BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
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ilac-MRA

Z 7008

FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Mortar, Cement and Fine-grained Cement Composites
ZMC 2021/1

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Proficiency testing provider at the SZK FAST
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1 Introduction and Important Contacts

In the year 2021, the Proficiency Testing Provider at the SZK FAST (PT Provider) initiated the Proficiency Testing Program (PTP) designated ZMC 2021/1 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

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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]

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

Testing procedures No **1, 2, 3, 7, 8, 11, 12, 13, 14, 17 and 19** were open. Other test methods were not opened due to low attendance. (interested laboratories).

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.

27 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 the PTP

ID/Part	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
0e6f72	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4bb8b1	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ef77b8	X	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-
3d7bfb	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-
87fd86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-
d856bb	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
f11905	-	X	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
5dbe4b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
c7dc55	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cd297b	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
aa7750	X	X	X	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	X	-	-
65dcf3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
830fc9	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
fd26b6	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
7daaa4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
843655	X	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10d1f1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
ea7194	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47a857	-	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-	-	X	-	X	-	-
1e39d6	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
35a6f1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
7d1d14	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
6043e6	X	X	X	-	-	-	-	X	X	-	-	-	-	X	-	-	-	-	-	-	-	-
412c89	-	-	X	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-
0788f7	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-
cbaf70	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
14ad73	-	-	-	-	-	-	-	-	-	-	-	-	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
BARG Laboratorium Budowlane Sp. z o.o.	Budowlana 19, Siemianowice Śląskie, 41-100, POLSKA / Slaskie	AB 804
BETOTECH, s.r.o.	Beroun 660, Beroun, 26601, Česká republika	AZL 1195
BHP Laboratories Limited	New Road Thomondgate, Limerick, V94P9X4, Ireland	INAB Red No. 5T
BauZert e.V.	Raiffeisenstr. 8, Großburgwedel, 30938, Niedersachsen	-
Bechtel ENKA UK Limited Ogranak Beograd	Jasicki put 52 đ, Kruševac, 37000, Serbia	-
Cement Hranice, akciová společnost - Betonářská laboratoř	Bělotínská 288, Hranice I - Město, 75301, Česká republika	1284
Cement Hranice, akciová společnost - SOMS	Bělotínská 288, Hranice I - Město, 75301, Česká republika	-
Cemex Czech Republic, s.r.o.	Semtín 102, Pardubice, 53354, Česká republika	1302
Institut pro testování a certifikaci, a.s.	třída Tomáše Bati 299, Louky, Zlín, 763 02, Česká republika	1004
Institut pro testování a certifikaci, a.s.	K Cihelně 304, Zlín - Louky, 764 32, Česká republika	1007.1
Laboratoire Central des Travaux Publics-LCTP	1. rue Kaddour RAHIM- HUSSEIN DEY, ALGER, 16005, ALGERIE	-
Laboratoire des Travaux Publics de l'Ouest LTP-Ouest	Rond point des Castors, Oran, 31000, 99B0103524	-
Magnel-Vandepitte Laboratory	Technologiepark-Zwijnaarde 60, GENT, 9052, Belgium	220-TEST
QCONTROL s.r.o., odštěpný závod	Lesní 693, Bílovice nad Svitavou, 66401, Česká republika	1737
QUALIFORM, a.s.	Mlaty 672/8, BRNO, 64200, Česká republika	1008
SQZ, s.r.o. - Ústřední laboratoř Praha - pracoviště Zbraslav	U místní dráhy, 939/5, 939/5, Olomouc - Nová Ulice, 779 00, Česko	-
Stachema CZ s.r.o. - zkušební laboratoř - pracoviště 2	Hasičská 1, Zibohlavy, Kolín, 28002, Česká republika	1433
Technický a zkušební ústav Praha, s.p., Centrální laboratoř, zkušebna Předměřice nad Labem	Průmyslová 283, Předměřice nad Labem, 503 02, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p. (zkušebna České Budějovice)	Nemanická 441, České Budějovice, 370 10, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p. - Pobočka Plzeň	Zahradní 15, Plzeň, 326 00, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p. - pobočka Praha	Prosecká 811/76a, Praha 9 - Prosek, 190 00, Česká republika	1018.3
Technický a zkušební ústav stavešbní Praha, s.p. - pobočka Plzeň	Zahradní 15, Plzeň, 326 00, Česká republika	1018.3

Continued on next page

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Laboratory	Address	Accreditation number
Testlita	Jankiškių g. 39, Vilnius, LT-02300, Lithuania	LA.01.013
UAB LABORATORINIU BANDYMU CENTRAS	R. KALANTOS ST. 85A, Kaunas, LT-52308, LITHUANIA	LA.01.002
Vysoké učení technické v Brně, Fakulta stavební, Zkušební laboratoř při ÚTHD FAST VUT v Brně - č. 1396	Veveří 331/95, Brno, 60200, Česká republika	L1396
České vysoké učení technické v Praze, Zkušební laboratoř Kloknerova ústavu	Šolínova 7, Praha 6, 16608, Česká republika	1061
Ředitelství silnic a dálnic ČR	Rebešovická 40, Brno-Chrlice, 643 00, Česká republika	1072

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.

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. 27 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	2	3	8	9	12	13	14	15	18	20
0e6f72	-	-	-	✓	-	-	-	-	-	-	-
4bb8b1	-	-	-	✓	-	-	-	-	-	-	-
ef77b8	✓	-	-	-	-	✓	✓	-	-	-	-
3d7bfb	-	-	-	-	-	-	-	X	-	!	-
87fd86	-	-	-	-	-	-	-	-	-	✓	✓
d856bb	✓	-	-	-	-	-	-	-	-	-	-
f11905	-	✓	✓	-	-	-	-	-	✓	-	-
5dbe4b	-	-	-	-	-	-	-	-	✓	-	-
c7dc55	-	-	-	✓	-	-	-	-	-	-	-
cd297b	-	-	-	-	-	-	-	✓	-	-	-
aa7750	✓	✓	✓	✓	✓	-	-	-	-	-	✓
65dcf3	-	-	-	-	-	-	-	-	✓	-	-
830fc9	✓	-	-	-	-	-	-	-	-	✓	-
fd26b6	-	-	-	-	-	-	-	✓	-	-	-
7daaa4	-	-	-	-	-	-	-	-	-	✓	-
843655	X	-	-	✓	-	-	-	-	-	-	-
10d1f1	-	-	-	-	-	-	-	-	✓	-	-
ea7194	-	✓	✓	-	-	-	-	-	-	-	-
47a857	-	-	-	-	✓	-	-	-	✓	✓	✓
1e39d6	-	-	-	-	-	-	-	✓	-	-	-
35a6f1	-	-	-	-	-	-	-	-	✓	-	-
7d1d14	-	-	-	-	-	-	-	✓	-	-	-
6043e6	✓	✓	✓	✓	✓	-	-	✓	-	-	-
412c89	-	-	✓	-	-	✓	✓	-	-	-	-
0788f7	-	-	-	-	-	✓	-	-	✓	-	-
cbaf70	-	-	-	-	-	✓	-	-	-	-	-
14ad73	-	-	-	-	-	-	✓	-	-	✓	-

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*. 1997.

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

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 [%]
843655	2.1	2.4	2.3	0.1	2.3	0.15	6.74
ef77b8	5.6	5.2	5.6	0.4	5.5	0.23	4.22
6043e6	5.4	5.7	5.8	0.1	5.6	0.19	3.39
d856bb	5.8	5.7	6.0	0.5	5.8	0.15	2.62
aa7750	6.2	6.4	7.2	0.7	6.6	0.5	7.52

1.1.2 The Numerical Procedure for Determining Outliers

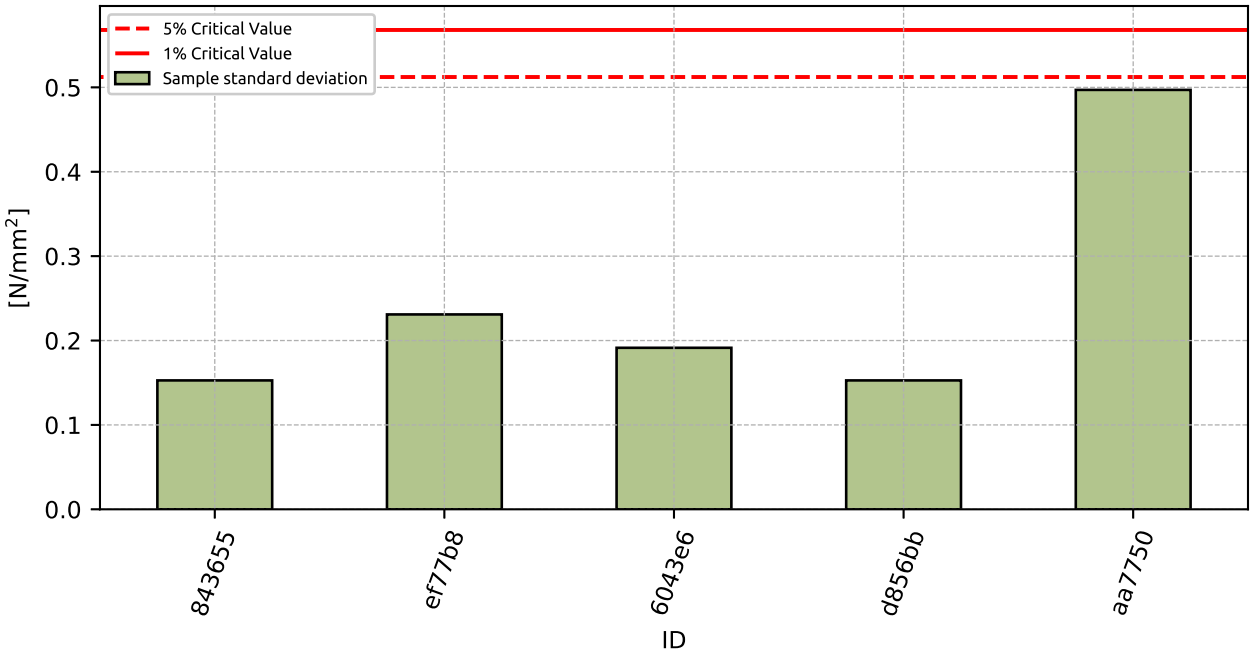

Figure 1: **Cochran's test** - sample standard deviations

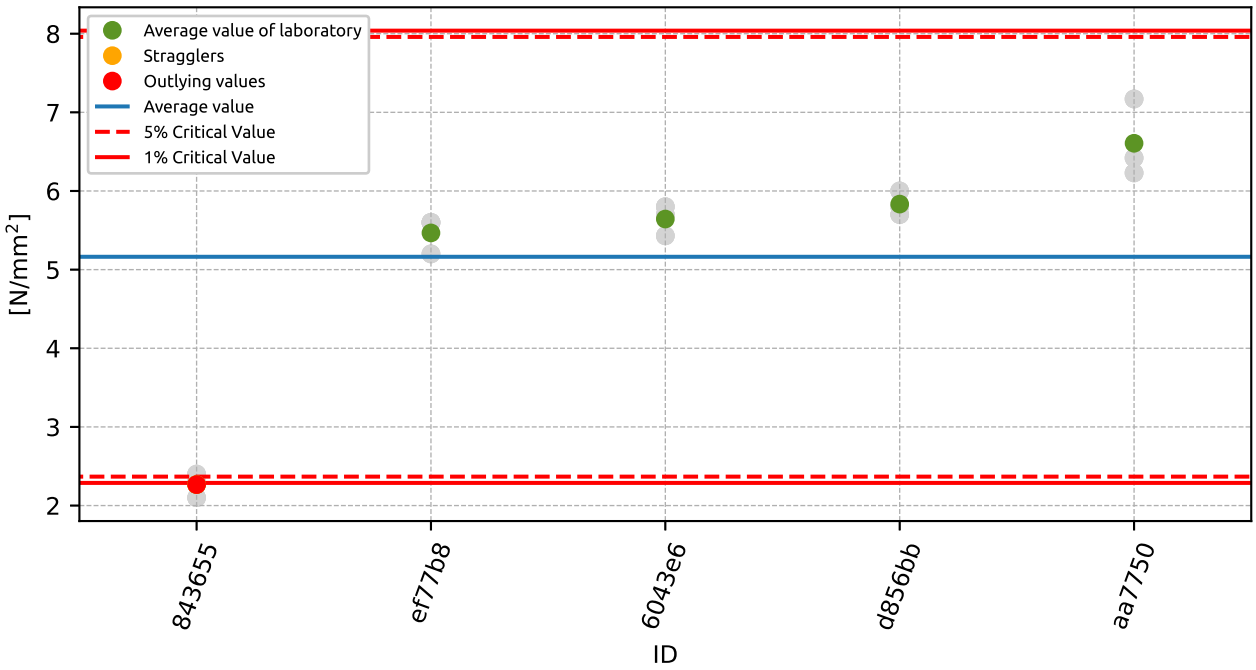

Figure 2: **Grubbs' test** - average values

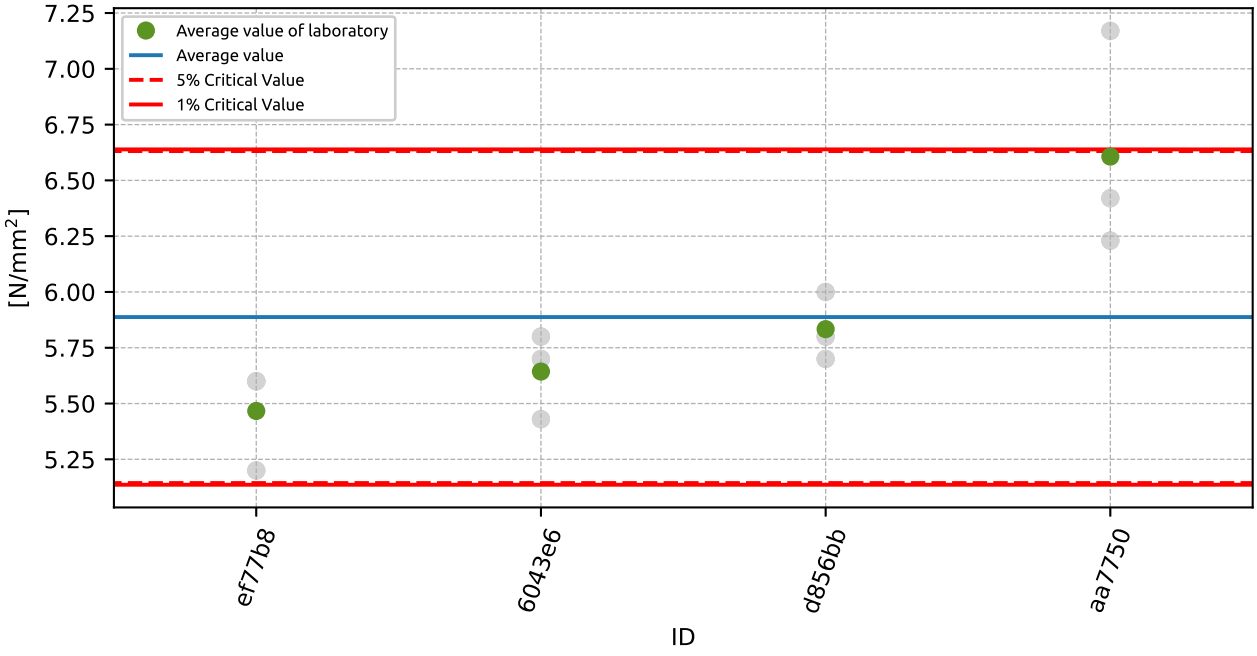

Figure 3: **Grubbs' test** - average values without outliers

1.1.3 Mandel's Statistics

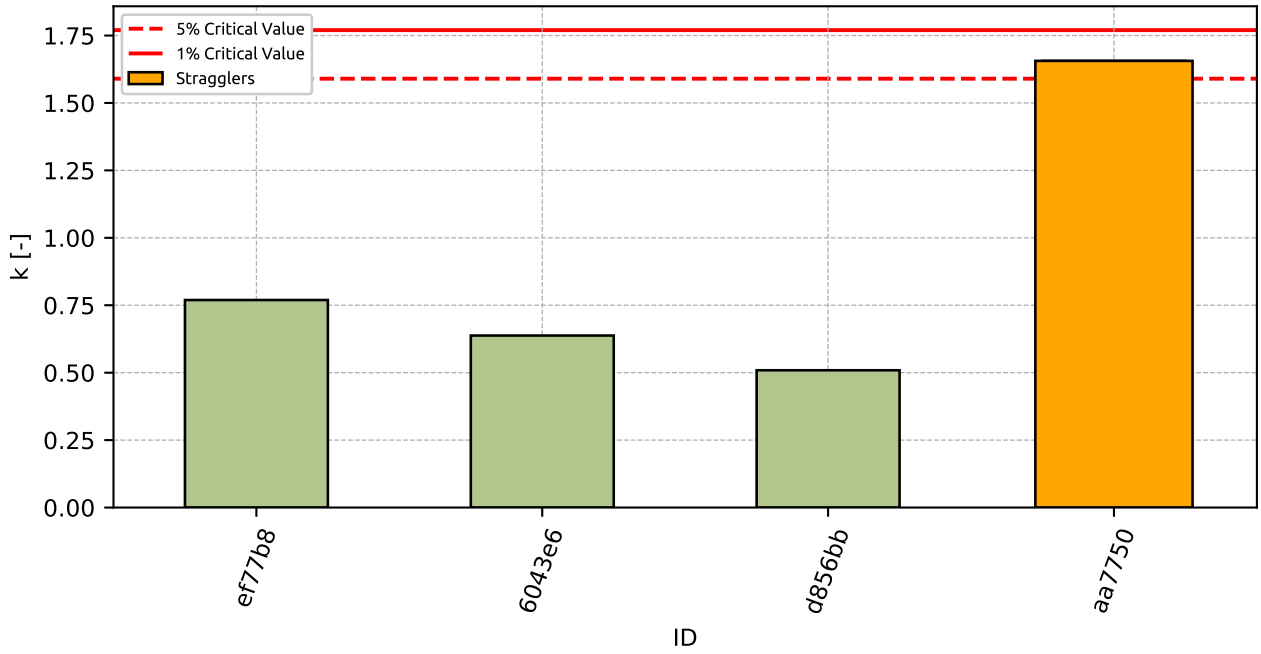

Figure 4: Intralaboratory Consistency Statistic

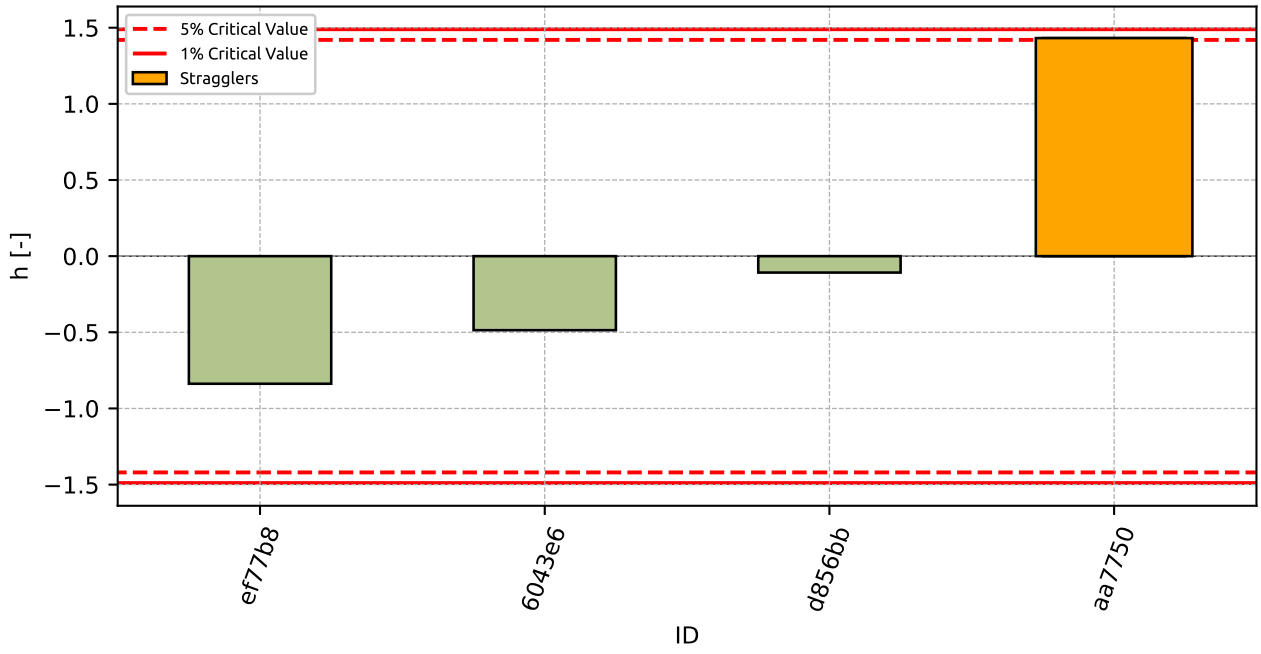

Figure 5: Interlaboratory Consistency Statistic

1.1.4 Descriptive statistics

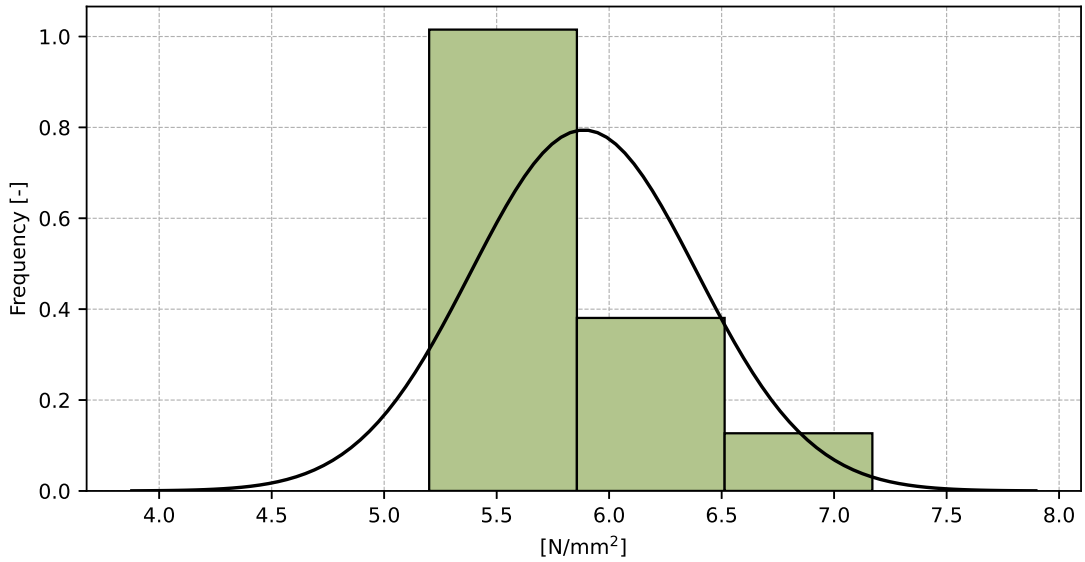

Figure 6: Histogram of all test results

Table 5: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	5.9
Sample standard deviation – s	0.5
Asigned value – x^*	5.9
Robust standard deviation – s^*	0.49
Measurement uncertainty of asigned value – u_X	0.31
p-value of normality test	0.117 [-]
Interlaboratory standard deviation – s_L	0.47
Repeatability standard deviation – s_r	0.3
Reproducibility standard deviation – s_R	0.56
Repeatability – r	0.8
Reproducibility – R	1.6

1.1.5 Evaluation of Performance Statistics

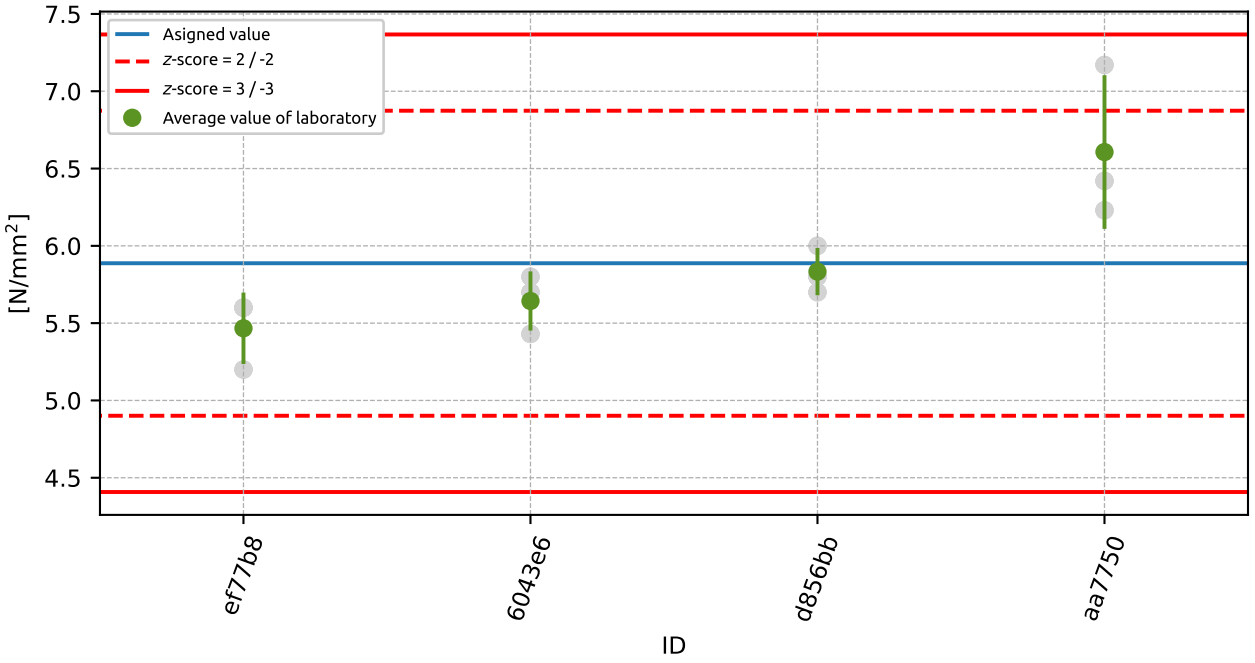

Figure 7: Average values and sample standard deviations

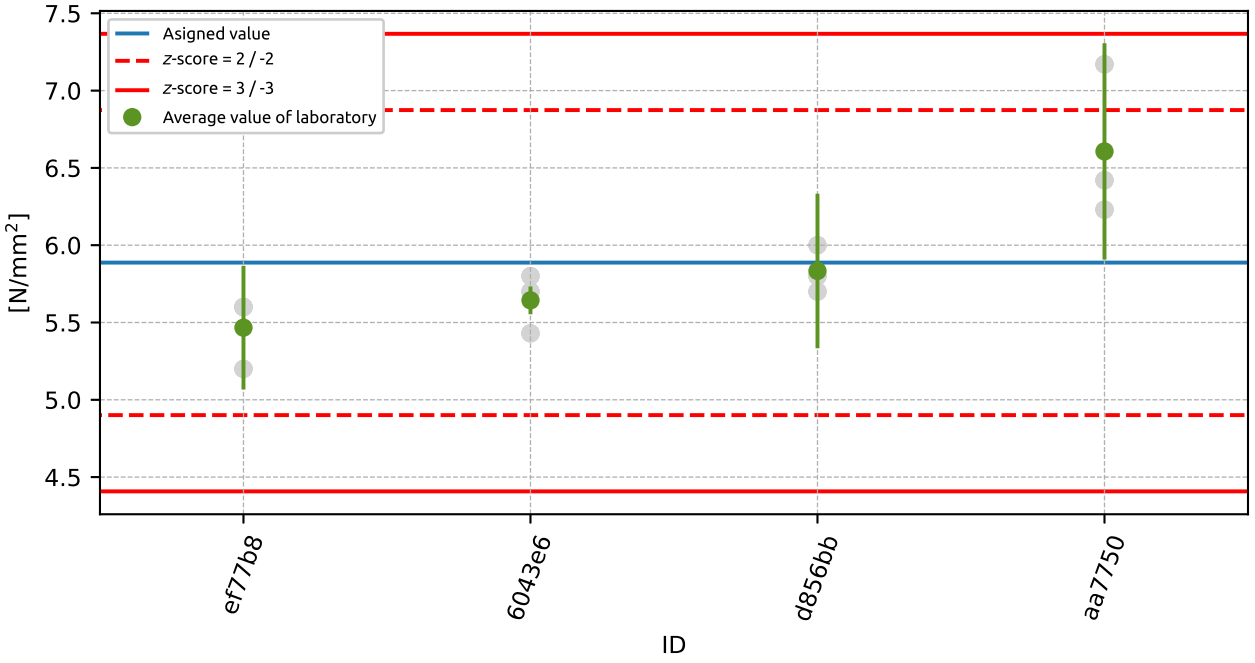

Figure 8: Average values and extended uncertainties of measurement

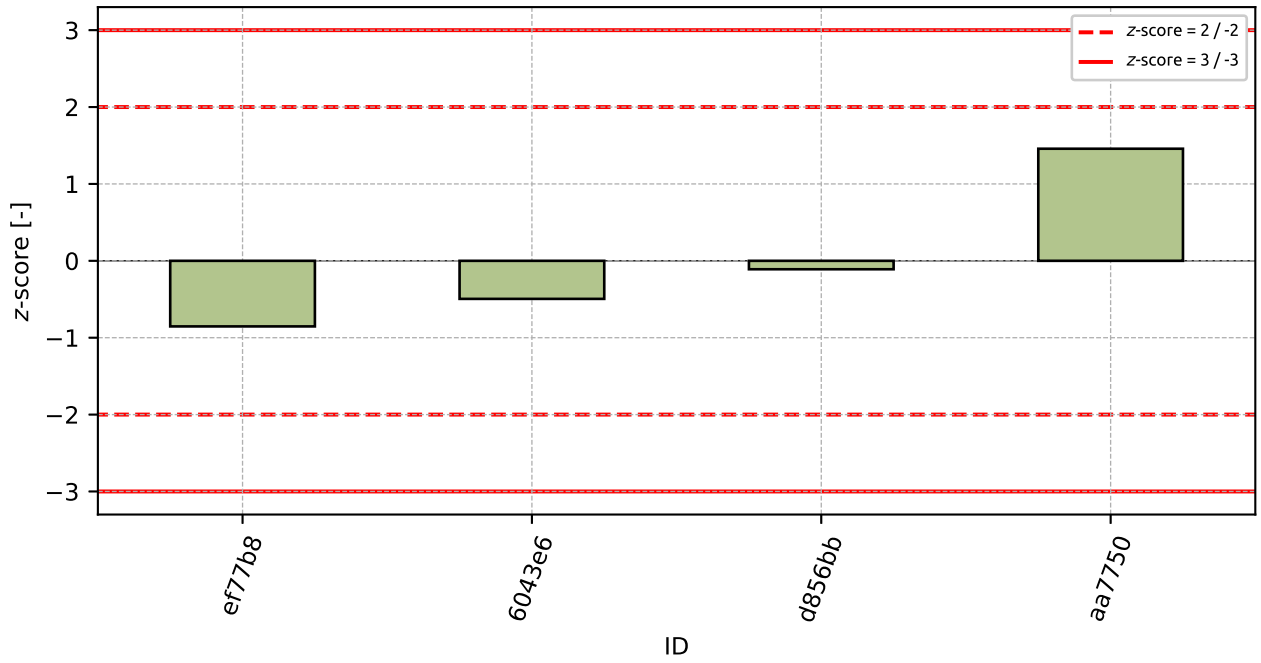

Figure 9: z-score

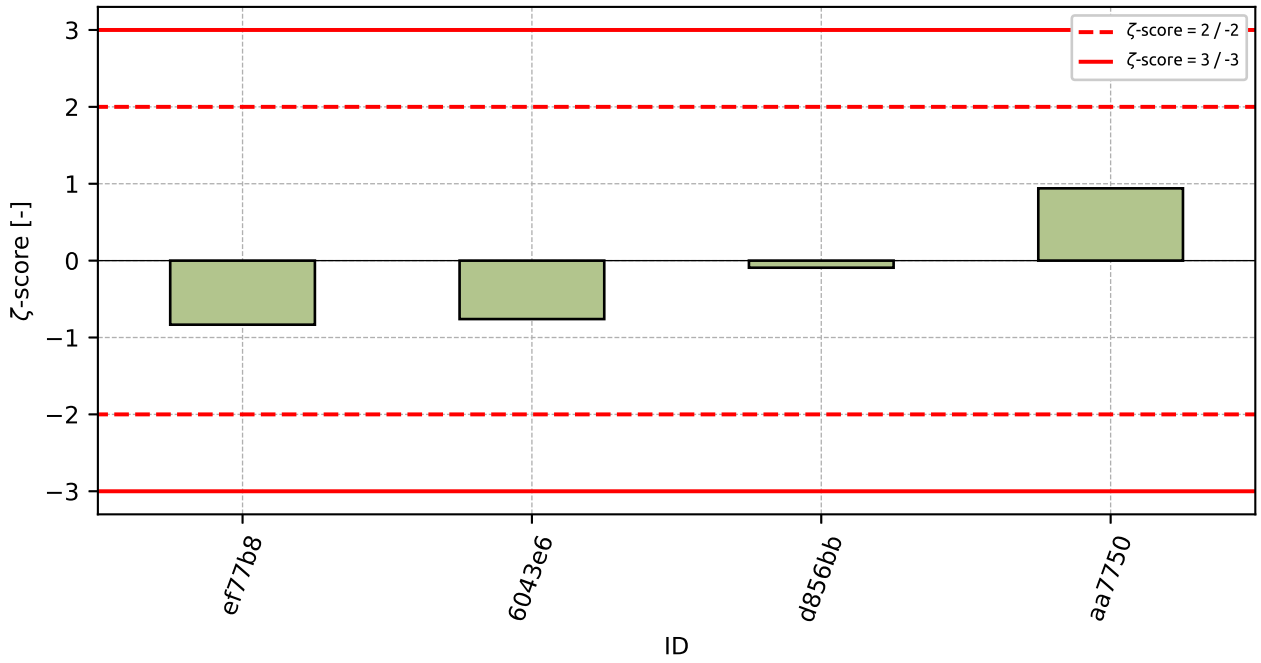

Figure 10: ζ-score

Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ef77b8	-0.85	-0.83
6043e6	-0.49	-0.76
d856bb	-0.11	-0.09
aa7750	1.46	0.94

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 [%]
843655	25.4	24.8	24.2	25.9	26.2	25.4	0.3	25.3	0.73	2.87
6043e6	30.1	29.0	30.1	28.8	29.8	30.7	0.2	29.8	0.76	2.54
ef77b8	30.9	30.1	30.7	30.0	29.4	30.9	2.0	30.3	0.6	1.99
d856bb	30.6	31.1	30.5	30.1	31.0	30.1	0.9	30.6	0.43	1.4
aa7750	31.9	30.6	31.9	31.2	31.6	31.6	1.4	31.5	0.47	1.49

1.2.2 The Numerical Procedure for Determining Outliers

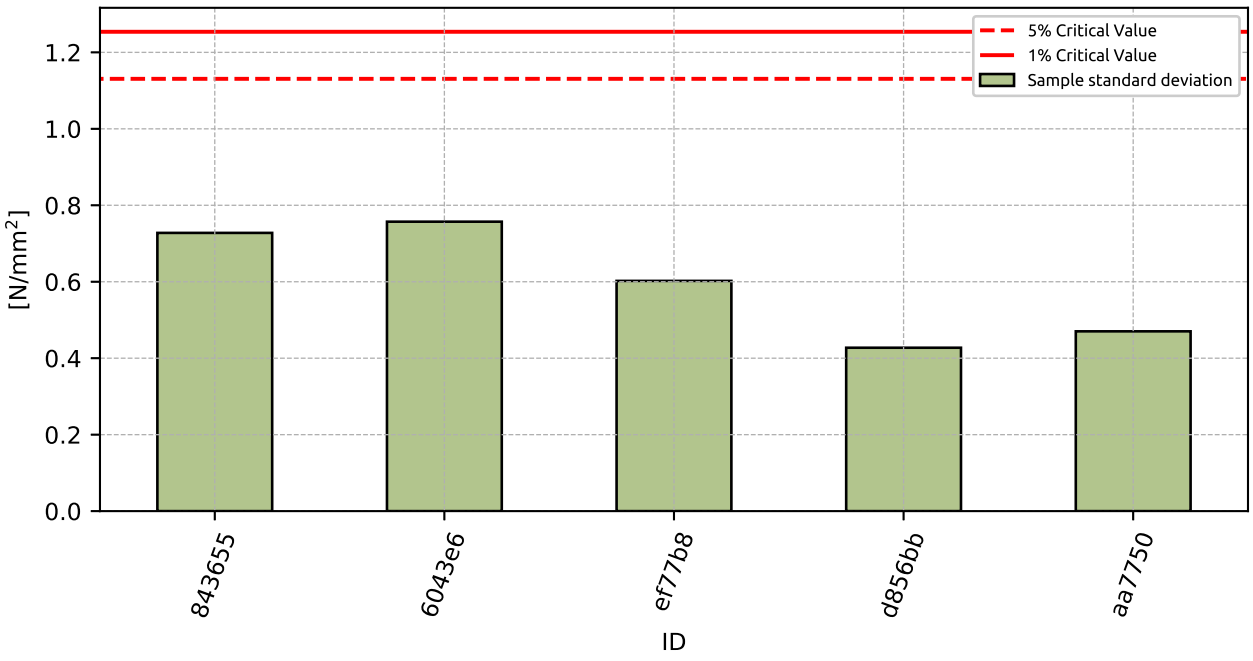

Figure 11: **Cochran's test** - sample standard deviations

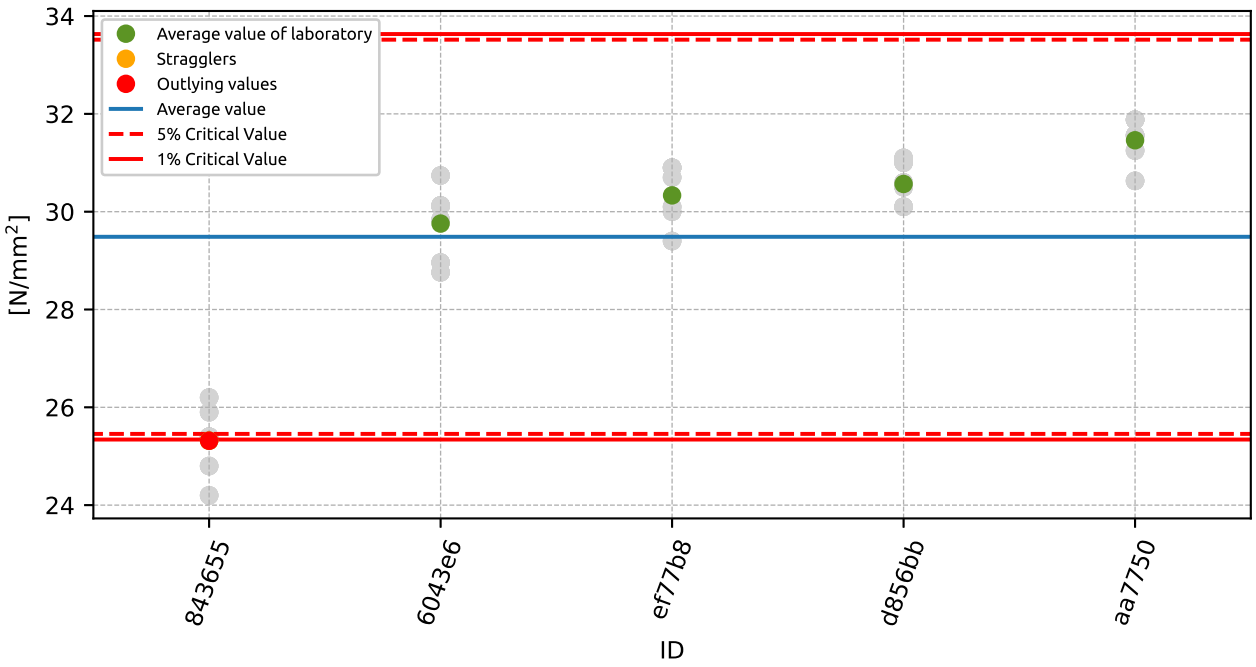

Figure 12: **Grubbs' test** - average values

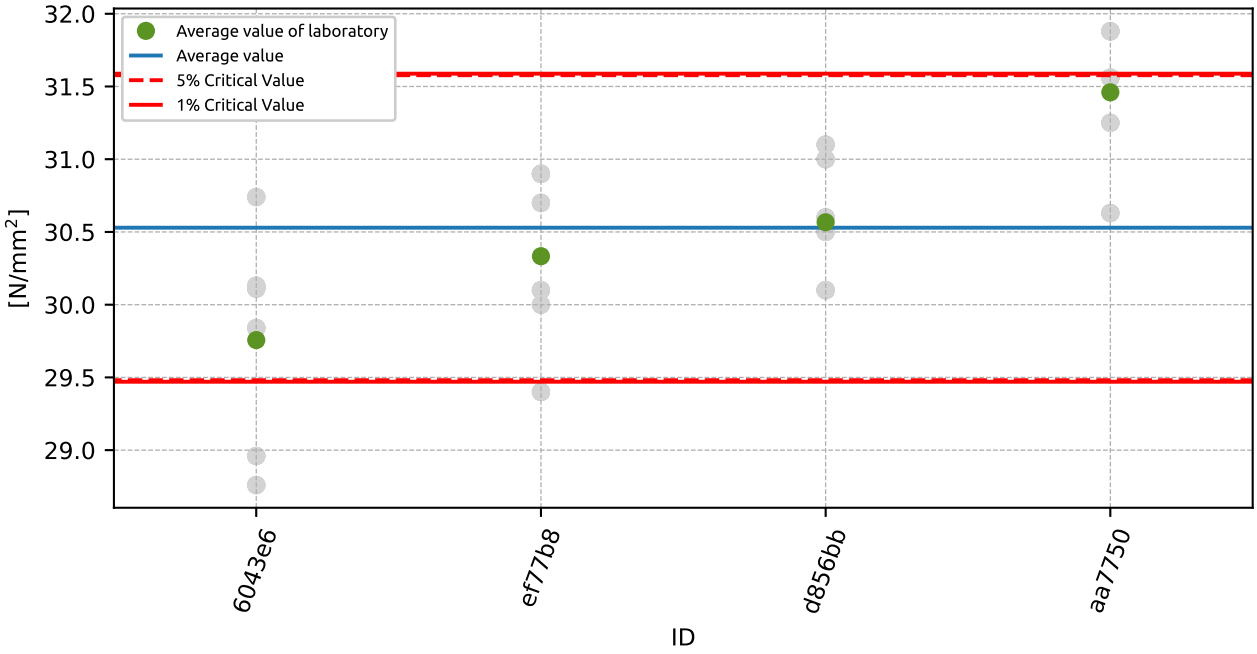

Figure 13: **Grubbs' test** - average values without outliers

1.2.3 Mandel's Statistics

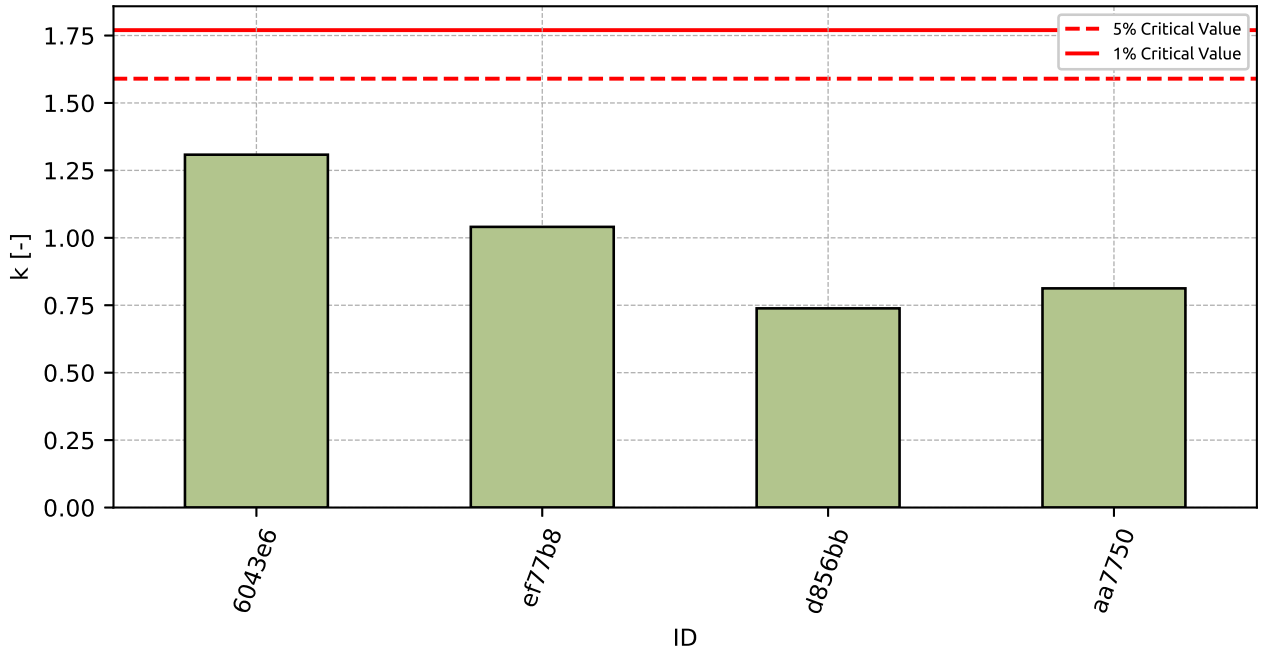

Figure 14: Intralaboratory Consistency Statistic

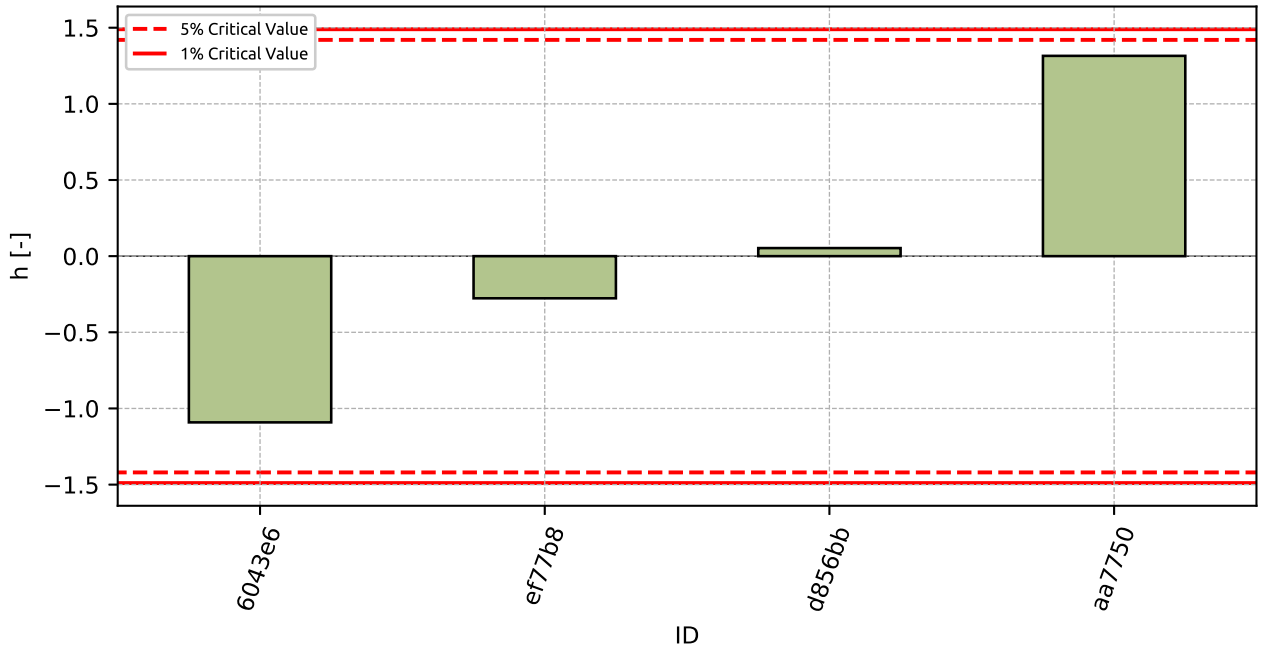

Figure 15: Interlaboratory Consistency Statistic

1.2.4 Descriptive statistics

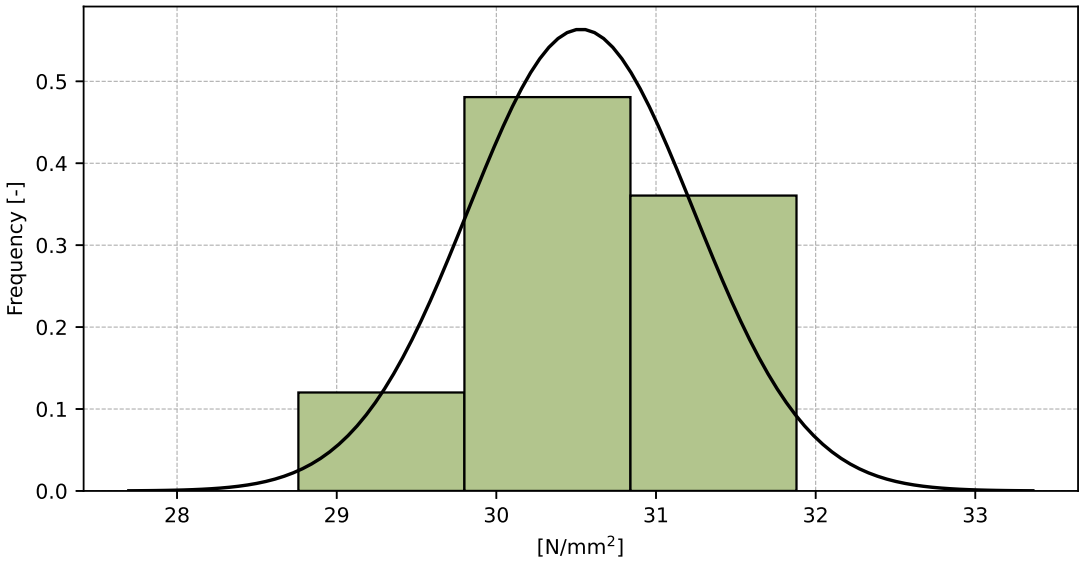

Figure 16: Histogram of all test results

Table 8: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	30.5
Sample standard deviation – s	0.71
Asigned value – x^*	30.5
Robust standard deviation – s^*	0.7
Measurement uncertainty of asigned value – u_X	0.43
p-value of normality test	0.593 [-]
Interlaboratory standard deviation – s_L	0.67
Repeatability standard deviation – s_r	0.58
Reproducibility standard deviation – s_R	0.88
Repeatability – r	1.6
Reproducibility – R	2.5

1.2.5 Evaluation of Performance Statistics

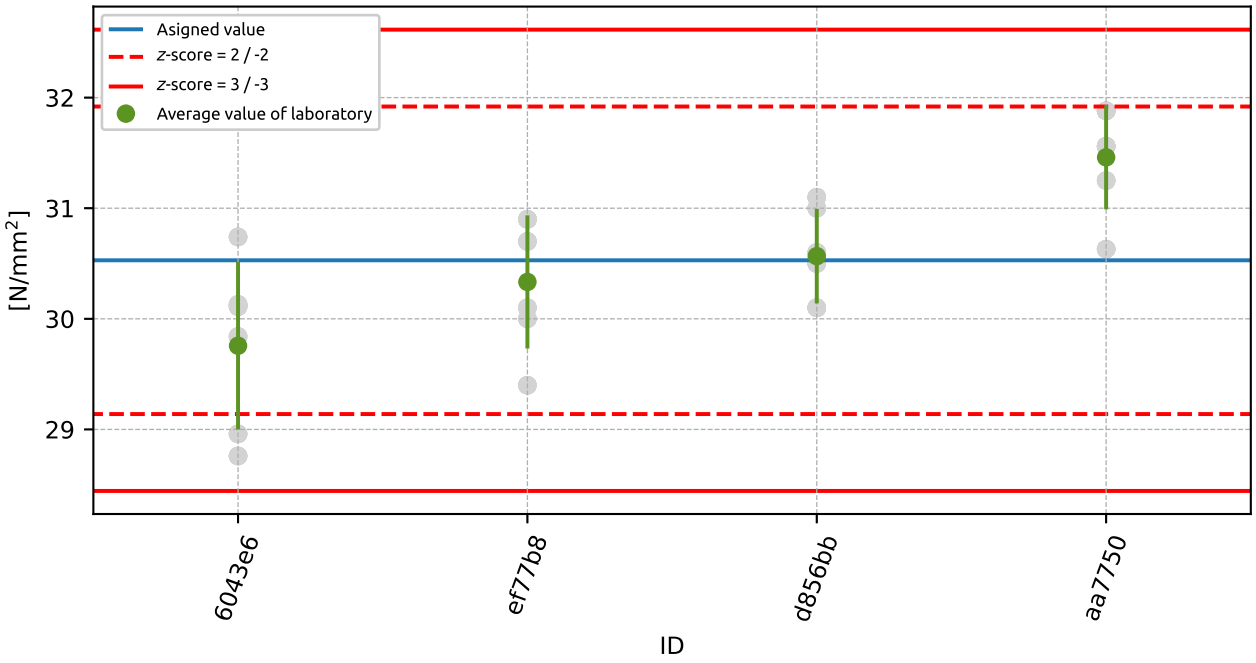

Figure 17: Average values and sample standard deviations

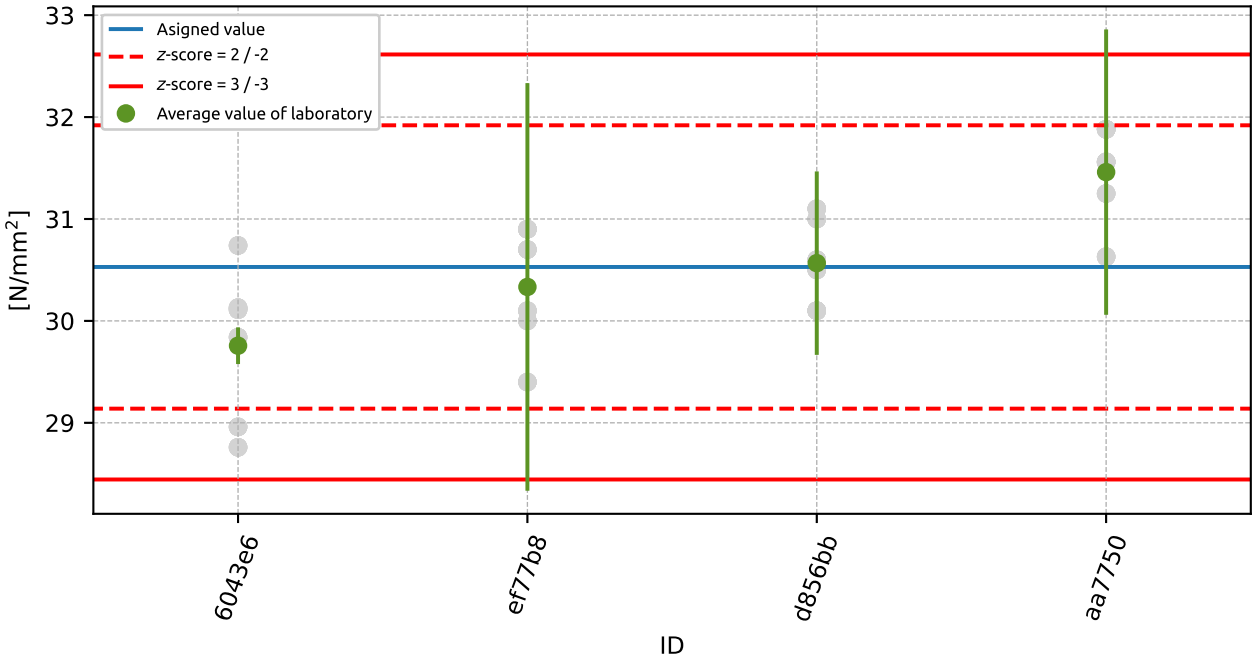

Figure 18: Average values and extended uncertainties of measurement

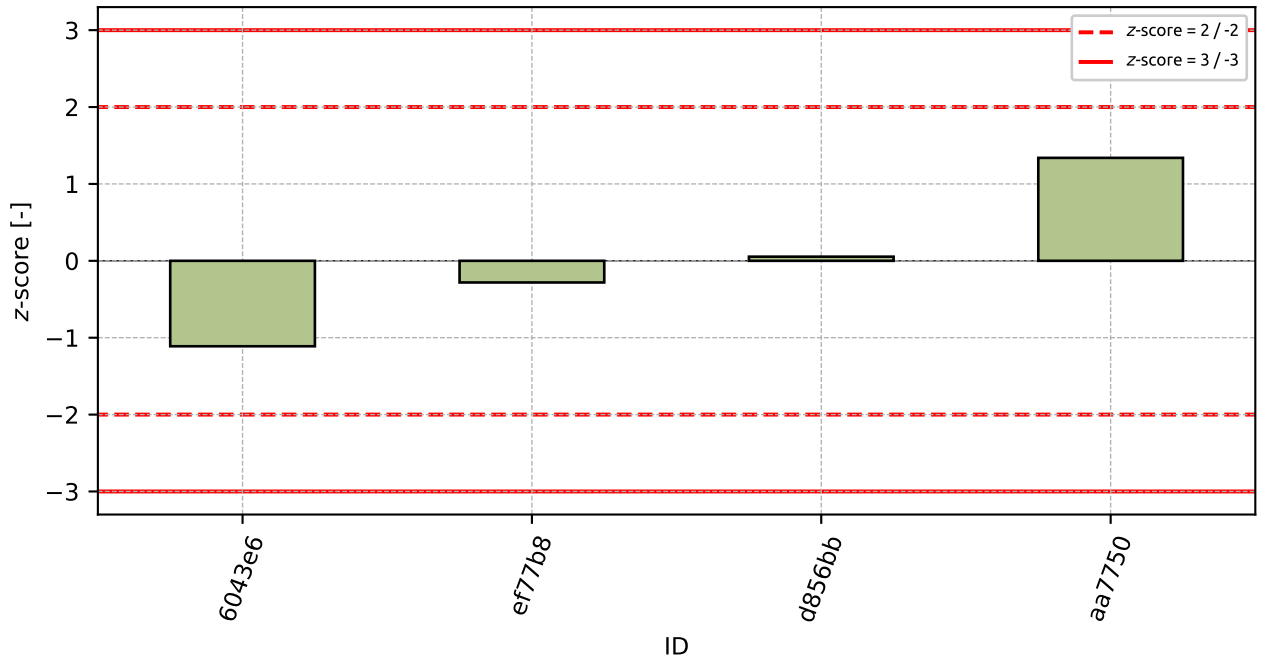

Figure 19: z-score

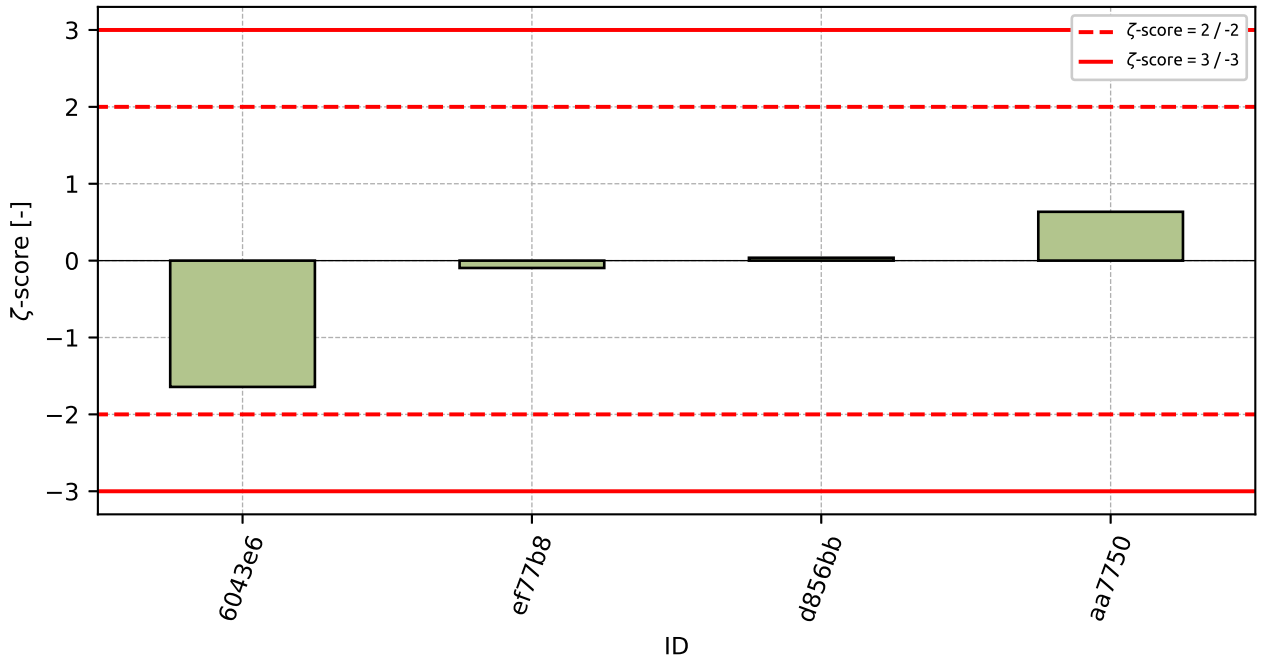

Figure 20: ζ-score

Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
6043e6	-1.11	-1.64
ef77b8	-0.28	-0.1
d856bb	0.05	0.04
aa7750	1.34	0.64

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 [%]
843655	5.0	4.8	4.7	0.2	4.8	0.15	3.16
6043e6	6.7	7.1	6.9	0.1	6.9	0.21	3.05
ef77b8	7.4	7.4	7.6	0.5	7.5	0.12	1.55
d856bb	8.0	7.4	7.0	1.3	7.5	0.5	6.74
aa7750	8.8	8.6	9.0	0.5	8.8	0.23	2.55

1.3.2 The Numerical Procedure for Determining Outliers

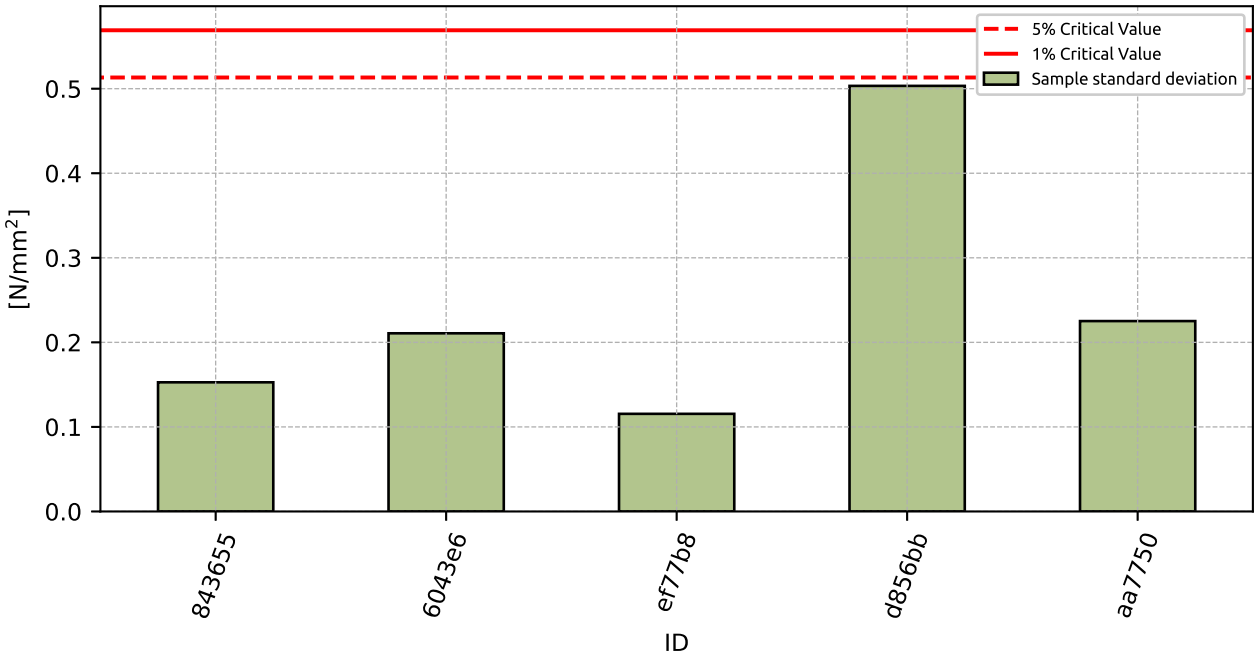

Figure 21: **Cochran's test** - sample standard deviations

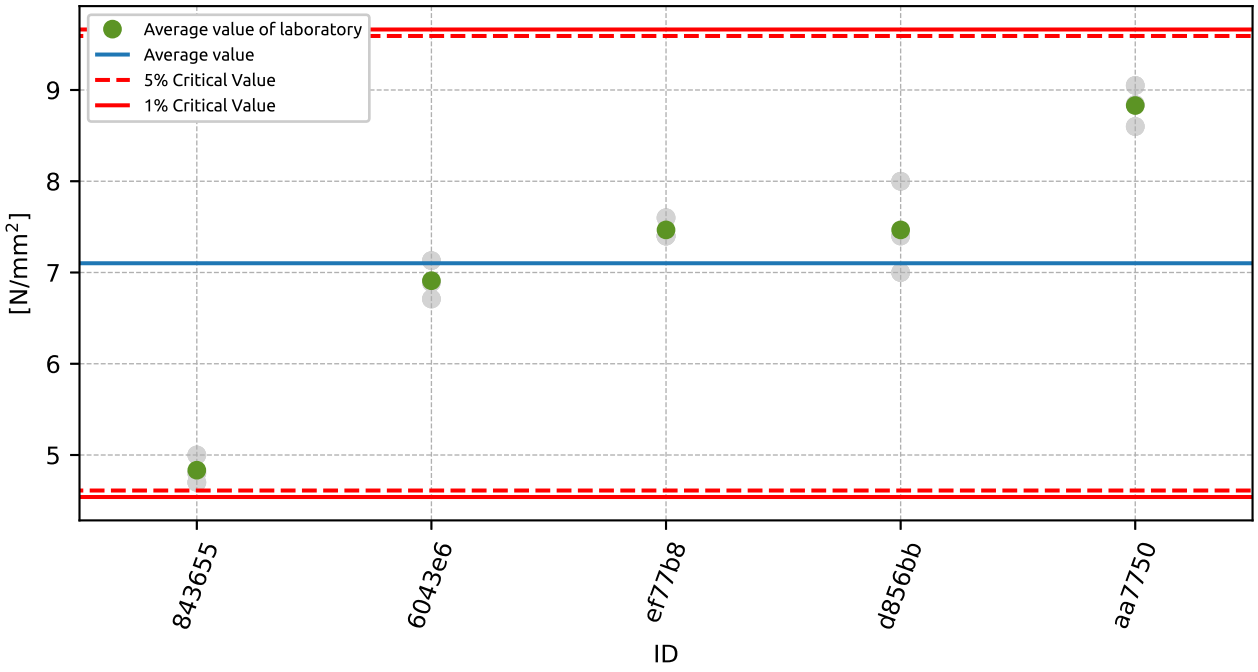

Figure 22: **Grubbs' test** - average values

1.3.3 Mandel's Statistics

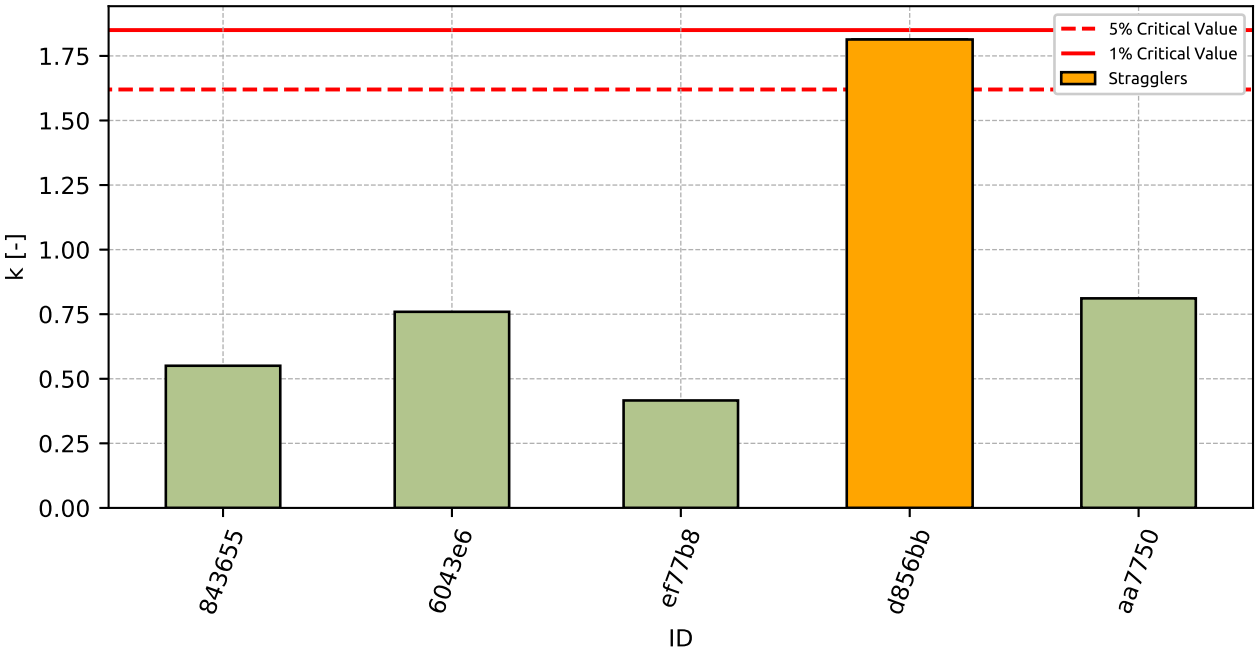

Figure 23: Intralaboratory Consistency Statistic

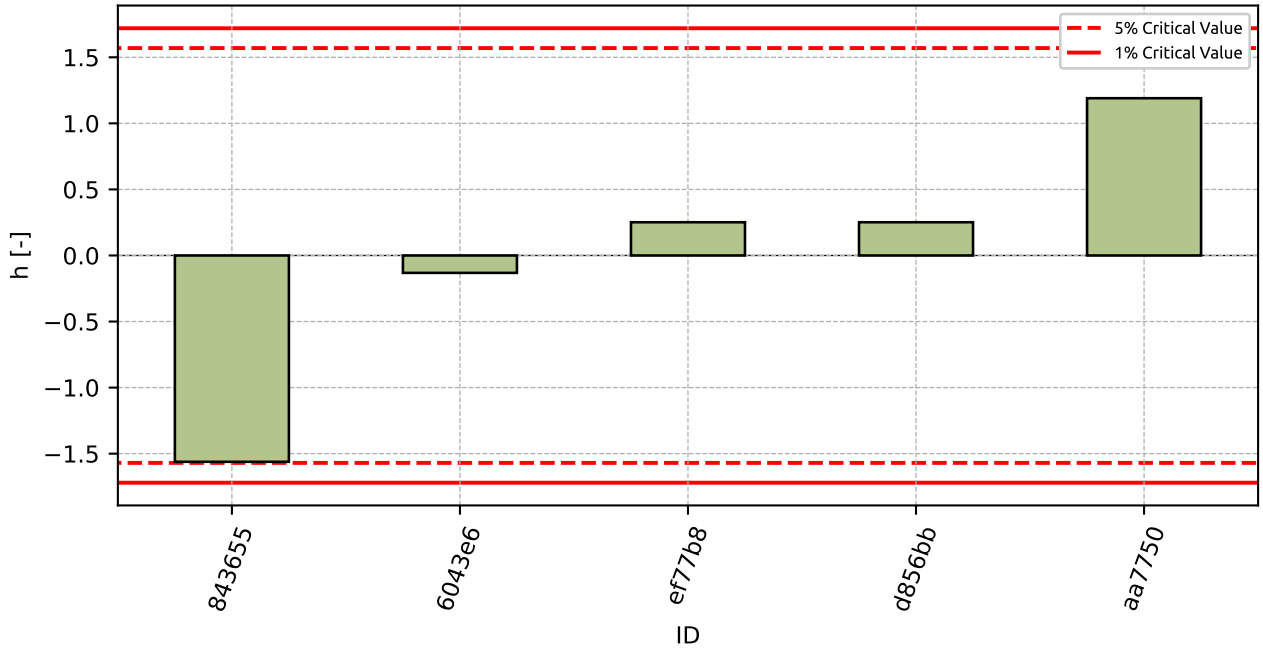

Figure 24: Interlaboratory Consistency Statistic

1.3.4 Descriptive statistics

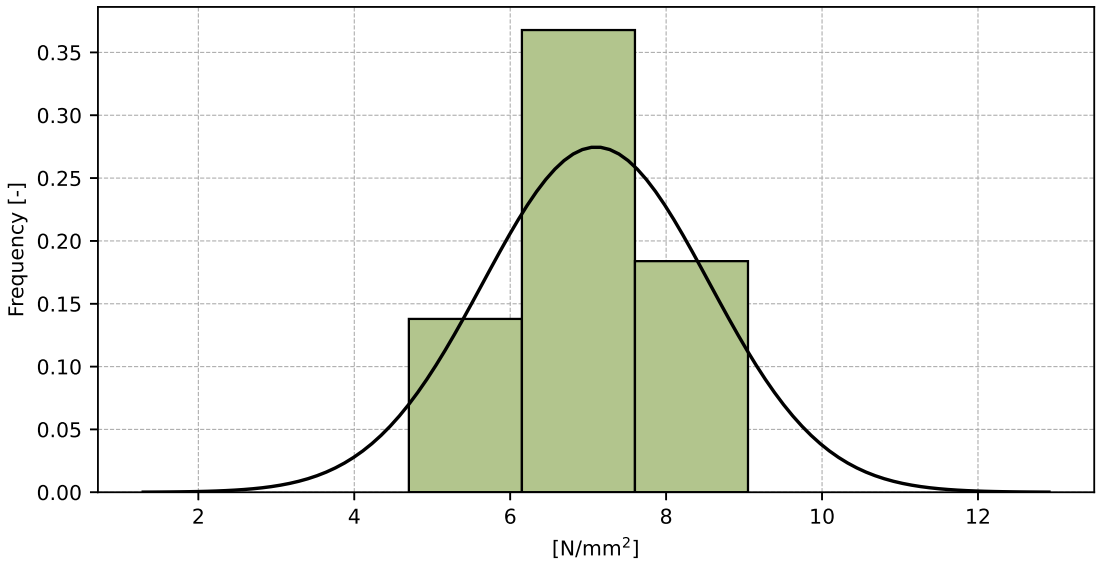

Figure 25: Histogram of all test results

Table 11: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	7.1
Sample standard deviation – s	1.45
Asigned value – x^*	7.4
Robust standard deviation – s^*	0.97
Measurement uncertainty of asigned value – u_X	0.54
p-value of normality test	0.115 [-]
Interlaboratory standard deviation – s_L	1.44
Repeatability standard deviation – s_r	0.28
Reproducibility standard deviation – s_R	1.47
Repeatability – r	0.8
Reproducibility – R	4.1

1.3.5 Evaluation of Performance Statistics

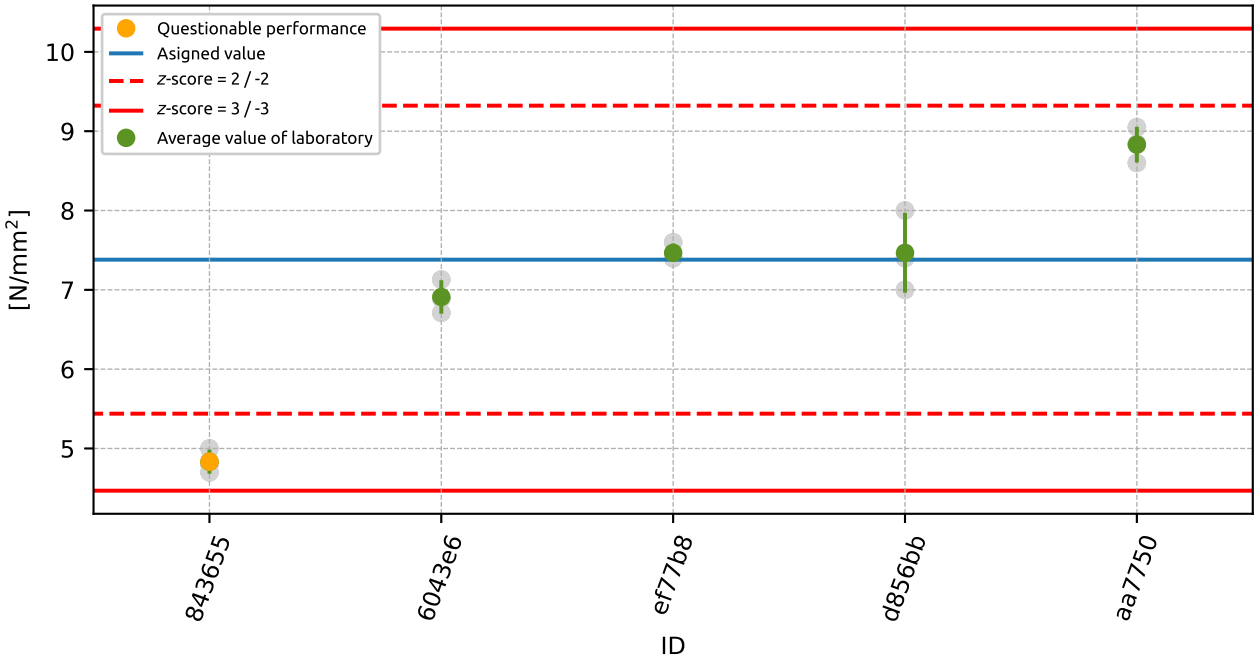

Figure 26: Average values and sample standard deviations

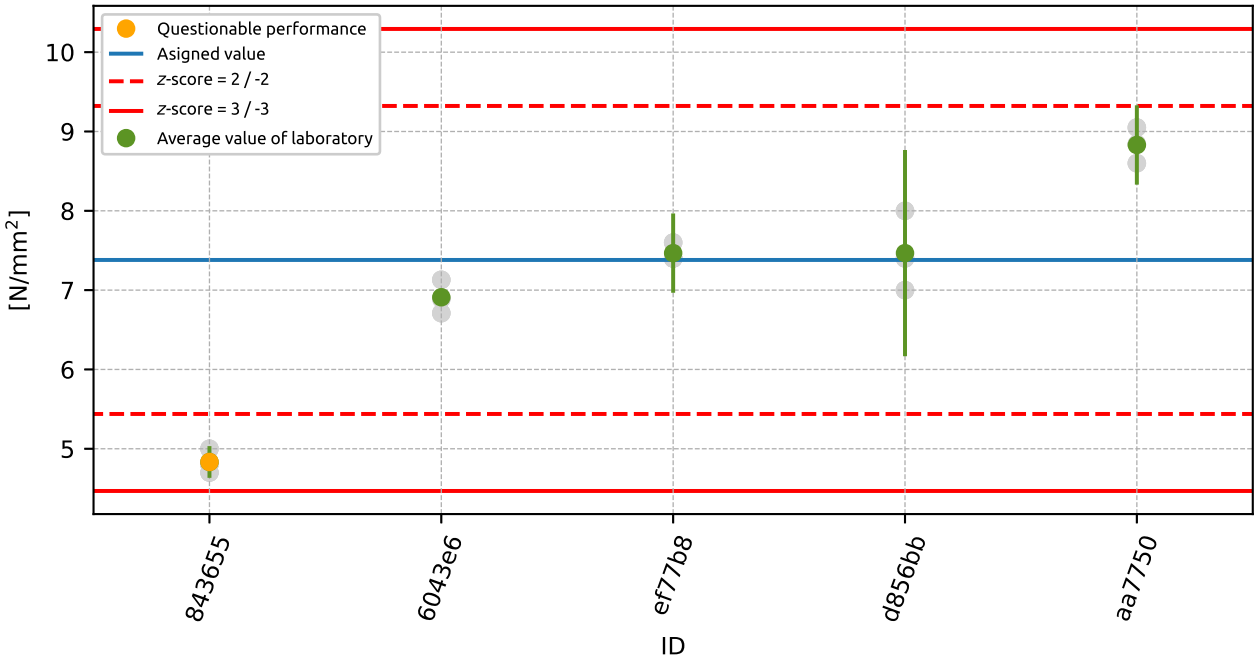

Figure 27: Average values and extended uncertainties of measurement

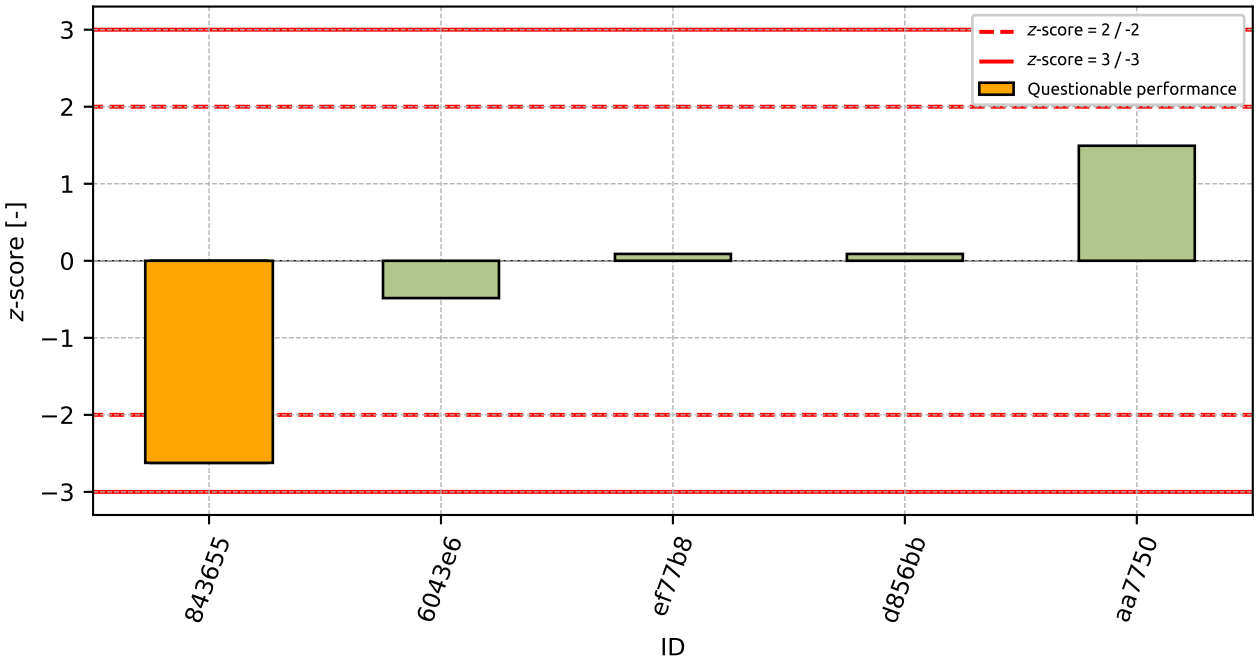

Figure 28: z-score

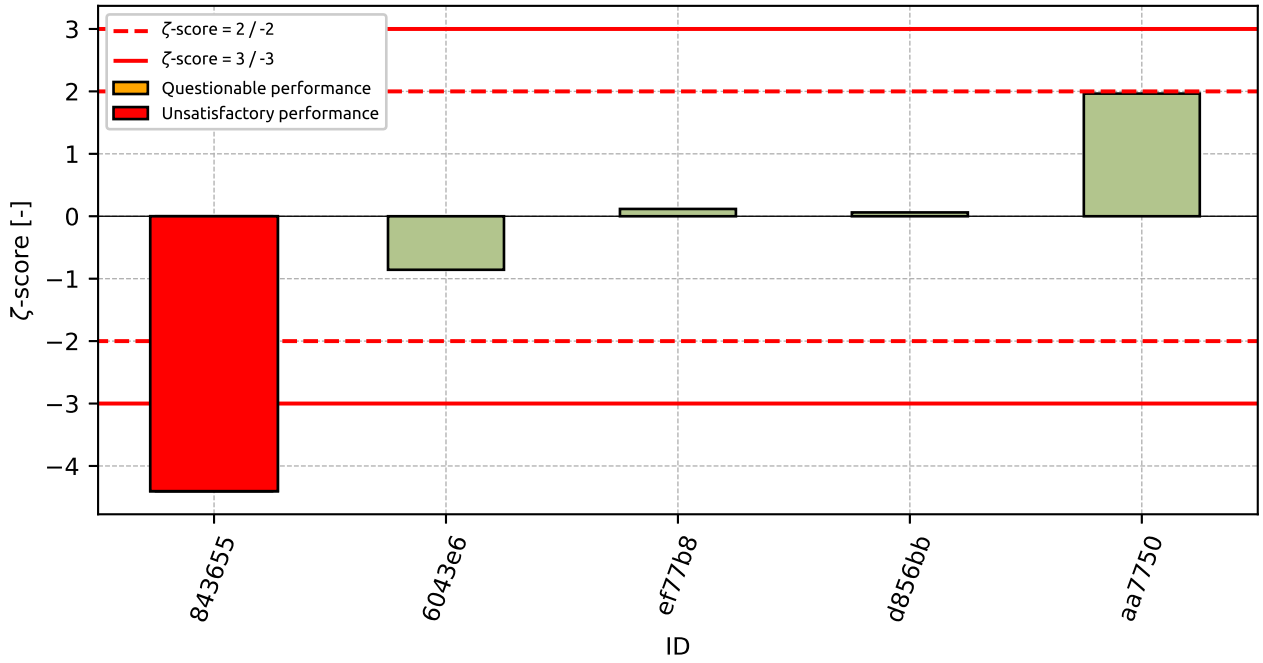

Figure 29: ζ-score

Table 12: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
843655	-2.62	-4.4
6043e6	-0.48	-0.86
ef77b8	0.09	0.12
d856bb	0.09	0.06
aa7750	1.49	1.96

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/mm^2]						u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
843655	44.1	44.5	44.7	45.0	45.2	45.0	0.5	44.8	0.4	0.9
6043e6	47.2	45.2	46.0	47.1	47.0	46.2	0.2	46.5	0.78	1.69
d856bb	51.3	50.3	50.1	49.8	51.2	51.0	1.3	50.6	0.63	1.25
aa7750	51.2	48.4	52.2	50.6	52.8	50.9	2.4	51.0	1.51	2.96
ef77b8	52.3	52.4	53.1	52.6	50.1	53.1	3.0	52.3	1.11	2.13

1.4.2 The Numerical Procedure for Determining Outliers

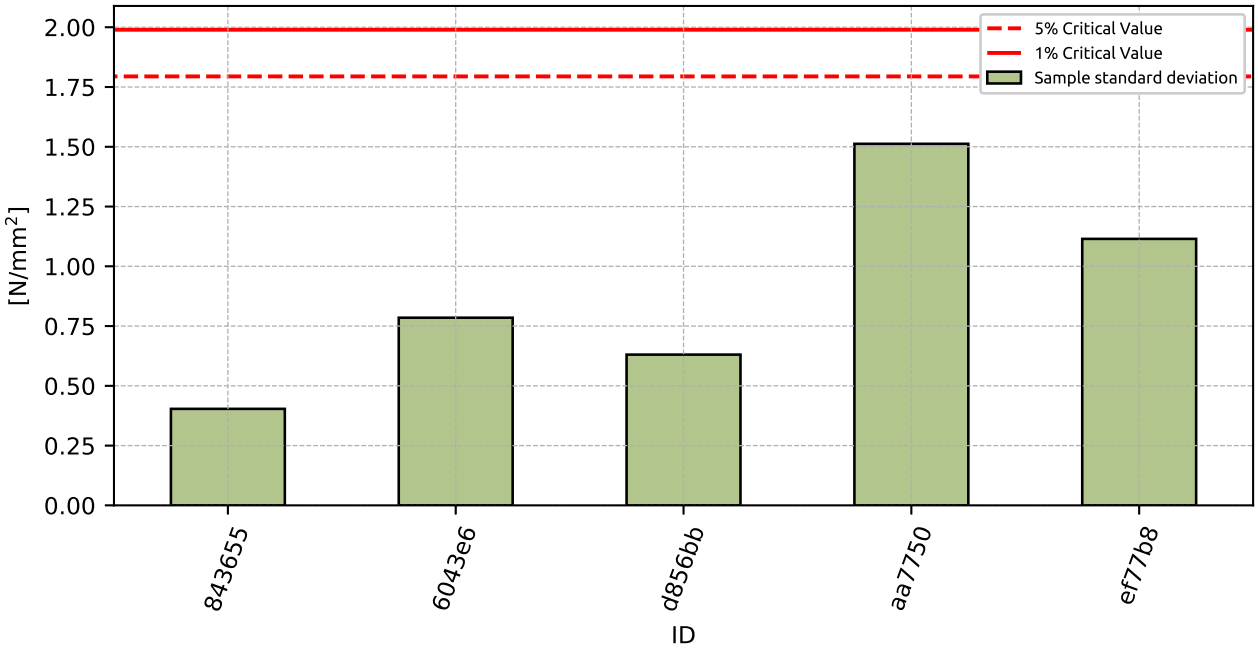

Figure 30: **Cochran's test** - sample standard deviations

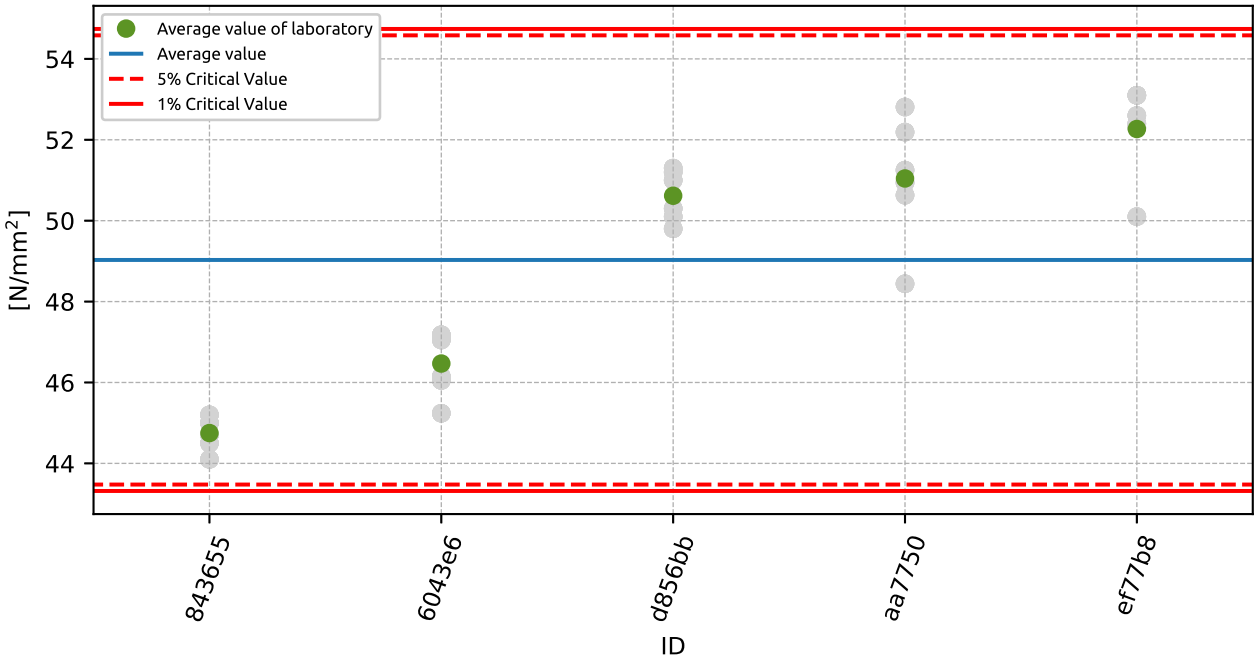

Figure 31: **Grubbs' test** - average values

1.4.3 Mandel's Statistics

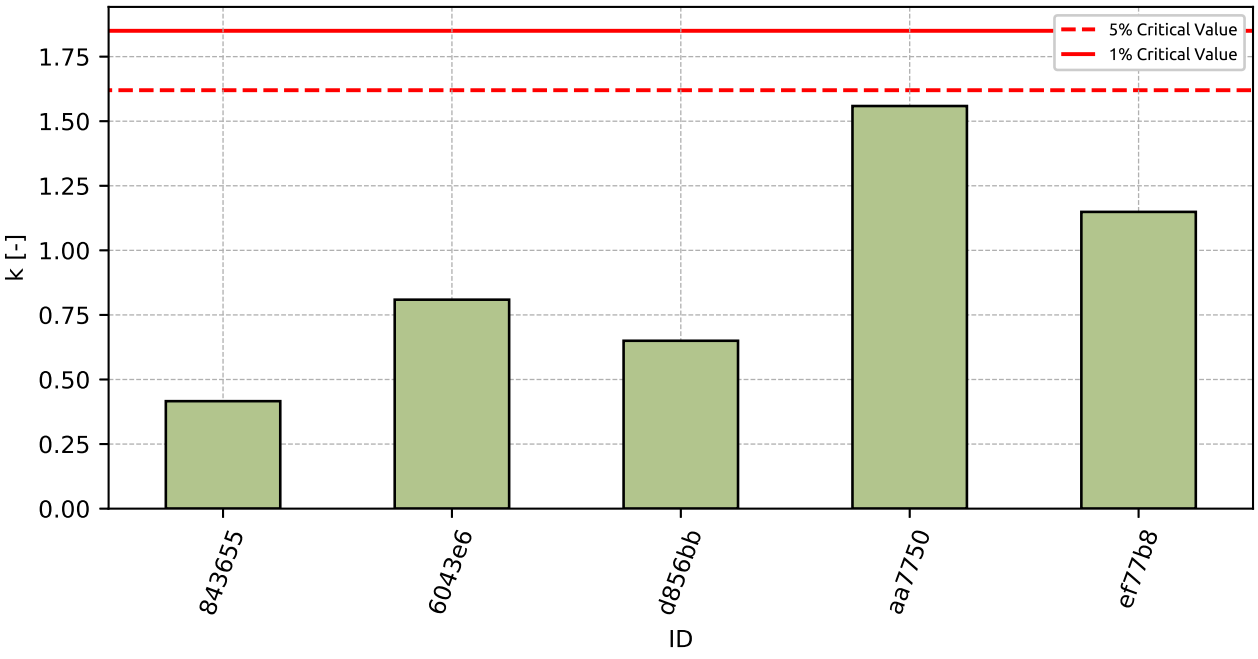

Figure 32: Intralaboratory Consistency Statistic

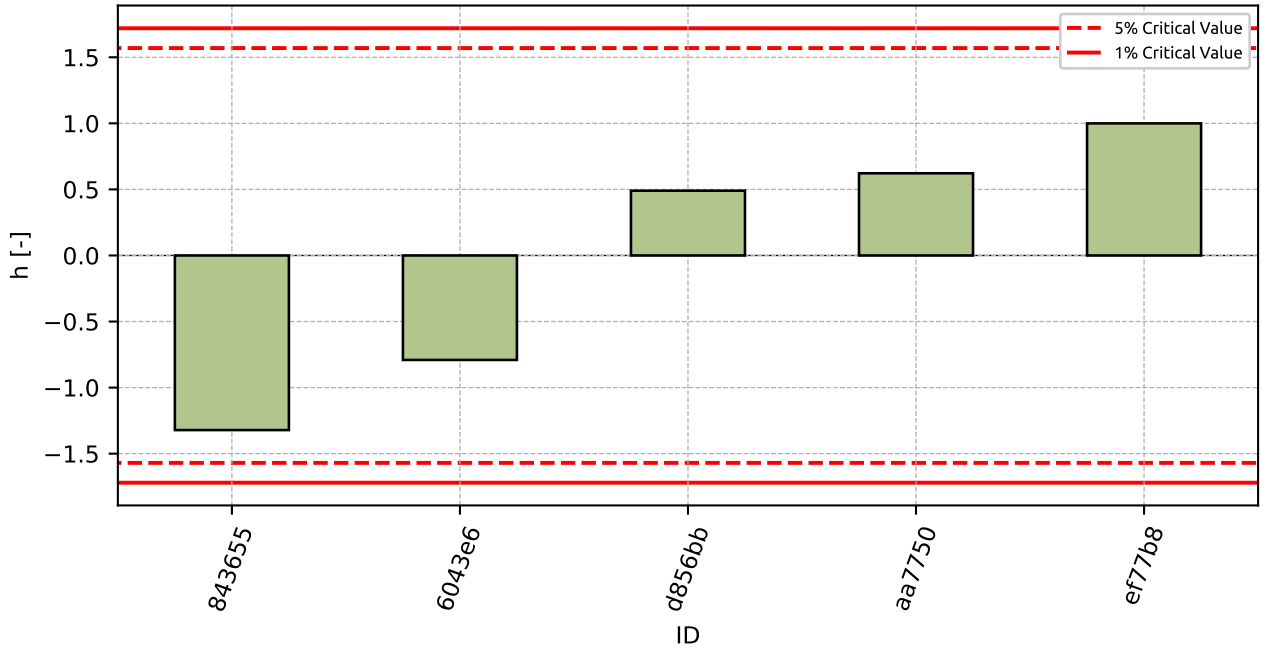

Figure 33: Interlaboratory Consistency Statistic

1.4.4 Descriptive statistics

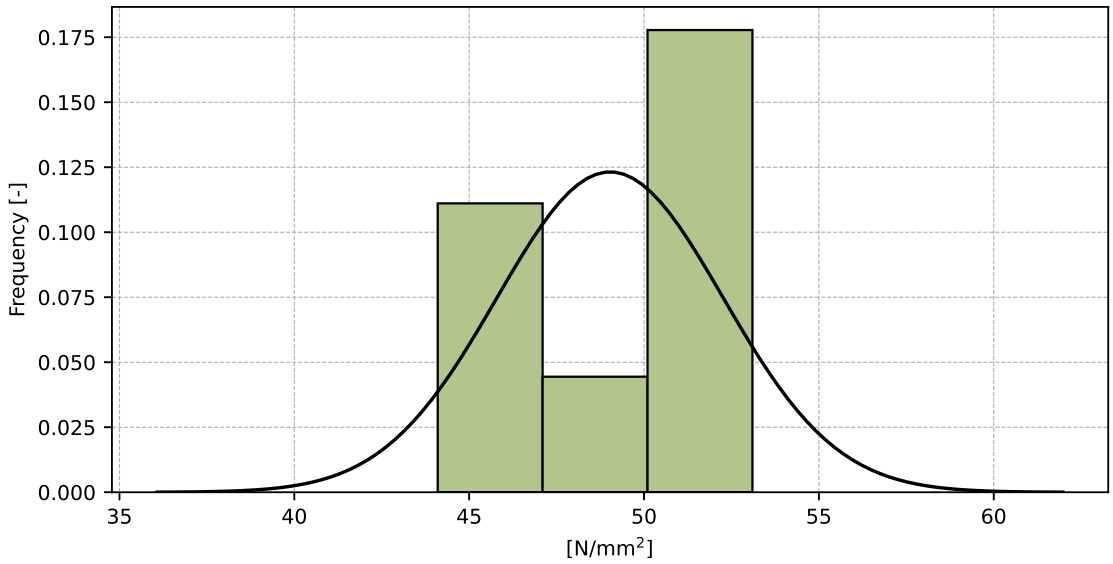

Figure 34: Histogram of all test results

Table 14: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	49.0
Sample standard deviation – s	3.24
Asigned value – x^*	49.6
Robust standard deviation – s^*	2.5
Measurement uncertainty of asigned value – u_X	1.4
p-value of normality test	0.006 [-]
Interlaboratory standard deviation – s_L	3.21
Repeatability standard deviation – s_r	0.97
Reproducibility standard deviation – s_R	3.36
Repeatability – r	2.7
Reproducibility – R	9.4

1.4.5 Evaluation of Performance Statistics

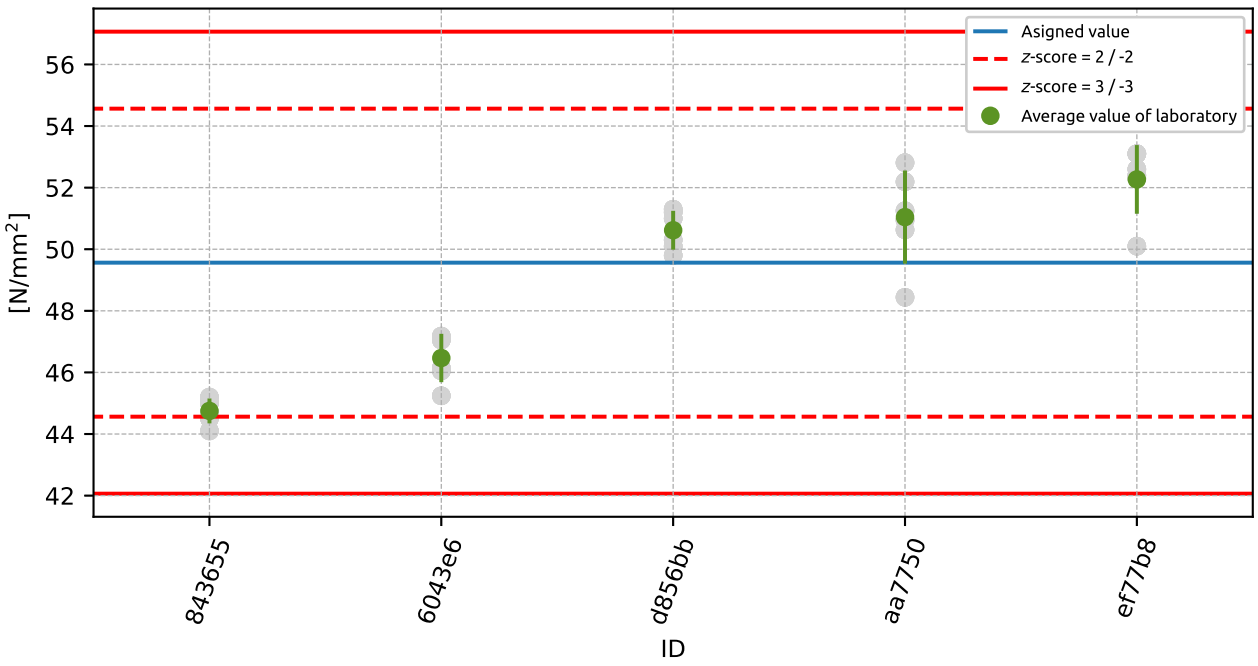

Figure 35: Average values and sample standard deviations

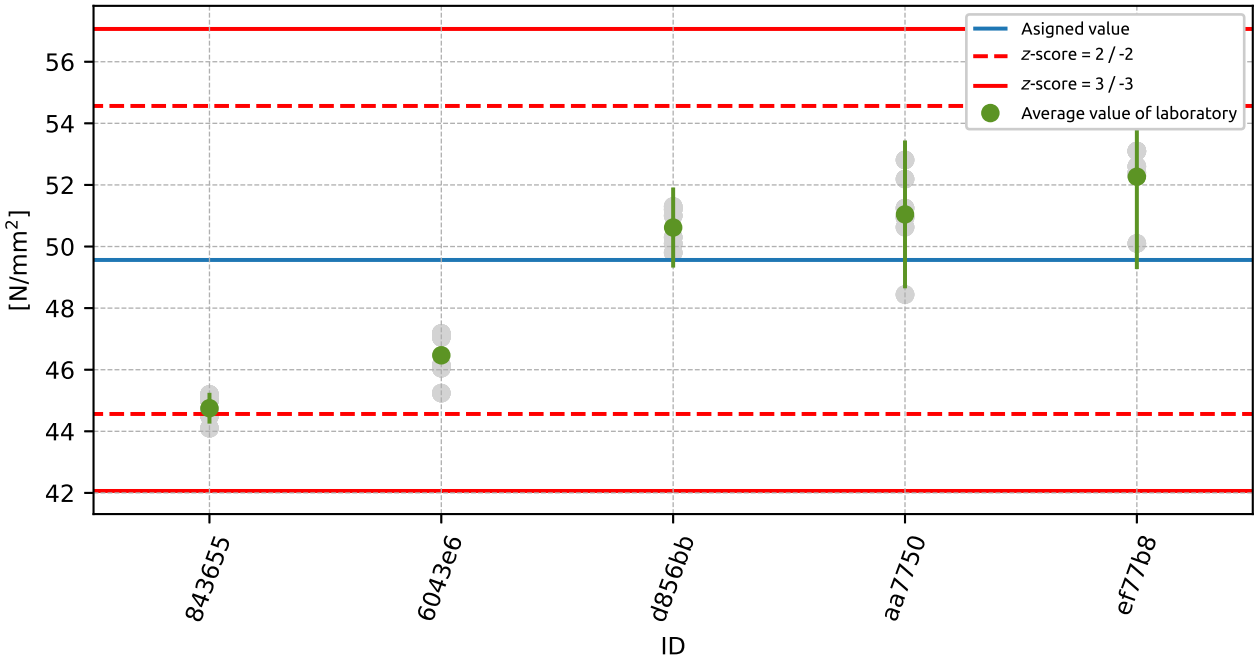

Figure 36: Average values and extended uncertainties of measurement

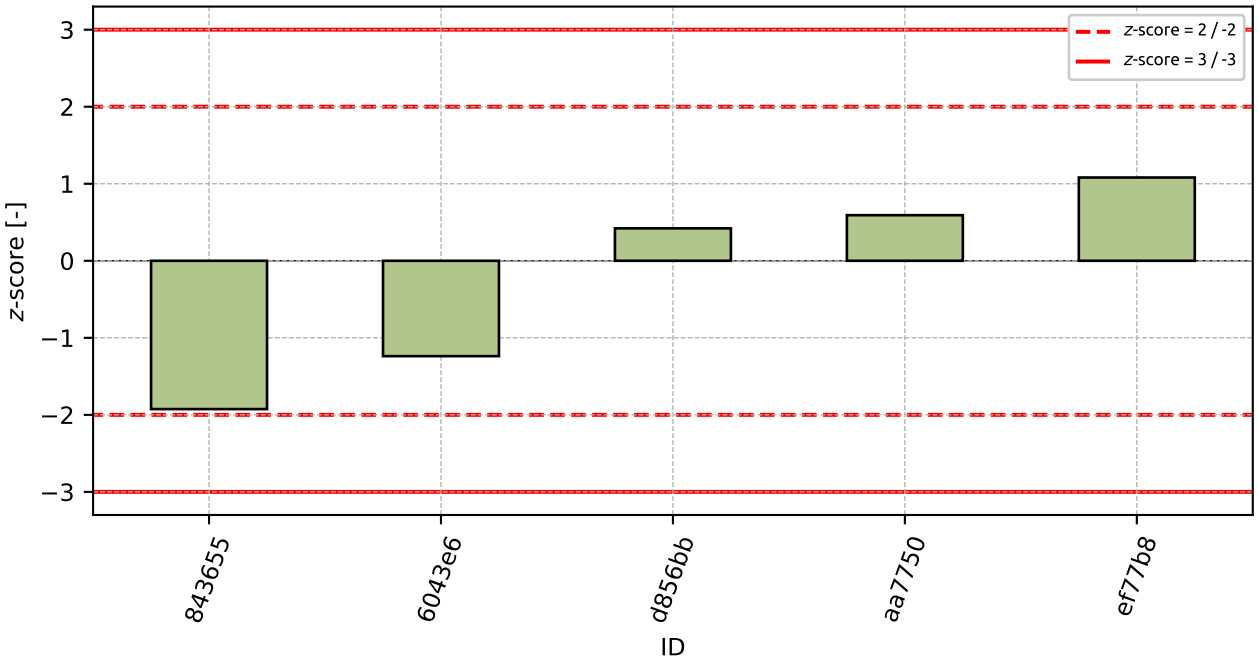

Figure 37: z-score

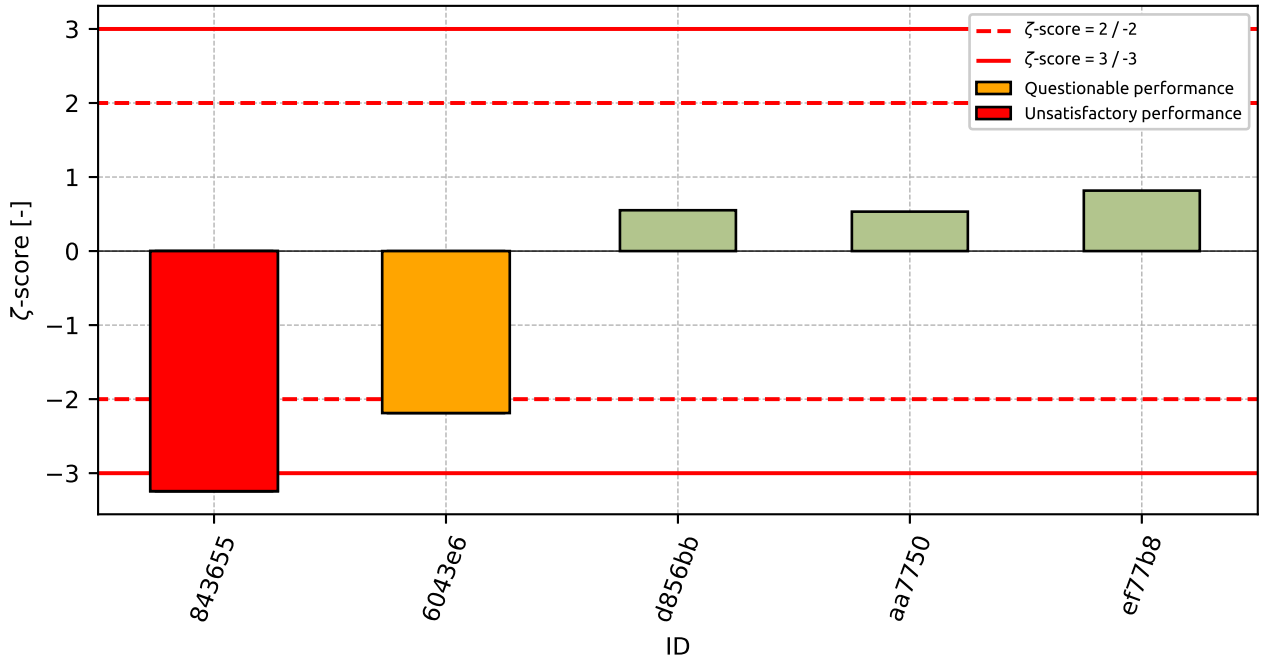

Figure 38: ζ-score

Table 15: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
843655	-1.93	-3.24
6043e6	-1.24	-2.19
d856bb	0.42	0.55
aa7750	0.59	0.53
ef77b8	1.08	0.82

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 [%]
830fc9	6.9	7.7	6.8	0.1	7.1	0.49	6.92
ef77b8	7.6	7.9	8.6	0.5	8.0	0.51	6.39
6043e6	8.2	8.5	8.2	0.1	8.3	0.15	1.85
d856bb	8.6	7.7	9.3	1.3	8.5	0.8	9.4
843655	9.3	9.1	8.9	0.5	9.1	0.2	2.2
aa7750	9.9	9.8	9.5	0.5	9.7	0.18	1.85

1.5.2 The Numerical Procedure for Determining Outliers

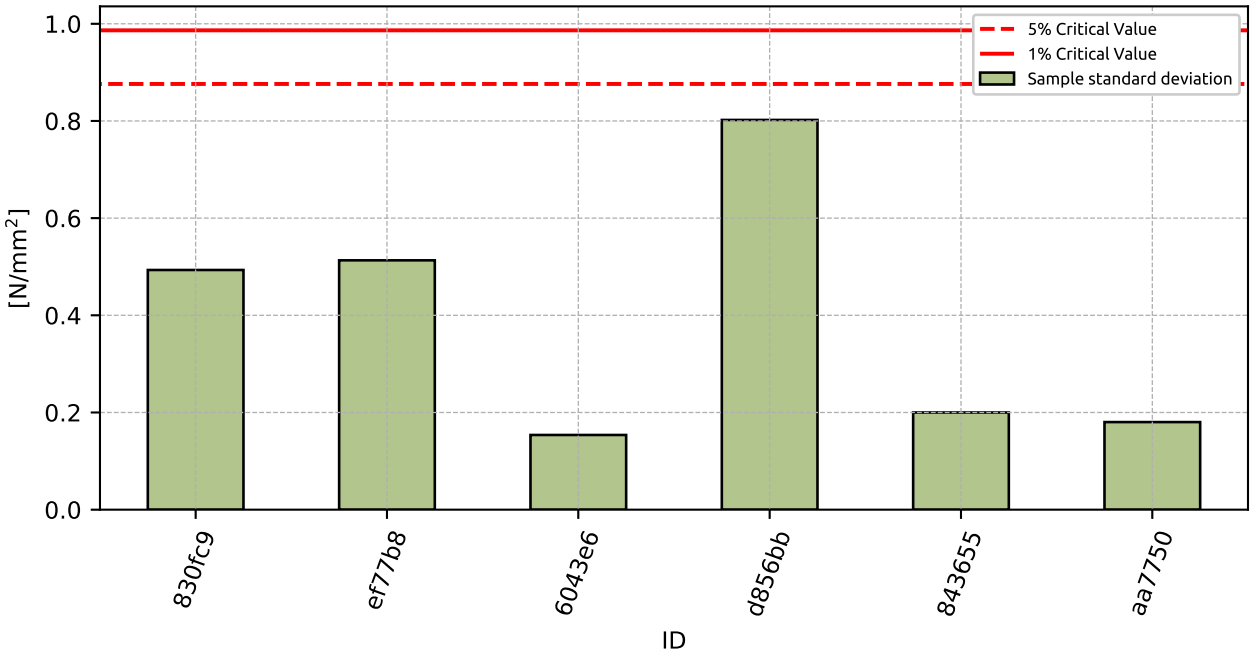

Figure 39: **Cochran's test** - sample standard deviations

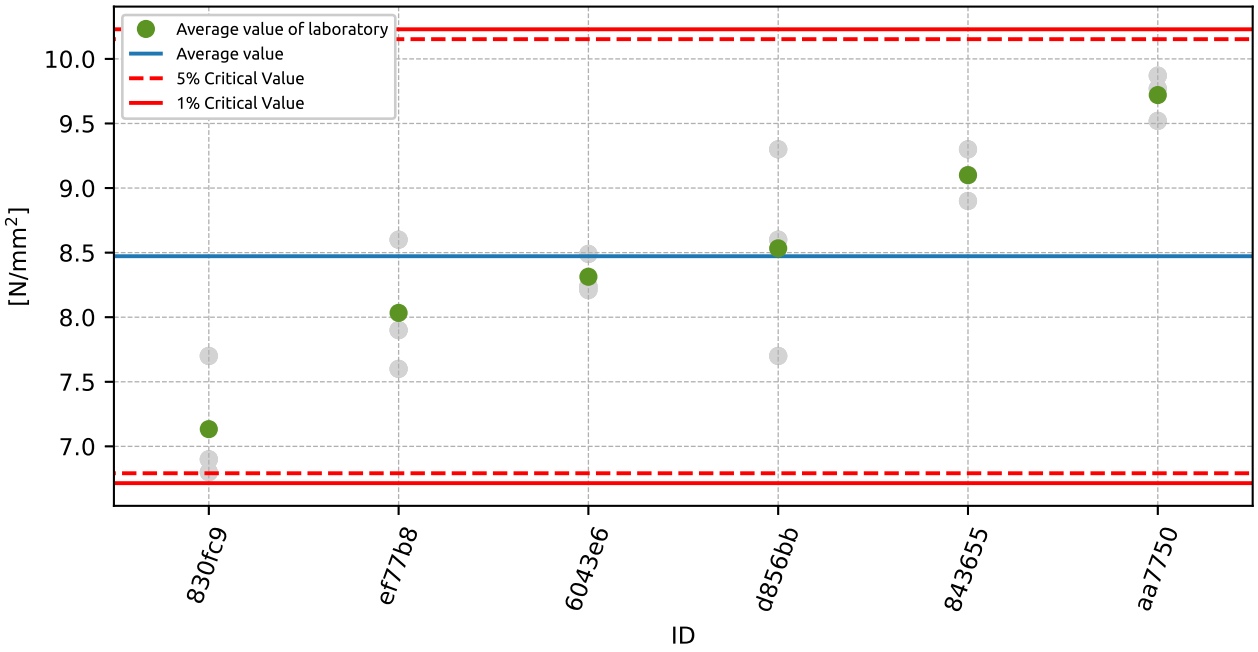

Figure 40: **Grubbs' test** - average values

1.5.3 Mandel's Statistics

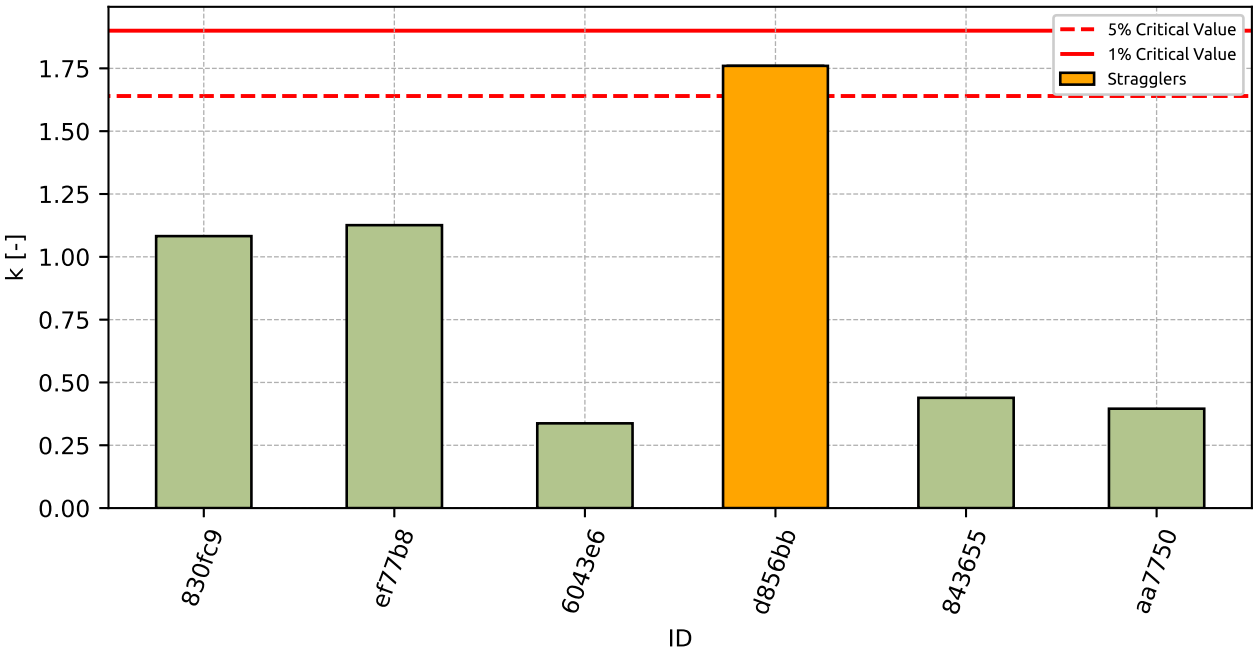

Figure 41: Intralaboratory Consistency Statistic

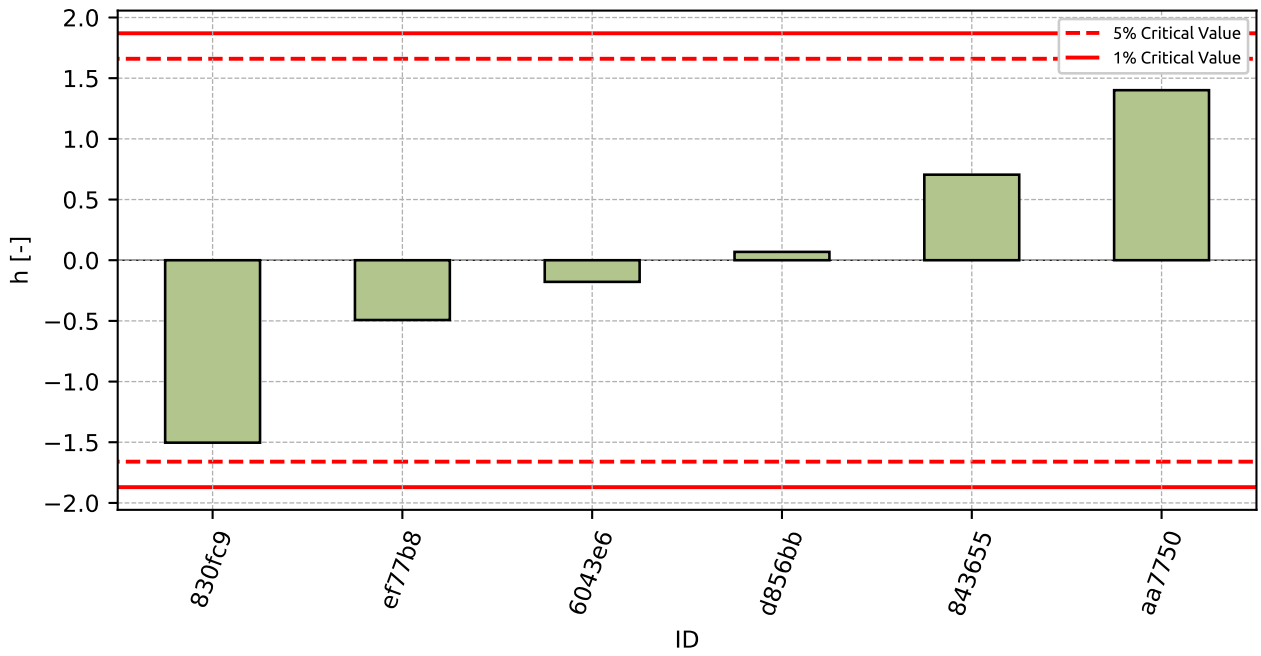

Figure 42: Interlaboratory Consistency Statistic

1.5.4 Descriptive statistics

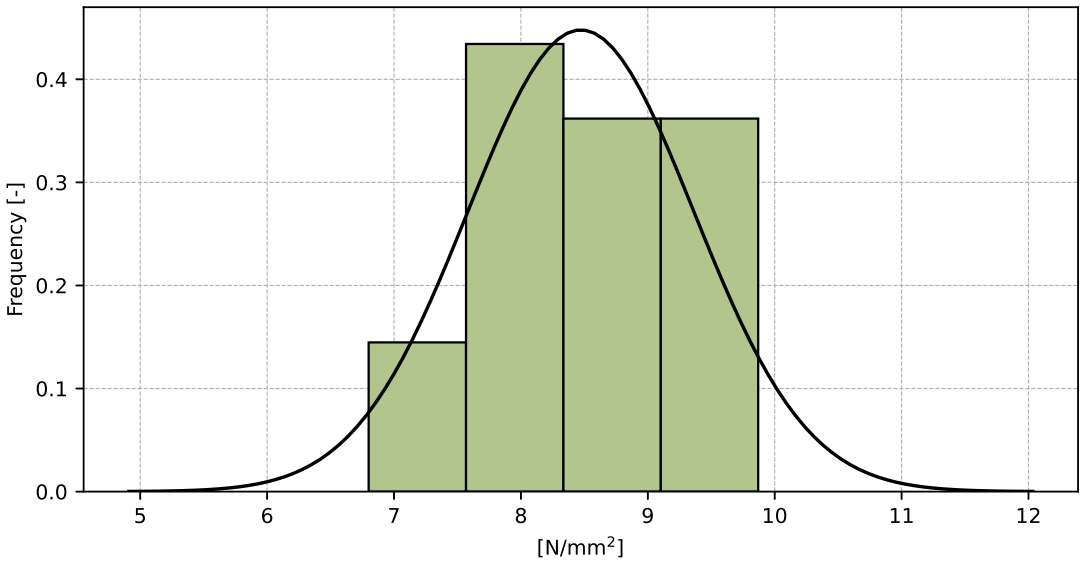

Figure 43: Histogram of all test results

Table 17: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	8.5
Sample standard deviation – s	0.89
Asigned value – x^*	8.5
Robust standard deviation – s^*	0.89
Measurement uncertainty of asigned value – u_X	0.45
p-value of normality test	0.67 [-]
Interlaboratory standard deviation – s_L	0.85
Repeatability standard deviation – s_r	0.46
Reproducibility standard deviation – s_R	0.97
Repeatability – r	1.3
Reproducibility – R	2.7

1.5.5 Evaluation of Performance Statistics

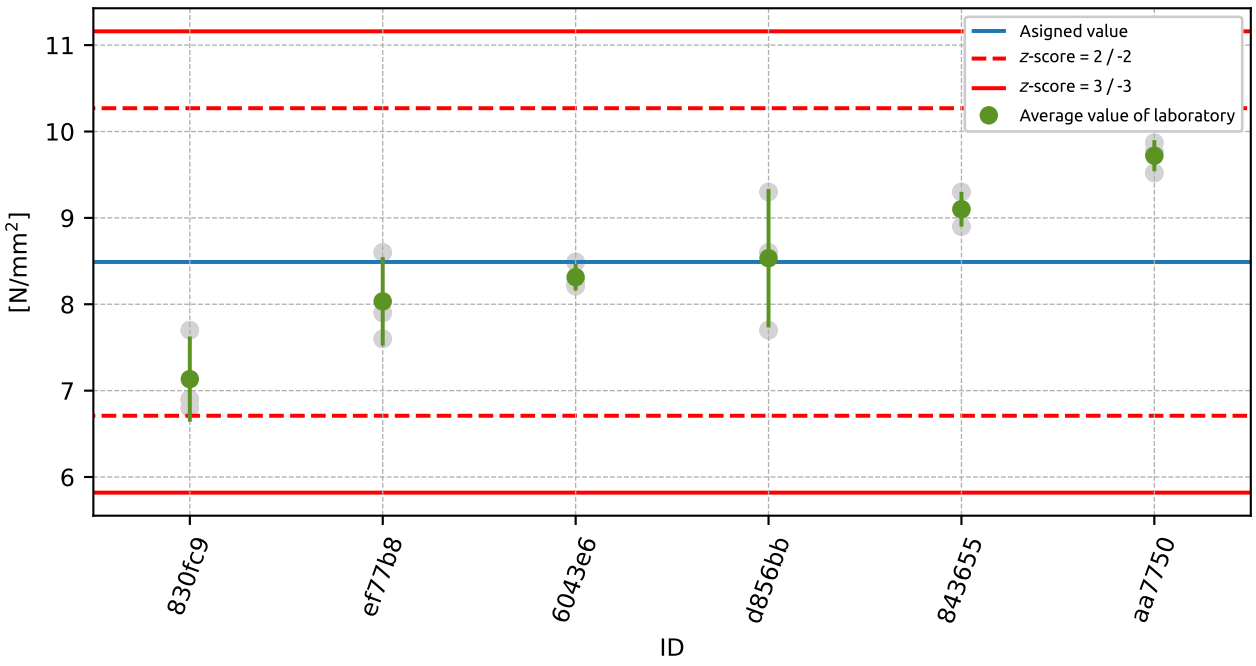

Figure 44: Average values and sample standard deviations

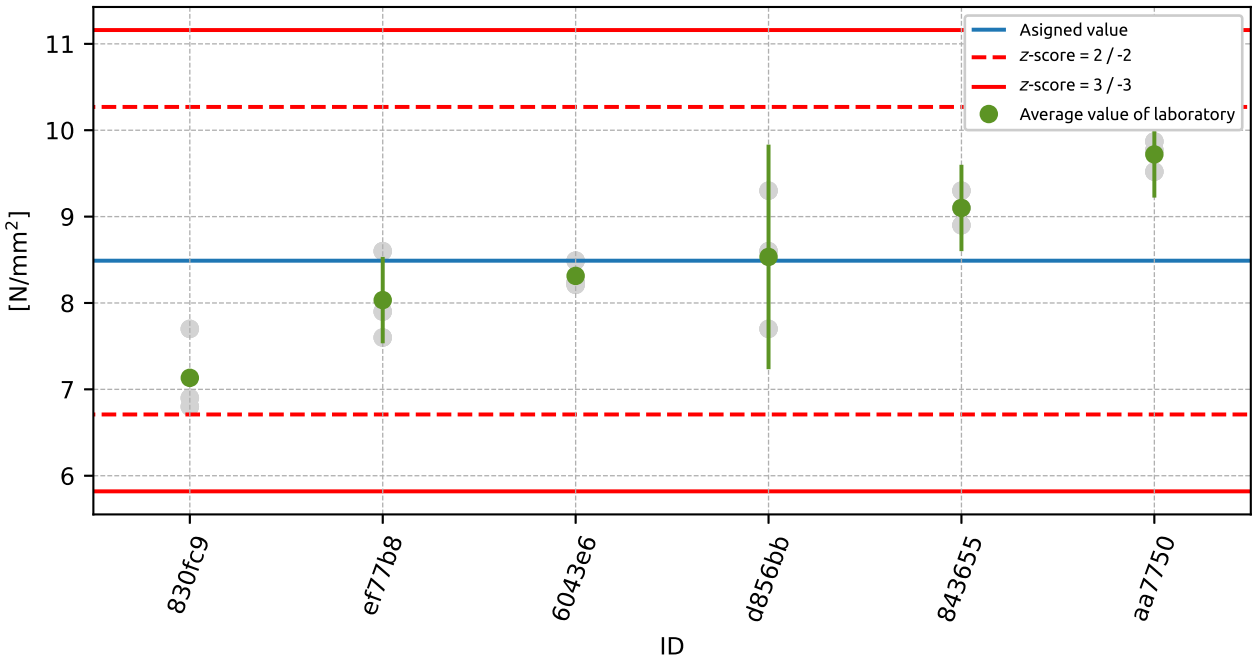

Figure 45: Average values and extended uncertainties of measurement

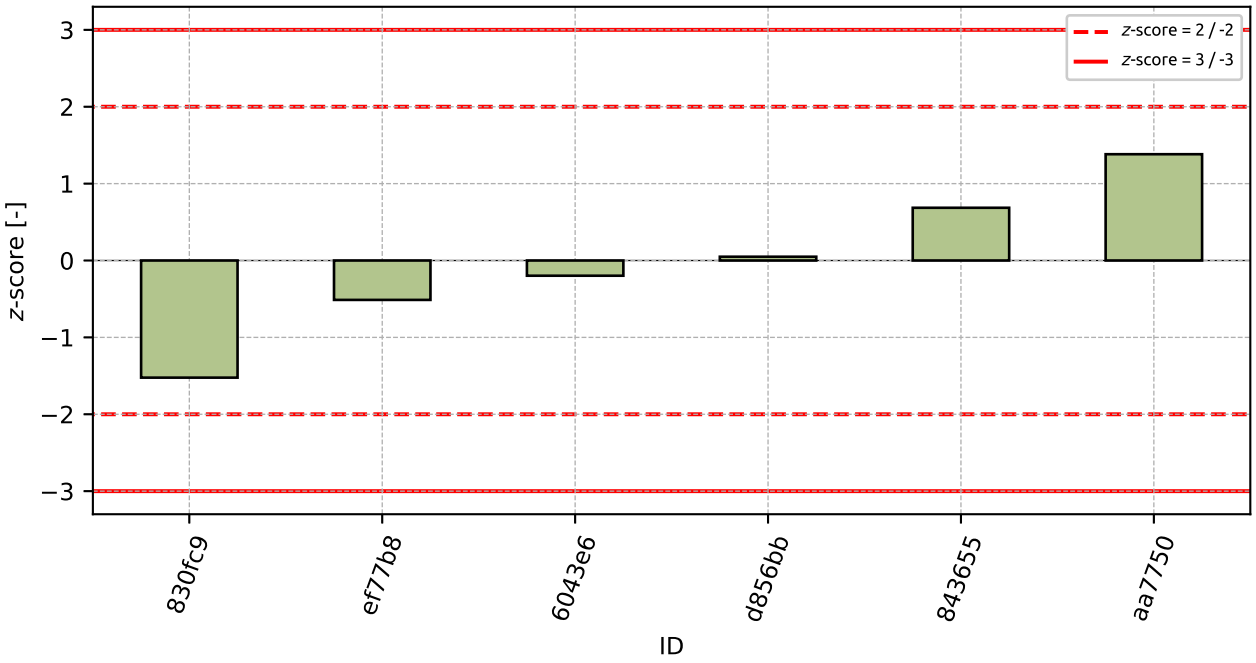

Figure 46: z-score

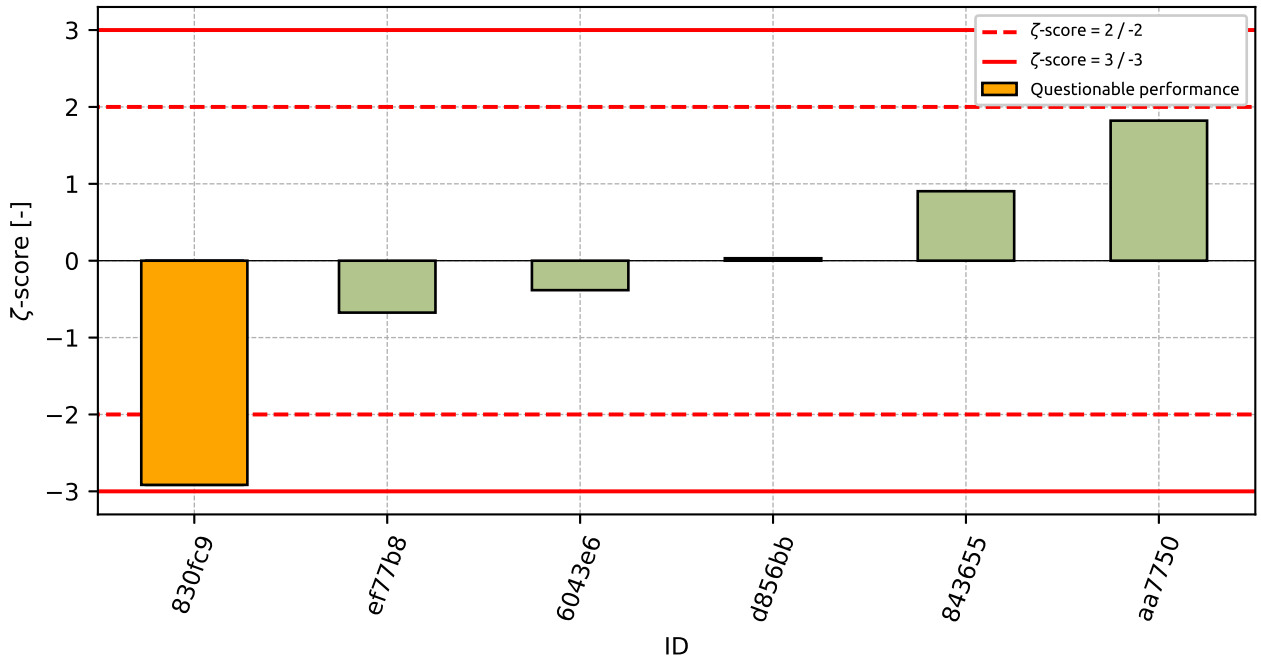

Figure 47: ζ-score

Table 18: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
830fc9	-1.52	-2.92
ef77b8	-0.51	-0.68
6043e6	-0.2	-0.38
d856bb	0.05	0.03
843655	0.69	0.9
aa7750	1.38	1.82

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/mm^2]						u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
843655	52.7	52.1	54.1	53.2	53.0	52.4	0.6	52.9	0.7	1.33
6043e6	56.4	57.0	56.8	56.8	54.1	54.1	0.2	55.9	1.38	2.46
830fc9	57.5	55.1	55.2	56.1	57.2	57.3	0.5	56.4	1.08	1.92
aa7750	60.9	60.9	59.7	60.6	61.2	58.8	2.6	60.4	0.96	1.59
ef77b8	62.9	60.3	62.4	56.3	58.2	64.1	3.0	60.7	3.0	4.95
d856bb	62.7	62.1	61.1	60.5	61.6	60.3	1.1	61.4	0.93	1.52

1.6.2 The Numerical Procedure for Determining Outliers

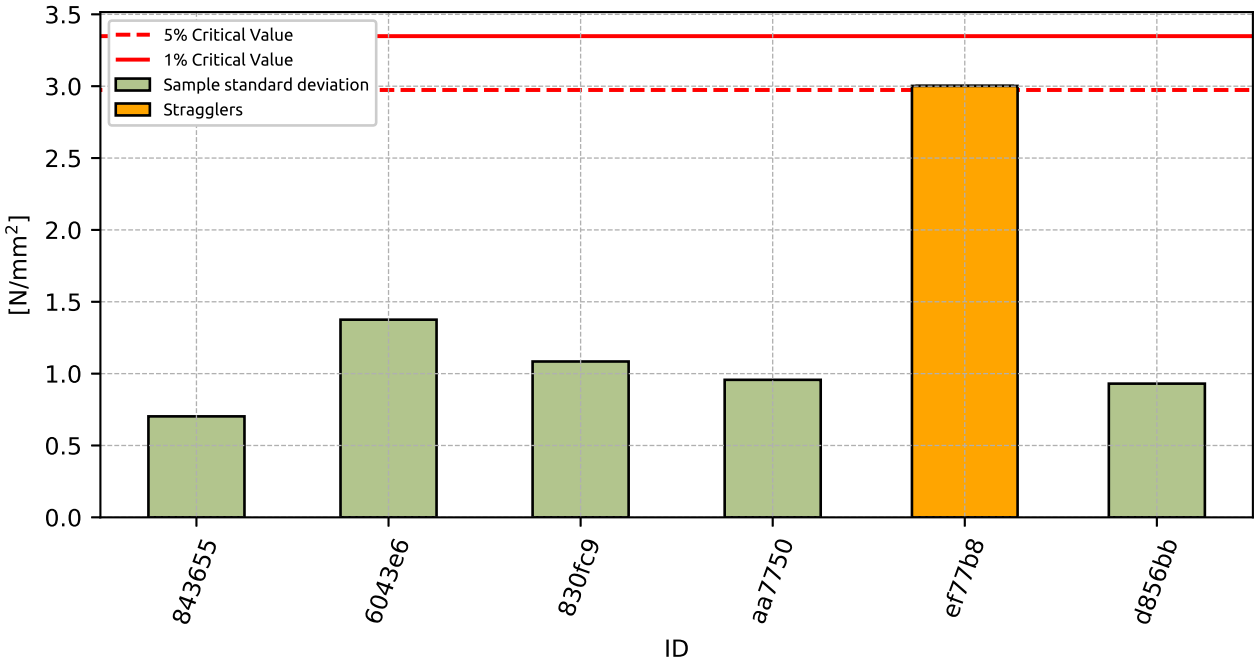

Figure 48: **Cochran's test** - sample standard deviations

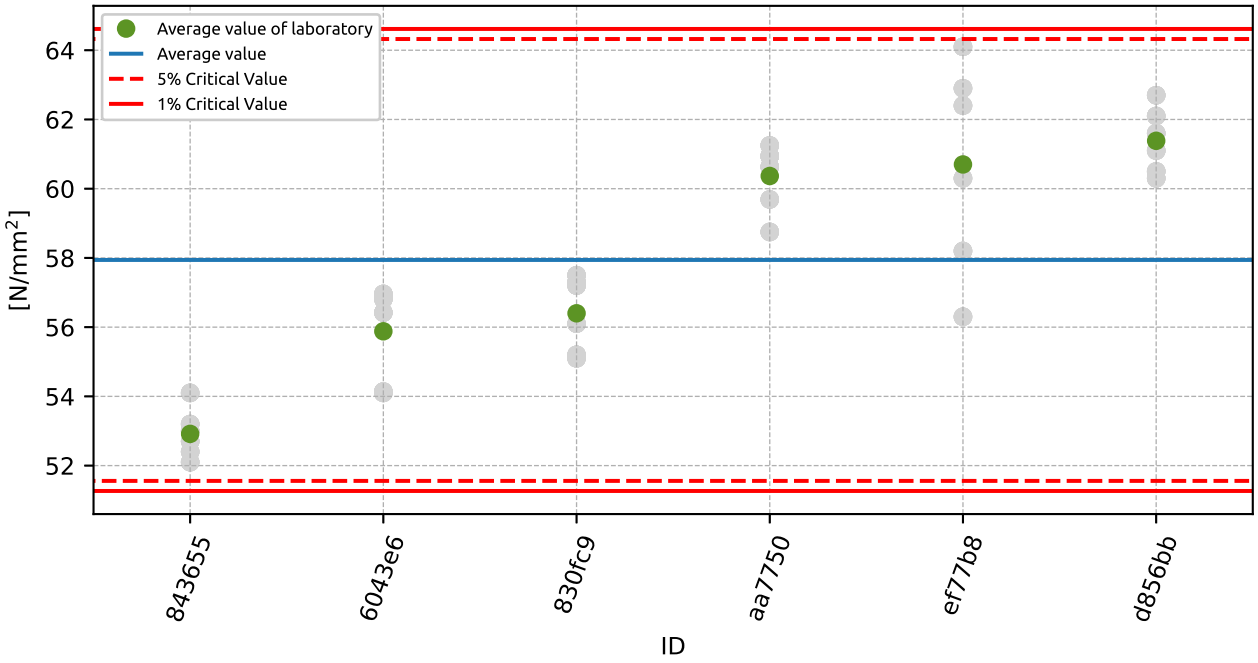

Figure 49: **Grubbs' test** - average values

1.6.3 Mandel's Statistics

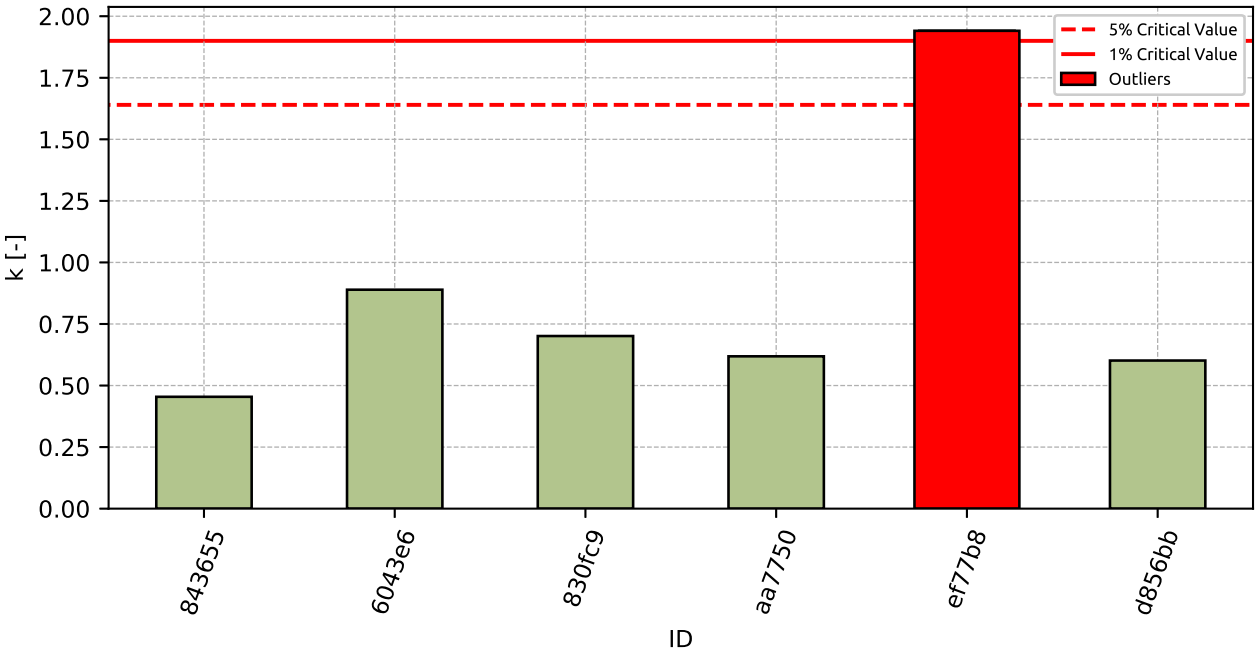

Figure 50: Intralaboratory Consistency Statistic

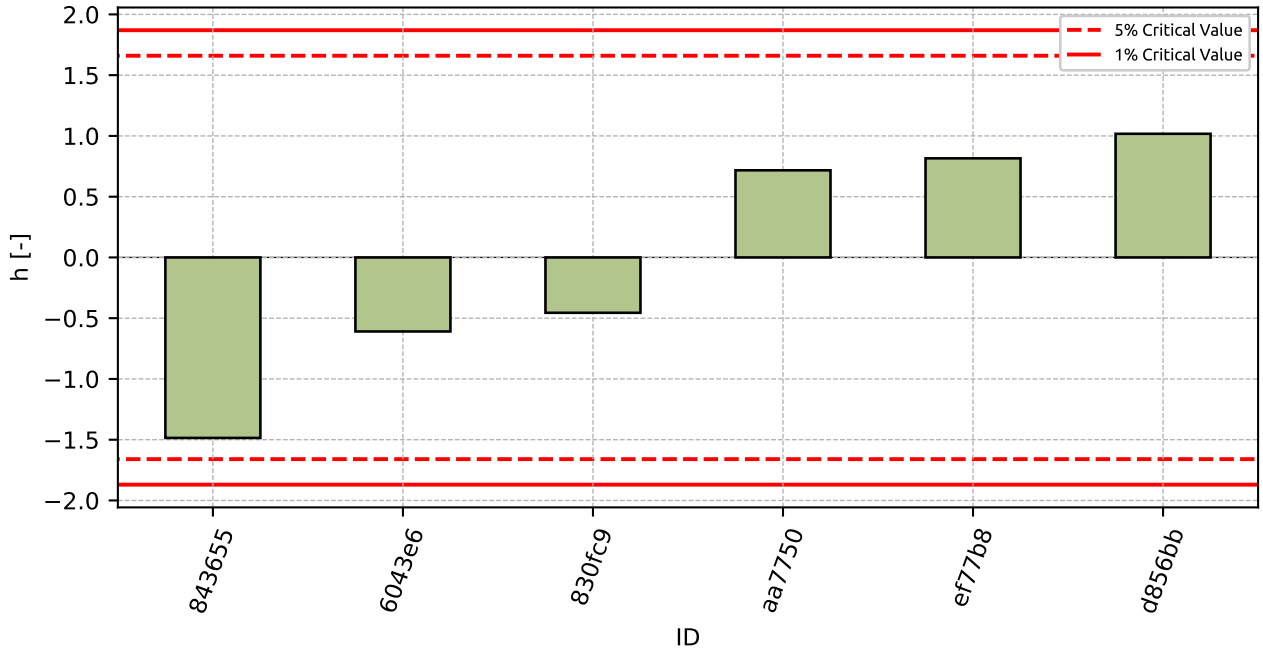

Figure 51: Interlaboratory Consistency Statistic

1.6.4 Descriptive statistics

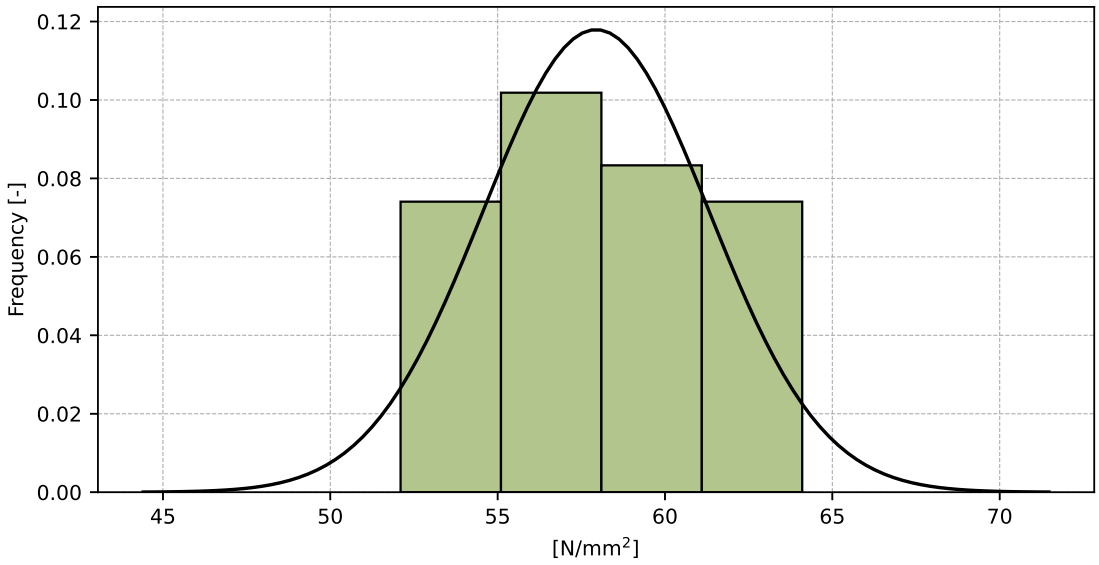

Figure 52: Histogram of all test results

Table 20: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	57.9
Sample standard deviation – s	3.38
Asigned value – x^*	58.0
Robust standard deviation – s^*	3.47
Measurement uncertainty of asigned value – u_X	1.77
p-value of normality test	0.125 [-]
Interlaboratory standard deviation – s_L	3.32
Repeatability standard deviation – s_r	1.55
Reproducibility standard deviation – s_R	3.67
Repeatability – r	4.3
Reproducibility – R	10.3

1.6.5 Evaluation of Performance Statistics

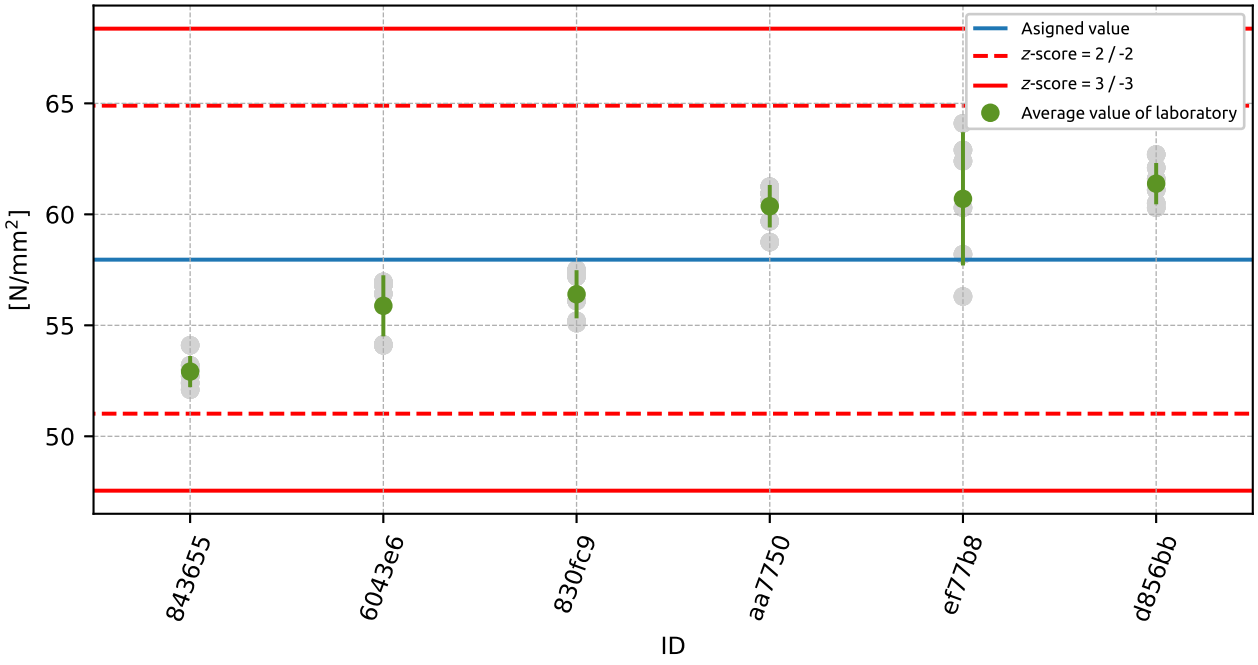

Figure 53: Average values and sample standard deviations

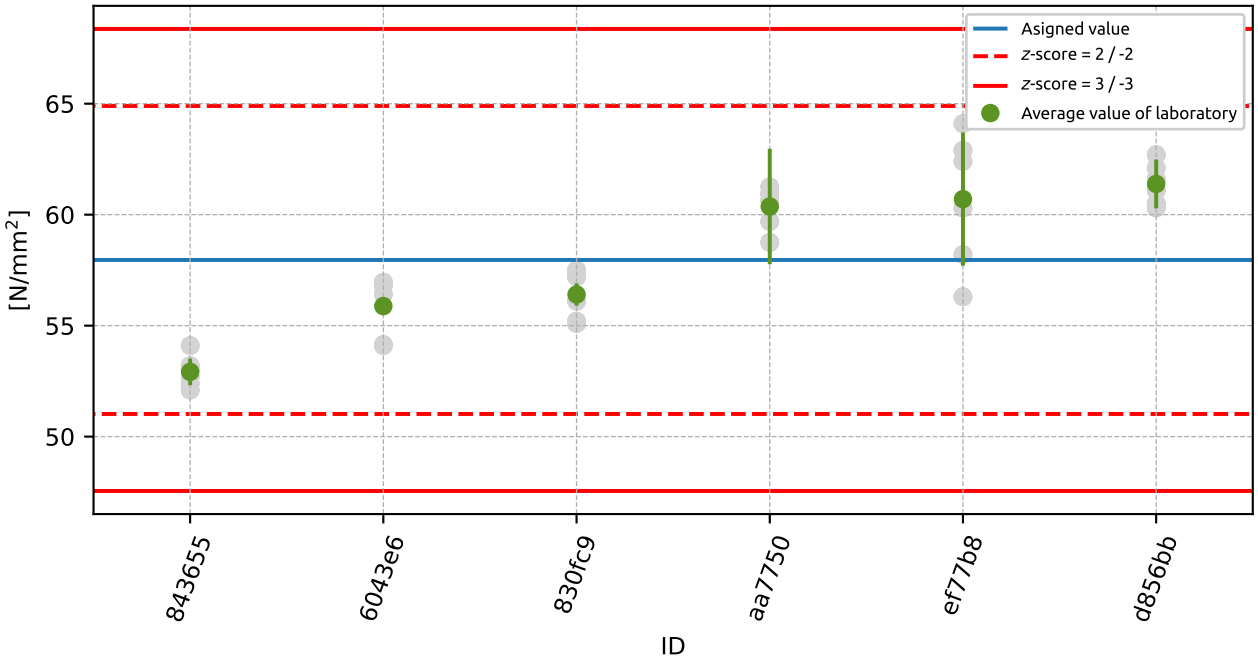

Figure 54: Average values and extended uncertainties of measurement

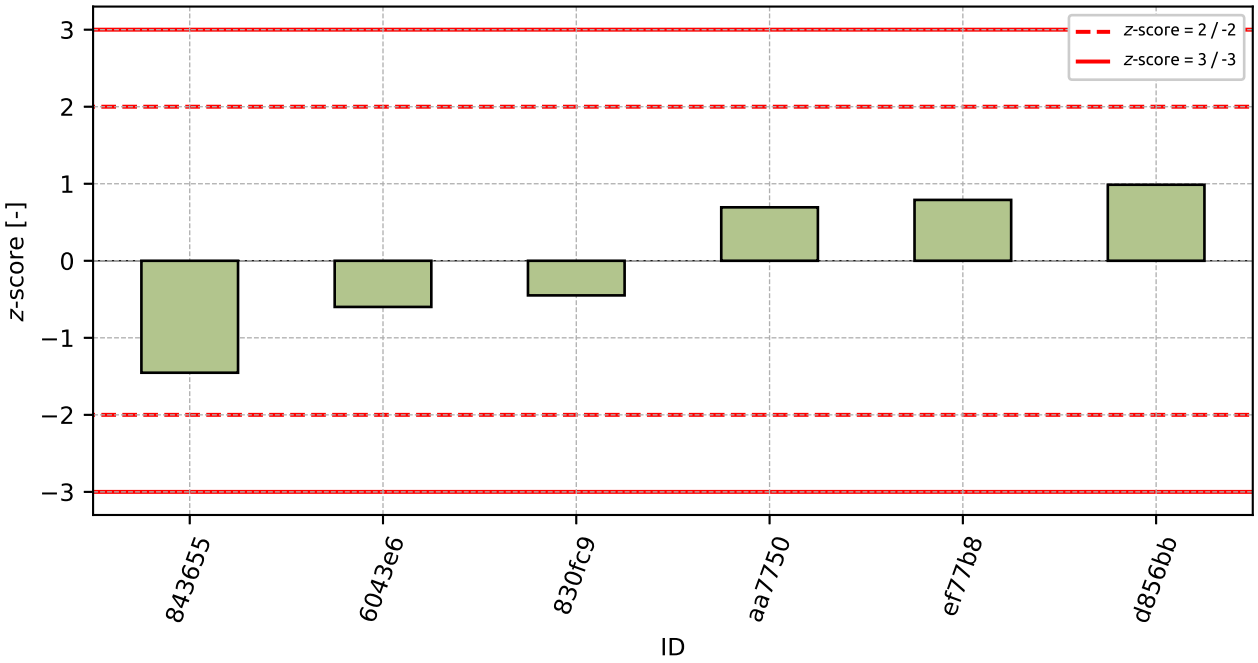

Figure 55: z-score

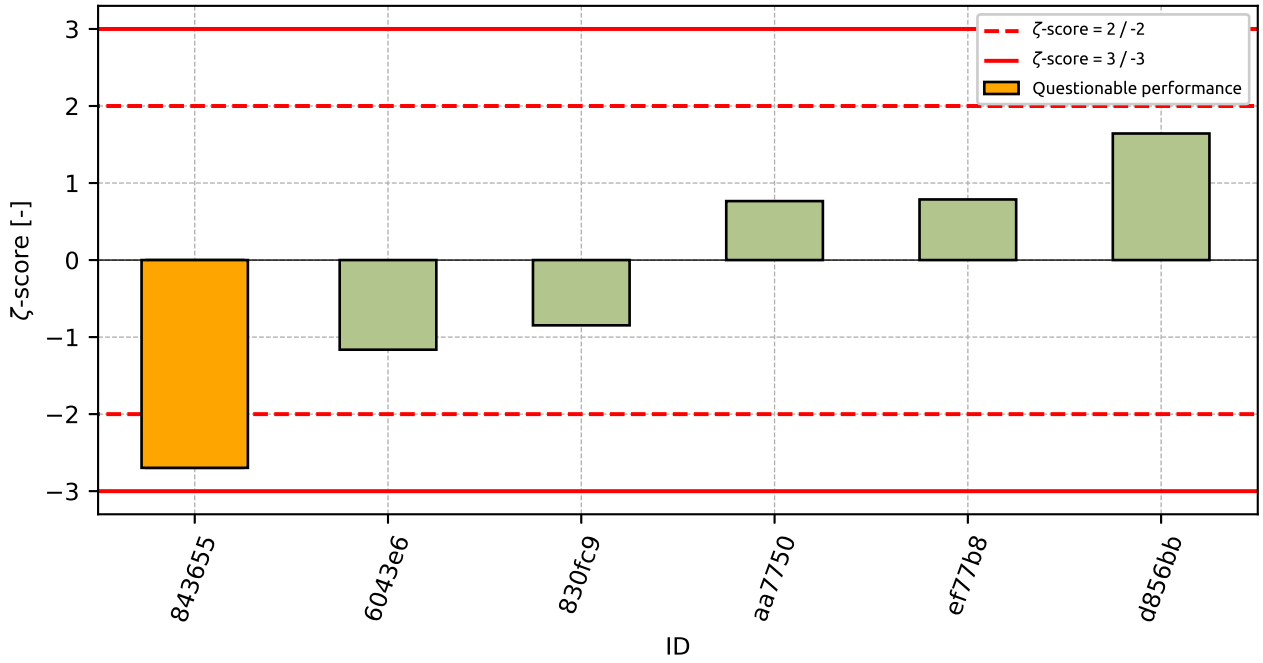

Figure 56: ζ-score

Table 21: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
843655	-1.45	-2.7
6043e6	-0.6	-1.16
830fc9	-0.45	-0.85
aa7750	0.69	0.77
ef77b8	0.79	0.79
d856bb	0.99	1.64

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

2.1 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 [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
ea7194	3.77	3.78	3.77	0.08	3.77	0.006	0.15
aa7750	3.9	3.89	3.87	0.24	3.89	0.015	0.39
6043e6	3.9	3.9	3.9	0.01	3.9	0.0	0.0
f11905	4.01	3.95	3.98	0.03	3.98	0.03	0.75

2.2 The Numerical Procedure for Determining Outliers

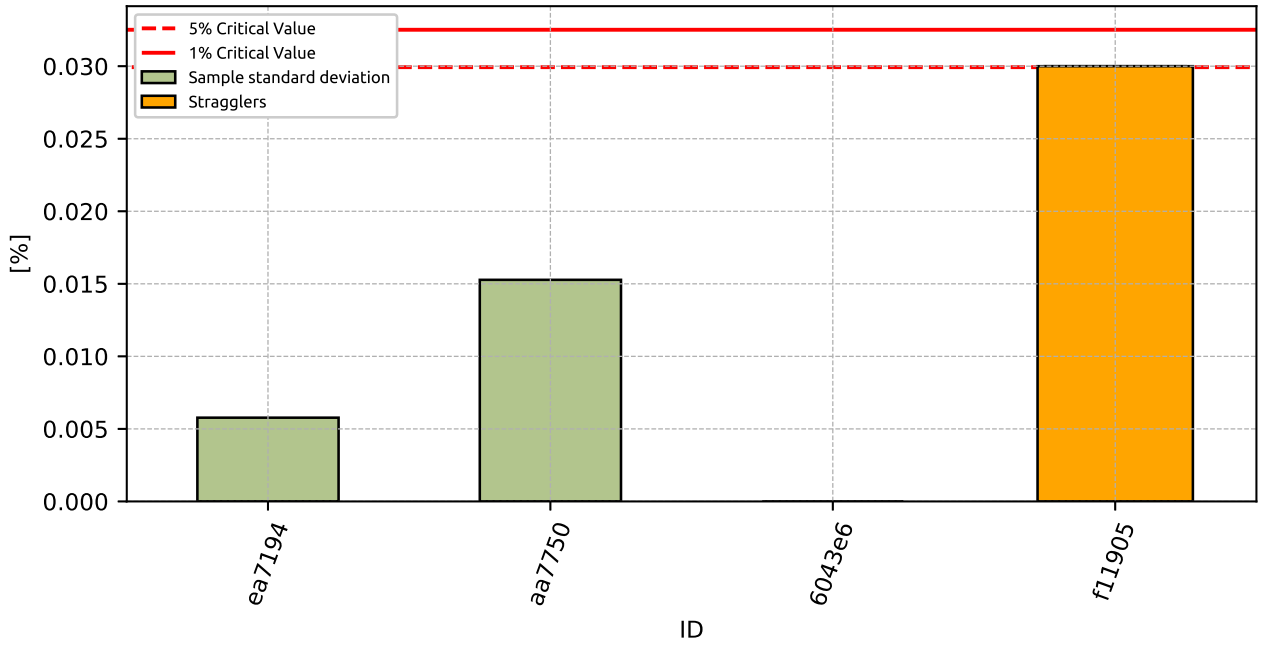

Figure 57: **Cochran's test** - sample standard deviations

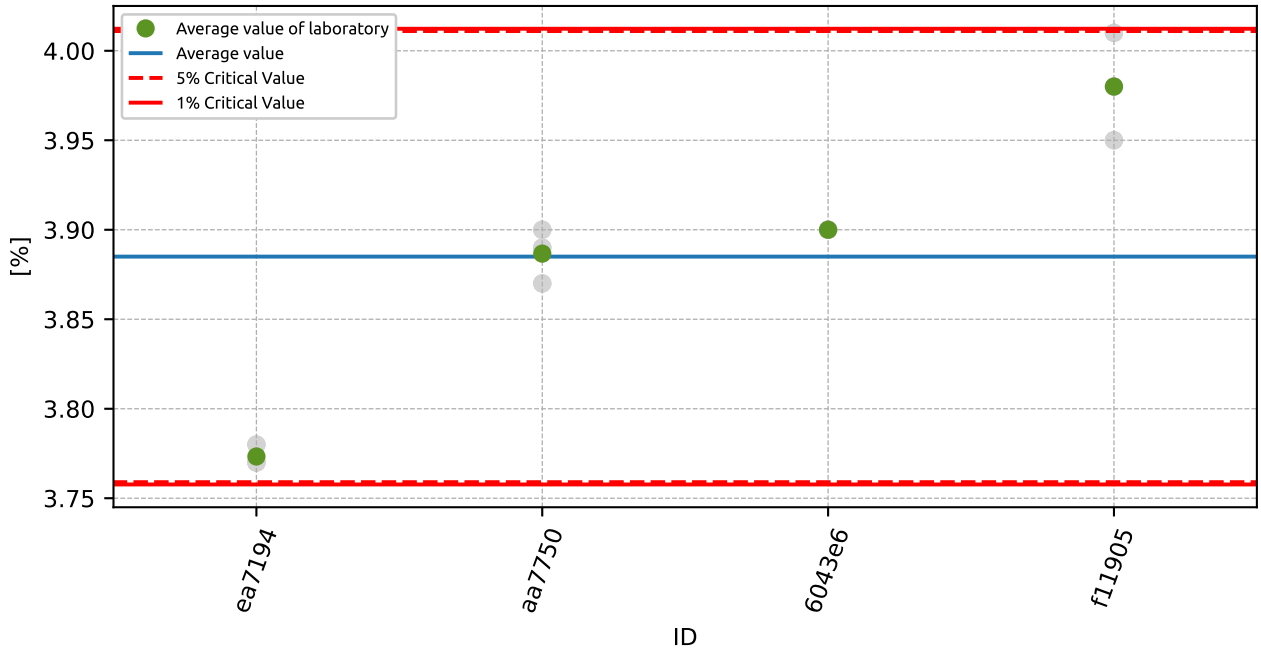

Figure 58: **Grubbs' test** - average values

2.3 Mandel's Statistics

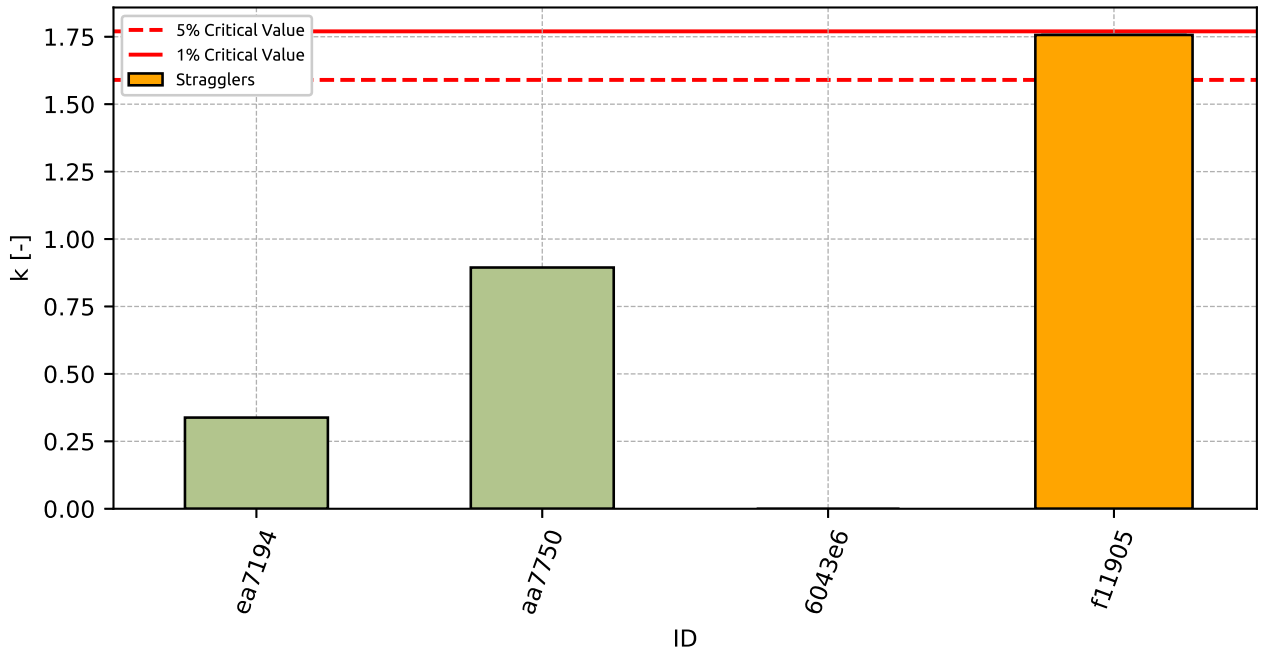

Figure 59: Intralaboratory Consistency Statistic

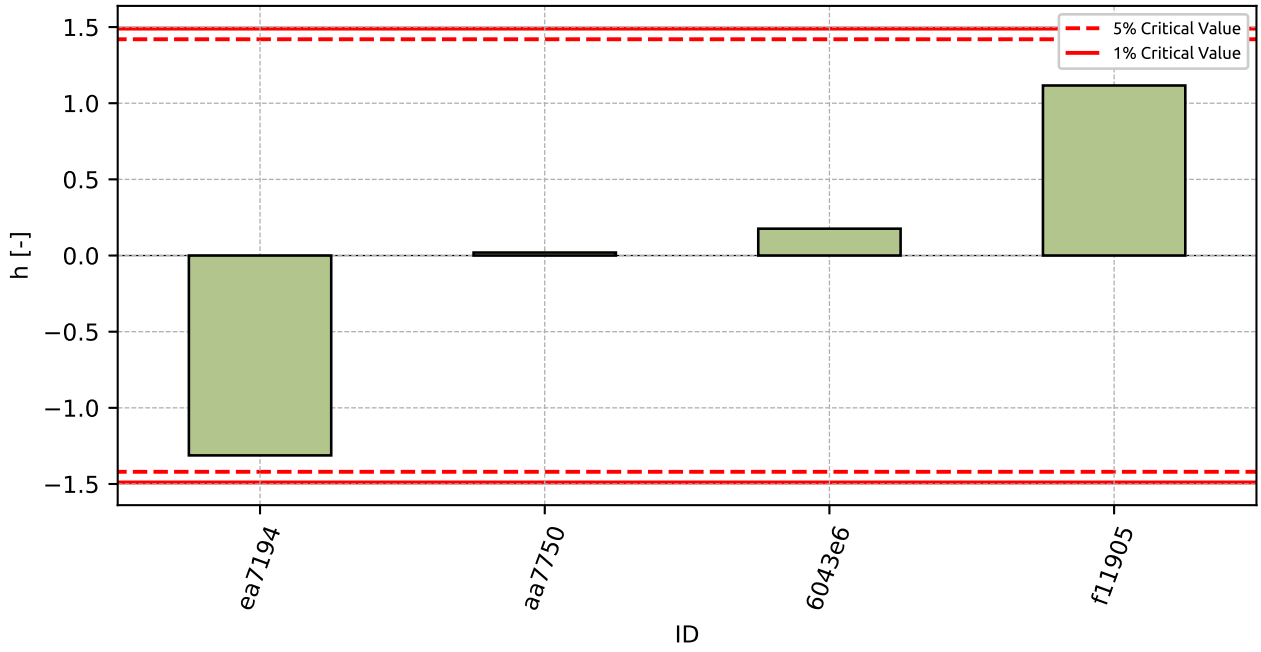

Figure 60: Interlaboratory Consistency Statistic

2.4 Descriptive statistics

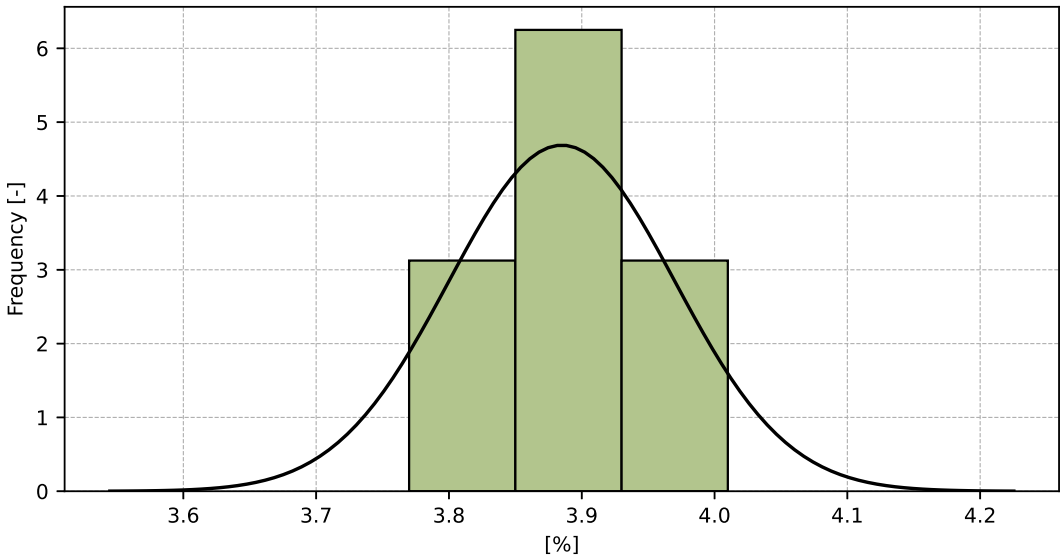

Figure 61: Histogram of all test results

Table 23: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	3.89
Sample standard deviation – s	0.085
Asigned value – x^*	3.89
Robust standard deviation – s^*	0.077
Measurement uncertainty of asigned value – u_X	0.048
p-value of normality test	0.17 [-]
Interlaboratory standard deviation – s_L	0.085
Repeatability standard deviation – s_r	0.017
Reproducibility standard deviation – s_R	0.086
Repeatability – r	0.05
Reproducibility – R	0.24

2.5 Evaluation of Performance Statistics

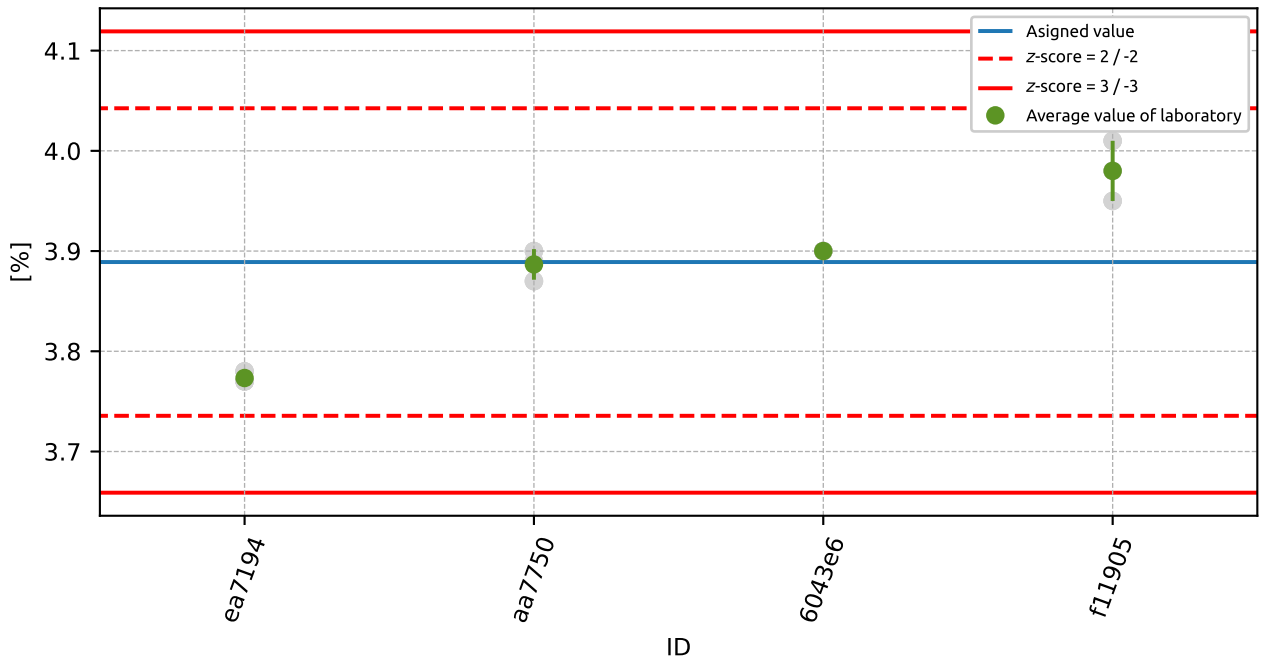

Figure 62: Average values and sample standard deviations

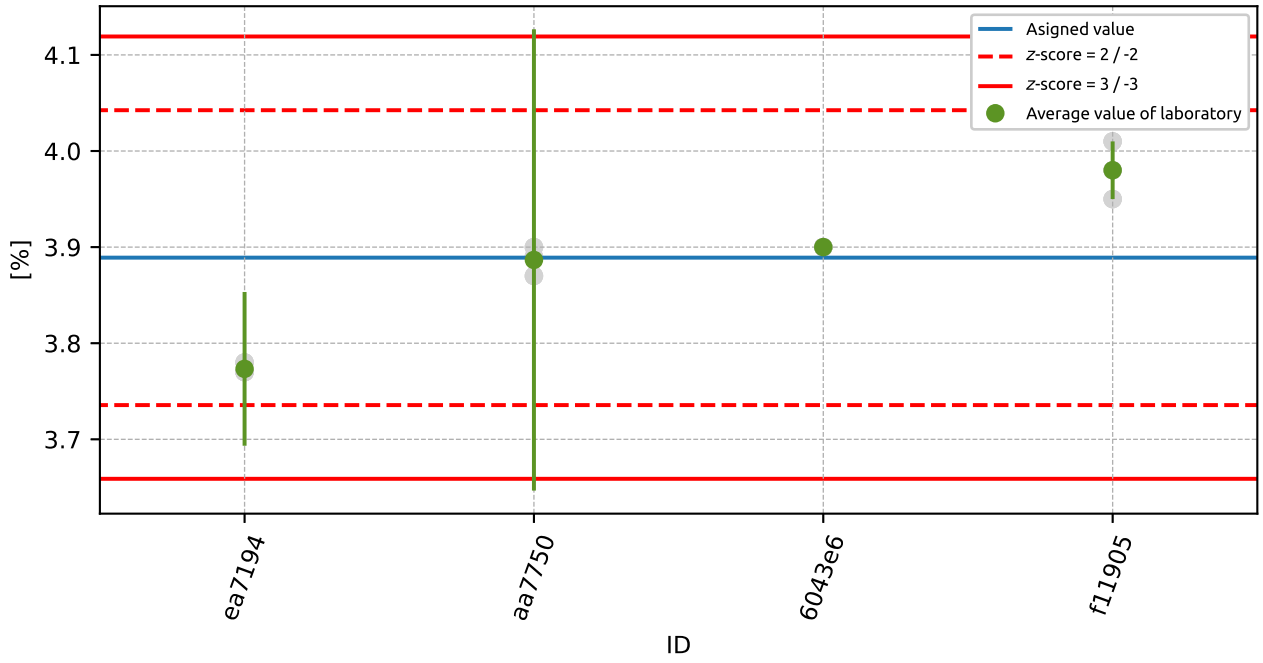

Figure 63: Average values and extended uncertainties of measurement

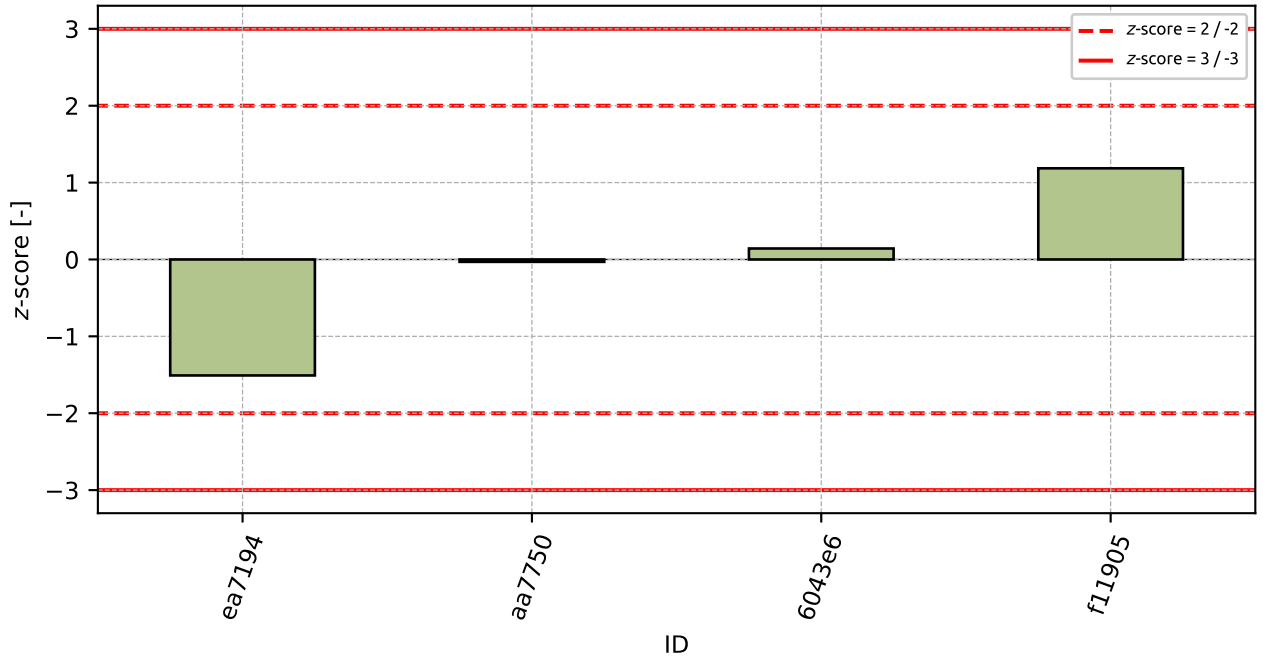

Figure 64: z-score

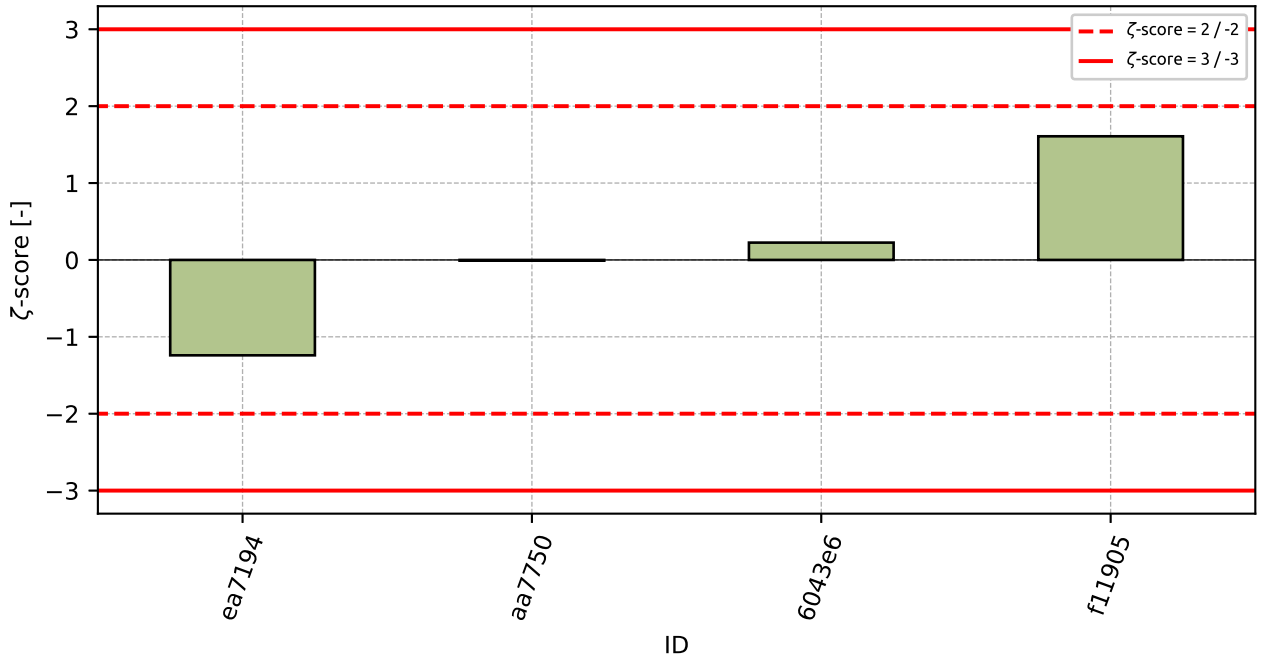

Figure 65: ζ-score

Table 24: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ea7194	-1.51	-1.24
aa7750	-0.03	-0.01
6043e6	0.14	0.23
f11905	1.19	1.61

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

3.1 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 [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
ea7194	2.82	2.81	2.82	0.18	2.82	0.006	0.2
f11905	2.95	2.92	2.96	0.02	2.94	0.021	0.71
6043e6	2.97	2.97	2.97	0.0	2.97	0.0	0.0
412c89	3.12	3.05	3.02	-	3.06	0.051	1.68
aa7750	3.09	3.16	3.17	0.2	3.14	0.044	1.39

3.2 The Numerical Procedure for Determining Outliers

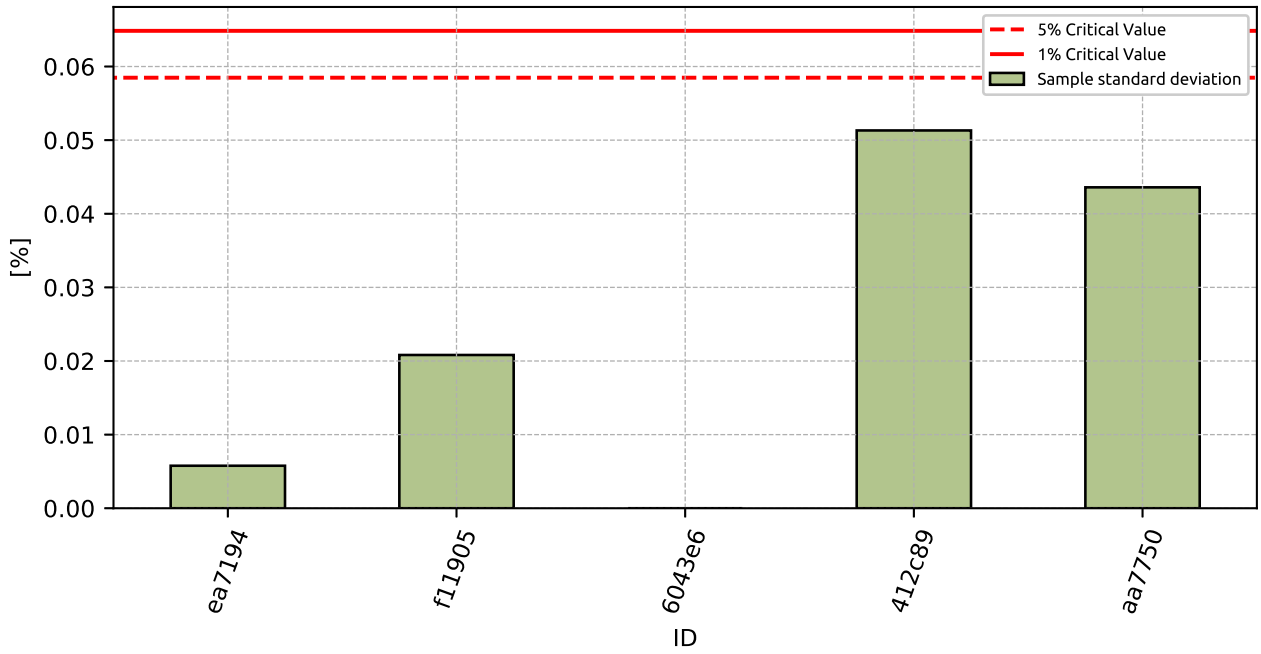

Figure 66: **Cochran's test** - sample standard deviations

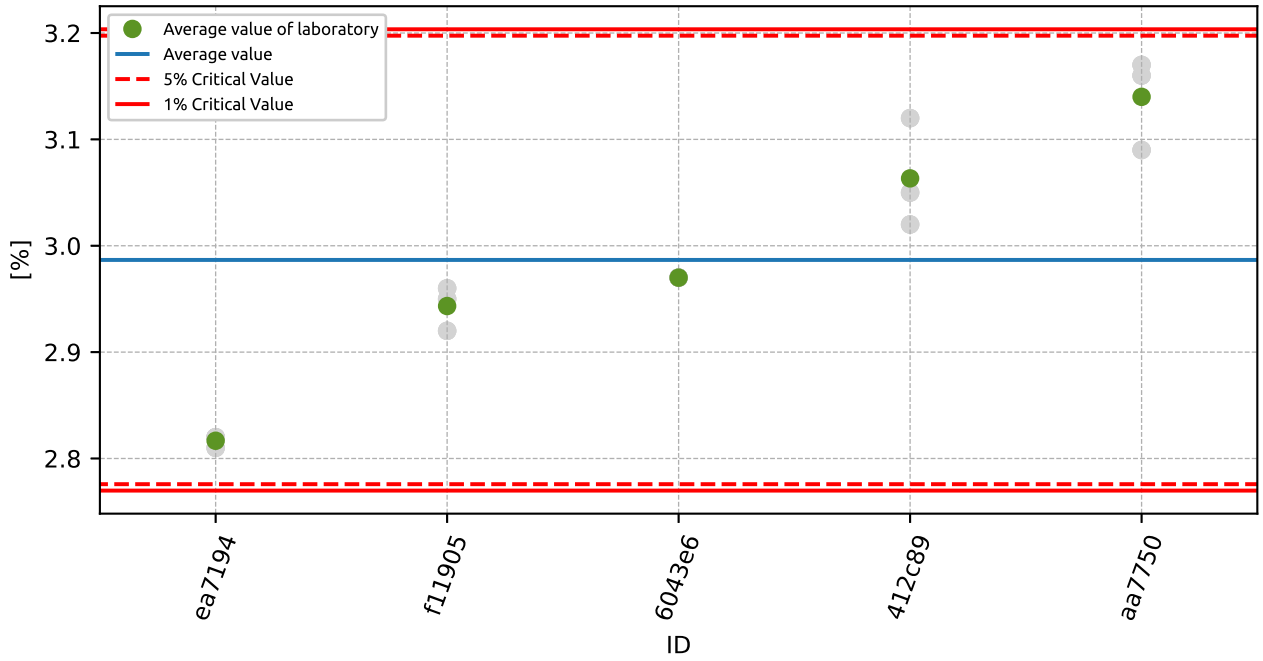

Figure 67: **Grubbs' test** - average values

3.3 Mandel's Statistics

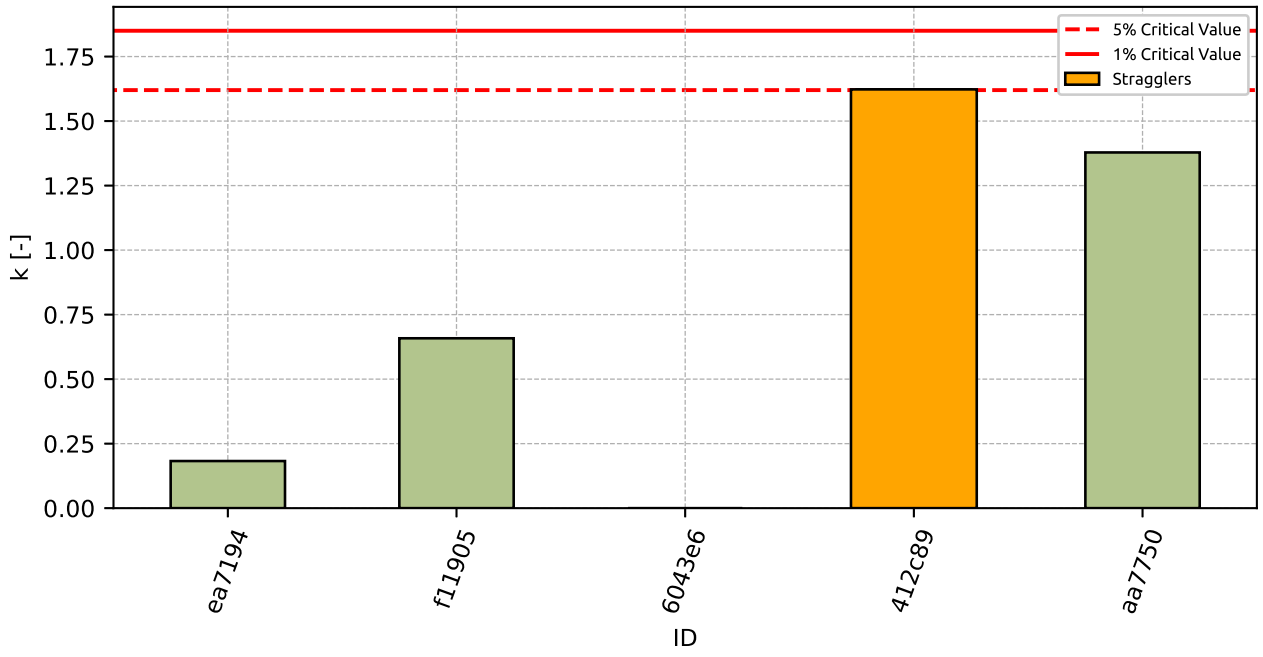

Figure 68: Intralaboratory Consistency Statistic

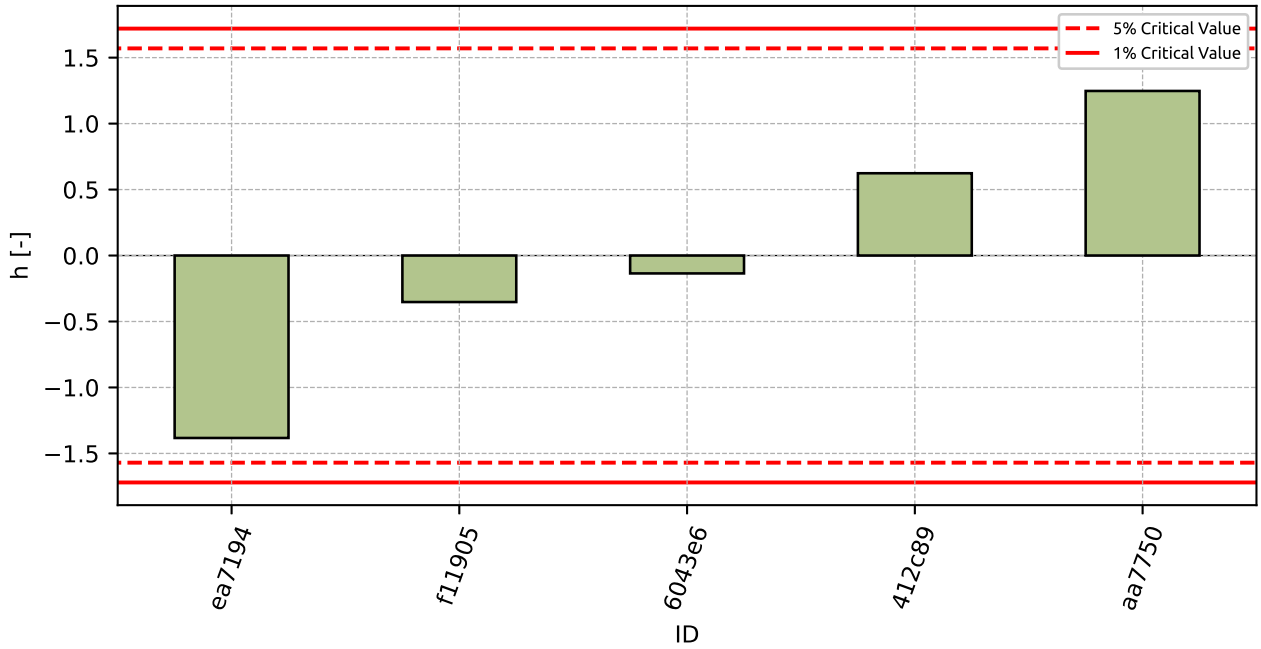

Figure 69: Interlaboratory Consistency Statistic

3.4 Descriptive statistics

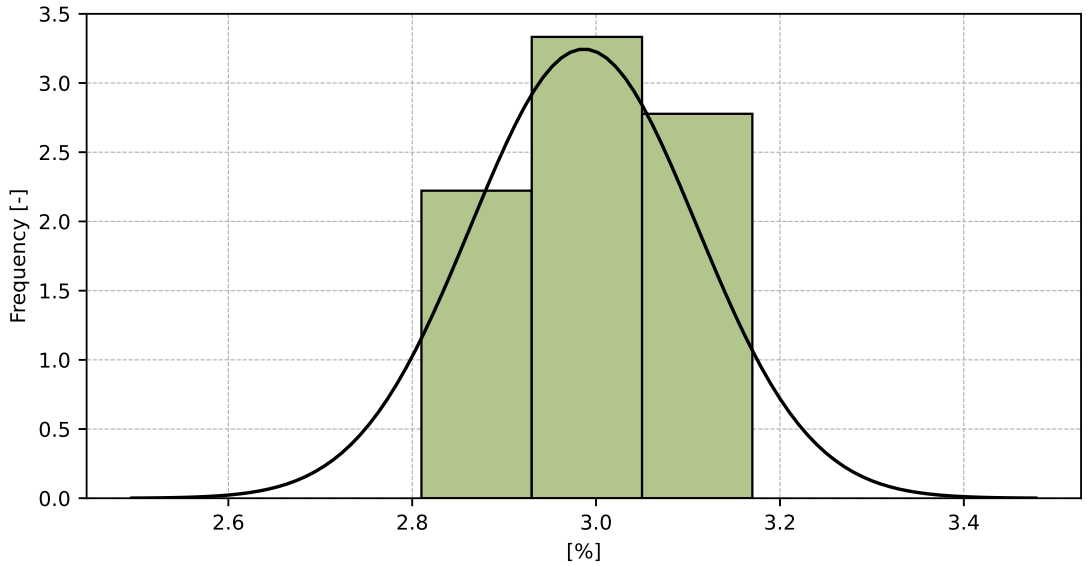

Figure 70: Histogram of all test results

Table 26: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	2.99
Sample standard deviation – s	0.123
Asigned value – x^*	2.99
Robust standard deviation – s^*	0.125
Measurement uncertainty of asigned value – u_X	0.07
p-value of normality test	0.344 [-]
Interlaboratory standard deviation – s_L	0.122
Repeatability standard deviation – s_r	0.032
Reproducibility standard deviation – s_R	0.126
Repeatability – r	0.09
Reproducibility – R	0.35

3.5 Evaluation of Performance Statistics

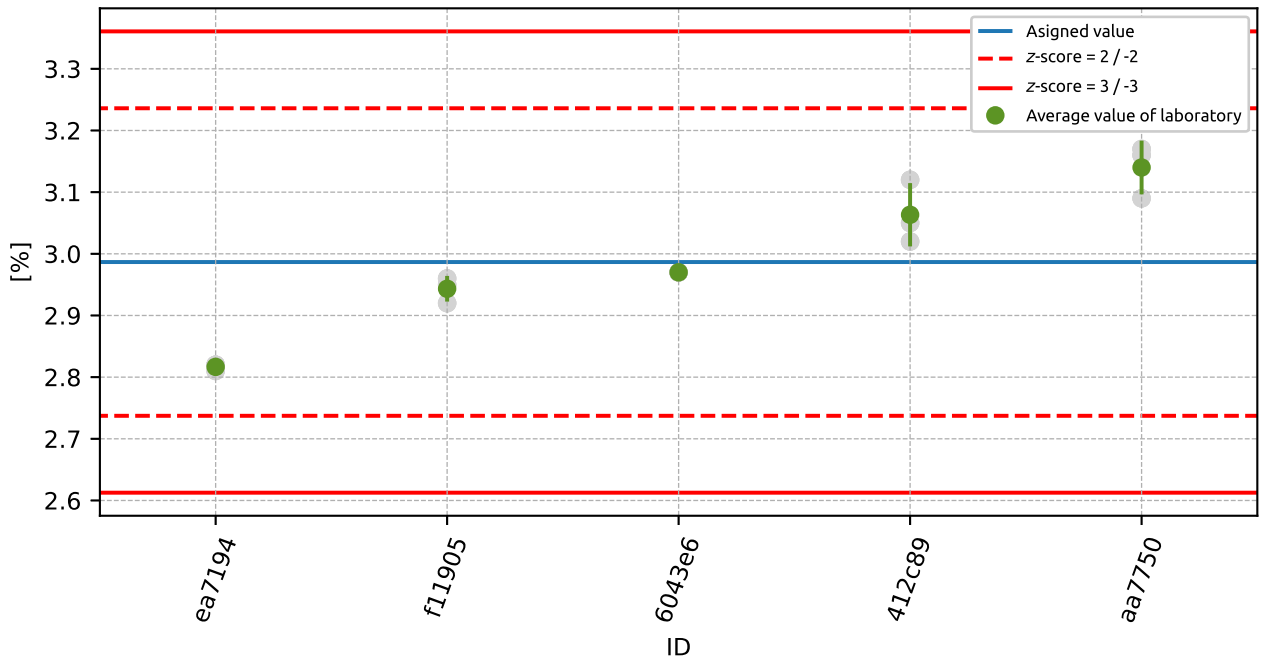

Figure 71: Average values and sample standard deviations

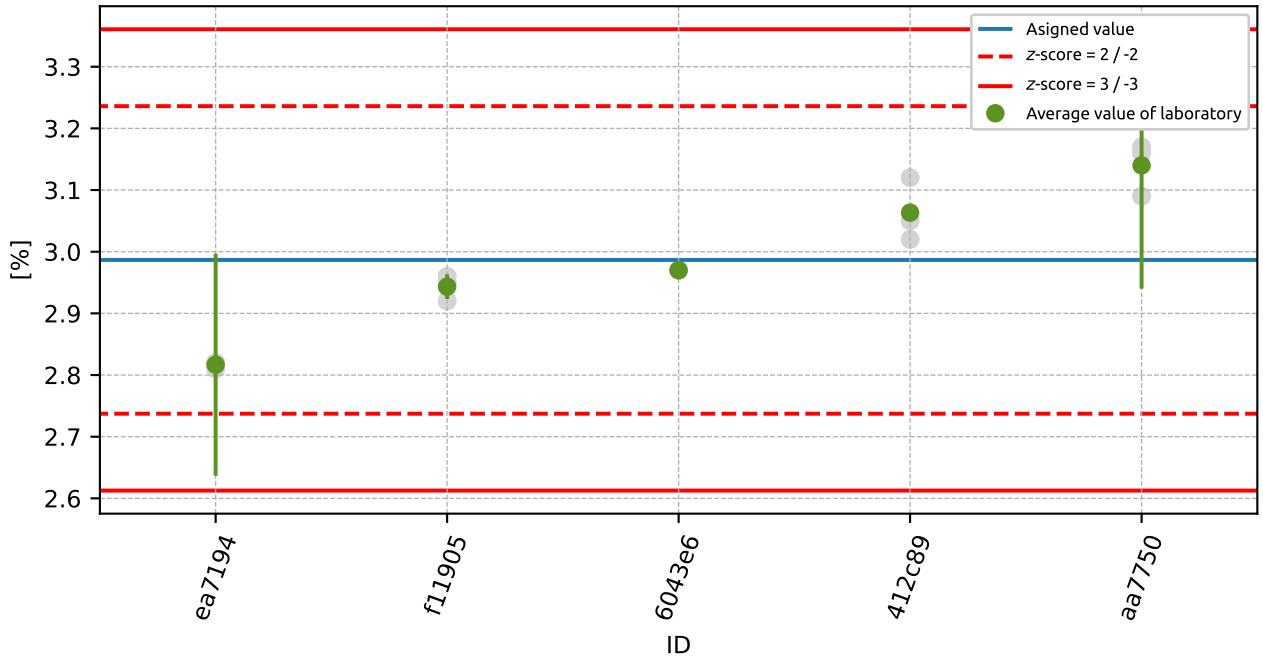

Figure 72: Average values and extended uncertainties of measurement

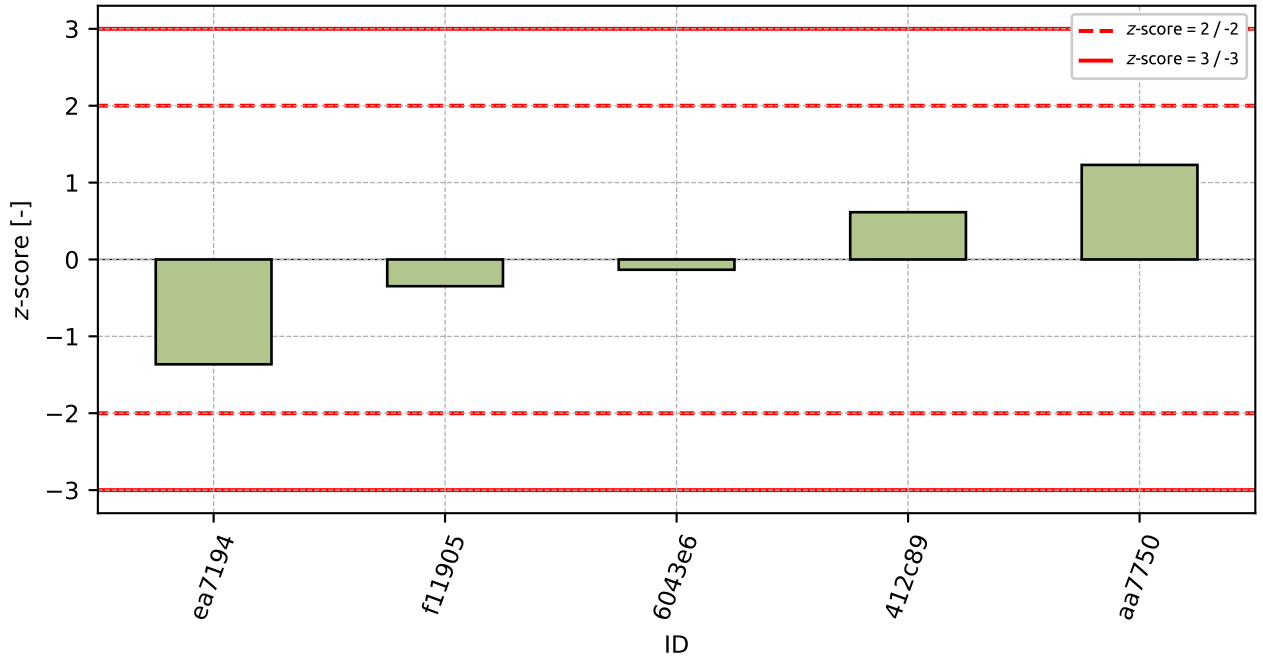

Figure 73: z-score

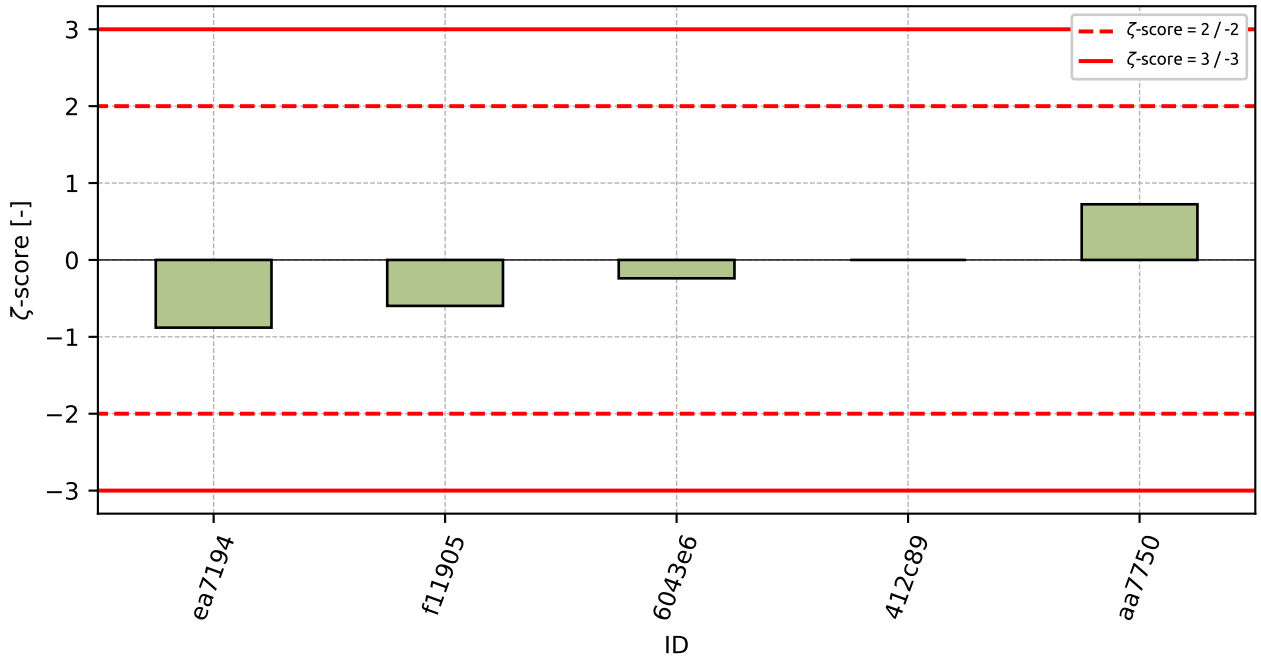

Figure 74: ζ-score

Table 27: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ea7194	-1.36	-0.88
f11905	-0.35	-0.6
6043e6	-0.13	-0.24
412c89	0.61	-
aa7750	1.23	0.72

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.

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

8.1 Initial setting time

8.1.1 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 [min.]			u_X [min.]	$\bar{x}$ [min.]	s_0 [min.]	V_X [%]
6043e6	180	180	180	0.0	180	0.0	0.0
843655	185	195	185	10.0	188	5.8	3.07
c7dc55	185	190	195	-	190	5.0	2.63
4bb8b1	195	199	205	8.0	200	5.0	2.52
aa7750	205	210	205	5.0	207	2.9	1.4
0e6f72	210	210	210	4.0	210	0.0	0.0

8.1.2 The Numerical Procedure for Determining Outliers

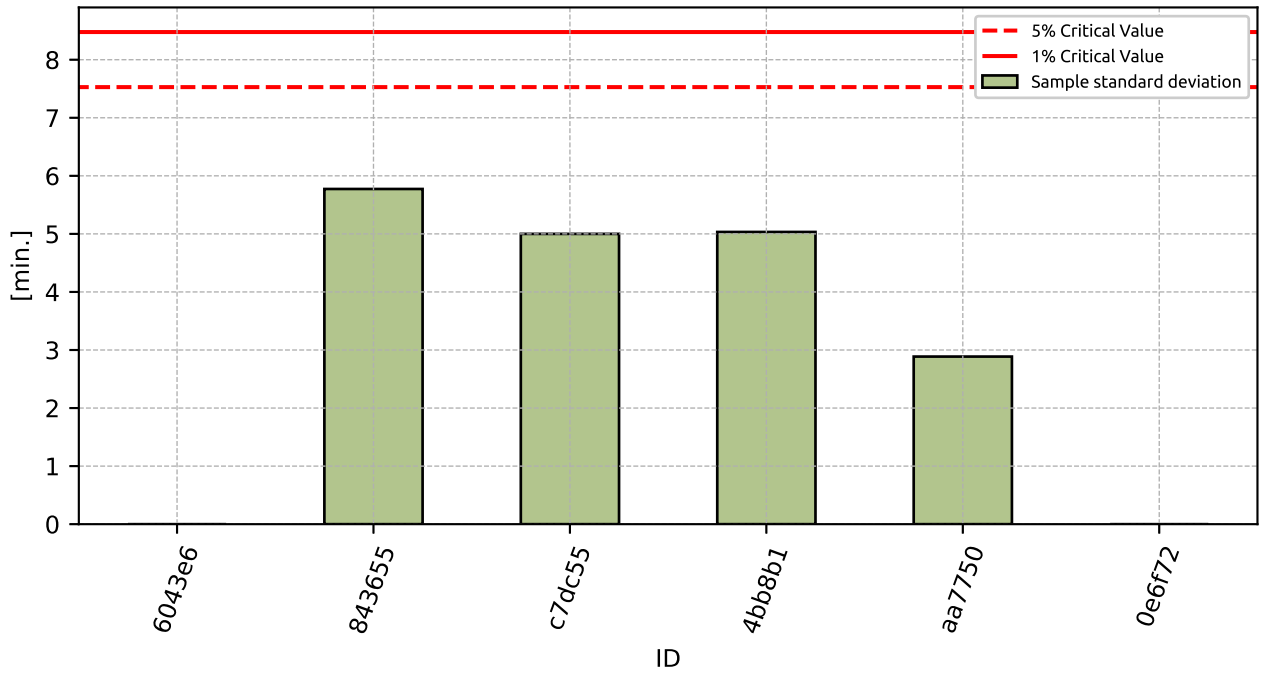

Figure 75: **Cochran's test** - sample standard deviations

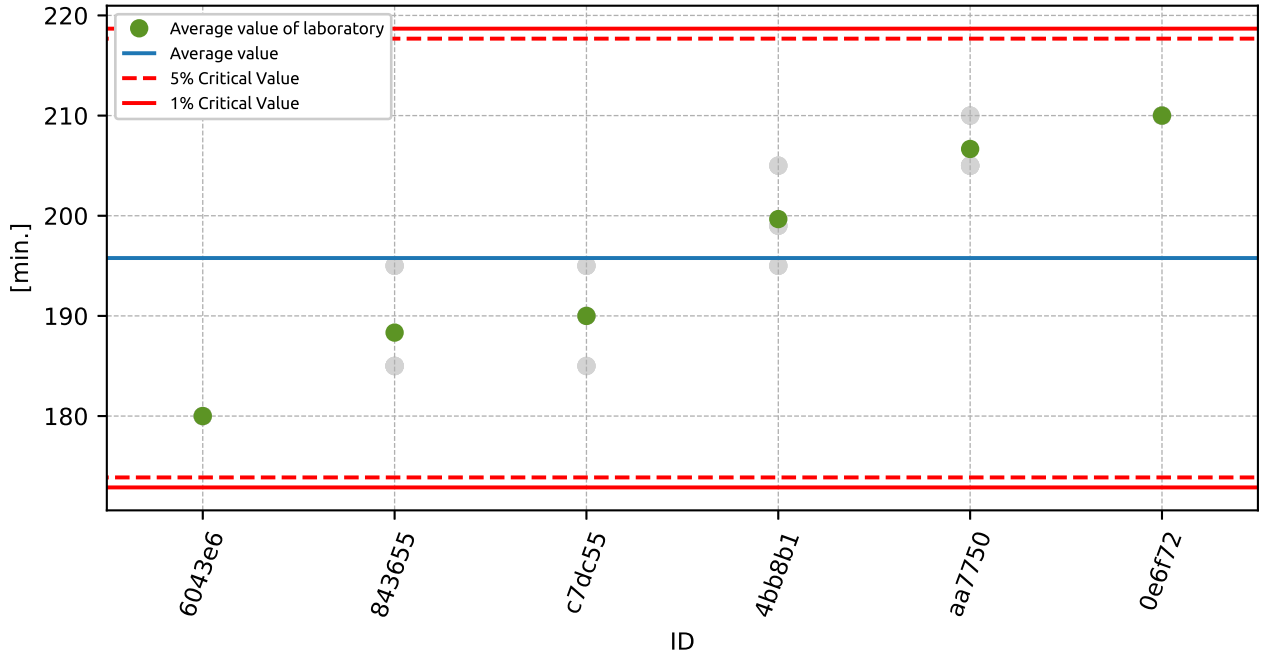

Figure 76: **Grubbs' test** - average values

8.1.3 Mandel's Statistics

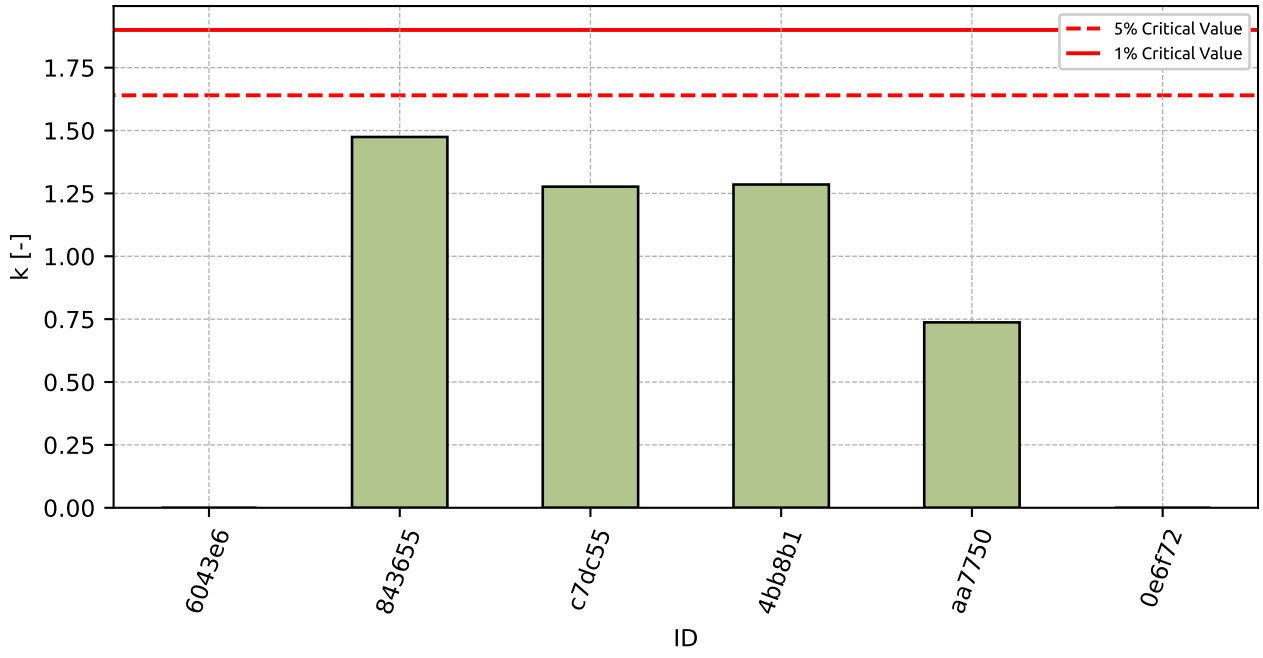

Figure 77: Intralaboratory Consistency Statistic

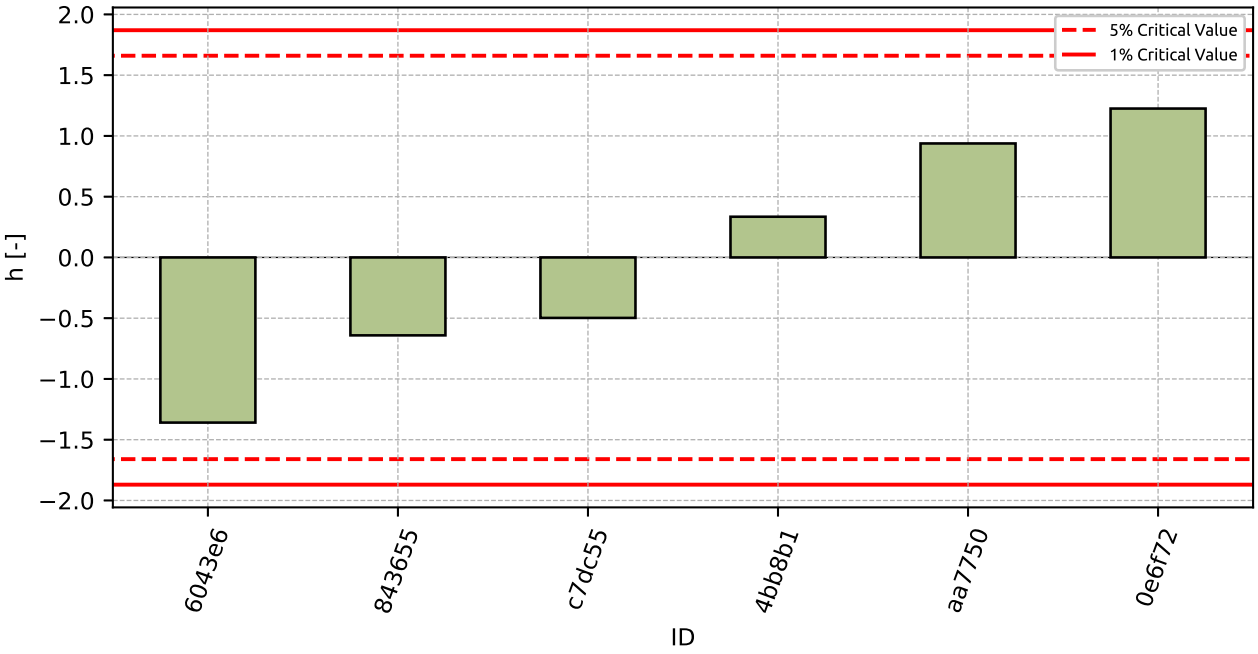

Figure 78: Interlaboratory Consistency Statistic

8.1.4 Descriptive statistics

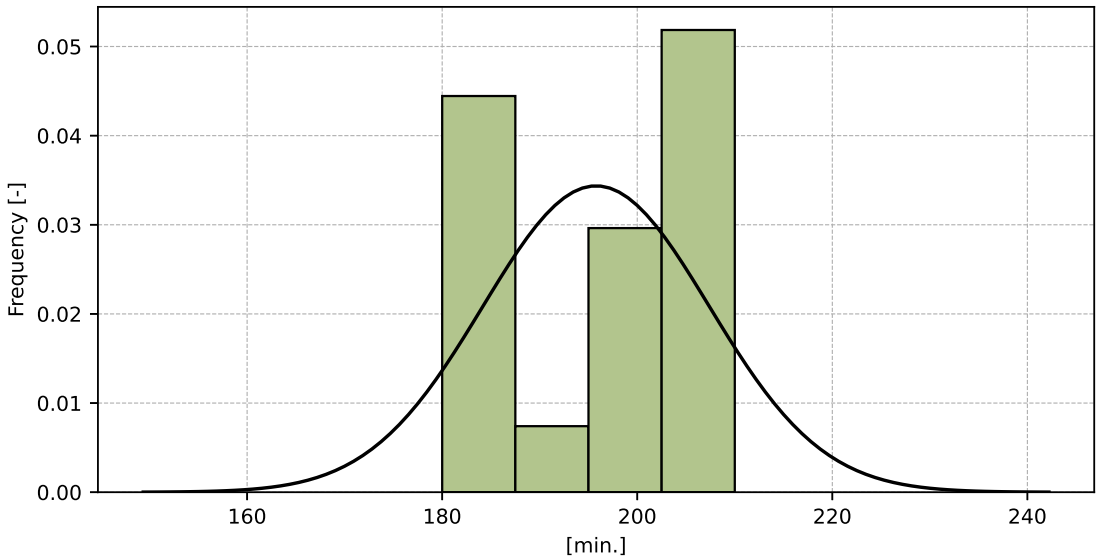

Figure 79: Histogram of all test results

Table 29: Descriptive statistics

Characteristics	[min.]
Average value – $\bar{x}$	196.0
Sample standard deviation – s	11.6
Asigned value – x^*	196.0
Robust standard deviation – s^*	12.0
Measurement uncertainty of asigned value – u_X	6.1
p-value of normality test	0.031 [-]
Interlaboratory standard deviation – s_L	11.4
Repeatability standard deviation – s_r	3.9
Reproducibility standard deviation – s_R	12.0
Repeatability – r	11.0
Reproducibility – R	34.0

8.1.5 Evaluation of Performance Statistics

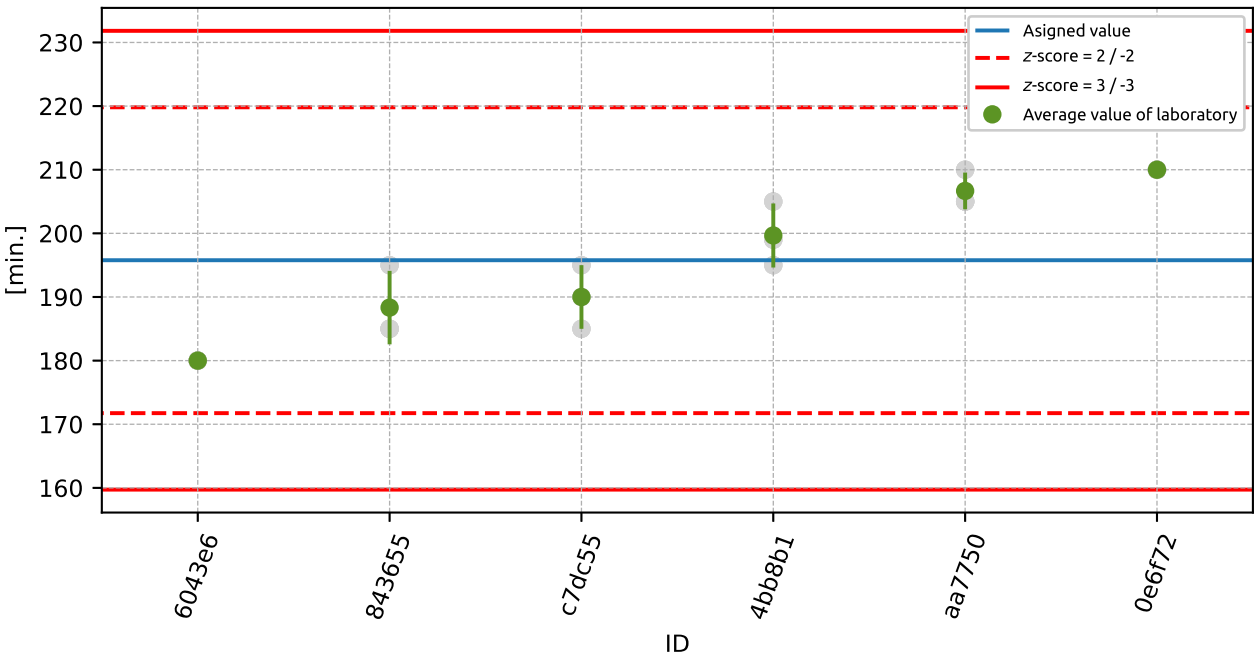

Figure 80: Average values and sample standard deviations

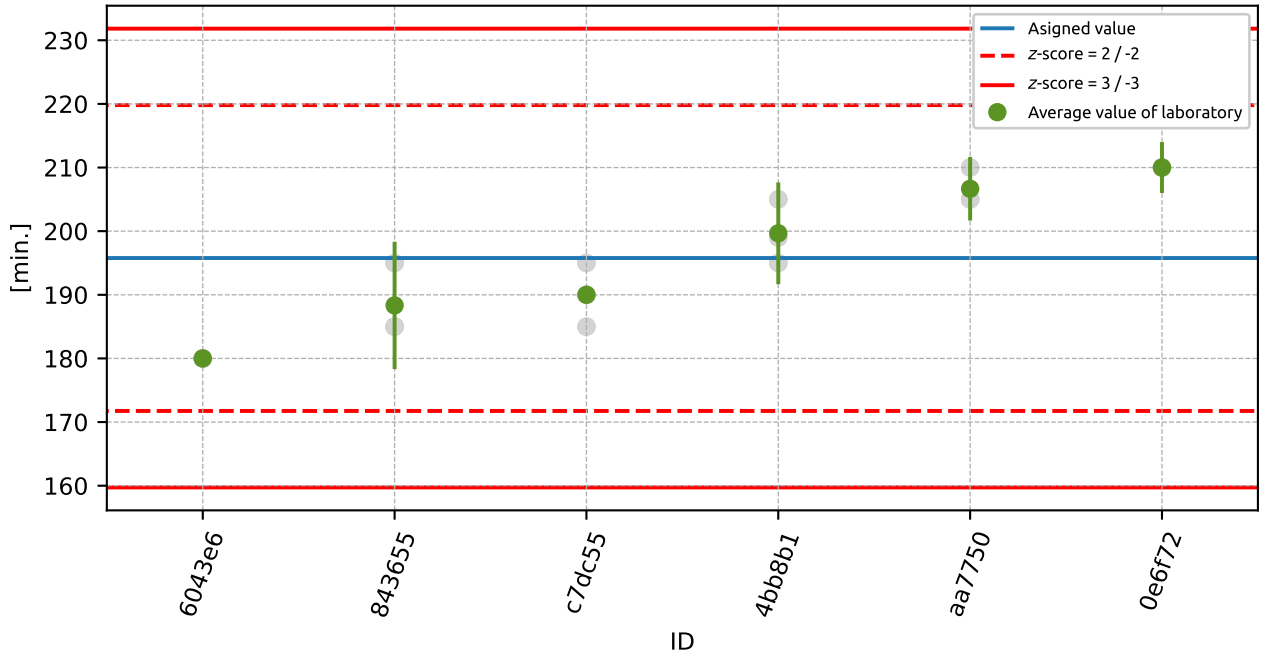

Figure 81: Average values and extended uncertainties of measurement

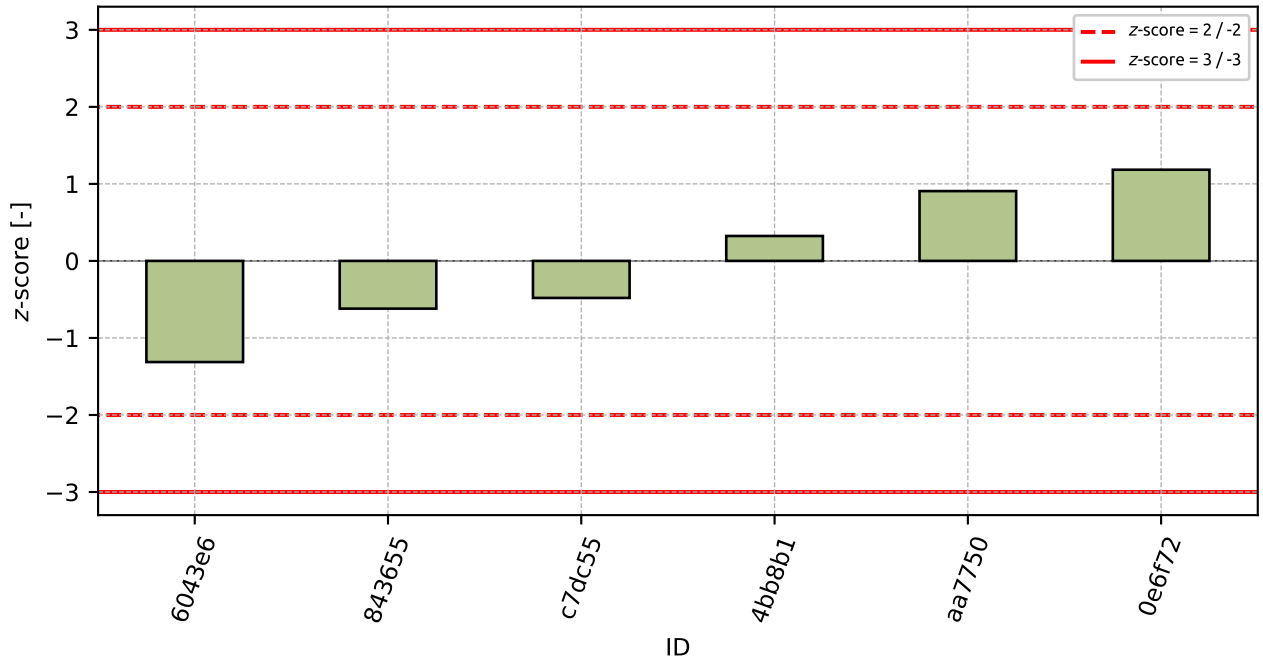

Figure 82: z-score

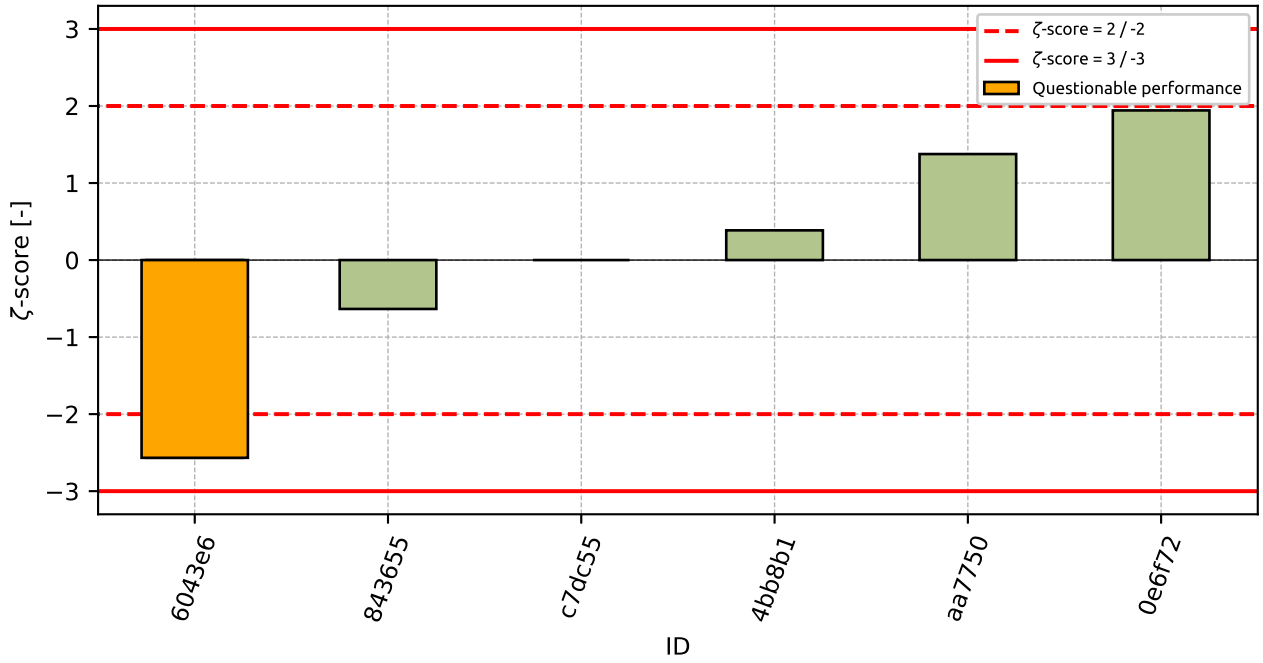

Figure 83: ζ-score

Table 30: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
6043e6	-1.31	-2.57
843655	-0.62	-0.63
c7dc55	-0.48	-
4bb8b1	0.32	0.39
aa7750	0.91	1.38
0e6f72	1.18	1.94

8.2 Final setting time

8.2.1 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 [min.]			u_X [min.]	$\bar{x}$ [min.]	s_0 [min.]	V_X [%]
c7dc55	230	225	235	-	230	5.0	2.17
843655	225	235	230	10.0	230	5.0	2.17
6043e6	240	240	240	1.0	240	0.0	0.0
0e6f72	240	255	255	5.0	250	8.7	3.46
aa7750	255	255	250	5.0	253	2.9	1.14
4bb8b1	277	280	280	12.0	279	1.7	0.62

8.2.2 The Numerical Procedure for Determining Outliers

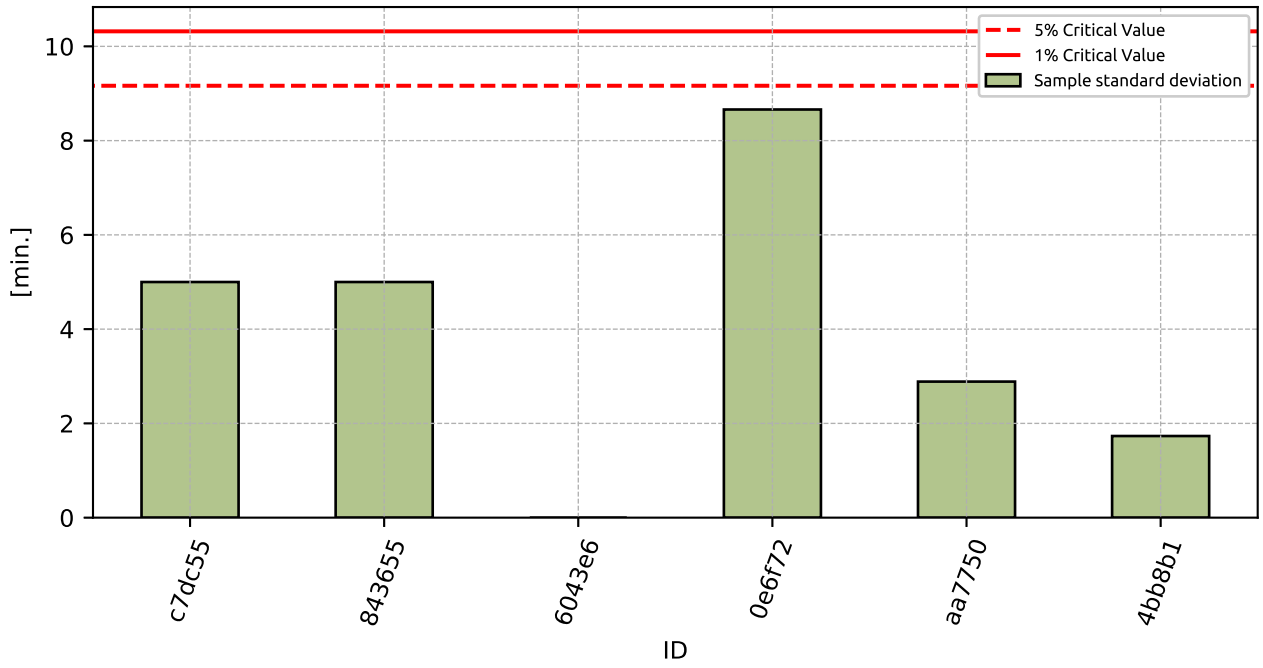

Figure 84: **Cochran's test** - sample standard deviations

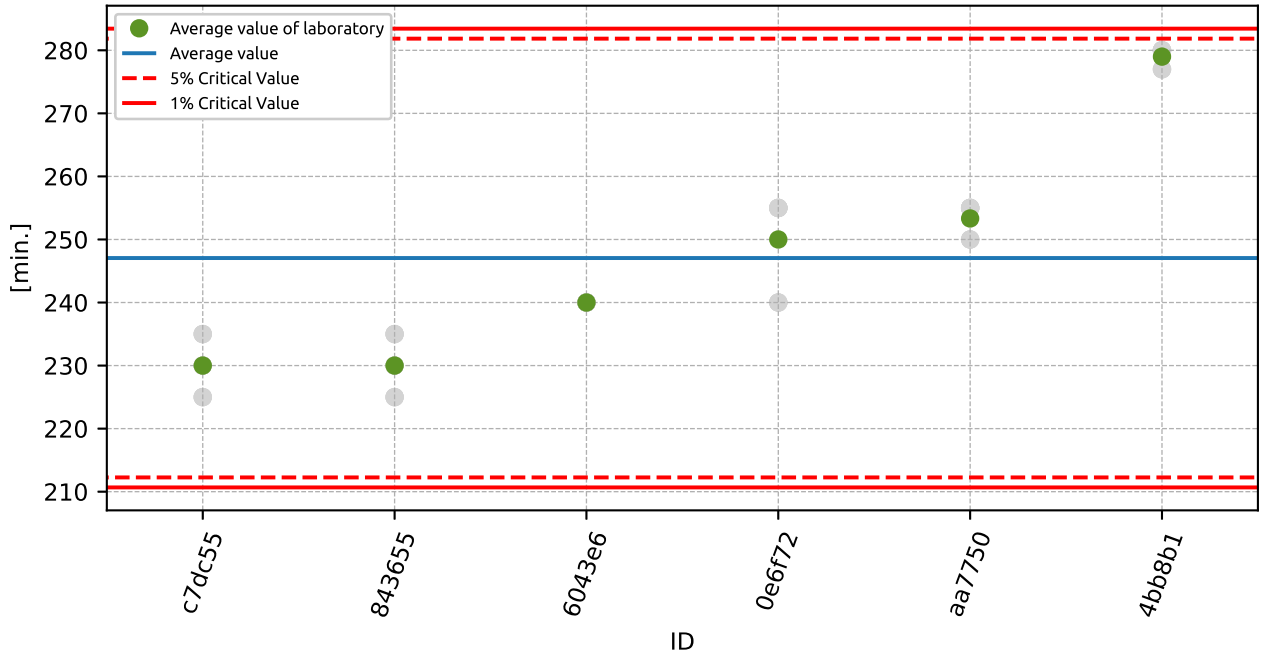

Figure 85: **Grubbs' test** - average values

8.2.3 Mandel's Statistics

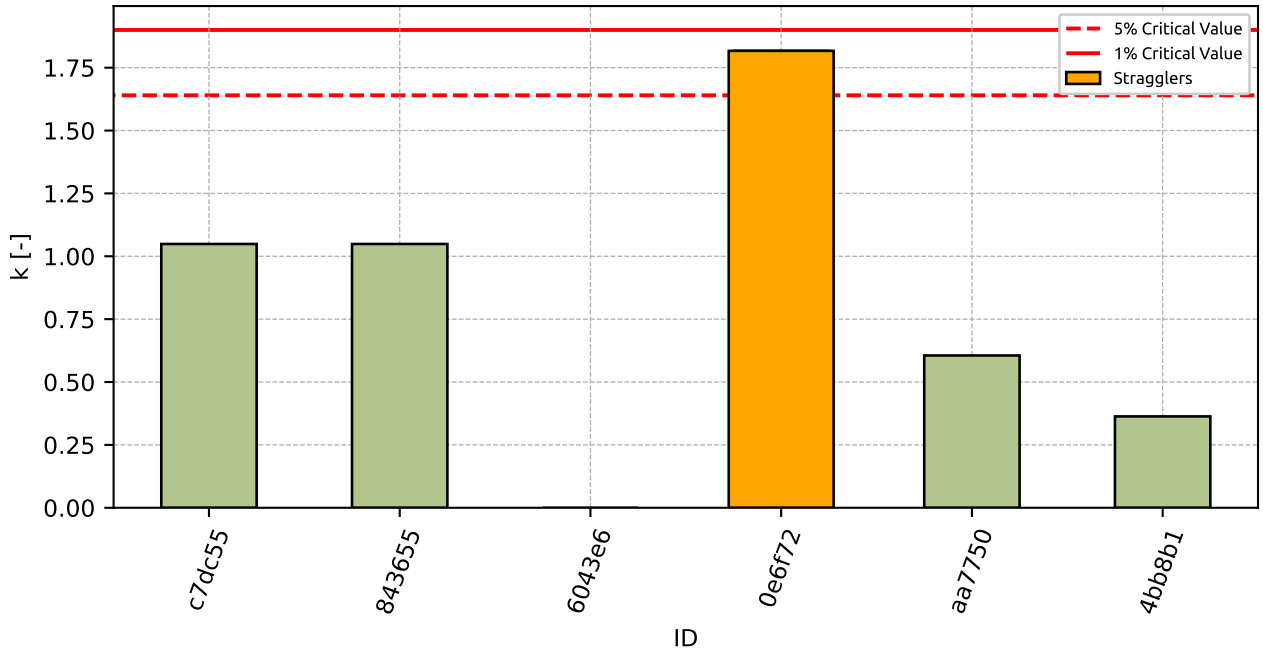

Figure 86: Intralaboratory Consistency Statistic

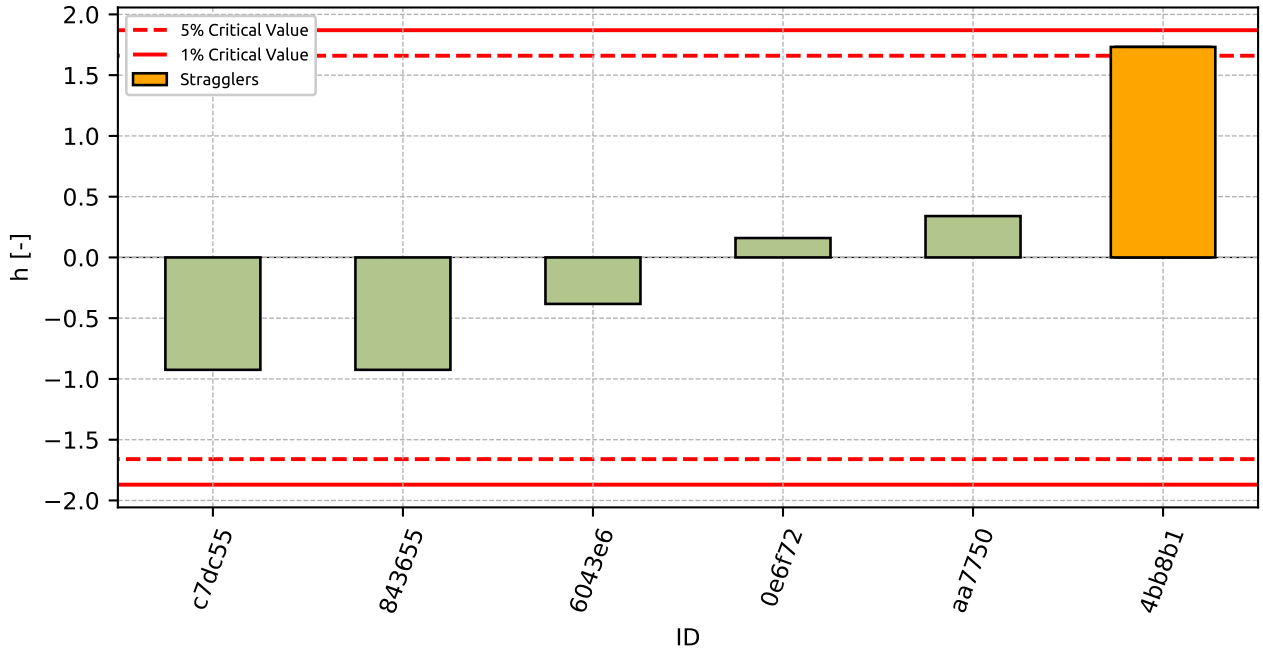

Figure 87: Interlaboratory Consistency Statistic

8.2.4 Descriptive statistics

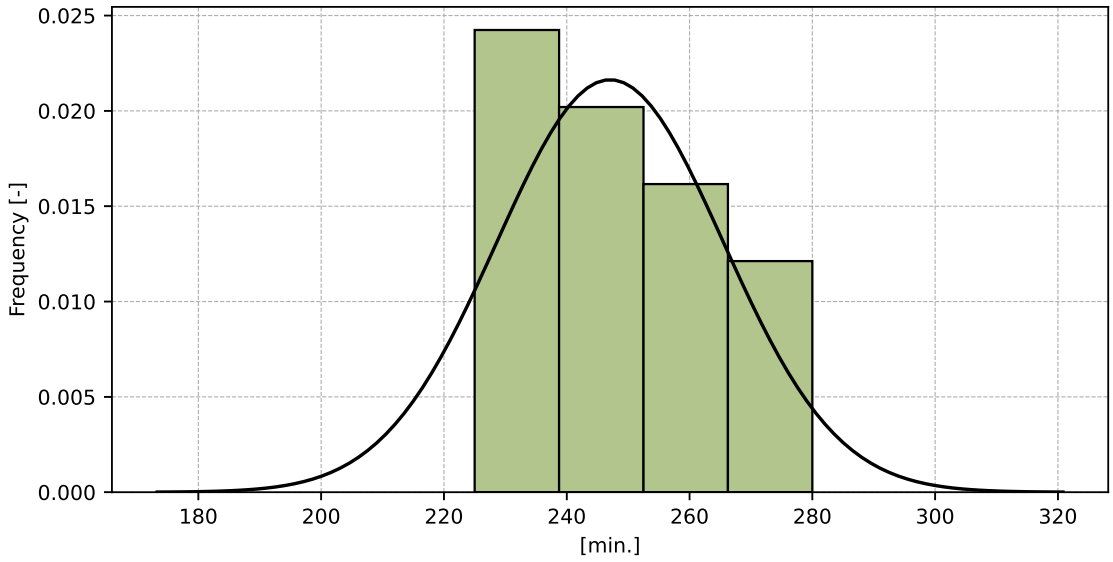

Figure 88: Histogram of all test results

Table 32: Descriptive statistics

Characteristics	[min.]
Average value – $\bar{x}$	247.0
Sample standard deviation – s	18.4
Asigned value – x^*	247.0
Robust standard deviation – s^*	19.1
Measurement uncertainty of asigned value – u_X	9.7
p-value of normality test	0.038 [-]
Interlaboratory standard deviation – s_L	18.2
Repeatability standard deviation – s_r	4.8
Reproducibility standard deviation – s_R	18.8
Repeatability – r	13.0
Reproducibility – R	53.0

8.2.5 Evaluation of Performance Statistics

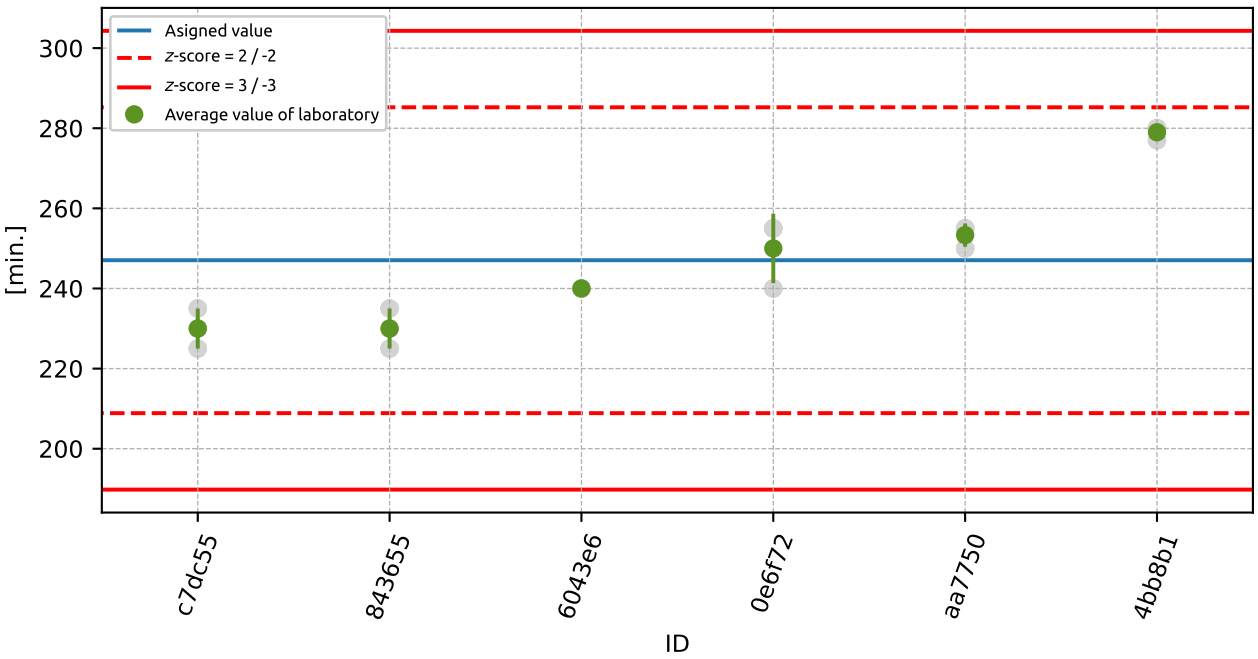

Figure 89: Average values and sample standard deviations

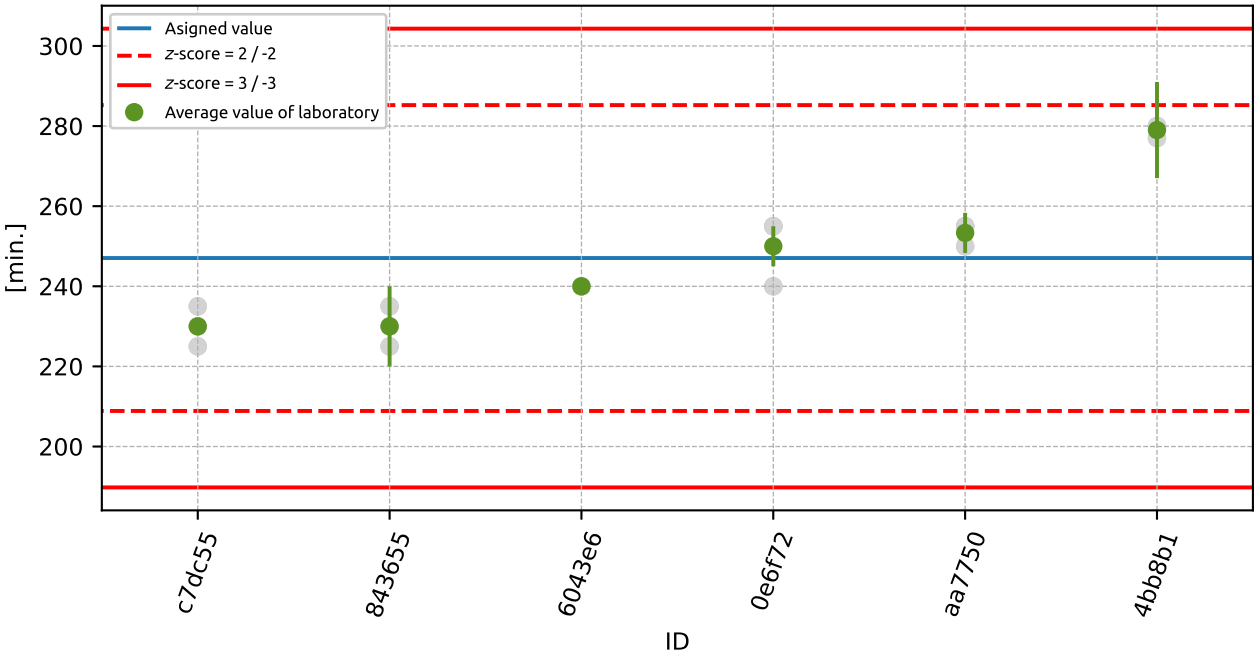

Figure 90: Average values and extended uncertainties of measurement

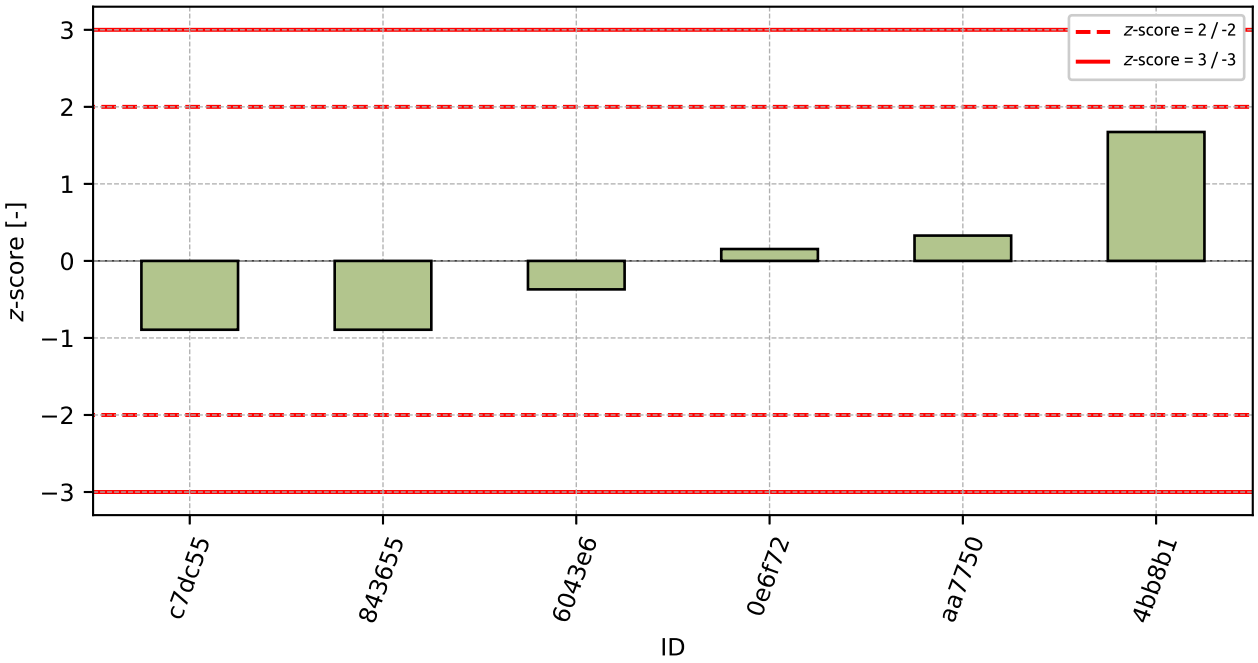

Figure 91: z-score

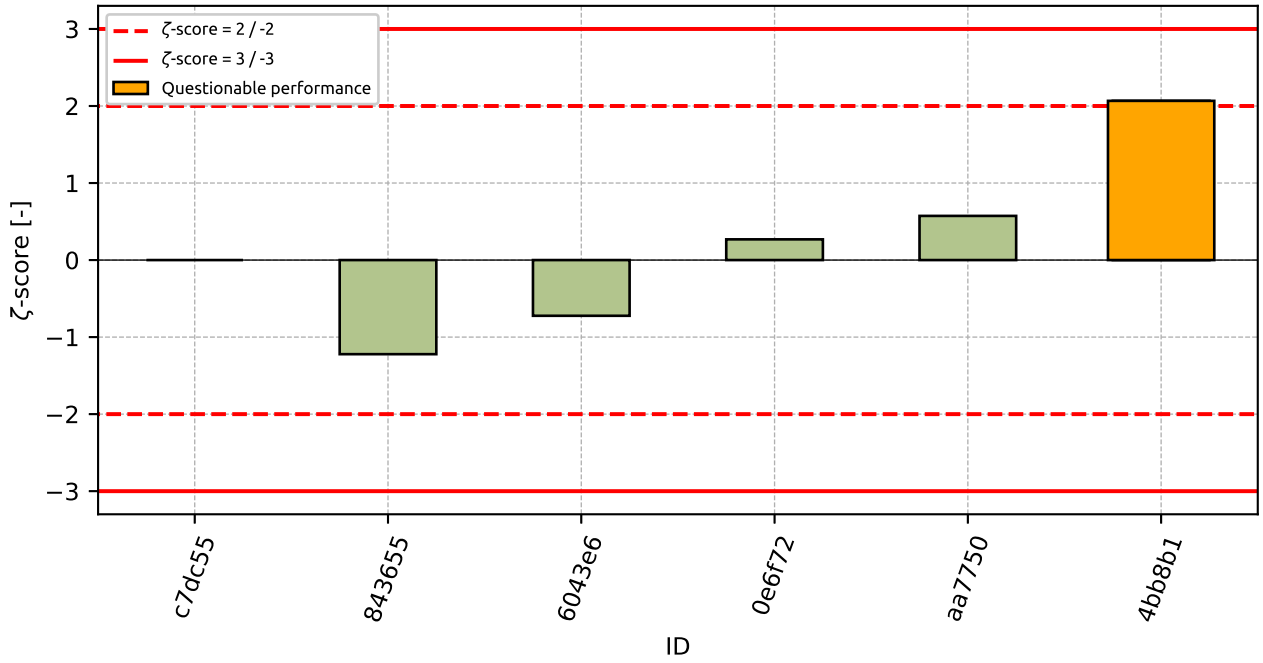

Figure 92: ζ-score

Table 33: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
c7dc55	-0.89	-
843655	-0.89	-1.22
6043e6	-0.37	-0.72
0e6f72	0.15	0.27
aa7750	0.33	0.57
4bb8b1	1.67	2.07

8.3 Soundness

8.3.1 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 [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
843655	0.3	0.6	0.5	0.5	0.5	0.15	32.73
aa7750	0.7	0.6	0.6	0.1	0.6	0.06	9.12
4bb8b1	0.7	0.7	0.8	0.1	0.7	0.06	7.87
6043e6	1.0	1.0	0.5	0.1	0.8	0.29	34.64
c7dc55	1.0	1.0	2.0	-	1.3	0.58	43.3

8.3.2 The Numerical Procedure for Determining Outliers

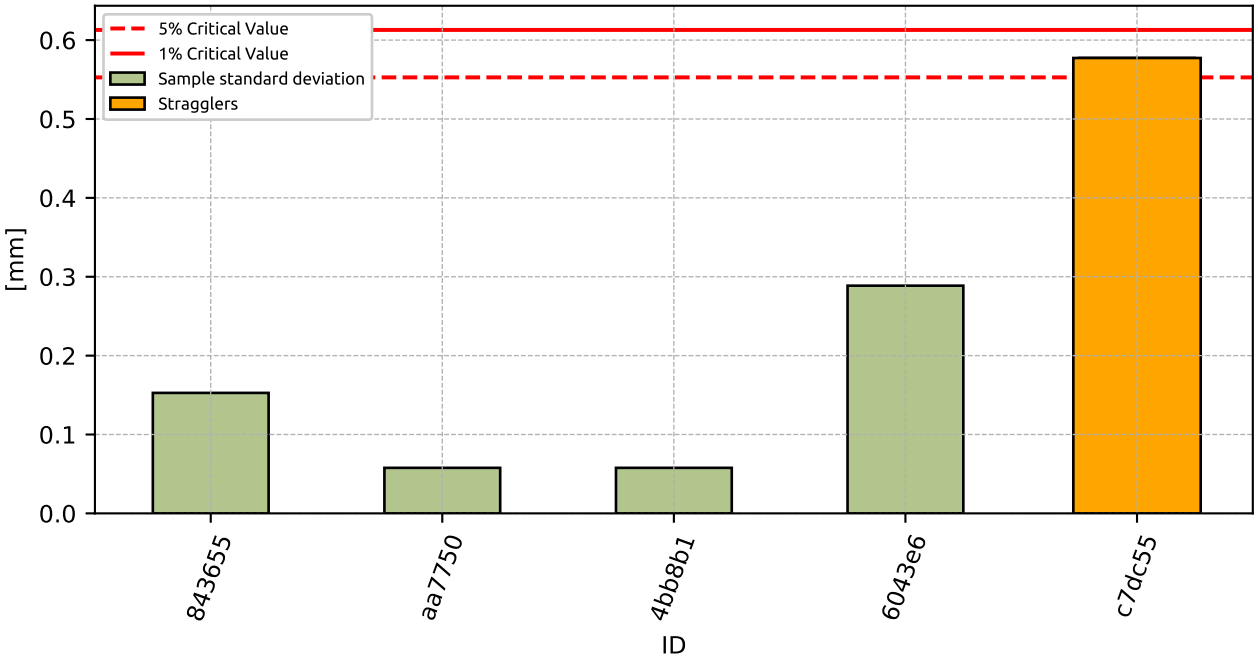

Figure 93: **Cochran's test** - sample standard deviations

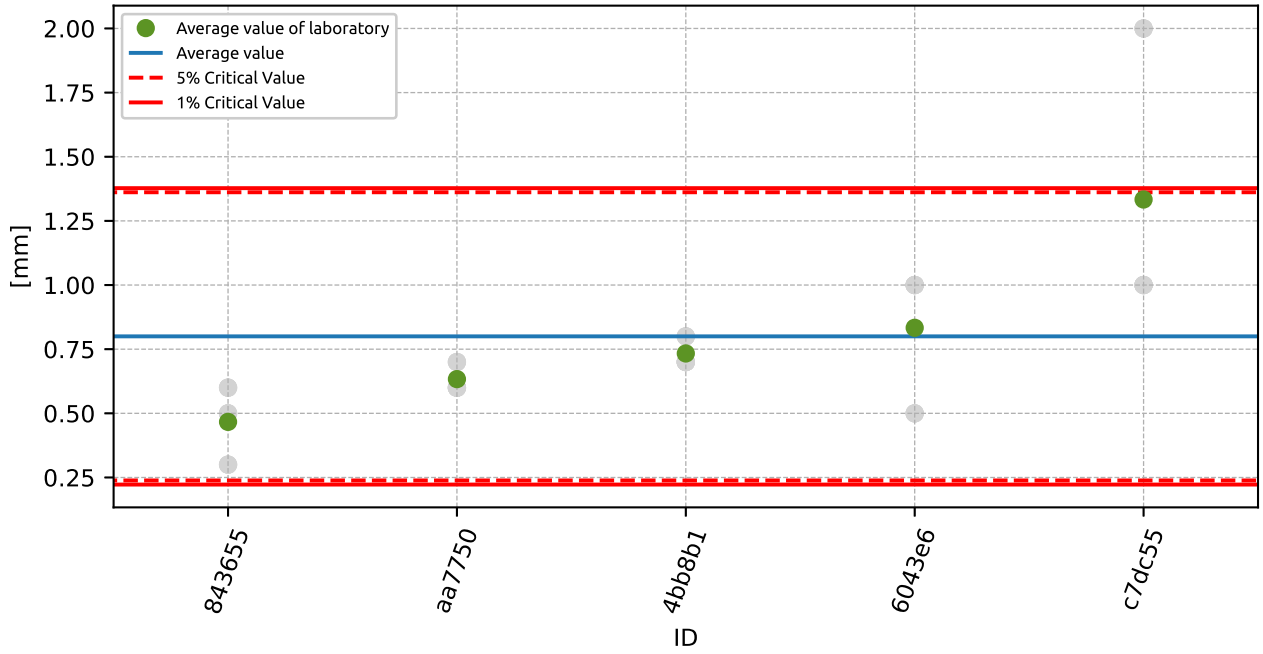

Figure 94: **Grubbs' test** - average values

8.3.3 Mandel's Statistics

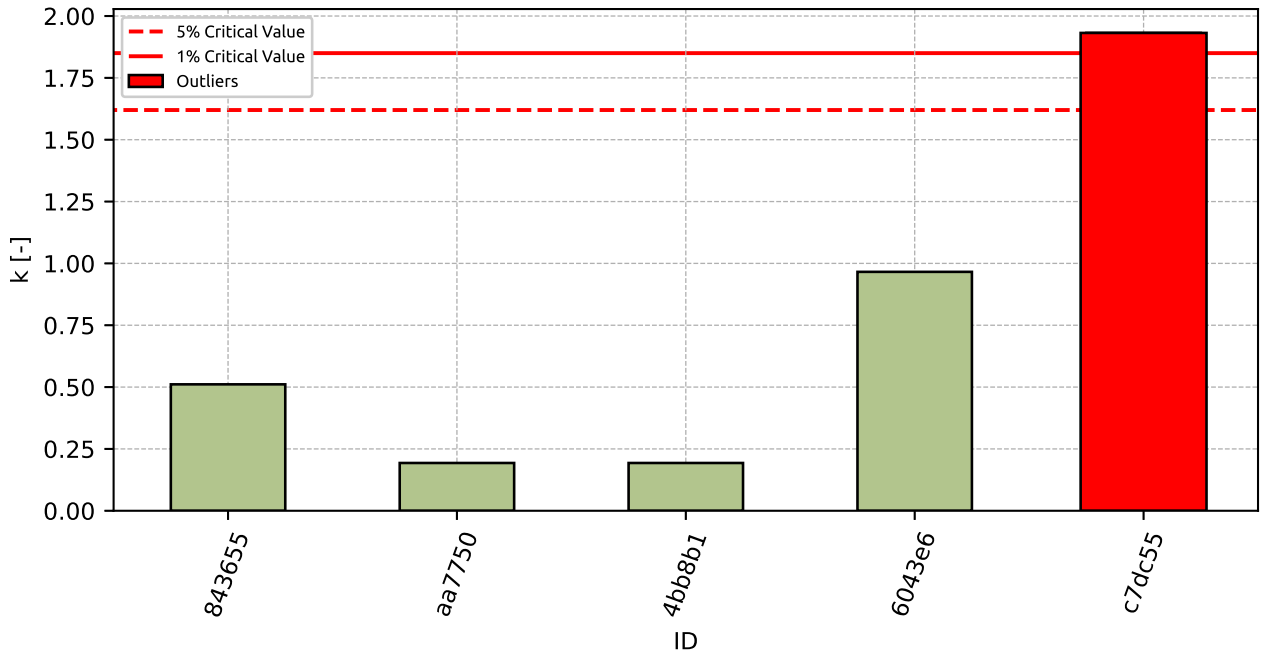

Figure 95: Intralaboratory Consistency Statistic

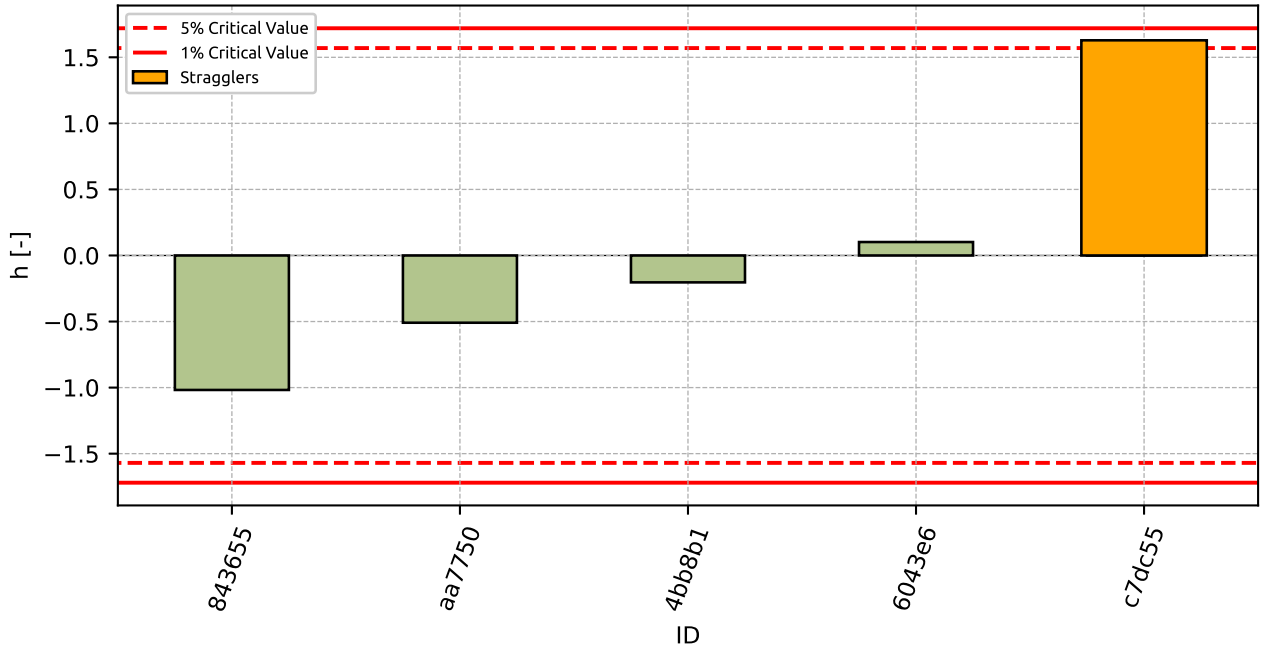

Figure 96: Interlaboratory Consistency Statistic

8.3.4 Descriptive statistics

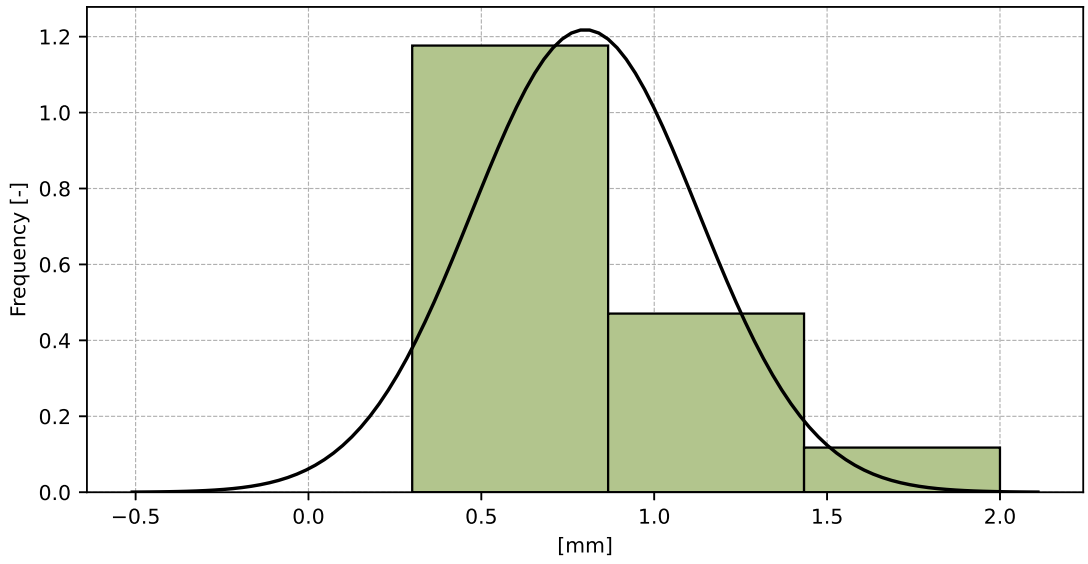

Figure 97: Histogram of all test results

Table 35: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	0.8
Sample standard deviation – s	0.33
Asigned value – x^*	0.8
Robust standard deviation – s^*	0.32
Measurement uncertainty of asigned value – u_X	0.18
p-value of normality test	0.003 [-]
Interlaboratory standard deviation – s_L	0.28
Repeatability standard deviation – s_r	0.3
Reproducibility standard deviation – s_R	0.41
Repeatability – r	0.8
Reproducibility – R	1.1

8.3.5 Evaluation of Performance Statistics

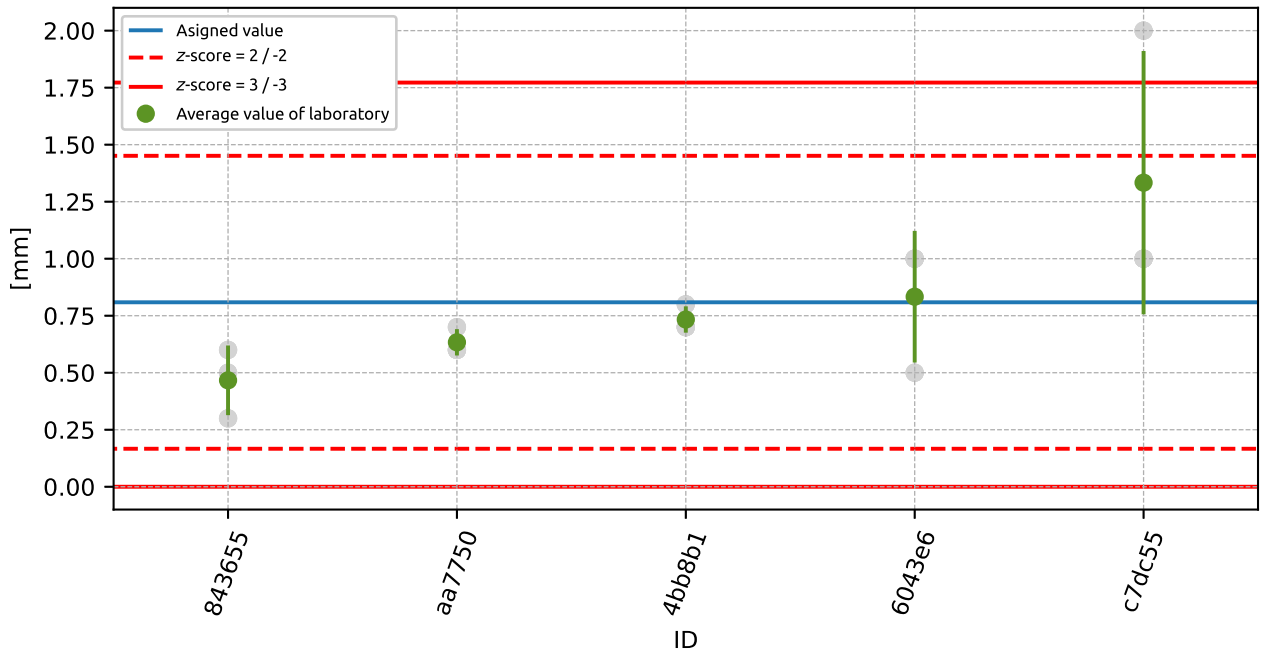

Figure 98: Average values and sample standard deviations

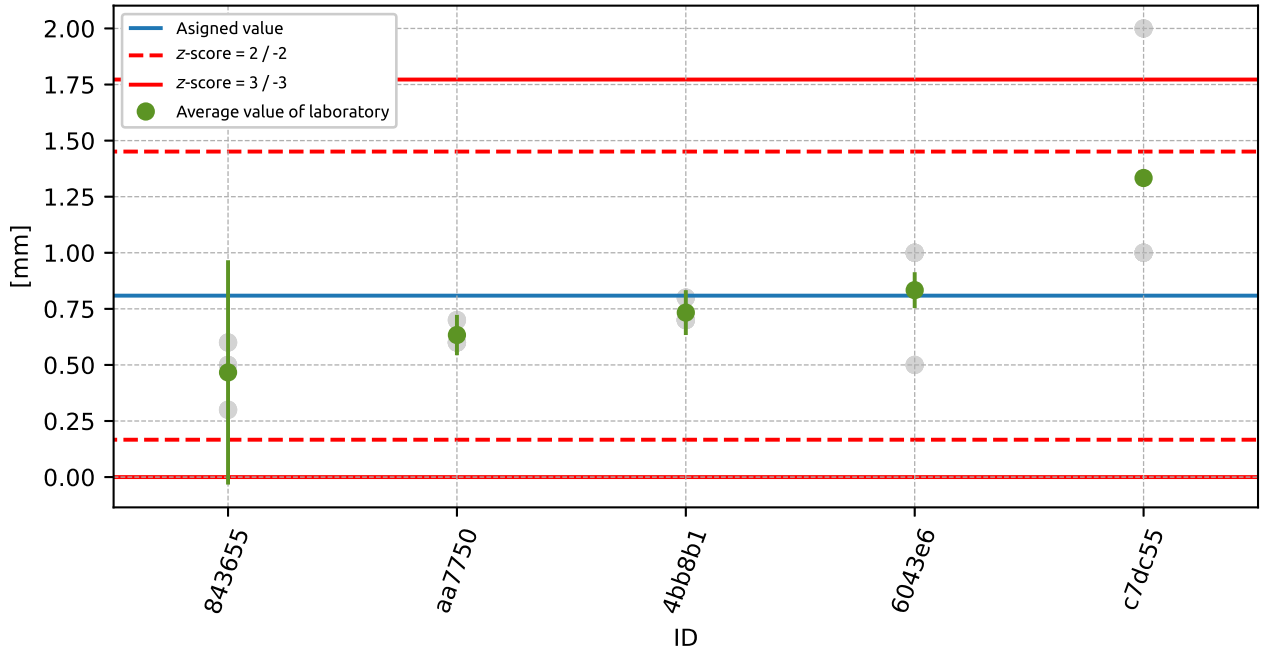

Figure 99: Average values and extended uncertainties of measurement

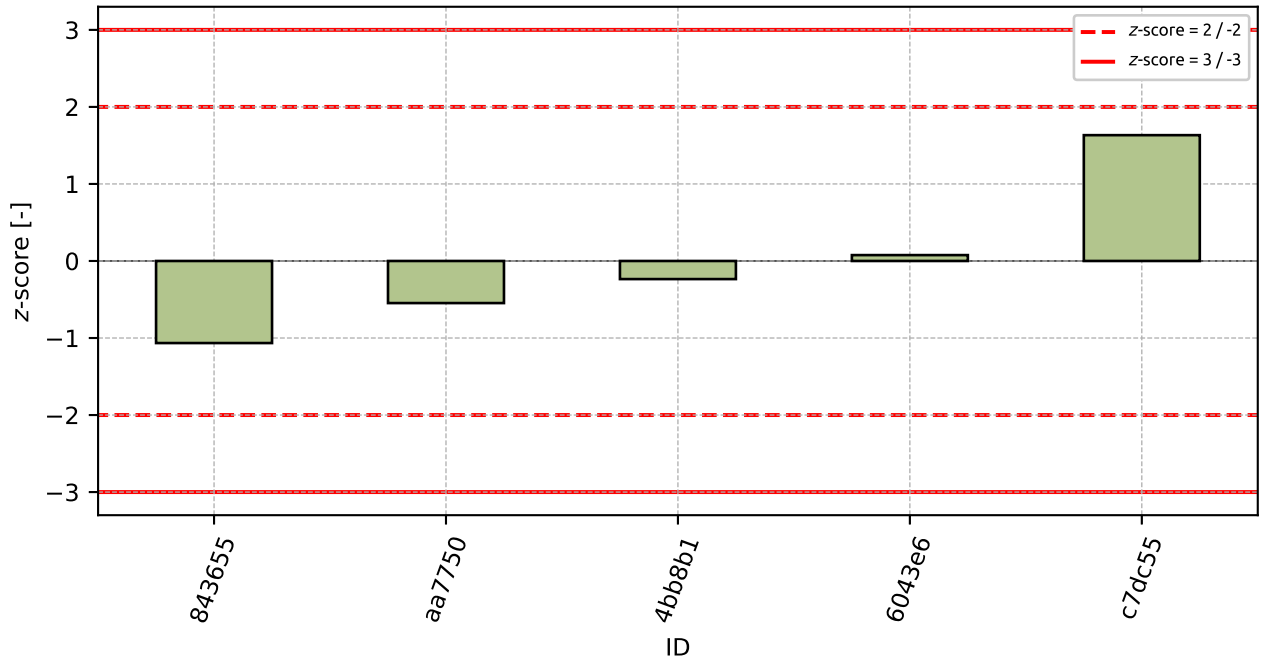

Figure 100: z-score

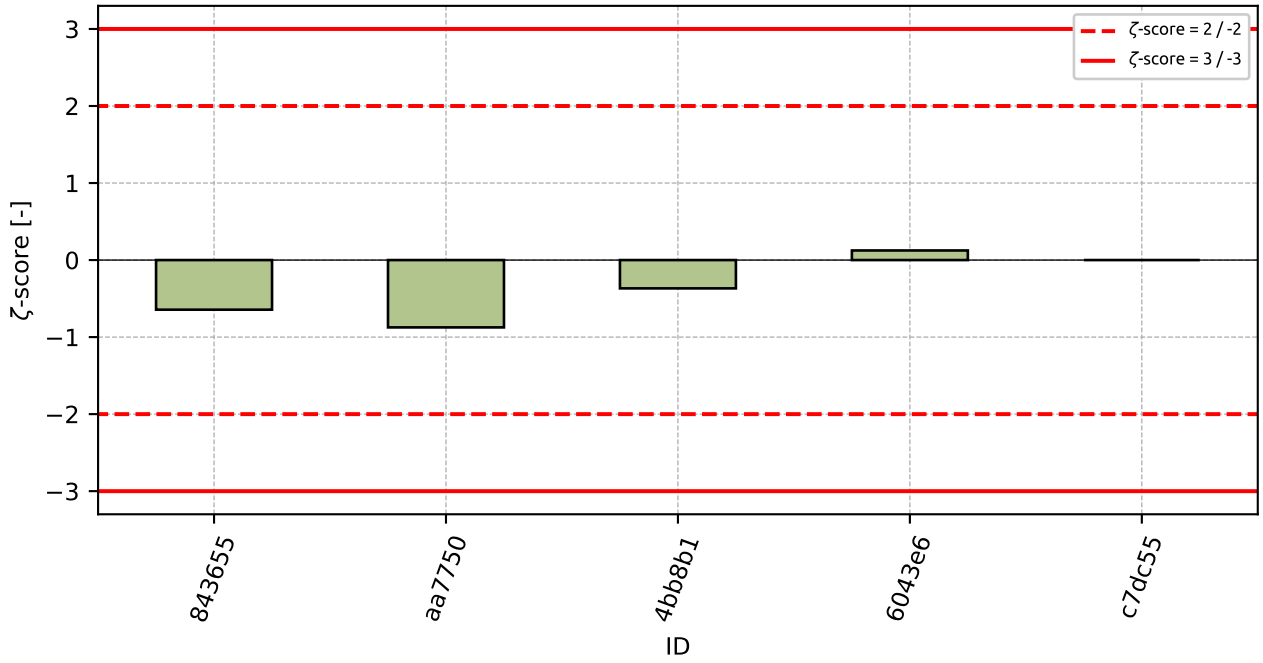

Figure 101: ζ-score

Table 36: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
843655	-1.07	-0.64
aa7750	-0.55	-0.87
4bb8b1	-0.24	-0.37
6043e6	0.08	0.12
c7dc55	1.63	-

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

9.1 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 [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
aa7750	0.00058	0.00056	0.00053	5e-05	0.00056	2.5e-05	4.52
6043e6	0.0008	0.0008	0.0008	2e-05	0.0008	0.0	0.0
47a857	0.00233	0.00233	0.00232	5e-05	0.00233	6e-06	0.25

9.2 The Numerical Procedure for Determining Outliers

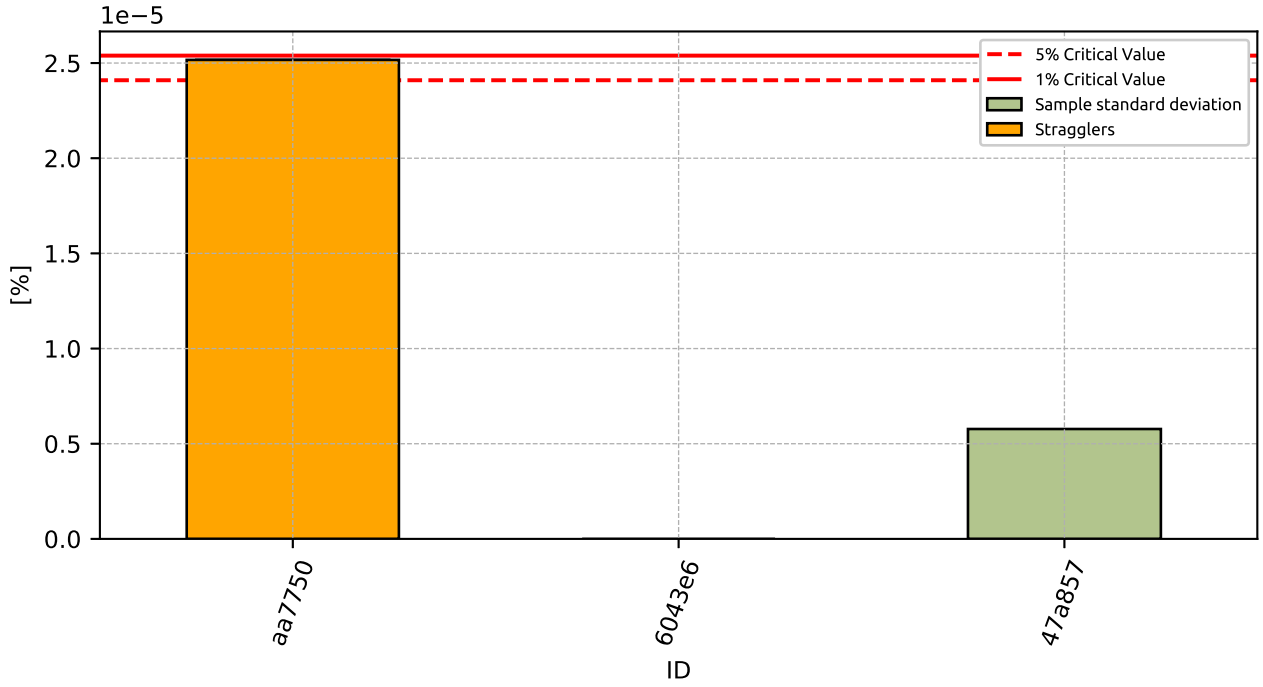

Figure 102: **Cochran's test** - sample standard deviations

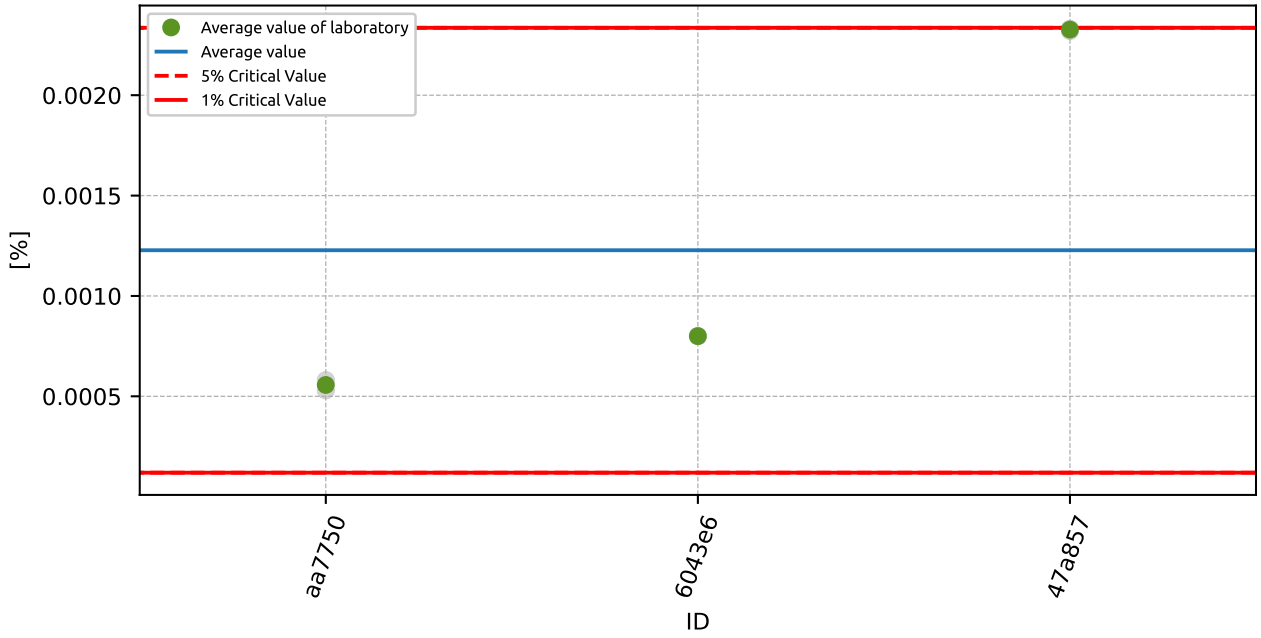

Figure 103: **Grubbs' test** - average values

9.3 Mandel's Statistics

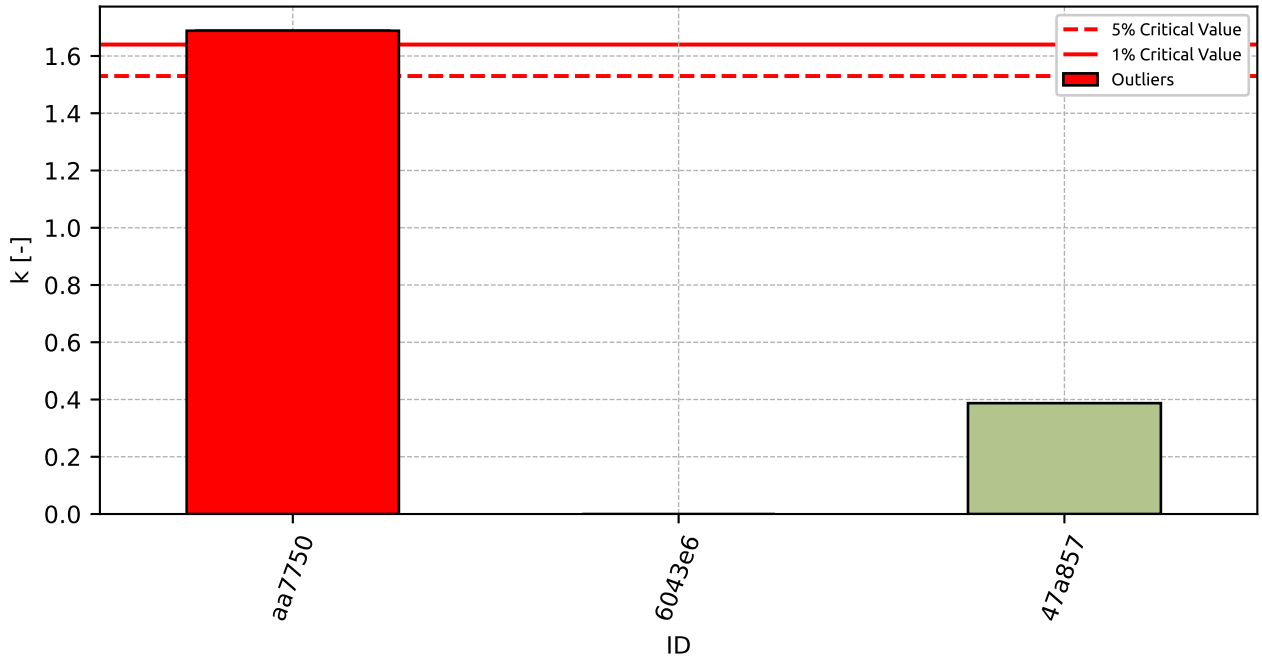

Figure 104: Intralaboratory Consistency Statistic

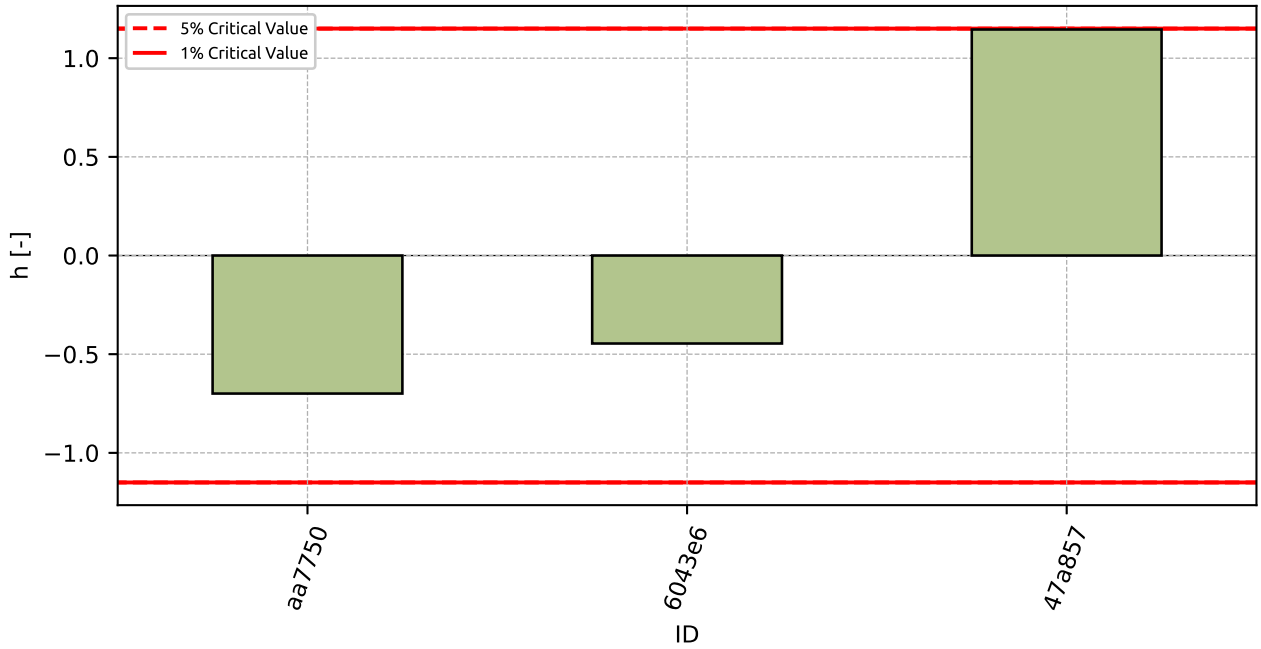

Figure 105: Interlaboratory Consistency Statistic

9.4 Descriptive statistics

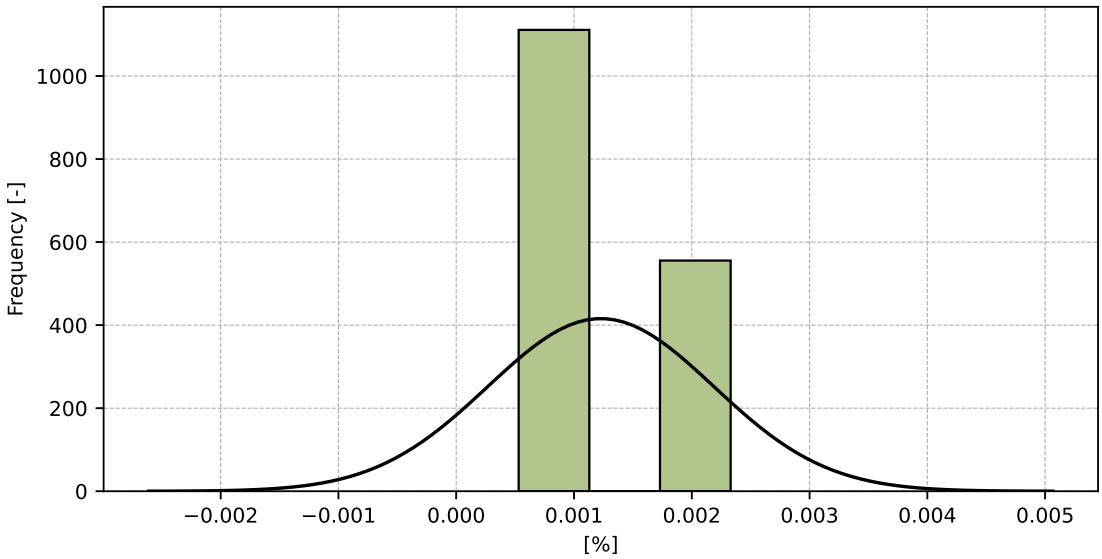

Figure 106: Histogram of all test results

Table 38: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	0.00123
Sample standard deviation – s	0.000959
Asigned value – x^*	0.00123
Robust standard deviation – s^*	0.000888
Measurement uncertainty of asigned value – u_X	0.000641
p-value of normality test	0.002 [-]
Interlaboratory standard deviation – s_L	0.000959
Repeatability standard deviation – s_r	1.5e-05
Reproducibility standard deviation – s_R	0.000959
Repeatability – r	4e-05
Reproducibility – R	0.00269

9.5 Evaluation of Performance Statistics

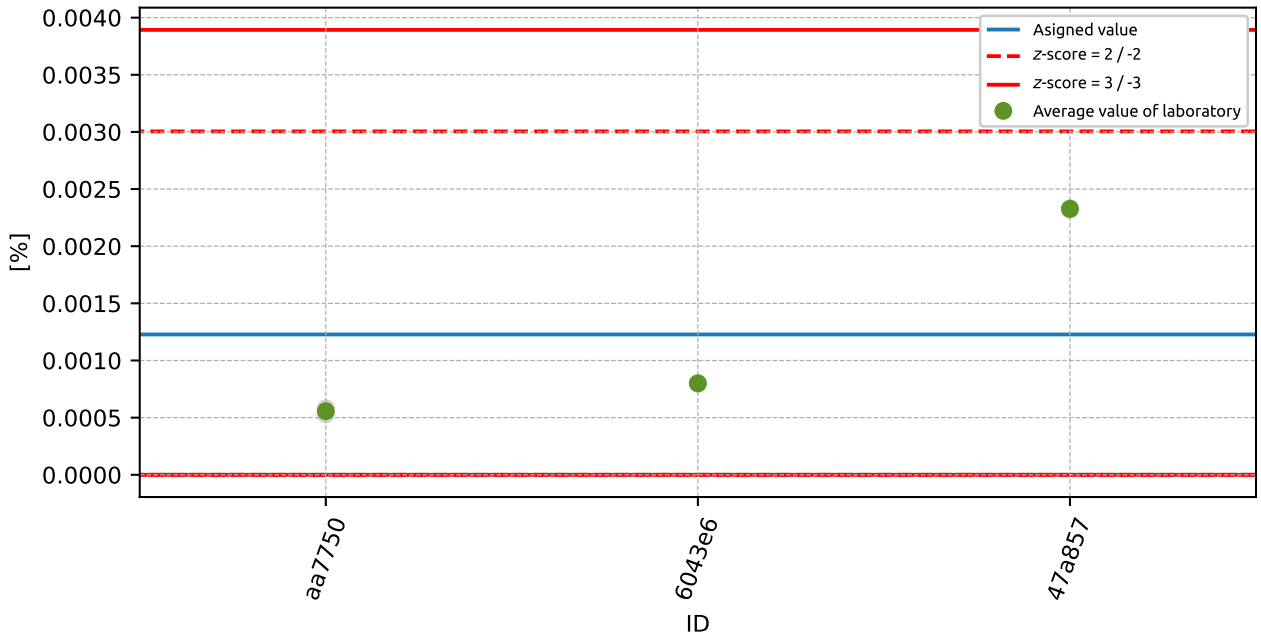

Figure 107: Average values and sample standard deviations

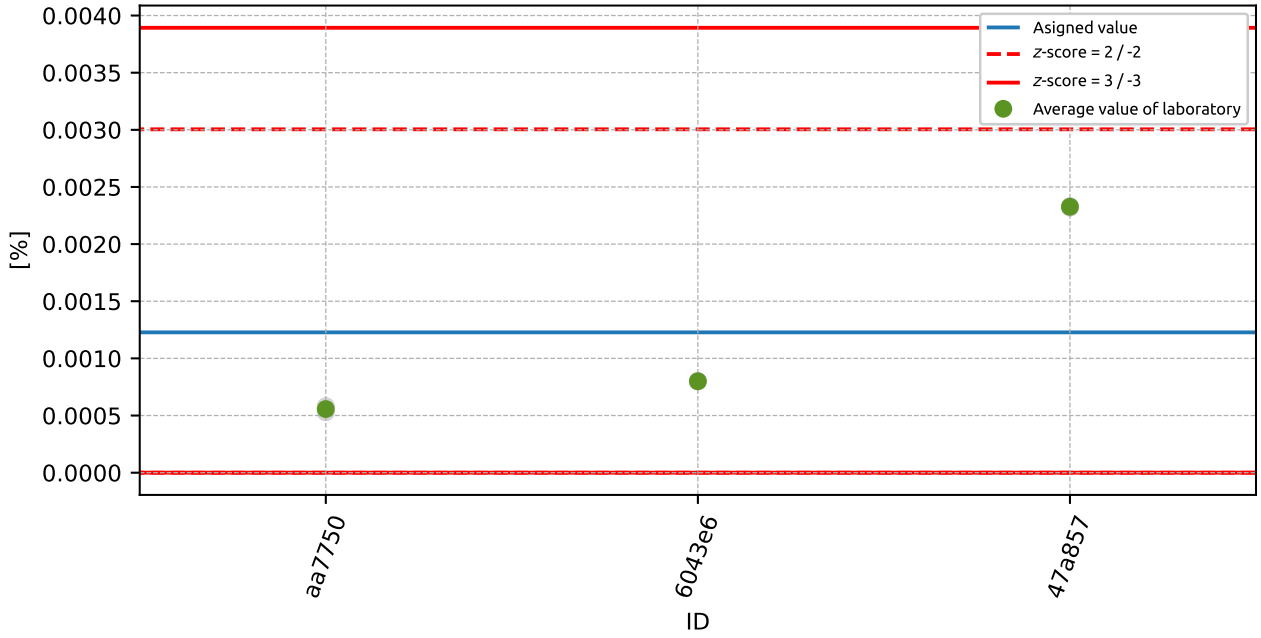

Figure 108: Average values and extended uncertainties of measurement

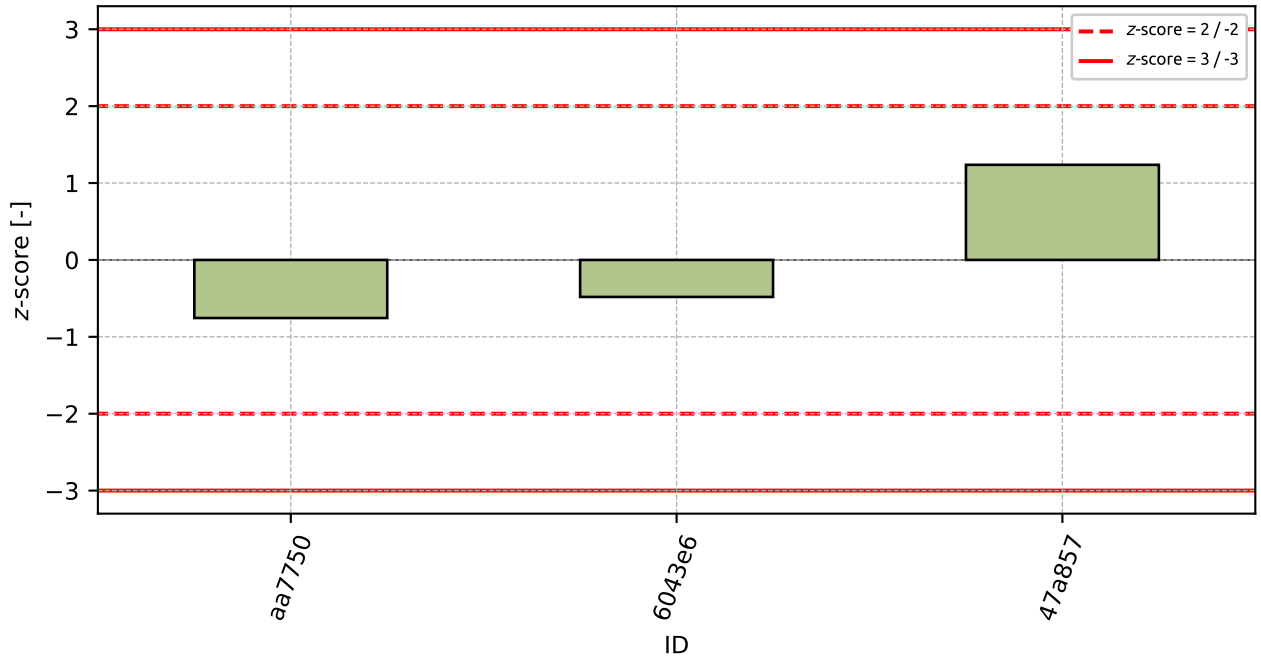

Figure 109: z-score

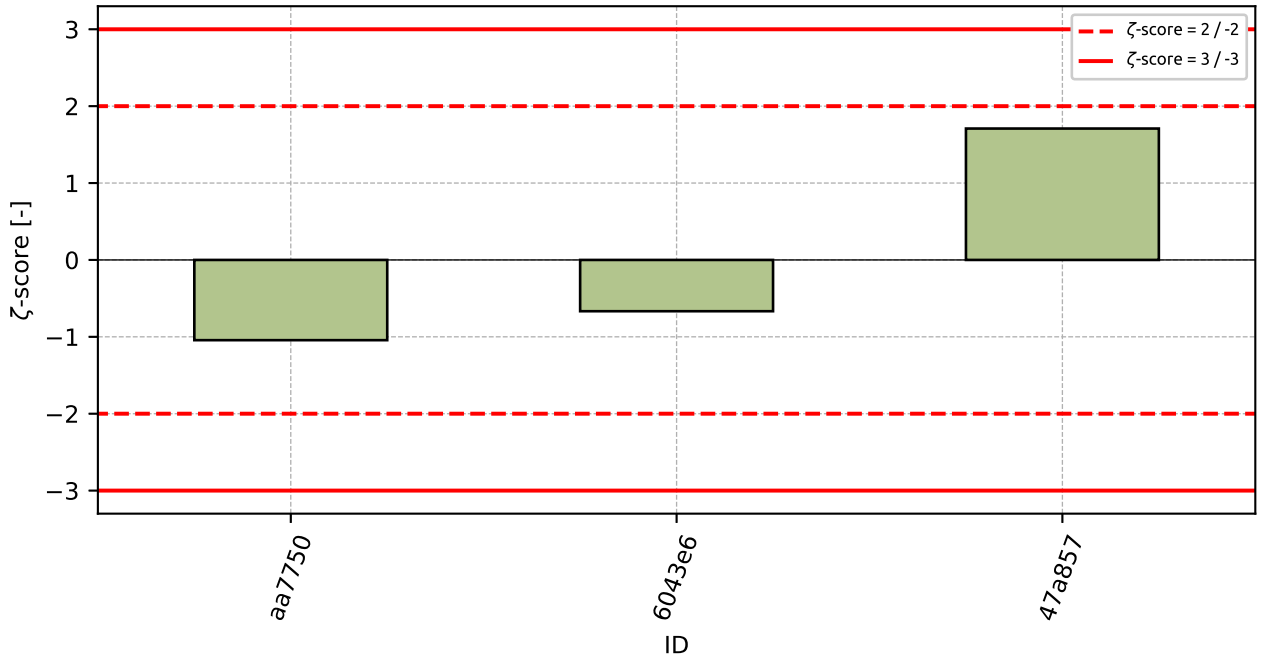

Figure 110: ζ-score

Table 39: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
aa7750	-0.76	-1.04
6043e6	-0.48	-0.67
47a857	1.24	1.71

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

12.1 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 [kg/m^3]			u_X [kg/m^3]	$\bar{x}$ [kg/m^3]	s_0 [kg/m^3]	V_X [%]
cbaf70	2043	2046	2034	40.0	2041	6.2	0.31
ef77b8	2090	2080	2090	20.0	2087	5.8	0.28
0788f7	2110	2070	2090	40.0	2090	20.0	0.96
412c89	2100	2100	2090	-	2097	5.8	0.28

12.2 The Numerical Procedure for Determining Outliers

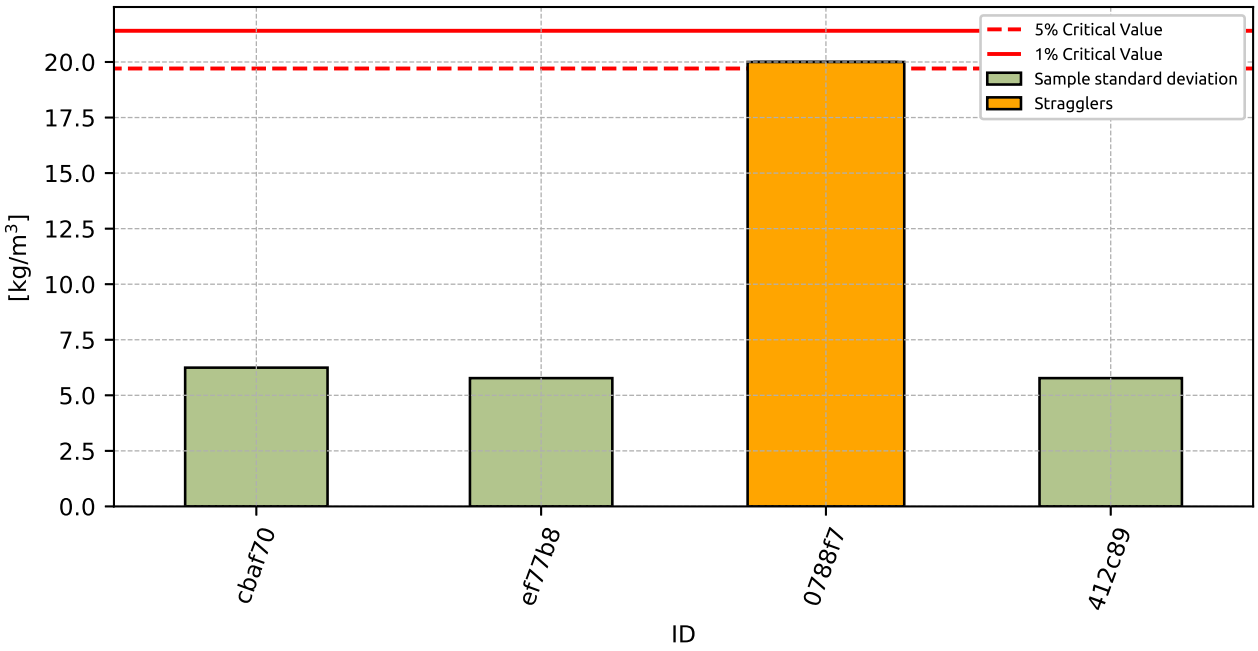

Figure 111: **Cochran's test** - sample standard deviations

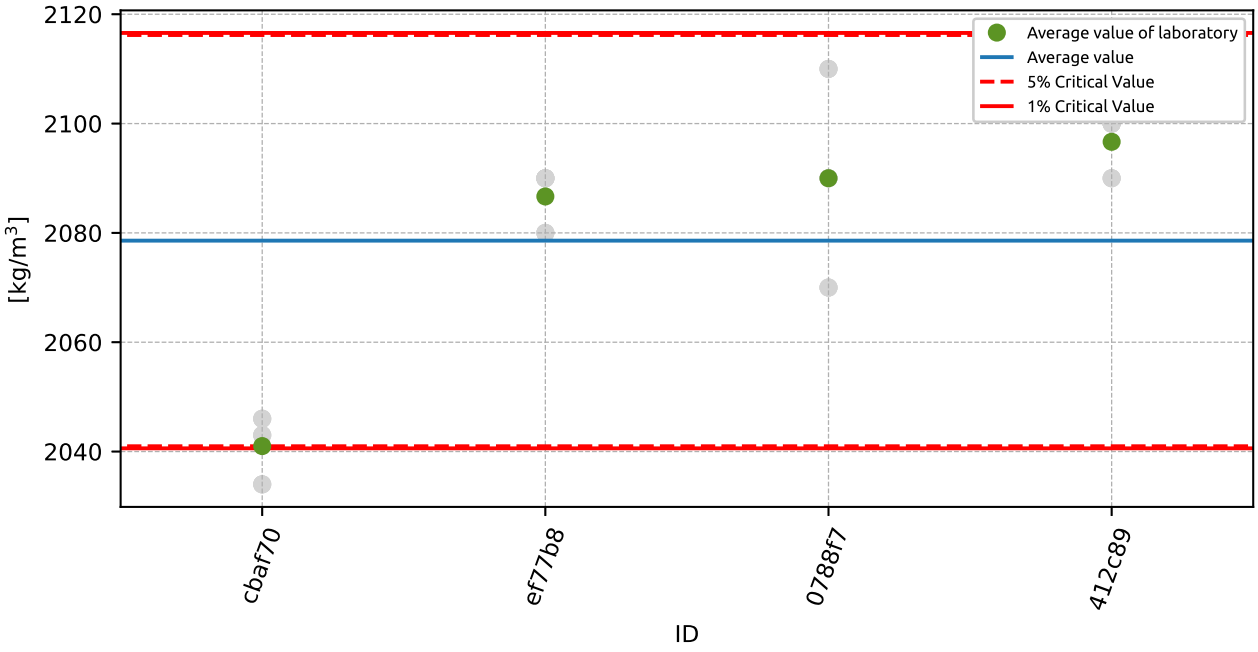

Figure 112: **Grubbs' test** - average values

12.3 Mandel's Statistics

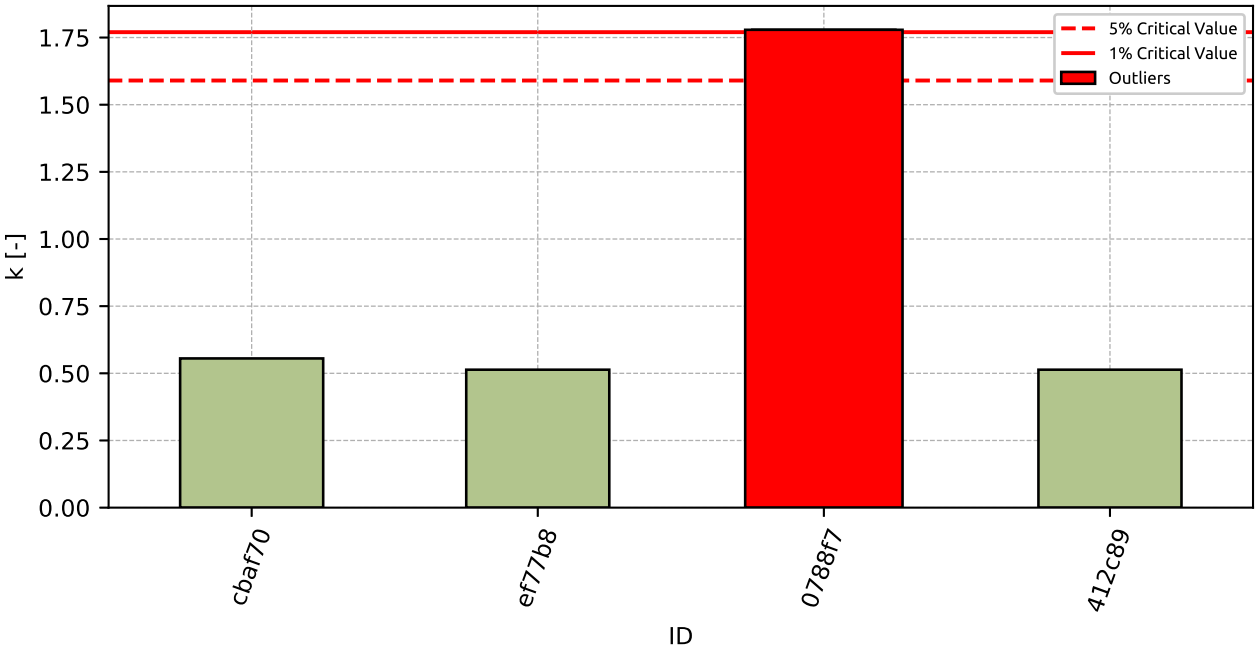

Figure 113: Intralaboratory Consistency Statistic

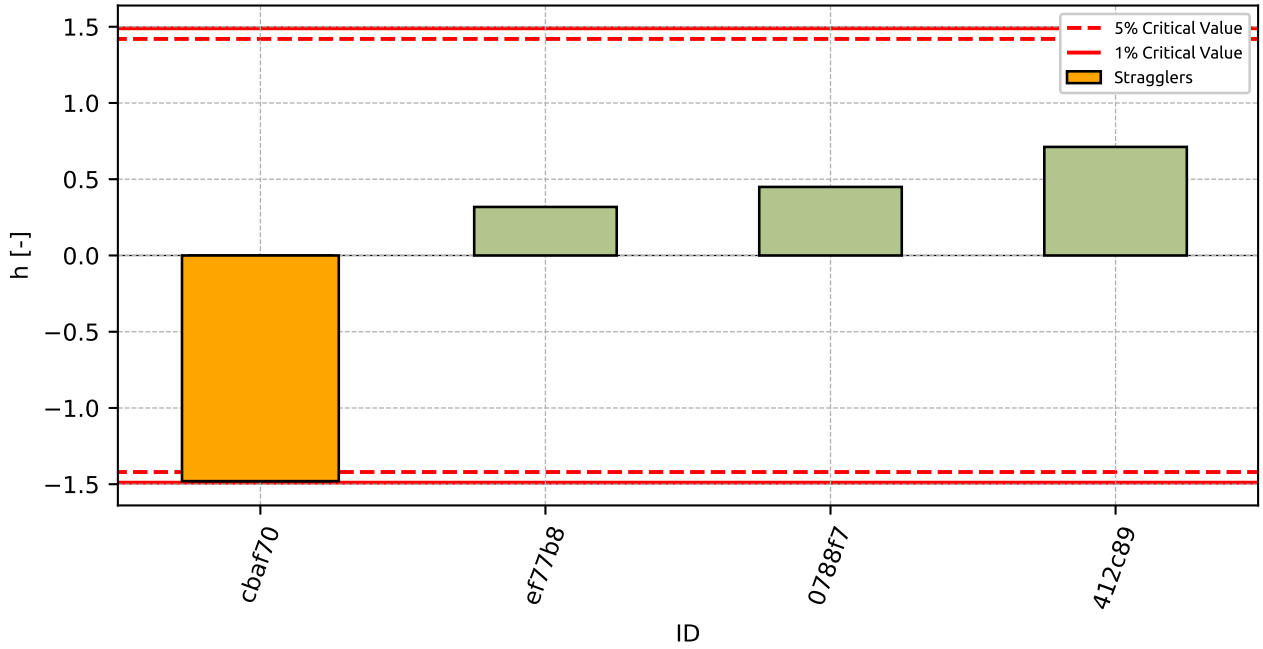

Figure 114: Interlaboratory Consistency Statistic

12.4 Descriptive statistics

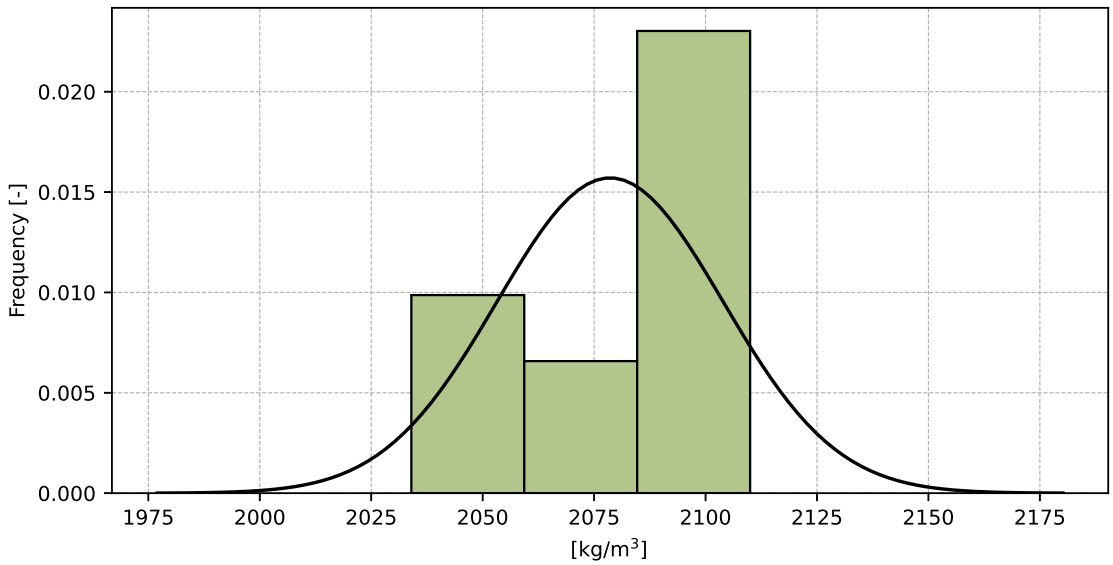

Figure 115: Histogram of all test results

Table 41: Descriptive statistics

Characteristics	[kg/m³]
Average value – $\bar{x}$	2079.0
Sample standard deviation – s	25.4
Asigned value – x^*	2088.0
Robust standard deviation – s^*	8.0
Measurement uncertainty of asigned value – u_X	5.0
p-value of normality test	0.081 [-]
Interlaboratory standard deviation – s_L	24.6
Repeatability standard deviation – s_r	11.2
Reproducibility standard deviation – s_R	27.0
Repeatability – r	31.0
Reproducibility – R	76.0

12.5 Evaluation of Performance Statistics

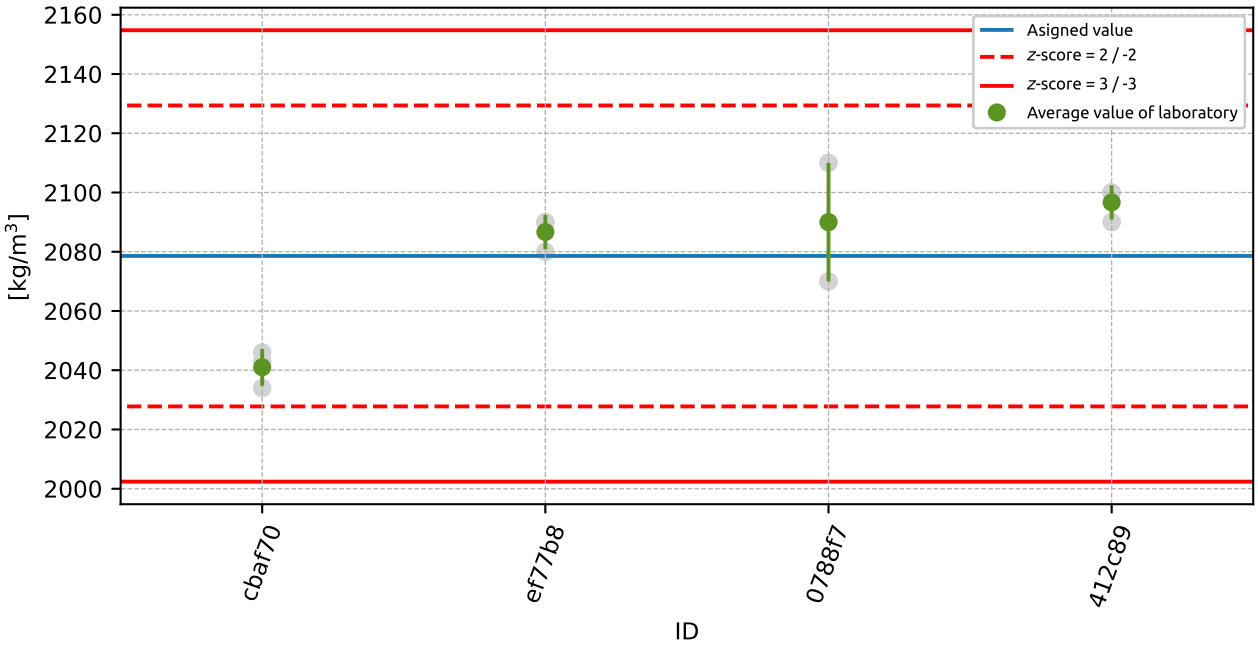

Figure 116: Average values and sample standard deviations

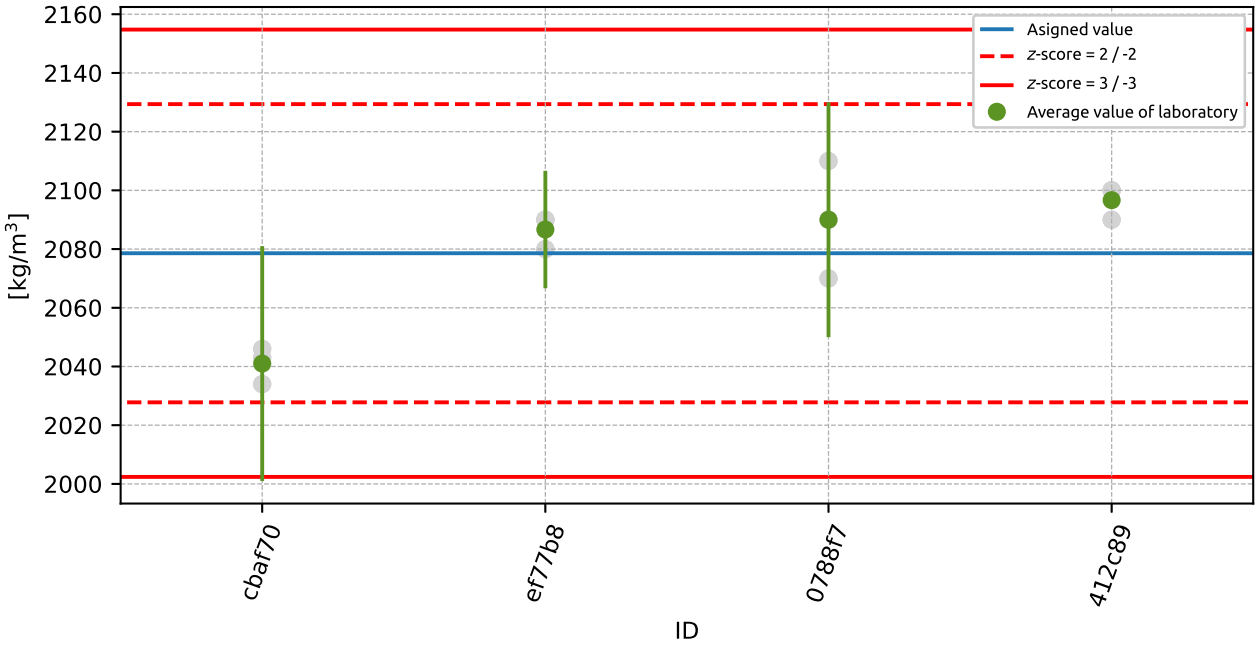

Figure 117: Average values and extended uncertainties of measurement

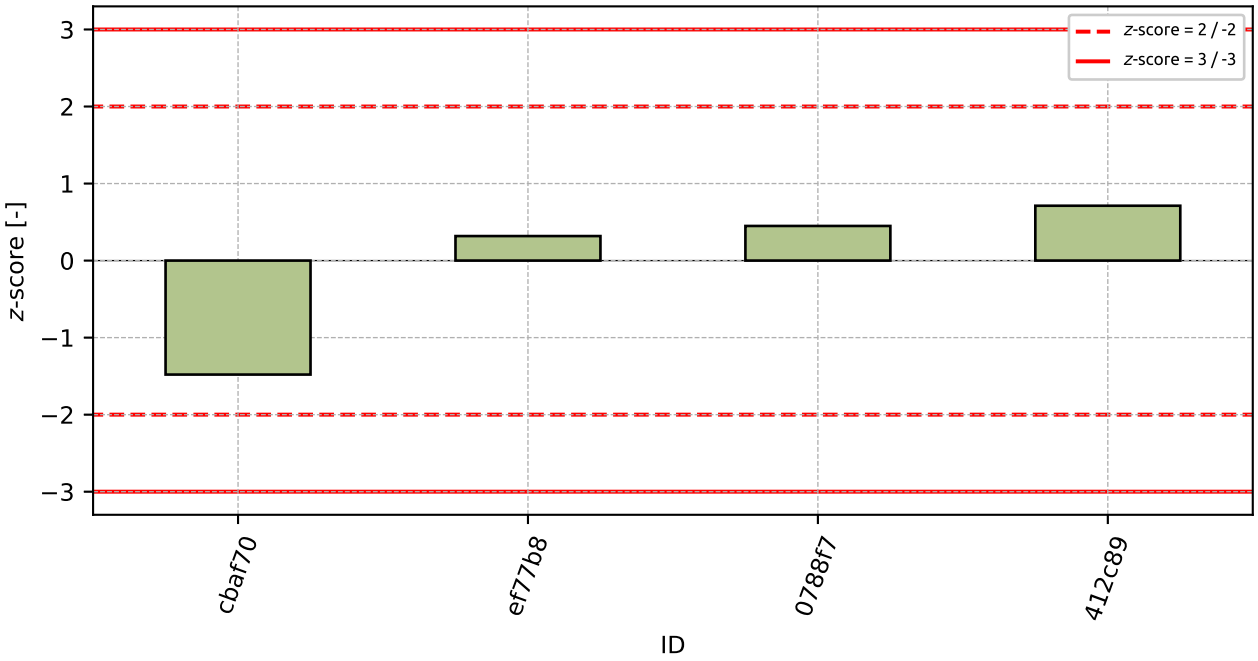

Figure 118: z-score

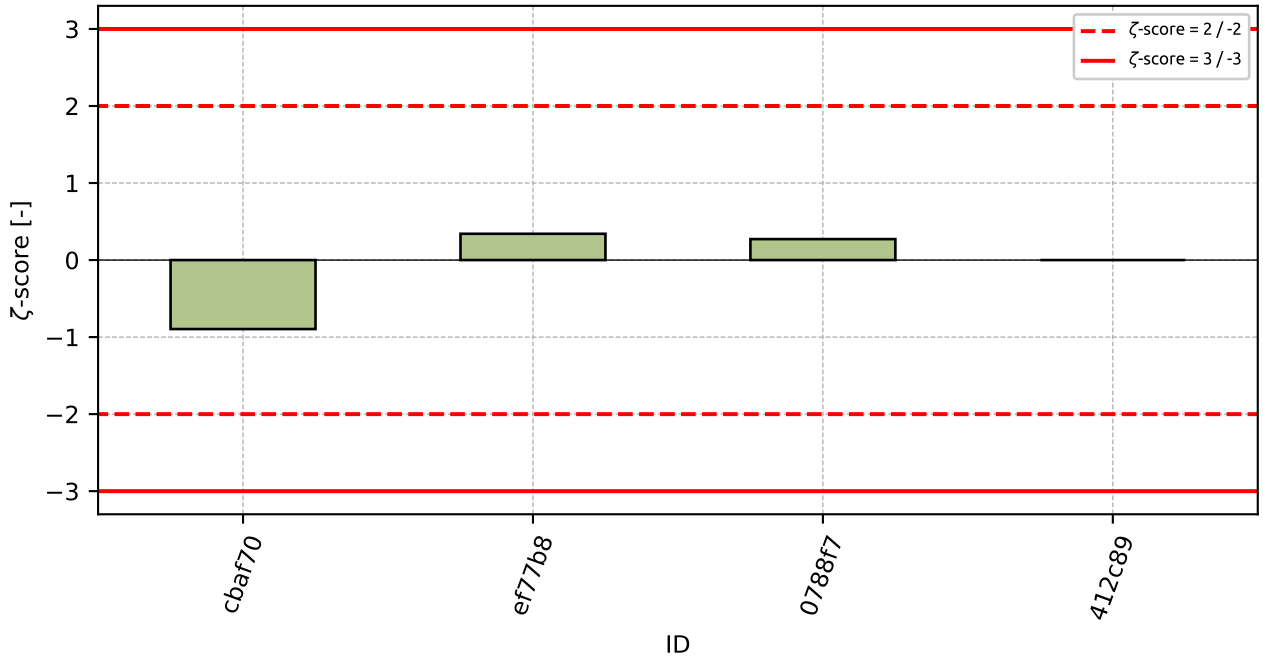

Figure 119: ζ-score

Table 42: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
cbaf70	-1.48	-0.9
ef77b8	0.32	0.34
0788f7	0.45	0.27
412c89	0.71	-

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

13.1 Test results

Table 43: 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 [kg/m³]			u_X [kg/m³]	$\bar{x}$ [kg/m³]	s_0 [kg/m³]	V_X [%]
412c89	1850	1880	1870	-	1867	15.3	0.82
14ad73	1900	1890	1900	20.0	1897	5.8	0.3
ef77b8	1940	1920	1940	20.0	1933	11.5	0.6

13.2 The Numerical Procedure for Determining Outliers

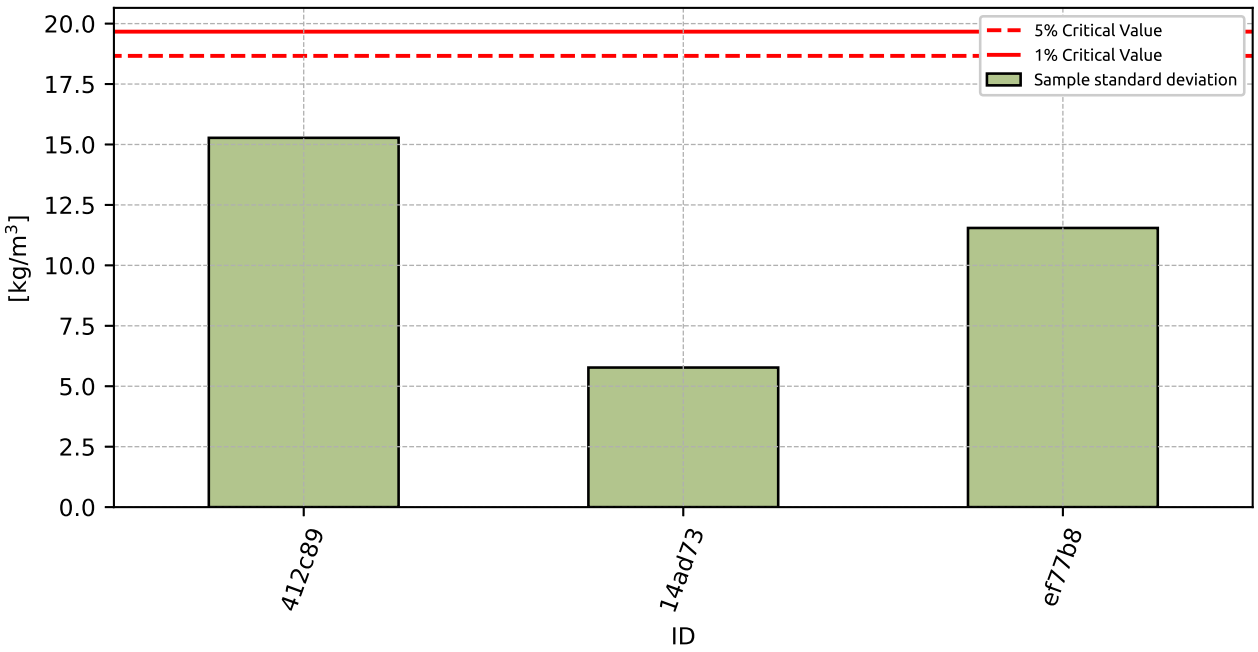

Figure 120: **Cochran's test** - sample standard deviations

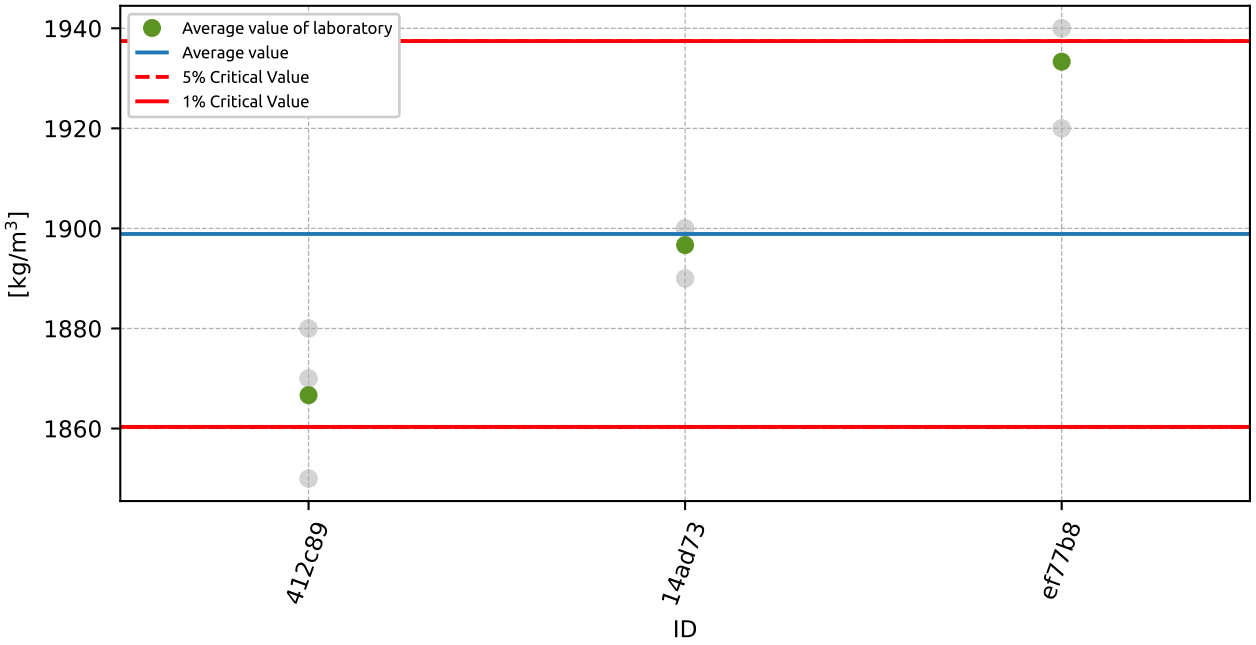

Figure 121: **Grubbs' test** - average values

13.3 Mandel's Statistics

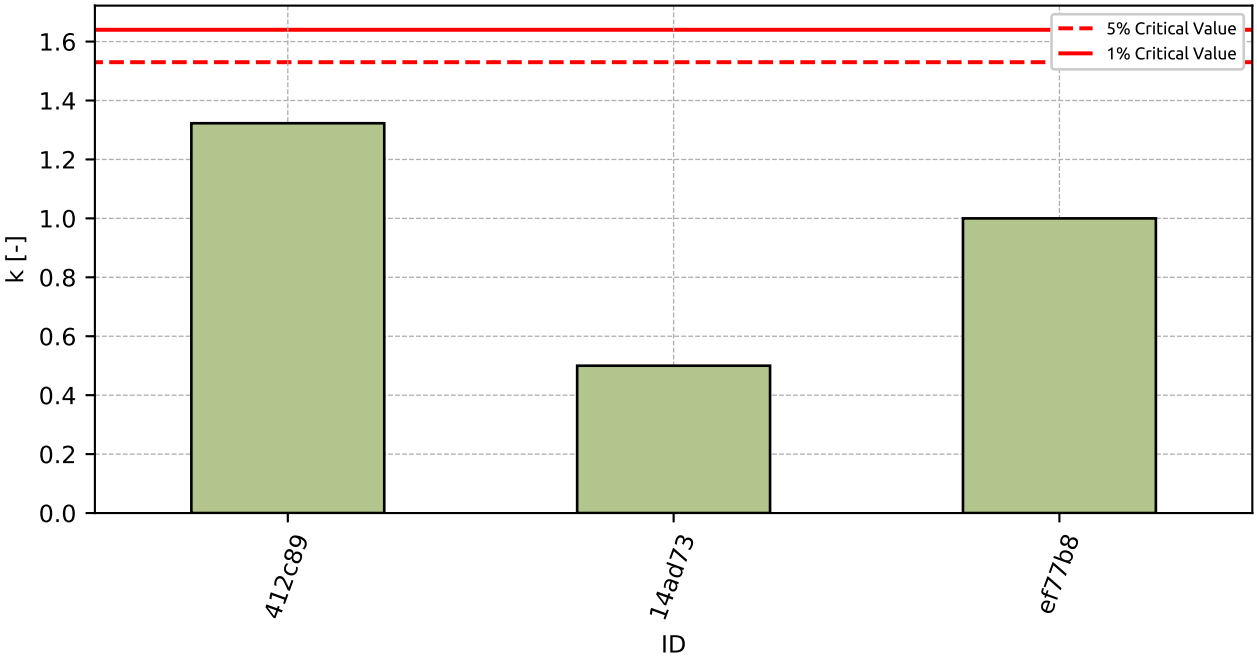

Figure 122: Intralaboratory Consistency Statistic

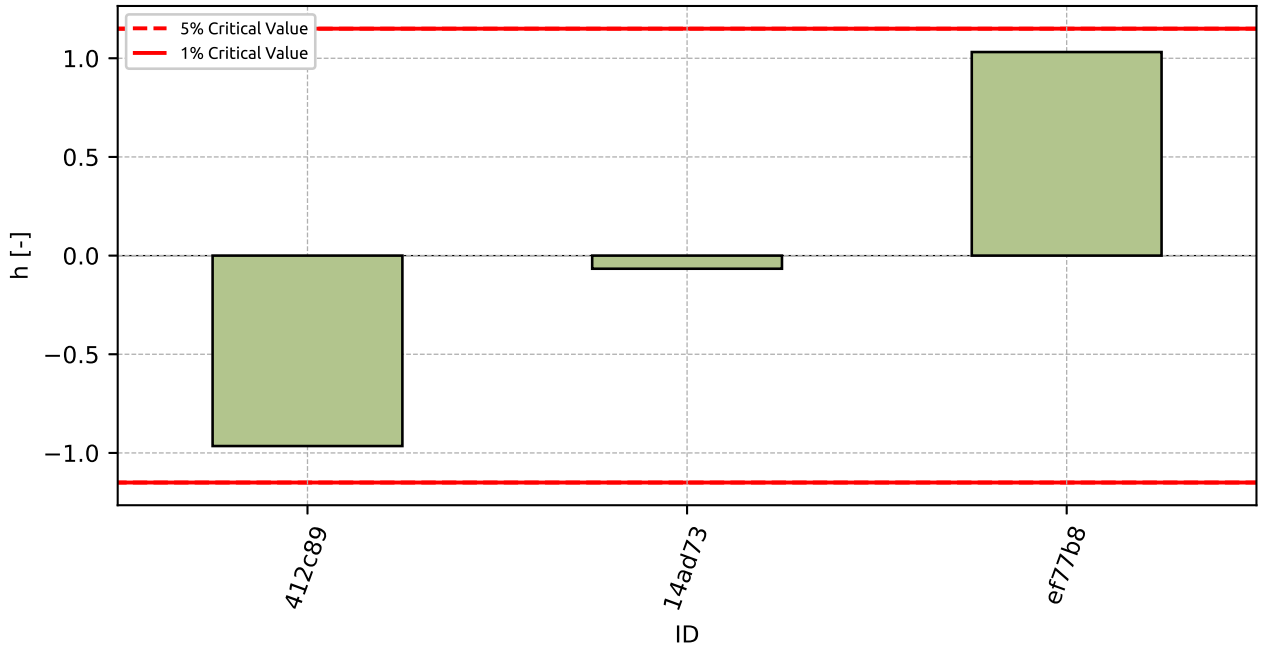

Figure 123: Interlaboratory Consistency Statistic

13.4 Descriptive statistics

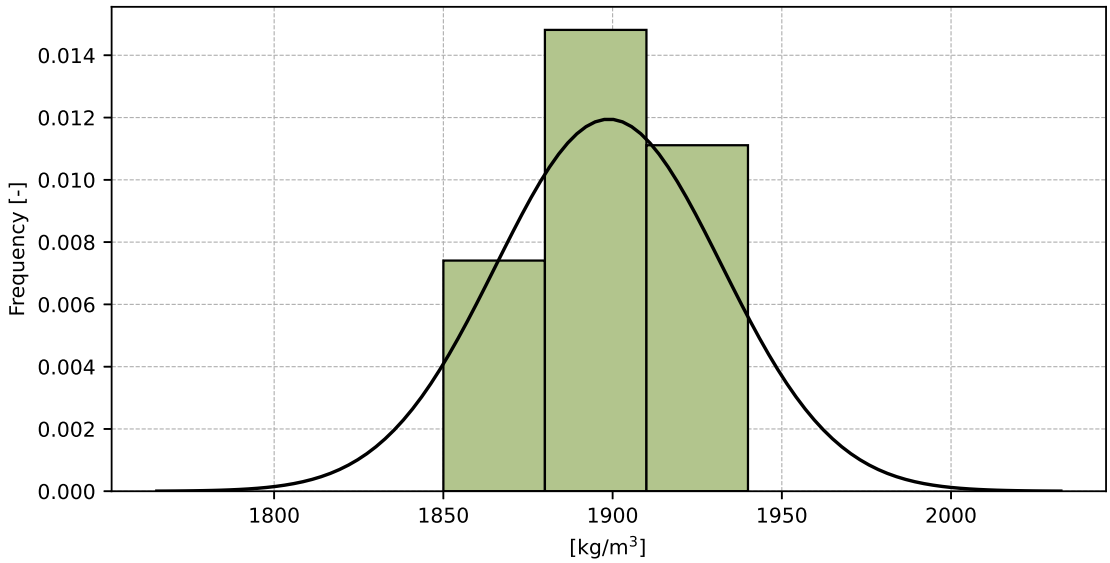

Figure 124: Histogram of all test results

Table 44: Descriptive statistics

Characteristics	[kg/m³]
Average value – $\bar{x}$	1899.0
Sample standard deviation – s	33.4
Asigned value – x^*	1899.0
Robust standard deviation – s^*	30.9
Measurement uncertainty of asigned value – u_X	22.3
p-value of normality test	0.742 [-]
Interlaboratory standard deviation – s_L	32.7
Repeatability standard deviation – s_r	11.5
Reproducibility standard deviation – s_R	34.7
Repeatability – r	32.0
Reproducibility – R	97.0

13.5 Evaluation of Performance Statistics

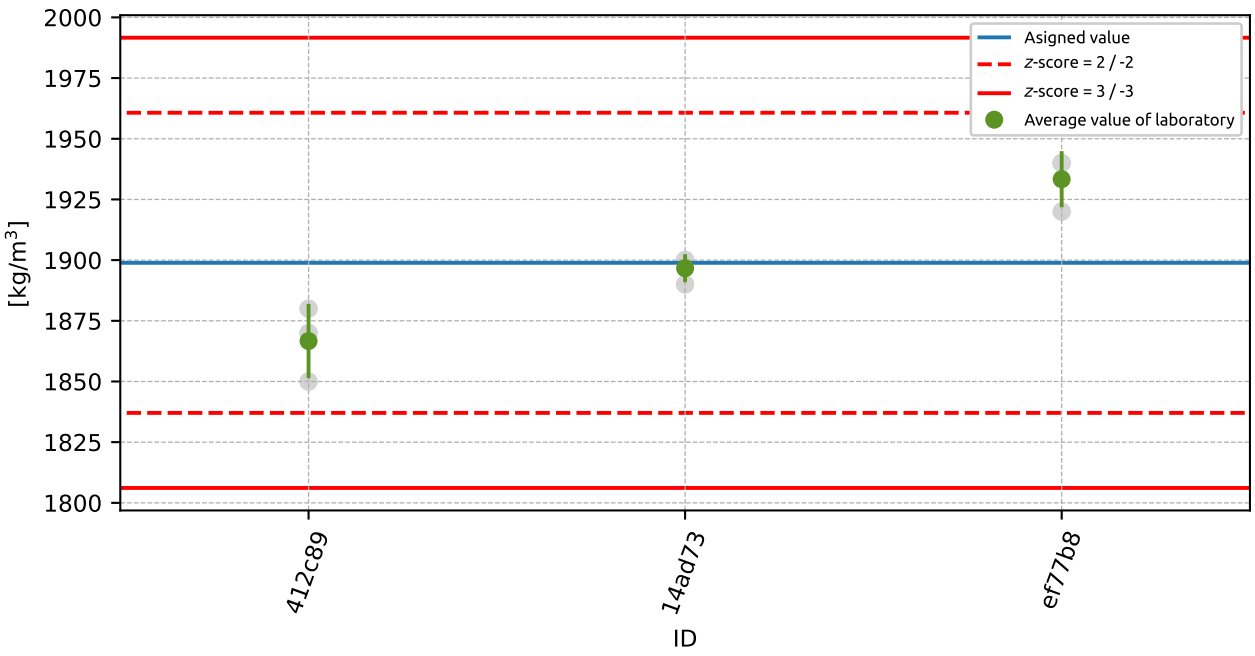

Figure 125: Average values and sample standard deviations

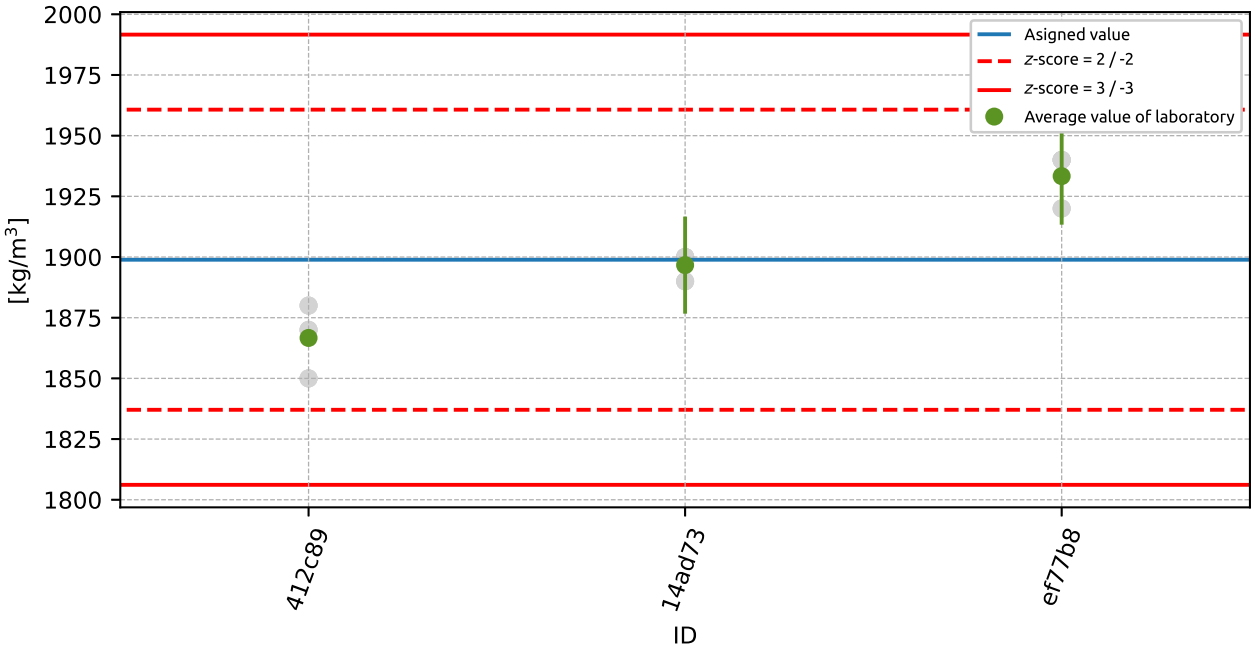

Figure 126: Average values and extended uncertainties of measurement

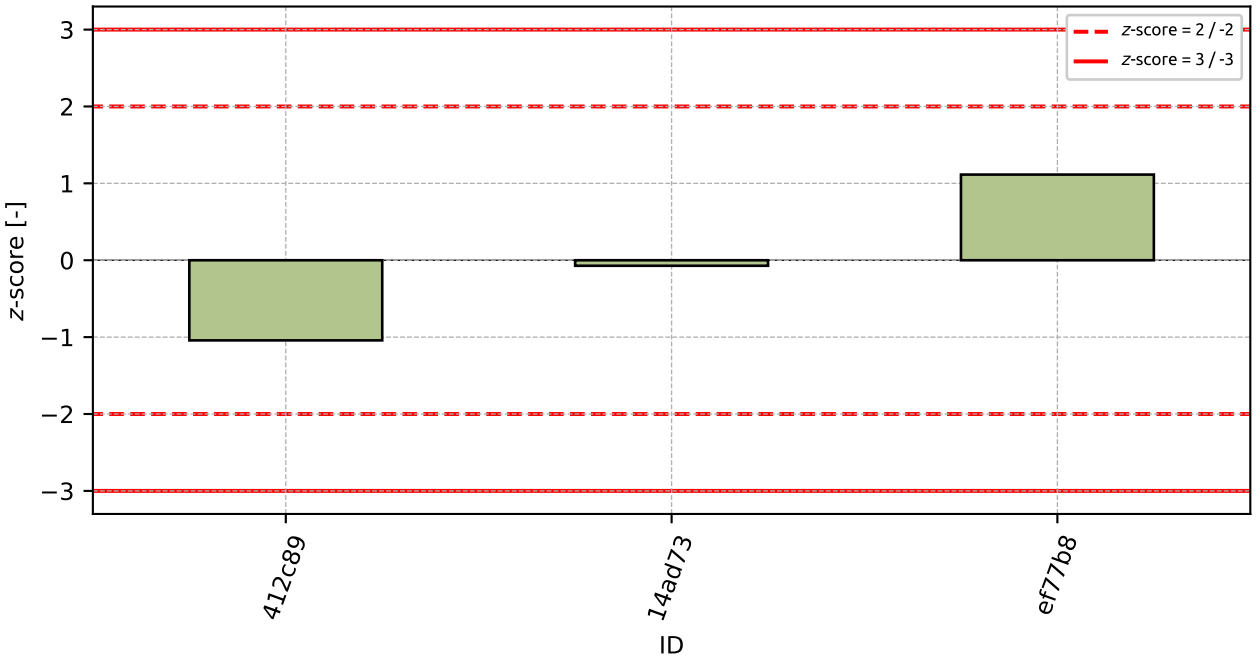

Figure 127: z-score

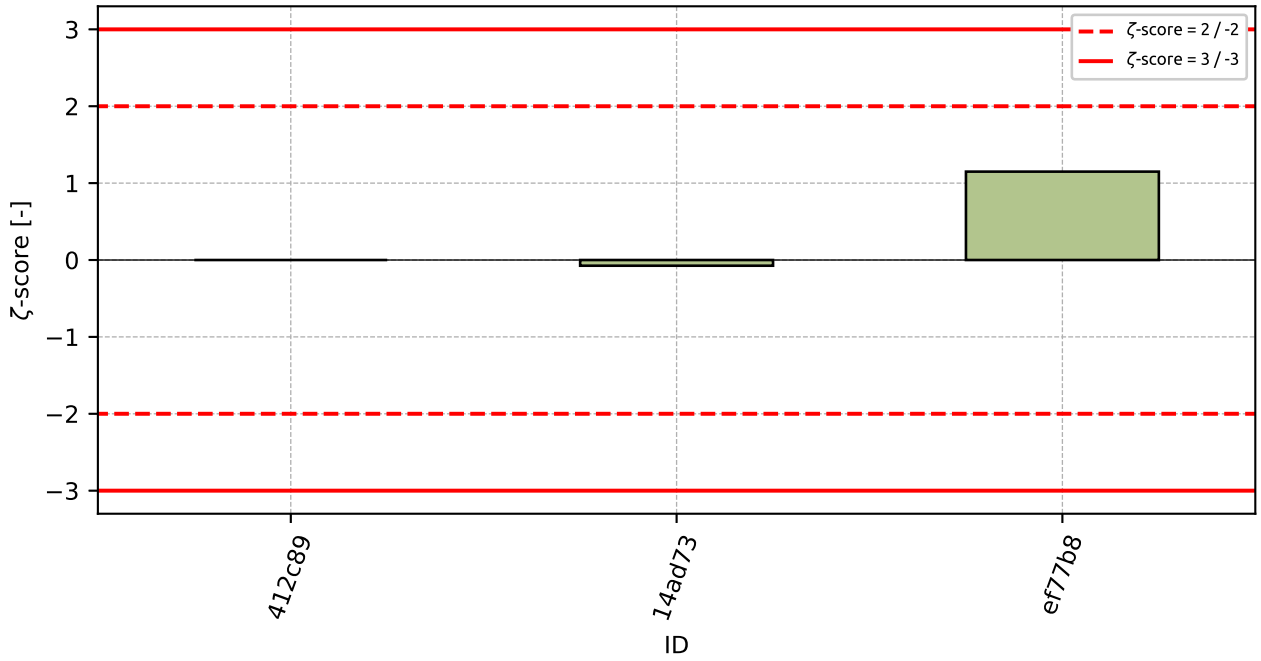

Figure 128: ζ-score

Table 45: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
412c89	-1.04	-
14ad73	-0.07	-0.07
ef77b8	1.11	1.15

14 Appendix – EN 1015-11 – Strength

14.1 Flexural Strength

14.1.1 Test results

Table 46: 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 [%]
3d7bfb	1.4	1.4	1.7	0.1	1.5	0.15	9.9
6043e6	2.1	2.2	2.2	0.0	2.2	0.06	2.56
7d1d14	2.9	2.8	2.4	0.1	2.7	0.28	10.14
cd297b	2.4	3.2	3.2	3.0	2.9	0.52	17.61
fd26b6	3.2	3.1	3.4	0.2	3.2	0.15	4.56
1e39d6	3.5	3.4	3.8	0.1	3.6	0.24	6.73

14.1.2 The Numerical Procedure for Determining Outliers

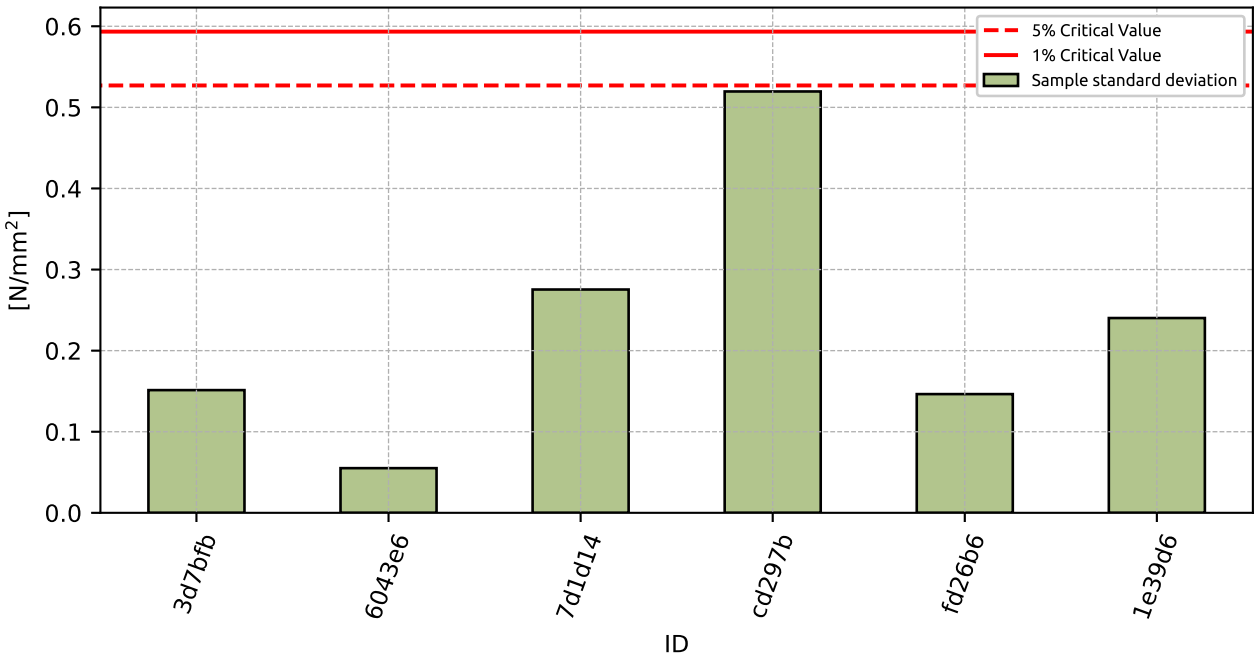

Figure 129: **Cochran's test** - sample standard deviations

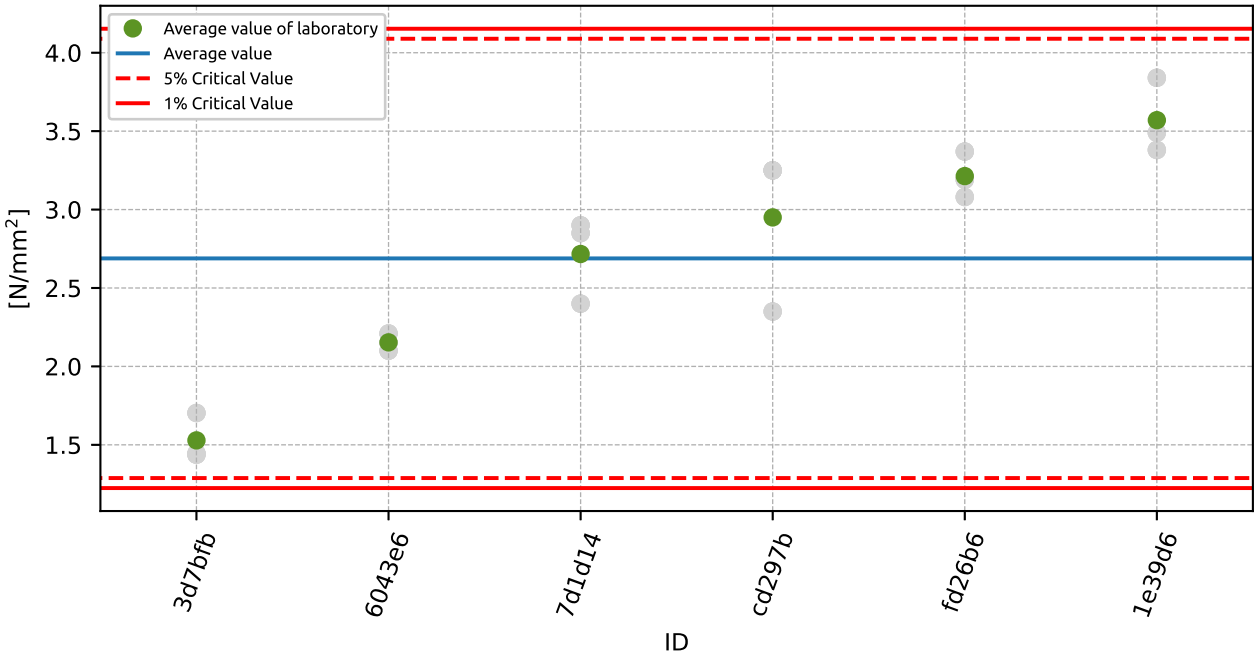

Figure 130: **Grubbs' test** - average values

14.1.3 Mandel's Statistics

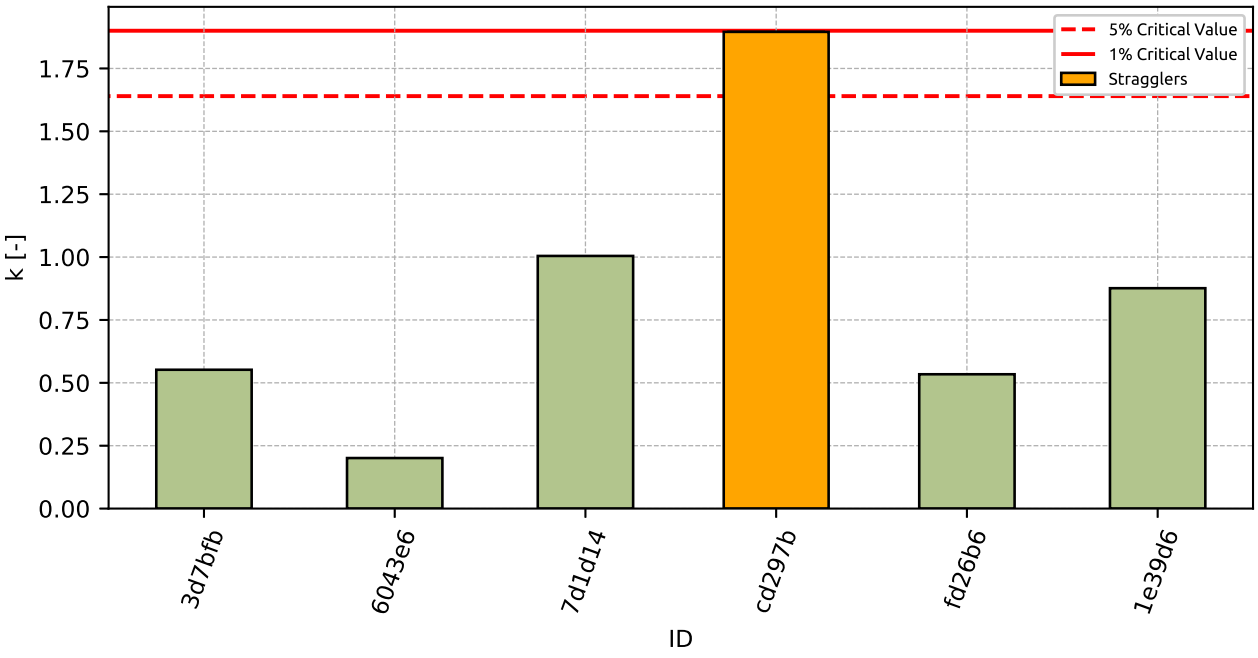

Figure 131: Intralaboratory Consistency Statistic

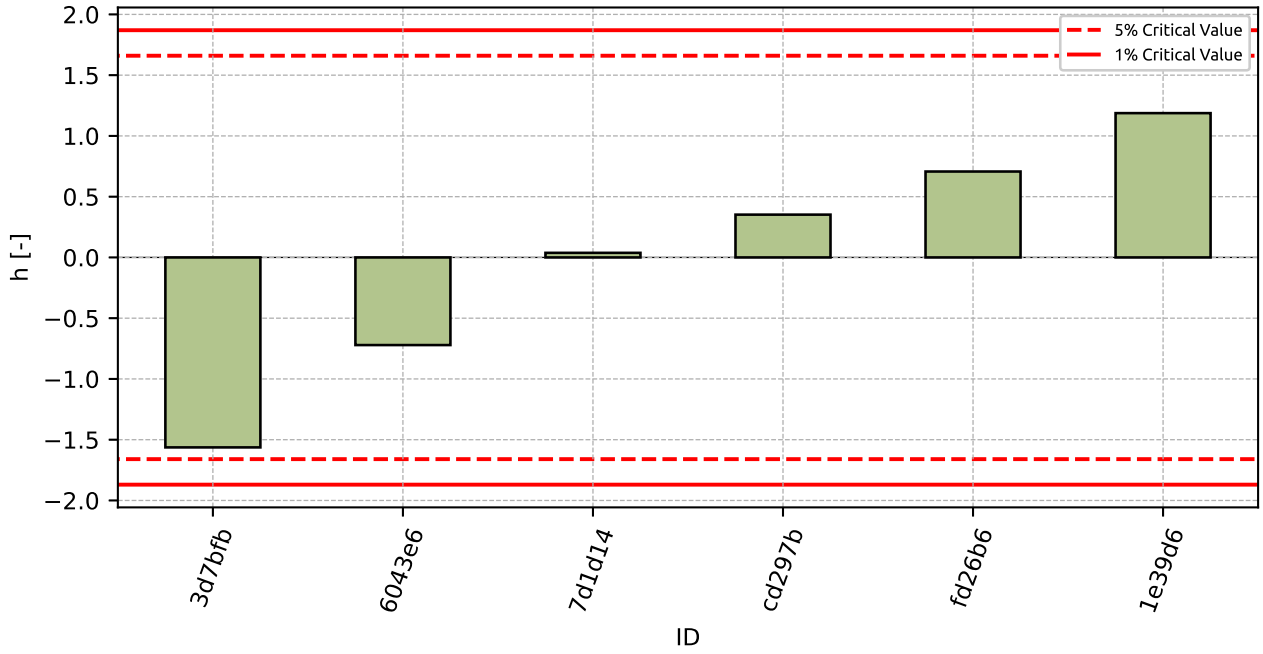

Figure 132: Interlaboratory Consistency Statistic

14.1.4 Descriptive statistics

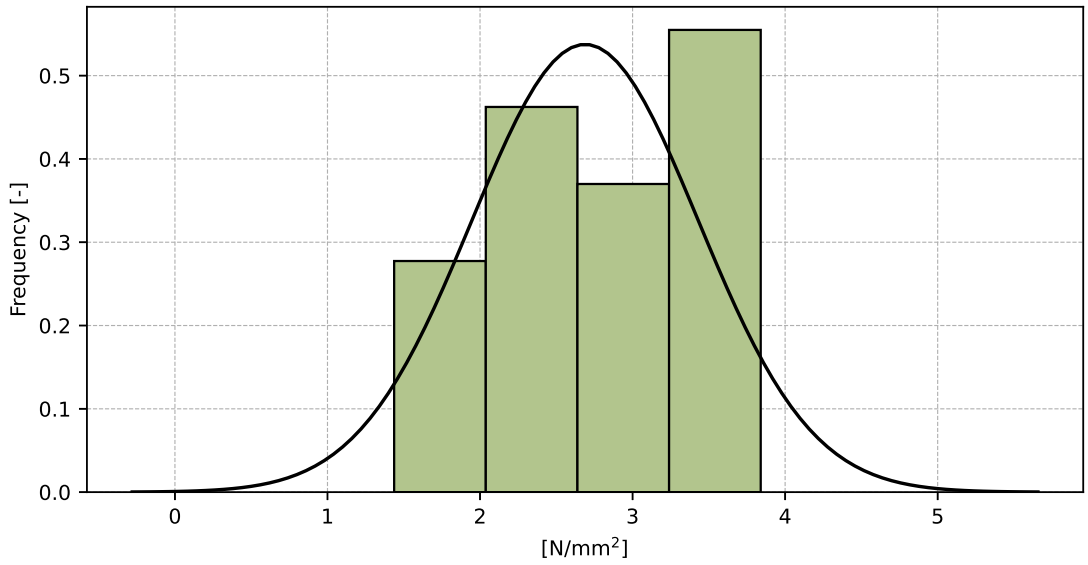

Figure 133: Histogram of all test results

Table 47: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	2.7
Sample standard deviation – s	0.74
Asigned value – x^*	2.7
Robust standard deviation – s^*	0.73
Measurement uncertainty of asigned value – u_X	0.37
p-value of normality test	0.247 [-]
Interlaboratory standard deviation – s_L	0.73
Repeatability standard deviation – s_r	0.27
Reproducibility standard deviation – s_R	0.78
Repeatability – r	0.8
Reproducibility – R	2.2

14.1.5 Evaluation of Performance Statistics

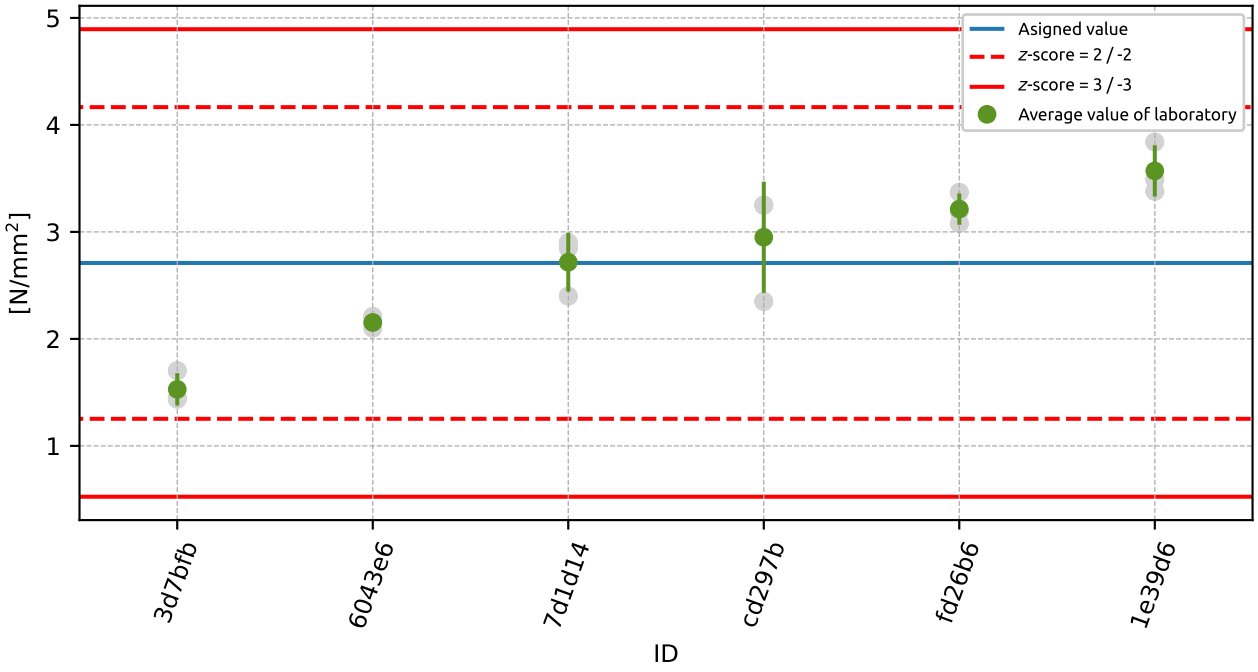

Figure 134: Average values and sample standard deviations

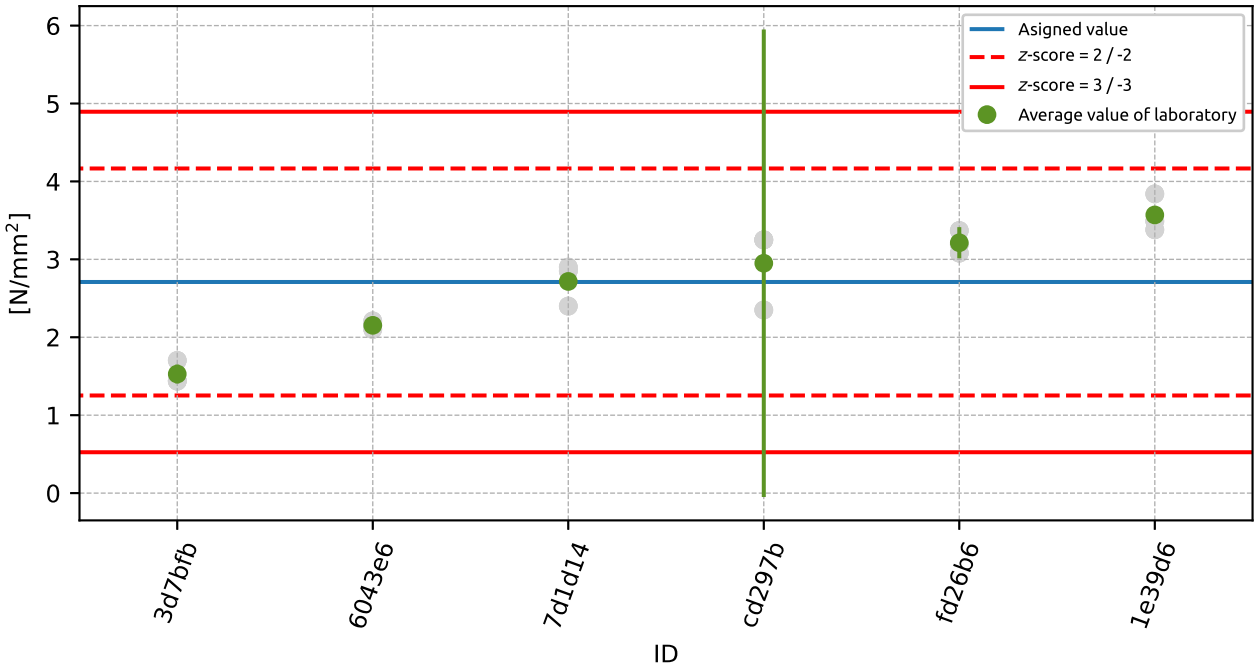

Figure 135: Average values and extended uncertainties of measurement

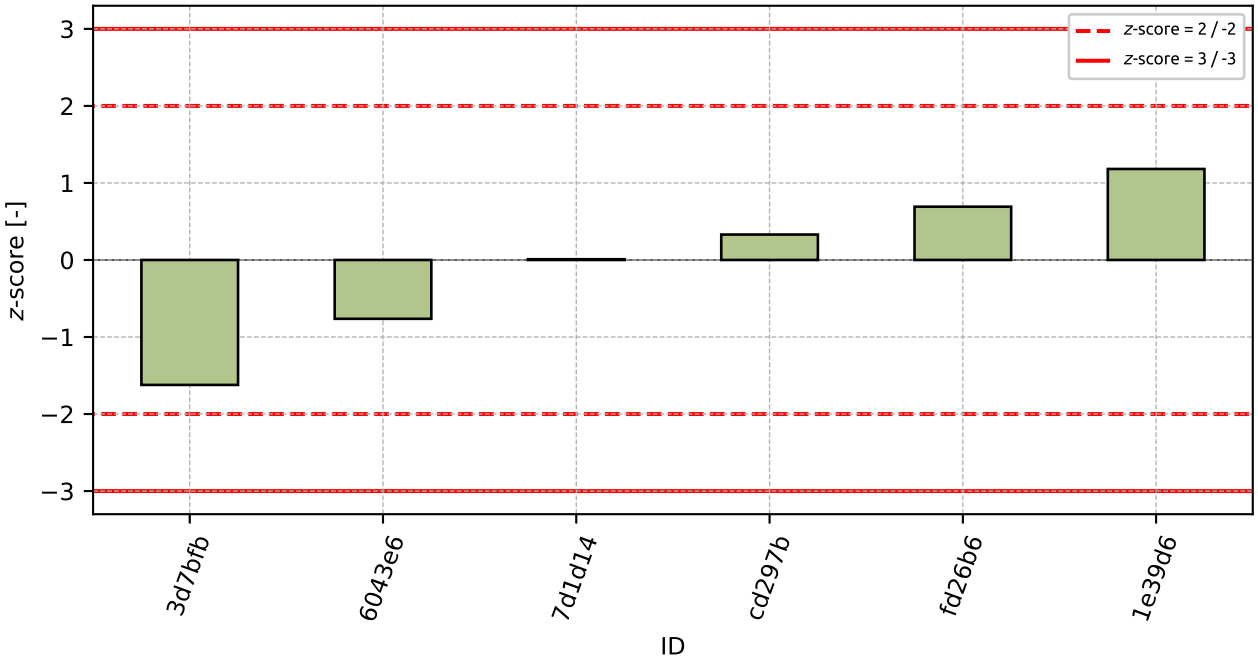

Figure 136: z-score

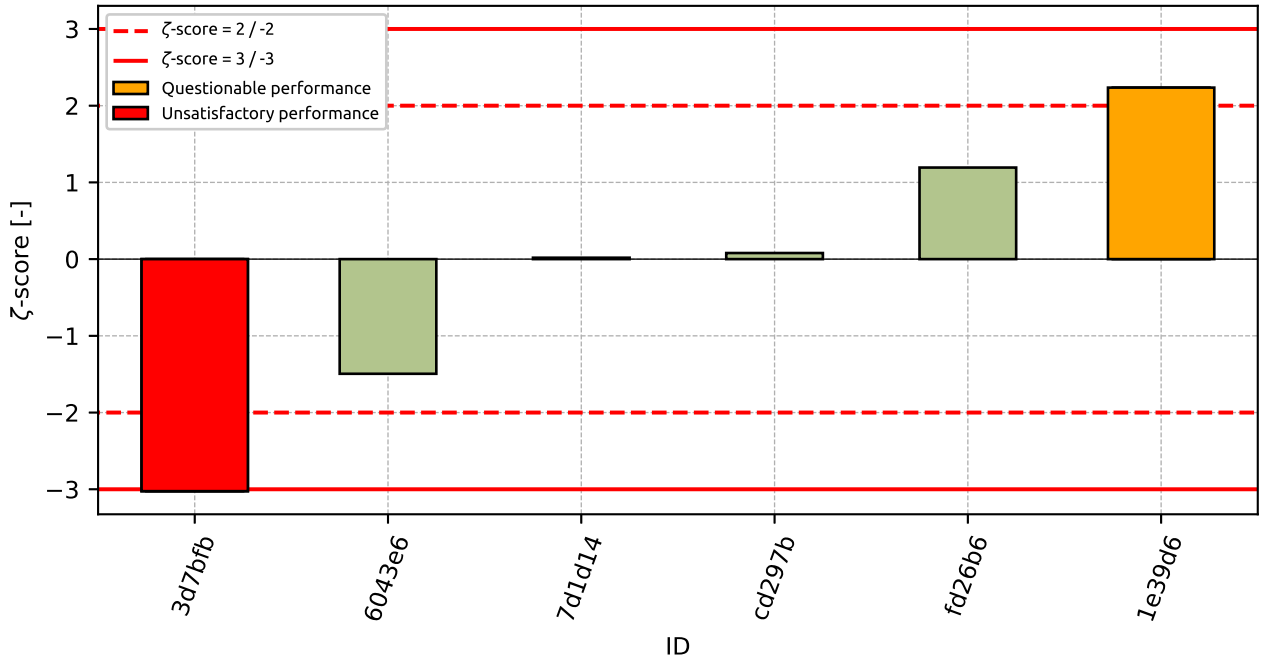

Figure 137: ζ-score

Table 48: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
3d7bfb	-1.62	-3.02
6043e6	-0.76	-1.49
7d1d14	0.01	0.02
cd297b	0.33	0.08
fd26b6	0.69	1.19
1e39d6	1.18	2.24

14.2 Compressive Strength

14.2.1 Test results

Table 49: 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 [%]
cd297b	6.1	6.6	10.2	9.1	9.6	10.6	8.7	8.7	1.9	21.83
1e39d6	10.3	10.8	10.1	10.3	10.3	10.5	0.2	10.4	0.24	2.31
fd26b6	11.2	10.5	11.0	10.3	10.6	10.7	0.5	10.7	0.34	3.13
7d1d14	11.4	11.3	11.4	11.2	11.2	11.7	0.8	11.4	0.19	1.7
6043e6	12.9	11.1	12.2	11.7	11.3	12.5	0.2	11.9	0.71	5.98
3d7bfb	23.3	24.2	24.2	24.0	23.9	24.5	1.7	24.0	0.41	1.69

14.2.2 The Numerical Procedure for Determining Outliers

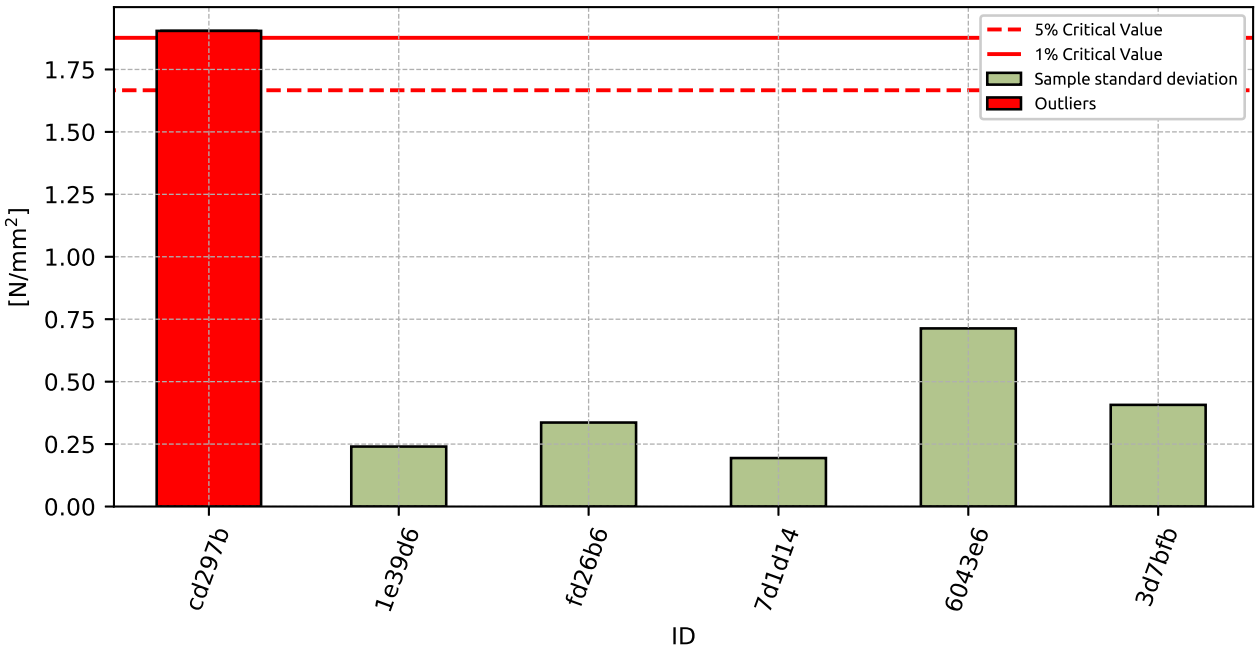

Figure 138: **Cochran's test** - sample standard deviations

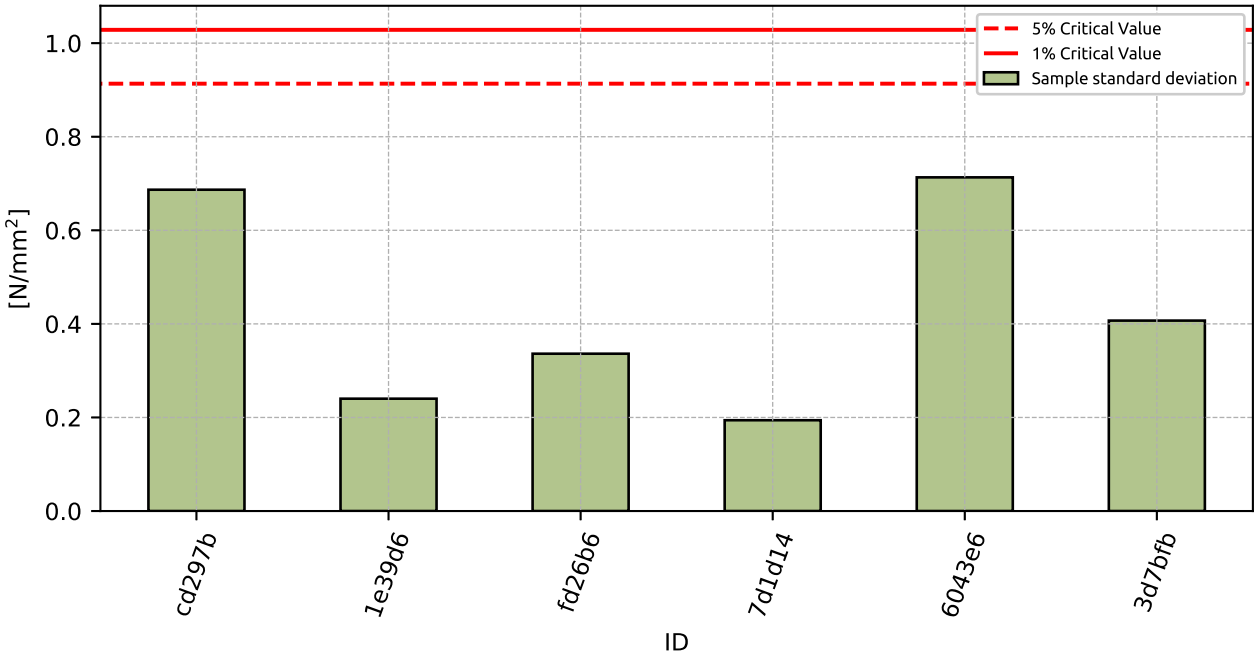

Figure 139: **Cochran's test** - sample standard deviations without outliers

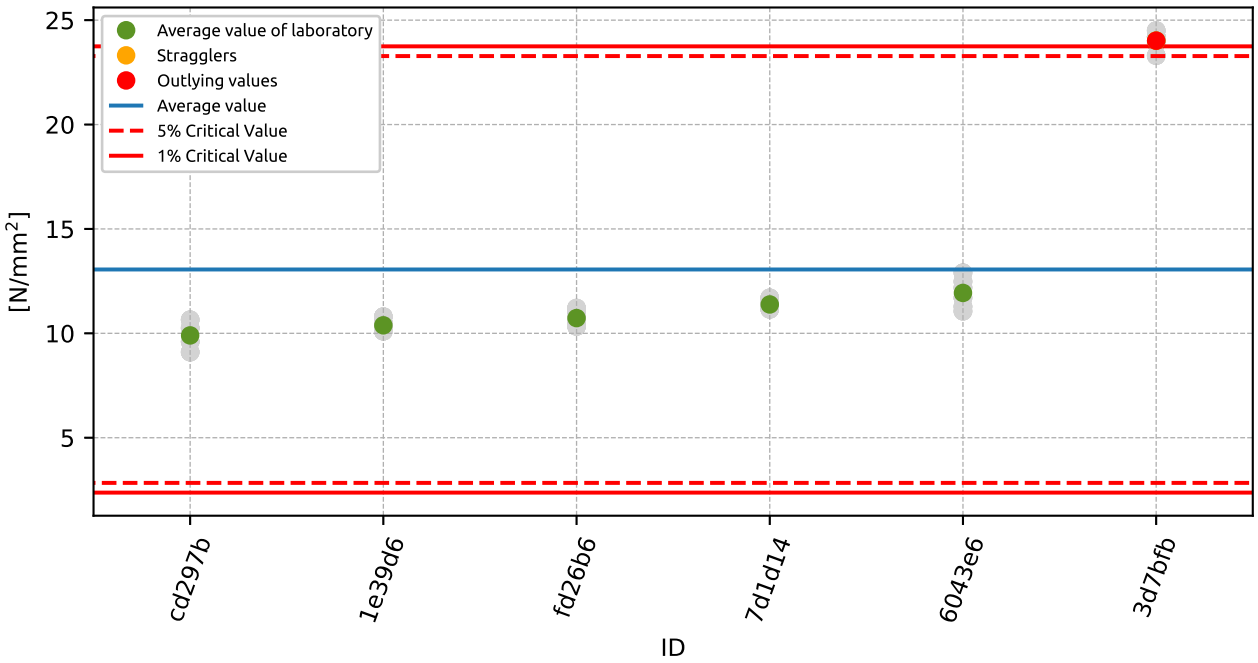

Figure 140: **Grubbs' test** - average values

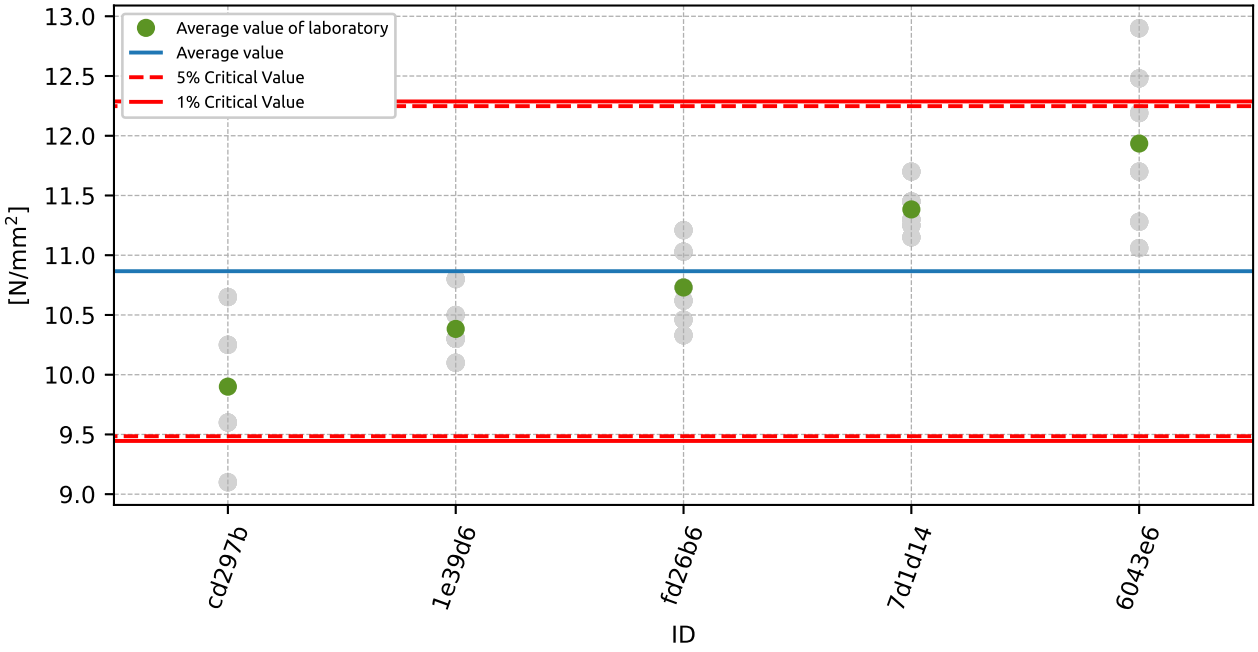

Figure 141: **Grubbs' test** - average values without outliers

14.2.3 Mandel's Statistics

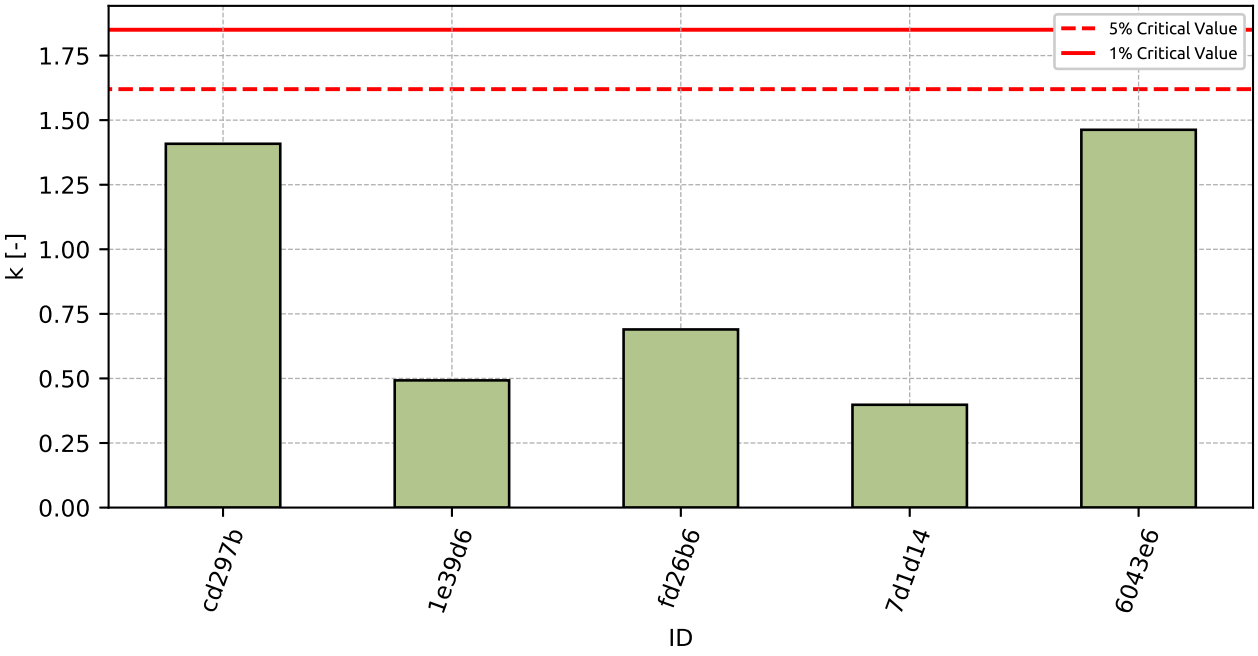

Figure 142: Intralaboratory Consistency Statistic

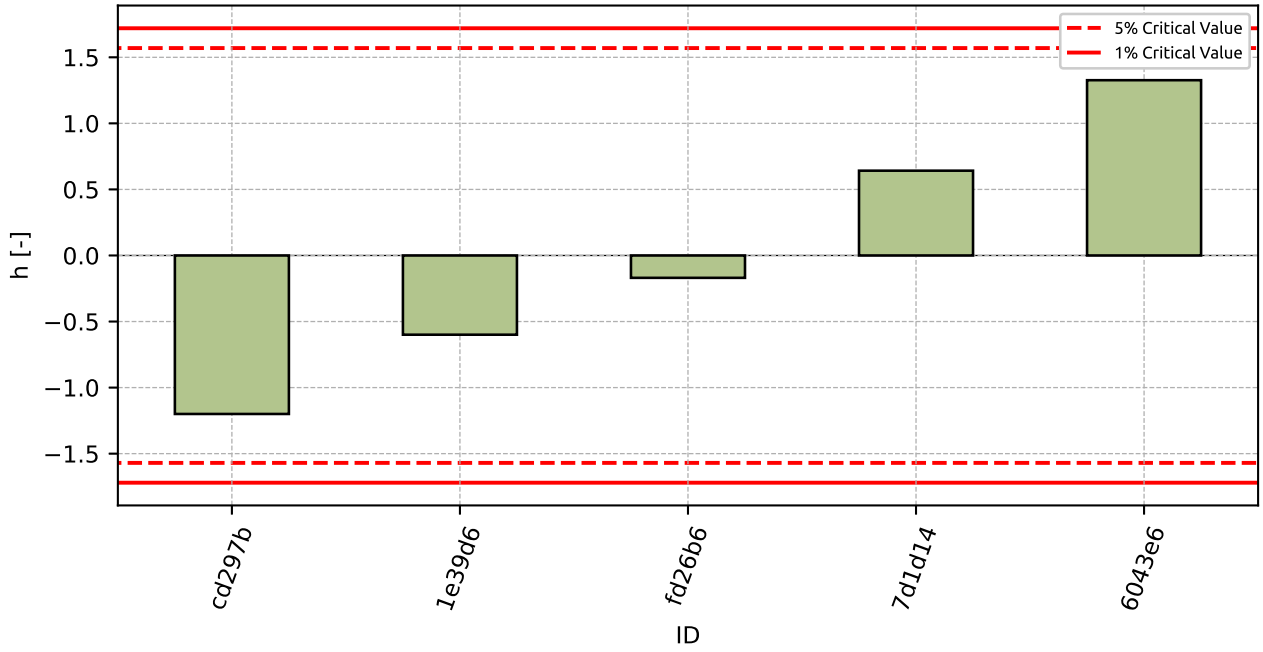

Figure 143: Interlaboratory Consistency Statistic

14.2.4 Descriptive statistics

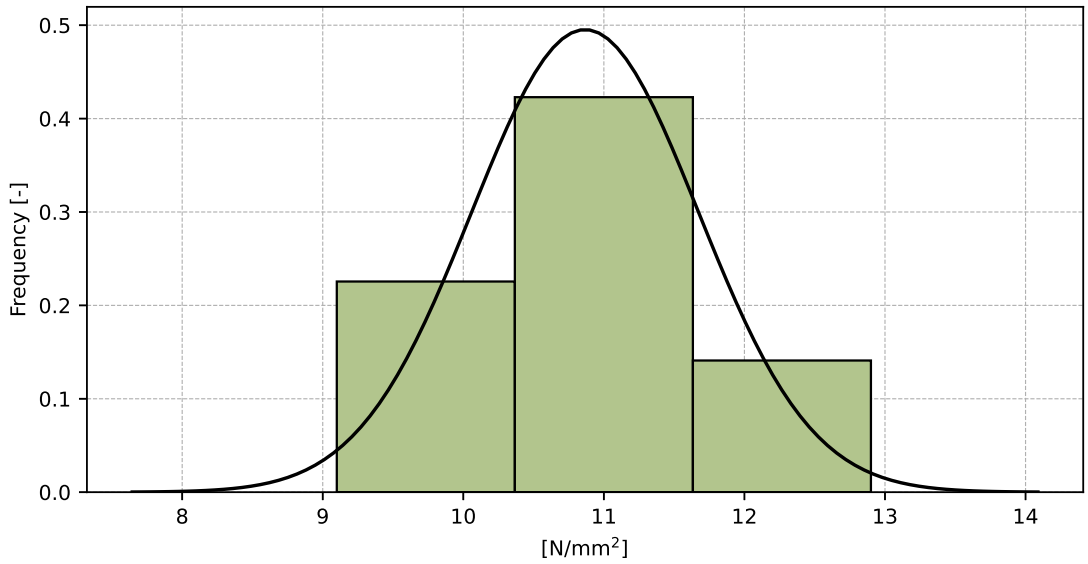

Figure 144: Histogram of all test results

Table 50: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	10.9
Sample standard deviation – s	0.81
Asigned value – x^*	10.9
Robust standard deviation – s^*	0.82
Measurement uncertainty of asigned value – u_X	0.46
p-value of normality test	1.0 [-]
Interlaboratory standard deviation – s_L	0.78
Repeatability standard deviation – s_r	0.49
Reproducibility standard deviation – s_R	0.92
Repeatability – r	1.4
Reproducibility – R	2.6

14.2.5 Evaluation of Performance Statistics

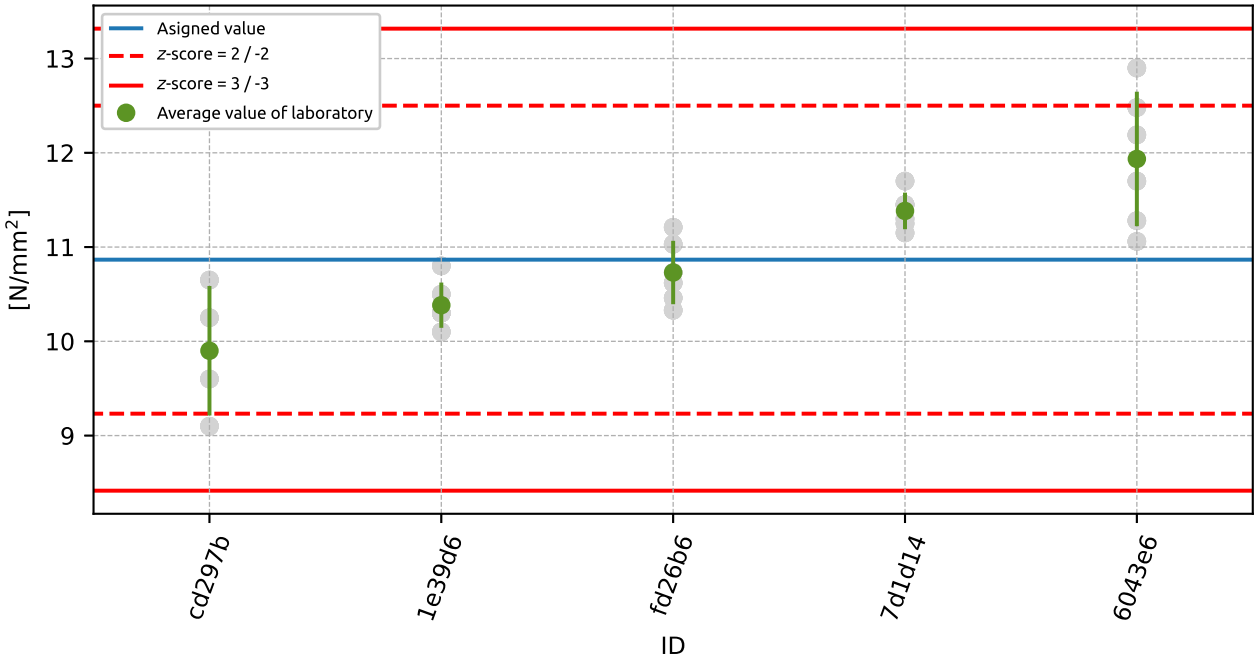

Figure 145: Average values and sample standard deviations

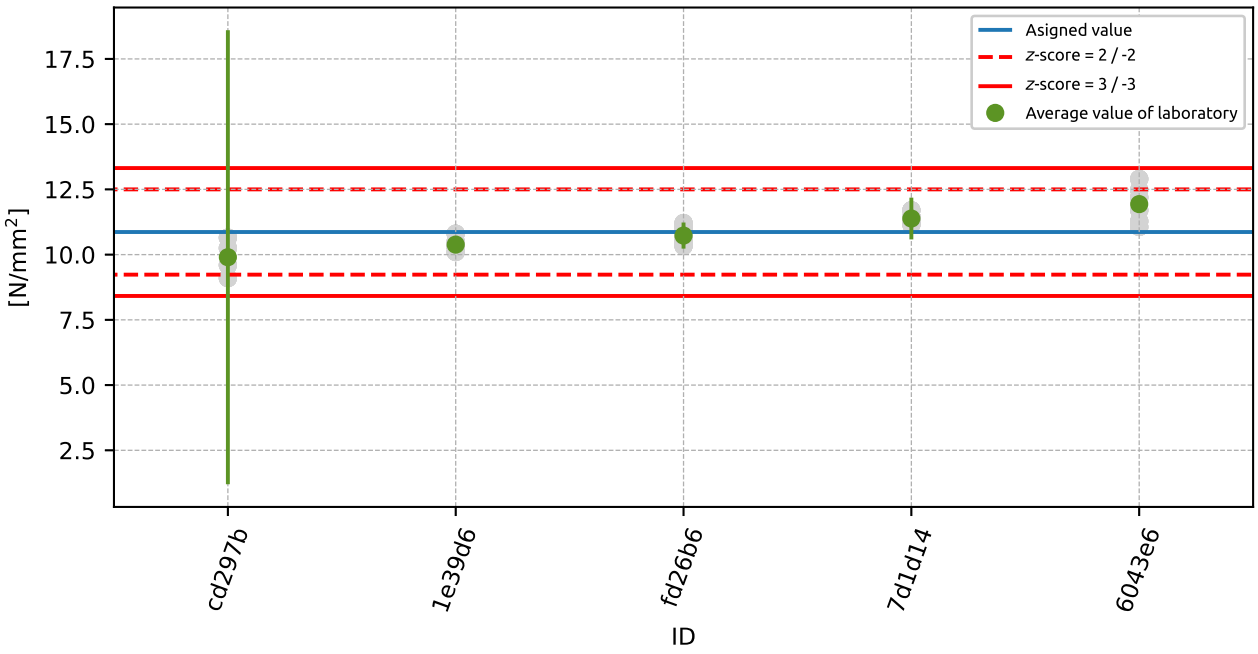

Figure 146: Average values and extended uncertainties of measurement

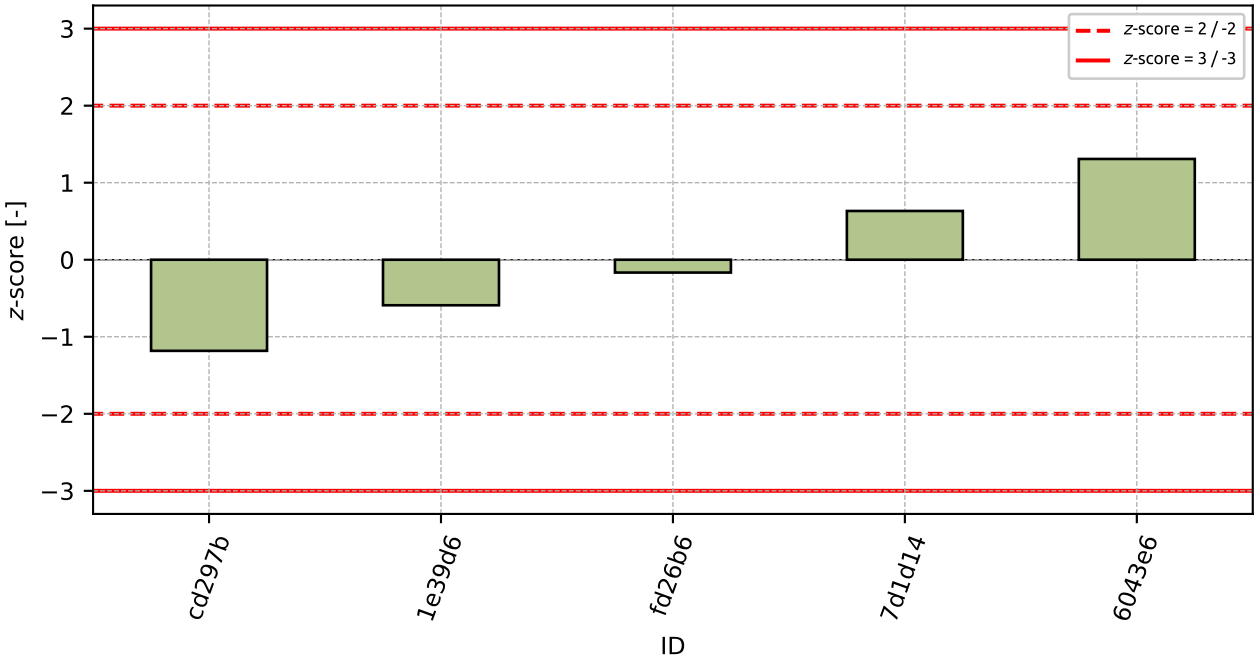

Figure 147: z-score

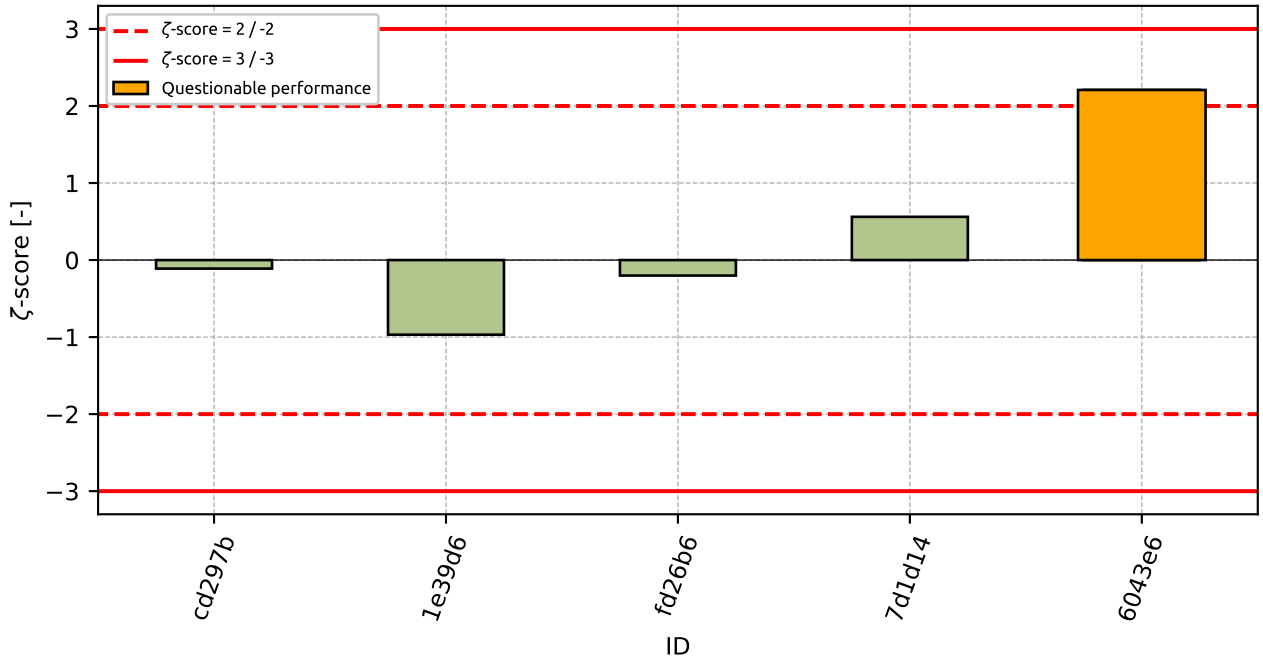

Figure 148: ζ-score

Table 51: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
cd297b	-1.18	-0.11
1e39d6	-0.59	-0.97
fd26b6	-0.17	-0.2
7d1d14	0.63	0.56
6043e6	1.31	2.21

15 Appendix – EN 1015-12 – Adhesion

15.1 Test results

Table 52: 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 [%]
0788f7	0.25	0.3	0.25	0.05	0.27	0.029	10.83
f11905	0.3	0.3	0.3	0.02	0.3	0.0	0.0
10d1f1	0.33	0.32	0.33	0.02	0.33	0.006	1.77
5dbe4b	0.35	0.35	0.3	0.05	0.33	0.029	8.66
47a857	0.35	0.45	0.35	0.15	0.38	0.058	15.06
35a6f1	0.4	0.35	0.4	0.02	0.38	0.029	7.53
65dcf3	0.45	0.45	0.55	0.1	0.48	0.058	11.95

15.2 The Numerical Procedure for Determining Outliers

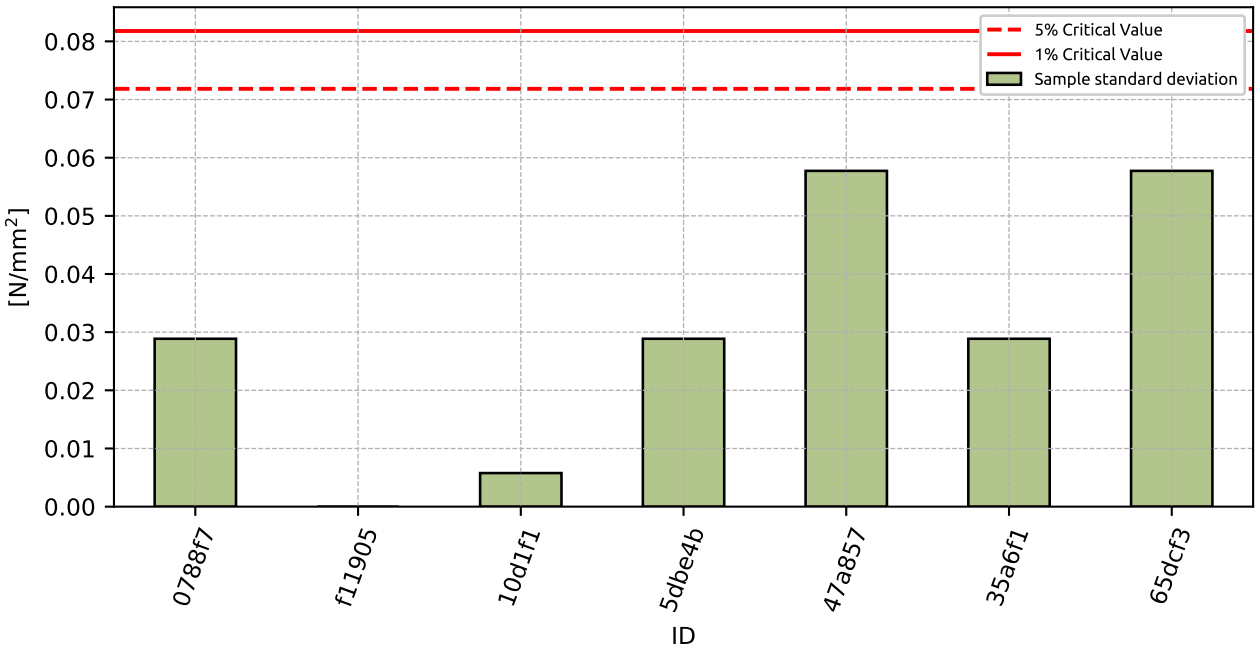

Figure 149: **Cochran's test** - sample standard deviations

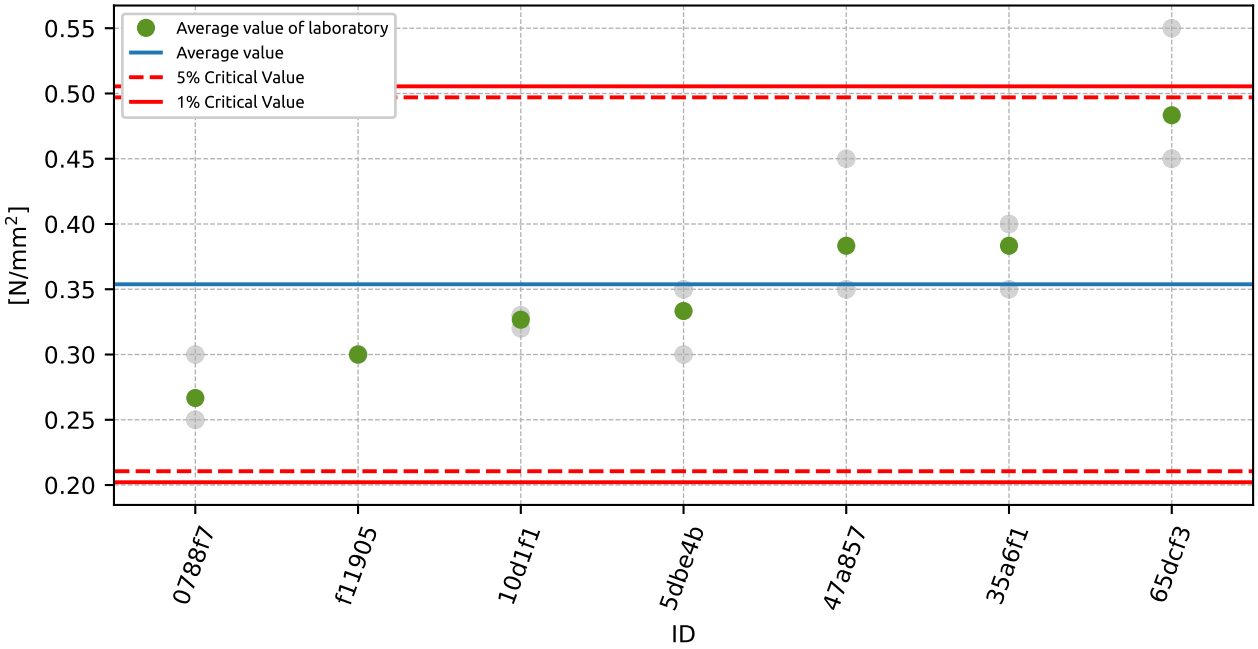

Figure 150: **Grubbs' test** - average values

15.3 Mandel's Statistics

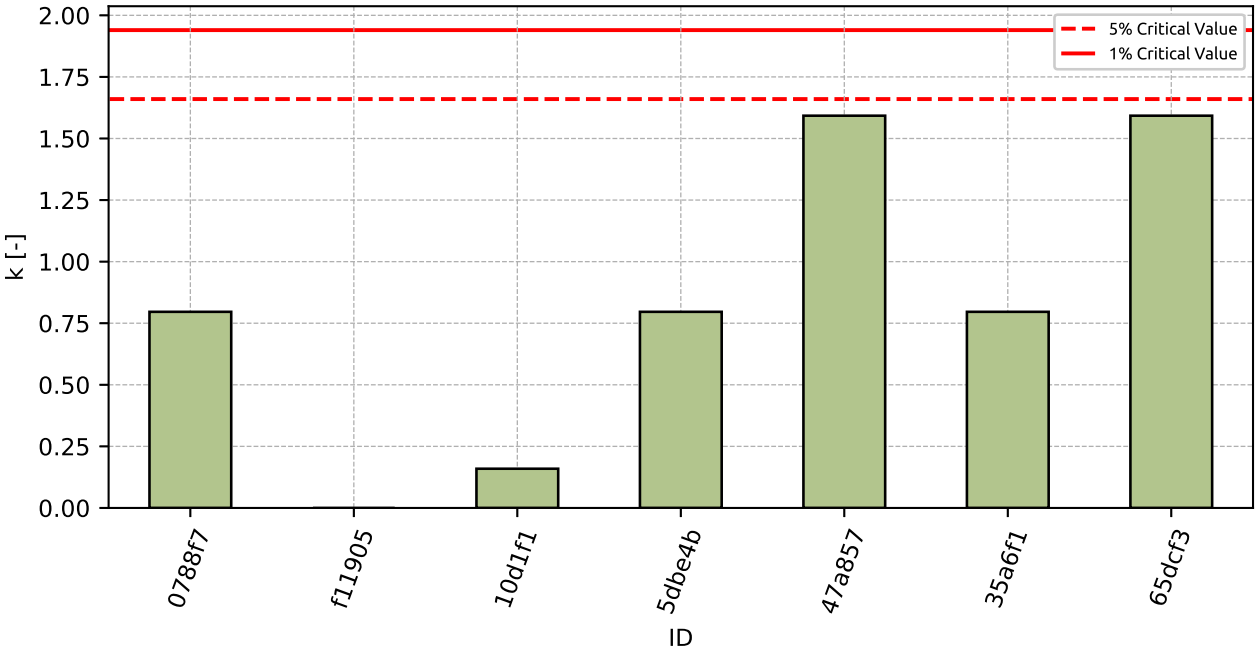

Figure 151: Intralaboratory Consistency Statistic

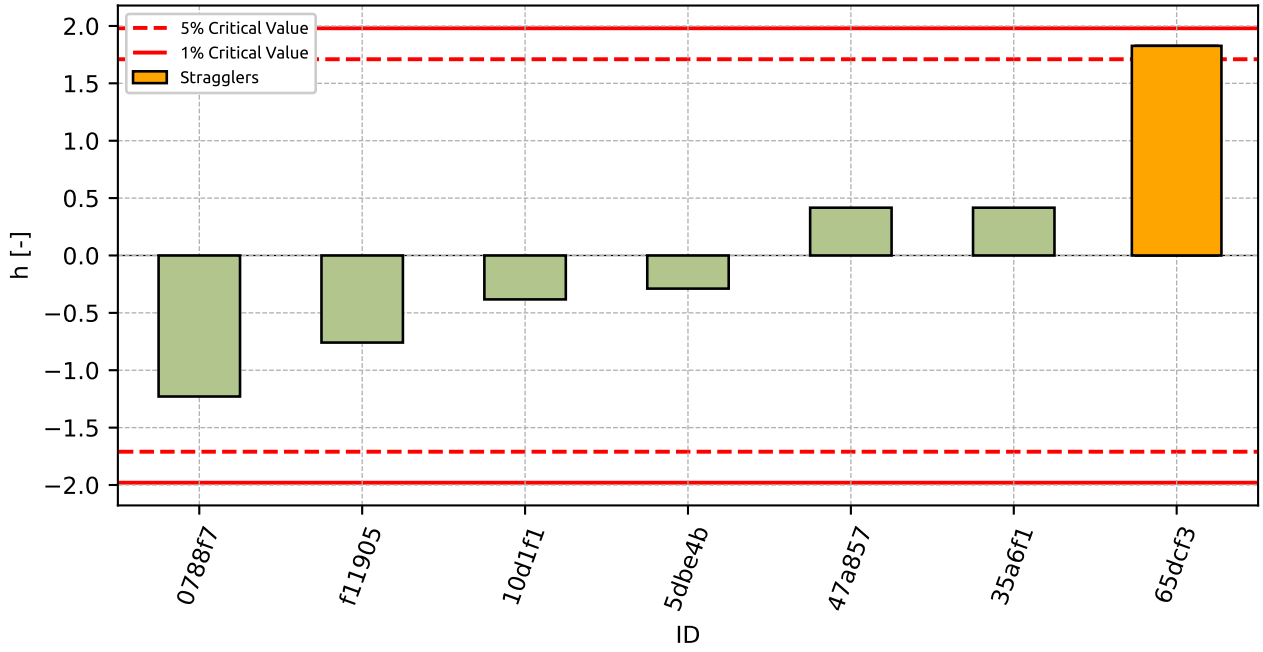

Figure 152: Interlaboratory Consistency Statistic

15.4 Descriptive statistics

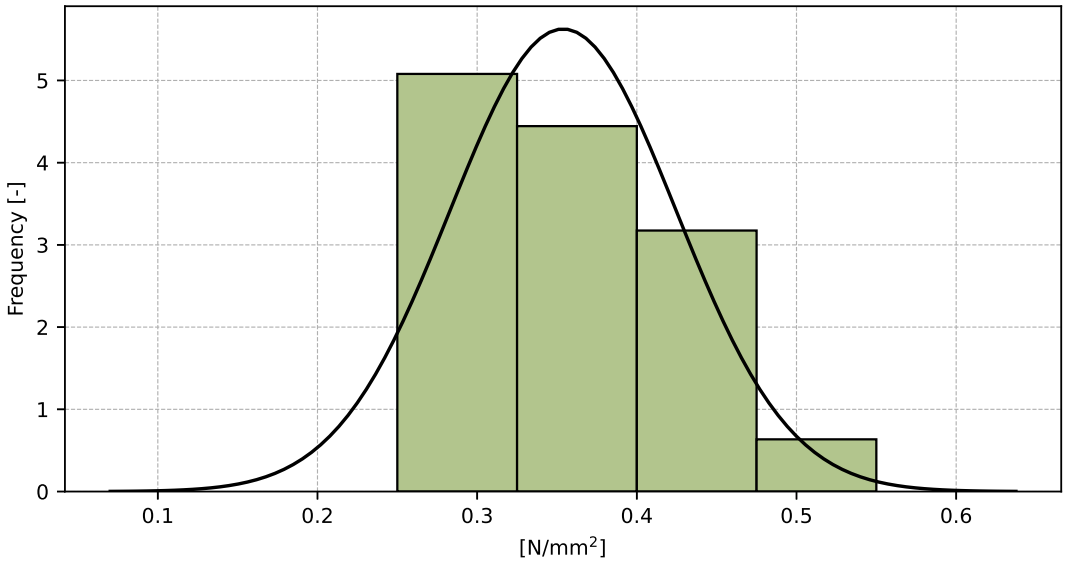

Figure 153: Histogram of all test results

Table 53: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	0.35
Sample standard deviation – s	0.071
Asigned value – x^*	0.35
Robust standard deviation – s^*	0.074
Measurement uncertainty of asigned value – u_X	0.035
p-value of normality test	0.048 [-]
Interlaboratory standard deviation – s_L	0.068
Repeatability standard deviation – s_r	0.036
Reproducibility standard deviation – s_R	0.077
Repeatability – r	0.1
Reproducibility – R	0.22

15.5 Evaluation of Performance Statistics

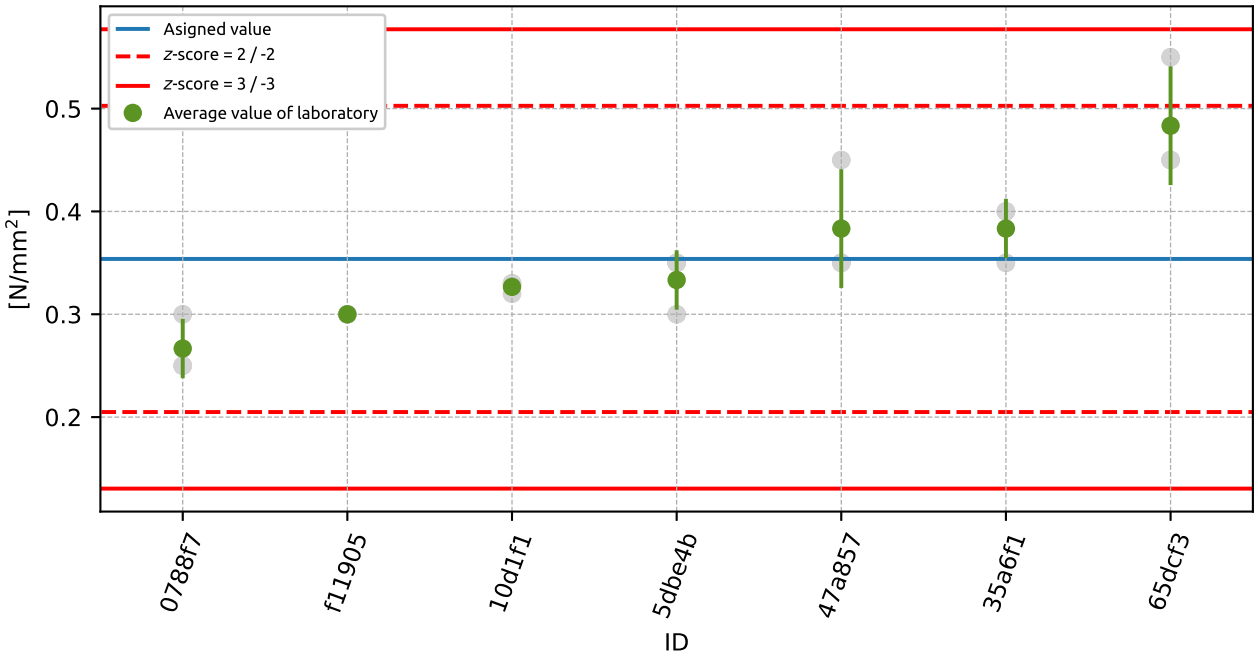

Figure 154: Average values and sample standard deviations

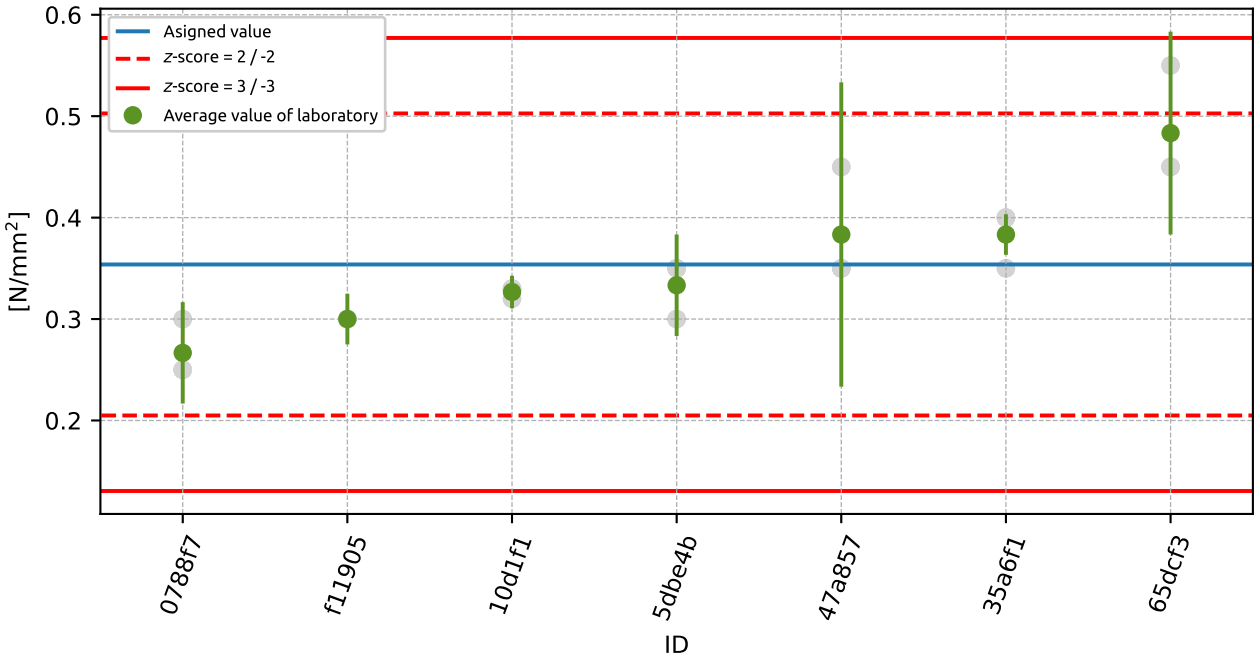

Figure 155: Average values and extended uncertainties of measurement

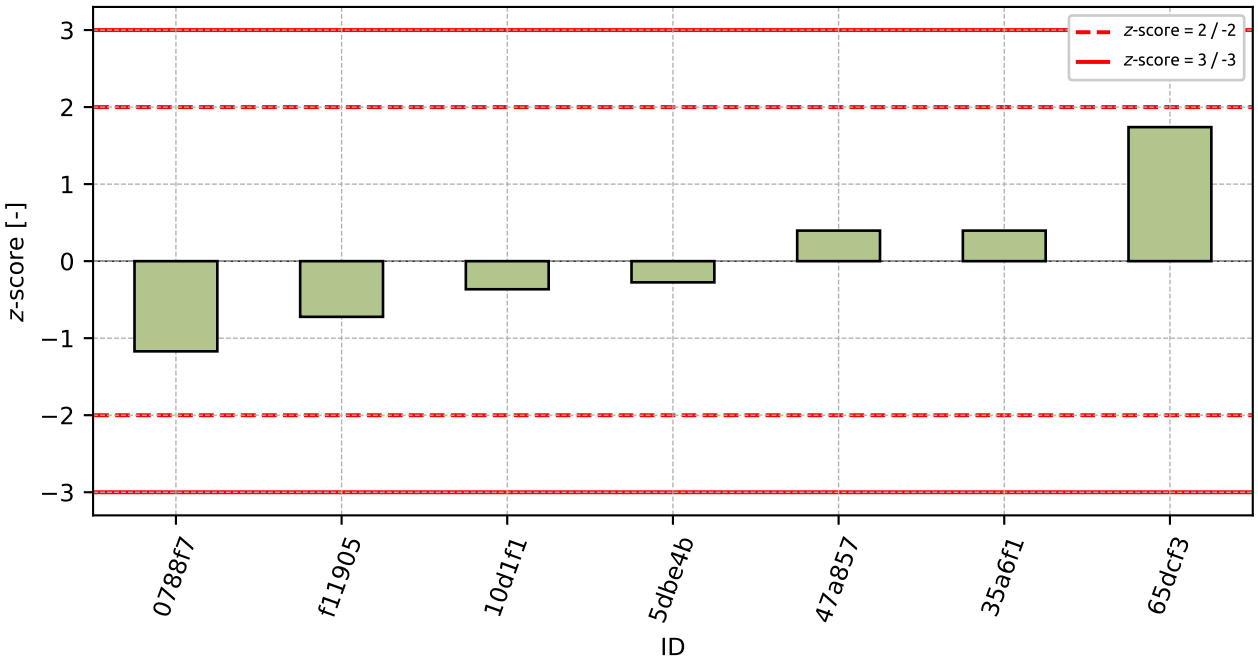

Figure 156: z-score

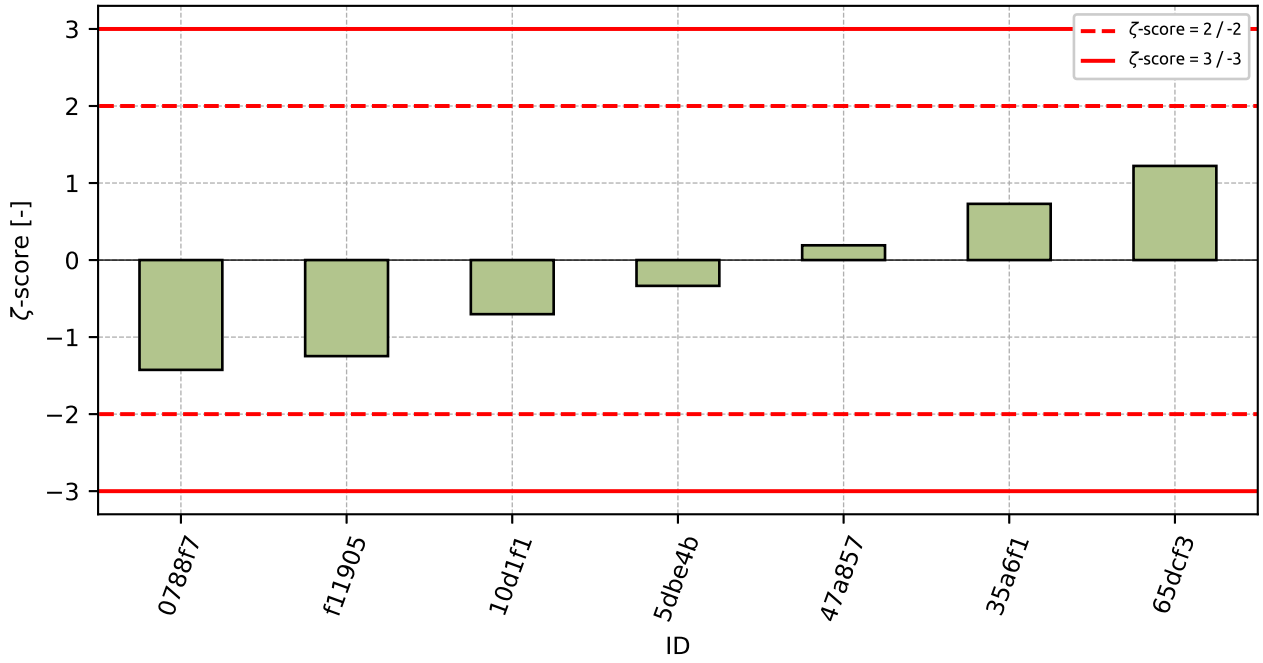

Figure 157: ζ-score

Table 54: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
0788f7	-1.17	-1.43
f11905	-0.72	-1.25
10d1f1	-0.36	-0.7
5dbe4b	-0.28	-0.33
47a857	0.4	0.19
35a6f1	0.4	0.73
65dcf3	1.74	1.22

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

This part of PT program was not open due to 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.

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

18.1 Flexural Strength

18.1.1 Test results

Table 55: 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 [%]
3d7bfb	2.4	2.4	2.6	0.2	2.5	0.1	4.24
14ad73	5.1	5.3	5.1	0.4	5.2	0.12	2.23
47a857	5.4	5.8	5.4	0.4	5.5	0.24	4.27
87fd86	6.3	6.1	6.1	0.3	6.2	0.12	1.87
830fc9	6.5	5.9	6.4	0.1	6.3	0.32	5.06
7daaa4	6.4	6.3	6.4	0.5	6.3	0.03	0.46

18.1.2 The Numerical Procedure for Determining Outliers

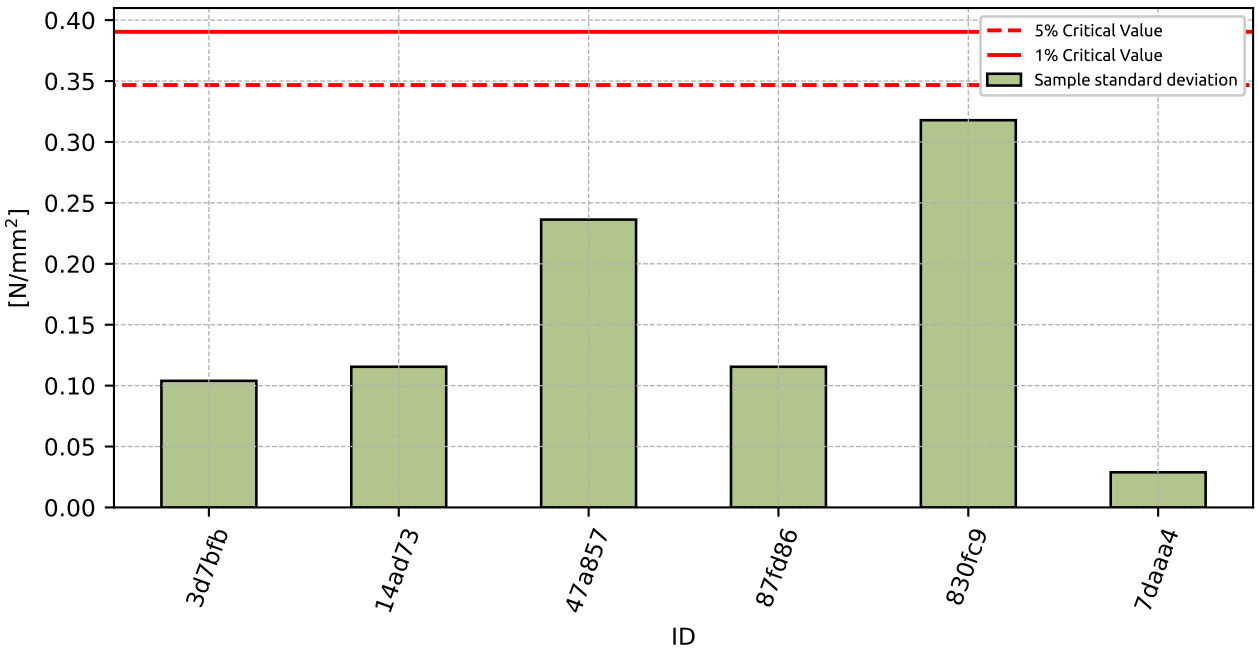

Figure 158: **Cochran's test** - sample standard deviations

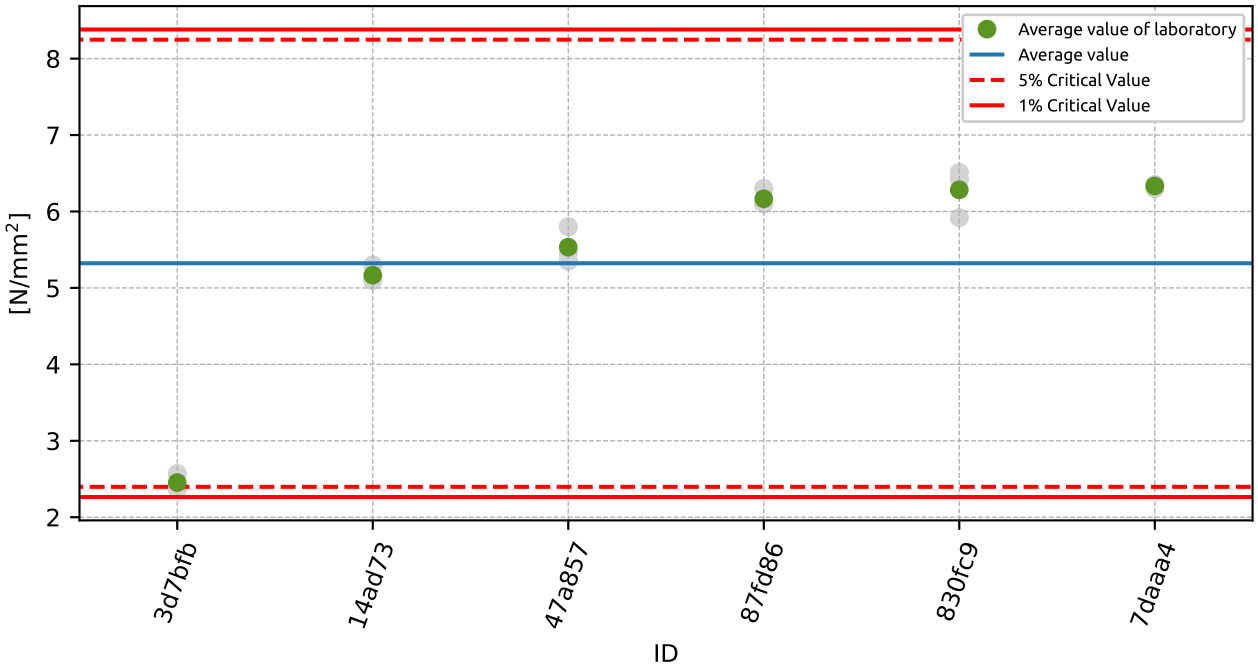

Figure 159: **Grubbs' test** - average values

18.1.3 Mandel's Statistics

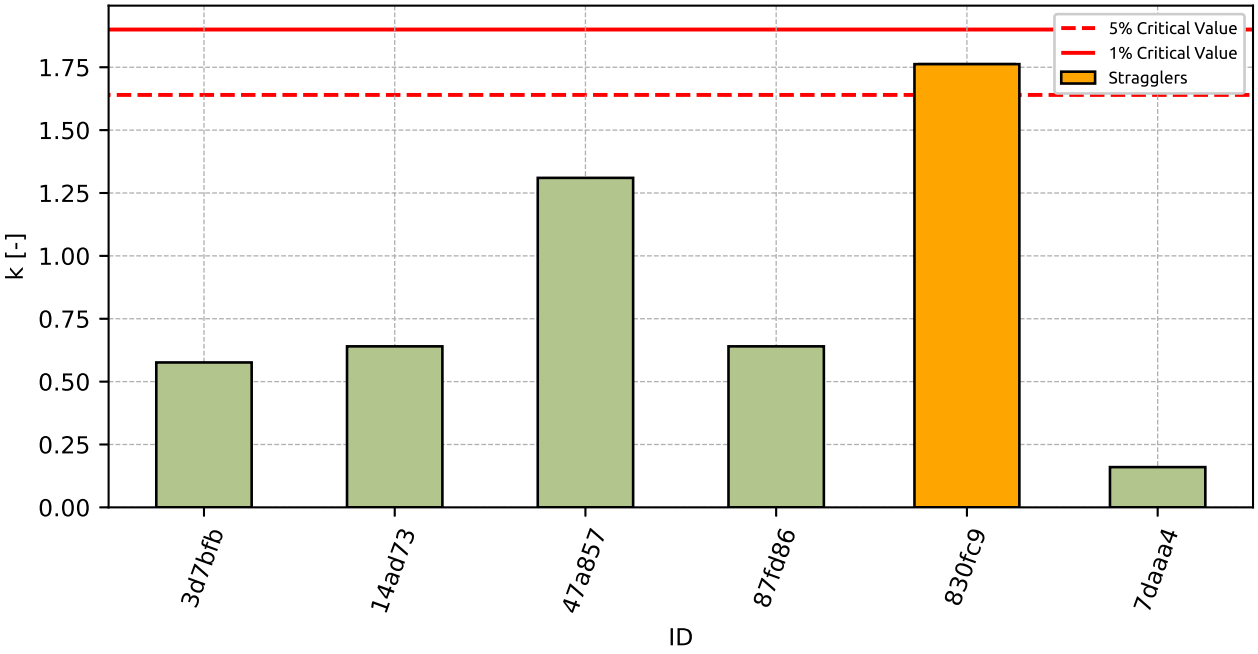

Figure 160: Intralaboratory Consistency Statistic

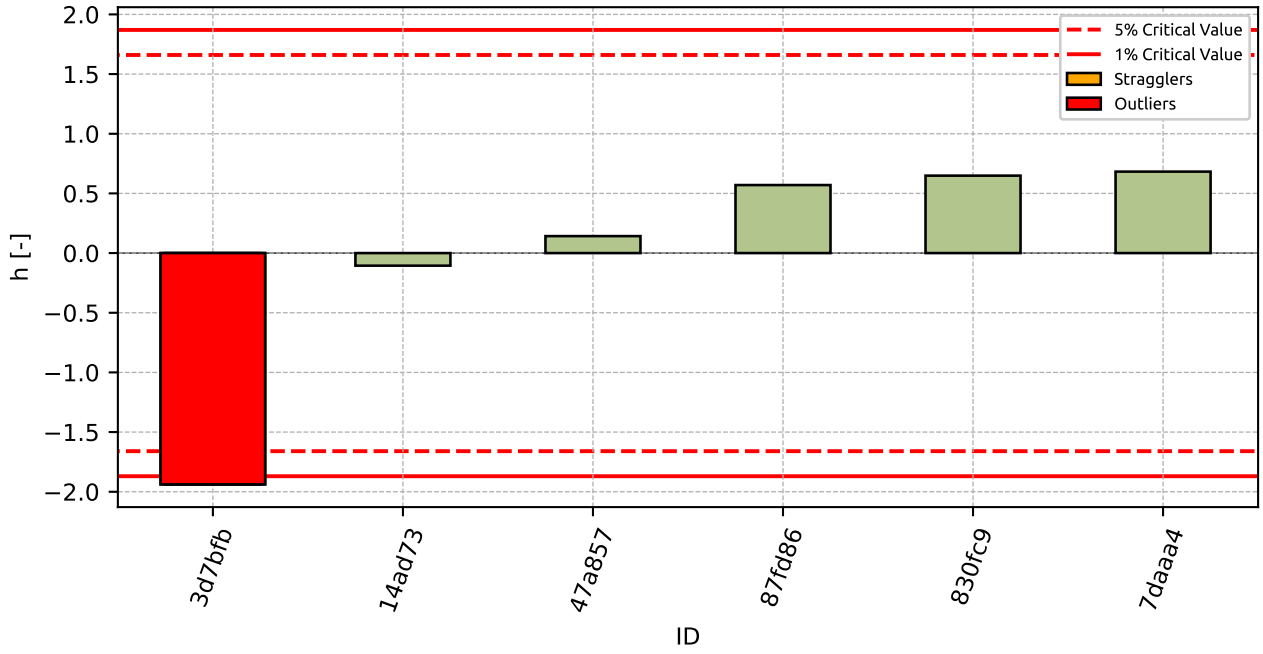

Figure 161: Interlaboratory Consistency Statistic

18.1.4 Descriptive statistics

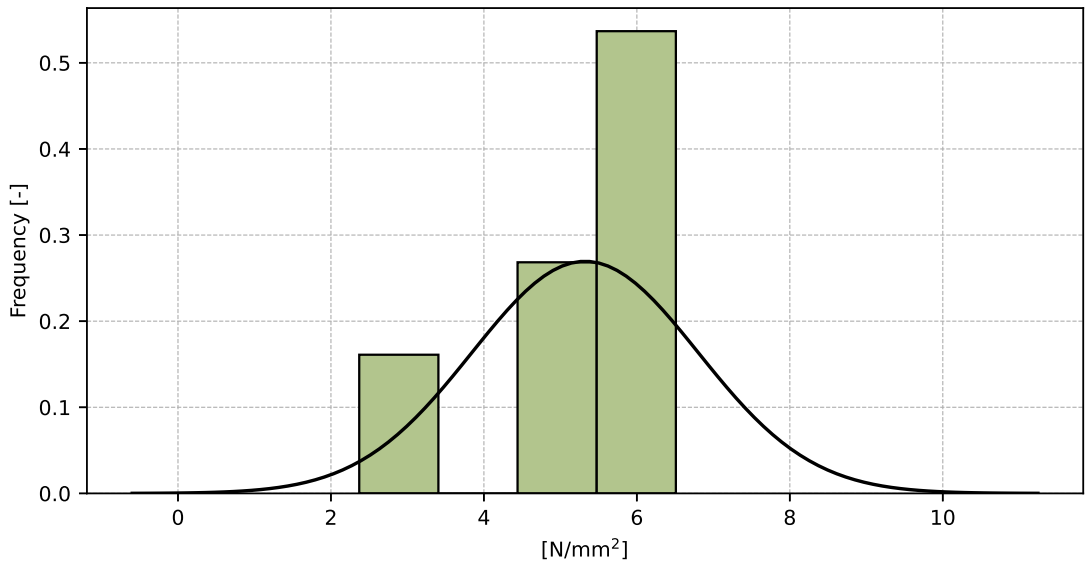

Figure 162: Histogram of all test results

Table 56: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	5.3
Sample standard deviation – s	1.48
Asigned value – x^*	5.7
Robust standard deviation – s^*	0.66
Measurement uncertainty of asigned value – u_X	0.34
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	1.48
Repeatability standard deviation – s_r	0.18
Reproducibility standard deviation – s_R	1.49
Repeatability – r	0.5
Reproducibility – R	4.2

18.1.5 Evaluation of Performance Statistics

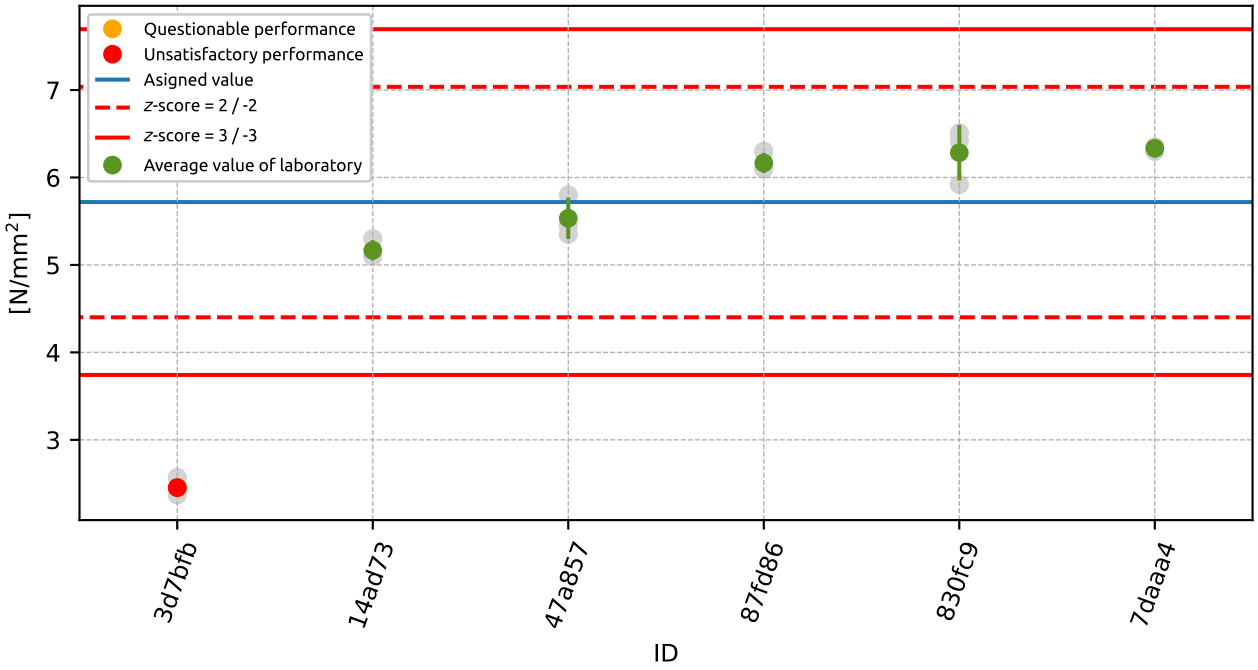

Figure 163: Average values and sample standard deviations

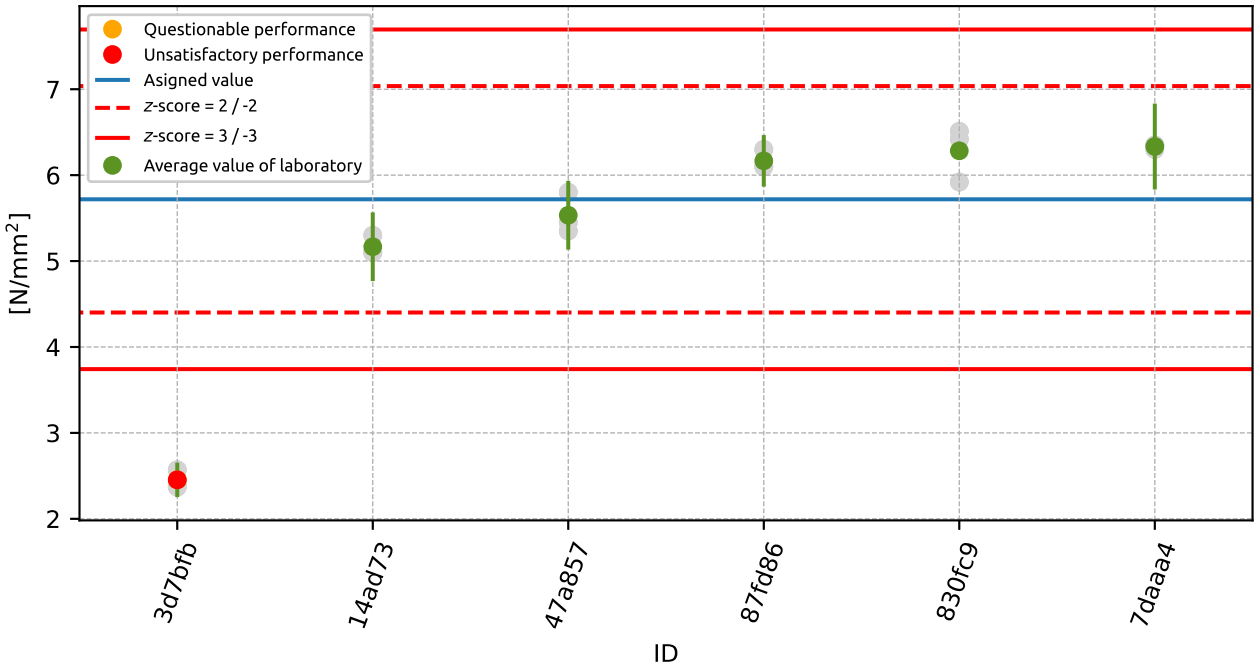

Figure 164: Average values and extended uncertainties of measurement

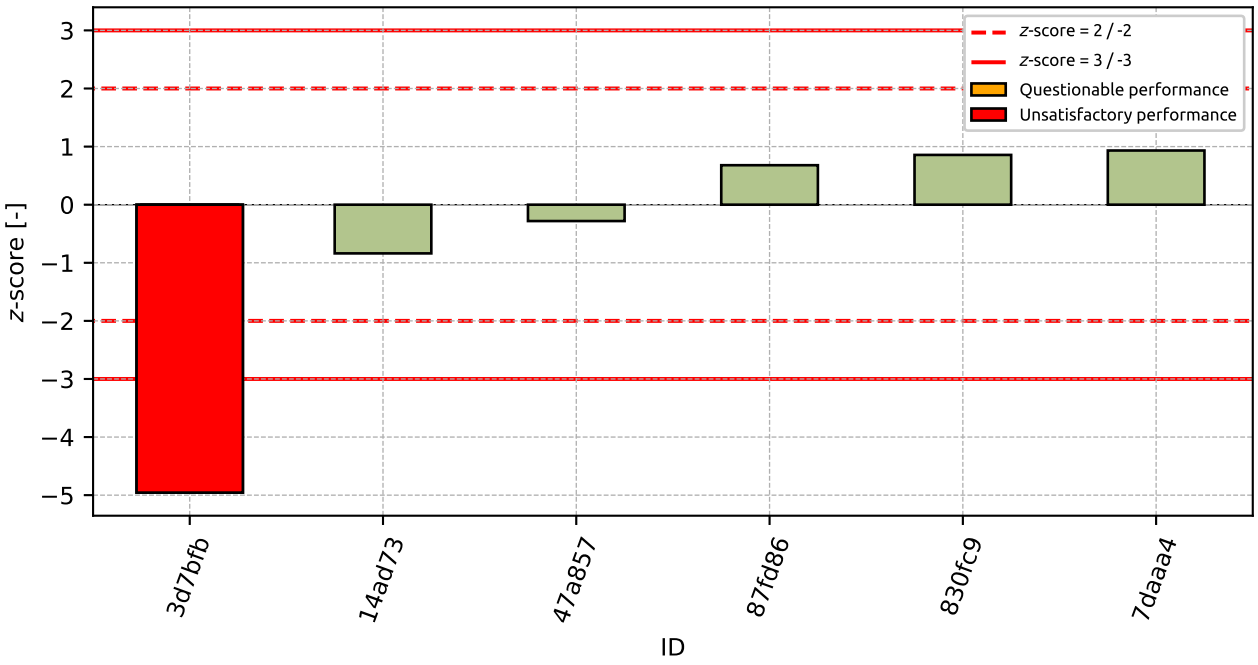

Figure 165: z-score

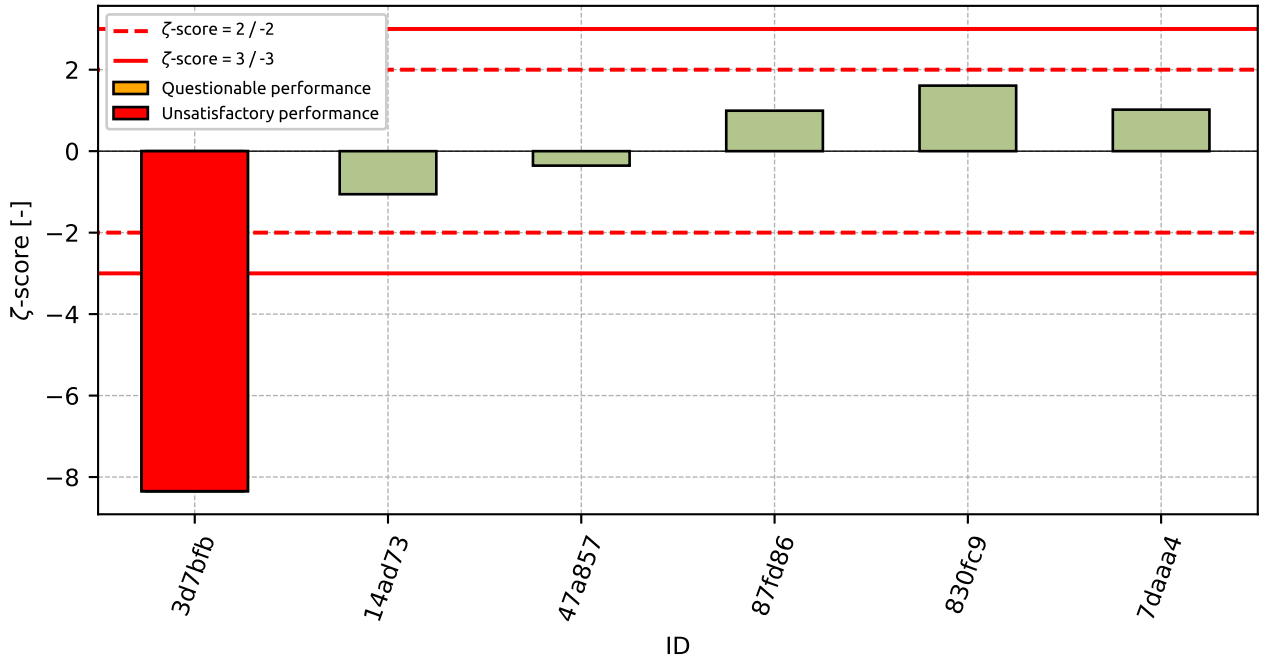

Figure 166: ζ-score

Table 57: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
3d7bfb	-4.96	-8.35
14ad73	-0.84	-1.06
47a857	-0.28	-0.36
87fd86	0.68	0.99
830fc9	0.86	1.61
7daaa4	0.93	1.02

18.2 Compressive Strength

18.2.1 Test results

Table 58: 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 [%]
14ad73	30.0	30.6	31.3	30.6	30.0	31.3	1.2	30.6	0.58	1.9
830fc9	34.1	32.6	30.8	30.9	32.5	31.6	0.5	32.1	1.24	3.88
7daaa4	34.2	35.0	34.3	33.7	33.1	35.8	1.3	34.3	0.95	2.78
87fd86	35.6	35.3	35.3	35.5	33.5	34.0	1.7	34.9	0.89	2.54
47a857	34.6	34.6	36.0	35.6	35.4	35.2	2.5	35.2	0.54	1.52
3d7bfb	59.4	61.5	57.9	59.1	61.1	62.5	4.3	60.2	1.73	2.87

18.2.2 The Numerical Procedure for Determining Outliers

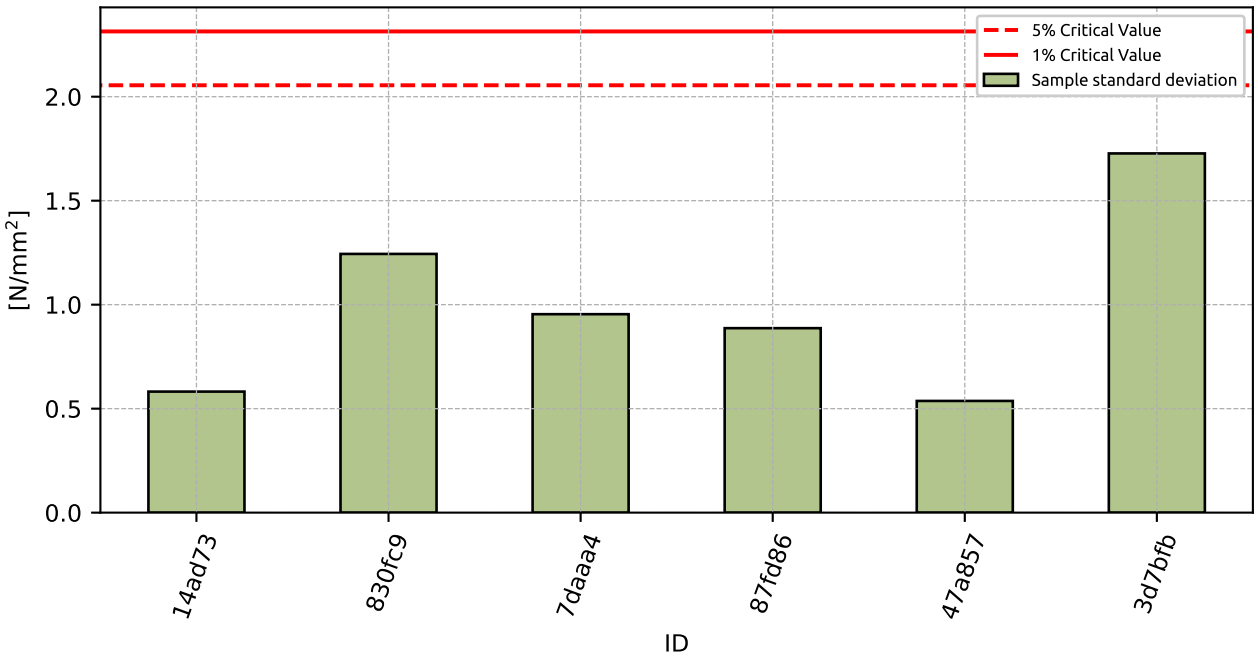

Figure 167: **Cochran's test** - sample standard deviations

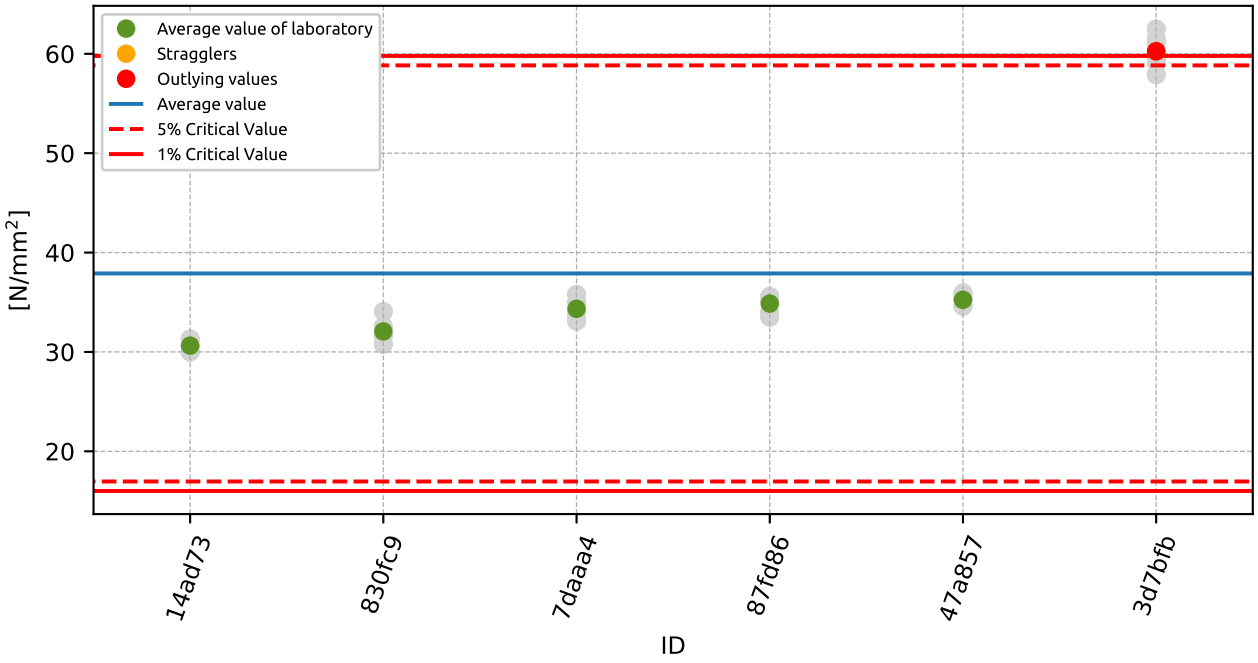

Figure 168: **Grubbs' test** - average values

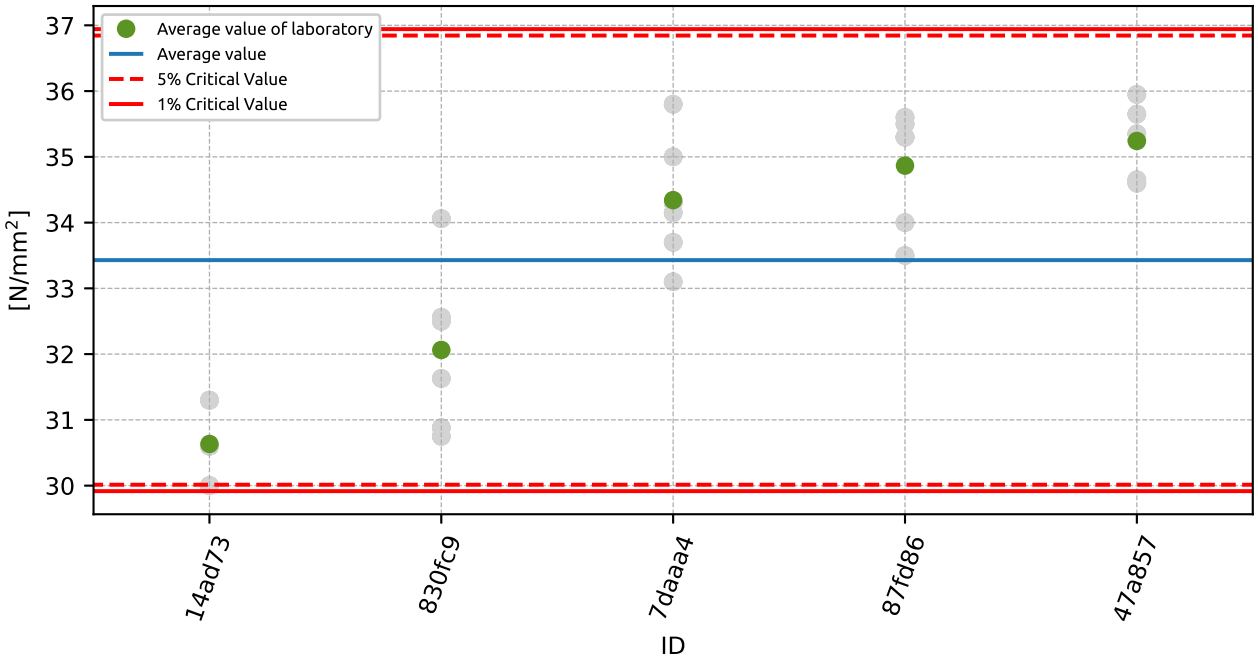

Figure 169: **Grubbs' test** - average values without outliers

18.2.3 Mandel's Statistics

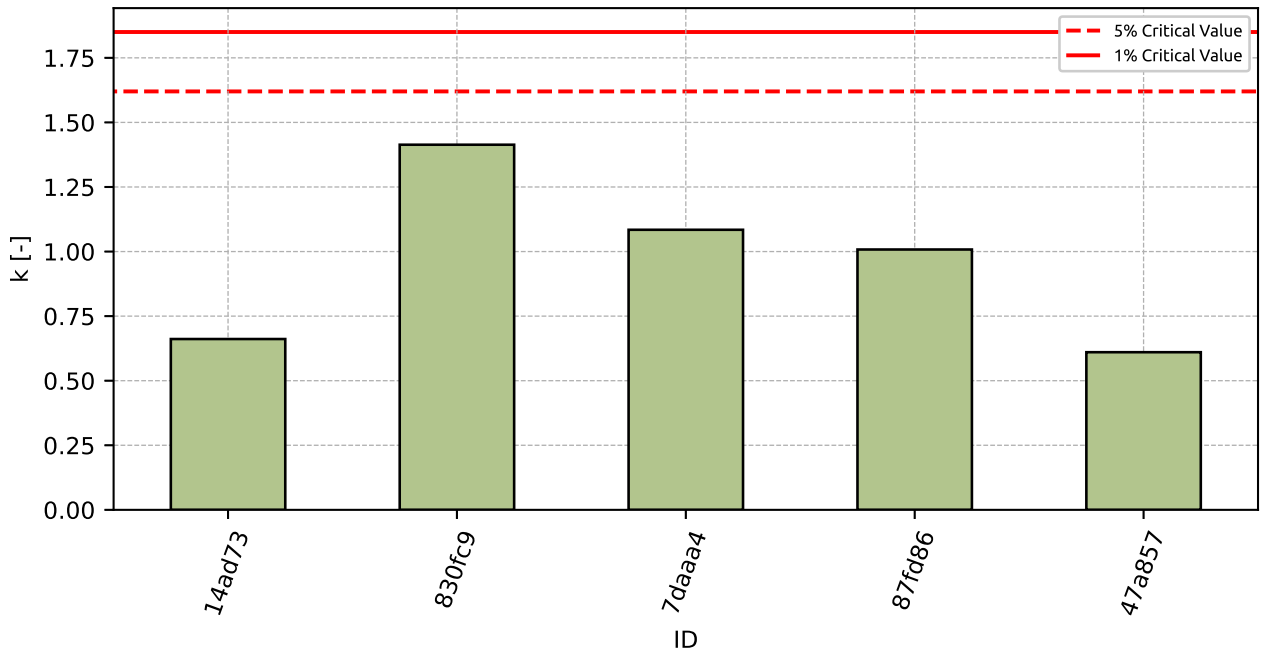

Figure 170: Intralaboratory Consistency Statistic

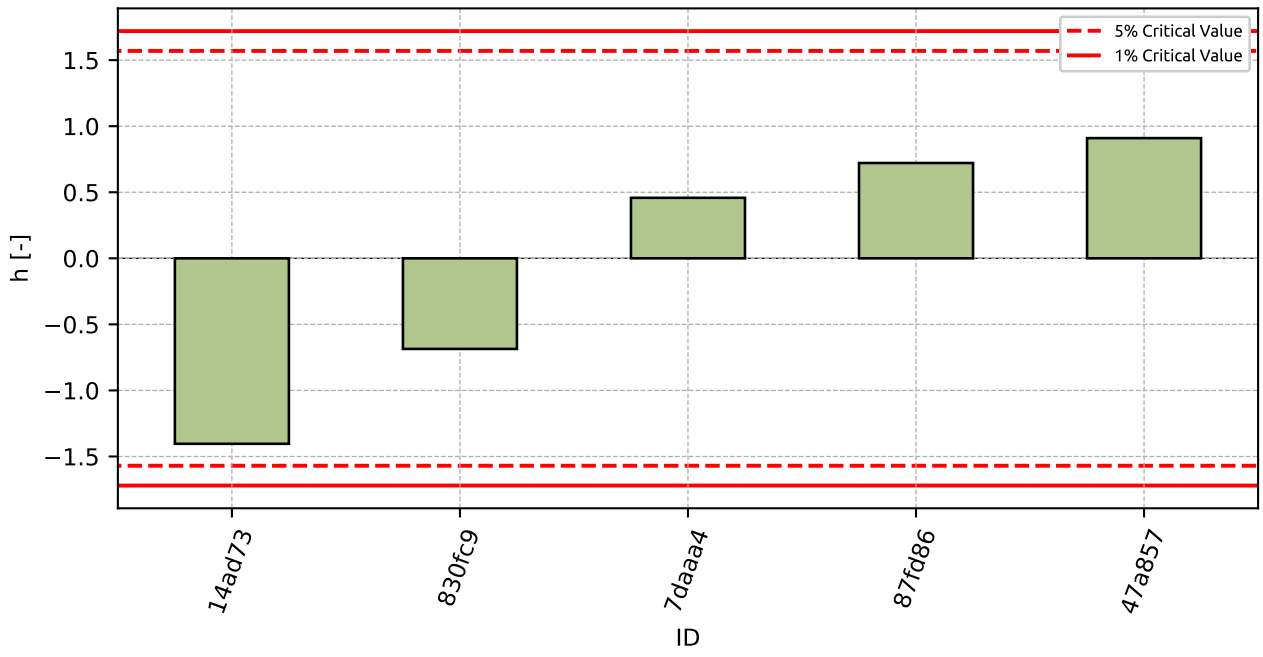

Figure 171: Interlaboratory Consistency Statistic

18.2.4 Descriptive statistics

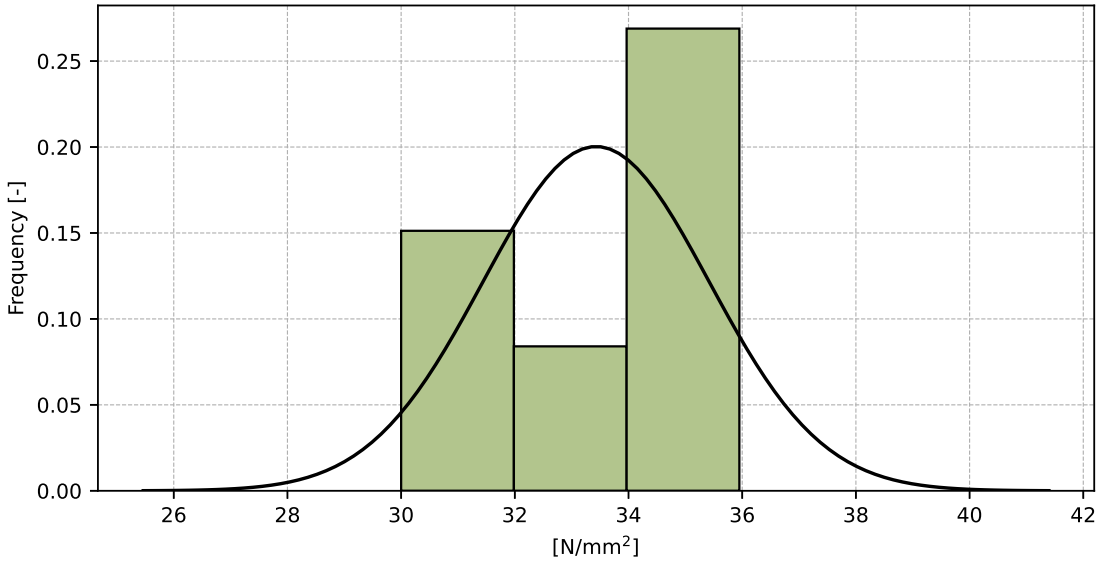

Figure 172: Histogram of all test results

Table 59: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	33.4
Sample standard deviation – s	1.99
Asigned value – x^*	33.8
Robust standard deviation – s^*	1.41
Measurement uncertainty of asigned value – u_X	0.79
p-value of normality test	0.007 [-]
Interlaboratory standard deviation – s_L	1.96
Repeatability standard deviation – s_r	0.88
Reproducibility standard deviation – s_R	2.15
Repeatability – r	2.5
Reproducibility – R	6.0

18.2.5 Evaluation of Performance Statistics

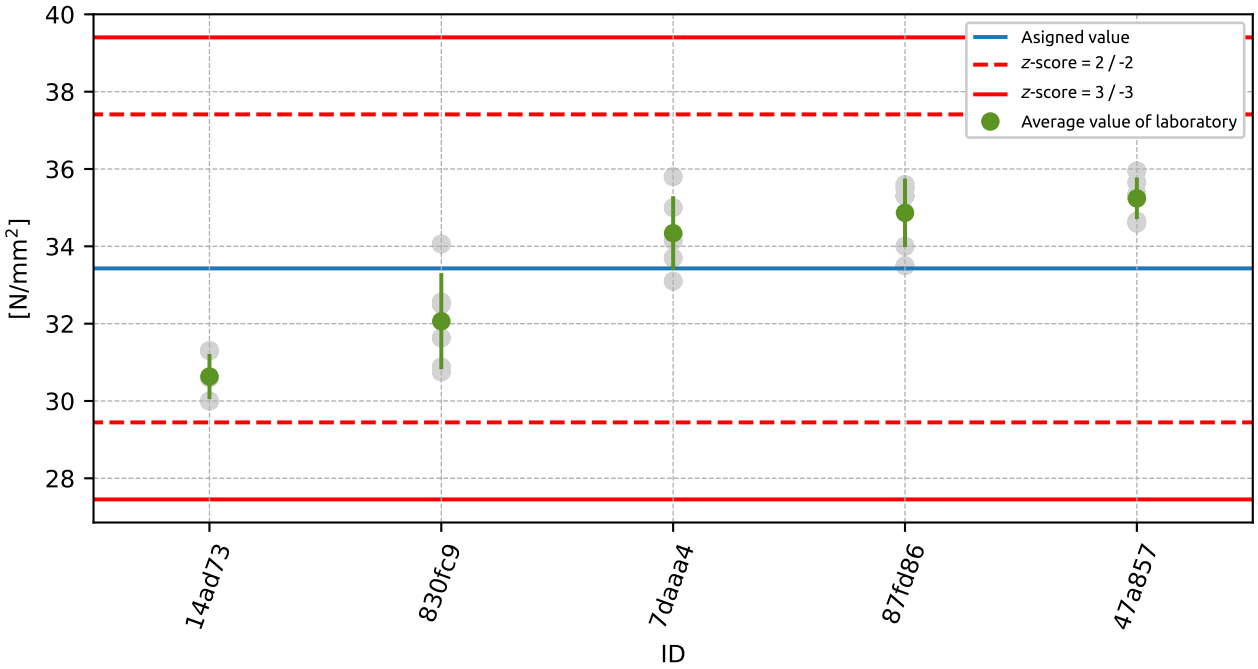

Figure 173: Average values and sample standard deviations

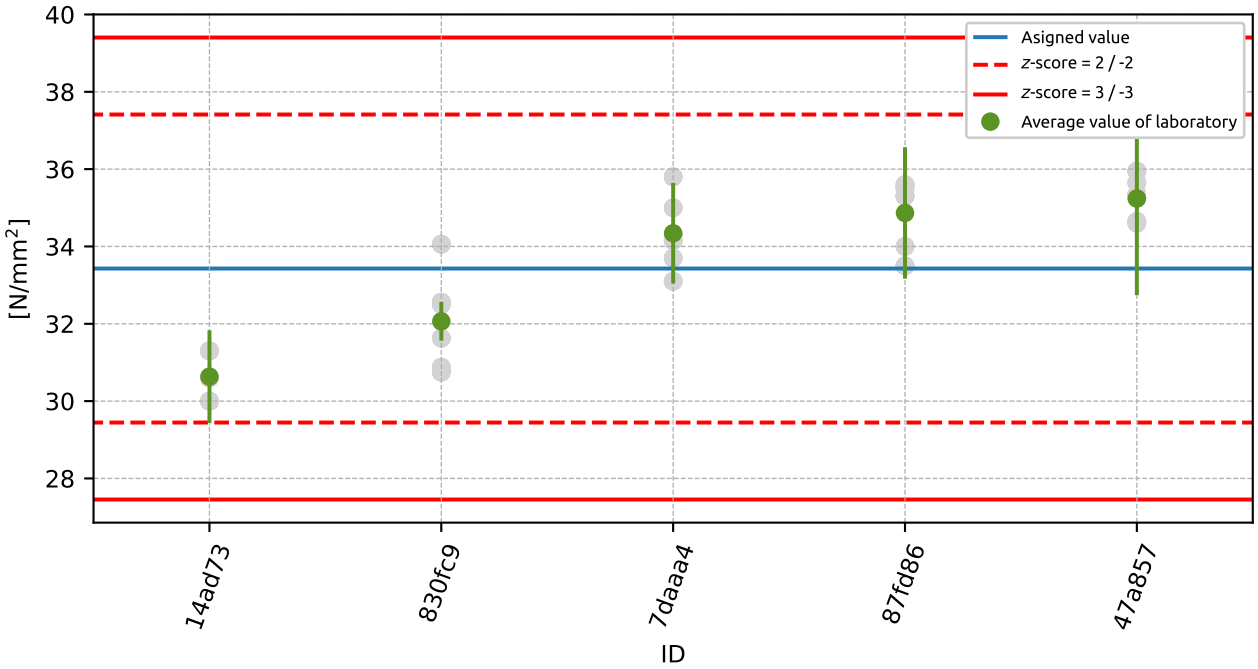

Figure 174: Average values and extended uncertainties of measurement

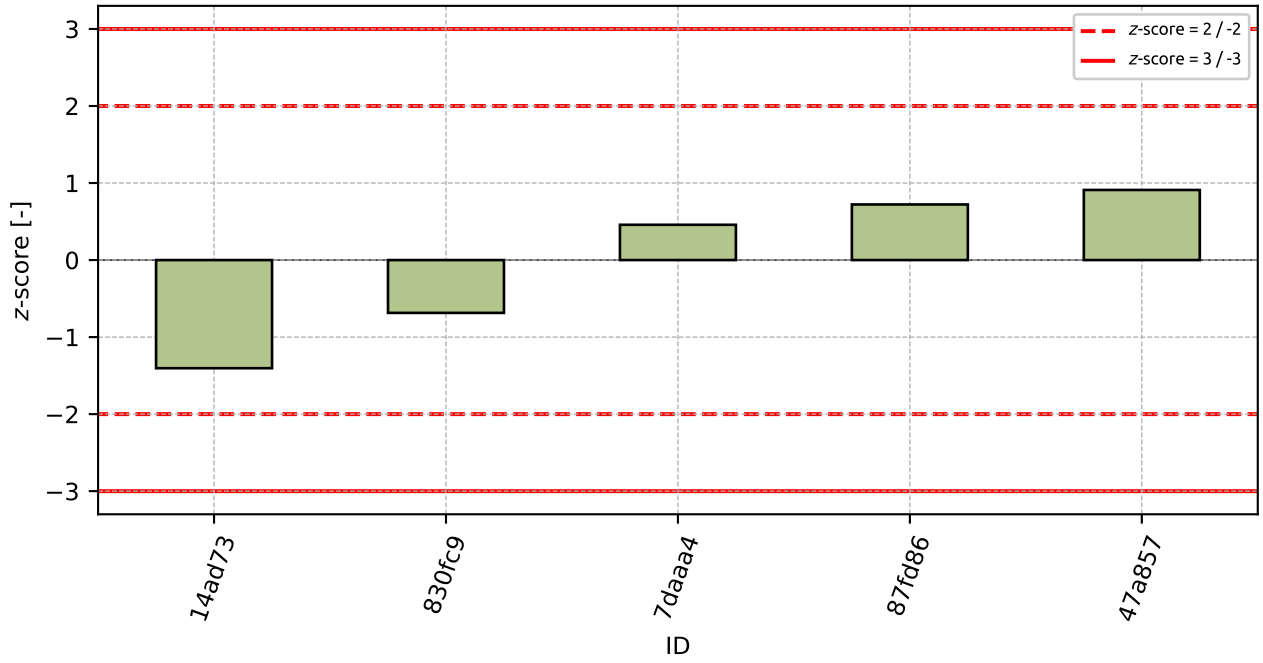

Figure 175: z-score

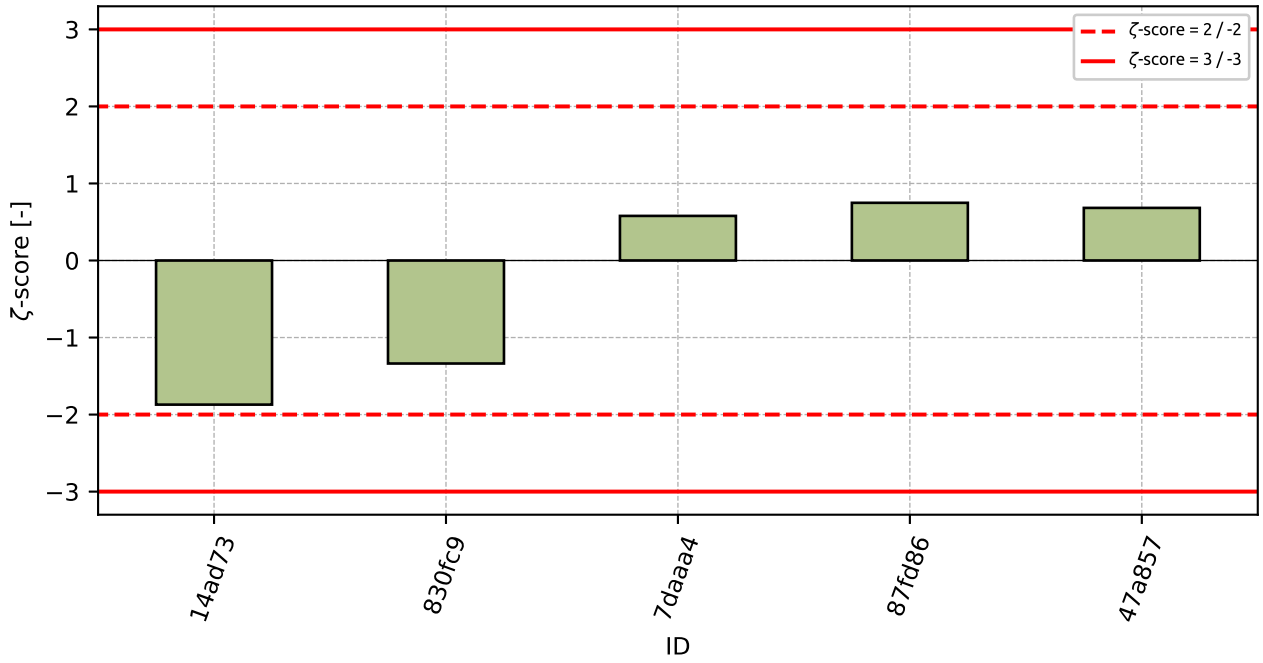

Figure 176: ζ-score

Table 60: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
14ad73	-1.4	-1.87
830fc9	-0.69	-1.34
7daaa4	0.46	0.58
87fd86	0.72	0.75
47a857	0.91	0.68

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

20.1 Test results

Table 61: 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 [%]
87fd86	0.3	0.4	0.3	0.1	0.3	0.06	17.32
47a857	0.4	0.4	0.4	0.0	0.4	0.03	7.53
aa7750	0.4	0.5	0.5	0.2	0.5	0.06	12.37

20.2 The Numerical Procedure for Determining Outliers

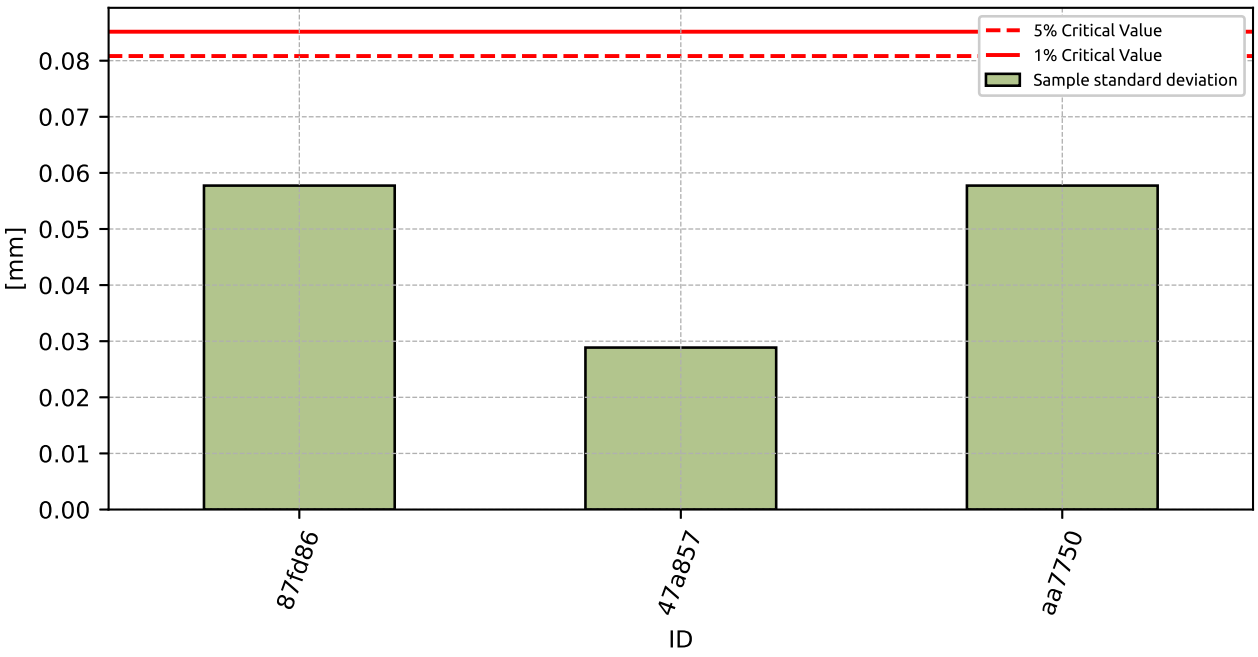

Figure 177: **Cochran's test** - sample standard deviations

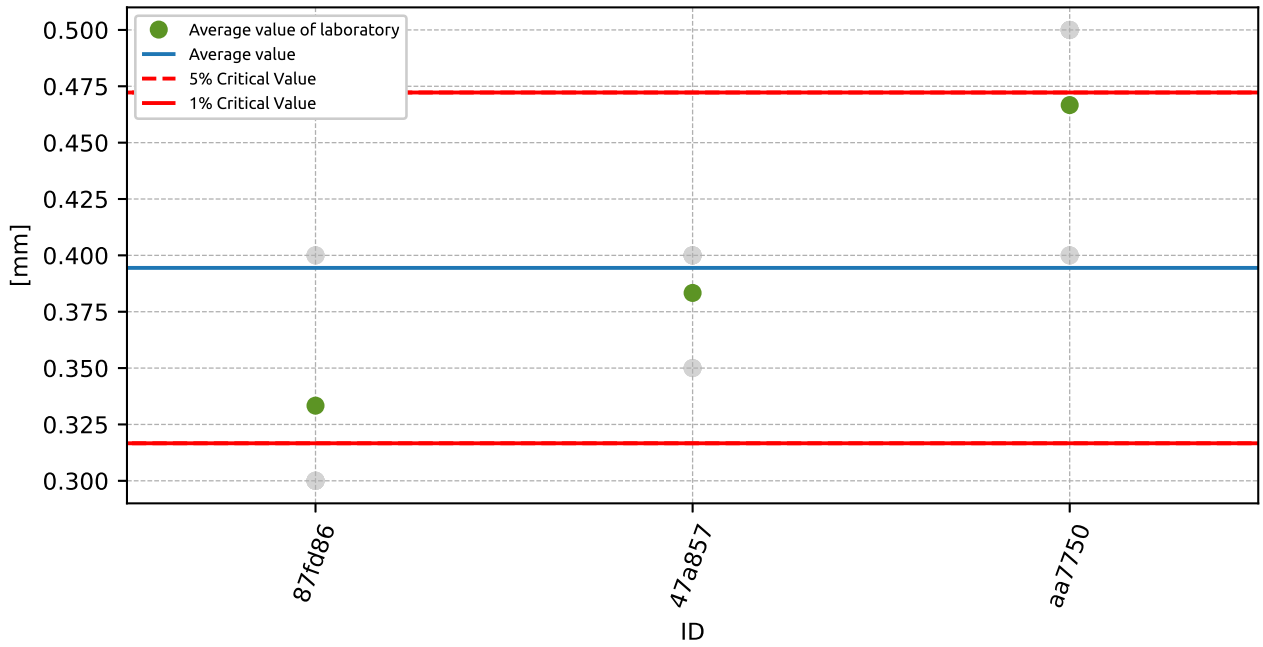

Figure 178: **Grubbs' test** - average values

20.3 Mandel's Statistics

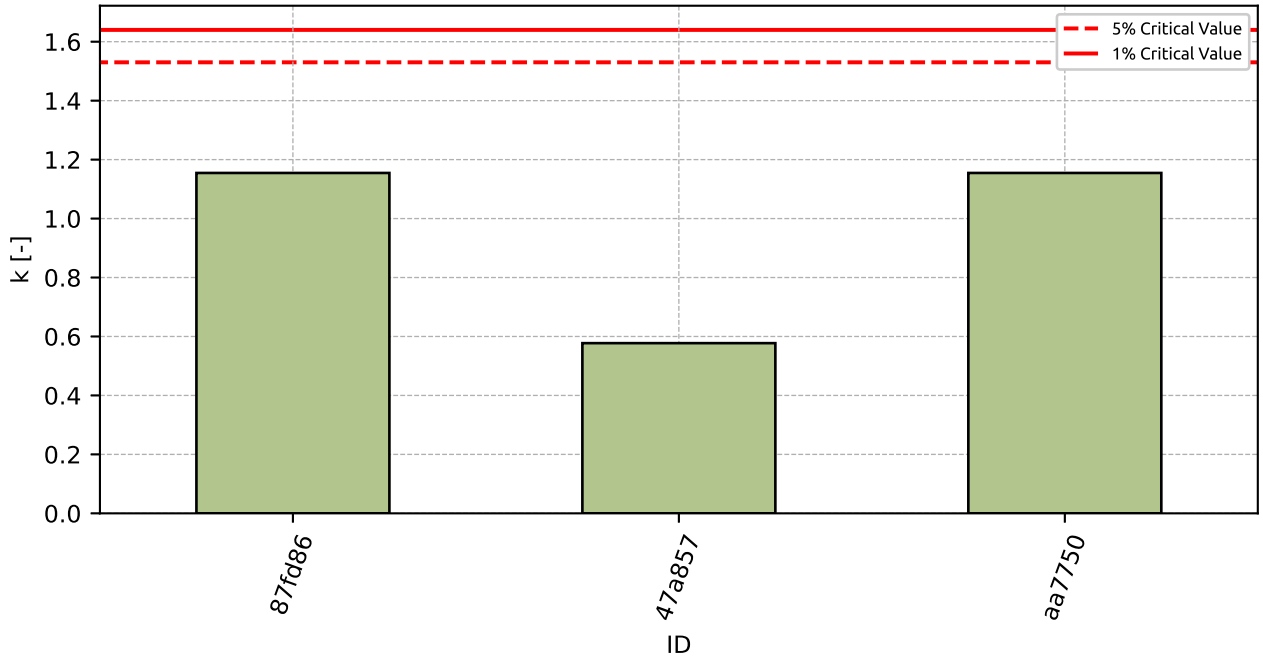

Figure 179: Intralaboratory Consistency Statistic

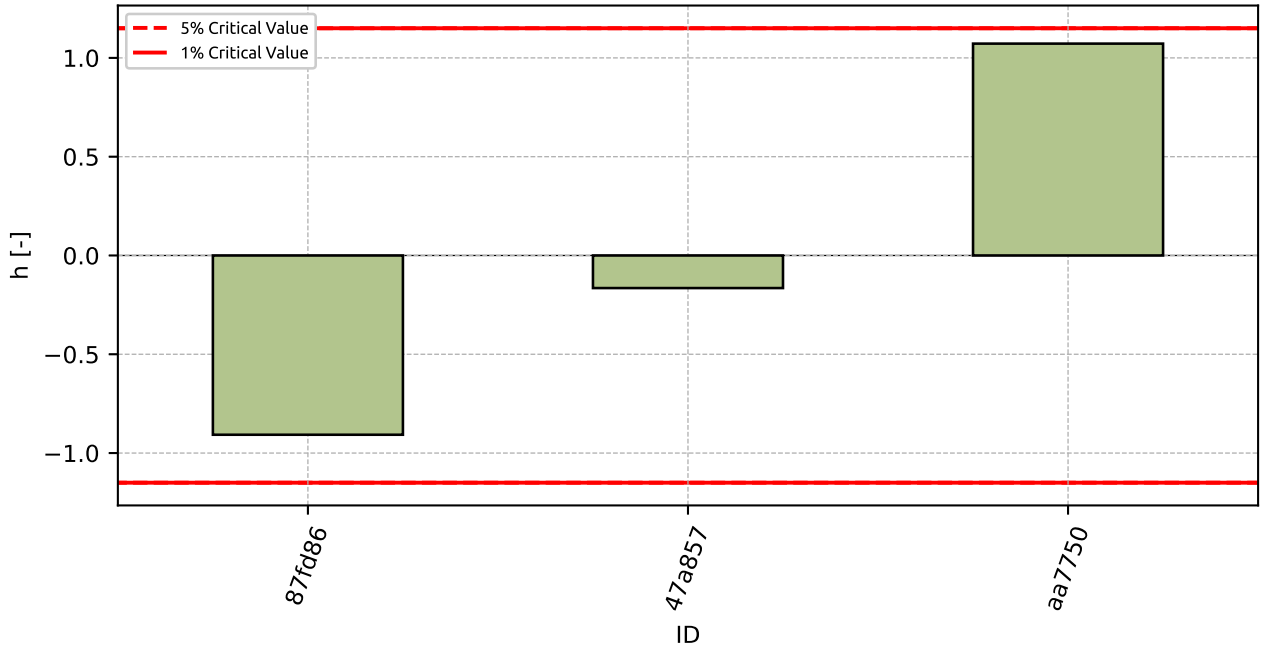

Figure 180: Interlaboratory Consistency Statistic

20.4 Descriptive statistics

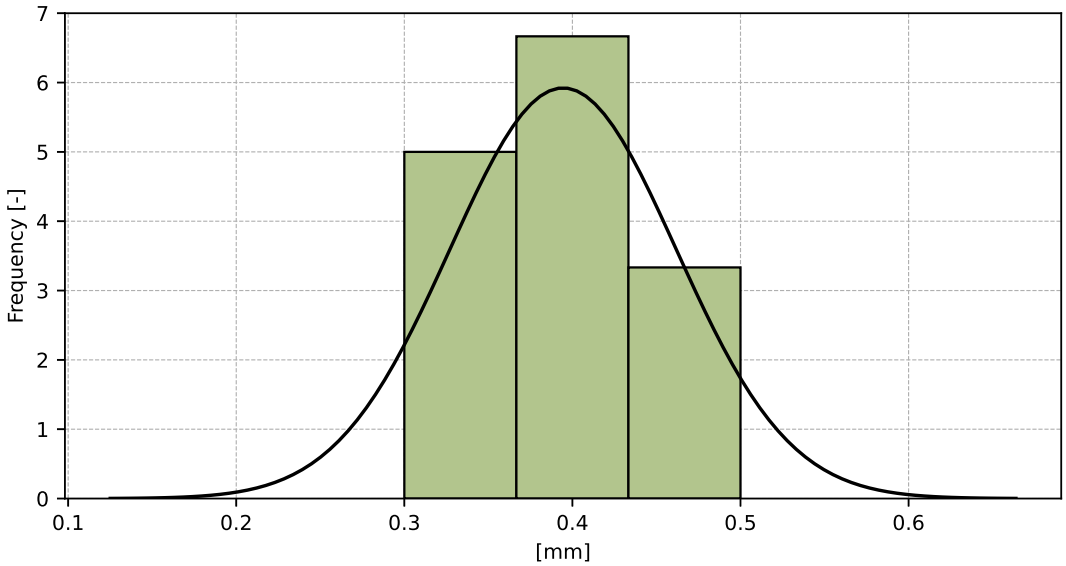

Figure 181: Histogram of all test results

Table 62: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	0.4
Sample standard deviation – s	0.07
Asigned value – x^*	0.4
Robust standard deviation – s^*	0.06
Measurement uncertainty of asigned value – u_X	0.05
p-value of normality test	0.148 [-]
Interlaboratory standard deviation – s_L	0.06
Repeatability standard deviation – s_r	0.05
Reproducibility standard deviation – s_R	0.08
Repeatability – r	0.1
Reproducibility – R	0.2

20.5 Evaluation of Performance Statistics

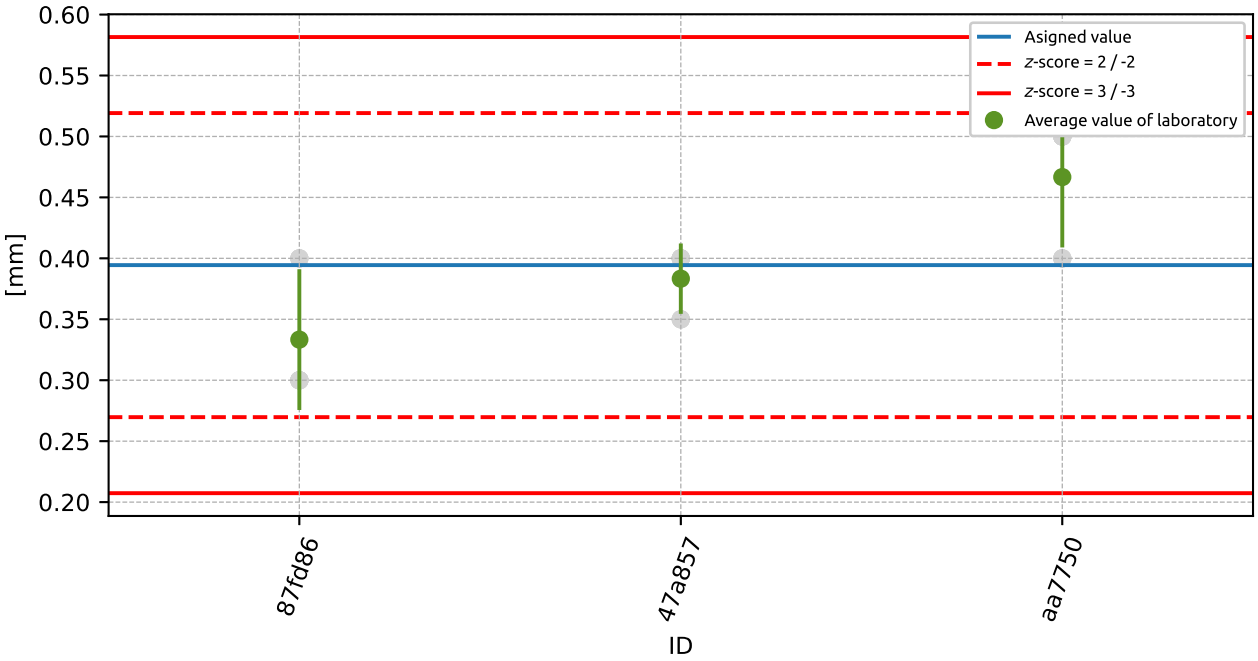

Figure 182: Average values and sample standard deviations

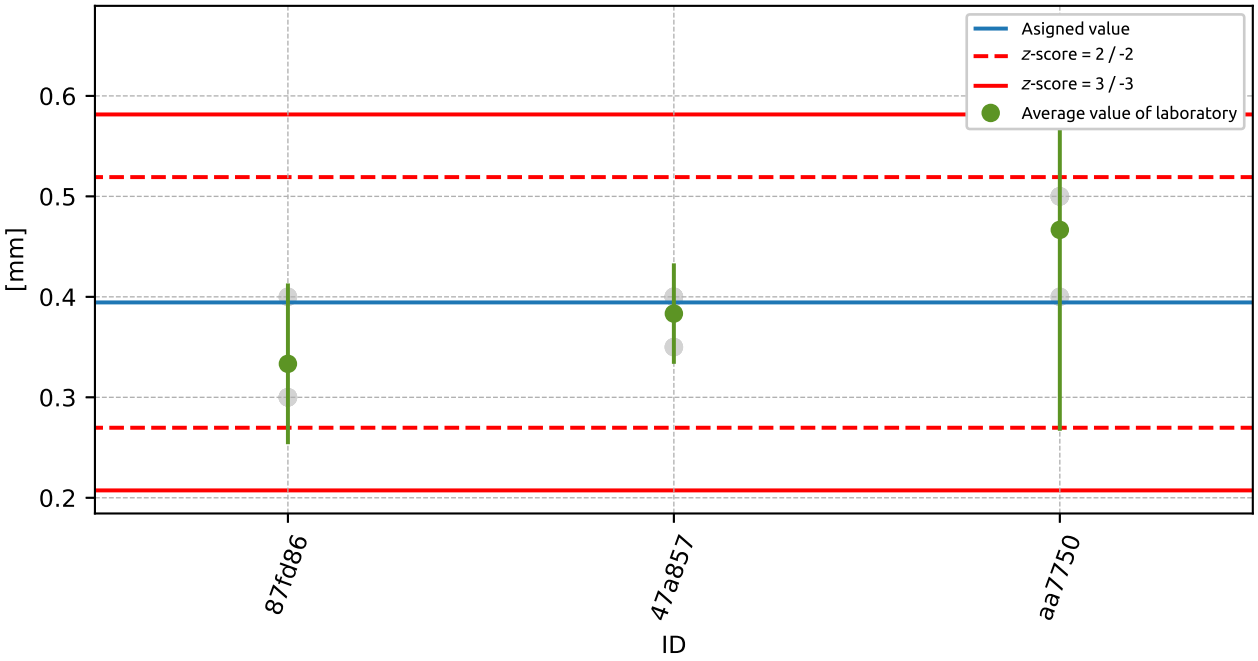

Figure 183: Average values and extended uncertainties of measurement

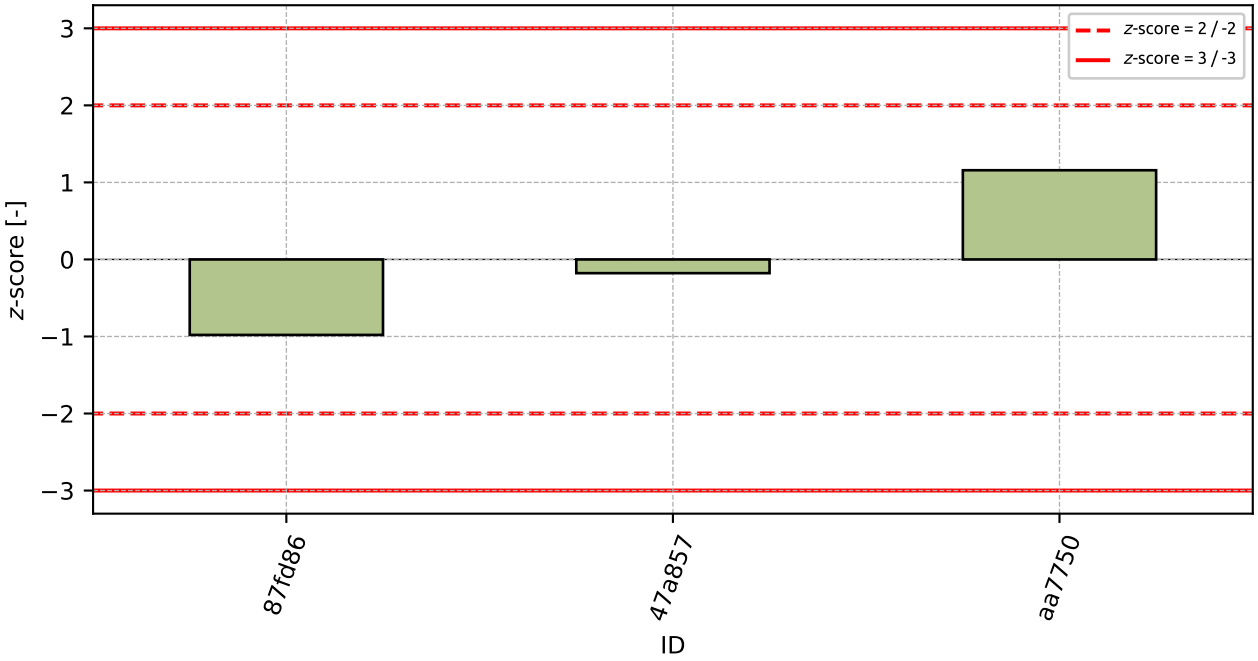

Figure 184: z-score

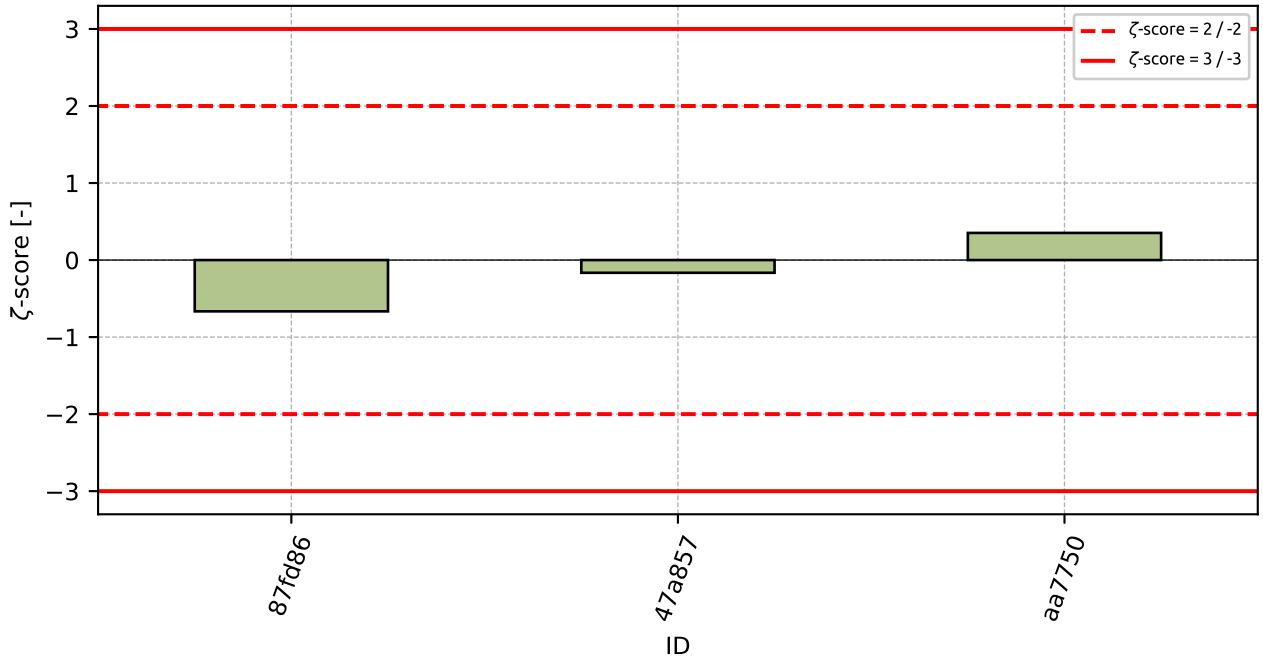

Figure 185: ζ-score

Table 63: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
87fd86	-0.98	-0.67
47a857	-0.18	-0.17
aa7750	1.16	0.35

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.