FINAL REPORT ON THE RESULTS OF INTERLABORATORY COMPARISON

PROFICIENCY TESTING PROGRAM
Aggregate Testing

ZK 2018/1
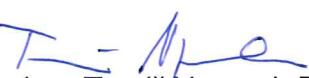
Date: 07/11/2018

Head of the PT Provider, PTP coordinator

Coordinator of PTP result assessment

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1 Introduction and Important Contacts

In the year 2018, the Proficiency Testing Provider at the SZK FAST (PT Provider) initiated the Proficiency Testing Program (PTP) designated ZK 2018/1 whose aim was to verify and assess the conformity of test results across laboratories when testing aggregate.

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 933-1 Determination of particle size distribution - Sieving method [1],

2. EN 933-3 Determination of particle shape - Flakiness index [2],

3. EN 933-4 Determination of particle shape - Shape index [3],

4. EN 933-5 Determinationm of percentage of crushed and broken surfaces in coarse aggregate particles [4],

5. EN 933-8 Assessment of fines - Sand equivalent test [5],

6. EN 933-9 Assessment of fines - Methylene blue test [6],

7. EN 933-10 Assessment of fines - Grading of filler aggregates (air jet sieving) [7],

8. EN 1097-1 Determination of the resistance to wear (micro-Deval) [8],

9. EN 1097-2 Methods for the determination of resistance to fragmentation - chapter 5 [9],

10. EN 1097-2 Methods for the determination of resistance to fragmentation - chapter 6 [9],

11. EN 1097-3 Determination of loose bulk density and voids [10],

12. EN 1097-5 Determination of the water content by drying in a ventilated oven [11],

13. EN 1097-6 Determination of particle density and water absorption [12],

14. EN 1097-7 Determination of the particle density of filer - Pyknometer method [13],

15. EN 1367-1 Determination of resistance to freezing and thawing [14],

16. EN 1367-2 Magnesium sulfate test [15],

17. EN 1367-3 Boiling test for "Sonnenbrand basalt" [16],

18. TP 137 - Příloha 1 a 2 – Reaktivnost kameniva s alkáliemi [17],

19. ČSN 72 1179 Determination of reactivity of aggregates in connection with alkalies – chapter B [18].

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Testing procedures No 6 to 10, 14 and 16 to 19 were not open according to the low number of participants.

The supplier, BETOTECH s. r. o. (L 1195.3), was responsible for the preparation of testing samples for the PTP. The supplier is responsible for homogeneity and stability of testing samples.

The specimens were taken from the same production with the same production date. The test results from individual PTP participants were compared via a method involving the statistical analysis of all their results in a manner complying with ISO 5725-2 [19] and with EN ISO/IEC 17043 [20]. The outcome is the present final report summarizing the results of the interlaboratory comparison, including statistical evaluation.

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

Table 1: Participation of individual laboratories in the PTP (tests designated according to part 1)

ID/Method	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0778f4	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121344	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
1443ba	-	X	-	-	-	-	-	-	-	-	-	X	X	-	X	-	-	-	-
14b449	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2077a5	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
325ba1	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37d6bc	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-
3e47f1	-	X	-	X	-	X	-	-	X	-	-	-	-	-	X	-	-	-	-
411d95	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
445a7b	X	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-
485eb2	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4b35f8	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
62f065	X	X	X	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
632be0	X	X	-	X	-	X	-	-	X	-	-	X	X	-	X	-	-	-	-
7fa70f	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86e058	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8a9bec	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
932f3a	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
9e18fc	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
a10c83	-	X	-	-	-	-	-	-	-	-	-	X	X	-	X	-	-	-	-
a2ea36	X	X	-	-	-	X	-	-	X	-	-	X	X	-	X	-	-	-	-
b98db3	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
bb7b5b	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c02c42	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
c44a23	-	-	-	X	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-
ccf1c0	X	X	X	X	-	X	-	-	-	-	-	X	X	-	X	-	-	-	-
ce7b10	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
d2f98b	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
df8ce3	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
f66ebc	X	-	X	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-
f90120	-	X	-	-	-	-	-	-	-	-	-	X	X	-	X	-	-	-	-

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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
BAS International Holding B.V.	Olivier van Noortweg,, 10, Venlo, 5928LX, Netherlands	
BEST, a.s.	Lučice 87, Chlumec nad Cidlinou, 50351, Česká republika	
BETOTECH, s.r.o., divize kamenivo	Gajdošova 4316/37, 615 00 Brno	1195.3
BETOTECH, s.r.o., zkušební laboratoř Ostrava	Beroun 660, BEROUN 2, 266 01, Česká republika	1195.2
CRH (Slovensko) a.s.	Rohožník, Rohožník, 90638, Slovensko	426/S-313
CTC Krepost	Asphalt plant Strabag, municipality Dimitrovgrad, area Haskovo, Krepost, 11111, Bulgaria	
DI Shahrokh Winter	Gewerbeparkstraße 5, Markgrafneusiedl, A-2282, Österraich	
Disoma	Krommewege 31, Maldegem, 9080, Belgium	
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2014
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft. - Győr	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2014
ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft. - Veszprém	Pf. 180., Szentendre, 2001, Hungary	NAH-1-1110/2014
Eurofins Environment Testing AS, Bergen	Sandviksveien 110, P. boks Måseskjæret 75, Bergen, N-5841, Norway	
Gradezen Institut " Makedonija " AD Skopje (Civil Engineering Institute " Makedonija " J.S. Skopje)	Drezdenska No 52, Skopje, 1000, Makedonija	LT-014
LABORATORUL DE ANALIZE SI INCERCARI IN CONSTRUCTII	Str. Sîngerului, nr. 11, sector 1,, Bucharest, 014617, Romania	
PI Institute for Urbanism, Civil Engineering and Ecology of Republic of Srpska	Save Mrkalja 16, Banja Luka, 78000, BiH	LI-79-01
QUALIFORM SLOVAKIA s.r.o. - organizační složka, Pracovisko 04 Děčín	Lesní 693, Bílovice nad Svitavou, 664 01, Česká republika	154/S-301
QUALIFORM SLOVAKIA s.r.o., Pracovisko 02 Svit	Pasienková 9 D, Bratislava, 82106, Slovenská republika	154/S-301
QUALIFORM, a.s.	Mlaty 672/8, Brno - Bosonohy, 64200, Česká republika	1008
Rudarski institut d.d. Tuzla	Rudarska 72, Tuzla, 75000, Bosna i Hercegovina	LI-47-01
STACHEMA Bratislava a.s., Skúšobné laboratórium STACHEMA	Rovinka 411, Rovinka, 900 41, Slovenská republika	S-275
Technický a zkušební ústav stavební Praha s.p.	Hněvkovského 77, Brno, 617 00, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p.	U Studia 14, Ostrava - Zábřeh, 700 30, Česká republika	1018.7
Technický a zkušební ústav stavební Praha, s.p. – pobočka Teplice	Tolstého 447, Teplice, 415 03, Česká republika	040 - Teplice
Technický a zkušební ústav stavební Praha, s.p., pobočka Praha	Prosecká 76a/811, Praha 9, 190 00, Česká republika	1018.3

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Laboratory	Address	Accreditation number
Technický a zkušební ústav stavební Praha, s.p., Prosecká 811/76a, 190 00 Praha 9 - Prosek	Zahradní 15, Plzeň, 326 00, Česká republika	1018.3
TPA spoločnosť pre zabezpečenie kvality a inovácie s.r.o - pracovisko Podunajské Biskupice	Neresnícka cesta 3, Zvolen, 960 01, SLOVENSKO	211/S-176
TPA spoločnosť pre zabezpečenie kvality a inovácie s.r.o - pracovisko Zvolen	Neresnícka cesta 3, Zvolen, 960 01, SLOVENSKO	211/S-176
TZÚS Praha, s.p. - pobočka České Budějovice	Nemanická 441, České Budějovice, 37010, Česká republika	1018.3
UNIGEO a.s., Středisko laboratoře mechaniky zemin	Místecká329/258, Ostrava-Hrabová, 720 00, Česká republika	1412
Vysoká škola báňská - Technická univerzita Ostrava, Zkušební laboratoře výzkumného centra hornin	17. listopadu 15/2172, Ostrava – Poruba, 708 33, Česká republika	1166.4
Zdravotní ústav se sídlem v Ústí nad Labem	Moskevská 15, Ústí nad Labem, 400 01, Česká republika	1388

2 Procedures used in the Statistical Analysis of Laboratory Results

To describe the accuracy of measuring methods, the terms trueness and precision are used. Trueness refers to the closeness to congruity between the arithmetic mean of a high number of test results and a real or accepted reference value. Precision means the closeness to congruity between test results. The necessity to consider precision is based on the fact that tests generally do not yield the same results even though they are supposed to be carried out on the same material and under the same conditions. This is caused by accidental errors that are impossible to avoid. These errors represent an integral part of every testing procedure and we are unable to control them fully. The comparative analysis of laboratory data does not focus on assessing the trueness of test results, but first and foremost on their precision. Results are thus compared with one another and not with any reference value or real value.

The basis of the statistical analysis is a critical data assessment complying with ISO 5725-2 [19], i.e. the determination of dubious and outlying values, and other irregularities. This assessment is carried out using mainly Grubbs' and Cochran's tests (numerical evaluation) as well as Mandel's statistics (graphical evaluation). Other observed statistical parameters are interlaboratory dispersion, repeatability dispersion, reproducibility dispersion and related characteristics of repeatability and reproducibility. The outcome of PTP is to assess the performance of participating laboratories in compliance with EN ISO/IEC 17043 [20], consisting of the determination of relative values and their uncertainties and a final comparison with the test results of PTP participants.

A prerequisite for using these methods is the unimodal probability distribution of measured data. Furthermore, p will stand for the number of participating laboratories marked by the index A prerequisite for using these methods is the unimodal probability distribution of measured data. Furthermore, p will stand for the number of participating laboratories marked by the index $i = 1, ..., p$, each of which carried out n number of tests., each of which carried out n number of tests.

2.1 The Numerical Procedure for Determining Outliers

To determine outliers, two basic statistical tests are used. One of them is Cochran's C test, which tests interlaboratory variabilities (in cases when the number of measurements of one quantity in one laboratory > 2) and is used first. If this test marks one participant's results as outlying, the laboratory is excluded and the test repeated. The second test (Grubbs' test) is first and foremost a test of interlaboratory variability and we can also employ it if Cochran's test raises the suspicion that only one of the test results is to blame for the high interlaboratory dispersion. Both tests assume a balanced experiment, i.e. the number of tests at one laboratory for the determination of one quantity must be constant.

When determining divergent or outlying values, three situations can occur:

- If the test statistic is within or equal to 5% of the critical value, the tested entity is considered to be *correct*;

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- If the test statistic diverges from the critical value by more than 5%, but is within or equal to 1% of the critical value, the tested entity is considered to be *divergent*;

- If the test statistic diverges from the critical value by more than 1%, the tested entity is considered to be *outlying*.

2.1.1 Cochran's test

The Cochran's C statistic is given by the equation:

$$C = \frac{s_{max}^2}{\sum_{i=1}^{P} s_i^2} \tag{1}$$

where s_{max} is the highest sample standard deviation, s_i are sample standard deviations determined according to the results from all laboratories and p means the number of laboratories participating in the PT program.

The sample standard deviation is determined from the equation

$$s_i = \sqrt{\frac{1}{n_i - 1} \sum_{k=1}^{n_i} (y_k - \bar{y})^2}, \tag{2}$$

where n_i is the number of test results from the determination of one quantity in i-th laboratory, y_k is the k-th value and $\bar{y}_i$ is the average value measured in the i-th laboratory. If only two results were measured for the relevant quantity, we can use the simplified equation:

$$s_i = \frac{|y_1 - y_2|}{\sqrt{2}}. \tag{3}$$

2.1.2 Grubbs' test – One Outlying Observation

From the given set of x_i data for $i = 1, 2, ..., p$, ordered upward according to size, Grubbs' statistic G_p is calculated in order to use Grubbs' test to determine whether the largest observation is an outlier:

$$G_p = \frac{x_p - \bar{x}}{s}, \tag{4}$$

whereby $\bar{x}$ is the arithmetic mean of the observed feature. The observed feature can be the average value of the quantity determined within the laboratory. Furthermore, s is a sample standard deviation of the observed feature, which in this case is a standard deviation calculated for all the laboratories.

For significance testing of the smallest observation the test statistic is calculated:

$$G_p = \frac{\bar{x} - x_p}{s}. \tag{5}$$

2.2 Mandel's Statistics

In order to determine data consistency, two values called Mandel's h and k statistics were used. These indicators are commonly used for the graphical evaluation of laboratories in a similar way to a description of variability.

2.2.1 Interlaboratory Consistency Statistic h

For each laboratory, the interlaboratory consistency statistic h was evaluated according to the formula

$$h_i = \frac{\bar{y}_i - \bar{\bar{y}}}{\sqrt{\frac{1}{p-1} \sum_{i=1}^{p_j} (\bar{y}_i - \bar{\bar{y}})}}, \tag{6}$$

where $\bar{y}_i$ is the average value for the i-th laboratory, $\bar{\bar{y}}$ is the arithmetic mean of all values and p is the number of laboratories. The values of the h_i statistics were plotted on graphs.

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2.2.2 Intralaboratory Consistency Statistic k

The intralaboratory consistency statistic k is calculated from the equation

$$k_i = \frac{s_i \sqrt{p}}{\sqrt{\sum_{i=1}^{p} s_i^2}}, \tag{7}$$

where s_i is a sample standard deviation of values measured at the i-th laboratory. Just as with h statistics, the k values are plotted on graphs.

Study of the graphs displaying h and k values may indicate that certain laboratories show a significantly different ordering of results than other studied laboratories. This is caused by a permanently large and/or permanently small dispersion of results or extreme averages of results across all levels.

2.3 Calculation of Variances Estimates

After the elimination of outliers (of laboratories), we can proceed to the calculation of basic variability characteristics, i.e. repeatability dispersion, interlaboratory dispersion and reproducibility dispersion. These characteristics are stated in the form of standard deviations, i.e. after extracting the root. It is advantageous when the variability characteristics and the observed quantity are of the same physical dimensions.

2.3.1 Repeatability Variance

$$s_r^2 = \frac{\sum_{i=1}^{p}(n_i - 1)s_i^2}{\sum_{i=1}^{p}(n_i - 1)} \tag{8}$$

2.3.2 Interlaboratory Variance

$$s_L^2 = \frac{s_d^2 - s_r^2}{\bar{\bar{n}}}, \tag{9}$$

where

$$s_d^2 = \frac{1}{p-1} \sum_{i=1}^{p} n_i \left(\bar{y}_i - \bar{\bar{y}}\right)^2 \tag{10}$$

and

$$\bar{\bar{n}} = \frac{1}{p-1} \left[\sum_{i=1}^{p} n_i - \frac{\sum_{i=1}^{p} n_i^2}{\sum_{i=1}^{p} n_i}\right]. \tag{11}$$

2.3.3 Reproducibility Variance

$$s_R^2 = s_r^2 + s_L^2, \tag{12}$$

where s_r^2 is repeatability variance and s_l^2 is interlaboratory variance.

2.4 Repeatability and Reproducibility

Repeatability expresses the fact that the difference between two test results from the same sample from tests carried out by the same person at the same facility and within the shortest time interval possible will not exceed the repeatability value r on average more than once in 20 cases if the method is employed in the common and correct manner.

The repeatability value is expressed by the relation

$$r = 2,8 s_r, \tag{13}$$

where $s_r = \sqrt{s_r^2}$ stands for the standard deviation of repeatability.

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Reproducibility expresses the fact that the reproducibility value R for test results from one sample obtained in the shortest time interval possible by two persons who used their own devices will not differ on average more than once in 20 cases if the method is employed in the common and correct manner.

The reproducibility value is expressed by the relation

$$R = 2,8s_R,\tag{14}$$

where $s_R = \sqrt{s_R^2}$ stands for the standard deviation of reproducibility.

2.5 Assigned Values

The PT Provider will ensure the determination of assigned value X and its uncertainty for every PTP. Assigned values are always only imparted to PTP participants after they have submitted their PTP results so that they cannot obtain any benefit from the premature revelation of the values.

The assigned values are determined by the PT Provider as consensual values derived from the results of participants in compliance with Appendix B of EN ISO/IEC 17043 [20] using the statistical methods described in ISO 13528 [21] and ISO 5725-5 [22]. The assigned value X is therefore determined as a robust estimate of the average value x^* (the A algorithm mentioned in [21] and [22]):

Initial values x^* and s^* (robust standard deviation) are calculated as

$$x^* = \text{median } x_i,\tag{15}$$

$$s^* = 1,483 \cdot \text{median} \left| x_i - x^* \right|,\tag{16}$$

where $i = 1, \dots, p$. The values of x^* and s^* are then processed as follows. First, $\varphi = 1,5 \cdot s^*$ is computed. For every x_i $(i = 1, \dots, p)$ value, the following is calculated

$$x_i^* = \begin{cases} x^* - \varphi & \text{if } x_i < x^* - \varphi, \\ x^* + \varphi & \text{if } x_i > x^* + \varphi, \\ x_i & \text{in other cases.} \end{cases}\tag{17}$$

New values of x^* and s^* are calculated from the following equations

$$x^* = \sum_{i=1}^{p} \frac{x_i^*}{p},\tag{18}$$

$$s^* = 1,134 \cdot \sqrt{\sum_{i=1}^{p} \frac{(x_i^* - x^*)^2}{p - 1}}.\tag{19}$$

Robust estimates are derived by iteration until the estimate changes between calculations become small.

The standard uncertainty u_X of an assigned value determined in this manner is calculated from the relation

$$u_X = 1,25 \cdot \frac{s^*}{\sqrt{p}}.\tag{20}$$

In the case of a small number of PTP participants, the PT Provider sets the assigned values as consensual values obtained from expert participants who have proven their competence to determine the measured quantity that is the subject of testing.

Furthermore, if the number of participants is small $(4\ p\ 20)$, the PT Provider can consider determining the relative values by using what is called **Horn's method**. This method consists in the determination of so-called pivots used as a basis for estimating location and variability. First, the assessed data are ordered upwards. The low pivot is then determined from the equation

$$x_D = x_{(H)},\tag{21}$$

where H is an ordinal index given by the equation $H = \frac{\text{int}\left(\frac{p+1}{2}\right)}{2}$ or $H = \frac{\text{int}\left(\frac{p+1}{2}+1\right)}{2}$.

The upper pivot is then determined from the equation

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$$x_H = x_{p+1-H}.$$ (22)

Using Horn's method, the assigned value is determined as a location estimate, i.e. as the so-called pivot half sum:

$$x^* = \frac{x_D + x_H}{2}.$$ (23)

The variability estimate is determined as the so-called pivot range

$$R_L = x_H - x_D$$ (24)

and the uncertainty of an assigned value calculated in this way is determined as a 95% interval estimate of the mean value

$$u_X = R_L \cdot t_{L;0,95}(p),$$ (25)

where $t_{L;0,95}(p)$ is the $(1 - \alpha)$ quantile of the T_L probability distribution with p degrees of freedom.

2.6 Calculation of Performance Statistics

Proficiency test results often need to be transformed into performance statistics in order to aid interpretation and to allow comparison with defined objectives. The aim is to express the divergence from the assigned value in a way that enables its comparison with performance criteria. In compliance with the EN ISO/IEC 17043 standard [20], the performance of participating laboratories is evaluated according to the so-called z-score and ζ-score (zeta-score).

For every non-outlying laboratory (participant), the z-score is calculated according to the equation

$$z_i = \frac{|\bar{x}_i - x^*|}{s^*}.$$ (26)

ζ-score is calculated using the equation

$$\zeta_i = \frac{|\bar{x}_i - x^*|}{\sqrt{u_i^2 + u_X^2}},$$ (27)

where u_i is a combined standard uncertainty of the i-th laboratory. Combined standard measurement uncertainties can be arrived at by dividing the extended uncertainty U by the extension coefficient k, which for normal probability division has the value $k = 2$. If the participant does not state the extended measurement uncertainty in their test result protocol, it is impossible to determine the ζ-score. For more about measurement uncertainties see document [23].

The following scales are applied for the z-score and ζ-score (to simplify the matter, only the z-score is shown):

$$z\text{-score} = \begin{cases} |z| \leq 2 & \text{shows that the laboratory performance is } \textbf{satisfactory} \text{ and generates no signal;} \\ 2 \leq |z| \leq 3 & \text{shows that the laboratory performance is } \textbf{questionable} \text{ and generates an action signal;} \\ 3 \leq |z| & \text{shows that the laboratory performance is } \textbf{unsatisfactory} \text{ and generates an action signal.} \end{cases}$$ (28)

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3 Conclusions of the Statistical Analysis

The present report summarizes the results of the Proficiency Testing Program ZK 2018/1 (PT Program) organized by the PT Provider at the SZK FAST, Brno University of Technology. 31 participants (laboratories) took part in the PT Program. PT program focused on ordinary standardized testing of aggregates. The test results are evaluated separately for each testing procedure examined. An evaluation of statistical characteristics is included in the Appendix, as well as test results and graphic presentations.

The most significant outcome of the PT Program is the so-called z-score and ζ-score (zeta-score).These characteristics assess the performance of individual participants by comparing it with the assigned value and measurement uncertainties. The assigned value and its uncertainty were determined according to the procedures stated in the section 2.6. z-score and ζ-score are compared with limit values (see part 2.6). The resulting ζ-score values are not taken into account during the final evaluation of the performance of participants as they are to a considerable degree dependent on the values of the measurement uncertainties of the assessed institutions.

3.1 EN 933-1 Determination of particle size distribution - Sieving method

The test results were evaluated as multilevel experiment according to the sieve size: 4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm and 0.063 mm. The outliers elimination and evaluation of statistical characteristics were carried out in every level of experiment. The test results are shown together with graphic presentation and evaluated statistical characteristics in part 1 of the Appendix. The test results were rated as outlying, questionable or unsatisfactory only if the limit values were exceeded in two levels at least.

The numerical critical evaluation of the test results using Grubbs' test has shown that results of participant No. **bb7b5b** exceeded the 1% critical value. The test result of this participant were **excluded as outlying**. After removal the critical values of Grubbs' test were no longer exceeded.

Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies. None of the other participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13528 [21]). The limit value z-score $= 3$ was exceeded in the case of participant No **ccf1c0**. The performance of this participant was rated as **unsatisfactory**. The limit value z-score $= 2$ was exceeded in the case of participants No **325ba1** and **86e058**. The performance of these participants was rated as **questionable**. The results of all other participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.2 EN 933-3 Determination of particle shape - Flakiness index

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

The numerical critical evaluation of the test results using Cochran's test has shown that results of participant No. ccf1c0 exceeded the 5% critical value. A more detailed analysis has revealed that the outlying variability of these participants was caused by two test result only; after its removal the critical values of Cochran's test were no longer exceeded. Participant No. ccf1c0 was not therefore excluded. Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the Horn's method . The limit value z-score $= 2$ was exceeded in the case of participant No **ccf1c0**. The performance of this participant was rated as **questionable**. The results of all other participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.3 EN 933-4 Determination of particle shape - Shape index

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

The numerical critical evaluation of the test results using Cochran's test has shown that results of participant No. 0778f4 exceeded the 1% critical value. A more detailed analysis has revealed that the outlying variability of these

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participants was caused by two test result only; after its removal the critical values of Cochran's test were no longer exceeded. Participant No. 0778f4 was not therefore excluded.

Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13528 [21]). The results of all participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.4 EN 933-5 Determinationm of percentage of crushed and broken surfaces in coarse aggregate particles

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 4 of the Appendix.

The numerical critical evaluation of the test results using Cochran's and Grubbs' test has shown that results C_r characteristic of participant No. **3e47f1** exceeded the 1% critical values. The test result of this participant were **excluded as outlying**. After removal the critical values of Grubbs' test were no longer exceeded.

Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies. None of the other participants were therefore excluded.

The assigned value and its uncertainty was determined using the Horn's method. The results of all non outlying participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.5 EN 933-8 Assessment of fines - Sand equivalent test

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

3.6 EN 933-9 Assessment of fines - Methylene blue test

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 6 of the Appendix.

The numerical critical evaluation of the test results using Cochran's test has shown that results of participant No. 62f065 exceeded the 5% critical value. A more detailed analysis has revealed that the outlying variability of these participants was caused by two test result only; after its removal the critical values of Cochran's test were no longer exceeded. Participant No. 62f065 was not therefore excluded.

Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13528 [21]). The limit value z-score $= 2$ was exceeded in the case of participant No **632be0**. The performance of this participant was rated as **questionable**. The results of all other participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.7 EN 933-10 Assessment of fines - Grading of filler aggregates (air jet sieving)

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

3.8 EN 1097-1 Determination of the resistance to wear (micro-Deval)

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

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3.9 EN 1097-2 Methods for the determination of resistance to fragmentation - chapter 5

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 9 of the Appendix.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13528 [21]). The results of all participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.10 EN 1097-2 Methods for the determination of resistance to fragmentation - chapter 6

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

3.11 EN 1097-3 Determination of loose bulk density and voids

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

3.12 EN 1097-5 Determination of the water content by drying in a ventilated oven

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 12 of the Appendix.

Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13528 [21]). The results of all participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.13 EN 1097-6 Determination of particle density and water absorption

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 13 of the Appendix.

The numerical critical evaluation of the test results using Grubbs' test has shown that results of participant No. **a10c83** exceeded the 1% critical value. The test result of this participant were **excluded as outlying**. After removal the critical values of Grubbs' test were no longer exceeded.

Graphical determination of the consistency of laboratories (Mandel's statistics) has shown an exceedance of the critical value in the test results from some participants. The exceedance of the critical values of Mandel's statistics does not indicate that the results of the laboratories concerned are wrong; it only suggests minor inconsistencies. None of the participants were therefore excluded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13528 [21]). The results of all participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

3.14 EN 1097-7 Determination of the particle density of filer - Pyknometer method

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

3.15 EN 1367-1 Determination of resistance to freezing and thawing

The test results are shown together with graphic presentation and evaluated statistical characteristics in part 15 of the Appendix.

The numerical critical evaluation of the test results using Grubbs' test has shown that results of participant No. **37d6bc** exceeded the 1% critical value. The test result of this participant were **excluded as outlying**. After removal the critical values of Grubbs' test were no longer exceeded.

The assigned value and its uncertainty was determined using the A algorithm (ISO 13528 [21]). The results of all participants did not exceed the limit value of z-score $= 2$ and thus can be rated as **satisfactory**.

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3.16   EN 1367-2 Magnesium sulfate test

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

3.17   EN 1367-3 Boiling test for "Sonnenbrand basalt"

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

3.18   TP 137 - Příloha 1 a 2 – Reaktivnost kameniva s alkáliemi

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

3.19   ČSN 72 1179 Determination of reactivity of aggregates in connection with alkalies – chapter B

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

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1 Appendix – EN 933-1 Determination of particle size distribution - Sieving method

1.1 4 mm

1.1.1 Test results

Table 3: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
bb7b5b	95.1*	96.6	96.2	30.0	96.0	0.8	0.81
ccf1c0	97.0	97.0	97.0	2.0	97.0	0.0	0.00
df8ce3	97.5	97.7	97.7	1.0	97.6	0.1	0.12
0778f4	98.0	97.0	98.0	0.7	97.7	0.6	0.59
485eb2	98.0	97.0	98.0	1.0	97.7	0.6	0.59
325ba1	97.7	97.6	98.0	0.1	97.8	0.2	0.21
f66ebc	97.6	97.9	97.8	1.1	97.8	0.2	0.16
62f065	97.8	97.7	97.8	-	97.8	0.1	0.06
7fa70f	97.9	97.6	97.8	-	97.8	0.1	0.12
445a7b	98.2	98.0	97.6	-	97.9	0.3	0.31
86e058	98.1	97.8	98.0	-	98.0	0.2	0.16
2077a5	97.9	97.9	98.1	3.5	98.0	0.1	0.12
411d95	98.0	-	-	1.0	98.0	0.0	0.00
632be0	98.0	98.0	98.0	2.9	98.0	0.0	0.00
a2ea36	98.0	98.0	98.0	1.0	98.0	0.0	0.00
b98db3	98.2	98.0	98.3	-	98.2	0.2	0.16
8a9bec	98.2	98.2	98.2	98.2	98.2	0.0	0.00

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1.1.2 The Numerical Procedure for Determining Outliers

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

Figure 2: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color

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Figure 3: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

1.1.3 Mandel's Statistics
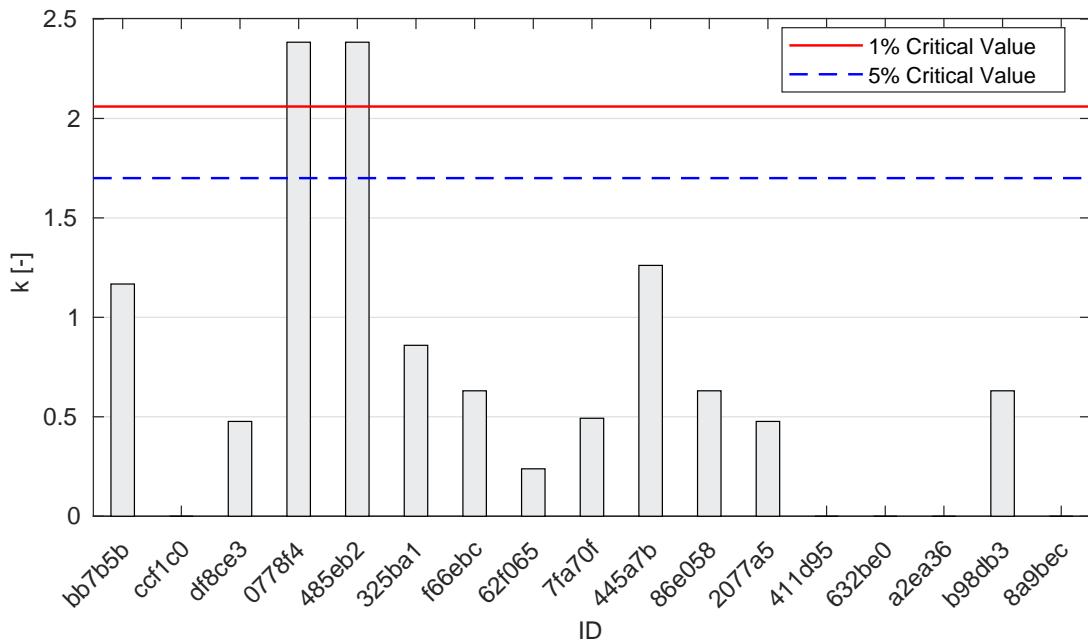
Figure 4: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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

1.1.4 Calculation of Performance Statistics
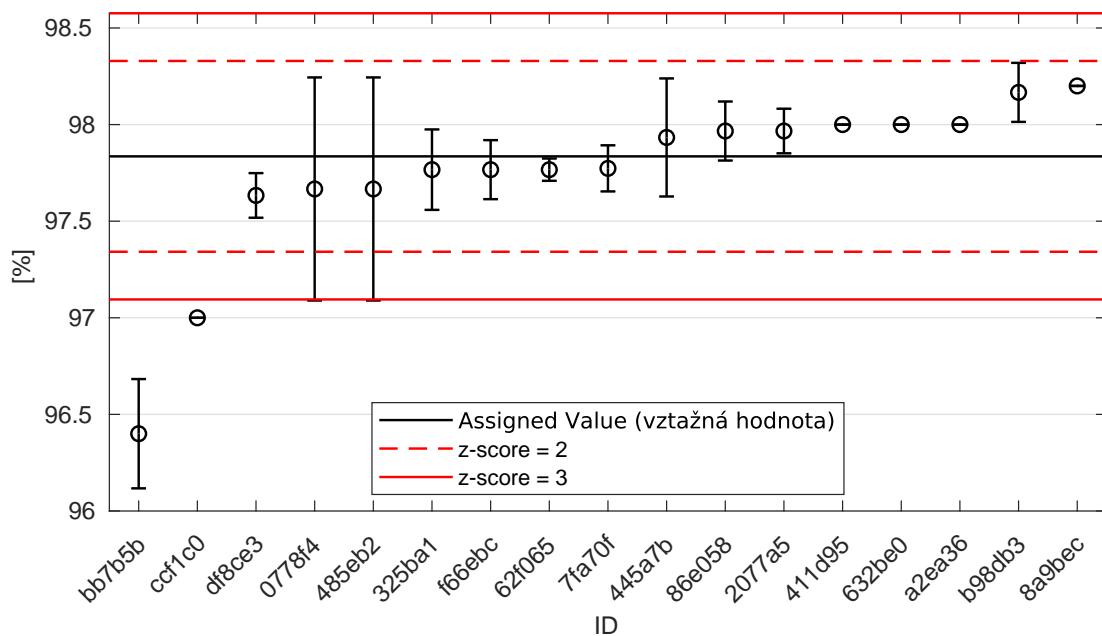
Figure 6: Average values and sample standard deviations

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Figure 7: Histogram of all test results

Figure 8: z-score and ζ-score

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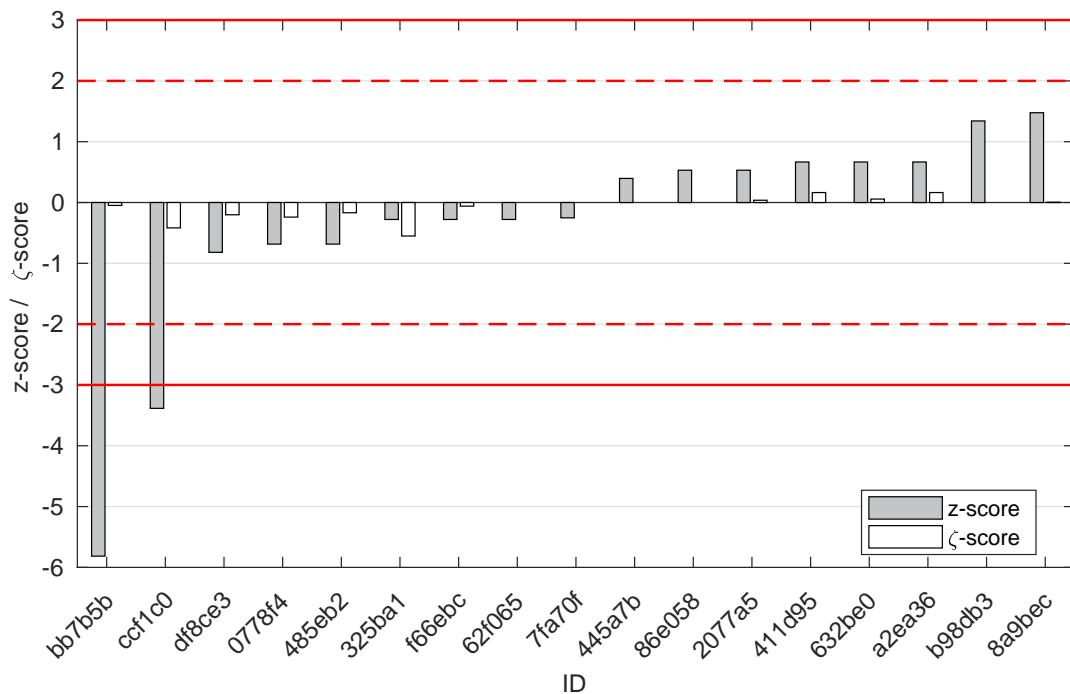
Table 4: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
bb7b5b	-5.82	-0.05
ccf1c0	-3.38	-0.42
df8ce3	-0.82	-0.20
0778f4	-0.68	-0.24
485eb2	-0.68	-0.17
325ba1	-0.28	-0.55
f66ebc	-0.28	-0.06
62f065	-0.28	-
7fa70f	-0.25	-
445a7b	0.40	-
86e058	0.53	-
2077a5	0.53	0.04
411d95	0.67	0.16
632be0	0.67	0.06
a2ea36	0.67	0.16
b98db3	1.34	-
8a9bec	1.48	0.00

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1.2   2 mm

1.2.1   Test results

Table 5: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
ccf1c0	81.0	84.0	82.0	2.0	82.3	1.5	1.86
bb7b5b	82.4	83.9	83.3	30.0	83.2	0.8	0.91
0778f4	87.0*	83.0	83.0	2.7	84.3	2.3	2.74
2077a5	84.0	84.4	84.8	3.5	84.4	0.4	0.47
7fa70f	85.1	84.8	83.5	-	84.5	0.8	1.00
445a7b	85.7	84.0	83.8	-	84.5	1.0	1.24
f66ebc	85.0	84.2	84.3	1.0	84.5	0.4	0.52
df8ce3	84.3	84.8	84.6	1.0	84.6	0.3	0.30
411d95	85.0	-	-	1.0	85.0	0.0	0.00
62f065	85.2	85.0	85.1	-	85.1	0.1	0.12
b98db3	85.3	85.1	85.1	-	85.2	0.1	0.14
8a9bec	85.2	85.2	85.2	85.2	85.2	0.0	0.00
485eb2	86.0	85.0	86.0	1.0	85.7	0.6	0.67
325ba1	87.2	85.4	85.3	0.1	86.0	1.1	1.24
632be0	86.0	86.0	86.0	2.1	86.0	0.0	0.00
a2ea36	87.0	86.0	86.0	1.0	86.3	0.6	0.67
86e058	86.1	86.8	86.6	-	86.5	0.4	0.42

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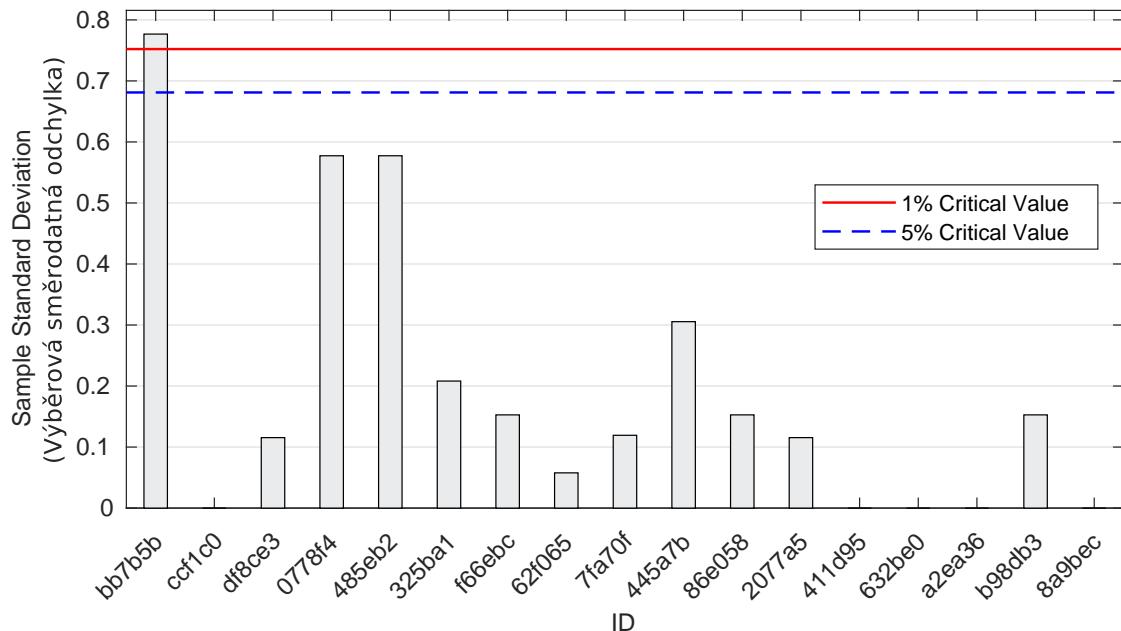### 1.2.2 The Numerical Procedure for Determining Outliers

Figure 9: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color
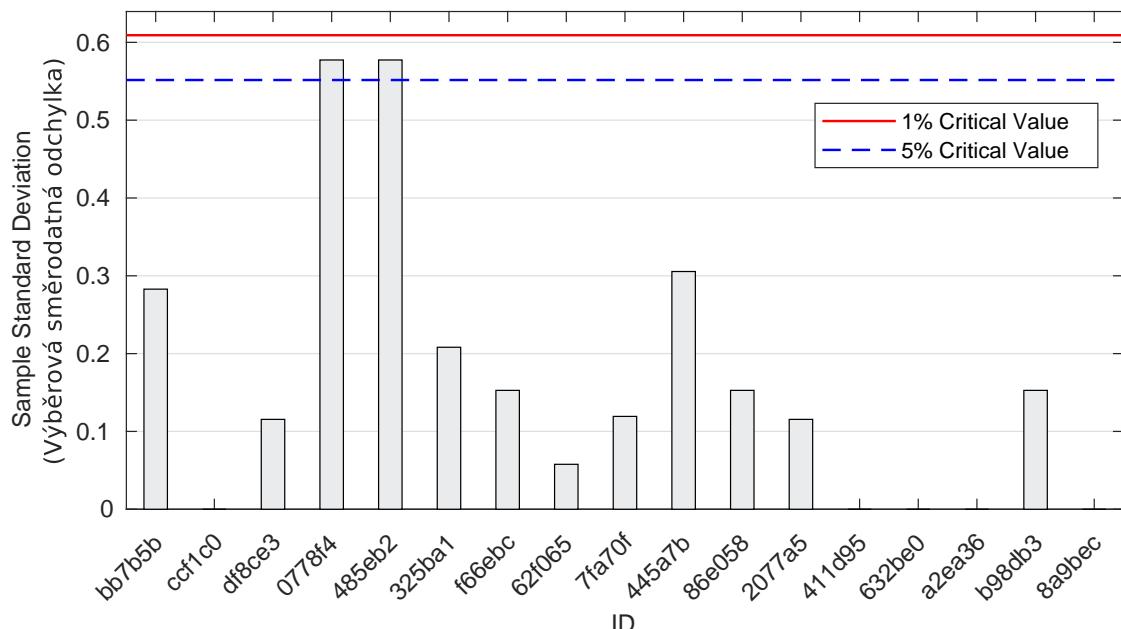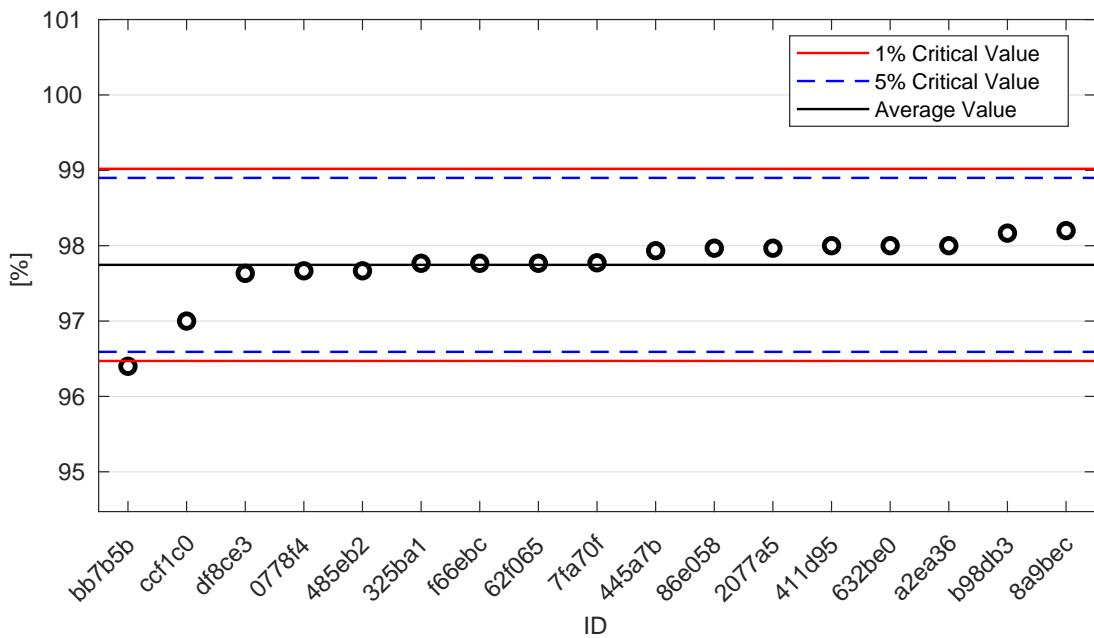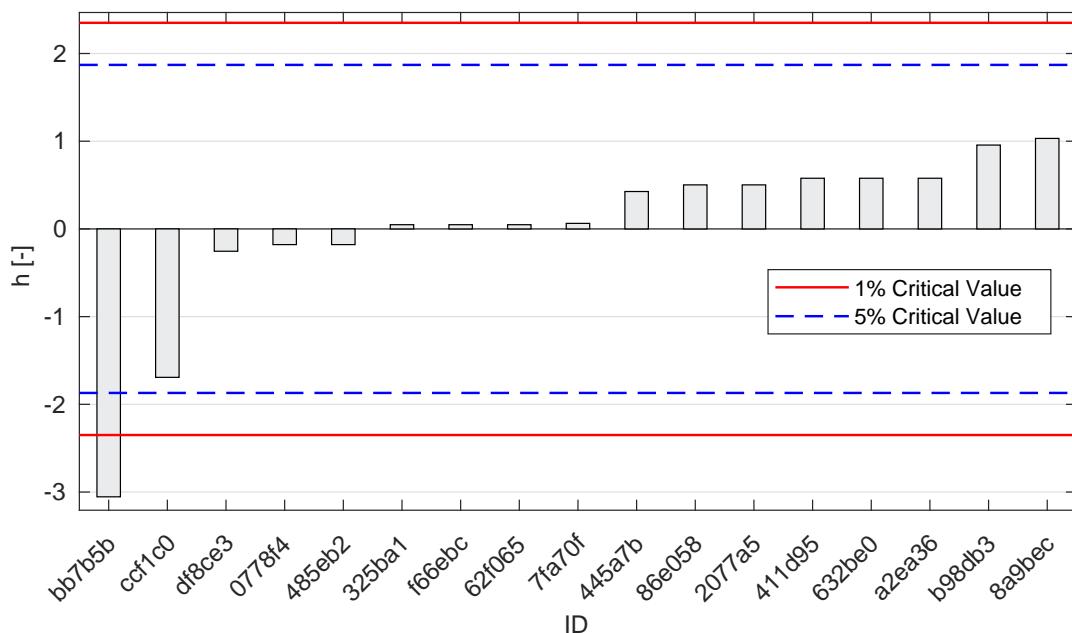

Figure 10: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color

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

1.2.3 Mandel's Statistics
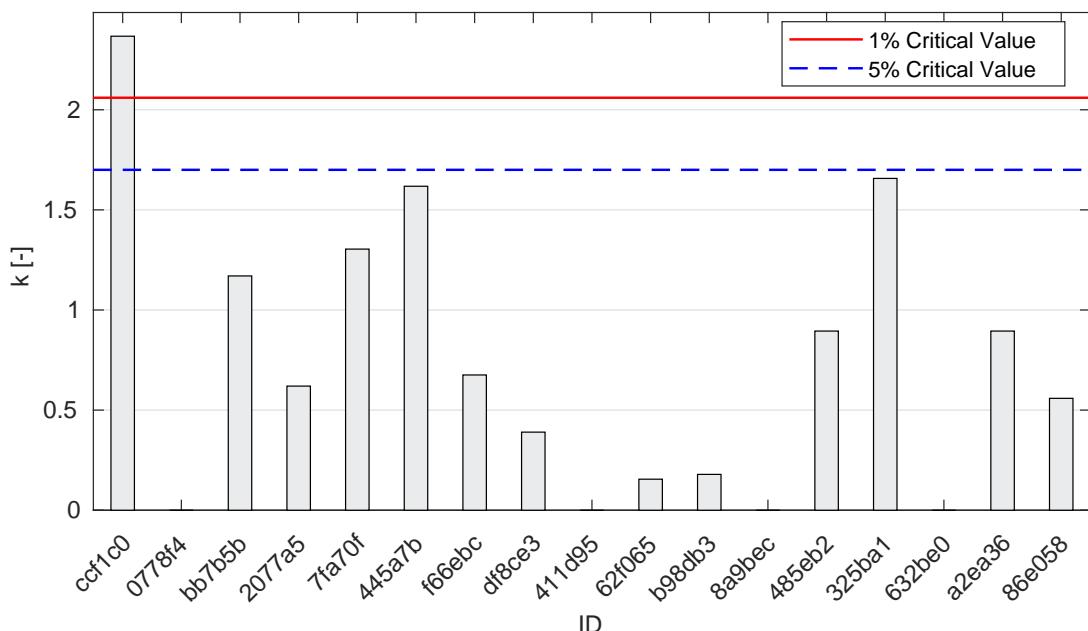
Figure 12: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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

1.2.4 Calculation of Performance Statistics
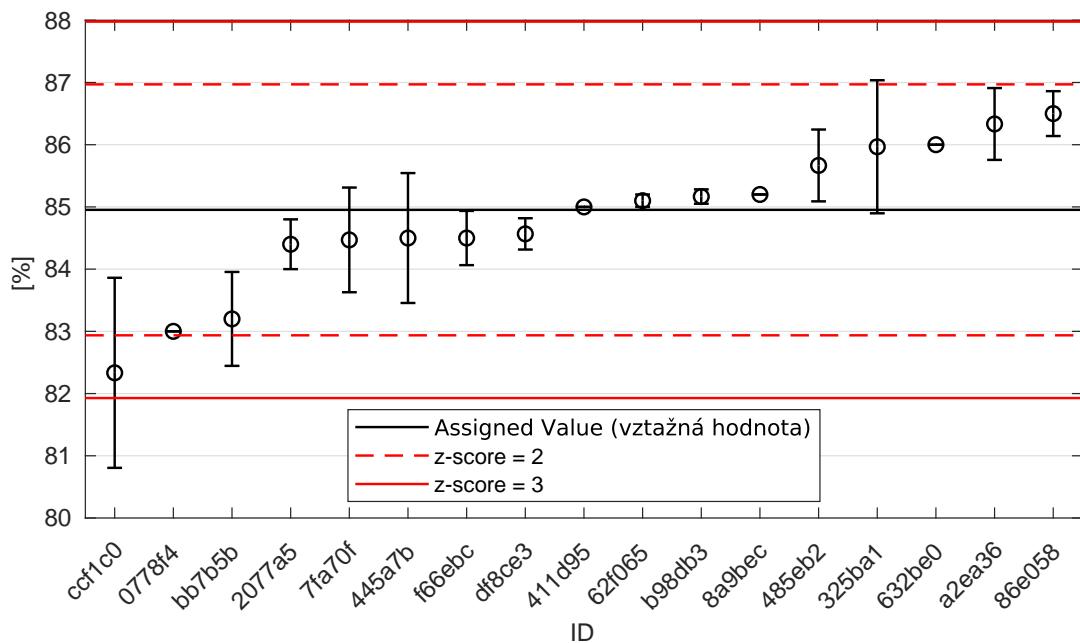
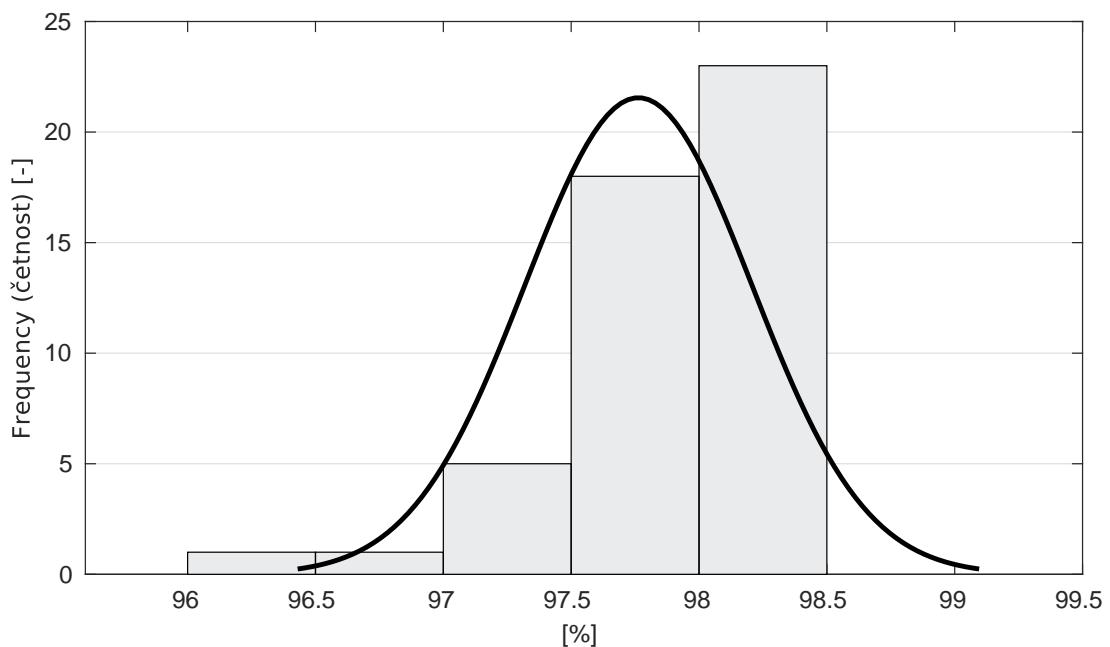Figure 14: Average values and sample standard deviations

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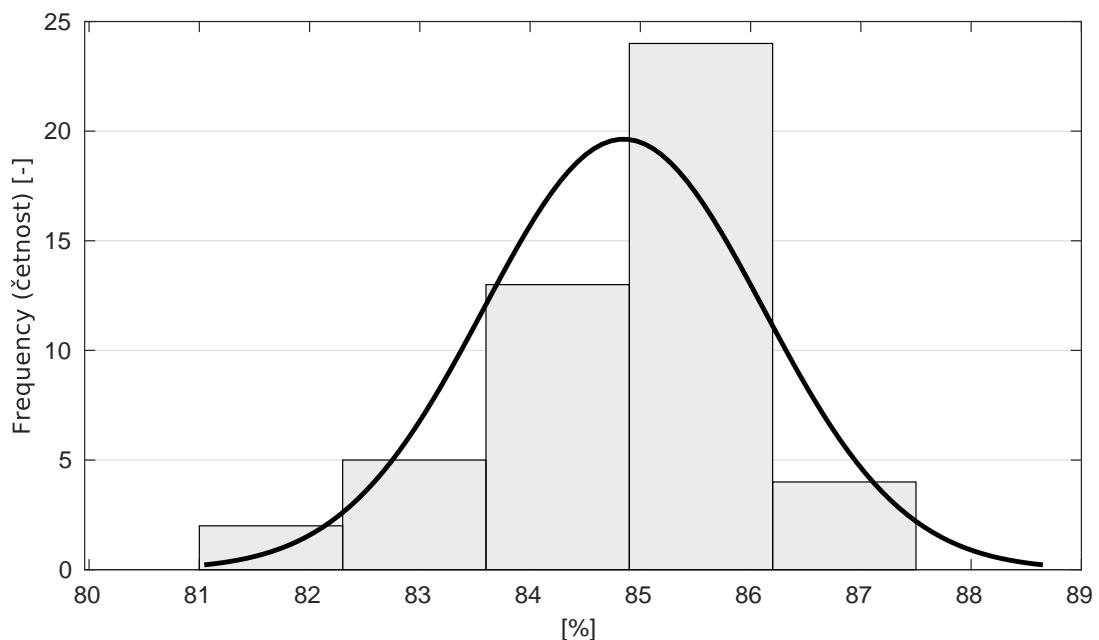
Figure 15: Histogram of all test results

Figure 16: z-score and ζ-score

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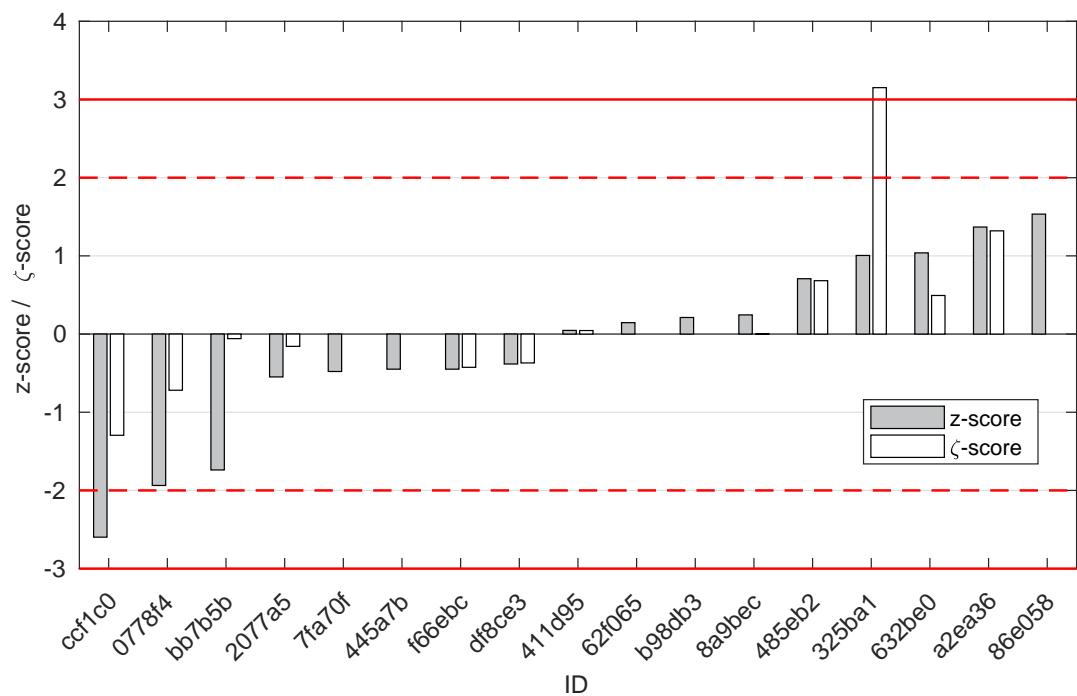
Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ccf1c0	-2.60	-1.29
0778f4	-1.94	-0.72
bb7b5b	-1.74	-0.06
2077a5	-0.55	-0.16
7fa70f	-0.48	-
445a7b	-0.45	-
f66ebc	-0.45	-0.43
df8ce3	-0.38	-0.37
411d95	0.05	0.04
62f065	0.15	-
b98db3	0.21	-
8a9bec	0.24	0.00
485eb2	0.71	0.68
325ba1	1.01	3.15
632be0	1.04	0.49
a2ea36	1.37	1.32
86e058	1.53	-

1.3 1 mm

1.3.1 Test results

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

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
ccf1c0	54.0	61.0	56.0	4.0	57.0	3.6	6.33
f66ebc	59.9	58.5	58.8	1.0	59.1	0.7	1.25
0778f4	63.0	58.0	57.0	3.7	59.3	3.2	5.42
7fa70f	62.2	60.3	57.1	-	59.9	2.5	4.25
411d95	60.0	-	-	1.0	60.0	0.0	0.00
445a7b	61.5	59.1	59.6	-	60.1	1.3	2.11
bb7b5b	59.4	60.5	60.9	40.0	60.3	0.8	1.29
df8ce3	59.9	60.5	60.7	0.5	60.4	0.4	0.69
62f065	60.7	60.4	60.5	-	60.5	0.2	0.25
b98db3	61.3	61.0	59.8	-	60.7	0.8	1.31
2077a5	60.4	60.9	61.1	3.5	60.8	0.4	0.59
8a9bec	60.9	60.9	60.9	60.9	60.9	0.0	0.00
632be0	61.0	61.0	61.0	1.6	61.0	0.0	0.00
485eb2	63.0	61.0	62.0	1.0	62.0	1.0	1.61
a2ea36	62.0	62.0	62.0	1.0	62.0	0.0	0.00
86e058	62.9	64.1	63.3	-	63.4	0.6	0.96
325ba1	67.8	63.0	62.9	0.1	64.6	2.8	4.34

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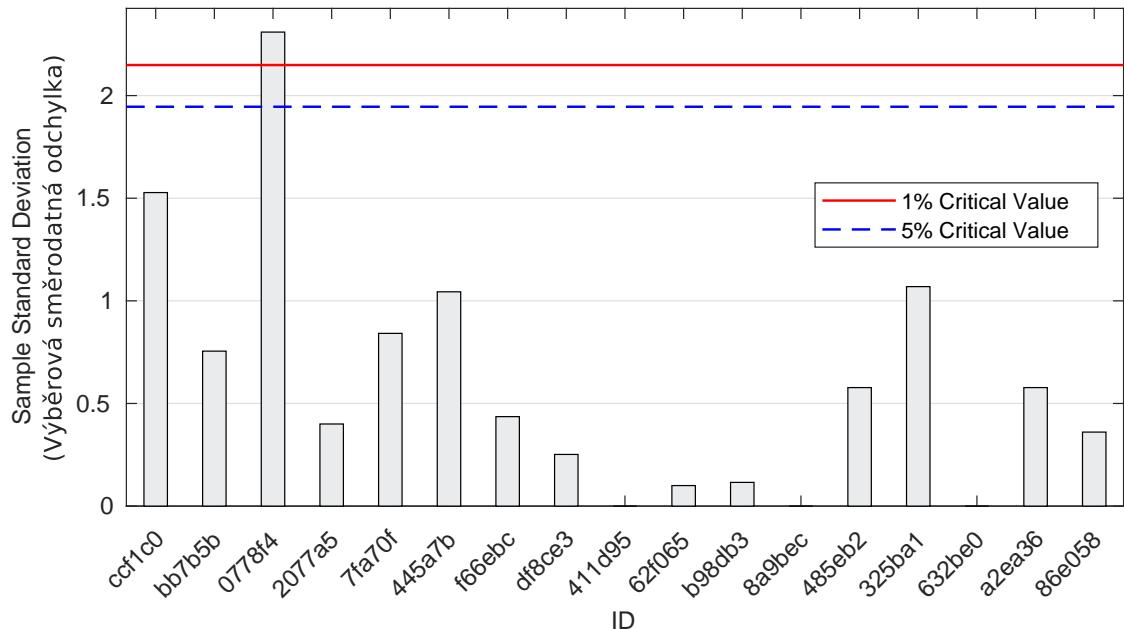## 1.3.2 The Numerical Procedure for Determining Outliers
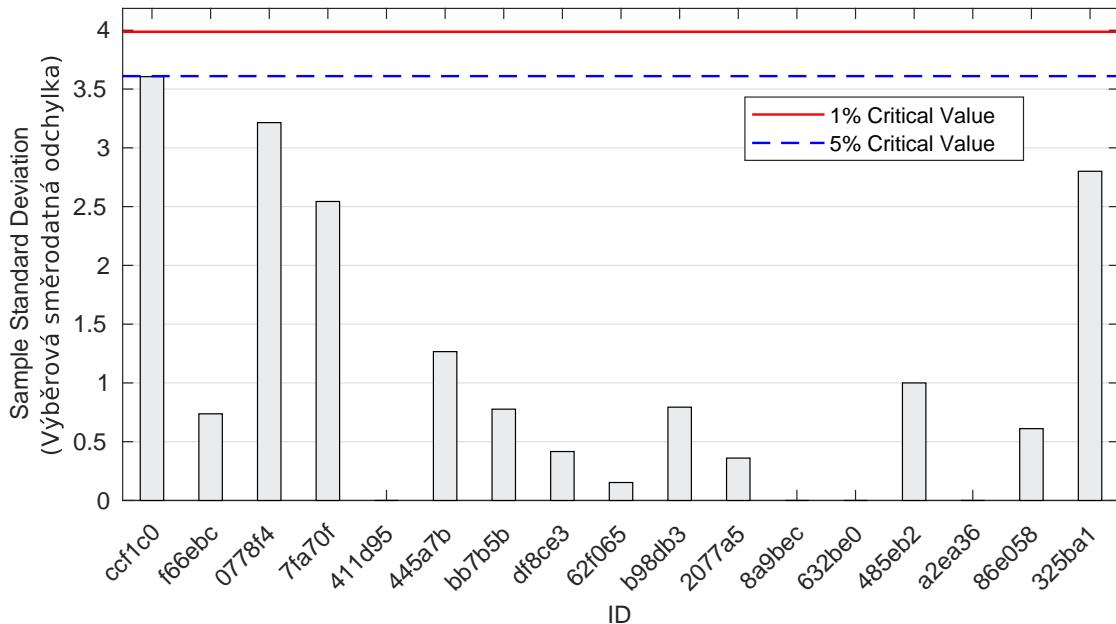
Figure 17: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color
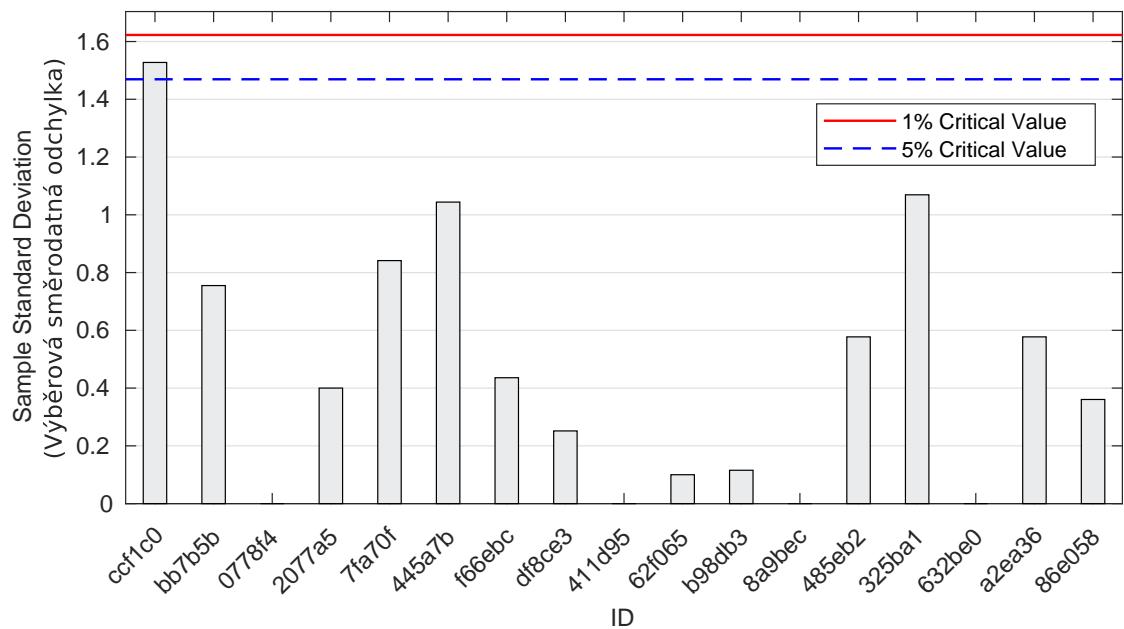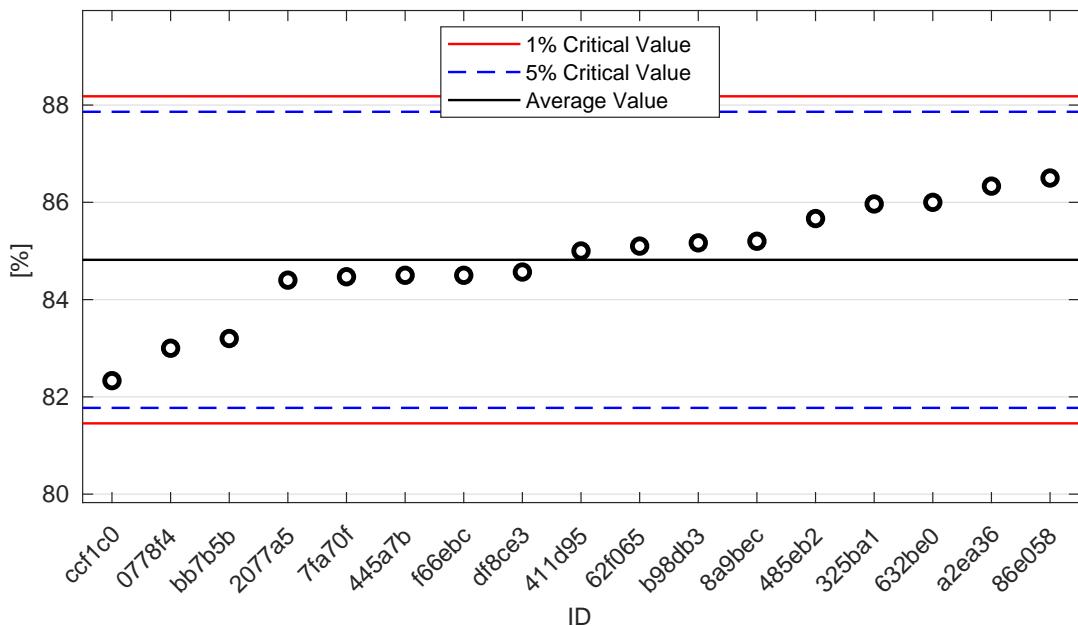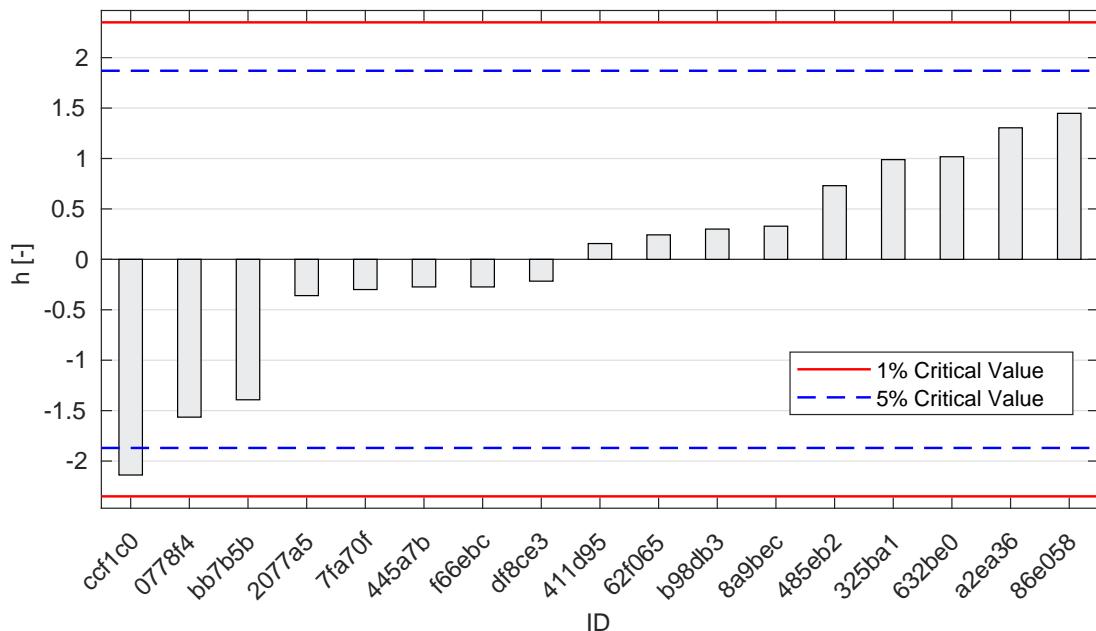

Figure 18: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

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1.3.3 Mandel's Statistics

Figure 19: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color
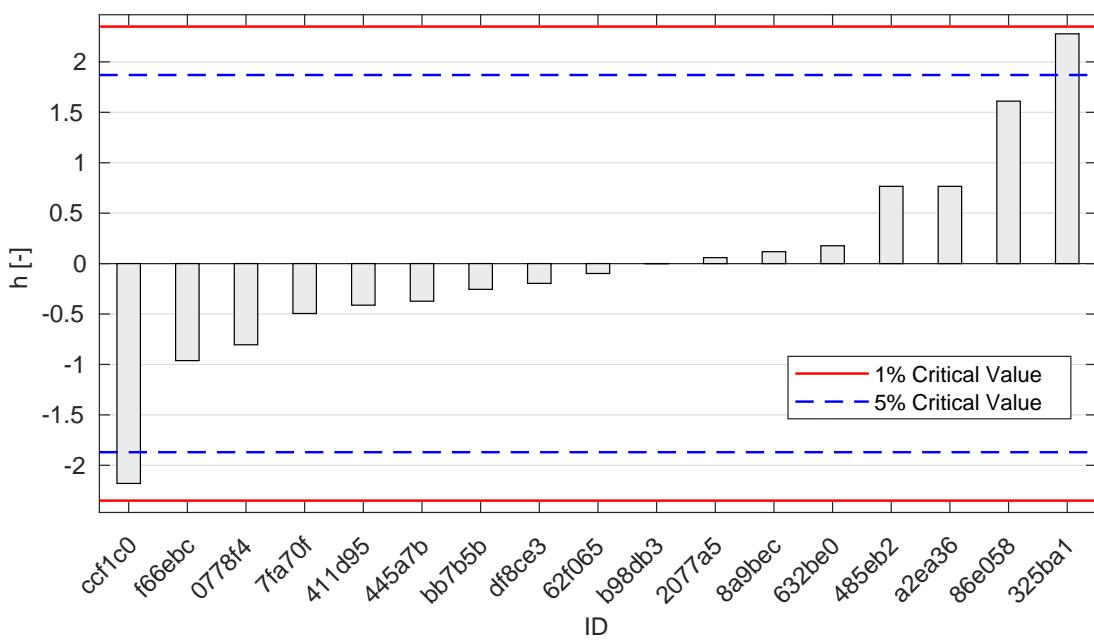
Figure 20: Interlaboratory Consistency Statistic h: 1% critical value - red color; 5% critical value - blue color

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1.3.4 Calculation of Performance Statistics
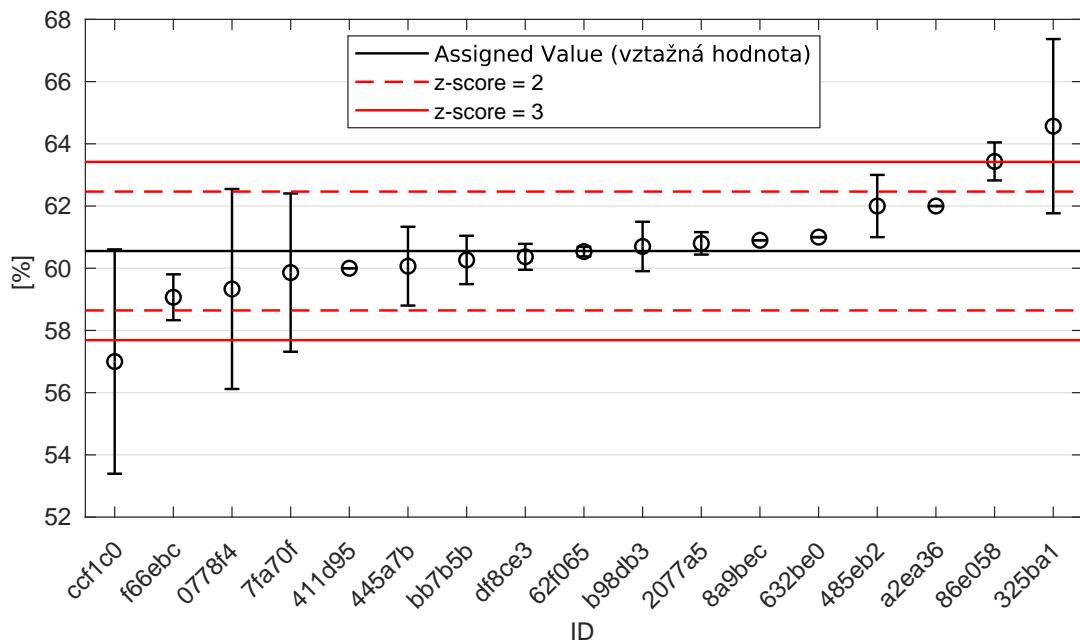
Figure 21: Average values and sample standard deviations
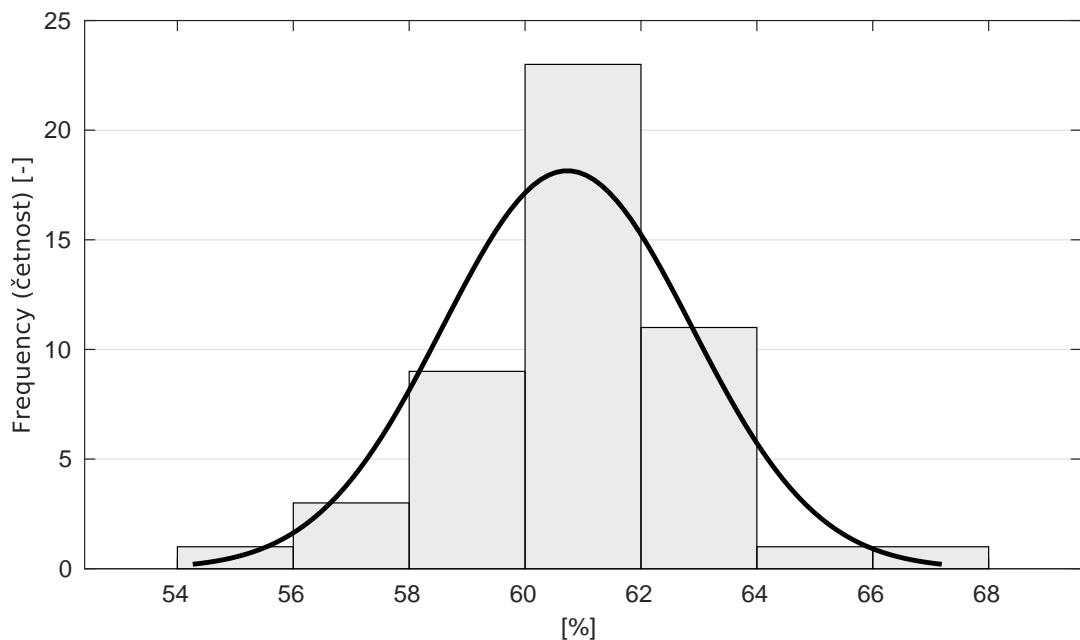
Figure 22: Histogram of all test results

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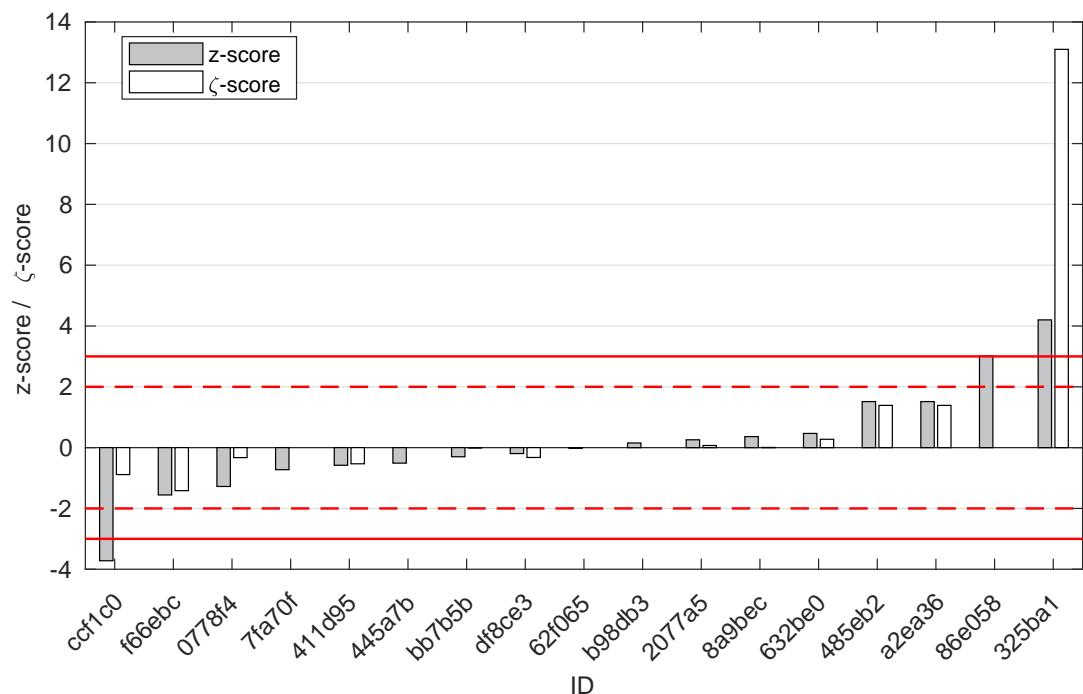
Figure 23: z-score and ζ-score

Table 8: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
ccf1c0	-3.72	-0.89
f66ebc	-1.56	-1.42
0778f4	-1.28	-0.33
7fa70f	-0.73	-
411d95	-0.58	-0.53
445a7b	-0.51	-
bb7b5b	-0.30	-0.01
df8ce3	-0.20	-0.32
62f065	-0.02	-
b98db3	0.15	-
2077a5	0.26	0.07
8a9bec	0.36	0.01
632be0	0.47	0.27
485eb2	1.51	1.39
a2ea36	1.51	1.39
86e058	3.01	-
325ba1	4.20	13.10

1.4   0.5 mm

1.4.1   Test results

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Table 9: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
ccf1c0	28.0	33.0	30.0	3.0	30.3	2.5	8.30
0778f4	35.0*	30.0	27.0	4.7	30.7	4.0	13.18
7fa70f	31.3	30.5	30.7	-	30.8	0.4	1.36
f66ebc	31.8	31.0	31.1	-	31.3	0.4	1.39
445a7b	33.3	30.3	31.5	-	31.7	1.5	4.76
411d95	32.0	-	-	1.0	32.0	0.0	0.00
632be0	32.0	32.0	32.0	1.1	32.0	0.0	0.00
b98db3	32.2	33.3	30.9	-	32.1	1.2	3.74
62f065	32.8	32.0	32.4	-	32.4	0.4	1.23
485eb2	33.0	32.0	33.0	1.0	32.7	0.6	1.77
df8ce3	32.5	32.9	32.6	0.5	32.7	0.2	0.64
2077a5	32.5	32.7	32.9	3.5	32.7	0.2	0.61
a2ea36	33.0	33.0	33.0	1.0	33.0	0.0	0.00
8a9bec	33.4	33.4	33.4	33.4	33.4	0.0	0.00
bb7b5b	33.6	33.5	33.9	40.0	33.7	0.2	0.62
86e058	33.8	34.8	32.6	-	33.7	1.1	3.27
325ba1	38.4	33.8	33.3	0.1	35.2	2.8	7.99

1.4.2 The Numerical Procedure for Determining Outliers
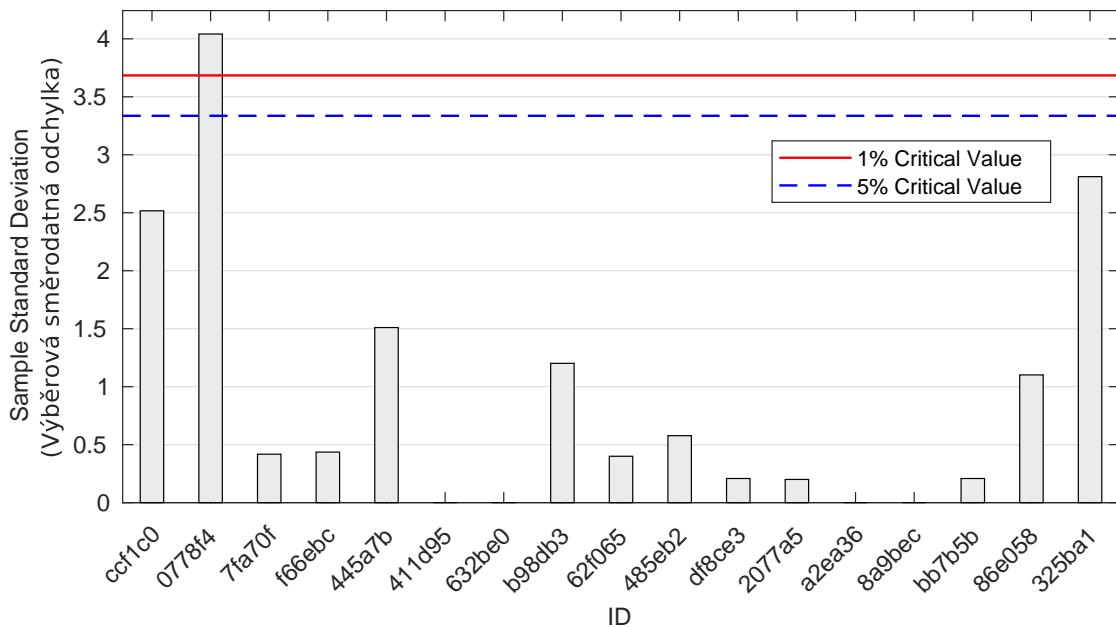
Figure 24: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color
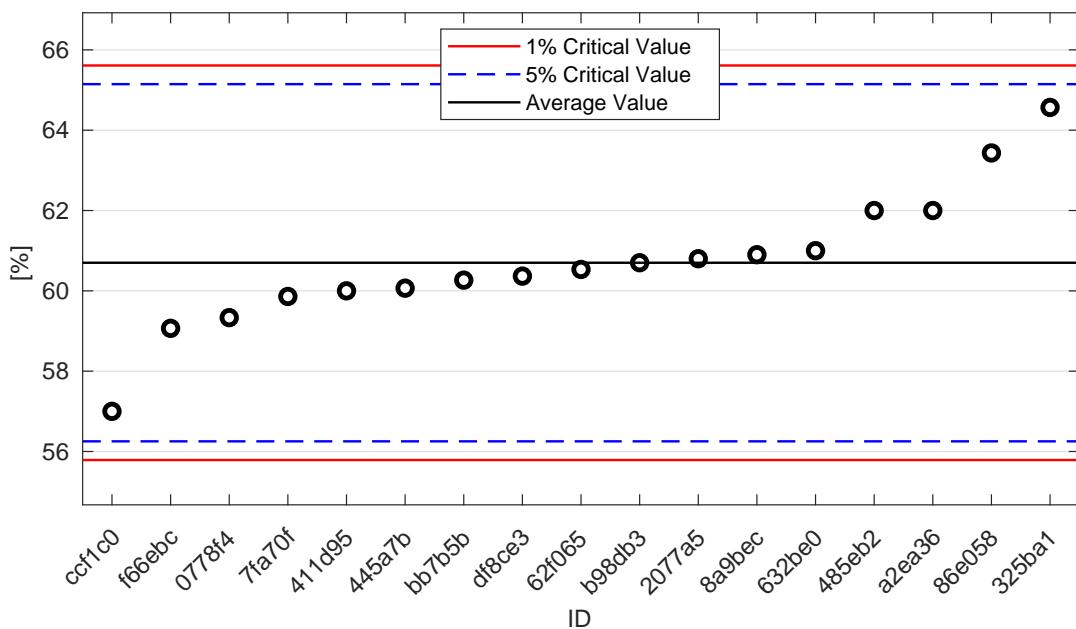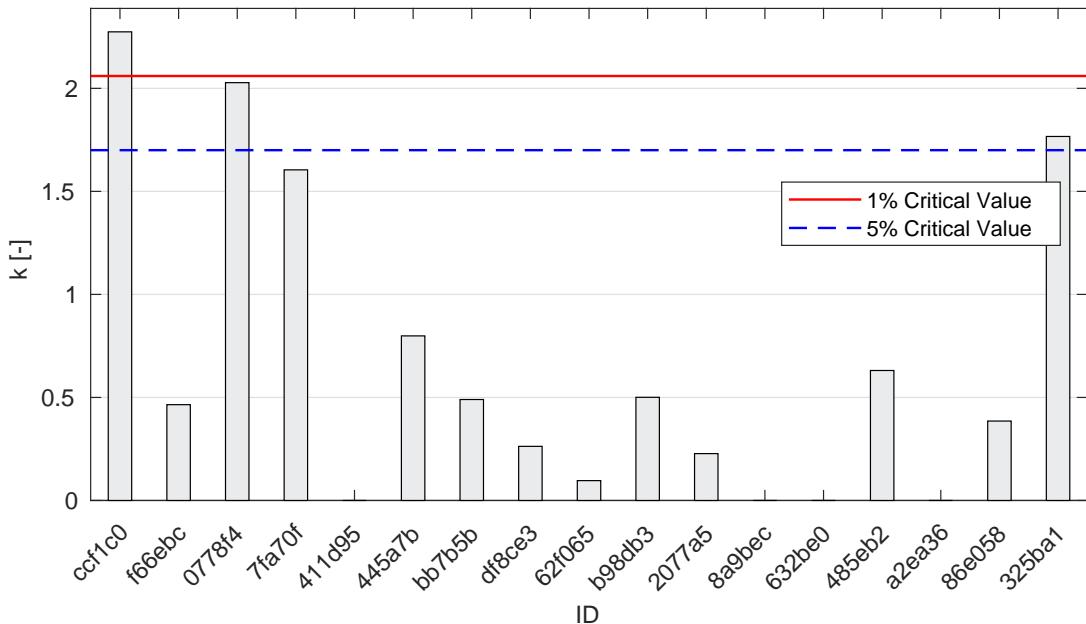
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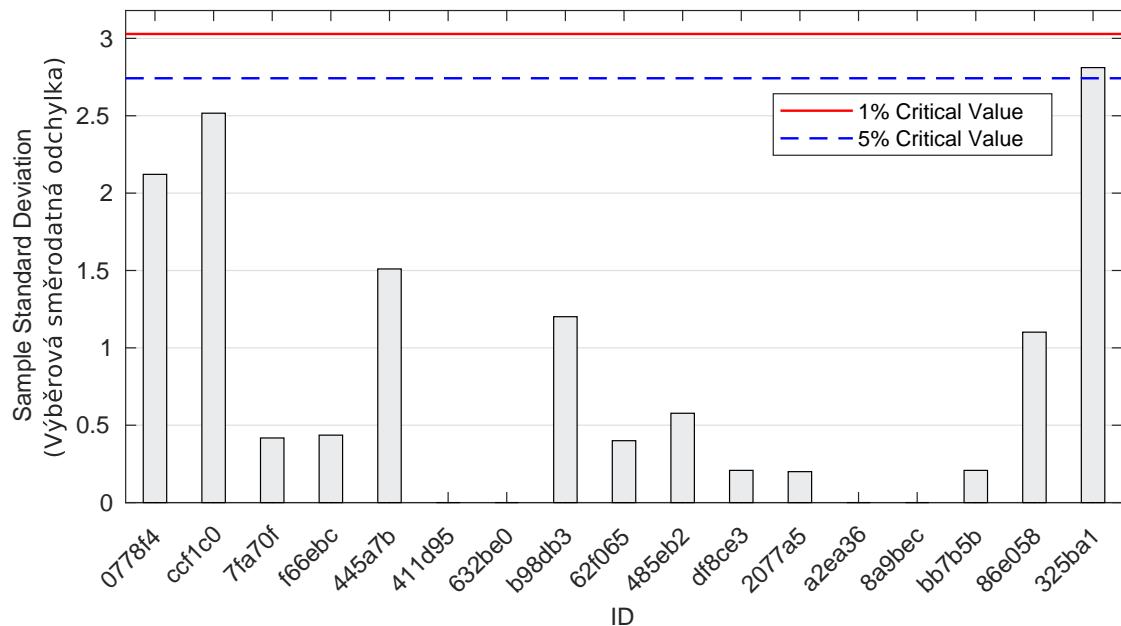
Figure 25: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color
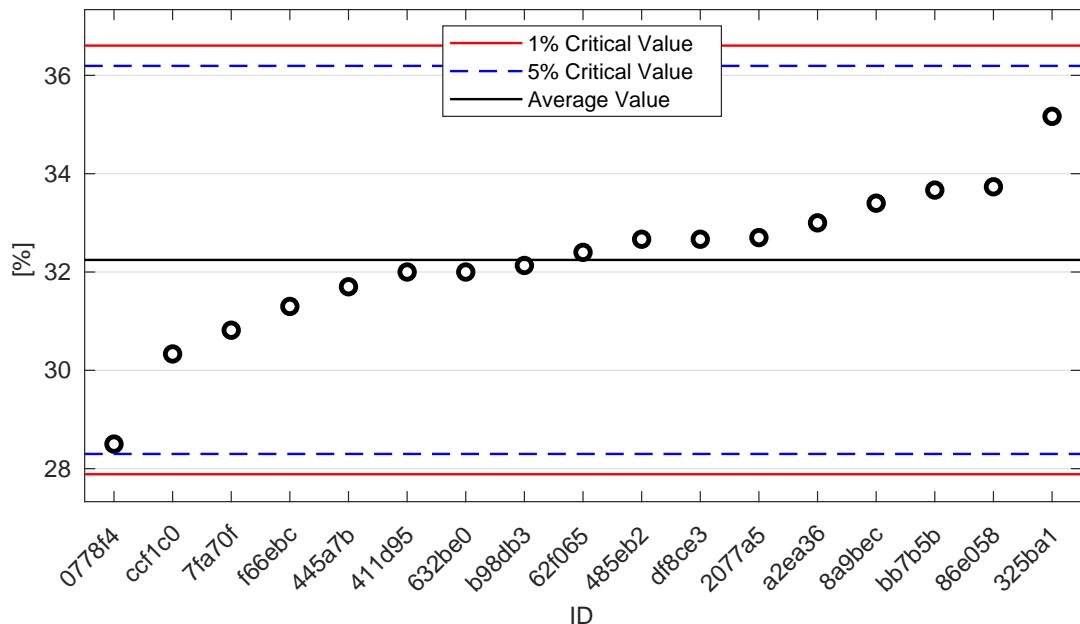
Figure 26: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

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1.4.3 Mandel's Statistics
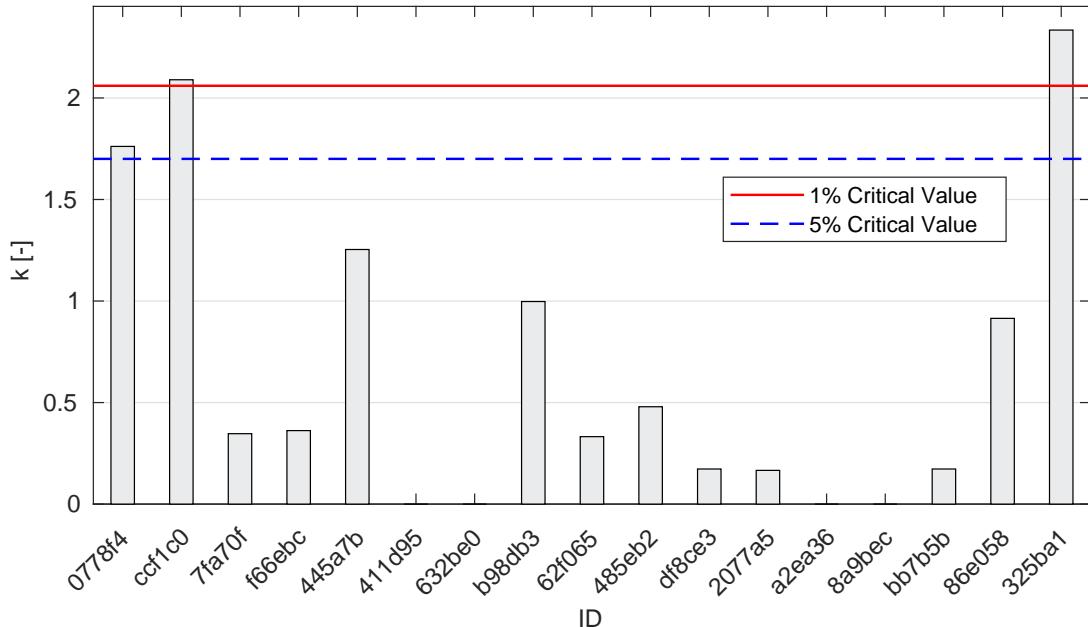
Figure 27: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color
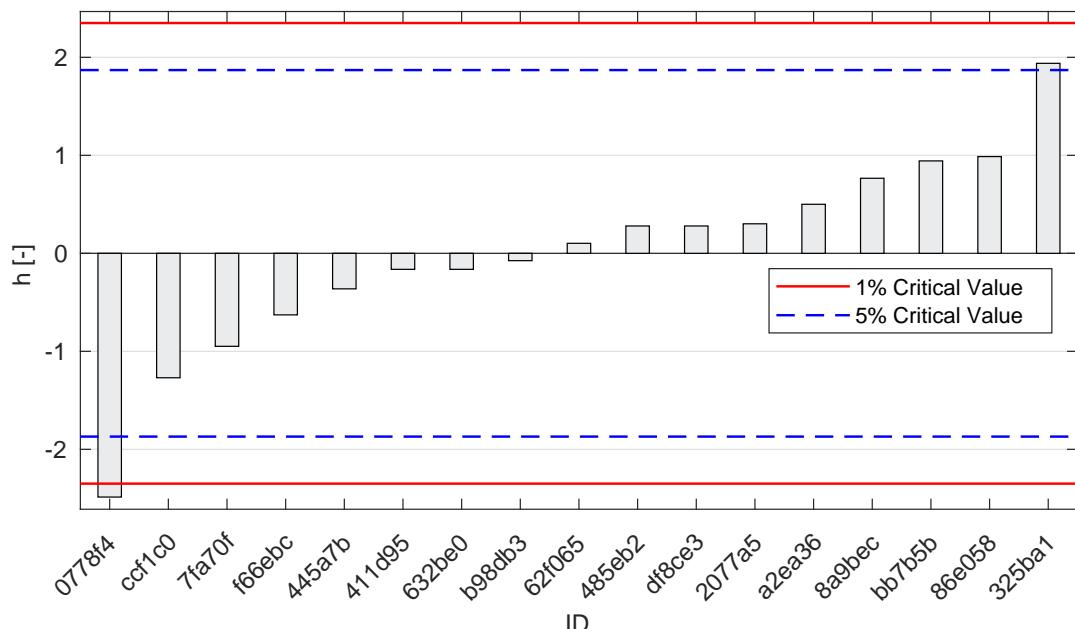
Figure 28: Interlaboratory Consistency Statistic h: 1% critical value - red color; 5% critical value - blue color

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1.4.4 Calculation of Performance Statistics
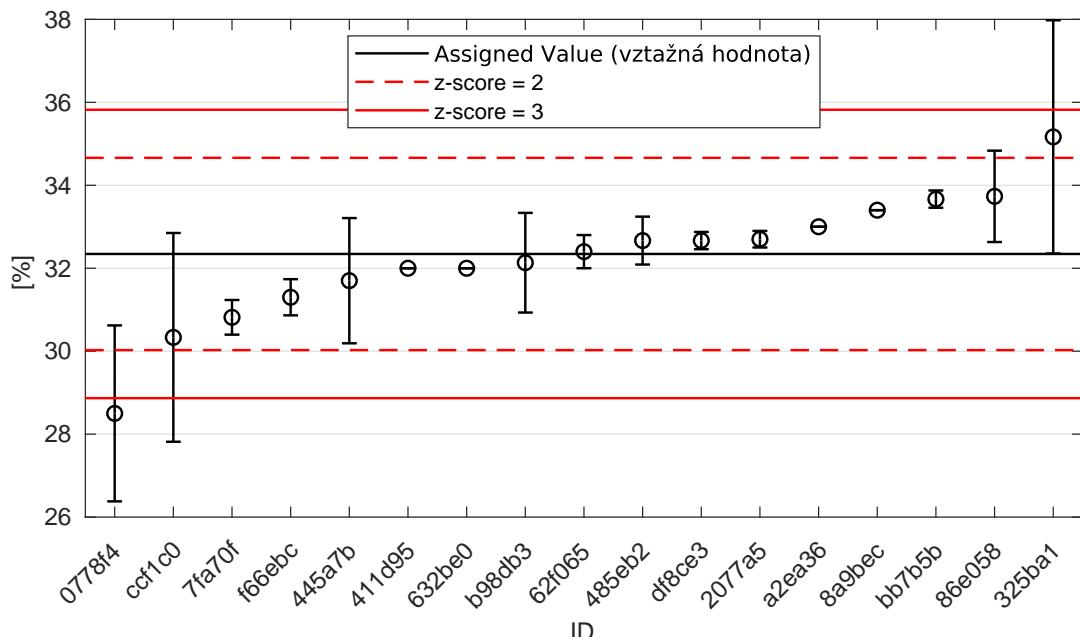
Figure 29: Average values and sample standard deviations
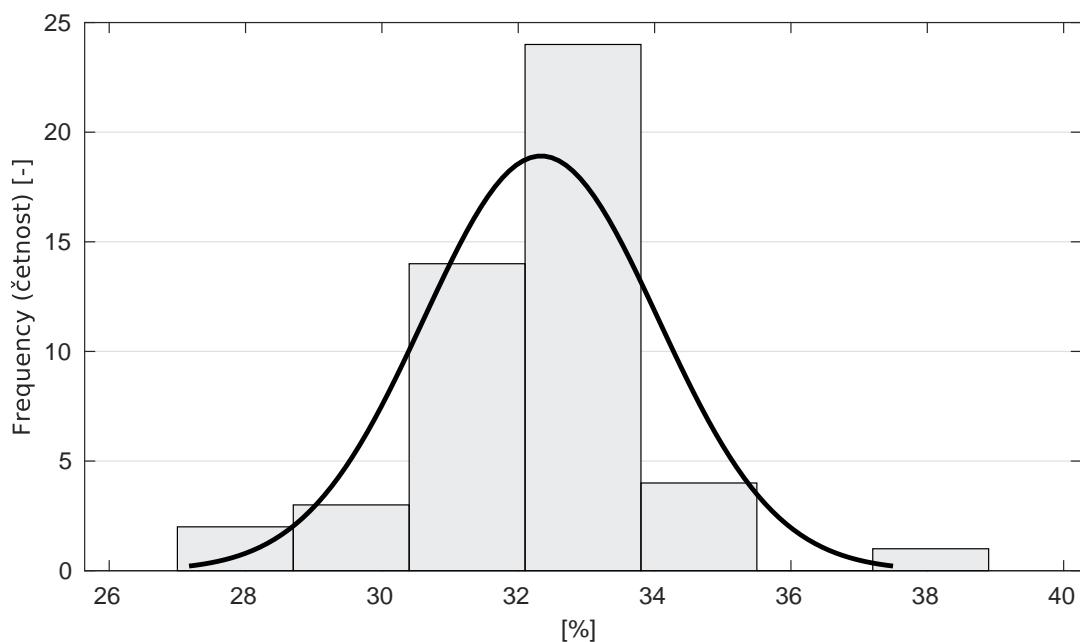
Figure 30: Histogram of all test results

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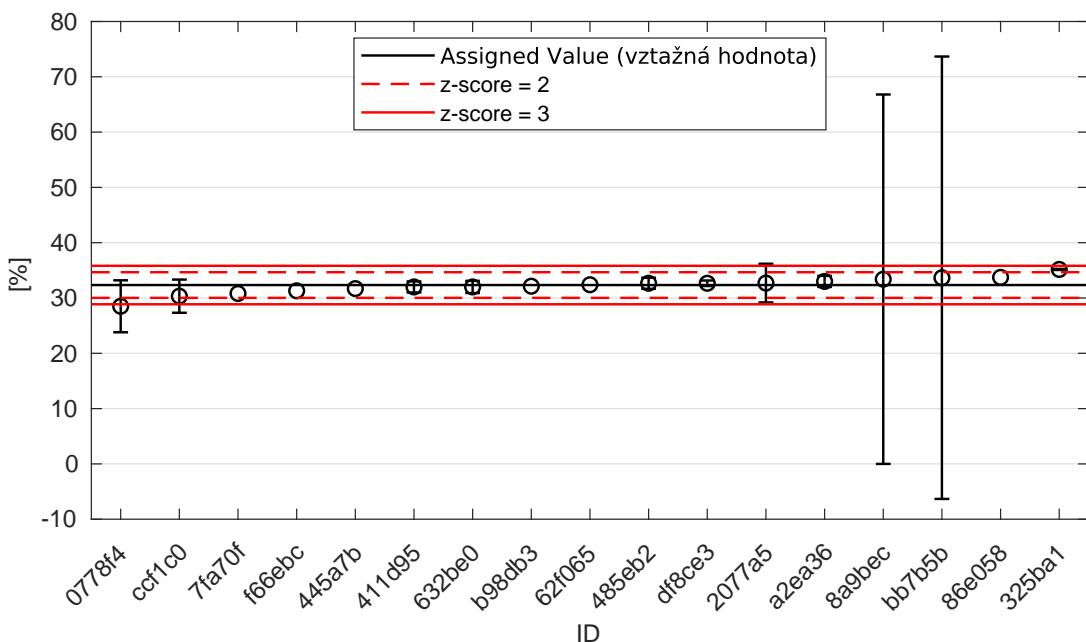
Figure 31: z-score and ζ-score

Table 10: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
0778f4	-3.32	-0.82
ccf1c0	-1.74	-0.67
7fa70f	-1.32	-
f66ebc	-0.90	-
445a7b	-0.56	-
411d95	-0.30	-0.32
632be0	-0.30	-0.30
b98db3	-0.18	-
62f065	0.05	-
485eb2	0.28	0.30
df8ce3	0.28	0.53
2077a5	0.31	0.10
a2ea36	0.57	0.62
8a9bec	0.91	0.03
bb7b5b	1.14	0.03
86e058	1.20	-
325ba1	2.44	7.73

1.5 0.25 mm

1.5.1 Test results

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

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
0778f4	9.0	8.0	6.0	1.8	7.7	1.5	19.92
7fa70f	7.8	8.5	10.0	-	8.8	1.1	12.64
62f065	9.7	8.1	8.9	-	8.9	0.8	8.99
ccf1c0	8.0	10.0	9.0	2.0	9.0	1.0	11.11
f66ebc	9.1	9.1	9.0	1.0	9.1	0.1	0.64
df8ce3	9.5	9.5	9.6	0.2	9.5	0.1	0.61
485eb2	10.0	9.0	10.0	1.0	9.7	0.6	5.97
b98db3	10.1	10.0	9.2	-	9.8	0.5	5.05
445a7b	10.6	9.0	10.0	-	9.9	0.8	8.19
411d95	10.0	-	-	0.5	10.0	0.0	0.00
632be0	10.0	10.0	10.0	0.6	10.0	0.0	0.00
86e058	10.4	10.3	9.5	-	10.1	0.5	4.90
8a9bec	10.2	10.2	10.2	10.2	10.2	0.0	0.00
325ba1	11.5	10.0	9.4	0.1	10.3	1.1	10.50
2077a5	10.4	10.6	10.6	3.5	10.5	0.1	1.10
a2ea36	11.0	11.0	11.0	0.8	11.0	0.0	0.00
bb7b5b	13.0	12.6	11.7	40.0	12.4	0.7	5.36

1.5.2 The Numerical Procedure for Determining Outliers
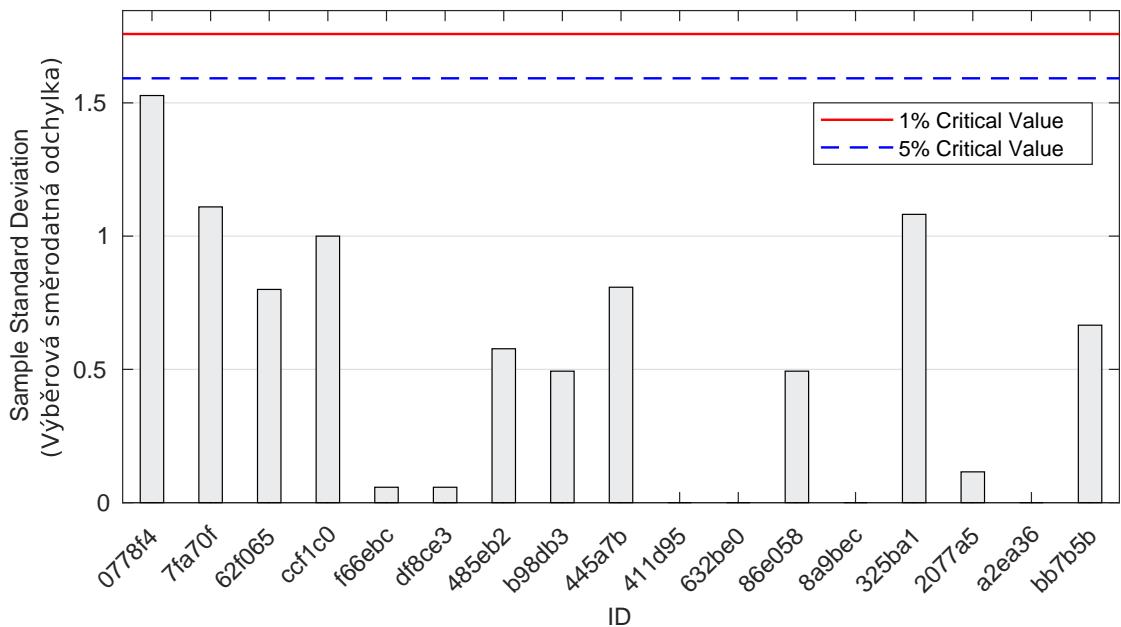
Figure 32: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

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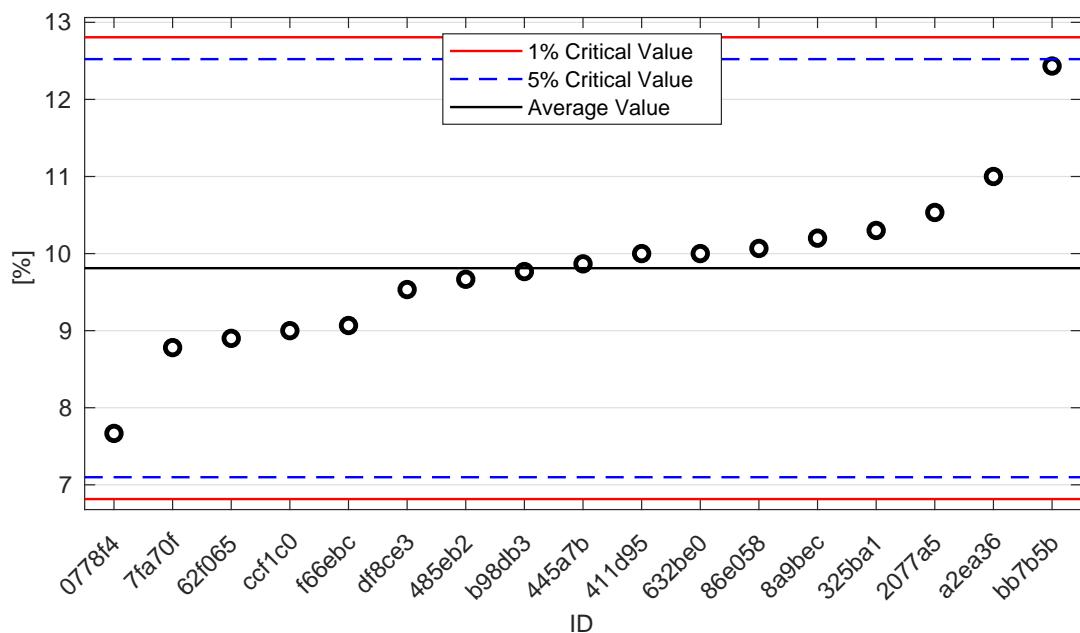
Figure 33: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

1.5.3 Mandel's Statistics
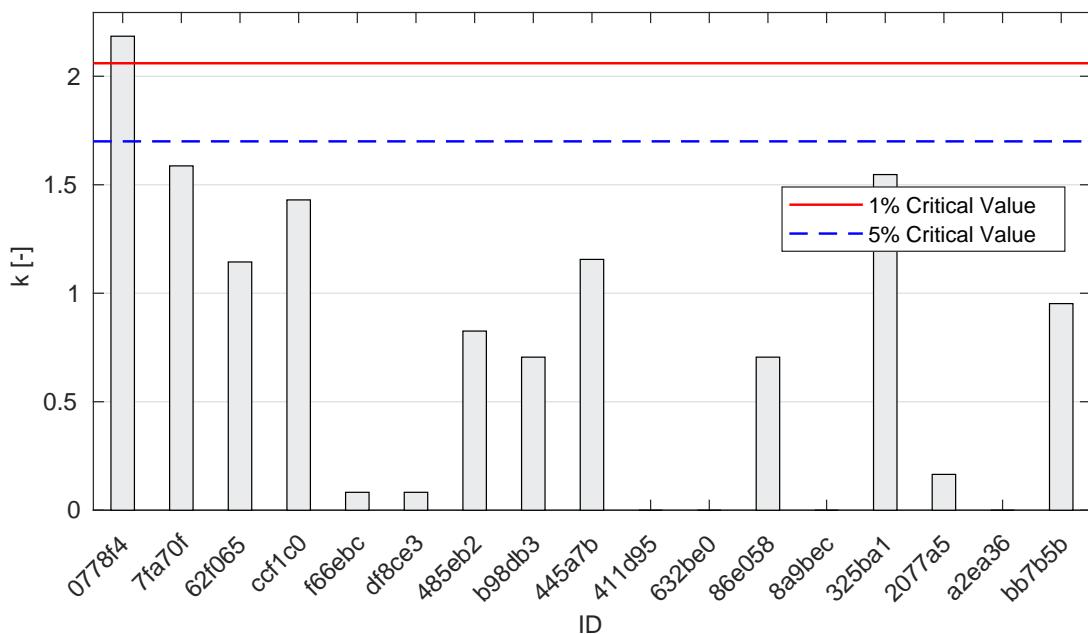
Figure 34: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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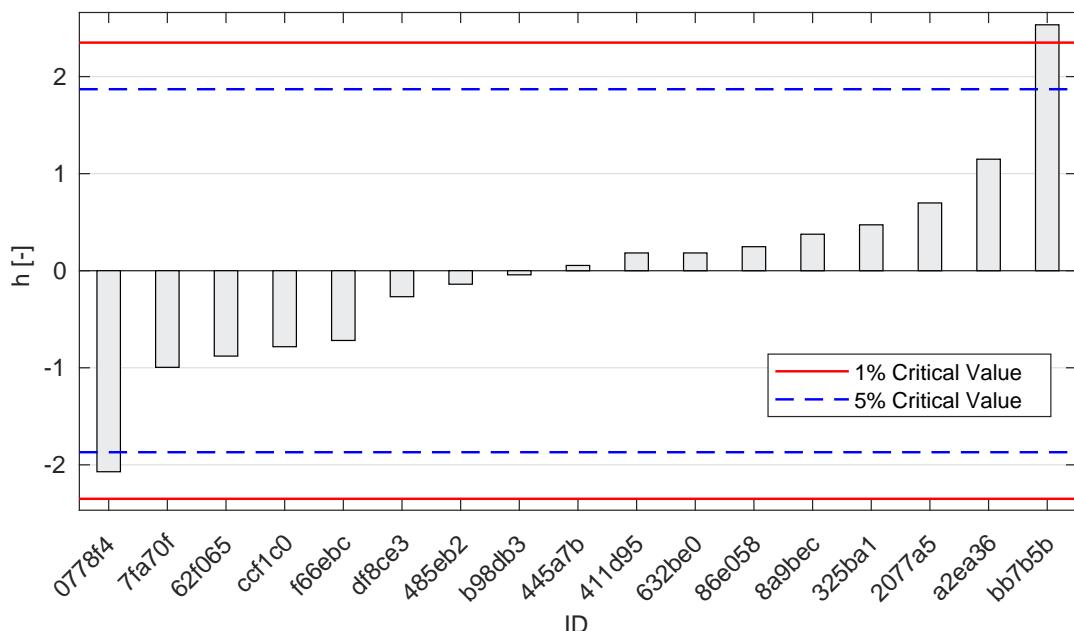
Figure 35: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

1.5.4 Calculation of Performance Statistics
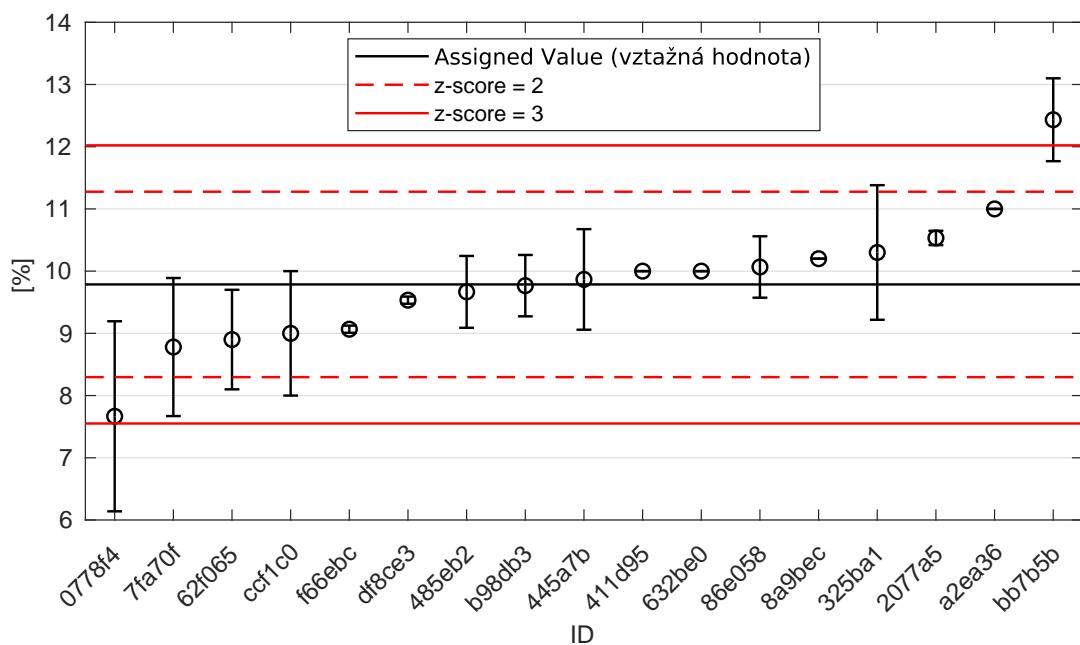
Figure 36: Average values and sample standard deviations

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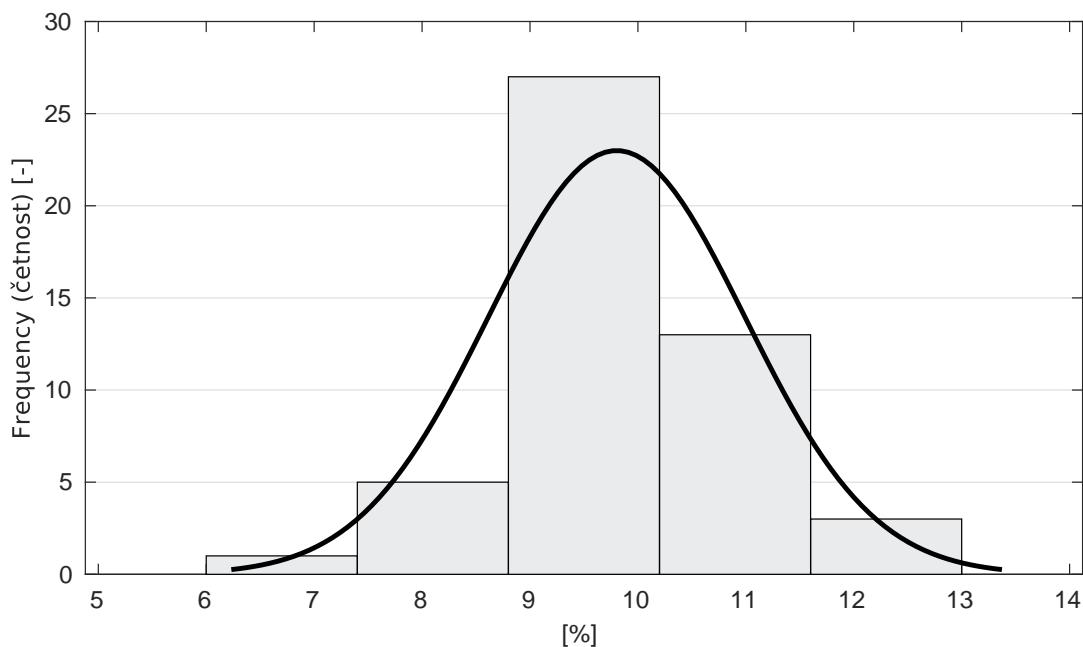
Figure 37: Histogram of all test results

Figure 38: z-score and ζ-score

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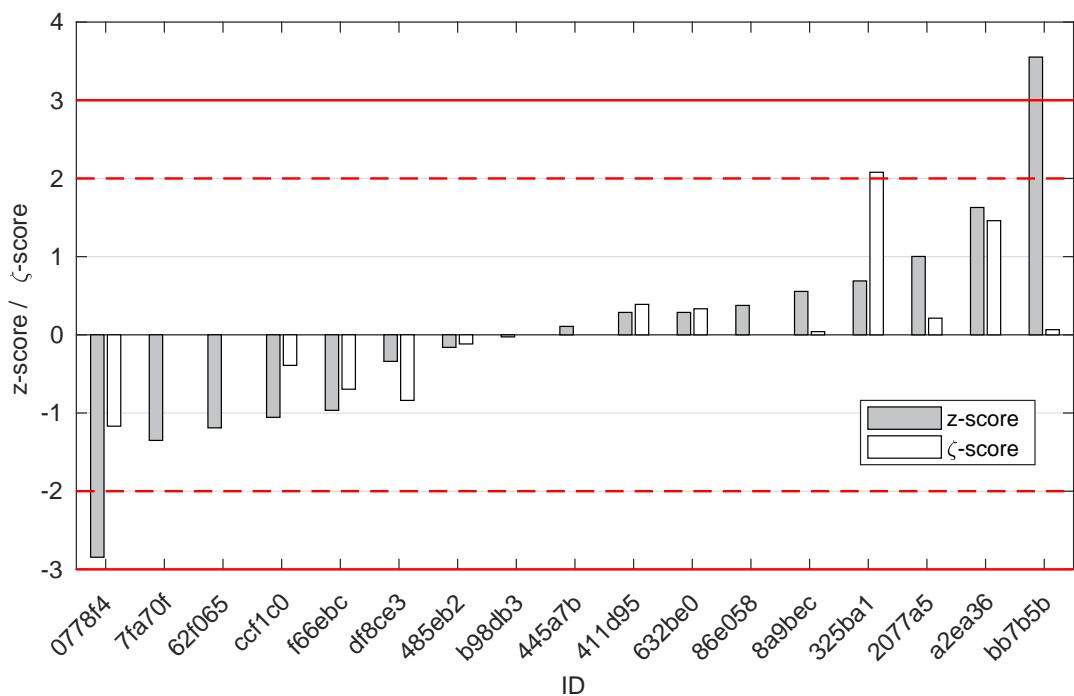
Table 12: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
0778f4	-2.84	-1.17
7fa70f	-1.35	-
62f065	-1.19	-
ccf1c0	-1.06	-0.39
f66ebc	-0.97	-0.70
df8ce3	-0.34	-0.84
485eb2	-0.16	-0.12
b98db3	-0.03	-
445a7b	0.11	-
411d95	0.29	0.39
632be0	0.29	0.33
86e058	0.38	-
8a9bec	0.56	0.04
325ba1	0.69	2.08
2077a5	1.00	0.21
a2ea36	1.63	1.46
bb7b5b	3.55	0.07

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1.6   0.125 mm

1.6.1   Test results

Table 13: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

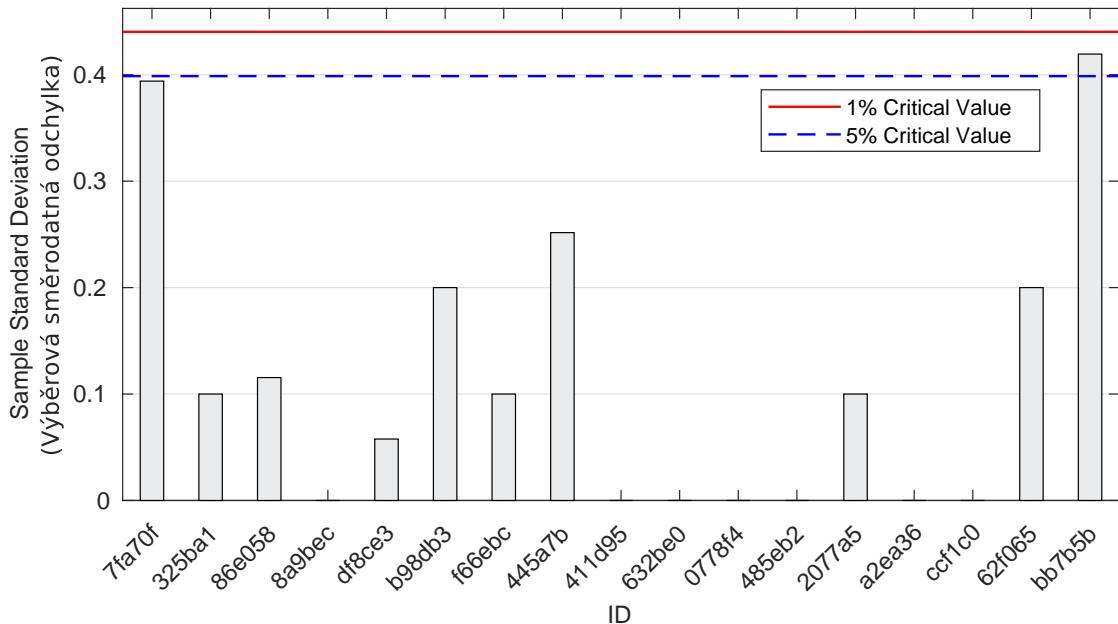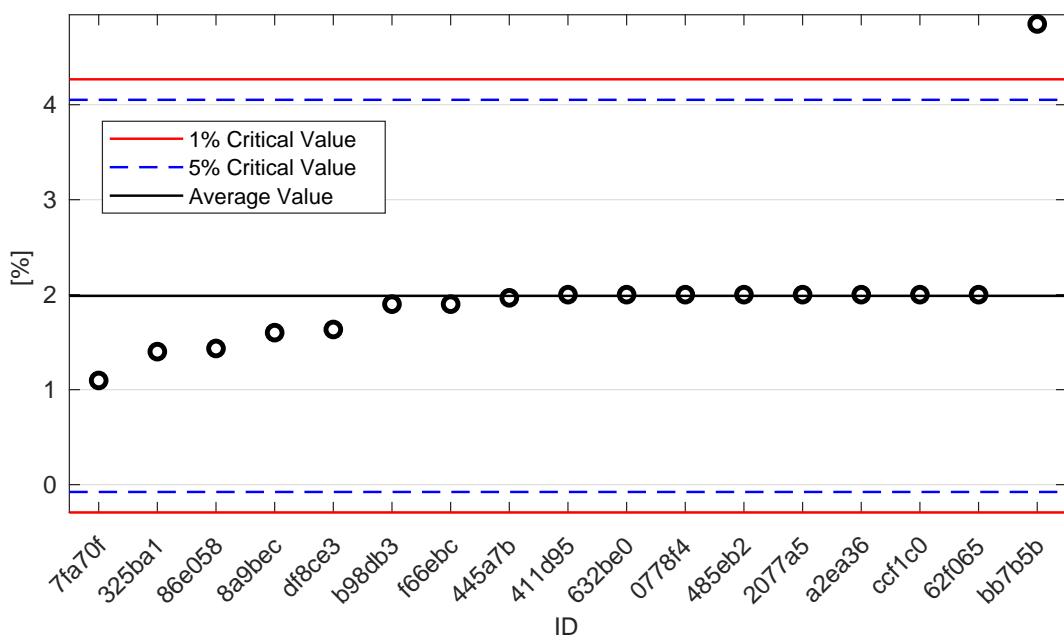| ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
7fa70f	0.8	1.0	1.5	-	1.1	0.4	35.93
325ba1	1.5	1.4	1.3	0.1	1.4	0.1	7.14
86e058	1.5	1.5	1.3	-	1.4	0.1	8.06
8a9bec	1.6	1.6	1.6	1.6	1.6	0.0	0.00
df8ce3	1.7	1.6	1.6	0.1	1.6	0.1	3.53
b98db3	2.1	1.7	1.9	-	1.9	0.2	10.53
f66ebc	1.9	2.0	1.8	-	1.9	0.1	5.26
445a7b	2.0	1.7	2.2	-	2.0	0.3	12.80
411d95	2.0	-	-	0.1	2.0	0.0	0.00
632be0	2.0	2.0	2.0	0.2	2.0	0.0	0.00
0778f4	2.0	2.0	2.0	0.0	2.0	0.0	0.00
485eb2	2.0	2.0	2.0	1.0	2.0	0.0	0.00
2077a5	2.1	1.9	2.0	3.5	2.0	0.1	5.00
a2ea36	2.0	2.0	2.0	0.5	2.0	0.0	0.00
ccf1c0	2.0	2.0	2.0	1.0	2.0	0.0	0.00
62f065	2.2	1.8	2.0	-	2.0	0.2	10.00
bb7b5b*	5.2	4.9	4.4	40.0	4.9	0.4	8.65

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1.6.2 The Numerical Procedure for Determining Outliers

Figure 39: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

Figure 40: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

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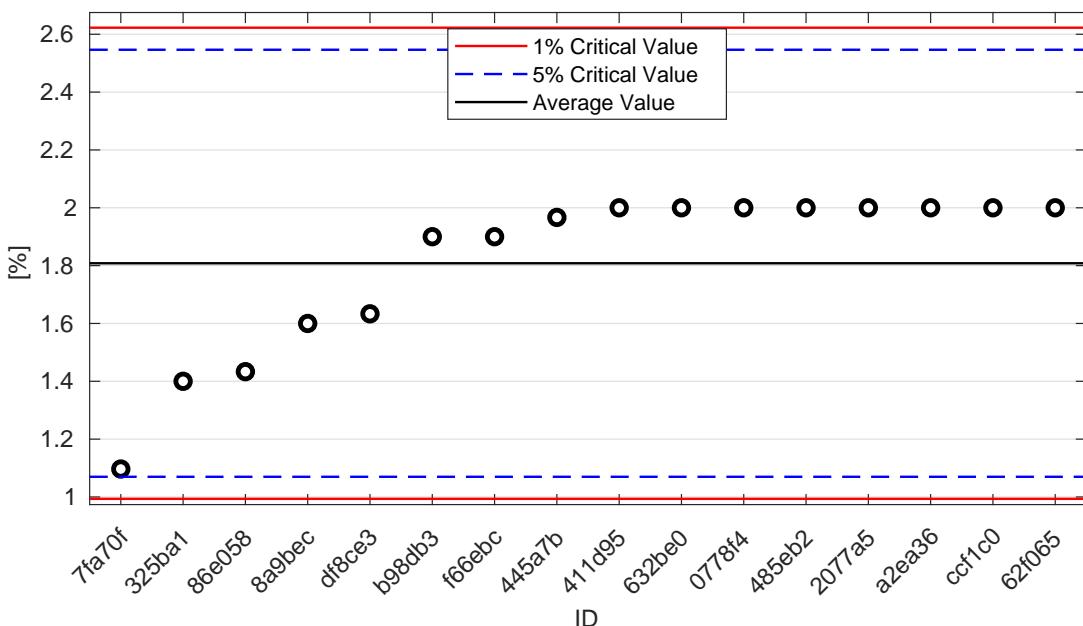
Figure 41: **Grubbs' test** - average values without outliers: 1% critical value - red color; 5% critical value - blue color

1.6.3 Mandel's Statistics
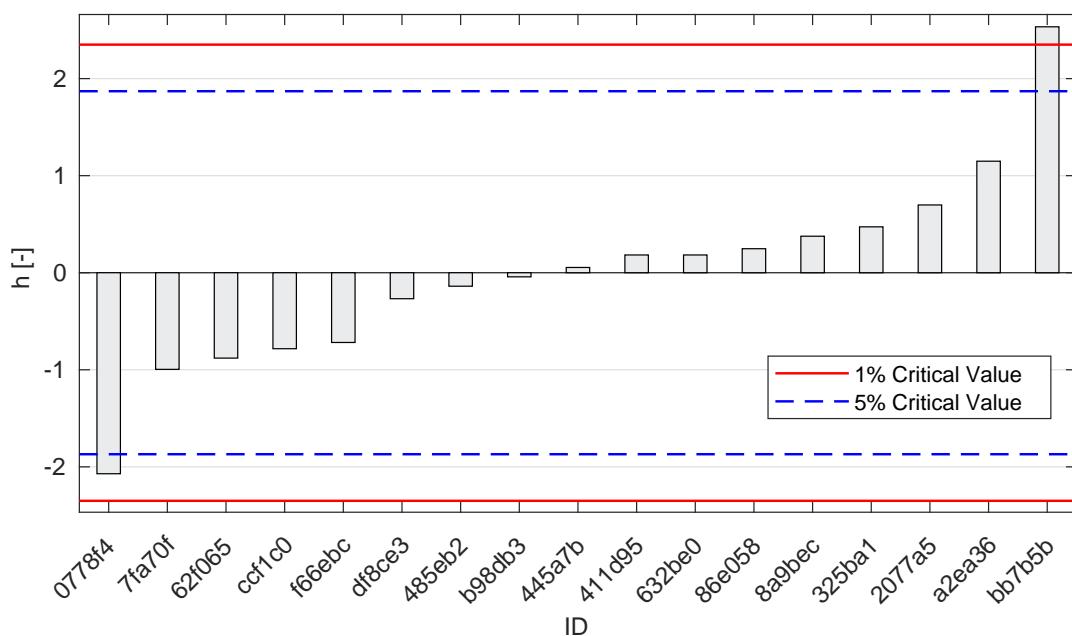
Figure 42: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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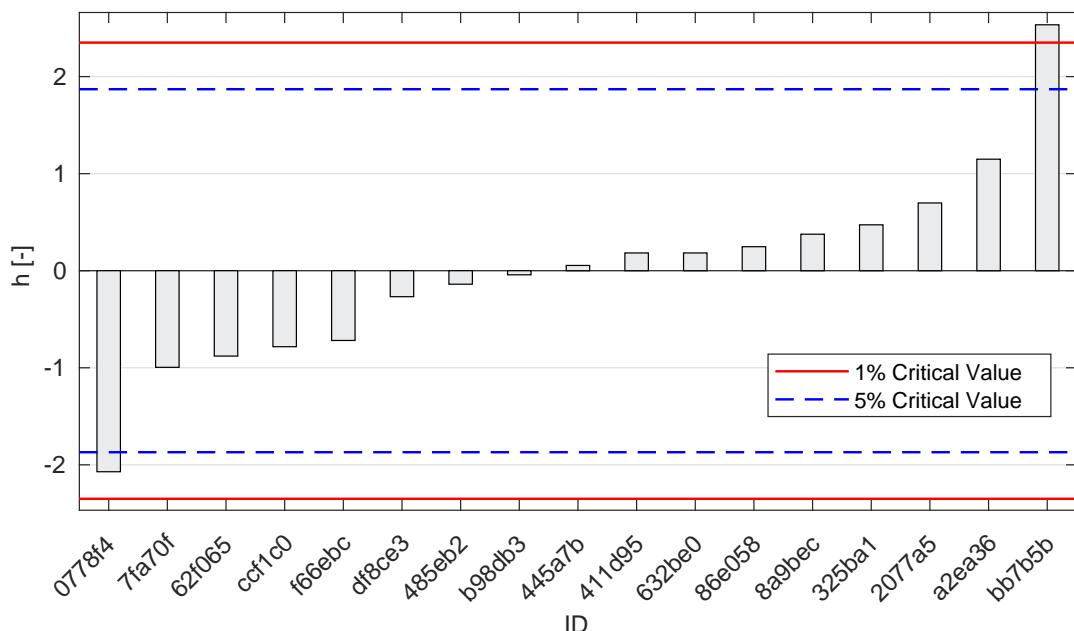
Figure 43: Interlaboratory Consistency Statistic h: 1% critical value - red color; 5% critical value - blue color

1.6.4 Calculation of Performance Statistics
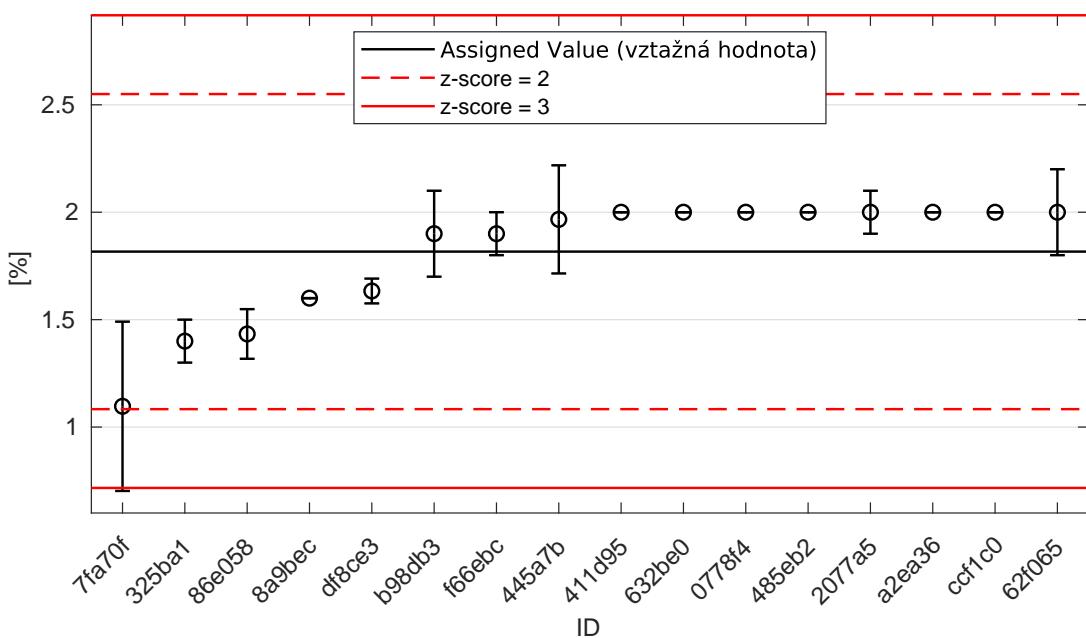
Figure 44: Average values and sample standard deviations

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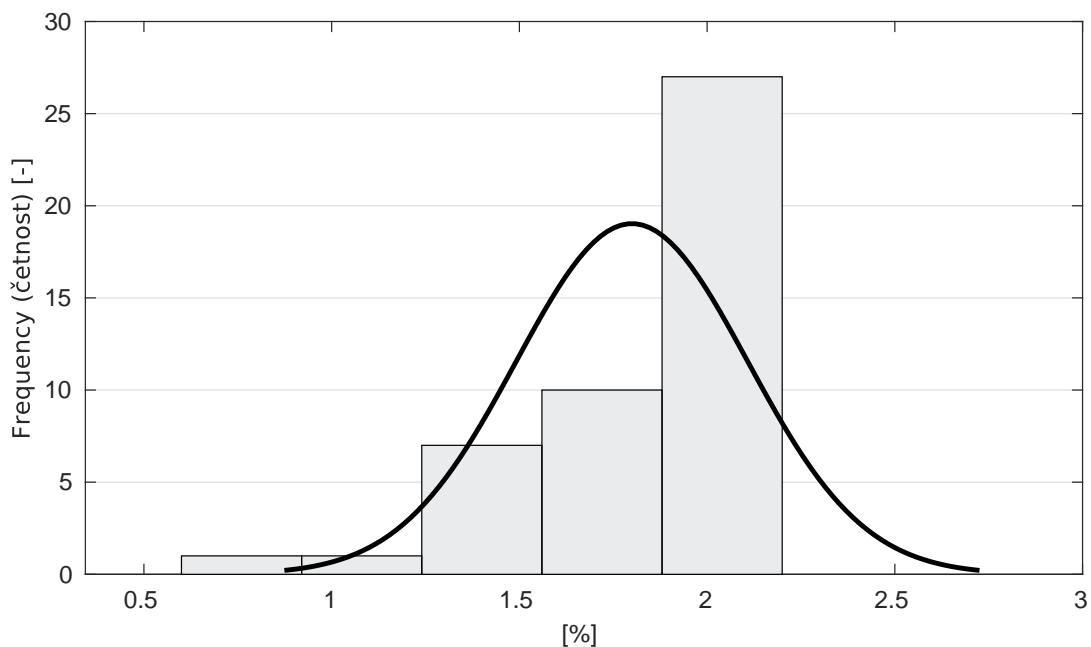
Figure 45: Histogram of all test results

Figure 46: z-score and ζ-score

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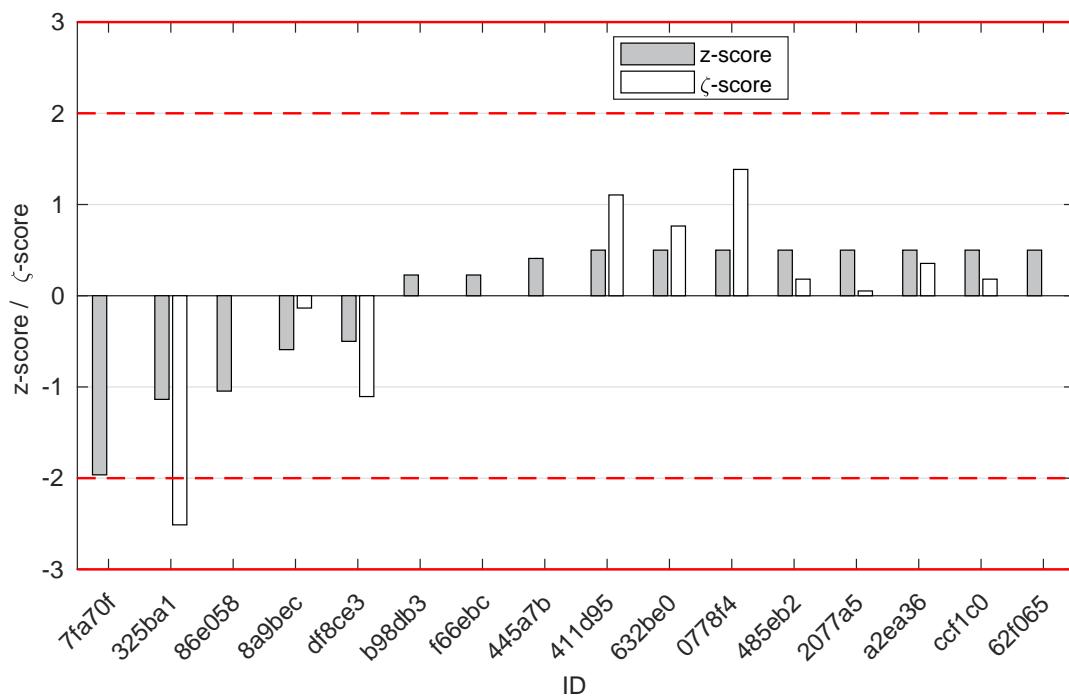
Table 14: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
7fa70f	-1.96	-
325ba1	-1.14	-2.51
86e058	-1.05	-
8a9bec	-0.59	-0.13
df8ce3	-0.50	-1.11
b98db3	0.23	-
f66ebc	0.23	-
445a7b	0.41	-
411d95	0.50	1.10
632be0	0.50	0.76
0778f4	0.50	1.38
485eb2	0.50	0.18
2077a5	0.50	0.05
a2ea36	0.50	0.35
ccf1c0	0.50	0.18
62f065	0.50	-

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1.7   0.063 mm

1.7.1   Test results

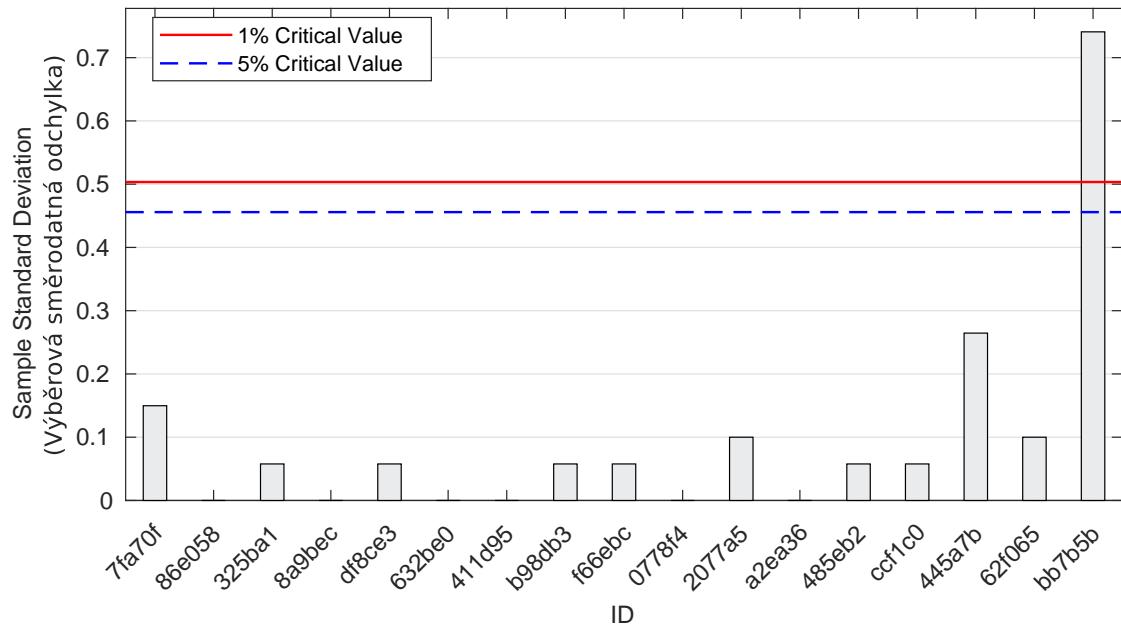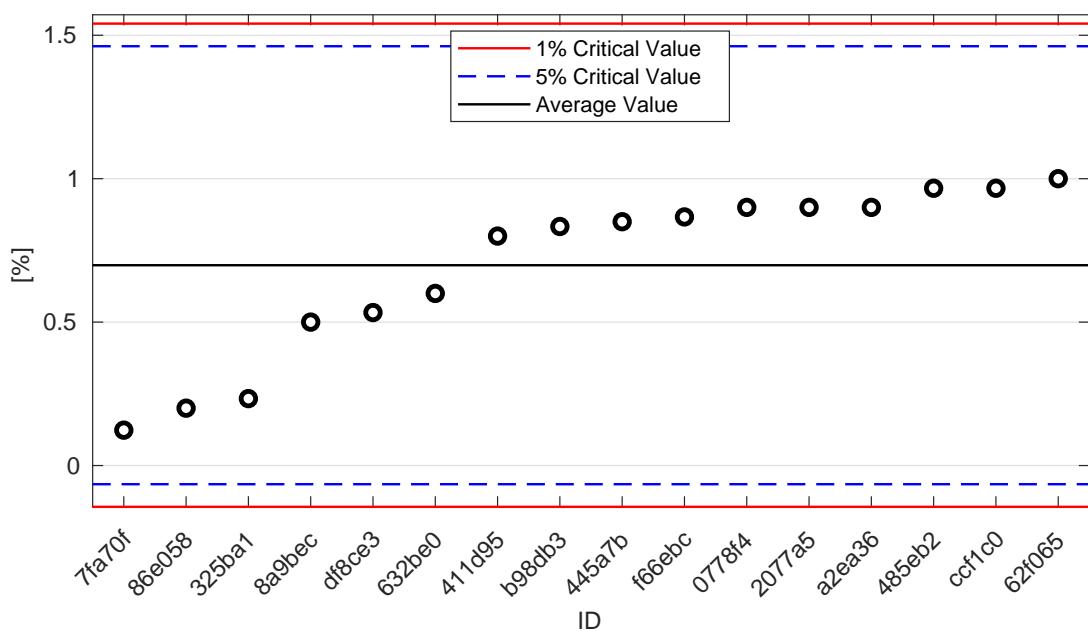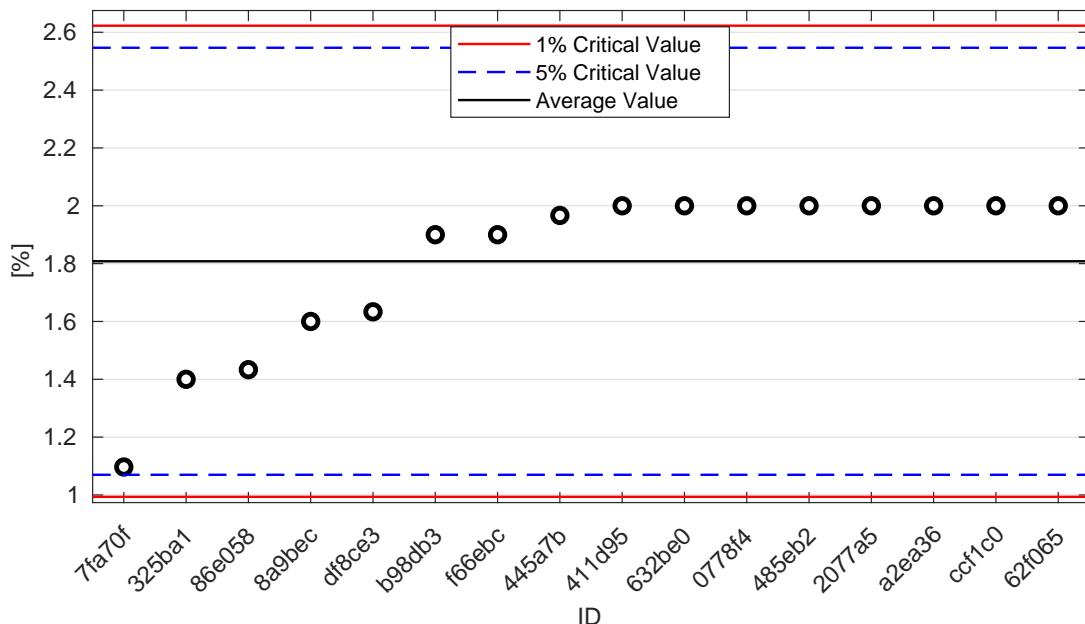Table 15: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
7fa70f	0.0	0.1	0.3	-	0.1	0.1	121.44
86e058	0.2	0.2	0.2	-	0.2	0.0	0.00
325ba1	0.3	0.2	0.2	0.1	0.2	0.1	24.74
8a9bec	0.5	0.5	0.5	0.5	0.5	0.0	0.00
df8ce3	0.6	0.5	0.5	0.1	0.5	0.1	10.83
632be0	0.6	0.6	0.6	0.1	0.6	0.0	0.00
411d95	0.8	-	-	0.1	0.8	0.0	0.00
b98db3	0.9	0.8	0.8	-	0.8	0.1	6.93
f66ebc	0.9	0.9	0.8	2.9	0.9	0.1	6.66
0778f4	0.9	0.9	0.9	0.0	0.9	0.0	0.00
2077a5	1.0	0.8	0.9	3.5	0.9	0.1	11.11
a2ea36	0.9	0.9	0.9	0.1	0.9	0.0	0.00
485eb2	1.0	0.9	1.0	1.0	1.0	0.1	5.97
ccf1c0	1.0	1.0	0.9	1.0	1.0	0.1	5.97
445a7b	0.9	0.8	1.3*	-	1.0	0.3	26.46
62f065	1.1	0.9	1.0	-	1.0	0.1	10.00
bb7b5b*	4.9	3.4	4.1	70.0	4.2	0.7	17.81

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1.7.2   The Numerical Procedure for Determining Outliers

Figure 47: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

Figure 48: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

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Figure 49: **Grubbs' test** - average values without outliers: 1% critical value - red color; 5% critical value - blue color
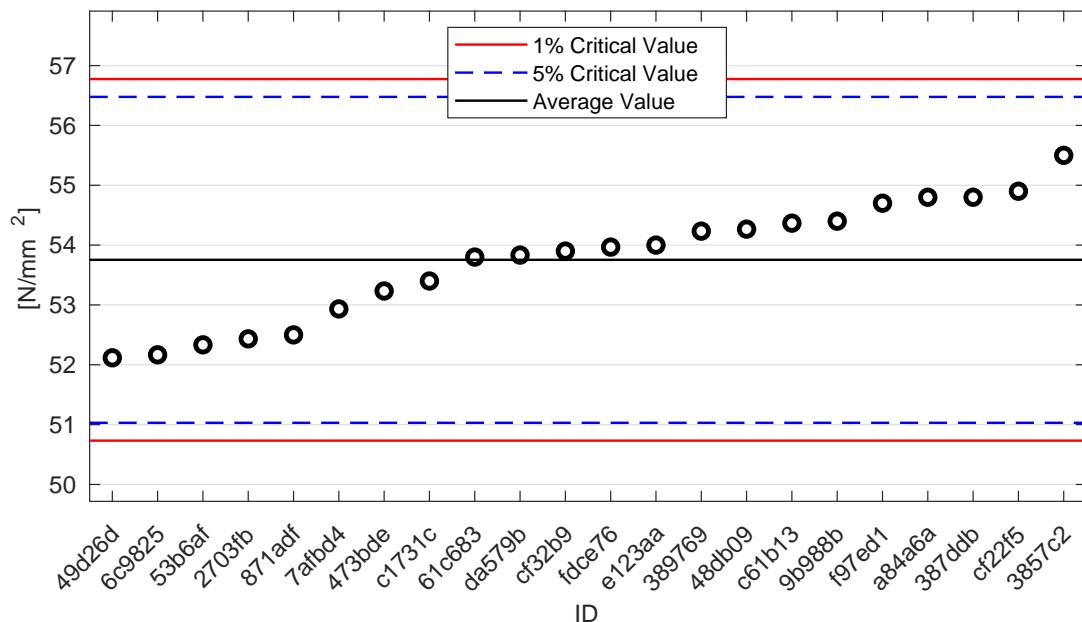
Figure 50: **Grubbs' test** - average values without outliers: 1% critical value - red color; 5% critical value - blue color

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1.7.3 Mandel's Statistics
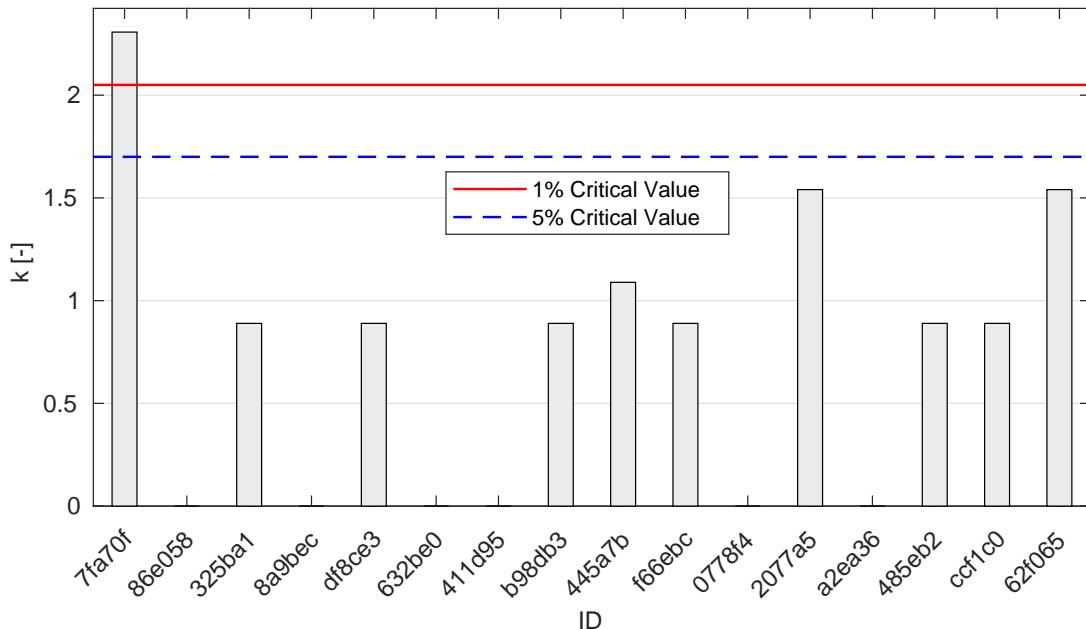
Figure 51: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color
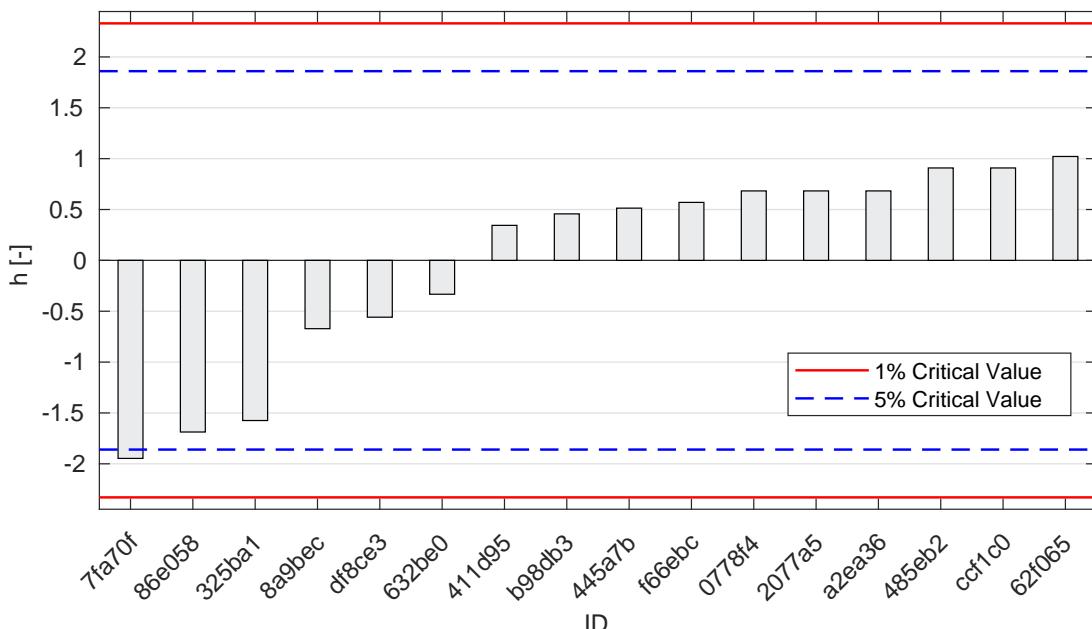
Figure 52: Interlaboratory Consistency Statistic h: 1% critical value - red color; 5% critical value - blue color

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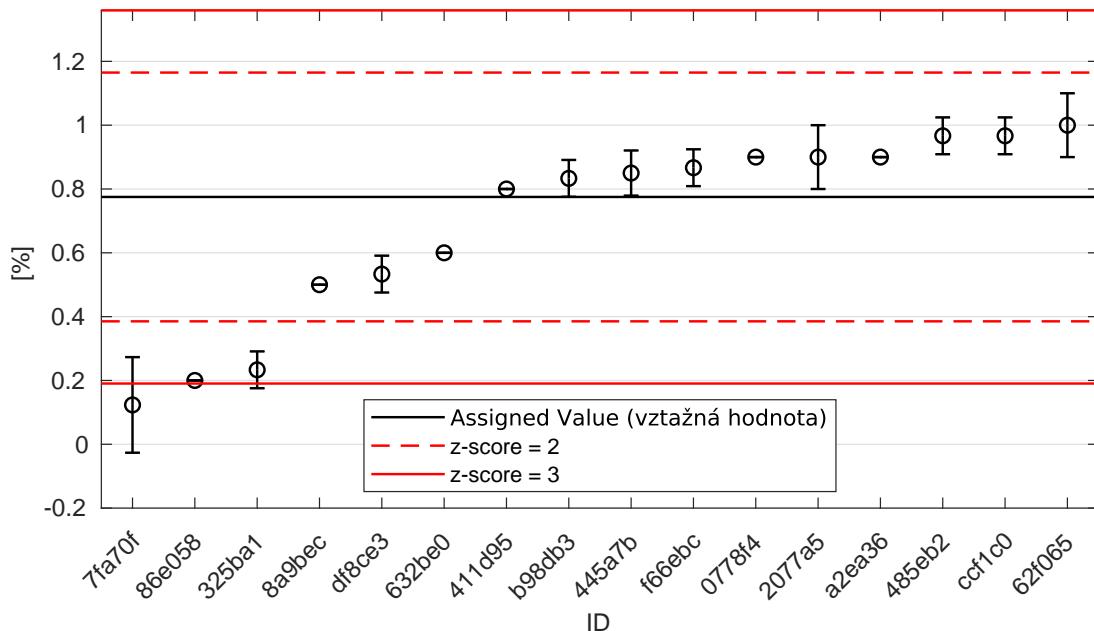
1.7.4 Calculation of Performance Statistics

Figure 53: Average values and sample standard deviations
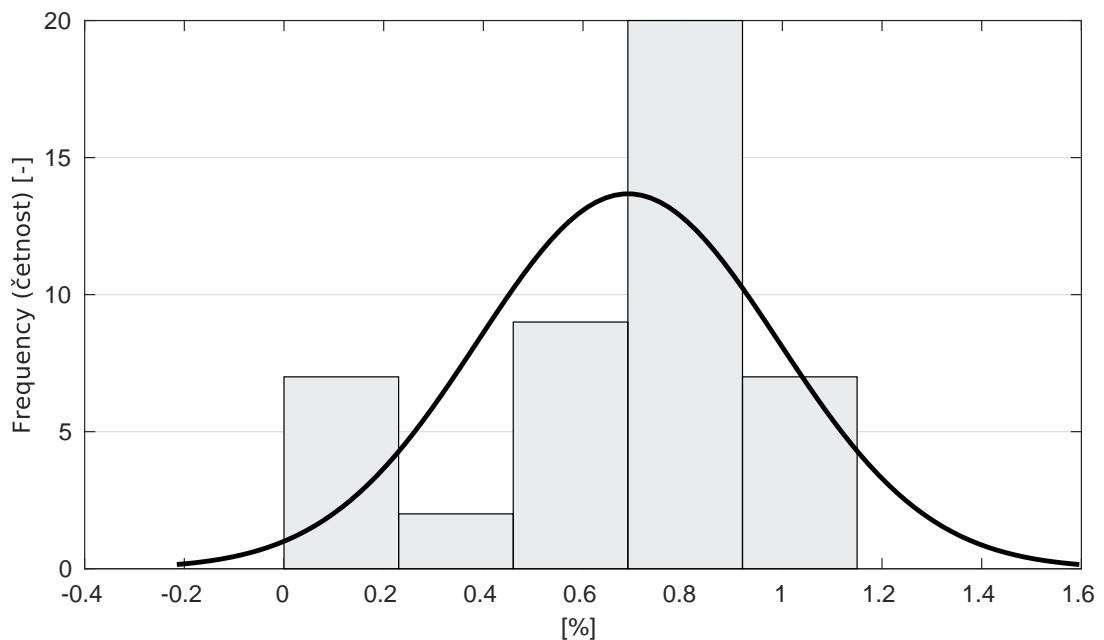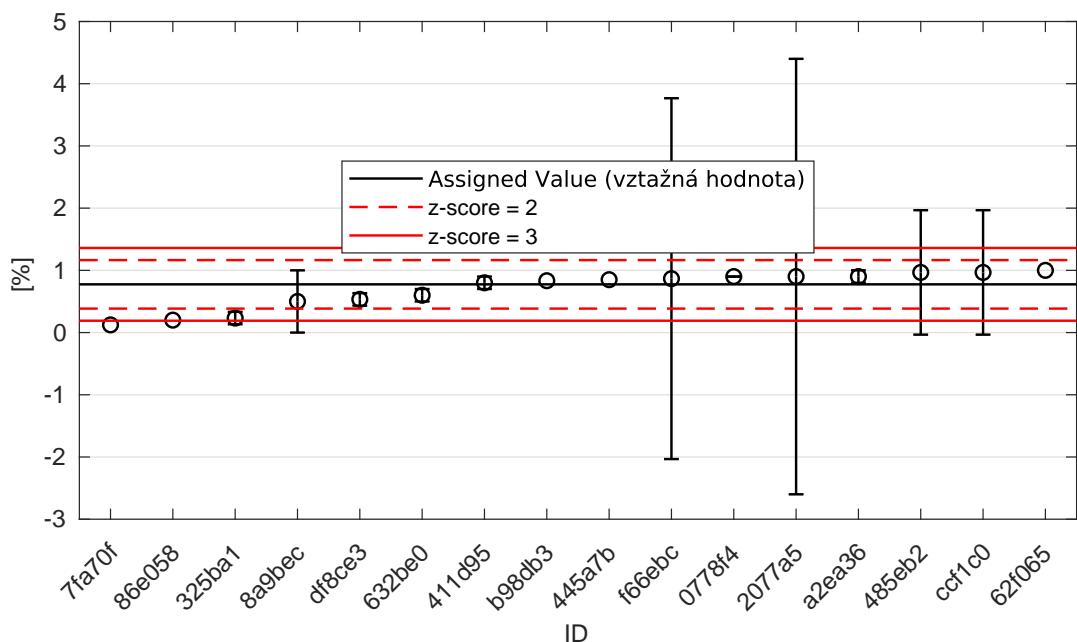

Figure 54: Histogram of all test results

Figure 55: z-score and ζ-score

Table 16: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
7fa70f	-3.34	-
86e058	-2.95	-
325ba1	-2.78	-4.63
8a9bec	-1.41	-0.55
df8ce3	-1.24	-2.06
632be0	-0.90	-1.50
411d95	0.13	0.21
b98db3	0.30	-
445a7b	0.38	-
f66ebc	0.47	0.03
0778f4	0.64	2.05
2077a5	0.64	0.04
a2ea36	0.64	1.07
485eb2	0.98	0.19
ccf1c0	0.98	0.19
62f065	1.15	-

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1.8 Summary

Table 17: $z-score$ values

ID	4 mm	2 mm	1 mm	0.5 mm	0.25 mm	0.125 mm	0.063 mm
0778f4	-0.68	-1.94	-1.28	-3.32	-2.84	0.50	0.64
2077a5	0.53	-0.55	0.26	0.31	1.00	0.50	0.64
325ba1	-0.28	1.01	4.20	2.44	0.69	-1.14	-2.78
411d95	0.67	0.05	-0.58	-0.30	0.29	0.50	0.13
445a7b	0.40	-0.45	-0.51	-0.56	0.11	0.41	0.38
485eb2	-0.68	0.71	1.51	0.28	-0.16	0.50	0.98
62f065	-0.28	0.15	-0.02	0.05	-1.19	0.50	1.15
632be0	0.67	1.04	0.47	-0.30	0.29	0.50	-0.90
7fa70f	-0.25	-0.48	-0.73	-1.32	-1.35	-1.96	-3.34
86e058	0.53	1.53	03.01	1.20	0.38	-1.05	-2.95
8a9bec	1.48	0.24	0.36	0.91	0.56	-0.59	-1.41
a2ea36	0.67	1.37	1.51	0.57	1.63	0.50	0.64
b98db3	1.34	0.21	0.15	-0.18	-0.03	0.23	0.30
bb7b5b	-5.82	-1.74	-0.30	1.14	3.55	-	-
ccf1c0	-3.38	-2.60	-3.72	-1.74	-1.06	0.50	0.98
df8ce3	-0.82	-0.38	-0.20	0.28	-0.34	-0.50	-1.24
f66ebc	-0.28	-0.45	-1.56	-0.90	-0.97	0.23	0.47

2 Appendix – EN 933-3 Determination of particle shape - Flakiness index

2.1 Test results

Table 18: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
a10c83	10.0	10.0	10.0	0.0	10.0	0.0	0.00
632be0	12.0	12.0	12.0	0.7	12.0	0.0	0.00
f90120	12.0	12.0	12.0	0.0	12.0	0.0	0.00
a2ea36	12.0	12.0	12.0	1.0	12.0	0.0	0.00
14b449	12.0	12.0	12.0	1.0	12.0	0.0	0.00
1443ba	13.0	13.0	13.0	0.0	13.0	0.0	0.00
3e47f1	14.7	14.2	14.0	0.2	14.3	0.3	2.40
62f065	14.7	13.9	14.3	0.3	14.3	0.4	2.80
ccf1c0	16.0	16.0	17.0	2.0	16.3	0.6	3.53

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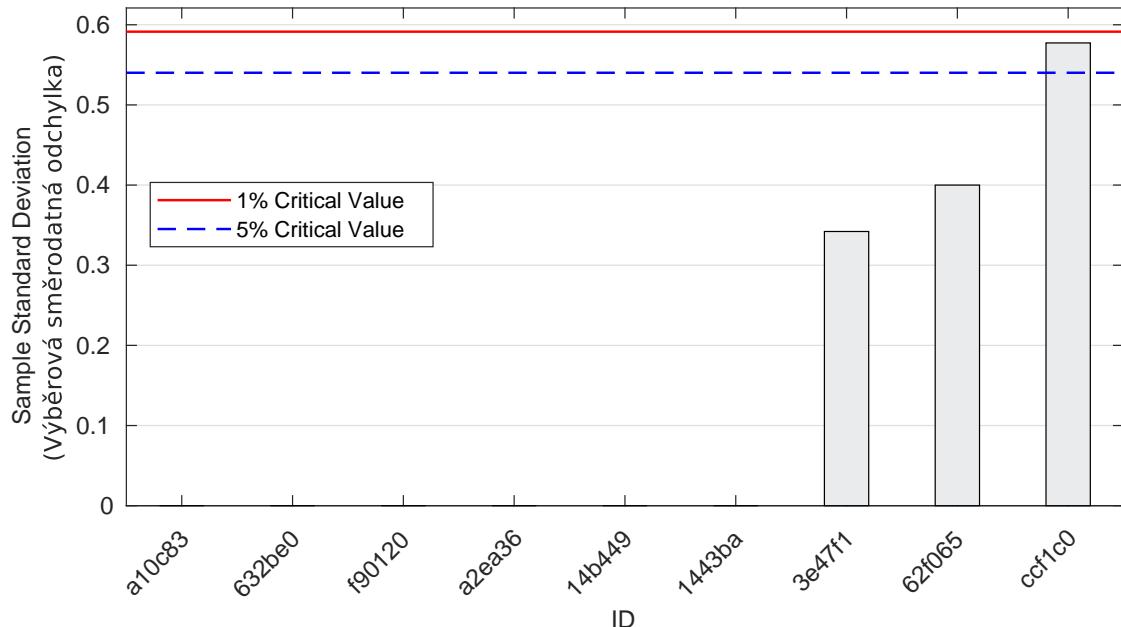## 2.2   The Numerical Procedure for Determining Outliers

Figure 56: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color
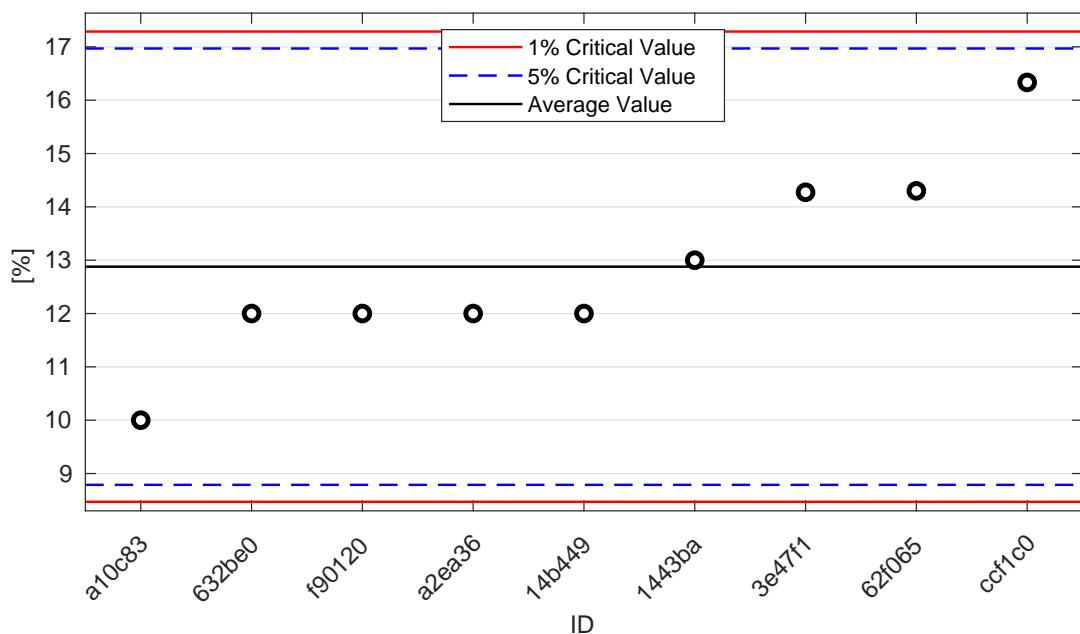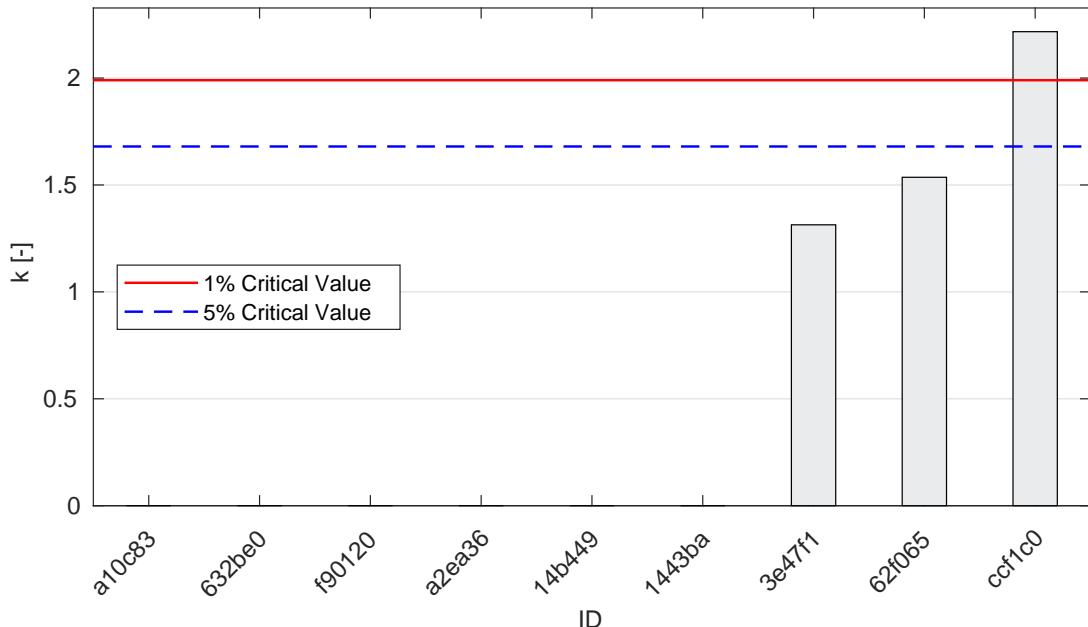

Figure 57: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

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2.3   Mandel's Statistics

Figure 58: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color
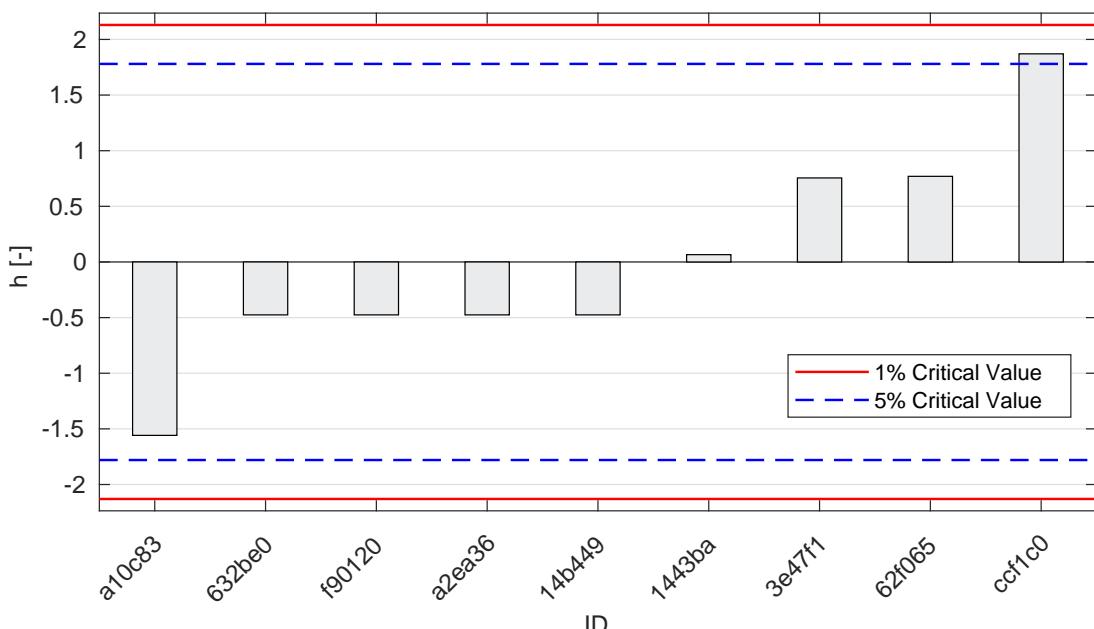
Figure 59: Interlaboratory Consistency Statistic h: 1% critical value - red color; 5% critical value - blue color

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2.4 Calculation of Performance Statistics
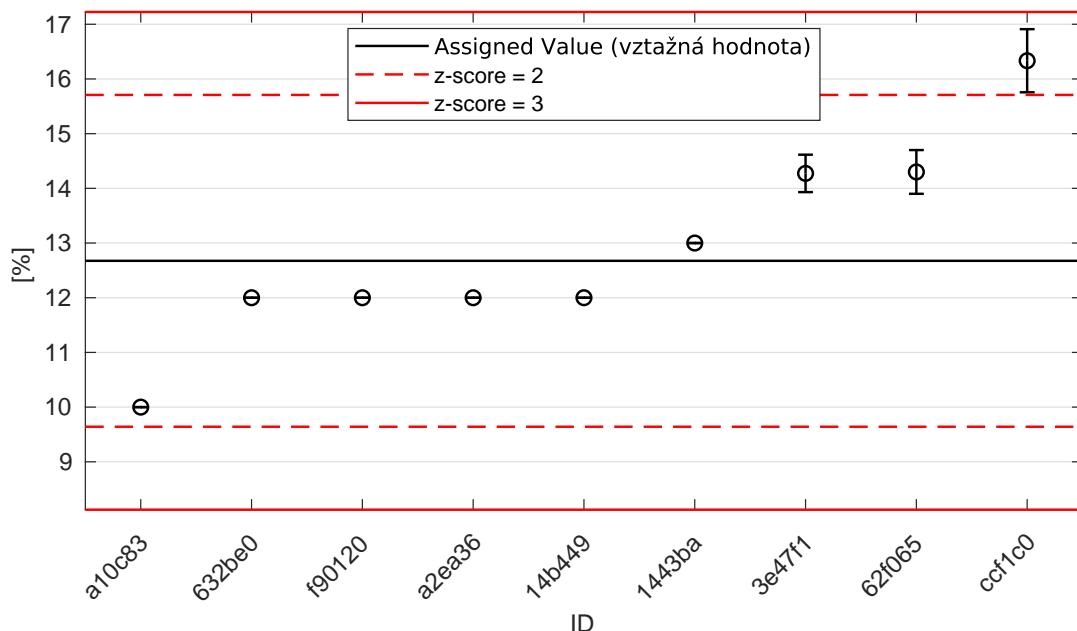

Figure 60: Average values and sample standard deviations
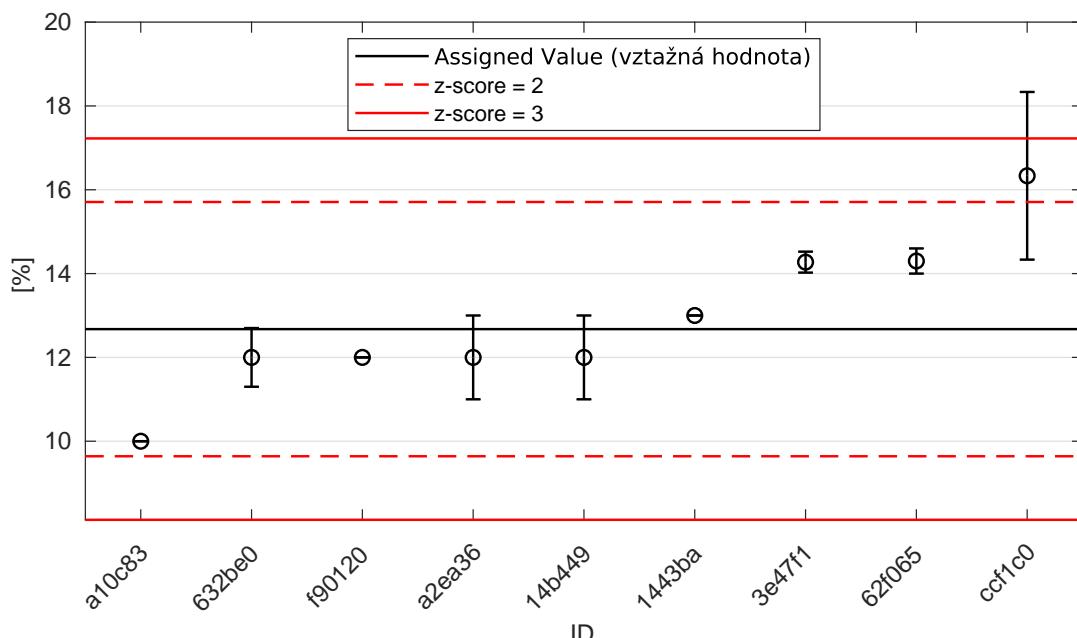
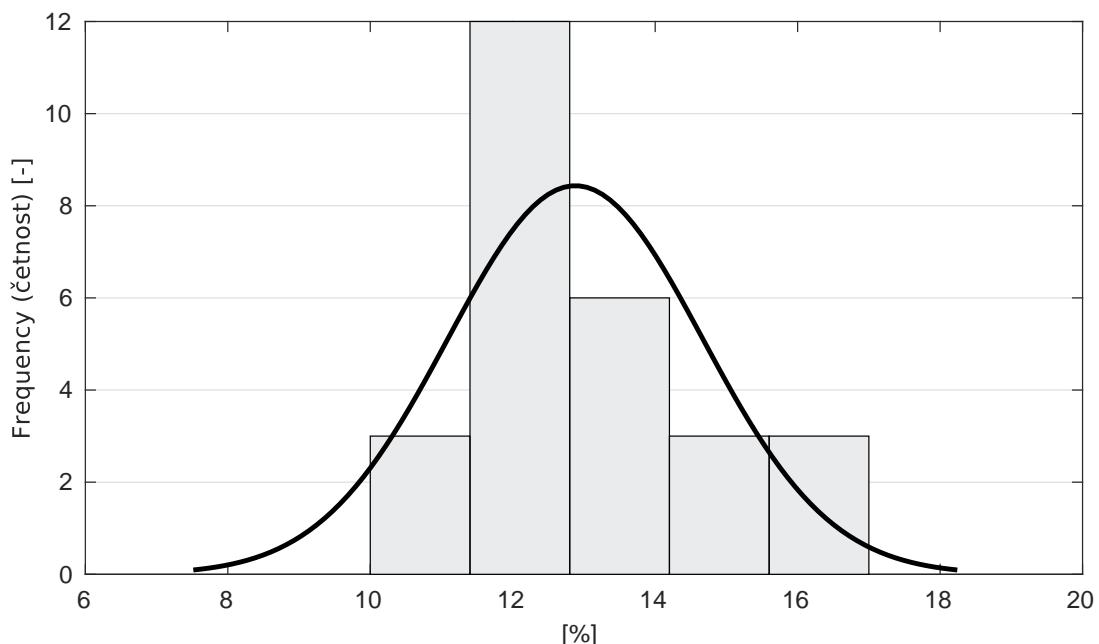Figure 61: Average values and extended uncertainties of measurement

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Figure 62: Histogram of all test results

Figure 63: z-score and ζ-score

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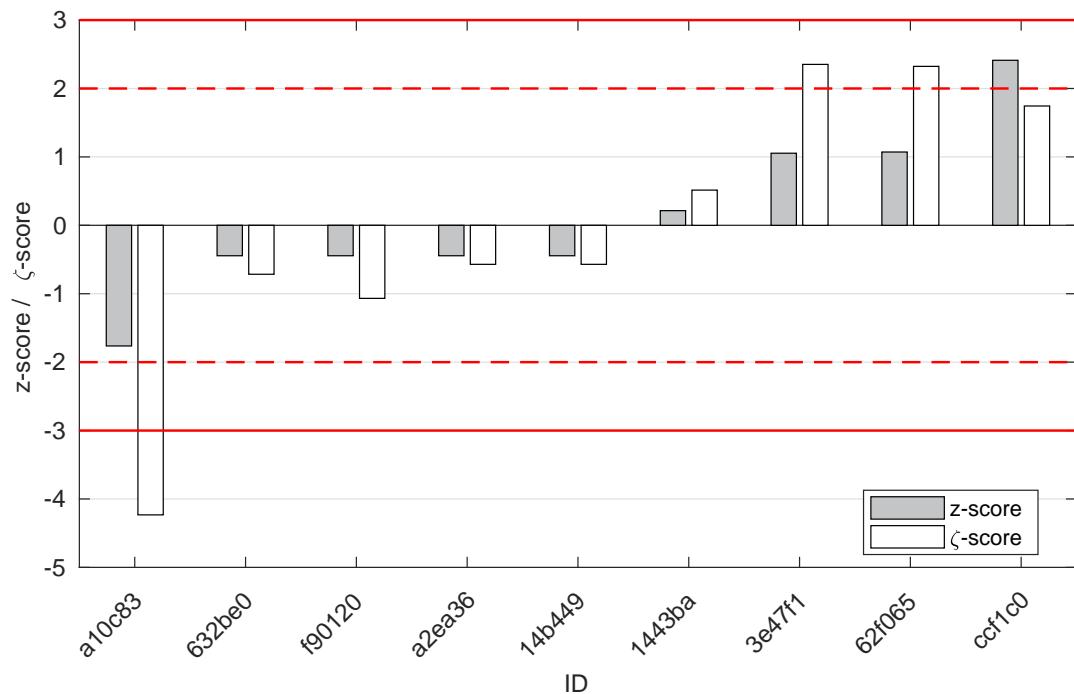
Table 19: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
a10c83	-1.76	-4.23
632be0	-0.44	-0.72
f90120	-0.44	-1.07
a2ea36	-0.44	-0.57
14b449	-0.44	-0.57
1443ba	0.21	0.51
3e47f1	1.05	2.35
62f065	1.07	2.32
ccf1c0	2.41	1.74

3   Appendix – EN 933-4 Determination of particle shape - Shape index

3.1   Test results

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

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
8a9bec	13.1	13.0	13.0	13.0	13.0	0.1	0.44
0778f4	15.0	14.0	12.0*	1.8	13.7	1.5	11.18
df8ce3	13.7	14.2	13.8	0.5	13.9	0.3	1.90
62f065	14.3	15.0	16.1	0.3	15.1	0.9	6.00
f66ebc	16.5	16.3	15.9	3.0	16.2	0.3	1.88
485eb2	17.0	17.0	17.0	0.1	17.0	0.0	0.00
411d95	18.0	18.0	18.0	1.0	18.0	0.0	0.00
2077a5	18.0	19.0	19.0	2.3	18.7	0.6	3.09
ccf1c0	21.0	-	-	-	21.0	0.0	0.00
325ba1	23.3	22.3	21.8	1.7	22.5	0.8	3.40

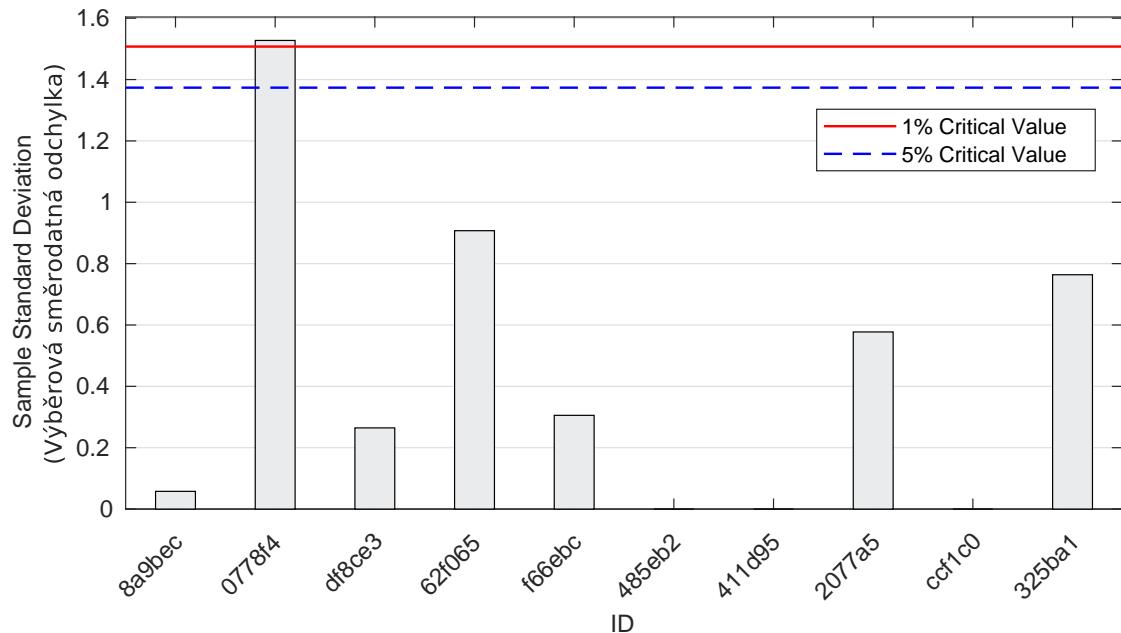## 3.2   The Numerical Procedure for Determining Outliers

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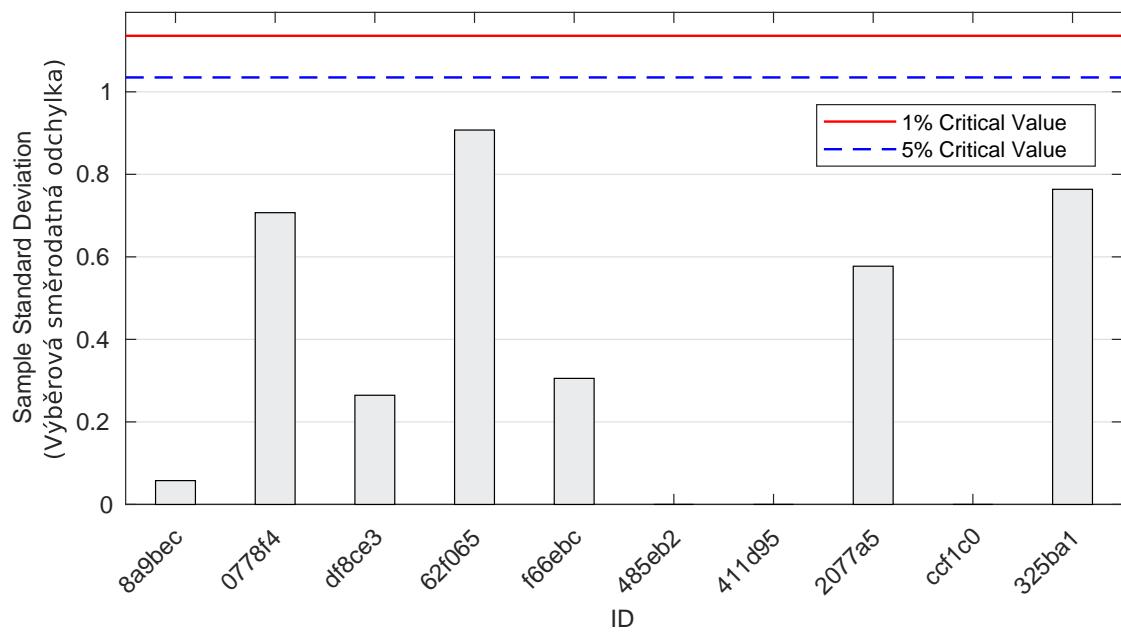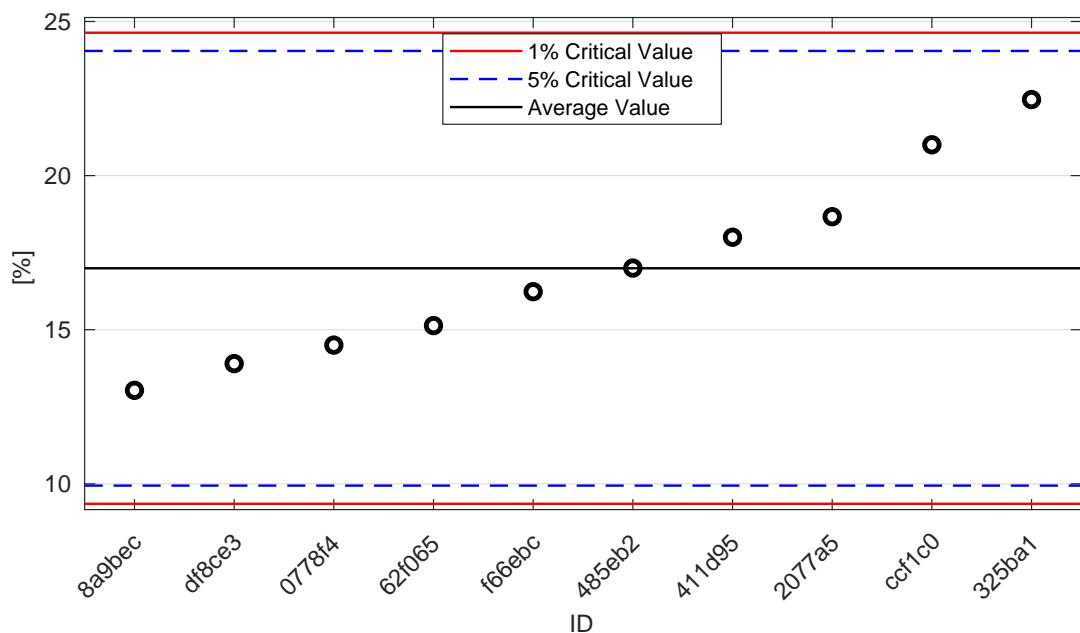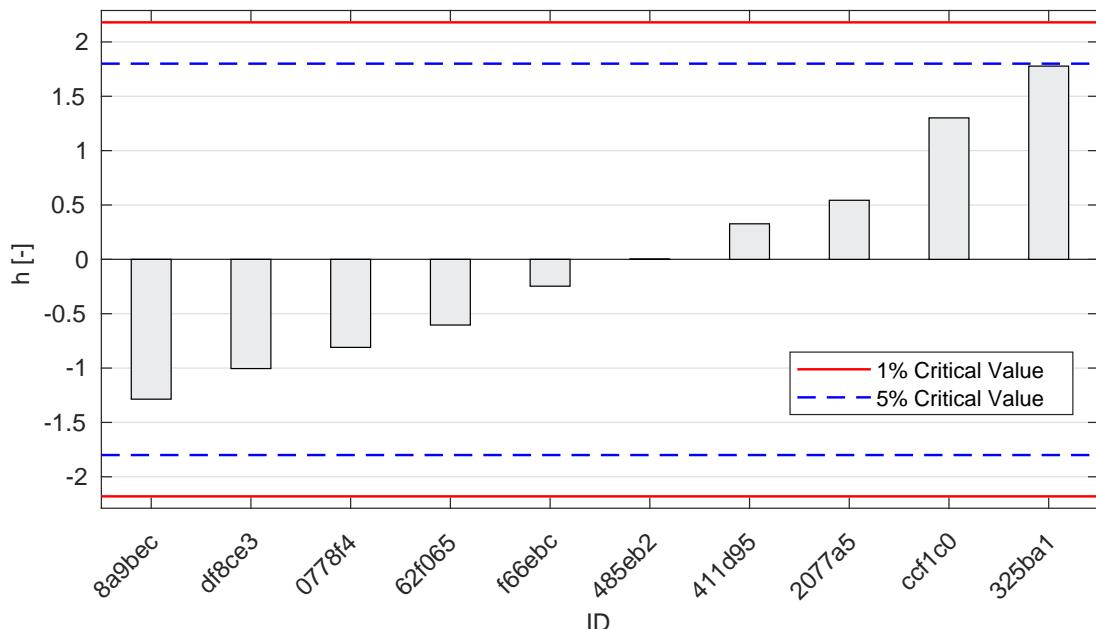

Figure 65: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color

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

3.3 Mandel's Statistics
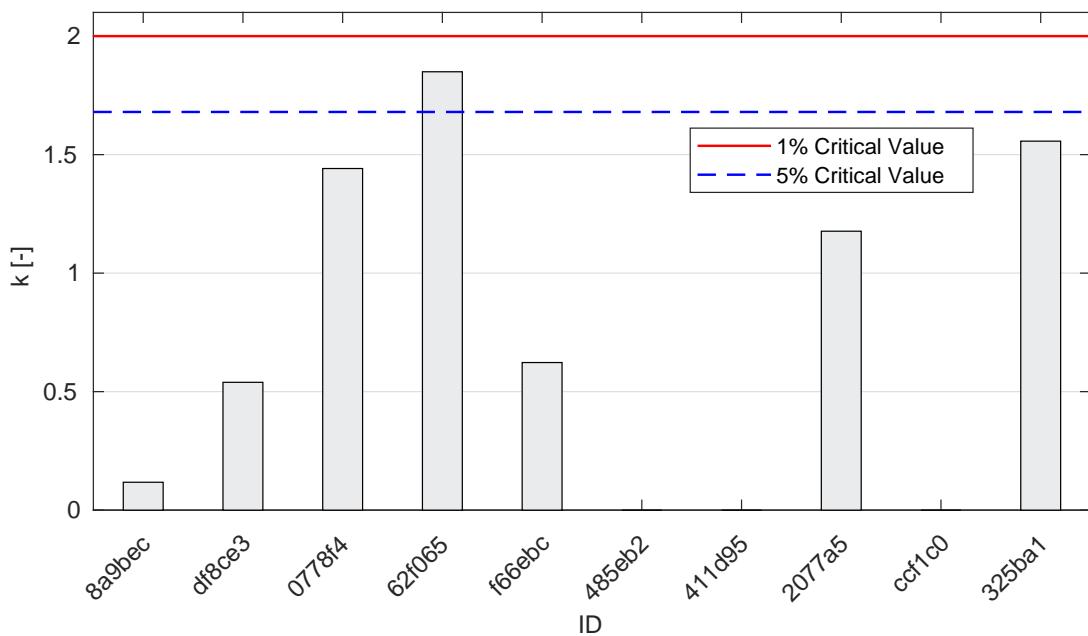
Figure 67: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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Figure 68: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color
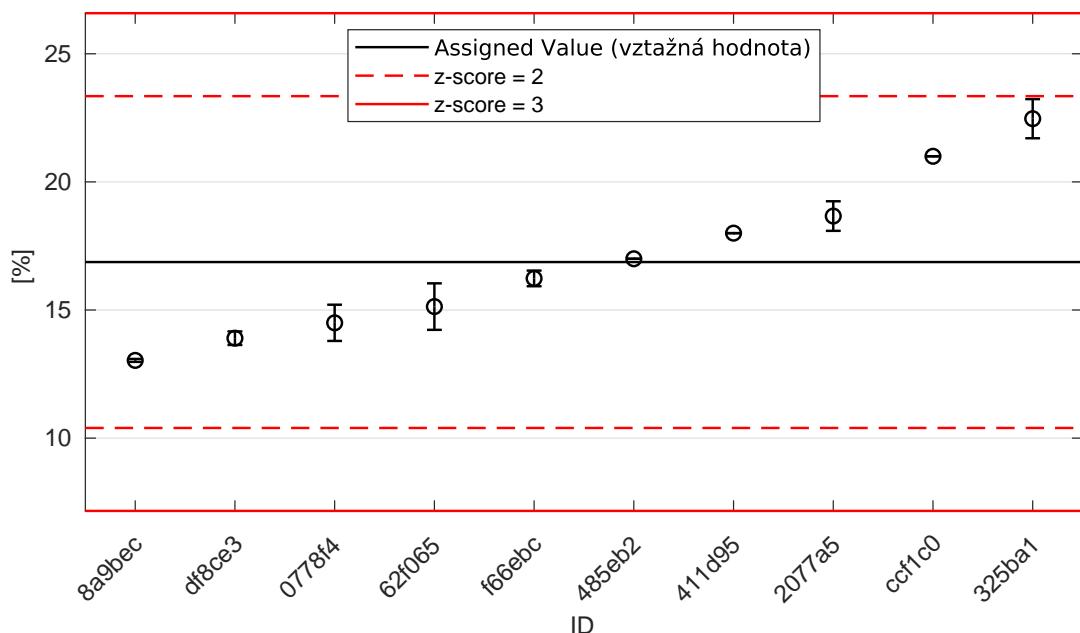
3.4 Calculation of Performance Statistics
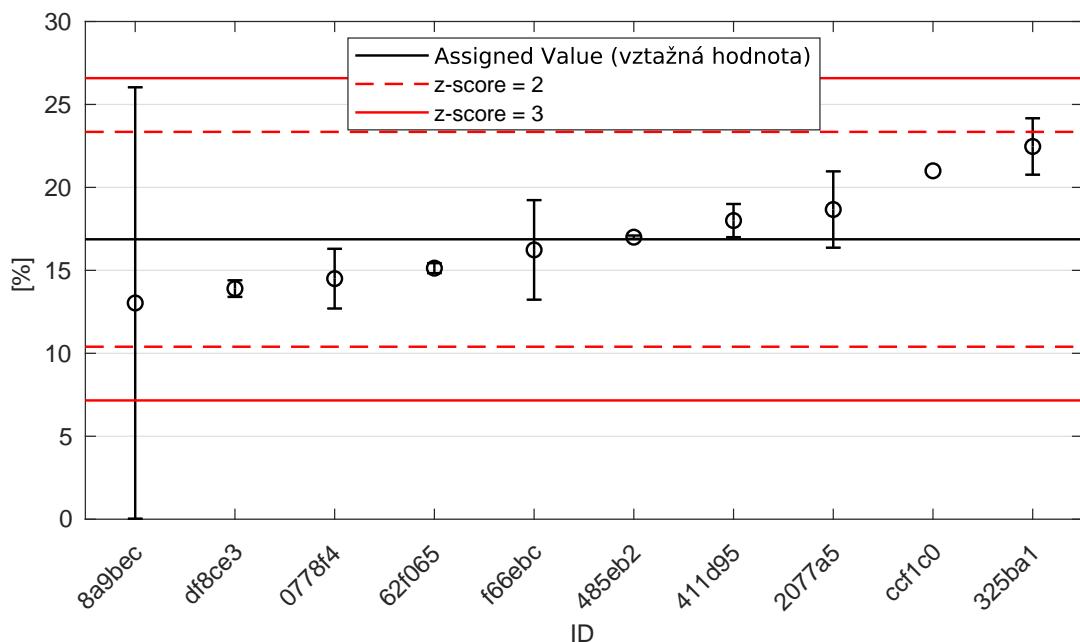

Figure 69: Average values and sample standard deviations

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Figure 70: Average values and extended uncertainties of measurement
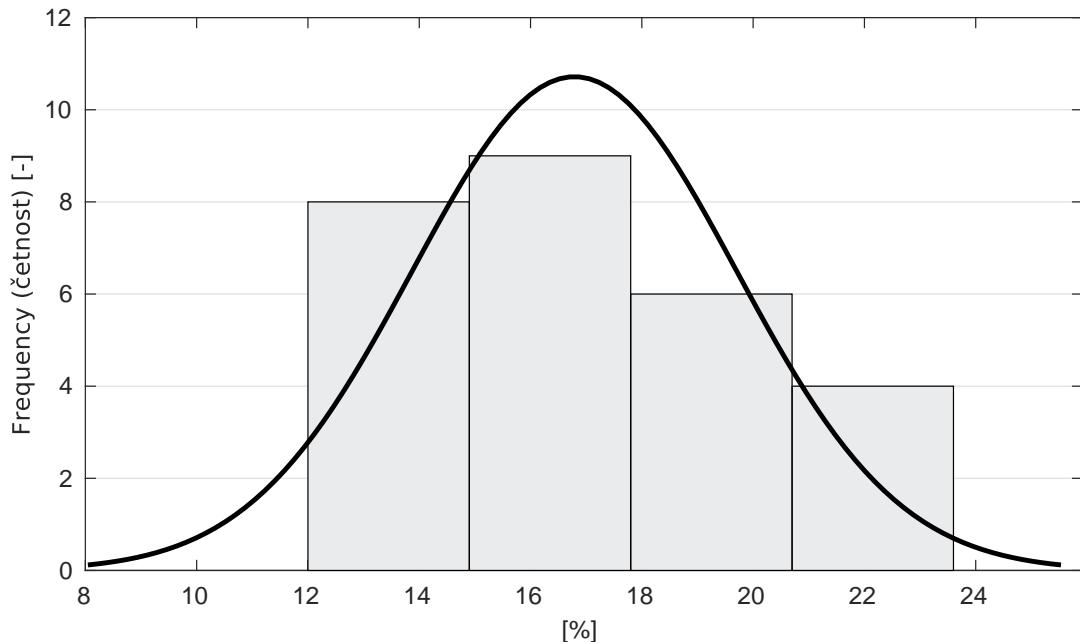
Figure 71: Histogram of all test results

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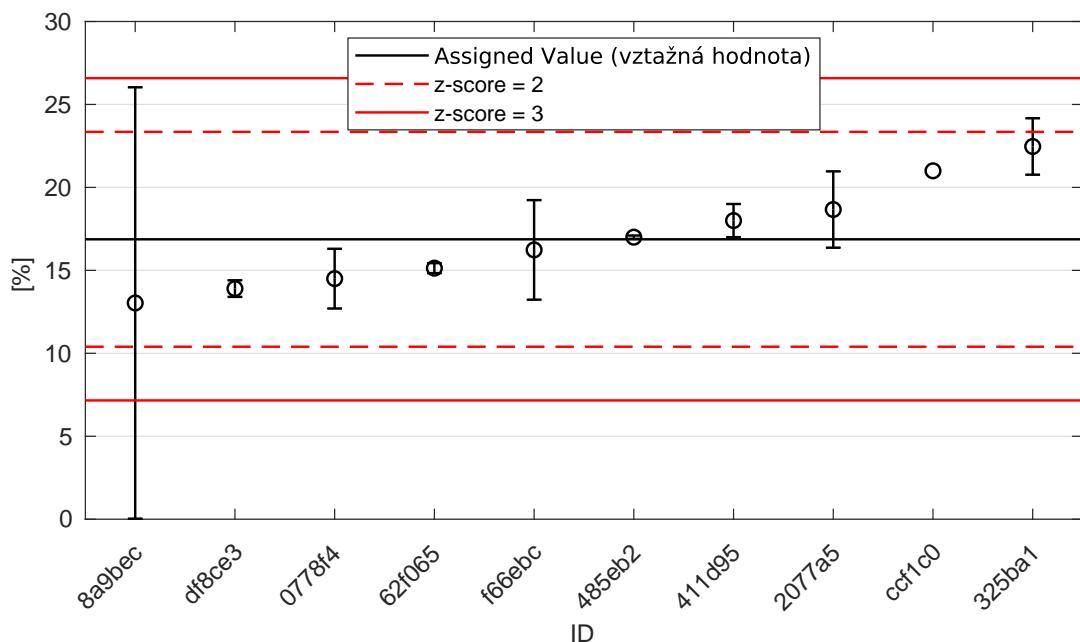
Figure 72: z-score and ζ-score

Table 21: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
8a9bec	-1.19	-0.29
df8ce3	-0.92	-2.16
0778f4	-0.73	-1.07
62f065	-0.54	-1.32
f66ebc	-0.20	-0.20
485eb2	0.04	0.10
411d95	0.35	0.69
2077a5	0.55	0.68
ccf1c0	1.28	-
325ba1	1.73	2.63

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4 Appendix – EN 933-5 Determinationm of percentage of crushed and broken surfaces in coarse aggregate particles

4.1 C_{tc}

4.1.1 Test results

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

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
632be0	0.00	0.00	0.00	2.00	0.00	0.00	-
62f065	0.00	0.00	0.50	0.10	0.17	0.29	173.21
c44a23	1.00	1.00	1.00	1.00	1.00	0.00	0.00
ccf1c0	1.00	-	-	-	1.00	0.00	0.00
3e47f1	1.54	1.88	1.25	3.00	1.56	0.32	20.26

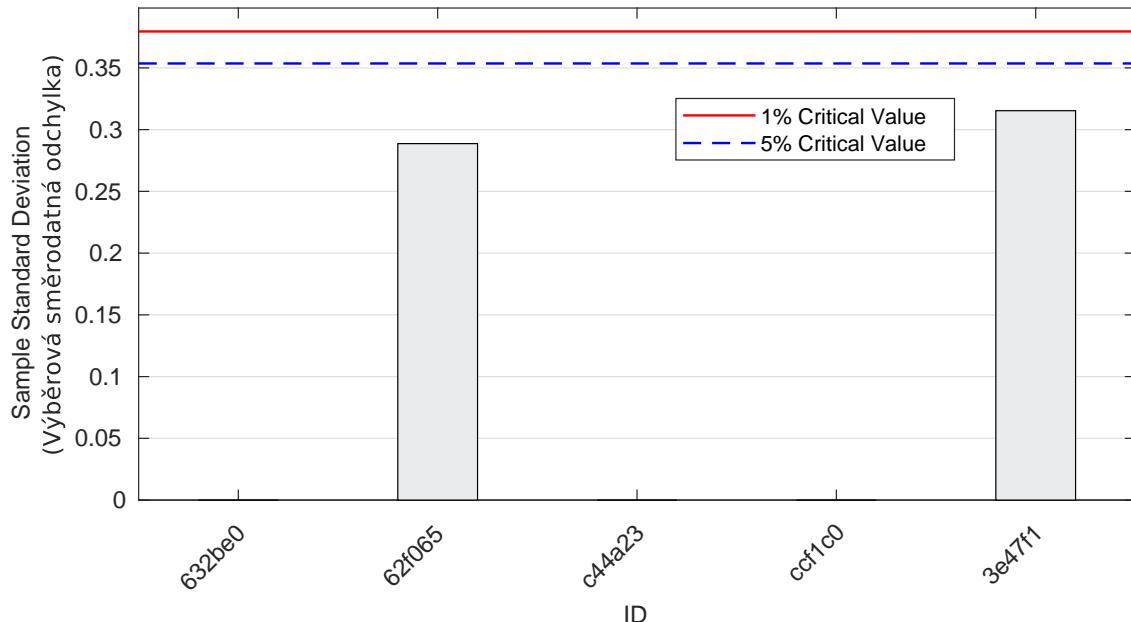### 4.1.2 The Numerical Procedure for Determining Outliers
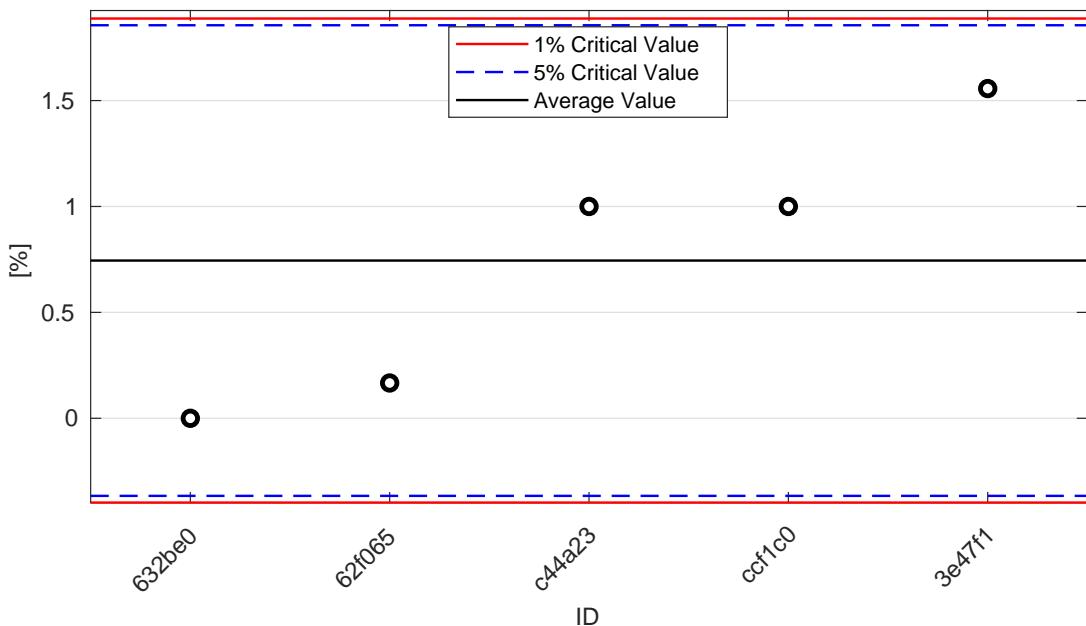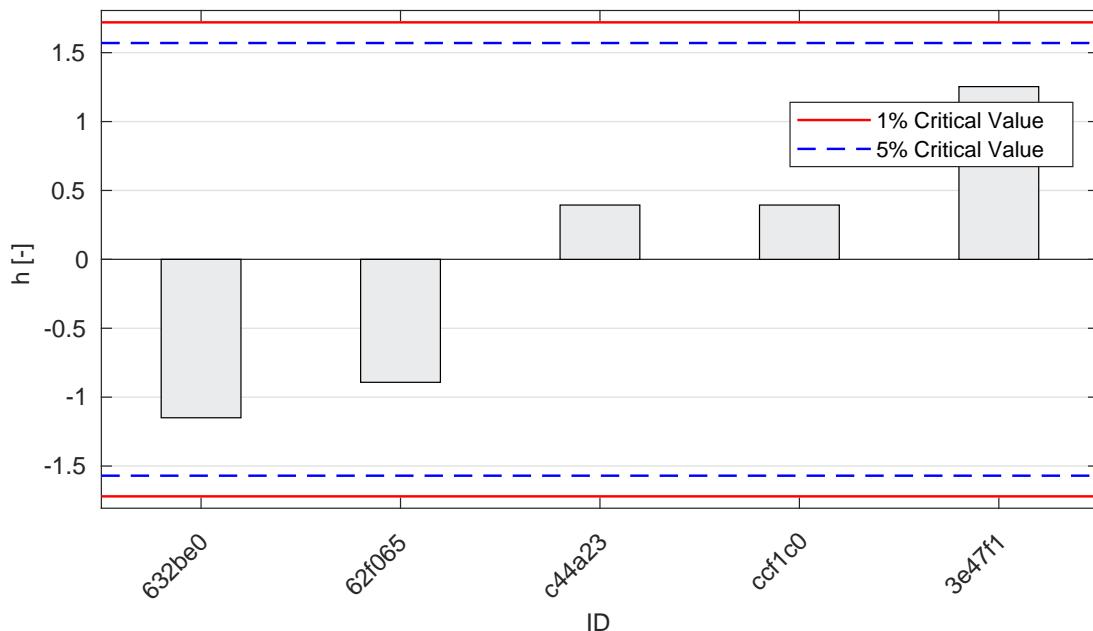

Figure 73: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

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Figure 74: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

4.1.3 Mandel's Statistics
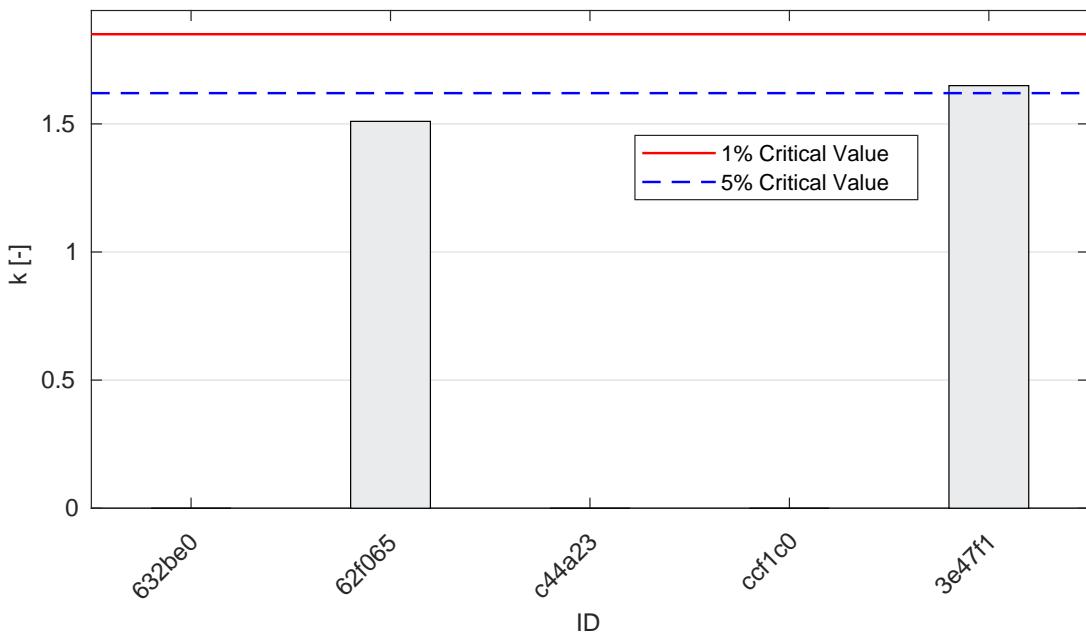
Figure 75: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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Figure 76: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color
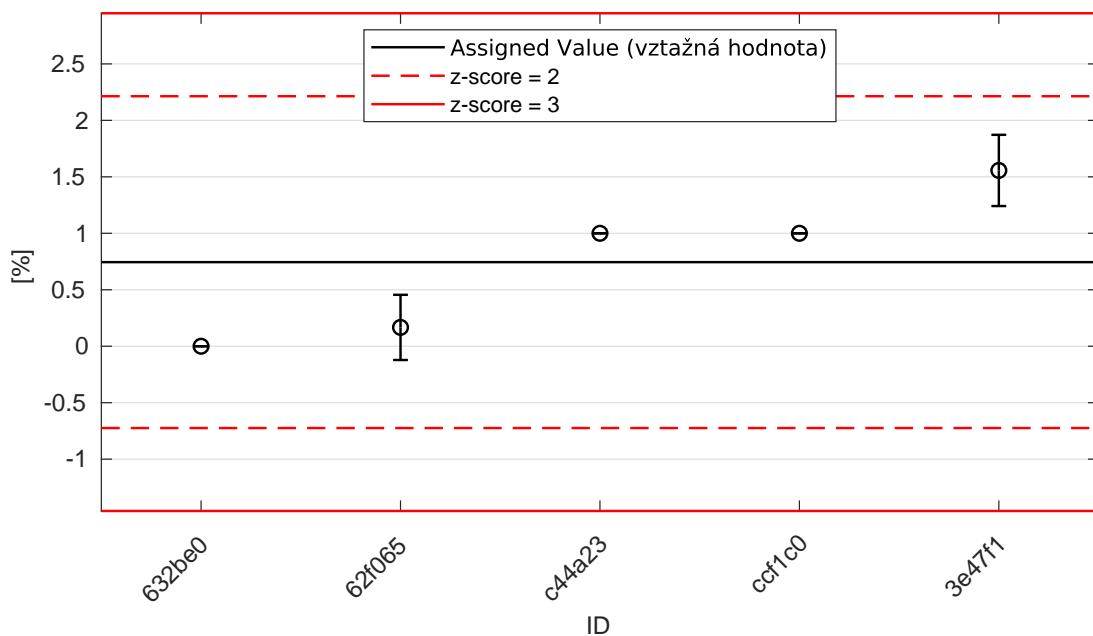
4.1.4 Calculation of Performance Statistics
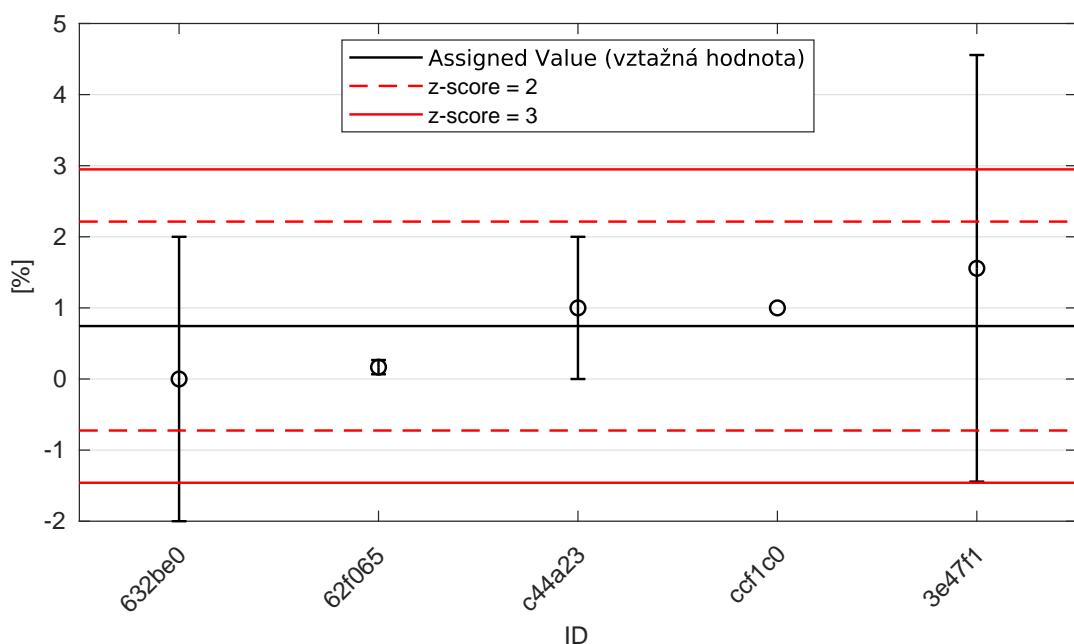

Figure 77: Average values and sample standard deviations

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Figure 78: Average values and extended uncertainties of measurement
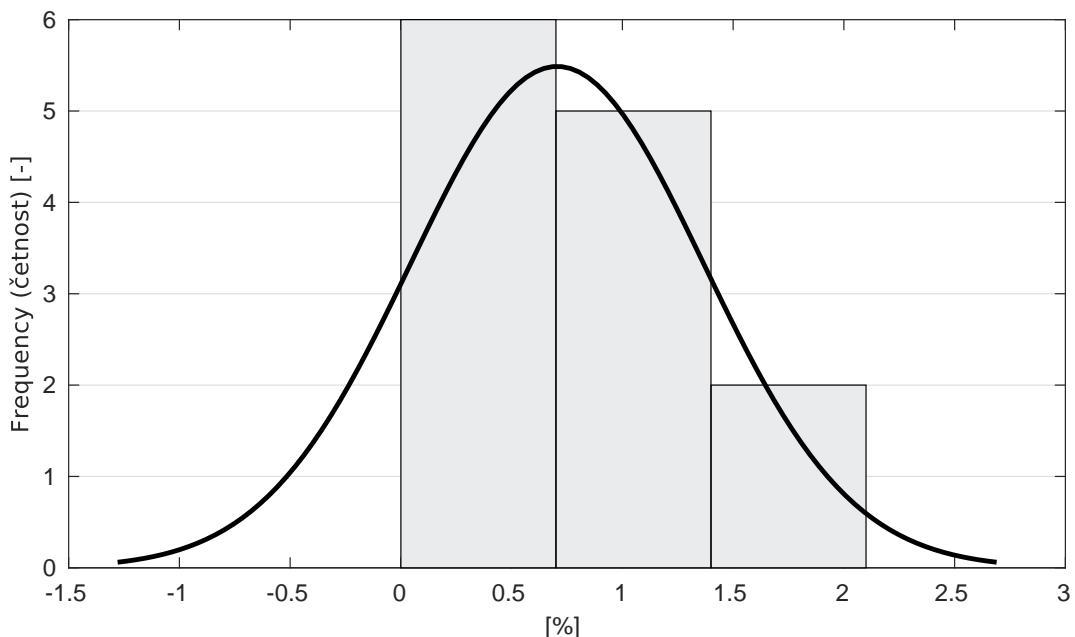
Figure 79: Histogram of all test results

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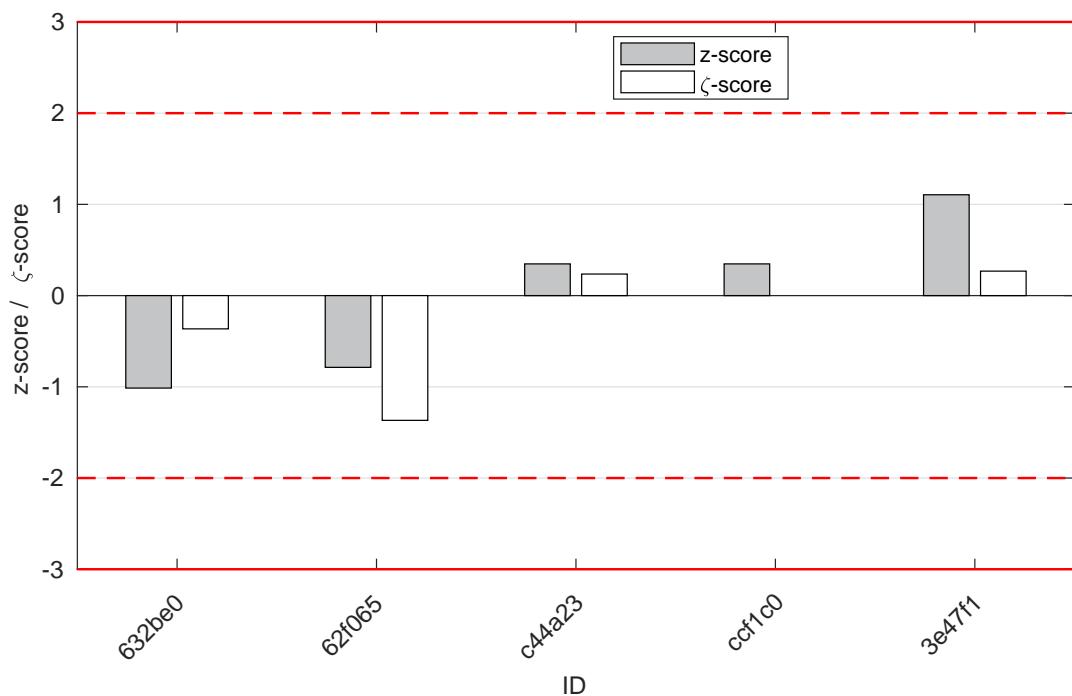
Figure 80: z-score and ζ-score

Table 23: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
632be0	-1.01	-0.36
62f065	-0.79	-1.37
c44a23	0.35	0.24
ccf1c0	0.35	-
3e47f1	1.11	0.27

4.2 C_c

4.2.1 Test results

Table 24: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
62f065	1.70	1.90	1.90	0.00	1.83	0.12	6.30
c44a23	2.00	2.00	2.00	1.00	2.00	0.00	0.00
ccf1c0	2.00	-	-	-	2.00	0.00	0.00
632be0	7.00	7.00	7.00	2.00	7.00	0.00	0.00
3e47f1	7.77	19.01*	6.17	3.00	10.98	7.00	63.71

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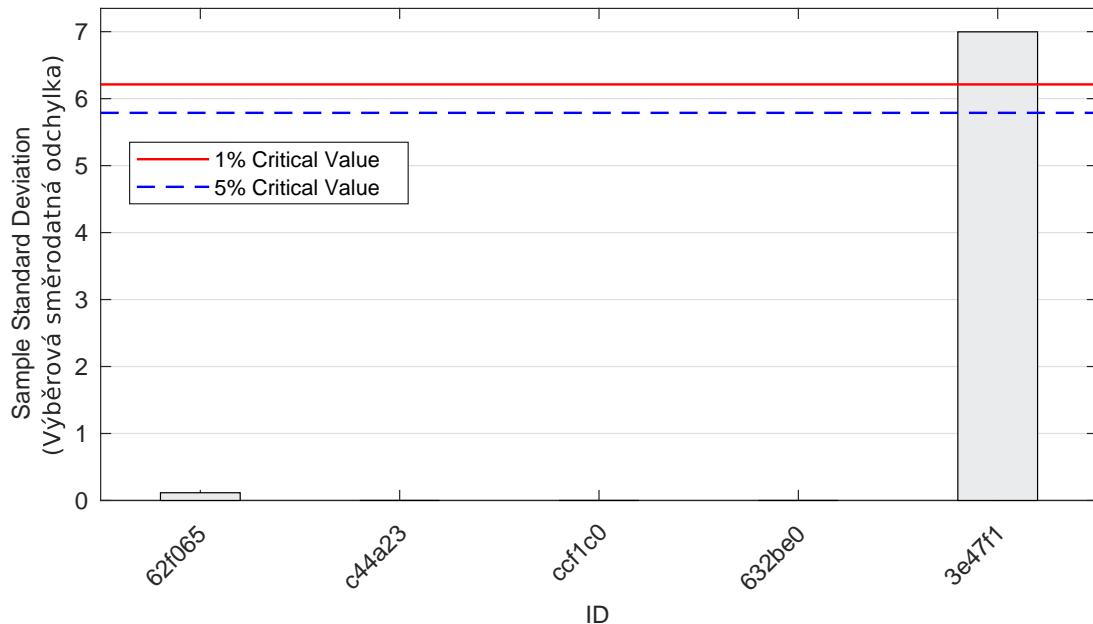### 4.2.2   The Numerical Procedure for Determining Outliers

Figure 81: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color
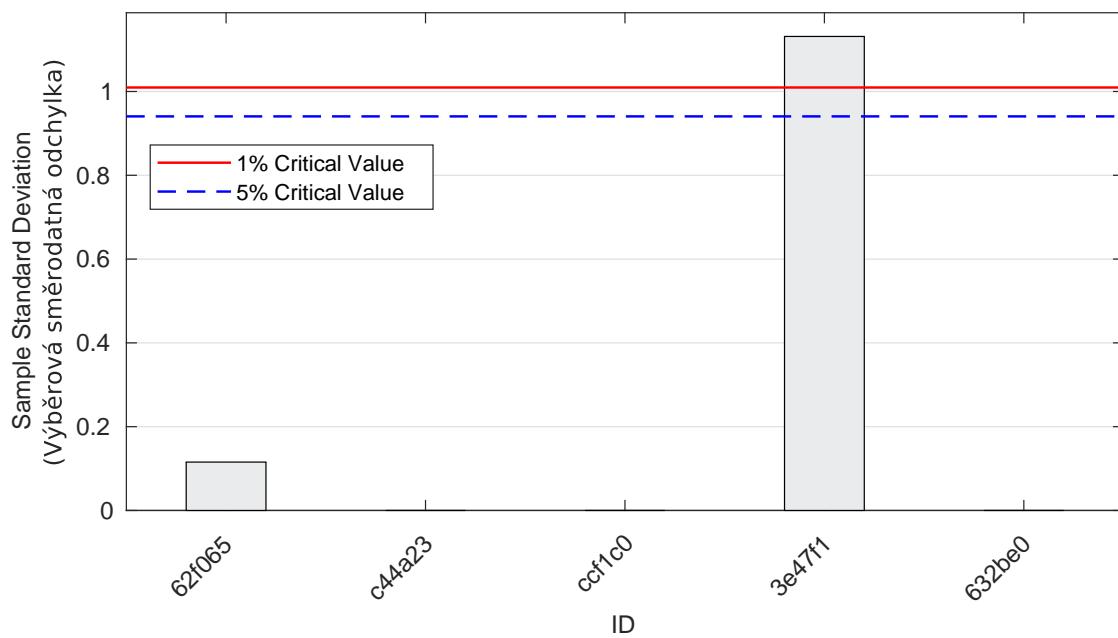

Figure 82: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color
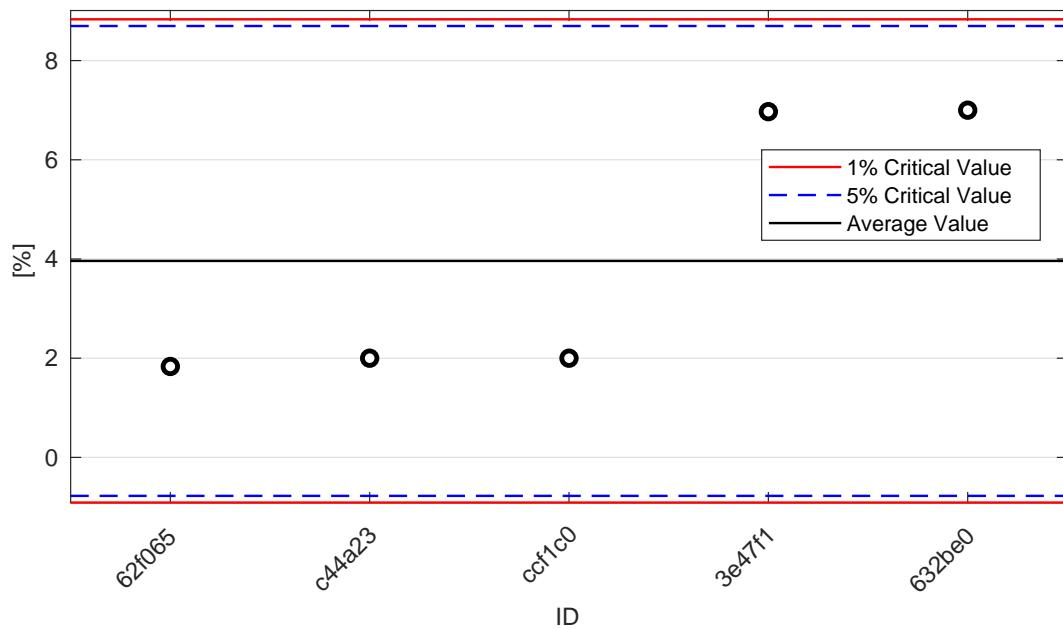
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Figure 83: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color
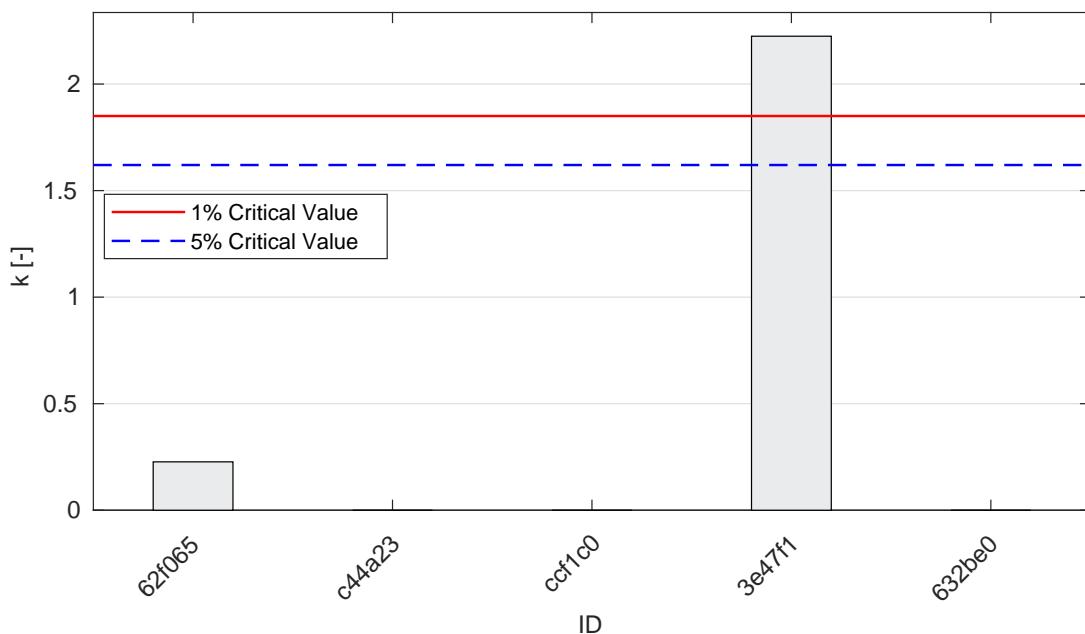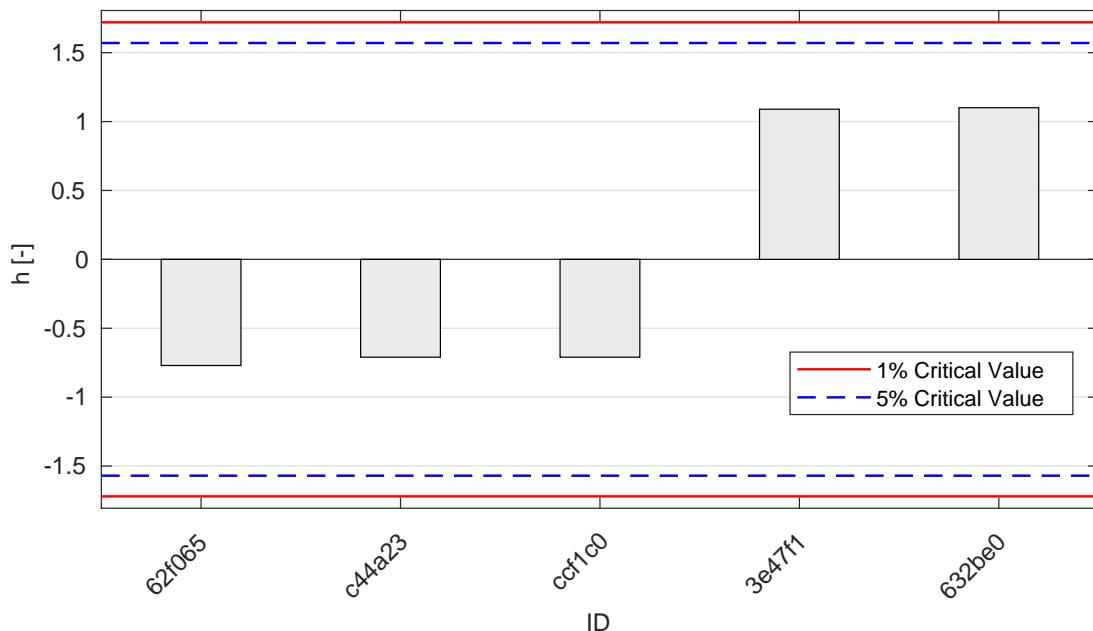
4.2.3 Mandel's Statistics

Figure 84: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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Figure 85: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color
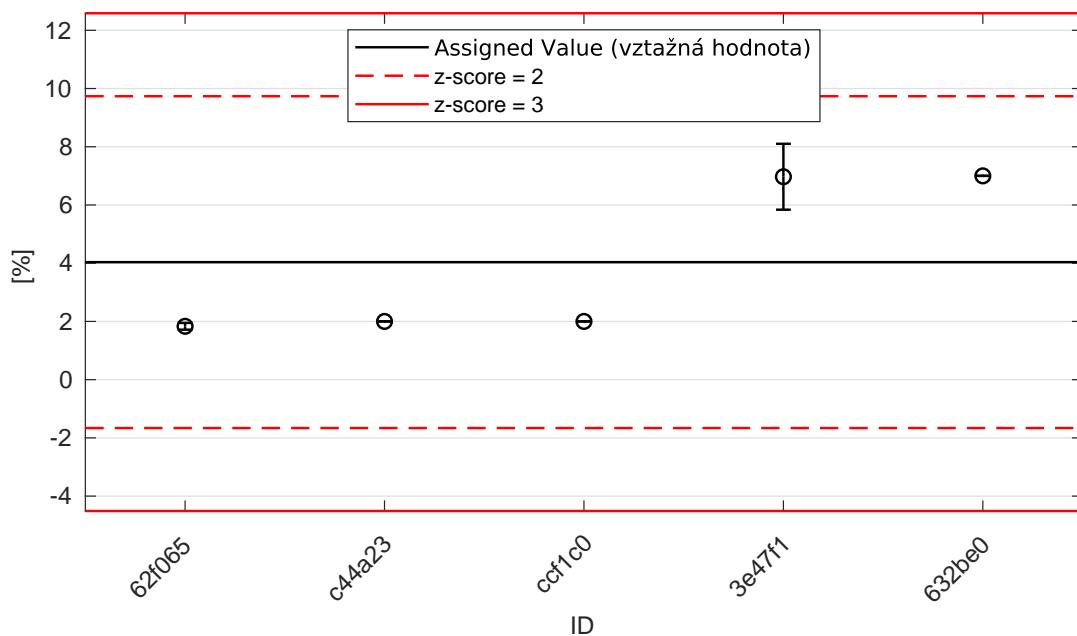
4.2.4 Calculation of Performance Statistics
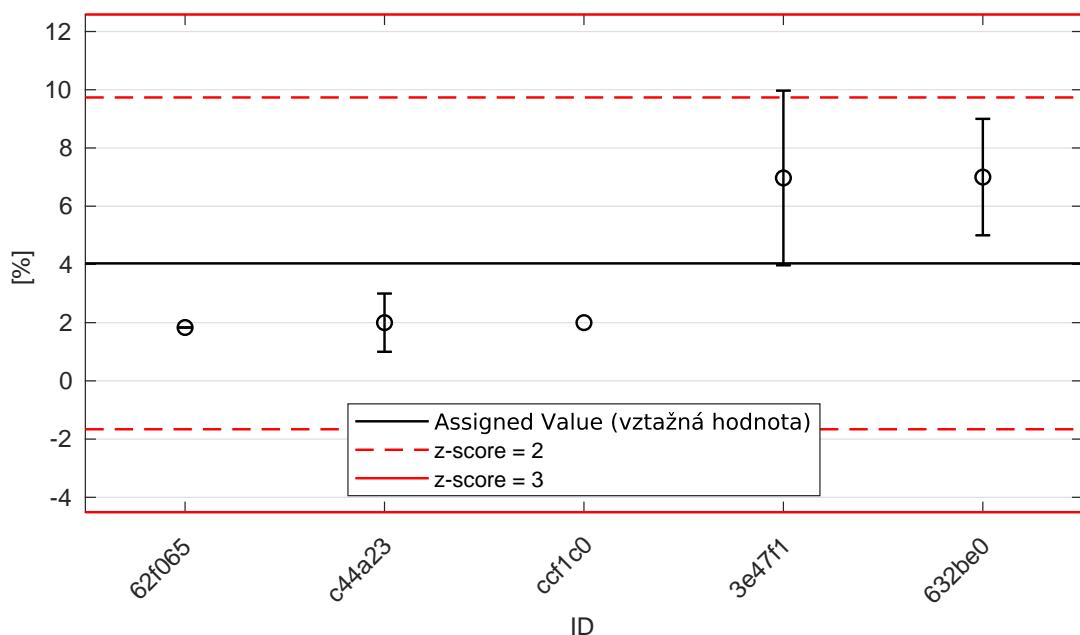

Figure 86: Average values and sample standard deviations

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Figure 87: Average values and extended uncertainties of measurement
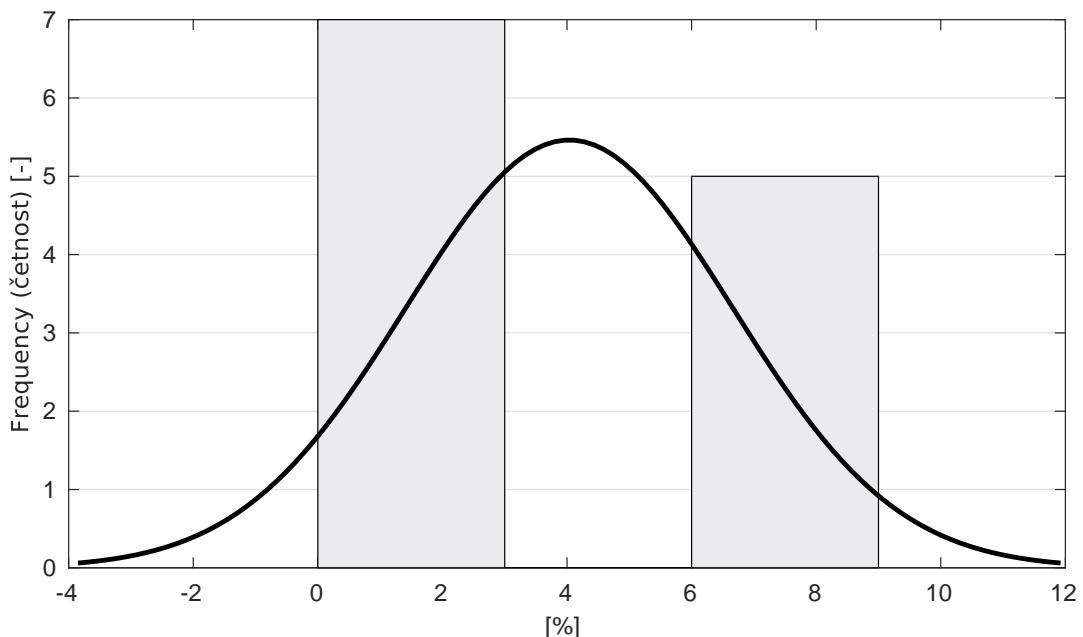
Figure 88: Histogram of all test results

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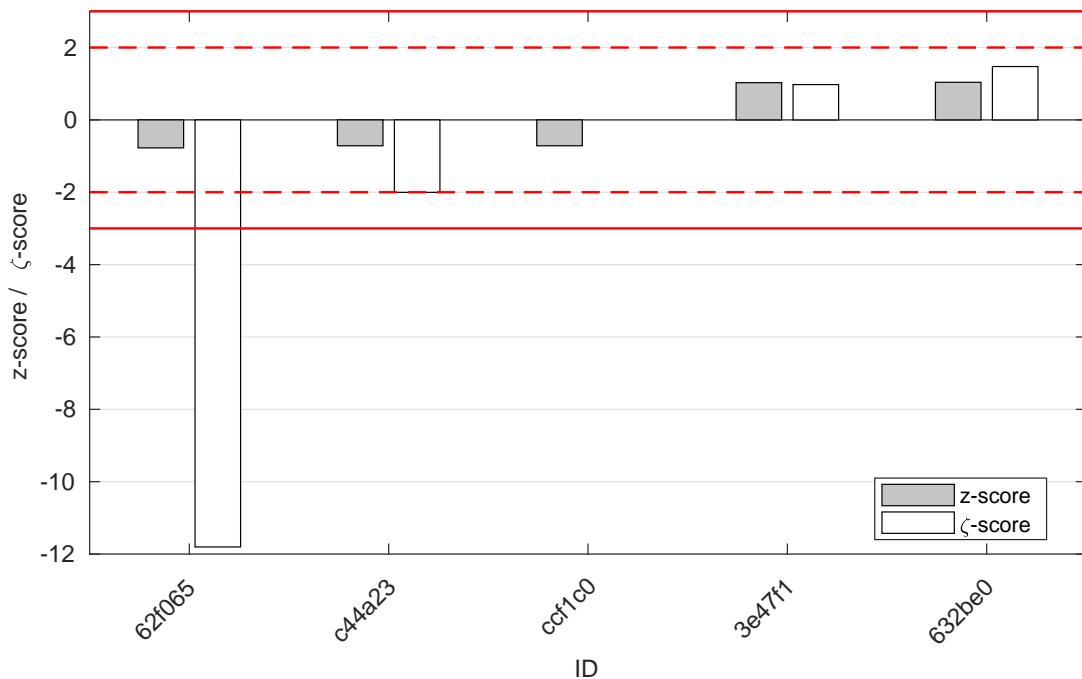
Figure 89: z-score and ζ-score

Table 25: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
62f065	-0.77	-11.80
c44a23	-0.71	-2.00
ccf1c0	-0.71	-
3e47f1	1.03	0.98
632be0	1.04	1.48

4.3 C_{tr}

4.3.1 Test results

Table 26: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
632be0	18.00	18.00	18.00	2.00	18.00	0.00	0.00
3e47f1	64.35	56.27	59.14	3.00	59.92	4.10	6.84
ccf1c0	91.00	-	-	-	91.00	0.00	0.00
c44a23	91.00	92.00	94.00	8.00	92.33	1.53	1.65
62f065	92.60	93.60	98.10	1.10	94.77	2.93	3.09

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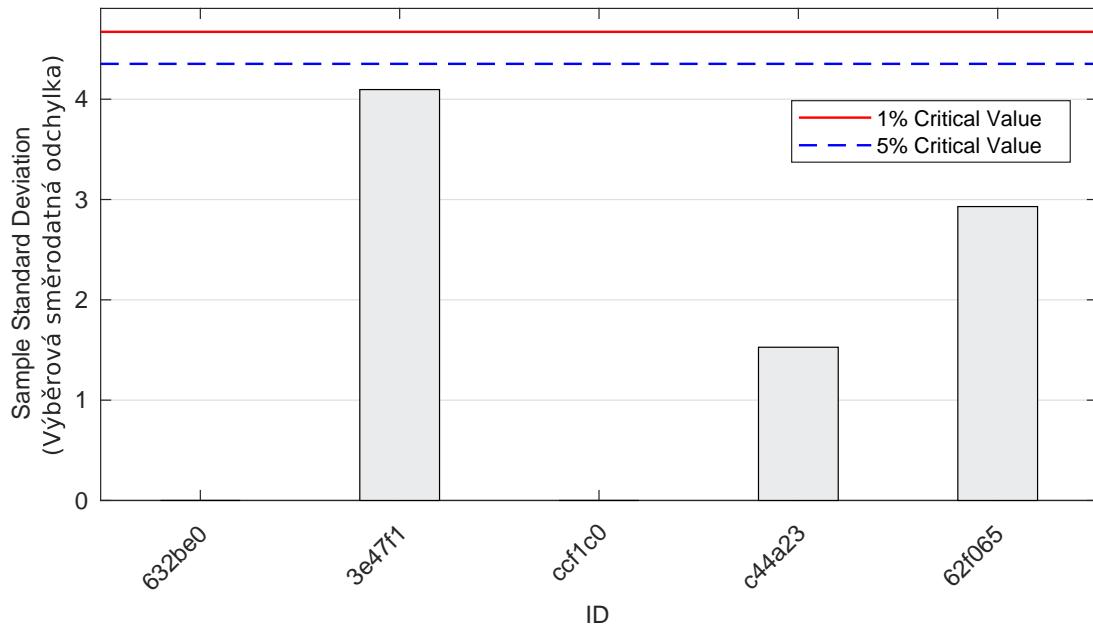### 4.3.2 The Numerical Procedure for Determining Outliers

Figure 90: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color
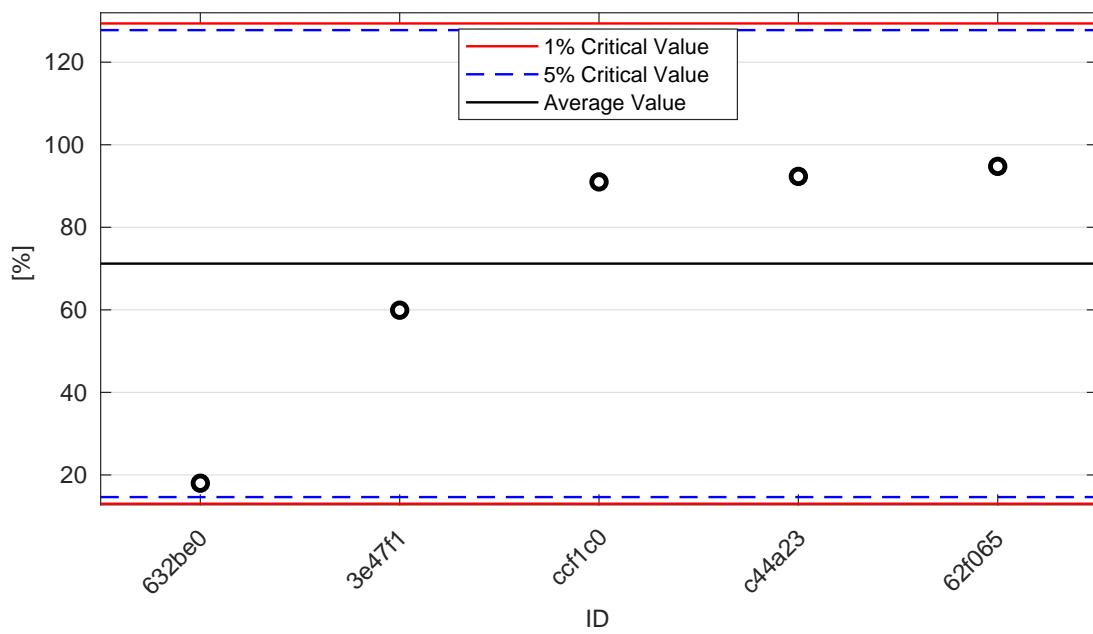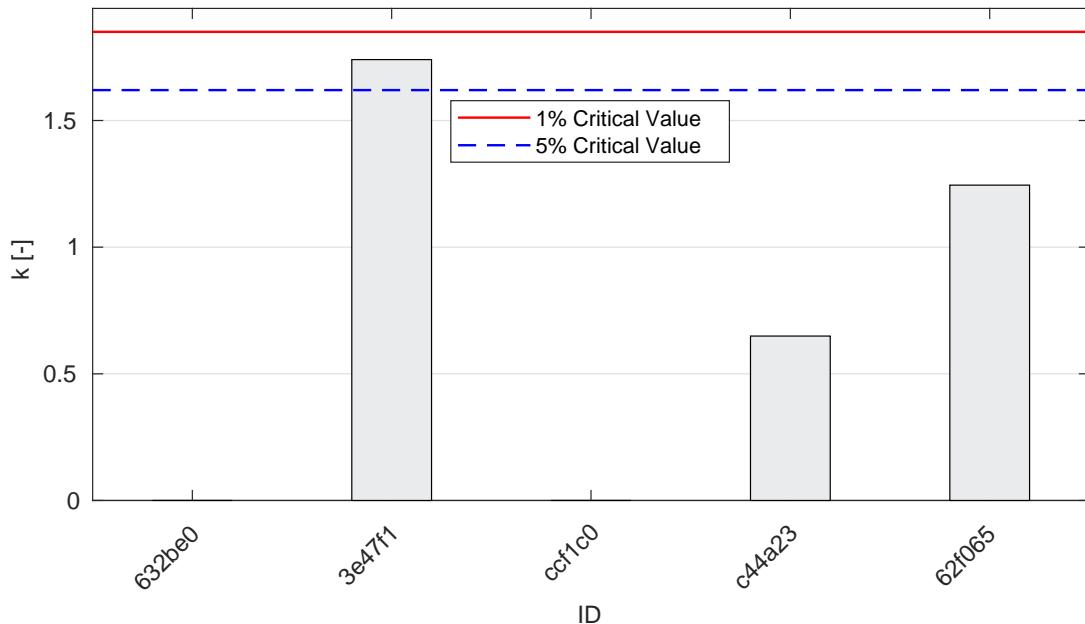

Figure 91: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

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4.3.3 Mandel's Statistics

Figure 92: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color
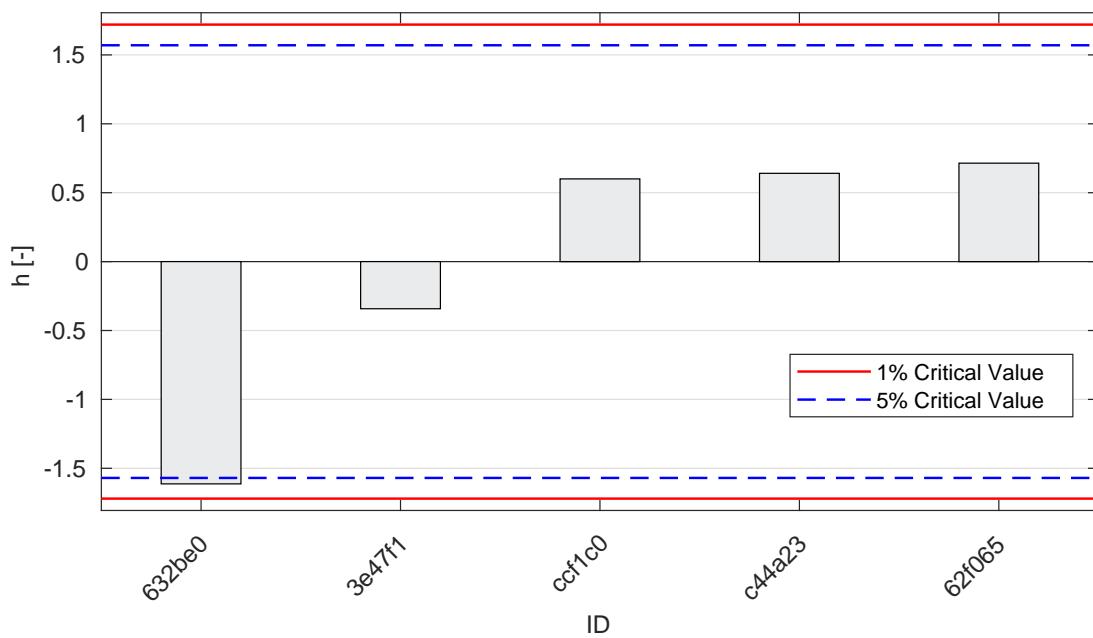
Figure 93: Interlaboratory Consistency Statistic h: 1% critical value - red color; 5% critical value - blue color

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4.3.4 Calculation of Performance Statistics
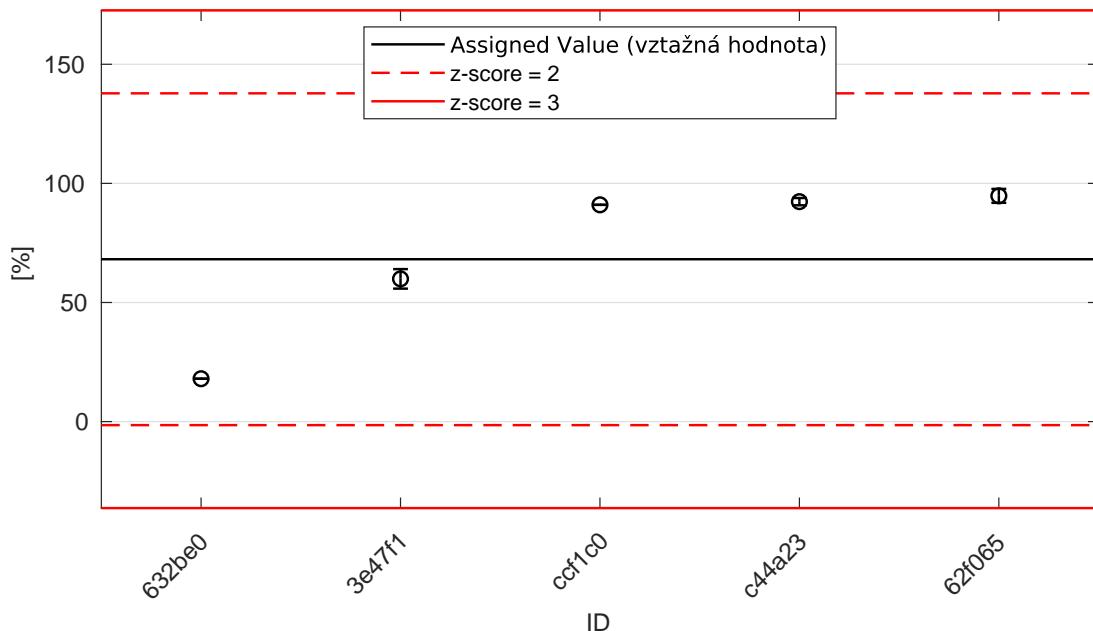

Figure 94: Average values and sample standard deviations
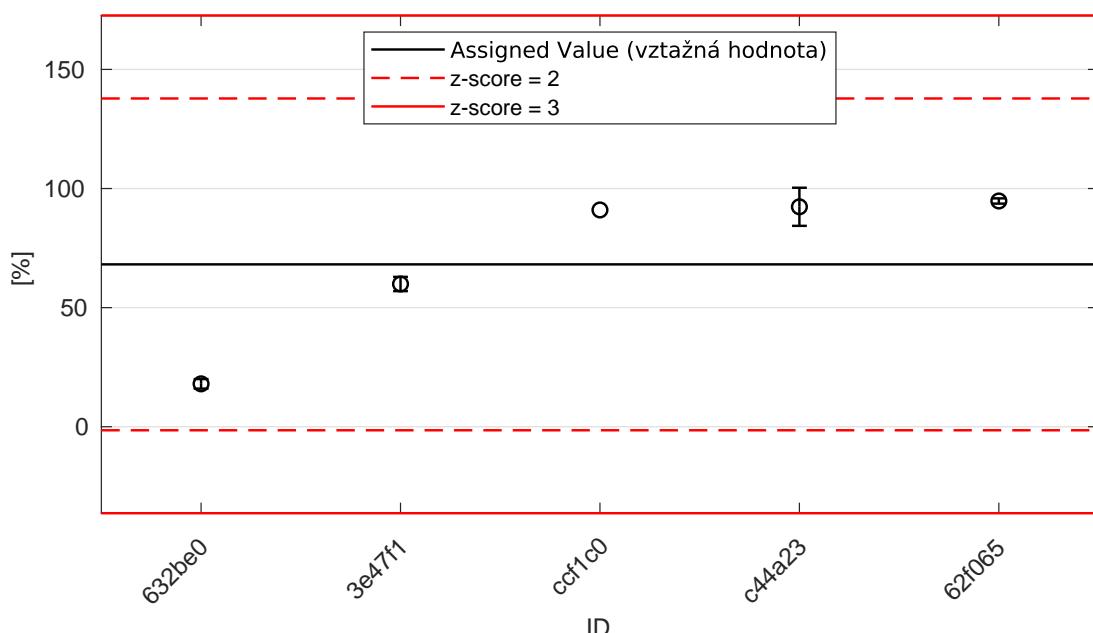
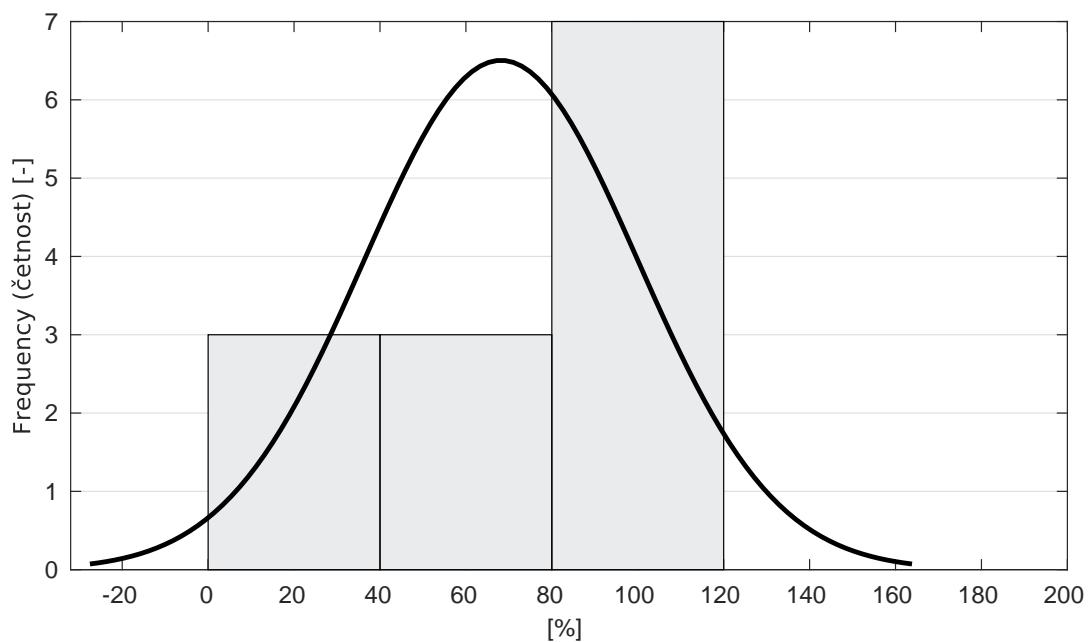Figure 95: Average values and extended uncertainties of measurement

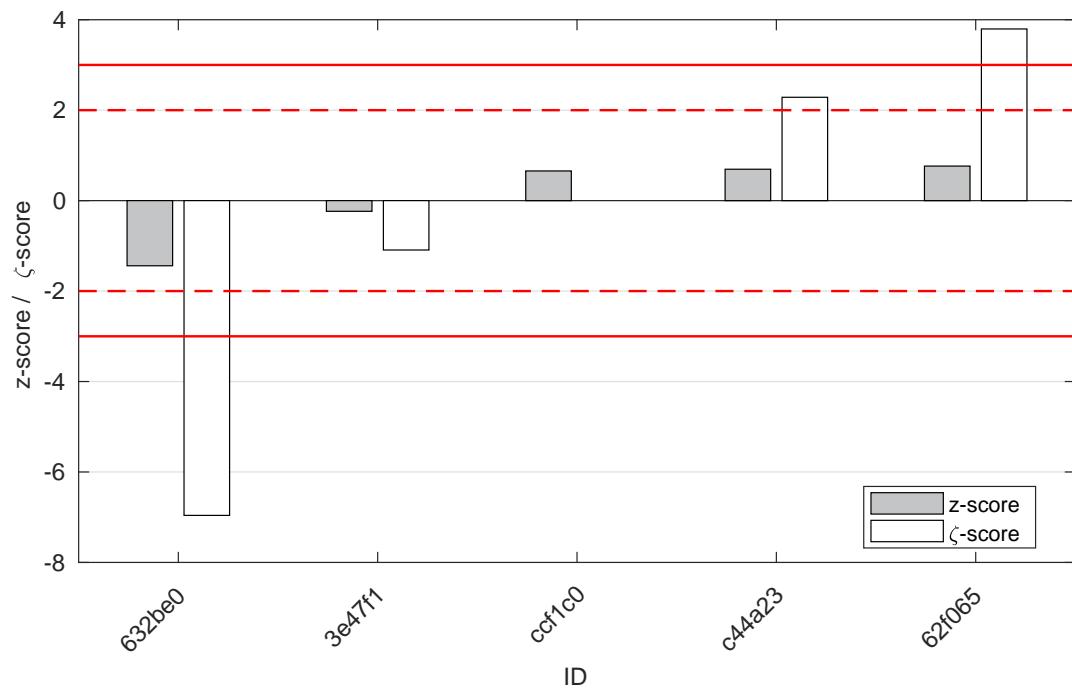Proficiency Testing Provider at the SZK FAST | Z 7008   79/118
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Figure 96: Histogram of all test results

Figure 97: z-score and ζ-score

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Table 27: *z*-score and ζ-score

| ID	*z*-score [-]	ζ-score [-]
632be0	-1.44	-6.96
3e47f1	-0.24	-1.09
ccf1c0	0.66	-
c44a23	0.69	2.28
62f065	0.76	3.80

4.4 C_r

4.4.1 Test results

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

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
3e47f1*	26.34	22.84	33.14	3.00	27.44	5.24	19.09
632be0	93.00	93.00	93.00	2.00	93.00	0.00	0.00
62f065	98.30	98.10	93.70	1.10	96.70	2.60	2.69
ccf1c0	98.00	-	-	-	98.00	0.00	0.00
c44a23	99.00	100.00	99.00	8.00	99.33	0.58	0.58

4.4.2 The Numerical Procedure for Determining Outliers
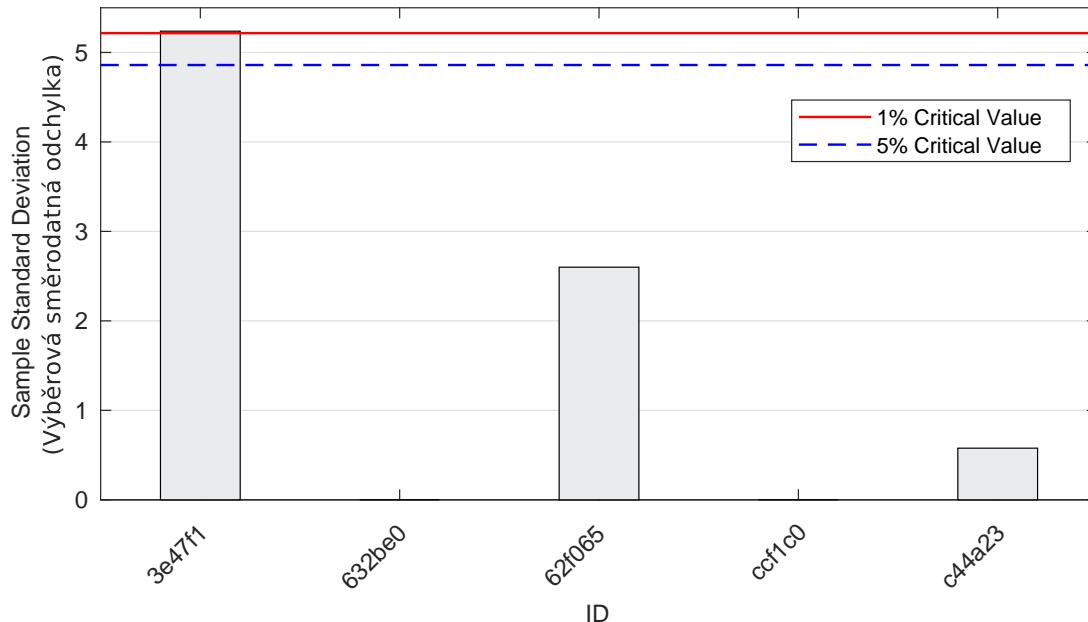
Figure 98: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

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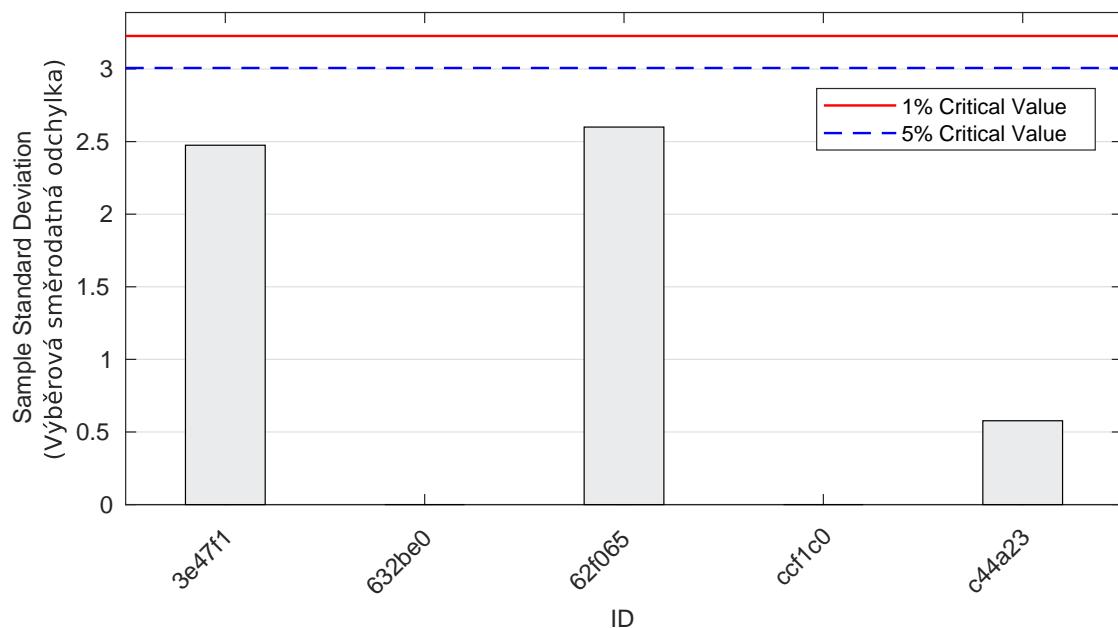szk.fce.vutbr.cz | ptprovider.cz

Figure 99: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color
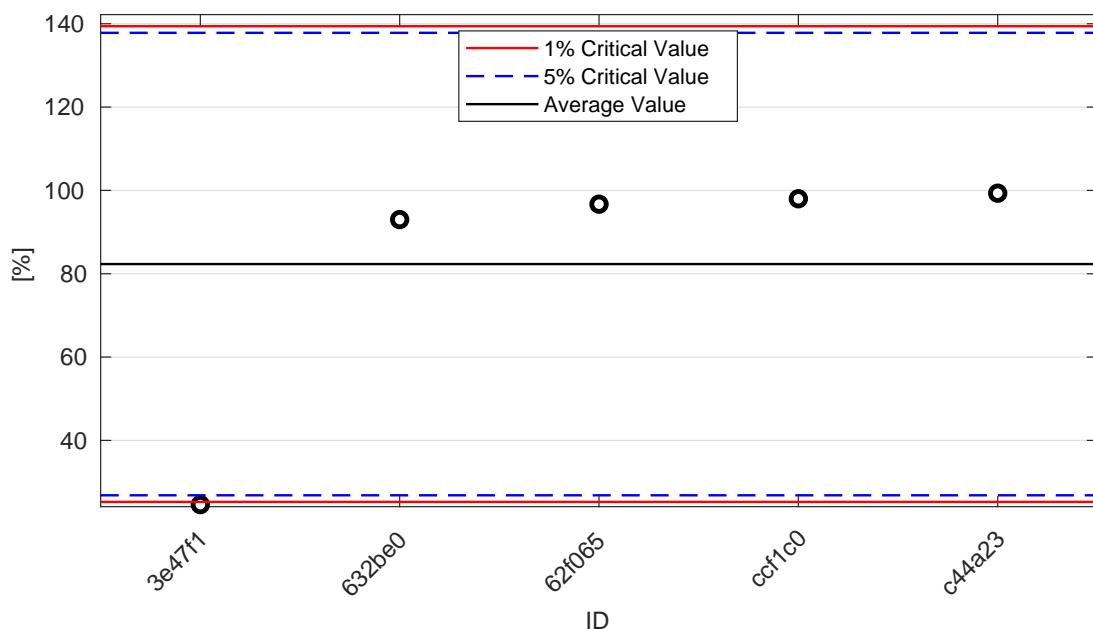

Figure 100: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color
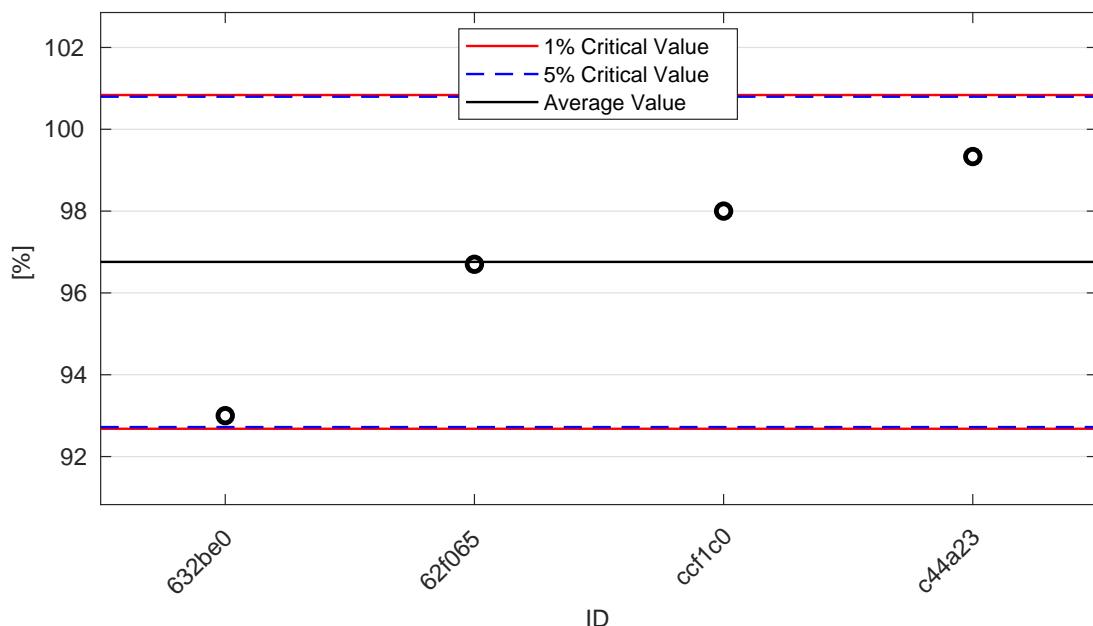
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Figure 101: **Grubbs' test** - average values without outliers: 1% critical value - red color; 5% critical value - blue color
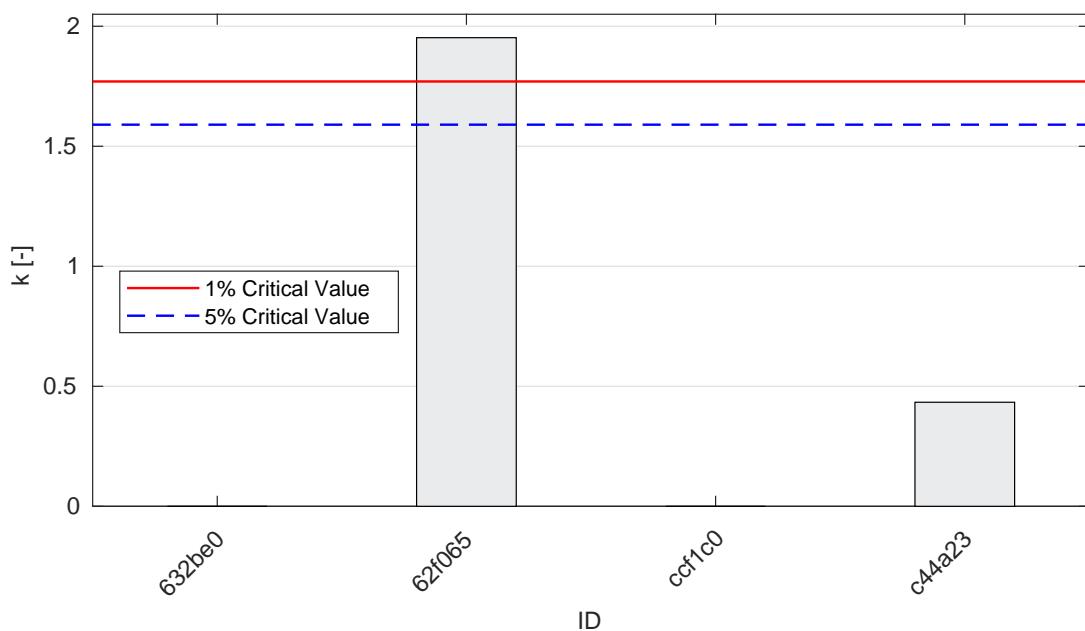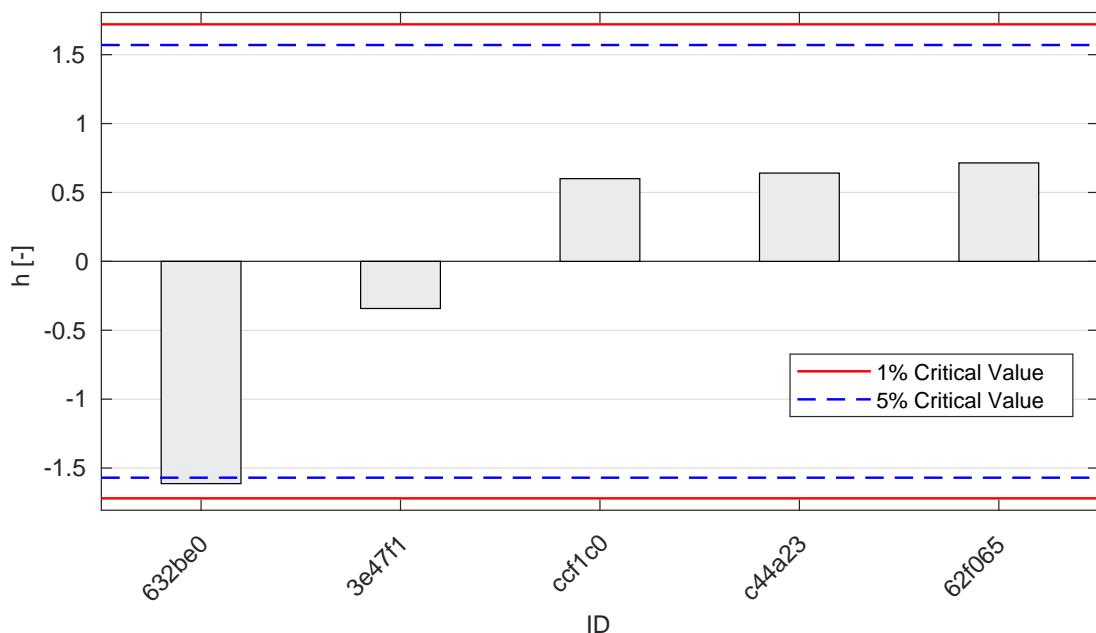
4.4.3 Mandel's Statistics

Figure 102: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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Figure 103: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color
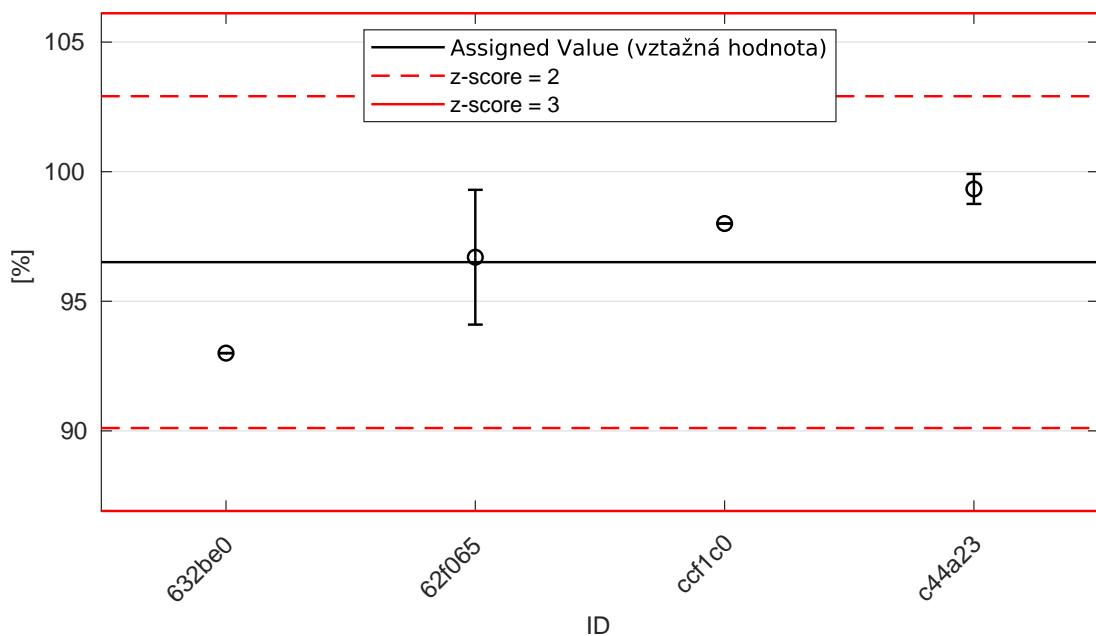
4.4.4 Calculation of Performance Statistics

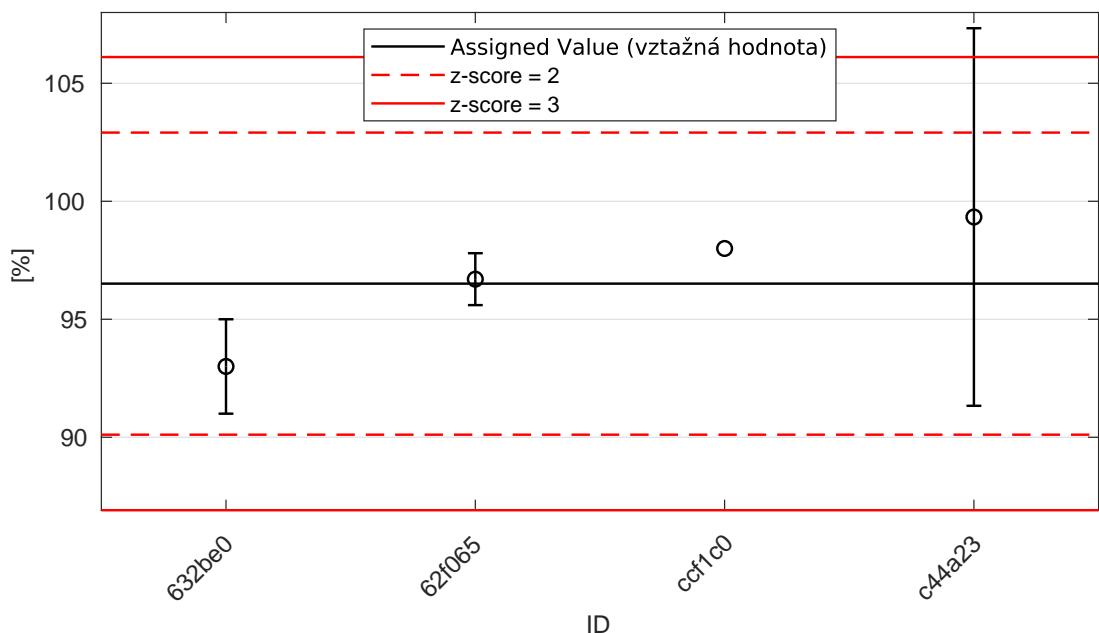

Figure 104: Average values and sample standard deviations

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Figure 105: Average values and extended uncertainties of measurement
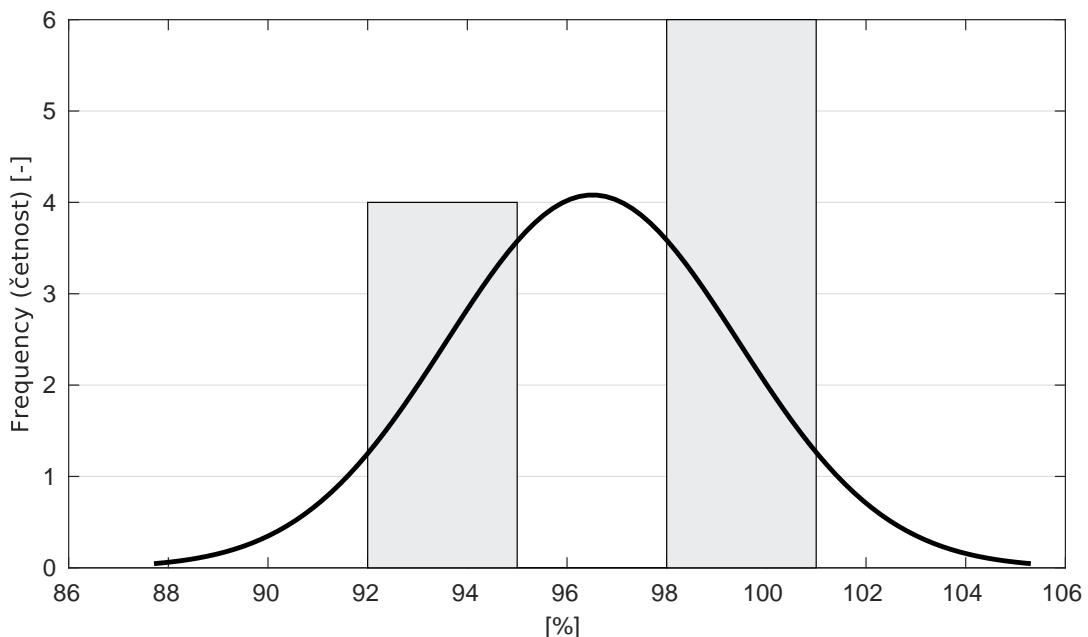
Figure 106: Histogram of all test results

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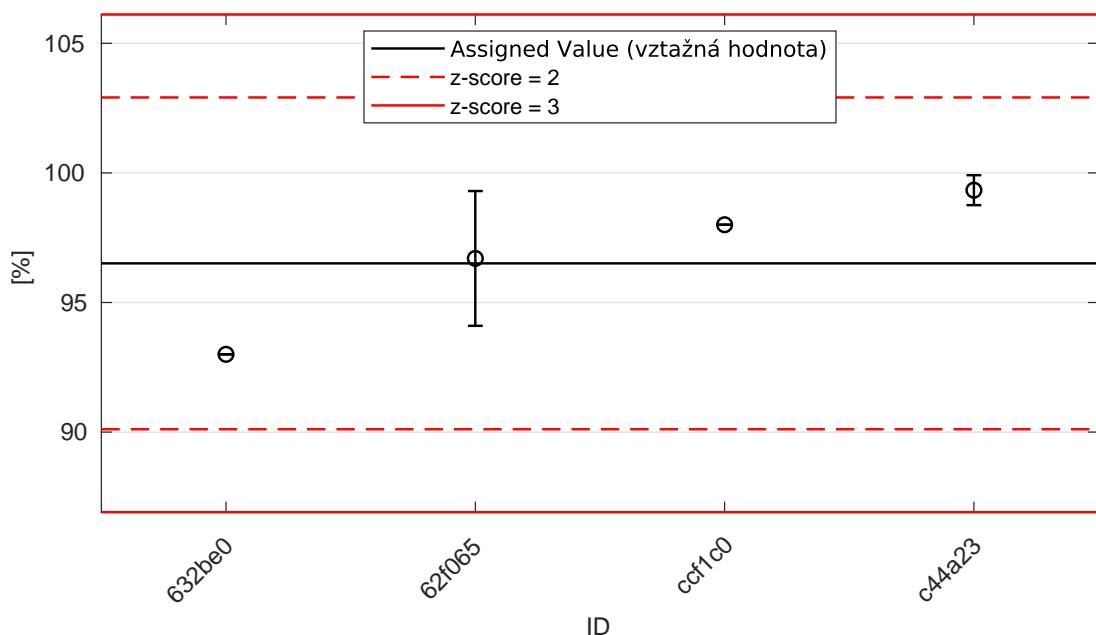
Figure 107: z-score and ζ-score

Table 29: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
632be0	-1.10	-1.13
62f065	0.06	0.07
ccf1c0	0.47	-
c44a23	0.88	0.34

5 Appendix – EN 933-8 Assessment of fines - Sand equivalent test

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

6 Appendix – EN 933-9 Assessment of fines - Methylene blue test

6.1 Test results

Table 30: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

ID of participant	Test results [g/kg]			u_X [g/kg]	$\bar{x}$ [g/kg]	s_0 [g/kg]	V_X [%]
a2ea36	0.3	0.3	0.4	0.1	0.3	0.1	17.32
ccf1c0	1.2	-	-	-	1.2	0.0	0.00
3e47f1	1.8	1.8	1.7	-	1.7	0.0	1.67
c02c42	2.4	2.3	2.4	0.5	2.3	0.0	0.43
62f065	2.5*	2.8	2.7	0.2	2.7	0.2	5.73
ce7b10	3.6	3.5	3.4	0.0	3.5	0.1	2.86
632be0	6.7	6.7	6.7	0.4	6.7	0.0	0.00

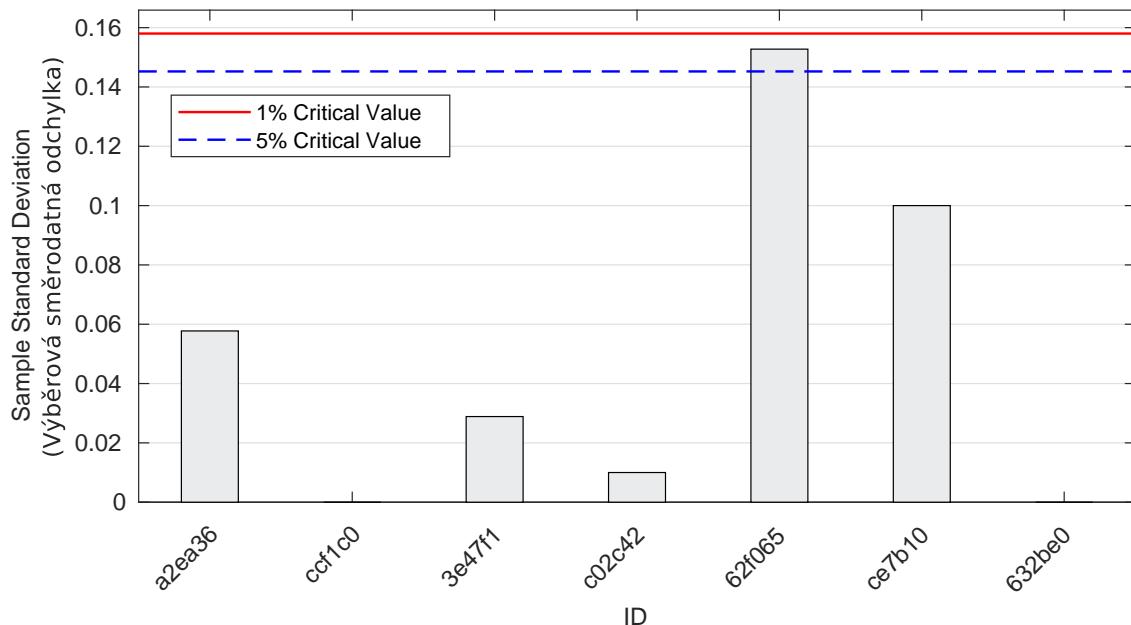## 6.2 The Numerical Procedure for Determining Outliers

Figure 108: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color
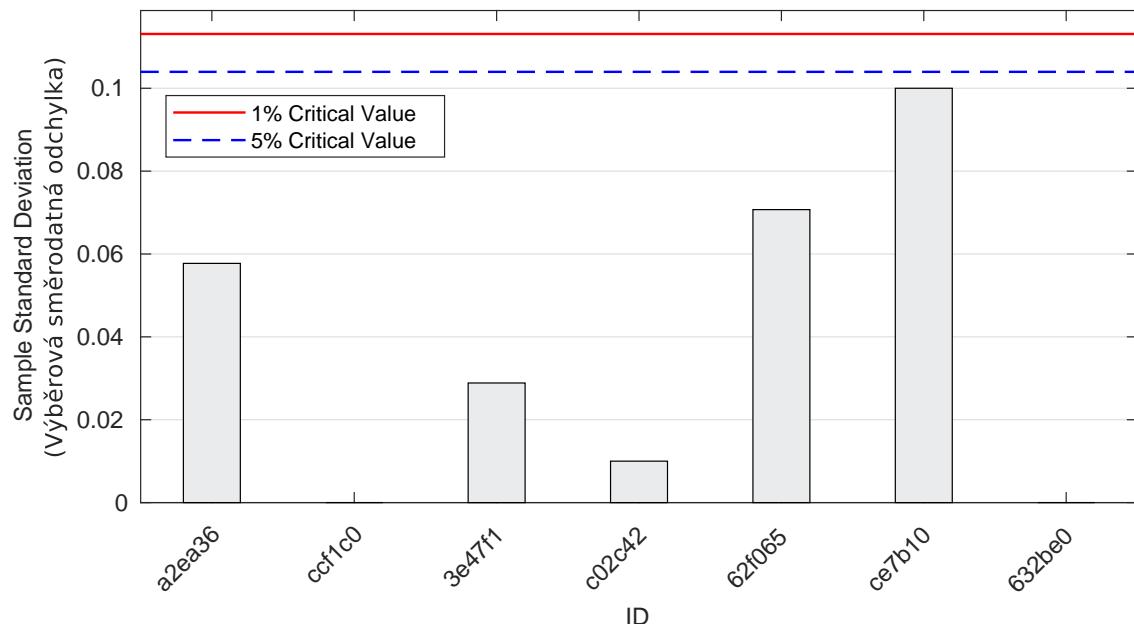
Figure 109: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color
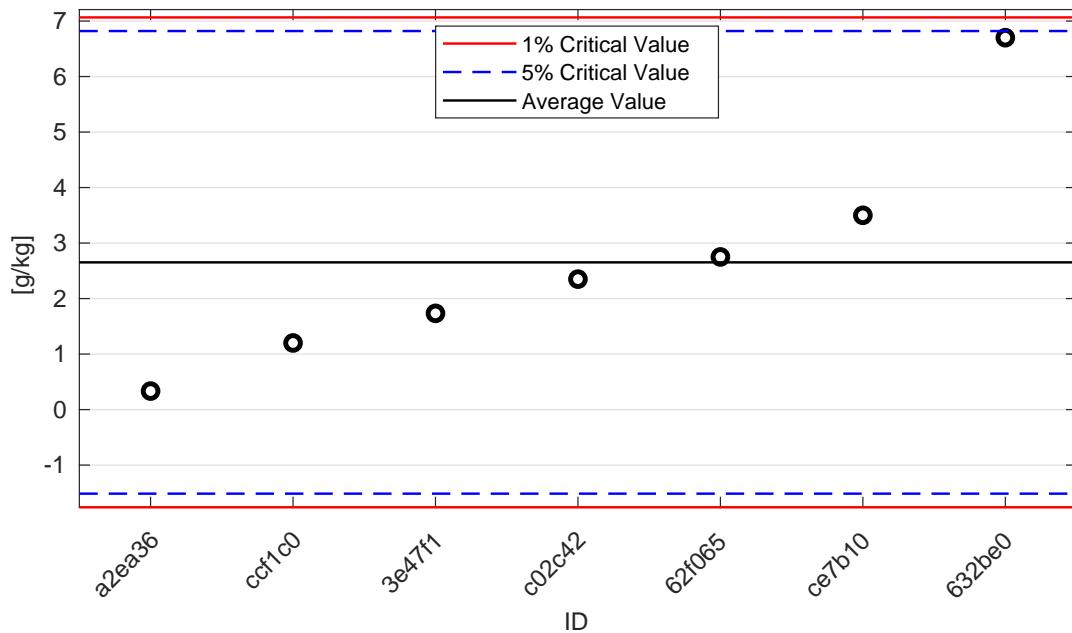

Figure 110: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

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6.3 Mandel's Statistics
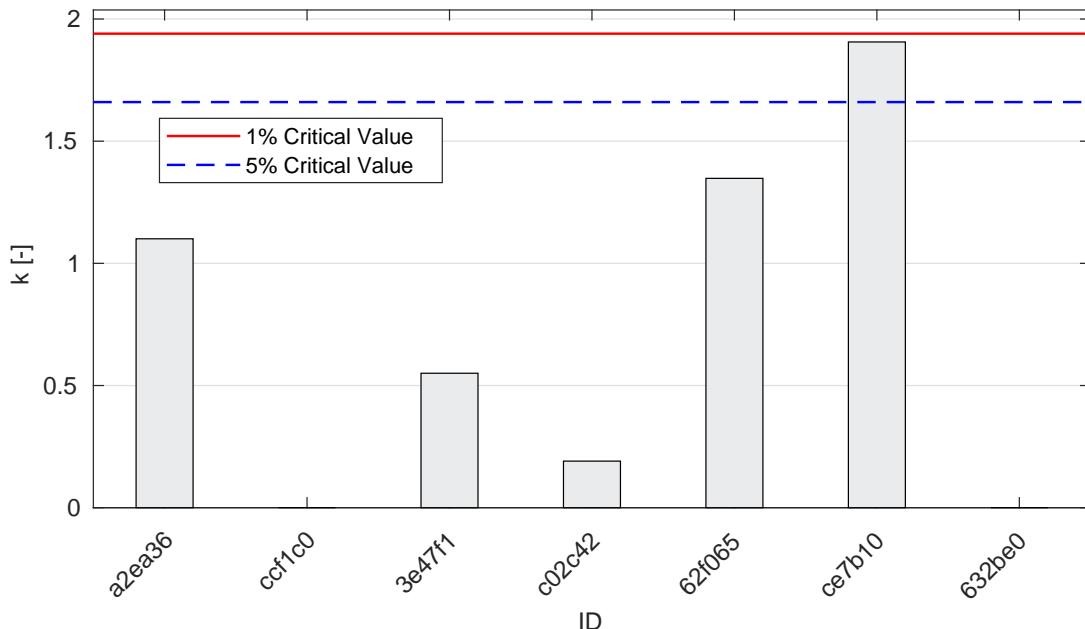
Figure 111: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color
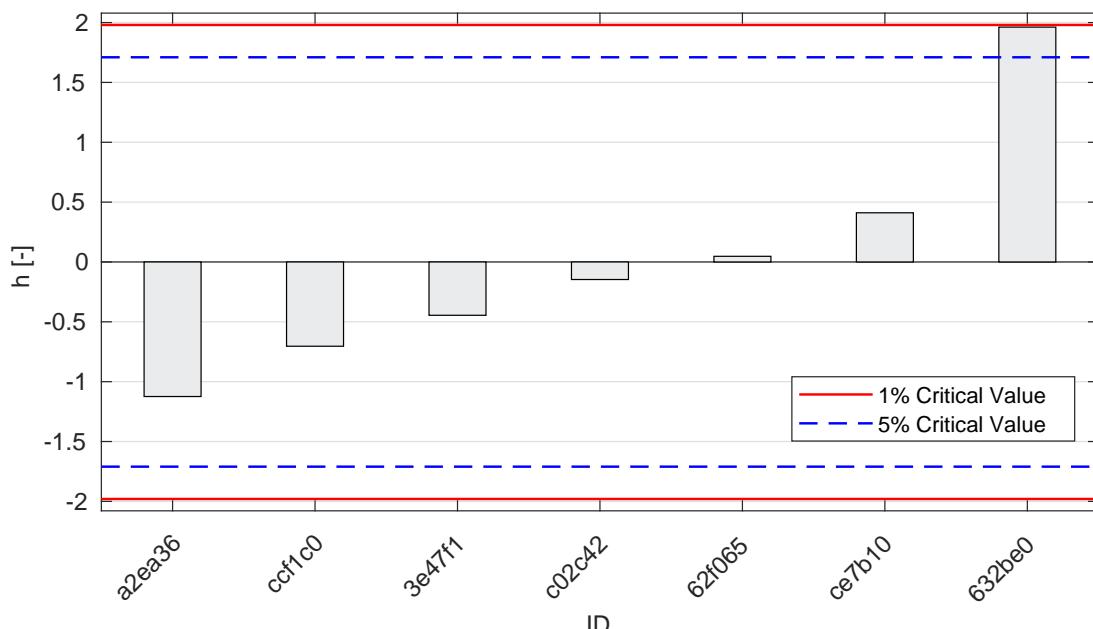
Figure 112: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

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6.4   Calculation of Performance Statistics

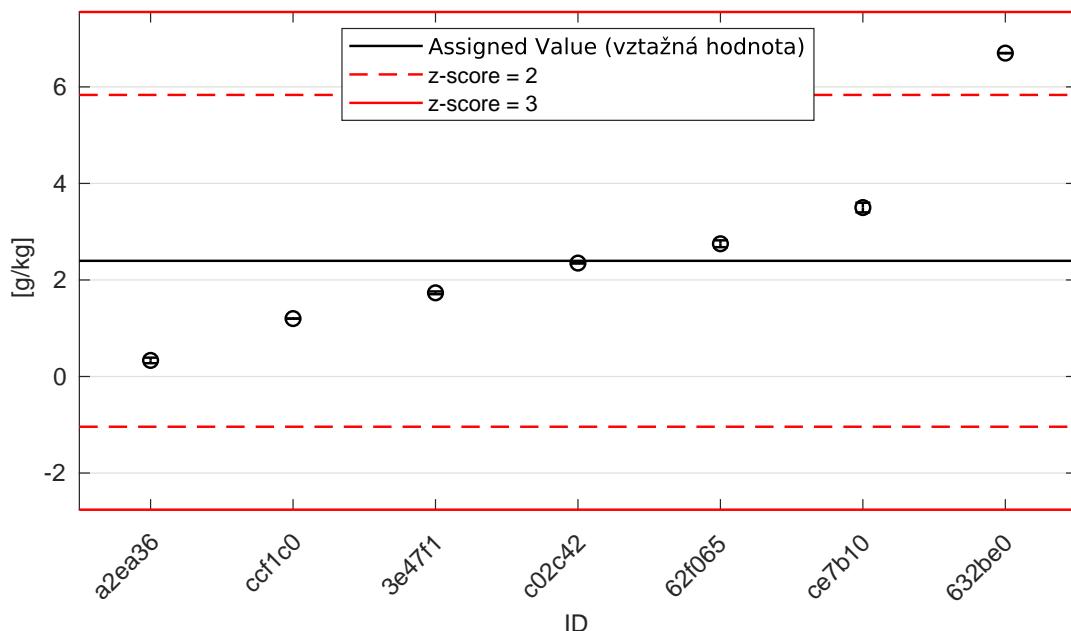Figure 113: Average values and sample standard deviations
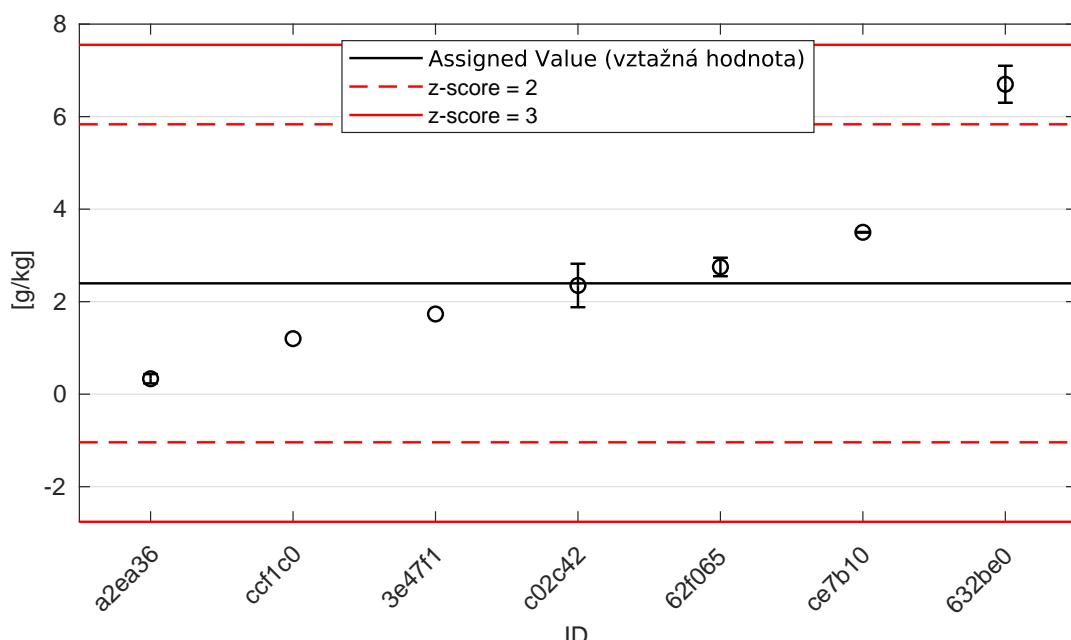
Figure 114: Average values and extended uncertainties of measurement

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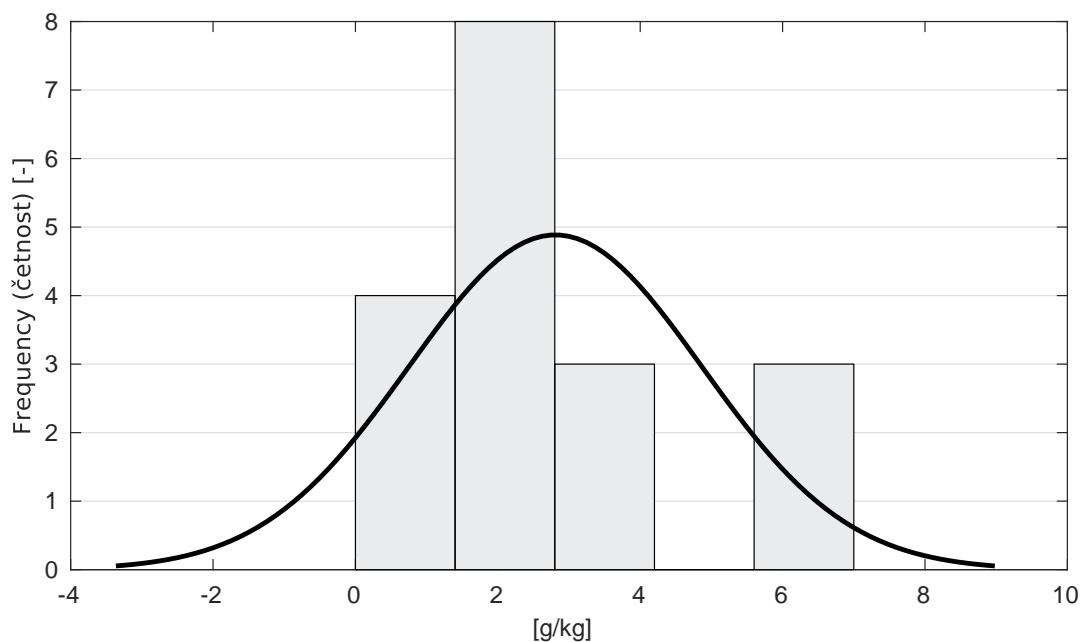
Figure 115: Histogram of all test results

Figure 116: z-score and ζ-score

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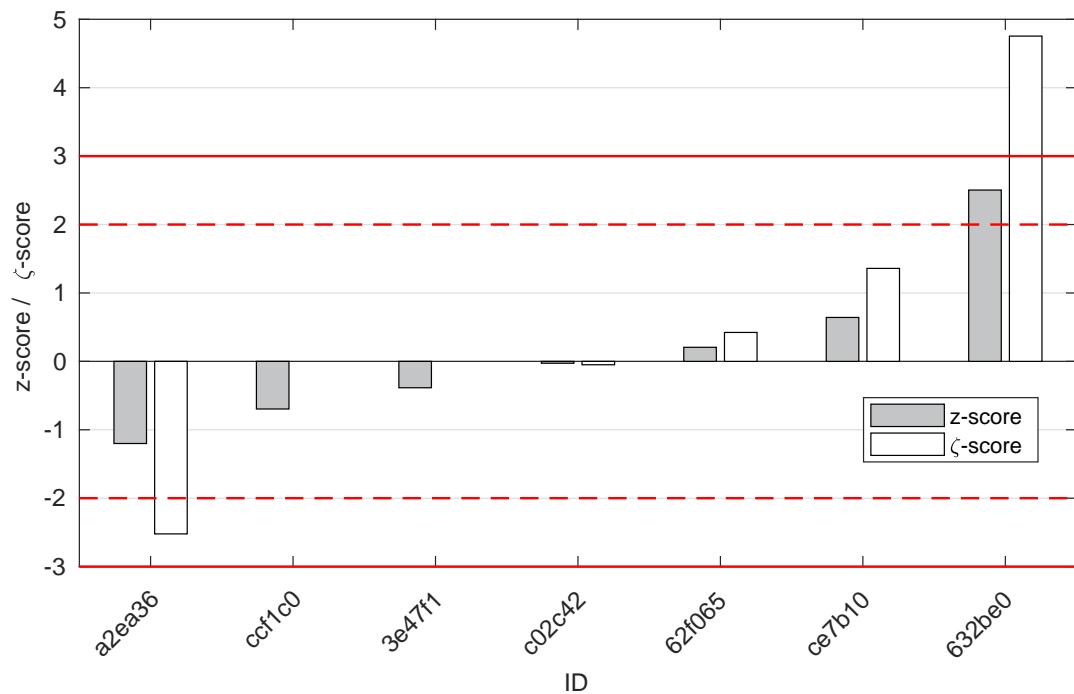
Table 31: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
a2ea36	-1.20	-2.52
ccf1c0	-0.70	-
3e47f1	-0.39	-
c02c42	-0.03	-0.05
62f065	0.21	0.42
ce7b10	0.64	1.36
632be0	2.50	4.75

7 Appendix – EN 933-10 Assessment of fines - Grading of filler aggregates (air jet sieving)

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

8 Appendix – EN 1097-1 Determination of the resistance to wear (micro-Deval)

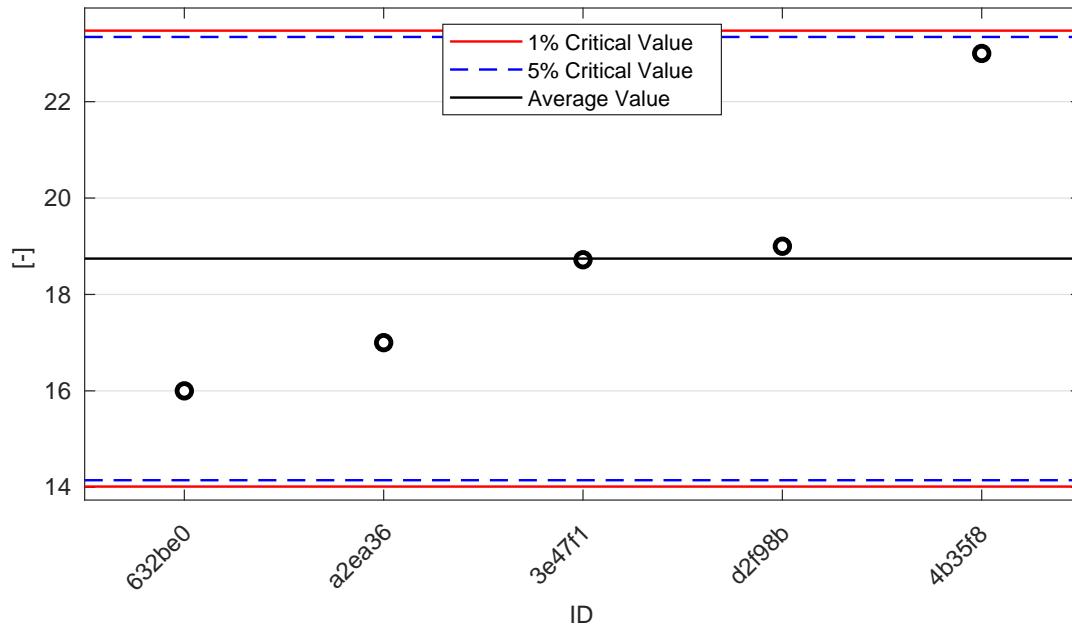This part of PT program was not open due to the low number of participants.

9 Appendix – EN 1097-2 Methods for the determination of resistance to fragmentation - chapter 5

9.1 Test results

Table 32: Test results - ordered. Outliers are marked by star. u_X - extended uncertainty of measurement;

ID of participant	Test results [-]	u_X [-]
632be0	16.0	2.0
a2ea36	17.0	1.0
3e47f1	18.7	3.0
d2f98b	19.0	0.3
4b35f8	23.0	0.7

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9.2 The Numerical Procedure for Determining Outliers

Figure 117: **Grubbs' test**: 1% critical value - red color; 5% critical value - blue color

9.3 Mandel's Statistics
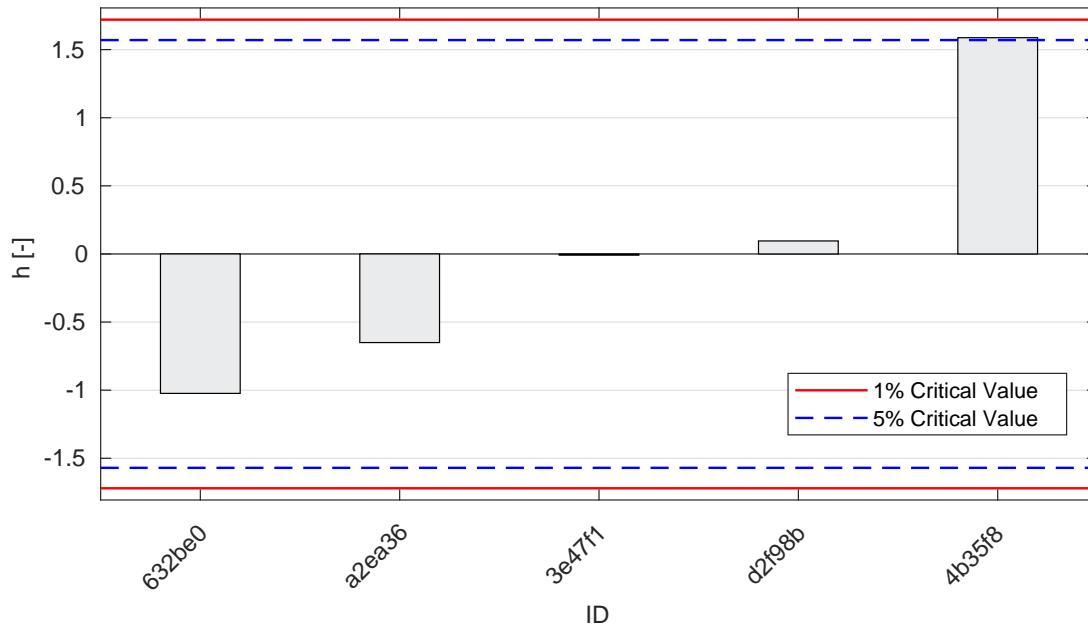
Figure 118: Interlaboratory Consistency Statistic h: 1% critical value - red color; 5% critical value - blue color

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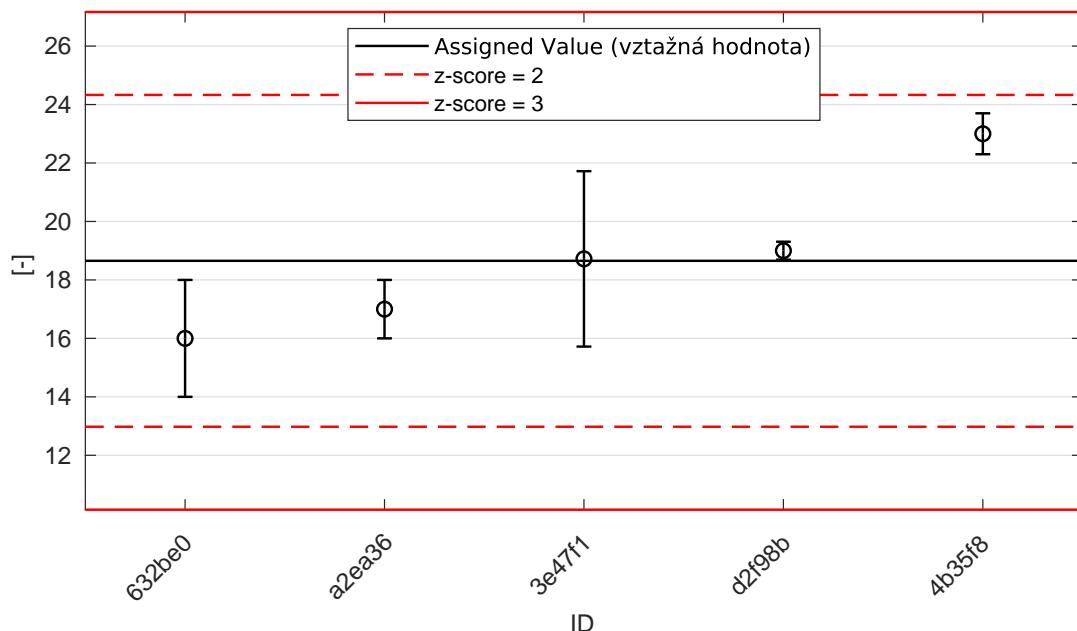szk.fce.vutbr.cz | ptprovider.cz

9.4 Calculation of Performance Statistics

Figure 119: Average values and extended uncertainties of measurement

Figure 120: Histogram of all test results
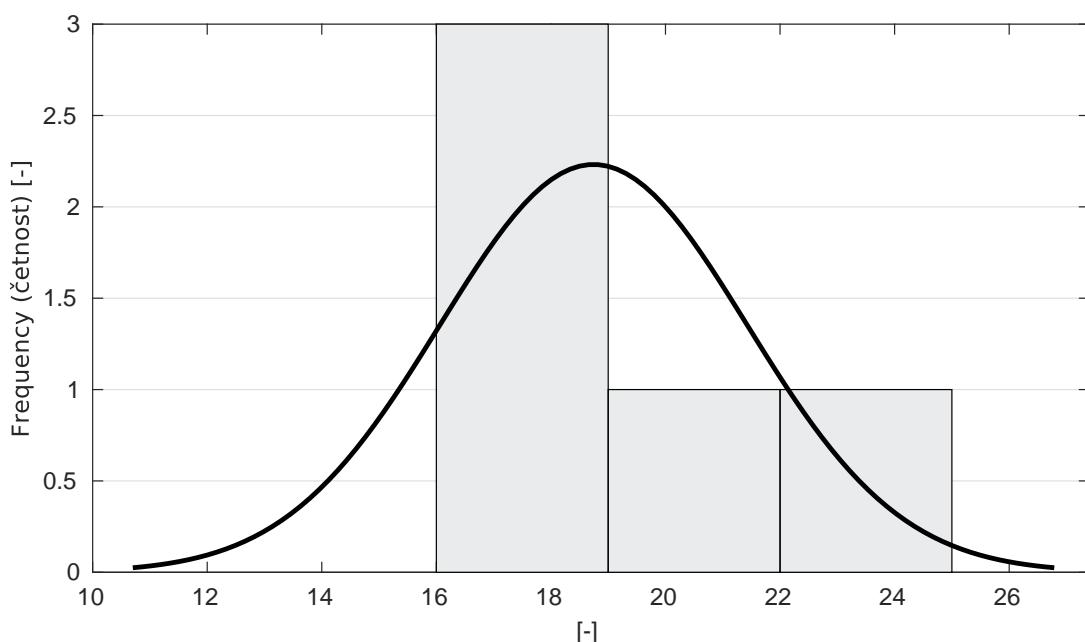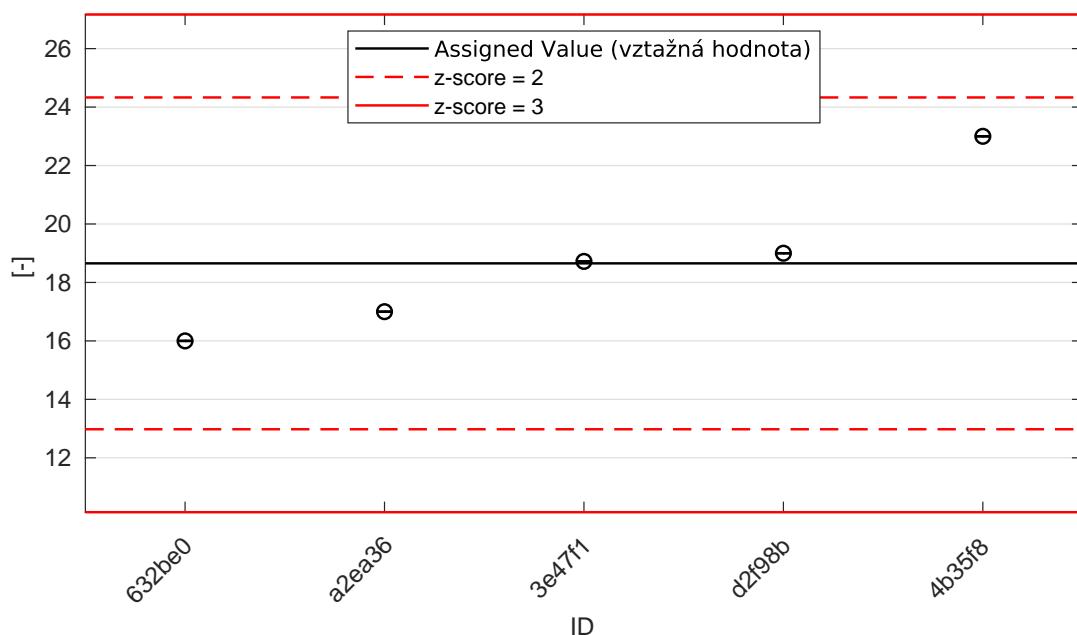
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Figure 121: *z*-score

Table 33: *z*-score

ID	*z*-score [-]	ζ-score [-]
632be0	-0.93	-1.04
a2ea36	-0.58	-0.88
3e47f1	0.02	0.02
d2f98b	0.12	0.21
4b35f8	1.53	2.51

10 Appendix – EN 1097-2 Methods for the determination of resistance to fragmentation - chapter 6

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

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11 Appendix – EN 1097-3 Determination of loose bulk density and voids

12 Appendix – EN 1097-5 Determination of the water content by drying in a ventilated oven

12.1 Test results

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

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
f66ebc	3.7	3.6	3.7	1.9	3.7	0.1	1.57
1443ba	3.8	3.8	3.7	0.1	3.8	0.1	1.53
a2ea36	3.8	3.8	3.7	0.1	3.8	0.1	1.53
121344	3.9	3.8	3.8	10.0	3.8	0.1	1.64
ccf1c0	4.0	3.9	4.0	0.2	4.0	0.1	1.46
445a7b	4.1	3.9	4.2	-	4.1	0.2	3.76
c44a23	4.1	4.0	4.2	0.3	4.1	0.1	1.72
a10c83	4.2	4.0	4.1	0.2	4.1	0.1	2.32
632be0	4.1	4.1	4.1	0.3	4.1	0.0	0.00
932f3a	4.1	4.1	4.2	0.4	4.1	0.1	1.40
f90120	4.4	4.3	4.3	0.2	4.3	0.1	1.33
9e18fc	4.5	4.2	4.3	-	4.3	0.2	3.53

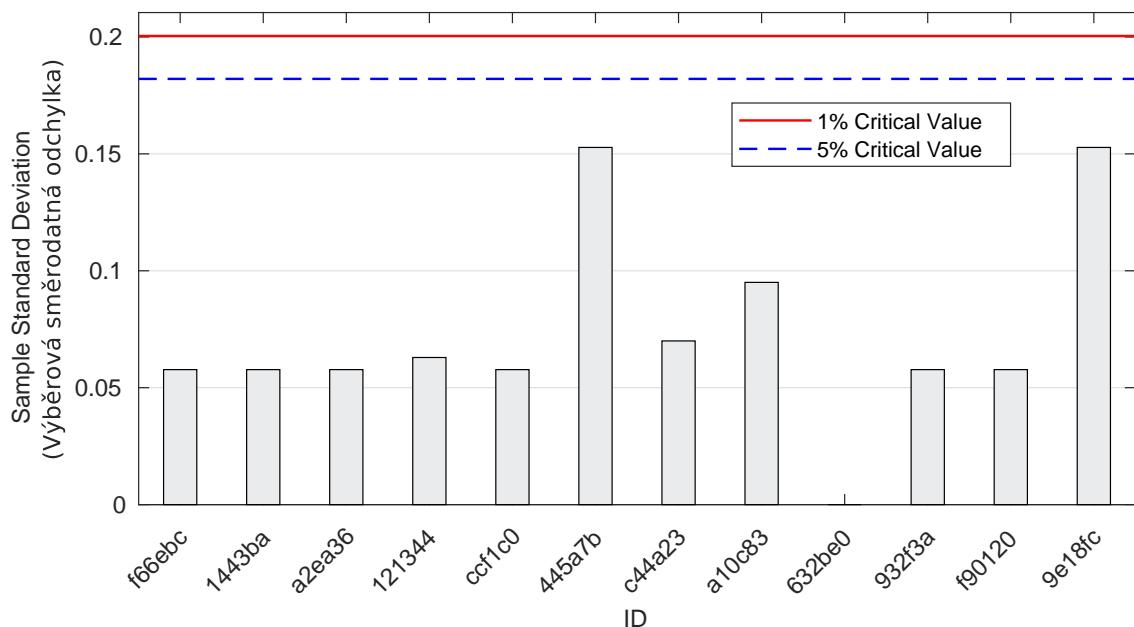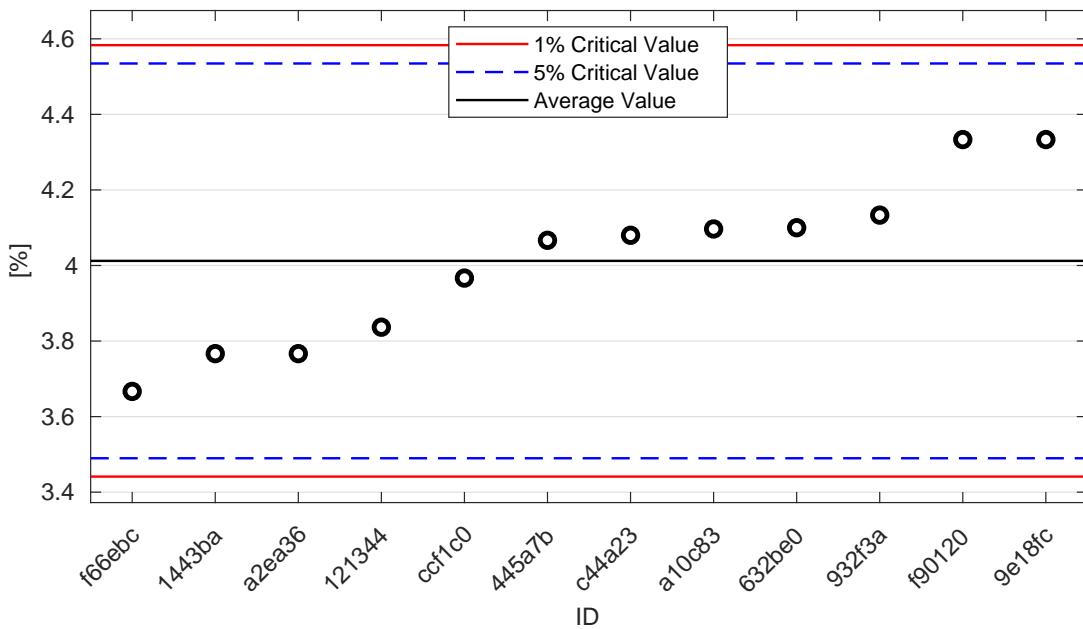## 12.2 The Numerical Procedure for Determining Outliers
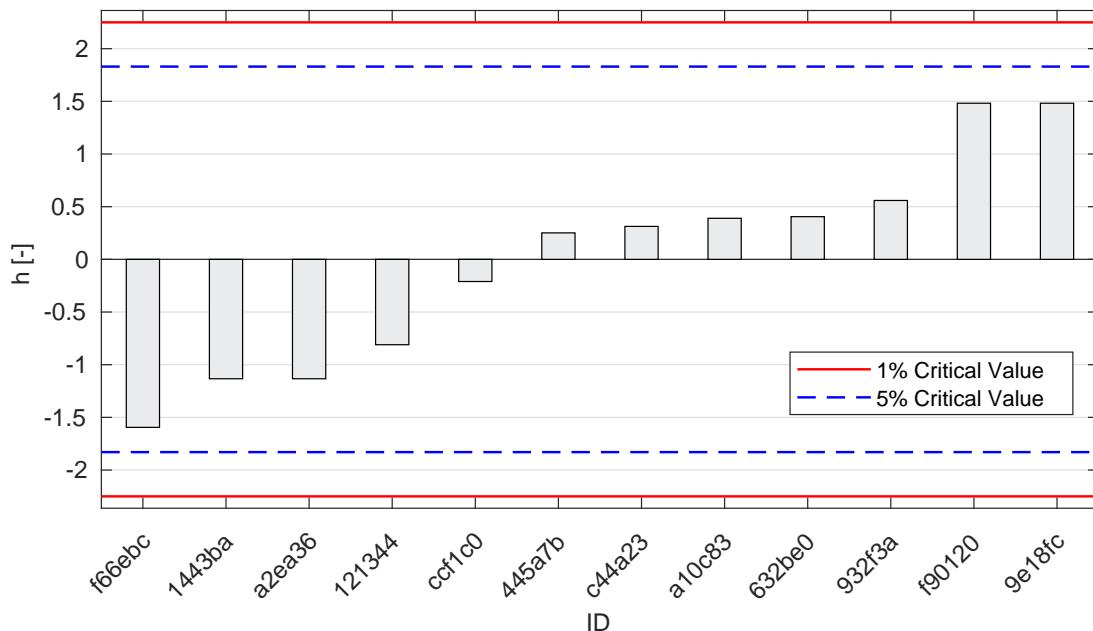

Figure 122: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

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Figure 123: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

12.3 Mandel's Statistics
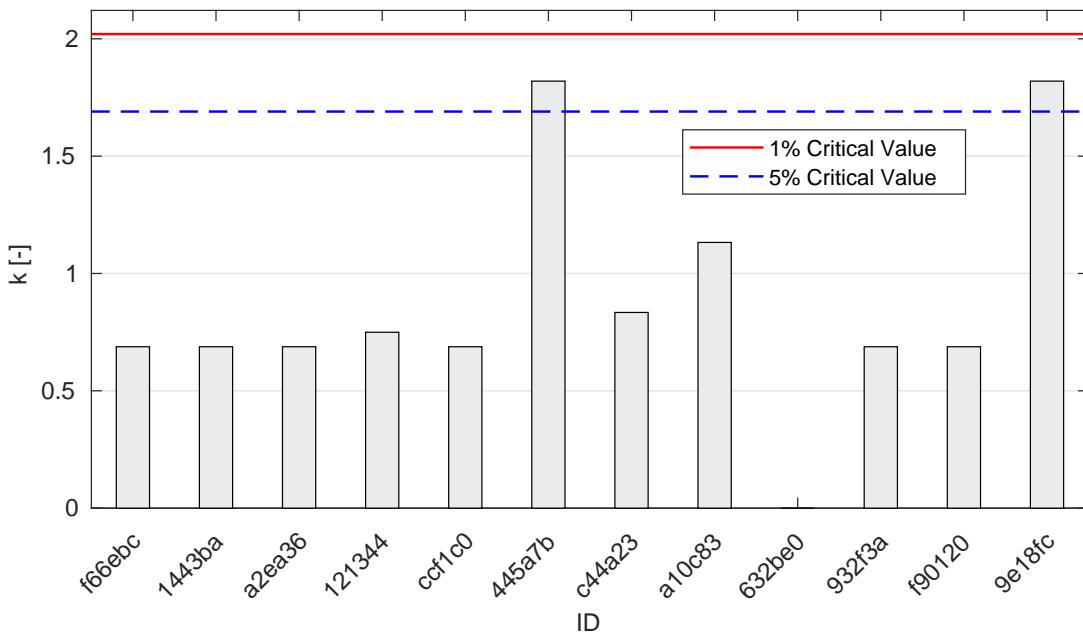
Figure 124: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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Figure 125: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color
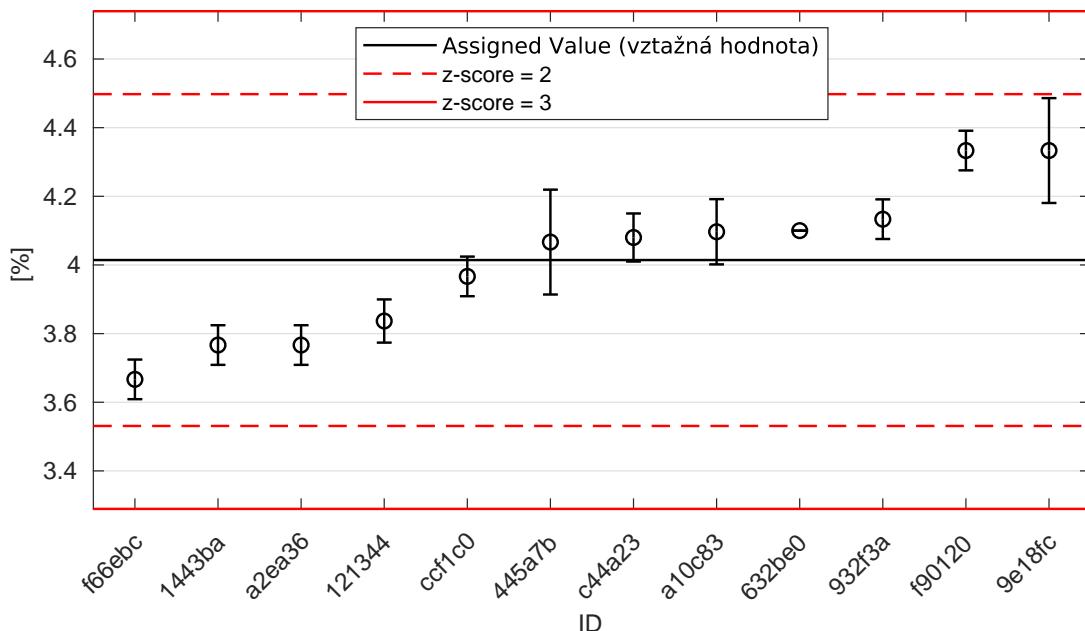
12.4   Calculation of Performance Statistics

Figure 126: Average values and sample standard deviations

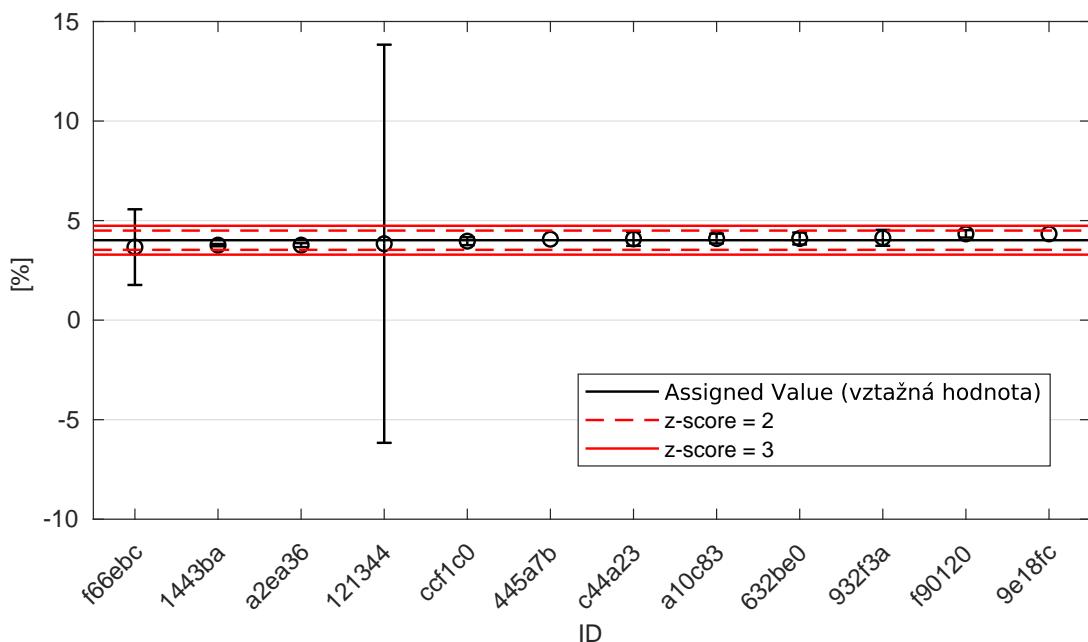Proficiency Testing Provider at the SZK FAST | Z 7008   98/118
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Figure 127: Average values and extended uncertainties of measurement
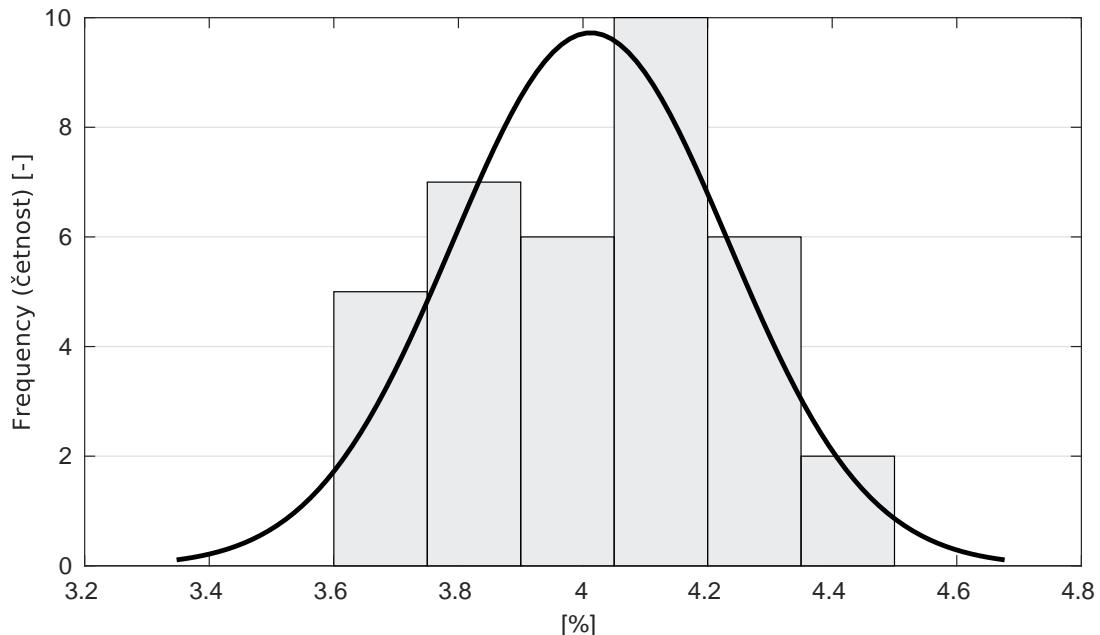
Figure 128: Histogram of all test results

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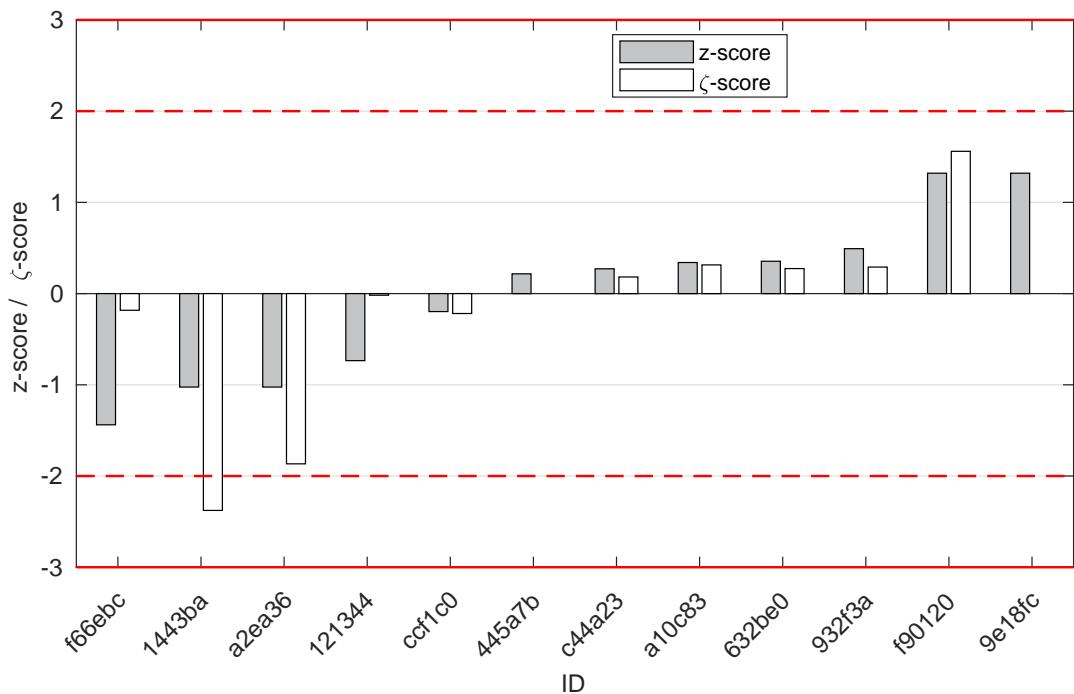
Figure 129: z-score and ζ-score

Table 35: *z*-score and ζ-score

ID	*z*-score [-]	ζ-score [-]
f66ebc	-1.44	-0.18
1443ba	-1.02	-2.38
a2ea36	-1.02	-1.87
121344	-0.73	-0.02
ccf1c0	-0.20	-0.22
445a7b	0.22	-
c44a23	0.27	0.18
a10c83	0.34	0.31
632be0	0.35	0.27
932f3a	0.49	0.29
f90120	1.32	1.56
9e18fc	1.32	-

13 Appendix – EN 1097-6 Determination of particle density and water absorption

13.1 Particle Density

13.1.1 Test results

Table 36: Test results - ordered by average value. Outliers are marked by star. u_X - extended uncertainty of measurement; $\bar{x}$ - average value; s_0 - sample standard deviation; V_X - variation coefficient

| ID of participant	Test results [kg/m^3]			u_X [kg/m^3]	$\bar{x}$ [kg/m^3]	s_0 [kg/m^3]	V_X [%]
a10c83*	2.68	2.68	2.69	0.05	2.68	0.01	0.22
632be0	2.78	2.75	2.77	0.03	2.77	0.02	0.55
c44a23	2.79	2.78	2.78	0.20	2.78	0.01	0.21
445a7b	2.79	2.79	2.78	-	2.79	0.01	0.21
ccf1c0	2.79	2.79	2.79	0.01	2.79	0.00	0.05
f90120	2.79	2.79	2.79	0.08	2.79	0.00	0.00
b98db3	2.79	2.79	2.79	-	2.79	0.00	0.00
a2ea36	2.79	2.79	2.79	0.01	2.79	0.00	0.00
37d6bc	2.79	2.80	2.79	0.04	2.79	0.01	0.21
f66ebc	2.85*	2.82	2.80	0.30	2.82	0.03	0.89
1443ba	2.80	2.82	2.87*	0.01	2.83	0.04	1.27

13.1.2 The Numerical Procedure for Determining Outliers
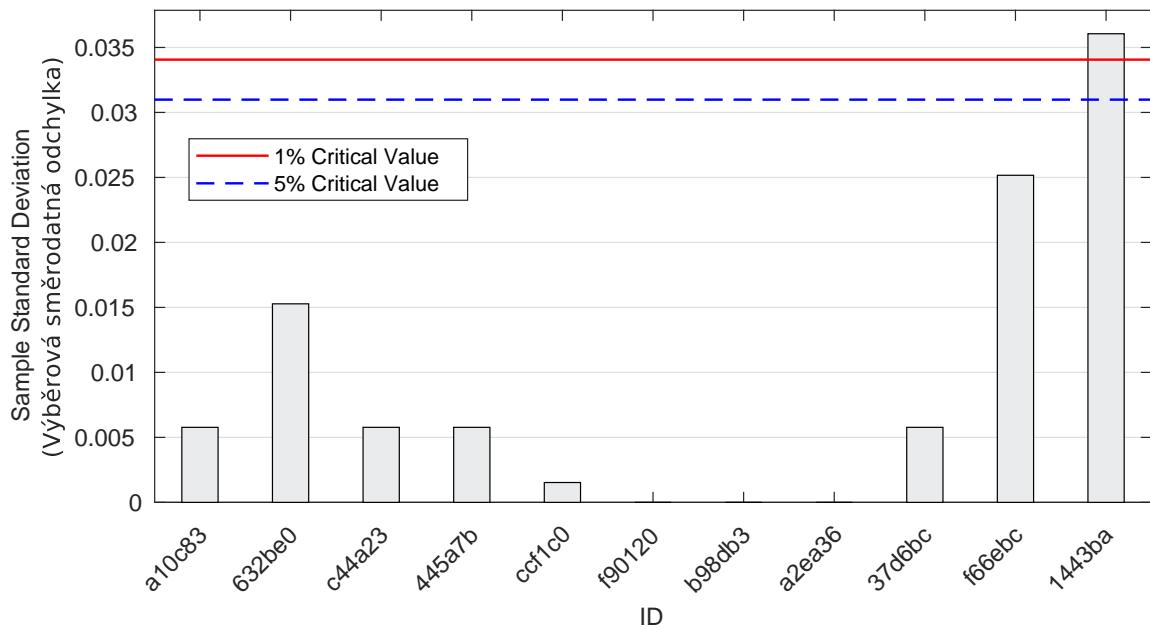
Figure 130: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

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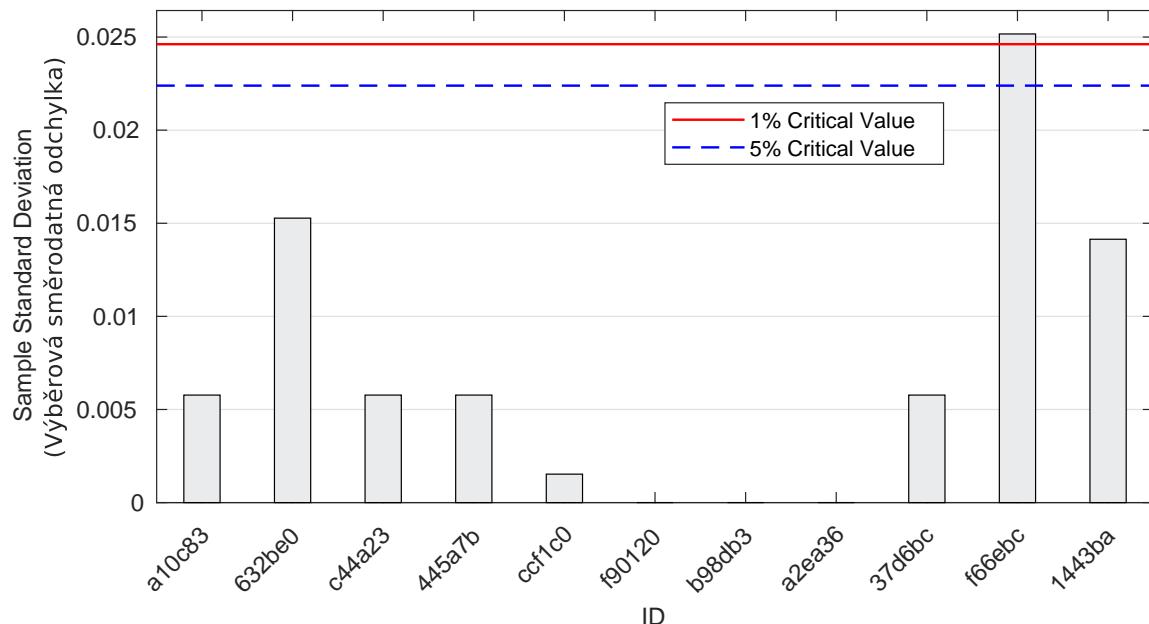szk.fce.vutbr.cz | ptprovider.cz

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Figure 131: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color

Figure 132: **Cochran's test** - sample standard deviations without outliers: 1% critical value - red color; 5% critical value - blue color
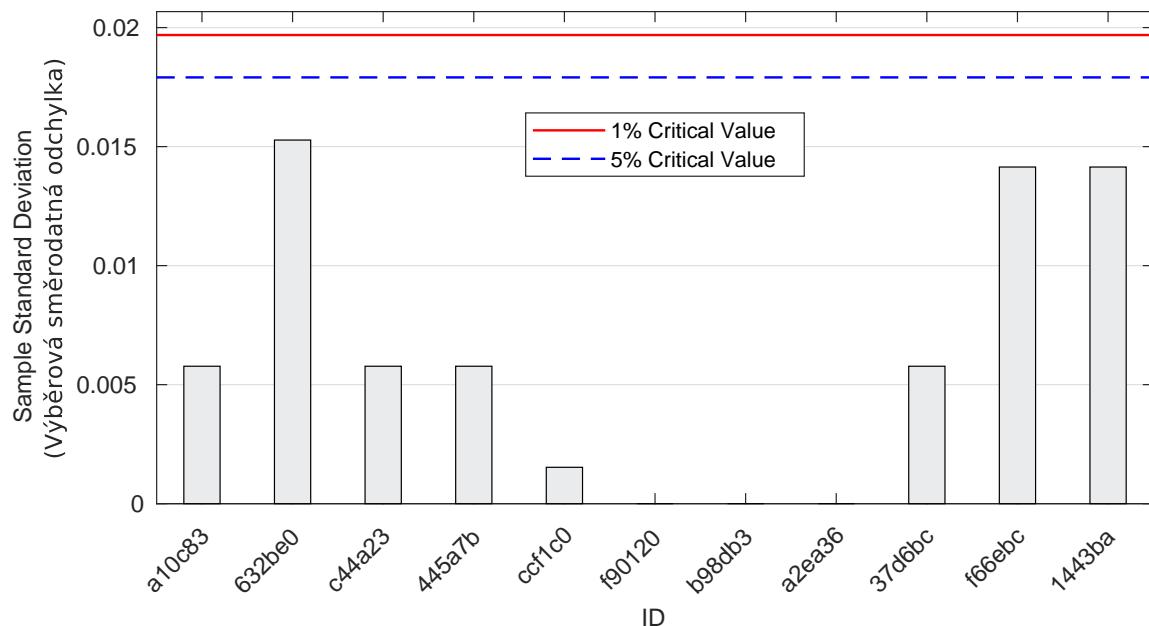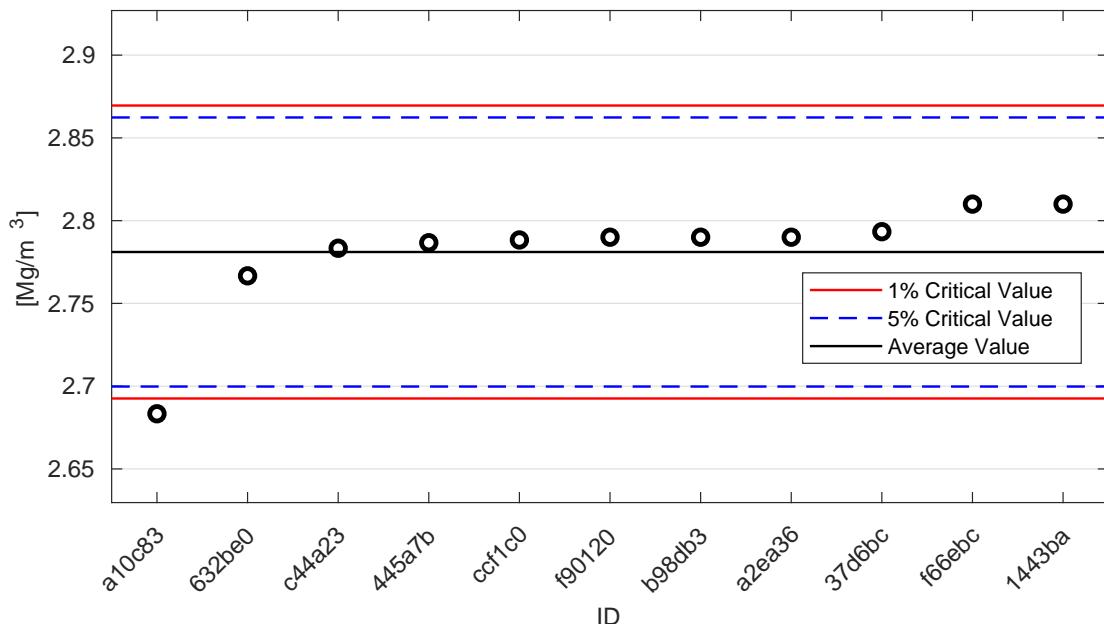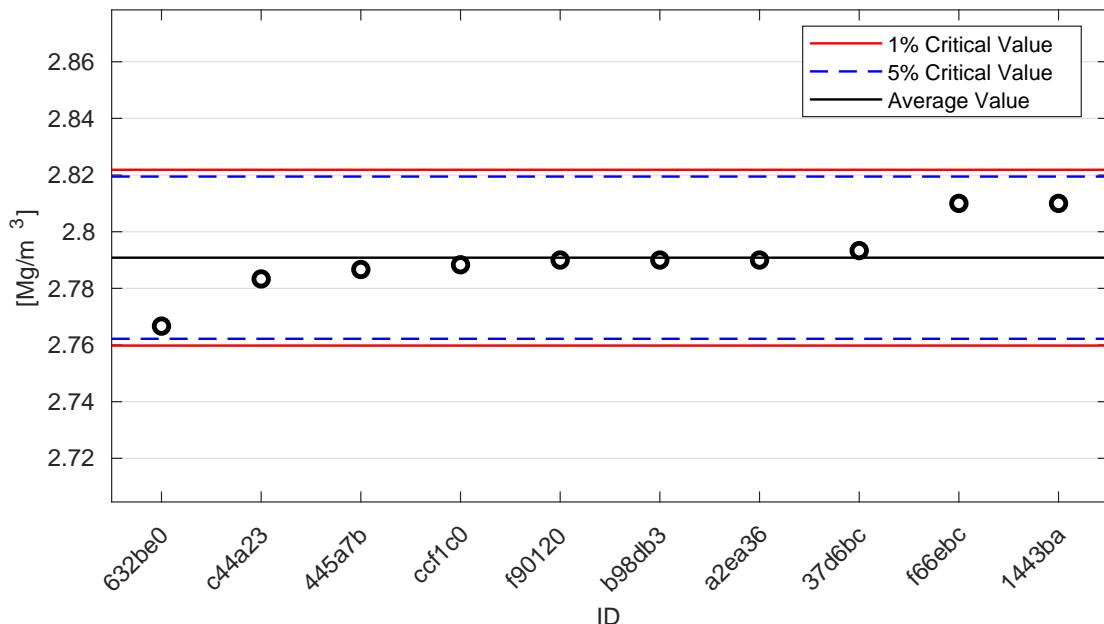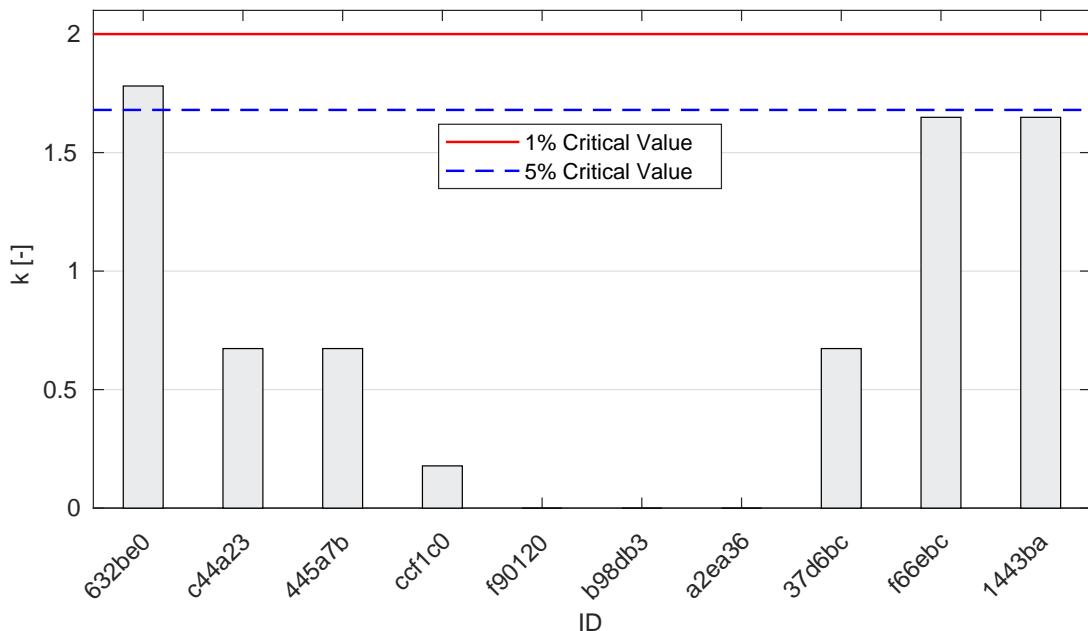
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Figure 133: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

Figure 134: **Grubbs' test** - average values without outliers: 1% critical value - red color; 5% critical value - blue color

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13.1.3 Mandel's Statistics

Figure 135: Intralaboratory Consistency Statistic *k*: 1% critical value - red color; 5% critical value - blue color
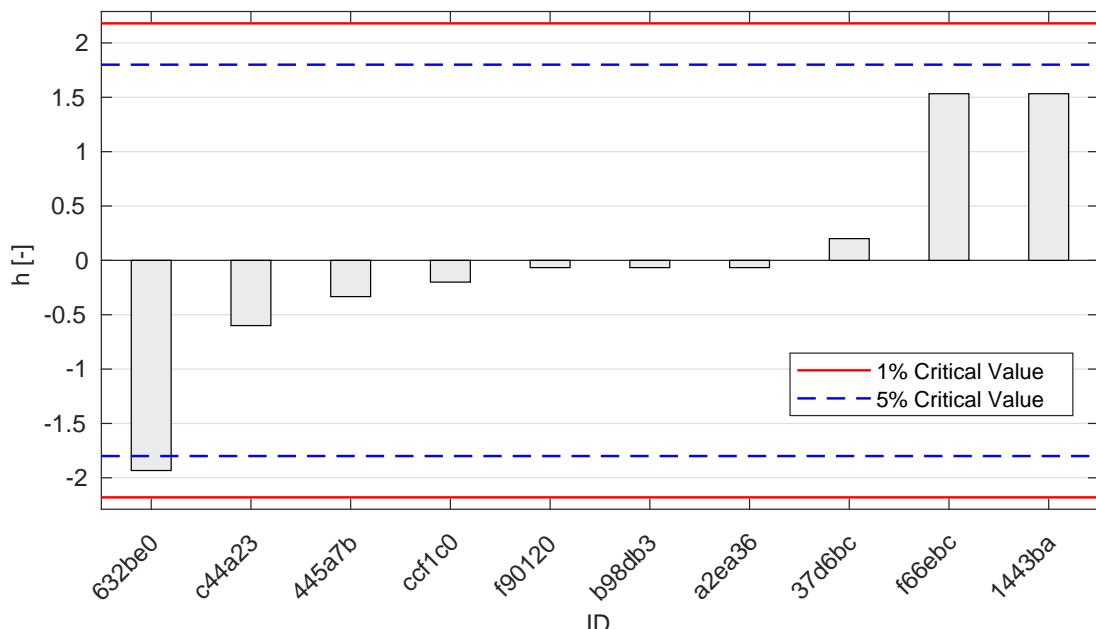
Figure 136: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

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13.1.4 Calculation of Performance Statistics

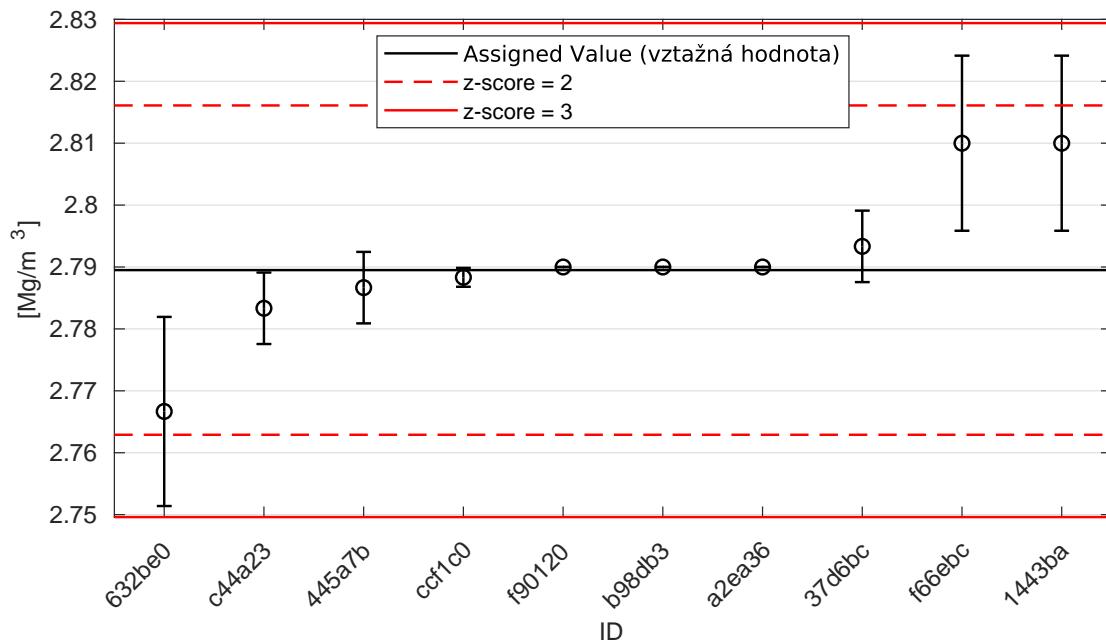
Figure 137: Average values and sample standard deviations
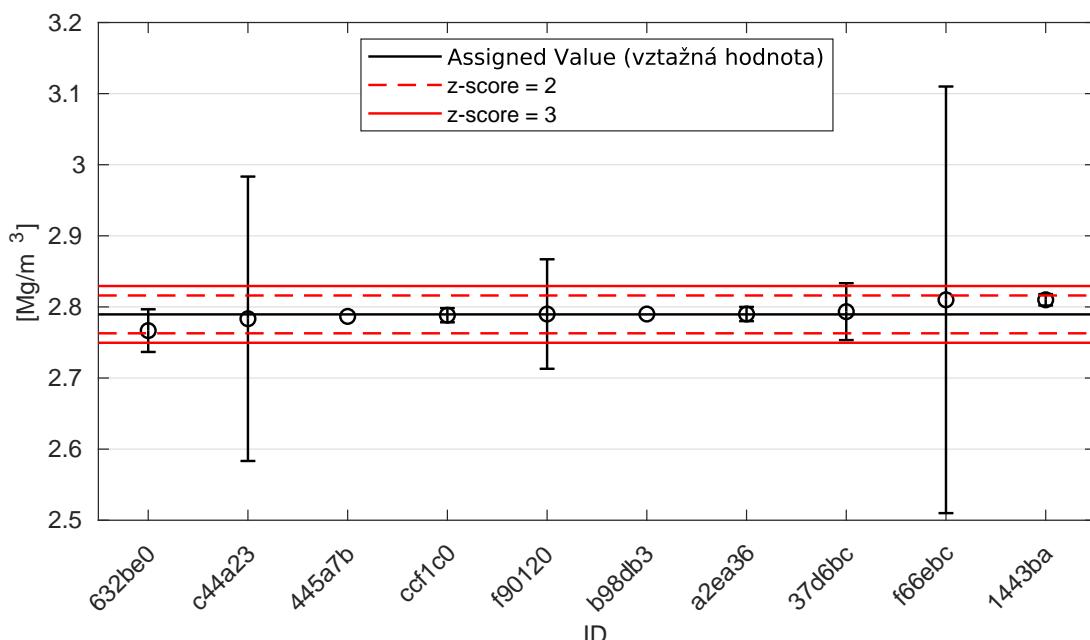
Figure 138: Average values and extended uncertainties of measurement

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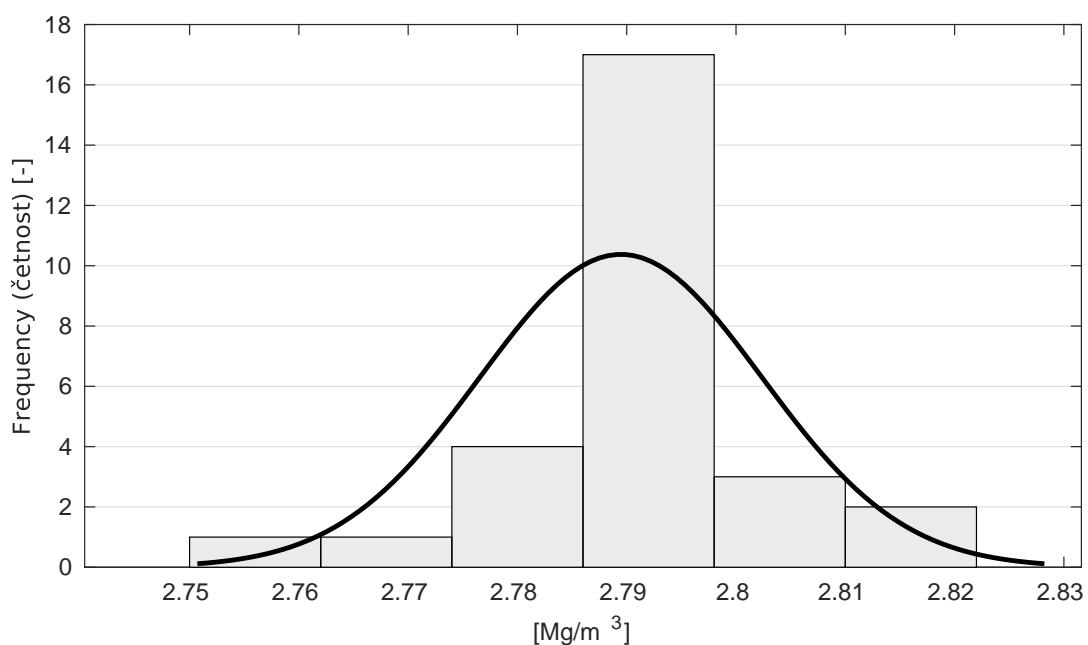
Figure 139: Histogram of all test results

Figure 140: z-score and ζ-score

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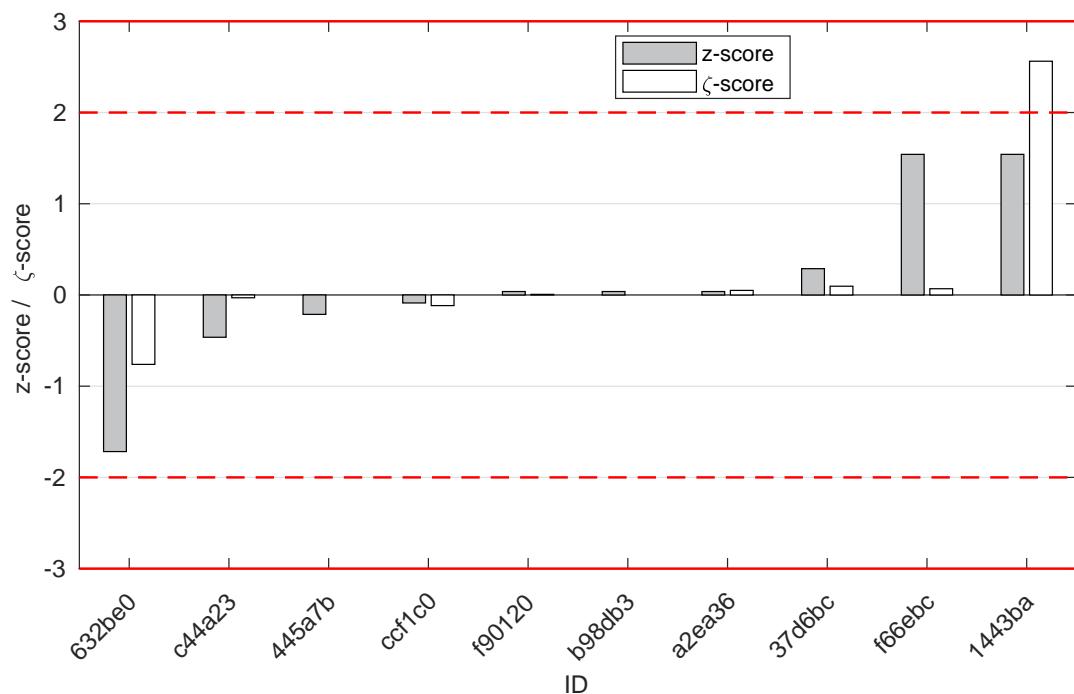
Table 37: z-score and ζ-score

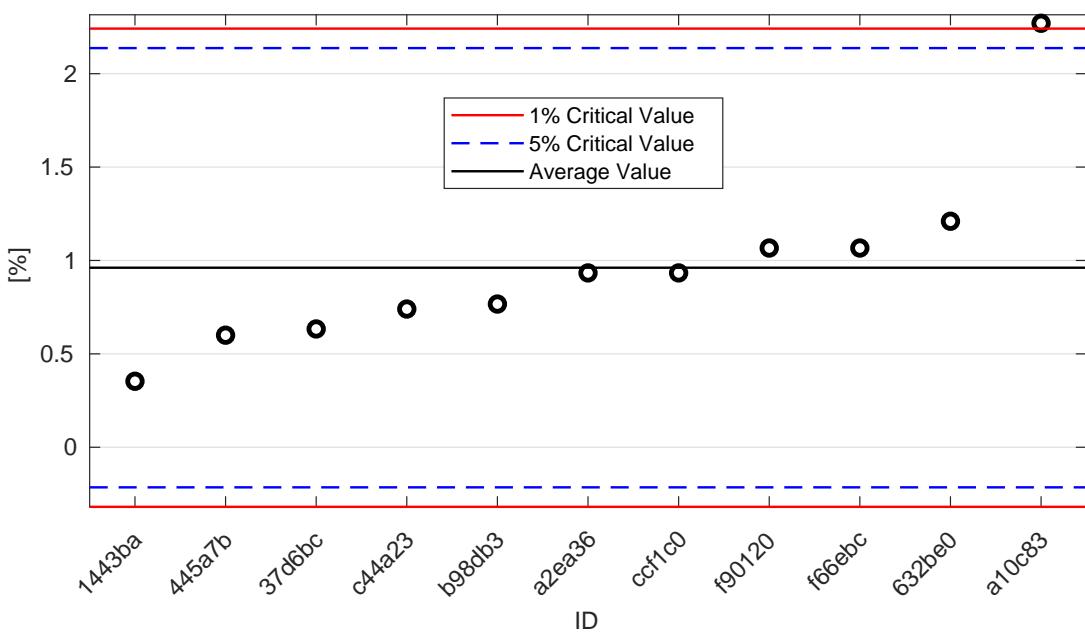| ID	z-score [-]	ζ-score [-]
632be0	-1.72	-0.76
c44a23	-0.46	-0.03
445a7b	-0.21	-
ccf1c0	-0.09	-0.12
f90120	0.04	0.01
b98db3	0.04	-
a2ea36	0.04	0.05
37d6bc	0.29	0.10
f66ebc	1.54	0.07
1443ba	1.54	2.56

13.2 Water Absorption

13.2.1 Test results

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

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
1443ba	0.42	0.29	0.35	0.10	0.35	0.07	18.41
445a7b	0.60	0.60	0.60	-	0.60	0.00	0.00
37d6bc	0.60	0.60	0.70	0.20	0.63	0.06	9.12
c44a23	0.71	0.75	0.76	0.06	0.74	0.03	3.58
b98db3	0.70	0.80	0.80	-	0.77	0.06	7.53
a2ea36	0.90	1.00	0.90	0.10	0.93	0.06	6.19
ccf1c0	0.80	1.00	1.00	0.20	0.93	0.12	12.37
f90120	1.00	1.10	1.10	0.01	1.07	0.06	5.41
f66ebc	1.20	1.00	1.00	2.30	1.07	0.12	10.83
632be0	1.18	1.22	1.23	0.30	1.21	0.03	2.19
a10c83*	2.28	2.26	2.27	0.03	2.27	0.01	0.44

13.2.2 The Numerical Procedure for Determining Outliers
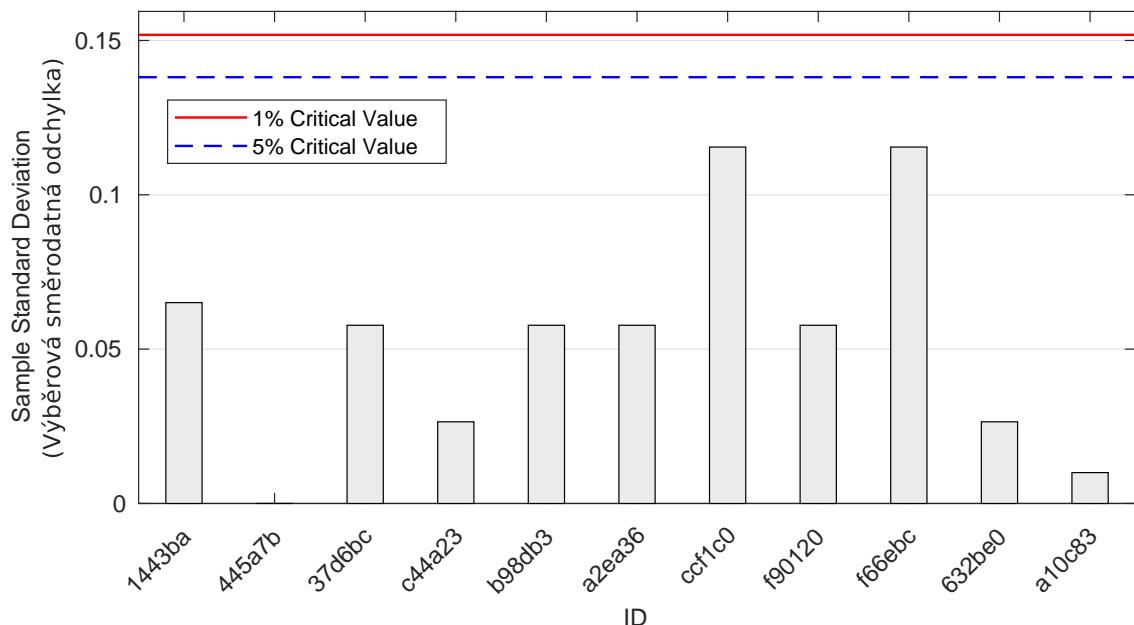
Figure 141: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

Figure 142: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

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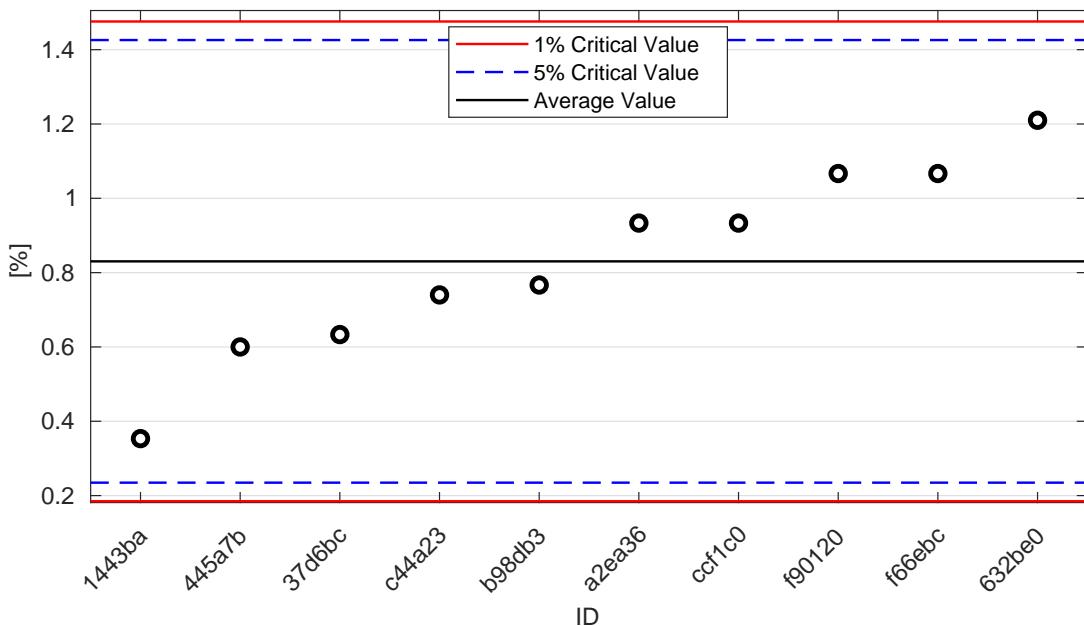szk.fce.vutbr.cz | ptprovider.cz

Figure 143: **Grubbs' test** - average values without outliers: 1% critical value - red color; 5% critical value - blue color

13.2.3 Mandel's Statistics

Figure 144: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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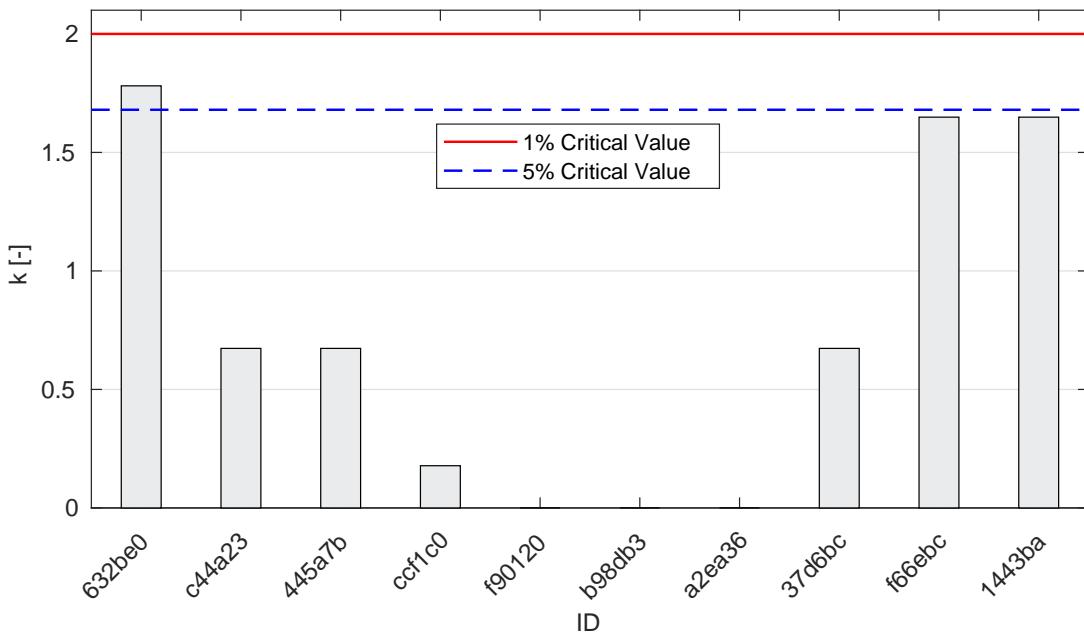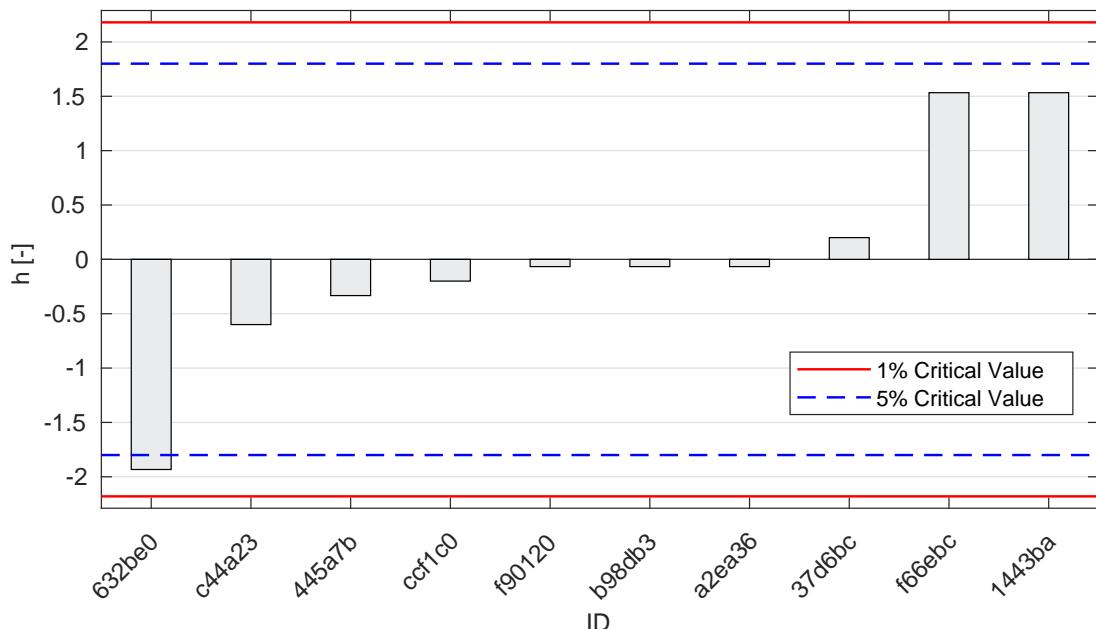Veveří 331/95 | 602 00 Brno | Czech Republic
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Figure 145: Interlaboratory Consistency Statistic h: 1% critical value - red color; 5% critical value - blue color

13.2.4   Calculation of Performance Statistics
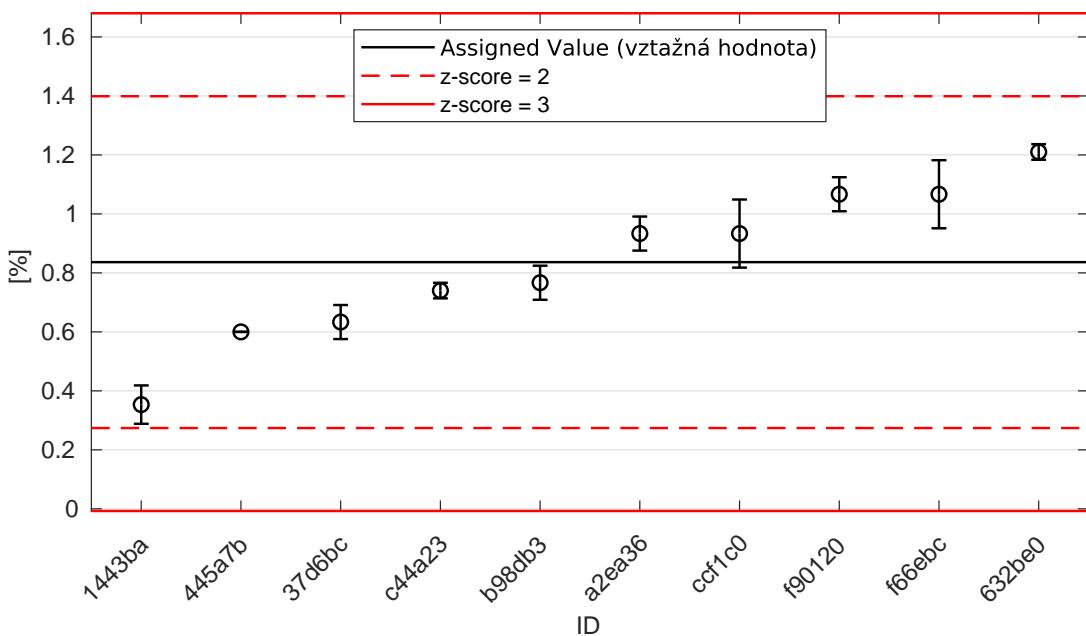
Figure 146: Average values and sample standard deviations

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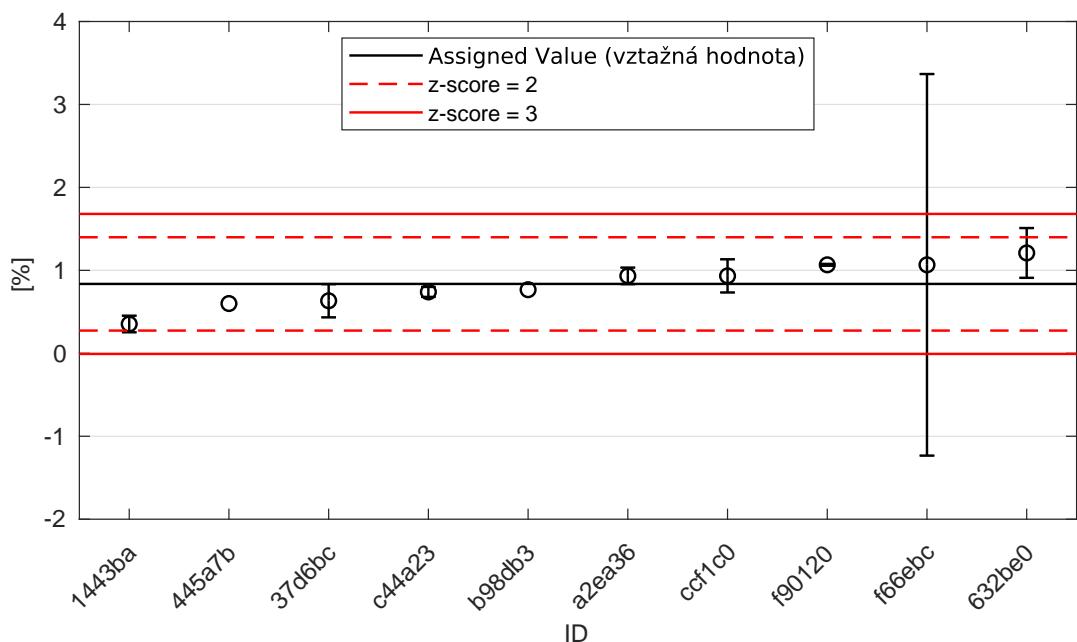
Figure 147: Average values and extended uncertainties of measurement
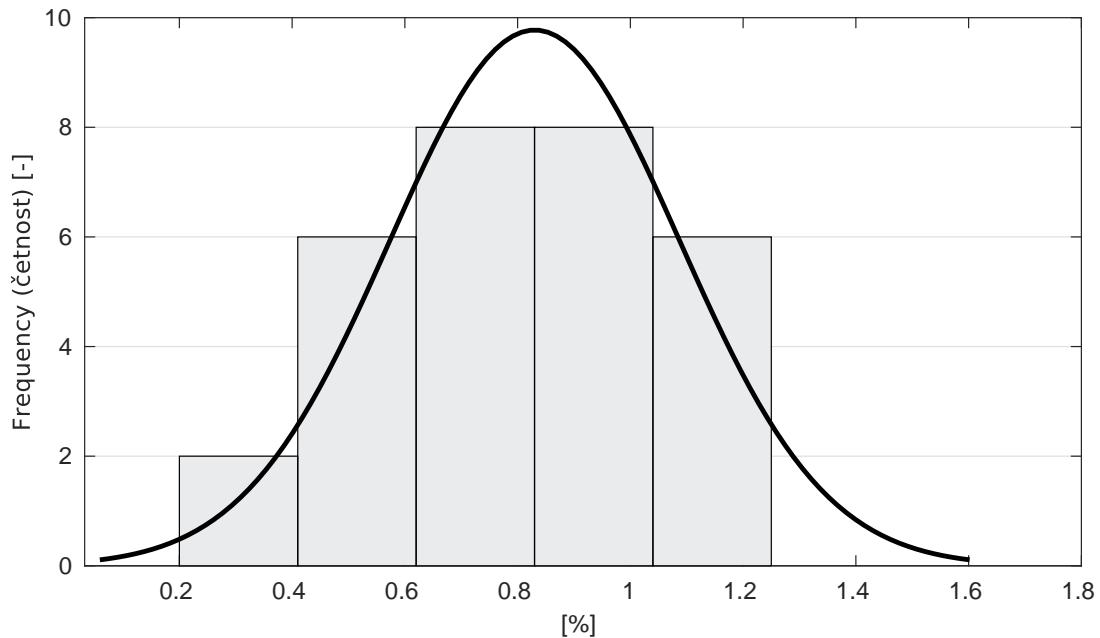
Figure 148: Histogram of all test results

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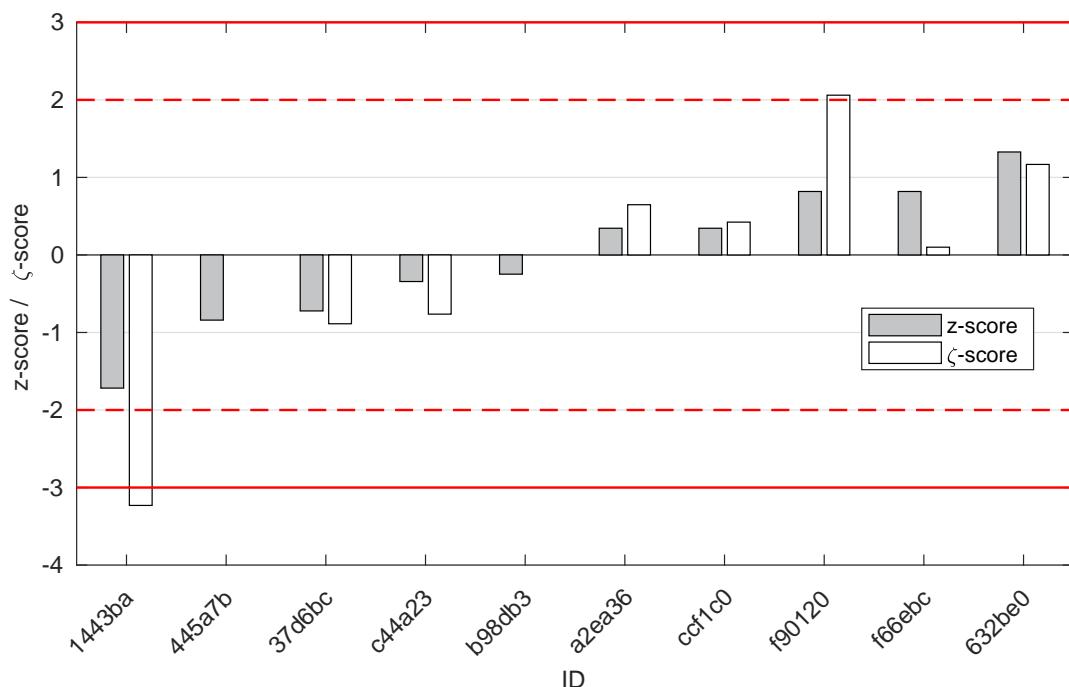
Figure 149: z-score and ζ-score

Table 39: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
1443ba	-1.72	-3.23
445a7b	-0.84	-
37d6bc	-0.72	-0.89
c44a23	-0.34	-0.76
b98db3	-0.25	-
a2ea36	0.34	0.65
ccf1c0	0.34	0.42
f90120	0.82	2.06
f66ebc	0.82	0.10
632be0	1.33	1.17

14 Appendix – EN 1097-7 Determination of the particle density of filer - Pyknometer method

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

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15 Appendix – EN 1367-1 Determination of resistance to freezing and thawing

15.1 Test results

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

ID of participant	Test results [%]			u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
f90120	0.03	0.03	0.05	0.01	0.04	0.01	31.49
a10c83	0.05	0.04	0.06	0.03	0.05	0.01	20.00
a2ea36	0.10	0.10	0.10	0.10	0.10	0.00	0.00
3e47f1	0.15	0.15	0.10	0.50	0.13	0.03	21.65
1443ba	0.50	0.20	0.20	0.26	0.30	0.17	57.74
632be0	0.32	0.29	0.30	0.10	0.30	0.02	5.04
ccf1c0	0.40	0.30	0.40	0.20	0.37	0.06	15.75
37d6bc*	4.60	4.90	4.90	0.30	4.80	0.17	3.61

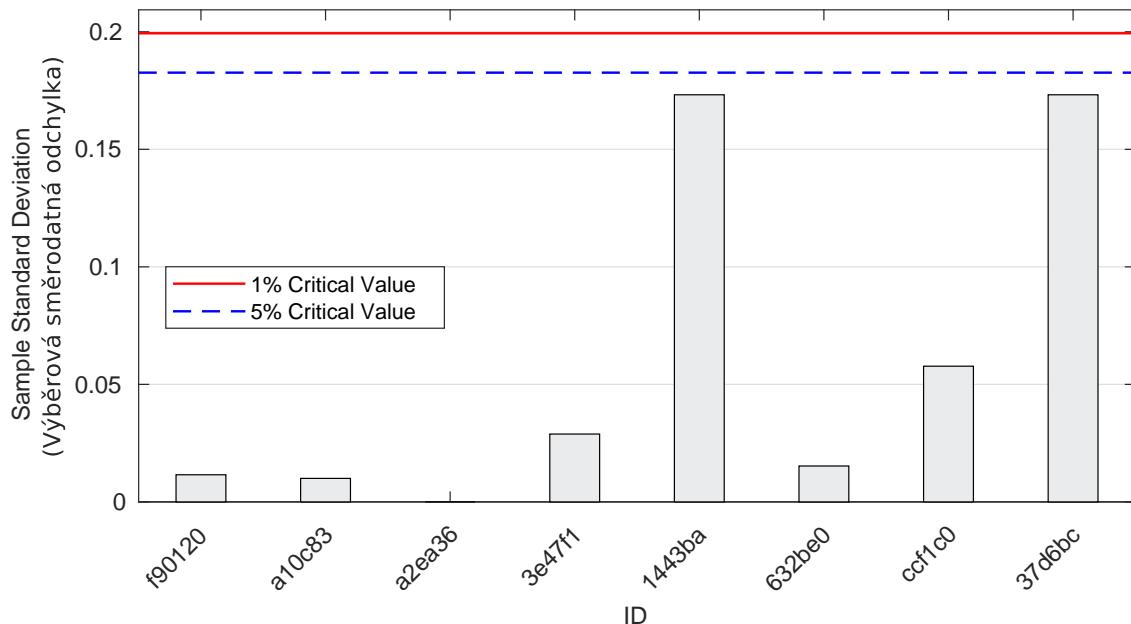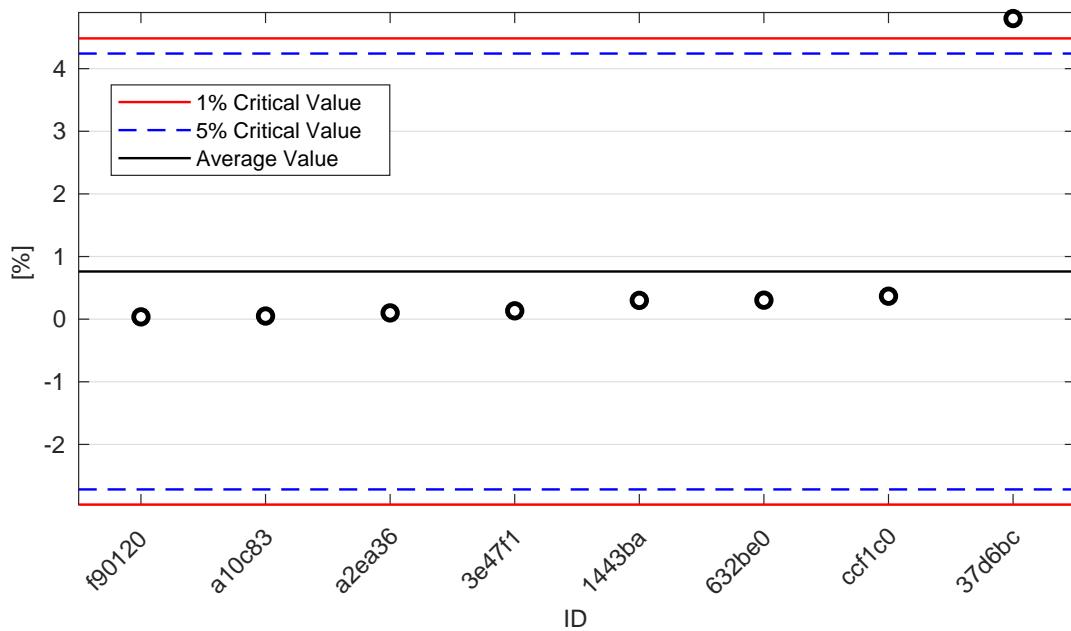### 15.2 The Numerical Procedure for Determining Outliers
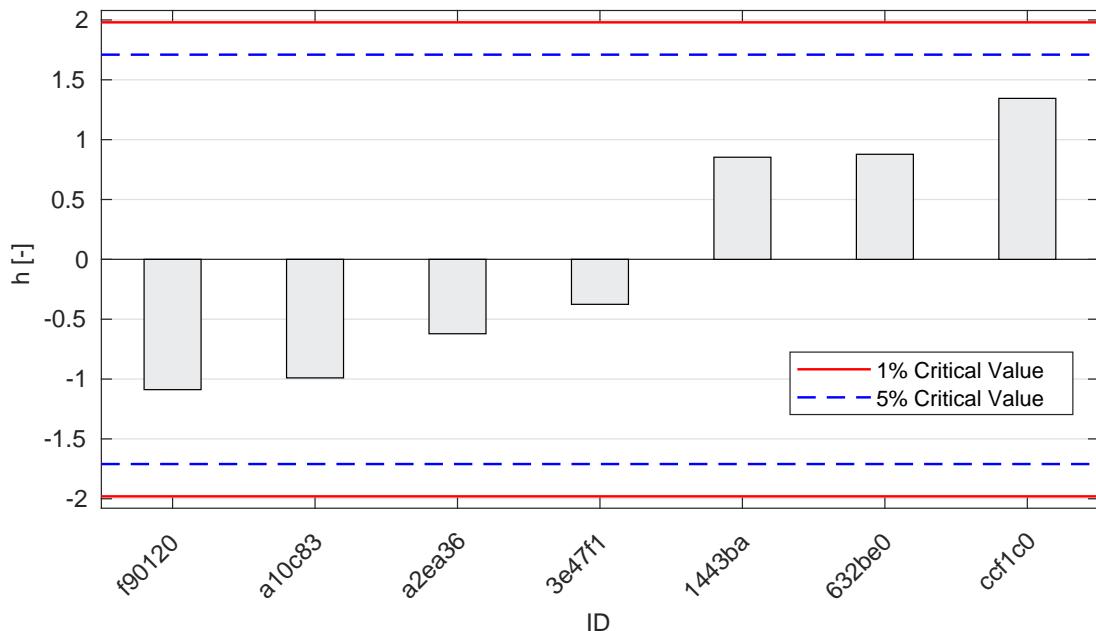

Figure 150: **Cochran's test** - sample standard deviations: 1% critical value - red color; 5% critical value - blue color

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Figure 151: **Grubbs' test** - average values: 1% critical value - red color; 5% critical value - blue color

15.3 Mandel's Statistics
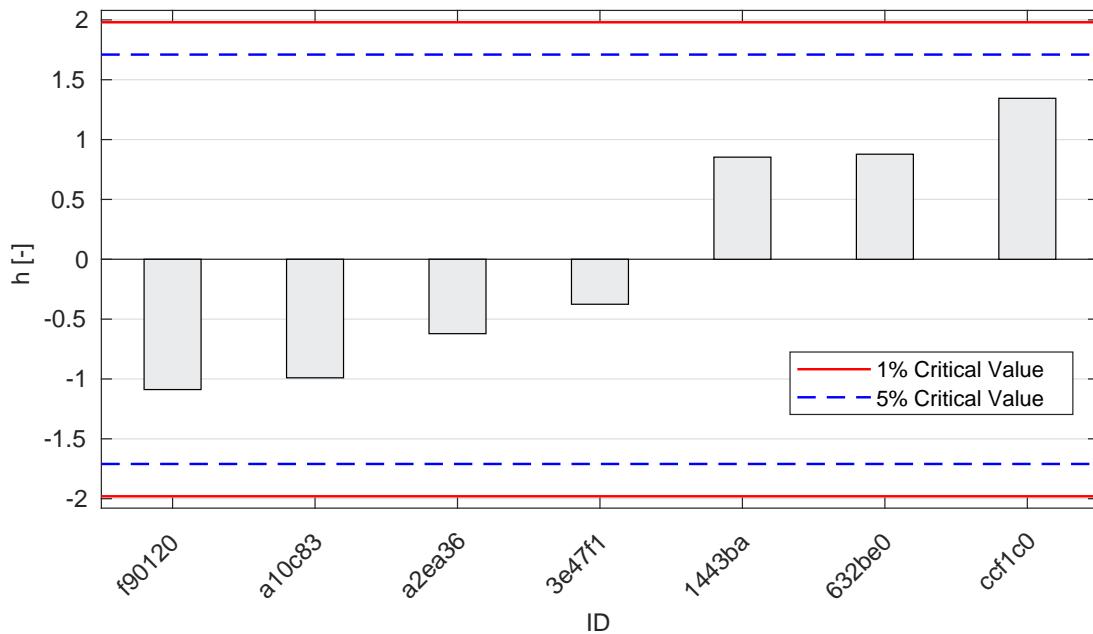
Figure 152: Intralaboratory Consistency Statistic k: 1% critical value - red color; 5% critical value - blue color

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Figure 153: Interlaboratory Consistency Statistic *h*: 1% critical value - red color; 5% critical value - blue color

15.4 Calculation of Performance Statistics
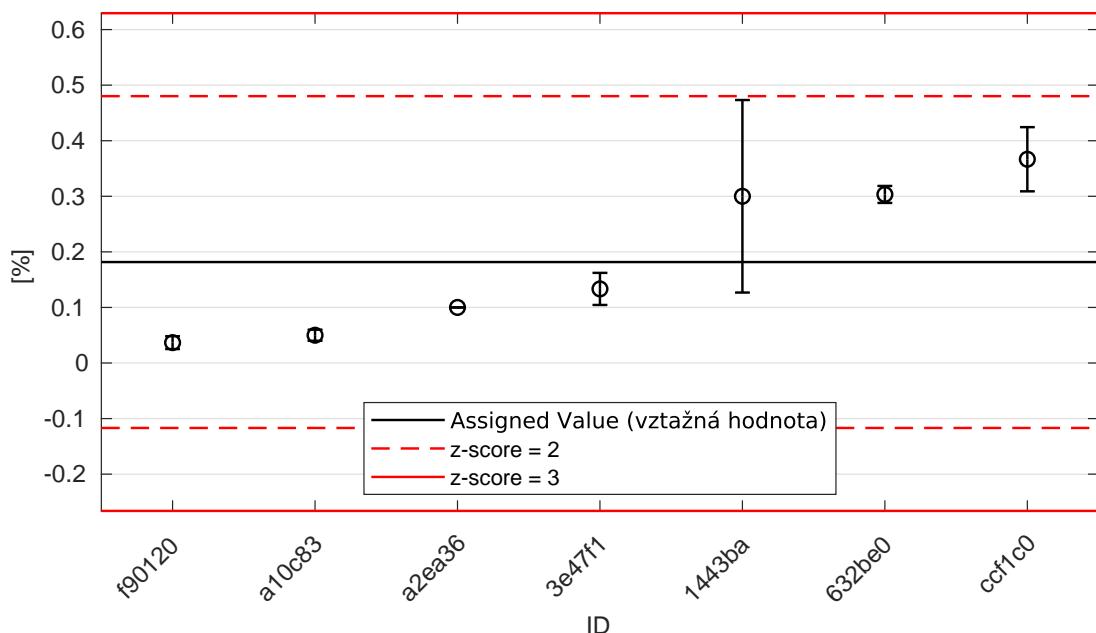
Figure 154: Average values and sample standard deviations

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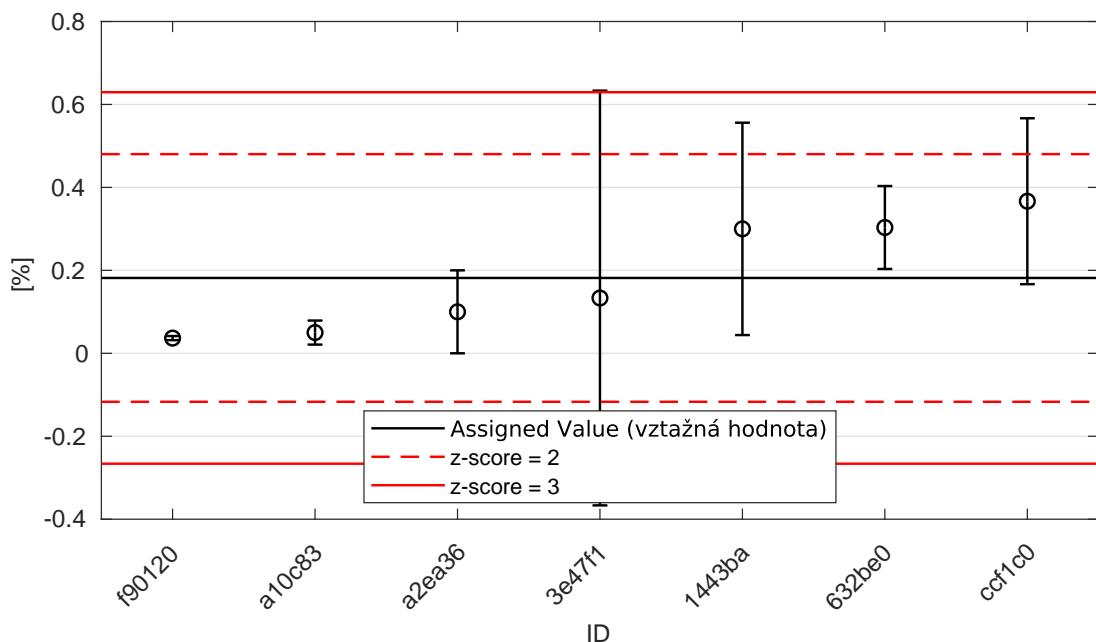
Figure 155: Average values and extended uncertainties of measurement
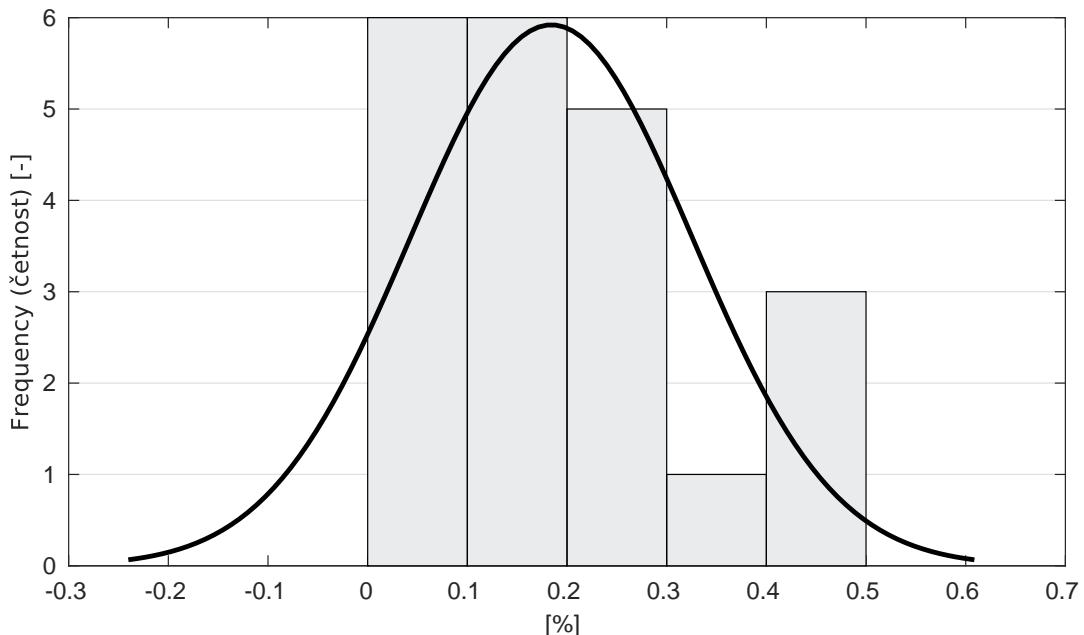
Figure 156: Histogram of all test results

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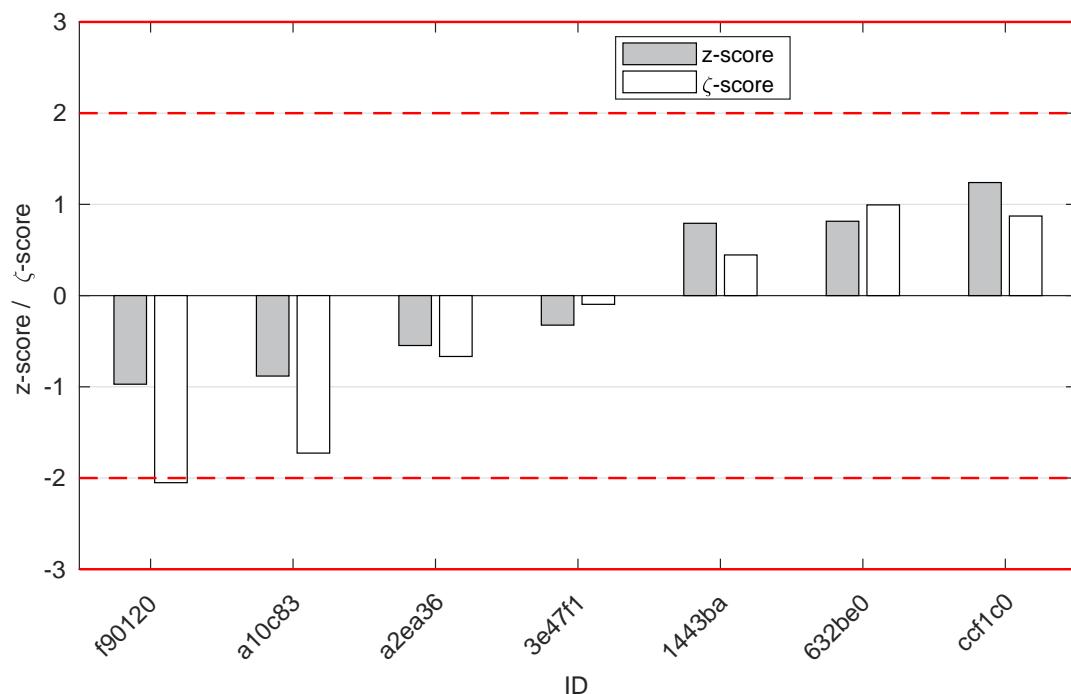
Figure 157: z-score and ζ-score

Table 41: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
f90120	-0.97	-2.05
a10c83	-0.88	-1.73
a2ea36	-0.55	-0.67
3e47f1	-0.32	-0.10
1443ba	0.79	0.45
632be0	0.82	0.99
ccf1c0	1.24	0.87

16   Appendix – EN 1367-2 Magnesium sulfate test

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

17   Appendix – EN 1367-3 Boiling test for "Sonnenbrand basalt"

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

18   Appendix – TP 137 - Příloha 1 a 2 – Reaktivnost kameniva s alkáliemi

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

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19 Appendix – ČSN 72 1179 Determination of reactivity of aggregates in connection with alkalies – chapter B

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

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