BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
institute of building testing

FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Strength and Durability of Hardened Concrete
ZZB 2022/1

Brno University of Technology
Proficiency testing provider at the SZK FAST
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Date: July, 29th 2022

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1 Introduction and Important Contacts

In the year 2022, the Proficiency Testing Provider at the SZK FAST (PT Provider) initiated the Proficiency Testing Program (PTP) designated ZZB 2022/1 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

Assoc. Prof. Ing. Tomáš Vymazal, Ph.D.
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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 12390-7** – Density of hardened concrete [2].
3. **EN 12390-8** – Depth of penetration of water under pressure [3].
4. **EN 480-11** – Determination of air void characteristics in hardened concrete [4].
5. **ČSN 73 1322** – Determination of frost resistance of concrete [5].
6. **ČSN 73 1324** – Determination of grindability of concrete [6].
7. **ČSN 73 1326** – Resistance of cement concrete surface to water and defrosting chemicals – Method A [7].
8. **ČSN 73 1326** – Resistance of cement concrete surface to water and defrosting chemicals – Method C [7].
9. **CEN/TS 12390-9** – Freeze-thaw resistance – Scaling [8].

Testing procedure 6 and 9 was not open due to low interest from laboratories.

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 [9]. 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 [10] and with EN ISO/IEC 17043 [11]. The outcome is the present final report summarizing the results of the interlaboratory comparison, including statistical evaluation.

54 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 (tests designated according to part 1)

ID / Testing method	1	2	3	4	5	6	7	8	9
b52acf	X	X	X	-	-	-	-	-	-
6c2487	-	-	X	-	-	-	-	-	-
df4d0f	X	-	X	X	-	-	X	-	-
989058	X	-	-	-	-	-	-	-	-
37c007	-	-	-	X	-	-	-	-	-
6ed82b	X	X	X	-	-	-	X	-	-
facf57	-	-	X	-	-	-	-	-	-
6e9ea6	X	X	X	-	X	-	-	-	-
af100e	X	-	-	-	-	-	X	-	-
4c82fb	X	-	-	-	-	-	-	-	-
bb6bdd	-	-	X	-	-	-	-	-	-
82c46f	-	-	X	-	-	-	-	X	-
c87900	X	X	X	-	-	-	-	X	-
01ddc2	X	X	-	-	-	-	-	-	-
1a9b52	-	-	-	-	-	-	X	-	-
cc07d4	X	-	-	-	-	-	-	-	-
26f900	X	-	-	-	-	-	-	-	-
fbc27e	X	X	-	-	-	-	-	-	-
169dcb	X	X	-	-	-	-	-	-	-
51e368	X	-	X	-	-	-	-	-	-
6dbc32	X	X	X	-	X	-	X	-	-
a27cc0	X	X	-	-	-	-	-	-	-
7e10c2	X	X	X	-	-	-	-	X	-
7ba334	X	X	-	X	-	-	-	-	-
a38a65	-	-	X	-	-	-	-	-	-
8fa288	X	X	-	-	-	-	-	-	-
d439b1	X	X	X	-	-	-	X	-	-
61962a	X	X	X	-	-	-	-	-	-
a35f46	X	X	-	-	-	-	-	-	-
71016f	X	X	-	-	-	-	-	-	-
cc1bc4	X	X	X	-	-	-	-	X	-
5c85f7	X	X	-	-	-	-	-	-	-
744786	-	-	X	-	-	-	-	-	-
426734	X	X	X	-	X	-	-	X	-
ad3746	X	X	X	-	-	-	-	X	-
c91771	X	X	X	-	-	-	-	-	-
153cae	X	X	X	-	-	-	-	X	-
cbcf55	X	X	X	-	-	-	-	-	-
b0f36e	X	X	X	-	-	-	-	-	-
9de304	X	X	X	-	-	-	X	-	-
c688a3	-	-	X	X	-	-	X	X	-
00ca75	-	-	-	-	X	-	X	-	-
91f096	X	-	-	-	-	-	-	-	-
cd9809	-	-	-	-	X	-	-	-	-
8ccfce	-	-	-	-	X	-	-	-	-
983fd0	X	X	-	-	-	-	-	-	-
61a7d1	-	-	X	X	-	-	-	-	-

ID / Testing method	1	2	3	4	5	6	7	8	9
7079bd	X	X	X	-	-	-	-	-	-
8b7553	X	X	X	-	-	-	-	-	-
3e5825	-	-	X	-	-	-	-	-	-
1ca5d9	X	X	X	-	-	-	X	-	-
70c873	X	X	-	-	-	-	-	-	-
3730f3	X	-	-	-	-	-	-	-	-
7d3785	X	X	X	-	-	-	-	-	-

Table 2: List of participants (laboratories) – the order in the table does not correspond to the identification number in Table 1

Laboratory	Address	Accreditation number
A.D. CRNAGORAPUT Sektor za laboratorijska ispitivanja - TPA	Ulica Zetskih Vladara broj 5, Podgorica, 81000, Montenegro , Europe	-
ALFA TEST	Palaiopanagias 13, Paiania, 190 02, Attiki, Greece	-
Ang Pin Wei	71 Toh Guan Road East #02-02, TCH Techcentre, Singapore 608598, Singapore, 608598, Singapore	-
BETOTECH, s.r.o. Laboratoř Ostrava	Místecká 1121, Ostrava - Vítkovice, 703 93, Česká republika	L 1195.2
BETOTECH, s.r.o. - pracoviště Beroun	Beroun 660, Beroun, 26601, Česká Republika	AZL 1195
BETOTECH, s.r.o. - pracoviště Cheb	Beroun 660, Beroun, 26601, Česká republika	AZL 1195
BETOTECH, s.r.o. - pracoviště Jindřichův Hradec	Beroun 660, Beroun, 26601, Česká republika	AZL 1195
BETOTECH, s.r.o. - pracoviště Klatovy	Beroun 660, Beroun, 26601, Česká republika	AZL 1195
BETOTECH, s.r.o. - pracoviště Most	Beroun 660, Beroun, 26601, Česká republika	AZL 1195
BETOTECH, s.r.o. - pracoviště Trutnov	Beroun 660, Beroun, 26601, Česká republika	AZL 1195
CS-BETON s.r.o.	Velké Žernoseky 184, Litoměřice, 412 01, Česká republika	1500
Camillo Sitte Versuchsanstalt für Bautechnik	Leberstrasse 4c, Vienna, 1030, Austria	0046
Cement Hranice, akciová společnost	Bělotínská 288, Hranice I - Město, 75301, Česká republika	1284
Cemex CR s.r.o.	Semtín 102, Pardubice, 533 54, Česká republika	1302
Centrum dopravního výzkumu, v. v. i.	Líšeňská 33a, Brno, 636 00, Česká republika	1506
D.O.O. "GEOMEHANIKA"	Dobropoljsla 21, Beograd, 11000, Srbija	01-198
Danucem Slovensko a.s. , Rohožník	Danucem Slovensko a. s., Technicko - kompetenčné centrum, Pestovateľská 2, Bratislava, 821 04, Slovenská republika	426/S-313

Laboratory	Address	Accreditation number
Generalna Dyrekcja Dróg Krajowych i Autostrad Oddział w Białymstoku	Zwycięstwa 2, Białystok, 15-703, Poland	-
Geoput d.o.o. Beograd	Tome Rosandića 2, Beograd, 11010, Srbija	126366206
Gratz University of Technology	Rechbauerstrasse 12, Graz, 8010, Austria	-
Holcim (Hrvatska) d.o.o.	Koromačno 7b, Koromačno, HR 52 222, Croatia	-
Institut za beton d.o.o.	Ugrinovački put 31. deo 50, Belgrade - Zemun, 11080, Serbia	01-511
Institut za građevinarstvo "IG"	Kralja Petra I Karađorđevića 92-98, Banja Luka, 78000, Bosna i Hercegovina	-
JKV TEST s.r.o.	Suhrady 148/4, Vřesina, 747 20, Česká republika	1294
Magnel-Vandepitte Laboratory	Technologiepark-Zwijnaarde 60, Zwijnaarde (Ghent), 9052, Belgium	220-TEST
Master Builders Solutions CZ s.r.o.	K Májovu 1244, Chrudim, 537 01, Česká republika	1495
Materialprüfinstitut Nord (MPI Nord)	Raiffeisenstrasse 8, Grossburgwedel, 30938, Germany	-
Northern Regional Lab	Canna Road, Tabuan Jaya, Kuching, 93350, Sarawak, Malaysia	-
Národná diaľničná spoločnosť a. s.	Dúbravská cesta 14, Bratislava, 84104, Slovenská republika	456/S-328
QCONTROL s.r.o., odštěpný závod - PRACOVIŠTĚ DĚČÍN	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 Dobřany	U místní dráhy, 939/5, Olomouc - Nová Ulice, 779 00, Česká republika	1135.2
Skanska a.s.	Křižíkova 682/34a, Praha 8- Karlín, 186 00, Česká republika	1355
Stachema CZ s.r.o. - zkušební laboratoř - pracoviště 1	Hasičská 1, Zibohlavy, Kolín, 28002, Česká republika	1433
TESTAV-LAB s.r.o.	Chodská 7, Liberec 3, 466 10, ČR	1180
TPA za obezbeđenje kvaliteta i inovacije d.o.o. Beograd	Milutina Milankovića 3B, Novi Beograd, 11070, Serbia	01-280
TPA ČR s.r.o. - pracoviště Ostrava	Vrbenská 1821/31, České Budějovice, 370 06, Česká republika	1181
TPA ČR, s.r.o. - pracoviště Praha	Vrbenská 1821/31, České Budějovice, 370 06, Česká republika	1181
TPA ČR, s.r.o. - pracoviště č.1 České Budějovice	Vrbenská 1821/31, České Budějovice, 370 06, Česká republika	1181
TPA ČR, s.r.o. pracoviště č.4 Velká Bystřice	Tovární 731, Velká Bystřice, 783 53, Česká republika	1181
TZÚS Praha, s.p. - pobočka 0200 České Budějovice	Nemanická 441/8, České Budějovice, 37010, Česká republika	1018.3
Technický a zkušební ústav Praha, s.p., Centrální laboratoř, zkušebna 0500 Předměřice nad Labem	Průmyslová 283, Předměřice nad Labem, 503 02, Česká republika	1018.3

Laboratory	Address	Accreditation number
Technický a zkušební ústav stavební Praha, s. p., Centrální laboratoř - zkušebna Brno	Hněvkovského 77, Brno, 61700, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p.	Tolstého 447, Teplice, 41503, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p.	U Studia 14, Ostrava - Zábřeh, 70030, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p. Pobočka Plzeň	Zahradní 15, Plzeň, 326 00, Česká republika	1018.3
Universität für Bodenkultur Wien, Department für Bautechnik und Naturgefahren, Institut für Konstruktiven Ingenieurbau	Peter-Jordan-Str. 82, Vienna, 1190, Austria	-
Univerzitet u Zenici, Institut "Kemal Kapetanovic" u Zenica	Travnička cesta br.7, Zenica, 72 000, Bosna i Herzegovina	-
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
Výzkumný ústav pozemních staveb - Certifikační společnost s.r.o. - Pobočka Brno	Pražská 810/16, Praha 10, 102 21, Česká republika	1234
Výzkumný ústav pozemních staveb - Certifikační společnost s.r.o. - Pobočka Praha-Uhříněves	Pražská 810/16, Praha 10, 102 21, Česká republika	1234
Z7008	Veveří 95, Brno, 60200, Česká republika	Z7008
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

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 Strength and Durability of Hardened Concrete (PT Program) organized by the PT Provider at the SZK FAST. 54 participants (laboratories) took part in the PT Program. The program focused on ordinary standardized testing of hardened concrete with emphasis on its strength and durability. 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 3 shows the evaluation of the laboratory performance according to EN ISO/IEC 17043 [11].

Test procedures 7 and 8 were evaluated as a multilevel experiment. The level of the experiment was always composed of the number of freeze-thaw cycles. Laboratory performance was marked other than satisfactory only when critical z-score values were exceeded at two or more experiment levels.

Table 3: 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
b52acf	✓	✓	✓	-	-	-	-	-	-
6c2487	-	-	✓	-	-	-	-	-	-
df4d0f	✓	-	✓	✓	-	-	✓	-	-
989058	✓	-	-	-	-	-	-	-	-
37c007	-	-	-	✓	-	-	-	-	-
6ed82b	?	✓	✓	-	-	-	✓	-	-
facf57	-	-	✓	-	-	-	-	-	-
6e9ea6	✓	✓	✓	-	✓	-	-	-	-
af100e	✓	-	-	-	-	-	?	-	-
4c82fb	✓	-	-	-	-	-	-	-	-
bb6bdd	-	-	✓	-	-	-	-	-	-
82c46f	-	-	✓	-	-	-	-	✓	-
c87900	?	✓	✓	-	-	-	-	✓	-
01ddc2	✓	✓	-	-	-	-	-	-	-
1a9b52	-	-	-	-	-	-	✓	-	-
cc07d4	?	-	-	-	-	-	-	-	-
26f900	✓	-	-	-	-	-	-	-	-
fbc27e	✓	✓	-	-	-	-	-	-	-
169dcb	✓	✓	-	-	-	-	-	-	-
51e368	?	-	?	-	-	-	-	-	-
6dbc32	✓	✓	✓	-	✓	-	✓	-	-
a27cc0	✓	✓	-	-	-	-	-	-	-
7e10c2	✓	✓	✓	-	-	-	-	✓	-
7ba334	✓	✓	-	✓	-	-	-	-	-
a38a65	-	-	✓	-	-	-	-	-	-

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ID / Method	1	2	3	4	5	6	7	8	9
8fa288	✓	✓	-	-	-	-	-	-	-
d439b1	✓	✓	✓	-	-	-	✓	-	-
61962a	✓	✓	✓	-	-	-	-	-	-
a35f46	✓	✓	-	-	-	-	-	-	-
71016f	✓	✓	-	-	-	-	-	-	-
cc1bc4	✓	✓	✓	-	-	-	-	✓	-
5c85f7	✓	✓	-	-	-	-	-	-	-
744786	-	-	✓	-	-	-	-	-	-
426734	✓	✓	✓	-	✓	-	-	✓	-
ad3746	✓	✓	✓	-	-	-	-	✓	-
c91771	✓	✓	✓	-	-	-	-	-	-
153cae	✓	✓	✓	-	-	-	-	✓	-
cbcf55	✓	✓	✓	-	-	-	-	-	-
b0f36e	✓	✓	✓	-	-	-	-	-	-
9de304	✓	✓	✓	-	-	-	✓	-	-
c688a3	-	-	✓	✓	-	-	✓	✓	-
00ca75	-	-	-	-	✓	-	✓	-	-
91f096	✓	-	-	-	-	-	-	-	-
cd9809	-	-	-	-	✓	-	-	-	-
8ccfce	-	-	-	-	✓	-	-	-	-
983fd0	✓	✓	-	-	-	-	-	-	-
61a7d1	-	-	✓	✓	-	-	-	-	-
7079bd	✓	✓	✓	-	-	-	-	-	-
8b7553	✓	✓	✓	-	-	-	-	-	-
3e5825	-	-	✓	-	-	-	-	-	-
1ca5d9	✓	✓	✓	-	-	-	✓	-	-
70c873	✓	✓	-	-	-	-	-	-	-
3730f3	✓	-	-	-	-	-	-	-	-
7d3785	X	✓	?	-	-	-	-	-	-

References

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

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

[3] EN 12390-8. *Testing hardened concrete - Part 8: Depth of penetration of water under pressure*. 2020.

[4] EN 480-11. *Admixtures for concrete, mortar and grout - Test methods - Part 11: Determination of air void characteristics in hardened concrete*. 2006.

[5] ČSN 73 1322. *Determination of frost resistance of concrete*. 2003.

[6] ČSN 73 1324. *Determination of grindability of concrete*. 2003.

[7] ČSN 73 1326. *Resistance of cement concrete surface to water and defrosting chemicals*. 2003.

[8] CEN/TS 12390-9. *Testing hardened concrete - Part 9: Freeze-thaw resistance - Scaling*. 2007.

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

[10] 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.

[11] 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 [%]
51e368	46.0	43.3	42.4	4.0	43.9	1.87	4.27
cc07d4	43.4	45.7	43.9	1.2	44.3	1.21	2.73
26f900	46.0	43.5	45.7	1.6	45.1	1.37	3.03
df4d0f	44.6	48.7	43.8	4.9	45.7	2.63	5.75
cc1bc4	45.1	46.9	46.5	2.3	46.2	0.95	2.05
af100e	47.4	44.5	47.0	0.0	46.3	1.61	3.47
9de304	45.6	47.8	45.5	2.9	46.3	1.3	2.81
4c82fb	46.7	45.7	46.6	0.3	46.3	0.55	1.19
983fd0	41.2	49.3	48.8	12.1	46.4	4.54	9.78
01ddc2	46.6	45.4	47.5	0.5	46.5	1.1	2.36
b52acf	46.5	46.4	47.0	2.5	46.6	0.32	0.69
6e9ea6	47.1	47.7	45.5	0.5	46.8	1.14	2.43
3730f3	48.7	46.7	45.4	-	46.9	1.68	3.58
61962a	47.3	47.7	46.1	-	47.0	0.83	1.77
8fa288	49.7	45.2	46.4	7.0	47.1	2.33	4.95
6dbc32	46.5	48.0	46.9	3.3	47.1	0.78	1.65
7ba334	48.3	47.7	45.4	1.0	47.1	1.53	3.25
a27cc0	48.5	46.2	47.4	2.5	47.4	1.15	2.43
fbc27e	47.5	51.5	43.5	0.4	47.5	4.0	8.42
d439b1	47.4	47.8	47.5	2.3	47.6	0.21	0.44
71016f	47.5	48.2	47.6	0.7	47.8	0.38	0.79
70c873	46.2	47.8	49.4	1.0	47.8	1.6	3.35
c91771	47.3	48.6	47.8	1.6	47.9	0.66	1.37
7e10c2	47.4	48.1	48.3	1.7	47.9	0.47	0.99
cbcf55	48.7	46.9	48.4	0.2	48.0	0.96	2.01
a35f46	48.0	47.7	48.8	1.0	48.2	0.57	1.18
153cae	48.3	48.8	47.5	1.2	48.2	0.66	1.36
b0f36e	48.5	47.8	48.5	1.2	48.3	0.4	0.84
169dcb	47.2	47.8	50.5	3.0	48.5	1.76	3.62
ad3746	49.3	47.7	48.7	0.2	48.6	0.81	1.66
1ca5d9	49.1	48.4	48.3	2.7	48.6	0.44	0.9
7079bd	48.0	49.3	48.6	2.0	48.6	0.65	1.34
5c85f7	50.3	47.5	48.6	1.5	48.8	1.41	2.89
426734	48.8	49.6	48.9	3.5	49.1	0.44	0.89
989058	50.3	48.3	49.5	-	49.4	1.01	2.04
8b7553	50.2	49.0	49.5	3.1	49.6	0.6	1.22
91f096	51.1	49.2	48.7	0.4	49.7	1.27	2.55
c87900	51.8	50.9	49.9	-	50.9	0.99	1.95
6ed82b	52.5	50.0	50.5	4.5	51.0	1.32	2.59
7d3785	55.9	55.3	54.3	-	55.2	0.81	1.47

1.2 The Numerical Procedure for Determining Outliers

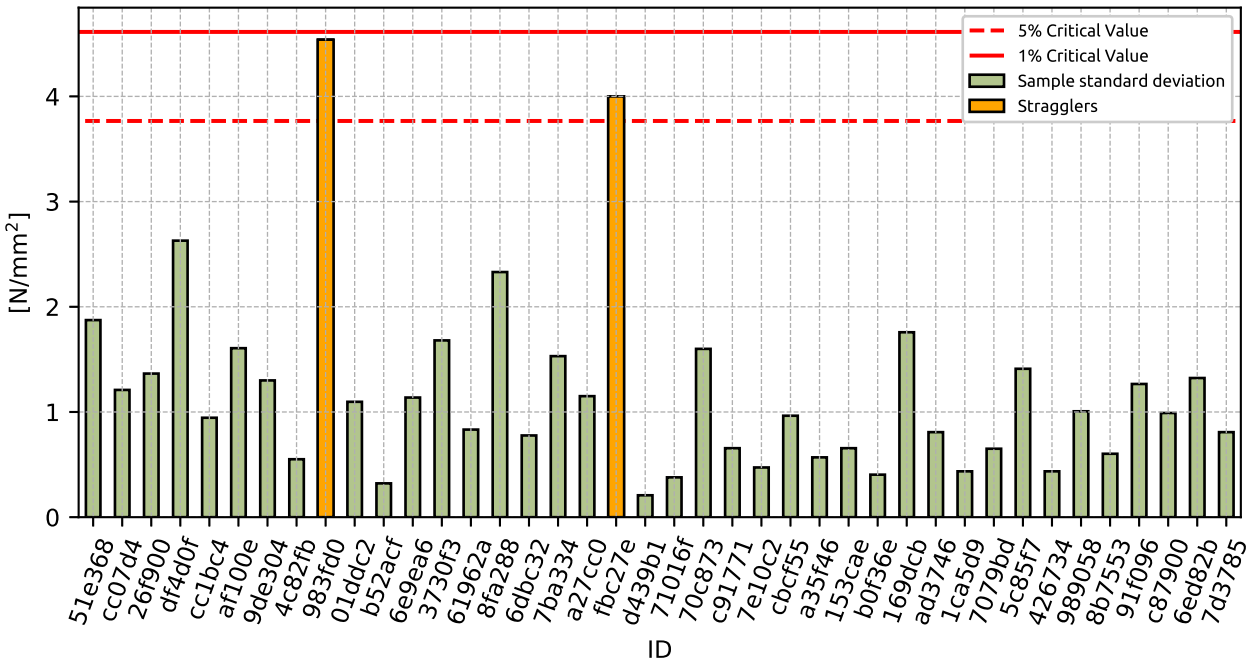

Figure 1: **Cochran's test** - sample standard deviations

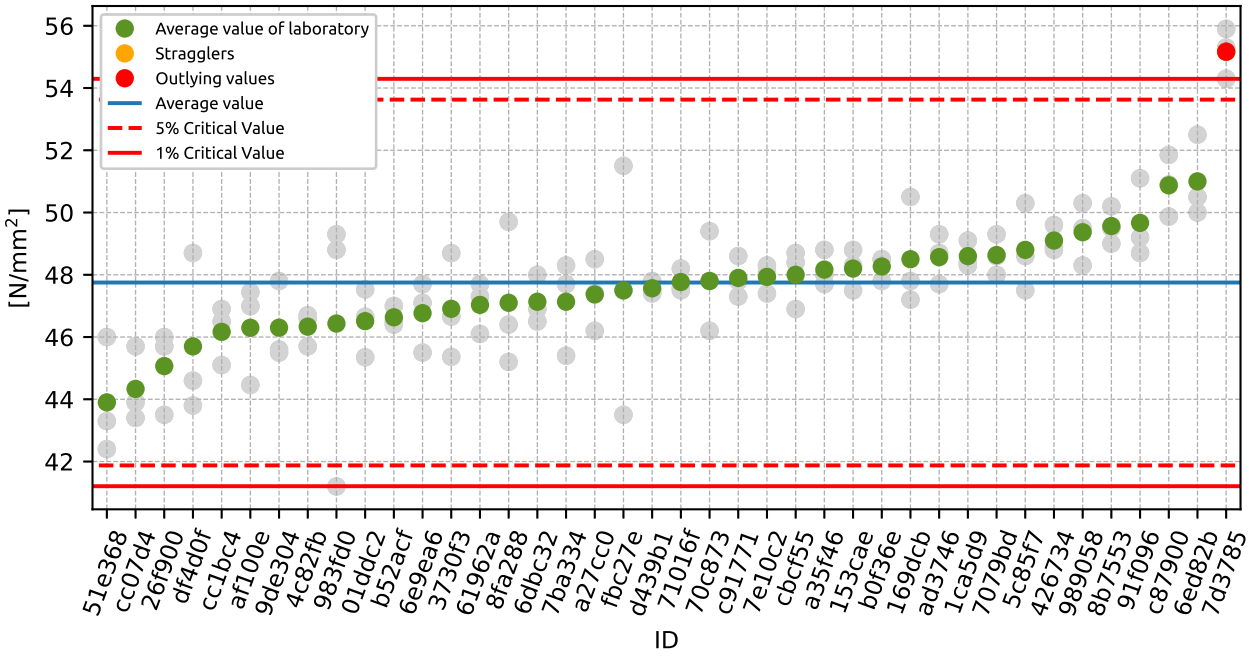

Figure 2: **Grubbs' test** - average values

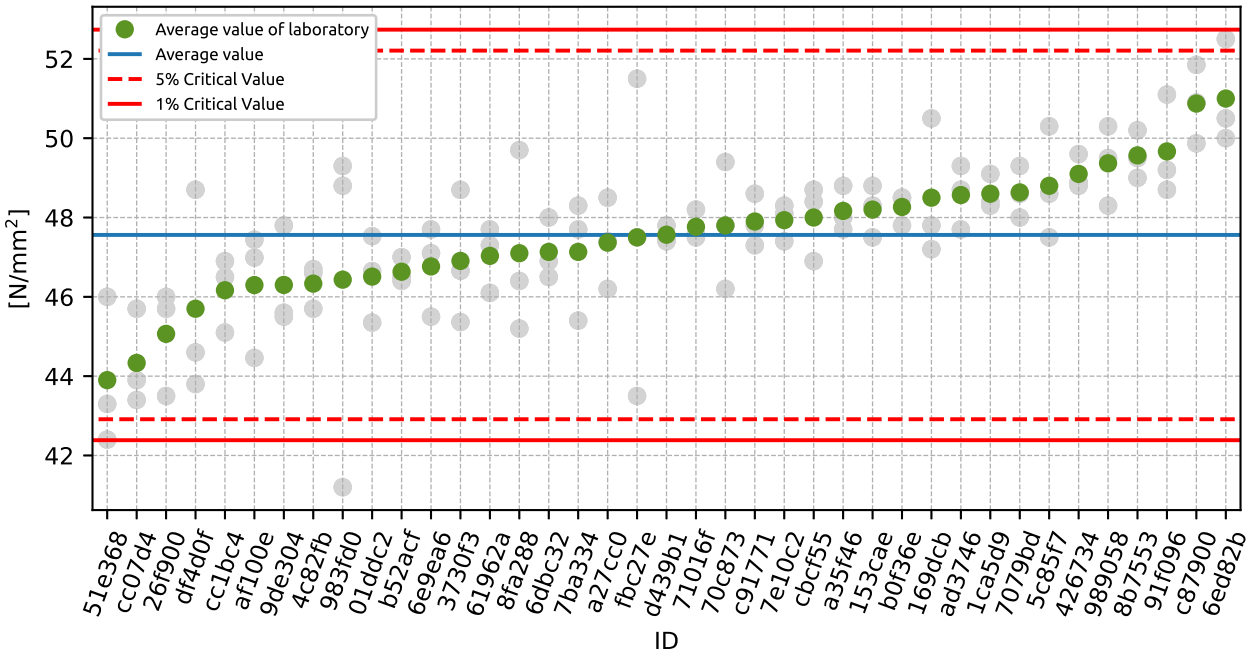

Figure 3: **Grubbs' test** - average values without outliers

1.3 Mandel's Statistics

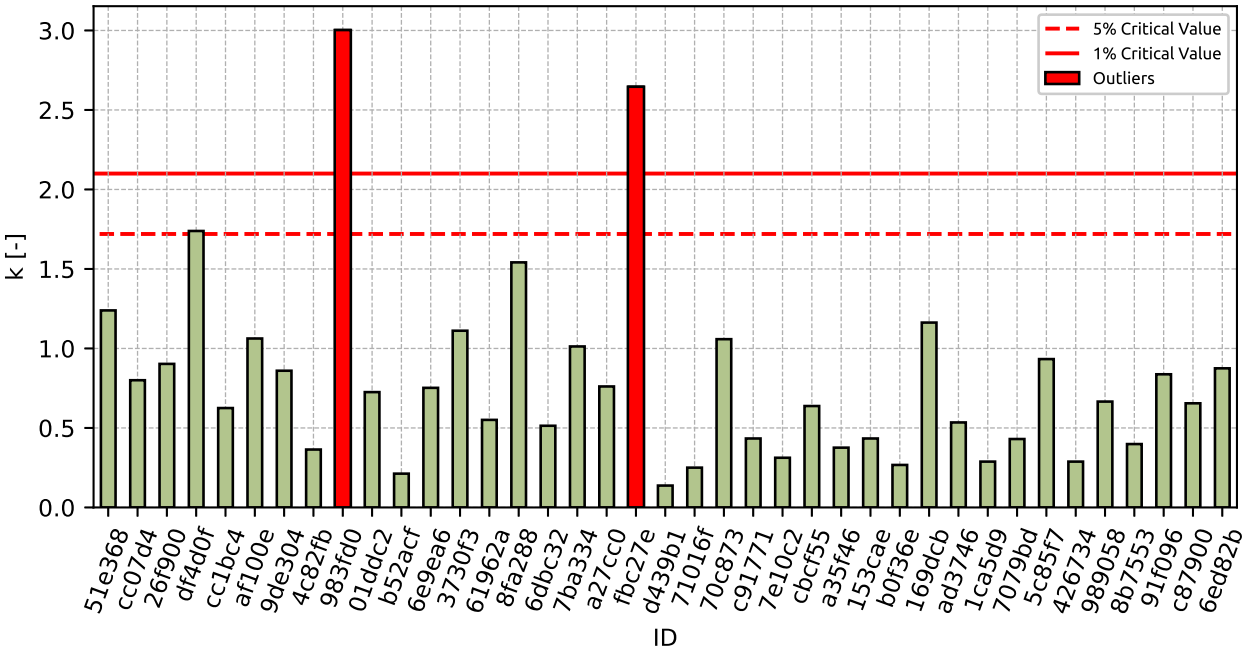

Figure 4: Intralaboratory Consistency Statistic

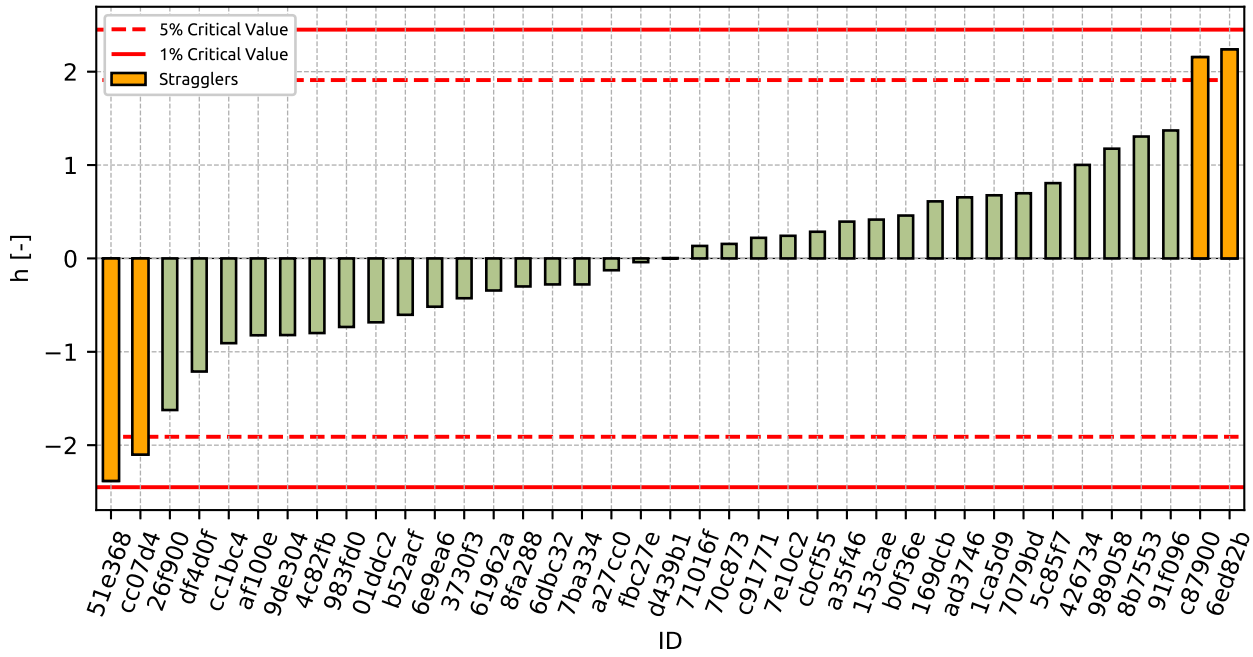

Figure 5: Interlaboratory Consistency Statistic

1.4 Descriptive statistics

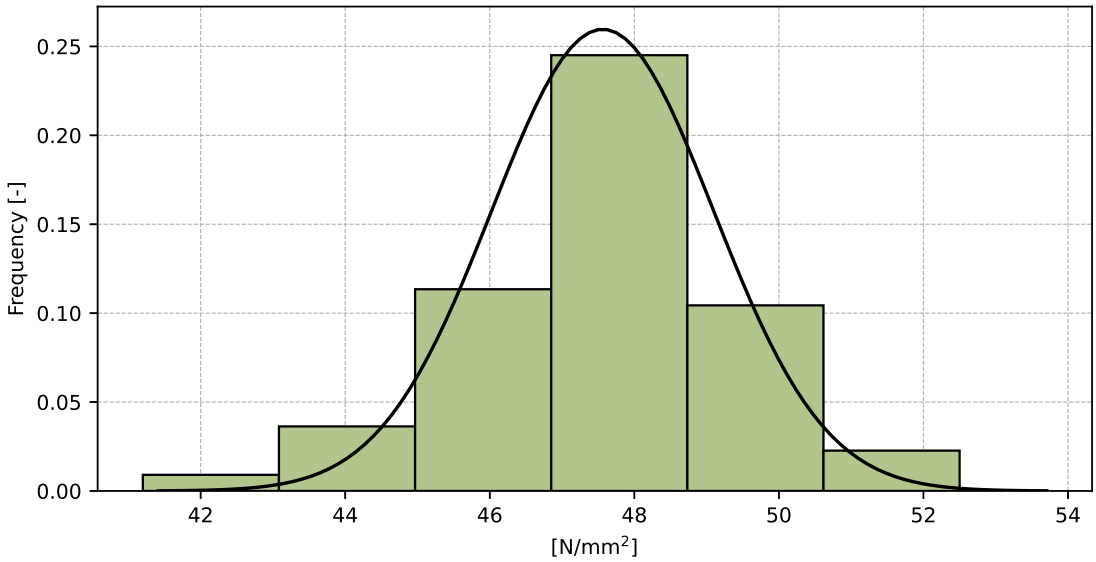

Figure 6: Histogram of all test results

Table 5: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	47.6
Sample standard deviation – s	1.54
Asigned value – x^*	47.6
Robust standard deviation – s^*	1.5
Measurement uncertainty of asigned value – u_X	0.3
p-value of normality test	0.083 [-]
Interlaboratory standard deviation – s_L	1.26
Repeatability standard deviation – s_r	1.51
Reproducibility standard deviation – s_R	1.97
Repeatability – r	4.2
Reproducibility – R	5.5

1.5 Evaluation of Performance Statistics

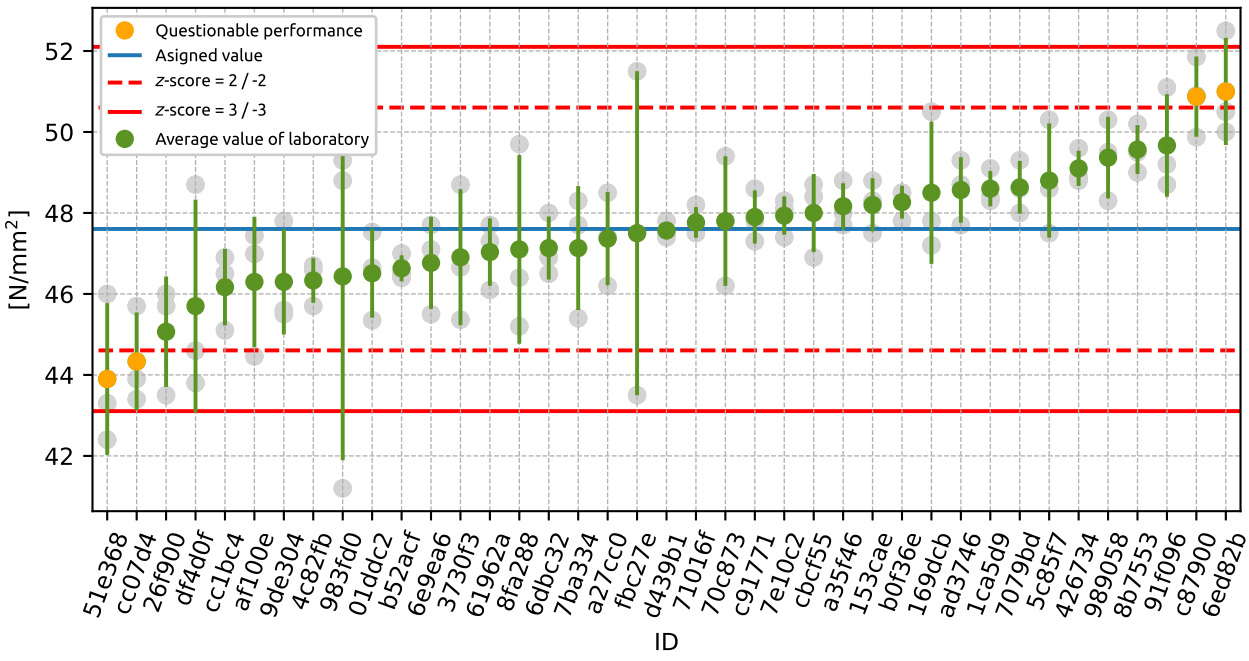

Figure 7: Average values and sample standard deviations

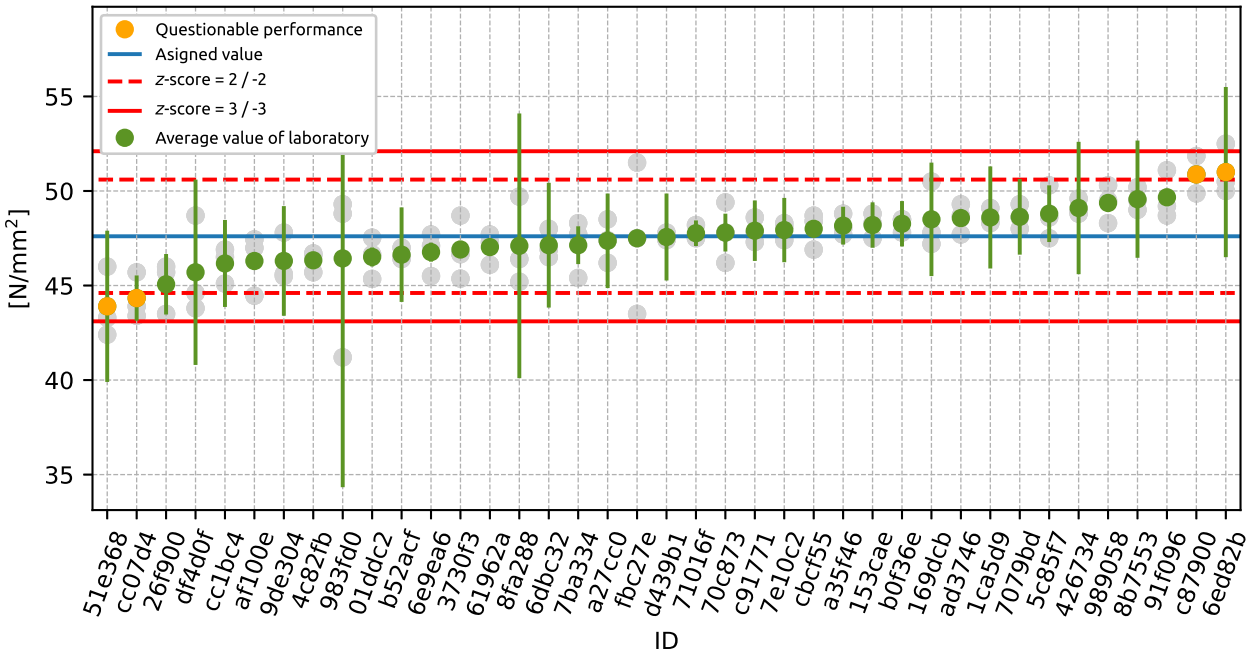

Figure 8: Average values and extended uncertainties of measurement

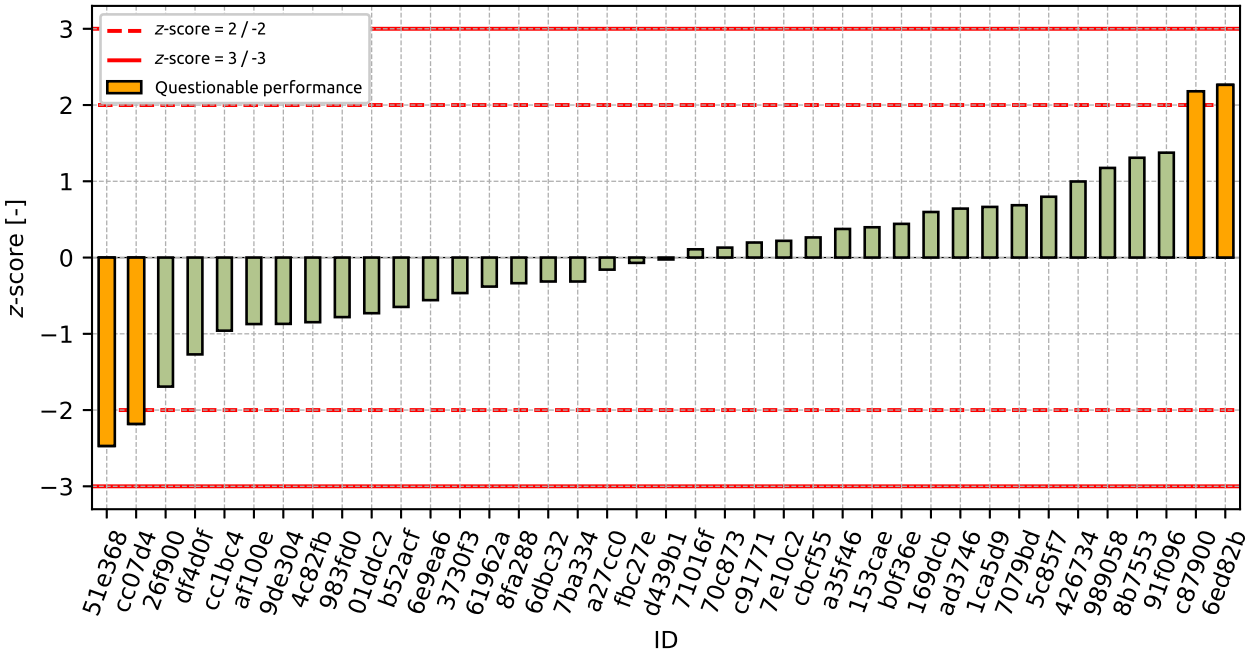

Figure 9: z-score

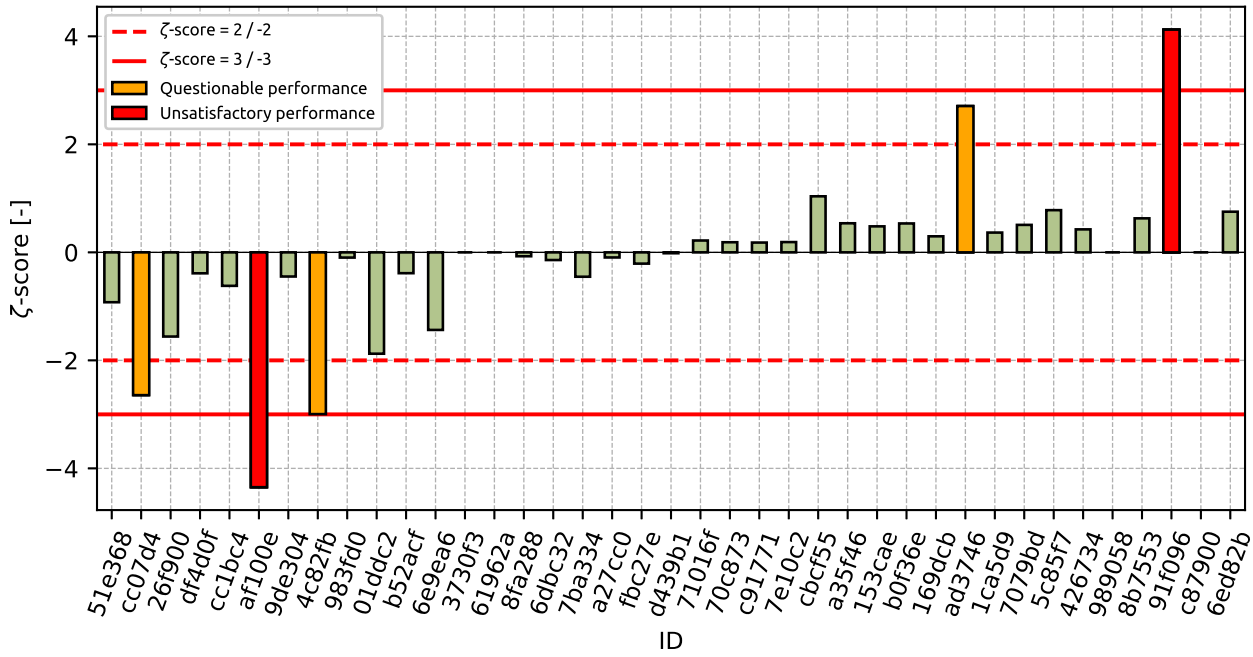

Figure 10: ζ-score

Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
51e368	-2.47	-0.92
cc07d4	-2.18	-2.64
26f900	-1.69	-1.56
df4d0f	-1.27	-0.39
cc1bc4	-0.96	-0.62
af100e	-0.87	-4.35
9de304	-0.87	-0.45
4c82fb	-0.85	-3.0
983fd0	-0.78	-0.1
01ddc2	-0.73	-1.88
b52acf	-0.65	-0.39
6e9ea6	-0.56	-1.44
3730f3	-0.47	-
61962a	-0.38	-
8fa288	-0.34	-0.07
6dbc32	-0.31	-0.14
7ba334	-0.31	-0.45
a27cc0	-0.16	-0.09
fbc27e	-0.07	-0.21
d439b1	-0.03	-0.02
71016f	0.11	0.22
70c873	0.13	0.19
c91771	0.2	0.18
7e10c2	0.22	0.19
cbcf55	0.26	1.04
a35f46	0.38	0.54
153cae	0.4	0.48
b0f36e	0.44	0.54
169dcb	0.6	0.3
ad3746	0.64	2.71
1ca5d9	0.66	0.37
7079bd	0.69	0.51
5c85f7	0.8	0.78
426734	1.0	0.43
989058	1.18	-
8b7553	1.31	0.63
91f096	1.38	4.12
c87900	2.18	-
6ed82b	2.26	0.75

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

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 [kg/m^3]			u_X [kg/m^3]	$\bar{x}$ [kg/m^3]	s_0 [kg/m^3]	V_X [%]
153cae	2280	2280	2280	32	2280	0.0	0.0
01ddc2	2275	2289	2278	20	2281	7.1	0.31
9de304	2290	2290	2290	10	2290	0.0	0.0
6e9ea6	2301	2276	2302	20	2293	14.7	0.64
983fd0	2280	2300	2300	41	2293	11.5	0.5
426734	2290	2300	2290	30	2293	5.8	0.25
a35f46	2290	2290	2300	10	2293	5.8	0.25
b0f36e	2300	2290	2300	32	2297	5.8	0.25
b52acf	2300	2290	2310	12	2300	10.0	0.43
8b7553	2300	2300	2300	30	2300	0.0	0.0
7079bd	2300	2300	2300	10	2300	0.0	0.0
c91771	2300	2300	2300	11	2300	0.0	0.0
71016f	2310	2290	2300	26	2300	10.0	0.43
a27cc0	2290	2300	2310	115	2300	10.0	0.43
8fa288	2300	2310	2290	14	2300	10.0	0.43
6ed82b	2300	2300	2300	35	2300	0.0	0.0
6dbc32	2290	2290	2320	30	2300	17.3	0.75
d439b1	2300	2290	2310	40	2300	10.0	0.43
cbcf55	2310	2290	2310	10	2303	11.5	0.5
61962a	2310	2300	2300	-	2303	5.8	0.25
7ba334	2310	2300	2300	32	2303	5.8	0.25
5c85f7	2300	2300	2310	10	2303	5.8	0.25
70c873	2310	2300	2300	10	2303	5.8	0.25
cc1bc4	2300	2320	2300	20	2307	11.5	0.5
1ca5d9	2310	2310	2300	20	2307	5.8	0.25
7d3785	2320	2303	2303	-	2309	9.8	0.43
169dcb	2320	2300	2310	30	2310	10.0	0.43
ad3746	2310	2320	2310	10	2313	5.8	0.25
c87900	2340	2306	2300	-	2315	21.6	0.93
7e10c2	2310	2320	2320	20	2317	5.8	0.25
fbc27e	2300	2320	2330	15	2317	15.3	0.66

2.2 The Numerical Procedure for Determining Outliers

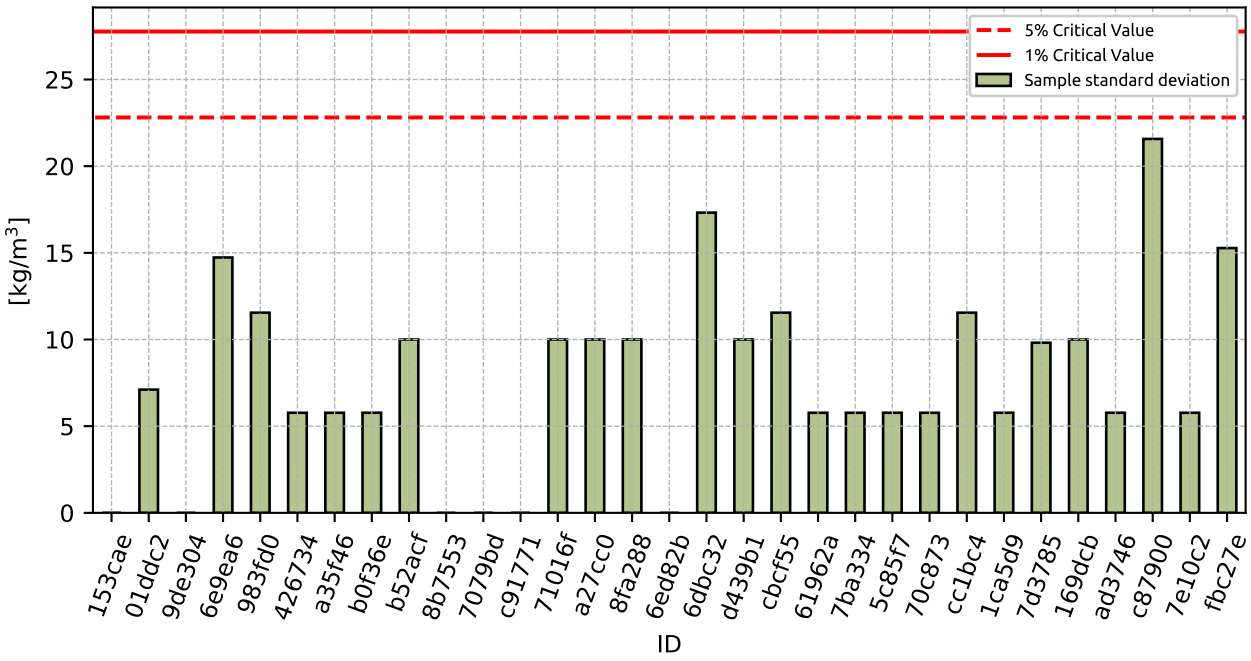

Figure 11: **Cochran's test** - sample standard deviations

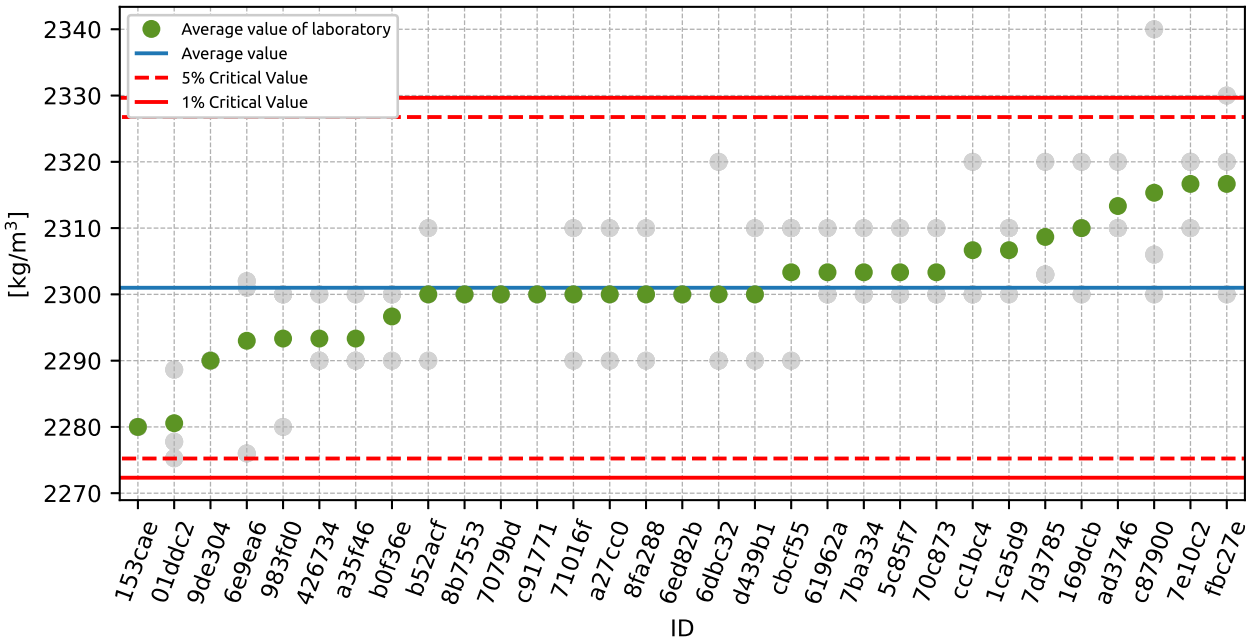

Figure 12: **Grubbs' test** - average values

2.3 Mandel's Statistics

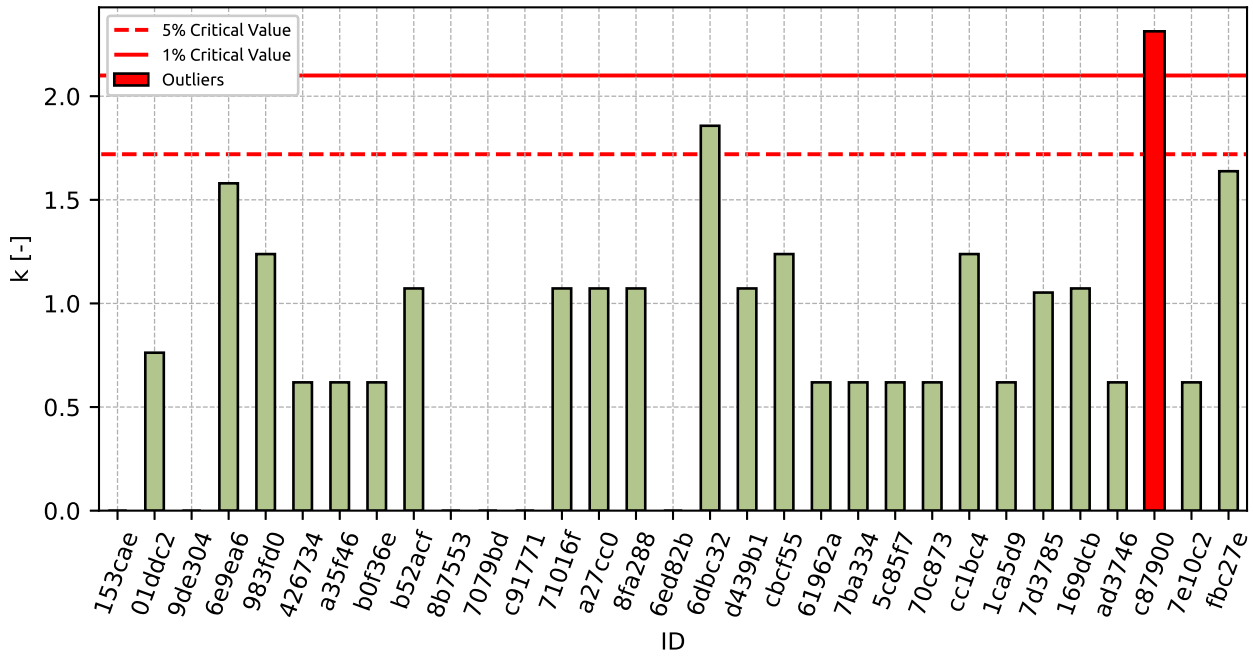

Figure 13: Intralaboratory Consistency Statistic

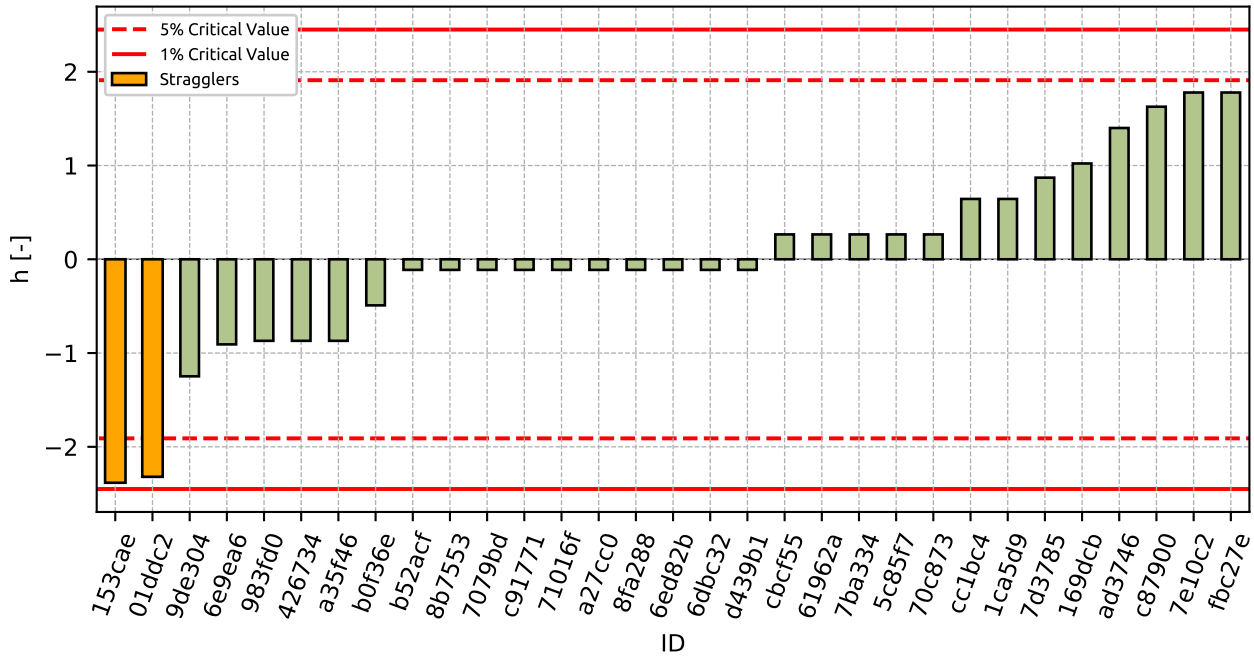

Figure 14: Interlaboratory Consistency Statistic

2.4 Descriptive statistics

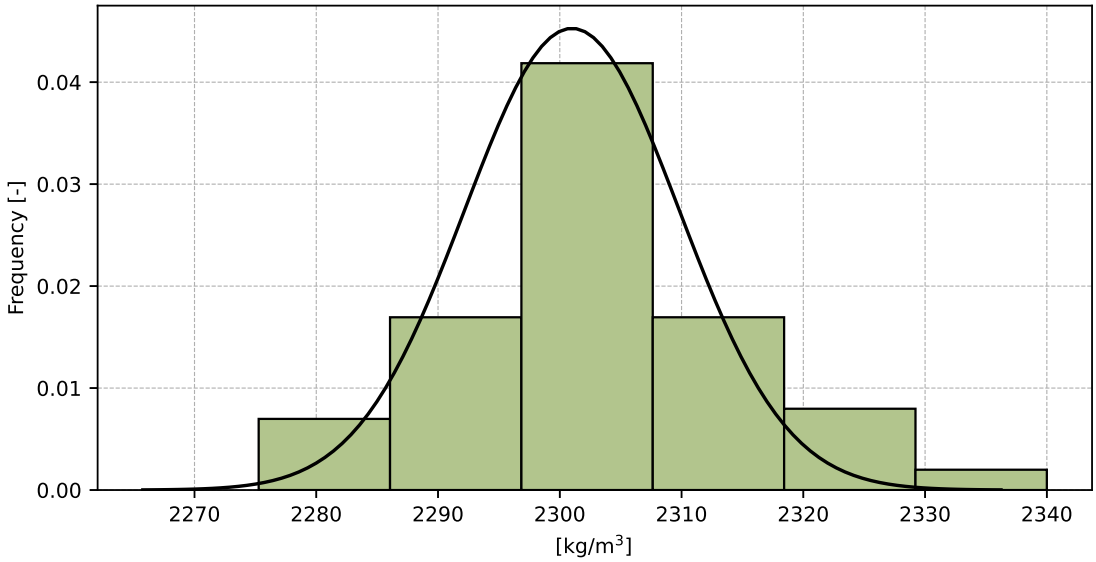

Figure 15: Histogram of all test results

Table 8: Descriptive statistics

Characteristics	**[kg/m³]**
Average value – $\bar{x}$	2301
Sample standard deviation – s	8.8
Asigned value – x^*	2301
Robust standard deviation – s^*	10.8
Measurement uncertainty of asigned value – u_X	1.9
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	7.0
Repeatability standard deviation – s_r	9.3
Reproducibility standard deviation – s_R	11.6
Repeatability – r	26
Reproducibility – R	33

2.5 Evaluation of Performance Statistics

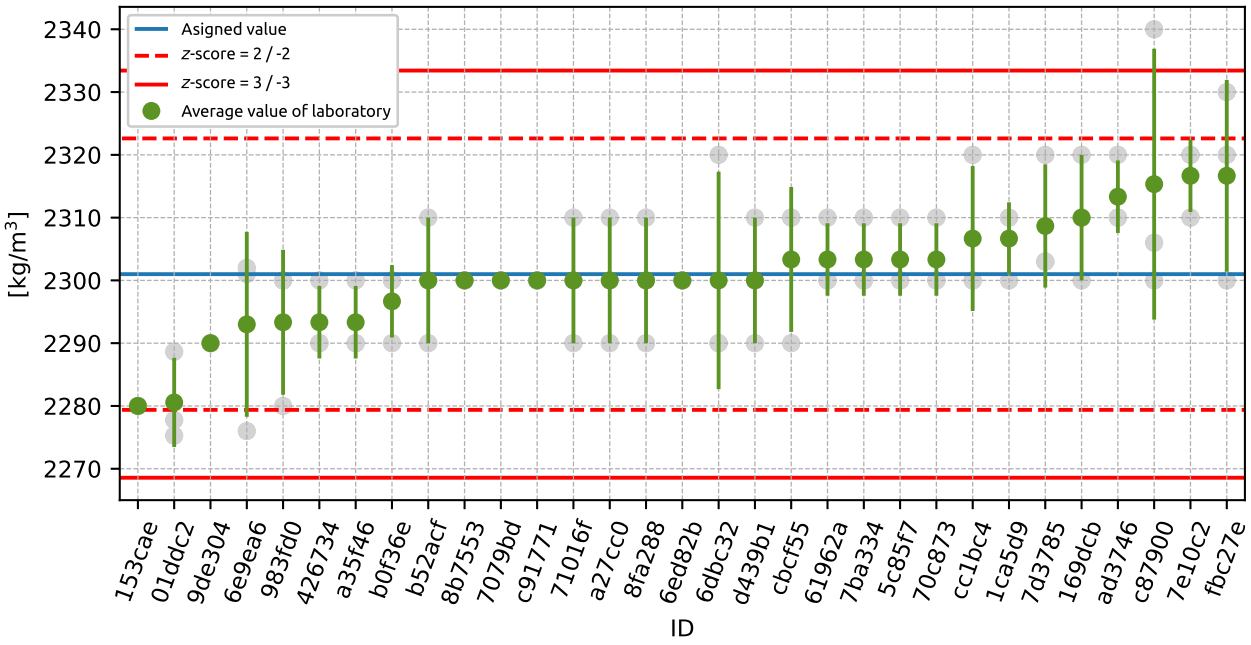

Figure 16: Average values and sample standard deviations

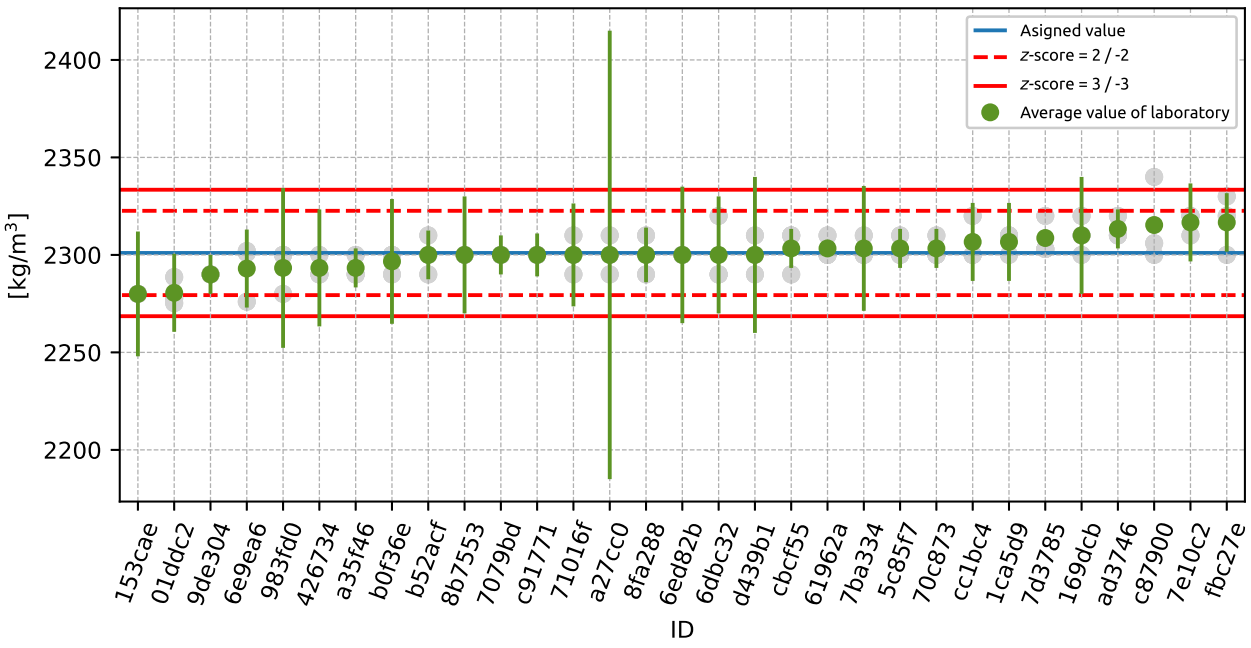

Figure 17: Average values and extended uncertainties of measurement

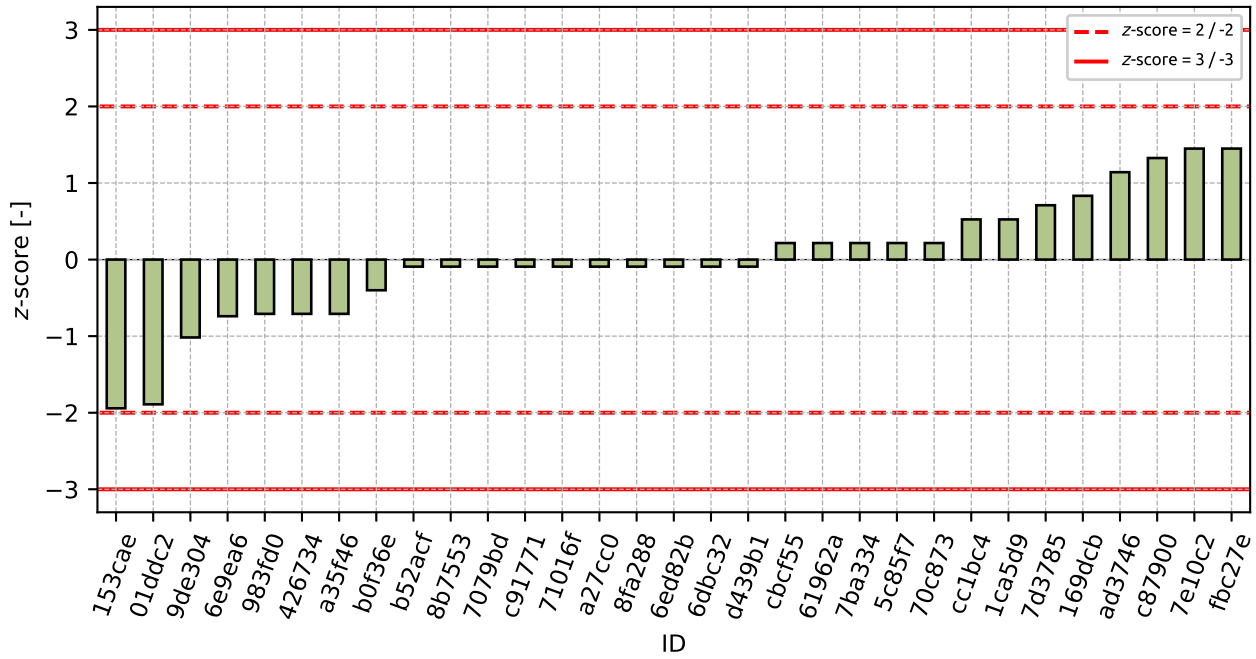

Figure 18: z-score

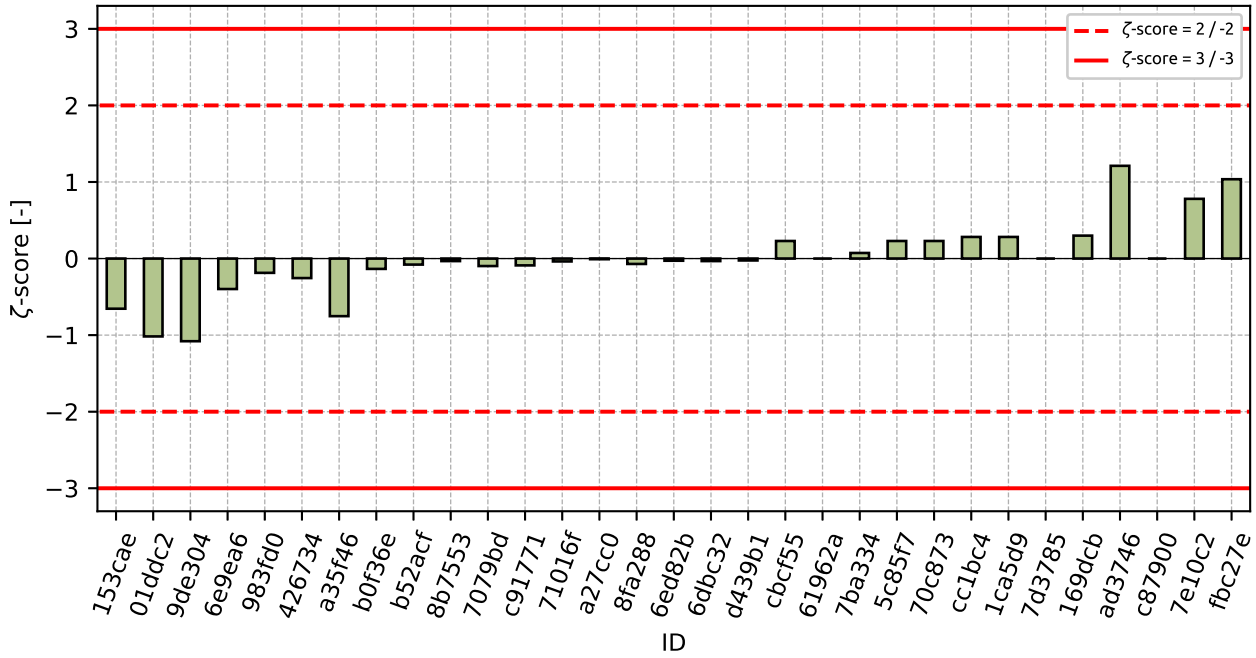

Figure 19: ζ-score

Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
153cae	-1.94	-0.65
01ddc2	-1.89	-1.02
9de304	-1.02	-1.08
6e9ea6	-0.74	-0.4
983fd0	-0.71	-0.19
426734	-0.71	-0.25
a35f46	-0.71	-0.75
b0f36e	-0.4	-0.14
b52acf	-0.09	-0.08
8b7553	-0.09	-0.03
7079bd	-0.09	-0.1
c91771	-0.09	-0.09
71016f	-0.09	-0.04
a27cc0	-0.09	-0.01
8fa288	-0.09	-0.07
6ed82b	-0.09	-0.03
6dbc32	-0.09	-0.03
d439b1	-0.09	-0.02
cbcf55	0.22	0.23
61962a	0.22	-
7ba334	0.22	0.07
5c85f7	0.22	0.23
70c873	0.22	0.23
cc1bc4	0.52	0.28
1ca5d9	0.52	0.28
7d3785	0.71	-
169dcb	0.83	0.3
ad3746	1.14	1.21
c87900	1.33	-
7e10c2	1.45	0.78
fbc27e	1.45	1.04

3 Appendix – EN 12390-8 – Depth of penetration of water under pressure

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 [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
7d3785	1	2	4	-	2	1.5	65.47
51e368	0	5	7	2.0	4	3.6	90.14
6e9ea6	10	8	9	3.0	9	1.0	11.11
3e5825	10	9	9	2.0	9	0.6	6.19
facf57	10	9	10	1.0	10	0.6	5.97
744786	8	13	8	0.0	10	2.9	29.86
6c2487	9	9	12	-	10	1.7	17.32
df4d0f	10	9	15	6.0	11	3.2	28.36
153cae	14	10	11	1.0	12	2.1	17.84
c91771	9	12	14	1.0	12	2.5	21.57
ad3746	12	14	10	2.0	12	2.0	16.67
b0f36e	14	10	13	0.0	12	2.1	16.88
d439b1	12	11	14	2.0	12	1.5	12.39
cc1bc4	10	12	15	3.0	12	2.5	20.4
c87900	14	10	13	-	12	2.1	16.88
a38a65	12	13	16	0.0	14	2.1	15.23
c688a3	11	16	16	3.0	14	2.9	20.14
7e10c2	13	16	14	1.0	14	1.5	10.66
61962a	14	16	14	-	15	1.2	7.87
b52acf	15	15	14	2.0	15	0.6	3.94
82c46f	17	15	13	0.0	15	2.0	13.33
cbcf55	15	17	13	2.0	15	2.0	13.33
426734	15	16	16	5.0	16	0.6	3.69
7079bd	15	17	16	2.0	16	1.0	6.25
1ca5d9	15	18	16	4.0	16	1.5	9.35
8b7553	17	17	18	2.0	17	0.6	3.33
9de304	17	18	18	2.0	18	0.6	3.27
61a7d1	17	15	23	3.0	18	4.2	22.71
6dbc32	12	29	17	24.0	19	8.7	45.19
bb6bdd	21	18	19	2.0	19	1.5	7.9
6ed82b	23	18	21	3.0	21	2.5	12.18

3.2 The Numerical Procedure for Determining Outliers

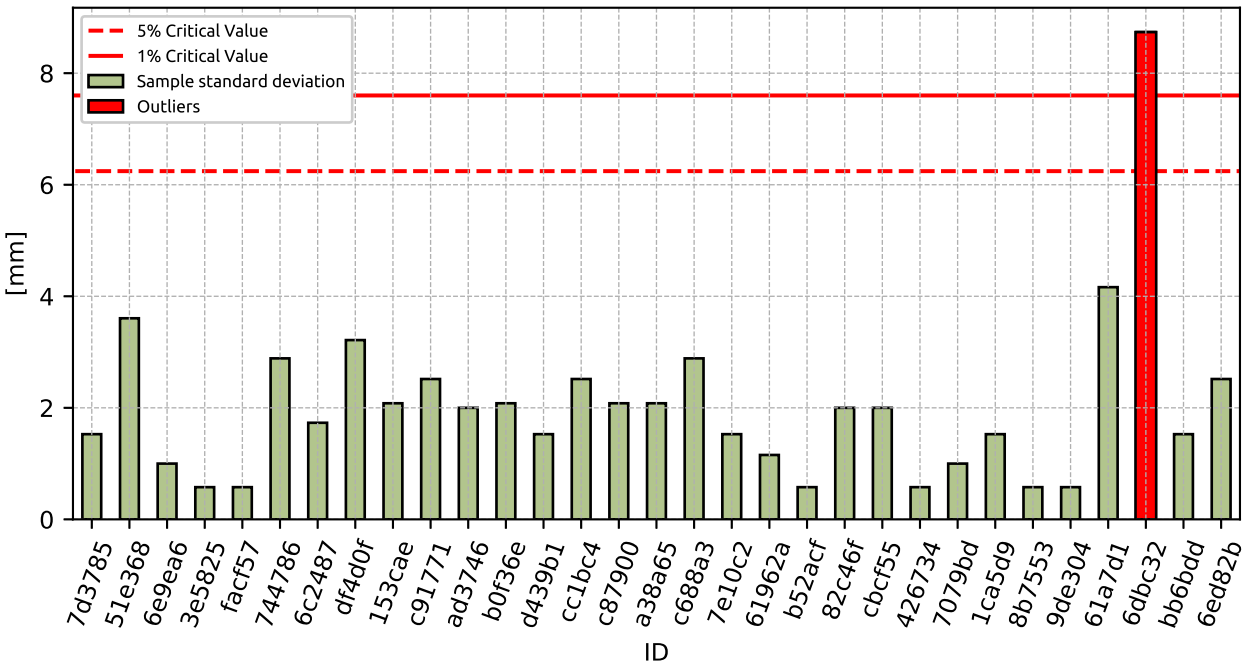

Figure 20: **Cochran's test** - sample standard deviations

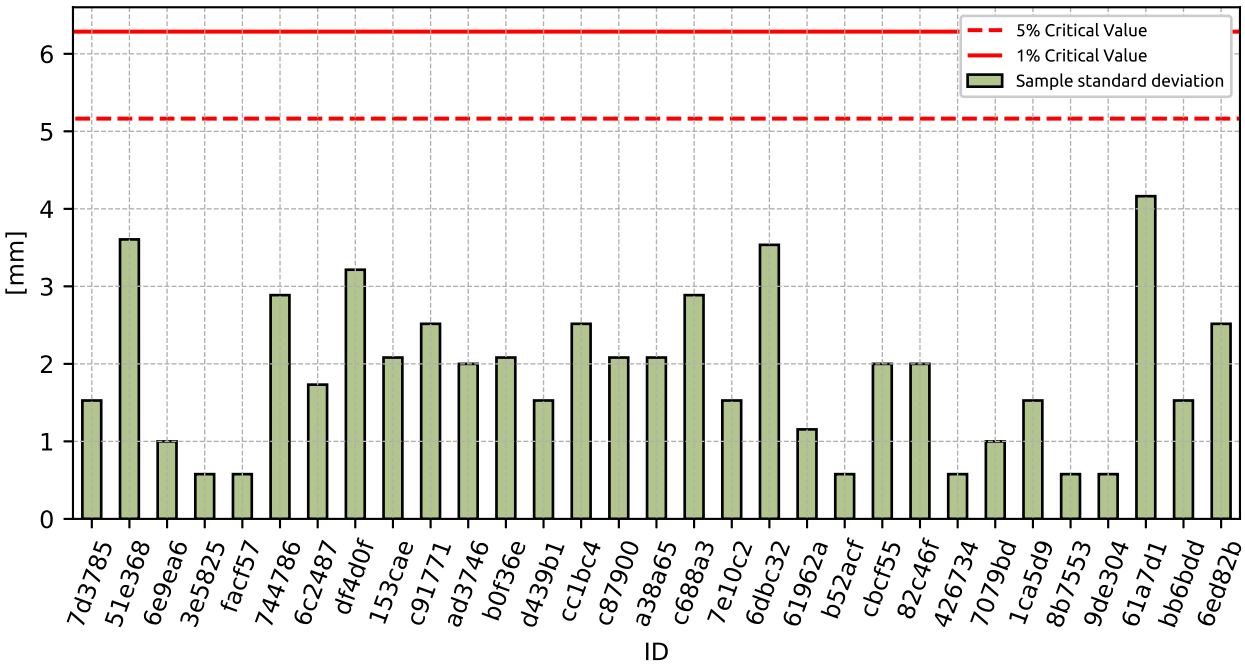

Figure 21: **Cochran's test** - sample standard deviations without outliers

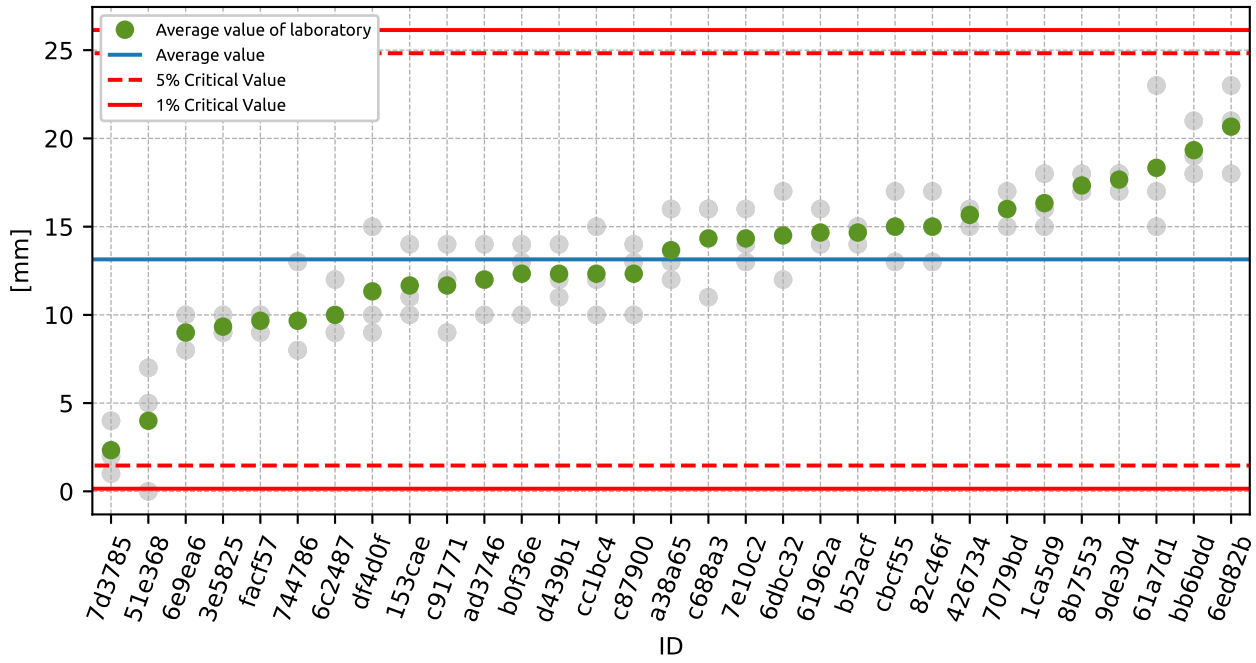

Figure 22: **Grubbs' test** - average values

3.3 Mandel's Statistics

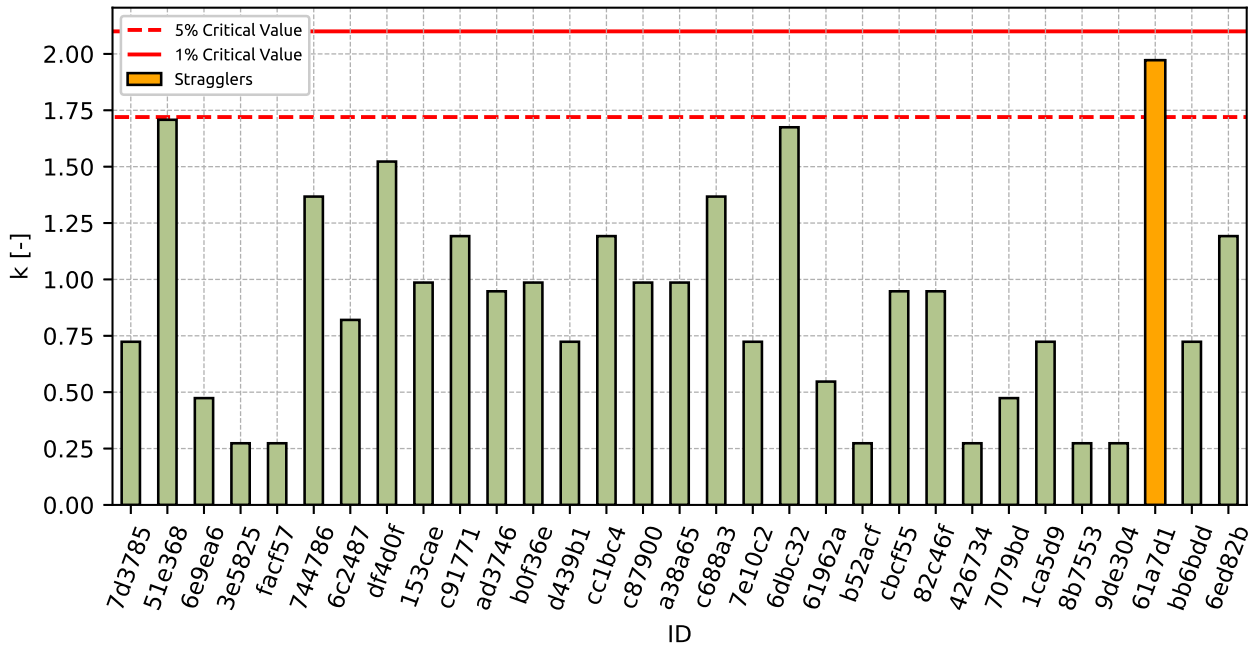

Figure 23: Intralaboratory Consistency Statistic

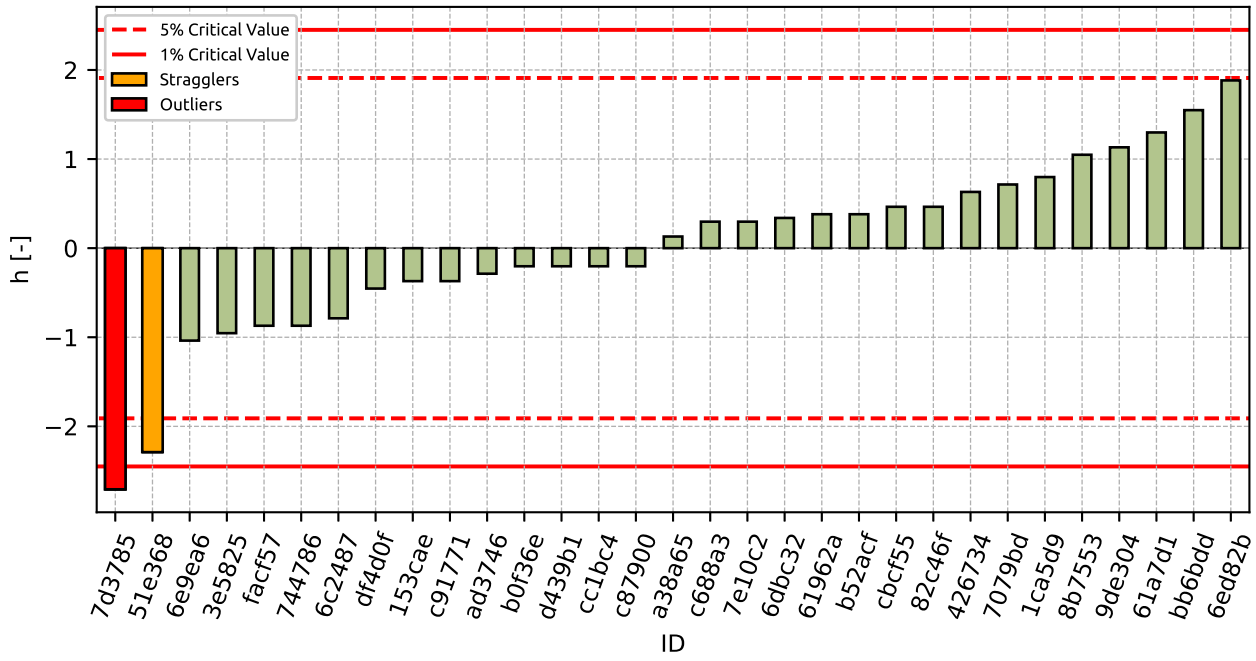

Figure 24: Interlaboratory Consistency Statistic

3.4 Descriptive statistics

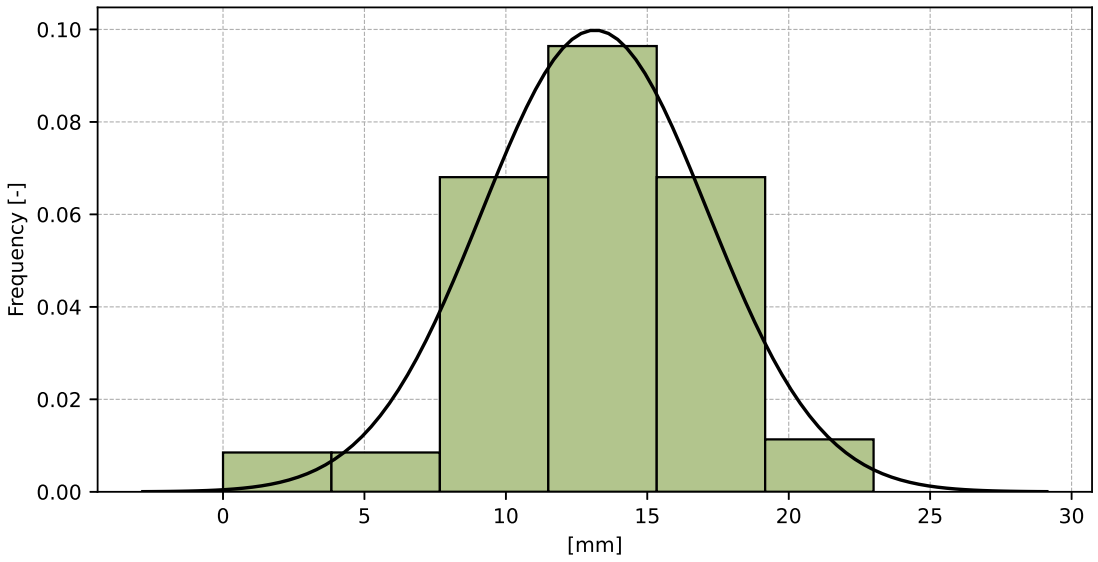

Figure 25: Histogram of all test results

Table 11: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	13.0
Sample standard deviation – s	4.0
Asigned value – x^*	13.0
Robust standard deviation – s^*	3.8
Measurement uncertainty of asigned value – u_X	0.8
p-value of normality test	1.0 [-]
Interlaboratory standard deviation – s_L	3.8
Repeatability standard deviation – s_r	2.1
Reproducibility standard deviation – s_R	4.4
Repeatability – r	6.0
Reproducibility – R	12.0

3.5 Evaluation of Performance Statistics

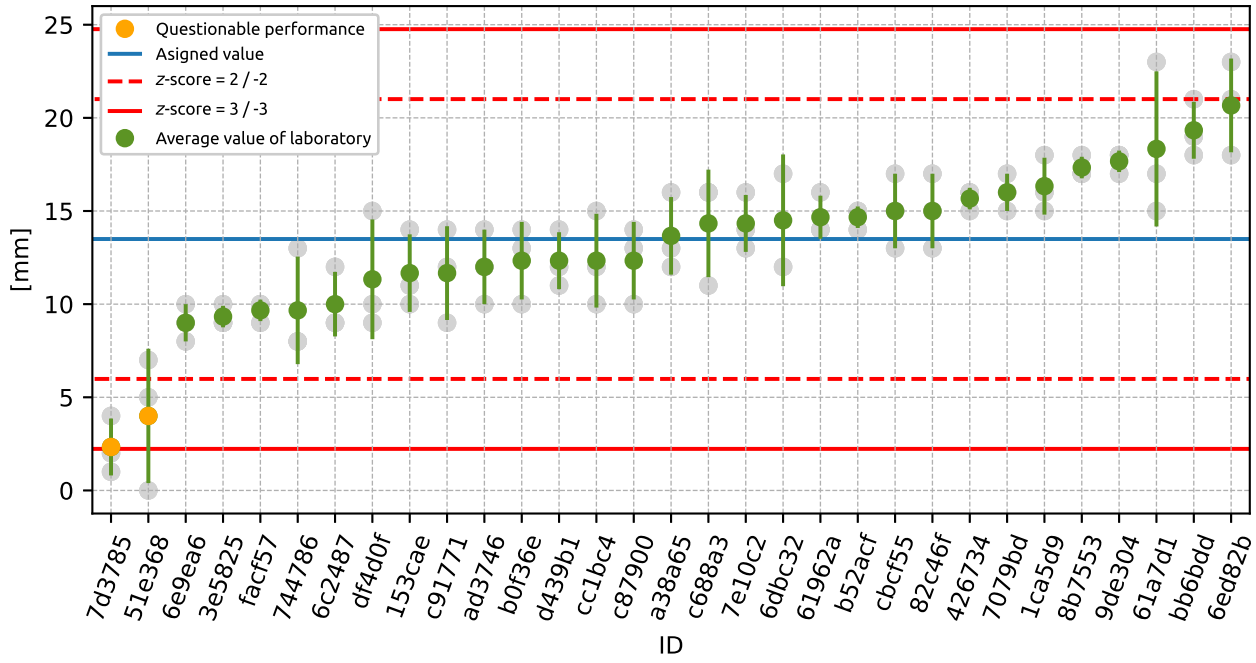

Figure 26: Average values and sample standard deviations

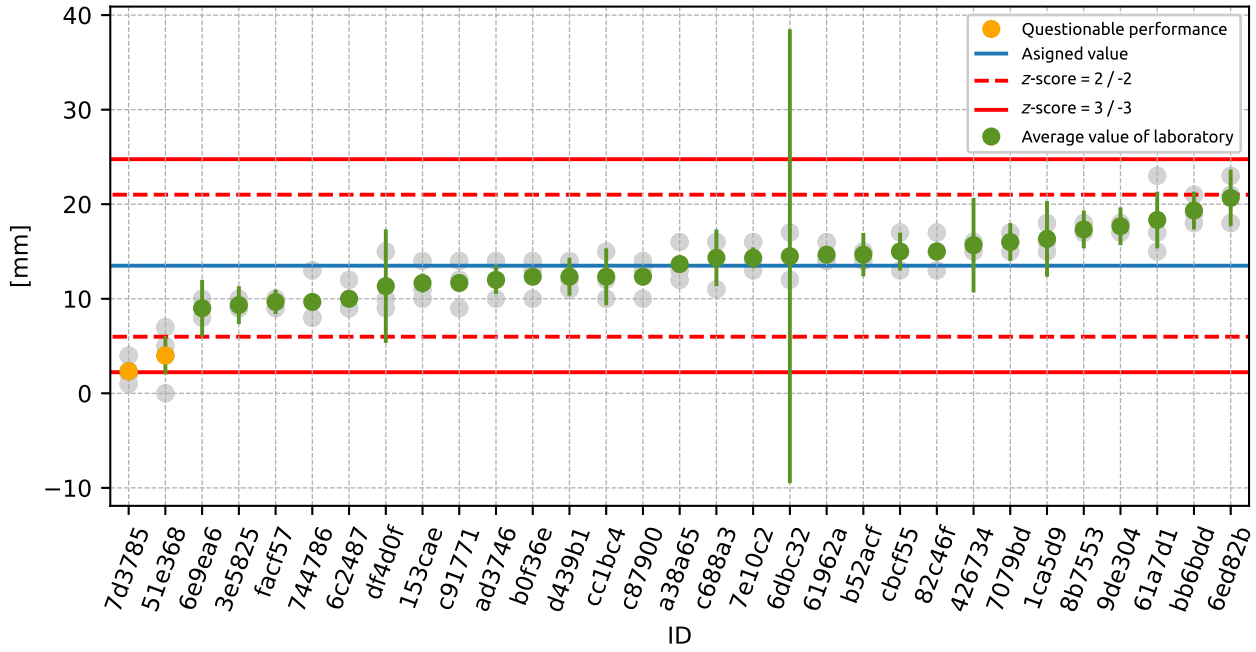

Figure 27: Average values and extended uncertainties of measurement

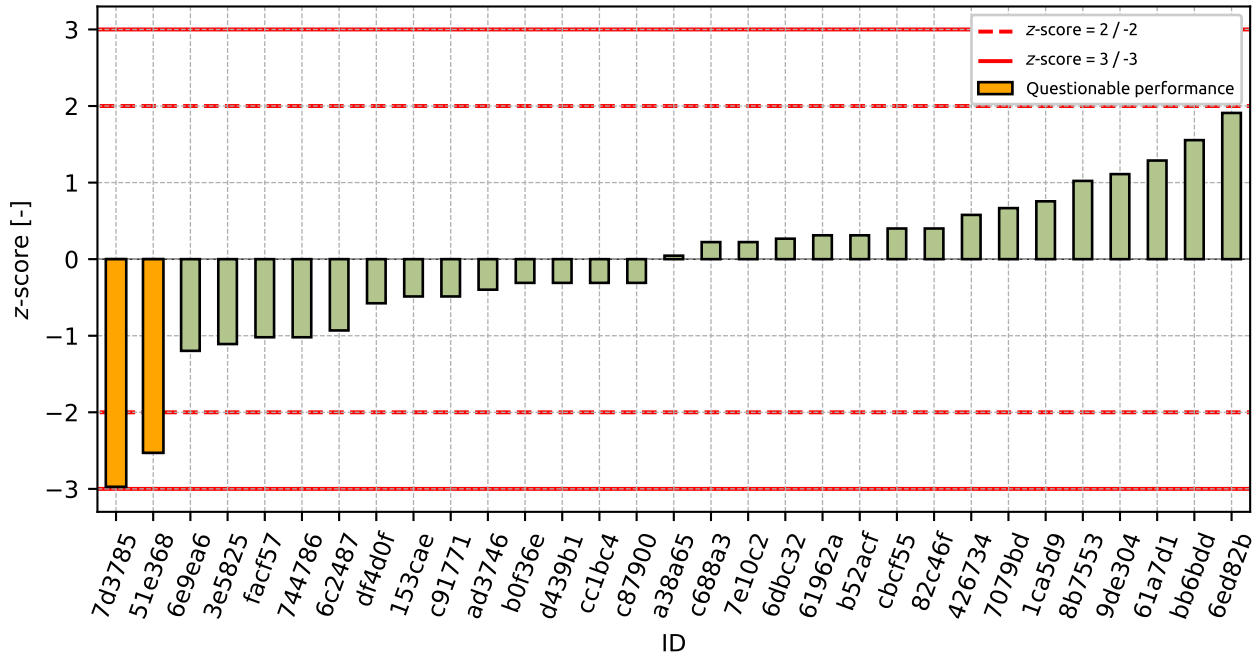

Figure 28: z-score

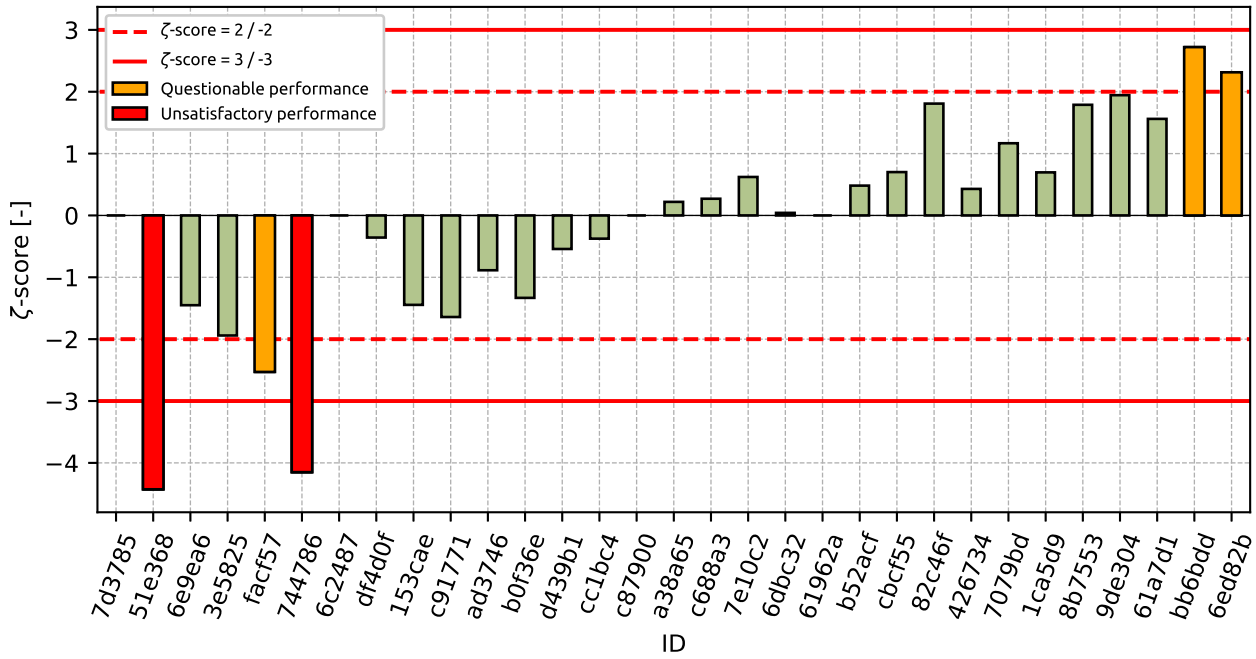

Figure 29: ζ-score

Table 12: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
7d3785	-2.97	-
51e368	-2.53	-4.43
6e9ea6	-1.2	-1.45
3e5825	-1.11	-1.94
facf57	-1.02	-2.53
744786	-1.02	-4.15
6c2487	-0.93	-
df4d0f	-0.58	-0.36
153cae	-0.49	-1.45
c91771	-0.49	-1.64
ad3746	-0.4	-0.89
b0f36e	-0.31	-1.33
d439b1	-0.31	-0.54
cc1bc4	-0.31	-0.38
c87900	-0.31	-
a38a65	0.05	0.22
c688a3	0.22	0.27
7e10c2	0.22	0.62
6dbc32	0.27	0.04
61962a	0.31	-
b52acf	0.31	0.48
cbcf55	0.4	0.7
82c46f	0.4	1.81
426734	0.58	0.43
7079bd	0.67	1.17
1ca5d9	0.76	0.7
8b7553	1.02	1.79
9de304	1.11	1.94
61a7d1	1.29	1.56
bb6bdd	1.55	2.72
6ed82b	1.91	2.31

4 Appendix – EN 480-11 – Determination of air void characteristics in hardened concrete

4.1 Total air content

4.1.1 Test results

Table 13: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [%]	u_X [%]
61a7d1	3.43	0.8
c688a3	3.89	0.08
7ba334	4.5	0.22
37c007	4.85	0.21
df4d0f	8.67	0.85

4.1.2 The Numerical Procedure for Determining Outliers

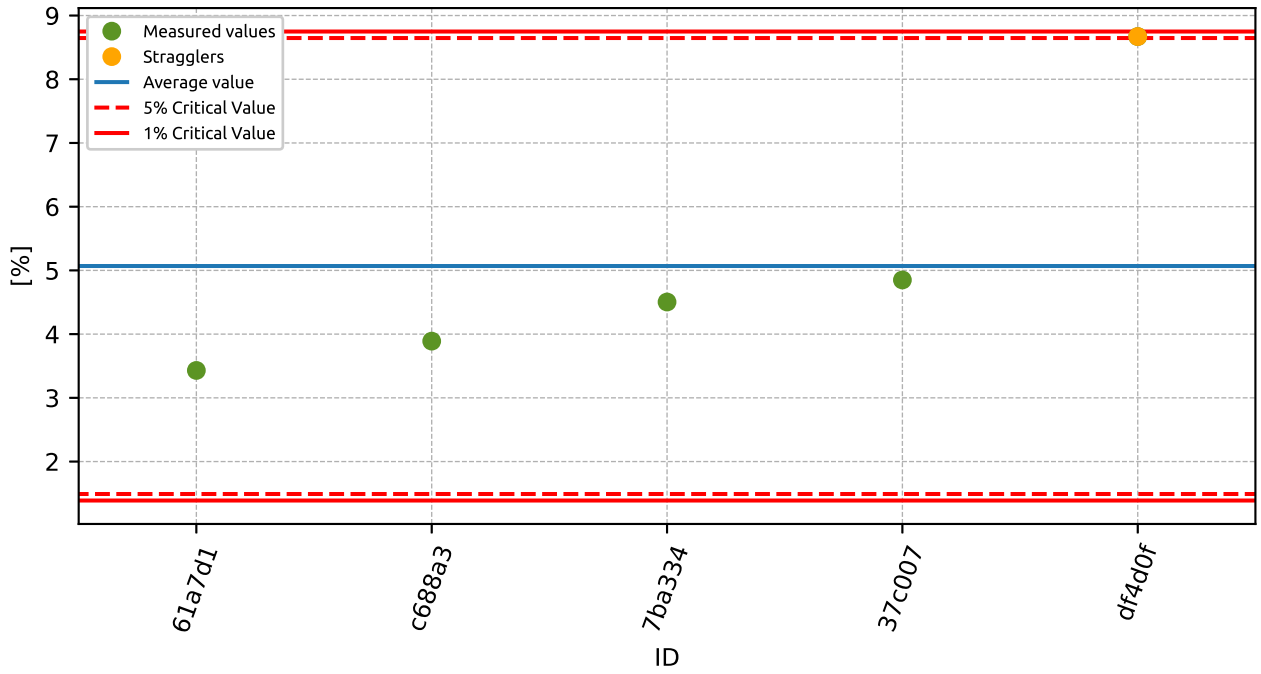

Figure 30: **Grubbs' test** - average values

4.1.3 Mandel's Statistics

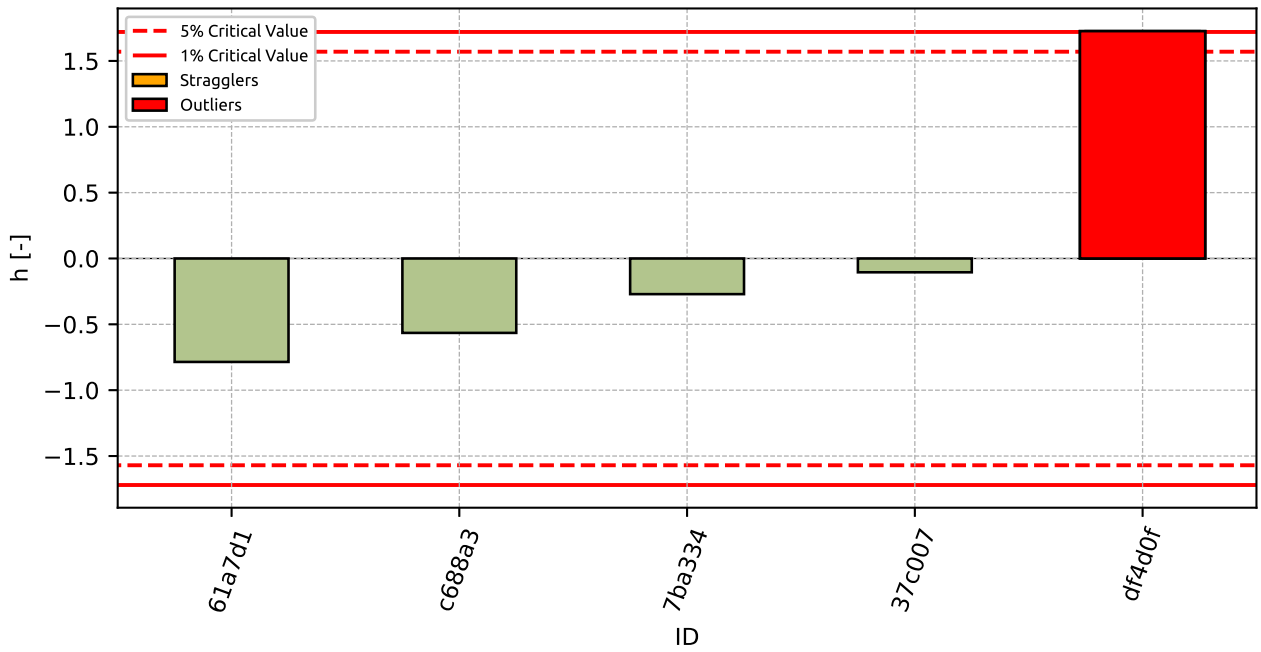

Figure 31: Interlaboratory Consistency Statistic

4.1.4 Descriptive statistics

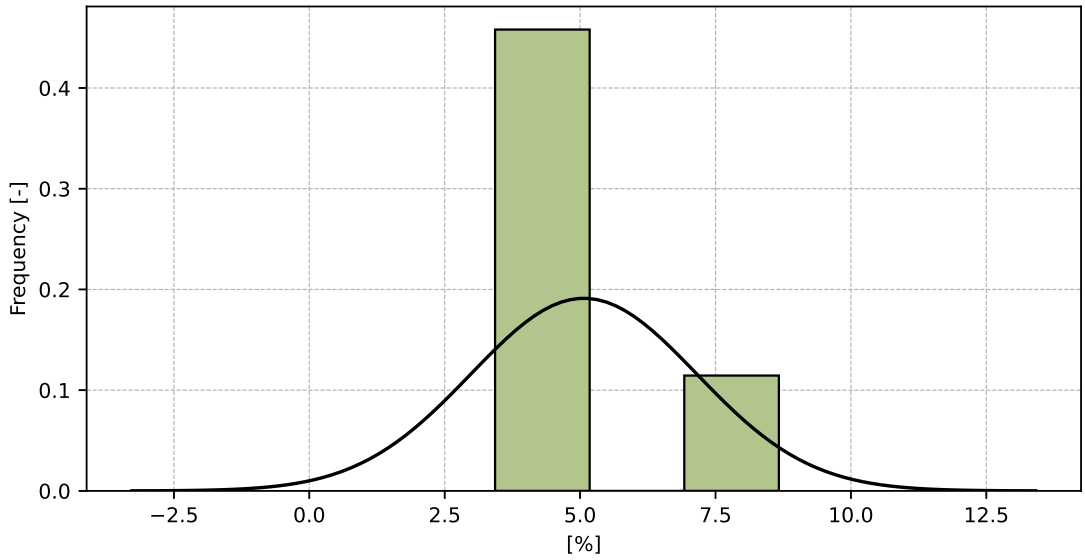

Figure 32: Histogram of all test results

Table 14: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	5.07
Sample standard deviation – s	2.086
Asigned value – x^*	5.07
Robust standard deviation – s^*	2.116
Measurement uncertainty of asigned value – u_X	1.183
p-value of normality test	0.07 [-]

4.1.5 Evaluation of Performance Statistics

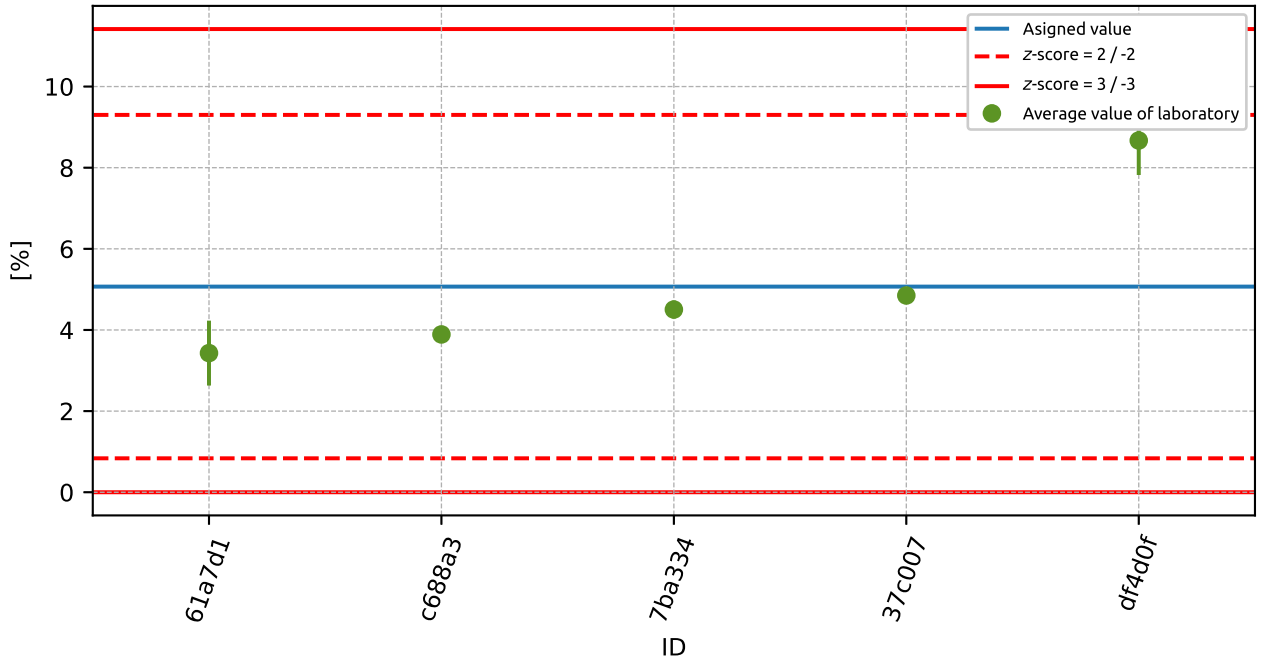

Figure 33: Average values and extended uncertainties of measurement

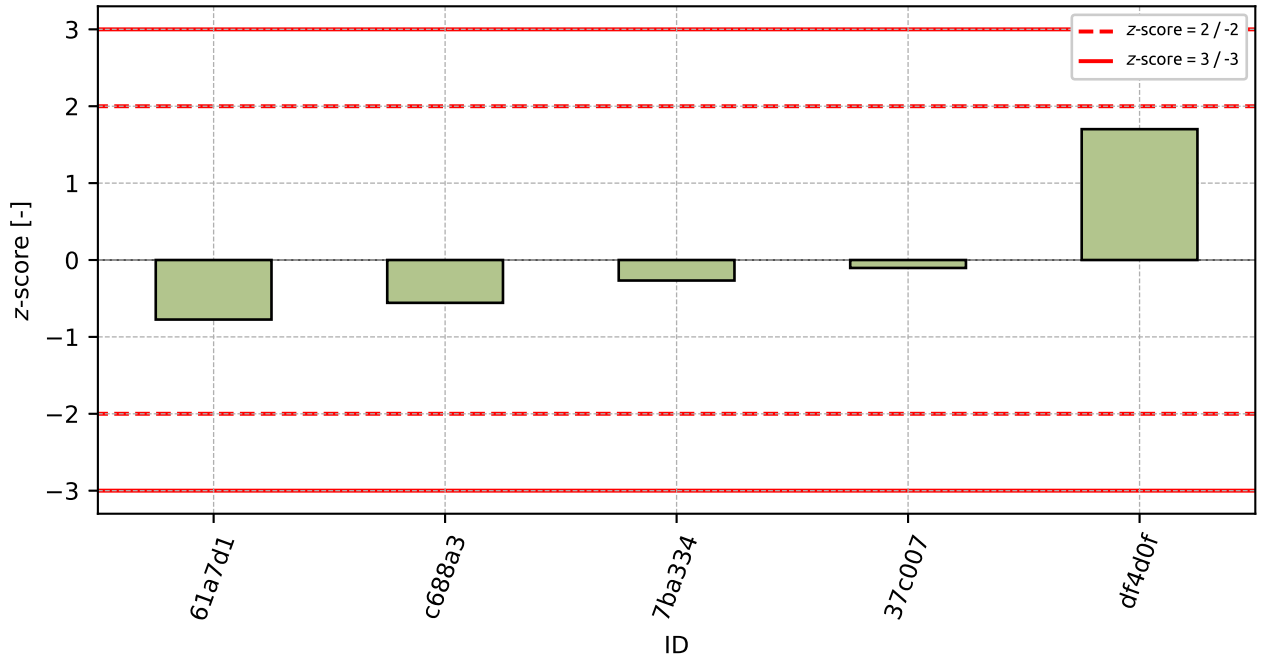

Figure 34: z-score

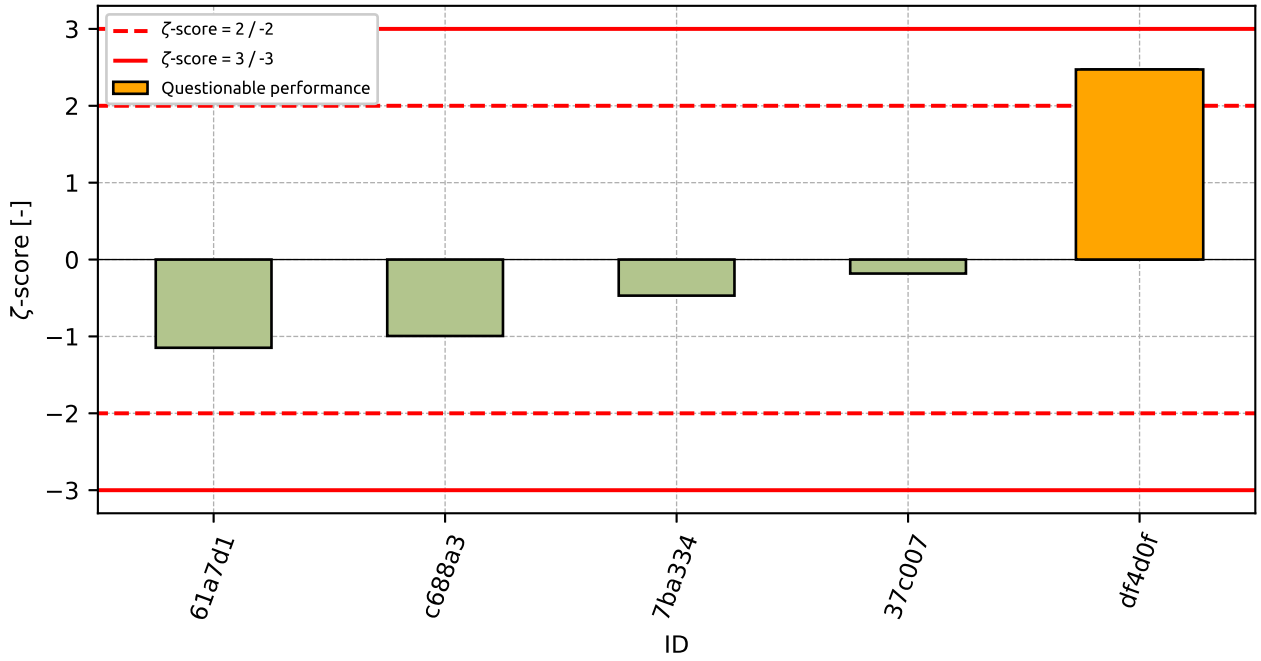

Figure 35: ζ-score

Table 15: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
61a7d1	-0.77	-1.15
c688a3	-0.56	-0.99
7ba334	-0.27	-0.47
37c007	-0.1	-0.18
df4d0f	1.7	2.47

4.2 Micro air content A_{300}

4.2.1 Test results

Table 16: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [%]	u_X [%]
37c007	1.36	0.07
7ba334	1.38	0.07
61a7d1	1.4	0.2
c688a3	1.82	0.08
df4d0f	3.72	0.42

4.2.2 The Numerical Procedure for Determining Outliers

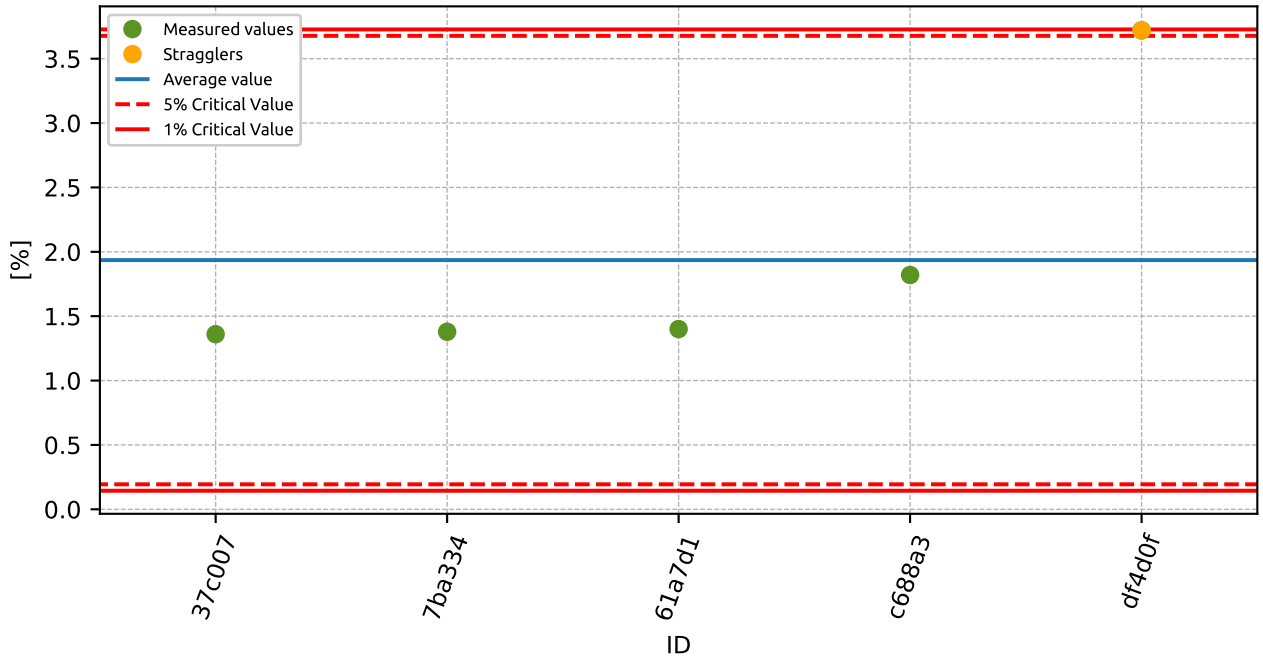

Figure 36: **Grubbs' test** - average values

4.2.3 Mandel's Statistics

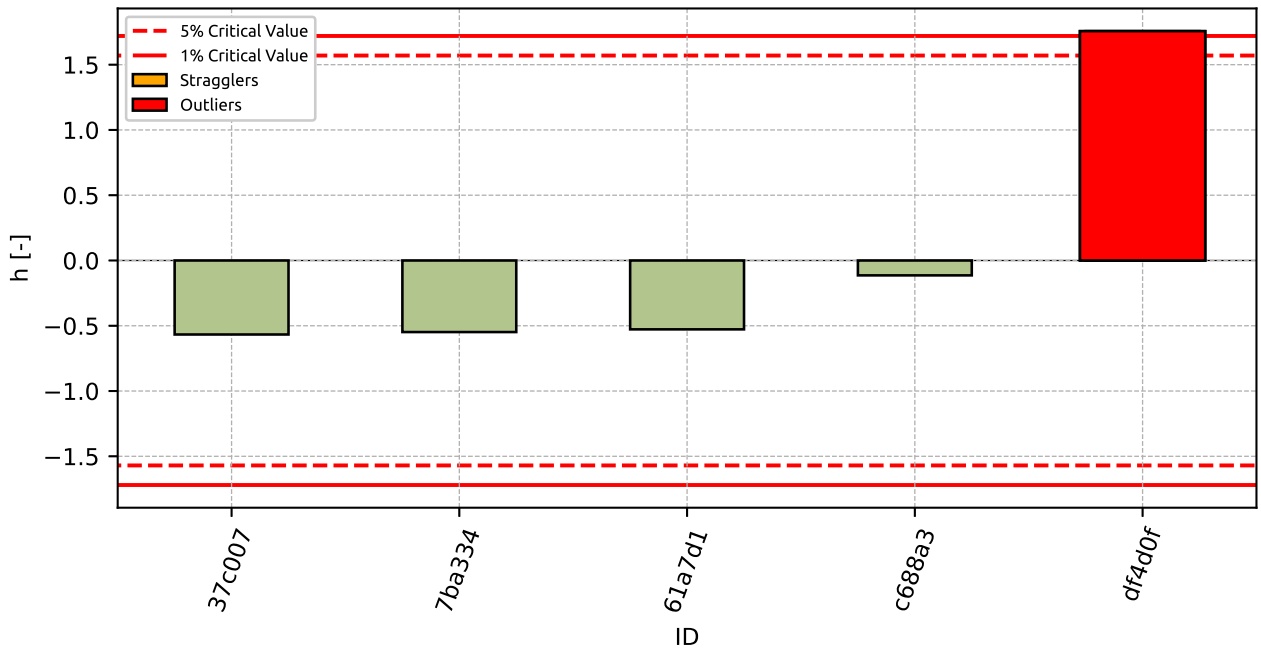

Figure 37: Interlaboratory Consistency Statistic

4.2.4 Descriptive statistics

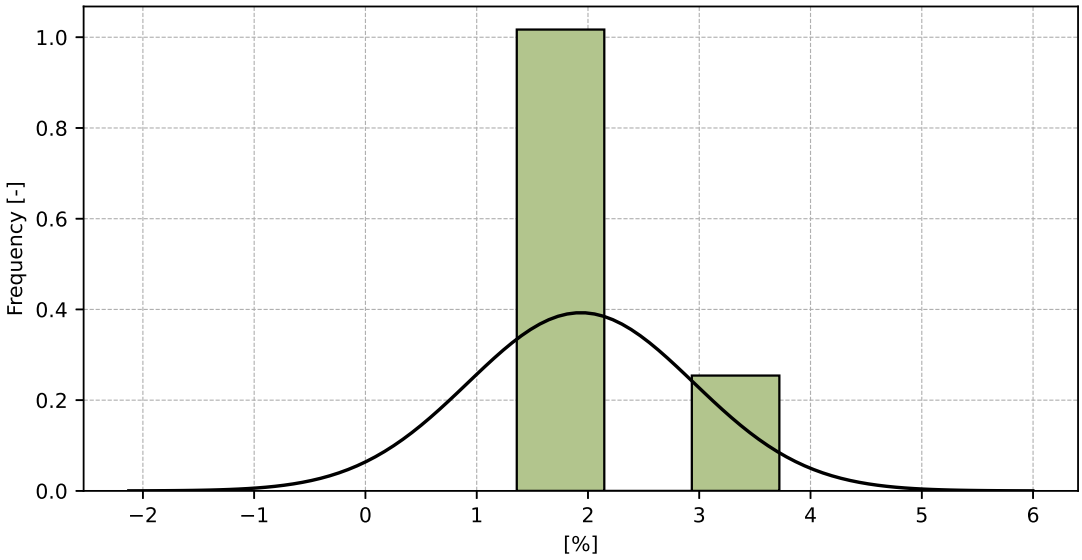

Figure 38: Histogram of all test results

Table 17: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	1.94
Sample standard deviation – s	1.016
Asigned value – x^*	1.87
Robust standard deviation – s^*	1.05
Measurement uncertainty of asigned value – u_X	0.587
p-value of normality test	0.006 [-]

4.2.5 Evaluation of Performance Statistics

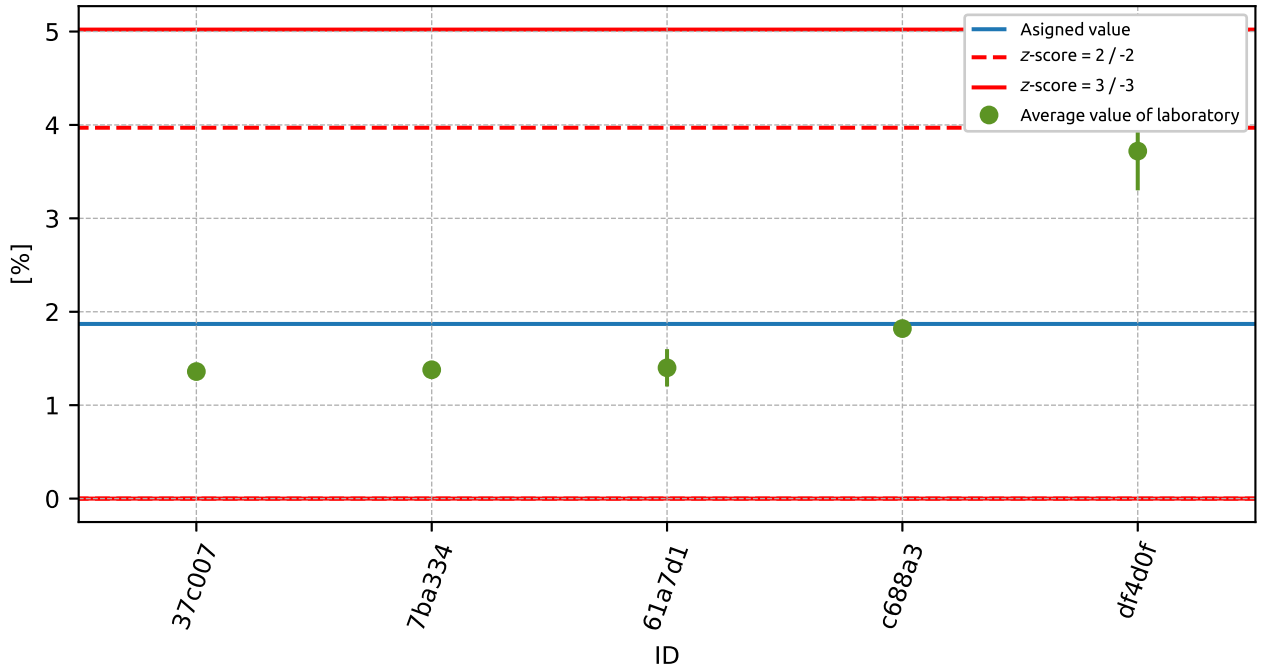

Figure 39: Average values and extended uncertainties of measurement

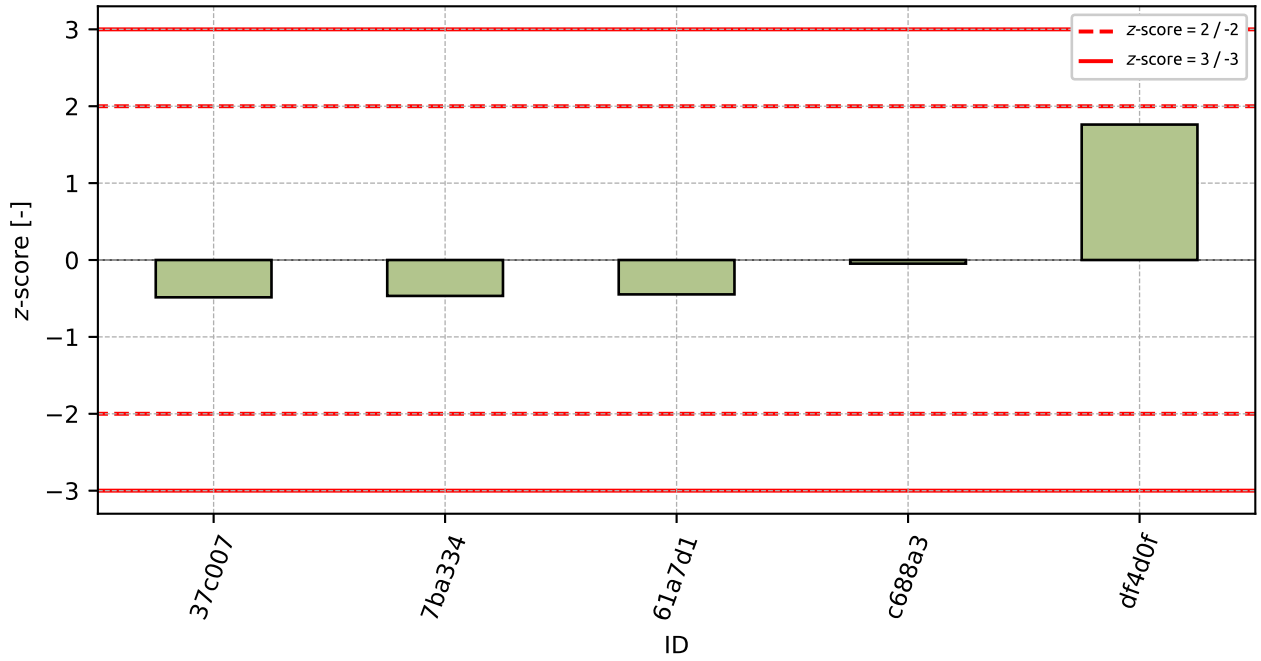

Figure 40: z-score

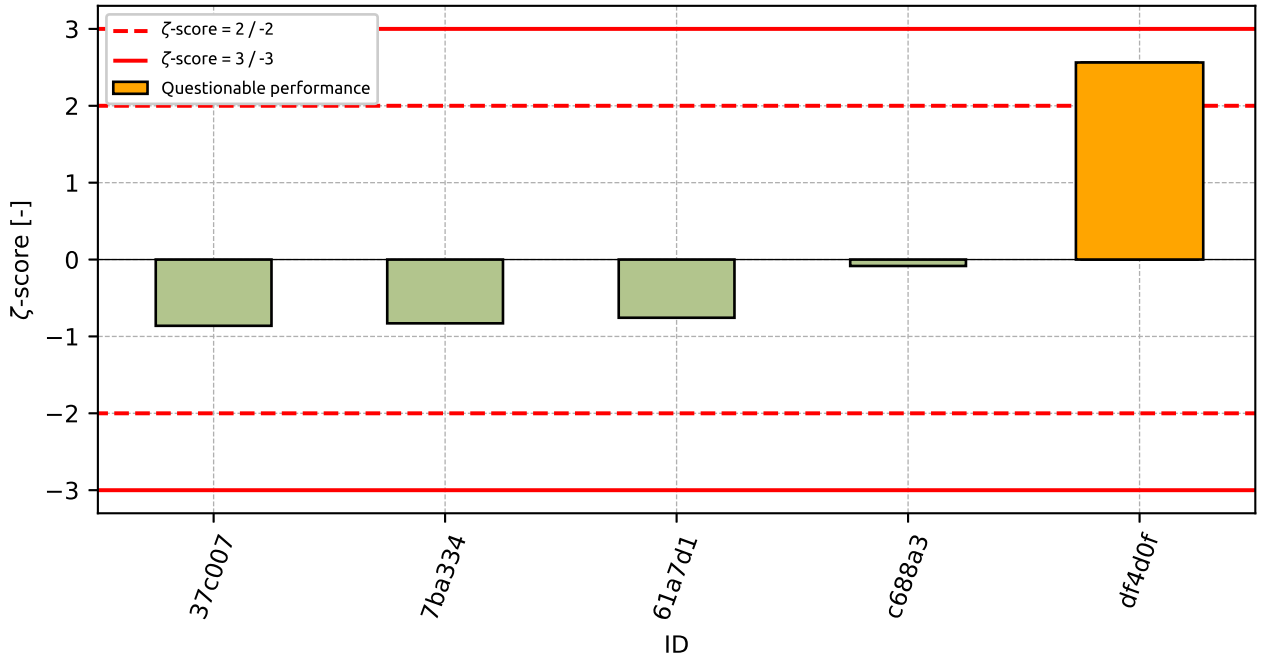

Figure 41: ζ-score

Table 18: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
37c007	-0.49	-0.86
7ba334	-0.47	-0.83
61a7d1	-0.45	-0.76
c688a3	-0.05	-0.08
df4d0f	1.76	2.56

4.3 Spacing factor L

4.3.1 Test results

Table 19: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [mm]	u_X [mm]
df4d0f	0.14	0.02
c688a3	0.173	0.003
61a7d1	0.21	0.02
7ba334	0.287	0.01
37c007	0.304	0.016

4.3.2 The Numerical Procedure for Determining Outliers

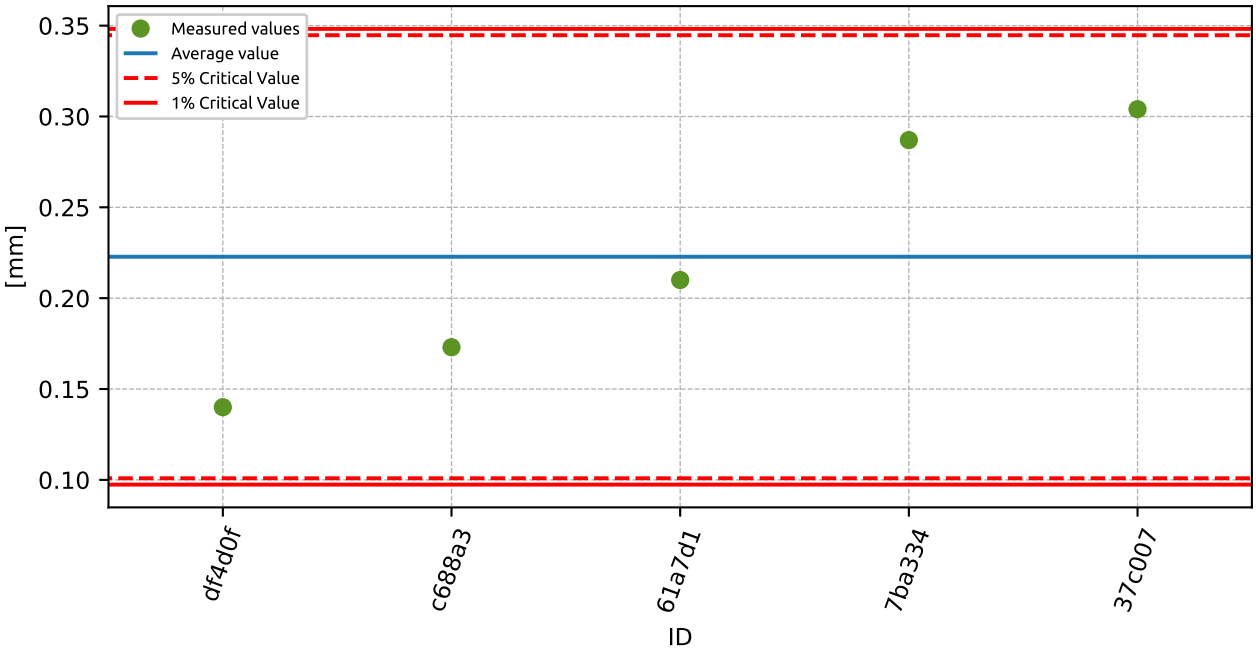

Figure 42: **Grubbs' test** - average values

4.3.3 Mandel's Statistics

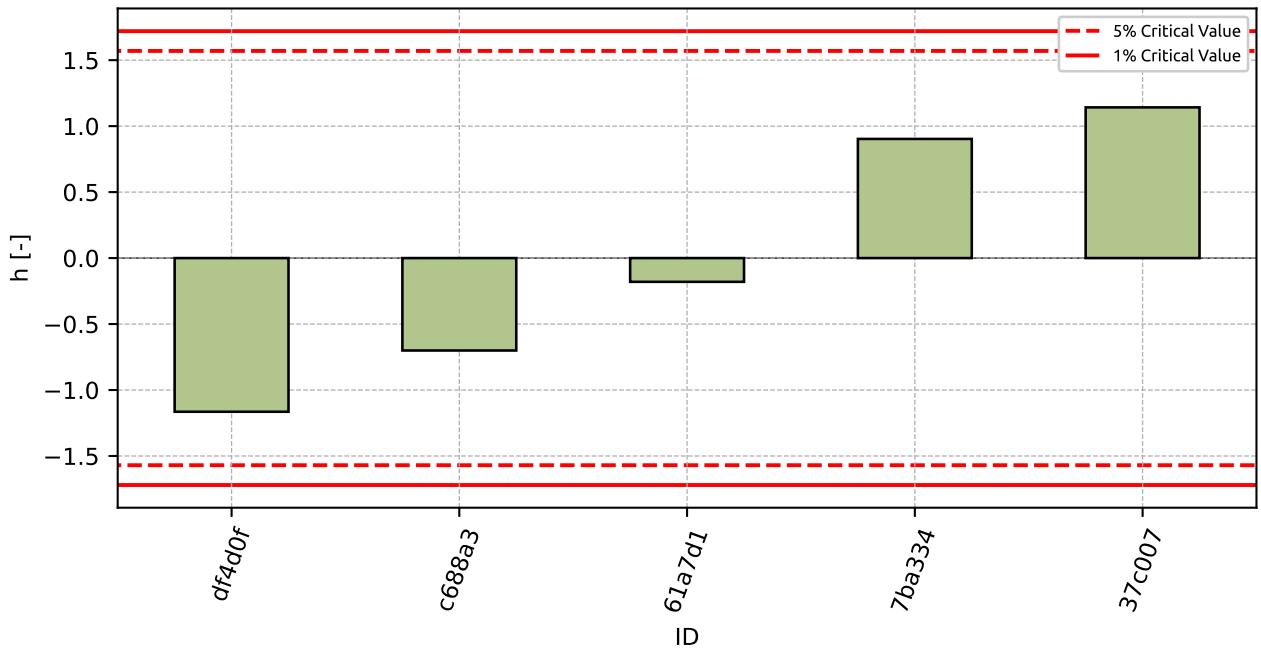

Figure 43: Interlaboratory Consistency Statistic

4.3.4 Descriptive statistics

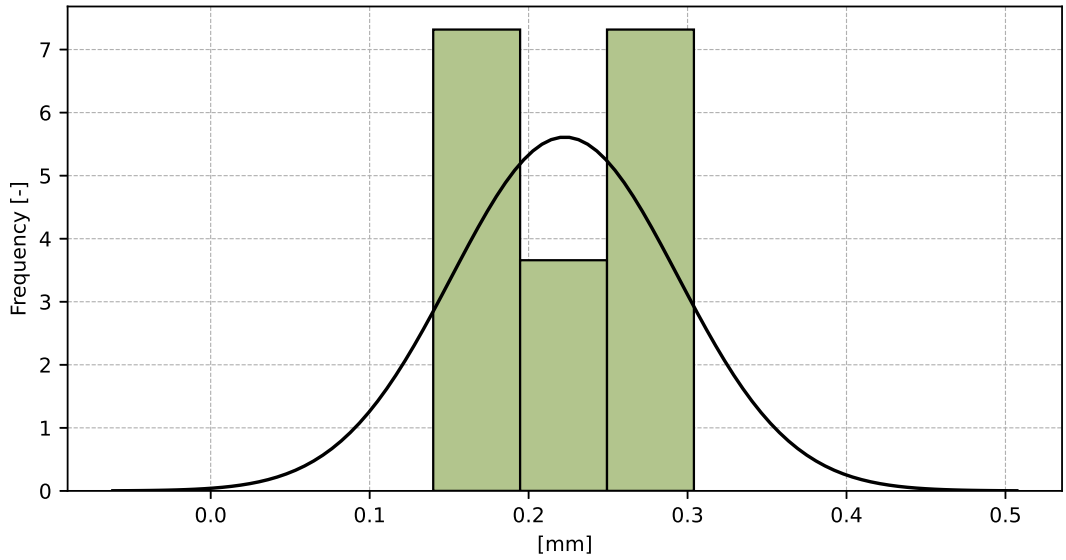

Figure 44: Histogram of all test results

Table 20: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	0.223
Sample standard deviation – s	0.0711
Asigned value – x^*	0.223
Robust standard deviation – s^*	0.0721
Measurement uncertainty of asigned value – u_X	0.0403
p-value of normality test	0.542 [-]

4.3.5 Evaluation of Performance Statistics

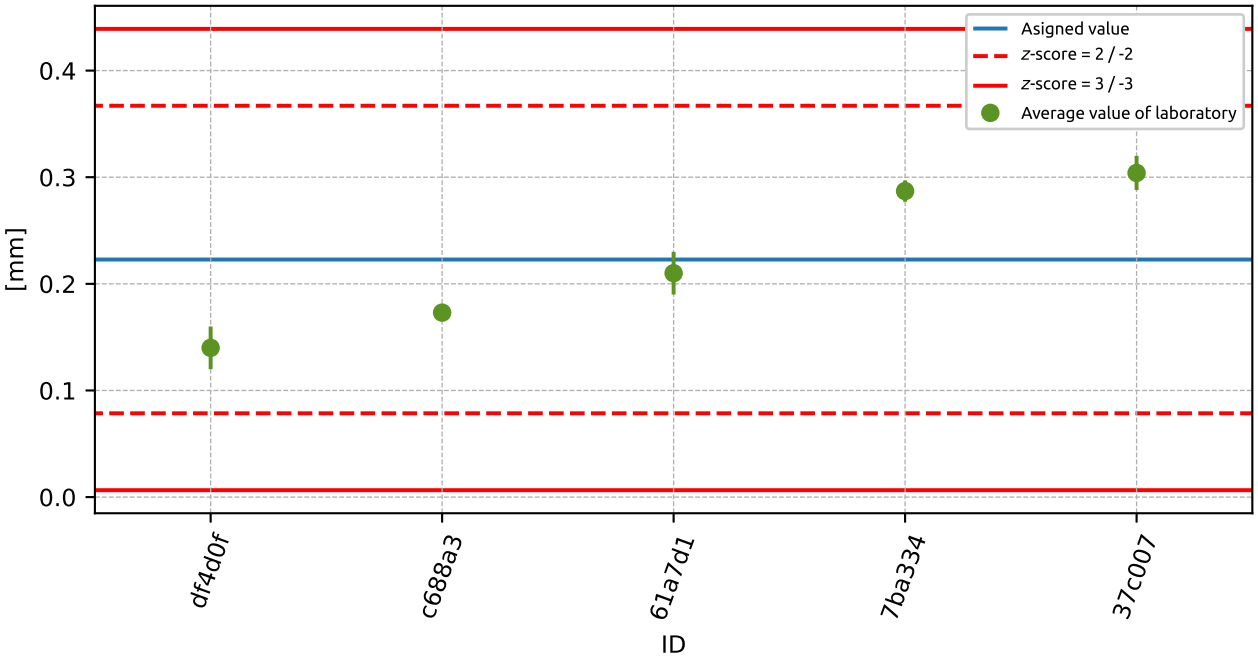

Figure 45: Average values and extended uncertainties of measurement

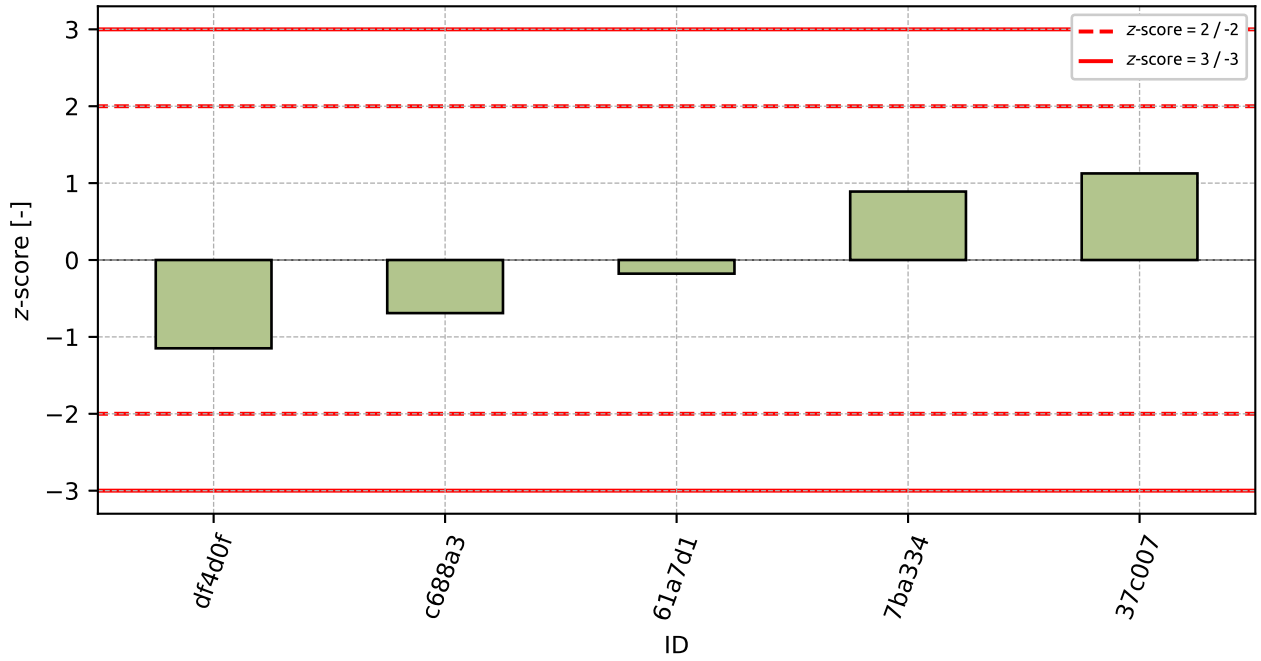

Figure 46: z-score

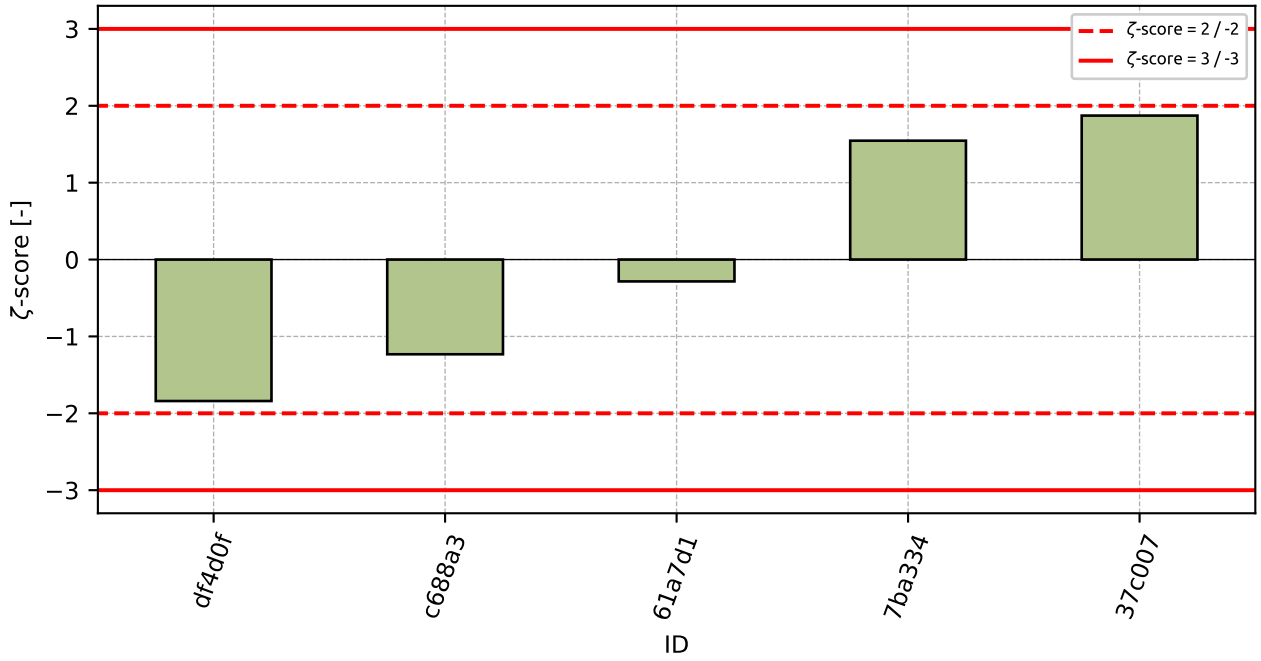

Figure 47: ζ-score

Table 21: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
df4d0f	-1.15	-1.84
c688a3	-0.69	-1.23
61a7d1	-0.18	-0.28
7ba334	0.89	1.55
37c007	1.13	1.87

5 Appendix – ČSN 73 1322 – Determination of frost resistance of concrete

5.1 Test results

Table 22: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [-]	u_X [-]
6e9ea6	0.13	0.05
6dbc32	0.15	-
cd9809	0.15	0.08
426734	0.16	0.0
8ccfce	0.16	0.09
00ca75	0.18	-

5.2 The Numerical Procedure for Determining Outliers

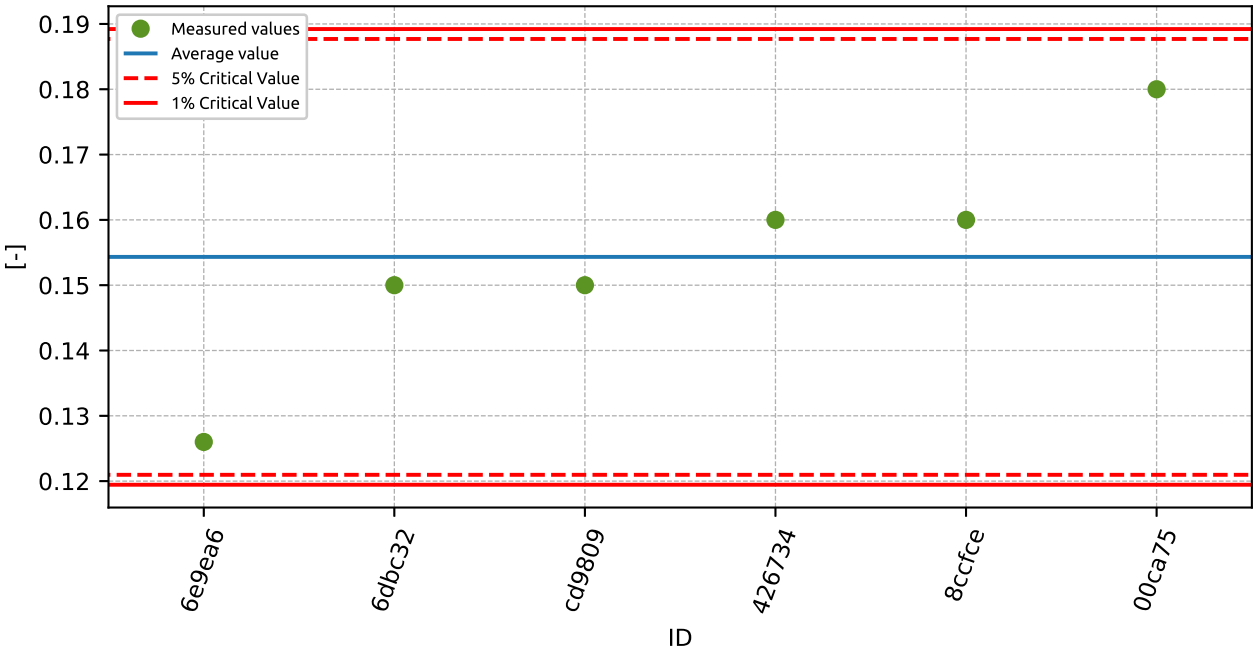

Figure 48: **Grubbs' test** - average values

5.3 Mandel's Statistics

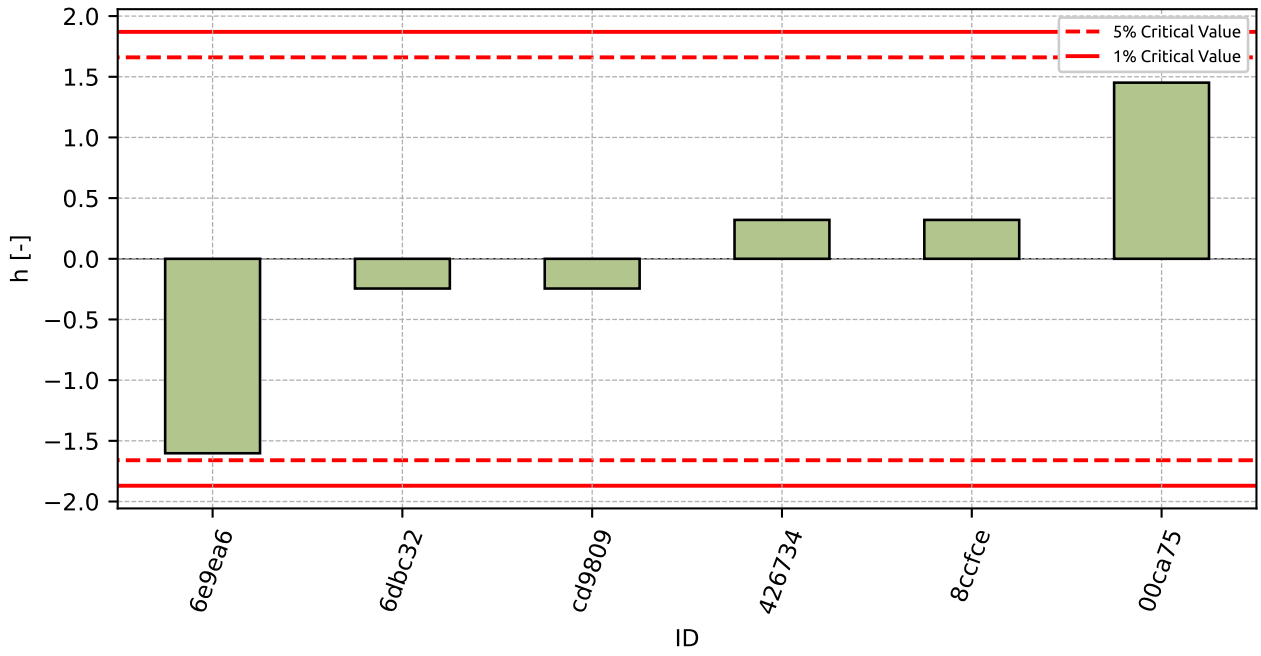

Figure 49: Interlaboratory Consistency Statistic

5.4 Descriptive statistics

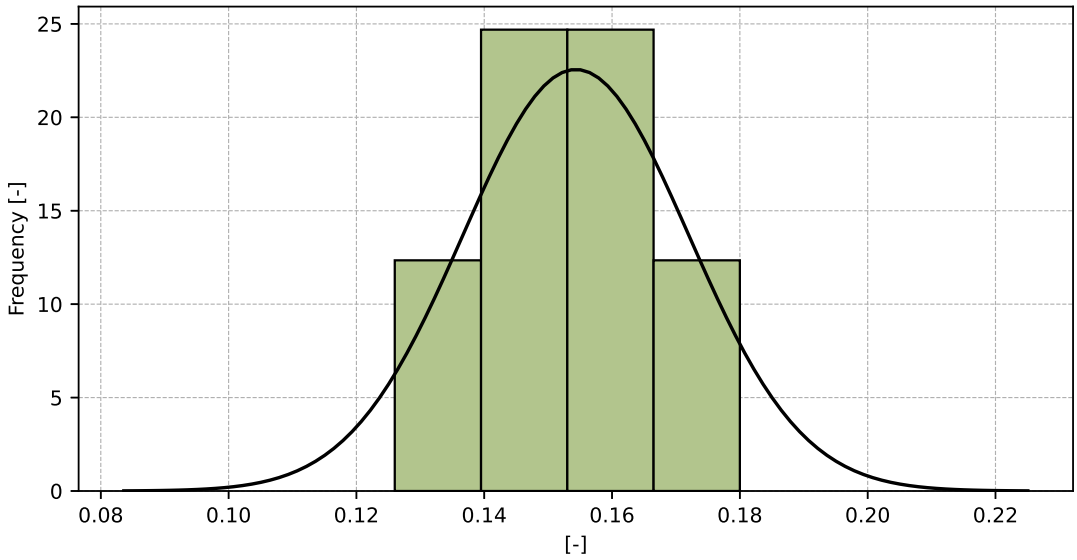

Figure 50: Histogram of all test results

Table 23: Descriptive statistics

Characteristics	[-]
Average value – $\bar{x}$	0.15
Sample standard deviation – s	0.018
Asigned value – x^*	0.16
Robust standard deviation – s^*	0.017
Measurement uncertainty of asigned value – u_X	0.007
p-value of normality test	0.689 [-]

5.5 Evaluation of Performance Statistics

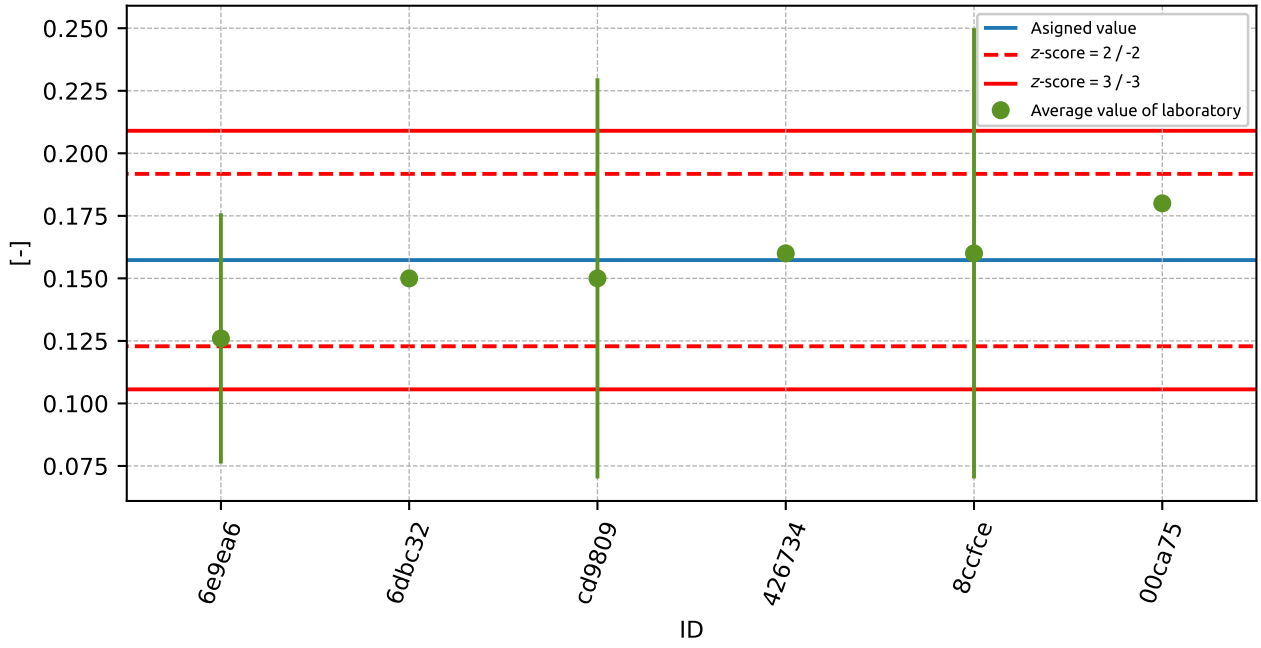

Figure 51: Average values and extended uncertainties of measurement

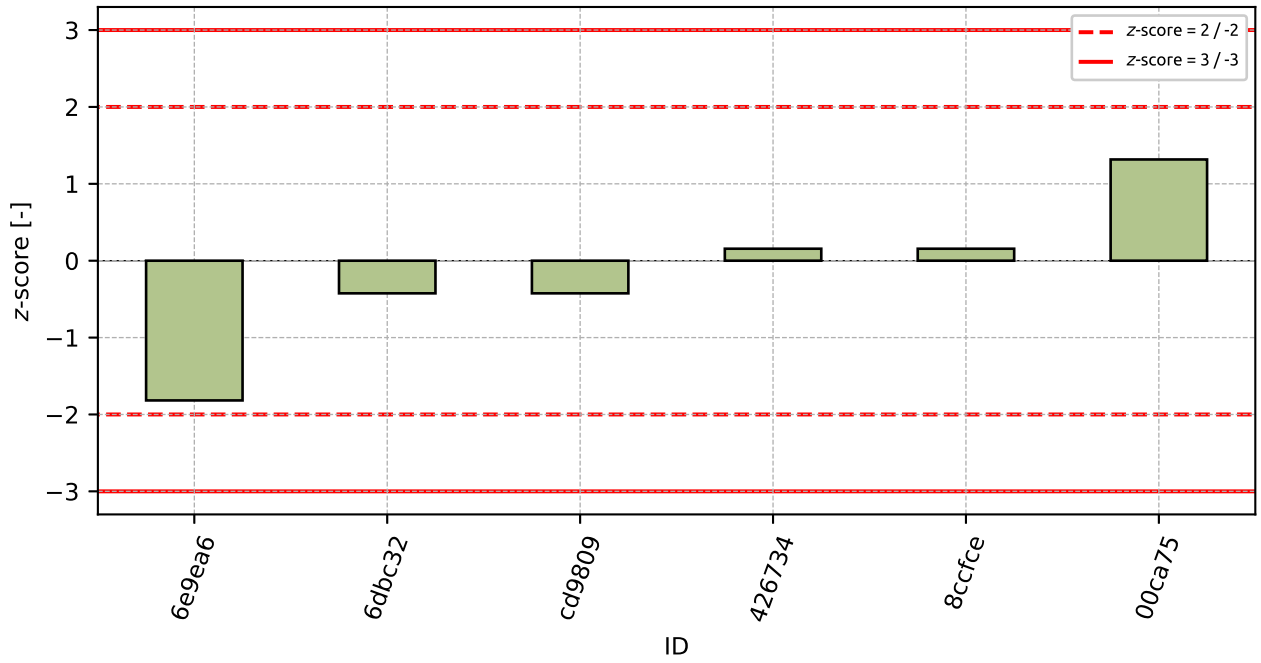

Figure 52: z-score

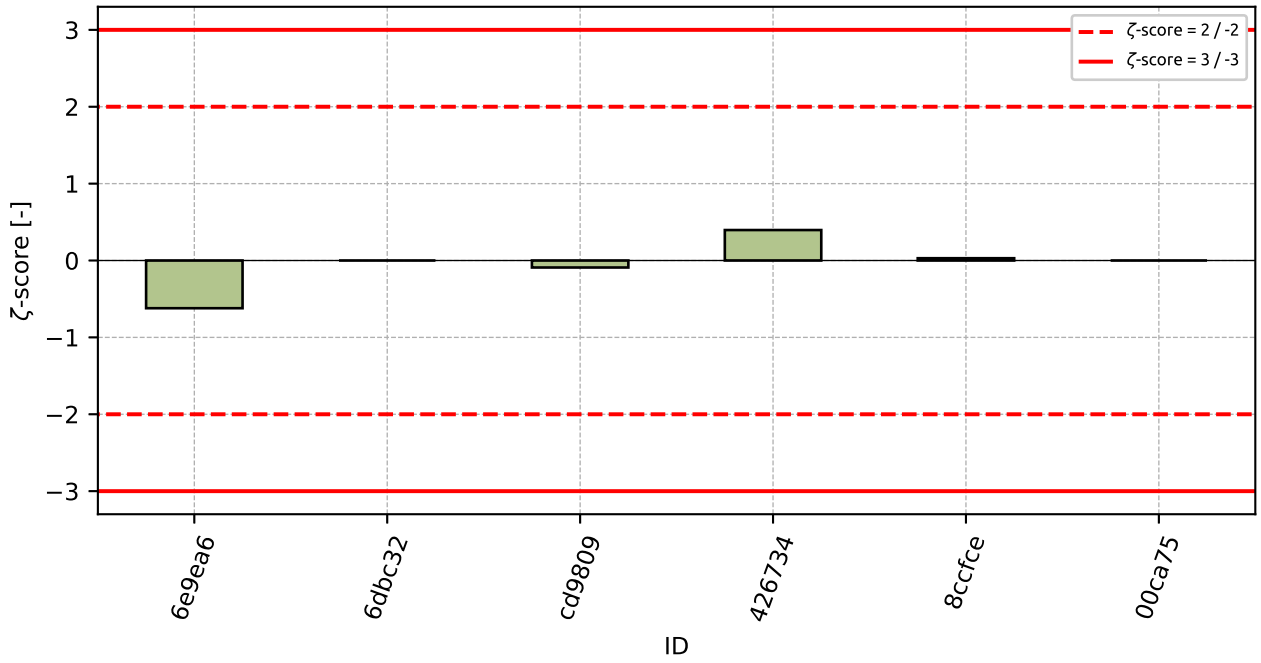

Figure 53: ζ-score

Table 24: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
6e9ea6	-1.82	-0.62
6dbc32	-0.42	-
cd9809	-0.42	-0.09
426734	0.16	0.4
8ccfce	0.16	0.03
00ca75	1.32	-

6 Appendix – ČSN 73 1324 – Determination of grindability of concrete

This part of the PT program was not opened due to low interest from laboratories.

7 Appendix – ČSN 73 1326 – Resistance of cement concrete surface to water and defrosting chemicals – Method A

7.1 25 cycles

7.1.1 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 [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
1a9b52	70.1	82.4	78.4	16.0	77.0	6.27	8.15
1ca5d9	83.1	133.3	77.6	4.0	98.0	30.69	31.32
d439b1	136.8	179.5	98.6	-	138.3	40.47	29.26
6dbc32	120.0	153.0	216.0	127.0	163.0	48.77	29.92
df4d0f	185.1	181.5	222.0	60.0	196.2	22.42	11.42
af100e	226.7	238.9	134.2	8.5	199.9	57.25	28.64
6ed82b	247.1	211.8	145.1	-	201.3	51.8	25.73
c688a3	235.0	251.0	184.0	100.0	223.3	34.99	15.67
9de304	243.7	231.1	210.3	34.3	228.4	16.87	7.39
00ca75	243.0	293.7	282.0	-	272.9	26.55	9.73

7.1.2 The Numerical Procedure for Determining Outliers

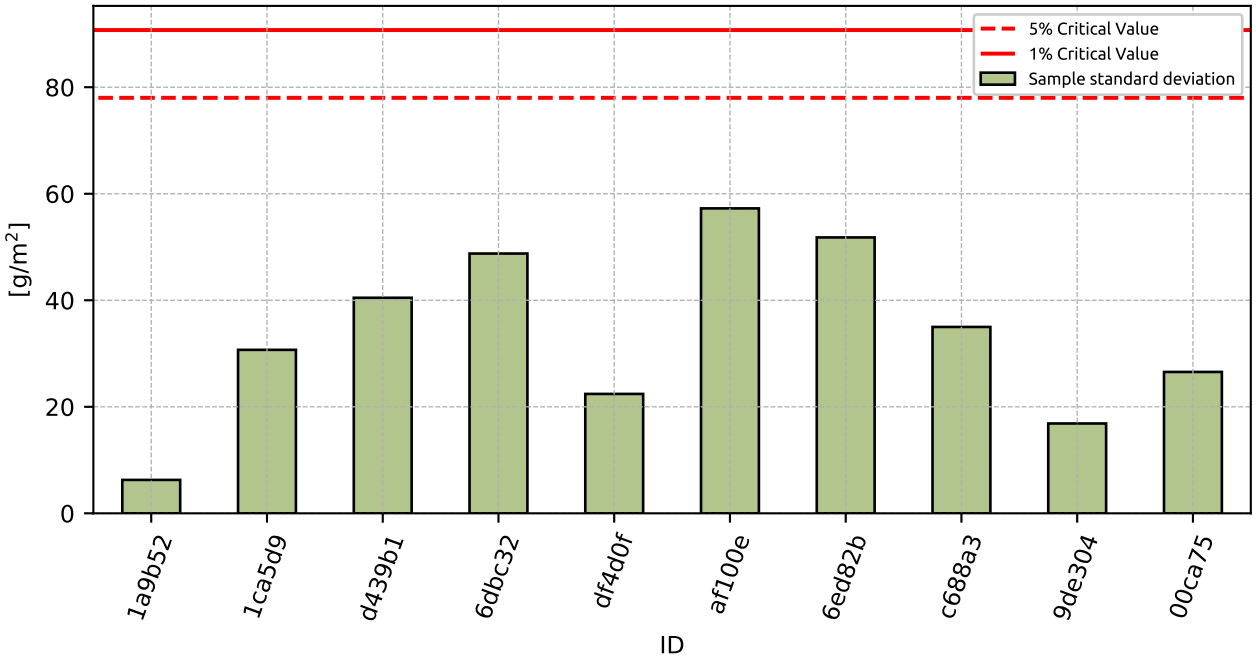

Figure 54: **Cochran's test** - sample standard deviations

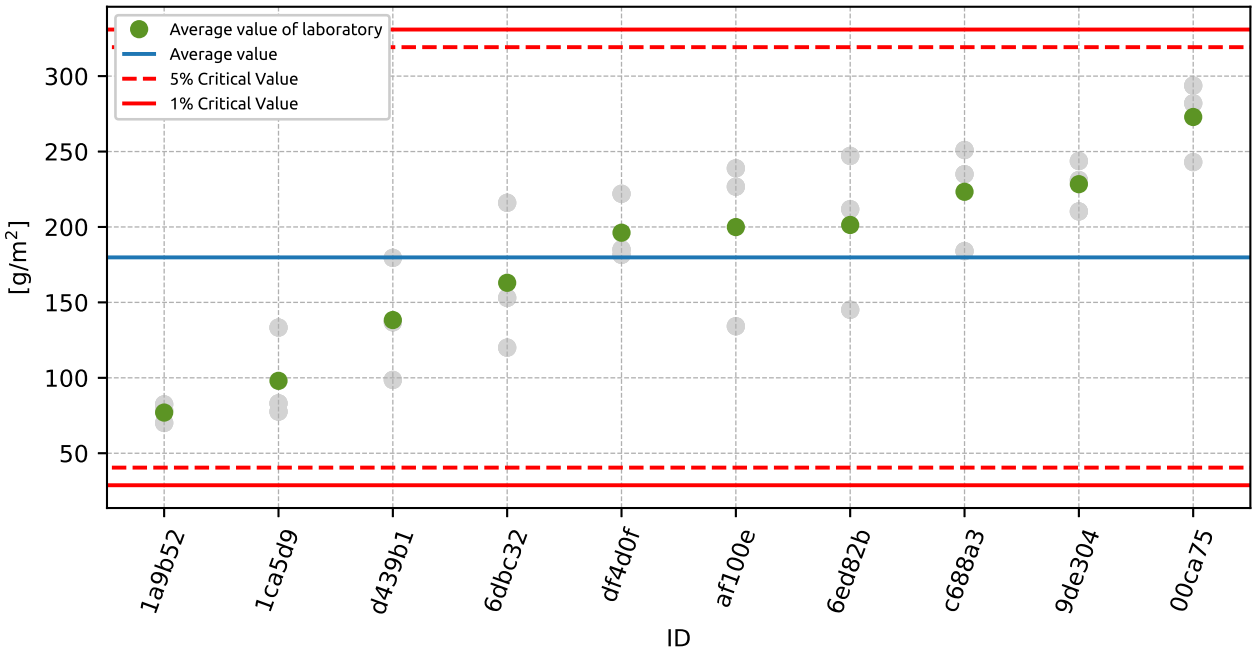

Figure 55: **Grubbs' test** - average values

7.1.3 Mandel's Statistics

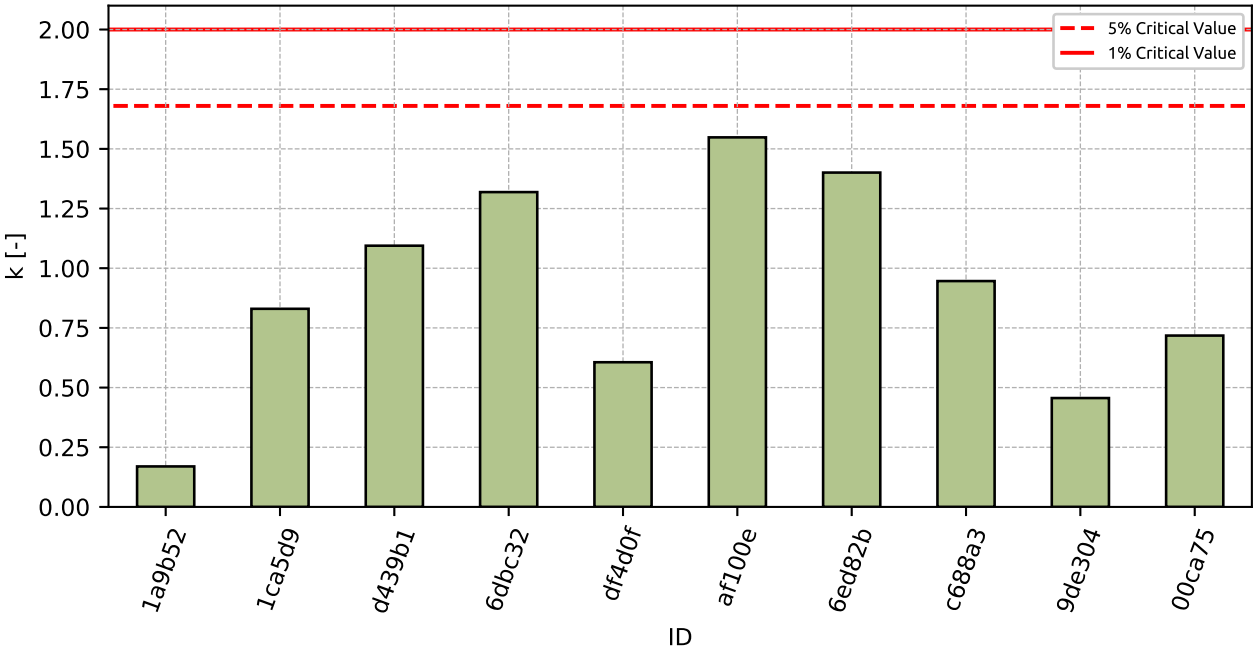

Figure 56: Intralaboratory Consistency Statistic

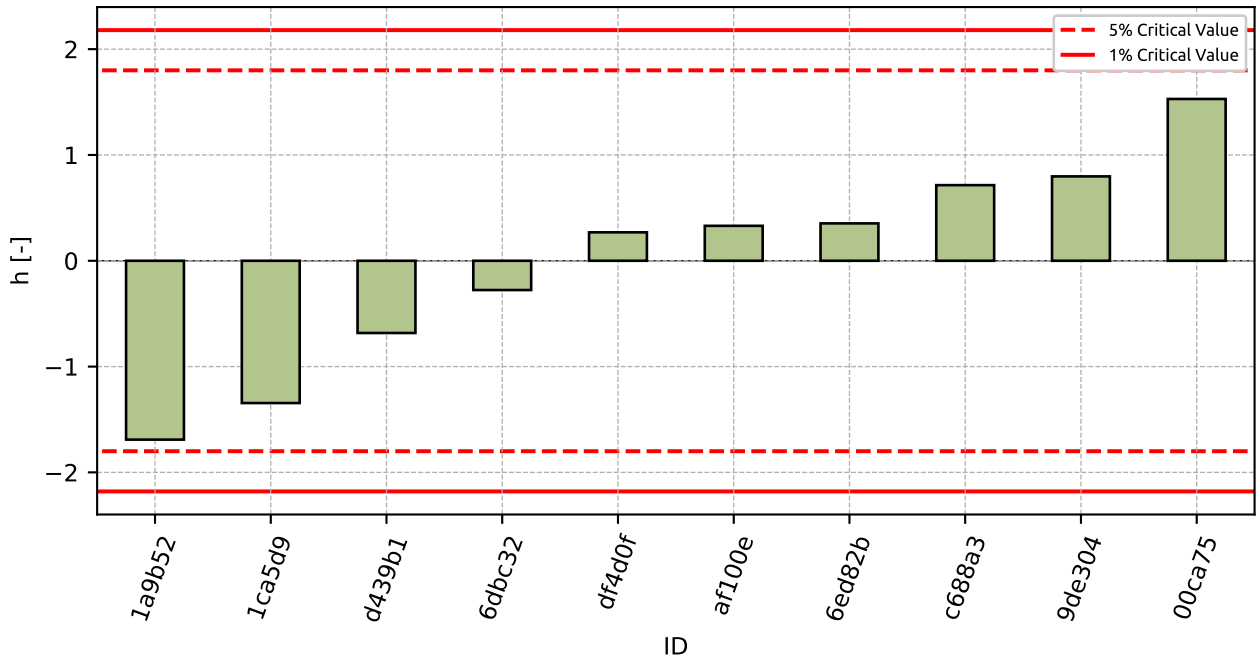

Figure 57: Interlaboratory Consistency Statistic

7.1.4 Descriptive statistics

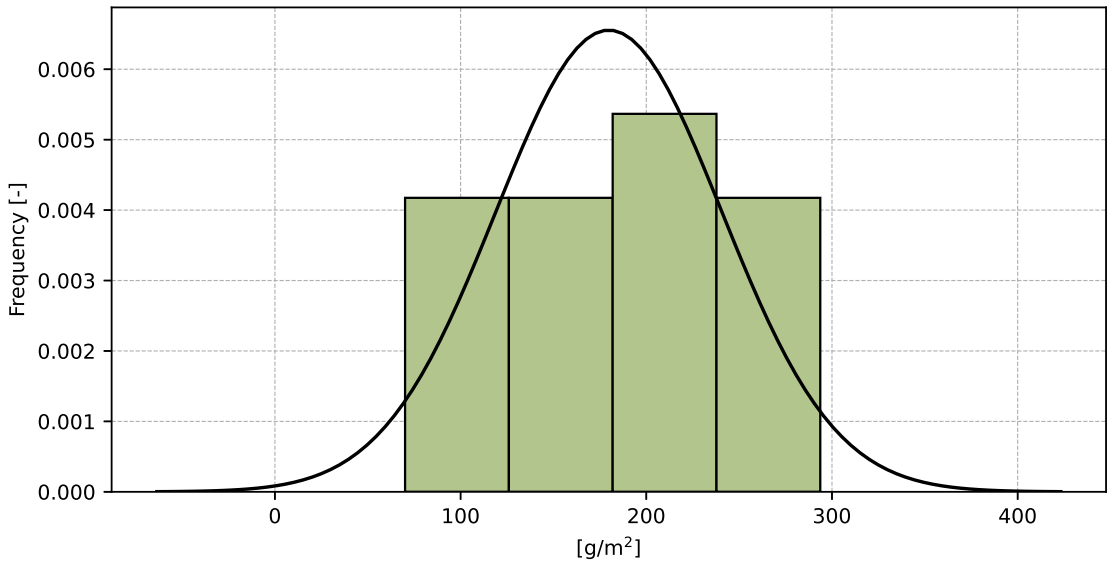

Figure 58: Histogram of all test results

Table 26: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	179.8
Sample standard deviation – s	60.85
Asigned value – x^*	187.4
Robust standard deviation – s^*	52.47
Measurement uncertainty of asigned value – u_X	20.74
p-value of normality test	0.081 [-]
Interlaboratory standard deviation – s_L	56.99
Repeatability standard deviation – s_r	36.98
Reproducibility standard deviation – s_R	67.93
Repeatability – r	103.5
Reproducibility – R	190.2

7.1.5 Evaluation of Performance Statistics

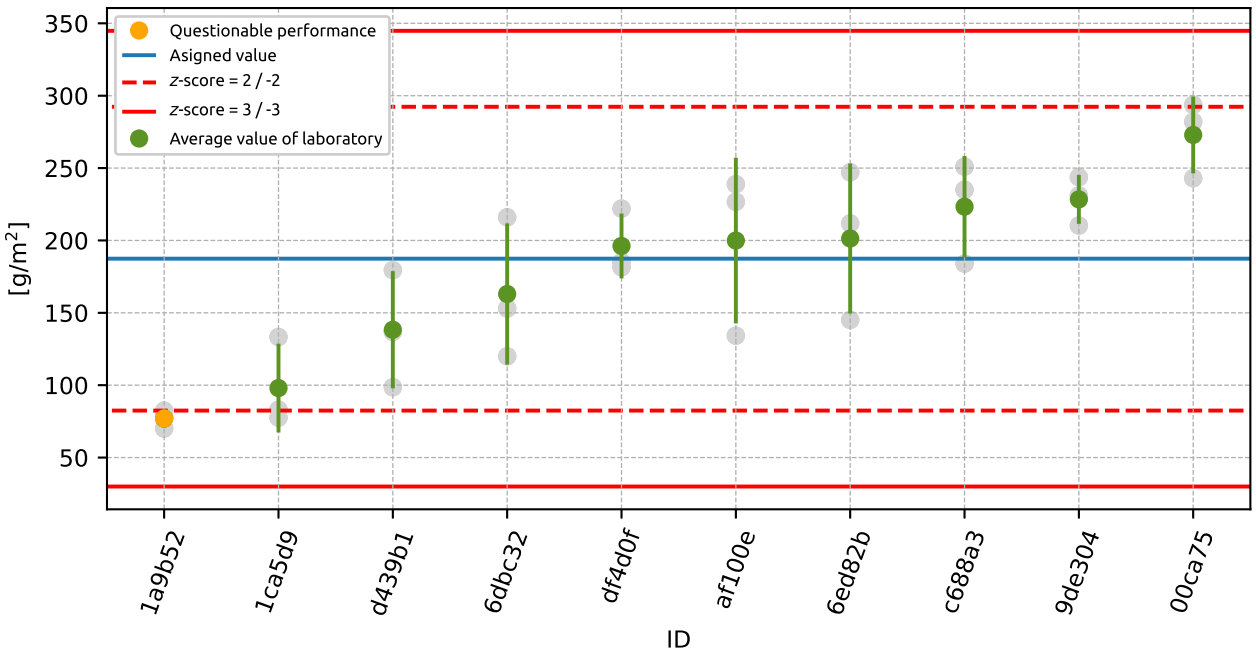

Figure 59: Average values and sample standard deviations

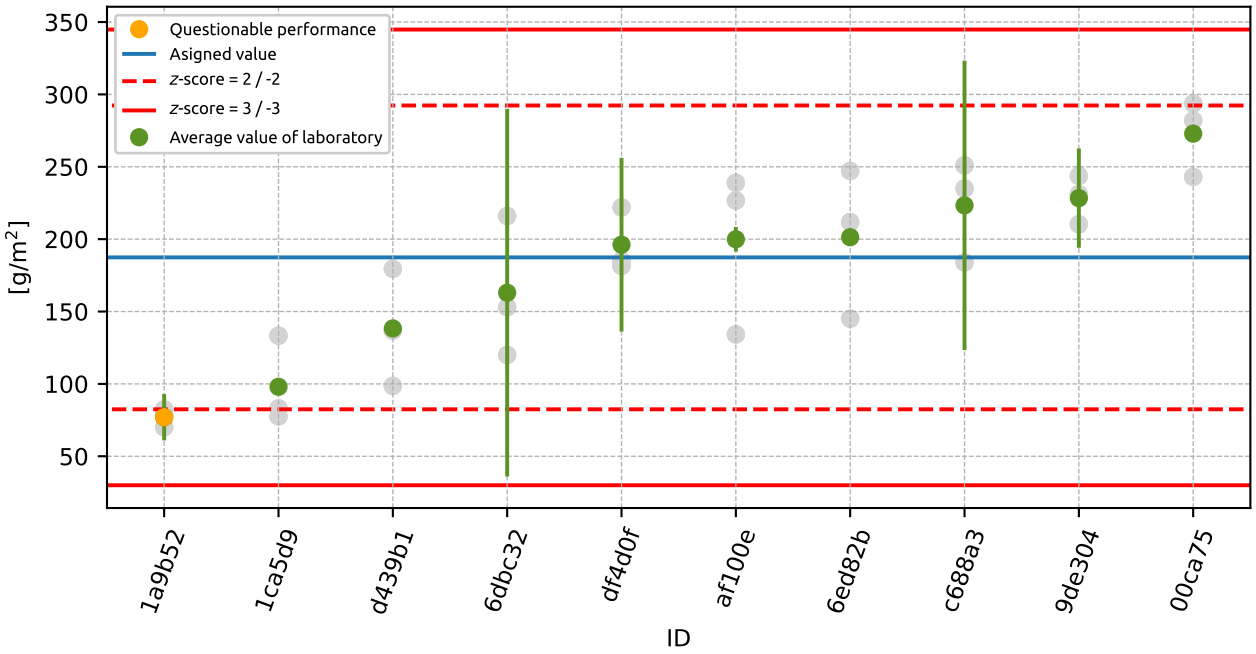

Figure 60: Average values and extended uncertainties of measurement

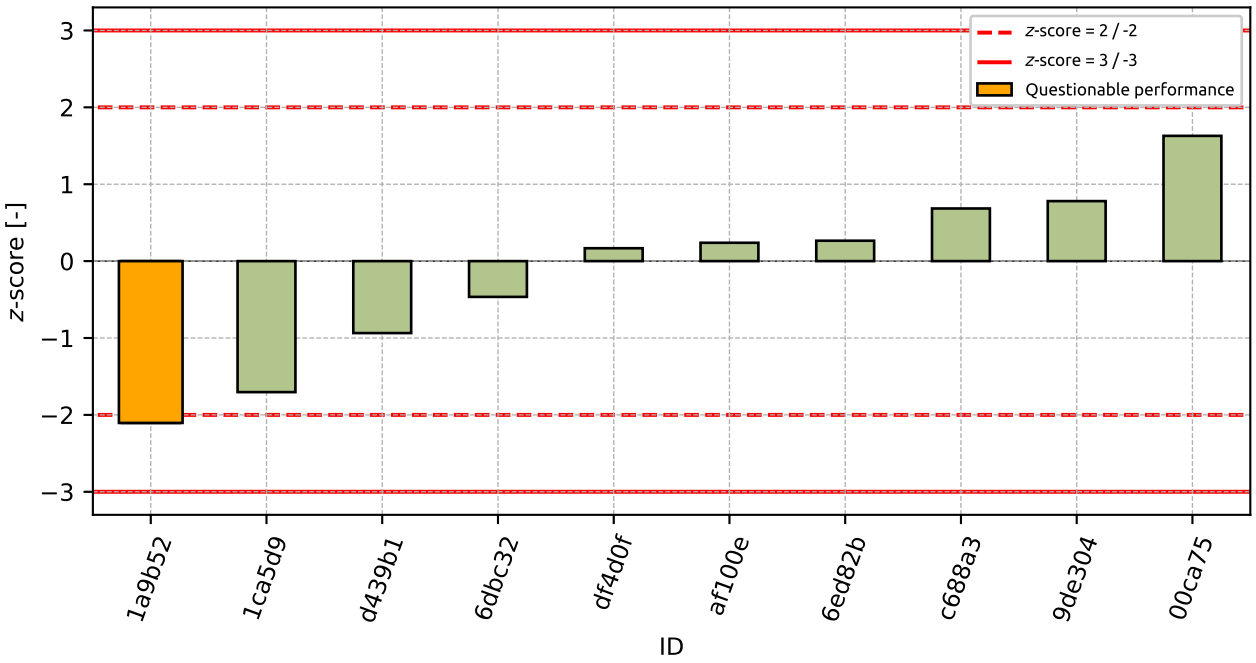

Figure 61: z-score

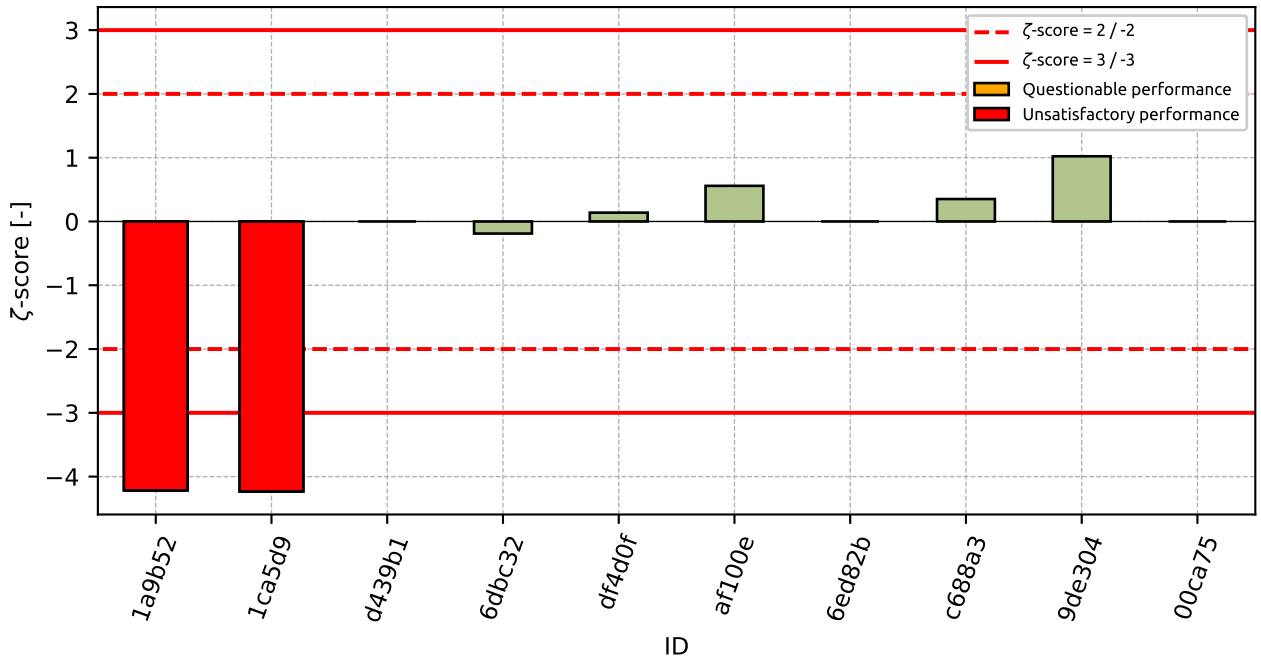

Figure 62: ζ-score

Table 27: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
1a9b52	-2.1	-4.22
1ca5d9	-1.7	-4.23
d439b1	-0.94	-
6dbc32	-0.47	-0.19
df4d0f	0.17	0.14
af100e	0.24	0.56
6ed82b	0.27	-
c688a3	0.68	0.35
9de304	0.78	1.02
00ca75	1.63	-

7.2 50 cycles

7.2.1 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 [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
af100e	183.6	88.1	88.9	8.5	120.2	54.91	45.68
9de304	186.8	188.5	196.6	28.5	190.6	5.24	2.75
1ca5d9	198.0	273.7	167.8	8.6	213.2	54.55	25.59
1a9b52	226.0	286.3	247.1	80.0	253.1	30.6	12.09
d439b1	270.1	404.0	197.1	-	290.4	104.93	36.13
6dbc32	256.0	305.0	452.0	266.0	337.7	102.0	30.21
df4d0f	351.3	369.9	431.5	113.0	384.2	41.98	10.92
6ed82b	443.1	415.7	294.1	-	384.3	79.31	20.64
00ca75	331.3	420.8	405.4	-	385.8	47.85	12.4
c688a3	412.0	459.0	388.0	100.0	419.7	36.12	8.61

7.2.2 The Numerical Procedure for Determining Outliers

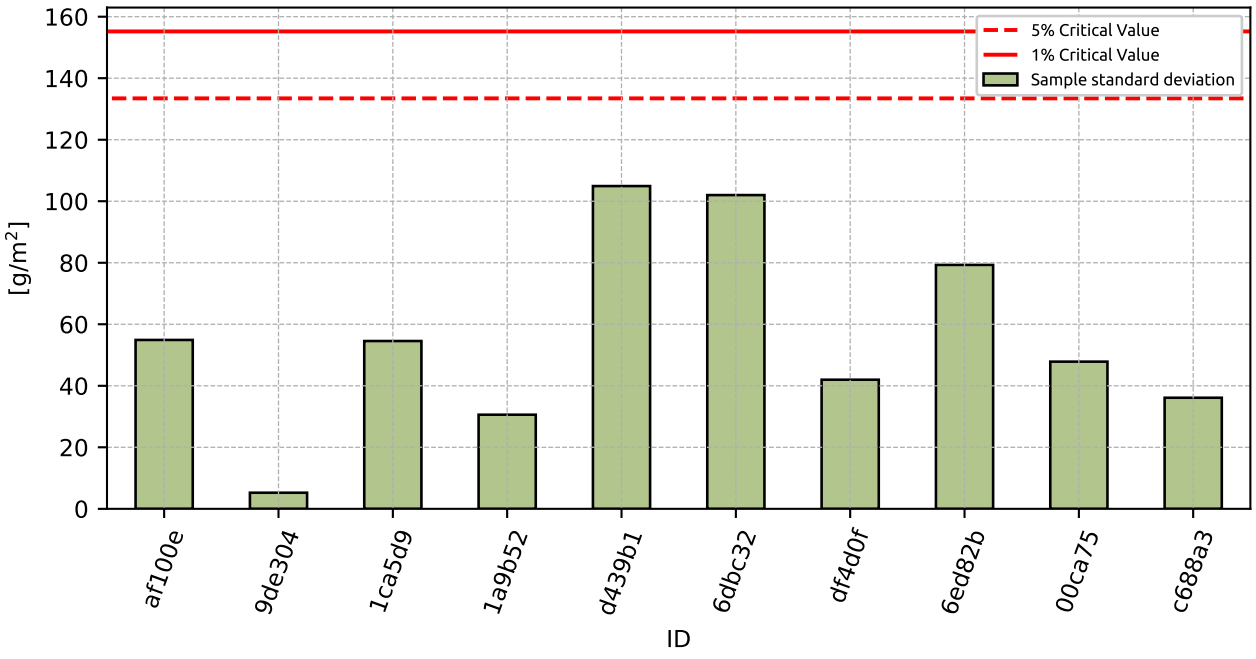

Figure 63: **Cochran's test** - sample standard deviations

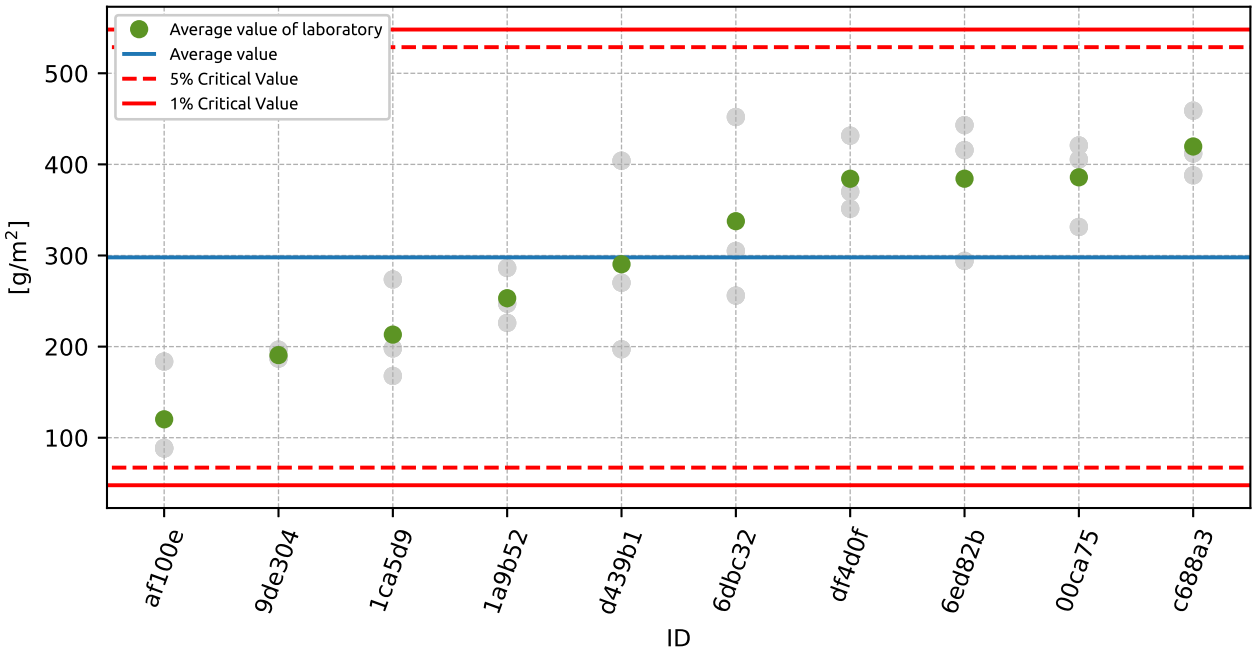

Figure 64: **Grubbs' test** - average values

7.2.3 Mandel's Statistics

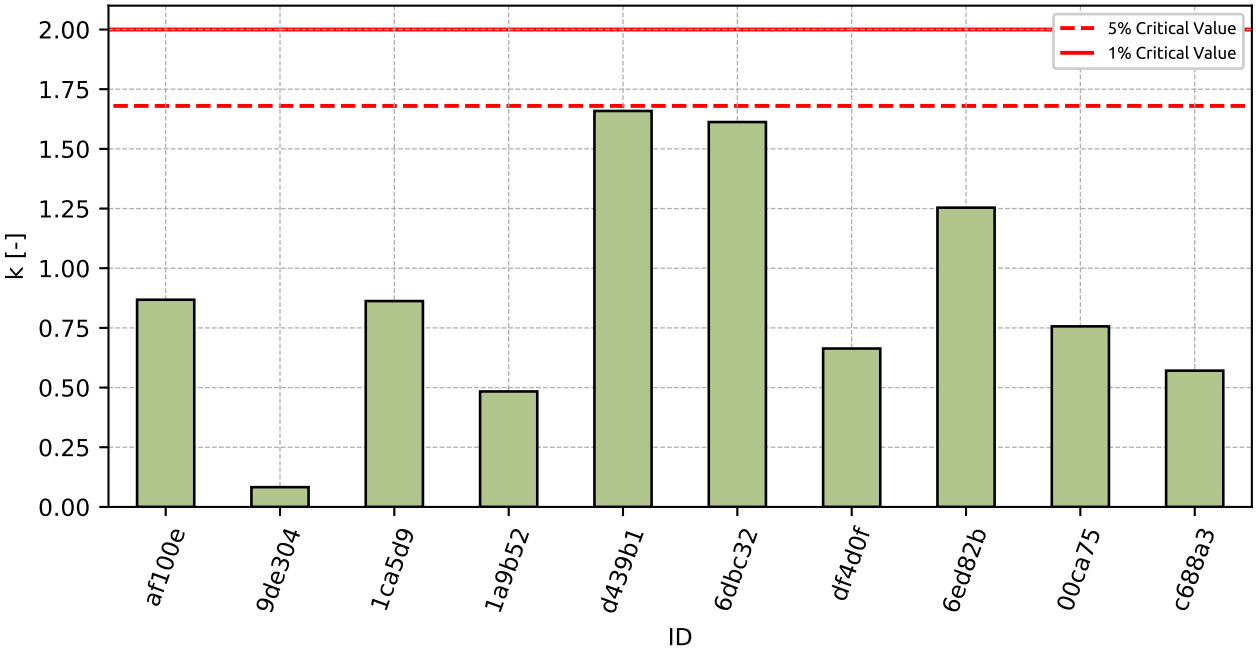

Figure 65: Intralaboratory Consistency Statistic

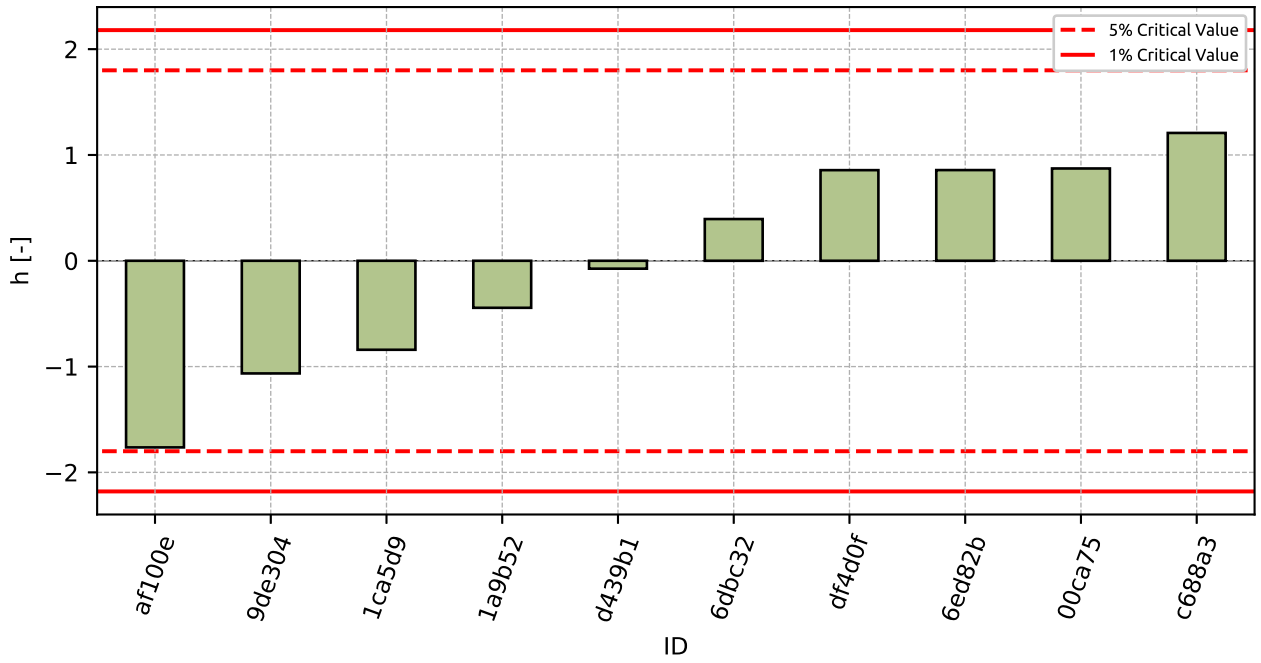

Figure 66: Interlaboratory Consistency Statistic

7.2.4 Descriptive statistics

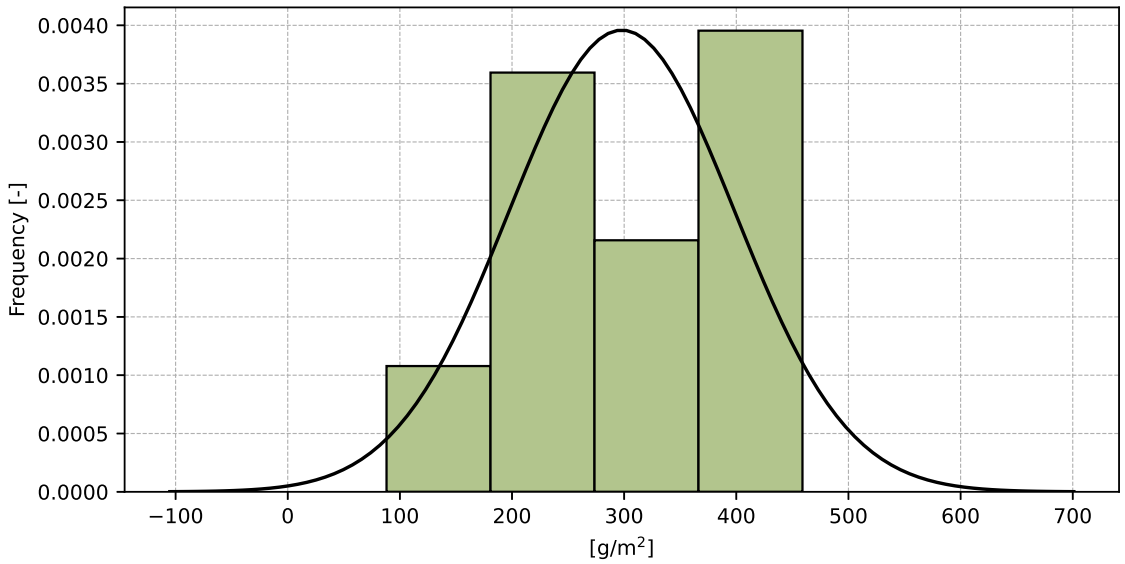

Figure 67: Histogram of all test results

Table 29: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	297.9
Sample standard deviation – s	100.77
Asigned value – x^*	301.5
Robust standard deviation – s^*	101.3
Measurement uncertainty of asigned value – u_X	40.04
p-value of normality test	0.085 [-]
Interlaboratory standard deviation – s_L	93.91
Repeatability standard deviation – s_r	63.26
Reproducibility standard deviation – s_R	113.23
Repeatability – r	177.1
Reproducibility – R	317.0

7.2.5 Evaluation of Performance Statistics

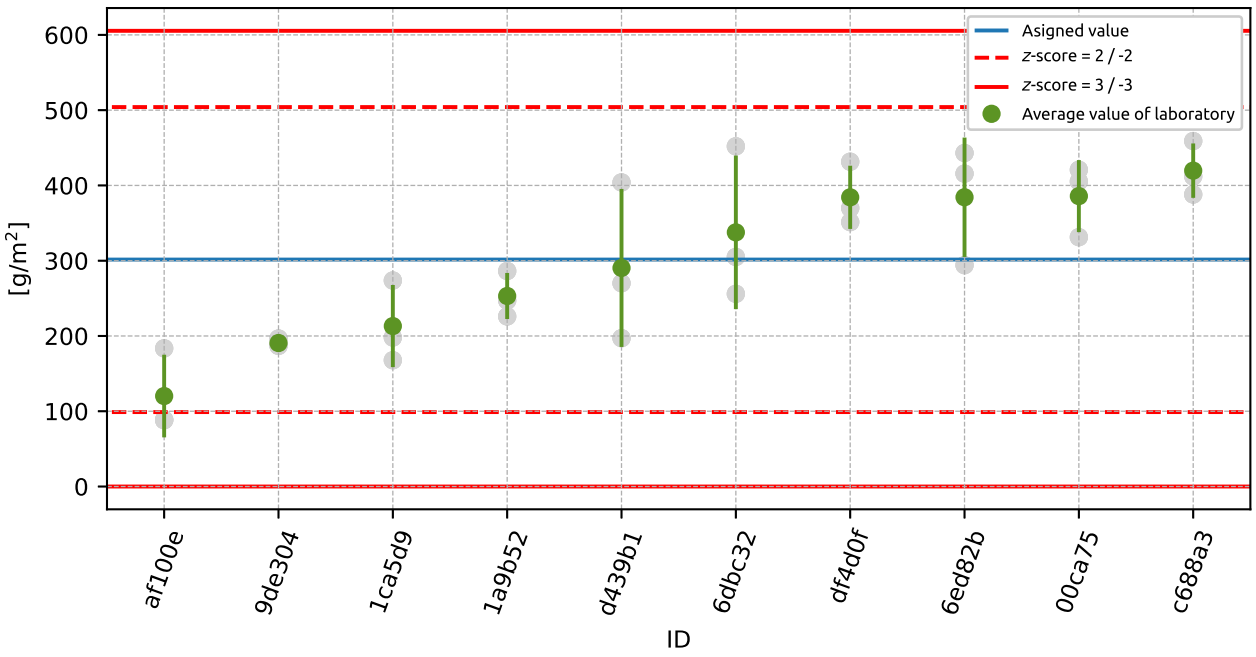

Figure 68: Average values and sample standard deviations

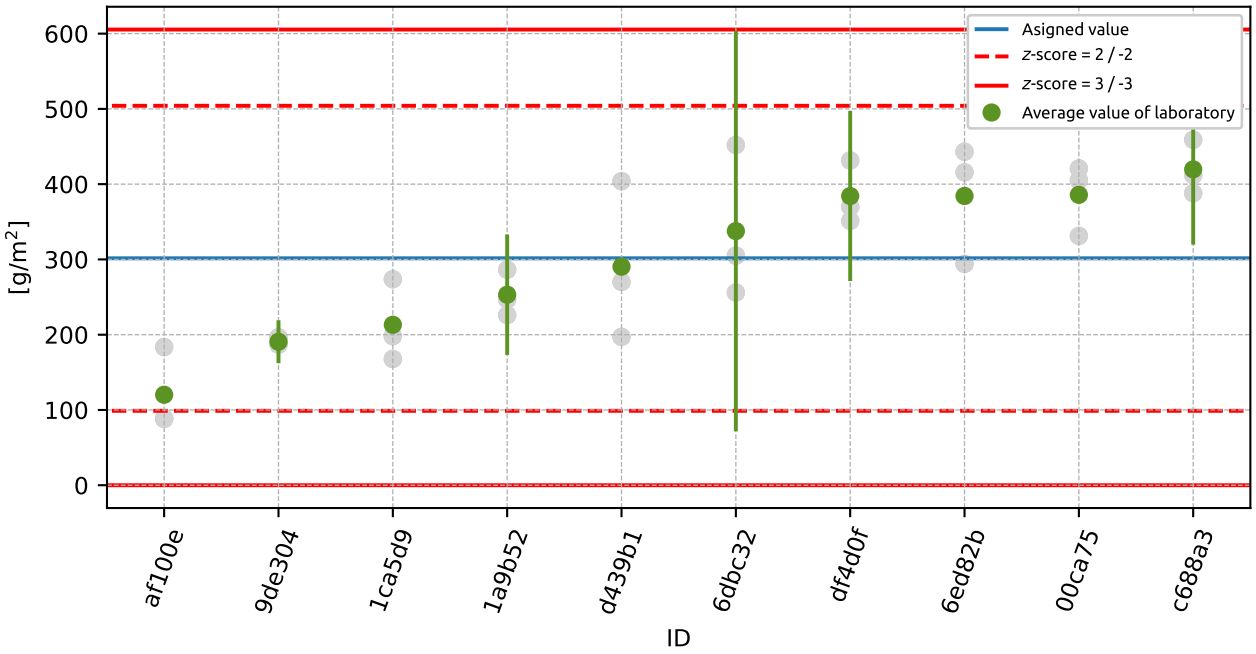

Figure 69: Average values and extended uncertainties of measurement

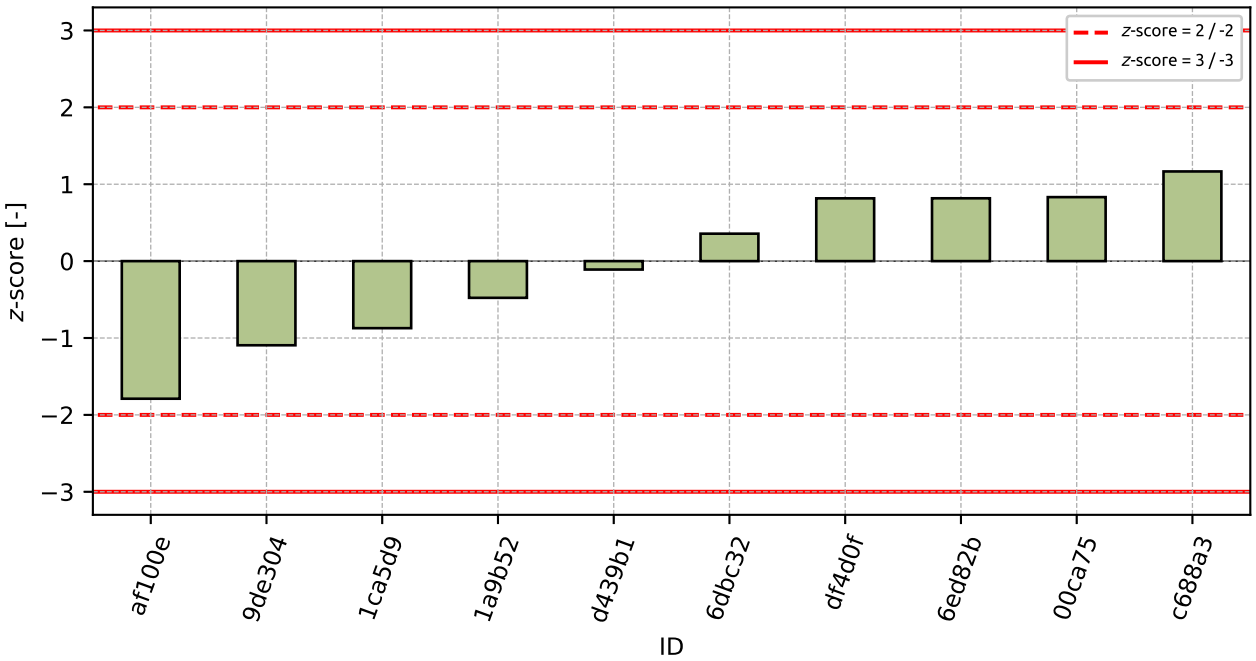

Figure 70: z-score

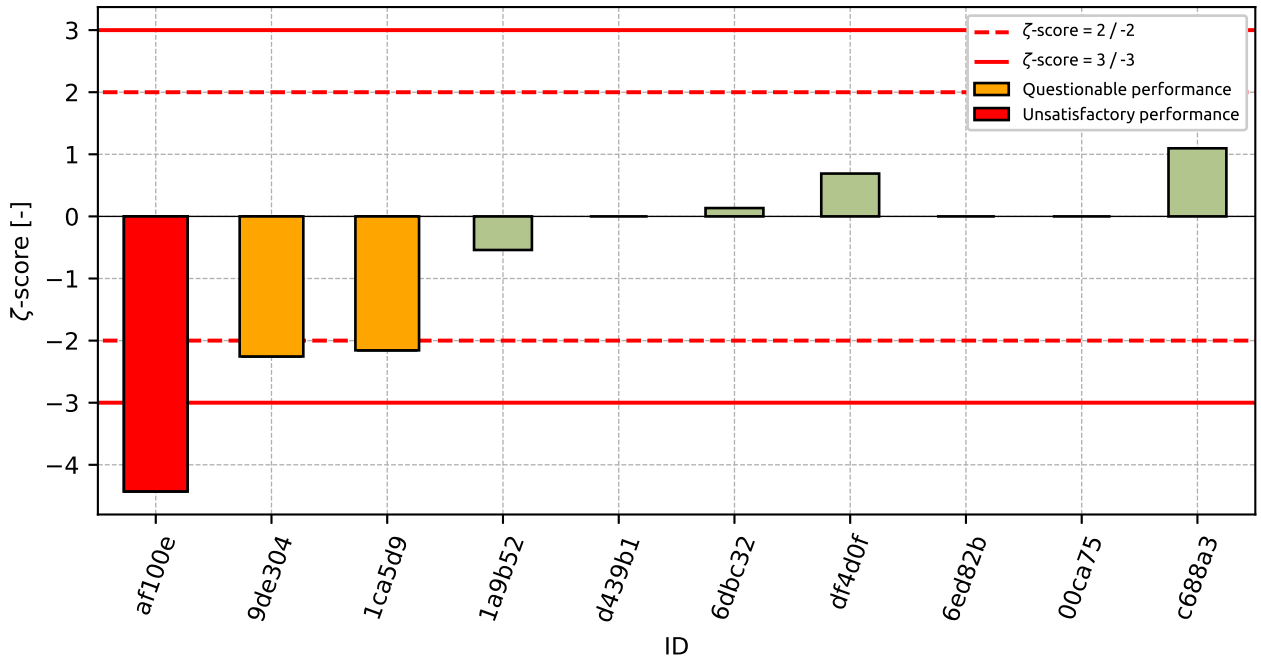

Figure 71: ζ-score

Table 30: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
af100e	-1.79	-4.43
9de304	-1.09	-2.26
1ca5d9	-0.87	-2.16
1a9b52	-0.48	-0.54
d439b1	-0.11	-
6dbc32	0.36	0.13
df4d0f	0.82	0.69
6ed82b	0.82	-
00ca75	0.83	-
c688a3	1.17	1.1

7.3 75 cycles

7.3.1 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 [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
af100e	74.7	137.8	54.7	8.5	89.1	43.37	48.7
9de304	181.8	231.5	244.4	32.9	219.2	33.05	15.08
1ca5d9	348.2	433.7	301.5	14.5	361.1	67.04	18.56
1a9b52	417.0	498.0	439.2	109.0	451.4	41.86	9.27
d439b1	424.5	628.4	306.3	-	453.1	162.94	35.96
00ca75	406.4	530.3	502.3	-	479.7	64.98	13.55
6dbc32	427.0	486.0	683.0	350.0	532.0	134.06	25.2
df4d0f	505.5	549.1	616.9	151.0	557.2	56.14	10.08
6ed82b	643.1	603.9	533.3	-	593.4	55.64	9.38
c688a3	577.0	671.0	572.0	150.0	606.7	55.77	9.19

7.3.2 The Numerical Procedure for Determining Outliers

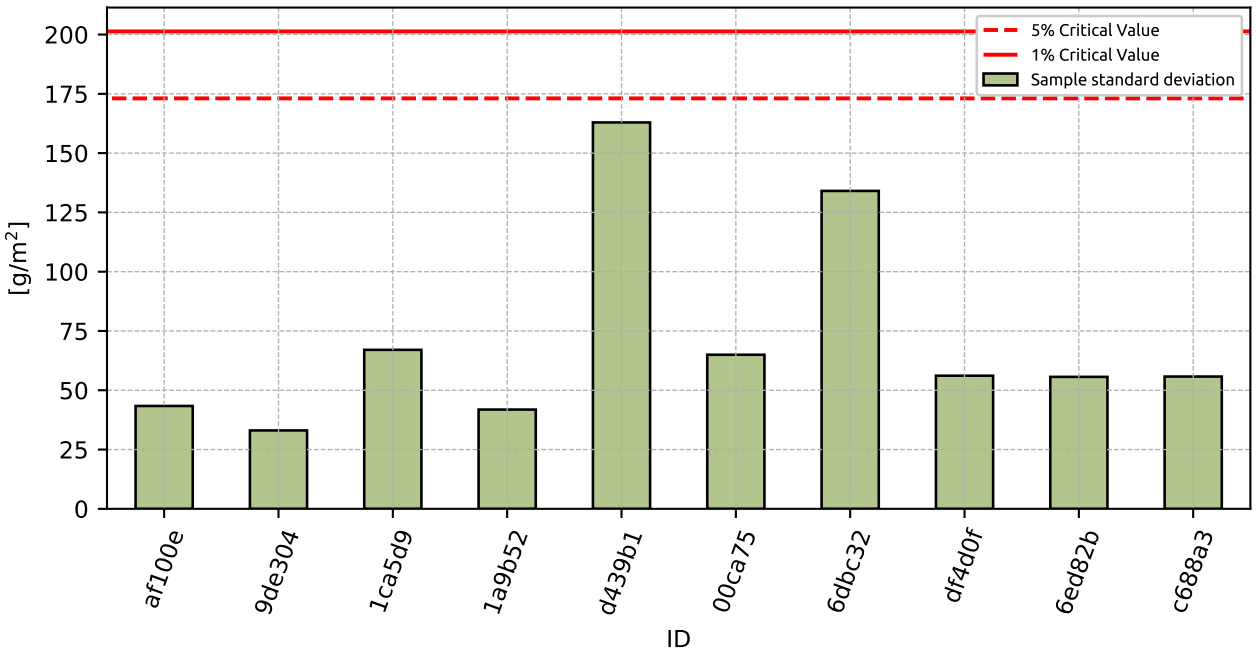

Figure 72: **Cochran's test** - sample standard deviations

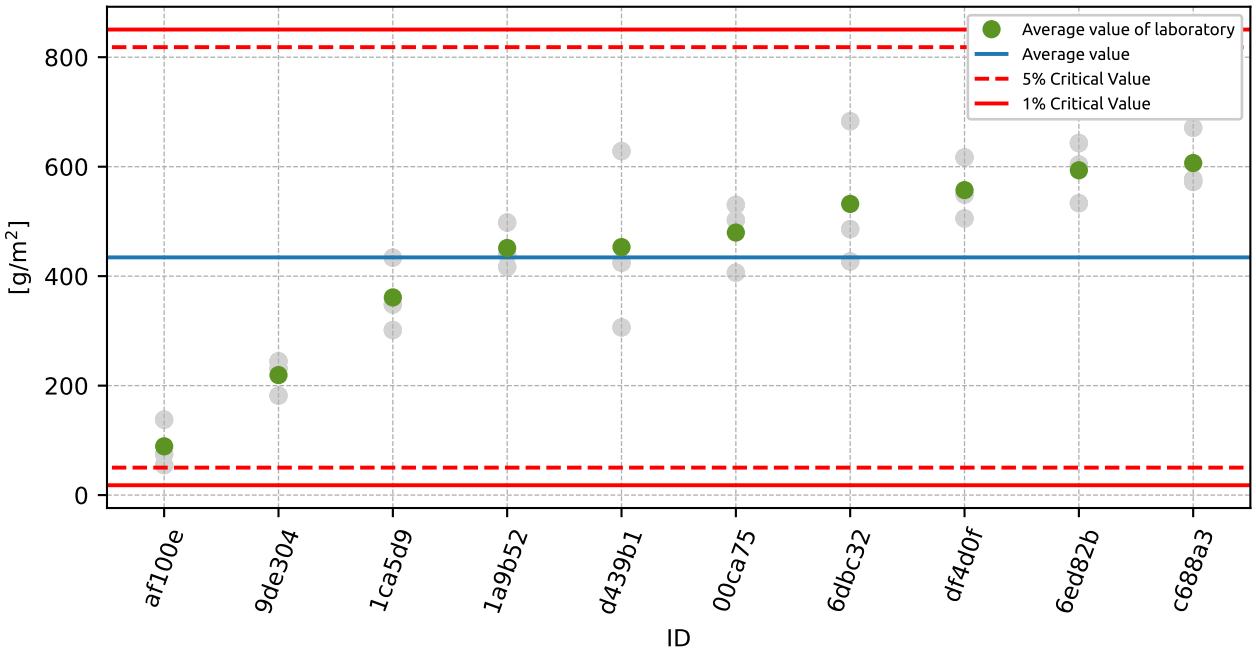

Figure 73: **Grubbs' test** - average values

7.3.3 Mandel's Statistics

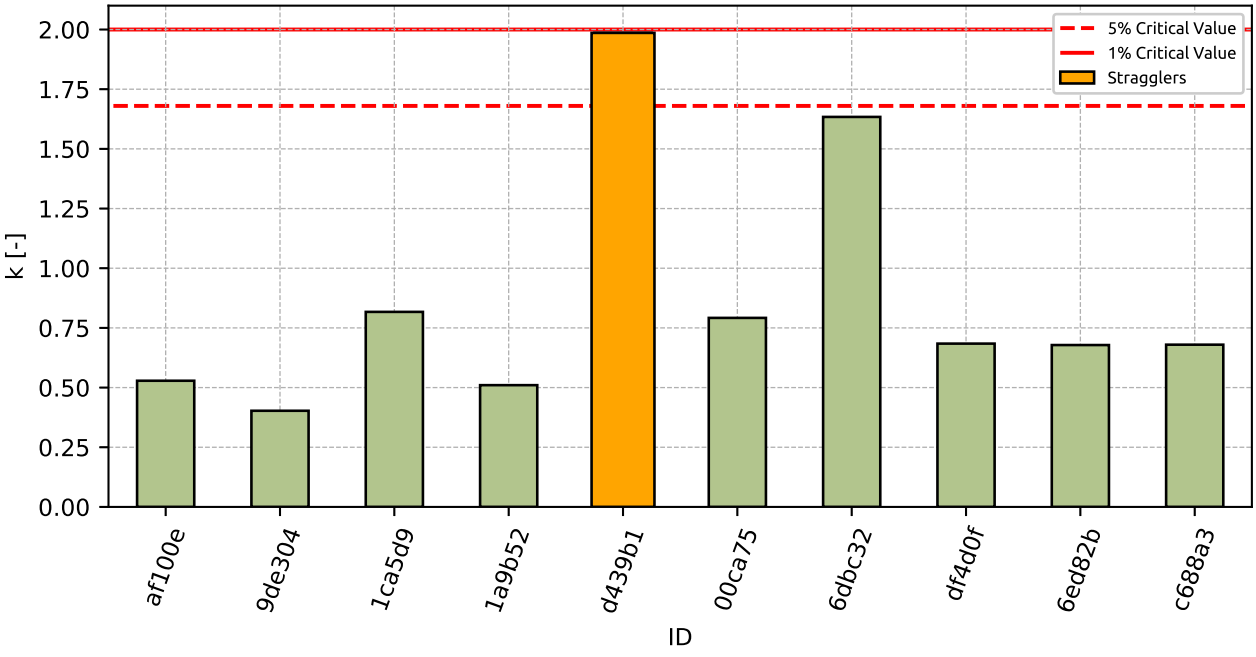

Figure 74: Intralaboratory Consistency Statistic

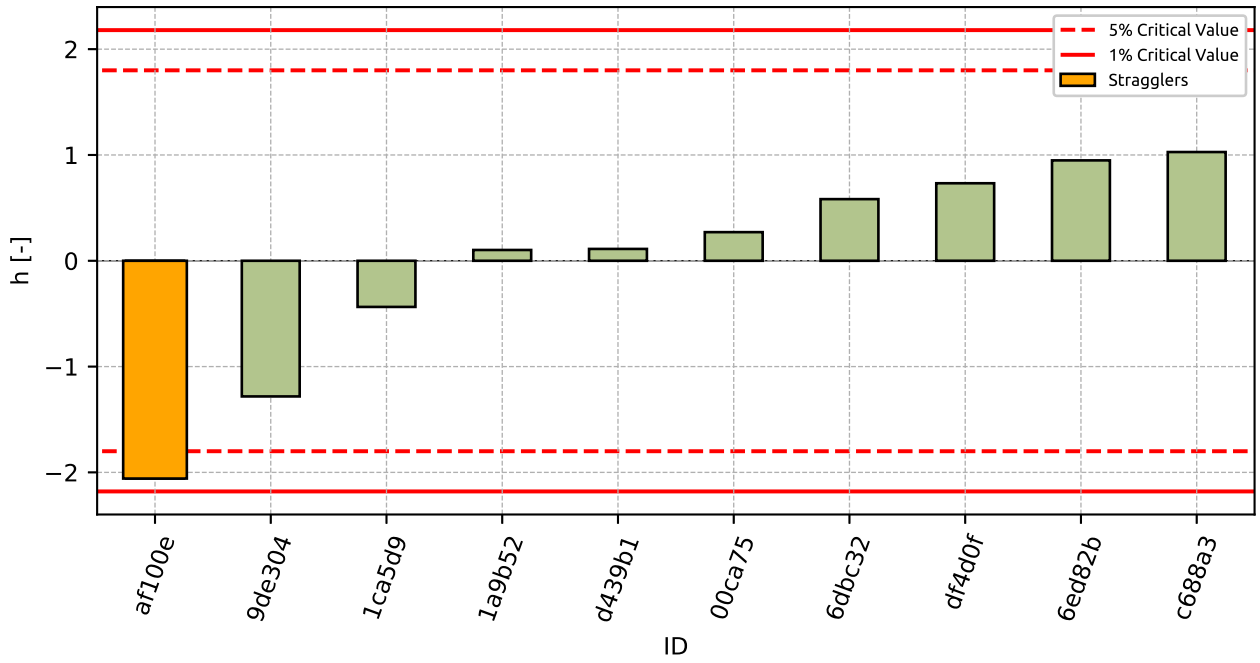

Figure 75: Interlaboratory Consistency Statistic

7.3.4 Descriptive statistics

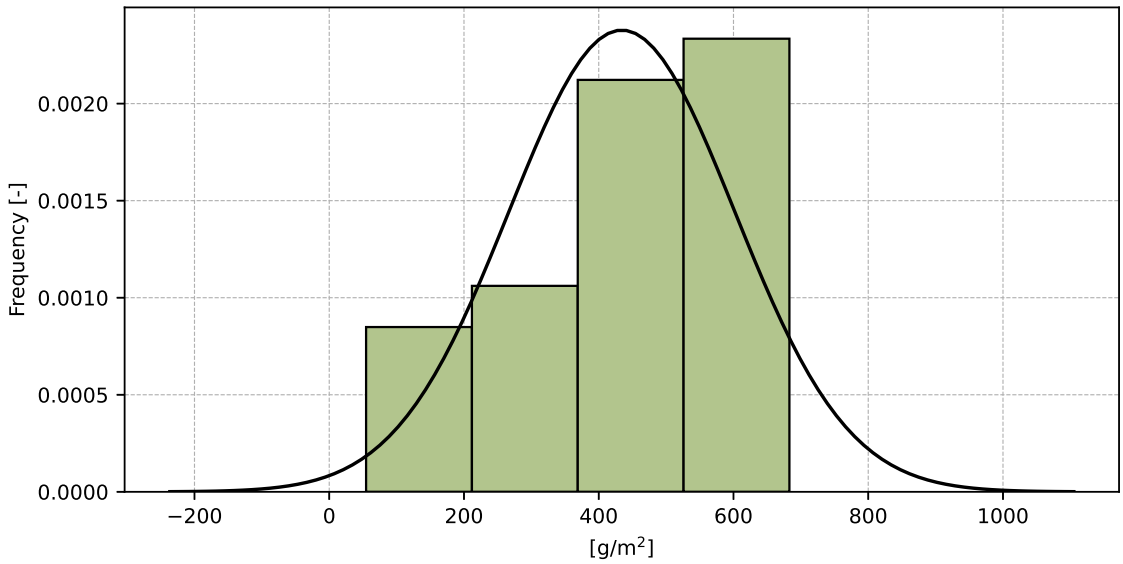

Figure 76: Histogram of all test results

Table 32: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	434.3
Sample standard deviation – s	167.72
Asigned value – x^*	453.1
Robust standard deviation – s^*	140.43
Measurement uncertainty of asigned value – u_X	55.51
p-value of normality test	0.094 [-]
Interlaboratory standard deviation – s_L	160.89
Repeatability standard deviation – s_r	82.05
Reproducibility standard deviation – s_R	180.6
Repeatability – r	229.7
Reproducibility – R	505.7

7.3.5 Evaluation of Performance Statistics

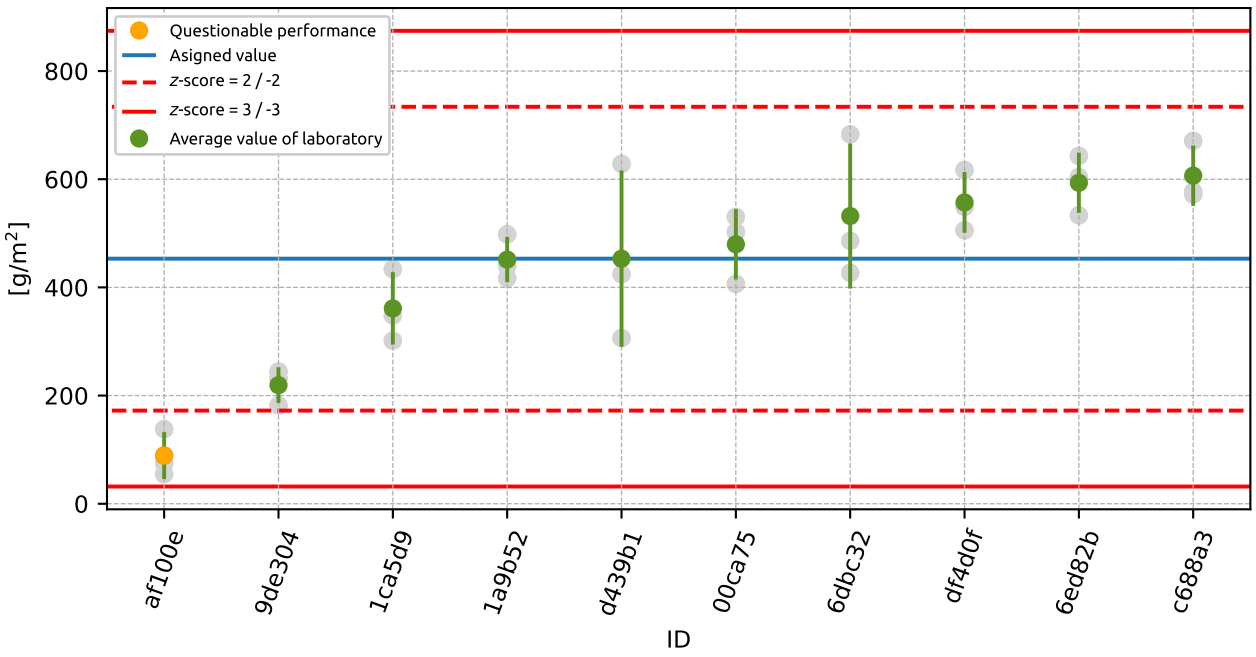

Figure 77: Average values and sample standard deviations

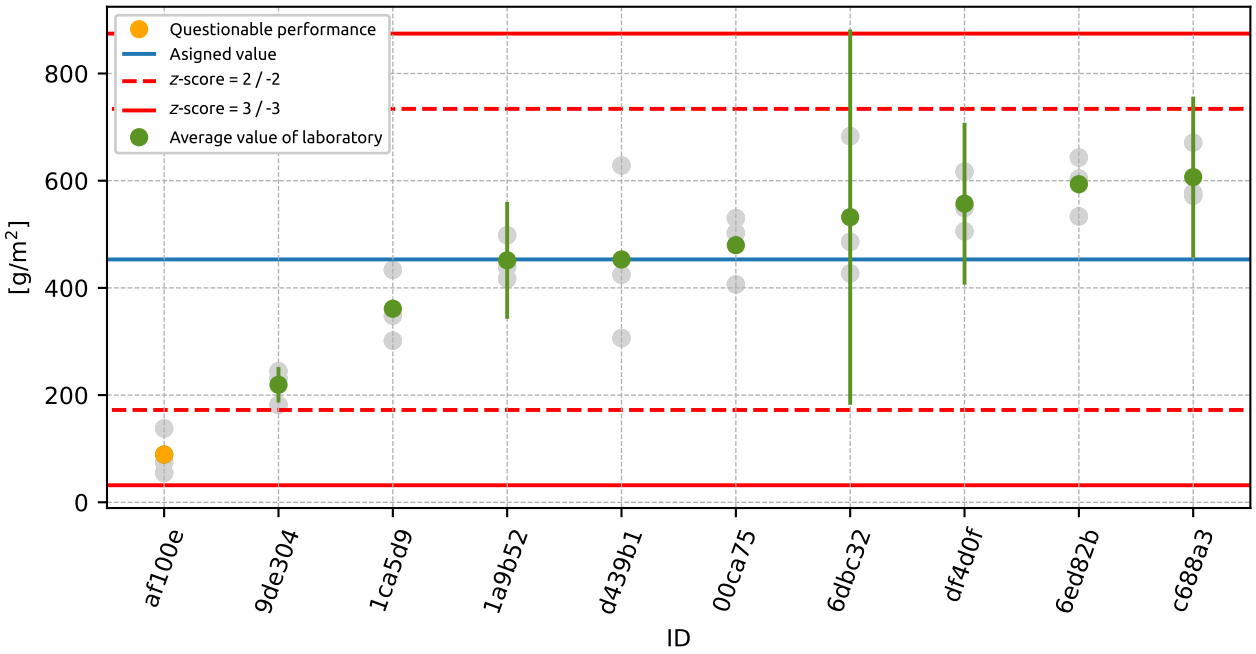

Figure 78: Average values and extended uncertainties of measurement

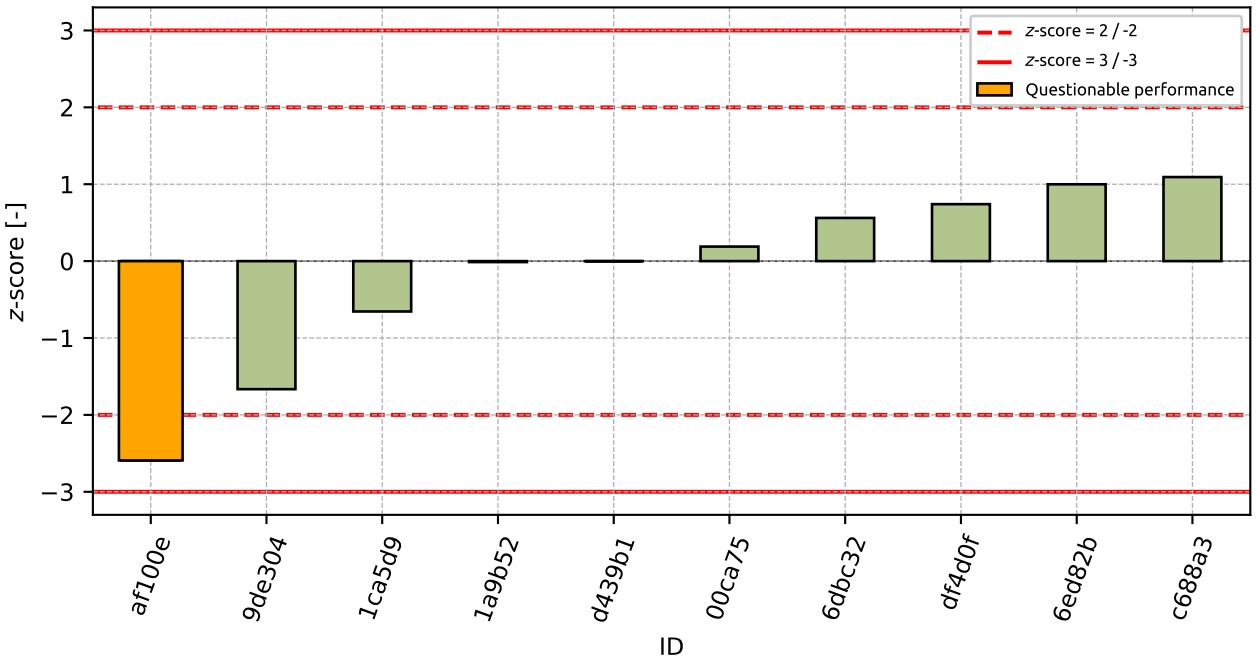

Figure 79: z-score

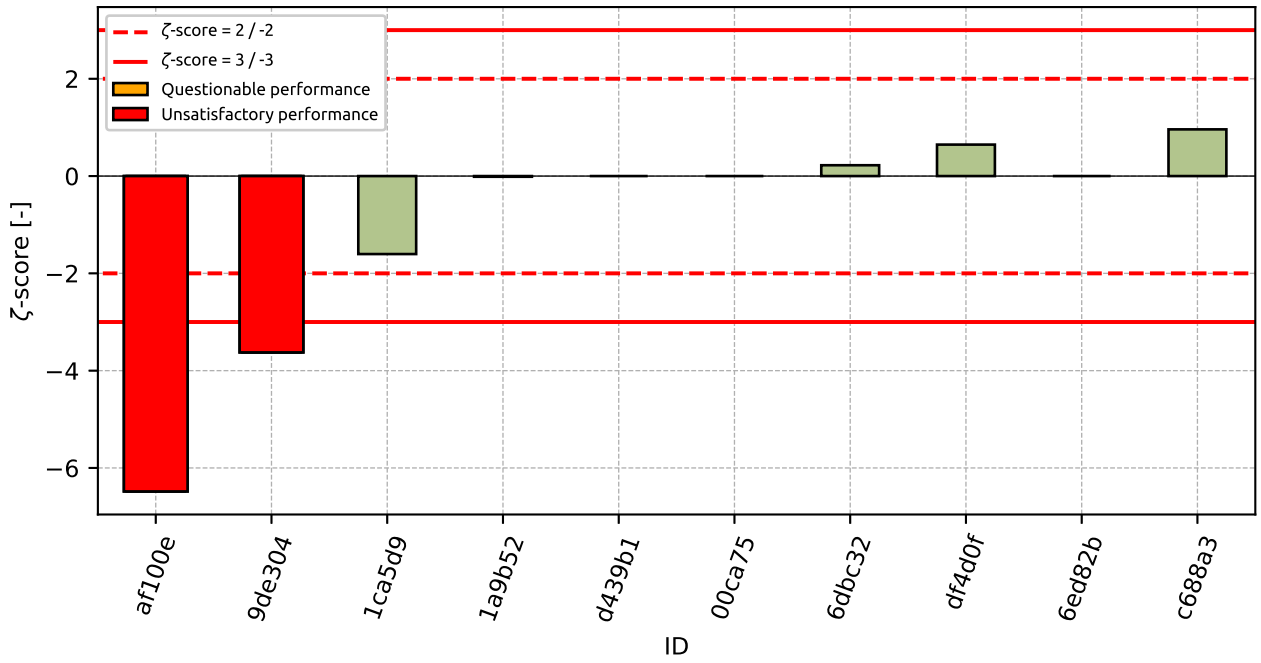

Figure 80: ζ-score

Table 33: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
af100e	-2.59	-6.48
9de304	-1.67	-3.62
1ca5d9	-0.66	-1.6
1a9b52	-0.01	-0.01
d439b1	-0.0	-
00ca75	0.19	-
6dbc32	0.56	0.22
df4d0f	0.74	0.65
6ed82b	1.0	-
c688a3	1.09	0.96

7.4 100 cycles

7.4.1 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 [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
af100e	72.9	149.0	73.3	8.5	98.4	43.82	44.53
9de304	203.9	221.0	237.9	33.2	220.9	17.0	7.69
1ca5d9	510.9	618.4	455.6	21.2	528.3	82.78	15.67
00ca75	477.1	626.8	590.4	-	564.8	78.07	13.82
d439b1	625.6	859.7	443.5	-	642.9	208.64	32.45
1a9b52	646.9	698.0	690.2	68.0	678.4	27.53	4.06
6dbc32	620.0	678.0	929.0	428.0	742.3	164.24	22.12
df4d0f	699.5	794.0	867.3	207.0	786.9	84.12	10.69
6ed82b	894.1	886.3	796.1	-	858.8	54.47	6.34
c688a3	773.0	1012.0	807.0	350.0	864.0	129.29	14.96

7.4.2 The Numerical Procedure for Determining Outliers

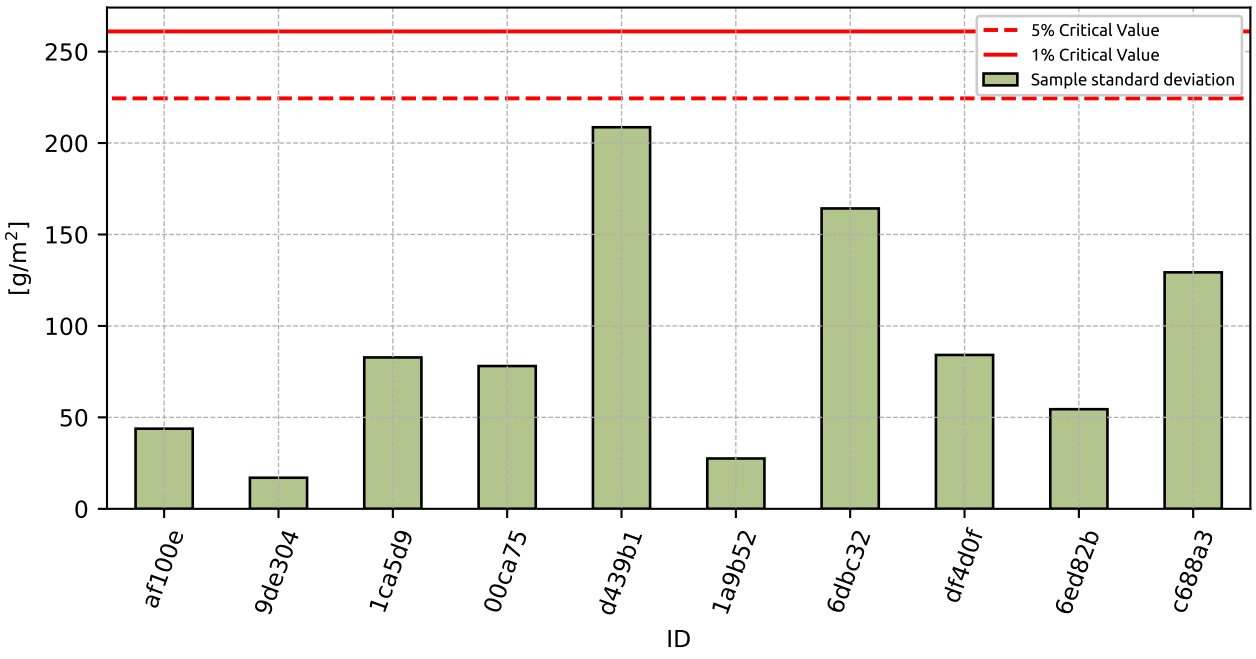

Figure 81: **Cochran's test** - sample standard deviations

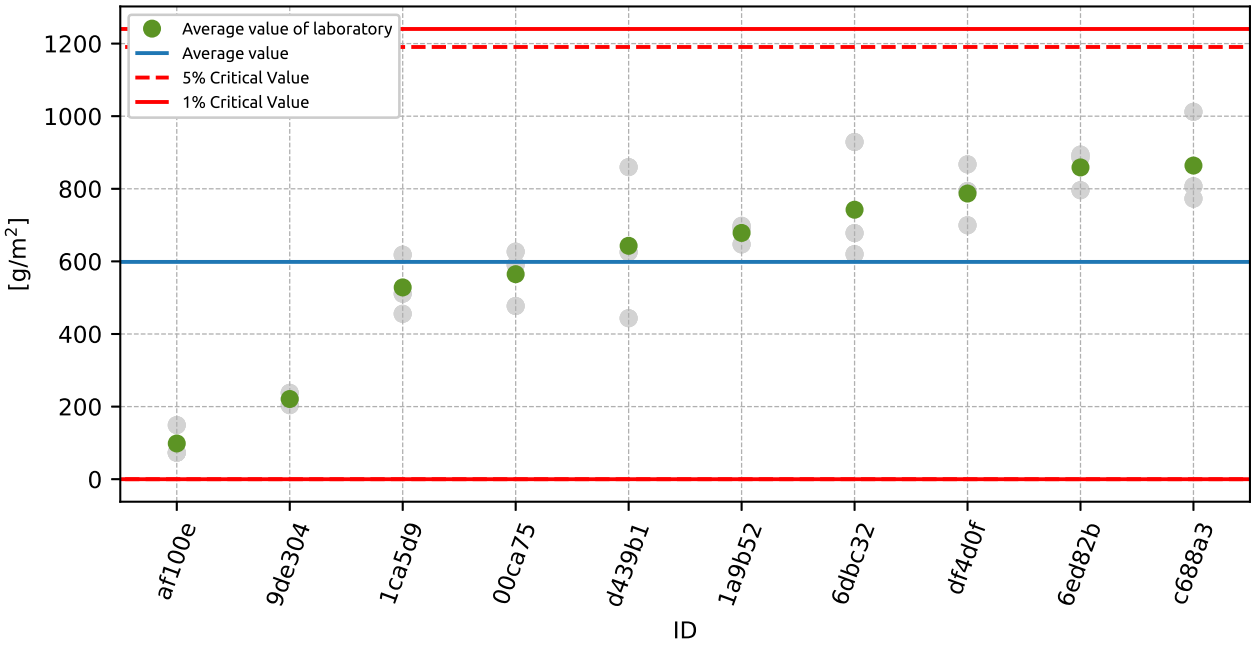

Figure 82: **Grubbs' test** - average values

7.4.3 Mandel's Statistics

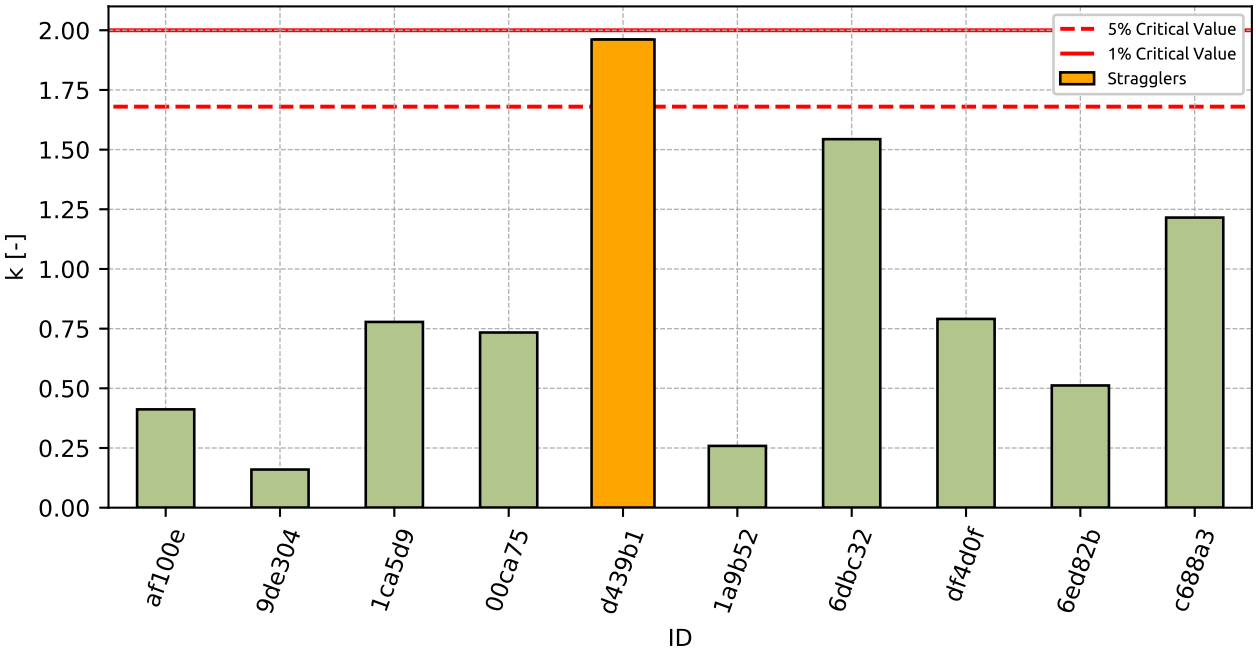

Figure 83: Intralaboratory Consistency Statistic

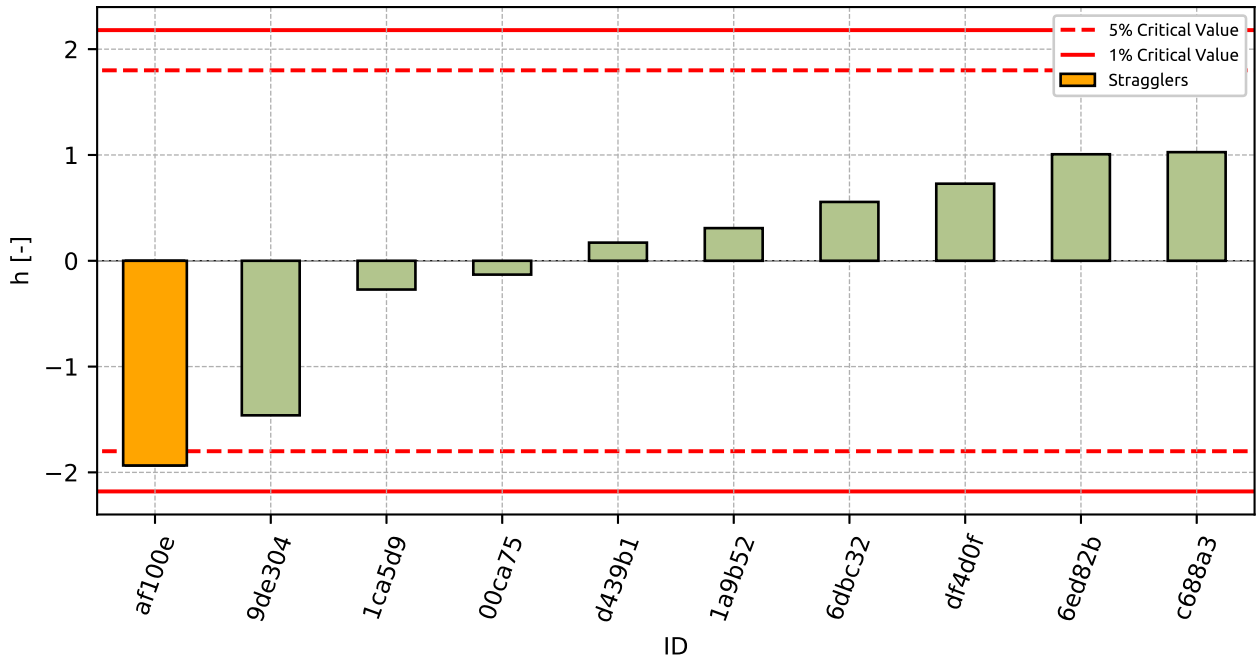

Figure 84: Interlaboratory Consistency Statistic

7.4.4 Descriptive statistics

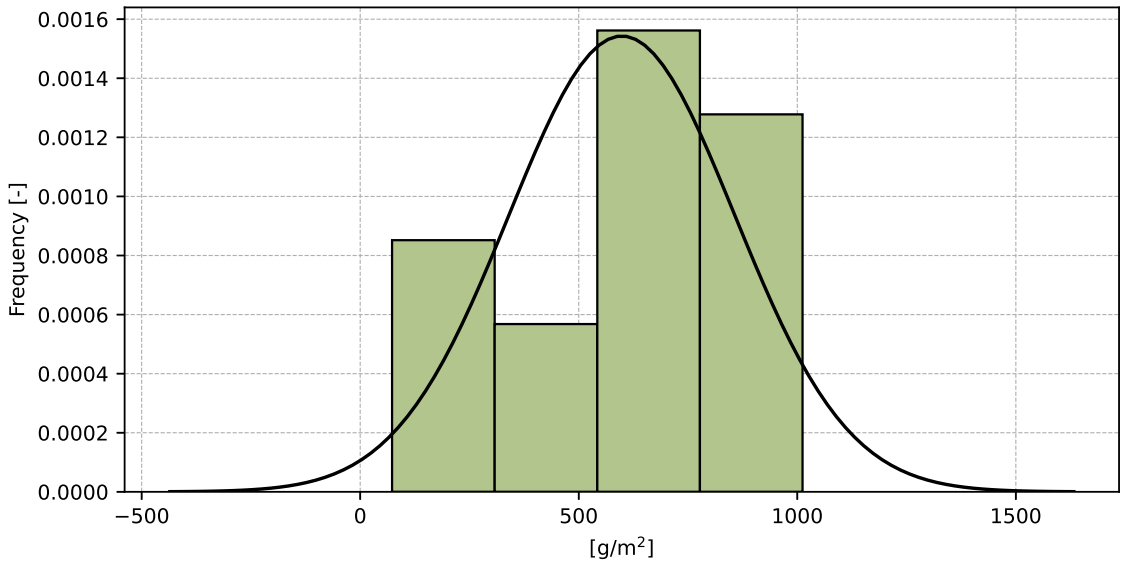

Figure 85: Histogram of all test results

Table 35: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	598.6
Sample standard deviation – s	258.53
Asigned value – x^*	641.2
Robust standard deviation – s^*	193.88
Measurement uncertainty of asigned value – u_X	76.64
p-value of normality test	0.042 [-]
Interlaboratory standard deviation – s_L	251.13
Repeatability standard deviation – s_r	106.39
Reproducibility standard deviation – s_R	272.73
Repeatability – r	297.9
Reproducibility – R	763.6

7.4.5 Evaluation of Performance Statistics

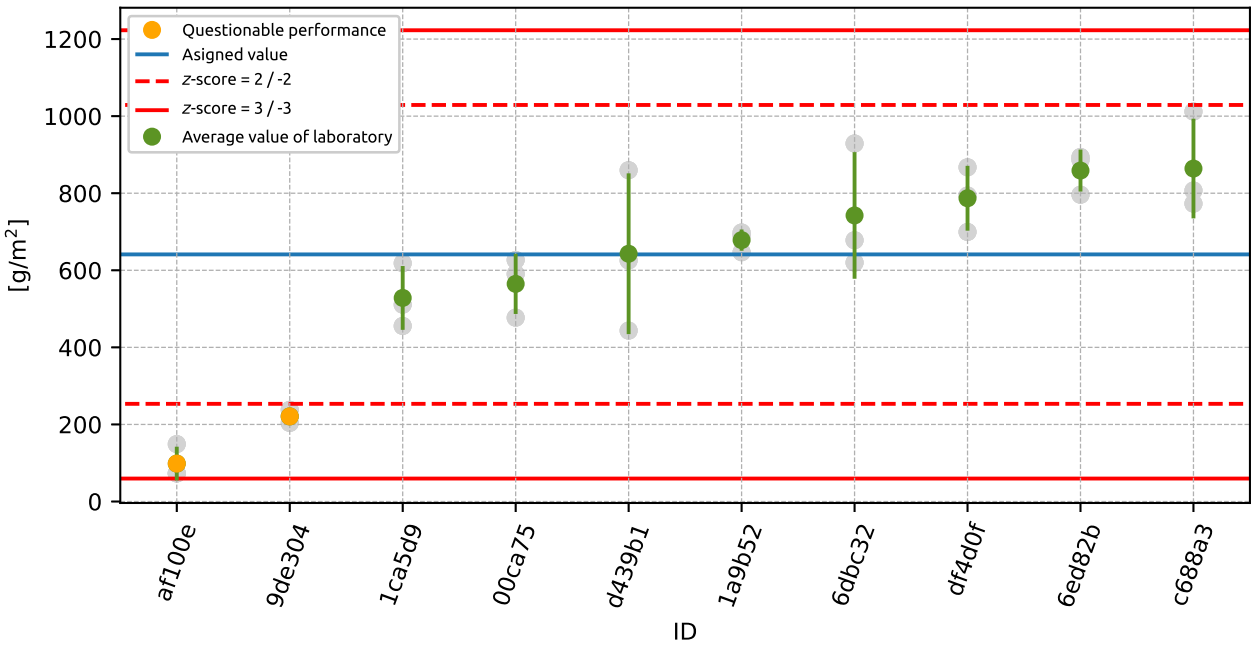

Figure 86: Average values and sample standard deviations

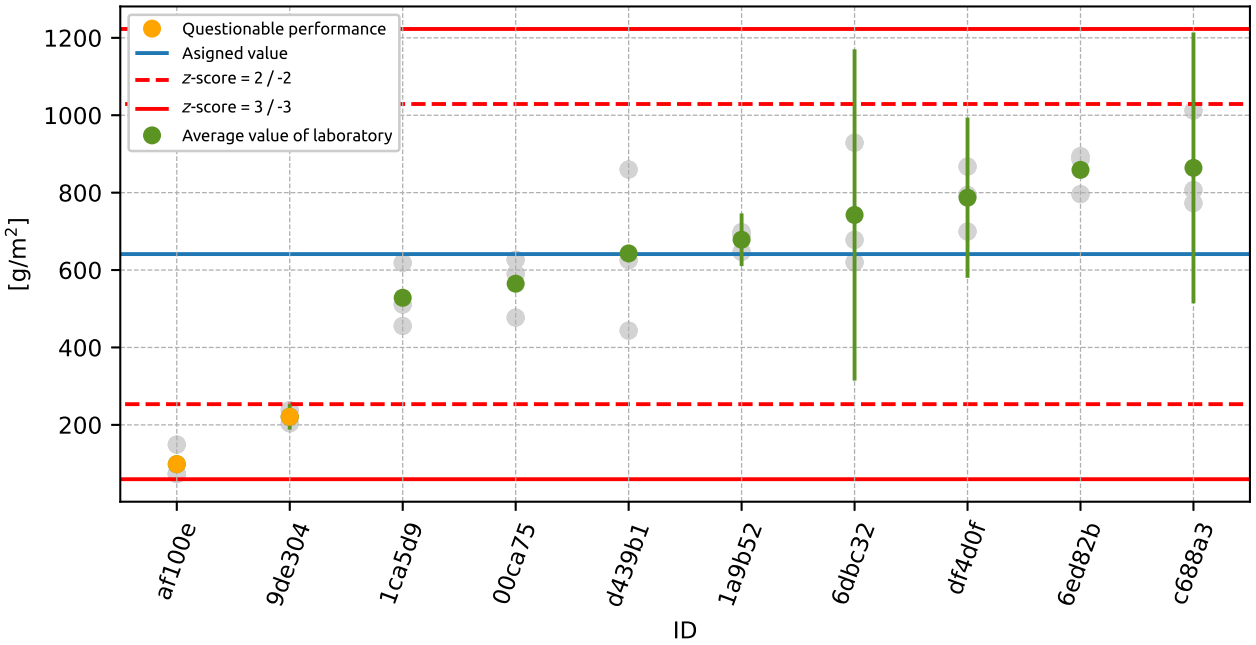

Figure 87: Average values and extended uncertainties of measurement

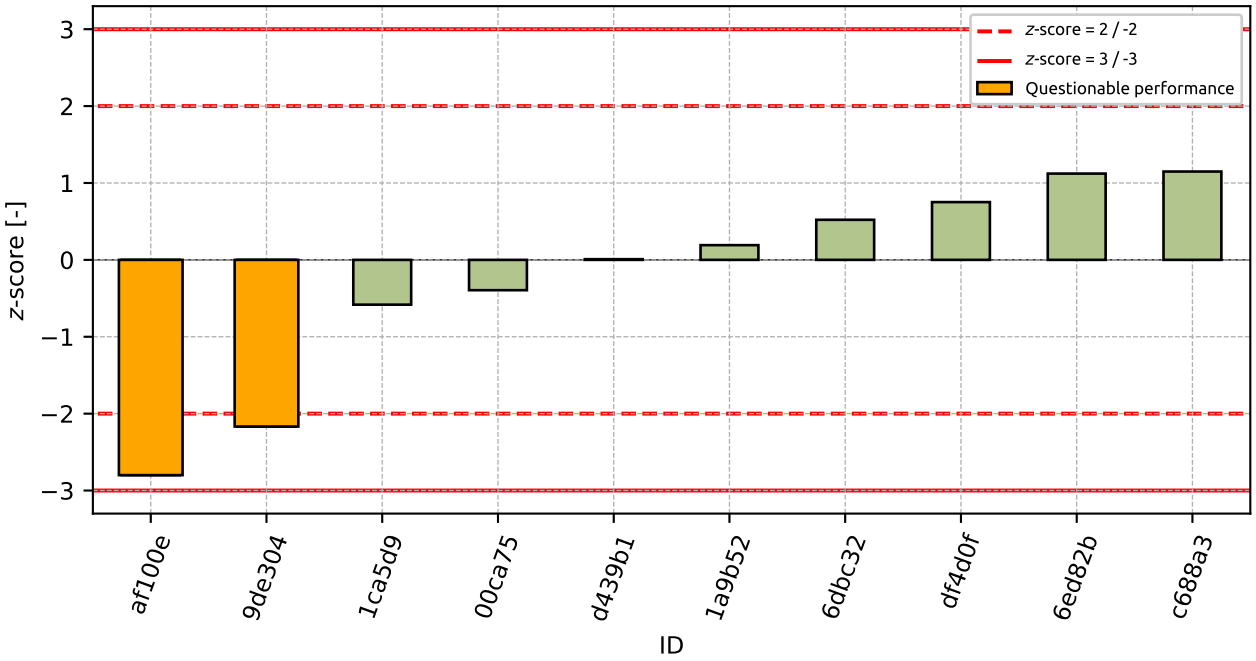

Figure 88: z-score

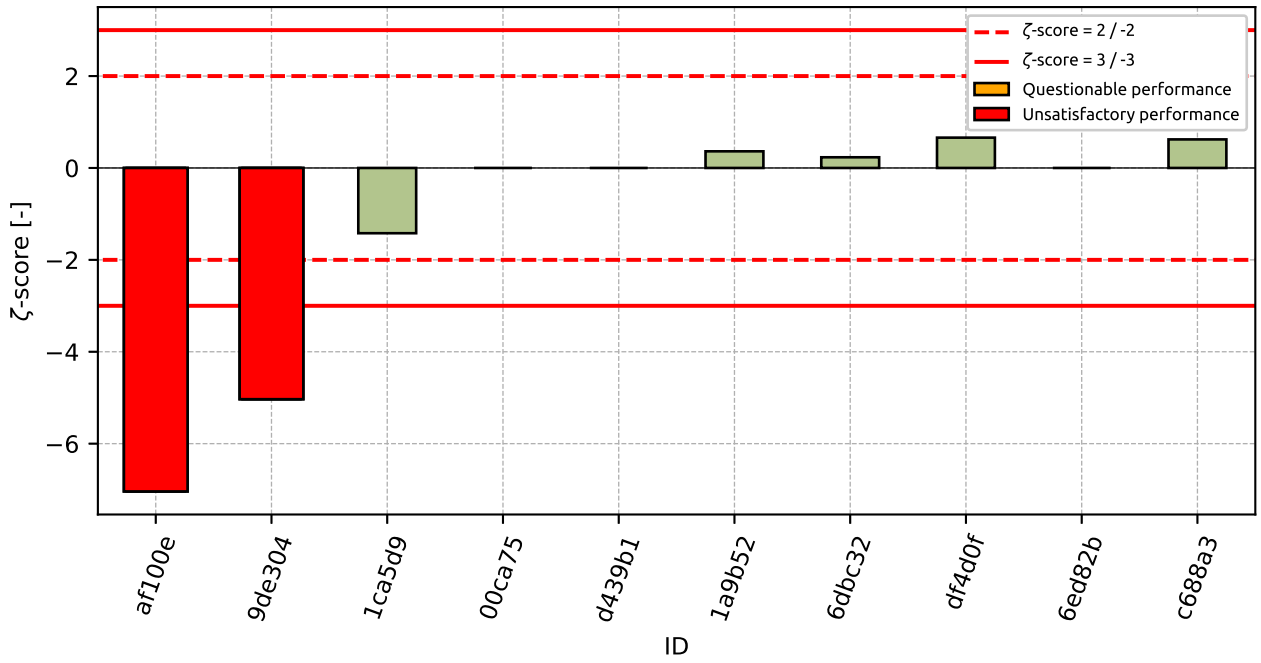

Figure 89: ζ-score

Table 36: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
af100e	-2.8	-7.04
9de304	-2.17	-5.03
1ca5d9	-0.58	-1.42
00ca75	-0.39	-
d439b1	0.01	-
1a9b52	0.19	0.36
6dbc32	0.52	0.23
df4d0f	0.75	0.66
6ed82b	1.12	-
c688a3	1.15	0.62

8 Appendix – ČSN 73 1326 – Resistance of cement concrete surface to water and defrosting chemicals – Method C

8.1 25 cycles

8.1.1 Test results

Table 37: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
c87900	1.6	1.1	1.4	-	1.4	0.25	18.41
426734	0.5	7.2	1.1	0.3	2.9	3.72	127.41
7e10c2	117.6	111.8	100.8	22.0	110.1	8.53	7.75
82c46f	120.0	130.0	120.0	3.5	123.3	5.77	4.68
ad3746	83.8	268.0	161.9	25.6	171.2	92.45	53.99
cc1bc4	260.0	390.0	300.0	70.0	316.7	66.58	21.03
153cae	350.8	355.9	304.9	26.6	337.2	28.09	8.33
c688a3	852.0	847.0	528.0	520.0	742.3	185.63	25.01

8.1.2 The Numerical Procedure for Determining Outliers

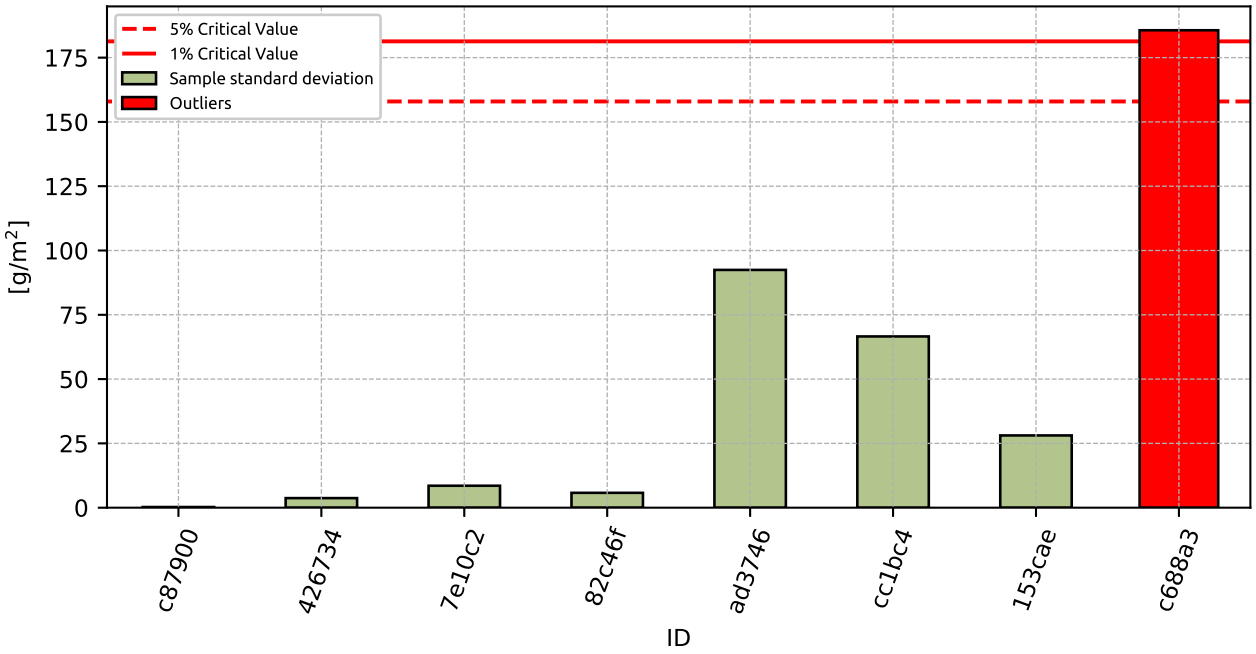

Figure 90: **Cochran's test** - sample standard deviations

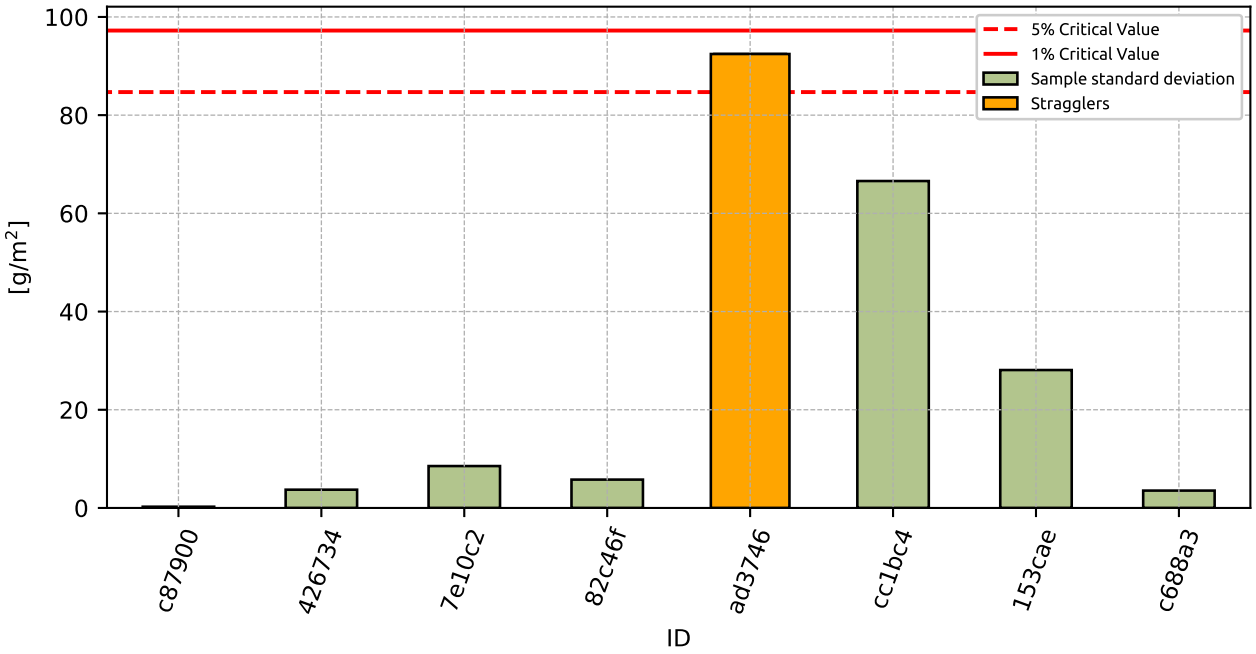

Figure 91: **Cochran's test** - sample standard deviations without outliers

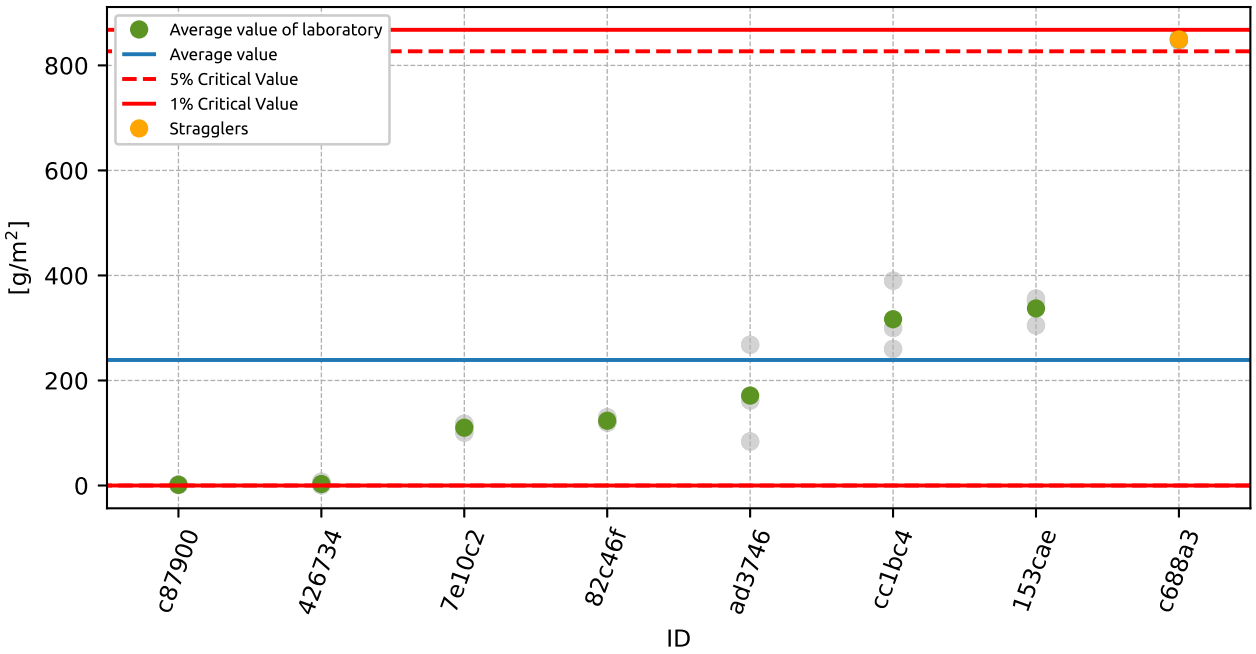

Figure 92: **Grubbs' test** - average values

8.1.3 Mandel's Statistics

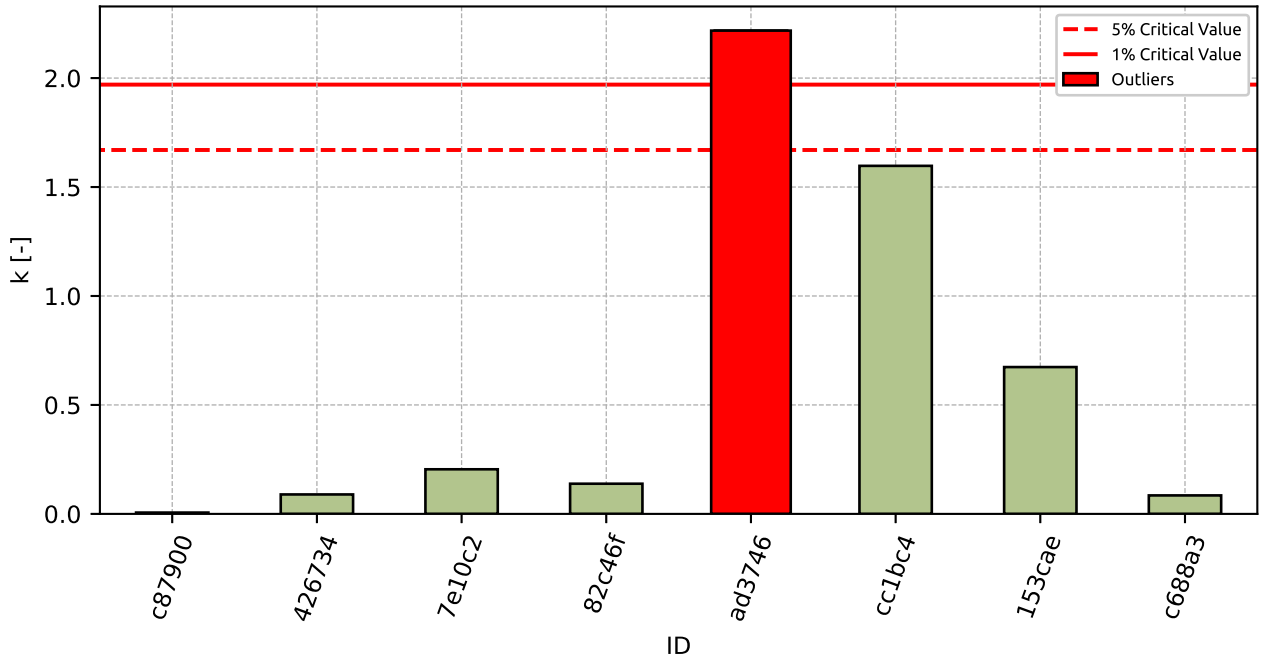

Figure 93: Intralaboratory Consistency Statistic

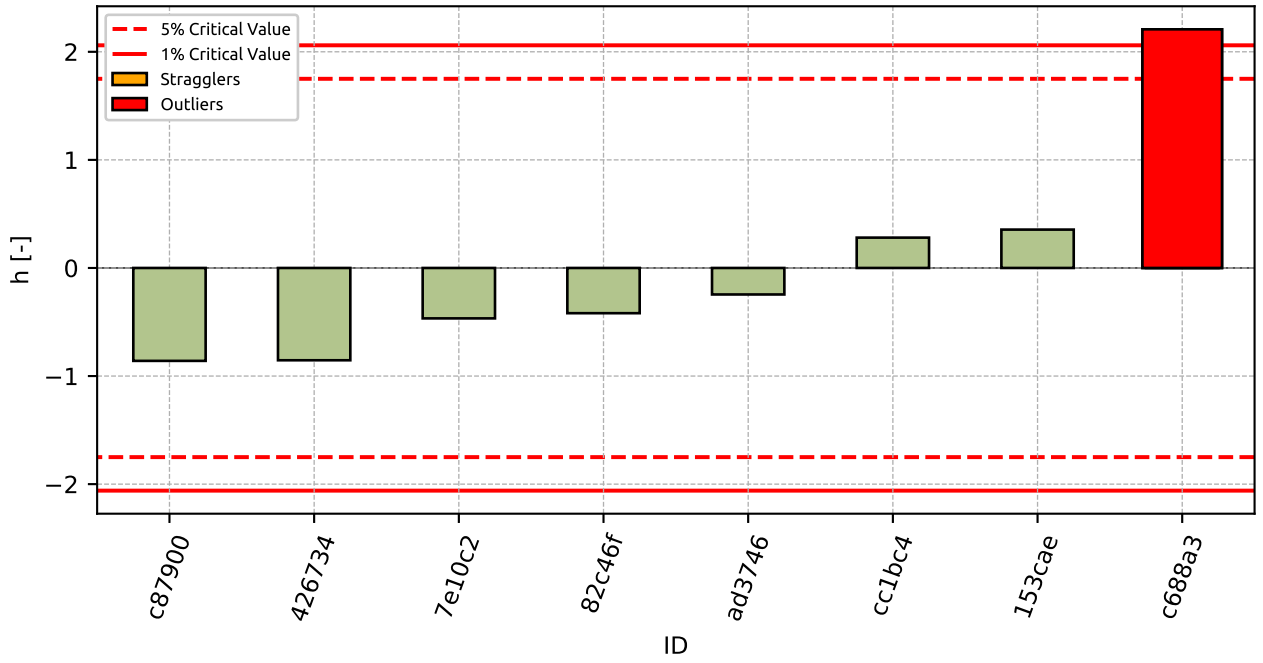

Figure 94: Interlaboratory Consistency Statistic

8.1.4 Descriptive statistics

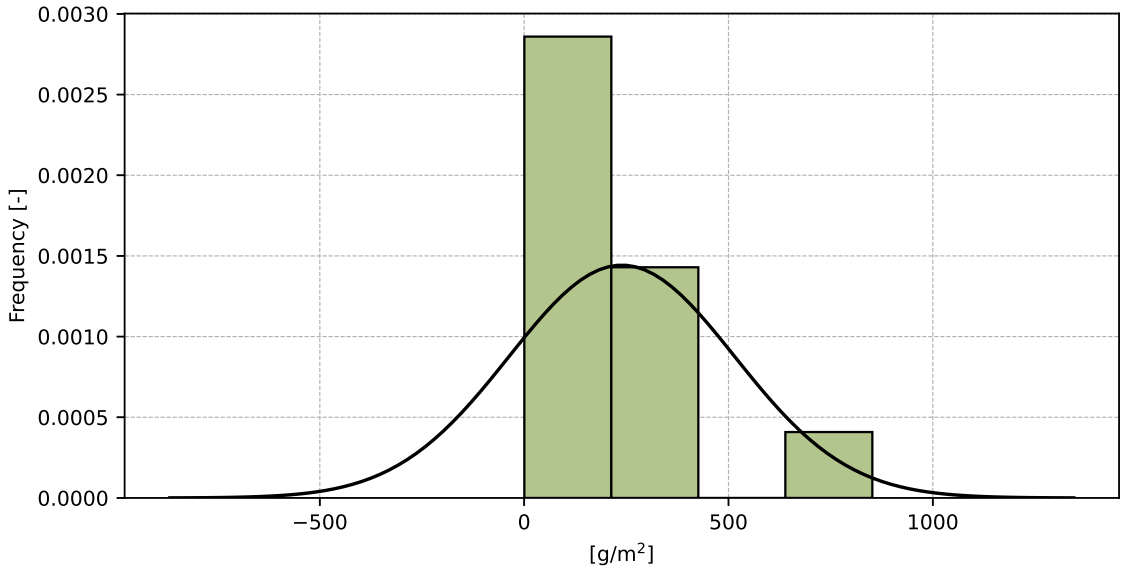

Figure 95: Histogram of all test results

Table 38: Descriptive statistics

Characteristics	[g/m²]
Average value – $\bar{x}$	239.0
Sample standard deviation – s	276.5
Asigned value – x^*	239.0
Robust standard deviation – s^*	293.31
Measurement uncertainty of asigned value – u_X	129.62
p-value of normality test	1.0 [-]
Interlaboratory standard deviation – s_L	275.46
Repeatability standard deviation – s_r	41.69
Reproducibility standard deviation – s_R	278.59
Repeatability – r	116.7
Reproducibility – R	780.1

8.1.5 Evaluation of Performance Statistics

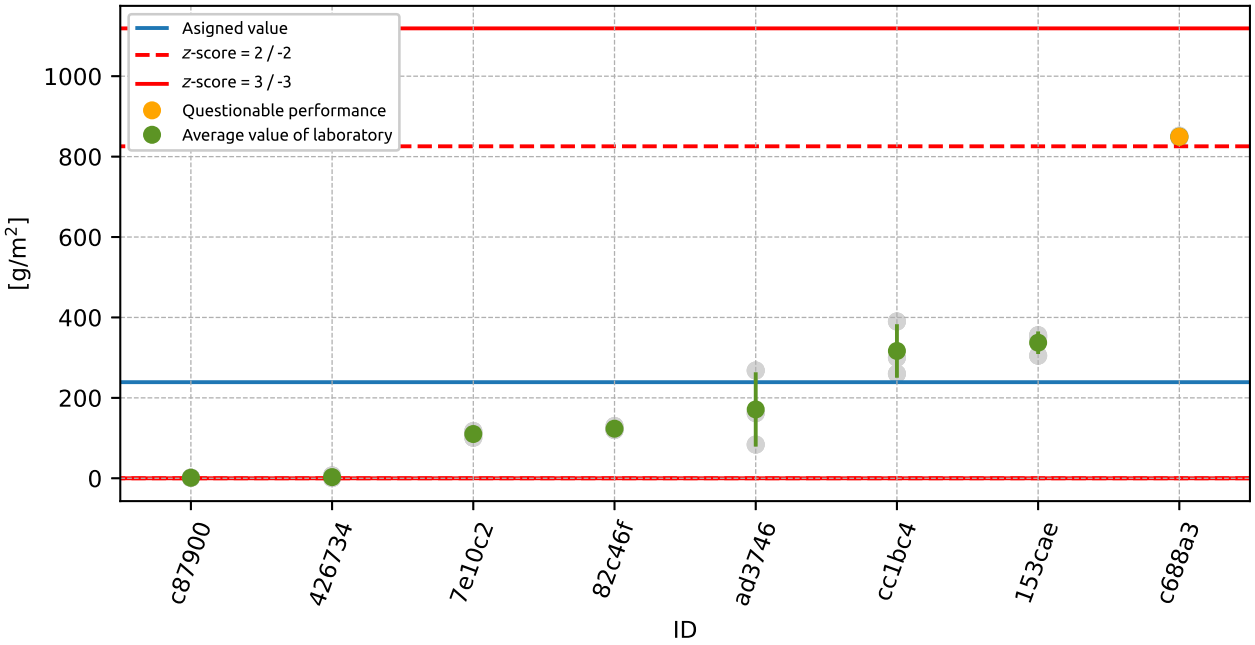

Figure 96: Average values and sample standard deviations

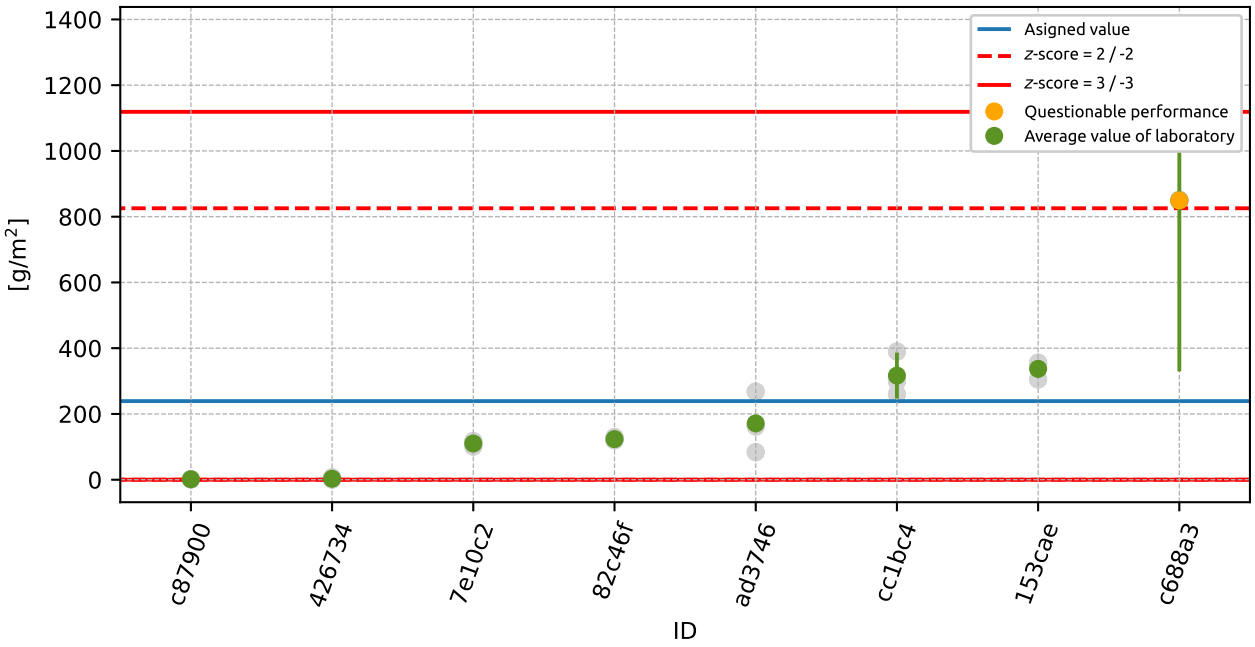

Figure 97: Average values and extended uncertainties of measurement

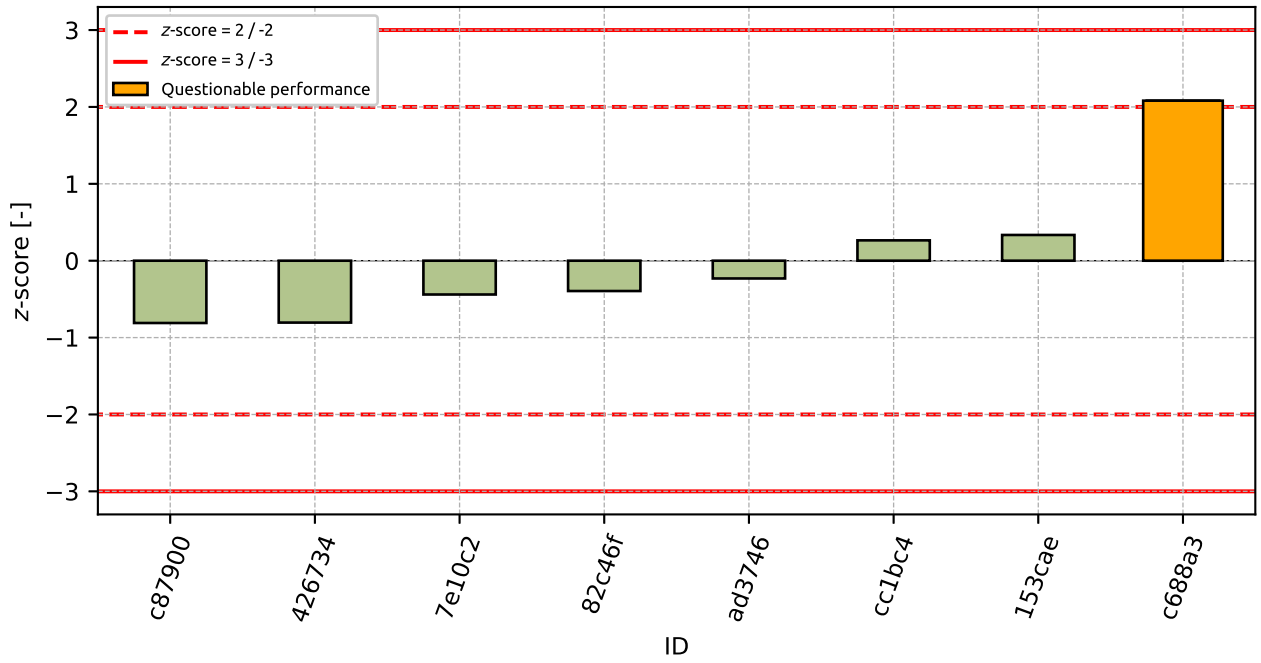

Figure 98: z-score

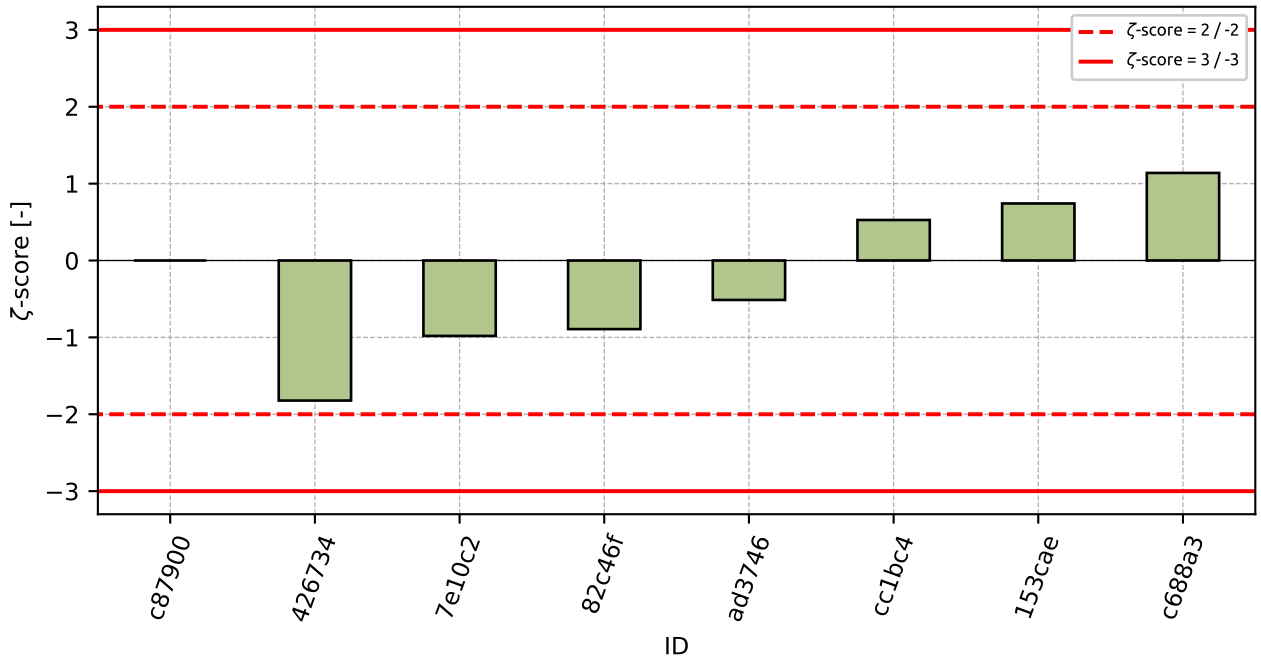

Figure 99: ζ-score

Table 39: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
c87900	-0.81	-
426734	-0.81	-1.82
7e10c2	-0.44	-0.98
82c46f	-0.39	-0.89
ad3746	-0.23	-0.51
cc1bc4	0.26	0.53
153cae	0.33	0.74
c688a3	2.08	1.14

8.2 50 cycles

8.2.1 Test results

Table 40: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
c87900	2.2	1.9	2.0	-	2.0	0.15	7.51
426734	1.2	14.8	17.7	1.5	11.2	8.82	78.45
82c46f	260.0	260.0	230.0	7.2	250.0	17.32	6.93
7e10c2	335.9	318.7	307.9	64.0	320.8	14.12	4.4
ad3746	318.3	614.3	329.5	72.0	420.7	167.76	39.88
153cae	585.6	649.0	500.0	45.7	578.2	74.78	12.93
cc1bc4	560.0	809.0	719.0	140.0	696.0	126.08	18.12
c688a3	1145.0	1123.0	857.0	470.0	1041.7	160.3	15.39

8.2.2 The Numerical Procedure for Determining Outliers

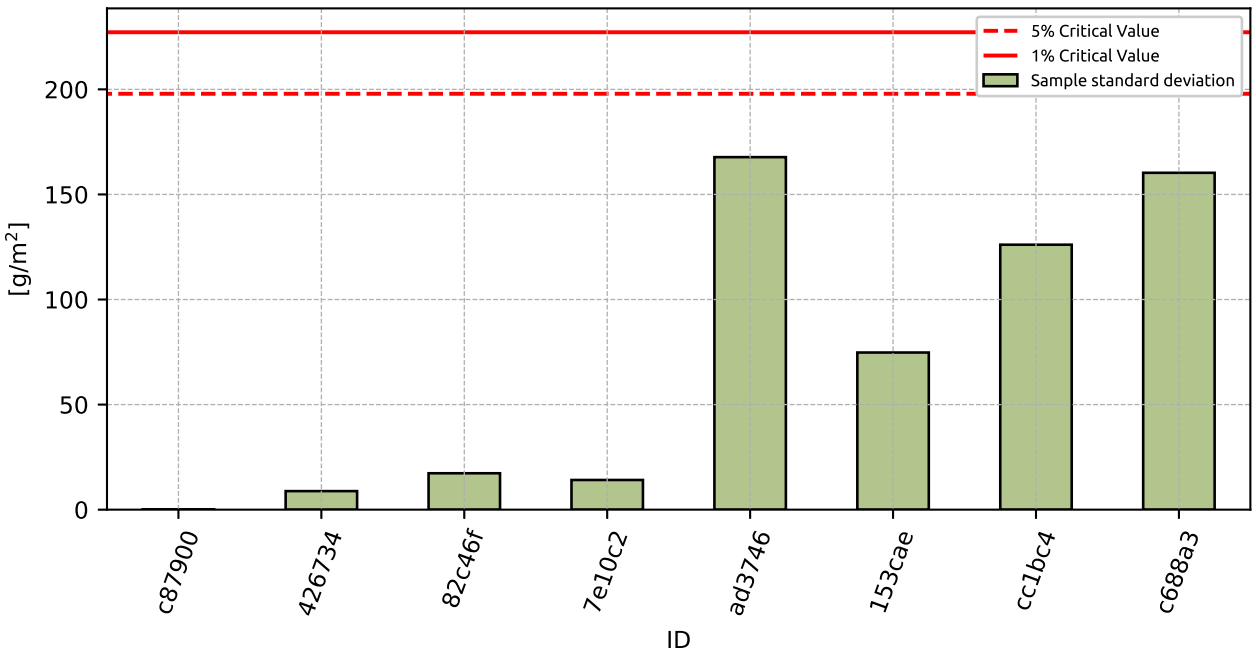

Figure 100: **Cochran's test** - sample standard deviations

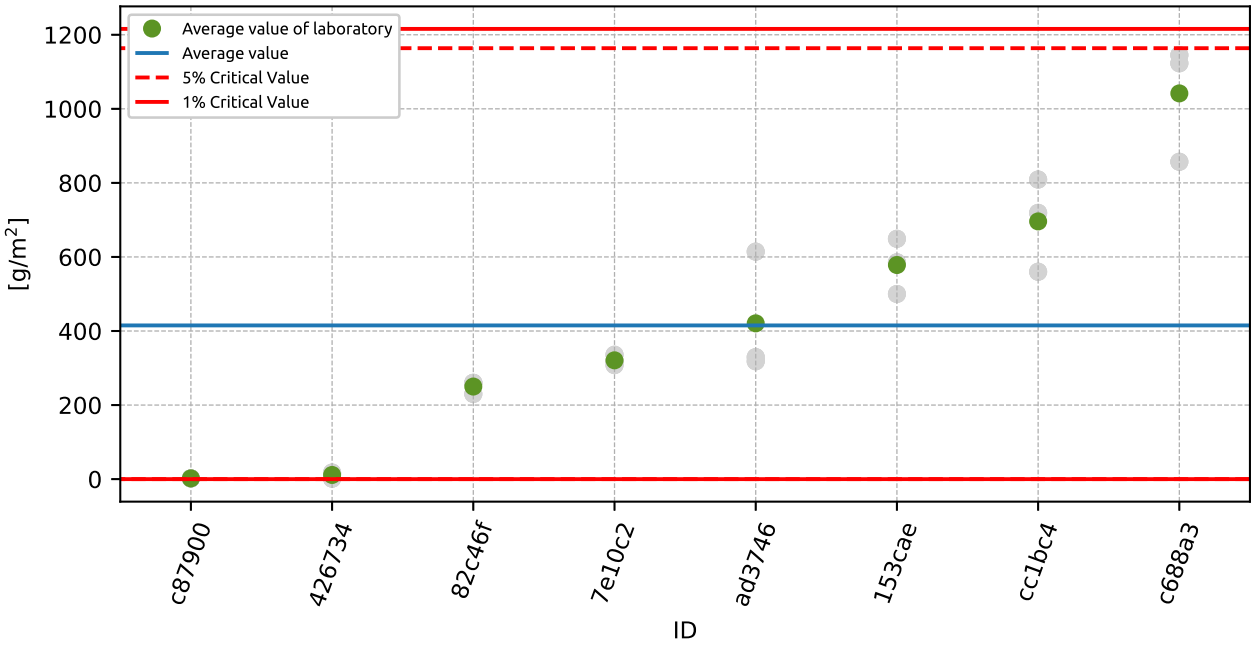

Figure 101: **Grubbs' test** - average values

8.2.3 Mandel's Statistics

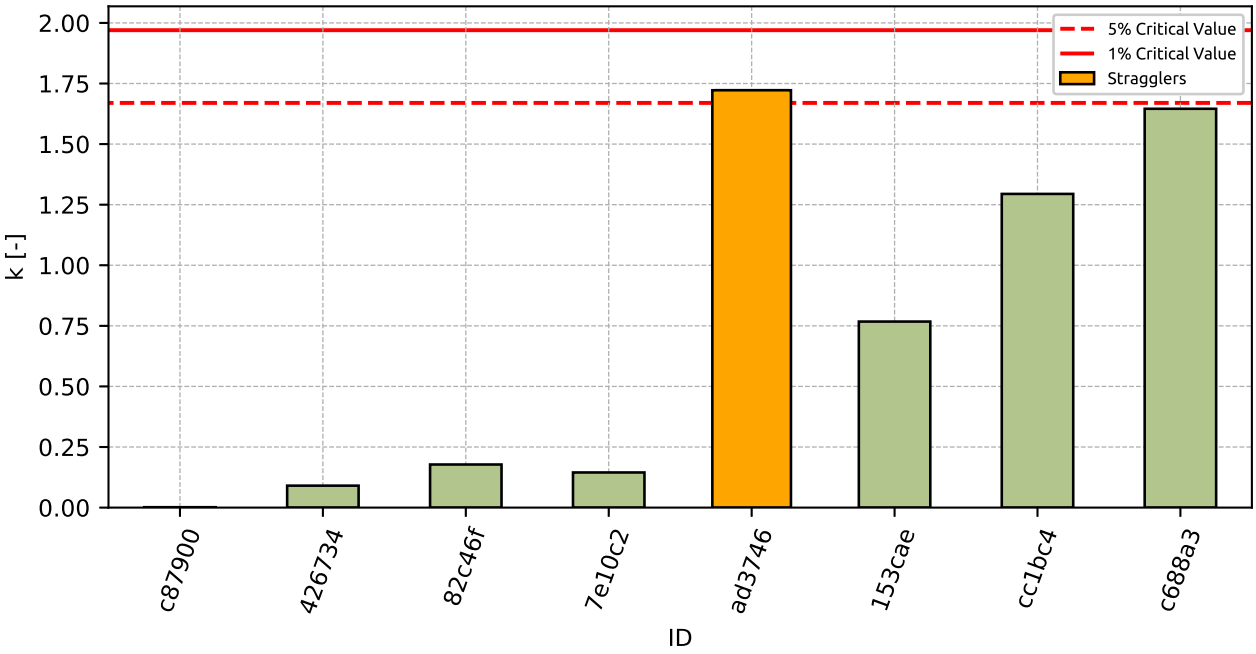

Figure 102: Intralaboratory Consistency Statistic

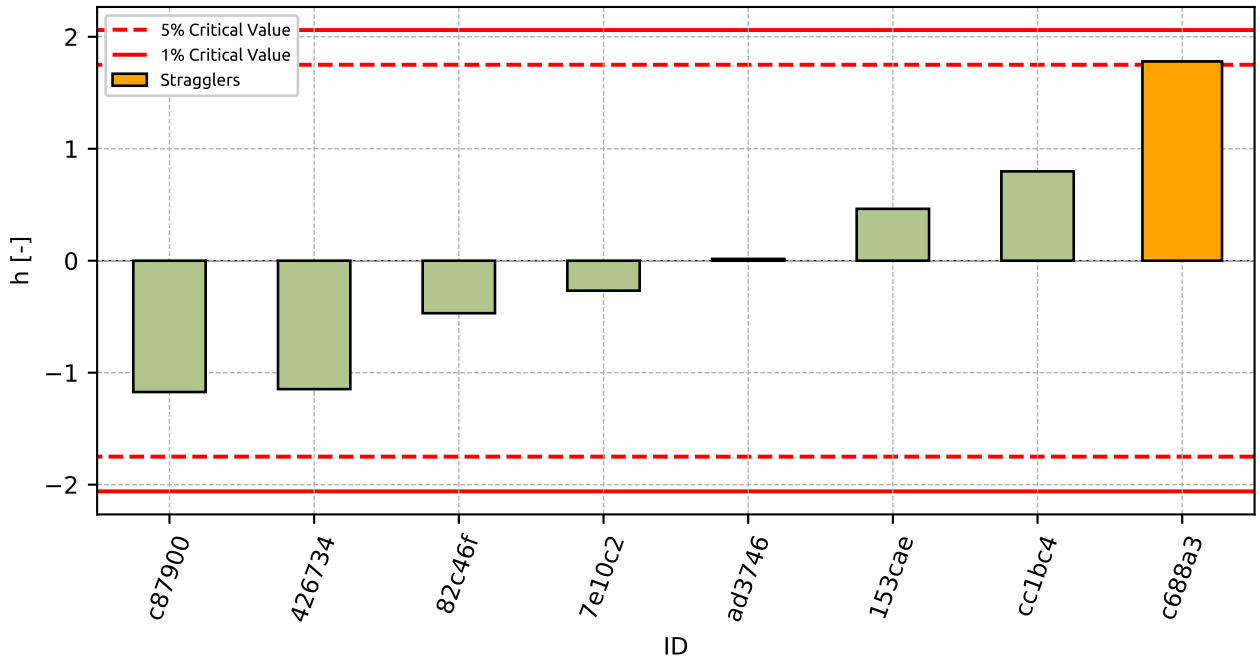

Figure 103: Interlaboratory Consistency Statistic

8.2.4 Descriptive statistics

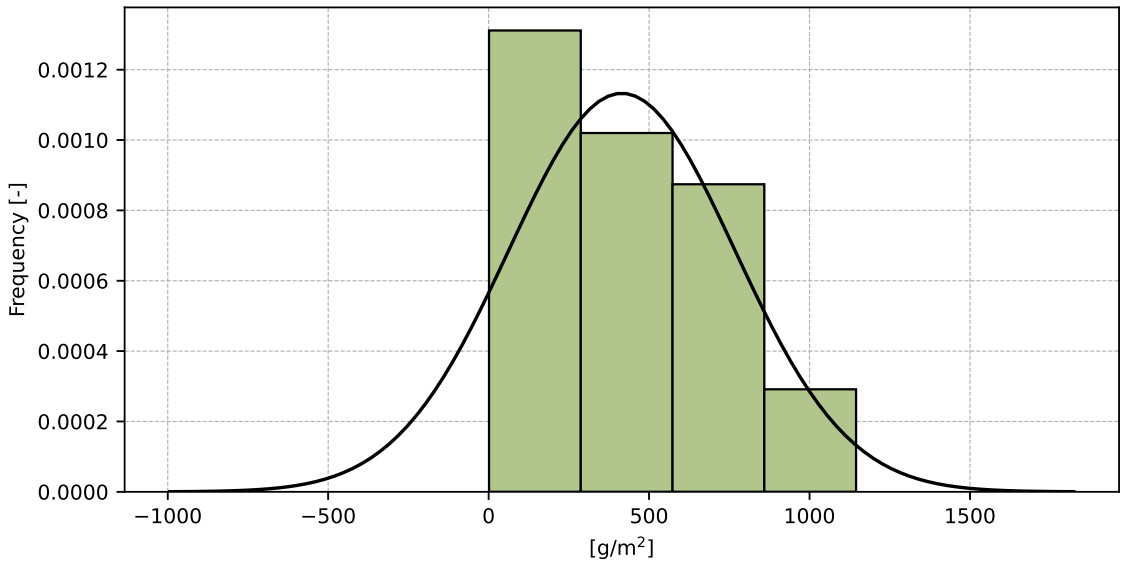

Figure 104: Histogram of all test results

Table 41: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	415.1
Sample standard deviation – s	352.13
Asigned value – x^*	415.1
Robust standard deviation – s^*	373.53
Measurement uncertainty of asigned value – u_X	165.08
p-value of normality test	0.053 [-]
Interlaboratory standard deviation – s_L	347.61
Repeatability standard deviation – s_r	97.41
Reproducibility standard deviation – s_R	361.0
Repeatability – r	272.7
Reproducibility – R	1010.8

8.2.5 Evaluation of Performance Statistics

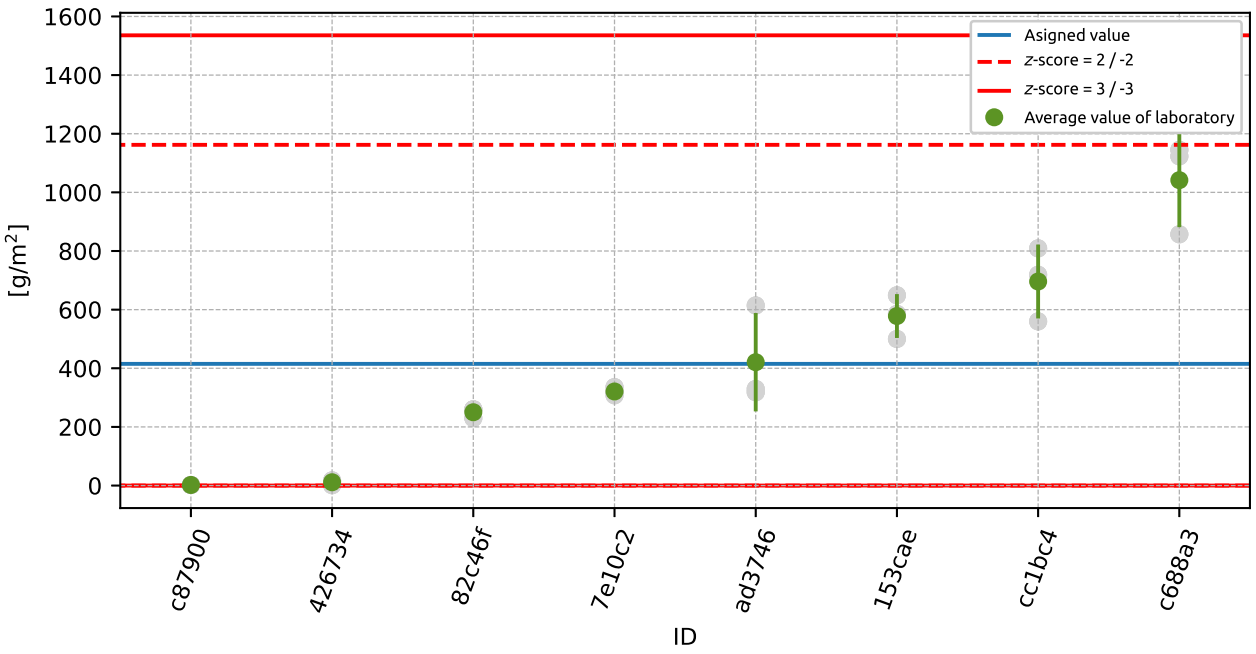

Figure 105: Average values and sample standard deviations

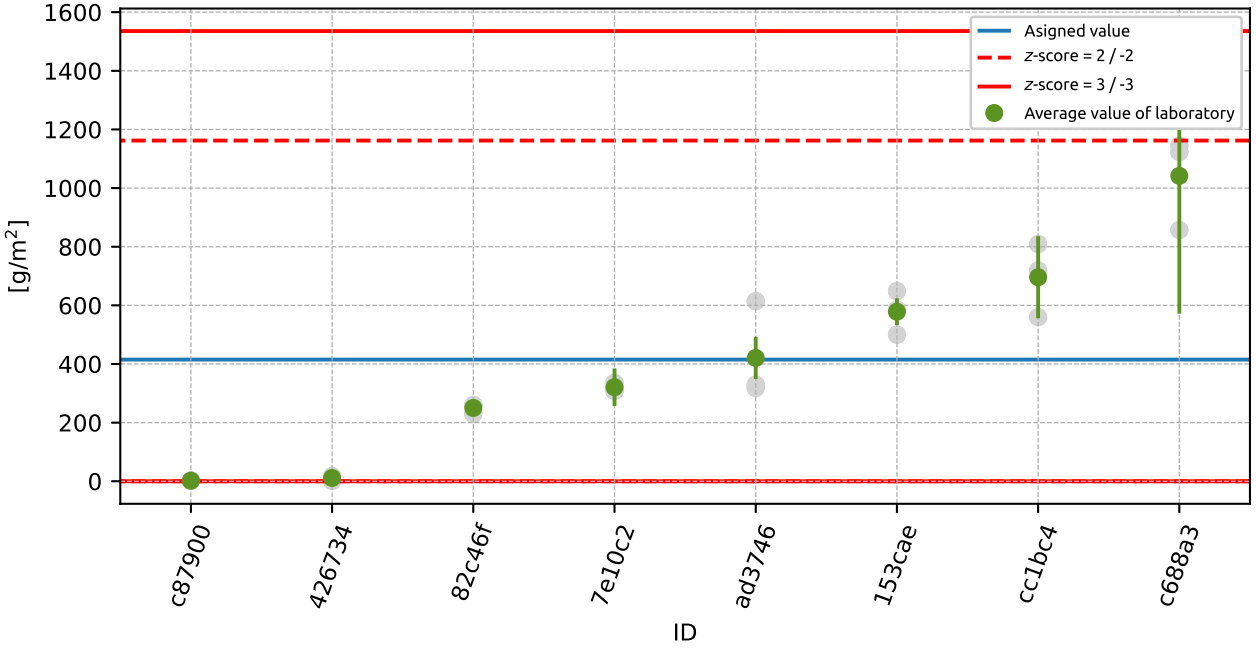

Figure 106: Average values and extended uncertainties of measurement

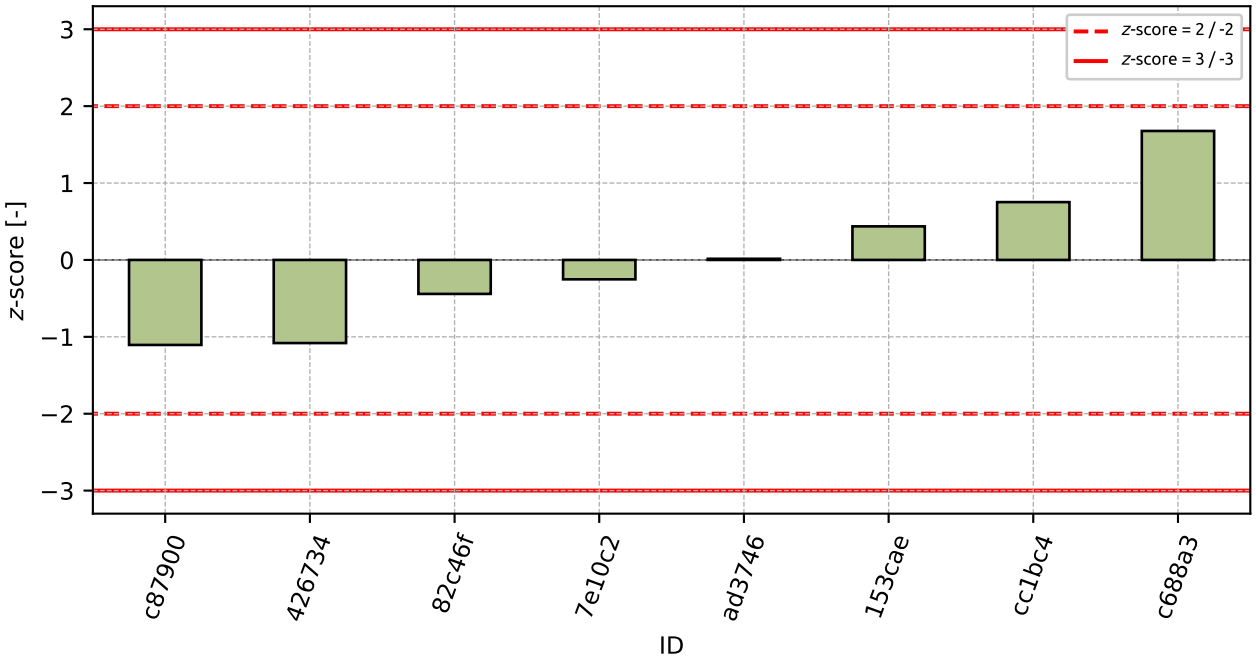

Figure 107: z-score

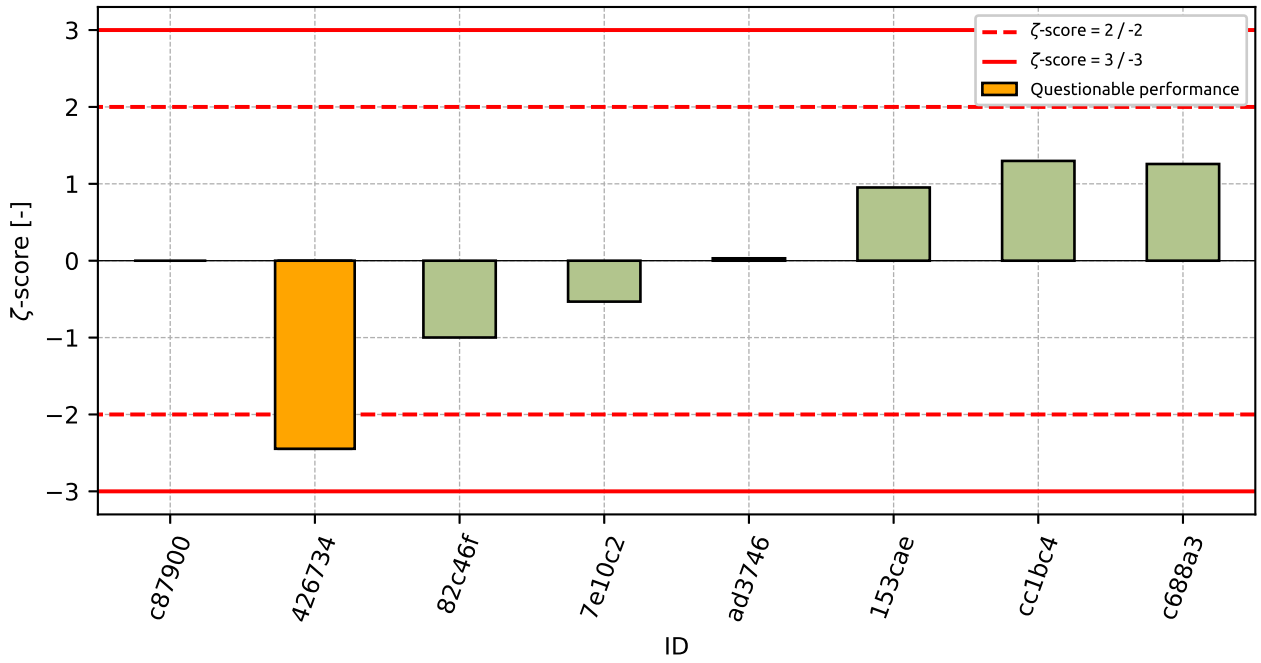

Figure 108: ζ-score

Table 42: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
c87900	-1.11	-
426734	-1.08	-2.45
82c46f	-0.44	-1.0
7e10c2	-0.25	-0.53
ad3746	0.02	0.03
153cae	0.44	0.95
cc1bc4	0.75	1.3
c688a3	1.68	1.26

8.3 75 cycles

8.3.1 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 [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
c87900	2.9	2.4	2.6	-	2.6	0.25	9.56
426734	1.8	19.2	22.1	1.9	14.3	10.98	76.52
82c46f	360.0	380.0	320.0	10.2	353.3	30.55	8.65
7e10c2	571.1	559.2	520.7	110.0	550.3	26.34	4.79
ad3746	731.5	954.9	614.3	128.0	766.9	173.04	22.56
153cae	747.1	912.7	748.1	63.4	802.6	95.32	11.88
cc1bc4	968.0	1239.0	1194.0	200.0	1133.7	145.23	12.81
c688a3	1405.0	1389.0	1214.0	340.0	1336.0	105.96	7.93

8.3.2 The Numerical Procedure for Determining Outliers

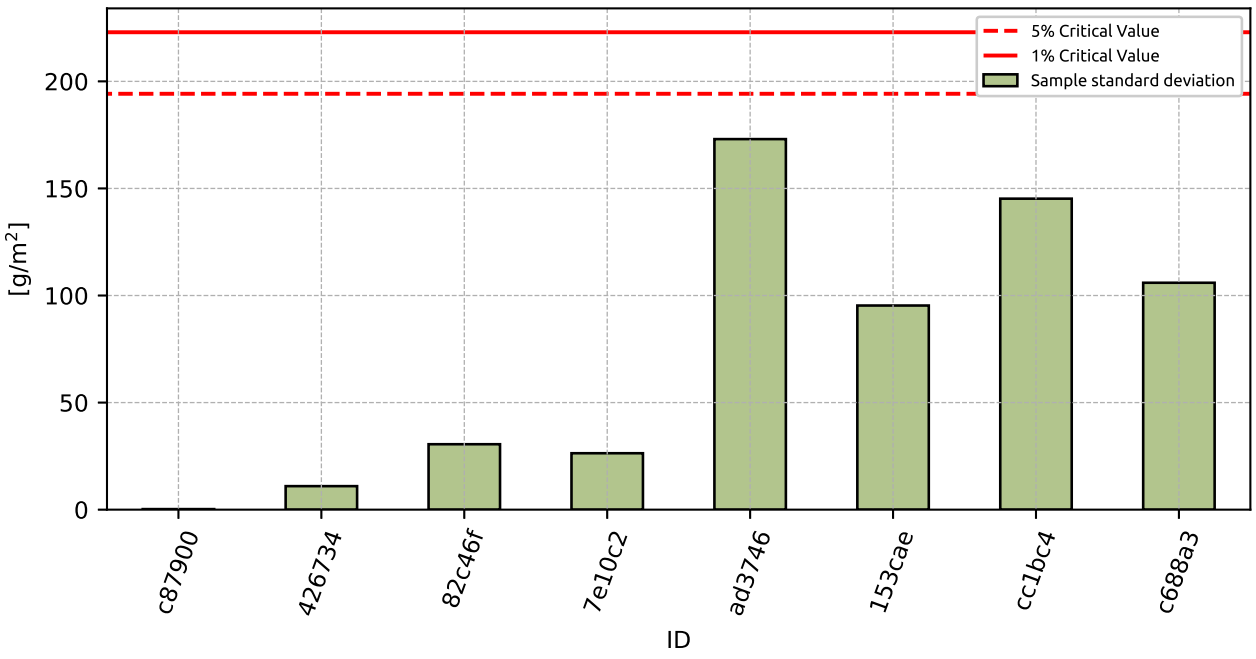

Figure 109: **Cochran's test** - sample standard deviations

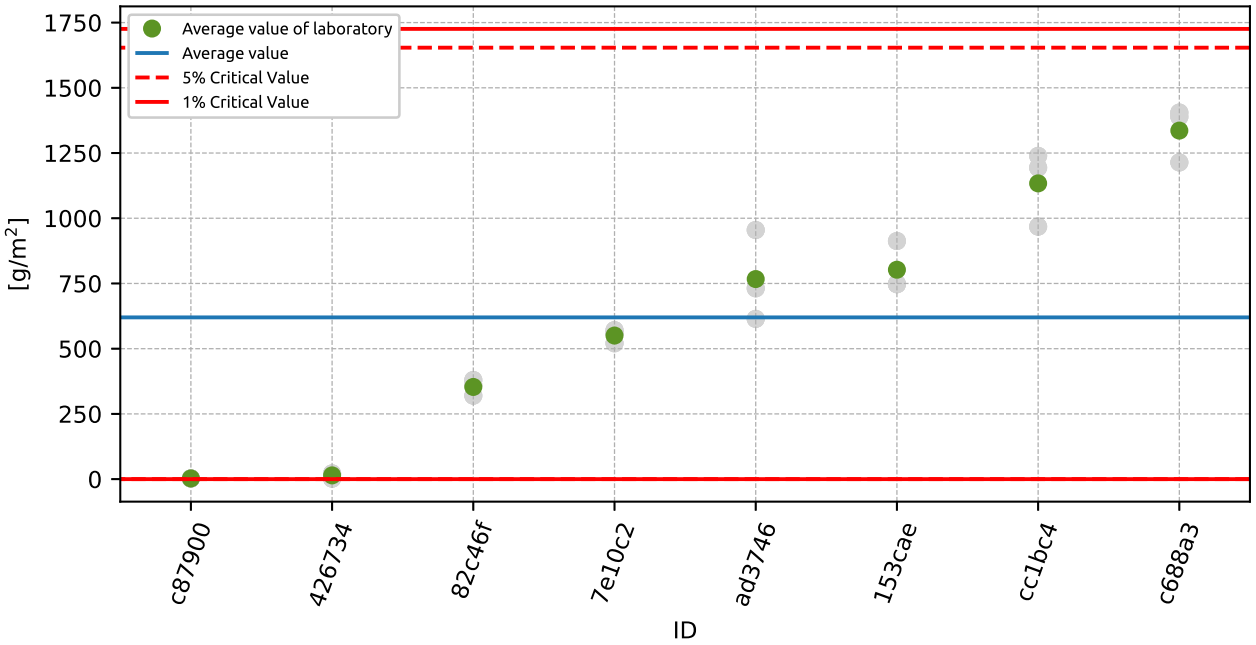

Figure 110: **Grubbs' test** - average values

8.3.3 Mandel's Statistics

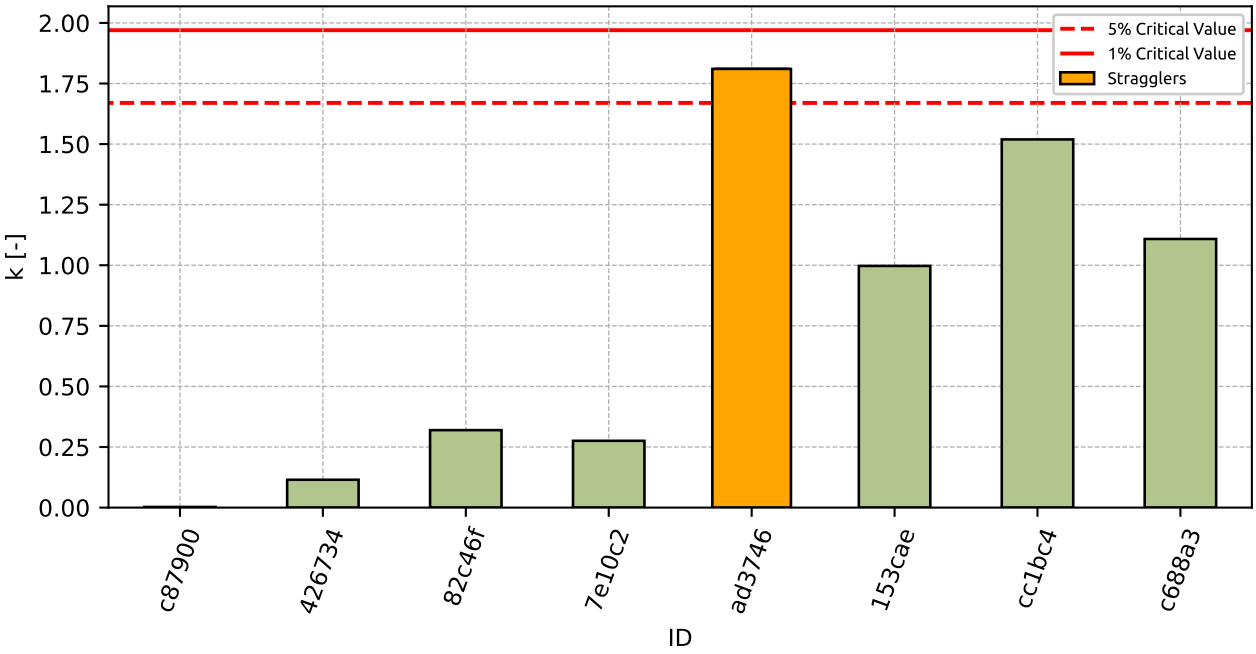

Figure 111: Intralaboratory Consistency Statistic

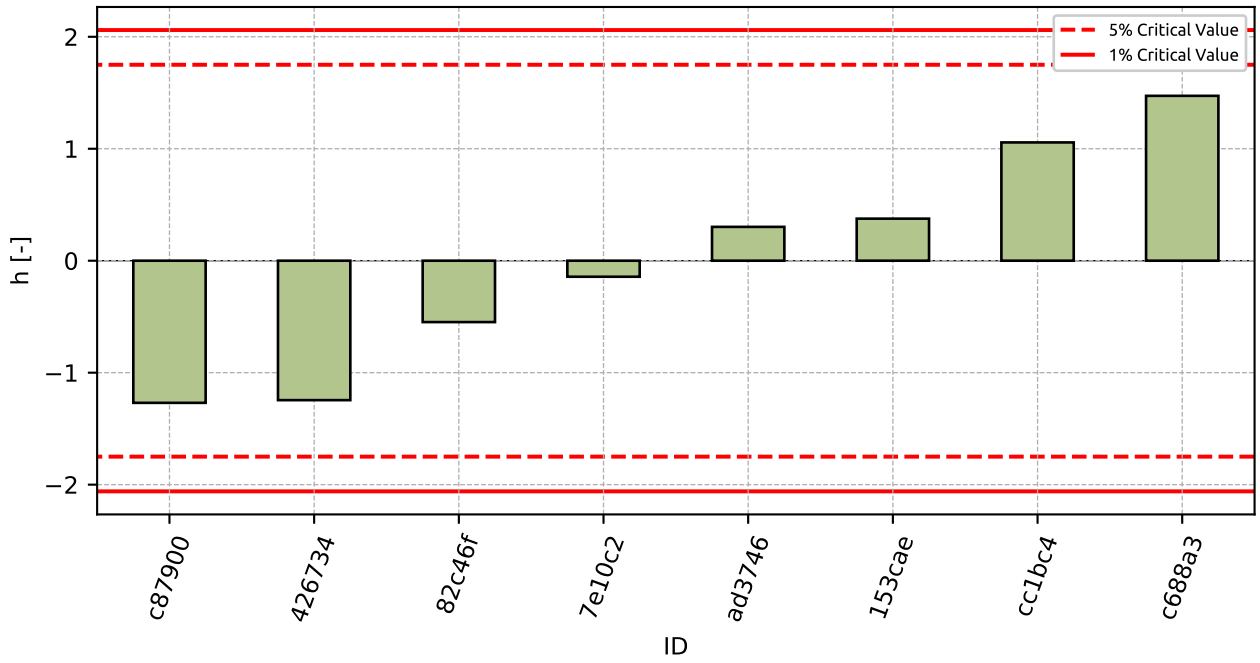

Figure 112: Interlaboratory Consistency Statistic

8.3.4 Descriptive statistics

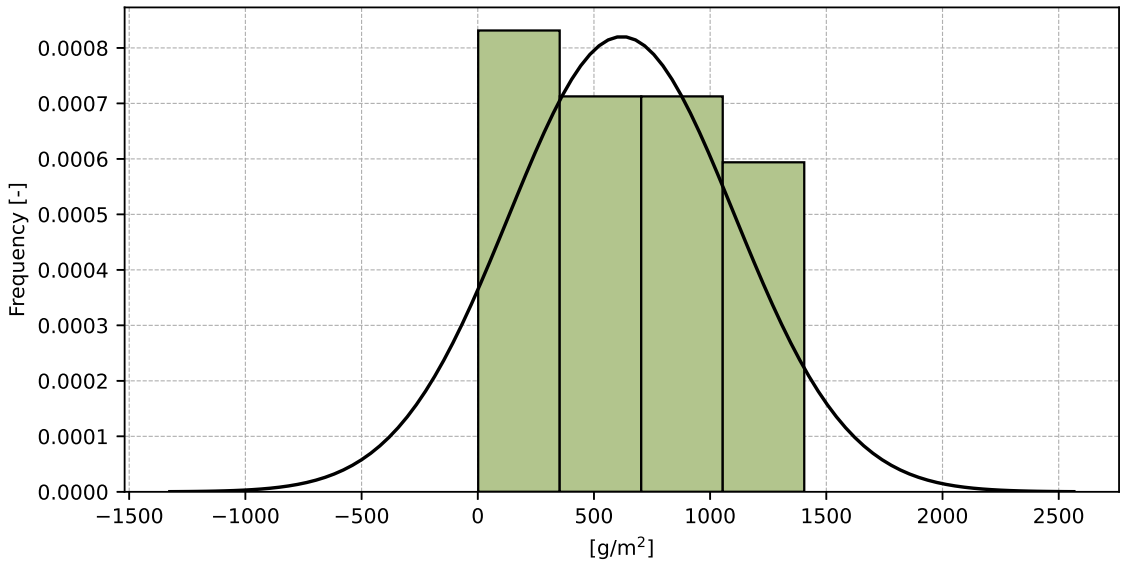

Figure 113: Histogram of all test results

Table 44: Descriptive statistics

Characteristics	[g/m²]
Average value – $\bar{x}$	620.0
Sample standard deviation – s	486.29
Asigned value – x^*	620.0
Robust standard deviation – s^*	515.84
Measurement uncertainty of asigned value – u_X	227.97
p-value of normality test	0.069 [-]
Interlaboratory standard deviation – s_L	483.15
Repeatability standard deviation – s_r	95.59
Reproducibility standard deviation – s_R	492.52
Repeatability – r	267.6
Reproducibility – R	1379.0

8.3.5 Evaluation of Performance Statistics

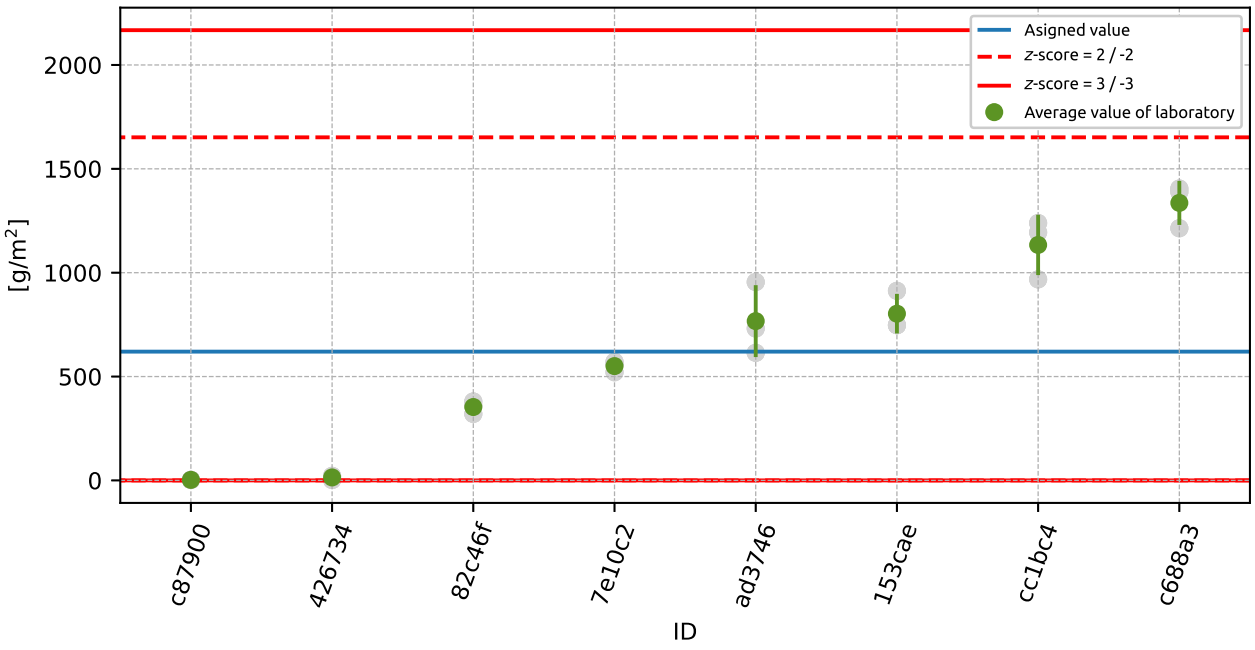

Figure 114: Average values and sample standard deviations

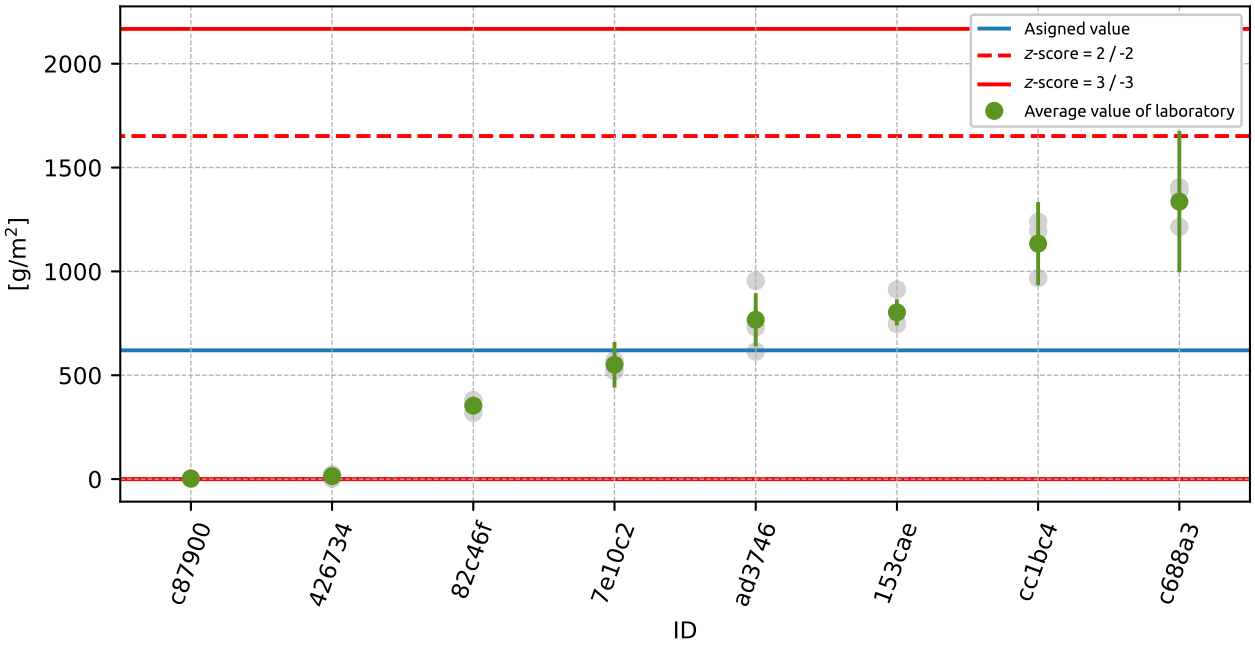

Figure 115: Average values and extended uncertainties of measurement

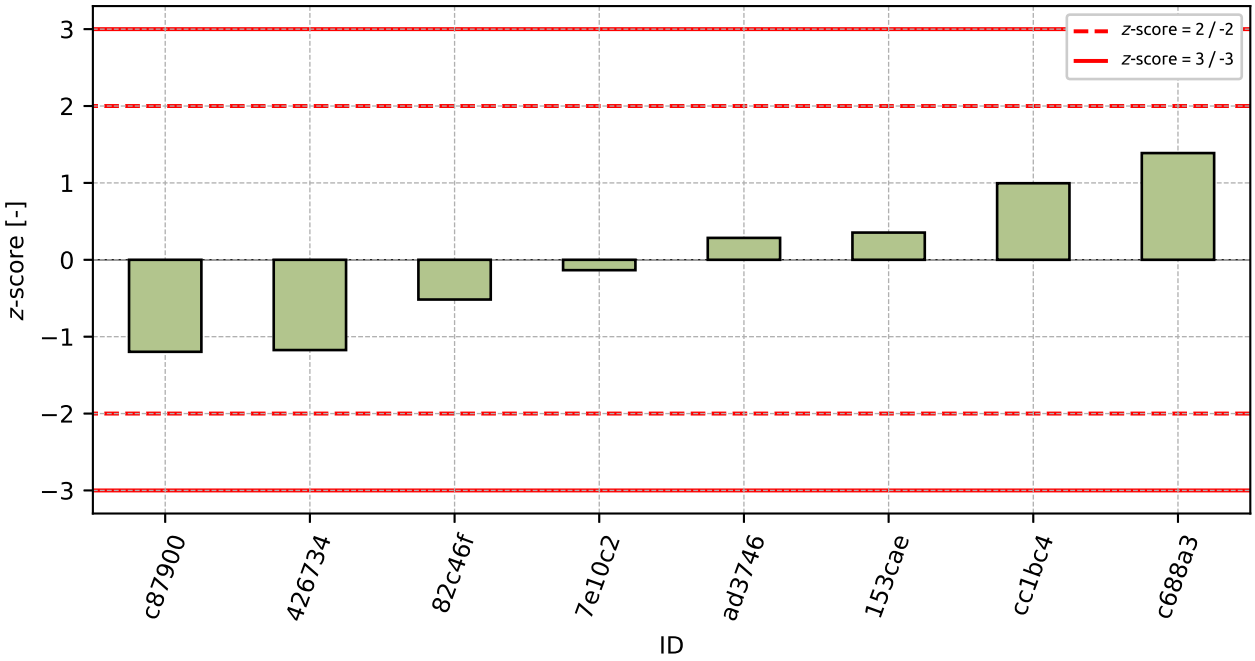

Figure 116: z-score

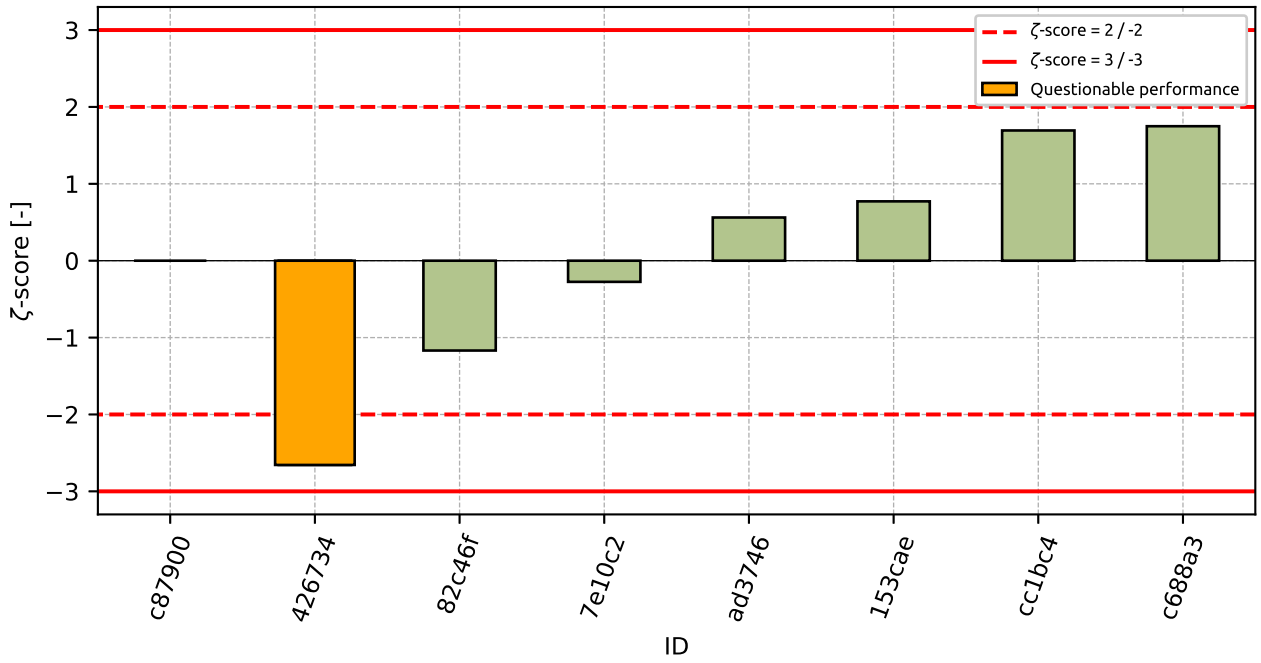

Figure 117: ζ-score

Table 45: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
c87900	-1.2	-
426734	-1.17	-2.66
82c46f	-0.52	-1.17
7e10c2	-0.14	-0.28
ad3746	0.28	0.56
153cae	0.35	0.77
cc1bc4	1.0	1.69
c688a3	1.39	1.75

9 Appendix – CEN/TS 12390-9 – Freeze-thaw resistance – Scaling

This part of the PT program was not opened due to low interest from laboratories.