BRNO UNIVERSITY OF TECHNOLOGY

Z 7008

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 2019/1

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1 Introduction and Important Contacts

In the year 2019, the Proficiency Testing Provider at the SZK FAST (PT Provider) initiated the Proficiency Testing Program (PTP) designated ZZB 2019/1 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

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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. **EN 12390-9** – Freeze-thaw resistance – Scaling [8].

Testing procedures No 6 and 9 were not open due to the lack of participants.

The supplier, BETOTECH s. r. o., was responsible for the preparation of hardened concrete for the PTP. Fresh concrete for the preparation of test samples was taken from one production batch prepared in accordance with methods stipulated in EN 206 [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.

61 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
225db2	-	-	X	-	-	-	-	-	-
a047ef	X	X	X	-	-	-	X	-	-
846d9f	-	-	X	-	-	-	-	-	-
104312	X	X	X	X	-	-	-	-	-
e9939d	X	X	X	X	-	-	-	X	-
927d69	X	X	X	-	-	-	-	-	-
7f01fe	X	X	X	-	-	-	-	-	-
ac423f	X	X	X	-	-	-	-	-	-
53746b	X	X	X	-	-	-	-	-	-
607715	X	X	X	-	X	-	X	-	-
41b551	X	X	X	X	-	-	-	-	-
3dca00	X	X	X	-	-	-	X	-	-
3223f9	X	-	-	-	-	-	-	-	-
f7b2a7	X	X	-	-	-	-	-	-	-
e4fac2	X	-	-	-	-	-	-	-	-
d7e593	-	-	X	-	-	-	-	-	-
2f5f6b	-	-	-	-	-	-	X	-	-
fadcfb	-	-	-	-	-	-	X	-	-
b05dca	X	X	X	-	-	-	-	-	-
4dcf37	X	-	-	-	-	-	-	-	-
6f4e0b	X	-	-	-	-	-	-	-	-
95a94b	-	-	-	-	-	-	X	-	-
06ae32	X	X	X	-	X	-	X	-	-
693362	X	X	-	-	-	-	X	-	-
a2c747	X	X	X	-	X	-	-	X	-
cba2c0	-	-	X	-	-	-	-	X	-
8b8895	X	X	X	-	X	-	-	X	-
7377a1	X	X	X	-	-	-	X	-	-
61aad6	-	-	-	-	X	-	-	-	-
9081b8	-	-	-	-	-	-	X	-	-
bfd580	-	-	-	-	-	-	X	-	-
0a5f17	-	-	-	-	-	-	X	-	-
f181ac	-	-	-	-	-	-	X	-	-
6110fc	-	-	-	-	-	-	X	-	-
ecacdb	-	-	-	-	-	-	X	-	-
11b3ff	X	X	-	-	-	-	-	-	-
2059ff	X	-	X	-	-	-	-	-	-
373ab3	-	-	X	-	-	-	-	X	-
0aba71	-	X	-	-	X	-	X	-	-
7cd562	-	-	-	-	X	-	X	-	-
e3d536	X	X	X	-	-	-	X	-	-
7f786d	X	X	-	-	-	-	-	-	-
63c6ad	-	-	-	X	-	-	-	-	-
98a141	X	-	X	-	X	-	-	-	-
64eca6	-	-	-	-	-	-	X	-	-
3c6e73	-	-	-	-	X	-	-	-	-
16d743	X	X	-	-	-	-	-	-	-

ID / Testing method	1	2	3	4	5	6	7	8	9
6a1808	X	X	-	-	-	-	-	-	-
54911e	X	X	-	-	-	-	-	-	-
f25f78	X	X	X	-	-	-	-	-	-
d87536	X	X	X	-	X	-	-	-	-
ced094	X	X	X	-	-	-	-	X	-
0b6f2b	-	-	-	-	-	-	X	-	-
1f5827	-	-	-	-	-	-	X	-	-
69a37c	-	X	-	-	-	-	-	-	-
a7e31f	-	-	X	-	-	-	X	-	-
0e3e27	-	-	-	X	-	-	X	-	-
50afa7	X	X	X	-	-	-	-	X	-
654483	-	-	X	X	X	-	X	X	-
717105	X	X	-	-	-	-	-	-	-
98d189	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
BASF Stavební hmoty Česká republika s.r.o. - Zkušební laboratoř betonu Praha	K Májovu 1244, Chrudim, 537 01, Česká republika	1495
BETONTEST, spol. s r. o.	Trnkova 162, Brno, 62800, Česká republika	1116
BETOTECH, s.r.o. - pracoviště Beroun	Beroun 660, Beroun, 266 01, Česká republika	1195
BETOTECH, s.r.o. - pracoviště Brno	Beroun 660, Beroun, 266 01, Česká republika	1195.3
BETOTECH, s.r.o. - pracoviště Cheb	Beroun 660, Beroun, 26601, Česká republika	1195
BETOTECH, s.r.o. - pracoviště Jindřichův Hradec	Beroun 660, Beroun, 26601, Česká republika	1195
BETOTECH, s.r.o. - pracoviště Klatovy	Beroun 660, Beroun, 26601, Česká republika	1195
BETOTECH, s.r.o. - pracoviště Most	Beroun 660, Beroun, 26601, Česká republika	1195
BETOTECH, s.r.o. - pracoviště Ostrava	Beroun 660, BEROUN, 266 01, Česká republika	1195.2
BETOTECH, s.r.o. - pracoviště Trutnov	Beroun 660, Beroun, 26601, Česká republika	1195
C-lab LLC testing laboratory	105 Artashisyan street, Yerevan, 0039, Armenia	005/T-052
CEMEX Czech Republic, s.r.o.	Semtín 102, Pardubice, 53354, Česká republika	1302
CRH (Slovensko)a.s.	Rohožník, Rohožník, 906 38, Slovenská republika	426/S-313
Cement Hranice. akciová společnost	Bělotínská 288, Hranice, 75301, Česká republika	1284
DOO Geomehanika, Ivica Ivandić	Dobropoljska 21, Belgrade, 11 000, Serbia	-
Danish Technological Institute	Kongsvang Allé 29, Aarhus C, DK-8000, Denmark	-

Laboratory	Address	Accreditation number
Dobrovolný laboratoř s.r.o.	bratří Mrštíků 315/15, Brno - Husovice, 61400, Česká republika	-
GEOTEST SHPK	AUTOSTRADA TIRANE-DURRES, KM2, MEZEZ, KASHAR, TIRANA, ALBANIA, TIRANA, KASHAR 1051, ALBANIA	LT 090 11/02/2019
Holcim (Hrvatska) d.o.o.	Koromačno 7b, Koromačno, HR – 52222 Koromačno, Croatia	1528
Institute for Materials Testing JSC	Bulevar vojvode Mišića 43, Belgrade, 11000, Serbia	-
JKV TEST s.r.o.	Suhrady 148/4, Vřesina (u Hlučína), 74720, Česká republika	1294
Kloknerův ústav - ČVUT v Praze	Šolínova 7, Praha 6, 16608, Czech republic	1061
LABBET-Betosan s.r.o.	Nová cesta 40/291, Praha 4 - Krč, 140 00, Česká republika	1687
Laboratoire Central des Travaux Publics - LCTP	1, rue Kaddour RAHIM- HUSSEIN DEY, ALGER, 16040, ALGERIE	-
M.I.S. a.s.	Resslova 956/13, Hradec Králové, 500 02, Česká republika	1197
MIRTEC S.A.(EBETAM A.E.), Thiva Branch	72nd Km of Athens-Lamia National Road, Ritsona, Chalkida, 34100, Greece	0453
Northern Regional Laboratory JKR Sarawak	Canna Road, Tabuan Jaya, Kuching, 93350, Sarawak, Malaysia	-
QUALIFORM SLOVAKIA s.r.o. , Pracovisko 01 Bratislava	Pasienková 9 D, Bratislava, 82106, Slovenská republika	154/S-301
QUALIFORM SLOVAKIA s.r.o. - organizační složka	Lesní 693, Bílovice nad Svitavou, 66401, Česká republika	S-301
QUALIFORM, a.s. - pracoviště č. 01, Brno	Mlaty 672/8, Brno - Bosonohy, 642 00, Česká republika	1008
QUALIFORM, a.s. - pracoviště č. 06, Praha	Mlaty 672/8, Brno - Bosonohy, 642 00, Česká republika	1008
SQZ s.r.o.	U místní dráhy 939/5, Olomouc - Nová ulice, 779 00, Česká republika	1135.2
SQZ, s.r.o. - organizačná zložka Bratislava	Mlynské Nivy 68, Bratislava, 82105, Slovensko	566/S-376
STACHEMA Bratislava a.s.	Železničná 714/180, Rovinka, 900 41, Slovenská republika	S-275
Sibotec cvba	Industriepark Oost 6, Beernem, 8730, Belgium	-
Stachema CZ s.r.o., Zkušební laboratoř, Pracoviště 1	Hasičská 1, Zibohlavy, Kolín, 28002, Česká republika	L 1433
Stachema CZ s.r.o., Zkušební laboratoř, Pracoviště 2	Hasičská 1, Zibohlavy, Kolín, 28002, Česká republika	L 1433
Stavební fakulta, ČVUTv Praze	Thákurova 7, Praha, 16629, Česká republika	1048
TZÚS Praha, s.p. - pobočka České Budějovice	Nemanická 441, České Budějovice, 37010, Česká republika	1018.3
TZÚS, s.p. Centrální laboratoř - zkušebna Plzeň	Zahradní 15, Plzeň, 326 00, Česká republika	1018.3
Technický a skúšobný ústav stavebný, n. o., skúšobné pracovisko Bratislava	Studená 3, Bratislava, 821 04, Slovenská republika	S-045

Laboratory	Address	Accreditation number
Technický a skúšobný ústav stavebný, n. o., skúšobné pracovisko Nitra	Studená 3, Bratislava, 821 04, Slovenská republika	S-045
Technický a skúšobný ústav stavebný, n. o., skúšobné pracovisko Nové Mesto nad Váhom	Studená 3, Bratislava, 821 04, Slovenská republika	S-045
Technický a skúšobný ústav stavebný, n. o., skúšobné pracovisko Prešov	Studená 3, Bratislava, 821 04, Slovenská republika	S-045
Technický a skúšobný ústav stavebný, n. o., skúšobné pracovisko Zvolen	Studená 3, Bratislava, 821 04, Slovenská republika	S-045
Technický a skúšobný ústav stavebný, n. o., skúšobné pracovisko Žilina	Studená 3, Bratislava, 821 04, Slovenská republika	S-045
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
Technický a zkušební ústav stavební Praha, s.p.	Tolstého 447, Teplice, 415 03, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p., pobočka Praha	Prosecká 76a/811, Praha 9, 190 00, Česká republika	1018.3
Universitaet fuer Bodenkultur Wien	Peter-Jordan-Str. 82, Wien - Vienna, 1190, Austria	-
Universiteit Gent (Laboratorium Magnel voor Betononderzoek)	Technologiepark - Zwijnaarde 60, Zwijnaarde (Ghent), 9052, Belgium	220-TEST
University of Technology - TVFA	Inffeldgasse 24, Graz, 8010, Austria	-
Vysoké učení technické v Brně, Fakulta stavební, Akreditovaná zkušební laboratoř při ÚTHD FAST VUT v Brně	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
Výzkumný ústav pro hnědé uhlí a.s.	tř. Budovatelů 2830/3, Most, 43401, Česká republika	1078
ZAPA beton a.s.	ZAPA beton a.s. , PO BOX č. 31, Klatovská tř. 127, Plzeň 20, 320 81, Česká republika	1439
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2018
Ústav stavebního zkušebnictví s.r.o.	Jiřího Potůčka 115, Pardubice, 53009, Česká republika	1115
Ústav stavebního zkušebnictví, Fakulta stavební VUT	Veveří 95, Brno, 60200, Česká republika	-
Ředitelství silnic a dálnic ČR	Rebešovická 40, Brno-Chrlice, 643 00, Česká republika	1072

2 Procedures used in the Statistical Analysis of Laboratory Results

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 ZZB 2019/1 (PT Program) organized by the PT Provider at the SZK FAST, Brno University of Technology. 61 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.

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. The assigned value and its uncertainty were determined according to the procedures stated in the section 2. z-score and ζ-score are compared with limit values (see part 2). 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.

3.1 EN 12390-3 – Compressive strength of test specimens

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 1 of the Appendix.

The numerical critical evaluation of the test results using Grubbs' test has shown that results of participant 7f786d exceeded the 5% critical value. A more detailed analysis has revealed that the outlying variability of this participant was caused by one test result only; after its removal the critical values of Grubbs' test were no longer exceeded. The numerical critical evaluation of the test results using Cochran's has not shown the exceedance of critical values. The graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. 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. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13258 [12]). The following table shows the results of statistical analysis.

Participant	Result	Evaluation
7f786d	z-score > 2	questionable performance

The results of all other participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.2 EN 12390-7 – Density of hardened concrete

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 2 of the Appendix.

The numerical critical evaluation of the test results using Cochran's and Grubbs' test has not shown any exceedance of critical values. Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. 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. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13258 [12]). The following table shows the results of statistical analysis.

Participant	Result	Evaluation
f7b2a7	z-score > 2	questionable performance

The results of all other participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.3 EN 12390-8 – Depth of penetration of water under pressure

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 3 of the Appendix.

The numerical critical evaluation of the test results using Cochran's and Grubbs' test has not shown any exceedance of critical values. Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. 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. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13258 [12]). The results of all participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

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

Three characteristics were measured within this testing method: Total air content A, Micro air content A_{300} and Spacing factor L. The test results were evaluated separately for each level (see part 4 of appendix).

The numerical and graphical critical evaluation of the test results has not shown any exceedance of critical values. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13258 [12]). The results of all participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.5 ČSN 73 1322 – Determination of frost resistance of concrete

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 5 of the Appendix.

The numerical critical evaluation of the test results using Cochran's and Grubbs' test has not shown any exceedance of critical values. Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. 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. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13258 [12]). The following table shows the results of statistical analysis.

Participant	Result	Evaluation
8b8895	z-score > 2	questionable performance

The results of all other participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.6 ČSN 73 1324 – Determination of grindability of concrete

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

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

The resistance of cement concrete surface to water and defrosting chemicals was tested in 4 levels given by number of freezing and thawing cycles – 25, 50, 75 and 100 cycles. The test results were evaluated separately for each level (see part 7 of appendix). Participant's results are marked as outlying, questionable or unsatisfactory if critical values are exceeded at two or more levels of the experiment. The assigned value and its uncertainty was determined using the A algorithm (ISO 13258 [12]). The following table shows the results of statistical analysis.

Level	Participant	Evaluation
25 cycles	0aba71	Cochran's test: test results of laboratory were evaluated as outlying and excluded from experiment
	9081b8	z-score > 2: questionable performance

Level	Participant	Evaluation
50 cycles	0aba71	Cochran's test: test results of laboratory were evaluated as outlying and excluded from experiment
	9081b8	Grubbs' test: test results of laboratory were evaluated as outlying and excluded from experiment
	0b6f2b	z-score > 2: questionable performance
75 cycles	9081b8	Grubbs' test: test results of laboratory were evaluated as straggling
	9081b8	z-score > 3: unsatisfactory performance
100 cycles	9081b8	Grubbs' test: test results of laboratory were evaluated as straggling
	9081b8	z-score > 2: questionable performance

Test results of participant **0aba71** were evaluated as **outlying** at two levels of experiment. The limit value z-score $= 2$ was exceeded in the case of participant **9081b8**. The performance of this participant was rated as **questionable**. The results of all other participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13258 [12]). The results of all participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

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

The resistance of cement concrete surface to water and defrosting chemicals was tested in 4 levels given by number of freezing and thawing cycles – 25, 50, 75 and 100 cycles. The test results were evaluated separately for each level (see part 8 of appendix). Participant's results are marked as outlying, questionable or unsatisfactory if critical values are exceeded at two or more levels of the experiment. The assigned value and its uncertainty was determined using the A algorithm (ISO 13258 [12]). The following table shows the results of statistical analysis.

Level	Participant	Evaluation
25 cycles	cba2c0	z-score > 2: questionable performance
50 cycles	-	-
75 cycles	a2c747	z-score > 2: questionable performance
100 cycles	a2c747	z-score > 2: questionable performance

The limit value z-score $= 2$ was exceeded in the case of participant **a2c747**. The performance of this participant was rated as **questionable**. The results of all other participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.9 ČSN P CEN/TS 12390-9 – Freeze-thaw resistance – Scaling

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

References

[1] EN 12390-3. *Testing hardened concrete - Part 3: Compressive strength of test specimens*. 2009.

[2] EN 12390-7. *Testing hardened concrete - Part 7: Density of hardened concrete*. 2009.

[3] EN 12390-8. *Testing hardened concrete - Part 8: Depth of penetration of water under pressure*. 2009.

[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. *Concrete - Specification, performance, production and conformity*. 2014.

[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.

[12] ISO 13 528. *Statistical methods for use in proficiency testing by interlaboratory comparisons*. 2005.

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

1.1 Test results

Table 8: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [N/mm²]			u_X [N/mm²]	$\bar{x}$ [N/mm²]	s_0 [N/mm²]	V_X [%]
7f786d	31.7*	34.8	35.6	0.6	35.2	0.57	1.61
3223f9	37.0	34.2	36.0	0.8	35.7	1.42	3.97
54911e	38.2	35.2	35.2	0.7	36.2	1.73	4.78
50afa7	36.5	37.1	35.2	2.0	36.3	0.97	2.68
927d69	37.7	35.1	36.7	0.3	36.5	1.31	3.59
d87536	36.6	34.5	38.6	1.5	36.6	2.05	5.61
e4fac2	37.3	37.7	35.2	2.1	36.7	1.34	3.66
ced094	36.7	38.2	36.2	1.5	37.0	1.04	2.81
6a1808	37.0	38.7	36.0	1.5	37.2	1.37	3.67
3dca00	40.0	36.7	35.2	-	37.3	2.46	6.58
8b8895	36.4	37.9	37.7	2.8	37.3	0.81	2.18
e9939d	37.7	36.9	37.5	0.3	37.4	0.42	1.11
11b3ff	38.4	37.2	37.1	1.0	37.6	0.72	1.93
2059ff	37.6	37.1	38.0	-	37.6	0.45	1.2
104312	37.0	38.0	37.9	0.2	37.6	0.55	1.46
b05dca	35.6	37.3	40.4	2.5	37.8	2.43	6.44
53746b	37.0	37.6	38.8	1.3	37.8	0.92	2.42
4dcf37	37.1	37.0	39.7	3.8	37.9	1.53	4.04
f25f78	38.3	38.7	36.9	-	38.0	0.96	2.53
693362	38.2	38.8	37.6	0.6	38.2	0.6	1.57
16d743	38.3	38.9	37.5	1.2	38.2	0.7	1.84
7f01fe	36.5	38.8	39.5	0.9	38.3	1.57	4.1
41b551	36.9	39.4	39.2	1.4	38.5	1.39	3.61
98a141	38.0	38.6	39.0	1.3	38.5	0.5	1.31
a2c747	39.8	37.2	38.7	2.0	38.6	1.31	3.38
717105	38.9	38.5	38.4	1.5	38.6	0.26	0.69
607715	38.2	39.2	38.7	1.7	38.7	0.5	1.29
98d189	38.6	38.7	38.9	1.5	38.7	0.15	0.39
e3d536	39.0	40.0	37.4	1.9	38.8	1.31	3.38
6f4e0b	38.0	39.1	39.5	1.8	38.9	0.78	2.0
06ae32	38.4	40.2	38.4	3.5	39.0	1.04	2.66
a047ef	38.8	40.6	39.2	0.7	39.5	0.95	2.39
7377a1	39.0	39.3	40.4	2.0	39.6	0.74	1.86
ac423f	39.9	39.1	40.1	1.2	39.7	0.53	1.33
f7b2a7	41.5	38.0	41.0	0.4	40.2	1.89	4.71

1.2 The Numerical Procedure for Determining Outliers

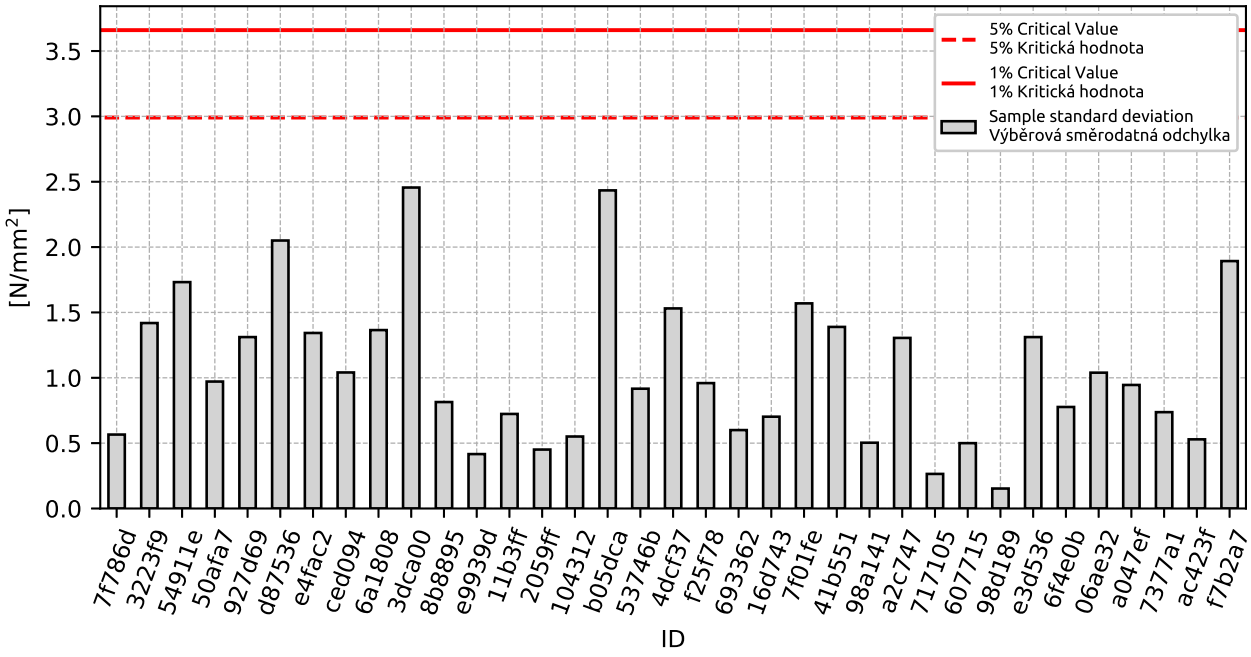

Figure 1: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

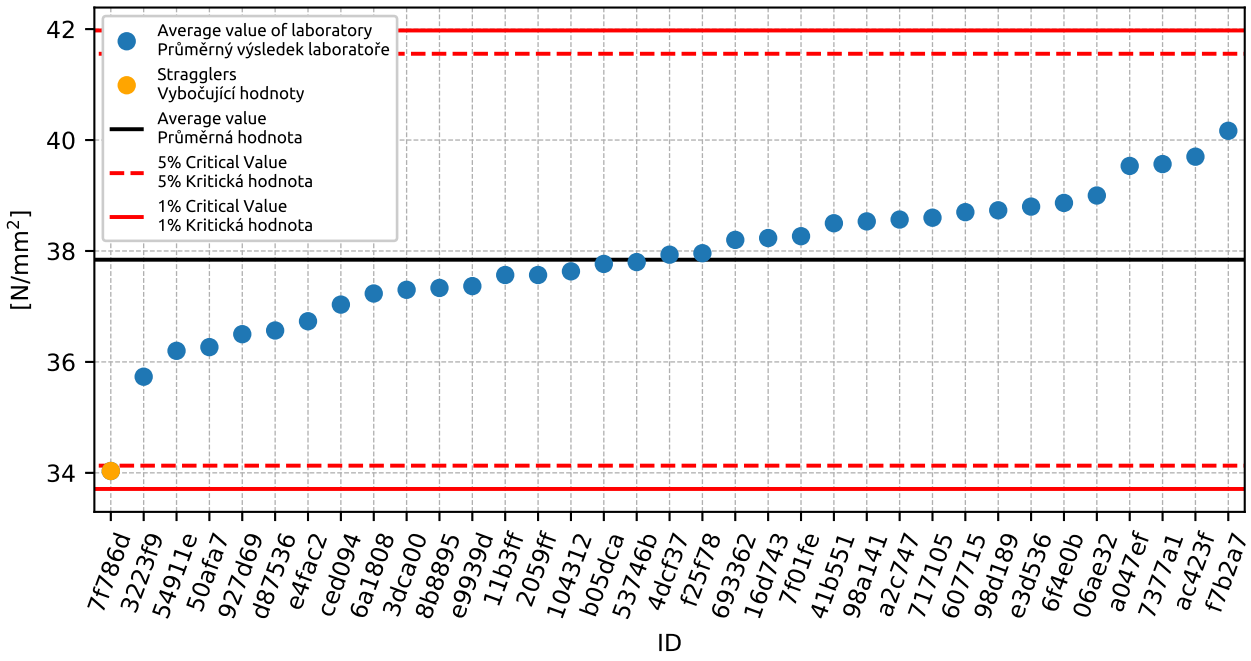

Figure 2: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

1.3 Mandel's Statistics

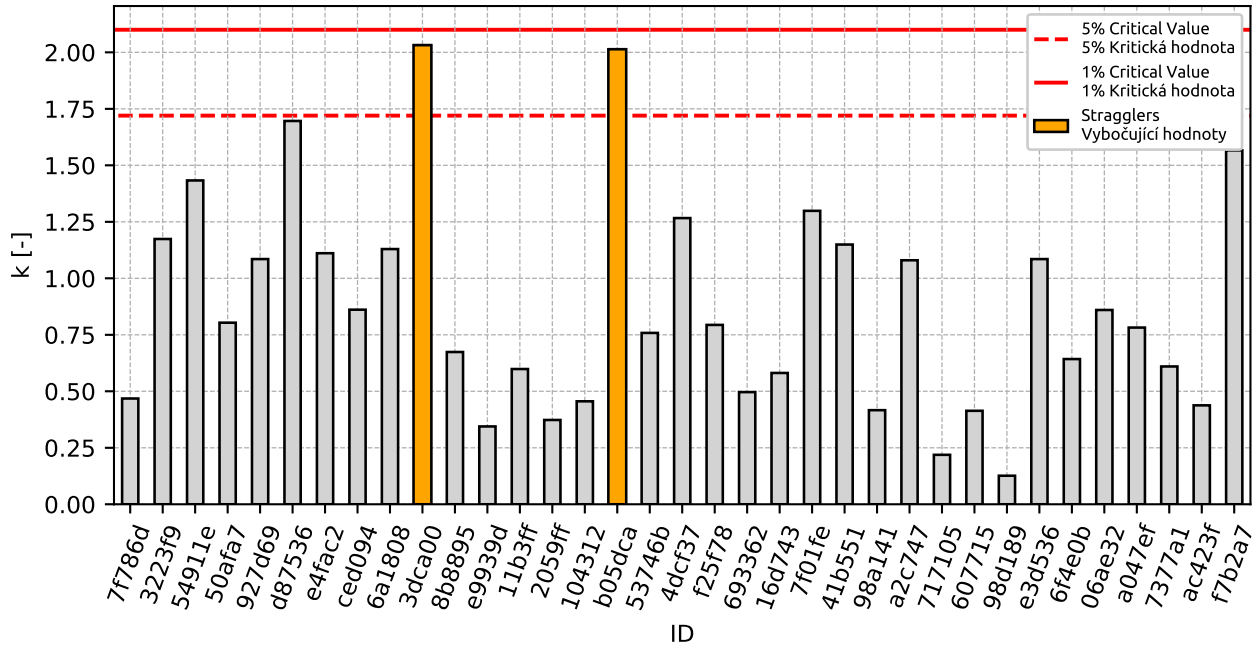

Figure 3: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

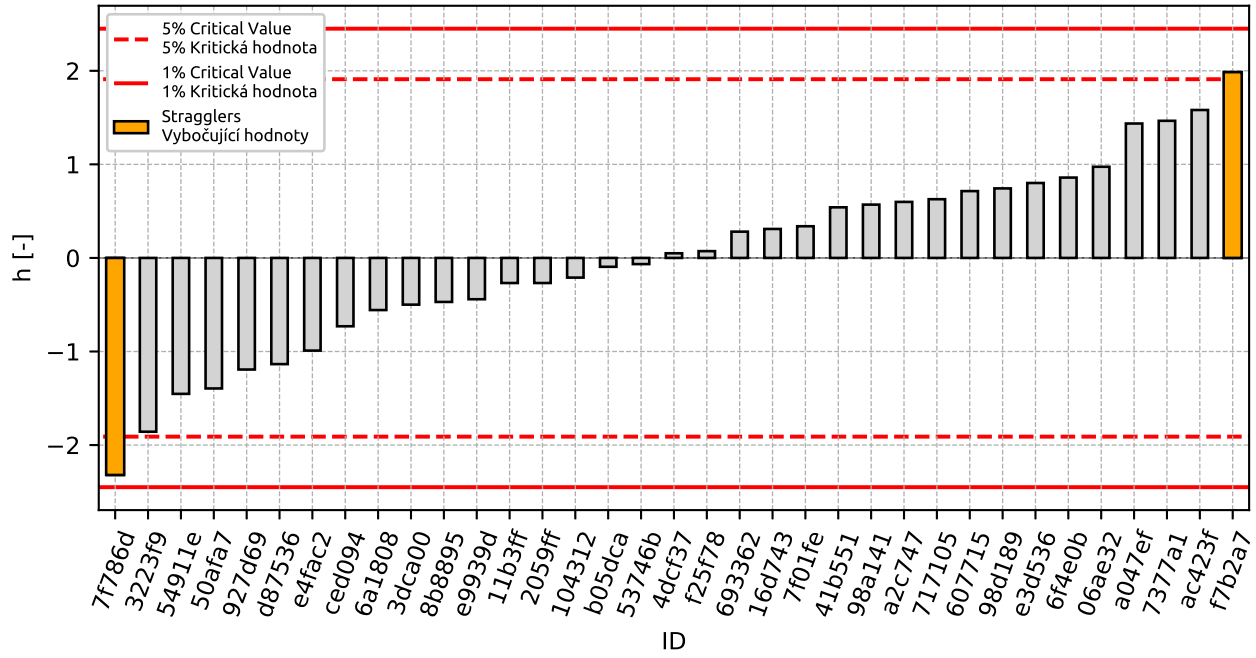

Figure 4: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

1.4 Descriptive statistics

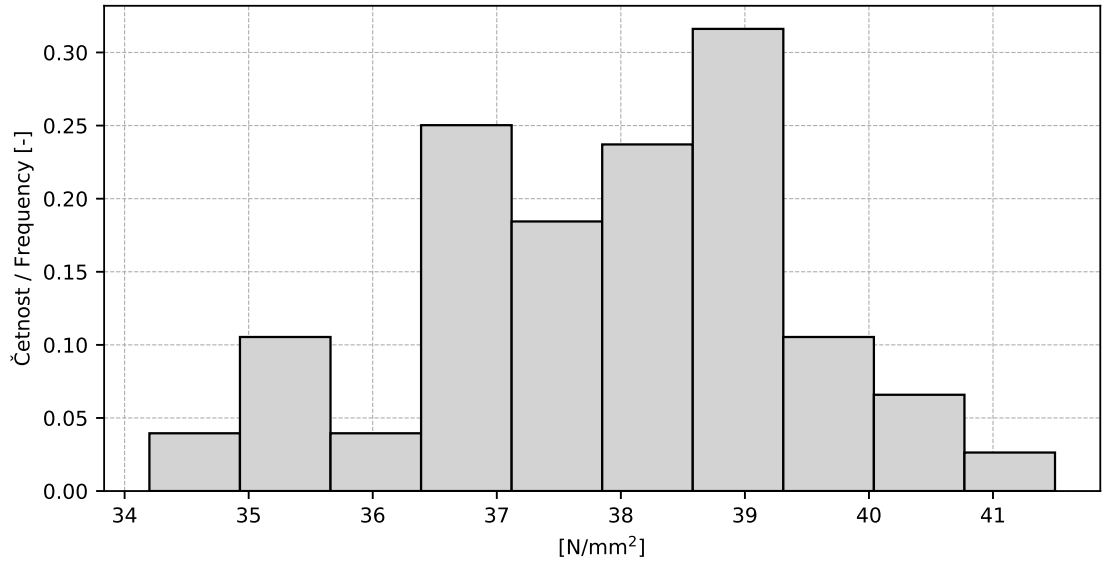

Figure 5: Histogram

Table 9: Descriptive statistics

Value	[N/mm^2]
Průměrná hodnota / Average value – $\bar{x}$	37.9
Výběrová směrodatná odchylka / Sample standard deviation – s	1.15
Vztažná hodnota / Asigned value – x^*	37.9
Robustní směrodatná odchylka / Robust standard deviation – s^*	1.15
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.24
p-hodnota testu normality / p-value of normality test	-
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	0.92
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	1.21
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	1.52
Opakovatelnost / Repeatability – r	3.4
Reprodukovatelnost / Reproducibility – R	4.3

1.5 Calculation of Performance Statistics

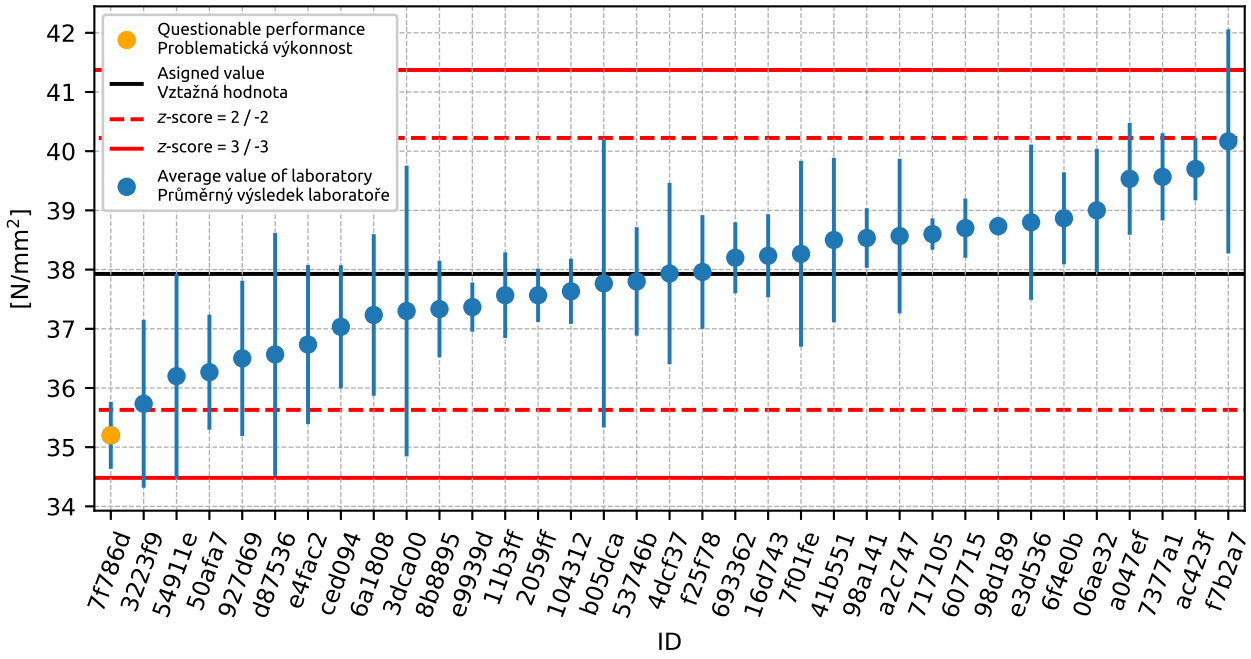

Figure 6: Average values and sample standard deviations

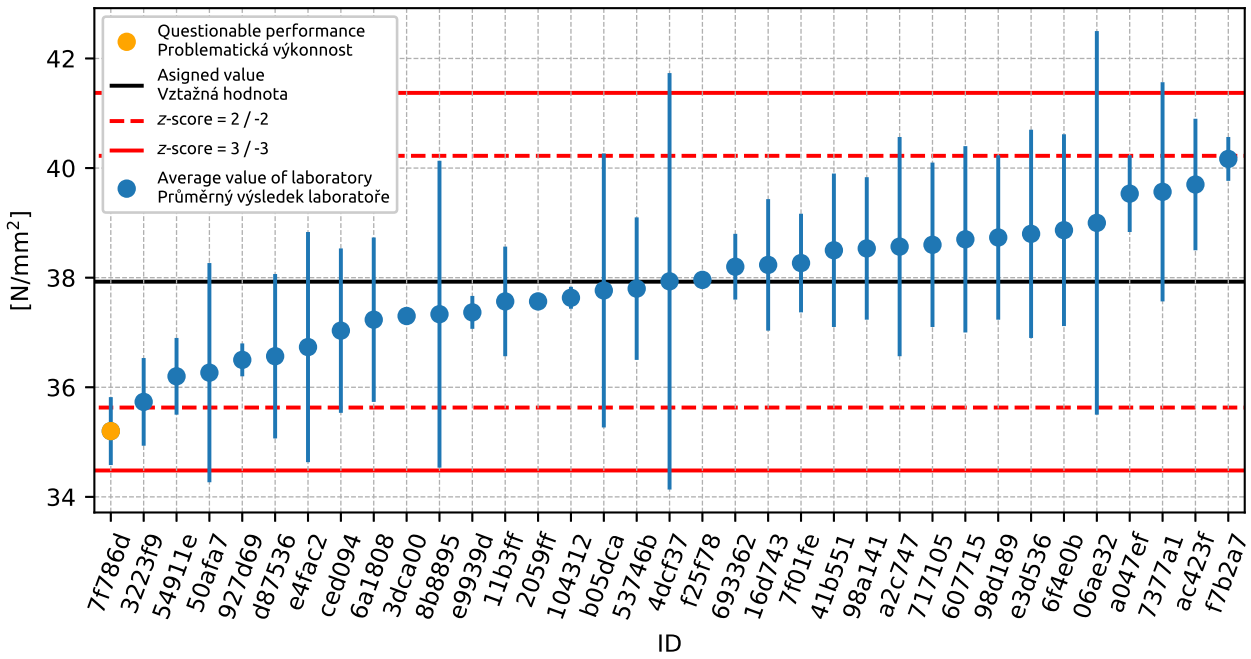

Figure 7: Average values and extended uncertainties of measurement

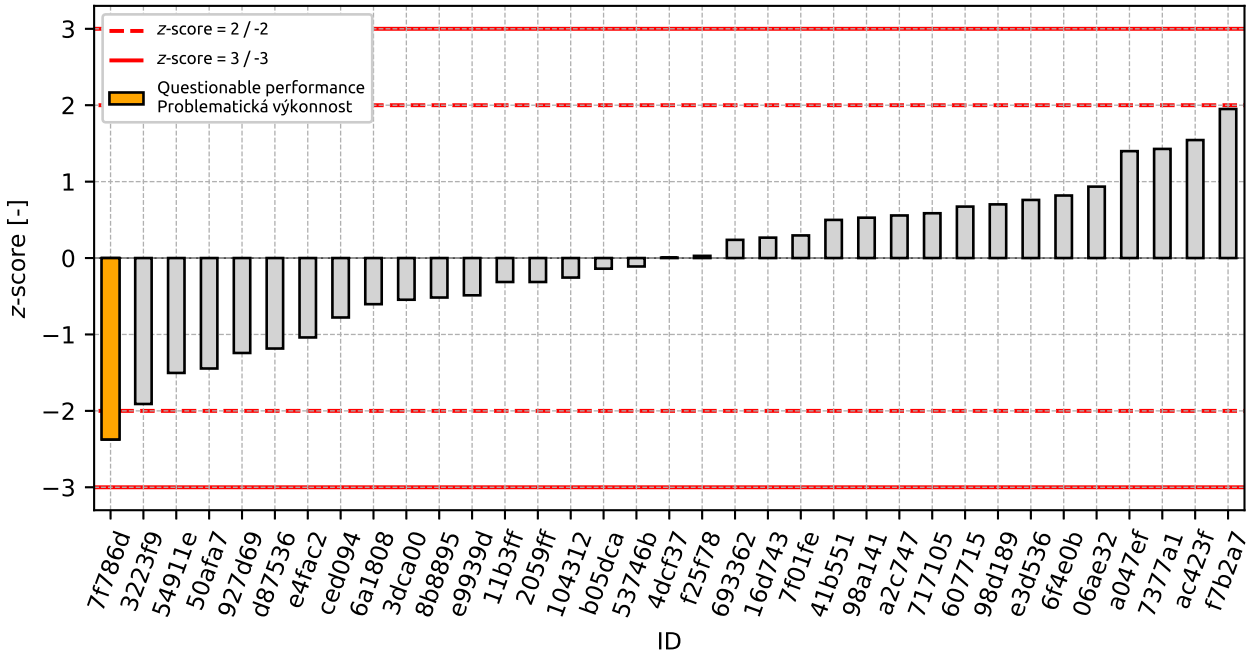

Figure 8: z-score

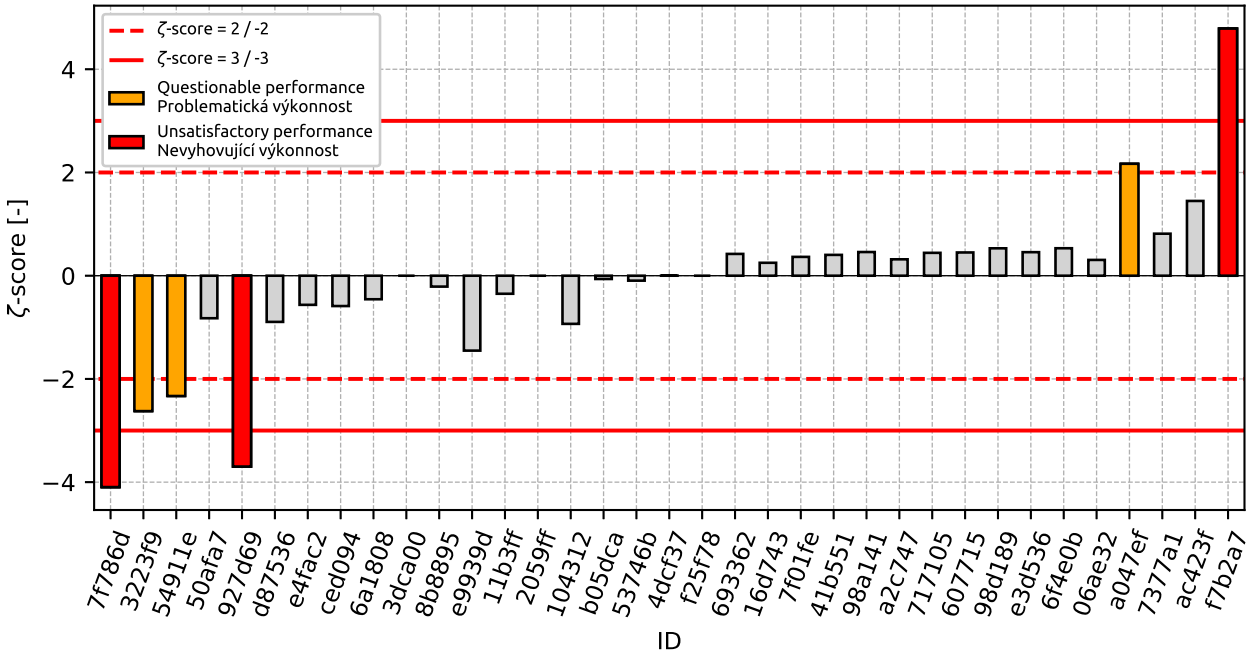

Figure 9: ζ-score

Table 10: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
7f786d	-2.37	-4.1
3223f9	-1.91	-2.62
54911e	-1.5	-2.33
50afa7	-1.45	-0.82
927d69	-1.24	-3.7
d87536	-1.18	-0.9
e4fac2	-1.04	-0.56
ced094	-0.78	-0.59
6a1808	-0.6	-0.46
3dca00	-0.55	-
8b8895	-0.52	-0.21
e9939d	-0.49	-1.45
11b3ff	-0.31	-0.35
2059ff	-0.31	-
104312	-0.26	-0.93
b05dca	-0.14	-0.06
53746b	-0.11	-0.1
4dcf37	0.01	0.0
f25f78	0.03	-
693362	0.24	0.42
16d743	0.27	0.25
7f01fe	0.3	0.36
41b551	0.5	0.4
98a141	0.53	0.46
a2c747	0.56	0.32
717105	0.59	0.44
607715	0.67	0.45
98d189	0.7	0.53
e3d536	0.76	0.46
6f4e0b	0.82	0.53
06ae32	0.93	0.31
a047ef	1.4	2.17
7377a1	1.43	0.81
ac423f	1.54	1.45
f7b2a7	1.95	4.79

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

2.1 Test results

Table 11: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [kg/m³]			u_X [kg/m³]	$\bar{x}$ [kg/m³]	s_0 [kg/m³]	V_X [%]
d87536	2260	2270	2280	25.0	2270.0	10.0	0.44
16d743	2267	2280	2271	23.0	2272.7	6.66	0.29
ac423f	2270	2280	2270	32.0	2273.3	5.77	0.25
e3d536	2300	2280	2260	40.0	2280.0	20.0	0.88
607715	2273	2289	2286	7.8	2282.7	8.5	0.37
ced094	2280	2290	2280	25.0	2283.3	5.77	0.25
b05dca	2270	2300	2280	13.0	2283.3	15.28	0.67
69a37c	2278	2283	2291	10.0	2284.0	6.56	0.29
a047ef	2287	2281	2286	34.0	2284.7	3.21	0.14
6a1808	2289	2286	2284	10.0	2286.3	2.52	0.11
927d69	2270	2290	2300	20.0	2286.7	15.28	0.67
7f01fe	2280	2280	2300	32.0	2286.7	11.55	0.5
7f786d	2280	2290	2290	2.0	2286.7	5.77	0.25
693362	2283	2287	2293	10.0	2287.7	5.03	0.22
11b3ff	2289	2295	2283	10.0	2289.0	6.0	0.26
8b8895	2290	2290	2290	30.0	2290.0	0.0	0.0
06ae32	2290	2290	2290	30.0	2290.0	0.0	0.0
53746b	2280	2300	2290	11.0	2290.0	10.0	0.44
3dca00	2291	2296	2284	-	2290.3	6.03	0.26
a2c747	2300	2300	2280	40.0	2293.3	11.55	0.5
0aba71	2300	2290	2290	17.9	2293.3	5.77	0.25
54911e	2300	2290	2300	10.0	2296.7	5.77	0.25
f25f78	2307	2298	2294	-	2299.7	6.66	0.29
98d189	2310	2290	2300	10.0	2300.0	10.0	0.43
50afa7	2310	2299	2293	25.0	2300.7	8.62	0.37
7377a1	2300	2300	2310	10.0	2303.3	5.77	0.25
717105	2310	2300	2300	10.0	2303.3	5.77	0.25
41b551	2310	2310	2300	12.0	2306.7	5.77	0.25
104312	2300	2310	2310	10.5	2306.7	5.77	0.25
e9939d	2310	2320	2310	20.0	2313.3	5.77	0.25
f7b2a7	2343	2318	2316	13.0	2325.7	15.04	0.65

2.2 The Numerical Procedure for Determining Outliers

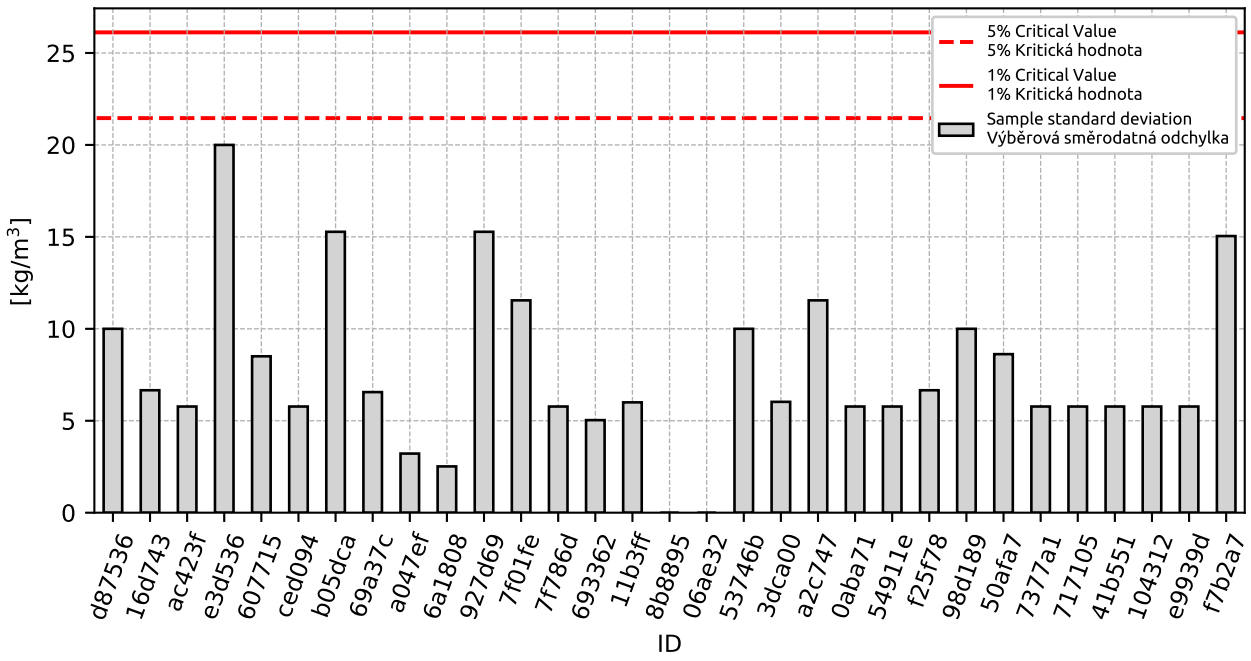

Figure 10: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

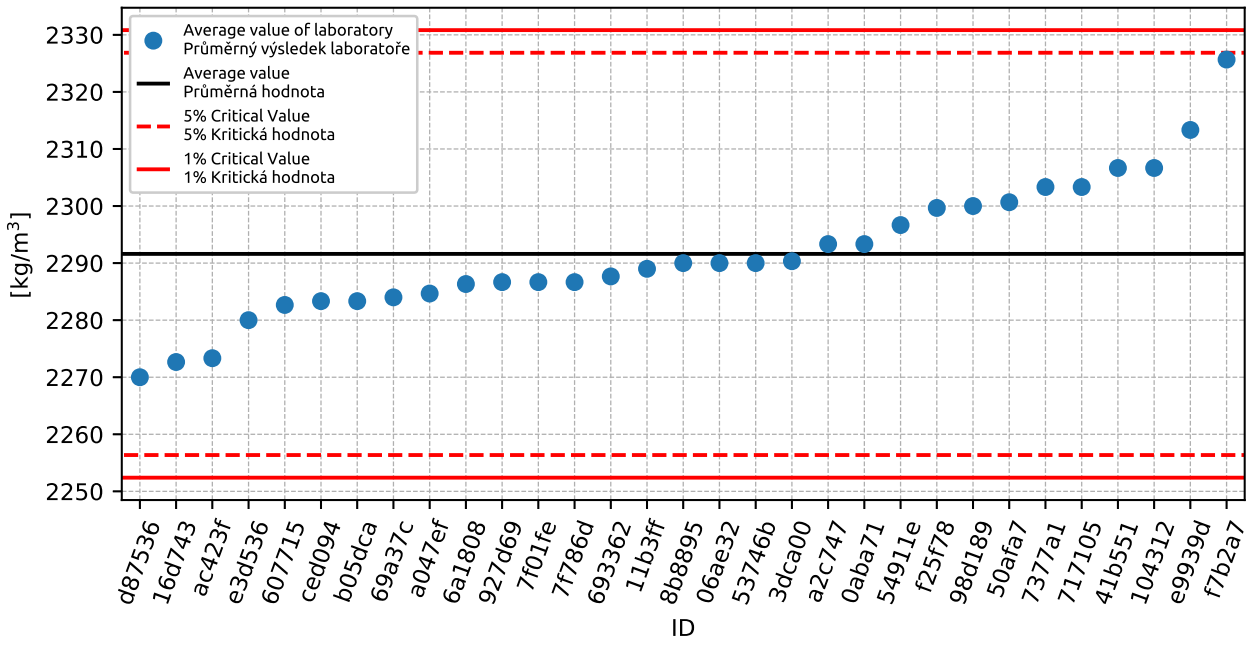

Figure 11: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

2.3 Mandel's Statistics

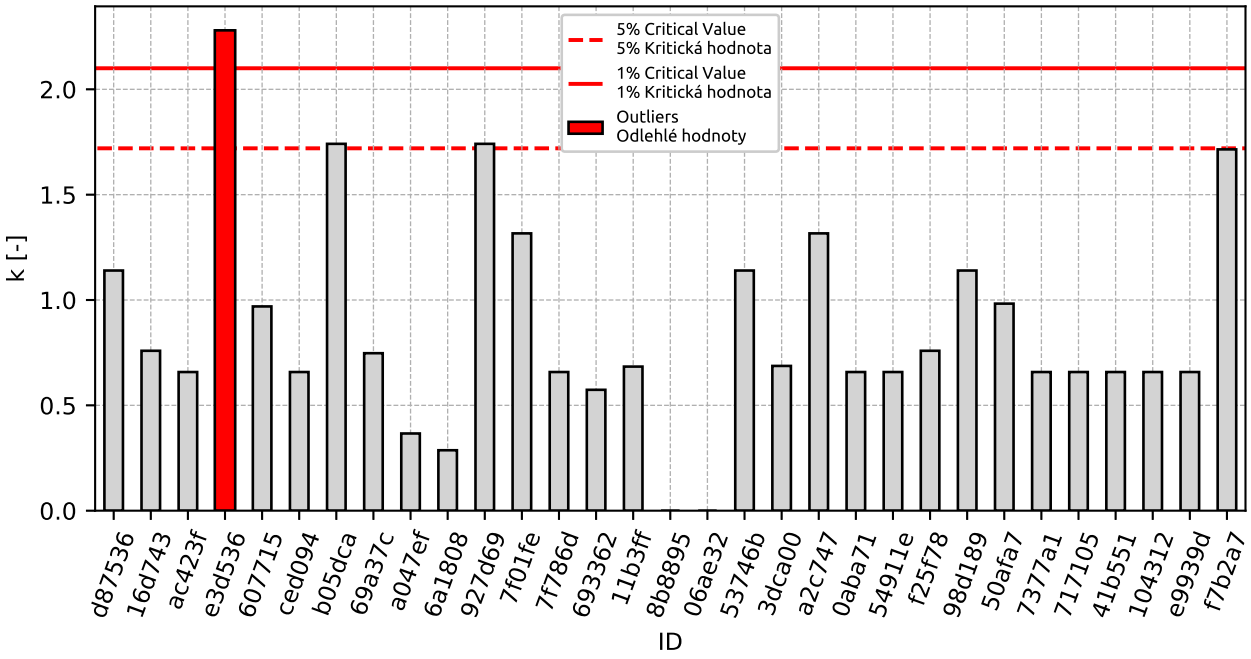

Figure 12: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

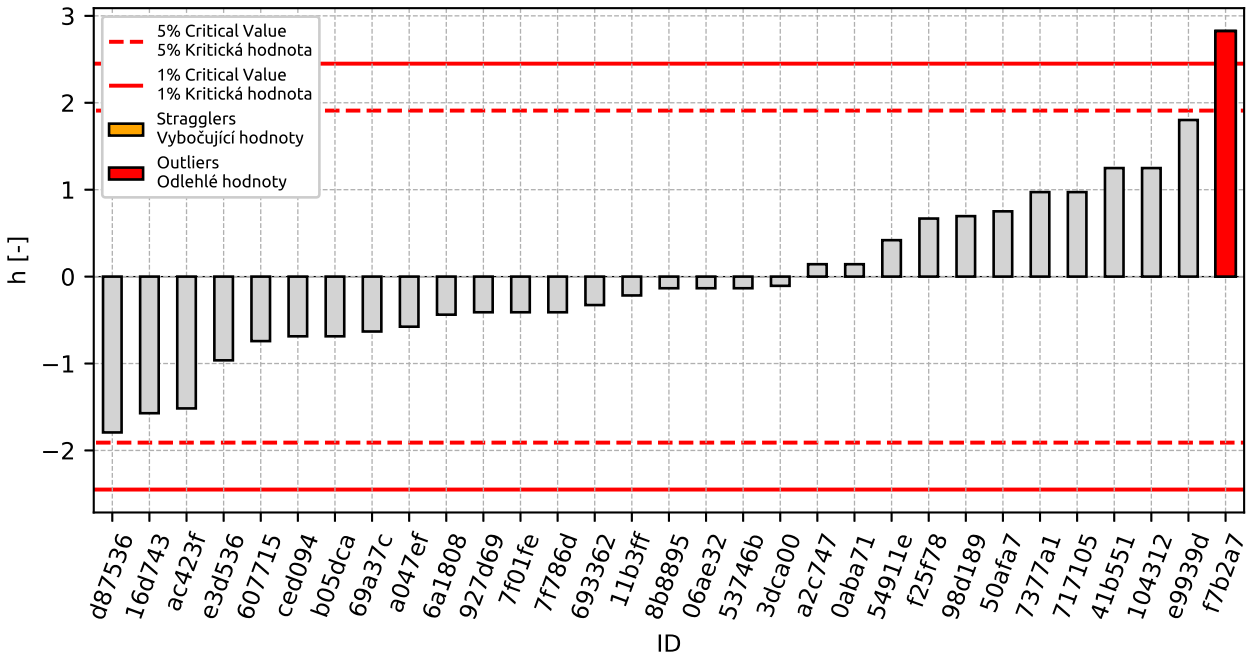

Figure 13: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

2.4 Descriptive statistics

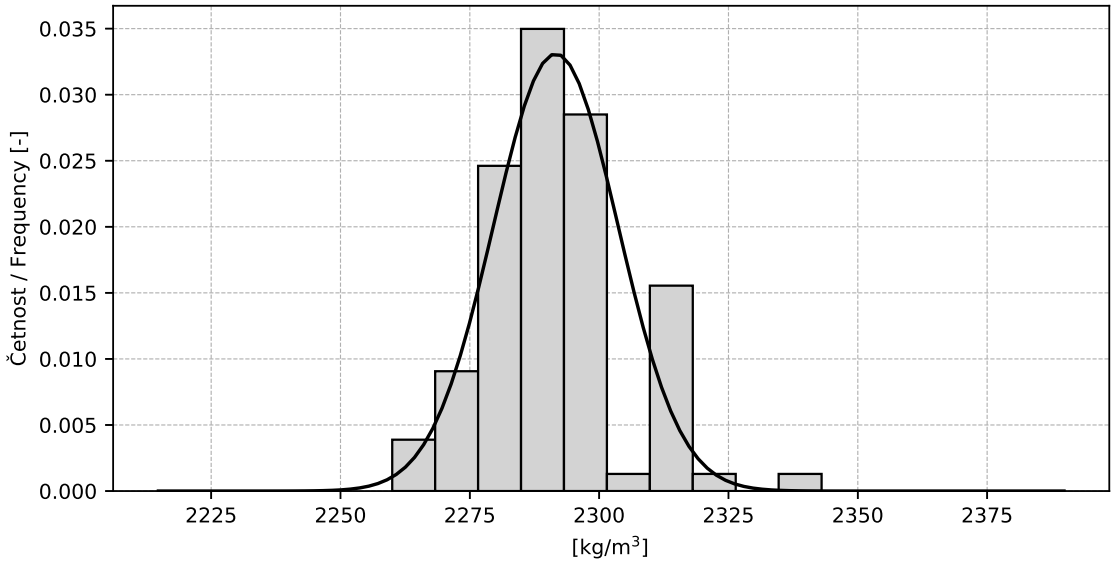

Figure 14: Histogram

Table 12: Descriptive statistics

Value	[kg/m^3]
Průměrná hodnota / Average value – $\bar{x}$	2291.6
Výběrová směrodatná odchylka / Sample standard deviation – s	12.05
Vztažná hodnota / Asigned value – x^*	2291.5
Robustní směrodatná odchylka / Robust standard deviation – s^*	12.24
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	2.75
p-hodnota testu normality / p-value of normality test	0.044 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	10.94
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	8.77
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	14.02
Opakovatelnost / Repeatability – r	24.6
Reprodukovatelnost / Reproducibility – R	39.3

2.5 Calculation of Performance Statistics

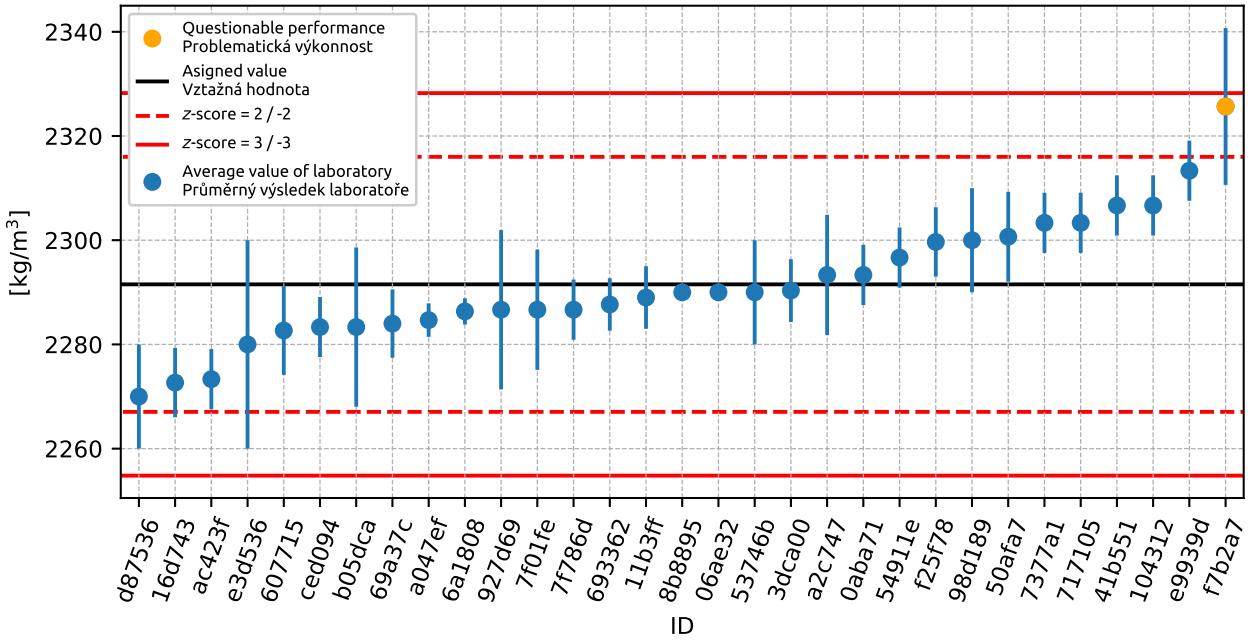

Figure 15: Average values and sample standard deviations

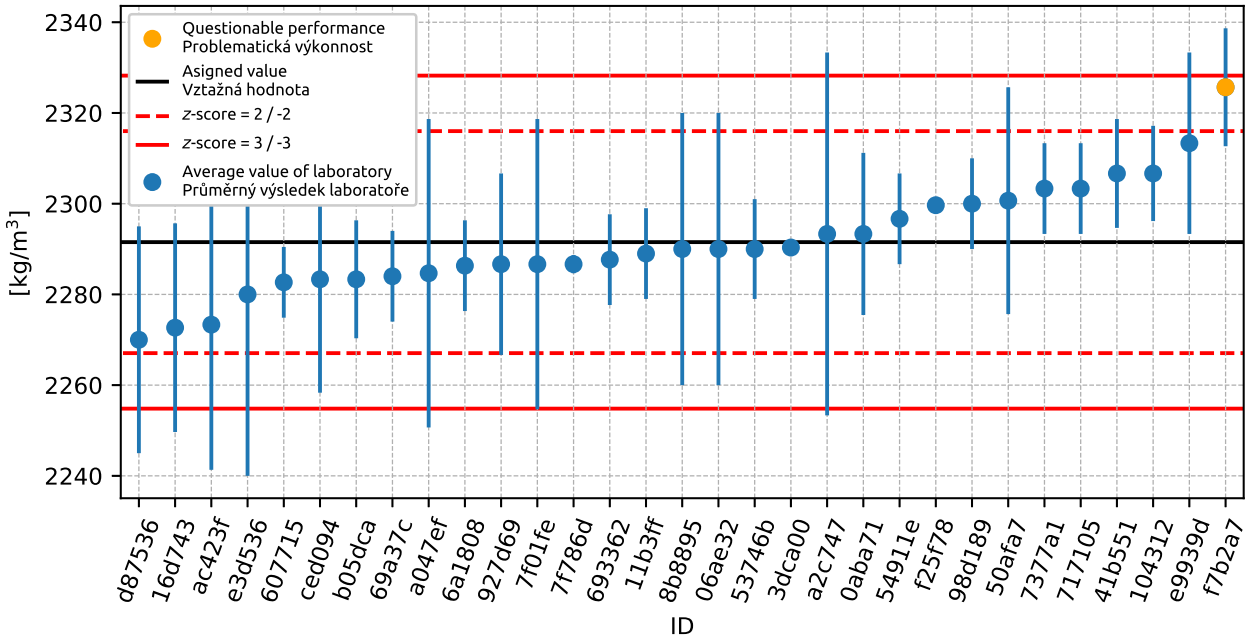

Figure 16: Average values and extended uncertainties of measurement

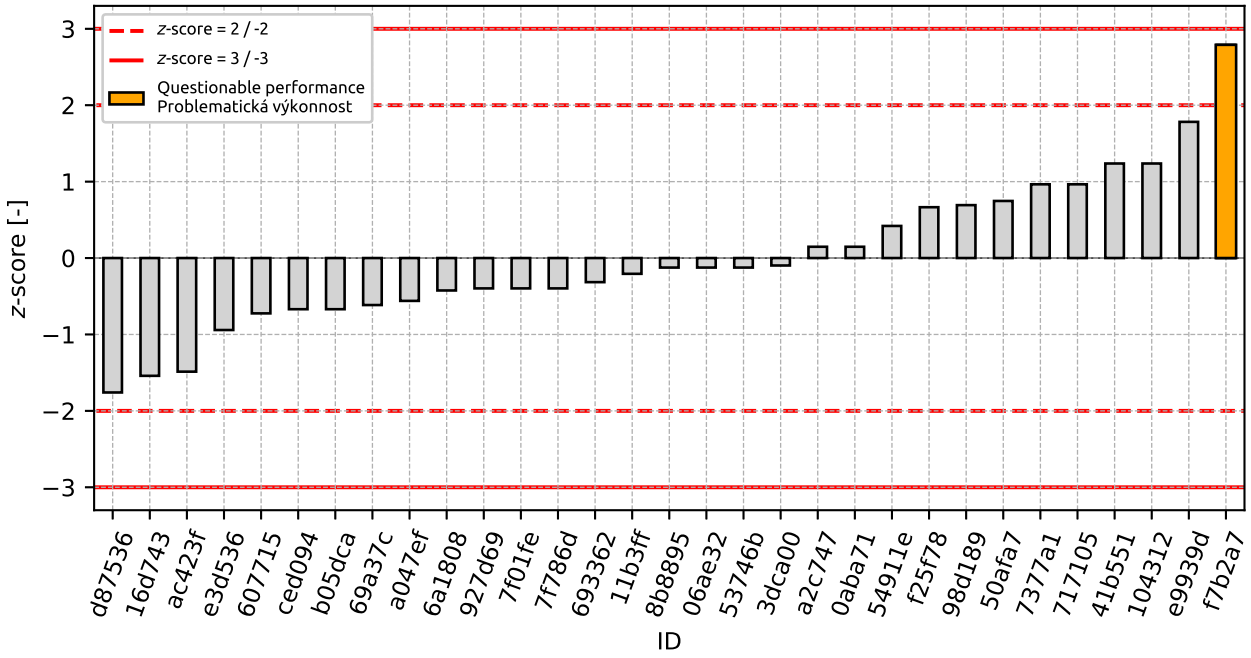

Figure 17: z-score

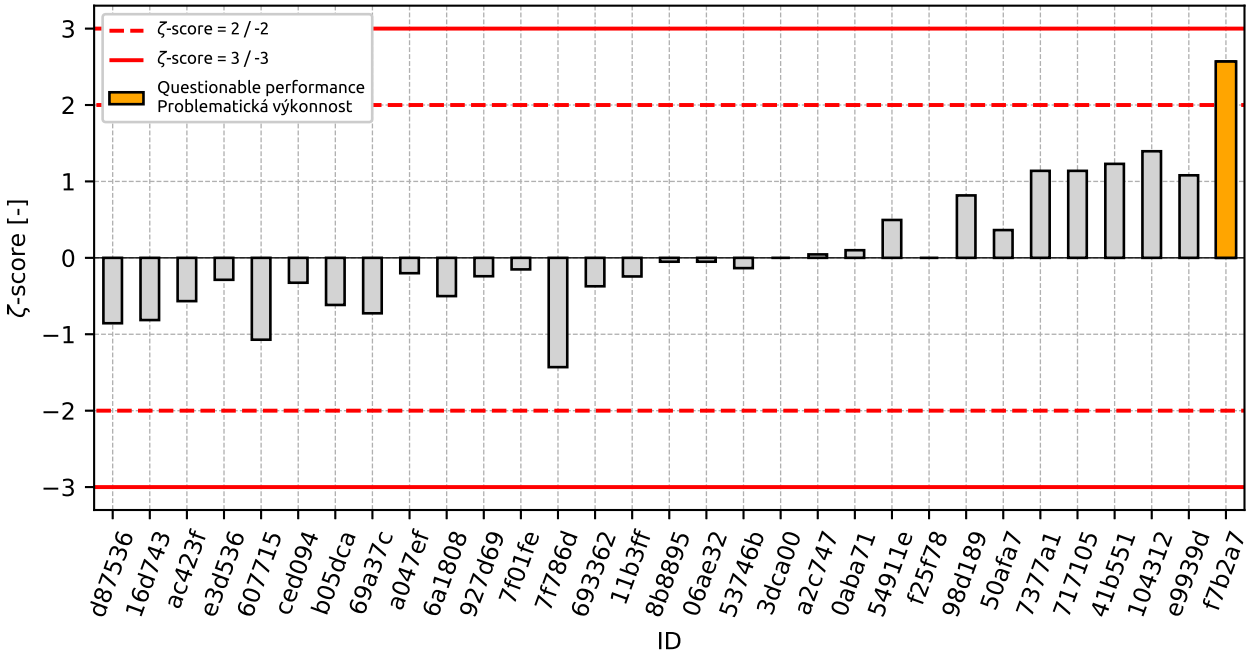

Figure 18: ζ-score

Table 13: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
d87536	-1.76	-0.86
16d743	-1.54	-0.81
ac423f	-1.49	-0.57
e3d536	-0.94	-0.29
607715	-0.72	-1.07
ced094	-0.67	-0.33
b05dca	-0.67	-0.62
69a37c	-0.62	-0.73
a047ef	-0.56	-0.2
6a1808	-0.42	-0.5
927d69	-0.4	-0.24
7f01fe	-0.4	-0.15
7f786d	-0.4	-1.43
693362	-0.32	-0.37
11b3ff	-0.21	-0.24
8b8895	-0.12	-0.05
06ae32	-0.12	-0.05
53746b	-0.12	-0.13
3dca00	-0.1	-
a2c747	0.15	0.05
0aba71	0.15	0.1
54911e	0.42	0.5
f25f78	0.67	-
98d189	0.69	0.82
50afa7	0.75	0.36
7377a1	0.96	1.14
717105	0.96	1.14
41b551	1.24	1.23
104312	1.24	1.39
e9939d	1.78	1.08
f7b2a7	2.79	2.57

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

3.1 Test results

Table 14: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
41b551	7	11	10	0.7	9.3	2.08	22.3
d87536	11	10	12	2.0	11.0	1.0	9.09
373ab3	12	10	11	0.3	11.0	1.0	9.09
d7e593	9	14	11	2.7	11.3	2.52	22.21
53746b	10	11	14	1.0	11.7	2.08	17.84
e9939d	14	10	13	2.0	12.3	2.08	16.88
ced094	13	14	11	2.0	12.7	1.53	12.06
7f01fe	14	12	12	1.0	12.7	1.15	9.12
7377a1	13	15	10	2.0	12.7	2.52	19.87
654483	17	13	8	10.0	12.7	4.51	35.6
b05dca	10	12	16	2.0	12.7	3.06	24.12
104312	15	13	11	2.3	13.0	2.0	15.38
8b8895	15	10	14	3.0	13.0	2.65	20.35
ac423f	14	12	15	1.0	13.7	1.53	11.18
06ae32	12	17	14	7.0	14.3	2.52	17.56
f25f78	17	15	14	-	15.3	1.53	9.96
3dca00	15	20	12	-	15.7	4.04	25.8
cba2c0	15	13	21	3.0	16.3	4.16	25.49
a7e31f	11	24	14	1.0	16.3	6.81	41.67
50afa7	21	11	18	2.0	16.7	5.13	30.79
225db2	14	16	20	4.0	16.7	3.06	18.33
607715	20	17	15	1.9	17.3	2.52	14.52
98a141	18	15	20	1.4	17.7	2.52	14.24
e3d536	18	15	21	3.0	18.0	3.0	16.67
a047ef	19	17	21	0.4	19.0	2.0	10.53
927d69	15	22	21	2.0	19.3	3.79	19.58
98d189	21	18	20	2.0	19.7	1.53	7.77
2059ff	20	25	15	-	20.0	5.0	25.0
a2c747	19	20	22	4.0	20.3	1.53	7.51
846d9f	17	21	24	4.0	20.7	3.51	16.99

3.2 The Numerical Procedure for Determining Outliers

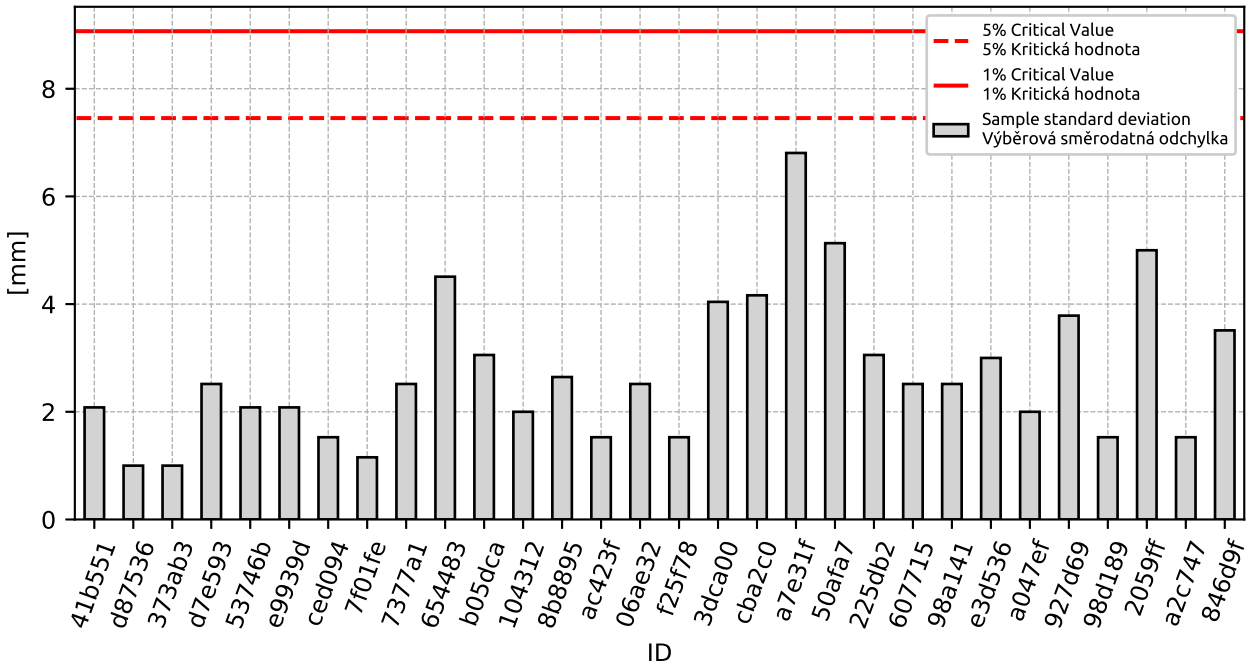

Figure 19: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

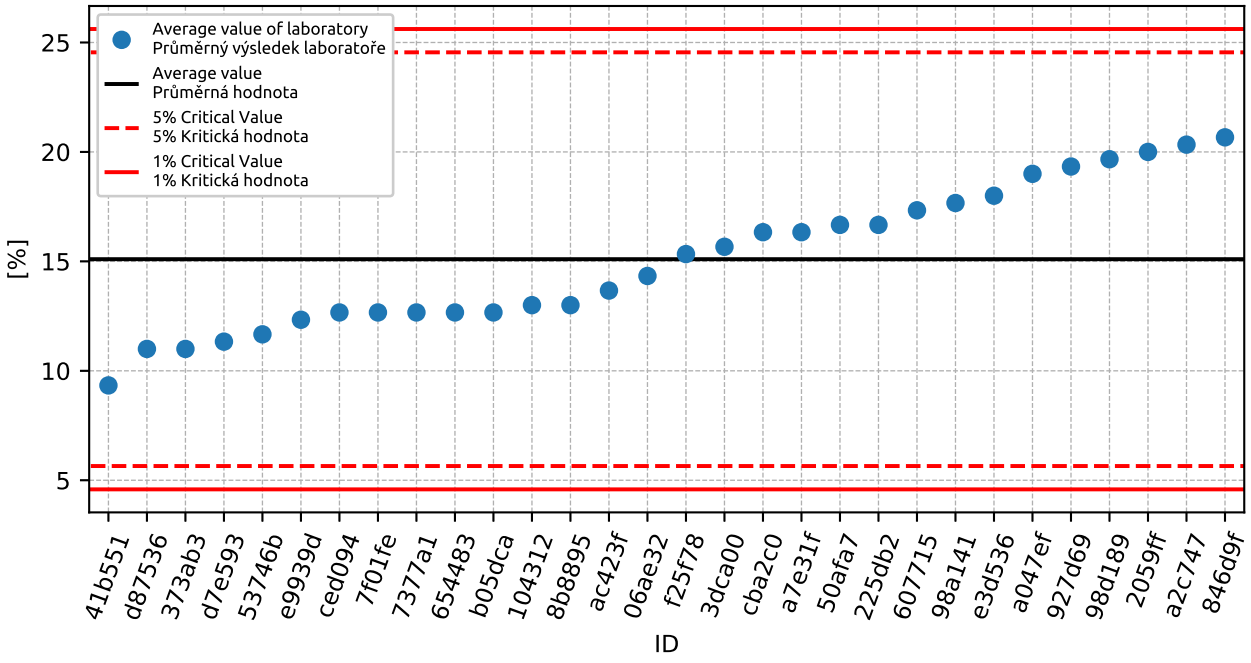

Figure 20: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

3.3 Mandel's Statistics

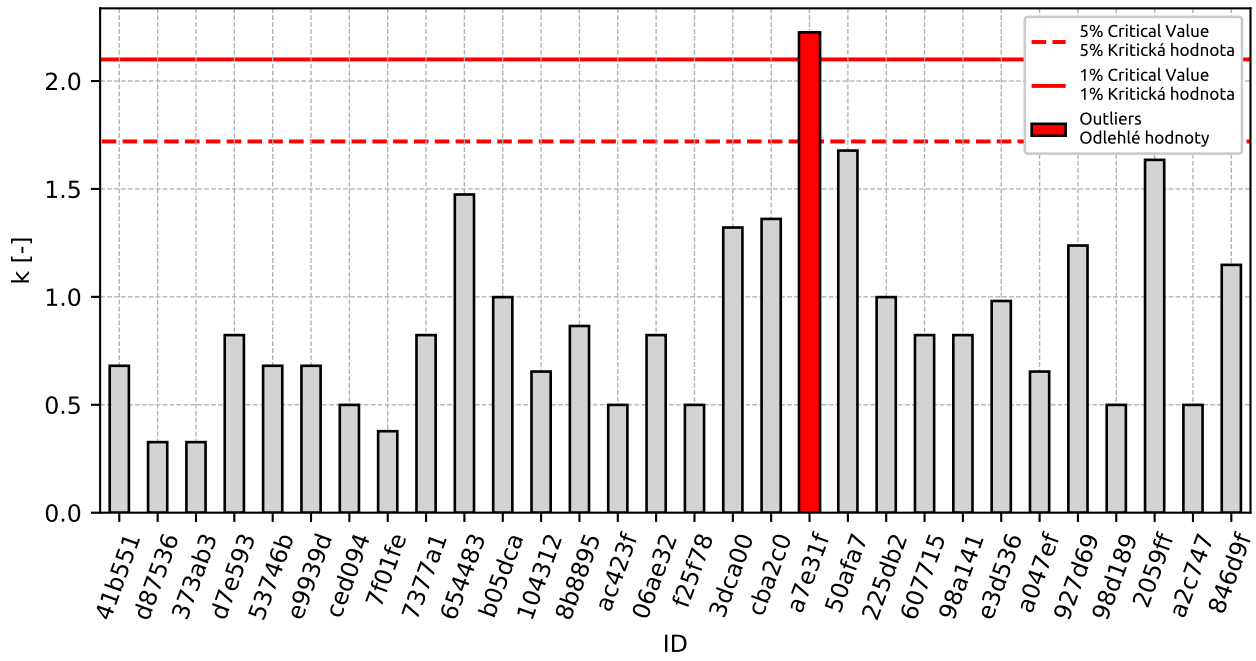

Figure 21: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

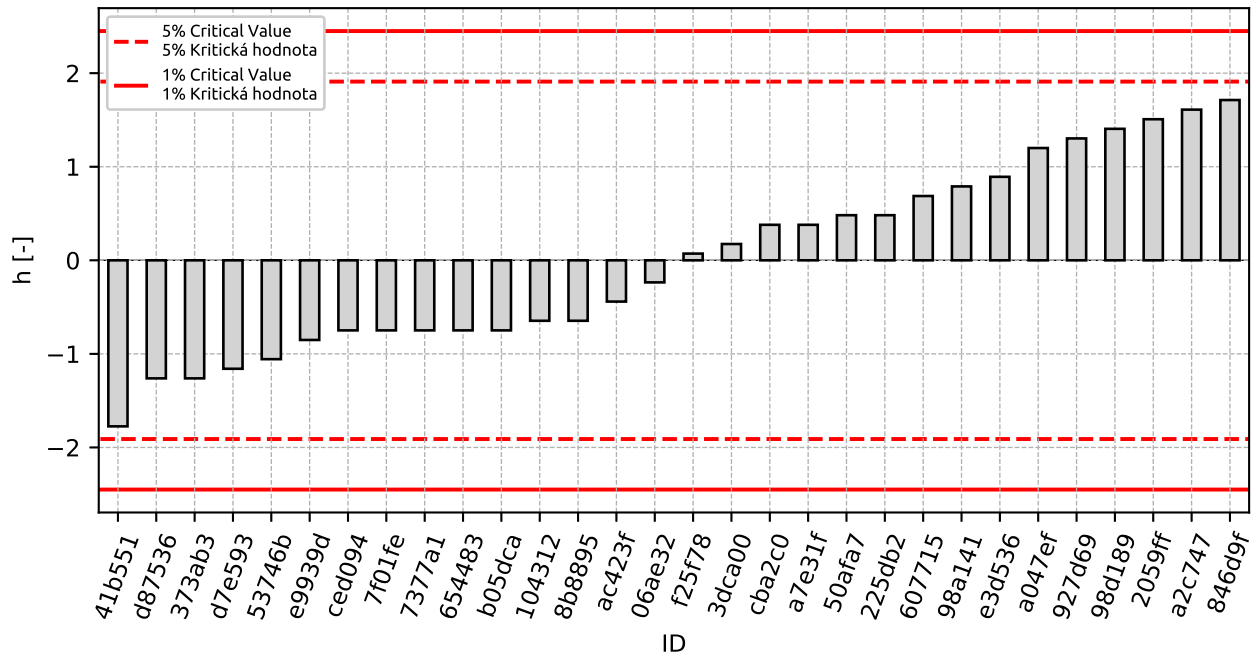

Figure 22: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

3.4 Descriptive statistics

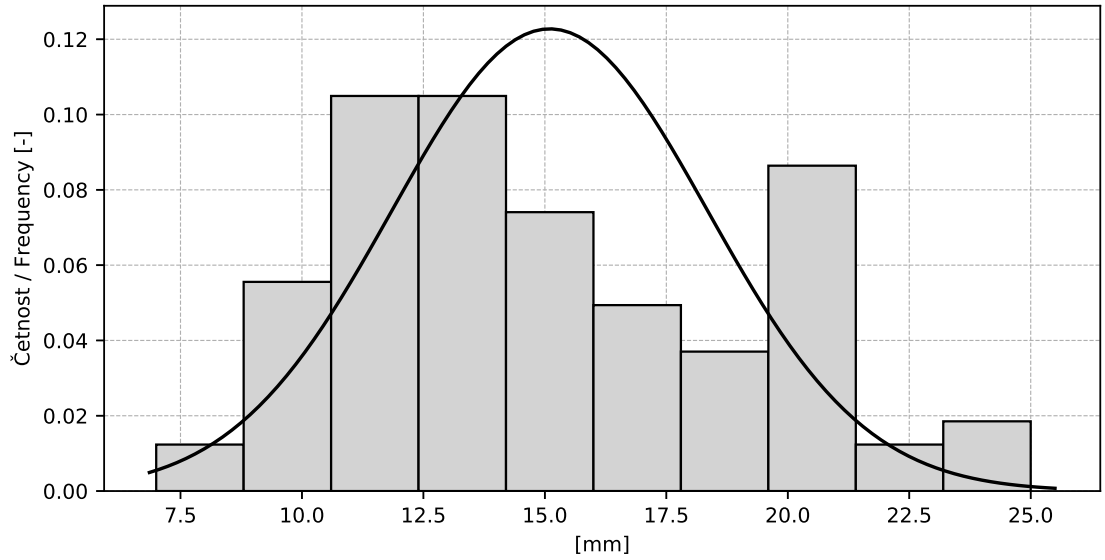

Figure 23: Histogram

Table 15: Descriptive statistics

Value	[mm]
Průměrná hodnota / Average value – $\bar{x}$	15.1
Výběrová směrodatná odchylka / Sample standard deviation – s	3.25
Vztažná hodnota / Asigned value – x^*	15.1
Robustní směrodatná odchylka / Robust standard deviation – s^*	3.58
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.82
p-hodnota testu normality / p-value of normality test	0.074 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	2.73
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	3.06
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	4.1
Opakovatelnost / Repeatability – r	8.6
Reprodukovatelnost / Reproducibility – R	11.5

3.5 Calculation of Performance Statistics

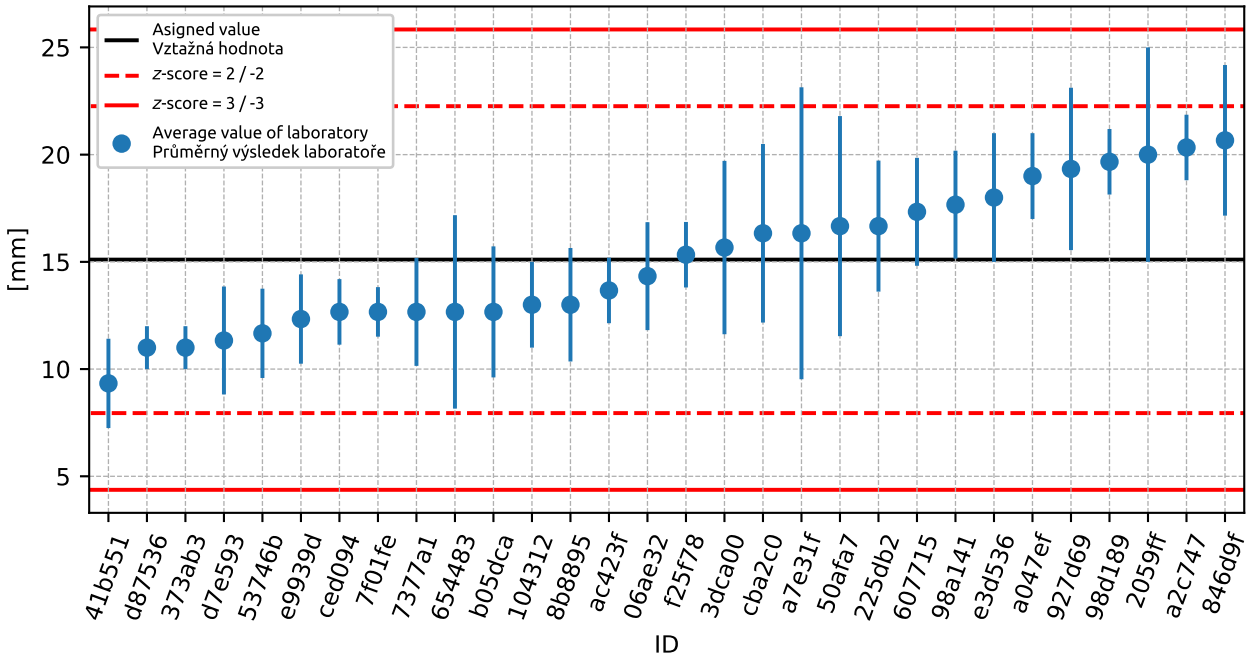

Figure 24: Average values and sample standard deviations

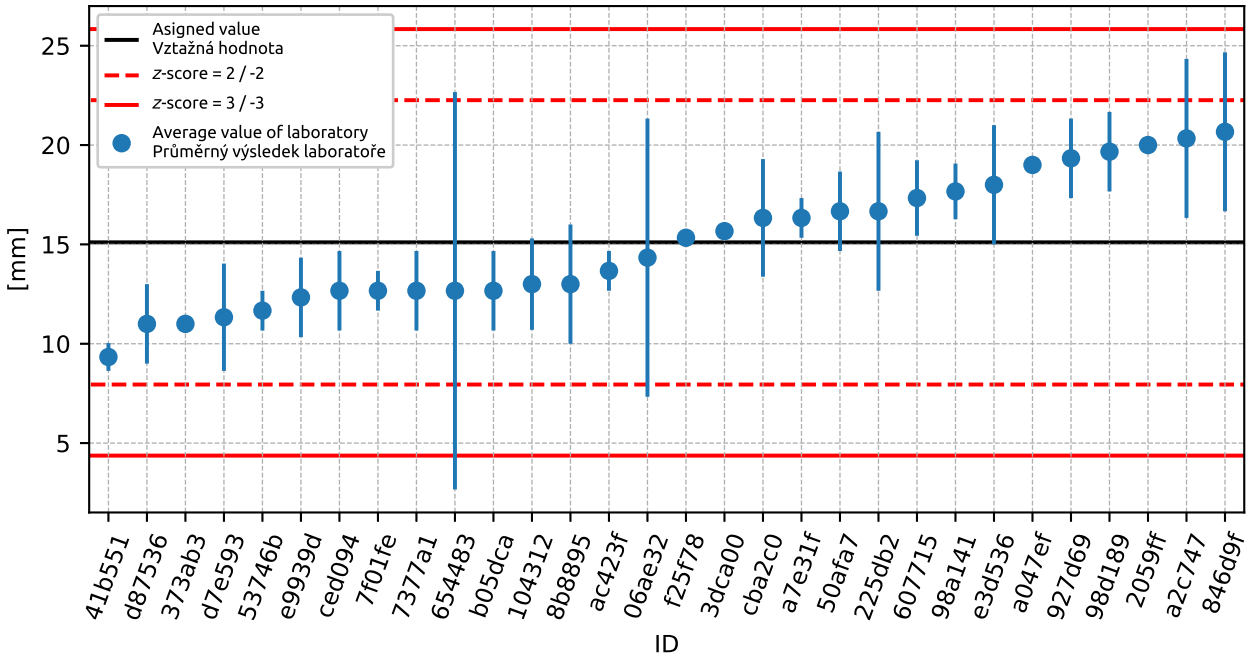

Figure 25: Average values and extended uncertainties of measurement

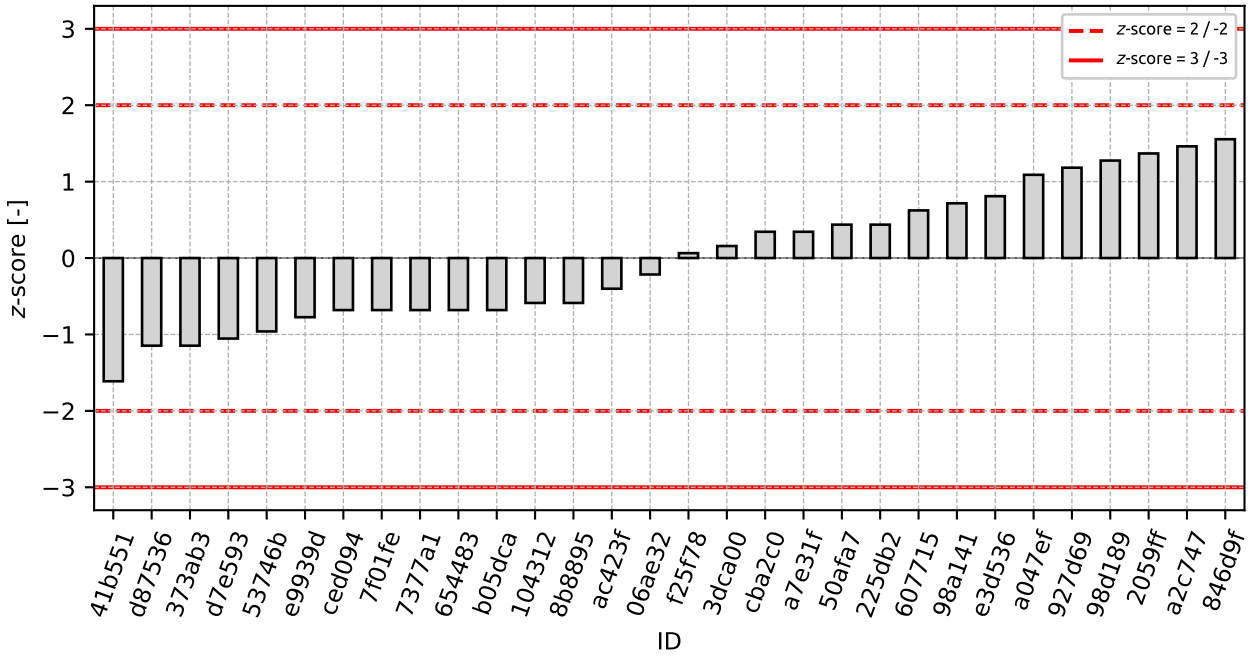

Figure 26: z-score

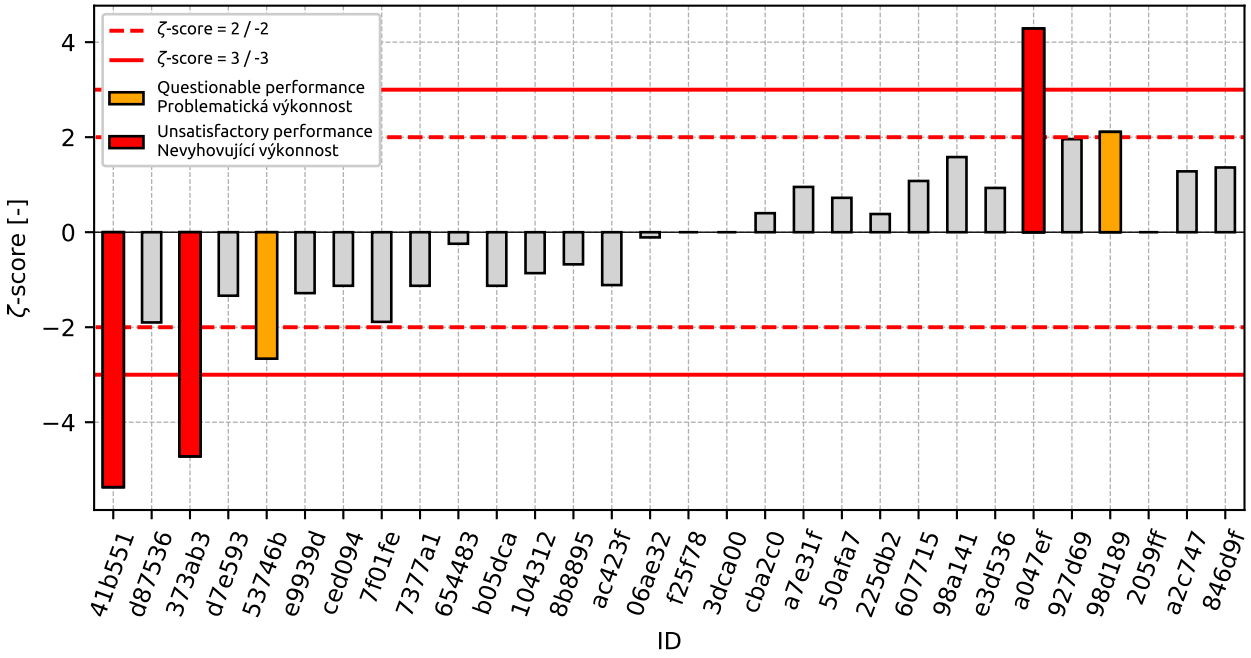

Figure 27: ζ-score

Table 16: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
41b551	-1.61	-5.36
d87536	-1.15	-1.9
373ab3	-1.15	-4.72
d7e593	-1.05	-1.34
53746b	-0.96	-2.66
e9939d	-0.77	-1.28
ced094	-0.68	-1.13
7f01fe	-0.68	-1.89
7377a1	-0.68	-1.13
654483	-0.68	-0.24
b05dca	-0.68	-1.13
104312	-0.59	-0.86
8b8895	-0.59	-0.68
ac423f	-0.4	-1.11
06ae32	-0.22	-0.11
f25f78	0.06	-
3dca00	0.16	-
cba2c0	0.34	0.4
a7e31f	0.34	0.95
50afa7	0.44	0.72
225db2	0.44	0.38
607715	0.62	1.08
98a141	0.72	1.58
e3d536	0.81	0.93
a047ef	1.09	4.29
927d69	1.18	1.96
98d189	1.28	2.11
2059ff	1.37	-
a2c747	1.46	1.28
846d9f	1.56	1.36

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

4.1 Total air content

4.1.1 Test results

Table 17: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]		u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
63c6ad	4.36	4.82	0.23	4.59	0.325	7.09
41b551	4.55	4.83	1.24	4.69	0.198	4.22
0e3e27	5.31	4.96	0.32	5.14	0.247	4.82
e9939d	5.0	5.4	0.3	5.2	0.283	5.44
104312	5.6	5.4	0.51	5.5	0.141	2.57
654483	5.71	-	0.58	5.71	-	-

4.1.2 The Numerical Procedure for Determining Outliers

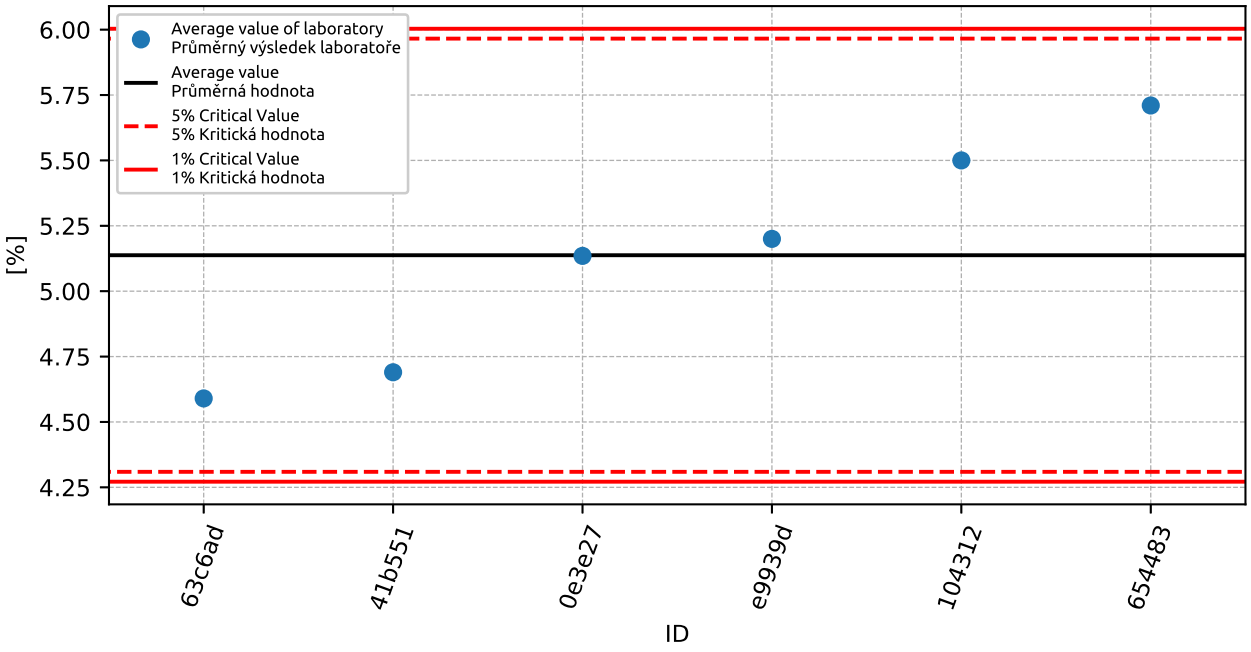

Figure 28: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

4.1.3 Mandel's Statistics

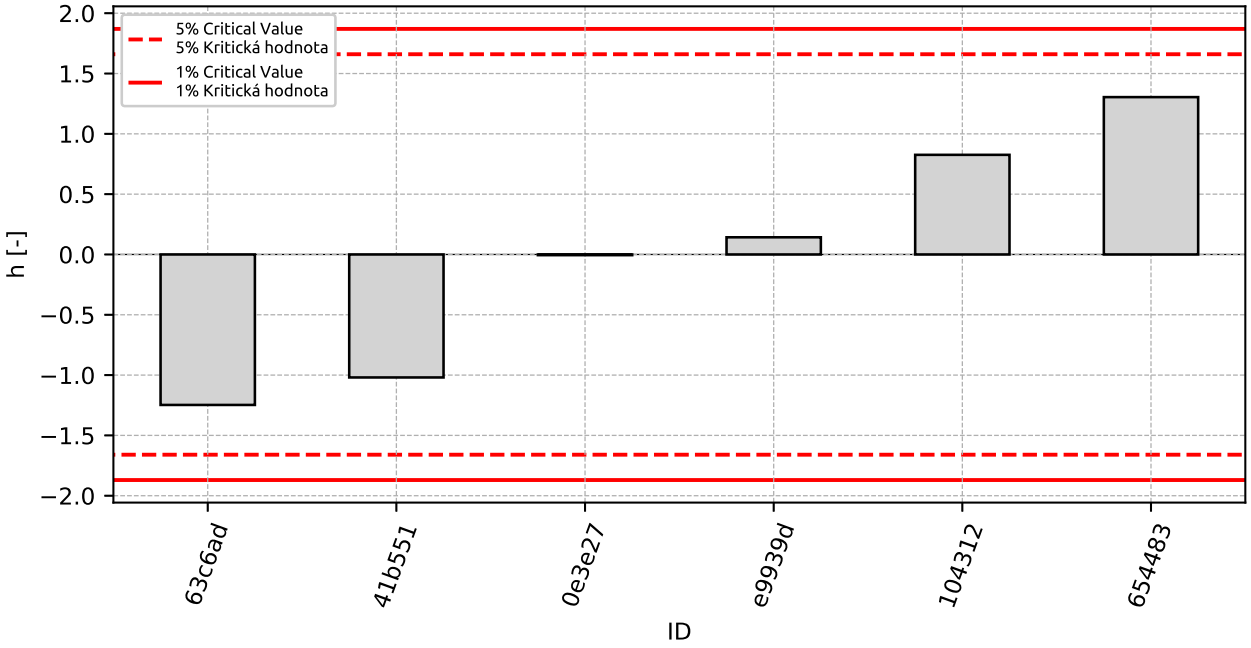

Figure 29: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

4.1.4 Descriptive statistics

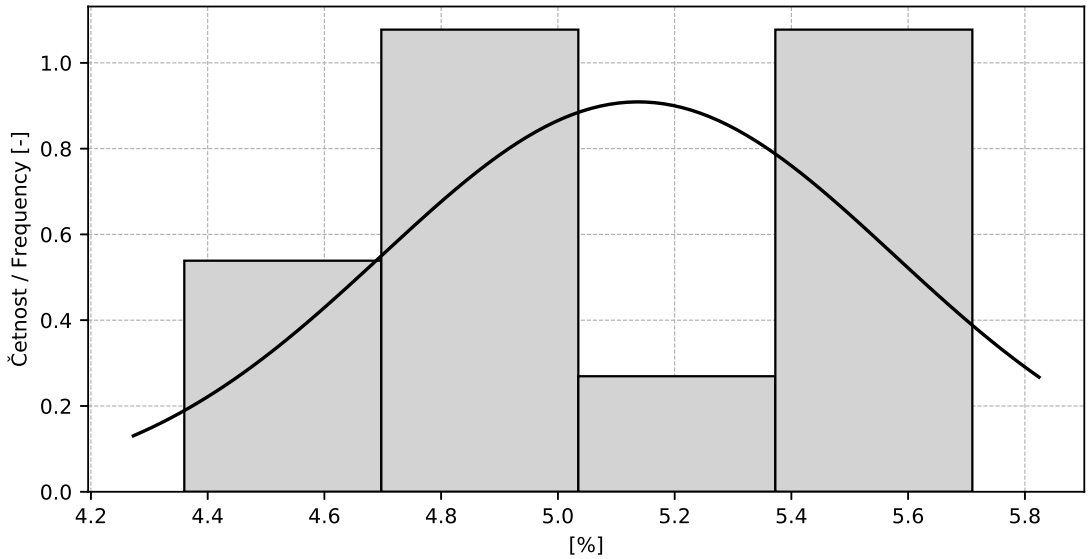

Figure 30: Histogram

Table 18: Descriptive statistics

Value	[%]
Průměrná hodnota / Average value – $\bar{x}$	5.14
Výběrová směrodatná odchylka / Sample standard deviation – s	0.439
Vztažná hodnota / Asigned value – x^*	5.14
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.454
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.232

4.1.5 Calculation of Performance Statistics

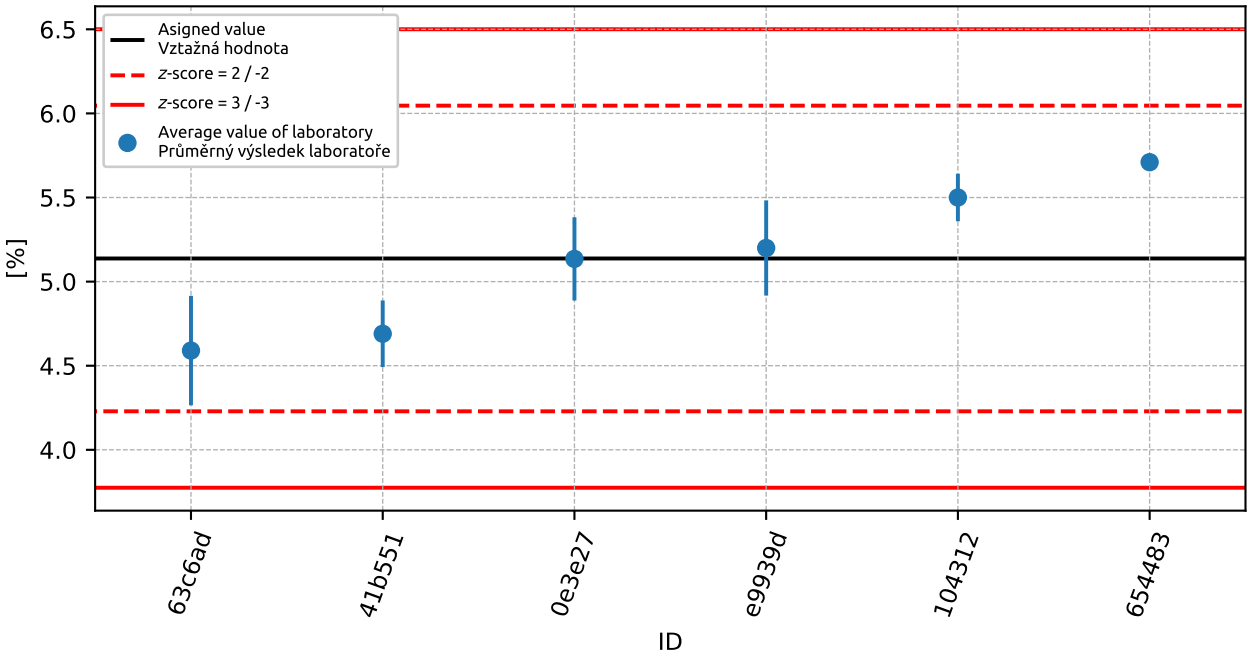

Figure 31: Average values and sample standard deviations

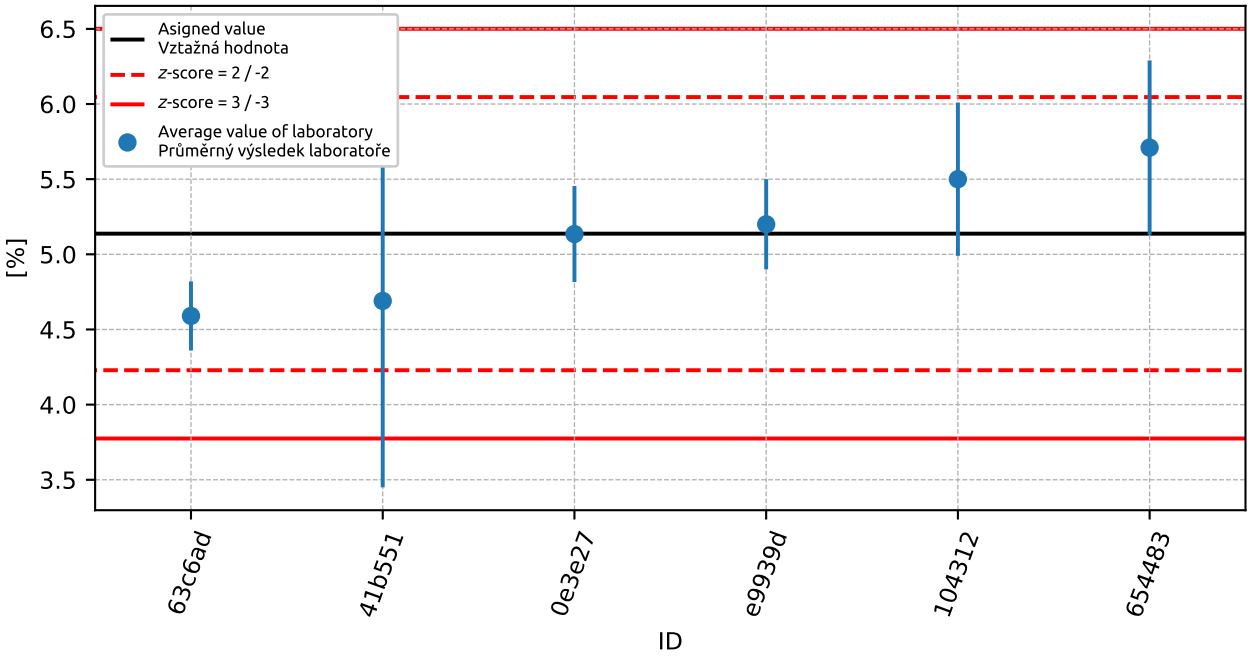

Figure 32: Average values and extended uncertainties of measurement

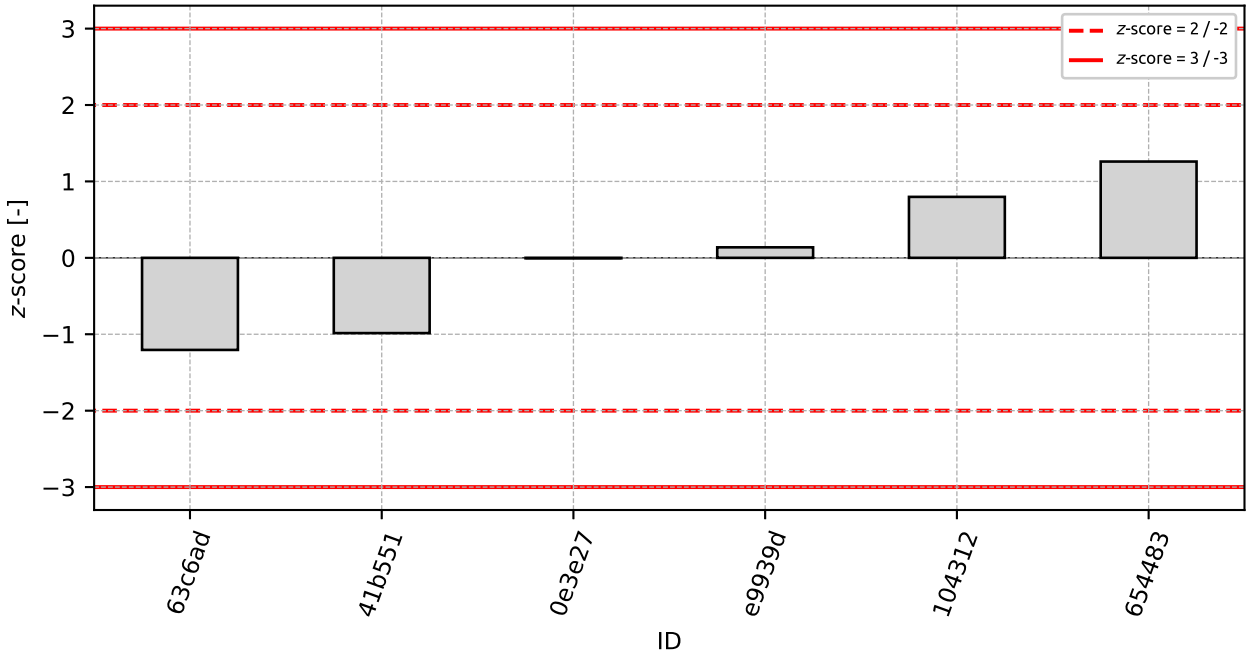

Figure 33: z-score

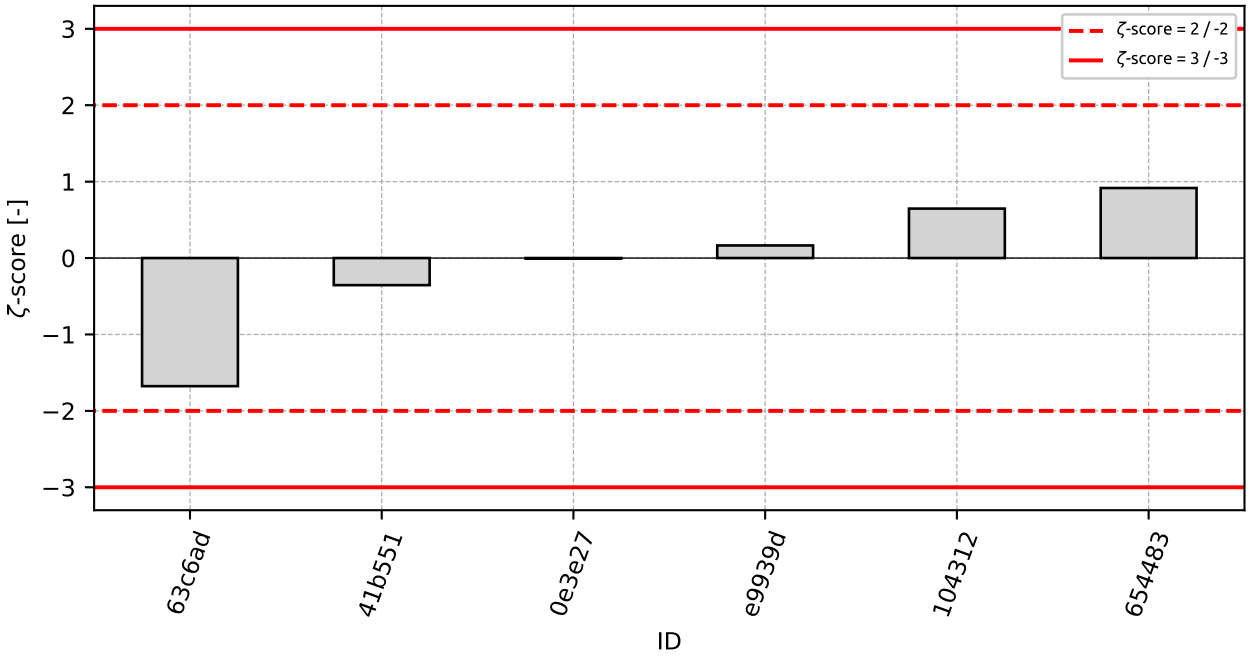

Figure 34: ζ-score

Table 19: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
63c6ad	-1.21	-1.68
41b551	-0.98	-0.35
0e3e27	-0.01	-0.01
e9939d	0.14	0.16
104312	0.8	0.65
654483	1.26	0.92

4.2 Micro air content A_{300}

4.2.1 Test results

Table 20: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]		u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
63c6ad	1.19	1.36	0.06	1.27	0.12	9.43
0e3e27	1.47	1.25	0.08	1.36	0.156	11.44
654483	1.73	-	0.2	1.73	-	-
e9939d	1.69	1.87	0.13	1.78	0.127	7.15
104312	2.2	1.7	0.07	1.95	0.354	18.13
41b551	2.19	2.45	1.24	2.32	0.184	7.92

4.2.2 The Numerical Procedure for Determining Outliers

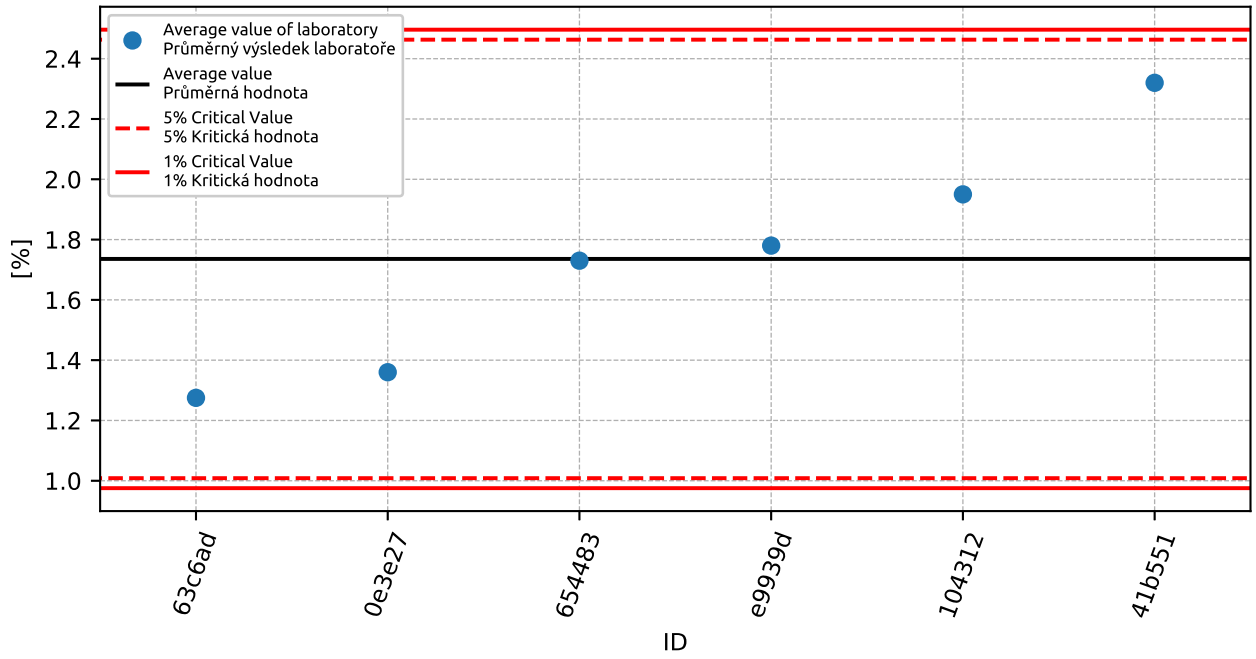

Figure 35: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

4.2.3 Mandel's Statistics

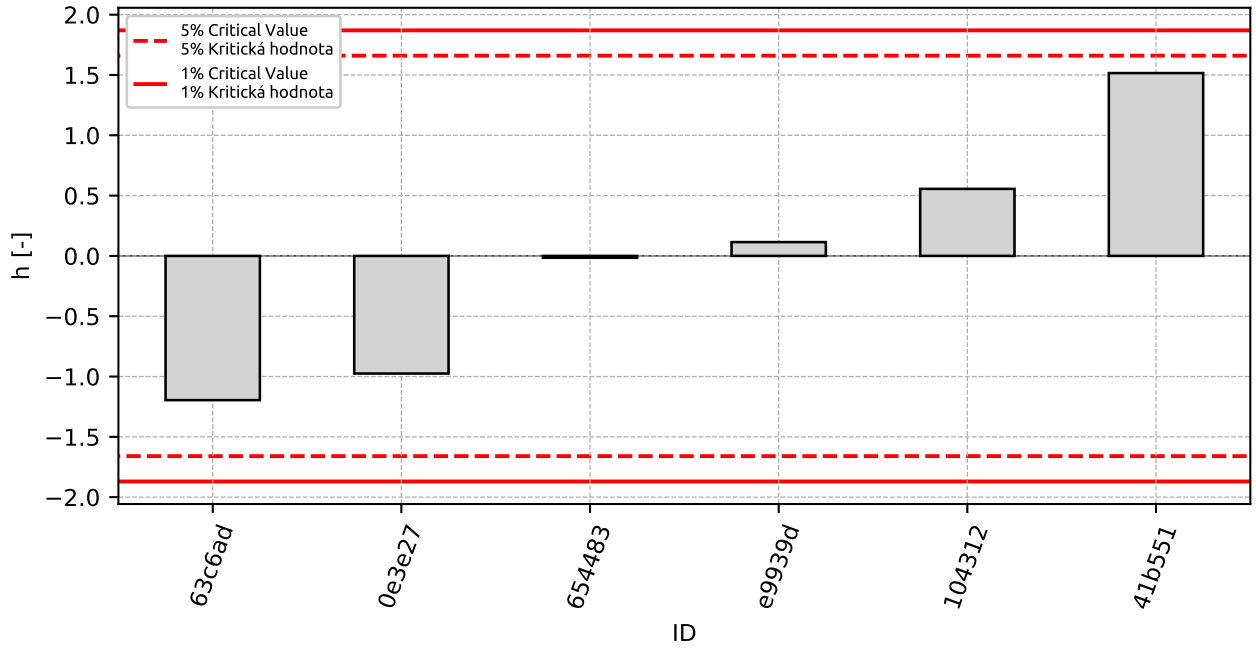

Figure 36: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

4.2.4 Descriptive statistics

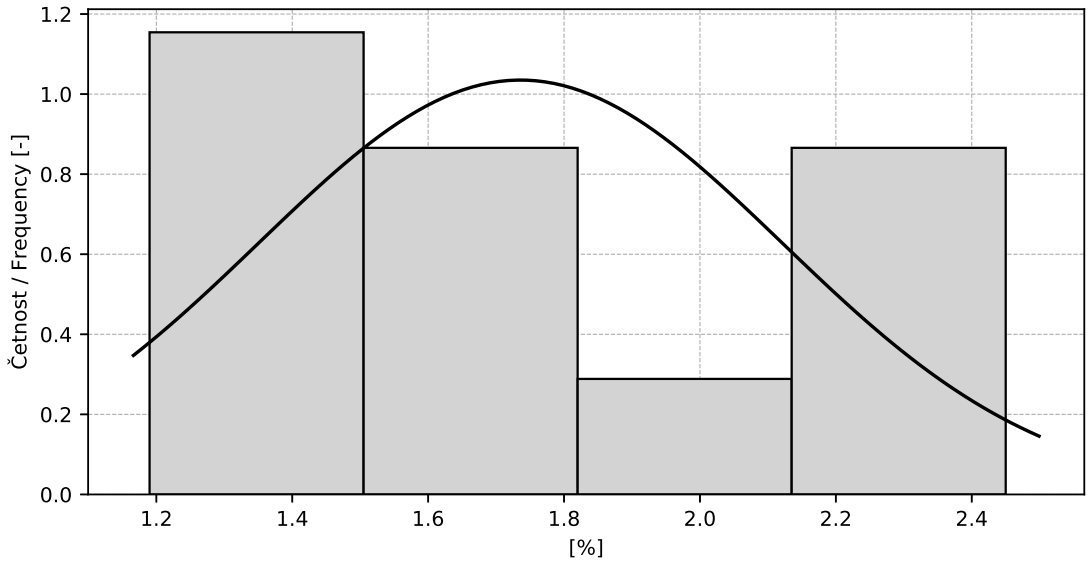

Figure 37: Histogram

Table 21: Descriptive statistics

Value	[%]
Průměrná hodnota / Average value – $\bar{x}$	1.74
Výběrová směrodatná odchylka / Sample standard deviation – s	0.385
Vztažná hodnota / Asigned value – x^*	1.74
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.399
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.204

4.2.5 Calculation of Performance Statistics

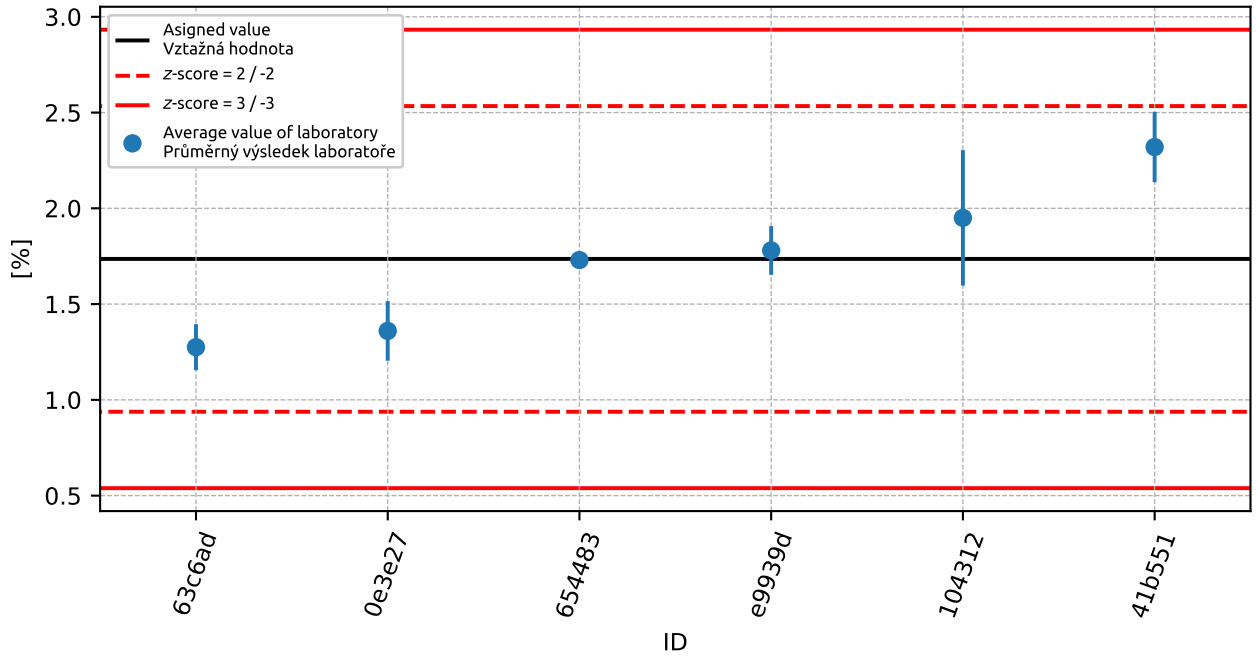

Figure 38: Average values and sample standard deviations

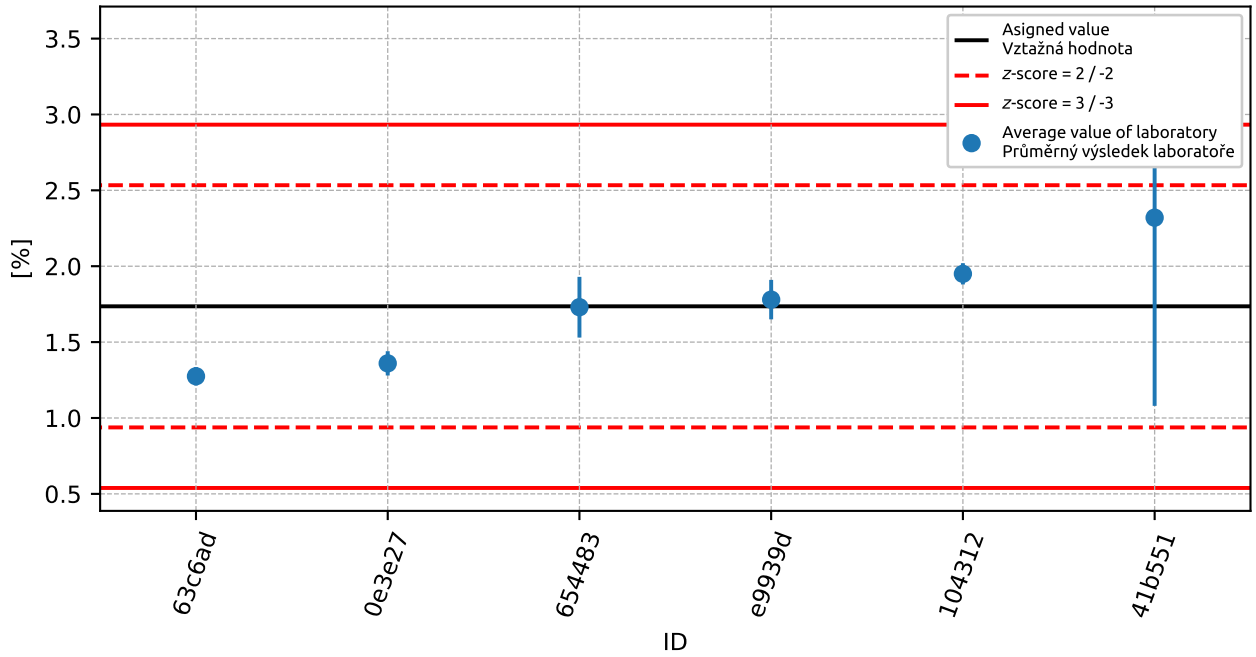

Figure 39: Average values and extended uncertainties of measurement

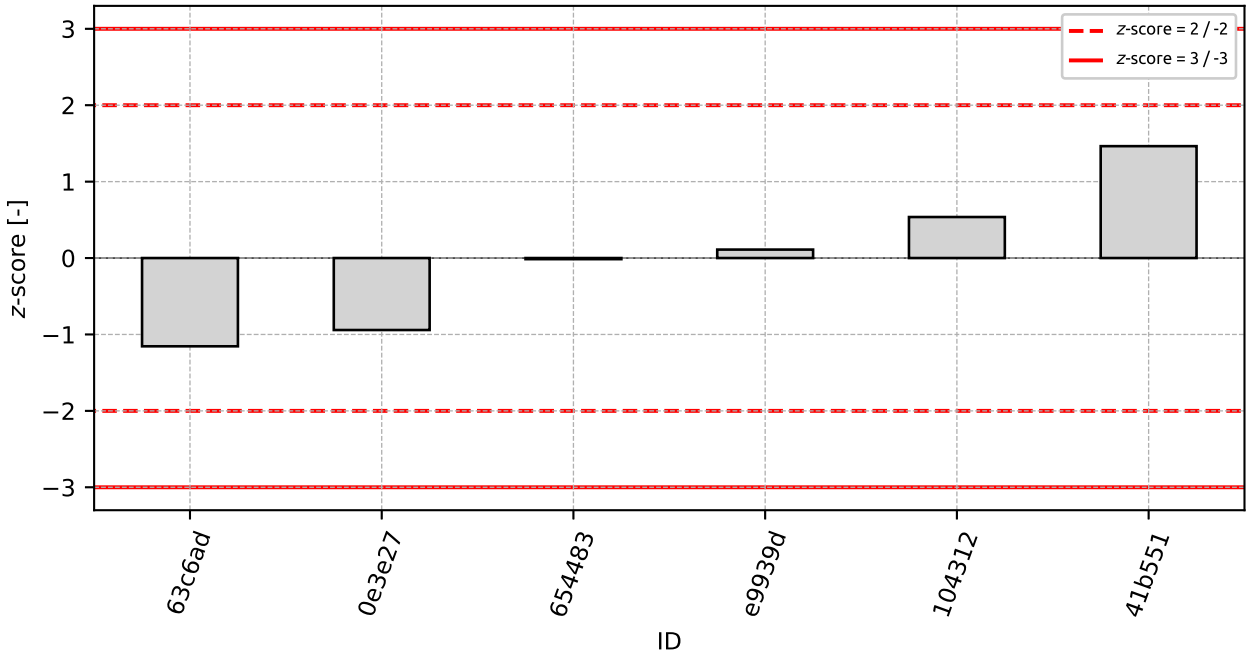

Figure 40: z-score

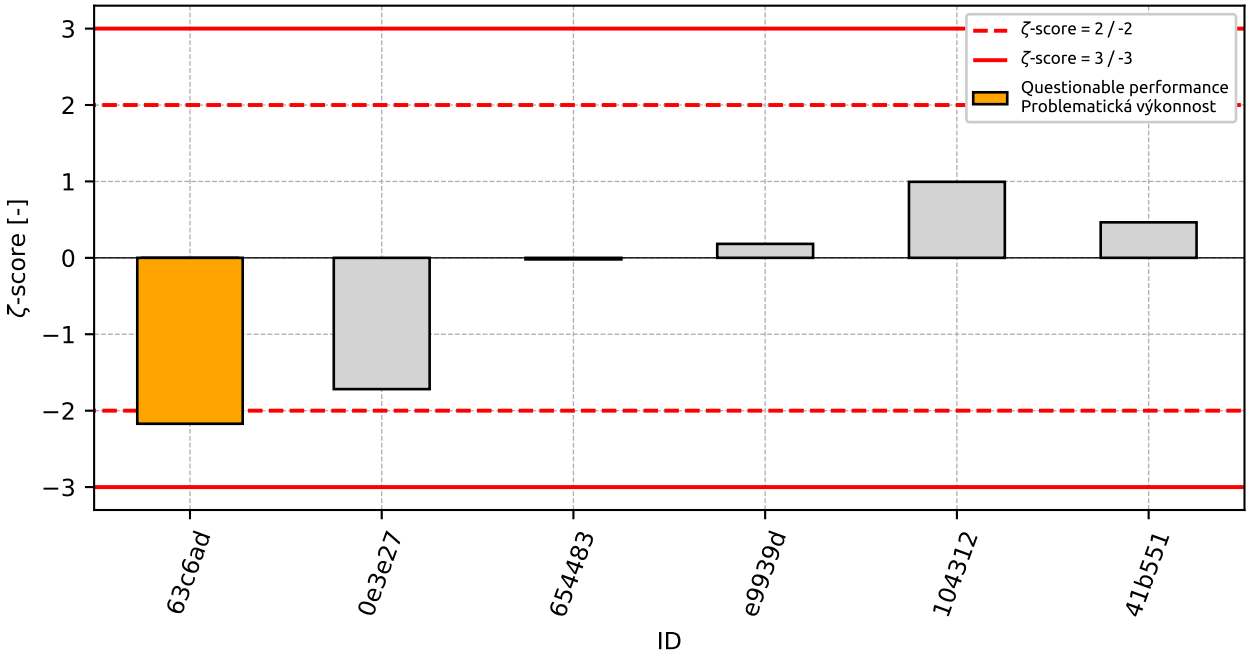

Figure 41: ζ-score

Table 22: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
63c6ad	-1.16	-2.17
0e3e27	-0.94	-1.72
654483	-0.01	-0.02
e9939d	0.11	0.18
104312	0.54	0.99
41b551	1.46	0.46

4.3 Spacing factor L

4.3.1 Test results

Table 23: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [mm]		u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
41b551	0.2	0.18	0.1	0.19	0.013	6.56
e9939d	0.24	0.2	0.01	0.22	0.031	14.27
63c6ad	0.27	0.24	0.01	0.26	0.017	6.6
0e3e27	0.26	0.28	0.01	0.27	0.021	7.61
654483	0.29	-	0.03	0.29	-	-
104312	0.29	0.34	0.01	0.32	0.035	11.22

4.3.2 The Numerical Procedure for Determining Outliers

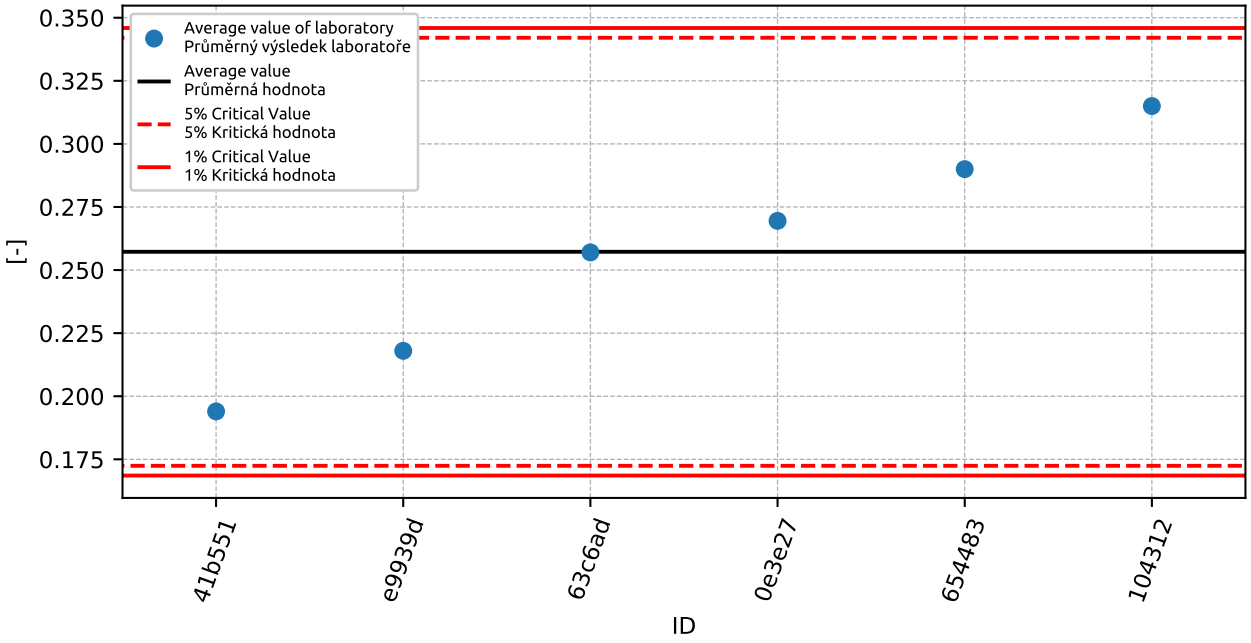

Figure 42: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

4.3.3 Mandel's Statistics

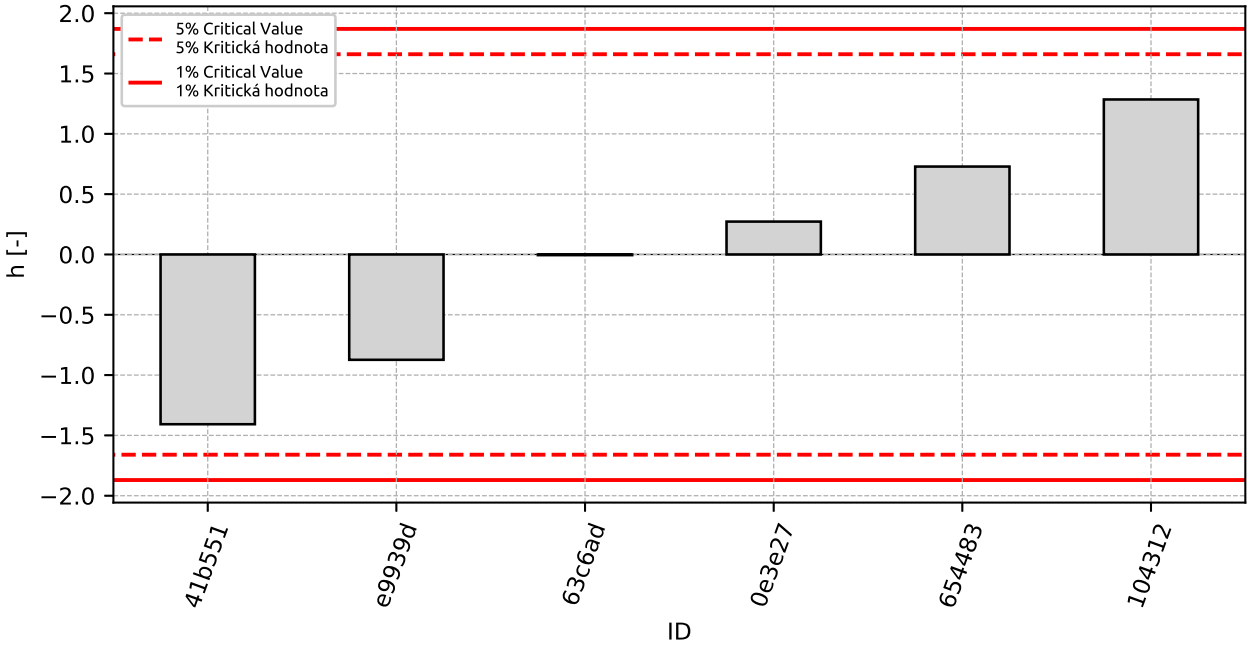

Figure 43: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

4.3.4 Descriptive statistics

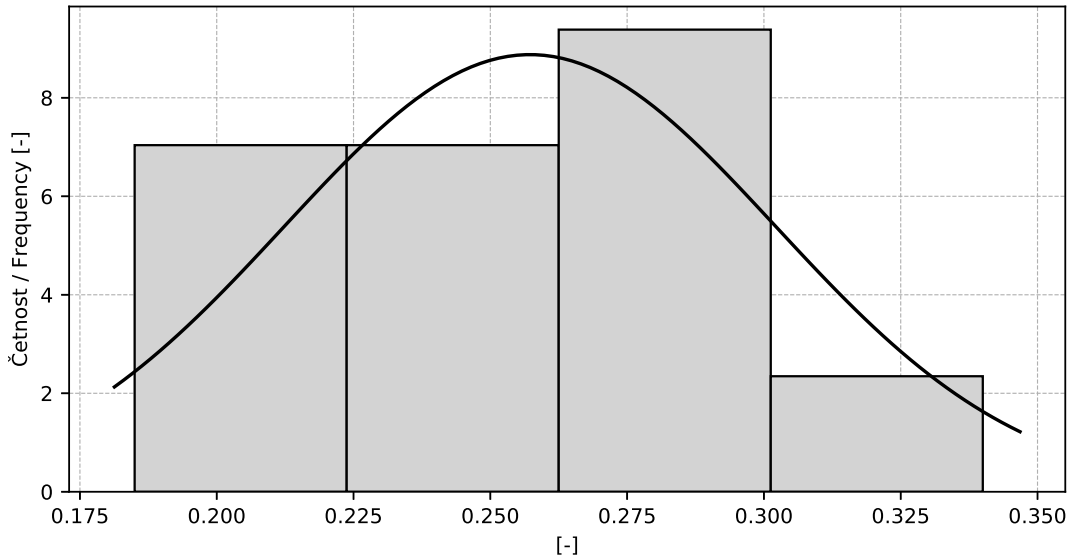

Figure 44: Histogram

Table 24: Descriptive statistics

Value	[mm]
Průměrná hodnota / Average value – $\bar{x}$	0.26
Výběrová směrodatná odchylka / Sample standard deviation – s	0.045
Vztažná hodnota / Asigned value – x^*	0.26
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.047
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.024

4.3.5 Calculation of Performance Statistics

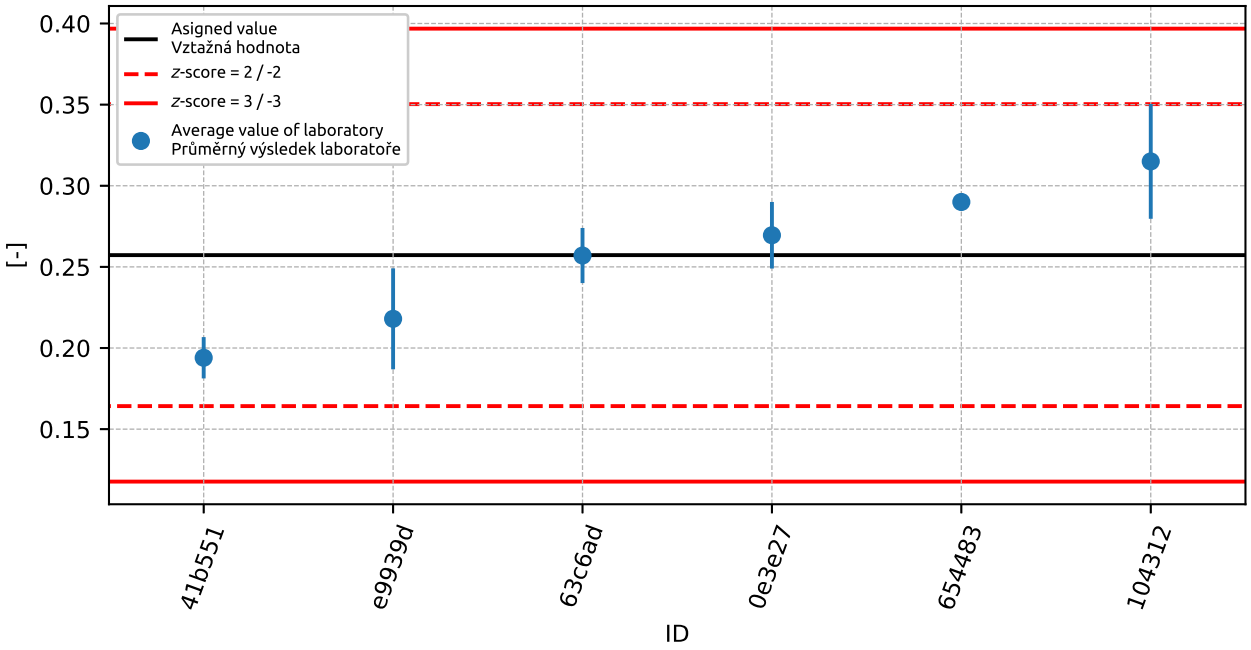

Figure 45: Average values and sample standard deviations

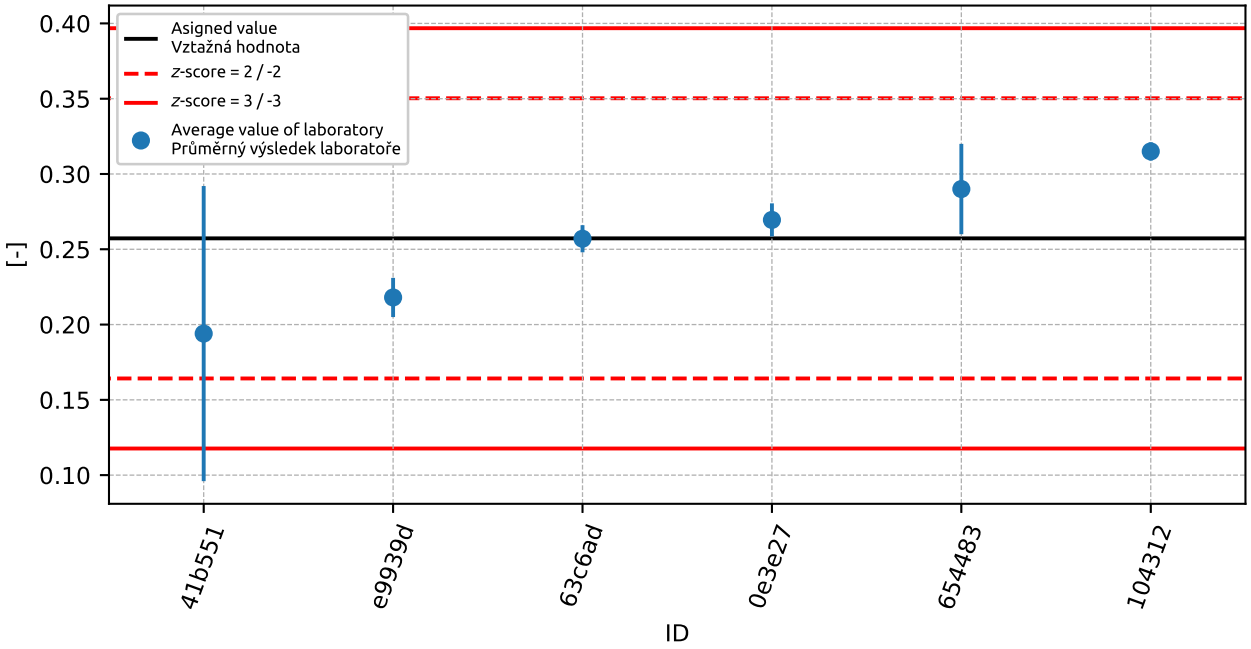

Figure 46: Average values and extended uncertainties of measurement

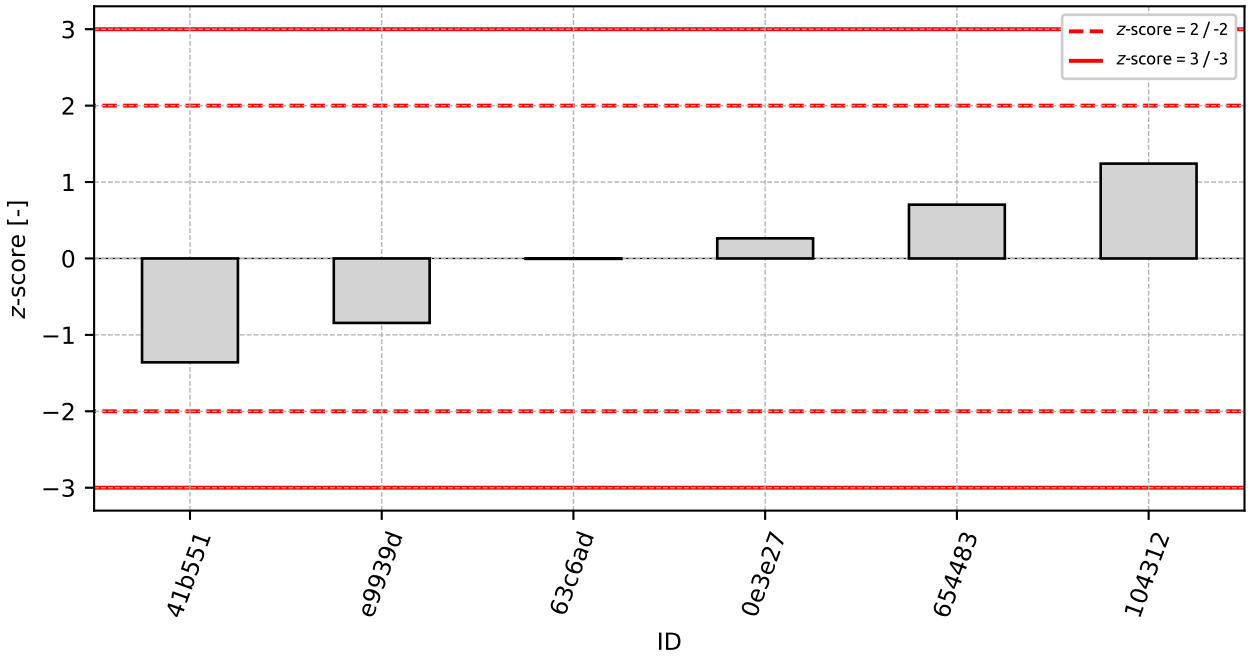

Figure 47: z-score

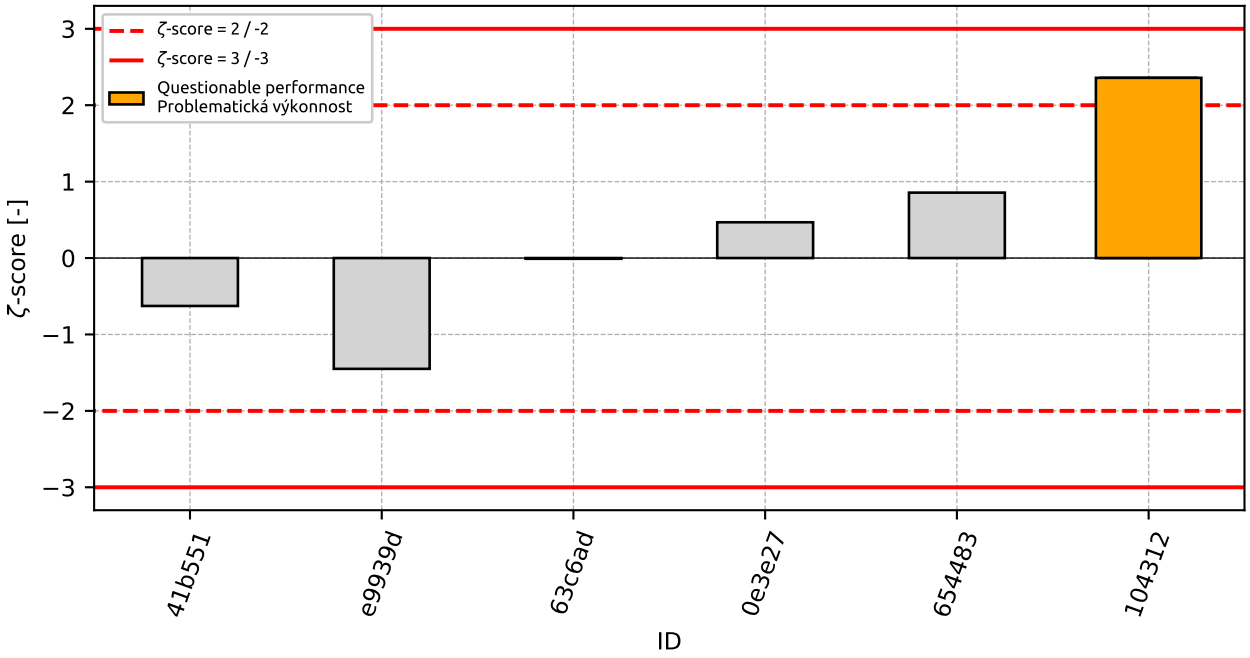

Figure 48: ζ-score

Table 25: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
41b551	-1.36	-0.63
e9939d	-0.84	-1.45
63c6ad	-0.01	-0.01
0e3e27	0.26	0.47
654483	0.7	0.86
104312	1.24	2.36

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

5.1 Test results

Table 26: Test results - ordered. Outliers are marked by star. u_X - extended uncertainty of measurement;

ID of participant	Test results [-]	u_X [-]
8b8895	0.62	0.06
a2c747	0.81	0.06
98a141	0.87	0.04
06ae32	0.94	0.61
607715	0.98	0.03
7cd562	1.02	0.39
654483	1.02	0.08
0aba71	1.06	0.04
3c6e73	1.12	0.08
61aad6	1.19	-
d87536	1.2	-

5.2 The Numerical Procedure for Determining Outliers

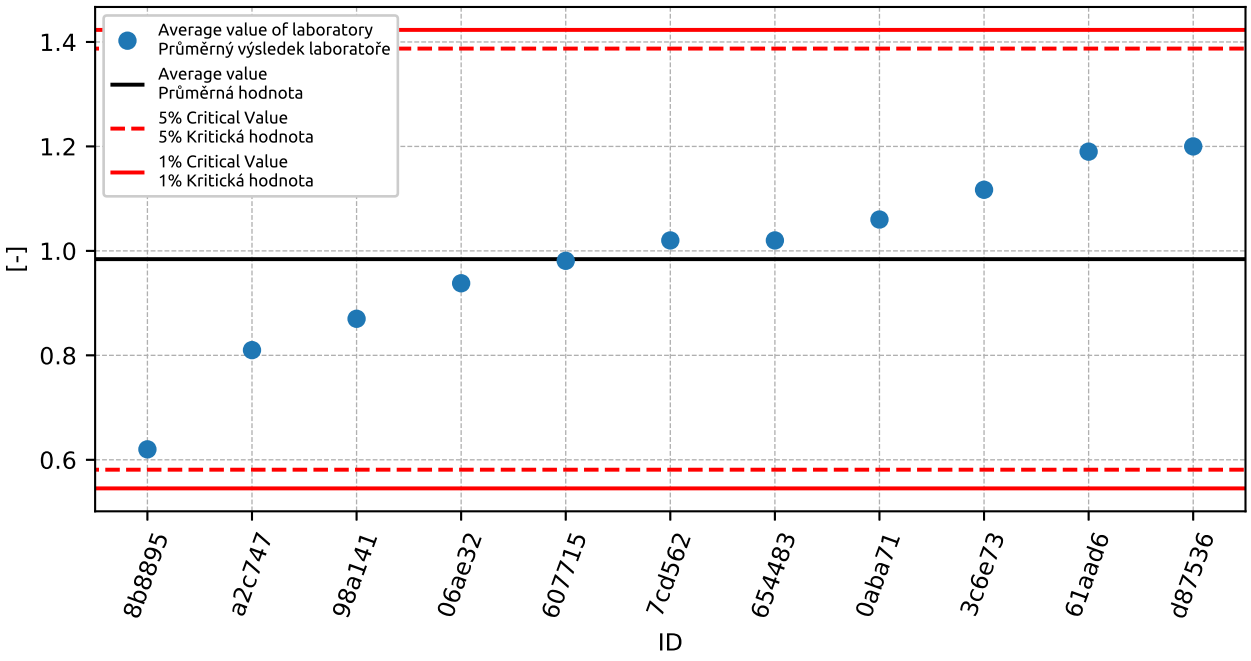

Figure 49: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

5.3 Mandel's Statistics

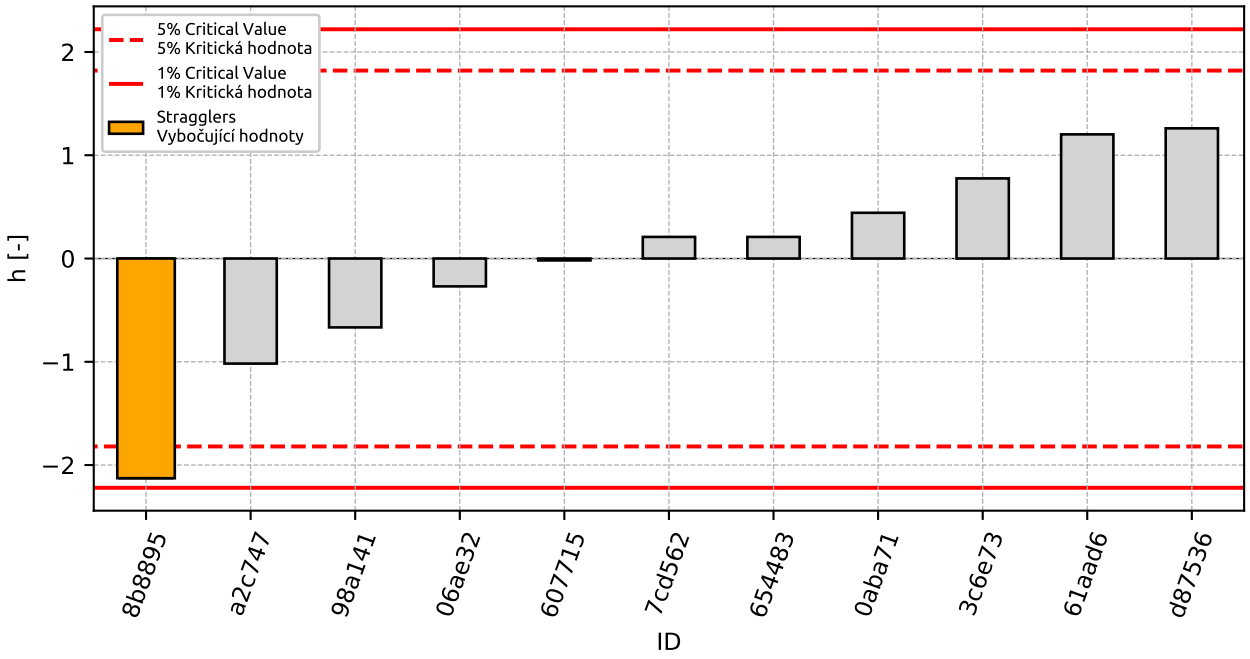

Figure 50: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

5.4 Descriptive statistics

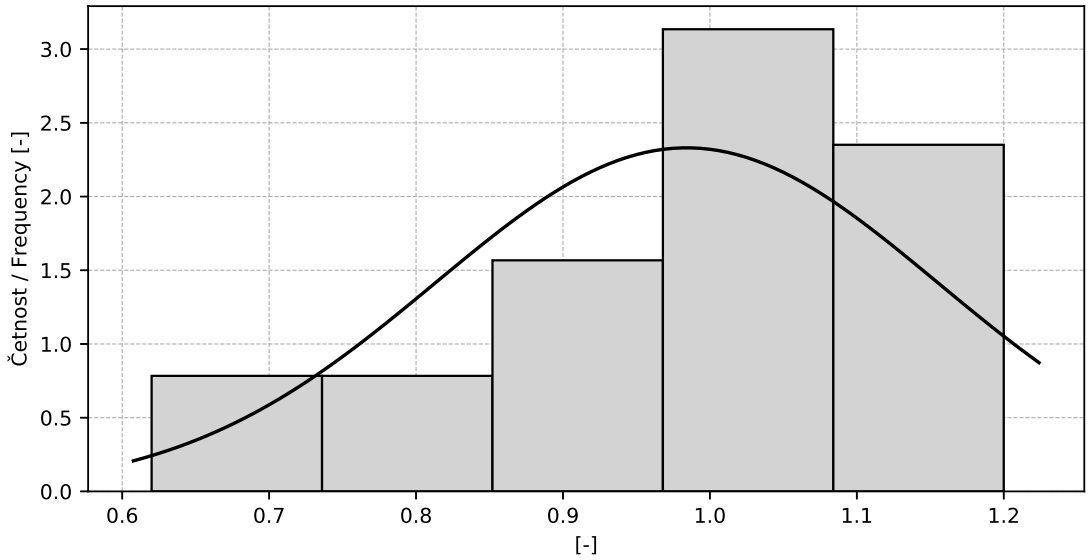

Figure 51: Histogram

Table 27: Descriptive statistics

Value	[-]
Průměrná hodnota / Average value – $\bar{x}$	0.98
Výběrová směrodatná odchylka / Sample standard deviation – s	0.171
Vztažná hodnota / Asigned value – x^*	1.0
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.149
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.056
p-hodnota testu normality / p-value of normality test	0.338 [-]

5.5 Calculation of Performance Statistics

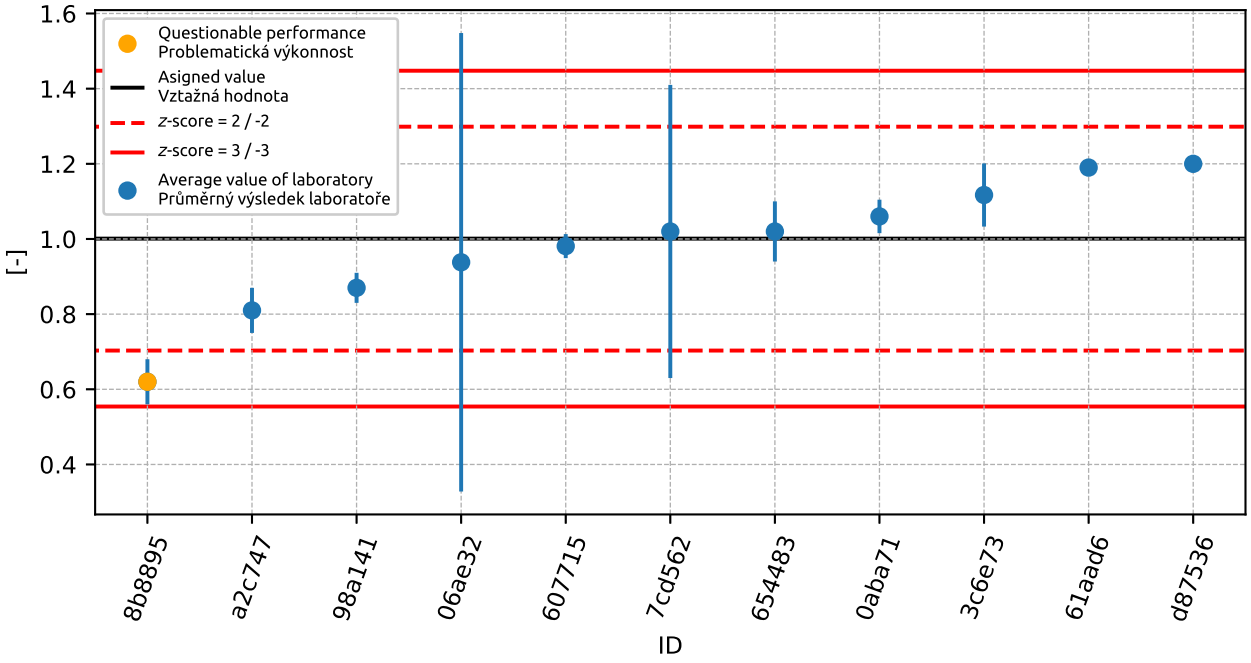

Figure 52: Average values and extended uncertainties of measurement

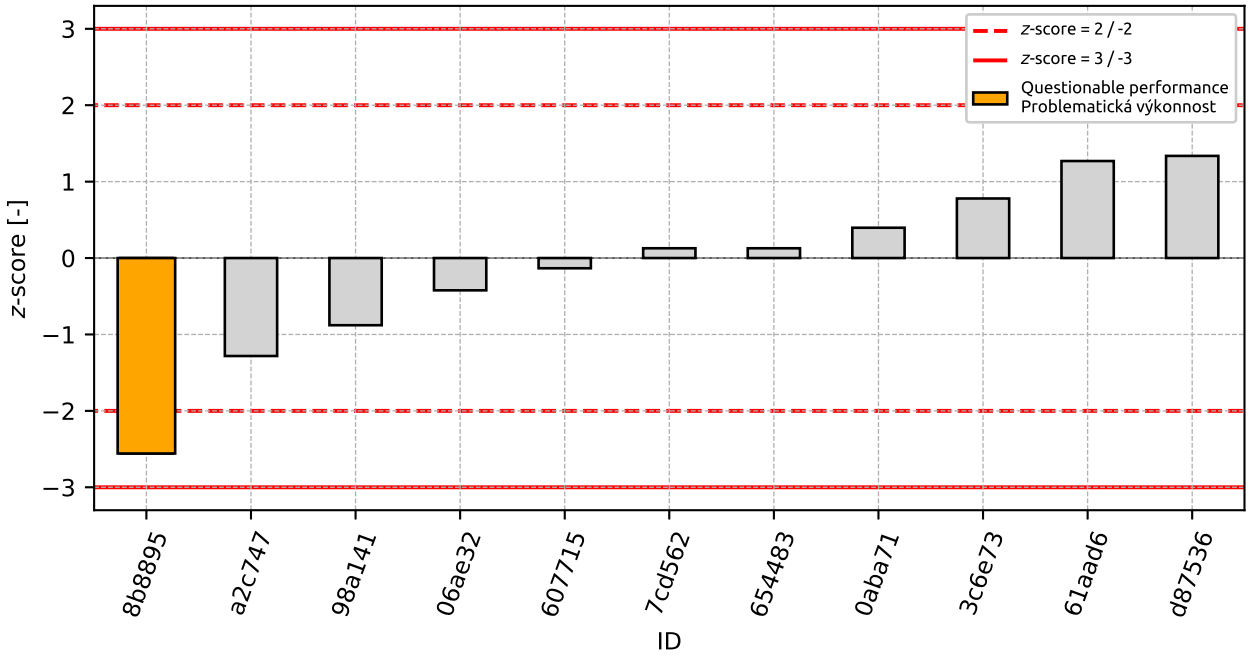

Figure 53: z-score

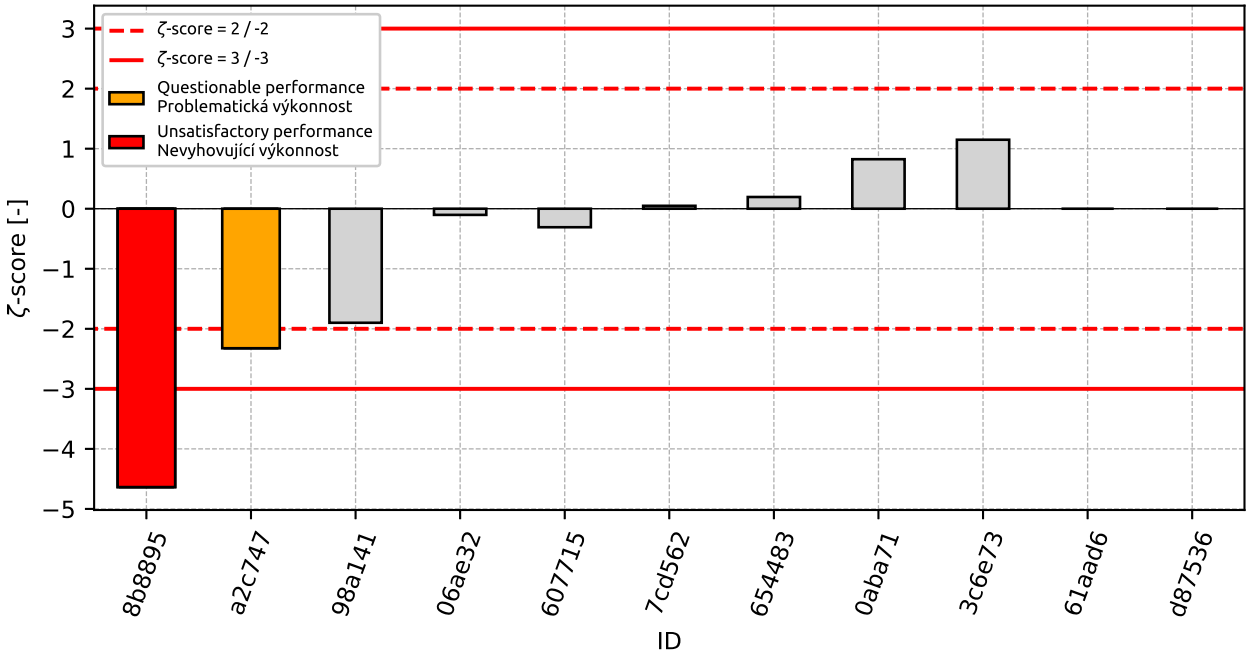

Figure 54: ζ-score

Table 28: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
8b8895	-2.56	-4.64
a2c747	-1.28	-2.32
98a141	-0.88	-1.9
06ae32	-0.42	-0.1
607715	-0.13	-0.31
7cd562	0.13	0.05
654483	0.13	0.2
0aba71	0.4	0.82
3c6e73	0.78	1.15
61aad6	1.27	-
d87536	1.34	-

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

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

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

ID of participant	Test results [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
6110fc	15.5	31.3	31.0	18.2	25.9	9.04	34.85
1f5827	27.1	29.2	24.5	5.0	26.9	2.35	8.74
95a94b	80.6	50.7	22.1	2.5	51.1	29.25	57.21
693362	54.9	62.7	39.2	12.0	52.3	11.97	22.9
ecacdb	68.8	35.0	66.6	20.7	56.8	18.91	33.29
a7e31f	72.0	54.1	55.9	3.3	60.7	9.86	16.25
2f5f6b	51.0	98.0	50.0	5.0	66.3	27.43	41.35
7cd562	75.4	57.4	79.9	33.0	70.9	11.91	16.79
7377a1	67.5	85.9	80.8	21.5	78.1	9.5	12.17
3dca00	56.4	101.8	89.8	-	82.7	23.53	28.46
06ae32	59.0	94.0	98.0	58.0	83.7	21.46	25.64
f181ac	59.0	78.1	135.3	45.2	90.8	39.7	43.73
0a5f17	97.2	112.8	89.2	18.2	99.7	12.0	12.03
607715	99.6	83.5	119.2	2.5	100.8	17.88	17.74
a047ef	98.0	114.0	94.0	2.0	102.0	10.58	10.38
fadcfb	137.8	114.5	106.7	5.9	119.7	16.18	13.52
64eca6	125.5	117.6	117.6	24.1	120.2	4.56	3.79
0e3e27	136.7	129.9	160.5	10.7	142.4	16.07	11.29
654483	121.4	158.5	156.5	56.0	145.5	20.87	14.34
bfd580	177.2	142.3	137.4	23.3	152.3	21.7	14.25
e3d536	173.0	118.0	177.0	-	156.0	32.97	21.13
0aba71*	263.8	181.5	79.8	37.7	175.0	92.17	52.66
0b6f2b	153.4	209.0	194.6	78.0	185.7	28.86	15.54
9081b8	232.1	215.8	274.7	19.5	240.9	30.41	12.63

7.1.2 The Numerical Procedure for Determining Outliers

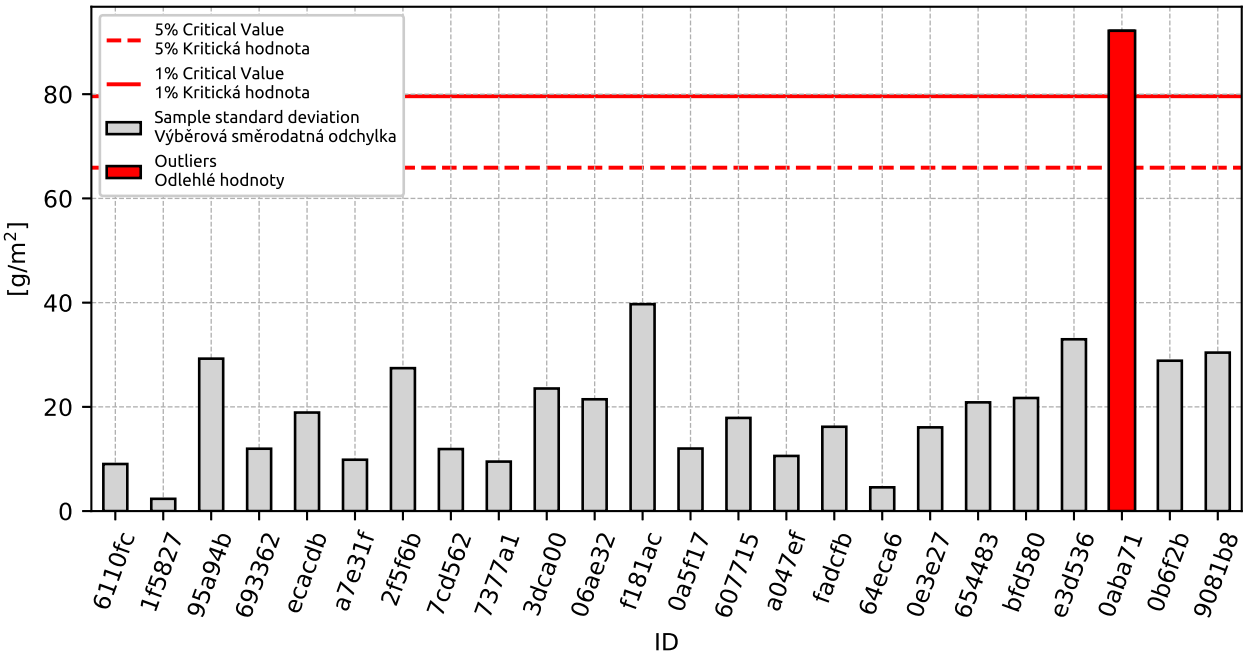

Figure 55: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

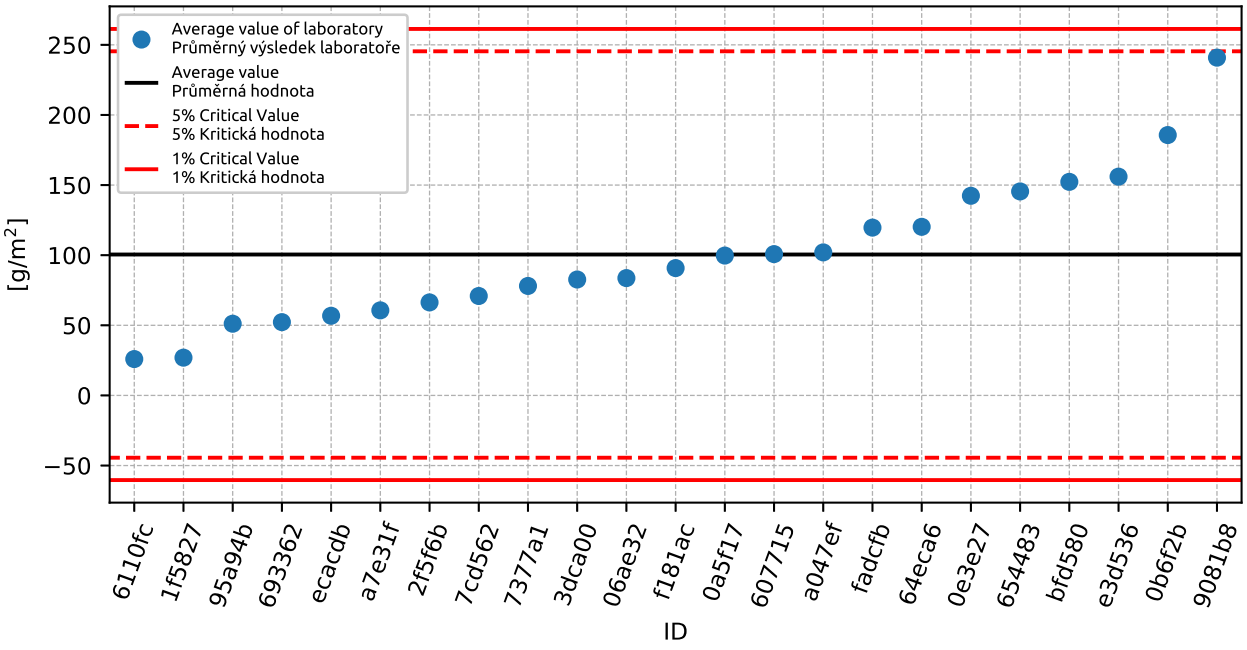

Figure 56: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

7.1.3 Mandel's Statistics

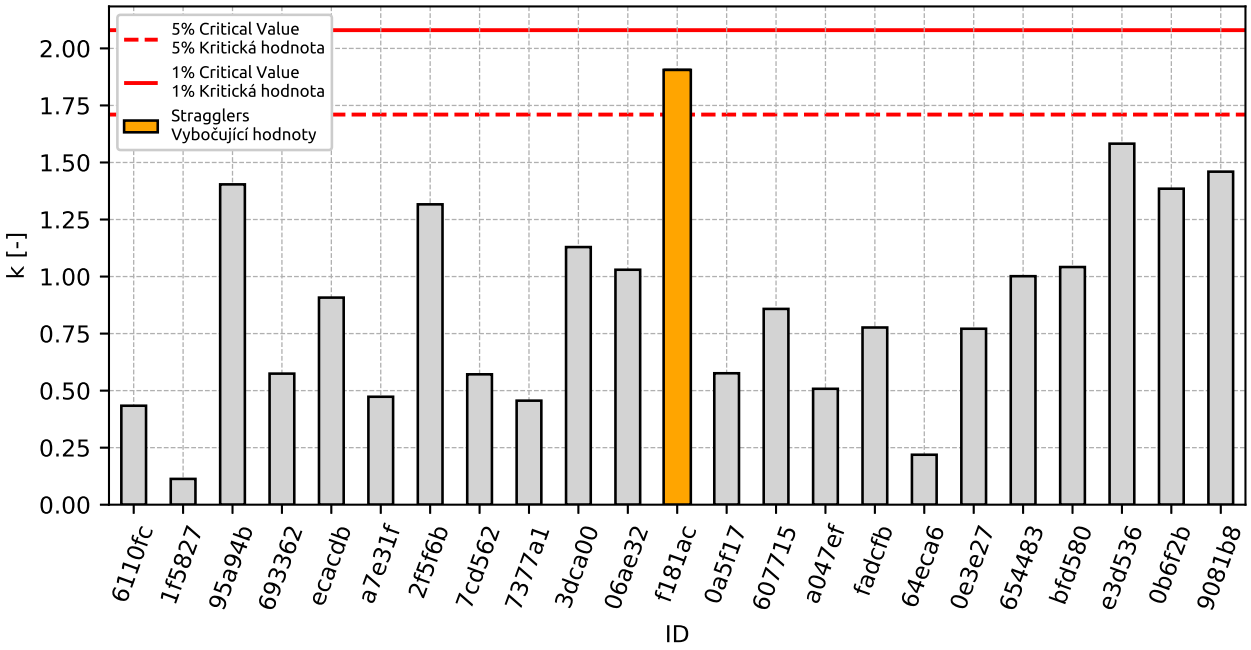

Figure 57: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

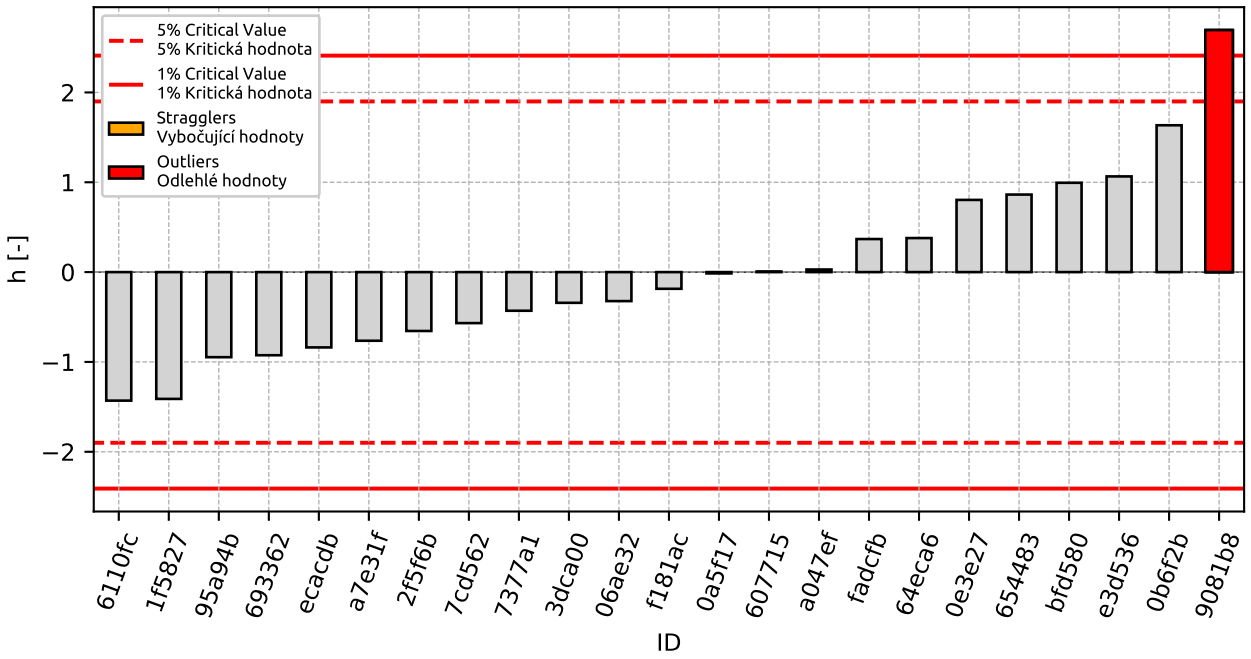

Figure 58: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

7.1.4 Descriptive statistics

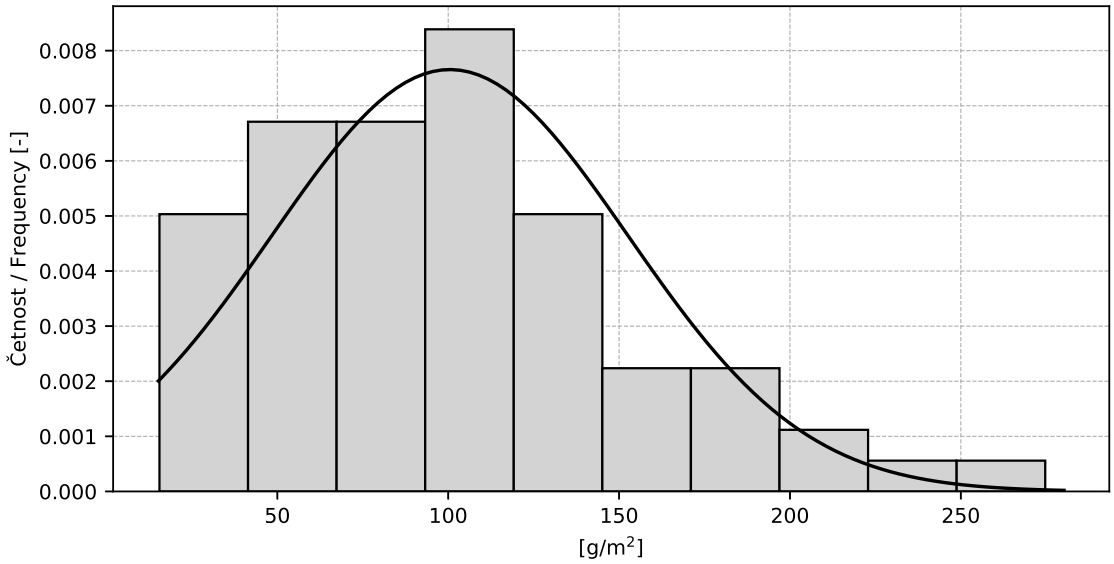

Figure 59: Histogram

Table 30: Descriptive statistics

Value	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	100.5
Výběrová směrodatná odchylka / Sample standard deviation – s	52.11
Vztažná hodnota / Asigned value – x^*	99.3
Robustní směrodatná odchylka / Robust standard deviation – s^*	55.82
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	14.55
p-hodnota testu normality / p-value of normality test	0.009 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	50.7
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	20.83
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	54.81
Opakovatelnost / Repeatability – r	58.3
Reprodukovatelnost / Reproducibility – R	153.5

7.1.5 Calculation of Performance Statistics

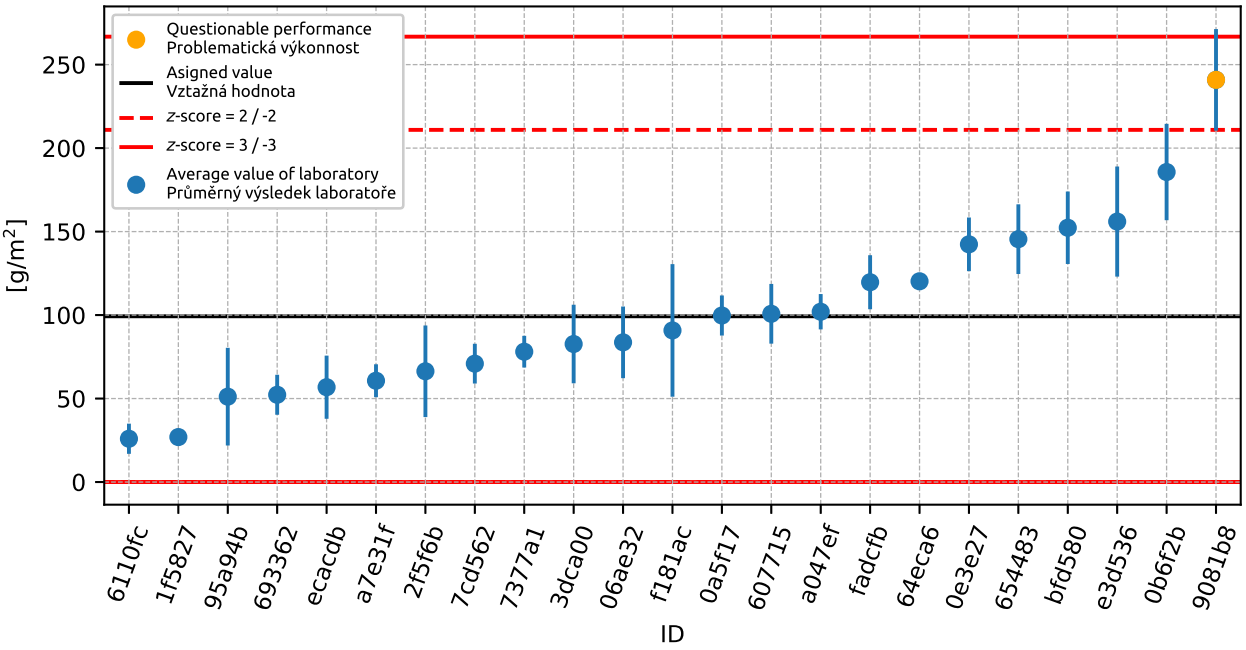

Figure 60: Average values and sample standard deviations

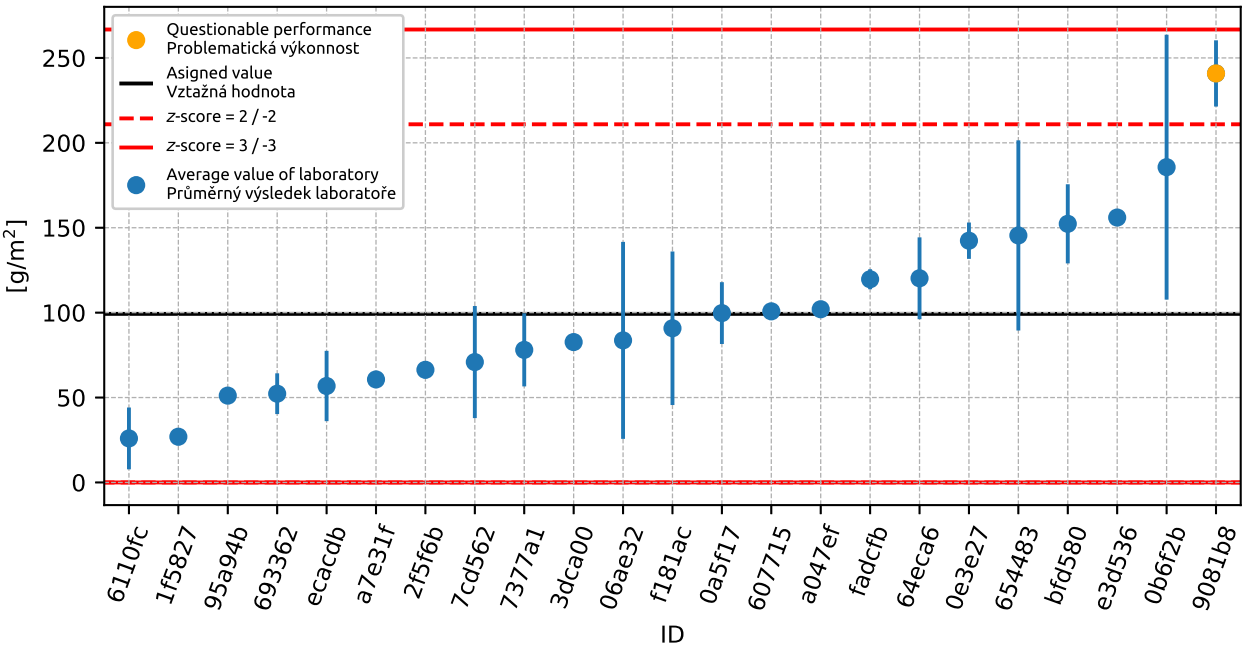

Figure 61: Average values and extended uncertainties of measurement

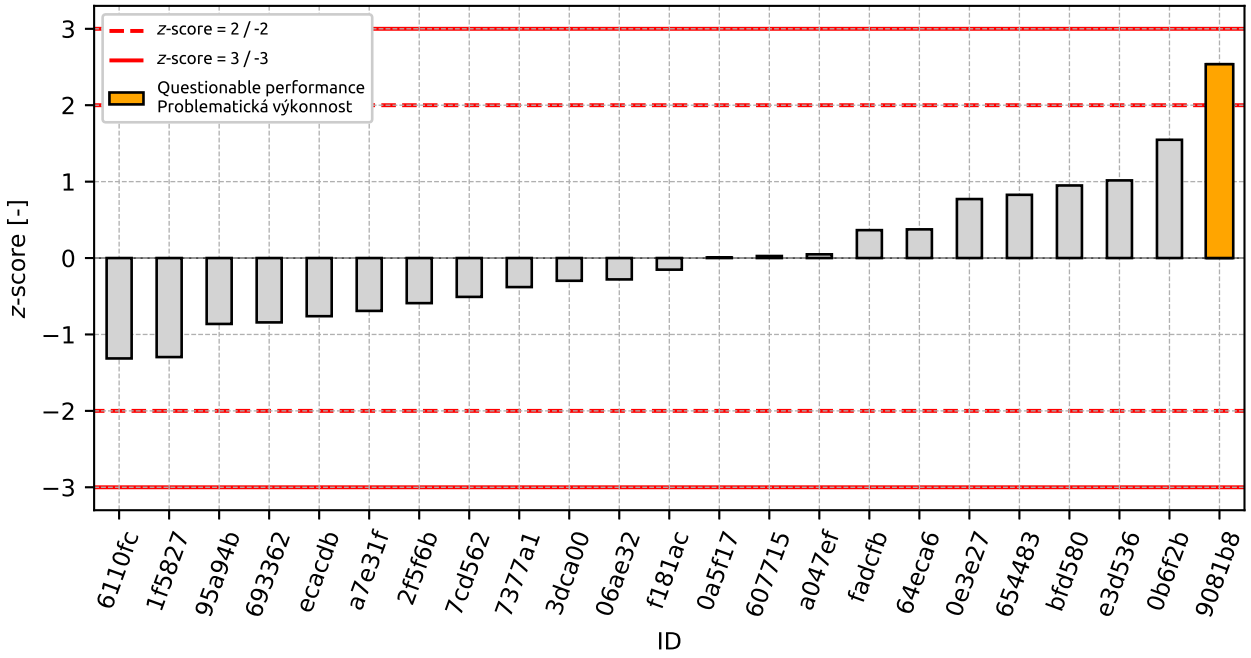

Figure 62: z-score

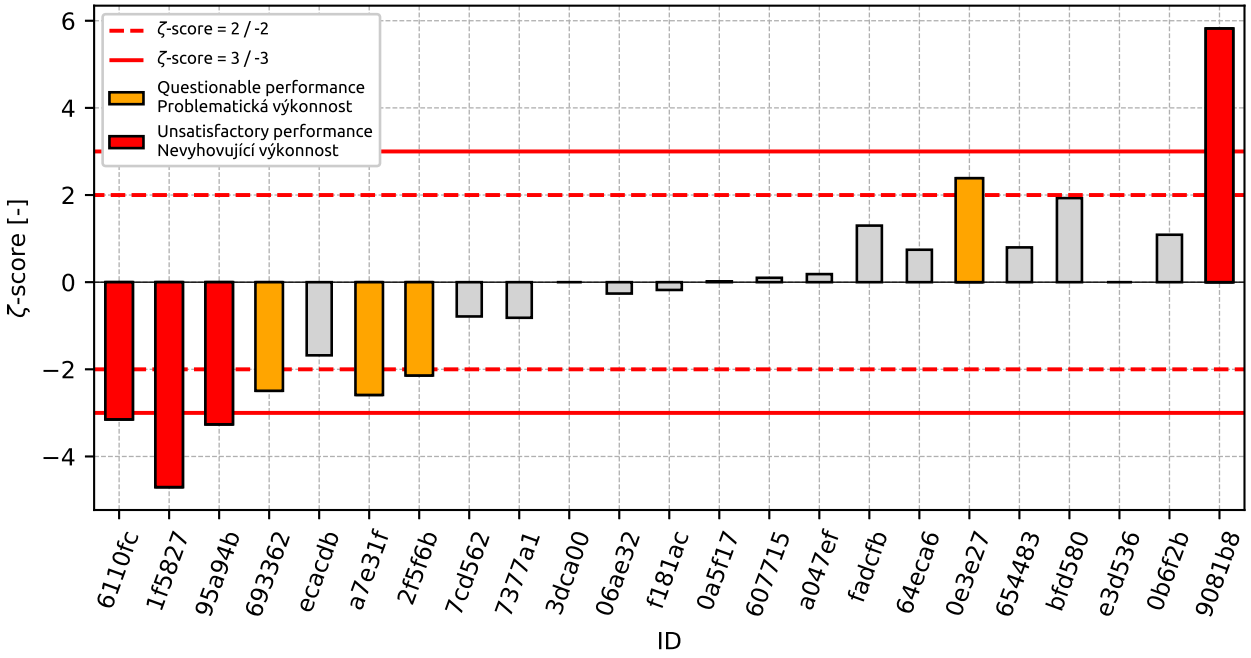

Figure 63: ζ-score

Table 31: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
6110fc	-1.31	-3.15
1f5827	-1.3	-4.7
95a94b	-0.86	-3.26
693362	-0.84	-2.49
ecacdb	-0.76	-1.68
a7e31f	-0.69	-2.59
2f5f6b	-0.59	-2.14
7cd562	-0.51	-0.79
7377a1	-0.38	-0.82
3dca00	-0.3	-
06ae32	-0.28	-0.26
f181ac	-0.15	-0.18
0a5f17	0.01	0.02
607715	0.03	0.1
a047ef	0.05	0.19
fadcfb	0.37	1.3
64eca6	0.38	0.74
0e3e27	0.77	2.39
654483	0.83	0.8
bfd580	0.95	1.93
e3d536	1.02	-
0b6f2b	1.55	1.09
9081b8	2.54	5.82

7.2 50 cycles

7.2.1 Test results

Table 32: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
1f5827	98.5	56.3	42.5	38.0	65.8	29.18	44.36
6110fc	92.8	89.8	77.6	45.2	86.7	8.05	9.28
ecacdb	139.8	90.1	111.5	26.5	113.8	24.93	21.91
2f5f6b	118.0	169.0	121.0	5.0	136.0	28.62	21.04
693362	160.8	196.1	105.9	45.0	154.3	45.45	29.46
a7e31f	193.5	132.5	169.3	9.1	165.1	30.72	18.6
7cd562	177.4	150.1	168.8	37.1	165.4	13.96	8.44
7377a1	148.3	202.0	187.5	21.5	179.3	27.78	15.5
06ae32	129.0	228.0	184.0	131.0	180.3	49.6	27.51
95a94b	203.1	155.3	200.9	9.3	186.4	26.98	14.47
f181ac	247.8	160.0	229.8	78.4	212.5	46.38	21.82
3dca00	196.1	254.8	213.1	-	221.3	30.2	13.65
a047ef	247.0	314.0	278.0	5.0	279.7	33.53	11.99
0aba71*	430.9	274.5	137.5	37.7	281.0	146.81	52.25
64eca6	286.3	302.0	274.5	57.5	287.6	13.8	4.8
607715	234.1	252.5	378.8	7.0	288.5	78.77	27.31
bfd580	310.2	296.4	272.4	26.1	293.0	19.13	6.53
0a5f17	287.7	322.7	290.9	44.4	300.4	19.35	6.44
0e3e27	347.5	338.5	364.0	26.3	350.0	12.93	3.7
654483	314.5	405.8	371.9	123.0	364.1	46.15	12.68
fadcfb	417.8	348.0	355.6	18.7	373.8	38.29	10.24
e3d536	421.0	353.0	508.0	-	427.3	77.69	18.18
0b6f2b	518.1	586.2	583.9	103.0	562.7	38.67	6.87
9081b8*	671.4	775.9	803.2	48.4	750.2	69.57	9.27

7.2.2 The Numerical Procedure for Determining Outliers

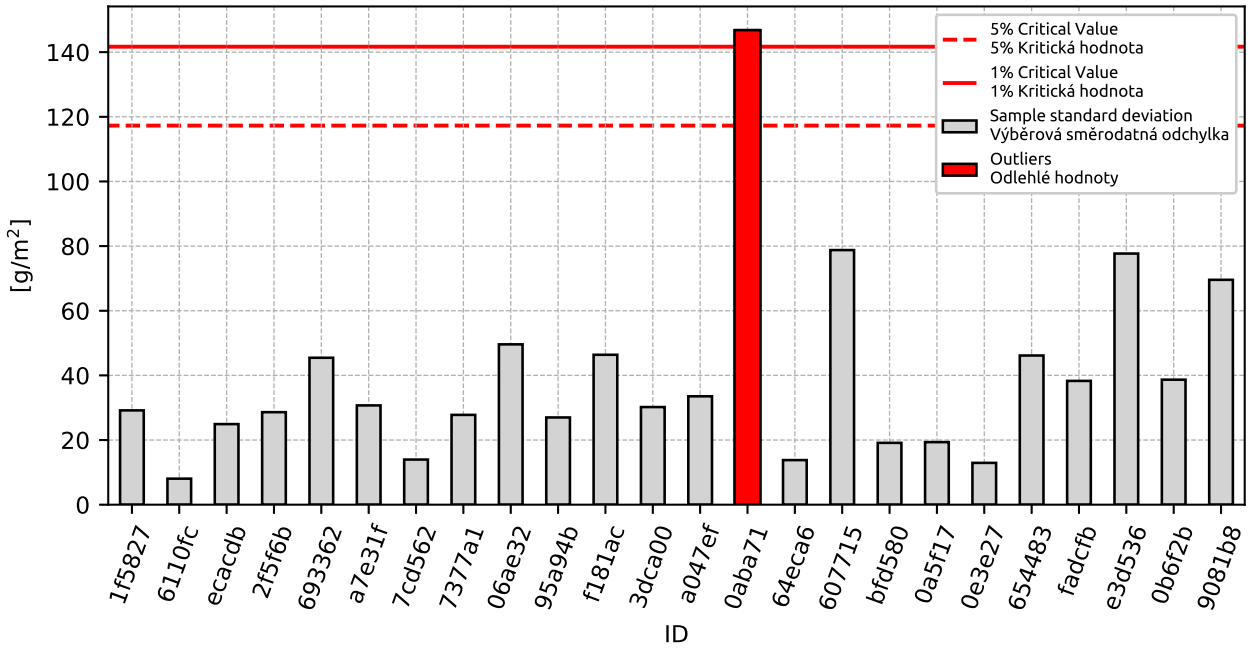

Figure 64: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

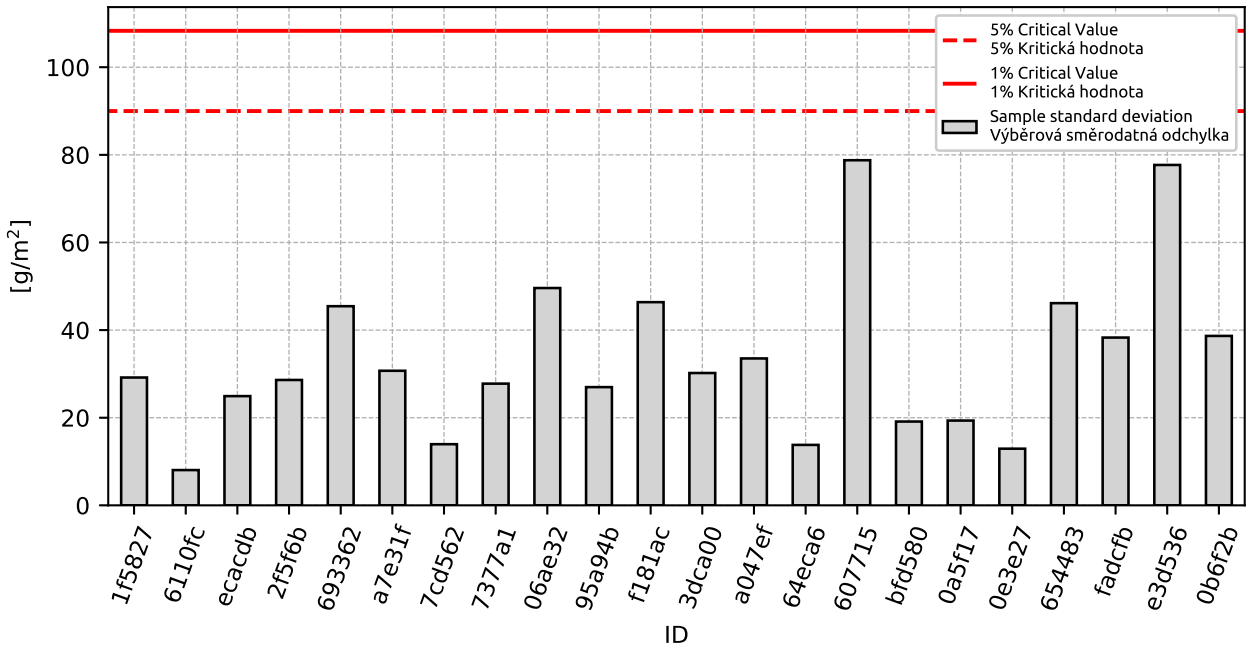

Figure 65: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color

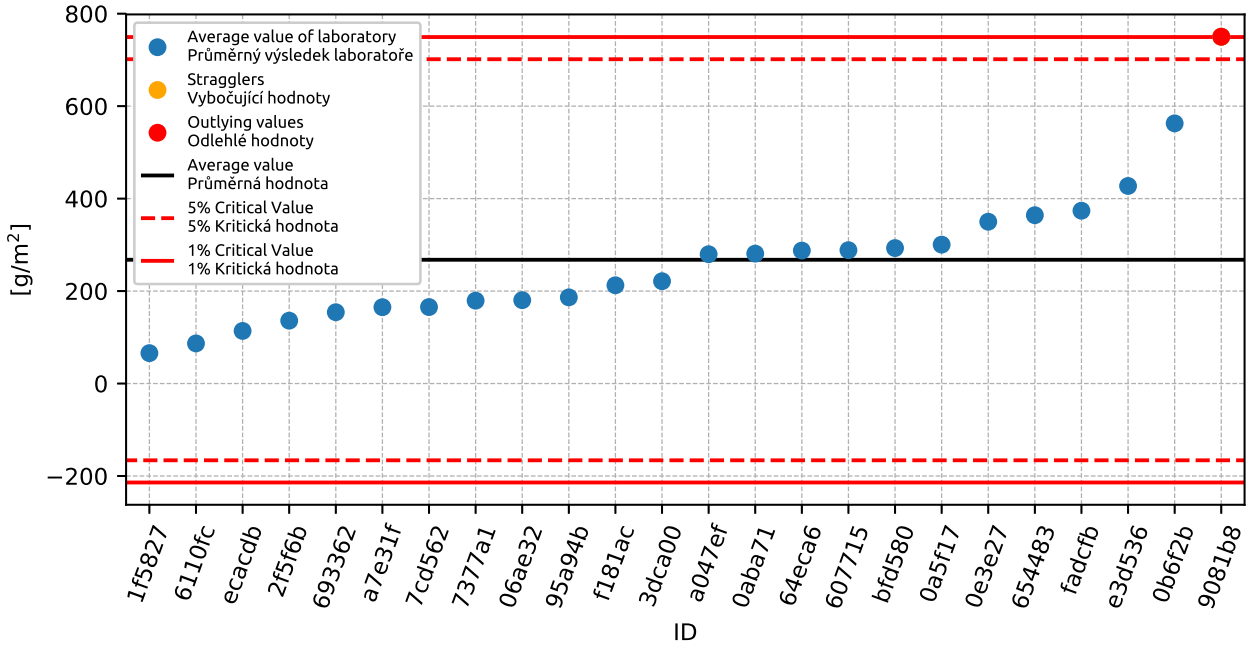

Figure 66: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

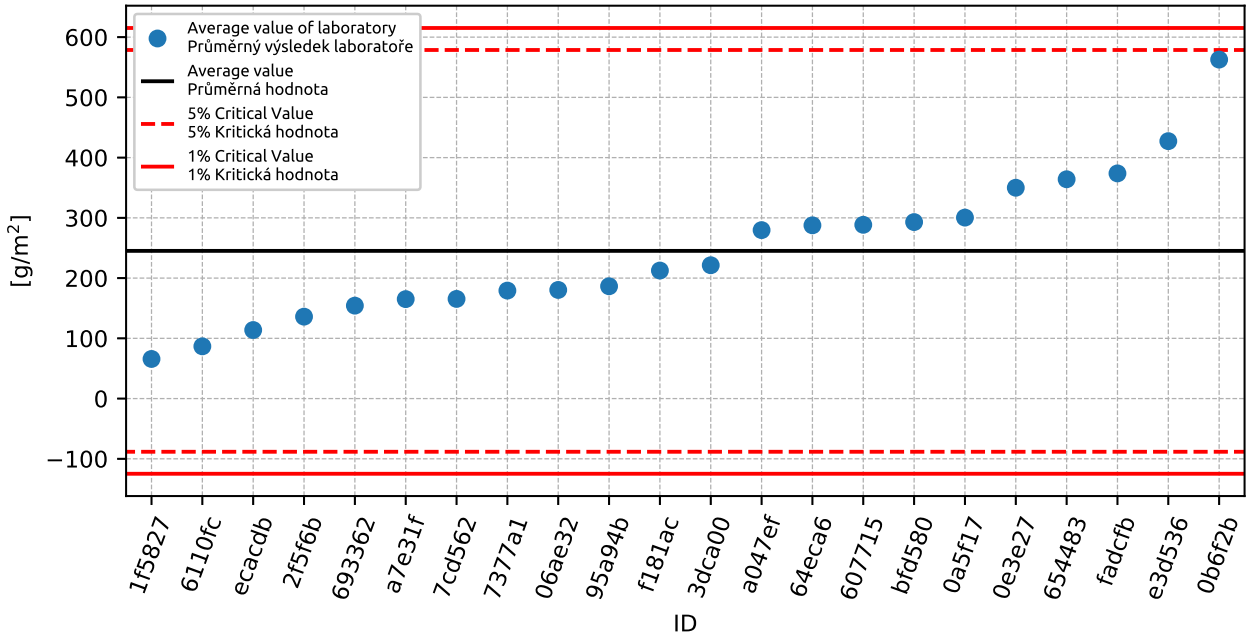

Figure 67: **Grubbs' test** - average values without outliers: 1% critical value - red color; 5% critical value - blue color

7.2.3 Mandel's Statistics

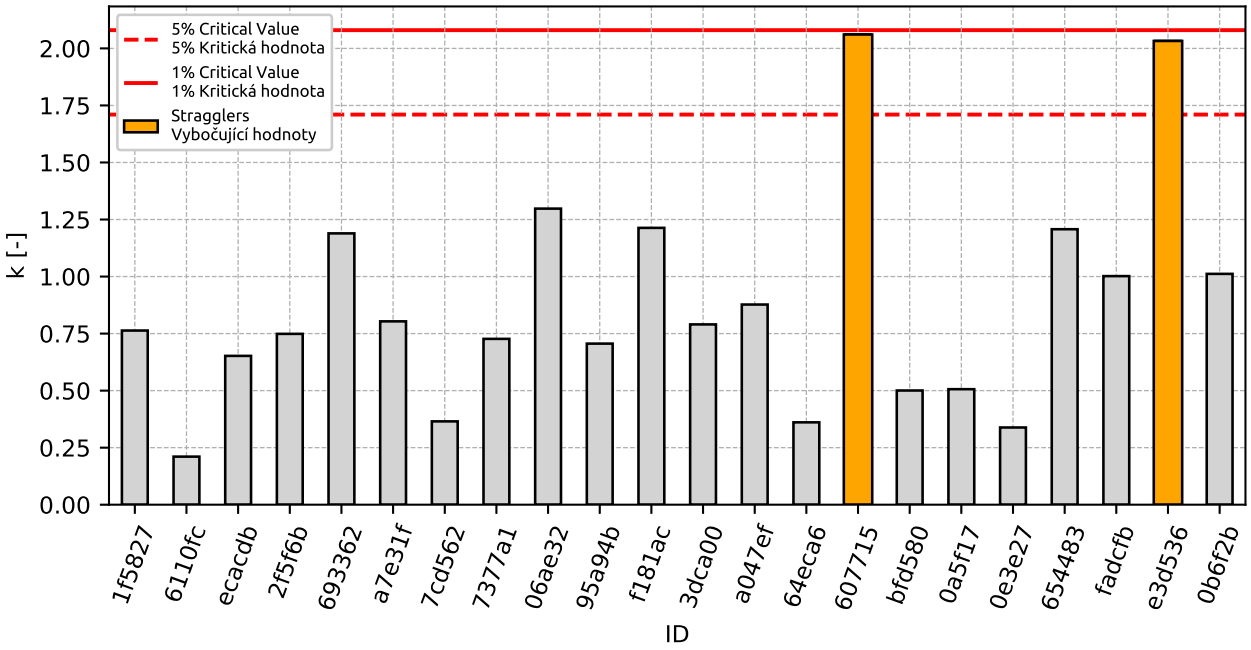

Figure 68: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

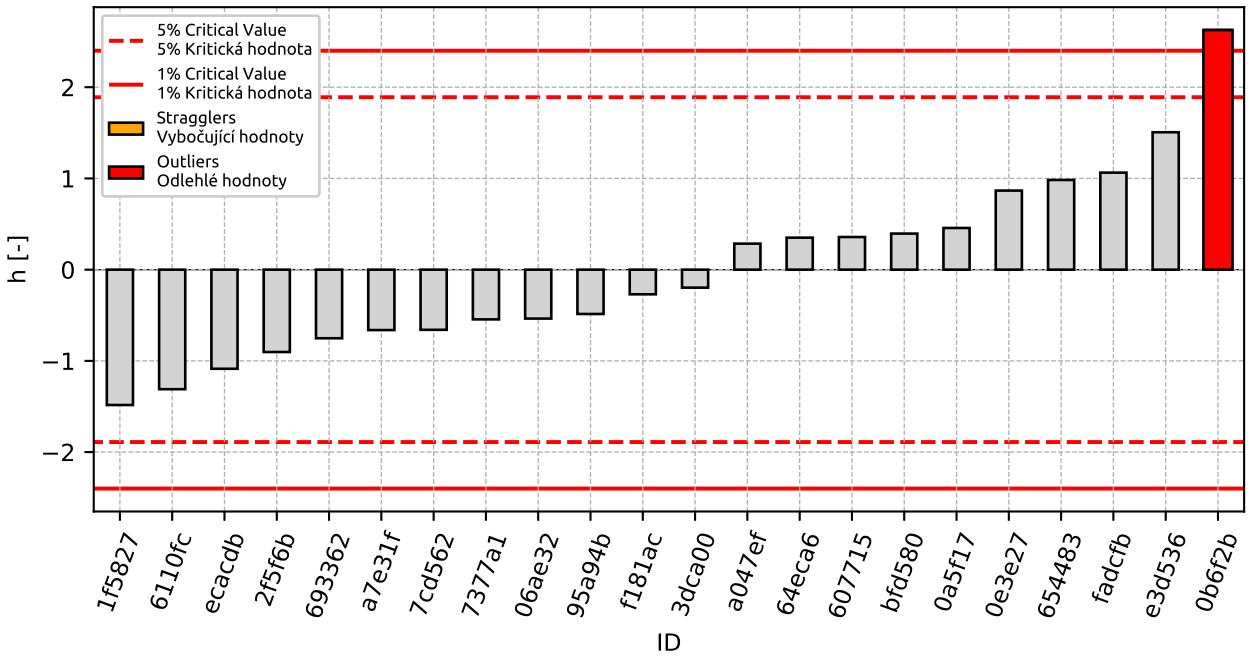

Figure 69: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

7.2.4 Descriptive statistics

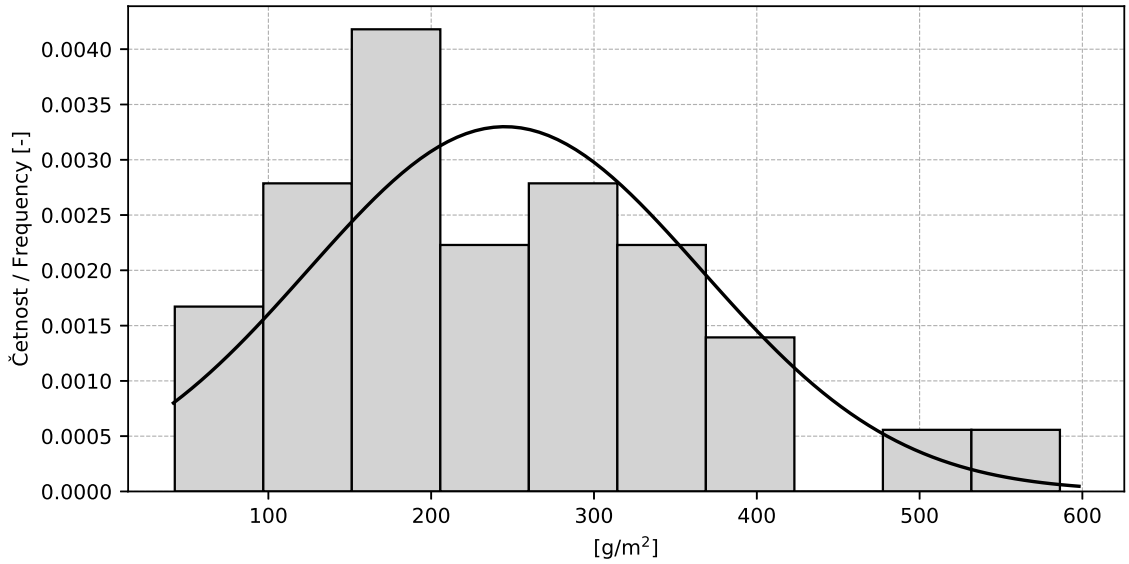

Figure 70: Histogram

Table 33: Descriptive statistics

Value	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	245.2
Výběrová směrodatná odchylka / Sample standard deviation – s	120.92
Vztažná hodnota / Asigned value – x^*	243.1
Robustní směrodatná odchylka / Robust standard deviation – s^*	130.7
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	34.83
p-hodnota testu normality / p-value of normality test	0.027 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	118.89
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	38.22
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	124.88
Opakovatelnost / Repeatability – r	107.0
Reprodukovatelnost / Reproducibility – R	349.7

7.2.5 Calculation of Performance Statistics

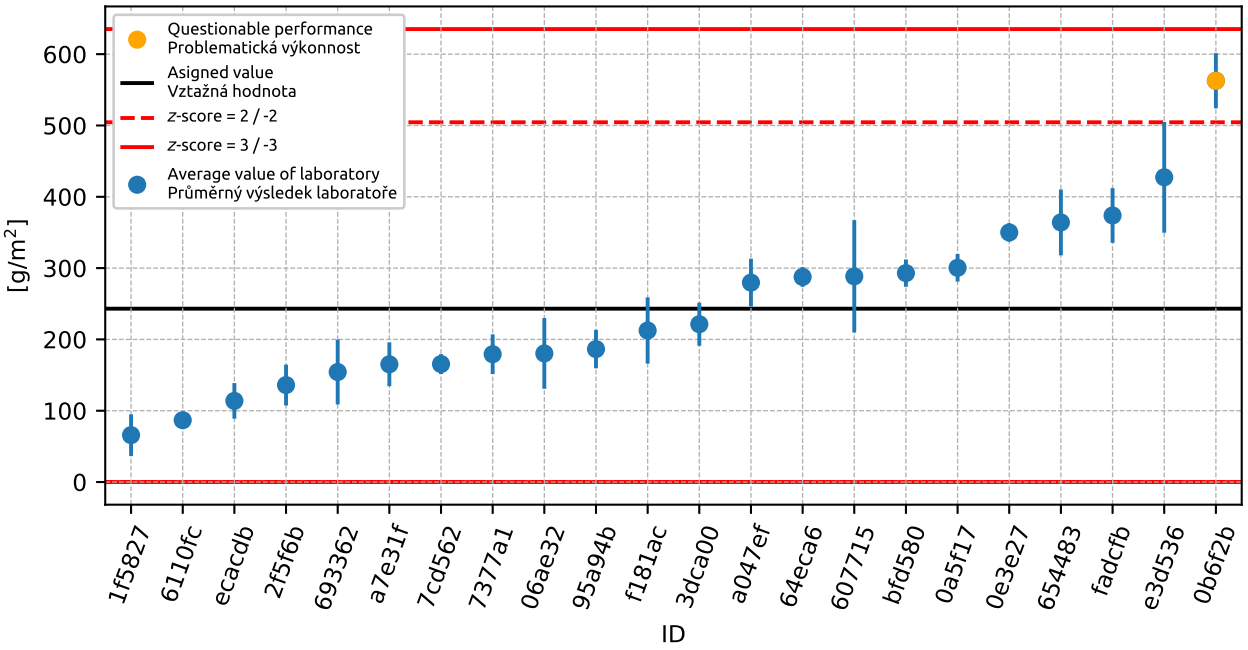

Figure 71: Average values and sample standard deviations

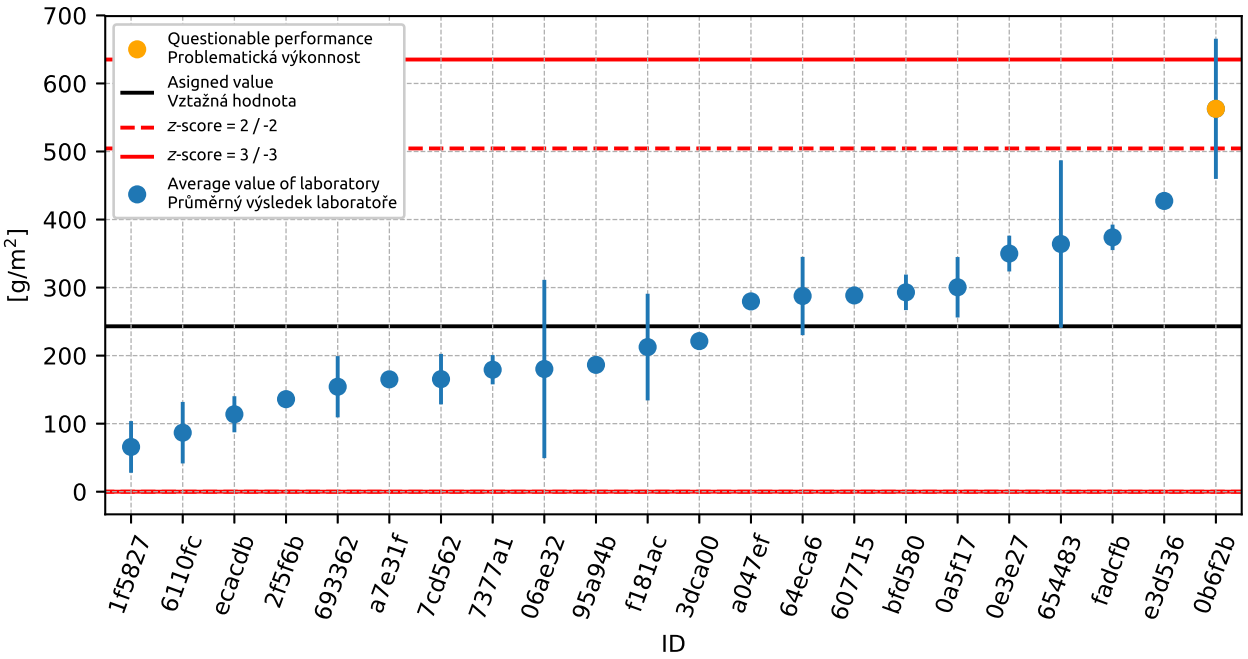

Figure 72: Average values and extended uncertainties of measurement

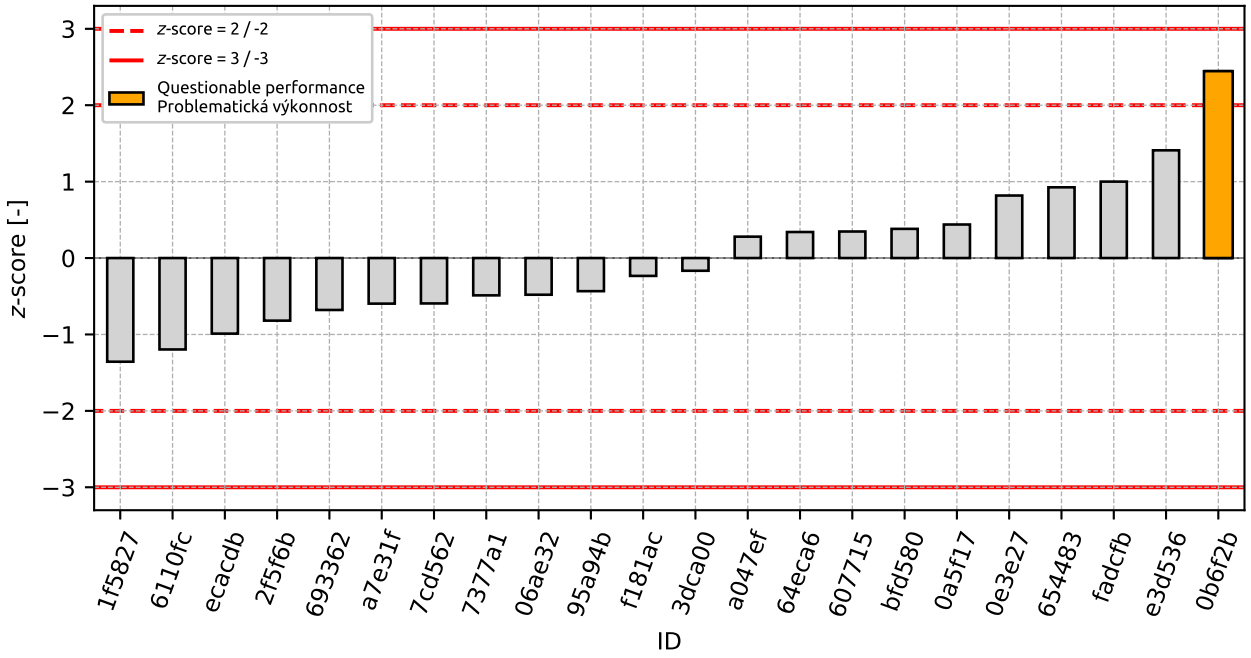

Figure 73: z-score

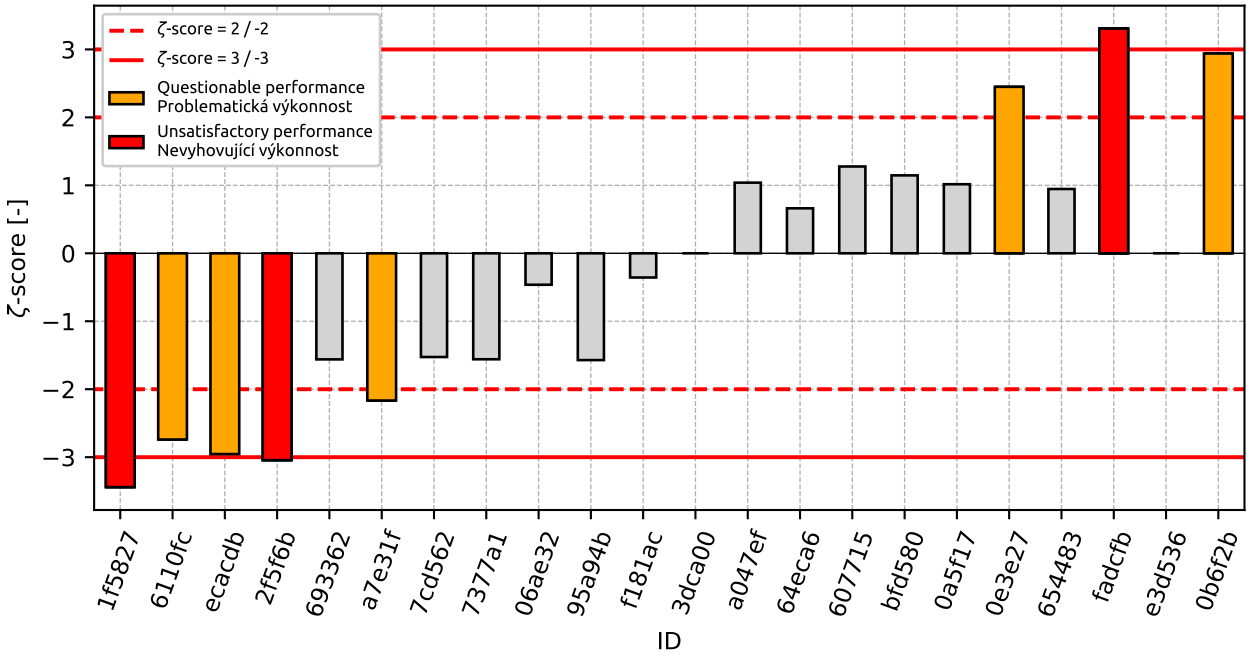

Figure 74: ζ-score

Table 34: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
1f5827	-1.36	-3.44
6110fc	-1.2	-2.74
ecacdb	-0.99	-2.95
2f5f6b	-0.82	-3.04
693362	-0.68	-1.56
a7e31f	-0.6	-2.17
7cd562	-0.59	-1.53
7377a1	-0.49	-1.56
06ae32	-0.48	-0.46
95a94b	-0.43	-1.57
f181ac	-0.23	-0.36
3dca00	-0.17	-
a047ef	0.28	1.04
64eca6	0.34	0.66
607715	0.35	1.28
bfd580	0.38	1.15
0a5f17	0.44	1.02
0e3e27	0.82	2.45
654483	0.93	0.95
fadcfb	1.0	3.31
e3d536	1.41	-
0b6f2b	2.45	2.94

7.3 75 cycles

7.3.1 Test results

Table 35: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
1f5827	171.3	105.7	67.5	65.0	114.8	52.5	45.72
6110fc	224.4	148.3	147.5	101.1	173.4	44.17	25.47
ecacdb	219.2	155.3	182.1	29.0	185.5	32.09	17.3
2f5f6b	220.0	282.0	224.0	5.0	242.0	34.7	14.34
7cd562	279.4	260.5	270.9	25.5	270.3	9.47	3.5
a7e31f	324.4	250.4	291.9	15.9	288.9	37.09	12.84
693362	290.2	411.8	207.8	102.0	303.3	102.63	33.84
06ae32	137.0	443.0	411.0	447.0	330.3	168.19	50.92
0aba71	558.5	336.4	168.6	37.7	354.5	195.58	55.17
7377a1	268.7	483.2	337.7	21.5	363.2	109.5	30.15
f181ac	480.7	294.9	334.5	110.2	370.0	97.86	26.45
a047ef	420.0	435.0	373.0	8.0	409.3	32.35	7.9
3dca00	458.5	508.1	384.0	-	450.2	62.46	13.87
bfd580	442.2	501.3	424.2	50.4	455.9	40.33	8.85
64eca6	423.5	505.9	462.7	92.8	464.0	41.22	8.88
95a94b	430.0	449.5	564.3	24.1	481.3	72.57	15.08
607715	432.9	503.5	697.3	14.0	544.6	136.9	25.14
0a5f17	536.6	633.8	589.6	99.3	586.7	48.67	8.3
0e3e27	714.5	621.9	692.8	50.7	676.4	48.43	7.16
654483	609.5	798.0	670.0	255.0	692.5	96.24	13.9
fadcfb	840.0	647.6	760.0	37.4	749.2	96.65	12.9
e3d536	887.0	776.0	1005.0	-	889.3	114.52	12.88
0b6f2b	1111.3	1139.1	1129.9	41.0	1126.8	14.16	1.26
9081b8	1338.6	1585.1	1502.3	107.4	1475.3	125.44	8.5

7.3.2 The Numerical Procedure for Determining Outliers

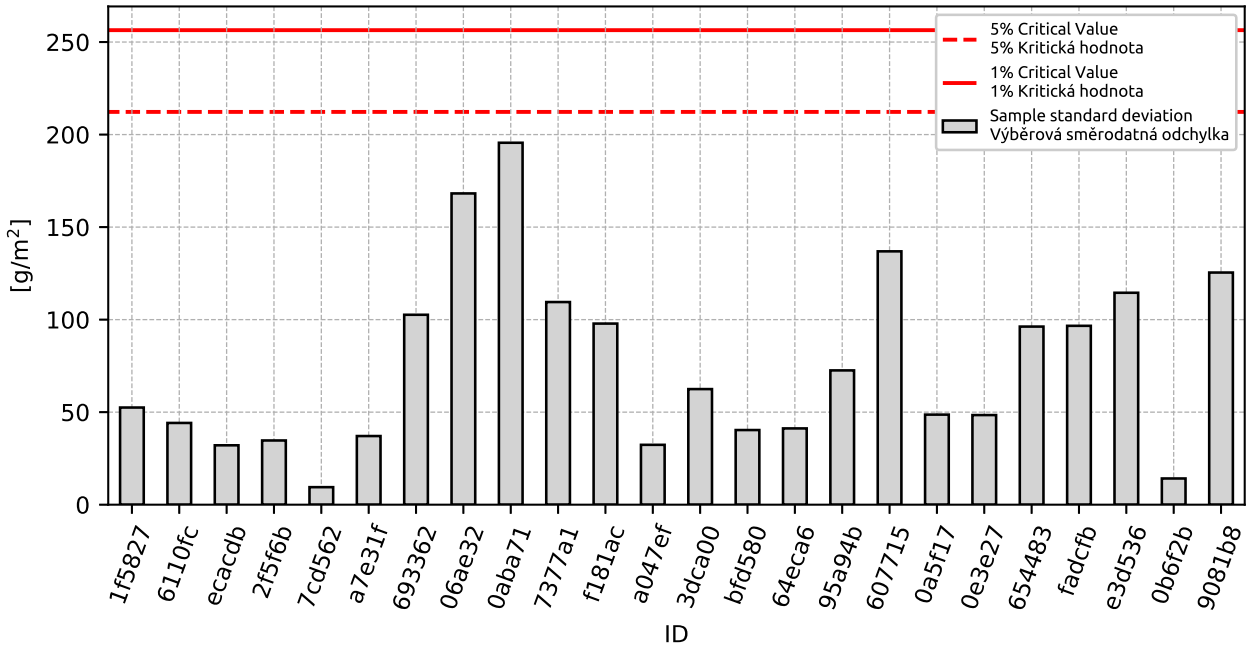

Figure 75: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

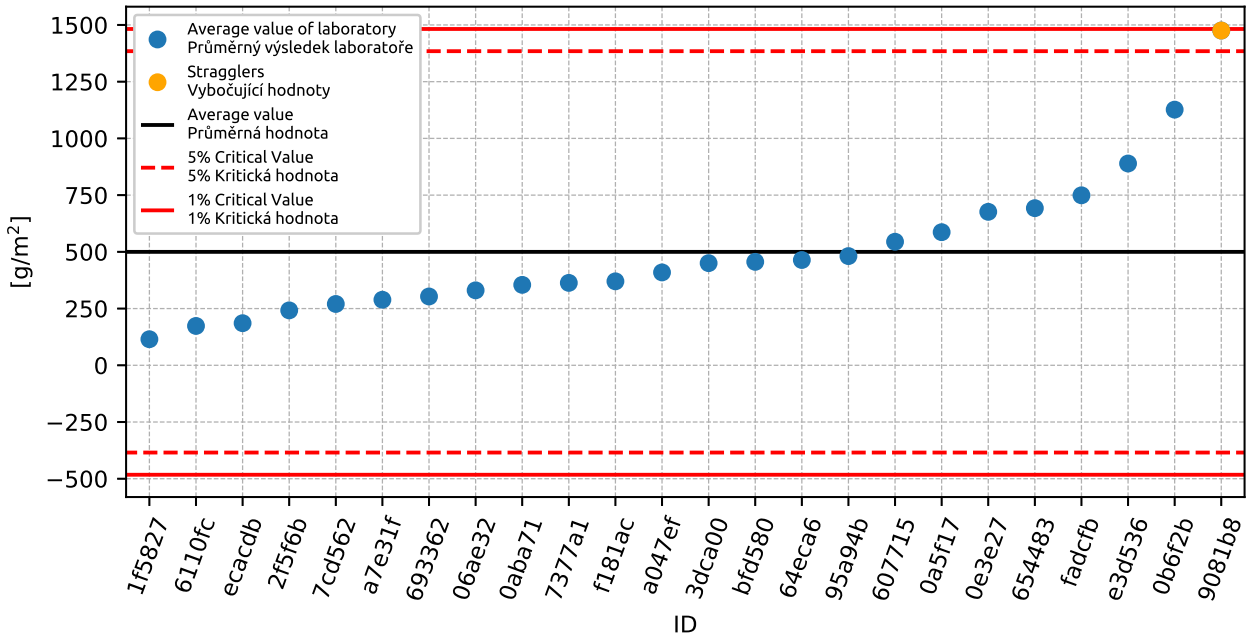

Figure 76: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

7.3.3 Mandel's Statistics

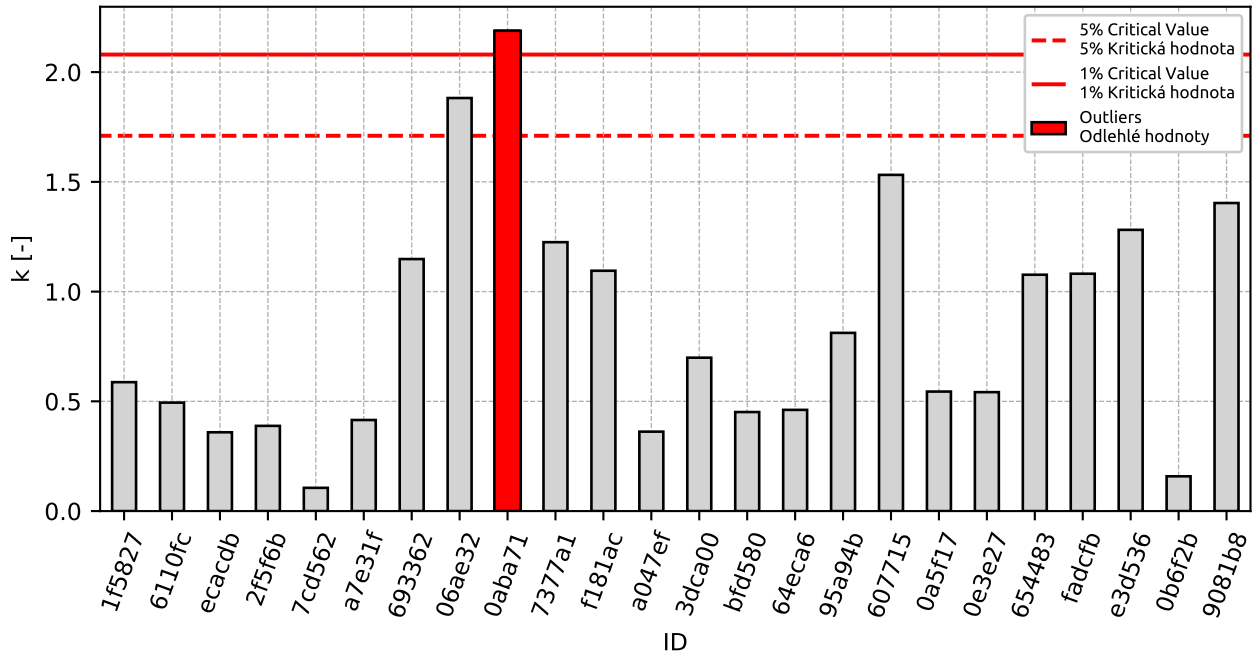

Figure 77: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

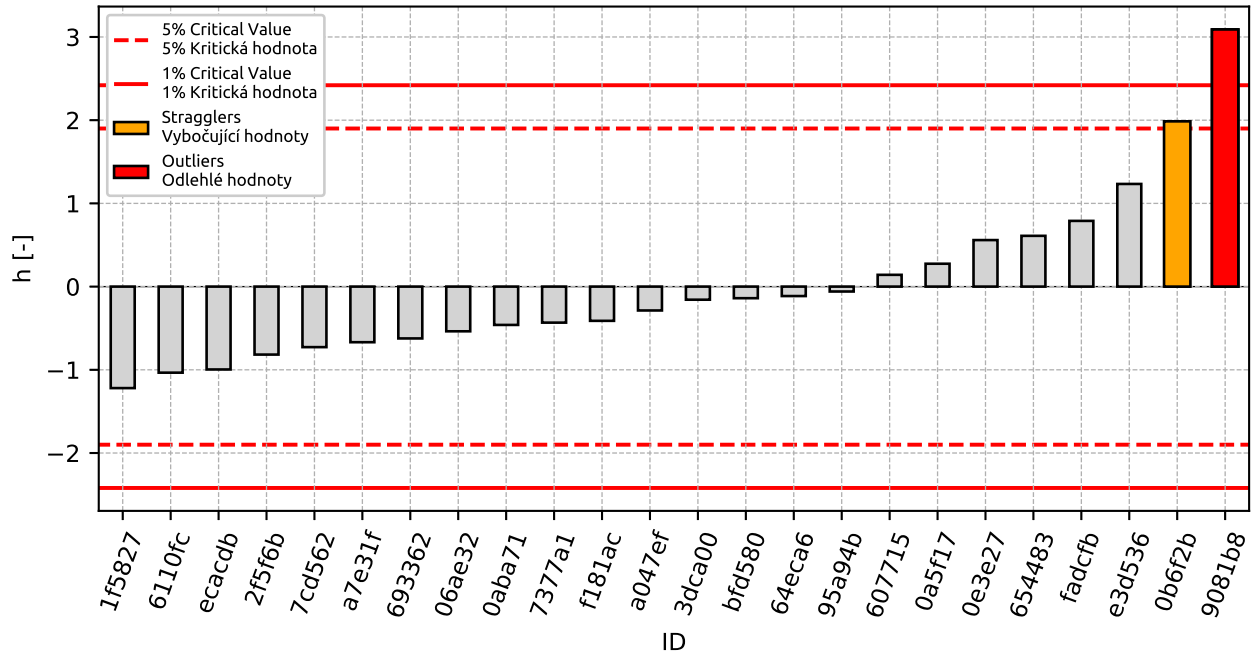

Figure 78: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

7.3.4 Descriptive statistics

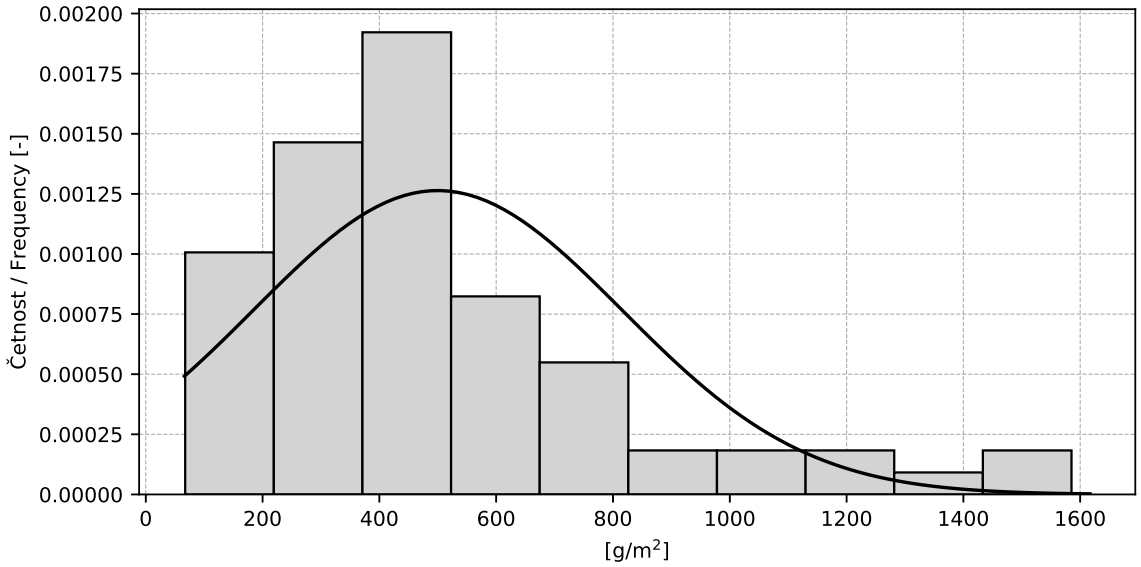

Figure 79: Histogram

Table 36: Descriptive statistics

Value	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	499.9
Výběrová směrodatná odchylka / Sample standard deviation – s	315.67
Vztažná hodnota / Asigned value – x^*	479.3
Robustní směrodatná odchylka / Robust standard deviation – s^*	328.1
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	80.84
p-hodnota testu normality / p-value of normality test	0.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	311.42
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	89.37
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	323.99
Opakovatelnost / Repeatability – r	250.2
Reprodukovatelnost / Reproducibility – R	907.2

7.3.5 Calculation of Performance Statistics

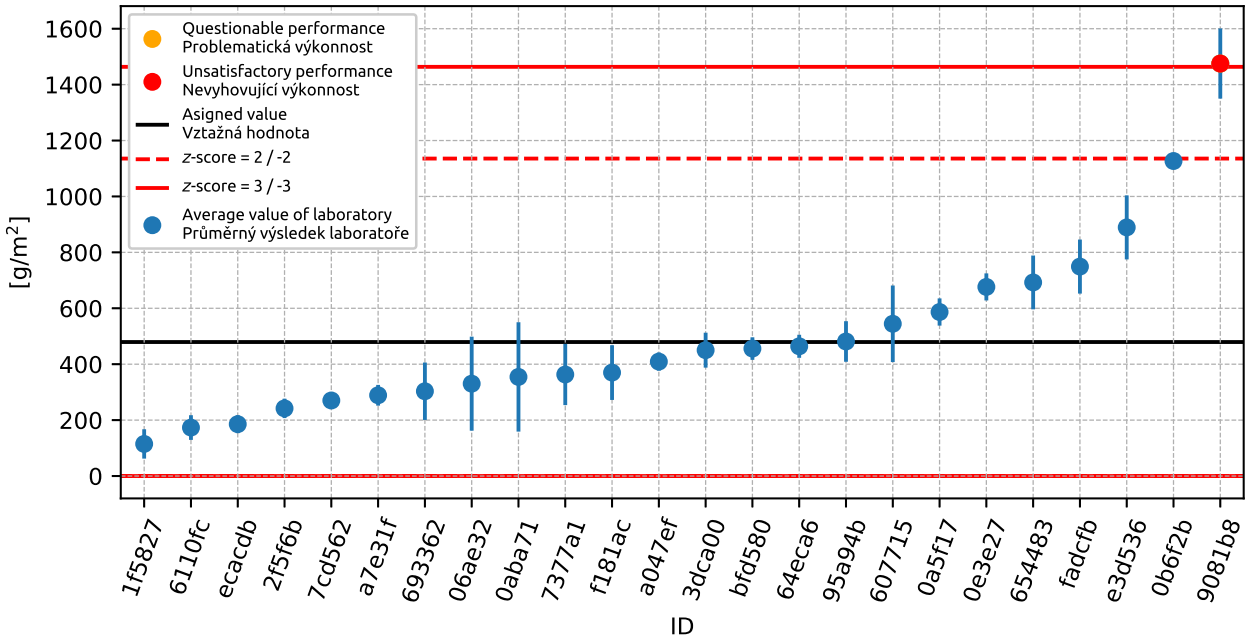

Figure 80: Average values and sample standard deviations

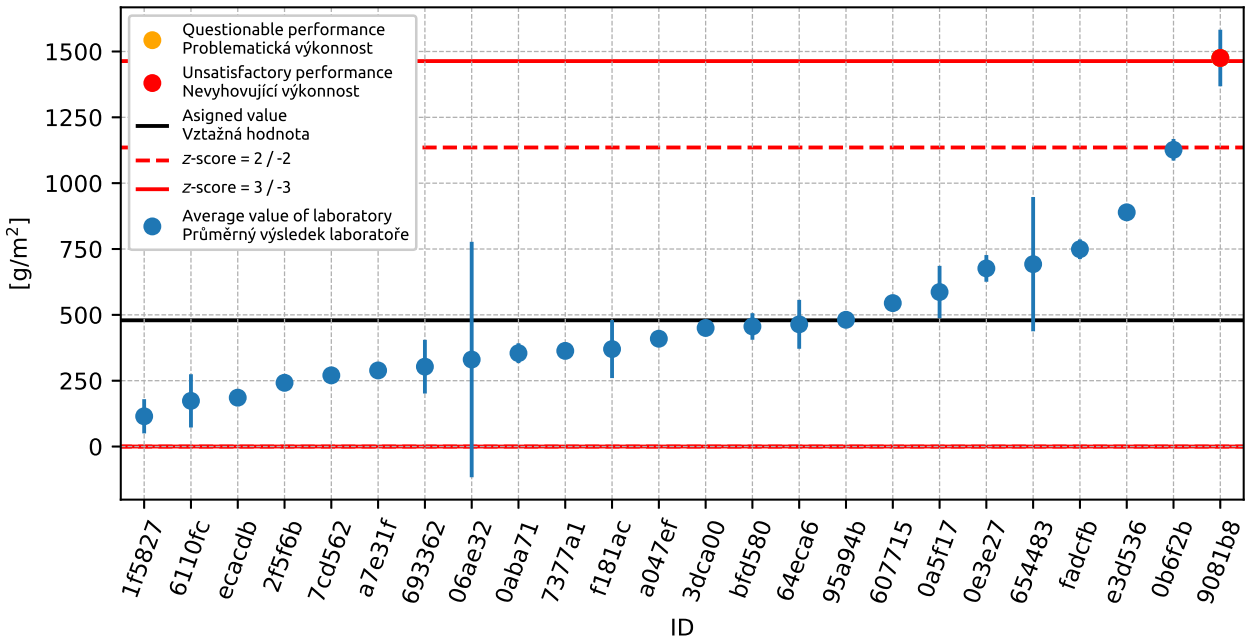

Figure 81: Average values and extended uncertainties of measurement

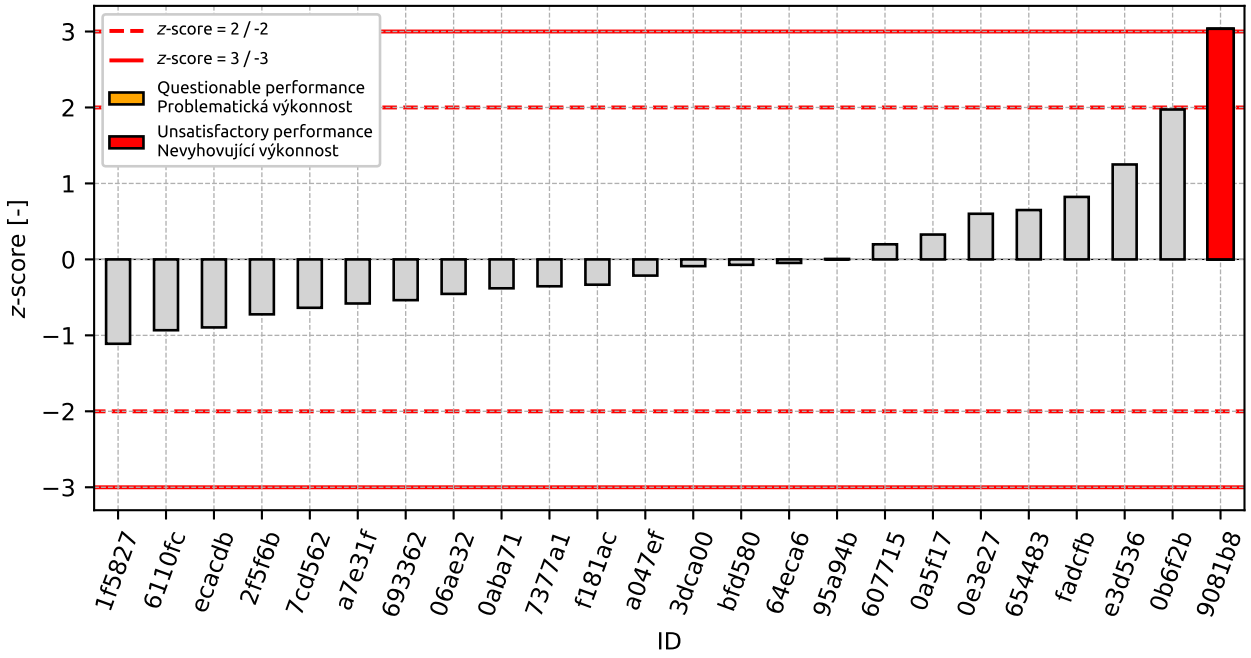

Figure 82: z-score

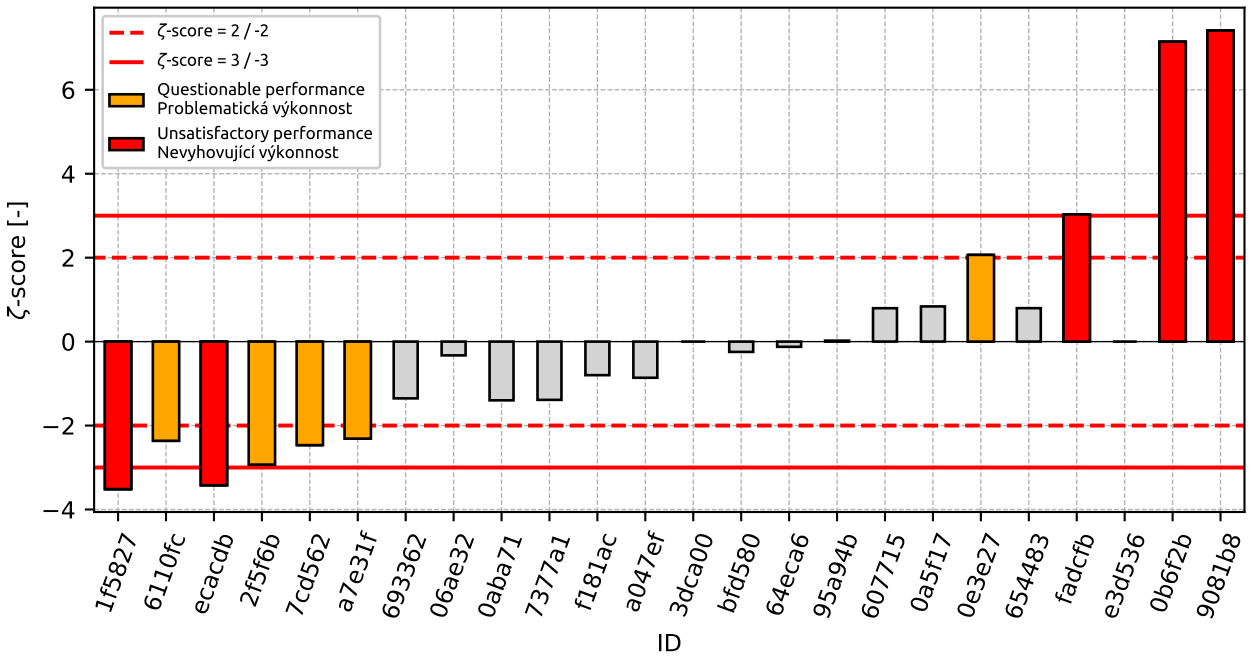

Figure 83: ζ-score

Table 37: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
1f5827	-1.11	-3.51
6110fc	-0.93	-2.36
ecacdb	-0.9	-3.42
2f5f6b	-0.72	-2.93
7cd562	-0.64	-2.47
a7e31f	-0.58	-2.31
693362	-0.54	-1.35
06ae32	-0.45	-0.33
0aba71	-0.38	-1.4
7377a1	-0.35	-1.39
f181ac	-0.33	-0.8
a047ef	-0.21	-0.86
3dca00	-0.09	-
bfd580	-0.07	-0.25
64eca6	-0.05	-0.12
95a94b	0.01	0.02
607715	0.2	0.8
0a5f17	0.33	0.84
0e3e27	0.6	2.07
654483	0.65	0.8
fadcfb	0.82	3.03
e3d536	1.25	-
0b6f2b	1.97	7.14
9081b8	3.04	7.41

7.4 100 cycles

7.4.1 Test results

Table 38: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
1f5827	282.6	177.4	108.6	110.0	189.5	87.63	46.24
6110fc	325.0	222.5	209.6	199.3	252.4	63.23	25.06
ecacdb	310.0	230.3	243.4	34.9	261.2	42.74	16.36
2f5f6b	299.0	369.0	311.0	5.0	326.3	37.43	11.47
0aba71	584.9	349.7	190.7	37.7	375.1	198.32	52.87
7cd562	408.1	450.3	346.4	142.3	401.6	52.25	13.01
a7e31f	470.9	398.0	447.2	24.1	438.7	37.19	8.48
693362	443.1	702.0	345.1	185.0	496.7	184.4	37.12
7377a1	376.5	746.3	488.3	21.5	537.0	189.66	35.32
a047ef	580.0	518.0	545.0	10.0	547.7	31.09	5.68
f181ac	725.3	496.9	492.6	123.3	571.6	133.13	23.29
06ae32	282.0	765.0	669.0	679.0	572.0	255.69	44.7
bfd580	577.1	712.3	573.4	66.4	620.9	79.15	12.75
64eca6	635.3	686.3	670.6	132.8	664.1	26.12	3.93
3dca00	792.3	810.3	583.8	-	728.8	125.9	17.27
607715	683.1	777.3	1072.9	21.0	844.4	203.39	24.09
95a94b	747.2	874.5	1021.2	44.1	881.0	137.11	15.56
0e3e27	870.7	956.5	919.8	68.7	915.7	43.05	4.7
0a5f17	843.7	1065.3	892.2	195.4	933.7	116.49	12.48
fadcfb	1226.7	951.5	1182.2	56.0	1120.1	147.73	13.19
654483	1087.5	1284.9	1044.4	337.0	1138.9	128.23	11.26
e3d536	1579.0	1301.0	1765.0	117.7	1548.3	233.52	15.08
0b6f2b	1828.3	1838.4	1929.9	142.0	1865.5	55.97	3.0
9081b8	2146.7	2352.7	2247.2	210.3	2248.9	103.01	4.58

7.4.2 The Numerical Procedure for Determining Outliers

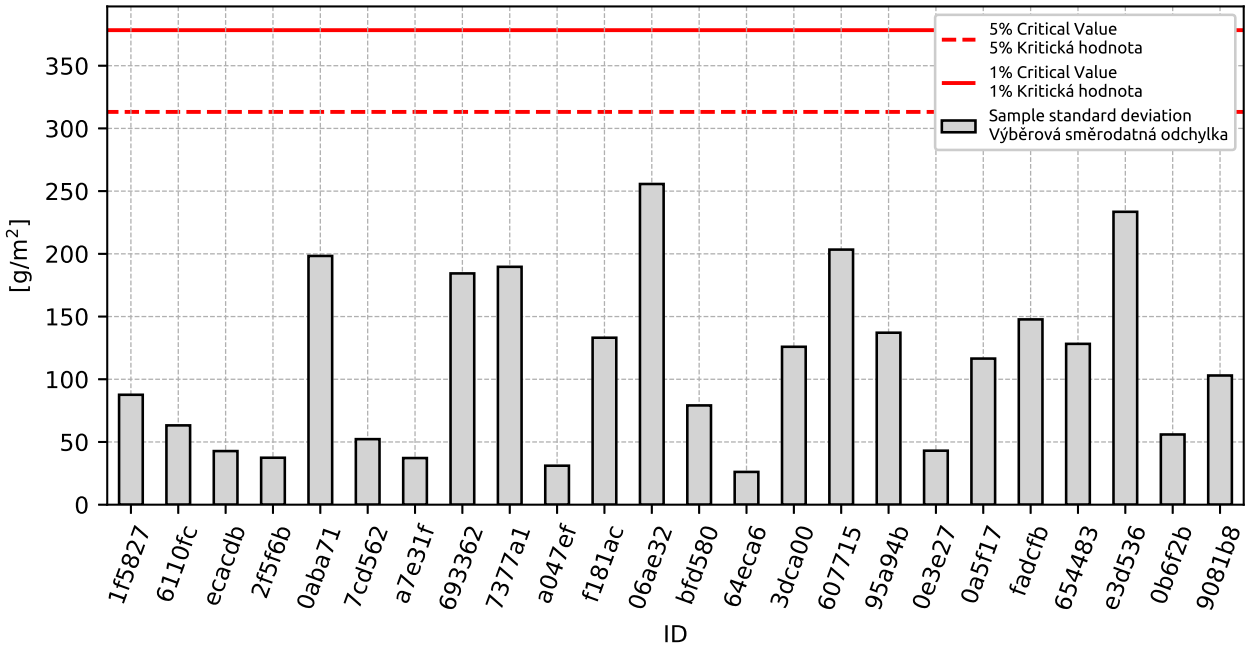

Figure 84: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

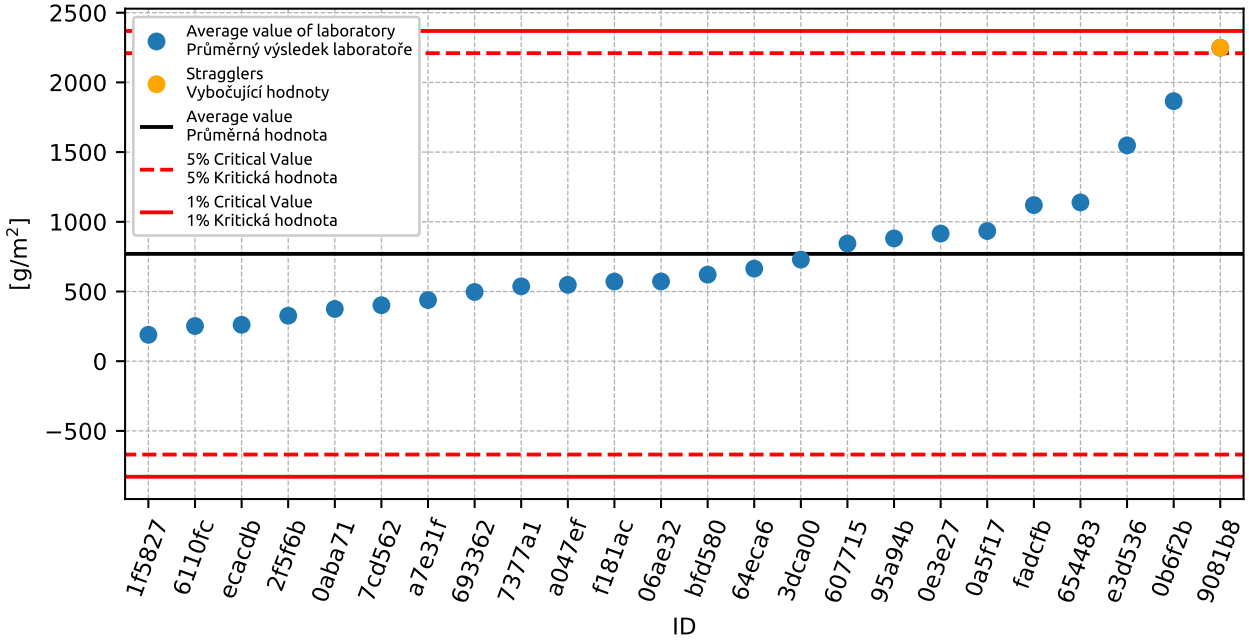

Figure 85: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

7.4.3 Mandel's Statistics

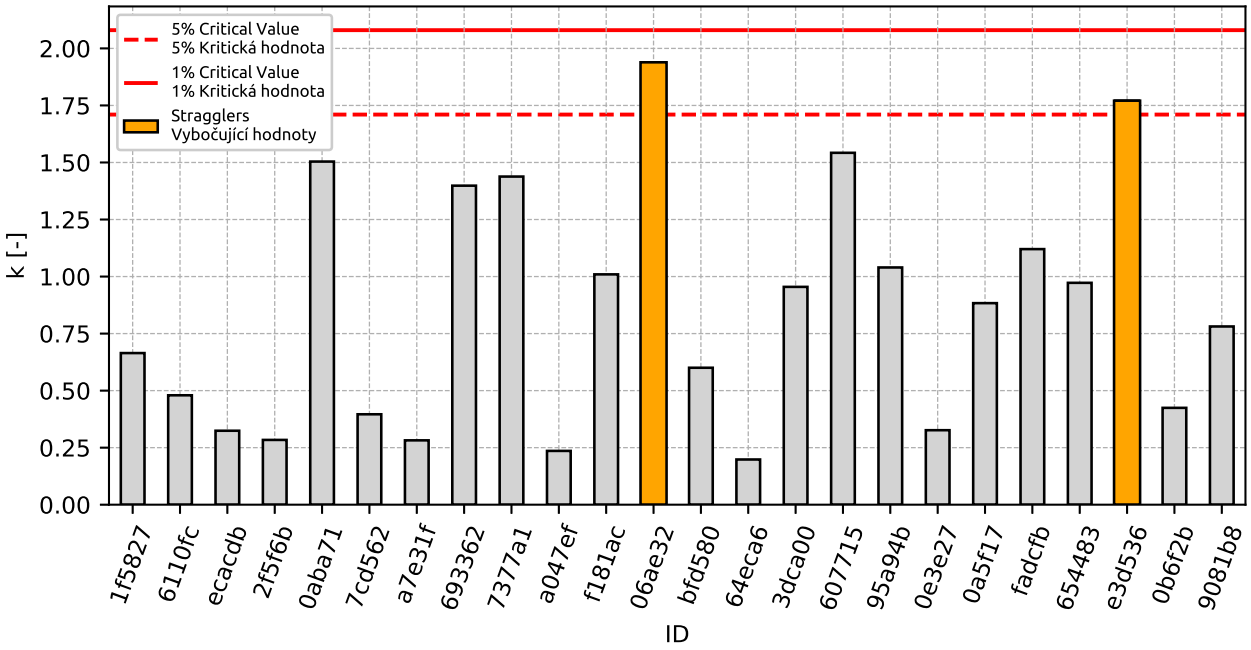

Figure 86: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

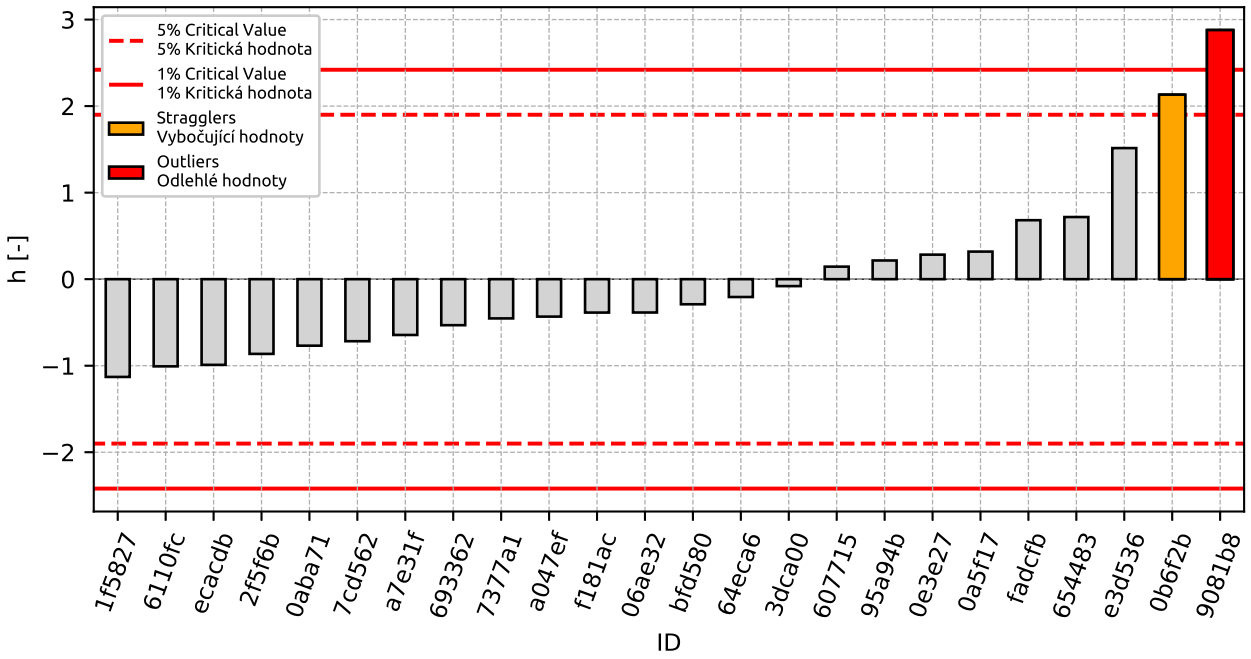

Figure 87: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

7.4.4 Descriptive statistics

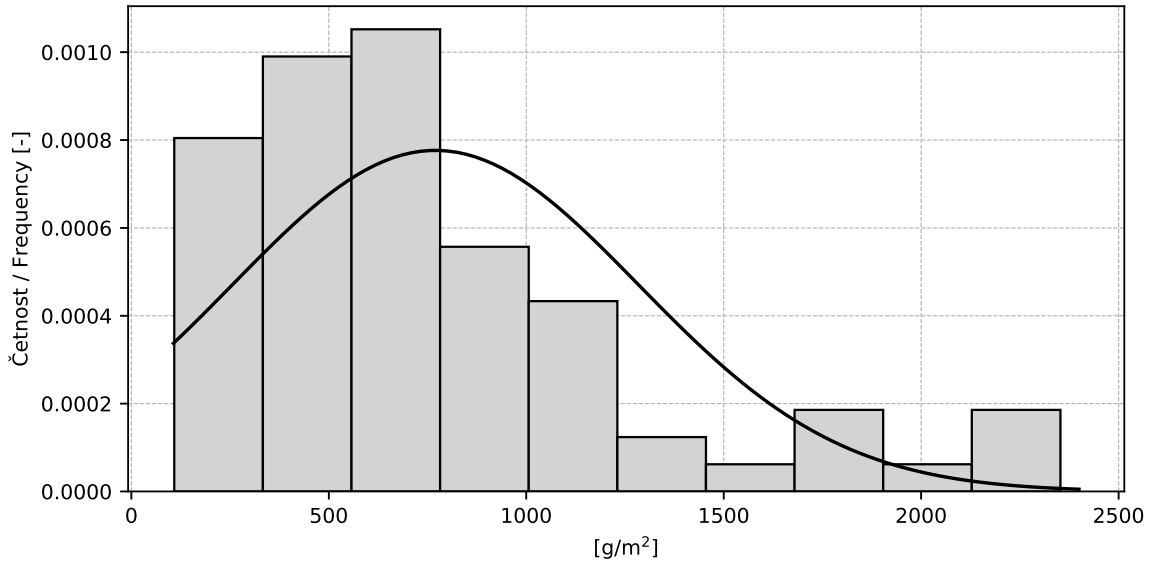

Figure 88: Histogram

Table 39: Descriptive statistics

Value	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	770.0
Výběrová směrodatná odchylka / Sample standard deviation – s	513.8
Vztažná hodnota / Asigned value – x^*	725.5
Robustní směrodatná odchylka / Robust standard deviation – s^*	493.35
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	125.88
p-hodnota testu normality / p-value of normality test	0.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	508.13
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	131.86
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	524.96
Opakovatelnost / Repeatability – r	369.2
Reprodukovatelnost / Reproducibility – R	1469.9

7.4.5 Calculation of Performance Statistics

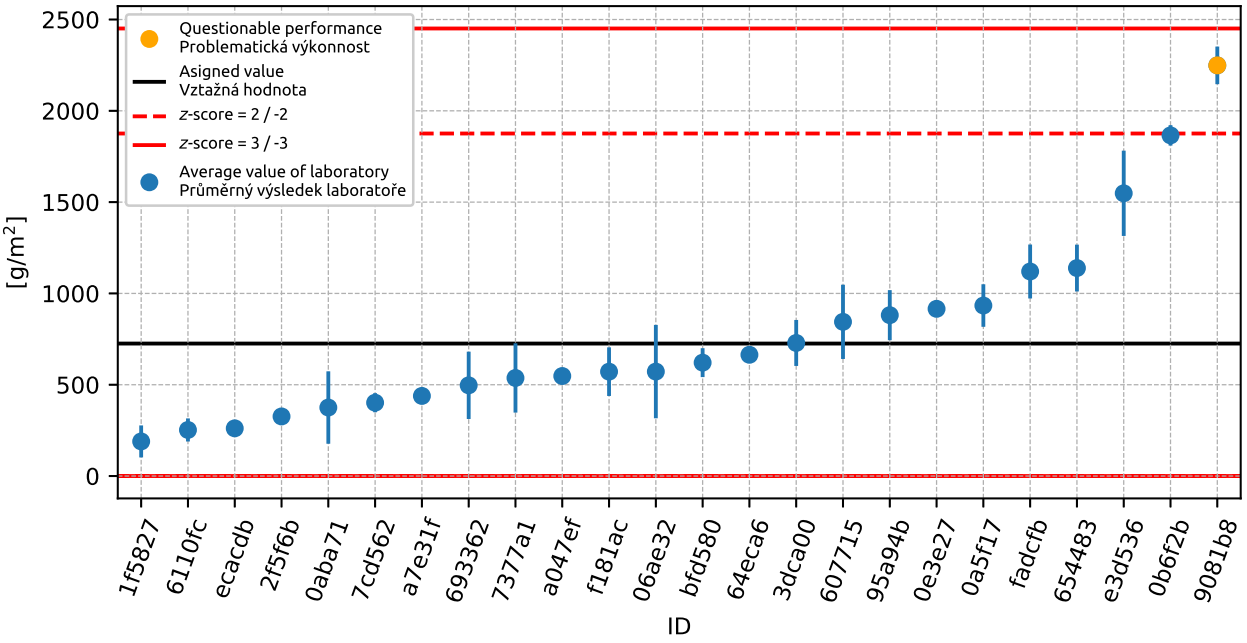

Figure 89: Average values and sample standard deviations

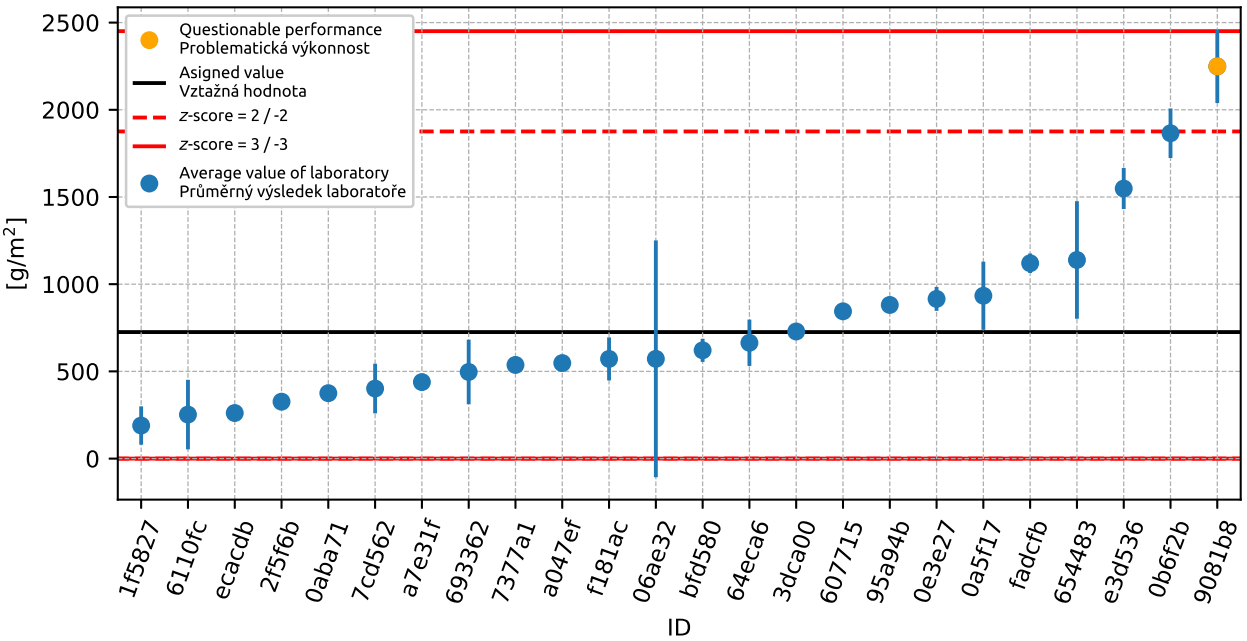

Figure 90: Average values and extended uncertainties of measurement

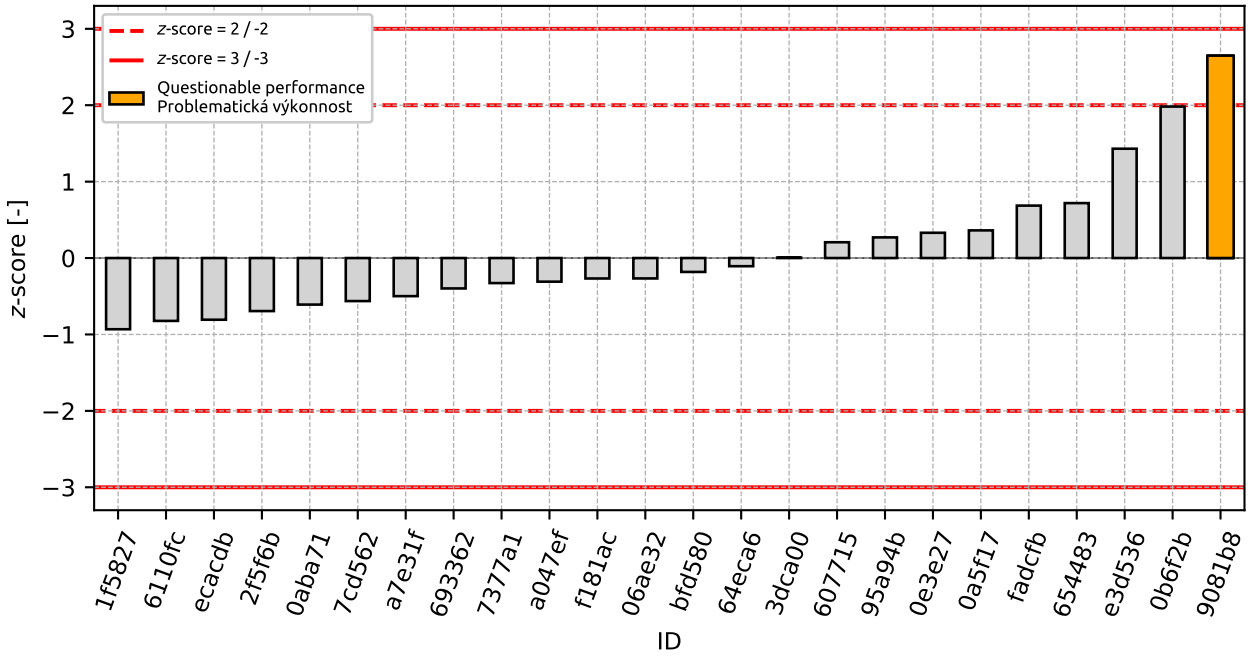

Figure 91: z-score

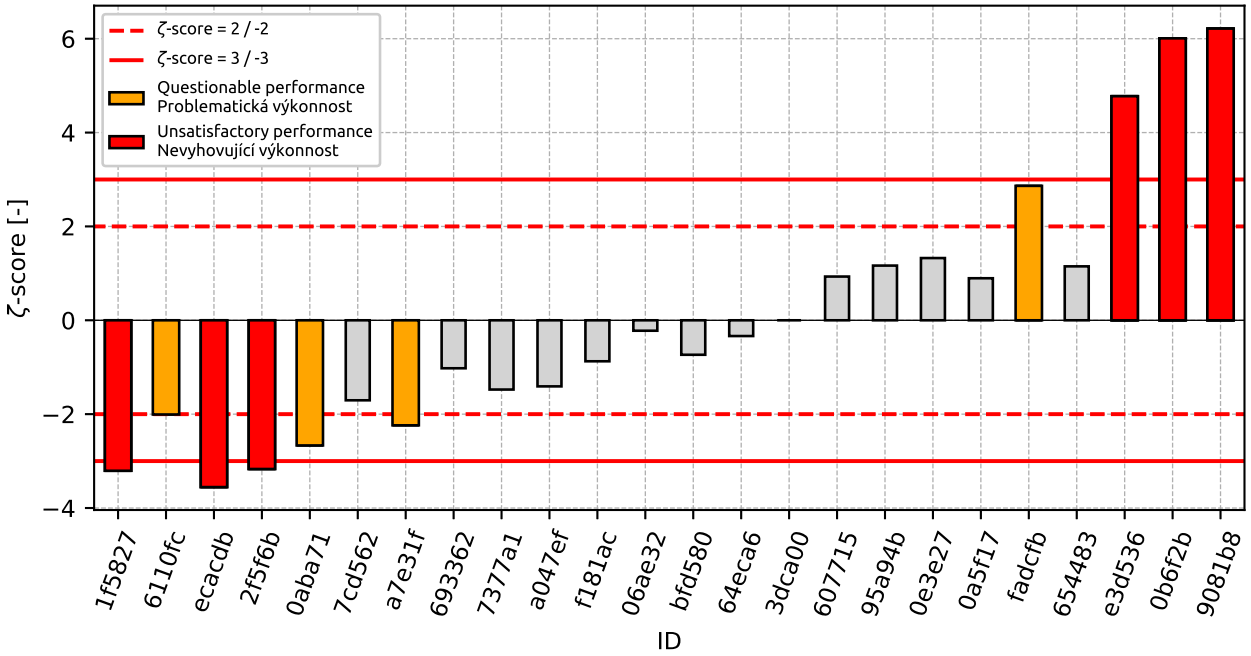

Figure 92: ζ-score

Table 40: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
1f5827	-0.93	-3.21
6110fc	-0.82	-2.01
ecacdb	-0.81	-3.55
2f5f6b	-0.69	-3.17
0aba71	-0.61	-2.67
7cd562	-0.56	-1.7
a7e31f	-0.5	-2.24
693362	-0.4	-1.02
7377a1	-0.33	-1.48
a047ef	-0.31	-1.41
f181ac	-0.27	-0.87
06ae32	-0.27	-0.22
bfd580	-0.18	-0.73
64eca6	-0.11	-0.34
3dca00	0.01	-
607715	0.21	0.93
95a94b	0.27	1.17
0e3e27	0.33	1.33
0a5f17	0.36	0.9
fadcfb	0.69	2.86
654483	0.72	1.15
e3d536	1.43	4.77
0b6f2b	1.98	6.01
9081b8	2.65	6.22

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

ID of participant	Test results [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
cba2c0	0.0	0.0	0.0	11.5	0.0	0.0	-
e9939d	30.0	20.0	10.0	2.0	20.0	10.0	50.0
ced094	19.2	28.5	24.8	-	24.2	4.68	19.37
654483	32.4	19.1	28.3	19.0	26.6	6.81	25.61
a2c747	38.0	28.0	33.0	3.0	33.0	5.0	15.15
8b8895	57.0	34.0	40.0	20.0	43.7	11.93	27.32
373ab3	49.1	44.0	41.2	1.3	44.8	4.01	8.95

8.1.2 The Numerical Procedure for Determining Outliers

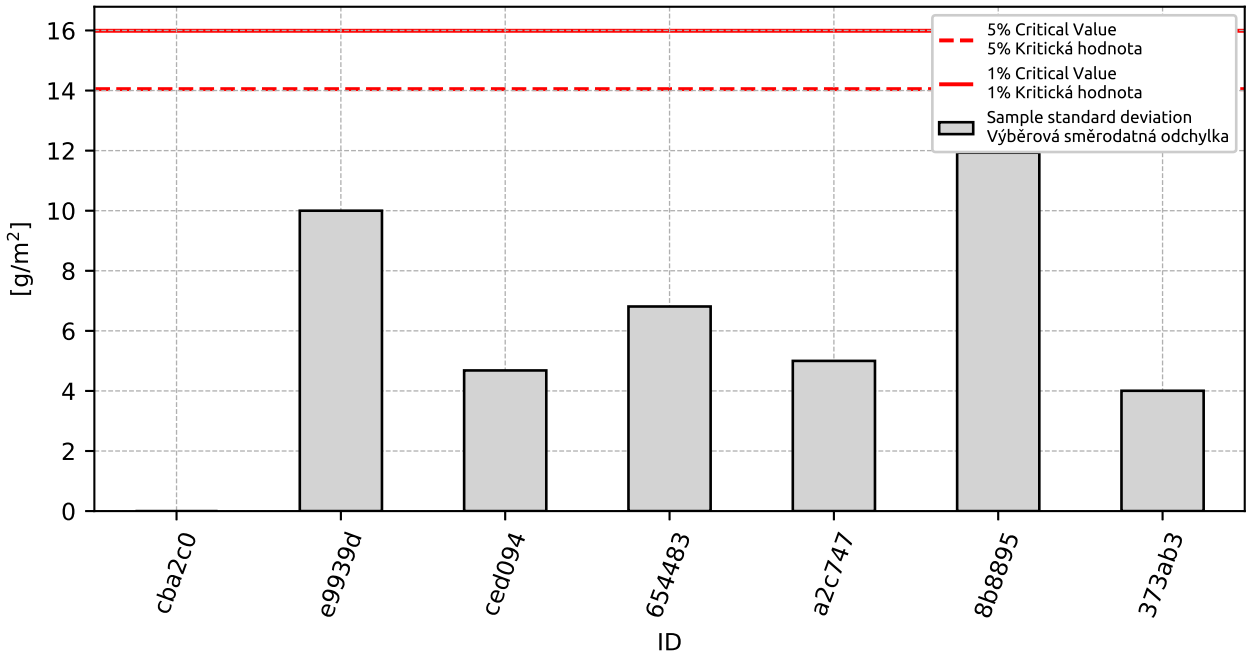

Figure 93: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

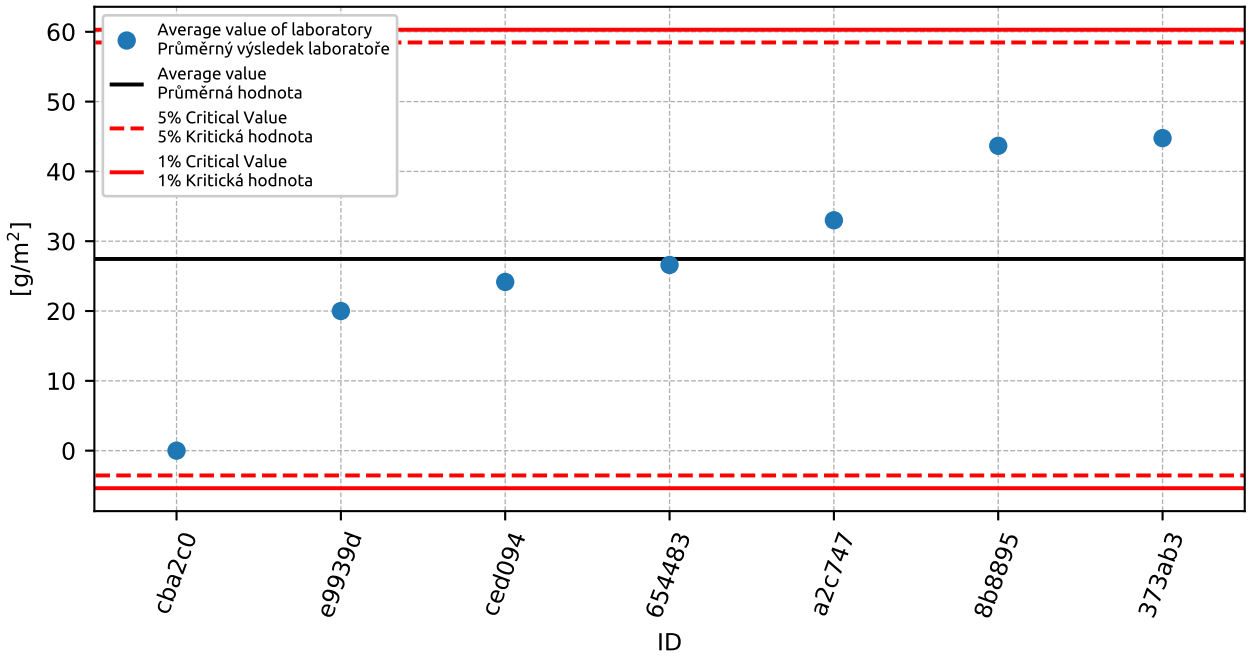

Figure 94: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

8.1.3 Mandel's Statistics

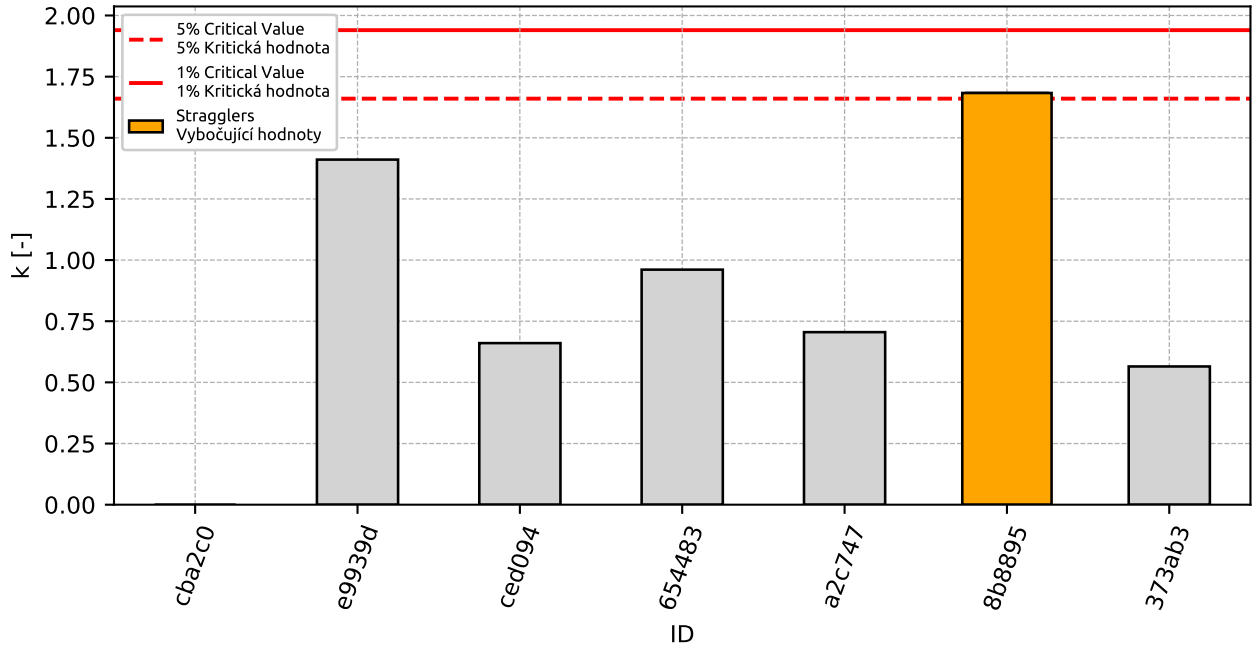

Figure 95: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

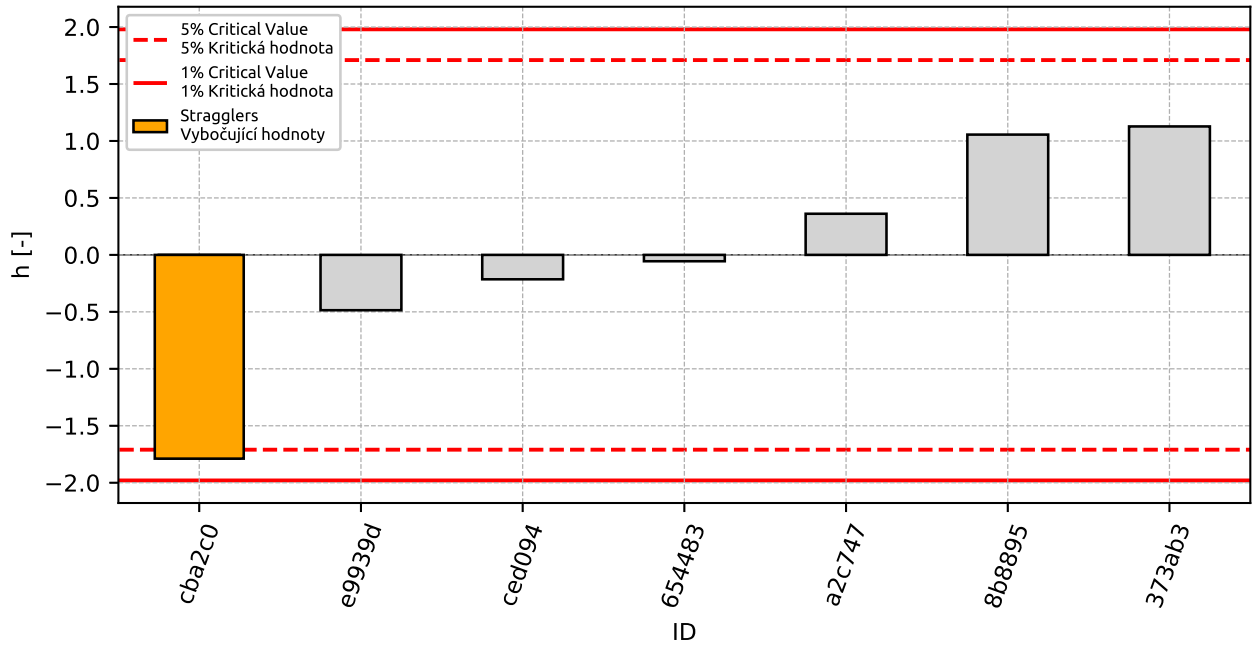

Figure 96: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

8.1.4 Descriptive statistics

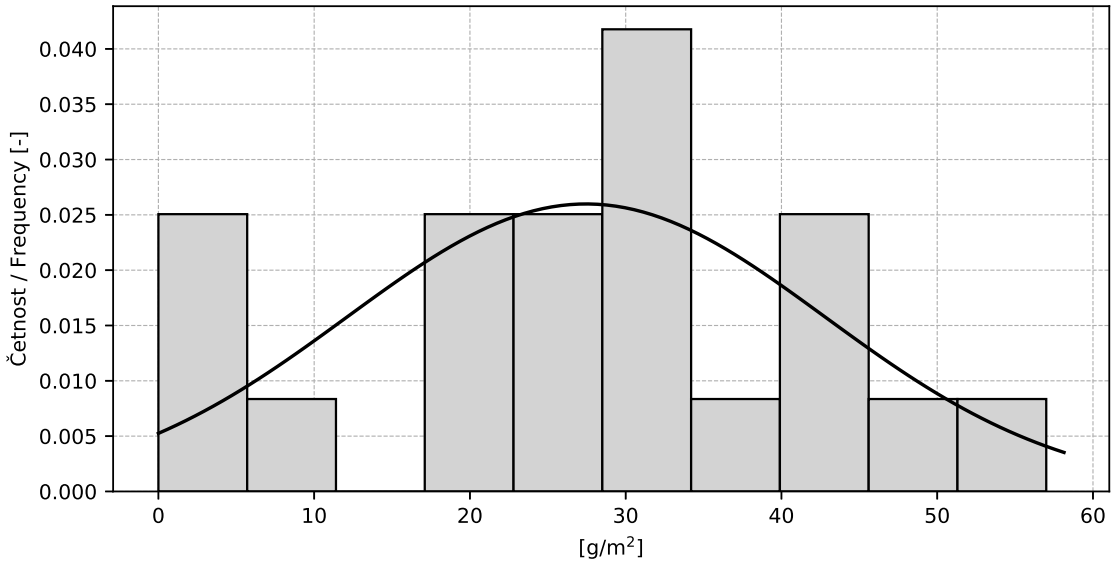

Figure 97: Histogram

Table 42: Descriptive statistics

Value	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	27.5
Výběrová směrodatná odchylka / Sample standard deviation – s	15.35
Vztažná hodnota / Asigned value – x^*	28.8
Robustní směrodatná odchylka / Robust standard deviation – s^*	12.25
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	5.79
p-hodnota testu normality / p-value of normality test	0.8 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	14.8
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	7.09
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	16.41
Opakovatelnost / Repeatability – r	19.8
Reprodukovatelnost / Reproducibility – R	45.9

8.1.5 Calculation of Performance Statistics

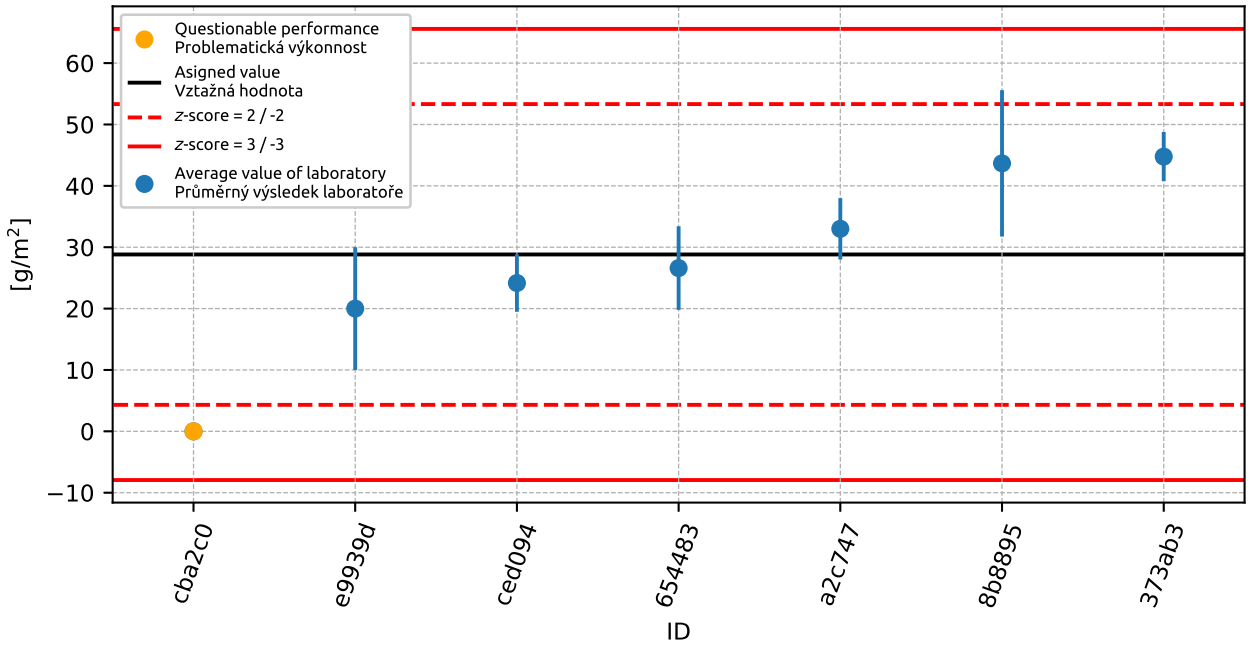

Figure 98: Average values and sample standard deviations

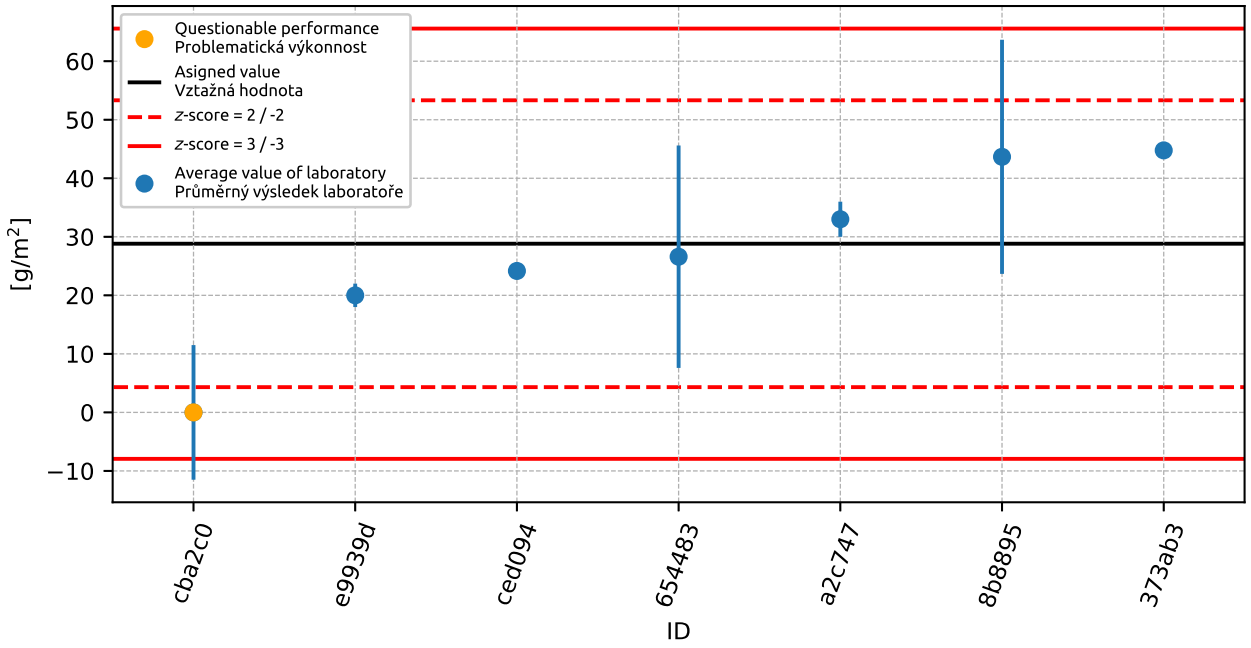

Figure 99: Average values and extended uncertainties of measurement

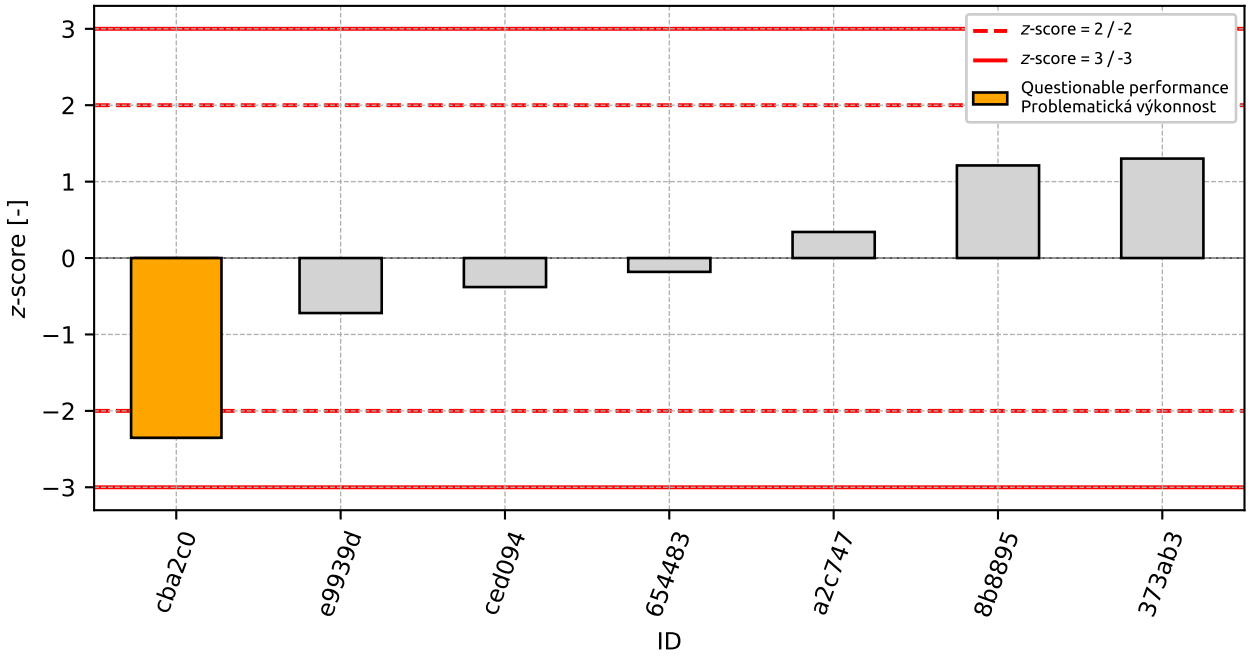

Figure 100: z-score

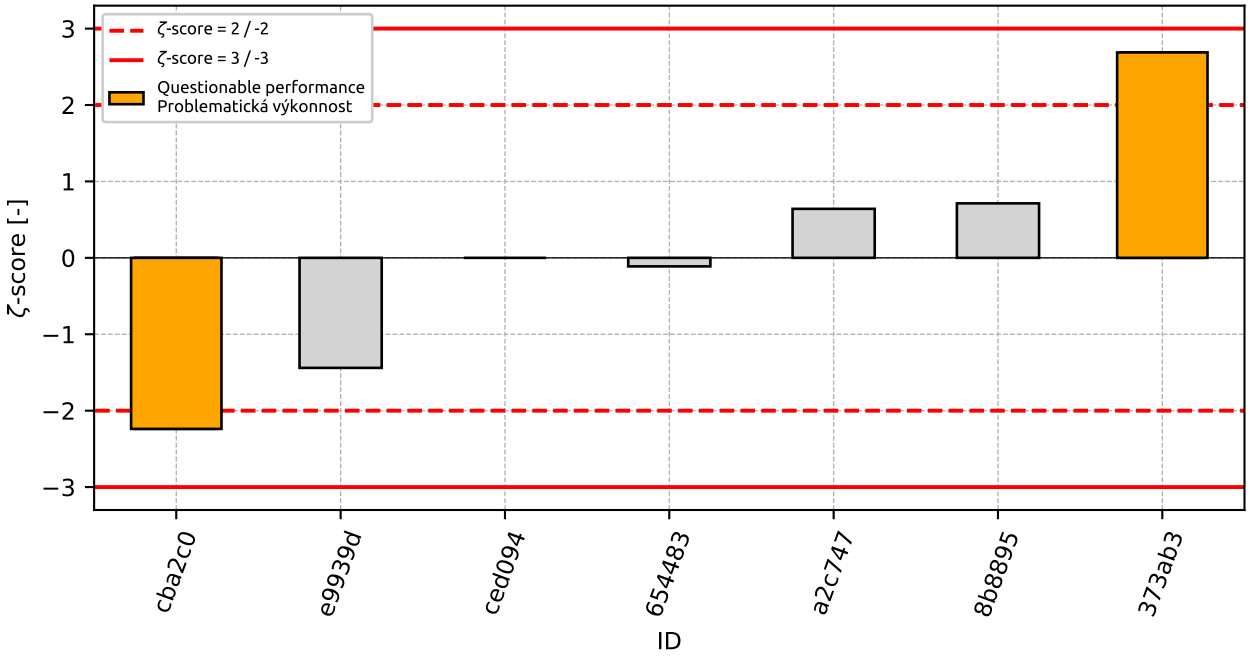

Figure 101: ζ-score

Table 43: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
cba2c0	-2.35	-2.24
e9939d	-0.72	-1.44
ced094	-0.38	-
654483	-0.18	-0.11
a2c747	0.34	0.64
8b8895	1.21	0.71
373ab3	1.3	2.69

8.2 50 cycles

8.2.1 Test results

Table 44: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
cba2c0	0.0	0.0	0.0	11.5	0.0	0.0	-
e9939d	40.0	30.0	20.0	3.3	30.0	10.0	33.33
654483	37.9	25.6	35.0	18.0	32.8	6.43	19.58
ced094	26.6	43.1	33.1	-	34.3	8.31	24.26
8b8895	74.0	40.0	45.0	30.0	53.0	18.36	34.64
a2c747	58.0	66.0	72.0	6.0	65.3	7.02	10.75
373ab3	106.0	98.0	86.8	2.8	96.9	9.64	9.95

8.2.2 The Numerical Procedure for Determining Outliers

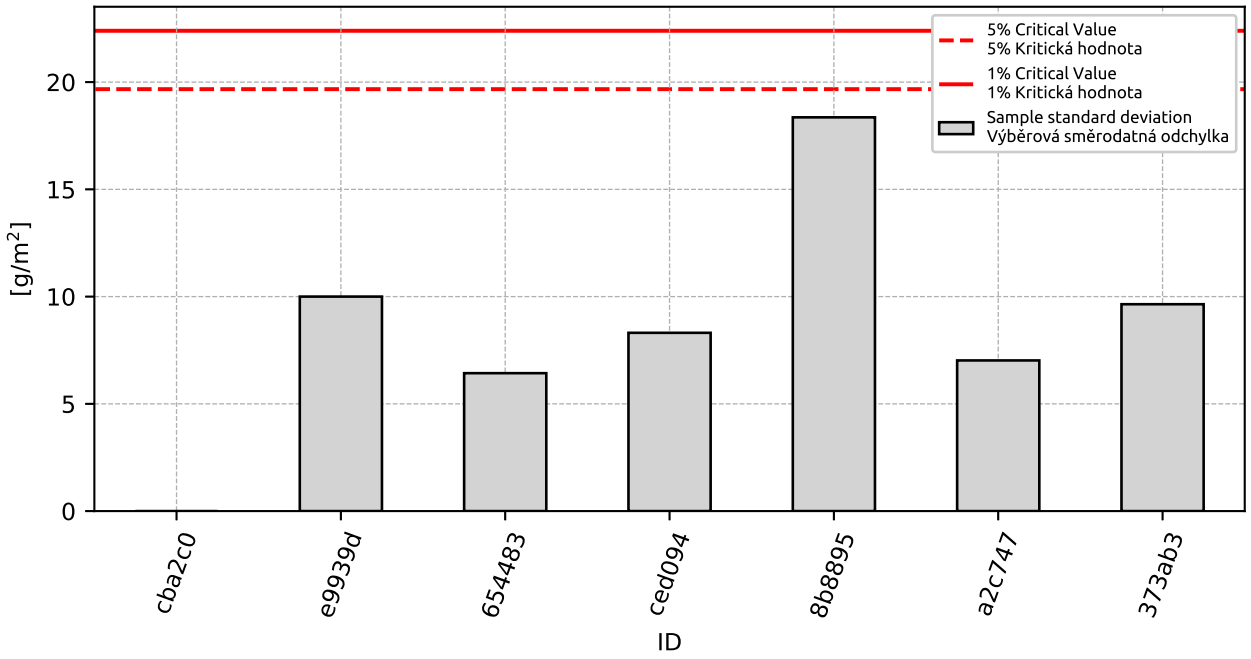

Figure 102: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

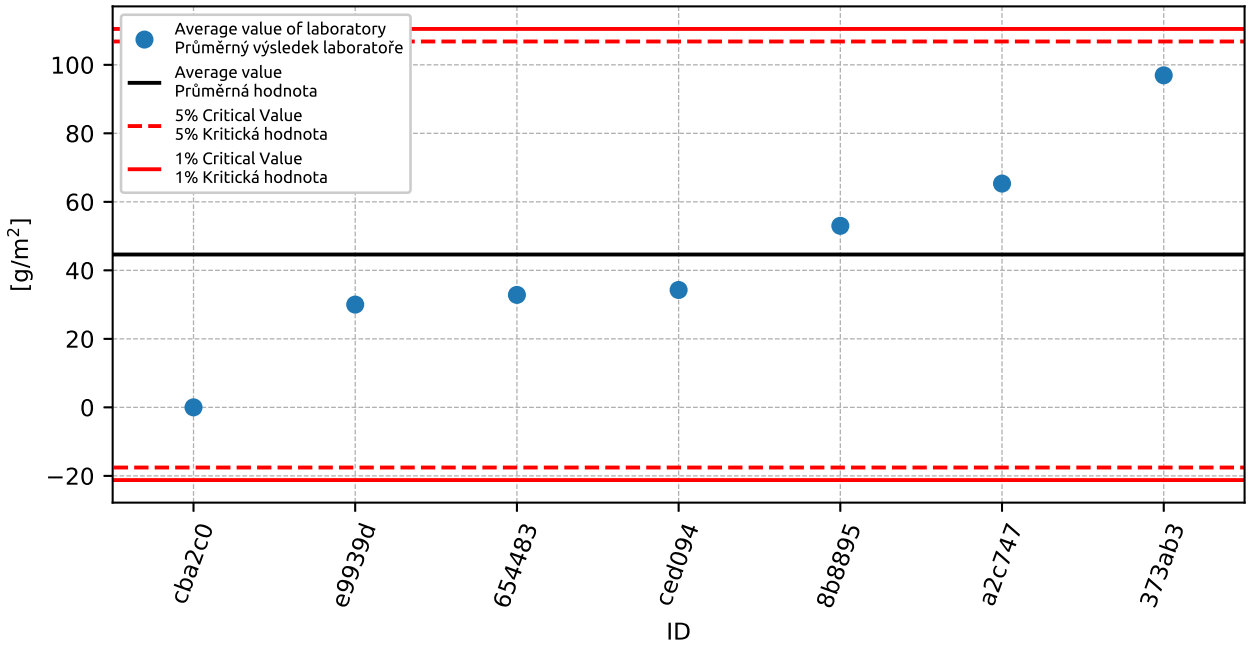

Figure 103: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

8.2.3 Mandel's Statistics

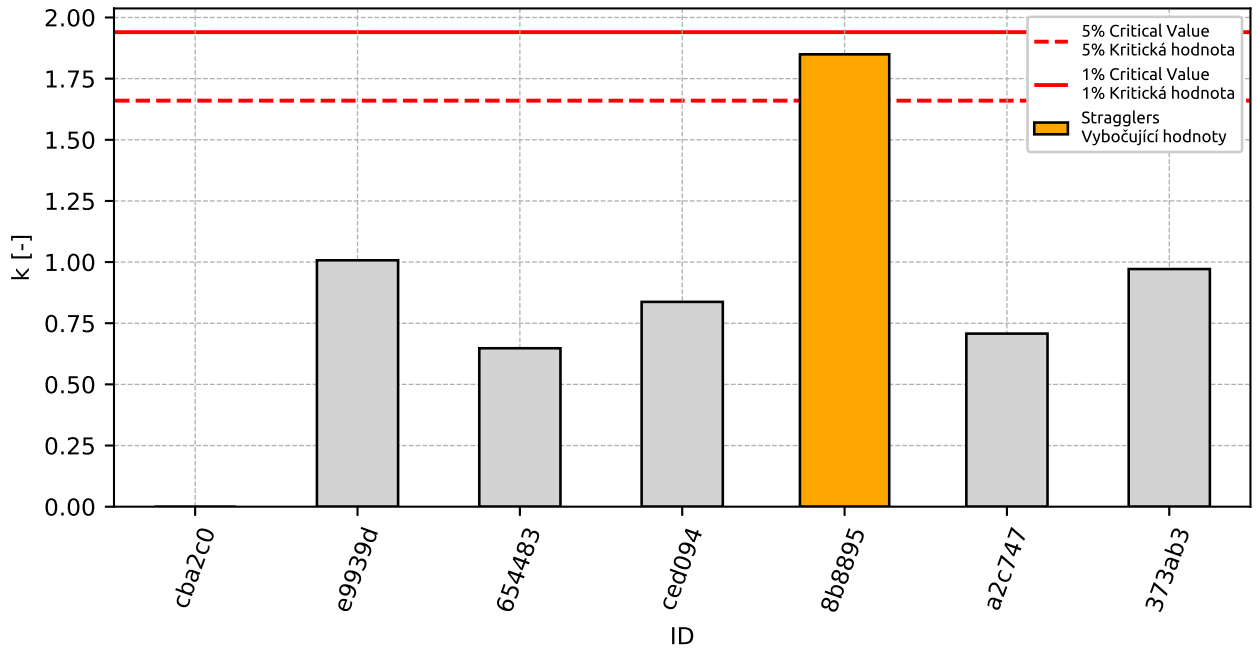

Figure 104: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

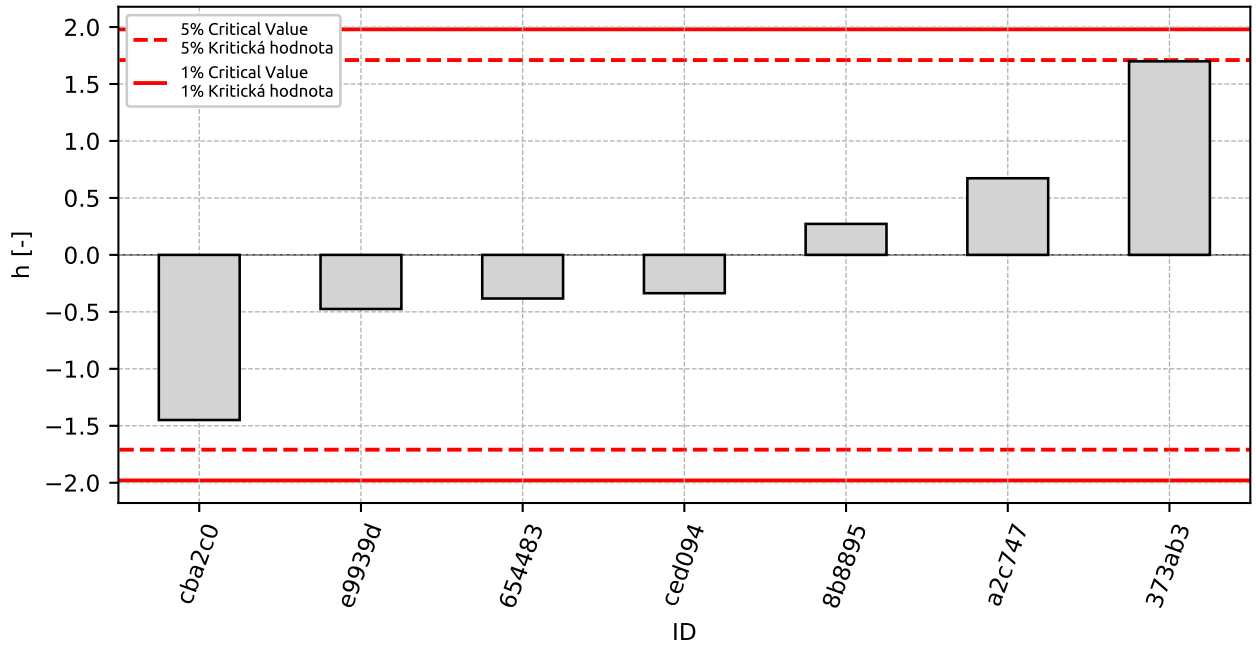

Figure 105: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

8.2.4 Descriptive statistics

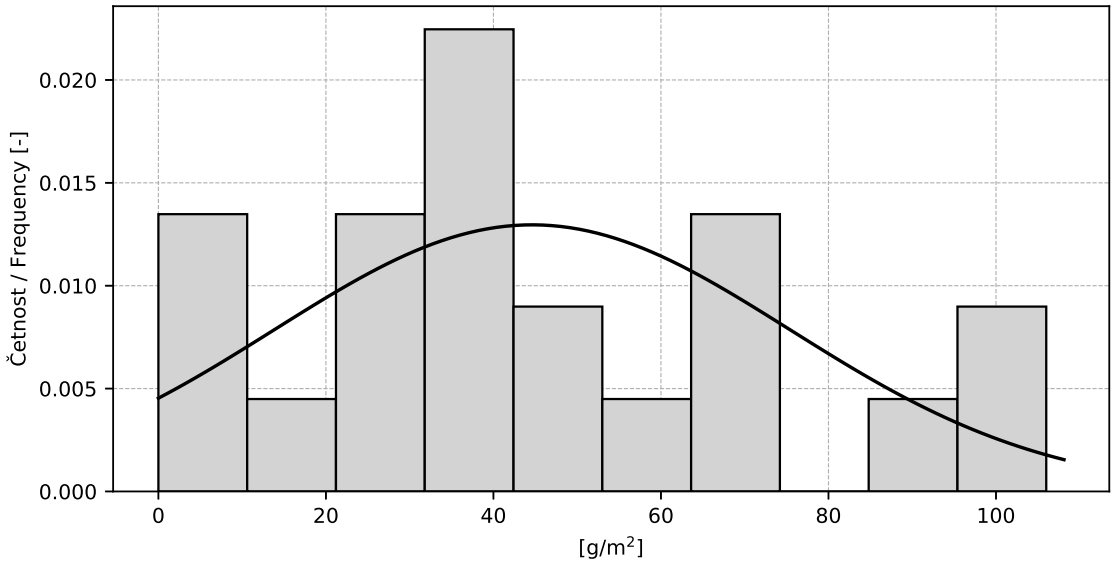

Figure 106: Histogram

Table 45: Descriptive statistics

Value	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	44.6
Výběrová směrodatná odchylka / Sample standard deviation – s	30.79
Vztažná hodnota / Asigned value – x^*	44.6
Robustní směrodatná odchylka / Robust standard deviation – s^*	32.32
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	15.27
p-hodnota testu normality / p-value of normality test	0.657 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	30.25
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	9.93
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	31.84
Opakovatelnost / Repeatability – r	27.8
Reprodukovatelnost / Reproducibility – R	89.1

8.2.5 Calculation of Performance Statistics

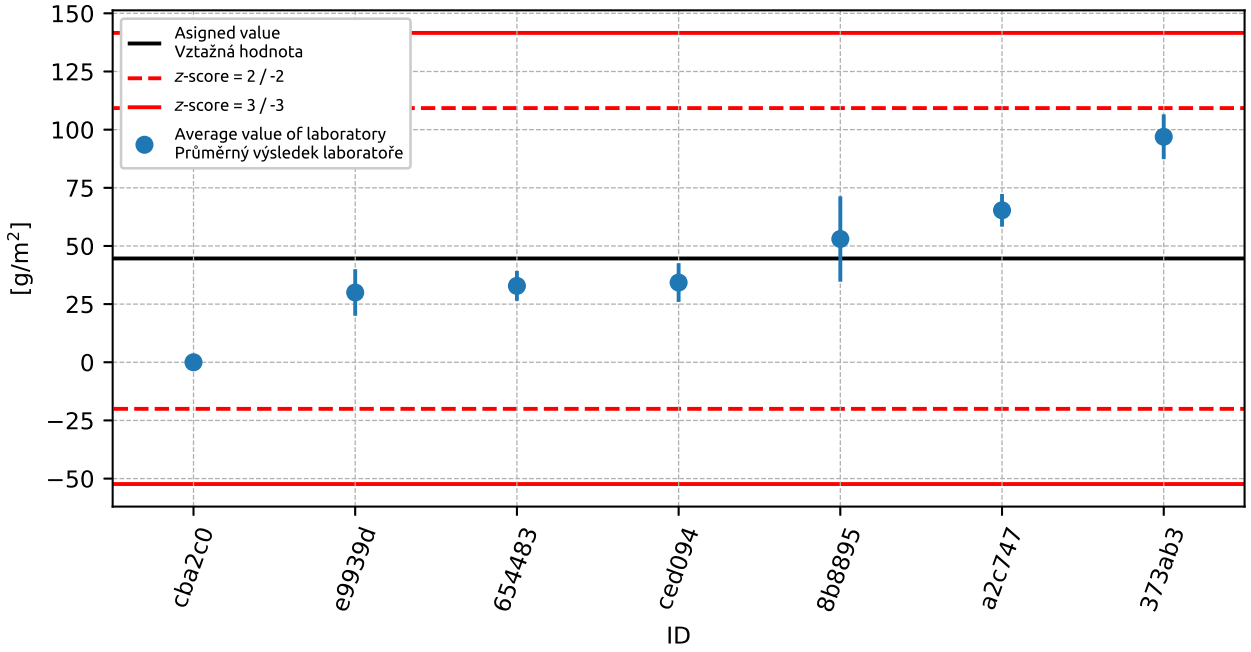

Figure 107: Average values and sample standard deviations

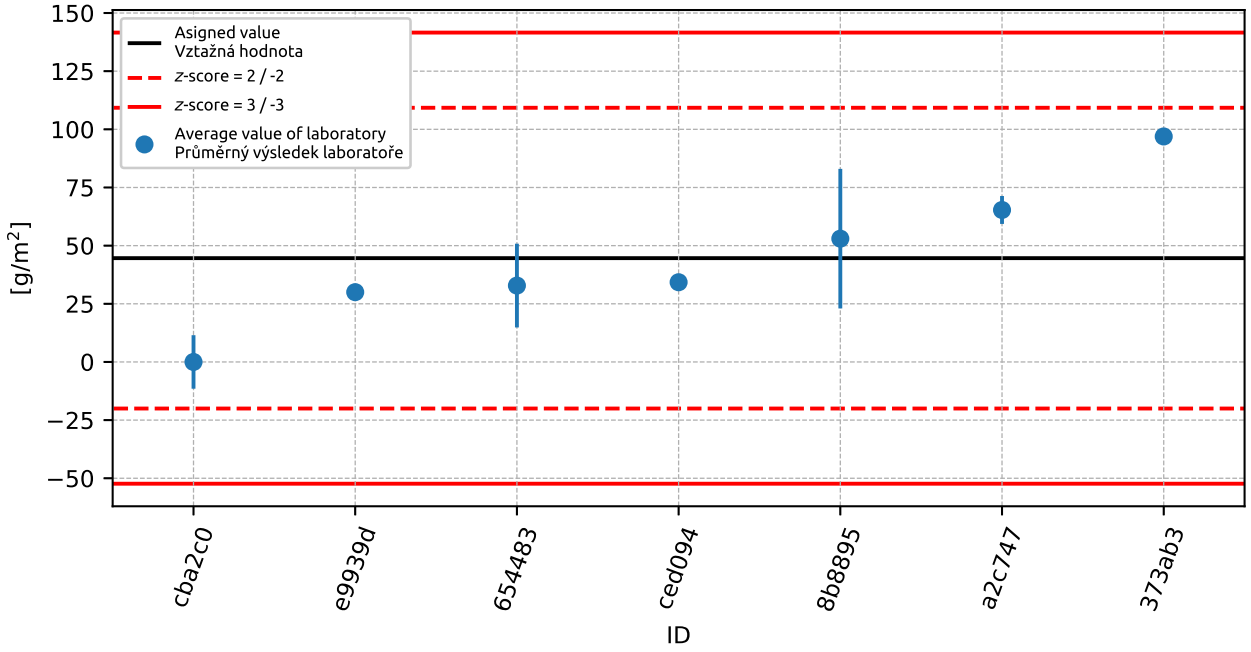

Figure 108: Average values and extended uncertainties of measurement

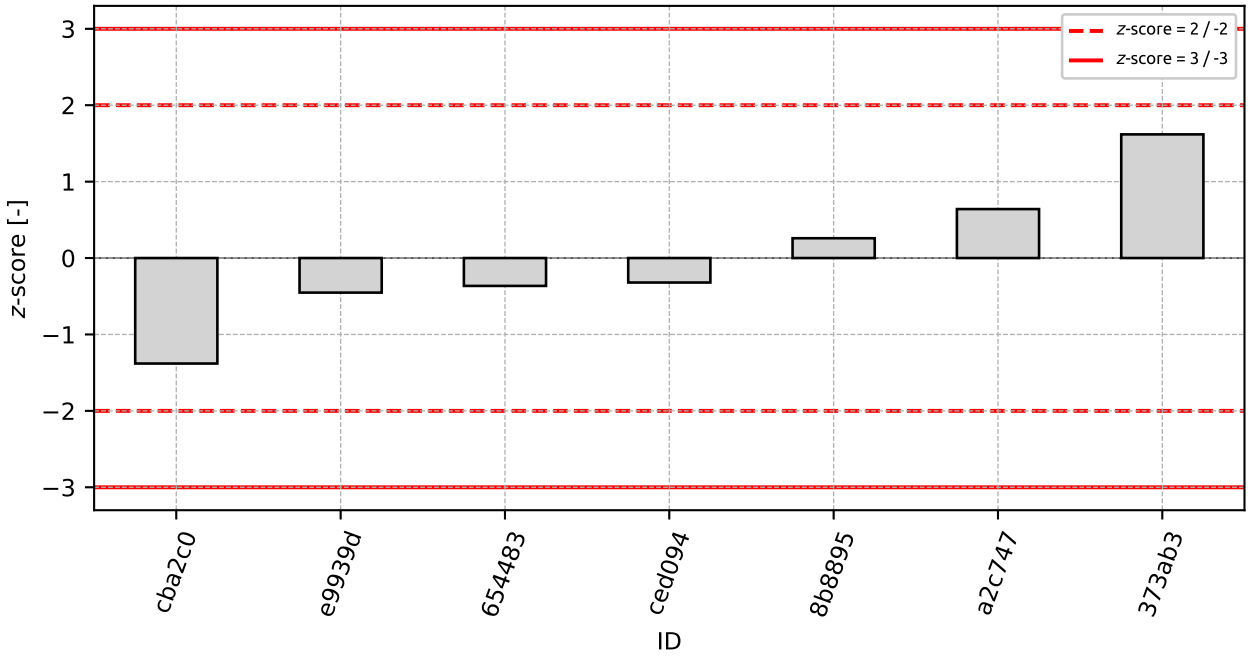

Figure 109: z-score

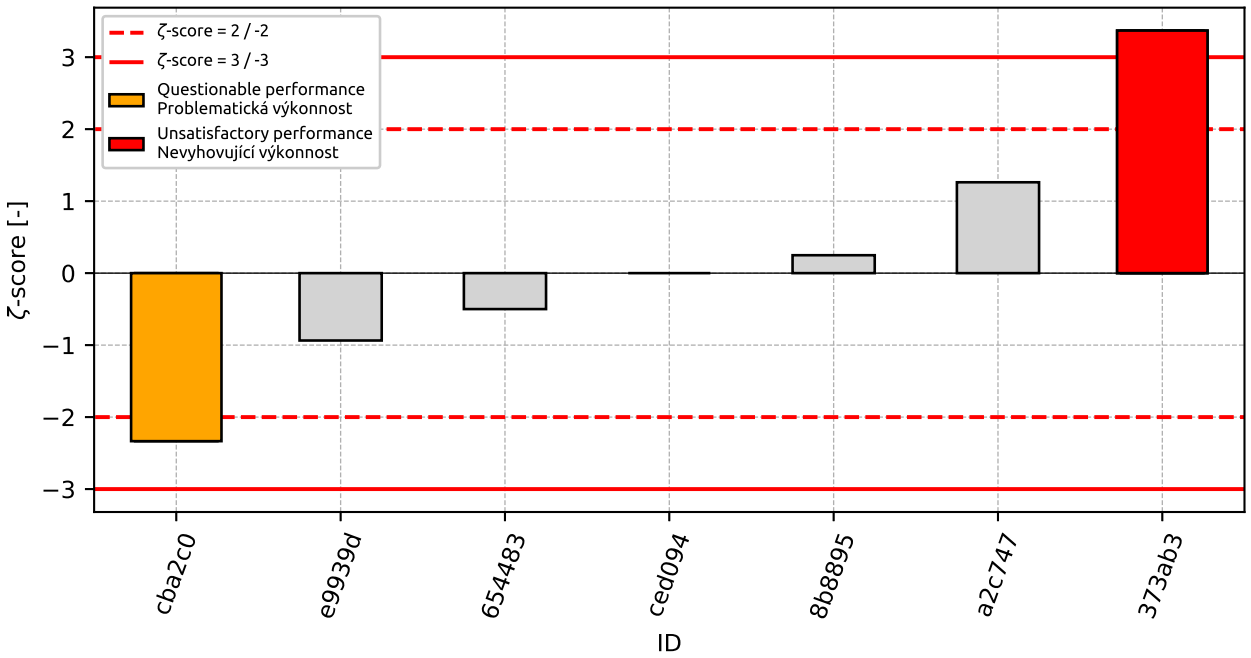

Figure 110: ζ-score

Table 46: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
cba2c0	-1.38	-2.33
e9939d	-0.45	-0.94
654483	-0.36	-0.5
ced094	-0.32	-
8b8895	0.26	0.25
a2c747	0.64	1.26
373ab3	1.62	3.37

8.3 75 cycles

8.3.1 Test results

Table 47: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
cba2c0	22.6	11.3	42.9	11.5	25.6	16.01	62.55
654483	42.3	28.9	37.8	19.0	36.3	6.82	18.77
ced094	34.3	52.1	39.7	-	42.0	9.13	21.71
e9939d	60.0	30.0	40.0	5.2	43.3	15.28	35.25
8b8895	113.0	68.0	51.0	50.0	77.3	32.04	41.43
373ab3	140.6	144.8	140.8	4.1	142.1	2.37	1.67
a2c747	217.0	185.0	211.0	20.0	204.3	17.01	8.32

8.3.2 The Numerical Procedure for Determining Outliers

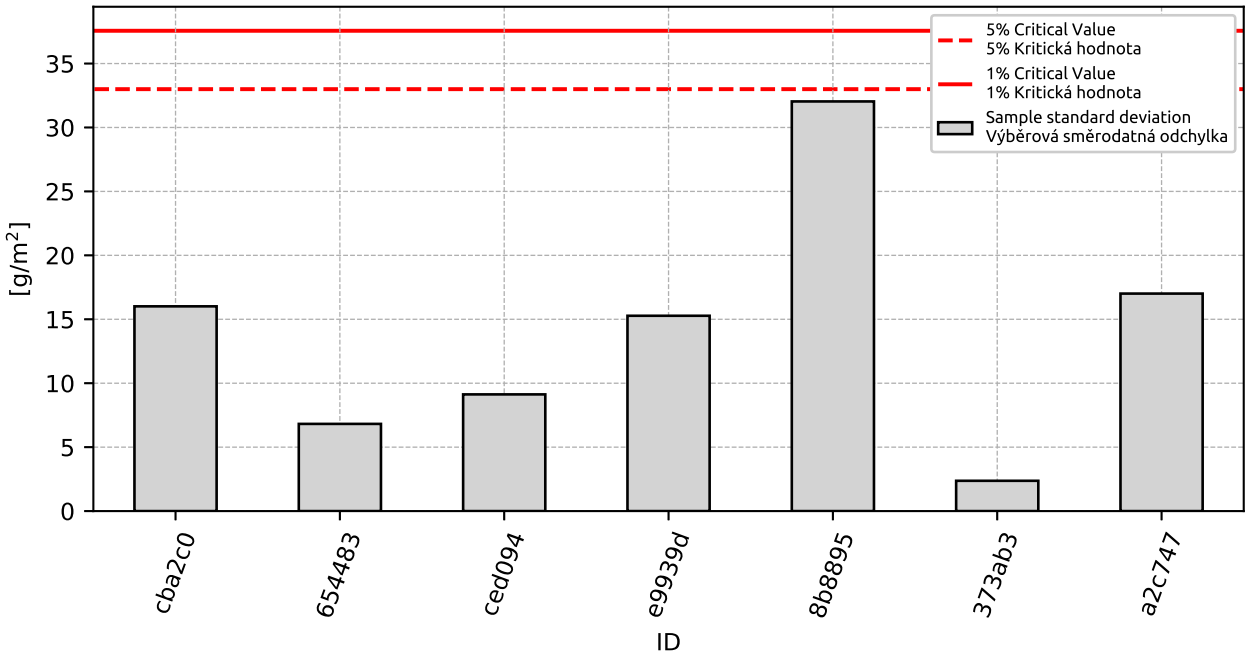

Figure 111: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

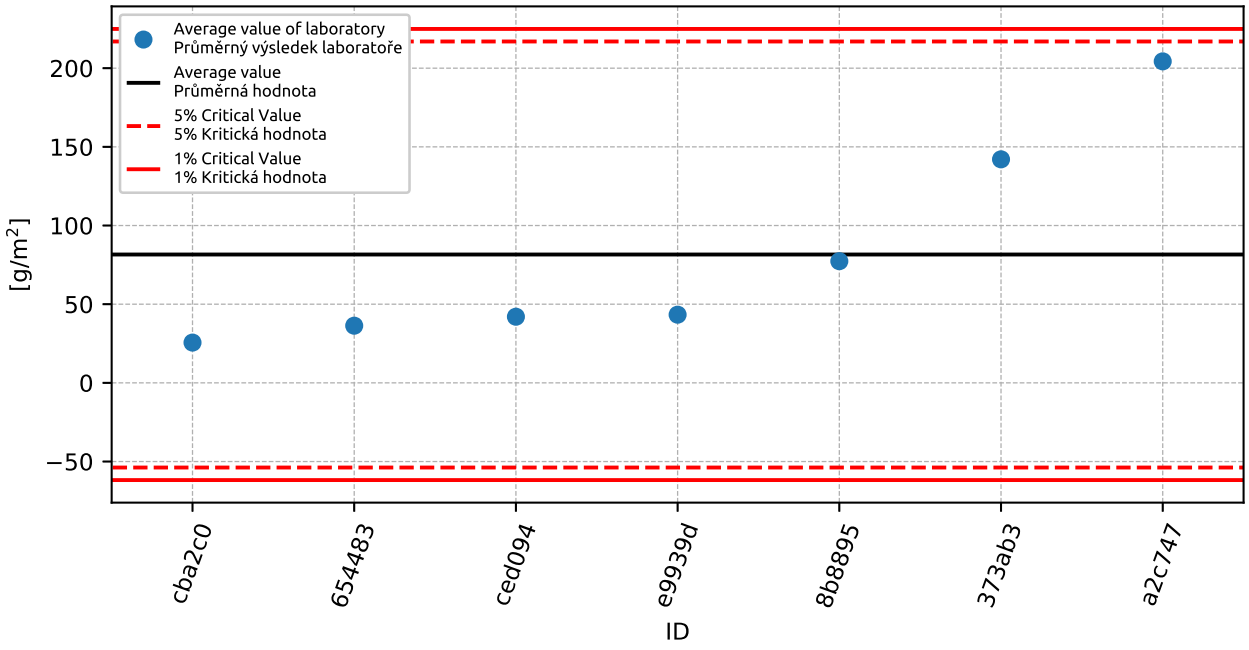

Figure 112: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

8.3.3 Mandel's Statistics

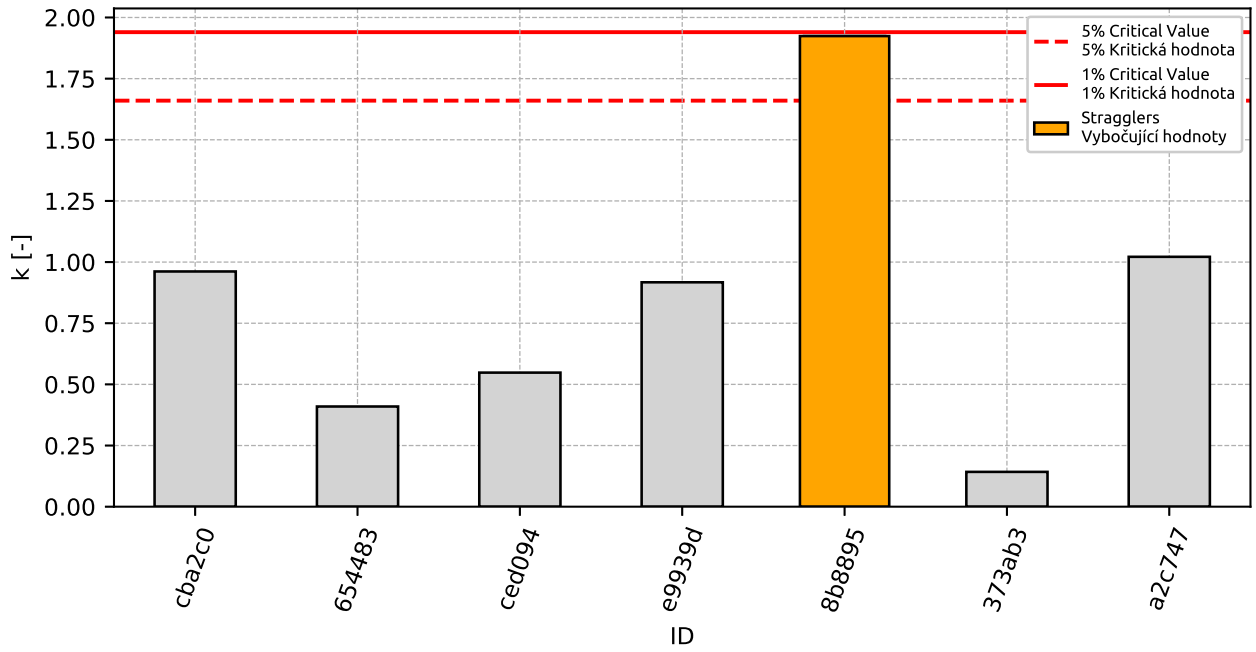

Figure 113: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

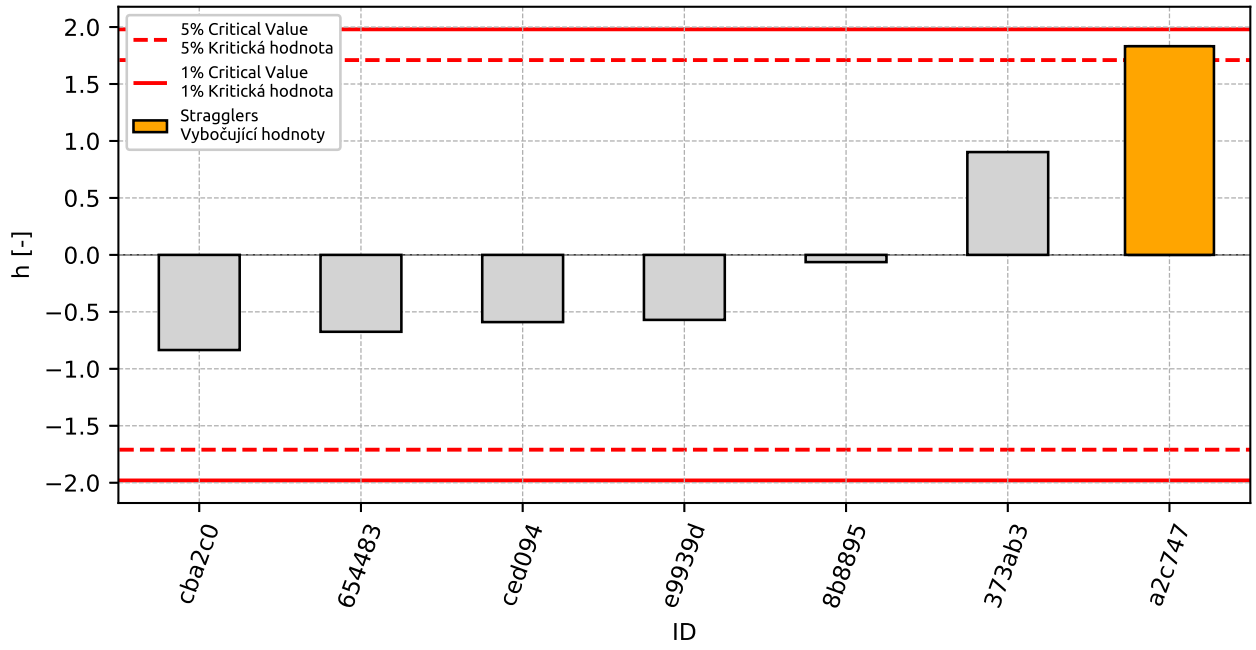

Figure 114: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

8.3.4 Descriptive statistics

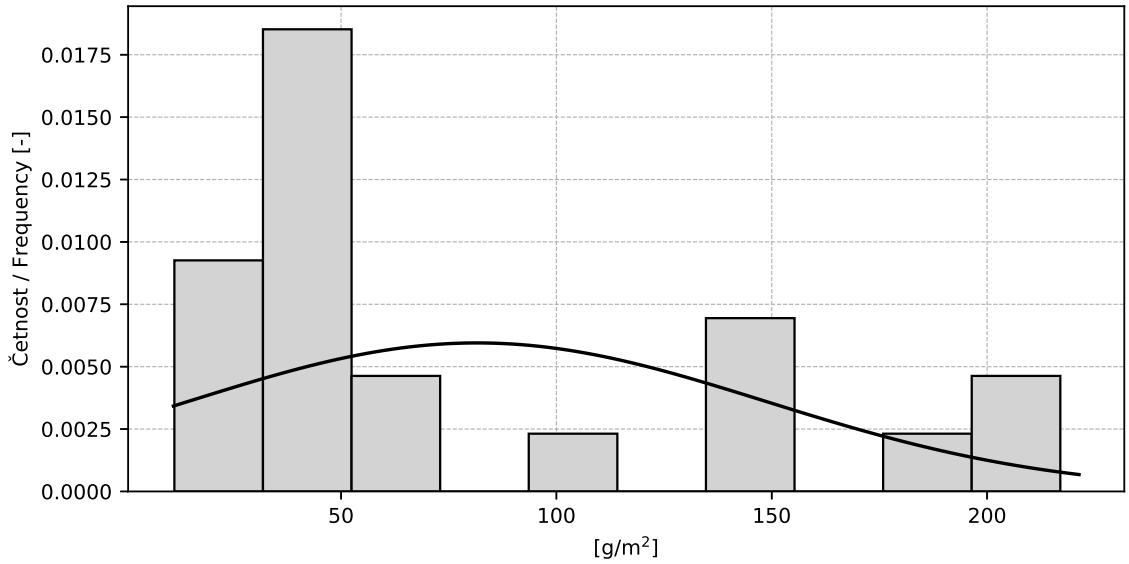

Figure 115: Histogram

Table 48: Descriptive statistics

Value	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	81.6
Výběrová směrodatná odchylka / Sample standard deviation – s	67.02
Vztažná hodnota / Asigned value – x^*	73.1
Robustní směrodatná odchylka / Robust standard deviation – s^*	64.71
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	30.57
p-hodnota testu normality / p-value of normality test	0.133 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	66.33
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	16.65
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	68.39
Opakovatelnost / Repeatability – r	46.6
Reprodukovatelnost / Reproducibility – R	191.5

8.3.5 Calculation of Performance Statistics

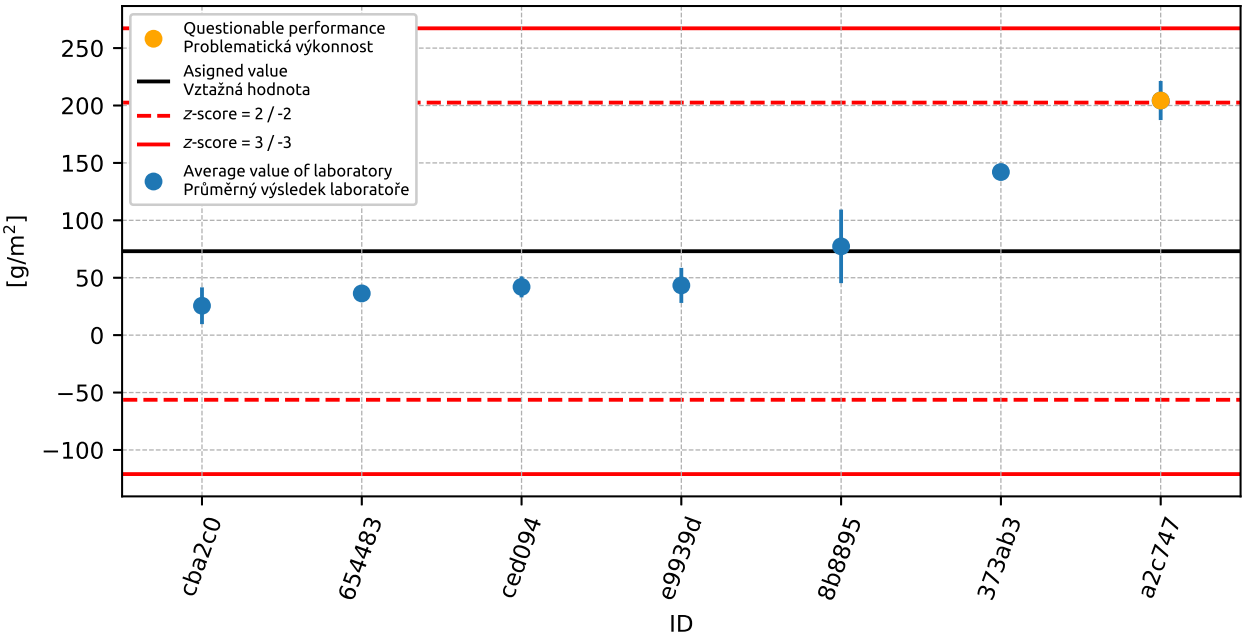

Figure 116: Average values and sample standard deviations

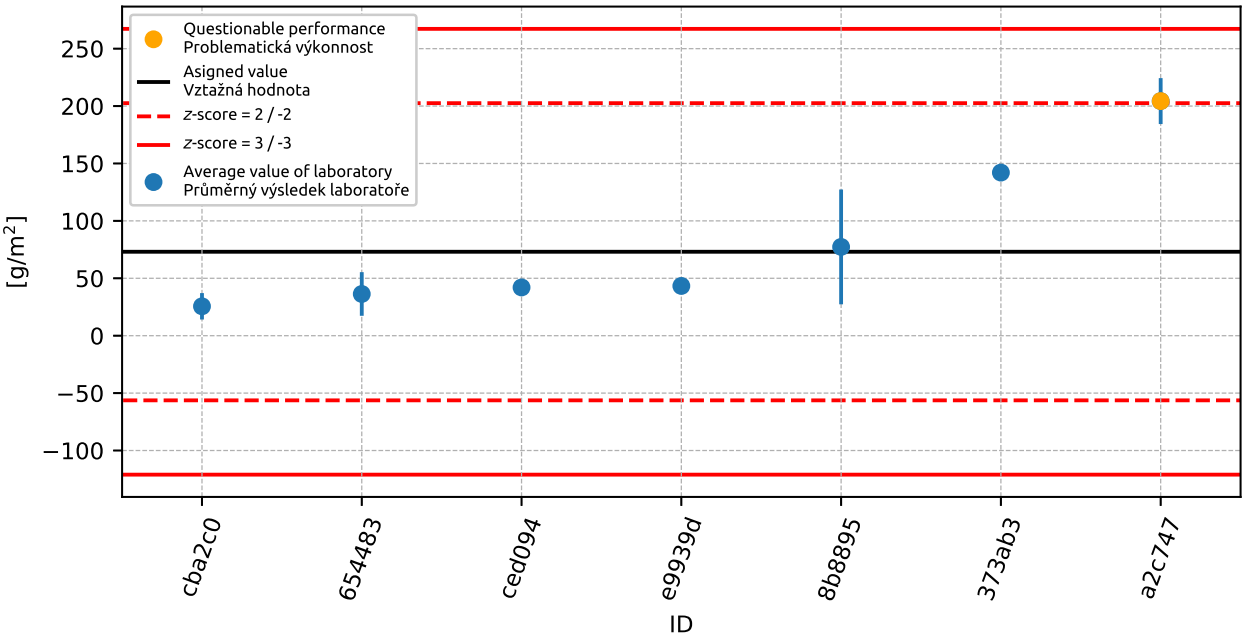

Figure 117: Average values and extended uncertainties of measurement

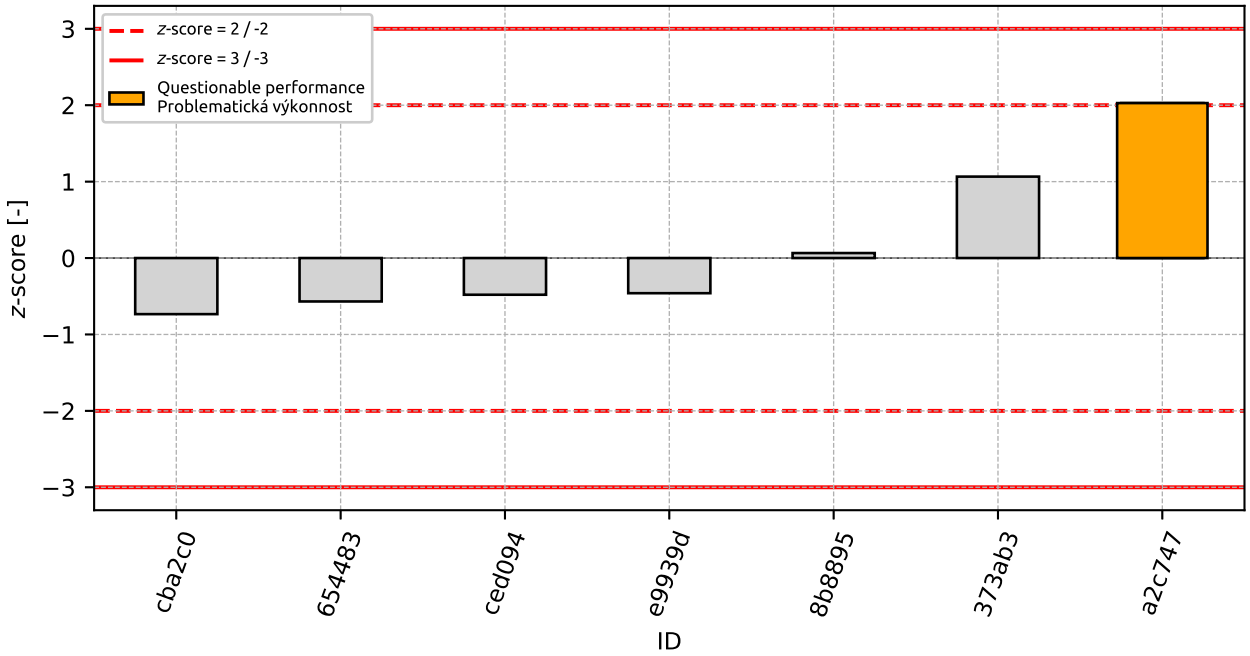

Figure 118: z-score

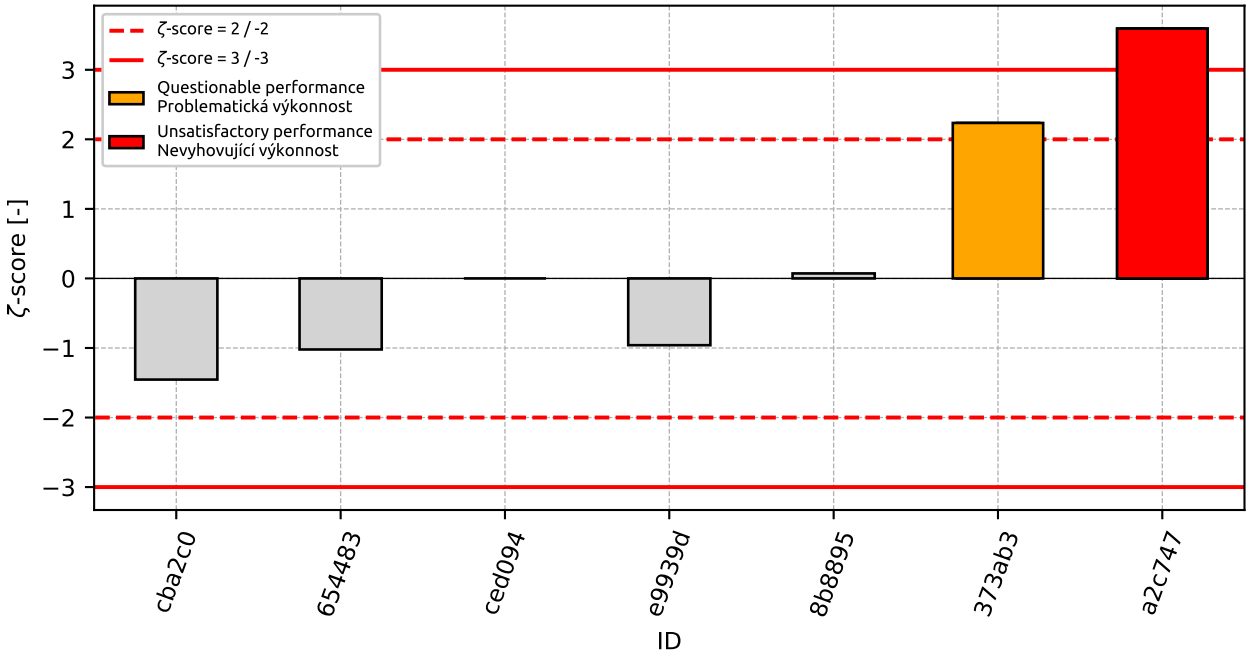

Figure 119: ζ-score

Table 49: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
cba2c0	-0.73	-1.45
654483	-0.57	-1.02
ced094	-0.48	-
e9939d	-0.46	-0.96
8b8895	0.07	0.07
373ab3	1.07	2.24
a2c747	2.03	3.59

8.4 100 cycles

8.4.1 Test results

Table 50: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [g/m²]			u_X [g/m²]	$\bar{x}$ [g/m²]	s_0 [g/m²]	V_X [%]
654483	45.1	30.0	41.1	21.0	38.7	7.82	20.2
ced094	45.5	76.3	47.1	-	56.3	17.34	30.8
cba2c0	56.5	33.9	82.5	11.5	57.6	24.32	42.2
50afa7	62.0	79.0	41.0	20.0	60.7	19.04	31.38
e9939d	70.0	70.0	60.0	8.9	66.7	5.77	8.66
8b8895	153.0	74.0	57.0	80.0	94.7	51.23	54.11
373ab3	277.3	213.0	209.2	6.8	233.2	38.27	16.41
a2c747	346.0	387.0	392.0	37.0	375.0	25.24	6.73

8.4.2 The Numerical Procedure for Determining Outliers

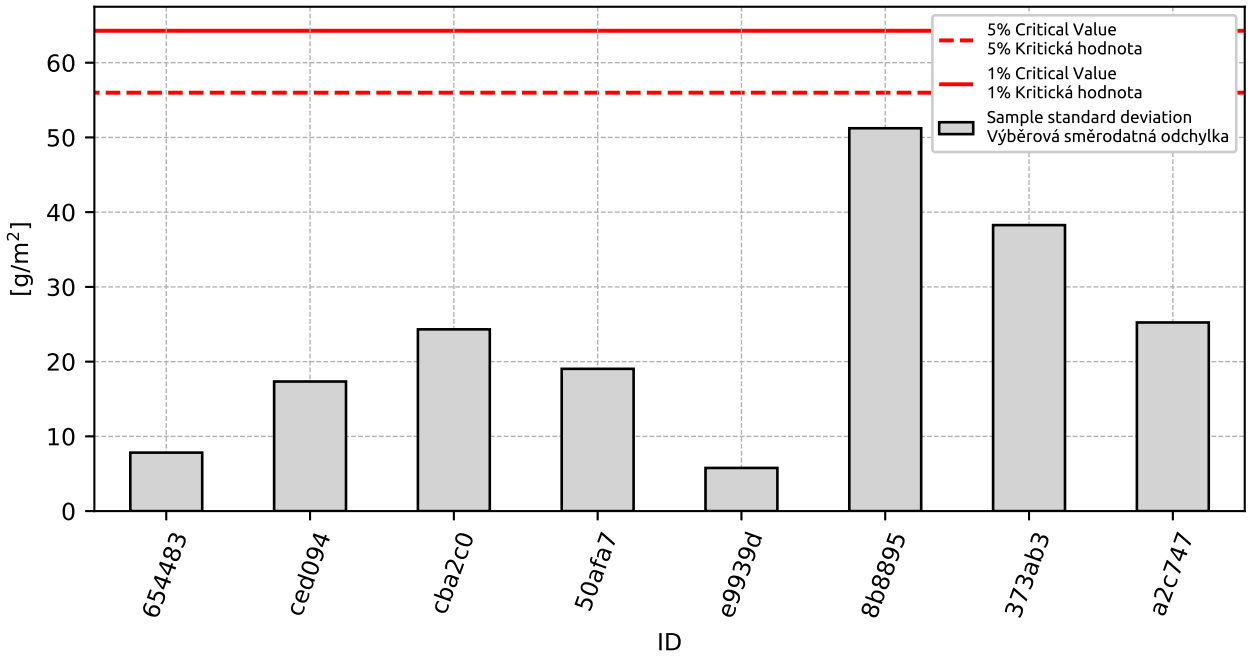

Figure 120: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

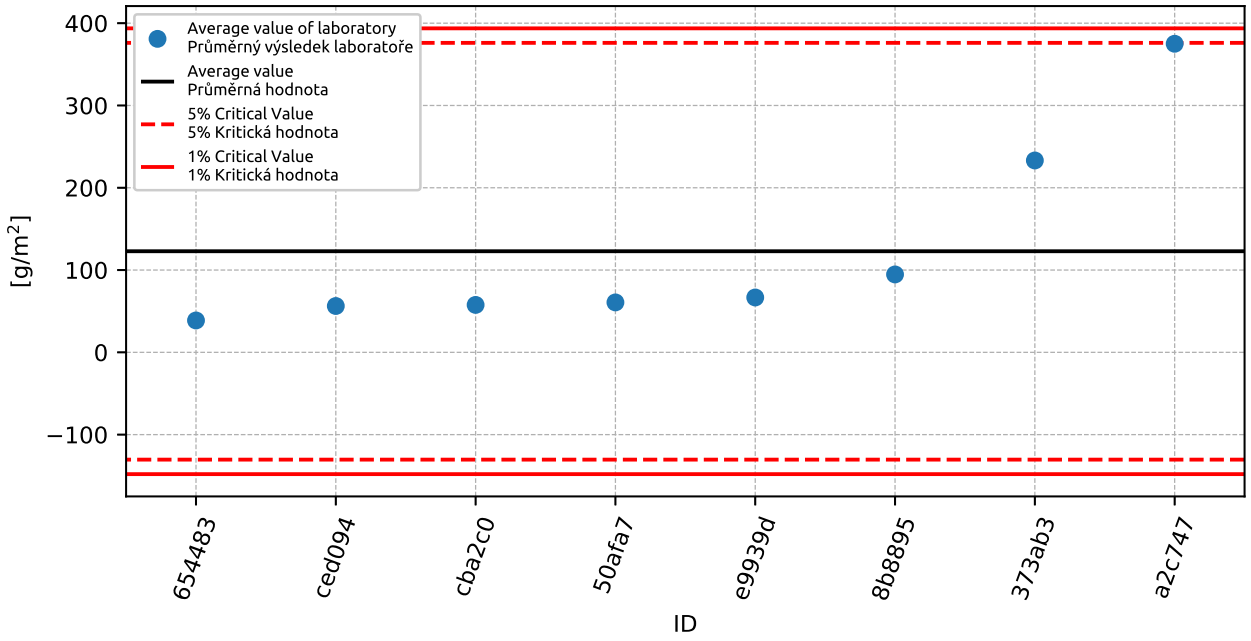

Figure 121: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

8.4.3 Mandel's Statistics

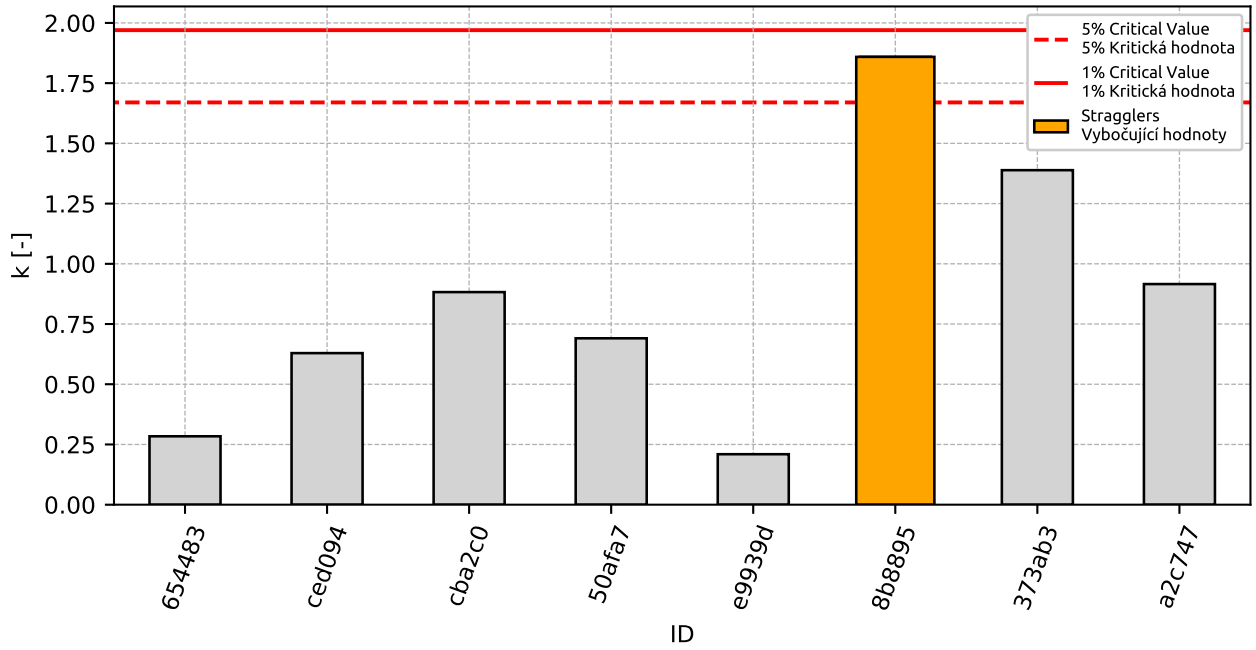

Figure 122: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color

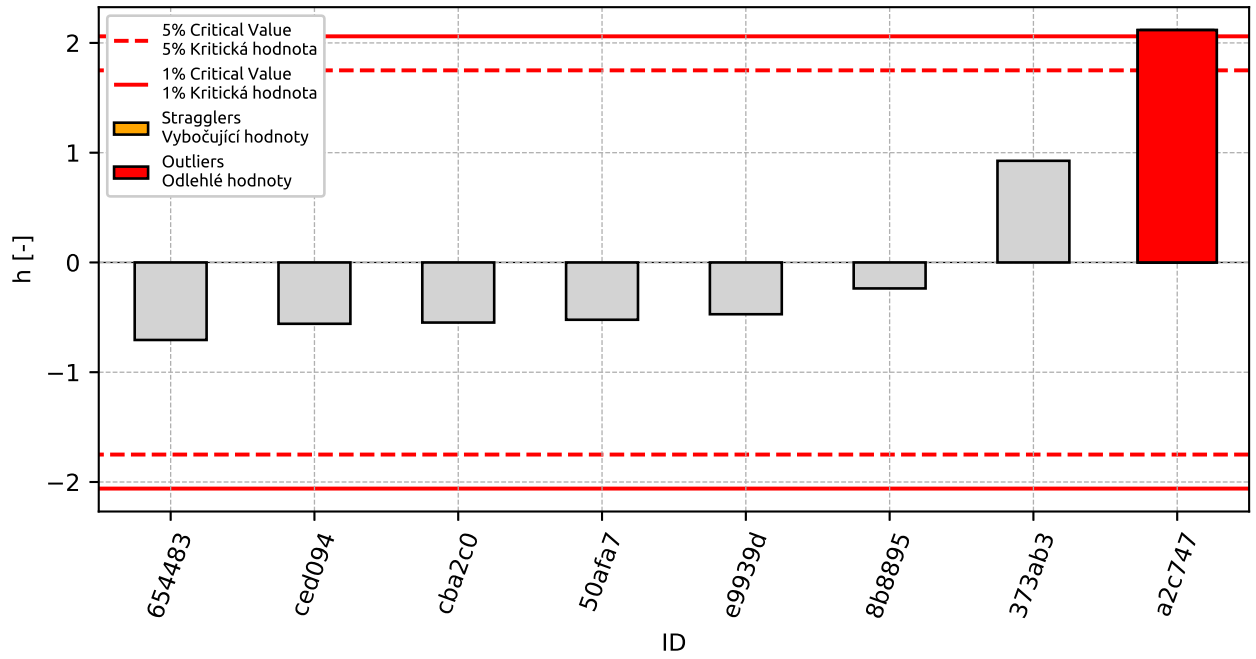

Figure 123: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

8.4.4 Descriptive statistics

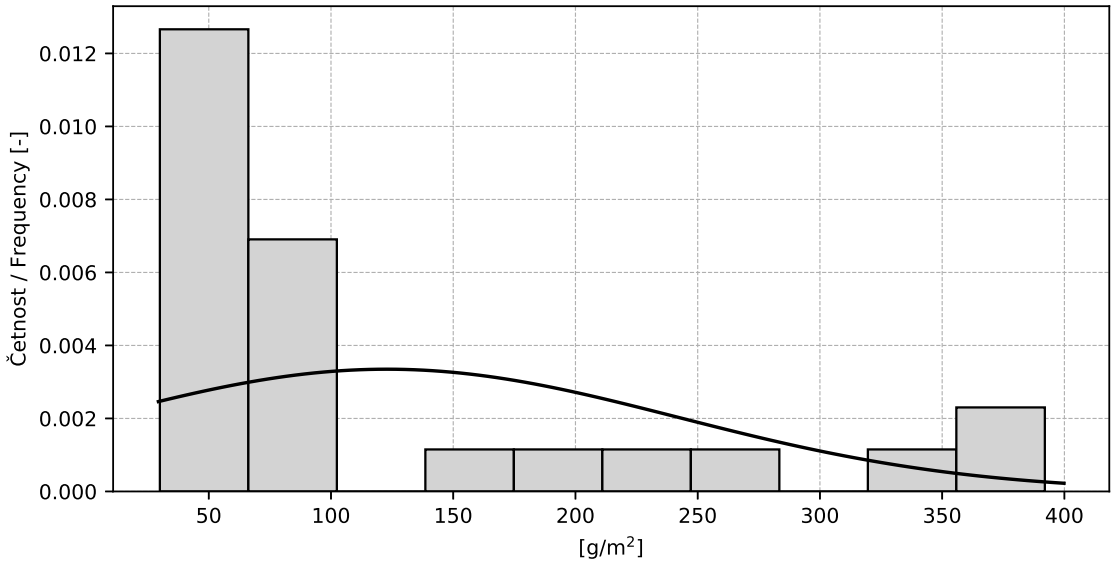

Figure 124: Histogram

Table 51: Descriptive statistics

Value	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	122.9
Výběrová směrodatná odchylka / Sample standard deviation – s	119.12
Vztažná hodnota / Asigned value – x^*	106.2
Robustní směrodatná odchylka / Robust standard deviation – s^*	117.21
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	51.8
p-hodnota testu normality / p-value of normality test	0.011 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	118.05
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	27.56
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	121.22
Opakovatelnost / Repeatability – r	77.2
Reprodukovatelnost / Reproducibility – R	339.4

8.4.5 Calculation of Performance Statistics

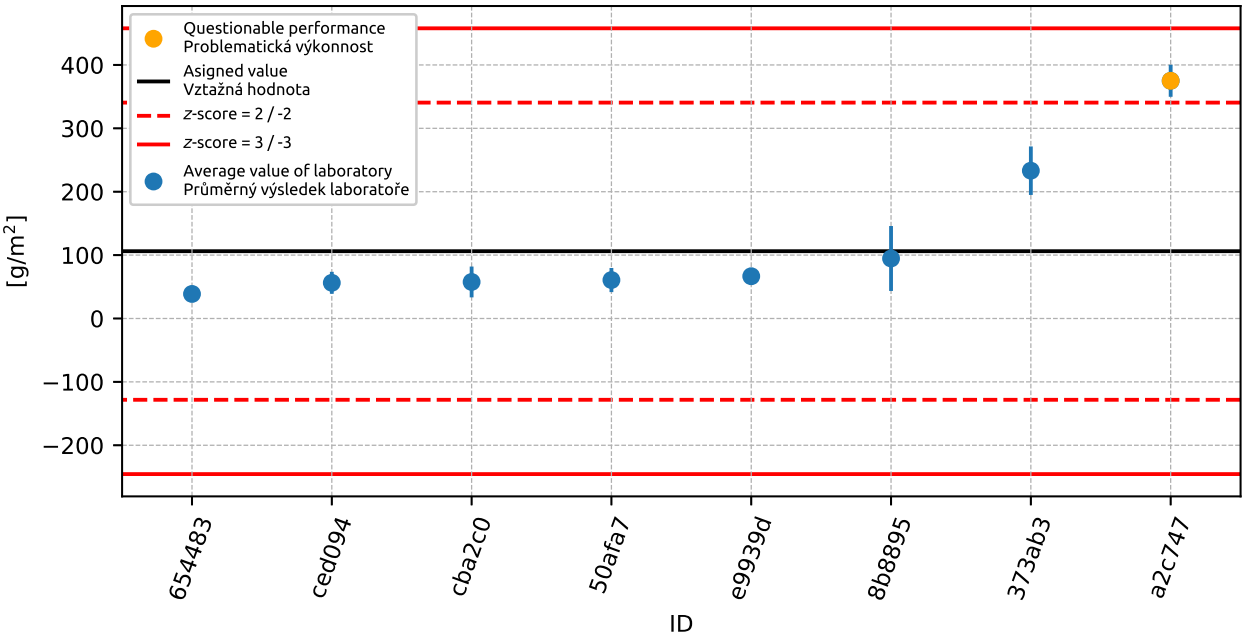

Figure 125: Average values and sample standard deviations

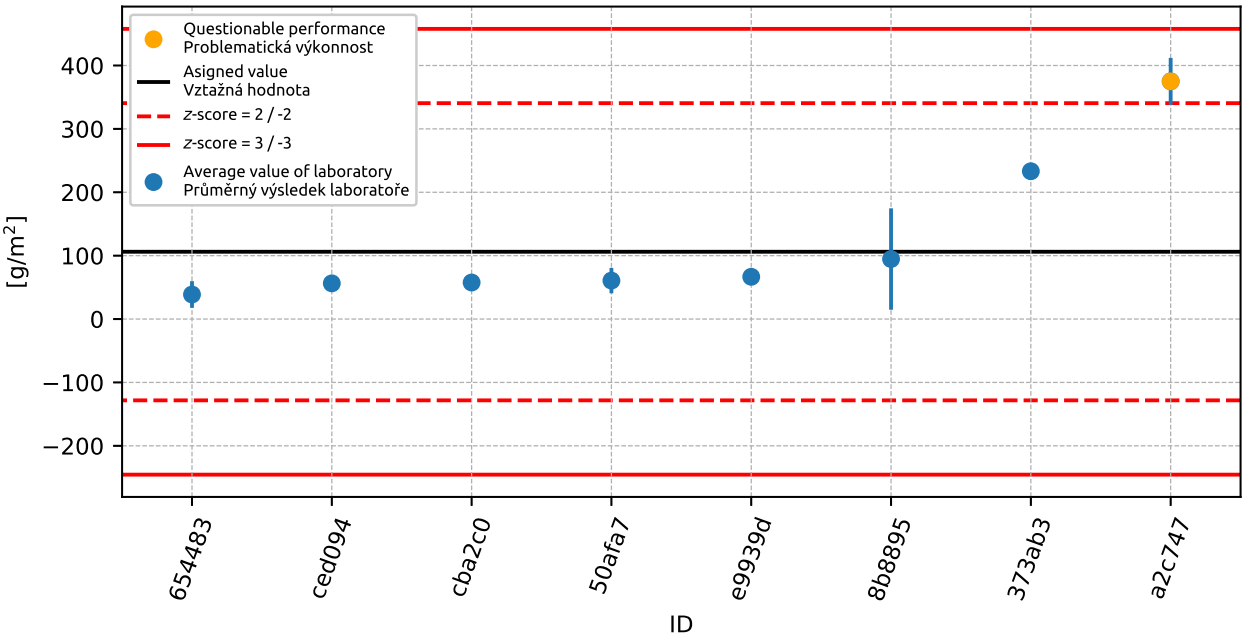

Figure 126: Average values and extended uncertainties of measurement

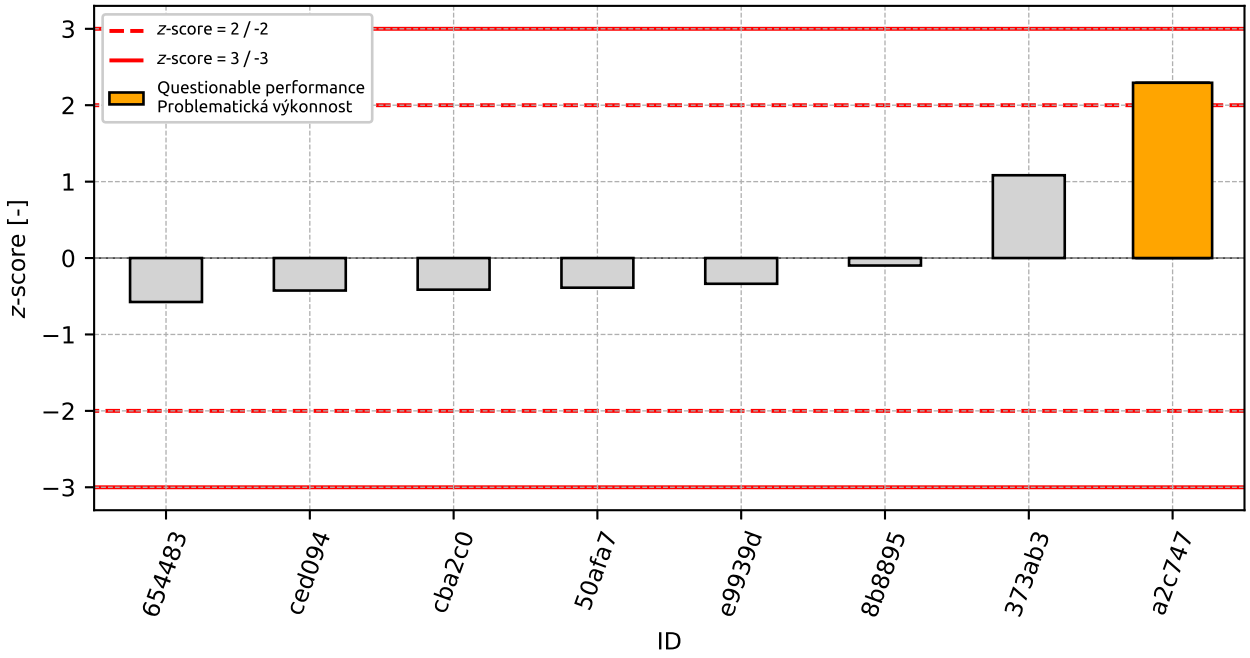

Figure 127: z-score

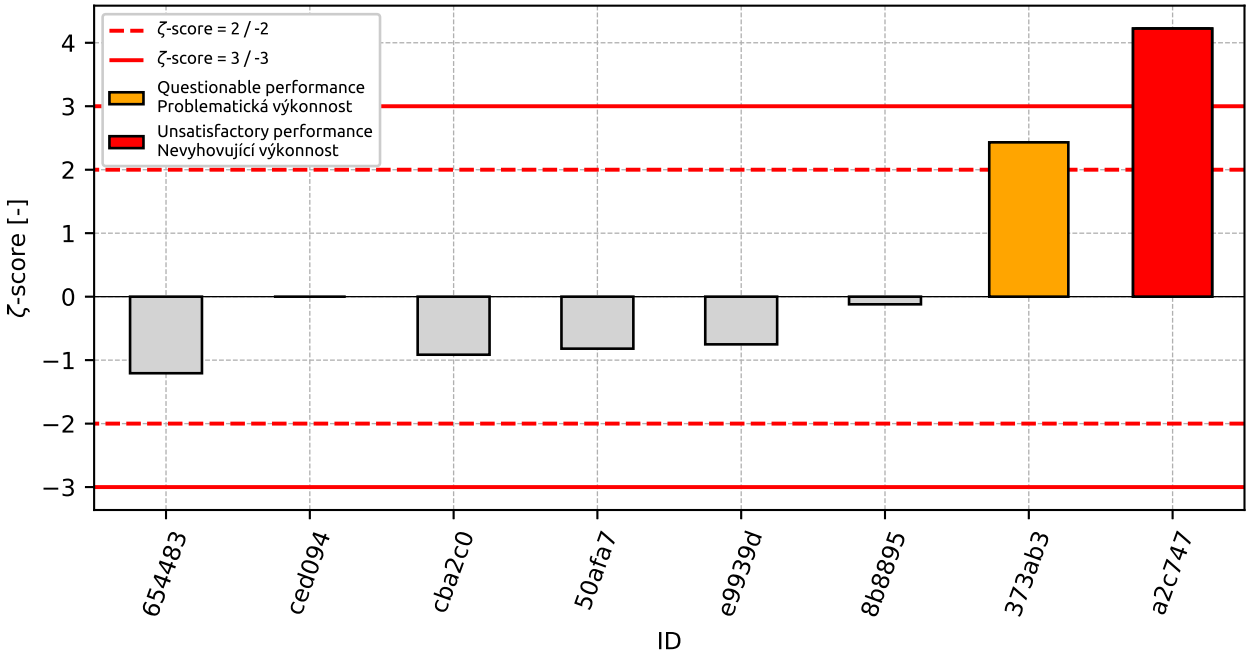

Figure 128: ζ-score

Table 52: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
654483	-0.58	-1.21
ced094	-0.43	-
cba2c0	-0.41	-0.91
50afa7	-0.39	-0.82
e9939d	-0.34	-0.75
8b8895	-0.1	-0.12
373ab3	1.08	2.43
a2c747	2.29	4.22

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

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