BRNO UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
institute of building testing

ilac-MRA

Z 7008

FINAL REPORT ON THE RESULTS OF PRECISION EXPERIMENT

Proficiency Testing Program
Steel Testing
ZO 2025/1

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

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

Date: January 7, 2026

Poskytovatel zkoušení způsobilosti při SZK FAST
Proficiency testing provider at the SZK FAST
Z 7008
Veveří 95
602 00 Brno
Czech Republic
szk.fce.vutbr.cz

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

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

Contents

1 Introduction and Important Contacts

In the year 2025, the Proficiency Testing Provider at the SZK FAST (PT Provider) initiated the Proficiency Testing Program (PTP) designated ZO 2025/1 whose aim was to verify and assess the conformity of test results across laboratories when testing steel.

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

Head of the PT Provider, PTP coordinator

Assoc. Prof. Ing. Tomáš Vymazal, Ph.D.
Brno University of Technology
Faculty of Civil Engineering
Institute of Building Testing
Veveří 95, Brno 602 00
Czech Republic
Tel.: +420 603 313 337
Email: Tomas.Vymazal@vut.cz

Coordinator of PTP result assessment PrZZ

Ing. Petr Misák, Ph.D.
Brno University of Technology
Faculty of Civil Engineering
Institute of Building Testing
Veveří 95, Brno 602 00
Czech Republic
Tel.: +420 774 980 255
Email: Petr.Misak@vut.cz

The subjects of proficiency testing were the following testing procedures:

1. **Testing of Concrete Reinforcement B500B - EN ISO 6892-1** – Tensile Strength [1],
2. **Testing of Concrete Reinforcement B500B - EN ISO 6892-1** – Yield Strength [1],
3. **Testing of Concrete Reinforcement B500B - EN ISO 6892-1** – Elongation [1],
4. **Testing of Concrete Reinforcement B500B - EN ISO 6892-1** – Contraction [1],
5. **Bar Test - EN ISO 6892-1** – Tensile Strength [1],
6. **Bar Test - EN ISO 6892-1** – Yield Strength [1],
7. **Bar Test - EN ISO 6892-1** – Elongation [1],
8. **Bar Test - EN ISO 6892-1** – Contraction [1].

Testing procedure 5 – 8 was not open due to low interest from laboratories.

The specimens were taken from the same production with the same production date. The test specimens were distributed among the individual participants in the PrZZ in such a way that their properties could not be affected.

The test results from individual PTP participants were compared via a method involving the statistical analysis of all their results in a manner complying with ISO 5725-2 [2] and with EN ISO/IEC 17043 [3]. The outcome is the present final report summarizing the results of the interlaboratory comparison, including statistical evaluation.

9 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

ID/Method	1	2	3	4	5	6	7	8
14981d	X	X	X	X	-	-	-	-
1d0d41	X	X	X	-	-	-	-	-
30f36e	X	X	X	X	-	-	-	-

Continued on next page

Continued from previous page

ID/Method	1	2	3	4	5	6	7	8
3798d1	X	X	X	-	-	-	-	-
3899a5	X	X	X	X	-	-	-	-
7ef1c0	X	X	X	X	-	-	-	-
b848ea	X	X	X	X	-	-	-	-
fc5128	X	X	X	X	-	-	-	-

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

Laboratory	Address	Accreditation number
Bechtel ENKA UK Limited Ogranak Beograd	Jasički put 52 đ, Kruševac, 37000, Serbia	-
Building Research Institute - NISI	Nikola Petkov Blvd., Sofia, 1618, Bulgaria	88 ЛИ
Technický a skúšobný ústav stavebný, n. o.	Studená, 967/3, Bratislava, 82104, Slovenská republika	-
Technický a zkušební ústav Praha, s.p., Centrální laboratoř, zkušebna 0500 Předměřice nad Labem	Průmyslová 283, Předměřice nad Labem, 503 02, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s. p. - Pobočka Plzeň	Zahradní 15, Plzeň, 32600, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s. p., Centrální laboratoř - zkušebna Brno	Hněvkovského 77, Brno, 617 00, Česká republika	1018.3
Technický a zkušební ústav stavební Praha, s.p.	Prosecká 811/76a, Praha 9, 19000, Česká republika	1018.3
VZLU AEROSPACE, a.s.	Beranových 130, Praha 9, 19900, Česká republika	1756

2 Procedures used in the Statistical Analysis of Laboratory Results

The statistical analysis is based on the following steps:

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

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

3 Conclusions of the Statistical Analysis

The present report summarizes the results of the Proficiency Testing Program Steel Testing (PT Program) organized by the PT Provider at the SZK FAST. 9 participants (laboratories) took part in the PT Program. The program focused on ordinary standardized testing of steel. The test results are evaluated separately for each testing procedure examined. An evaluation of statistical characteristics is included in the Appendix, as well as test results and graphic presentations. Testing methods can be found in part 1 of this report. Table 3 shows the evaluation of the laboratory performance according to EN ISO/IEC 17043 [3].

Table 3: Evaluation of overall performance and outliers.
✓ – satisfactory performance; ? – questionable performance; ! – unsatisfactory performance; X – outlier;

ID / Method	1	2	3	4
14981d	✓	✓	✓	✓
1d0d41	✓	✓	✓	-
30f36e	✓	?	✓	✓
3798d1	✓	✓	✓	-
3899a5	✓	✓	✓	✓
7ef1c0	✓	✓	✓	✓
b848ea	✓	✓	✓	✓
fc5128	✓	✓	✓	✓

References

[1] EN ISO 6892-1. *Metallic materials - Tensile testing - Part 1: Method of test at room temperature*. 2021.

[2] ISO 5725-2. *Accuracy (trueness and precision) of measurement methods and results - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*. 2019.

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

1 Appendix – Testing of Concrete Reinforcement B500B – EN ISO 6892-1 – Tensile Strength

1.1 Test results

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

ID	Test results [N/mm^2]						u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
3899a5	636	632	640	640	637	637	2.8	637	3.0	0.47
fc5128	637	643	641	640	638	638	-	640	2.3	0.35
3798d1	639	641	647	638	641	639	5.0	641	3.3	0.51
b848ea	639	643	642	646	643	643	1.7	643	2.3	0.35
30f36e	648	647	650	643	649	650	5.0	648	2.6	0.41
14981d	648	647	646	648	651	650	2.0	648	1.9	0.29
7ef1c0	651	647	650	655	651	653	2.6	651	2.7	0.42
1d0d41	653	649	656	652	656	657	4.0	654	3.1	0.47

1.2 The Numerical Procedure for Determining Outliers

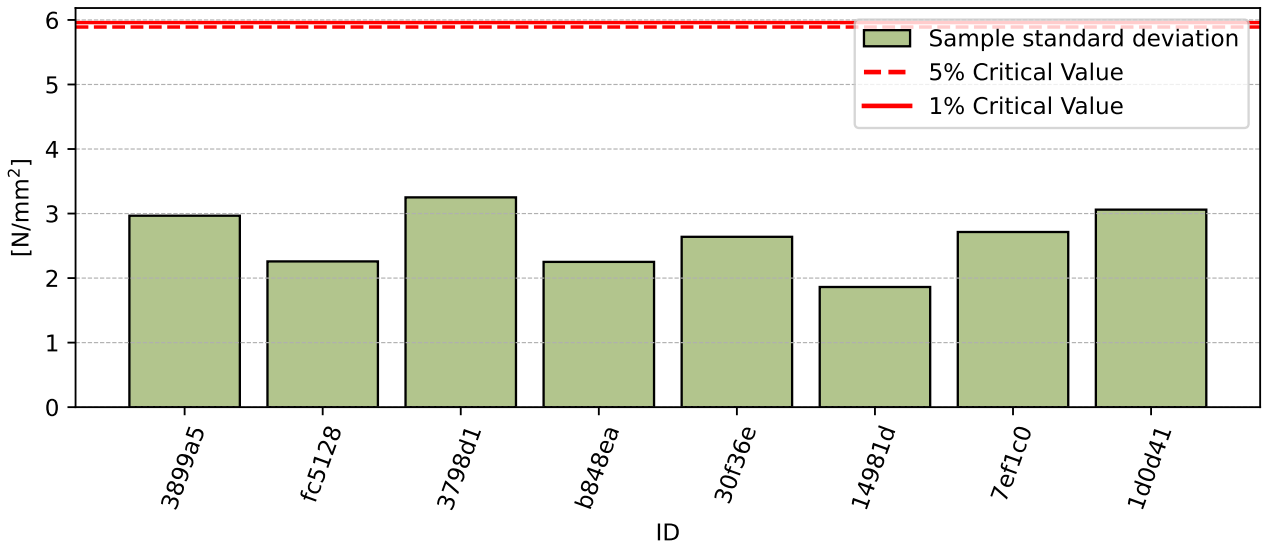

Figure 1: **Cochran's test** - sample standard deviations

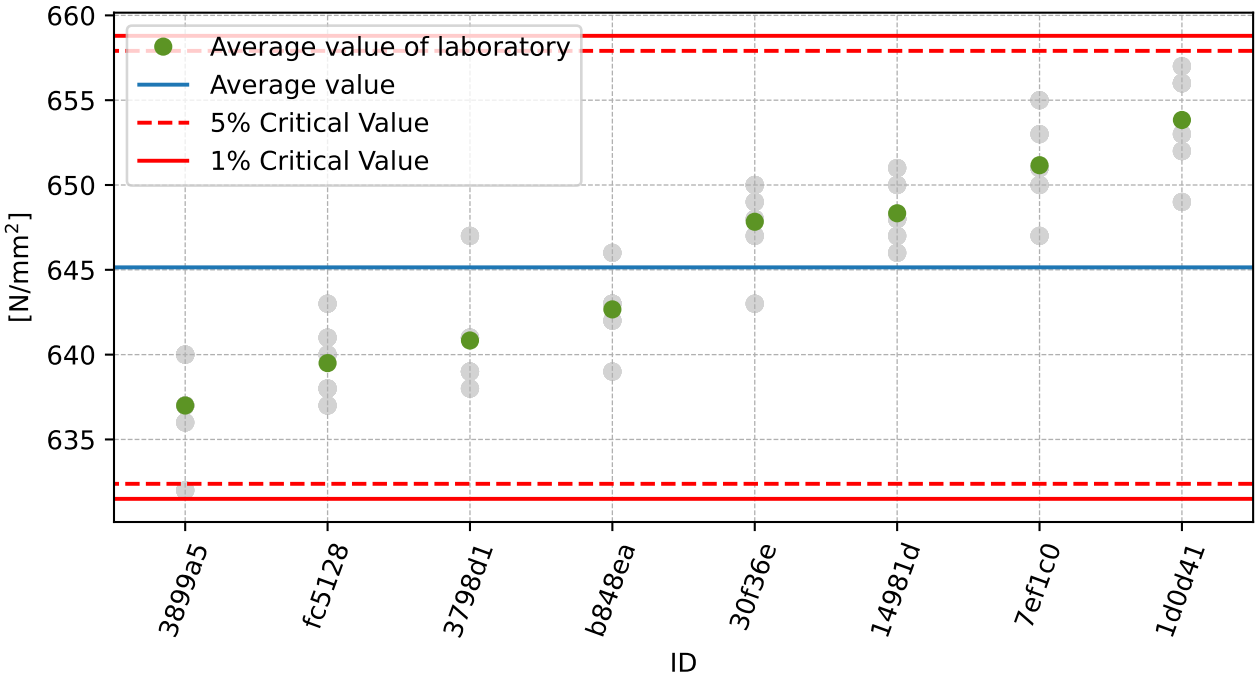

Figure 2: **Grubbs' test** - average values

1.3 Mandel's Statistics

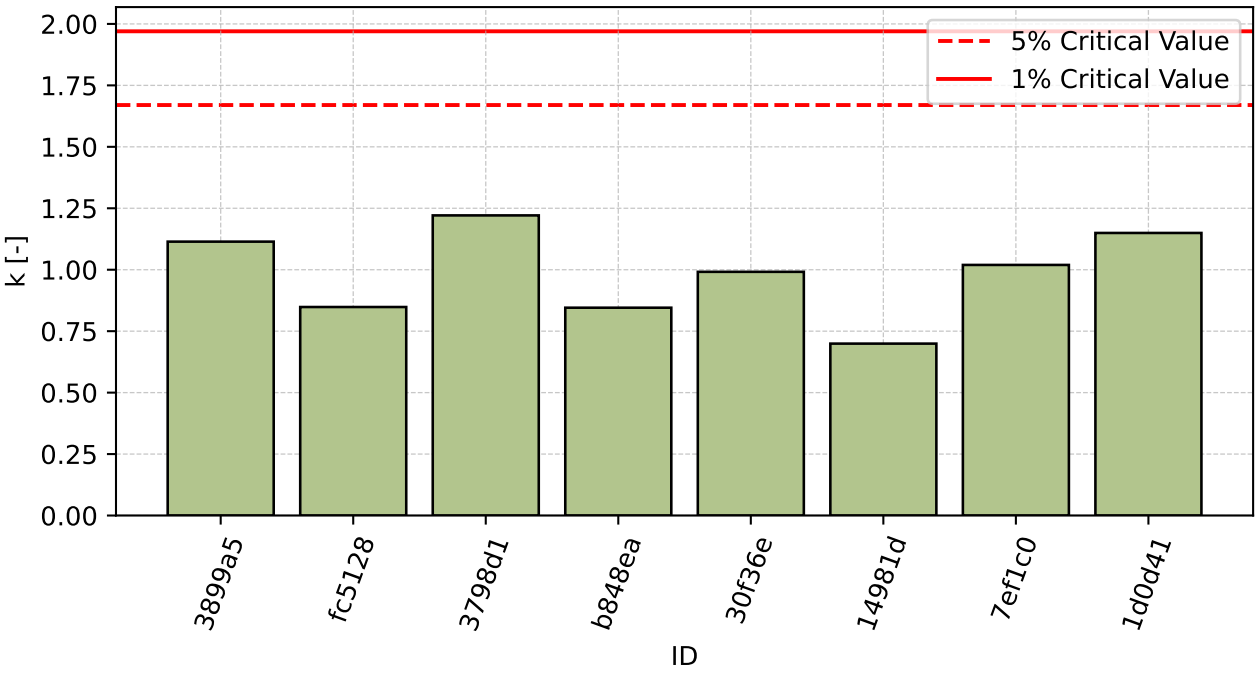

Figure 3: Intralaboratory Consistency Statistic

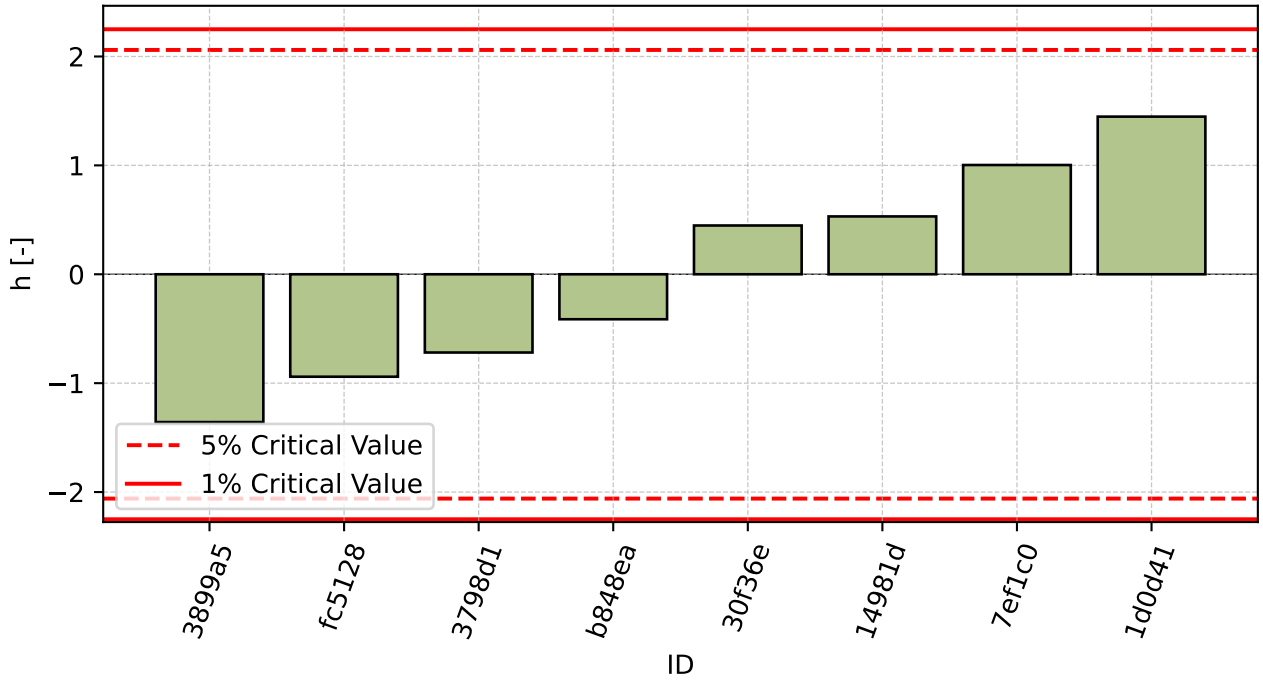

Figure 4: Interlaboratory Consistency Statistic

1.4 Descriptive statistics

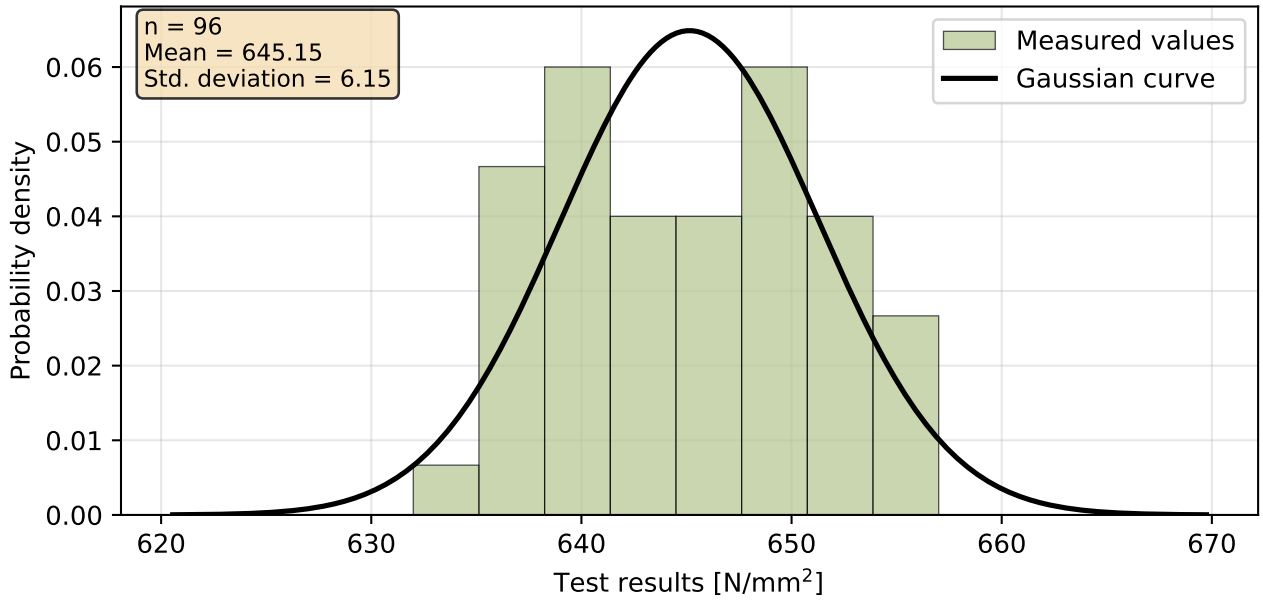

Figure 5: Histogram of all test results

Table 5: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	645
Sample standard deviation – s	6.0
Asigned value – x^*	645
Robust standard deviation – s^*	6.0
Measurement uncertainty of asigned value – u_X	2.1
p-value of normality test	0.198 [-]
Interlaboratory standard deviation – s_L	5.9
Repeatability standard deviation – s_r	2.7
Reproducibility standard deviation – s_R	6.5
Repeatability – r	7
Reproducibility – R	18

1.5 Evaluation of Performance Statistics

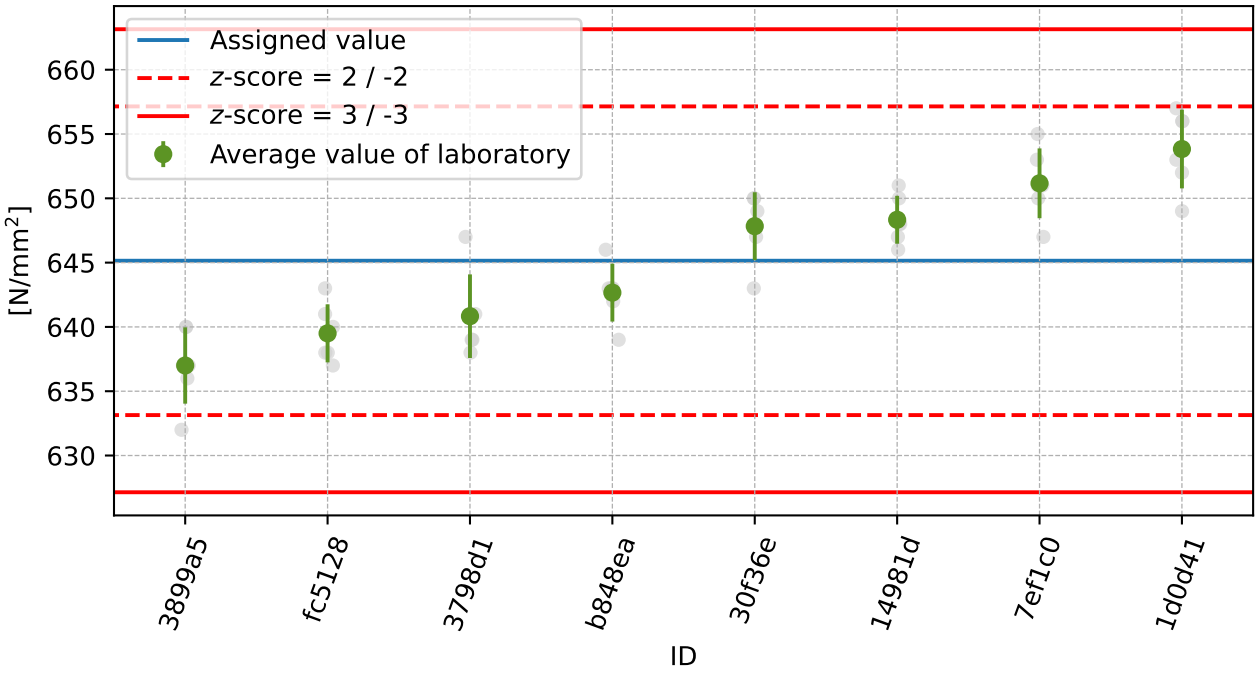

Figure 6: Average values and sample standard deviations

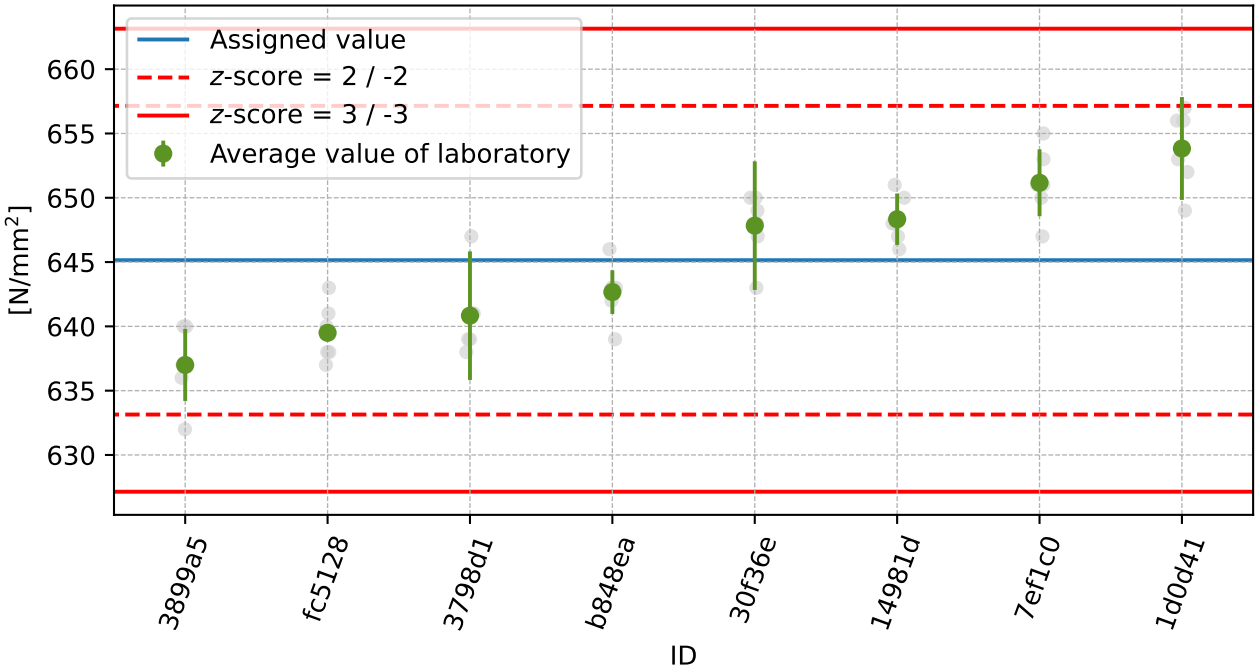

Figure 7: Average values and extended uncertainties of measurement

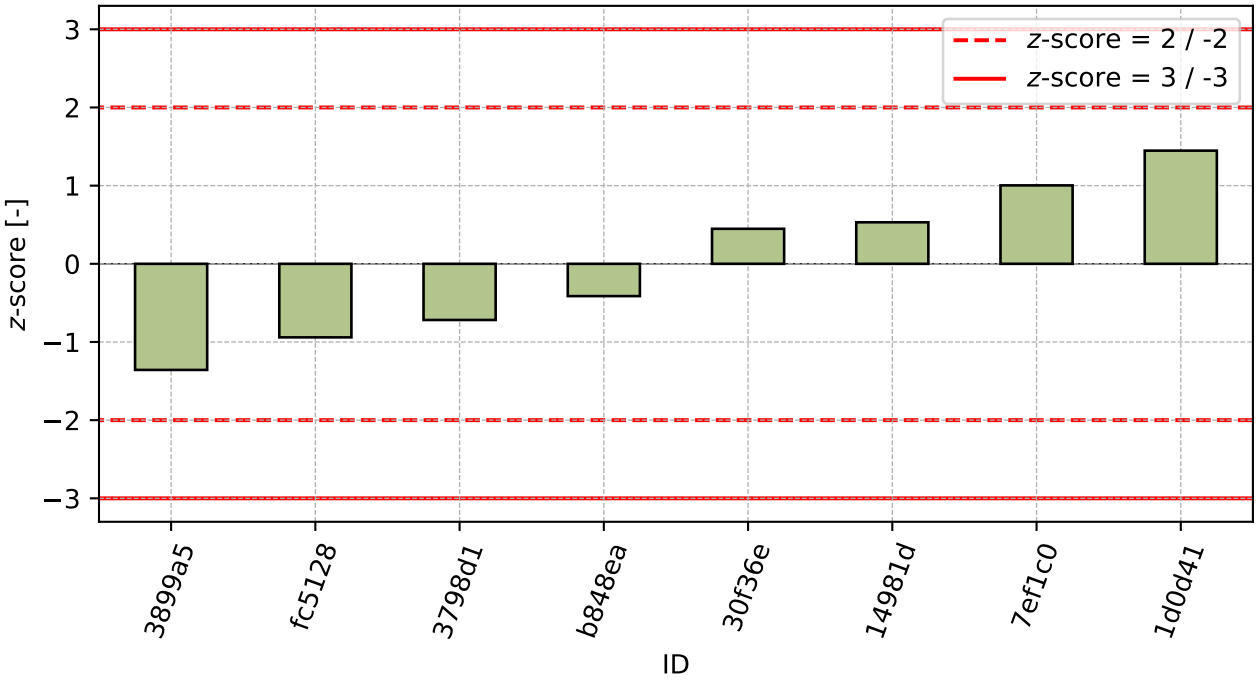

Figure 8: z-score

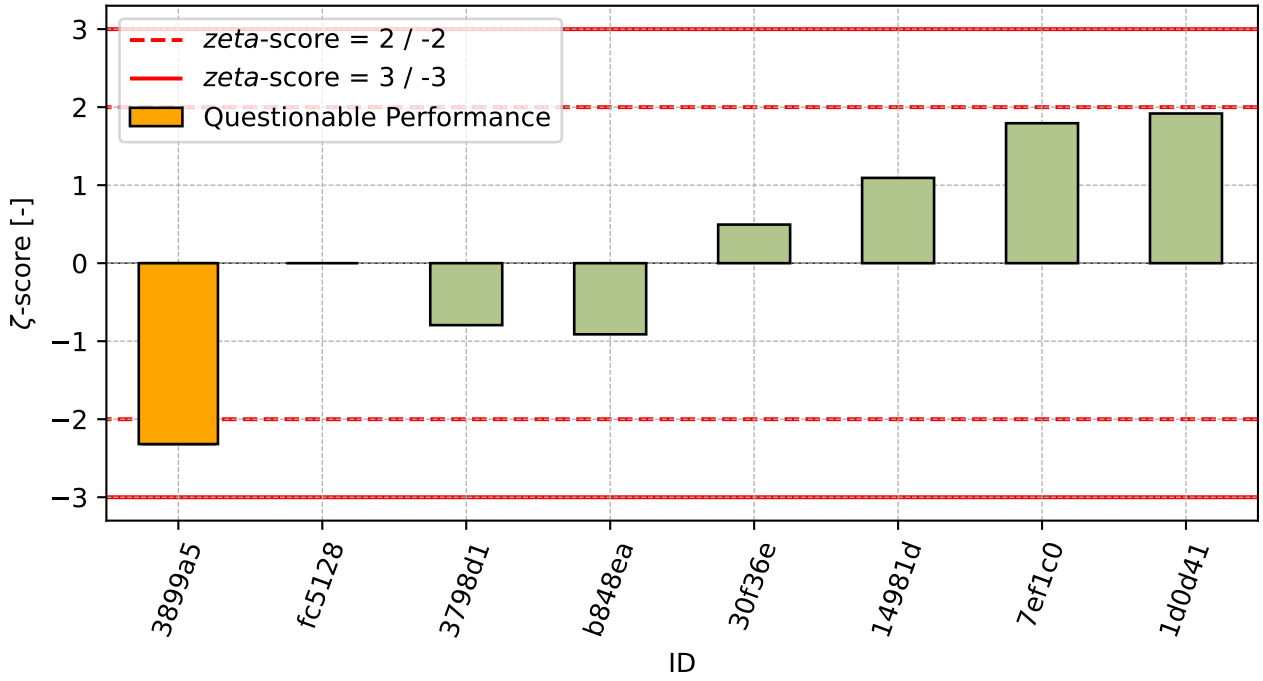

Figure 9: ζ-score

Table 6: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
3899a5	-1.36	-2.32
fc5128	-0.94	-
3798d1	-0.72	-0.79
b848ea	-0.41	-0.91
30f36e	0.45	0.49
14981d	0.53	1.09
7ef1c0	1.0	1.79
1d0d41	1.45	1.92

2 Appendix – Testing of Concrete Reinforcement B500B – EN ISO 6892-1 – Yield Strength

2.1 Test results

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

ID	Test results [N/mm^2]						u_X [N/mm^2]	$\bar{x}$ [N/mm^2]	s_0 [N/mm^2]	V_X [%]
3899a5	514	513	515	517	518	511	2.4	515	2.6	0.50
3798d1	512	512	521	514	516	514	4.0	515	3.4	0.65
7ef1c0	513	516	516	521	521	517	3.1	517	3.1	0.61
fc5128	519	520	519	517	520	510	-	518	3.8	0.74
b848ea	518	518	518	524	516	517	1.7	518	2.8	0.54
1d0d41	522	519	528	526	525	523	5.0	524	3.2	0.61
14981d	524	526	527	524	528	527	2.0	526	1.7	0.32
30f36e	536	536	538	536	537	541	4.0	537	2.0	0.37

2.2 The Numerical Procedure for Determining Outliers

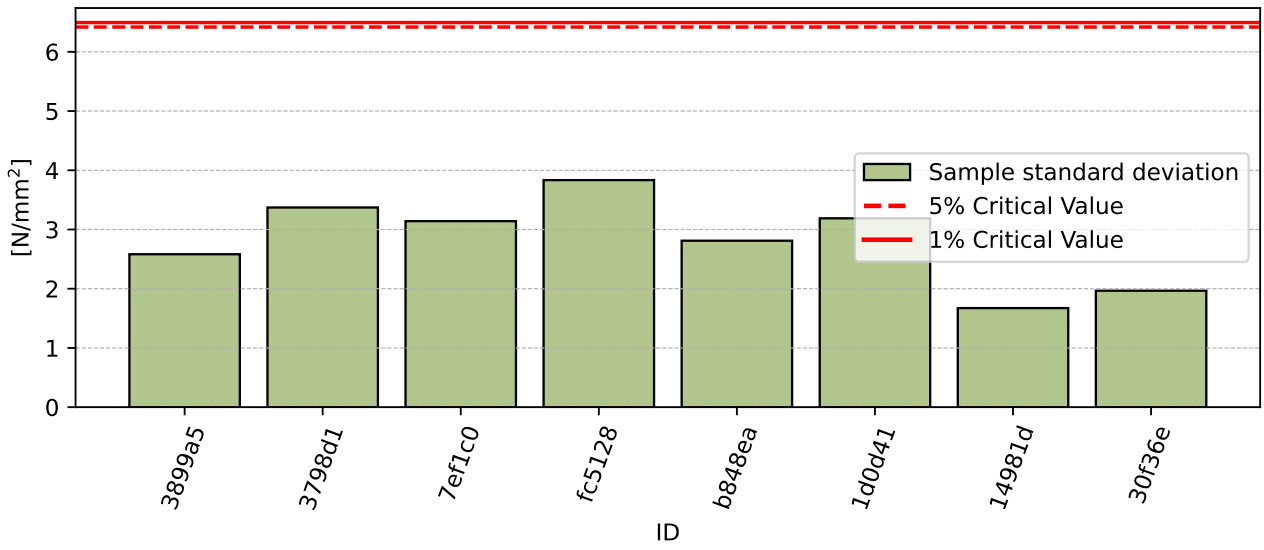

Figure 10: **Cochran's test** - sample standard deviations

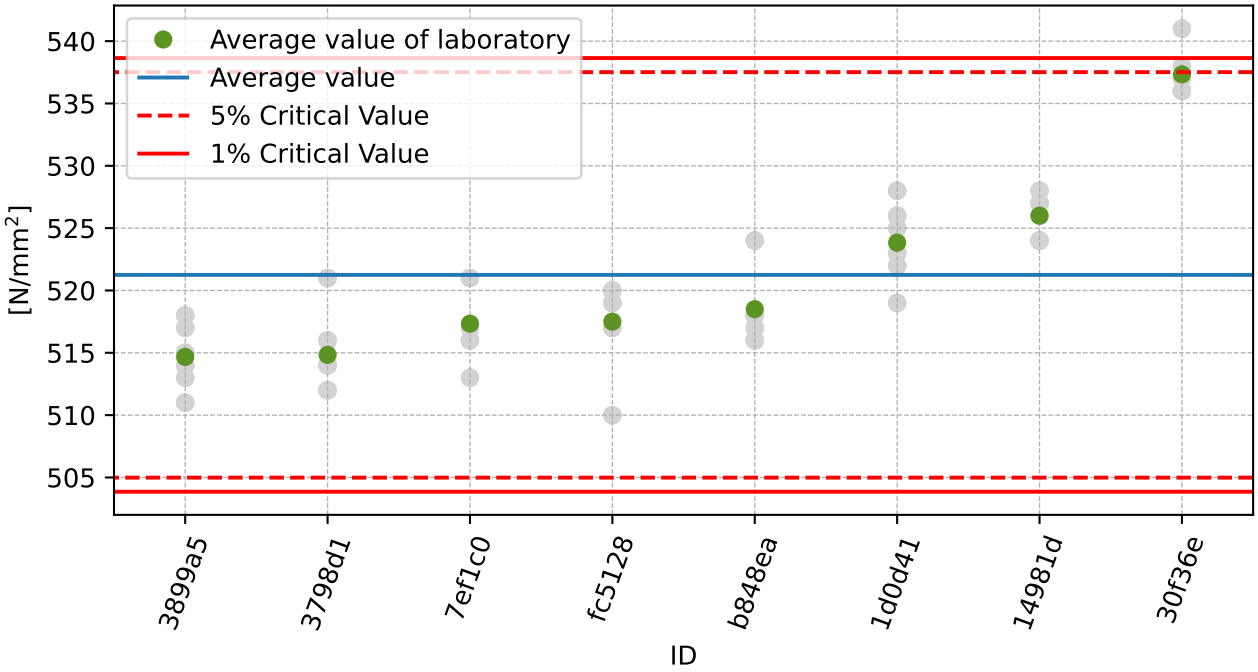

Figure 11: **Grubbs' test** - average values

2.3 Mandel's Statistics

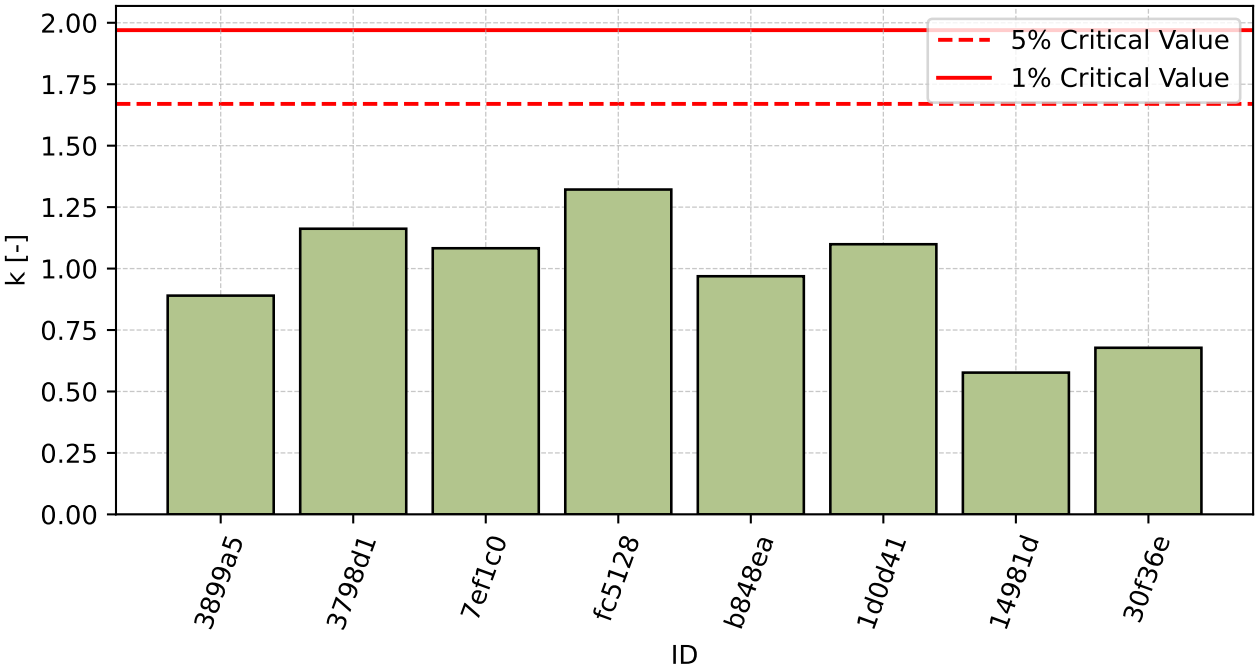

Figure 12: Intralaboratory Consistency Statistic

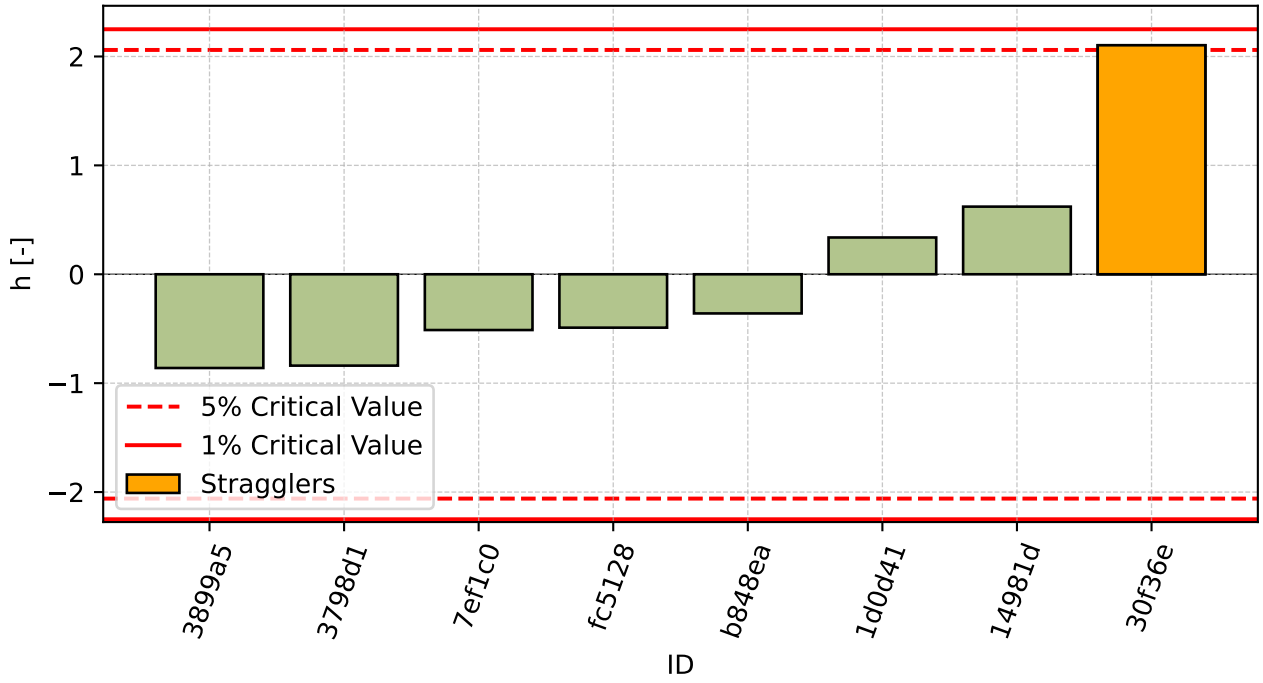

Figure 13: Interlaboratory Consistency Statistic

2.4 Descriptive statistics

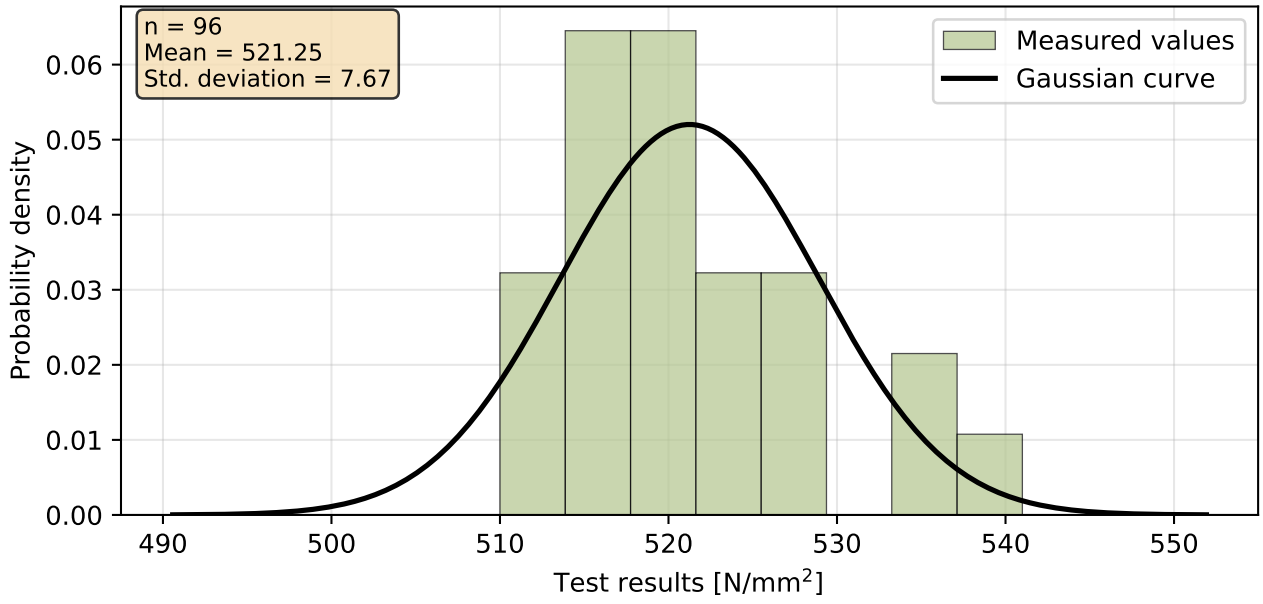

Figure 14: Histogram of all test results

Table 8: Descriptive statistics

Characteristics	[N/mm^2]
Average value – $\bar{x}$	521
Sample standard deviation – s	7.6
Asigned value – x^*	521
Robust standard deviation – s^*	7.6
Measurement uncertainty of asigned value – u_X	2.7
p-value of normality test	0.002 [-]
Interlaboratory standard deviation – s_L	7.6
Repeatability standard deviation – s_r	2.9
Reproducibility standard deviation – s_R	8.1
Repeatability – r	8
Reproducibility – R	23

2.5 Evaluation of Performance Statistics

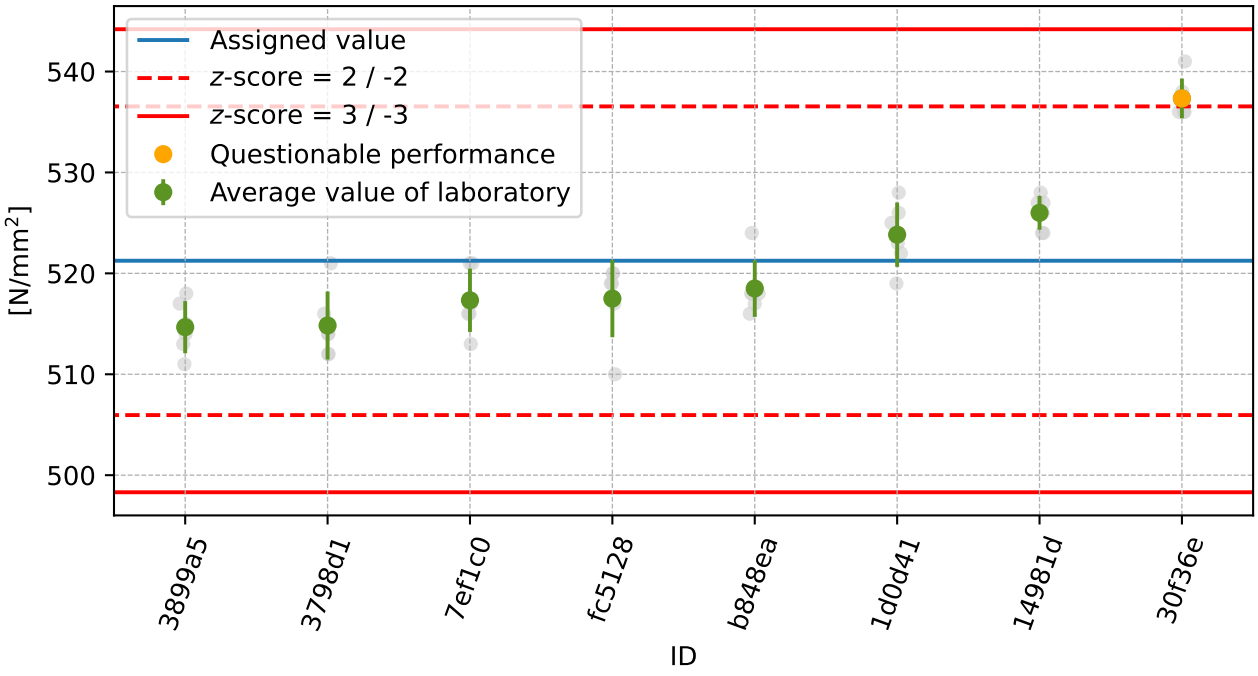

Figure 15: Average values and sample standard deviations

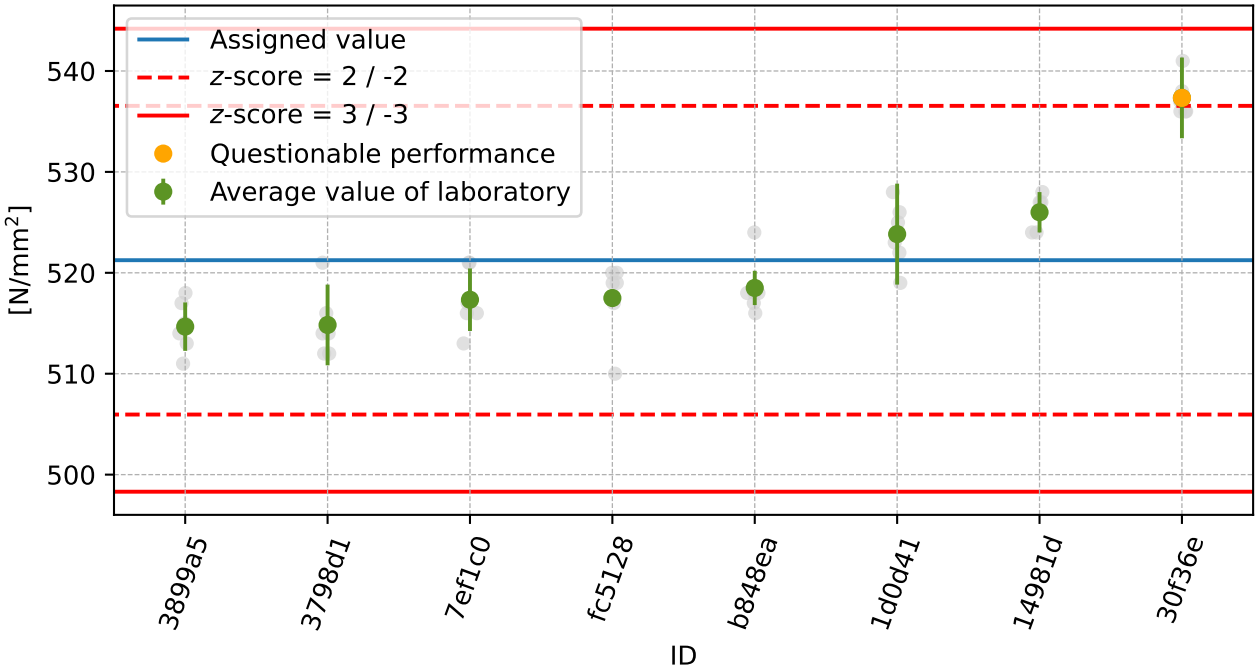

Figure 16: Average values and extended uncertainties of measurement

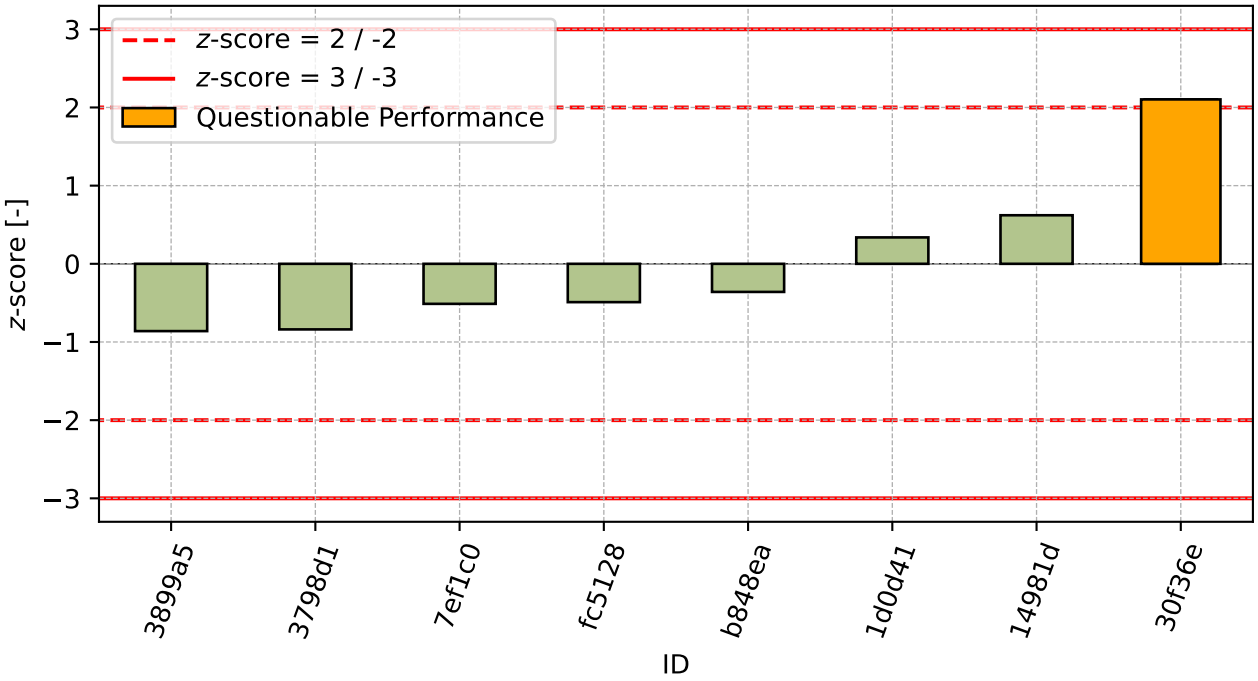

Figure 17: z-score

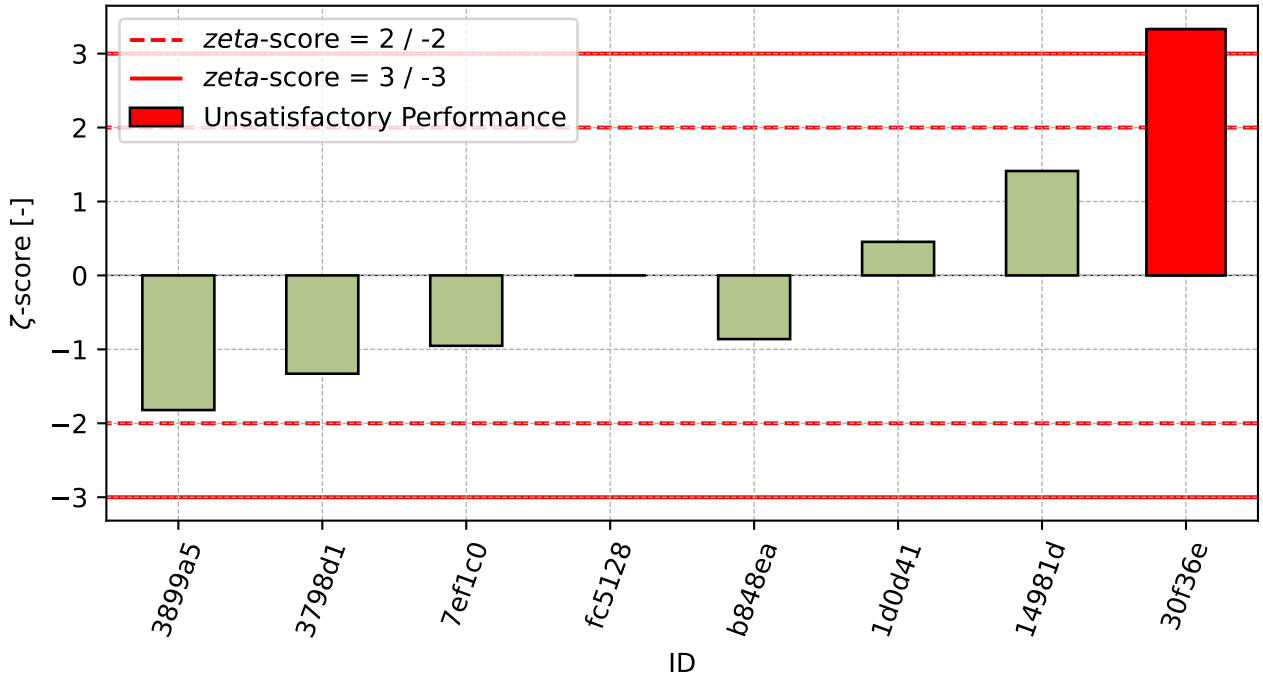

Figure 18: ζ-score

Table 9: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
3899a5	-0.86	-1.82
3798d1	-0.84	-1.33
7ef1c0	-0.51	-0.95
fc5128	-0.49	-
b848ea	-0.36	-0.86
1d0d41	0.34	0.45
14981d	0.62	1.41
30f36e	2.1	3.33

3 Appendix – Testing of Concrete Reinforcement B500B – EN ISO 6892-1 – Elongation

3.1 Test results

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

ID	Test results [%]						u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
30f36e	11.3	10.6	10.7	10.1	10.4	10.4	0.50	10.6	0.41	3.85
fc5128	10.5	10.5	12.0	11.5	11.0	12.0	-	11.2	0.69	6.13
b848ea	20.7	20.6	18.8	19.5	19.9	20.1	0.73	19.9	0.71	3.57
7ef1c0	24.0	25.7	24.1	23.7	24.2	24.8	0.72	24.4	0.73	2.97
3899a5	25.3	26.0	26.2	25.0	23.2	25.0	1.50	25.1	1.07	4.25
1d0d41	25.4	25.6	26.4	24.8	25.0	24.4	1.00	25.3	0.70	2.77
14981d	26.0	28.0	27.0	24.0	25.0	26.0	2.00	26.0	1.41	5.44
3798d1	26.6	27.2	25.7	26.4	27.0	26.8	0.60	26.6	0.53	1.99

3.2 The Numerical Procedure for Determining Outliers

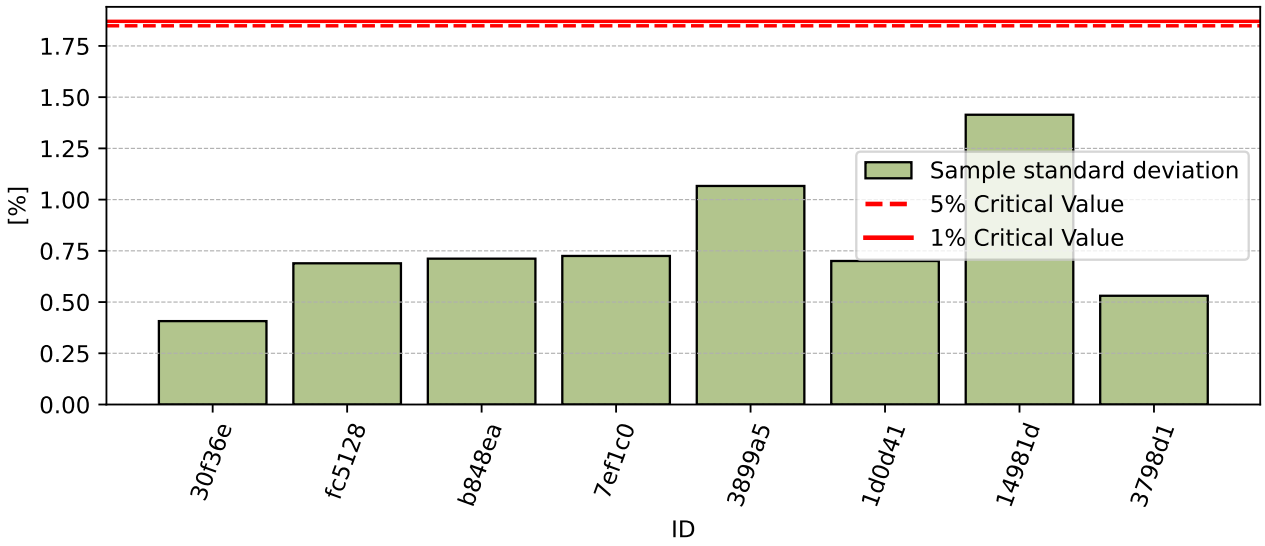

Figure 19: **Cochran's test** - sample standard deviations

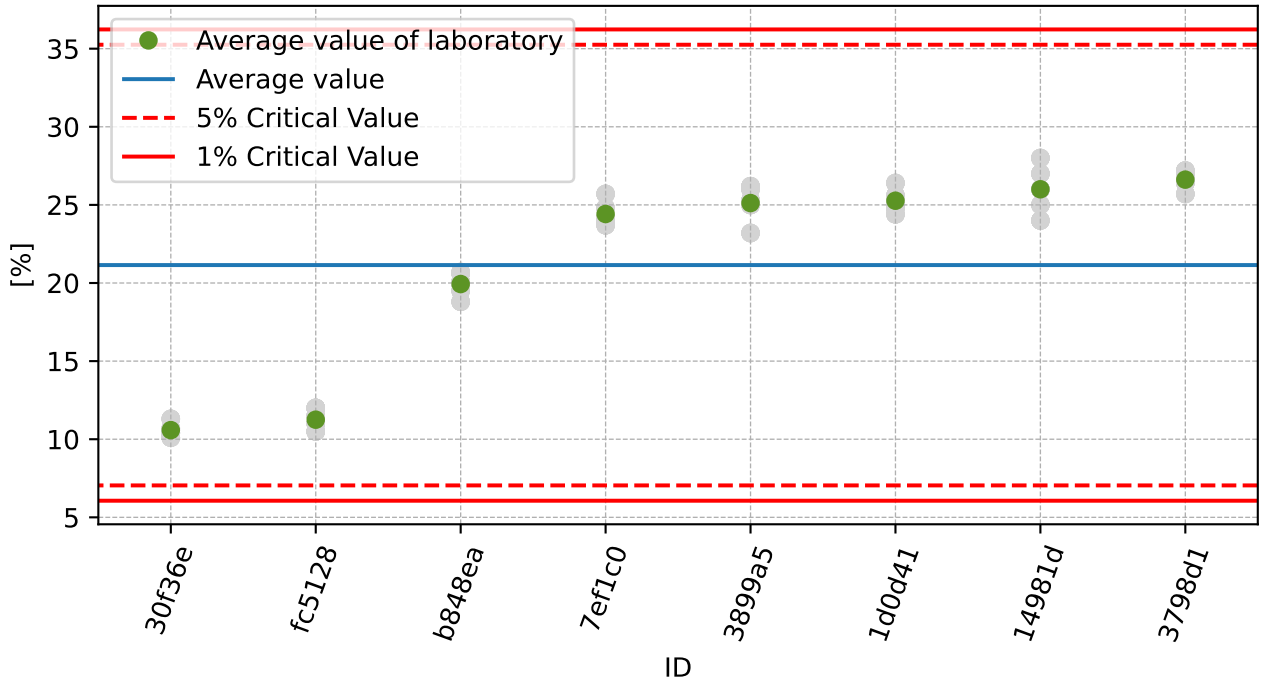

Figure 20: **Grubbs' test** - average values

3.3 Mandel's Statistics

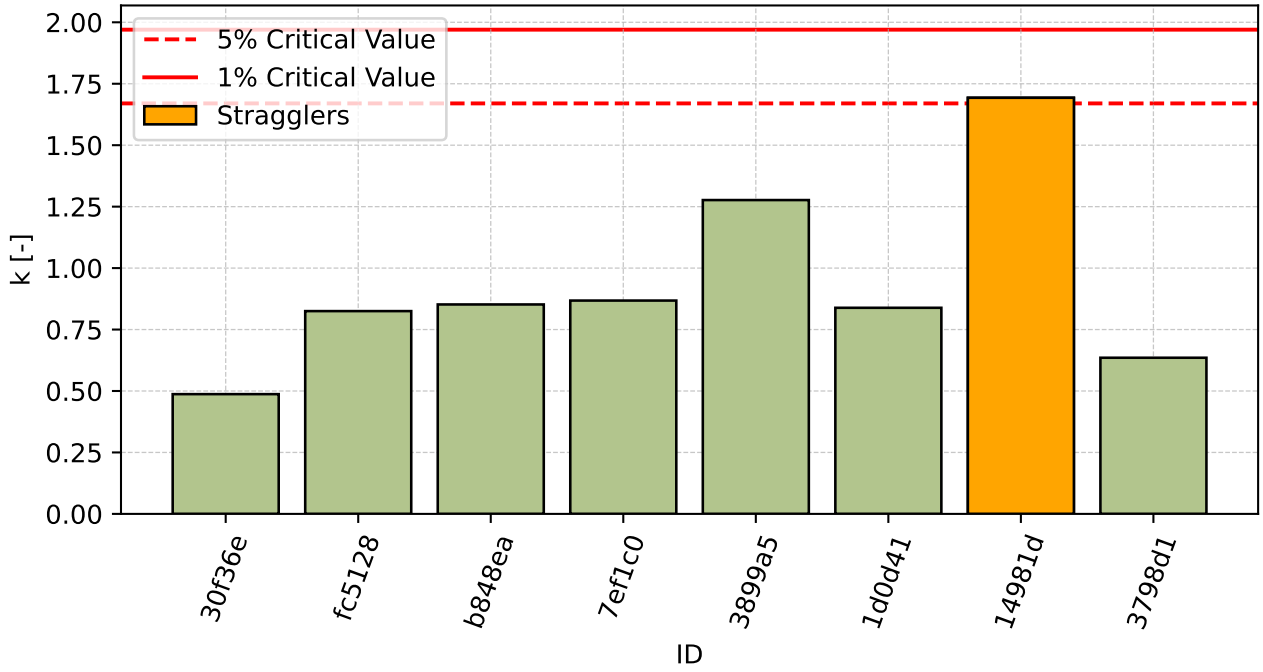

Figure 21: Intralaboratory Consistency Statistic

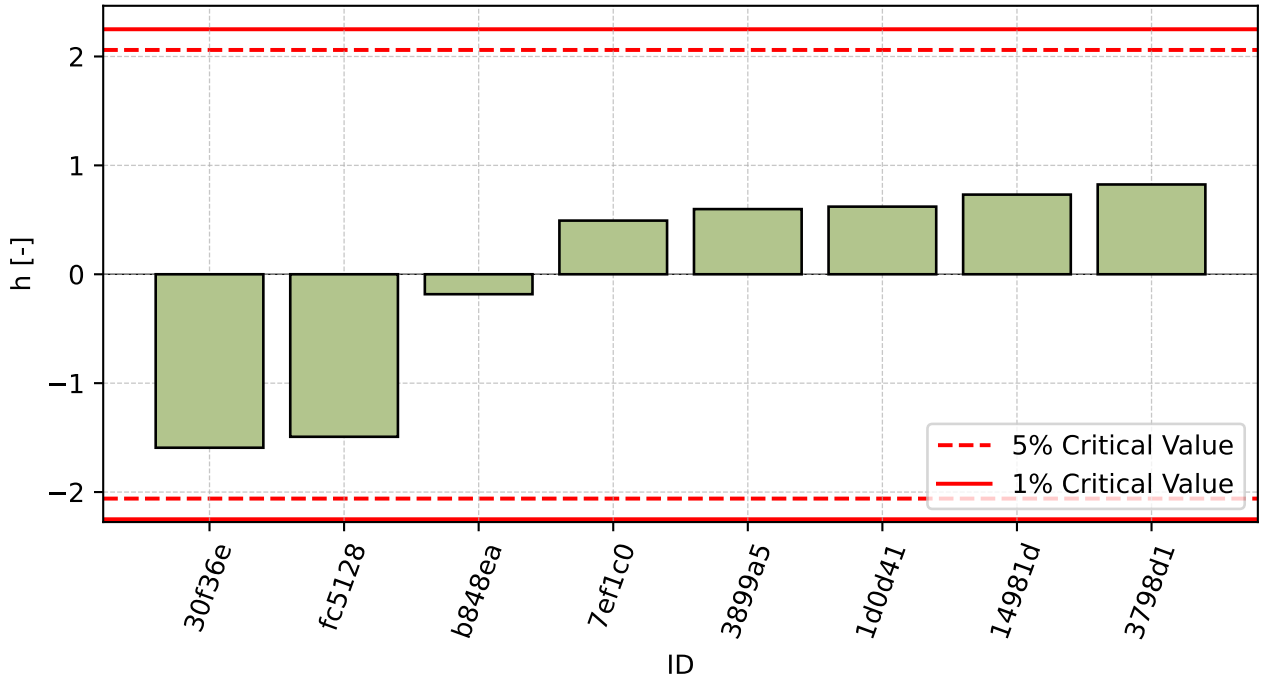

Figure 22: Interlaboratory Consistency Statistic

3.4 Descriptive statistics

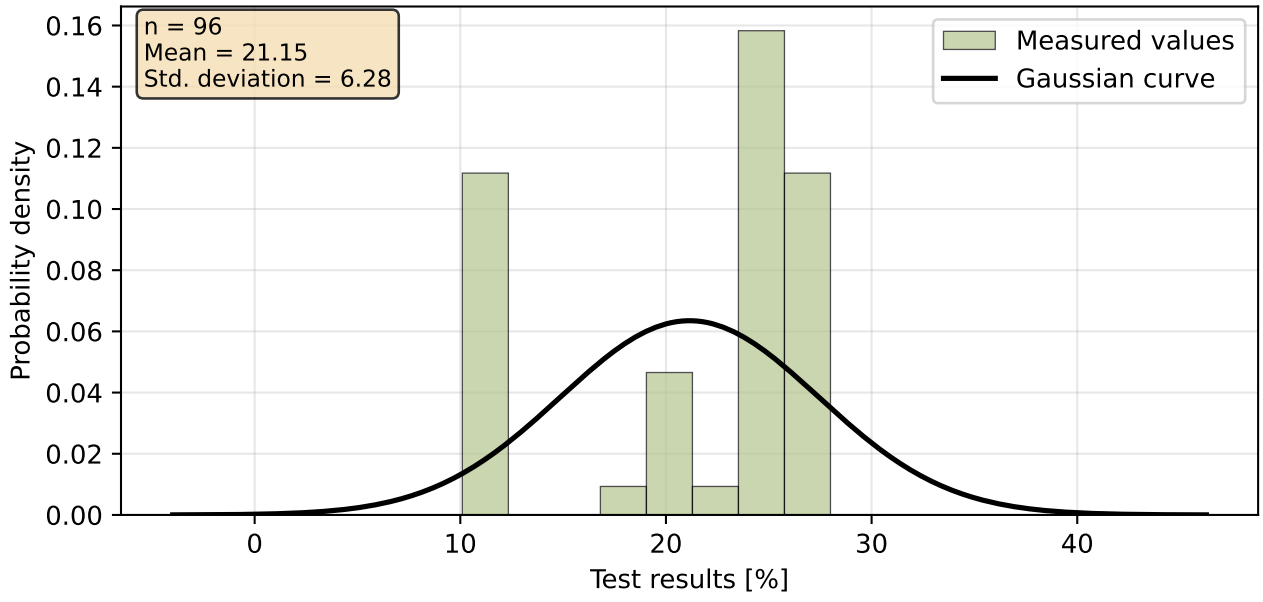

Figure 23: Histogram of all test results

Table 11: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	21.1
Sample standard deviation – s	6.63
Asigned value – x^*	21.1
Robust standard deviation – s^*	6.63
Measurement uncertainty of asigned value – u_X	2.34
p-value of normality test	0.0 [-]
Interlaboratory standard deviation – s_L	6.62
Repeatability standard deviation – s_r	0.84
Reproducibility standard deviation – s_R	6.68
Repeatability – r	2.3
Reproducibility – R	18.7

3.5 Evaluation of Performance Statistics

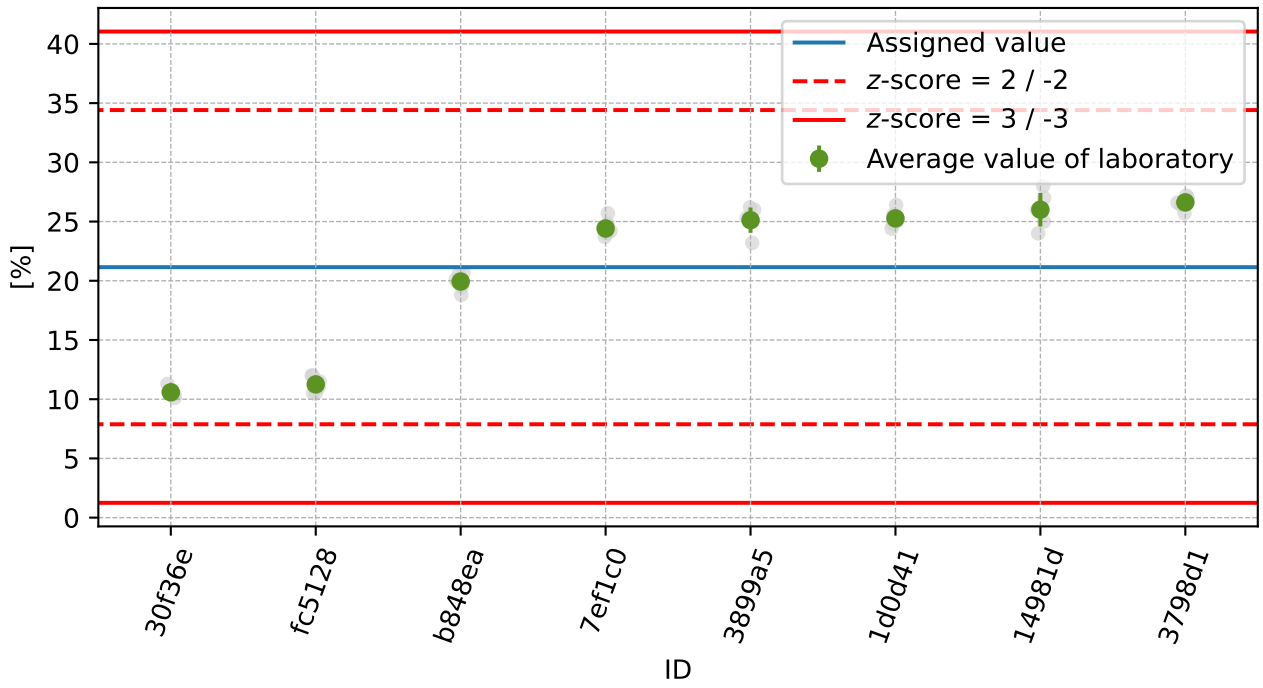

Figure 24: Average values and sample standard deviations

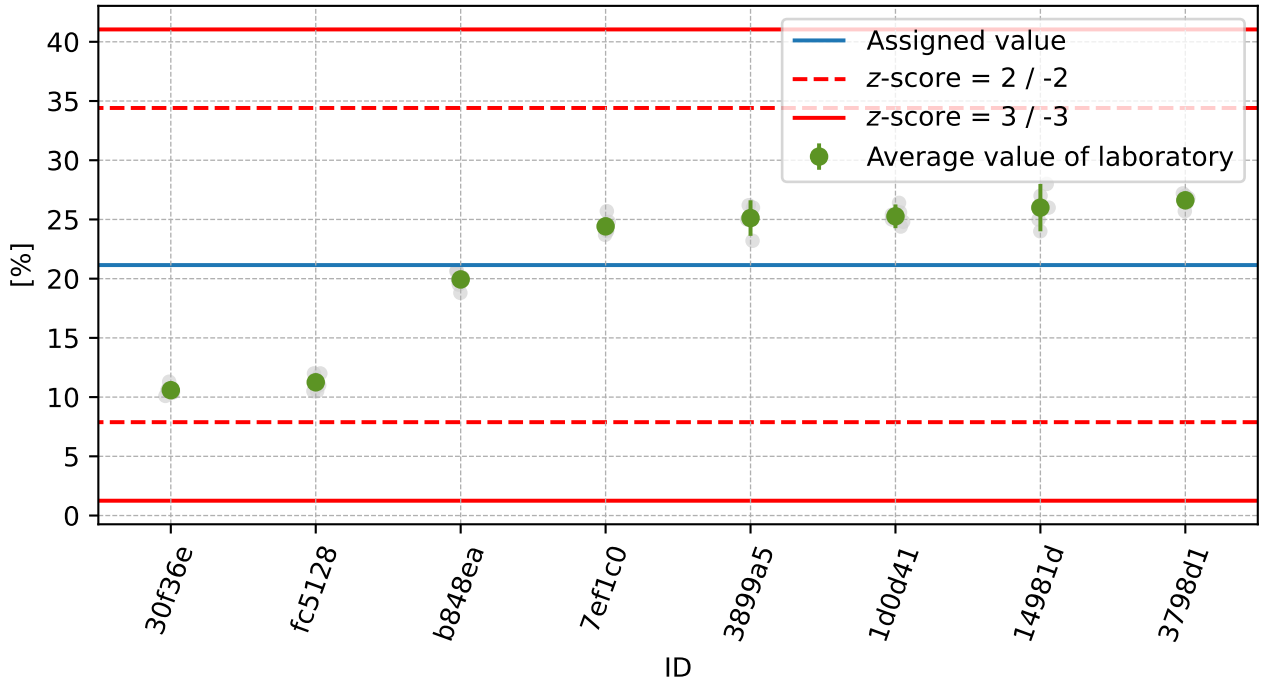

Figure 25: Average values and extended uncertainties of measurement

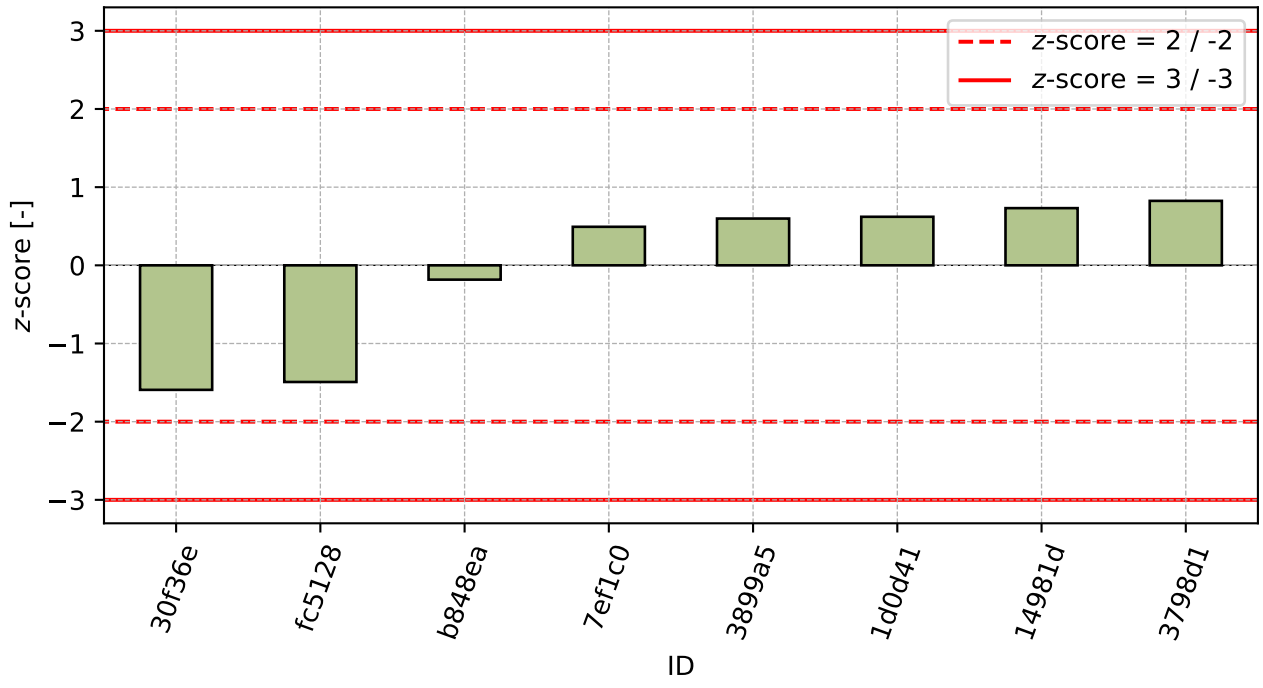

Figure 26: z-score

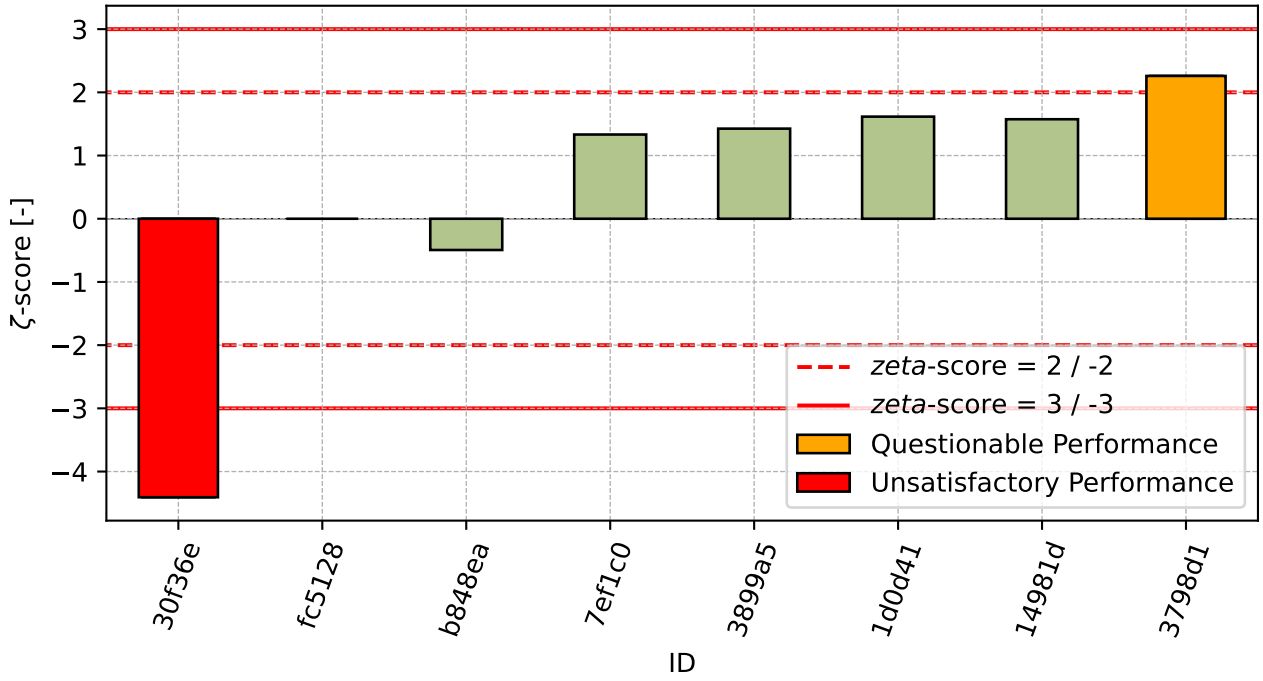

Figure 27: ζ-score

Table 12: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
30f36e	-1.59	-4.41
fc5128	-1.49	-
b848ea	-0.18	-0.49
7ef1c0	0.49	1.33
3899a5	0.6	1.43
1d0d41	0.62	1.62
14981d	0.73	1.57
3798d1	0.82	2.26

4 Appendix – Testing of Concrete Reinforcement B500B – EN ISO 6892-1 – Contraction

4.1 Test results

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

ID	Test results [%]						u_X [%]	$\bar{x}$ [%]	s_0 [%]	V_X [%]
fc5128	34.1	31.4	35.8	35.0	31.0	36.0	-	33.9	2.19	6.46
30f36e	44.0	46.0	45.0	45.0	45.0	44.0	2.00	44.8	0.75	1.68
7ef1c0	44.0	51.1	45.8	46.5	48.9	47.5	2.48	47.3	2.48	5.25
14981d	50.0	48.0	52.0	49.0	47.0	53.0	2.00	49.8	2.32	4.65
3899a5	52.9	54.0	58.3	47.1	48.2	50.6	3.80	51.9	4.12	7.94
b848ea	50.0	56.3	54.8	56.6	49.9	48.6	1.69	52.7	3.59	6.82

4.2 The Numerical Procedure for Determining Outliers

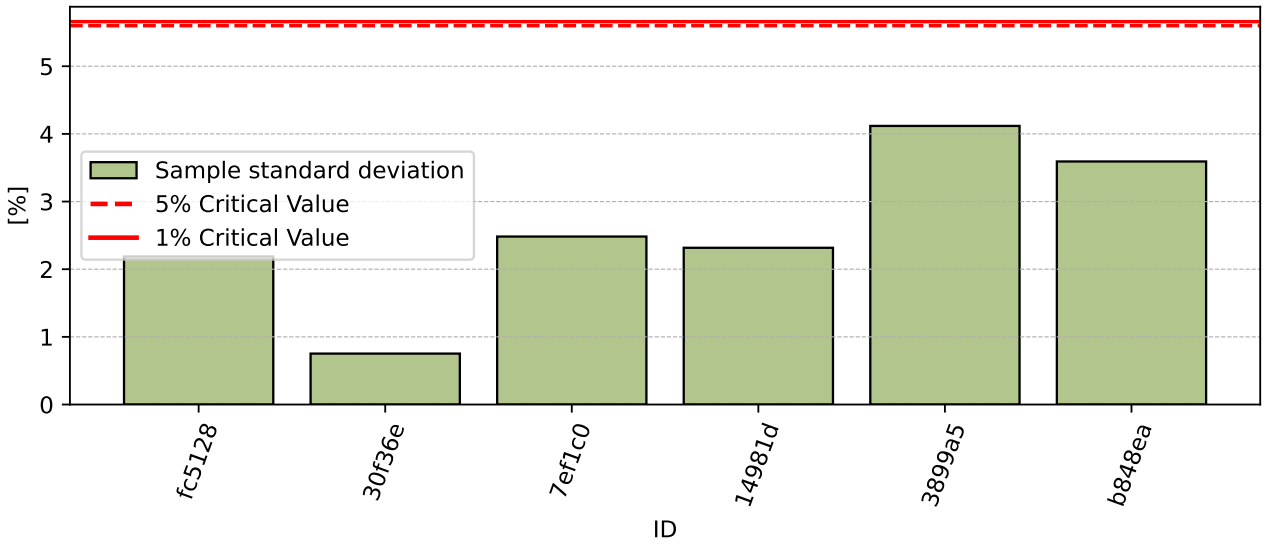

Figure 28: **Cochran's test** - sample standard deviations

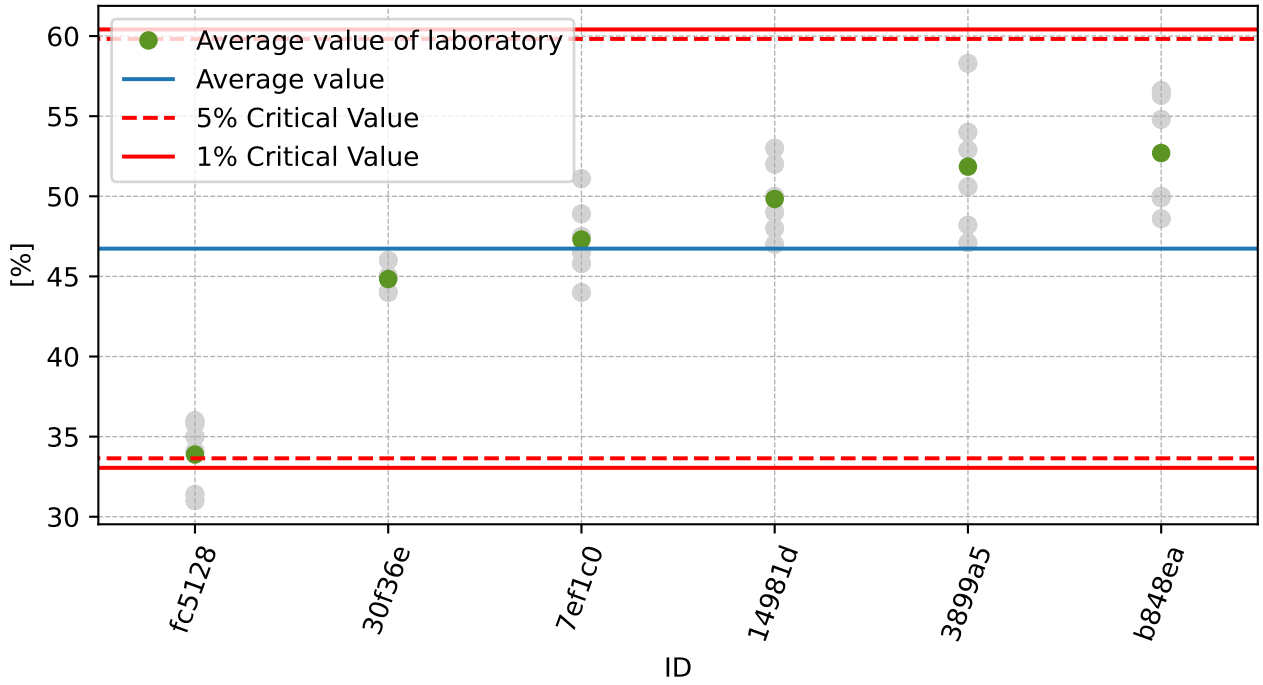

Figure 29: **Grubbs' test** - average values

4.3 Mandel's Statistics

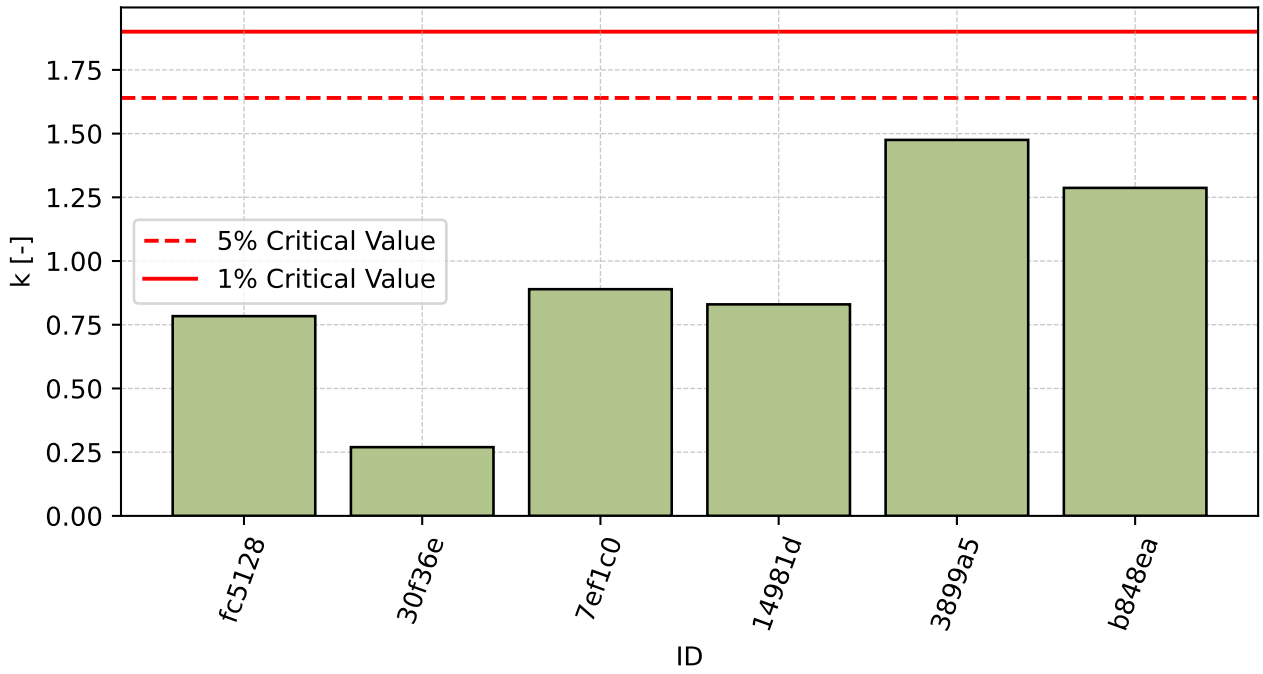

Figure 30: Intralaboratory Consistency Statistic

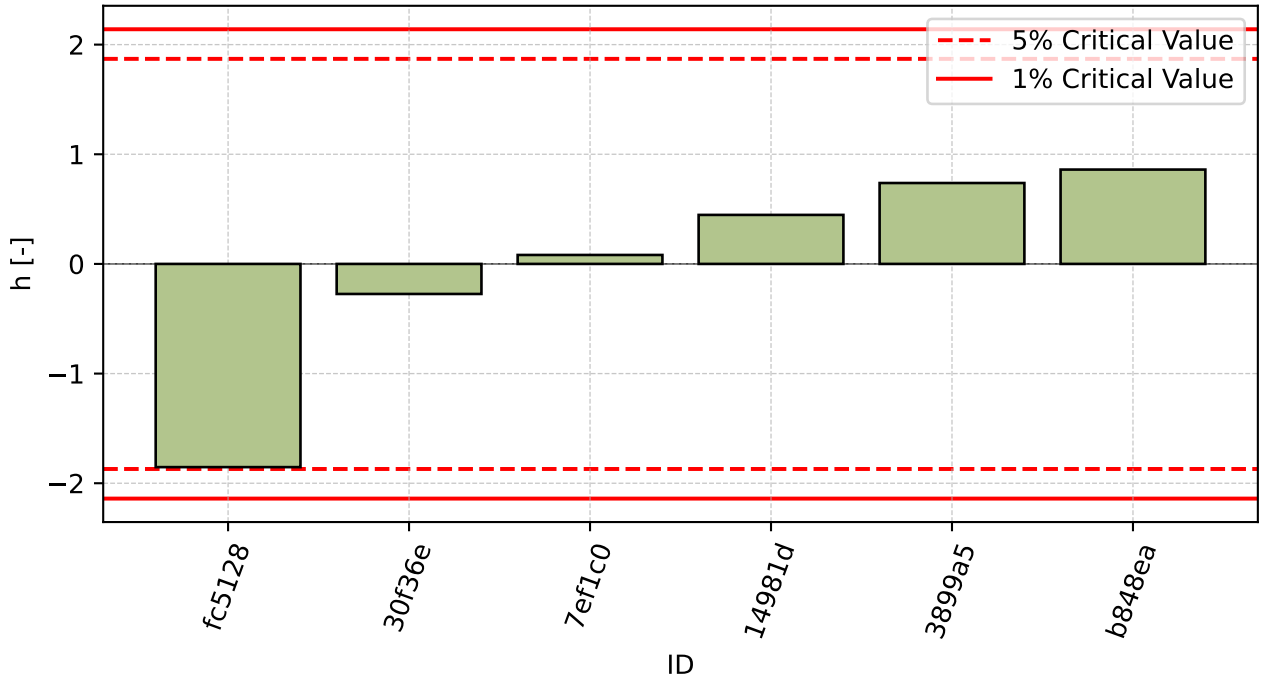

Figure 31: Interlaboratory Consistency Statistic

4.4 Descriptive statistics

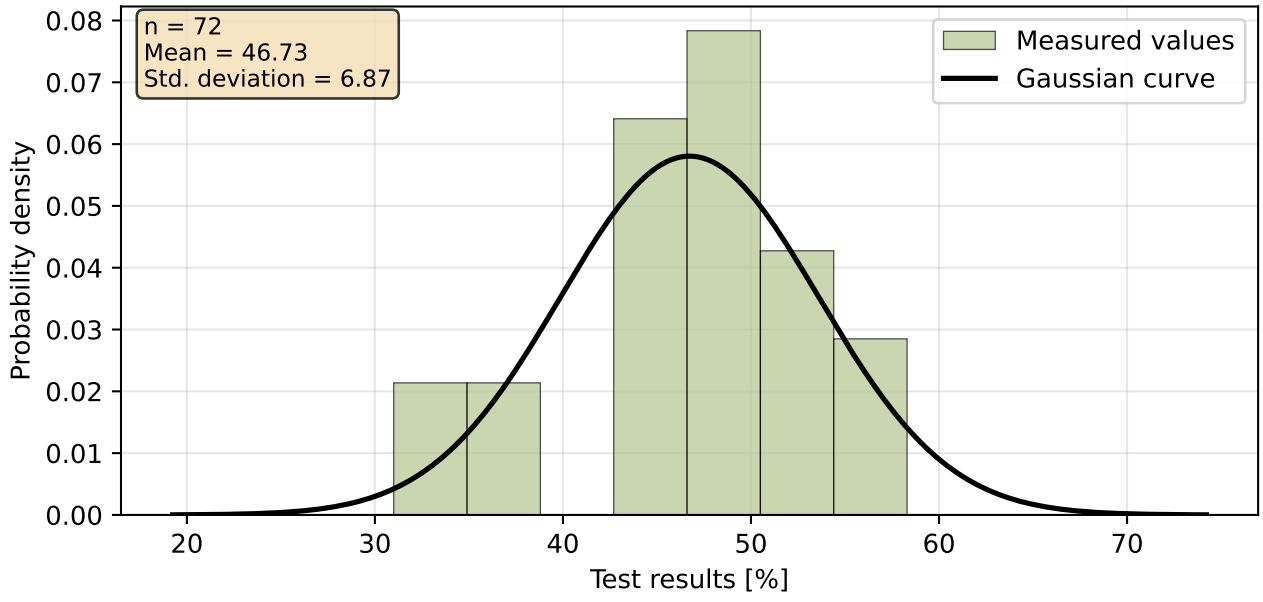

Figure 32: Histogram of all test results

Table 14: Descriptive statistics

Characteristics	[%]
Average value – $\bar{x}$	46.7
Sample standard deviation – s	6.93
Asigned value – x^*	46.7
Robust standard deviation – s^*	6.93
Measurement uncertainty of asigned value – u_X	2.83
p-value of normality test	0.017 [-]
Interlaboratory standard deviation – s_L	6.84
Repeatability standard deviation – s_r	2.79
Reproducibility standard deviation – s_R	7.39
Repeatability – r	7.8
Reproducibility – R	20.7

4.5 Evaluation of Performance Statistics

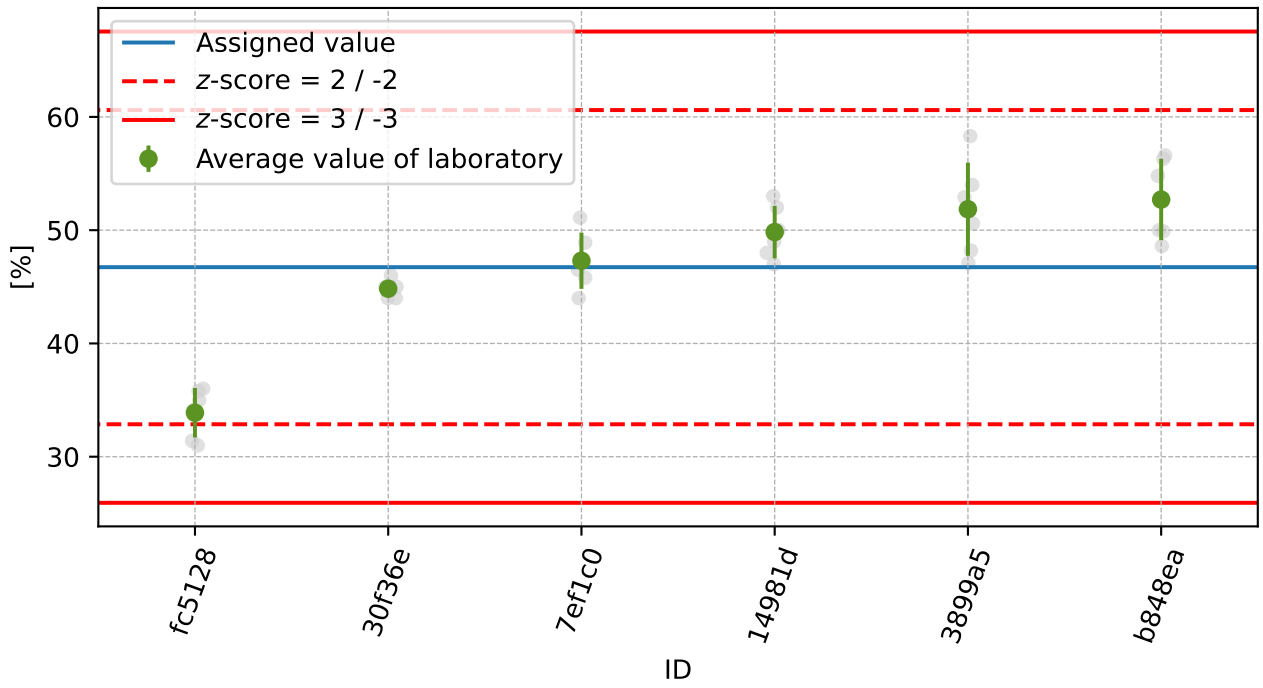

Figure 33: Average values and sample standard deviations

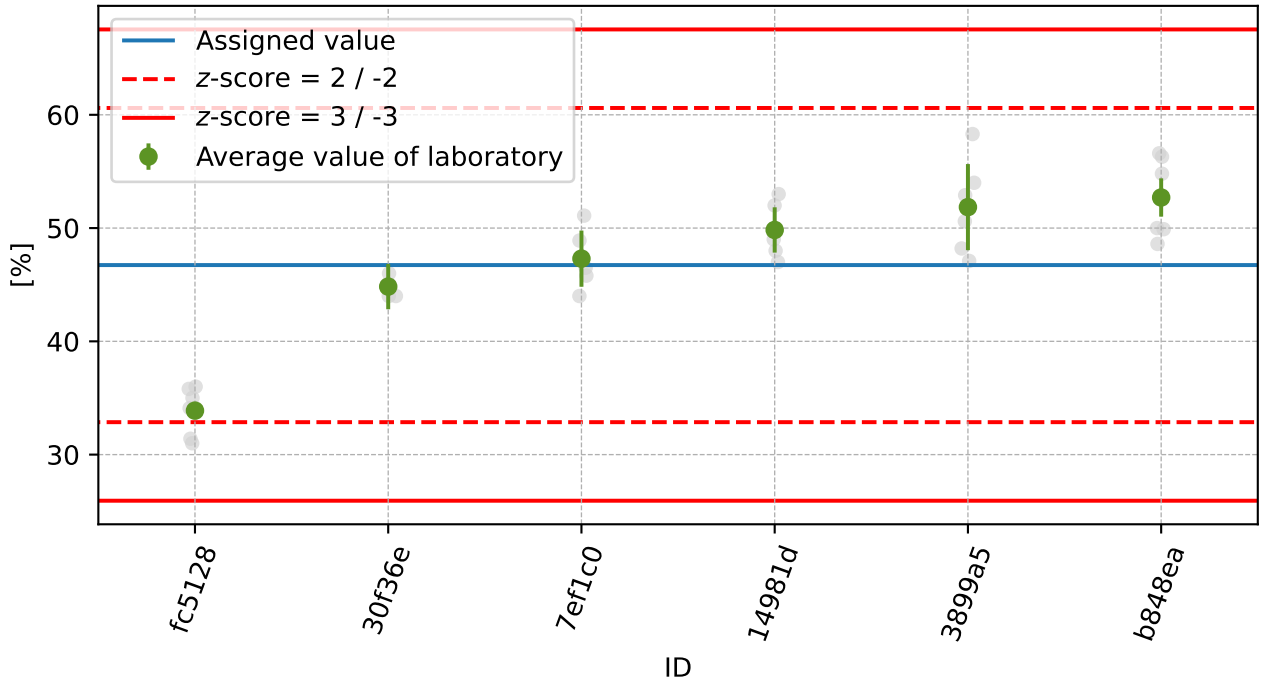

Figure 34: Average values and extended uncertainties of measurement

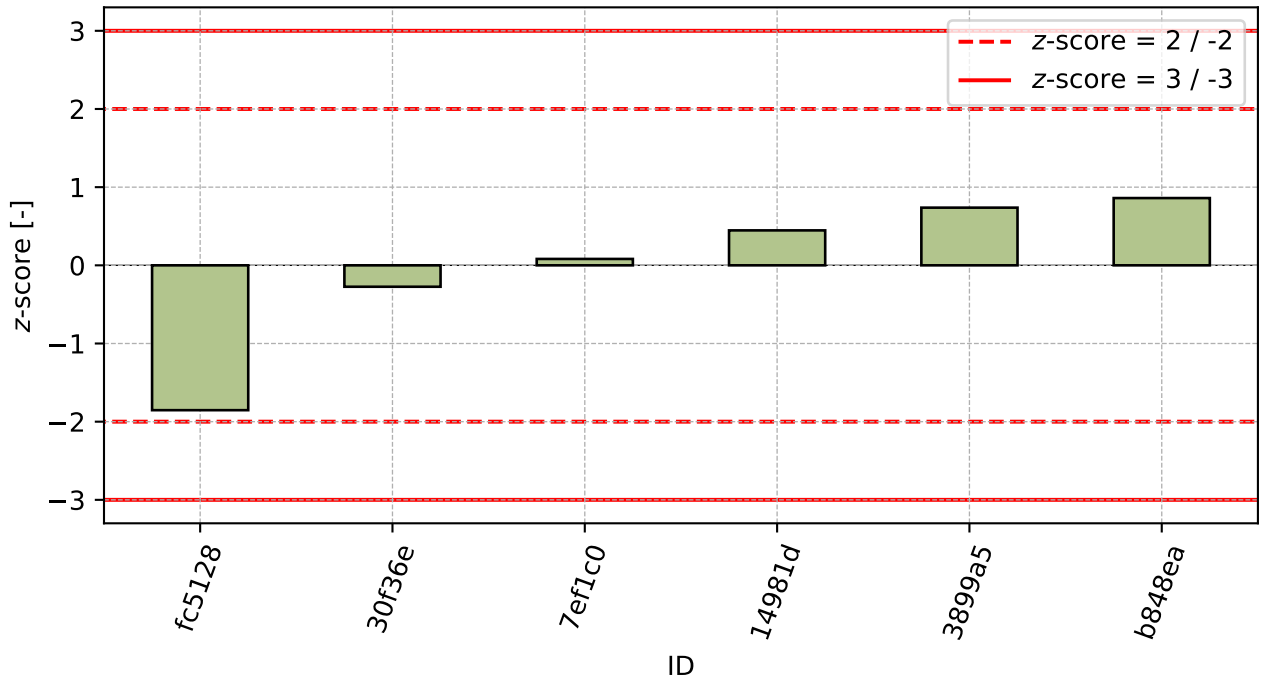

Figure 35: z-score

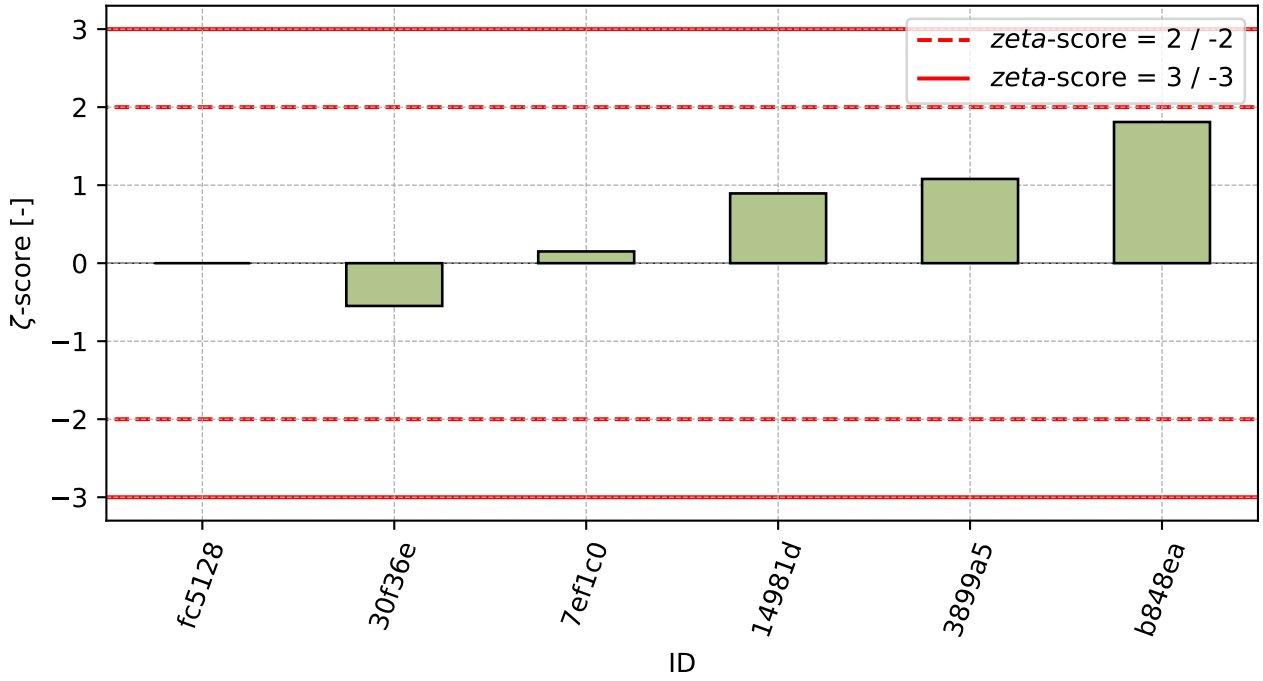

Figure 36: ζ-score

Table 15: z-score and ζ-score

ID	z-score [-]	ζ-score [-]
fc5128	-1.85	-
30f36e	-0.27	-0.55
7ef1c0	0.08	0.15
14981d	0.45	0.89
3899a5	0.74	1.08
b848ea	0.86	1.81

5 Appendix – Bar Test – EN ISO 6892-1 – Tensile Strength

The test method was not opened due to low number of participants.

6 Appendix – Bar Test – EN ISO 6892-1 – Yield Strength

The test method was not opened due to low number of participants.

7 Appendix – Bar Test – EN ISO 6892-1 – Elongation

The test method was not opened due to low number of participants.

8 Appendix – Bar Test – EN ISO 6892-1 – Contraction

The test method was not opened due to low number of participants.