FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Concrete paving blocks testing
(ZDB 1338 - This PT scheme is out of the range of accreditation of Z7008)
ZDB 2020/1

Brno University of Technology
Proficiency testing provider at the SZK FAST
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www.ptprovider.cz

Date: December, 18th 2020

Poskytovatel zkoušení
způsobilosti při SZK FAST

Proficiency testing
provider at the SZK FAST

Z 7008

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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 ZDB 2020/1 whose aim was to verify and assess the conformity of test results across laboratories when testing Concrete paving blocks testing. This PT scheme is out of the range of accreditation of PT provider.

The assessment of the results of the Proficiency Testing Program was carried out by a committee consisting of the following PT Provider employees:

Head of the PT Provider, PTP coordinator

Assoc. Prof. Ing. Tomáš Vymazal, Ph.D.
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Coordinator of PTP result assessment PrZZ

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The subjects of proficiency testing were the following testing procedures:

1. **EN 1338 – Appendix E** – Total water absorption [1],

2. **EN 1338 – Appendix F** – Tensile splitting strength [1],

3. **EN 1338 – Appendix G** – Abrasion resistance [1].

Testing procedure No 3 was not open due to the lack of participants.

The supplier, CS-BETON s.r.o. – Zkušební laboratoř CS-BETON (L1500), was responsible for the preparation of testing specimens. In order to maintain an acceptable degree of homogeneity and stability, the test specimens were selected and sorted so that each participant received a sufficiently representative set.

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 [2] and with EN ISO/IEC 17043 [3]. The outcome is the present final report summarizing the results of the interlaboratory comparison, including statistical evaluation.

11 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
f52359	X	X	-
473c3c	X	X	-
6ddf42	X	X	-
3f82fe	-	X	-
5d13ed	-	X	-
98e209	-	X	-
4b72b2	X	X	-
75a9db	X	-	-
87ed4b	-	X	-
a6829c	X	X	-
55c591	X	X	-

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

Laboratory	Address	Accreditation number
BEST a.s.	Rybnice 148, Kaznějov, 331 51, Česká republika	1739
CS-BETON s.r.o. Zkušební laboratoř CS-BETON	Velké Žernoseky 184, Litoměřice, 412 01, Česká republika	1500
Kilsaran Concrete Unlimited Company	PIERCETOWN, DUNBOYNE, MEATH, A86 W820, Meath	241T
Magnel-Vandepitte Laboratory for Structural Engineering and Building Materials	Technologiepark - Zwijnaarde 60, Zwijnaarde (Ghent), 9052, Belgium	220-TEST
Materialprüfinstitut Nord	Raiffeisenstraße 8, Großburgwedel, 30938, Germany	-
QUALIFORM, a.s.	Mlaty 672/8, Brno - Bosonohy, 628 00, Česká republika	1008
STACHEMA CZ s.r.o.	Hasičská 1, Zibohlavy, Kolín, 28002, Česká republika	1433
TPA EOOD CTC SOFIA	Rezbarska str. № 7, SOFIA, 1510, BULGARIA	-
Vysoké učení technické v Brně, Fakulta stavební, Akreditovaná zkušební laboratoř při ÚTHD FAST VUT v Brně	Veveří 331/95, Brno, 61200, Česká republika	L1396
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2018
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Korlátolt Felelősségű Társaság	Dózsa György, Szentendre, 2000, 26	-

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

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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 Concrete paving blocks testing
(ZDB 1338 - This PT scheme is out of the range of accreditation of Z7008) (PT Program) organized by the PT Provider at the SZK FAST. 11 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
f52359	✓	✓	-
473c3c	✓	✓	-
6ddf42	✓	✓	-

Continued on next page

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Continued from previous page

ID / Method	1	2	3
3f82fe	-	?	-
5d13ed	-	✓	-
98e209	-	✓	-
4b72b2	✓	✓	-
75a9db	✓	-	-
87ed4b	-	✓	-
a6829c	✓	✓	-
55c591	✓	✓	-

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References

[1] EN 1338. *Concrete paving blocks - Requirements and test methods*. 2004.

[2] 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.

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

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1   Appendix – EN 1338 – Annex E – Total water absorption

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 [%]
f52359	3.7	3.9	3.5	0.5	3.7	0.2	5.41
a6829c	3.3	3.8	4.0	1.7	3.7	0.36	9.74
55c591	3.8	3.5	3.8	0.0	3.7	0.17	4.68
473c3c	4.0	3.9	3.3	-	3.7	0.38	10.14
6ddf42	3.9	3.6	4.1	0.2	3.9	0.27	6.83
75a9db	4.1	3.6	4.2	0.2	3.9	0.31	7.95
4b72b2	4.2	3.7	3.9	0.2	3.9	0.25	6.4

1.2   The Numerical Procedure for Determining Outliers
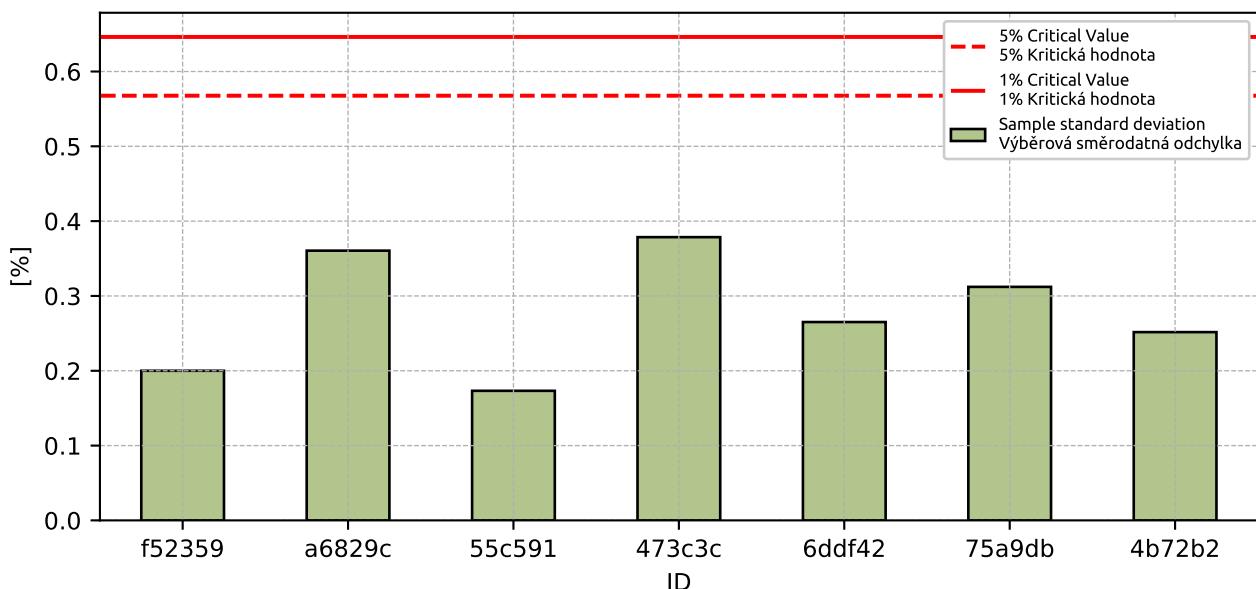
Figure 1: **Cochran's test** - sample standard deviations

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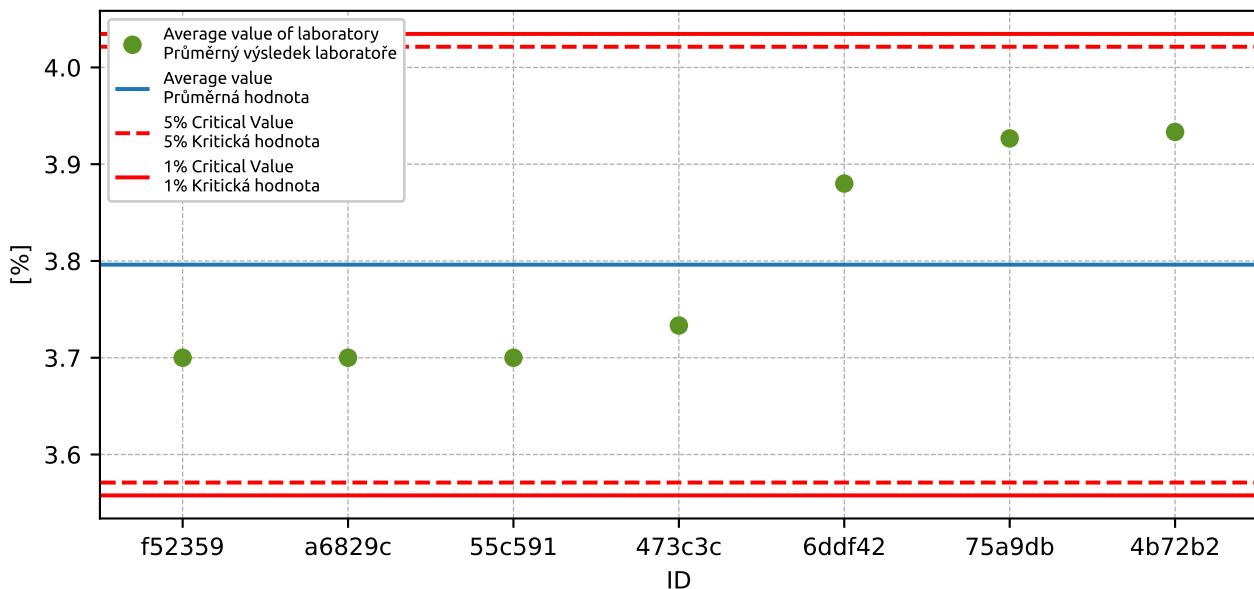
Figure 2: **Grubbs' test** - average values

1.3   Mandel's Statistics
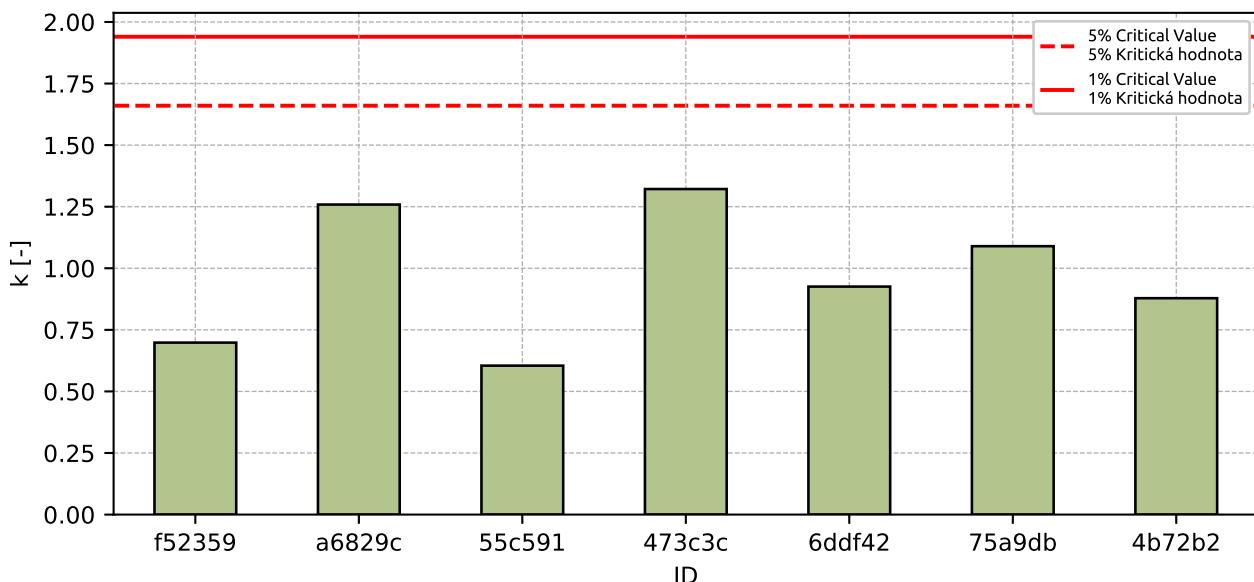
Figure 3: Intralaboratory Consistency Statistic

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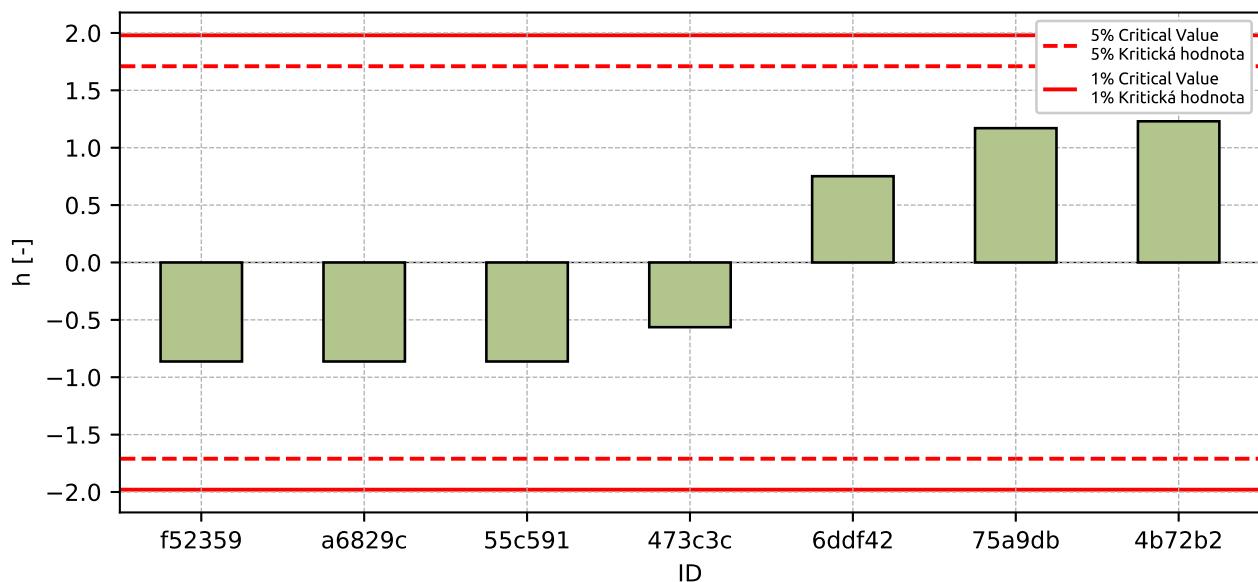
Figure 4: Interlaboratory Consistency Statistic

1.4   Descriptive statistics
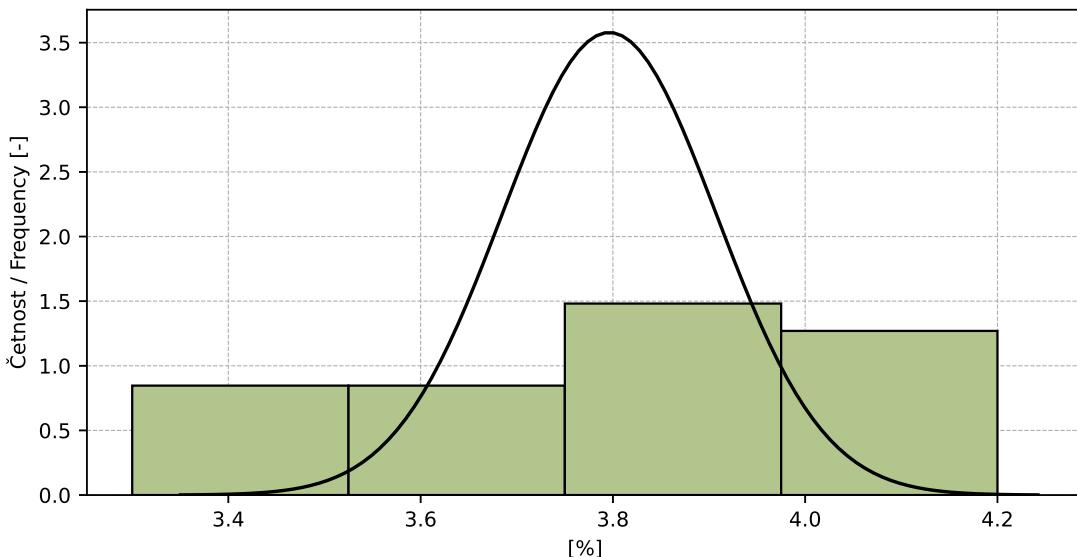
Figure 5: Histogram of all test results

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Table 5: Descriptive statistics

Characteristics	[%]
Průměrná hodnota / Average value – $\bar{x}$	3.8
Výběrová směrodatná odchylka / Sample standard deviation – s	0.11
Vztažná hodnota / Asigned value – x^*	3.8
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.11
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.33
p-hodnota testu normality / p-value of normality test	0.473 [-]
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	0.29
Opakovatelnost / Repeatability – r	0.8

1.5   Evaluation of Performance Statistics
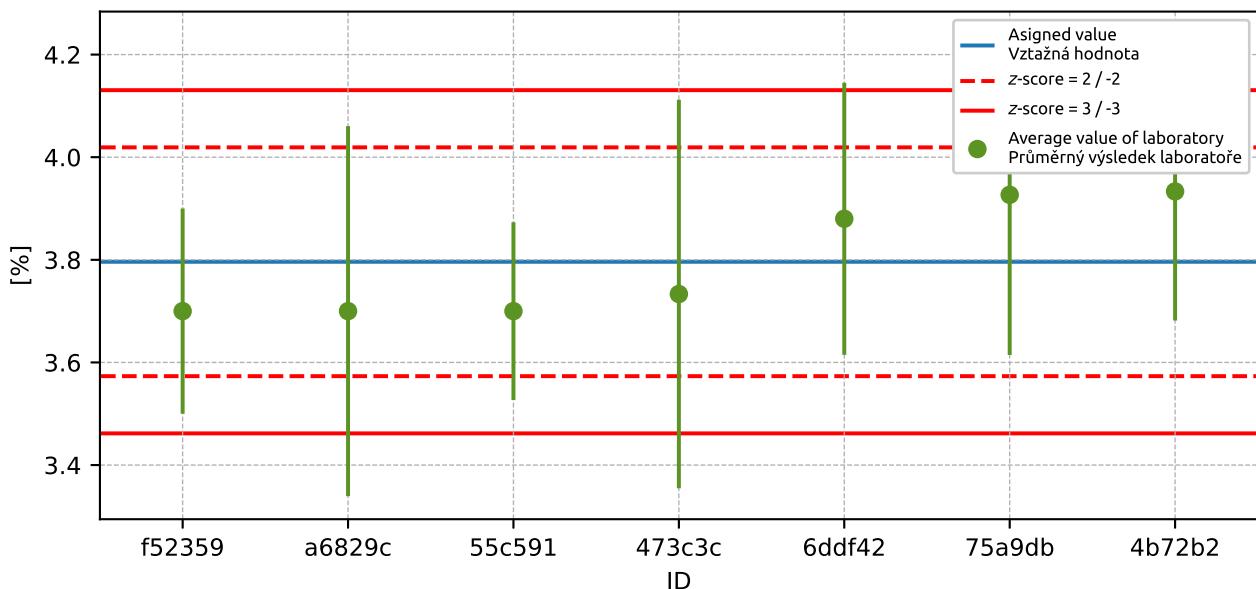
Figure 6: Average values and sample standard deviations

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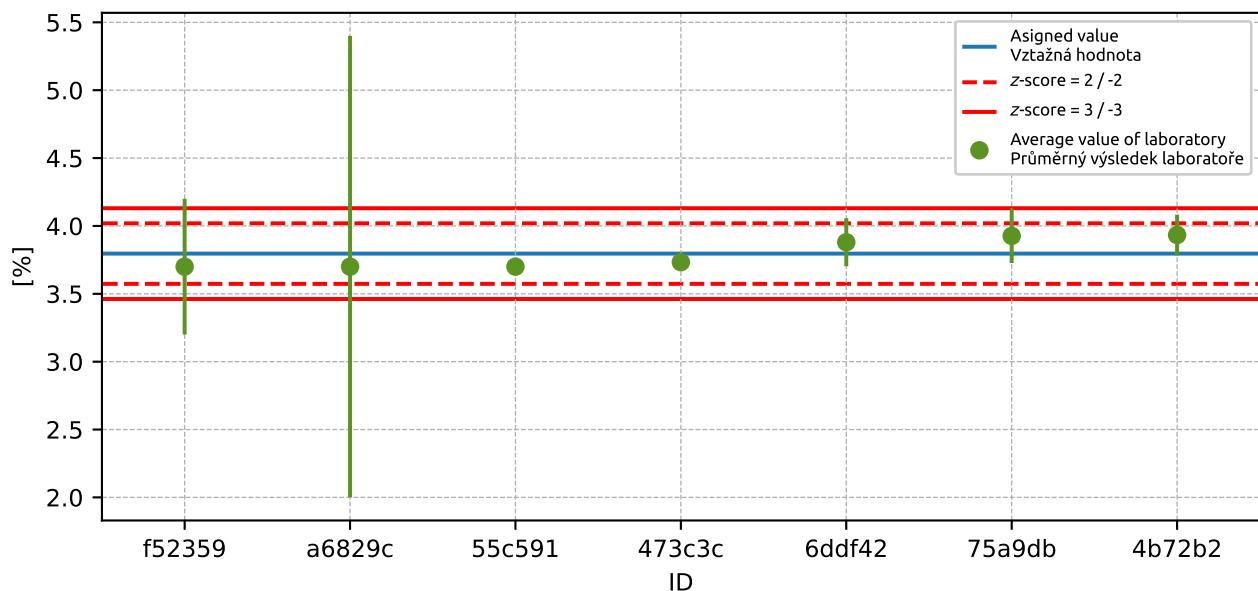
Figure 7: Average values and extended uncertainties of measurement

Figure 8: z-score

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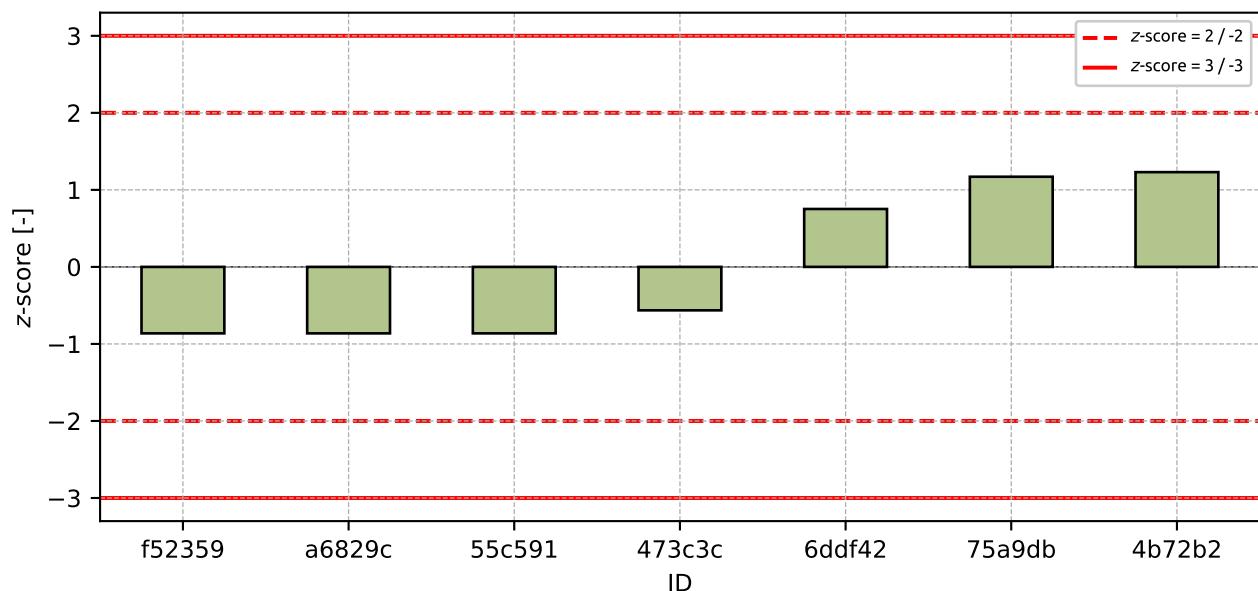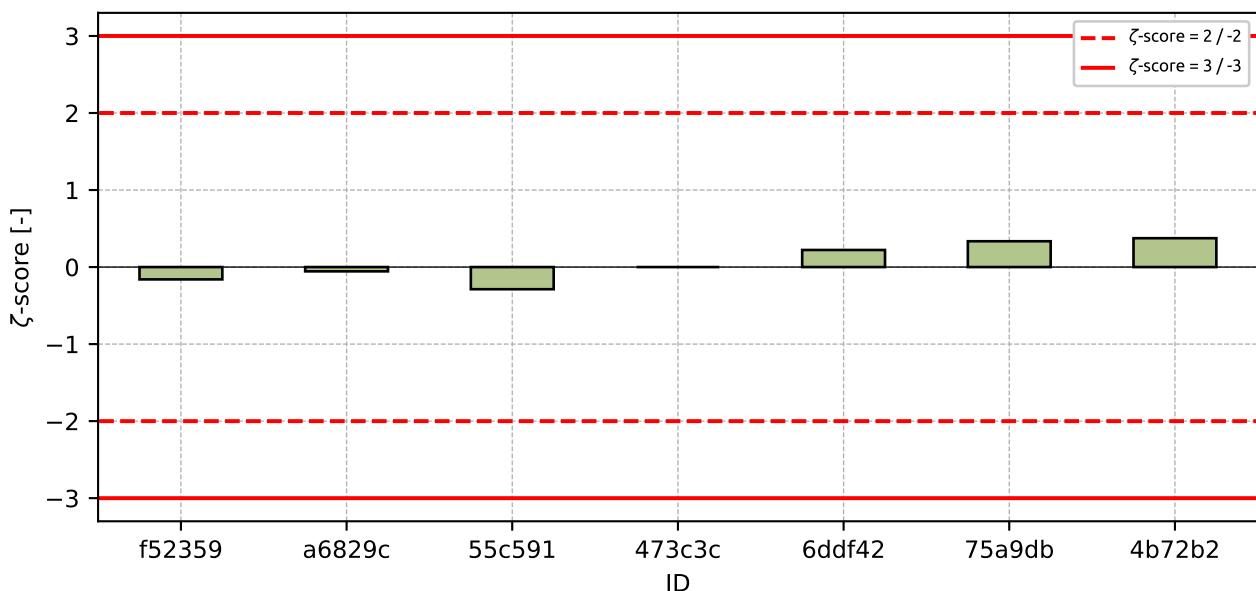
Figure 9: ζ-score

Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
f52359	-0.86	-0.16
a6829c	-0.86	-0.06
55c591	-0.86	-0.29
473c3c	-0.56	-
6ddf42	0.75	0.22
75a9db	1.17	0.34
4b72b2	1.23	0.37

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2   Appendix – EN 1338 – Annex F – Tensile splitting strength

2.1   Tensile splitting strength

2.1.1   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 [N/mm^2]								u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
3f82fe	6.6	5.4	5.2	4.8	5.2	4.3	4.3	6.1	1.0	5.2	0.81	15.44
87ed4b	6.0	6.5	6.0	6.6	6.5	6.6	6.4	6.1	0.3	6.3	0.26	4.13
6ddf42	7.1	6.2	6.5	6.1	6.0	6.9	6.9	6.2	0.1	6.5	0.41	6.32
a6829c	6.3	6.6	6.8	6.5	6.3	6.5	7.2	7.2	1.1	6.7	0.36	5.42
5d13ed	7.1	6.9	6.2	6.7	5.6	6.0	7.6	7.6	0.3	6.7	0.73	10.93
4b72b2	6.9	7.5	7.3	6.2	6.3	6.9	6.4	7.0	0.3	6.8	0.47	6.95
98e209	7.4	6.6	7.8	7.1	7.0	7.2	5.6	5.9	0.6	6.8	0.75	10.99
55c591	6.0	6.8	6.5	7.0	8.0	8.3	6.4	6.3	0.1	6.9	0.83	11.94
f52359	6.4	8.2	8.5	7.4	8.1	7.5	7.0	8.0	0.6	7.6	0.7	9.15

2.1.2   The Numerical Procedure for Determining Outliers
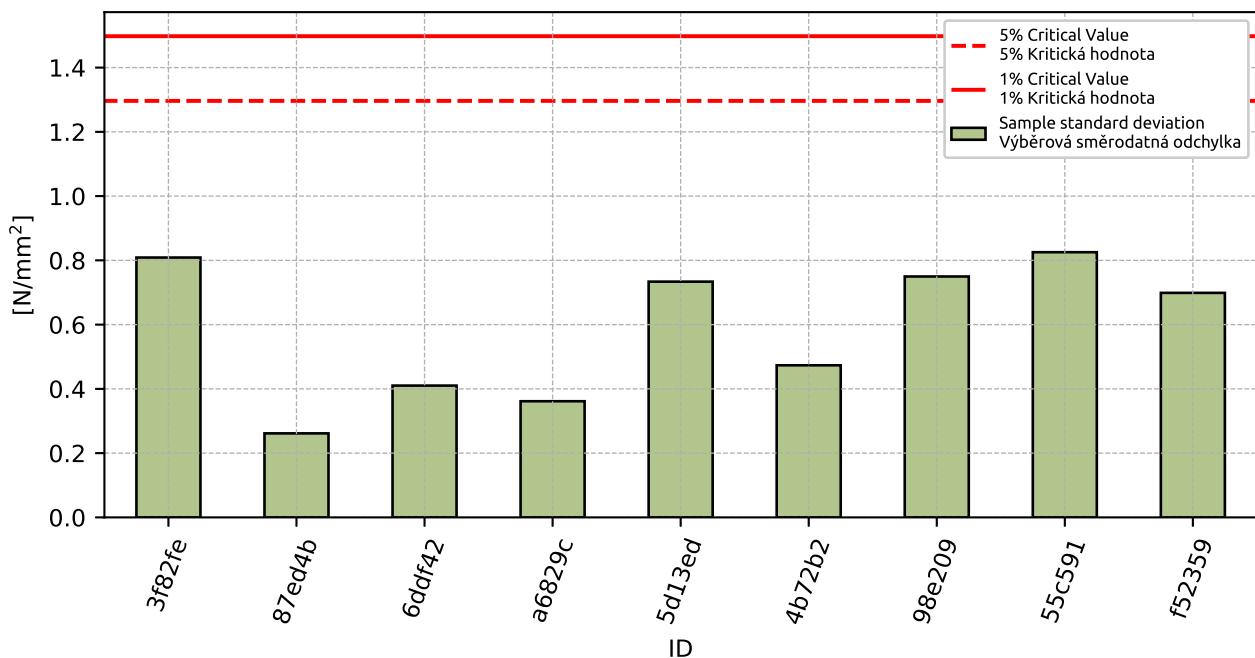
Figure 10: **Cochran's test** - sample standard deviations

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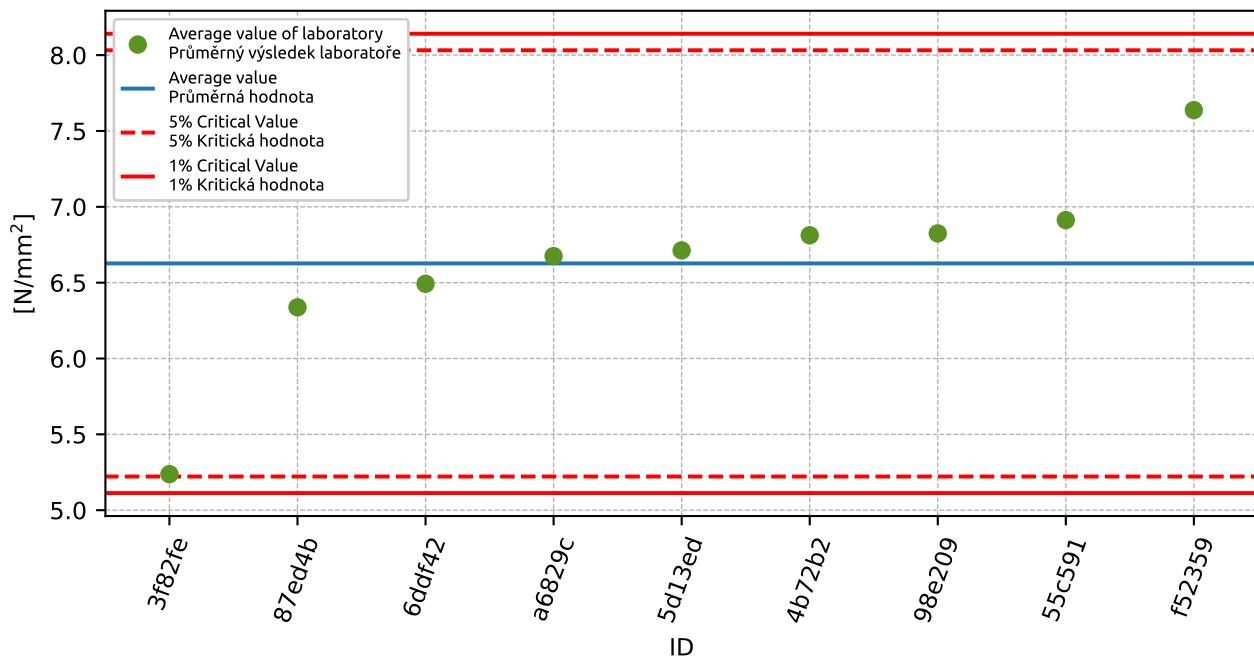
Figure 11: **Grubbs' test** - average values

2.1.3 Mandel's Statistics
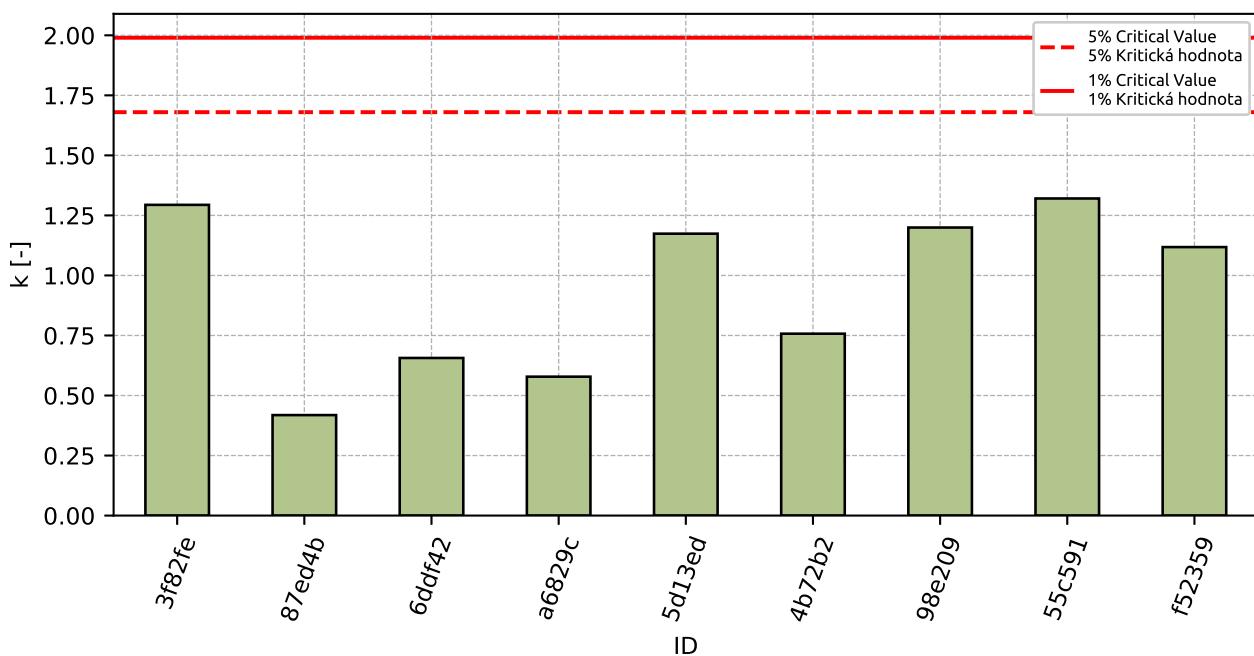
Figure 12: Intralaboratory Consistency Statistic

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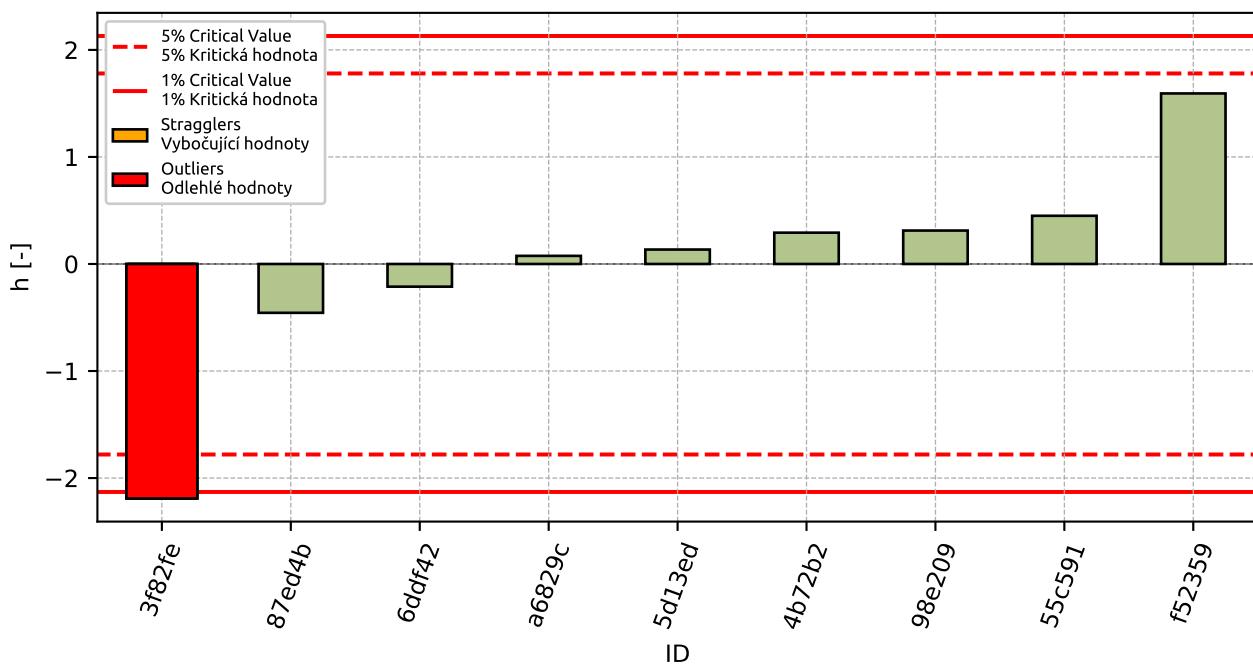
Figure 13: Interlaboratory Consistency Statistic

2.1.4   Descriptive statistics
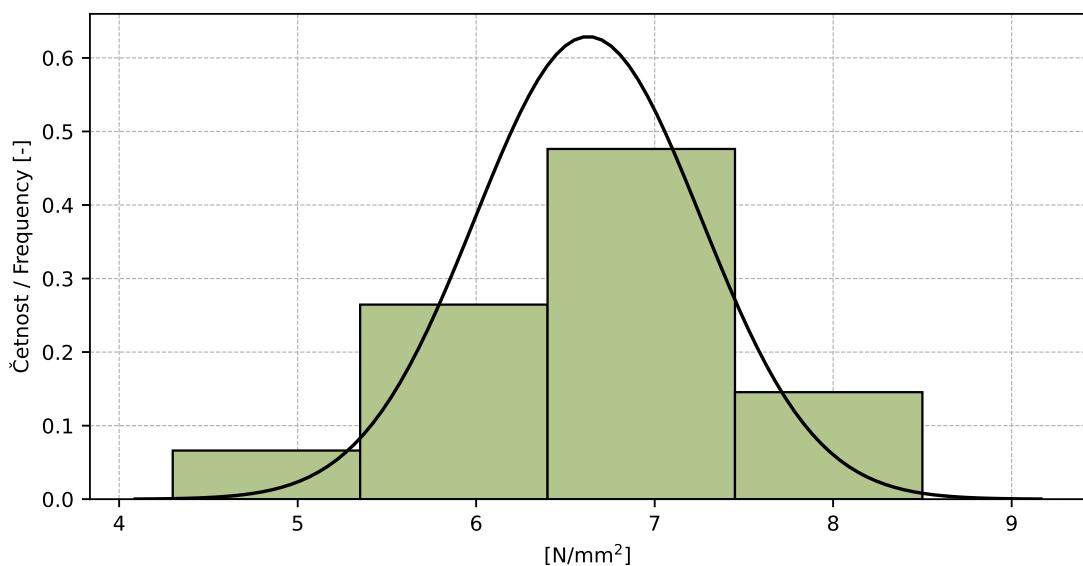
Figure 14: Histogram of all test results

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Table 8: Descriptive statistics

Characteristics	[N/mm^2]
Průměrná hodnota / Average value – $\bar{x}$	6.6
Výběrová směrodatná odchylka / Sample standard deviation – s	0.63
Vztažná hodnota / Asigned value – x^*	6.6
Robustní směrodatná odchylka / Robust standard deviation – s^*	0.63
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	0.8
p-hodnota testu normality / p-value of normality test	0.15 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	0.59
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	0.63
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	0.86
Opakovatelnost / Repeatability – r	1.8
Reprodukovatelnost / Reproducibility – R	2.4

2.1.5   Evaluation of Performance Statistics
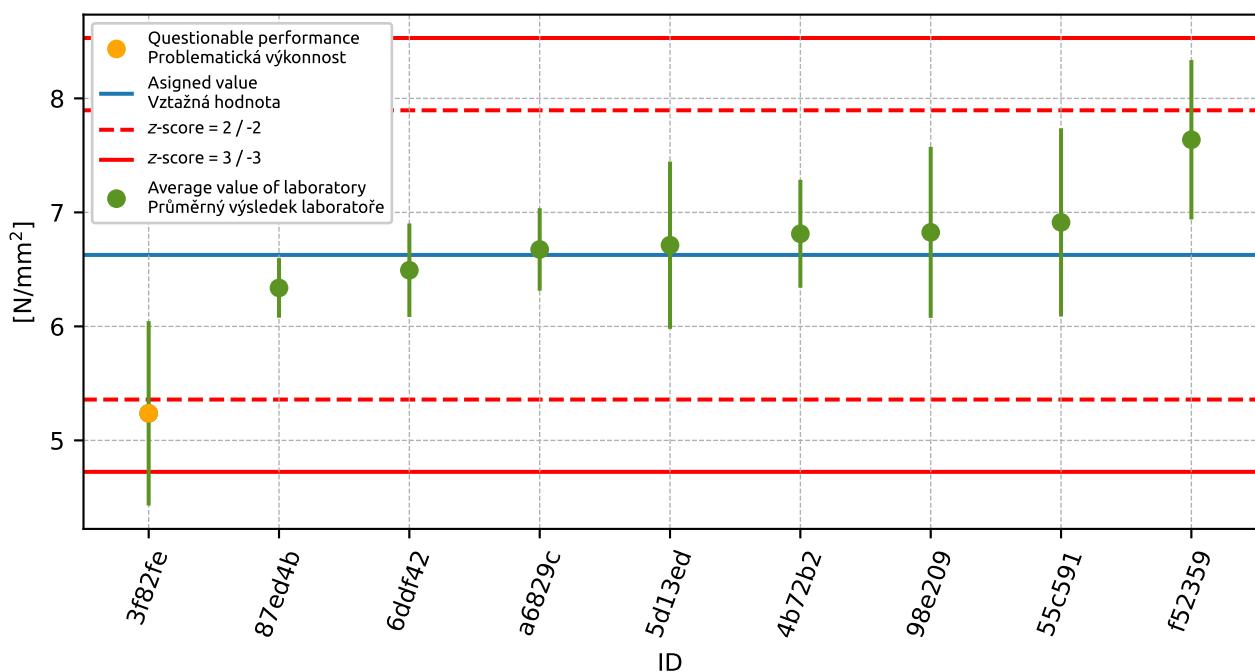
Figure 15: Average values and sample standard deviations

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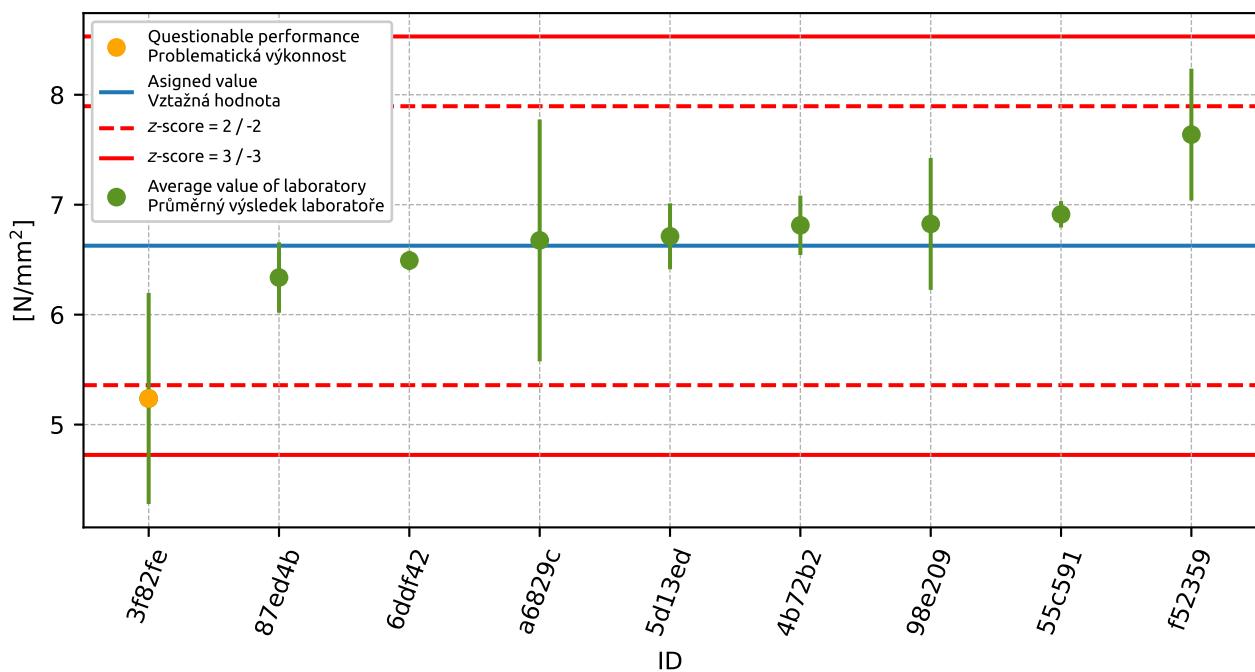
Figure 16: Average values and extended uncertainties of measurement

Figure 17: z-score

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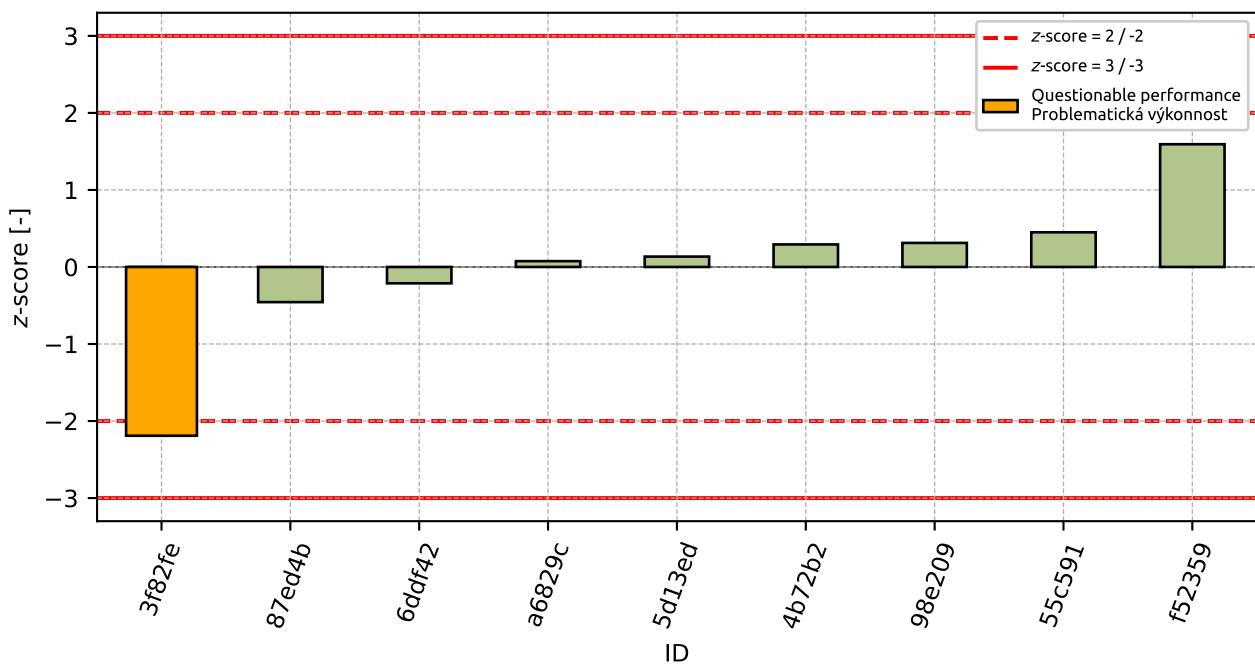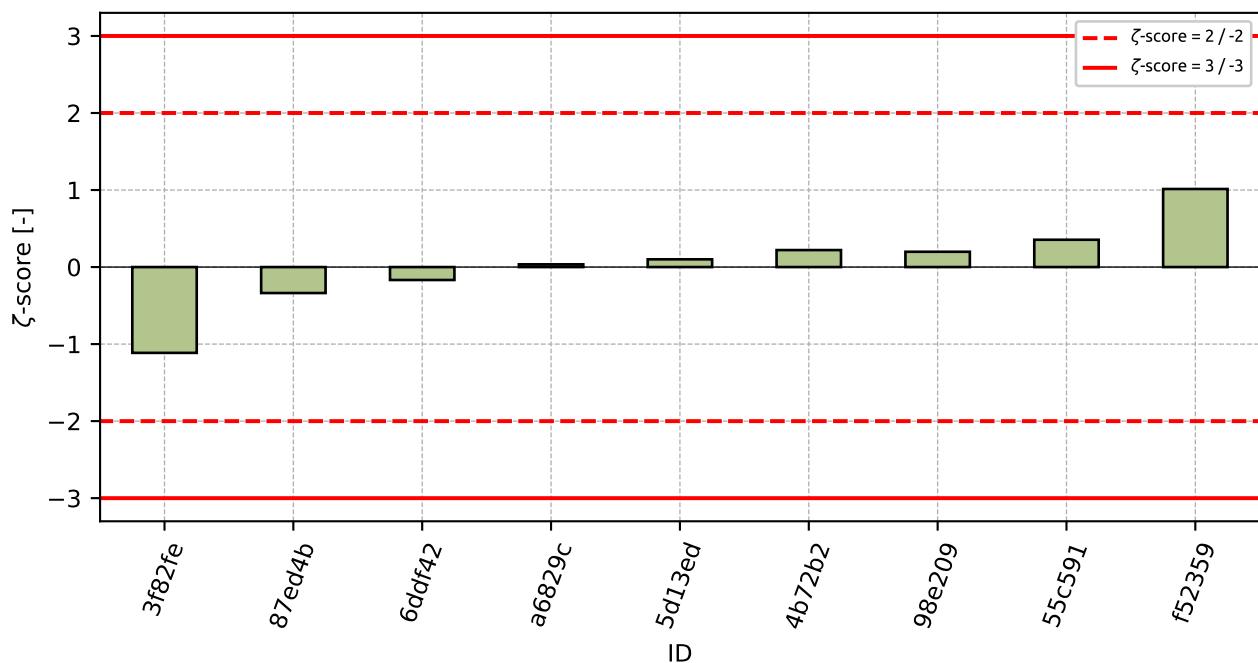
Figure 18: ζ-score

Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
3f82fe	-2.19	-1.11
87ed4b	-0.46	-0.34
6ddf42	-0.21	-0.17
a6829c	0.08	0.04
5d13ed	0.13	0.1
4b72b2	0.29	0.22
98e209	0.31	0.2
55c591	0.45	0.35
f52359	1.59	1.01

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2.2   Fracture load per length unit

2.2.1   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 [N/mm]								u_X [N/mm]	$\bar{x}$ [N/mm]	s_0 [N/mm]	V_X [%]
3f82fe	720	590	570	540	560	460	460	660	106	570	89.6	15.72
87ed4b	650	700	650	720	710	710	690	670	34	688	27.6	4.02
6ddf42	790	688	727	672	650	758	746	692	10	715	47.5	6.64
55c591	630	710	680	730	840	870	670	660	18	724	86.8	12.0
5d13ed	780	760	680	720	600	660	830	820	0.3	731	81.0	11.07
98e209	800	710	840	760	750	760	610	640	70	734	77.4	10.56
a6829c	697	733	734	713	693	722	783	799	-	734	38.3	5.21
473c3c	690	730	740	700	780	760	760	770	-	741	32.7	4.41
4b72b2	747	817	792	670	691	758	697	767	30	742	51.9	6.99
f52359	690	910	920	810	890	830	750	870	70	834	81.1	9.72

2.2.2   The Numerical Procedure for Determining Outliers
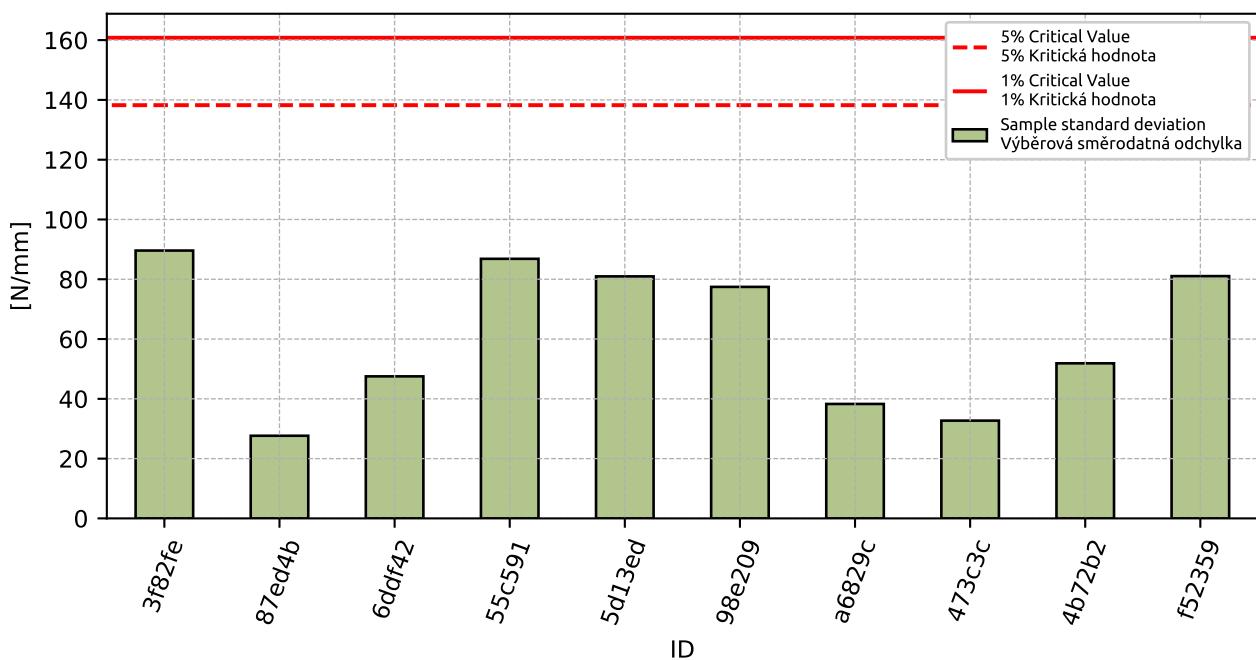
Figure 19: **Cochran's test** - sample standard deviations

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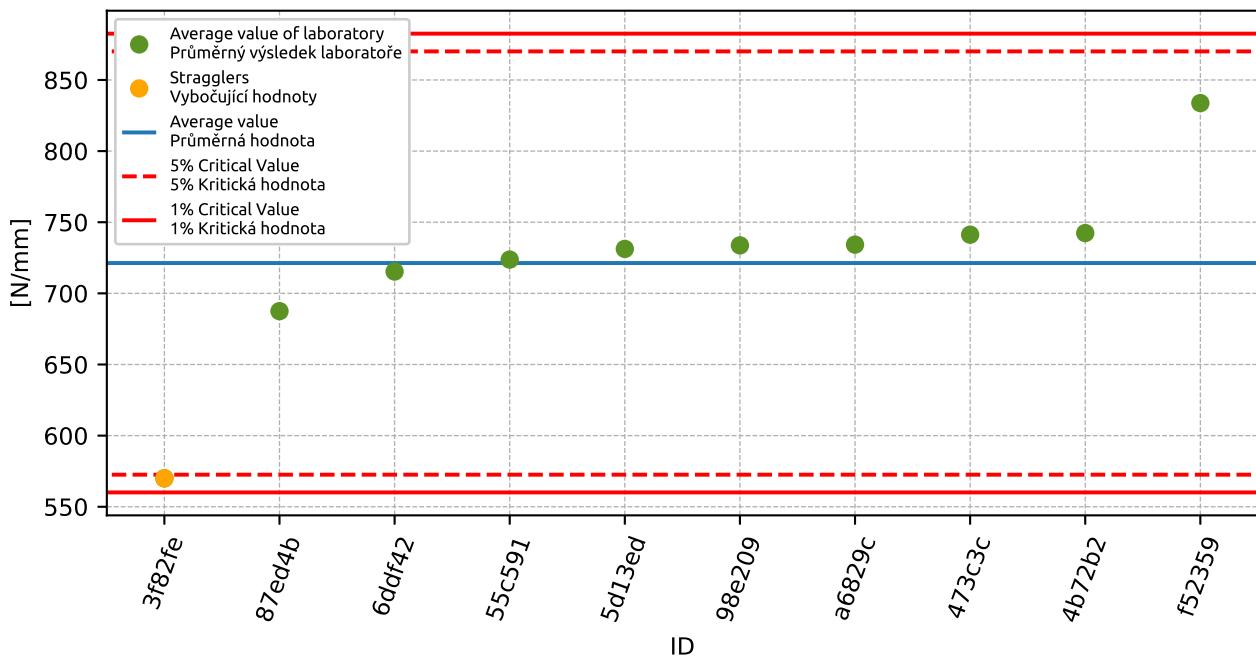
Figure 20: **Grubbs' test** - average values

2.2.3 Mandel's Statistics
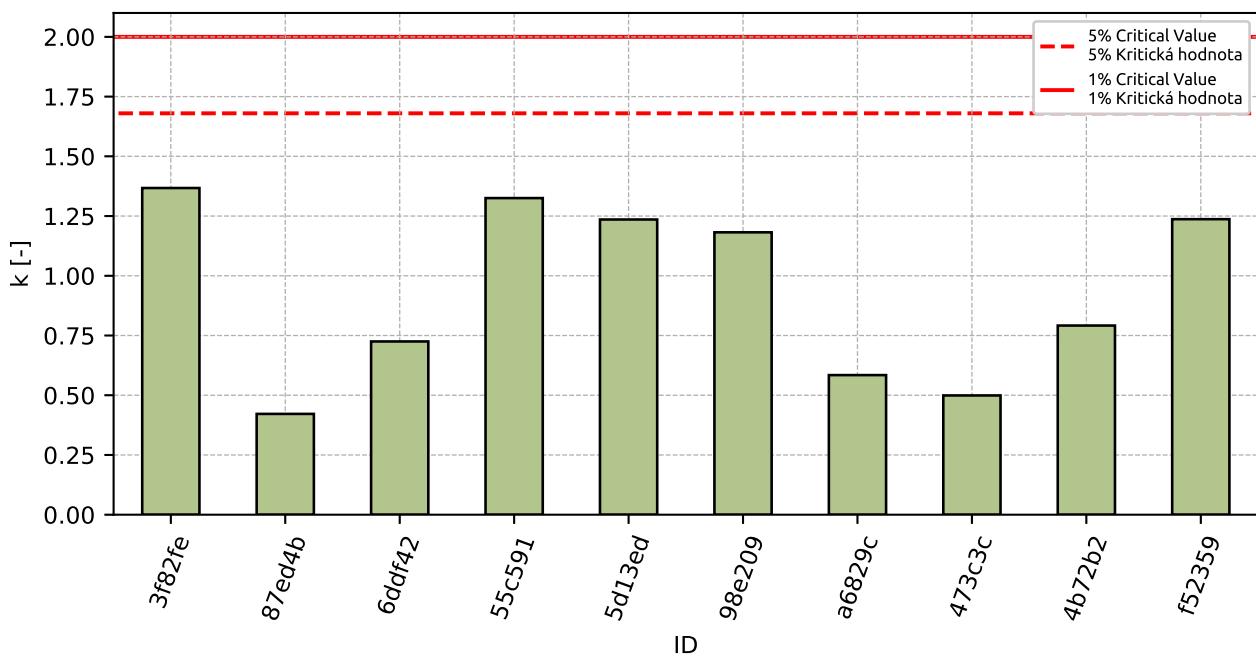
Figure 21: Intralaboratory Consistency Statistic

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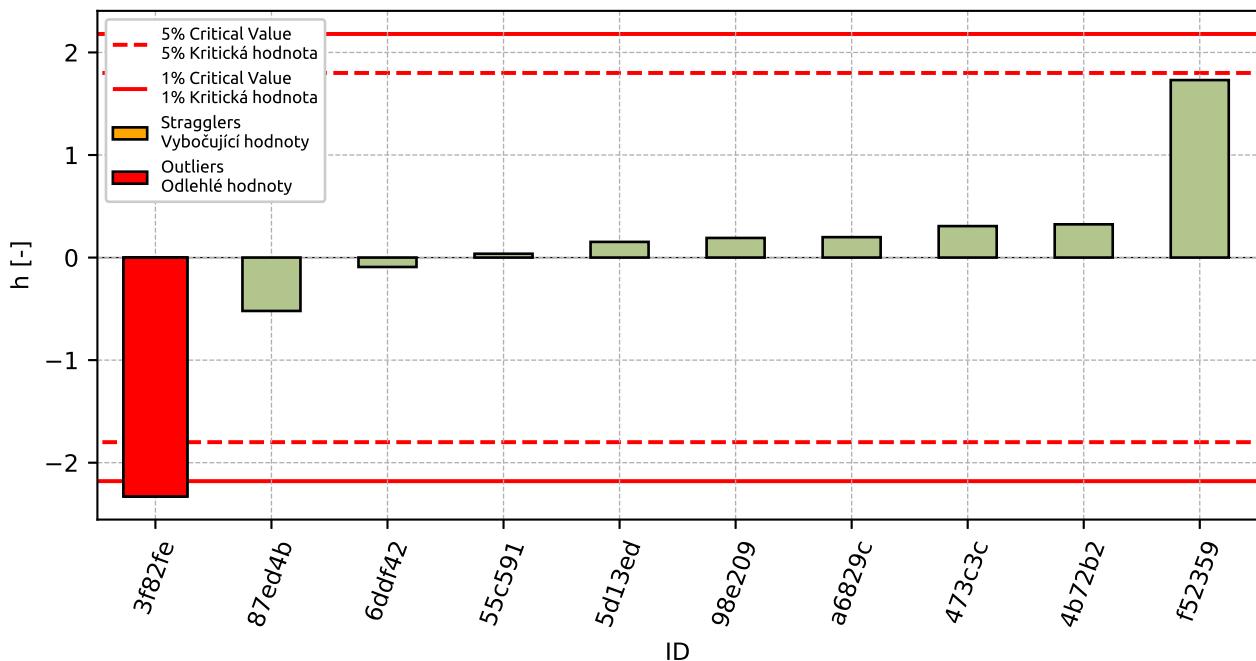
Figure 22: Interlaboratory Consistency Statistic

2.2.4 Descriptive statistics
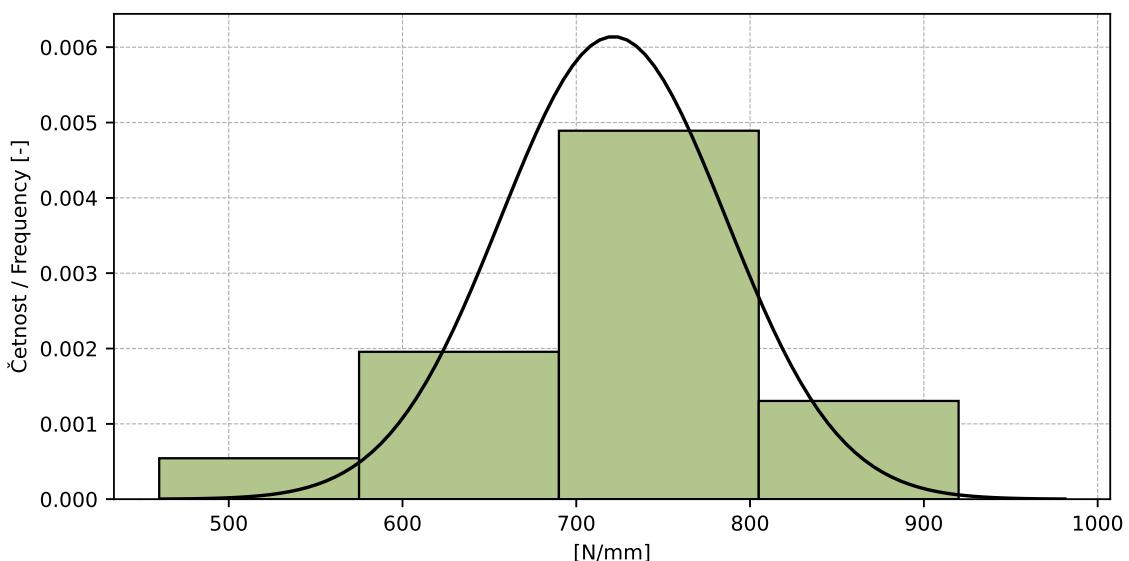
Figure 23: Histogram of all test results

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Table 11: Descriptive statistics

Characteristics	[N/mm]
Průměrná hodnota / Average value – $\bar{x}$	721.0
Výběrová směrodatná odchylka / Sample standard deviation – s	65.0
Vztažná hodnota / Asigned value – x^*	721.0
Robustní směrodatná odchylka / Robust standard deviation – s^*	65.0
Nejistota měření vztažné hodnoty / Measurement uncertainty of asigned value – u_X	8.1
p-hodnota testu normality / p-value of normality test	0.091 [-]
Mezilaboratorní sm. odch. / Interlaboratory standard deviation – s_L	60.7
Směrodatná odchylka opakovatelnosti / Repeatability standard deviation – s_r	65.5
Směrodatná odchylka reprodukovatelnosti / Reproducibility standard deviation – s_R	89.3
Opakovatelnost / Repeatability – r	183.0
Reprodukovatelnost / Reproducibility – R	250.0

2.2.5 Evaluation of Performance Statistics
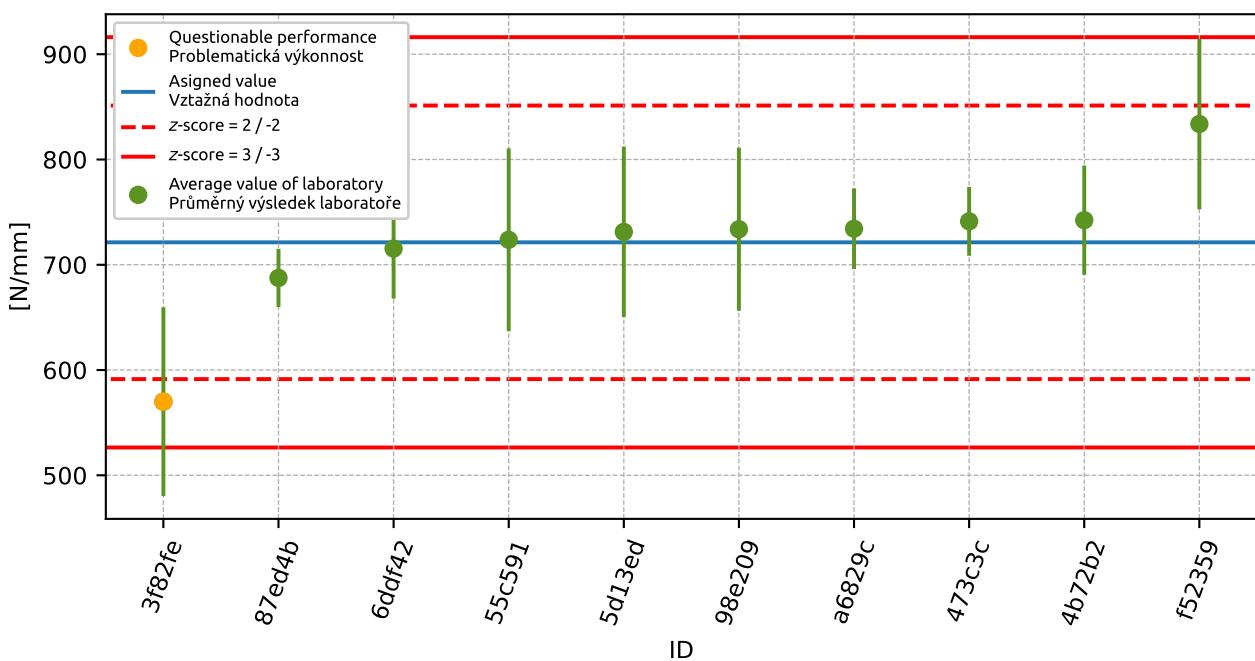
Figure 24: Average values and sample standard deviations

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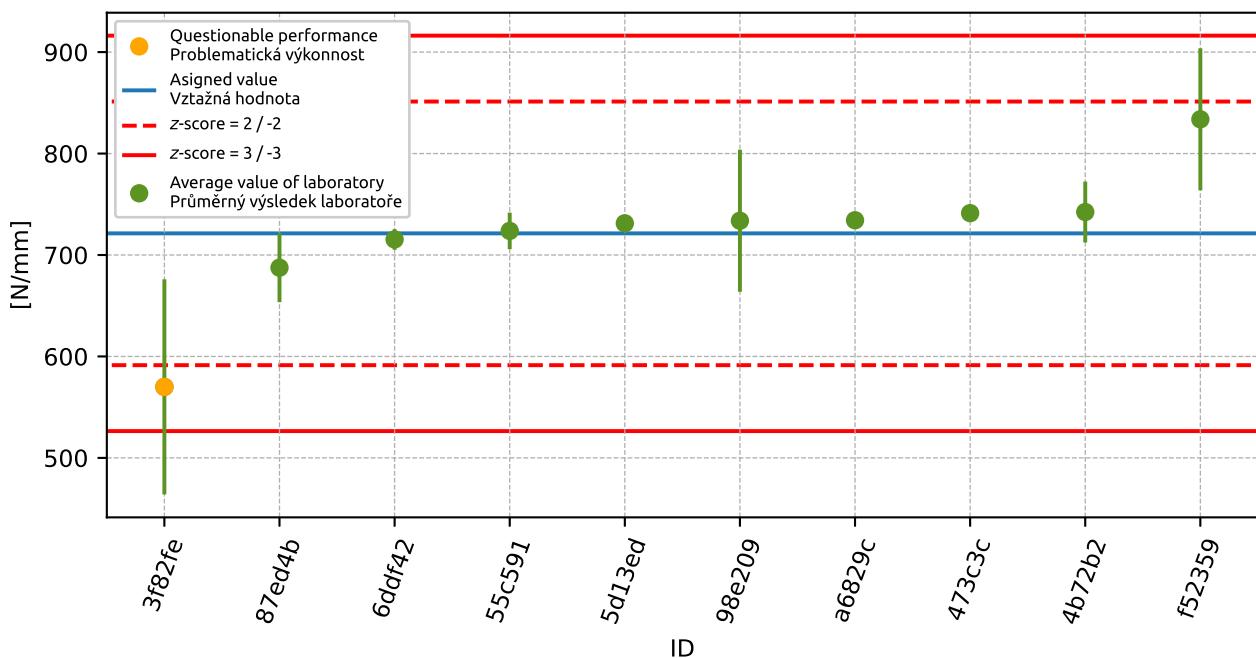
Figure 25: Average values and extended uncertainties of measurement

Figure 26: z-score

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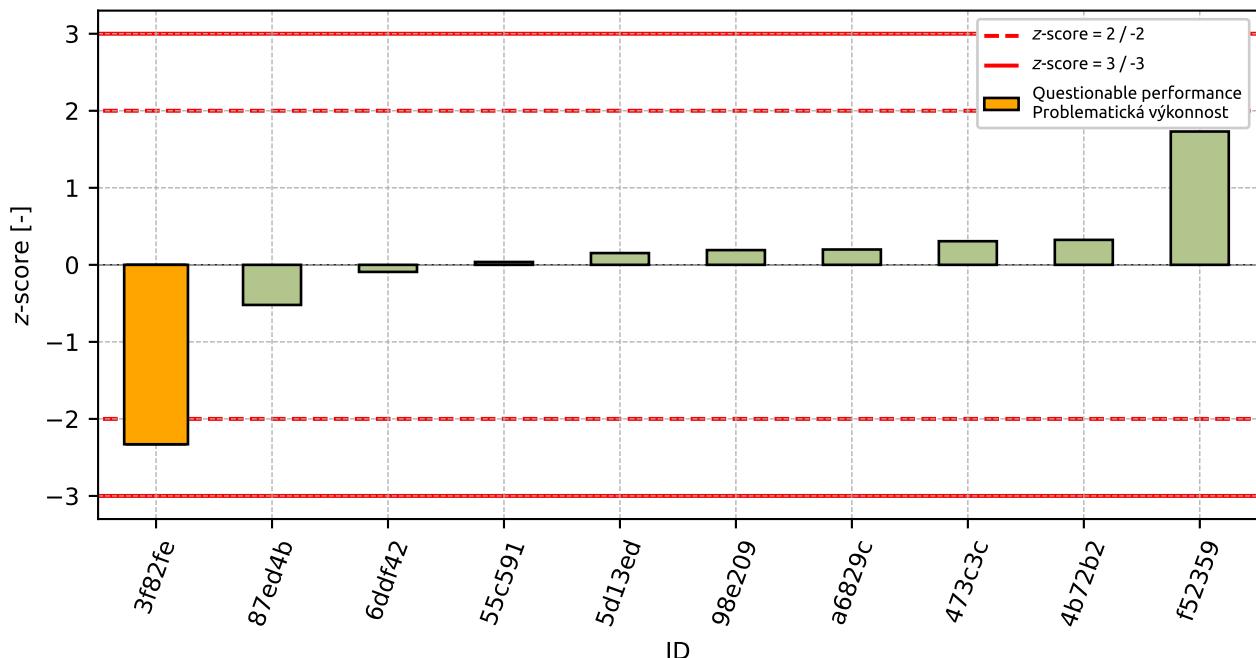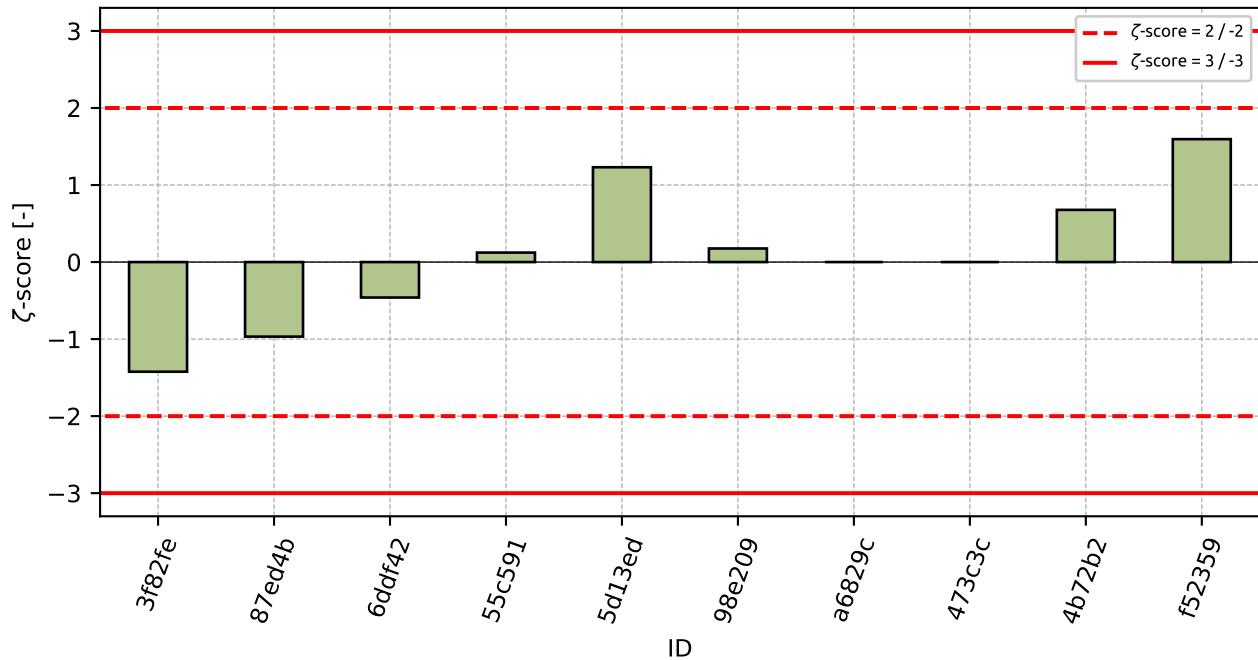
Figure 27: ζ-score

Table 12: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
3f82fe	-2.33	-1.42
87ed4b	-0.52	-0.97
6ddf42	-0.09	-0.46
55c591	0.04	0.12
5d13ed	0.15	1.23
98e209	0.19	0.18
a6829c	0.2	-
473c3c	0.31	-
4b72b2	0.32	0.68
f52359	1.73	1.6

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3   Appendix – EN 1338 – Annex G – Abrasion resistance

This part of the proficiency testing program was not open due to the low number of participants.

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