BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
institute of building testing

Z 7008

FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Strength and Durability of Hardened Concrete
ZZB 2020/1

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

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

Date: September, 21st 2020

Poskytovatel zkoušení
způsobilosti při SZK FAST

Proficiency testing
provider at the SZK FAST

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Assoc. Prof. Ing. Tomáš Vymazal, Ph.D.
Head of the PT Provider, PTP coordinator

Ing. Petr Misák, Ph.D.
Coordinator of PTP results assessment

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1   Introduction and Important Contacts

In the year 2020, the Proficiency Testing Provider at the SZK FAST (PT Provider) initiated the Proficiency Testing Program (PTP) designated ZZB 2020/1 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	Coordinator of PTP result assessment PrZZ
Assoc. Prof. Ing. Tomáš Vymazal, Ph.D.	**Ing. Petr Misák, Ph.D**.
Brno University of Technology	Brno University of Technology
Faculty of Civil Engineering	Faculty of Civil Engineering
Institute of Building Testing	Institute of Building Testing
Veveří 95, Brno 602 00	Veveří 95, Brno 602 00
Czech Republic	Czech Republic
Tel.: +420 603 313 337	Tel.: +420 774 980 255
Email: Tomas.Vymazal@vutbr.cz	Email: Petr.Misak@vutbr.cz

The subjects of proficiency testing were the following testing procedures:

1. **EN 12390-3** – Compressive strength of test specimens [1].

2. **EN 12390-7** – Density of hardened concrete [2].

3. **EN 12390-8** – Depth of penetration of water under pressure [3].

4. **EN 480-11** – Determination of air void characteristics in hardened concrete [4].

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

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

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

8. **ČSN 73 1326** – Resistance of cement concrete surface to water and defrosting chemicals – Method C [7].

9. **CEN/TS 12390-9** – Freeze-thaw resistance – Scaling [8].

Testing procedures No 5 and 6 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.

55 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.

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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
8350f4	X	X	X	-	-	-	-	-	-
ede0fb	X	X	-	-	-	-	X	X	-
566549	X	X	-	-	-	-	-	-	X
01375e	-	-	-	-	-	-	-	-	X
0b7831	-	-	-	-	-	-	-	X	-
47aaa2	X	X	X	-	-	-	X	-	-
592ba1	X	X	X	-	-	-	-	-	X
6d48a0	X	X	-	-	-	-	-	-	-
e6d683	X	-	-	-	-	-	-	-	-
071636	X	X	X	-	-	-	X	-	-
d1736b	-	-	-	X	-	-	-	-	-
3ed0b7	X	-	-	-	-	-	-	-	-
9a1ab9	X	-	-	-	-	-	-	-	-
7c8abe	X	X	-	-	-	-	X	-	-
a17e65	X	-	X	-	-	-	-	-	-
179752	X	X	-	-	-	-	-	-	-
5f4d43	X	X	-	-	-	-	-	-	-
45a86d	X	X	X	-	-	-	-	-	-
8e5d38	X	-	-	-	-	-	X	-	-
476218	-	-	-	X	-	-	-	-	-
0b87e9	X	-	-	-	-	-	-	-	-
b59be8	X	X	-	-	-	-	-	-	-
1b82df	X	X	X	-	-	-	X	-	-
85e4d1	-	-	-	-	-	-	-	-	X
b98c68	X	X	X	-	-	-	X	-	-
b5d62d	X	X	X	-	-	-	X	-	-
6107a3	X	X	-	-	-	-	-	-	-
65a7af	X	-	-	-	-	-	-	-	-
0c35f1	-	-	X	-	-	-	-	-	-
cfbafd	-	-	X	-	-	-	-	-	-
dfb231	X	-	-	-	-	-	-	-	-
446f1b	X	-	-	-	-	-	-	-	-
18624c	X	X	X	-	-	-	-	X	-
b57ea7	-	-	-	X	-	-	-	-	X
1df0b4	X	X	X	-	-	-	-	-	-
bae402	X	X	X	-	-	-	-	X	-
08b0bd	X	X	X	-	-	-	-	X	-
daffbb	X	X	X	-	-	-	-	-	-
0a6560	X	X	X	-	-	-	-	-	-
37d168	X	X	X	-	-	-	-	-	-
ff1c7c	X	X	X	-	-	-	-	-	-
574628	X	X	X	-	-	-	X	-	-
bffe8e	X	X	X	-	-	-	X	-	-
2c02b2	X	X	-	-	-	-	-	-	-
a95211	X	X	-	-	-	-	-	-	-
0e388f	-	-	-	X	-	-	-	-	-
a46a78	X	X	-	-	-	-	X	-	-

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ID / Testing method	1	2	3	4	5	6	7	8	9
272f2f	X	-	-	-	-	-	-	-	-
f51f73	X	X	X	-	-	-	-	X	-
1d7992	-	-	X	-	-	-	-	-	-
e3cd3f	-	-	-	-	-	-	X	-	-
675a67	X	X	-	-	-	-	-	-	-
f72457	-	-	X	-	-	-	-	-	-
547b9d	-	X	-	-	-	-	-	-	-
7d1353	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, 53701, Česká republika	1495
BETOTECH, s.r.o. - pracoviště Beroun	Beroun 660, Beroun, 26601, 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 Trutnov	Beroun 660, Beroun, 26601, Česká republika	1195
CEMEX Czech Republic, s.r.o.	Semtín 102, Pardubice, 53354, Česká republika	1302
CONSULTEST s.r.o. (ZL Znojmo)	Veveří 95, Brno, 662 37, Česká republika	-
CRH (Slovensko) a. s., 906 38 Rohožník	CRH (Slovensko) a. s., Technicko - kompetenčné centrum, Pestovateľská 2, Bratislava, 821 04, Slovenská republika	426/S-313
Cement Hranice, akciová společnost	Bělotínská 288, Hranice I - Město, 75301, Česká republika	1284
Centar za Projektovanje i Konsalting CPK doo Banja Luka, CPK Institut -Laboratorija	Bulevar Desanke Maksimović 2, Banja Luka, 78000, Bosna i Hercegovina	-
DTQ d.o.o. Sarajevo, Laboratorija za građevinske materijale i konstrukcije	Lužansko polje 7, Sarajevo, 71000, Bosna and Hercegovina	-
Delogne Marc	Chemin des Maréchaux, 36, Wavre, 1300, Belgium	-
Disoma	Krommewege 31G, Maldegem, 9990, Belgium	-
GUBT	Gewerbeparkstraße 5, Markgrafneusiedl, A-2282, Austria	-
Holcim (Hrvatska) d.o.o	Koromačno 7b, Koromačno, 52 222, Croatia	1528

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Laboratory	Address	Accreditation number
Hon Sin Chin	Canna Road, Tabuan Jaya, Kuching, 93350, Sarawak	-
Horský s.r.o.	Klánovická 286, Praha, 198 00, Česká republika	1207
Institut pro testování a certifikaci a.s. - Praha	třída Tomáše Bati 299, Zlín, 76302, Česká republika	1007.4
Institut pro testování a certifikaci, a.s.	třída Tomáše Bati 299, Louky, Zlín, 76302, Česká republika	1004
Instytut Podstawowych Problemow Techniki PAN	Pawinskiego 5 B, Warszawa, 02-106, Poland	-
LABORATOIRE DES TRAVAUX PUBLICS DU SUD	Zone des activités Bouhraoua- PB 332 GHARDAIA, GHARDAIA, 47000, ALGERIA	-
Laboratorium Drogowe Szczecin Sp. z o.o.	Goleniowska 92, Szczecin, Polska, 70-830, Zachodniopomorskie	-
QCONTROL s.r.o. - odštěpný závod - pracoviště Brno	Lesní 693, Bílovice nad Svitavou, 66401, Česká republika	1737
QCONTROL s.r.o. - odštěpný závod - pracoviště Děčín	Lesní 693, Bílovice nad Svitavou, 66401, 28311060	1737
QCONTROL s.r.o. - odštěpný závod - pracoviště Hradec Králové	Lesní 693, Bílovice nad Svitavou, 66401, Česká republika	1737
QCONTROL s.r.o. - odštěpný závod - pracoviště Olomouc	Lesní 693, Bílovice nad Svitavou, 66401, Česká republika	1737
QCONTROL s.r.o. - odštěpný závod - pracoviště Praha	Lesní 693, Bílovice nad Svitavou, 66401, 28311060	1737
QUALIFORM SLOVAKIA s.r.o.	Pasienková 9 D, Bratislava, 821 06, Slovenská republika	154/S-301
SAC Testing and Consulting doo Sarajevo, BiH	Rajlovac bb, Sarajevo, 71000, Bosnia and Herzegovi	-
SIBOTEC CVBA	Industriepark Oost 6, Beernem, 8730, Belgium	-
SQZ s.r.o. - Zbraslav	U místní dráhy 939/5, Olomouc - Nová Ulice, 779 00, Česká republika	1135.2
SQZ, s.r.o. - organizačná zložka Bratislava	U místní dráhy 939/5 77900, Olomouc, 77900, Česká republika	566/S-376
SQZ, s.r.o. - organizačná zložka Bratislava - pracoviště Chminianská n. Ves	U místní dráhy 939/5, Olomouc, 77900, Česká republika	566/S-376
STACHEMA CZ s.r.o.	Hasičská 1, Zibohlavy, Kolín, 28002, Česká republika	L 1433
Skanska Transbeton, s.r.o. - Zkušební laboratoř Letňany	Skanska a.s. , Křižíkova 682/34a, Praha 8 - Karlín, 18600, Česká republika	1122
Skanska Transbeton, s.r.o. - Zkušební laboratoř Olomouc	Skanska a.s., Křižíkova 682/34a, Praha 8 - Karlín, 18600, Česká republika	1122
TESTAV-LAB s.r.o.	Chodská 7, Liberec 3, 46010, Česká republika	1180
TPA za obezbeđenje kvaliteta i inovacije d.o.o. Beograd (lokacija Čačak)	Milutina Milankovića 3b, Novi Beograd, 11070, Srbija	01-280

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Laboratory	Address	Accreditation number
TZÚS Praha, s.p. - pobočka České Budějovice	Nemanická 441, České Budějovice, 37010, Česká republika	1018.3
Technický a zkušební ústav Praha, s.p., Centrální laboratoř, zkušebna 0500 Předměřice nad Labem	Průmyslová 283, Předměřice nad Labem, 503 02, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p. - pobočka Ostrava	U Studia 14, Ostrava - Zábřeh, 70030, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p., Centrální laboratoř - zkušebna Brno	Hněvkovského 77, Brno, 617 00, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p., zkušebna Plzeň	Zahradní 15, Plzeň, 326 00, Česká republika	1018.3
Technische Universität Graz	Inffeldgasse 24, Graz, 8010, Austria	-
Teststav spol s r.o.	Františka Lýska 1599/6, Ostrava - Bělský Les, 700 30, Česká republika	1290
UAB "Testlita"	J. Basanavičiaus str. 160 D-2, Šiauliai, LT-76128, Lithuania	LA013
Universität für Bodenkultur Wien, Department für Bautechnik und Naturgefahren, Institut für Konstruktiven Ingenieurbau	Peter-Jordan-Str. 82, Wien - Vienna, 1190, AUSTRIA	P0252
Výzkumný ústav pozemních staveb - Certifikační společnost, s.r.o. - pobočka Brno	Pražská 810/16, Praha 10, 10221, Česká republika	1234
Výzkumný ústav pozemních staveb - Certifikační společnost, s.r.o. - pobočka Uhříněves	Pražská 810/16, Praha 10, 10221, Česká republika	1234
ZAPA beton a.s.	Vídeňská 495, Praha, 14200, Česká republika	-
Ředitelství silnic a dálnic ČR - Brno	Rebešovická 40, Brno-Chrlice, 643 00, Česká republika	1072
Ředitelství silnic a dálnic ČR - Praha	Na Pankráci 546/56, Praha 4 - Nusle, 14000, Česká republika	1734

2   Procedures used in the Statistical Analysis of Laboratory Results

The statistical analysis is based on the following steps:

1. Evaluation of intralaboratory variabilities by Cochran's C test: If 5% or 1% critical value is exceeded, the effect of the individual observations is first considered. If the results indicate that high participant variability is caused by a single observation, this value is excluded from the experiment, but the participant is not excluded as outlying. By overcoming 1% of the critical value, the participant's results can be marked as outlying and excluded from the experiment (symbol **X**).

2. The numerical critical evaluation of the test results using Grubbs' test: By overcoming 1% critical value, the participant's results can be marked as outlying and excluded from the experiment (symbol **X**).

3. Graphical determination of the consistency of laboratories (Mandel's statistics): The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies.

4. Evaluation of descriptive statistics and, if possible, taking into account the number of observations, the repeatability and reproducibility.

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5. Evaluation of the assigned value.

6. The performance evaluation: The most significant outcome of the PT Program is the so-called z-score and ζ-score (zeta-score). These characteristics assess the performance of individual participants by comparing it with the assigned value and measurement uncertainties. z-score and ζ-score are compared with limit values. The resulting ζ-score values are not taken into account during the final evaluation of the performance of participants as they are to a considerable degree dependent on the values of the measurement uncertainties of the assessed institutions. The following scales are applied for the z-score values:

- $|z\text{-score}| < 2 \Rightarrow$ shows that the laboratory performance is **satisfactory** and generates no signal – ✓.
- $2 \leq |z\text{-score}| < 3 \Rightarrow$ shows that the laboratory performance is **questionable** and generates an action signal – **?**.
- $|z\text{-score}| \geq 3 \Rightarrow$ shows that the laboratory performance is **unsatisfactory** and generates an action signal – **!**.

Procedures used in the statistical analysis of proficiency testing programs can be found here: http://ptprovider.cz/?lang=en.

3   Conclusions of the Statistical Analysis

The present report summarizes the results of the Proficiency Testing Program Strength and Durability of Hardened Concrete (PT Program) organized by the PT Provider at the SZK FAST. 55 participants (laboratories) took part in the PT Program. The program focused on ordinary standardized testing of hardened concrete with emphasis on its strength and durability. The test results are evaluated separately for each testing procedure examined. An evaluation of statistical characteristics is included in the Appendix, as well as test results and graphic presentations. Testing methods can be found in part 1 of this report.

Table 4: Evaluation of overall performance and outliers.
✓ – satisfactory performance; **?** – questionable performance; **!** – unsatisfactory performance; **X** – outlier;

ID / Method	1	2	3	4	5	6	7	8	9
8350f4	✓	✓	✓	-	-	-	-	-	-
ede0fb	✓	✓	-	-	-	-	✓	✓	-
566549	✓	?	-	-	-	-	-	-	?
01375e	-	-	-	-	-	-	-	-	✓
0b7831	-	-	-	-	-	-	-	✓	-
47aaa2	✓	✓	✓	-	-	-	✓	-	-
592ba1	✓	✓	✓	-	-	-	-	-	✓
6d48a0	✓	✓	-	-	-	-	-	-	-
e6d683	✓	-	-	-	-	-	-	-	-
71636	✓	✓	✓	-	-	-	✓	-	-
d1736b	-	-	-	✓	-	-	-	-	-
3ed0b7	✓	-	-	-	-	-	-	-	-
9a1ab9	?	-	-	-	-	-	-	-	-
7c8abe	✓	✓	-	-	-	-	✓	-	-
a17e65	✓	-	✓	-	-	-	-	-	-

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ID / Method	1	2	3	4	5	6	7	8	9
179752	✓	✓	-	-	-	-	-	-	-
5f4d43	✓	✓	-	-	-	-	-	-	-
45a86d	✓	✓	✓	-	-	-	-	-	-
8e5d38	✓	-	-	-	-	-	✓	-	-
476218	-	-	-	✓	-	-	-	-	-
0b87e9	✓	-	-	-	-	-	-	-	-
b59be8	✓	✓	-	-	-	-	-	-	-
1b82df	✓	✓	✓	-	-	-	?	-	-
85e4d1	-	-	-	-	-	-	-	-	✓
b98c68	✓	✓	✓	-	-	-	✓	-	-
b5d62d	✓	✓	✓	-	-	-	✓	-	-
6107a3	✓	✓	-	-	-	-	-	-	-
65a7af	?	-	-	-	-	-	-	-	-
0c35f1	-	-	✓	-	-	-	-	-	-
cfbafd	-	-	✓	-	-	-	-	-	-
dfb231	✓	-	-	-	-	-	-	-	-
446f1b	✓	-	-	-	-	-	-	-	-
18624c	✓	✓	✓	-	-	-	-	✓	-
b57ea7	-	-	-	✓	-	-	-	-	✓
1df0b4	✓	✓	✓	-	-	-	-	-	-
bae402	✓	✓	✓	-	-	-	-	✓	-
08b0bd	✓	✓	✓	-	-	-	-	✓	-
daffbb	✓	✓	✓	-	-	-	-	-	-
0a6560	✓	✓	✓	-	-	-	-	-	-
37d168	✓	✓	✓	-	-	-	-	-	-
ff1c7c	✓	✓	✓	-	-	-	-	-	-
574628	✓	✓	✓	-	-	-	✓	-	-
bffe8e	X	✓	✓	-	-	-	?	-	-
2c02b2	✓	✓	-	-	-	-	-	-	-
a95211	?	?	-	-	-	-	-	-	-
0e388f	-	-	-	✓	-	-	-	-	-
a46a78	✓	✓	-	-	-	-	✓	-	-
272f2f	✓	-	-	-	-	-	-	-	-
f51f73	✓	✓	✓	-	-	-	-	✓	-
1d7992	-	-	✓	-	-	-	-	-	-
e3cd3f	-	-	-	-	-	-	✓	-	-
675a67	✓	✓	-	-	-	-	-	-	-
f72457	-	-	?	-	-	-	-	-	-

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ID / Method	1	2	3	4	5	6	7	8	9
547b9d	-	✓	-	-	-	-	-	-	-
7d1353	✓	-	-	-	-	-	-	-	-

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

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

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

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[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.

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

1.1 Test results

Table 4: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [N/mm^2]			u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
bffe8e	46.9	47.9	49.9	1.5	48.2	1.53	3.17
a95211	57.3	50.9	57.0	5.5	55.1	3.6	6.54
65a7af	56.9	56.1	54.5	1.2	55.8	1.22	2.19
b59be8	55.2	59.0	56.0	2.8	56.7	2.0	3.53
675a67	52.4	60.9	59.9	12.9	57.7	4.65	8.05
6d48a0	55.5	58.5	61.0	0.5	58.3	2.75	4.72
e6d683	55.3	58.9	61.0	1.0	58.4	2.88	4.94
566549	59.7	59.4	56.3	9.3	58.5	1.88	3.22
daffbb	59.8	57.7	59.3	0.6	58.9	1.1	1.86
8e5d38	56.6	59.5	60.7	3.2	58.9	2.11	3.58
0b87e9	59.3	56.2	61.3	3.8	58.9	2.57	4.36
a17e65	60.9	57.0	59.1	3.0	59.0	1.95	3.31
18624c	61.7	56.3	59.1	3.8	59.0	2.7	4.57
6107a3	59.2	59.4	58.6	0.5	59.1	0.42	0.7
1df0b4	58.6	59.6	59.0	3.3	59.1	0.5	0.85
2c02b2	59.1	59.2	59.9	0.3	59.4	0.44	0.73
8350f4	60.6	59.0	58.8	1.0	59.5	0.99	1.66
dfb231	59.7	58.4	60.3	0.6	59.5	0.99	1.67
71636	58.5	59.0	61.5	2.7	59.7	1.61	2.69
a46a78	59.7	60.9	58.7	2.0	59.8	1.1	1.84
08b0bd	58.6	60.6	60.9	0.6	60.0	1.25	2.08
47aaa2	60.3	60.6	59.9	-	60.3	0.35	0.58
592ba1	61.8	60.0	59.1	1.9	60.3	1.37	2.28
7c8abe	60.5	61.0	59.8	1.7	60.4	0.6	1.0
ff1c7c	60.7	60.6	60.1	2.0	60.5	0.32	0.53
574628	60.5	61.5	59.7	2.9	60.6	0.9	1.49
7d1353	61.4	60.0	60.5	0.9	60.7	0.71	1.17
f51f73	61.3	61.0	59.9	-	60.7	0.74	1.21
1b82df	60.6	61.2	61.2	3.4	61.0	0.35	0.57
bae402	59.5	63.2	60.6	3.1	61.1	1.9	3.11
272f2f	62.2	61.6	59.6	2.3	61.1	1.36	2.23
179752	60.1	61.9	62.1	0.7	61.4	1.1	1.79
b5d62d	61.9	61.5	61.2	1.9	61.5	0.35	0.57
45a86d	60.7	61.3	62.7	2.7	61.6	1.03	1.67
5f4d43	62.4	62.0	61.4	1.3	61.9	0.5	0.81
37d168	61.9	62.8	61.6	1.9	62.1	0.62	1.01
b98c68	62.4	61.8	62.7	2.0	62.3	0.46	0.74
0a6560	62.4	62.6	62.1	1.4	62.4	0.25	0.4
446f1b	62.9	61.7	63.7	-	62.8	1.01	1.6
3ed0b7	62.7	63.2	63.2	1.1	63.0	0.29	0.46
9a1ab9	66.2	63.1	64.0	1.9	64.4	1.59	2.48
ede0fb	61.8	73.4	63.3	5.0	66.2	6.31	9.53

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## 1.2 The Numerical Procedure for Determining Outliers
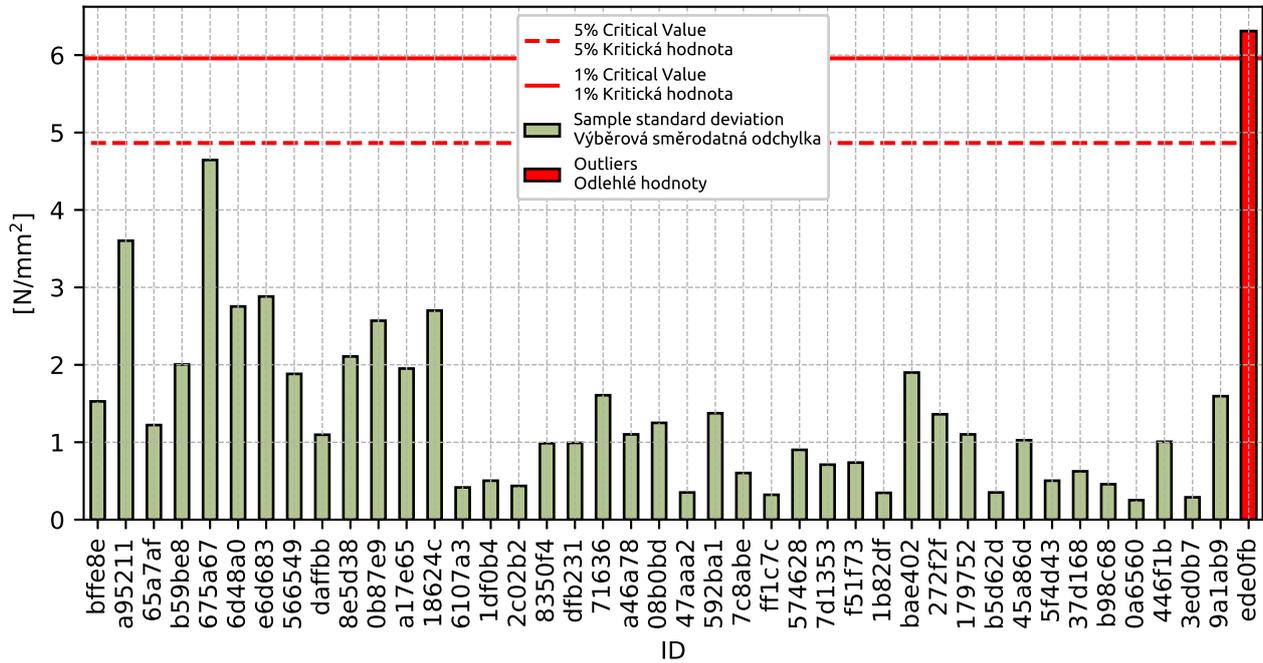
Figure 1: **Cochran's test** - sample standard deviations
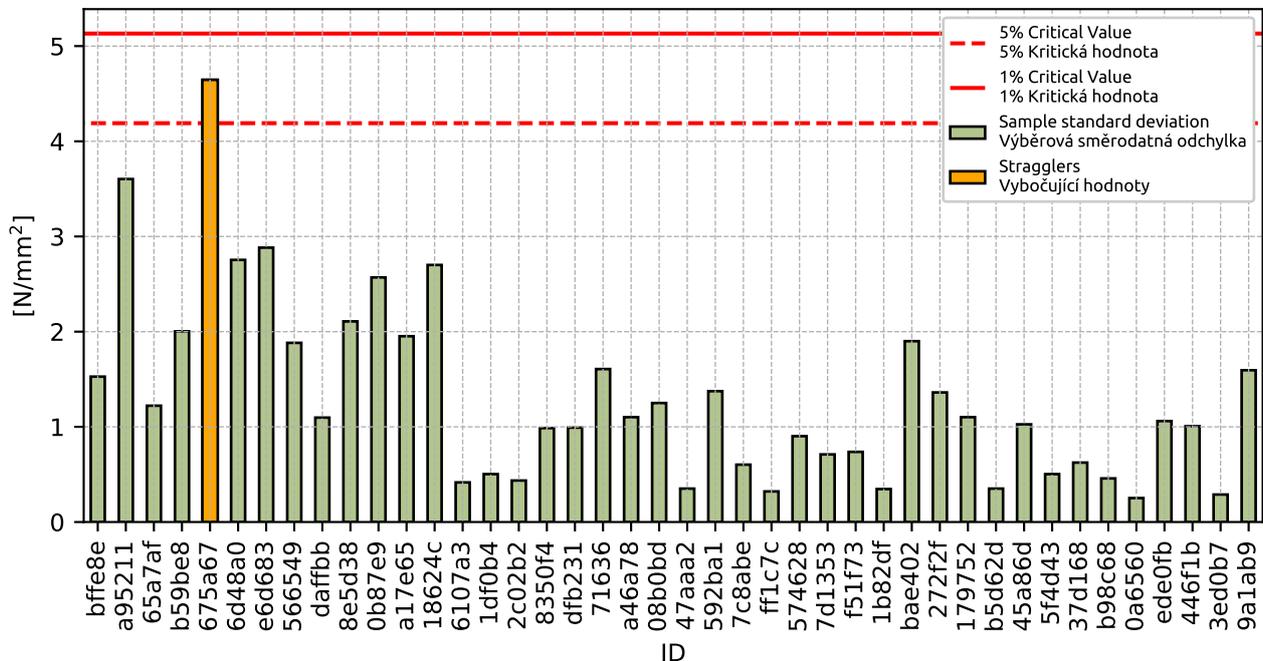
Figure 2: **Cochran's test** - sample standard deviations without outliers

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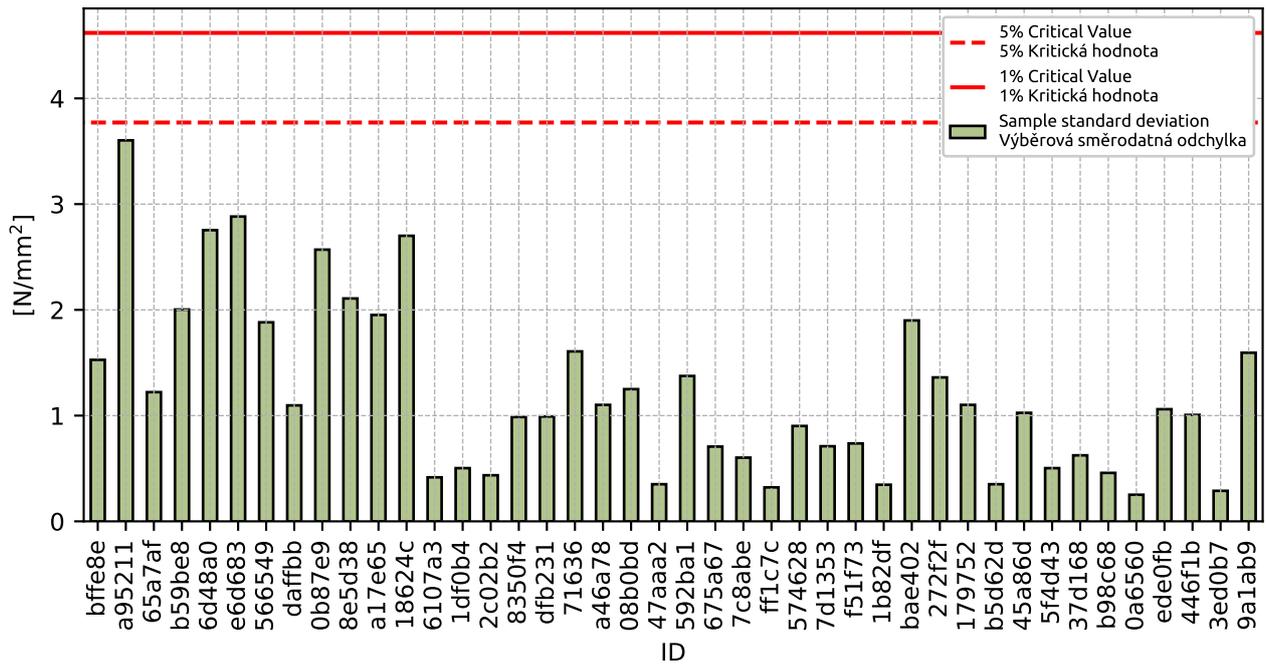
Figure 3: **Cochran's test** - sample standard deviations without outliers
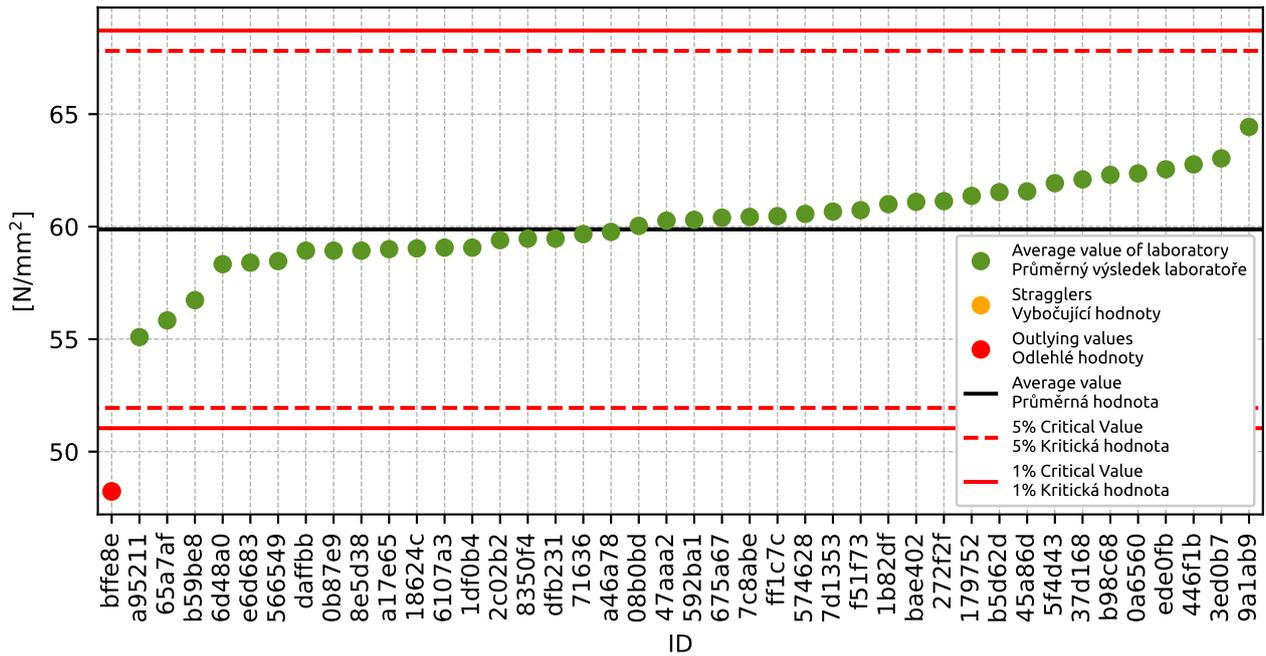
Figure 4: **Grubbs' test** - average values

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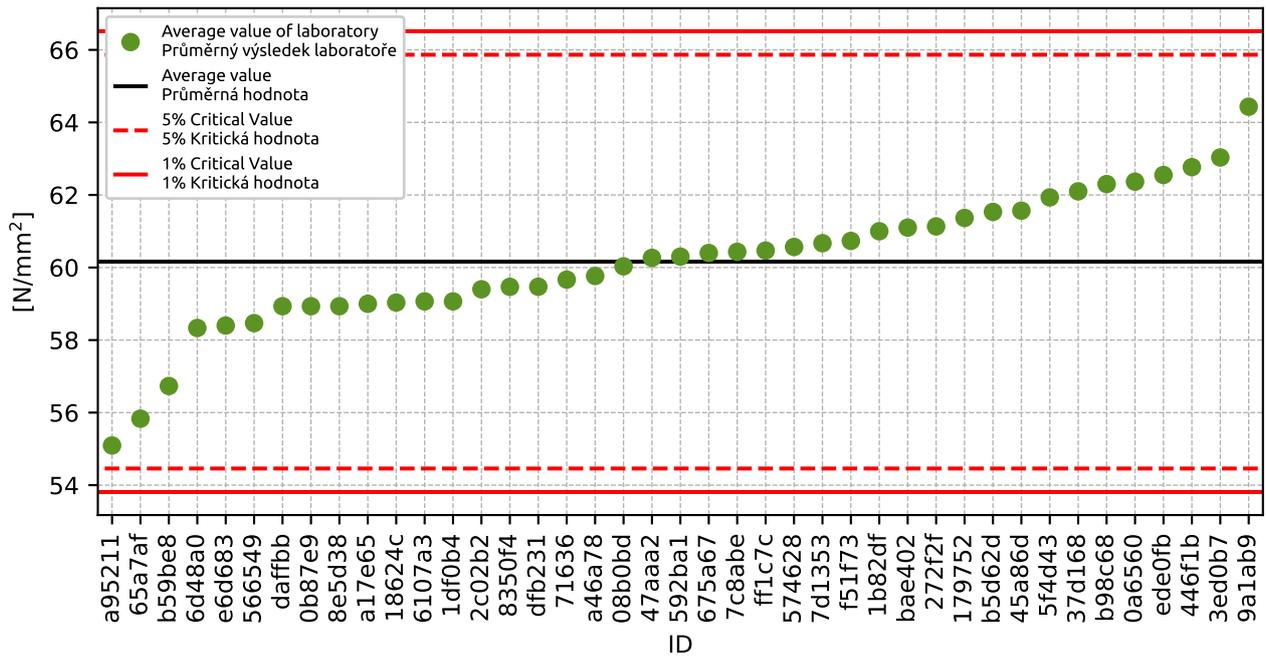
Figure 5: **Grubbs' test** - average values without outliers

1.3 Mandel's Statistics
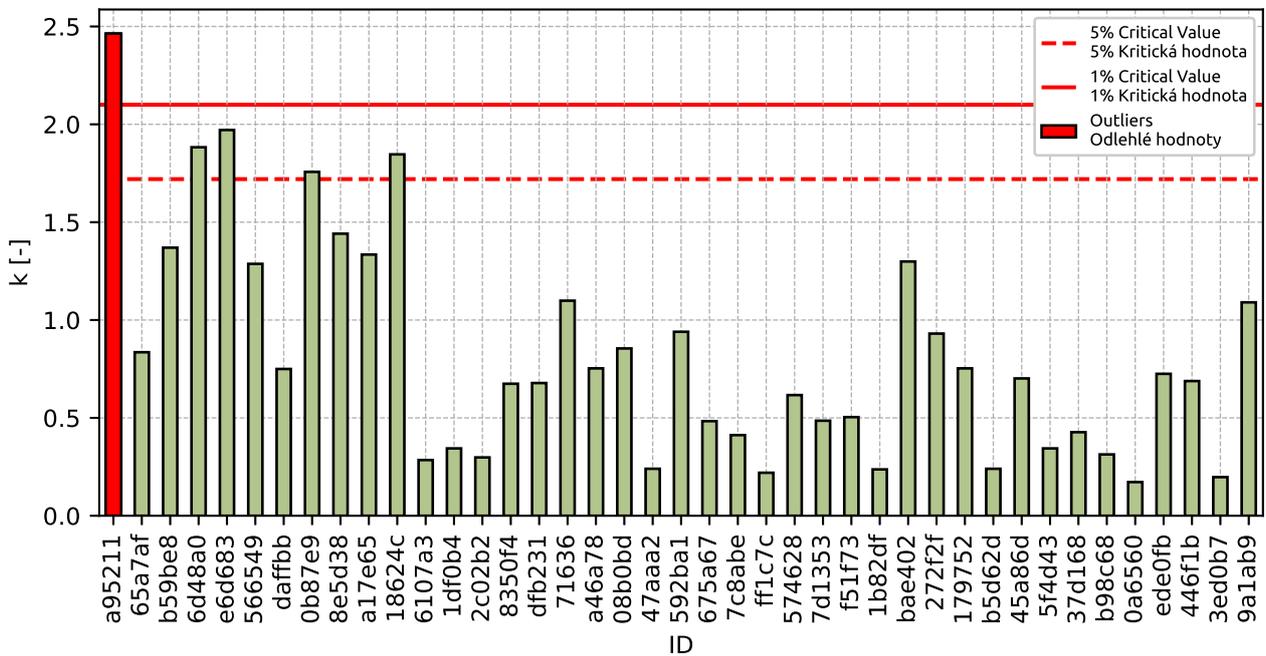
Figure 6: Intralaboratory Consistency Statistic

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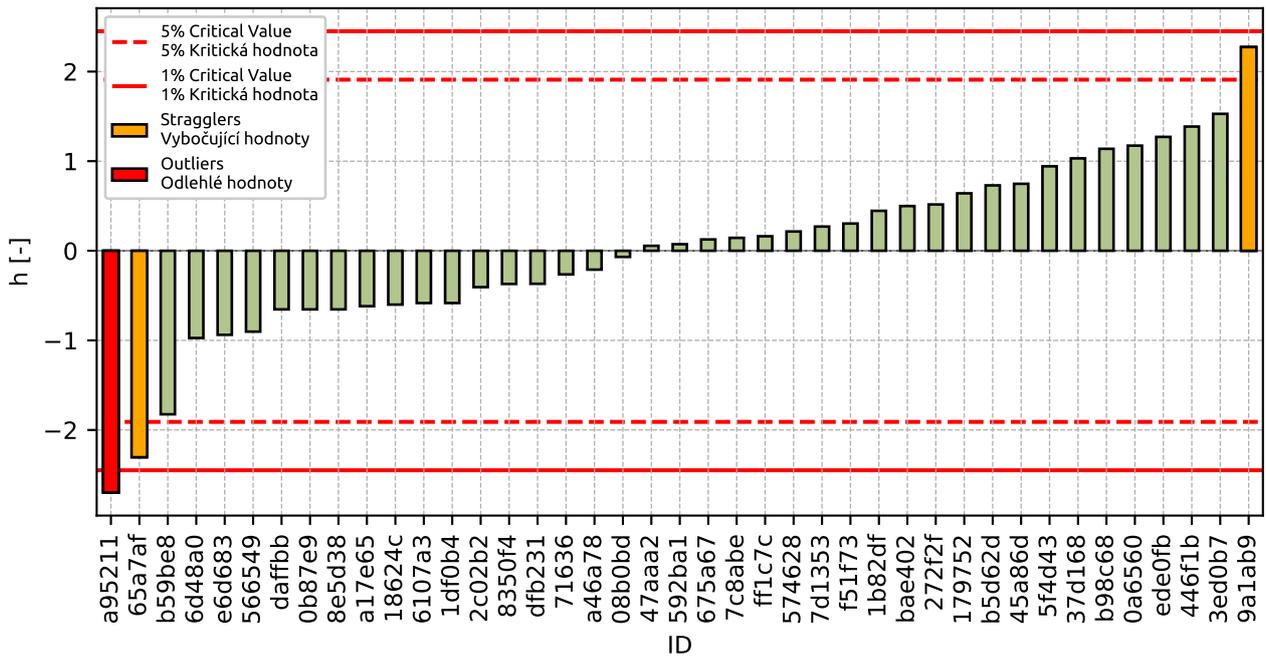
Figure 7: Interlaboratory Consistency Statistic

1.4 Descriptive statistics
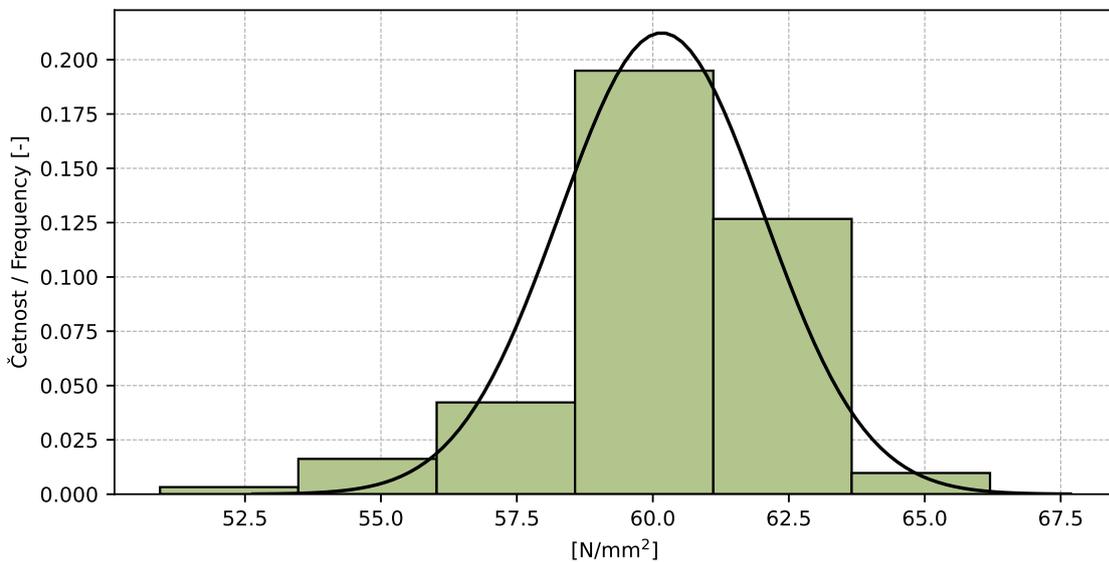
Figure 8: Histogram of all test results

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Table 5: Descriptive statistics

Characteristics	[N/mm^2]
Průměrná hodnota / Average value – $\bar{x}$	60.2
Výběrová směrodatná odchylka / Sample standard deviation – s	1.88
Vztažná hodnota / Asigned value – x^*	60.3
Robustní směrodatná odchylka / Robust standard deviation – s^*	1.81
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.35
p-hodnota testu normality / p-value of normality test	1.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	1.68
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	1.46
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	2.23
Opakovatelnost / Repeatability – r	4.1
Reprodukovatelnost / Reproducibility – R	6.2

1.5 Evaluation of Performance Statistics
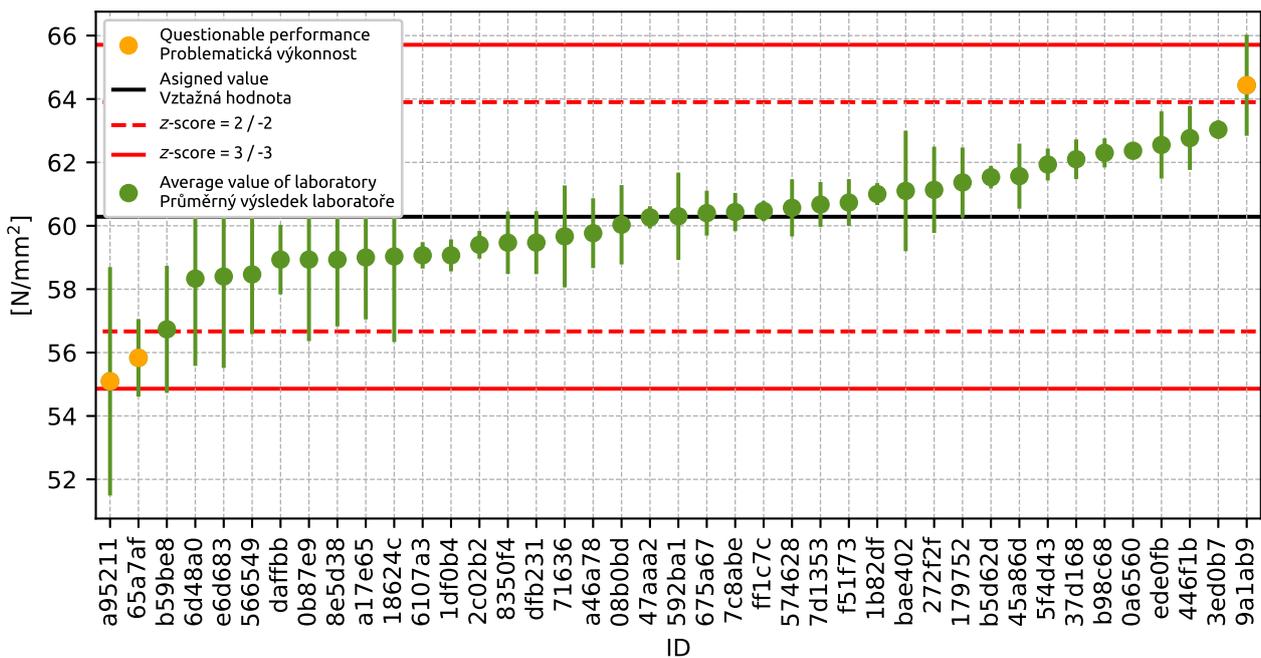
Figure 9: Average values and sample standard deviations

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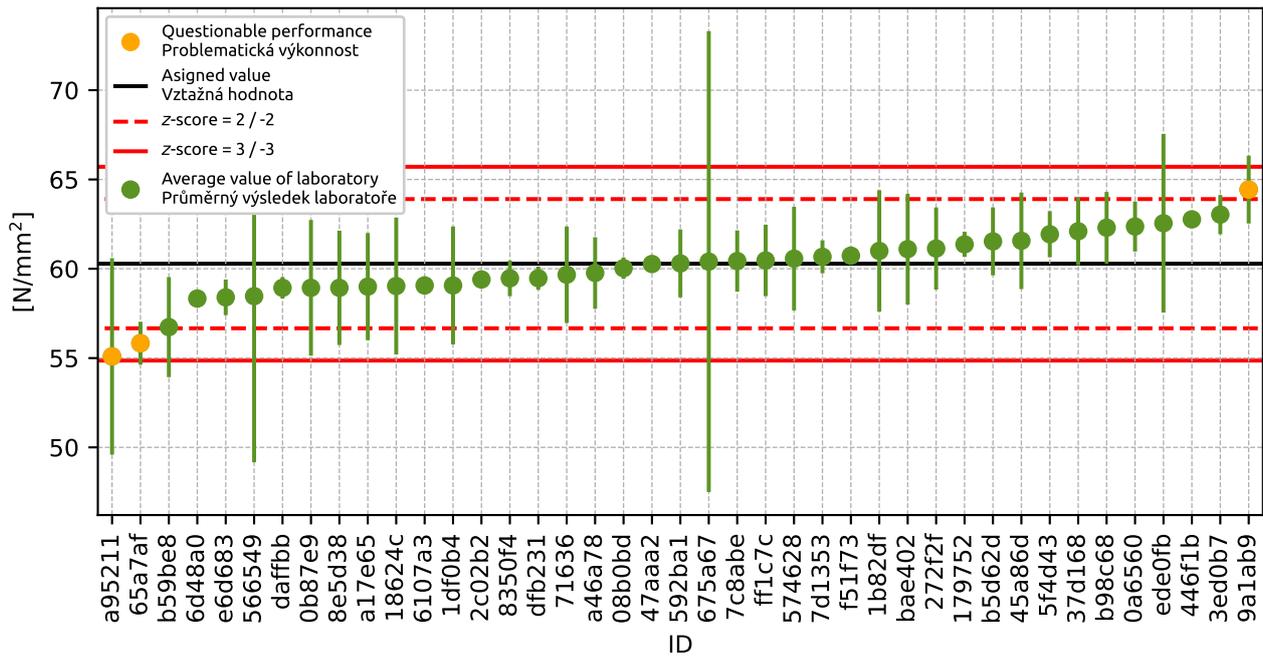
Figure 10: Average values and extended uncertainties of measurement

Figure 11: z-score

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Figure 12: ζ-score

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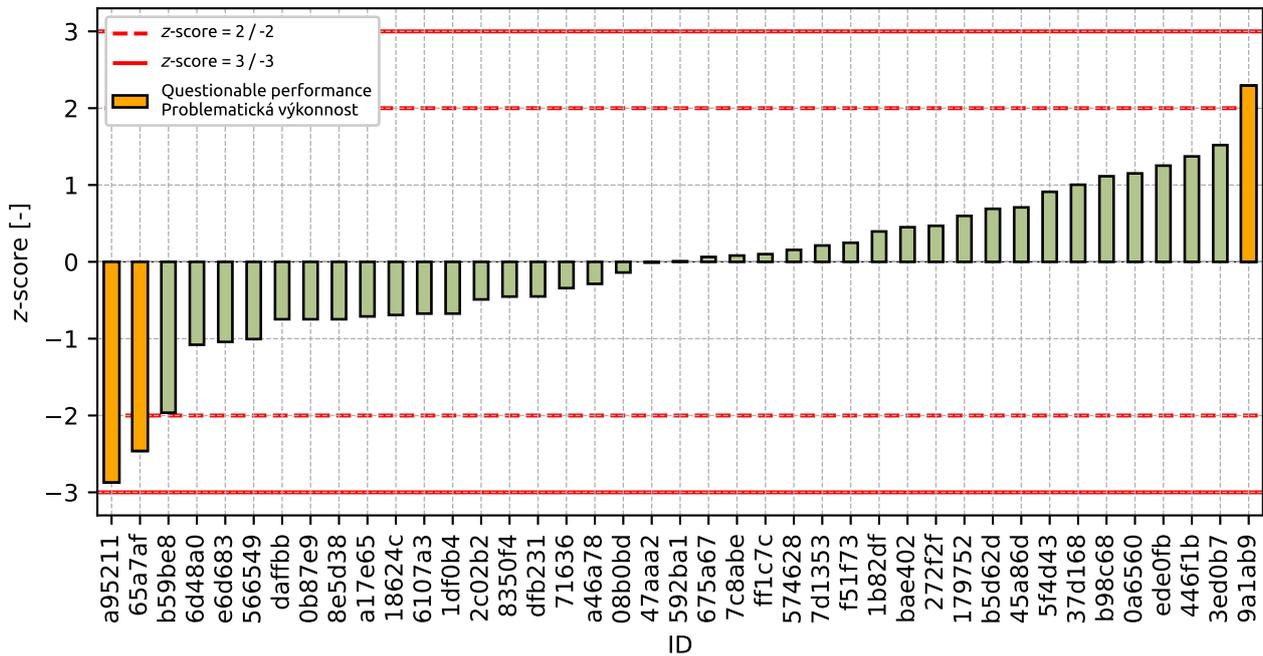
Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
a95211	-2.87	-0.94
65a7af	-2.46	-3.56
b59be8	-1.96	-1.26
6d48a0	-1.08	-3.19
e6d683	-1.04	-1.78
566549	-1.01	-0.2
daffbb	-0.75	-1.94
0b87e9	-0.75	-0.35
8e5d38	-0.75	-0.42
a17e65	-0.71	-0.43
18624c	-0.69	-0.33
6107a3	-0.67	-1.99
1df0b4	-0.67	-0.37
2c02b2	-0.49	-1.91
8350f4	-0.45	-0.77
dfb231	-0.45	-1.1
71636	-0.34	-0.23
a46a78	-0.29	-0.26
08b0bd	-0.14	-0.36
47aaa2	-0.01	-
592ba1	0.01	0.01
675a67	0.06	0.01
7c8abe	0.08	0.08
ff1c7c	0.1	0.09
574628	0.16	0.1
7d1353	0.21	0.39
f51f73	0.25	-
1b82df	0.4	0.21
bae402	0.45	0.26
272f2f	0.47	0.36
179752	0.6	1.38
b5d62d	0.69	0.65
45a86d	0.71	0.47
5f4d43	0.91	1.23
37d168	1.0	0.94
b98c68	1.11	0.99
0a6560	1.15	1.44
ede0fb	1.25	0.45
446f1b	1.37	-
3ed0b7	1.52	2.38
9a1ab9	2.29	2.15

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

2.1 Test results

Table 7: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results			u_X	$\bar{x}$	s_0	V_X
	[kg/m³]			[kg/m³]	[kg/m³]	[kg/m³]	[%]
a95211	2220	2240	2230	20	2230	9	0.4
179752	2230	2300	2290	20	2270	38	1.67
574628	2300	2260	2260	40	2270	23	12.00
675a67	2280	2280	2280	40	2280	0	0.00
6107a3	2280	2290	2270	10	2280	10	0.44
6d48a0	2250	2280	2330	10	2290	40	1.77
a46a78	2290	2280	2290	20	2290	6	0.25
45a86d	2280	2300	2280	20	2290	12	0.5
547b9d	2280	2290	2290	0	2290	6	0.25
71636	2300	2280	2290	10	2290	7	0.29
8350f4	2290	2300	2280	10	2290	10	0.44
47aaa2	2280	2300	2290	-	2290	10	0.44
2c02b2	2300	2280	2290	20	2290	10	0.44
5f4d43	2300	2270	2300	50	2290	19	0.84
f51f73	2290	2290	2300	-	2290	6	0.25
bffe8e	2290	2290	2300	30	2290	6	0.25
ede0fb	2280	2320	2280	20	2290	23	11.00
1b82df	2280	2300	2310	20	2300	15	0.67
7c8abe	2300	2290	2300	20	2300	6	0.25
1df0b4	2300	2300	2290	10	2300	5	0.2
bae402	2300	2300	2300	40	2300	0	0.00
b5d62d	2290	2300	2310	20	2300	10	0.43
b59be8	2290	2300	2310	120	2300	10	0.43
18624c	2300	2300	2300	20	2300	0	0.00
daffbb	2290	2320	2300	30	2300	15	0.66
37d168	2310	2300	2310	30	2310	6	0.25
08b0bd	2300	2320	2310	30	2310	10	0.43
0a6560	2320	2320	2290	30	2310	17	0.75
ff1c7c	2320	2310	2310	10	2310	6	0.25
b98c68	2310	2320	2320	20	2320	6	0.25
592ba1	2320	2330	2300	50	2320	15	0.66
566549	2330	2310	2330	40	2320	12	0.50

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2.2 The Numerical Procedure for Determining Outliers
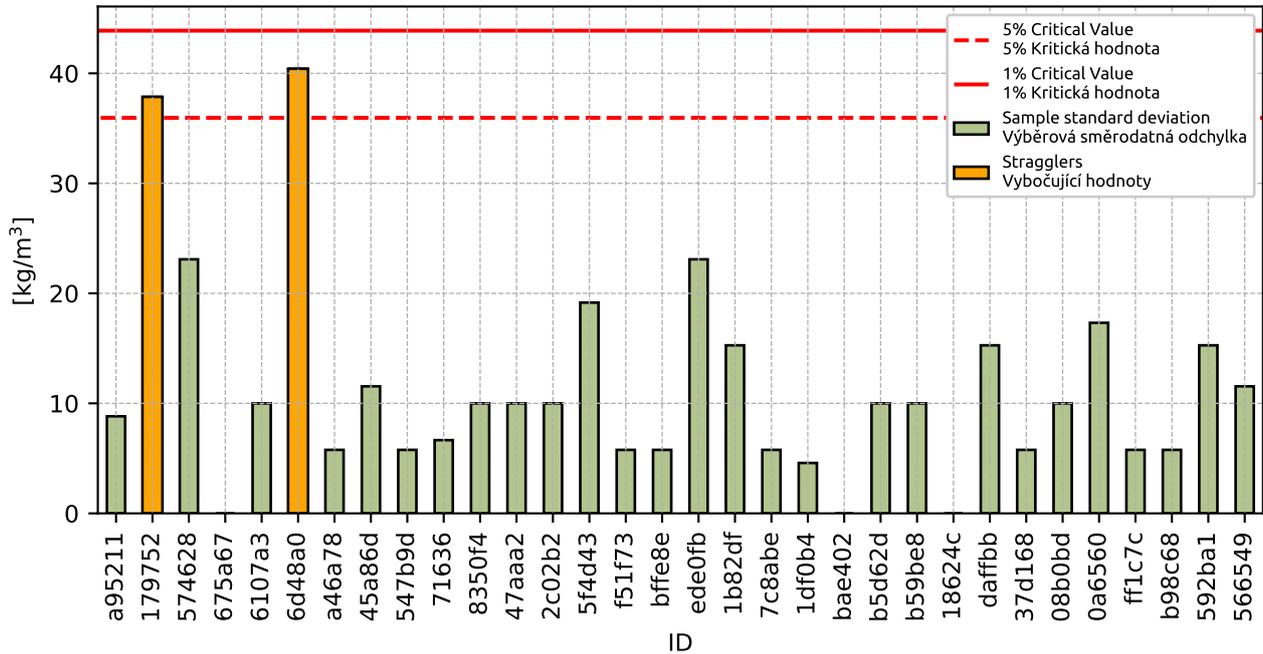
Figure 13: **Cochran's test** - sample standard deviations
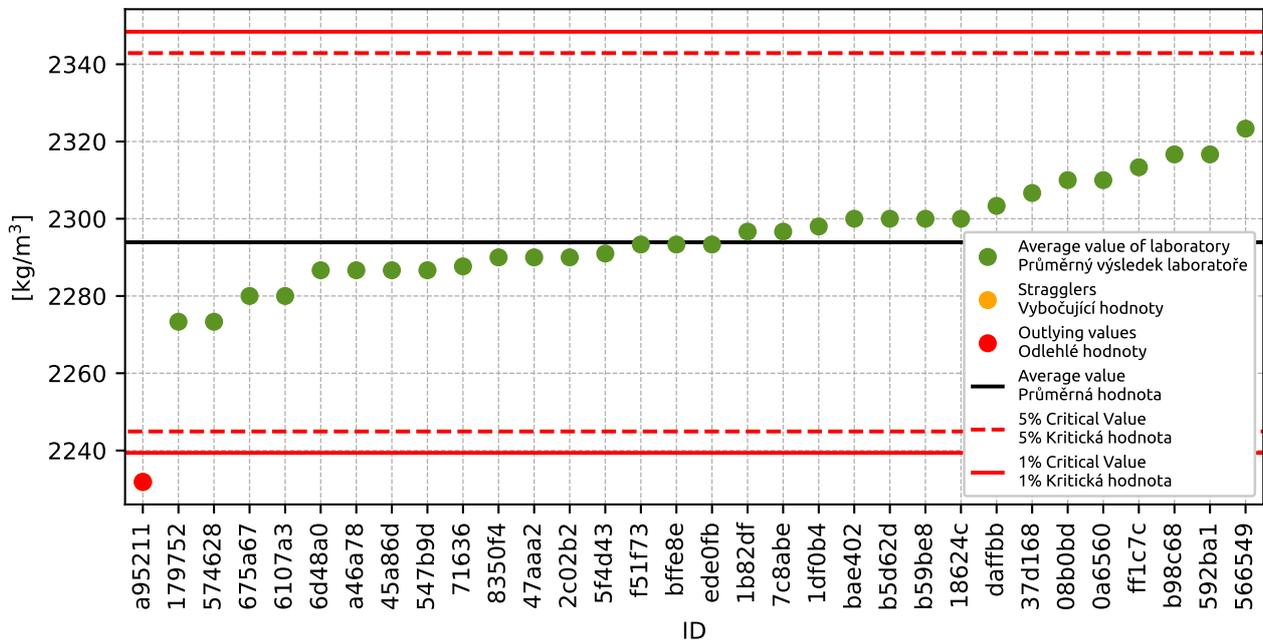
Figure 14: **Grubbs' test** - average values

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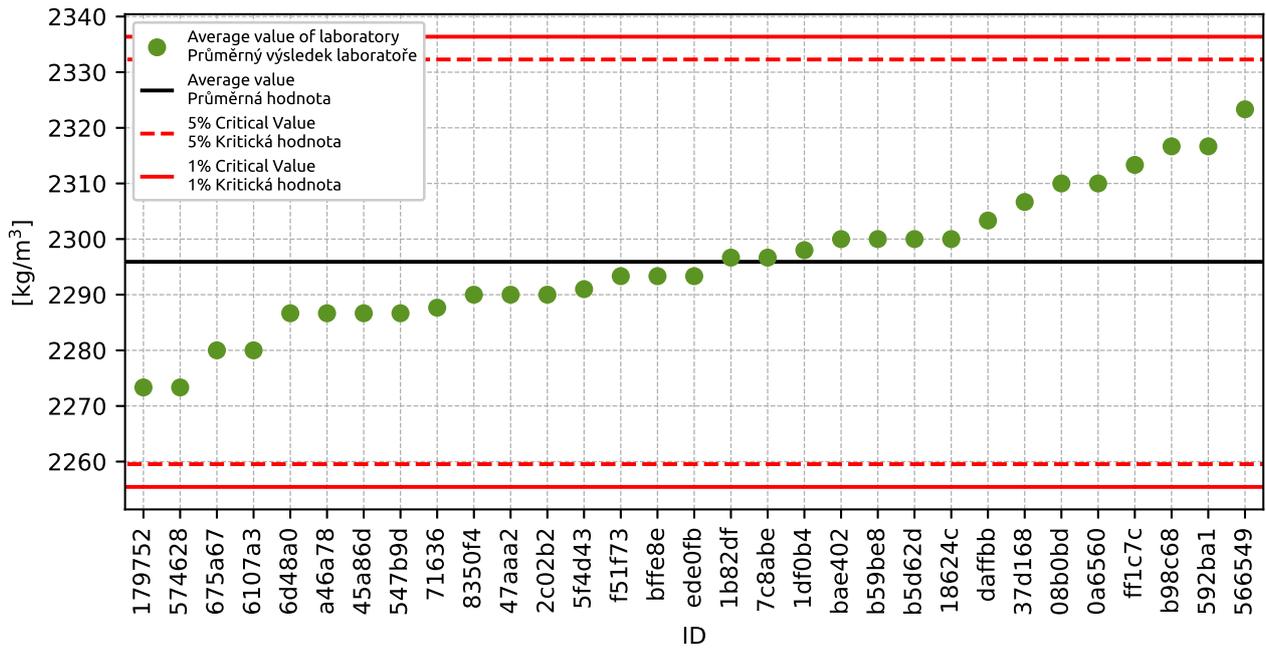
Figure 15: **Grubbs' test** - average values without outliers

2.3　Mandel's Statistics
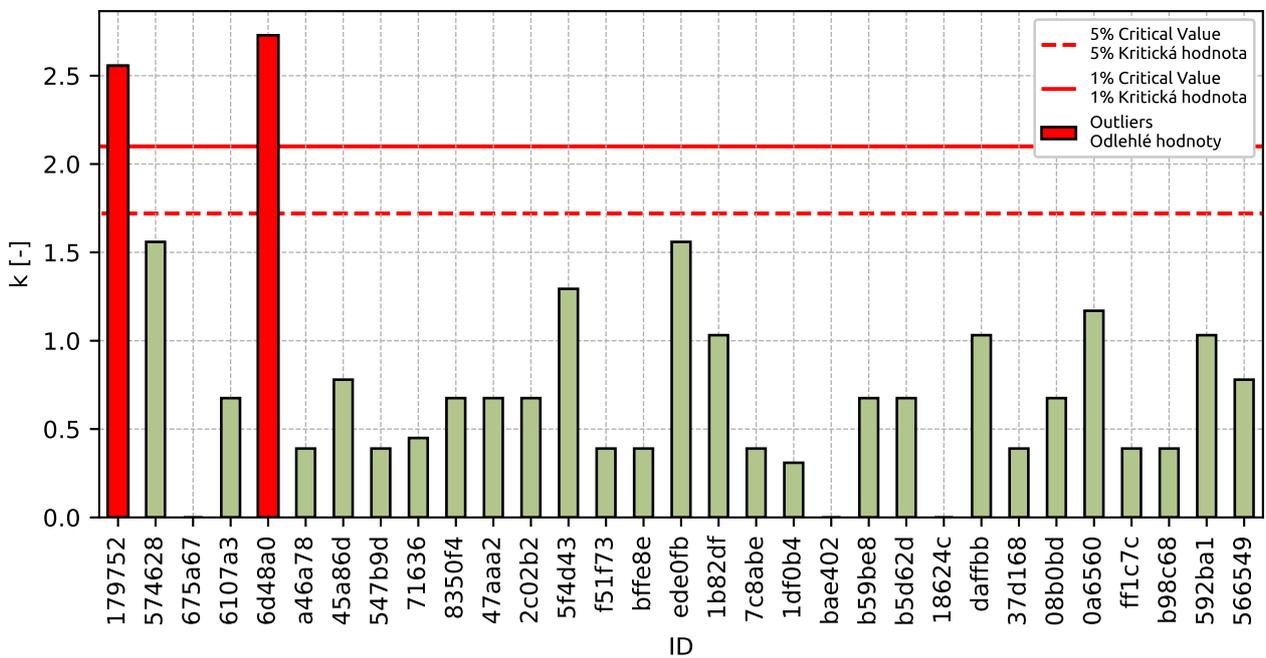
Figure 16: Intralaboratory Consistency Statistic

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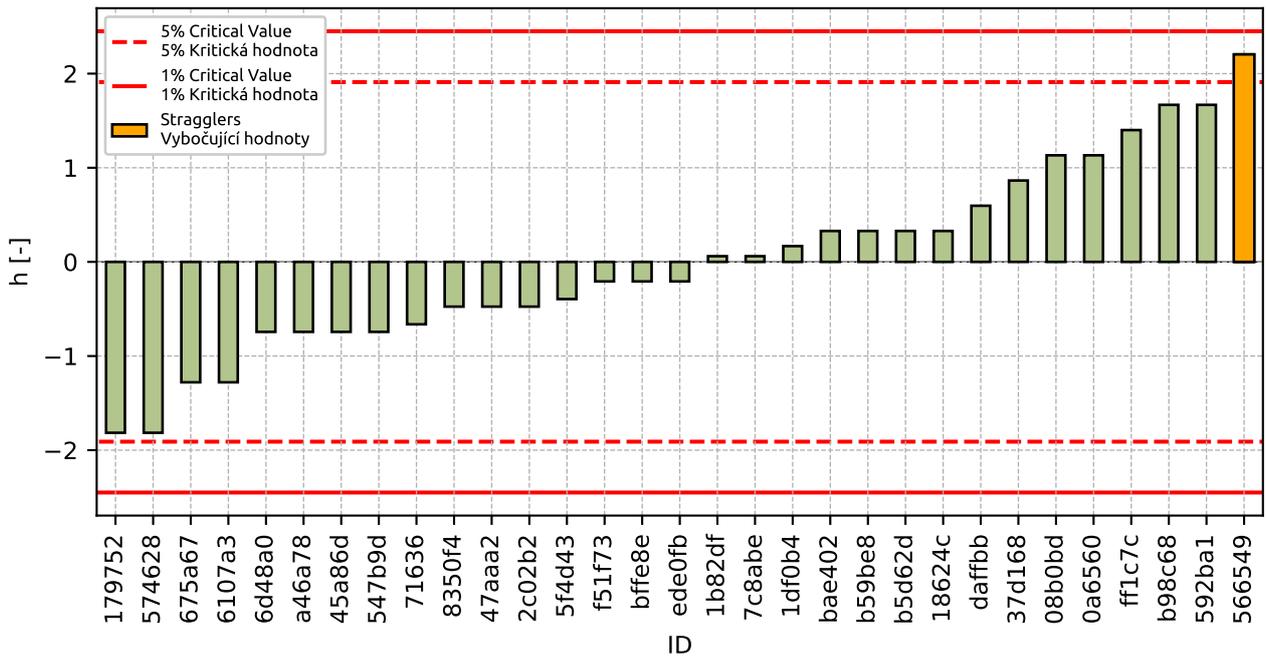
Figure 17: Interlaboratory Consistency Statistic

2.4 Descriptive statistics
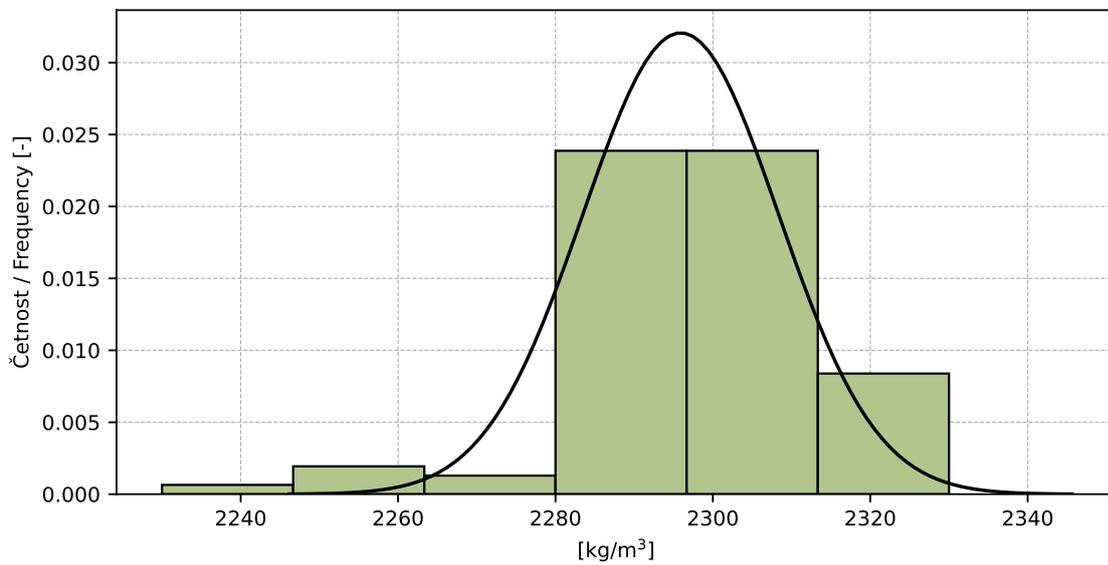
Figure 18: Histogram of all test results

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Table 8: Descriptive statistics

Characteristics	[kg/m³]
Průměrná hodnota / Average value – $\bar{x}$	2300
Výběrová směrodatná odchylka / Sample standard deviation – s	12
Vztažná hodnota / Asigned value – x^*	2300
Robustní směrodatná odchylka / Robust standard deviation – s^*	12
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	3
p-hodnota testu normality / p-value of normality test	0.001 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	9
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	15
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	17
Opakovatelnost / Repeatability – r	40
Reprodukovatelnost / Reproducibility – R	50

2.5 Evaluation of Performance Statistics
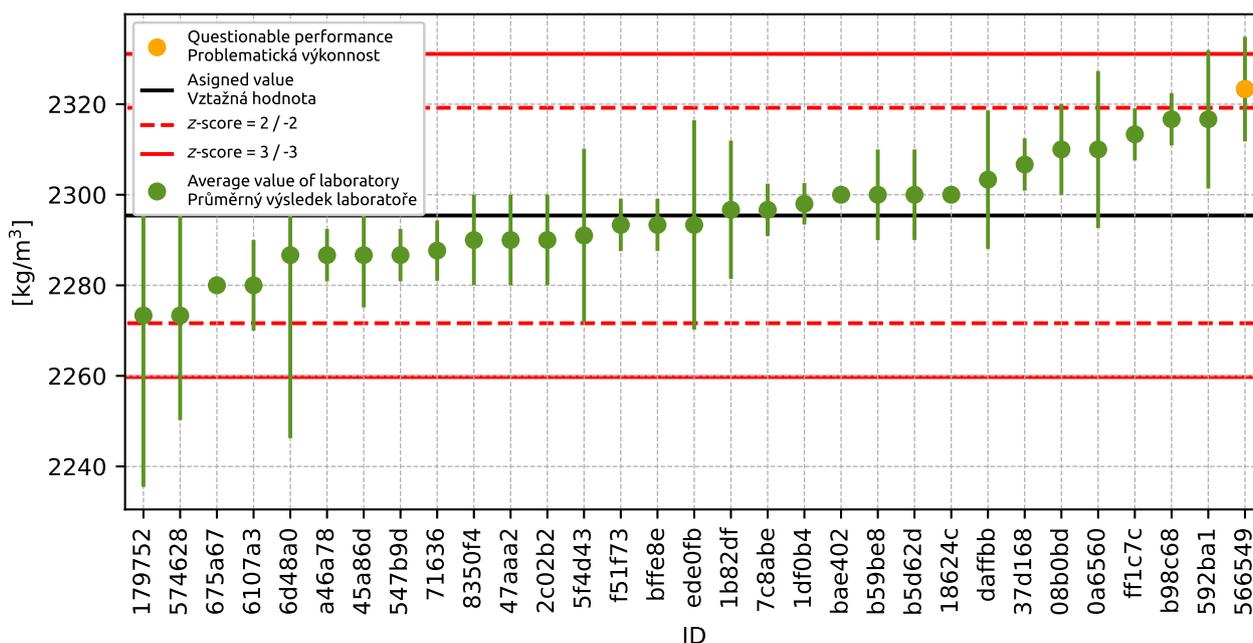
Figure 19: Average values and sample standard deviations

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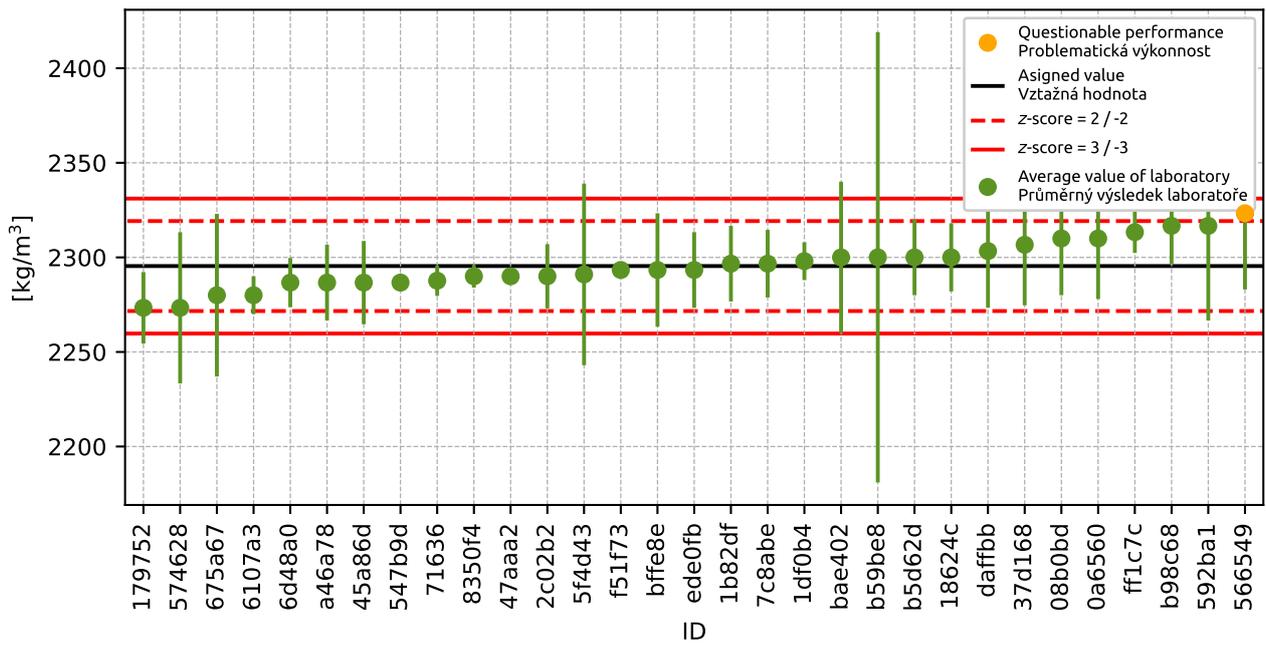
Figure 20: Average values and extended uncertainties of measurement

Figure 21: z-score

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Figure 22: ζ-score

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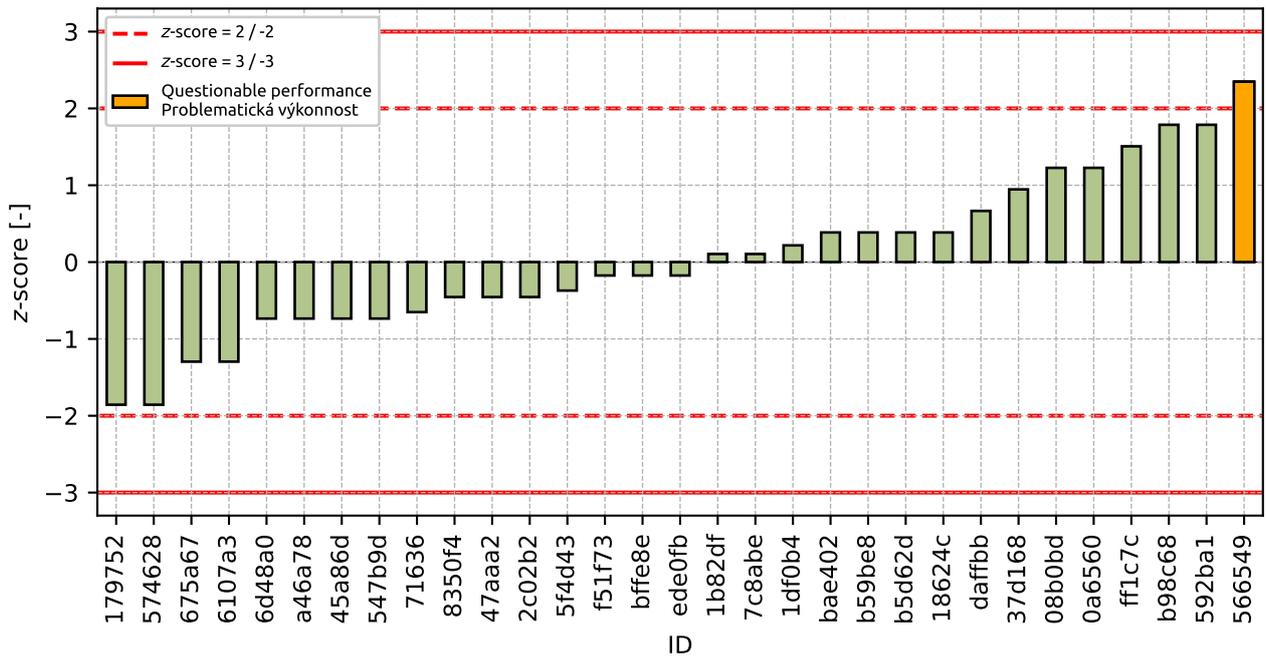
Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
179752	-1.86	-1.16
574628	-1.86	-0.55
675a67	-1.3	-0.36
6107a3	-1.3	-1.49
6d48a0	-0.74	-0.66
a46a78	-0.74	-0.43
45a86d	-0.74	-0.39
547b9d	-0.74	-3.27
71636	-0.65	-0.92
8350f4	-0.46	-0.82
47aaa2	-0.46	-
2c02b2	-0.46	-0.31
5f4d43	-0.37	-0.09
f51f73	-0.17	-
bffe8e	-0.17	-0.07
ede0fb	-0.17	-0.1
1b82df	0.11	0.06
7c8abe	0.11	0.07
1df0b4	0.22	0.25
bae402	0.39	0.11
b59be8	0.39	0.04
b5d62d	0.39	0.23
18624c	0.39	0.25
daffbb	0.67	0.26
37d168	0.95	0.35
08b0bd	1.23	0.48
0a6560	1.23	0.45
ff1c7c	1.51	1.58
b98c68	1.79	1.05
592ba1	1.79	0.42
566549	2.35	0.69

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

3.1 Test results

Table 10: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [mm]			u_X [mm]	$\bar{x}$ [mm]	s_0 [mm]	V_X [%]
f51f73	5	4	6	-	5	1.0	20.0
1d7992	5	7	8	1	7	1.5	22.91
08b0bd	8	6	6	1	7	1.2	17.32
ff1c7c	6	9	7	1	7	1.5	20.83
cfbafd	8	6	8	3	7	1.2	15.75
45a86d	9	8	8	1	8	0.6	6.93
0c35f1	8	10	8	3	9	1.2	13.32
8350f4	8	10	8	2	9	1.2	13.32
71636	10	7	13	3	10	3.0	30.0
18624c	12	8	10	3	10	2.0	20.0
bae402	10	12	9	3	10	1.5	14.78
574628	11	10	10	2	10	0.6	5.59
0a6560	13	10	9	0	11	2.1	19.52
bffe8e	11	13	10	2	11	1.5	13.48
37d168	14	9	12	0	12	2.5	21.57
daffbb	10	15	13	3	13	2.5	19.87
a17e65	17	18	14	3	16	2.1	12.74
b98c68	15	14	20	3	16	3.2	19.68
1df0b4	30	15	18	2	21	7.9	37.8
1b82df	21	20	23	4	21	1.5	7.16
592ba1	18	21	25	10	21	3.5	16.46
47aaa2	20	21	23	-	21	1.5	7.16
b5d62d	28	10	27	3	22	10.1	46.69
f72457	17	32	32	2	27	8.7	32.08

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3.2   The Numerical Procedure for Determining Outliers
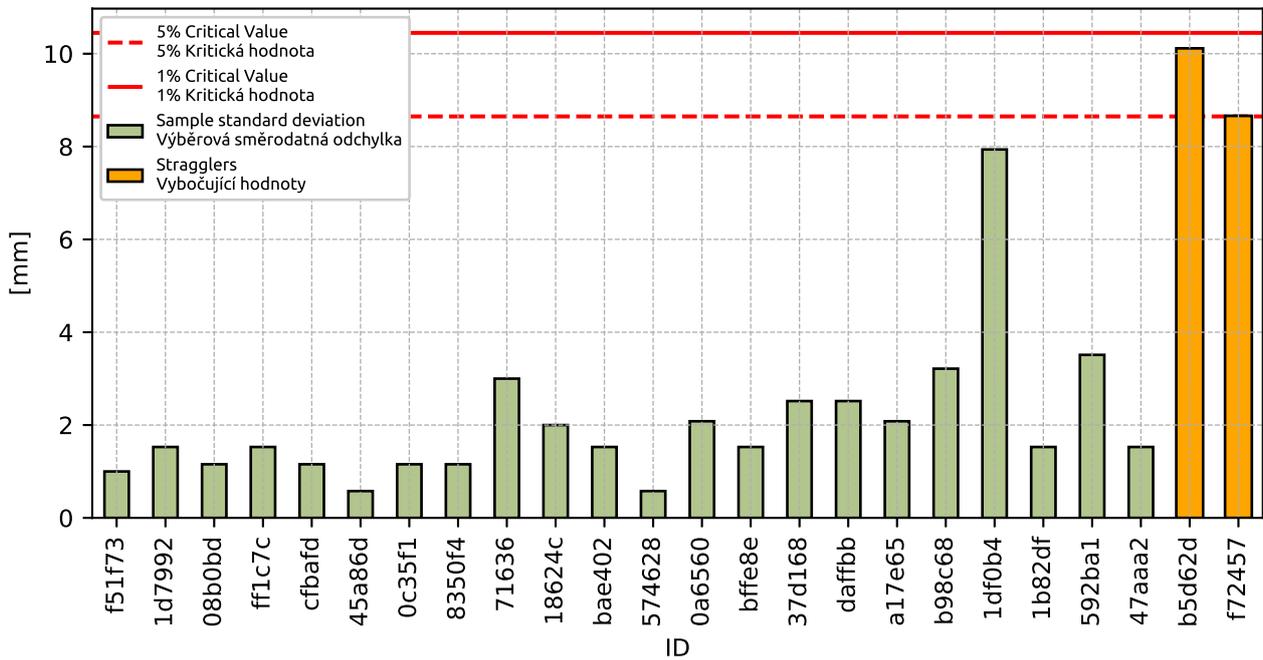

Figure 23: **Cochran's test** - sample standard deviations
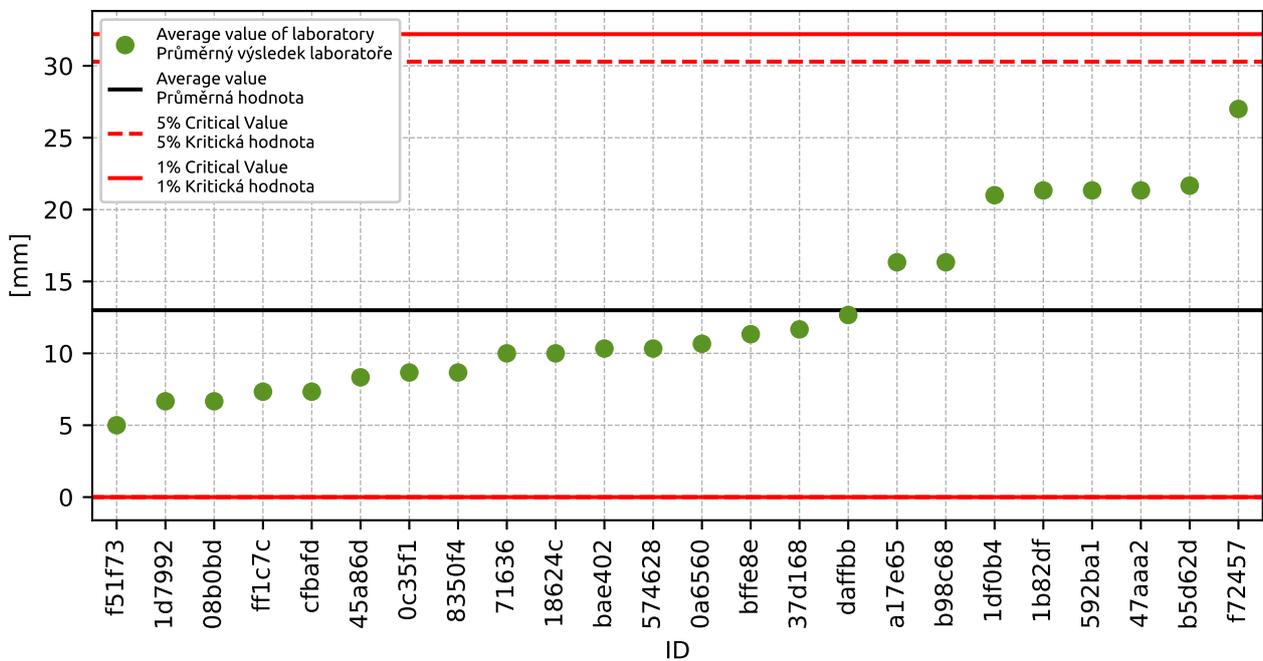

Figure 24: **Grubbs' test** - average values

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3.3 Mandel's Statistics
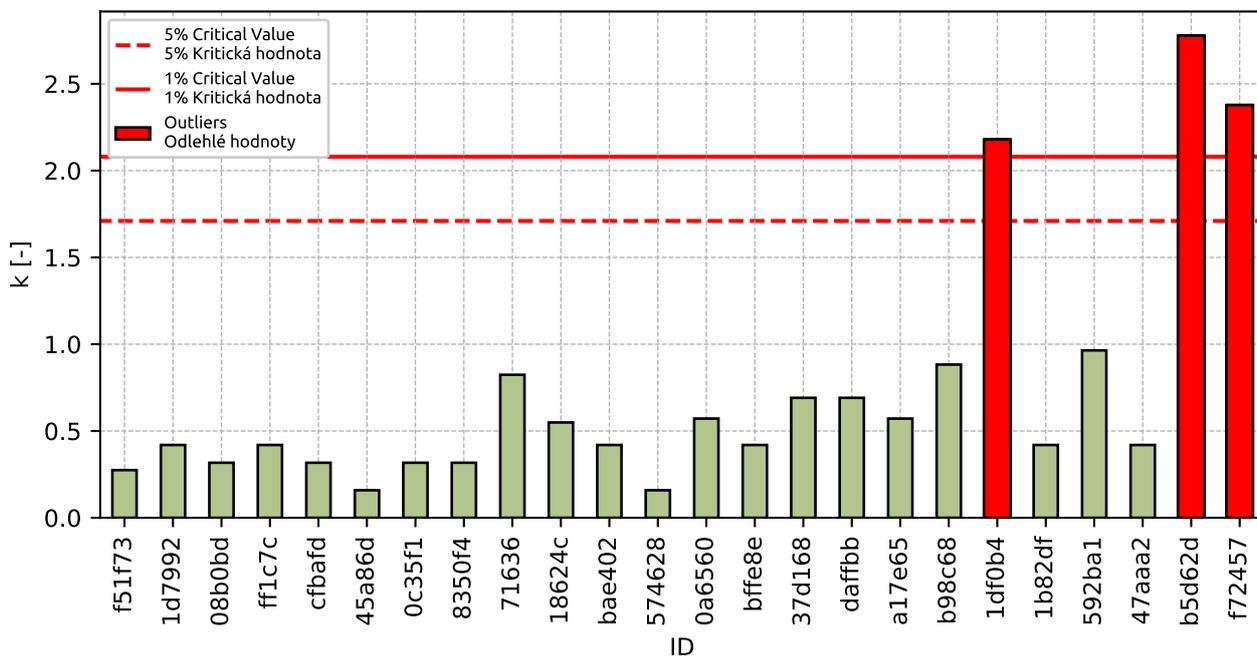
Figure 25: Intralaboratory Consistency Statistic
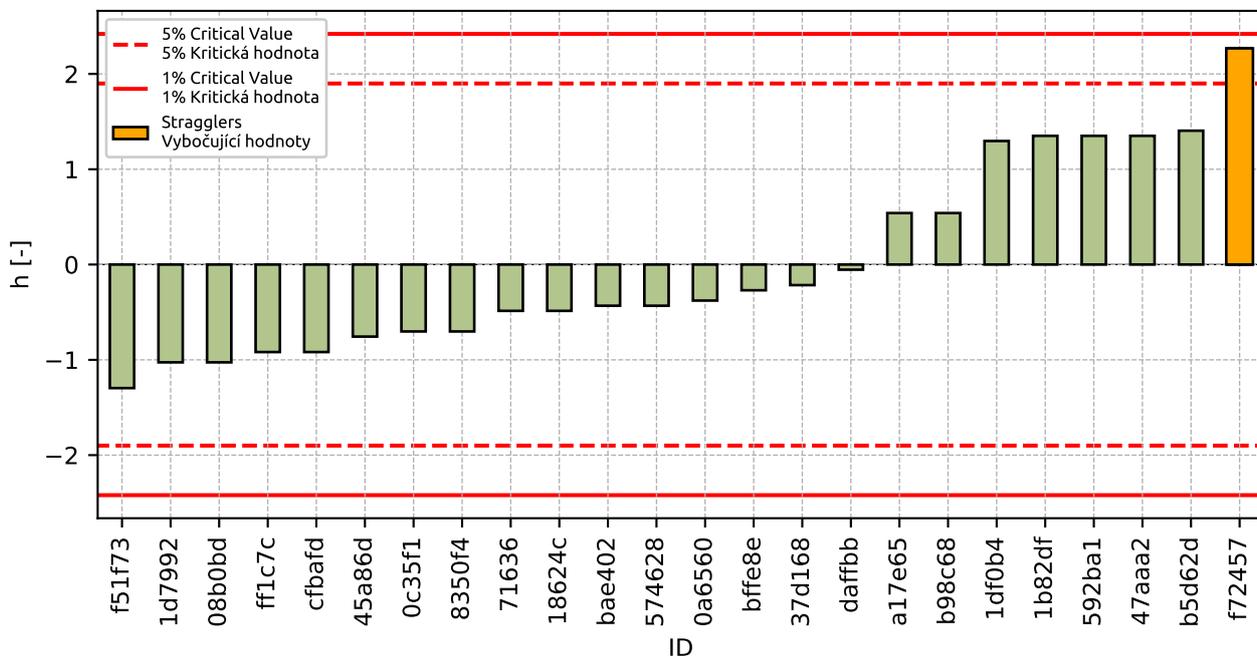
Figure 26: Interlaboratory Consistency Statistic

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3.4　Descriptive statistics
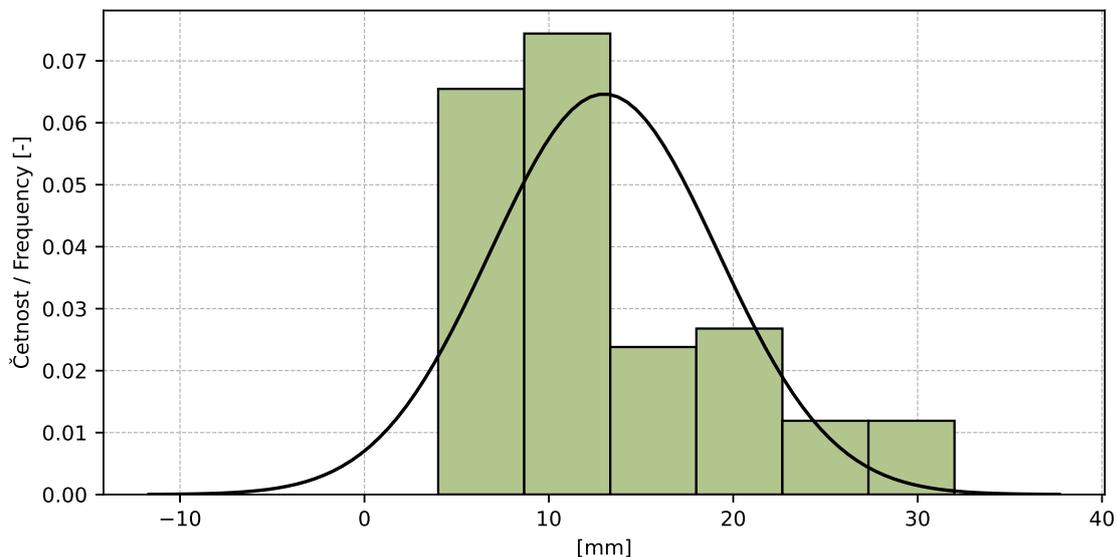
Figure 27: Histogram of all test results

Table 11: Descriptive statistics

Characteristics	[mm]
Průměrná hodnota / Average value – $\bar{x}$	13.0
Výběrová směrodatná odchylka / Sample standard deviation – s	6.2
Vztažná hodnota / Asigned value – x^*	12.0
Robustní směrodatná odchylka / Robust standard deviation – s^*	5.7
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	1.5
p-hodnota testu normality / p-value of normality test	0.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	5.8
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	3.6
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	6.8
Opakovatelnost / Repeatability – r	10.0
Reprodukovatelnost / Reproducibility – R	19.0

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3.5   Evaluation of Performance Statistics
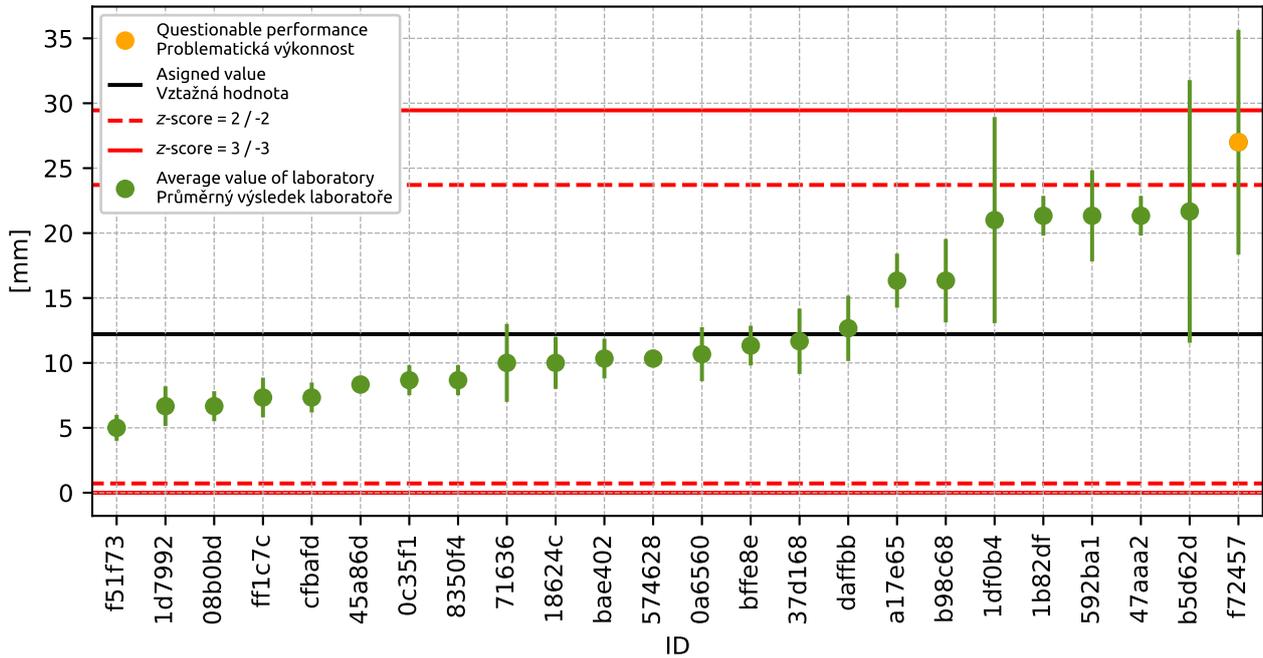
Figure 28: Average values and sample standard deviations
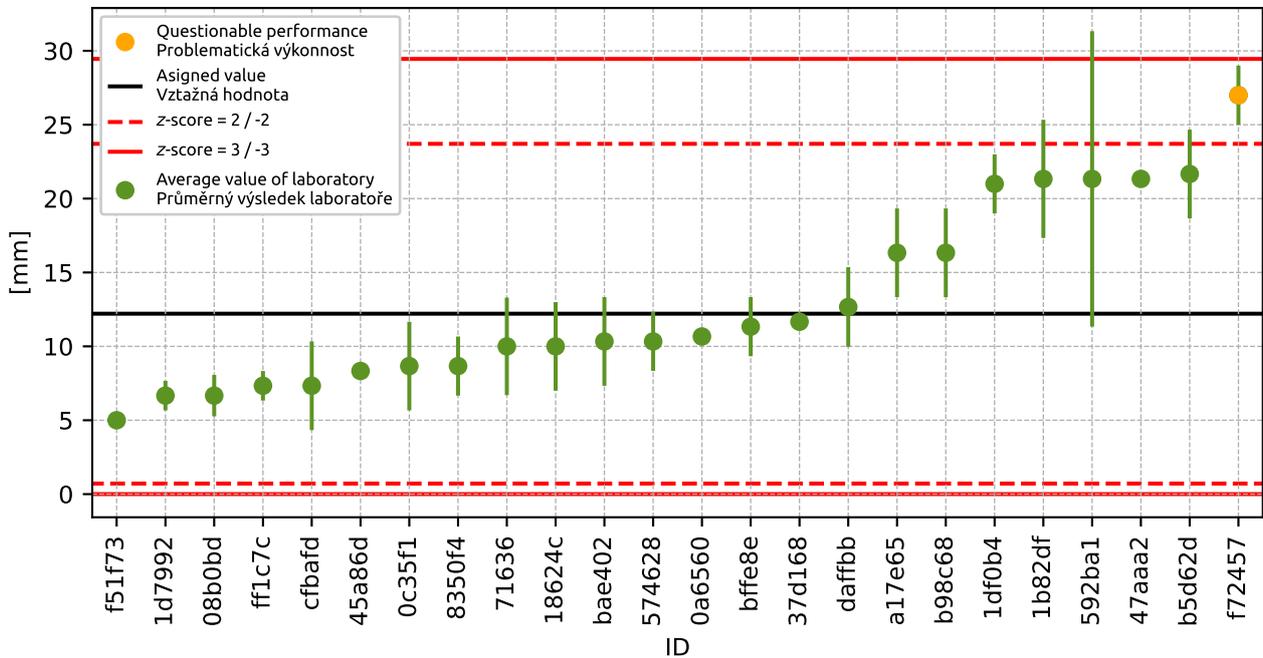
Figure 29: Average values and extended uncertainties of measurement

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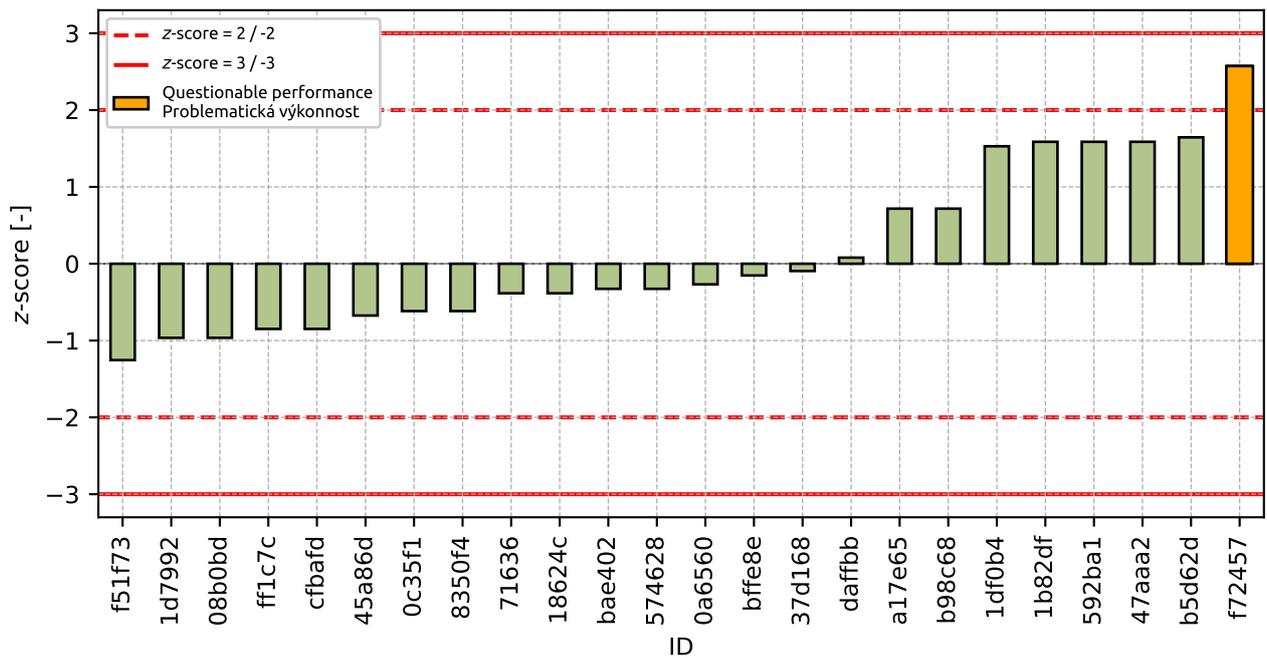
Figure 30: z-score

Figure 31: ζ-score

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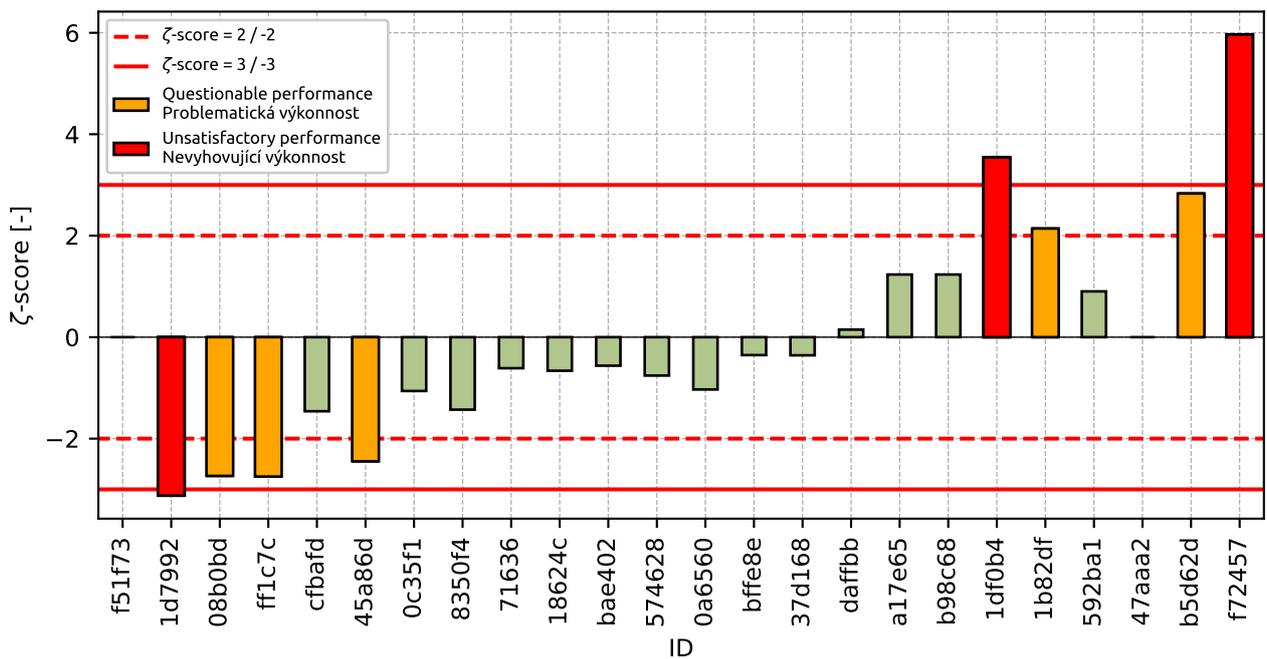
Table 12: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
f51f73	-1.25	-
1d7992	-0.96	-3.12
08b0bd	-0.96	-2.73
ff1c7c	-0.85	-2.75
cfbafd	-0.85	-1.46
45a86d	-0.67	-2.45
0c35f1	-0.62	-1.06
8350f4	-0.62	-1.43
71636	-0.38	-0.61
18624c	-0.38	-0.66
bae402	-0.33	-0.56
574628	-0.33	-0.76
0a6560	-0.27	-1.03
bffe8e	-0.15	-0.35
37d168	-0.09	-0.36
daffbb	0.08	0.15
a17e65	0.72	1.23
b98c68	0.72	1.23
1df0b4	1.53	3.54
1b82df	1.59	2.14
592ba1	1.59	0.9
47aaa2	1.59	-
b5d62d	1.65	2.83
f72457	2.57	5.96

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

4.1   Total air content

4.1.1   Test results

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

ID	Test results [%]	u_X [%]
476218	4.49	0.73
0e388f	4.64	0.2
d1736b	5.03	0.29
b57ea7	7.9	0.66

4.1.2   The Numerical Procedure for Determining Outliers
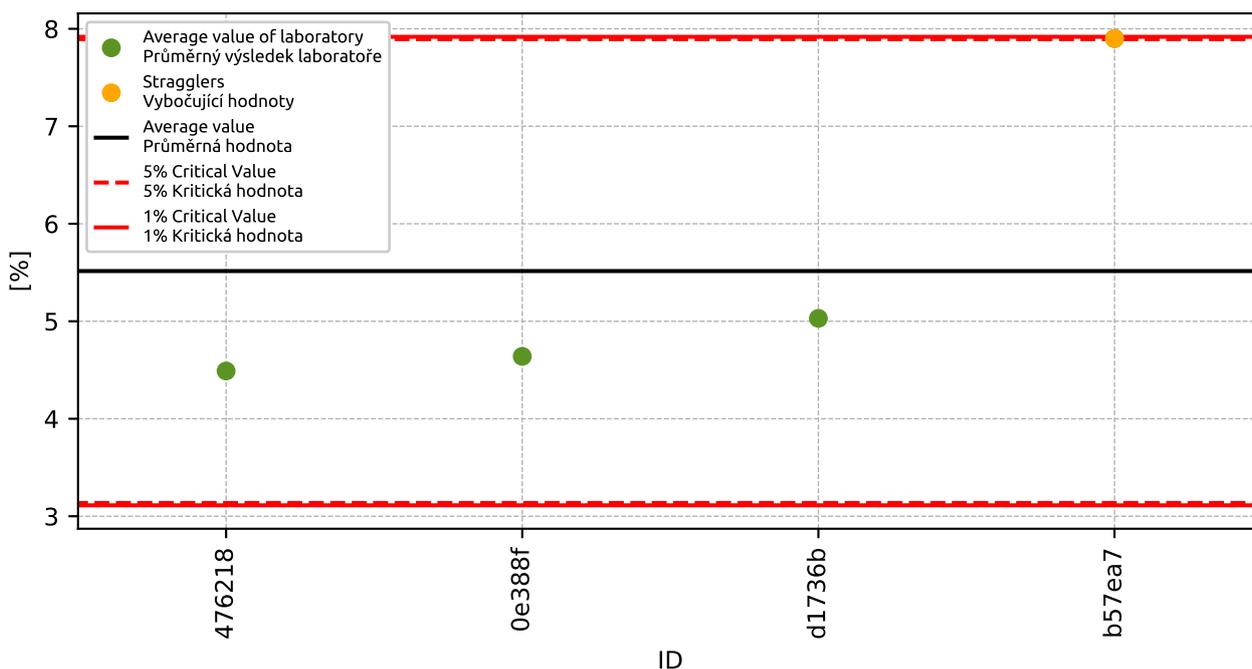
Figure 32: **Grubbs' test** - average values

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4.1.3   Mandel′s Statistics
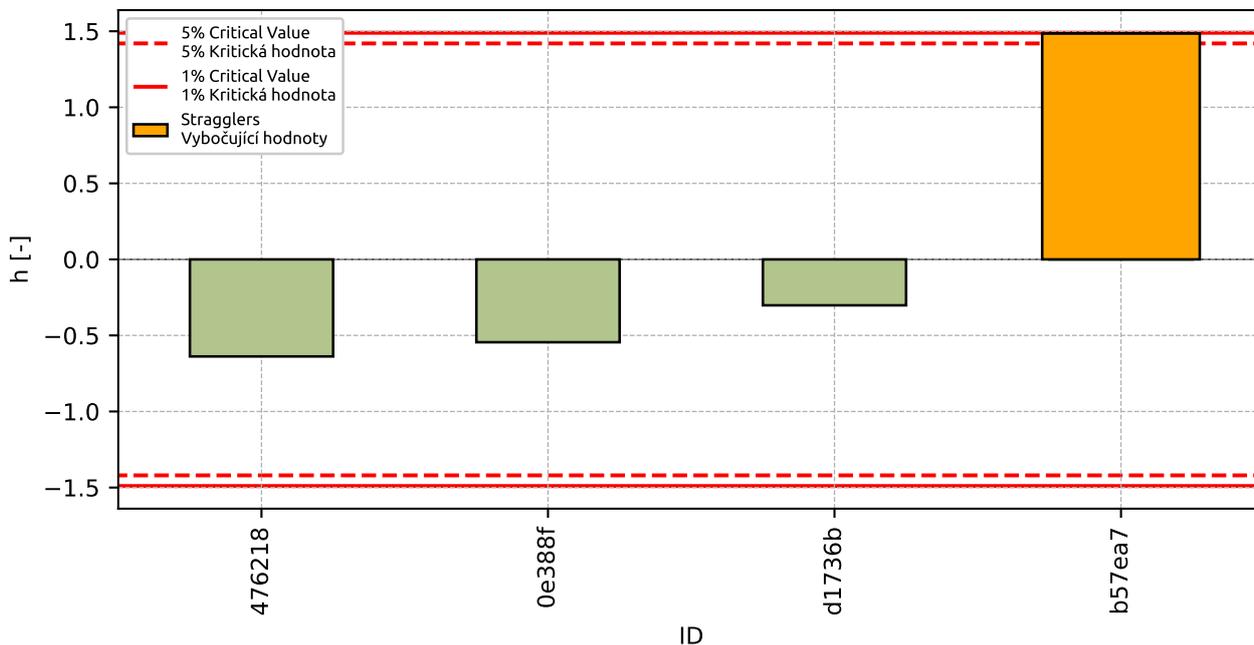

Figure 33: Interlaboratory Consistency Statistic

4.1.4   Descriptive statistics
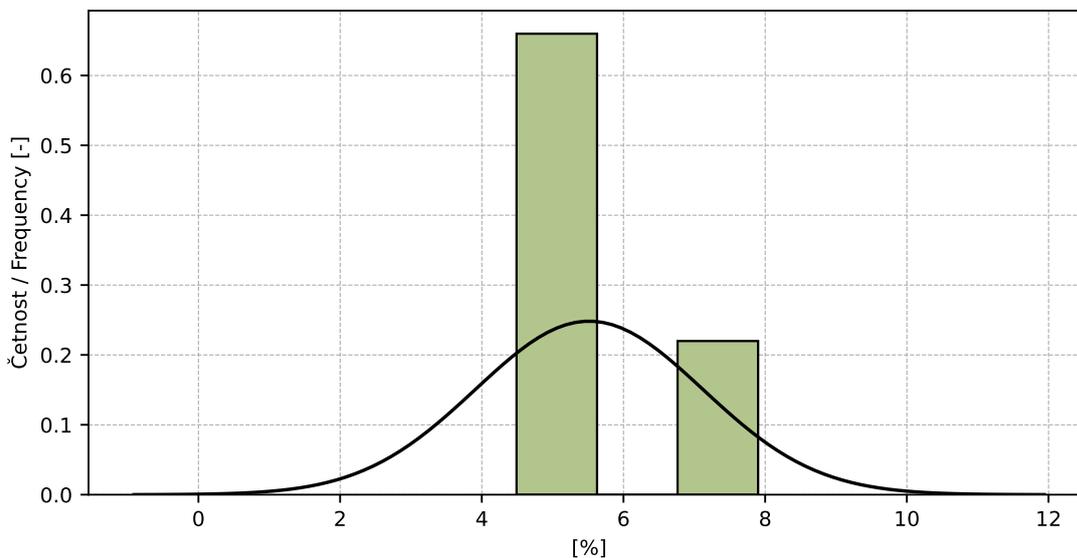
Figure 34: Histogram of all test results

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Table 14: Descriptive statistics

Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	5.52
Výběrová směrodatná odchylka / Sample standard deviation – s	1.606
Vztažná hodnota / Asigned value – x^*	5.52
Robustní směrodatná odchylka / Robust standard deviation – s^*	1.577
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.986
p-hodnota testu normality / p-value of normality test	0.038 [-]

## 4.1.5   Evaluation of Performance Statistics
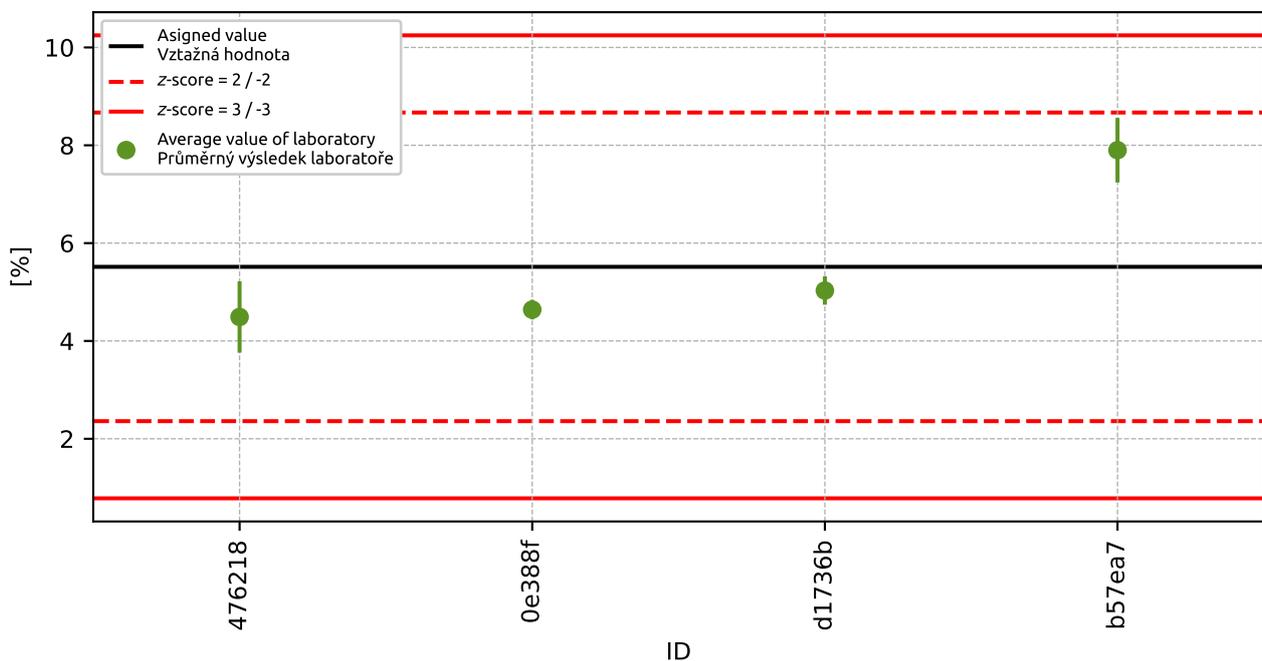
Figure 35: Average values and extended uncertainties of measurement

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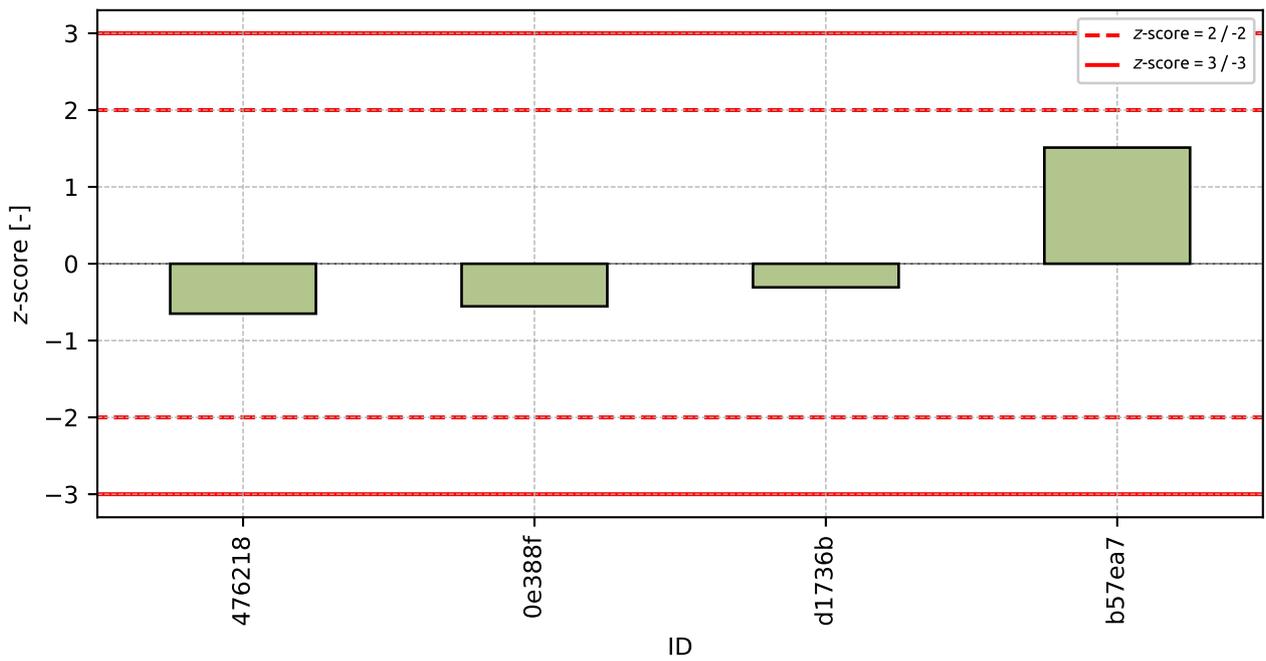
Figure 36: z-score

Figure 37: ζ-score

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Table 15: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
476218	-0.65	-0.84
0e388f	-0.55	-0.87
d1736b	-0.31	-0.47
b57ea7	1.51	2.01

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4.2   Micro air content A$_{300}$

4.2.1   Test results

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

ID	Test results	u_X
	[%]	[%]
476218	1.07	0.17
0e388f	1.24	0.06
d1736b	1.52	0.15
b57ea7	2.5	0.11

4.2.2   The Numerical Procedure for Determining Outliers
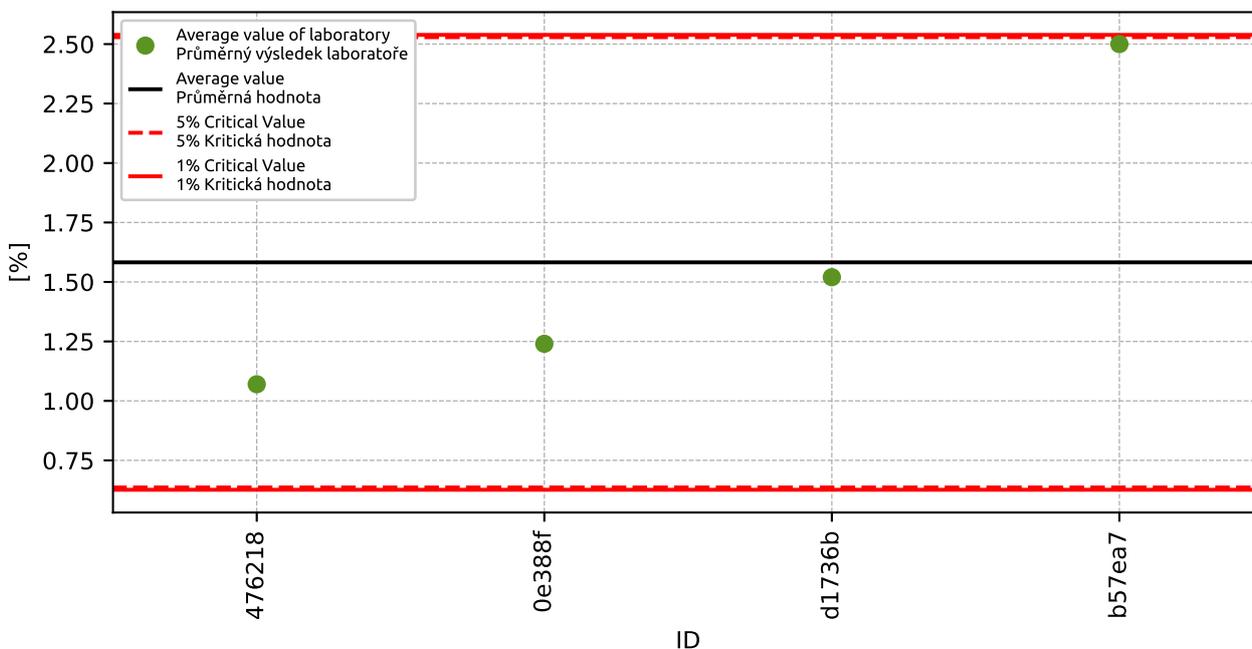
Figure 38: **Grubbs' test** - average values

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### 4.2.3   Mandel′s Statistics
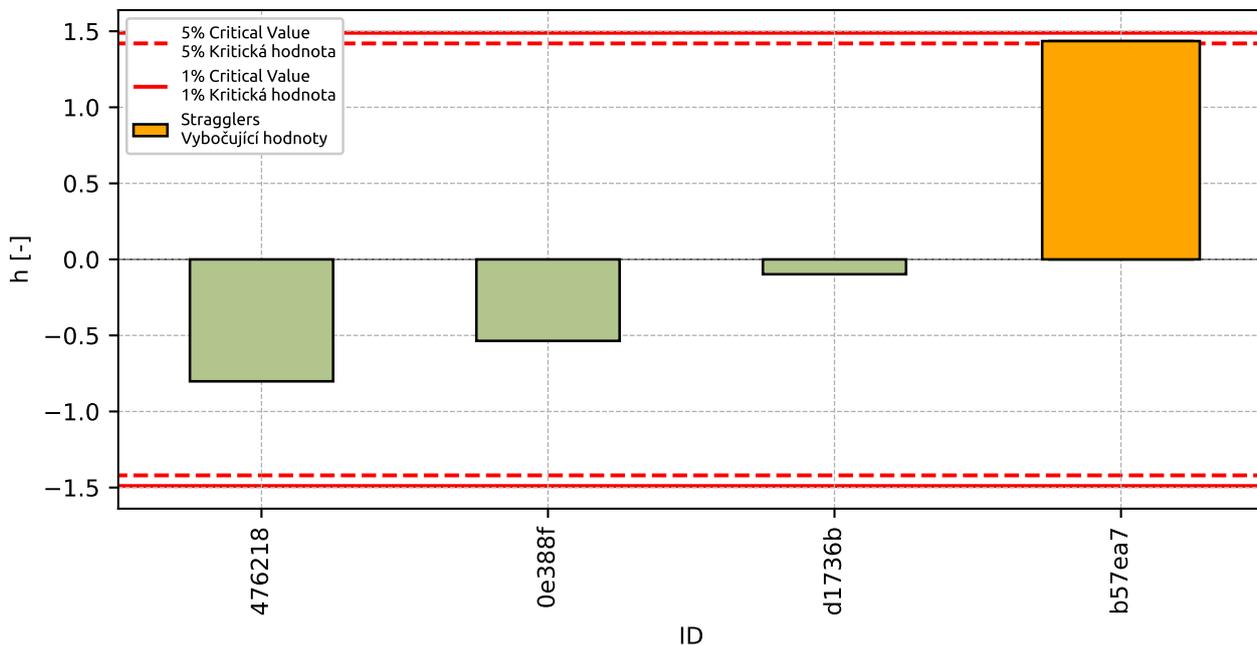
Figure 39: Interlaboratory Consistency Statistic

4.2.4   Descriptive statistics
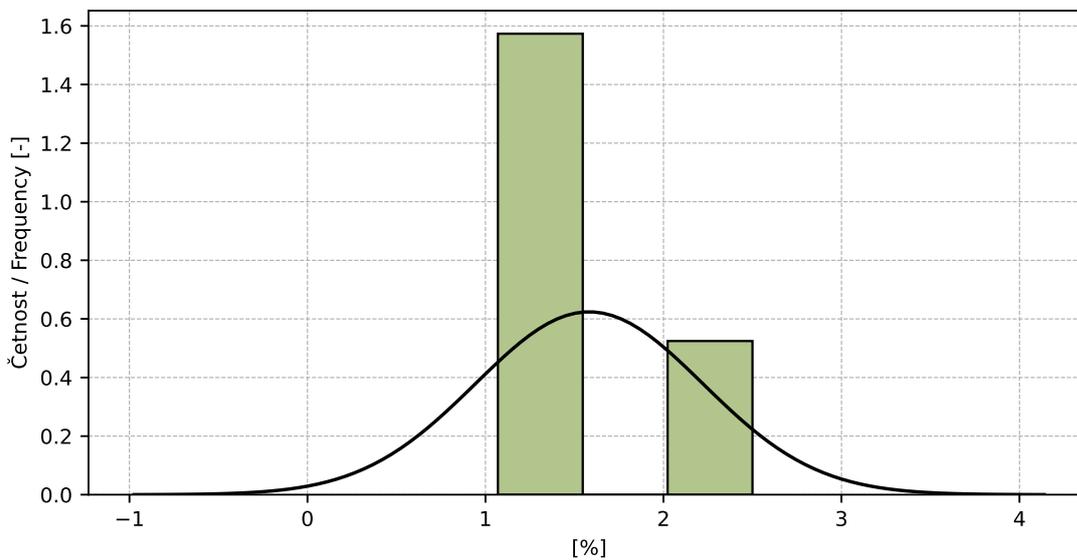
Figure 40: Histogram of all test results

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Table 17: Descriptive statistics

| Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	1.58
Výběrová směrodatná odchylka / Sample standard deviation – s	0.639
Vztažná hodnota / Asigned value – x^*	1.58
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.628
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.392
p-hodnota testu normality / p-value of normality test	0.277 [-]

4.2.5 Evaluation of Performance Statistics
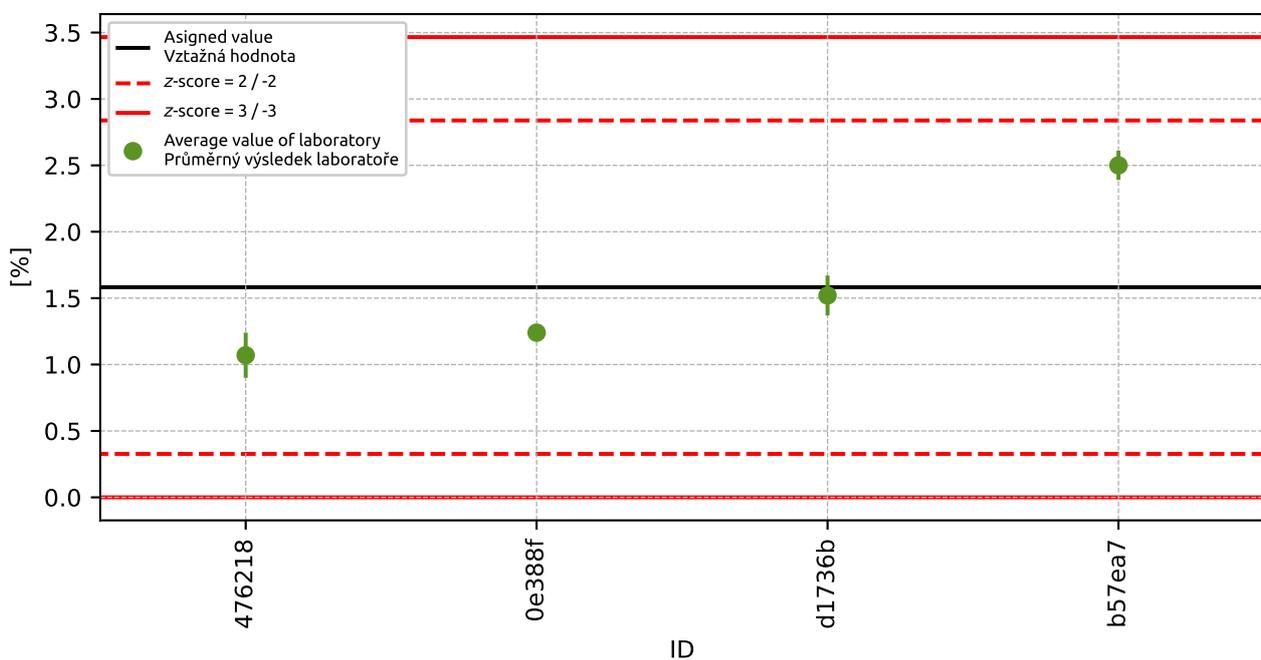
Figure 41: Average values and extended uncertainties of measurement

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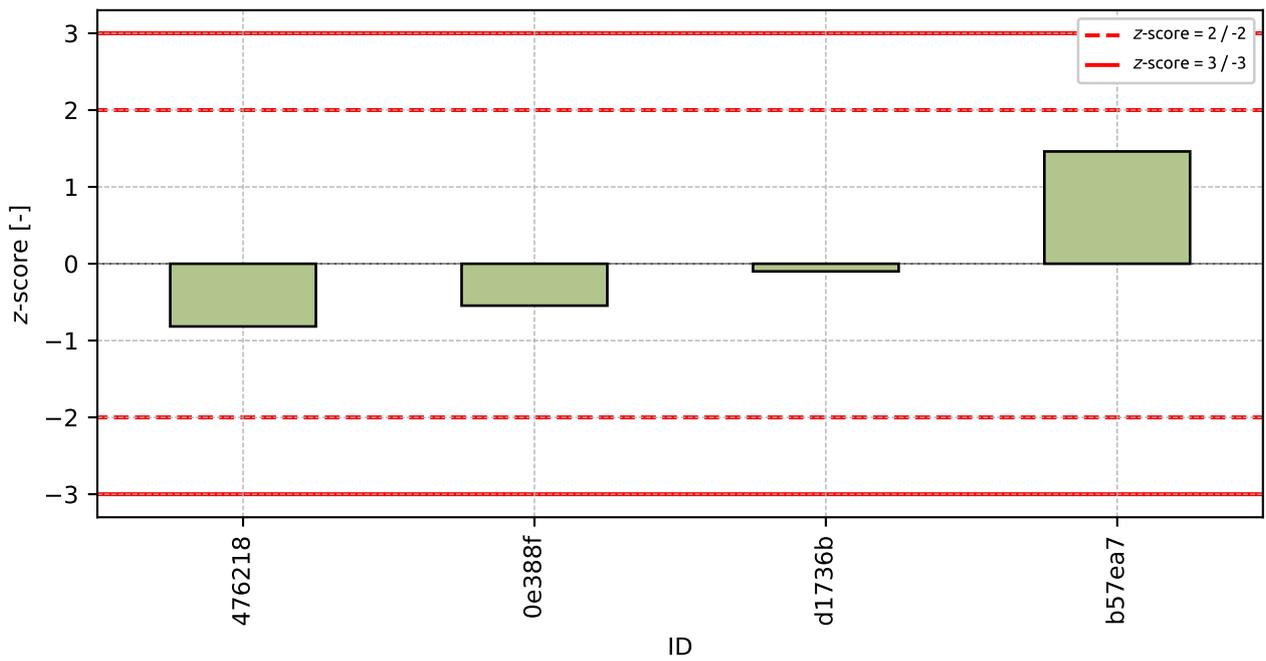
Figure 42: z-score

Figure 43: ζ-score

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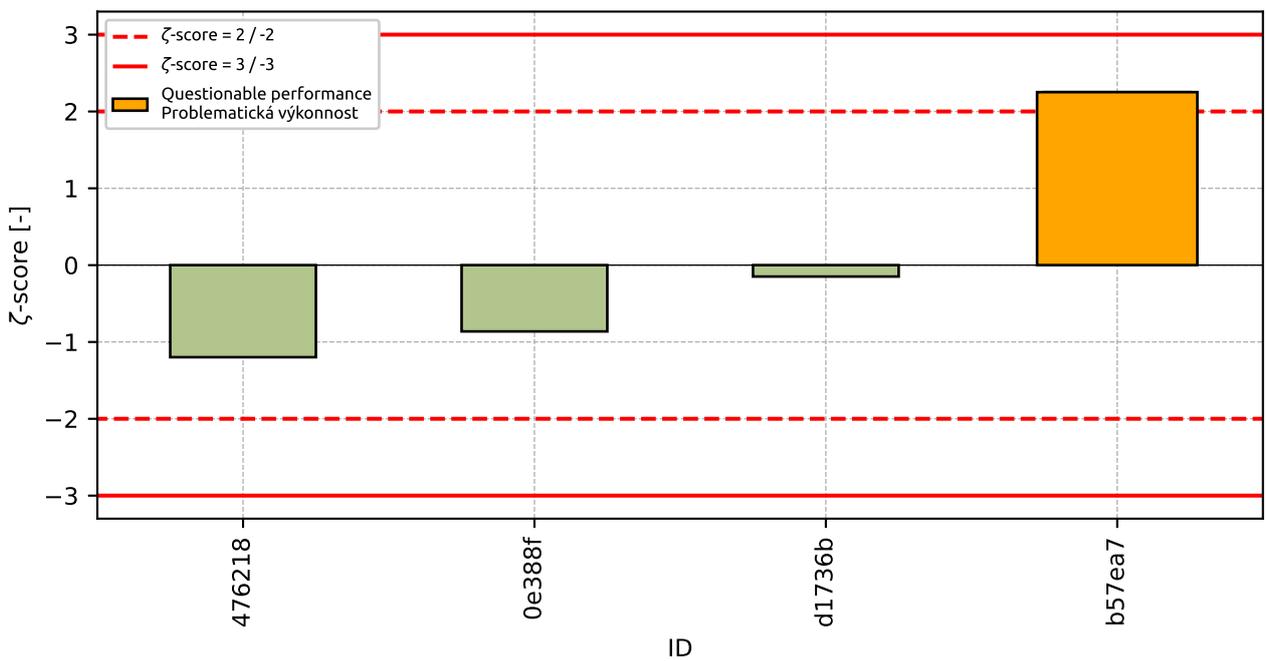
Table 18: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
476218	-0.82	-1.2
0e388f	-0.55	-0.86
d1736b	-0.1	-0.15
b57ea7	1.46	2.25

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4.3   Spacing factor L

4.3.1   Test results

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

ID	Test results [mm]	u_X [mm]
b57ea7	0.21	0.005
d1736b	0.242	0.024
0e388f	0.262	0.0140
476218	0.28	0.02

4.3.2   The Numerical Procedure for Determining Outliers
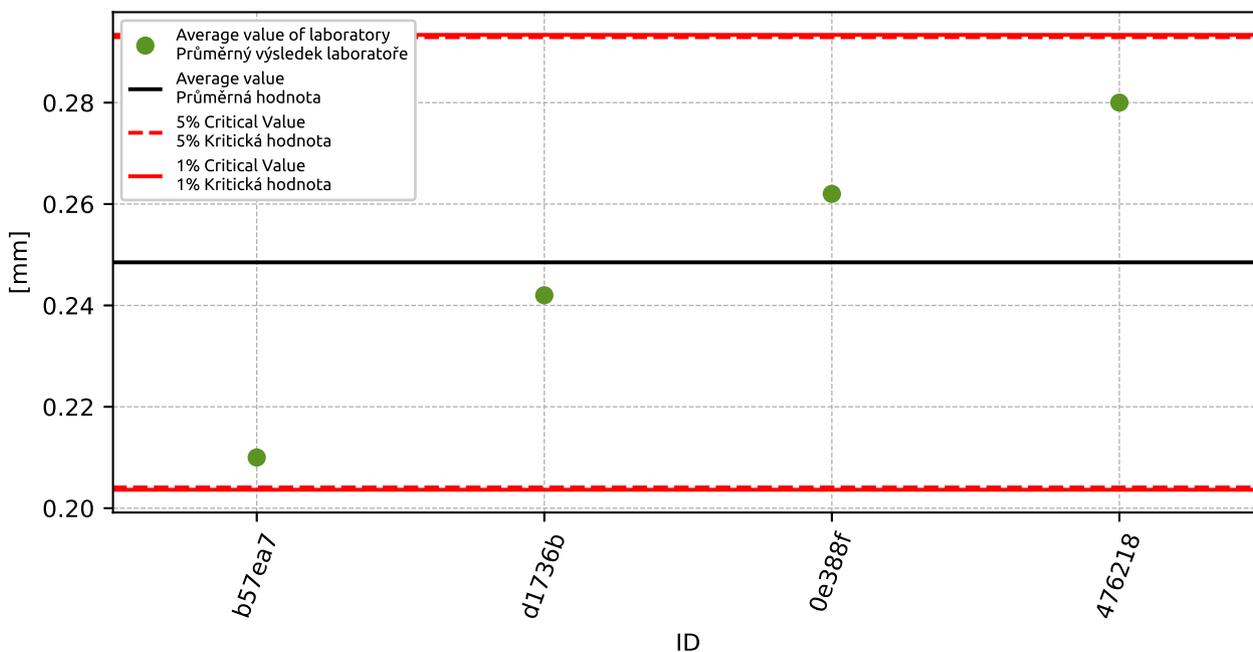
Figure 44: **Grubbs' test** - average values

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4.3.3   Mandel′s Statistics
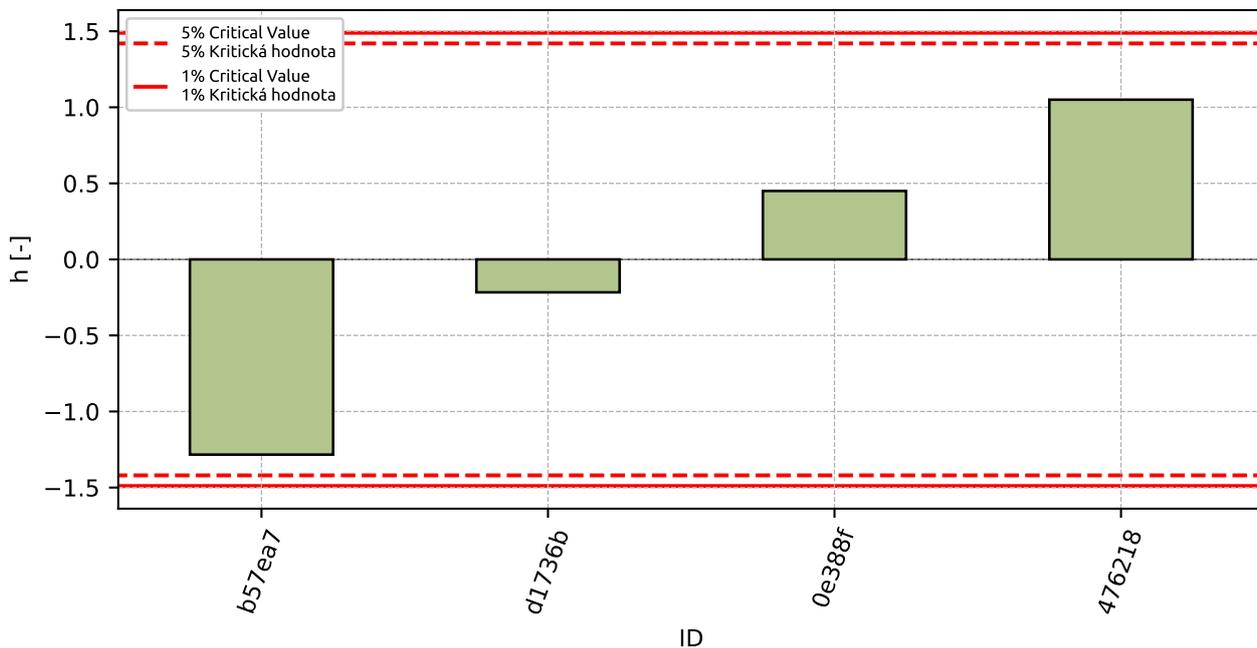
Figure 45: Interlaboratory Consistency Statistic

4.3.4   Descriptive statistics
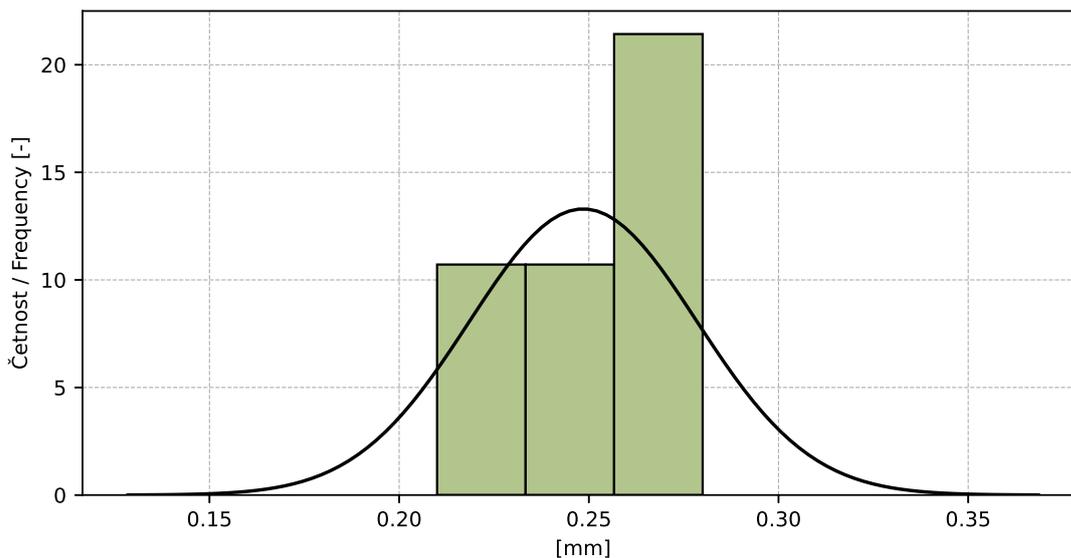
Figure 46: Histogram of all test results

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Table 20: Descriptive statistics

| Characteristics	[mm]
Průměrná hodnota / Average value – $\bar{x}$	0.248
Výběrová směrodatná odchylka / Sample standard deviation – s	0.03
Vztažná hodnota / Asigned value – x^*	0.248
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.0295
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.0184
p-hodnota testu normality / p-value of normality test	0.903 [-]

4.3.5 Evaluation of Performance Statistics
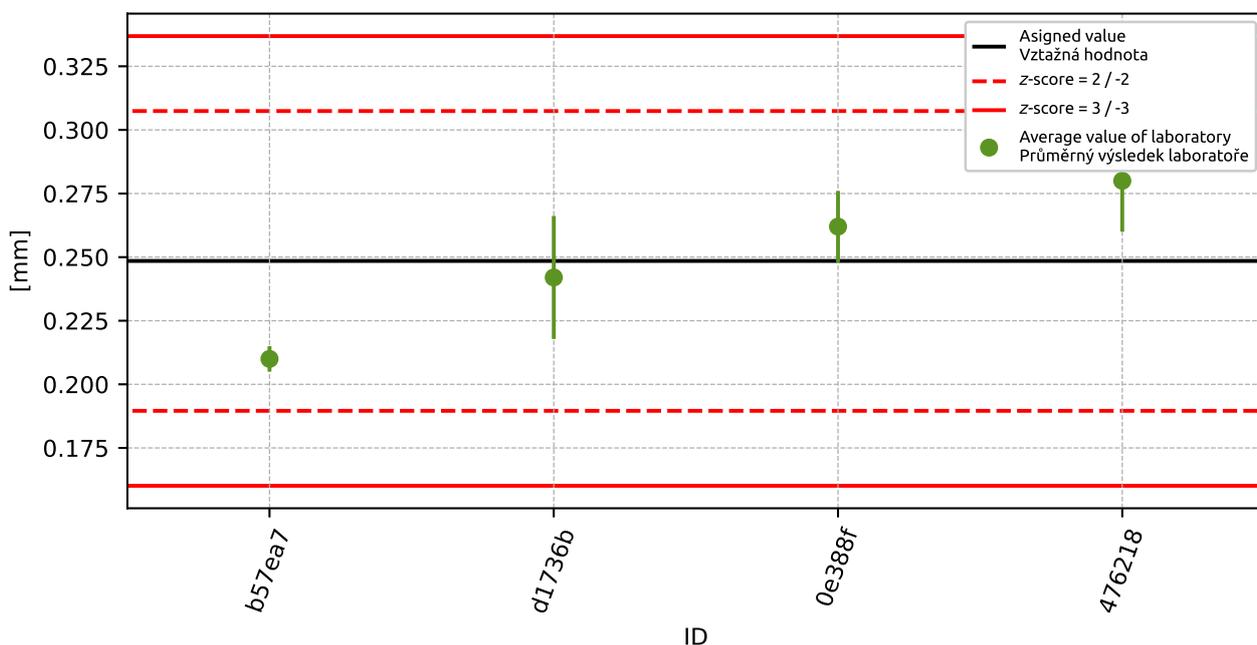
Figure 47: Average values and extended uncertainties of measurement

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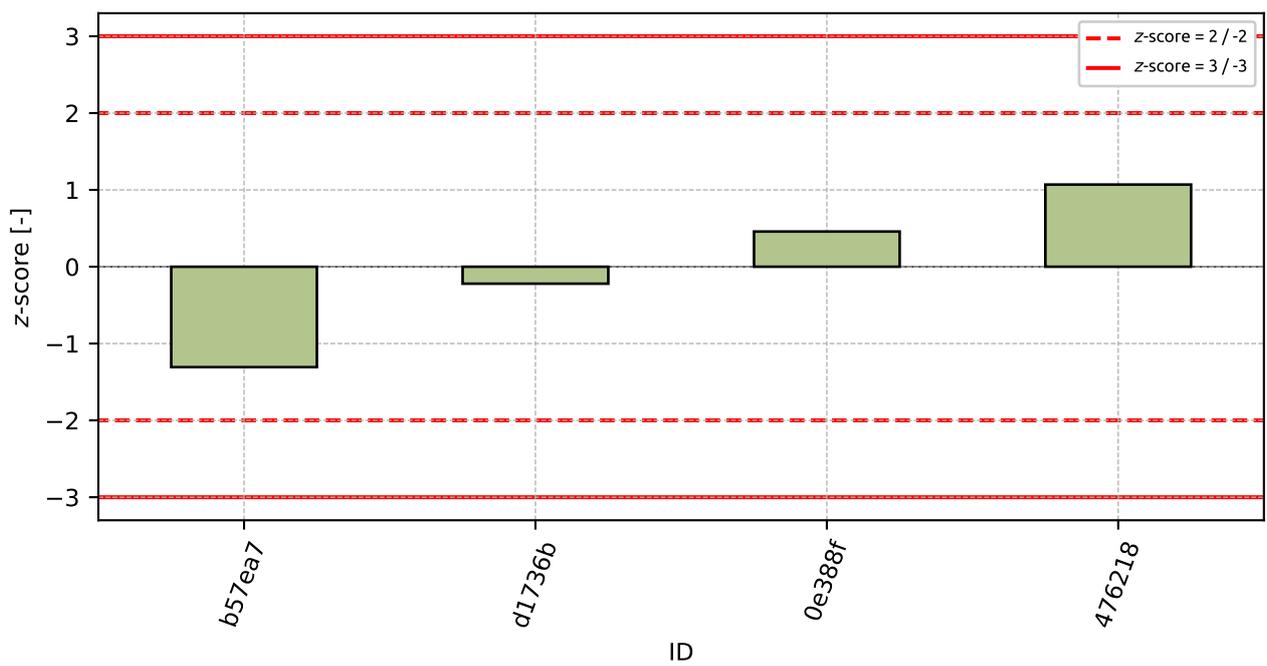
Figure 48: z-score

Figure 49: ζ-score

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Table 21: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
b57ea7	-1.31	-2.02
d1736b	-0.22	-0.21
0e388f	0.46	0.58
476218	1.07	1.16

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

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

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

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

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

ID	Test results [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
71636	40.8	58.0	38.0	1.1	45.6	10.83	23.75
b98c68	50.0	80.0	60.0	10.0	63.3	15.28	24.12
8e5d38	105.6	70.2	98.0	20.0	91.3	18.64	20.42
47aaa2	128.0	165.0	35.0	-	109.3	66.98	61.26
b5d62d	170.0	120.0	110.0	20.0	133.3	32.15	24.11
e3cd3f	195.7	136.9	125.3	11.4	152.6	37.75	24.73
ede0fb	164.8	175.9	124.9	50.0	155.2	26.82	17.28
a46a78	242.7	137.1	175.5	13.8	185.1	53.45	28.88
7c8abe	216.6	195.0	259.6	37.7	223.7	32.89	14.7
574628	314.0	259.0	368.0	27.0	313.7	54.5	17.38
bffe8e	459.0	471.0	431.0	30.0	453.7	20.53	4.52
1b82df	456.1	547.1	360.9	18.2	454.7	93.11	20.48

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7.1.2   The Numerical Procedure for Determining Outliers
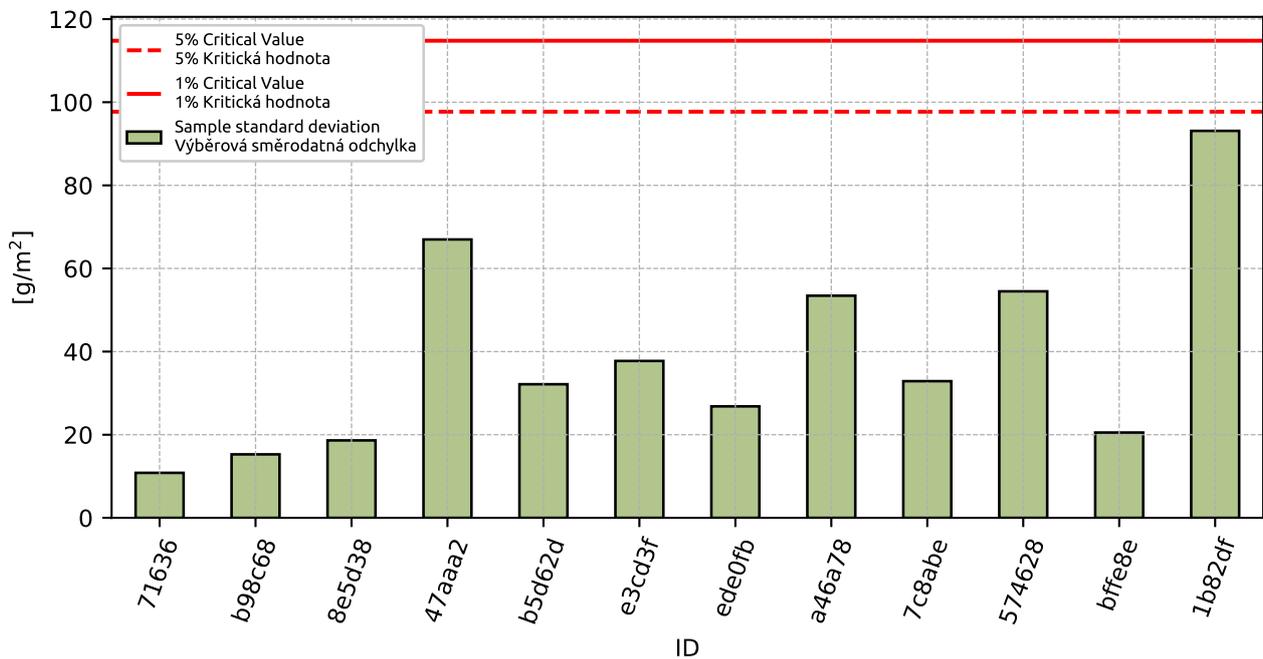
Figure 50: **Cochran's test** - sample standard deviations
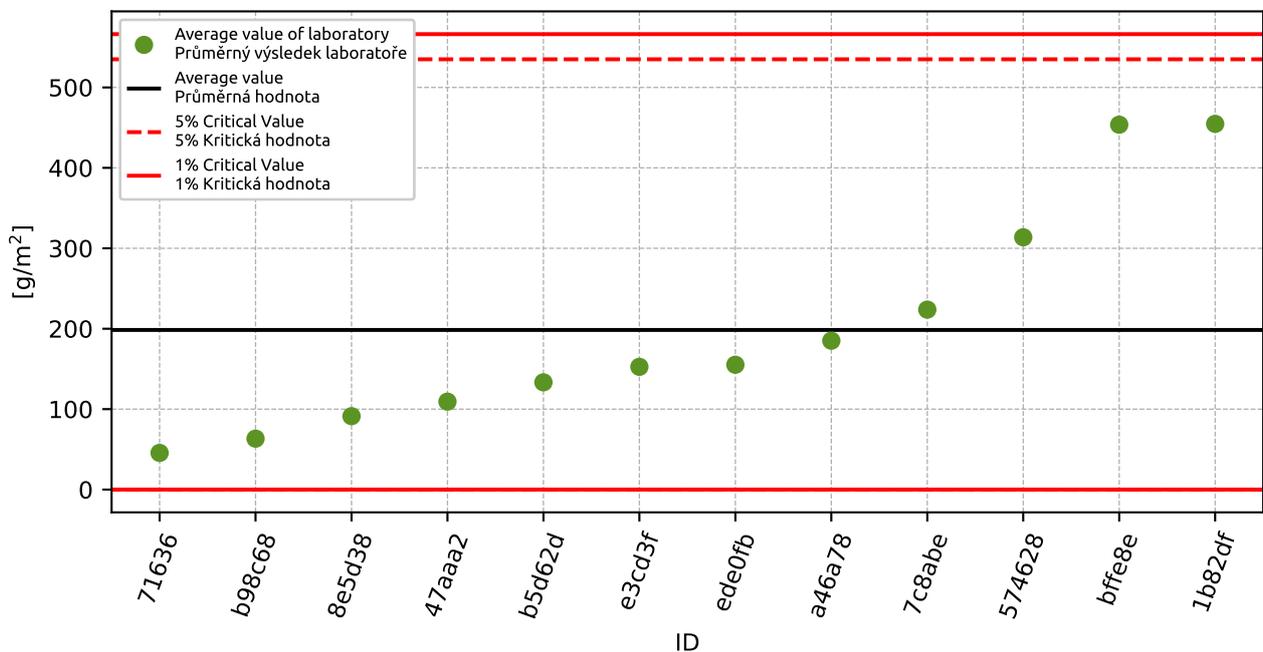
Figure 51: **Grubbs' test** - average values

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7.1.3   Mandel′s Statistics
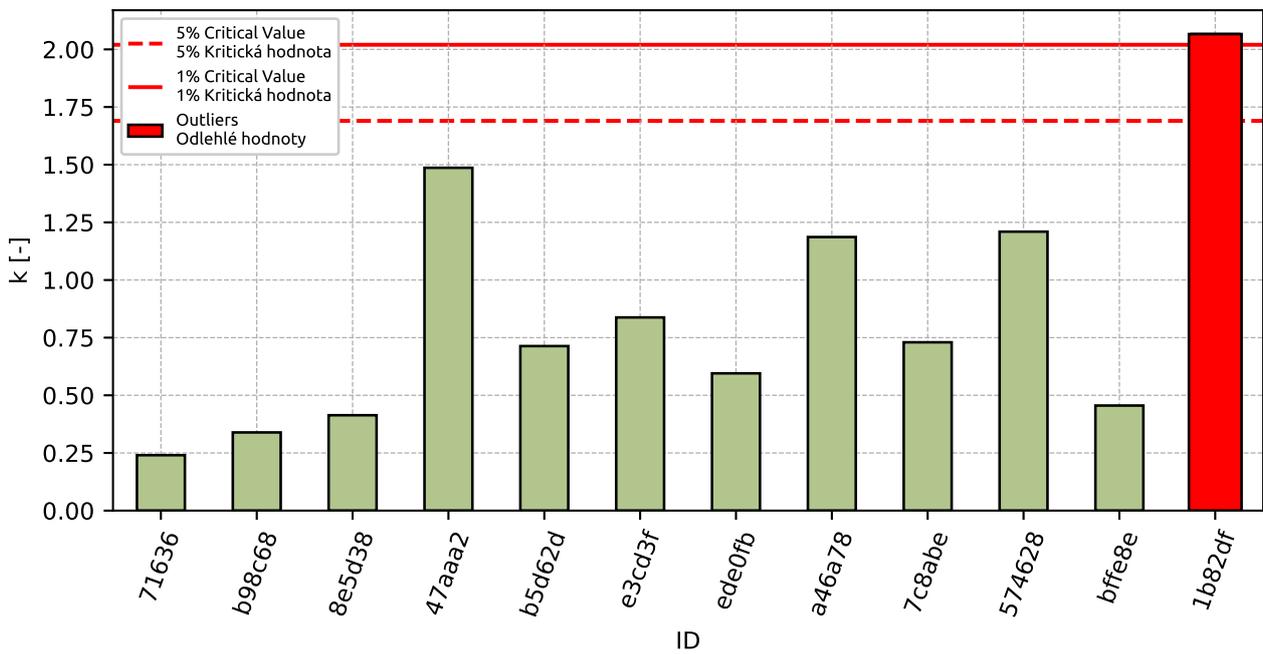
Figure 52: Intralaboratory Consistency Statistic
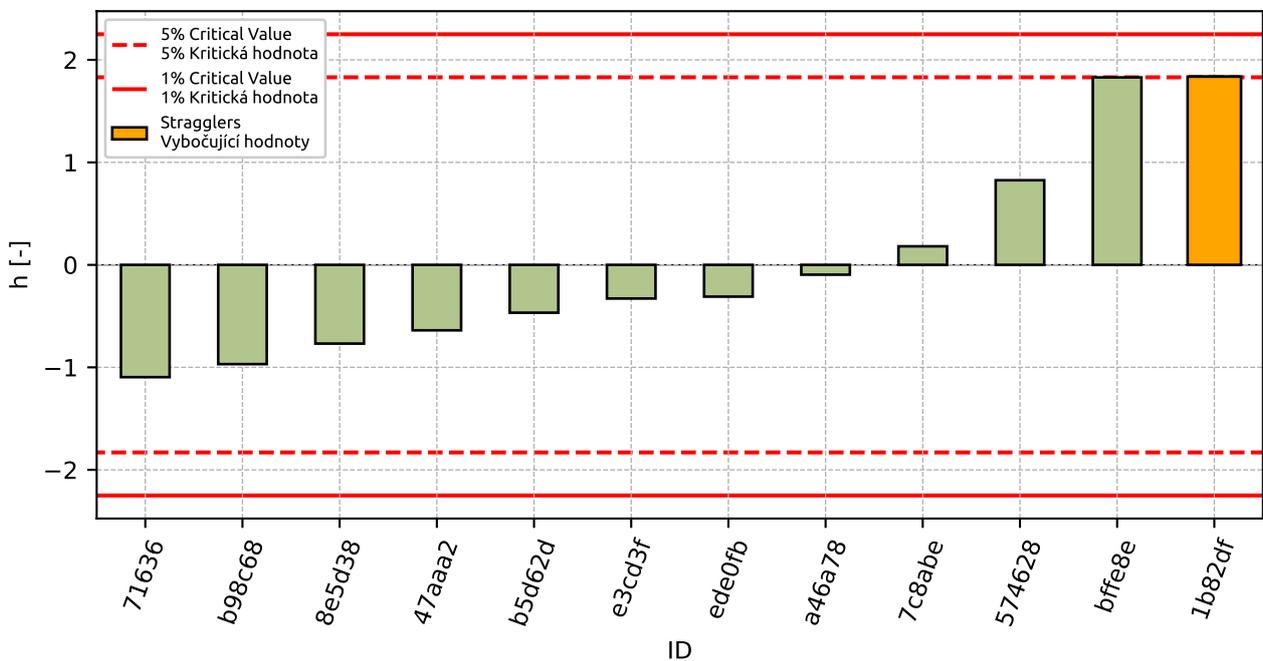
Figure 53: Interlaboratory Consistency Statistic

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7.1.4   Descriptive statistics
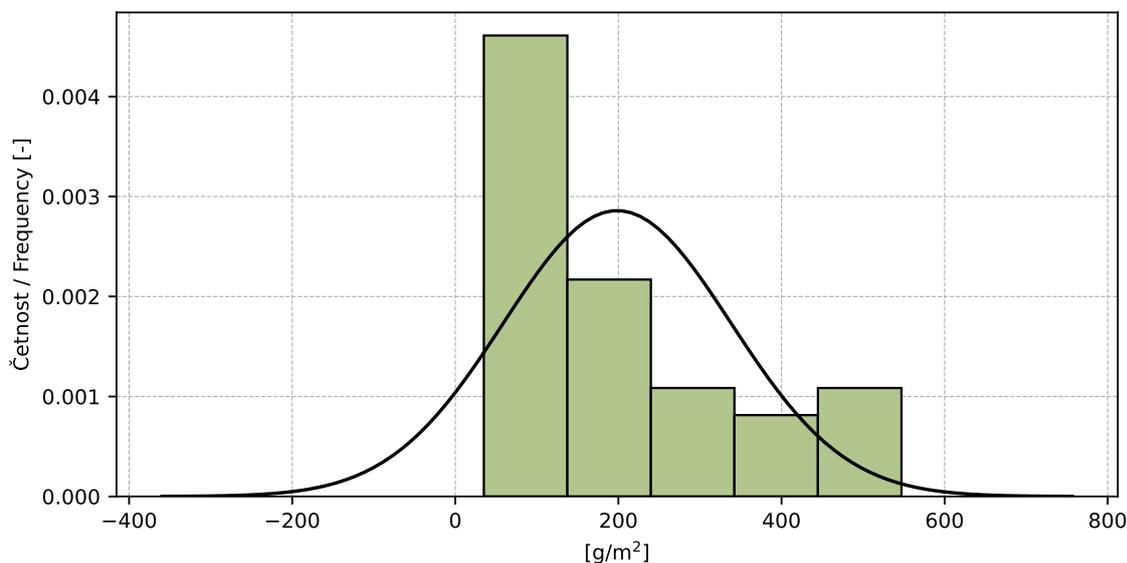
Figure 54: Histogram of all test results

Table 23: Descriptive statistics

Characteristics	[g/m²]
Průměrná hodnota / Average value – $\bar{x}$	198.5
Výběrová směrodatná odchylka / Sample standard deviation – s	139.53
Vztažná hodnota / Asigned value – x^*	184.7
Robustní směrodatná odchylka / Robust standard deviation – s^*	128.72
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	46.45
p-hodnota testu normality / p-value of normality test	0.001 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	137.08
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	45.06
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	144.3
Opakovatelnost / Repeatability – r	126.2
Reprodukovatelnost / Reproducibility – R	404.0

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7.1.5   Evaluation of Performance Statistics
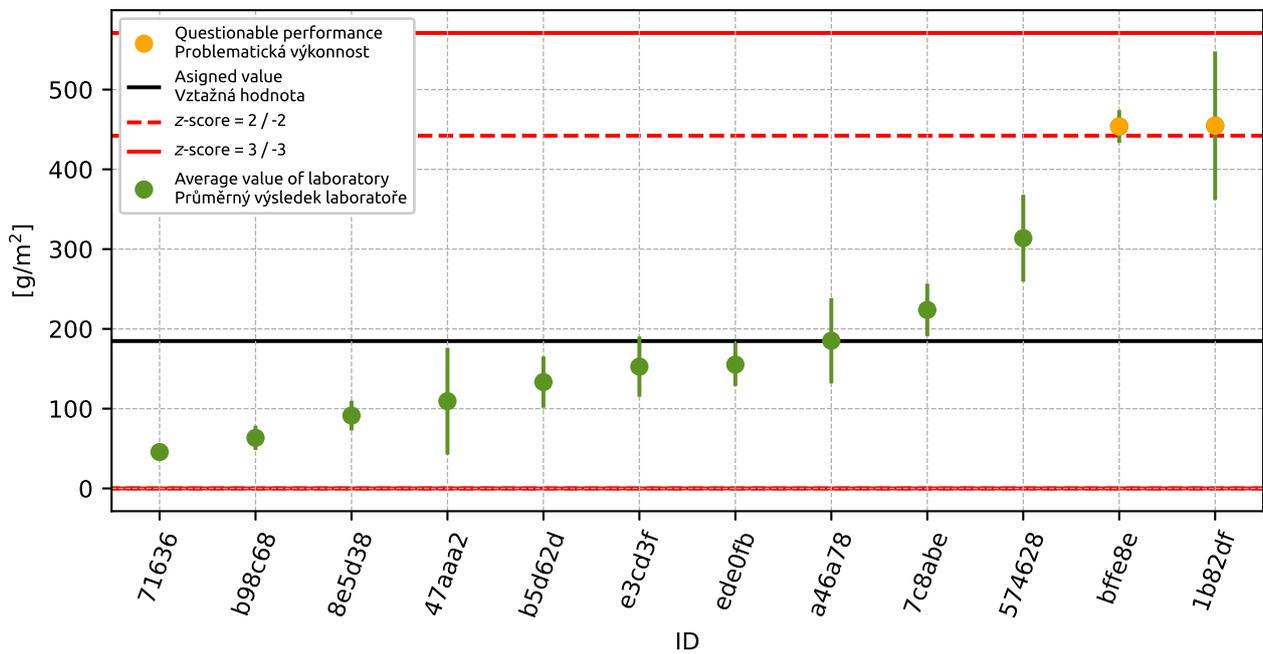
Figure 55: Average values and sample standard deviations
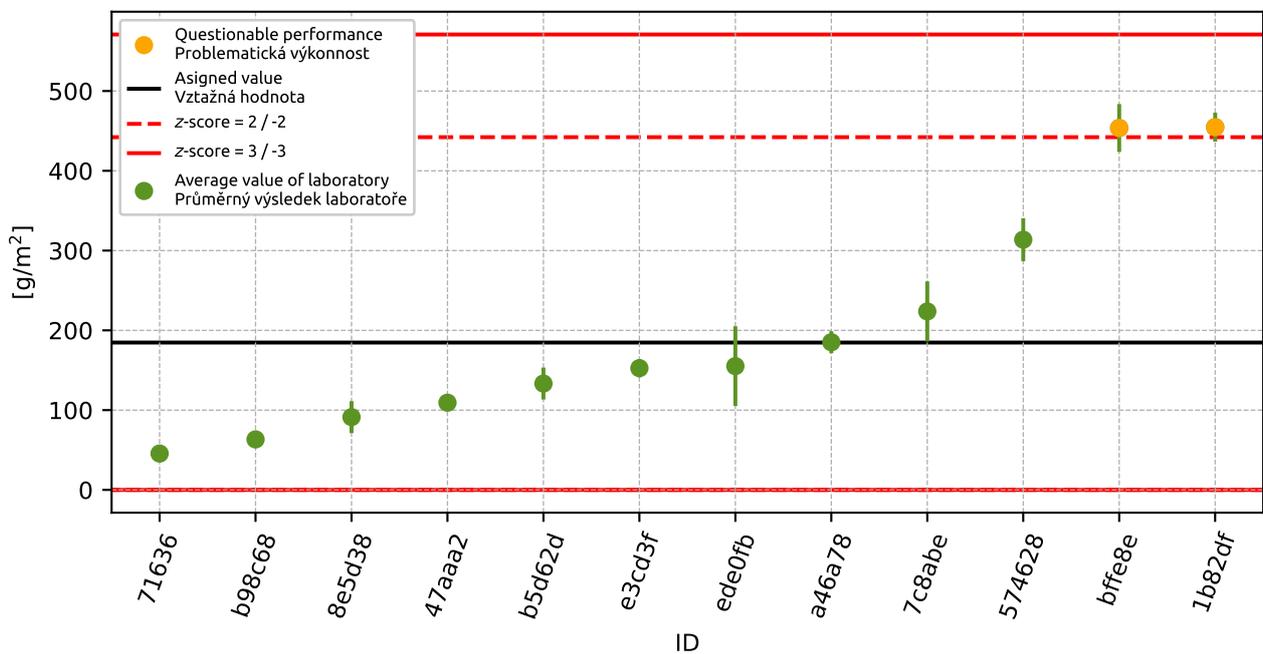
Figure 56: Average values and extended uncertainties of measurement

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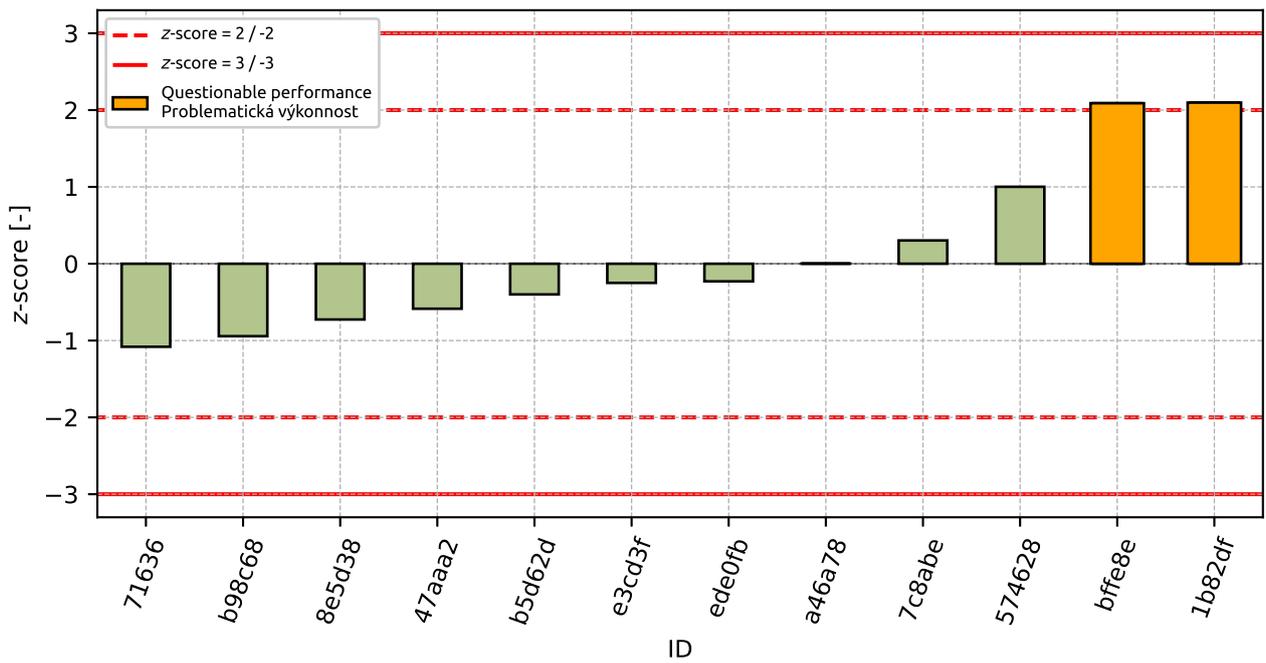
Figure 57: z-score

Figure 58: ζ-score

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Table 24: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
71636	-1.08	-2.99
b98c68	-0.94	-2.55
8e5d38	-0.73	-1.85
47aaa2	-0.59	-
b5d62d	-0.4	-1.02
e3cd3f	-0.25	-0.67
ede0fb	-0.23	-0.43
a46a78	0.0	0.01
7c8abe	0.3	0.65
574628	1.0	2.4
bffe8e	2.09	4.86
1b82df	2.1	5.41

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7.2 50 cycles

7.2.1 Test results

Table 25: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
71636	145.9	192.2	120.0	3.7	152.7	36.58	23.95
b98c68	160.0	200.0	140.0	30.0	166.7	30.55	18.33
b5d62d	360.0	240.0	230.0	40.0	276.7	72.34	26.15
8e5d38	305.1	230.1	297.9	70.0	277.7	41.38	14.9
ede0fb	294.3	355.7	199.0	50.0	283.0	78.96	27.9
47aaa2	331.0	403.0	132.0	-	288.7	140.37	48.63
a46a78	340.5	293.7	315.9	23.7	316.7	23.41	7.39
7c8abe	300.6	328.0	409.2	37.7	345.9	56.48	16.33
e3cd3f	555.8	336.4	317.1	30.2	403.1	132.59	32.89
574628	666.0	545.0	808.0	51.8	673.0	131.64	19.56
1b82df	1082.4	1158.4	871.4	41.5	1037.4	148.7	14.33
bffe8e	1180.0	1008.0	941.0	40.0	1043.0	123.28	11.82

7.2.2 The Numerical Procedure for Determining Outliers
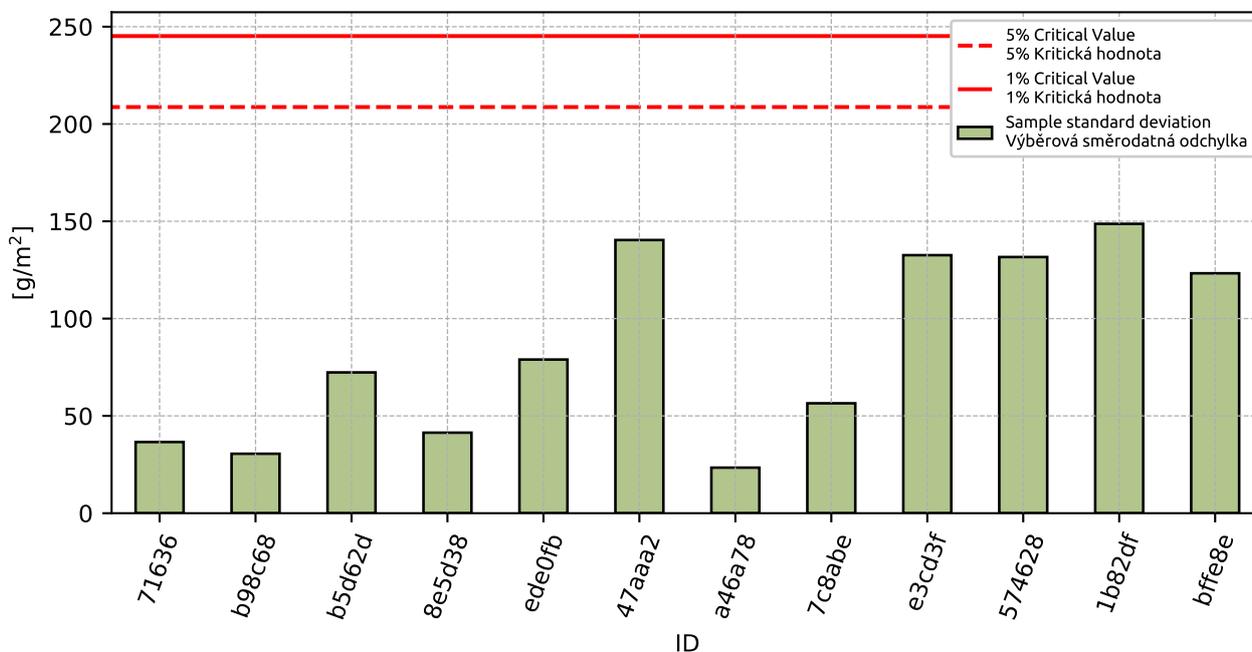

Figure 59: **Cochran's test** - sample standard deviations

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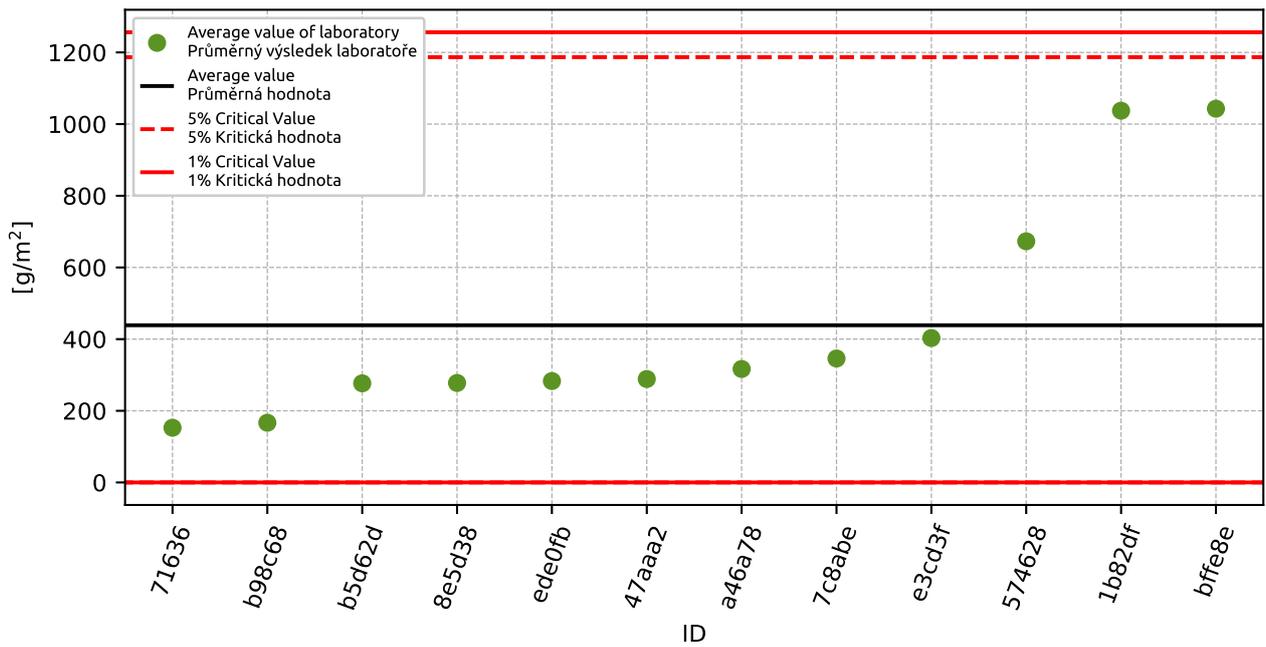
Figure 60: **Grubbs' test** - average values

7.2.3   Mandel's Statistics
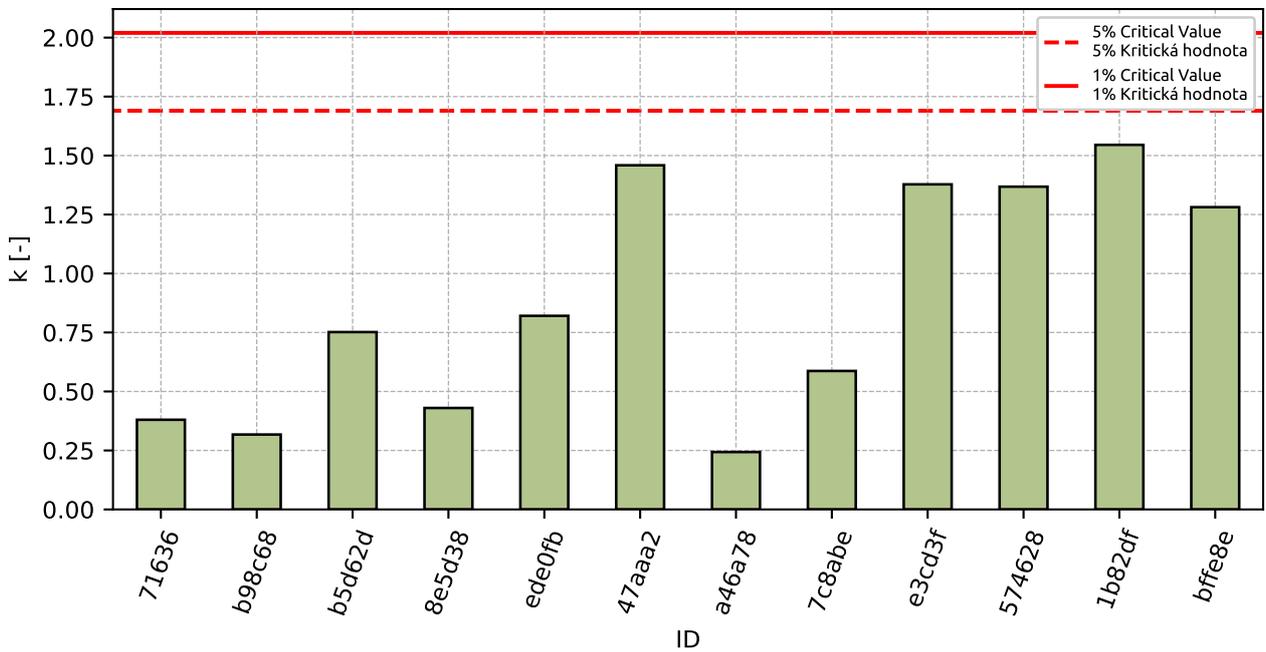
Figure 61: Intralaboratory Consistency Statistic

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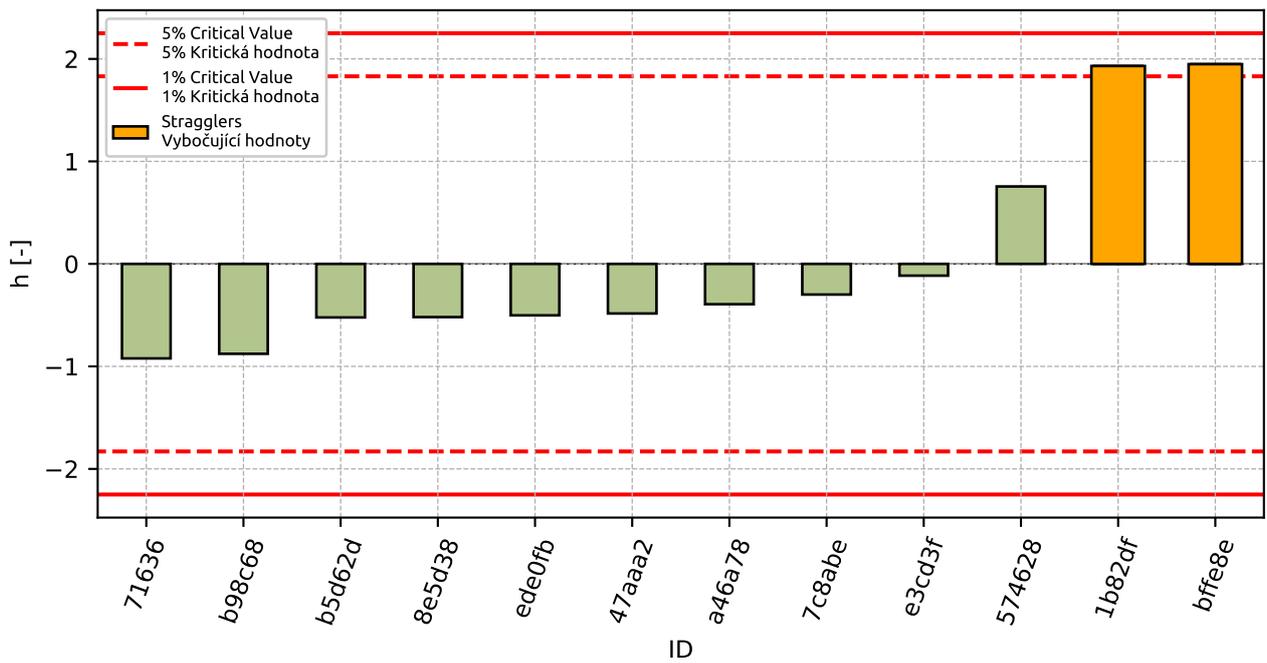
Figure 62: Interlaboratory Consistency Statistic

7.2.4   Descriptive statistics
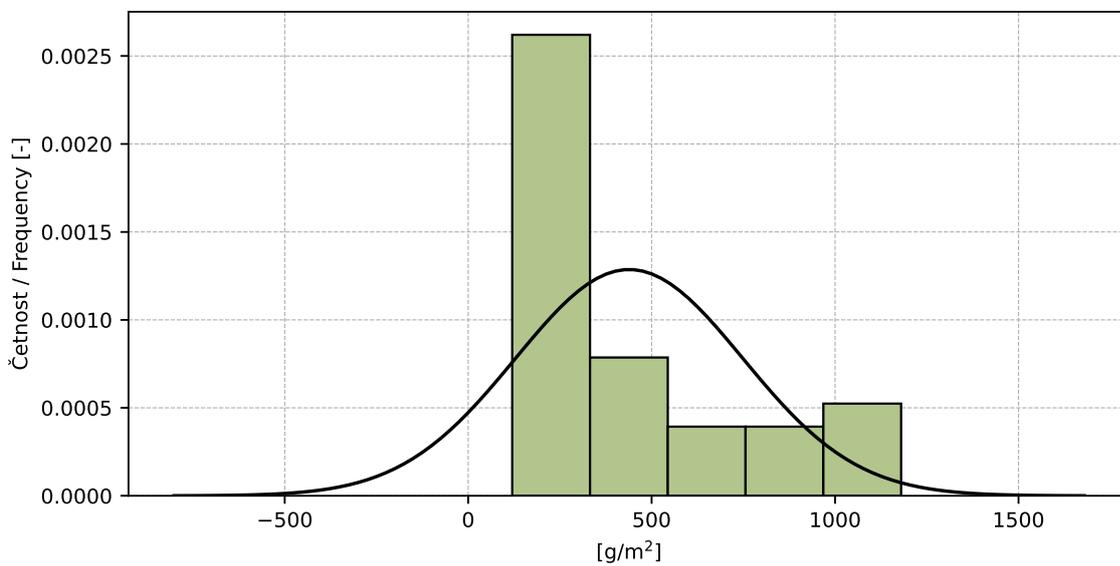
Figure 63: Histogram of all test results

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Table 26: Descriptive statistics

| Characteristics	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	438.7
Výběrová směrodatná odchylka / Sample standard deviation – s	310.13
Vztažná hodnota / Asigned value – x^*	373.3
Robustní směrodatná odchylka / Robust standard deviation – s^*	252.38
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	91.07
p-hodnota testu normality / p-value of normality test	0.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	305.12
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	96.23
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	319.93
Opakovatelnost / Repeatability – r	269.4
Reprodukovatelnost / Reproducibility – R	895.8

7.2.5   Evaluation of Performance Statistics
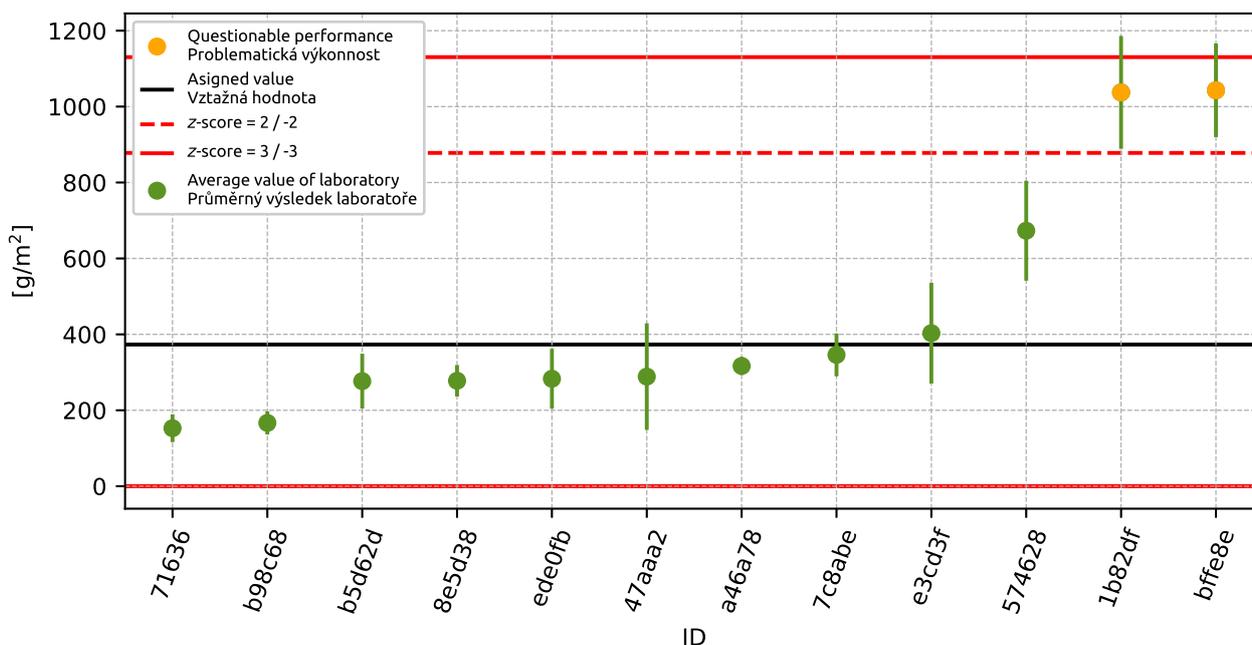
Figure 64: Average values and sample standard deviations

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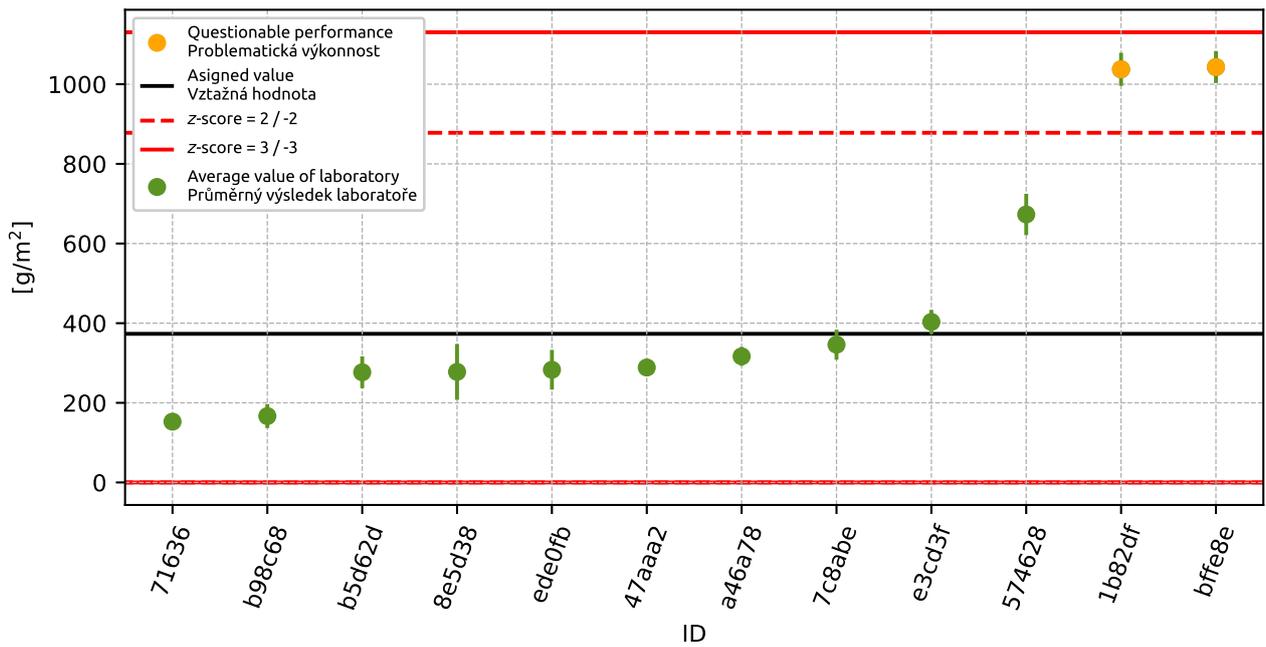
Figure 65: Average values and extended uncertainties of measurement

Figure 66: z-score

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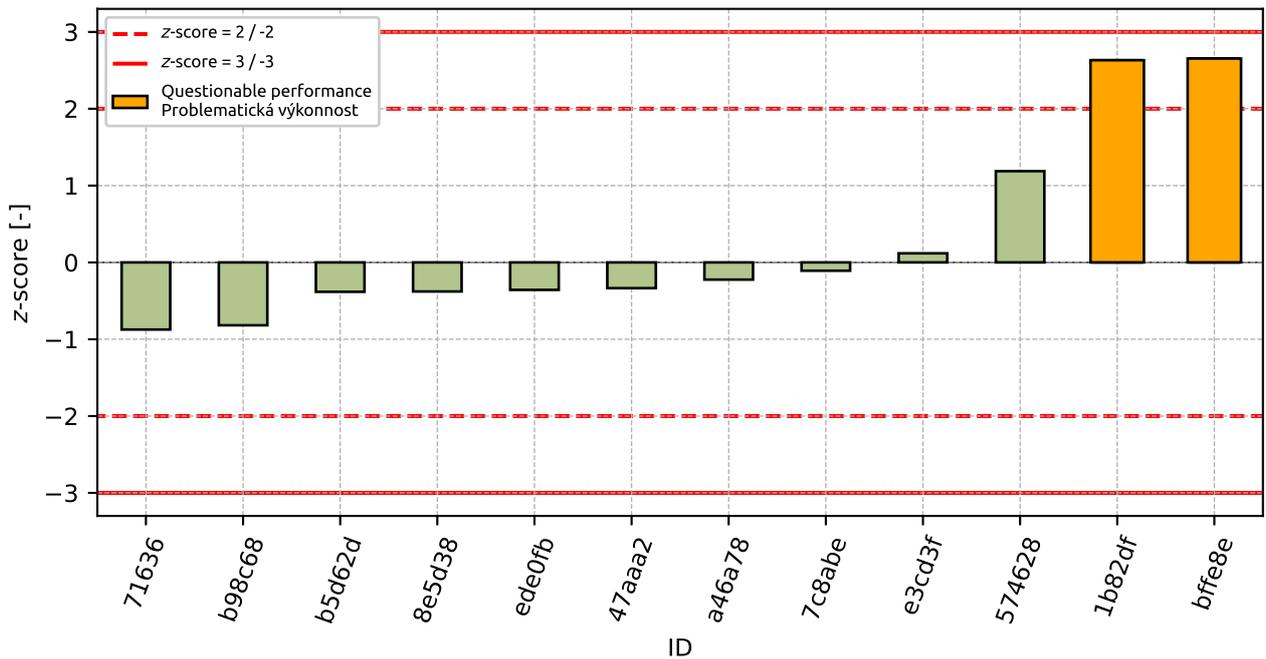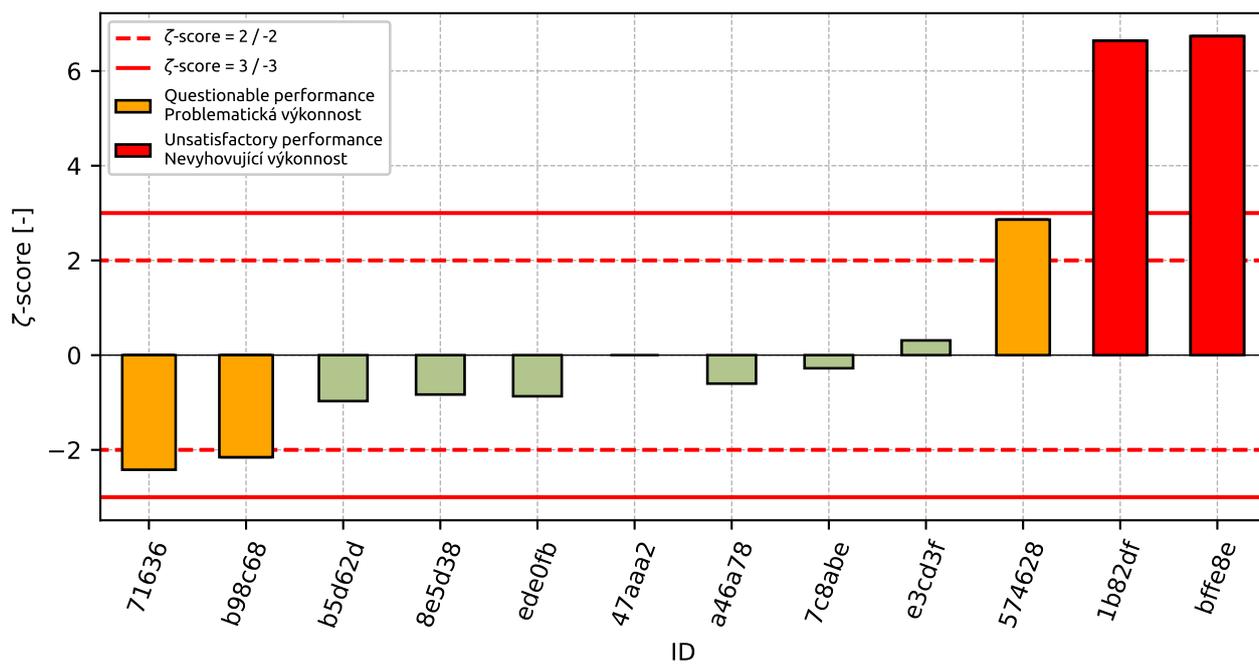
Figure 67: ζ-score

Table 27: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
71636	-0.87	-2.42
b98c68	-0.82	-2.15
b5d62d	-0.38	-0.97
8e5d38	-0.38	-0.83
ede0fb	-0.36	-0.87
47aaa2	-0.34	-
a46a78	-0.22	-0.6
7c8abe	-0.11	-0.28
e3cd3f	0.12	0.31
574628	1.19	2.86
1b82df	2.63	6.64
bffe8e	2.65	6.73

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7.3 75 cycles

7.3.1 Test results

Table 28: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
71636	348.2	396.1	264.3	8.1	336.2	66.71	19.84
b98c68	310.0	430.0	270.0	50.0	336.7	83.27	24.73
ede0fb	357.1	492.6	253.6	50.0	367.8	119.86	32.59
7c8abe	340.4	443.3	510.4	37.7	431.4	85.63	19.85
b5d62d	590.0	400.0	360.0	60.0	450.0	122.88	27.31
a46a78	504.9	454.3	503.0	36.5	487.4	28.68	5.88
8e5d38	606.3	425.0	564.4	160.0	531.9	94.92	17.85
47aaa2	661.0	776.0	310.0	-	582.3	242.76	41.69
e3cd3f	904.2	618.1	567.6	52.2	696.6	181.52	26.06
574628	1074.0	931.0	1275.0	83.1	1093.3	172.81	15.81
1b82df	1648.3	1764.6	1522.2	65.8	1645.0	121.23	7.37
bffe8e	1910.0	1592.0	1529.0	50.0	1677.0	204.23	12.18

7.3.2 The Numerical Procedure for Determining Outliers
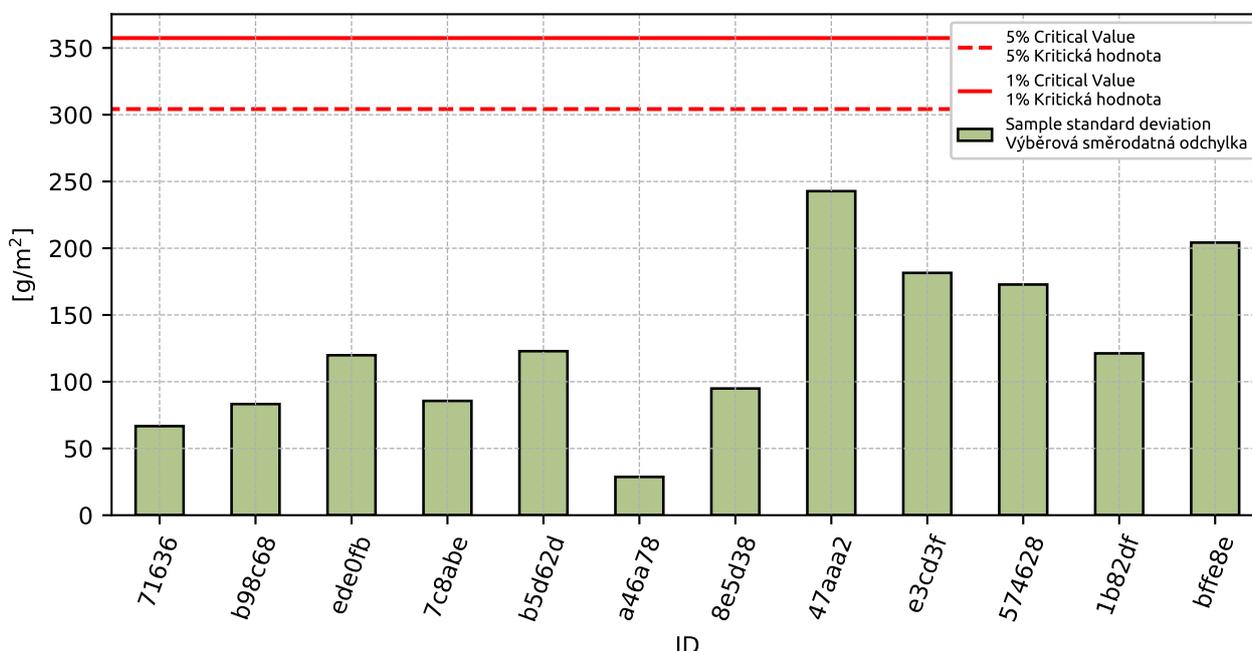
Figure 68: **Cochran's test** - sample standard deviations

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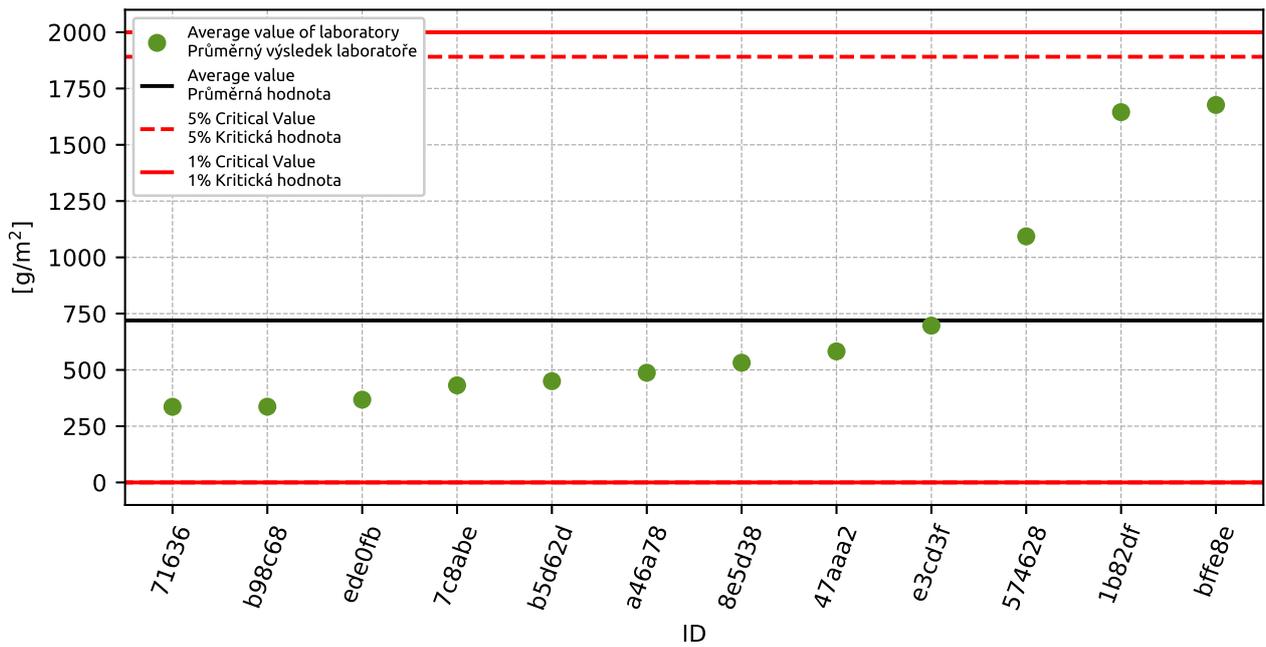
Figure 69: **Grubbs' test** - average values

7.3.3   Mandel's Statistics
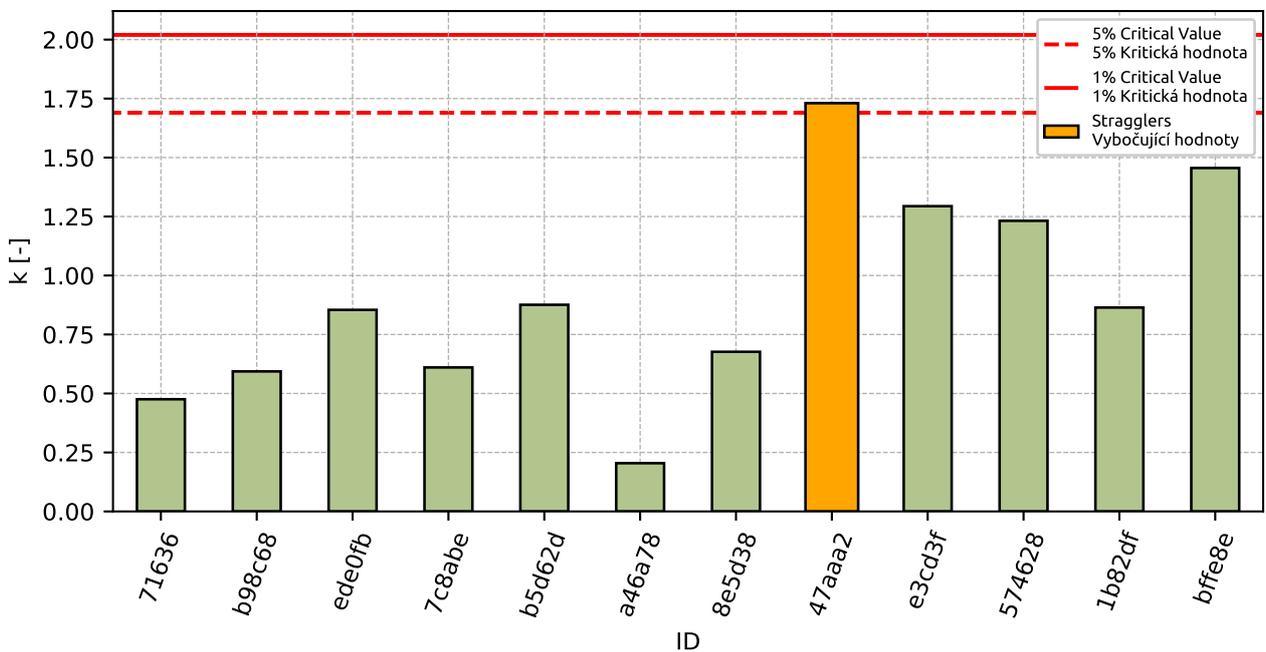
Figure 70: Intralaboratory Consistency Statistic

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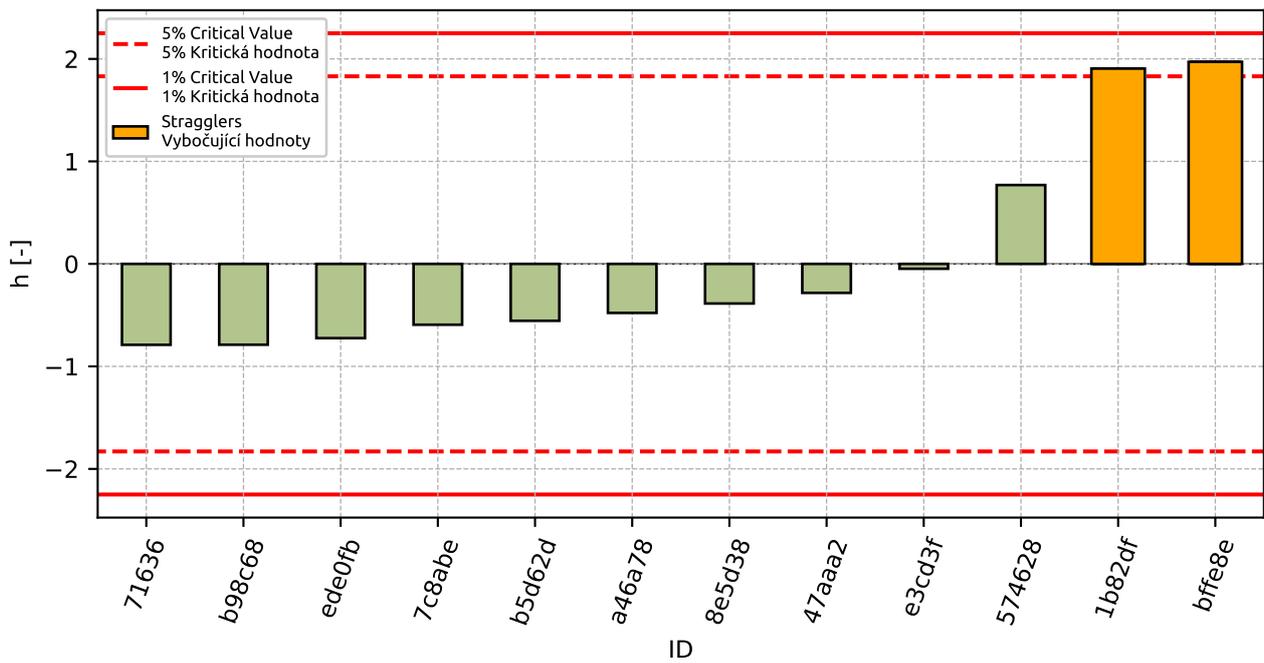
Figure 71: Interlaboratory Consistency Statistic

7.3.4   Descriptive statistics
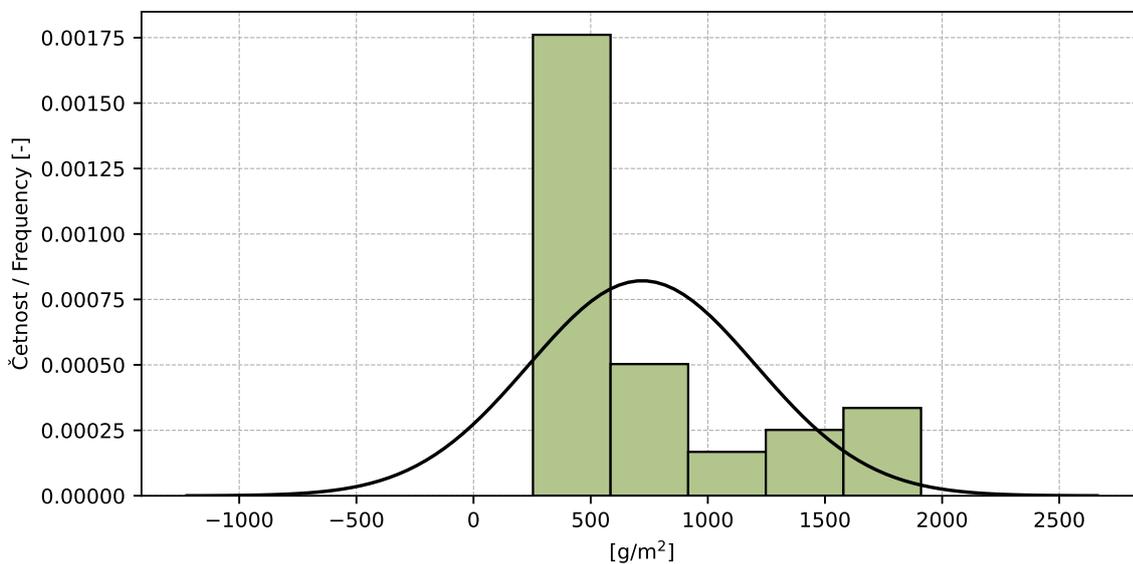
Figure 72: Histogram of all test results

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Table 29: Descriptive statistics

Characteristics	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	719.6
Výběrová směrodatná odchylka / Sample standard deviation – s	485.65
Vztažná hodnota / Asigned value – x^*	634.7
Robustní směrodatná odchylka / Robust standard deviation – s^*	407.72
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	147.12
p-hodnota testu normality / p-value of normality test	0.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	478.85
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	140.29
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	498.98
Opakovatelnost / Repeatability – r	392.8
Reprodukovatelnost / Reproducibility – R	1397.1

### 7.3.5   Evaluation of Performance Statistics
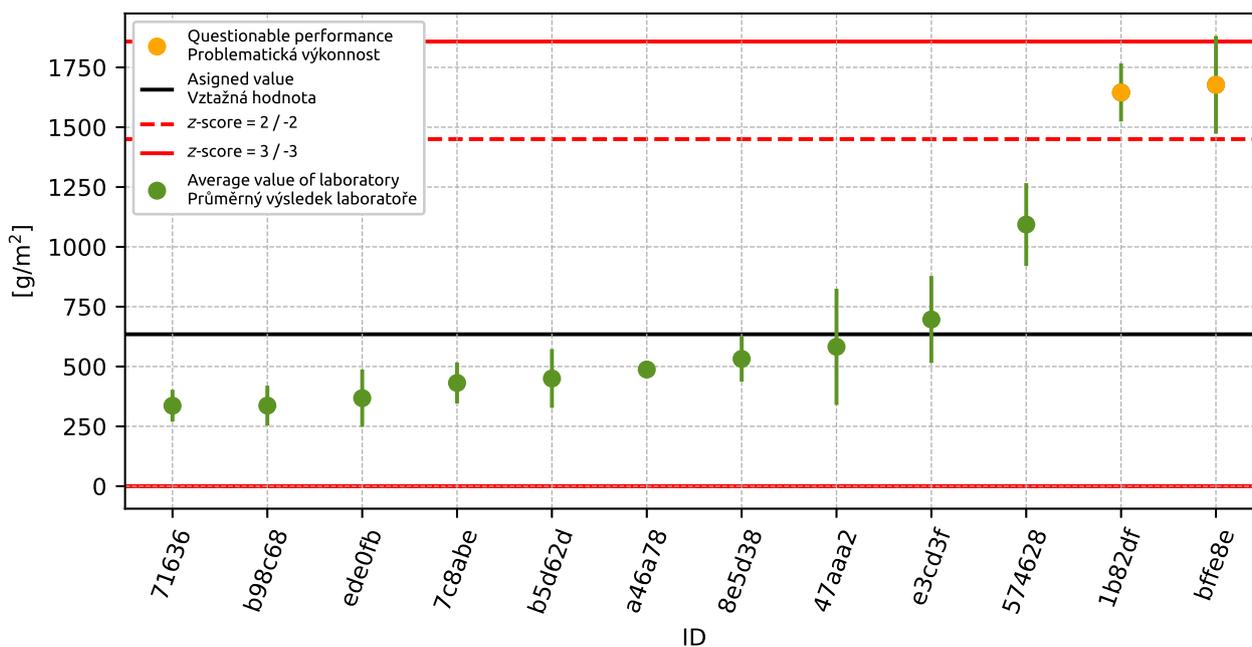
Figure 73: Average values and sample standard deviations

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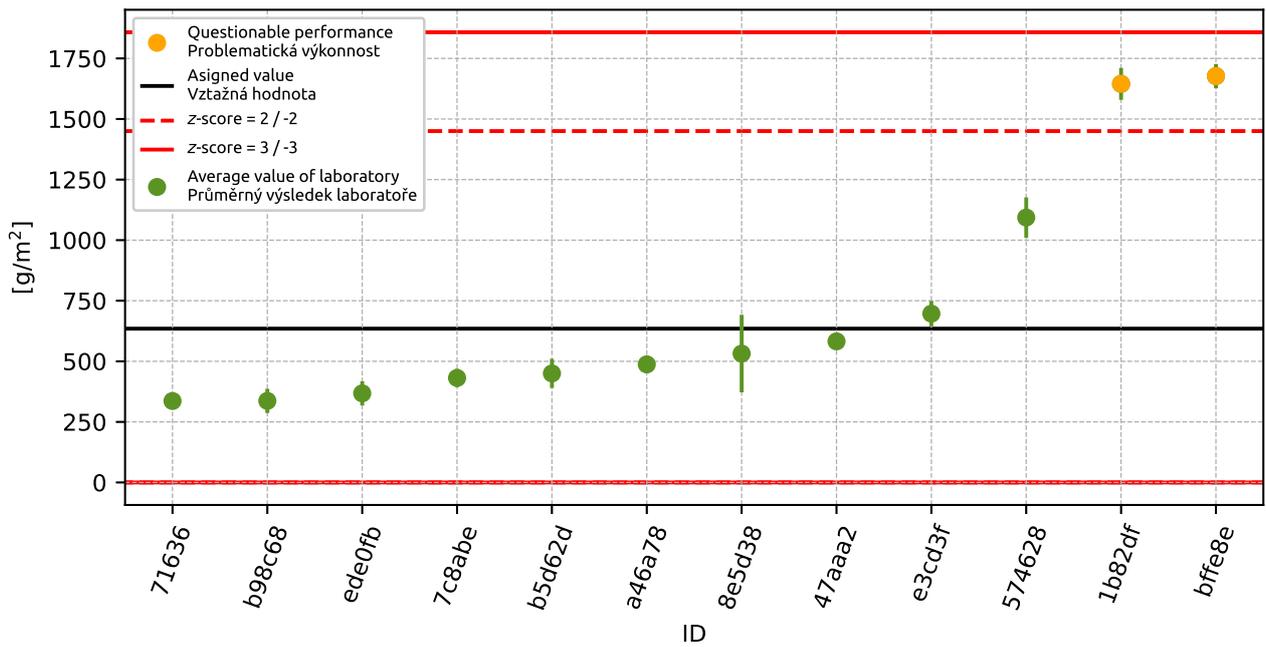
Figure 74: Average values and extended uncertainties of measurement

Figure 75: z-score

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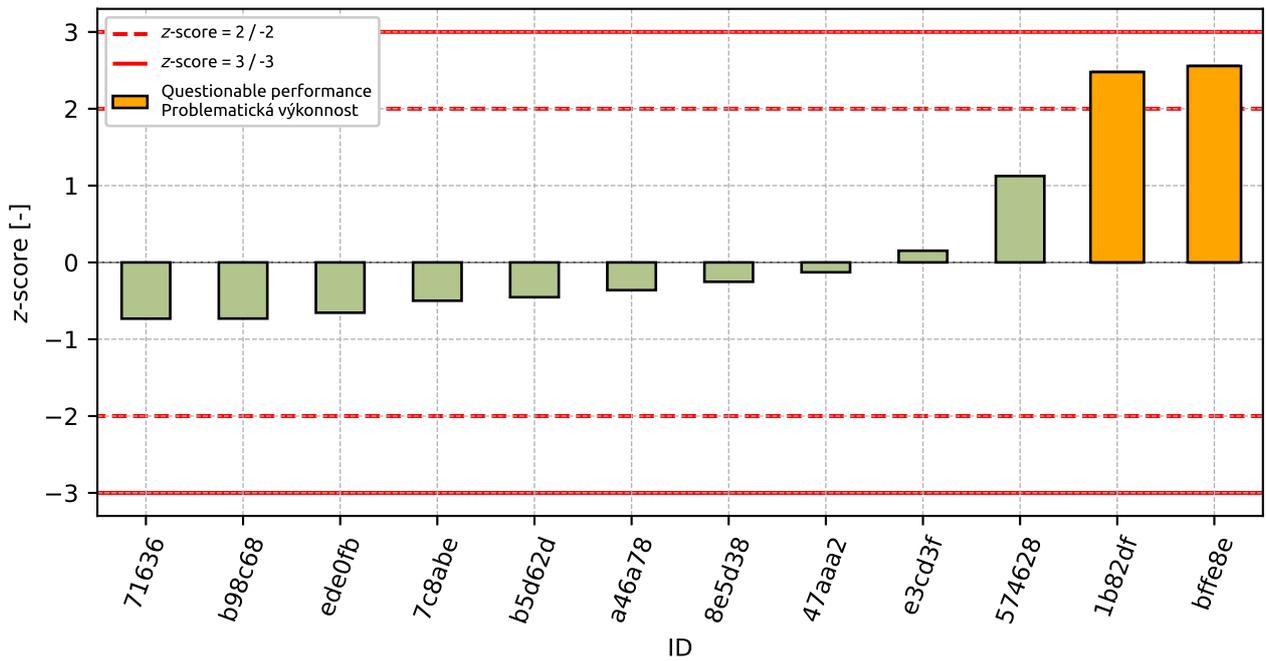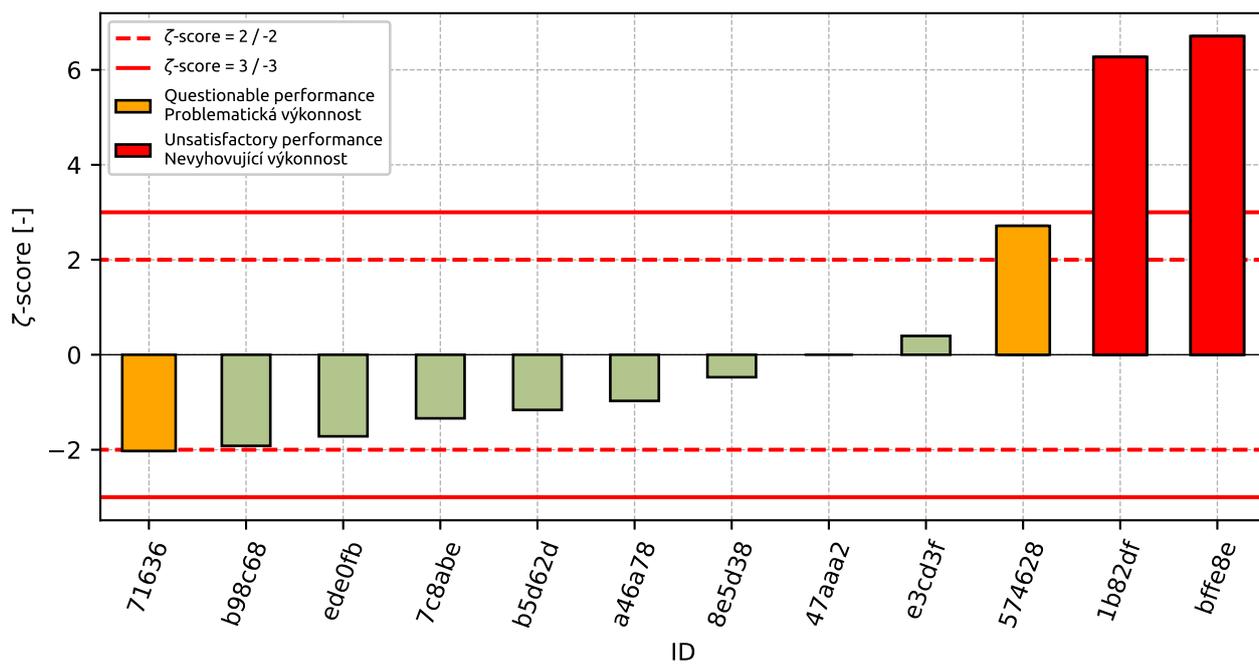
Figure 76: ζ-score

Table 30: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
71636	-0.73	-2.03
b98c68	-0.73	-1.92
ede0fb	-0.65	-1.72
7c8abe	-0.5	-1.34
b5d62d	-0.45	-1.16
a46a78	-0.36	-0.97
8e5d38	-0.25	-0.47
47aaa2	-0.13	-
e3cd3f	0.15	0.4
574628	1.12	2.71
1b82df	2.48	6.27
bffe8e	2.56	6.71

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7.4   100 cycles

7.4.1   Test results

Table 31: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [g/m^2]			u_X [g/m^2]	$\bar{x}$ [g/m^2]	s_0 [g/m^2]	V_X [%]
ede0fb	400.3	602.0	323.9	50.0	442.1	143.68	32.5
7c8abe	393.5	554.1	607.2	37.7	518.3	111.27	21.47
b98c68	510.0	720.0	460.0	70.0	563.3	137.96	24.49
71636	596.1	698.0	478.4	15.0	590.8	109.89	18.6
a46a78	692.8	658.0	709.7	51.5	686.8	26.36	3.84
b5d62d	900.0	630.0	580.0	90.0	703.3	172.14	24.48
8e5d38	864.5	662.9	783.8	200.0	770.4	101.47	13.17
47aaa2	1125.0	1203.0	512.0	-	946.7	378.45	39.98
e3cd3f	1397.4	950.6	935.5	82.1	1094.5	262.43	23.98
574628	1459.0	1324.0	1672.0	111.4	1485.0	175.45	11.81
1b82df	2160.8	2258.4	2162.4	87.8	2193.9	55.89	2.55
bffe8e	2541.0	2173.0	2118.0	70.0	2277.3	229.99	10.1

7.4.2   The Numerical Procedure for Determining Outliers
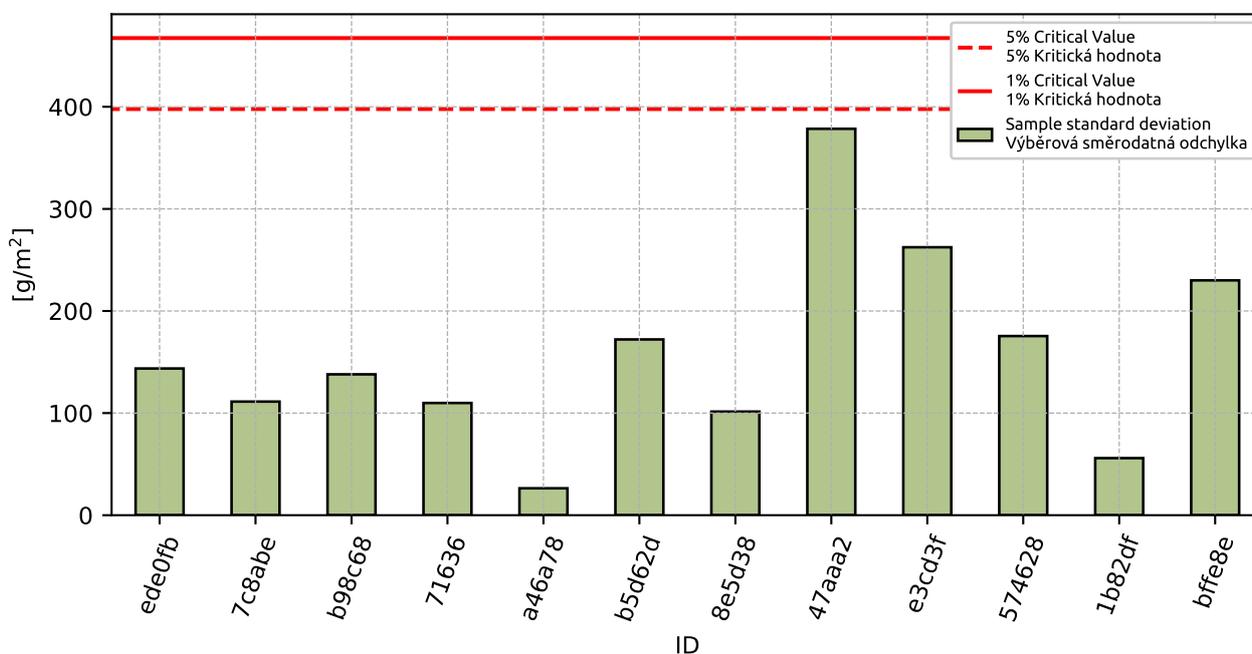
Figure 77: **Cochran's test** - sample standard deviations

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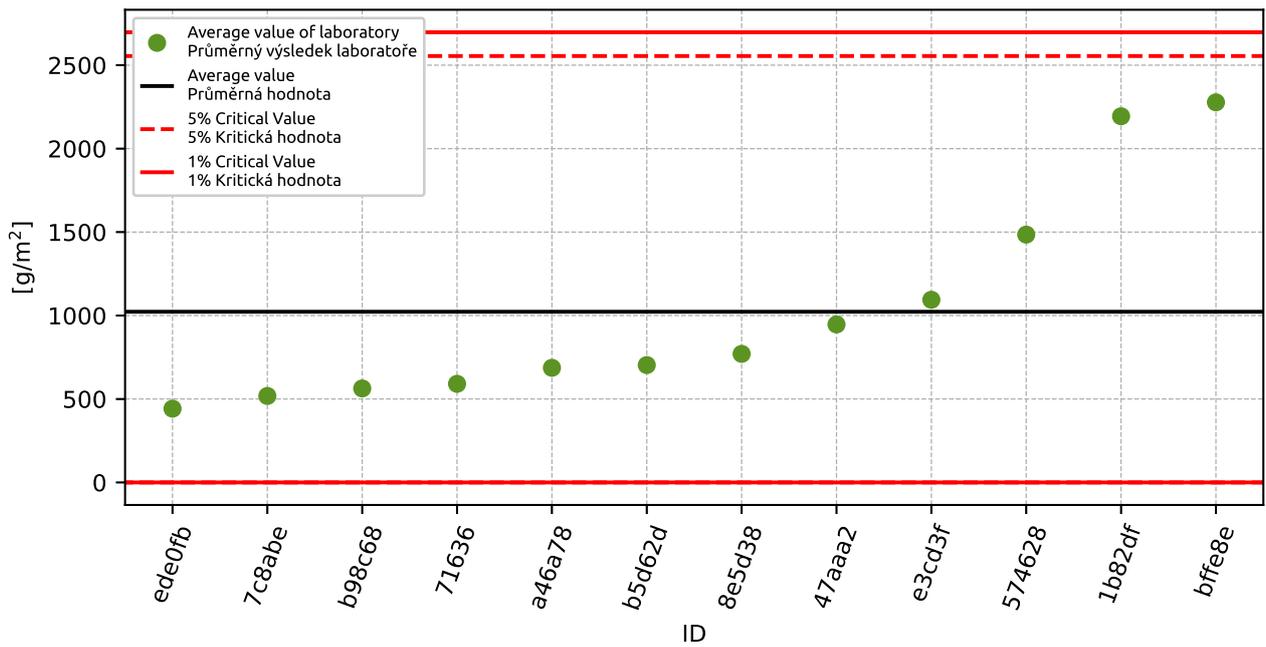
Figure 78: **Grubbs' test** - average values

7.4.3   Mandel′s Statistics
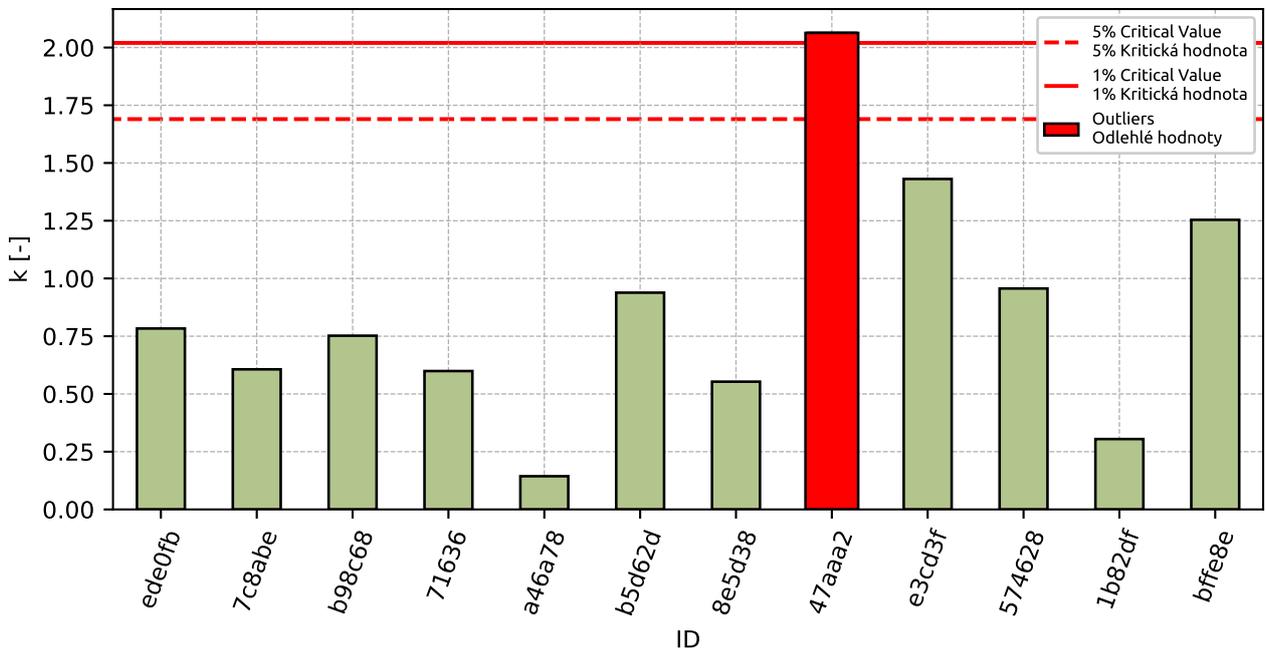
Figure 79: Intralaboratory Consistency Statistic

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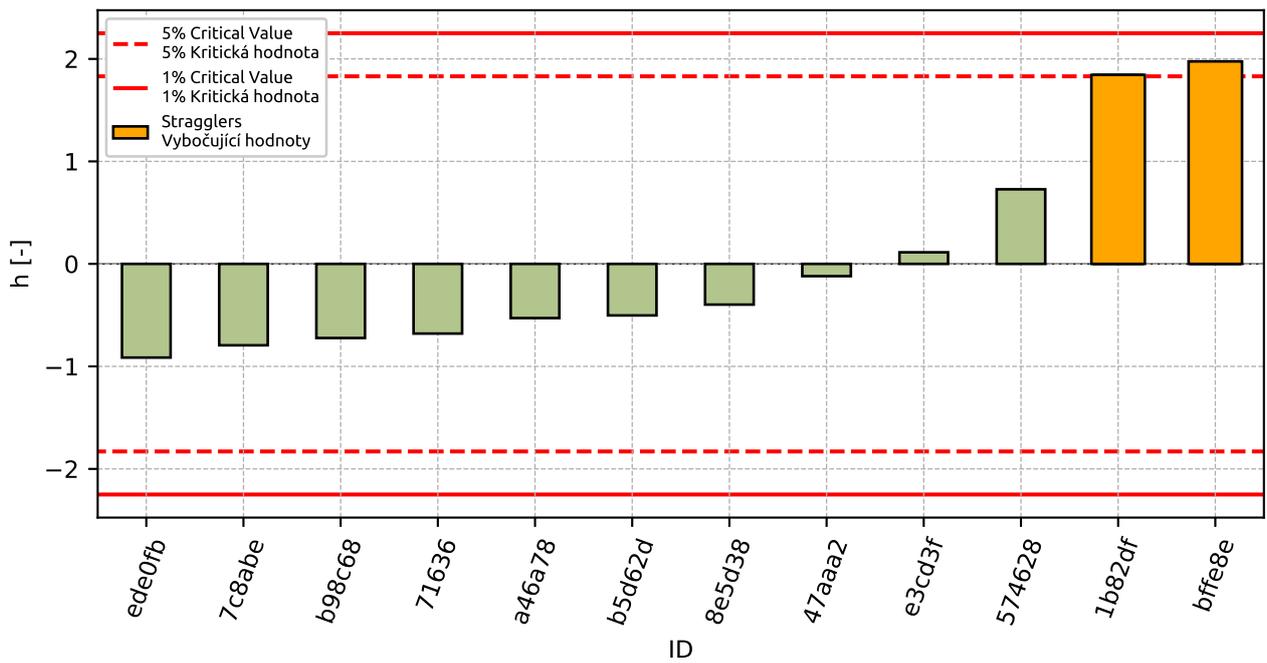
Figure 80: Interlaboratory Consistency Statistic

7.4.4   Descriptive statistics
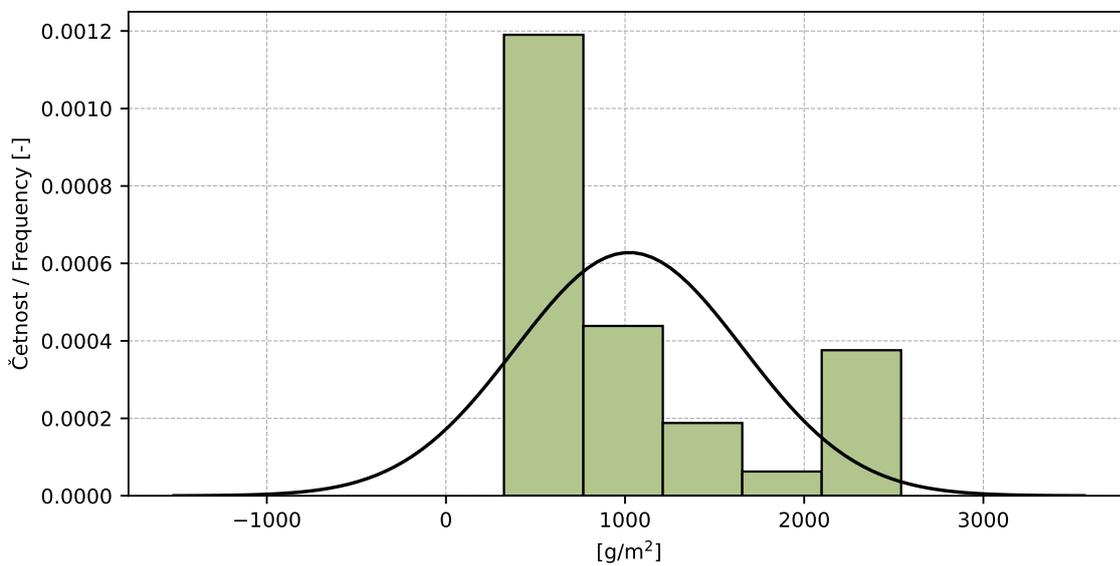
Figure 81: Histogram of all test results

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Table 32: Descriptive statistics

| Characteristics	[g/m²]
Průměrná hodnota / Average value – $\bar{x}$	1022.7
Výběrová směrodatná odchylka / Sample standard deviation – s	635.18
Vztažná hodnota / Asigned value – x^*	918.4
Robustní směrodatná odchylka / Robust standard deviation – s^*	547.25
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	197.47
p-hodnota testu normality / p-value of normality test	0.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	626.29
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	183.41
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	652.59
Opakovatelnost / Repeatability – r	513.5
Reprodukovatelnost / Reproducibility – R	1827.3

7.4.5   Evaluation of Performance Statistics
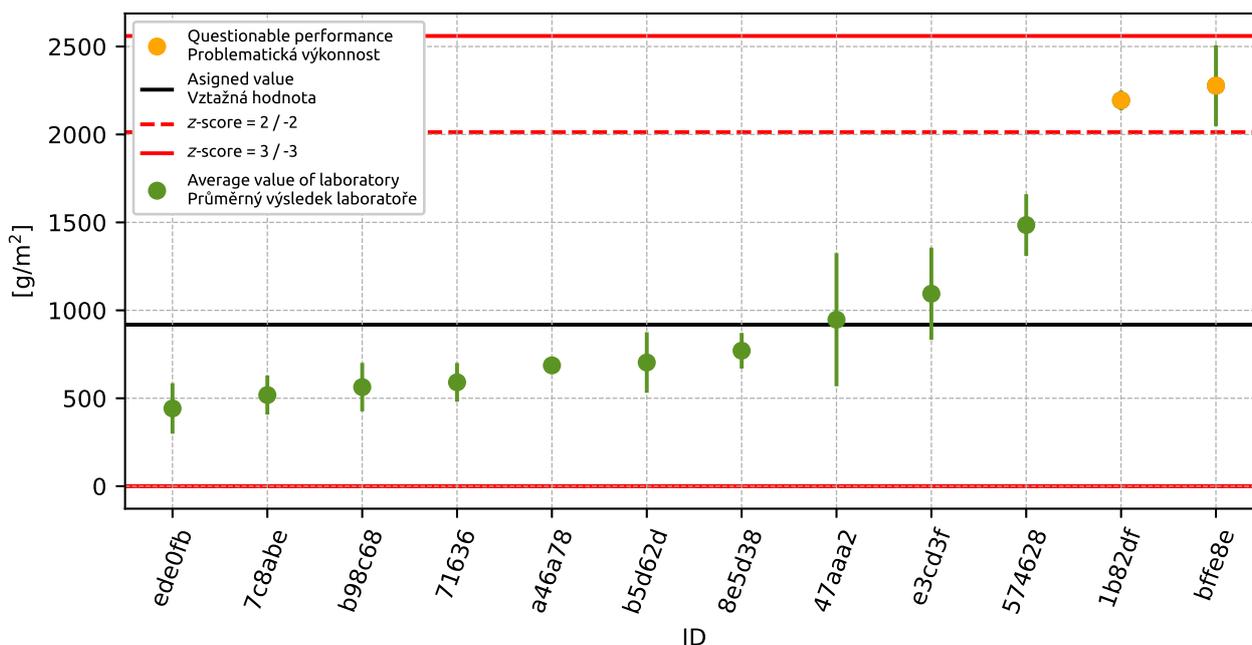
Figure 82: Average values and sample standard deviations

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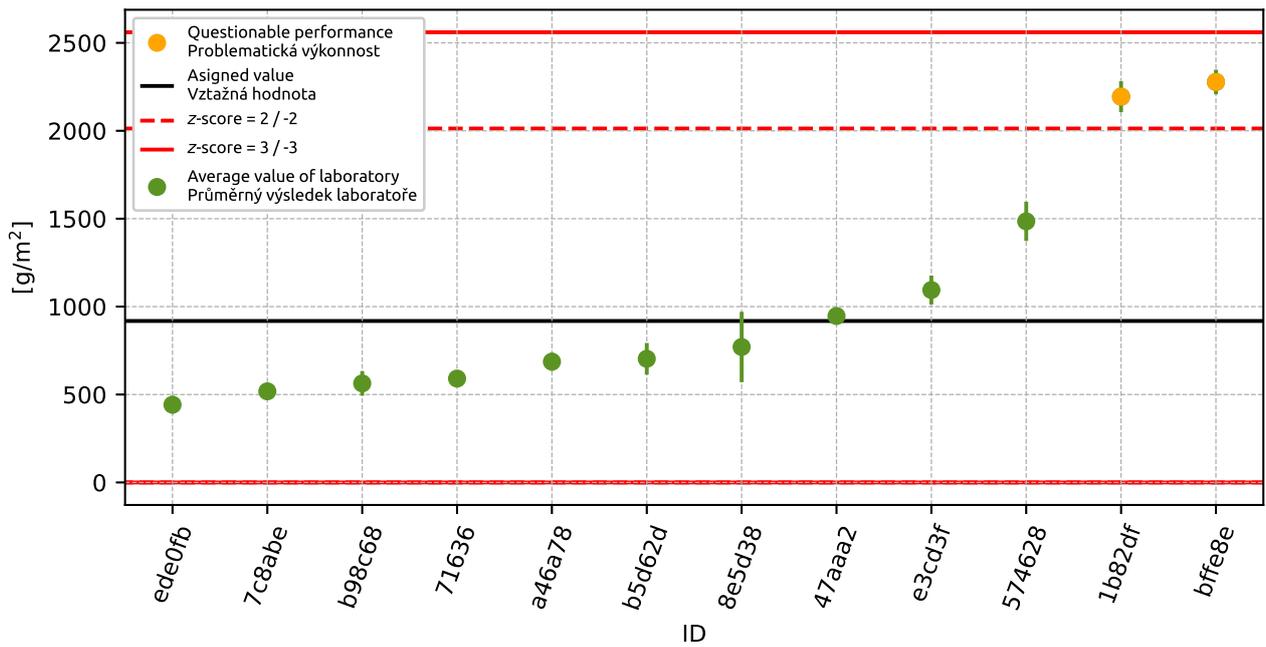
Figure 83: Average values and extended uncertainties of measurement

Figure 84: z-score

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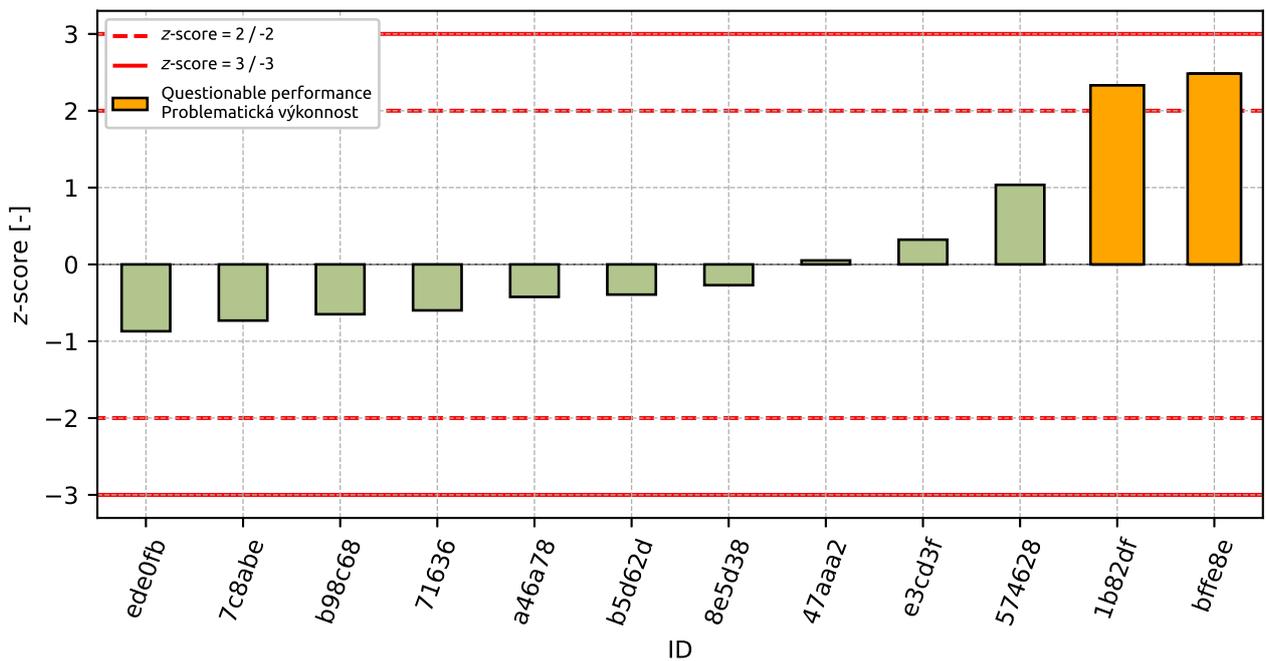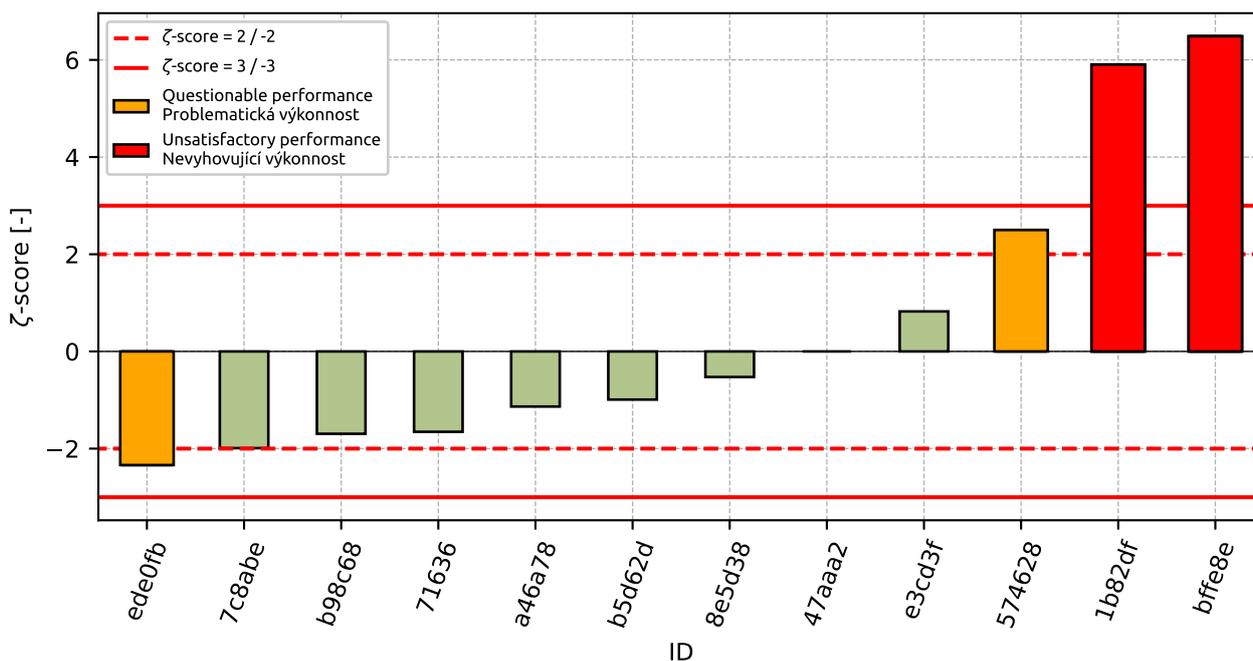
Figure 85: ζ-score

Table 33: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ede0fb	-0.87	-2.34
7c8abe	-0.73	-1.99
b98c68	-0.65	-1.69
71636	-0.6	-1.65
a46a78	-0.42	-1.13
b5d62d	-0.39	-0.99
8e5d38	-0.27	-0.53
47aaa2	0.05	-
e3cd3f	0.32	0.82
574628	1.04	2.5
1b82df	2.33	5.9
bffe8e	2.48	6.49

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

ID	Test results			u_X	$\bar{x}$	s_0	V_X
	[g/m^2]			[g/m^2]	[g/m^2]	[g/m^2]	[%]
bae402	11.3	34.0	22.6	20.1	22.6	11.35	50.15
18624c	128.0	83.0	67.0	18.5	92.7	31.63	34.13
ede0fb	58.5	117.0	130.0	50.0	101.8	38.09	37.4
08b0bd	107.5	169.8	118.8	15.7	132.0	33.19	25.14
0b7831	40.0	370.0	20.0	85.0	143.3	196.55	137.13
f51f73	110.7	237.9	320.9	-	223.2	105.87	47.44

8.1.2   The Numerical Procedure for Determining Outliers
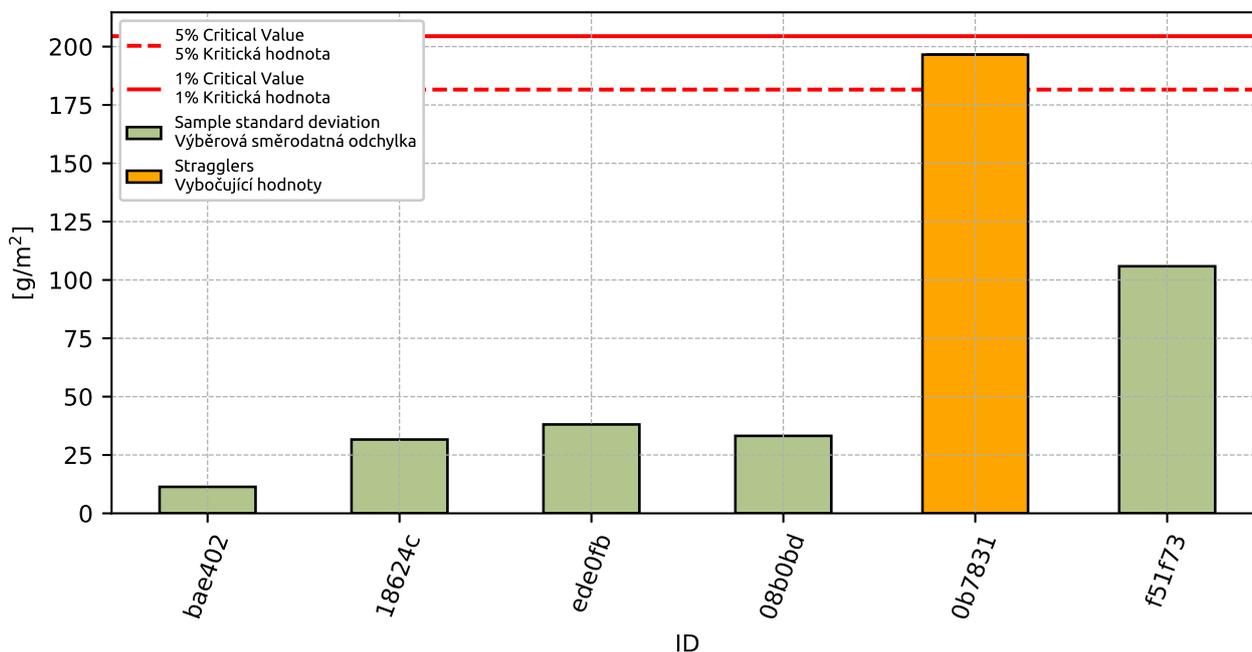
Figure 86: **Cochran's test** - sample standard deviations

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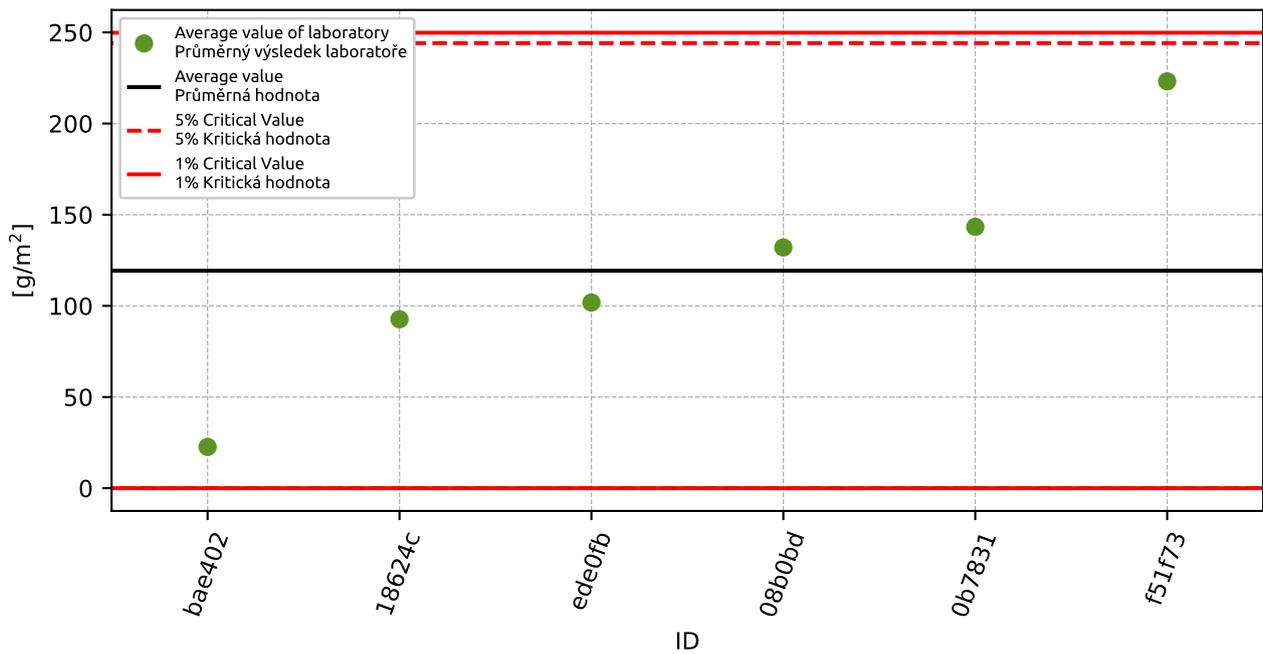
Figure 87: **Grubbs' test** - average values

8.1.3   Mandel's Statistics
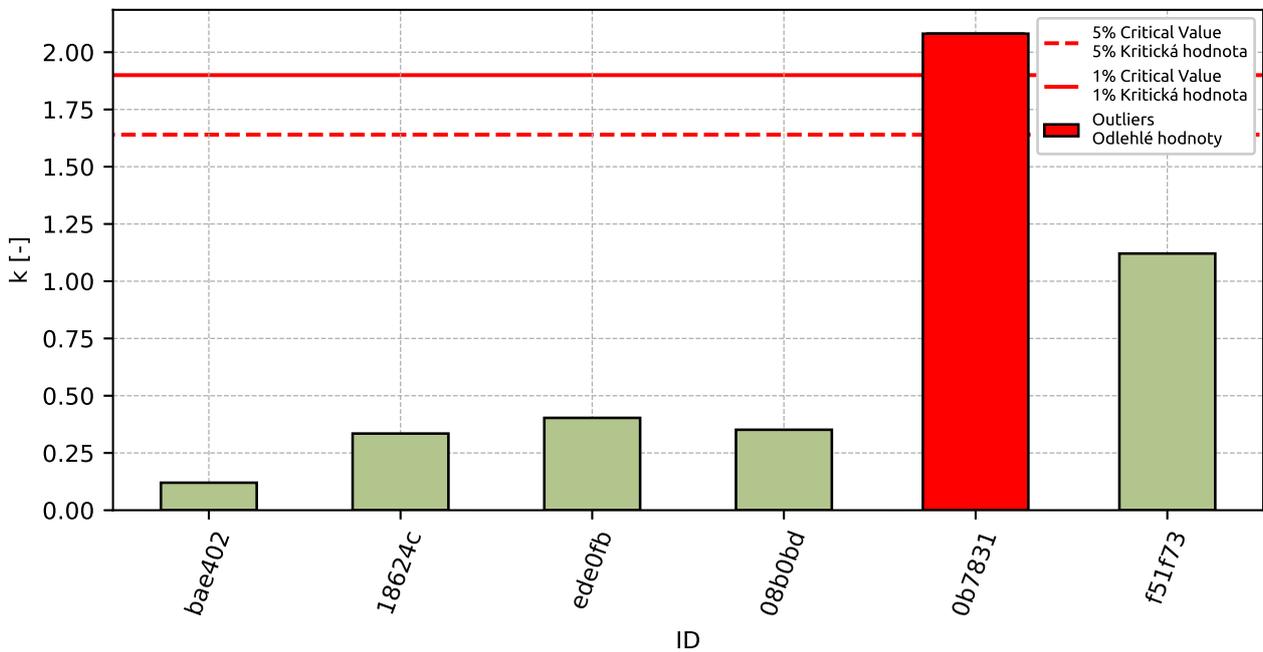
Figure 88: Intralaboratory Consistency Statistic

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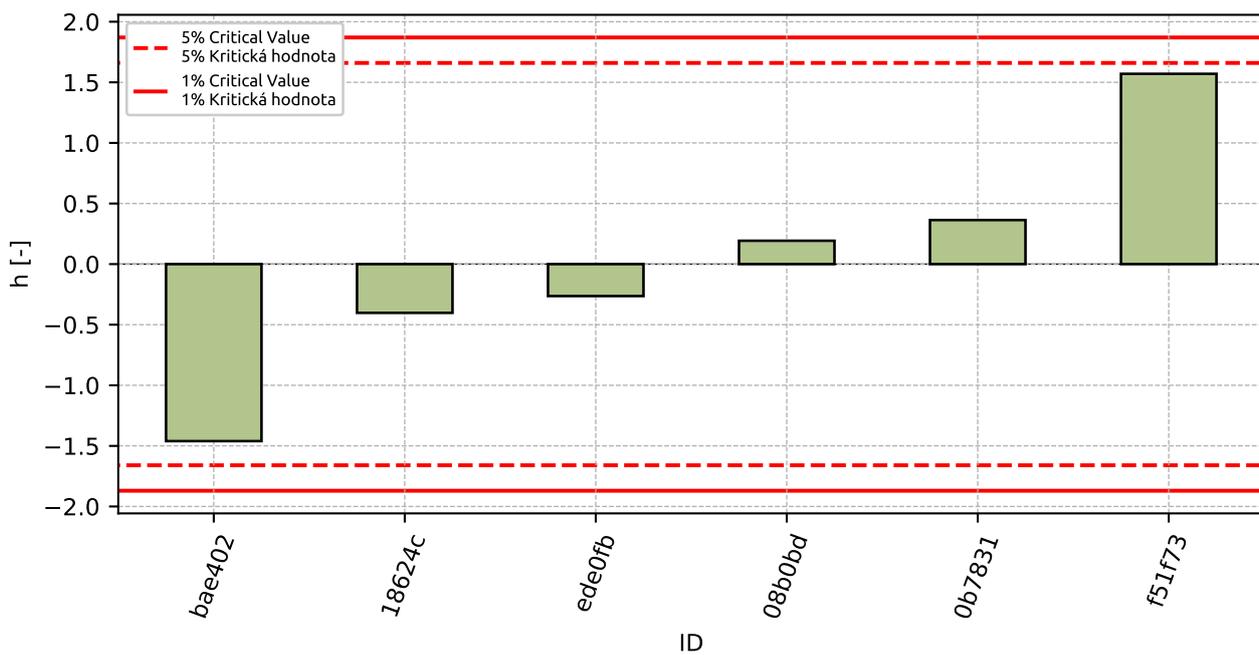
Figure 89: Interlaboratory Consistency Statistic

8.1.4   Descriptive statistics
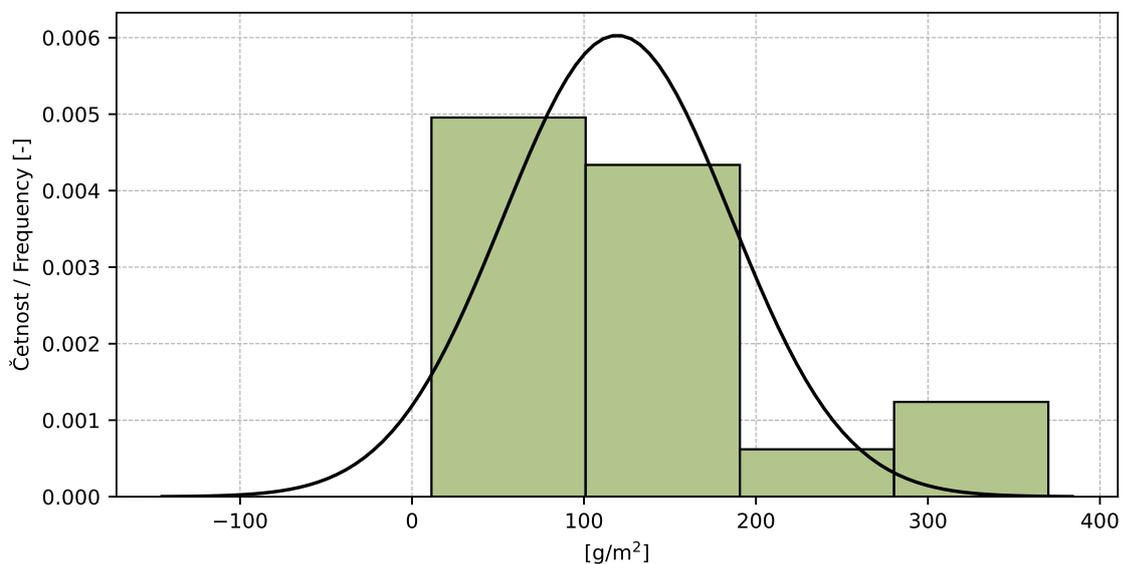
Figure 90: Histogram of all test results

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Table 35: Descriptive statistics

Characteristics	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	119.3
Výběrová směrodatná odchylka / Sample standard deviation – s	66.16
Vztažná hodnota / Asigned value – x^*	125.6
Robustní směrodatná odchylka / Robust standard deviation – s^*	58.1
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	29.65
p-hodnota testu normality / p-value of normality test	0.01 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	37.47
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	94.45
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	101.61
Opakovatelnost / Repeatability – r	264.5
Reprodukovatelnost / Reproducibility – R	284.5

## 8.1.5   Evaluation of Performance Statistics
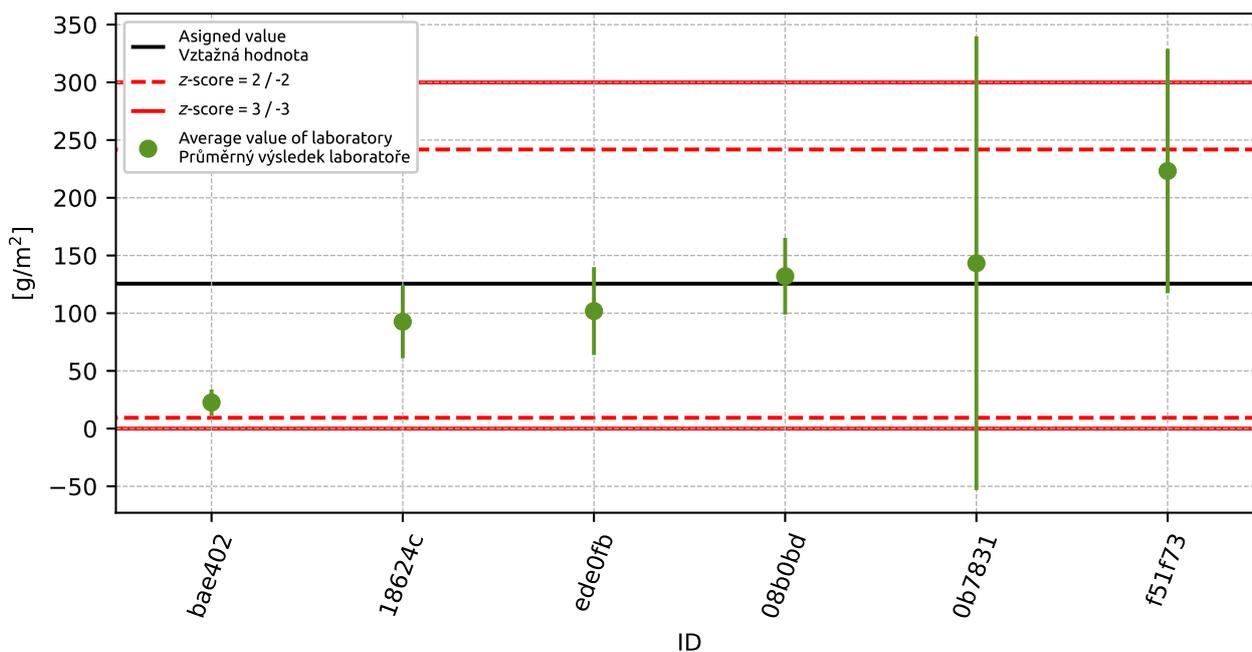
Figure 91: Average values and sample standard deviations

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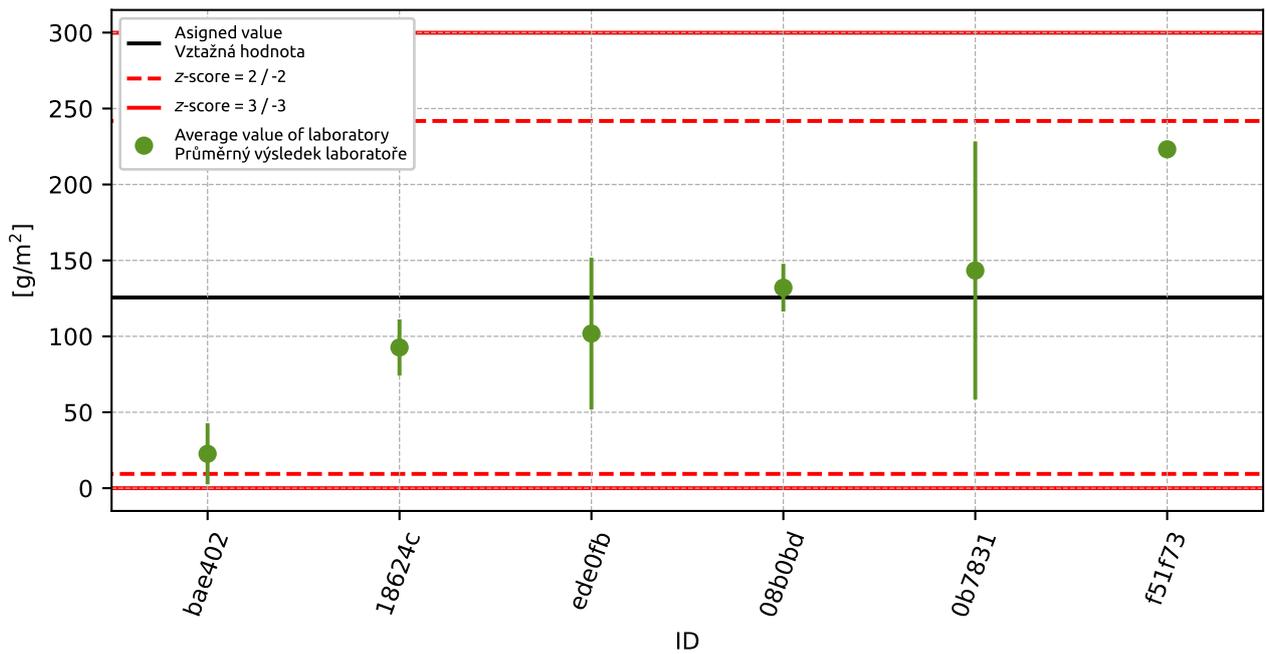
Figure 92: Average values and extended uncertainties of measurement

Figure 93: z-score

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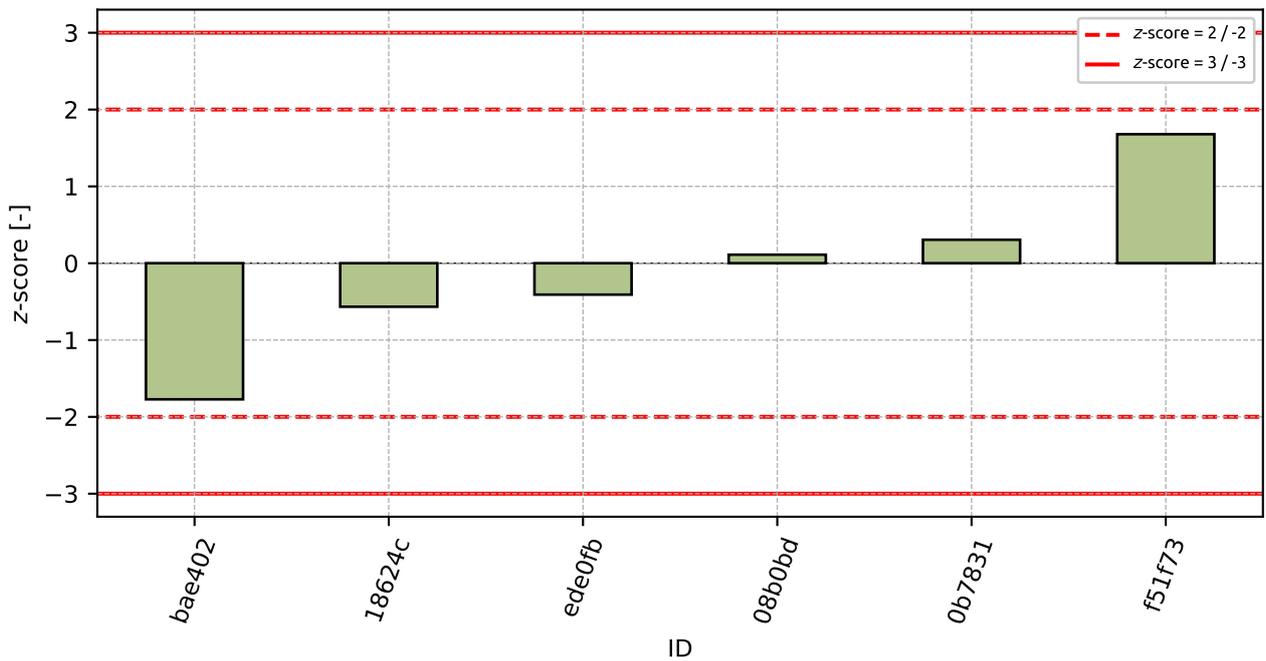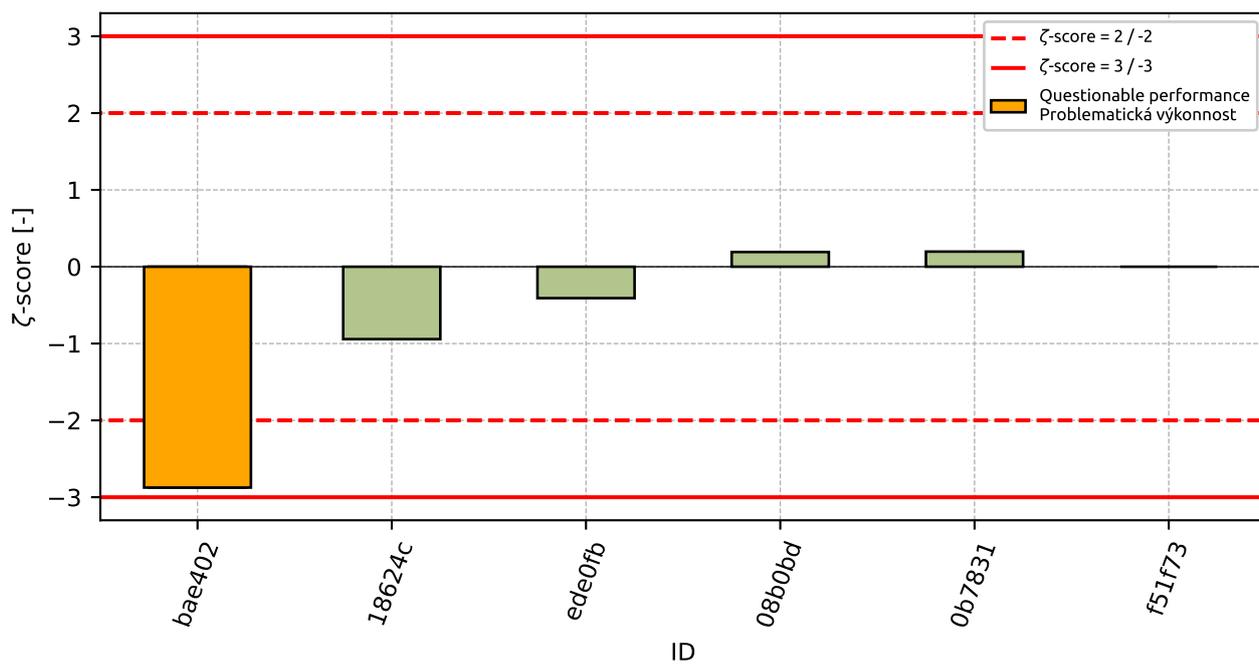
Figure 94: ζ-score

Table 36: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
bae402	-1.77	-2.87
18624c	-0.57	-0.94
ede0fb	-0.41	-0.41
08b0bd	0.11	0.19
0b7831	0.31	0.2
f51f73	1.68	-

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8.2   50 cycles

8.2.1   Test results

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

ID	Test results			u_X	$\bar{x}$	s_0	V_X
	[g/m²]			[g/m²]	[g/m²]	[g/m²]	[%]
ede0fb	84.5	221.0	182.0	50.0	162.5	70.31	43.27
f51f73	116.6	255.5	288.8	-	220.3	91.34	41.46
08b0bd	203.7	339.5	169.8	28.3	237.7	89.8	37.79
18624c	390.0	187.0	173.0	50.0	250.0	121.45	48.58
0b7831	50.0	960.0	50.0	219.0	353.3	525.39	148.69
bae402	718.4	296.7	134.1	32.6	383.1	301.57	78.73

8.2.2   The Numerical Procedure for Determining Outliers
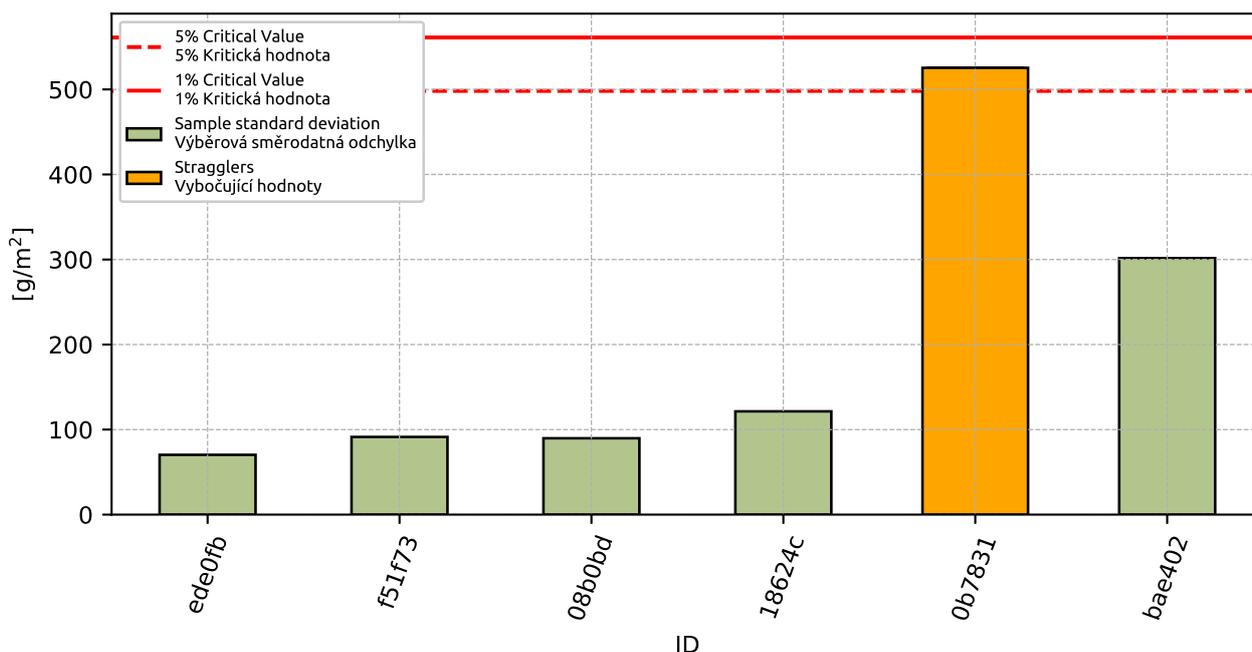
Figure 95: **Cochran's test** - sample standard deviations

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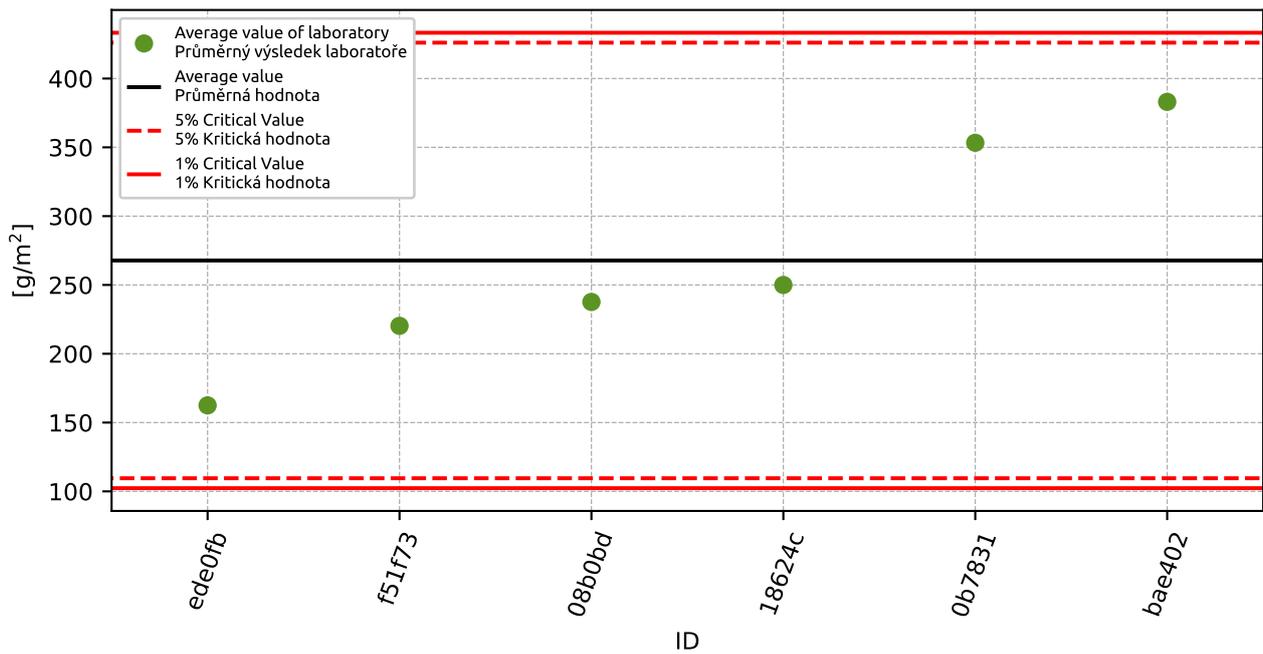
Figure 96: **Grubbs' test** - average values

8.2.3   Mandel's Statistics
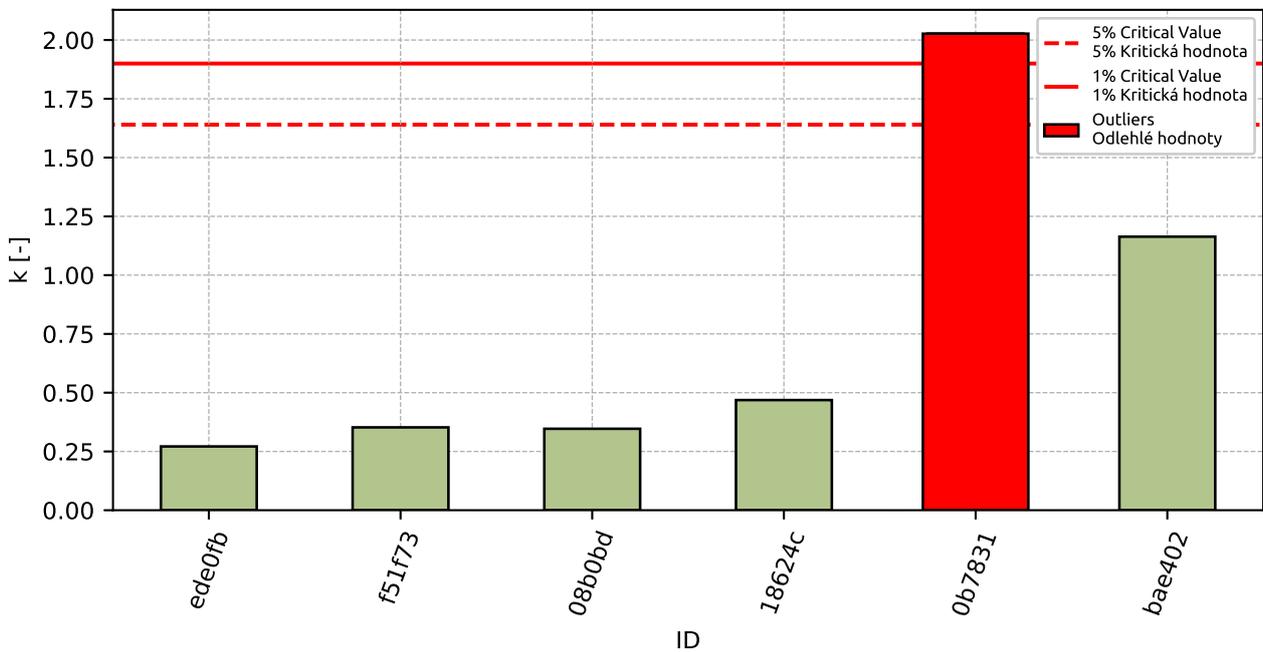
Figure 97: Intralaboratory Consistency Statistic

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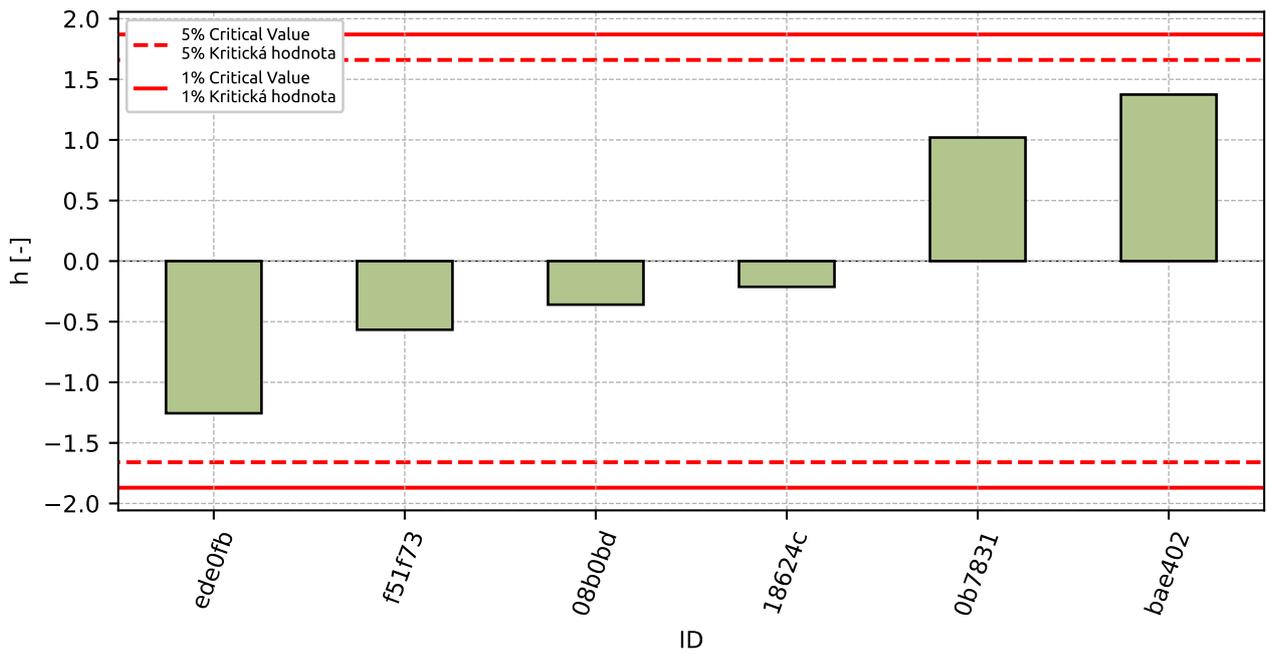
Figure 98: Interlaboratory Consistency Statistic

8.2.4 Descriptive statistics
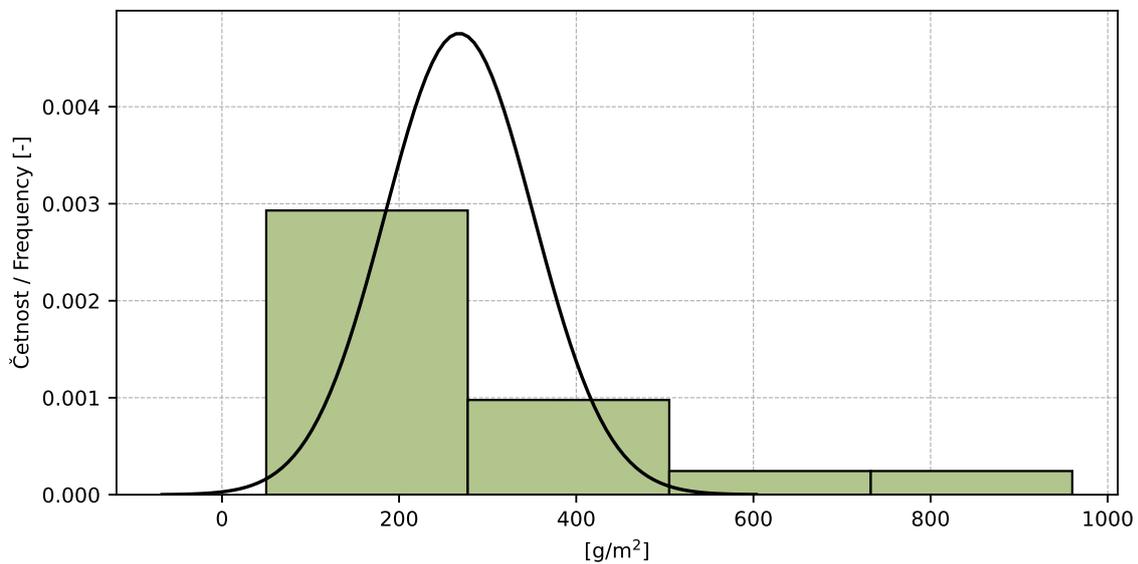
Figure 99: Histogram of all test results

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Table 38: Descriptive statistics

| Characteristics	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	267.8
Výběrová směrodatná odchylka / Sample standard deviation – s	83.87
Vztažná hodnota / Asigned value – x^*	267.8
Robustní směrodatná odchylka / Robust standard deviation – s^*	86.82
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	44.31
p-hodnota testu normality / p-value of normality test	0.0 [-]
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	259.19
Opakovatelnost / Repeatability – r	725.7

8.2.5   Evaluation of Performance Statistics
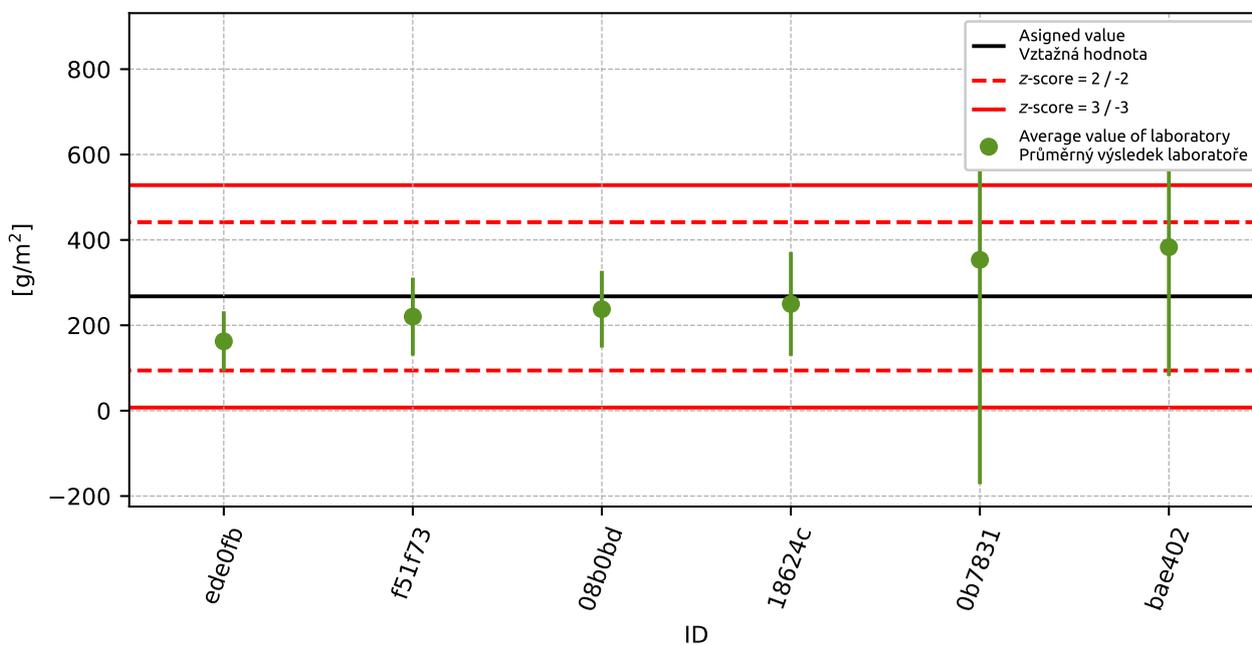
Figure 100: Average values and sample standard deviations

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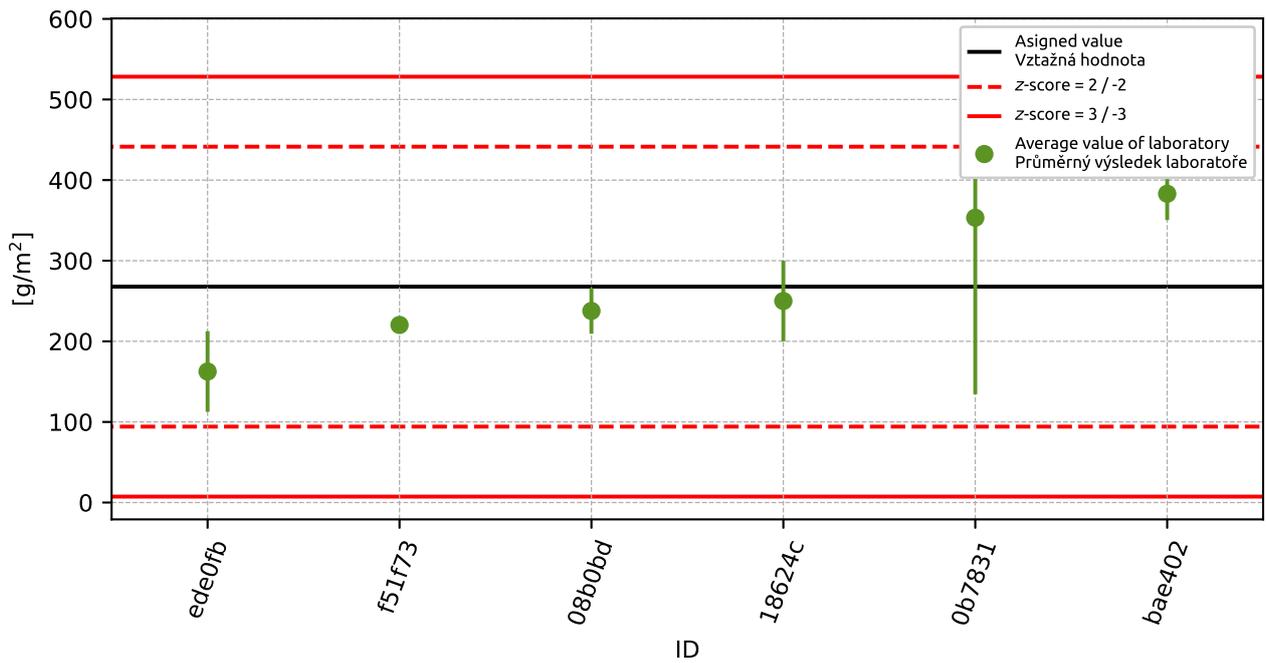
Figure 101: Average values and extended uncertainties of measurement

Figure 102: z-score

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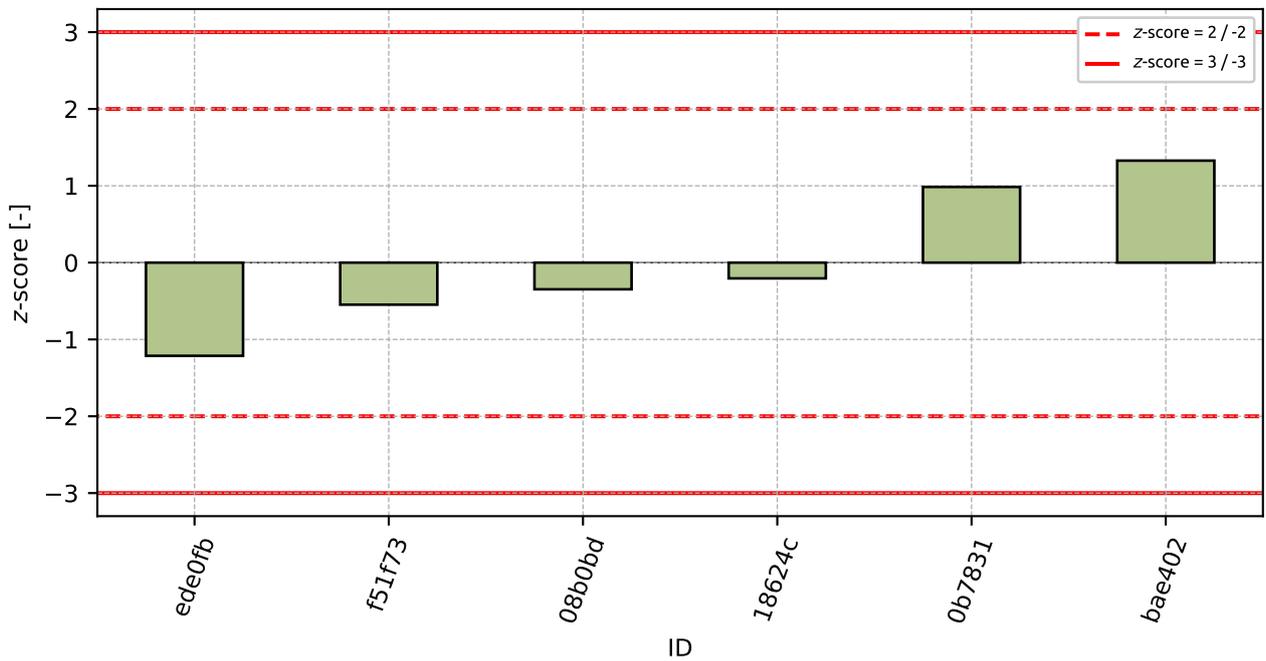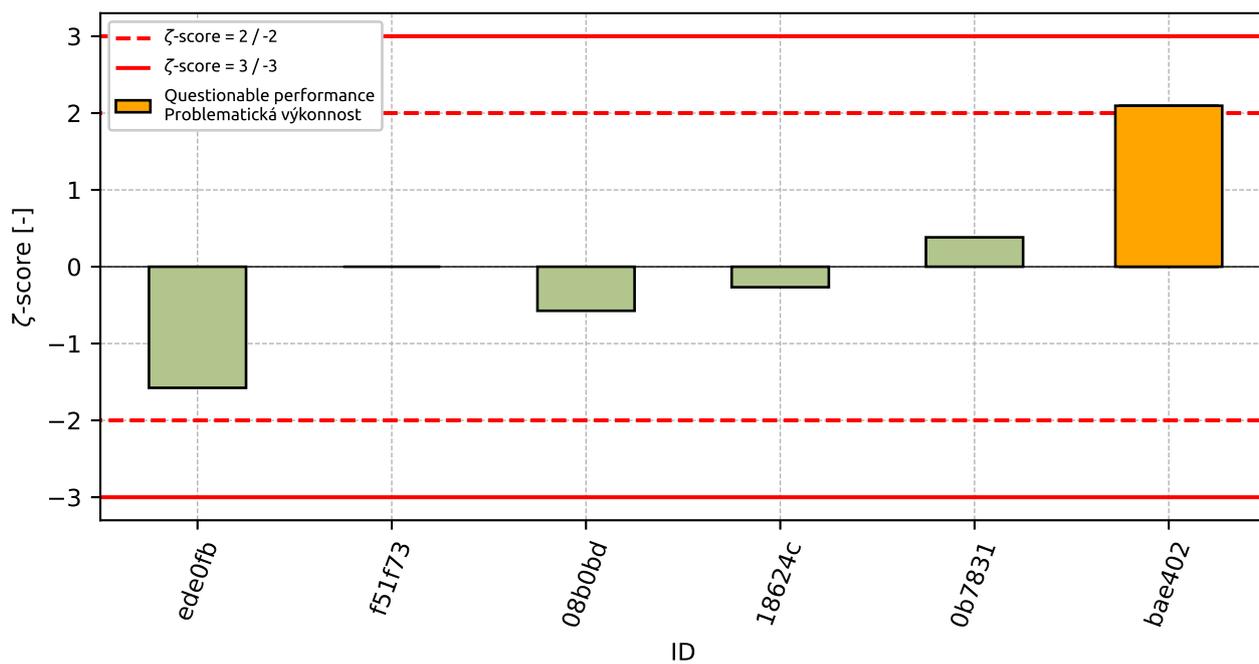
Figure 103: ζ-score

Table 39: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ede0fb	-1.21	-1.58
f51f73	-0.55	-
08b0bd	-0.35	-0.57
18624c	-0.21	-0.27
0b7831	0.99	0.38
bae402	1.33	2.1

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8.3   75 cycles

8.3.1   Test results

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

ID	Test results			u_X	$\bar{x}$	s_0	V_X
	[g/m^2]			[g/m^2]	[g/m^2]	[g/m^2]	[%]
0b7831	210.0	224.0	240.0	512.0	224.7	15.01	6.68
f51f73	161.1	266.6	333.3	-	253.7	86.83	34.23
ede0fb	188.5	448.5	266.5	50.0	301.2	133.42	44.3
18624c	891.0	358.0	336.0	105.7	528.3	314.27	59.48
08b0bd	673.4	1080.8	543.2	91.1	765.8	280.46	36.62
bae402	1194.0	978.9	525.3	88.3	899.4	341.37	37.95

8.3.2   The Numerical Procedure for Determining Outliers
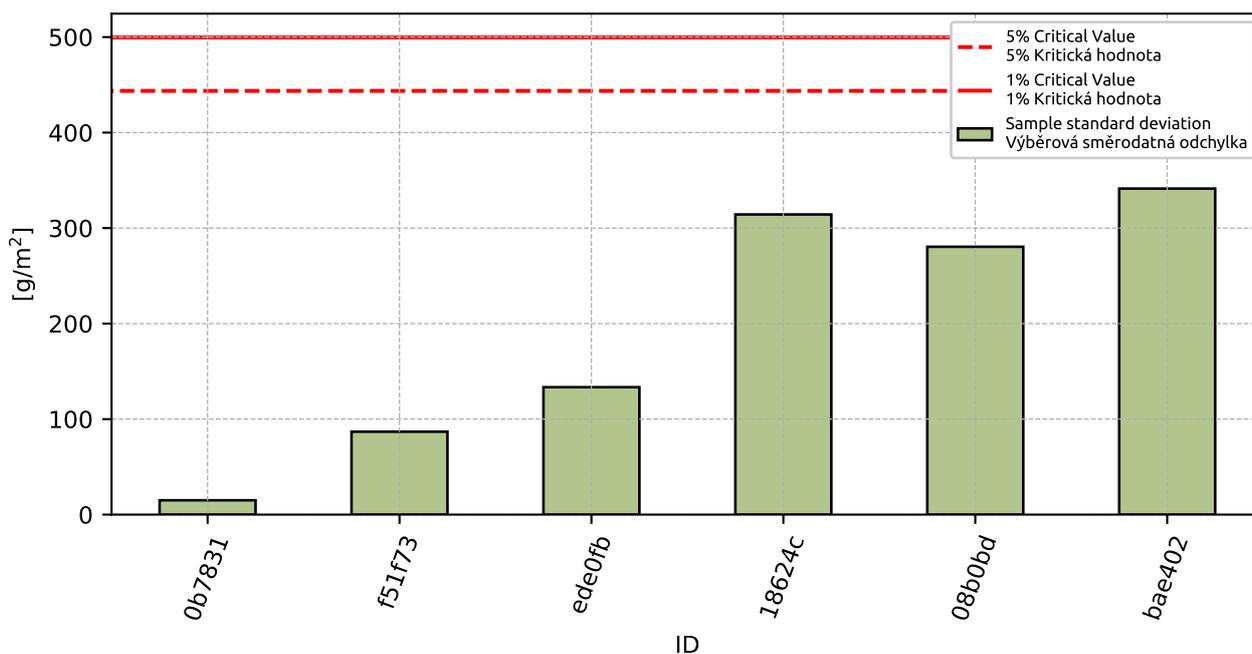
Figure 104: **Cochran's test** - sample standard deviations

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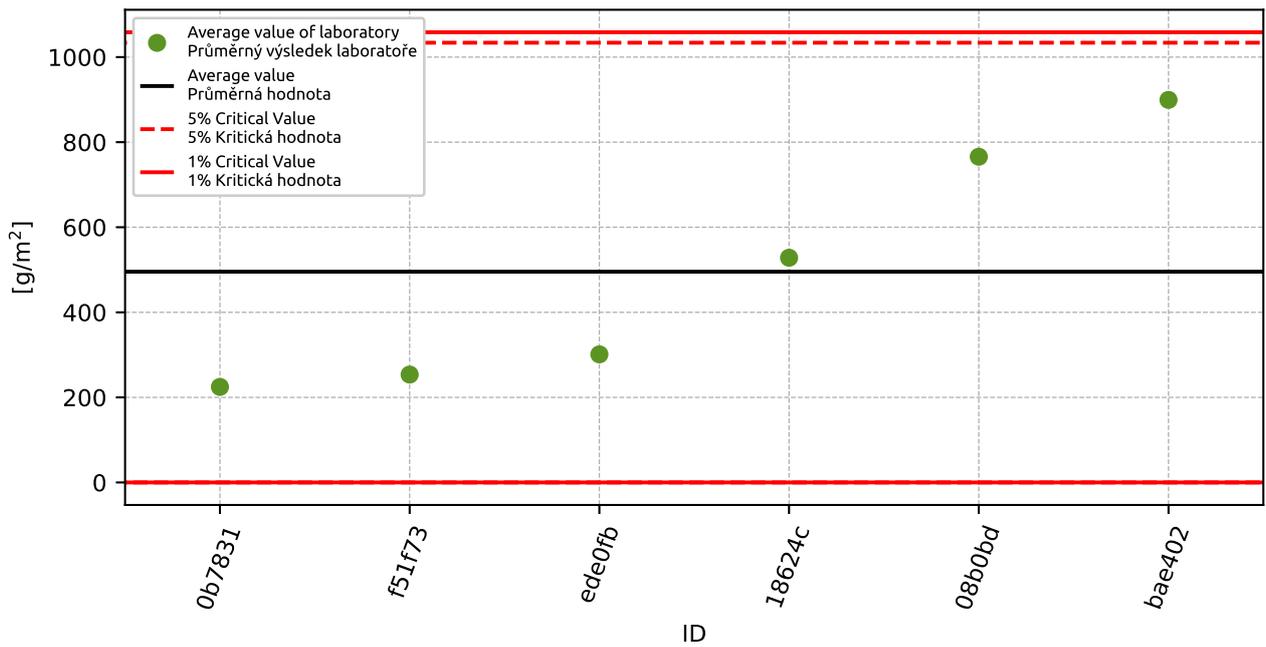
Figure 105: **Grubbs' test** - average values

8.3.3 Mandel's Statistics
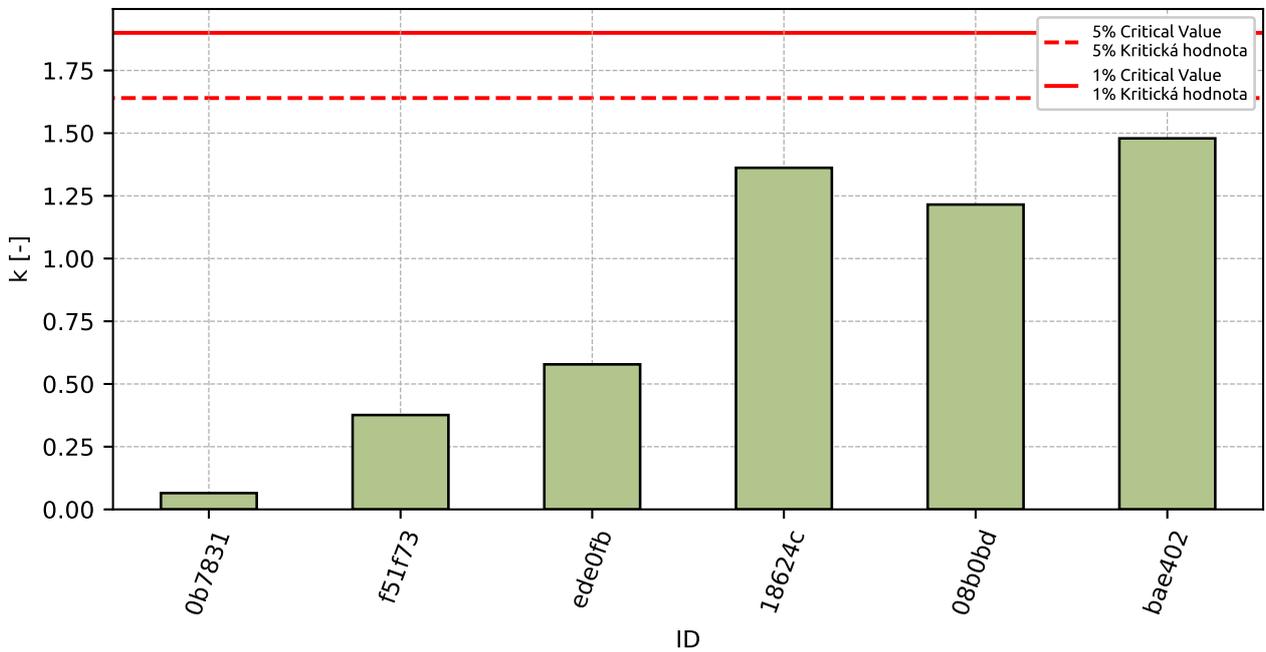
Figure 106: Intralaboratory Consistency Statistic

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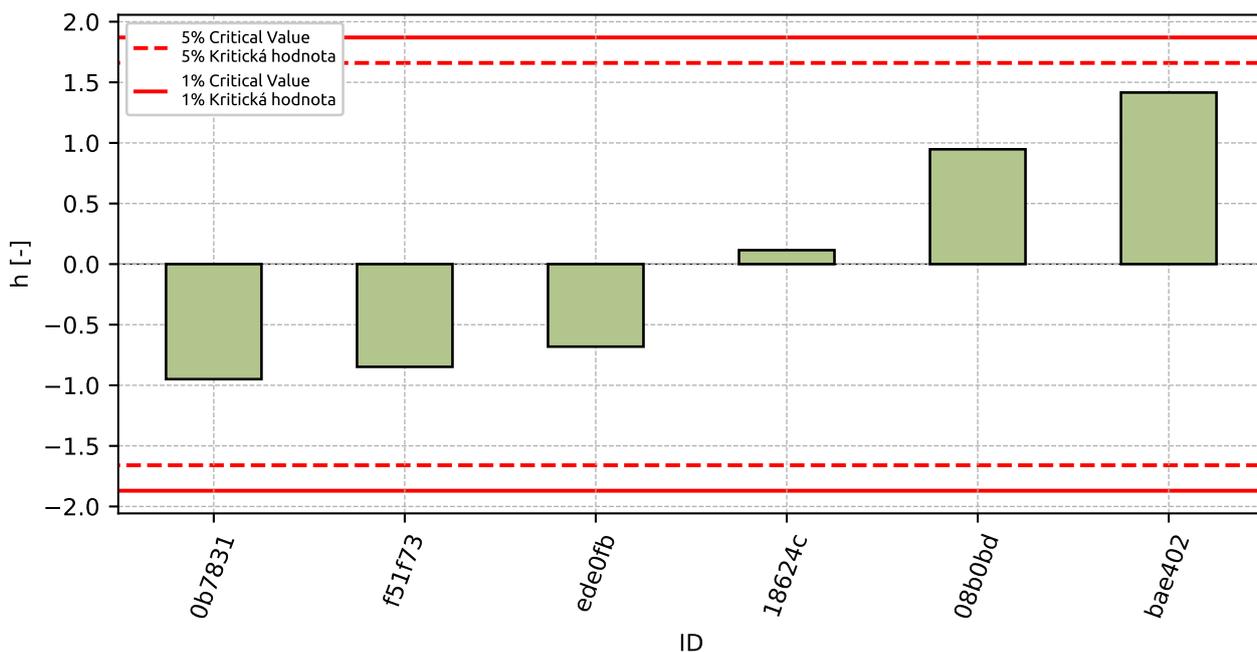
Figure 107: Interlaboratory Consistency Statistic

8.3.4   Descriptive statistics
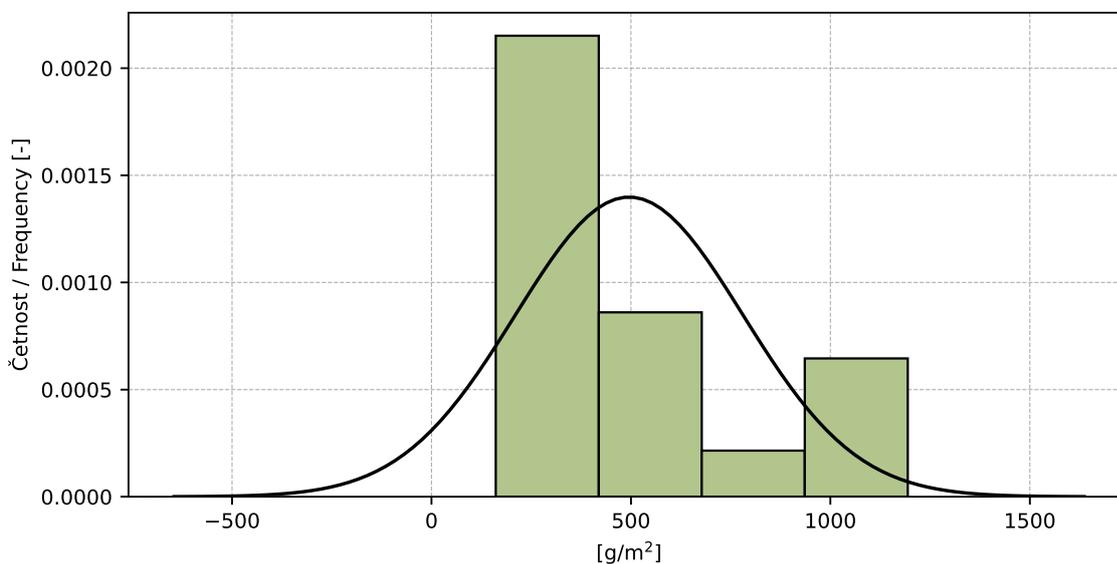
Figure 108: Histogram of all test results

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Table 41: Descriptive statistics

| Characteristics	[g/m^2]
Průměrná hodnota / Average value – $\bar{x}$	495.5
Výběrová směrodatná odchylka / Sample standard deviation – s	285.26
Vztažná hodnota / Asigned value – x^*	495.5
Robustní směrodatná odchylka / Robust standard deviation – s^*	295.3
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	150.7
p-hodnota testu normality / p-value of normality test	0.008 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	252.24
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	230.77
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	341.87
Opakovatelnost / Repeatability – r	646.1
Reprodukovatelnost / Reproducibility – R	957.2

8.3.5   Evaluation of Performance Statistics
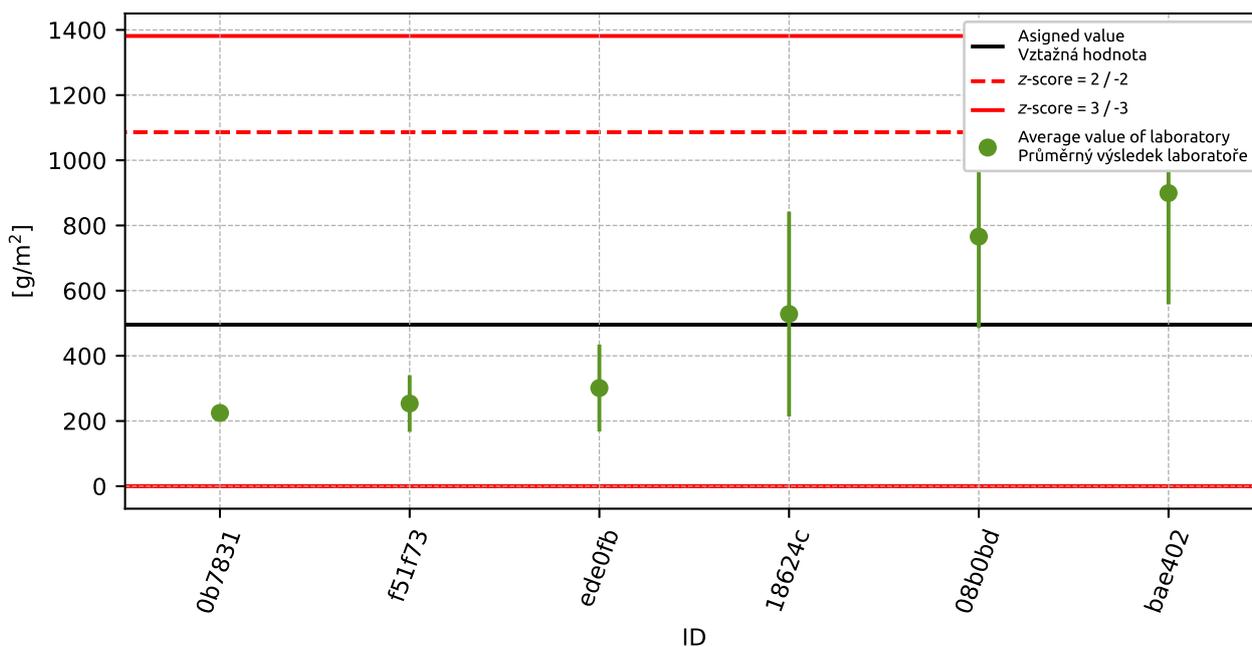
Figure 109: Average values and sample standard deviations

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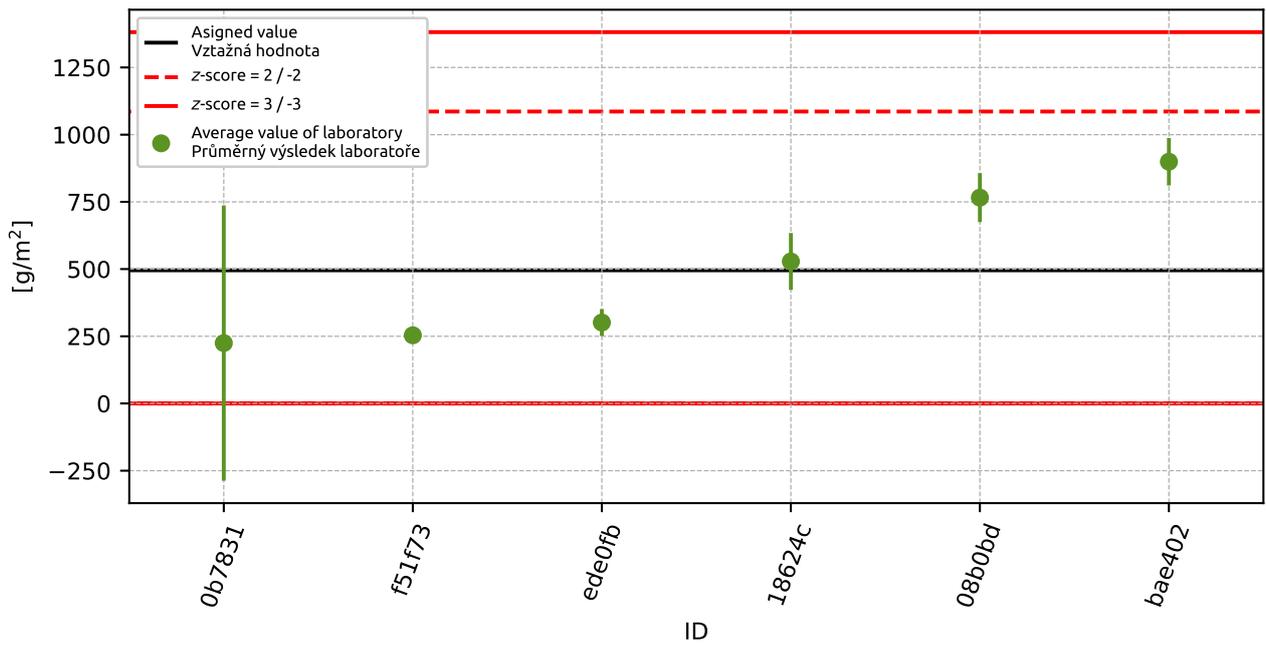
Figure 110: Average values and extended uncertainties of measurement

Figure 111: z-score

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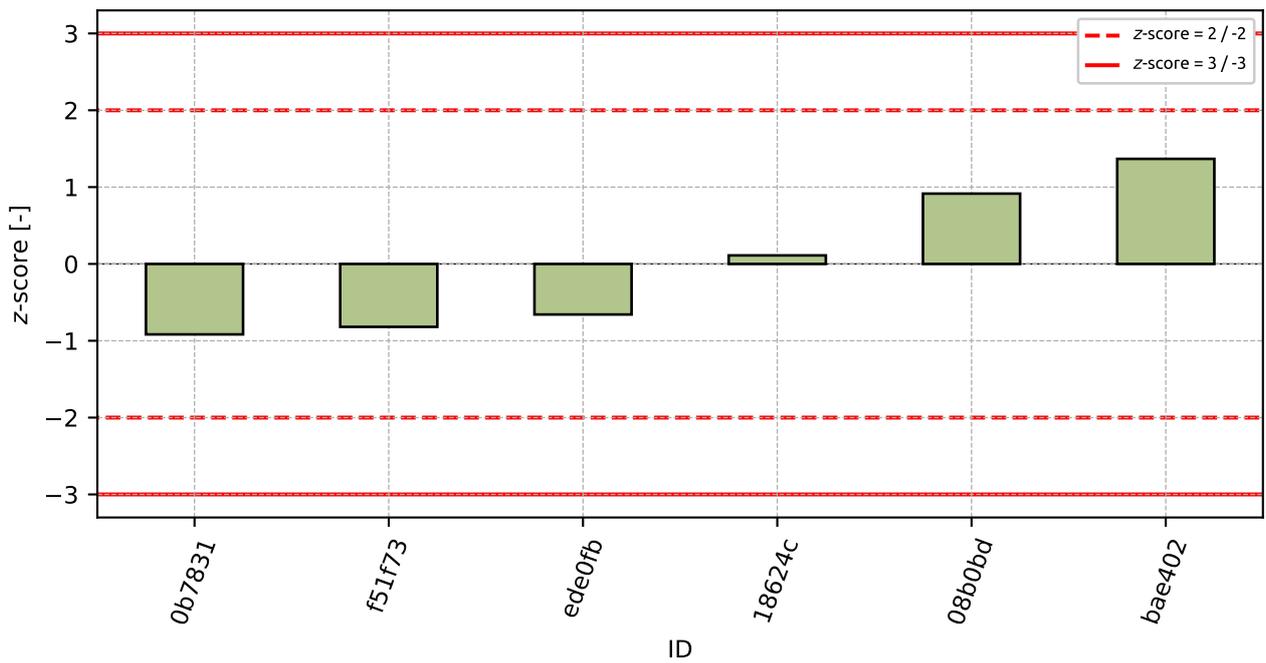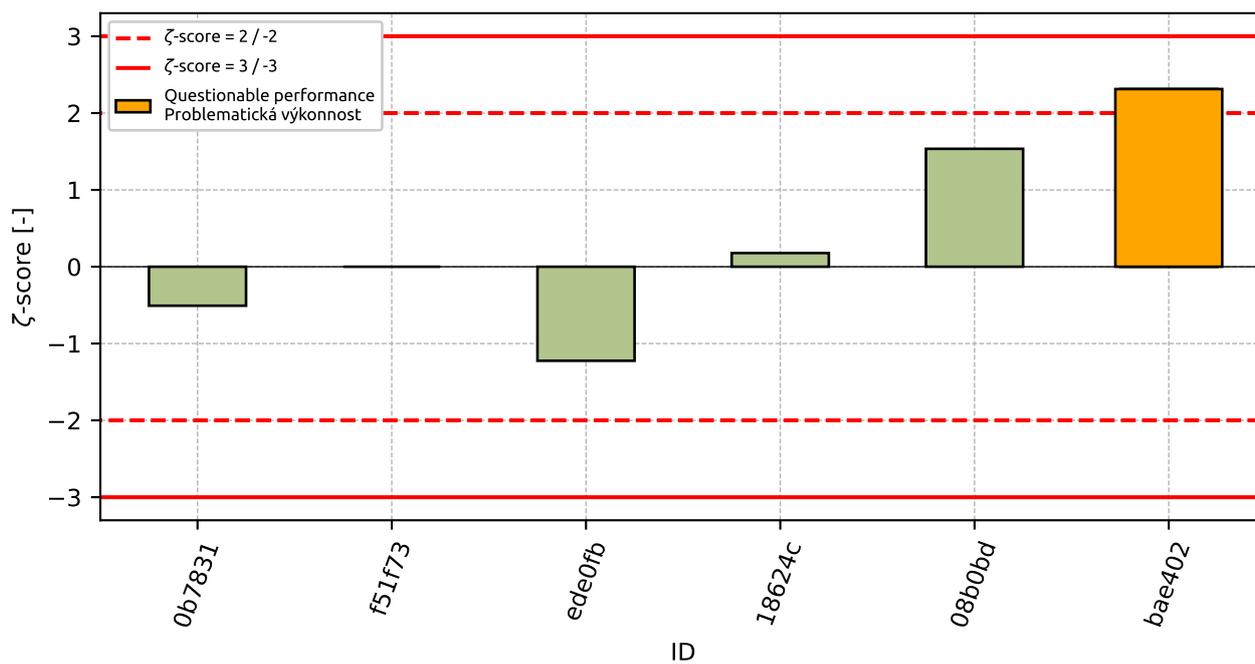
Figure 112: ζ-score

Table 42: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
0b7831	-0.92	-0.51
f51f73	-0.82	-
ede0fb	-0.66	-1.22
18624c	0.11	0.18
08b0bd	0.92	1.53
bae402	1.37	2.31

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

9.1 Test results

Table 43: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
566549	0.38	0.38	0.45	0.07	0.4	0.04	10.02
b57ea7	23.0	23.0	26.0	4.0	24.0	1.732	7.22
592ba1	35.88	26.84	32.82	9.26	31.85	4.598	14.44
01375e	20.0	40.0	40.0	12.0	33.33	11.547	34.64
85e4d1	51.1	32.6	51.5	4.5	45.07	10.798	23.96

9.2 The Numerical Procedure for Determining Outliers
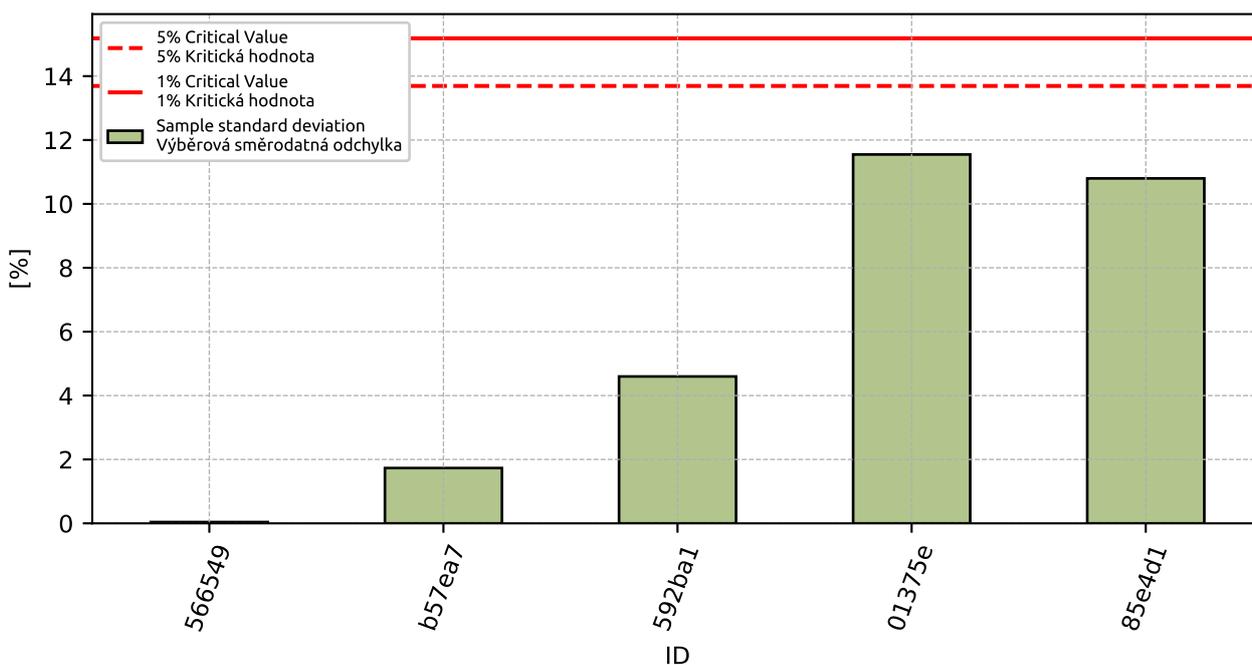
Figure 113: **Cochran's test** - sample standard deviations

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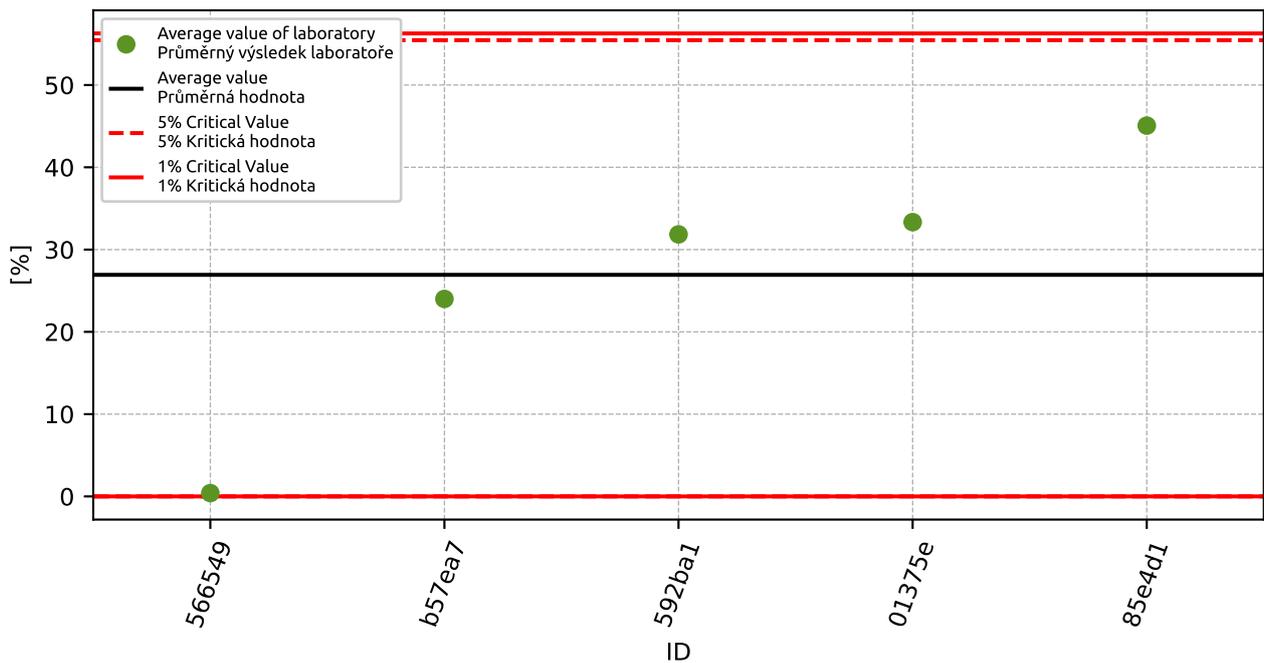
Figure 114: **Grubbs' test** - average values

9.3   Mandel's Statistics
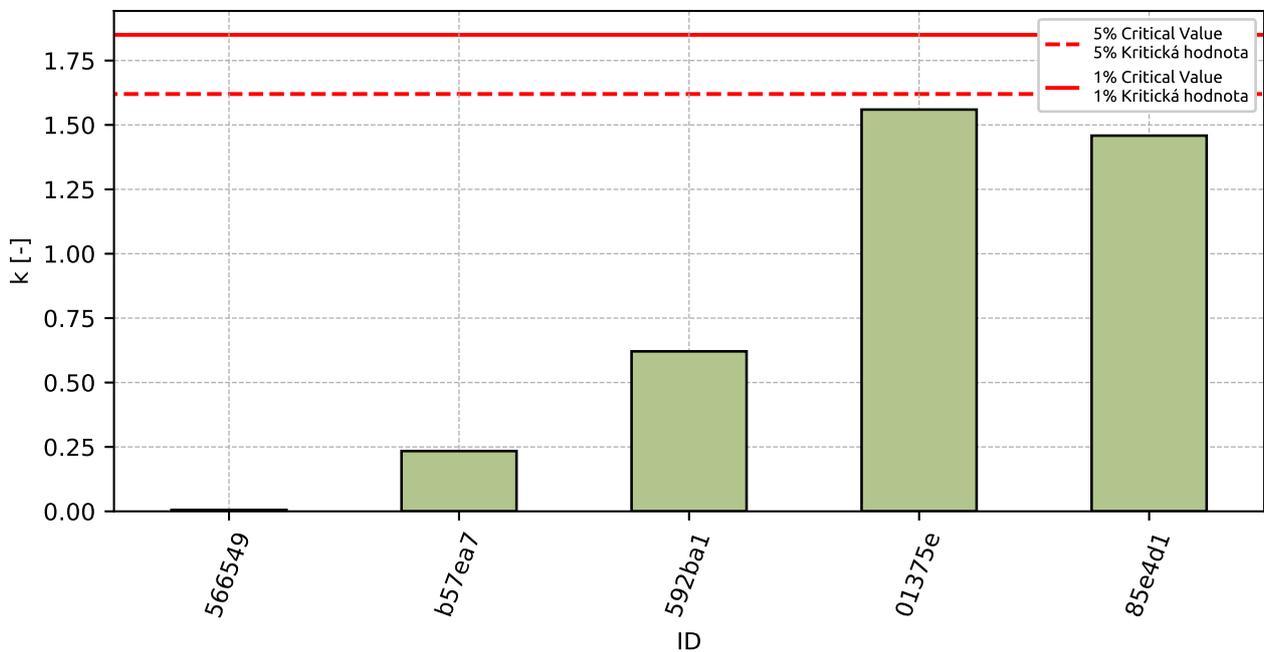
Figure 115: Intralaboratory Consistency Statistic

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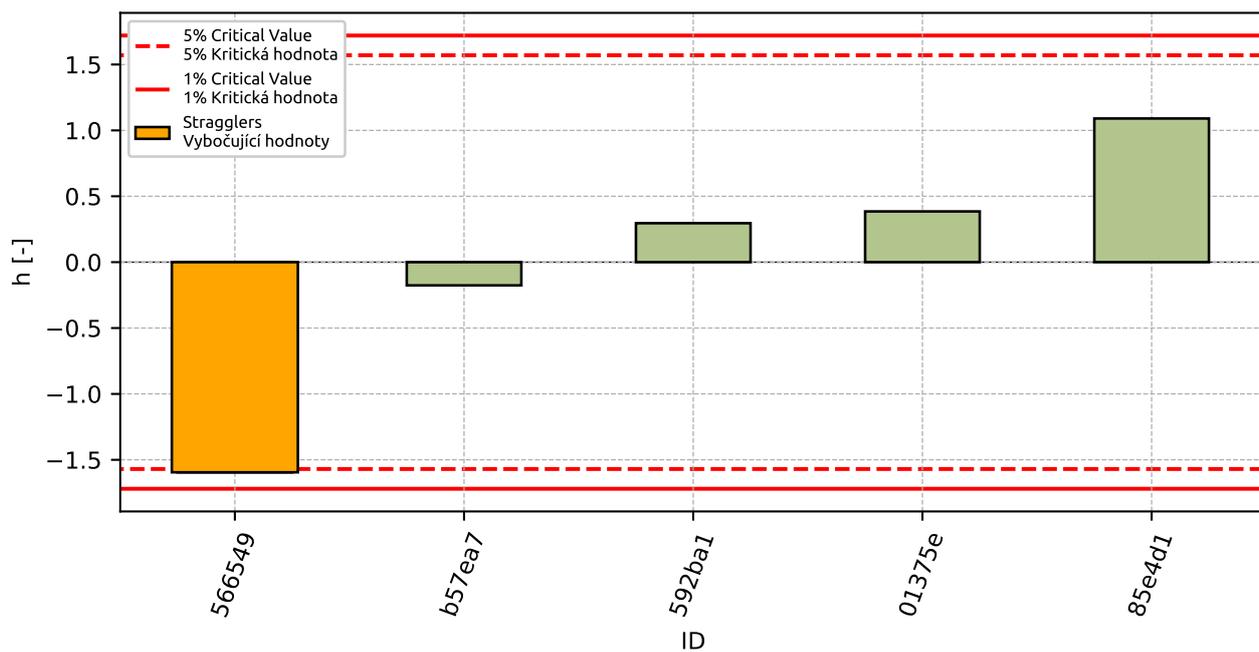
Figure 116: Interlaboratory Consistency Statistic

9.4 Descriptive statistics
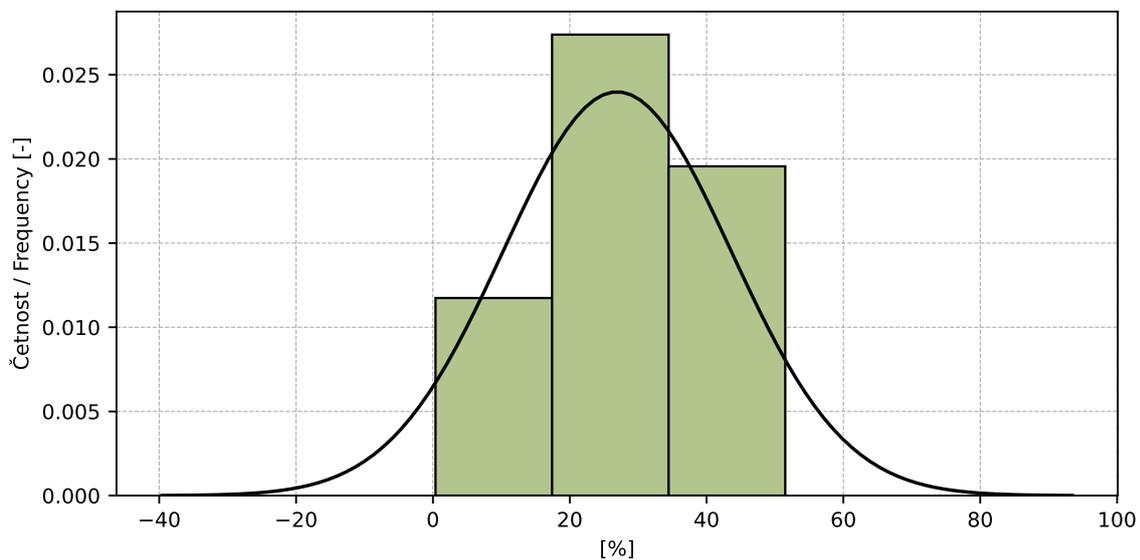
Figure 117: Histogram of all test results

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Table 44: Descriptive statistics

Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	26.93
Výběrová směrodatná odchylka / Sample standard deviation – s	16.631
Vztažná hodnota / Asigned value – x^*	29.73
Robustní směrodatná odchylka / Robust standard deviation – s^*	11.573
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	6.47
p-hodnota testu normality / p-value of normality test	0.185 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	16.072
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	7.404
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	17.696
Opakovatelnost / Repeatability – r	20.73
Reprodukovatelnost / Reproducibility – R	49.55

## 9.5   Evaluation of Performance Statistics
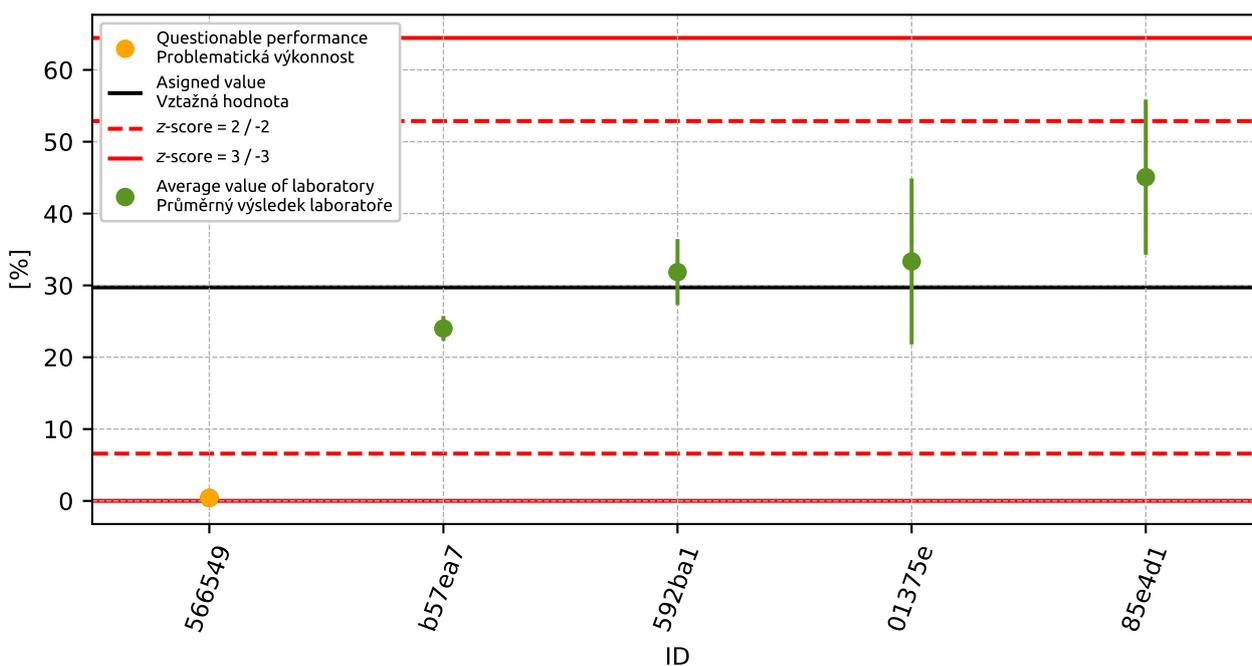
Figure 118: Average values and sample standard deviations

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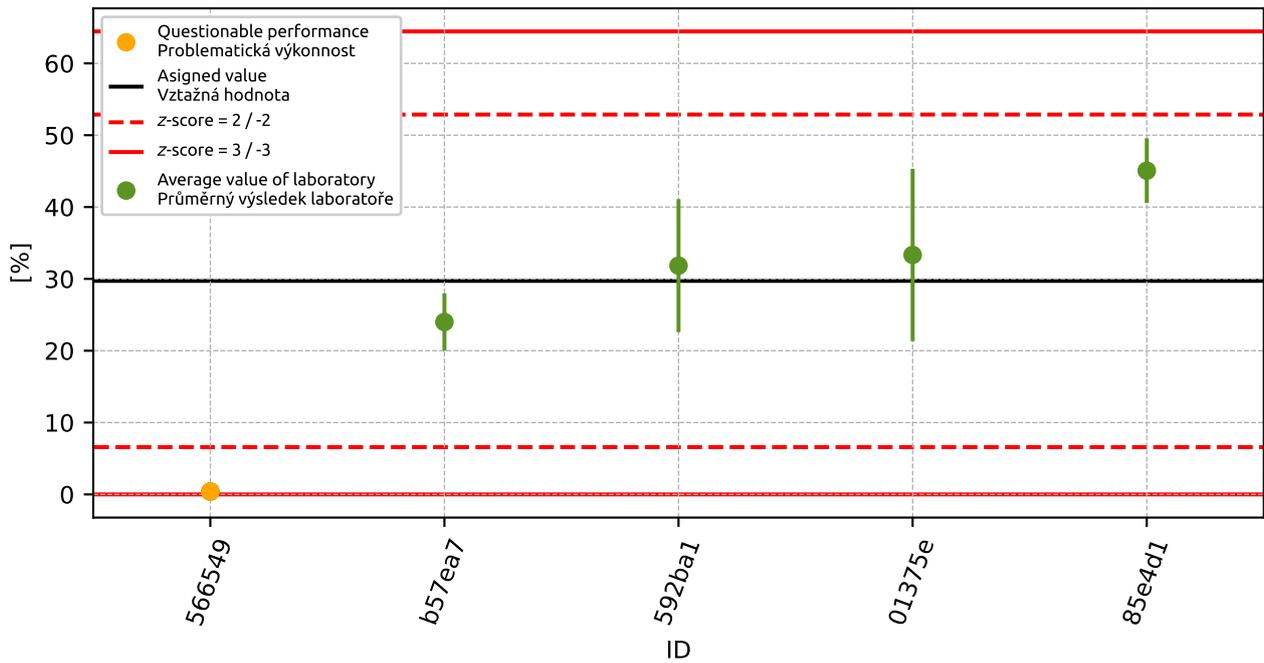
Figure 119: Average values and extended uncertainties of measurement

Figure 120: z-score

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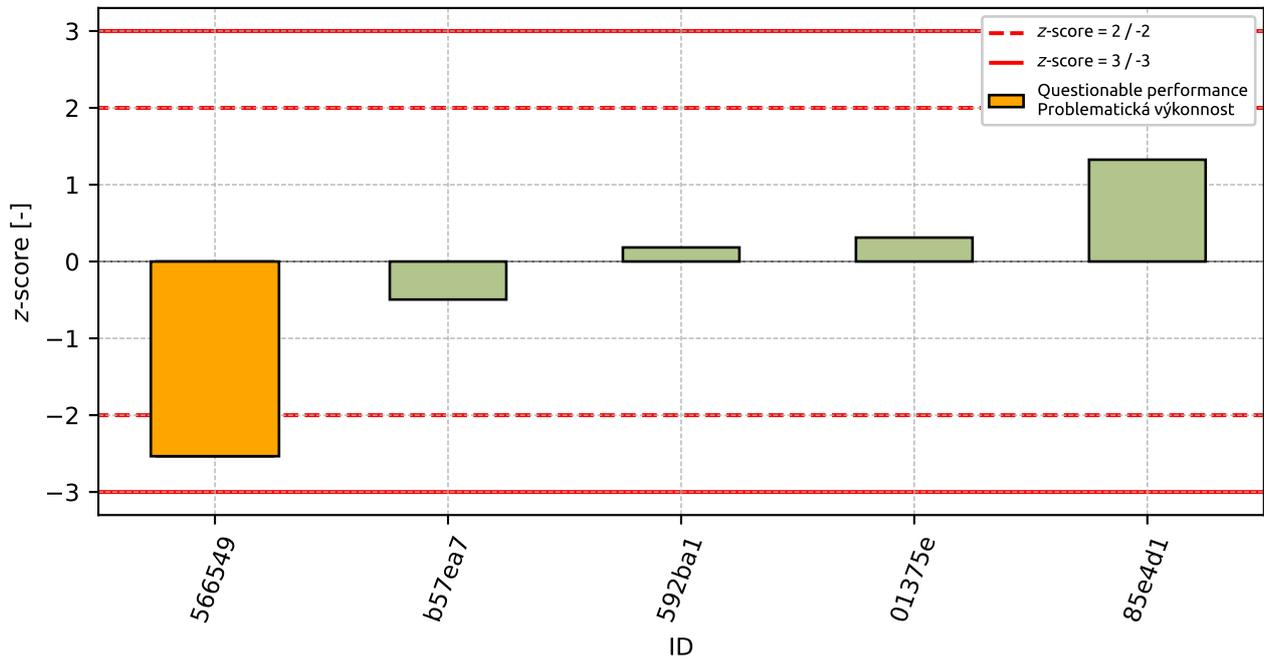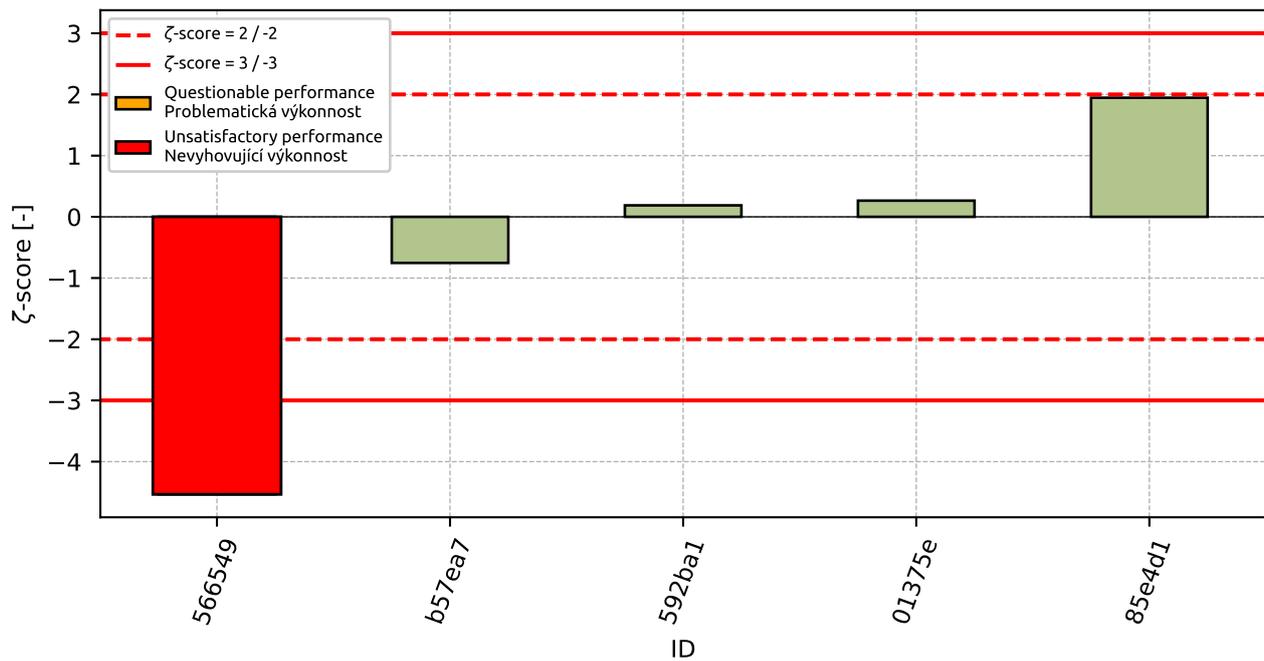
Figure 121: ζ-score

Table 45: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
566549	-2.53	-4.53
b57ea7	-0.49	-0.75
592ba1	0.18	0.19
01375e	0.31	0.26
85e4d1	1.33	1.95

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