FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Mortar, Cement and Fine-grained Cement Composites
ZMC 2025/1

Brno University of Technology
Proficiency testing provider at the SZK FAST
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způsobilosti při SZK FAST
Proficiency testing
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Coordinator of PTP results assessment

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1   Introduction and Important Contacts

In the year 2025, the Proficiency Testing Provider at the SZK FAST (PT Provider) initiated the Proficiency Testing Program (PTP) designated ZMC 2025/1 whose aim was to verify and assess the conformity of test results across laboratories when testing mortar, cement and fine-grained cement composites.

   The assessment of the results of the Proficiency Testing Program was carried out by a committee consisting of the following PT Provider employees:

Head of the PT Provider, PTP coordinator	Coordinator of PTP result assessment PrZZ
Assoc. Prof. Ing. Tomáš Vymazal, Ph.D.	**Ing. Petr Misák, Ph.D**.
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   The subjects of proficiency testing were the following testing procedures:

1. EN 196-1 – Strength [1]

2. EN 196-2 (art. 4.4.1) – Determination of loss on ignition [2]

3. EN 196-2 (art. 4.4.2) – Determination of sulphate content [2]

4. EN 196-2 (art. 4.4.3) – Determination of the residue insoluble in hydrochloric acid and sodium carbonate [2]

5. EN 196-2 (art. 4.4.4) – Determination of the residue insoluble in hydrochloric acid and potassium hydroxide [2]

6. EN 196-2 (art. 4.4.5) – Determination of sulphite content [2]

7. EN 196-2 (art. 4.4.6) – Determination of manganese content [2]

8. EN 196-3 – Setting time, Soundness[3]

9. EN 196-10 – Determination of the water-soluble chromium (Cr^{6+}) [4]

10. EN 1015-1 – Granularity [5]

11. EN 1015-3 – Consistency [6]

12. EN 1015-6 – Density of fresh mortar [7]

13. EN 1015-10 – Density of hardened mortar [8]

14. EN 1015-11 – Strength [9]

15. EN 1015-12 – Adhesion [10]

16. EN 1015-18 – Capillary absorption coefficient (C_m) [11]

17. EN 1015-19 – Water vapor flow [12]

18. EN 13892-2 – Determination of flexural and compressive strength [13]

19. EN 12004-2 (art. 8.1) – Open time [14]

20. EN 12004-2 (art. 8.2) – Slippage [14]

21. EN 12004-2 (art. 8.3.3.2) – Adhesion [14]

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22. EN 12004-2 (art. 8.3.3.3) – Adhesion [14]

Test procedures labeled **2, 4–10, 19, 21, and 22** were not opened due to low participation..

The specimens were taken from the same production with the same production date. 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 [15] and with EN ISO/IEC 17043 [16]. The outcome is the present final report summarizing the results of the interlaboratory comparison, including statistical evaluation.

19 laboratories took part in the program. 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 open test procedures

ID	1	8	14	18
fb95a0	-	-	X	X
f8f516	-	-	-	X
b23494	-	X	-	-
bffdf4	-	-	X	-
d8cb68	-	-	-	X
6b5478	X	-	X	-
8f06b9	-	-	-	X
1fa25d	X	-	-	-
3063ef	-	-	X	-
b0f850	X	-	-	-
7101b5	X	-	-	-
f93fca	X	-	X	X
48ed1d	X	X	-	-
a879e5	X	-	X	-
64e4db	X	X	-	X
35a951	-	-	X	-
22fa1d	X	X	-	-
97940a	-	-	X	-
a02675	-	-	X	X
41c705	X	-	-	-
80a214	-	X	-	-
b62f59	X	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
BEST, a.s. pracoviště 1 Lučice	Rybnice 148, Kaznějov, 33151, Česká republika	1739

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Continued from previous page

Laboratory	Address	Accreditation number
BEST, a.s. pracoviště 2 Nové Hrady	Rybnice 148, Kaznějov, 33151, Česká republika	-
BETOTECH, s.r.o. - Pracoviště Beroun	Beroun 660, Beroun, 26601, Česká republika	1195
CONTROL-VHS-SK, s.r.o. Priemyselná 6, 821 09 Bratislava Skúšobné laboratórium Žilin	Kamenná 14, Žilina, 010 01, Slovenská republika	437/S-317
Cement Hranice, akciová společnost - Betonářská laboratoř	Bělotínská 288, Hranice I - Město, 75301, Česká republika	1284
EXAMEN lab d.o.o.	Ljudevita Gaja 26a, Samobor, 10430, Croatia	-
Gradezen Institut "Makedonija" AD Skopje	Drezdenska No.52, SKOPJE KARPOS, 1000, North Macedonia	LT-014
LABKONSULT	Airport Sofia, North Area, str. "8-th", Sofia, 1540, Bulgaria	-
Magnel-Vandepitte Laboratory (University Ghent)	Technologiepark - Zwijnaarde 60, Zwijnaarde (Ghent), 9052, Belgium	220-TEST
Materialversuchsanstalt Strass GmbH	Oberdorf 103, Strass im Zillertal, 6261, Austria	0455
Mattest (Ireland) Limited	Unit 2, Northwest Business Park, Ballycoolin, Dublin, D15 EF1H, Dublin - Ireland	-
QCONTROL s.r.o., odštěpný závod - pracoviště Děčín	Lesní 693, 66401 Bílovice nad Svitavou, Česká republika	1737
QUALIFORM, a.s.	Mlaty 672/8, Bosonohy, Brno, 642 00, Česká republika	1008
SQZ, s.r.o. - pracoviště Olomouc	939/5 U místní dráhy, Olomouc, 779 00, Česká republika	1135.1
Stachema CZ s.r.o. - Zkušební laboratoř - pracoviště 2	Hasičská 1, Zibohlavy, Kolín, 28002, Česká republika	1433
TESScontrol, s. r. o. Oblastné Laboratórium Zvolen, Laboratórium Zvolen	Zvolen, 960 93, Česká republika	S-375
TESTSTAV group s.r.o.	Orlovská 347/160, Ostrava-Heřmanice, 713 00, Česká republika	1290
Technický a skúšobný ústav stavebný, n. o.	Studená, 967/3, Bratislava, 82104, Slovenská republika	S-045
Technický a skúšobný ústav stavebný, n.o.	Bellova 72/24, Tatranská Štrba, 05941, Slovenská republika	004/S-045
UAB Laboratoriniu bandymu centras	R. Kalantos street 85a, Kaunas, 45293, Lithuania	LA.01.002
Ústav stavebního zkušebnictví s.r.o.	Jiřího Potůčka 115, Pardubice, 53009, Česká republika	1115
Ředitelství silnic a dálnic s. p.	Čerčanská 2023/12, Praha 4 - Krč, 140 00, Česká republika	1072

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2   Procedures used in the Statistical Analysis of Laboratory Results

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.

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3 Conclusions of the Statistical Analysis

The present report summarizes the results of the Proficiency Testing Program Mortar, Cement and Fine-grained Cement Composites (PT Program) organized by the PT Provider at the SZK FAST. 19 participants (laboratories) took part in the PT Program. The program focused on ordinary standardized testing of mortar, cement, fine-grained cement composites. The test results are evaluated separately for each testing procedure examined. An evaluation of statistical characteristics is included in the Appendix, as well as test results and graphic presentations. Testing methods can be found in part 1 of this report.

Table 4: Evaluation of overall performance and outliers.

✓ – satisfactory performance; **?** – questionable performance; **!** – unsatisfactory performance; **X** – outlier;

ID / Method	1	8	14	18
1fa25d	✓	-	-	-
22fa1d	✓	✓	-	-
41c705	✓	-	-	-
48ed1d	✓	✓	-	-
64e4db	✓	✓	-	✓
6b5478	✓	-	✓	-
7101b5	✓	-	-	-
80a214	-	✓	-	-
8f06b9	-	-	-	✓
97940a	-	-	✓	-
a02675	-	-	✓	✓
a879e5	✓	-	✓	-
b0f850	✓	-	-	-
b23494	-	✓	-	-
b62f59	✓	✓	-	-
bffdf4	-	-	✓	-
d8cb68	-	-	-	✓
f8f516	-	-	-	✓
f93fca	✓	-	✓	✓
fb95a0	-	-	✓	✓

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References

[1] EN 196-1. *Methods of testing cement - Part 1: Determination of strength*. 2016.

[2] EN 196-2. *Method of testing cement - Part 2: Chemical analysis of cement*. 2013.

[3] EN 196-3. *Methods of testing cement - Part 3: Determination of setting times and soundness*. 2017.

[4] EN 196-10. *Methods of testing cement - Part 10: Determination of the water-soluble chromium (VI) content of cement*. 2017.

[5] EN 1015-1. *Methods of test for mortar for masonry - Part 1: Determination of particle size distribution (by sieve analysis)*. 1999.

[6] EN 1015-3. *Methods of test for mortar for masonry - Part 3: Determination of consistence of fresh mortar (by flow table)*. 2000.

[7] EN 1015-6. *Methods of test for mortar for masonry - Part 6: Determination of bulk density of fresh mortar*. 1999.

[8] EN 1015-10. *Methods of test for mortar for masonry - Part 10: Determination of dry bulk density of hardened mortar*. 2000.

[9] EN 1015-11. *Methods of test for mortar for masonry - Part 11: Determination of flexural and compressive strentgth of hardened mortar*. 2000.

[10] EN 1015-12. *Methods of test for mortar for masonry - Part 12: Determination of adhesive strength of hardened rendering and plastering mortars on substrates*. 2000.

[11] EN 1015-18. *Methods of test for mortar for masonry - Part 18: Determination of water absorption coefficient due to capillarity action of hardened mortar*. 2003.

[12] EN 1015-19. *Methods of test for mortar for masonry - Part 19: Determination of water vapour permeability of hardened rendering and plastering mortars*. 1999.

[13] EN 13892-2. *Methods of test for screed materials - Part 2: Determination of flexural and compressive strength*. 2003.

[14] EN 12004-2. *Adhesives for ceramic tiles - Part 2: Test methods*. 2017.

[15] 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.

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

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1 Appendix – EN 196-1 – Strength

1.1 Flexural Strength after 2 days of ageing

1.1.1 Test results

Table 4: 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 [N/mm^2]			u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
22fa1d	3.9	3.7	3.5	-	3.7	0.20	5.41
6b5478	3.7	3.9	4.0	0.20	3.9	0.15	3.95
1fa25d	3.5	4.2	4.5	1.90	4.1	0.51	12.62
7101b5	4.0	4.1	4.1	0.10	4.1	0.06	1.42
48ed1d	4.2	4.3	4.3	-	4.3	0.06	1.35
a879e5	4.5	4.9	4.6	0.40	4.7	0.21	4.46
b0f850	5.0	4.6	4.7	-	4.8	0.21	4.37
41c705	4.7	6.0	5.3	0.20	5.3	0.65	12.20
b62f59	6.2	5.9	5.8	-	6.0	0.21	3.49
64e4db	6.0	6.0	6.2	-	6.1	0.12	1.90

1.1.2 The Numerical Procedure for Determining Outliers
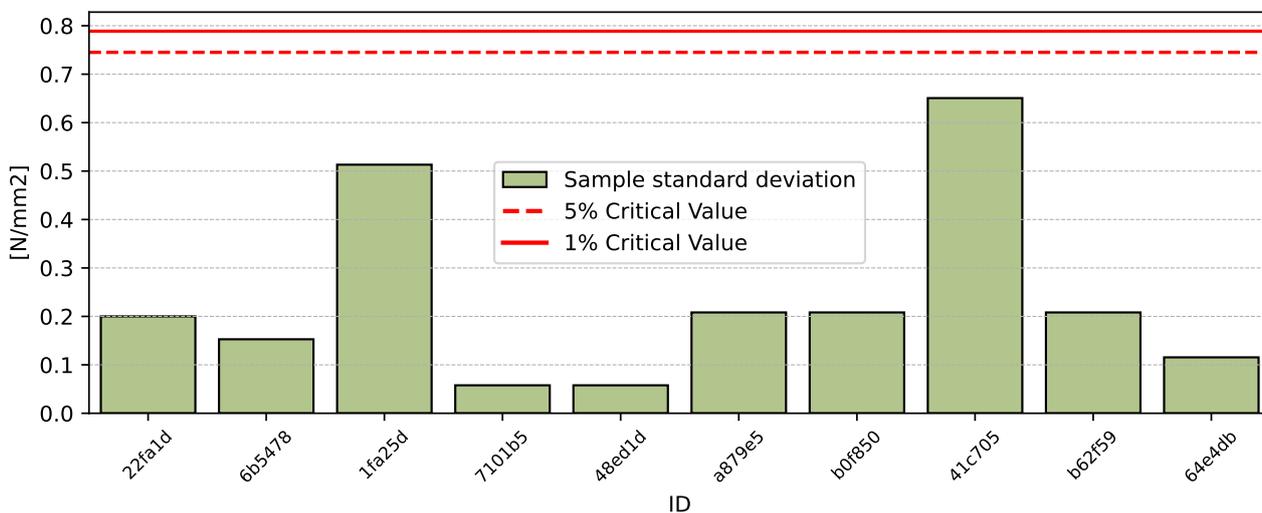
Figure 1: **Cochran's test** - sample standard deviations

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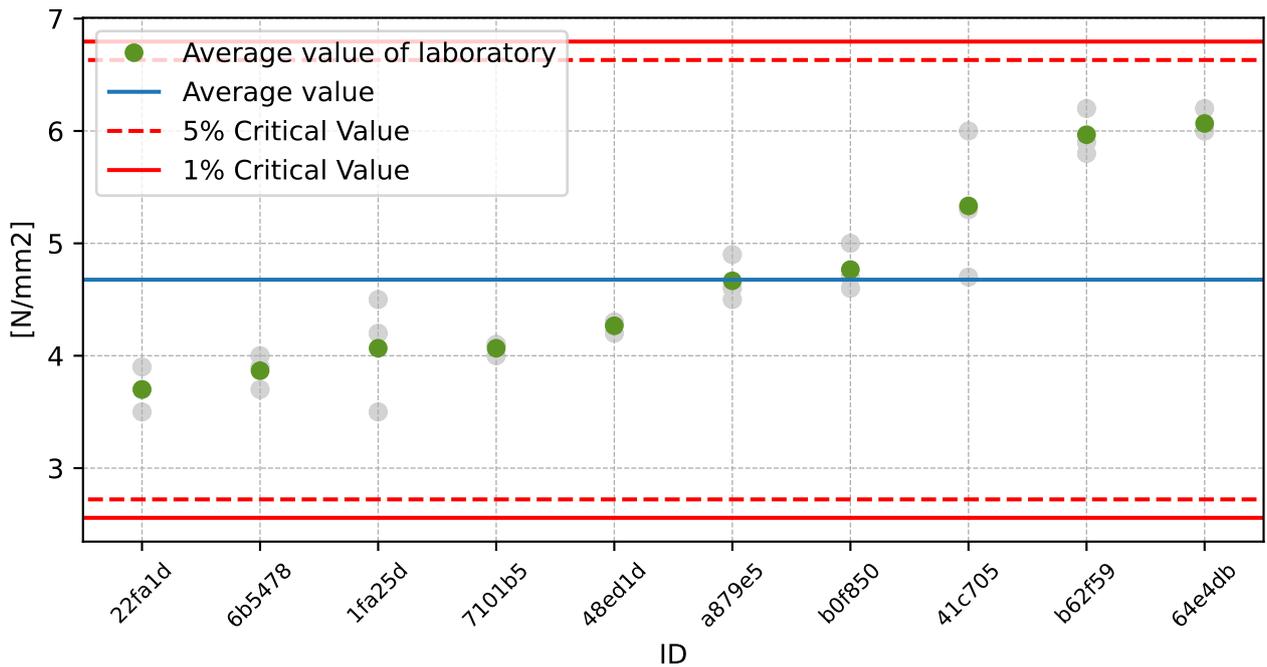
Figure 2: **Grubbs' test** - average values

1.1.3   Mandel′s Statistics
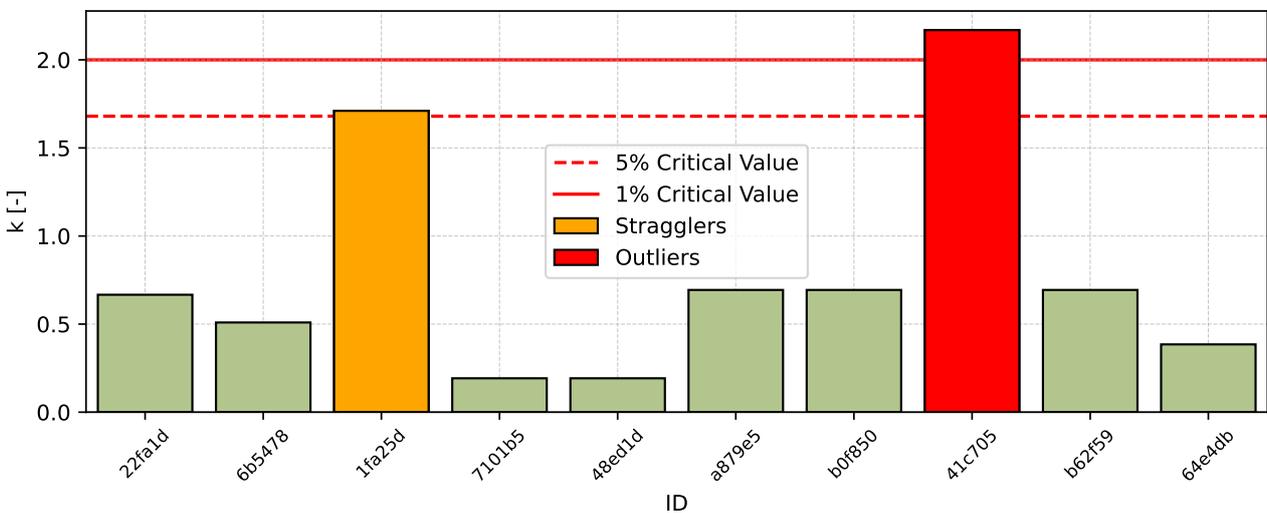
Figure 3: Intralaboratory Consistency Statistic

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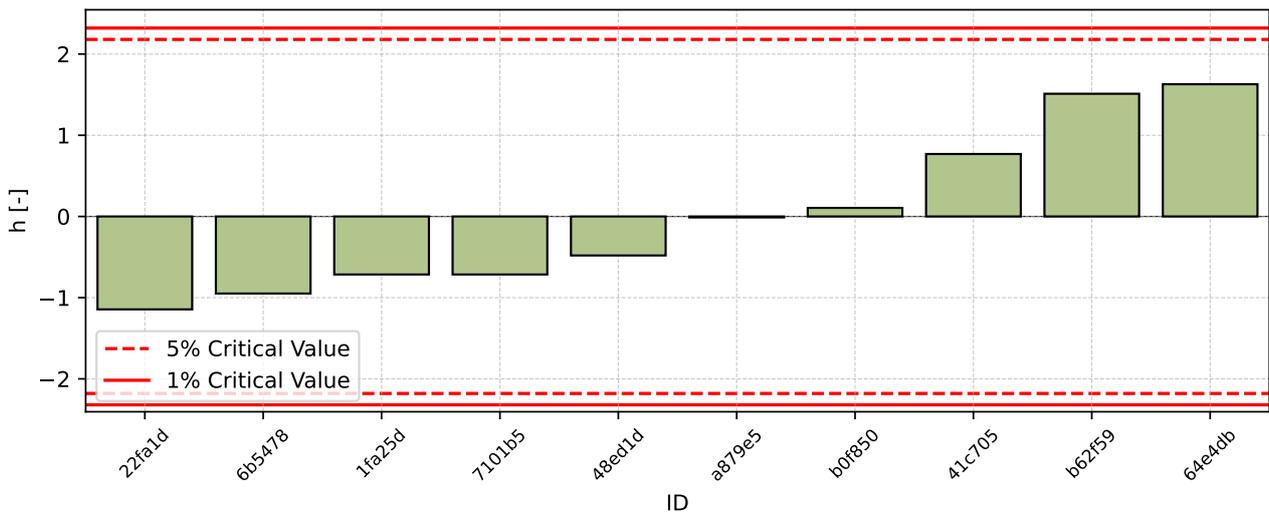
Figure 4: Interlaboratory Consistency Statistic

1.1.4 Descriptive statistics
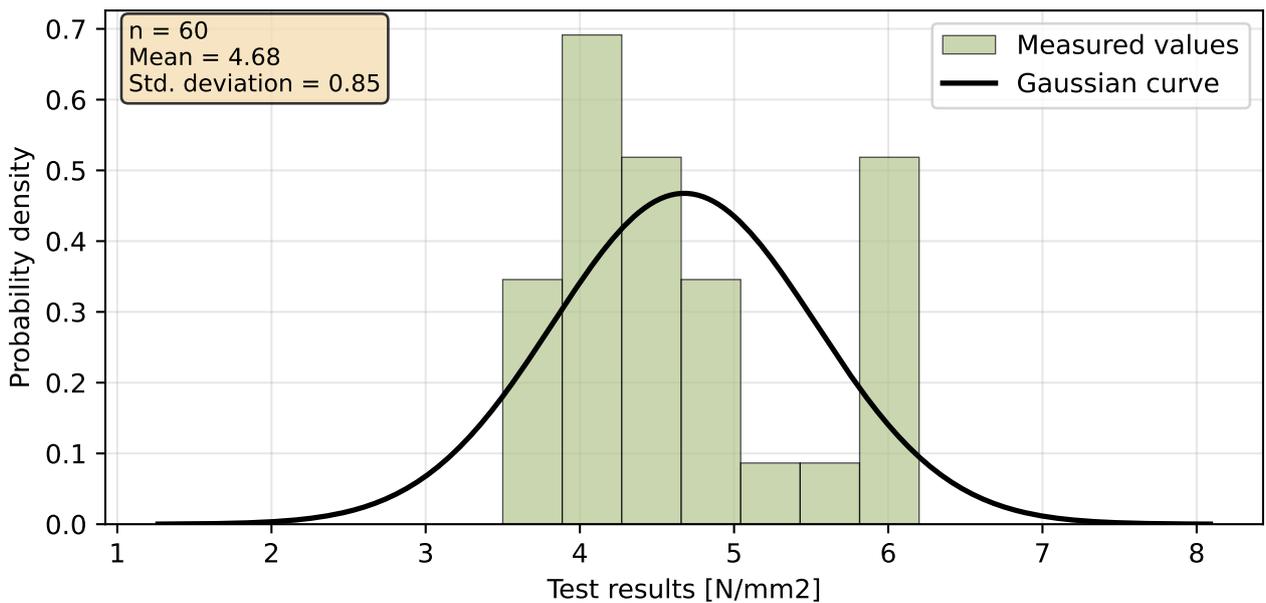
Figure 5: Histogram of all test results

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Table 5: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	4.7
Sample standard deviation – s	0.85
Asigned value – x^*	4.7
Robust standard deviation – s^*	0.9
Measurement uncertainty of asigned value – u_X	0.29
p-value of normality test	0.008 [-]
Interlaboratory standard deviation – s_L	0.84
Repeatability standard deviation – s_r	0.3
Reproducibility standard deviation – s_R	0.89
Repeatability – r	0.8
Reproducibility – R	2.5

1.1.5 Evaluation of Performance Statistics
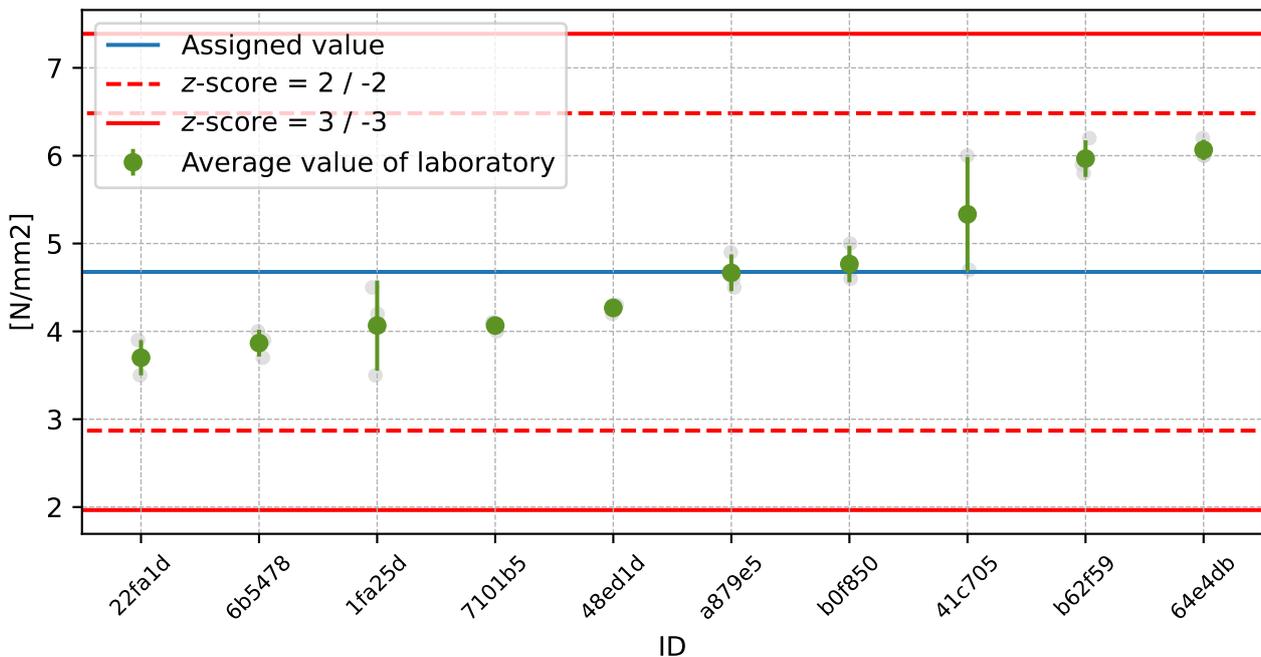
Figure 6: Average values and sample standard deviations

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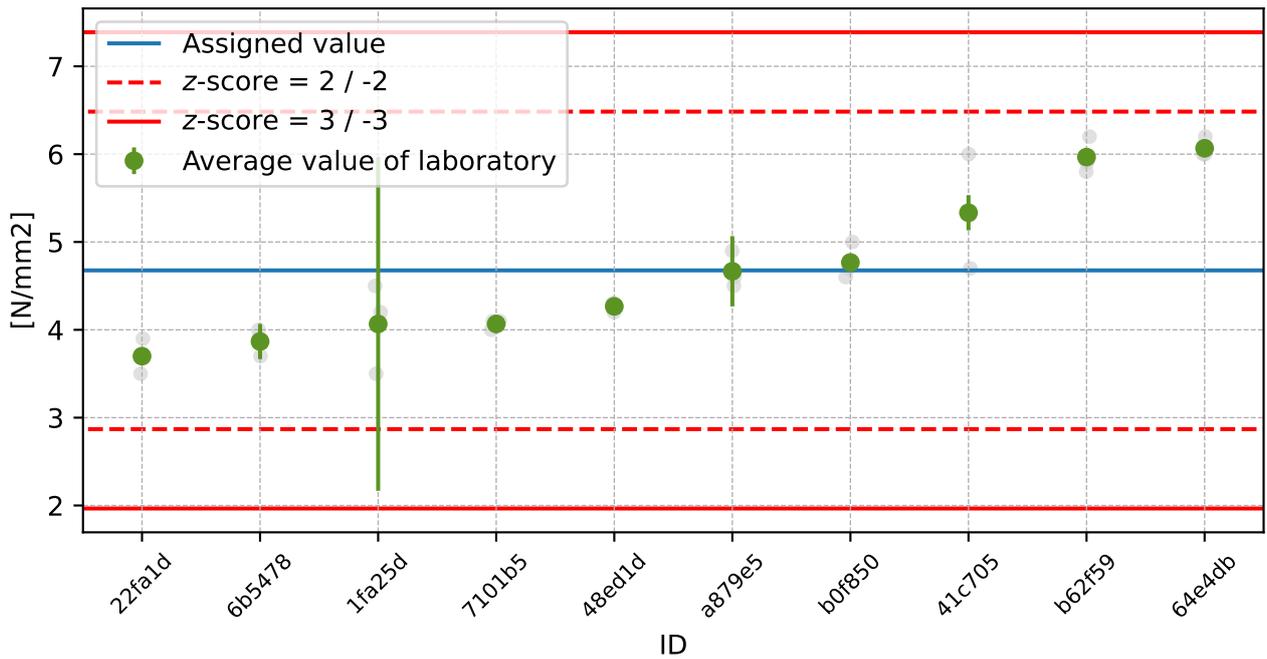
Figure 7: Average values and extended uncertainties of measurement

Figure 8: z-score

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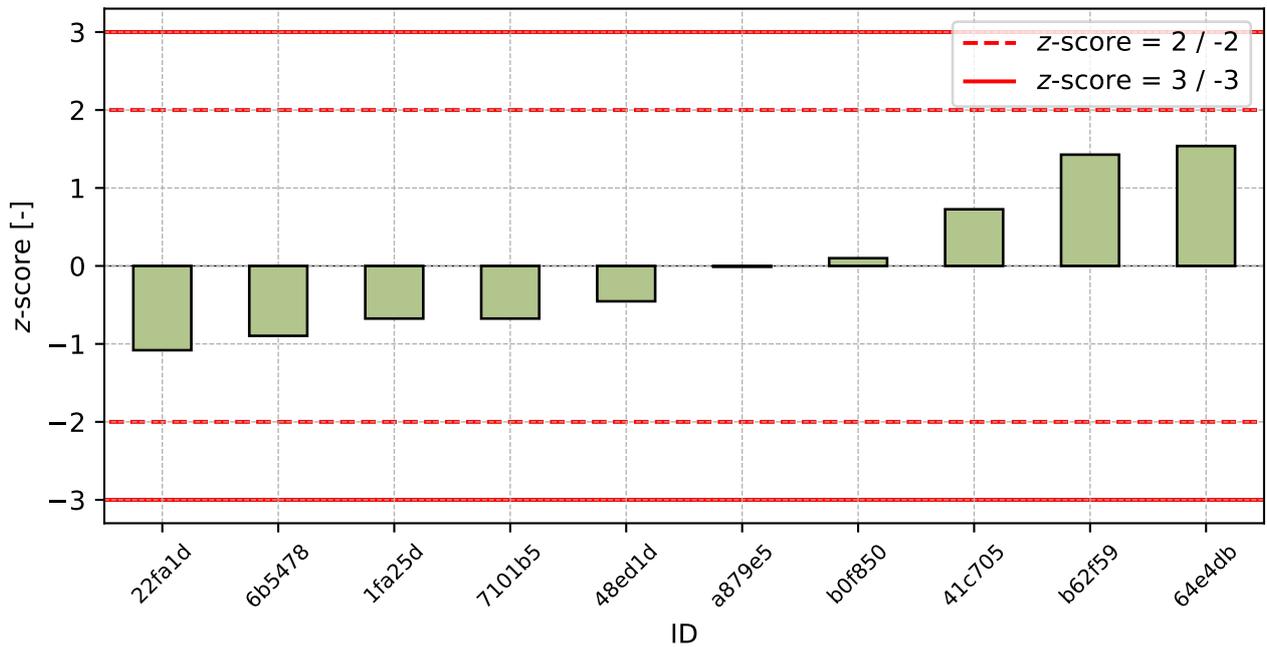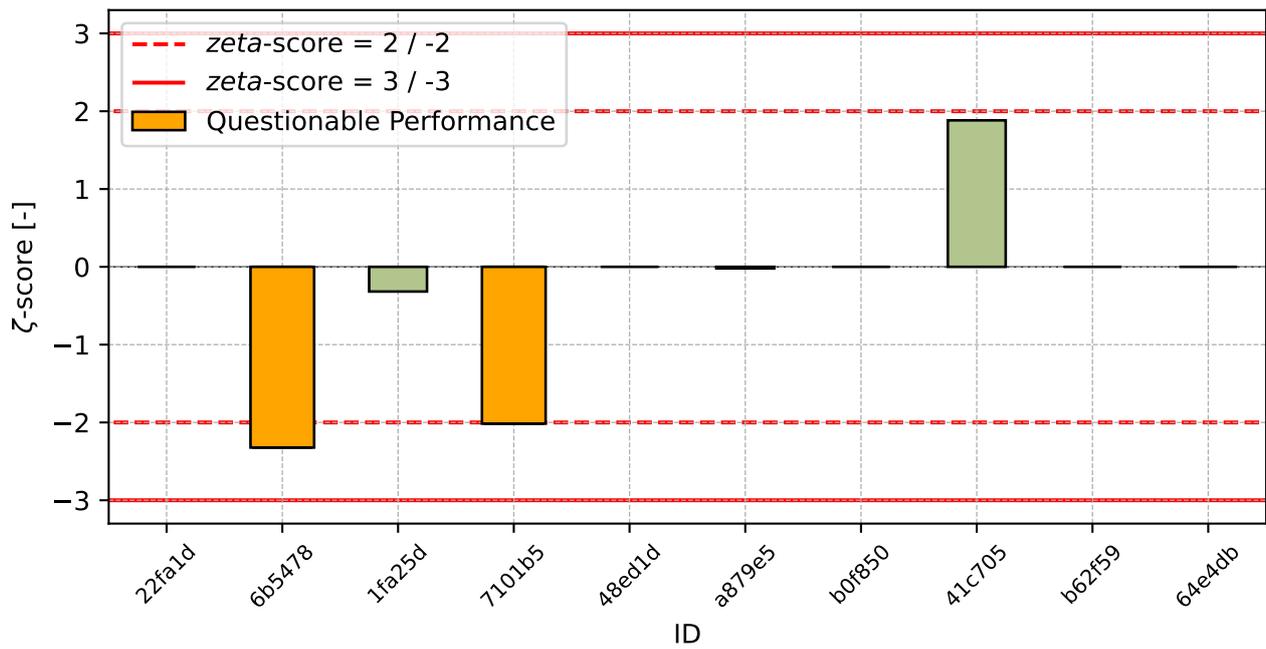
Figure 9: ζ-score

Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
22fa1d	-1.08	-
6b5478	-0.9	-2.32
1fa25d	-0.68	-0.32
7101b5	-0.68	-2.01
48ed1d	-0.45	-
a879e5	-0.01	-0.02
b0f850	0.1	-
41c705	0.73	1.88
b62f59	1.43	-
64e4db	1.54	-

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1.2 Compressive Strength after 2 days of ageing

1.2.1 Test results

Table 7: 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 [N/mm^2]						u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
22fa1d	17.6	18.2	18.1	18.5	17.7	17.8	-	18.0	0.34	1.91
6b5478	19.8	19.9	19.9	19.7	20.0	20.8	1.50	20.0	0.40	1.98
41c705	20.3	19.4	20.9	20.0	21.6	20.9	1.20	20.5	0.78	3.79
7101b5	20.2	21.5	22.3	21.3	18.8	19.9	3.00	20.7	1.27	6.14
b0f850	20.7	21.5	21.0	20.7	20.8	21.5	-	21.0	0.38	1.80
1fa25d	21.9	21.3	20.6	21.3	22.5	21.3	2.60	21.5	0.65	3.01
48ed1d	22.2	22.2	22.4	21.7	21.1	23.0	-	22.1	0.64	2.92
b62f59	24.4	24.5	24.8	24.2	24.9	24.2	-	24.5	0.30	1.21
a879e5	25.7	26.7	24.8	25.7	26.3	25.1	2.00	25.7	0.71	2.77
64e4db	27.1	27.1	25.6	26.4	26.8	28.4	-	26.9	0.93	3.44

1.2.2 The Numerical Procedure for Determining Outliers
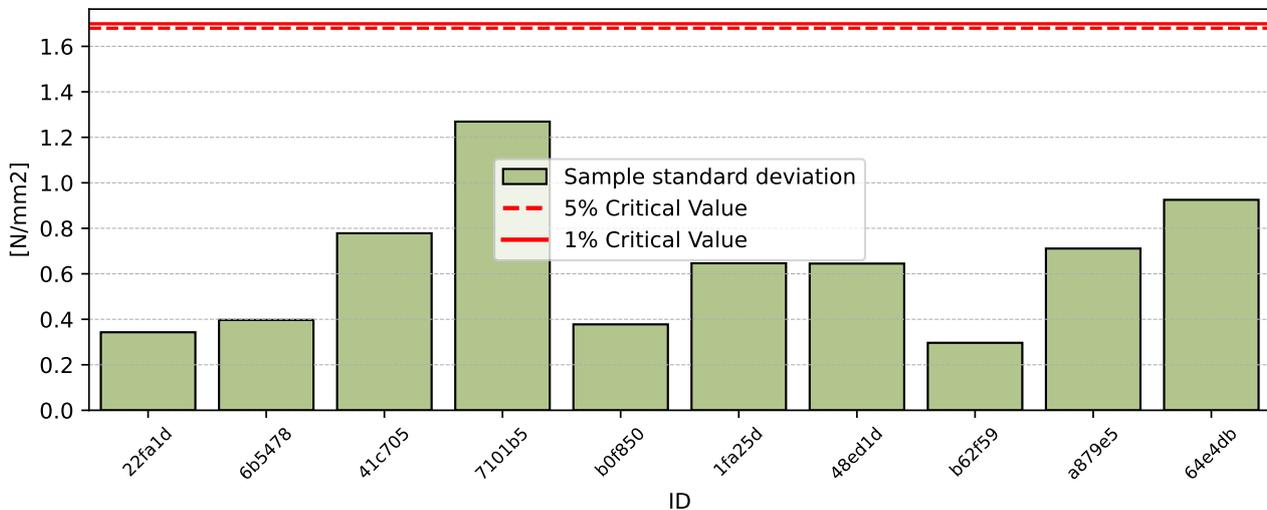
Figure 10: **Cochran's test** - sample standard deviations

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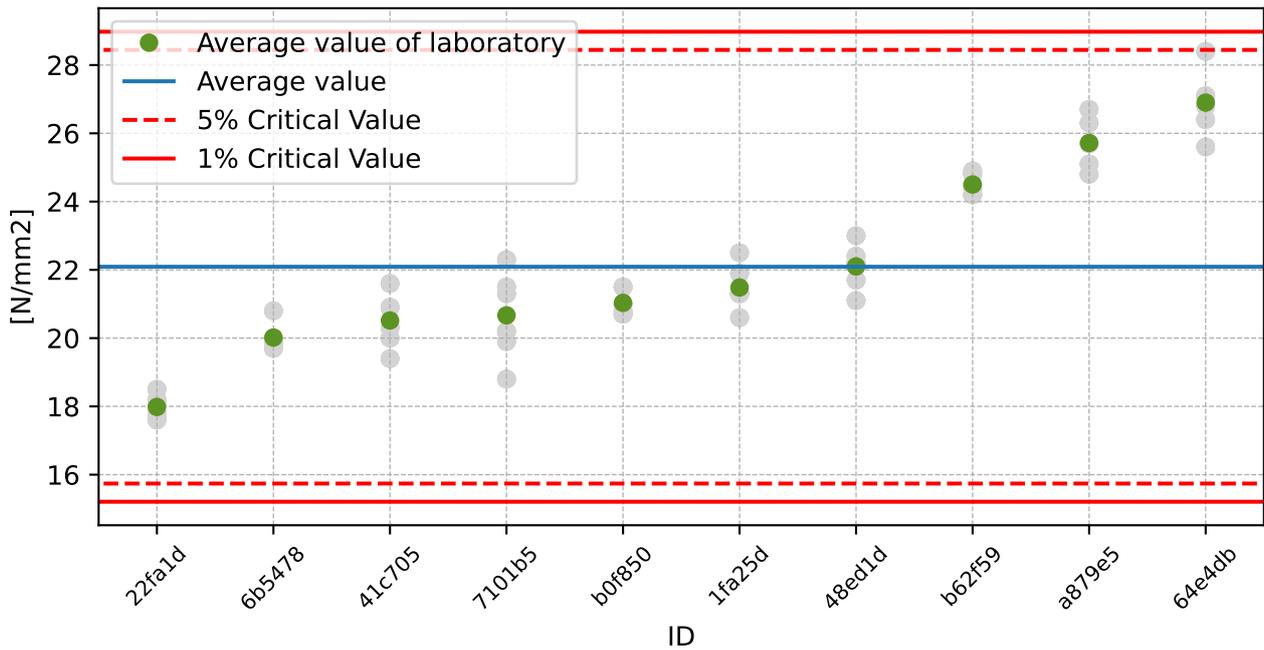
Figure 11: **Grubbs' test** - average values

1.2.3 Mandel's Statistics
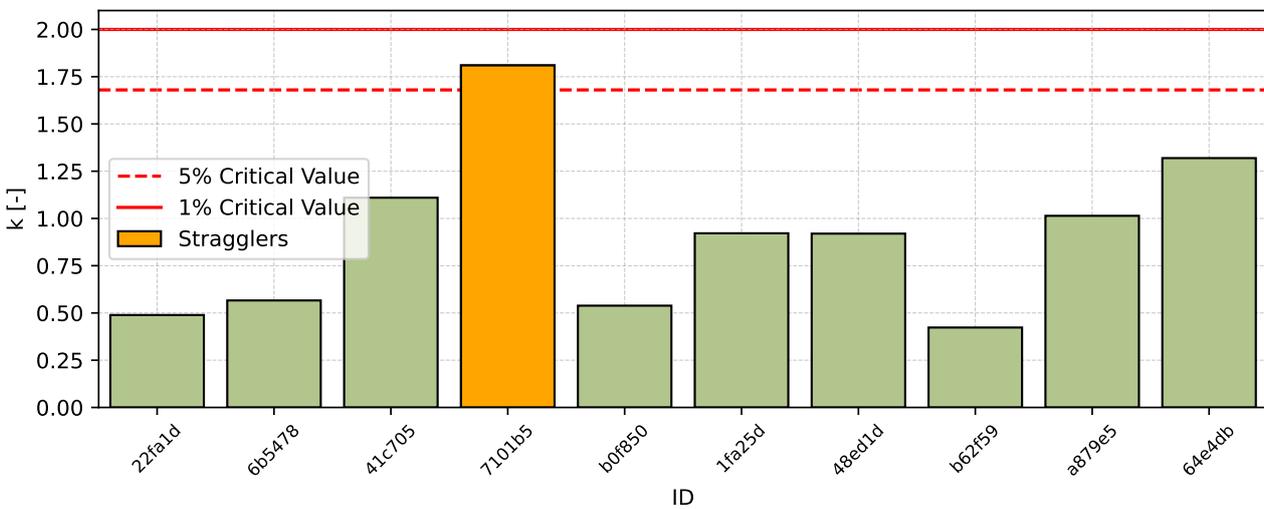
Figure 12: Intralaboratory Consistency Statistic

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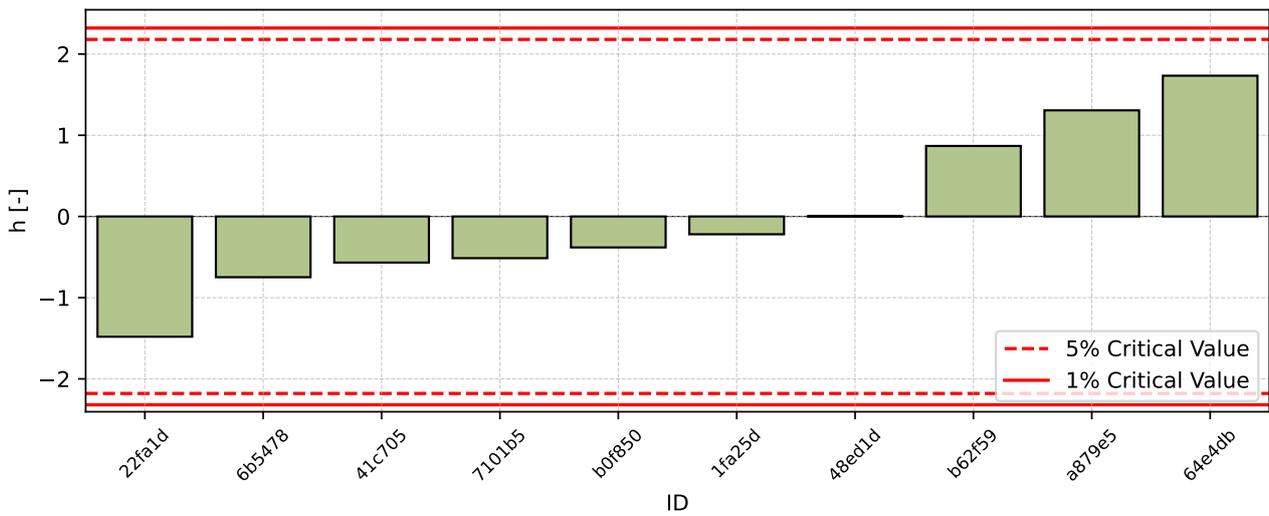
Figure 13: Interlaboratory Consistency Statistic

1.2.4 Descriptive statistics
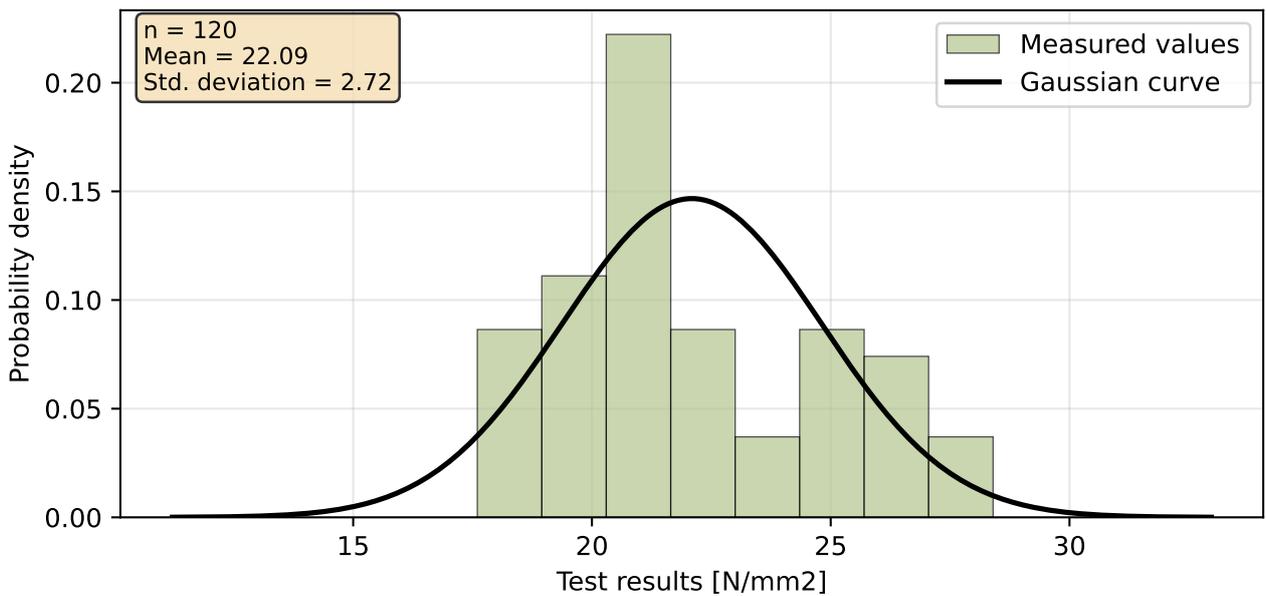
Figure 14: Histogram of all test results

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Table 8: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	22.1
Sample standard deviation – s	2.77
Asigned value – x^*	22.1
Robust standard deviation – s^*	2.77
Measurement uncertainty of asigned value – u_X	0.88
p-value of normality test	0.012 [-]
Interlaboratory standard deviation – s_L	2.76
Repeatability standard deviation – s_r	0.7
Reproducibility standard deviation – s_R	2.85
Repeatability – r	2.0
Reproducibility – R	8.0

1.2.5 Evaluation of Performance Statistics
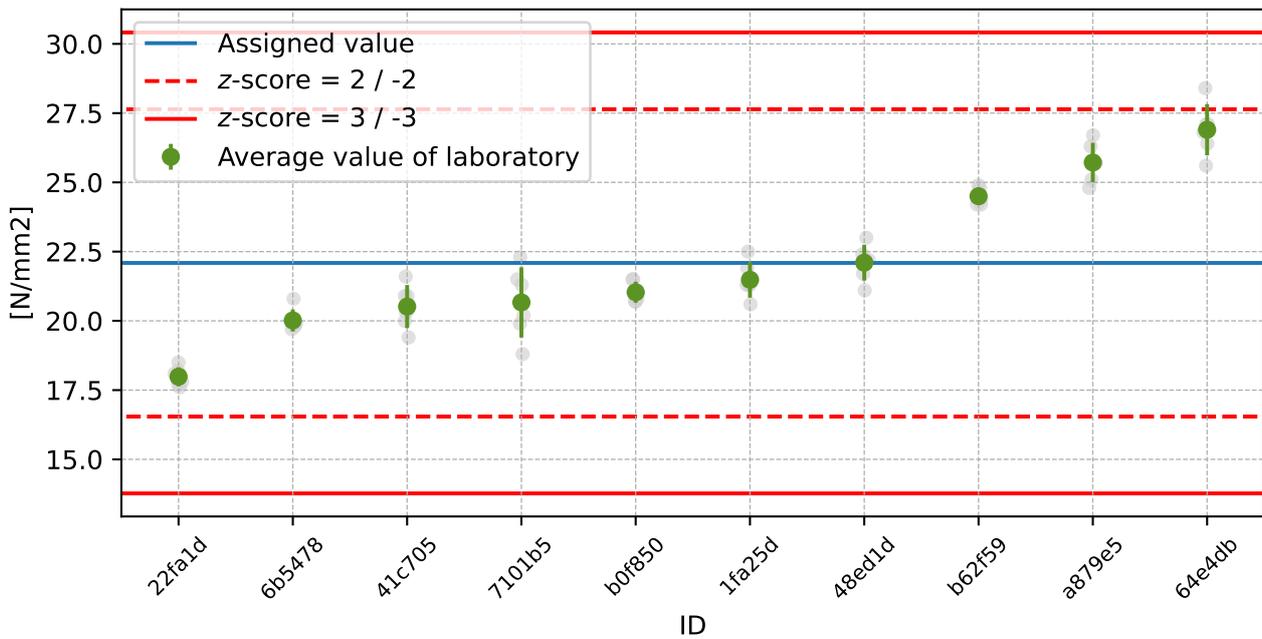
Figure 15: Average values and sample standard deviations

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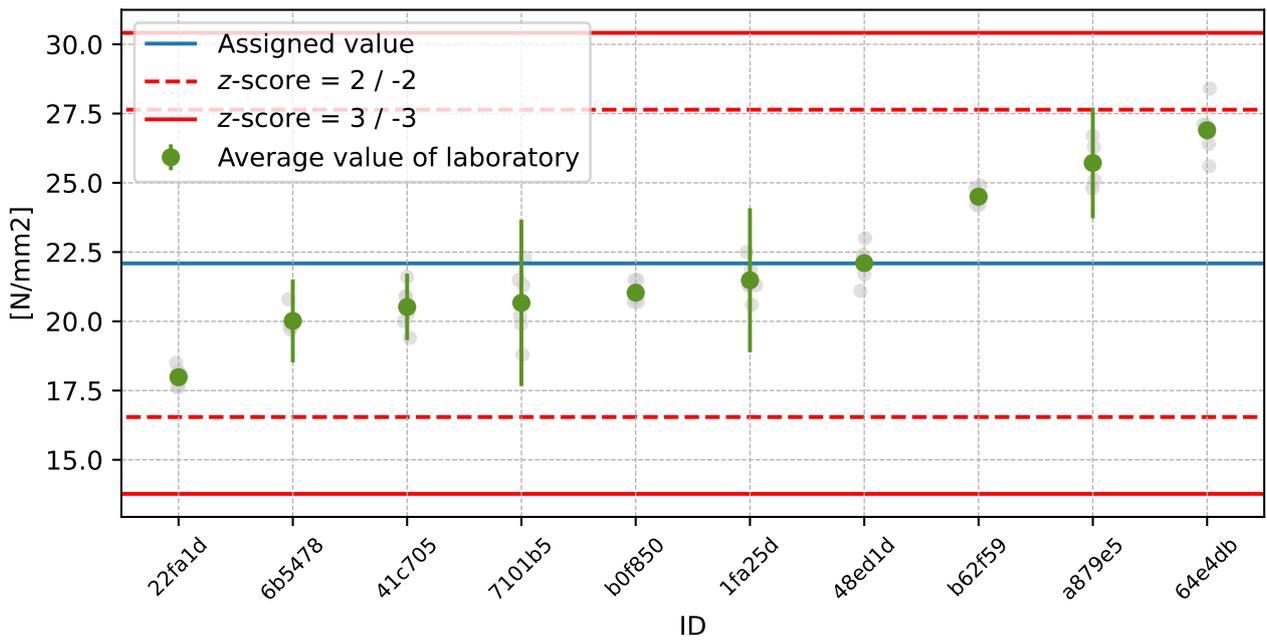
Figure 16: Average values and extended uncertainties of measurement

Figure 17: z-score

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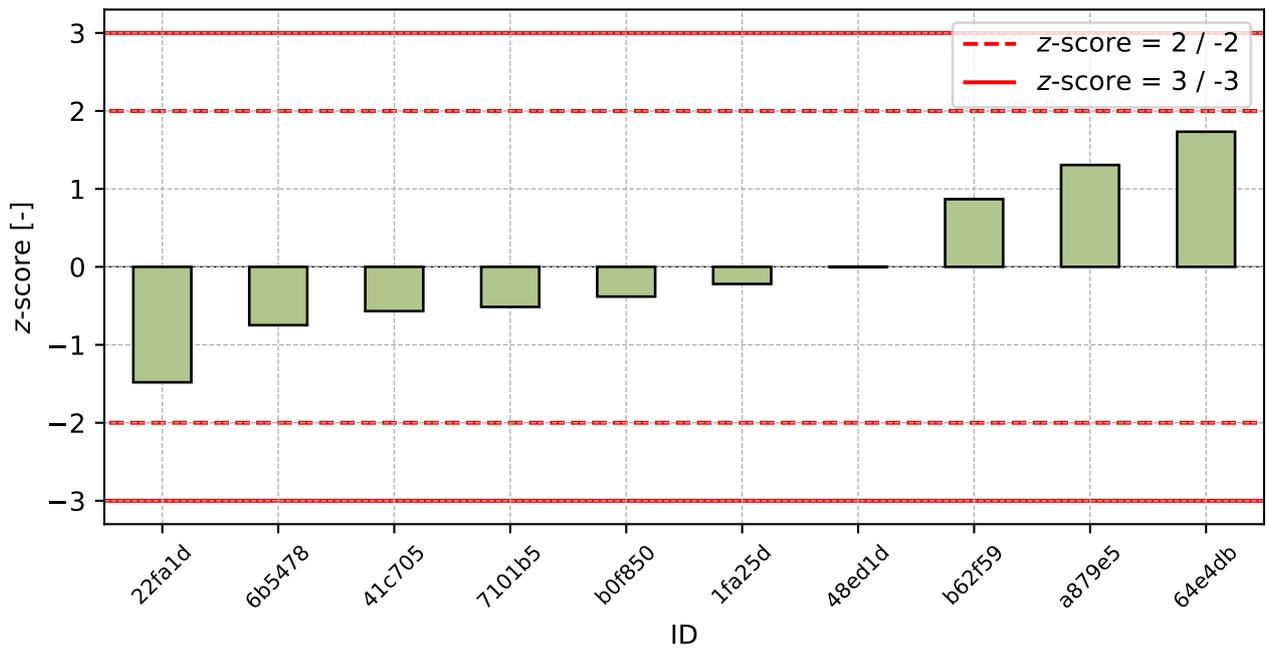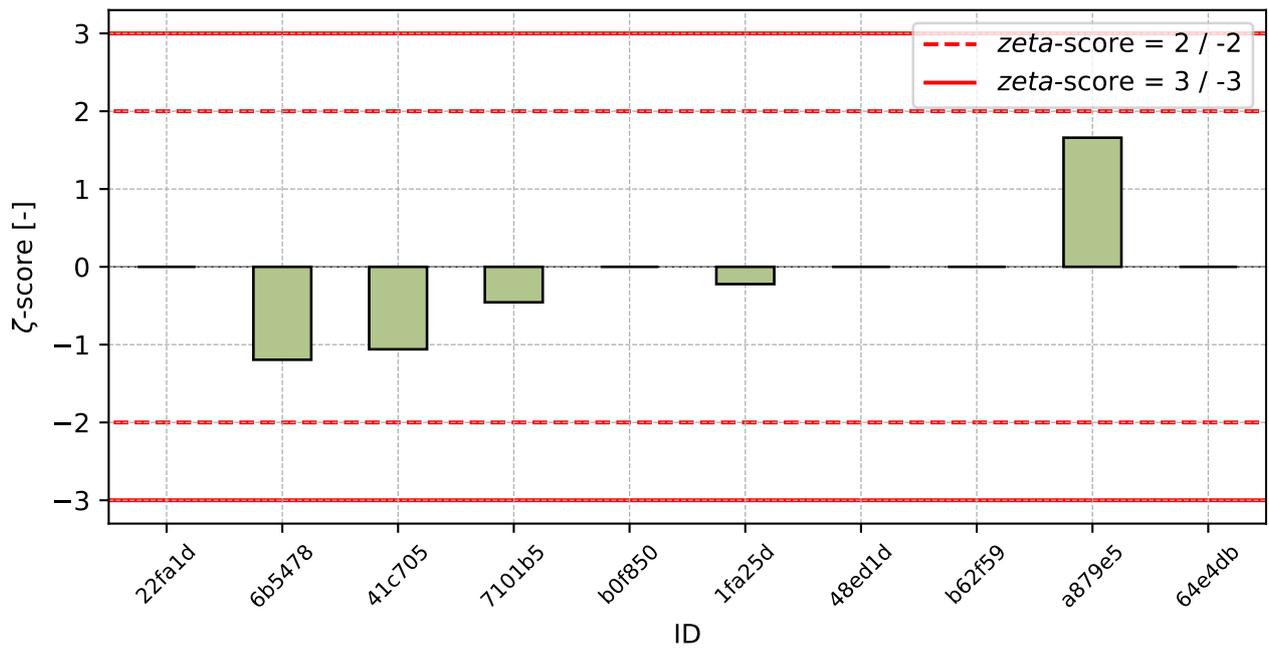
Figure 18: ζ-score

Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
22fa1d	-1.48	-
6b5478	-0.75	-1.19
41c705	-0.57	-1.06
7101b5	-0.51	-0.46
b0f850	-0.38	-
1fa25d	-0.22	-0.22
48ed1d	0.0	-
b62f59	0.87	-
a879e5	1.31	1.66
64e4db	1.73	-

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1.3 Flexural Strength after 7 days of ageing

1.3.1 Test results

Table 10: 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 [N/mm^2]			u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
22fa1d	6.2	6.5	6.0	-	6.2	0.25	4.04
48ed1d	6.4	6.5	6.4	-	6.4	0.06	0.90
a879e5	6.4	6.5	6.8	0.60	6.6	0.21	3.17
64e4db	7.1	7.0	7.0	-	7.0	0.06	0.82
6b5478	6.5	7.5	7.4	0.40	7.1	0.55	7.72
7101b5	6.6	7.3	7.5	0.10	7.1	0.47	6.62
1fa25d	6.8	7.7	7.3	1.90	7.3	0.45	6.21
b62f59	7.4	7.2	7.2	-	7.3	0.12	1.59
41c705	7.5	7.7	7.2	0.20	7.5	0.25	3.37
b0f850	8.1	7.8	7.9	-	7.9	0.15	1.93

1.3.2 The Numerical Procedure for Determining Outliers
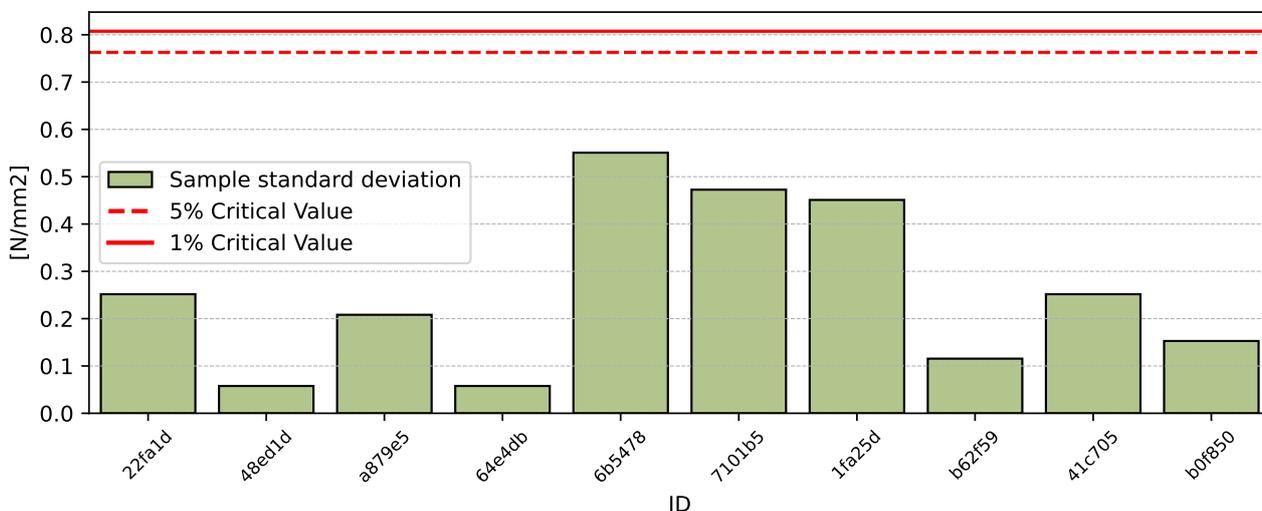
Figure 19: **Cochran's test** - sample standard deviations

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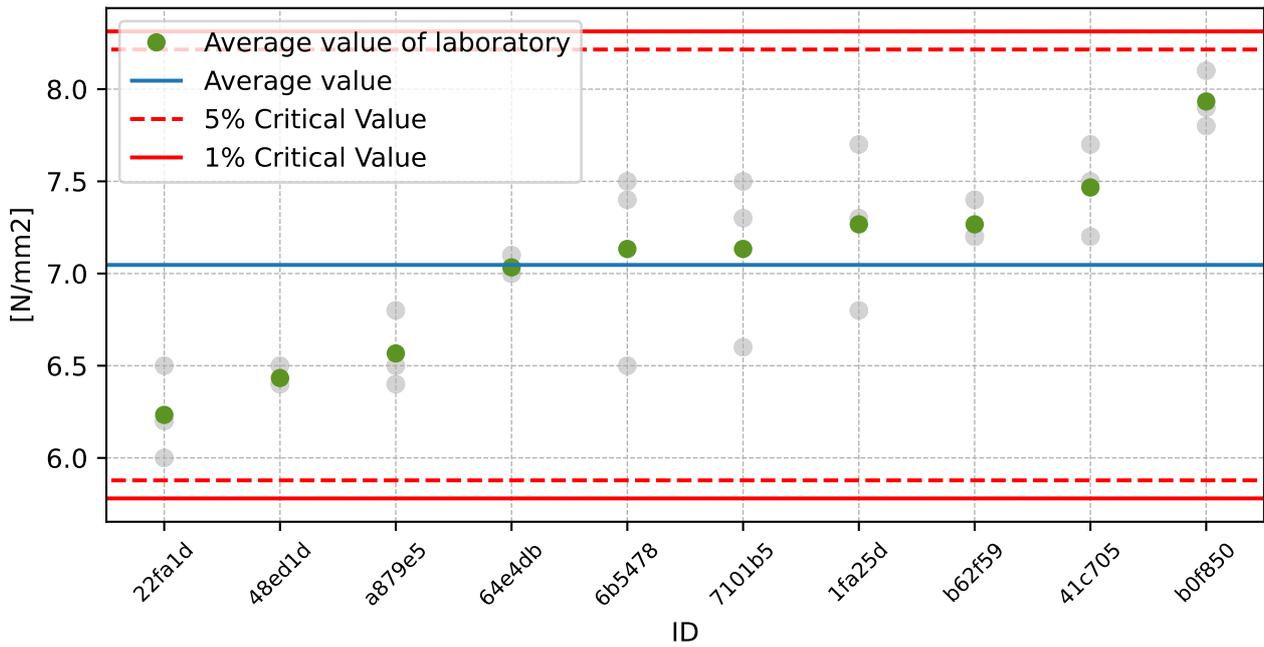
Figure 20: **Grubbs' test** - average values

1.3.3   Mandel's Statistics
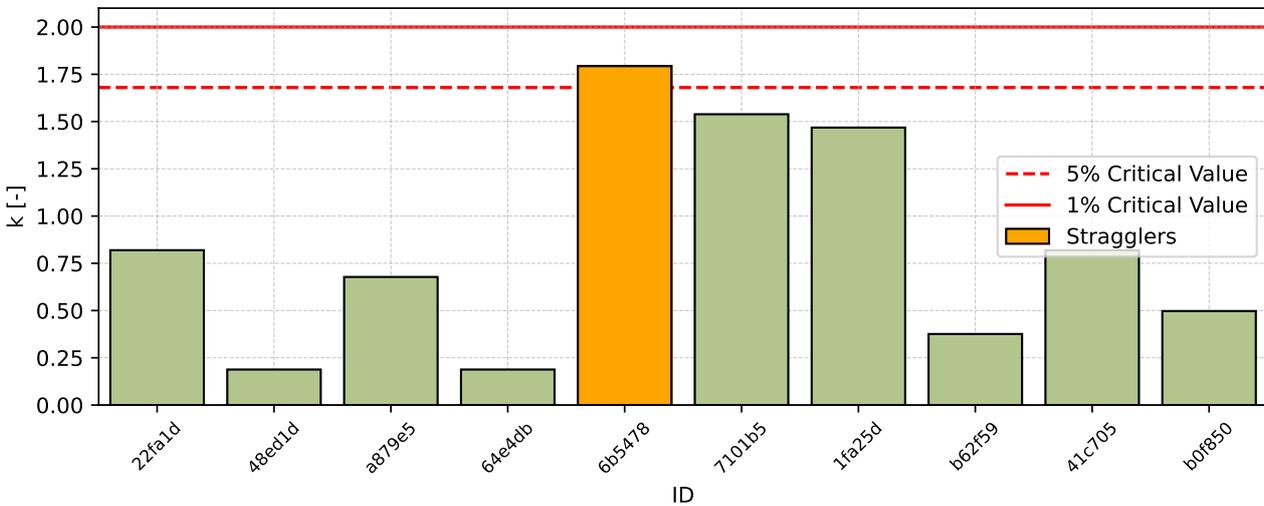
Figure 21: Intralaboratory Consistency Statistic

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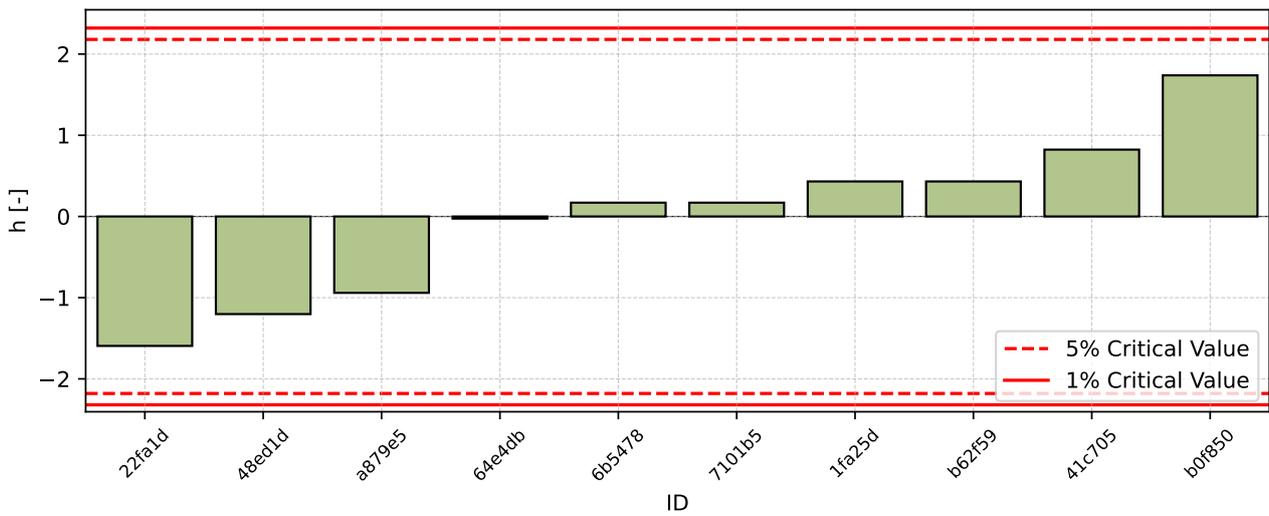
Figure 22: Interlaboratory Consistency Statistic

1.3.4 Descriptive statistics

n = 60
Mean = 7.05
Std. deviation = 0.55
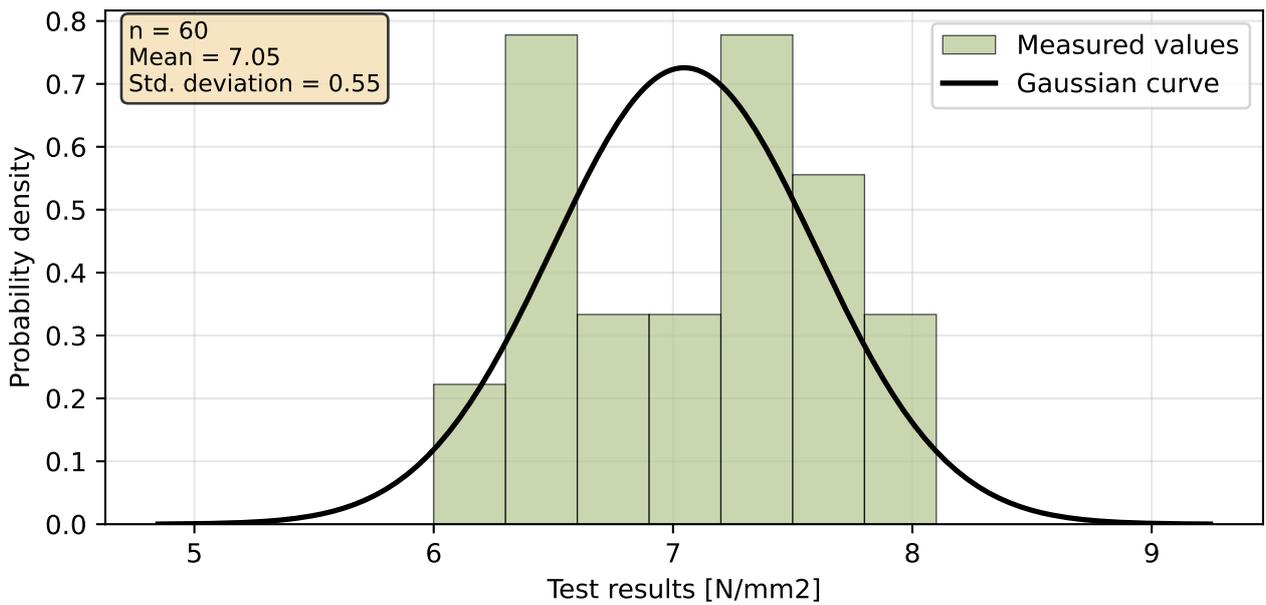
Figure 23: Histogram of all test results

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Table 11: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	7.0
Sample standard deviation – s	0.51
Asigned value – x^*	7.0
Robust standard deviation – s^*	0.51
Measurement uncertainty of asigned value – u_X	0.16
p-value of normality test	0.399 [-]
Interlaboratory standard deviation – s_L	0.48
Repeatability standard deviation – s_r	0.31
Reproducibility standard deviation – s_R	0.57
Repeatability – r	0.9
Reproducibility – R	1.6

1.3.5 Evaluation of Performance Statistics
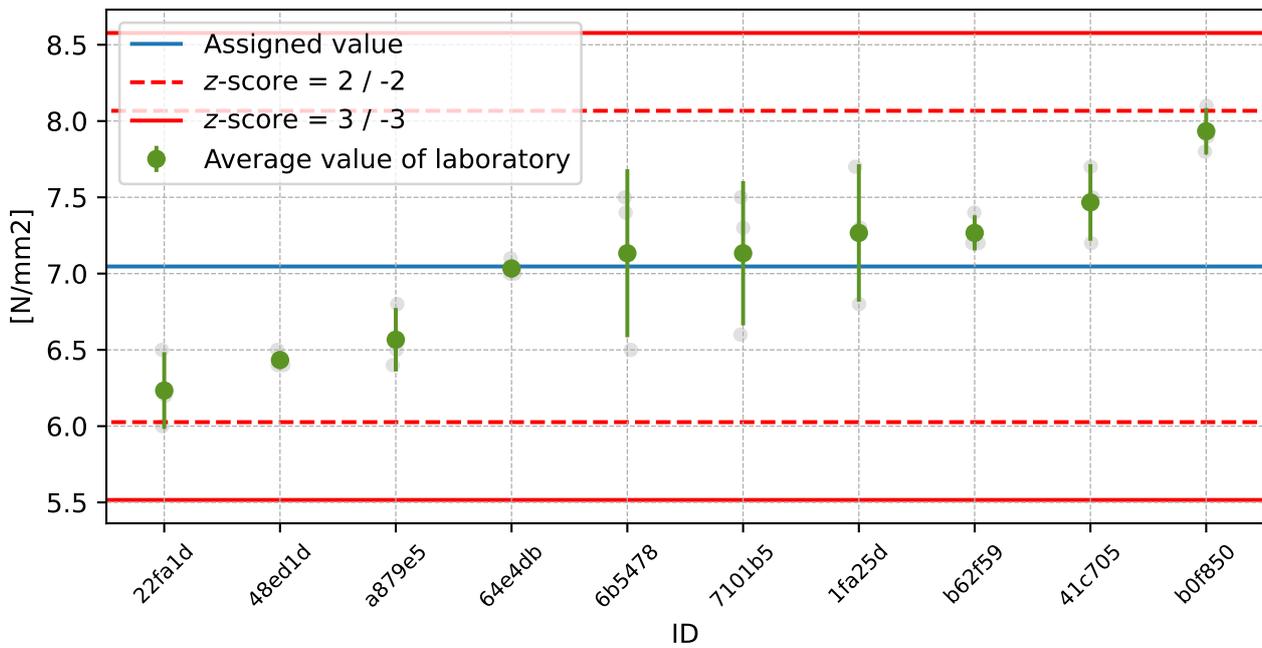
Figure 24: Average values and sample standard deviations

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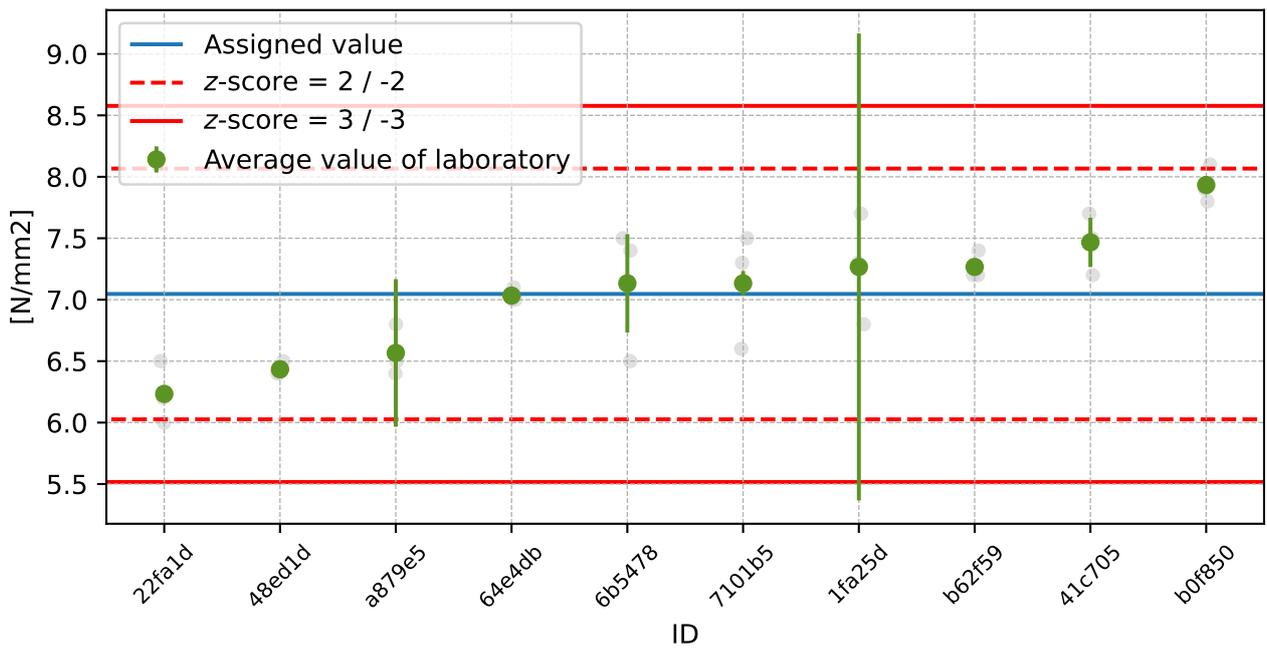
Figure 25: Average values and extended uncertainties of measurement

Figure 26: z-score

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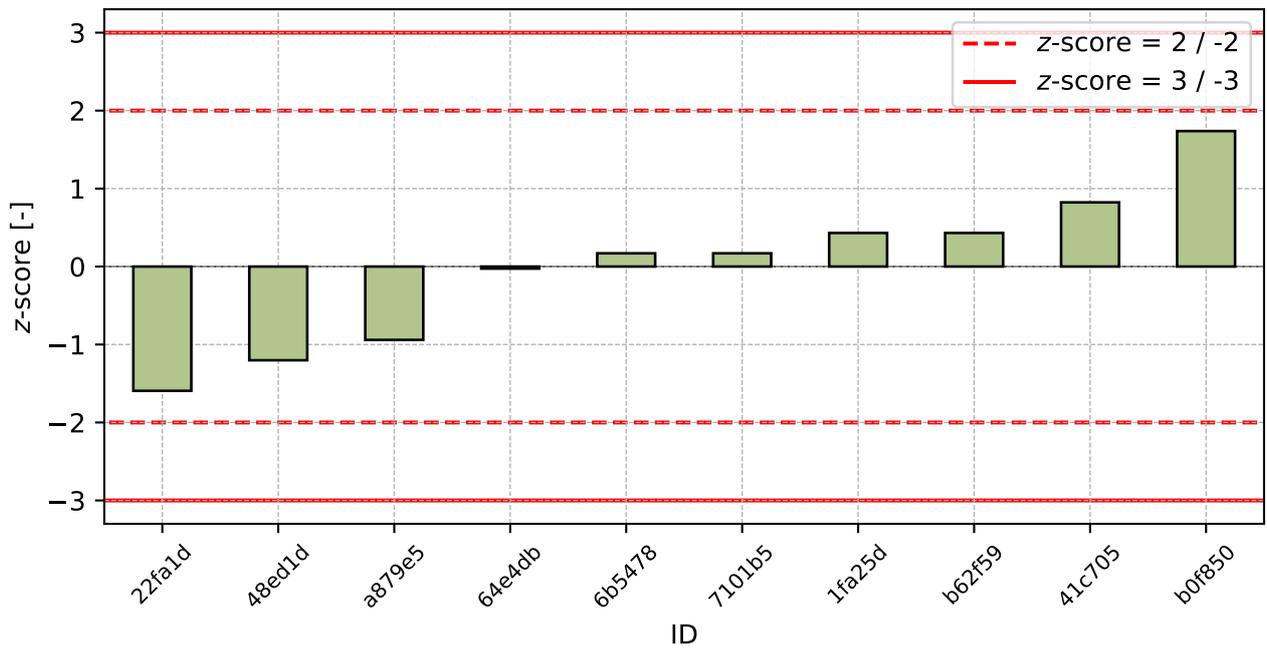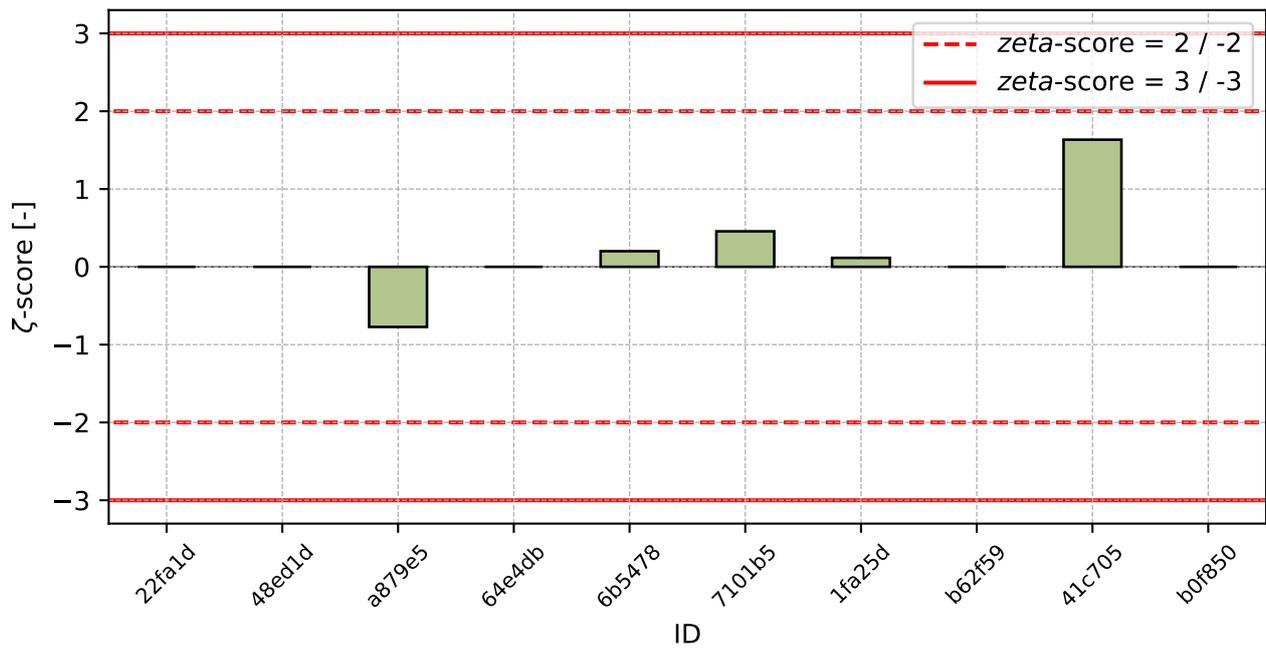
Figure 27: ζ-score

Table 12: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
22fa1d	-1.59	-
48ed1d	-1.2	-
a879e5	-0.94	-0.77
64e4db	-0.03	-
6b5478	0.17	0.2
7101b5	0.17	0.46
1fa25d	0.43	0.12
b62f59	0.43	-
41c705	0.82	1.63
b0f850	1.74	-

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1.4 Compressive Strength after 7 days of ageing

1.4.1 Test results

Table 13: 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 [N/mm²]						u_X [N/mm²]	$\bar{x}$ [N/mm²]	s_0 [N/mm²]	V_X [%]
41c705	28.3	28.1	28.8	29.1	27.8	28.1	1.20	28.4	0.49	1.72
6b5478	35.8	35.7	36.1	36.2	37.6	36.9	2.60	36.4	0.73	2.01
b0f850	37.0	37.6	35.7	36.8	35.5	36.2	-	36.5	0.81	2.22
22fa1d	35.4	36.8	36.4	36.2	37.5	36.6	-	36.5	0.69	1.90
1fa25d	40.0	40.0	37.5	38.1	39.4	40.6	2.60	39.3	1.21	3.09
64e4db	39.3	41.8	44.1	43.6	40.0	40.1	-	41.5	2.02	4.86
a879e5	42.8	40.2	42.2	44.3	41.2	43.8	2.50	42.4	1.55	3.66
b62f59	43.0	42.9	42.5	42.9	42.8	42.8	-	42.8	0.17	0.40
48ed1d	42.7	43.3	42.5	43.0	43.7	42.6	-	43.0	0.46	1.08
7101b5	45.3	47.7	47.3	45.8	45.8	47.9	3.00	46.6	1.13	2.42

1.4.2 The Numerical Procedure for Determining Outliers
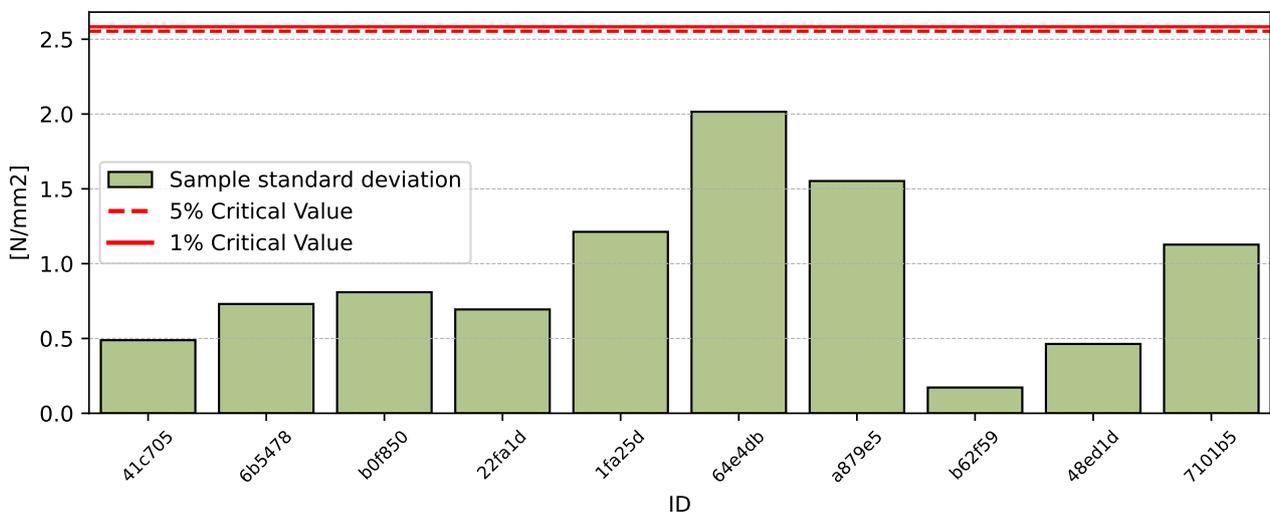
Figure 28: **Cochran's test** - sample standard deviations

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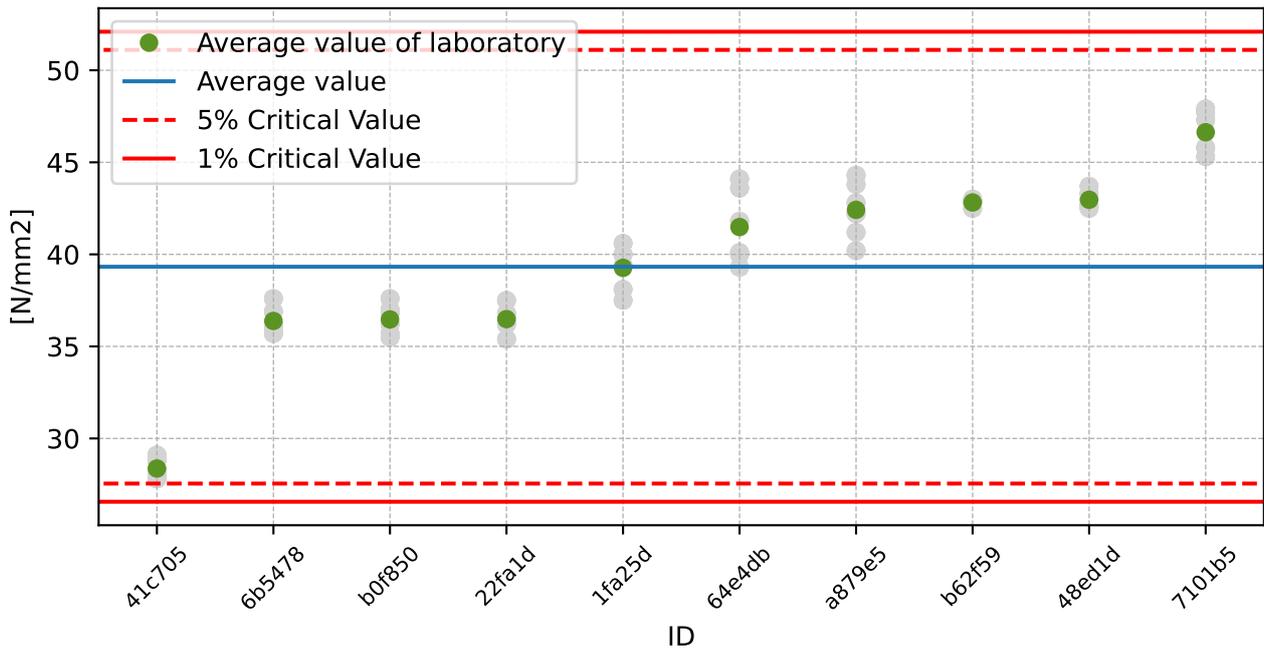
Figure 29: **Grubbs' test** - average values

1.4.3   Mandel's Statistics
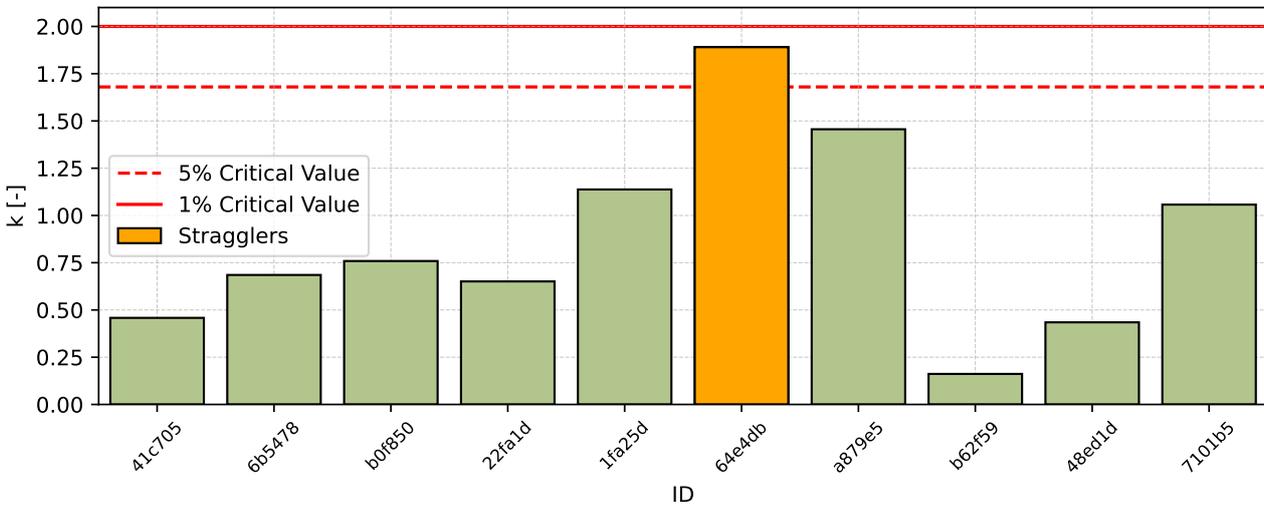
Figure 30: Intralaboratory Consistency Statistic

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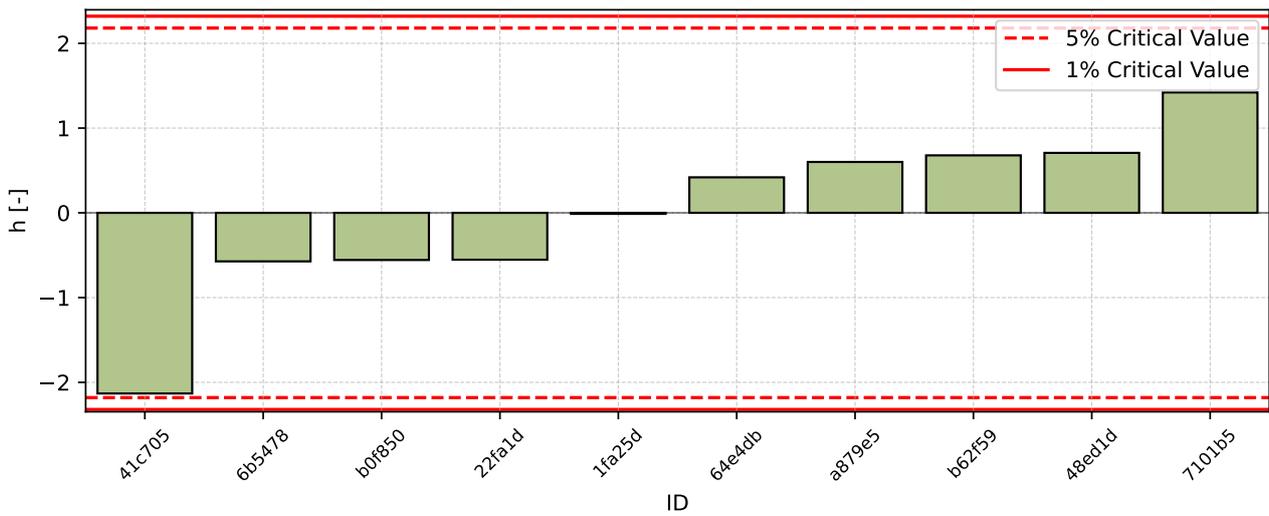
Figure 31: Interlaboratory Consistency Statistic

1.4.4   Descriptive statistics
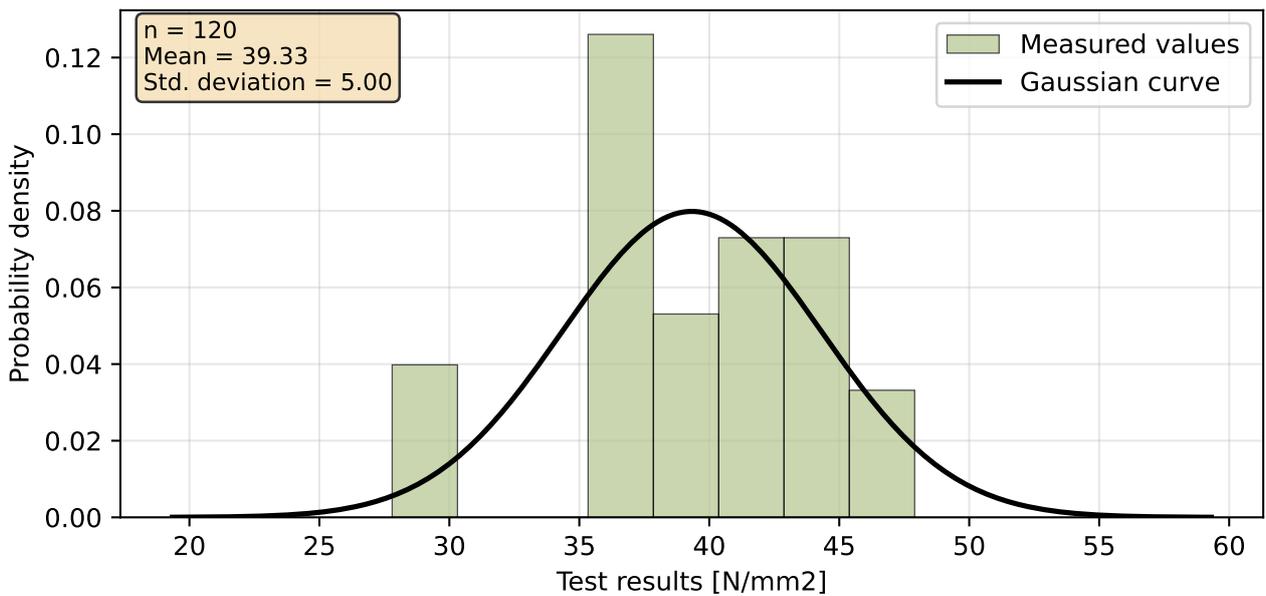
Figure 32: Histogram of all test results

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Table 14: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	39.3
Sample standard deviation – s	5.14
Asigned value – x^*	39.3
Robust standard deviation – s^*	5.54
Measurement uncertainty of asigned value – u_X	1.75
p-value of normality test	0.002 [-]
Interlaboratory standard deviation – s_L	5.12
Repeatability standard deviation – s_r	1.07
Reproducibility standard deviation – s_R	5.23
Repeatability – r	3.0
Reproducibility – R	14.7

1.4.5 Evaluation of Performance Statistics
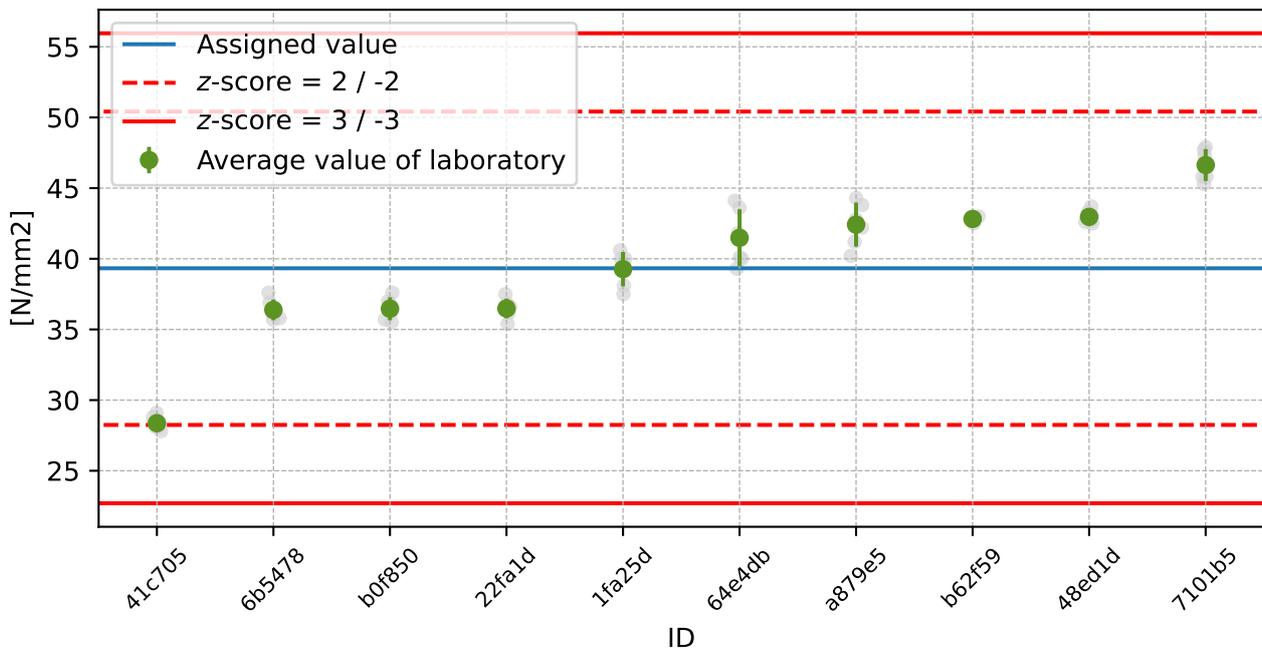
Figure 33: Average values and sample standard deviations

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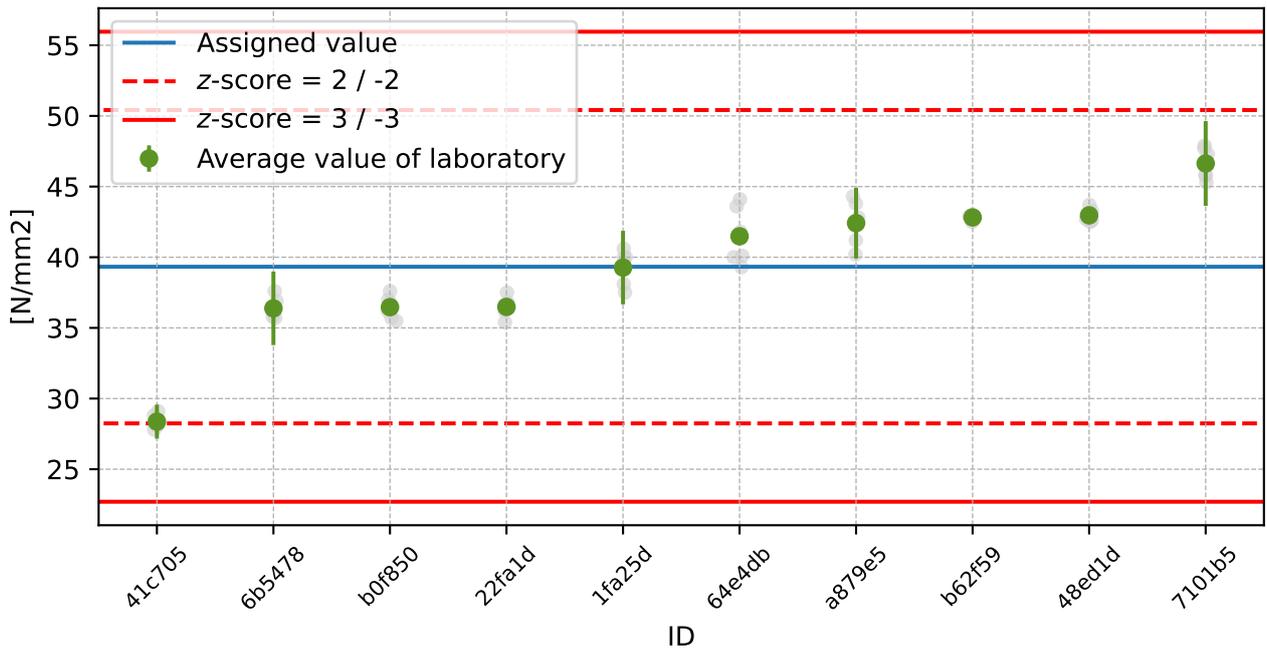
Figure 34: Average values and extended uncertainties of measurement

Figure 35: z-score

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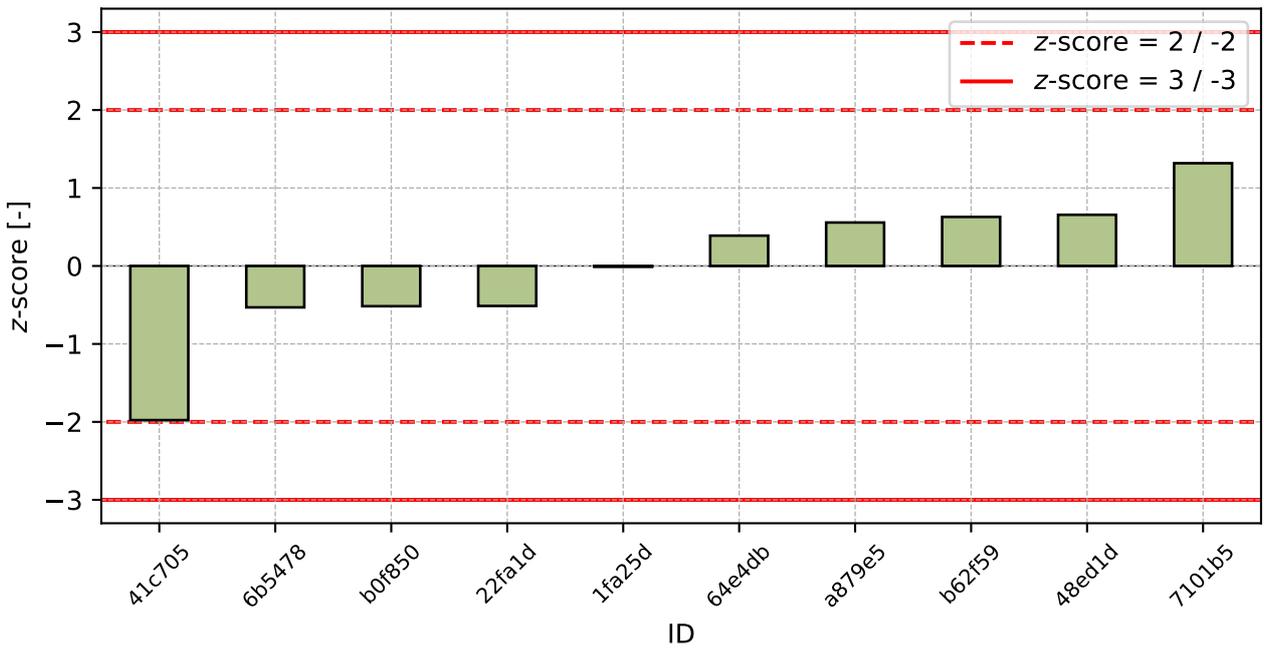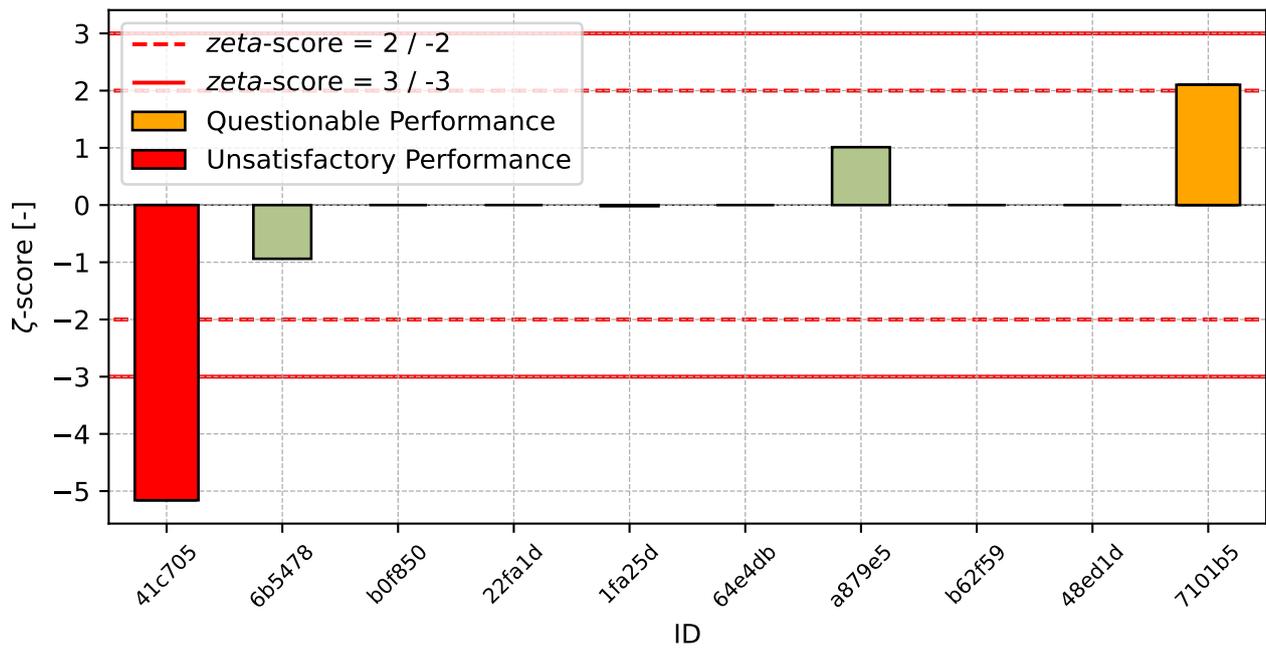
Figure 36: ζ-score

Table 15: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
41c705	-1.98	-5.16
6b5478	-0.53	-0.94
b0f850	-0.52	-
22fa1d	-0.51	-
1fa25d	-0.01	-0.02
64e4db	0.39	-
a879e5	0.56	1.01
b62f59	0.63	-
48ed1d	0.66	-
7101b5	1.32	2.1

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1.5 Flexural Strength after 28 days of ageing

1.5.1 Test results

Table 16: 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 [N/mm^2]			u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
f93fca	7.8	7.2	7.2	0.50	7.4	0.35	4.68
a879e5	8.4	7.5	7.6	0.70	7.8	0.49	6.30
7101b5	8.2	7.8	7.8	0.10	7.9	0.23	2.91
48ed1d	8.1	8.0	7.9	-	8.0	0.10	1.25
41c705	8.8	7.6	8.0	0.20	8.1	0.61	7.51
22fa1d	8.4	8.6	8.3	-	8.4	0.15	1.81
1fa25d	8.2	8.9	8.4	1.90	8.5	0.36	4.24
6b5478	8.4	8.7	8.7	0.40	8.6	0.17	2.01
64e4db	8.8	8.3	8.8	-	8.6	0.29	3.34
b0f850	9.1	8.6	8.9	-	8.9	0.25	2.84
b62f59	9.1	8.9	9.1	-	9.0	0.12	1.28

1.5.2 The Numerical Procedure for Determining Outliers
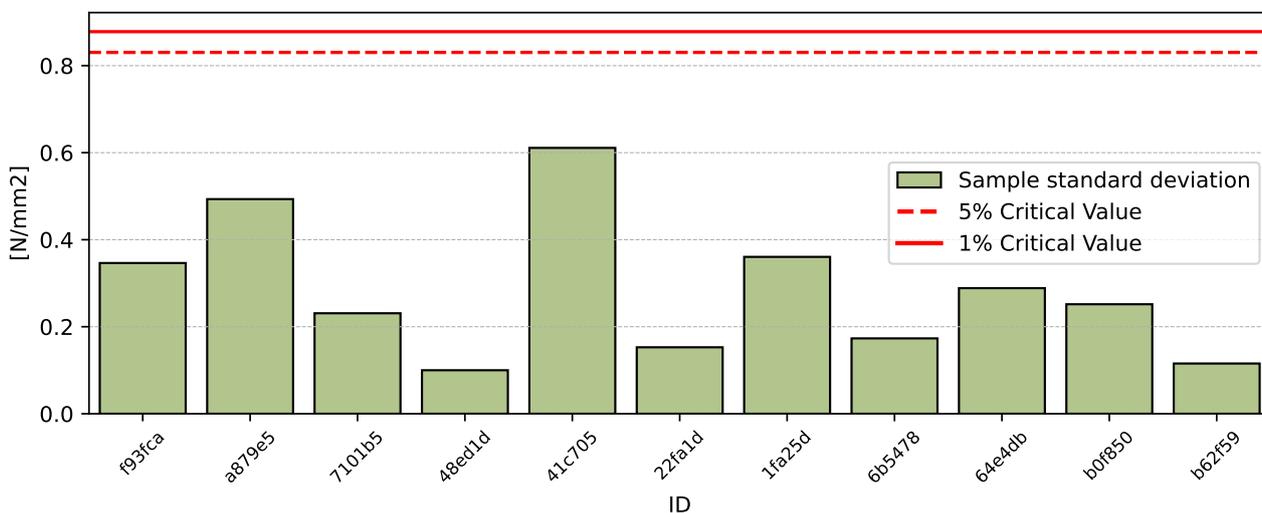
Figure 37: **Cochran's test** - sample standard deviations

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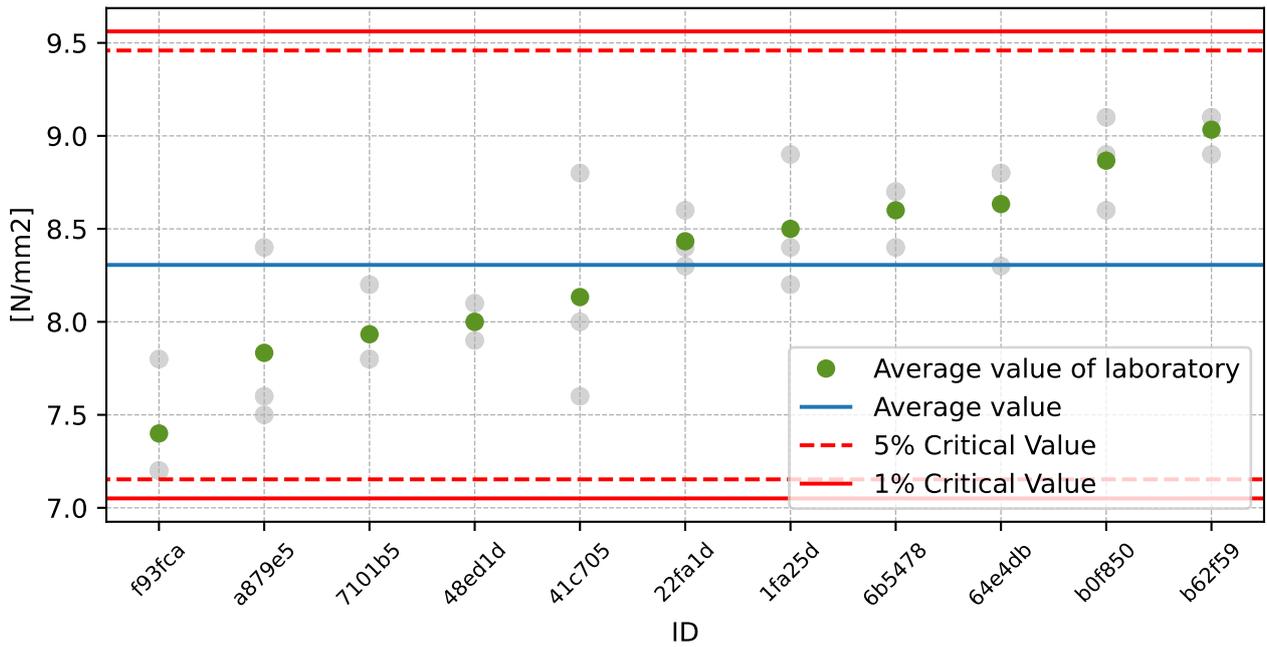
Figure 38: **Grubbs' test** - average values

1.5.3   Mandel's Statistics
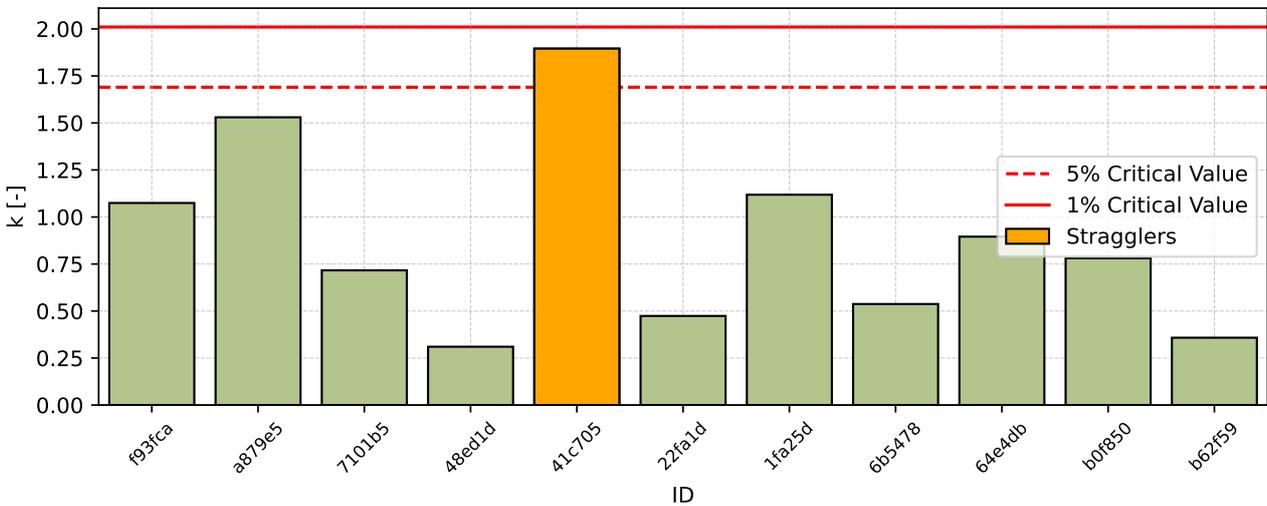
Figure 39: Intralaboratory Consistency Statistic

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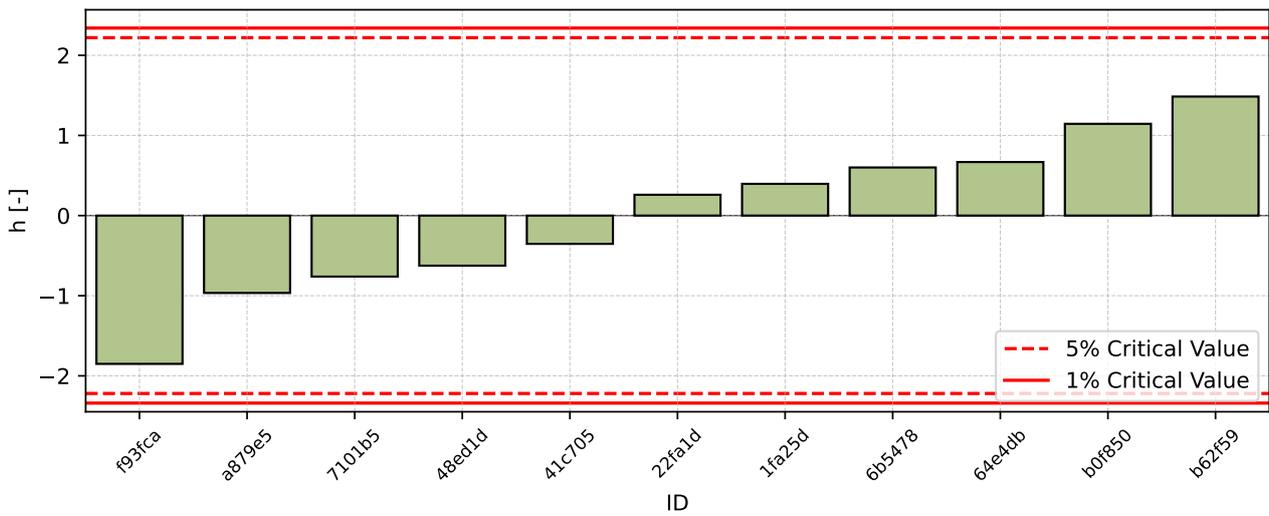
Figure 40: Interlaboratory Consistency Statistic

1.5.4 Descriptive statistics
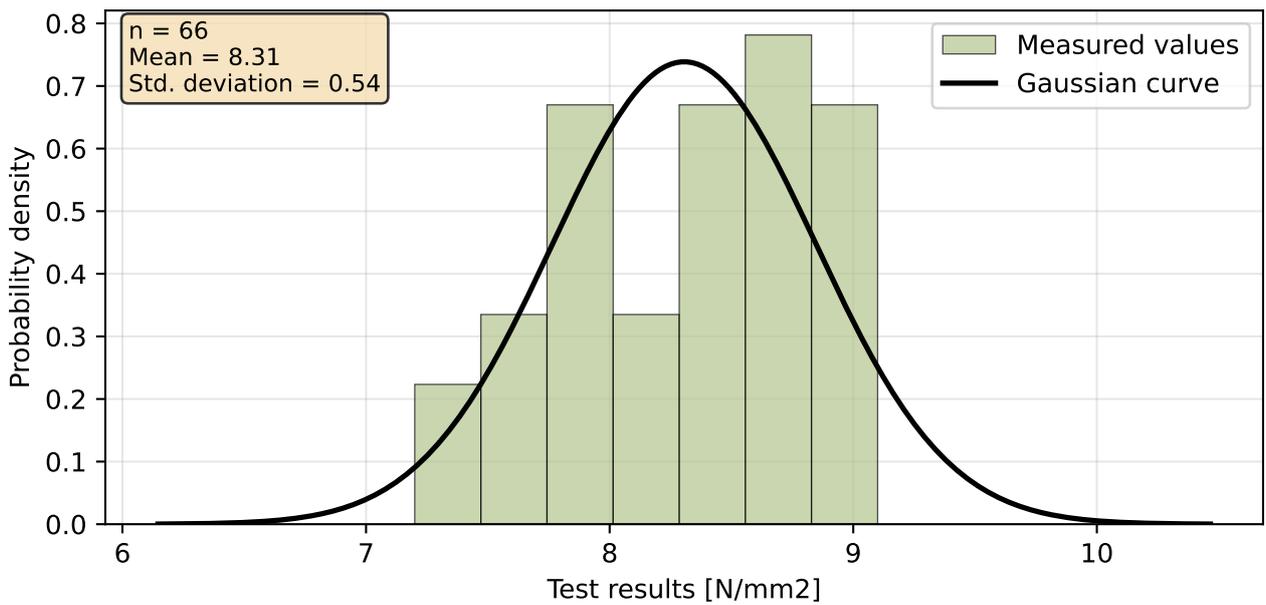
Figure 41: Histogram of all test results

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Table 17: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	8.3
Sample standard deviation – s	0.49
Asigned value – x^*	8.3
Robust standard deviation – s^*	0.54
Measurement uncertainty of asigned value – u_X	0.16
p-value of normality test	0.187 [-]
Interlaboratory standard deviation – s_L	0.45
Repeatability standard deviation – s_r	0.32
Reproducibility standard deviation – s_R	0.56
Repeatability – r	0.9
Reproducibility – R	1.6

1.5.5 Evaluation of Performance Statistics
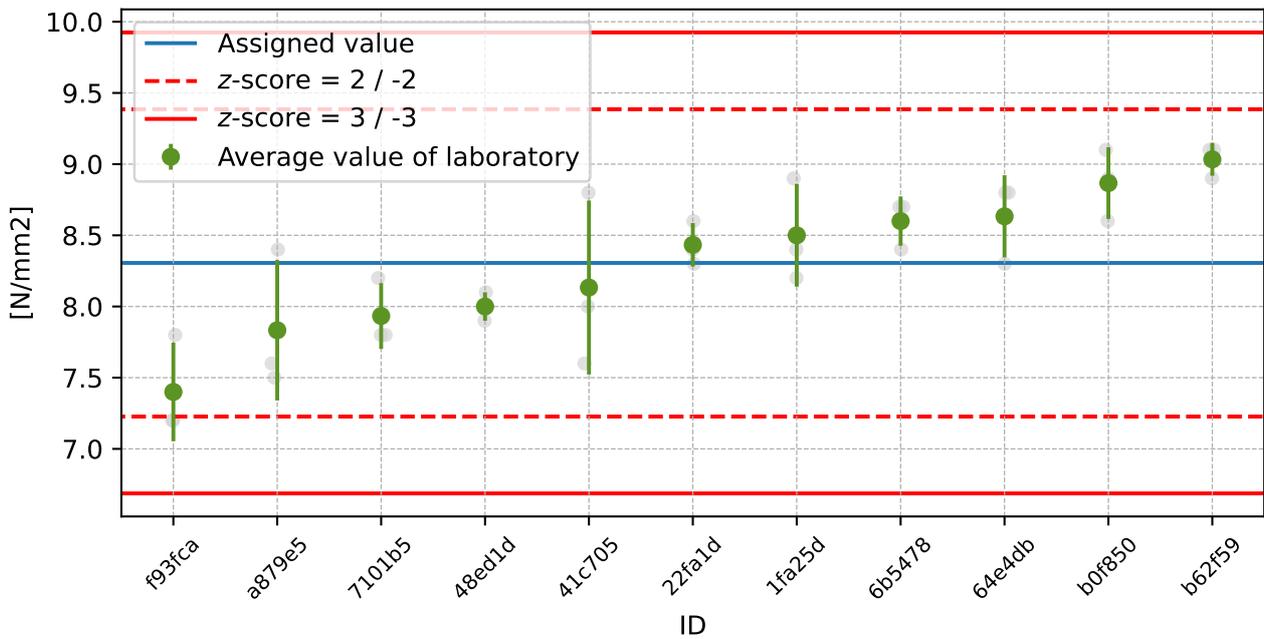
Figure 42: Average values and sample standard deviations

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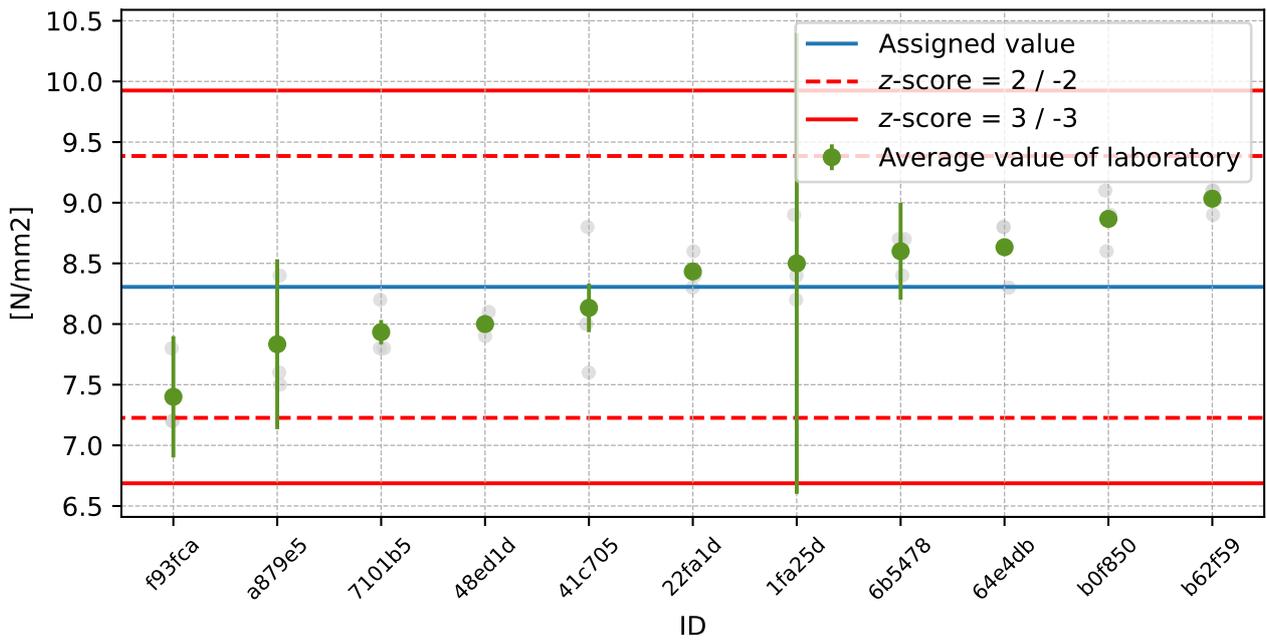
Figure 43: Average values and extended uncertainties of measurement

Figure 44: z-score

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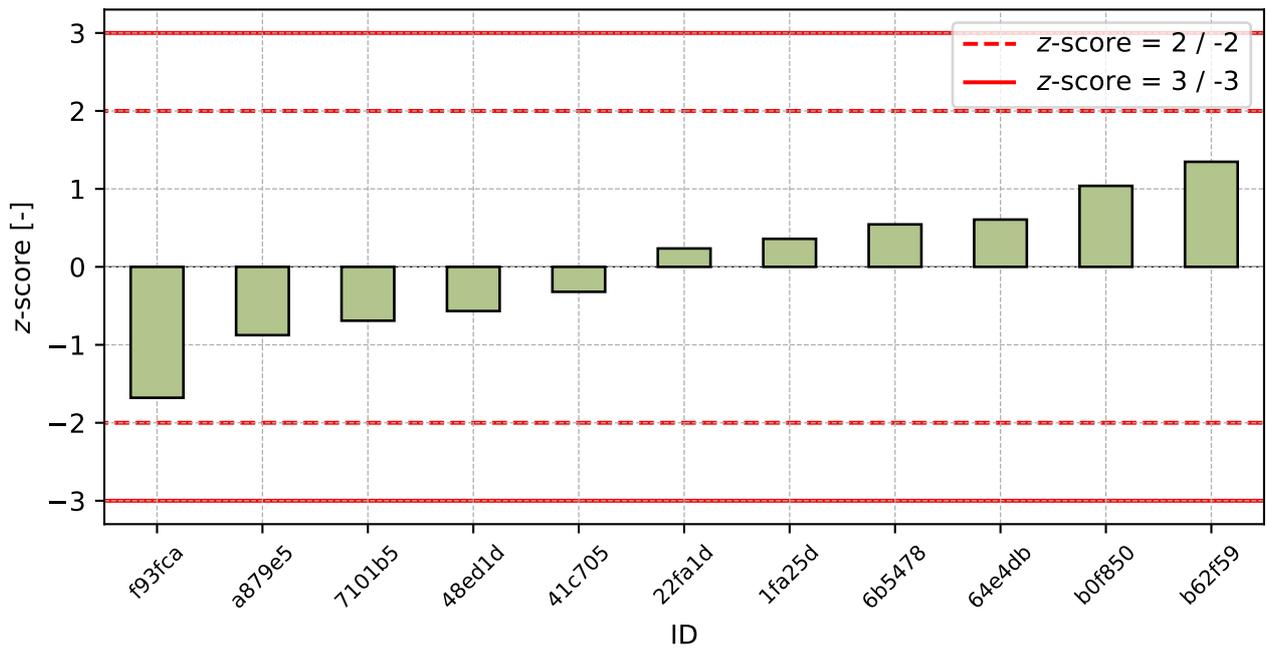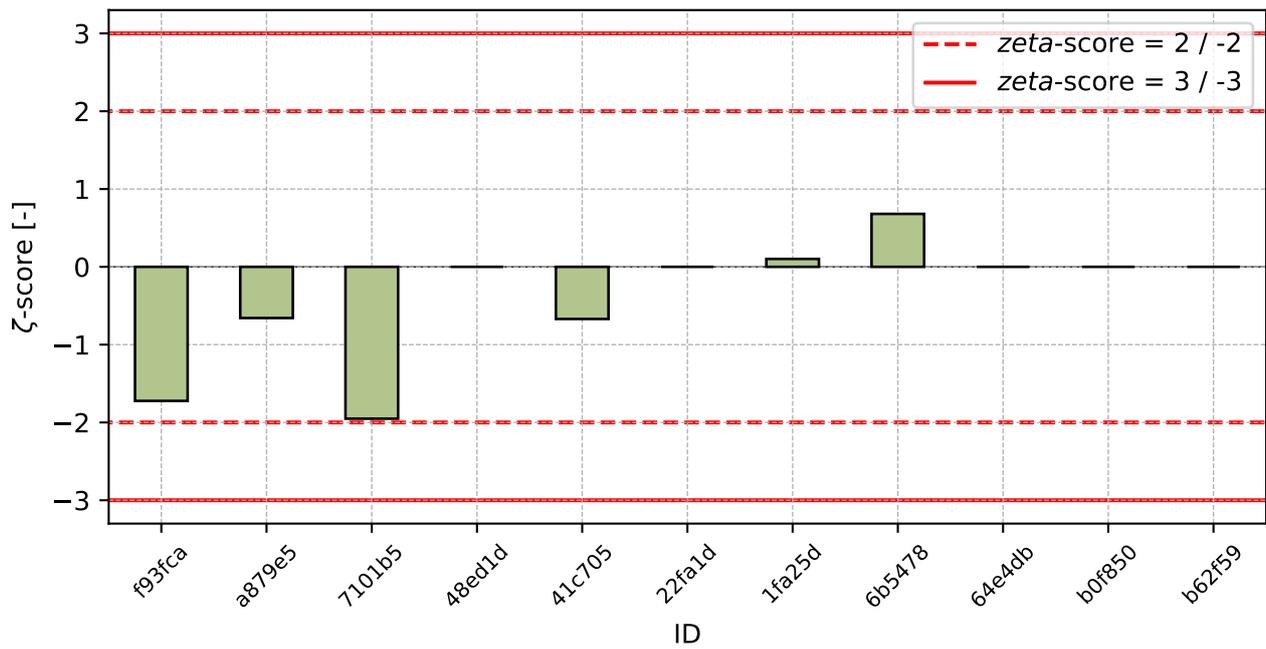
Figure 45: ζ-score

Table 18: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
f93fca	-1.68	-1.72
a879e5	-0.88	-0.66
7101b5	-0.69	-1.95
48ed1d	-0.57	-
41c705	-0.32	-0.67
22fa1d	0.24	-
1fa25d	0.36	0.1
6b5478	0.54	0.68
64e4db	0.61	-
b0f850	1.04	-
b62f59	1.35	-

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1.6   Compressive Strength after 28 days of ageing

1.6.1   Test results

Table 19: 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 [N/mm²]						u_X [N/mm²]	$\bar{x}$ [N/mm²]	s_0 [N/mm²]	V_X [%]
22fa1d	47.3	46.8	45.9	45.1	47.0	47.6	-	46.6	0.94	2.02
41c705	48.8	49.1	47.2	46.0	45.3	45.0	1.20	46.9	1.76	3.76
b0f850	50.0	48.2	48.7	47.7	47.6	48.0	-	48.4	0.89	1.84
1fa25d	48.1	50.0	48.8	48.8	46.9	48.1	2.60	48.4	1.03	2.12
6b5478	50.7	49.9	51.0	49.6	50.7	48.9	3.60	50.1	0.81	1.61
a879e5	57.4	50.3	52.1	52.9	49.5	49.7	3.00	52.0	2.98	5.73
f93fca	51.4	50.7	51.6	52.7	53.1	55.1	2.30	52.4	1.57	3.00
64e4db	51.6	52.7	50.7	52.0	53.7	55.3	-	52.7	1.64	3.11
b62f59	55.3	55.1	55.0	55.6	54.6	55.1	-	55.1	0.33	0.60
7101b5	55.5	55.9	55.8	54.0	56.4	55.7	3.00	55.5	0.82	1.47
48ed1d	54.7	55.6	56.2	56.3	57.1	56.8	-	56.1	0.87	1.54

1.6.2   The Numerical Procedure for Determining Outliers
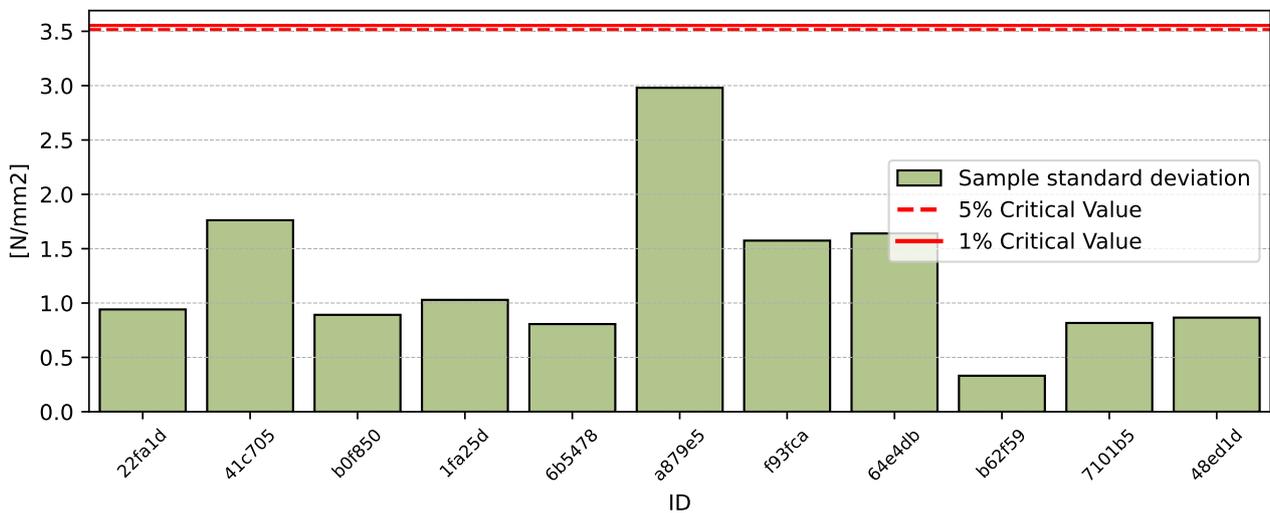
Figure 46: **Cochran's test** - sample standard deviations

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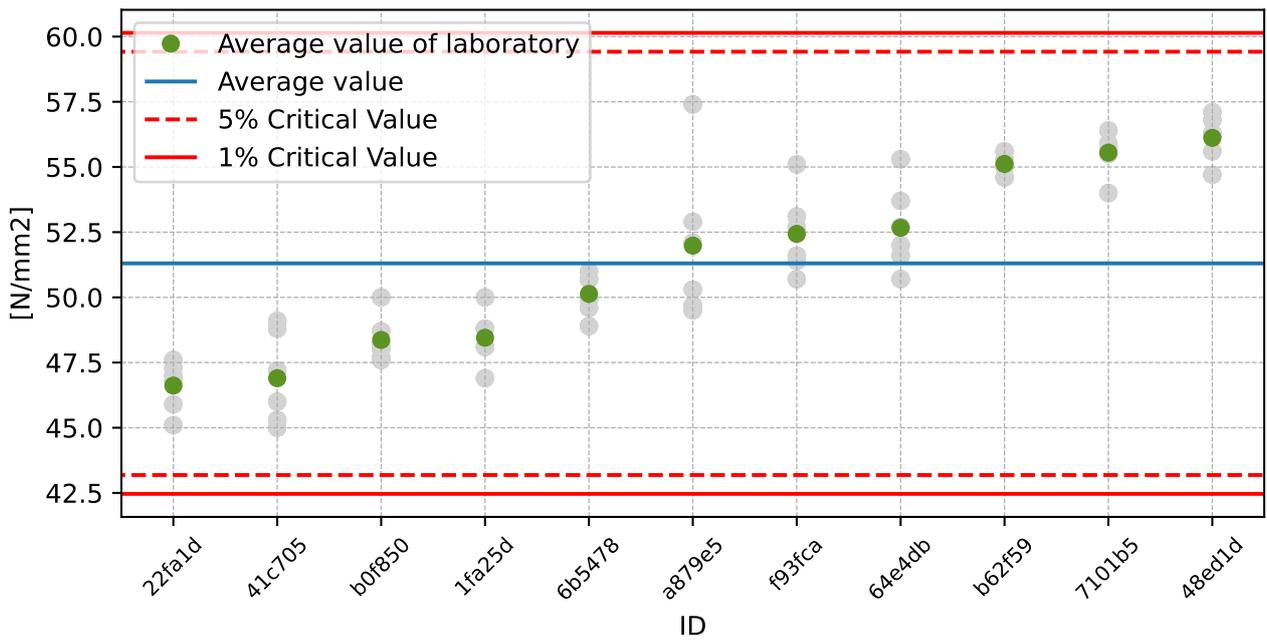
Figure 47: **Grubbs' test** - average values

1.6.3   Mandel's Statistics
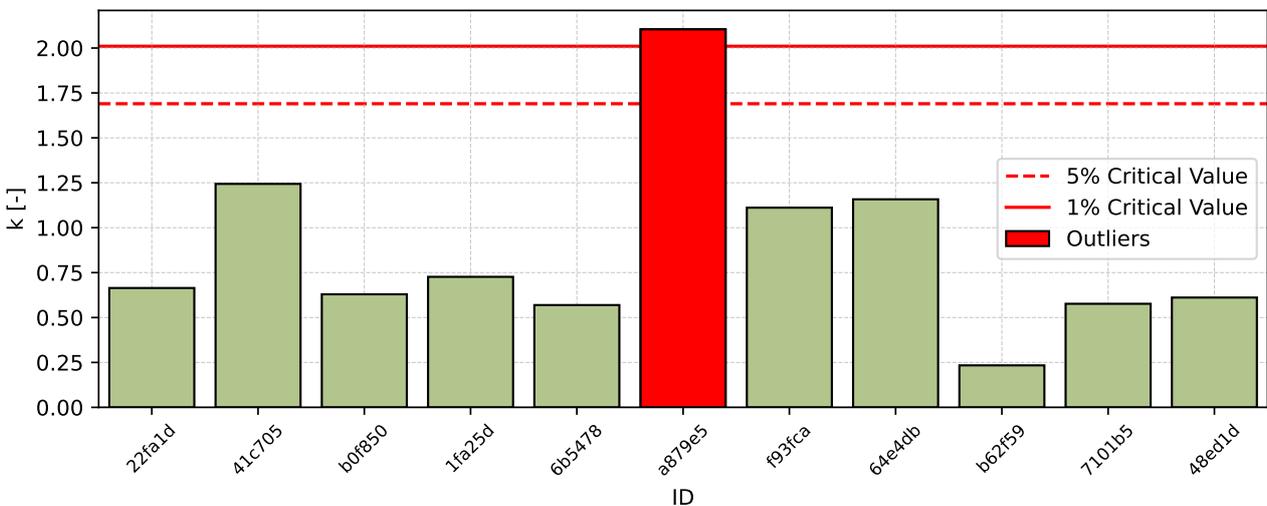
Figure 48: Intralaboratory Consistency Statistic

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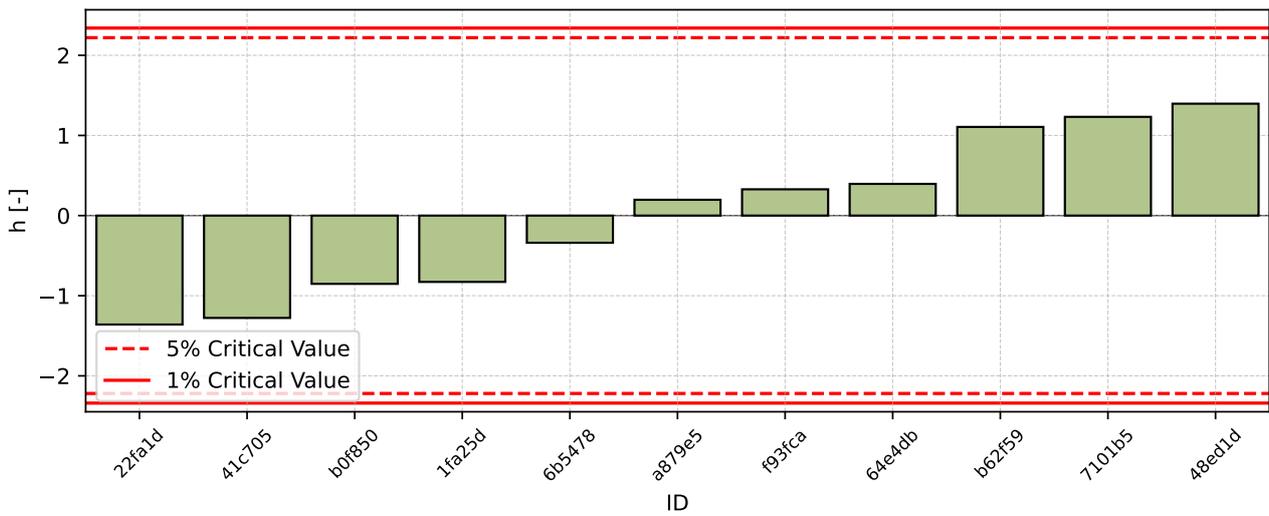
Figure 49: Interlaboratory Consistency Statistic

1.6.4 Descriptive statistics
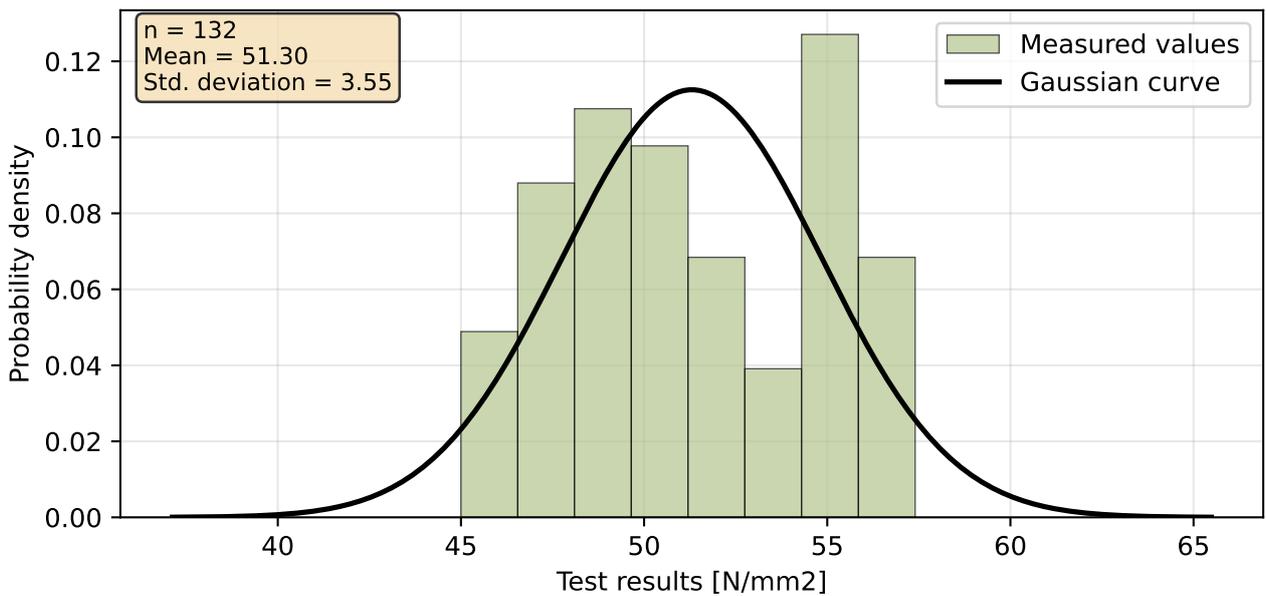
Figure 50: Histogram of all test results

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Table 20: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	51.3
Sample standard deviation – s	3.45
Asigned value – x^*	51.3
Robust standard deviation – s^*	3.55
Measurement uncertainty of asigned value – u_X	1.07
p-value of normality test	0.006 [-]
Interlaboratory standard deviation – s_L	3.4
Repeatability standard deviation – s_r	1.42
Reproducibility standard deviation – s_R	3.68
Repeatability – r	4.0
Reproducibility – R	10.3

1.6.5   Evaluation of Performance Statistics
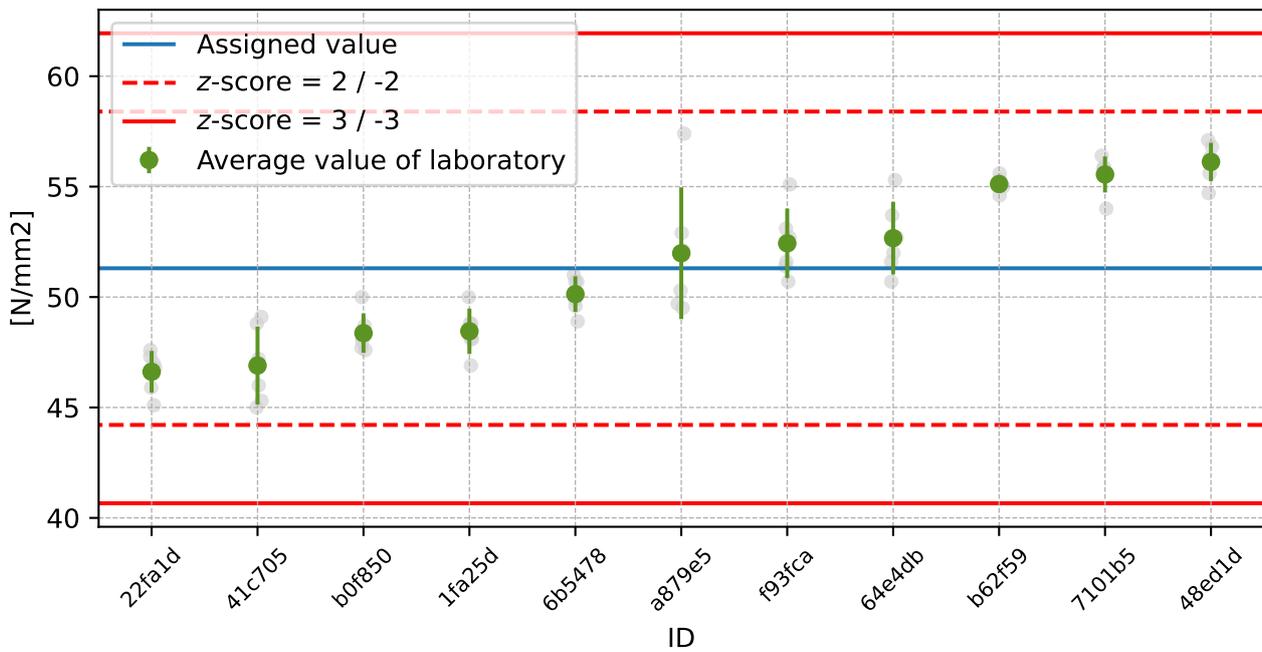
Figure 51: Average values and sample standard deviations

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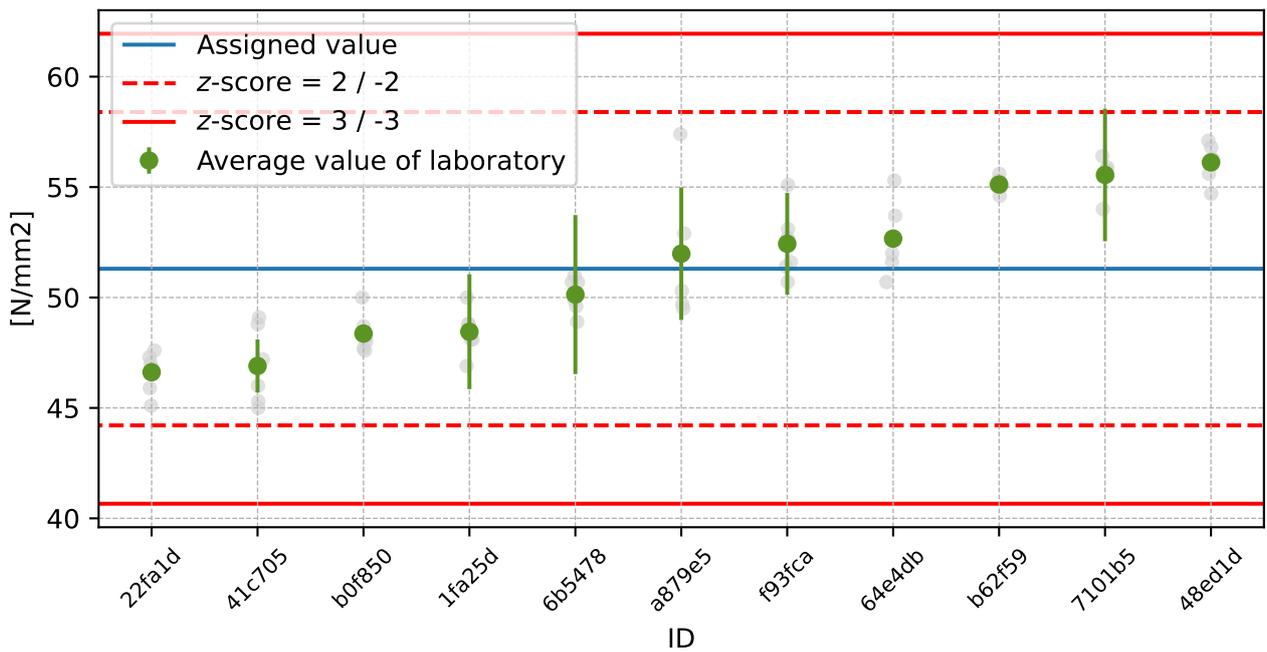
Figure 52: Average values and extended uncertainties of measurement

Figure 53: z-score

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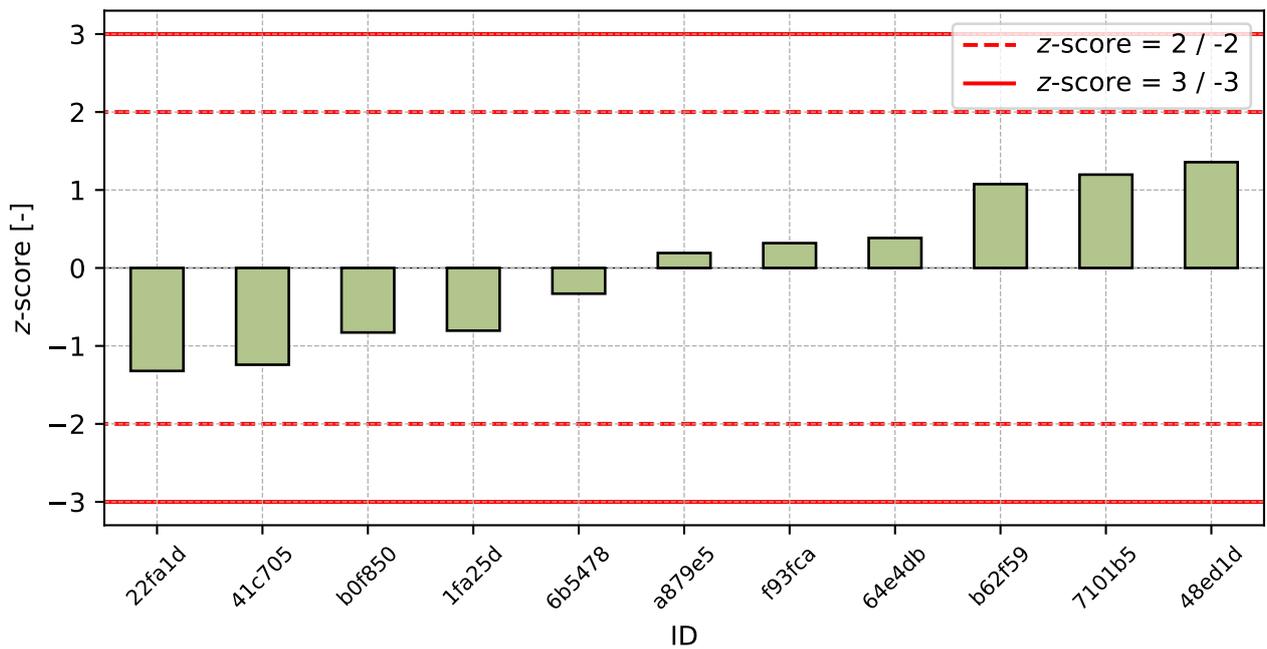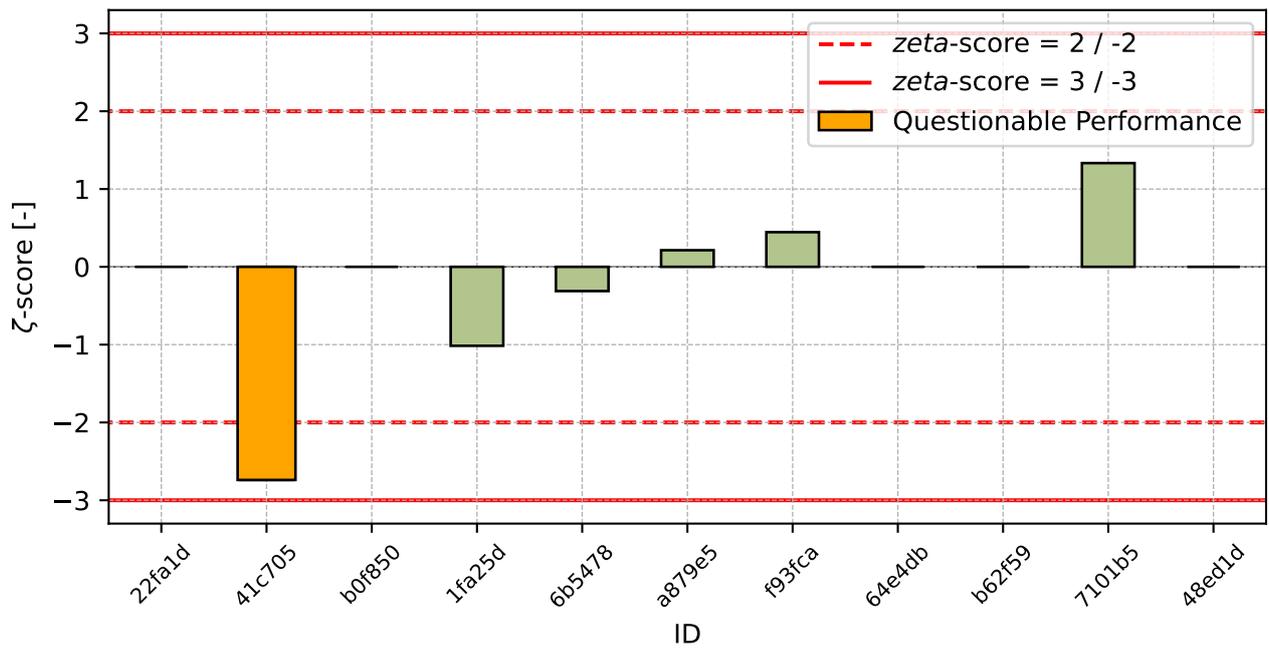
Figure 54: ζ-score

Table 21: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
22fa1d	-1.32	-
41c705	-1.24	-2.74
b0f850	-0.83	-
1fa25d	-0.8	-1.01
6b5478	-0.33	-0.31
a879e5	0.19	0.21
f93fca	0.32	0.45
64e4db	0.38	-
b62f59	1.08	-
7101b5	1.2	1.33
48ed1d	1.36	-

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2   Appendix – EN 196-2 (art. 4.4.1) – Determination of loss on ignition

This part of PT program was not open according to the low number of participants.

3   Appendix – EN 196-2 (art. 4.4.2) – Determination of sulphate content

This part of PT program was not open according to the low number of participants.

4   Appendix – EN 196-2 (art. 4.4.3) – Determination of the residue insoluble in hydrochloric acid and sodium carbonate

This part of PT program was not open due to low number of participants.

5   Appendix – EN 196-2 (art. 4.4.4) – Determination of the residue insoluble in hydrochloric acid and potassium hydroxide

This part of PT program was not open due to low number of participants.

6   Appendix – EN 196-2 (art. 4.4.5) – Determination of sulphite content

This part of PT program was not open due to low number of participants.

7   Appendix – EN 196-2 (art. 4.4.6) – Determination of manganese content

This part of PT program was not open due to low number of participants.

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8   Appendix – EN 196-3 – Setting time, Soundness

8.1   Initial setting time

8.1.1   Test results

Table 22: 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 [min.]			u_X [min.]	$\bar{x}$ [min.]	s_0 [min.]	V_X [%]
64e4db	208	210	212	-	210	2.0	0.95
b23494	212	214	208	± 3.6	211	3.1	1.45
80a214	220	230	230	-	227	5.8	2.55
48ed1d	235	231	230	-	232	2.6	1.14
b62f59	250	-	-	-	250	0.0	0.00
22fa1d	262	262	262	-	262	0.0	0.00

8.1.2   The Numerical Procedure for Determining Outliers
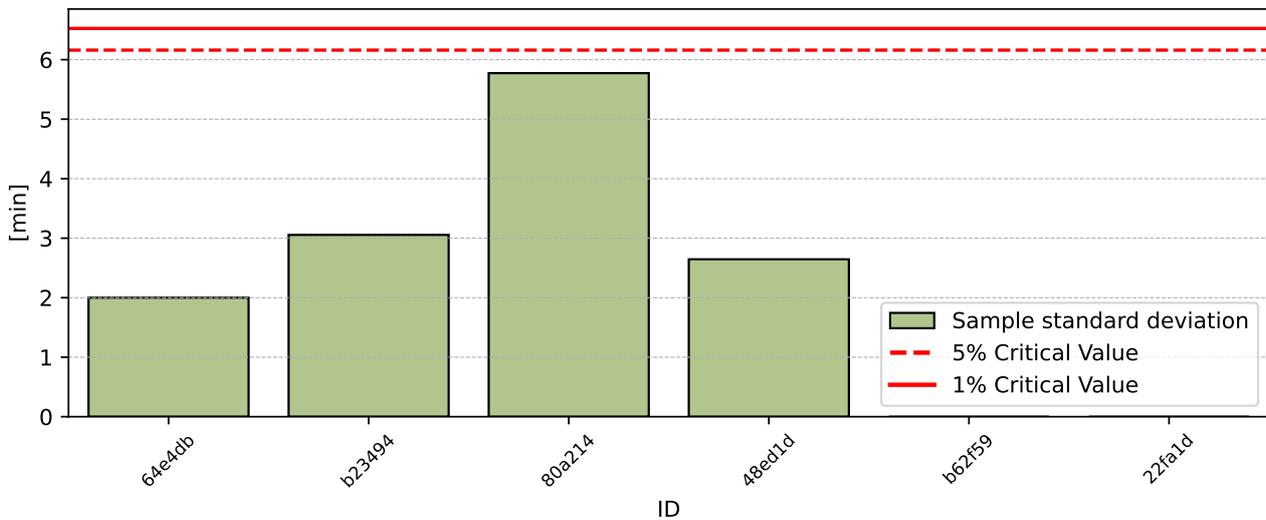
Figure 55: **Cochran's test** - sample standard deviations

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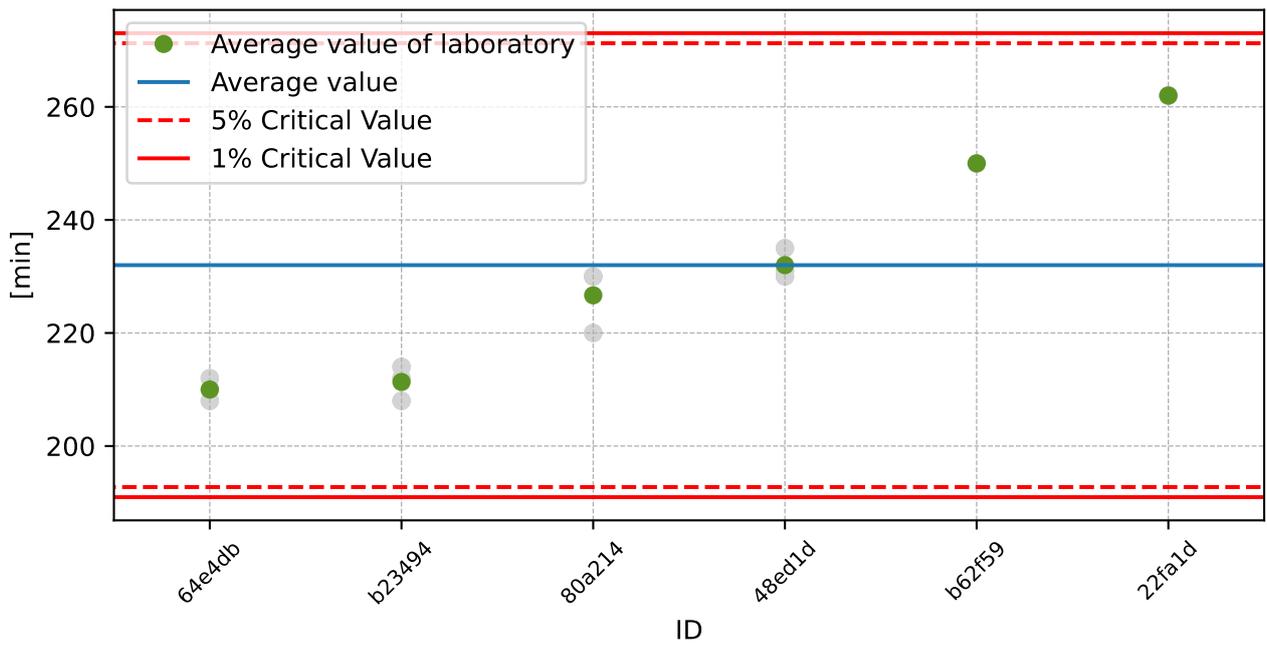
Figure 56: **Grubbs' test** - average values

8.1.3   Mandel's Statistics
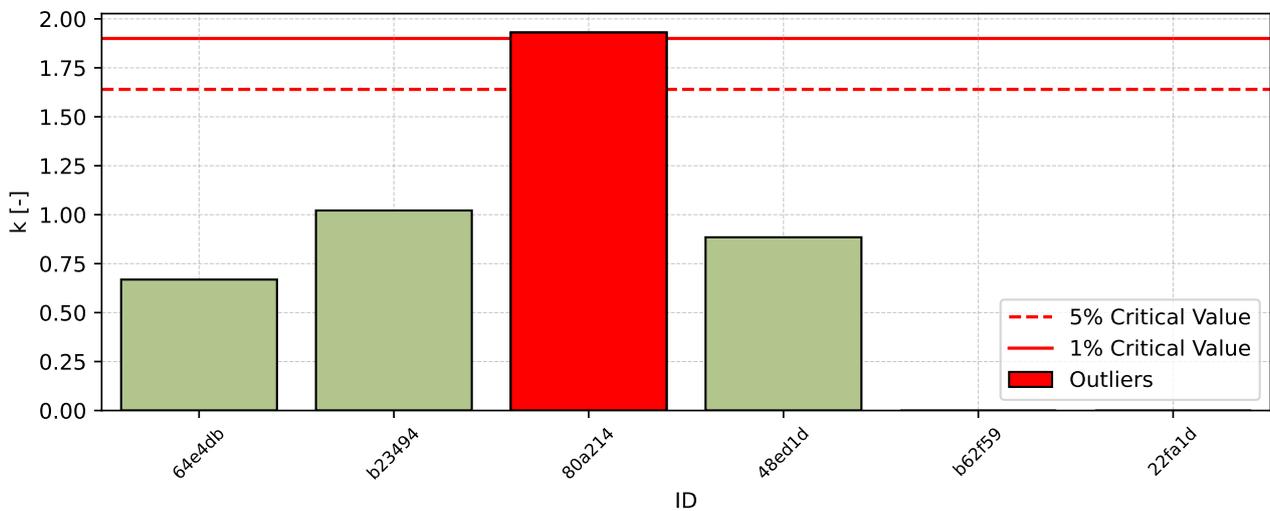
Figure 57: Intralaboratory Consistency Statistic

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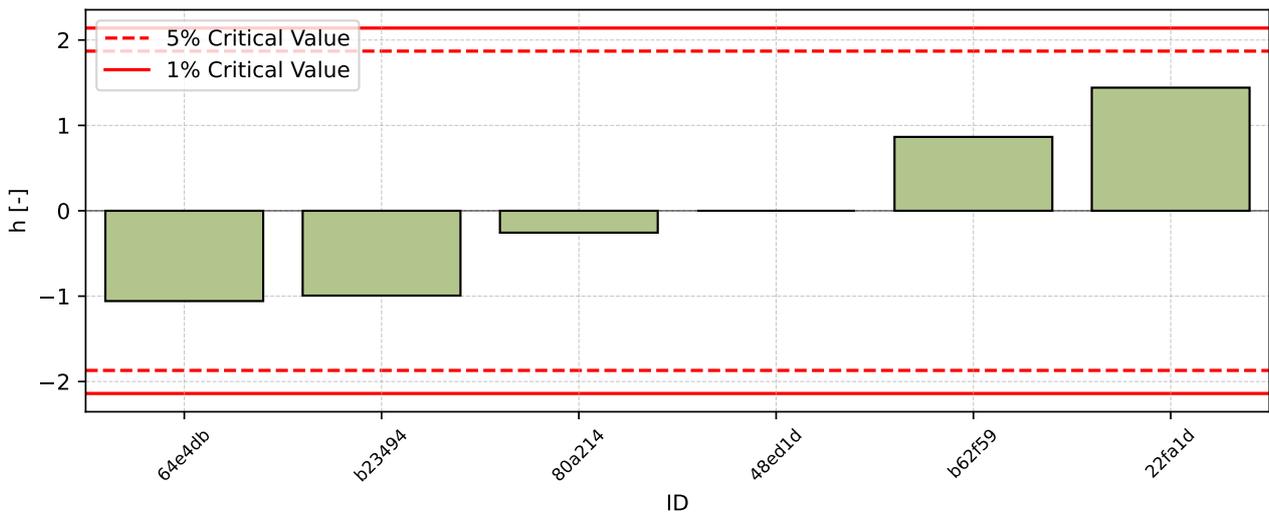
Figure 58: Interlaboratory Consistency Statistic

8.1.4 Descriptive statistics
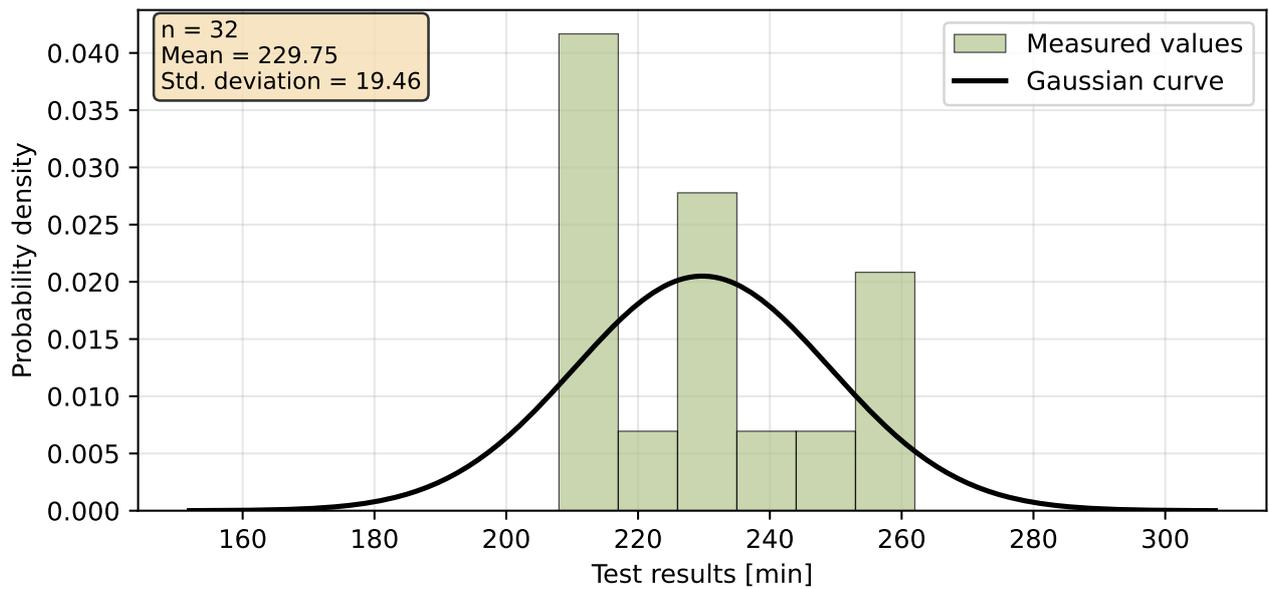
Figure 59: Histogram of all test results

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Table 23: Descriptive statistics

Characteristics	[min.]
Average value – $\bar{x}$	232
Sample standard deviation – s	20.8
Asigned value – x^*	232
Robust standard deviation – s^*	20.8
Measurement uncertainty of asigned value – u_X	8.5
p-value of normality test	0.021 [-]
Interlaboratory standard deviation – s_L	20.7
Repeatability standard deviation – s_r	3.0
Reproducibility standard deviation – s_R	20.9
Repeatability – r	8
Reproducibility – R	59

8.1.5 Evaluation of Performance Statistics
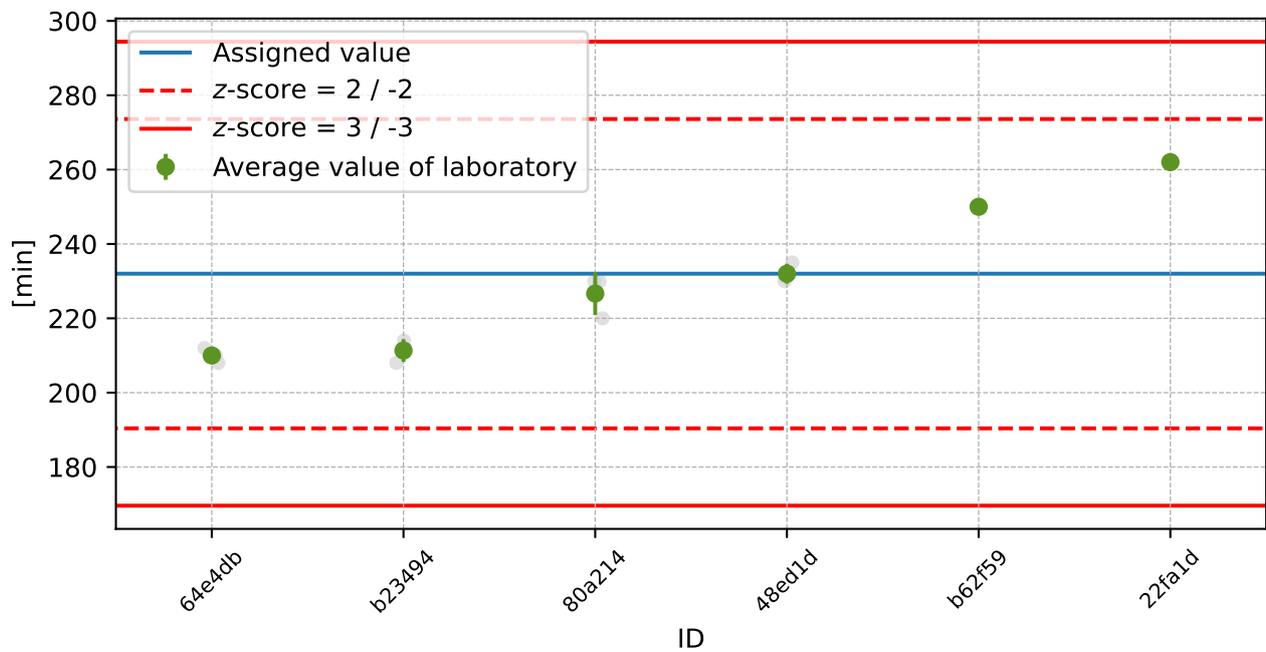
Figure 60: Average values and sample standard deviations

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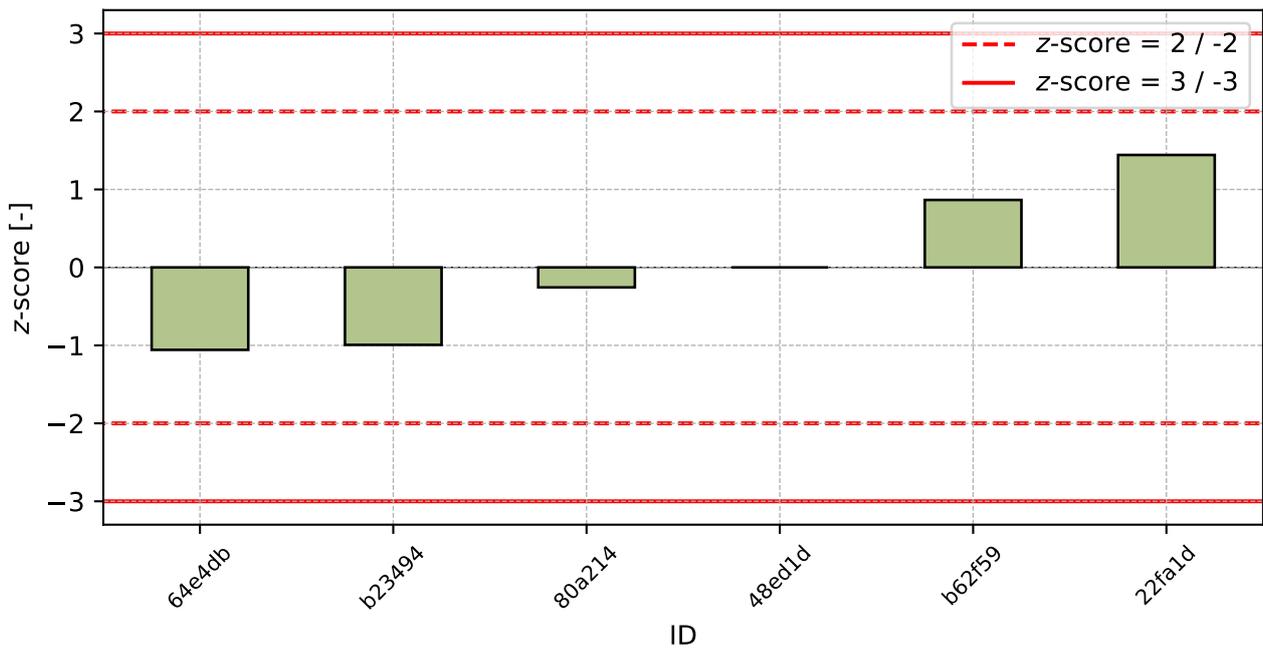
Figure 61: z-score

Table 24: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
64e4db	-1.06	-
b23494	-0.99	-
80a214	-0.26	-
48ed1d	0.0	-
b62f59	0.87	-
22fa1d	1.44	-

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8.2   Final setting time

8.2.1   Test results

Table 25: 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 [min.]			u_X [min.]	$\bar{x}$ [min.]	s_0 [min.]	V_X [%]
64e4db	295	297	294	-	295	1.5	0.52
22fa1d	311	311	311	-	311	0.0	0.00
b62f59	315	-	-	-	315	0.0	0.00
48ed1d	335	311	320	-	322	12.1	3.77
80a214	320	330	330	-	327	5.8	1.77
b23494	348	342	338	± 5.8	343	5.0	1.47

8.2.2   The Numerical Procedure for Determining Outliers
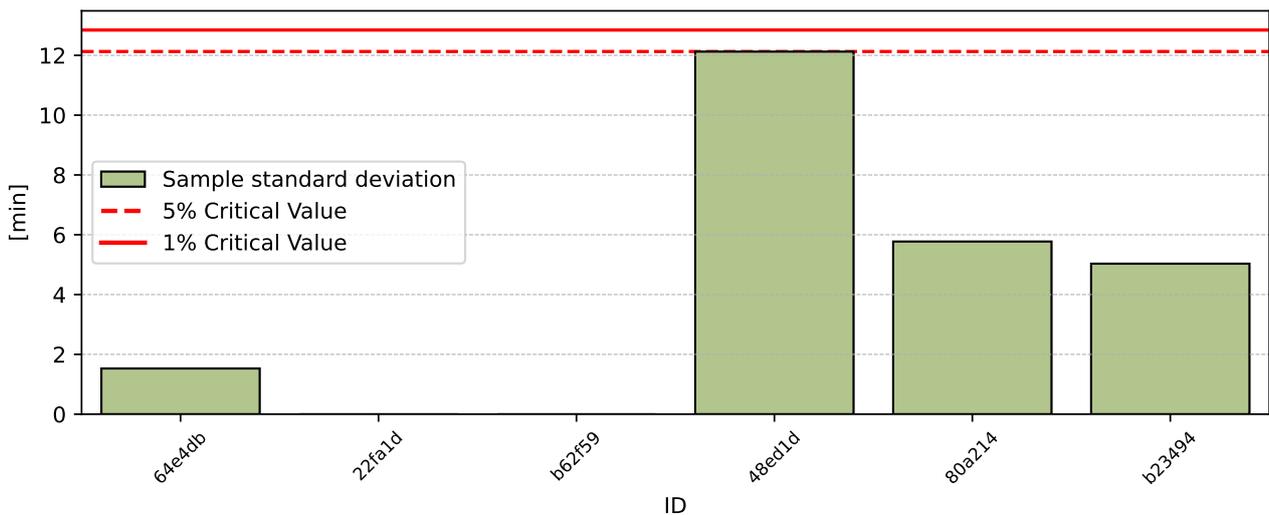
Figure 62: **Cochran's test** - sample standard deviations

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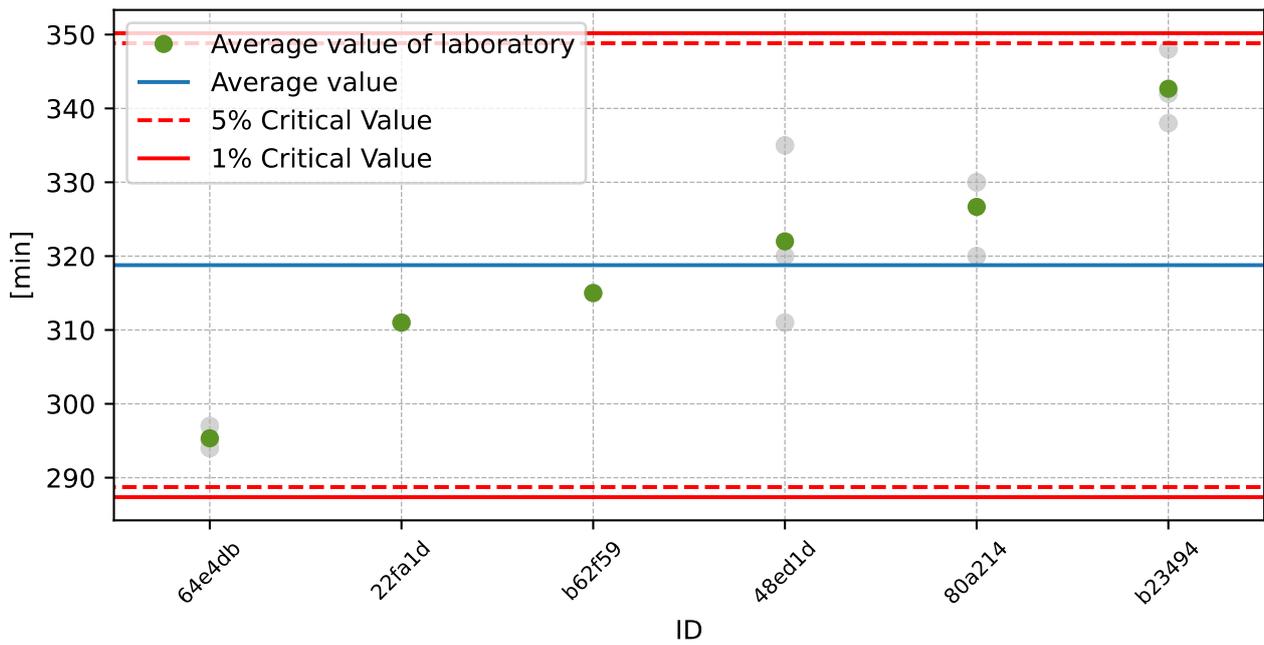Figure 63: **Grubbs' test** - average values

8.2.3 Mandel's Statistics
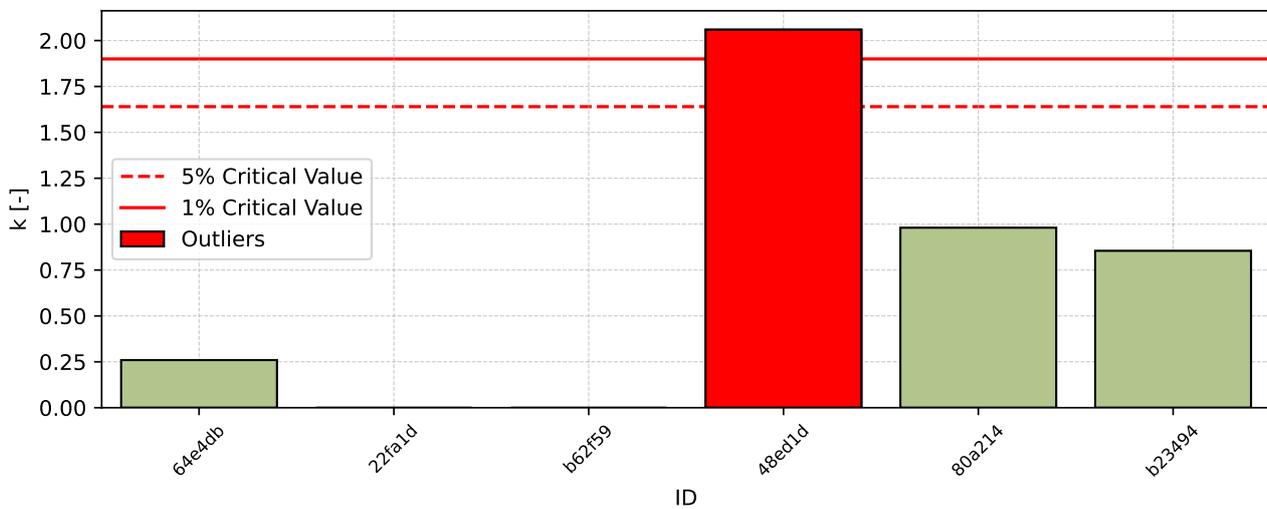
Figure 64: Intralaboratory Consistency Statistic

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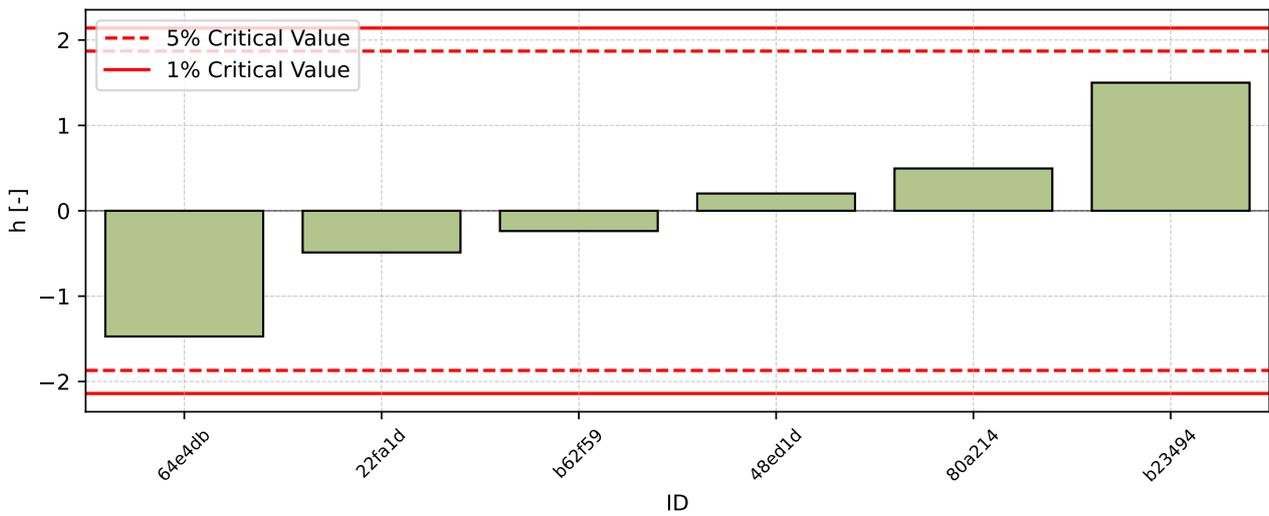Figure 65: Interlaboratory Consistency Statistic

8.2.4   Descriptive statistics
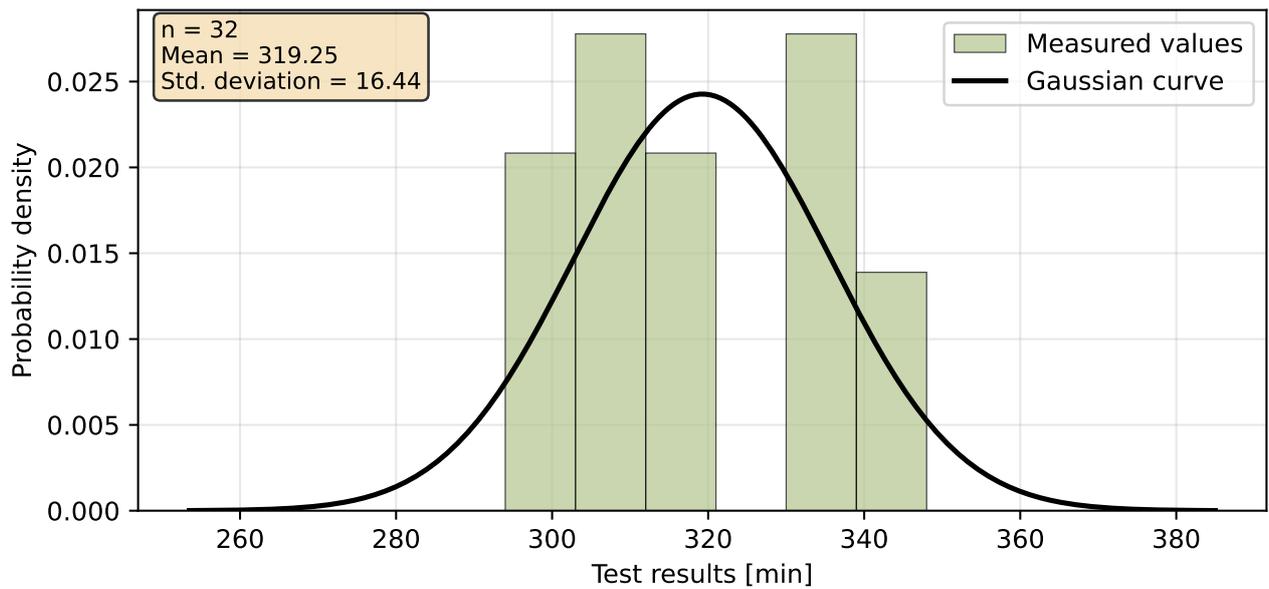
Figure 66: Histogram of all test results

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Table 26: Descriptive statistics

Characteristics	[min.]
Average value – $\bar{x}$	319
Sample standard deviation – s	15.9
Asigned value – x^*	319
Robust standard deviation – s^*	15.9
Measurement uncertainty of asigned value – u_X	6.5
p-value of normality test	0.479 [-]
Interlaboratory standard deviation – s_L	15.6
Repeatability standard deviation – s_r	5.9
Reproducibility standard deviation – s_R	16.6
Repeatability – r	16
Reproducibility – R	47

8.2.5 Evaluation of Performance Statistics
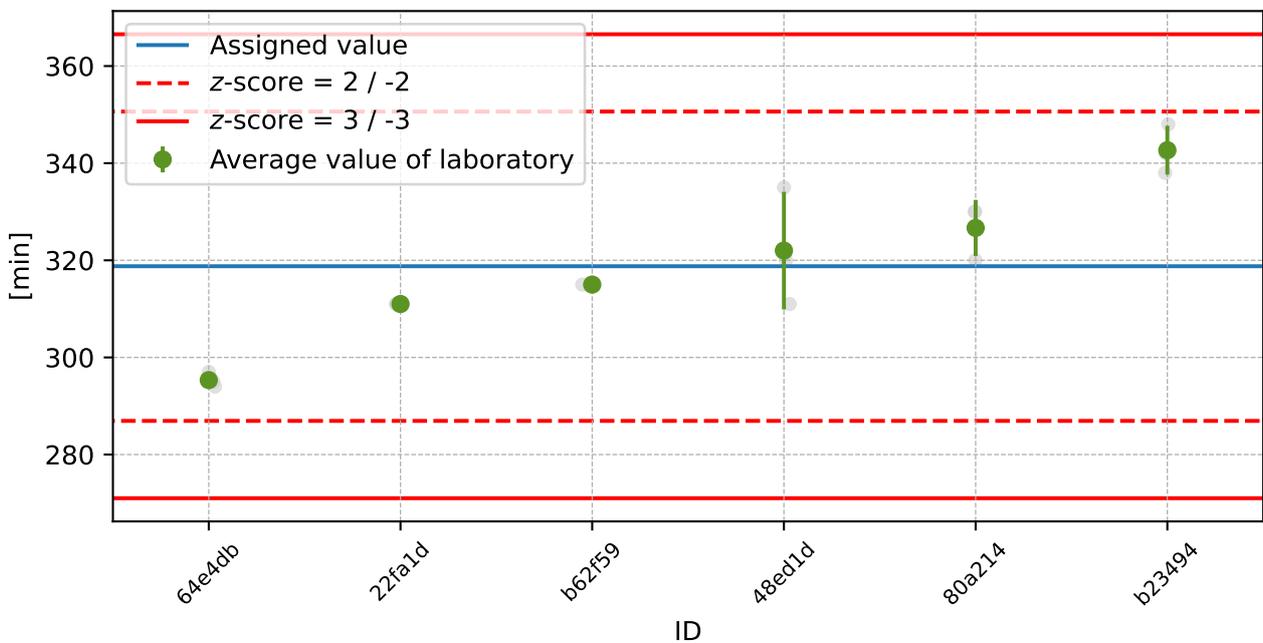
Figure 67: Average values and sample standard deviations

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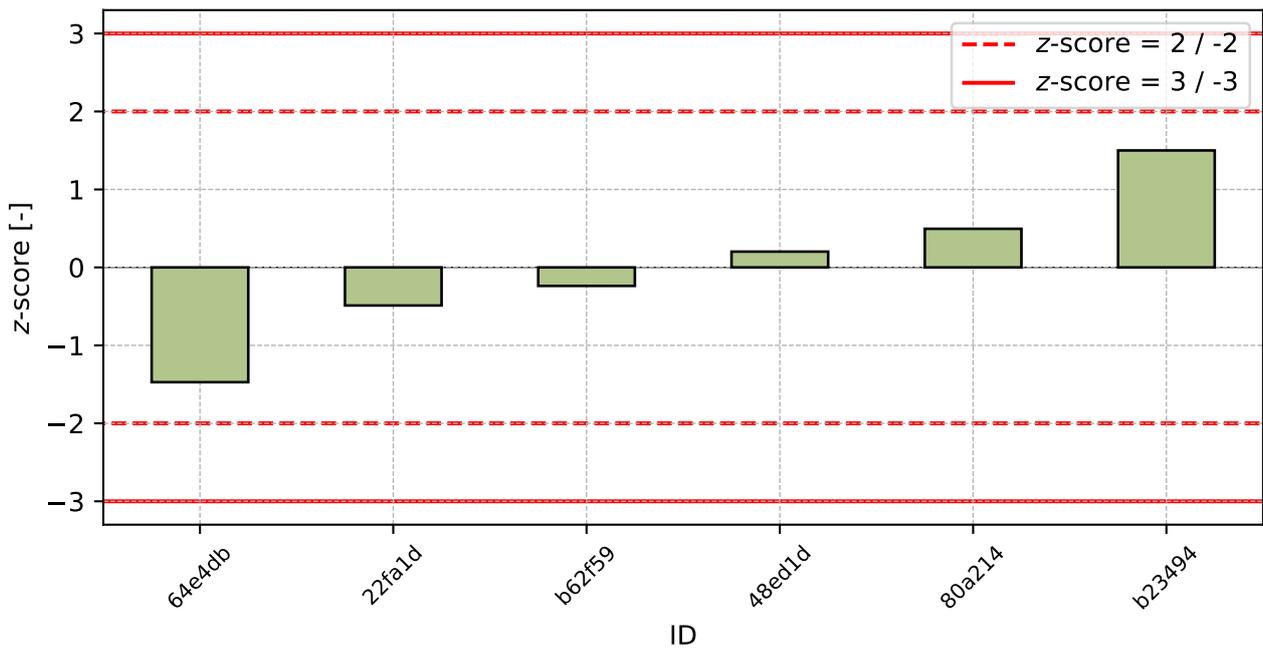
Figure 68: z-score

Table 27: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
64e4db	-1.47	-
22fa1d	-0.49	-
b62f59	-0.24	-
48ed1d	0.2	-
80a214	0.5	-
b23494	1.5	-

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8.3   Soundness

8.3.1   Test results

Table 28: 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 [%]
64e4db	0	1	0	-	0	0.6	173.21
48ed1d	0	1	1	-	1	0.6	86.60
b23494	1	1	1	0.1	1	0.0	0.00
80a214	1	1	1	-	1	0.0	0.00
b62f59	1	1	-	-	1	0.0	0.00

8.3.2   The Numerical Procedure for Determining Outliers
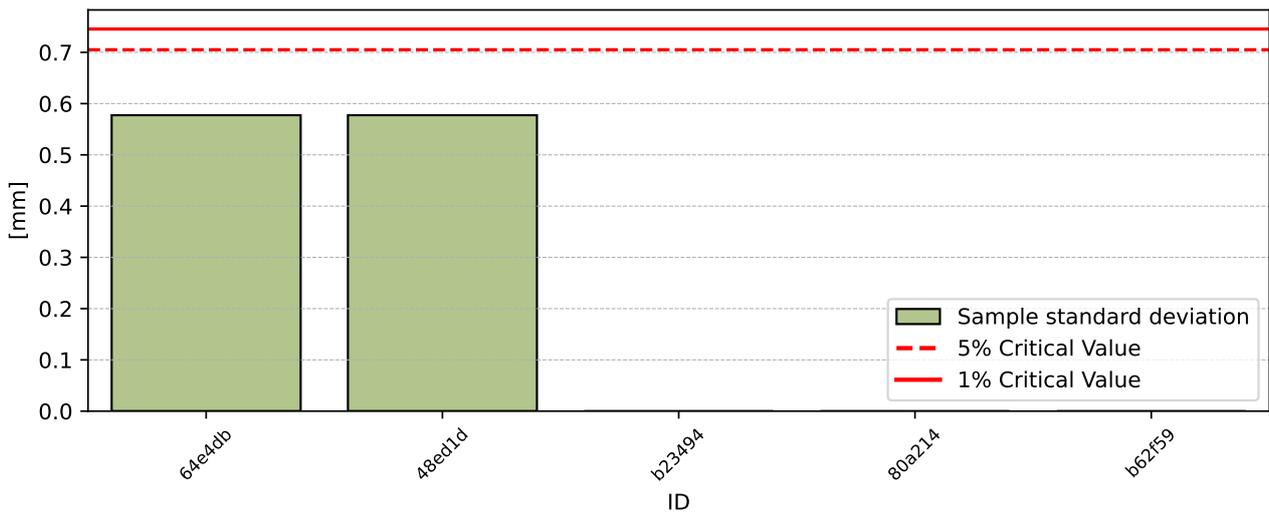
Figure 69: **Cochran's test** - sample standard deviations

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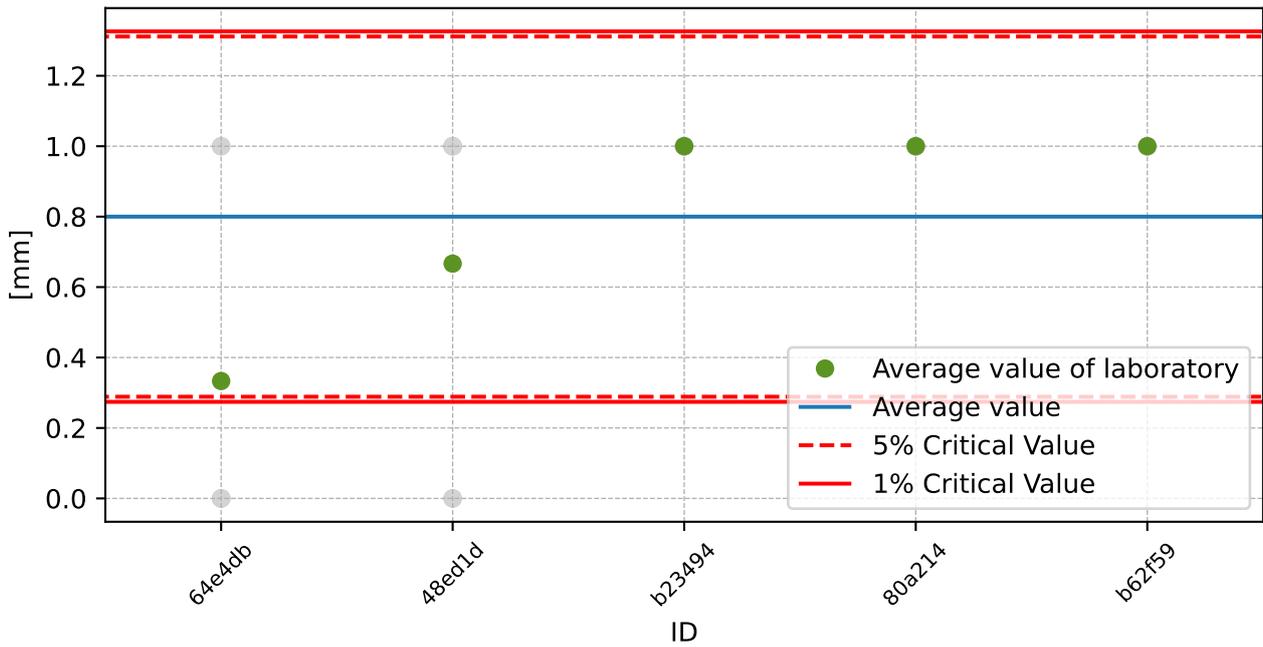
Figure 70: **Grubbs' test** - average values

8.3.3 Mandel's Statistics
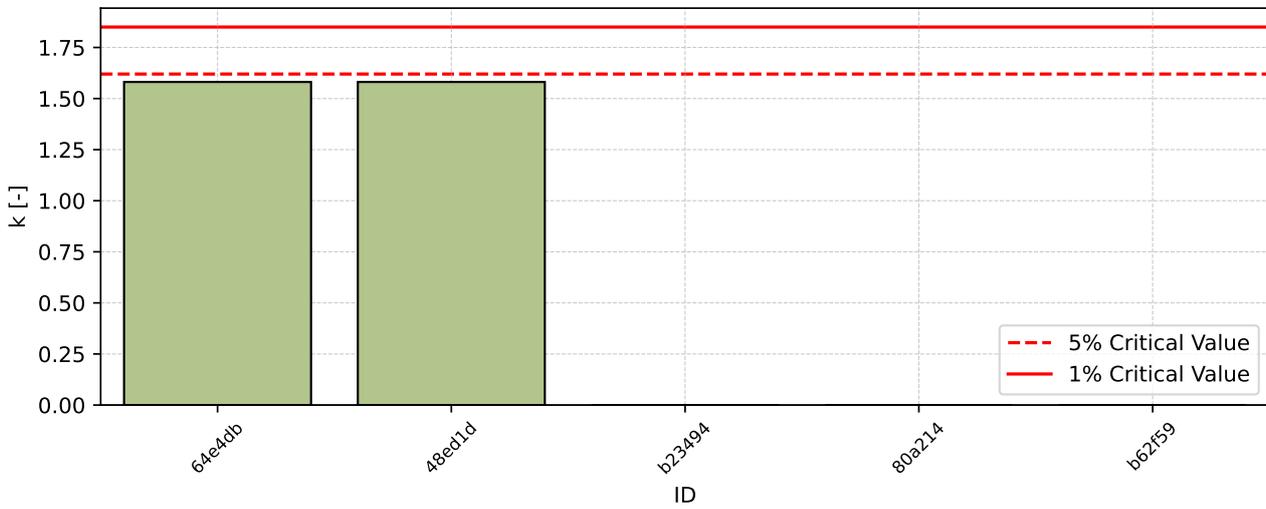
Figure 71: Intralaboratory Consistency Statistic

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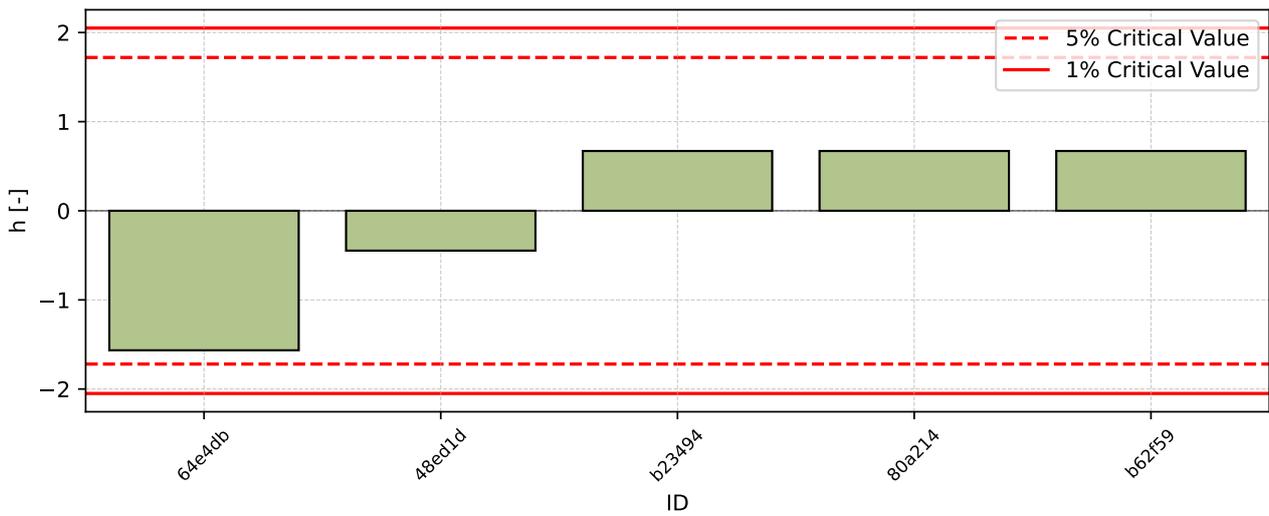
Figure 72: Interlaboratory Consistency Statistic

8.3.4 Descriptive statistics
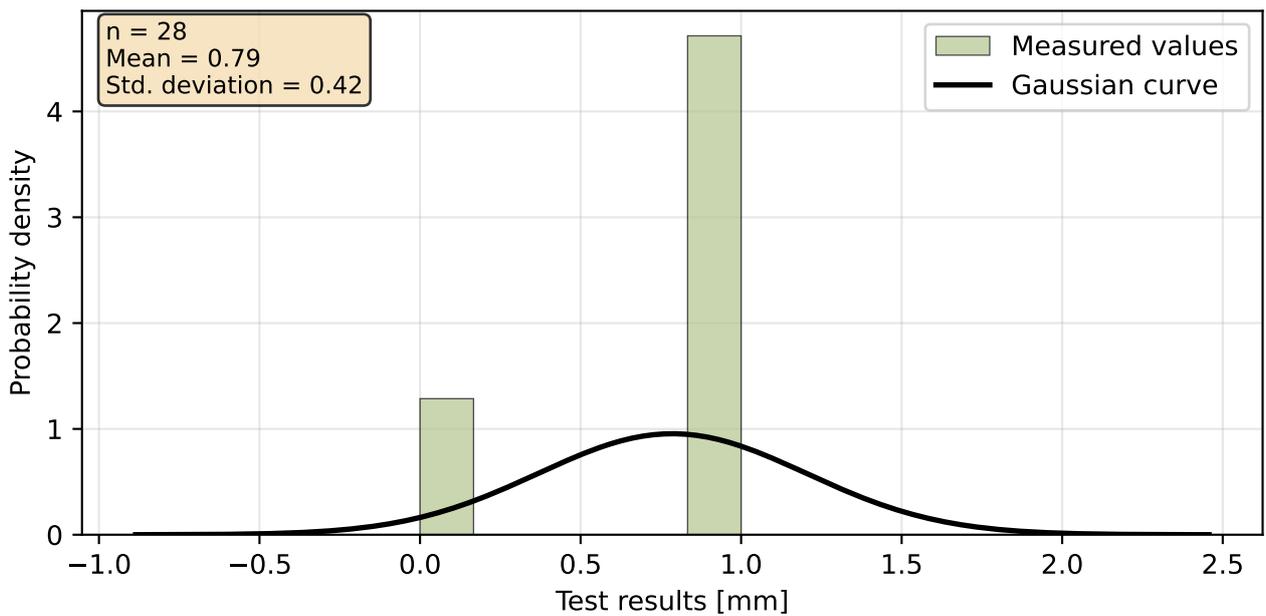
Figure 73: Histogram of all test results

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Table 29: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	1
Sample standard deviation – s	0.3
Asigned value – x^*	1
Robust standard deviation – s^*	0.5
Measurement uncertainty of asigned value – u_X	0.2
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	0.2
Repeatability standard deviation – s_r	0.4
Reproducibility standard deviation – s_R	0.4
Repeatability – r	1
Reproducibility – R	1

8.3.5   Evaluation of Performance Statistics
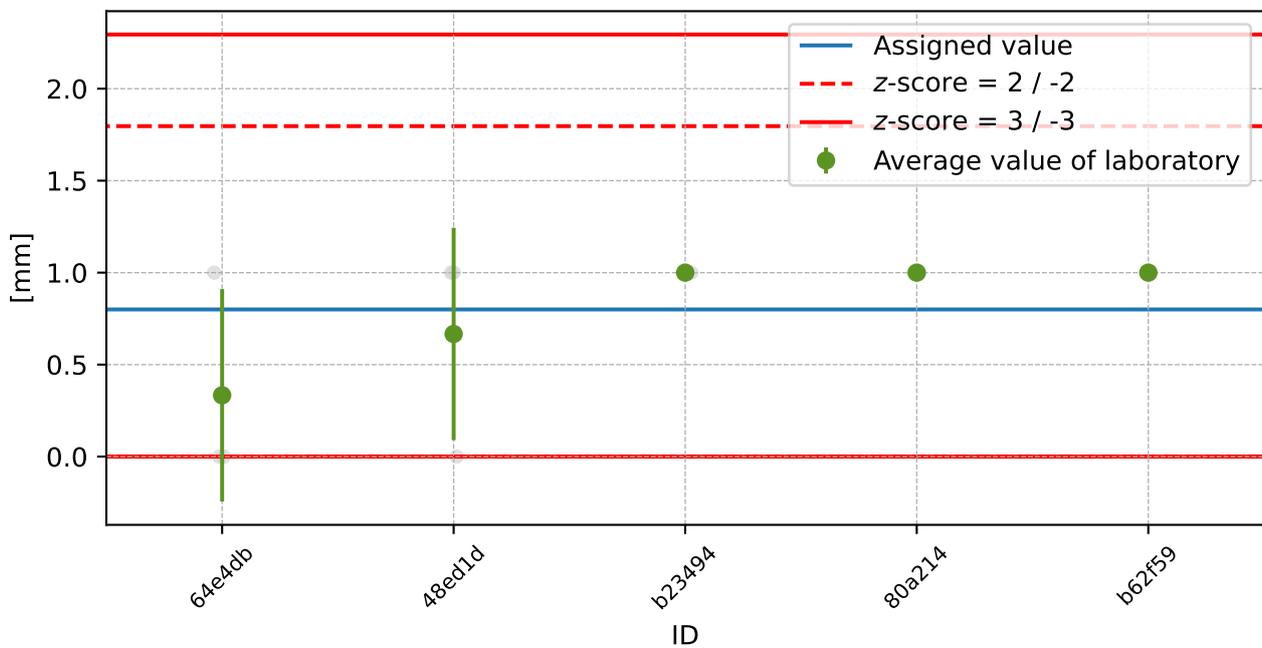
Figure 74: Average values and sample standard deviations

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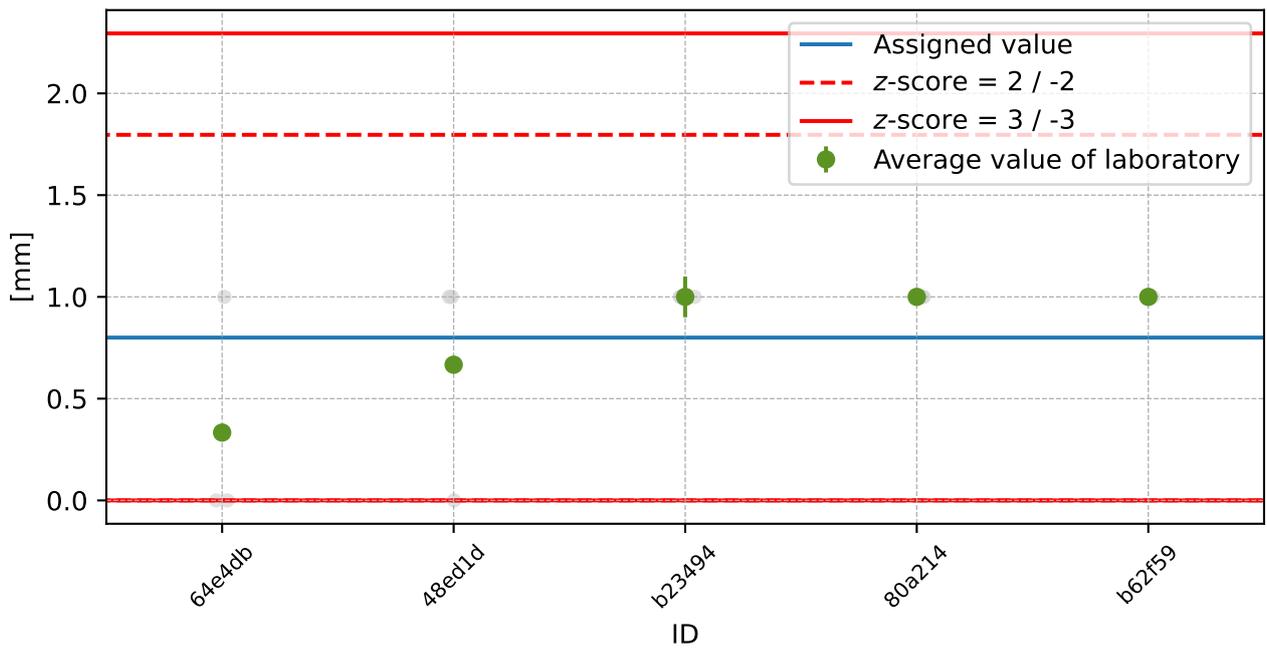
Figure 75: Average values and extended uncertainties of measurement

Figure 76: z-score

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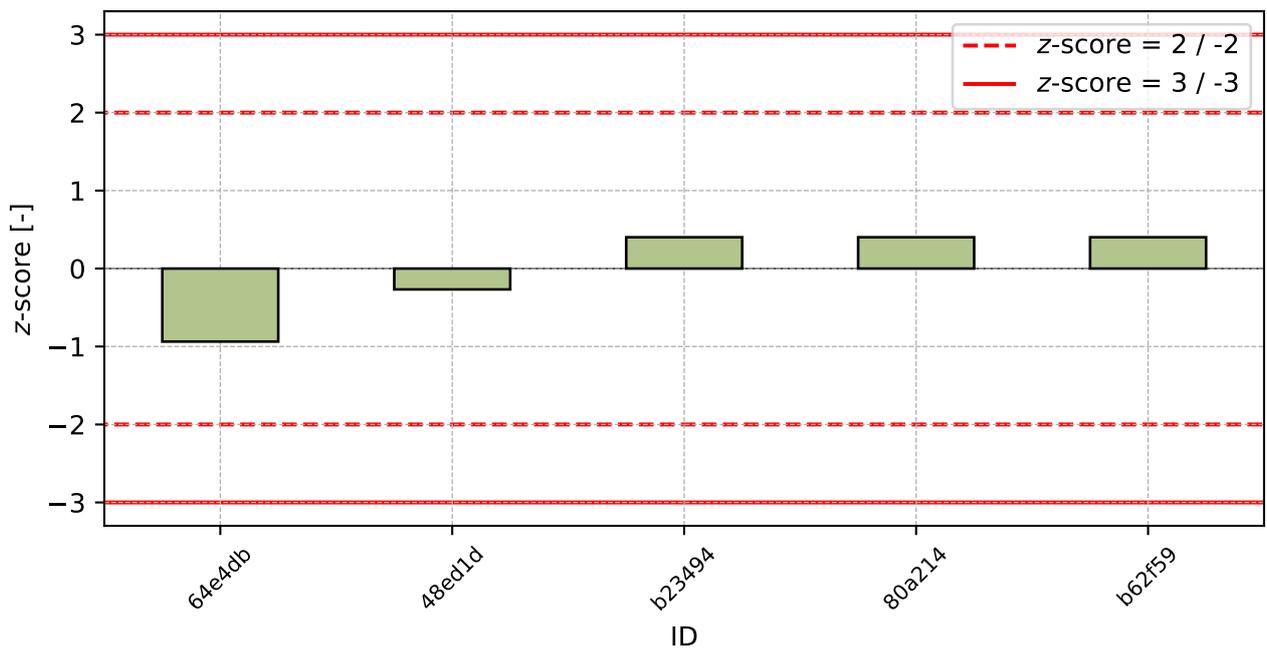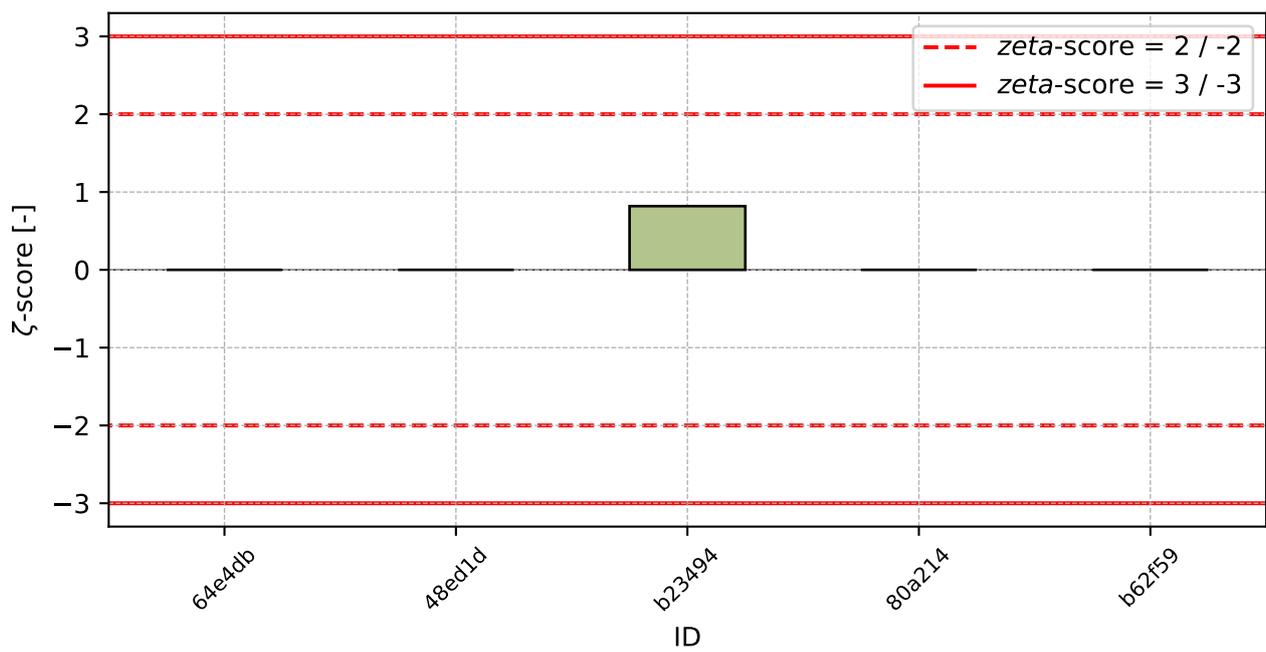
Figure 77: ζ-score

Table 30: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
64e4db	-0.94	-
48ed1d	-0.27	-
b23494	0.4	0.82
80a214	0.4	-
b62f59	0.4	-

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9   Appendix – EN 196-10 – Determination of the water-soluble chromium (Cr^{6+})

This part of PT program was not open according to the low number of participants.

10   Appendix – EN 1015-1 – Granularity

This part of PT program was not open due to low number of participants.

11   Appendix – EN 1015-3 – Consistency

This part of PT program was not open due to low number of participants.

12   Appendix – EN 1015-6 – Density of fresh mortar

This part of PT program was not open according to the low number of participants.

13   Appendix – EN 1015-10 – Density of hardened mortar

This part of PT program was not open according to the low number of participants.

14   Appendix – EN 1015-11 – Strength

14.1   Flexural Strength

14.1.1   Test results

Table 31: 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 [N/mm^2]			u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
97940a	1.99	1.80	2.07	0.100	1.95	0.139	7.10
bffdf4	2.29	1.86	1.75	-	1.97	0.285	14.51
6b5478	2.05	1.95	2.00	0.100	2.00	0.050	2.50
a02675	2.04	1.89	2.23	0.070	2.05	0.170	8.30
f93fca	2.70	2.40	2.80	0.100	2.63	0.208	7.91
a879e5	2.60	2.70	2.90	0.200	2.73	0.153	5.59
fb95a0	3.11	3.23	2.97	0.200	3.10	0.130	4.19

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14.1.2   The Numerical Procedure for Determining Outliers
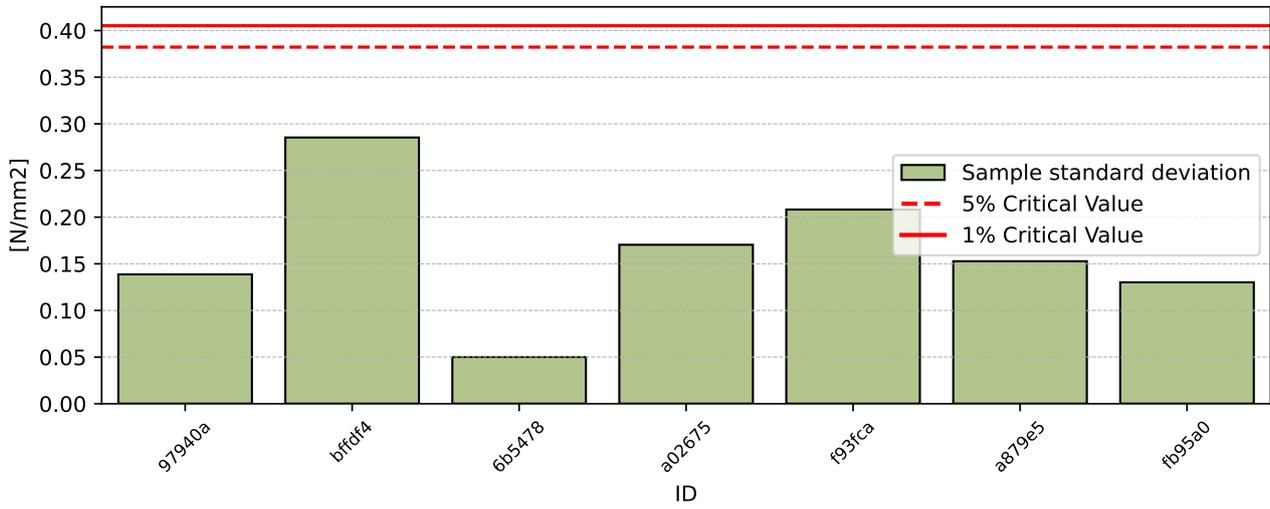
Figure 78: **Cochran's test** - sample standard deviations
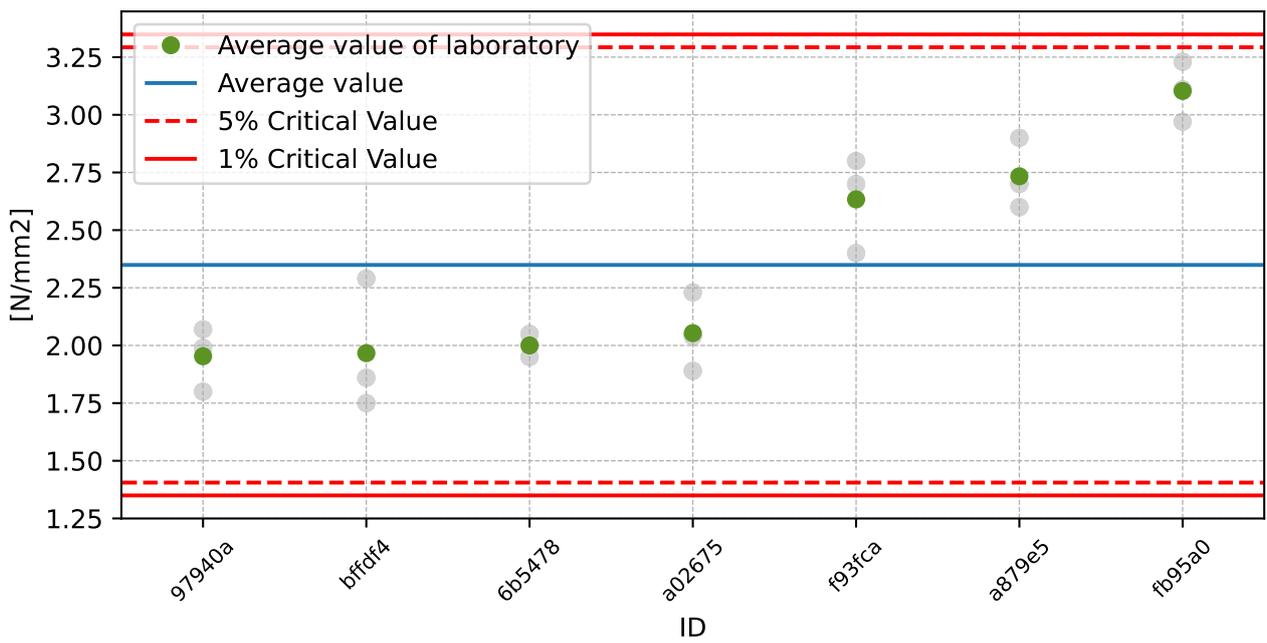
Figure 79: **Grubbs' test** - average values

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14.1.3   Mandeľs Statistics
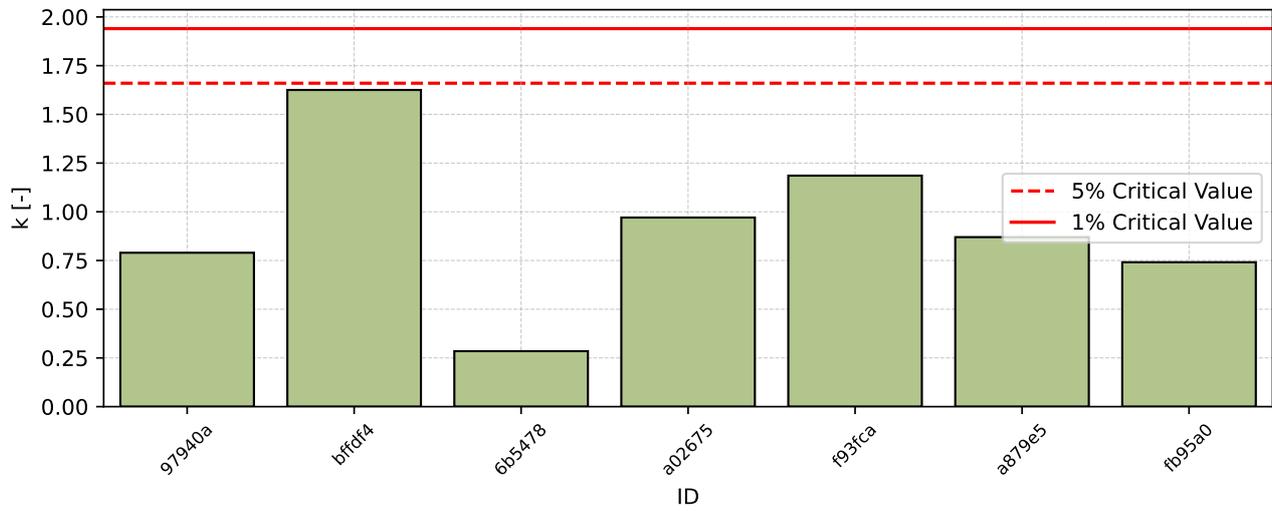
Figure 80: Intralaboratory Consistency Statistic
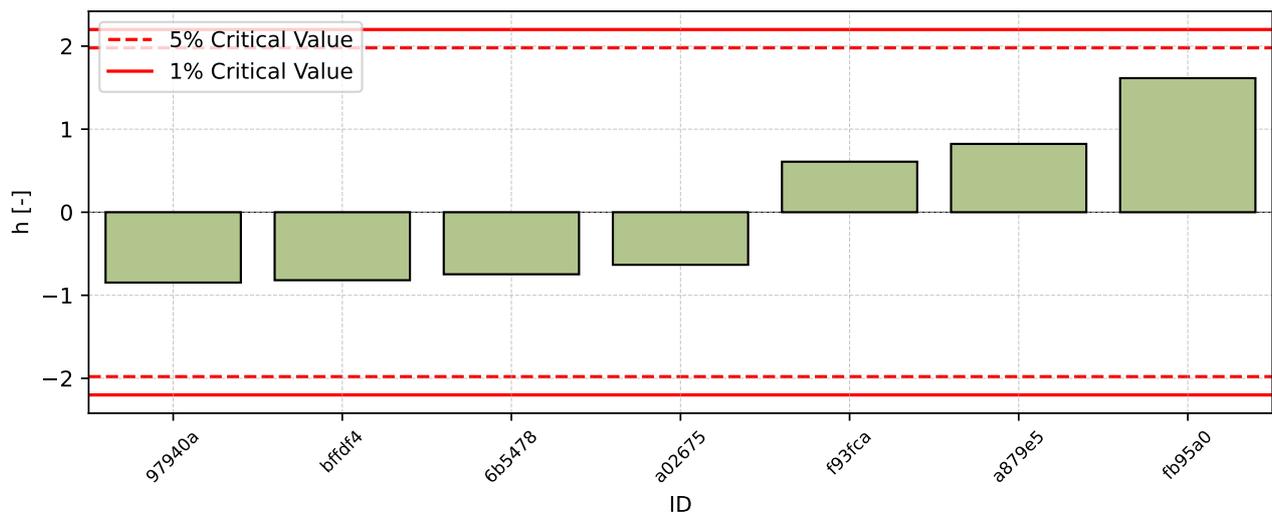
Figure 81: Interlaboratory Consistency Statistic

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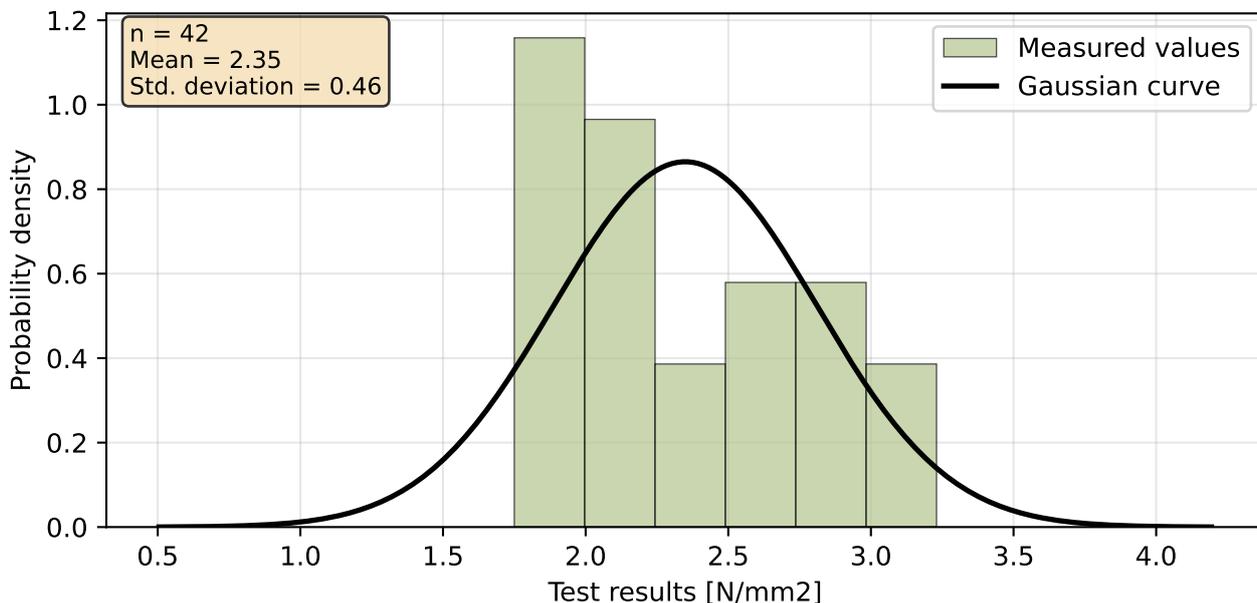Veveří 331/95 | 602 00 Brno | Czech Republic
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14.1.4 Descriptive statistics

Figure 82: Histogram of all test results

Table 32: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	2.35
Sample standard deviation – s	0.467
Asigned value – x^*	2.35
Robust standard deviation – s^*	0.467
Measurement uncertainty of asigned value – u_X	0.177
p-value of normality test	0.064 [-]
Interlaboratory standard deviation – s_L	0.456
Repeatability standard deviation – s_r	0.176
Reproducibility standard deviation – s_R	0.489
Repeatability – r	0.49
Reproducibility – R	1.37

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14.1.5 Evaluation of Performance Statistics

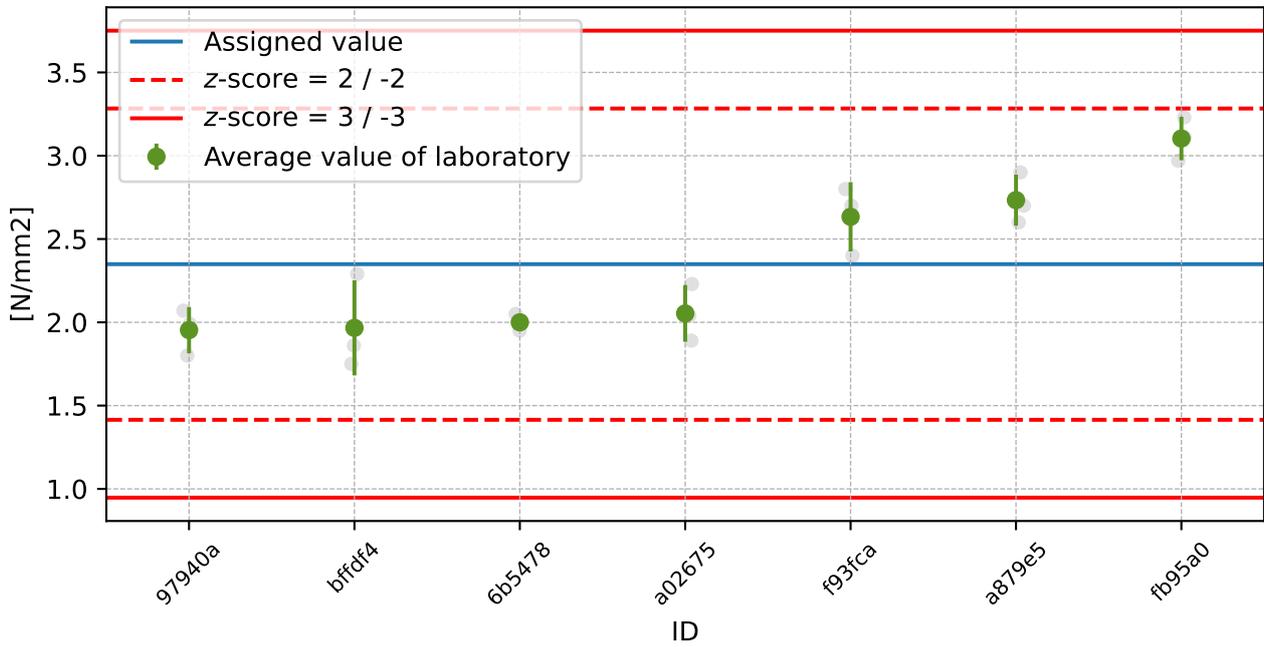Figure 83: Average values and sample standard deviations
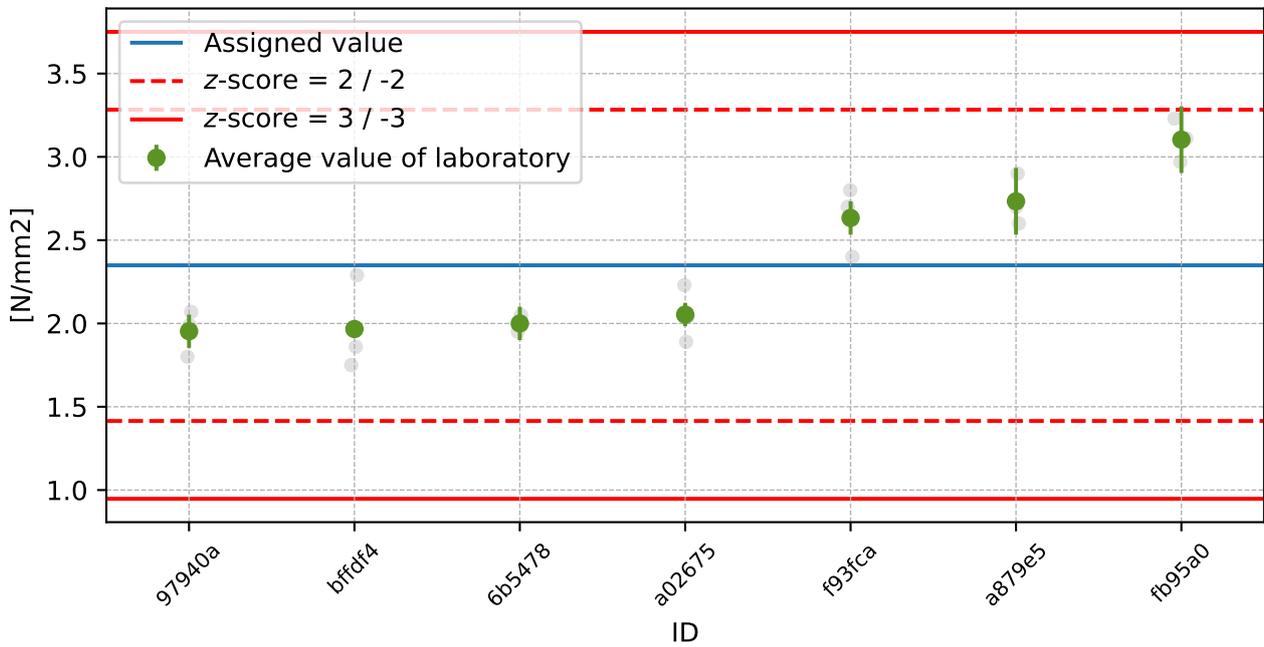
Figure 84: Average values and extended uncertainties of measurement

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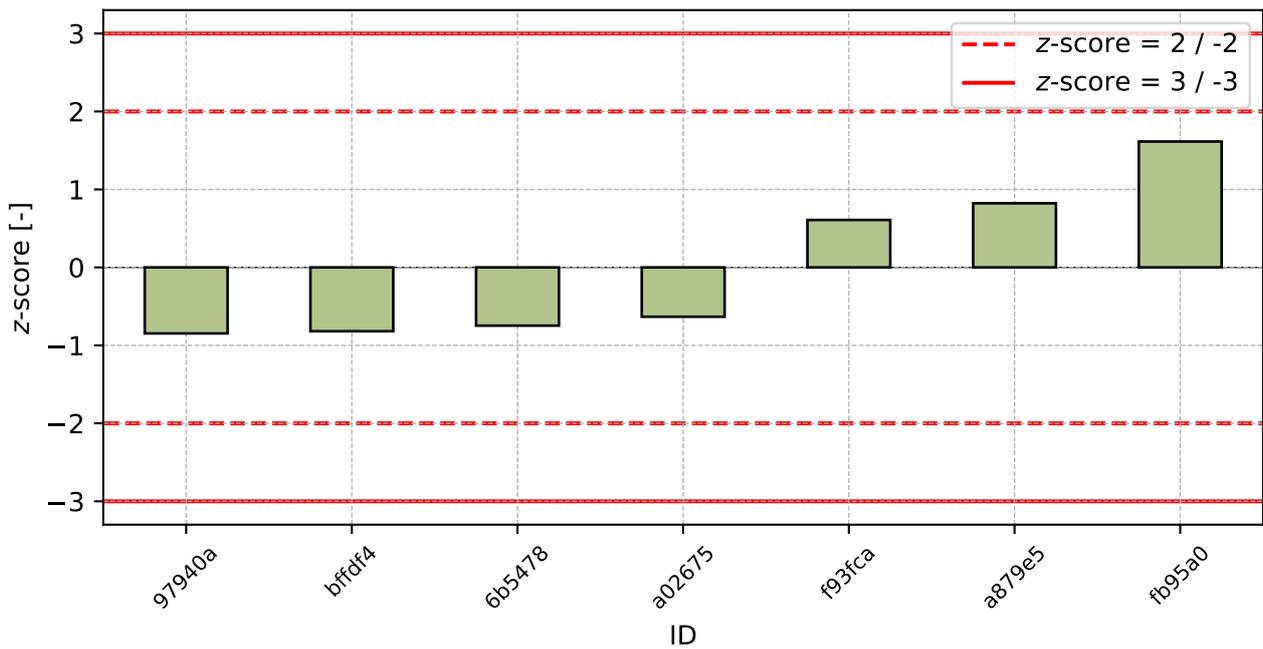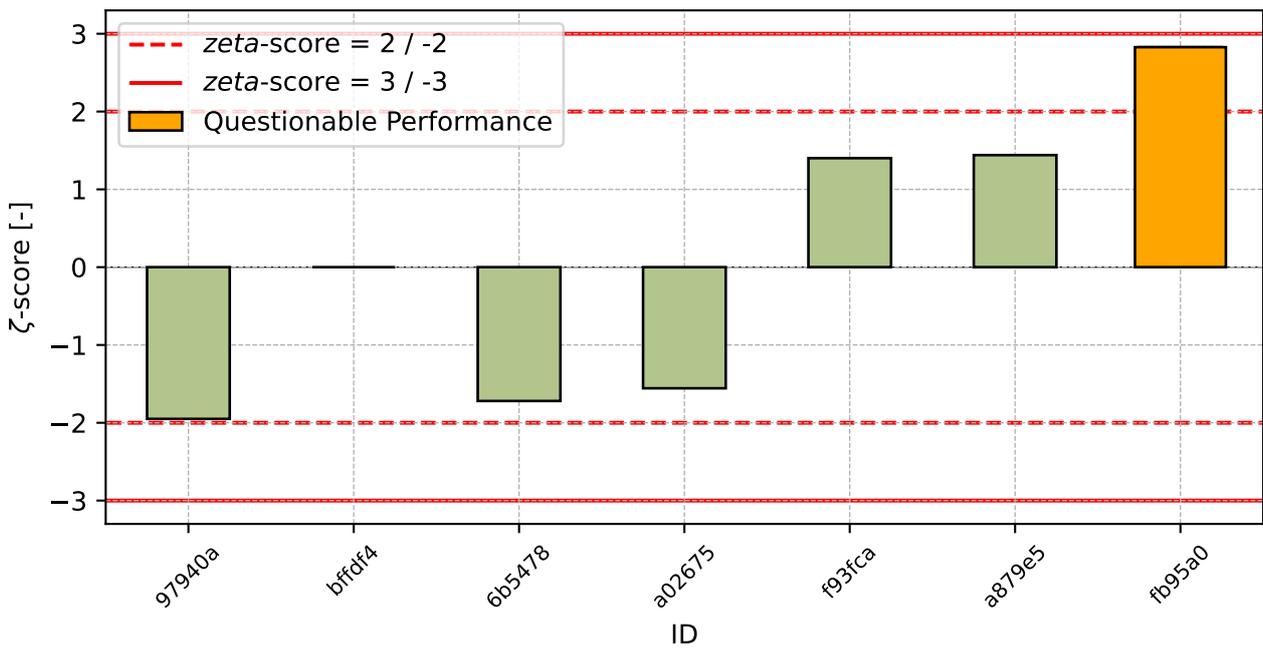
Figure 85: z-score

Figure 86: ζ-score

Table 33: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
97940a	-0.85	-1.95

Continued on next page

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Continued from previous page

ID	z-score [-]	ζ-score [-]
bffdf4	-0.82	-
6b5478	-0.75	-1.72
a02675	-0.63	-1.56
f93fca	0.61	1.4
a879e5	0.82	1.44
fb95a0	1.61	2.83

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14.2 Compressive Strength

14.2.1 Test results

Table 34: 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 [N/mm²]						u_X [N/mm²]	$\bar{x}$ [N/mm²]	s_0 [N/mm²]	V_X [%]
a02675	5.73	5.13	5.26	5.47	5.49	5.61	0.170	5.45	0.221	4.06
bffdf4	6.64	7.80	6.60	7.21	7.76	7.12	-	7.19	0.520	7.24
97940a	7.89	7.09	7.77	7.70	7.76	7.55	0.200	7.63	0.285	3.74
a879e5	8.50	8.60	8.60	8.30	8.30	8.60	0.500	8.48	0.147	1.74
6b5478	8.75	9.10	8.65	8.80	9.05	9.00	0.600	8.89	0.183	2.06
f93fca	9.95	10.40	9.55	10.05	10.45	11.40	0.800	10.30	0.631	6.12
fb95a0	12.21	12.27	11.83	12.00	12.71	12.15	0.300	12.20	0.298	2.44

14.2.2 The Numerical Procedure for Determining Outliers
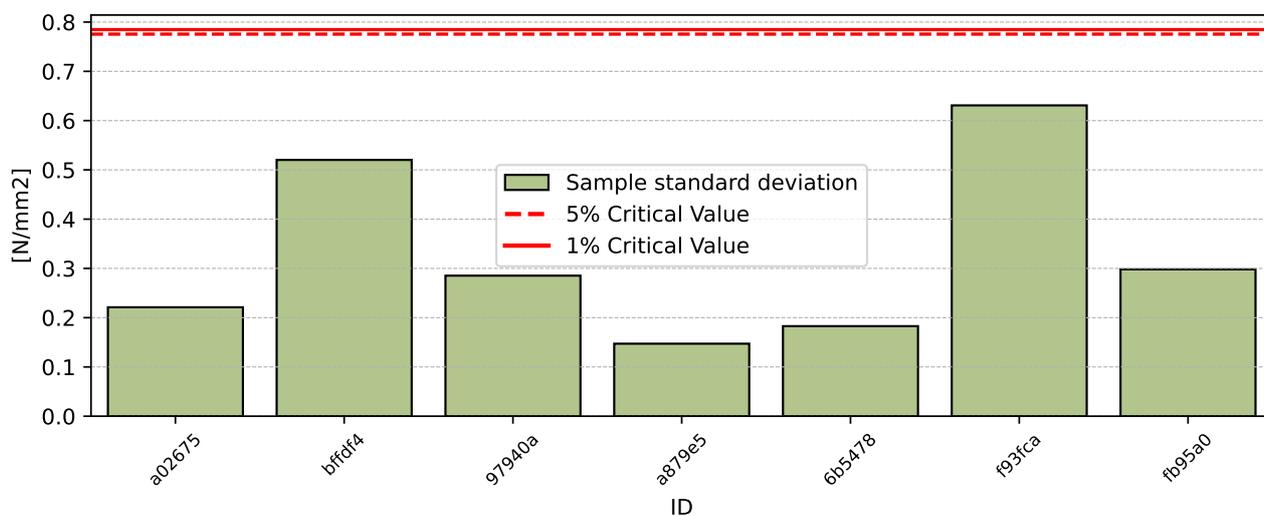
Figure 87: **Cochran's test** - sample standard deviations
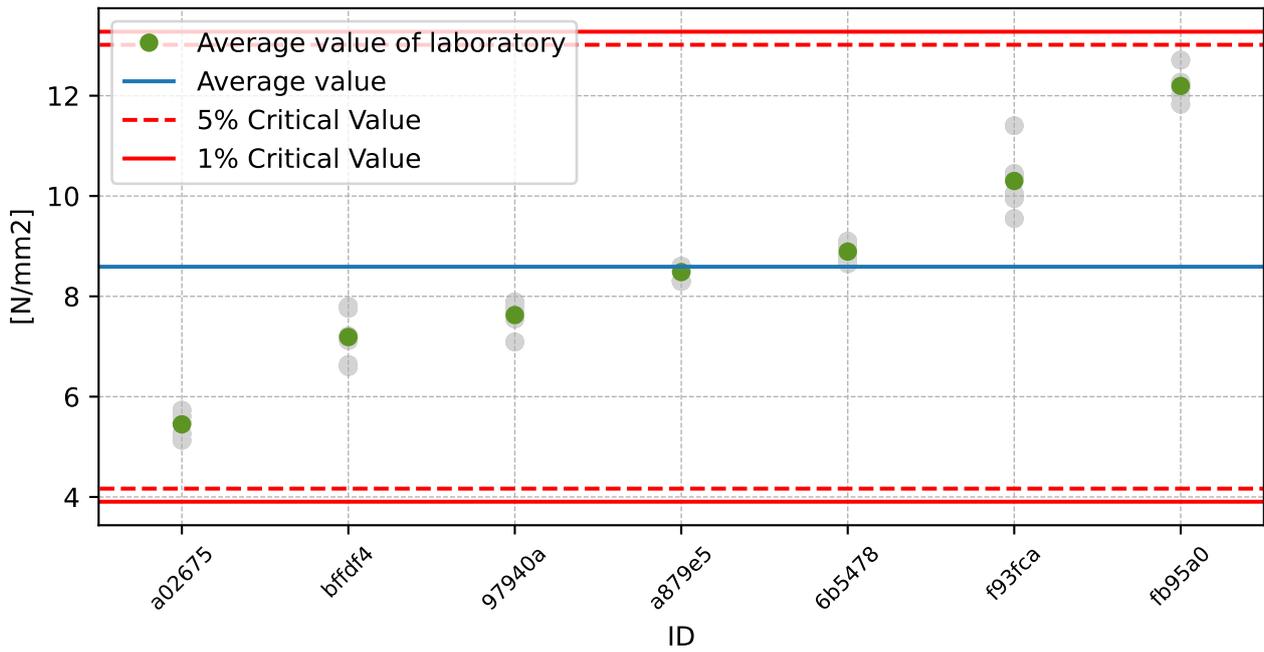
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Figure 88: **Grubbs' test** - average values

14.2.3   Mandel's Statistics
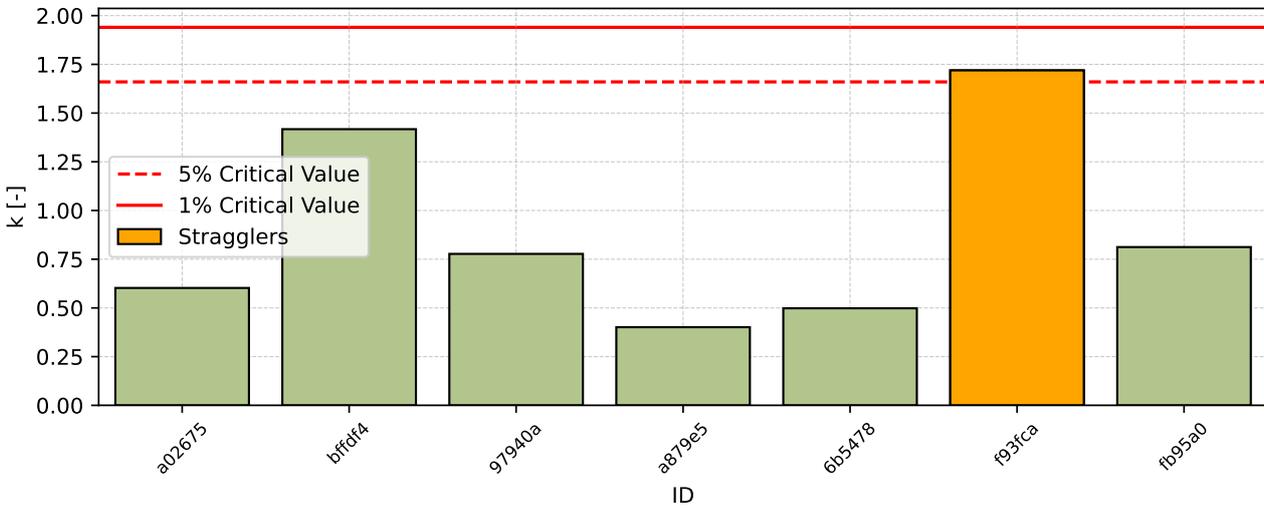
Figure 89: Intralaboratory Consistency Statistic

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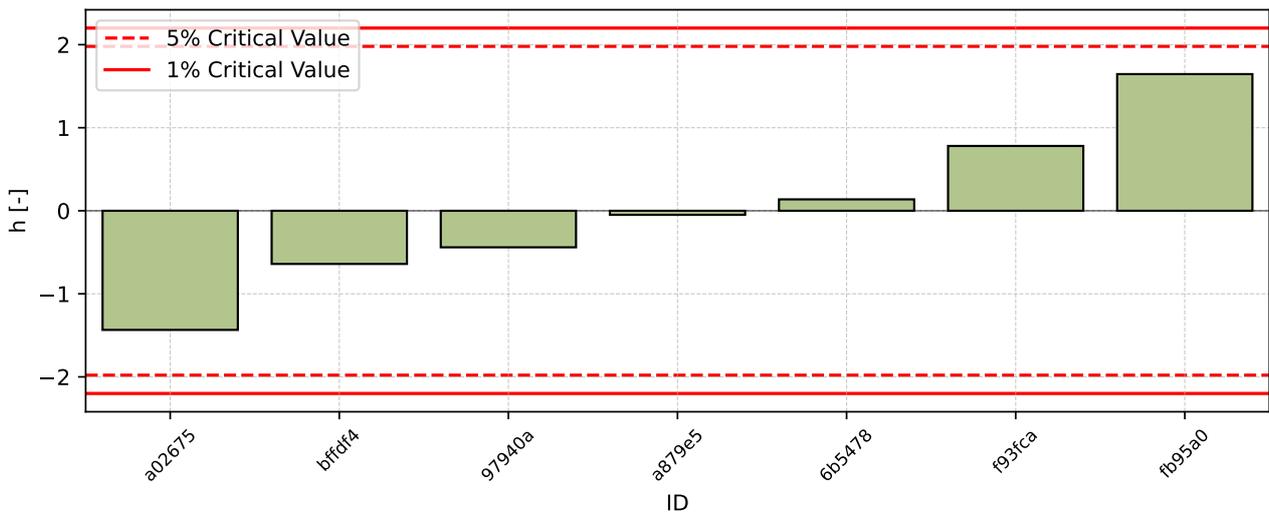Veveří 331/95 | 602 00 Brno | Czech Republic
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Figure 90: Interlaboratory Consistency Statistic

14.2.4 Descriptive statistics
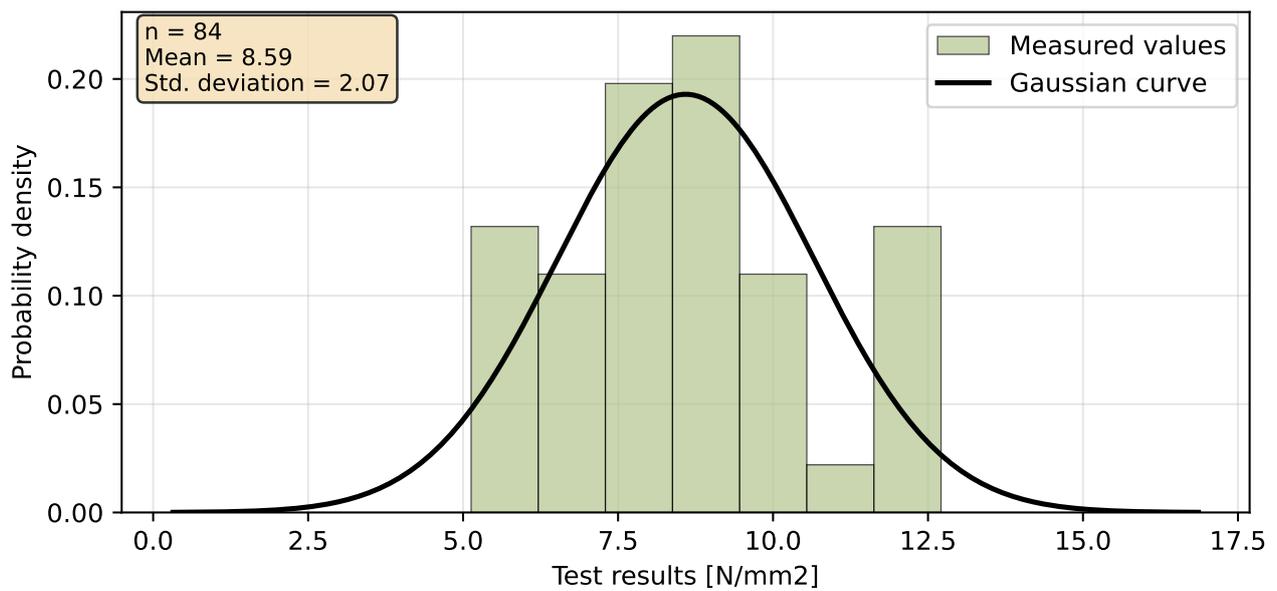
Figure 91: Histogram of all test results

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Table 35: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	8.59
Sample standard deviation – s	2.19
Asigned value – x^*	8.59
Robust standard deviation – s^*	2.19
Measurement uncertainty of asigned value – u_X	0.828
p-value of normality test	0.085 [-]
Interlaboratory standard deviation – s_L	2.185
Repeatability standard deviation – s_r	0.367
Reproducibility standard deviation – s_R	2.216
Repeatability – r	1.03
Reproducibility – R	6.2

14.2.5   Evaluation of Performance Statistics
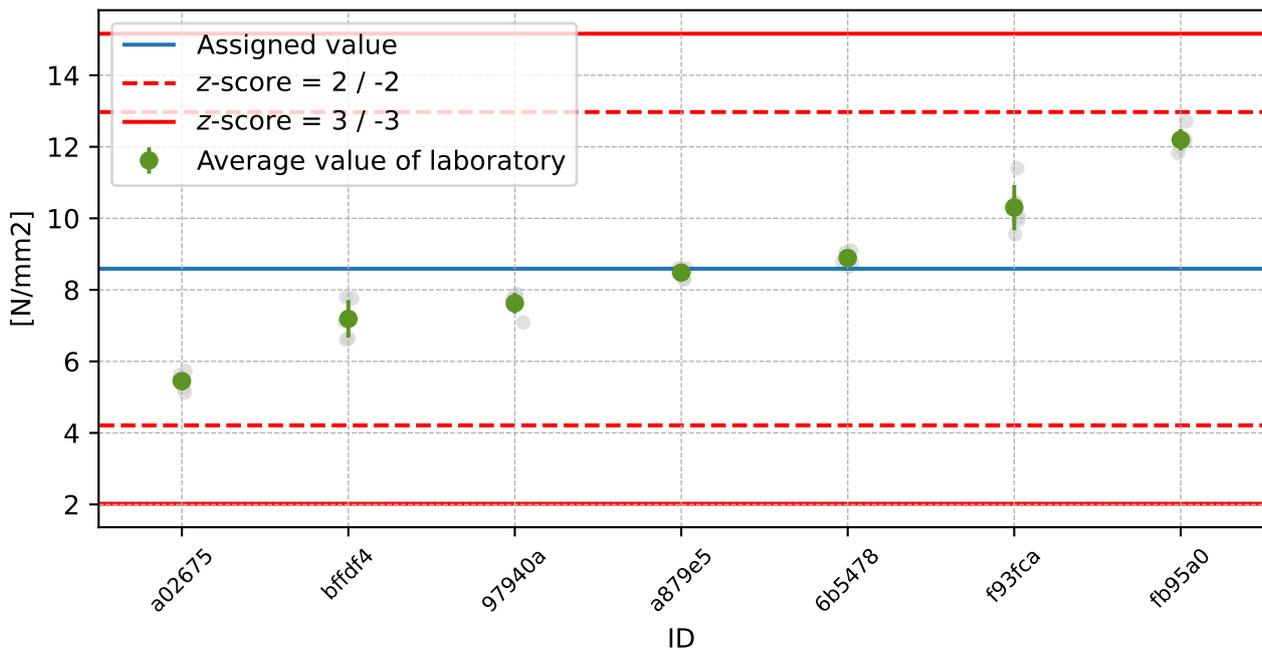
Figure 92: Average values and sample standard deviations

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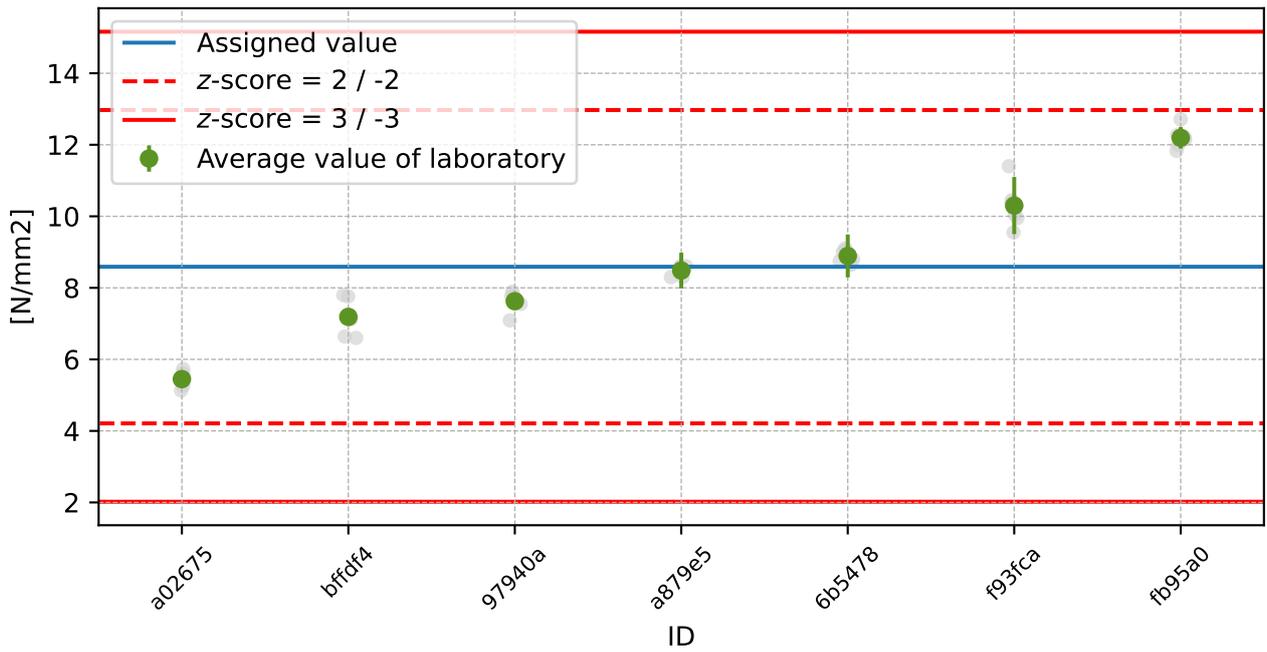
Figure 93: Average values and extended uncertainties of measurement

Figure 94: z-score

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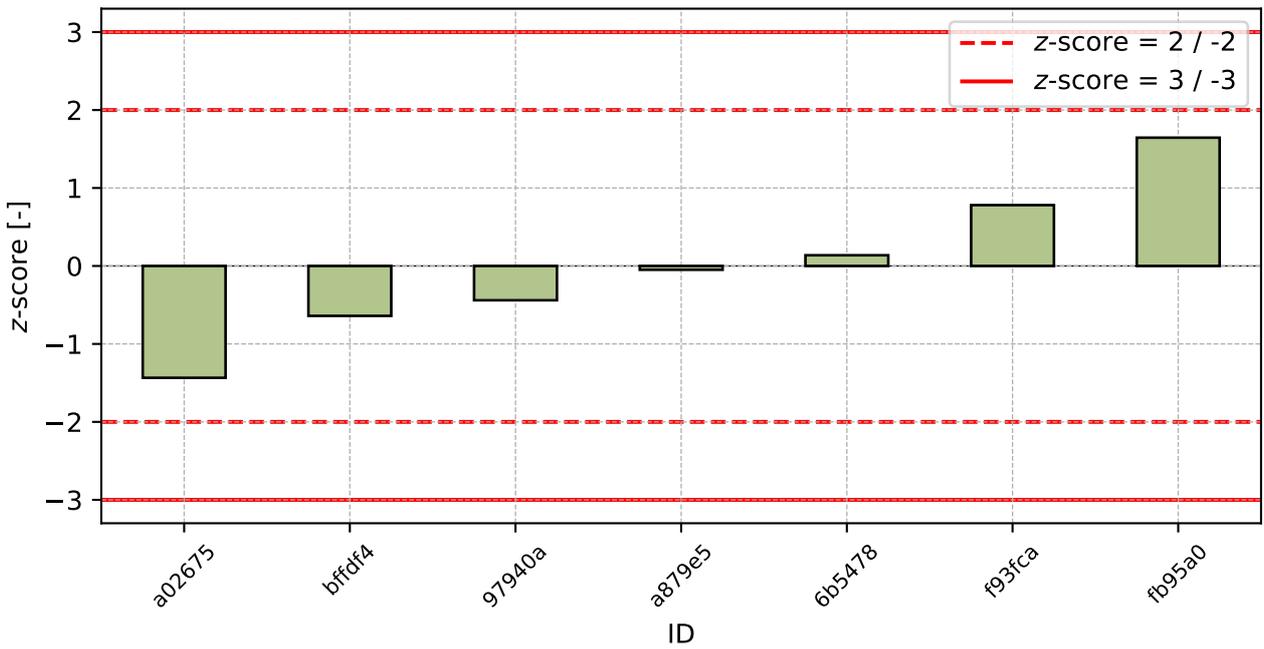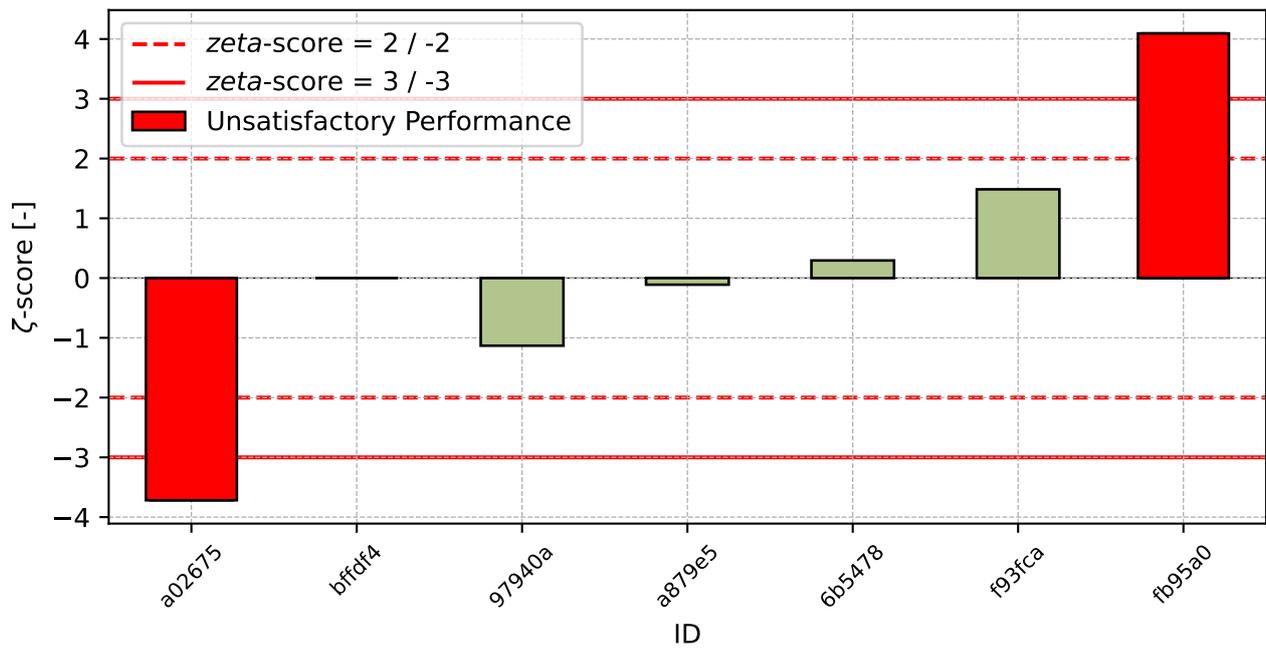
Figure 95: ζ-score

Table 36: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
a02675	-1.43	-3.72
bffdf4	-0.64	-
97940a	-0.44	-1.13
a879e5	-0.05	-0.11
6b5478	0.14	0.29
f93fca	0.78	1.48
fb95a0	1.65	4.09

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15   Appendix – EN 1015-12 – Adhesion

This part of PT program was not open according to the low number of participants.

16   Appendix – EN 1015-18 – Capillary absorption coefficient (C_m)

This part of PT program was not open according to the low number of participants.

17   Appendix – EN 1015-19 – Water vapor flow

This part of PT program was not open due to low number of participants.

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18   Appendix – EN 13892-2 – Determination of flexural and compressive strength

18.1   Flexural Strength

18.1.1   Test results

Table 37: 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 [N/mm^2]			u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
64e4db	4.09	3.70	4.04	-	3.94	0.212	5.38
f93fca	5.30	5.40	4.40	0.400	5.03	0.551	10.94
f8f516	5.15	5.30	5.25	0.100	5.23	0.076	1.46
a02675	5.61	5.09	5.15	0.170	5.28	0.284	5.38
8f06b9	5.75	5.60	5.40	0.900	5.58	0.176	3.14
d8cb68	6.10	6.00	6.10	0.300	6.07	0.058	0.95
fb95a0	6.31	6.02	6.24	0.200	6.19	0.151	2.44

18.1.2   The Numerical Procedure for Determining Outliers
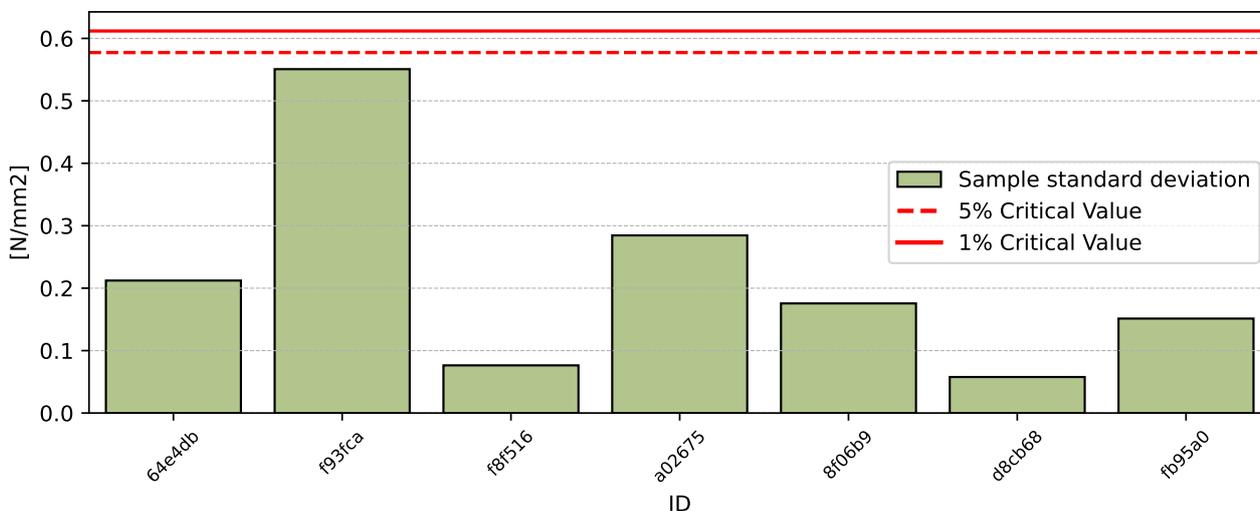
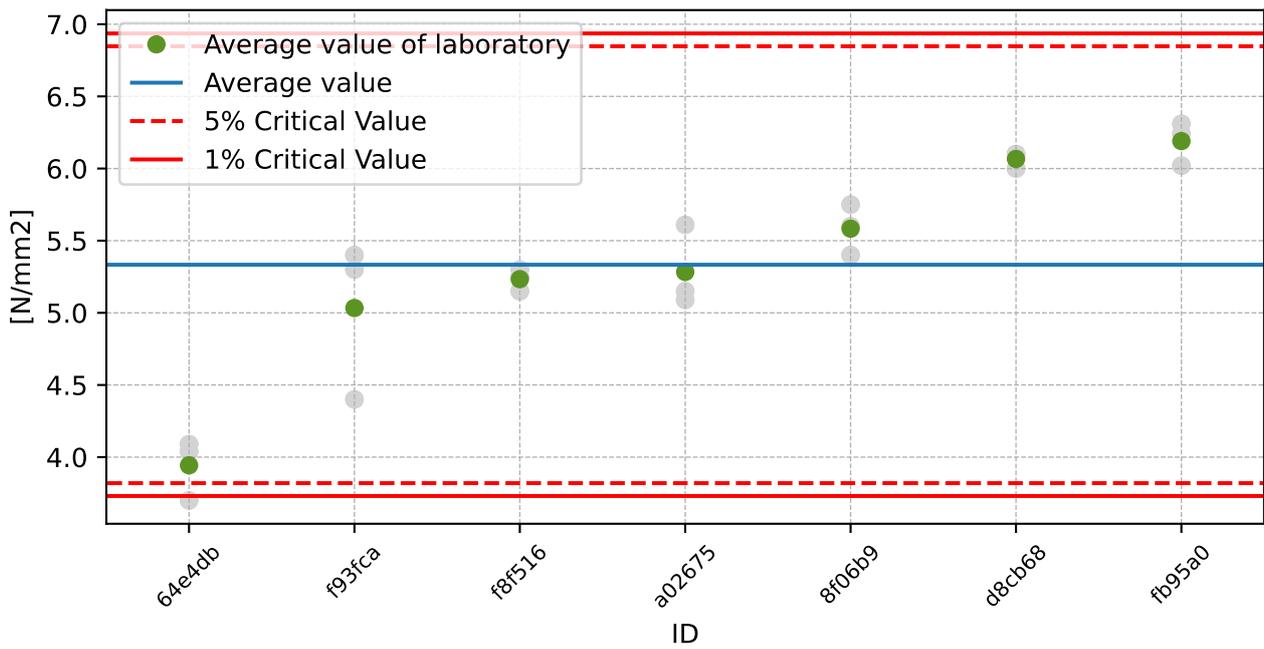
Figure 96: **Cochran's test** - sample standard deviations

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

18.1.3   Mandel's Statistics
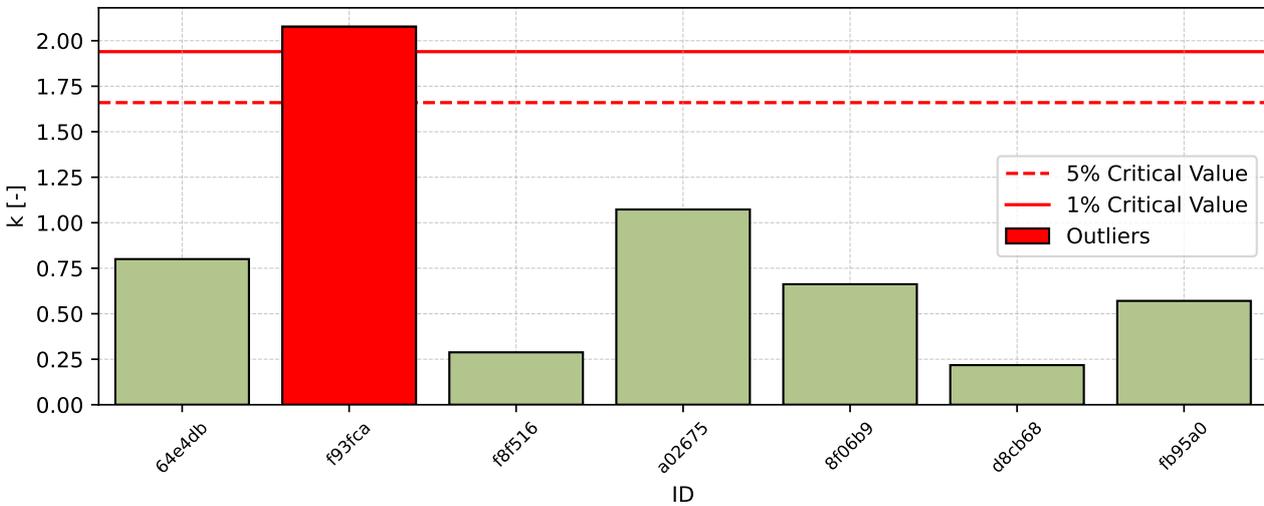
Figure 98: Intralaboratory Consistency Statistic

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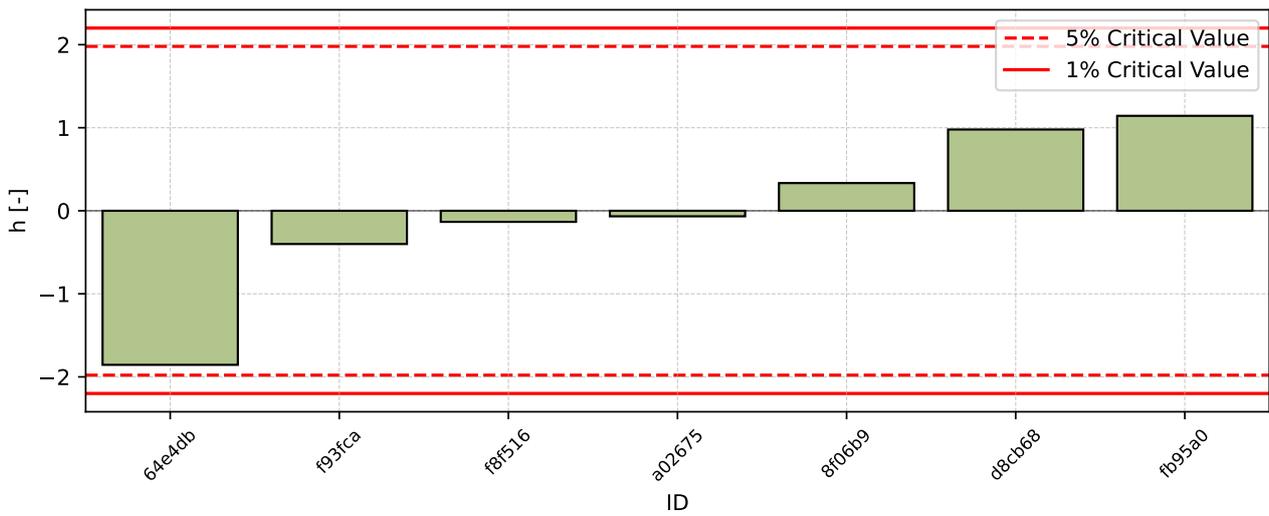
Figure 99: Interlaboratory Consistency Statistic

18.1.4 Descriptive statistics
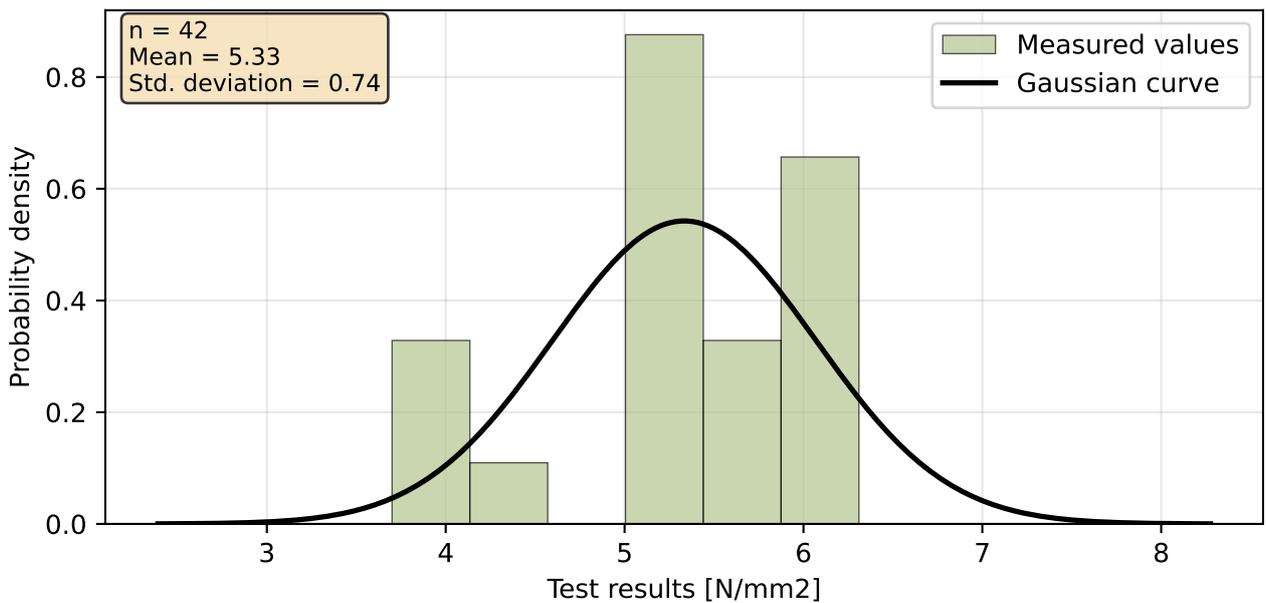
Figure 100: Histogram of all test results

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Table 38: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	5.33
Sample standard deviation – s	0.749
Asigned value – x^*	5.33
Robust standard deviation – s^*	0.749
Measurement uncertainty of asigned value – u_X	0.283
p-value of normality test	0.064 [-]
Interlaboratory standard deviation – s_L	0.733
Repeatability standard deviation – s_r	0.265
Reproducibility standard deviation – s_R	0.78
Repeatability – r	0.74
Reproducibility – R	2.18

18.1.5 Evaluation of Performance Statistics
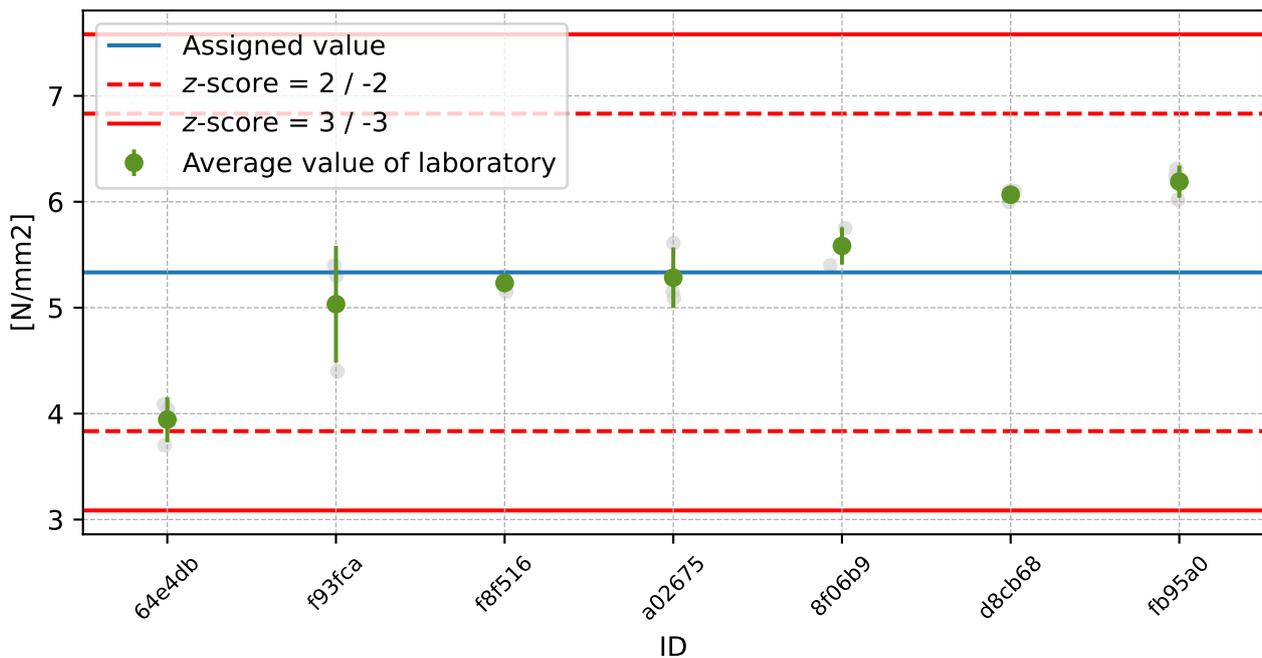
Figure 101: Average values and sample standard deviations

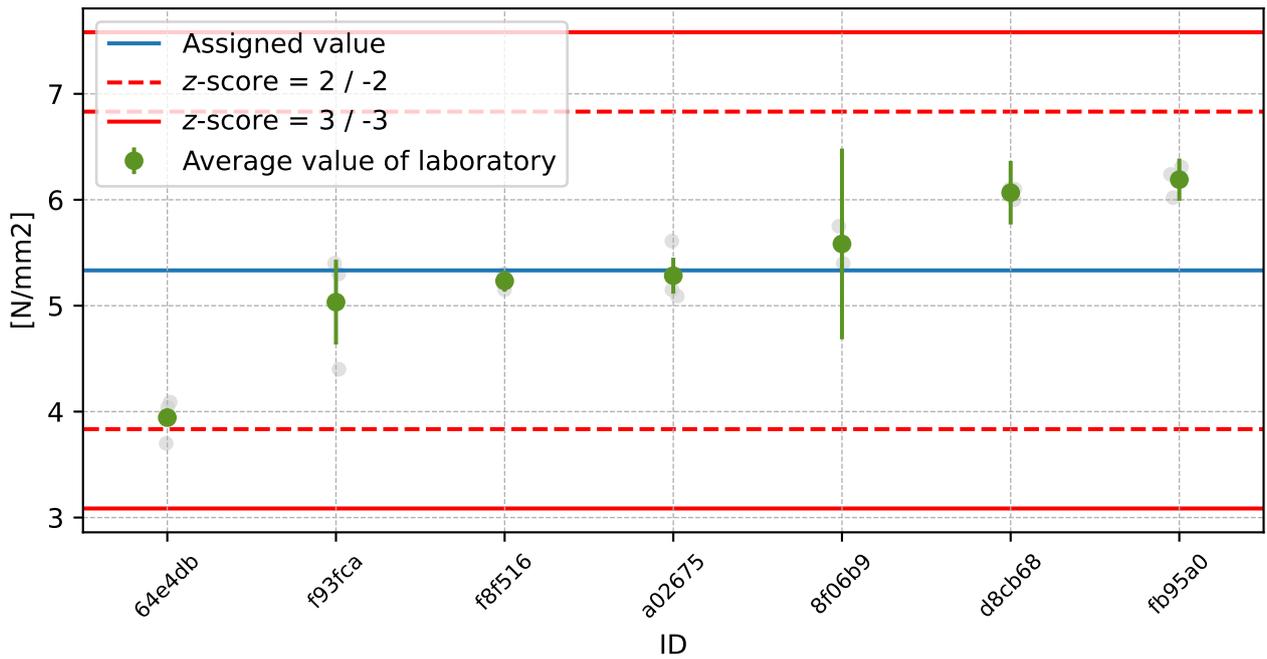Proficiency Testing Provider at the SZK FAST | Z 7008   80/89
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Figure 102: Average values and extended uncertainties of measurement

Figure 103: z-score

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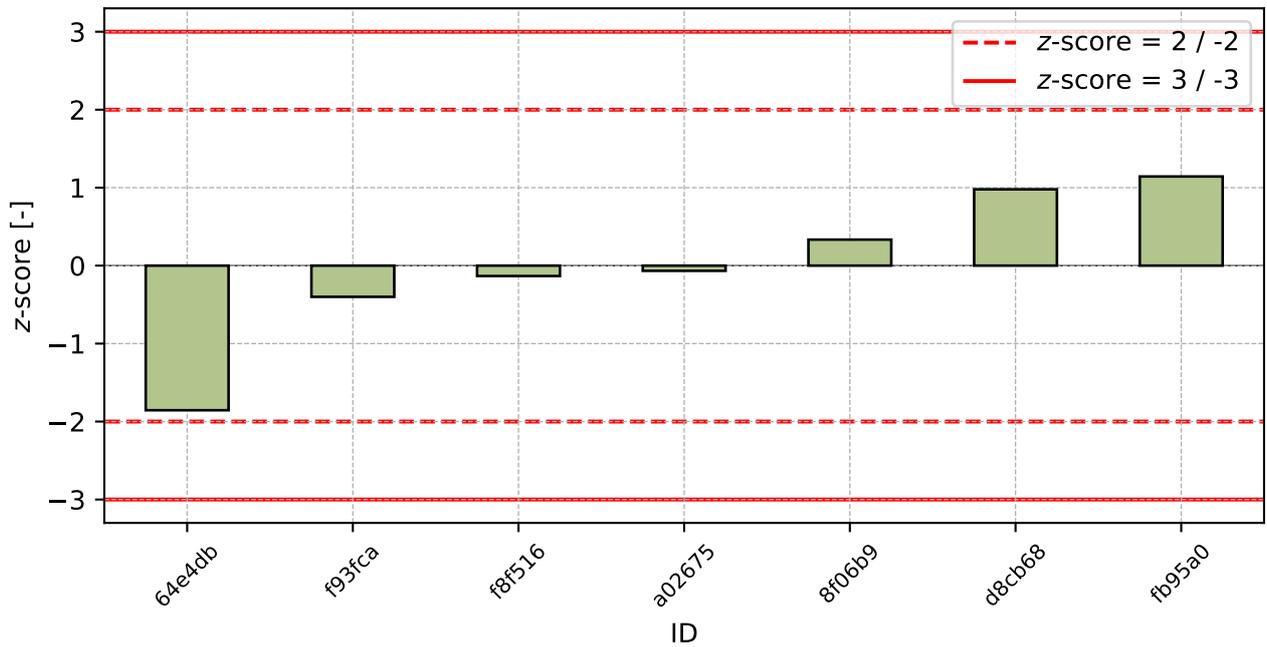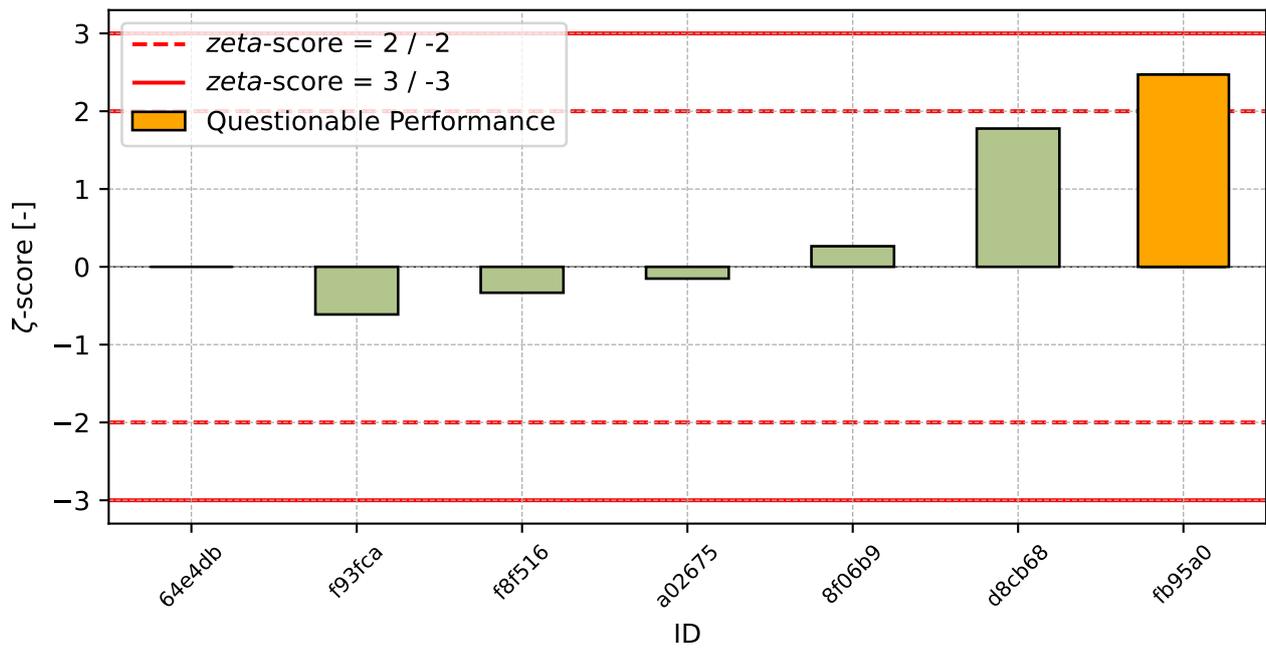
Figure 104: ζ-score

Table 39: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
64e4db	-1.86	-
f93fca	-0.4	-0.61
f8f516	-0.13	-0.33
a02675	-0.07	-0.15
8f06b9	0.33	0.26
d8cb68	0.98	1.78
fb95a0	1.14	2.47

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18.2　Compressive Strength

18.2.1　Test results

Table 40: 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 [N/mm^2]						u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
64e4db	26.90	29.30	25.80	25.60	29.30	28.20	-	27.52	1.663	6.04
f93fca	27.45	28.00	28.40	28.90	28.55	29.25	1.100	28.43	0.641	2.25
d8cb68	30.90	32.20	32.40	31.10	30.80	31.50	1.600	31.48	0.679	2.16
a02675	33.19	31.17	34.17	30.54	32.41	32.73	1.030	32.37	1.329	4.11
f8f516	33.35	33.20	31.50	31.95	33.20	33.80	0.800	32.83	0.898	2.73
fb95a0	34.60	33.90	33.30	33.30	33.40	33.00	0.500	33.58	0.578	1.72
8f06b9	34.85	35.25	35.65	36.20	34.70	34.25	0.900	35.15	0.702	2.00

18.2.2　The Numerical Procedure for Determining Outliers
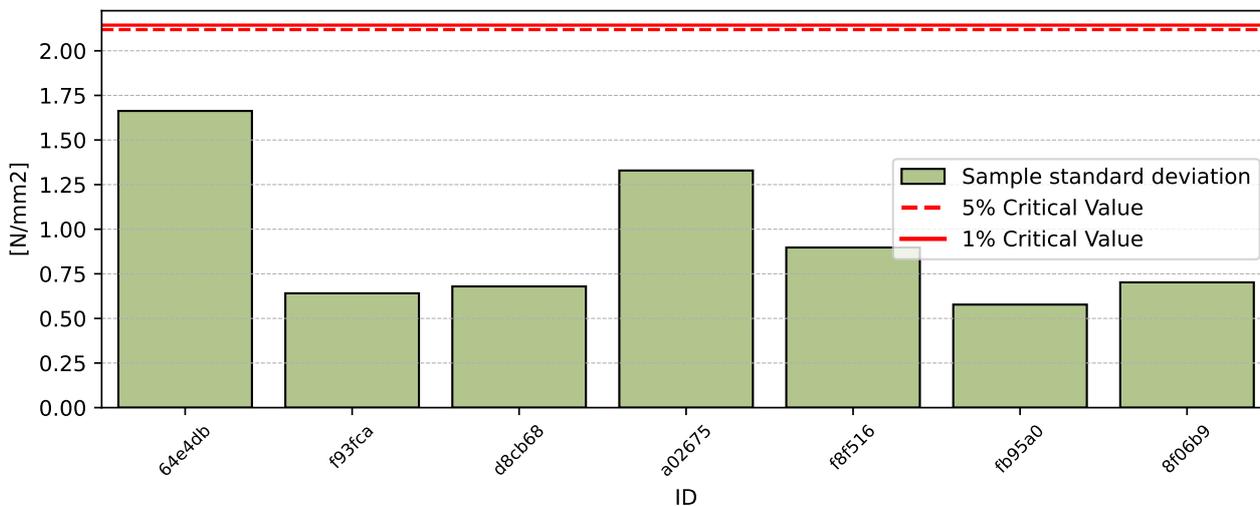
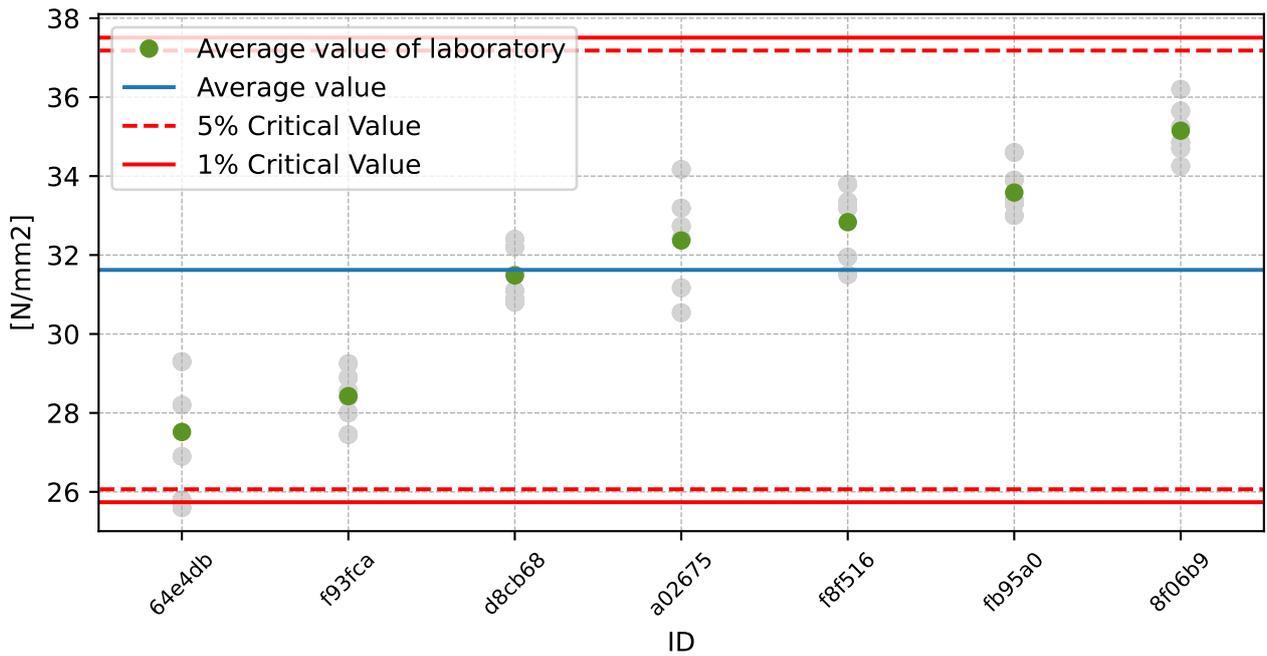Figure 105: **Cochran's test** - sample standard deviations

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Figure 106: **Grubbs' test** - average values

18.2.3   Mandel's Statistics
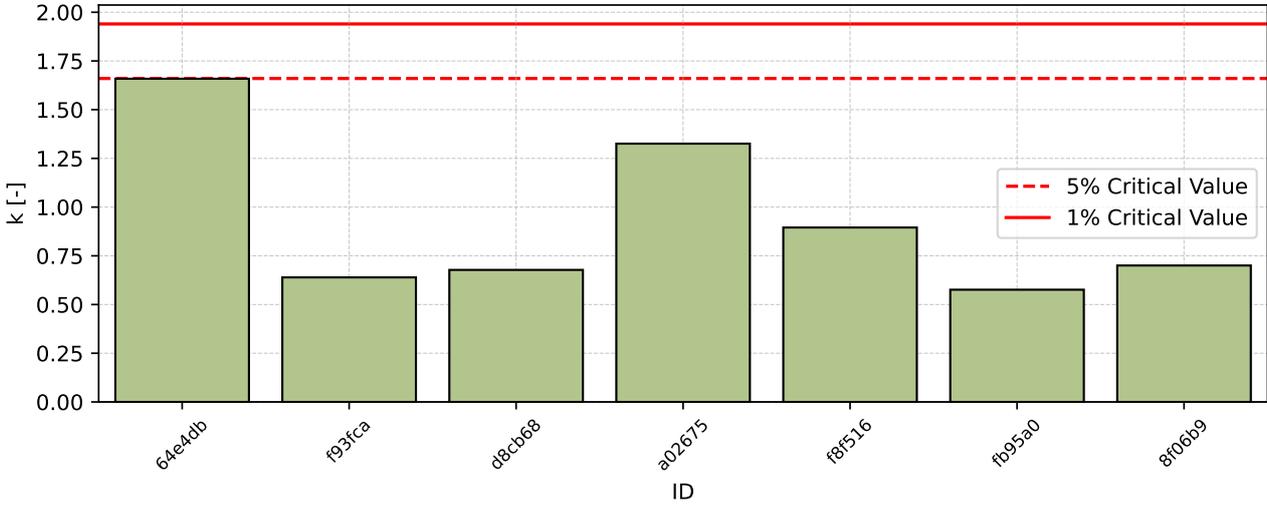
Figure 107: Intralaboratory Consistency Statistic

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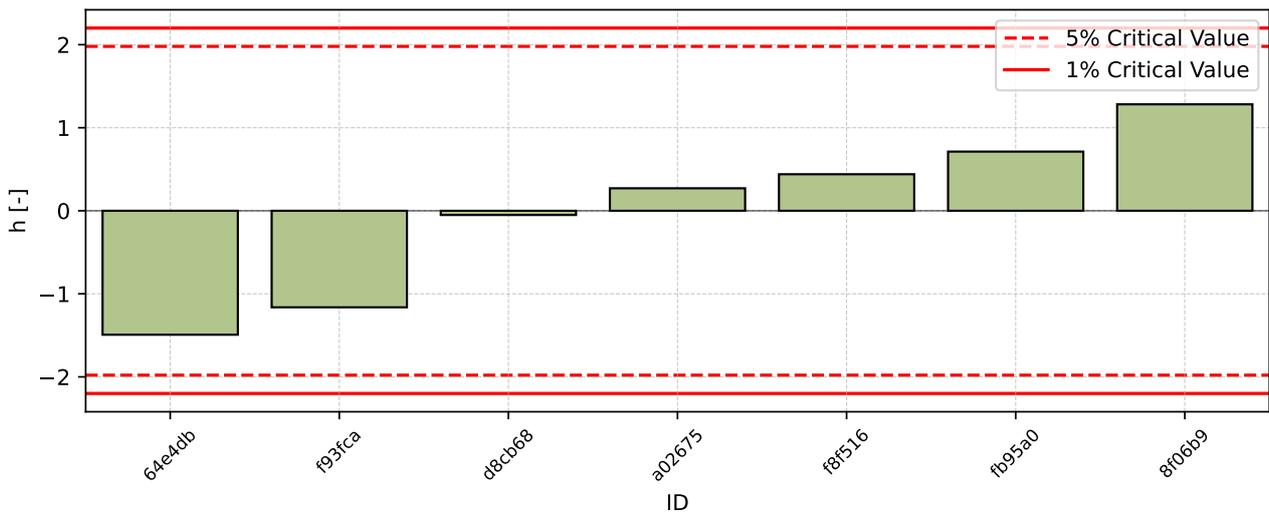
Figure 108: Interlaboratory Consistency Statistic

18.2.4 Descriptive statistics
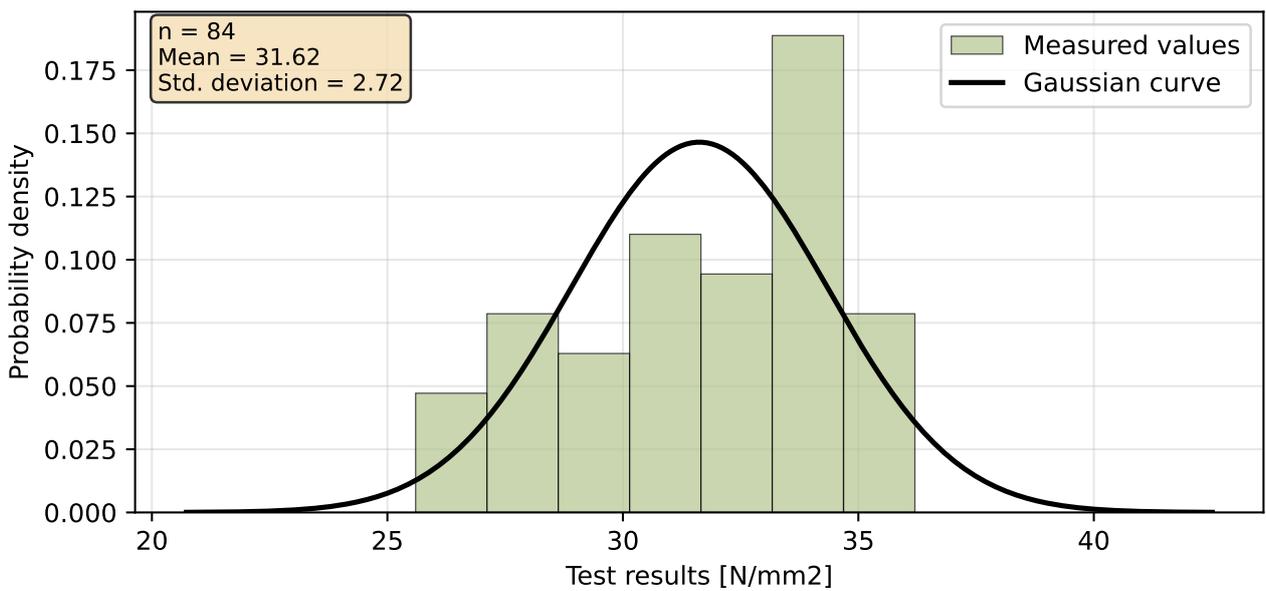
Figure 109: Histogram of all test results

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Table 41: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	31.62
Sample standard deviation – s	2.751
Asigned value – x^*	31.62
Robust standard deviation – s^*	2.751
Measurement uncertainty of asigned value – u_X	1.04
p-value of normality test	0.098 [-]
Interlaboratory standard deviation – s_L	2.72
Repeatability standard deviation – s_r	1.003
Reproducibility standard deviation – s_R	2.899
Repeatability – r	2.81
Reproducibility – R	8.12

18.2.5　Evaluation of Performance Statistics
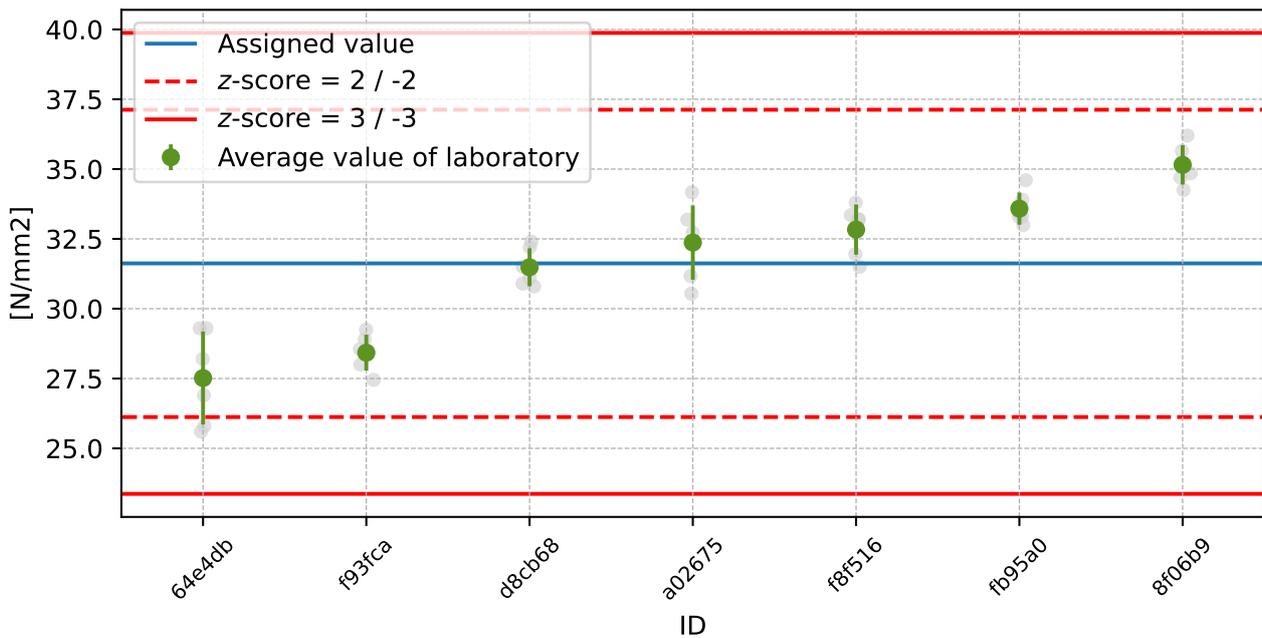
Figure 110: Average values and sample standard deviations
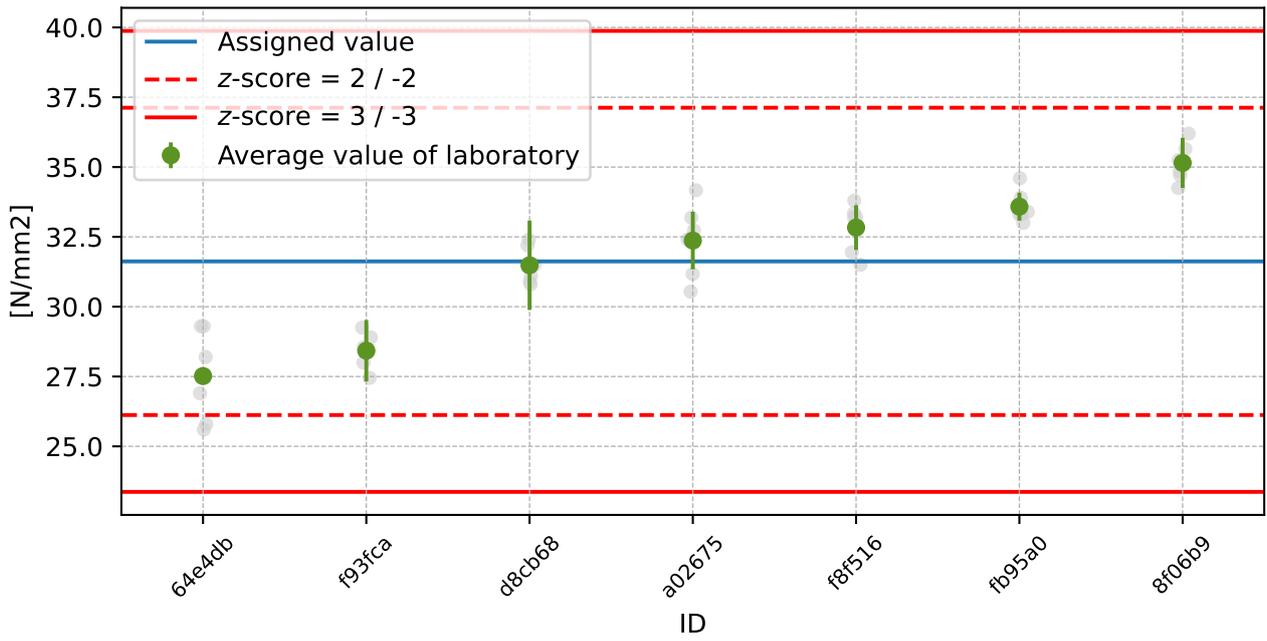
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Figure 111: Average values and extended uncertainties of measurement

Figure 112: z-score

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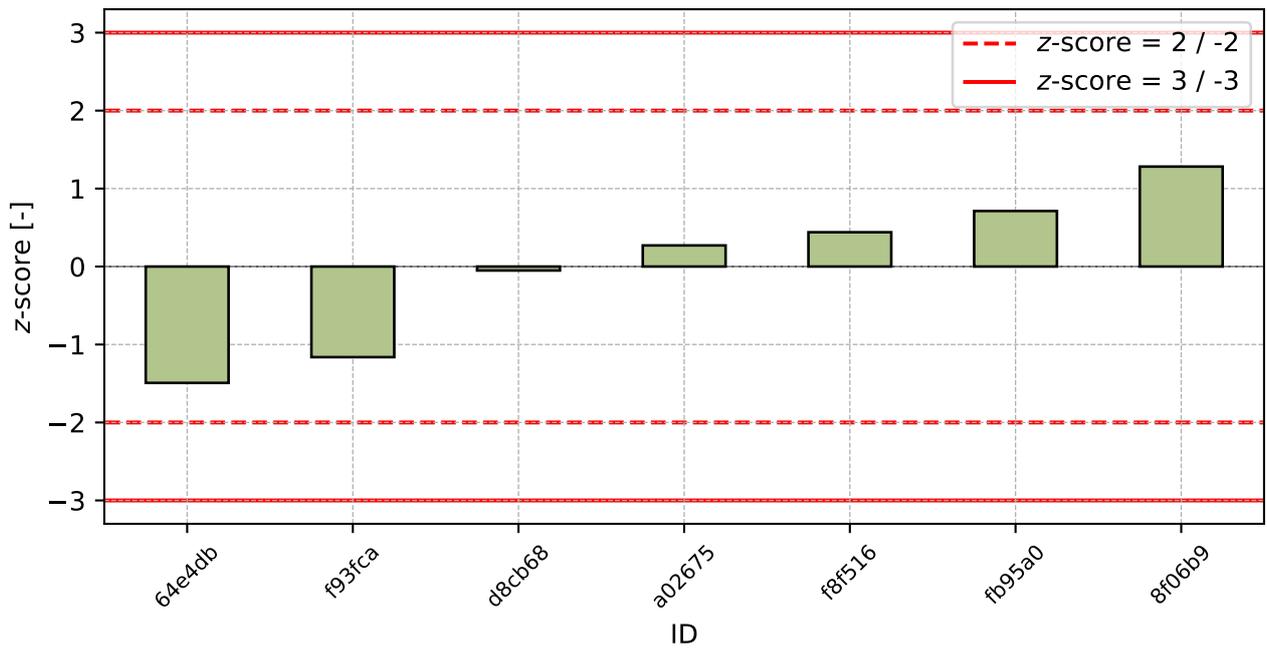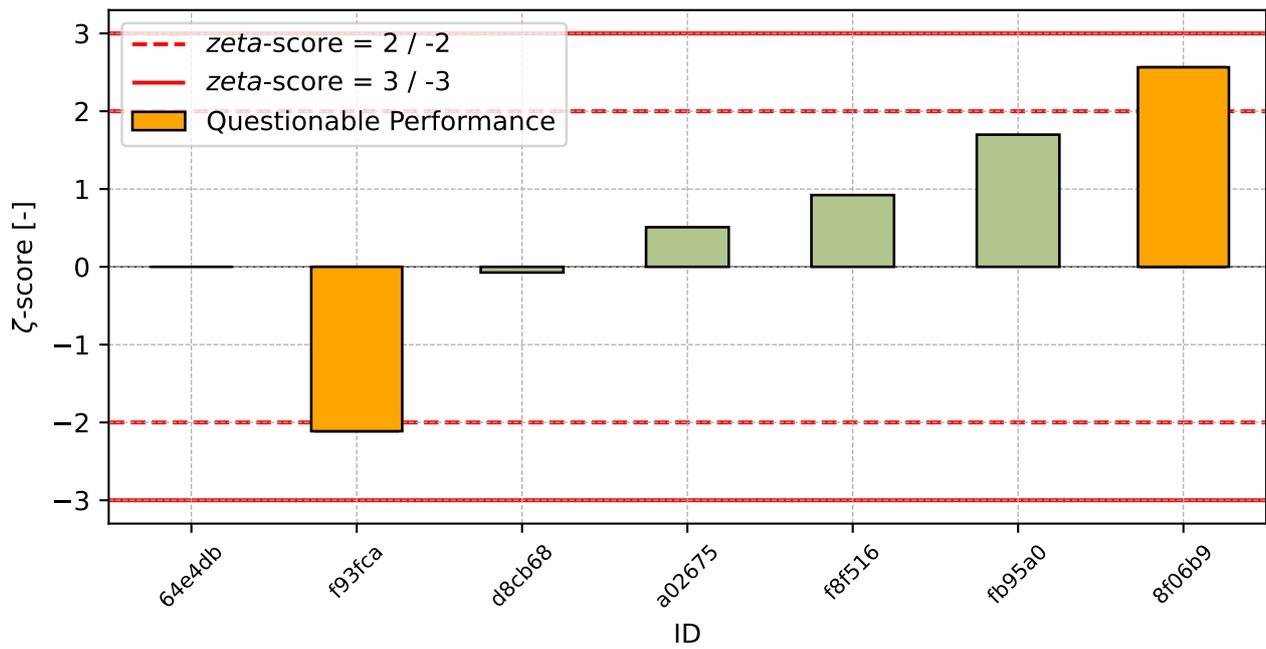
Figure 113: ζ-score

Table 42: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
64e4db	-1.49	-
f93fca	-1.16	-2.11
d8cb68	-0.05	-0.07
a02675	0.27	0.51
f8f516	0.44	0.92
fb95a0	0.71	1.7
8f06b9	1.28	2.56

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19   Appendix – EN 12004-2 (art. 8.1) – Open time

This part of PT program was not open due to low number of participants.

20   Appendix – EN 12004-2 (art. 8.2) – Slippage

This part of PT program was not open according to the low number of participants.

21   Appendix – EN 12004-2 (art. 8.3.3.2) – Adhesion

This part of PT program was not open due to low number of participants.

22   Appendix – EN 12004-2 (art. 8.3.3.3) – Adhesion

This part of PT program was not open due to low number of participants.

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