BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
institute of building testing

FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Strenght and Elasticity of Hardened Concrete
ZZB 2021/2

Brno University of Technology
Proficiency testing provider at the SZK FAST
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Czech Republic

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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 ZZB 2021/2 whose aim was to verify and assess the conformity of test results across laboratories when testing hardened concrete.

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 12390-3** – Compressive strength of test specimens [1].
2. **EN 12390-5** – Flexural strength of test specimens [2].
3. **EN 12390-6** – Tensile splitting strength of test specimens [3].
4. **EN 12390-7** – Density of hardened concrete [4].
5. **ISO 1920-10** – Determination of static modulus of elasticity in compression [5].
6. **EN 12390-13** – method A – Determination of secant modulus of elasticity in compression [6].
7. **EN 12390-13** – method B – Determination of secant modulus of elasticity in compression [6].
8. **EN 12504-4, ČSN 731371** – Non-destructive testing of concrete [7], [8].
9. **ČSN 731373, EN 12504-2** – Determination of rebound number [9], [10].
10. **EN 1542, ČSN 736242** – Appendix B – Measurement of bond strength by pull-off [11], [12].

Testing procedures No 6 and 7 were not open due to the low number of participants.

The supplier, BETOTECH s. r. o., was responsible for the preparation of hardened concrete for the PTP. Fresh concrete for the preparation of test samples was taken from one production batch prepared in accordance with methods stipulated in EN 206 [13]. Fresh concrete was poured into test molds, which were always of the same type, and after removal from the molds the test specimens were placed under identical conditions in storage rooms complying with the requirements for individual specifications.

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 [14] and with EN ISO/IEC 17043 [15]. The outcome is the present final report summarizing the results of the interlaboratory comparison, including statistical evaluation.

50 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/Method	1	2	3	4	5	6	7	8	9	10
d3790c	X	-	-	-	-	-	-	-	-	-
85dca9	X	X	-	X	-	-	-	-	X	X
b116cc	-	-	X	-	X	-	-	X	-	-
78ecc0	X	-	-	X	-	-	-	-	-	X
010369	X	-	-	X	-	-	-	-	X	-
da779f	X	X	-	X	X	-	-	-	-	-
b24024	X	-	-	X	-	-	-	-	-	-
6056c9	-	-	-	-	-	-	-	-	X	-
fbf223	-	-	-	-	-	-	-	-	-	X
a8eab4	X	-	-	-	-	-	-	-	-	-
9ad08a	X	-	-	-	-	-	-	-	-	-
d2a76e	X	-	-	X	X	-	-	-	X	X
92b8be	X	-	-	X	-	-	-	-	-	-
7a10f6	-	-	-	-	-	-	-	-	X	X
91e89f	-	-	-	-	-	-	-	-	X	X
8e9c95	X	X	X	X	X	-	-	X	X	X
44d3a3	X	-	-	-	-	-	-	-	-	-
6725e5	X	-	-	-	-	-	-	X	X	-
9a306f	-	-	-	-	-	-	-	-	X	-
a2d4c1	-	X	-	-	-	-	-	-	-	-
5d46aa	X	X	X	X	-	-	-	-	-	-
e679b2	-	-	-	-	-	-	-	X	-	-
8fe1e3	X	-	-	-	-	-	-	-	-	-
200b13	X	-	-	X	-	-	-	-	X	-
fb45d2	X	X	-	X	-	-	-	-	-	-
8bd06b	X	-	-	X	-	-	-	-	-	-
0c0c26	X	X	-	-	X	-	-	-	X	-
105a8a	-	-	X	-	-	-	-	-	-	X
855dc5	X	X	-	X	-	-	-	-	-	-
9a863a	-	X	X	-	-	-	-	-	-	-
4d7195	-	X	X	-	-	-	-	-	-	-
23c817	X	X	X	X	-	-	-	-	-	-
5b34fc	X	-	-	-	-	-	-	-	-	-
b94a23	X	-	X	X	-	-	-	-	-	-
b81e93	X	X	-	-	-	-	-	-	-	X
060c5b	X	-	-	X	-	-	-	-	X	-
f60587	-	-	-	-	-	-	-	-	X	X
67aadb	X	-	-	X	X	-	-	-	-	-
f1d2af	X	X	-	X	-	-	-	-	-	-
1631d2	-	X	X	X	-	-	-	-	-	-
1152e1	X	-	-	X	-	-	-	-	-	-
4a9e22	-	X	-	X	-	-	-	-	X	X
4d7d48	X	X	-	X	-	-	-	-	X	-
d97a4f	X	X	X	X	-	-	-	-	X	-

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ID/Method	1	2	3	4	5	6	7	8	9	10
344791	X	-	-	X	-	-	-	-	-	-
2ad9e0	X	X	X	X	-	-	-	-	X	X
ec96b5	X	X	X	X	-	-	-	-	X	X
eaa338	X	-	-	X	-	-	-	-	-	-
c313e3	X	-	X	-	-	-	-	-	X	-
80b88f	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
”AB” AD	boulevard ”Saedinenie” №38, Haskovo, 6300, Haskovo	№ 46LI from BSA
BETOSAN, s.r.o. - ZL LABBET	Nová cesta 40/291, Praha 4, 14000, Česká republika	1687
BETOTECH, s.r.o. - pracoviště Beroun	Beroun 660, Beroun, 26601, Česká republika	AZL 1195
BETOTECH, s.r.o. - pracoviště Brno	Beroun 660, Beroun, 26601, Česká republika	1195.3
BETOTECH, s.r.o. - pracoviště Most	Beroun 660, Beroun, 266 01, Česká republika	1195
BETOTECH, s.r.o. - pracoviště Ostrava	Beroun 660, 26601 Beroun, Ostrava, 70300, Česká republika	1195.2
Bautechnische Versuchs- und Forschungsanstalt Salzburg	Alpenstraße 157, Salzburg, 5020, Austria	0003
Bechtel ENKA UK Limited Ogranak Beograd	Jasicki put 52 đ, Kruševac, 37000, Serbia	-
Builld Lab EOOD (Билд Лаб ЕООД)	128 Georgi Sava Rakovski st, floor 8, Sofia, 1000, Rupublic of Bulgaria	-
CEMEX Czech Republic, s.r.o.	Semtín 102, Pardubice, 53354, Česká republika	1302
Centrum dopravního výzkumu, v. v. i.	Líšeňská 33a, Brno, 636 00, Česká republika	1506
Delogne Marc	Chemin des Maréchaux, 36, Wavre, 1300, Belgium	-
Disoma NV	Krommewege 31g, Maldegem, 9990, Belgium	-
ECOVISION d.o.o. Banja Luka	Boze Varicaka 19/I, Banja Luka, 78000, Bosna i Hercegovina	-
GEORGIOS KARYDIS	DISTOMOU 97, ATHENS, 10443, GREECE	-
GUBT	Gewerbeparkstrasse 5, Markgrafneusiedl, 2282, Austria	-
Geoput d.o.o. Beograd	Tome Rosandića 2, Beograd, 11010, Srbija	126366206

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Laboratory	Address	Accreditation number
Gradjevinsko-arhitektonski fakultet Univerziteta u Nišu	Aleksandra Medvedeva 14, Niš, 18000, Serbia	-
Institut pro testování a certifikaci, a.s.	třída Tomáše Bati 299, Louky, Zlín, 763 02, Česká republika	1004
JKV TEST s.r.o.	Holvekova 164/25, Ostrava-Kunčičky, 718 00, Česká republika	1294
Koncept CB spol. s r.o.	nám. Švabinského 961/10, České Budějovice, 370 08, Česká republika	1534
Laboratorium Drogowe Szczecin Sp. z o.o.	Goleniowska 92, Szczecin, 70-830, Zachodniopomorskie	-
Magnel-Vandepitte Laboratory	Technologiepark-Zwijnaarde 60, GENT, 9052, Belgium	220-TEST
Mining and Metallurgy Institute Bor	Zeleni bulevar 35, Bor, 19210, Serbia	01-308, ATS Serbia
NIEVELT Labor CZ s.r.o.	Za Olomouckou 4184/17, Prostějov, 79601, Česká republika	1716
QCONTROL s.r.o., odštěpný závod - PRACOVIŠTĚ DĚČÍN	Lesní 693, Bílovice nad Svitavou, 66401, Česká republika	1737
QCONTROL s.r.o., odštěpný závod - PRACOVIŠTĚ OLOMOUC	Lesní 693, Bílovice nad Svitavou, 66401, Česká republika	1737
QUALIFORM, a.s.	Mlaty 672/8, BRNO, 642 00, Česká republika	1008
SGS Colombia S.A.S	Carrera 51 No. 12B Sur - 33, Medellin (Colombia), 050023, Antioquia	-
SQZ, s.r.o. - Ústřední laboratoř Olomouc	U místní dráhy 939/5, Olomouc, 77900, Česká republika	-
SQZ, s.r.o. - Ústřední laboratoř Praha - pracoviště Rohanský ostrov	U místní dráhy 939/5, Olomouc, 77900, Česká republika	1135.1
Skanska a.s., divize Inženýrské stavitelství	Křižíkova 682/34a, Praha 8- Karlín, 186 00, Česká republika	1355
TESTSTAV, spol. s r.o.	Františka Lýska 1599/6, Ostrava - Bělský Les, 700 30, Česká republika	1290
Technický a zkušební ústav stavební Praha, s.p.	Prosecká 811/76a, Praha 9, 190 00, Česká republika	1018.3
University of Natural Resources and Life Sciences, Vienna	Peter-Jordan-Str. 82, Vienna, 1190, Austria	P0252
VIALAB CZ s.r.o. - CL01	U Michelského lesa 1581/2, Praha 4, 140 00, Česká republika	1112
VIALAB CZ s.r.o. - CL07	U Michelského lesa 1581/2, Praha 4, 140 00, Česká republika	1112
VIALAB CZ s.r.o. - CL12	U Michelského lesa 1581/2, Praha 4, 140 00, Česká republika	1112
VIALAB CZ, s.r.o. - Laboratoř Morava, LM 4 Ostrava	MUCODE 1593, PO Box 207, 160 41, Česká republika	1170
Vilnius Gediminas Technical University	Sauletekio av. 11, Vilnius, LT-10223, Lithuania	L.A. 086-01-5
Výzkumný ústav pozemních staveb - Certifikační společnost, s.r.o. - Pobočka Brno	Pražská 810/16, Praha 10, 10221, Česká republika	1234

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Laboratory	Address	Accreditation number
Výzkumný ústav pozemních staveb - Certifikační společnost, s.r.o. - Pobočka Praha-Uhříněves	Pražská 810/16, Praha 10, 10221, Česká republika	1234
Z7008	Veveří 95, Brno, 60200, Česká republika	Z7008
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2018/K
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft. - Debrecen	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2018/K
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft. - Győr	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2018/K
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft. - Szentendre	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2018/K
Ústav stavebního zkušebnictví s.r.o.	Jiřího Potůčka 115, Pardubice, 53009, Česká republika	1115
Ředitelství silnic a dálnic ČR	Rebešovická 40, Brno-Chrlice, 643 00, Česká republika	1072
ГЛАВБОЛГАРСТРОЙ АД /GLAVBOLGARSTROY AD/	region Vitosha, 3-5 Dmyanitsa Str., Sofia, 1619, Bulgaria	-

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 Strenght and Elasticity of Hardened Concrete (PT Program) organized by the PT Provider at the SZK FAST. 50 participants (laboratories) took part in the PT Program. The program focused on ordinary standardized testing of hardened concrete with emphasis on its strength and elasticity. 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	4	5	6	7	8	9	10
d3790c	✓	-	-	-	-	-	-	-	-	-
85dca9	✓	✓	-	✓	-	-	-	-	✓	✓
b116cc	-	-	✓	-	✓	-	-	✓	-	-
78ecc0	✓	-	-	✓	-	-	-	-	-	✓
010369	✓	-	-	✓	-	-	-	-	✓	-
da779f	✓	✓	-	✓	✓	-	-	-	-	-
b24024	✓	-	-	✓	-	-	-	-	-	-
6056c9	-	-	-	-	-	-	-	-	✓	-
fbf223	-	-	-	-	-	-	-	-	-	✓
a8eab4	✓	-	-	-	-	-	-	-	-	-
9ad08a	✓	-	-	-	-	-	-	-	-	-
d2a76e	✓	-	-	✓	X	-	-	-	✓	✓
92b8be	✓	-	-	✓	-	-	-	-	-	-
7a10f6	-	-	-	-	-	-	-	-	✓	✓
91e89f	-	-	-	-	-	-	-	-	✓	✓
8e9c95	✓	✓	✓	✓	✓	-	-	✓	✓	✓
44d3a3	✓	-	-	-	-	-	-	-	-	-
6725e5	✓	-	-	-	-	-	-	✓	✓	-
9a306f	-	-	-	-	-	-	-	-	✓	-
a2d4c1	-	✓	-	-	-	-	-	-	-	-
5d46aa	✓	✓	✓	✓	-	-	-	-	-	-
e679b2	-	-	-	-	-	-	-	✓	-	-
8fe1e3	✓	-	-	-	-	-	-	-	-	-
200b13	✓	-	-	✓	-	-	-	-	✓	-
fb45d2	✓	✓	-	X	-	-	-	-	-	-
8bd06b	✓	-	-	✓	-	-	-	-	-	-
0c0c26	✓	✓	-	-	✓	-	-	-	✓	-
105a8a	-	-	✓	-	-	-	-	-	-	✓

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ID / Method	1	2	3	4	5	6	7	8	9	10
855dc5	?	?	-	X	-	-	-	-	-	-
9a863a	-	✓	✓	-	-	-	-	-	-	-
4d7195	-	✓	✓	-	-	-	-	-	-	-
23c817	✓	✓	✓	✓	-	-	-	-	-	-
5b34fc	✓	-	-	-	-	-	-	-	-	-
b94a23	✓	-	?	✓	-	-	-	-	-	-
b81e93	✓	✓	-	-	-	-	-	-	-	✓
060c5b	✓	-	-	✓	-	-	-	-	✓	-
f60587	-	-	-	-	-	-	-	-	✓	✓
67aadb	✓	-	-	✓	✓	-	-	-	-	-
f1d2af	✓	✓	-	✓	-	-	-	-	-	-
1631d2	-	✓	?	✓	-	-	-	-	-	-
1152e1	✓	-	-	✓	-	-	-	-	-	-
4a9e22	-	✓	-	✓	-	-	-	-	✓	✓
4d7d48	✓	?	-	✓	-	-	-	-	✓	-
d97a4f	✓	✓	✓	✓	-	-	-	-	✓	-
344791	✓	-	-	✓	-	-	-	-	-	-
2ad9e0	✓	✓	✓	✓	-	-	-	-	✓	✓
ec96b5	✓	✓	✓	✓	-	-	-	-	✓	✓
eaa338	✓	-	-	✓	-	-	-	-	-	-
c313e3	✓	-	✓	-	-	-	-	-	✓	-
80b88f	?	-	-	✓	-	-	-	-	-	-

References

[1] EN 12390-3. *Testing hardened concrete - Part 3: Compressive strength of test specimens*. 2020.

[2] EN 12390-5. *Testing hardened concrete - Part 5: Flexural strength of test specimens*. 2020.

[3] EN 12390-6. *Testing hardened concrete - Part 6: Tensile splitting strength of test specimens*. 2010.

[4] EN 12390-7. *Testing hardened concrete - Part 7: Density of hardened concrete*. 2020.

[5] ISO 1920-10. *Testing of concrete - Part 10: Determination of static modulus of elasticity in compression*. 2016.

[6] EN 12390-13. *Testing hardened concrete - Part 13: Determination of secant modulus of elasticity in compression*. 2014.

[7] EN 12504-4. *Testing concrete - Part 4: Determination of ultrasonic pulse velocity*. 2005.

[8] ČSN 731371. *Non-destructive testing of concrete - Method of ultrasonic pulse testing of concrete*. 2011.

[9] ČSN 731373. *Non-destructive testing of concrete - Determination of compressive strength by hardness testing methods*. 2011.

[10] EN 12504-2. *Testing concrete in structures - Part 2: Non-destructive testing - Determination of rebound number*. 2013.

[11] EN 1542. *Products and systems for the protection and repair of concrete structures - Test methods - Measurement of bond strength by pull-off*. 2000.

[12] ČSN 736242. *Design and construction of pavements on road bridges*. 2010.

[13] EN 206:2013+A2:2021. *Concrete - Specification, performance, production and conformity*. 2021.

[14] 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.

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

1 Appendix – EN 12390-3 – Compressive strength of test specimens

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 [%]
855dc5	40.0	41.1	41.2	4.0	40.7	0.65	1.6
80b88f	41.5	40.2	42.4	-	41.4	1.11	2.67
92b8be	44.4	42.7	46.1	3.1	44.4	1.7	3.83
1152e1	46.5	40.2	46.8	5.6	44.5	3.73	8.38
c313e3	46.9	45.2	41.8	0.6	44.6	2.6	5.82
6725e5	44.9	45.5	43.9	1.8	44.8	0.81	1.81
200b13	44.4	44.5	45.8	-	44.9	0.78	1.74
67aadb	43.2	47.4	45.2	0.2	45.3	2.1	4.64
5b34fc	46.2	44.6	45.0	0.9	45.3	0.83	1.83
344791	44.1	46.5	45.7	2.5	45.4	1.22	2.69
5d46aa	46.0	45.0	46.4	3.0	45.8	0.72	1.57
f1d2af	45.5	45.5	46.7	2.8	45.9	0.69	1.51
b94a23	46.5	46.3	45.0	1.8	45.9	0.81	1.77
2ad9e0	46.0	46.3	46.2	-	46.2	0.15	0.33
d97a4f	46.7	46.1	46.7	1.5	46.5	0.35	0.74
d3790c	46.5	44.4	48.8	1.2	46.6	2.2	4.73
85dca9	45.9	46.7	47.4	-	46.7	0.75	1.61
9ad08a	46.0	47.3	47.1	2.0	46.8	0.7	1.5
0c0c26	47.3	46.7	46.5	1.8	46.8	0.42	0.89
010369	45.2	48.7	46.6	1.9	46.8	1.76	3.76
eaa338	46.9	47.0	48.1	2.1	47.3	0.67	1.41
d2a76e	47.2	47.7	47.5	3.3	47.5	0.25	0.53
8e9c95	47.2	49.6	47.4	1.2	48.1	1.33	2.77
44d3a3	49.2	48.5	47.1	-	48.3	1.07	2.22
4d7d48	47.2	49.6	48.1	1.8	48.3	1.21	2.51
b81e93	47.9	48.0	49.7	2.5	48.5	1.01	2.08
fb45d2	50.1	47.3	49.0	9.3	48.8	1.41	2.89
ec96b5	49.6	47.9	49.8	2.7	49.1	1.04	2.13
da779f	48.5	50.1	49.3	2.2	49.3	0.8	1.62
78ecc0	50.4	49.8	47.9	1.0	49.4	1.31	2.64
8bd06b	49.9	49.5	50.0	0.5	49.8	0.26	0.53
23c817	48.7	52.5	51.9	1.2	51.0	2.04	4.0
b24024	50.3	52.6	51.4	-	51.4	1.15	2.24
8fe1e3	52.4	50.2	51.9	0.2	51.5	1.16	2.25
060c5b	52.9	50.7	51.6	1.3	51.7	1.11	2.14
a8eab4	53.3	52.8	50.9	0.5	52.3	1.27	2.42

1.2 The Numerical Procedure for Determining Outliers

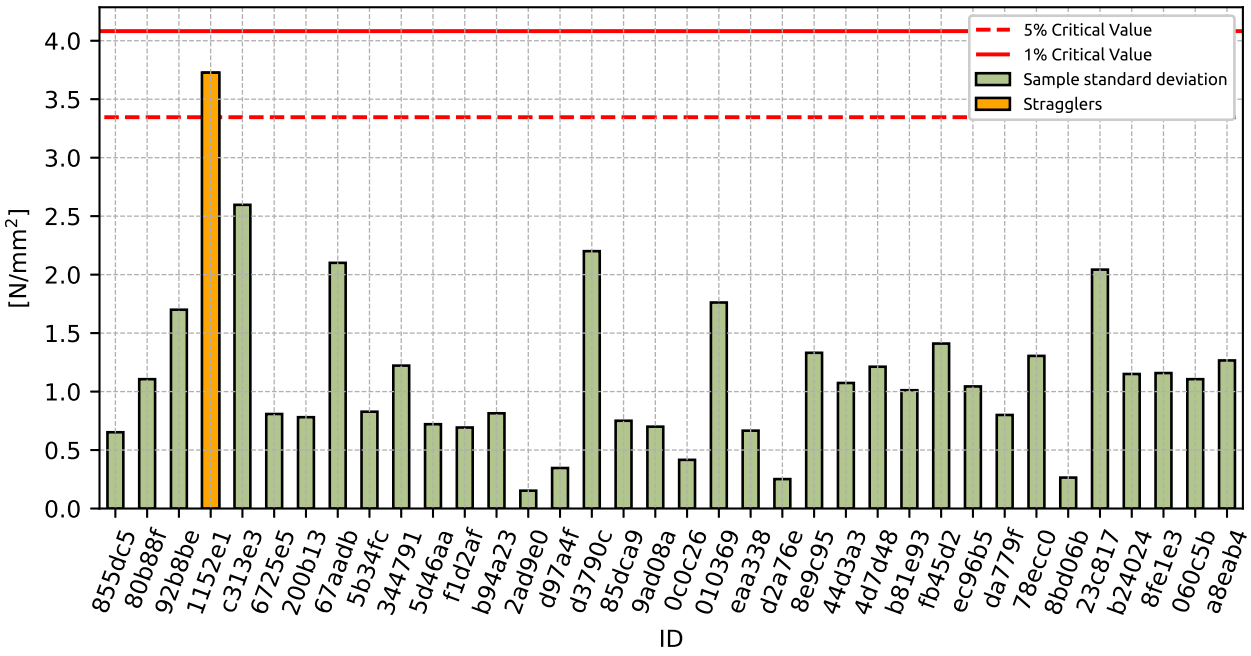

Figure 1: **Cochran's test** - sample standard deviations

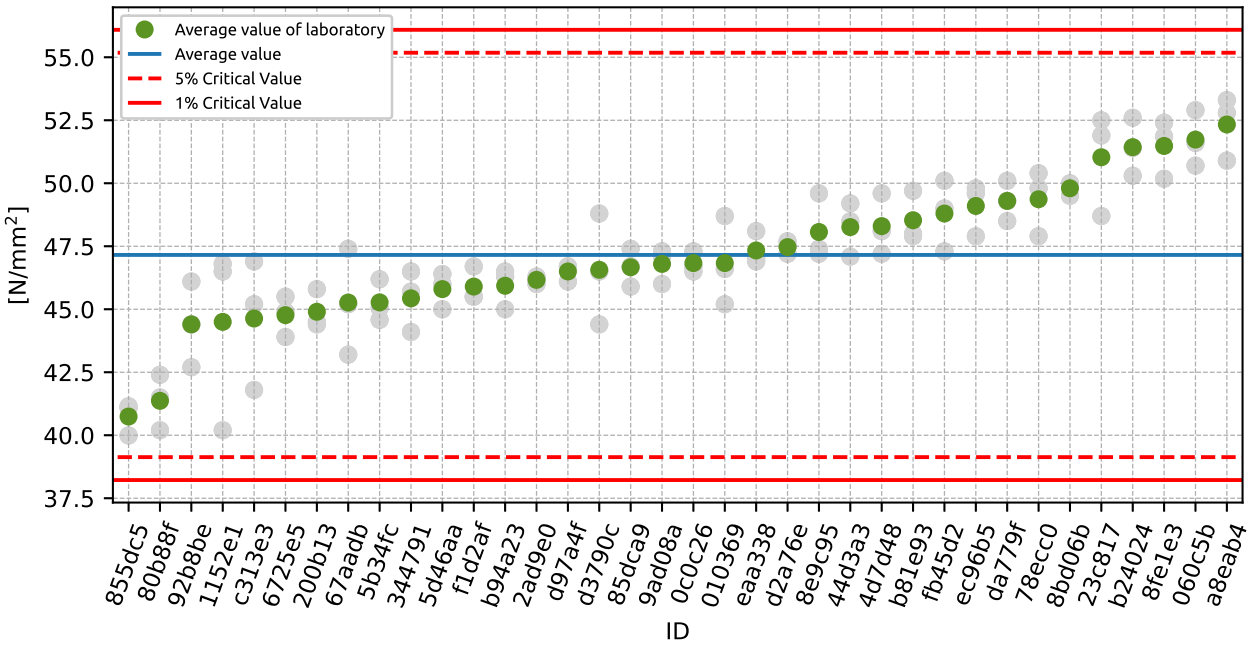

Figure 2: **Grubbs' test** - average values

1.3 Mandel's Statistics

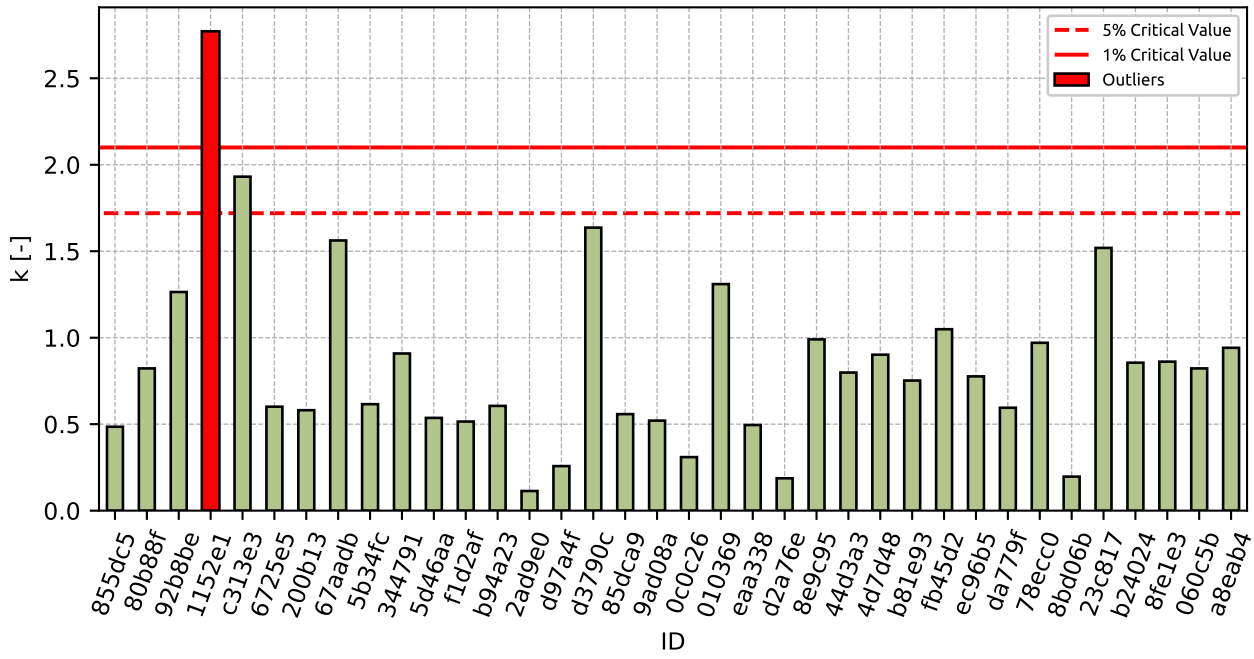

Figure 3: Intralaboratory Consistency Statistic

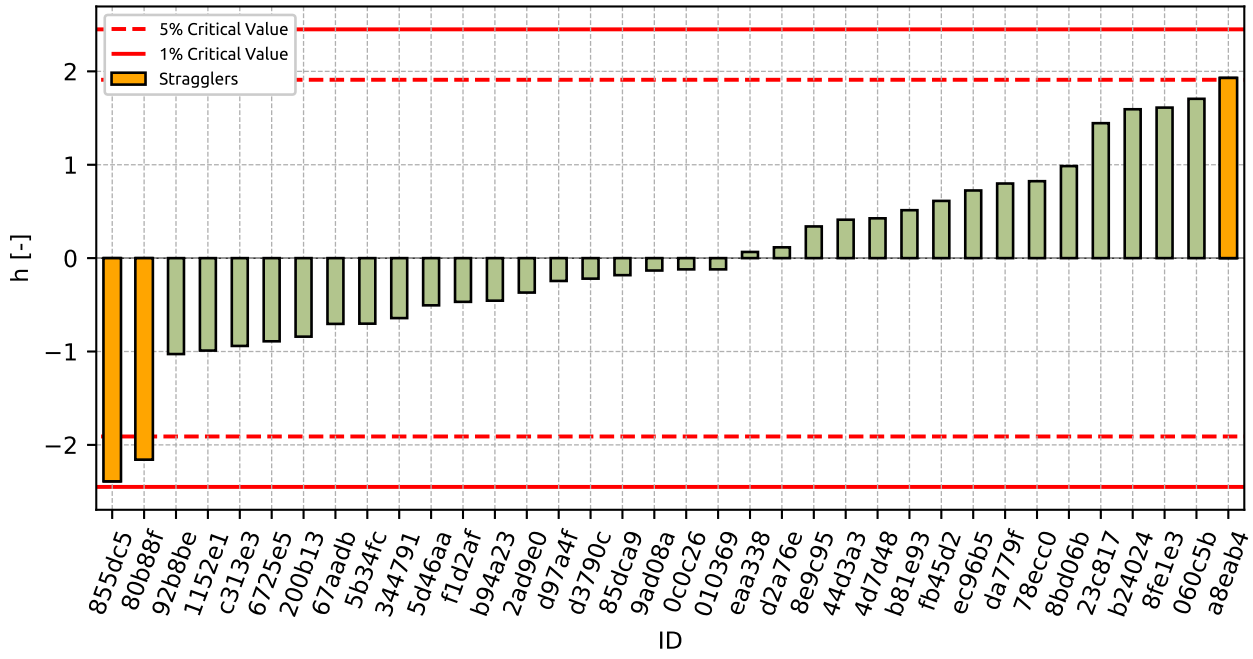

Figure 4: Interlaboratory Consistency Statistic

1.4 Descriptive statistics

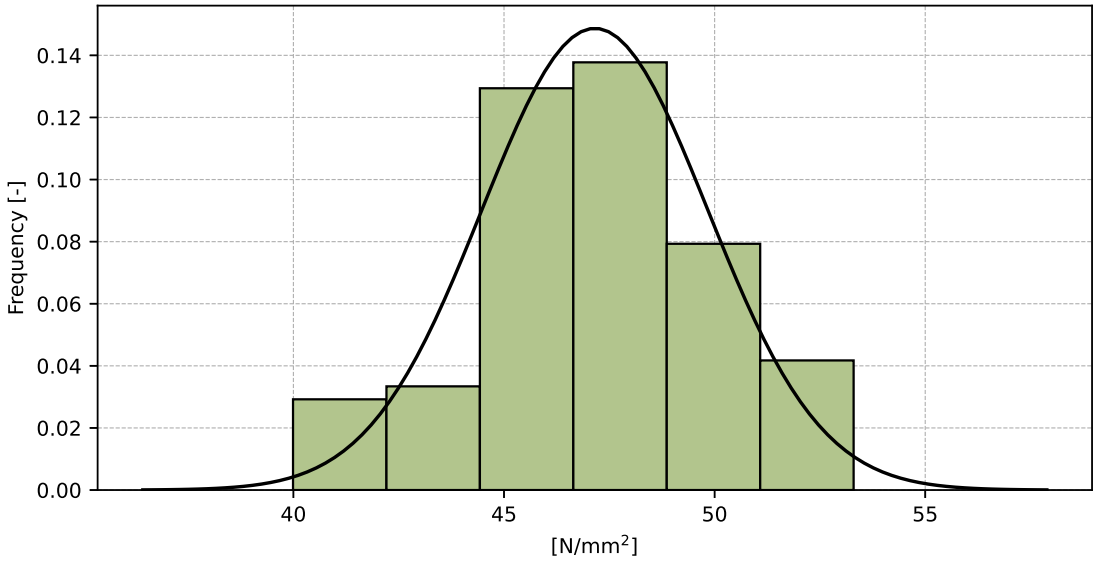

Figure 5: Histogram of all test results

Table 5: Descriptive statistics

Characteristics	**[N/mm²]**
Average value – $\bar{x}$	47.2
Sample standard deviation – s	2.68
Asigned value – x^*	47.2
Robust standard deviation – s^*	2.68
Measurement uncertainty of asigned value – u_X	0.45
p-value of normality test	0.069 [-]
Interlaboratory standard deviation – s_L	2.57
Repeatability standard deviation – s_r	1.34
Reproducibility standard deviation – s_R	2.9
Repeatability – r	3.8
Reproducibility – R	8.1

1.5 Evaluation of Performance Statistics

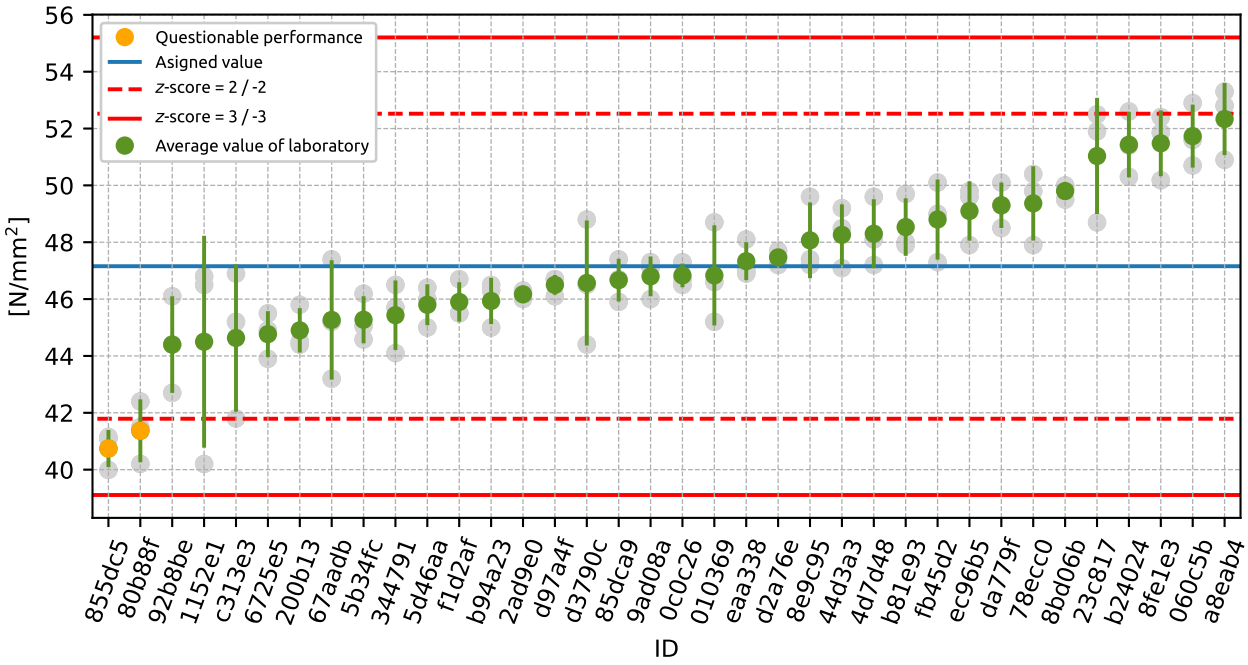

Figure 6: Average values and sample standard deviations

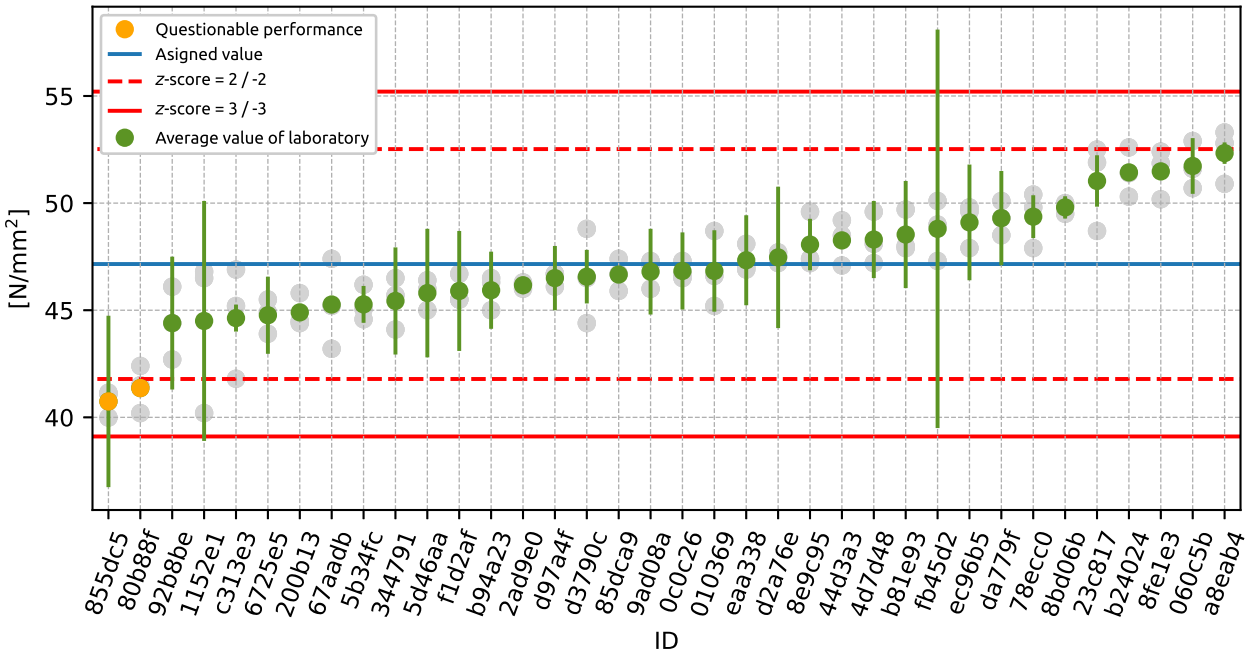

Figure 7: Average values and extended uncertainties of measurement

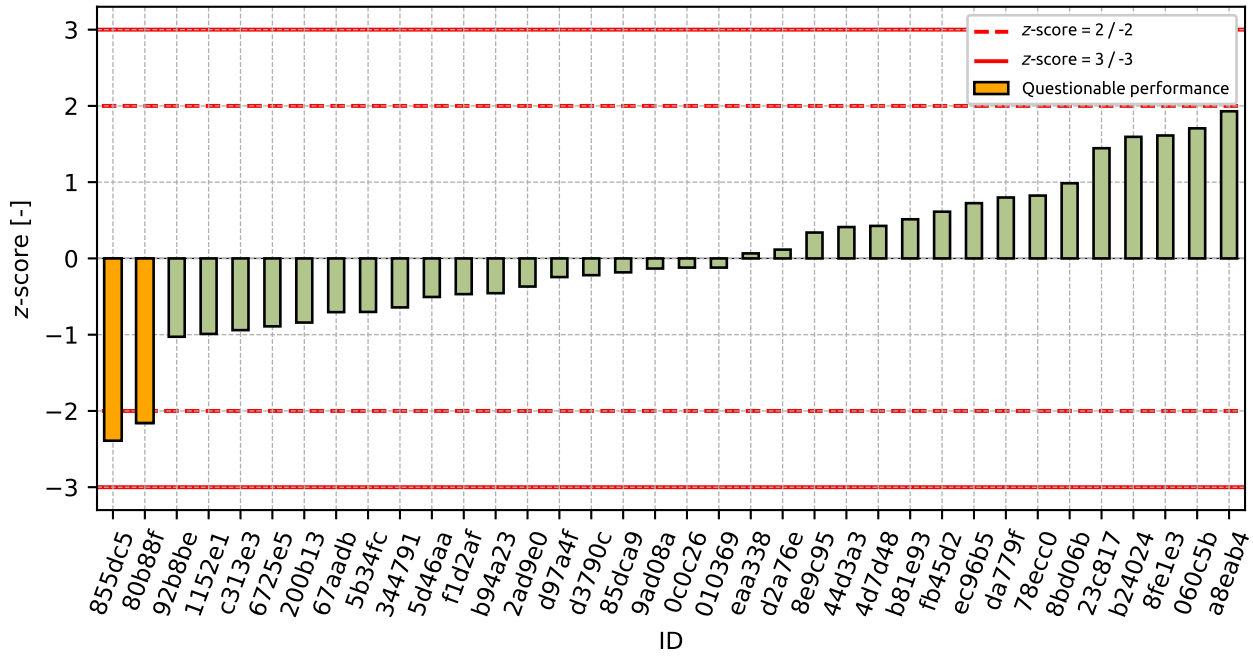

Figure 8: z-score

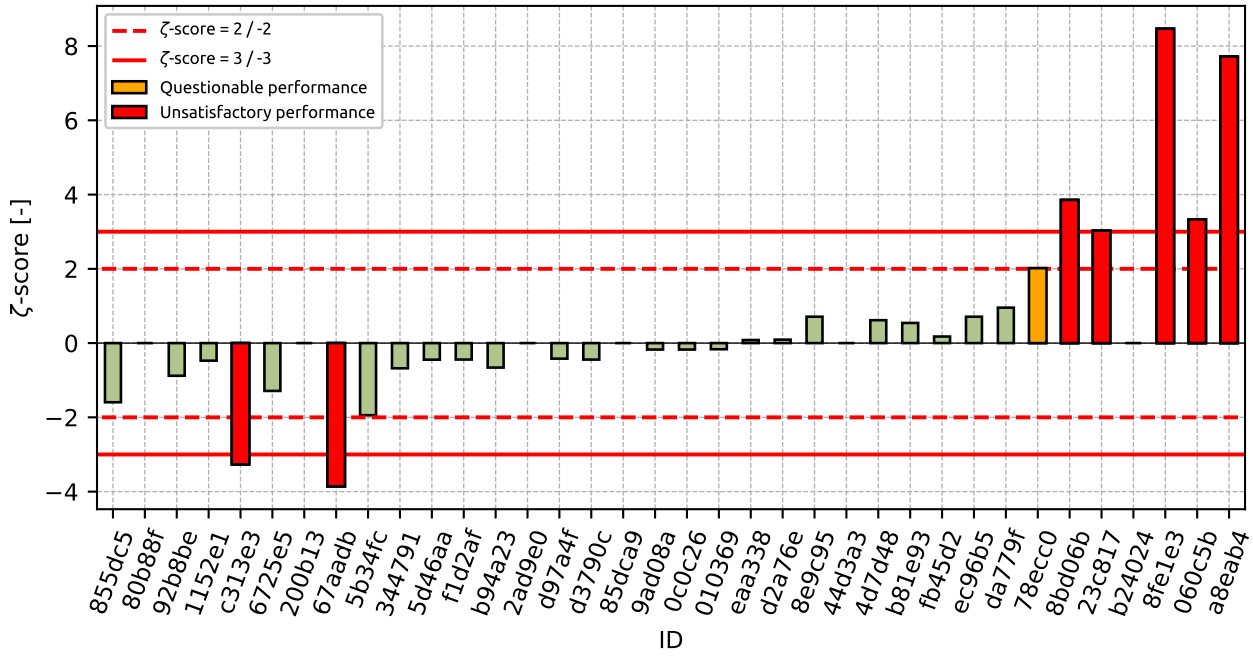

Figure 9: ζ-score

Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
855dc5	-2.39	-1.59
80b88f	-2.16	-
92b8be	-1.03	-0.88
1152e1	-0.99	-0.47
c313e3	-0.94	-3.27
6725e5	-0.89	-1.29
200b13	-0.84	-
67aadb	-0.7	-3.86
5b34fc	-0.7	-1.94
344791	-0.64	-0.68
5d46aa	-0.51	-0.45
f1d2af	-0.47	-0.44
b94a23	-0.46	-0.66
2ad9e0	-0.37	-
d97a4f	-0.24	-0.42
d3790c	-0.22	-0.44
85dca9	-0.18	-
9ad08a	-0.13	-0.17
0c0c26	-0.12	-0.17
010369	-0.12	-0.17
eaa338	0.07	0.08
d2a76e	0.12	0.09
8e9c95	0.34	0.71
44d3a3	0.41	-
4d7d48	0.43	0.62
b81e93	0.51	0.54
fb45d2	0.61	0.18
ec96b5	0.72	0.71
da779f	0.8	0.95
78ecc0	0.82	2.02
8bd06b	0.99	3.86
23c817	1.45	3.03
b24024	1.59	-
8fe1e3	1.61	8.47
060c5b	1.71	3.33
a8eab4	1.93	7.72

2 Appendix – EN 12390-5 – Flexural strength of test specimens

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 [%]
855dc5	5.3	5.0	4.7	0.5	5.0	0.3	5.99
5d46aa	5.4	5.6	5.4	0.3	5.5	0.12	2.11
1631d2	5.3	5.4	5.8	0.7	5.5	0.26	4.81
85dca9	6.2	5.3	5.3	-	5.6	0.52	9.28
8e9c95	5.1	6.3	5.8	0.5	5.7	0.6	10.51
a2d4c1	5.6	5.9	5.7	-	5.7	0.15	2.66
9a863a	5.3	6.2	5.7	0.9	5.7	0.45	7.86
fb45d2	5.8	5.8	5.8	0.2	5.8	0.0	0.0
0c0c26	5.8	5.7	6.1	0.4	5.9	0.21	3.55
f1d2af	5.8	5.8	6.3	0.3	6.0	0.28	4.72
d97a4f	5.6	6.5	5.9	1.2	6.0	0.46	7.64
b81e93	6.2	6.1	5.7	0.7	6.0	0.26	4.41
23c817	5.9	6.2	6.1	0.2	6.1	0.15	2.47
4d7195	6.0	5.9	6.5	0.8	6.1	0.32	5.24
ec96b5	6.0	6.1	6.4	0.4	6.2	0.21	3.38
da779f	5.9	7.1	6.0	0.2	6.4	0.64	10.08
4a9e22	6.6	6.6	6.0	0.9	6.4	0.35	5.41
2ad9e0	6.4	6.7	7.1	-	6.7	0.35	5.22
4d7d48	6.6	7.2	7.4	1.1	7.1	0.42	5.89

2.2 The Numerical Procedure for Determining Outliers

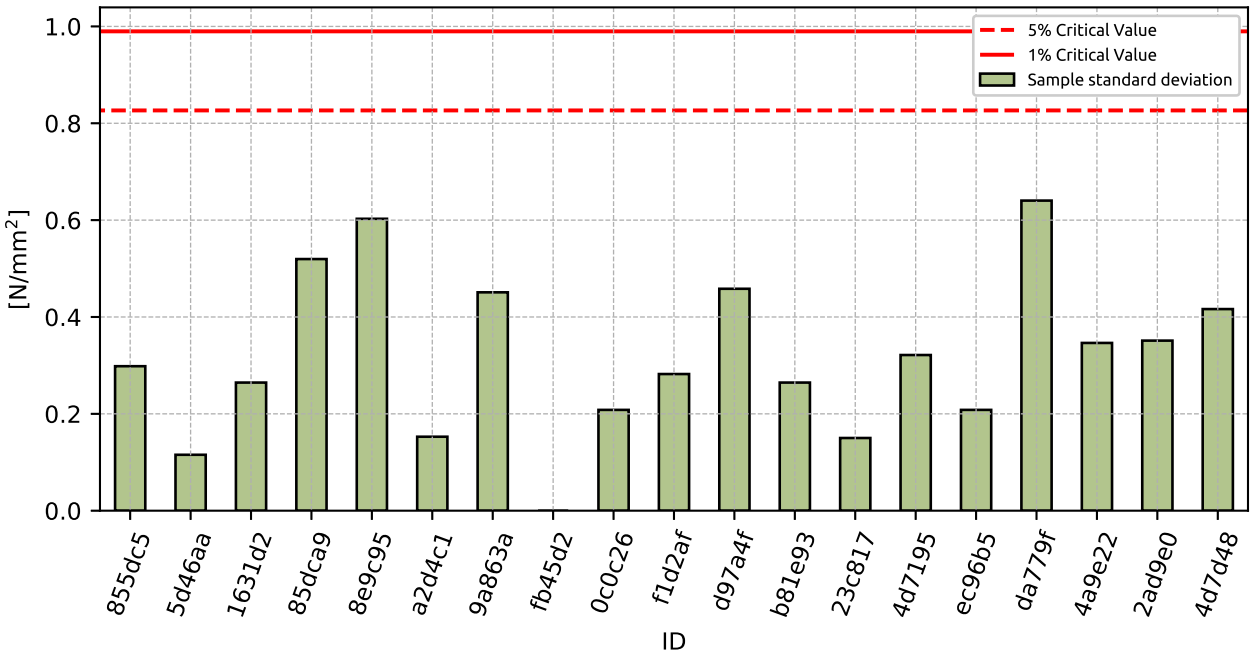

Figure 10: **Cochran's test** - sample standard deviations

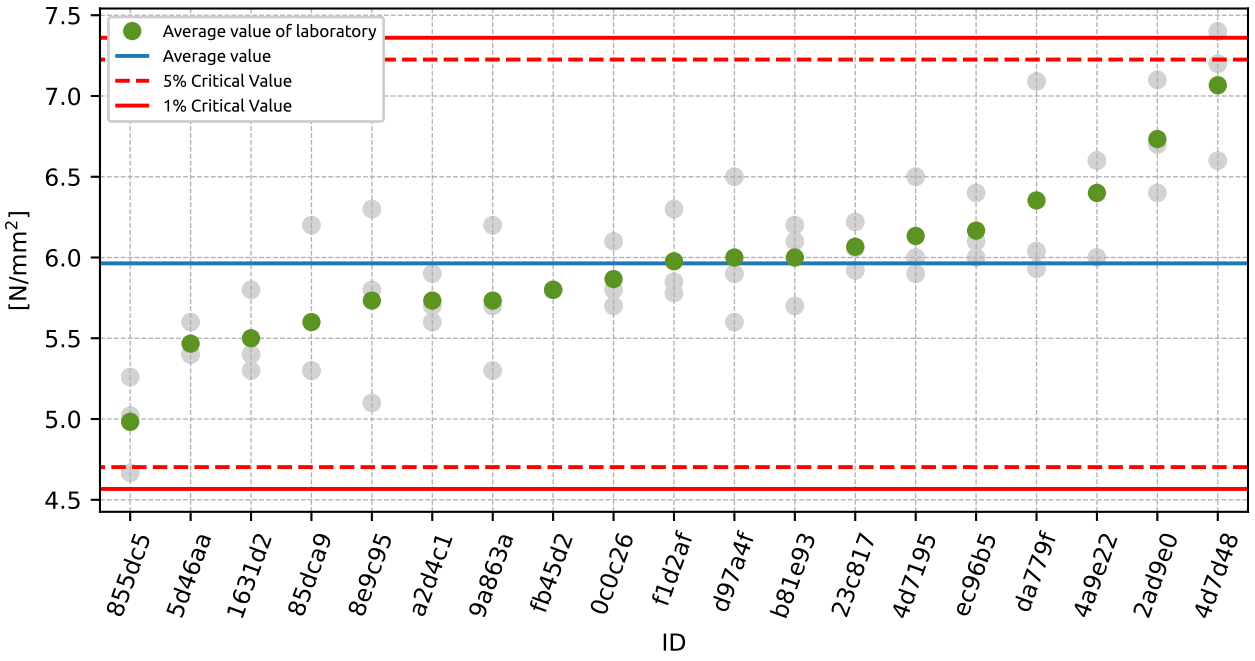

Figure 11: **Grubbs' test** - average values

2.3 Mandel's Statistics

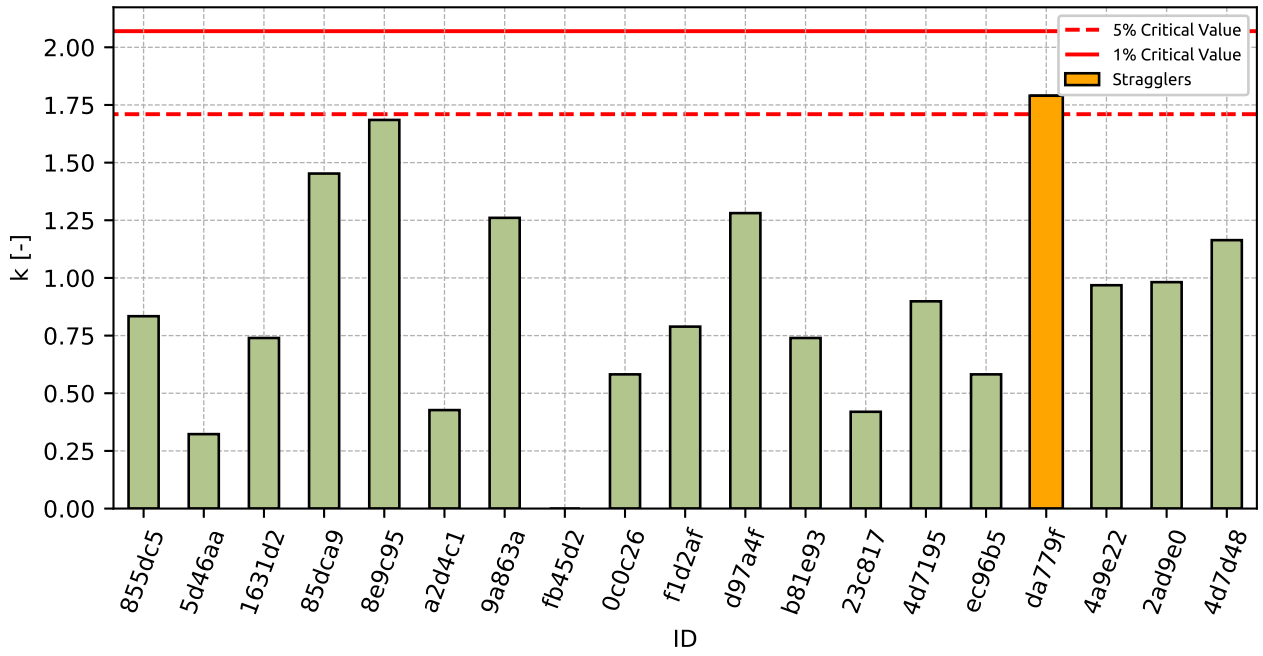

Figure 12: Intralaboratory Consistency Statistic

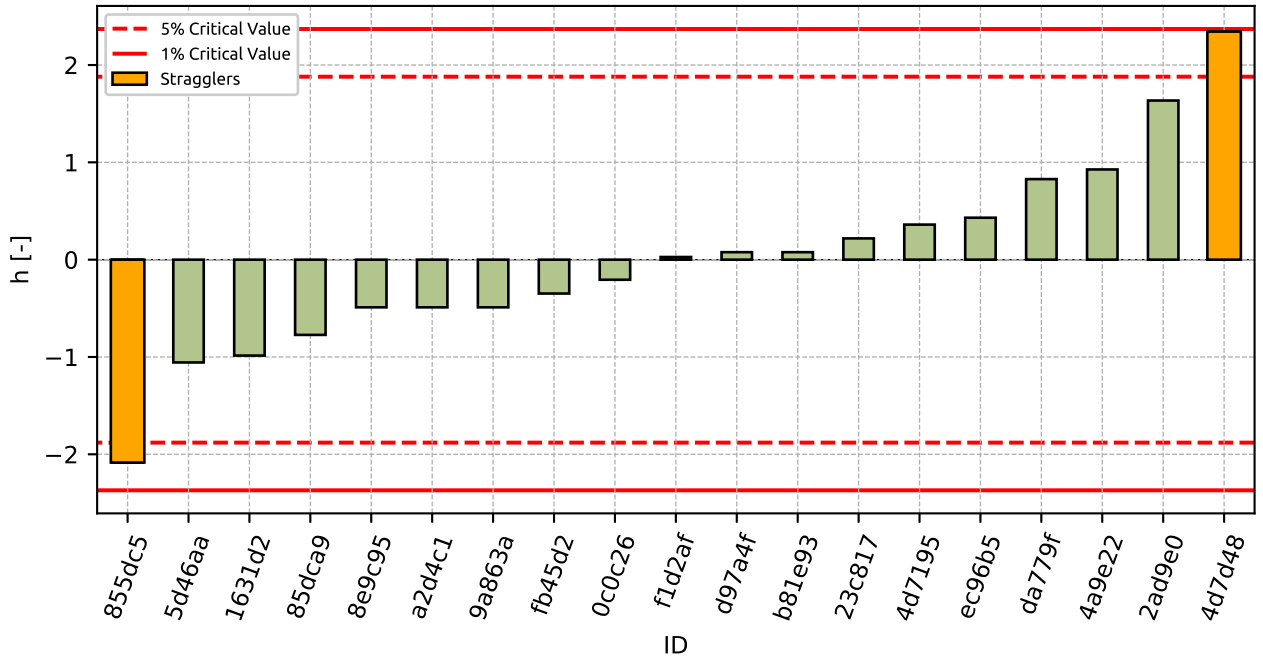

Figure 13: Interlaboratory Consistency Statistic

2.4 Descriptive statistics

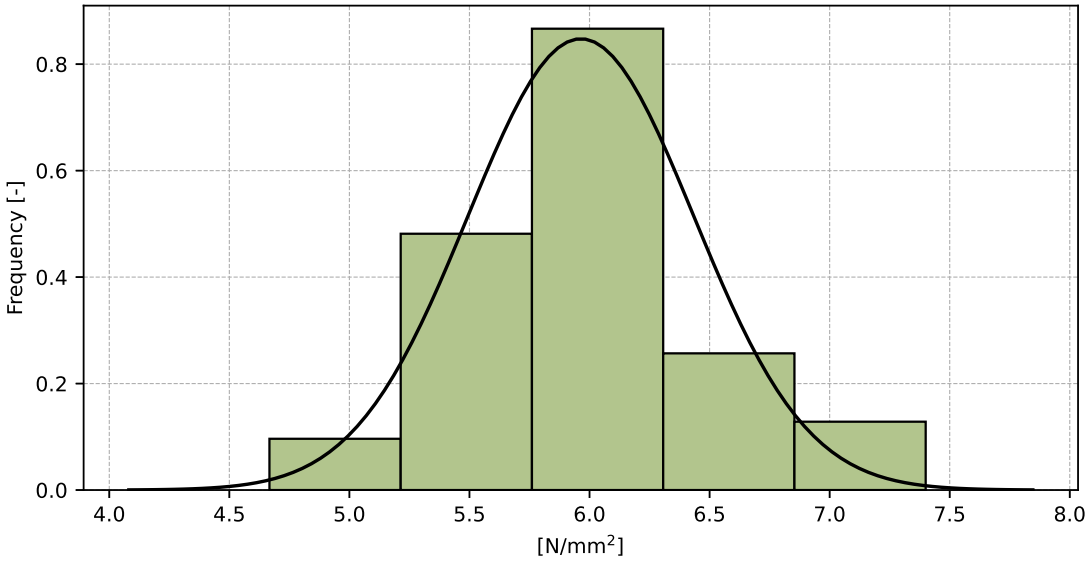

Figure 14: Histogram of all test results

Table 8: Descriptive statistics

Characteristics	**[N/mm²]**
Average value – $\bar{x}$	6.0
Sample standard deviation – s	0.47
Asigned value – x^*	6.0
Robust standard deviation – s^*	0.45
Measurement uncertainty of asigned value – u_X	0.13
p-value of normality test	0.364 [-]
Interlaboratory standard deviation – s_L	0.42
Repeatability standard deviation – s_r	0.36
Reproducibility standard deviation – s_R	0.55
Repeatability – r	1.0
Reproducibility – R	1.6

2.5 Evaluation of Performance Statistics

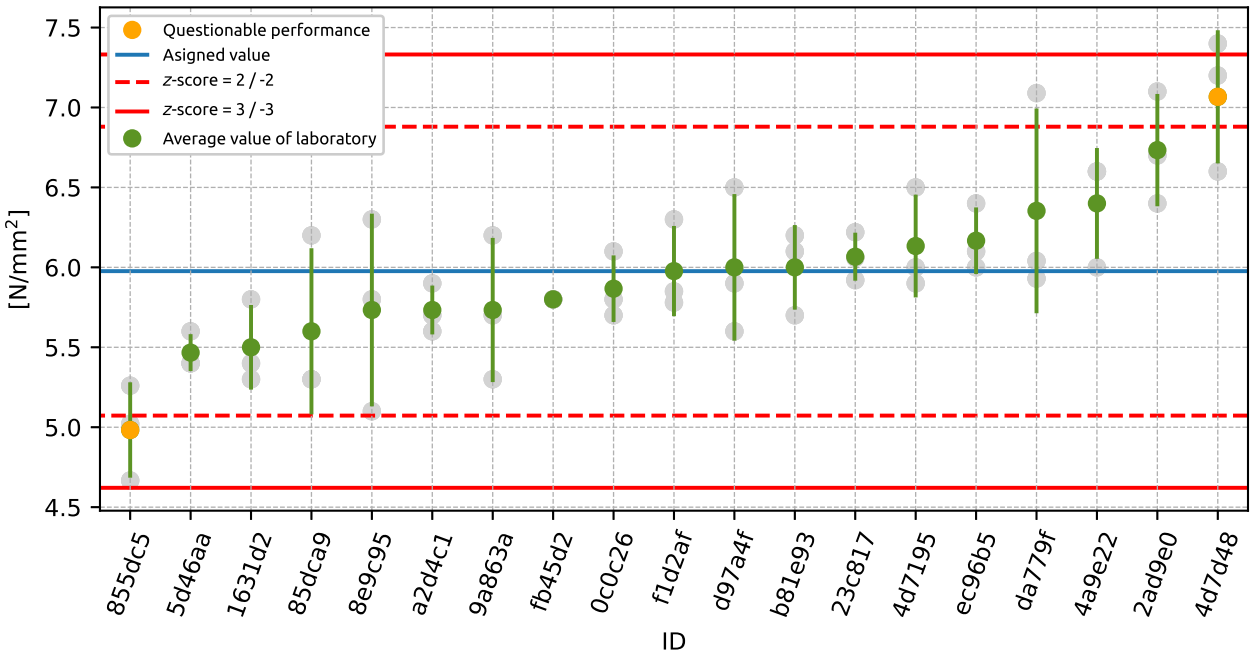

Figure 15: Average values and sample standard deviations

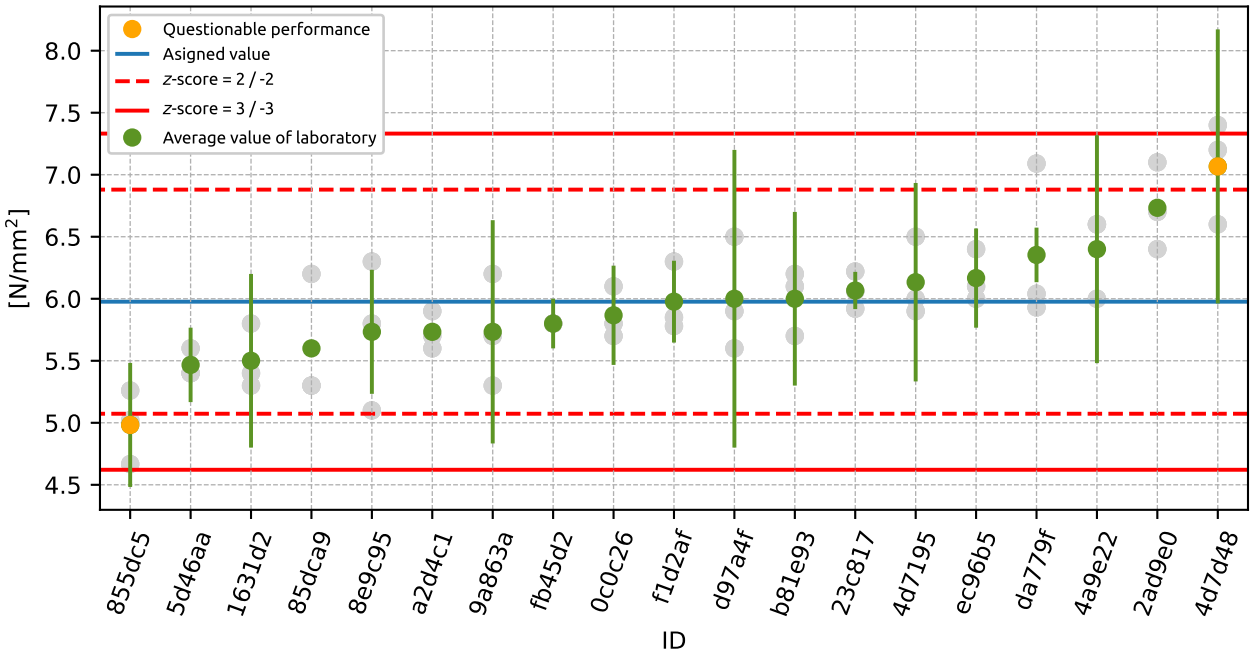

Figure 16: Average values and extended uncertainties of measurement

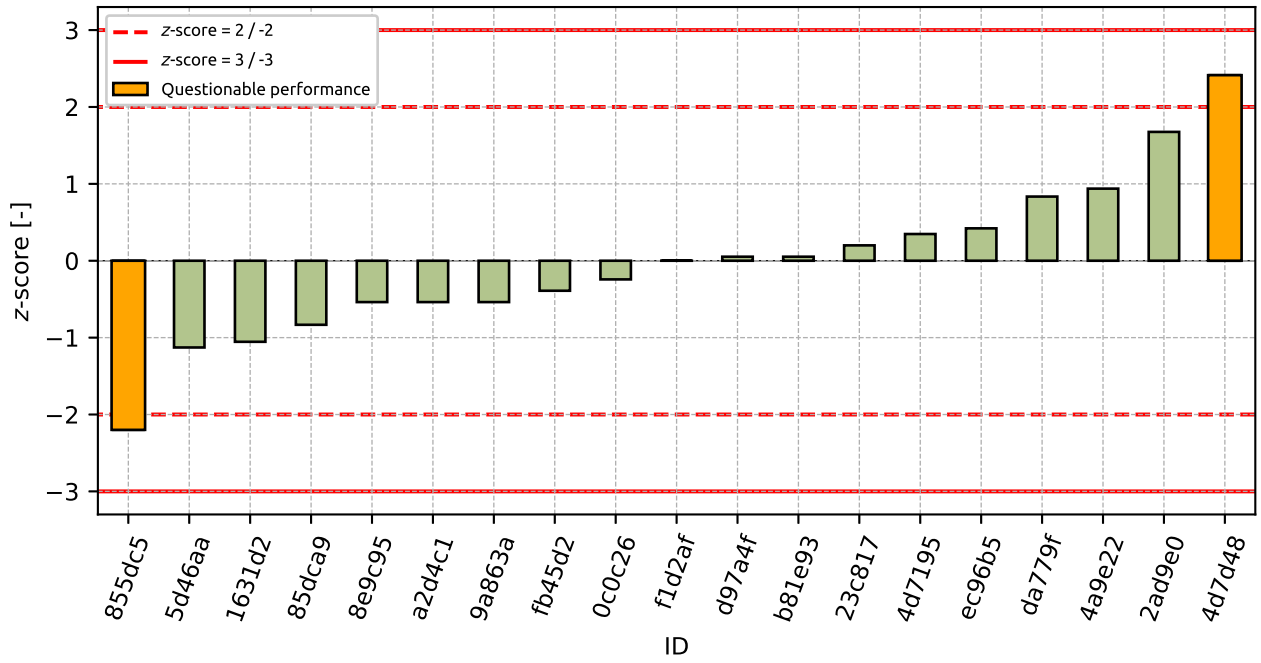

Figure 17: z-score

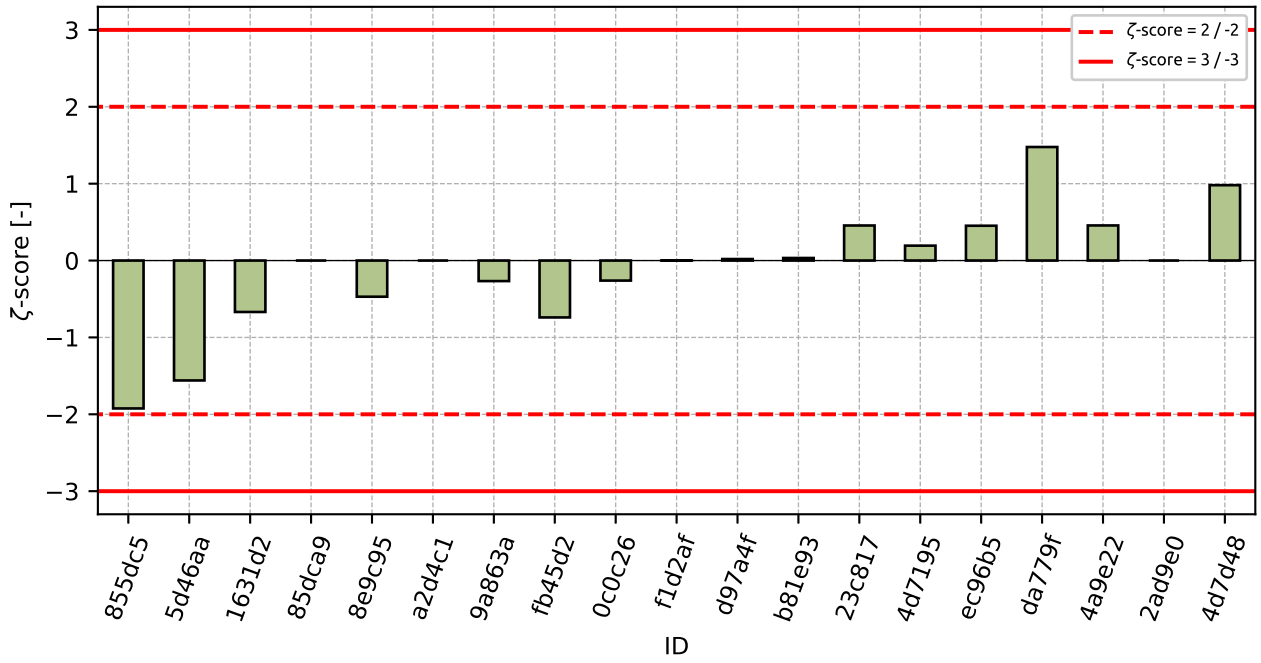

Figure 18: ζ-score

Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
855dc5	-2.2	-1.92
5d46aa	-1.13	-1.56
1631d2	-1.05	-0.67
85dca9	-0.83	-
8e9c95	-0.54	-0.47
a2d4c1	-0.54	-
9a863a	-0.54	-0.27
fb45d2	-0.39	-0.74
0c0c26	-0.24	-0.26
f1d2af	0.0	0.0
d97a4f	0.05	0.02
b81e93	0.05	0.03
23c817	0.2	0.46
4d7195	0.35	0.19
ec96b5	0.42	0.45
da779f	0.83	1.48
4a9e22	0.94	0.46
2ad9e0	1.68	-
4d7d48	2.41	0.98

3 Appendix – EN 12390-6 – Tensile splitting strength of test specimens

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/mm²]			u_X [N/mm²]	$\bar{x}$ [N/mm²]	s_0 [N/mm²]	V_X [%]
b94a23	2.21	2.72	3.21	1.0	2.71	0.5	18.43
105a8a	3.37	2.69	3.29	0.23	3.12	0.372	11.93
9a863a	3.55	3.05	3.05	0.3	3.22	0.289	8.97
ec96b5	3.8	3.4	2.75	0.2	3.32	0.53	15.98
c313e3	3.28	3.46	3.21	0.08	3.32	0.129	3.89
4d7195	3.35	3.4	3.25	0.2	3.33	0.076	2.29
23c817	3.3	3.25	3.45	0.1	3.33	0.104	3.12
2ad9e0	3.35	3.4	3.25	-	3.33	0.076	2.29
8e9c95	3.35	3.55	3.4	0.15	3.43	0.104	3.03
5d46aa	3.5	3.3	3.5	0.2	3.43	0.115	3.36
b116cc	3.5	3.5	3.4	0.8	3.47	0.058	1.67
d97a4f	3.5	3.6	3.55	0.3	3.55	0.05	1.41
1631d2	3.85	4.1	3.85	0.39	3.93	0.144	3.67

3.2 The Numerical Procedure for Determining Outliers

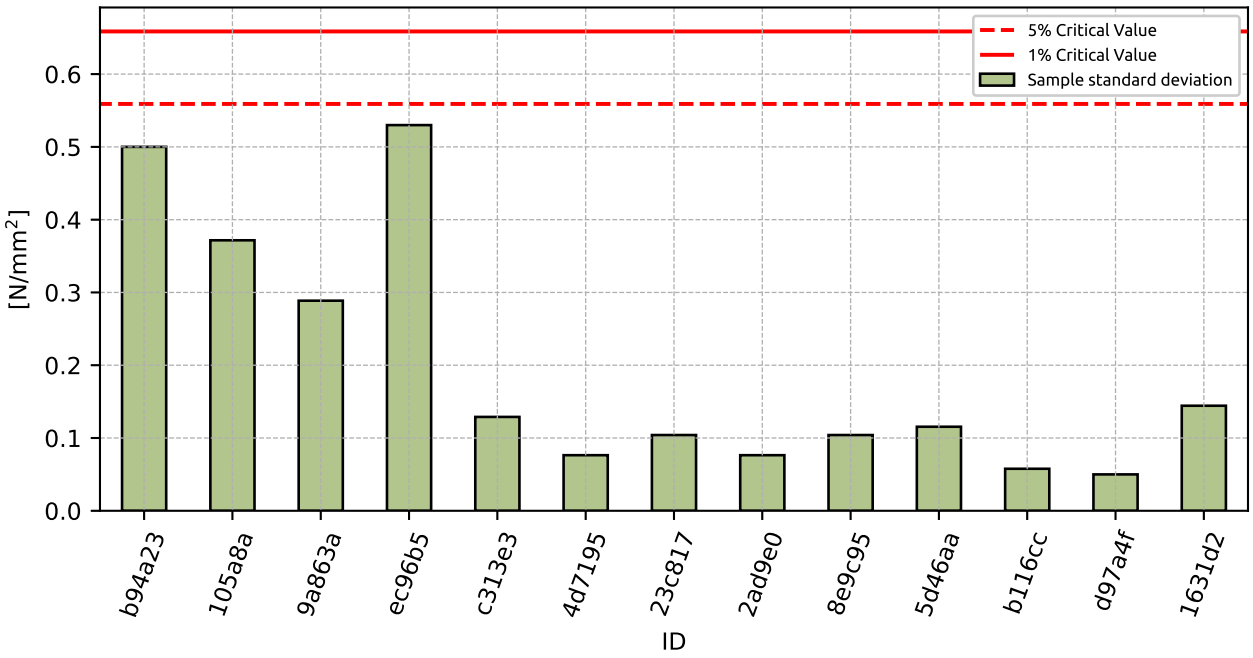

Figure 19: **Cochran's test** - sample standard deviations

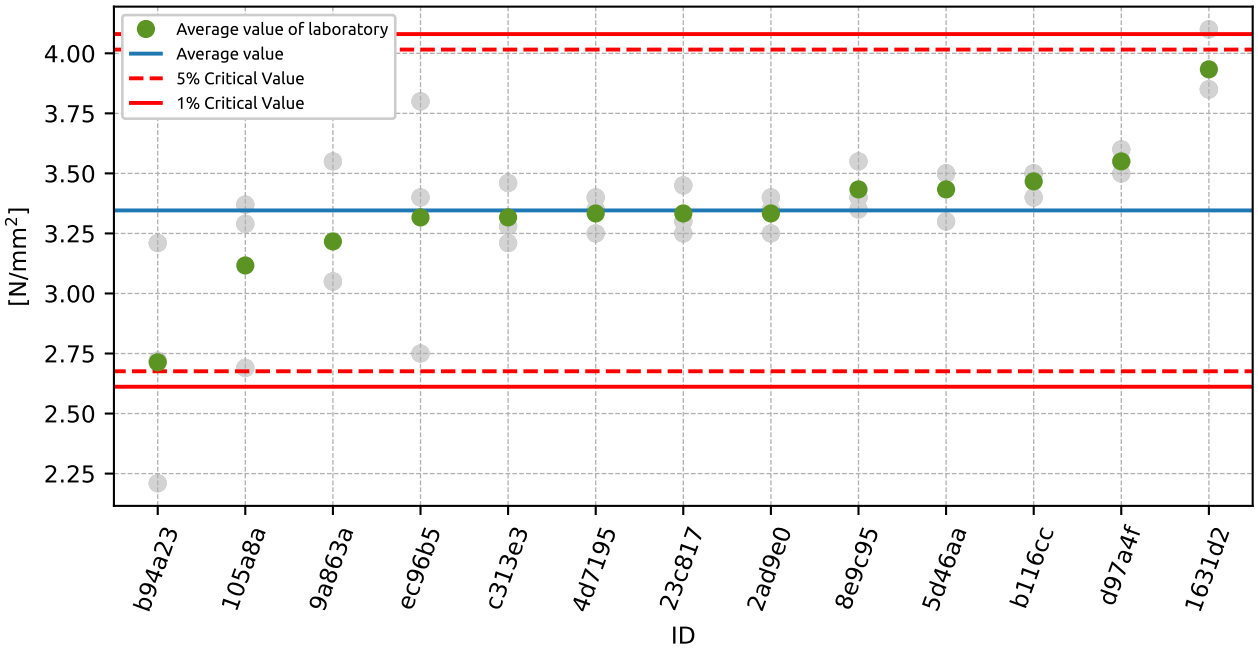

Figure 20: **Grubbs' test** - average values

3.3 Mandel's Statistics

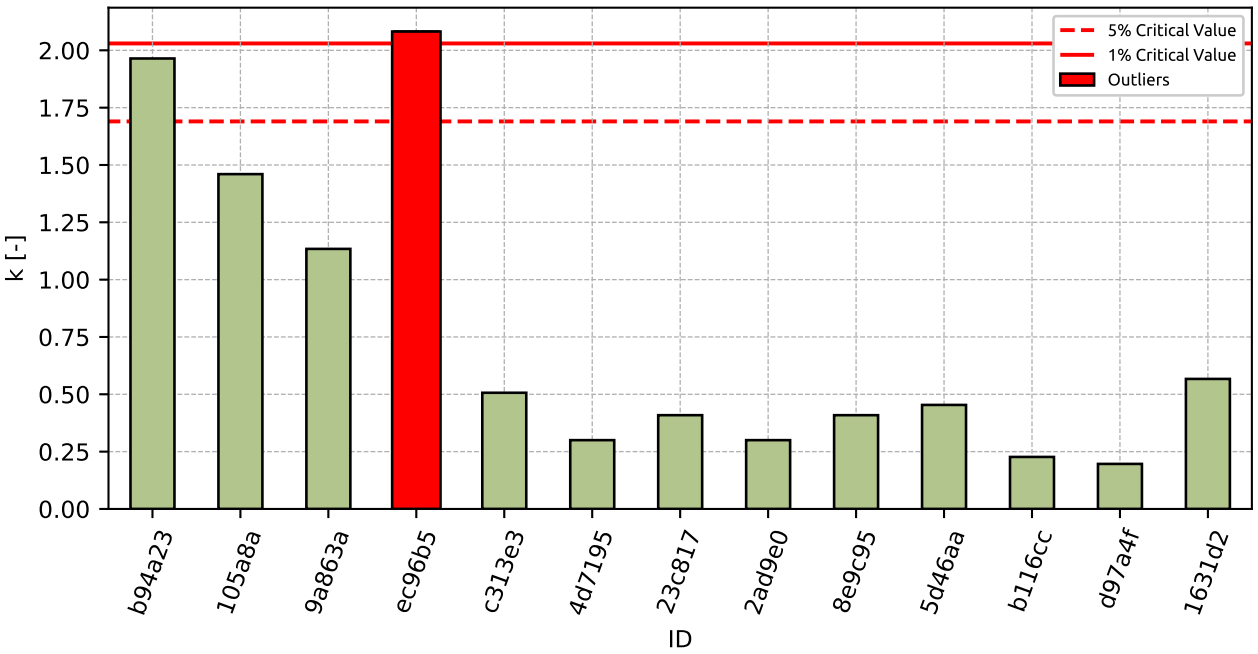

Figure 21: Intralaboratory Consistency Statistic

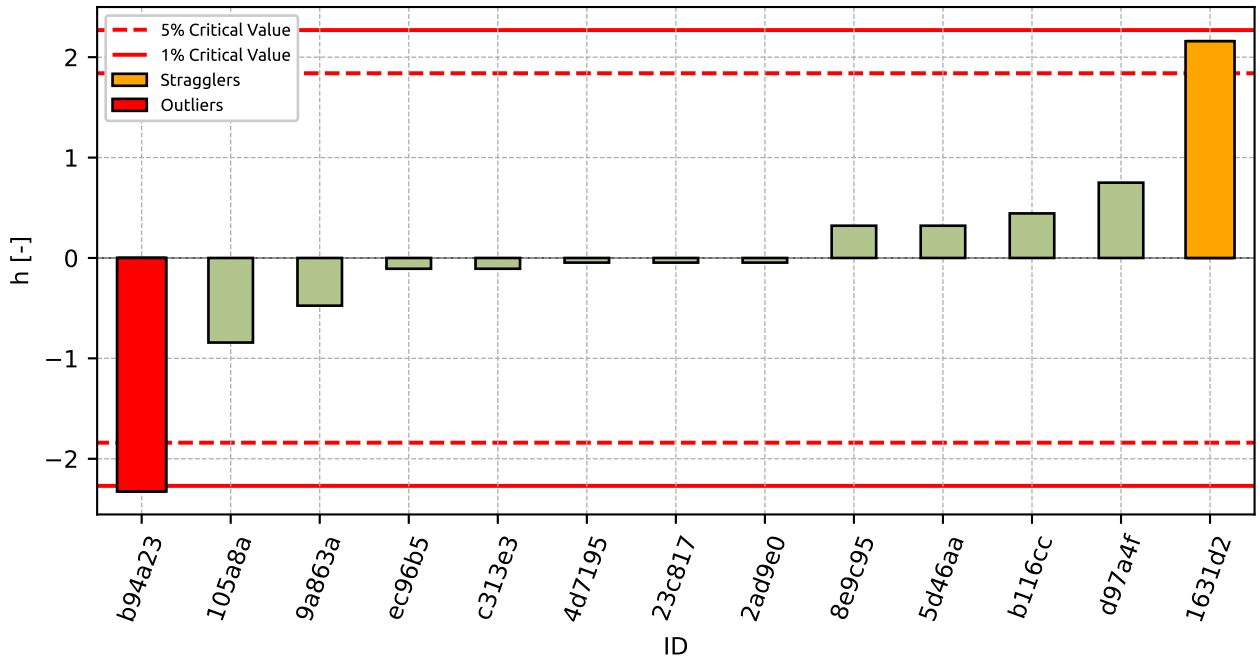

Figure 22: Interlaboratory Consistency Statistic

3.4 Descriptive statistics

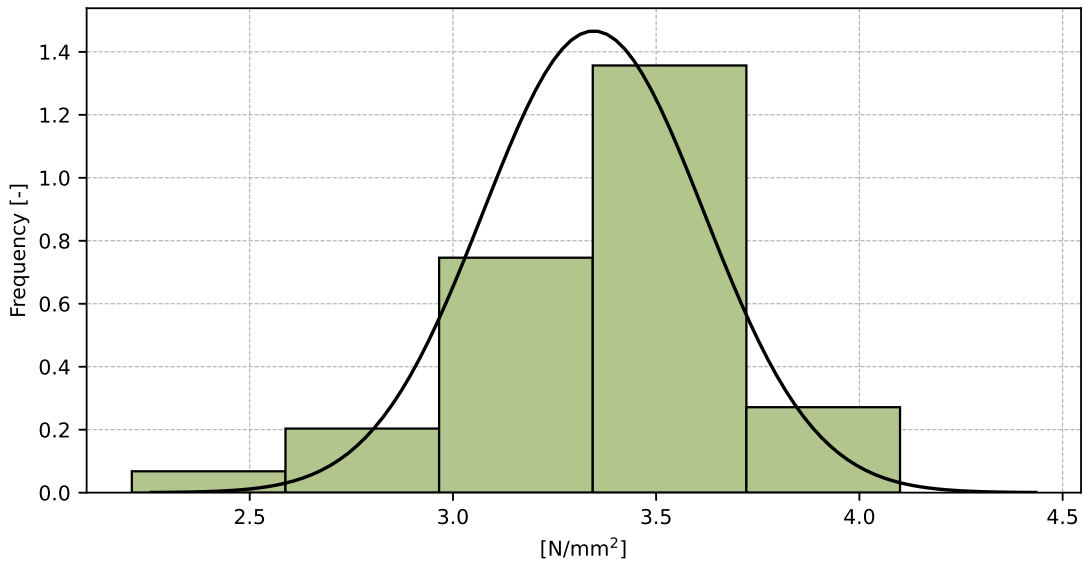

Figure 23: Histogram of all test results

Table 11: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	3.35
Sample standard deviation – s	0.272
Asigned value – x^*	3.38
Robust standard deviation – s^*	0.229
Measurement uncertainty of asigned value – u_X	0.079
p-value of normality test	0.002 [-]
Interlaboratory standard deviation – s_L	0.229
Repeatability standard deviation – s_r	0.255
Reproducibility standard deviation – s_R	0.342
Repeatability – r	0.71
Reproducibility – R	0.96

3.5 Evaluation of Performance Statistics

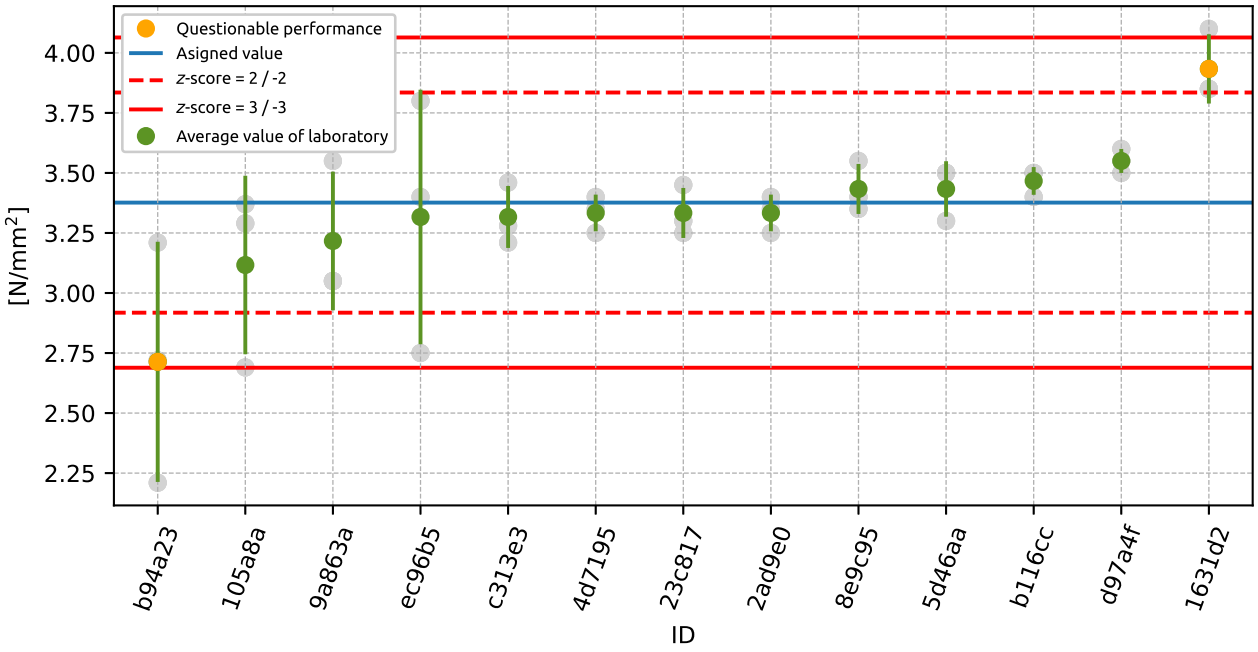

Figure 24: Average values and sample standard deviations

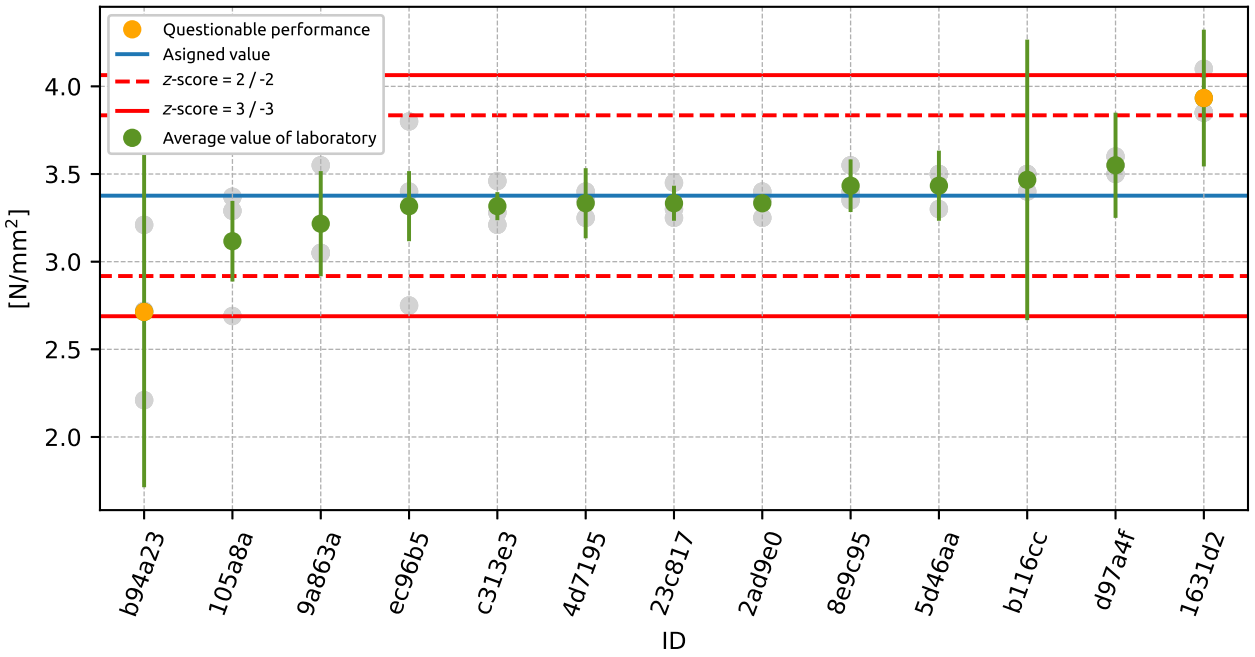

Figure 25: Average values and extended uncertainties of measurement

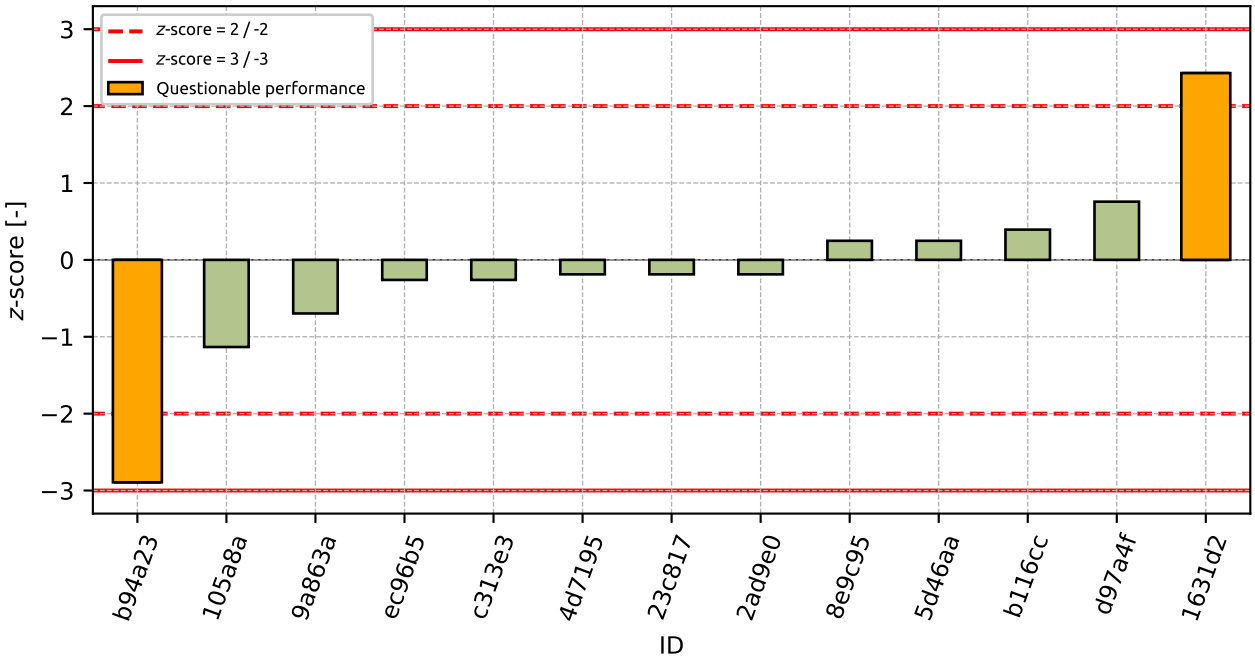

Figure 26: z-score

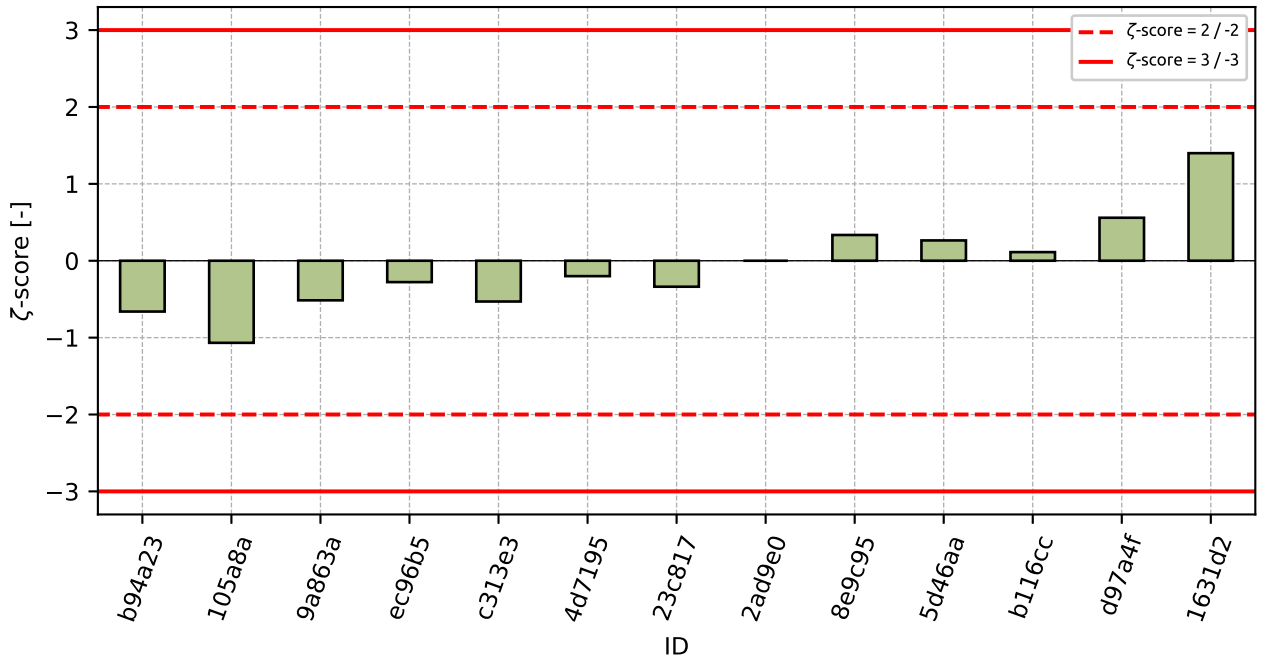

Figure 27: ζ-score

Table 12: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
b94a23	-2.89	-0.66
105a8a	-1.13	-1.07
9a863a	-0.7	-0.51
ec96b5	-0.26	-0.28
c313e3	-0.26	-0.53
4d7195	-0.19	-0.2
23c817	-0.19	-0.34
2ad9e0	-0.19	-
8e9c95	0.25	0.33
5d46aa	0.25	0.26
b116cc	0.39	0.11
d97a4f	0.76	0.56
1631d2	2.43	1.4

4 Appendix – EN 12390-7 – Density of hardened concrete

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 [kg/m^3]			u_X [kg/m^3]	$\bar{x}$ [kg/m^3]	s_0 [kg/m^3]	V_X [%]
fb45d2	2220	2200	2200	40.0	2207	11.5	0.52
855dc5	2250	2250	2260	20.0	2253	5.8	0.26
200b13	2290	2300	2290	-	2293	5.8	0.25
1631d2	2290	2300	2300	9.0	2297	5.8	0.25
8e9c95	2295	2304	2293	15.0	2297	5.9	0.26
80b88f	2300	2310	2290	30.0	2300	10.0	0.43
4a9e22	2300	2310	2300	9.0	2303	5.8	0.25
5d46aa	2310	2300	2300	40.0	2303	5.8	0.25
da779f	2311	2302	2300	6.0	2304	5.9	0.25
23c817	2308	2315	2301	10.0	2308	7.0	0.3
1152e1	2310	2311	2308	3.0	2310	1.5	0.07
010369	2310	2300	2320	10.0	2310	10.0	0.43
4d7d48	2300	2320	2310	15.0	2310	10.0	0.43
78ecc0	2310	2320	2300	10.0	2310	10.0	0.43
060c5b	2310	2320	2300	60.0	2310	10.0	0.43
85dca9	2310	2310	2310	-	2310	0.0	0.0
8bd06b	2310	2310	2310	4.0	2310	0.0	0.0
d97a4f	2300	2320	2320	30.0	2313	11.5	0.5
d2a76e	2320	2310	2310	21.0	2313	5.8	0.25
2ad9e0	2310	2320	2320	-	2317	5.8	0.25
92b8be	2310	2310	2340	21.0	2320	17.3	0.75
eaa338	2312	2332	2318	55.0	2321	10.3	0.44
ec96b5	2330	2310	2330	20.0	2323	11.5	0.5
f1d2af	2320	2340	2330	40.0	2330	10.0	0.43
344791	2352	2321	2326	18.0	2333	16.6	0.71
67aadb	2340	2340	2320	30.0	2333	11.5	0.49
b24024	2340	2330	2340	-	2337	5.8	0.25
b94a23	2350	2320	2350	20.0	2340	17.3	0.74

4.2 The Numerical Procedure for Determining Outliers

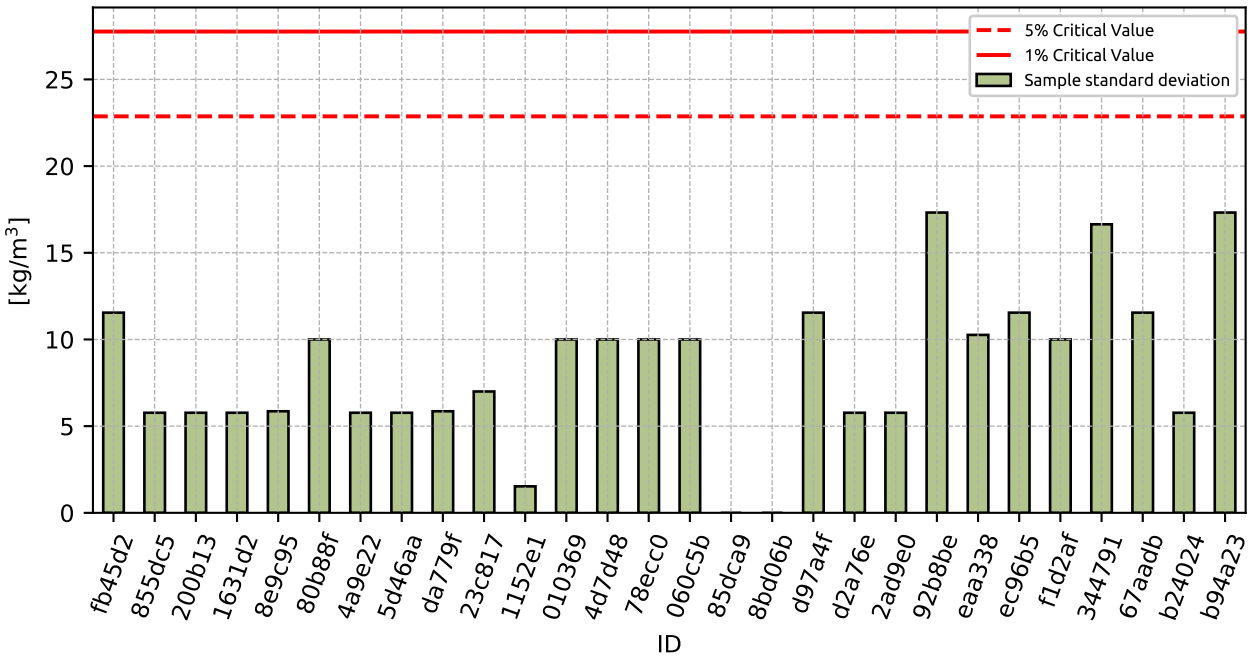

Figure 28: **Cochran's test** - sample standard deviations

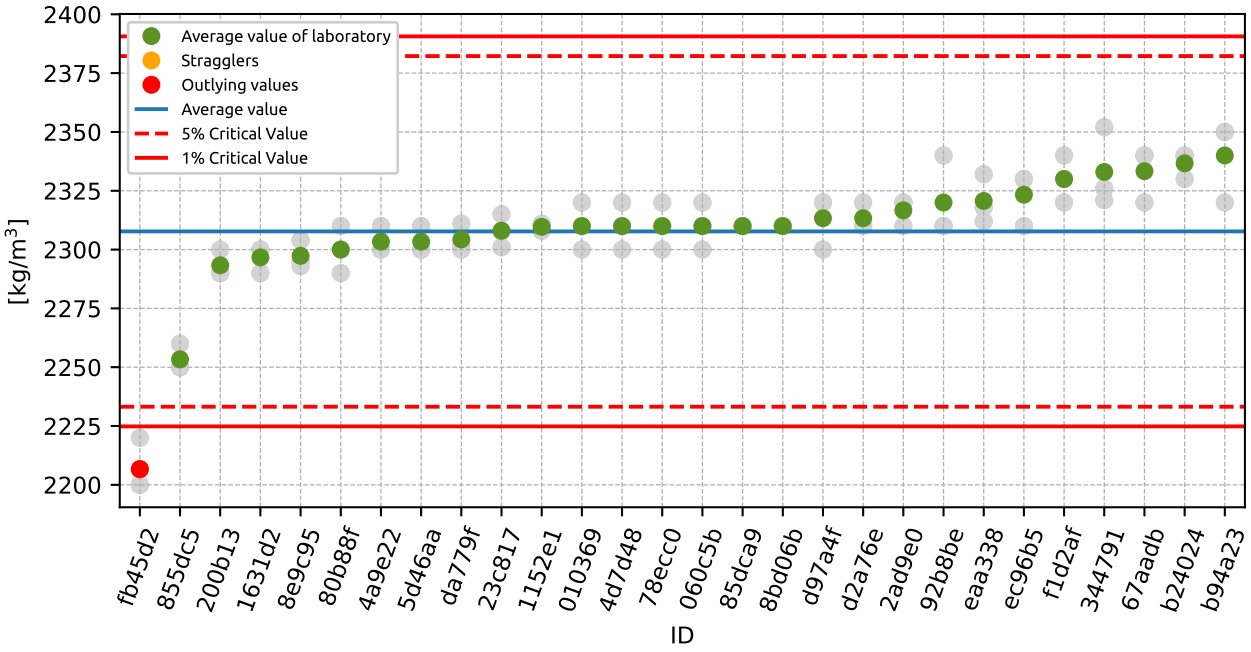

Figure 29: **Grubbs' test** - average values

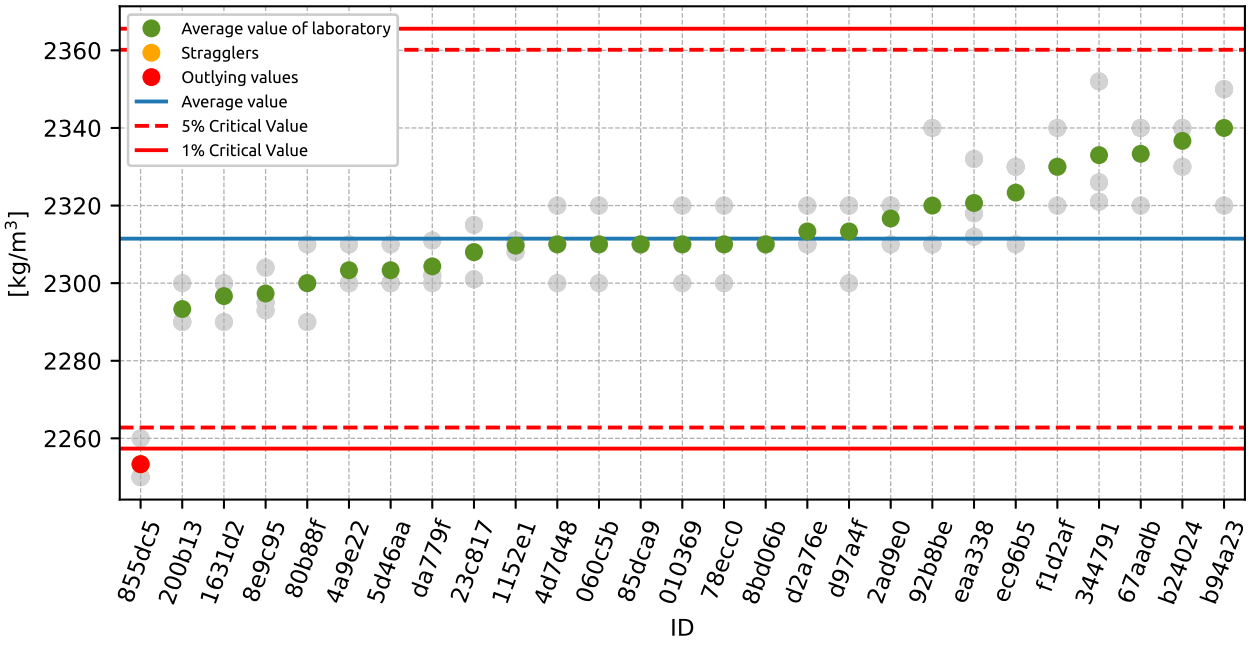

Figure 30: **Grubbs' test** - average values without outliers

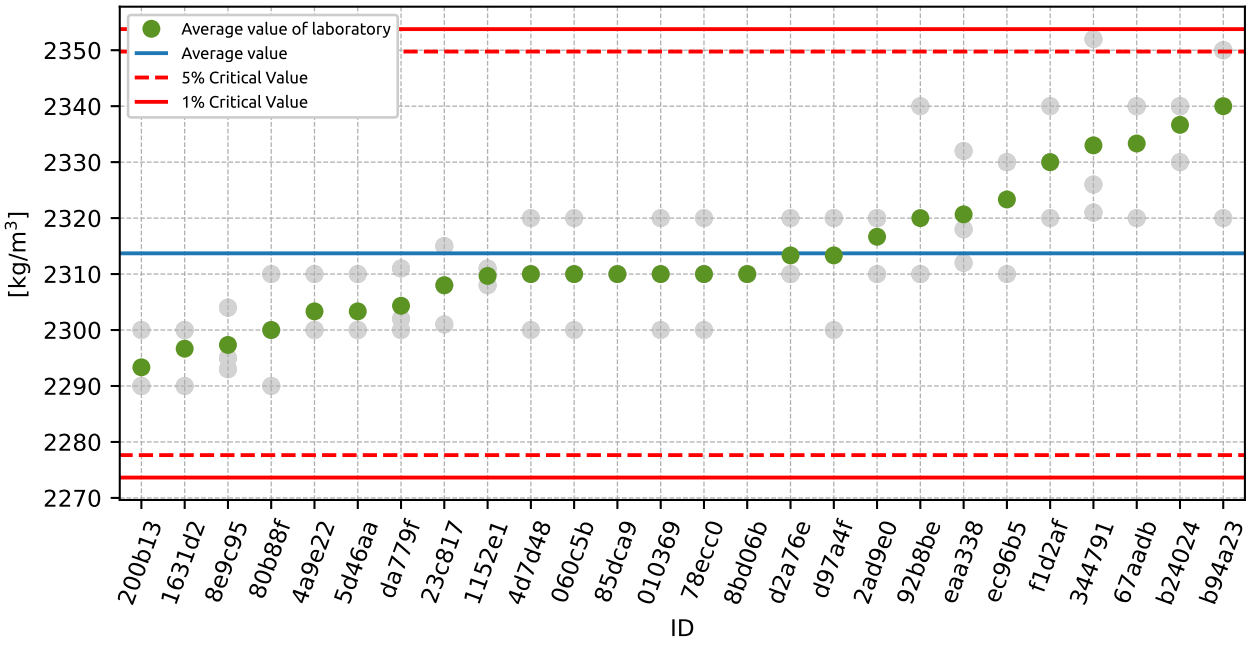

Figure 31: **Grubbs' test** - average values without outliers

4.3 Mandel's Statistics

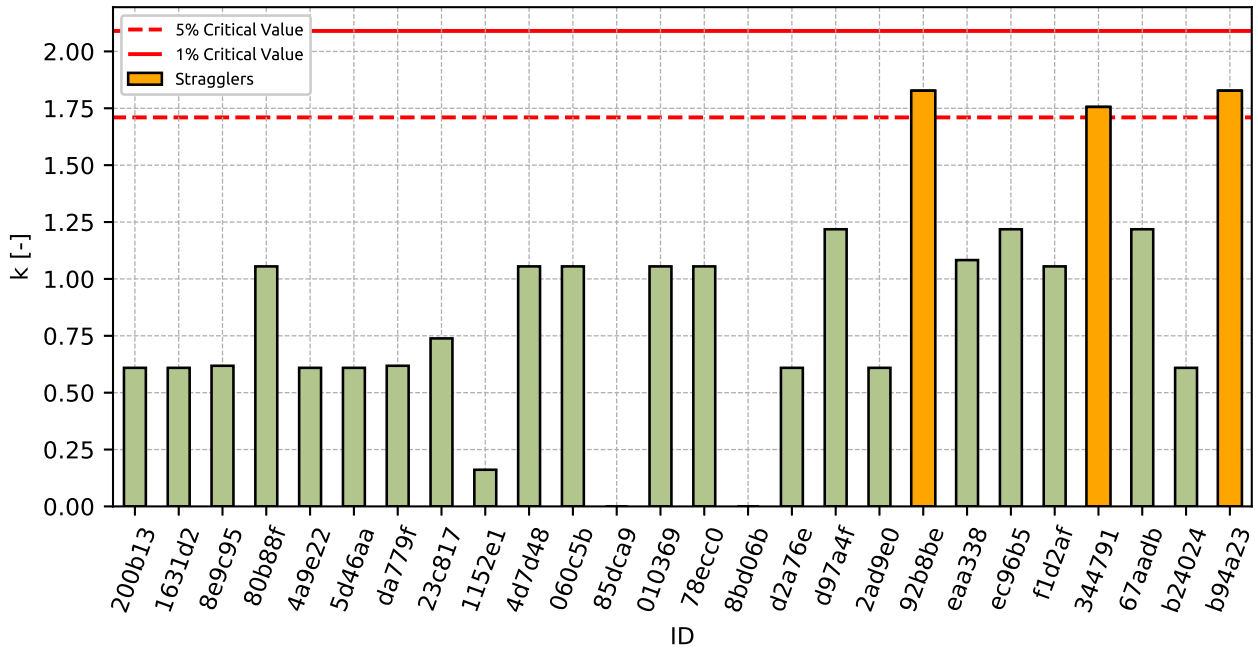

Figure 32: Intralaboratory Consistency Statistic

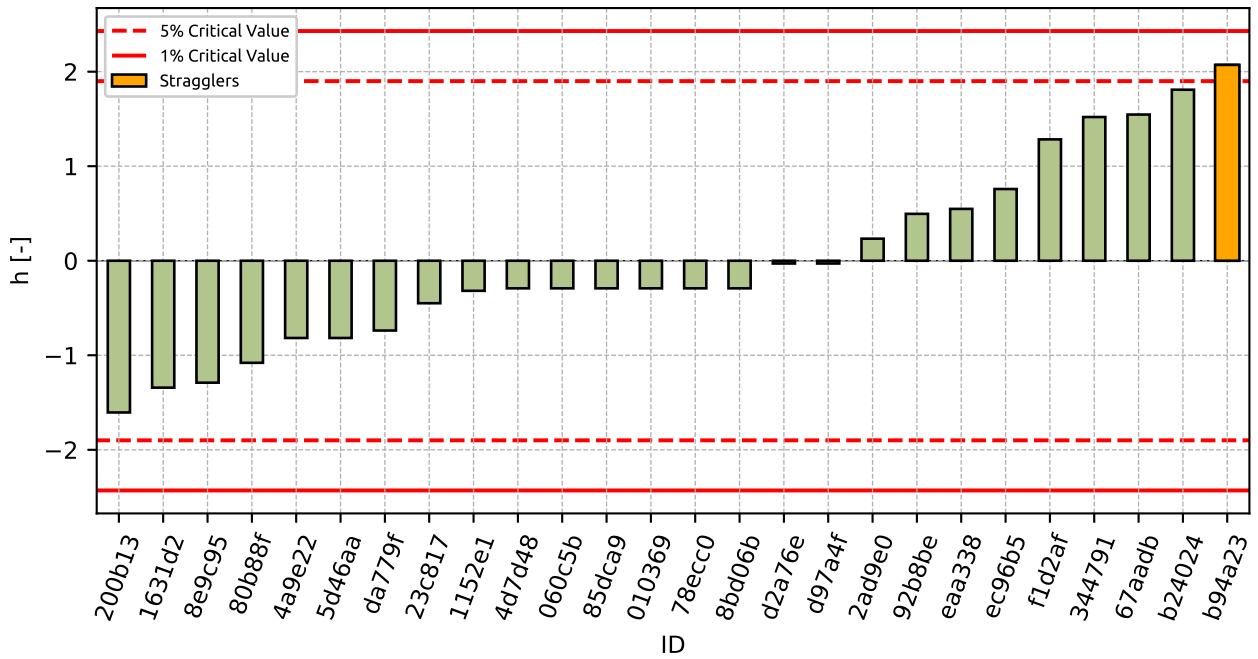

Figure 33: Interlaboratory Consistency Statistic

4.4 Descriptive statistics

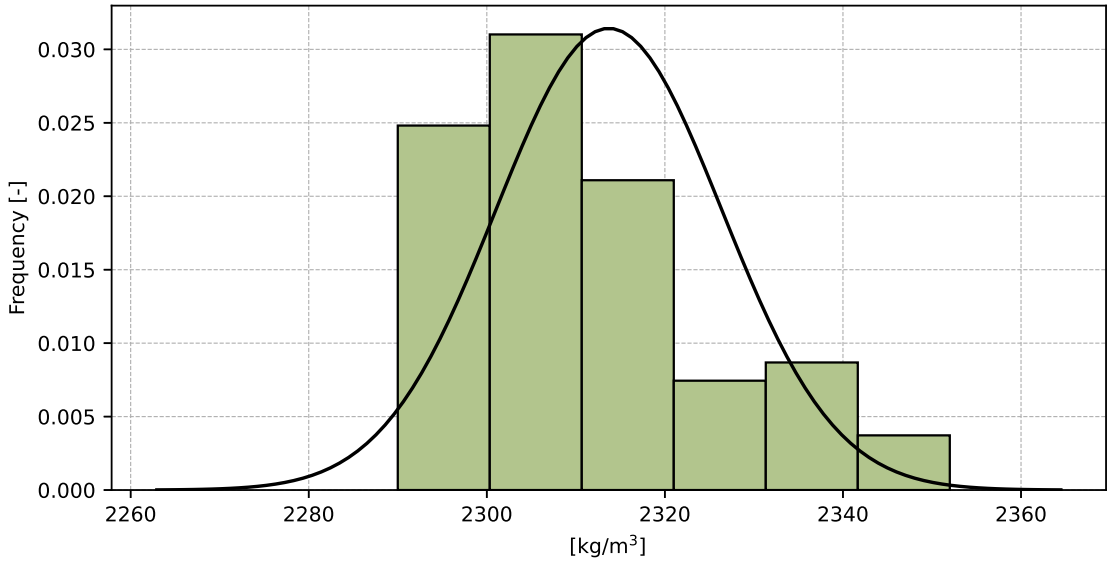

Figure 34: Histogram of all test results

Table 14: Descriptive statistics

Characteristics	[kg/m³]
Average value – $\bar{x}$	2314
Sample standard deviation – s	12.7
Asigned value – x^*	2314
Robust standard deviation – s^*	13.7
Measurement uncertainty of asigned value – u_X	2.7
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	11.5
Repeatability standard deviation – s_r	9.5
Reproducibility standard deviation – s_R	14.9
Repeatability – r	27
Reproducibility – R	42

4.5 Evaluation of Performance Statistics

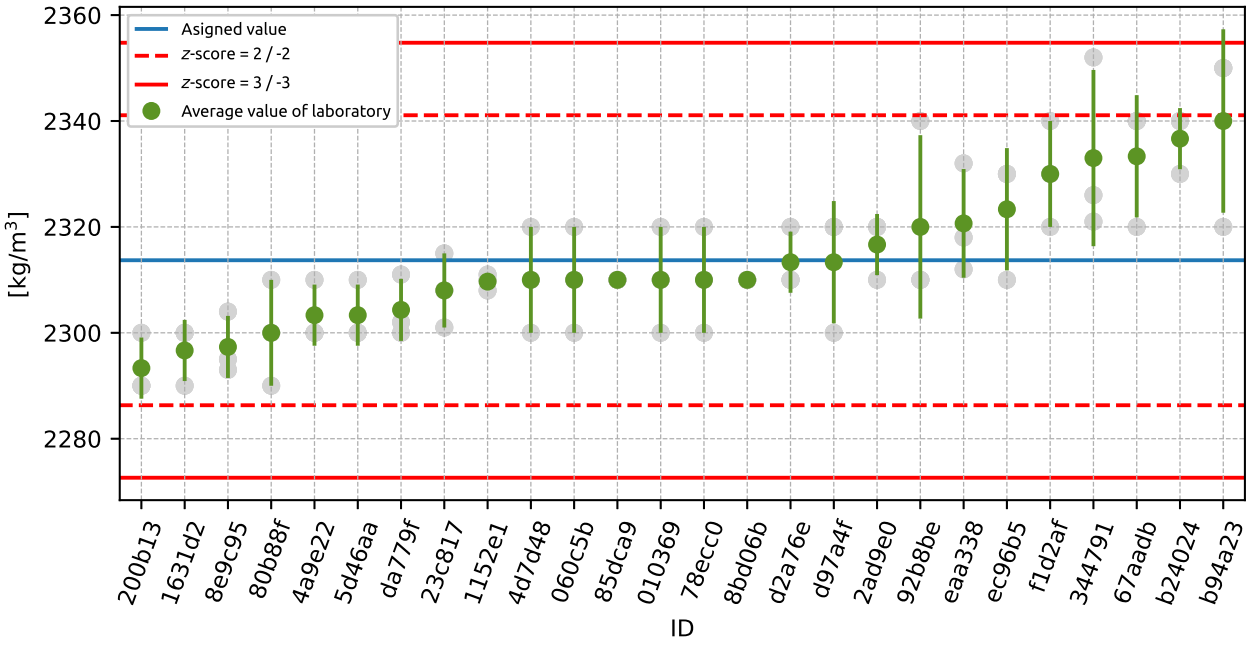

Figure 35: Average values and sample standard deviations

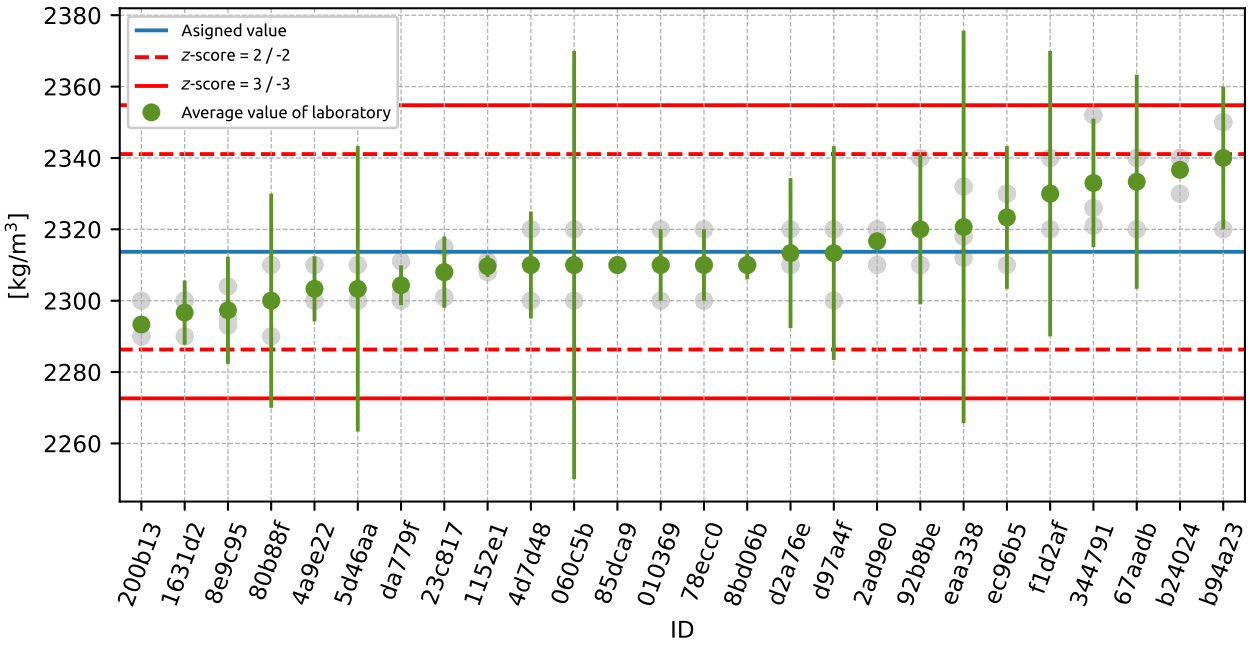

Figure 36: Average values and extended uncertainties of measurement

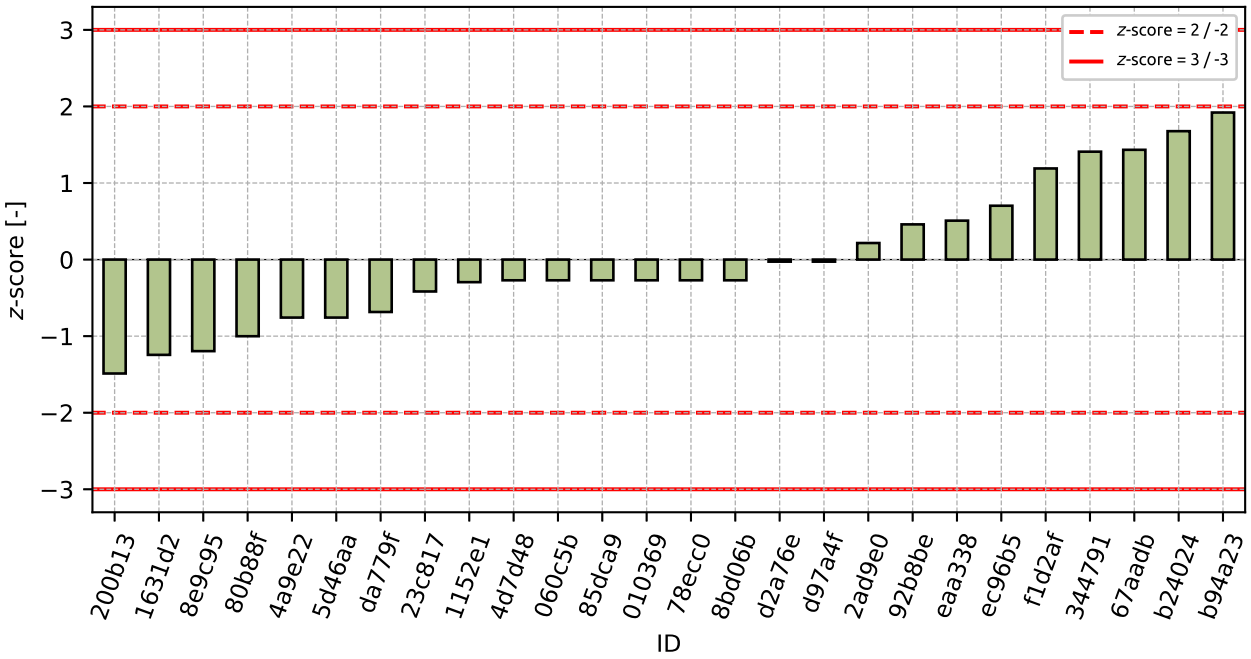

Figure 37: z-score

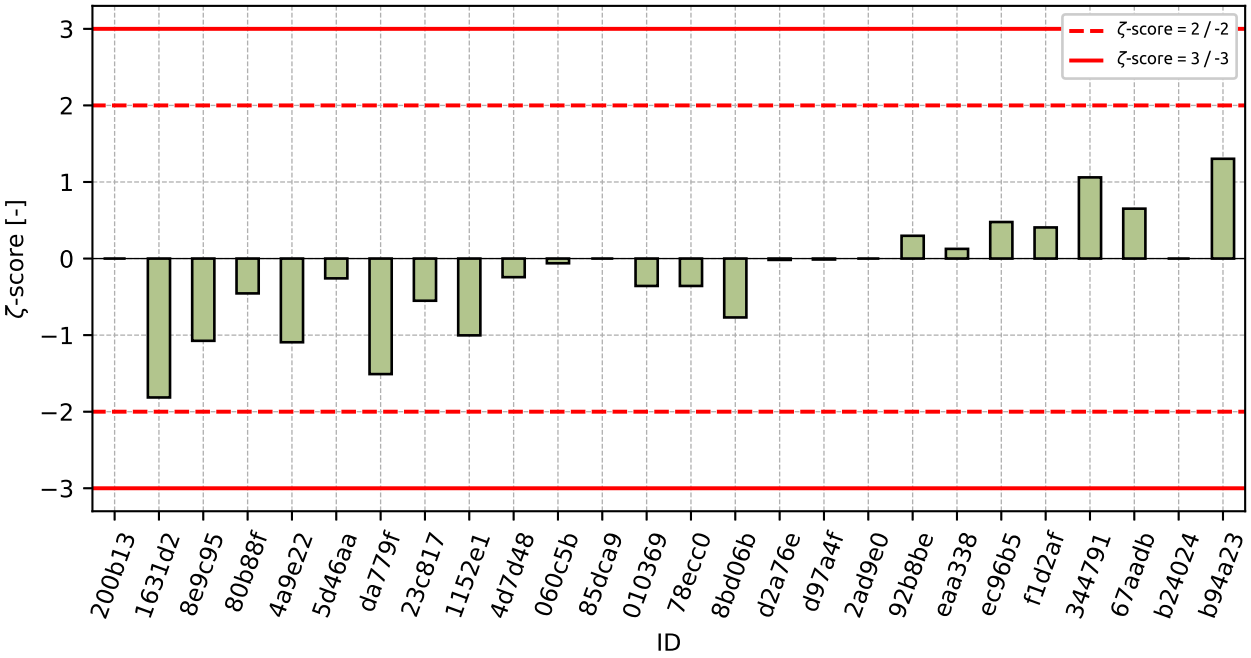

Figure 38: ζ-score

Table 15: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
200b13	-1.49	-
1631d2	-1.24	-1.81
8e9c95	-1.2	-1.07
80b88f	-1.0	-0.46
4a9e22	-0.76	-1.09
5d46aa	-0.76	-0.26
da779f	-0.68	-1.51
23c817	-0.42	-0.55
1152e1	-0.29	-1.0
4d7d48	-0.27	-0.24
060c5b	-0.27	-0.06
85dca9	-0.27	-
010369	-0.27	-0.36
78ecc0	-0.27	-0.36
8bd06b	-0.27	-0.77
d2a76e	-0.03	-0.02
d97a4f	-0.03	-0.01
2ad9e0	0.22	-
92b8be	0.46	0.3
eaa338	0.51	0.13
ec96b5	0.7	0.48
f1d2af	1.19	0.41
344791	1.41	1.06
67aadb	1.43	0.65
b24024	1.68	-
b94a23	1.92	1.3

5 Appendix – ISO 1920-10 – Determination of static modulus of elasticity in compression

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 [%]
b116cc	34725	34419	100	34572	216.4	0.63
da779f	34515	35373	1643	34944	606.7	1.74
8e9c95	36260	37050	1260	36655	558.6	1.52
0c0c26	37000	36400	1500	36700	424.3	1.16
67aadb	42200	39800	720	41000	1697.1	4.14
d2a76e	63570	63770	1000	63670	141.4	0.22

5.2 The Numerical Procedure for Determining Outliers

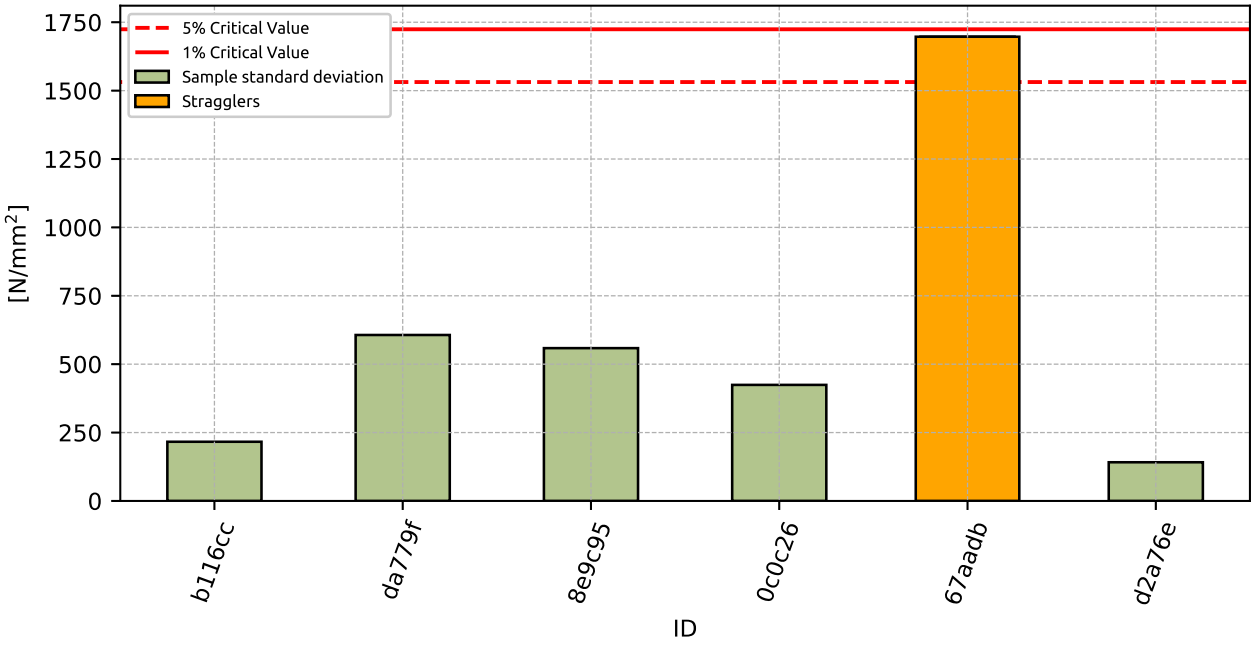

Figure 39: **Cochran's test** - sample standard deviations

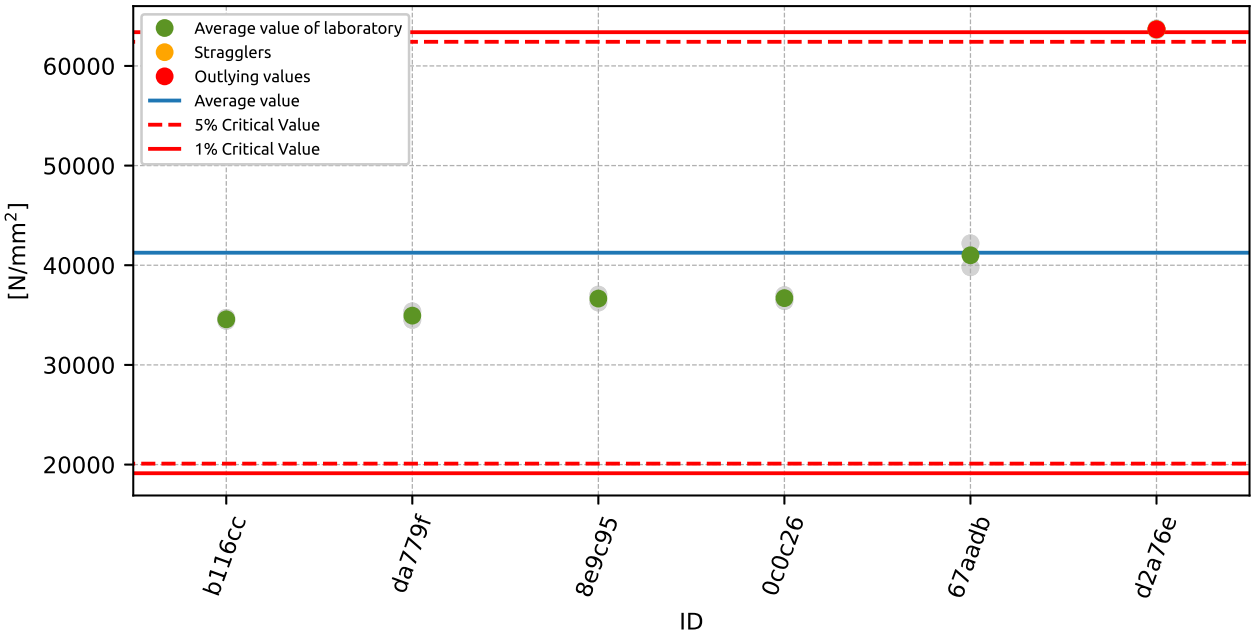

Figure 40: **Grubbs' test** - average values

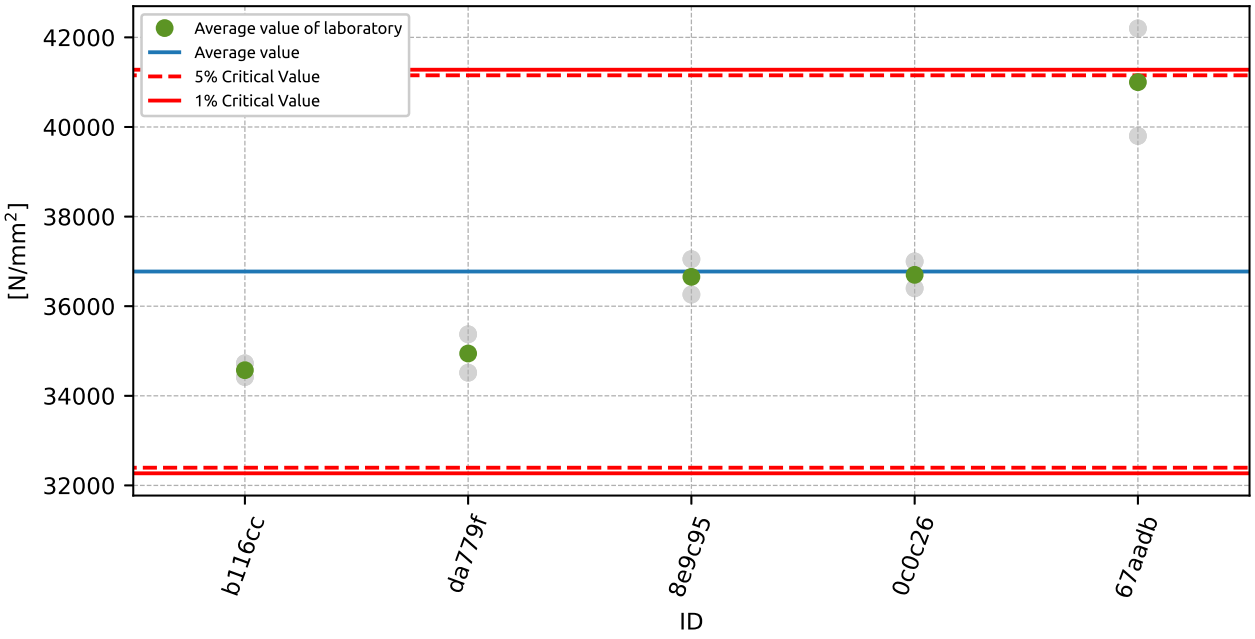

Figure 41: **Grubbs' test** - average values without outliers

5.3 Mandel's Statistics

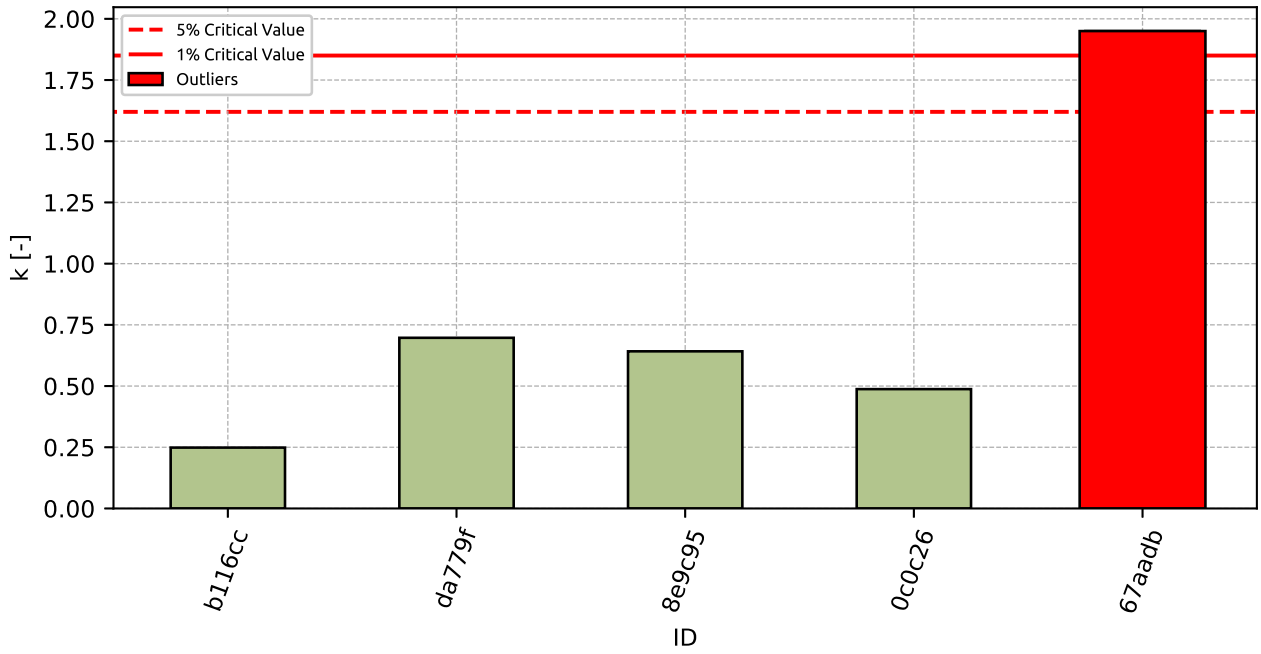

Figure 42: Intralaboratory Consistency Statistic

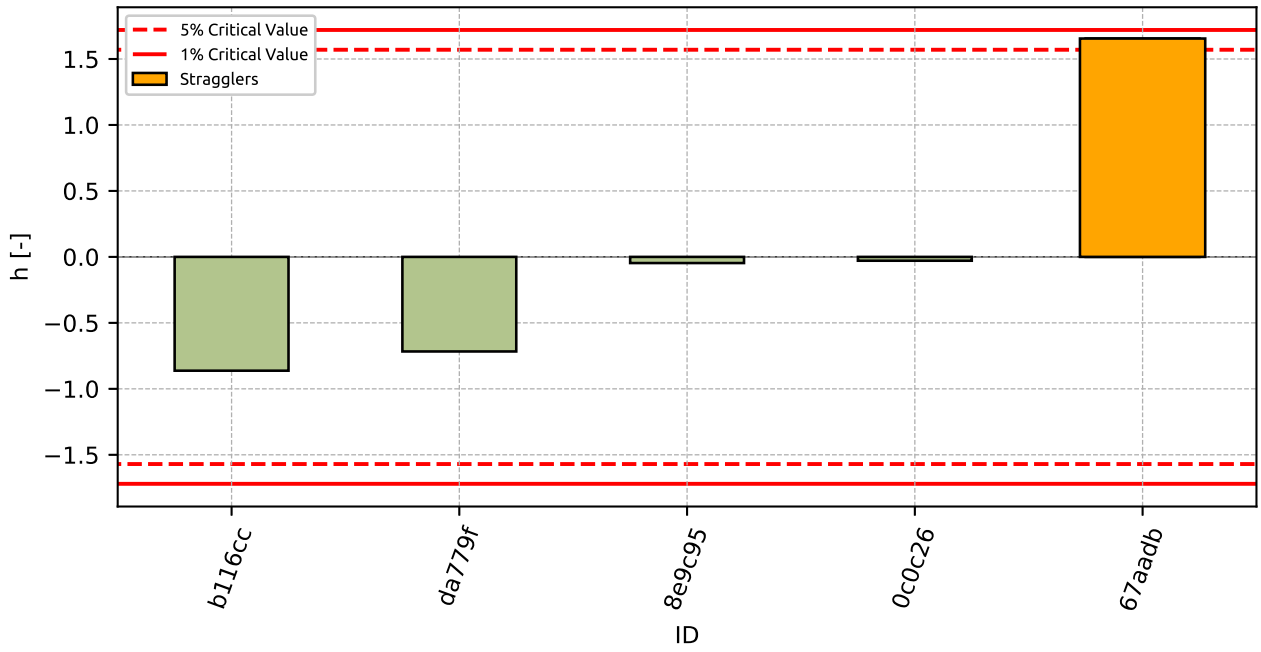

Figure 43: Interlaboratory Consistency Statistic

5.4 Descriptive statistics

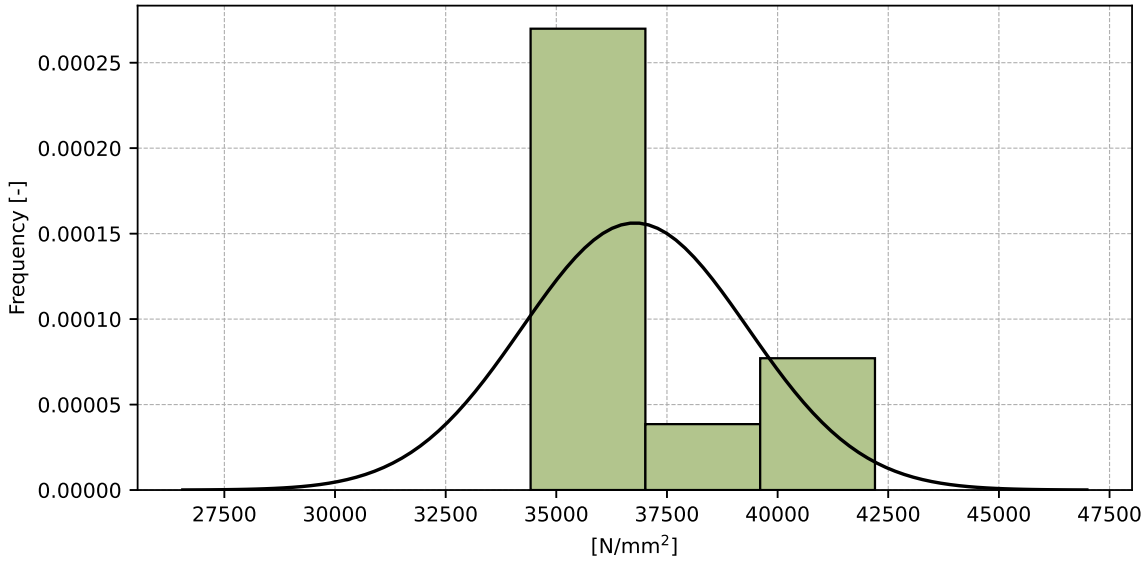

Figure 44: Histogram of all test results

Table 17: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	36774
Sample standard deviation – s	2553.3
Asigned value – x^*	36774
Robust standard deviation – s^*	2589.7
Measurement uncertainty of asigned value – u_X	1447.7
p-value of normality test	0.063 [-]
Interlaboratory standard deviation – s_L	2478.0
Repeatability standard deviation – s_r	870.3
Reproducibility standard deviation – s_R	2626.4
Repeatability – r	2437
Reproducibility – R	7354

5.5 Evaluation of Performance Statistics

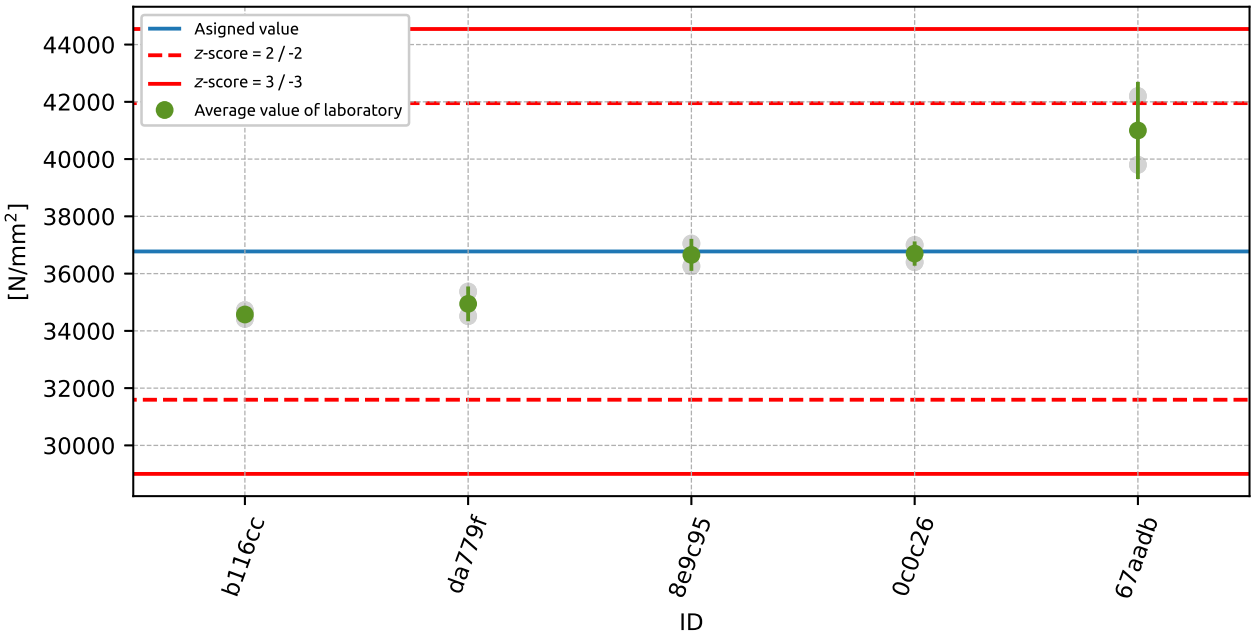

Figure 45: Average values and sample standard deviations

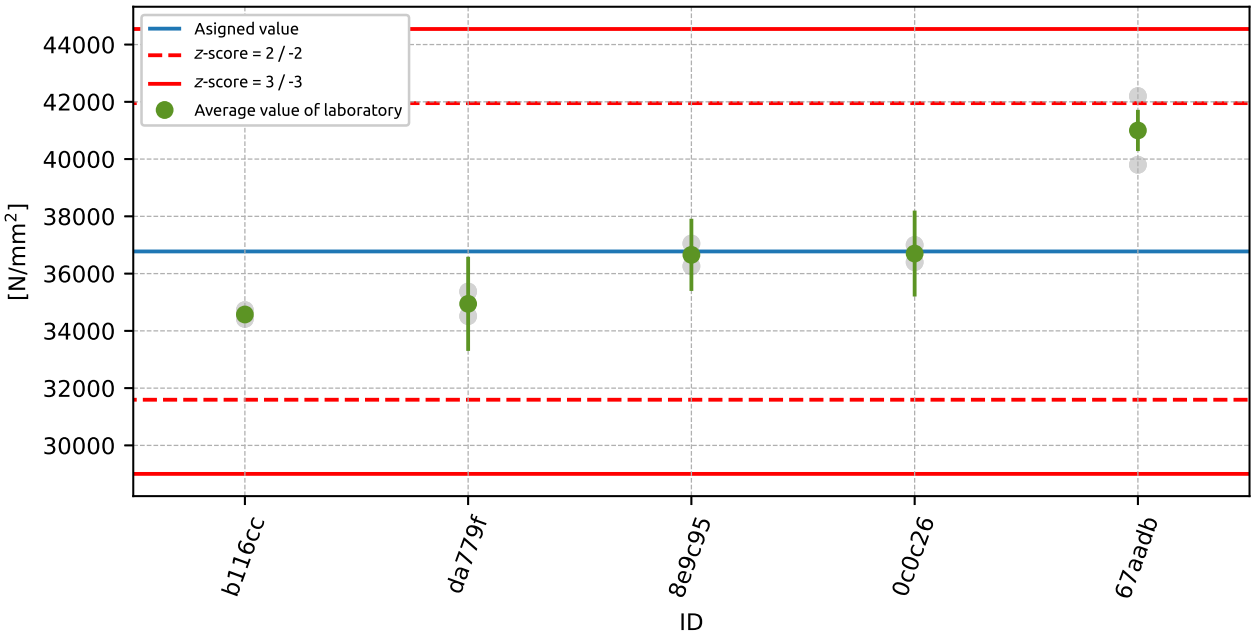

Figure 46: Average values and extended uncertainties of measurement

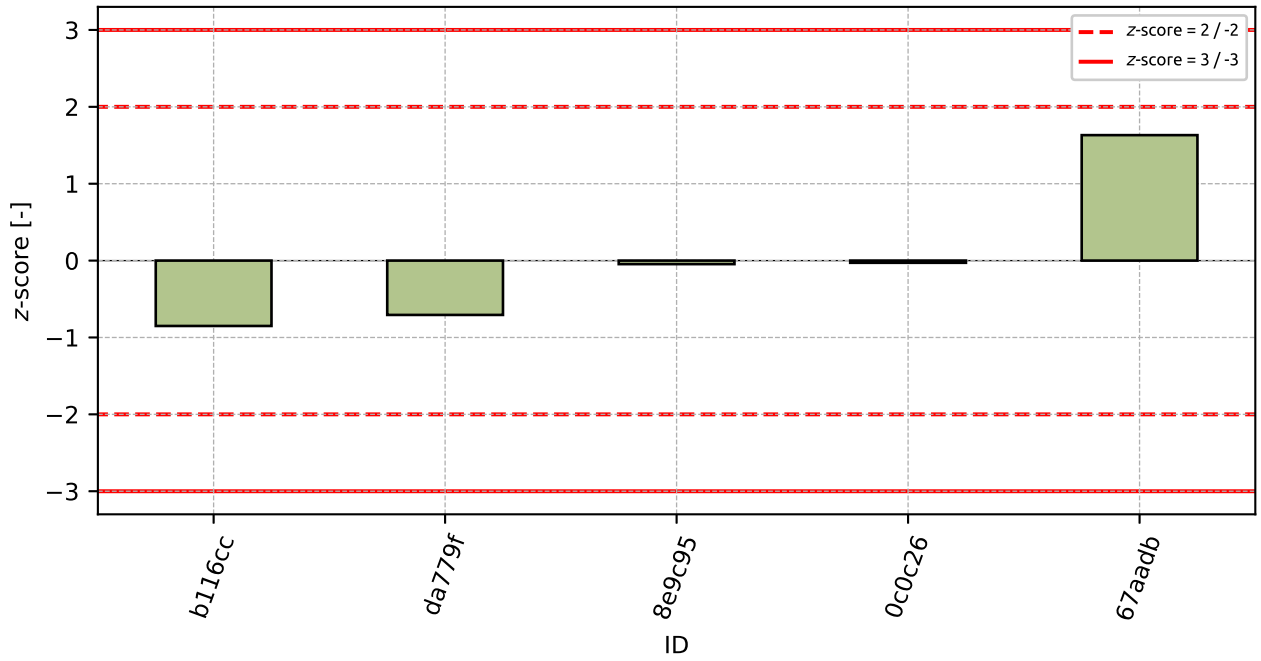

Figure 47: z-score

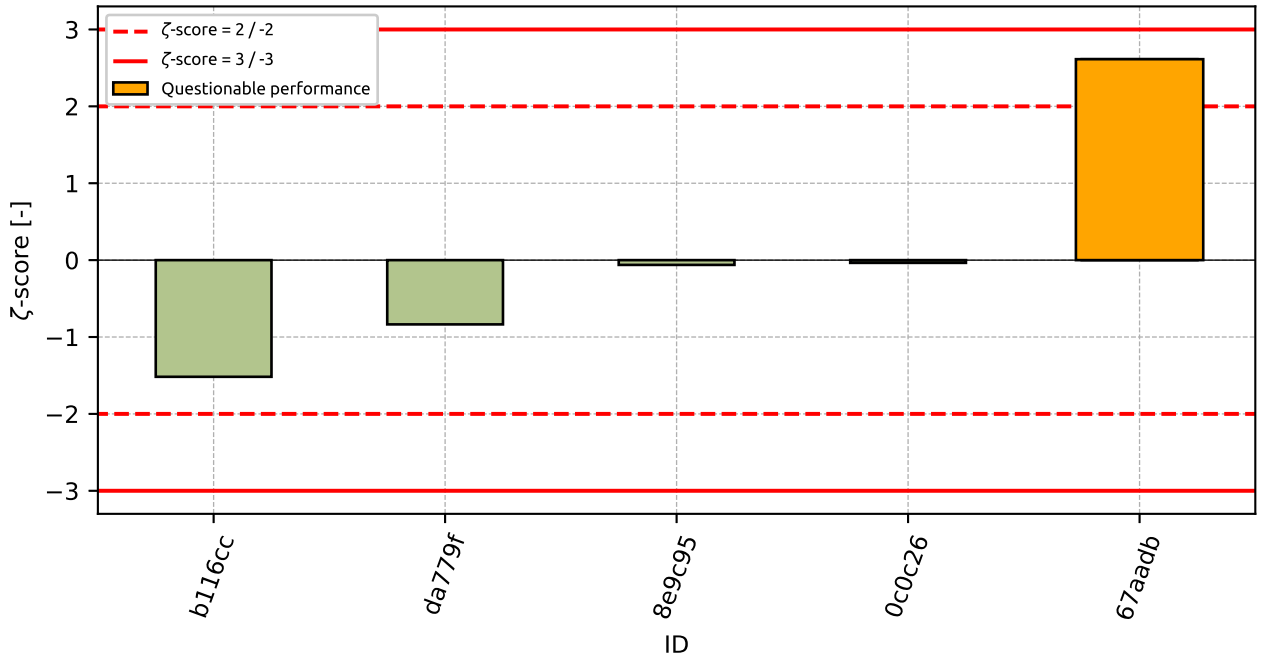

Figure 48: ζ-score

Table 18: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
b116cc	-0.85	-1.52
da779f	-0.71	-0.84
8e9c95	-0.05	-0.06
0c0c26	-0.03	-0.04
67aadb	1.63	2.61

6 Appendix – EN 12390-13, method A – Determination of secant modulus of elasticity in compression

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

7 Appendix – EN 12390-13, method B – Determination of secant modulus of elasticity in compression

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

8 Appendix – EN 12504-4, ČSN 731371 – Non-destructive testing of concrete

8.1 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 [km/s]			u_X [km/s]	$\bar{x}$ [km/s]	s_0 [km/s]	V_X [%]
e679b2	4.34	4.53	4.47	0.03	4.45	0.095	2.13
6725e5	4.88	4.87	4.88	0.02	4.88	0.006	0.12
8e9c95	5.01	5.0	5.04	0.1	5.02	0.021	0.41
b116cc	5.45	5.48	5.51	-	5.48	0.03	0.54

8.2 The Numerical Procedure for Determining Outliers

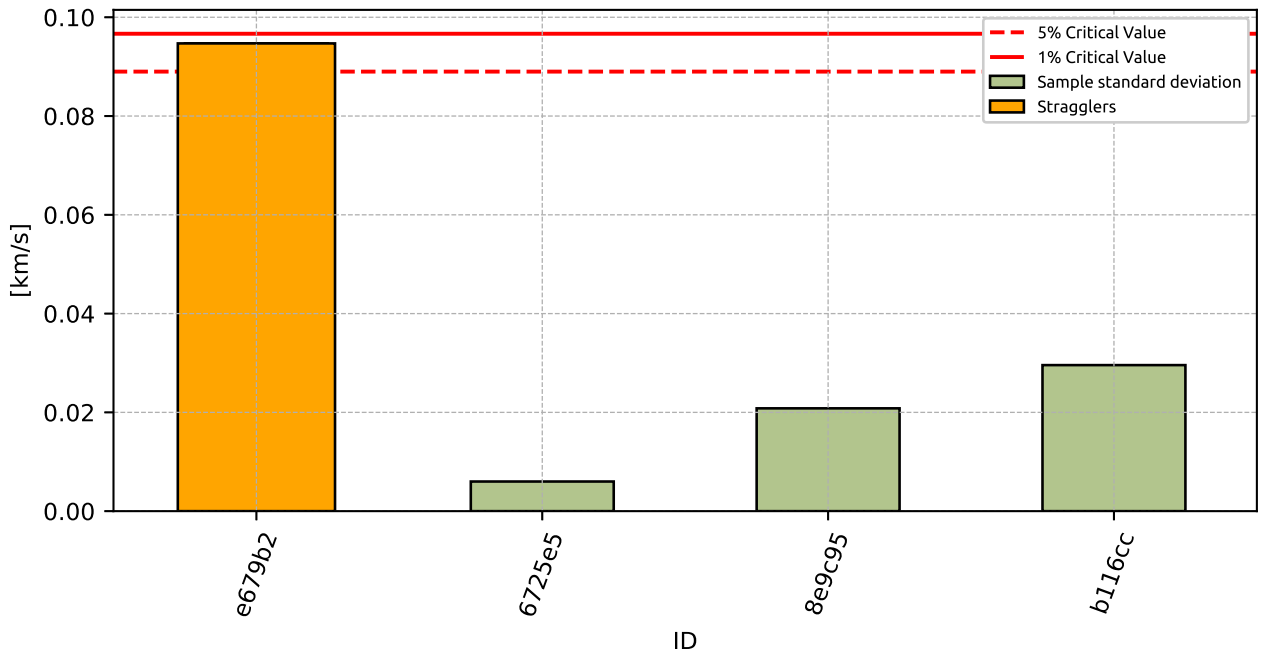

Figure 49: **Cochran's test** - sample standard deviations

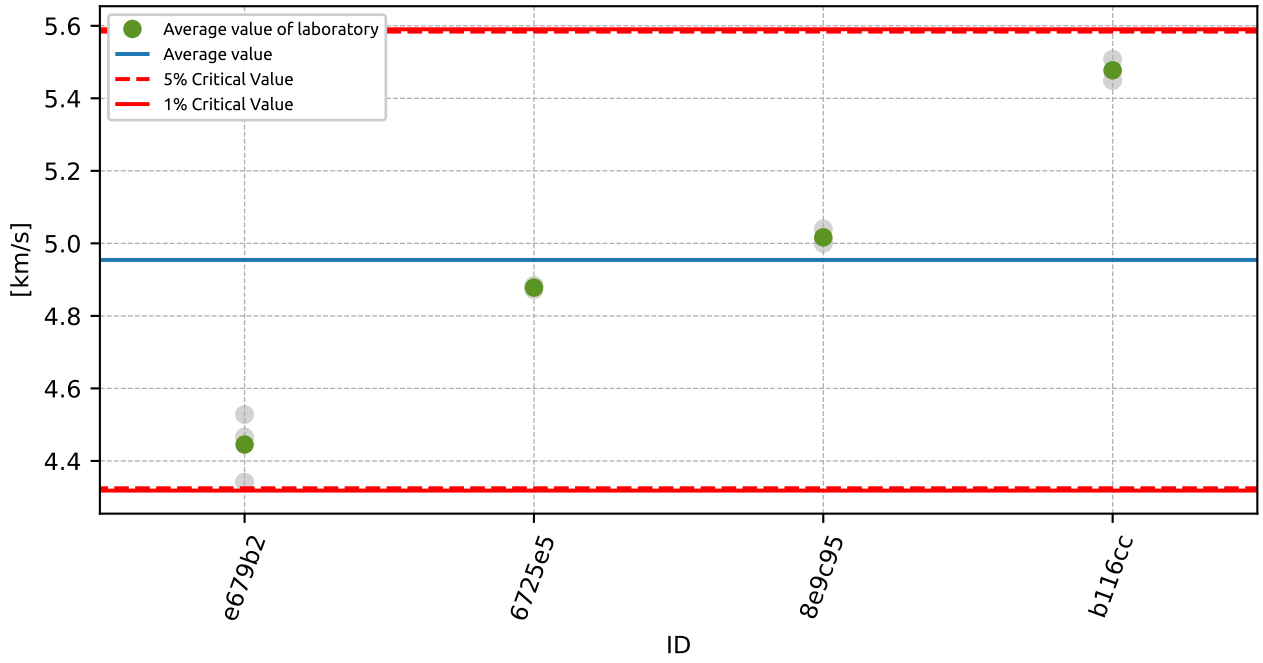

Figure 50: **Grubbs' test** - average values

8.3 Mandel's Statistics

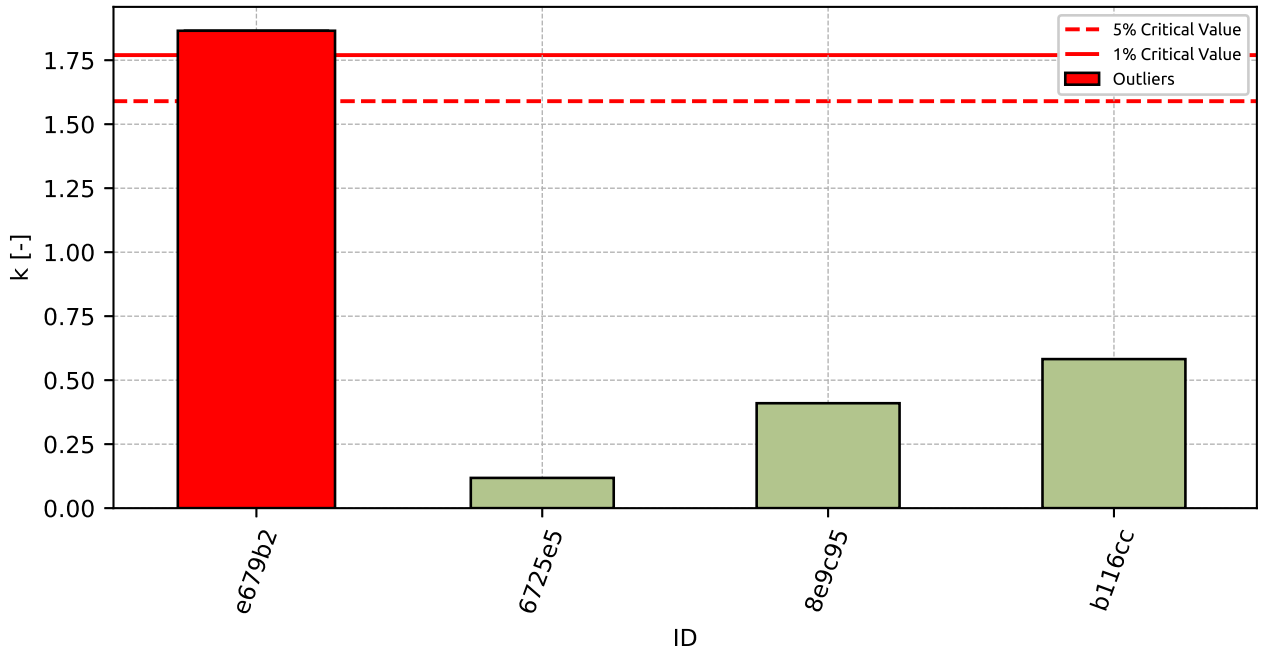

Figure 51: Intralaboratory Consistency Statistic

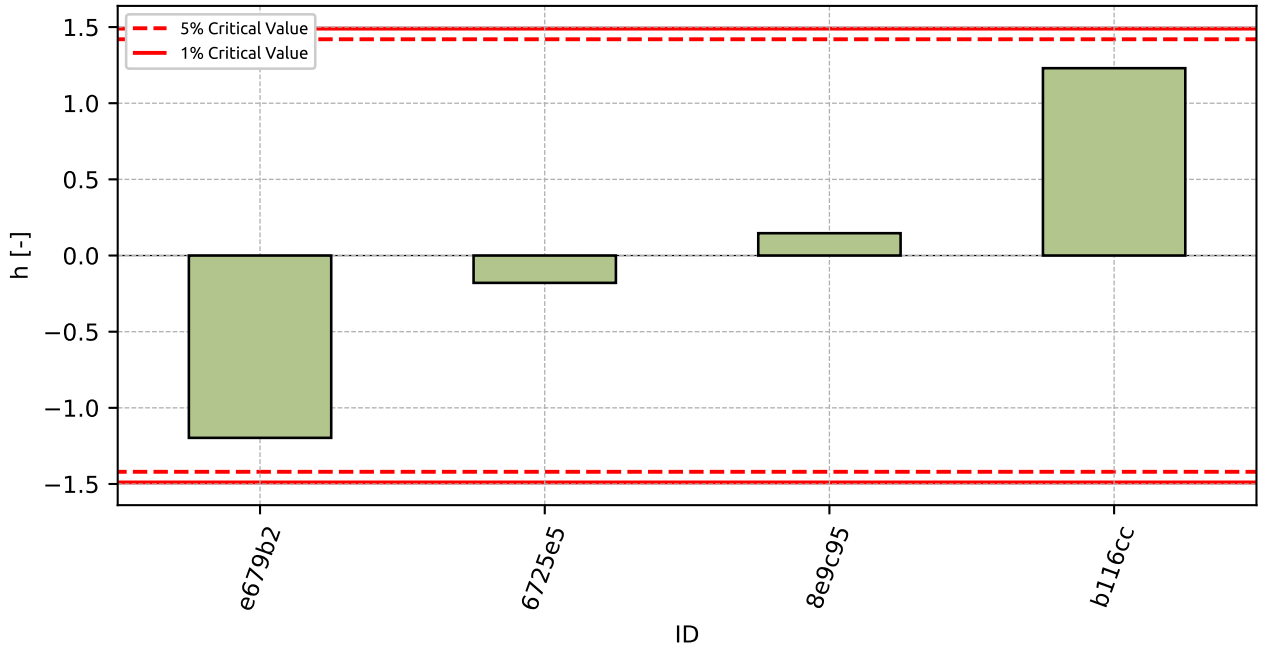

Figure 52: Interlaboratory Consistency Statistic

8.4 Descriptive statistics

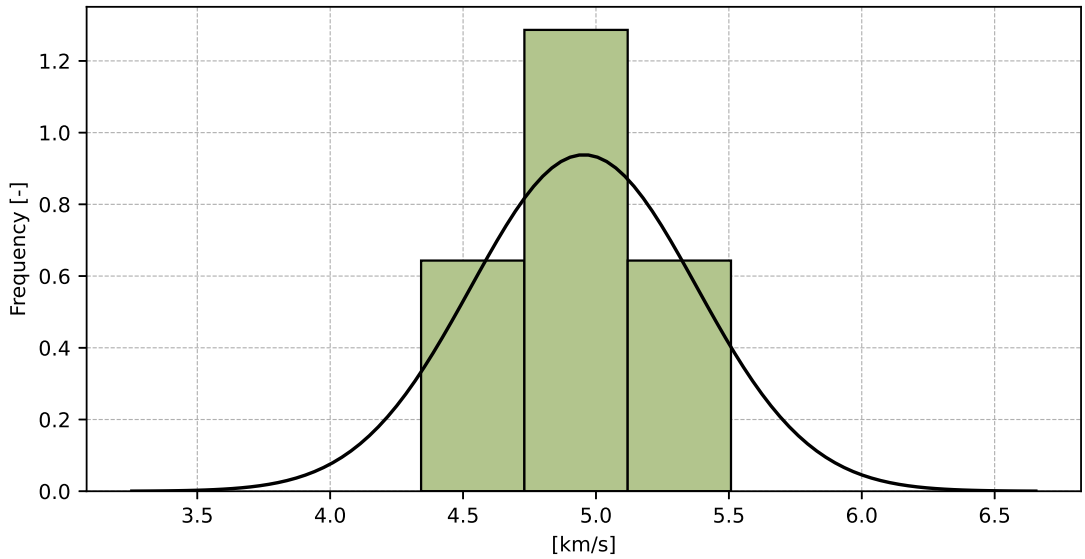

Figure 53: Histogram of all test results

Table 20: Descriptive statistics

Characteristics	[km/s]
Average value – $\bar{x}$	4.95
Sample standard deviation – s	0.425
Asigned value – x^*	4.95
Robust standard deviation – s^*	0.418
Measurement uncertainty of asigned value – u_X	0.261
p-value of normality test	0.3 [-]
Interlaboratory standard deviation – s_L	0.424
Repeatability standard deviation – s_r	0.051
Reproducibility standard deviation – s_R	0.427
Repeatability – r	0.14
Reproducibility – R	1.2

8.5 Evaluation of Performance Statistics

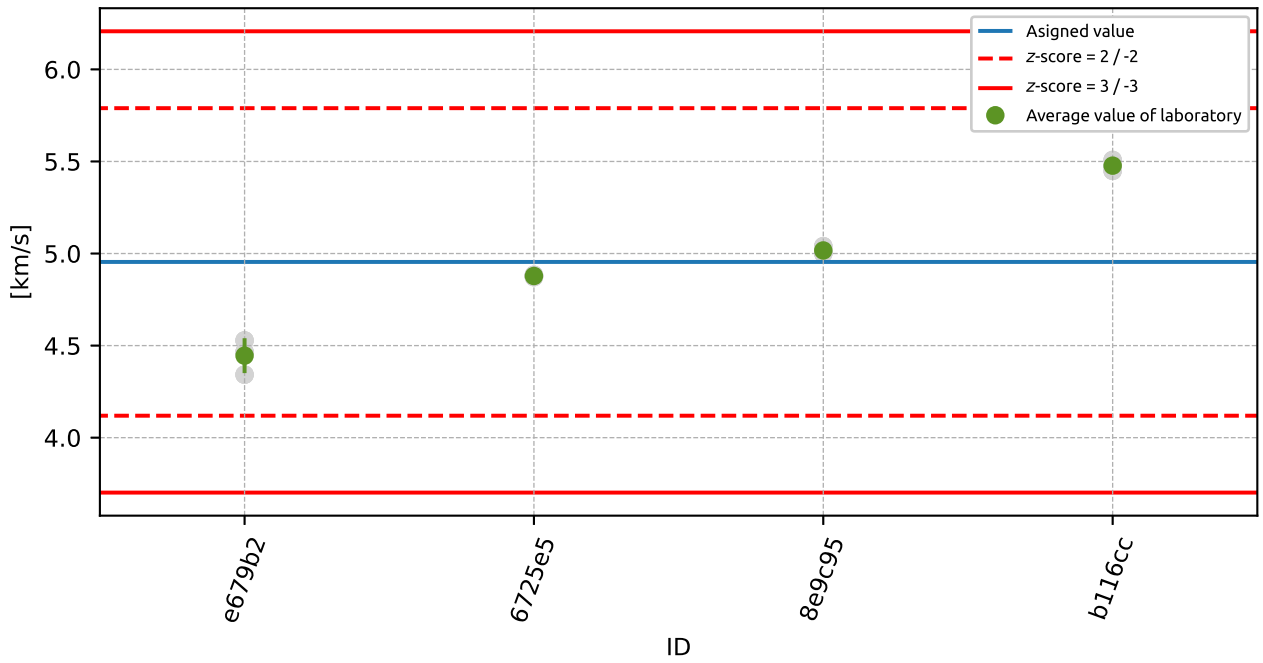

Figure 54: Average values and sample standard deviations

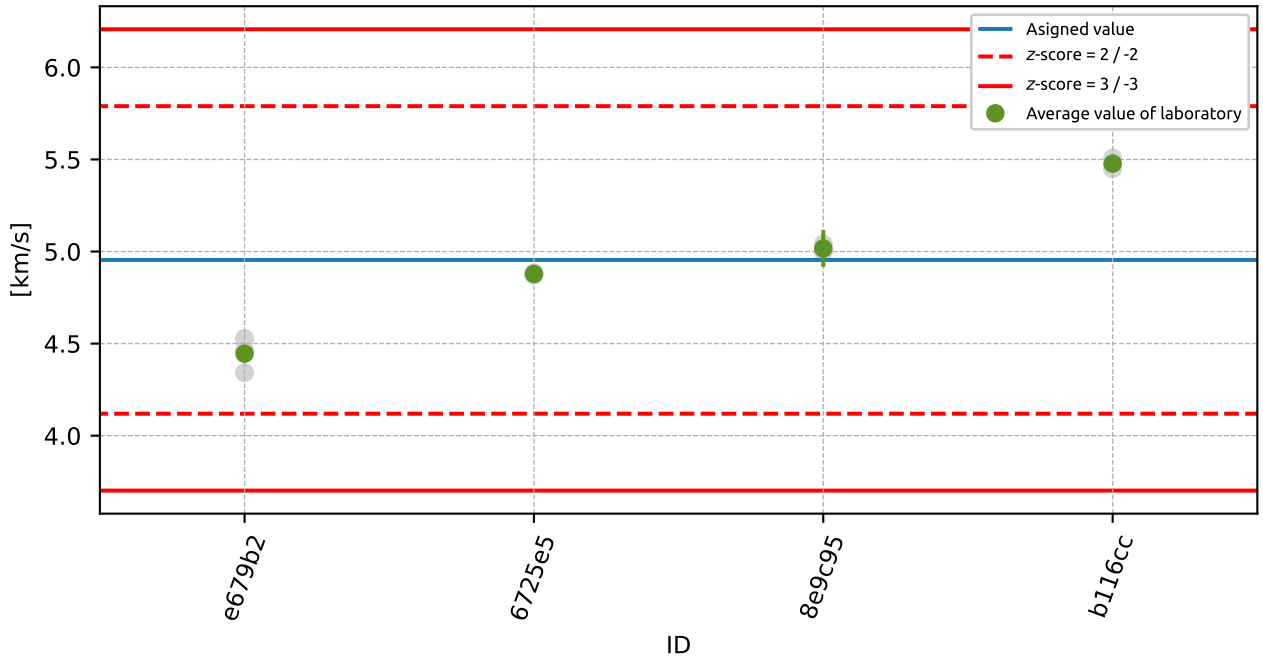

Figure 55: Average values and extended uncertainties of measurement

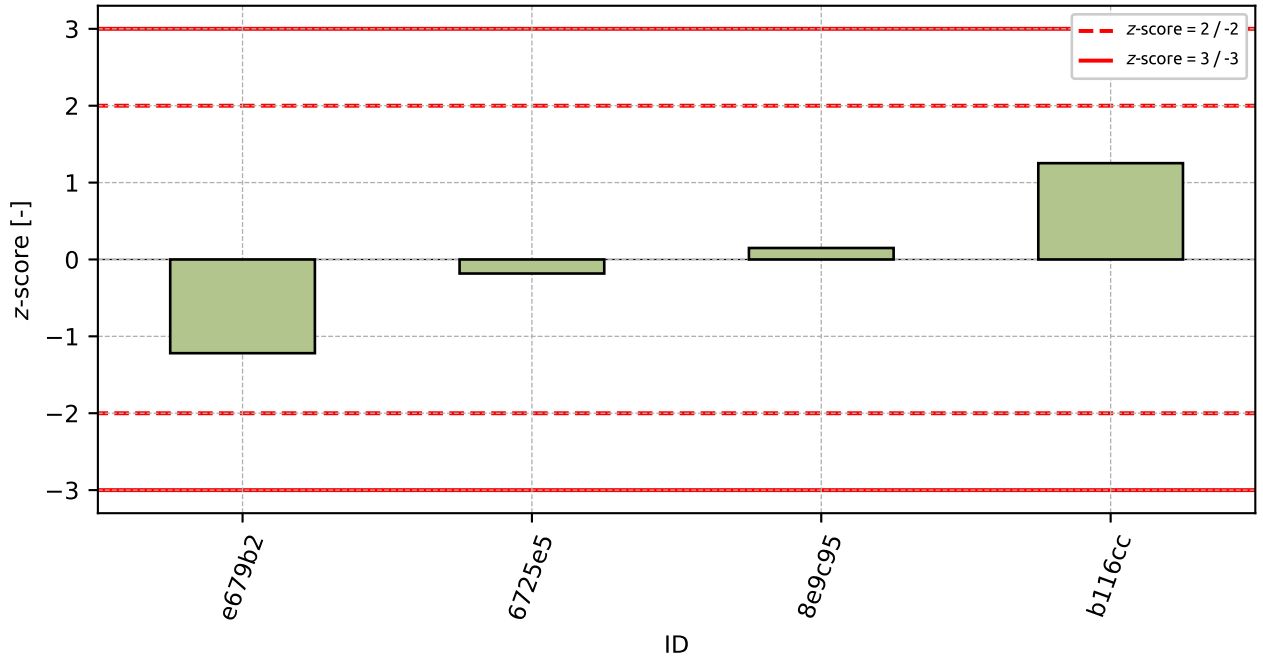

Figure 56: z-score

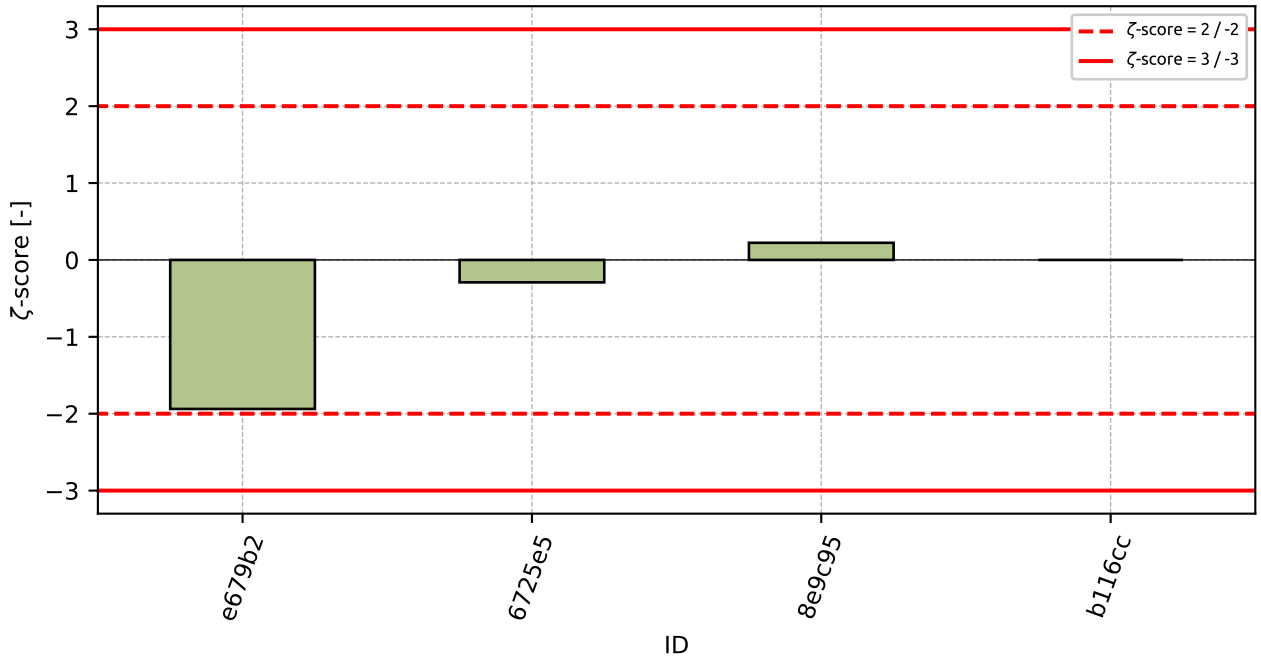

Figure 57: ζ-score

Table 21: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
e679b2	-1.22	-1.94
6725e5	-0.18	-0.29
8e9c95	0.15	0.22
b116cc	1.25	-

9 Appendix – ČSN 731373, EN 12504-2 – Determination of rebound number

9.1 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 [%]
4d7d48	28.0	29.0	29.0	0.4	28.7	0.58	2.01
9a306f	29.0	31.0	30.0	-	30.0	1.0	3.33
7a10f6	32.0	32.0	32.0	5.8	32.0	0.0	0.0
200b13	32.0	33.0	33.0	-	32.7	0.58	1.77
d97a4f	36.0	35.0	34.0	3.0	35.0	1.0	2.86
6056c9	36.0	34.0	36.0	2.2	35.3	1.15	3.27
f60587	36.5	37.0	32.9	3.4	35.5	2.24	6.31
ec96b5	37.0	37.0	36.0	3.0	36.7	0.58	1.57
85dca9	35.5	37.0	37.5	-	36.7	1.04	2.84
8e9c95	38.0	36.2	37.3	1.6	37.2	0.91	2.44
91e89f	39.0	36.0	37.0	1.0	37.3	1.53	4.09
2ad9e0	37.0	38.0	37.0	-	37.3	0.58	1.55
6725e5	37.0	37.0	38.0	2.7	37.3	0.58	1.55
d2a76e	38.0	38.0	38.0	6.8	38.0	0.0	0.0
c313e3	37.9	37.9	38.2	1.9	38.0	0.17	0.46
010369	39.0	40.0	39.0	2.0	39.3	0.58	1.47
4a9e22	40.0	41.0	41.0	2.0	40.7	0.58	1.42
0c0c26	42.0	42.0	42.0	2.0	42.0	0.0	0.0
060c5b	43.0	42.0	43.0	0.8	42.7	0.58	1.35

9.2 The Numerical Procedure for Determining Outliers

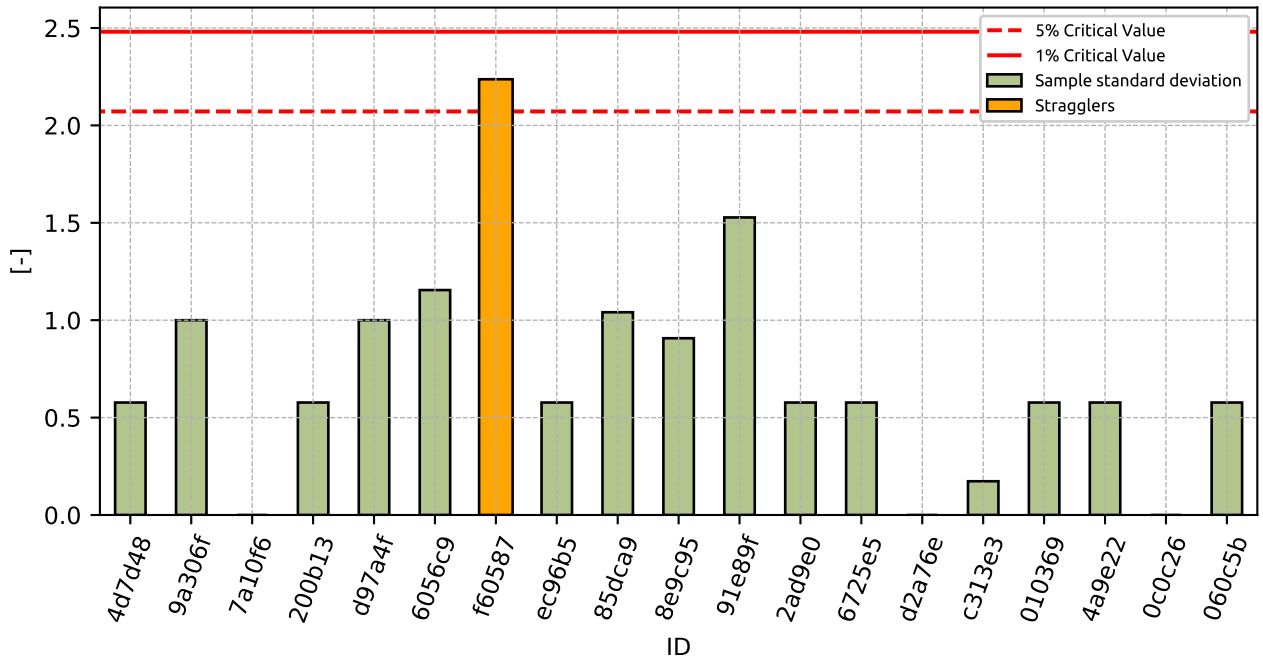

Figure 58: **Cochran's test** - sample standard deviations

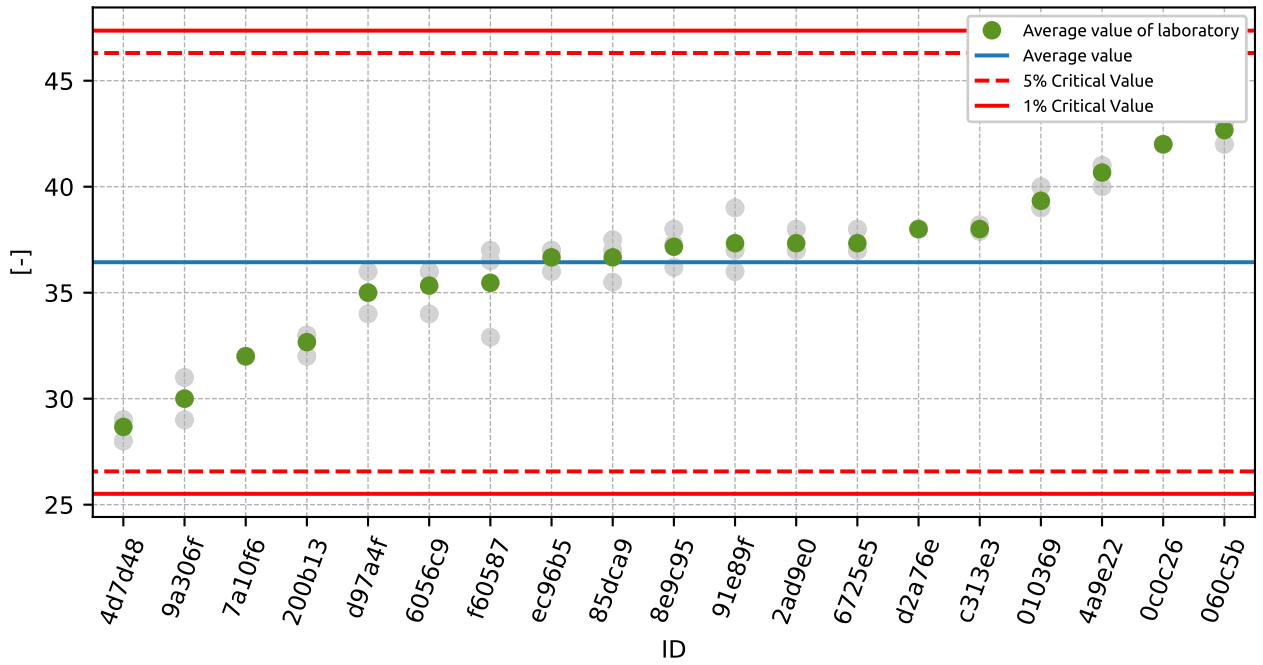

Figure 59: **Grubbs' test** - average values

9.3 Mandel's Statistics

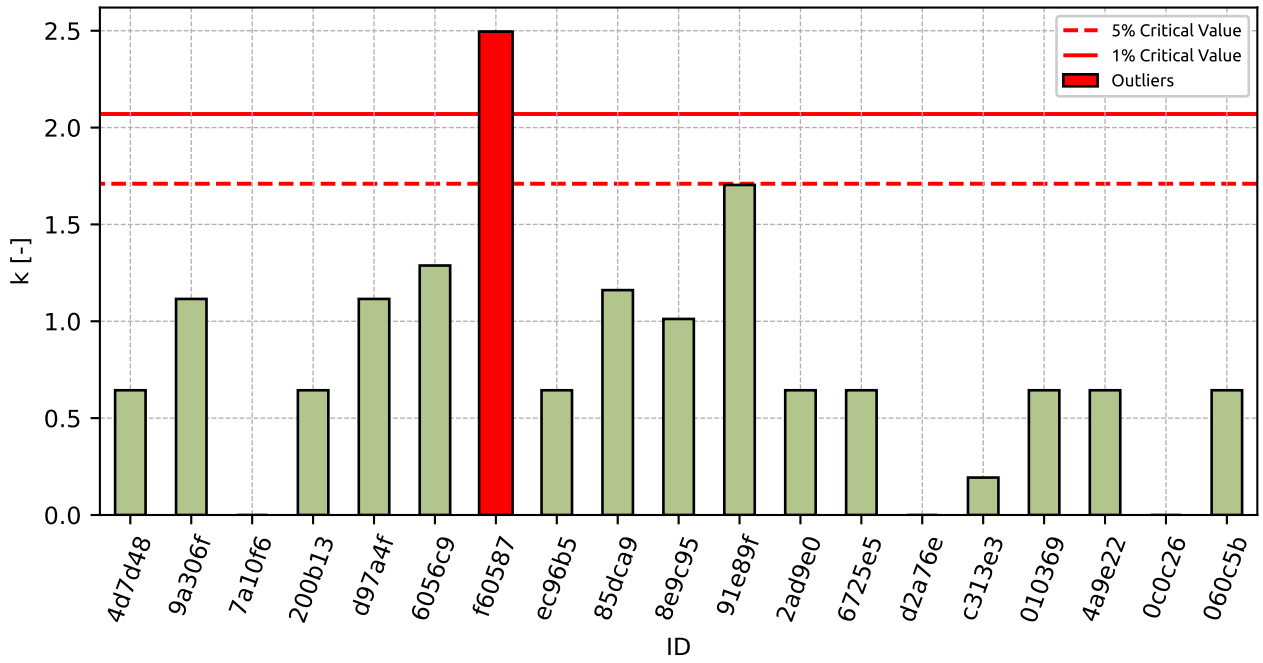

Figure 60: Intralaboratory Consistency Statistic

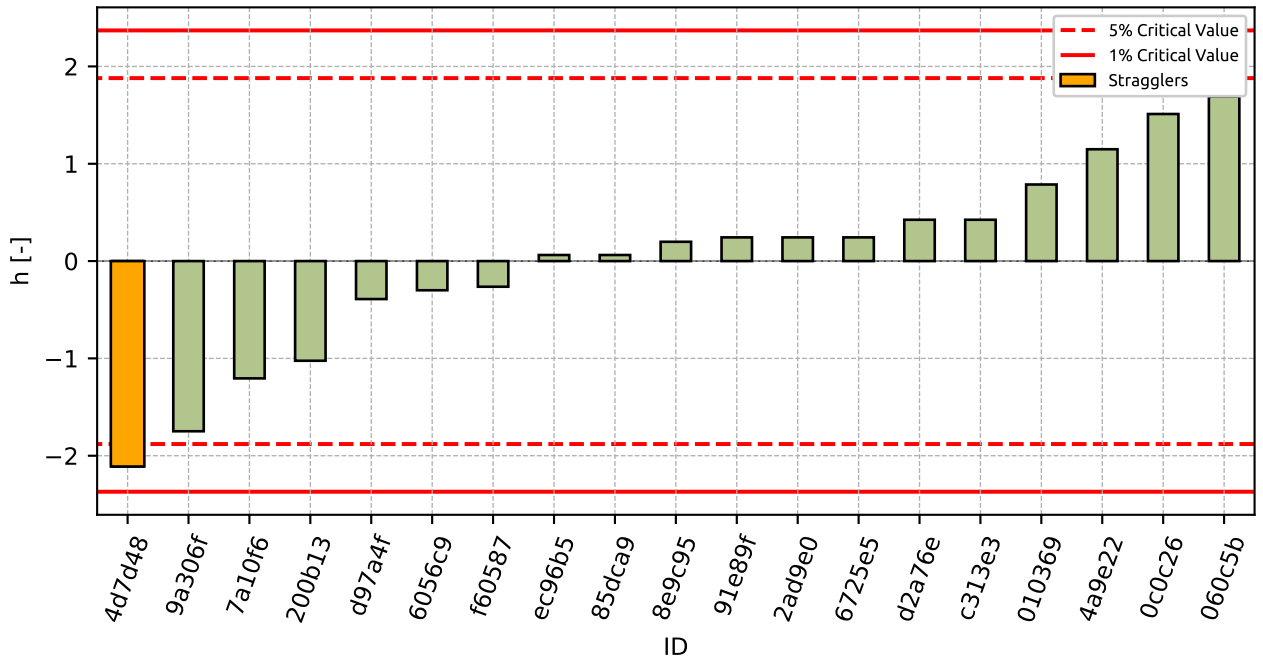

Figure 61: Interlaboratory Consistency Statistic

9.4 Descriptive statistics

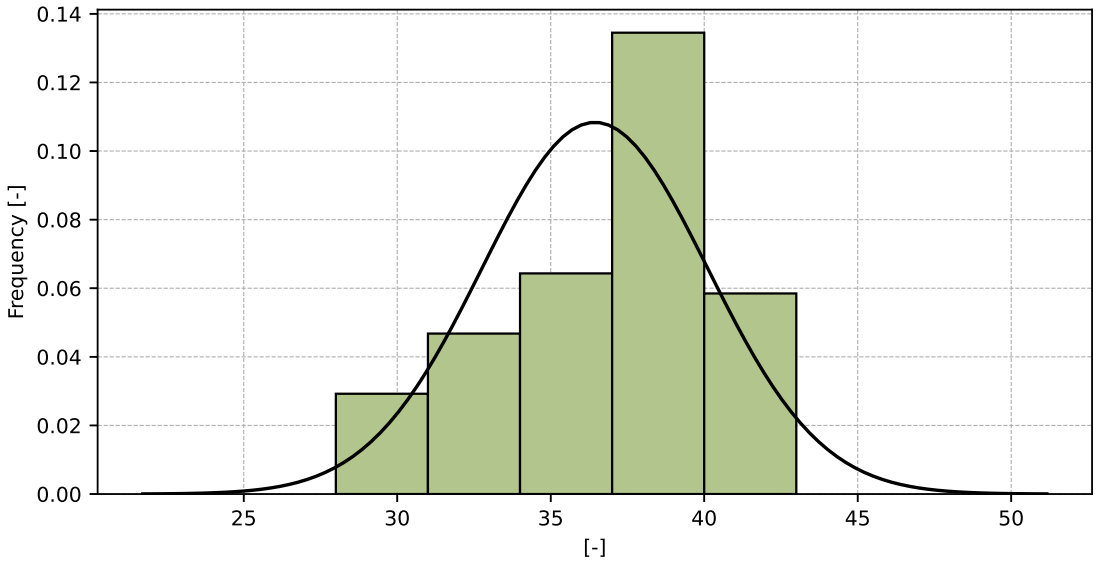

Figure 62: Histogram of all test results

Table 23: Descriptive statistics

Characteristics	[-]
Average value – $\bar{x}$	36.4
Sample standard deviation – s	3.68
Asigned value – x^*	36.4
Robust standard deviation – s^*	3.98
Measurement uncertainty of asigned value – u_X	0.91
p-value of normality test	0.03 [-]
Interlaboratory standard deviation – s_L	3.64
Repeatability standard deviation – s_r	0.9
Reproducibility standard deviation – s_R	3.75
Repeatability – r	2.5
Reproducibility – R	10.5

9.5 Evaluation of Performance Statistics

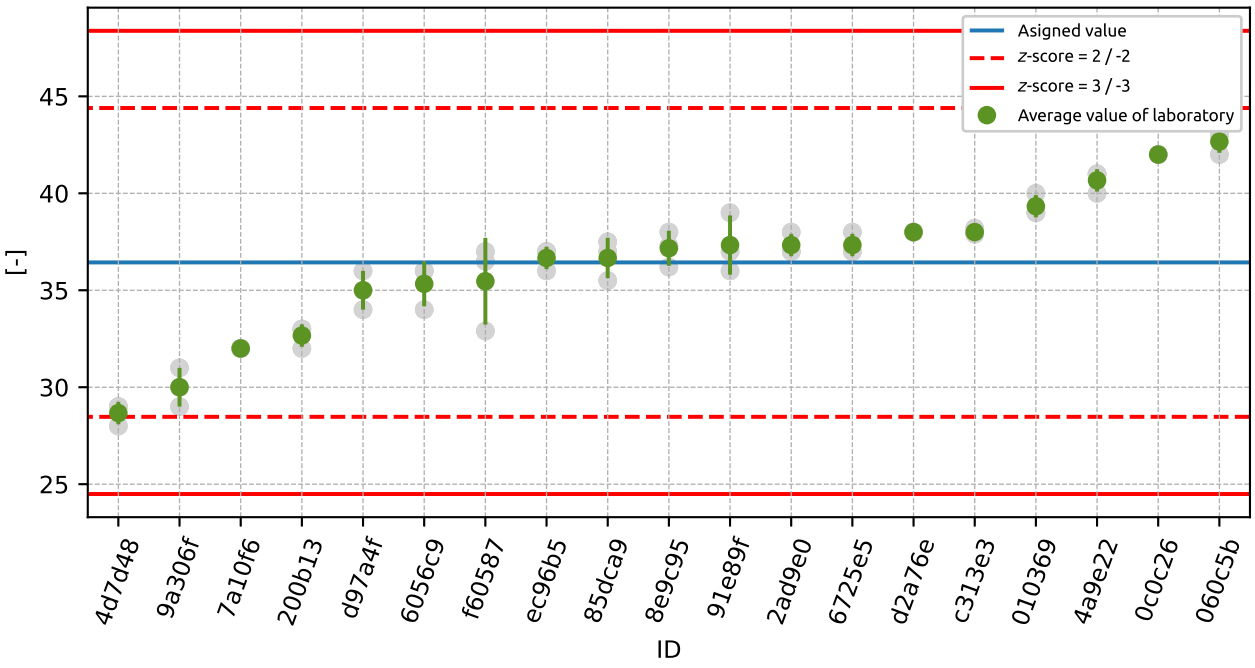

Figure 63: Average values and sample standard deviations

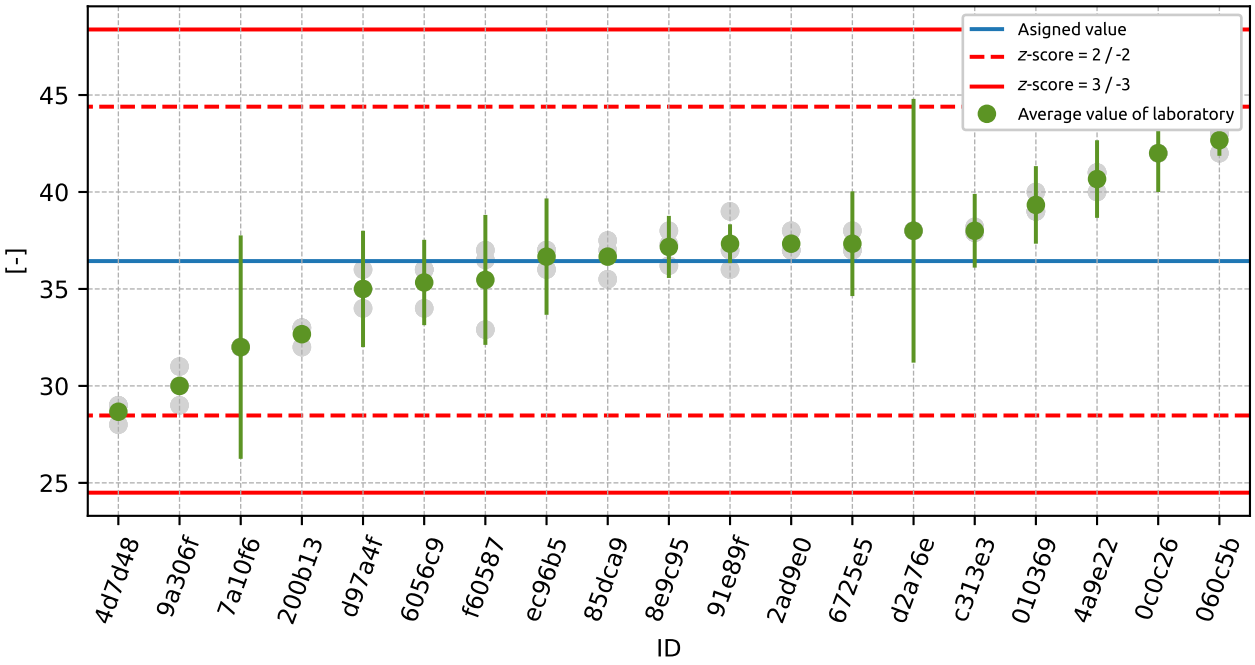

Figure 64: Average values and extended uncertainties of measurement

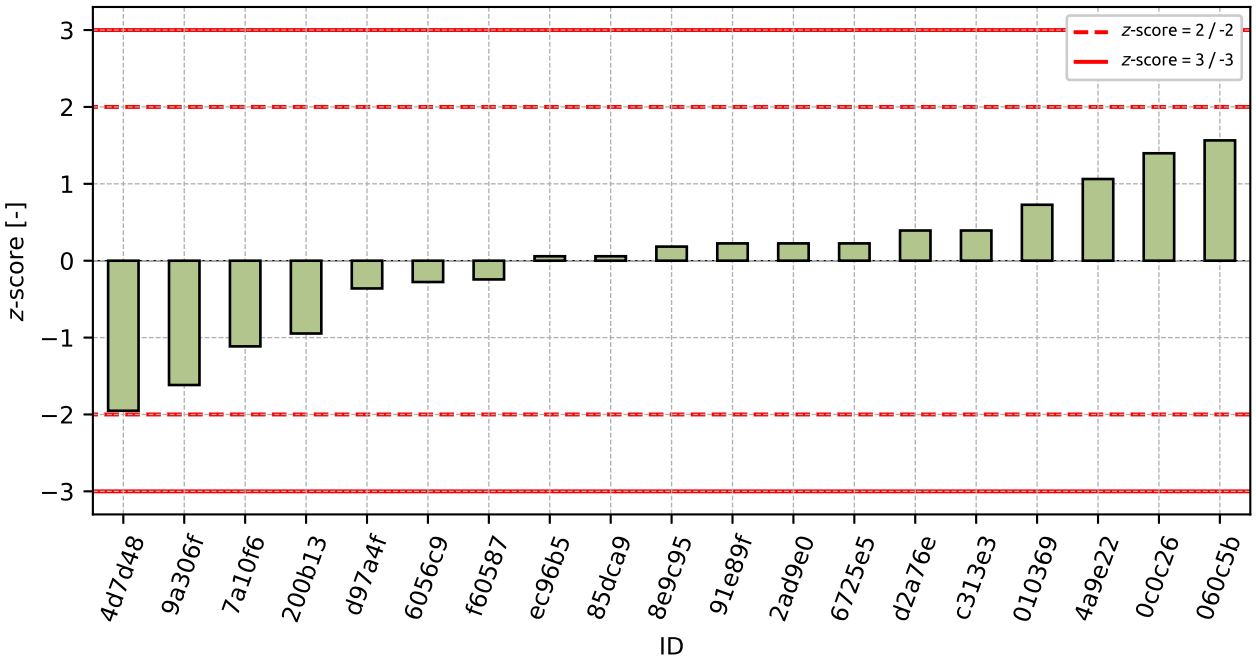

Figure 65: z-score

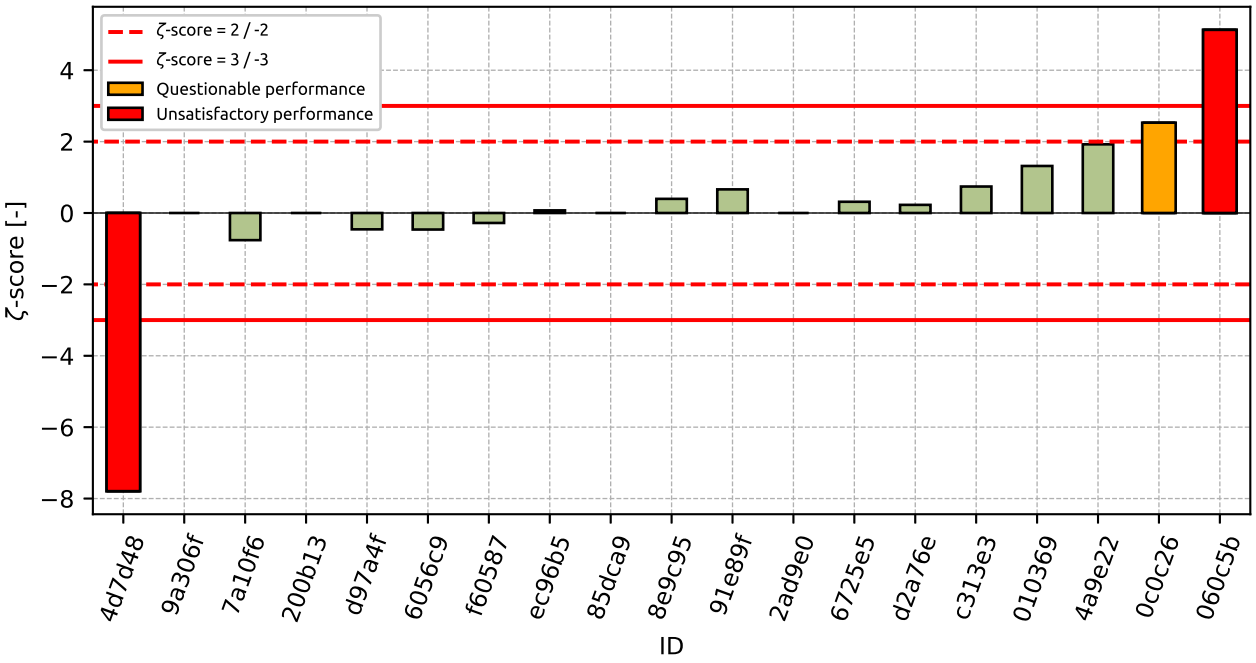

Figure 66: ζ-score

Table 24: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
4d7d48	-1.95	-7.79
9a306f	-1.62	-
7a10f6	-1.11	-0.76
200b13	-0.95	-
d97a4f	-0.36	-0.46
6056c9	-0.28	-0.46
f60587	-0.24	-0.28
ec96b5	0.06	0.07
85dca9	0.06	-
8e9c95	0.18	0.4
91e89f	0.23	0.66
2ad9e0	0.23	-
6725e5	0.23	0.31
d2a76e	0.39	0.23
c313e3	0.39	0.74
010369	0.73	1.32
4a9e22	1.06	1.92
0c0c26	1.4	2.53
060c5b	1.56	5.13

10 Appendix – EN 1542, ČSN 736242, Appendix B – Measurement of bond strength by pull-off

10.1 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 [MPa]					u_X [MPa]	$\bar{x}$ [MPa]	s_0 [MPa]	V_X [%]
d2a76e	3.1	3.2	2.8	2.9	3.6	0.3	3.1	0.31	9.97
ec96b5	3.2	3.7	2.0	3.4	3.8	0.5	3.2	0.71	21.9
b81e93	3.5	3.8	3.6	3.6	3.5	0.2	3.6	0.12	3.4
4a9e22	4.1	3.8	4.0	3.1	3.5	0.3	3.7	0.41	10.98
8e9c95	3.4	4.0	3.8	3.8	3.7	0.2	3.7	0.22	5.86
2ad9e0	3.8	3.9	3.7	3.8	3.8	-	3.8	0.08	2.13
91e89f	4.3	3.5	3.7	3.1	4.5	0.1	3.8	0.58	15.08
5b34fc	3.8	3.9	3.7	4.0	4.1	0.3	3.9	0.16	4.05
85dca9	3.8	4.1	3.8	4.0	4.0	-	3.9	0.16	4.1
7a10f6	4.1	4.1	3.7	4.2	3.9	0.4	4.0	0.2	5.0
fbf223	3.5	3.9	4.2	4.4	4.5	0.5	4.1	0.41	9.91
105a8a	4.0	4.3	4.3	4.4	4.0	0.7	4.2	0.18	4.25
78ecc0	4.8	3.7	4.7	4.6	4.1	0.4	4.4	0.47	10.64
f60587	4.6	4.3	5.0	4.2	4.5	0.6	4.5	0.3	6.65

10.2 The Numerical Procedure for Determining Outliers

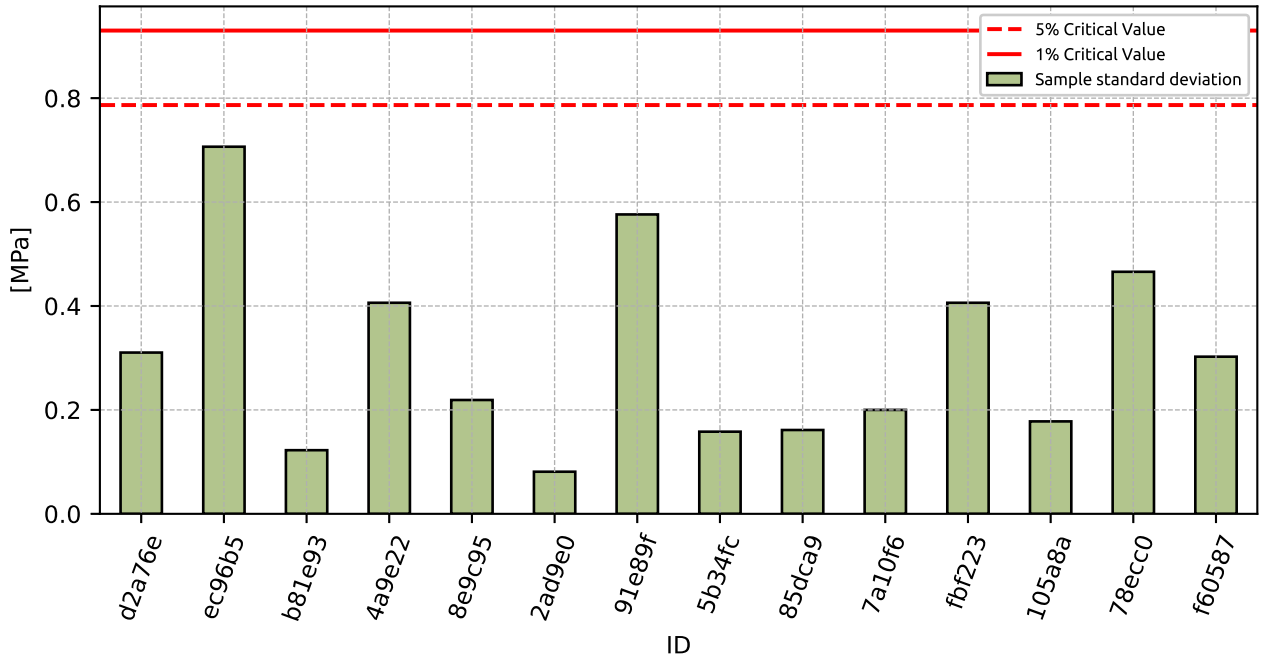

Figure 67: **Cochran's test** - sample standard deviations

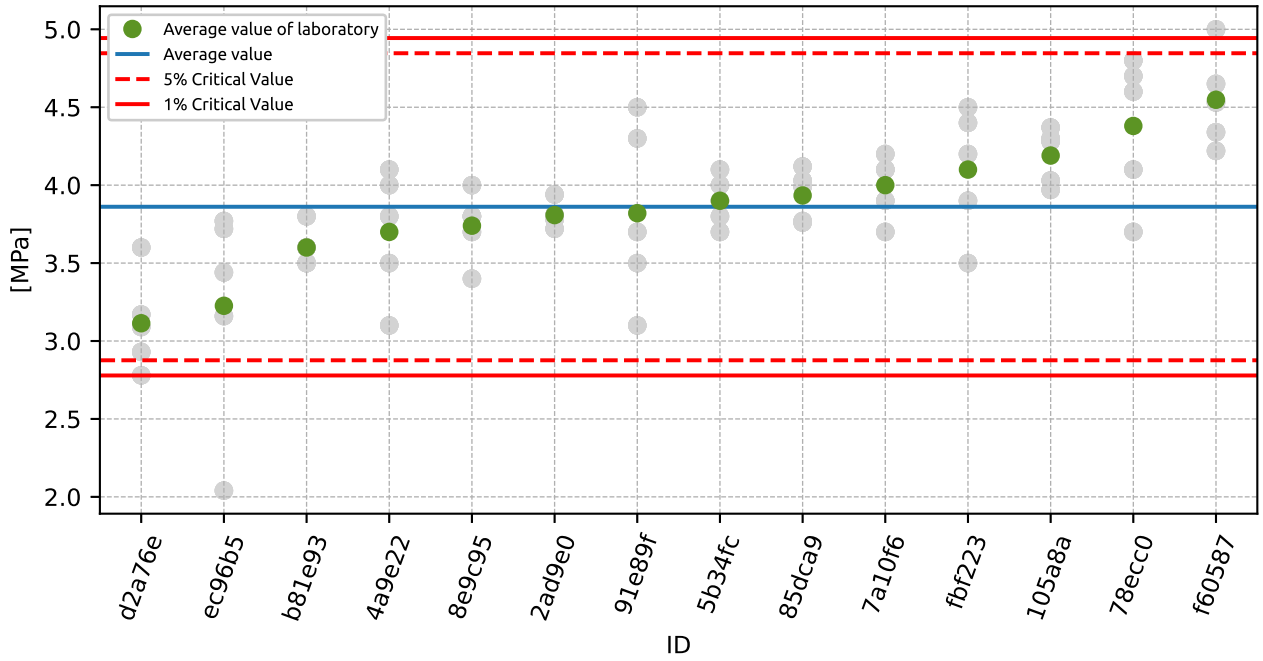

Figure 68: **Grubbs' test** - average values

10.3 Mandel's Statistics

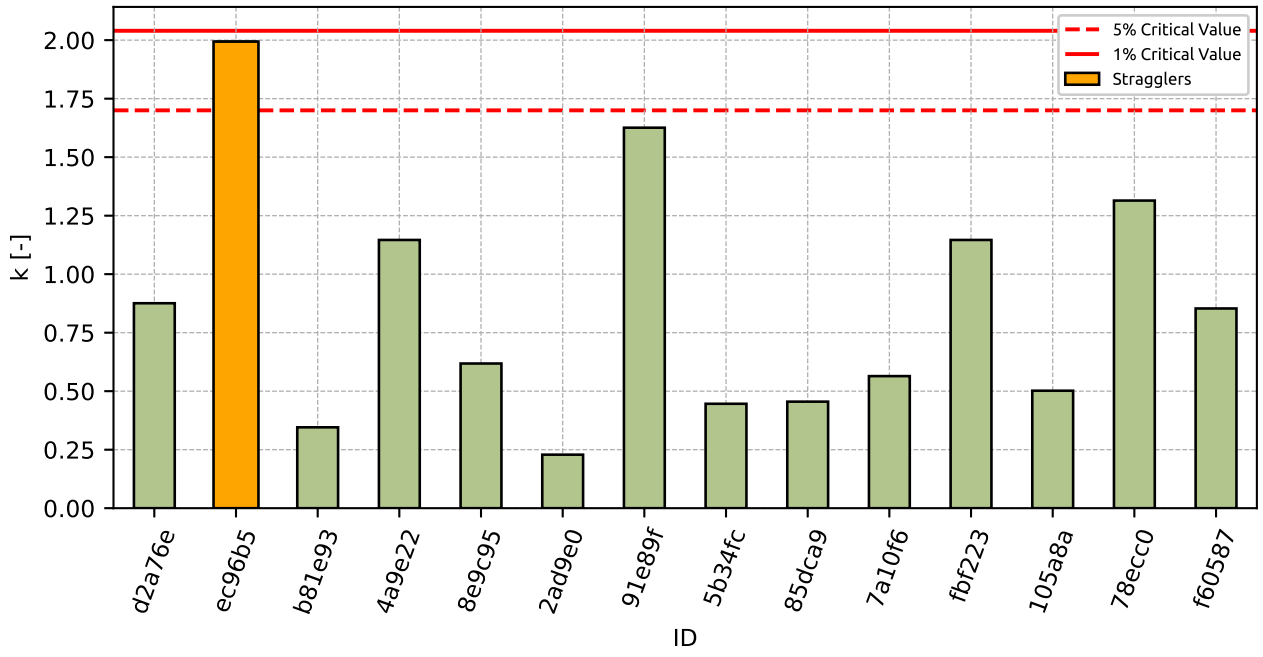

Figure 69: Intralaboratory Consistency Statistic

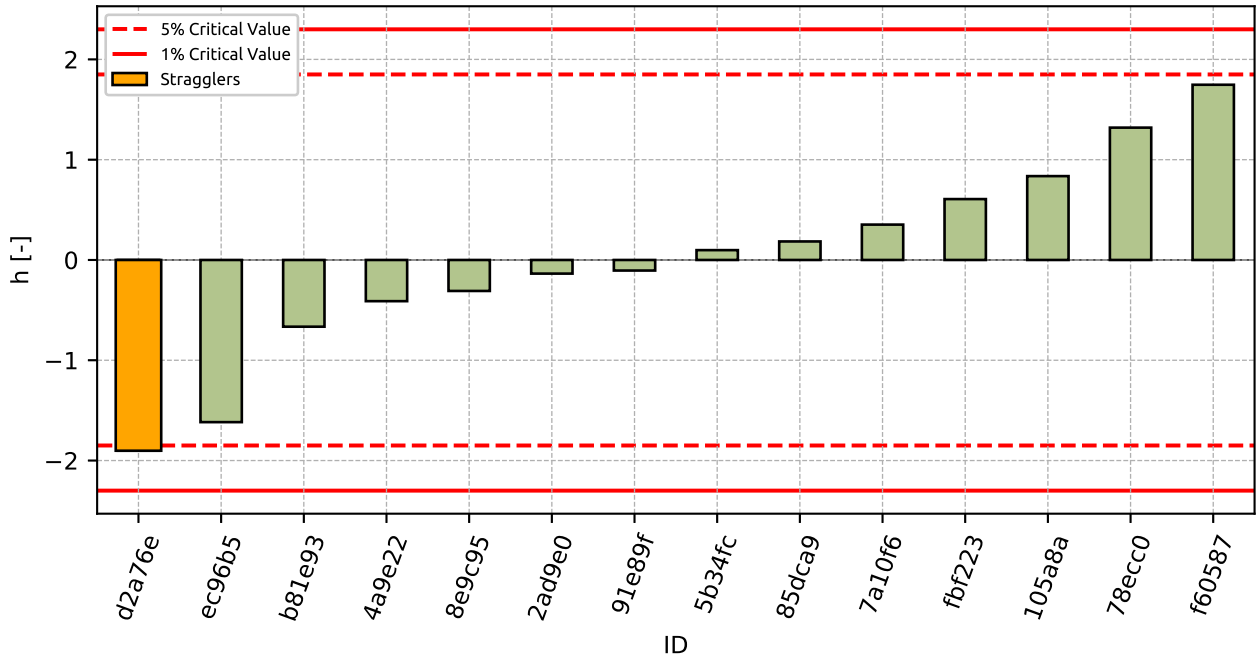

Figure 70: Interlaboratory Consistency Statistic

10.4 Descriptive statistics

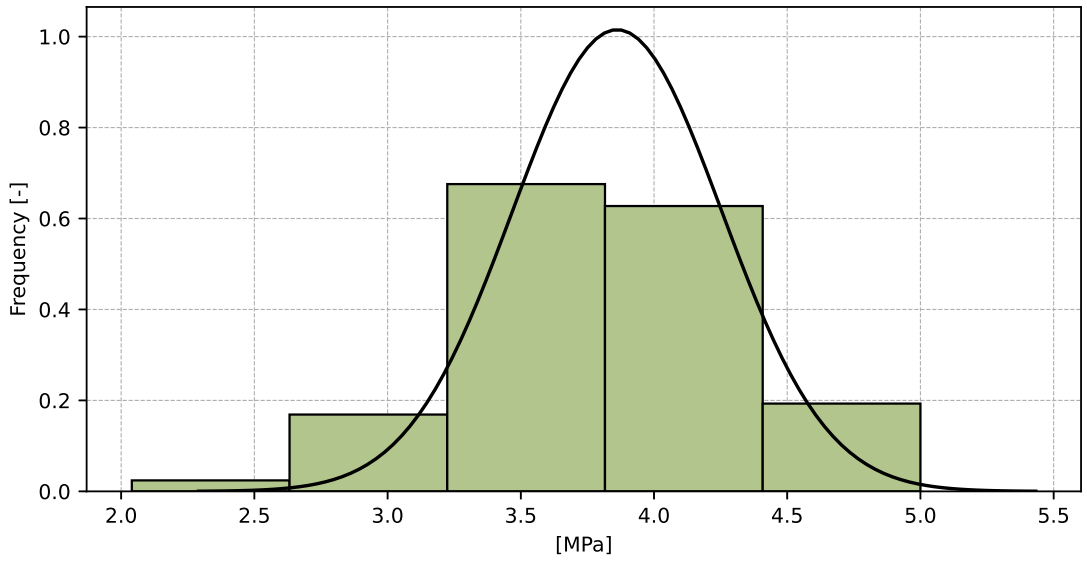

Figure 71: Histogram of all test results

Table 26: Descriptive statistics

Characteristics	[MPa]
Average value – $\bar{x}$	3.9
Sample standard deviation – s	0.39
Asigned value – x^*	3.9
Robust standard deviation – s^*	0.39
Measurement uncertainty of asigned value – u_X	0.11
p-value of normality test	0.062 [-]
Interlaboratory standard deviation – s_L	0.36
Repeatability standard deviation – s_r	0.35
Reproducibility standard deviation – s_R	0.5
Repeatability – r	1.0
Reproducibility – R	1.4

10.5 Evaluation of Performance Statistics

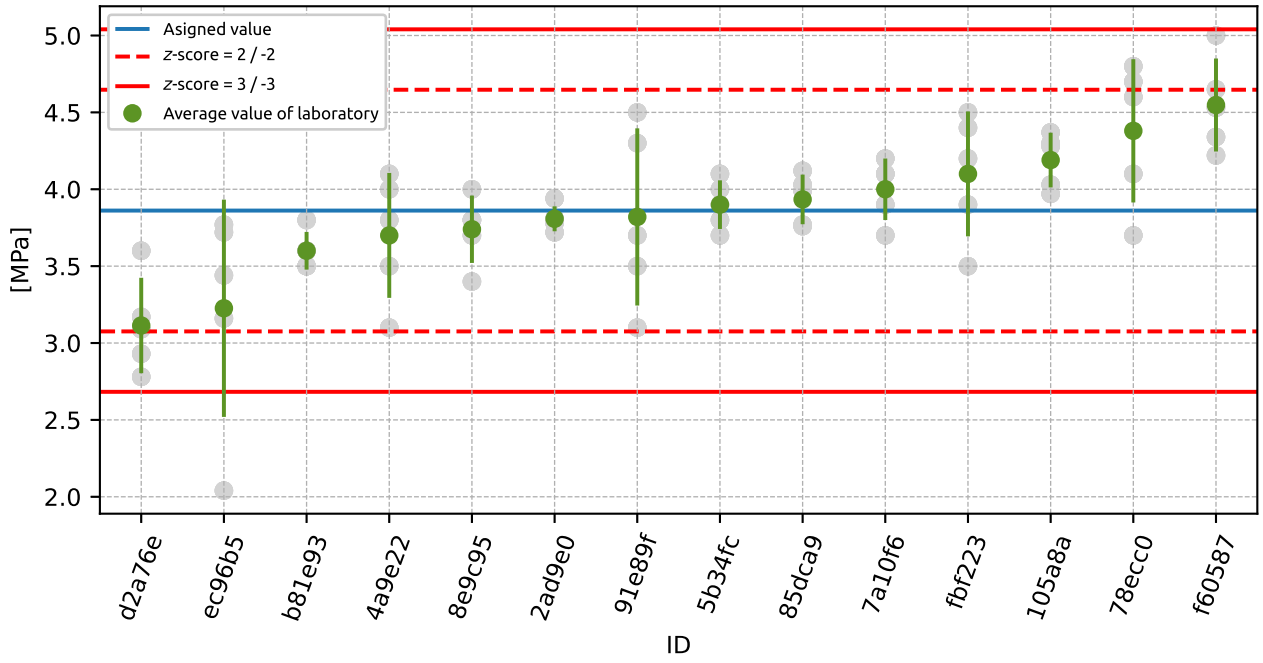

Figure 72: Average values and sample standard deviations

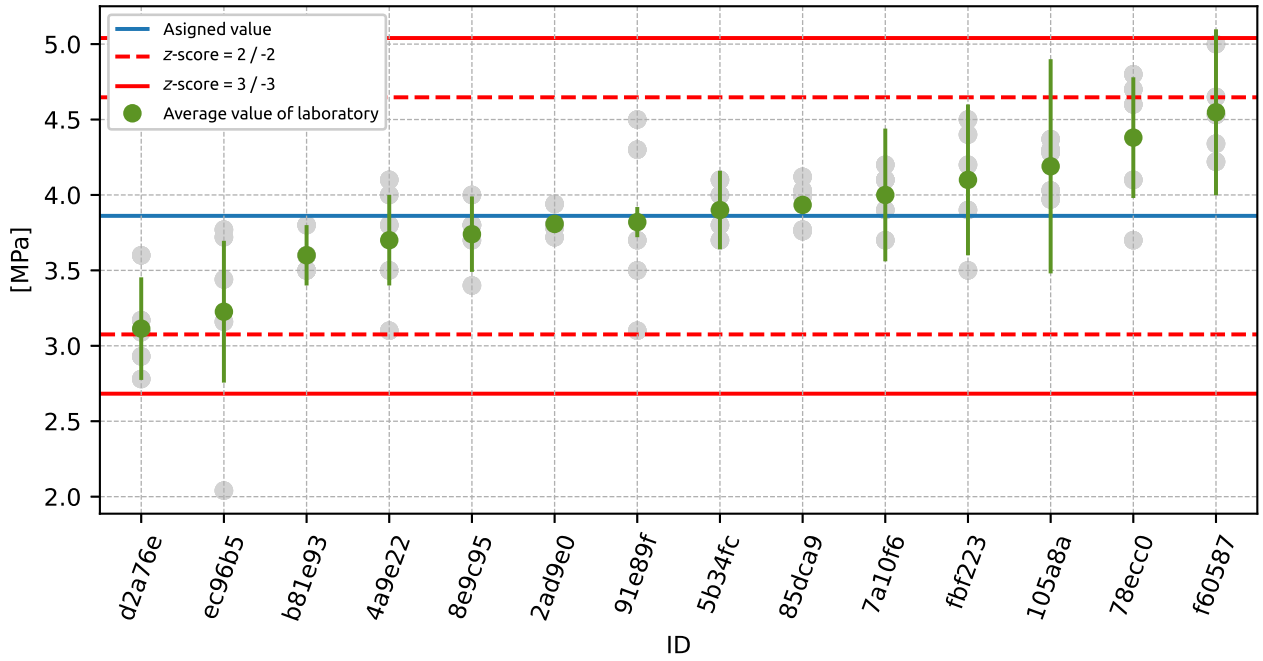

Figure 73: Average values and extended uncertainties of measurement

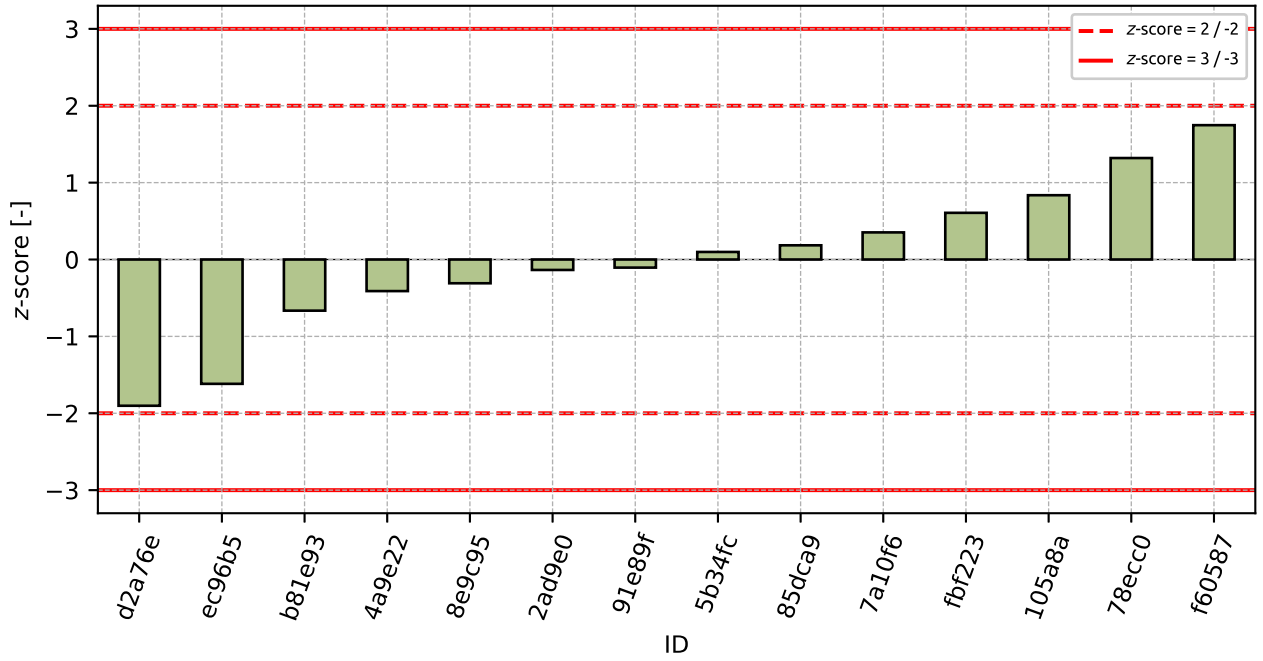

Figure 74: z-score

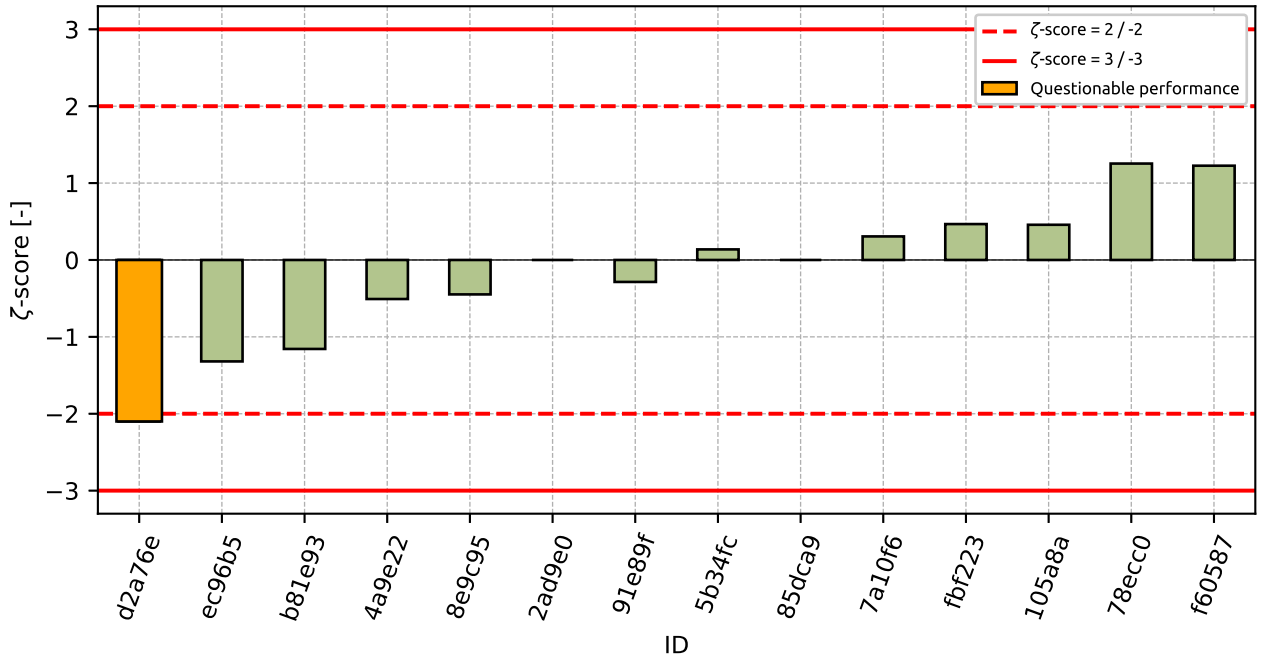

Figure 75: ζ-score

Table 27: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
d2a76e	-1.9	-2.1
ec96b5	-1.62	-1.32
b81e93	-0.67	-1.16
4a9e22	-0.41	-0.51
8e9c95	-0.31	-0.45
2ad9e0	-0.14	-
91e89f	-0.11	-0.29
5b34fc	0.1	0.14
85dca9	0.18	-
7a10f6	0.35	0.31
fbf223	0.61	0.47
105a8a	0.84	0.46
78ecc0	1.32	1.25
f60587	1.75	1.23