BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
institute of building testing

ilac-MRA

Z 7008

FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Soil Testing
ZZ 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

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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 ZZ 2020/1 whose aim was to verify and assess the conformity of test results across laboratories when testing soils.

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 ISO 17892-1 Geotechnical investigation and testing - Laboratory testing of soil - Part 1: Determination of water content [1],
2. EN ISO 17892-3 Geotechnical investigation and testing - Laboratory testing of soil - Part 3: Determination of particle density [2],
3. EN ISO 17892-4 Geotechnical investigation and testing - Laboratory testing of soil - Part 4: Determination of particle size distribution [3],
4. EN ISO 17892-5 Geotechnical investigation and testing - Laboratory testing of soil - Part 5: Incremental loading oedometer test [4],
5. EN ISO 17892-7 Geotechnical investigation and testing - Laboratory testing of soil - Part 7: Unconfined compression test [5],
6. CEN ISO/TS 17892-10 Geotechnical investigation and testing - Laboratory testing of soil - Part 10: Direct shear tests [6],
7. EN ISO 17892-12 Geotechnical investigation and testing - Laboratory testing of soil - Part 12: Determination of liquid and plastic limits [7],
8. EN 13286-2 Unbound and hydraulically bound mixtures - Part 2: Test methods for laboratory reference density and water content -Proctor compaction [8],
9. EN 13286-47 Unbound and hydraulically bound mixtures - Part 47: Test method for the determination of California Bearing ratio, immediate bearing index and linear swelling [9].

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.

46 laboratories from Europe took part in the program. In order to maintain the anonymity of the PTP, each laboratory was given an identification number that will be used henceforth in this document. An integral part of the present final report is a Certificate of Participation in the Proficiency Testing Program. It is unique for each participant and includes the participant's ID used in this report. The following chart shows the participation of laboratories in individual parts of the PTP.

Table 1: Participation of individual laboratories in the PTP

ID/Method	1	2	3	4	5	6	7	8	9
326a1e	-	-	-	-	-	X	-	-	-
6e00c8	X	-	-	-	-	-	-	-	-
b1cde8	X	X	X	X	X	X	-	X	X
784bc8	-	-	-	-	-	-	-	X	X
46073a	X	X	X	-	-	-	X	X	X
063fae	X	X	X	-	-	-	X	-	X
2a33ae	-	-	X	X	-	-	-	-	-
f58f15	X	-	-	-	-	-	-	-	-
337ed8	X	-	X	-	-	-	X	-	-
b83369	-	X	-	-	X	X	-	-	-
c0cb8d	X	-	-	-	-	-	-	-	-
7b95a7	X	-	X	-	-	-	-	-	-
c356d4	X	-	-	-	-	X	X	X	-
54619e	X	-	-	-	-	-	-	X	-
574330	-	X	X	-	-	-	-	X	X
bfa8ba	X	-	X	-	-	-	-	-	-
4d6008	X	-	-	-	-	-	-	-	-
b9d4d8	X	-	-	-	-	-	-	-	-
23baf0	X	X	X	X	X	X	X	X	-
39f1b5	-	-	-	-	-	-	-	X	-
05e7f9	X	-	X	-	-	-	-	X	-
a6ea3e	X	X	X	-	-	-	X	X	X
6adc5c	X	-	X	-	-	-	X	-	-
416678	X	-	X	-	-	-	X	-	-
7e7687	X	-	X	-	-	-	X	-	-
05973c	X	-	X	-	-	-	X	-	-
cce554	X	-	X	-	-	-	X	-	-
6c6ace	-	-	-	-	-	-	-	X	-
c9711f	-	-	-	X	-	X	-	-	-
47c275	X	X	X	-	-	-	X	X	X
fb08d9	X	-	-	-	-	-	-	-	-
0ce4c1	-	-	-	-	-	-	-	X	-
aa5576	X	-	-	-	-	-	-	X	X
baa257	-	-	X	-	-	-	X	-	-
7453ba	-	X	-	-	-	-	-	X	X
581a3d	X	X	X	X	X	X	-	X	X
6b079d	-	-	-	-	-	-	-	X	-
b018b1	X	X	X	X	X	X	X	X	X
b620ea	X	X	X	X	-	-	-	X	-
27f94b	-	-	-	-	-	-	X	X	X
6c73e9	X	-	X	-	-	-	X	X	X
e111a4	X	-	-	-	-	-	-	X	-
3e11f6	X	-	-	-	-	-	-	X	X
e09919	X	-	X	-	-	-	X	-	-

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ID/Method	1	2	3	4	5	6	7	8	9
747268	X	X	X	X	X	X	-	X	X

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

Laboratory	Address	Accreditation number
4G consite s.r.o.	Šlikova 406/29, Praha 6, 169 00, Česká republika	1518
A.D. Zavod za geotehniku	Segedinski put 86, Subotica, 24000, Serbia	01-334
AZ Consult, spol. s r.o., Laboratoř AZ Consult	Klíšská 1334/12, Ústí nad Labem, 400 01, 44567430	1740
B-PROJEKTY Teplice s.r.o.	Kollárova 1879/11, Teplice, 415 01, Česká republika	AZL 1428
Centrum dopravního výzkumu v.v.i.	Líšeňská 33a, Brno, 63600, Česká republika	1506
DSP a.s.	Kostěnice 111, Pardubice, 530 02, Česká republika	-
Dimitra Barbagianni	89 Chlois & Likovriseos, Metamorfosi, 14452, Athens	-
EIE ECHEVERRY INGENIERIA Y ENSAYOS SAS	CARRERA 29C 71A-30, Bogota D.C, 111211, Cundinamarca	-
Estonian Environmental Research Centre	Marja 4d, Tallinn, 10617, Estonia	L008
GEMATEST s.r.o.	Dr.Janského 954, Černošice - Praha západ, 25228, Česká republika	1291
GEOPUT DOO BEOGRAD	Tome Rosandića 2, Beograd, 11010, Srbija	126 366206
Geom d.o.o. Beograd	Kumodraska 328/1a, Belgrade, 11000, Serbia	01-337
Geotest, a.s.	Šmahova 1244/112, Brno, 62700, 46344942	1271.2
IBIS - INŽENJERING d.o.o.	Omladinska 28, Banja Luka, 78000, Bosnia & Herzegovina	-
IGH d.o.o.	Bišće polje bb, Mostar, 88000, Bosna i Hercegovina	BATA LI-31-01
Institut za građevinarstvo "IG" Banja Luka	Kralja Petra I Karađorđevića 95-98, Banja Luka, 78000, Bosna i Hercegovina	-
JV EPTISA SERVICIOS DE INGENIERIA SL – THEODOROS PAPAIOANNOU	15A XENOFONTOS Str., ATHENS, 105 57, GREECE	-
KOLEJCONSULT & servis, spol. s r.o.	Křenová 131/35, Brno, 60200, Česká republika	1305
Laboratoire des Travaux Publics de l'Ouest LTP-Ouest	Rond point des Castors, Oran, 31014, ALGERIA	-
Laboratorija Koridori Srbije	Kralja Petra 21, Beograd, 11000, Srbija	-

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Laboratory	Address	Accreditation number
M.I.S. a.s.	Resslova 956/13, Hradec Králové, 500 02, Česká republika	1197
Ministeries van de Vlaamse Gemeenschap – Departement mobiliteit en openbare werken - Geotechniek	Technologiepark-Zwijnaarde 68, Gent, 9000, Belgium	-
NIEVELT Labor CZ s.r.o.	Za Olomouckou 4184/17, Prostějov, 79601, Česká republika	1716
Národná diaľničná spoločnosť a.s.	Dúbravská cesta 14, Bratislava, 841 04, Slovenská republika	456/S-328
QUALIFORM, a.s.	Mlaty 672/8, Brno-Bosonohy, 642 00, Česká republika	1008
Rudarski institut d.d. Tuzla	Rudarska 72, Tuzla, 75000, Bosna i Herzegovina	LI-47-01
Rudarski institut d.o.o Beograd	Batajnički put br.2, Beograd-Zemun, 11080, Srbija	01-309
S.C. GEOSTUD S.R.L.	Str. Sîngerului, nr. 11, sector 1„ Bucharest, 014617, Romania	LI 974
SQZ, s.r.o. - Ústřední laboratoř Olomouc - pracoviště Olomouc	U místní dráhy 939/5, Olomouc, 779 00, Česká republika	1135.1
Slovenská správa ciest - IVSC BA	Miletičova 19, Bratislava, 820 05, Slovenská republika	S-281
TEPVERAM s.r.o.	Třibřichy 13, Třibřichy, 53701, Česká republika	-
TPA EOOD CTC KREPOST	Rezbarska str. № 7, SOFIA, 1510, BULGARIA	-
TPA Spoločnosť pre zabezpečenie kvality a inovácie s.r.o - pracovisko Geča	Neresnická cesta 3, Zvolen, 960 01, Slovenská republika	211/S-176
TPA Spoločnosť pre zabezpečenie kvality a inovácie s.r.o - pracovisko K2	Neresnická cesta 3, Zvolen, 960 01, Slovenská republika	211/S-176
TPA Spoločnosť pre zabezpečenie kvality a inovácie s.r.o - pracovisko Podunajské Biskupice	Neresnická cesta 3, Zvolen, 960 01, Slovenská republika	211/S-176
TPA Spoločnosť pre zabezpečenie kvality a inovácie s.r.o - pracovisko Zvolen	Neresnická cesta 3, Zvolen, 960 01, Slovenská republika	211/S-176
TPA za obezbeđenje kvaliteta i inovacije d.o.o. Beograd	Milutina Milankovića 3B, Novi Beograd, 11070, Serbia	01-280
University Of Belgrade, Faculty of Civil Engineering	Bulevar kralja Aleksandra 73, Belgrade, 11000, Serbia	-
VIALAB CZ s.r.o. - Laboratoř Morava, LM3	PO BOX 207; MUCODE 1592, Praha 6, 160 41, Česká republika	1170
VIALAB CZ s.r.o. - Laboratoř Morava, LM4	PO Box 207; MUCODE 1592, Praha 6, 160 41, Česká republika	1170
VIALAB CZ, s.r.o. - Laboratoř Morava, LM1	PO Box 207; MUCODE 1592, Praha 6, 160 41, Česká republika	1170

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Laboratory	Address	Accreditation number
Vysoké učení technické v Brně, Fakulta stavební, Akreditovaná zkušební laboratoř při ÚTHD FAST VUT v Brně	Veveří 331/95, Brno, 60200, Česká republika	L1396
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2018
České vysoké učení technické v Praze, Fakulta stavební, Katedra železničních staveb	Thákurova 7„ Praha 6 - Dejvice, 166 29, ČR	1048
Ředitelství silnic a dálnic ČR	Rebešovická 40, Brno-Chrlice, 643 00, Česká republika	1072

2 Procedures used in the Statistical Analysis of Laboratory Results

The statistical analysis is based on the following steps:

1. Evaluation of intralaboratory variabilities by Cochran's C test: If 5% or 1% critical value is exceeded, the effect of the individual observations is first considered. If the results indicate that high participant variability is caused by a single observation, this value is excluded from the experiment, but the participant is not excluded as outlying. By overcoming 1% of the critical value, the participant's results can be marked as outlying and excluded from the experiment (symbol **X**).
2. The numerical critical evaluation of the test results using Grubbs' test: By overcoming 1% critical value, the participant's results can be marked as outlying and excluded from the experiment (symbol **X**).
3. Graphical determination of the consistency of laboratories (Mandel's statistics): The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies.
4. Evaluation of descriptive statistics and, if possible, taking into account the number of observations, the repeatability and reproducibility.
5. Evaluation of the assigned value.
6. The performance evaluation: The most significant outcome of the PT Program is the so-called z-score and ζ-score (zeta-score). These characteristics assess the performance of individual participants by comparing it with the assigned value and measurement uncertainties. z-score and ζ-score are compared with limit values. The resulting ζ-score values are not taken into account during the final evaluation of the performance of participants as they are to a considerable degree dependent on the values of the measurement uncertainties of the assessed institutions. The following scales are applied for the z-score values:
   - $|z\text{-score}| < 2 \Rightarrow$ shows that the laboratory performance is **satisfactory** and generates no signal – ✓.
   - $2 \leq |z\text{-score}| < 3 \Rightarrow$ shows that the laboratory performance is **questionable** and generates an action signal – **?**.
   - $|z\text{-score}| \geq 3 \Rightarrow$ shows that the laboratory performance is **unsatisfactory** and generates an action signal – **!**.

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

3 Conclusions of the Statistical Analysis

The present report summarizes the results of the Proficiency Testing Program Soil Testing (PT Program) organized by the PT Provider at the SZK FAST. 46 participants (laboratories) took part in the PT Program. The program focused on ordinary standardized testing of soil. 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.

In the evaluation of test No. 1, 1% critical value of the Cochran's test was exceeded in the case of participant b1cde8. As the participant provided fewer test results than the other participants, this exceedance was not taken into account in the overall evaluation.

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
326a1e	-	-	-	-	-	!	-	-	-
6e00c8	✓	-	-	-	-	-	-	-	-
b1cde8	✓	✓	X	✓	✓	✓	-	✓	✓
784bc8	-	-	-	-	-	-	-	✓	✓
46073a	✓	?	✓	-	-	-	✓	✓	✓
063fae	✓	✓	✓	-	-	-	✓	-	✓
2a33ae	-	-	✓	✓	-	-	-	-	-
f58f15	✓	-	-	-	-	-	-	-	-
337ed8	✓	-	✓	-	-	-	✓	-	-
b83369	-	✓	-	-	✓	✓	-	-	-
c0cb8d	✓	-	-	-	-	-	-	-	-
7b95a7	✓	-	✓	-	-	-	-	-	-
c356d4	✓	-	-	-	-	✓	✓	✓	-
54619e	✓	-	-	-	-	-	-	✓	-
574330	-	✓	✓	-	-	-	-	✓	✓
bfa8ba	✓	-	✓	-	-	-	-	-	-
4d6008	✓	-	-	-	-	-	-	-	-
b9d4d8	✓	-	-	-	-	-	-	-	-
23baf0	✓	✓	✓	✓	✓	✓	✓	✓	-
39f1b5	-	-	-	-	-	-	-	✓	-
05e7f9	✓	-	✓	-	-	-	-	✓	-
a6ea3e	✓	✓	✓	-	-	-	✓	✓	✓
6adc5c	?	-	✓	-	-	-	✓	-	-
416678	?	-	✓	-	-	-	?	-	-
7e7687	✓	-	✓	-	-	-	?	-	-
05973c	✓	-	✓	-	-	-	!	-	-
cce554	✓	-	?	-	-	-	?	-	-

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ID / Method	1	2	3	4	5	6	7	8	9
6c6ace	-	-	-	-	-	-	-	✓	-
c9711f	-	-	-	✓	-	!	-	-	-
47c275	✓	✓	✓	-	-	-	✓	✓	✓
fb08d9	✓	-	-	-	-	-	-	-	-
0ce4c1	-	-	-	-	-	-	-	✓	-
aa5576	✓	-	-	-	-	-	-	✓	✓
baa257	-	-	✓	-	-	-	✓	-	-
7453ba	-	✓	-	-	-	-	-	✓	✓
581a3d	✓	✓	✓	✓	✓	✓	-	✓	✓
6b079d	-	-	-	-	-	-	-	✓	-
b018b1	✓	✓	✓	✓	✓	✓	✓	✓	✓
b620ea	✓	✓	✓	✓	-	-	-	✓	-
27f94b	-	-	-	-	-	-	✓	✓	✓
6c73e9	✓	-	✓	-	-	-	✓	✓	✓
e111a4	✓	-	-	-	-	-	-	✓	-
3e11f6	✓	-	-	-	-	-	-	✓	✓
e09919	✓	-	✓	-	-	-	✓	-	-
747268	✓	✓	✓	✓	✓	✓	-	✓	✓

References

[1] EN ISO 17892-1. *Geotechnical investigation and testing - Laboratory testing of soil - Part 1: Determination of water content*. 2015.

[2] EN ISO 17892-3. *Geotechnical investigation and testing - Laboratory testing of soil - Part 3: Determination of particle density*. 2016.

[3] EN ISO 17892-4. *Geotechnical investigation and testing - Laboratory testing of soil - Part 4: Determination of particle size distribution*. 2017.

[4] EN ISO 17892-5. *Geotechnical investigation and testing - Laboratory testing of soil - Part 5: Incremental loading oedometer test*. 2017.

[5] EN ISO 17892-7. *Geotechnical investigation and testing - Laboratory testing of soil - Part 7: Unconfined compression test*. 2018.

[6] EN ISO 17892-10. *Geotechnical investigation and testing - Laboratory testing of soil - Part 10: Direct shear tests*. 2018.

[7] EN ISO 17892-12. *Geotechnical investigation and testing - Laboratory testing of soil - Part 12: Determination of liquid and plastic limits*. 2018.

[8] EN 13286-2. *Unbound and hydraulically bound mixtures - Part 2: Test methods for laboratory reference density and water content - Proctor compaction*. 2011.

[9] EN 13286-47. *Unbound and hydraulically bound mixtures - Part 47: Test method for the determination of California Bearing ratio, immediate bearing index and linear swelling*. 2012.

[10] ISO 5725-2. *Accuracy (trueness and precision) of measurement methods and results - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*. 1997.

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

1 Appendix – EN ISO 17892-1 – Water content

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 [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
e09919	11.3	11.5	11.2	2.0	11.3	0.15	1.35
6adc5c	18.3	18.3	18.1	-	18.2	0.12	0.63
416678	19.0	18.4	18.8	0.4	18.7	0.31	1.67
bfa8ba	19.2	19.1	19.1	0.4	19.2	0.03	0.18
e111a4	19.0	19.8	19.1	0.0	19.3	0.44	2.26
54619e	19.4	19.5	19.5	-	19.5	0.06	0.3
063fae	19.7	19.8	19.9	1.7	19.8	0.1	0.51
f58f15	19.5	20.0	19.9	0.7	19.8	0.26	1.34
47c275	20.1	20.2	20.3	-	20.2	0.1	0.5
4d6008	20.4	20.2	20.3	2.6	20.3	0.08	0.4
aa5576	20.4	20.6	20.5	1.8	20.5	0.1	0.49
b018b1	20.5	20.6	20.5	-	20.5	0.08	0.37
747268	20.7	20.8	20.9	-	20.8	0.08	0.36
b1cde8	21.9	19.9	-	6.8	20.9	1.41	6.77
cce554	20.9	20.9	20.9	0.4	20.9	0.03	0.12
7e7687	21.2	21.1	20.5	0.4	20.9	0.36	1.72
c0cb8d	21.1	20.9	20.9	0.2	20.9	0.11	0.54
05973c	20.9	21.1	21.0	0.4	21.0	0.1	0.48
b620ea	21.2	21.2	21.1	0.1	21.2	0.06	0.27
c356d4	21.2	21.2	21.2	0.3	21.2	0.01	0.05
46073a	21.2	21.2	21.2	0.7	21.2	0.0	0.0
b9d4d8	21.2	21.3	21.3	-	21.3	0.06	0.27
581a3d	21.4	21.4	21.4	1.2	21.4	0.0	0.0
6e00c8	21.5	21.5	21.3	2.0	21.4	0.12	0.54
23baf0	21.6	21.2	21.6	2.0	21.5	0.23	1.08
7b95a7	21.5	21.5	21.5	0.3	21.5	0.02	0.1
a6ea3e	21.7	21.4	21.4	0.2	21.5	0.17	0.81
05e7f9	21.6	21.4	21.6	1.0	21.5	0.12	0.54
337ed8	21.6	21.6	21.4	0.3	21.5	0.12	0.54
fb08d9	21.5	21.6	21.5	0.3	21.5	0.06	0.27
6c73e9	21.7	21.5	21.5	0.4	21.6	0.12	0.54
3e11f6	21.8	21.7	21.6	0.1	21.7	0.1	0.46

1.2 The Numerical Procedure for Determining Outliers

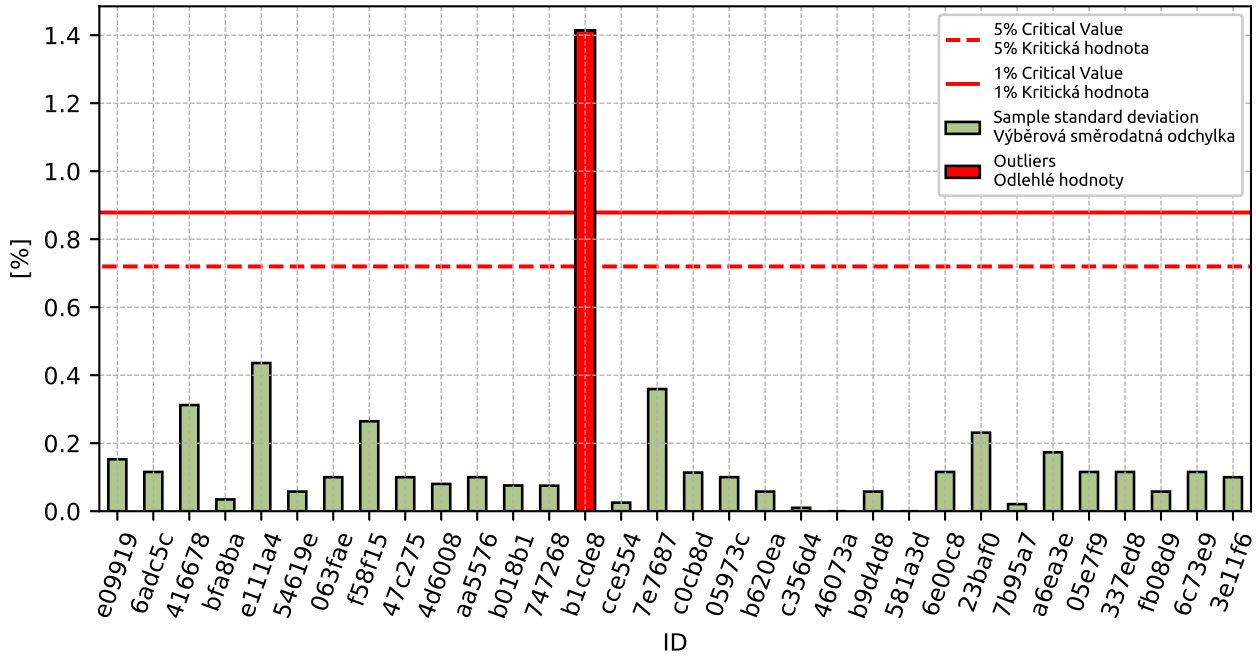

Figure 1: **Cochran's test** - sample standard deviations

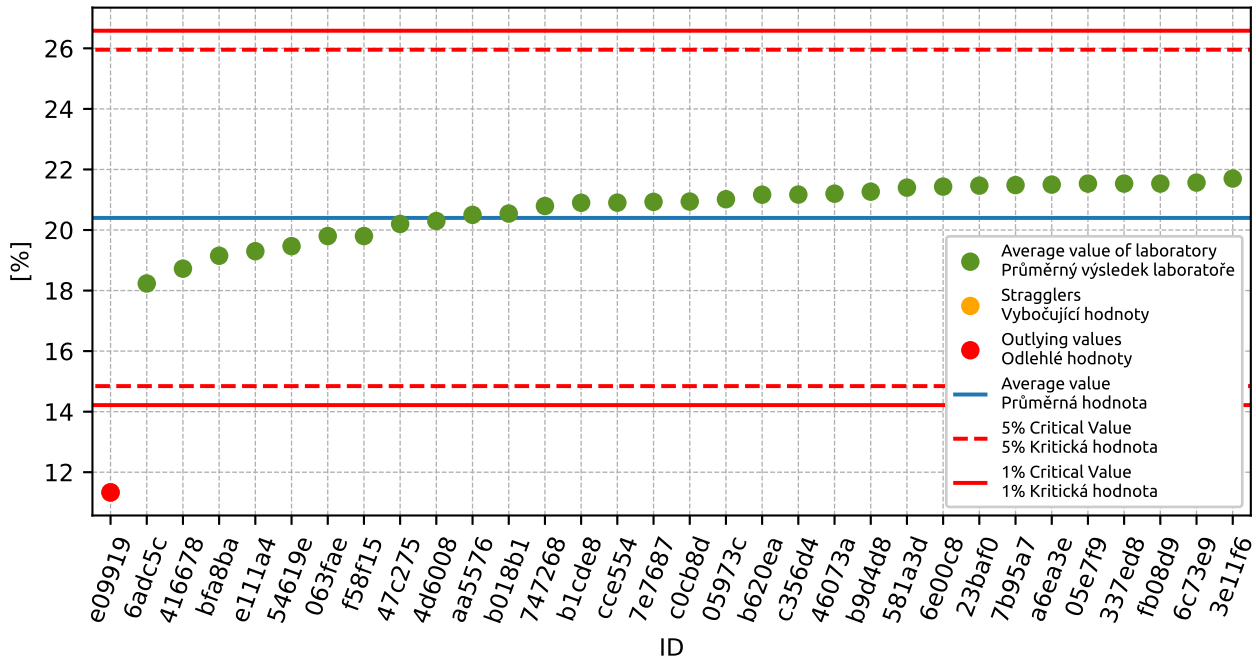

Figure 2: **Grubbs' test** - average values

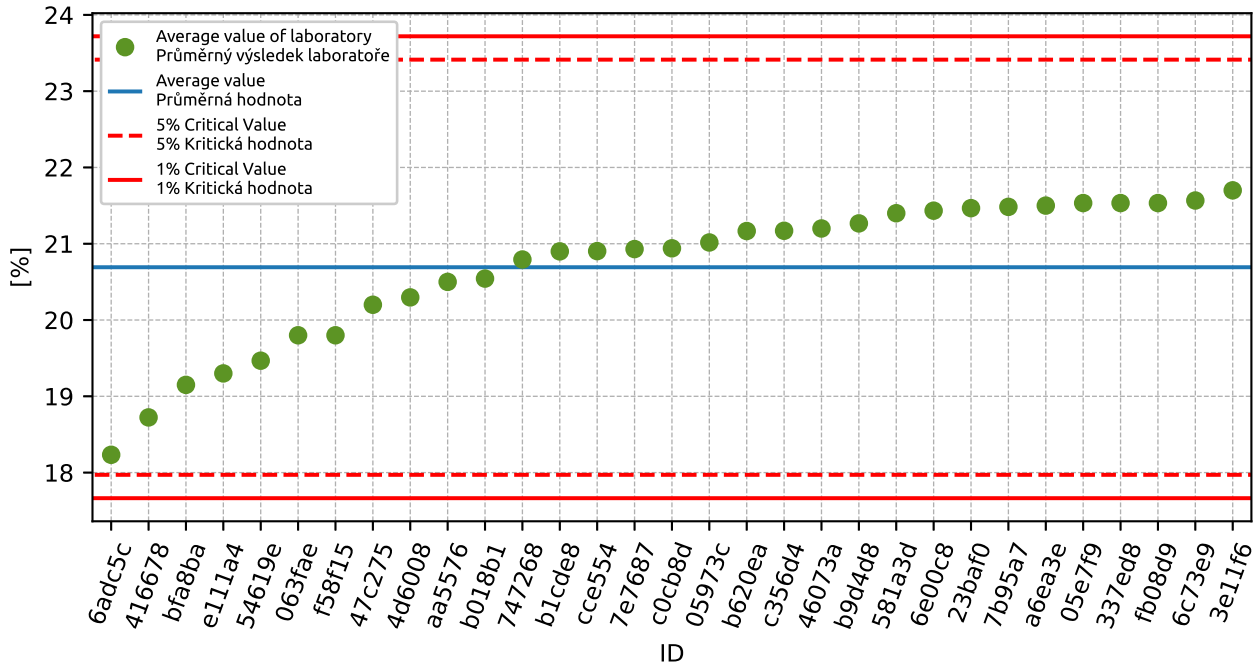

Figure 3: **Grubbs' test** - average values without outliers

1.3 Mandel's Statistics

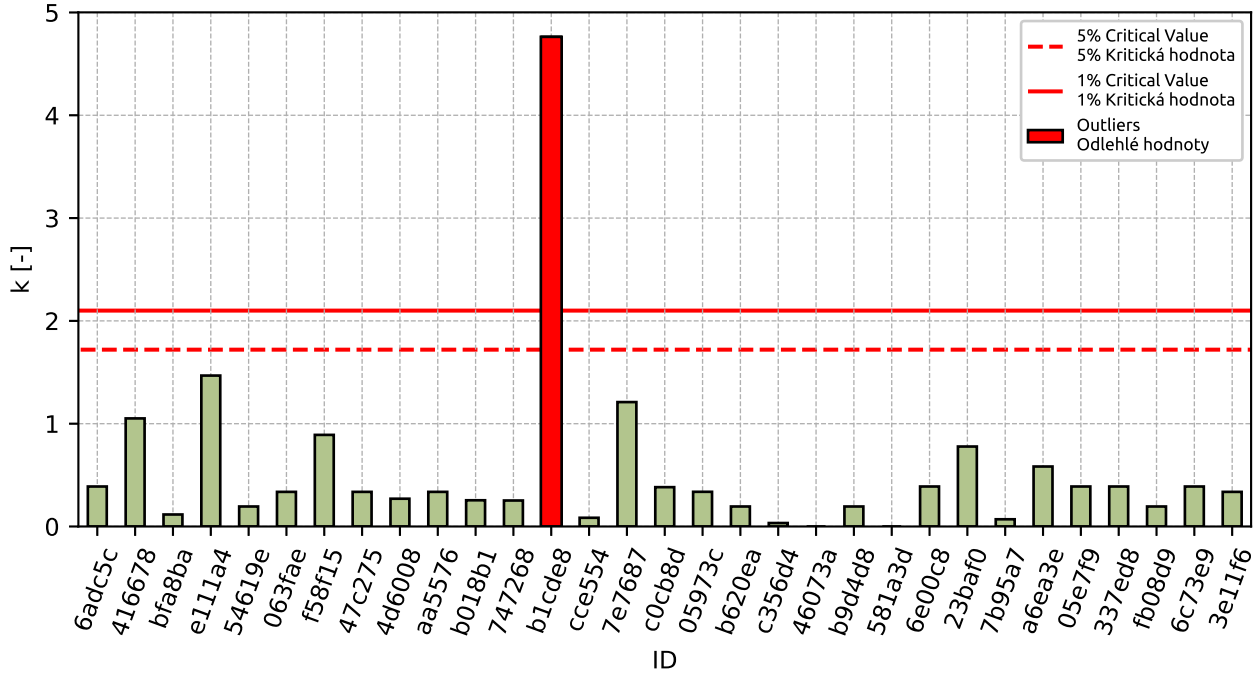

Figure 4: Intralaboratory Consistency Statistic

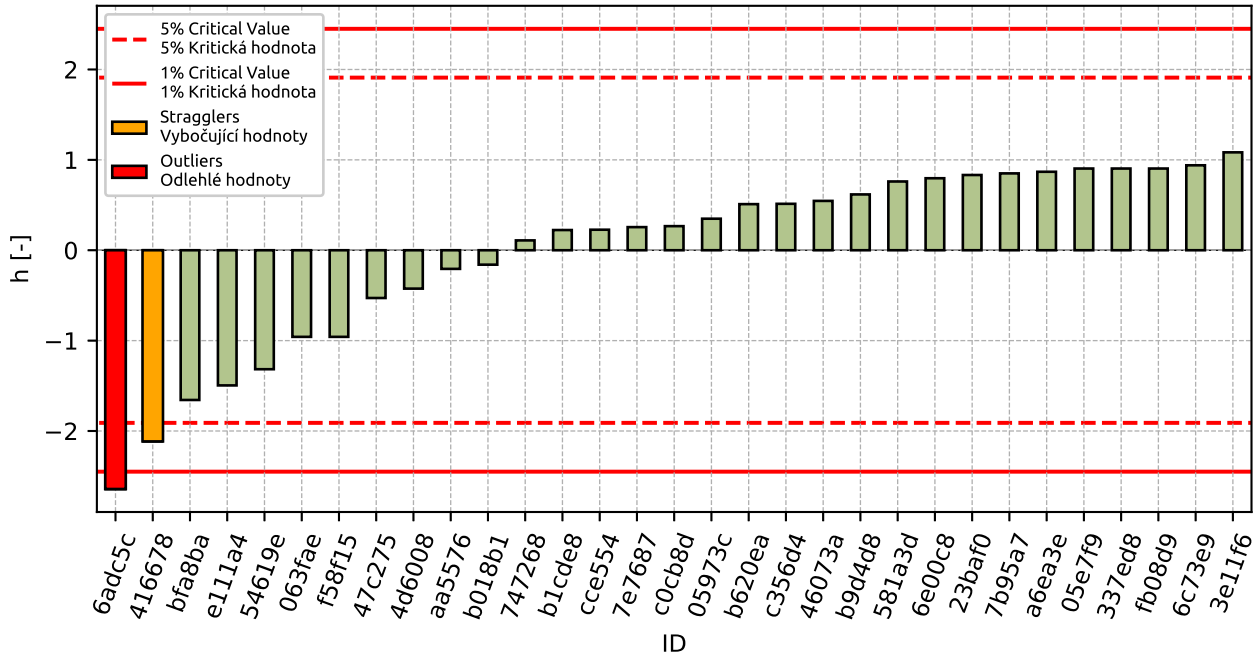

Figure 5: Interlaboratory Consistency Statistic

1.4 Descriptive statistics

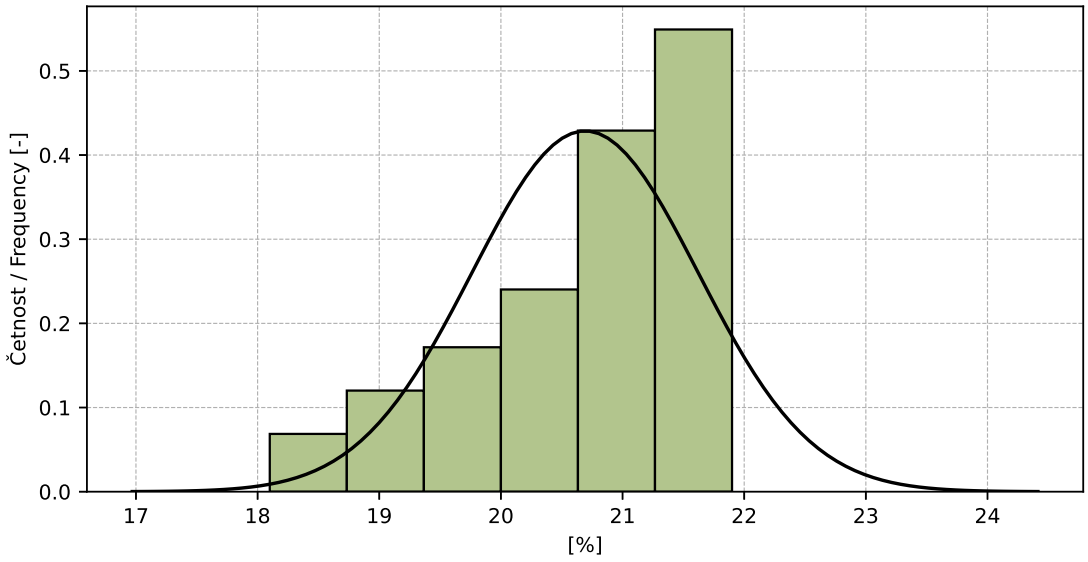

Figure 6: Histogram of all test results

Table 5: Descriptive statistics

Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	20.7
Výběrová směrodatná odchylka / Sample standard deviation – s	0.93
Vztažná hodnota / Asigned value – x^*	20.8
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.77
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.17
p-hodnota testu normality / p-value of normality test	1.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	0.91
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	0.3
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	0.96
Opakovatelnost / Repeatability – r	0.8
Reprodukovatelnost / Reproducibility – R	2.7

1.5 Evaluation of Performance Statistics

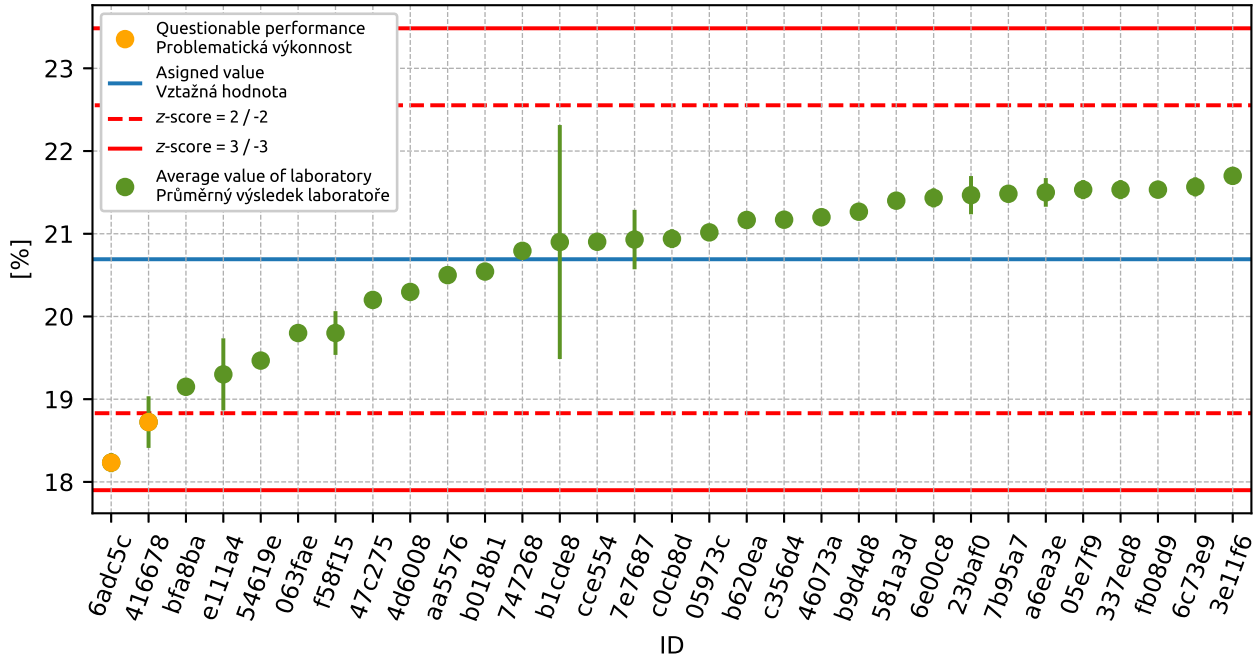

Figure 7: Average values and sample standard deviations

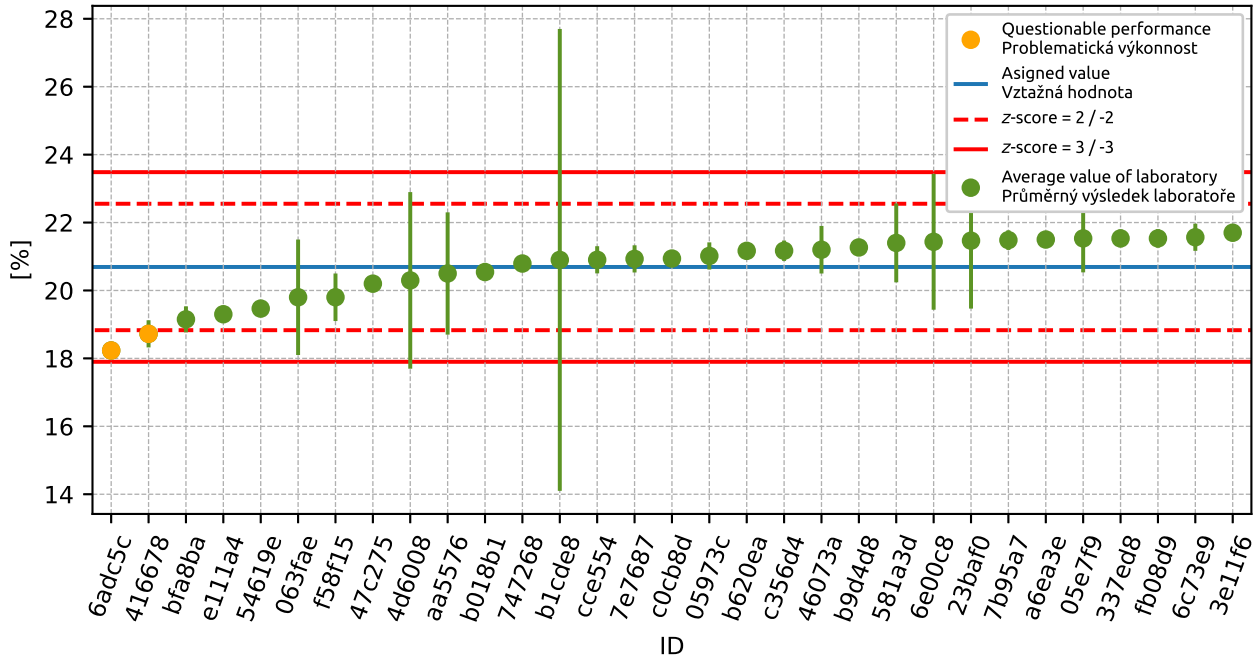

Figure 8: Average values and extended uncertainties of measurement

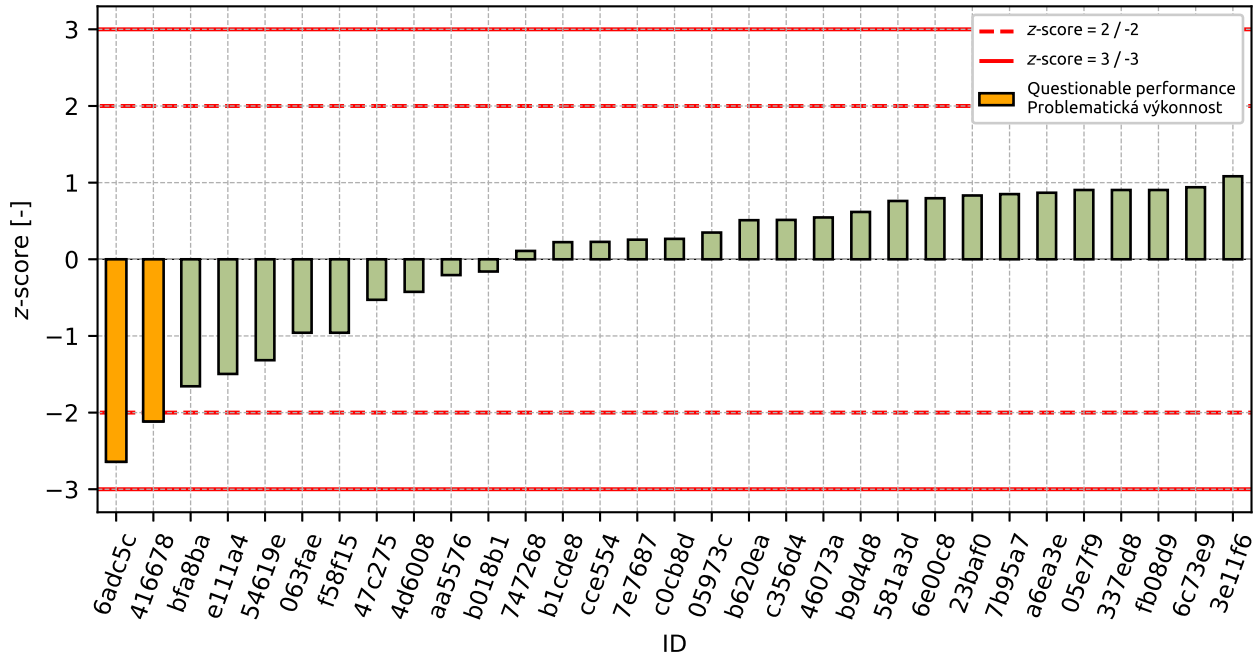

Figure 9: z-score

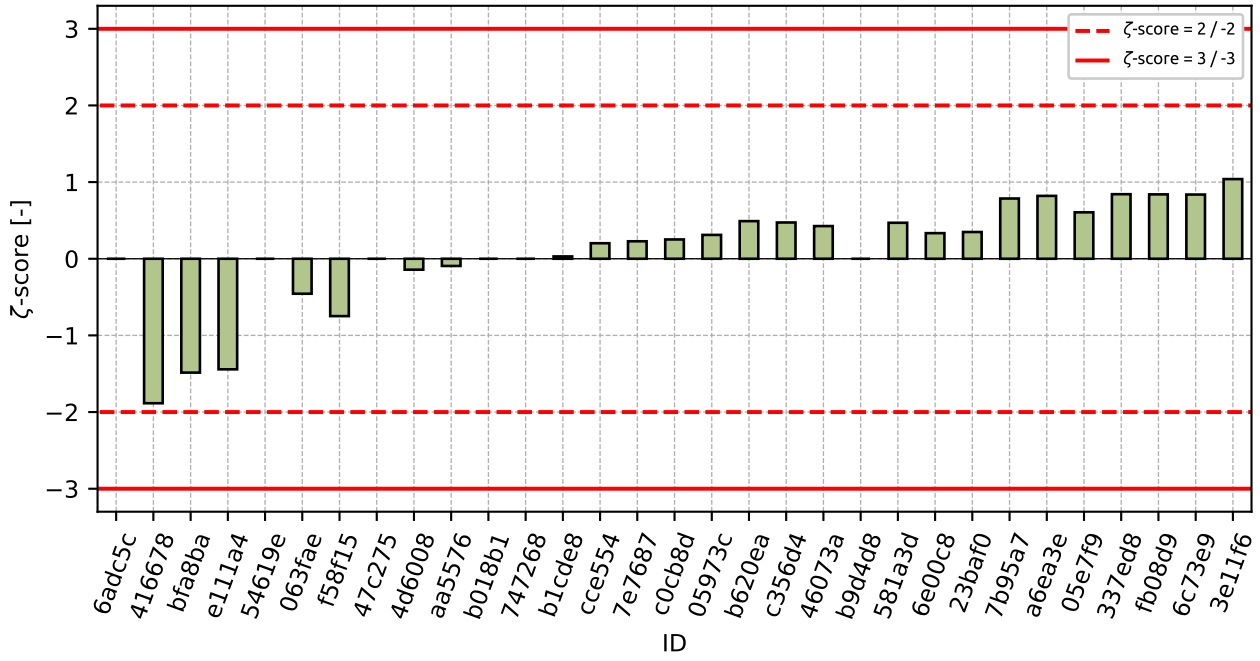

Figure 10: ζ-score

Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
6adc5c	-2.64	-
416678	-2.12	-1.88
bfa8ba	-1.66	-1.49
e111a4	-1.5	-1.44
54619e	-1.32	-
063fae	-0.96	-0.46
f58f15	-0.96	-0.75
47c275	-0.53	-
4d6008	-0.42	-0.14
aa5576	-0.21	-0.09
b018b1	-0.16	-
747268	0.11	-
b1cde8	0.22	0.03
cce554	0.23	0.2
7e7687	0.26	0.23
c0cb8d	0.27	0.25
05973c	0.35	0.31
b620ea	0.51	0.49
c356d4	0.51	0.47
46073a	0.55	0.43
b9d4d8	0.62	-
581a3d	0.76	0.47
6e00c8	0.8	0.33
23baf0	0.83	0.35
7b95a7	0.85	0.79
a6ea3e	0.87	0.82
05e7f9	0.9	0.61
337ed8	0.9	0.84
fb08d9	0.9	0.84
6c73e9	0.94	0.84
3e11f6	1.08	1.04

2 Appendix – EN ISO 17892-3 – Particle density

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 [Mg/m^3]			u_X [Mg/m^3]	$\bar{x}$ [Mg/m^3]	s_0 [Mg/m^3]	V_X [%]
574330	2.67	2.68	2.65	-	2.67	0.015	0.57
581a3d	2.67	2.66	2.67	0.0	2.67	0.006	0.22
b83369	2.67	2.67	2.67	-	2.67	0.001	0.04
063fae	2.67	2.66	2.68	0.03	2.67	0.01	0.37
b620ea	2.68	2.67	2.66	0.01	2.67	0.01	0.37
b018b1	2.67	2.68	2.67	-	2.67	0.003	0.11
47c275	2.68	2.67	2.67	0.02	2.67	0.006	0.22
7453ba	2.69	2.68	2.69	-	2.69	0.006	0.21
23baf0	2.69	2.69	2.69	0.05	2.69	0.0	0.0
747268	2.69	2.69	2.69	-	2.69	0.001	0.02
b1cde8	2.69	2.69	2.69	0.04	2.69	0.002	0.06
a6ea3e	2.72	2.7	2.71	0.04	2.71	0.01	0.37
46073a	2.73	2.72	2.73	0.01	2.73	0.001	0.02

2.2 The Numerical Procedure for Determining Outliers

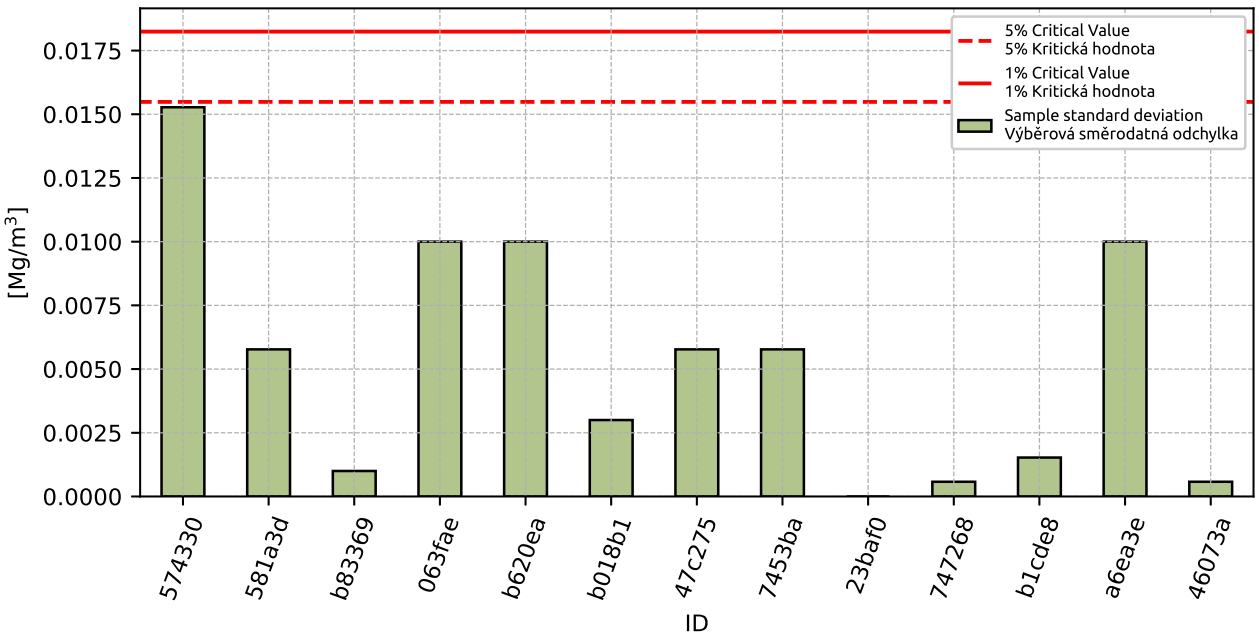

Figure 11: **Cochran's test** - sample standard deviations

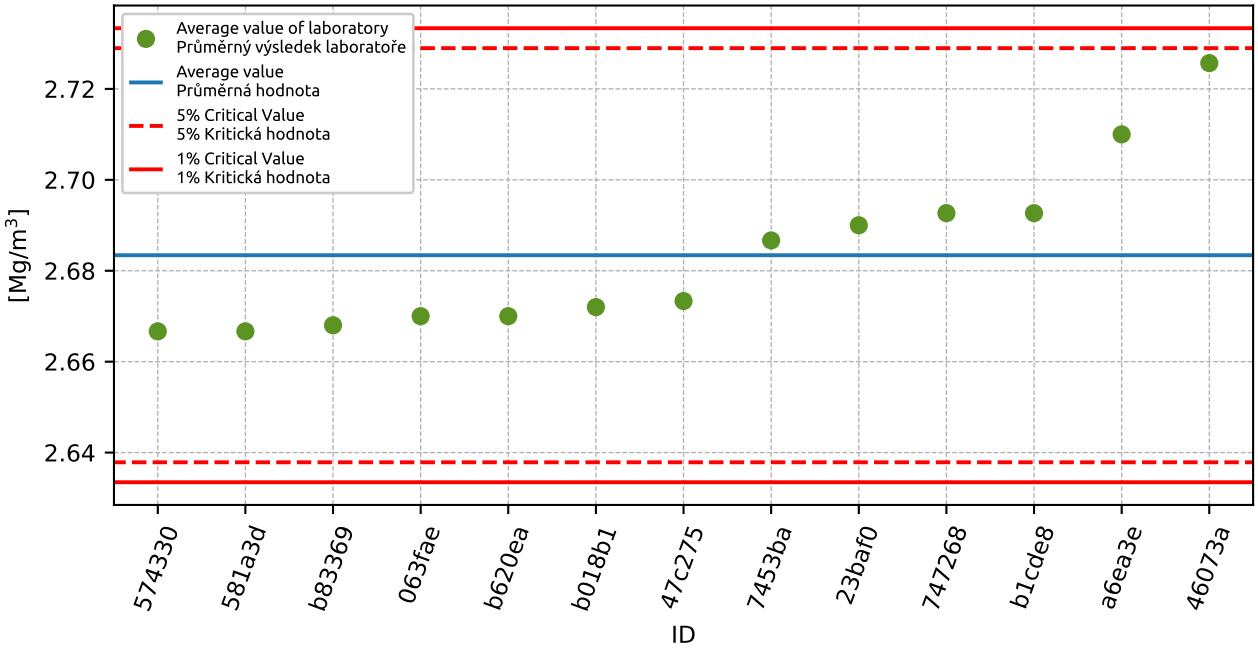

Figure 12: **Grubbs' test** - average values

2.3 Mandel's Statistics

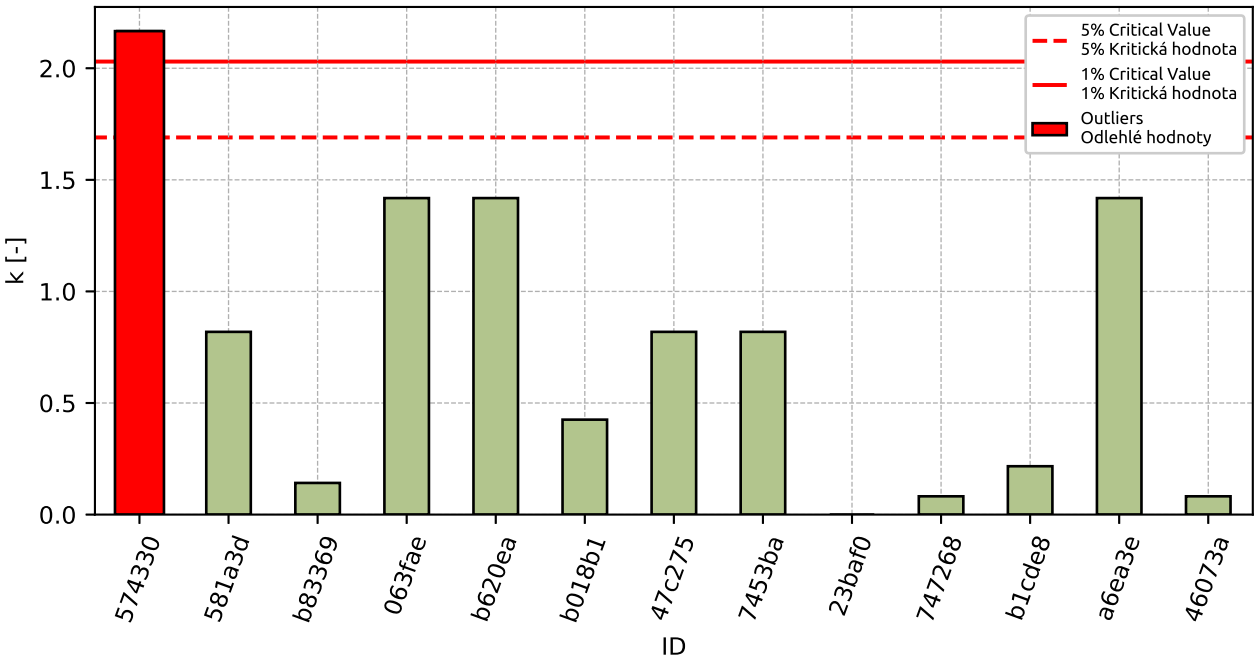

Figure 13: Intralaboratory Consistency Statistic

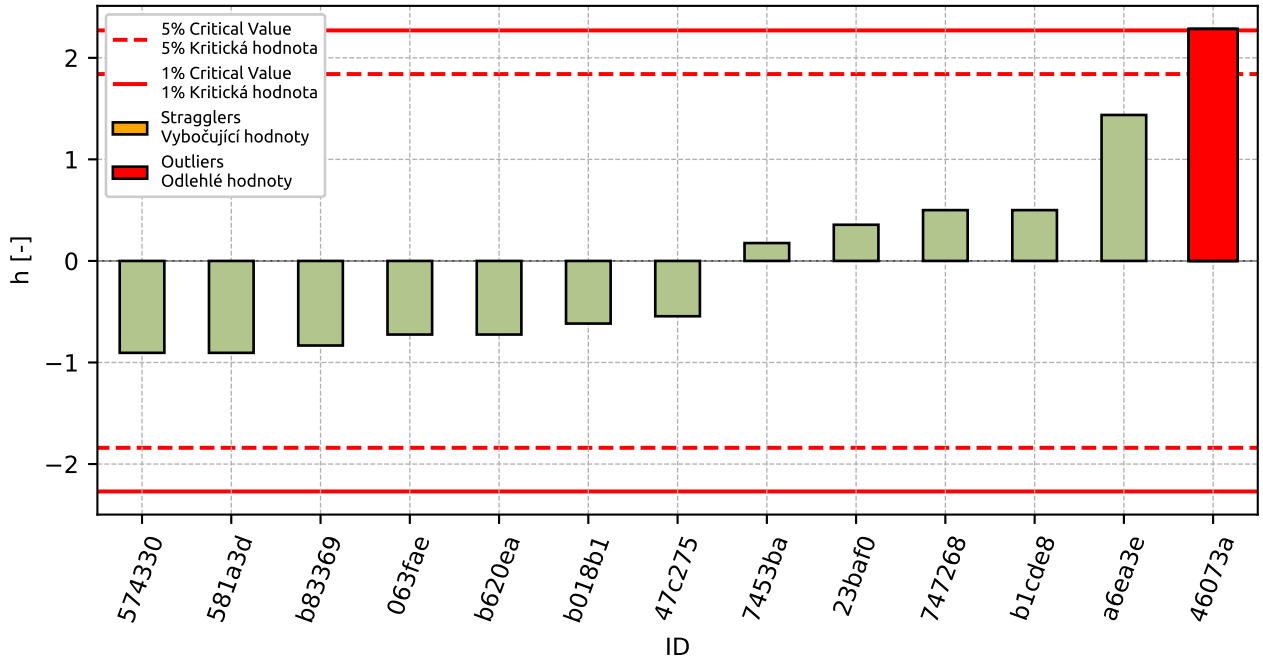

Figure 14: Interlaboratory Consistency Statistic

2.4 Descriptive statistics

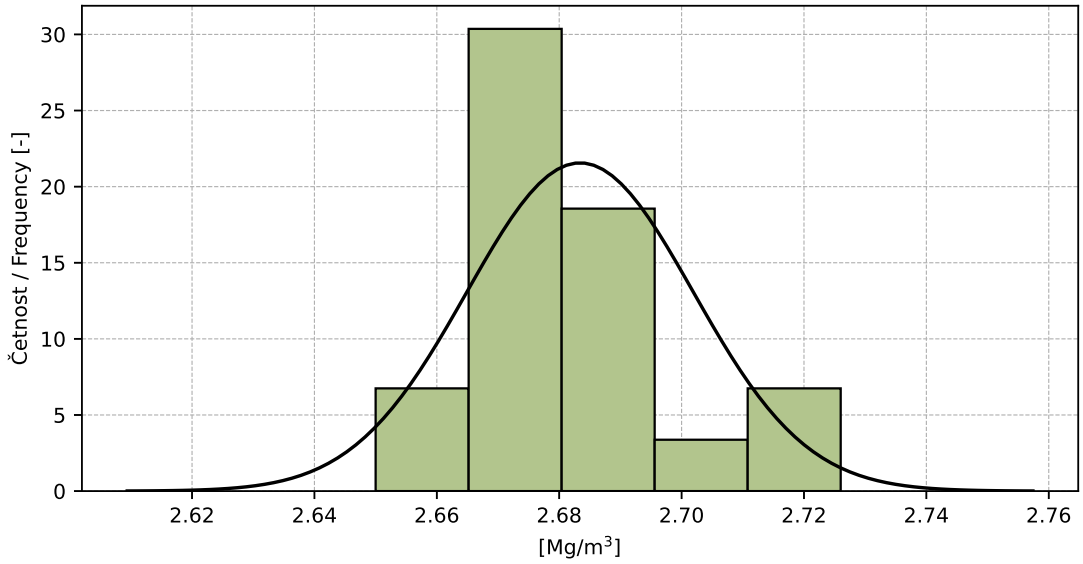

Figure 15: Histogram of all test results

Table 8: Descriptive statistics

Characteristics	[Mg/m³]
Průměrná hodnota / Average value – $\bar{x}$	2.68
Výběrová směrodatná odchylka / Sample standard deviation – s	0.019
Vztažná hodnota / Asigned value – x^*	2.68
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.019
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.136
p-hodnota testu normality / p-value of normality test	0.006 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	0.018
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	0.007
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	0.019
Opakovatelnost / Repeatability – r	0.02
Reprodukovatelnost / Reproducibility – R	0.05

2.5 Evaluation of Performance Statistics

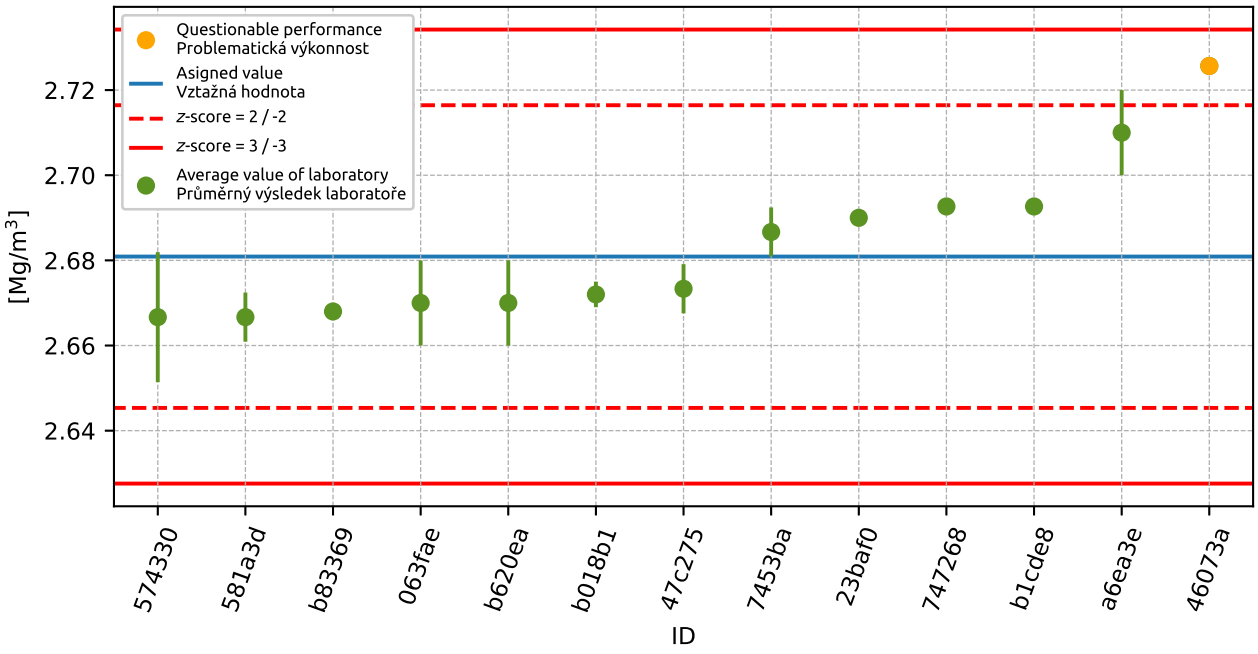

Figure 16: Average values and sample standard deviations

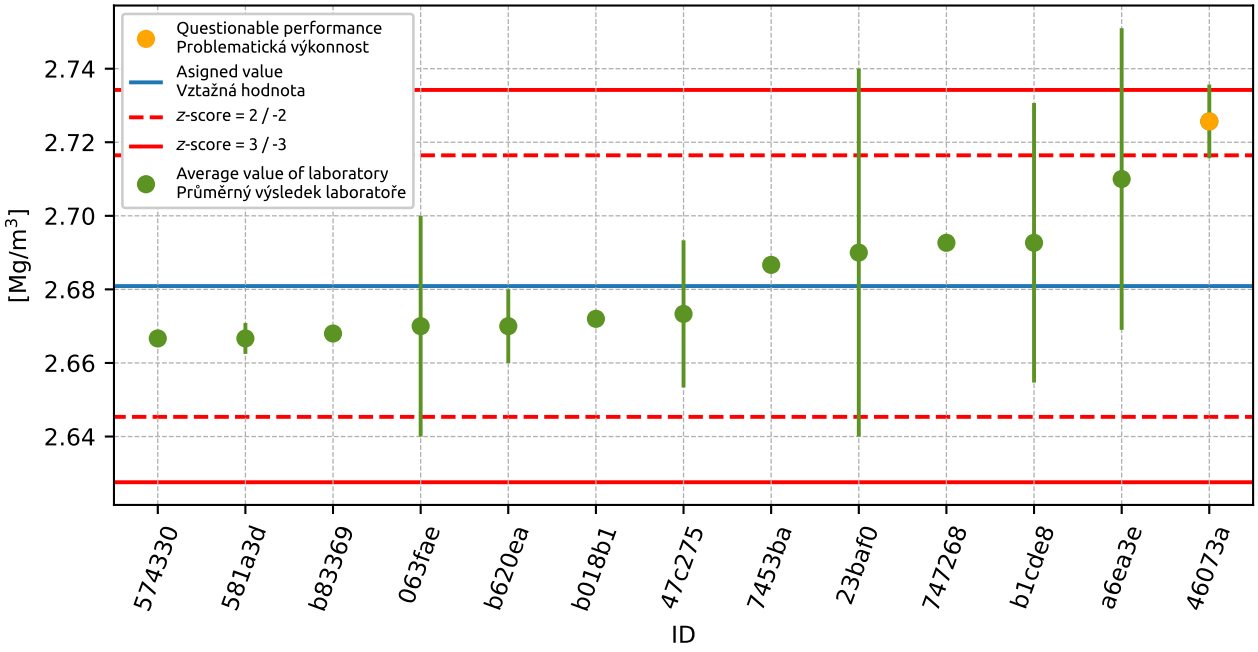

Figure 17: Average values and extended uncertainties of measurement

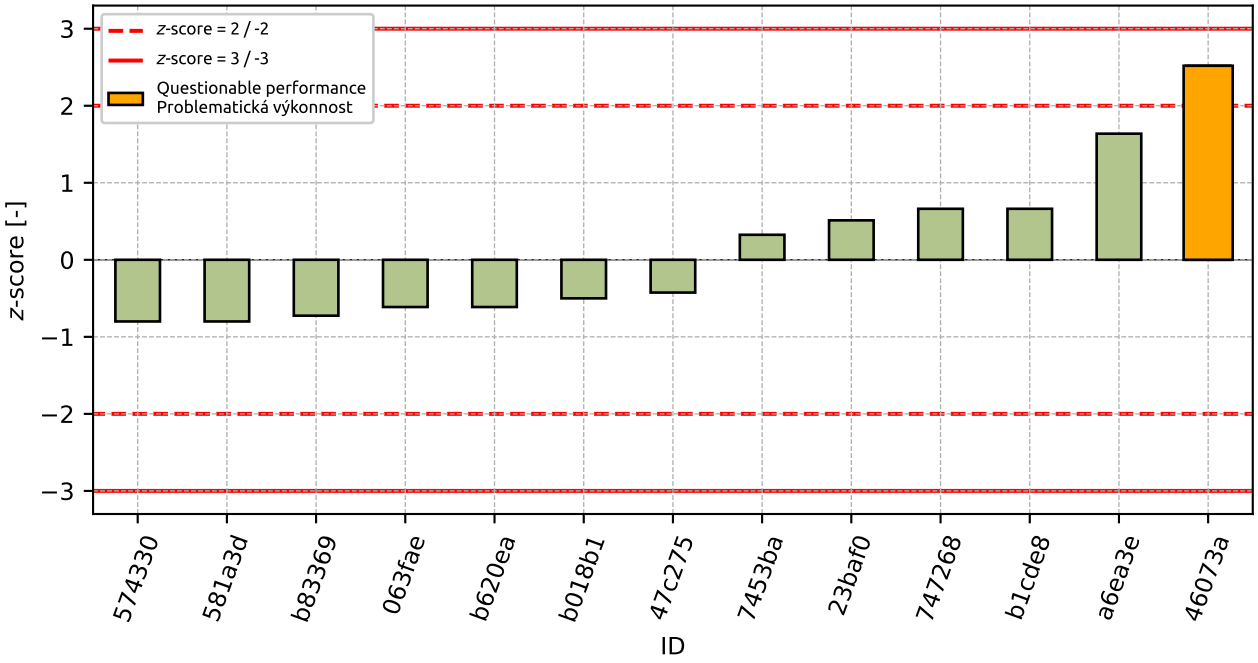

Figure 18: z-score

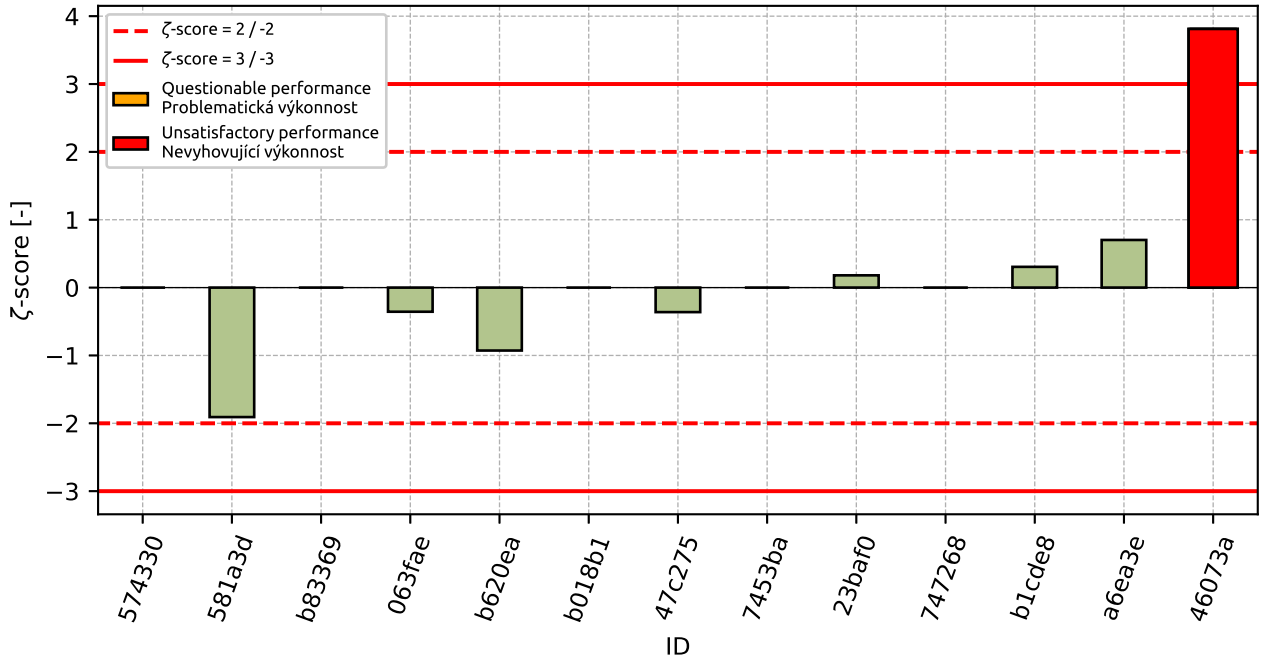

Figure 19: ζ-score

Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
574330	-0.8	-
581a3d	-0.8	-1.91
b83369	-0.73	-
063fae	-0.61	-0.36
b620ea	-0.61	-0.93
b018b1	-0.5	-
47c275	-0.43	-0.36
7453ba	0.32	-
23baf0	0.51	0.18
747268	0.66	-
b1cde8	0.66	0.31
a6ea3e	1.64	0.7
46073a	2.52	3.81

3 Appendix – EN ISO 17892-4 – Particle size distribution

Table 10: Test results - Sieve through [%]

ID	Sieve through [%]						
of participant	4 mm	2 mm	1 mm	0.5 mm	0.25 mm	0.125 mm	0.063 mm
b1cde8	95.5	95.1	94.8	94.3	93.8	93.0	90.4
46073a	100.0	99.7	99.2	98.4	97.7	96.9	93.2
063fae	100.0	100.0	99.0	98.0	96.0	94.0	90.8
2a33ae	99.9	99.5	98.9	98.0	97.2	96.3	89.4
337ed8	99.9	99.7	99.1	98.2	97.4	96.7	93.2
7b95a7	99.9	99.7	99.3	98.6	98.0	97.3	93.4
574330	99.9	99.6	99.3	98.5	97.5	91.5	79.2
bfa8ba	100.0	100.0	99.8	99.1	98.2	97.0	93.2
23baf0	100.0	99.8	99.4	98.9	98.2	97.2	88.7
05e7f9	99.8	99.5	99.0	98.1	97.2	96.3	92.8
a6ea3e	99.7	99.4	98.8	97.1	94.2	91.9	87.1
6adc5c	99.9	99.7	99.0	97.5	95.1	91.8	89.3
416678	100.0	99.0	99.0	98.0	95.0	92.0	86.0
7e7687	100.0	100.0	99.0	98.0	95.0	91.0	85.2
05973c	100.0	100.0	99.0	98.0	97.0	95.0	91.5
cce554	99.0	99.0	98.0	97.0	93.0	84.0	72.7
47c275	99.9	99.7	99.2	98.5	97.8	96.9	97.7
baa257	99.7	99.2	98.7	98.0	97.3	96.5	93.6
581a3d	99.8	99.5	99.1	98.3	96.1	94.3	89.7
b018b1	99.9	99.6	99.2	98.5	97.7	97.0	94.7
b620ea	99.9	99.7	99.3	98.7	98.0	97.4	92.9
6c73e9	99.9	99.5	98.9	97.8	97.0	96.1	92.6
e09919	100.0	99.7	99.4	98.9	98.1	97.3	93.1
747268	100.0	99.9	99.8	99.2	98.5	97.5	93.5

Table 11: Grubbs' test [%]

Value	4 mm	2 mm	1 mm	0.5 mm	0.25 mm	0.125 mm	0.063 mm
G_{min}	4.574	4.495	4.352	3.864	2.377	3.376	3.285
G_{max}	0.336	0.583	0.923	1.163	1.148	0.849	1.418
$G_{0.05}$	2.802	2.802	2.802	2.802	2.802	2.802	2.802
$G_{0.01}$	3.112	3.112	3.112	3.112	3.112	3.112	3.112

Table 12: Grubbs' test - without outliers [%]

Value	4 mm	2 mm	1 mm	0.5 mm	0.25 mm	0.125 mm	0.063 mm
G_{min}	-	2.198	3.037	2.174	2.619	1.744	2.062
G_{max}	-	1.313	1.913	1.713	1.137	0.952	2.027
$G_{0.05}$	2.781	2.781	2.781	2.781	2.781	2.758	2.733
$G_{0.01}$	3.087	3.087	3.087	3.087	3.087	3.06	3.031

Table 13: *z*-score

ID of participant	*z*-score [-] / sieve 4 mm	2 mm	1 mm	0.5 mm	0.25 mm	0.125 mm	0.063 mm
46073a	0.6	0.26	0.26	0.3	0.59	0.68	0.55
063fae	0.6	1.31	-0.29	-0.41	-0.57	-0.62	-0.23
2a33ae	0.12	-0.44	-0.56	-0.41	0.25	0.41	-0.69
337ed8	0.12	0.26	-0.01	-0.05	0.39	0.59	0.55
7b95a7	0.12	0.26	0.54	0.65	0.8	0.86	0.62
574330	0.12	-0.09	0.54	0.48	0.45	-1.74	-
bfa8ba	0.6	1.31	1.91	1.54	0.93	0.73	0.55
23baf0	0.6	0.61	0.81	1.18	0.93	0.82	-0.92
05e7f9	-0.35	-0.44	-0.29	-0.23	0.25	0.41	0.42
a6ea3e	-0.82	-0.79	-0.84	-2.0	-1.8	-1.56	-1.44
6adc5c	0.12	0.26	-0.29	-1.29	-1.18	-1.61	-0.72
416678	0.6	-2.2	-0.29	-0.41	-1.25	-1.52	-1.8
7e7687	0.6	1.31	-0.29	-0.41	-1.25	-1.74	-2.06
05973c	0.6	1.31	-0.29	-0.41	0.11	-0.17	-0.0
cce554	-4.13	-2.2	-3.04	-2.17	-2.62	-	-
47c275	0.12	0.26	0.26	0.48	0.66	0.68	2.03
baa257	-0.82	-1.5	-1.11	-0.41	0.32	0.5	0.69
581a3d	-0.35	-0.44	-0.01	0.12	-0.5	-0.49	-0.59
b018b1	0.12	-0.09	0.26	0.48	0.59	0.73	1.05
b620ea	0.12	0.26	0.54	0.83	0.8	0.91	0.46
6c73e9	0.12	-0.44	-0.56	-0.76	0.11	0.32	0.36
e09919	0.6	0.26	0.81	1.18	0.86	0.86	0.52
747268	0.6	0.96	1.91	1.71	1.14	0.95	0.65

4 Appendix – EN ISO 17892-5 – Incremental loading oedometer test

4.1 50 – 100 kPa

4.1.1 Test results

Table 14: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [MPa]	u_X [MPa]
c9711f	2.03	0.91
581a3d	5.6	0.61
b018b1	7.14	-
b620ea	9.3	0.16
23baf0	10.16	0.51
2a33ae	10.3	0.2
b1cde8	13.3	-
747268	20.66	-

4.1.2 The Numerical Procedure for Determining Outliers

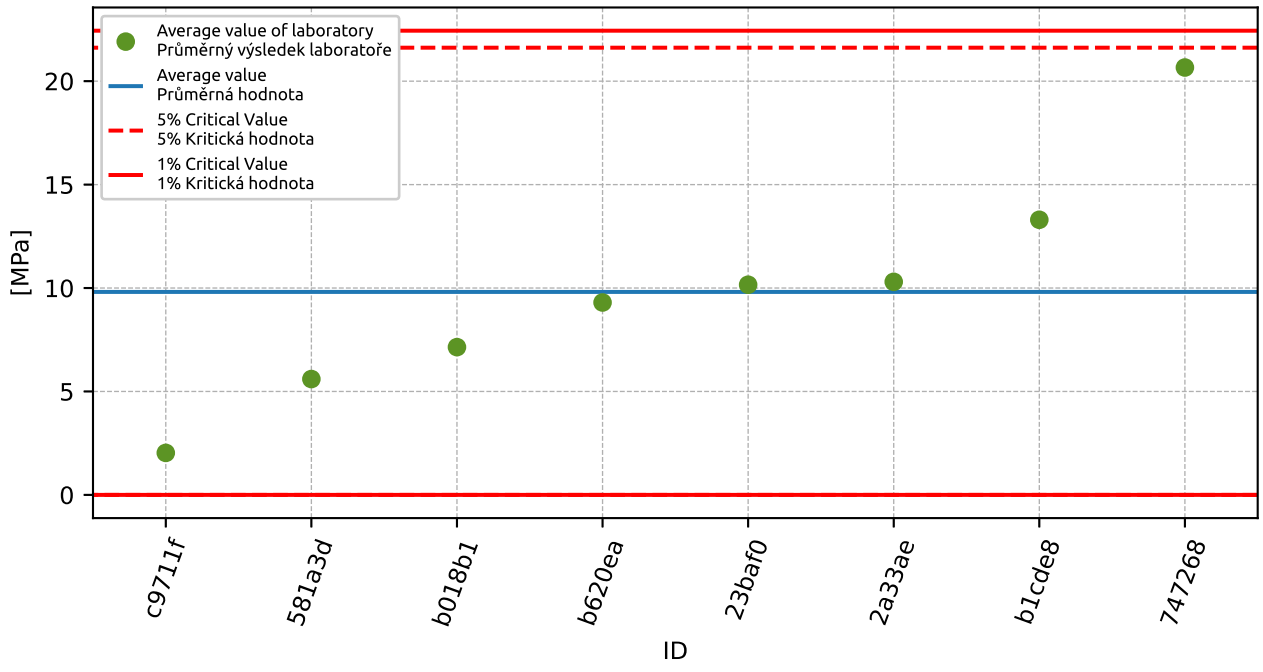

Figure 20: **Grubbs' test** - average values

4.1.3 Mandel's Statistics

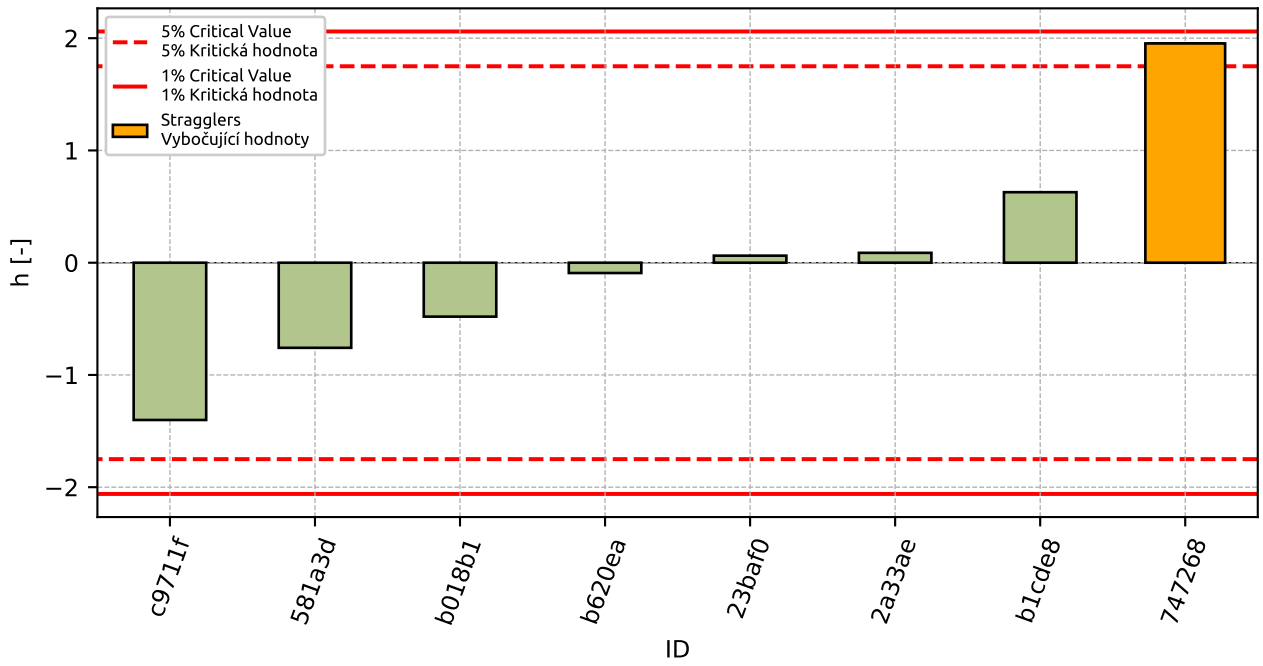

Figure 21: Interlaboratory Consistency Statistic

4.1.4 Descriptive statistics

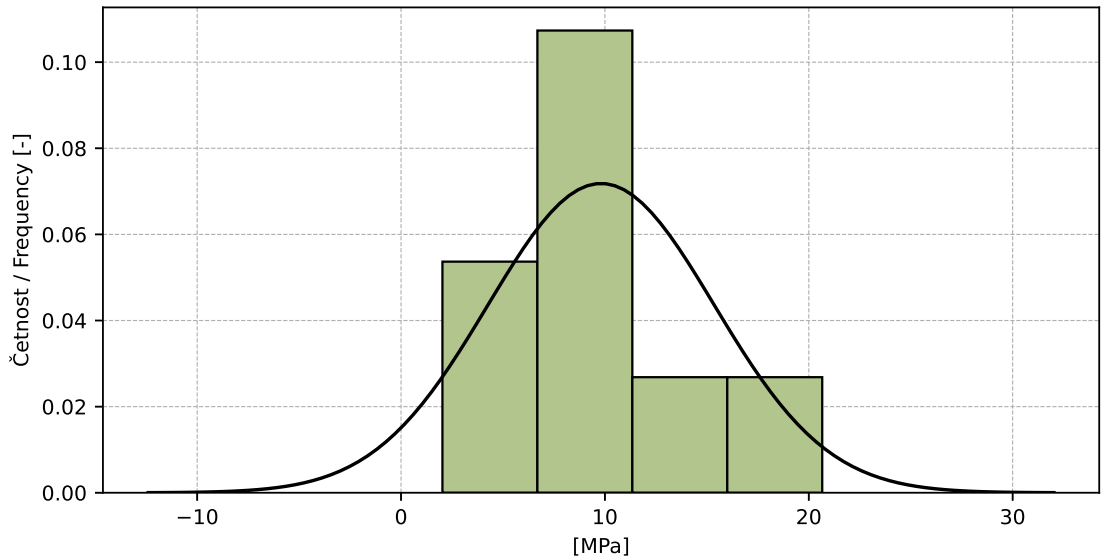

Figure 22: Histogram of all test results

Table 15: Descriptive statistics

Characteristics	[MPa]
Průměrná hodnota / Average value – $\bar{x}$	9.81
Výběrová směrodatná odchylka / Sample standard deviation – s	5.554
Vztažná hodnota / Asigned value – x^*	9.92
Robustní směrodatná odchylka / Robust standard deviation – s^*	6.789
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	2.526
p-hodnota testu normality / p-value of normality test	0.695 [-]

4.1.5 Evaluation of Performance Statistics

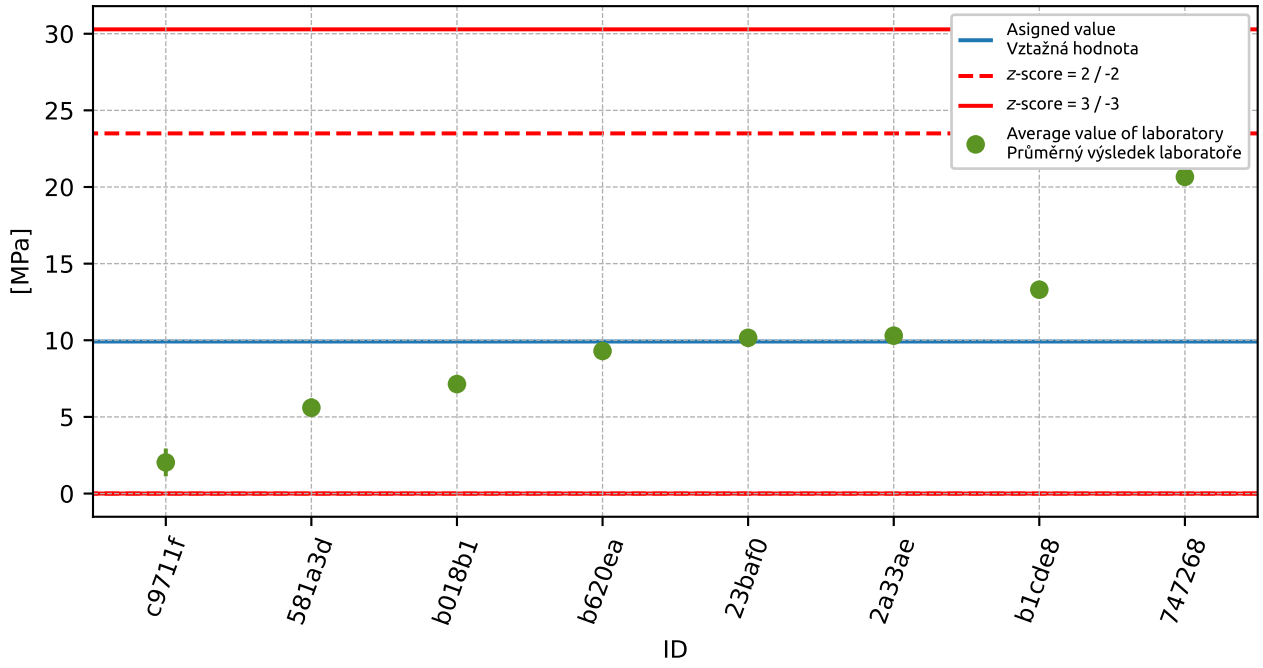

Figure 23: Average values and extended uncertainties of measurement

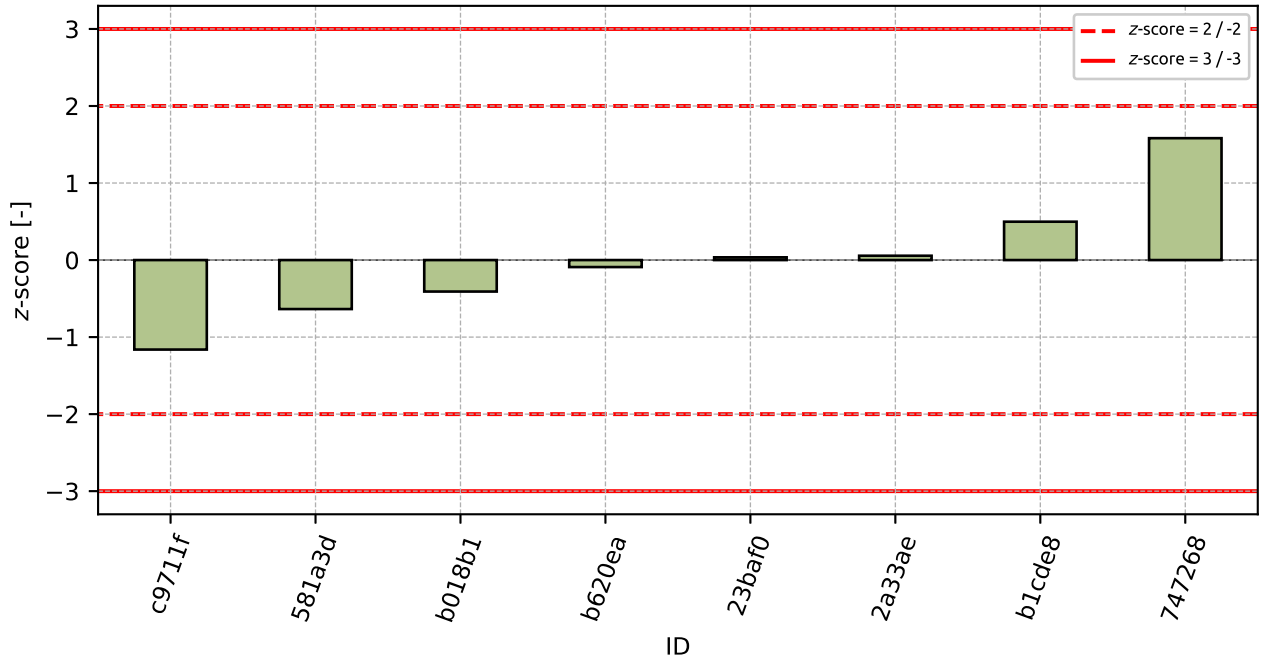

Figure 24: z-score

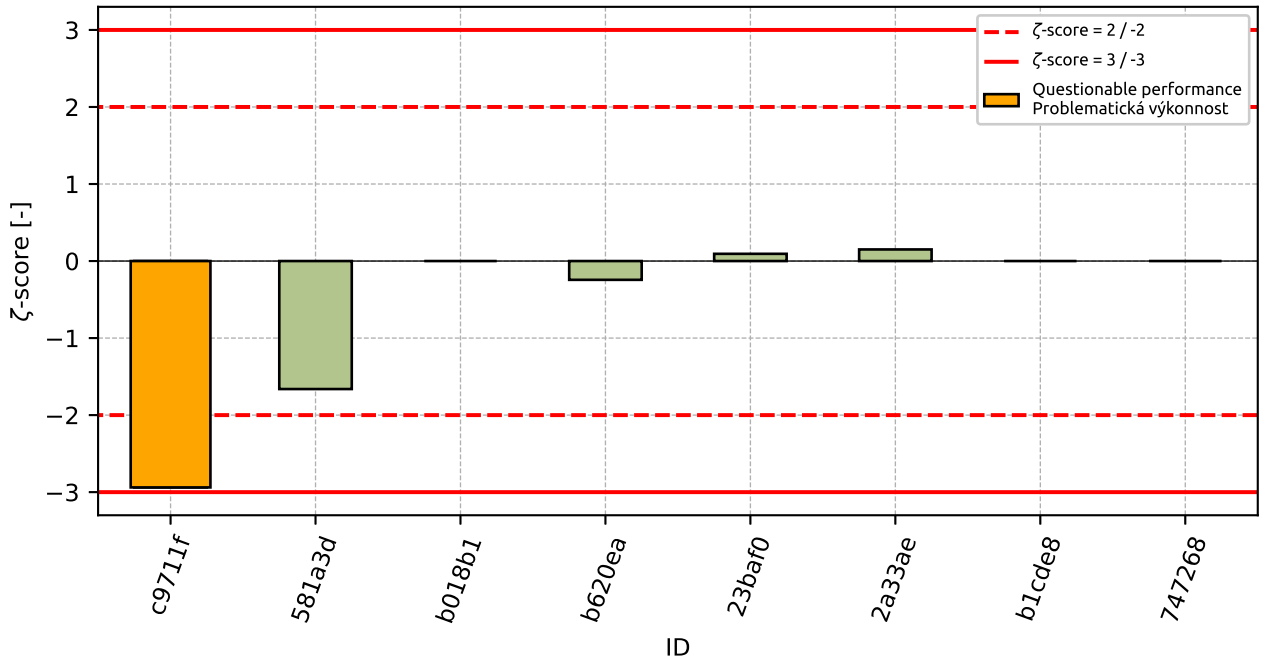

Figure 25: ζ-score

Table 16: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
c9711f	-1.16	-2.94
581a3d	-0.64	-1.66
b018b1	-0.41	-
b620ea	-0.09	-0.24
23baf0	0.04	0.09
2a33ae	0.06	0.15
b1cde8	0.5	-
747268	1.58	-

4.2 100 – 200 kPa

4.2.1 Test results

Table 17: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [MPa]	u_X [MPa]
c9711f	3.39	0.91
581a3d	9.24	1.09
b018b1	10.53	-
23baf0	11.53	0.58
b620ea	11.63	0.12
2a33ae	13.6	0.2
b1cde8	15.4	-
747268	24.52	-

4.2.2 The Numerical Procedure for Determining Outliers

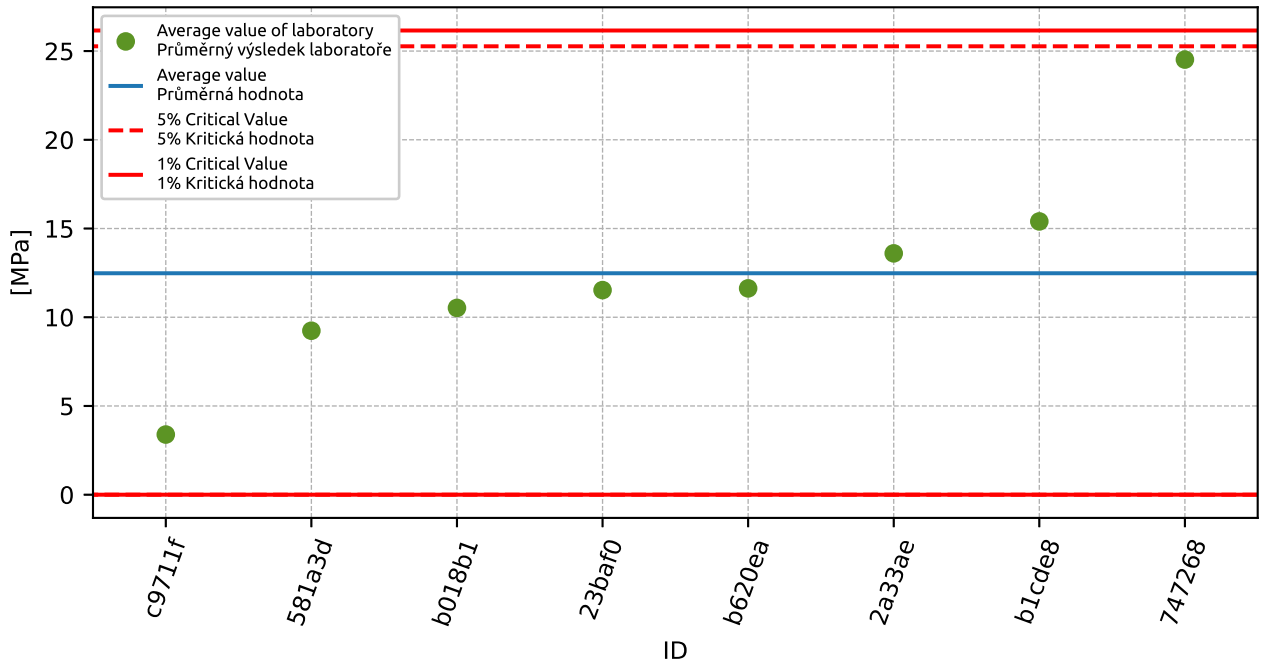

Figure 26: **Grubbs' test** - average values

4.2.3 Mandel's Statistics

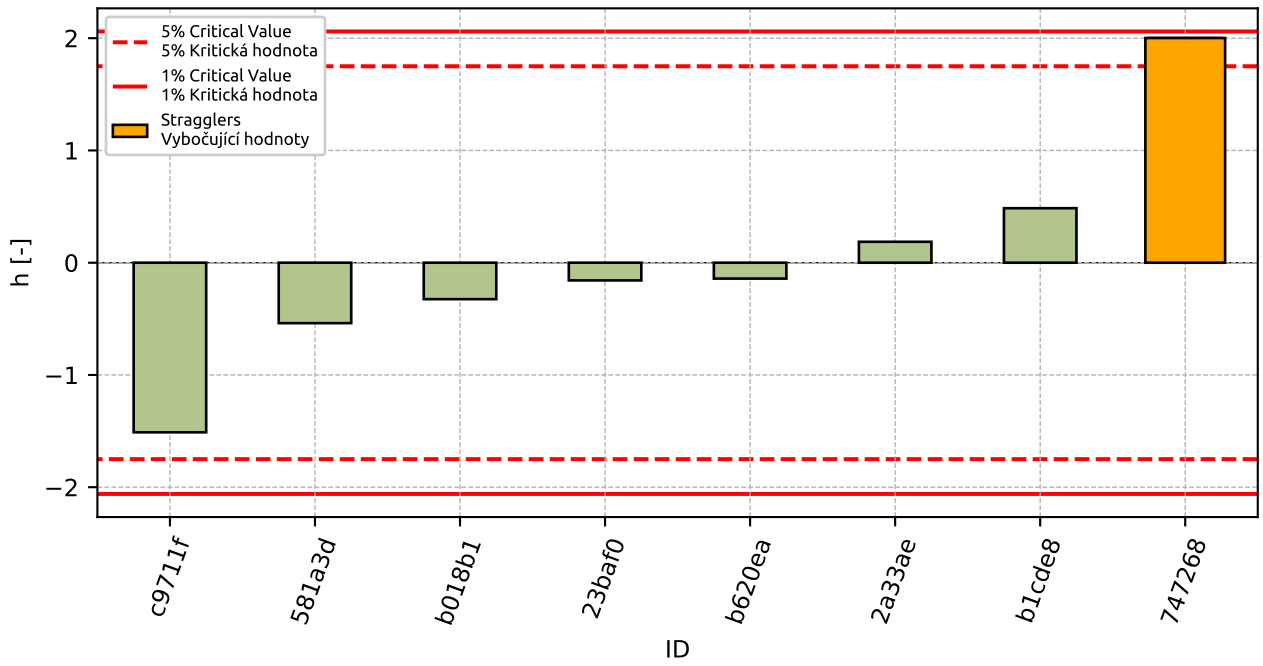

Figure 27: Interlaboratory Consistency Statistic

4.2.4 Descriptive statistics

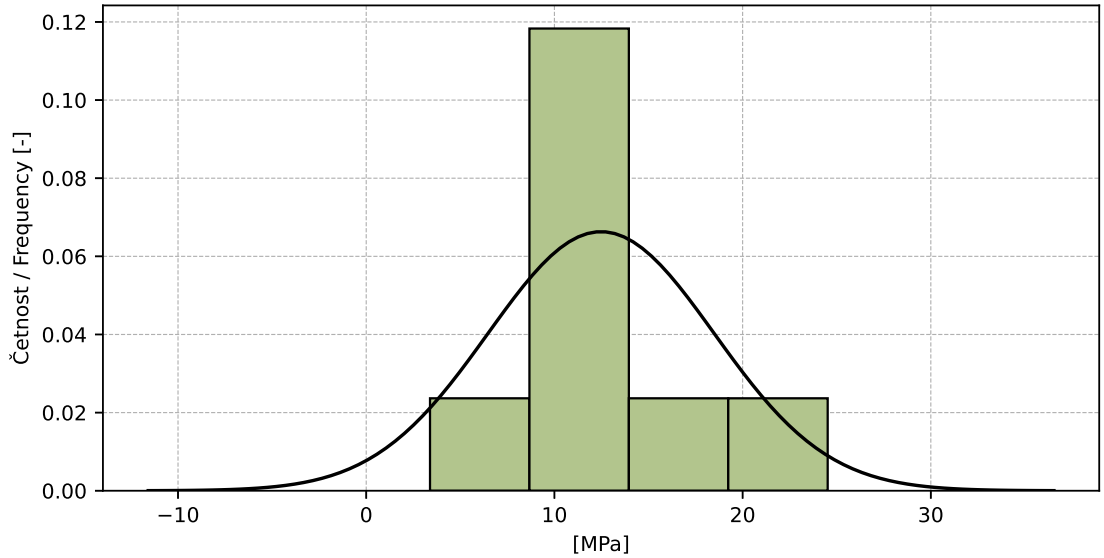

Figure 28: Histogram of all test results

Table 18: Descriptive statistics

Characteristics	[MPa]
Průměrná hodnota / Average value – $\bar{x}$	12.48
Výběrová směrodatná odchylka / Sample standard deviation – s	6.016
Vztažná hodnota / Asigned value – x^*	12.9
Robustní směrodatná odchylka / Robust standard deviation – s^*	5.9
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	2.521
p-hodnota testu normality / p-value of normality test	0.441 [-]

4.2.5 Evaluation of Performance Statistics

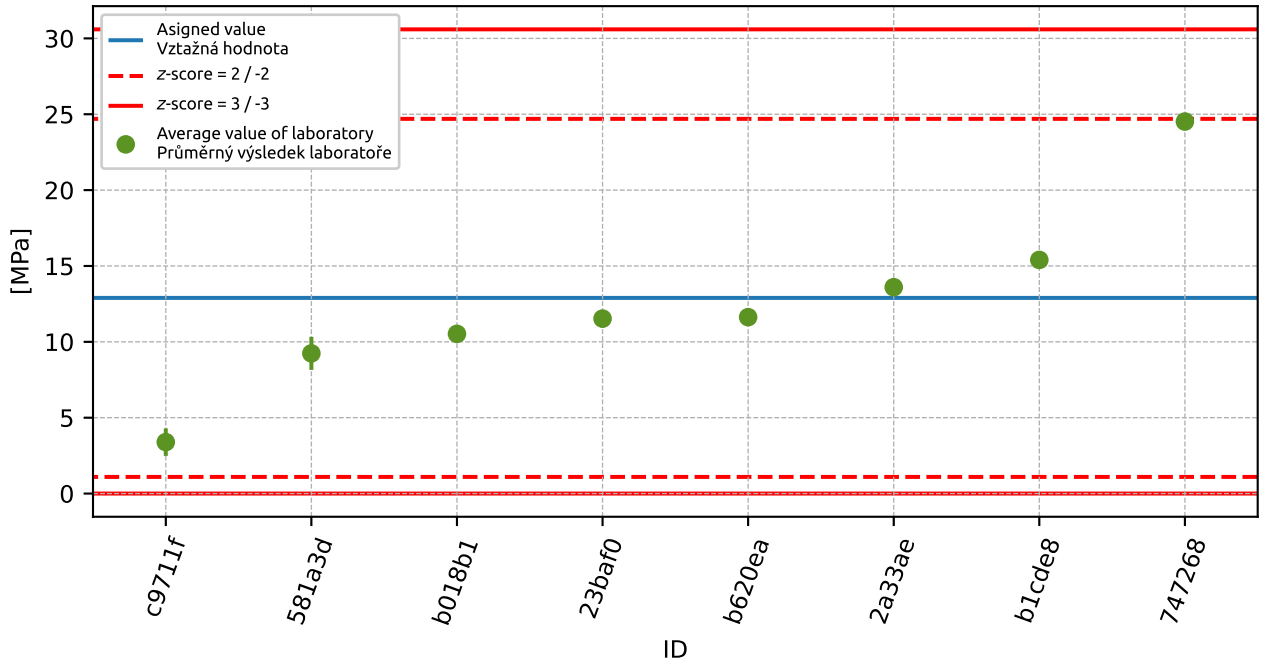

Figure 29: Average values and extended uncertainties of measurement

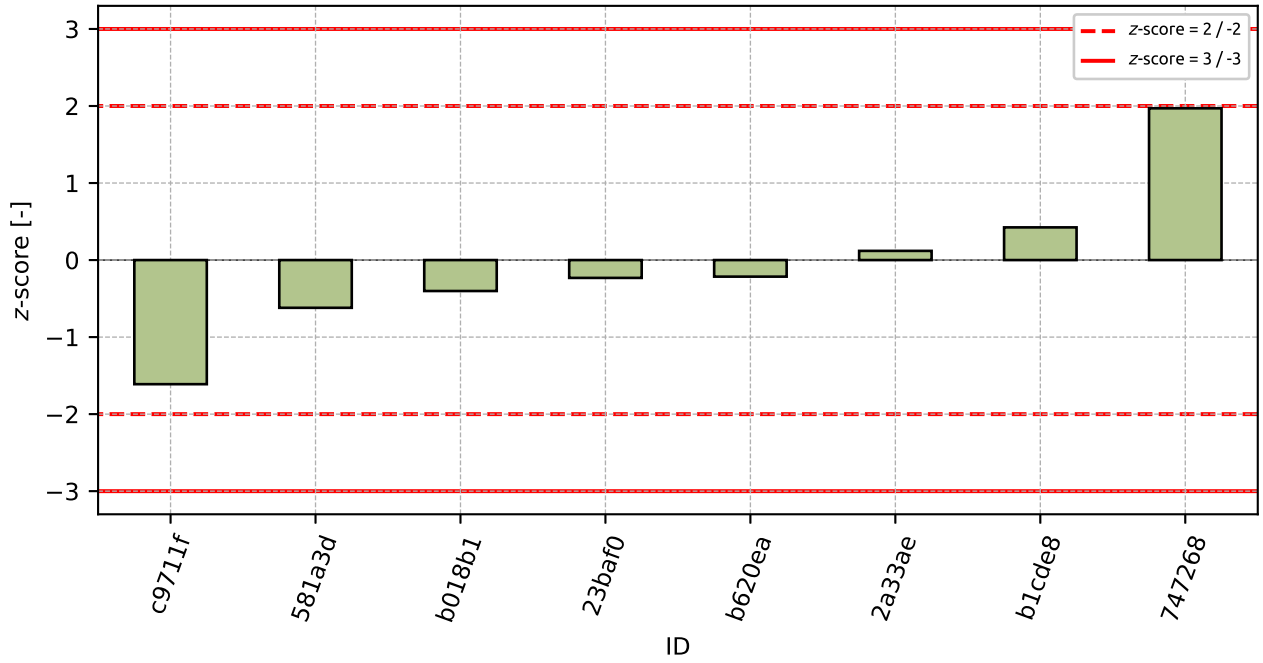

Figure 30: z-score

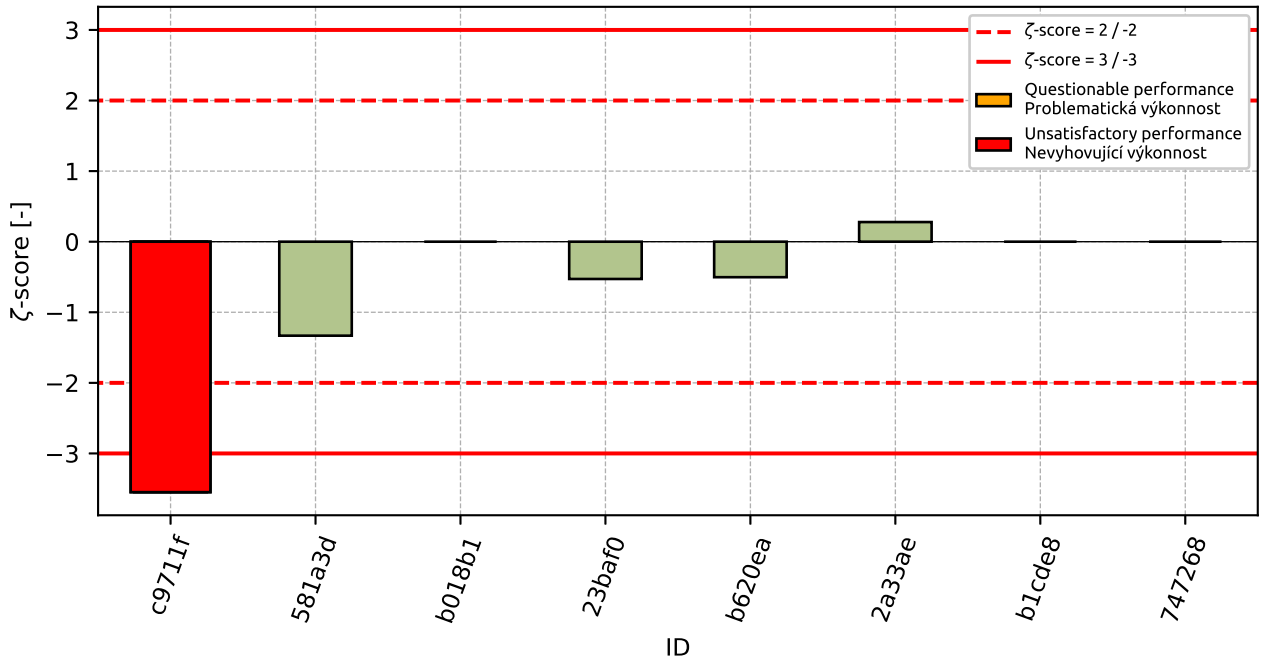

Figure 31: ζ-score

Table 19: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
c9711f	-1.61	-3.55
581a3d	-0.62	-1.33
b018b1	-0.4	-
23baf0	-0.23	-0.53
b620ea	-0.22	-0.5
2a33ae	0.12	0.28
b1cde8	0.42	-
747268	1.97	-

4.3 200 – 400 kPa

4.3.1 Test results

Table 20: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [MPa]	u_X [MPa]
c9711f	3.07	0.91
581a3d	12.76	1.69
2a33ae	14.0	0.2
b018b1	15.38	-
b620ea	15.43	0.11
23baf0	17.65	0.88
b1cde8	19.1	-
747268	28.67	-

4.3.2 The Numerical Procedure for Determining Outliers

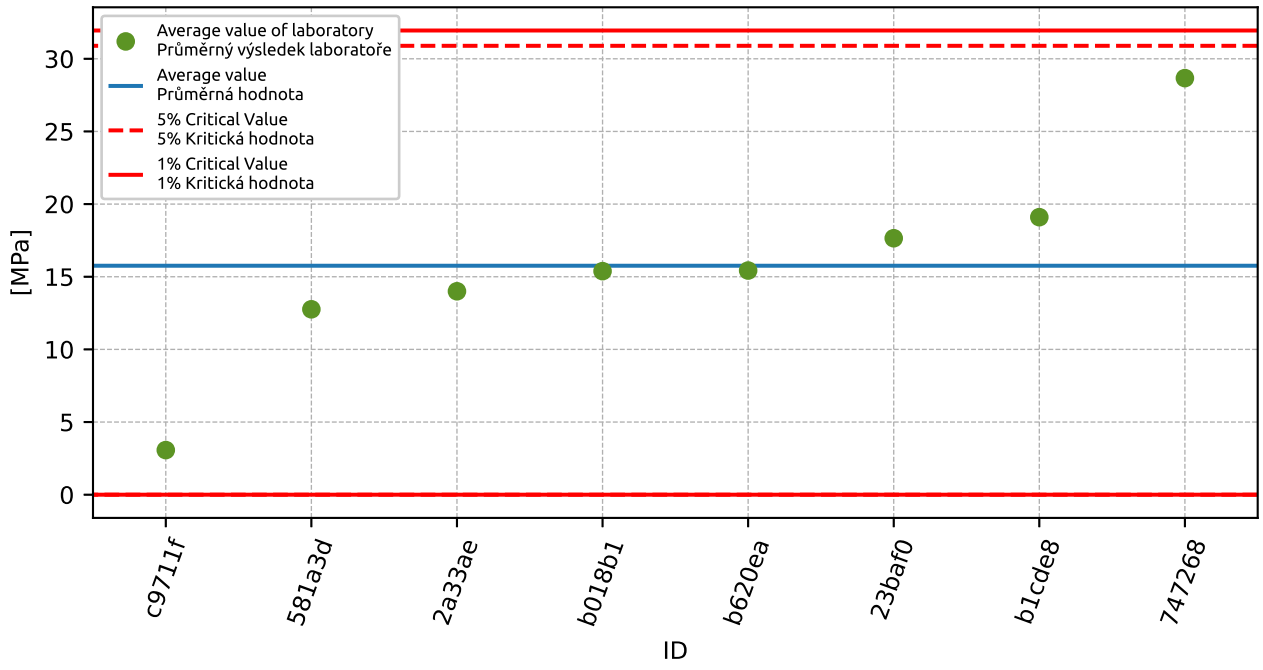

Figure 32: **Grubbs' test** - average values

4.3.3 Mandel's Statistics

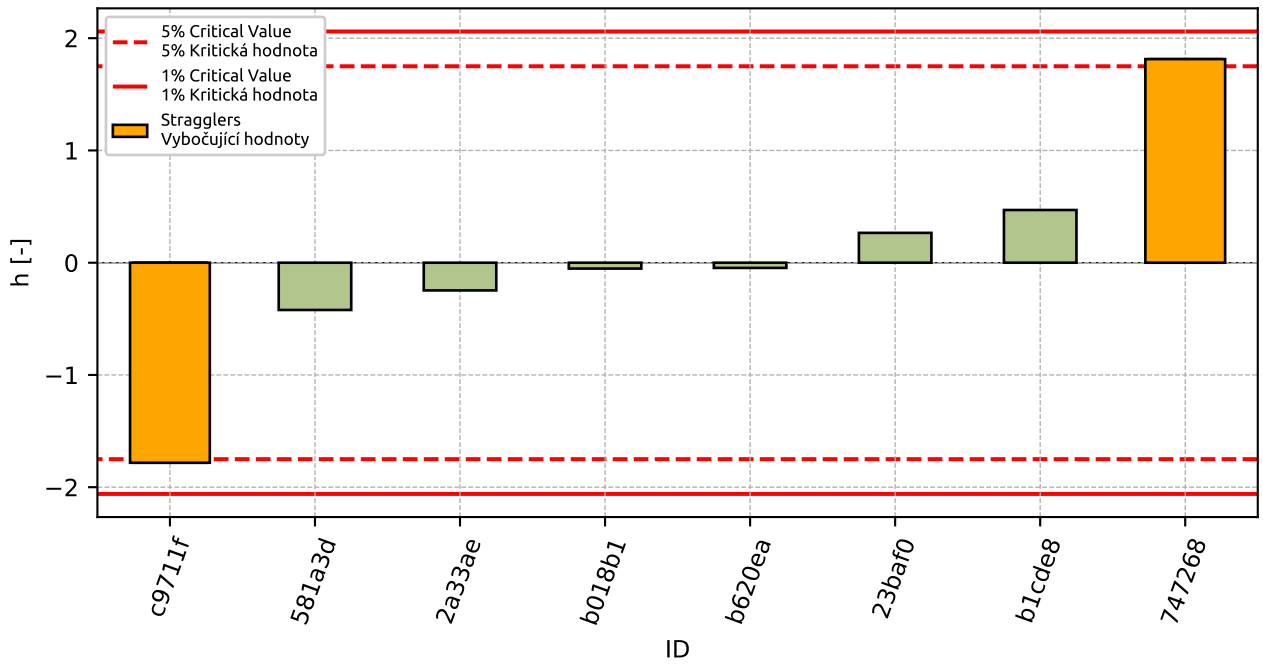

Figure 33: Interlaboratory Consistency Statistic

4.3.4 Descriptive statistics

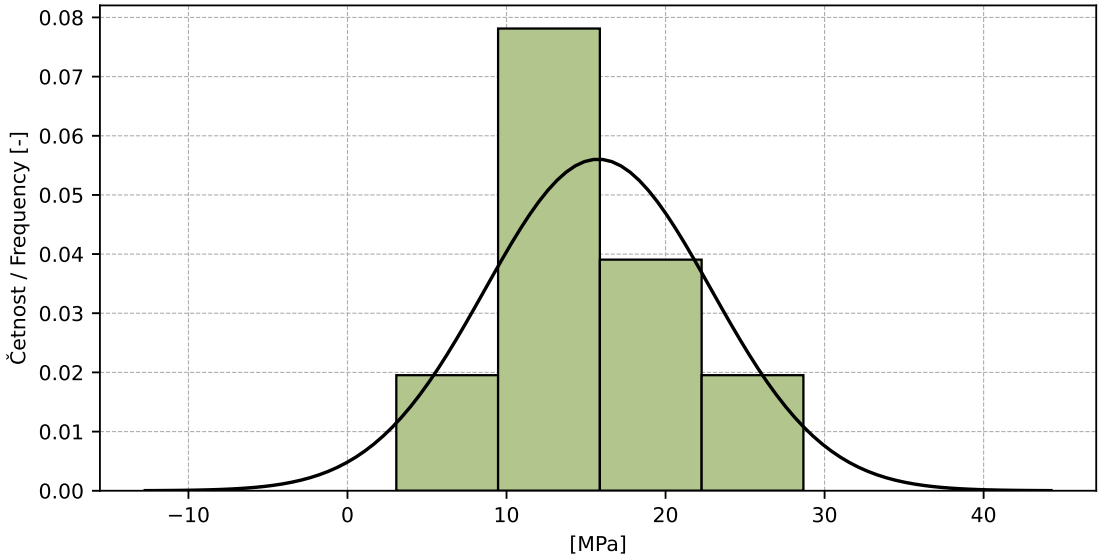

Figure 34: Histogram of all test results

Table 21: Descriptive statistics

Characteristics	[MPa]
Průměrná hodnota / Average value – $\bar{x}$	15.76
Výběrová směrodatná odchylka / Sample standard deviation – s	7.119
Vztažná hodnota / Asigned value – x^*	16.62
Robustní směrodatná odchylka / Robust standard deviation – s^*	6.789
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	2.636
p-hodnota testu normality / p-value of normality test	0.49 [-]

4.3.5 Evaluation of Performance Statistics

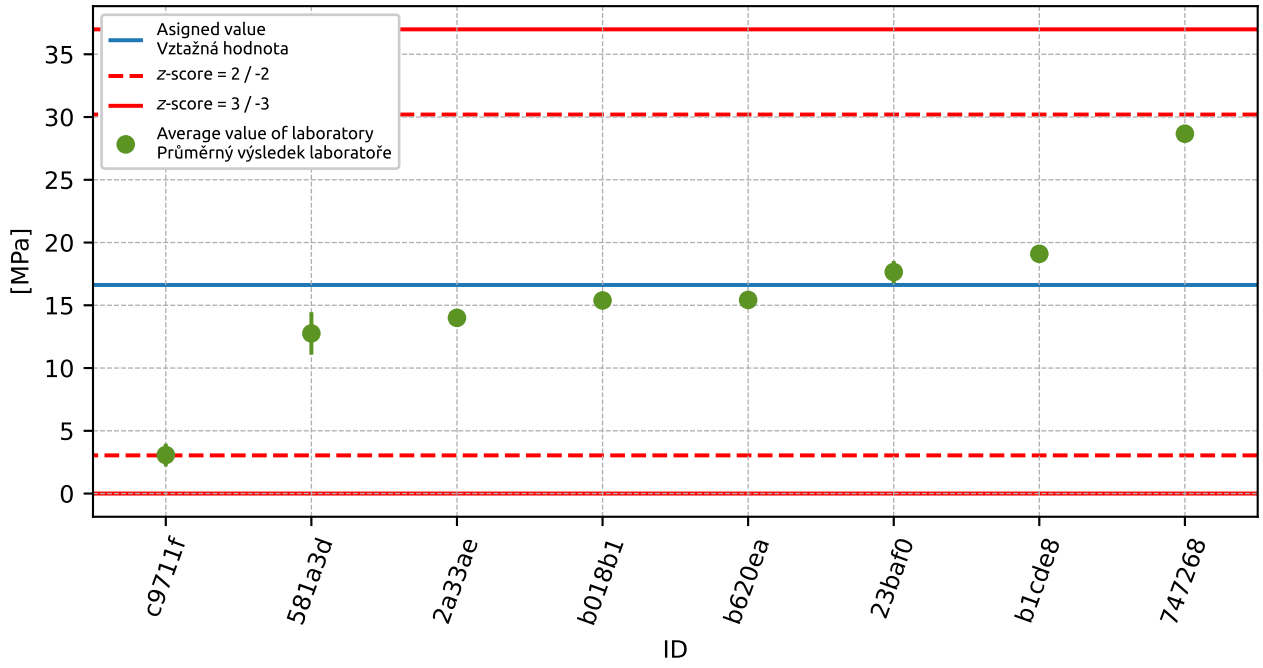

Figure 35: Average values and extended uncertainties of measurement

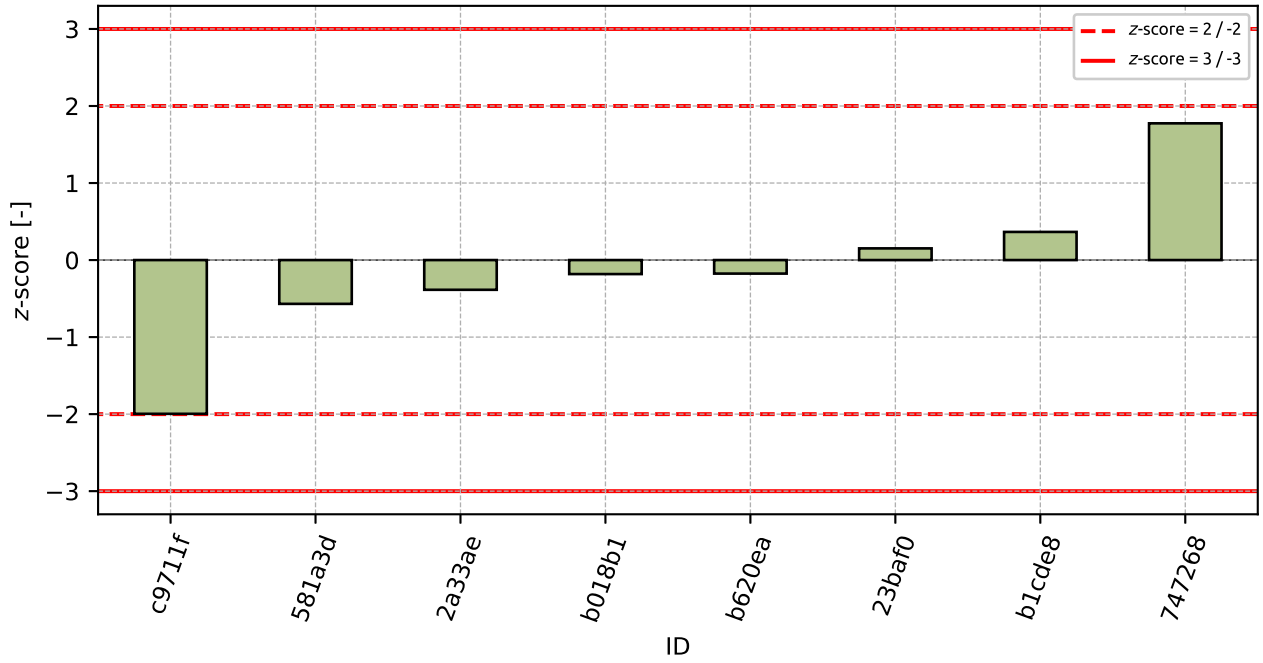

Figure 36: z-score

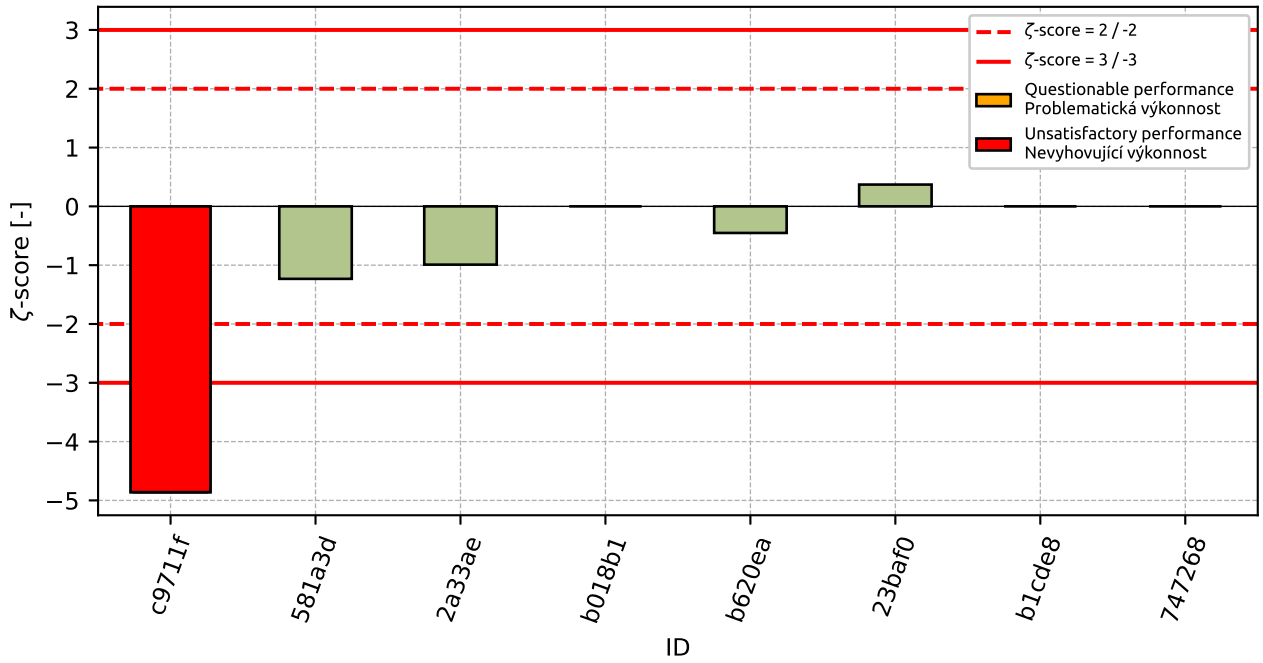

Figure 37: ζ-score

Table 22: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
c9711f	-2.0	-4.86
581a3d	-0.57	-1.23
2a33ae	-0.39	-0.99
b018b1	-0.18	-
b620ea	-0.18	-0.45
23baf0	0.15	0.37
b1cde8	0.37	-
747268	1.77	-

5 Appendix – EN ISO 17892-7 – Unconfined compressive strength, Strain at failure

5.1 Unconfined compressive strength

5.1.1 Test results

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

ID	Test results [MPa]				u_X [MPa]	$\bar{x}$ [MPa]	s_0 [MPa]	V_X [%]
b1cde8	0.132	0.138	-	-	-	0.135	0.0042	3.14
b018b1	0.169	0.176	0.177	-	-	0.174	0.0044	2.51
581a3d	0.193	0.177	0.174	0.181	0.002	0.181	0.0083	4.6
747268	0.208	0.206	0.212	0.229	-	0.214	0.0105	4.9
23baf0	0.304	0.268	0.307	-	0.006	0.293	0.0217	7.41
b83369	0.412	0.335	0.403	0.322	-	0.368	0.0461	12.52

5.1.2 The Numerical Procedure for Determining Outliers

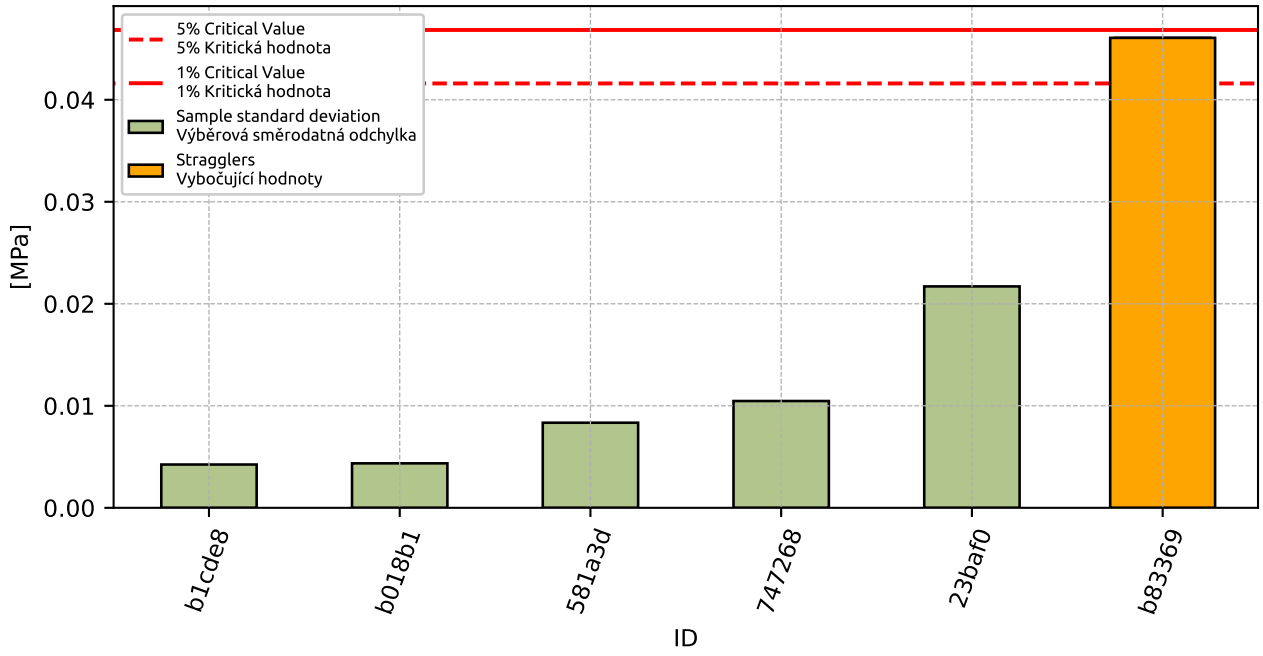

Figure 38: **Cochran's test** - sample standard deviations

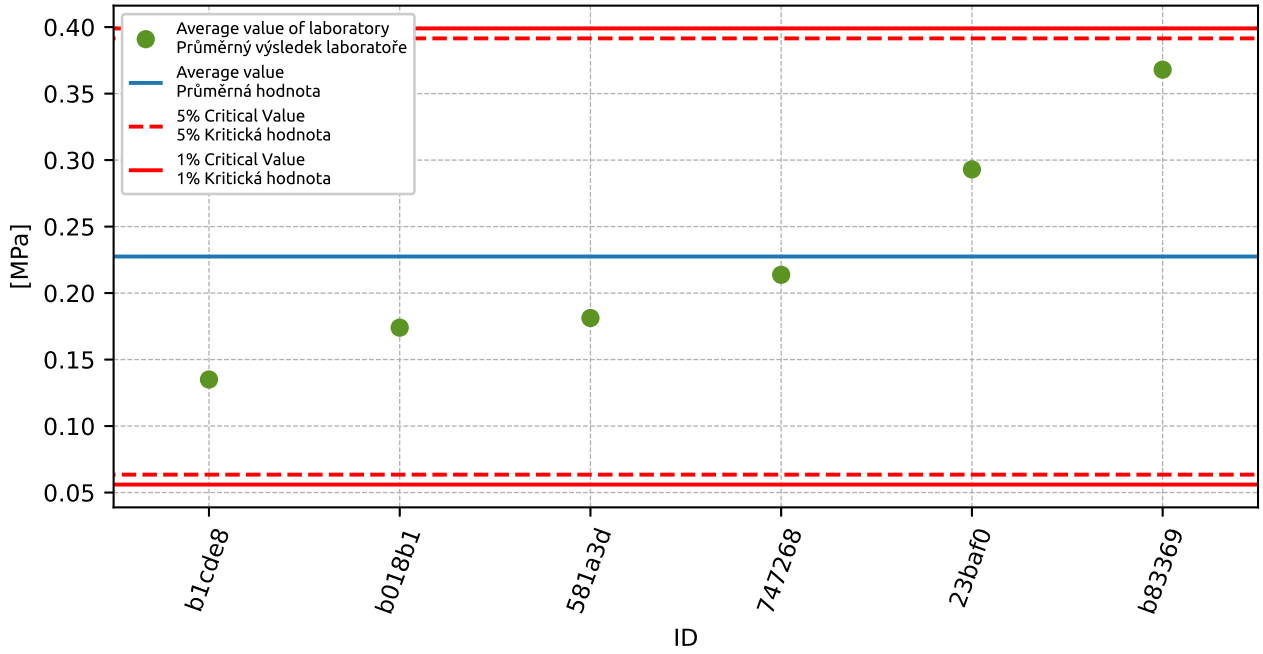

Figure 39: **Grubbs' test** - average values

5.1.3 Mandel's Statistics

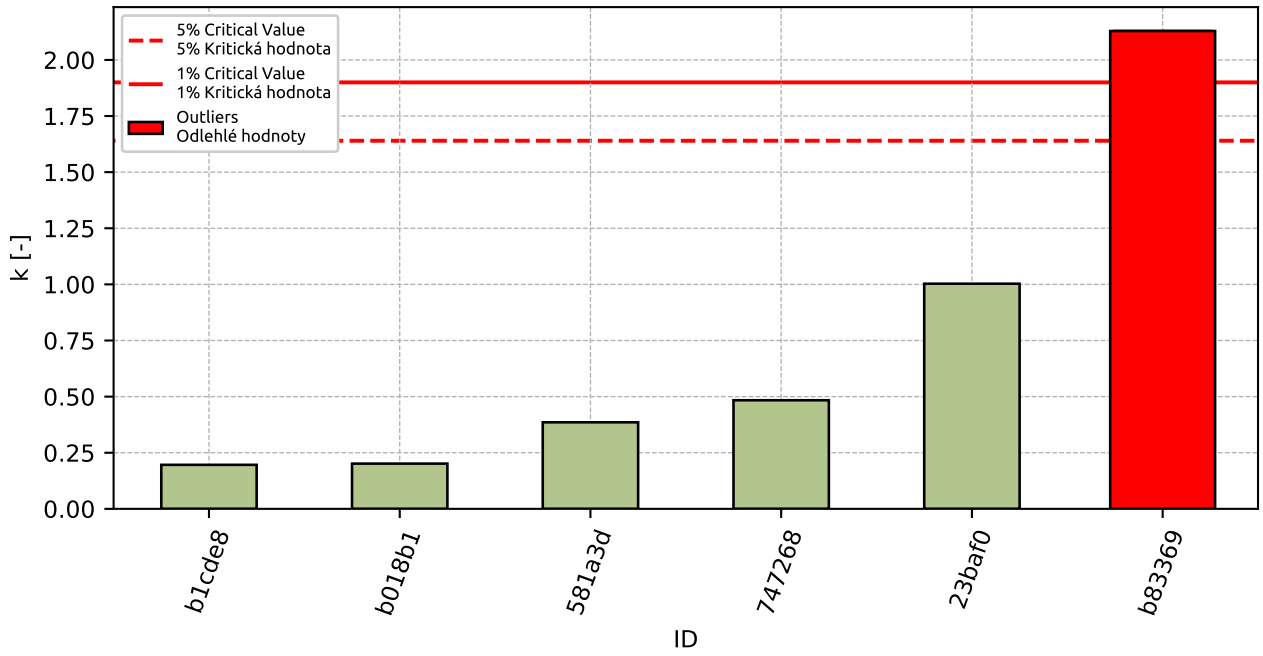

Figure 40: Intralaboratory Consistency Statistic

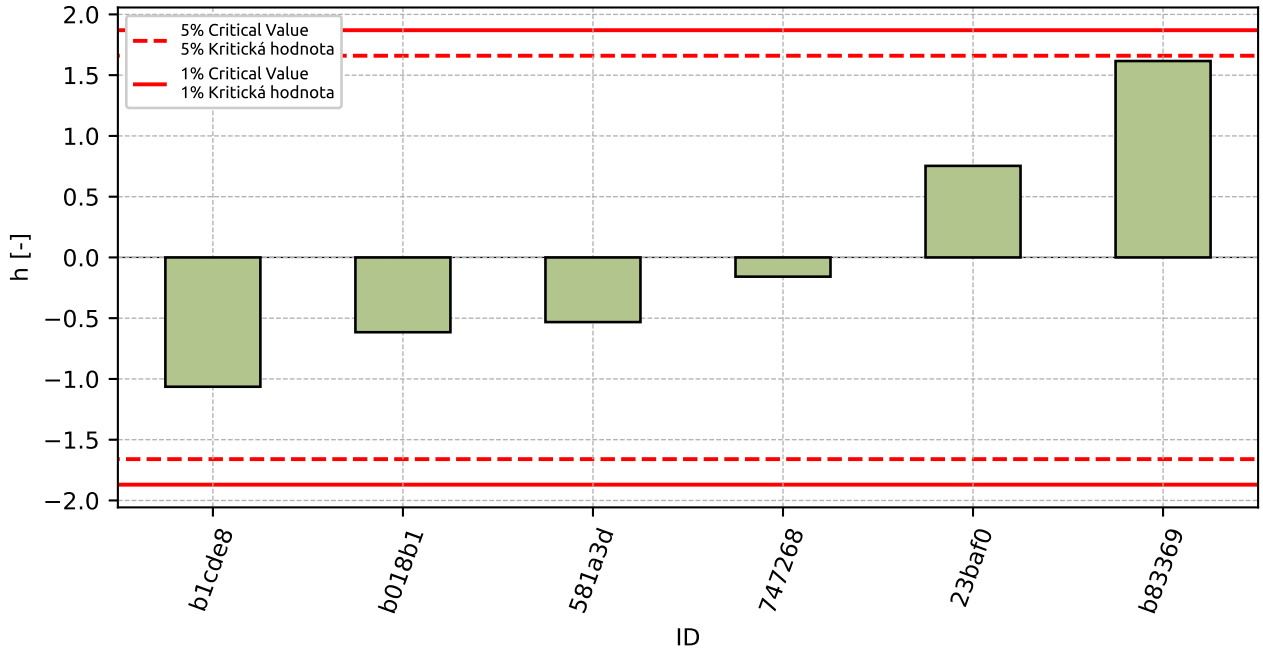

Figure 41: Interlaboratory Consistency Statistic

5.1.4 Descriptive statistics

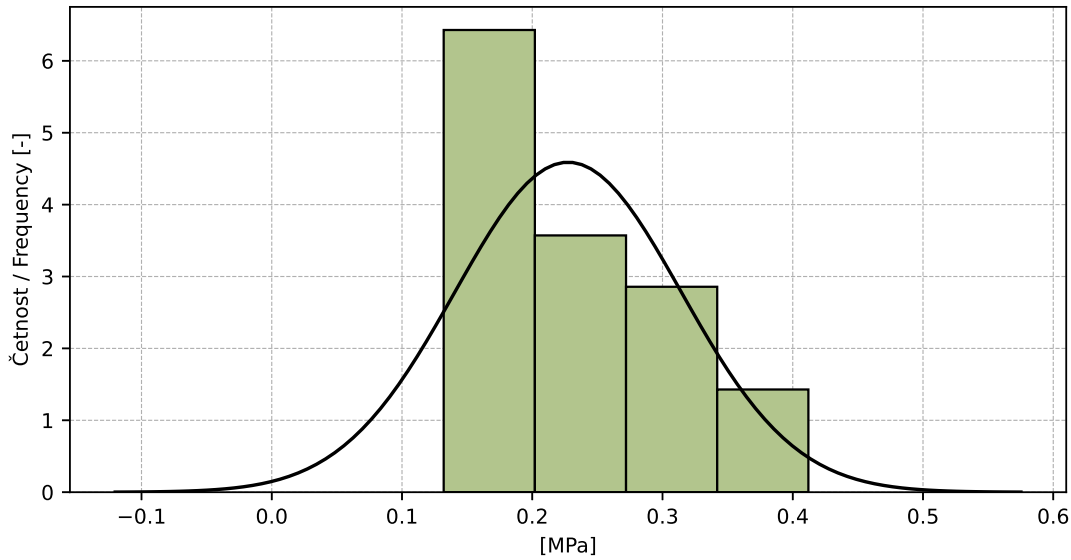

Figure 42: Histogram of all test results

Table 24: Descriptive statistics

Characteristics	[MPa]
Průměrná hodnota / Average value – $\bar{x}$	0.228
Výběrová směrodatná odchylka / Sample standard deviation – s	0.0869
Vztažná hodnota / Asigned value – x^*	0.228
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.09
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.0459
p-hodnota testu normality / p-value of normality test	1.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	0.0862
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	0.0216
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	0.0889
Opakovatelnost / Repeatability – r	0.061
Reprodukovatelnost / Reproducibility – R	0.249

5.1.5 Evaluation of Performance Statistics

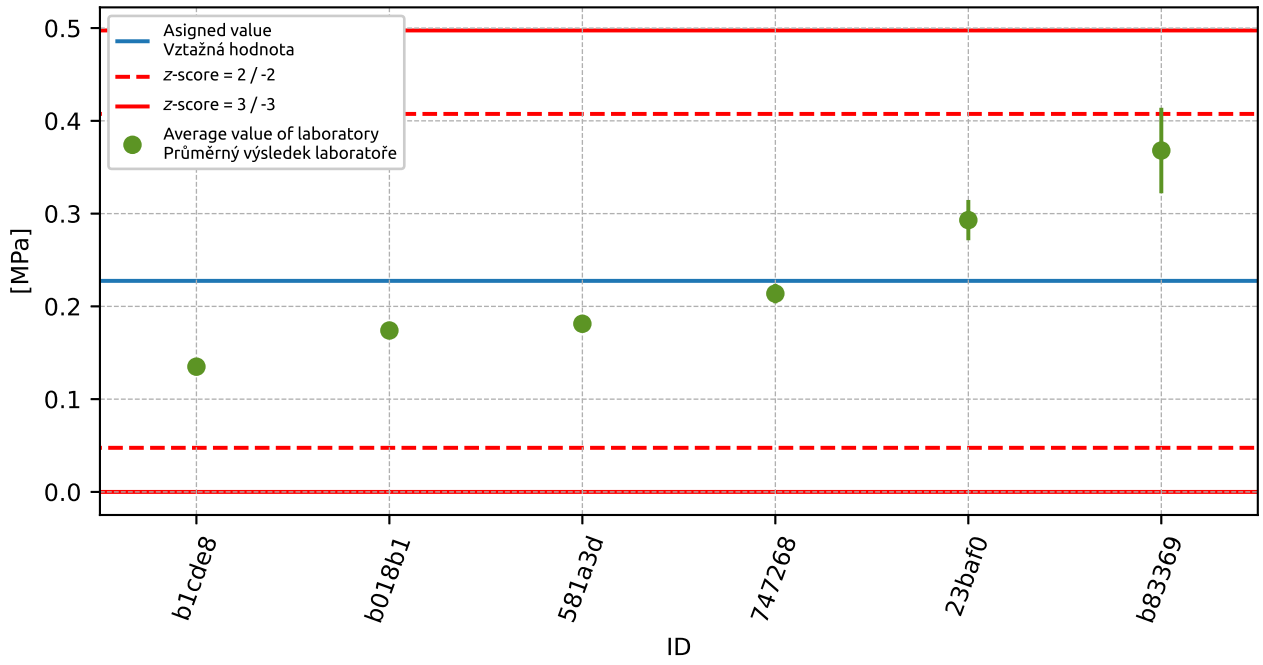

Figure 43: Average values and sample standard deviations

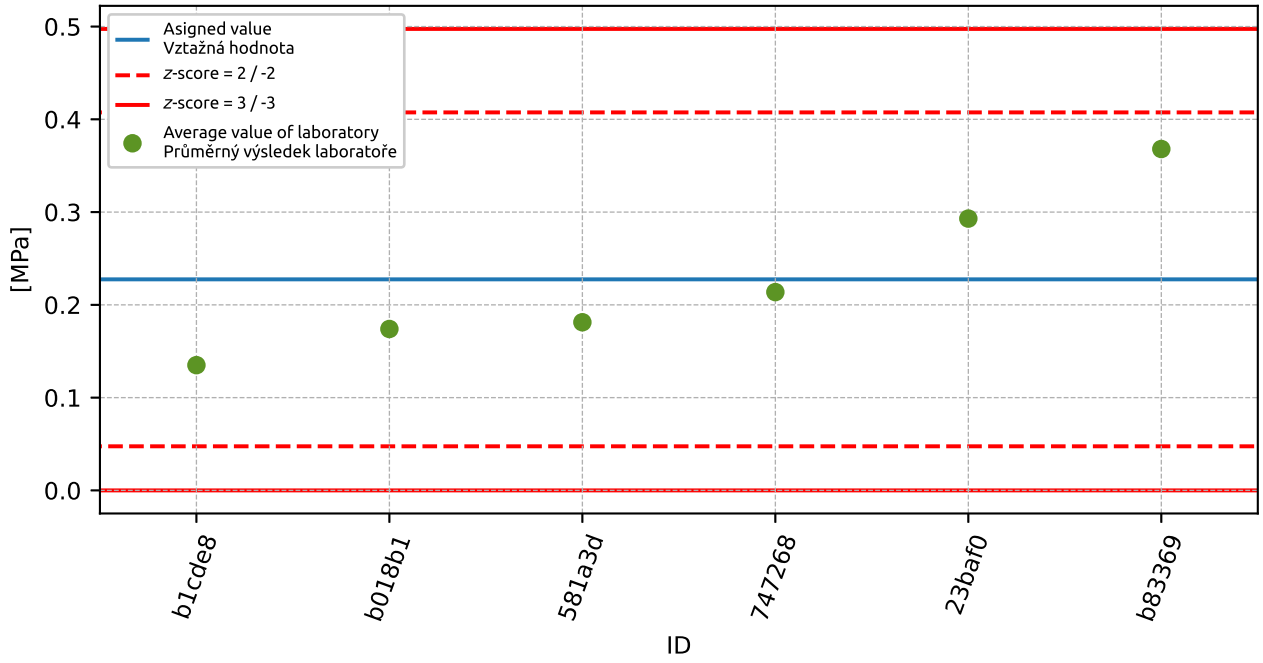

Figure 44: Average values and extended uncertainties of measurement

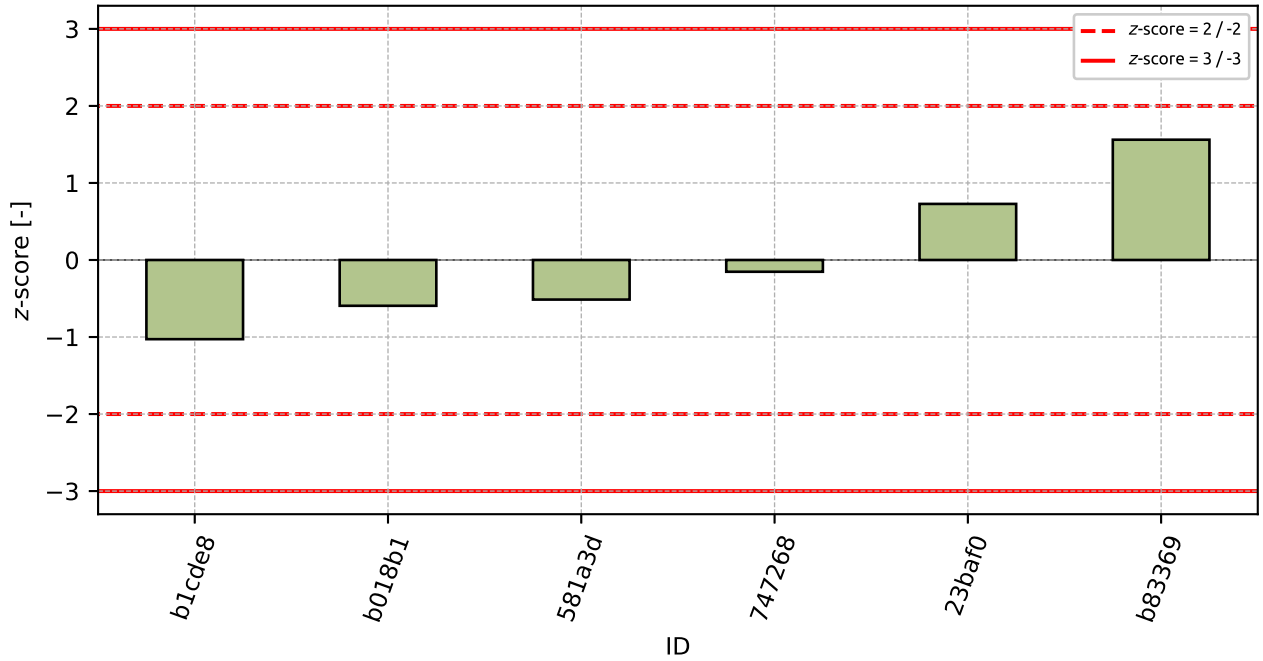

Figure 45: z-score

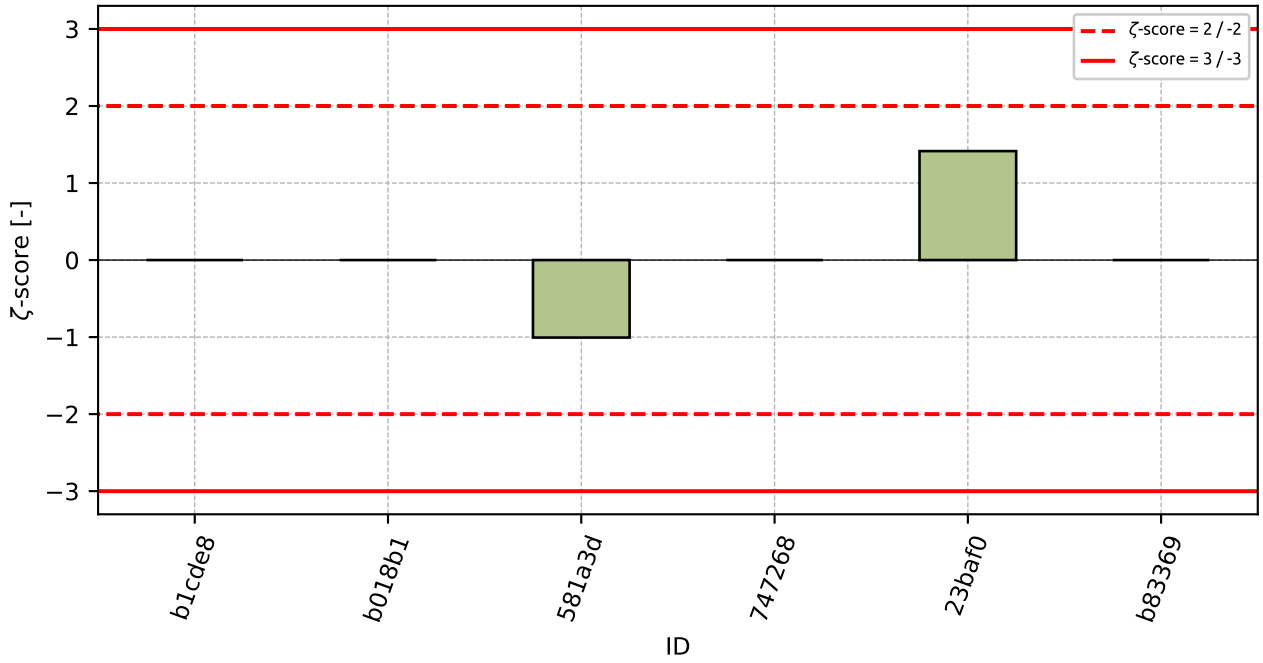

Figure 46: ζ-score

Table 25: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
b1cde8	-1.03	-
b018b1	-0.59	-
581a3d	-0.51	-1.01
747268	-0.15	-
23baf0	0.73	1.41
b83369	1.56	-

5.2 Strain at failure

5.2.1 Test results

Table 26: 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 [%]
b1cde8	2.0	1.9	-	-	-	1.95	0.0707	3.63
747268	2.67	2.74	2.7	2.83	-	2.735	0.0695	2.54
581a3d	3.59	3.52	3.57	3.56	0.04	3.56	0.0294	0.83
23baf0	5.85	5.17	6.86	-	2.0	5.96	0.8504	14.27
b018b1	6.63	5.83	5.44	-	-	5.967	0.6067	10.17
b83369	4.6	4.1	7.3	8.3	-	6.075	2.0435	33.64

5.2.2 The Numerical Procedure for Determining Outliers

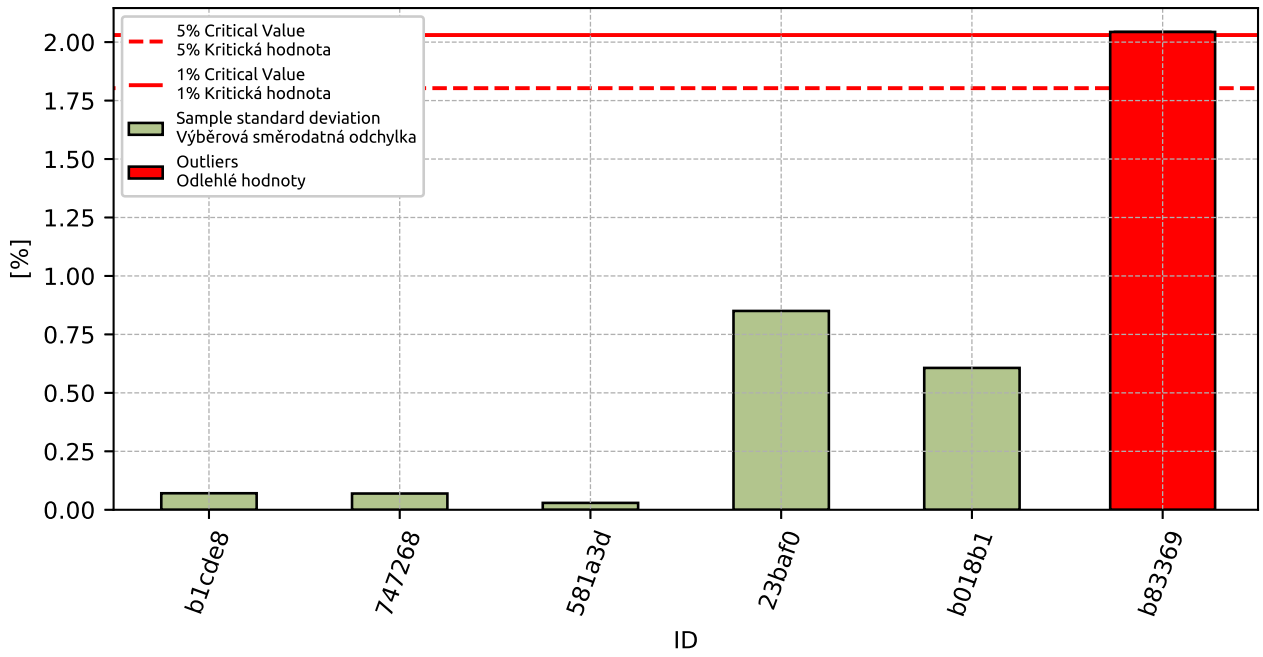

Figure 47: **Cochran's test** - sample standard deviations

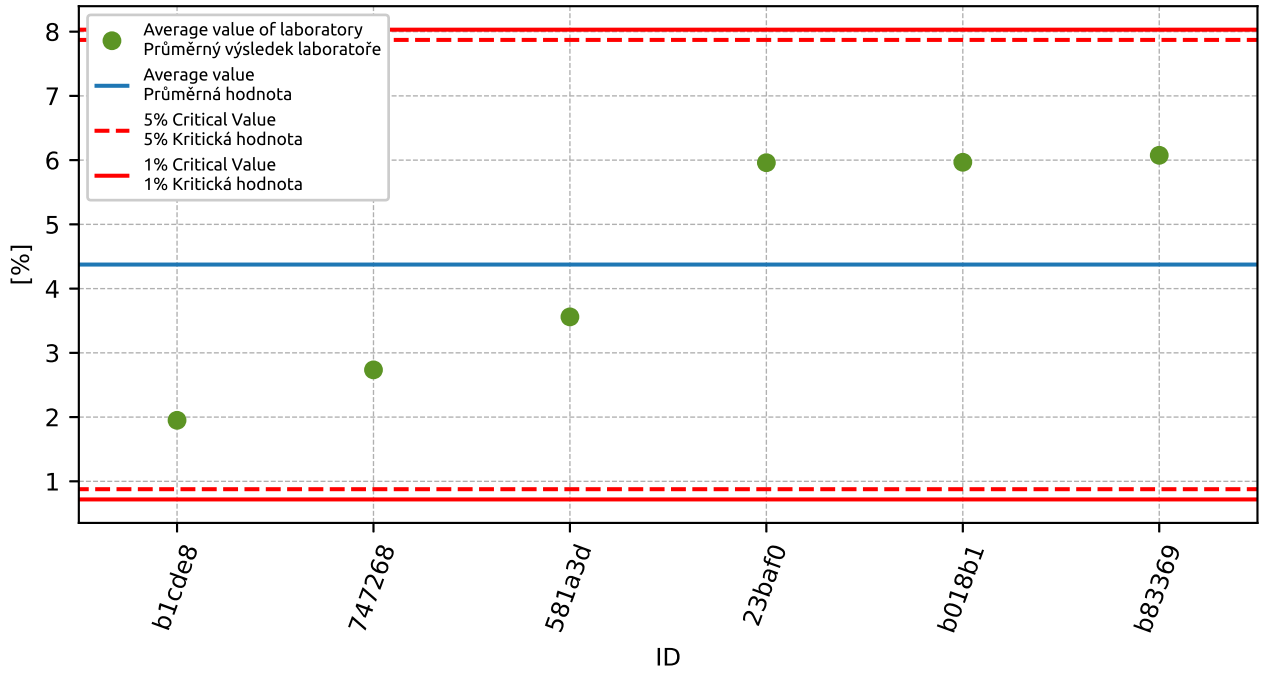

Figure 48: **Grubbs' test** - average values

5.2.3 Mandel's Statistics

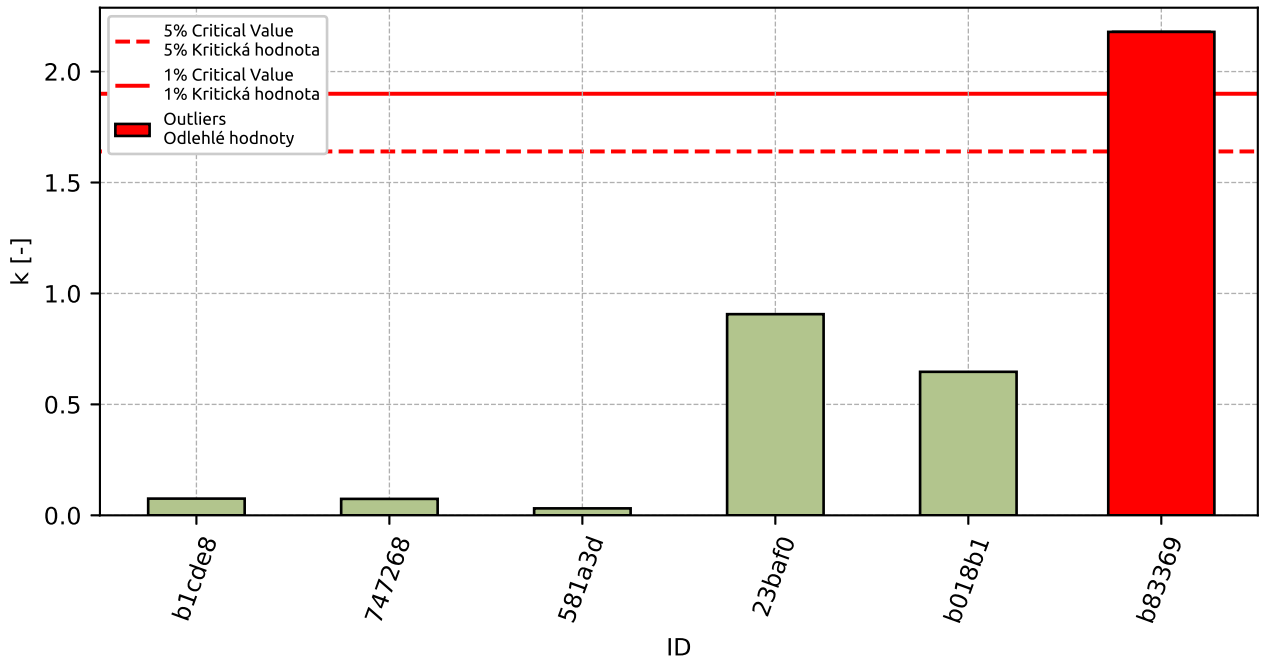

Figure 49: Intralaboratory Consistency Statistic

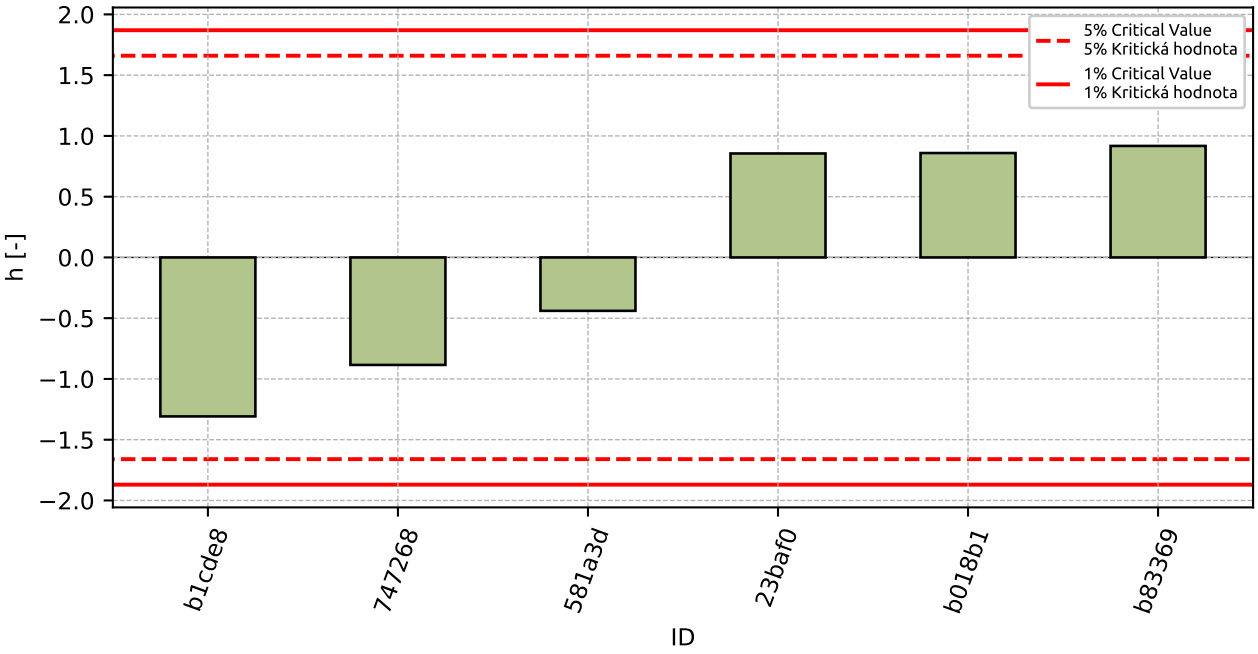

Figure 50: Interlaboratory Consistency Statistic

5.2.4 Descriptive statistics

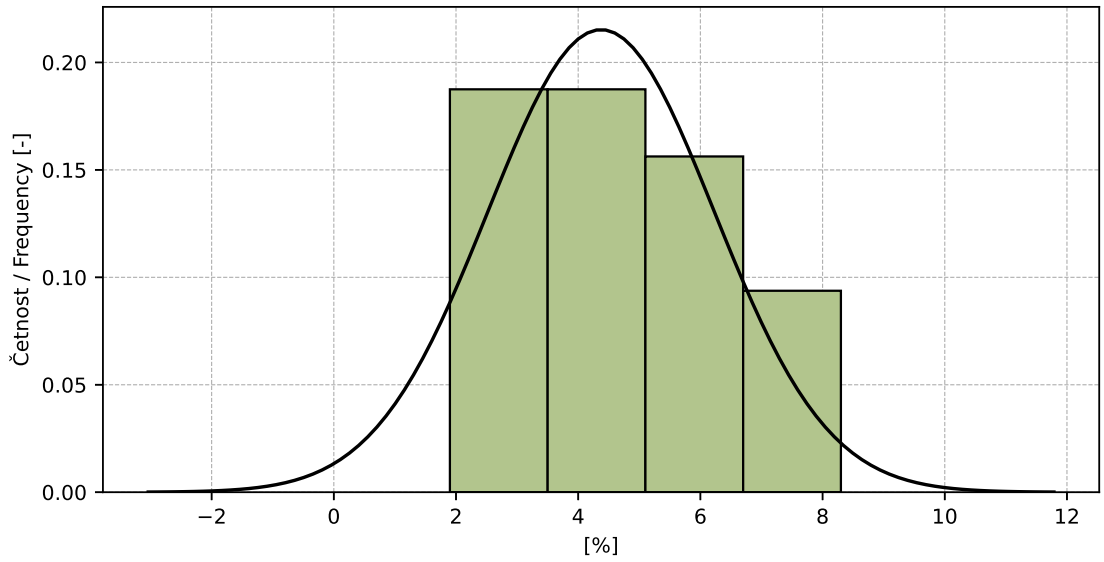

Figure 51: Histogram of all test results

Table 27: Descriptive statistics

Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	4.374
Výběrová směrodatná odchylka / Sample standard deviation – s	1.8531
Vztažná hodnota / Asigned value – x^*	4.375
Robustní směrodatná odchylka / Robust standard deviation – s^*	1.9169
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.9782
p-hodnota testu normality / p-value of normality test	1.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	1.7928
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	0.9379
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	2.0233
Opakovatelnost / Repeatability – r	2.626
Reprodukovatelnost / Reproducibility – R	5.665

5.2.5 Evaluation of Performance Statistics

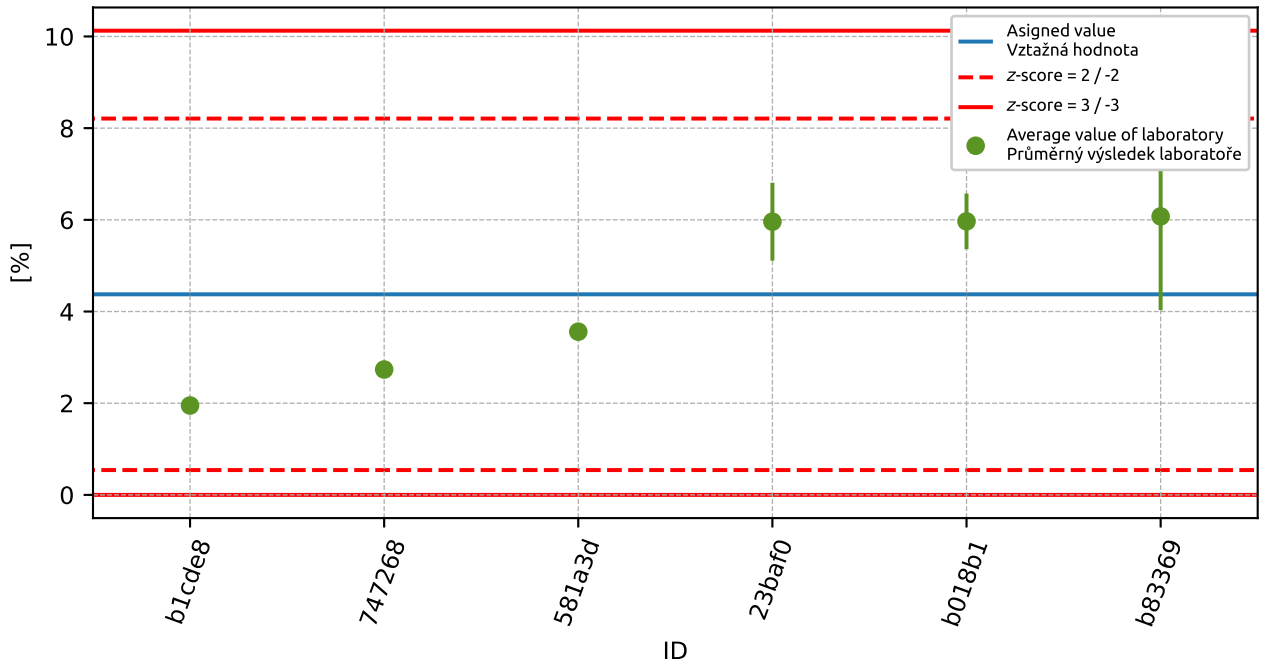

Figure 52: Average values and sample standard deviations

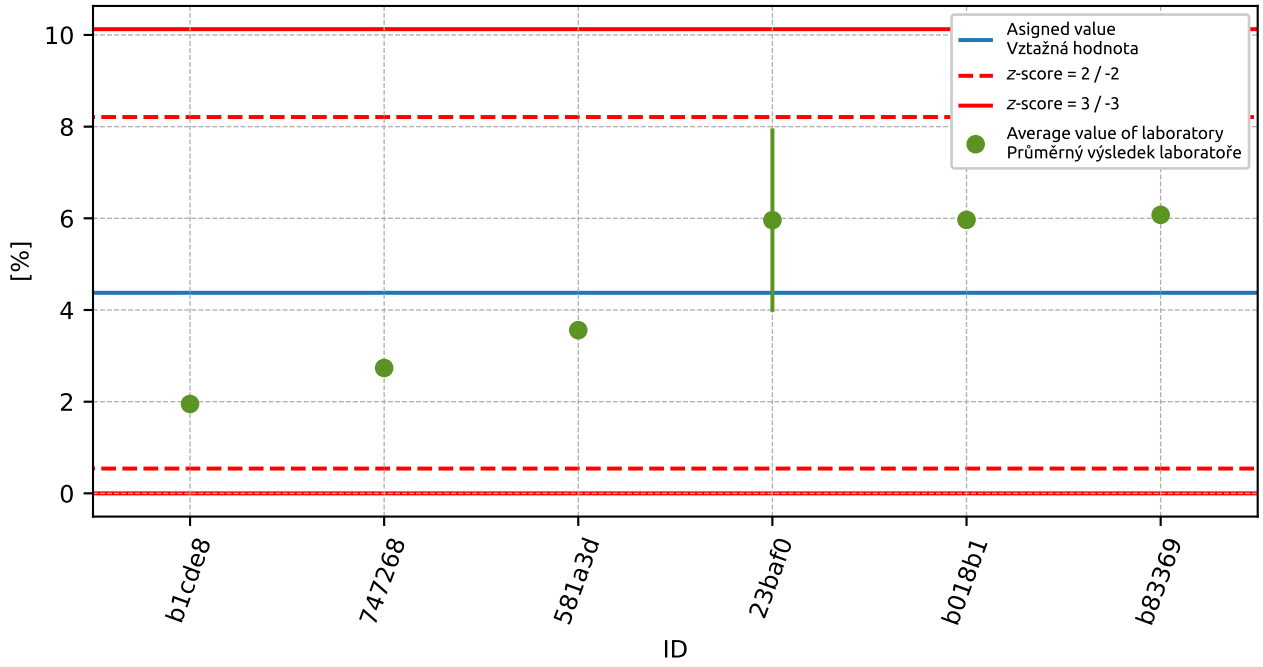

Figure 53: Average values and extended uncertainties of measurement

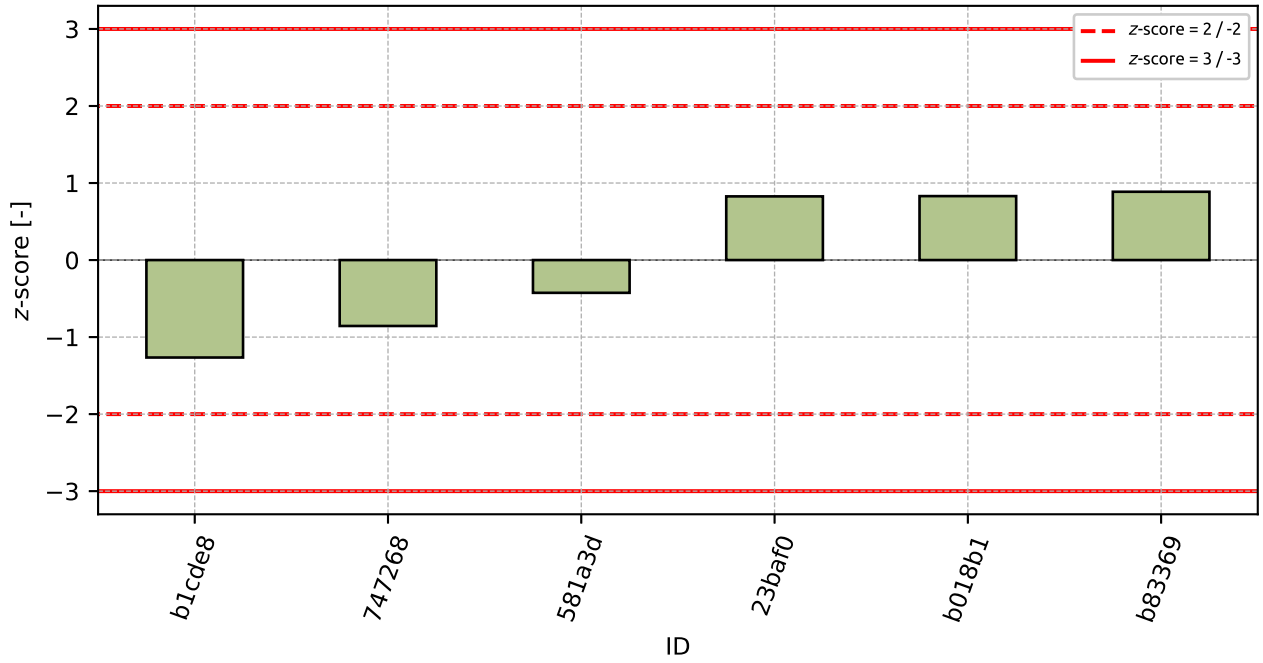

Figure 54: z-score

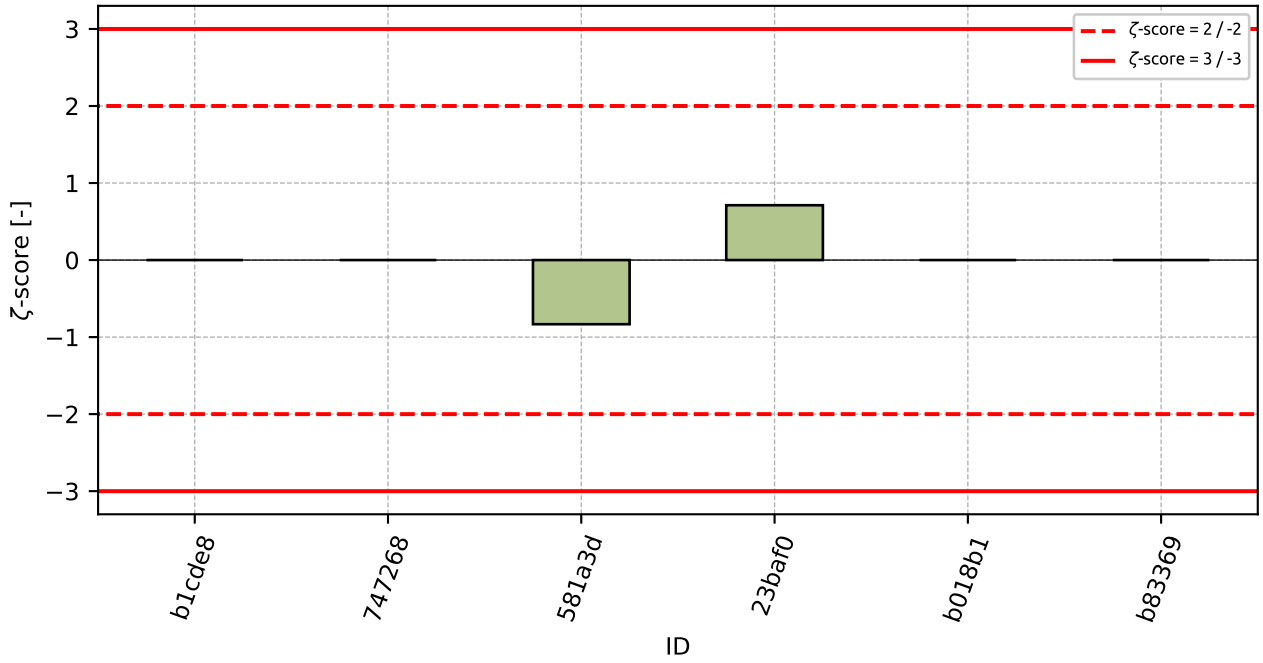

Figure 55: ζ-score

Table 28: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
b1cde8	-1.27	-
747268	-0.86	-
581a3d	-0.43	-0.83
23baf0	0.83	0.71
b018b1	0.83	-
b83369	0.89	-

6 Appendix – CEN ISO/TS 17892-10 – Effective shear parameters

6.1 50 kPa

6.1.1 Test results

Table 29: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [kPa]	u_X [kPa]
326a1e	0.31	0.02
c9711f	25.72	1.44
581a3d	44.9	-
b83369	45.28	-
23baf0	47.5	2.4
b018b1	51.4	-
b1cde8	53.0	5.0
747268	55.0	-
c356d4	77.0	-

6.1.2 The Numerical Procedure for Determining Outliers

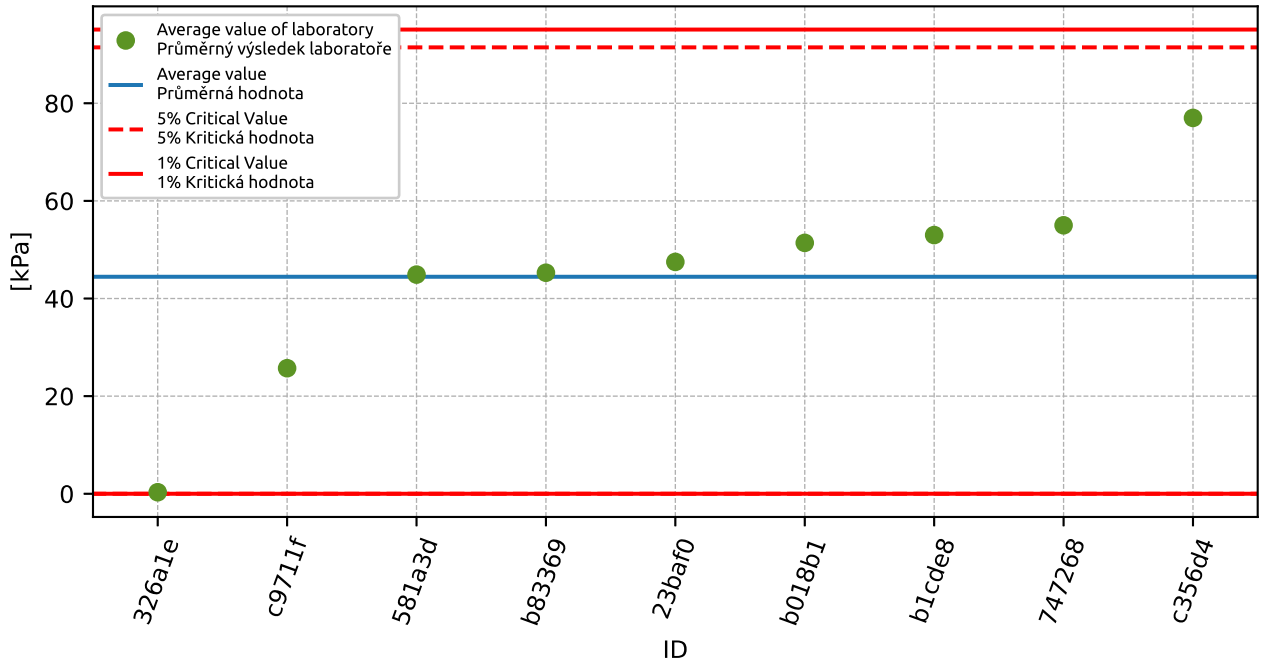

Figure 56: **Grubbs' test** - average values

6.1.3 Mandel's Statistics

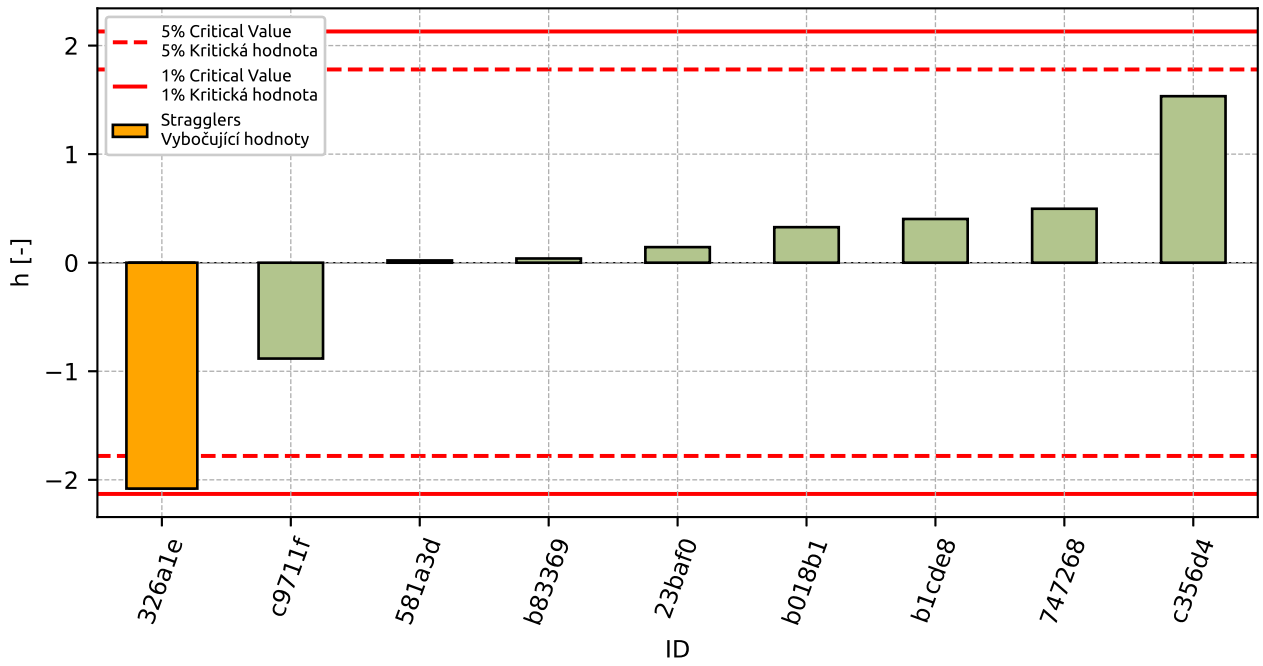

Figure 57: Interlaboratory Consistency Statistic

6.1.4 Descriptive statistics

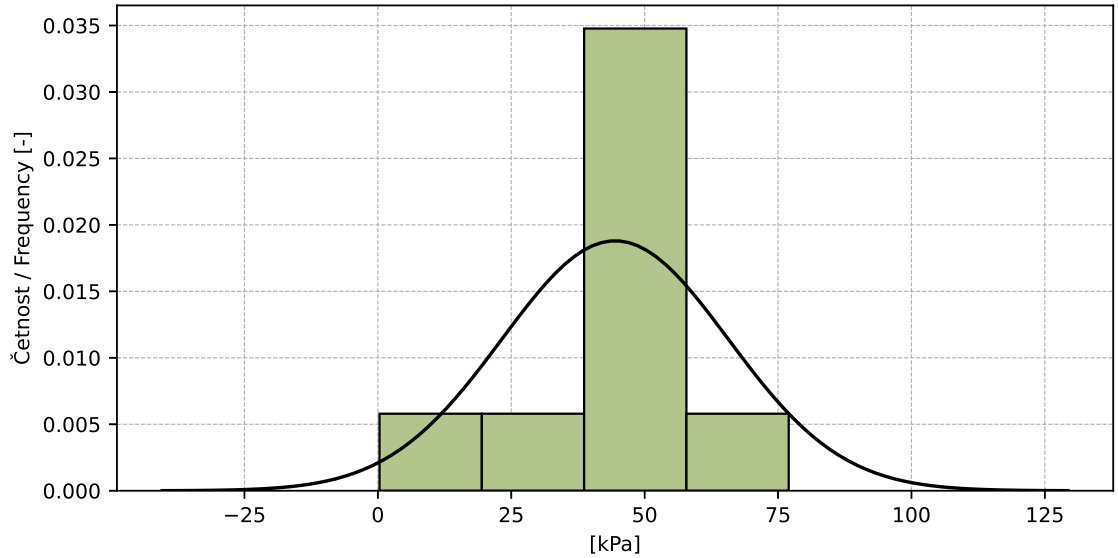

Figure 58: Histogram of all test results

Table 30: Descriptive statistics

Characteristics	[kPa]
Průměrná hodnota / Average value – $\bar{x}$	44.46
Výběrová směrodatná odchylka / Sample standard deviation – s	21.218
Vztažná hodnota / Asigned value – x^*	49.4
Robustní směrodatná odchylka / Robust standard deviation – s^*	13.367
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	5.57
p-hodnota testu normality / p-value of normality test	0.233 [-]

6.1.5 Evaluation of Performance Statistics

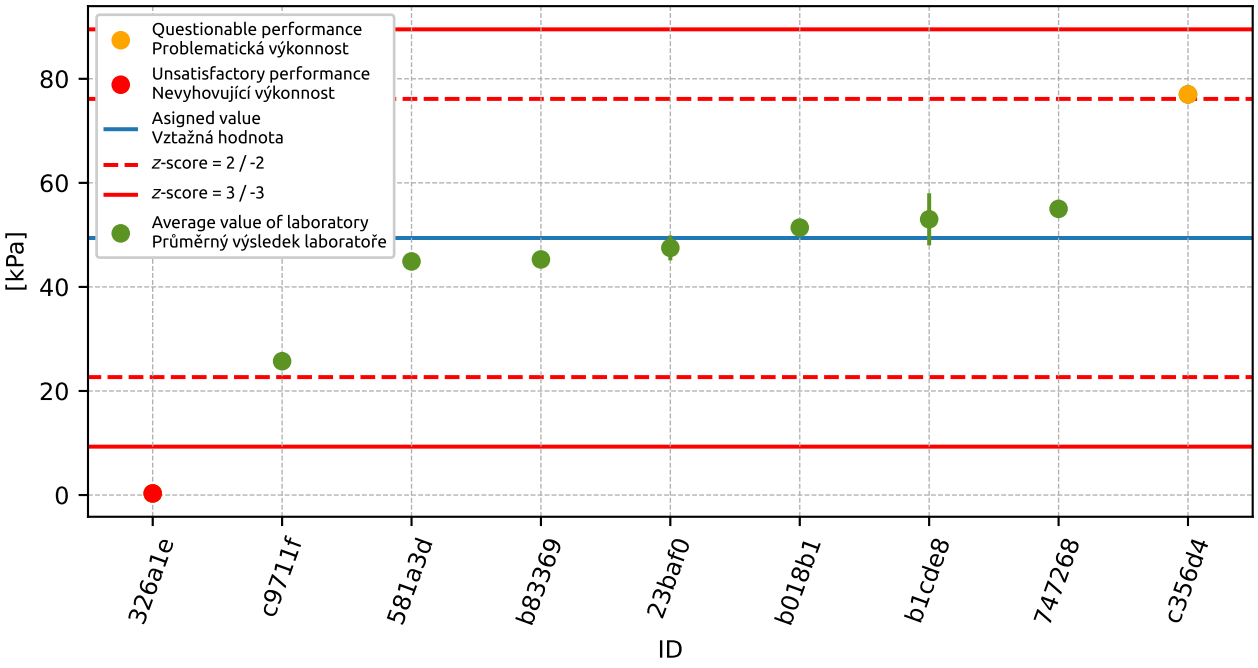

Figure 59: Average values and extended uncertainties of measurement

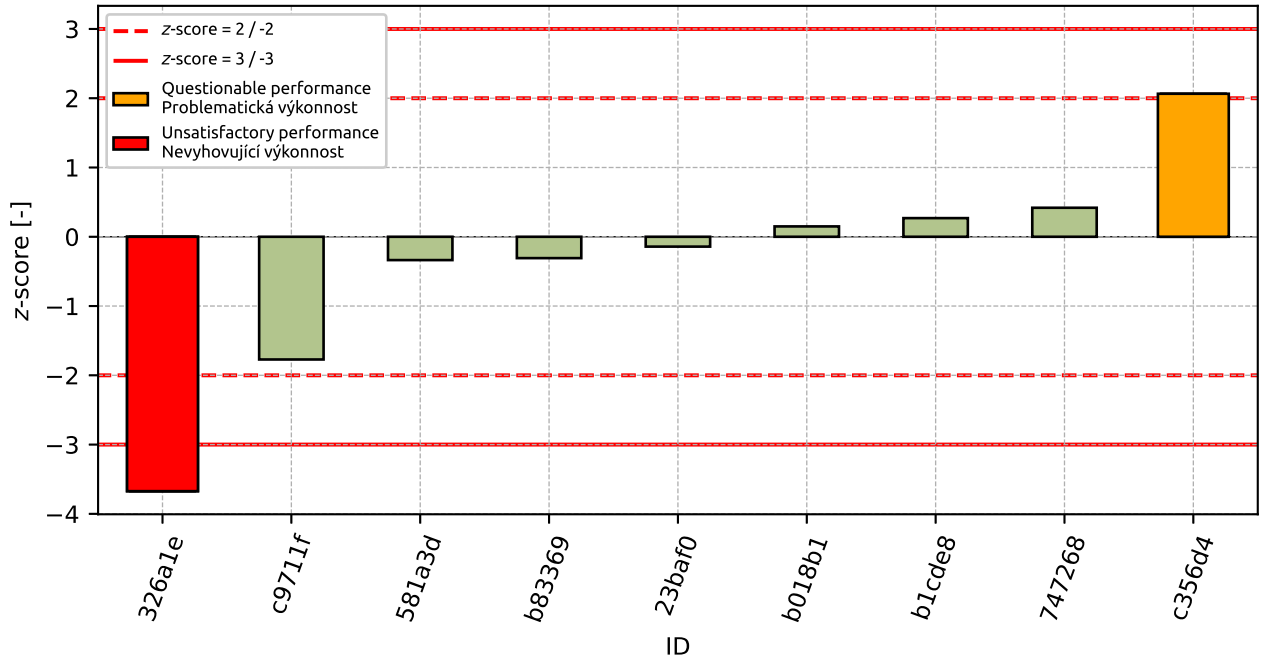

Figure 60: z-score

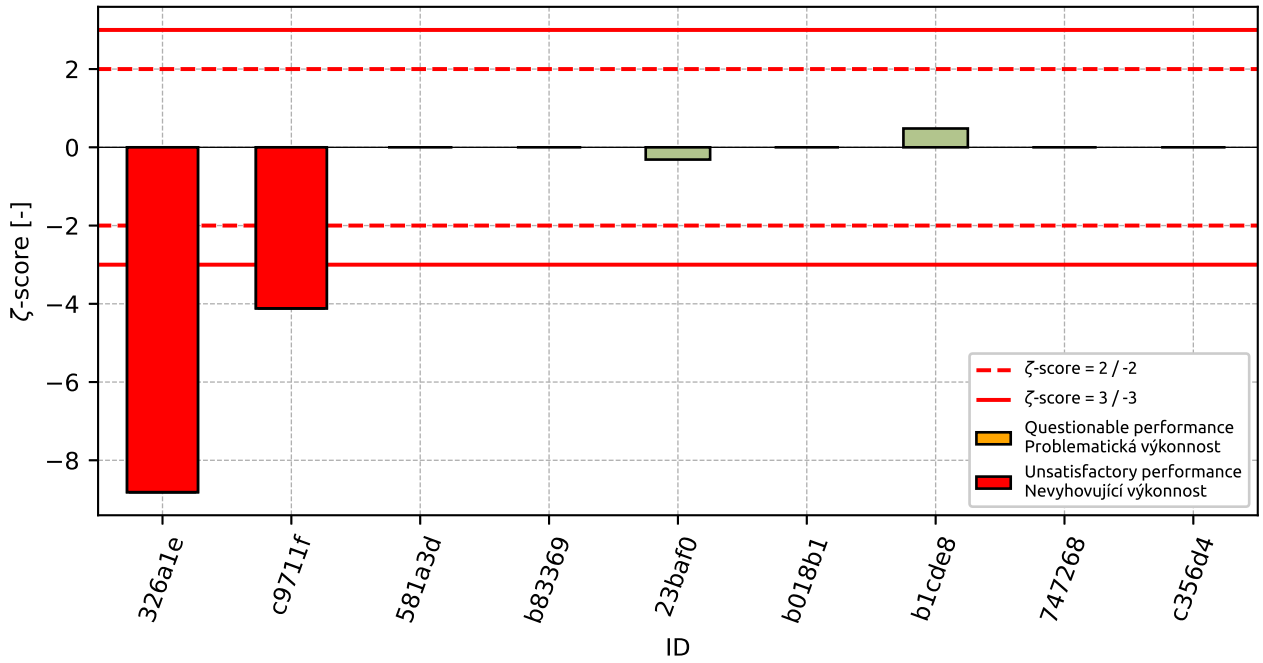

Figure 61: ζ-score

Table 31: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
326a1e	-3.67	-8.81
c9711f	-1.77	-4.12
581a3d	-0.34	-
b83369	-0.31	-
23baf0	-0.14	-0.31
b018b1	0.15	-
b1cde8	0.27	0.48
747268	0.42	-
c356d4	2.06	-

6.2 100 kPa

6.2.1 Test results

Table 32: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [kPa]	u_X [kPa]
326a1e	0.97	0.02
c9711f	32.26	1.44
23baf0	55.0	2.8
581a3d	69.3	-
747268	75.0	-
b1cde8	78.0	5.0
b83369	87.78	-
b018b1	91.8	-
c356d4	103.0	-

6.2.2 The Numerical Procedure for Determining Outliers

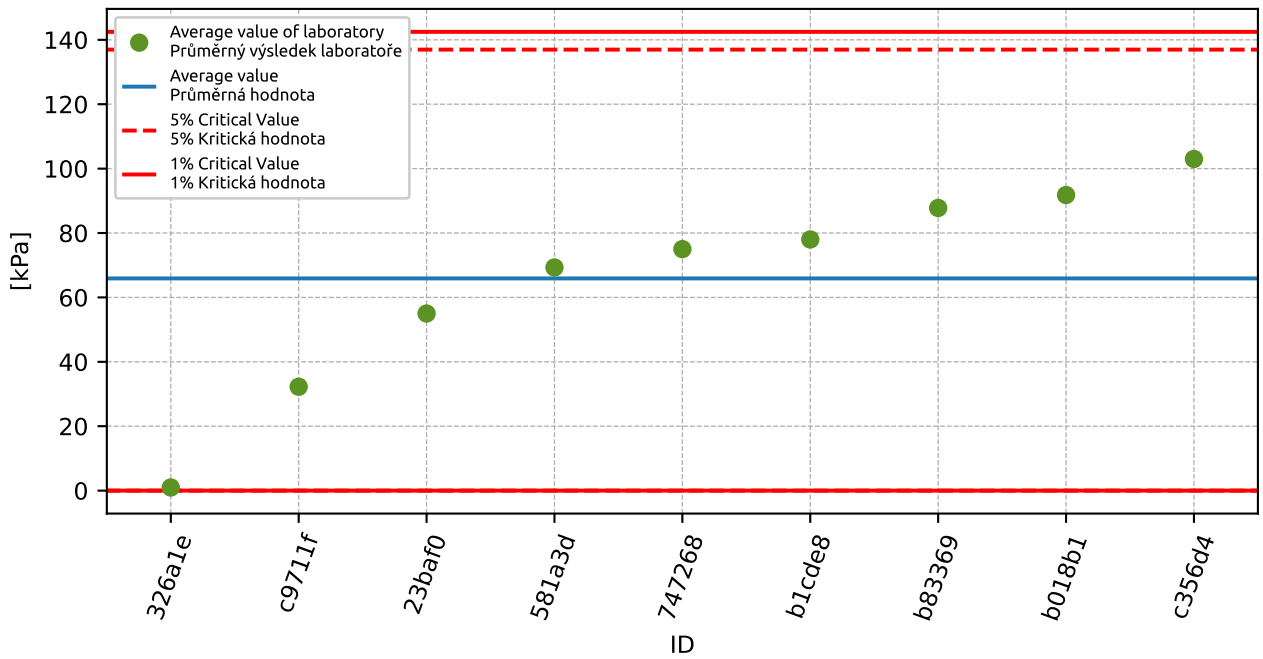

Figure 62: **Grubbs' test** - average values

6.2.3 Mandel's Statistics

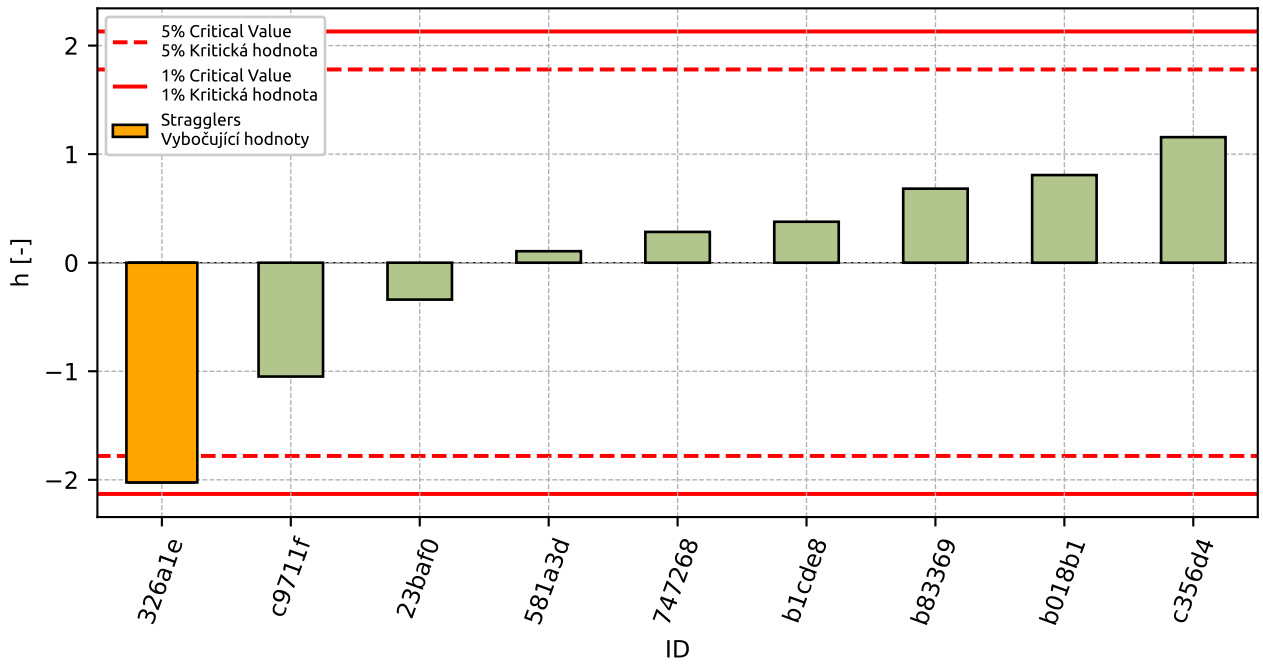

Figure 63: Interlaboratory Consistency Statistic

6.2.4 Descriptive statistics

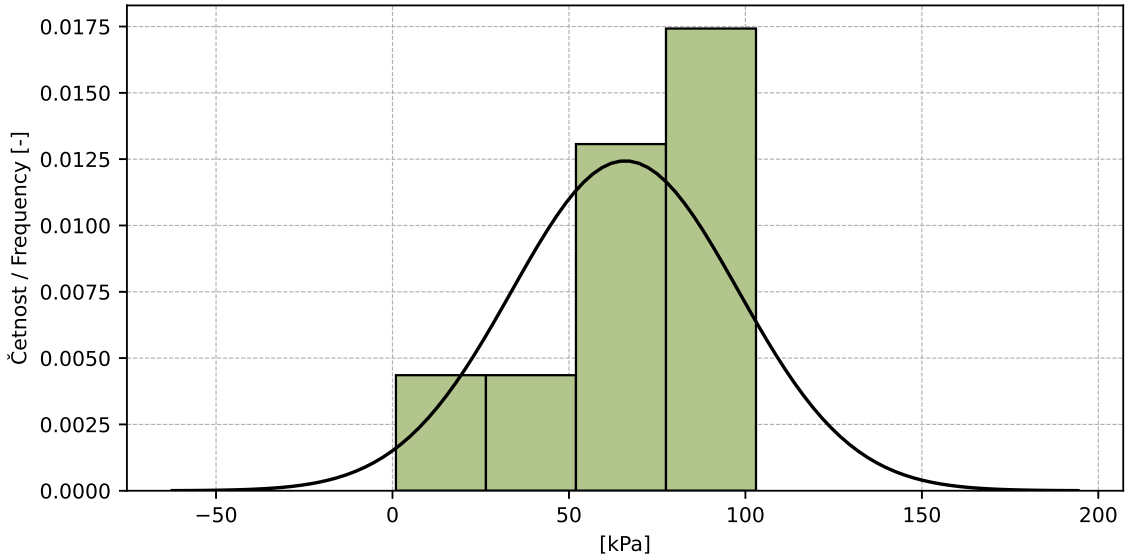

Figure 64: Histogram of all test results

Table 33: Descriptive statistics

Characteristics	[kPa]
Průměrná hodnota / Average value – $\bar{x}$	65.9
Výběrová směrodatná odchylka / Sample standard deviation – s	32.08
Vztažná hodnota / Asigned value – x^*	70.57
Robustní směrodatná odchylka / Robust standard deviation – s^*	24.752
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	10.313
p-hodnota testu normality / p-value of normality test	0.336 [-]

6.2.5 Evaluation of Performance Statistics

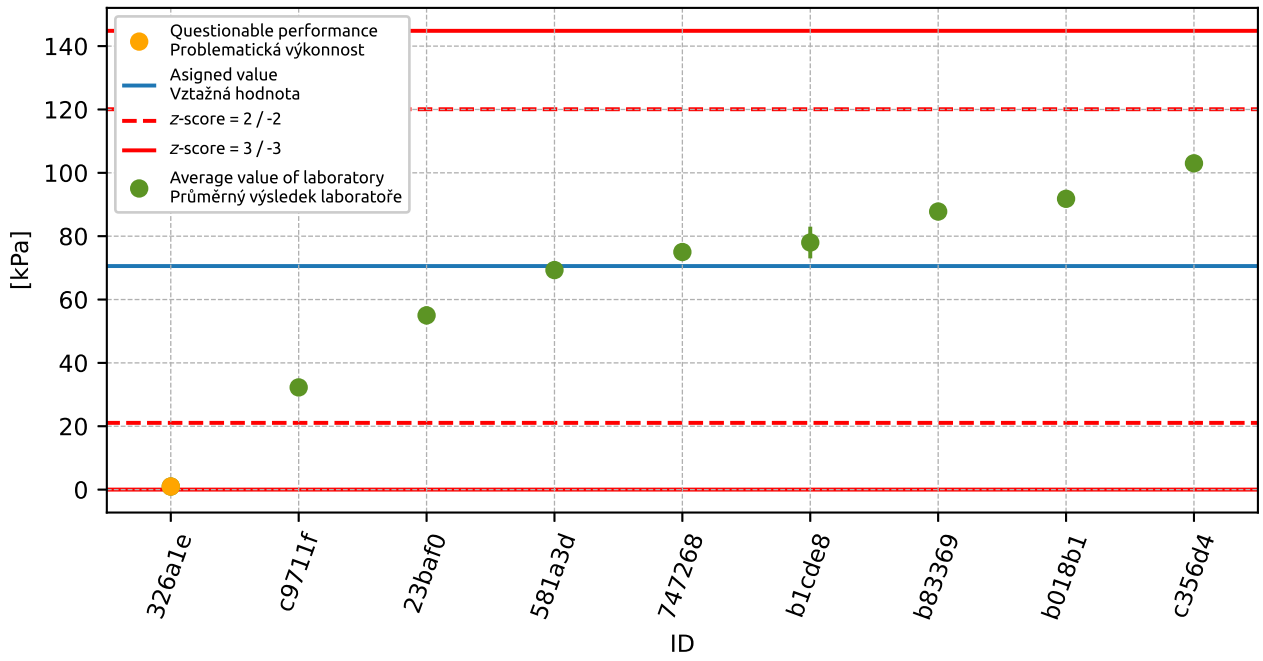

Figure 65: Average values and extended uncertainties of measurement

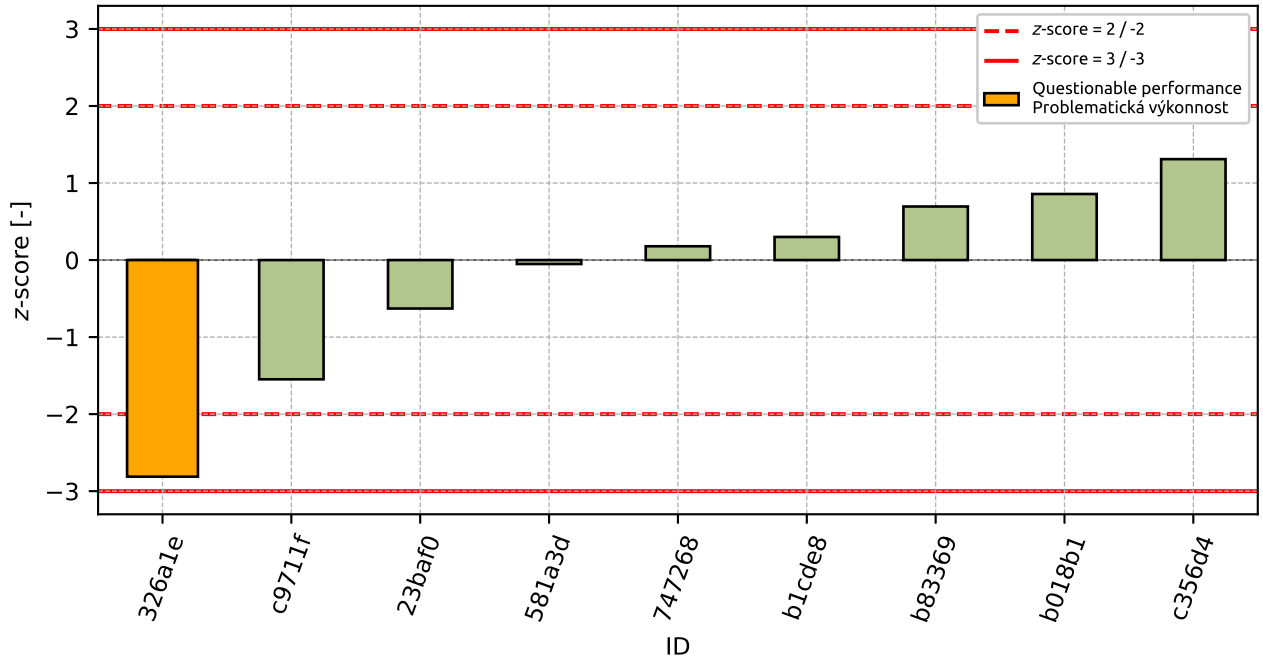

Figure 66: z-score

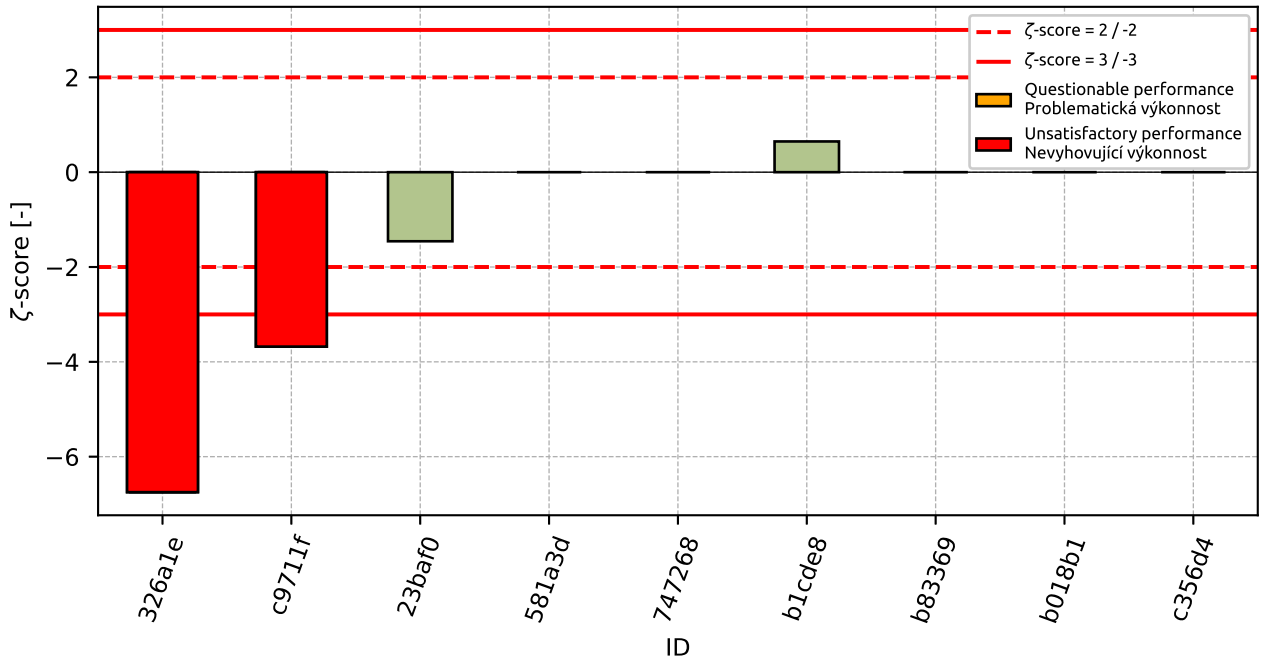

Figure 67: ζ-score

Table 34: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
326a1e	-2.81	-6.75
c9711f	-1.55	-3.68
23baf0	-0.63	-1.46
581a3d	-0.05	-
747268	0.18	-
b1cde8	0.3	0.65
b83369	0.7	-
b018b1	0.86	-
c356d4	1.31	-

6.3 200 kPa

6.3.1 Test results

Table 35: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [kPa]	u_X [kPa]
326a1e	1.59	0.02
c9711f	36.7	1.44
747268	122.0	-
b1cde8	133.0	10.0
b018b1	134.6	-
581a3d	139.9	-
23baf0	140.0	7.0
b83369	157.78	-
c356d4	167.0	-

6.3.2 The Numerical Procedure for Determining Outliers

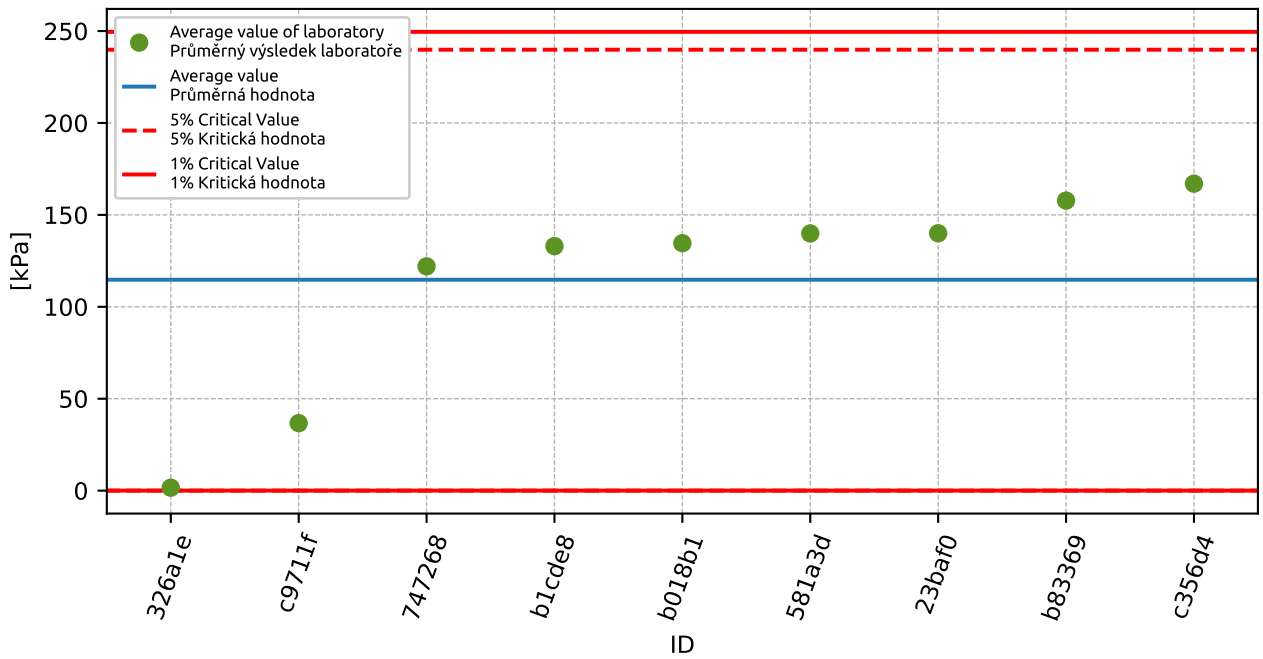

Figure 68: **Grubbs' test** - average values

6.3.3 Mandel's Statistics

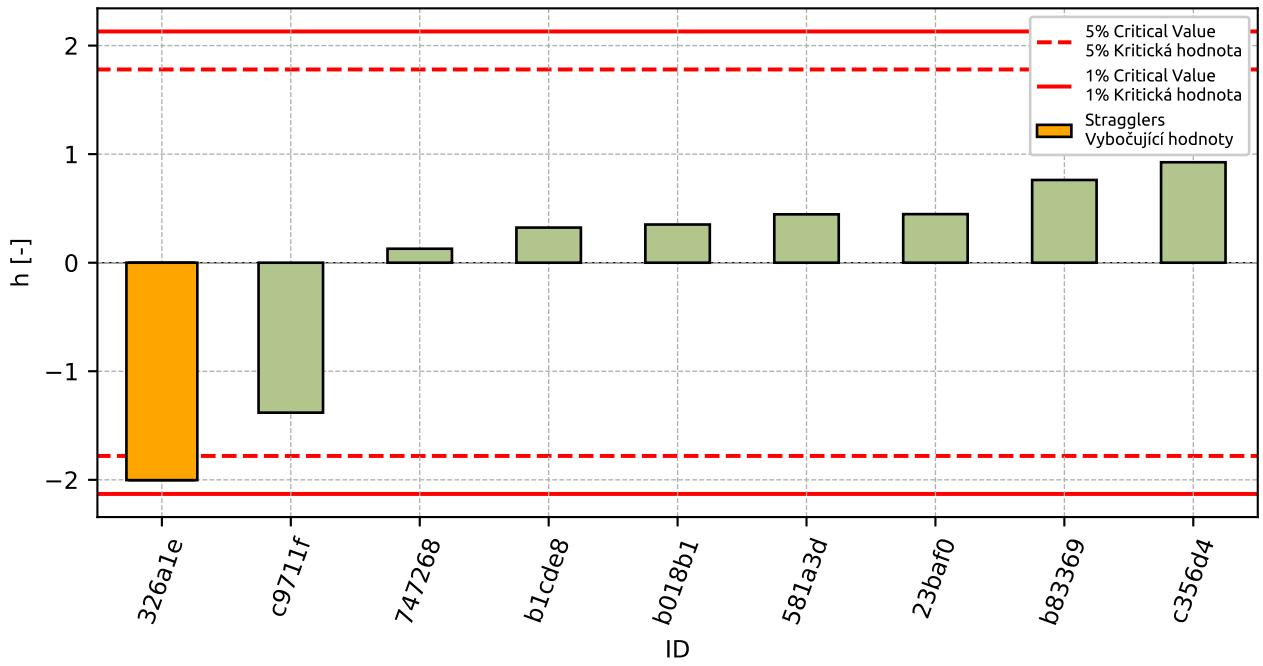

Figure 69: Interlaboratory Consistency Statistic

6.3.4 Descriptive statistics

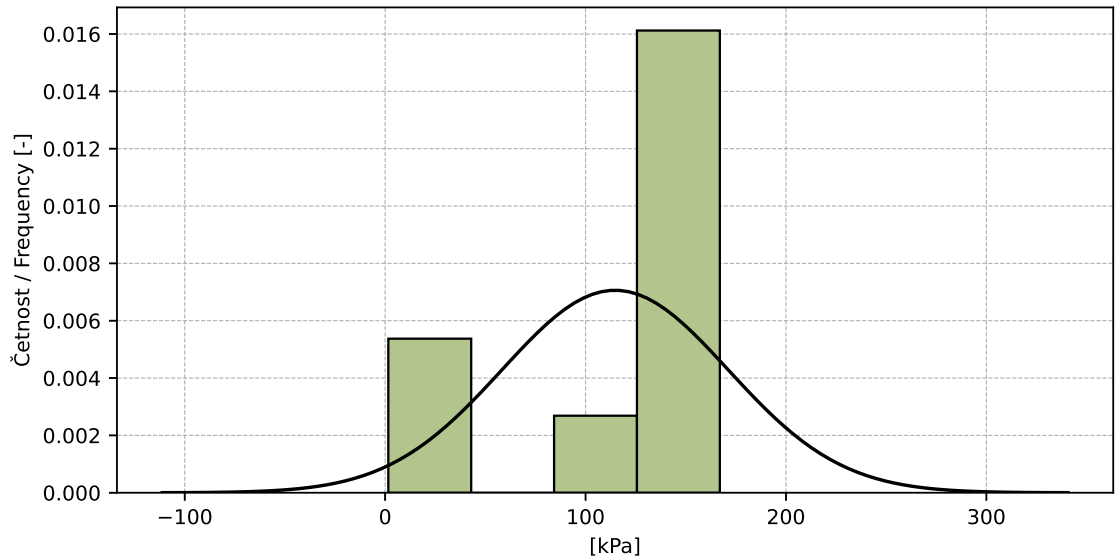

Figure 70: Histogram of all test results

Table 36: Descriptive statistics

Characteristics	[kPa]
Průměrná hodnota / Average value – $\bar{x}$	114.73
Výběrová směrodatná odchylka / Sample standard deviation – s	56.489
Vztažná hodnota / Asigned value – x^*	134.16
Robustní směrodatná odchylka / Robust standard deviation – s^*	21.96
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	9.15
p-hodnota testu normality / p-value of normality test	0.011 [-]

6.3.5 Evaluation of Performance Statistics

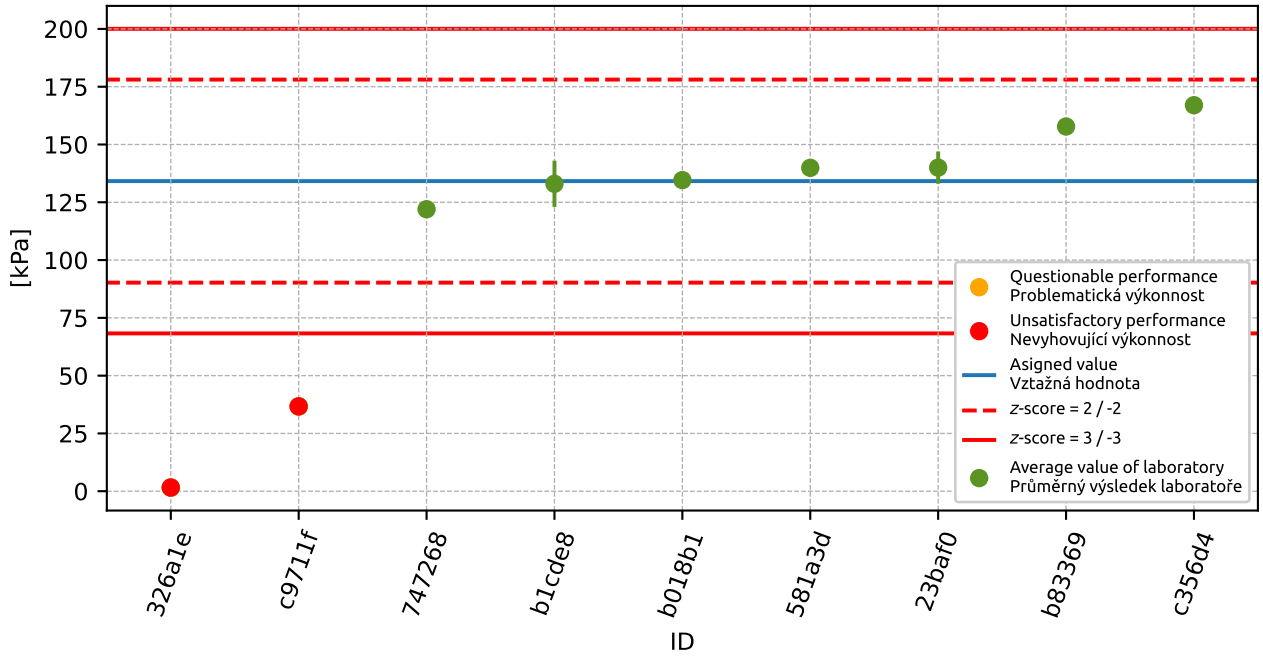

Figure 71: Average values and extended uncertainties of measurement

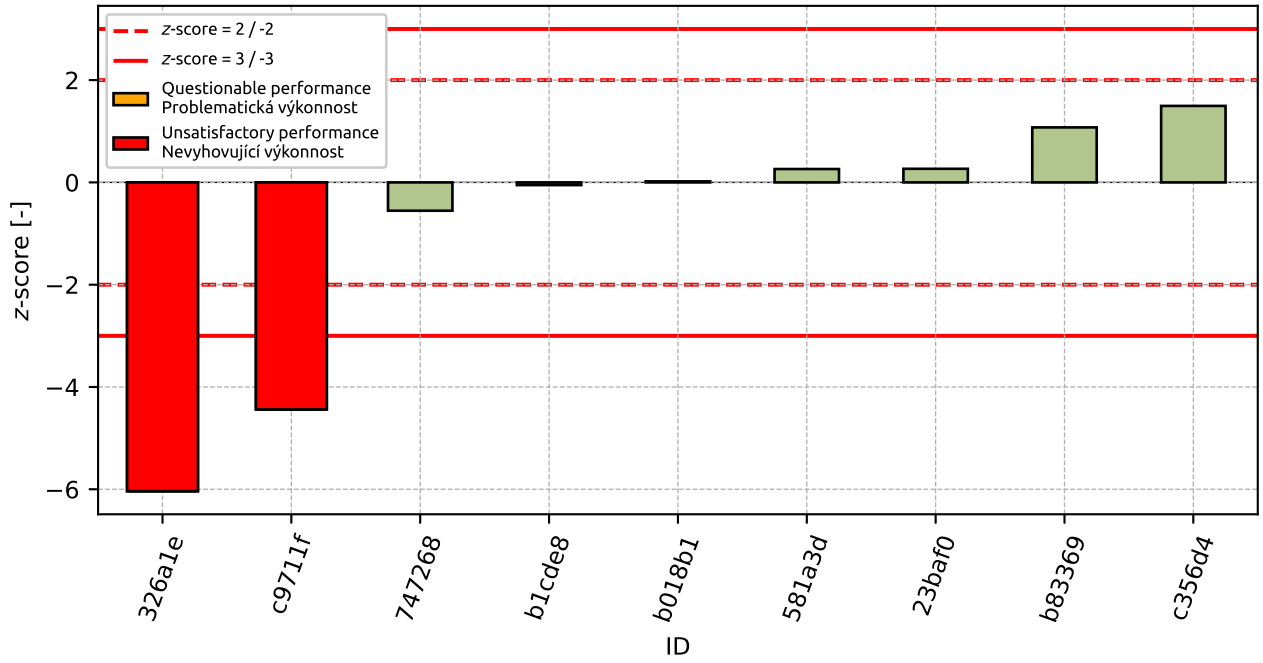

Figure 72: z-score

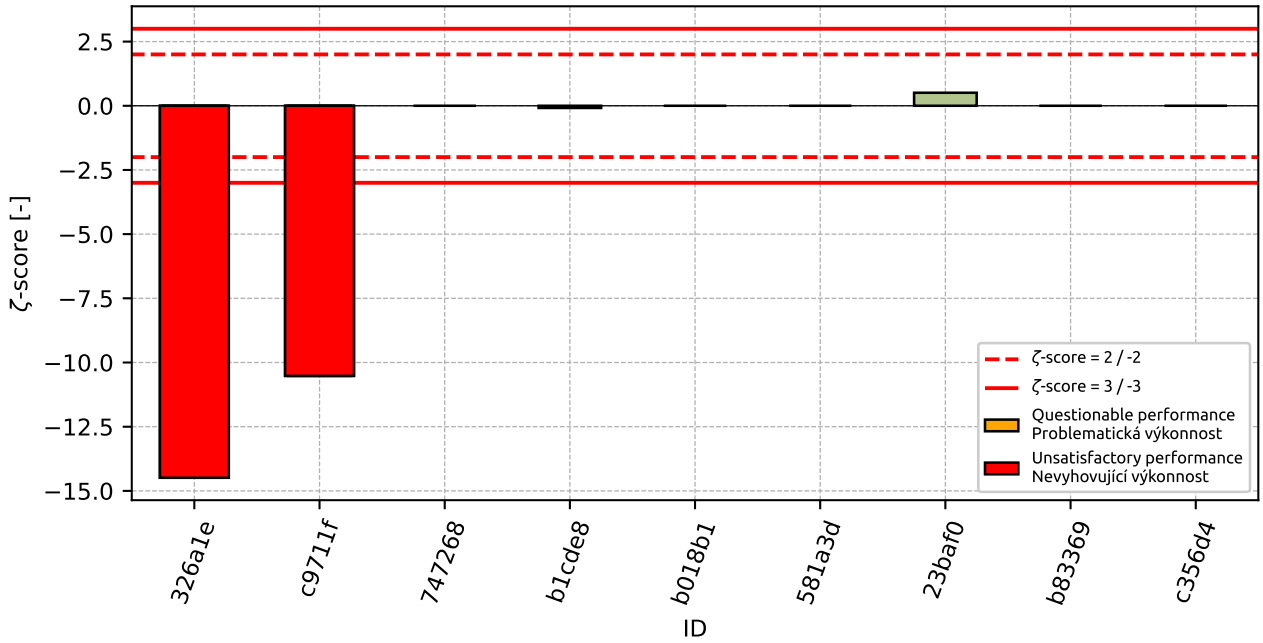

Figure 73: ζ-score

Table 37: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
326a1e	-6.04	-14.49
c9711f	-4.44	-10.52
747268	-0.55	-
b1cde8	-0.05	-0.09
b018b1	0.02	-
581a3d	0.26	-
23baf0	0.27	0.51
b83369	1.08	-
c356d4	1.5	-

6.4 400 kPa

6.4.1 Test results

Table 38: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [kPa]	u_X [kPa]
326a1e	3.36	0.02
c9711f	32.48	1.44
c356d4	203.0	-
747268	223.0	-
b83369	246.94	-
b018b1	251.5	-
b1cde8	260.0	8.0
581a3d	262.6	-
23baf0	280.0	14.0

6.4.2 The Numerical Procedure for Determining Outliers

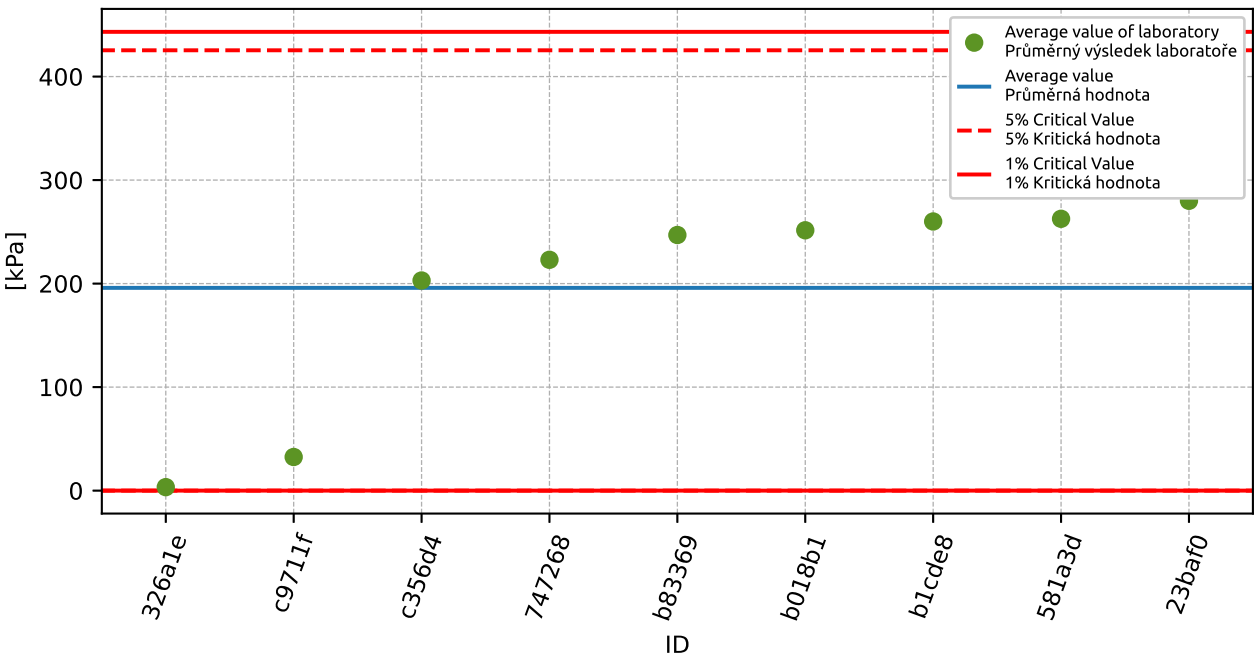

Figure 74: **Grubbs' test** - average values

6.4.3 Mandel's Statistics

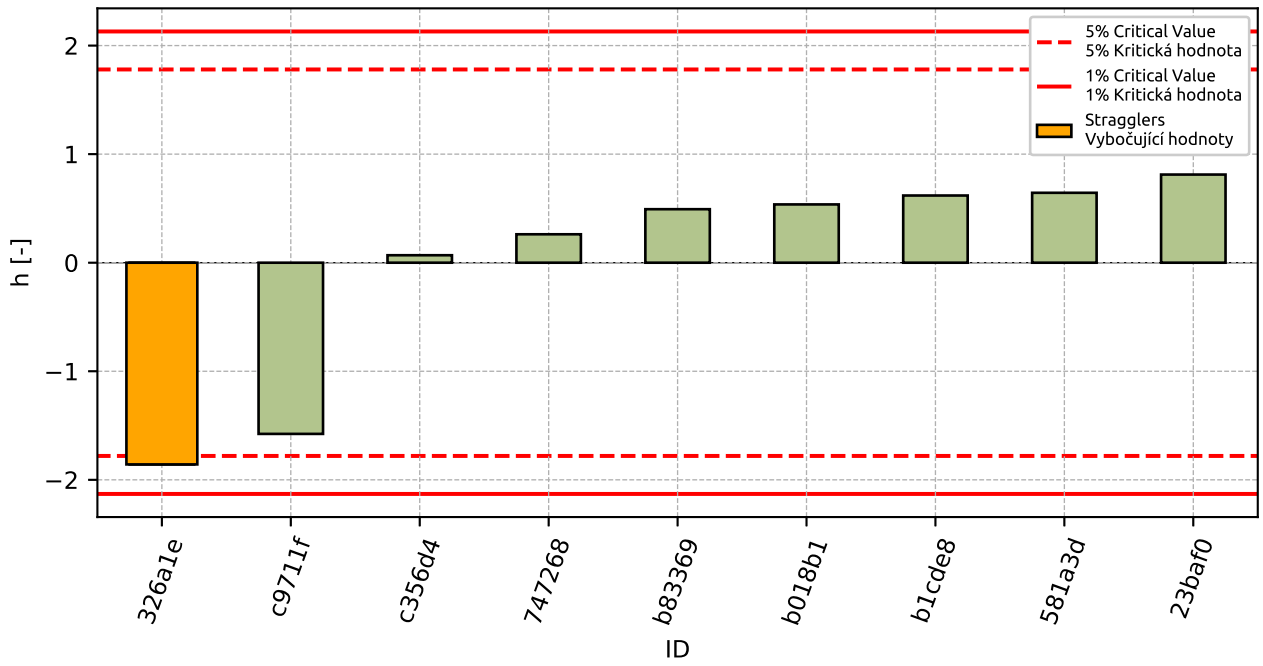

Figure 75: Interlaboratory Consistency Statistic

6.4.4 Descriptive statistics

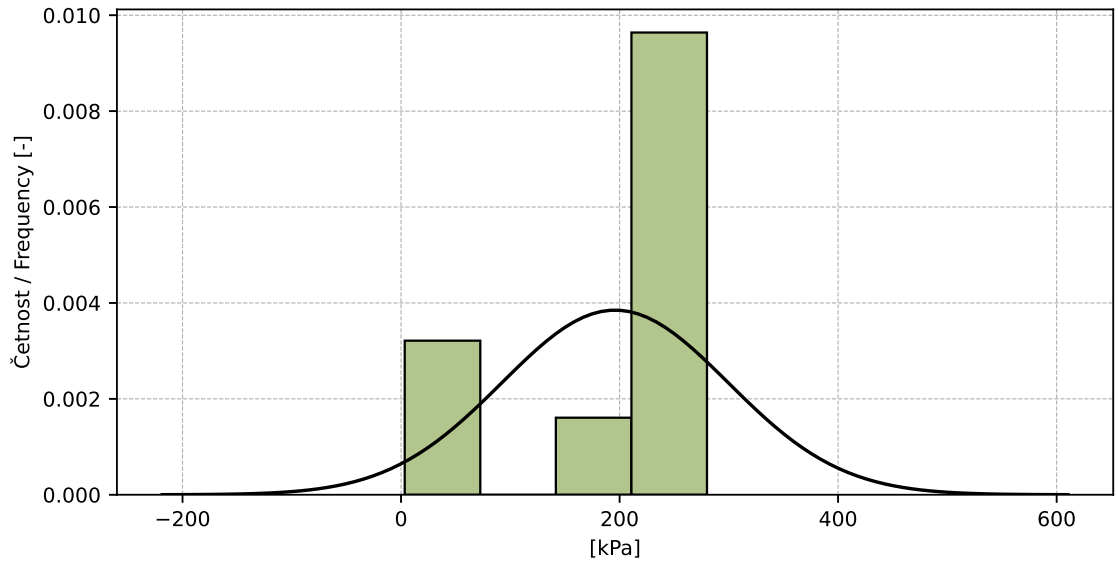

Figure 76: Histogram of all test results

Table 39: Descriptive statistics

Characteristics	[kPa]
Průměrná hodnota / Average value – $\bar{x}$	195.88
Výběrová směrodatná odchylka / Sample standard deviation – s	103.616
Vztažná hodnota / Asigned value – x^*	234.93
Robustní směrodatná odchylka / Robust standard deviation – s^*	34.661
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	14.442
p-hodnota testu normality / p-value of normality test	0.004 [-]

6.4.5 Evaluation of Performance Statistics

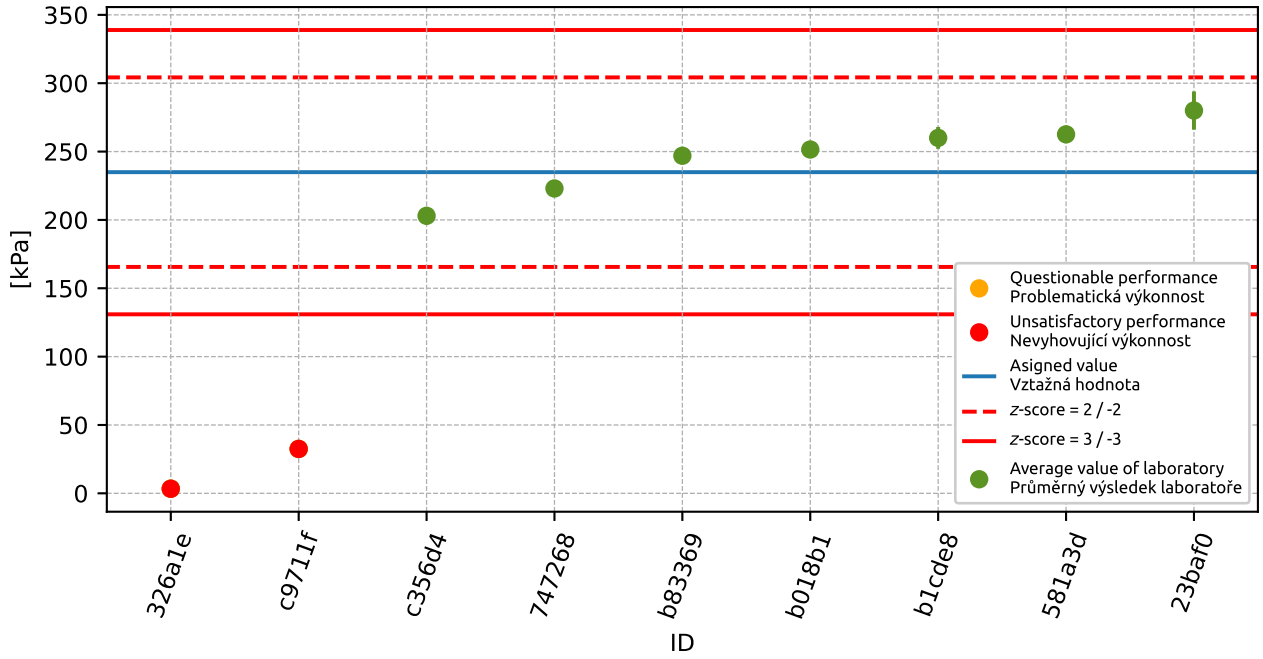

Figure 77: Average values and extended uncertainties of measurement

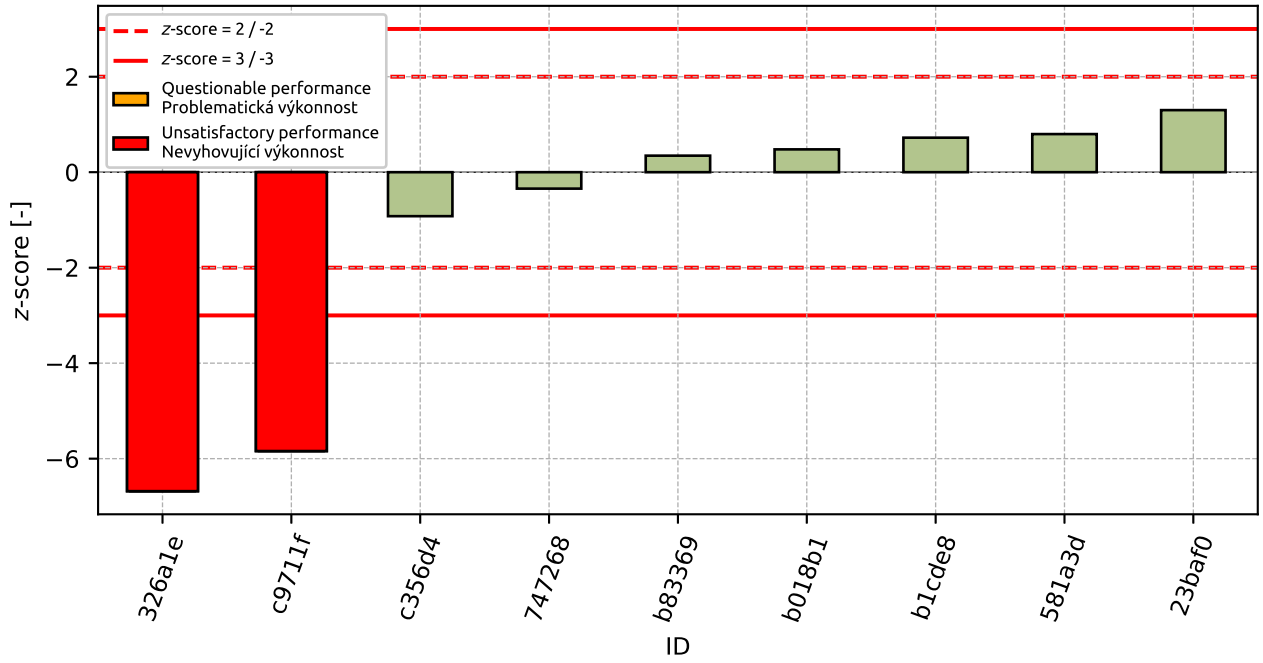

Figure 78: z-score

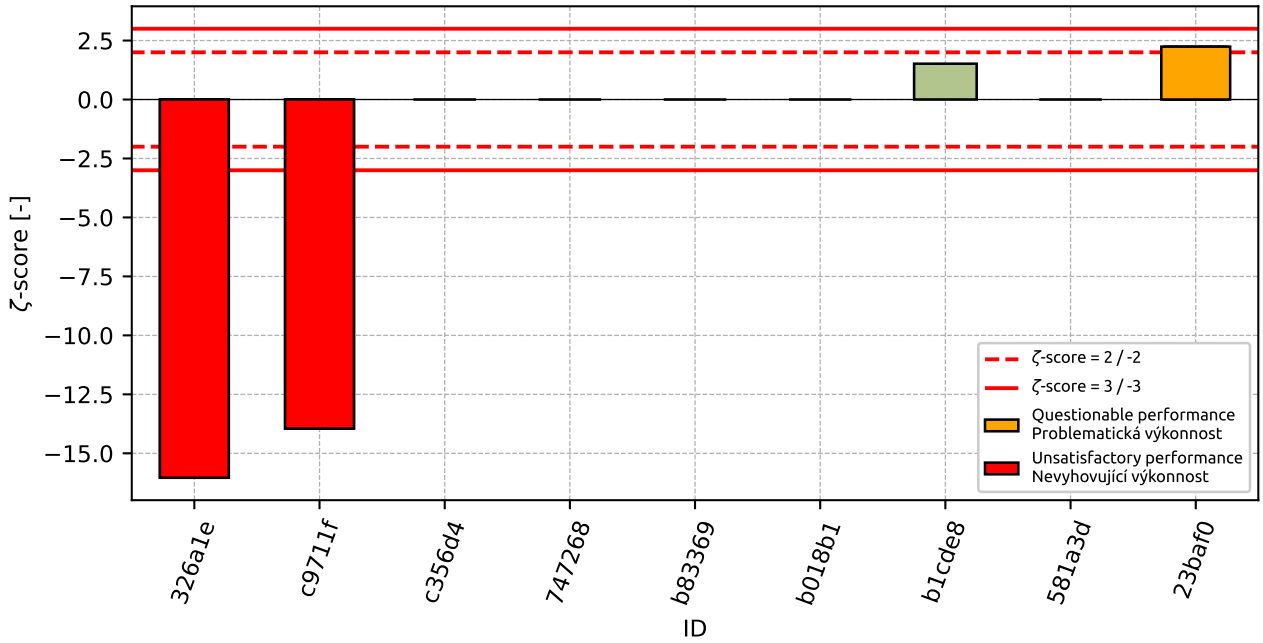

Figure 79: ζ-score

Table 40: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
326a1e	-6.68	-16.03
c9711f	-5.84	-13.95
c356d4	-0.92	-
747268	-0.34	-
b83369	0.35	-
b018b1	0.48	-
b1cde8	0.72	1.52
581a3d	0.8	-
23baf0	1.3	2.24

7 Appendix – EN ISO 17892-12 – Atterberg limits

7.1 Liquit limit

7.1.1 Test results

Table 41: 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 [%]
cce554	20.77	20.82	20.77	0.4	20.79	0.029	0.14
7e7687	20.83	20.81	21.09	0.4	20.91	0.156	0.75
05973c	21.06	20.97	21.51	0.4	21.18	0.289	1.37
416678	21.01	21.0	21.79	0.4	21.27	0.453	2.13
27f94b	32.9	-	-	2.6	32.9	0.0	0.0
baa257	33.0	-	-	-	33.0	0.0	0.0
c356d4	33.3	32.9	33.6	0.31	33.27	0.35	1.06
a6ea3e	34.0	34.0	32.0	0.02	33.33	1.155	3.46
6adc5c	33.2	33.6	33.2	-	33.33	0.231	0.69
47c275	33.6	33.1	33.4	0.8	33.37	0.252	0.75
063fae	33.0	34.0	34.0	2.5	33.67	0.577	1.71
b018b1	32.9	33.7	36.2	-	34.27	1.721	5.02
23baf0	35.2	34.9	36.0	2.0	35.37	0.569	1.61
46073a	35.3	35.9	35.2	1.6	35.47	0.379	1.07
337ed8	35.4	36.0	35.8	0.9	35.73	0.306	0.85
6c73e9	37.98	-	-	1.6	37.98	0.0	0.0
e09919	45.88	46.63	47.52	5.0	46.68	0.821	1.76

7.1.2 The Numerical Procedure for Determining Outliers

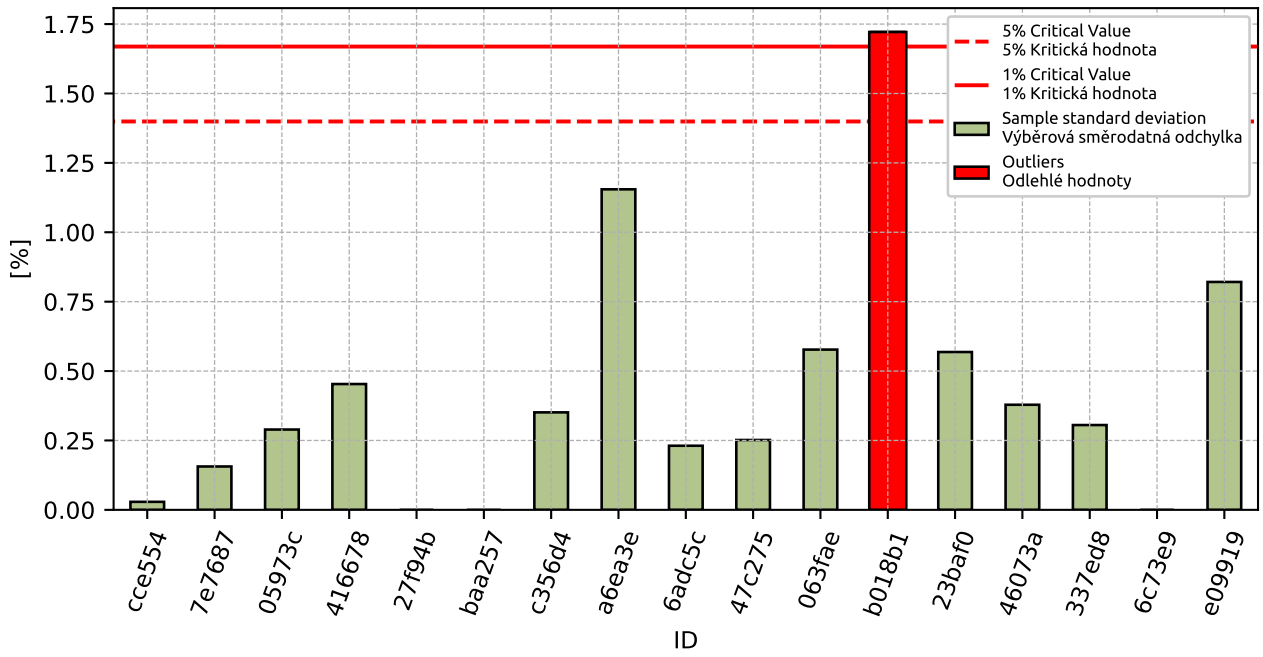

Figure 80: **Cochran's test** - sample standard deviations

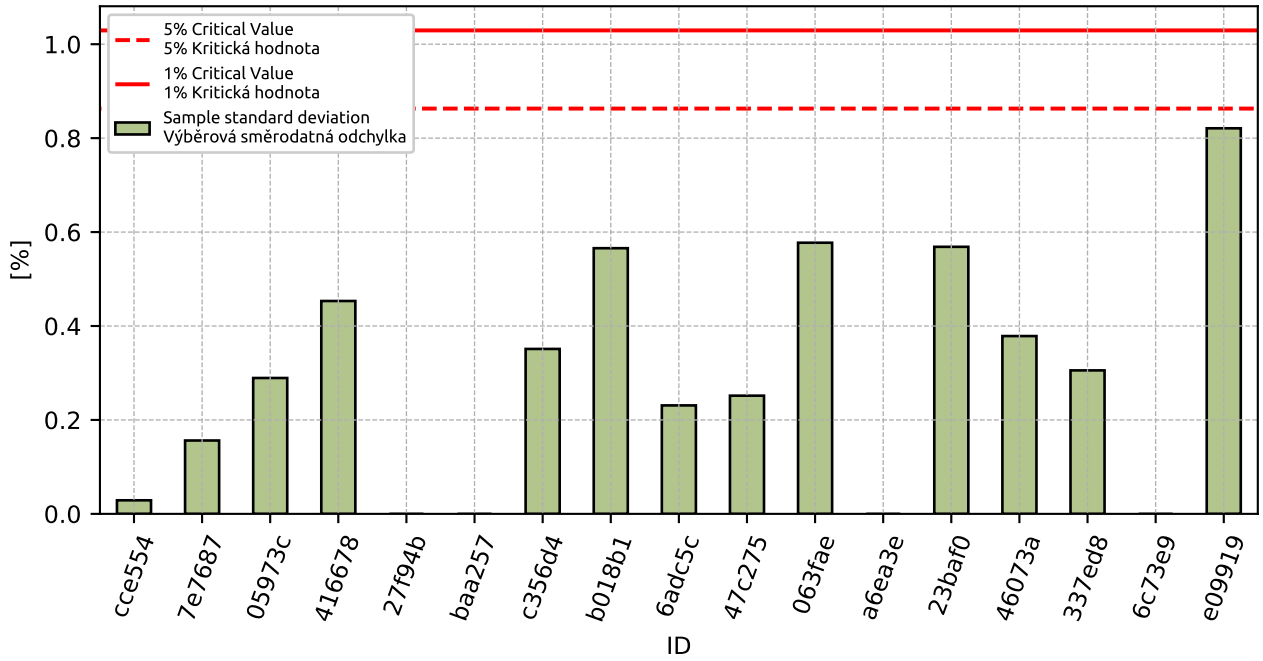

Figure 81: **Cochran's test** - sample standard deviations without outliers

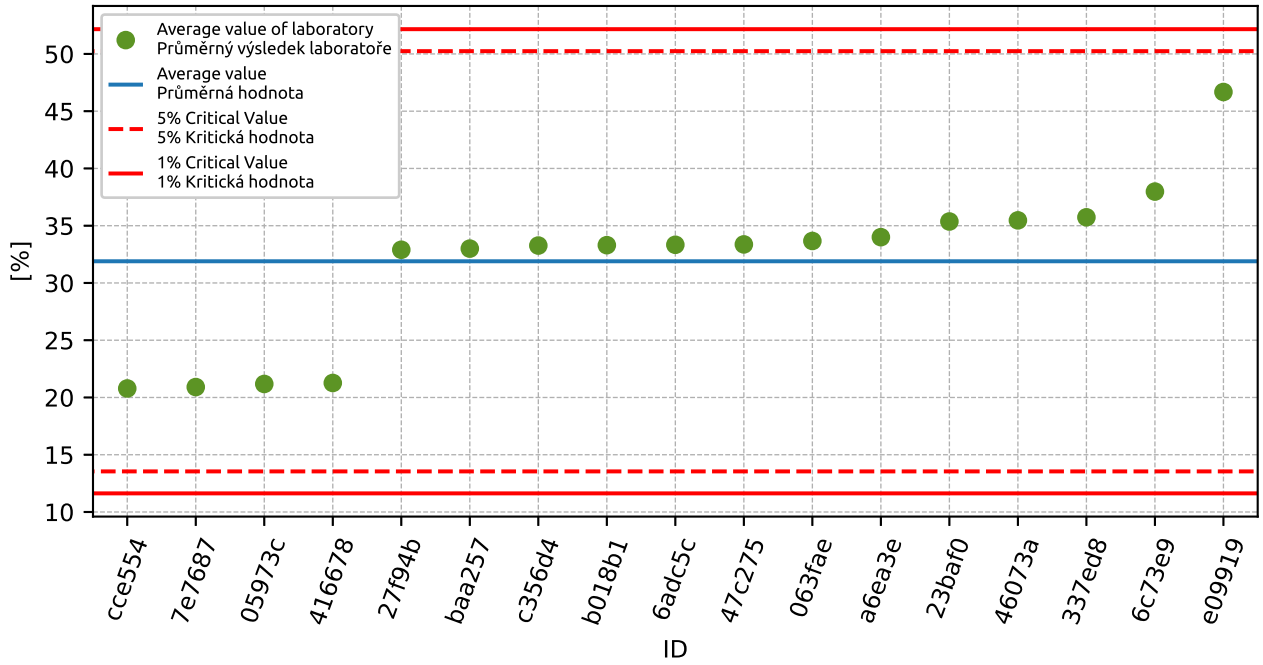

Figure 82: **Grubbs' test** - average values

7.1.3 Mandel's Statistics

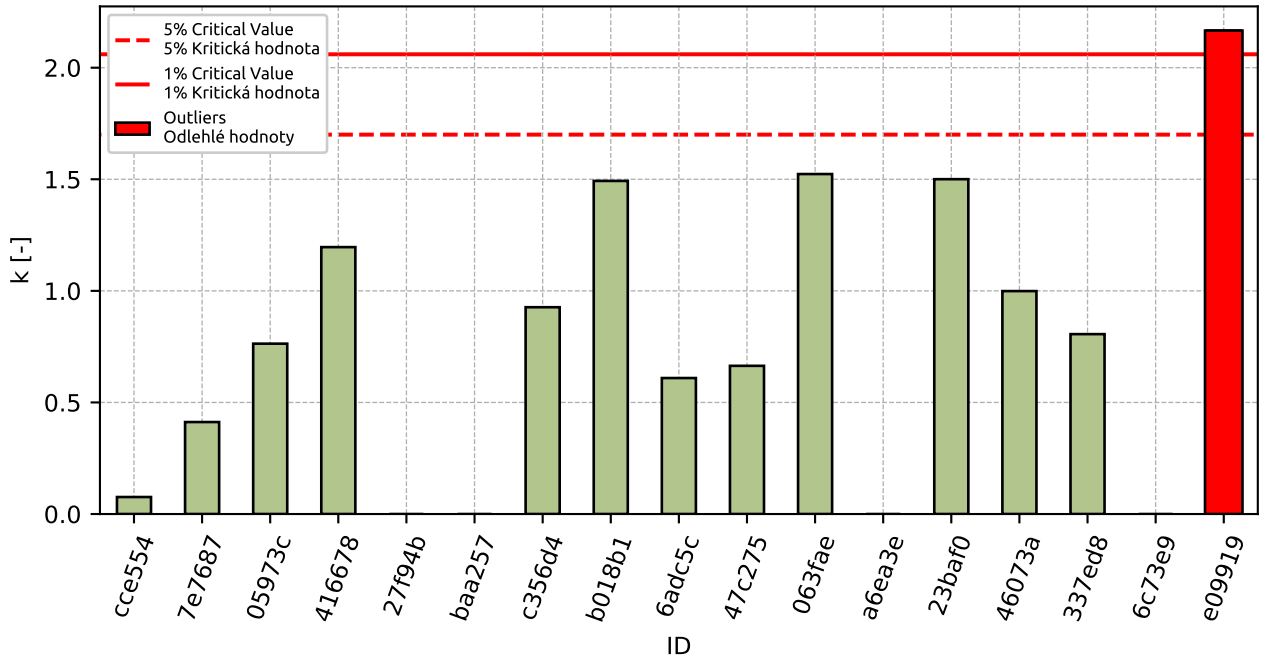

Figure 83: Intralaboratory Consistency Statistic

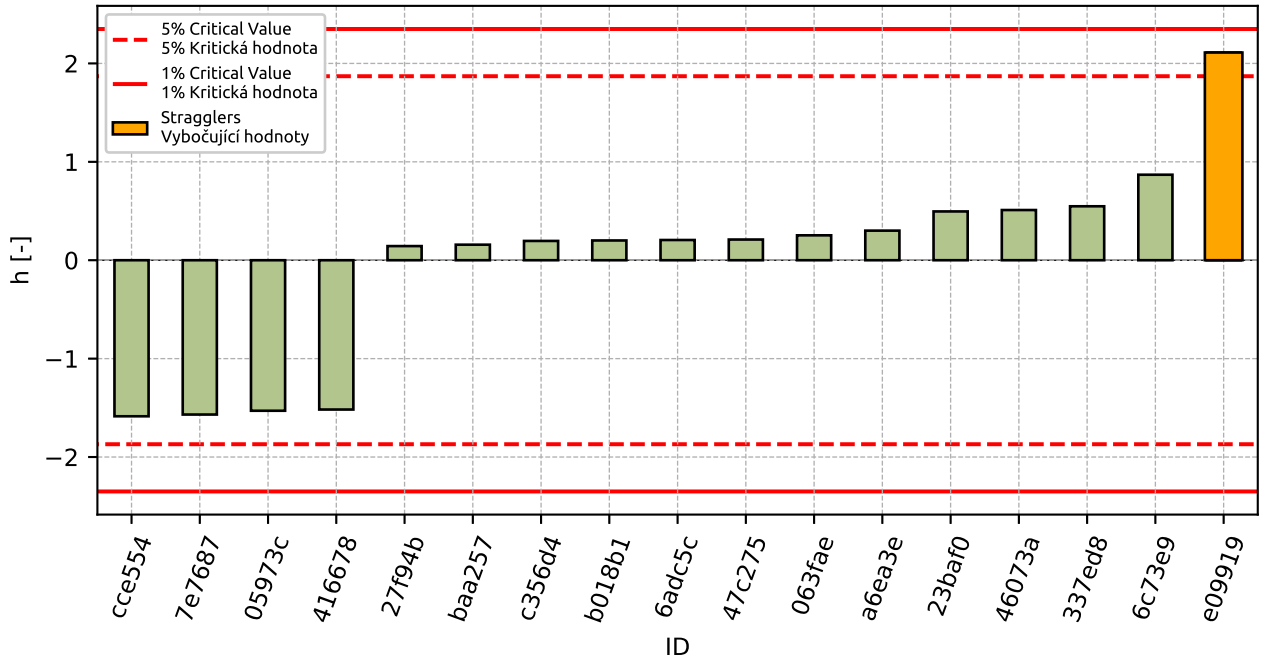

Figure 84: Interlaboratory Consistency Statistic

7.1.4 Descriptive statistics

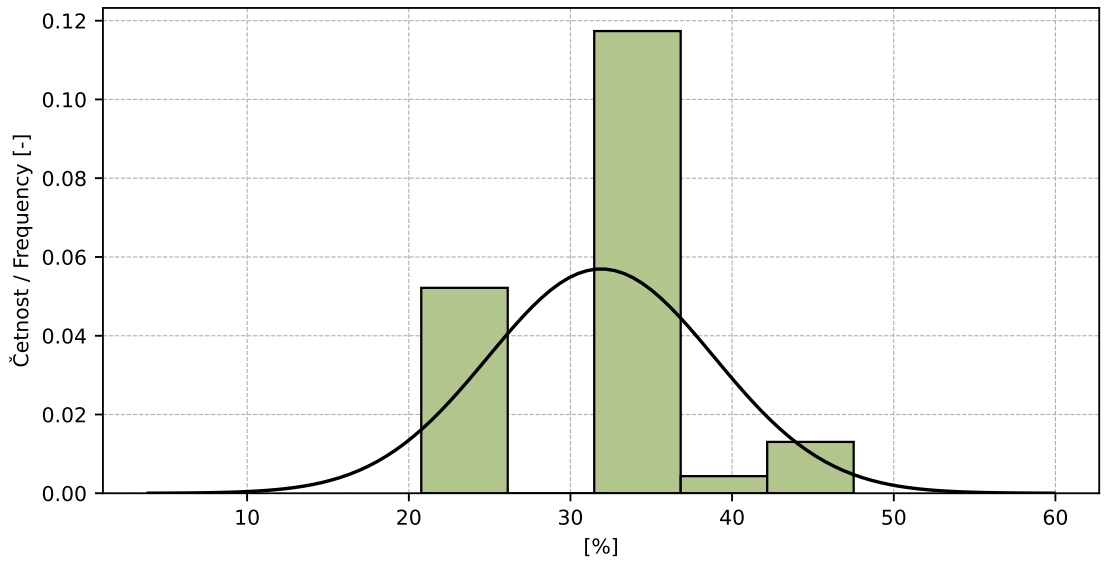

Figure 85: Histogram of all test results

Table 42: Descriptive statistics

Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	31.89
Výběrová směrodatná odchylka / Sample standard deviation – s	7.004
Vztažná hodnota / Asigned value – x^*	33.72
Robustní směrodatná odchylka / Robust standard deviation – s^*	4.709
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	1.428
p-hodnota testu normality / p-value of normality test	1.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	7.0
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	0.379
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	7.01
Opakovatelnost / Repeatability – r	1.06
Reprodukovatelnost / Reproducibility – R	19.63

7.1.5 Evaluation of Performance Statistics

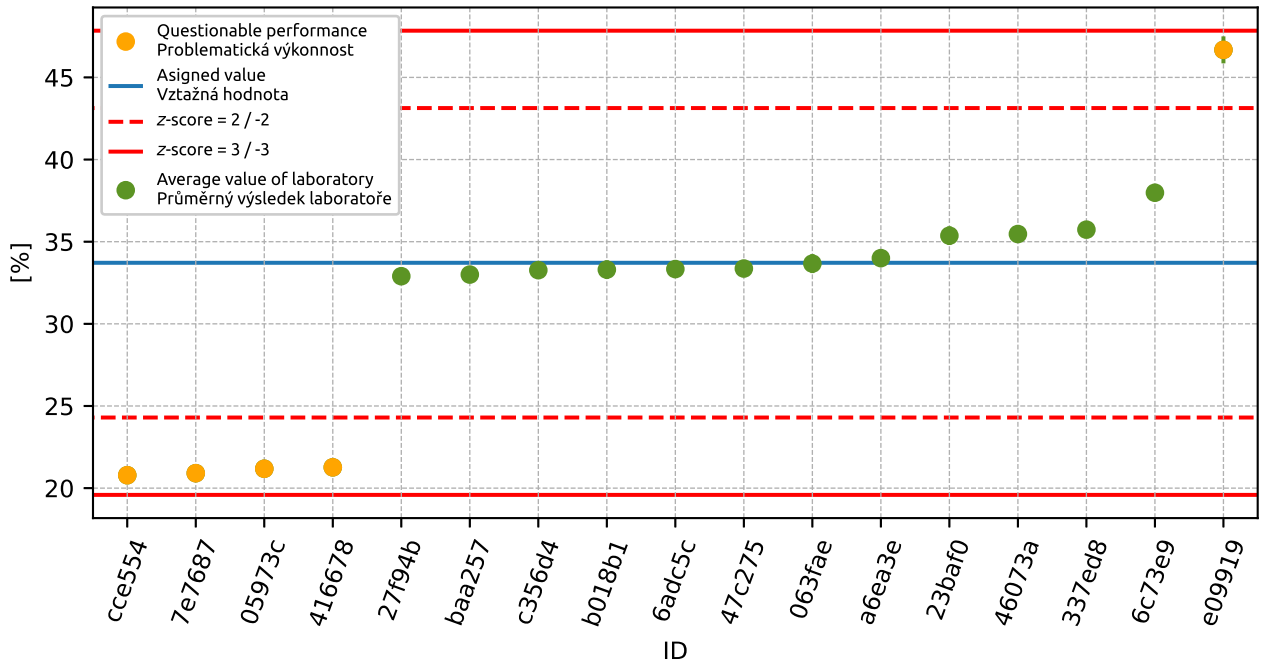

Figure 86: Average values and sample standard deviations

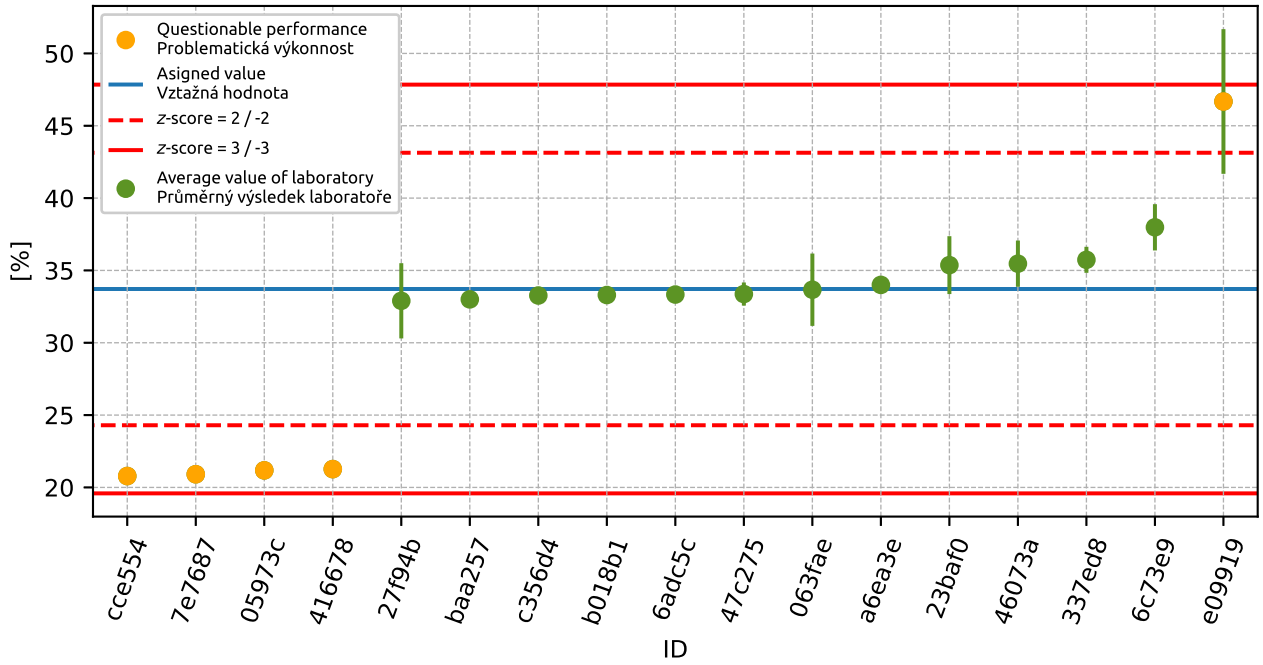

Figure 87: Average values and extended uncertainties of measurement

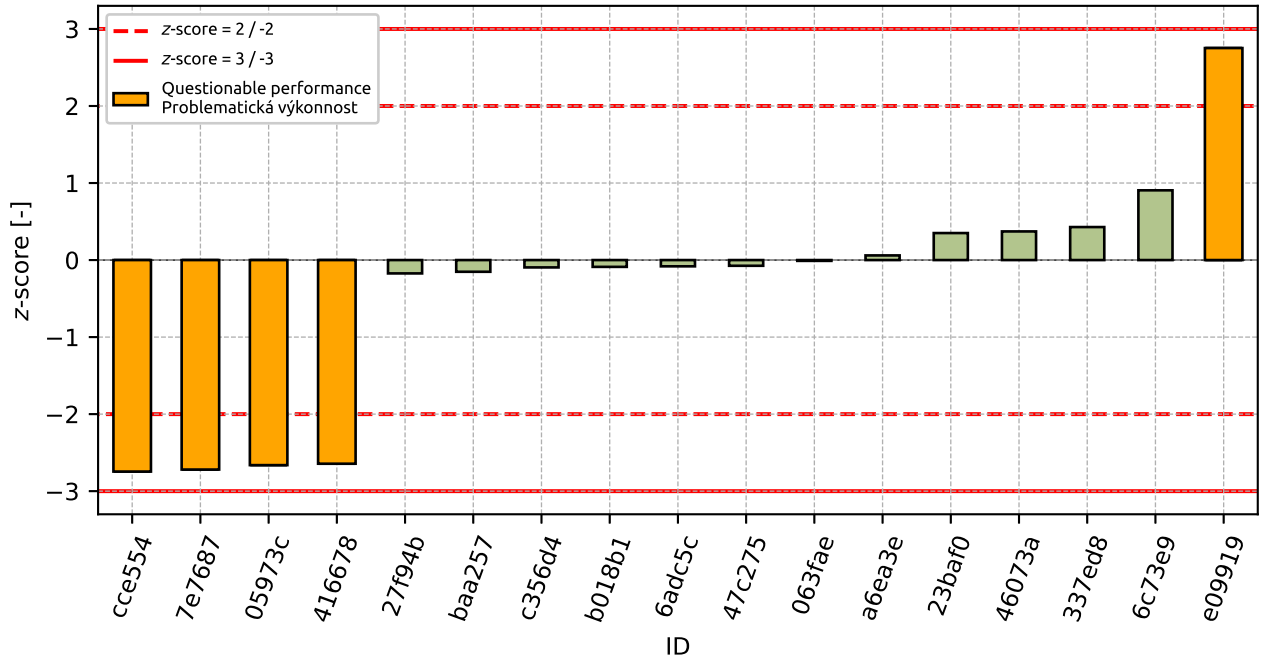

Figure 88: z-score

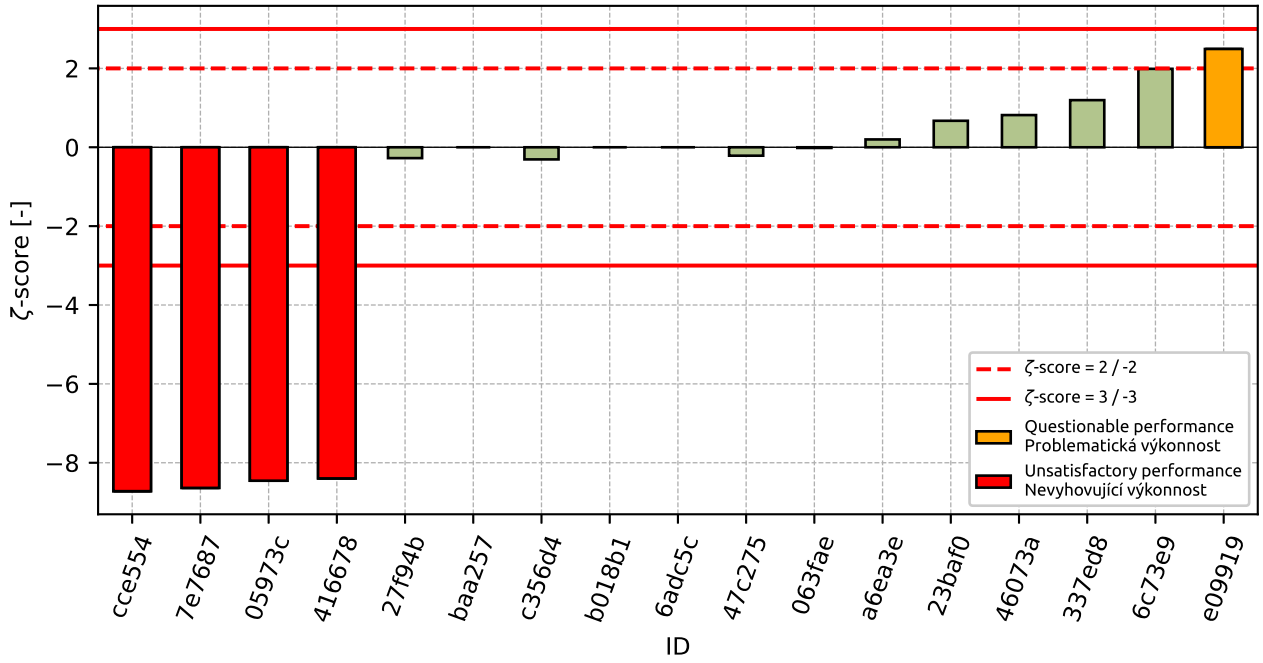

Figure 89: ζ-score

Table 43: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
cce554	-2.75	-8.72
7e7687	-2.72	-8.64
05973c	-2.66	-8.46
416678	-2.64	-8.4
27f94b	-0.17	-0.28
baa257	-0.15	-
c356d4	-0.1	-0.31
b018b1	-0.09	-
6adc5c	-0.08	-
47c275	-0.07	-0.21
063fae	-0.01	-0.02
a6ea3e	0.06	0.2
23baf0	0.35	0.67
46073a	0.37	0.82
337ed8	0.43	1.2
6c73e9	0.91	1.99
e09919	2.75	2.49

7.2 Plastic limit

7.2.1 Test results

Table 44: 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 [%]
6c73e9	16.4	16.5	-	2.66	16.45	0.07	0.43
a6ea3e	19.0	19.0	19.0	0.01	19.0	0.0	0.0
b018b1	19.8	19.8	19.9	-	19.83	0.06	0.29
baa257	20.0	-	-	-	20.0	0.0	0.0
46073a	20.5	19.5	20.5	1.5	20.17	0.57	2.86
27f94b	20.4	-	-	1.0	20.4	0.0	0.0
c356d4	20.1	20.8	20.5	0.22	20.47	0.35	1.72
337ed8	20.6	20.9	20.6	1.2	20.7	0.171	0.84
6adc5c	20.8	21.1	20.9	-	20.93	0.15	0.73
47c275	21.3	21.2	21.4	0.6	21.3	0.1	0.47
063fae	21.0	21.0	22.0	0.7	21.33	0.58	2.71
23baf0	21.9	22.0	22.5	2.0	22.13	0.32	1.45
e09919	22.55	21.99	22.59	5.0	22.38	0.34	1.5
cce554	30.39	30.59	30.69	0.4	30.56	0.15	0.5
416678	30.34	30.9	30.81	0.4	30.68	0.30	0.98
7e7687	32.75	32.99	32.3	0.4	32.68	0.35	1.07
05973c	33.8	34.21	34.1	0.4	34.04	0.21	0.62

7.2.2 The Numerical Procedure for Determining Outliers

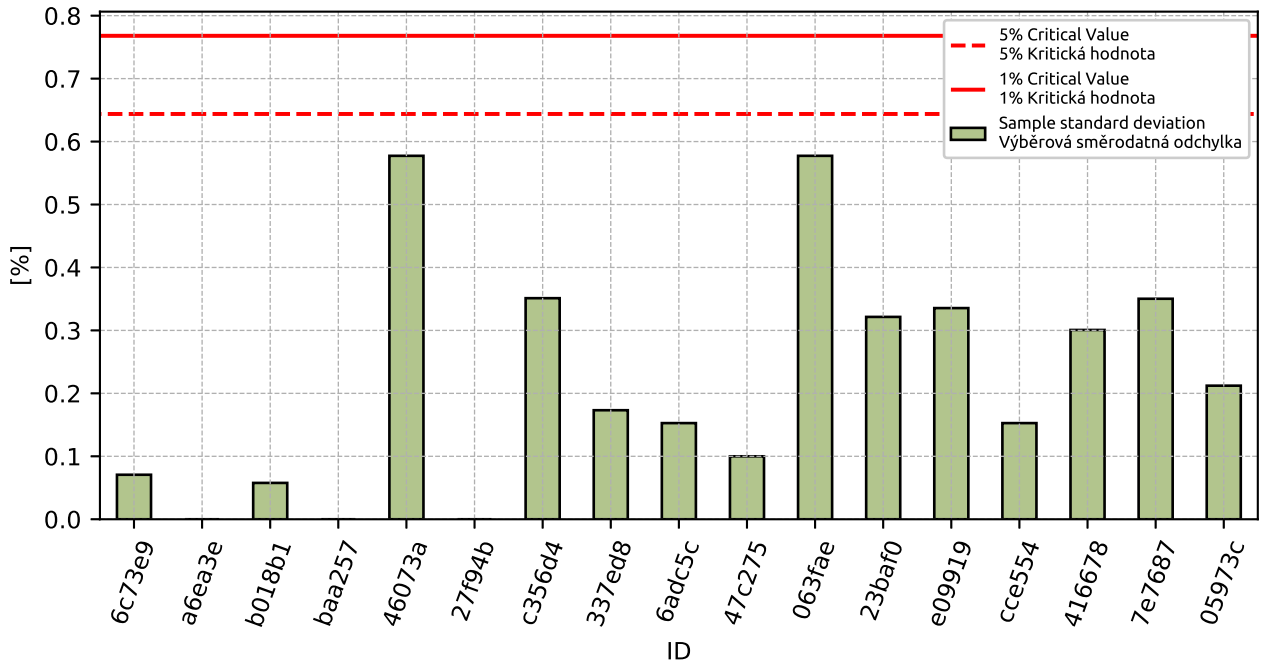

Figure 90: **Cochran's test** - sample standard deviations

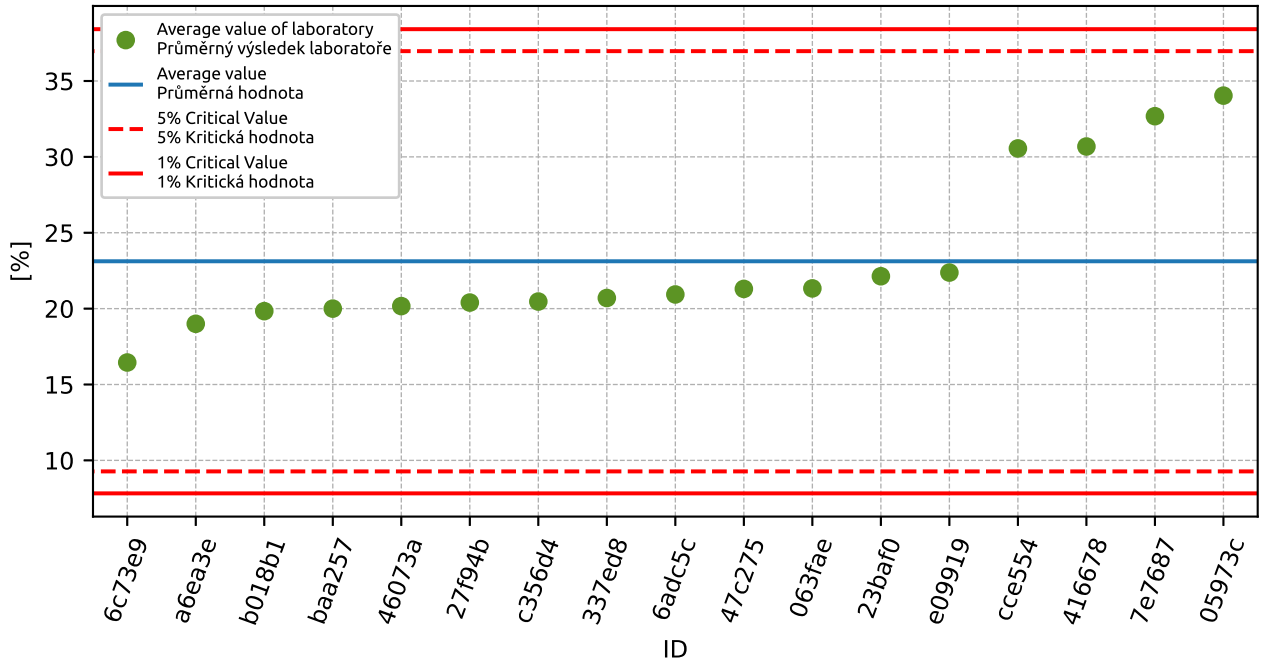

Figure 91: **Grubbs' test** - average values

7.2.3 Mandel's Statistics

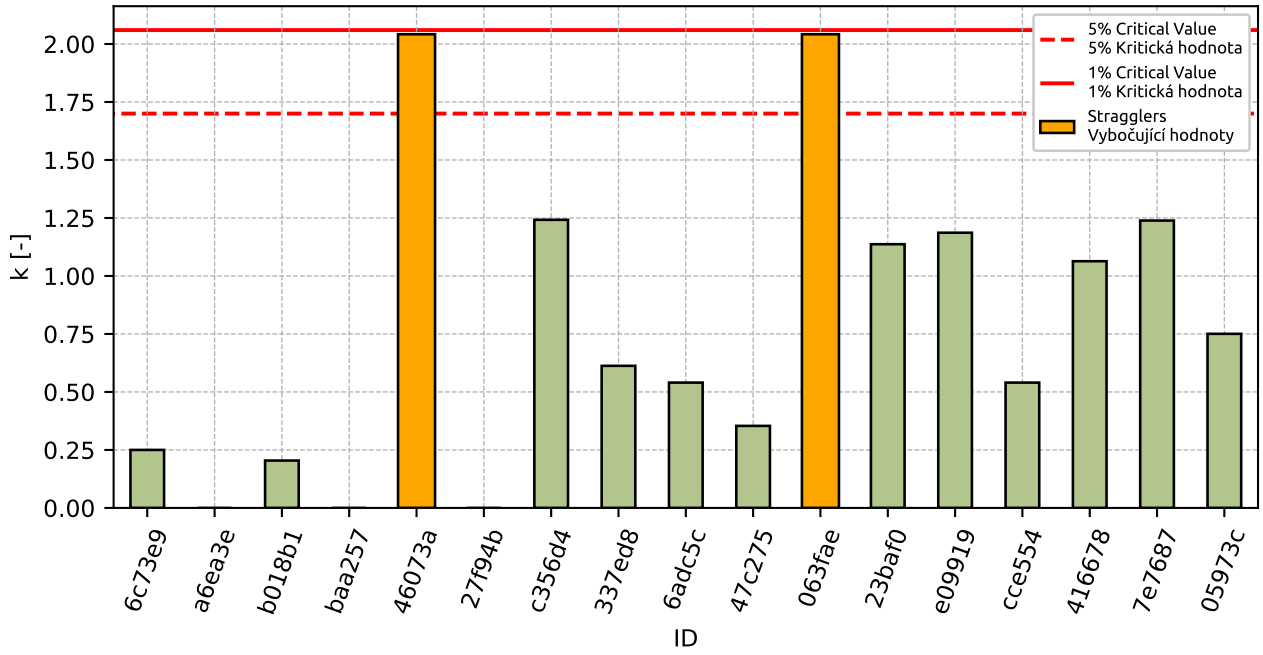

Figure 92: Intralaboratory Consistency Statistic

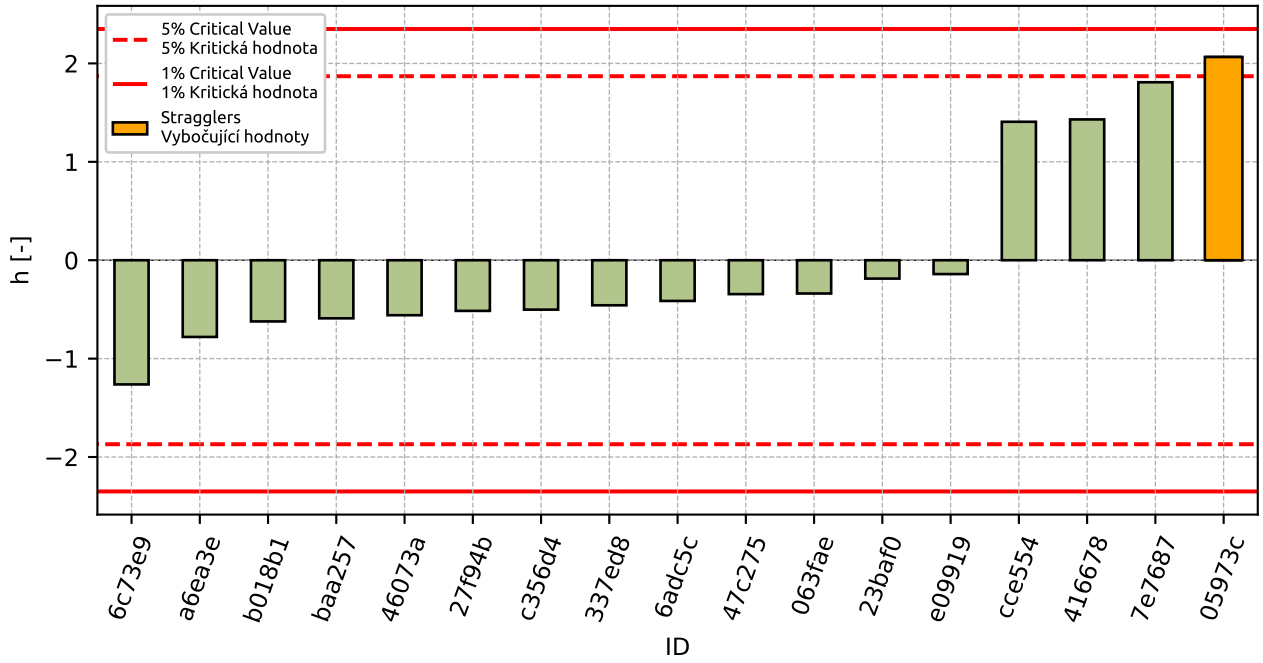

Figure 93: Interlaboratory Consistency Statistic

7.2.4 Descriptive statistics

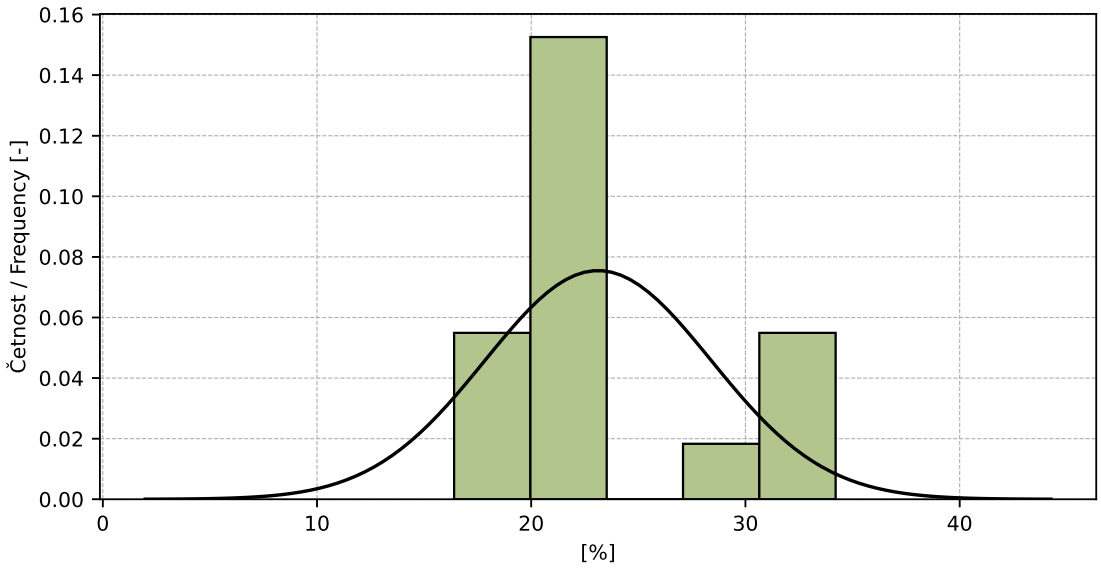

Figure 94: Histogram of all test results

Table 45: Descriptive statistics

Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	23.12
Výběrová směrodatná odchylka / Sample standard deviation – s	5.285
Vztažná hodnota / Asigned value – x^*	21.84
Robustní směrodatná odchylka / Robust standard deviation – s^*	3.815
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	1.157
p-hodnota testu normality / p-value of normality test	1.0 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	5.283
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	0.283
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	5.29
Opakovatelnost / Repeatability – r	0.79
Reprodukovatelnost / Reproducibility – R	14.81

7.2.5 Evaluation of Performance Statistics

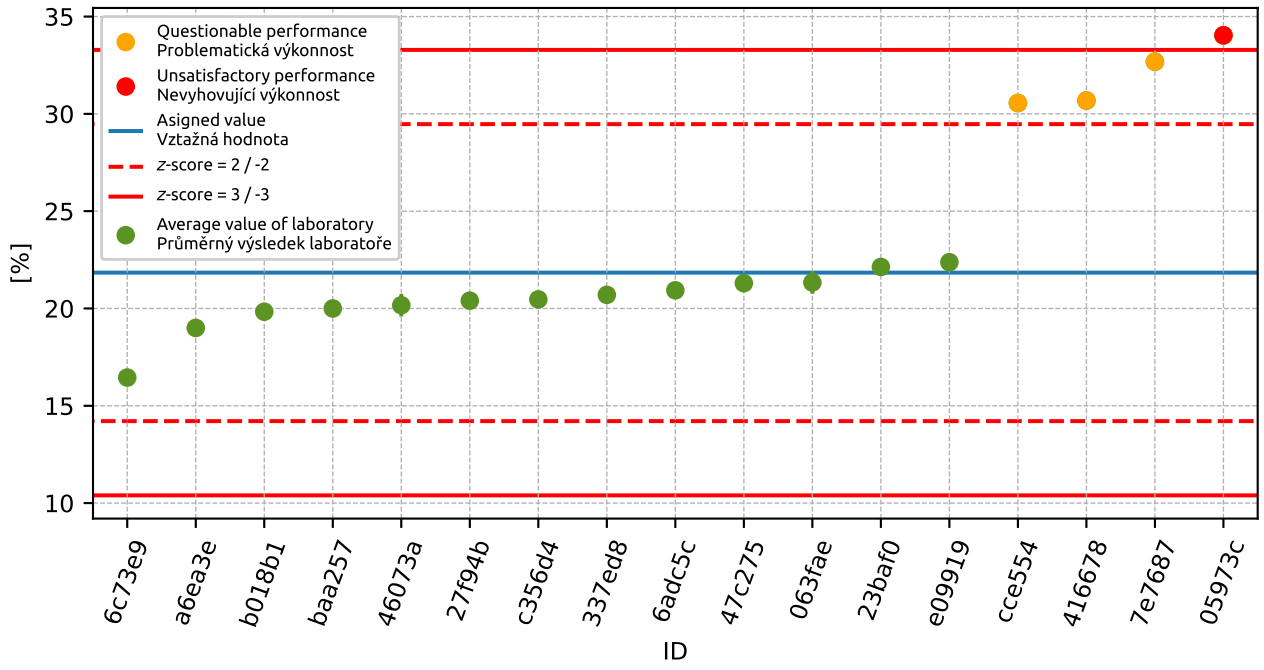

Figure 95: Average values and sample standard deviations

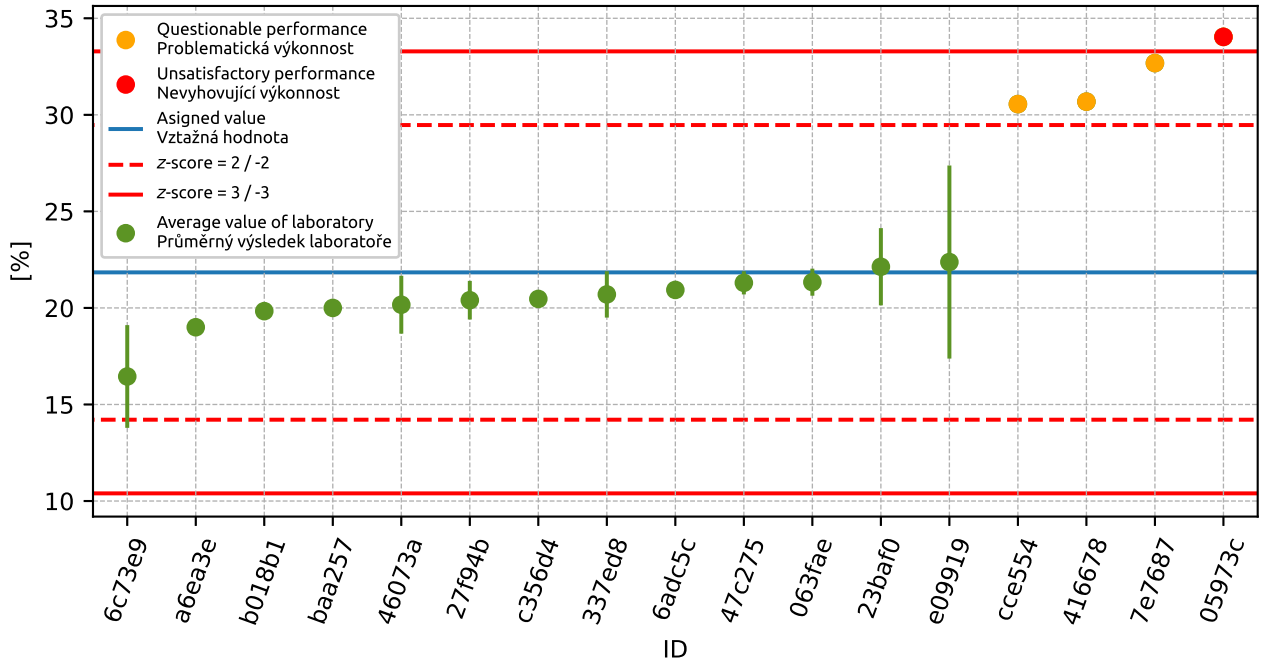

Figure 96: Average values and extended uncertainties of measurement

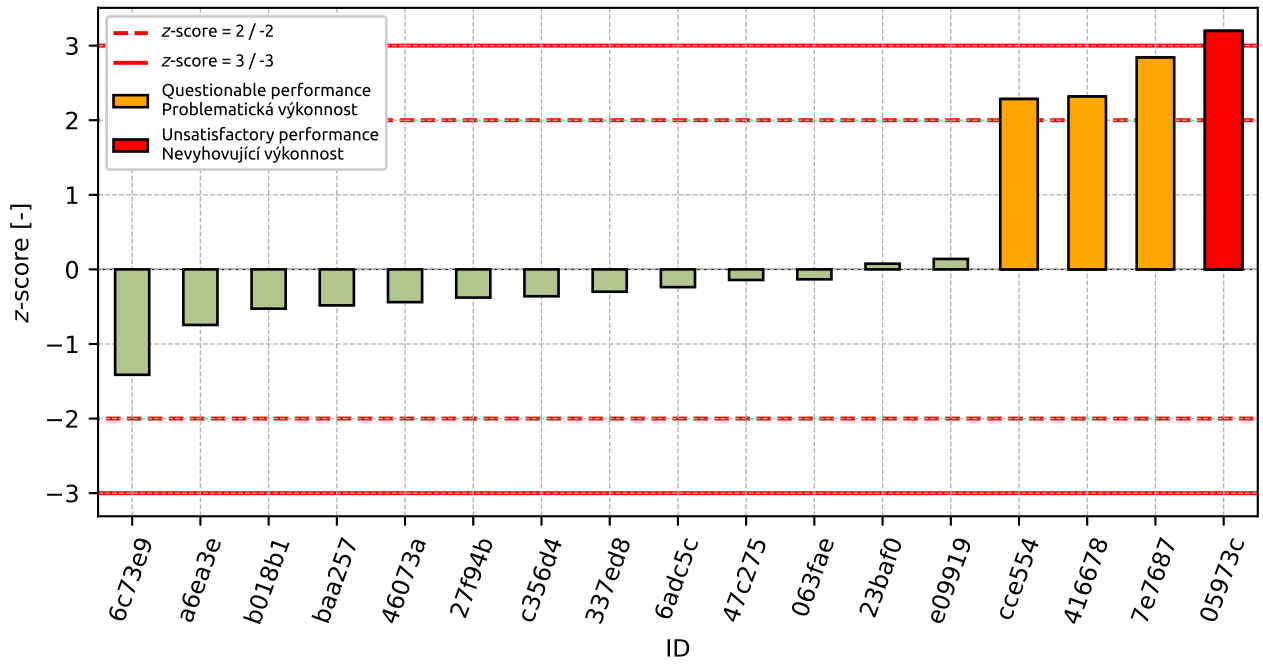

Figure 97: z-score

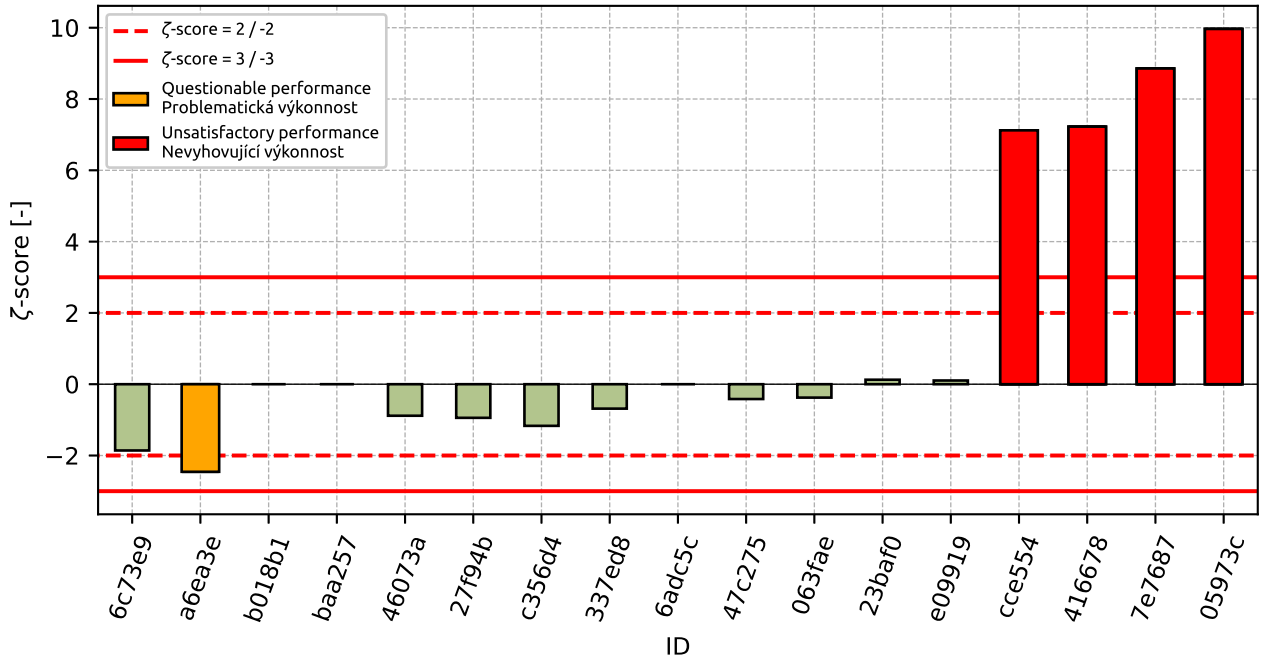

Figure 98: ζ-score

Table 46: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
6c73e9	-1.41	-1.86
a6ea3e	-0.74	-2.46
b018b1	-0.53	-
baa257	-0.48	-
46073a	-0.44	-0.88
27f94b	-0.38	-0.94
c356d4	-0.36	-1.17
337ed8	-0.3	-0.68
6adc5c	-0.24	-
47c275	-0.14	-0.42
063fae	-0.13	-0.38
23baf0	0.08	0.13
e09919	0.14	0.1
cce554	2.28	7.12
416678	2.32	7.22
7e7687	2.84	8.86
05973c	3.2	9.96

8 Appendix – EN 13286-2 – Proctor

8.1 Proctor density

8.1.1 Test results

Table 47: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [kg/m^3]	u_X [kg/m^3]
e111a4	1710	12.0
7453ba	1720	-
54619e	1723	-
46073a	1746	25.0
27f94b	1746	1.0
581a3d	1750	5.0
c356d4	1750	30.0
b620ea	1760	5.0
747268	1770	-
0ce4c1	1770	30.0
6b079d	1773	17.0
05e7f9	1780	40.0
574330	1780	-
784bc8	1780	20.0
39f1b5	1784	-
23baf0	1790	40.0
b018b1	1790	-
aa5576	1798	2.0
47c275	1810	35.0
a6ea3e	1810	16.0
6c6ace	1814	36.0
b1cde8	1814	50.0
6c73e9	1844	11.0
3e11f6	1860	20.0

8.1.2 The Numerical Procedure for Determining Outliers

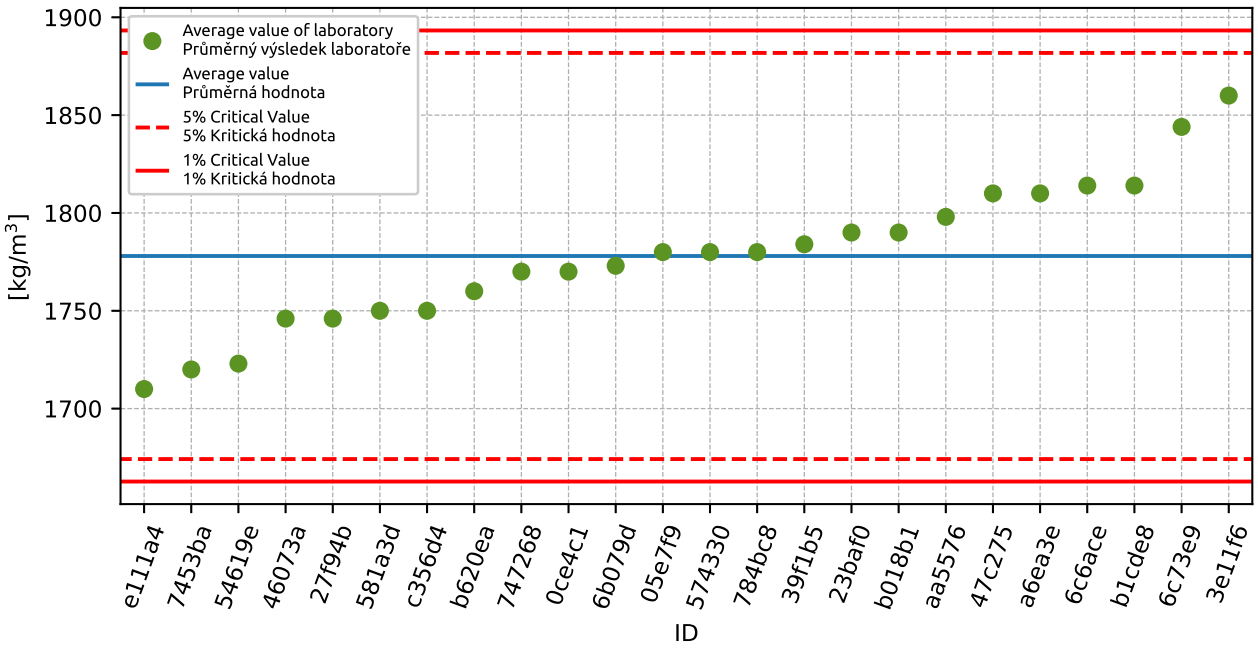

Figure 99: **Grubbs' test** - average values

8.1.3 Mandel's Statistics

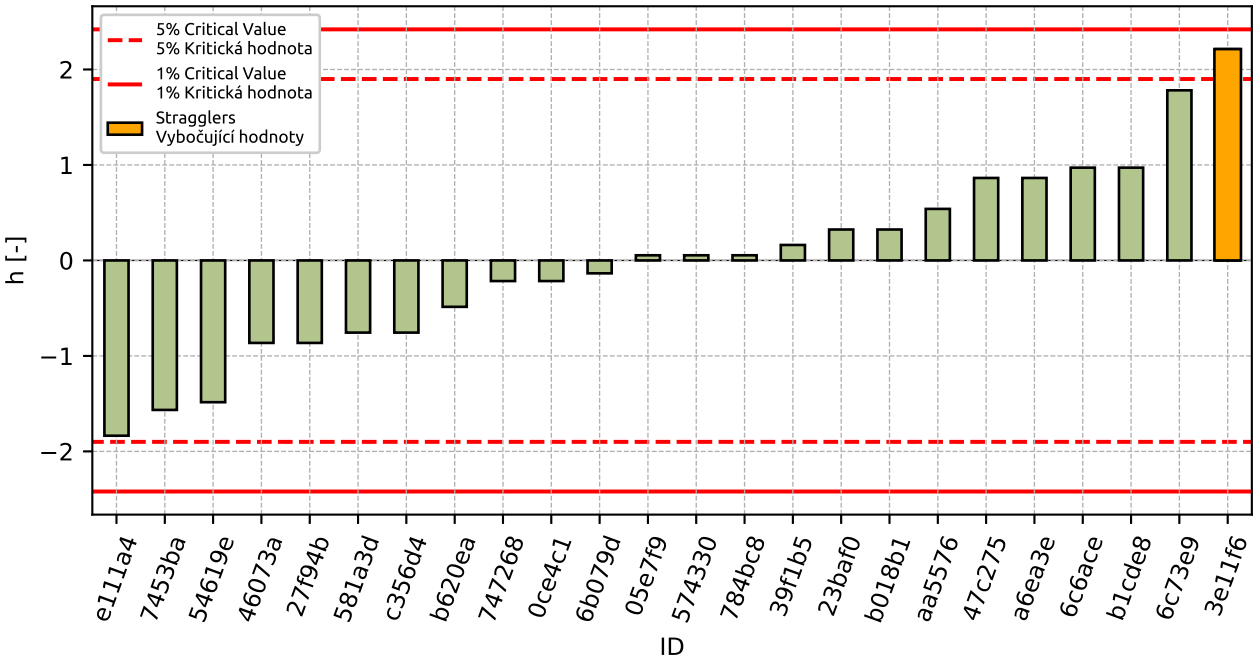

Figure 100: Interlaboratory Consistency Statistic

8.1.4 Descriptive statistics

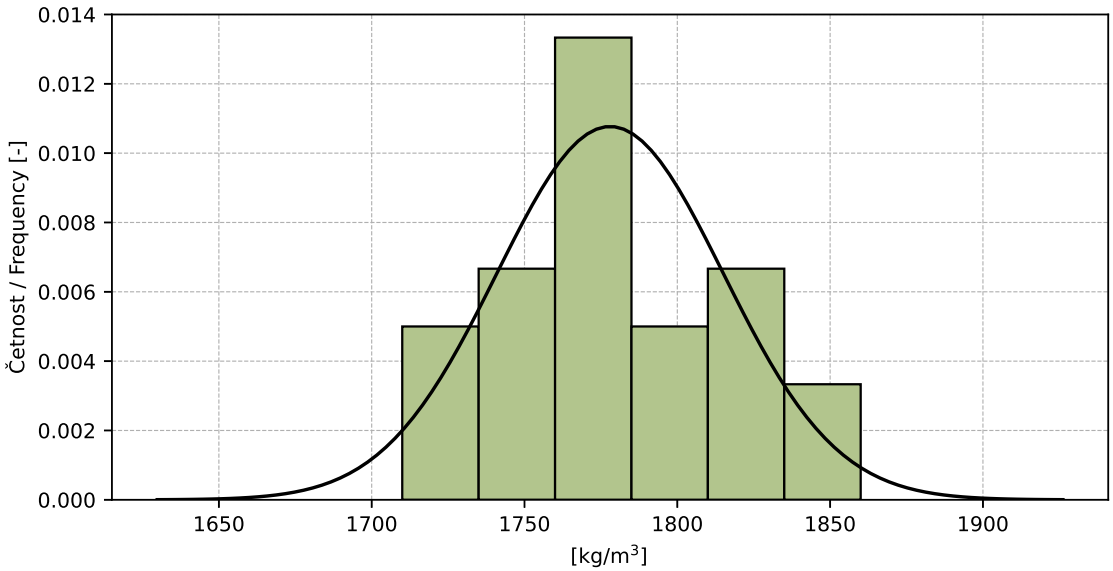

Figure 101: Histogram of all test results

Table 48: Descriptive statistics

Characteristics	**[kg/m³]**
Průměrná hodnota / Average value – $\bar{x}$	1778.0
Výběrová směrodatná odchylka / Sample standard deviation – s	37.0
Vztažná hodnota / Asigned value – x^*	1778.0
Robustní směrodatná odchylka / Robust standard deviation – s^*	40.0
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	10.2
p-hodnota testu normality / p-value of normality test	0.886 [-]

8.1.5 Evaluation of Performance Statistics

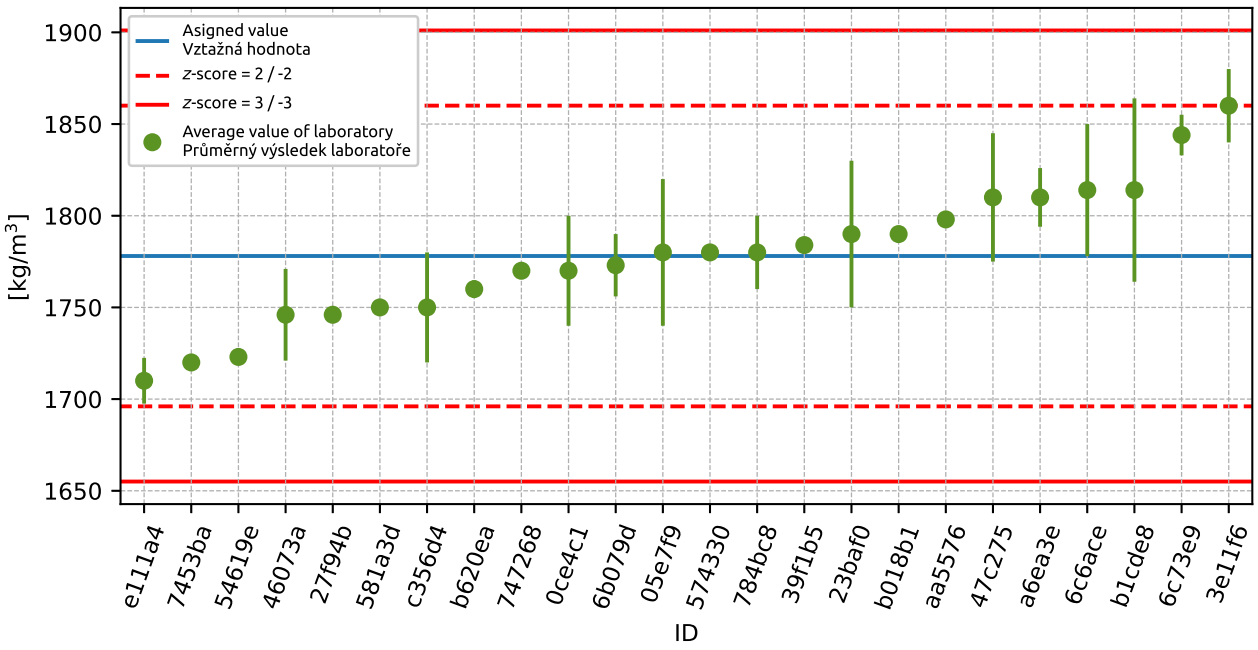

Figure 102: Average values and extended uncertainties of measurement

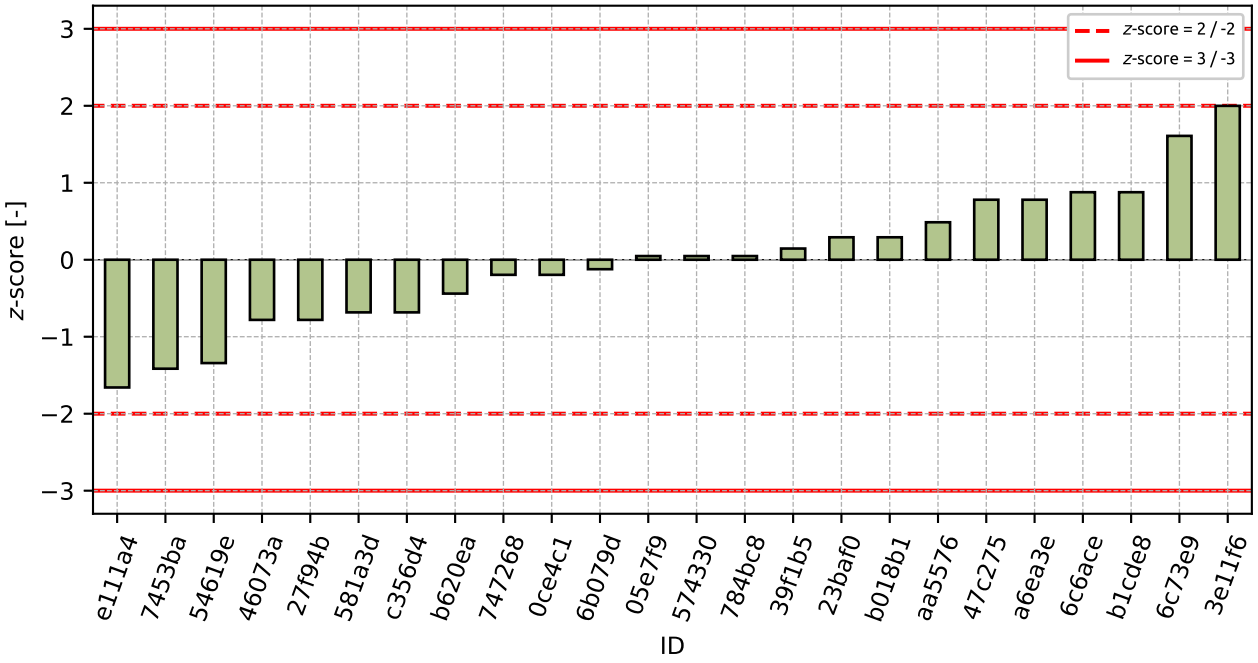

Figure 103: z-score

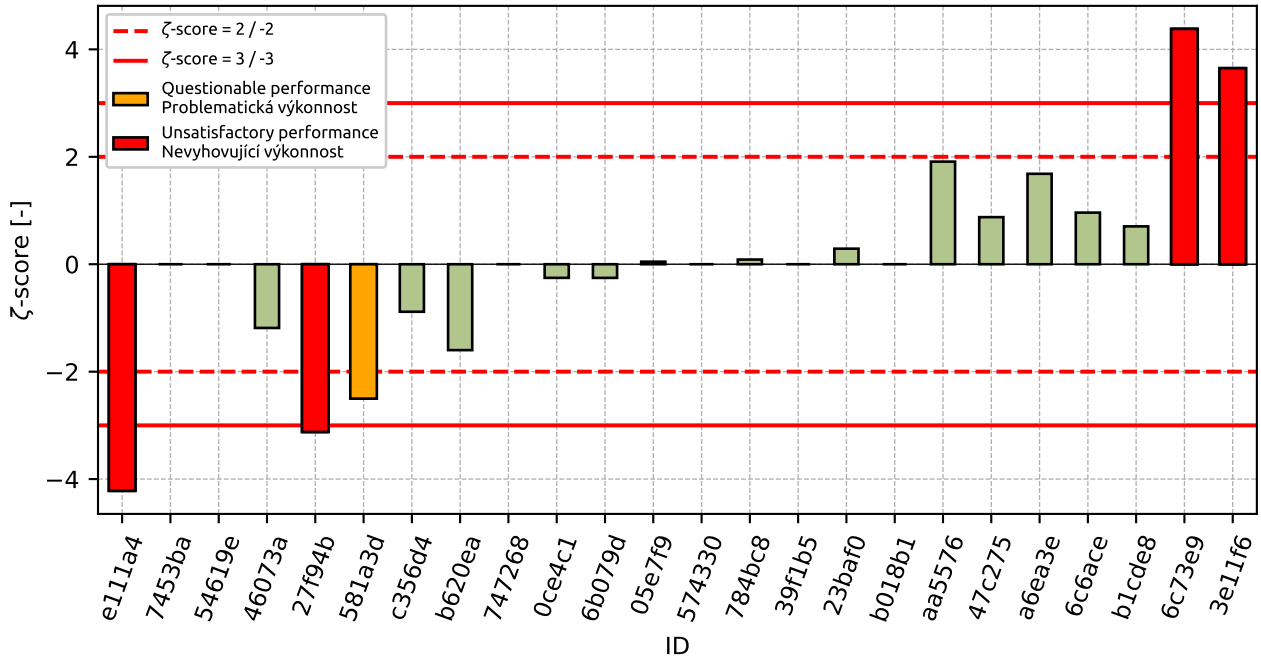

Figure 104: ζ-score

Table 49: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
e111a4	-1.66	-4.22
7453ba	-1.42	-
54619e	-1.34	-
46073a	-0.78	-1.19
27f94b	-0.78	-3.12
581a3d	-0.68	-2.5
c356d4	-0.68	-0.88
b620ea	-0.44	-1.6
747268	-0.2	-
0ce4c1	-0.2	-0.25
6b079d	-0.12	-0.25
05e7f9	0.05	0.05
574330	0.05	-
784bc8	0.05	0.09
39f1b5	0.15	-
23baf0	0.29	0.29
b018b1	0.29	-
aa5576	0.49	1.91
47c275	0.78	0.88
a6ea3e	0.78	1.68
6c6ace	0.88	0.96
b1cde8	0.88	0.7
6c73e9	1.61	4.38
3e11f6	2.0	3.65

8.2 Optimum water content

8.2.1 Test results

Table 50: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [%]	u_X [%]
47c275	14.3	0.4
05e7f9	14.3	1.0
54619e	14.9	-
b018b1	15.0	-
784bc8	15.0	2.0
0ce4c1	15.0	0.7
3e11f6	15.1	0.2
27f94b	15.3	0.1
23baf0	15.3	2.0
39f1b5	15.3	-
6c73e9	15.4	0.2
7453ba	15.5	-
6b079d	15.6	0.4
747268	15.6	-
46073a	15.7	1.0
6c6ace	15.9	1.0
b1cde8	15.9	1.8
a6ea3e	16.0	0.6
aa5576	16.1	0.7
c356d4	16.4	1.8
574330	16.5	-
b620ea	16.7	0.0
581a3d	16.8	0.1
e111a4	17.3	0.2

8.2.2 The Numerical Procedure for Determining Outliers

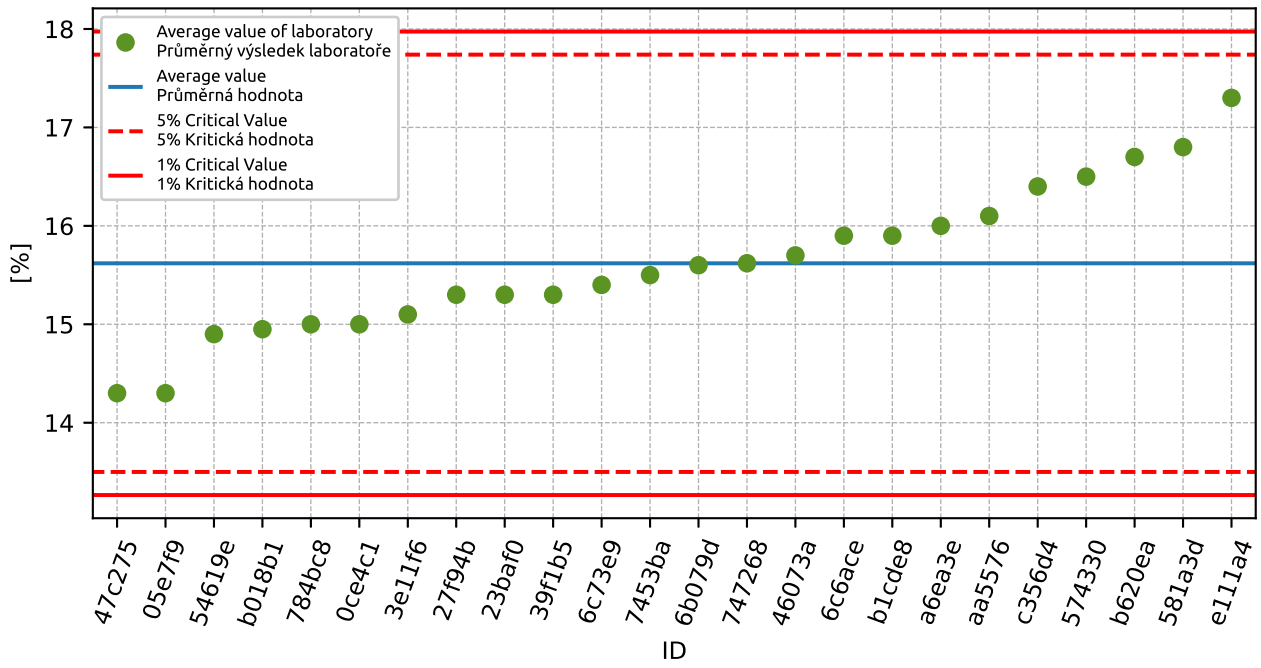

Figure 105: **Grubbs' test** - average values

8.2.3 Mandel's Statistics

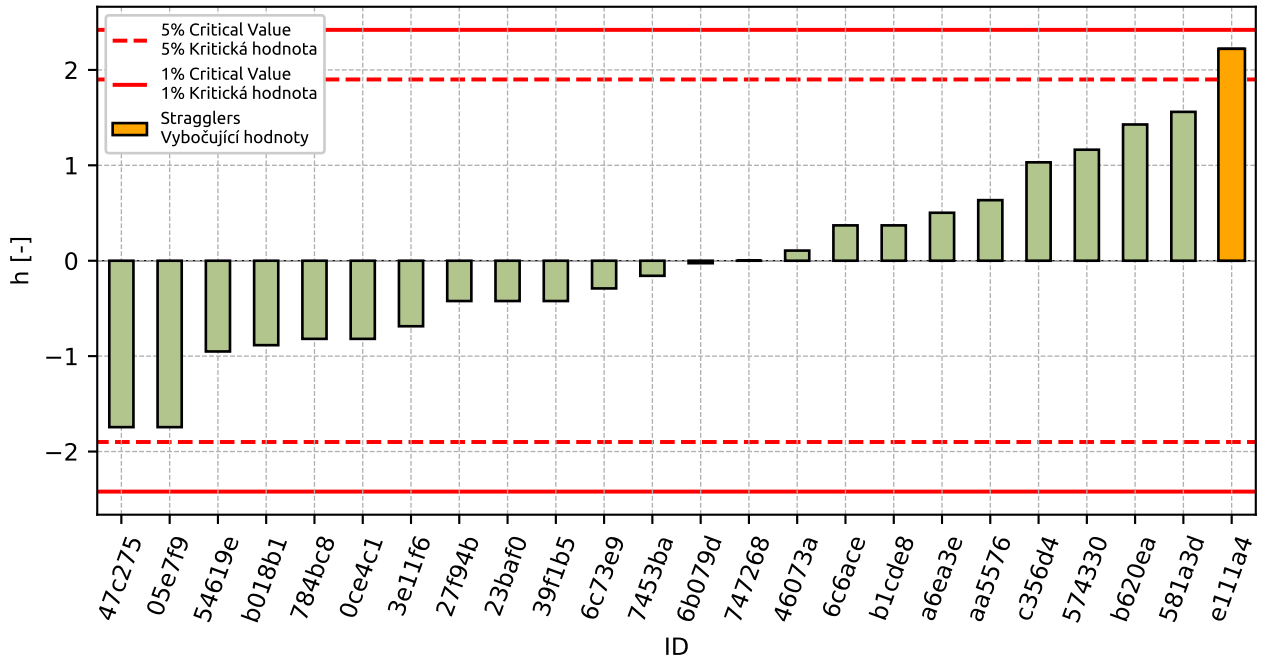

Figure 106: Interlaboratory Consistency Statistic

8.2.4 Descriptive statistics

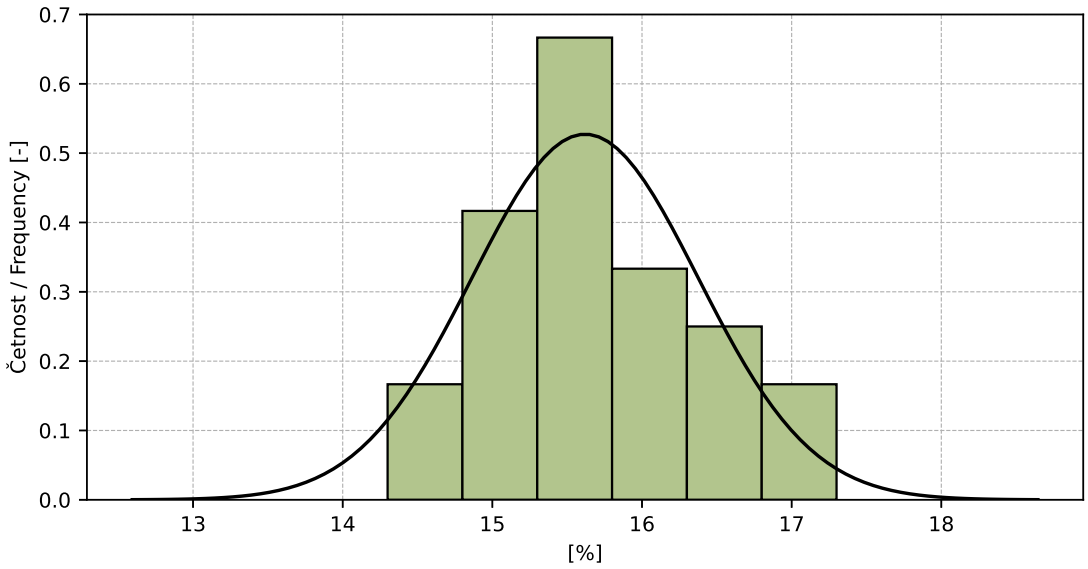

Figure 107: Histogram of all test results

Table 51: Descriptive statistics

Characteristics	**[%]**
Průměrná hodnota / Average value – $\bar{x}$	15.6
Výběrová směrodatná odchylka / Sample standard deviation – s	0.76
Vztažná hodnota / Asigned value – x^*	15.6
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.8
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.21
p-hodnota testu normality / p-value of normality test	0.792 [-]

8.2.5 Evaluation of Performance Statistics

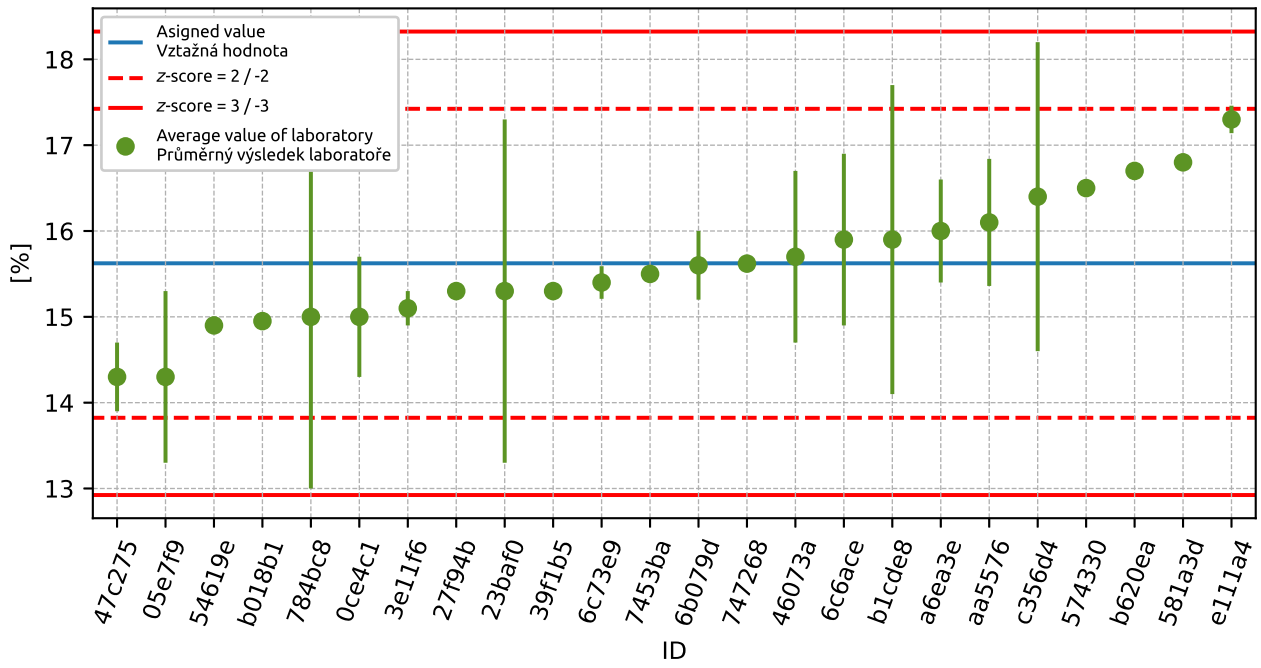

Figure 108: Average values and extended uncertainties of measurement

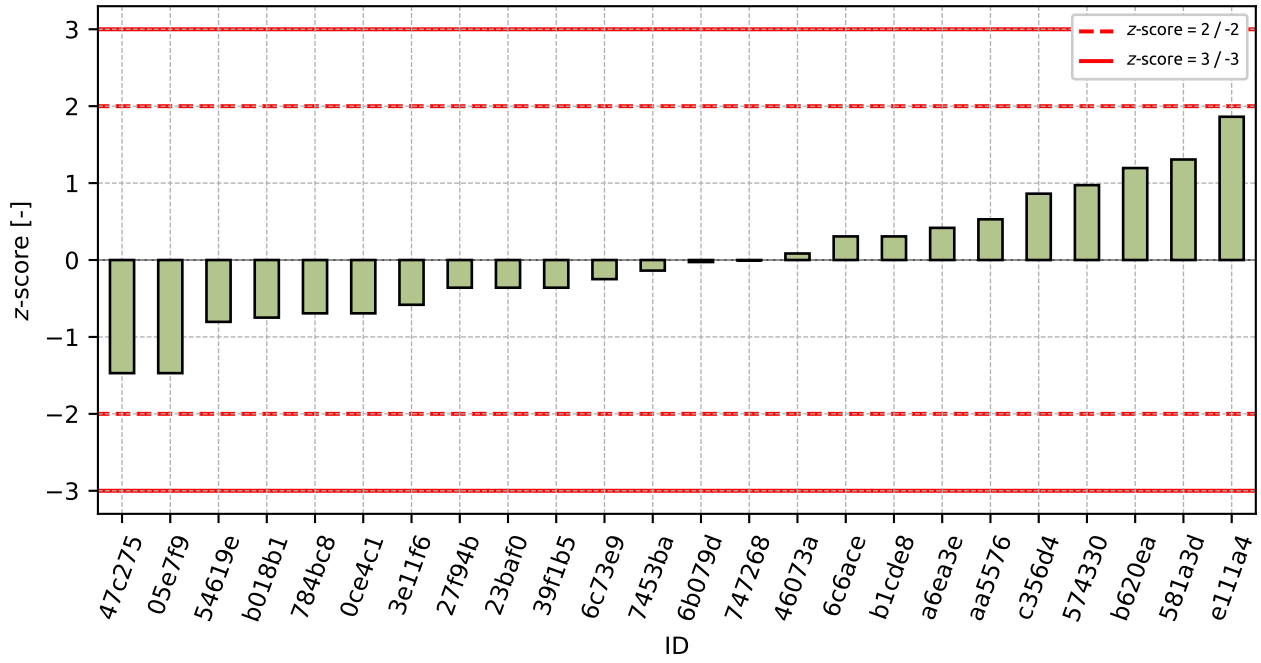

Figure 109: z-score

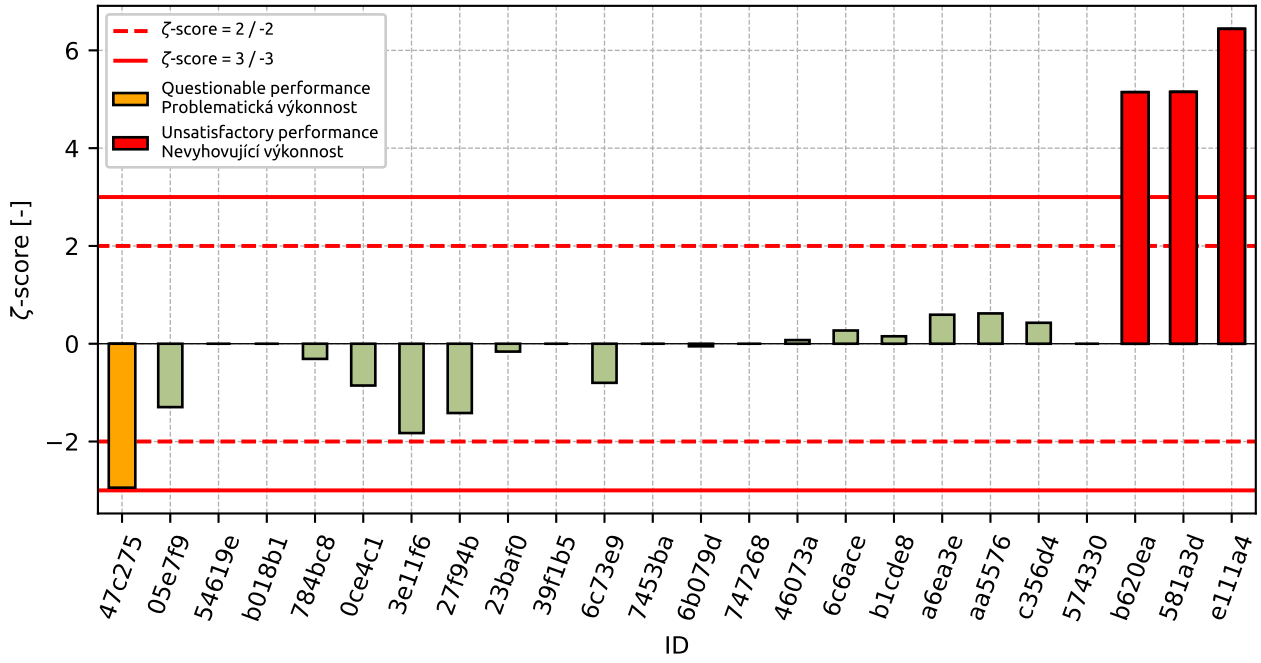

Figure 110: ζ-score

Table 52: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
47c275	-1.47	-2.94
05e7f9	-1.47	-1.3
54619e	-0.8	-
b018b1	-0.75	-
784bc8	-0.69	-0.31
0ce4c1	-0.69	-0.86
3e11f6	-0.58	-1.83
27f94b	-0.36	-1.42
23baf0	-0.36	-0.16
39f1b5	-0.36	-
6c73e9	-0.25	-0.8
7453ba	-0.14	-
6b079d	-0.03	-0.05
747268	-0.0	-
46073a	0.08	0.07
6c6ace	0.31	0.27
b1cde8	0.31	0.15
a6ea3e	0.42	0.59
aa5576	0.53	0.62
c356d4	0.86	0.43
574330	0.97	-
b620ea	1.2	5.14
581a3d	1.31	5.15
e111a4	1.86	6.44

9 Appendix – EN 13286-47 – IBI

9.1 Test results

Table 53: Test results - ordered by average value. Outliers are marked by red color. u_X - extended uncertainty of measurement.

ID	Test results [%]	u_X [%]
581a3d	10	1.0
063fae	10	4.0
b1cde8	11	-
47c275	12	-
b018b1	13	-
784bc8	15	2.0
747268	15	-
6c73e9	16	1.0
7453ba	17	-
3e11f6	17	1.0
574330	18	-
46073a	19	2.0
27f94b	20	1.0
aa5576	21	-
a6ea3e	21	-

9.2 The Numerical Procedure for Determining Outliers

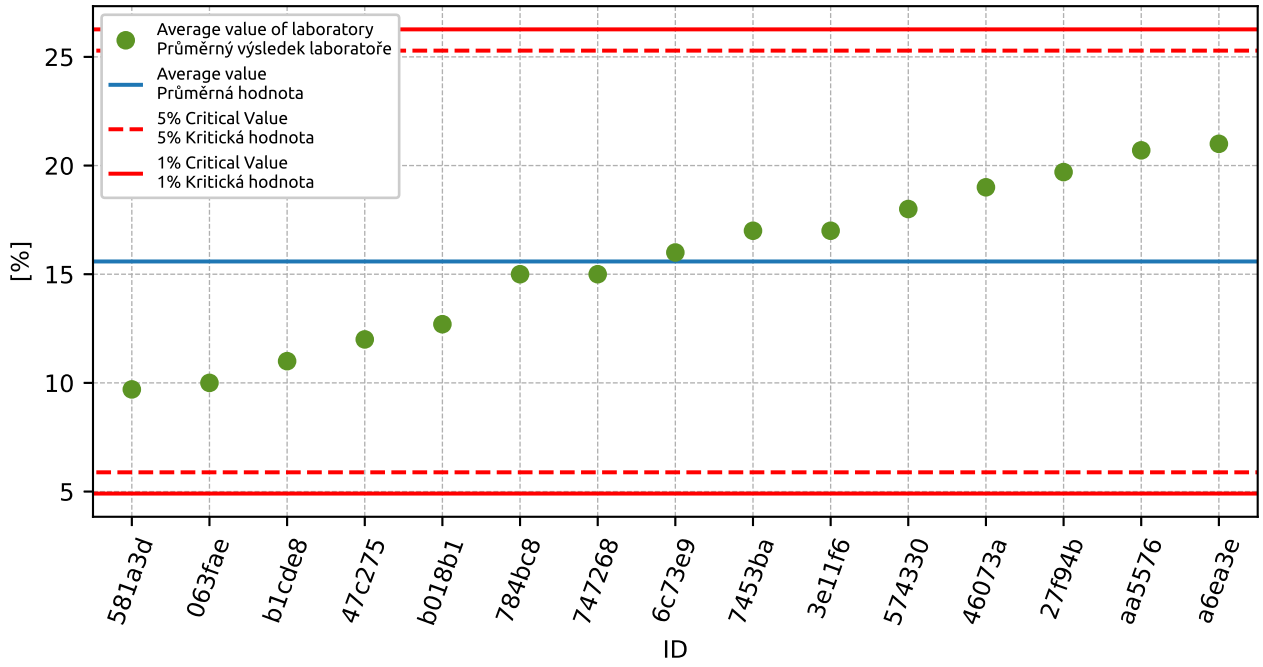

Figure 111: **Grubbs' test** - average values

9.3 Mandel's Statistics

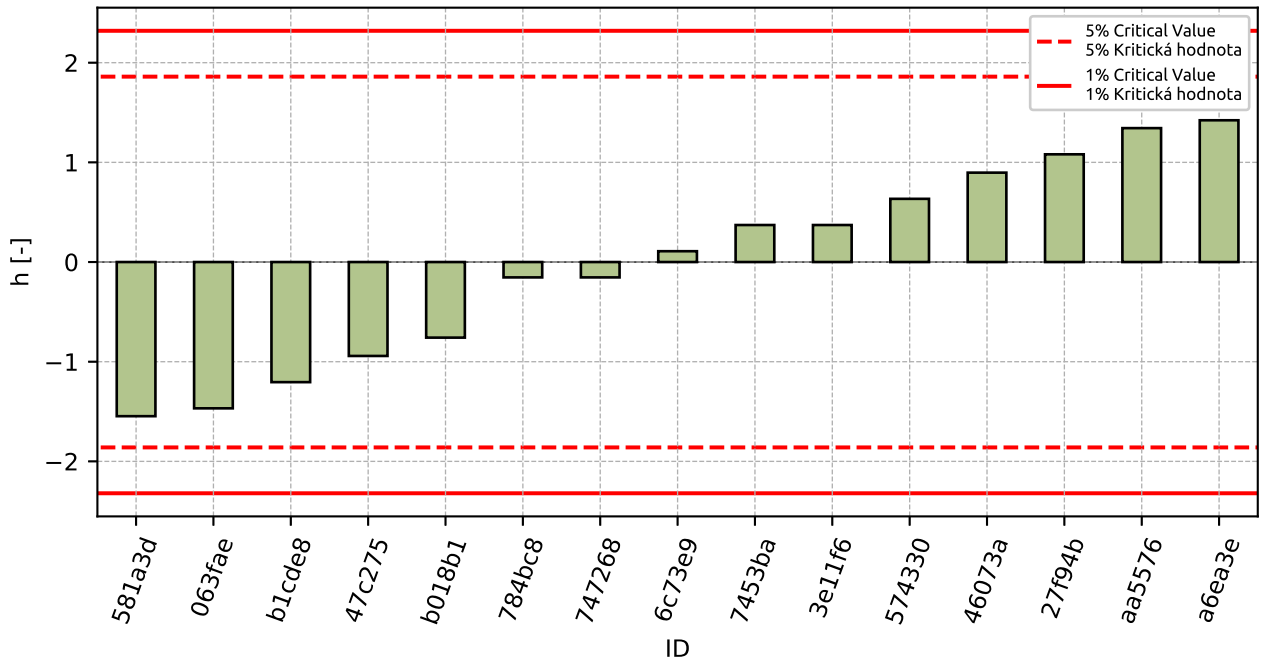

Figure 112: Interlaboratory Consistency Statistic

9.4 Descriptive statistics

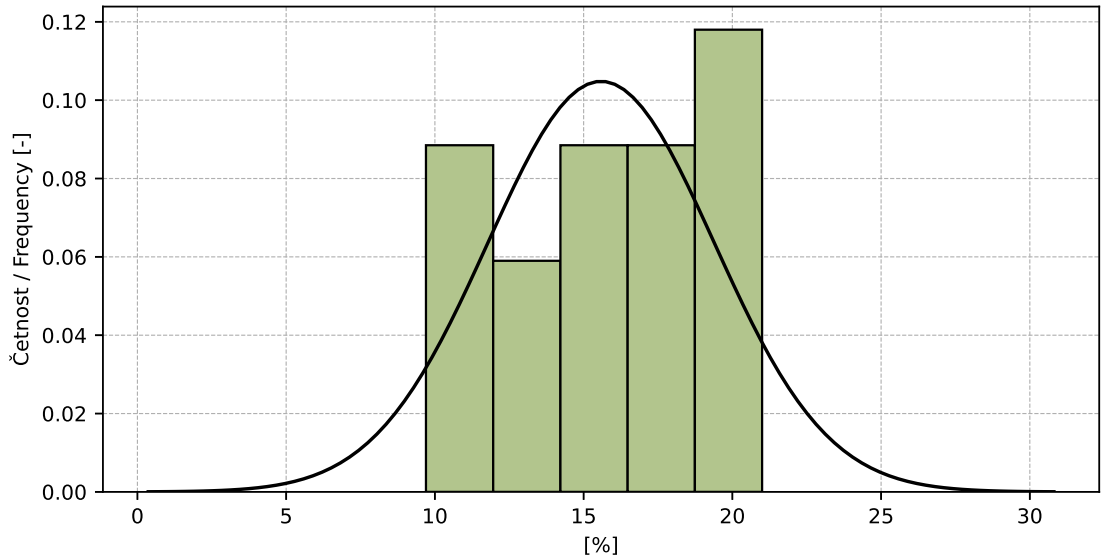

Figure 113: Histogram of all test results

Table 54: Descriptive statistics

Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	16.0
Výběrová směrodatná odchylka / Sample standard deviation – s	3.8
Vztažná hodnota / Asigned value – x^*	16.0
Robustní směrodatná odchylka / Robust standard deviation – s^*	4.2
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	1.3
p-hodnota testu normality / p-value of normality test	0.41 [-]

9.5 Evaluation of Performance Statistics

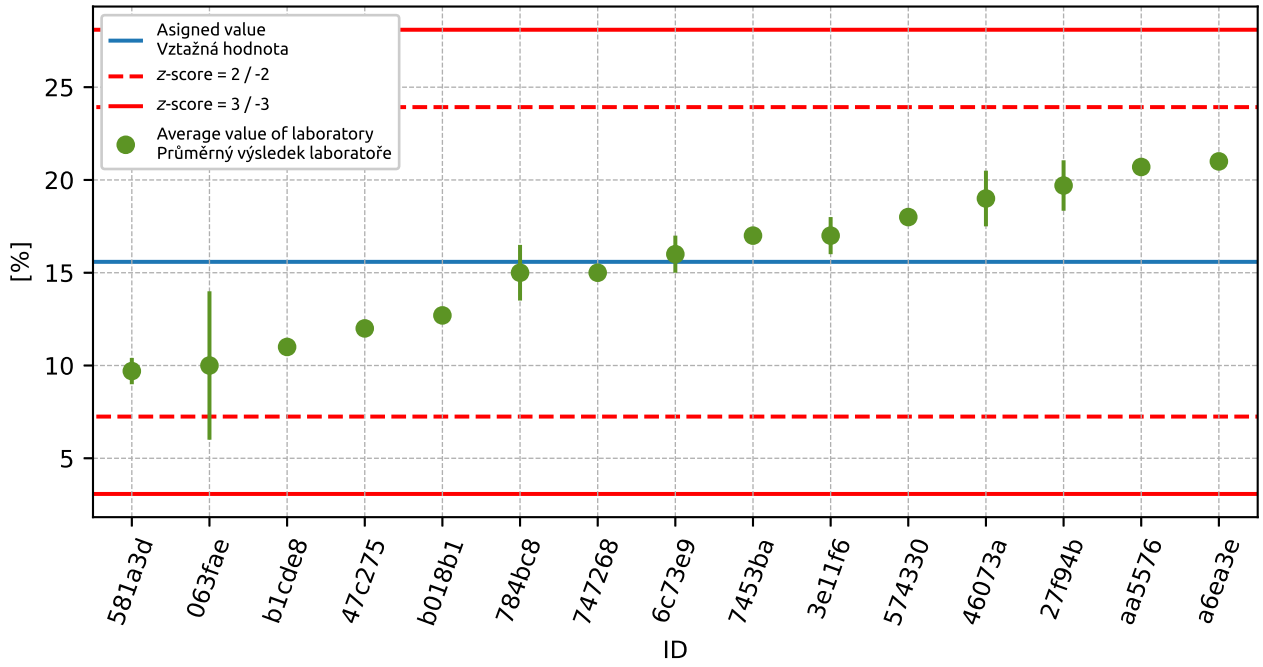

Figure 114: Average values and extended uncertainties of measurement

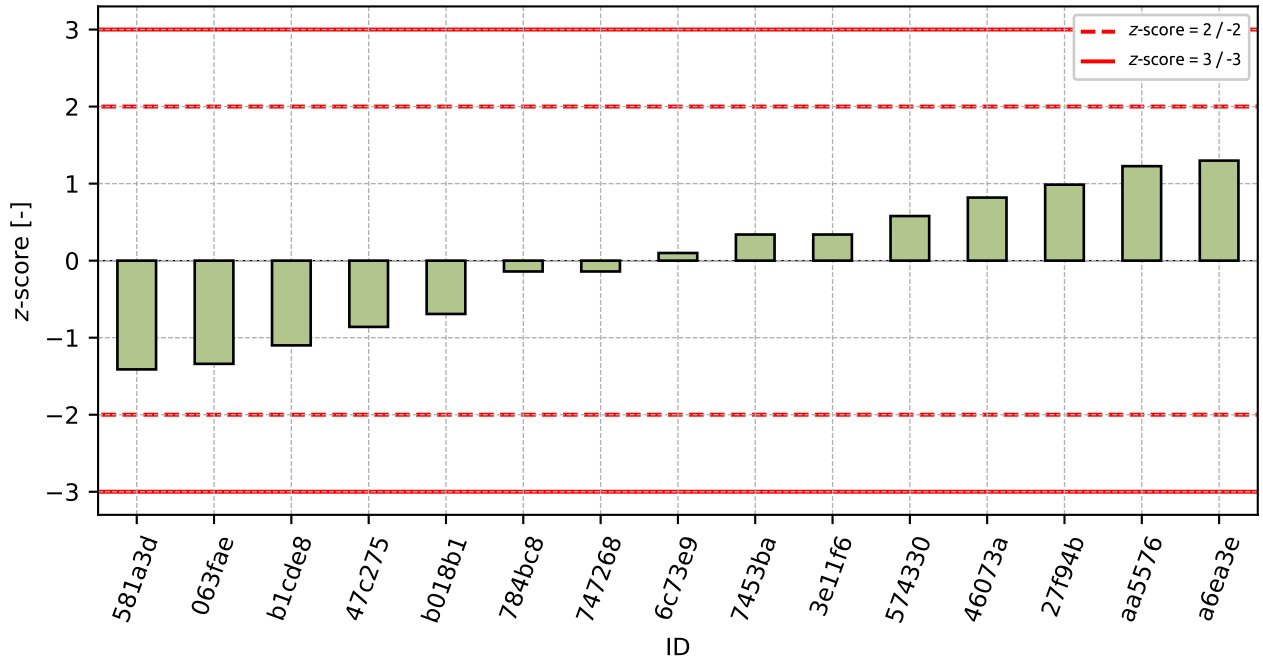

Figure 115: z-score

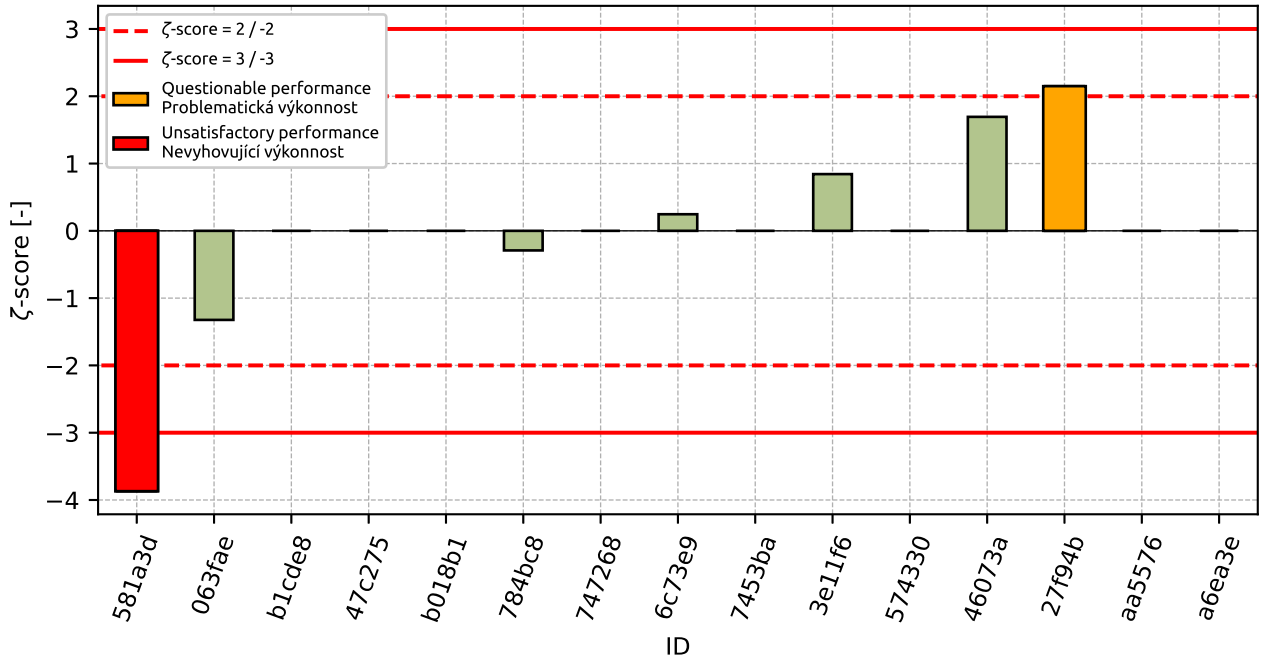

Figure 116: ζ-score

Table 55: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
581a3d	-1.41	-3.87
063fae	-1.34	-1.32
b1cde8	-1.1	-
47c275	-0.86	-
b018b1	-0.69	-
784bc8	-0.14	-0.29
747268	-0.14	-
6c73e9	0.1	0.25
7453ba	0.34	-
3e11f6	0.34	0.84
574330	0.58	-
46073a	0.82	1.69
27f94b	0.99	2.15
aa5576	1.23	-
a6ea3e	1.3	-