BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
institute of building testing

ilac-MRA

Z 7008

FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Strength and Durability of Hardened Concrete
ZZB 2023/1

Brno University of Technology
Proficiency testing provider at the SZK FAST
Veveří 95, Brno 602 00
Czech Republic

www.szk.fce.vutbr.cz
www.ptprovider.cz

Date: July 31, 2023

Poskytovatel zkoušení způsobilosti při SZK FAST
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Ing. Petr Misák, Ph.D.
Coordinator of PTP results assessment

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1 Introduction and Important Contacts

In the year 2023, the Proficiency Testing Provider at the SZK FAST (PT Provider) initiated the Proficiency Testing Program (PTP) designated ZZB 2023/1 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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Coordinator of PTP result assessment PrZZ

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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 4, 5, 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.

62 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
ce5dd4	-	-	-	-	-	-	X	-	-
889292	X	-	-	-	-	-	-	-	-
056d76	X	X	X	-	-	-	-	-	-
d3d8f0	X	X	X	-	-	-	-	-	-
b68435	-	-	X	-	-	-	-	-	-
e9bb88	X	X	-	-	-	-	X	-	-
992896	X	X	-	-	-	-	-	-	-
597a29	-	X	X	-	-	-	-	-	-
dbeae5	X	X	-	-	-	-	-	-	-
25bec1	X	X	X	-	-	-	-	X	-
74dcfd	X	X	X	-	-	-	-	X	-
02a747	X	X	X	-	-	-	-	-	-
cb382a	X	X	X	-	-	-	-	-	-
71c95d	X	X	X	-	-	-	-	X	-
d66e98	X	X	X	-	-	-	-	-	-
ed56ac	-	-	X	-	-	-	-	-	-
06c821	X	X	-	-	-	-	-	-	-
0a4c1c	X	-	-	-	-	-	-	-	-
66161a	X	X	-	-	-	-	-	-	-
1fc047	X	-	X	-	-	-	-	-	-
4828a6	X	X	-	-	-	-	X	-	-
72b3f2	X	X	-	-	-	-	-	-	-
ee2b41	X	-	-	-	-	-	-	-	-
5e0f68	X	-	-	-	-	-	-	-	-
de56a7	-	-	X	-	-	-	-	-	-
ae4568	X	-	-	-	-	-	X	-	-
a61557	X	X	-	-	-	-	-	-	-
9bdcd5	X	X	X	-	-	-	-	X	-
e6265b	X	X	X	-	-	-	-	-	-
1887c9	X	X	X	-	-	-	-	X	-
71d584	X	X	X	-	-	-	X	-	-
15c6ef	X	X	X	-	-	-	X	-	-
9f866f	X	X	-	-	-	-	-	-	-
b5ccd7	X	X	-	-	-	-	-	-	-
d1f1e8	X	X	X	-	-	-	X	-	-
c62844	X	X	-	-	-	-	-	-	-
b174bb	X	X	-	-	-	-	-	-	-
a80858	X	X	-	-	-	-	-	-	-
f872cf	X	X	-	-	-	-	-	-	-
64e370	X	X	X	-	-	-	-	-	-
2134a0	X	X	X	-	-	-	-	-	-
00d359	-	-	X	-	-	-	X	-	-
acf631	-	X	X	-	-	-	-	-	-
efa406	X	X	-	-	-	-	-	-	-

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ID/Method	1	2	3	4	5	6	7	8	9
17ac3d	X	X	-	-	-	-	-	-	-
f4c29a	-	-	X	-	-	-	-	-	-
94d1f2	X	X	-	-	-	-	-	-	-
e7a3e3	X	X	-	-	-	-	-	-	-
470e81	X	X	X	-	-	-	X	-	-
c3db5a	X	X	X	-	-	-	X	-	-
72f0ed	-	X	-	-	-	-	-	-	-
2e1f69	X	-	X	-	-	-	-	-	-
f5891b	X	X	X	-	-	-	-	-	-
0df26d	-	-	X	-	-	-	X	-	-
dd1c39	X	X	-	-	-	-	X	-	-
9546fe	-	-	X	-	-	-	-	-	-
53893f	-	-	X	-	-	-	-	-	-
0af3ee	-	-	X	-	-	-	-	-	-
ac4800	-	-	X	-	-	-	-	-	-
3e1f2d	-	-	X	-	-	-	-	-	-
51f494	X	X	-	-	-	-	-	-	-
7c965c	-	-	-	-	-	-	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
"STROYCONTROL 2003 " LTD	Kostenetz str 12, Sofia, 1612, Bulgaria	182LI
"Център за изпитване и европейска сертификация" ЕООД	2 Industrialna street, Stara Zagora, 6000, Bulgaria	252 ЛИ
BANAT INŽENJERING 223 DOO	Makedanska 15, Zrenjanin, 23000, Serbia	-
BEST, a.s.	Rybnice 148, Kaznějov, 331 51, Česká republika	1739
BETONTEST, spol. s r. o.	Trnkova 3083/162, Brno - Líšeň, 62800, Česká republika	1116
BETOTECH s.r.o. - pracoviště Brno	Beroun 660, Beroun, 26601, Česká republika	1195.3
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 Most	Beroun 660, Beroun, 26601, Česká Republika	AZL 1195
BETOTECH, s.r.o. - Pracoviště Trutnov	Beroun 660, Beroun, 26601, Česká Republika	AZL 1195

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Laboratory	Address	Accreditation number
BETOTECH, s.r.o. - pracoviště Klatovy	Beroun 660, Beroun, 26601, Česká Republika	AZL 1195
Baustoffprüfstelle an der HTBLuVA Villach	Tschinowitscherweg 5, Villach, 9500, Österreich	-
BetónRacio, s.r.o., Skúšobné laboratórium, Pracovisko Lietavská Lúčka	Skladová 2, Trnava, 917 01, Slovenská republika	S-320
BetónRacio, s.r.o., Skúšobné laboratórium, Pracovisko Trnava	Skladová 2, Trnava, 917 01, Slovenská republika	S-320
BetónRacio, s.r.o., Skúšobné laboratórium, Pracovisko Veľký Šariš	Skladová 2, Trnava, 917 01, Slovenská republika	S-320
CEMEX Czech Republic, s.r.o.	Semtín 102, Pardubice, 53354, Česká republika	1302
Cement Hranice, akciová společnost	Bělotínská 288, Hranice I - Město, 75301, Česká republika	1284
Central Regional Laboratory	Canna Road, Tabuan Jaya, Kuching, 93350, Sarawak, Malaysia	-
Danucem Slovensko a.s., Skúšobné laboratórium Bratislava	Pestovateľská 2, Bratislava, 82104, Slovenská republika	426/S-313
Debbie van den Hemel	Industriepark Oost 6, Beernem, 8730, West - Vlaanderen	-
EDAFOMICHANIKI SA	19 EMMANUEL PAPADAKI, NEO IRAKLEIO, 14121, GREECE	-
Group Van Vooren	Industriepark Rosteyne 1, Zelzate, 9060, Oost-Vlaanderen	296-TEST
Holcim (Hrvatska) d.o.o.	Koromačno 7b, Koromačno, 52222, Croatia	1528
IGH d.o.o.	Bišće polje bb, Mostar, 88000, Bosna i Hercegovina	LI-31-01
INSTITUT ZA GRAĐEVINARSTVO DOO SUBOTICA	MAGNETNA POLJA 9, SUBOTICA, 24105, SRBIJA	-
INŻ-GEO Badania i Roboty Geotechniczne Sp z o.o. Sp komandytowa	Wolności 20, Psary, 51-180, Dolnośląskie	AB 1750
Innovation Hub/ PPC SA	Leontariou 9, Kantza-Pallini-Athens, 15351, Greece	-
Institut für Materialprüfung und Baustofftechnologie mit angeschlossener TVFA für Festigkeits- und Materialprüfung Akkreditierte Prüf-, Inspektions- und Zertifizierungsstelle	Rechbauerstraße 12, Graz, 8010, Austria	-
Institut za Beton doo	Ugrinovački put, 31 deo, br 50, Beograd, 11283, Srbija	-
Laboratoř Praha ŘSD ČR	Na Pankráci 546/56, Praha 4, 140 00, Česká republika	1734
Lafarge Cement, a.s.	Čížkovice 27, Čížkovice, 411 12, Česká republika	1426

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Laboratory	Address	Accreditation number
Master Builders Solutions CZ s.r.o.	K Májovu 1244, Chrudim, 537 01, Česká republika	1495
Mattest (Ireland) Ltd. Galway	Coolough Coolough Road, Galway	286T
Mattest Ireland Ltd (Cork)	Mattest (Ireland) Ltd. Cork Unit 18, University Hall Industrial Park, Sarsfield Road, Wilton, Cork, T12 EV20, ROI	-
Národná diaľničná spoločnosť a.s.	Dúbravská cesta 14, Bratislava, 841 04, Slovenská republika	456/S-328
Panevezio statybos trestas, AB	P. Puzino g. 1, Panevezys, LT-35173, Lithuania	LA.01.022
Rudarski institut d.d. Tuzla	Rudarska 72, Tuzla, 75000, Bosna i Hercegovina	LI-47-01
SQZ, s.r.o. - organizačná zložka Bratislava	Mlynské Nivy 68, Bratislava, 82105, Slovensko	S-376
SQZ, s.r.o. - pracoviště Lišov	U místní dráhy 939/5, Olomouc, 779 00, Česká republika	1135.2
SQZ, s.r.o. - pracoviště Srch	U místní dráhy 939/5, Olomouc, 779 00, Česká republika	1135.2
STACHEMA Bratislava a.s.	Železničná 714/180, Rovinka, 90041, Slovenská republika	-
Skanska Transbeton, s.r.o. - Zkušební laboratoř Letňany	Skanska a.s., Křižíkova 682/34a, Praha 8 - Karlín, 18600, Česká republika	1122
Skanska Transbeton, s.r.o. - Zkušební laboratoř Olomouc	Skanska a.s., Křižíkova 682/34a, Praha 8 - Karlín, 18600, Česká republika	1122
Slovenská správa ciest - Bratislava	Studena 9, Bratislava, 821 04, Slovenská republika	181/S-281
Slovenská správa ciest - Žilina	Martina Rázusa 104/A, Žilina, 010 01, Slovenská republika	181/S-322
TESScontrol, s.r.o. - Laboratórium Prešov	Hronská 3211/1; alebo efaktury@tesscontrol.sk, Zvolen, 960 93, Slovenská republika	S-375
TESScontrol, s.r.o. - Oblastné laboratórium Bratislava	Hronská 3211/1; alebo efaktury@tesscontrol.sk, Zvolen, 960 93, Slovenská republika	S-375
TESScontrol, s.r.o. - Oblastné laboratórium Zvolen	Hronská 3211/1; alebo efaktury@tesscontrol.sk, Zvolen, 960 93, Slovenská republika	S-375
TESScontrol, s.r.o. - Oblastné laboratórium Žilina	Hronská 3211/1; alebo efaktury@tesscontrol.sk, Zvolen, 960 93, Slovenská republika	S-375
TESTAV - LAB s.r.o.	Chodská 7, Liberec 3, 466 02, Česká republika	1180
TPA ČR, s.r.o.	Vrbenská 1821/31, České Budějovice, 370 06, Česká republika	1181
Technický a skúšobný ústav stavebný, n. o. - Bratislava	Studená, 967/3, Bratislava, 82104, Slovenská republika	S-045

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Laboratory	Address	Accreditation number
Technický a skúšobný ústav stavebný, n. o. - Nitra	Studená, 967/3, Bratislava, 82104, Slovenská republika	S-045
Technický a skúšobný ústav stavebný, n. o. - Nové Mesto nad Váhom	Studená, 967/3, Bratislava, 82104, Slovenská republika	S-045
Technický a skúšobný ústav stavebný, n. o. - Prešov	Studená, 967/3, Bratislava, 82104, Slovenská republika	S-045
Technický a skúšobný ústav stavebný, n. o. - Žilina	Studená, 967/3, Bratislava, 82104, Slovenská republika	S-045
UAB "Testlita"	J.Basanavičiaus g. 160D-2, Šiauliai, LT-76128, Lithuania	LA 01.013
University of Natural Resources and Life Sciences Vienna, Institute for Structural Engineering	Peter-Jordan-Str. 82, Wien, 1190, AUSTRIA	-
Výzkumný ústav pozemních staveb - Certifikační společnost, s.r.o. - pobočka Praha-Uhříněves	Pražská 810/16, Praha, 10200, Česká republika	1234
VŠB - Technická univerzita Ostrava, Zkušební laboratoře výzkumného centra hornin, Hornicko-geologická fakulta	17. listopadu 2172/15, Ostrava-Poruba, 70800, Česká republika	1166.4
Ústav stavebního zkušebnictví s.r.o.	Jiřího Potůčka 115, Trnová, Pardubice, 53009, Česká republika	1115

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. 62 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
ce5dd4	-	-	-	-	-	-	✓	-	-
889292	✓	-	-	-	-	-	-	-	-
056d76	?	✓	?	-	-	-	-	-	-
d3d8f0	✓	✓	✓	-	-	-	-	-	-
b68435	-	-	✓	-	-	-	-	-	-
e9bb88	✓	✓	-	-	-	-	?	-	-
992896	✓	✓	-	-	-	-	-	-	-
597a29	-	✓	✓	-	-	-	-	-	-
dbeae5	✓	✓	-	-	-	-	-	-	-
cee05b	✓	✓	-	-	-	-	-	-	-
e43ce3	✓	✓	✓	-	-	-	-	-	-
25bec1	✓	✓	✓	-	-	-	-	✓	-
74dcfd	✓	✓	✓	-	-	-	-	✓	-
02a747	✓	✓	✓	-	-	-	-	-	-
cb382a	✓	✓	✓	-	-	-	-	-	-
71c95d	✓	✓	✓	-	-	-	-	✓	-
d66e98	✓	✓	✓	-	-	-	-	-	-
ed56ac	-	-	✓	-	-	-	-	-	-
06c821	✓	✓	-	-	-	-	-	-	-
0a4c1c	✓	-	-	-	-	-	-	-	-
66161a	✓	✓	-	-	-	-	-	-	-
1fc047	✓	-	✓	-	-	-	-	-	-
4828a6	✓	✓	-	-	-	-	✓	-	-
72b3f2	✓	✓	-	-	-	-	-	-	-
ee2b41	✓	-	-	-	-	-	-	-	-

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ID / Method	1	2	3	4	5	6	7	8	9
5e0f68	X	-	-	-	-	-	-	-	-
de56a7	-	-	✓	-	-	-	-	-	-
ae4568	✓	-	-	-	-	-	✓	-	-
a61557	✓	✓	-	-	-	-	-	-	-
9bdcd5	?	✓	✓	-	-	-	-	✓	-
e6265b	✓	✓	✓	-	-	-	-	-	-
1887c9	X	?	!	-	-	-	-	✓	-
71d584	✓	✓	✓	-	-	-	✓	-	-
15c6ef	✓	✓	✓	-	-	-	✓	-	-
9f866f	✓	✓	-	-	-	-	-	-	-
b5ccd7	✓	✓	-	-	-	-	-	-	-
d1f1e8	✓	✓	✓	-	-	-	✓	-	-
c62844	✓	✓	-	-	-	-	-	-	-
b174bb	✓	✓	-	-	-	-	-	-	-
a80858	✓	✓	-	-	-	-	-	-	-
f872cf	✓	✓	-	-	-	-	-	-	-
64e370	✓	✓	✓	-	-	-	-	-	-
2134a0	✓	✓	✓	-	-	-	-	-	-
00d359	-	-	✓	-	-	-	✓	-	-
acf631	-	✓	✓	-	-	-	-	-	-
efa406	✓	✓	-	-	-	-	-	-	-
17ac3d	✓	✓	-	-	-	-	-	-	-
f4c29a	-	-	✓	-	-	-	-	-	-
94d1f2	✓	✓	-	-	-	-	-	-	-
e7a3e3	✓	✓	-	-	-	-	-	-	-
470e81	✓	✓	✓	-	-	-	✓	-	-
c3db5a	✓	✓	✓	-	-	-	✓	-	-
72f0ed	-	✓	-	-	-	-	-	-	-
2e1f69	✓	-	✓	-	-	-	-	-	-
f5891b	✓	✓	?	-	-	-	-	-	-
0df26d	-	-	✓	-	-	-	✓	-	-
dd1c39	✓	✓	-	-	-	-	✓	-	-
9546fe	-	-	✓	-	-	-	-	-	-
53893f	-	-	✓	-	-	-	-	-	-
0af3ee	-	-	✓	-	-	-	-	-	-
ac4800	-	-	X	-	-	-	-	-	-
3e1f2d	-	-	✓	-	-	-	-	-	-

Continued on next page

Continued from previous page

ID / Method	1	2	3	4	5	6	7	8	9
51f494	✓	✓	-	-	-	-	-	-	-
7c965c	-	-	-	-	-	-	✓	-	-

References

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

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[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.

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[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 [%]
5e0f68	35.1	34.0	34.4	1.1	34.5	0.56	1.61
9bdcd5	42.7	48.2	48.6	8.0	46.5	3.3	7.09
a80858	46.0	47.2	48.5	-	47.2	1.25	2.65
0a4c1c	50.4	47.3	46.4	-	48.0	2.1	4.37
ae4568	48.7	48.1	47.5	1.8	48.1	0.6	1.25
71c95d	48.3	48.8	47.5	1.2	48.2	0.66	1.36
e7a3e3	48.0	49.1	49.2	1.7	48.8	0.67	1.37
15c6ef	48.1	50.8	47.4	2.4	48.8	1.8	3.68
1fc047	48.4	48.4	50.4	4.4	49.1	1.15	2.35
4828a6	51.0	47.7	48.6	3.1	49.1	1.71	3.47
dd1c39	48.7	50.1	49.2	1.3	49.3	0.71	1.44
2134a0	51.7	49.5	47.2	-	49.5	2.25	4.55
94d1f2	48.2	49.2	51.3	2.7	49.6	1.58	3.19
66161a	49.5	50.0	49.7	1.4	49.7	0.25	0.51
71d584	50.1	49.8	50.0	-	50.0	0.15	0.31
9f866f	50.7	48.8	50.7	-	50.1	1.1	2.19
74dcfd	50.0	51.0	50.1	0.6	50.4	0.55	1.09
d3d8f0	51.3	51.0	48.9	-	50.4	1.31	2.59
f872cf	51.3	51.6	48.5	-	50.5	1.71	3.39
a61557	48.8	50.1	52.5	5.3	50.5	1.88	3.72
cb382a	49.4	50.8	51.6	1.7	50.6	1.11	2.2
470e81	50.2	50.5	51.1	1.7	50.6	0.46	0.91
d1f1e8	53.1	48.5	50.5	-	50.7	2.31	4.55
b5ccd7	49.9	52.2	50.4	-	50.8	1.21	2.38
889292	51.7	50.1	50.7	0.5	50.8	0.81	1.59
ee2b41	51.6	49.1	52.0	1.0	50.9	1.57	3.09
17ac3d	50.2	52.0	50.7	1.3	51.0	0.93	1.82
b174bb	50.5	52.7	49.9	-	51.0	1.47	2.89
d66e98	49.9	51.4	52.0	1.3	51.1	1.08	2.12
992896	51.1	50.8	51.5	-	51.1	0.35	0.69
02a747	52.4	50.5	51.4	0.6	51.4	0.95	1.85
06c821	51.0	52.0	51.5	0.4	51.5	0.5	0.97
2e1f69	48.8	53.0	53.0	1.8	51.6	2.42	4.7
c3db5a	53.4	50.9	50.8	1.6	51.7	1.47	2.85
25bec1	52.3	51.4	51.8	2.5	51.8	0.45	0.87
64e370	51.3	52.3	52.8	2.1	52.1	0.76	1.47
e9bb88	52.3	54.6	49.5	2.2	52.1	2.55	4.9
c62844	52.5	52.8	51.5	-	52.3	0.68	1.3
51f494	46.7	55.8	54.9	10.0	52.5	5.01	9.56
e6265b	52.9	52.1	52.7	1.0	52.5	0.43	0.81
f5891b	54.6	53.8	52.3	0.7	53.6	1.17	2.18
efa406	54.1	53.8	52.9	-	53.6	0.62	1.17
72b3f2	53.9	54.2	54.0	1.2	54.0	0.17	0.31
dbeae5	53.0	55.5	54.0	0.5	54.2	1.26	2.32
056d76	55.4	54.4	56.1	-	55.3	0.85	1.55
1887c9	59.8	58.8	58.5	0.1	59.0	0.66	1.11

1.2 The Numerical Procedure for Determining Outliers

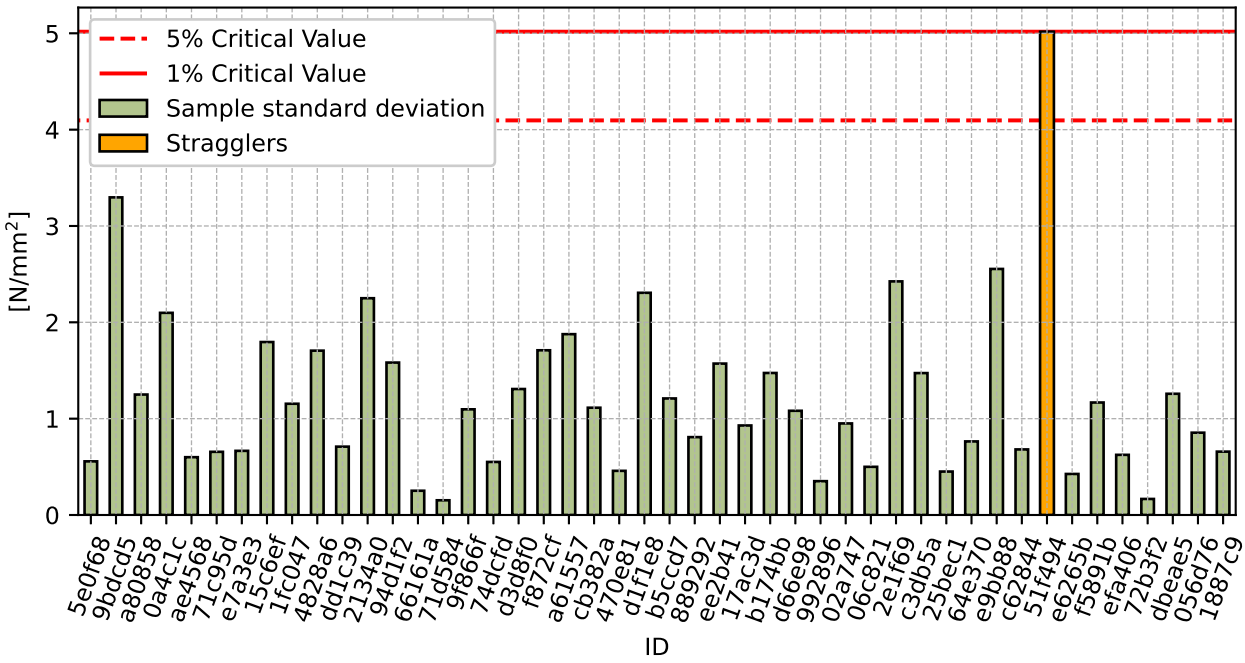

Figure 1: **Cochran's test** - sample standard deviations

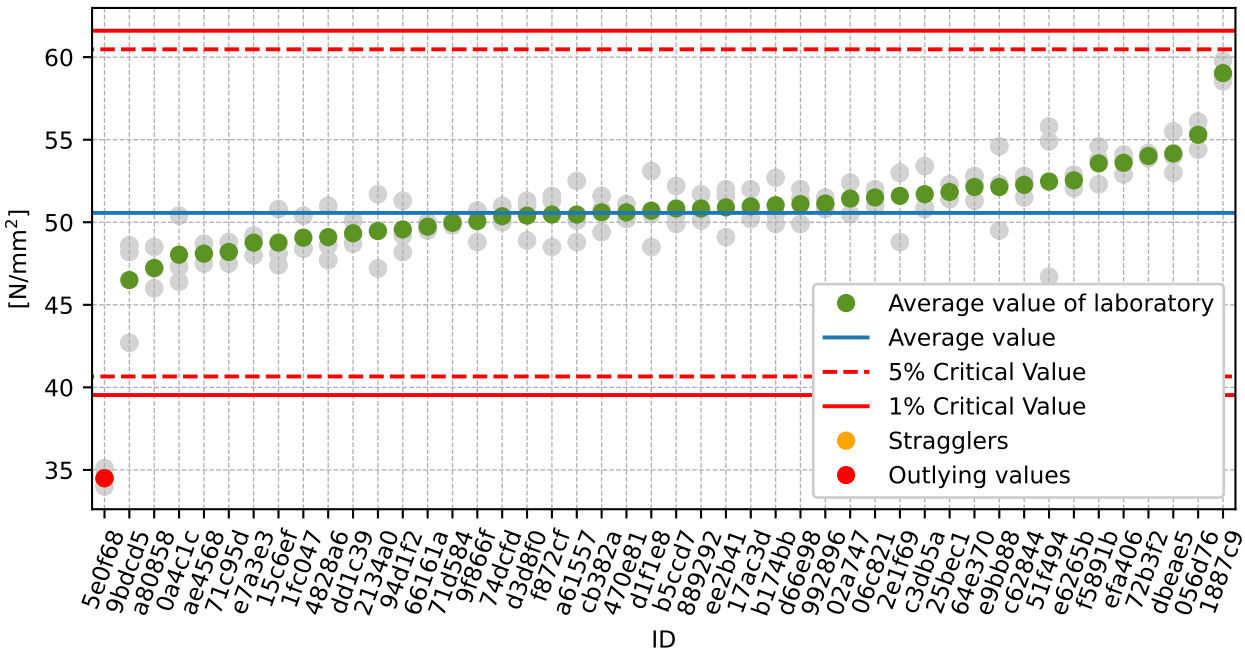

Figure 2: **Grubbs' test** - average values

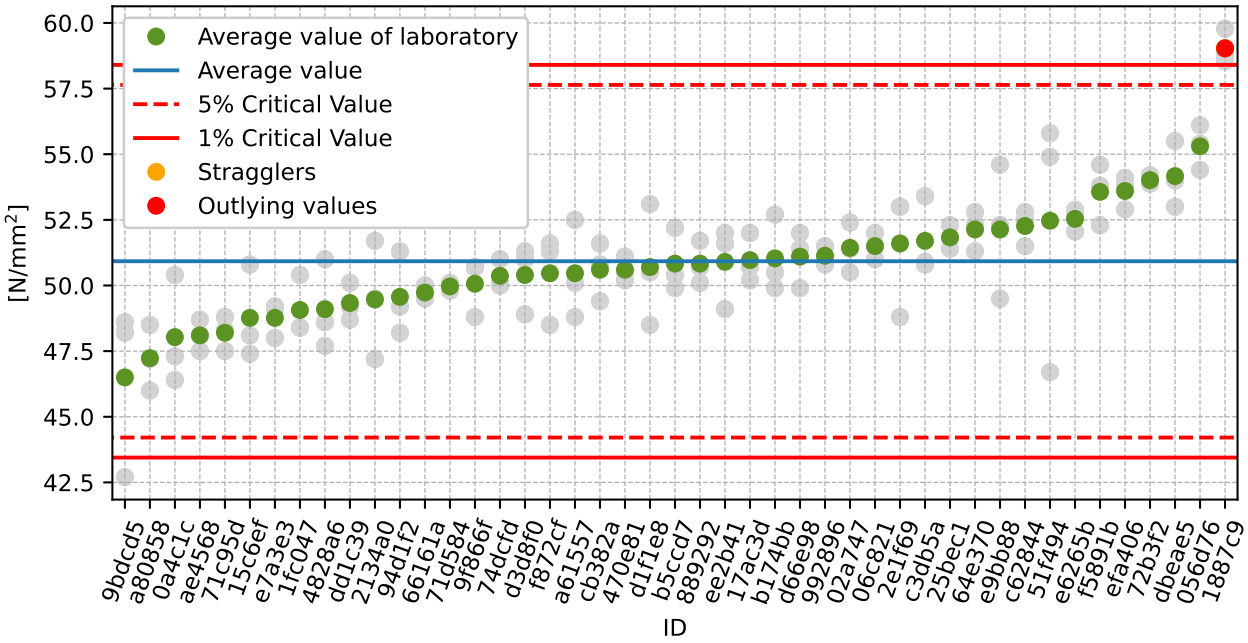

Figure 3: **Grubbs' test** - average values without outliers

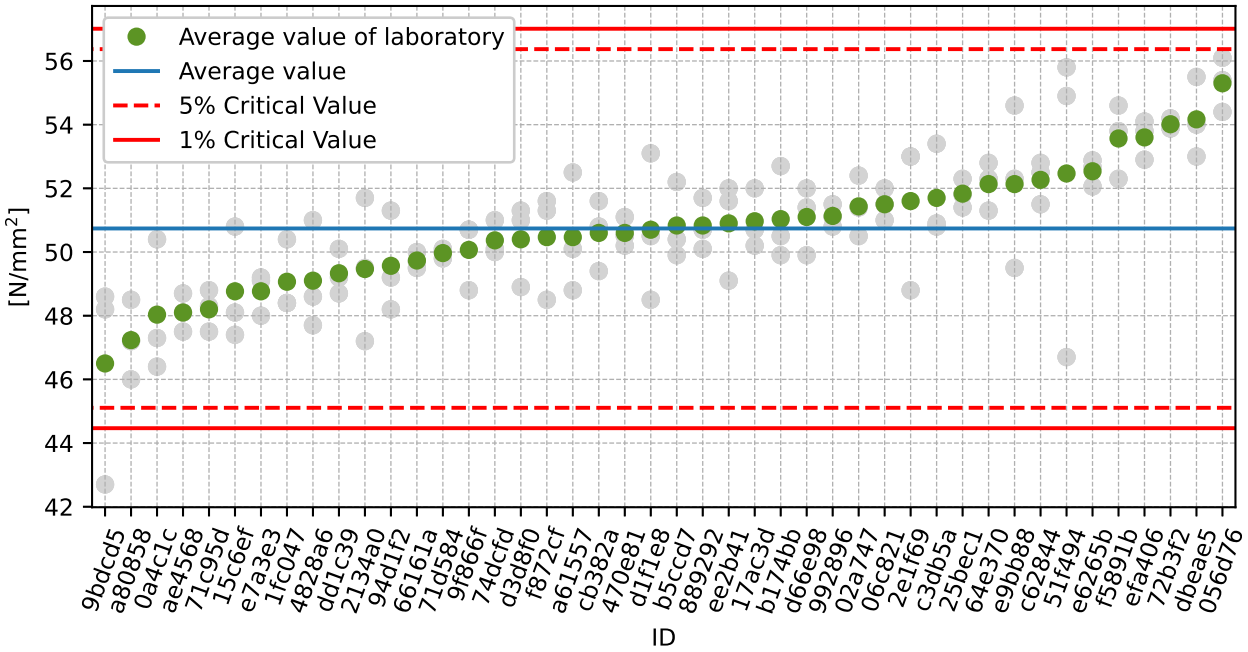

Figure 4: **Grubbs' test** - average values without outliers

1.3 Mandel's Statistics

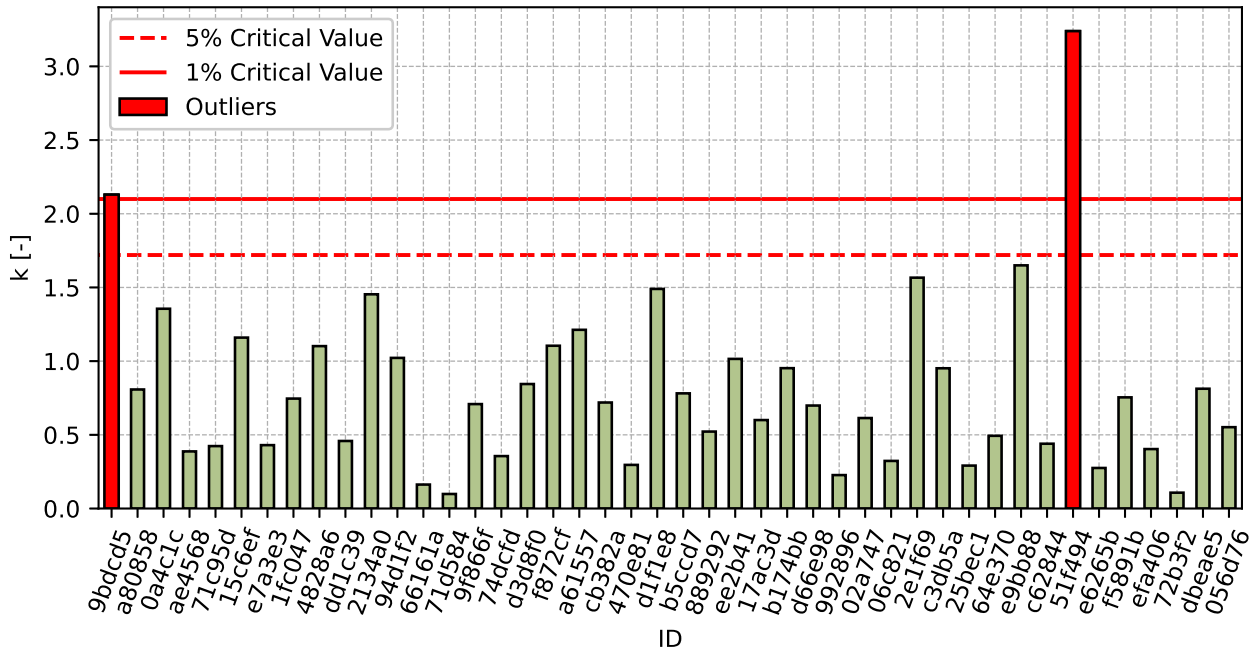

Figure 5: Intralaboratory Consistency Statistic

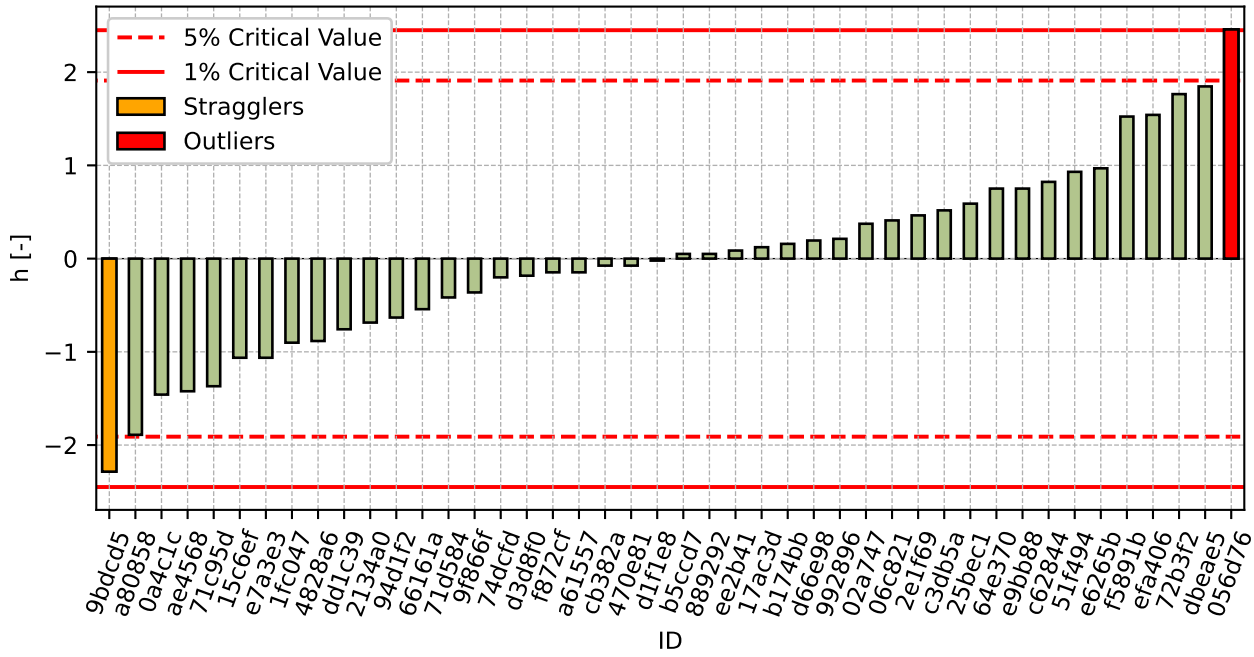

Figure 6: Interlaboratory Consistency Statistic

1.4 Descriptive statistics

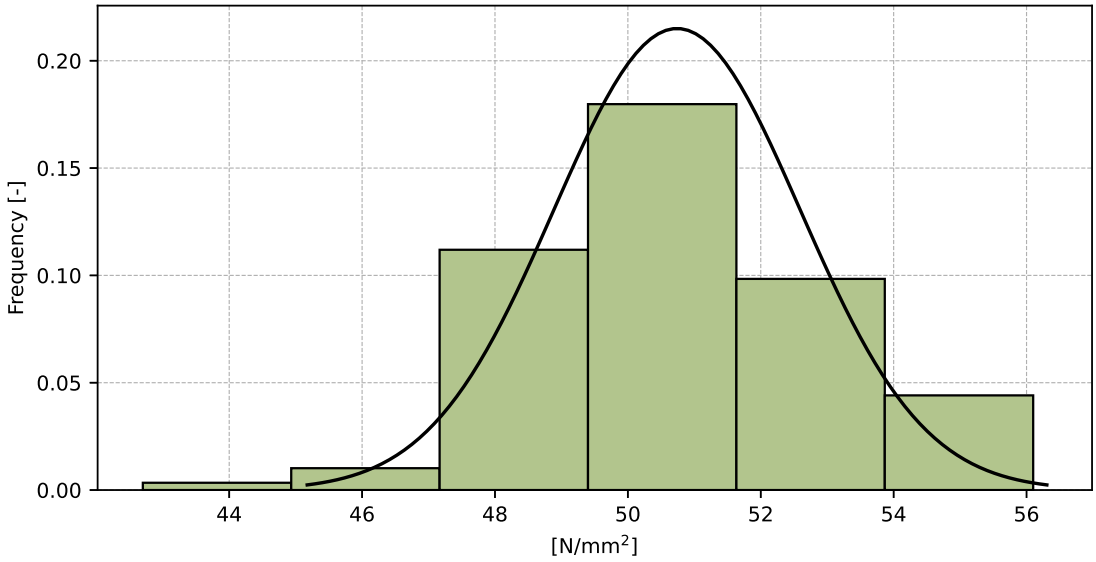

Figure 7: Histogram of all test results

Table 5: Descriptive statistics

Characteristics	[N/mm²]
Average value – $\bar{x}$	50.7
Sample standard deviation – s	1.86
Asigned value – x^*	50.8
Robust standard deviation – s^*	1.84
Measurement uncertainty of asigned value – u_X	0.35
p-value of normality test	0.501 [-]
Interlaboratory standard deviation – s_L	1.63
Repeatability standard deviation – s_r	1.55
Reproducibility standard deviation – s_R	2.24
Repeatability – r	4.3
Reproducibility – R	6.3

1.5 Evaluation of Performance Statistics

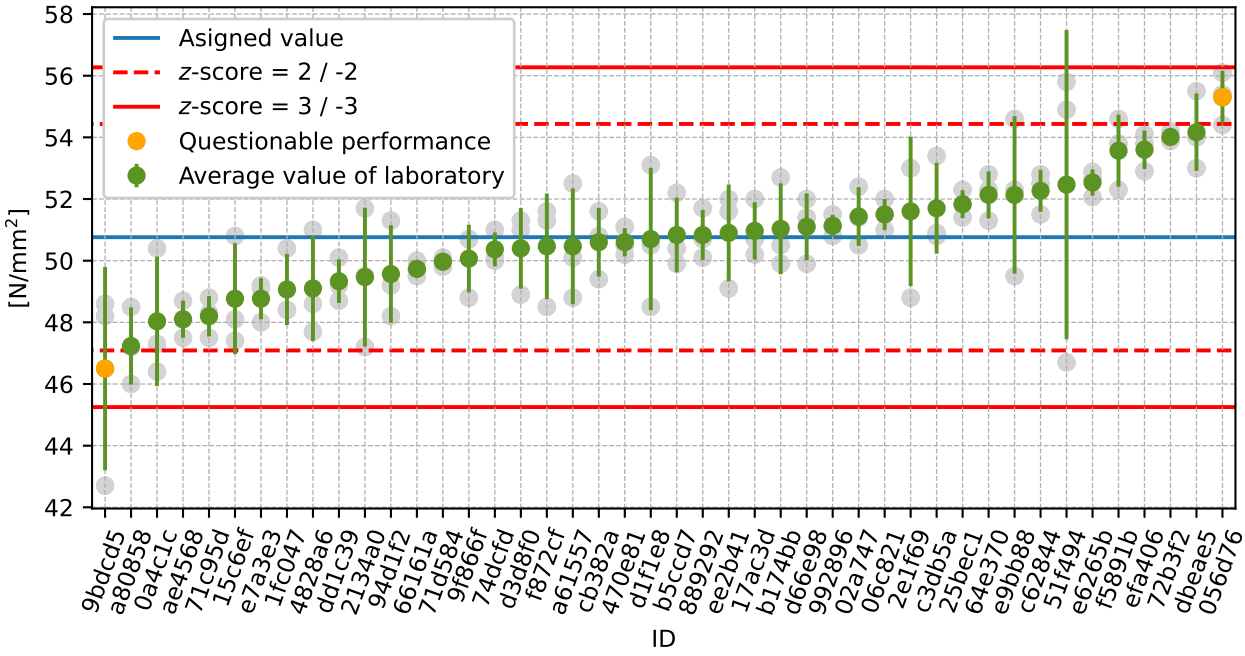

Figure 8: Average values and sample standard deviations

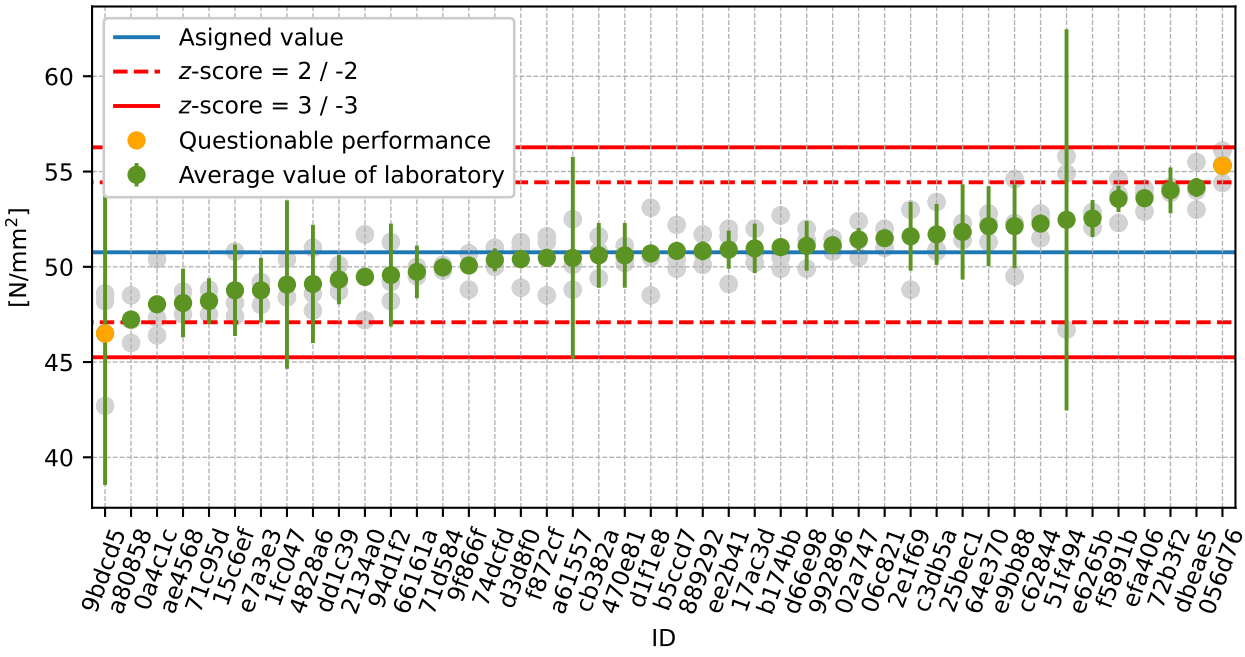

Figure 9: Average values and extended uncertainties of measurement

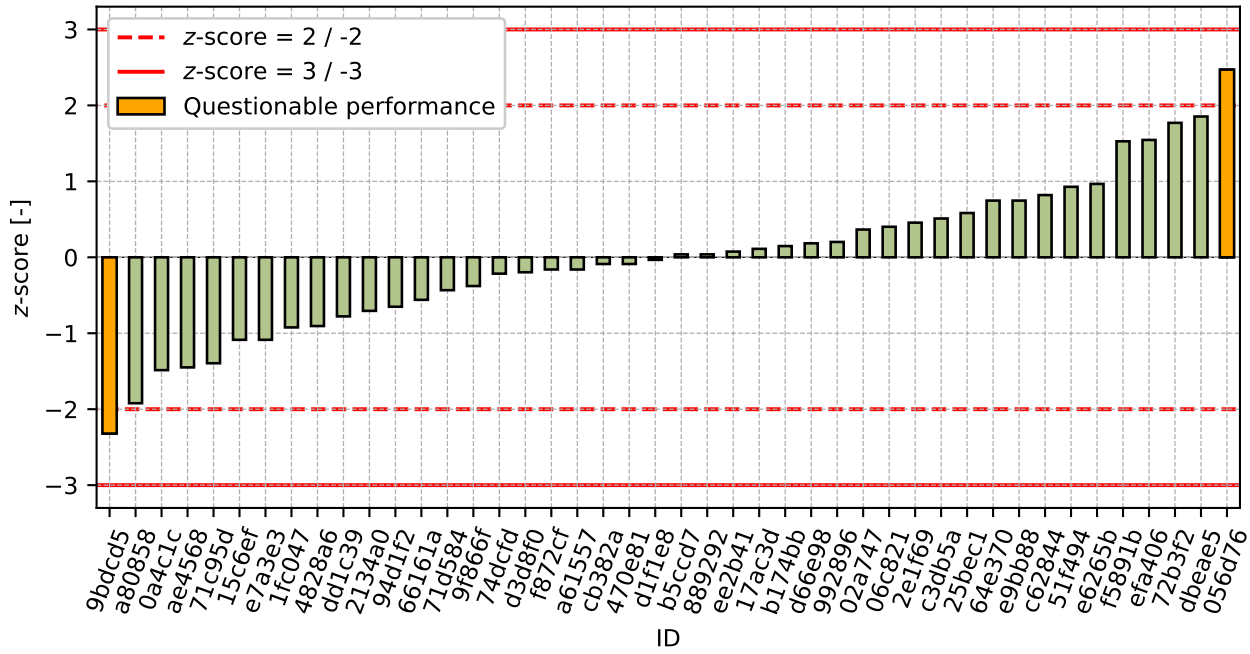

Figure 10: z-score

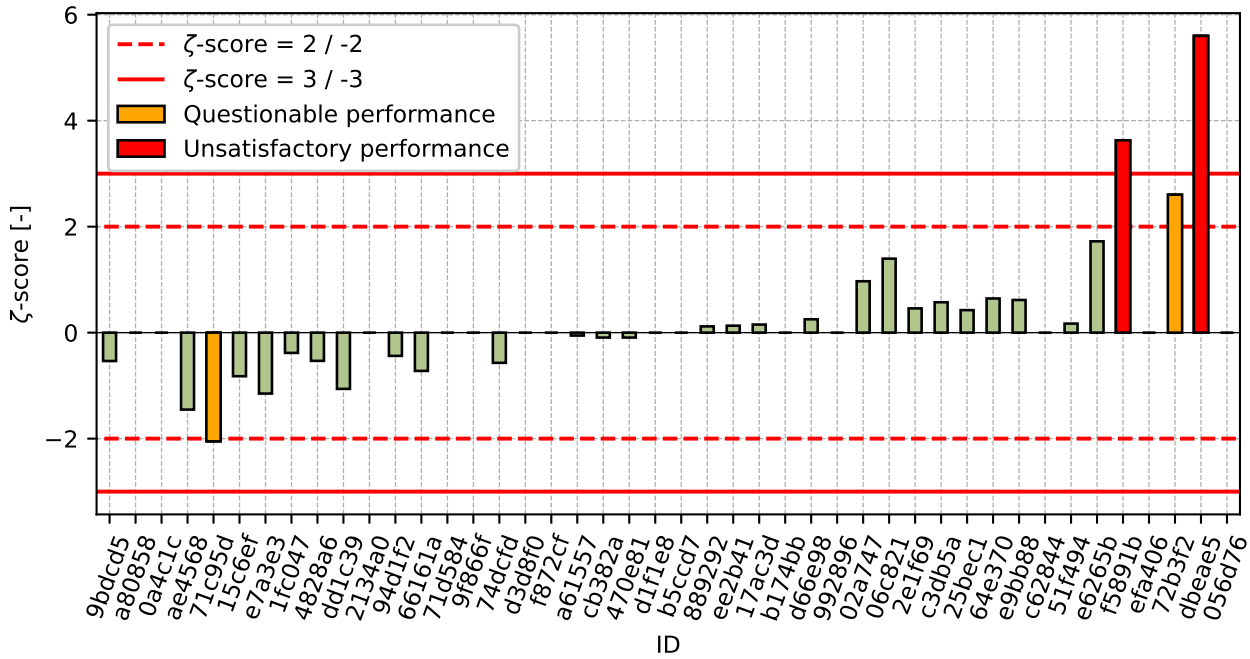

Figure 11: ζ-score

Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
9bdcd5	-2.32	-0.54
a80858	-1.92	-
0a4c1c	-1.49	-
ae4568	-1.45	-1.45
71c95d	-1.39	-2.05
15c6ef	-1.09	-0.82
e7a3e3	-1.09	-1.15
1fc047	-0.92	-0.38
4828a6	-0.9	-0.53
dd1c39	-0.78	-1.06
2134a0	-0.71	-
94d1f2	-0.65	-0.44
66161a	-0.56	-0.72
71d584	-0.43	-
9f866f	-0.38	-
74dcfd	-0.22	-0.57
d3d8f0	-0.2	-
f872cf	-0.16	-
a61557	-0.16	-0.06
cb382a	-0.09	-0.09
470e81	-0.09	-0.09
d1f1e8	-0.03	-
b5ccd7	0.04	-
889292	0.04	0.12
ee2b41	0.08	0.13
17ac3d	0.11	0.15
b174bb	0.15	-
d66e98	0.18	0.25
992896	0.2	-
02a747	0.37	0.97
06c821	0.4	1.4
2e1f69	0.46	0.46
c3db5a	0.51	0.57
25bec1	0.58	0.42
64e370	0.75	0.64
e9bb88	0.75	0.62
c62844	0.82	-
51f494	0.93	0.17
e6265b	0.97	1.72
f5891b	1.53	3.63
efa406	1.55	-
72b3f2	1.77	2.6
dbeae5	1.85	5.6
056d76	2.47	-

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 [%]
597a29	2270	2250	2280	2.0	2267	15.3	0.67
d3d8f0	2270	2270	2270	-	2270	0.0	0.0
d1f1e8	2270	2270	2270	-	2270	0.0	0.0
51f494	2280	2253	2287	30.0	2273	18.0	0.79
f5891b	2270	2280	2270	44.0	2273	5.8	0.25
17ac3d	2280	2280	2260	60.0	2273	11.5	0.51
b174bb	2290	2270	2270	-	2277	11.5	0.51
c62844	2280	2270	2280	-	2277	5.8	0.25
a61557	2268	2285	2285	30.0	2279	9.8	0.43
72f0ed	2270	2290	2280	25.0	2280	10.0	0.44
a80858	2270	2270	2300	-	2280	17.3	0.76
71d584	2270	2270	2300	-	2280	17.3	0.76
71c95d	2280	2280	2280	32.0	2280	0.0	0.0
f872cf	2300	2280	2270	-	2283	15.3	0.67
cb382a	2280	2290	2280	11.0	2283	5.8	0.25
64e370	2280	2300	2280	44.0	2287	11.5	0.5
dd1c39	2280	2280	2300	12.0	2287	11.5	0.5
25bec1	2280	2300	2280	40.0	2287	11.5	0.5
d66e98	2290	2280	2290	32.0	2287	5.8	0.25
74dcfd	2300	2290	2280	10.0	2290	10.0	0.44
94d1f2	2280	2280	2310	12.0	2290	17.3	0.76
15c6ef	2280	2290	2300	40.0	2290	10.0	0.44
e7a3e3	2293	2291	2294	10.0	2293	1.5	0.07
e9bb88	2310	2300	2270	16.0	2293	20.8	0.91
dbeae5	2290	2300	2290	10.0	2293	5.8	0.25
06c821	2310	2290	2280	20.0	2293	15.3	0.67
9bdcd5	2280	2300	2300	21.0	2293	11.5	0.5
056d76	2300	2290	2300	-	2297	5.8	0.25
2134a0	2288	2301	2304	-	2298	8.5	0.37
9f866f	2310	2300	2300	-	2303	5.8	0.25
72b3f2	2300	2310	2300	0.0	2303	5.8	0.25
4828a6	2310	2300	2300	30.0	2303	5.8	0.25
c3db5a	2310	2290	2310	20.0	2303	11.5	0.5
992896	2310	2290	2310	-	2303	11.5	0.5
e6265b	2317	2306	2296	13.0	2306	10.5	0.46
acf631	2310	2310	2300	80.0	2307	5.8	0.25
02a747	2310	2310	2310	10.0	2310	0.0	0.0
b5ccd7	2320	2290	2330	-	2313	20.8	0.9
66161a	2319	2305	2330	32.0	2318	12.5	0.54
efa406	2320	2350	2290	-	2320	30.0	1.29
470e81	2310	2350	2320	20.0	2327	20.8	0.89
1887c9	2297	2356	2384	5.0	2346	44.4	1.89

2.2 The Numerical Procedure for Determining Outliers

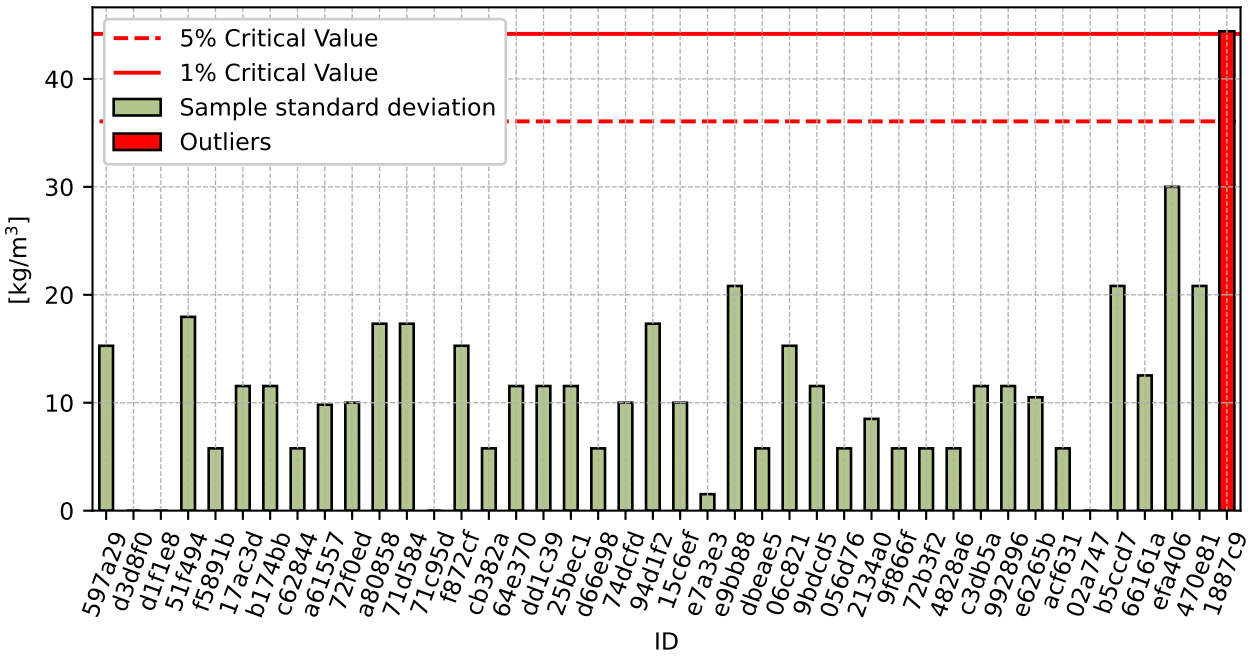

Figure 12: **Cochran's test** - sample standard deviations

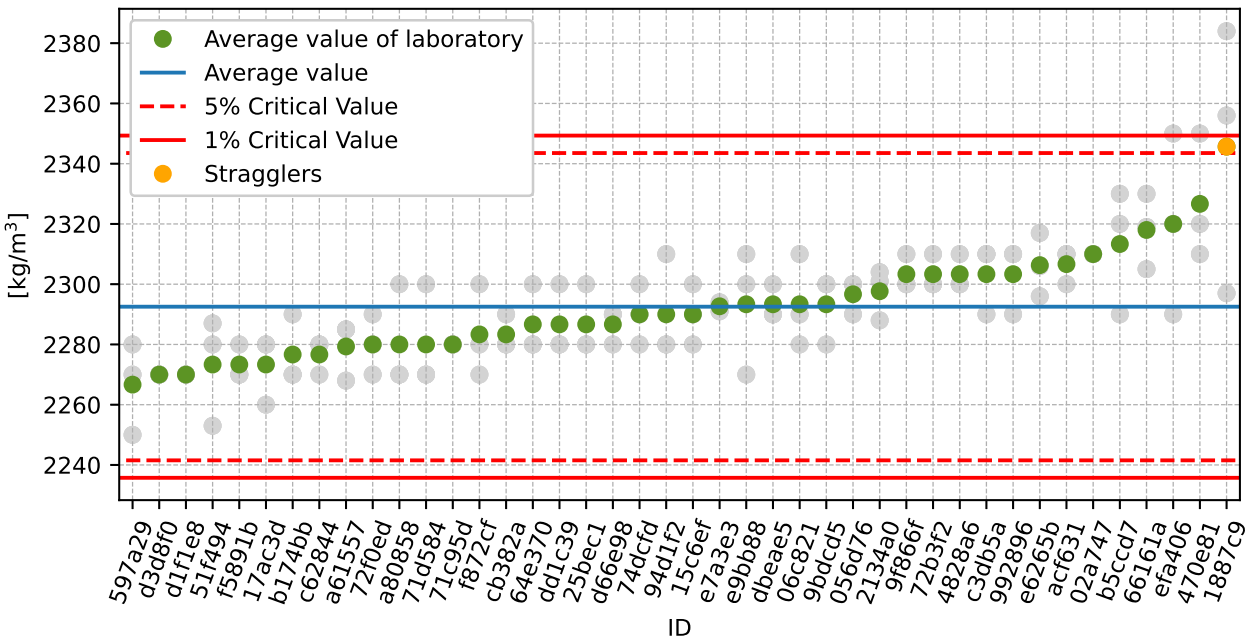

Figure 13: **Grubbs' test** - average values

2.3 Mandel's Statistics

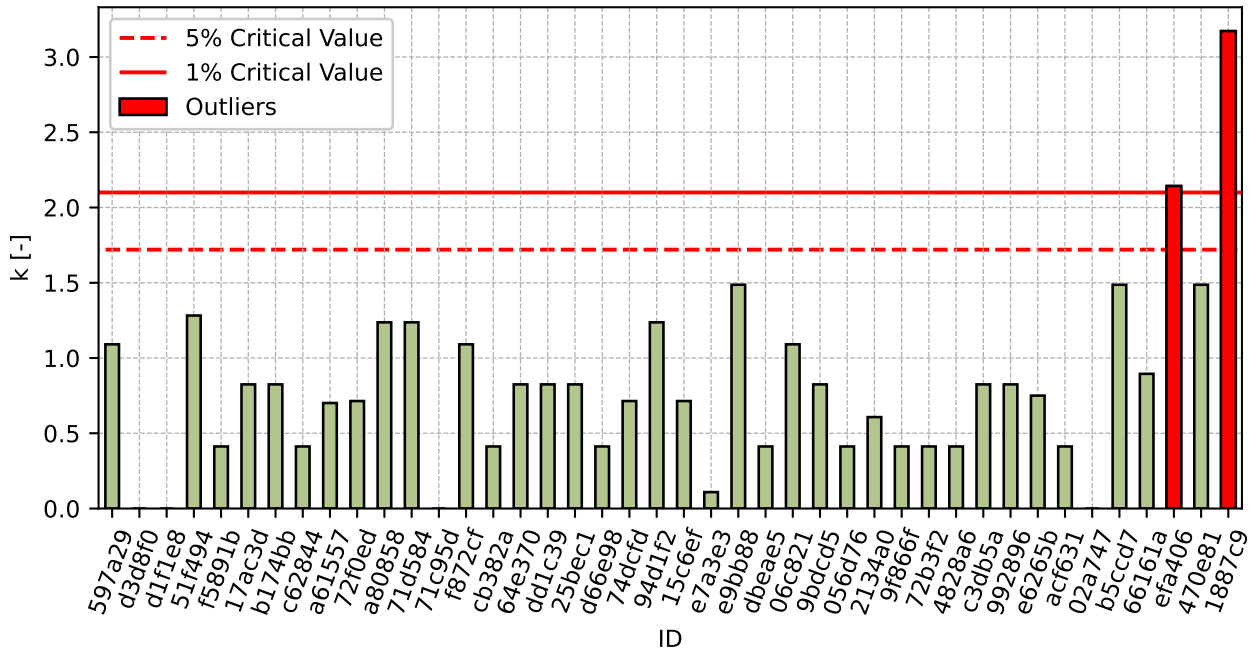

Figure 14: Intralaboratory Consistency Statistic

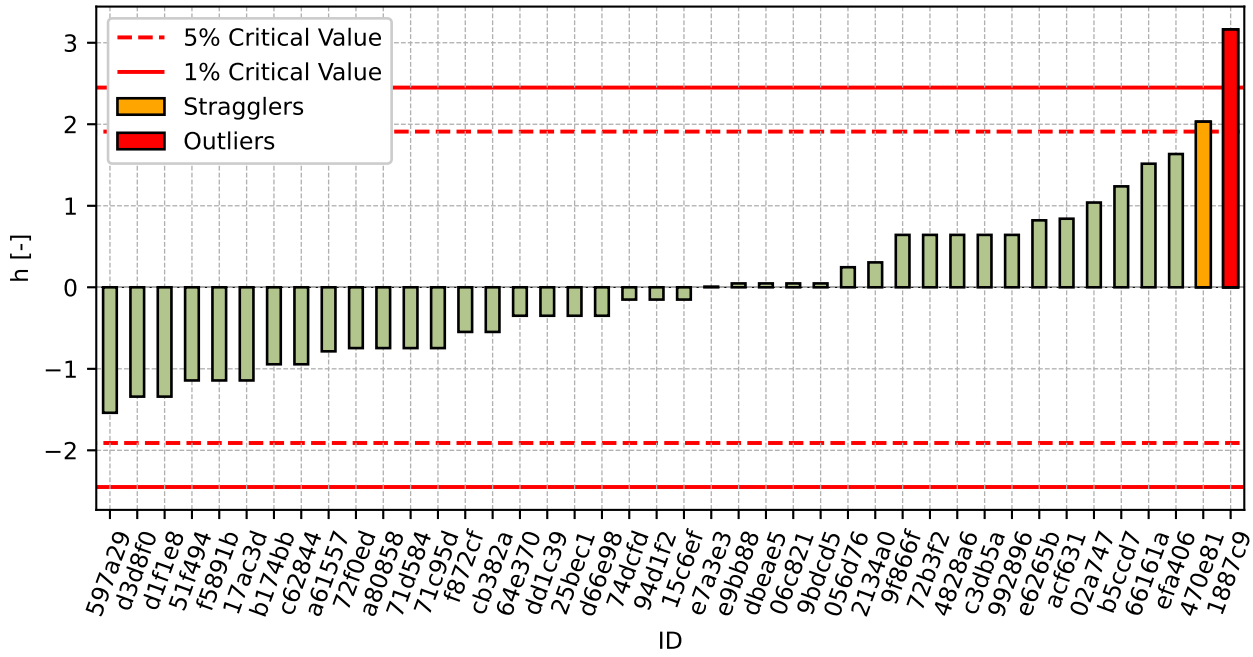

Figure 15: Interlaboratory Consistency Statistic

2.4 Descriptive statistics

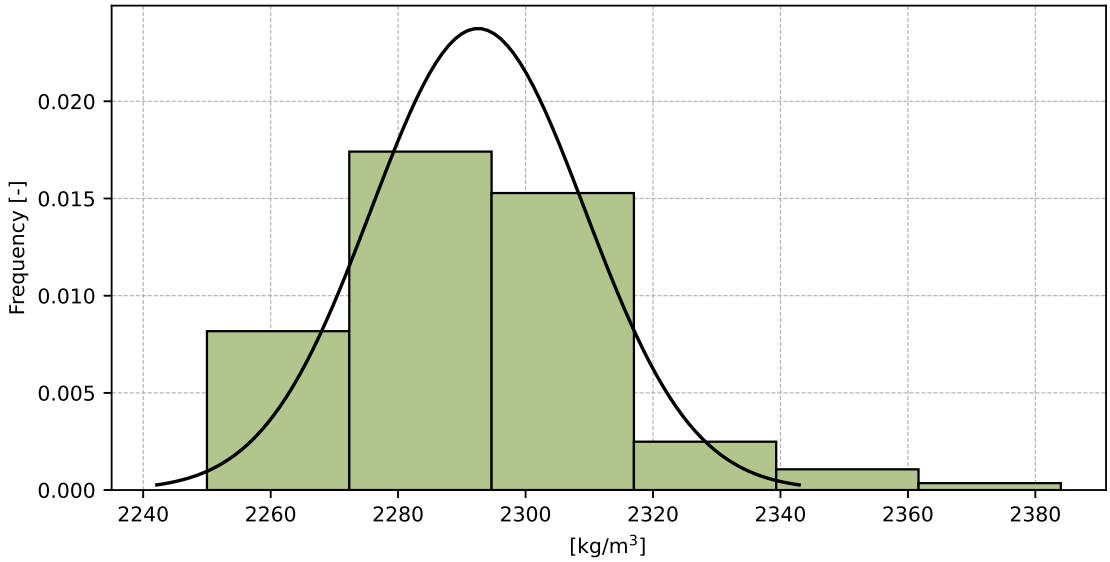

Figure 16: Histogram of all test results

Table 8: Descriptive statistics

Characteristics	[kg/m³]
Average value – $\bar{x}$	2293.0
Sample standard deviation – s	16.8
Asigned value – x^*	2292.0
Robust standard deviation – s^*	18.1
Measurement uncertainty of asigned value – u_X	3.5
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	14.7
Repeatability standard deviation – s_r	14.0
Reproducibility standard deviation – s_R	20.3
Repeatability – r	39.0
Reproducibility – R	57.0

2.5 Evaluation of Performance Statistics

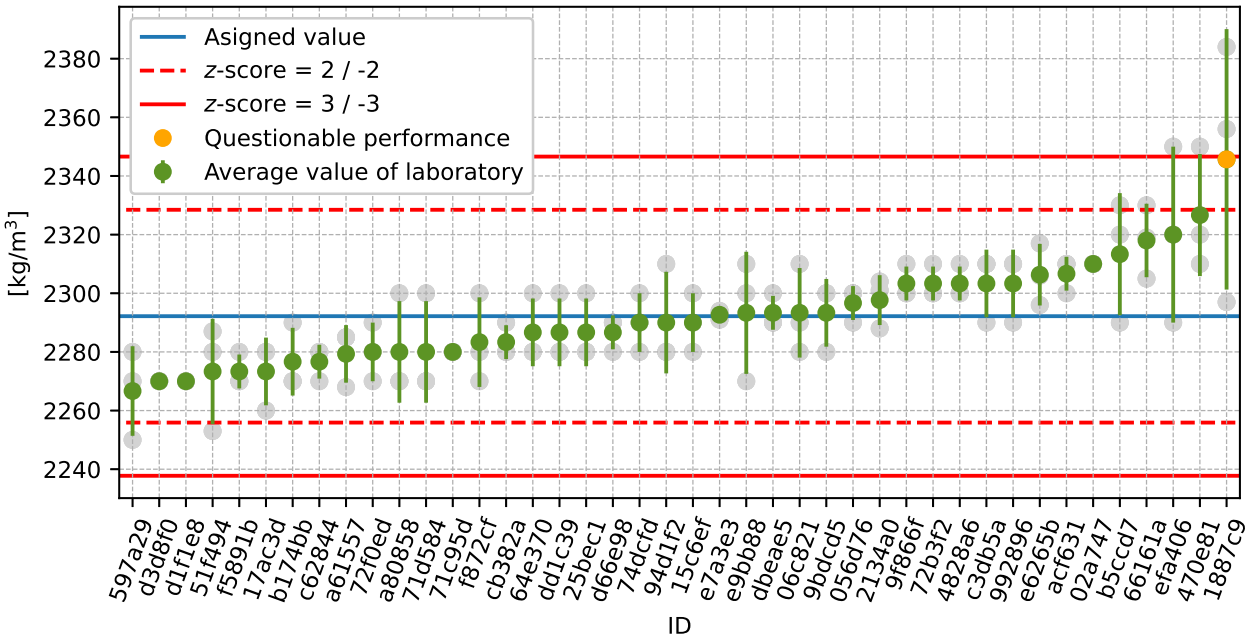

Figure 17: Average values and sample standard deviations

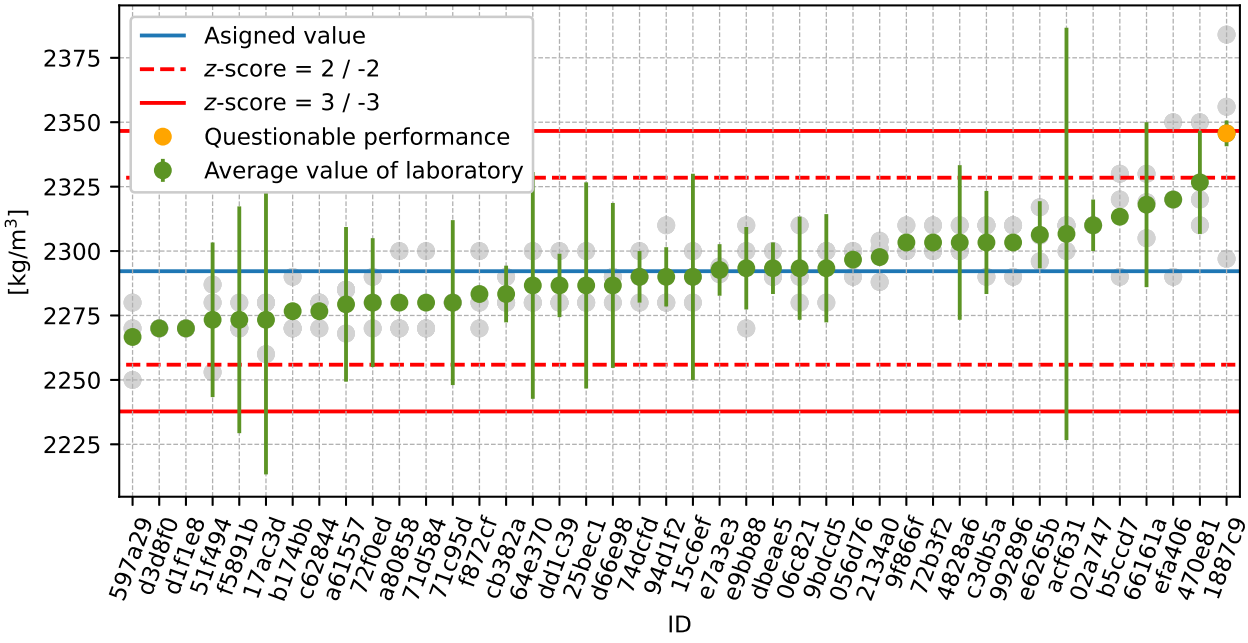

Figure 18: Average values and extended uncertainties of measurement

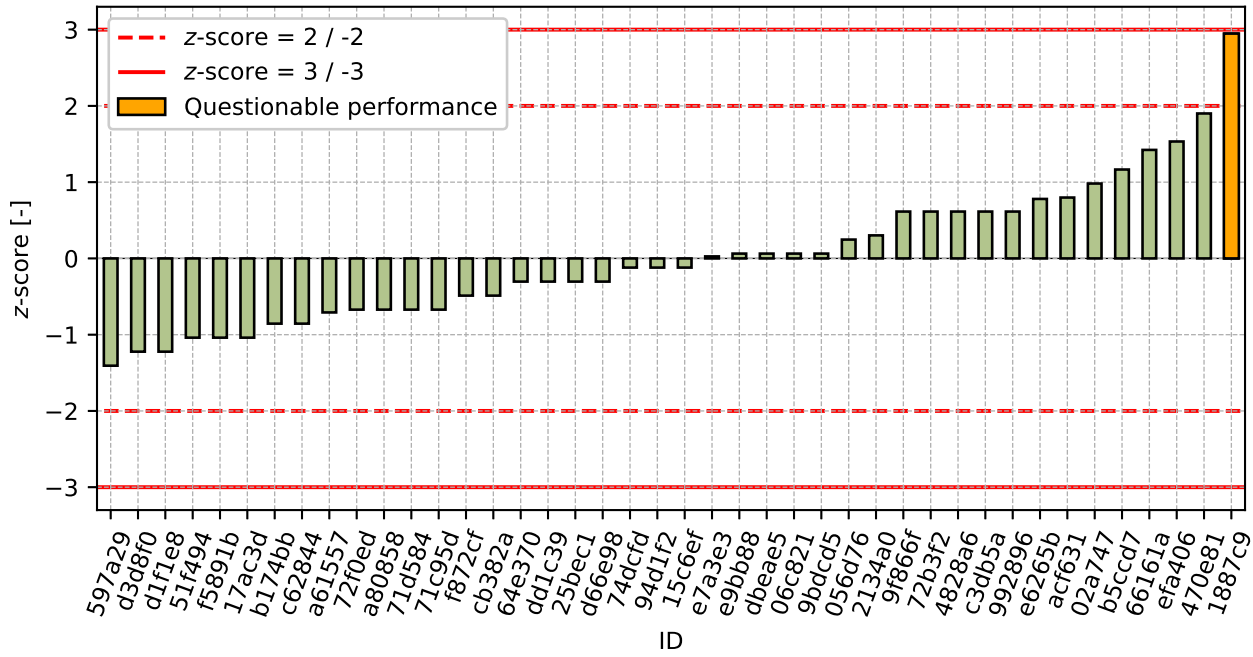

Figure 19: z-score

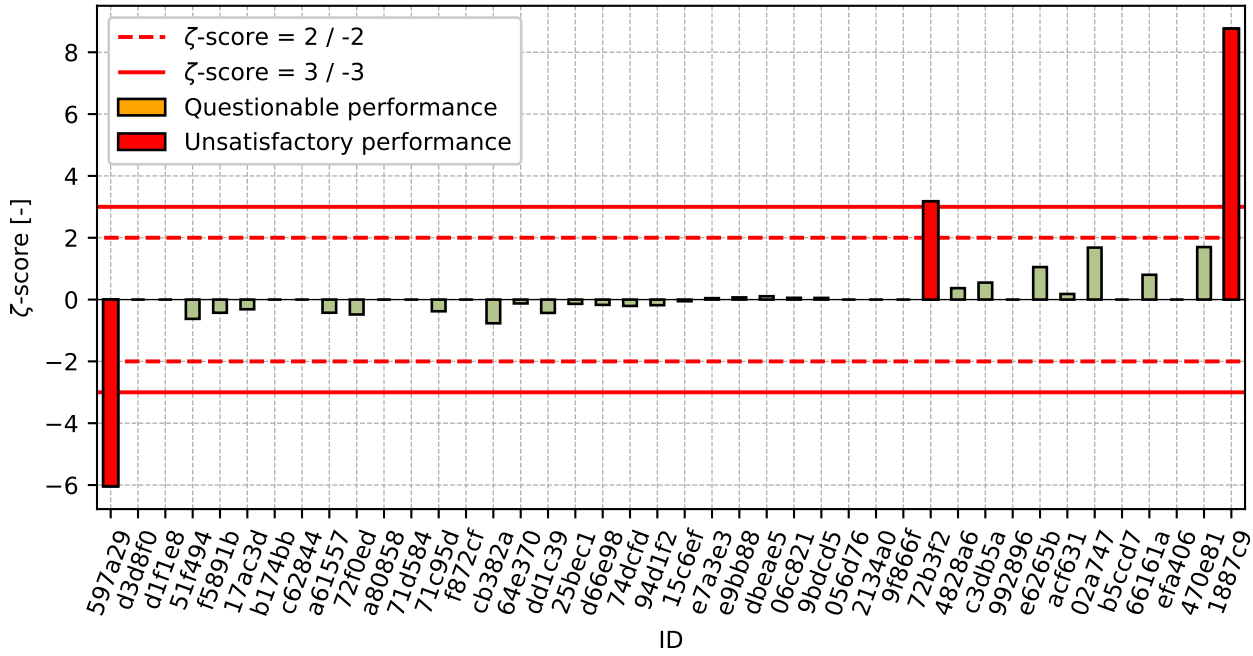

Figure 20: ζ-score

Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
597a29	-1.41	-6.04
d3d8f0	-1.22	-
d1f1e8	-1.22	-
51f494	-1.04	-0.62
f5891b	-1.04	-0.43
17ac3d	-1.04	-0.31
b174bb	-0.86	-
c62844	-0.86	-
a61557	-0.71	-0.43
72f0ed	-0.67	-0.48
a80858	-0.67	-
71d584	-0.67	-
71c95d	-0.67	-0.38
f872cf	-0.49	-
cb382a	-0.49	-0.77
64e370	-0.3	-0.13
dd1c39	-0.3	-0.43
25bec1	-0.3	-0.14
d66e98	-0.3	-0.17
74dcfd	-0.12	-0.21
94d1f2	-0.12	-0.18
15c6ef	-0.12	-0.05
e7a3e3	0.03	0.05
e9bb88	0.06	0.07
dbeae5	0.06	0.11
06c821	0.06	0.06
9bdcd5	0.06	0.05
056d76	0.25	-
2134a0	0.3	-
9f866f	0.61	-
72b3f2	0.61	3.18
4828a6	0.61	0.37
c3db5a	0.61	0.55
992896	0.61	-
e6265b	0.78	1.05
acf631	0.8	0.18
02a747	0.98	1.68
b5ccd7	1.17	-
66161a	1.42	0.8
efa406	1.53	-
470e81	1.9	1.7
1887c9	2.95	8.76

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 [%]
1887c9	1	2	1	0.0	1	0.2	14.19
9bdcd5	9	10	8	3.0	9	1.0	11.11
d66e98	8	12	9	1.0	10	2.1	21.53
64e370	10	9	12	4.0	10	1.5	14.78
1fc047	8	12	13	5.0	11	2.6	24.05
0af3ee	12	10	12	1.0	11	1.2	10.19
9546fe	14	9	12	3.0	12	2.5	21.57
25bec1	11	9	15	2.0	12	3.1	26.19
02a747	10	13	12	2.0	12	1.5	13.09
71c95d	14	10	11	1.0	12	2.1	17.84
2e1f69	11	12	12	2.0	12	0.6	4.95
15c6ef	13	13	10	2.0	12	1.7	14.43
cb382a	11	14	12	1.0	12	1.5	12.39
0df26d	14	13	13	2.0	13	0.6	4.33
3e1f2d	13	16	11	3.0	13	2.5	18.87
74dcfd	15	12	13	2.0	13	1.5	11.46
71d584	17	14	10	-	14	3.5	25.7
d3d8f0	17	10	15	-	14	3.6	25.75
c3db5a	12	13	17	3.0	14	2.6	18.9
e6265b	14	14	14	1.0	14	0.0	0.0
f4c29a	15	13	15	0.0	14	1.2	8.06
470e81	17	15	11	3.0	14	3.1	21.31
acf631	12	18	14	3.0	15	3.1	20.83
2134a0	12	10	24	-	15	7.6	49.38
53893f	16	18	14	2.0	16	2.0	12.5
de56a7	17	15	17	1.0	16	1.2	7.07
d1f1e8	16	12	22	-	17	5.0	30.2
ed56ac	15	18	18	6.0	17	1.7	10.19
597a29	20	15	17	1.0	17	2.5	14.52
00d359	22	16	17	2.0	18	3.2	17.53
b68435	18	16	22	22.0	19	3.1	16.37
f5891b	22	23	20	2.0	22	1.5	7.05
056d76	17	24	31	-	24	7.0	29.17
ac4800	27	34	32	4.0	31	3.6	11.63

3.2 The Numerical Procedure for Determining Outliers

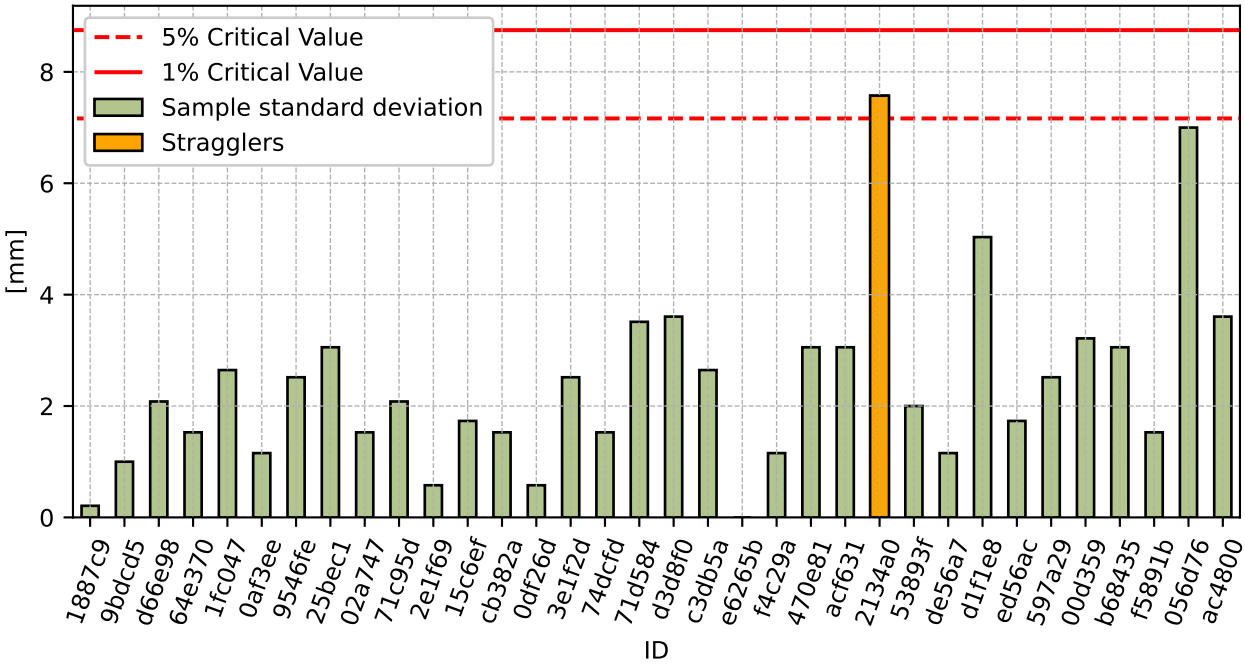

Figure 21: **Cochran's test** - sample standard deviations

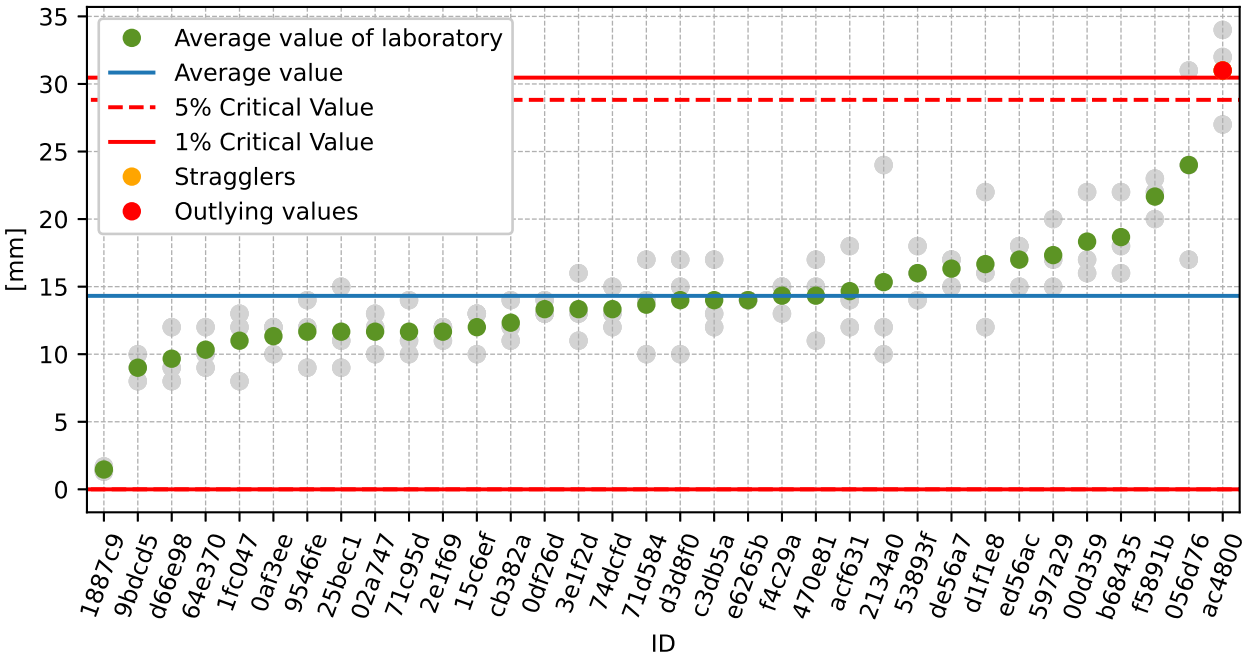

Figure 22: **Grubbs' test** - average values

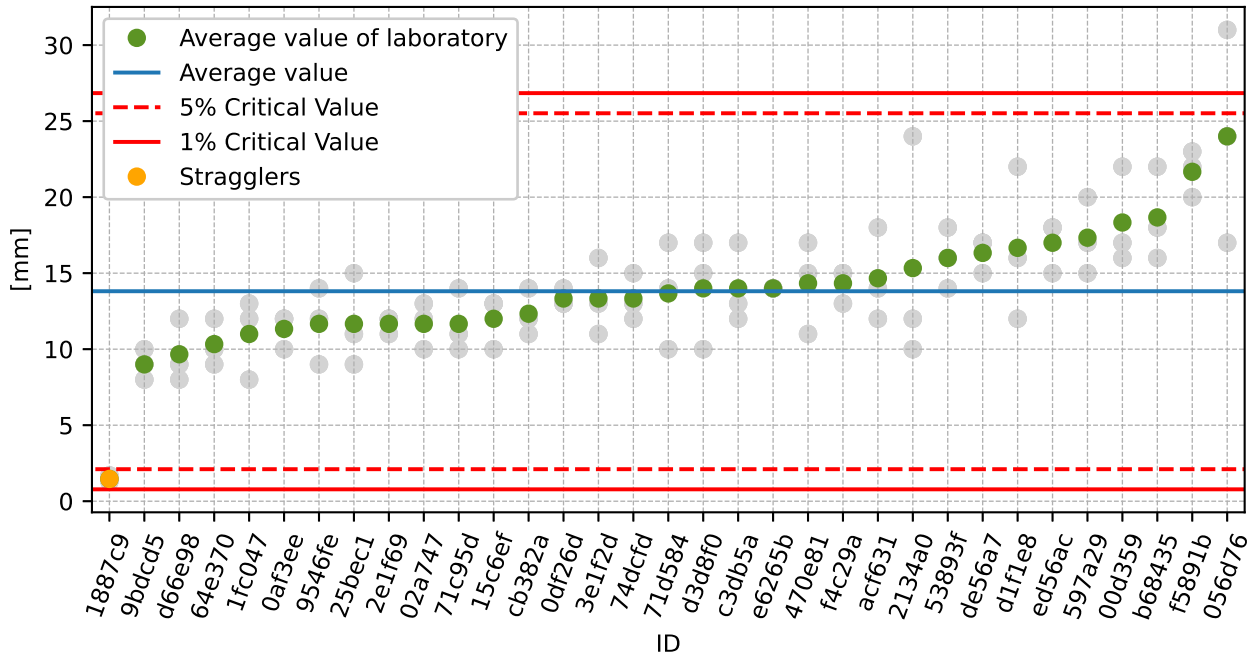

Figure 23: **Grubbs' test** - average values without outliers

3.3 Mandel's Statistics

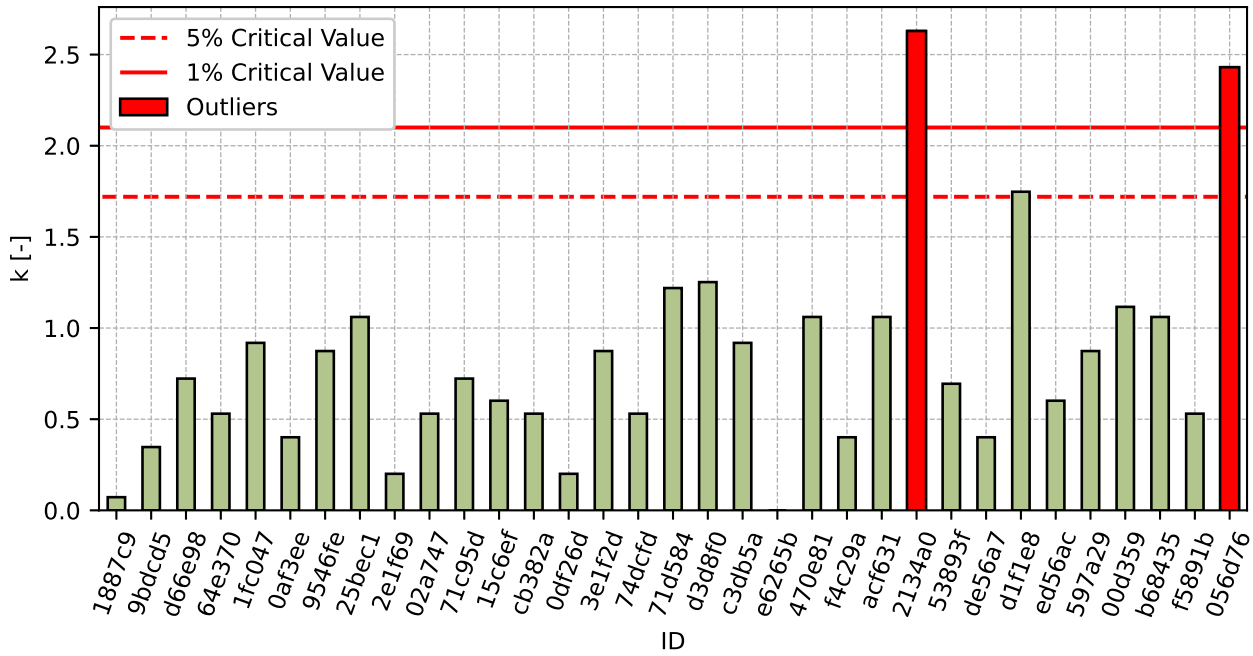

Figure 24: Intralaboratory Consistency Statistic

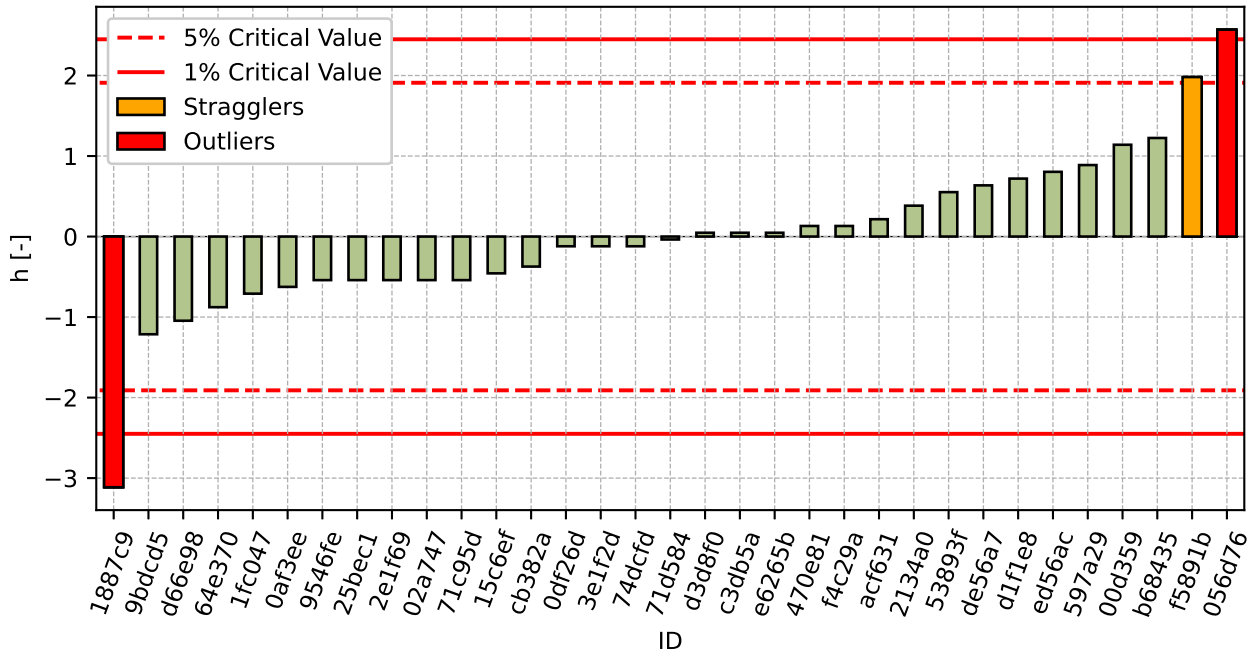

Figure 25: Interlaboratory Consistency Statistic

3.4 Descriptive statistics

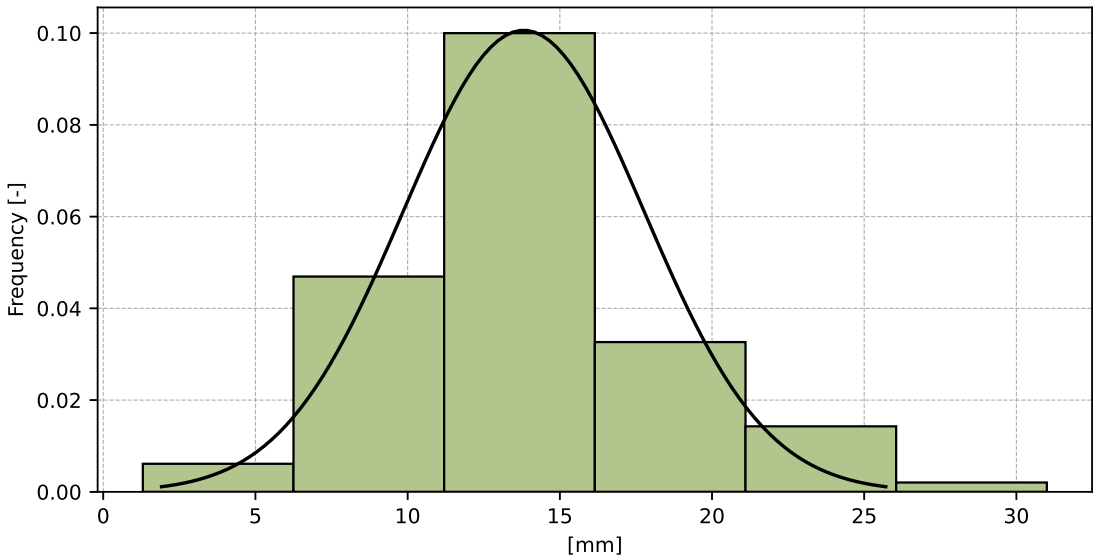

Figure 26: Histogram of all test results

Table 11: Descriptive statistics

Characteristics	[mm]
Average value – $\bar{x}$	14.0
Sample standard deviation – s	4.0
Asigned value – x^*	14.0
Robust standard deviation – s^*	3.5
Measurement uncertainty of asigned value – u_X	0.8
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	3.6
Repeatability standard deviation – s_r	2.9
Reproducibility standard deviation – s_R	4.6
Repeatability – r	8.0
Reproducibility – R	13.0

3.5 Evaluation of Performance Statistics

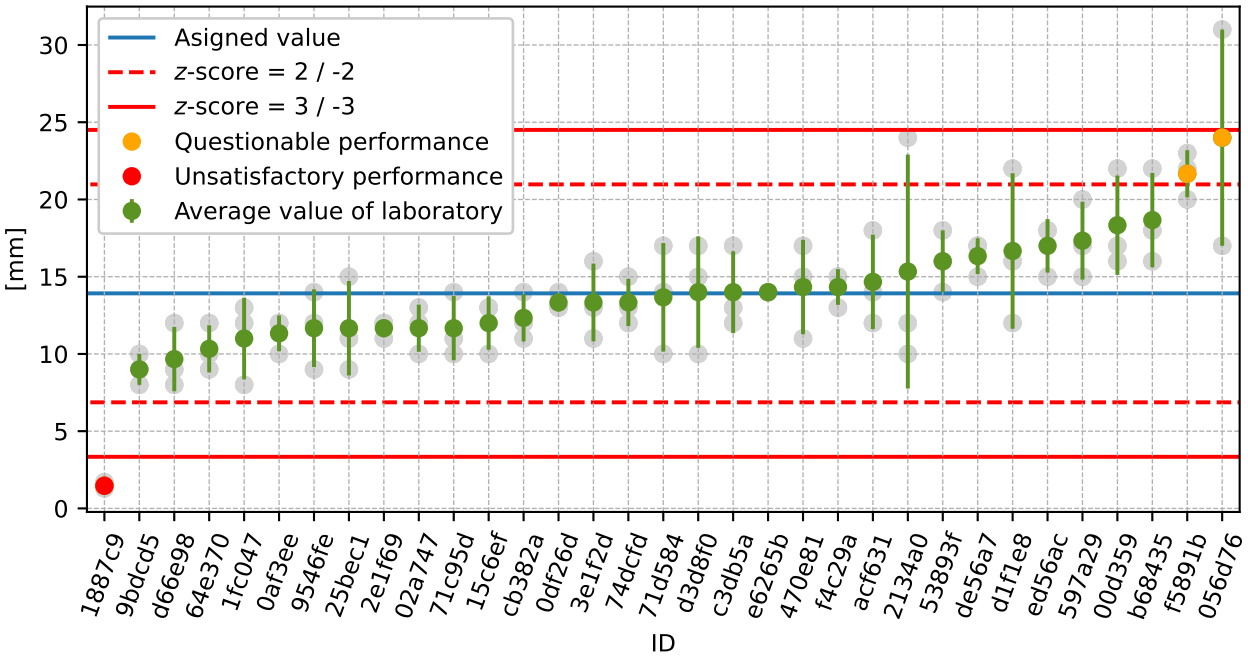

Figure 27: Average values and sample standard deviations

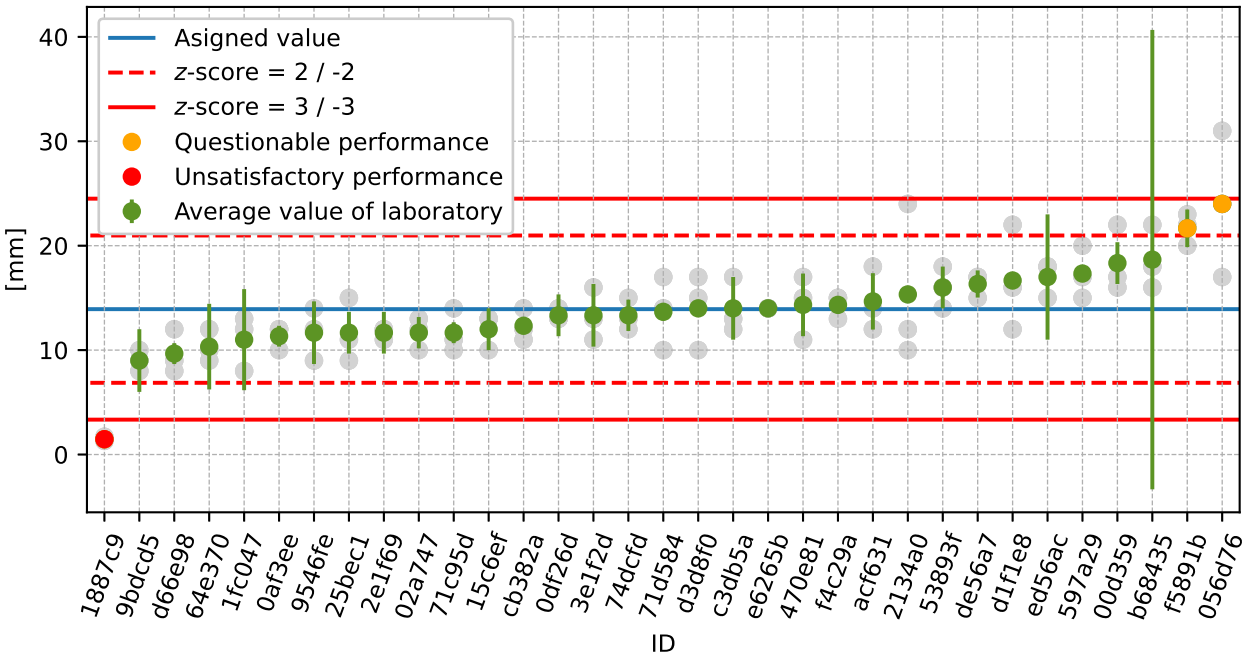

Figure 28: Average values and extended uncertainties of measurement

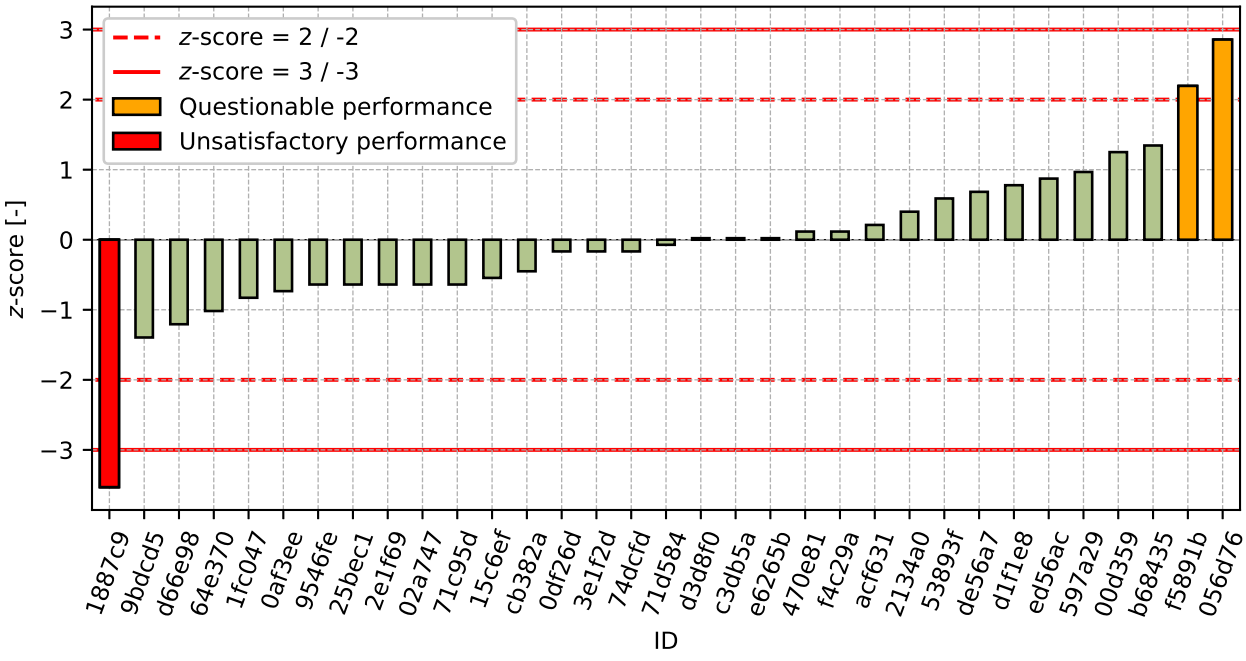

Figure 29: z-score

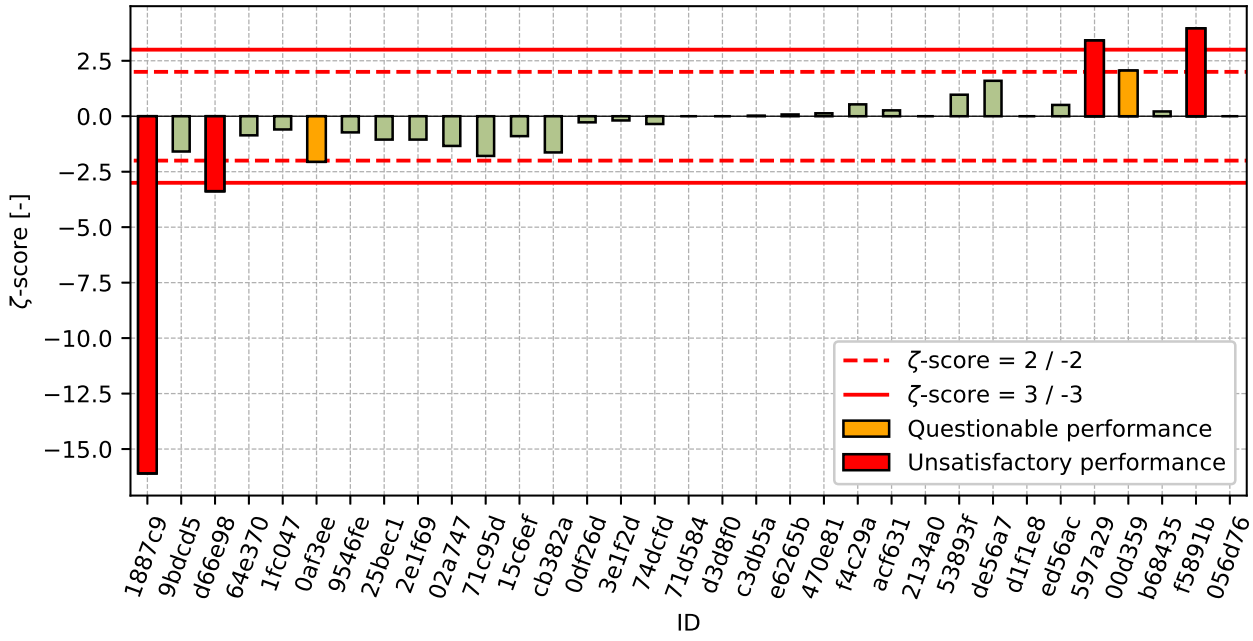

Figure 30: ζ-score

Table 12: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
1887c9	-3.53	-16.09
9bdcd5	-1.4	-1.59
d66e98	-1.21	-3.38
64e370	-1.02	-0.86
1fc047	-0.83	-0.6
0af3ee	-0.73	-2.05
9546fe	-0.64	-0.73
25bec1	-0.64	-1.05
2e1f69	-0.64	-1.05
02a747	-0.64	-1.34
71c95d	-0.64	-1.79
15c6ef	-0.55	-0.9
cb382a	-0.45	-1.63
0df26d	-0.17	-0.28
3e1f2d	-0.17	-0.19
74dcfd	-0.17	-0.35
71d584	-0.07	-
d3d8f0	0.02	-
c3db5a	0.02	0.02
e6265b	0.02	0.08
470e81	0.12	0.13
f4c29a	0.12	0.53
acf631	0.21	0.27
2134a0	0.4	-
53893f	0.59	0.97
de56a7	0.68	1.6
d1f1e8	0.78	-
ed56ac	0.87	0.51
597a29	0.97	3.41
00d359	1.25	2.06
b68435	1.34	0.22
f5891b	2.2	3.96
056d76	2.86	-

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

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

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

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

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 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 [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
ae4568	30	24	23	15	26	3.9	15.17
7c965c	22	31	40	2	31	8.8	28.29
c3db5a	50	40	60	10	50	10.0	20.0
4828a6	67	71	39	4	59	17.4	29.55
dd1c39	53	85	47	2	62	20.5	33.23
d1f1e8	27	85	88	-	67	34.4	51.58
15c6ef	95	51	91	-	79	24.3	30.8
00d359	82	112	91	21	95	15.6	16.39
470e81	70	200	200	20	157	75.1	47.91
ce5dd4	129	187	172	17	163	30.0	18.4
0df26d	167	219	187	17	191	26.2	13.71
71d584	266	203	140	-	203	62.8	30.91
e9bb88	310	337	451	22	366	74.9	20.45

7.1.2 The Numerical Procedure for Determining Outliers

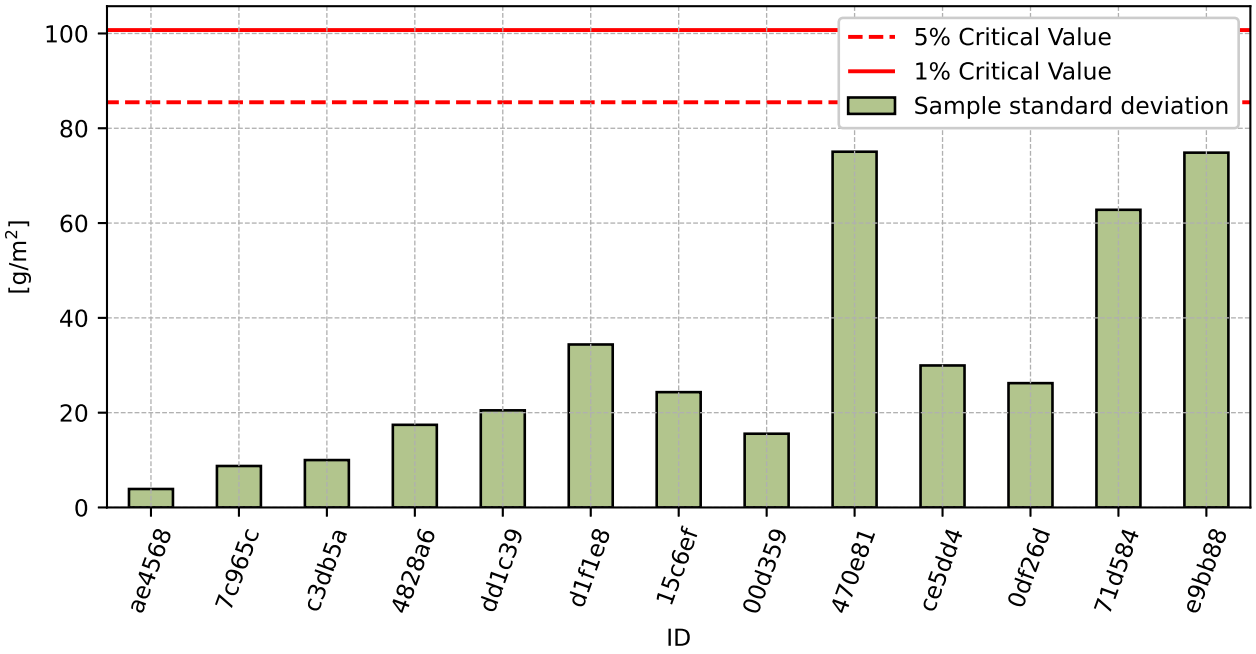

Figure 31: **Cochran's test** - sample standard deviations

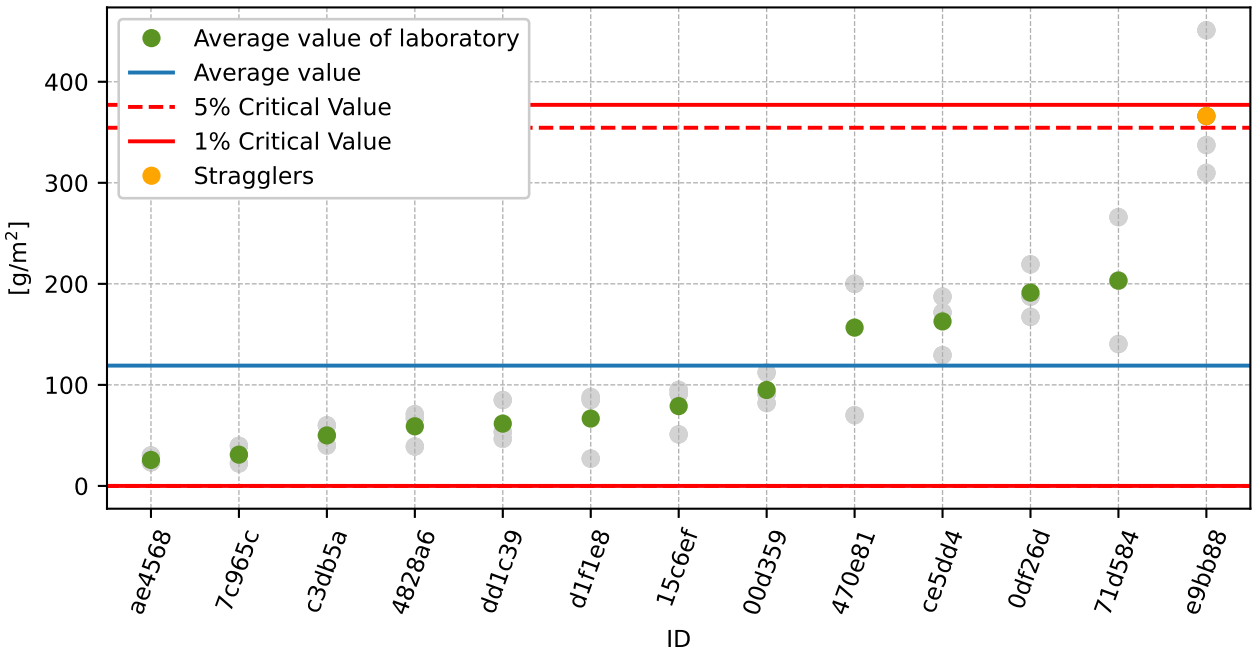

Figure 32: **Grubbs' test** - average values

7.1.3 Mandel's Statistics

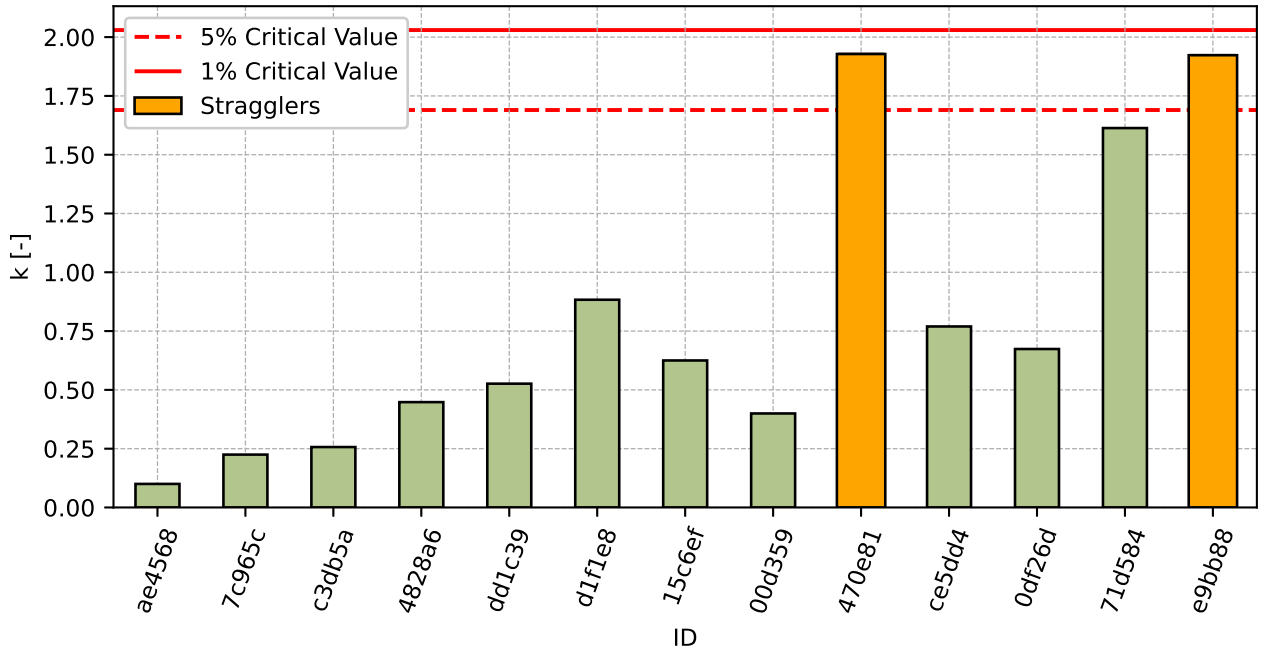

Figure 33: Intralaboratory Consistency Statistic

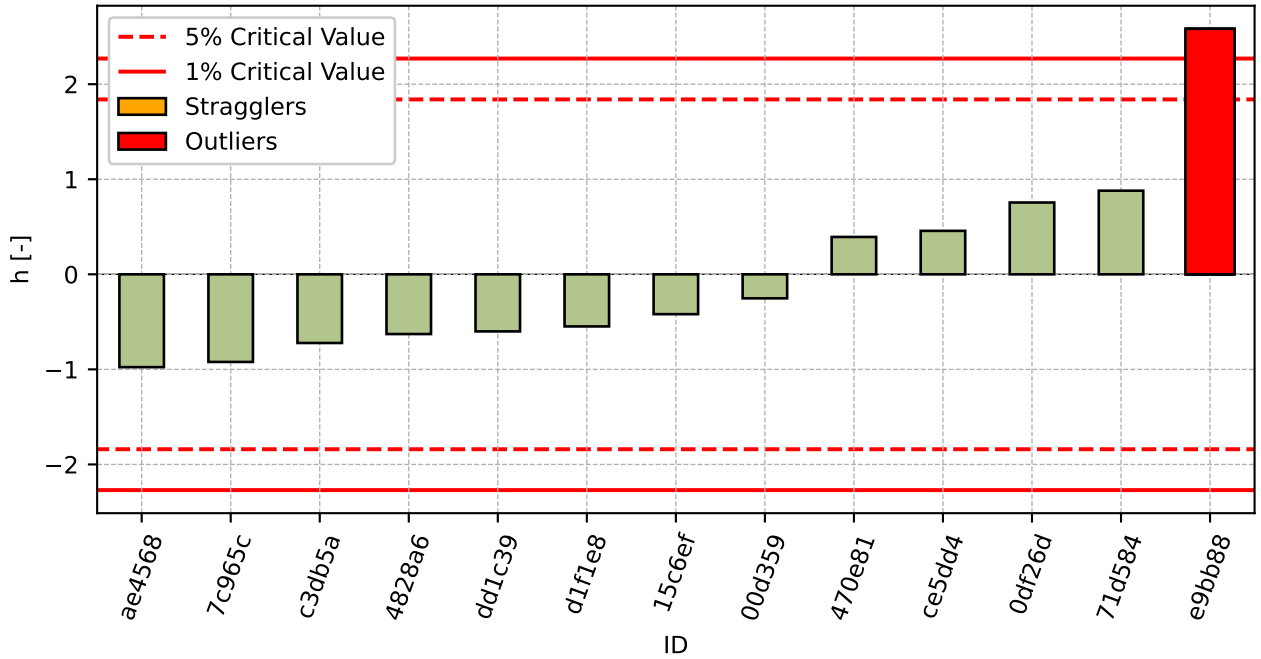

Figure 34: Interlaboratory Consistency Statistic

7.1.4 Descriptive statistics

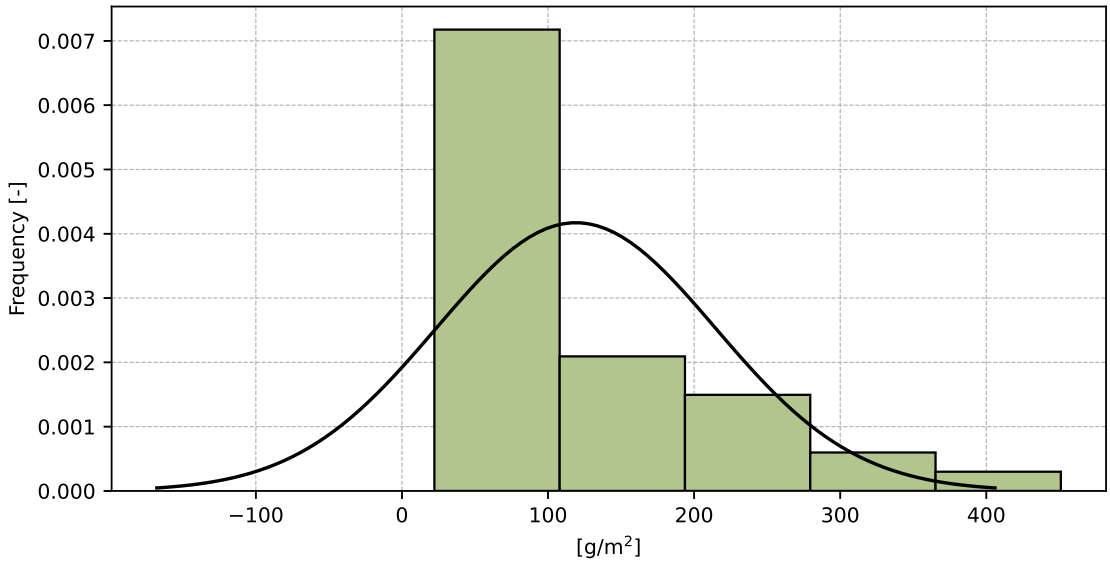

Figure 35: Histogram of all test results

Table 14: Descriptive statistics

Characteristics	**[g/m²]**
Average value – $\bar{x}$	119.0
Sample standard deviation – s	95.6
Asigned value – x^*	117.0
Robust standard deviation – s^*	102.5
Measurement uncertainty of asigned value – u_X	35.6
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	92.9
Repeatability standard deviation – s_r	38.9
Reproducibility standard deviation – s_R	100.8
Repeatability – r	109.0
Reproducibility – R	282.0

7.1.5 Evaluation of Performance Statistics

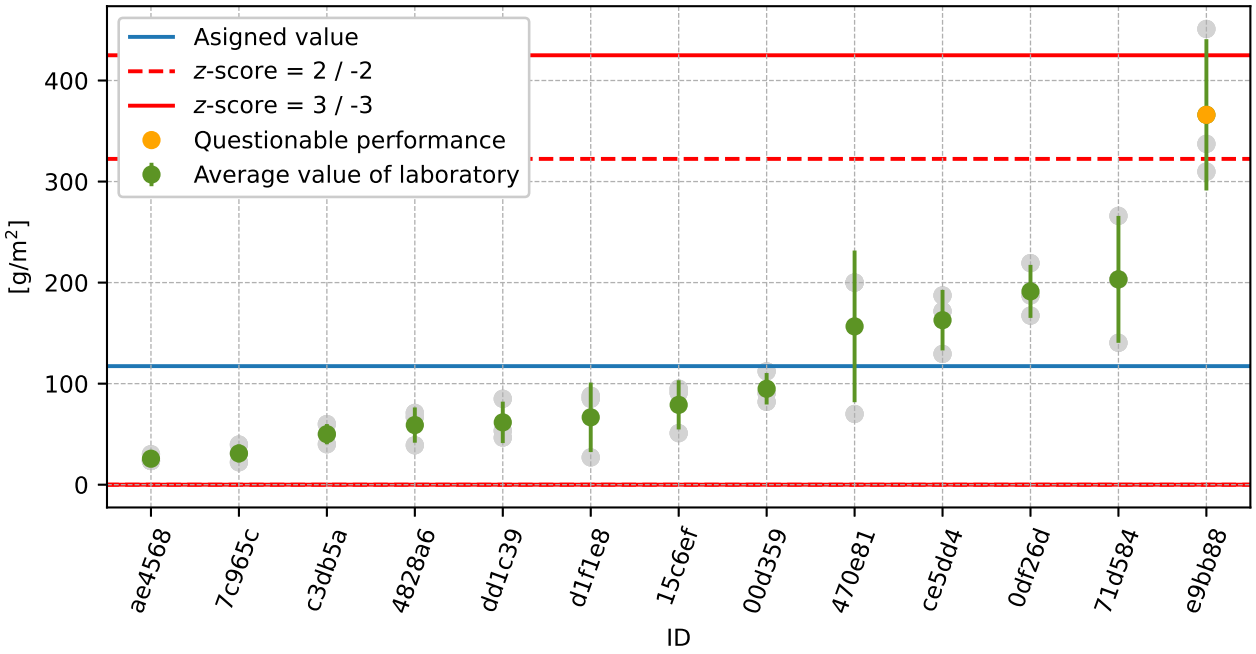

Figure 36: Average values and sample standard deviations

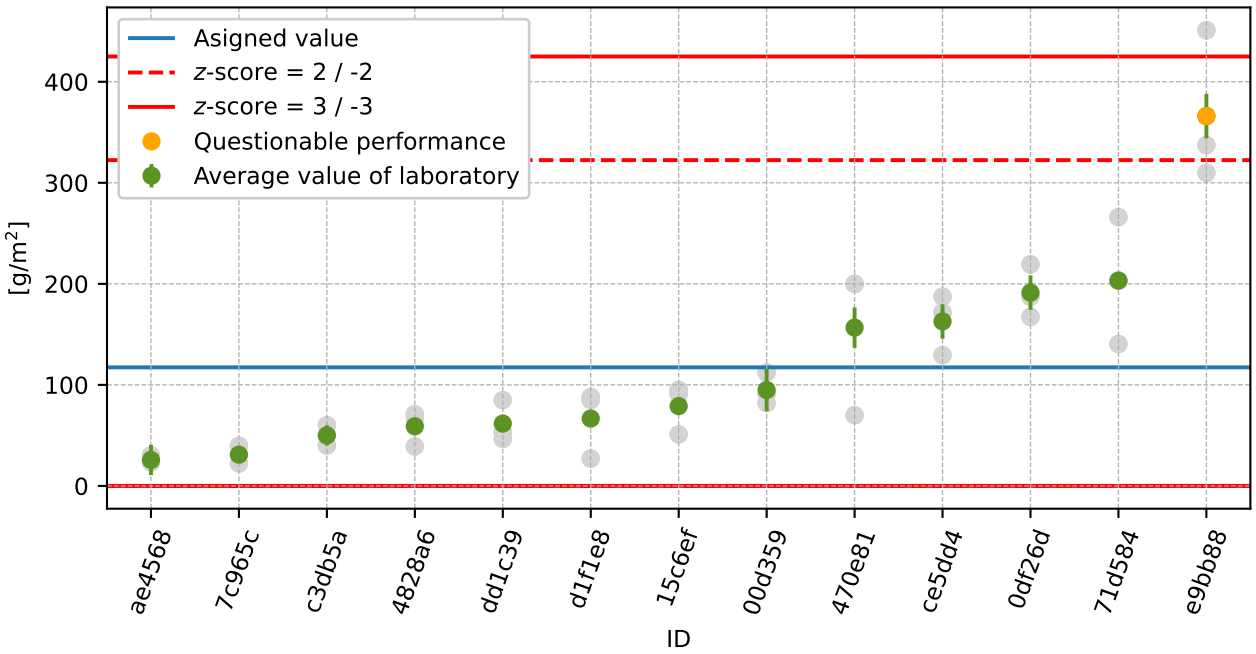

Figure 37: Average values and extended uncertainties of measurement

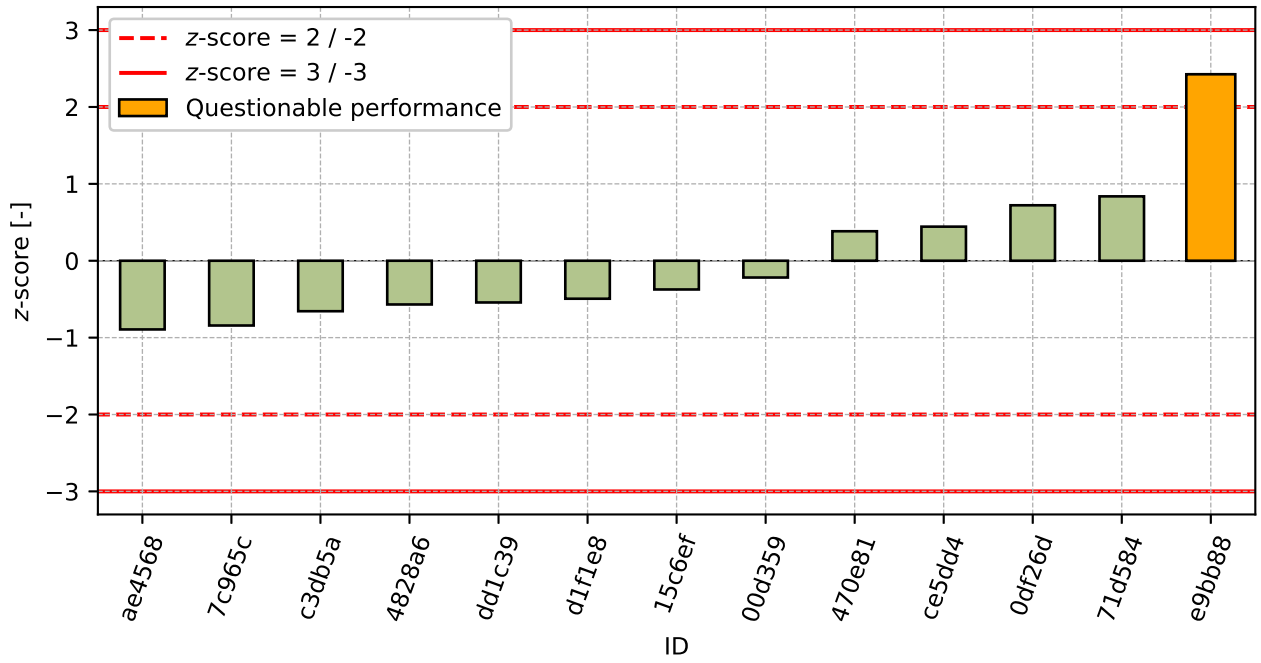

Figure 38: z-score

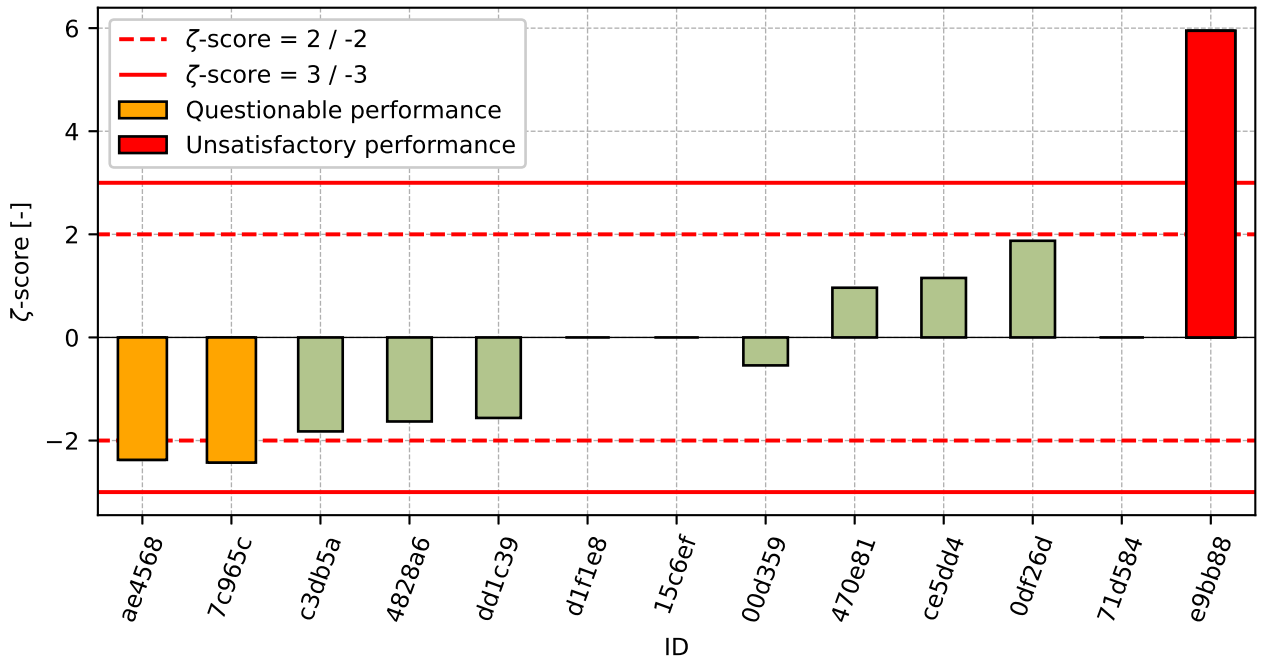

Figure 39: ζ-score

Table 15: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ae4568	-0.89	-2.37
7c965c	-0.84	-2.43
c3db5a	-0.66	-1.82
4828a6	-0.57	-1.63
dd1c39	-0.54	-1.56
d1f1e8	-0.49	-
15c6ef	-0.37	-
00d359	-0.22	-0.54
470e81	0.38	0.96
ce5dd4	0.44	1.15
0df26d	0.72	1.88
71d584	0.84	-
e9bb88	2.43	5.95

7.2 50 cycles

7.2.1 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 [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
dd1c39	179	110	93	5	127	45.5	35.74
4828a6	169	82	281	14	177	99.8	56.26
d1f1e8	165	210	230	-	202	33.3	16.51
7c965c	230	225	269	14	242	23.9	9.91
ae4568	350	224	205	80	260	79.0	30.39
c3db5a	250	250	280	40	260	17.3	6.66
470e81	170	450	230	40	283	147.4	52.03
00d359	241	316	360	68	305	60.1	19.67
ce5dd4	316	346	336	17	333	15.5	4.65
15c6ef	378	347	409	-	378	31.0	8.2
0df26d	451	608	477	52	512	84.4	16.49
71d584	728	614	421	-	588	154.8	26.36
e9bb88	957	1008	1180	63	1048	117.1	11.17

7.2.2 The Numerical Procedure for Determining Outliers

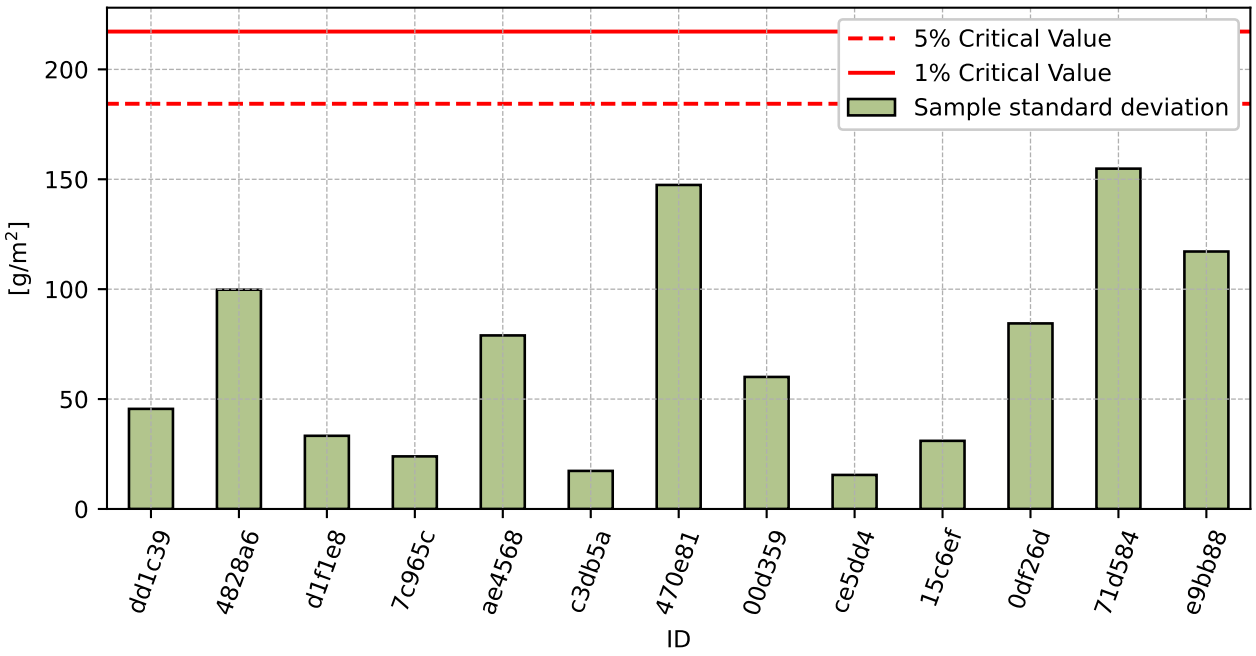

Figure 40: **Cochran's test** - sample standard deviations

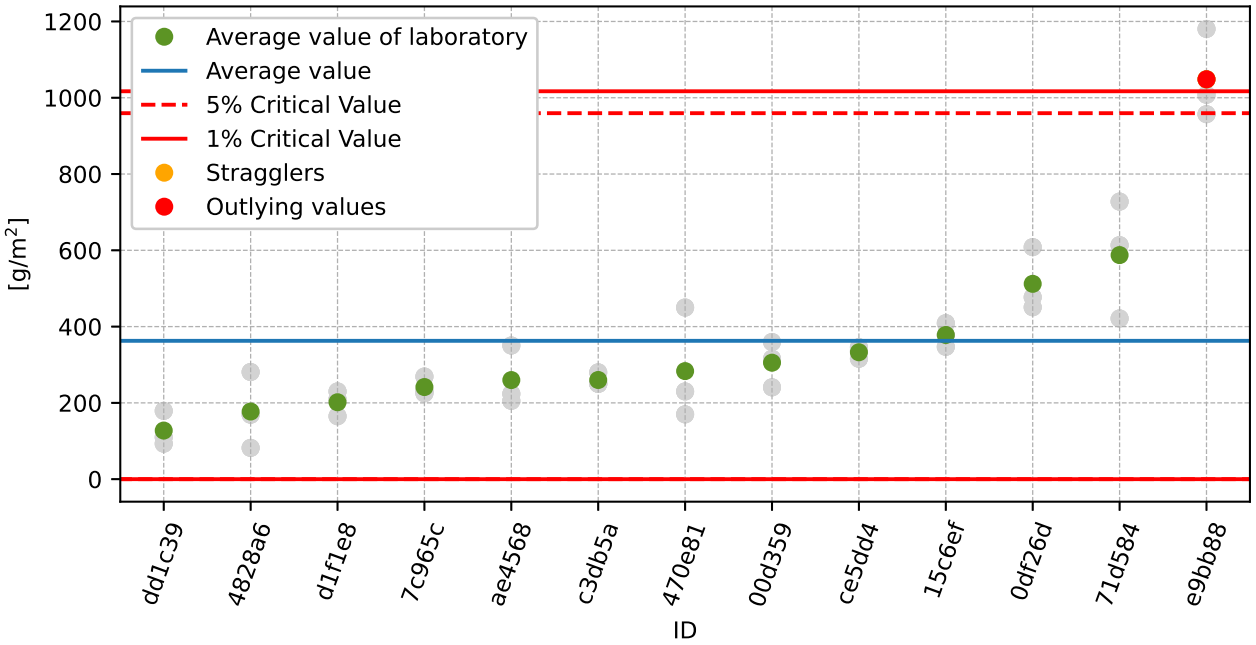

Figure 41: **Grubbs' test** - average values

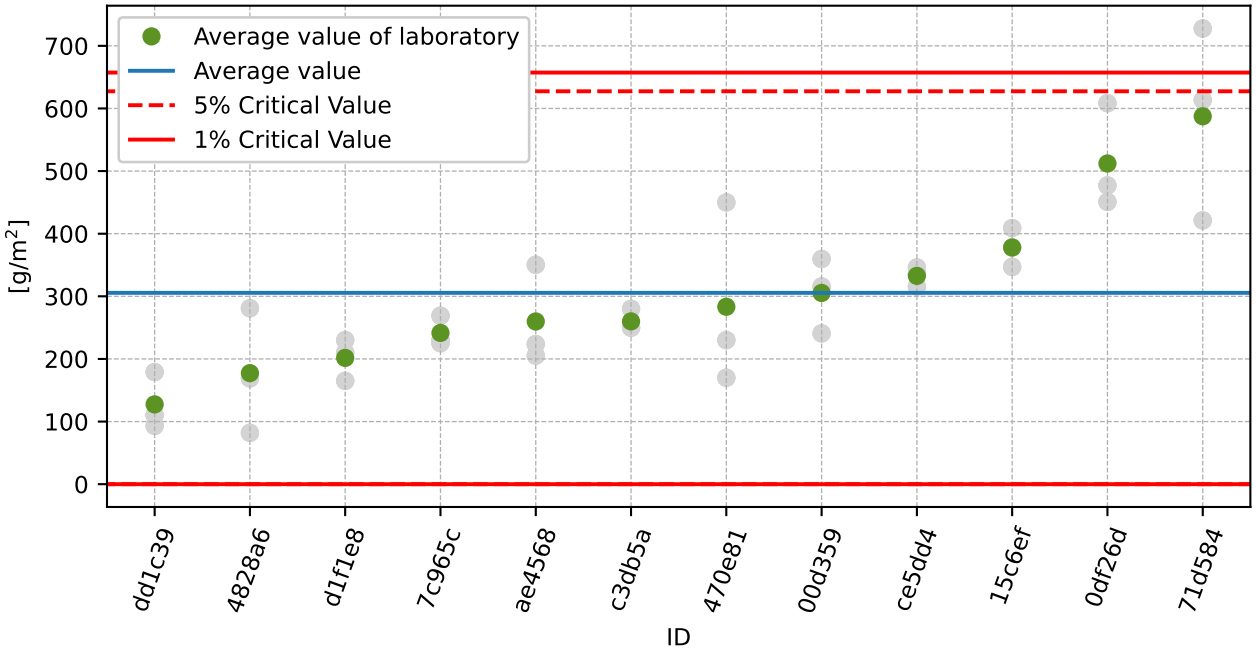

Figure 42: **Grubbs' test** - average values without outliers

7.2.3 Mandel's Statistics

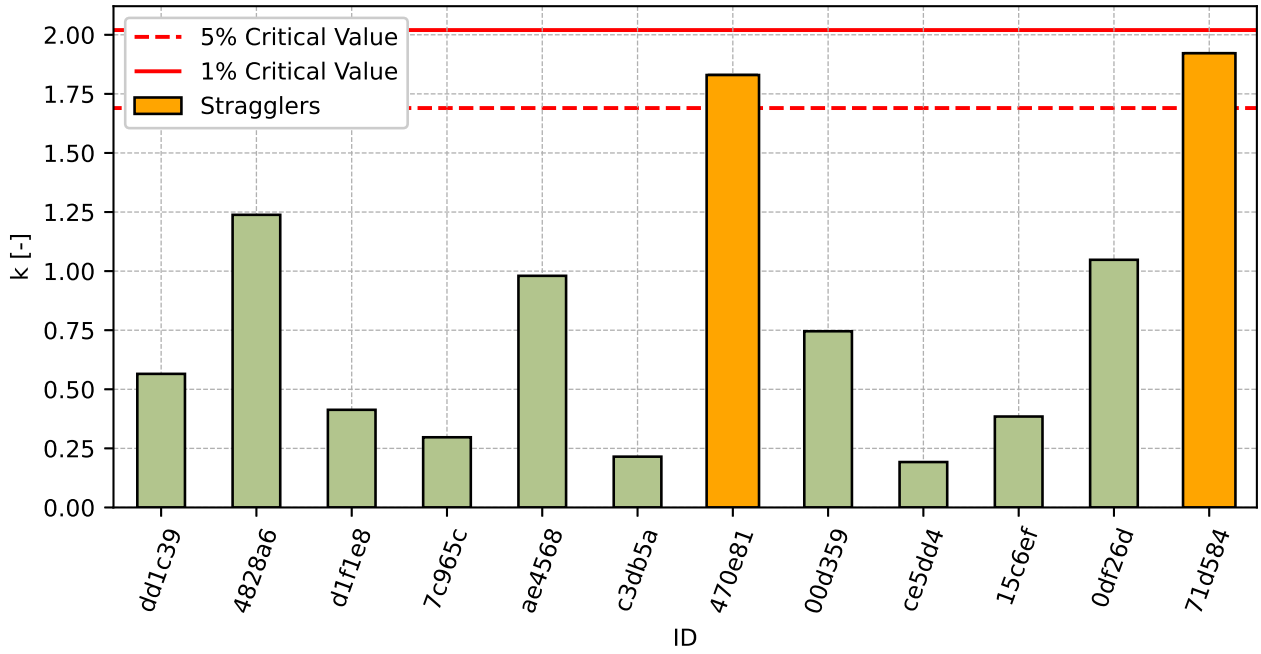

Figure 43: Intralaboratory Consistency Statistic

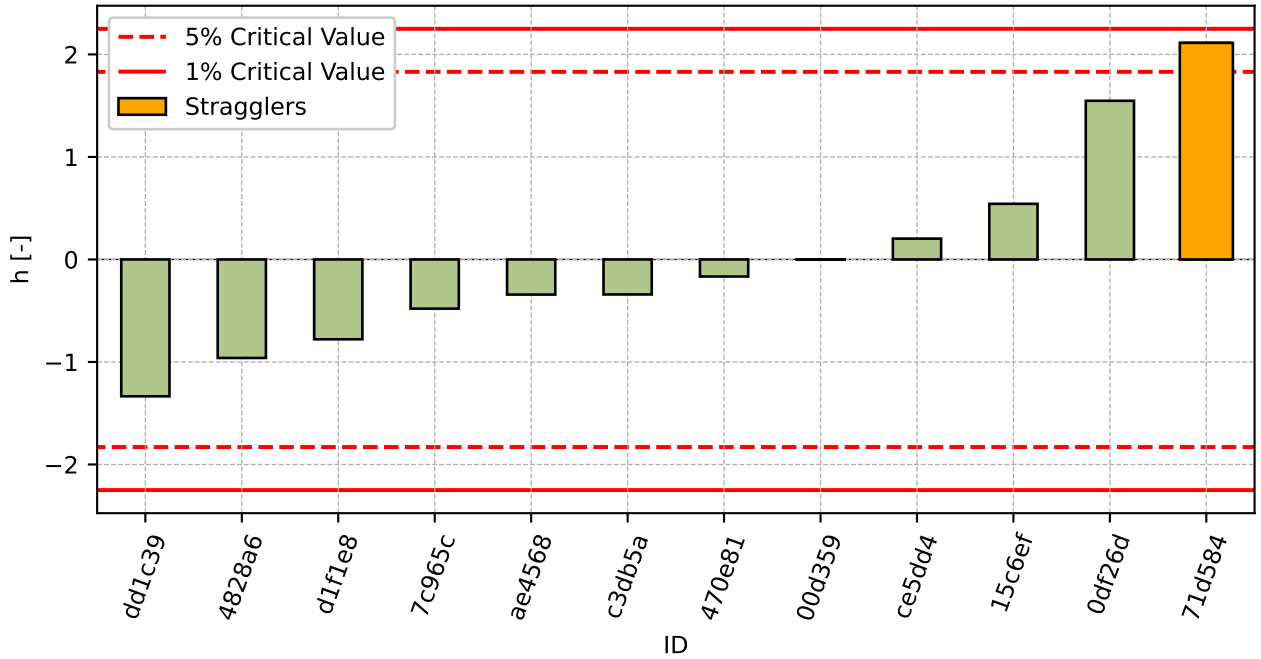

Figure 44: Interlaboratory Consistency Statistic

7.2.4 Descriptive statistics

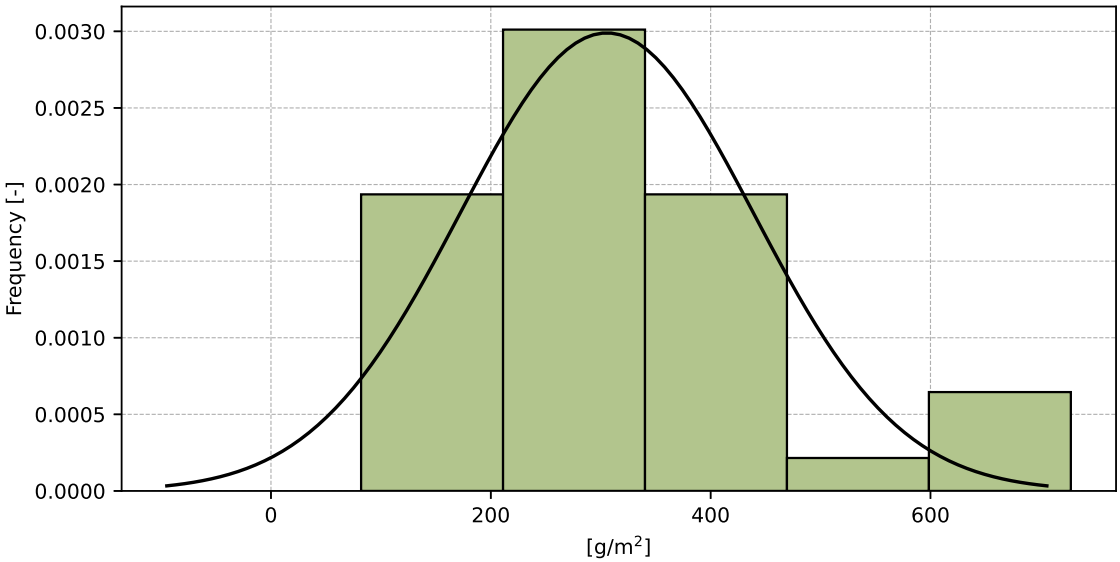

Figure 45: Histogram of all test results

Table 17: Descriptive statistics

Characteristics	**[g/m²]**
Average value – $\bar{x}$	306.0
Sample standard deviation – s	133.4
Asigned value – x^*	298.0
Robust standard deviation – s^*	133.0
Measurement uncertainty of asigned value – u_X	48.0
p-value of normality test	0.028 [-]
Interlaboratory standard deviation – s_L	125.1
Repeatability standard deviation – s_r	80.6
Reproducibility standard deviation – s_R	148.8
Repeatability – r	226.0
Reproducibility – R	417.0

7.2.5 Evaluation of Performance Statistics

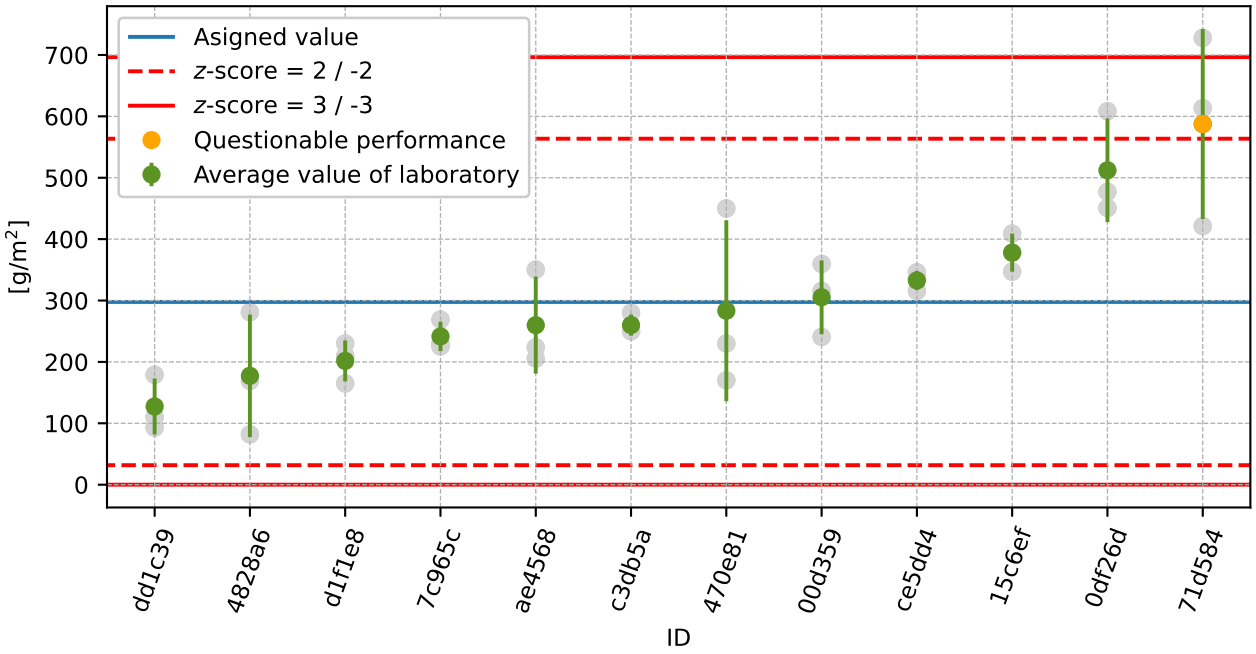

Figure 46: Average values and sample standard deviations

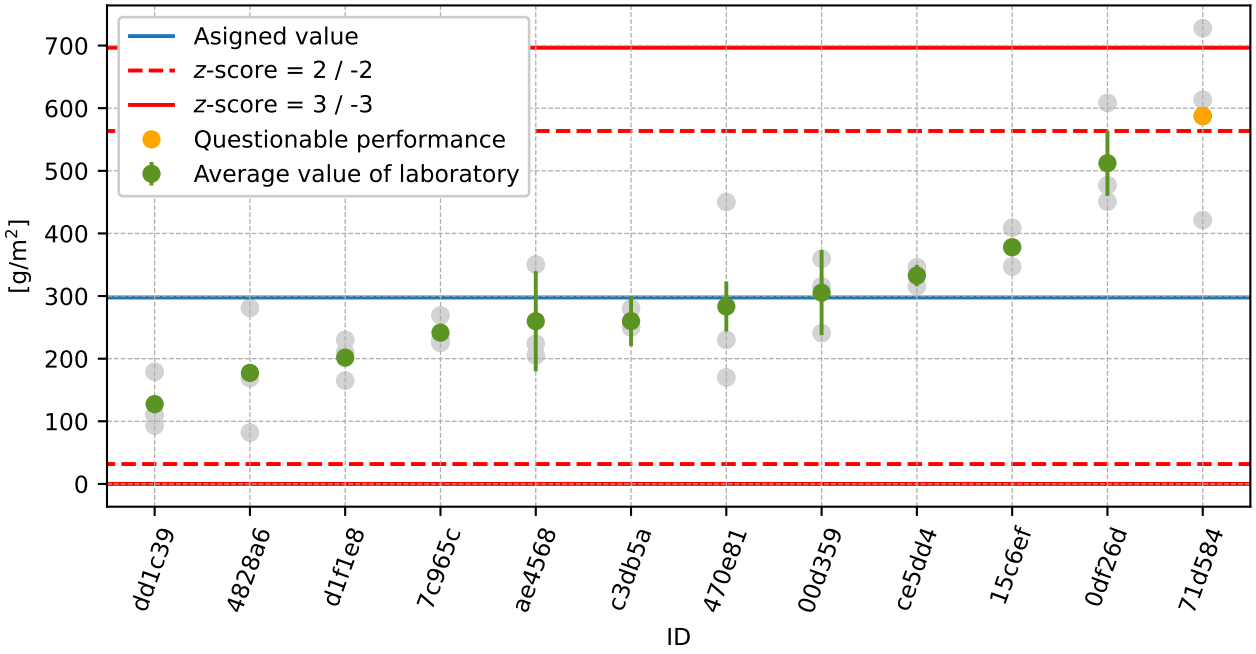

Figure 47: Average values and extended uncertainties of measurement

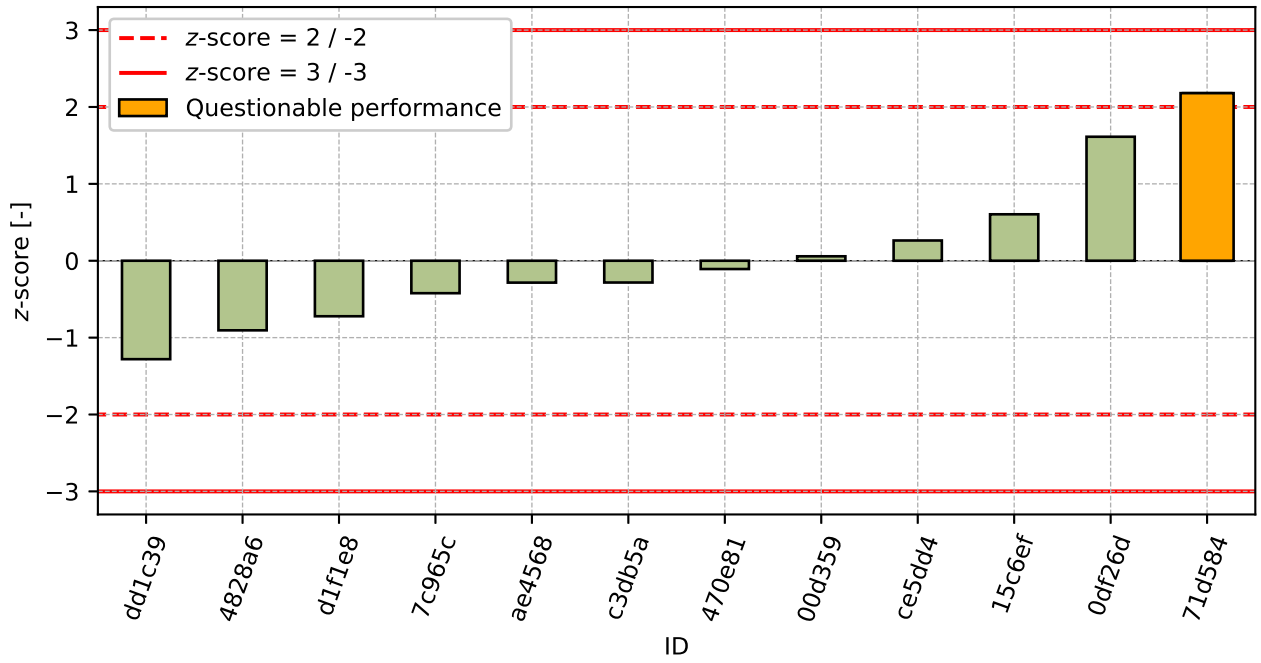

Figure 48: z-score

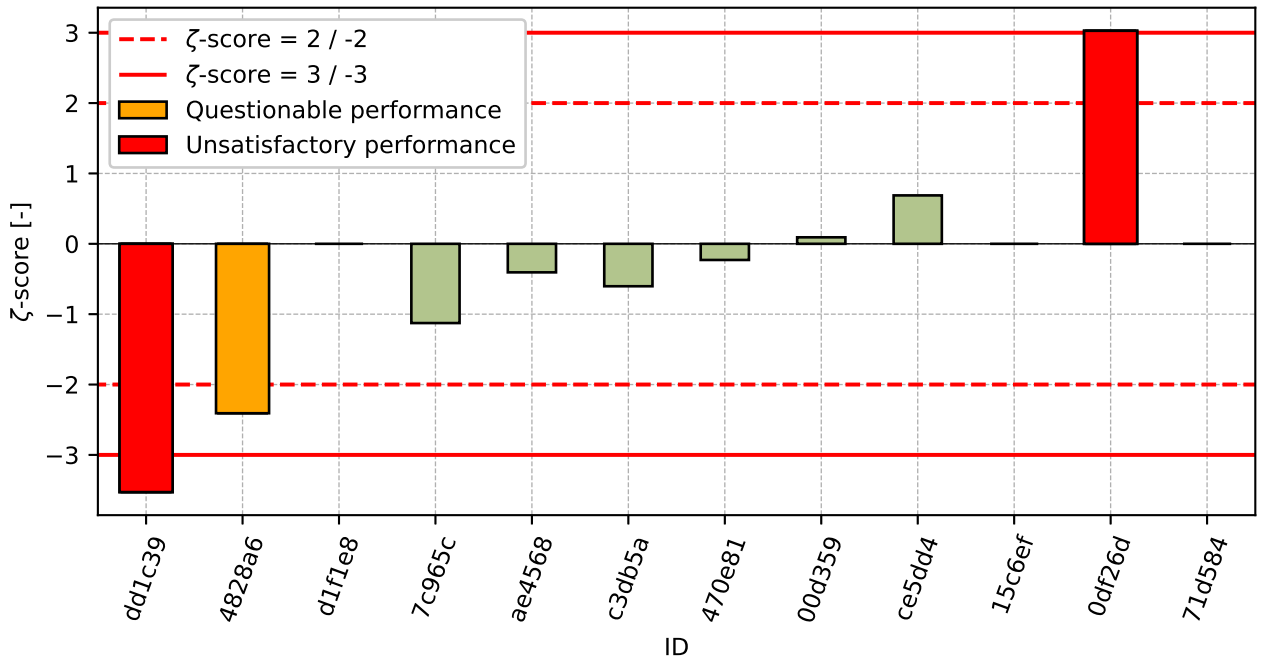

Figure 49: ζ-score

Table 18: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
dd1c39	-1.28	-3.53
4828a6	-0.91	-2.41
d1f1e8	-0.72	-
7c965c	-0.42	-1.13
ae4568	-0.28	-0.41
c3db5a	-0.28	-0.6
470e81	-0.11	-0.23
00d359	0.06	0.09
ce5dd4	0.26	0.69
15c6ef	0.6	-
0df26d	1.61	3.03
71d584	2.18	-

7.3 75 cycles

7.3.1 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 [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
00d359	348	361	431	84	380	44.9	11.81
dd1c39	514	419	457	18	463	47.6	10.28
4828a6	534	329	659	33	507	166.6	32.84
470e81	400	790	530	70	573	198.6	34.64
ce5dd4	574	561	616	17	584	28.3	4.85
c3db5a	670	620	540	80	610	65.6	10.75
7c965c	780	790	798	44	789	9.2	1.17
15c6ef	836	720	873	-	810	79.8	9.86
ae4568	1005	930	852	130	929	76.3	8.21
0df26d	826	1096	899	121	940	139.8	14.87
71d584	1401	1395	936	-	1244	266.5	21.43
e9bb88	1686	1722	1957	107	1788	147.1	8.23

7.3.2 The Numerical Procedure for Determining Outliers

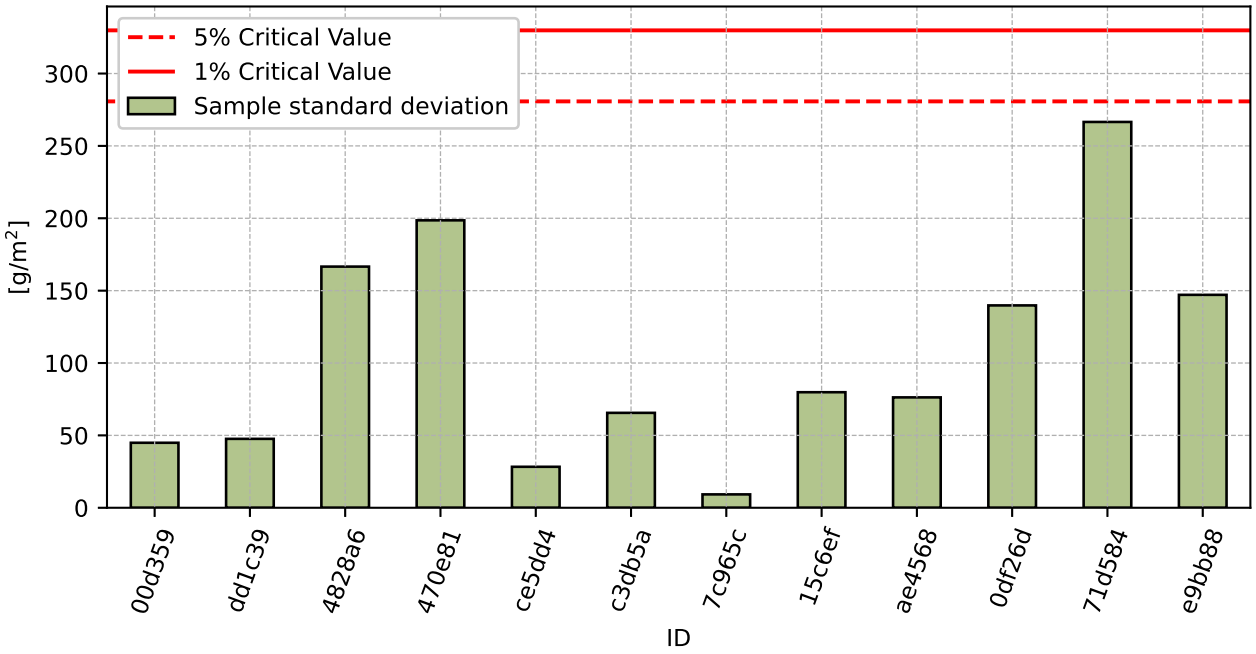

Figure 50: **Cochran's test** - sample standard deviations

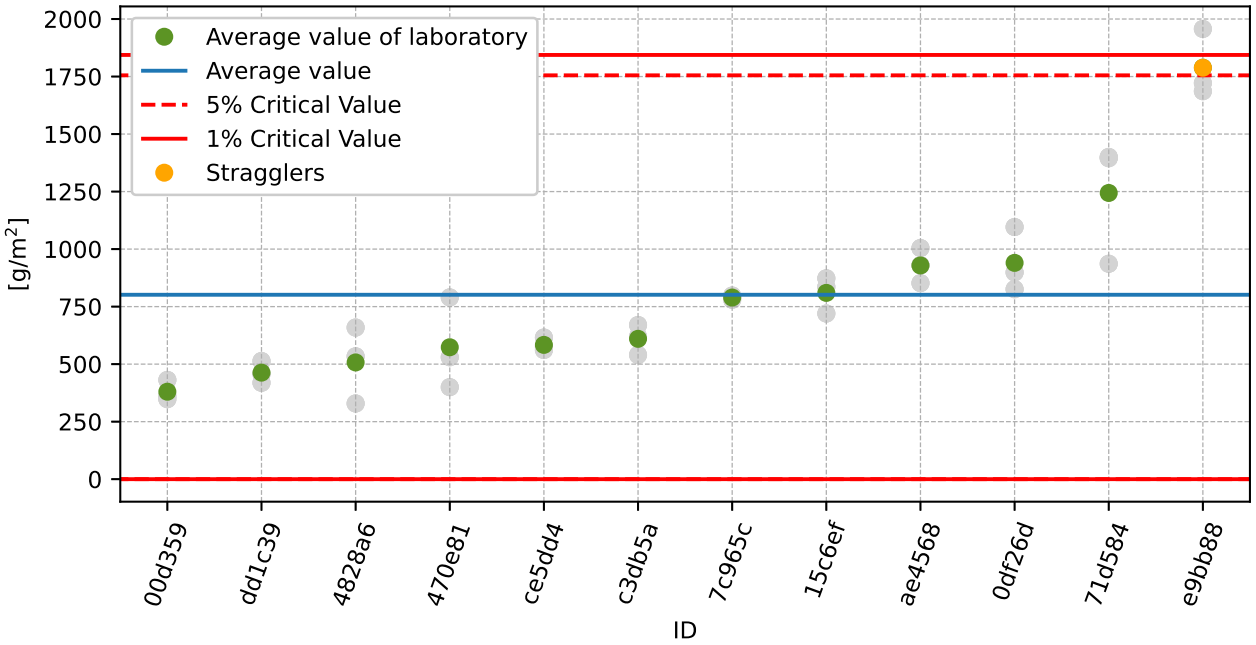

Figure 51: **Grubbs' test** - average values

7.3.3 Mandel's Statistics

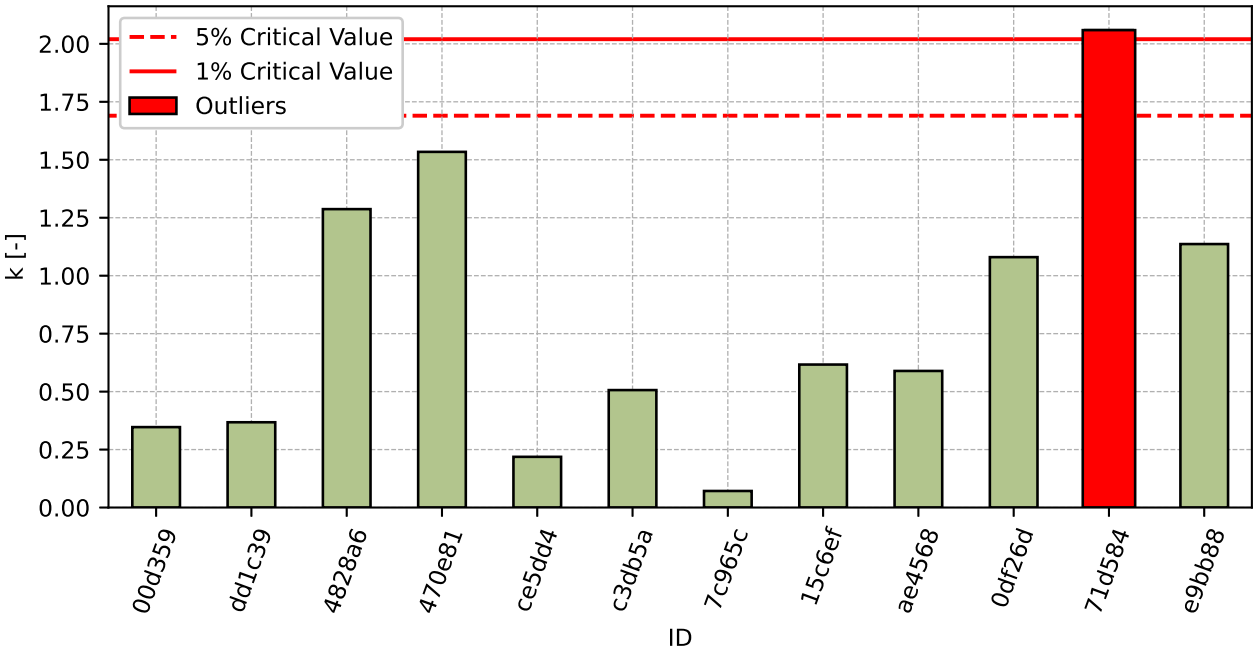

Figure 52: Intralaboratory Consistency Statistic

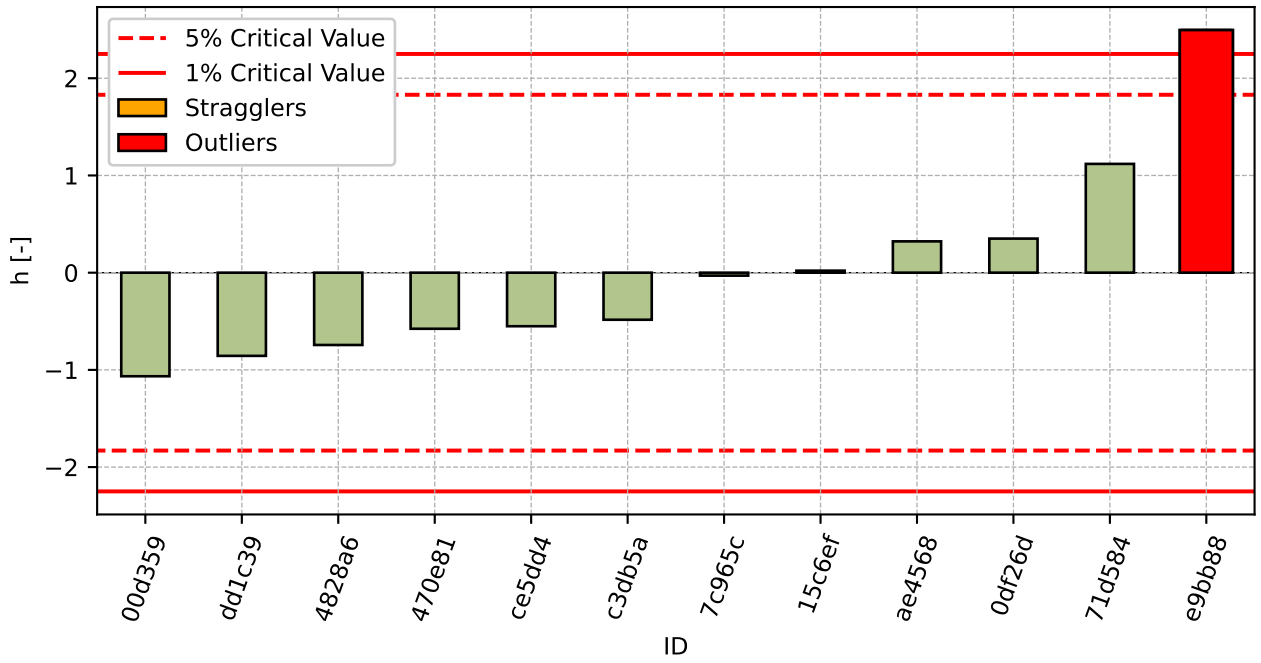

Figure 53: Interlaboratory Consistency Statistic

7.3.4 Descriptive statistics

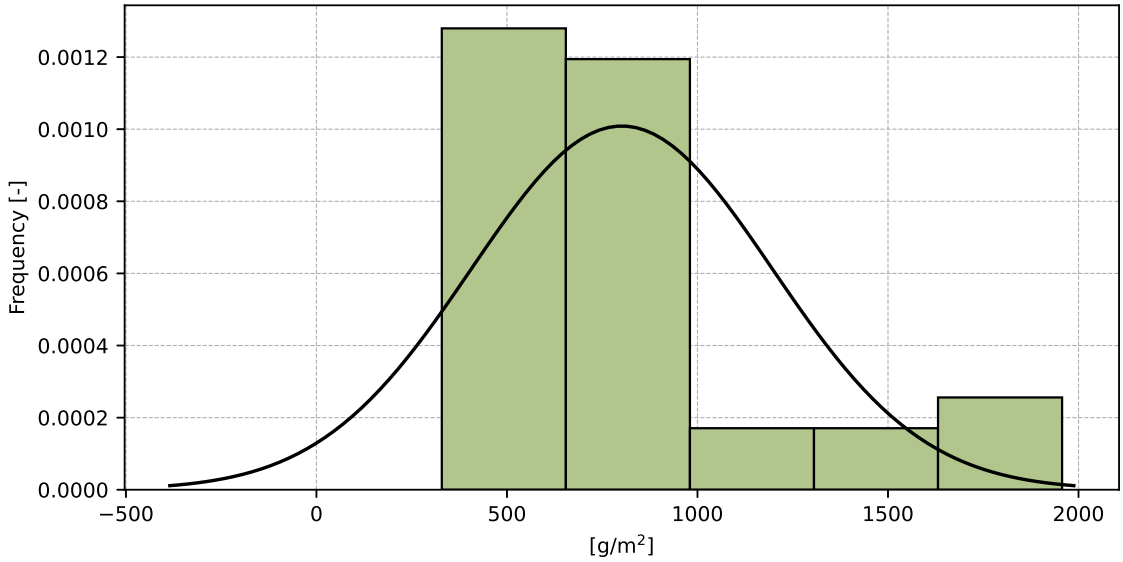

Figure 54: Histogram of all test results

Table 20: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	801.0
Sample standard deviation – s	395.4
Asigned value – x^*	795.0
Robust standard deviation – s^*	421.6
Measurement uncertainty of asigned value – u_X	152.1
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	388.3
Repeatability standard deviation – s_r	129.4
Reproducibility standard deviation – s_R	409.3
Repeatability – r	362.0
Reproducibility – R	1146.0

7.3.5 Evaluation of Performance Statistics

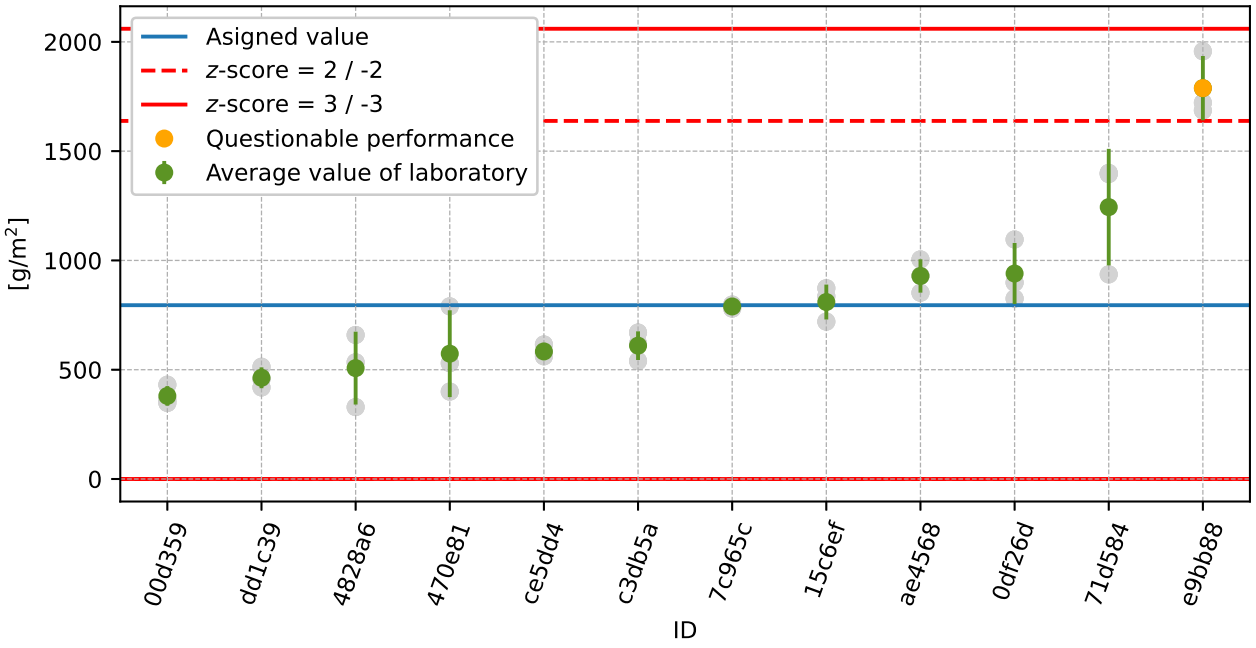

Figure 55: Average values and sample standard deviations

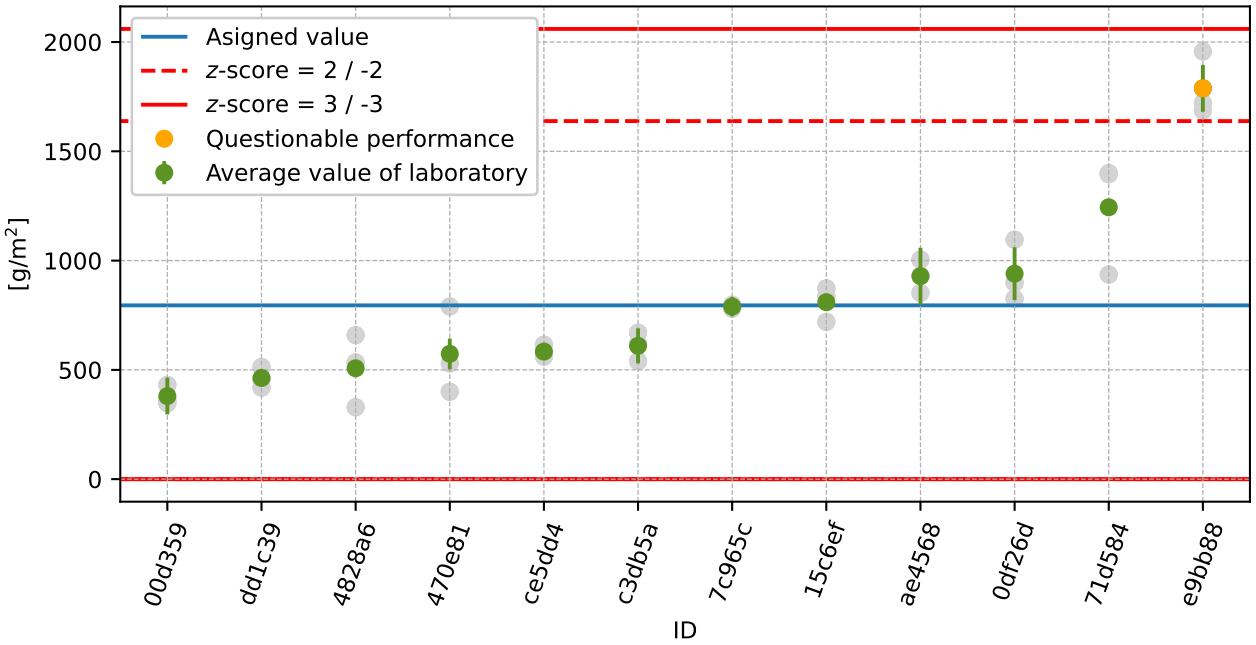

Figure 56: Average values and extended uncertainties of measurement

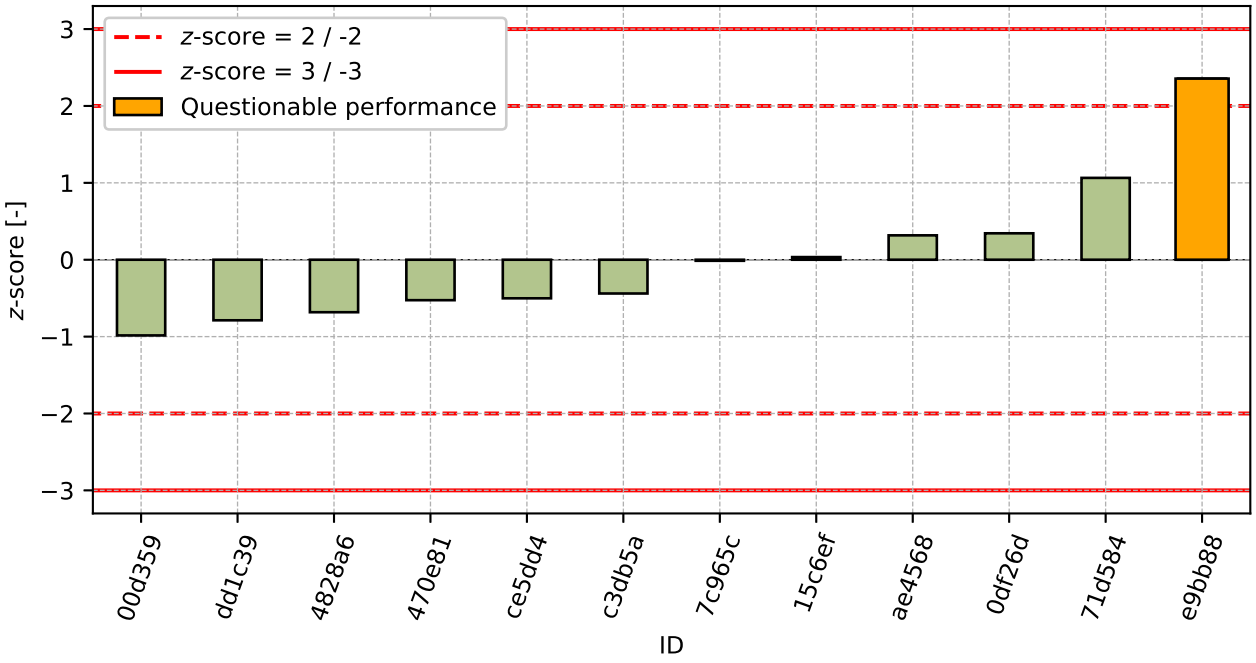

Figure 57: z-score

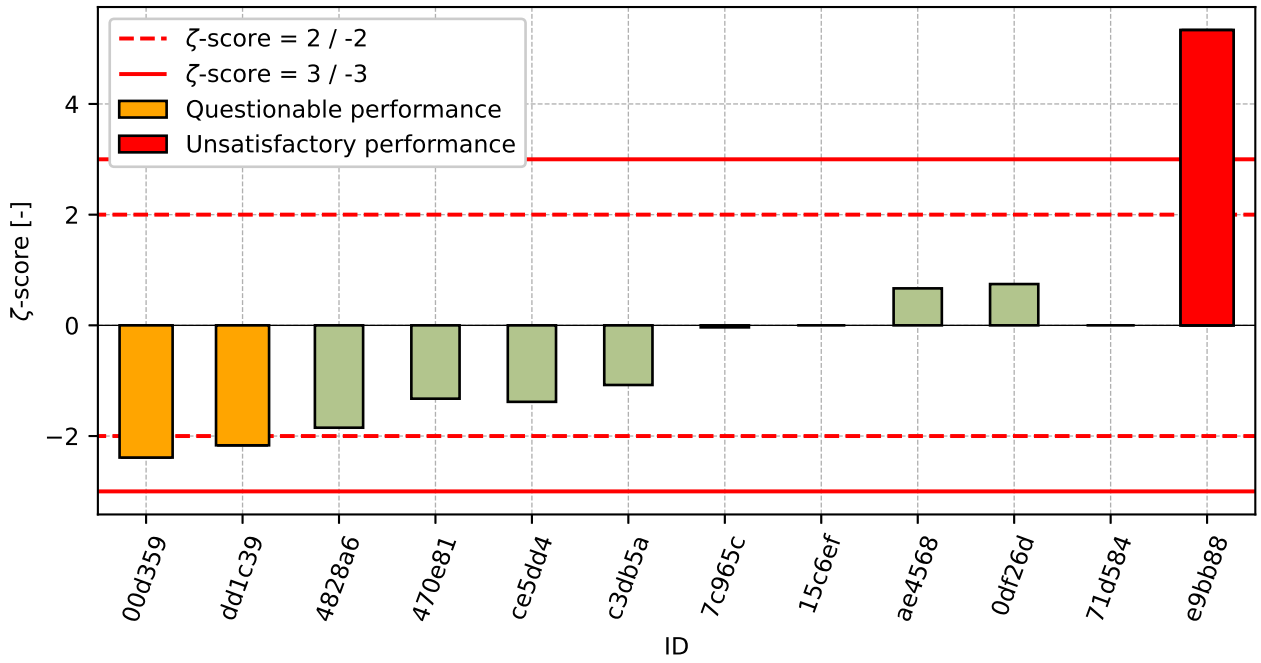

Figure 58: ζ-score

Table 21: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
00d359	-0.98	-2.39
dd1c39	-0.79	-2.17
4828a6	-0.68	-1.85
470e81	-0.53	-1.32
ce5dd4	-0.5	-1.38
c3db5a	-0.44	-1.08
7c965c	-0.01	-0.04
15c6ef	0.03	-
ae4568	0.32	0.67
0df26d	0.34	0.75
71d584	1.06	-
e9bb88	2.36	5.33

7.4 100 cycles

7.4.1 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 [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
00d359	412	418	507	98	446	53.2	11.93
ce5dd4	505	535	584	17	541	39.9	7.38
dd1c39	715	687	636	27	679	39.9	5.87
470e81	680	1000	880	110	853	161.7	18.94
c3db5a	1260	1130	920	140	1103	171.6	15.55
4828a6	1139	1003	1313	66	1152	155.4	13.49
15c6ef	1286	1134	1258	-	1226	80.9	6.6
7c965c	1271	1280	1314	72	1289	22.5	1.75
0df26d	1354	1660	1466	259	1494	154.7	10.35
ae4568	1730	1774	1582	180	1695	100.8	5.94
71d584	1964	1966	1420	-	1783	314.6	17.64
e9bb88	2420	2447	2671	151	2512	137.7	5.48

7.4.2 The Numerical Procedure for Determining Outliers

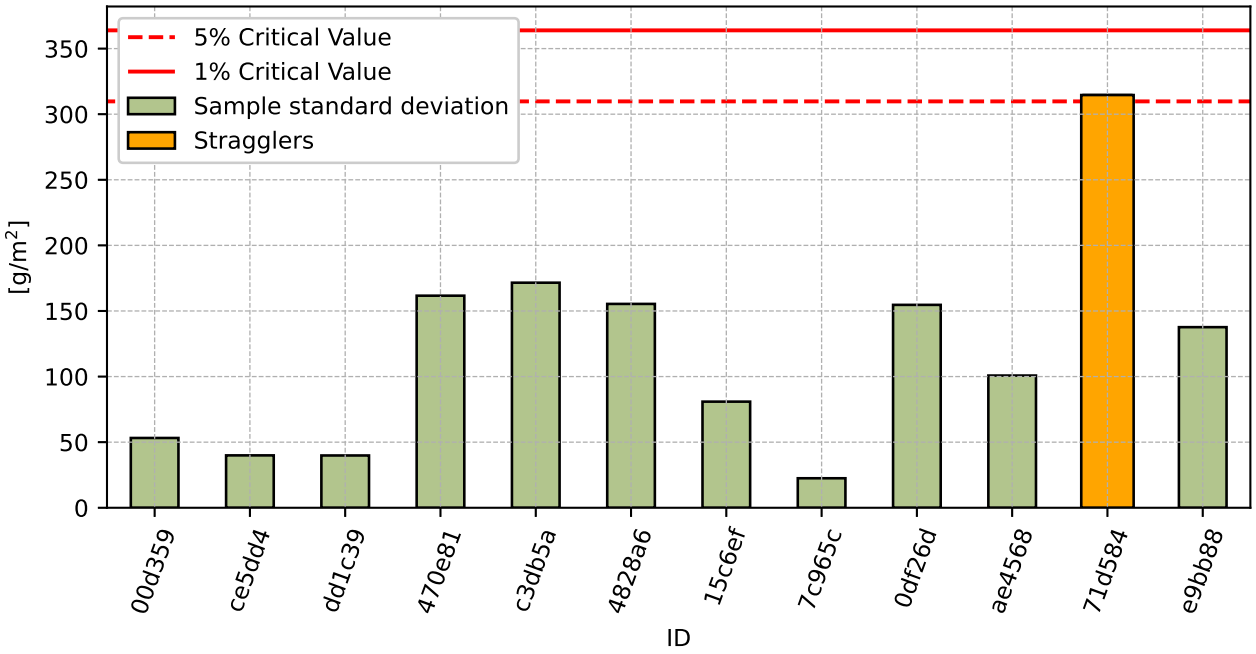

Figure 59: **Cochran's test** - sample standard deviations

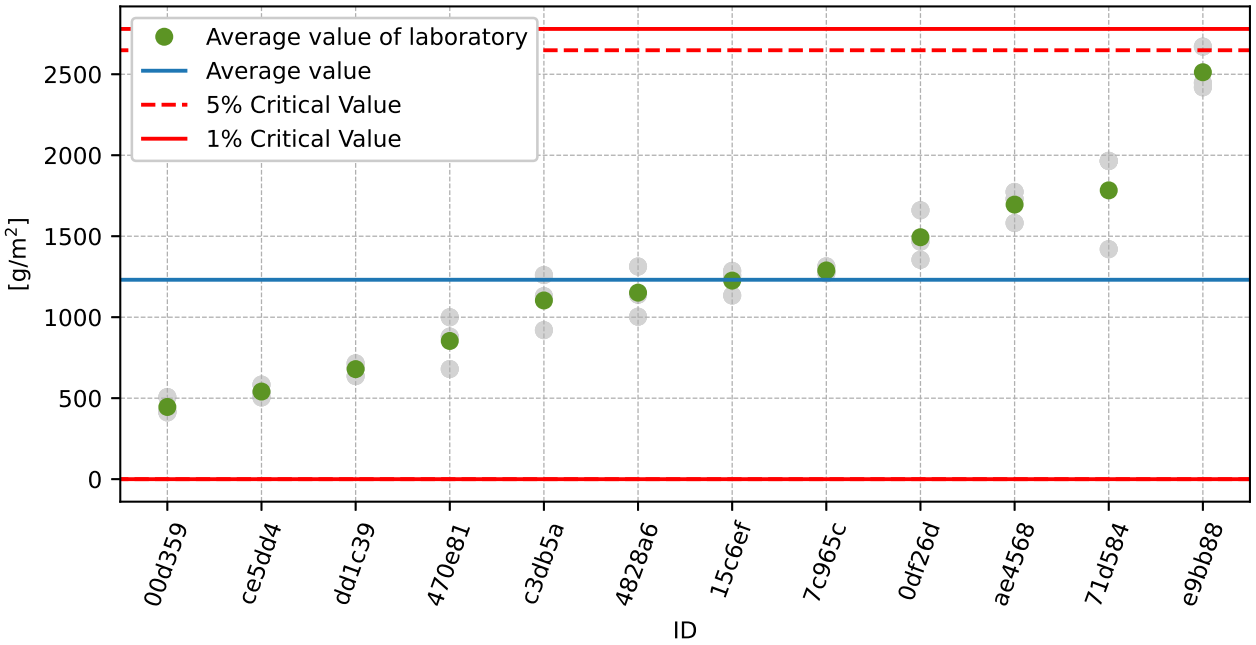

Figure 60: **Grubbs' test** - average values

7.4.3 Mandel's Statistics

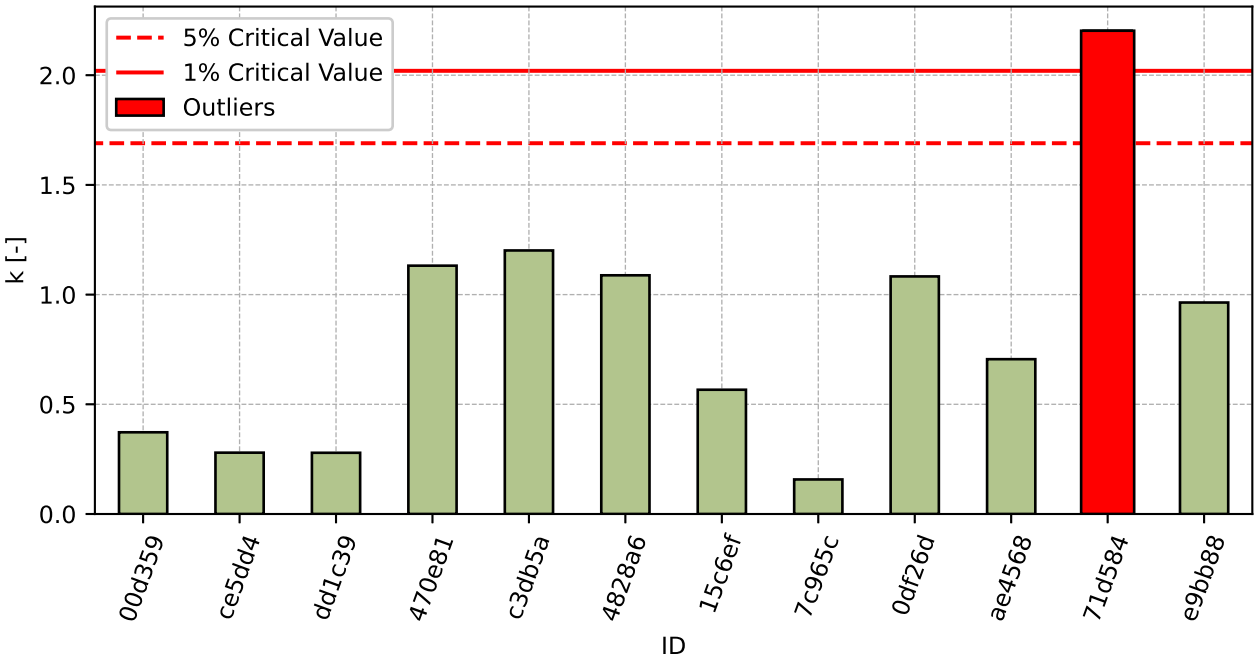

Figure 61: Intralaboratory Consistency Statistic

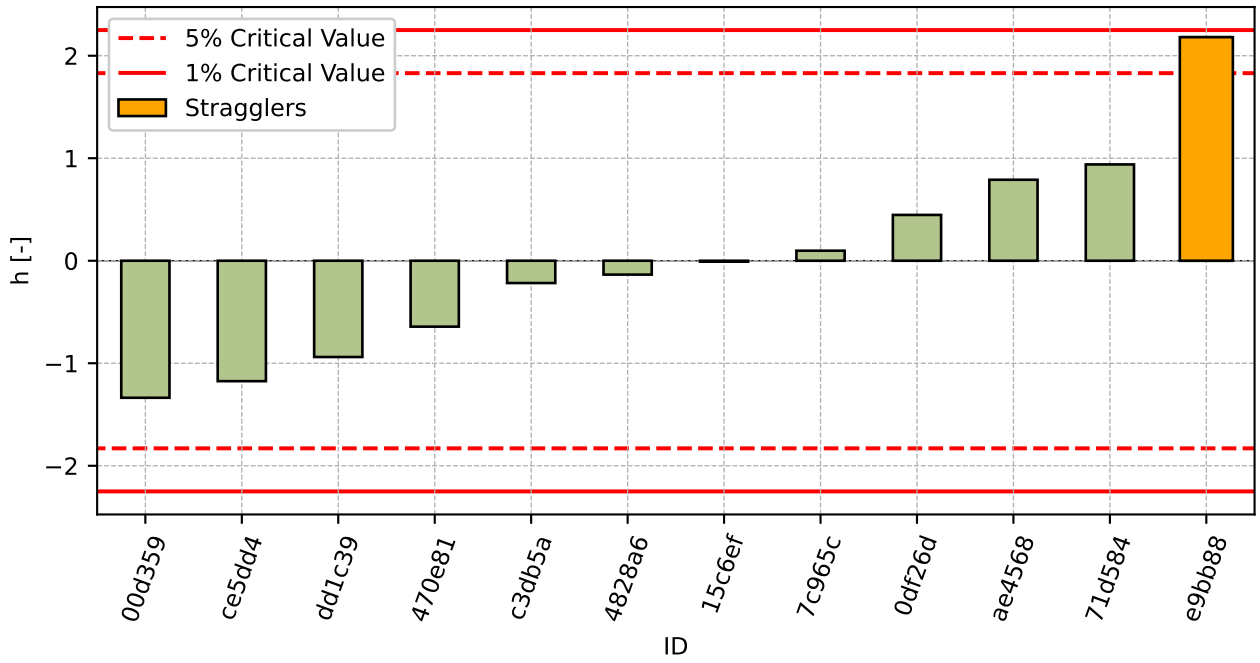

Figure 62: Interlaboratory Consistency Statistic

7.4.4 Descriptive statistics

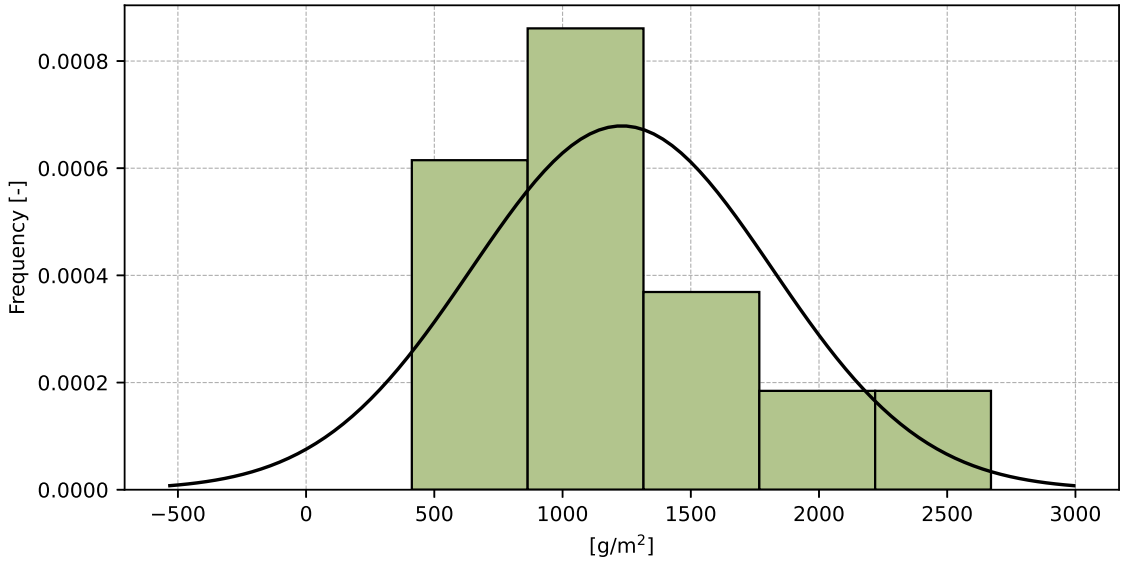

Figure 63: Histogram of all test results

Table 23: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	1231.0
Sample standard deviation – s	587.5
Asigned value – x^*	1231.0
Robust standard deviation – s^*	637.9
Measurement uncertainty of asigned value – u_X	230.2
p-value of normality test	0.064 [-]
Interlaboratory standard deviation – s_L	581.7
Repeatability standard deviation – s_r	142.8
Reproducibility standard deviation – s_R	599.0
Repeatability – r	400.0
Reproducibility – R	1677.0

7.4.5 Evaluation of Performance Statistics

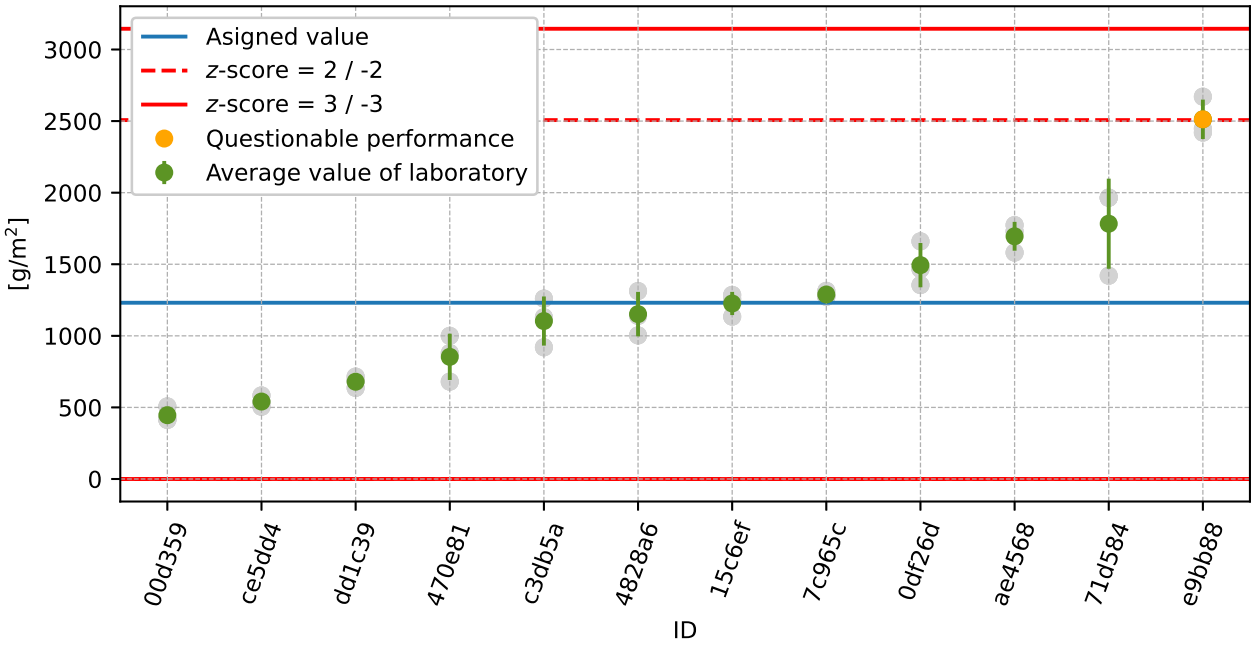

Figure 64: Average values and sample standard deviations

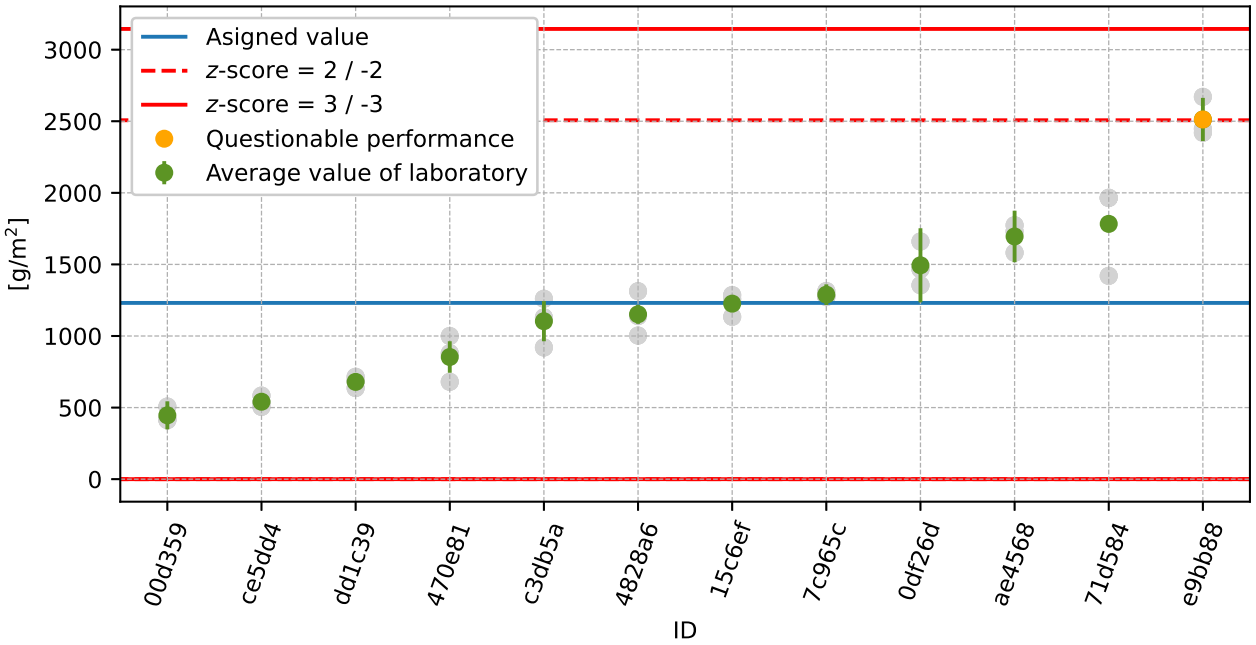

Figure 65: Average values and extended uncertainties of measurement

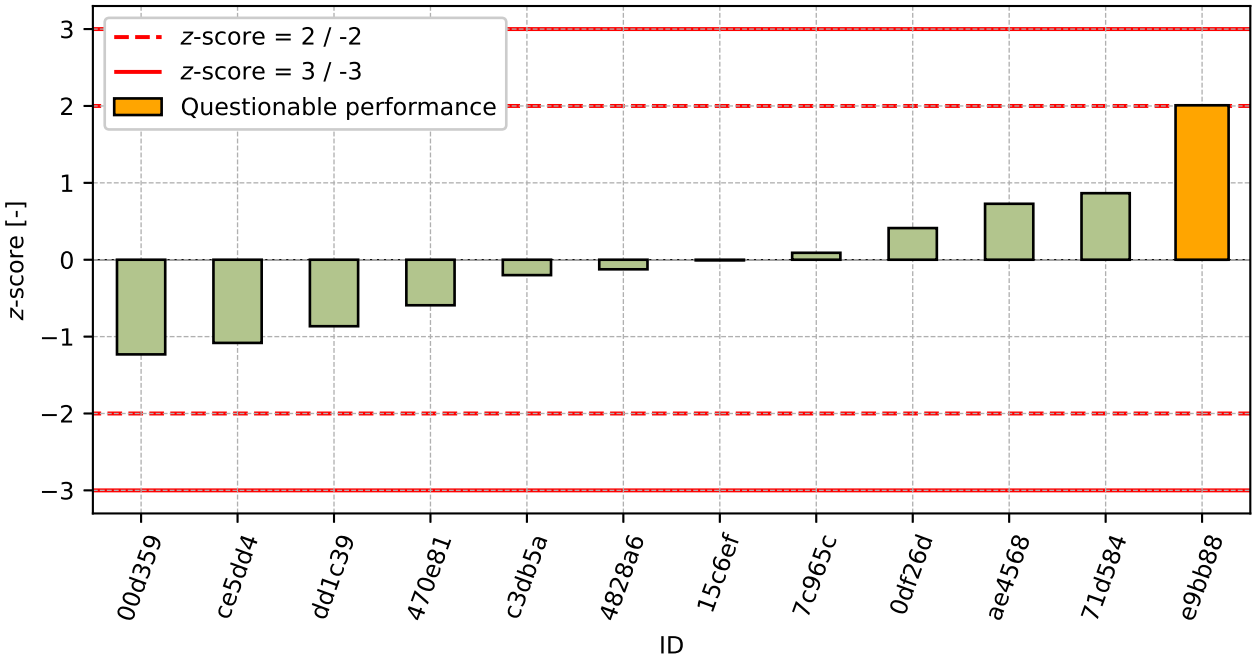

Figure 66: z-score

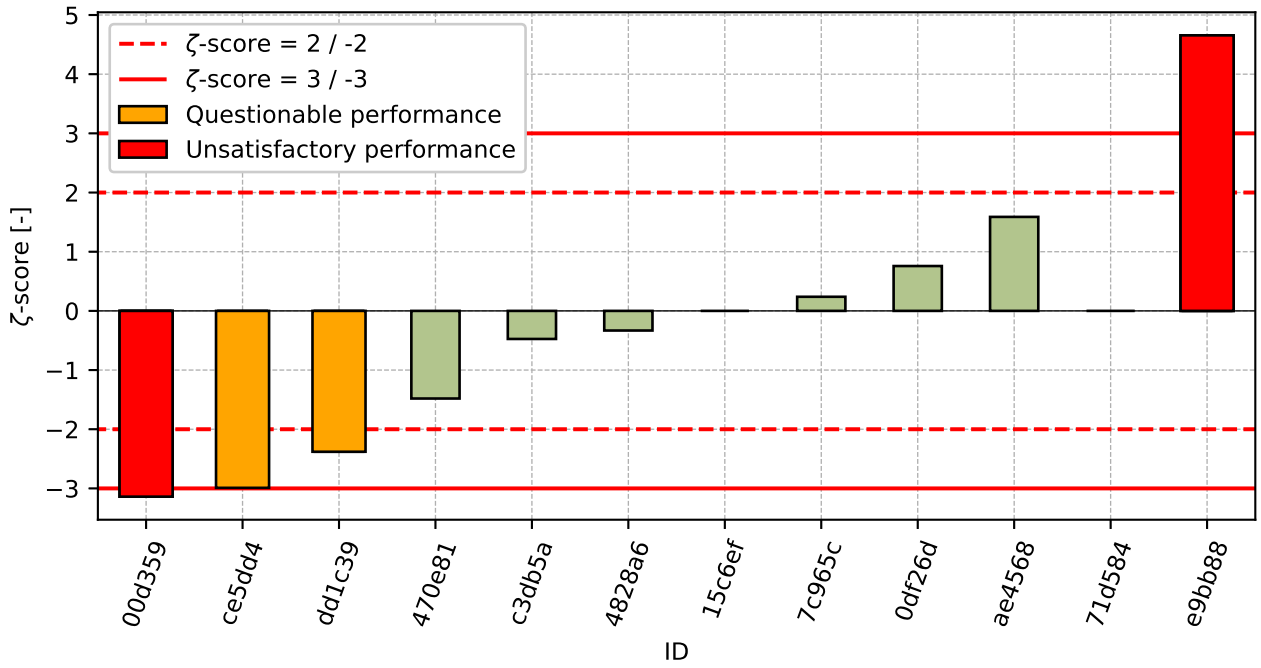

Figure 67: ζ-score

Table 24: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
00d359	-1.23	-3.14
ce5dd4	-1.08	-2.99
dd1c39	-0.86	-2.38
470e81	-0.59	-1.48
c3db5a	-0.2	-0.47
4828a6	-0.12	-0.33
15c6ef	-0.01	-
7c965c	0.09	0.24
0df26d	0.41	0.76
ae4568	0.73	1.59
71d584	0.87	-
e9bb88	2.01	4.66

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 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/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
1887c9	14	12	17	1	15	2.5	16.87
74dcfd	84	56	34	53	58	25.2	43.78
71c95d	73	87	72	6	77	8.2	10.69
9bdcd5	101	84	78	53	88	11.9	13.61
25bec1	243	139	204	20	195	52.9	27.08

8.1.2 The Numerical Procedure for Determining Outliers

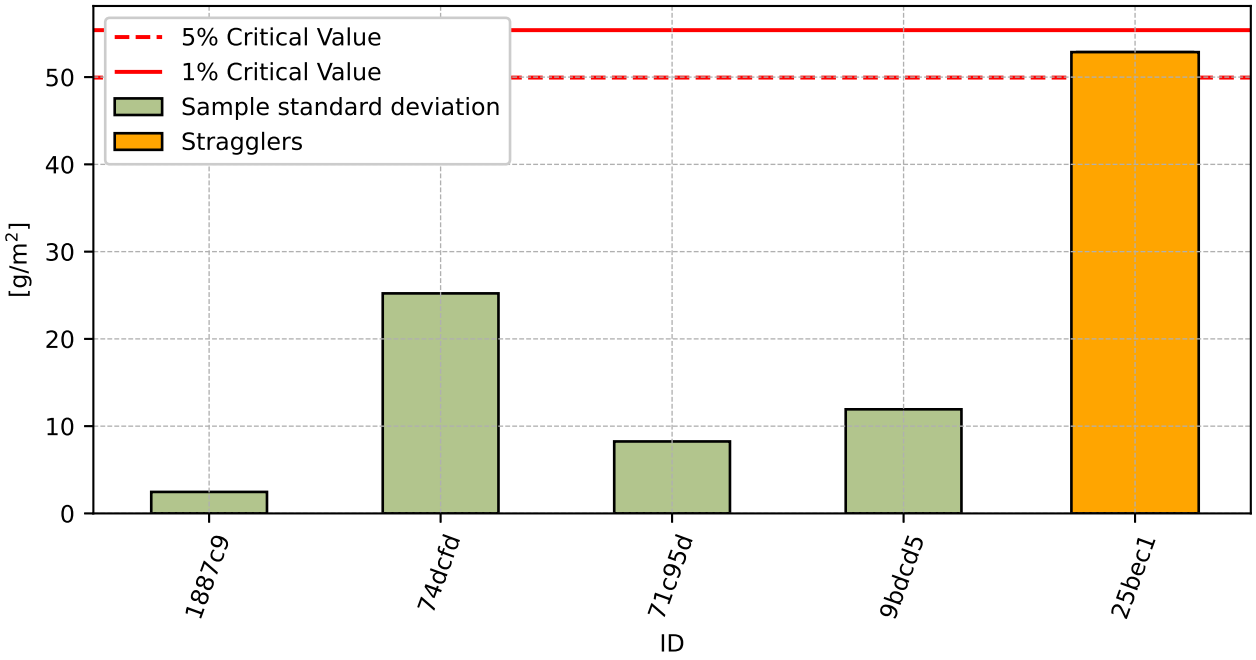

Figure 68: **Cochran's test** - sample standard deviations

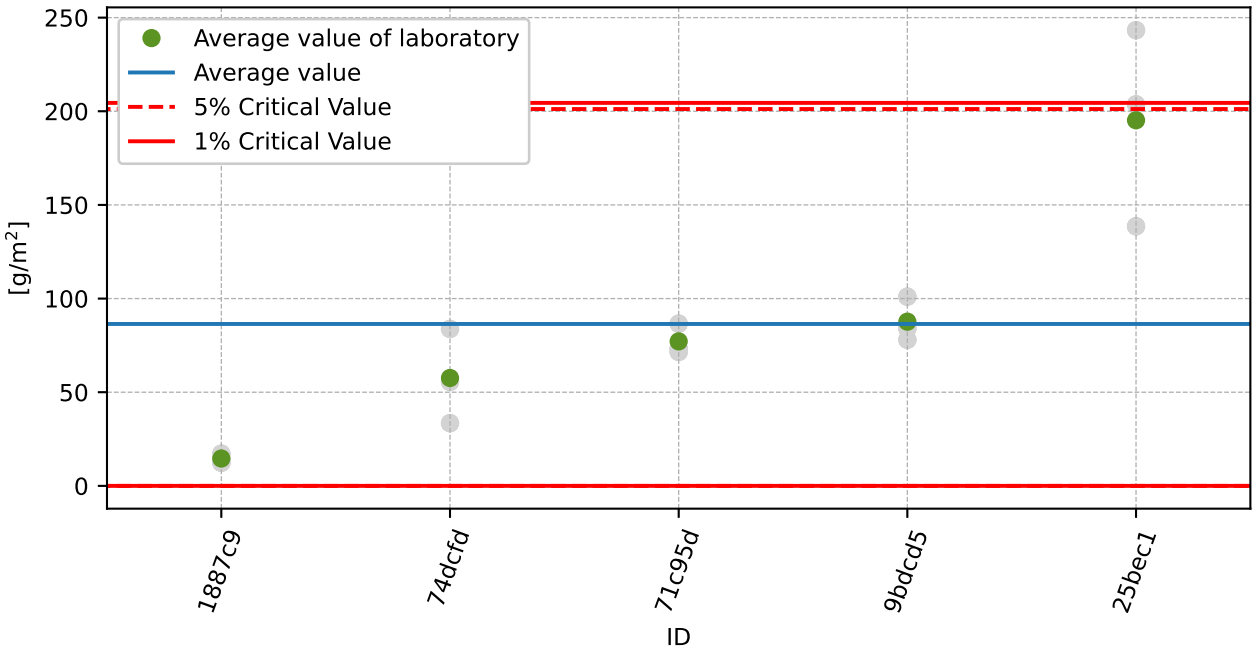

Figure 69: **Grubbs' test** - average values

8.1.3 Mandel's Statistics

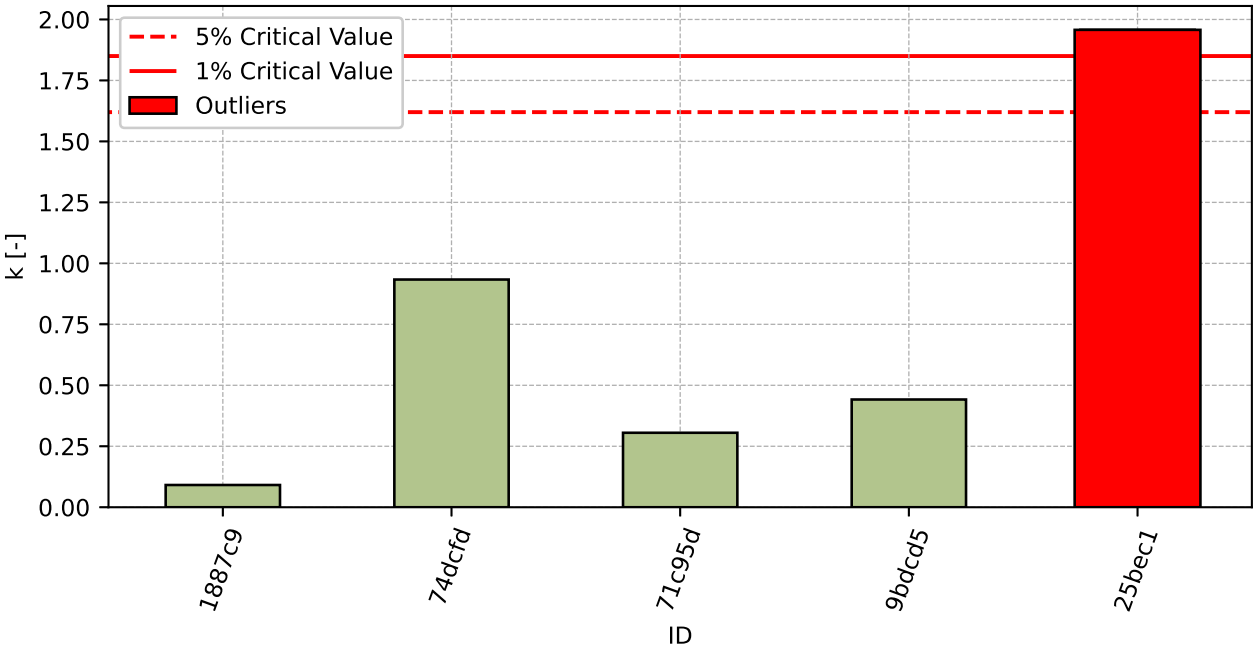

Figure 70: Intralaboratory Consistency Statistic

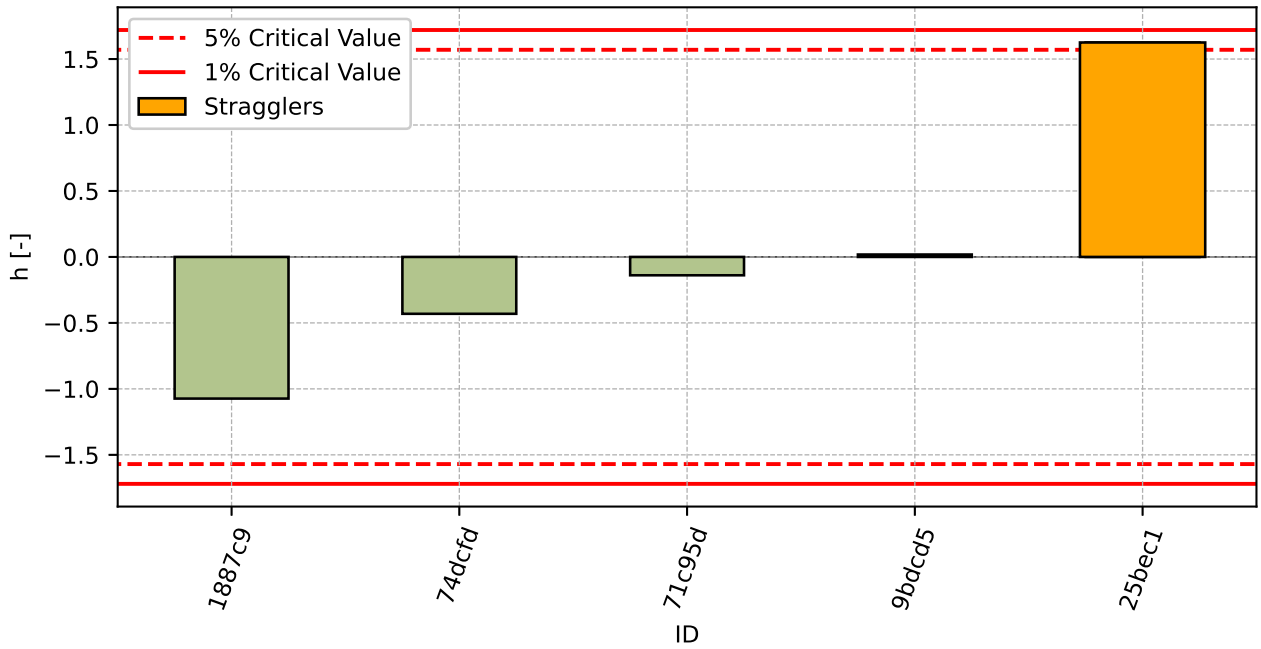

Figure 71: Interlaboratory Consistency Statistic

8.1.4 Descriptive statistics

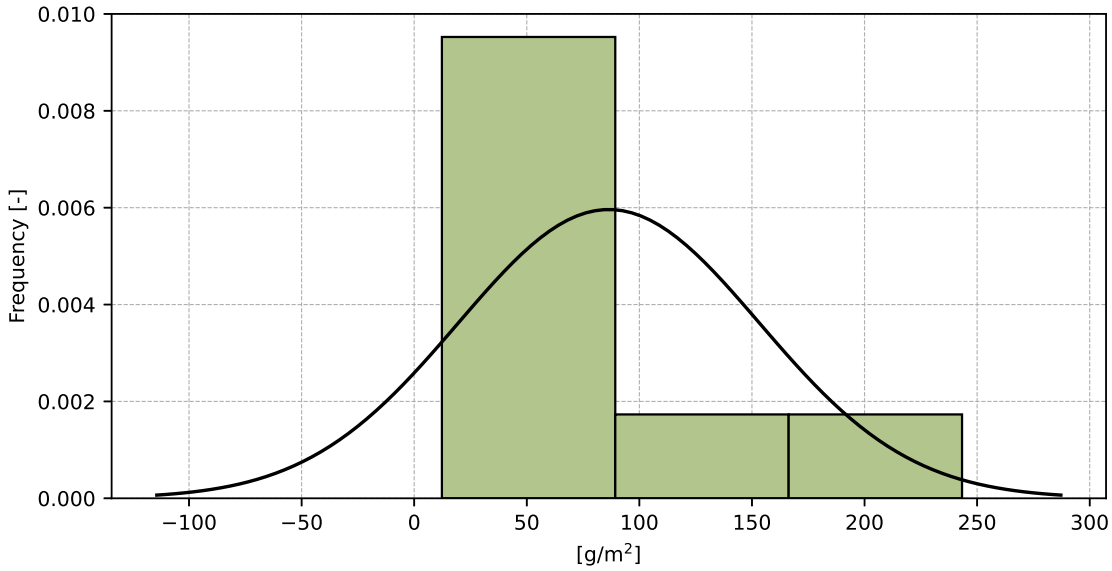

Figure 72: Histogram of all test results

Table 26: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	86.0
Sample standard deviation – s	66.9
Asigned value – x^*	90.0
Robust standard deviation – s^*	63.1
Measurement uncertainty of asigned value – u_X	35.2
p-value of normality test	0.033 [-]
Interlaboratory standard deviation – s_L	65.1
Repeatability standard deviation – s_r	27.0
Reproducibility standard deviation – s_R	70.5
Repeatability – r	76.0
Reproducibility – R	197.0

8.1.5 Evaluation of Performance Statistics

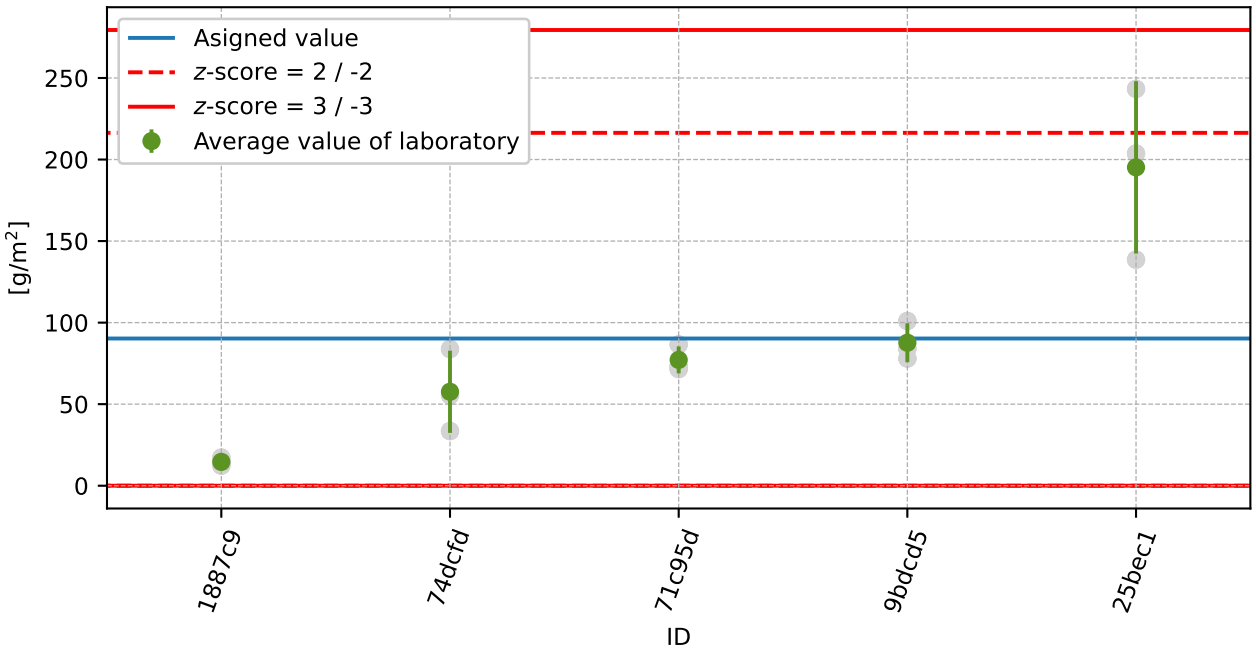

Figure 73: Average values and sample standard deviations

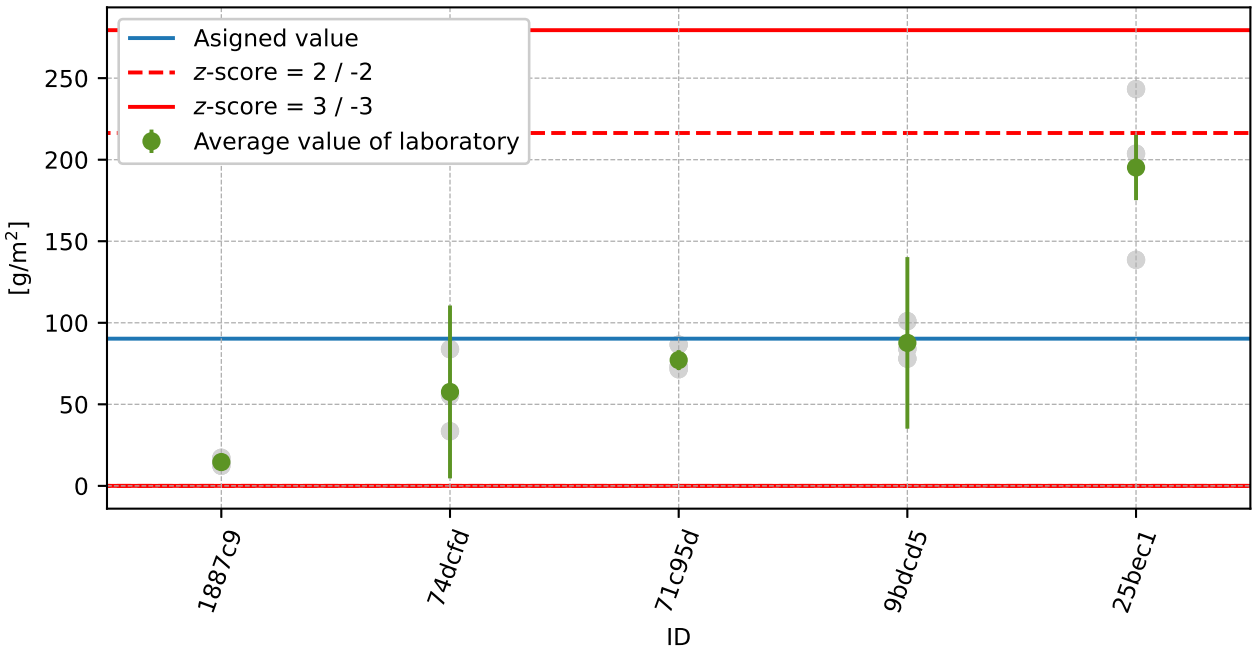

Figure 74: Average values and extended uncertainties of measurement

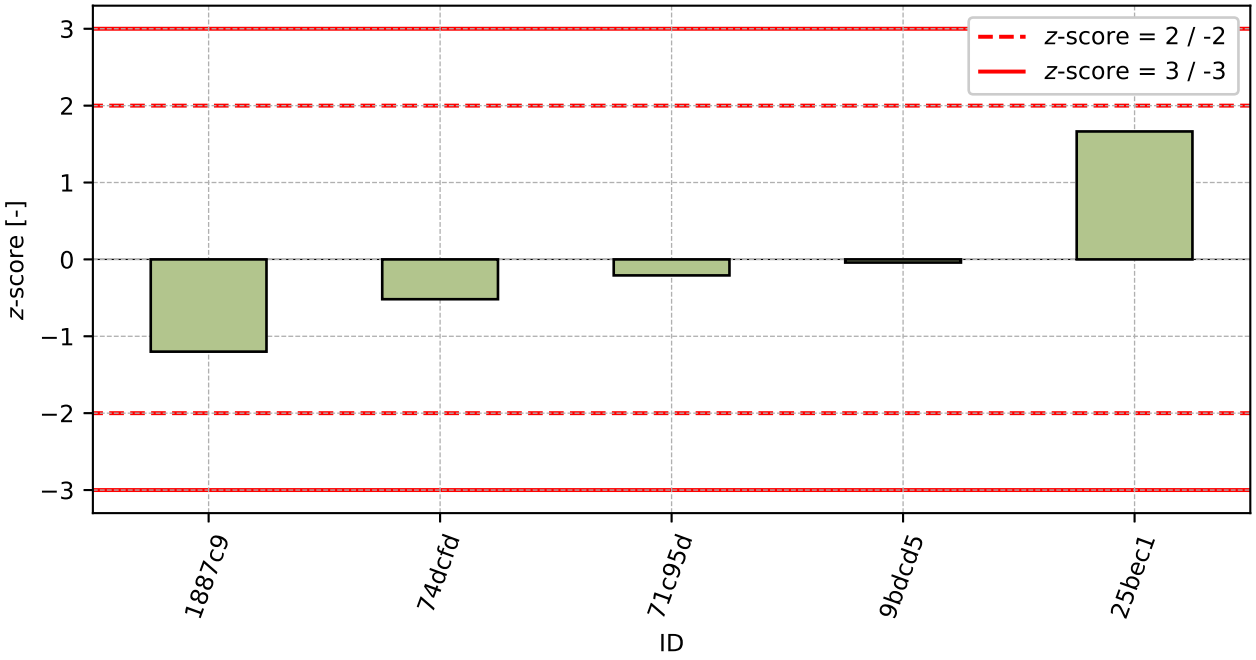

Figure 75: z-score

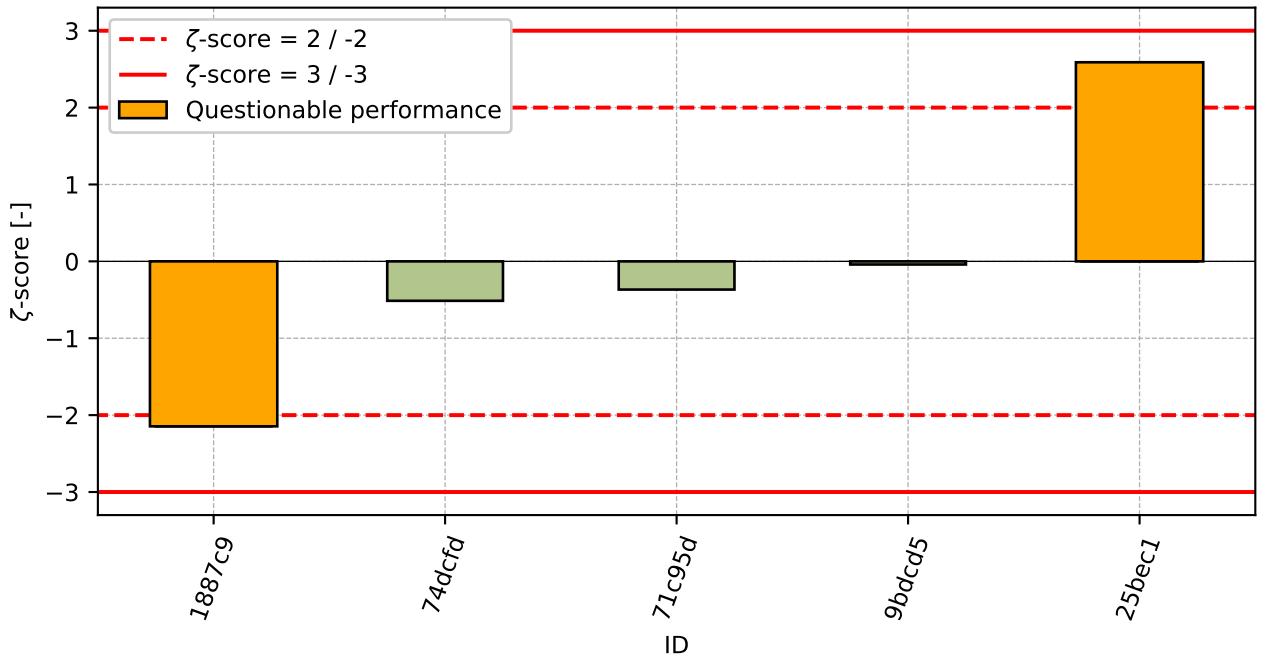

Figure 76: ζ-score

Table 27: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
1887c9	-1.2	-2.15
74dcfd	-0.52	-0.51
71c95d	-0.21	-0.37
9bdcd5	-0.04	-0.04
25bec1	1.66	2.59

8.2 50 cycles

8.2.1 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 [%]
71c95d	104	184	111	10	133	44.3	33.35
74dcfd	285	178	56	106	173	114.6	66.34
9bdcd5	219	173	157	110	183	32.2	17.59
25bec1	559	230	370	32	386	165.0	42.72

8.2.2 The Numerical Procedure for Determining Outliers

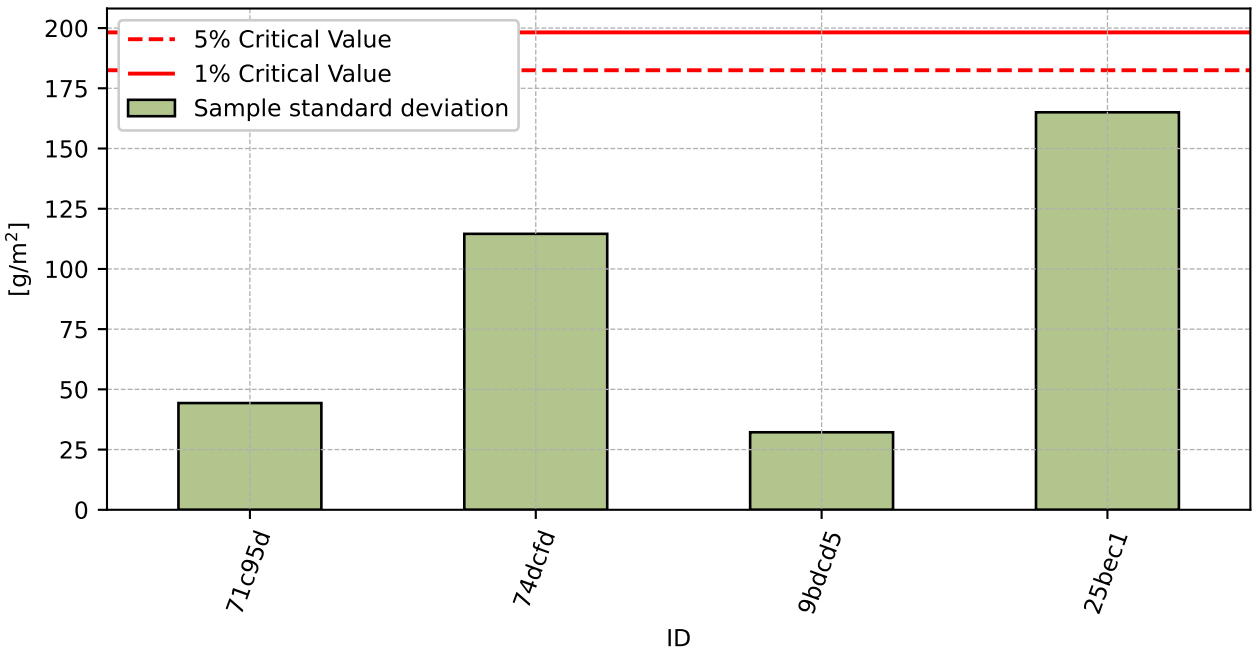

Figure 77: **Cochran's test** - sample standard deviations

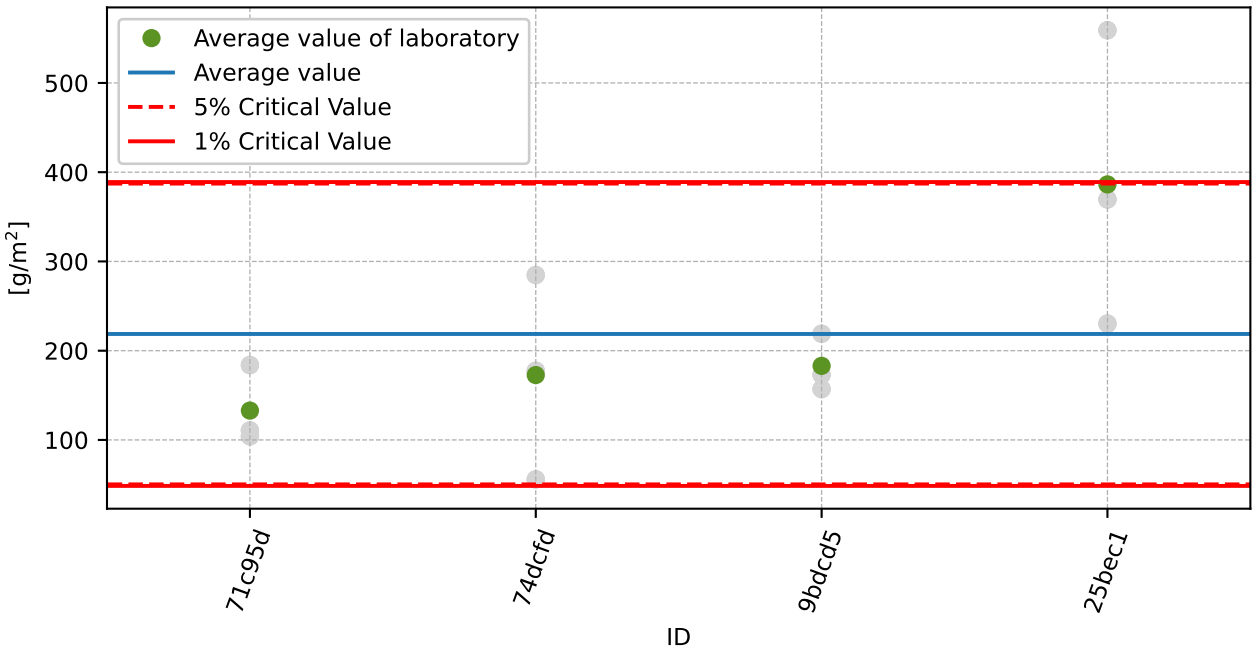

Figure 78: **Grubbs' test** - average values

8.2.3 Mandel's Statistics

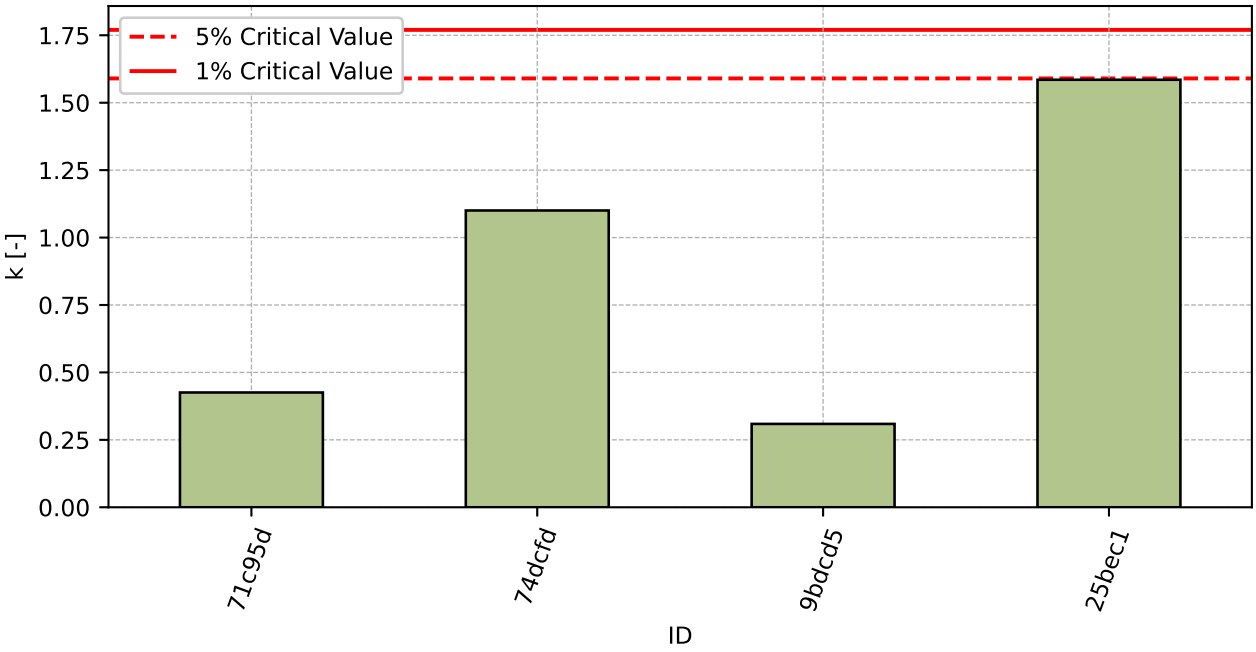

Figure 79: Intralaboratory Consistency Statistic

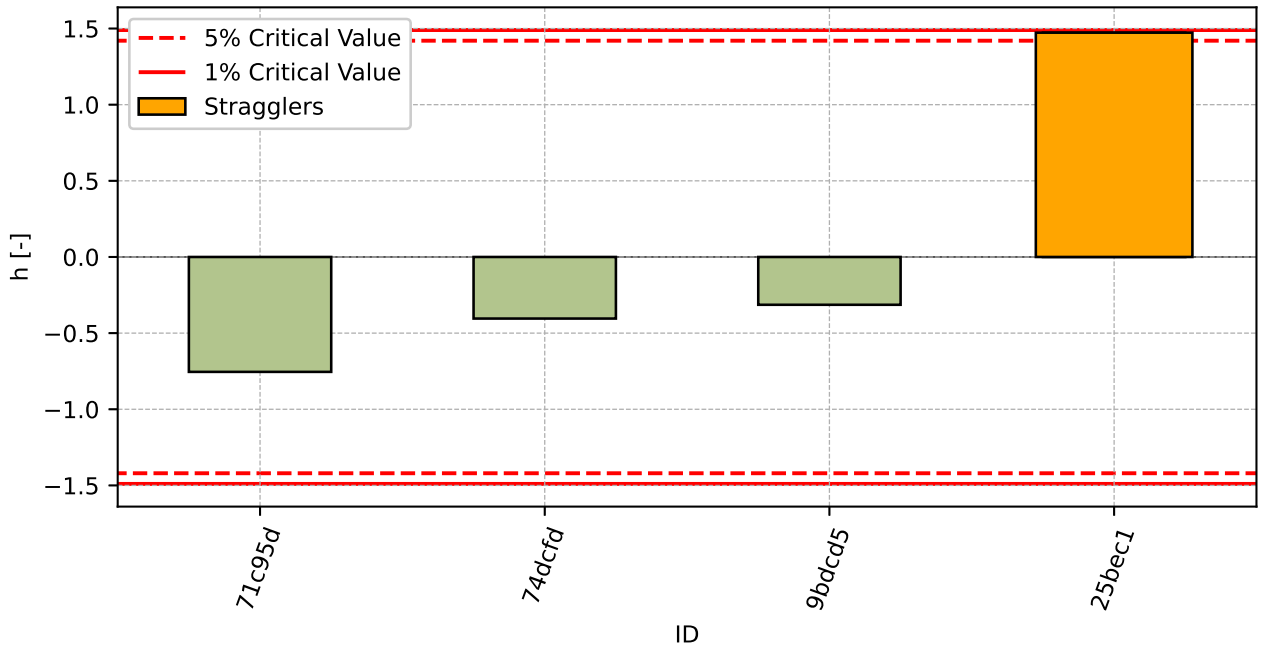

Figure 80: Interlaboratory Consistency Statistic

8.2.4 Descriptive statistics

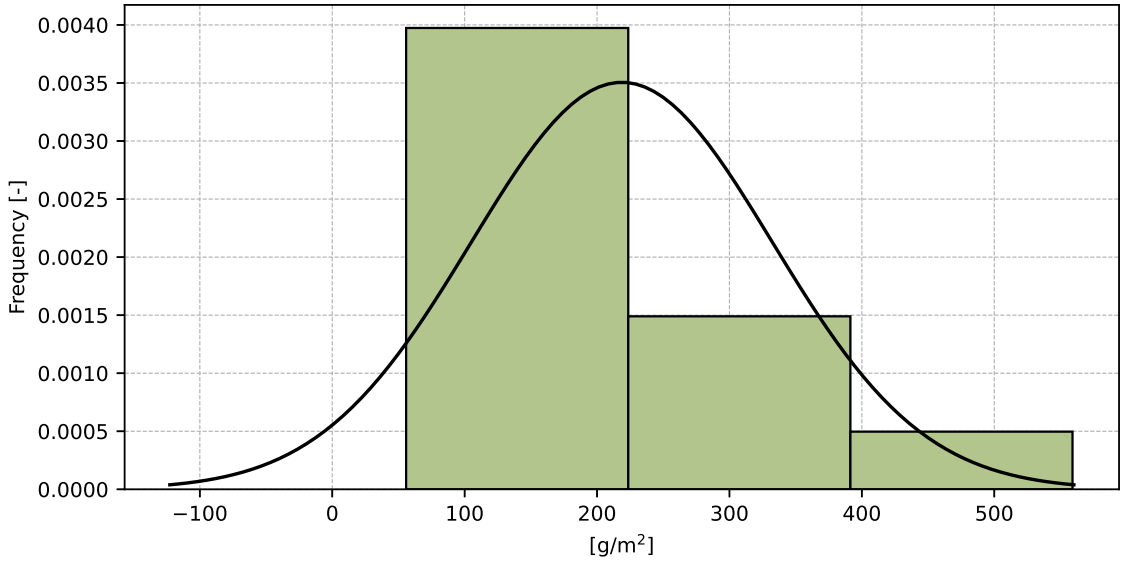

Figure 81: Histogram of all test results

Table 29: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	219.0
Sample standard deviation – s	113.8
Asigned value – x^*	219.0
Robust standard deviation – s^*	111.8
Measurement uncertainty of asigned value – u_X	69.8
p-value of normality test	0.067 [-]
Interlaboratory standard deviation – s_L	96.6
Repeatability standard deviation – s_r	104.1
Reproducibility standard deviation – s_R	142.0
Repeatability – r	292.0
Reproducibility – R	398.0

8.2.5 Evaluation of Performance Statistics

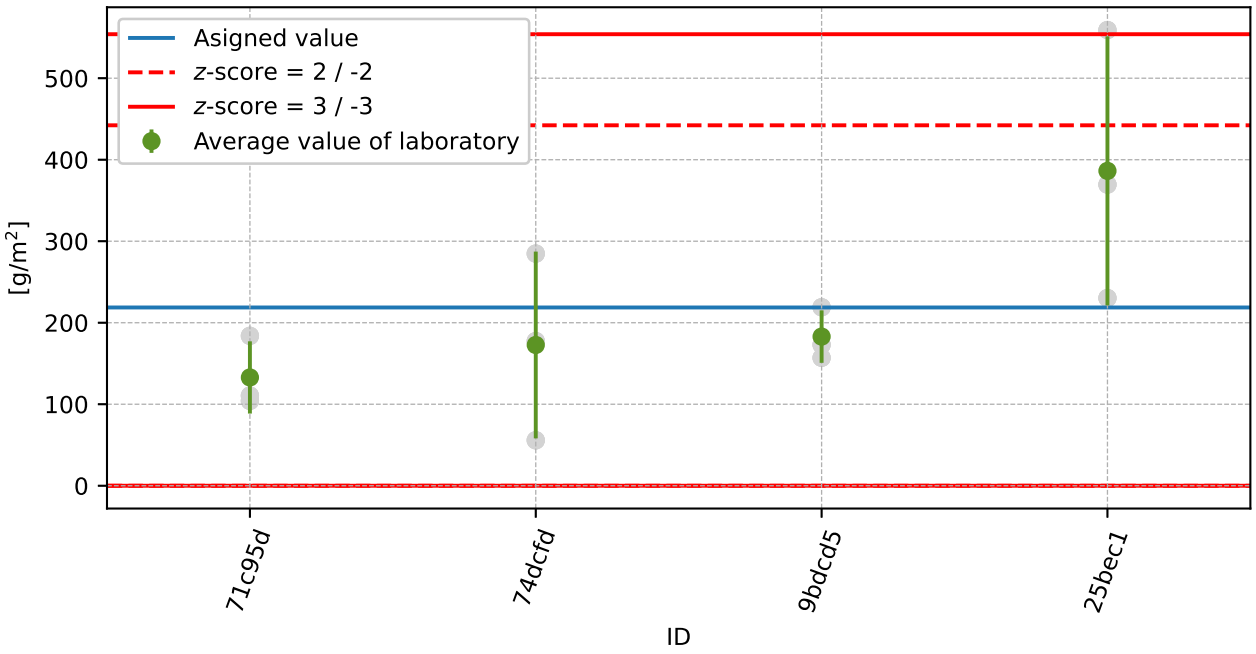

Figure 82: Average values and sample standard deviations

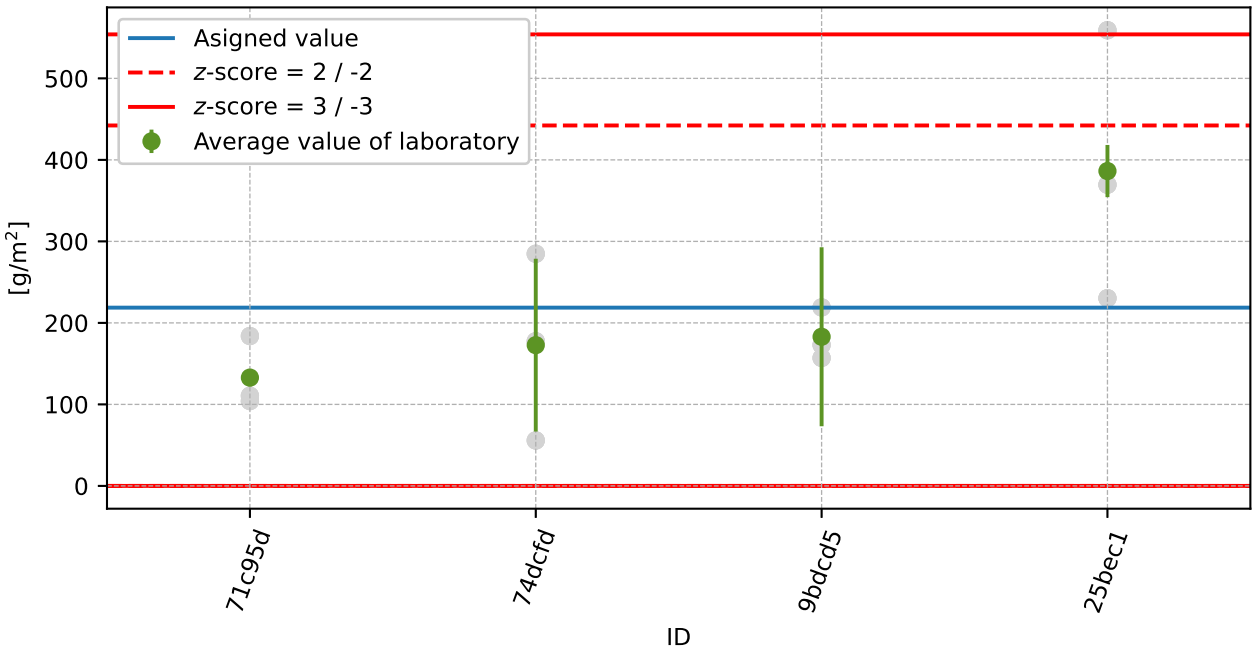

Figure 83: Average values and extended uncertainties of measurement

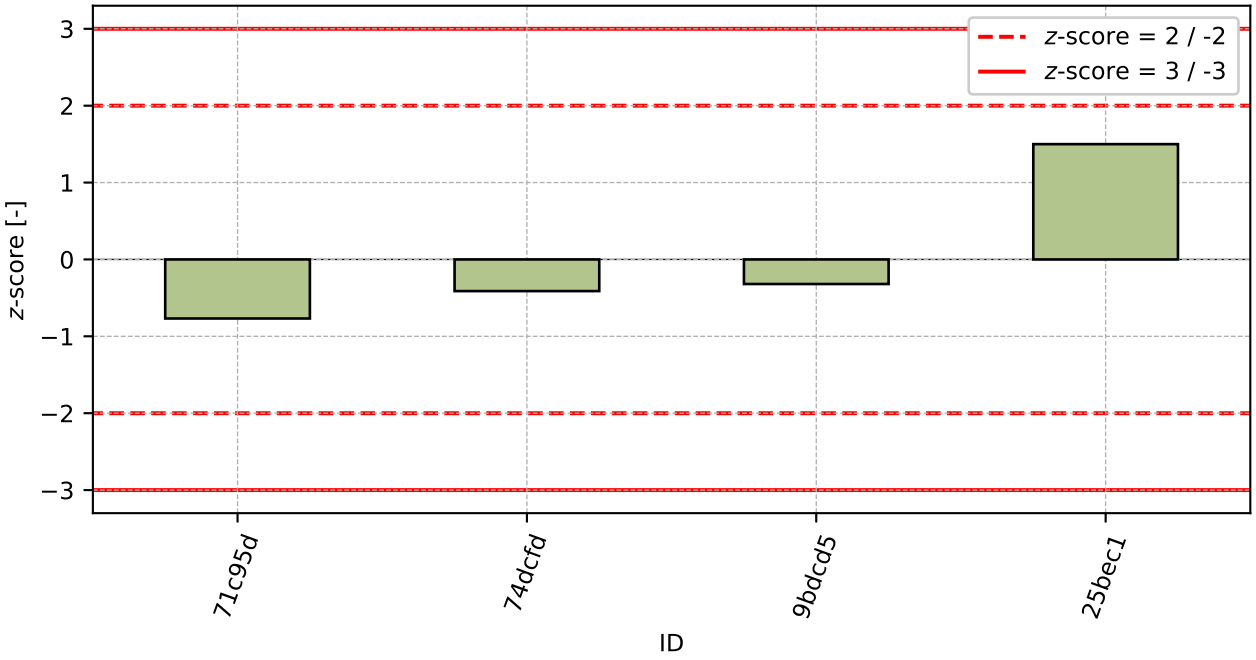

Figure 84: z-score

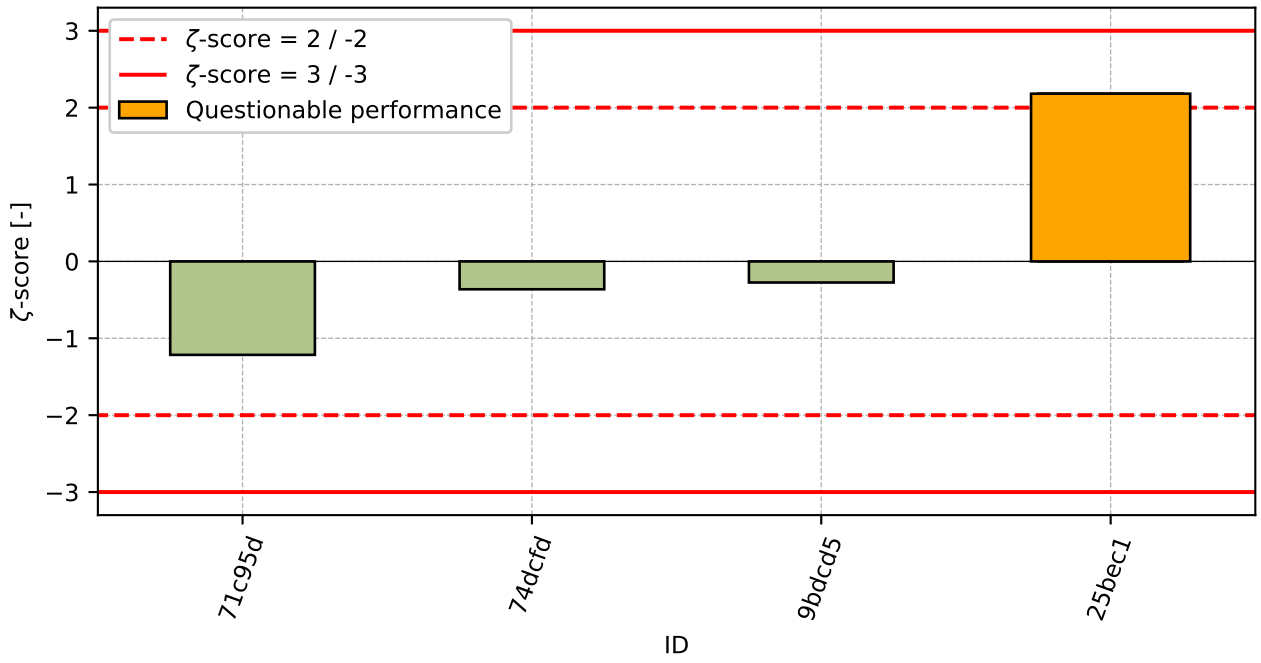

Figure 85: ζ-score

Table 30: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
71c95d	-0.77	-1.22
74dcfd	-0.41	-0.36
9bdcd5	-0.32	-0.27
25bec1	1.5	2.18

8.3 75 cycles

8.3.1 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/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
71c95d	193	283	218	18	231	46.4	20.05
74dcfd	620	566	84	159	423	295.1	69.74
9bdcd5	875	525	773	435	724	180.0	24.85
25bec1	1906	1349	1286	78	1514	341.4	22.55

8.3.2 The Numerical Procedure for Determining Outliers

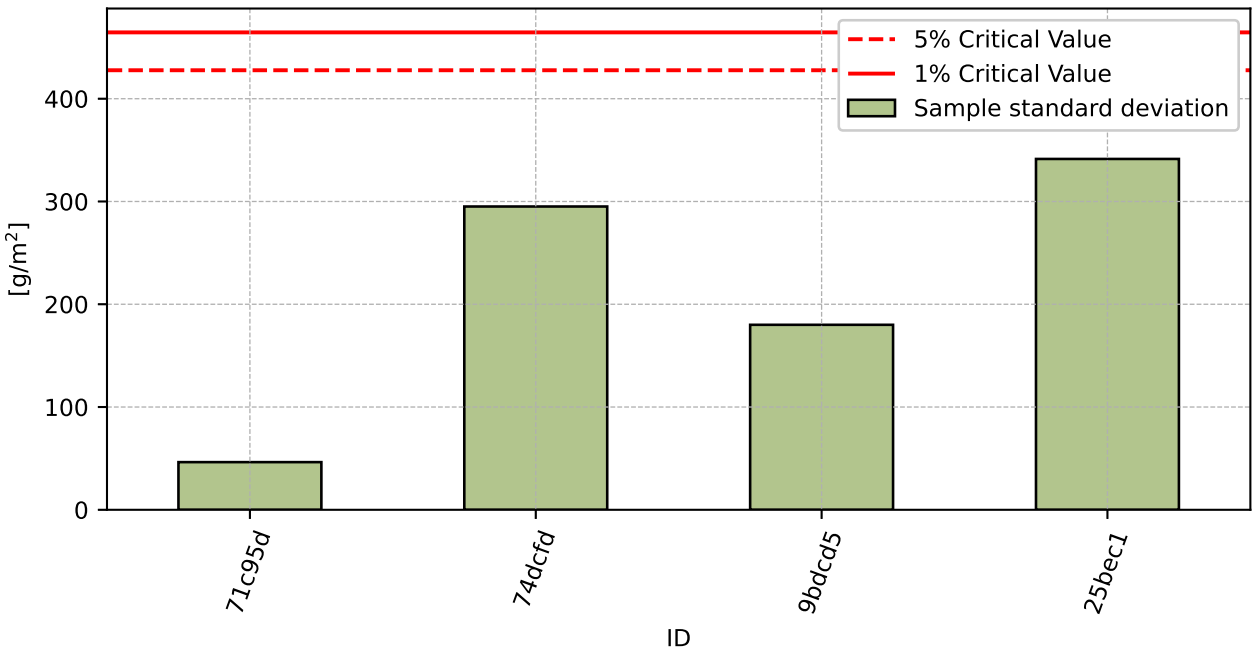

Figure 86: **Cochran's test** - sample standard deviations

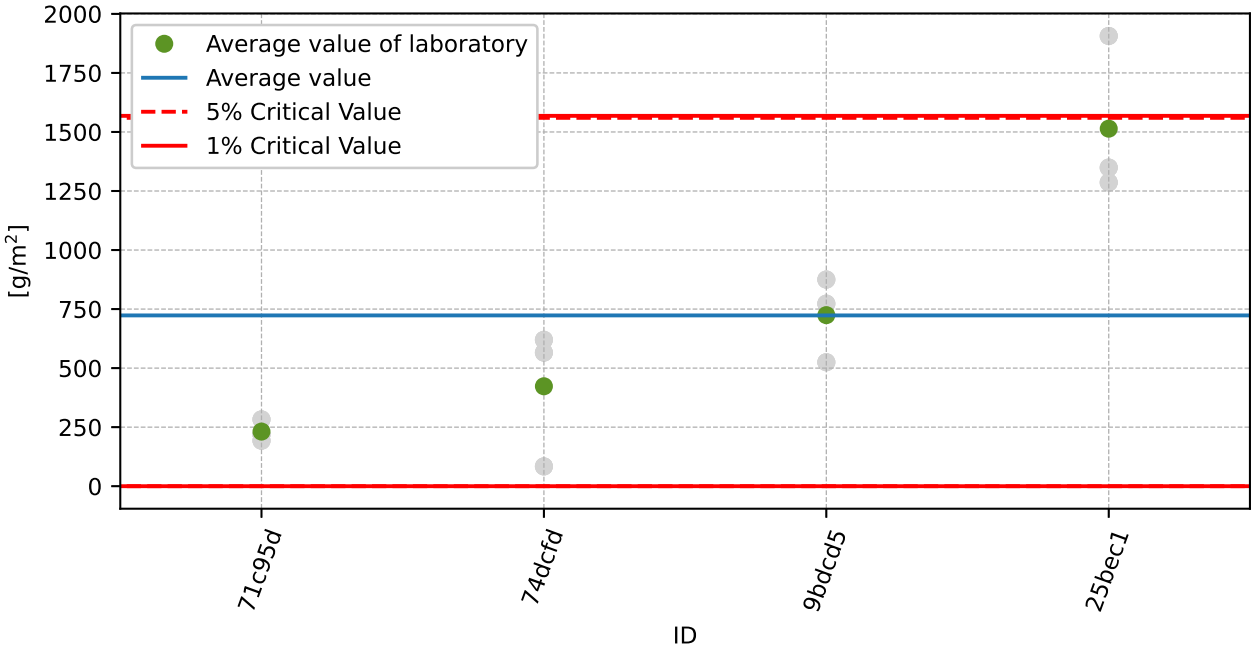

Figure 87: **Grubbs' test** - average values

8.3.3 Mandel's Statistics

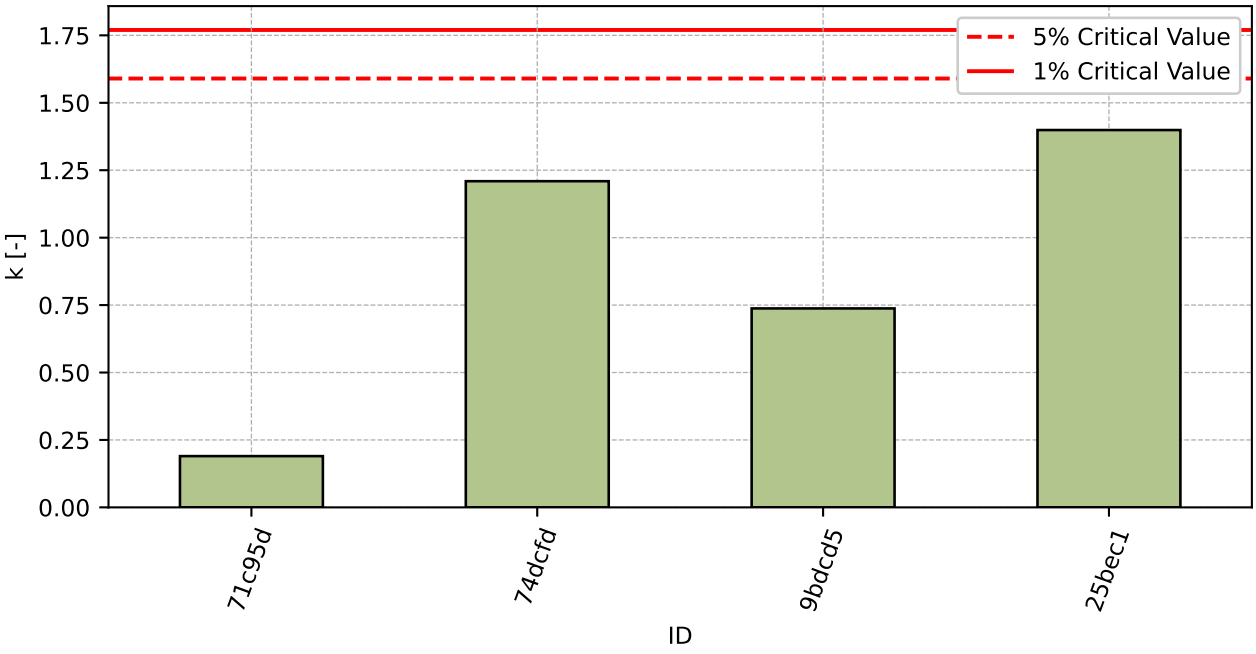

Figure 88: Intralaboratory Consistency Statistic

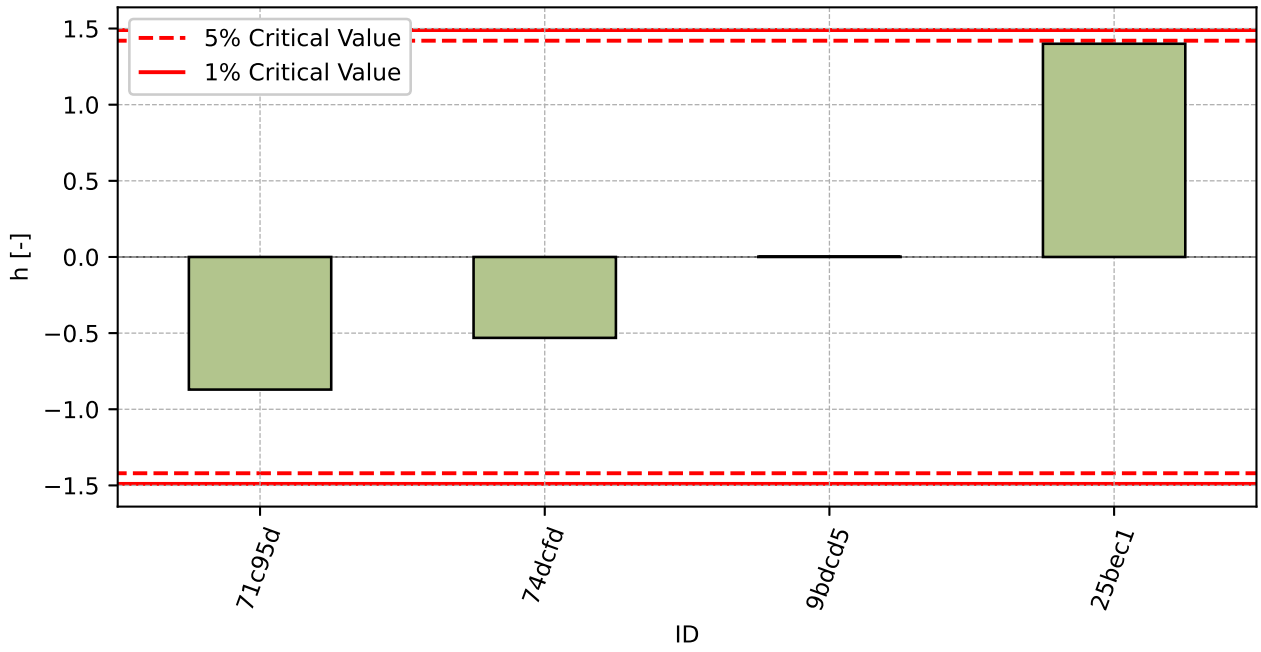

Figure 89: Interlaboratory Consistency Statistic

8.3.4 Descriptive statistics

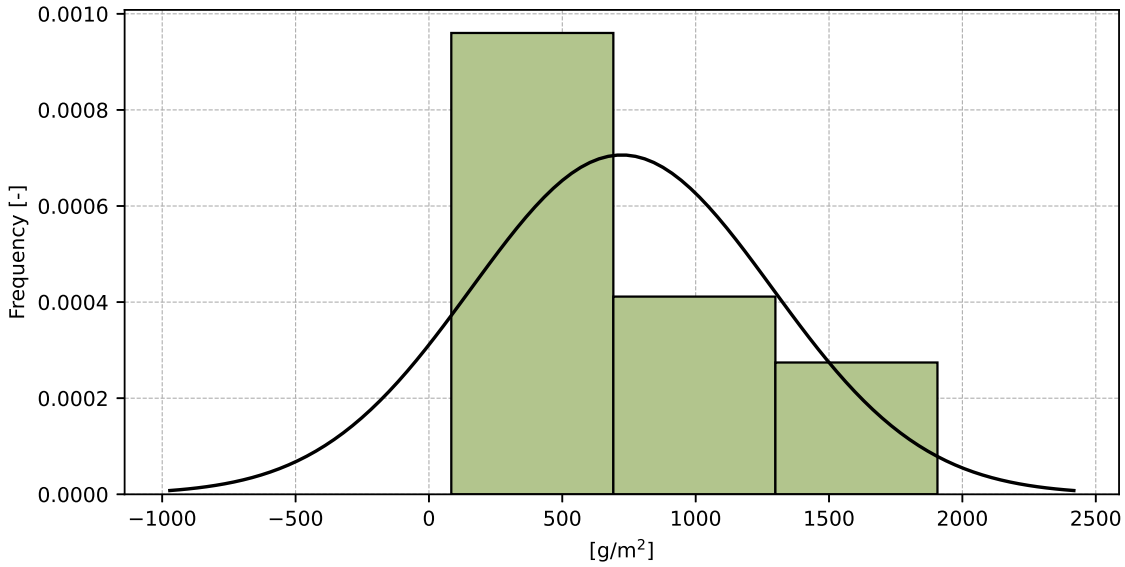

Figure 90: Histogram of all test results

Table 32: Descriptive statistics

Characteristics	[g/m^2]
Average value – $\bar{x}$	723.0
Sample standard deviation – s	564.9
Asigned value – x^*	723.0
Robust standard deviation – s^*	554.8
Measurement uncertainty of asigned value – u_X	346.7
p-value of normality test	0.256 [-]
Interlaboratory standard deviation – s_L	547.0
Repeatability standard deviation – s_r	244.0
Reproducibility standard deviation – s_R	599.0
Repeatability – r	683.0
Reproducibility – R	1677.0

8.3.5 Evaluation of Performance Statistics

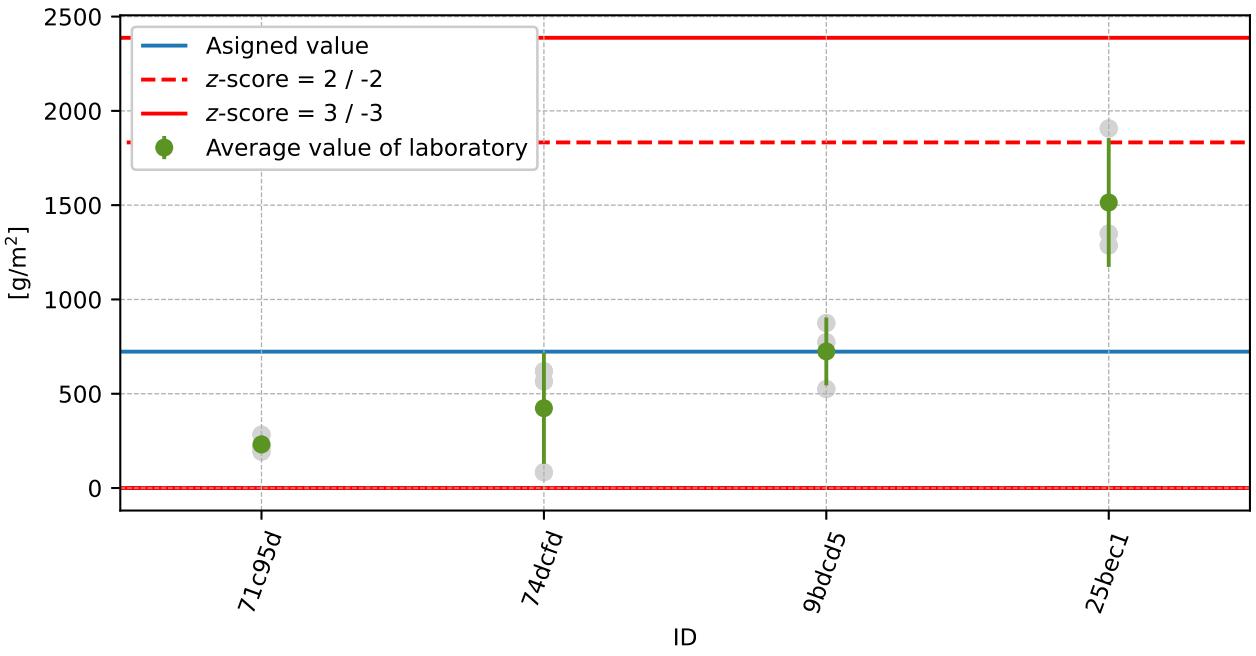

Figure 91: Average values and sample standard deviations

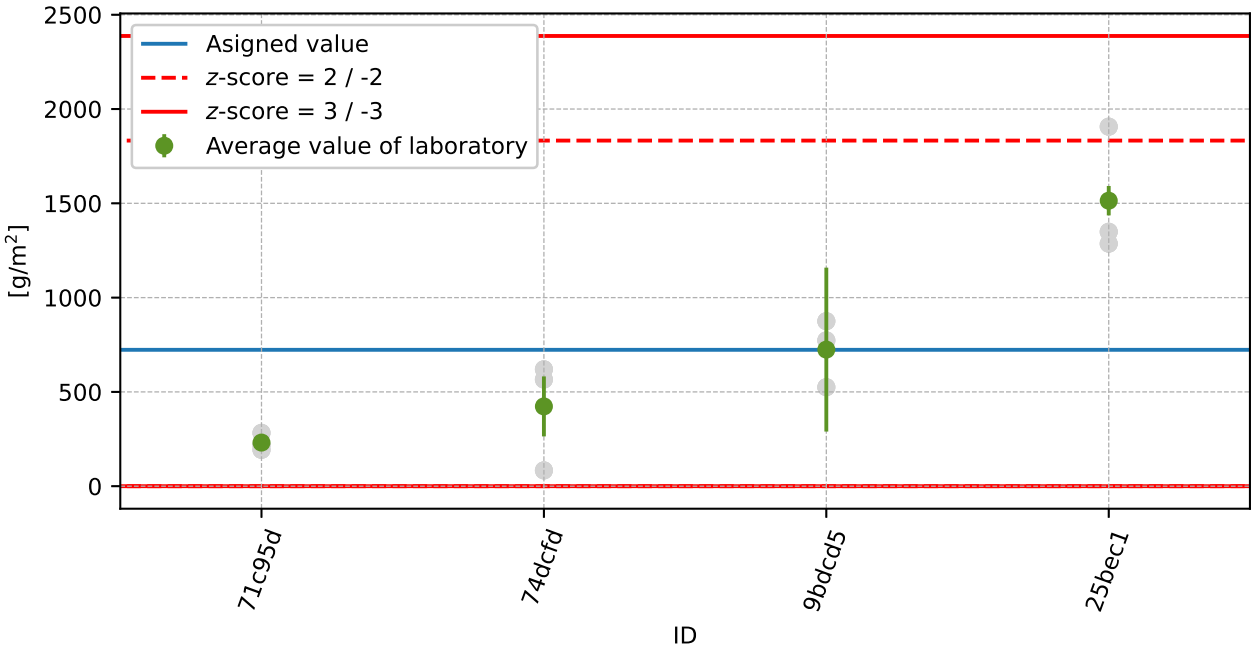

Figure 92: Average values and extended uncertainties of measurement

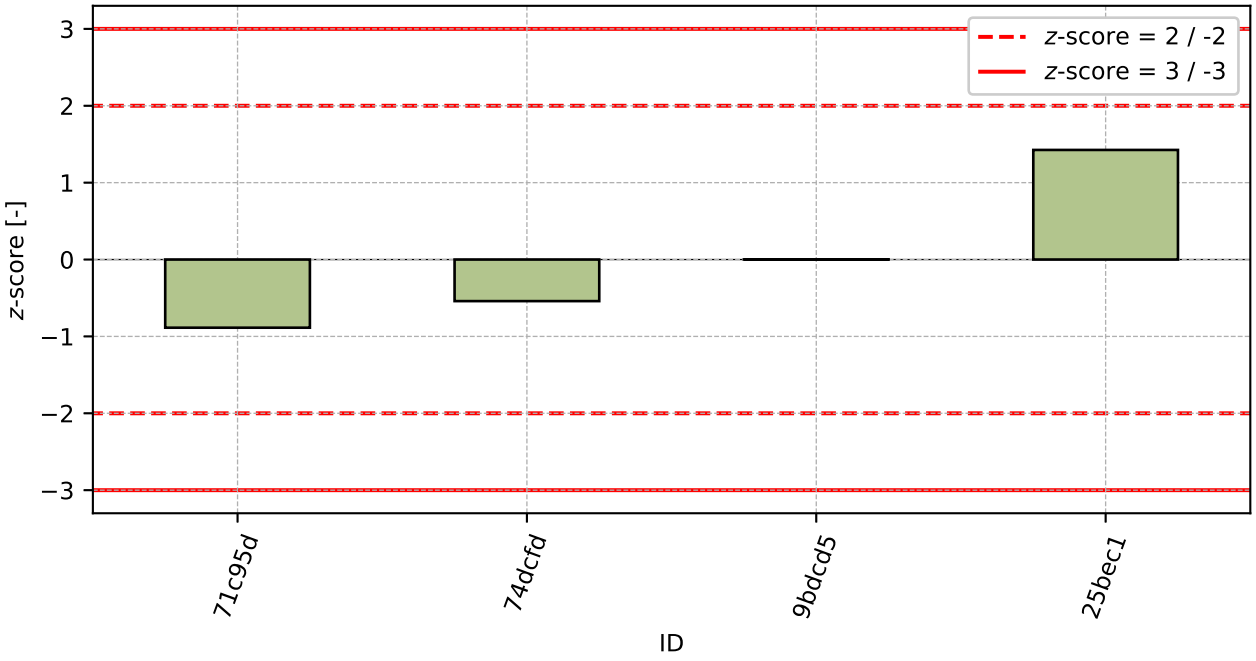

Figure 93: z-score

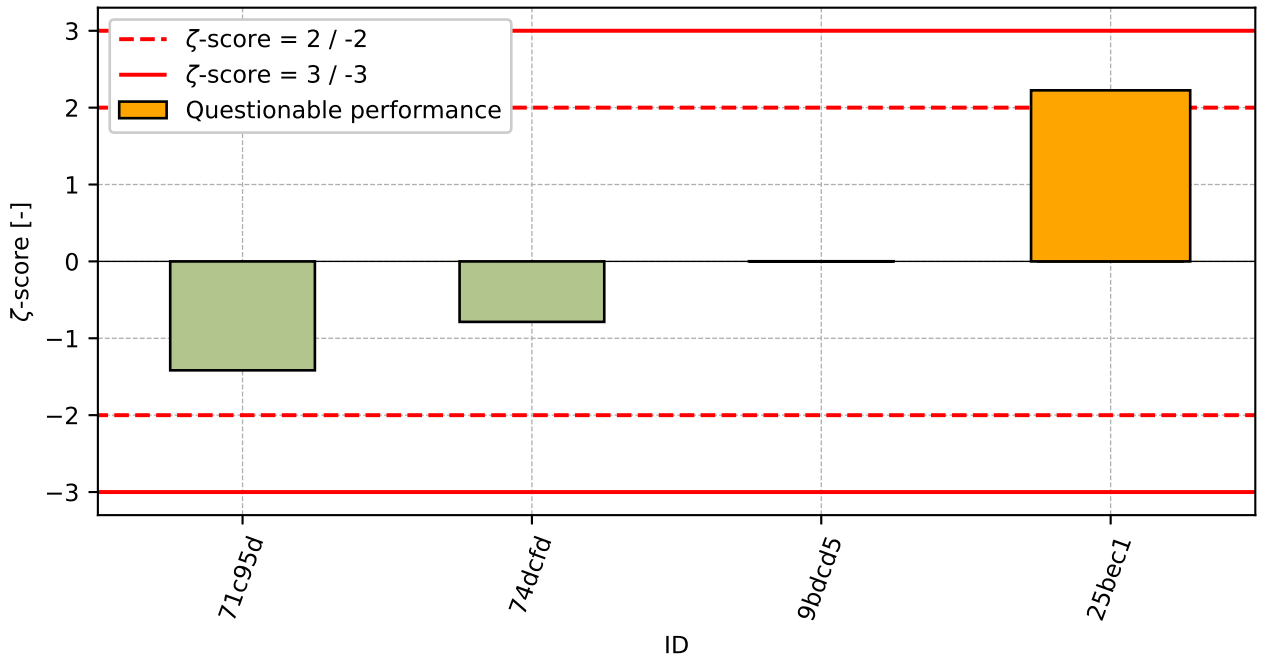

Figure 94: ζ-score

Table 33: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
71c95d	-0.89	-1.42
74dcfd	-0.54	-0.79
9bdcd5	0.0	0.0
25bec1	1.43	2.23

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.