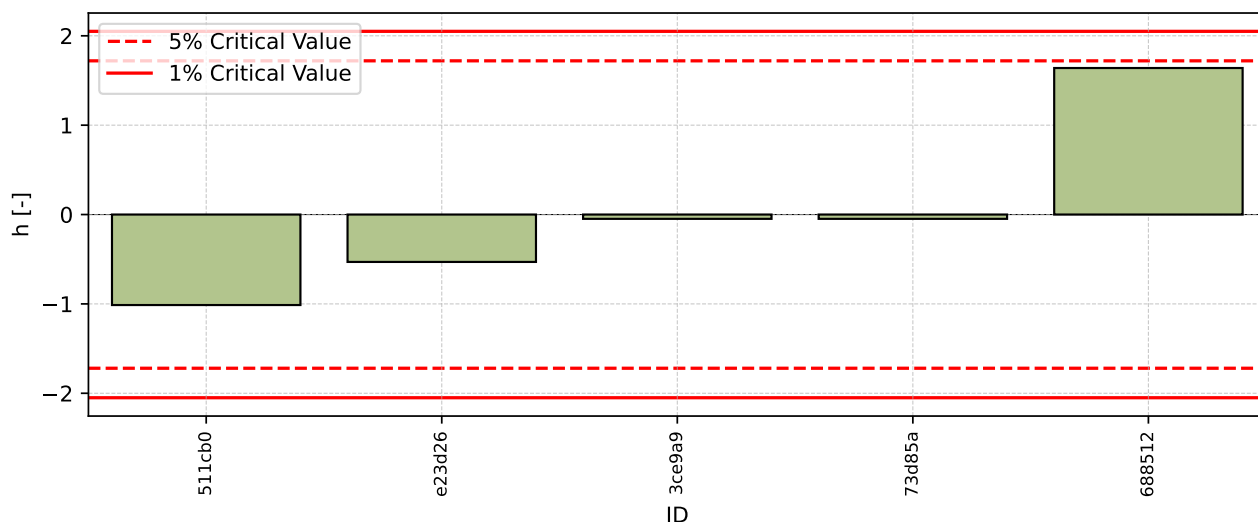


Figure 82: Interlaboratory Consistency Statistic

5.4 Descriptive statistics

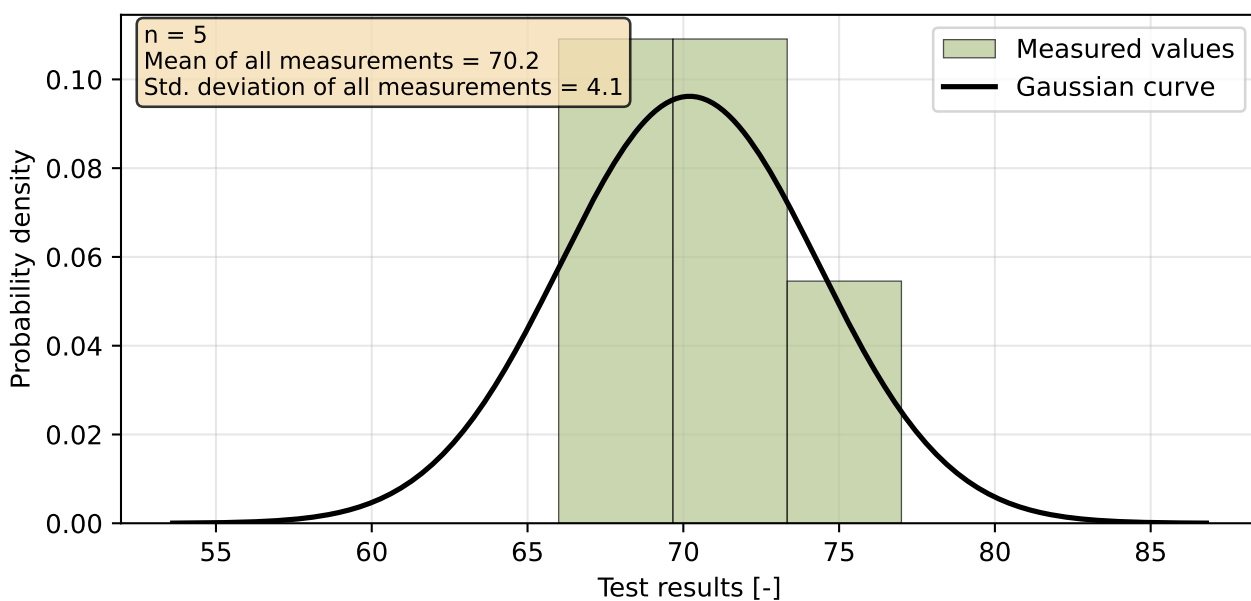


Figure 83: Histogram of all test results

Table 33: Descriptive statistics

Characteristics	[-]
Average value – $\bar{x}$	70.2
Sample standard deviation – s	4.1
Assigned value – x^*	70.2
Robust standard deviation – s^*	4.1
Measurement uncertainty of assigned value – u_X	1.9
p -value of normality test [-]	0.323

5.5 Evaluation of Performance Statistics

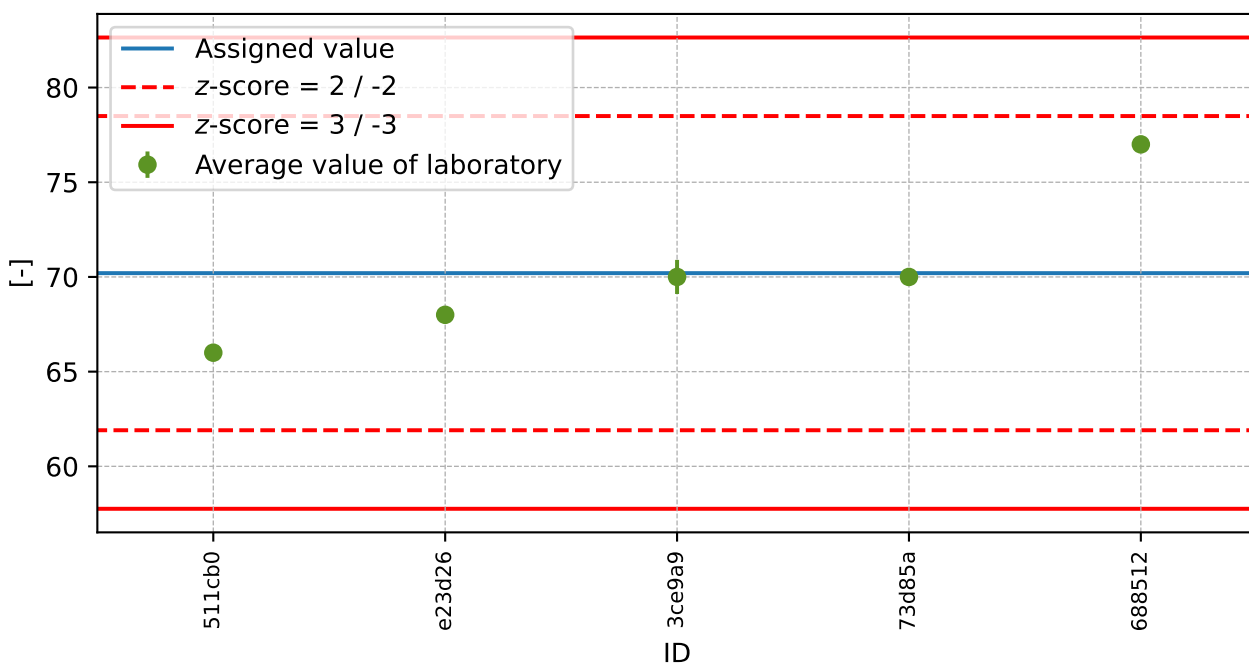


Figure 84: Average values and extended uncertainties of measurement

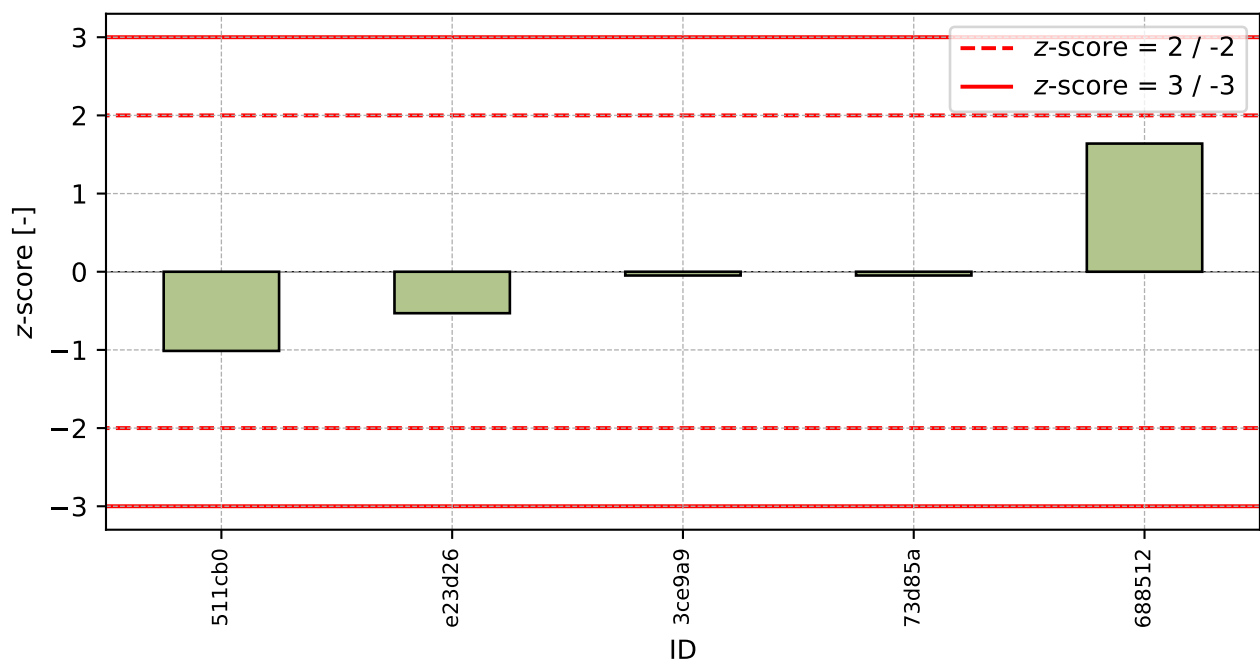


Figure 85: z-score

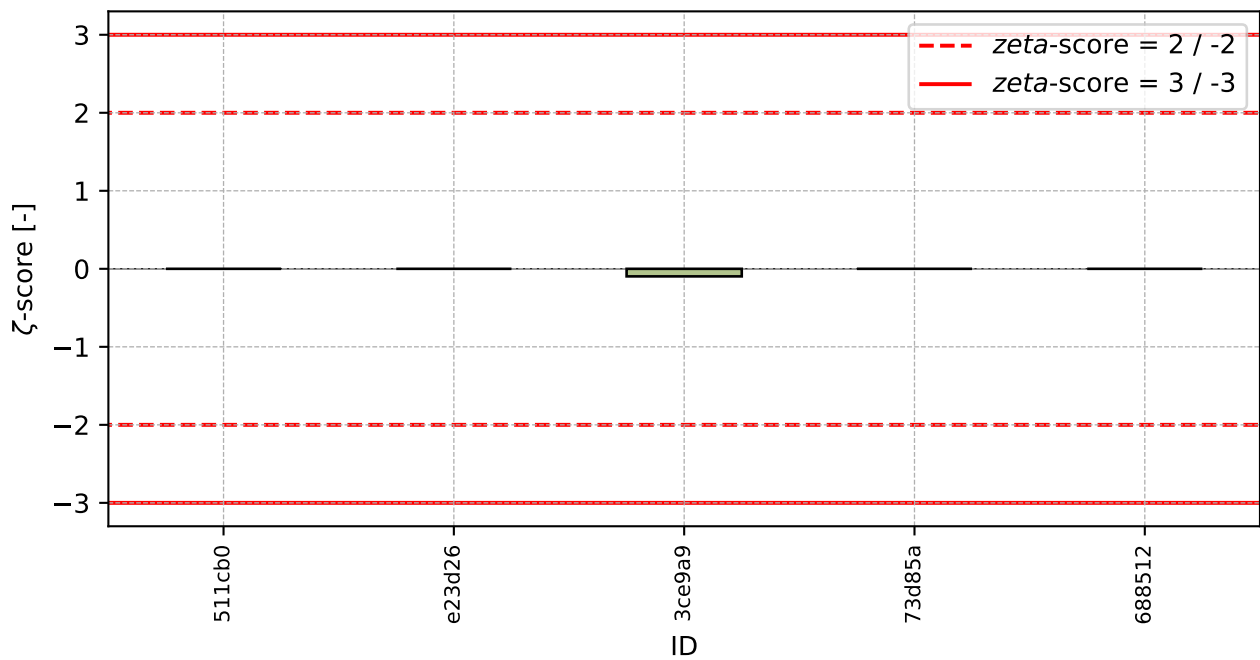


Figure 86: ζ-score

Table 34: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
511cb0	-1.01	-
e23d26	-0.53	-
3ce9a9	-0.05	-0.10
73d85a	-0.05	-
688512	1.64	-

6 Appendix – EN 13036-7 Irregularity measurement of pavement courses – The straightedge test

6.1 Longitudinal unevenness

6.1.1 Test results

Table 35: Test results – ordered by average value. Outliers are marked by red color. Columns 1–10 are individual determinations; u_X – extended uncertainty of measurement; $\bar{x}$ – average value; s_0 – sample standard deviation; V_X – variation coefficient

ID	1	2	3	4	5	6	7	8	9	10	u_X	$\bar{x}$	s_0	V_X
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[%]
3ce9a9	0	2	3	1	3	0	0	2	1	0	0.1	1	1.2	102.44
73d85a	0	2	3	1	3	0	0	2	1	0	-	1	1.2	102.44
511cb0	2	4	3	1	2	1	2	1	2	3	-	2	1.0	47.35
688512	2	4	3	1	2	2	1	1	2	4	-	2	1.1	51.60
e23d26	2	5	3	1	2	2	2	1	2	3	-	2	1.2	50.41

6.1.2 The Numerical Procedure for Determining Outliers

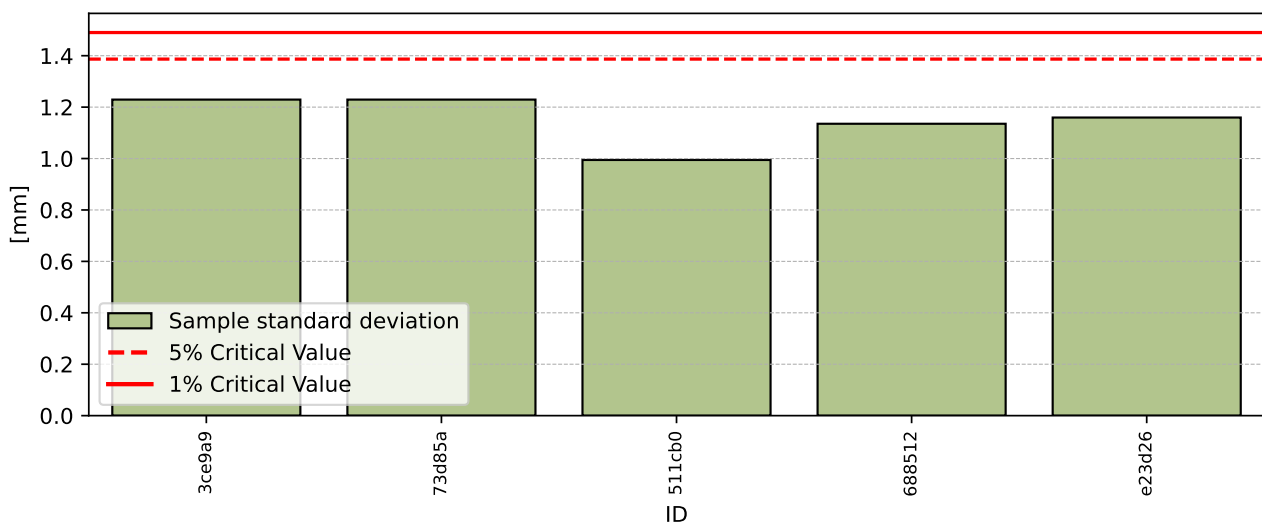
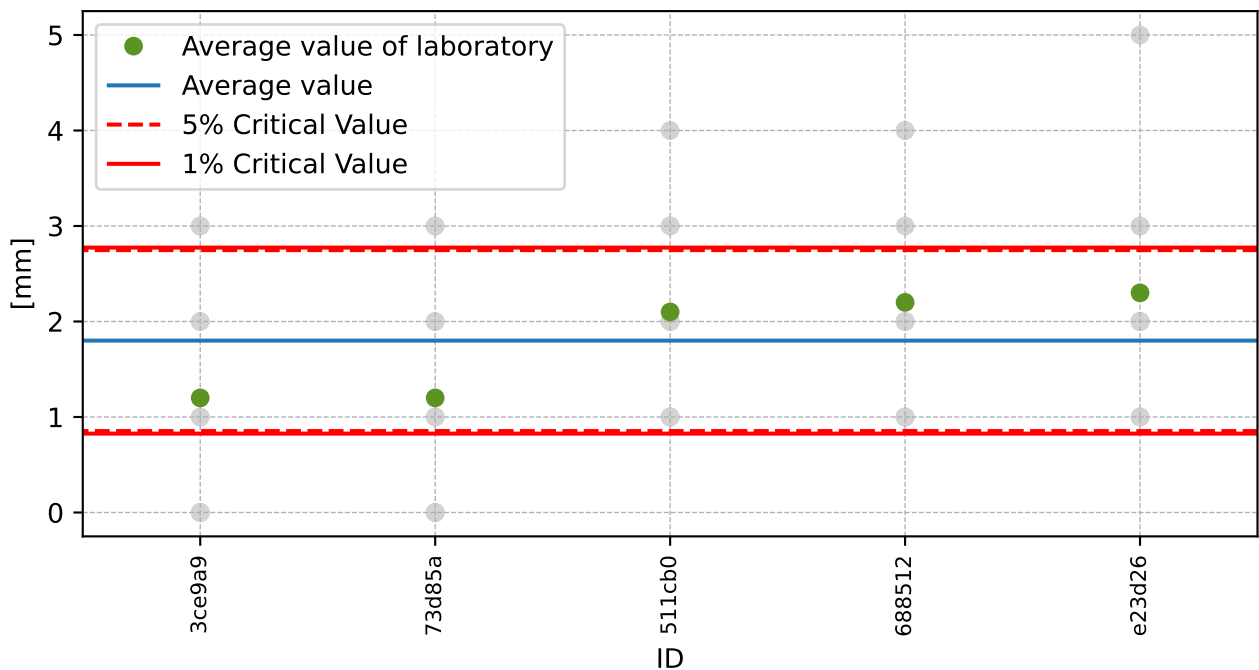


Figure 87: **Cochran's test** - sample standard deviations

Figure 88: **Grubbs' test** - average values

6.1.3 Mandel's Statistics

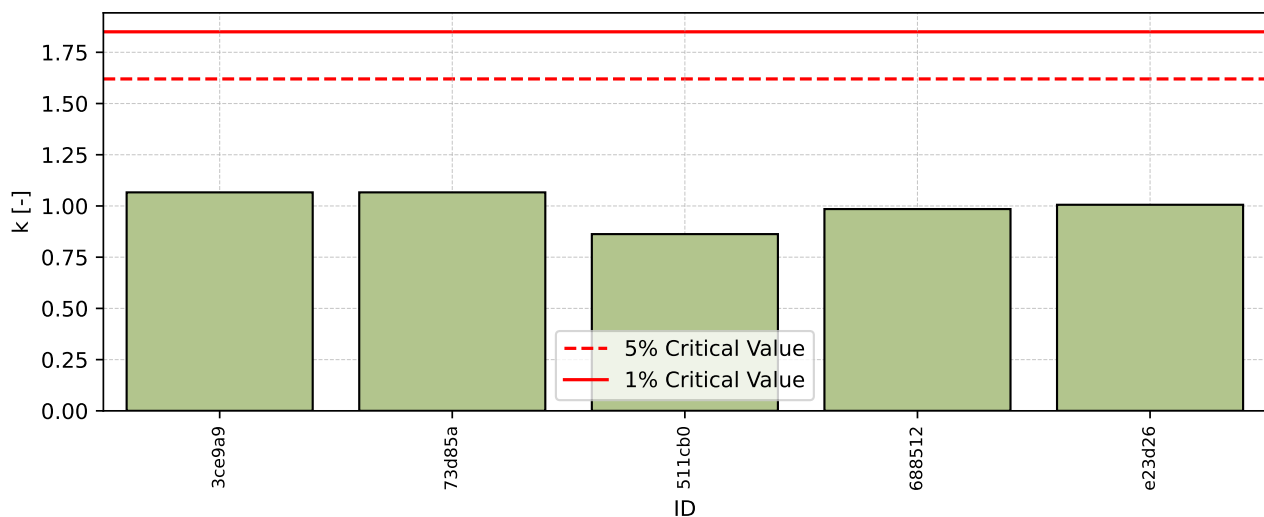


Figure 89: Intralaboratory Consistency Statistic

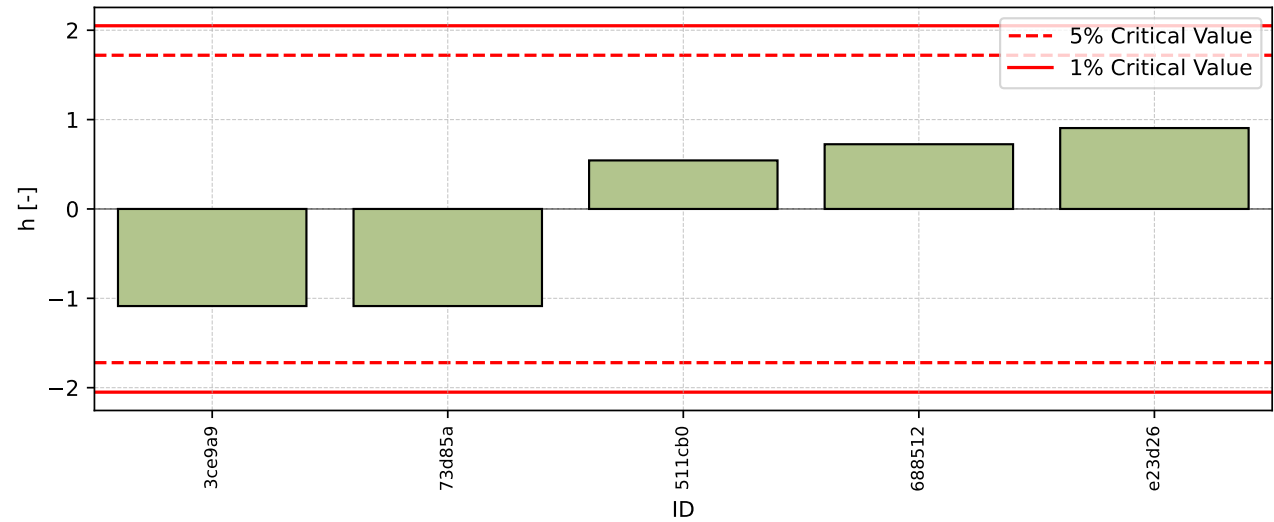


Figure 90: Interlaboratory Consistency Statistic

6.1.4 Descriptive statistics

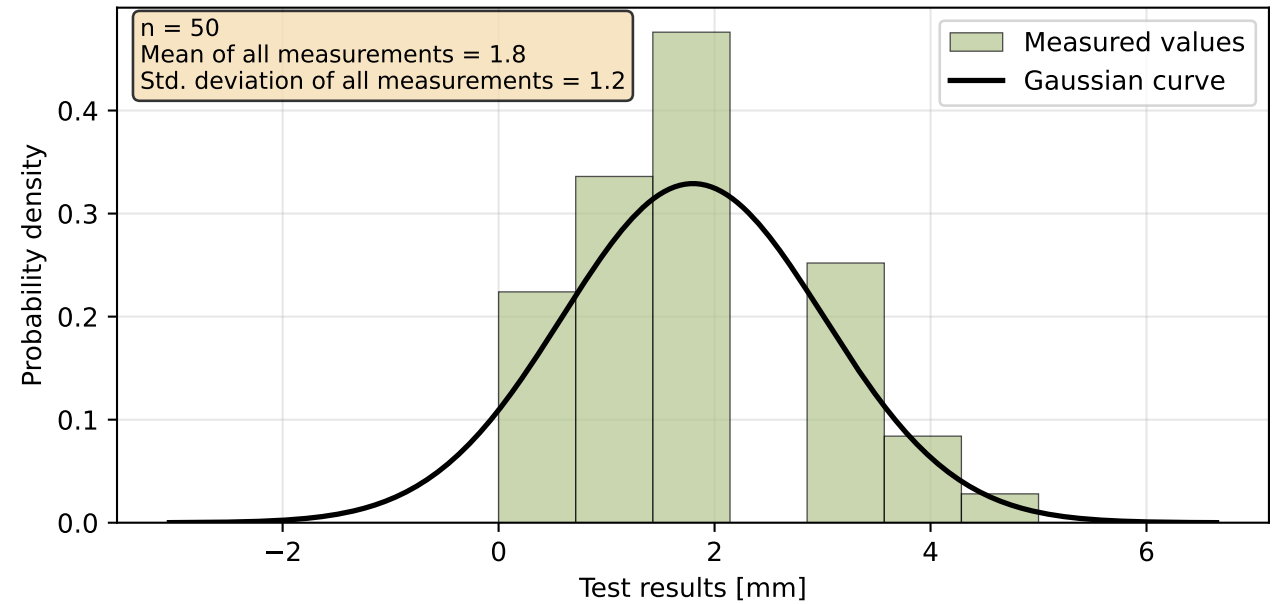


Figure 91: Histogram of all test results

Table 36: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	1.8
Sample standard deviation – s	0.6
Assigned value – x^*	1.8
Robust standard deviation – s^*	0.6
Measurement uncertainty of assigned value – u_X	0.2
p -value of normality test [-]	0.003
Interlaboratory standard deviation – s_L	0.4
Repeatability standard deviation – s_r	1.2
Reproducibility standard deviation – s_R	1.2
Repeatability – r	3.2
Reproducibility – R	3.4

6.1.5 Evaluation of Performance Statistics

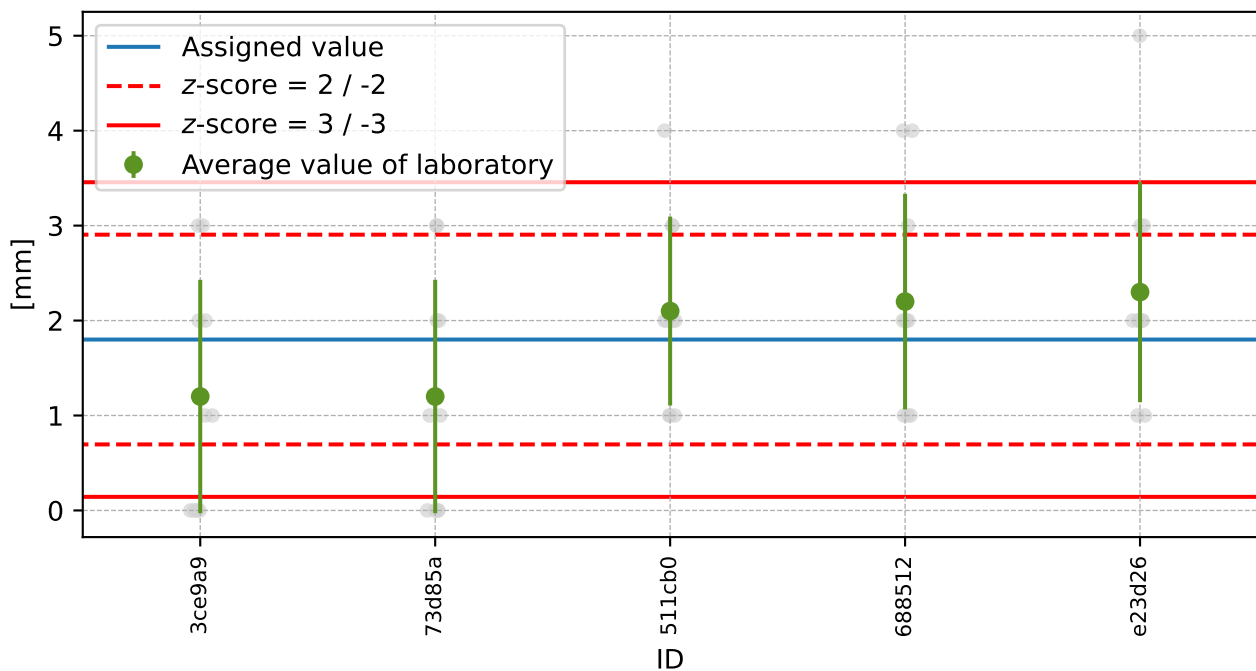


Figure 92: Average values and sample standard deviations

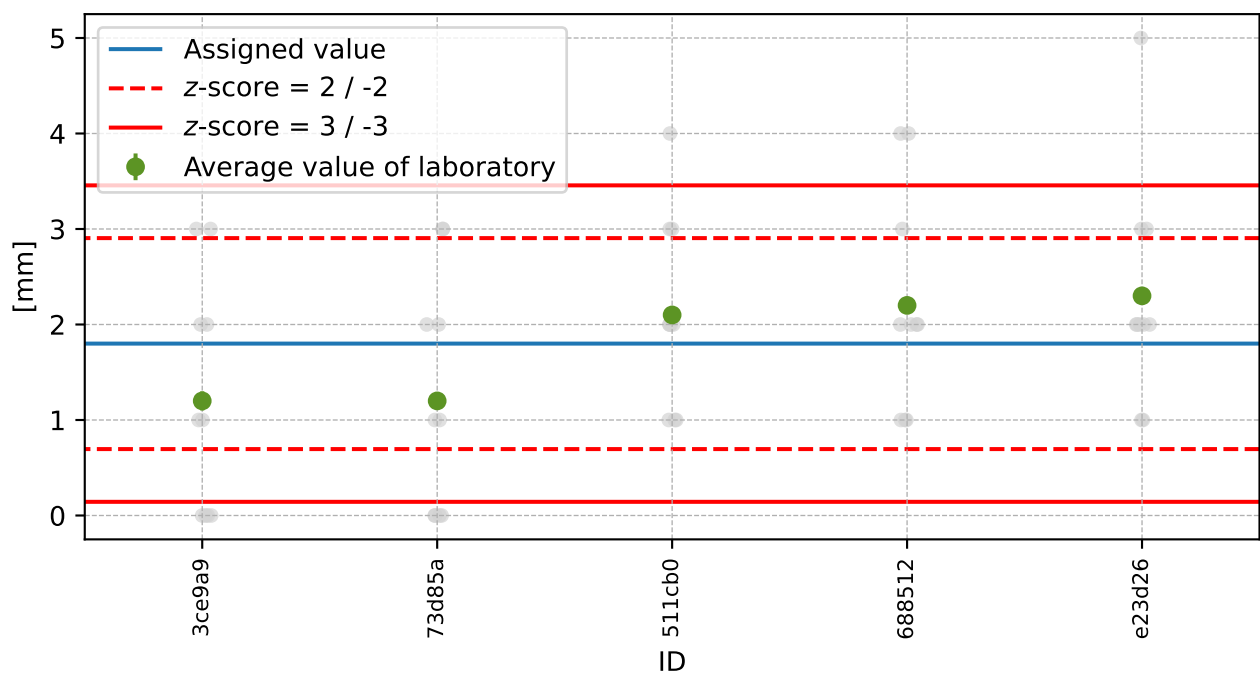


Figure 93: Average values and extended uncertainties of measurement

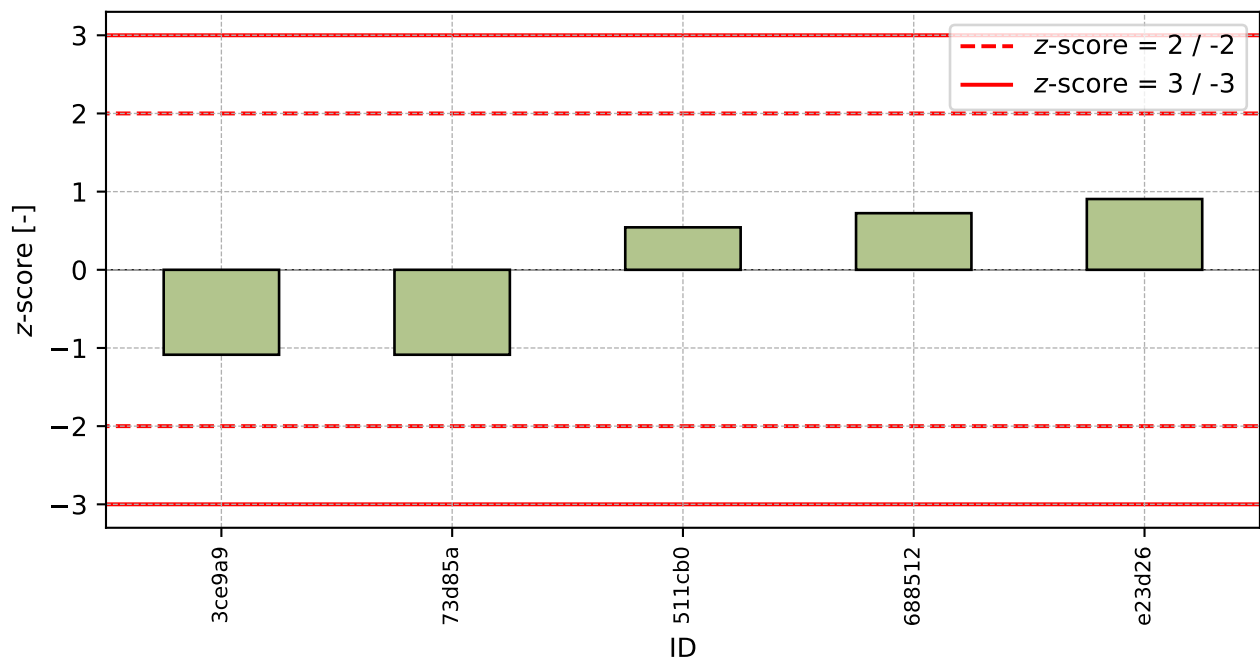


Figure 94: z-score

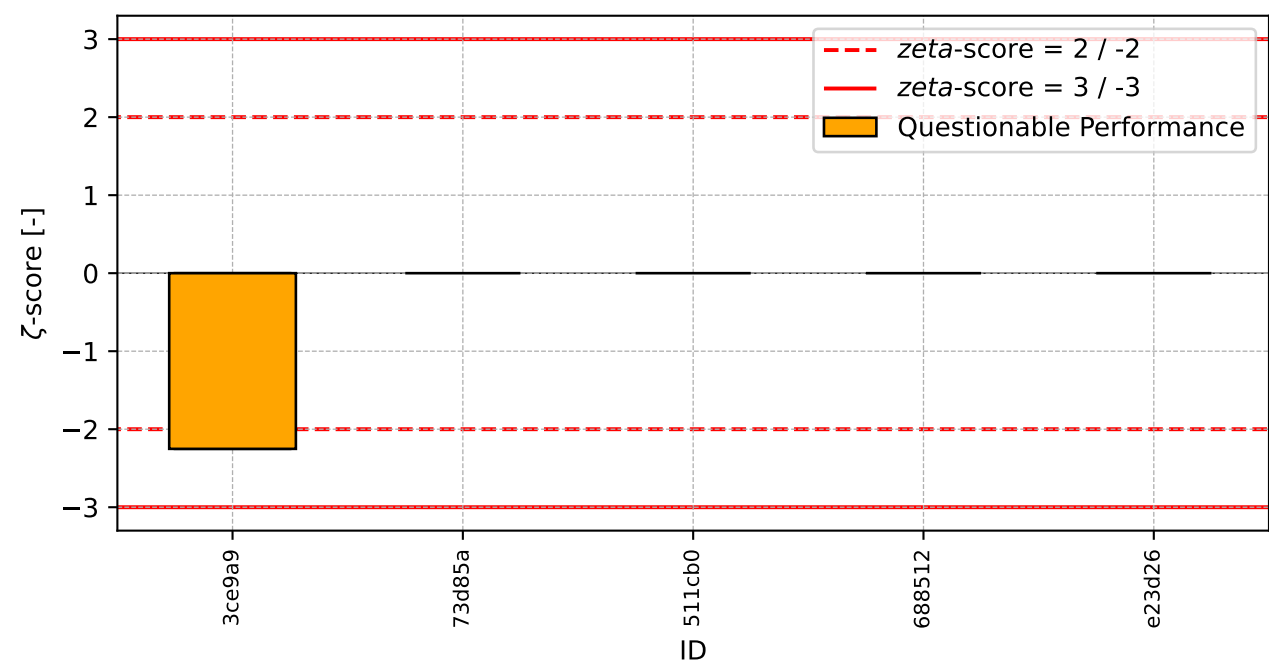


Figure 95: ζ-score

Table 37: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
3ce9a9	-1.09	-2.25
73d85a	-1.09	-
511cb0	0.54	-
688512	0.72	-
e23d26	0.91	-

6.2 Transverse unevenness

6.2.1 Test results

Table 38: Test results – ordered by average value. Outliers are marked by red color. Columns 1–10 are individual determinations; u_X – extended uncertainty of measurement; $\bar{x}$ – average value; s_0 – sample standard deviation; V_X – variation coefficient

ID	1	2	3	4	5	6	7	8	9	10	u_X	$\bar{x}$	s_0	V_X
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[%]
73d85a	4	0	1	0	4	1	1	0	1	3	-	2	1.6	105.41
688512	4	3	2	1	1	1	0	1	1	1	-	2	1.2	78.57
511cb0	4	3	2	1	1	1	0	1	1	1	-	2	1.2	78.57
3ce9a9	4	0	1	0	3	1	1	0	2	4	0.1	2	1.6	98.60
e23d26	4	3	2	1	1	1	1	1	1	1	-	2	1.1	67.19

6.2.2 The Numerical Procedure for Determining Outliers

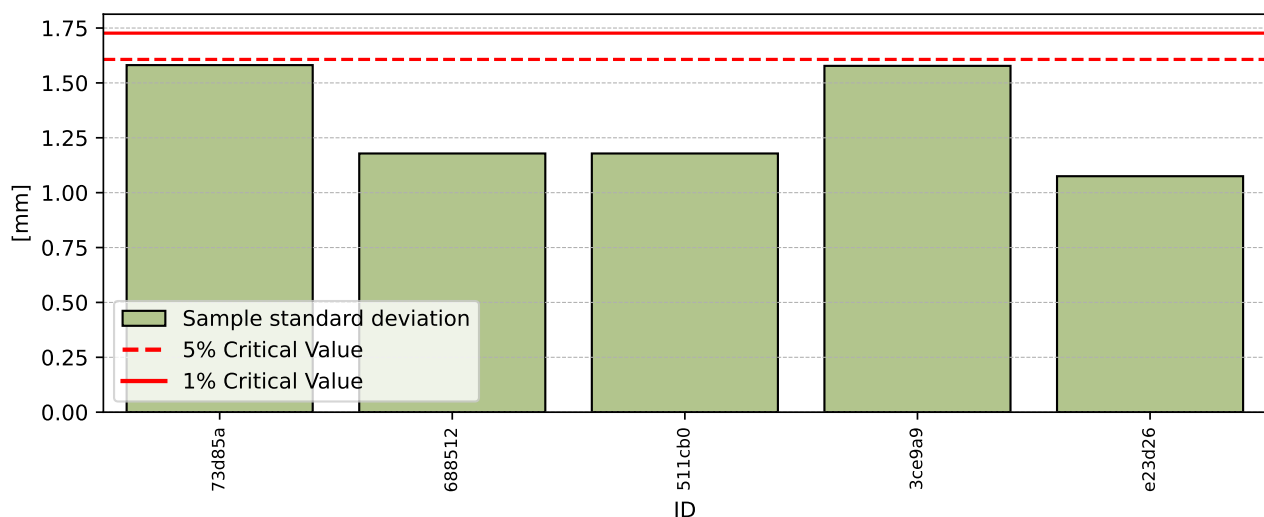


Figure 96: **Cochran's test** - sample standard deviations

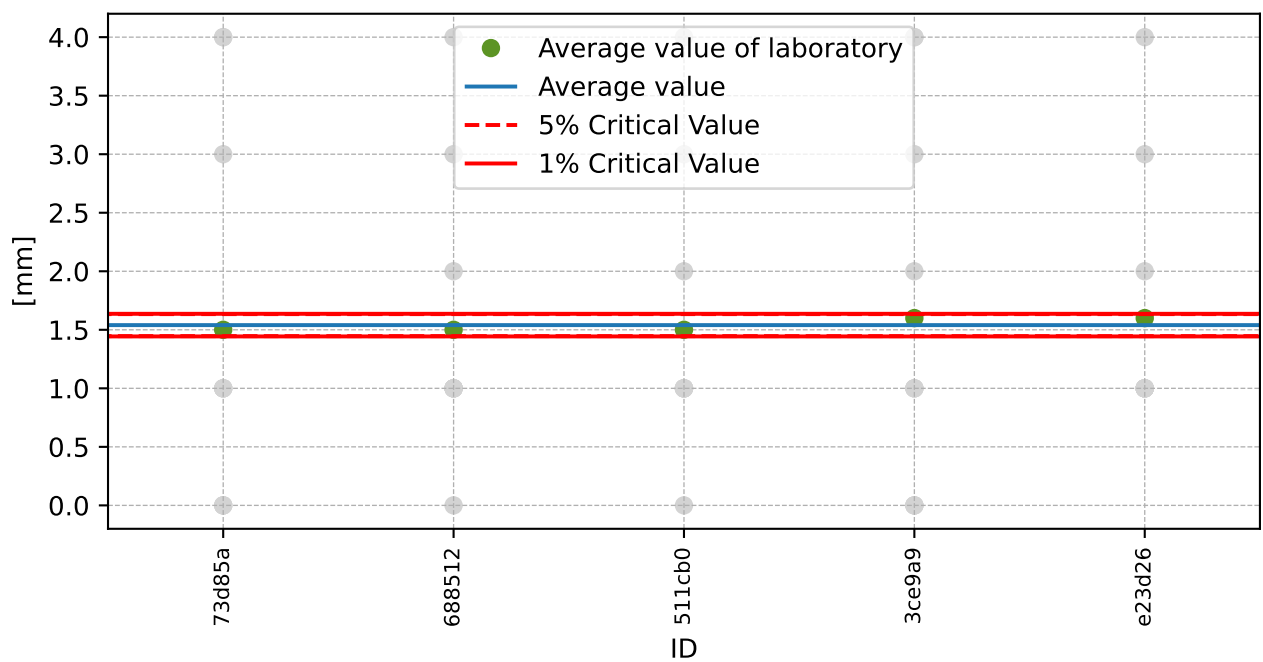


Figure 97: **Grubbs' test** - average values

6.2.3 Mandel's Statistics

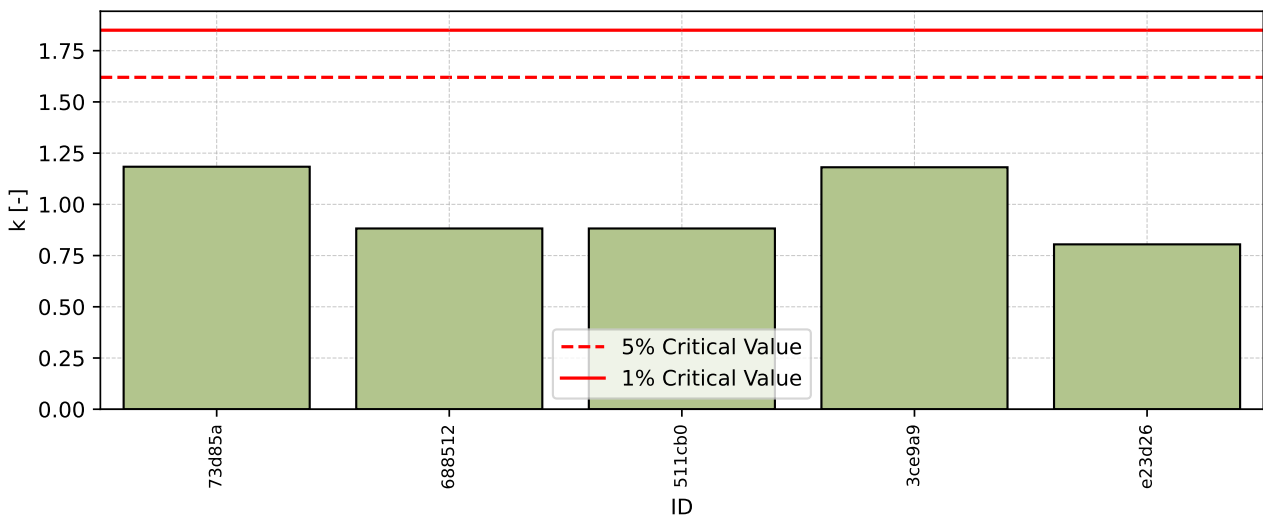


Figure 98: Intralaboratory Consistency Statistic

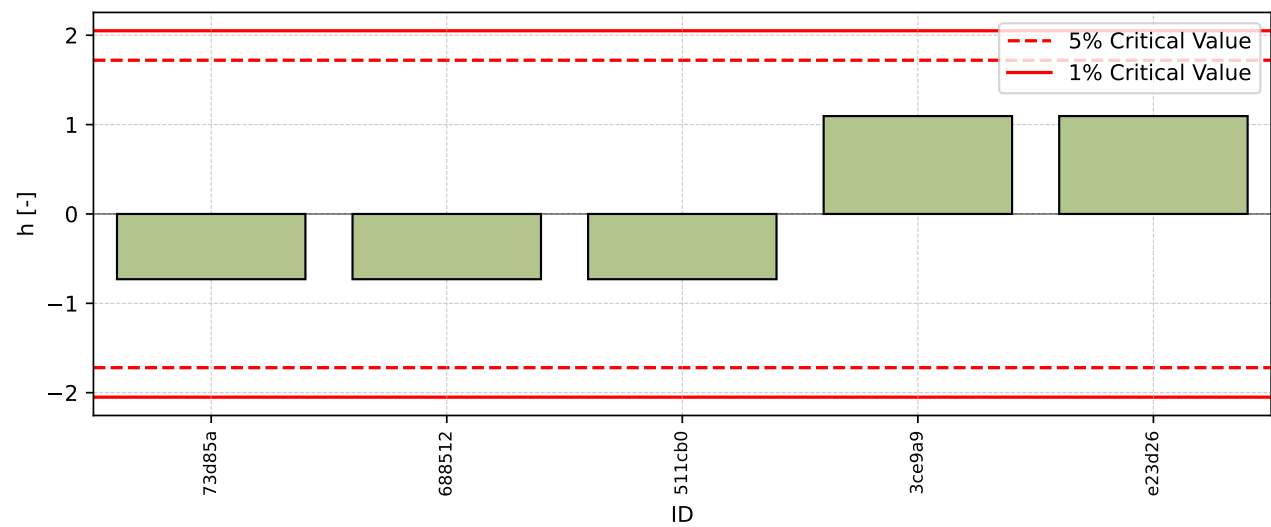


Figure 99: Interlaboratory Consistency Statistic

6.2.4 Descriptive statistics

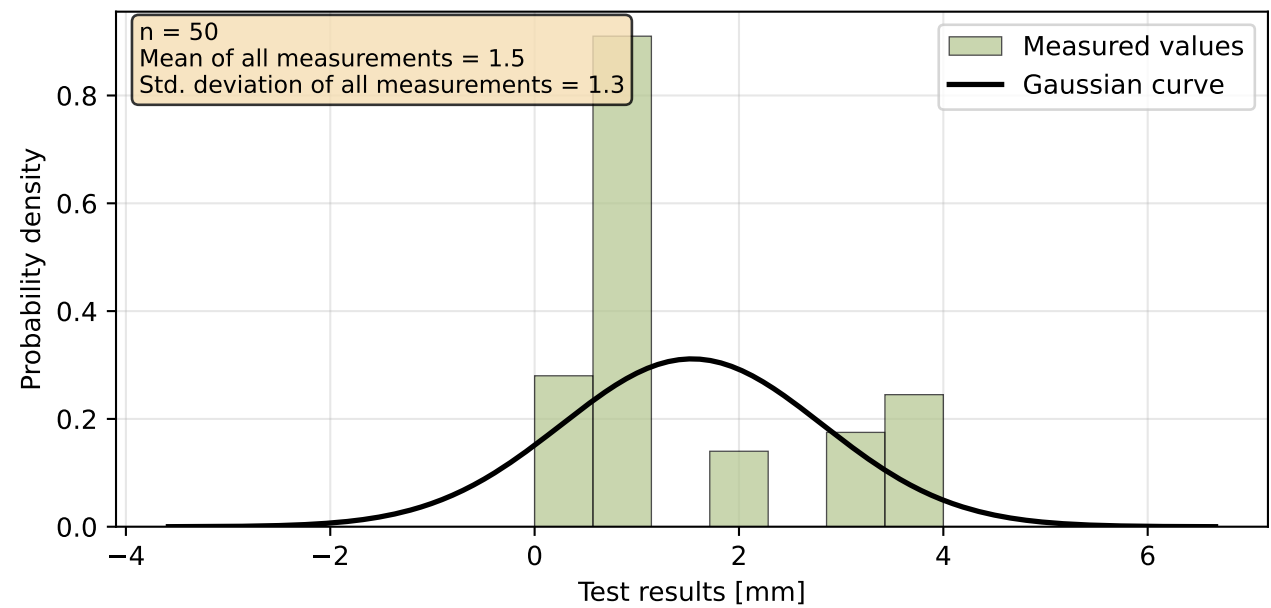


Figure 100: Histogram of all test results

Table 39: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	1.5
Sample standard deviation – s	0.1
Assigned value – x^*	1.5
Robust standard deviation – s^*	0.1
Measurement uncertainty of assigned value – u_X	0.0
p -value of normality test [-]	< 0.001
Repeatability standard deviation – s_r	1.3
Repeatability – r	3.7

6.2.5 Evaluation of Performance Statistics

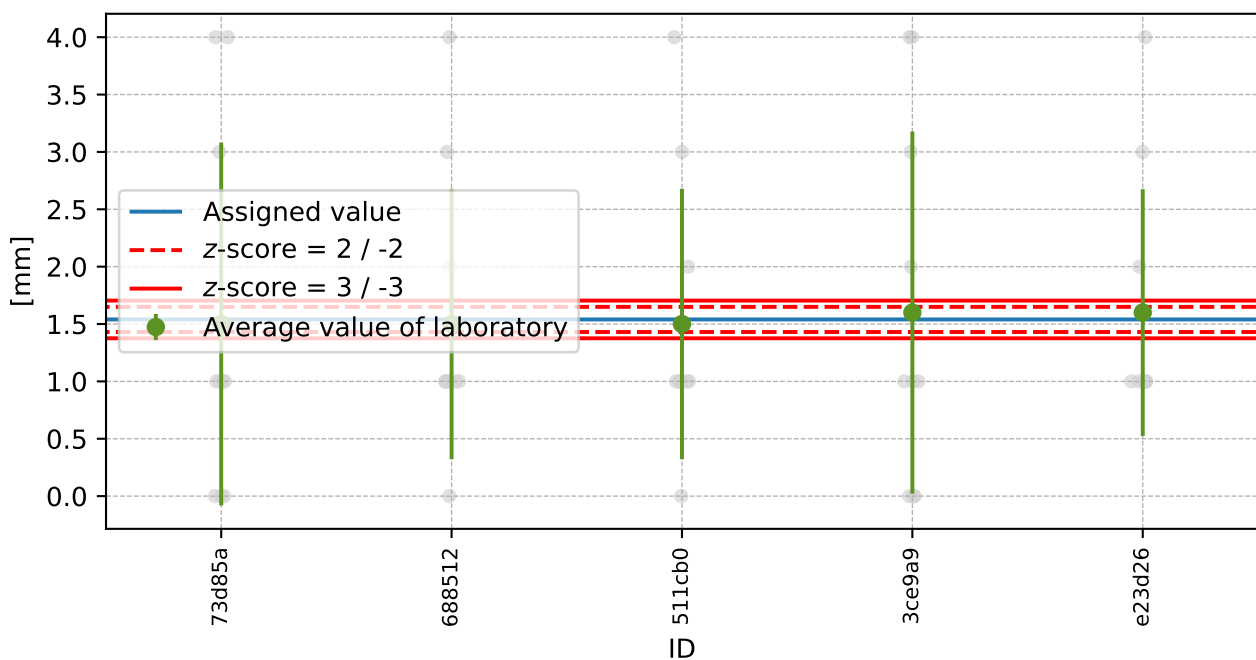


Figure 101: Average values and sample standard deviations

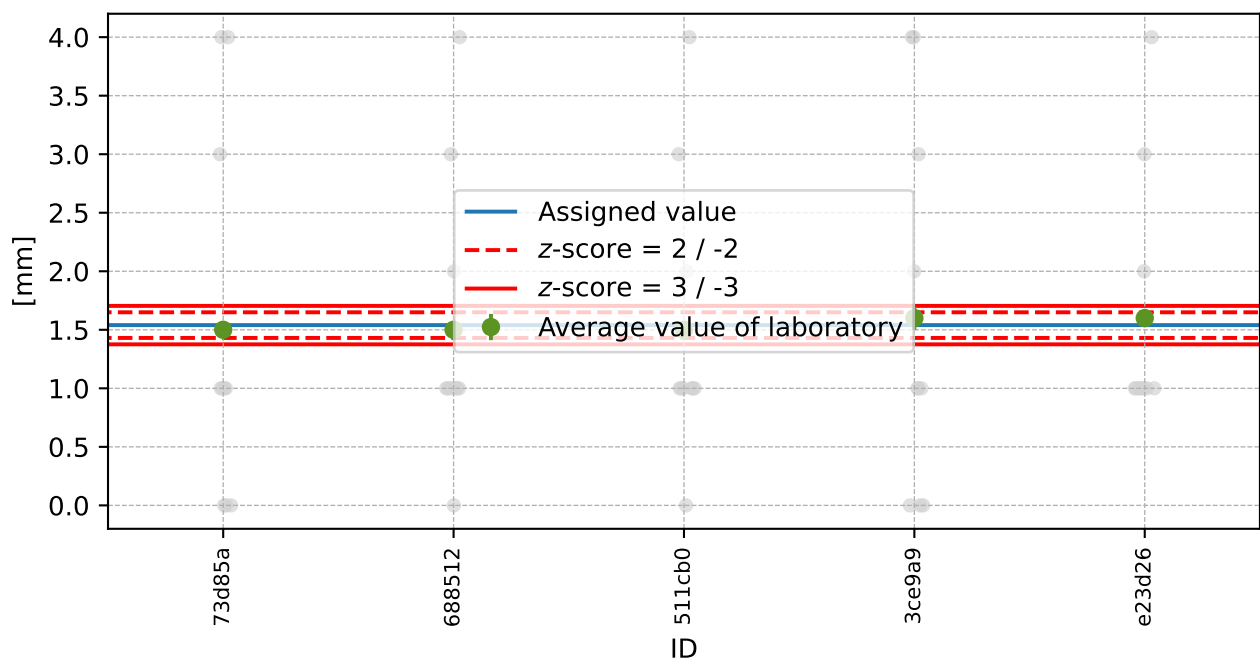


Figure 102: Average values and extended uncertainties of measurement

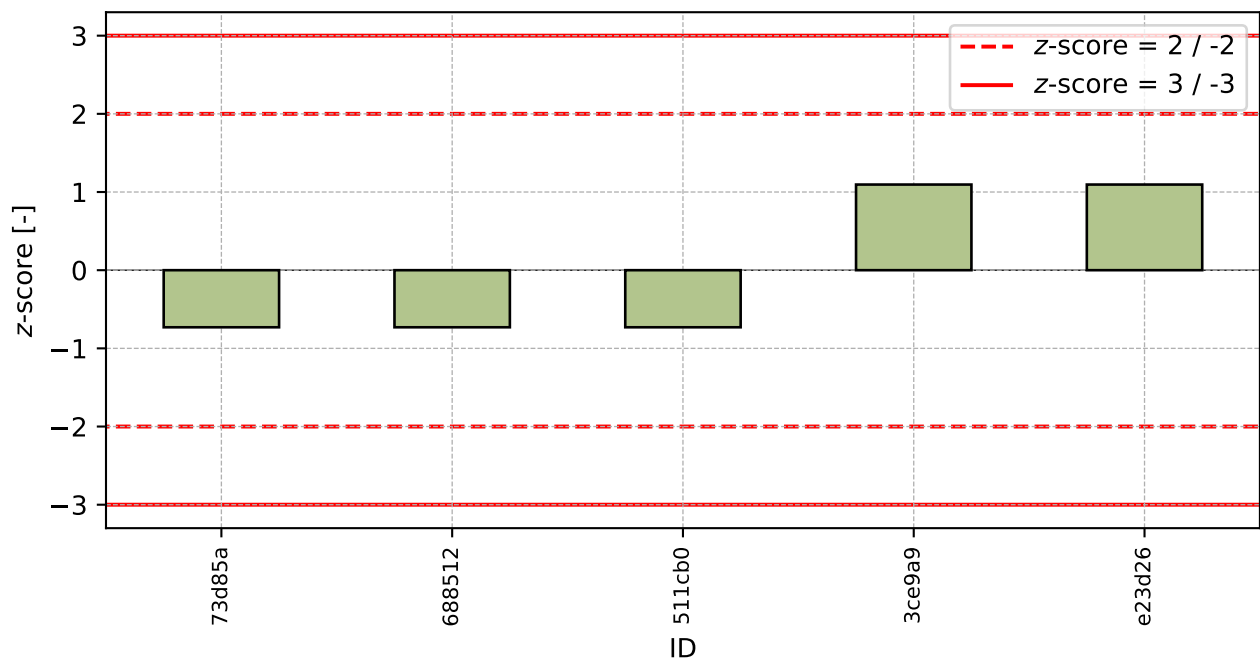


Figure 103: z-score

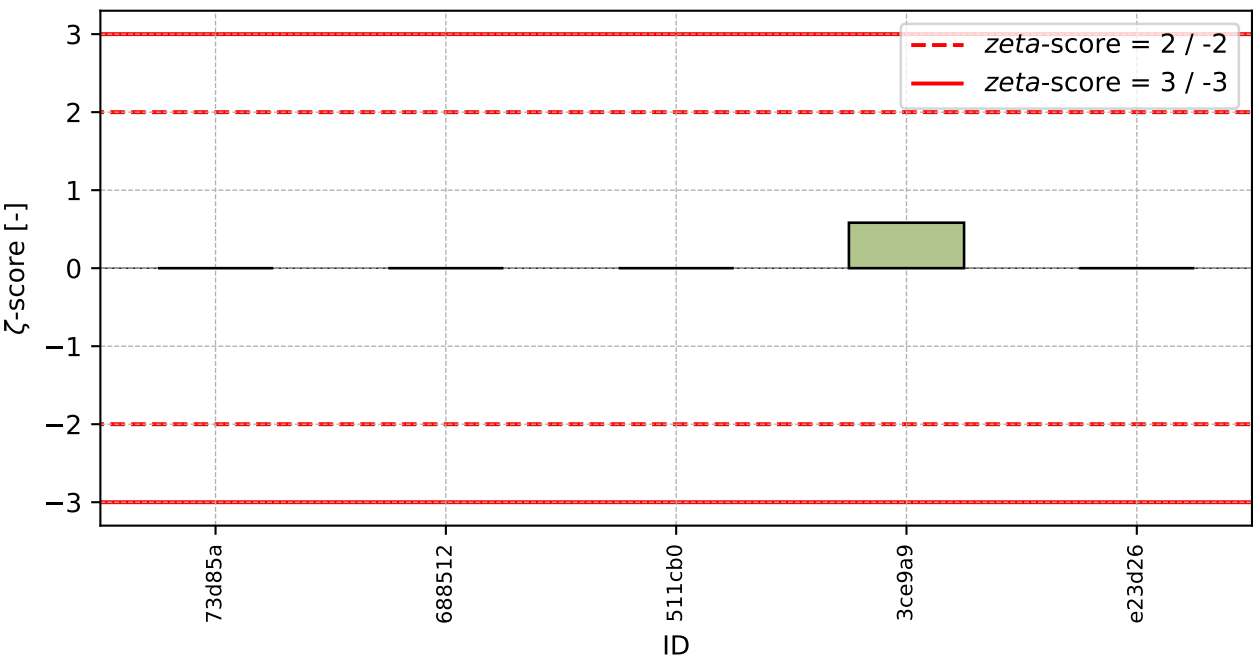


Figure 104: ζ -score

Table 40: z-score and ζ -score

ID	z-score [-]	ζ -score [-]
73d85a	-0.73	-
688512	-0.73	-
511cb0	-0.73	-
3ce9a9	1.10	0.58
e23d26	1.10	-