**TECHNICKÝ A SKÚŠOBNÝ ÚSTAV STAVEBNÝ, n. o.**
**BUILDING TESTING AND RESEARCH INSTITUTE, Slovak Republic**
Studená 3, 821 04 Bratislava

Application / archive No. 20-22-0008

# „Cement Ring Tests 2022“ final report

## No.: 20-22-0008

Organizer: Building testing and research institute, Bratislava branch
Sampling material: Portland-slag cement EN 197-1 – CEM II/A-S 42,5 R
Test methods: STN EN 196 – parts 1, 2, 3, 4, 6, 8, 10

Participant' code:

| Chemical analyses | Physical tests | Mechanical tests |
|---|---|---|
| x1, x2, x3, x4, x5, x6, x7, x8 | y1, y2, y3, y4, y5, y6, y7 | z1, z2, z3, z4 |

Date of issue: 20. 05. 2022

Coordinator: Dipl. Eng. Marián K u b i š

Analyst of testing: Dipl. Eng. Ladislav G i l á n y i, PhD.

Head of testing laboratories: Dipl. Eng. Daniel P e t h ő

Director of Bratislava branch: Dipl. Eng. Patrik Š e v č í k

CONTENT

# 1 SCOPE

Main objective of the final report is evaluation of the comparative tests of participating laboratories. These tests entitled as "Cement Ring Tests" are alternately organized by laboratories TZÚS Prague and TSÚS Bratislava. The Cement Ring Test 2022 was attended by 17 laboratories include laboratories working in building material industry and laboratories operating as independent testing institutes. Invitation to these comparative tests was accepted by following laboratories (*written in alphabetical order*):

**Czech Republic (CZ) (10)**
Cemex Czech Republic, s.r.o. (mlýnice Dětmarovice); Areál Edě č. p. 1216; 735 71 Dětmarovice - ČR
CEMEX Czech Republic, s.r.o.; Tovární 296; 538 04 Prachovice - ČR
Českomoravský cement a. s.; Mokrá 359; 664 09 Mokrá-Horákov
ČESKOMORAVSKÝ CEMENT A.S.; K Cementárně 1261/25; 15302 Praha Radotín - ČR
Lafarge Cement a.s.; Čížkovice 27; 411 12 Čížkovice - ČR
Technický a zkušební ústav stavební Praha, s. p., pobočka Brno; Hněvkovského 77; Brno - ČR
Technický a zkušební ústav stavební Praha, s. p., pobočka Teplice; Tolstého 447; Teplice 415 03 - ČR
LB Cemix, s.r.o., výrobní závod Kotouč Štramberk; Libotín 500; 742 66 Štramberk - ČR
Výzkumný ústav maltovin Praha, s.r.o.; Na Cikánce 614/2; Praha 5 – Radotín - ČR
Výzkumný ústav stavebních hmot, a.s.; Hněvkovského 30/65; 617 00 Brno – ČR

**Slovak Republic (SK) (07)**
BetónRacio, s.r.o., Skúšobné laboratórium, Pracovisko Trnava; Skladová 2; 917 01 Trnava
CEMMAC a.s.; Cementárska 14; 91442 Horné Srnie
Danucem Slovensko a.s., závod Turňa nad Bodvou; 044 02 Turňa nad Bodvou; Slovenská republika
Danucem Slovensko a.s., závod Rohožník; Senická cesta; 906 38 Rohožník
Považská cementáreň, a. s.; ul. J. Kráľa; 018 63 Ladce; Slovenská republika
Technický a skúšobný ústav stavebný, n. o., pobočka Bratislava; Studená 967/3; 821 04 Bratislava, Slovenská republika
ZEOCEM, a.s. Bystré; Bystré 282; 094 34 Bystré, okr. Vranov nad Topľou

To compare the test results homogenized Portland-slag cement EN 197-1 – CEM II/A-S 42,5 R (according to STN EN 197-1) was used. The test results were evaluated according to STN ISO 5725-2, while comparisons of the deviations were performed within the participated laboratories.

For this testing, cement, which contains not reduced content of water-soluble chromium (VI) was chosen.

## 1.1 Test data

| | |
|---|---|
| Ordering party / organizer:<br>(proficiency testing provider) | Building Testing and Research Institute,<br>(abbrev: TSÚS), Studená 3, 821 04 Bratislava |
| Cement Manufacturer: | unreported (information archiving by organizer) |
| Evaluator: | Building Testing and Research Institute,<br>director's department<br>Studená 967/3, 821 04 B r a t i s l a v a |

Competence and authorization of the test provider / organizer:
TSÚS is Notified body No.:1301 according to Regulation (EU) No 305/2011 – Construction products, regards to building materials and Construction.

TSÚS, testing laboratory Bratislava has developed system of quality according to requirements of STN EN ISO/IEC 17025: 2018, article 1.2 as holder of Certificate of accreditation No.: S-045 valid until 20. 12. 2024, is acting as independent testing and research institute.

Head of tests (coordinator): Dipl. Eng. Marián K u b i š

Character of the tests: study according to STN 73 2031;
Type of tests: STN EN 196 - parts 1, 2, 3, 4, 6, 8, 10;

The tests were performed according to standard test methods in a range of organizer's requirements whilst following a test schedule.

## 1.2 Statistic execution

Organizer: Building testing and research institute (TSUS),
Bratislava branch, Studená 967/3, 821 04 Bratislava

Analyst of the tests: Dipl. Eng. Ladislav Gilányi, PhD,
Consultant: Dipl. Eng. Michal Bačuvčík, PhD.

## 1.3 Background to execution of the tests and results of the evaluation

Quoted standards and technical regulations

STN ISO 2602: 1993 Statistical interpretation of test results. Estimation of the mean. Confidence interval [*Štatistická interpretácia výsledkov skúšok. Odhad priemeru. Interval spoľahlivosti*] (01 0231)

ISO 13528: 2015 Statistical methods for use in proficiency testing by interlaboratory comparison

STN ISO 16269-6: 2007 Statistical interpretation of data. Part 6: Determination of statistical tolerance intervals [*Štatistická interpretácia dát. Časť 6: Stanovenie štatistických tolerančných intervalov*] (01 0233)

STN ISO 5725-1: 2000/C1: 2006 Accuracy (trueness and precision) of measurement methods and results. Part 1: General principles and definitions [*Presnosť (správnosť a zhodnosť) metód a výsledkov merania. Časť 1: Všeobecné zásady a definície*] (01 0251)

STN ISO 5725-2: 2000/ C1: 2010 Accuracy (trueness and precision) of measurement methods and results. Part 3: Intermediate measures of the precision of a standard measurement method [*Presnosť (správnosť a zhodnosť) metód a výsledkov merania. Časť 2: Základná metóda stanovenia opakovateľnosti a reprodukovateľnosti normalizovanej metódy merania*] (01 0251)

STN EN ISO/IEC 17025: 2018 General requirements for the competence of testing and calibration laboratories [*Všeobecné požiadavky na kompetentnosť skúšobných a kalibračných laboratórií (ISO/IEC 17025: 2017)*] (01 5253)

STN EN 196-1: 2019 Methods of testing cement. Part 1: Determination of strength [*Metódy skúšania cementu. Časť 1: Stanovenie pevnosti*] (72 2100)

STN EN 196-2: 2013 Methods of testing cement. Part 2: Chemical analysis of cement [*Metódy skúšania cementu. Časť 2: Chemický rozbor cementu*] (72 2100)

STN EN 196-3: 2020 Methods of testing cement. Part 3: Determination of setting time and soundness [*Metódy skúšania cementu. Časť 3: Stanovenie času tuhnutia a objemovej stálosti (Konsolidovaný text)*] (72 2100)

STN P ENV 196-4: 1996 Methods of testing cement. Part 4: Quantitative determination of constituents [*Metódy skúšania cementu. 4. časť: Kvantitatívne stanovenie hlavných zložiek*] (72 2100)

STN EN 196-6: 2020 Methods of testing cement. Part 6: Determination of fineness [*Metódy skúšania cementu. Stanovenie jemnosti mletia*] (72 2100)

STN EN 196-7: 2008 Methods of testing cement. Part 7: Methods of taking and preparing samples of cement [*Metódy skúšania cementu. Časť 7: Postupy na odber a úpravu vzoriek cementu*] (72 2100)

STN EN 196-8: 2010 Methods of testing cement. Part 8: Heat of hydration. Solution method [*Metódy skúšania cementu. Časť 8: Stanovenie hydratačného tepla. Rozpúšťacia metóda*] (72 2100)

| | |
|---|---|
| STN EN 196-10: 2019 | Methods of testing cement. Part 10: Determination of the water-soluble chromium (VI) content of cement [*Metódy skúšania cementu. Časť 10: Stanovenie obsahu vo vode rozpustného šesťmocného chrómu (VI) v cemente*] (72 2100) |
| STN EN 197-1: 2012 | Cement Part 1: Composition, specifications and conformity criteria for common cements [*Cement. Časť 1: Zloženie, špecifikácie a kritériá na preukazovanie zhody cementov na všeobecné použitie*] (72 2101) |
| STN EN 197-2: 2021 | Cement. Part 2: Conformity evaluation [*Cement. Časť 2: Hodnotenie zhody*] (72 2101) |
| STN 73 2031: 1985 | Testing of structures, building constructions and elements. Common regulations [*Skúšanie stavebných objektov, konštrukcií a dielcov. Spoločné ustanovenia*] (73 2031) |

## 1.4 List of references

[1] Likeš J., Laga J.: Základní statistické tabulky, SNTL – Nakladatelství technické literatury, Praha 1978

[2] Jílek M.: Statistické toleranční meze, SNTL – Nakladatelství technické literatury, Praha 1988

[3] MSA – L/14: Stanovenie rozsahu a frekvencie účasti v skúškach spôsobilosti, Metodická smernica na akreditáciu, SNAS, Bratislava 2013

[4] K. Kersting, J. Wehde, W. Leimbrock, D. Breuer: Bestimmung des Chrom(VI)-Gehaltes in Zementen, in: Gefahrstoffe -Reinhaltung der Luft 62 (2002) Nr. 7/8

# 2 ELIGIBILITY OF THE TEST

## 2.1 Requirements of compliances of the tests

### Organization of the Cement Ring Test 2022

These tests are organized alternately by the laboratories of TSÚS Bratislava branch and TZÚS Teplice branch since 1996.

### Laboratories recruitments

To attend the comparative tests, the laboratories of cement manufacturers from Slovak republic were invited as well as laboratories of cement manufacturers and independent testing institutes from Czech Republic and Slovak Republic. Laboratories involvement was based on experience from previous years.

### Preparation of testing materials

For execution of comparative tests approximately 250 kg of homogenized cement was used.

Verification of stability and homogeneity of testing material: Previous to transport organizer of the tests confirmed homogeneity of testing material according to STN EN 196-7.

### Selection of the test methods

Subject of comparison was based on standard testing method such as chemical analyses, physical methods and stability of cement according to EN 196. In addition alternative test methods were offered.

### Instructions for participants of international laboratories comparative tests

Test attendants received questionnaire in which they established physical units, number of decimal digits and form of presentation include testing instruction.

Based on previous experience, the test results are presented in such form that each participating laboratory is able to find only its own results. The overall review of the test results can be seen in section 4 and 5 in a following form:

| Chemical analyses | Physical tests | Mechanical tests |
|---|---|---|
| x1, x2, x3, x4, x5, x6, x7, x8 | y1, y2, y3, y4, y5, y6, y7 | z1, z2, z3, z4 |

Where:

| | |
|---|---|
| x1, x2, x3, x4, x5, x6, x7, x8 | are row numbers in table 4.1 and 5.1.1, 5.1.2 |
| y1, y2, y3, y4, y5, y6, y7 | are row numbers in table 4.2 and 5.2.1, 5.2.2 |
| z1, z2, z3, z4 | are row numbers in table 4.3 and 5.3.1, 5.3.2 |

The code numbers will be announced to each laboratory separately.

## 2.2 Statistics analyse of the test compliance

### Basic statistics for evaluation of the tests

$p$ Sample size / Count

Central trend parameters

$\bar{x}$ Average, arithmetic mean

$$\bar{x} = \frac{1}{p} \sum_{i=1}^{p} x_i \qquad (2.1)$$

Dispersion parameters

$v$ Coefficient of variation / Variance

$$v(\%) = \frac{s \cdot 100}{|\bar{x}|} \qquad (2.2)$$

$s$ Standard deviation of a sample

$$s = \sqrt{\frac{1}{p-1} \sum_{i=1}^{p} (x_i - \bar{x})^2} \qquad (2.3)$$

$s_o$ Standard deviation

$$s_o = \sqrt{\frac{1}{p} \sum_{i=1}^{p} (x_i - x_m)^2} \qquad (2.4)$$

$x_{min}$ Minimum value

$x_{max}$ Maximum value

$R$ Sample range

$$R = x_{max} - x_{min} \qquad (2.5)$$

Standard Skewness

Skewness is symmetry ratio of distribution of dividing function
Skewness is defined with regards to central third degree moment:

$$SK_{est} = \frac{1}{n \odot s^3} \sum_{i=1}^{p} (x_i - \bar{x})^3 \qquad (2.6)$$

which is mean value of divided cubature Z-score.

Standard Kurtosis

Kurtosis is commonly defined as the fourth cumulant divided by the square of the variance of the probability distribution.

Excess is defined as:

$$\gamma_2 = \beta_2 - 3 \qquad (2.7)$$

$$\beta_2 = \frac{1}{n \odot s^4} \sum_{i=1}^{p} (x_i - \bar{x})^4 \qquad (2.8)$$

where:

$s$ is decisive deviation of a sample.

*Note: Values of skewness and kurtosis were formally evaluated without any precise analyse of dividing. In case that statistic values are out of interval ≤ -2; +2 ≥, a higher consideration should be taken since these values represent significant deviations from standard dividing.*

## Tests of outlier observations

outlier (accordance with ISO 13528: 2015): member of a set of values which is inconsistent with other members of that set

*Note 1 to entry: An outlier can arise by chance from the expected population, originate from a different population, or be the result of an incorrect recording or other blunder.*

*Note 2 to entry: Many schemes use the term outlier to designate a result that generates an action signal. This is not the intended use of the term. While outliers will usually generate action signals, it is possible to have action signals from results that are not outliers*

To test outlier of the results STN ISO 5725-2, Grubbs' method, Irwin' method or Dan-Dixon' tests were used.

Occurrence of one outlier observation was evaluated according Grubbs' statistic $G_p$, and $G_1$ respectively:

Definitions of Grubbs' tests are based on hypothesis $H_0$ against $H_a$ where:

$H_0$: no outlier in a sample

$H_a$: at least one outlier in a sample

Grubbs' test statistic is defined as:

$$G_p = \frac{(x_p - \bar{x})}{s} \qquad (2.10)$$

$$G_1 = \frac{( \quad - x_1)}{s} \qquad (2.11)$$

Or in accordance with [1] :

$$k_{vyp} = \frac{x_{max} - \bar{x}_n}{s_n} \geq k_{krit} = k_\alpha(n) \qquad (2.12)$$

$$k_{vyp} = \frac{x_{min} - \bar{x}_n}{s_n} \geq k_{krit} = k_\alpha(n) \qquad (2.13)$$

where $\bar{x}_n$ and $s_n$ are mean values and decisive deviation.

The Grubb´s test statistic is the largest absolute deviation from a sample mean value in units of a sample standard deviation.

Significance Level:
critical region: The hypothesis of no outliers is rejected if:

$$G > \frac{(n-1)}{\sqrt{n}} \sqrt{\frac{t^2_{(\alpha/(2n),n-2)}}{n-2+t^2_{(\alpha/(2n),n-2)}}} \qquad (2.14)$$

where

. $t_{(\alpha/(2n),n-2)}$

is the critical value of the t-distribution with (N-2) degrees of freedom and a significance level of α /(2N).

In the above formulas for the critical regions, the Handbook follows the convention that is the upper critical value from the t-distribution and is the lower critical value from the t-distribution. Note that this is the opposite of what is used in some texts and software programs. In particular, Data plot uses the opposite convention.

Irwin test, in which the biased of two the closest elements on the edge of ordered selection is verified according to:

$$\lambda_{vyp} = \frac{x_n - x_{n-1}}{s_n} \geq \lambda_\alpha(n) \qquad (2.15)$$

$$\lambda_{vyp} = \frac{x_2 - x_1}{s_n} \geq \lambda_\alpha(n) \qquad (2.16)$$

$(x_1 \leq x_2 \leq x_3 \leq x_4 \leq \ldots \leq x_i \leq \ldots \leq x_{n-1} \leq x_n)$

Critical value was approximately calculated for number of elements *n* as:

$$\lambda_\alpha(n) = 11{,}58849 - 10{,}752151 \cdot \exp(-0{,}30788516 \cdot n^{(-0.67230923)}) \qquad (2.17)$$

For regression curve the Weibull model was used, where:

y=a-b·exp(-c·x^d)

with parameters:

*a* = *11,58849*
*b* = *10,752151*
*c* = *0,30788516*
*d* = *-0,67230923*

Significance of outlier value and biased value correspond to definitions within STN ISO 5725-2: 2000.

As a result of relatively small number of participating laboratories added to not fulfilled condition of standard distribution measurements in some cases (Cl-content, Natriumoxid content, Potassium content, Chrome content, volume of soundness, initial setting time) it seems to be more appropriate to apply calculation of robust algorithms.

Intervals of confidence for outlier values were evaluated as minimum $L_m$ and maximum $L_M$ at level of α=0,05 as a result of applying Student' dividing for N=(n-1) degree of freedom:

$$L_m = \bar{x} - s \cdot t_{(n-1)} \qquad (2.18)$$

$$L_M = \bar{x} + s \cdot t_{(n-1)} \qquad (2.19)$$

where

$L_{m\ 95\%}$ Lower confidence limitsafterelimination of outliers.

$L_{M\ 95\%}$ Upper confidence limitsafterelimination of outliers.

For evaluation of deviation ε following equation was applied:

$$\varepsilon = \frac{s}{\sqrt{(n-1)}} \cdot t_{(n-1)} \qquad (2.20)$$

where

$t_{(n-1)}$ is value of Student's dividing for N=n-1 degree of freedom when level of significance is selected.

## Test of interlaboratory dispersion

Cochran's test for evaluation interlaboratory dispersion was used according to article 7.3.3 of STN ISO 5725-2.
Cochran's statistic is given by equation:

$$C = \frac{s^2_{max}}{\sum_{i=1}^{p} s_i^2} \qquad (2.21)$$

where

$s_{max}$ is the highest decisive deflection from given data set
$p$ is set rate of selected decisive deflections (laboratory count).

## Z-SCORE

The Z-SCORE (standard score) indicates how many standard deviations an element is from the mean.

Z-SCORE1 is defined as:

where and s are calculated for the complete sample.

$$Z\text{–}SCORE1 = \frac{\left(\bar{x} - x_i\right)}{s} \qquad (2.22)$$

$\bar{x}$

Z-SCORE2 is defined as:

$$Z\text{–}SCORE2 = \frac{\left(\bar{x_2} - x_i\right)}{s_2} \qquad (2.23)$$

where and $s_2$ are calculated for the sample without outliers.

if $|Z_i| \leq 2$, than the result is satisfactory,
if $2 < |Z_i| < 3$, than the result is questionable,
if $|Z_i| \geq 3$, than the result is unsatisfactory.

$\bar{x}_2$

z-score: standardized measure of performance, calculated using the participant result, assigned value and the standard deviation for proficiency assessment.

# 3 PARTIAL RESULTS

Summary of statistic comparative results testing methods is illustrated in the Annex.
The results are presented in tables in Section 4.
The Z-SCORE1, Z-SCORE2 of the results is presented in tables in Section 5.

The result selection:
each laboratory has received code which consists of 3 number series: - $x_i$ / $y_j$ / $z_k$.

The first number cluster represents the code of lines for the results and Z-SCORE presented in Table 4.1 and 5.1.1, 5.1.2 resp.,
the second number cluster represents the code for the results and Z-SCORE presented in Table 4.2 and 5.2.1, 5.2.2 resp., and
the third number cluster represents the code for the results and Z-SCORE presented in Table 4.3 and 5.3.1, 5.3.2 resp.

# 4 SUMMARY OF THE RESULTS

## 4.1 Results of chemical analysis

The results of chemical analyses are presented in Table 4.1

**Table 4.1 - The results of chemical analysis**

| Laboratory key numbers | Sulfate content (as $SO_3$) | Chloride content | Loss on Ignition | Insoluble residue | $Na_2O$ content | $K_2O$ content | Slag content | Chromium (VI) content |
|---|---|---|---|---|---|---|---|---|
| | (% by mass) | (% by mass) | (% by mass) | (% by mass) | (% by mass) | (% by mass) | (% by mass) | (ppm) |
| $x_j$ | x1 | x2 | x3 | x4 | x5 | x6 | x7 | x8 |
| **1** | 2,910 | 0,049 | ***3,375 ***** | ***0,011 ***** | 0,180 | 0,560 | 10,57 $^{w}$ | 1,50 |
| **2** | 2,949 | 0,049 | 3,795 | 0,710 | 0,190 | 0,665 | 12,60 $^{m}$ | 2,30 |
| **3** | 2,950 | 0,053 | 3,830 | 0,740 | 0,200 | 0,710 | 13,05 $^{w}$ | 2,44 |
| **4** | 2,965 | 0,053 | 3,830 | 0,815 | 0,215 | 0,720 | 13,12 $^{w}$ | 2,57 |
| **5** | 2,985 | 0,054 | 3,880 | 0,850 | 0,220 | 0,720 | 13,20 $^{w}$ | 3,65 |
| **6** | 3,020 | 0,054 | 3,885 | 0,870 | 0,220 | 0,720 | 13,50 $^{w}$ | 4,01 |
| **7** | 3,020 | 0,055 | 3,890 | 0,885 | 0,225 | 0,730 | 14,62 $^{m}$ | 4,21 |
| **8** | 3,060 | 0,056 | 3,895 | 0,930 | 0,230 | 0,730 | 16,00 $^{m}$ | 4,35 |
| **9** | 3,070 | 0,057 | 3,900 | 0,980 | 0,240 | 0,740 | 17,25 $^{w}$ | 5,70 |
| **10** | 3,075 | 0,058 | 3,905 | 1,010 | 0,240 | 0,745 | 17,46 $^{m}$ | 5,90 |
| **11** | 3,085 | 0,059 | 3,940 | 1,030 | 0,240 | 0,750 | 18,20 $^{m}$ | ***7,53 ***** |
| **12** | 3,090 | 0,060 | 3,960 | 1,095 | 0,255 | 0,750 | 18,60 $^{m}$ | - |
| **13** | 3,110 | 0,062 | 4,000 | 1,135 | 0,310 | 0,760 | 19,00 $^{m}$ | - |
| **14** | 3,215 | 0,062 | 4,010 | 1,140 | ***0,420 ***** | 0,825 | - | - |
| **15** | 3,235 | 0,065 | 4,020 | 1,240 | ***0,445 ***** | ***1,070 ***** | - | - |
| **16** | ***3,300 **** | ***0,070 ***** | 4,100 | - | - | - | - | - |
| **17** | - | - | - | - | - | - | - | - |
| **18** | - | - | - | - | - | - | - | - |
| **19** | - | - | - | - | - | - | - | - |
| **20** | - | - | - | - | - | - | - | - |
| **21** | - | - | - | - | - | - | - | - |
| **22** | - | - | - | - | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as biased values.*
*Values marked with two stars (**) are considered as outliers.*
*(w) – tested by wet way, (m) – tested microscopically.*

## 4.2 Results of physical tests

The results of physical tests are presented in Table 4.2.

**Table 4.2 - The results of physical tests**

| Laboratory key numbers | Hydrating heat | Grinding fineness | | Setting time | | Water for standard consistency | Volume soundness |
|---|---|---|---|---|---|---|---|
| | | Specific surface | Specific gravity | Initial setting time | Final setting time | | |
| | (J/g) | ($m^2$/kg) | ($g/m^3$) | (min) | (min) | (% by mass) | (mm) |
| $y_j$ | y1 | y2 | y3 | y4 | y5 | y6 | y7 |
| **1** | ***254*** [S] ** | ***399,5*** ** | ***2,94*** ** | ***145*** ** | 227 | 28,8 | 0,0 |
| **2** | 288 [S] | 463,3 | 3,01 | 163 | 235 | 29,0 | 0,0 |
| **3** | 296 [D] | 464,1 | 3,04 | 169 | 240 | 29,2 | 0,3 |
| **4** | 312 [D] | 468,0 | 3,05 | 170 | 240 | 29,4 | 0,5 |
| **5** | 314 [D] | 479,0 | 3,05 | 180 | 240 | 29,6 | 0,5 |
| **6** | - | 481,0 | 3,06 | 185 | 243 | 29,6 | 0,5 |
| **7** | - | 485,8 | 3,06 | 190 | 247 | 29,9 | 0,5 |
| **8** | - | 492,3 | 3,06 | 192 | 249 | 30,0 | 0,5 |
| **9** | - | 493,7 | 3,06 | 194 | 252 | 30,0 | 0,8 |
| **10** | - | 495,0 | 3,07 | 195 | 255 | 30,0 | 0,8 |
| **11** | - | 499,0 | 3,07 | 198 | 257 | 30,4 | 1,0 |
| **12** | - | 502,0 | 3,08 | 198 | 268 | 30,7 | 1,0 |
| **13** | - | 509,5 | 3,10 | 205 | 270 | 30,8 | 1,0 |
| **14** | - | 513,9 | ***3,16*** ** | 208 | 273 | 31,0 | 1,3 |
| **15** | - | - | - | 208 | 277 | 31,5 | 1,5 |
| **16** | - | - | - | 209 | 285 | ***32,0*** * | ***2,6*** ** |
| **17** | - | - | - | - | - | - | - |
| **18** | - | - | - | - | - | - | - |
| **19** | - | - | - | - | - | - | - |
| **20** | - | - | - | - | - | - | - |
| **21** | - | - | - | - | - | - | - |
| **22** | - | - | - | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as biased values.*
*Values marked with two stars (**) are considered as outliers.*
*([D]) – tested by dissolution metod, ([S]) – tested by semidiabatic metod.*

## 4.3 Results of mechanical tests

The results of mechanical tests are presented in Table 4.3.

**Table 4.3 - The results of mechanical tests**

| Laboratory key numbers | Strength | | | |
|---|---|---|---|---|
| | Flexural strength | | Compressive strength | |
| | 2 days | 28 days | 2 days | 28 days |
| | (MPa) | (MPa) | (MPa) | (MPa) |
| $z_k$ | z1 | z2 | z3 | z4 |
| **1** | 4,87 | ***7,58 ***** | 25,64 | **57,93 / o** |
| **2** | 5,03 | ***8,03 **** | 26,89 | 59,39 |
| **3** | 5,29 | 8,75 | 26,92 | 59,78 |
| **4** | 5,40 | 8,91 | 26,97 | 60,21 |
| **5** | 5,45 | 8,95 | 27,02 | **60,77 / β** |
| **6** | 5,46 | 9,11 | 27,08 | 60,98 |
| **7** | 5,55 | 9,18 | 27,54 | **61,92 / o** |
| **8** | 5,58 | 9,27 | 27,76 | 62,33 |
| **9** | 5,60 | 9,32 | 28,37 | 62,42 |
| **10** | 5,61 | 9,33 | 28,64 | 62,52 |
| **11** | 5,67 | 9,38 | 29,20 | 62,68 |
| **12** | 5,85 | 9,42 | 29,42 | 62,91 |
| **13** | 5,86 | 9,78 | 29,53 | 64,84 |
| **14** | 6,03 | 9,80 | 30,50 | 65,51 |
| **15** | 6,12 | 9,85 | 30,51 | 66,72 |
| **16** | ***6,46 **** | 9,98 | ***32,65 ***** | ***68,31 **** |
| **17** | - | - | - | - |
| **18** | - | - | - | - |
| **19** | - | - | - | - |
| **20** | - | - | - | - |
| **21** | - | - | - | - |
| **22** | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as biased values.*
*Values marked with two stars (**) are considered as outliers.*
*Values marked with "β" are considered as biased values for the interlaboratory deviations due to Cochran´s test.*
*Values marked with "o" are considered as outliers for the interlaboratory deviations due to Cochran´s test.*

# 5 Z-SCORE EVALUATION

## 5.1 Z-SCORE for chemical analysis

The Z-SCORE1 for chemical analyses is presented in Table 5.1.1

**Table 5.1.1 – Z-SCORE1 for chemical analysis**

| Laboratory key numbers | Sulfate content (as $SO_3$) | Chloride content | Loss on Ignition | Insoluble residue | $Na_2O$ content | $K_2O$ content | Slag content | Chromium (VI) content |
|---|---|---|---|---|---|---|---|---|
| $x_j$ | x1 | x2 | x3 | x4 | x5 | x6 | x7 | x8 |
| **1** | 1,410 | 1,469 | ***3,239 ***** | ***3,068 ***** | 0,964 | 1,762 | 1,685 | 1,387 |
| **2** | 1,055 | 1,469 | 0,589 | 0,645 | 0,836 | 0,769 | 0,941 | 0,946 |
| **3** | 1,046 | 0,761 | 0,368 | 0,541 | 0,708 | 0,343 | 0,776 | 0,869 |
| **4** | 0,910 | 0,761 | 0,368 | 0,281 | 0,516 | 0,249 | 0,750 | 0,797 |
| **5** | 0,727 | 0,584 | 0,053 | 0,160 | 0,452 | 0,249 | 0,721 | 0,201 |
| **6** | 0,409 | 0,584 | 0,021 | 0,090 | 0,452 | 0,249 | 0,611 | 0,003 |
| **7** | 0,409 | 0,407 | -0,010 | 0,038 | 0,388 | 0,154 | 0,201 | -0,108 |
| **8** | 0,045 | 0,230 | -0,042 | -0,117 | 0,324 | 0,154 | -0,305 | -0,185 |
| **9** | -0,046 | 0,053 | -0,073 | -0,291 | 0,196 | 0,060 | -0,764 | -0,929 |
| **10** | -0,092 | -0,124 | -0,105 | -0,395 | 0,196 | 0,012 | -0,841 | -1,040 |
| **11** | -0,183 | -0,301 | -0,326 | -0,464 | 0,196 | -0,035 | -1,112 | ***-1,939 ***** |
| **12** | -0,229 | -0,478 | -0,452 | -0,689 | 0,004 | -0,035 | -1,258 | - |
| **13** | -0,411 | -0,832 | -0,704 | -0,828 | -0,700 | -0,130 | -1,405 | - |
| **14** | -1,367 | -0,832 | -0,767 | -0,845 | ***-2,108 ***** | -0,744 | - | - |
| **15** | -1,549 | -1,363 | -0,830 | -1,192 | ***-2,428 ***** | ***-3,062 ***** | - | - |
| **16** | ***-2,140 **** | ***-2,248 ***** | -1,335 | - | - | - | - | - |
| **17** | - | - | - | - | - | - | - | - |
| **18** | - | - | - | - | - | - | - | - |
| **19** | - | - | - | - | - | - | - | - |
| **20** | - | - | - | - | - | - | - | - |
| **21** | - | - | - | - | - | - | - | - |
| **22** | - | - | - | - | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as questionable values.*
*Values marked with two stars (**) are considered as unsatisfactory values.*
*Bar charts of Z-SCORE for results are illustrated in the Annex.*

The Z-SCORE2 for chemical analyses is presented in Table 5.1.2

**Table 5.1.2 – Z-SCORE2 for chemical analysis**

| Laboratory key numbers | Sulfate content (as $SO_3$) | Chloride content | Loss on Ignition | Insoluble residue | $Na_2O$ content | $K_2O$ content | Slag content | Chromium (VI) content |
|---|---|---|---|---|---|---|---|---|
| $x_j$ | x1 | x2 | x3 | x4 | x5 | x6 | x7 | x8 |
| **1** | 1,492 | 1,585 | ***6,628 ***** | ***5,987 ***** | 1,477 | 2,798 | 1,685 | 1,478 |
| **2** | 1,074 | 1,585 | 1,545 | 1,574 | 1,170 | 0,998 | 0,941 | 0,931 |
| **3** | 1,064 | 0,728 | 1,122 | 1,385 | 0,863 | 0,226 | 0,776 | 0,836 |
| **4** | 0,903 | 0,728 | 1,122 | 0,911 | 0,402 | 0,055 | 0,750 | 0,747 |
| **5** | 0,689 | 0,514 | 0,517 | 0,690 | 0,249 | 0,055 | 0,721 | 0,009 |
| **6** | 0,314 | 0,514 | 0,456 | 0,564 | 0,249 | 0,055 | 0,611 | -0,237 |
| **7** | 0,314 | 0,300 | 0,396 | 0,469 | 0,095 | -0,117 | 0,201 | -0,374 |
| **8** | -0,115 | 0,086 | 0,335 | 0,185 | -0,058 | -0,117 | -0,305 | -0,469 |
| **9** | -0,222 | -0,128 | 0,275 | -0,131 | -0,365 | -0,288 | -0,764 | -1,392 |
| **10** | -0,275 | -0,343 | 0,214 | -0,320 | -0,365 | -0,374 | -0,841 | -1,529 |
| **11** | -0,382 | -0,557 | -0,209 | -0,446 | -0,365 | -0,459 | -1,112 | ***-2,643 ***** |
| **12** | -0,436 | -0,771 | -0,451 | -0,857 | -0,826 | -0,459 | -1,258 | - |
| **13** | -0,650 | -1,199 | -0,935 | -1,109 | -2,515 | -0,631 | -1,405 | - |
| **14** | -1,775 | -1,199 | -1,057 | -1,141 | ***-5,892 ***** | -1,745 | - | - |
| **15** | -1,989 | -1,842 | -1,178 | -1,772 | ***-6,660 ***** | ***-5,945 ***** | - | - |
| **16** | ***-2,685 **** | ***-2,912 ***** | -2,146 | - | - | - | - | - |
| **17** | - | - | - | - | - | - | - | - |
| **18** | - | - | - | - | - | - | - | - |
| **19** | - | - | - | - | - | - | - | - |
| **20** | - | - | - | - | - | - | - | - |
| **21** | - | - | - | - | - | - | - | - |
| **22** | - | - | - | - | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as questionable values.*
*Values marked with two stars (**) are considered as unsatisfactory values.*
*Bar charts of Z-SCORE for results are illustrated in the Annex.*

## 5.2 Z-SCORE for physical tests

The Z-SCORE1 for physical tests is presented in Table 5.2.1.

**Table 5.2.1 – Z-SCORE1 for physical tests**

| Laboratory. key numbers | Hydrating heath | Grinding fineness | | Setting time | | Water for standard consistency | Volume soundness |
|---|---|---|---|---|---|---|---|
| | | Specific surface | Specific gravity | Initial setting time | Final setting time | | |
| $y_j$ | y1 | y2 | y3 | y4 | y5 | y6 | y7 |
| **1** | ***1,599 ***** | ***2,888 ***** | ***2,474 ***** | ***2,345 ***** | 1,592 | 1,472 | 1,256 |
| **2** | 0,198 | 0,651 | 1,006 | 1,366 | 1,113 | 1,249 | 1,256 |
| **3** | -0,132 | 0,623 | 0,377 | 1,039 | 0,814 | 1,026 | 0,785 |
| **4** | -0,791 | 0,486 | 0,168 | 0,985 | 0,814 | 0,803 | 0,471 |
| **5** | -0,874 | 0,100 | 0,168 | 0,441 | 0,814 | 0,580 | 0,471 |
| **6** | - | 0,030 | -0,042 | 0,169 | 0,634 | 0,580 | 0,471 |
| **7** | - | -0,138 | -0,042 | -0,103 | 0,395 | 0,245 | 0,471 |
| **8** | - | -0,366 | -0,042 | -0,212 | 0,275 | 0,134 | 0,471 |
| **9** | - | -0,415 | -0,042 | -0,321 | 0,096 | 0,134 | 0,000 |
| **10** | - | -0,461 | -0,252 | -0,375 | -0,084 | 0,089 | 0,000 |
| **11** | - | -0,601 | -0,252 | -0,539 | -0,203 | -0,312 | -0,314 |
| **12** | - | -0,706 | -0,461 | -0,539 | -0,862 | -0,647 | -0,314 |
| **13** | - | -0,969 | -0,881 | -0,919 | -0,981 | -0,758 | -0,314 |
| **14** | - | -1,124 | ***-2,138 ***** | -1,083 | -1,161 | -0,981 | -0,785 |
| **15** | - | | - | -1,083 | -1,400 | -1,538 | -1,099 |
| **16** | - | - | - | -1,137 | -1,879 | ***-2,096 **** | ***-2,826 ***** |
| **17** | - | - | - | - | - | - | - |
| **18** | - | - | - | - | - | - | - |
| **19** | - | - | - | - | - | - | - |
| **20** | - | - | - | - | - | - | - |
| **21** | - | - | - | - | - | - | - |
| **22** | - | - | - | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as questionable values.*
*Bar charts of Z-SCORE for results are illustrated in the Annex.*

The Z-SCORE2 for physical tests is presented in Table 5.2.2.

**Table 5.2.2 – Z-SCORE2 for physical tests**

| Laboratory. key numbers | Hydrating heath | Grinding fineness | | Setting time | | Water for standard consistency | Volume soundness |
|---|---|---|---|---|---|---|---|
| | | Specific surface | Specific gravity | Initial setting time | Final setting time | | |
| $y_j$ | y1 | y2 | y3 | y4 | y5 | y6 | y7 |
| **1** | ***3,855 ***** | ***5,377 ***** | ***5,434 ***** | ***3,091 ***** | 1,592 | 1,558 | 1,570 |
| **2** | 1,153 | 1,509 | 2,237 | 1,879 | 1,113 | 1,299 | 1,570 |
| **3** | 0,517 | 1,461 | 0,868 | 1,475 | 0,814 | 1,039 | 0,878 |
| **4** | -0,755 | 1,224 | 0,411 | 1,407 | 0,814 | 0,779 | 0,416 |
| **5** | -0,914 | 0,558 | 0,411 | 0,734 | 0,814 | 0,519 | 0,416 |
| **6** | - | 0,436 | -0,046 | 0,397 | 0,634 | 0,519 | 0,416 |
| **7** | - | 0,145 | -0,046 | 0,061 | 0,395 | 0,130 | 0,416 |
| **8** | - | -0,249 | -0,046 | -0,074 | 0,275 | 0,000 | 0,416 |
| **9** | - | -0,333 | -0,046 | -0,209 | 0,096 | 0,000 | -0,277 |
| **10** | - | -0,412 | -0,502 | -0,276 | -0,084 | -0,052 | -0,277 |
| **11** | - | -0,655 | -0,502 | -0,478 | -0,203 | -0,519 | -0,739 |
| **12** | - | -0,837 | -0,959 | -0,478 | -0,862 | -0,909 | -0,739 |
| **13** | - | -1,291 | -1,872 | -0,949 | -0,981 | -1,039 | -0,739 |
| **14** | - | -1,558 | ***-4,612 ***** | -1,152 | -1,161 | -1,299 | -1,432 |
| **15** | - | - | - | -1,152 | -1,400 | -1,948 | -1,894 |
| **16** | - | - | - | -1,219 | -1,879 | ***-2,597 **** | ***-4,434 ***** |
| **17** | - | - | - | - | - | - | - |
| **18** | - | - | - | - | - | - | - |
| **19** | - | - | - | - | - | - | - |
| **20** | - | - | - | - | - | - | - |
| **21** | - | - | - | - | - | - | - |
| **22** | - | - | - | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as questionable values.*
*Bar charts of Z-SCORE for results are illustrated in the Annex.*

## 5.3 Z-SCORE for mechanical tests

The Z-SCORE1 for mechanical tests is presented in Table 5.3.1.

**Table 5.3.1 – Z-SCORE1 for mechanical tests**

| Labor key numbers | Strength | | | |
|---|---|---|---|---|
| | Flexural strength | | Compressive strength | |
| | 2 days | 28 days | 2 days | 28 days |
| $z_k$ | z1 | z2 | z3 | z4 |
| **1** | 1,874 | ***2,470 ***** | 1,537 | 1,632 |
| **2** | 1,471 | ***1,769 **** | 0,845 | 1,105 |
| **3** | 0,816 | 0,647 | 0,828 | 0,964 |
| **4** | 0,539 | 0,397 | 0,801 | 0,809 |
| **5** | 0,413 | 0,335 | 0,773 | 0,607 |
| **6** | 0,388 | 0,086 | 0,740 | 0,531 |
| **7** | 0,161 | -0,023 | 0,485 | 0,192 |
| **8** | 0,086 | -0,164 | 0,363 | 0,044 |
| **9** | 0,035 | -0,242 | 0,025 | 0,011 |
| **10** | 0,010 | -0,257 | -0,125 | -0,025 |
| **11** | -0,141 | -0,335 | -0,435 | -0,083 |
| **12** | -0,594 | -0,397 | -0,557 | -0,166 |
| **13** | -0,619 | -0,959 | -0,618 | -0,862 |
| **14** | -1,048 | -0,990 | -1,155 | -1,104 |
| **15** | -1,274 | -1,068 | -1,161 | -1,541 |
| **16** | ***-2,130 **** | -1,270 | ***-2,346 ***** | ***-2,115 **** |
| **17** | - | - | - | - |
| **18** | - | - | - | - |
| **19** | - | - | - | - |
| **20** | - | - | - | - |
| **21** | - | - | - | - |
| **22** | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as questionable values.*
*Values marked with two stars (**) are considered as unsatisfactory values.*
*Bar charts of Z-SCORE for results are illustrated in the Annex.*

The Z-SCORE2 for mechanical tests is presented in Table 5.3.2.

**Table 5.3.2 – Z-SCORE2 for mechanical tests**

| Labor key numbers | Strength | | | |
|---|---|---|---|---|
| | Flexural strength | | Compressive strength | |
| | 2 days | 28 days | 2 days | 28 days |
| $z_k$ | z1 | z2 | z3 | z4 |
| **1** | 2,033 | ***4,720 ***** | 1,711 | 1,744 |
| **2** | 1,560 | ***3,526 **** | 0,853 | 1,128 |
| **3** | 0,792 | 1,616 | 0,832 | 0,963 |
| **4** | 0,467 | 1,191 | 0,798 | 0,782 |
| **5** | 0,319 | 1,085 | 0,764 | 0,545 |
| **6** | 0,290 | 0,661 | 0,723 | 0,456 |
| **7** | 0,024 | 0,475 | 0,407 | 0,060 |
| **8** | -0,065 | 0,236 | 0,256 | -0,114 |
| **9** | -0,124 | 0,103 | -0,163 | -0,152 |
| **10** | -0,154 | 0,077 | -0,348 | -0,194 |
| **11** | -0,331 | -0,056 | -0,732 | -0,261 |
| **12** | -0,863 | -0,162 | -0,883 | -0,358 |
| **13** | -0,892 | -1,117 | -0,959 | -1,173 |
| **14** | -1,395 | -1,170 | -1,624 | -1,456 |
| **15** | -1,661 | -1,303 | -1,631 | -1,967 |
| **16** | ***-2,665 **** | -1,648 | ***-3,099 ***** | ***-2,639 **** |
| **17** | - | - | - | - |
| **18** | - | - | - | - |
| **19** | - | - | - | - |
| **20** | - | - | - | - |
| **21** | - | - | - | - |
| **22** | - | - | - | - |

*Note:*
*Values marked with single star (*) are considered as questionable values.*
*Values marked with two stars (**) are considered as unsatisfactory values.*
*Bar charts of Z-SCORE for results are illustrated in the Annex.*

# 6 SUMMARY OF THE RESULTS

The results of the Cement Ring Tests 2022 are summarised in Table 6.1.

Table 6.1 - Results summary (without biased values and outliers)

| Sample without outliers | Average (Arithmetic mean) | Precision of a measure of the mean | Ratio $\frac{(2*\varepsilon)}{\bar{x}}$ | Lower confi-dence | Upper confi-dence | Ratio $\frac{(L_M - L_m)}{\bar{x}}$ | Standard deviation of a sample | Coefficient of variation (%) | Count (Sample size) |
|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}$ | ε | | $L_{m95\%}$ | $L_{M95\%}$ | | $s_{(n-1)}$ | v | n |
| Sulfate content (as $SO_3$) (% by mass) | 3,0493 | 0,0630 | 0,0413 | 2,8308 | 3,3782 | 0,1795 | 0,09337 | 3,1 | 15 |
| Chloride content (% by mass) | 0,0564 | 0,0032 | 0,1135 | 0,0453 | 0,0693 | 0,4255 | 0,00467 | 8,3 | 15 |
| Loss on Ignition (% by mass) | 3,9227 | 0,0908 | 0,0463 | 3,5506 | 4,2262 | 0,1722 | 0,08263 | 2,1 | 15 |
| Insoluble residue (% by mass) | 0,9593 | 0,1729 | 0,3605 | 0,2773 | 1,5149 | 1,2901 | 0,15838 | 16,5 | 14 |
| $Na_2O$ content (% by mass) | 0,2281 | 0,0491 | 0,4305 | 0,0877 | 0,4229 | 1,4695 | 0,03257 | 14,3 | 13 |
| $K_2O$ content (% by mass) | 0,7232 | 0,0633 | 0,1751 | 0,5196 | 0,9730 | 0,6269 | 0,05833 | 8,1 | 14 |
| Slag content (% by mass) | 15,167 | 1,716 | 0,2263 | 9,223 | 21,111 | 0,7838 | 2,7281 | 18,0 | 13 +) |
| Chromium (VI) content (ppm) | 3,663 | 1,367 | 0,7464 | - | 8,054 | 2,1987 | 1,4633 | 17,1 | 10 |
| Hydrating heath (J/g) | 292,8 | 33,7 | 0,2302 | 225,41 | 360,19 | 0,4603 | 24,273 | 8,3 | 5 ++) |
| Specific surface ($m^2$/kg) | 488,2 | 17,94 | 0,0735 | 420,25 | 543,47 | 0,2524 | 16,497 | 3,4 | 13 |
| Specific gravity ($g/m^3$) | 3,059 | 0,015 | 0,0098 | 2,955 | 3,161 | 0,0673 | 0,0219 | 0,7 | 12 |
| Initial setting time (min) | 190,9 | 10,5 | 0,11 | 148,9 | 227,3 | 0,4107 | 14,85 | 7,8 | 15 |
| Final setting time (min) | 253,6 | 9,2 | 0,0726 | 218,0 | 289,2 | 0,2808 | 16,71 | 6,6 | 16 |
| Water for standard consistency (% by mass) | 30,0 | 0,44 | 0,293 | 28,21 | 32,03 | 0,1273 | 0,77 | 2,6 | 15 |
| Volume soundness (mm) | 0,68 | 0,25 | 0,7353 | - | 2,16 | 3,1765 | 0,433 | 63,7 | 15 |
| Flexural strength - 2 days (MPa) | 5,558 | 0,194 | 0,0698 | 4,768 | 6,460 | 0,3044 | 0,3384 | 6,1 | 15 |
| Flexural strength - 28 days (MPa) | 9,359 | 0,226 | 0,0483 | 7,797 | 10,533 | 0,2923 | 0,3769 | 4,0 | 14 |
| Compressive strength - 2 days (MPa) | 28,133 | 0,835 | 0,0594 | 24,568 | 32,262 | 0,2735 | 1,4574 | 5,2 | 15 |
| Compressive strength - 28 days (MPa) | 62,061 | 1,358 | 0,0438 | 56,546 | 68,356 | 0,1903 | 2,3683 | 3,8 | 15 |

*+) Remark: All results by wet-way or microscopically testing are included due to the very small count of results.*
*++) Remark: Outliers are included also due to the small number of results..*

Elaborated by: Dipl. Eng. Ladislav Gilányi, PhD.
Checked by: Dipl. Eng. Michal Bačuvčík, PhD.

Date: 20. 05. 2022

Dipl. Eng. Patrik Ševčík
Director of Bratislava branch

List of annexes

| Annex No. | Content of annex | Form |
|---|---|---|
| **1** | Summary statistics and bar charts of frequency distribution | (16+14+08) xA4 |

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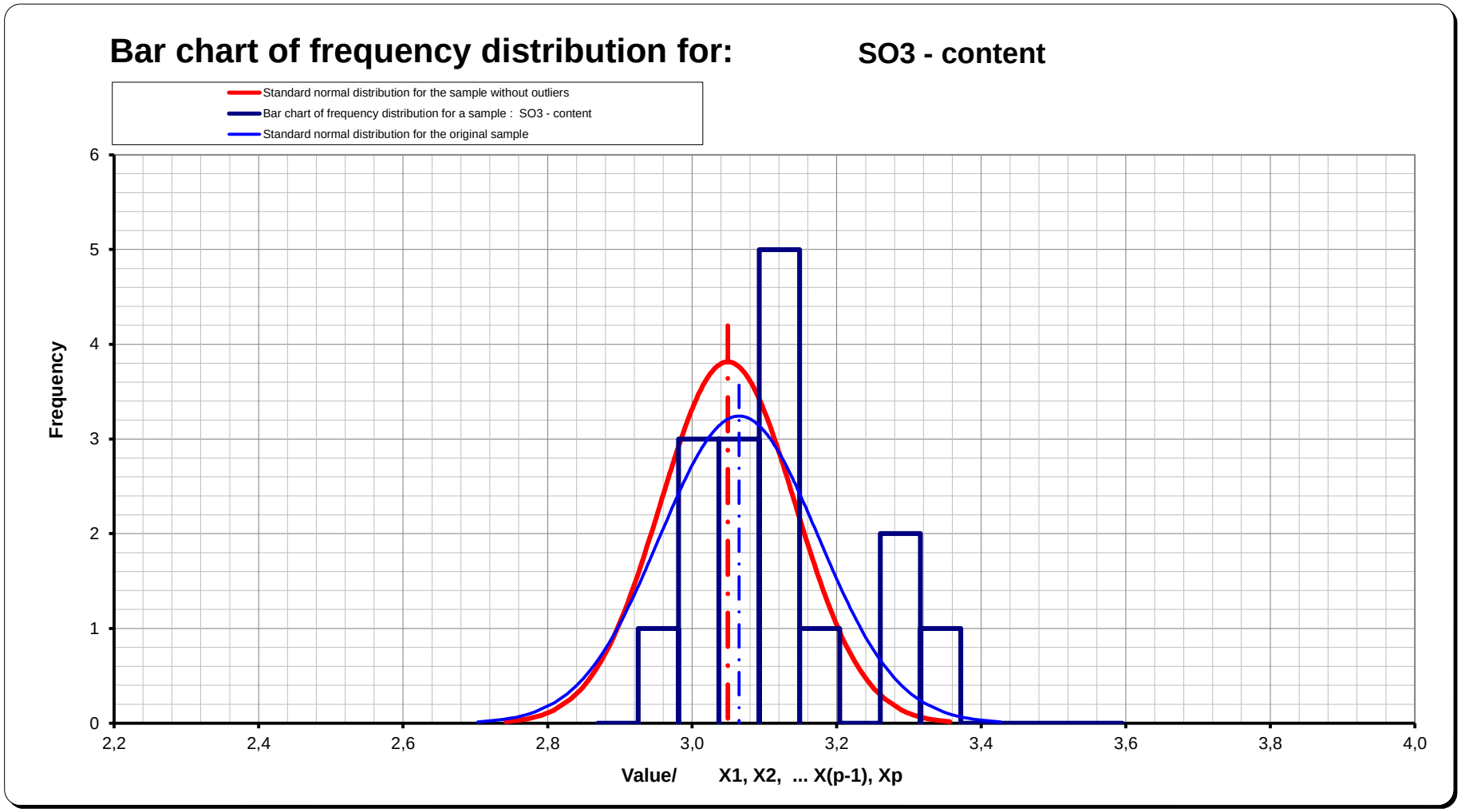
**A) Summary statistics for a sample :**

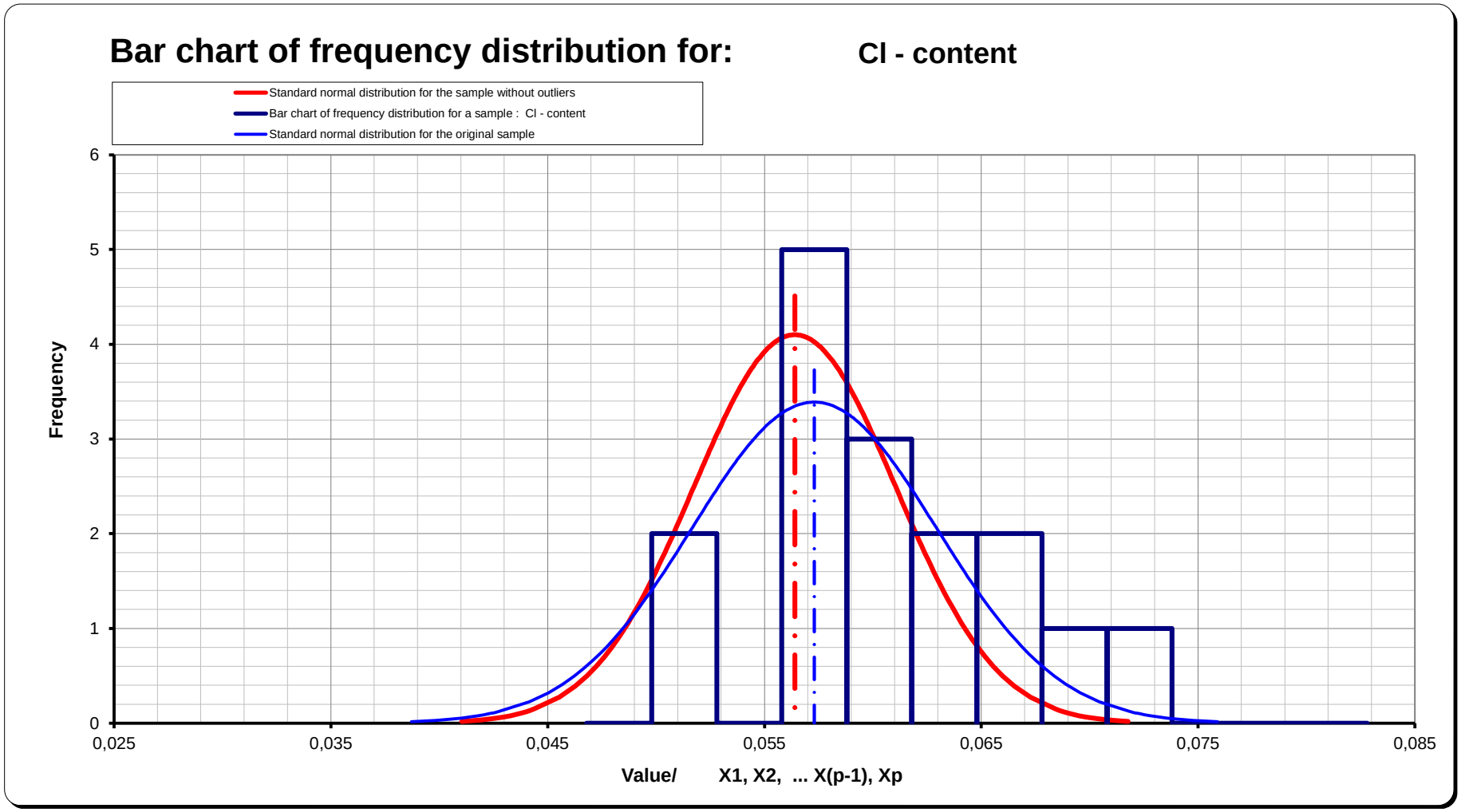
| | | SO3 - content | | | | | |
|---|---|---|---|---|---|---|---|
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 14 | 15 |
| Minimum value | $x_{min} = x_1$ | 2,91 | 2,95 | 2,95 | 2,91 | 2,91 | 2,91 |
| Maximum value | $x_{max} = x_p$ | 3,3 | 3,30 | 3,30 | 3,24 | 3,22 | 3,24 |
| Range of sample R = | $x_{max} - x_{min}$ | 0,39 | 0,35 | 0,35 | 0,33 | 0,31 | 0,33 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 0,4682 | | | | | 0,4006 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 2,7790 | | | | | 2,8043 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 2,8308 | | | | | 2,849 |
| Lower Irwin confidence limit (for P=95%) | xminIw1-5% | 2,8068 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | xminG1-1% | 2,7516 | 2,7797 | | | | |
| Lower Grubbs confidence limit (for P=95%) | xminG1-5% | 2,781 | 2,8384 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 3,0649 | 3,0753 | 3,0843 | 3,0493 | 3,0360 | 3,0493 |
| Precision of a measure of the mean (for P=95%) | ± ε | 0,0605 | 0,0630 | 0,0658 | 0,0630 | 0,0658 | 0,0535 |
| Upper Grubbs confidence limit (for P=99%) | xmaxGp-5% | 3,3488 | | | 3,2593 | | |
| Upper Grubbs confidence limit (for P=95%) | xmaxGp-1% | 3,3782 | | | 3,3113 | | |
| Upper Irwin confidence limit (for P=99%) | xmaxIw1-5% | 3,3772 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 3,2990 | | | | | 3,2496 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 3,3508 | | | | | 3,2943 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,10984 | 0,10535 | 0,10314 | 0,09337 | 0,0809 | 0,09337 |
| Standard deviation | $s_{x,0}$ | 0,10635 | 0,10178 | 0,09939 | 0,0902 | 0,07796 | 0,0902 |
| Coefficient of variation | v | 3,6% | 3,4% | 3,3% | 3,1% | 2,7% | 3,1% |
| Standard skewness | $Sk_{est}$ | 0,743 | 0,832 | 0,823 | 0,579 | 0,463 | 0,579 |
| Standard kurtosis (exces) | $\gamma_2$ | 0,043 | 0,083 | 0,088 | 0,000 | 0,362 | 0,000 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,160 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,650 | 2,625 |


Bar chart of frequency distribution for: SO3 - content
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : SO3 - content
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
2,2
2,4
2,6
2,8
3,0
3,2
3,4
3,6
3,8
4,0
Value/ X1, X2, ... X(p-1), Xp

## A) Summary statistics for a sample :

**Cl - content**

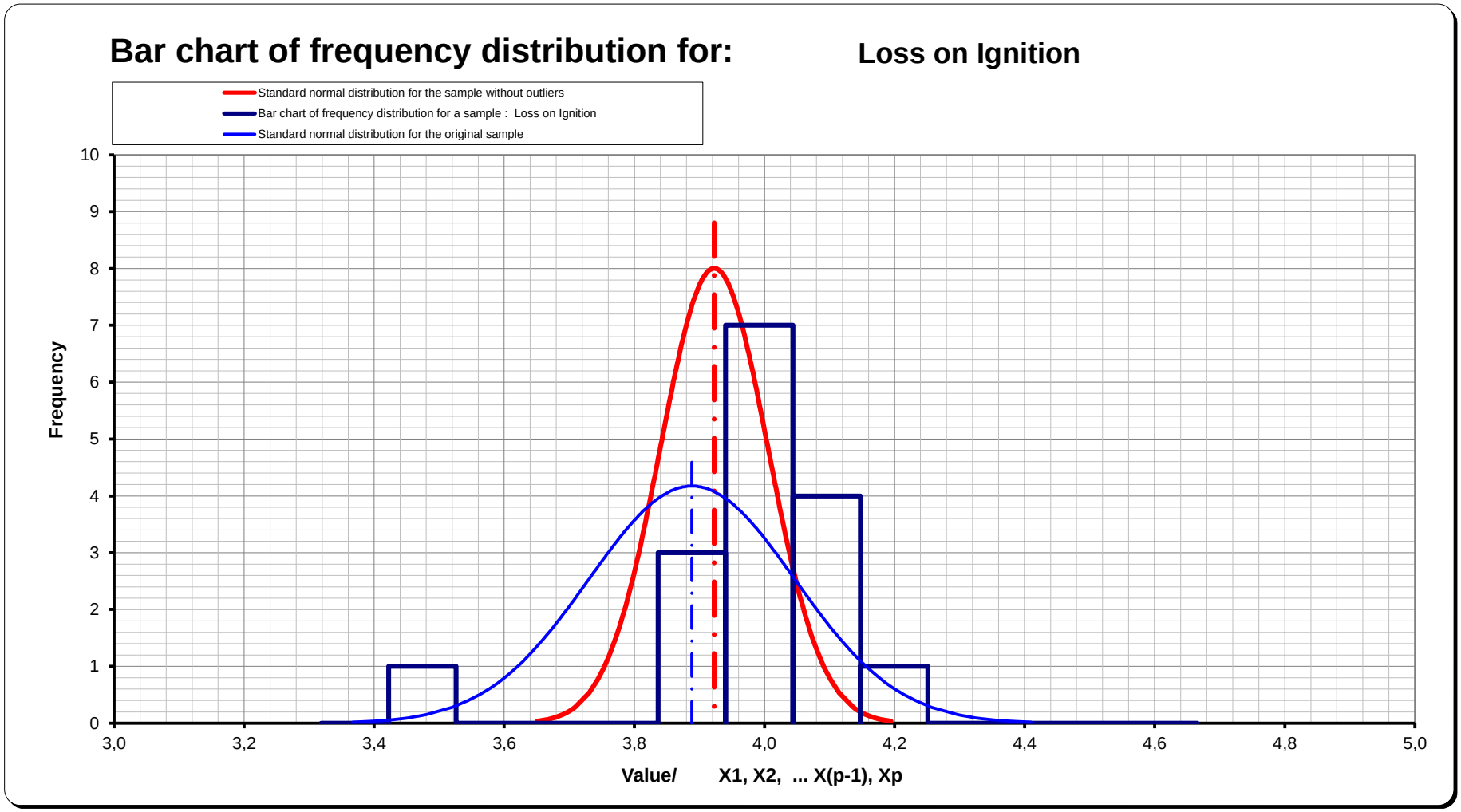
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 16 | 14 | 12 | 15 | 14 | 15 |
| Minimum value | $x_{min} = x_1$ | 0,049 | 0,05 | 0,05 | 0,05 | 0,05 | 0,05 |
| Maximum value | $x_{max} = x_p$ | 0,07 | 0,07 | 0,07 | 0,07 | 0,06 | 0,07 |
| Range of sample R = | $x_{max} - x_{min}$ | 0,021 | 0,02 | 0,02 | 0,02 | 0,01 | 0,02 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 0,024 | | | | | 0,02 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 0,0426 | | | | | 0,0441 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 0,0453 | | | | | 0,0464 |
| Lower Irwin confidence limit (for P=95%) | xminIw1-5% | 0,0457 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | xminG1-1% | 0,0412 | 0,0447 | | | | |
| Lower Grubbs confidence limit (for P=95%) | xminG1-5% | 0,0427 | 0,0459 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 0,0573 | 0,0584 | 0,0593 | 0,0564 | 0,0558 | 0,0564 |
| Precision of a measure of the mean (for P=95%) | ± ε | 0,0031 | 0,0034 | 0,0037 | 0,0032 | 0,0034 | 0,0027 |
| Upper Grubbs confidence limit (for P=99%) | xmaxGp-5% | 0,0719 | | | 0,0681 | | |
| Upper Grubbs confidence limit (for P=95%) | xmaxGp-1% | 0,0734 | | | 0,0693 | | |
| Upper Irwin confidence limit (for P=99%) | xmaxIw1-5% | 0,0723 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 0,0693 | | | | | 0,0664 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 0,0720 | | | | | 0,0687 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,00565 | 0,00499 | 0,00481 | 0,00467 | 0,00417 | 0,00467 |
| Standard deviation | $s_{x,0}$ | 0,00547 | 0,00481 | 0,00461 | 0,00451 | 0,00402 | 0,00451 |
| Coefficient of variation | v | 9,9% | 8,5% | 8,1% | 8,3% | 7,5% | 8,3% |
| Standard skewness | $Sk_{est}$ | 0,600 | 0,996 | 0,976 | 0,110 | -0,098 | 0,110 |
| Standard kurtosis (exces) | $\gamma_2$ | 0,325 | 0,669 | 0,731 | -0,542 | -0,687 | -0,542 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,160 | 2,201 | 2,145 | 2,160 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,650 | 2,718 | 2,625 | 2,650 | 2,625 |


Bar chart of frequency distribution for: Cl - content
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Cl - content
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
0,025
0,035
0,045
0,055
0,065
0,075
0,085
Value/ X1, X2, ... X(p-1), Xp

## A) Summary statistics for a sample :

**Loss on Ignition**

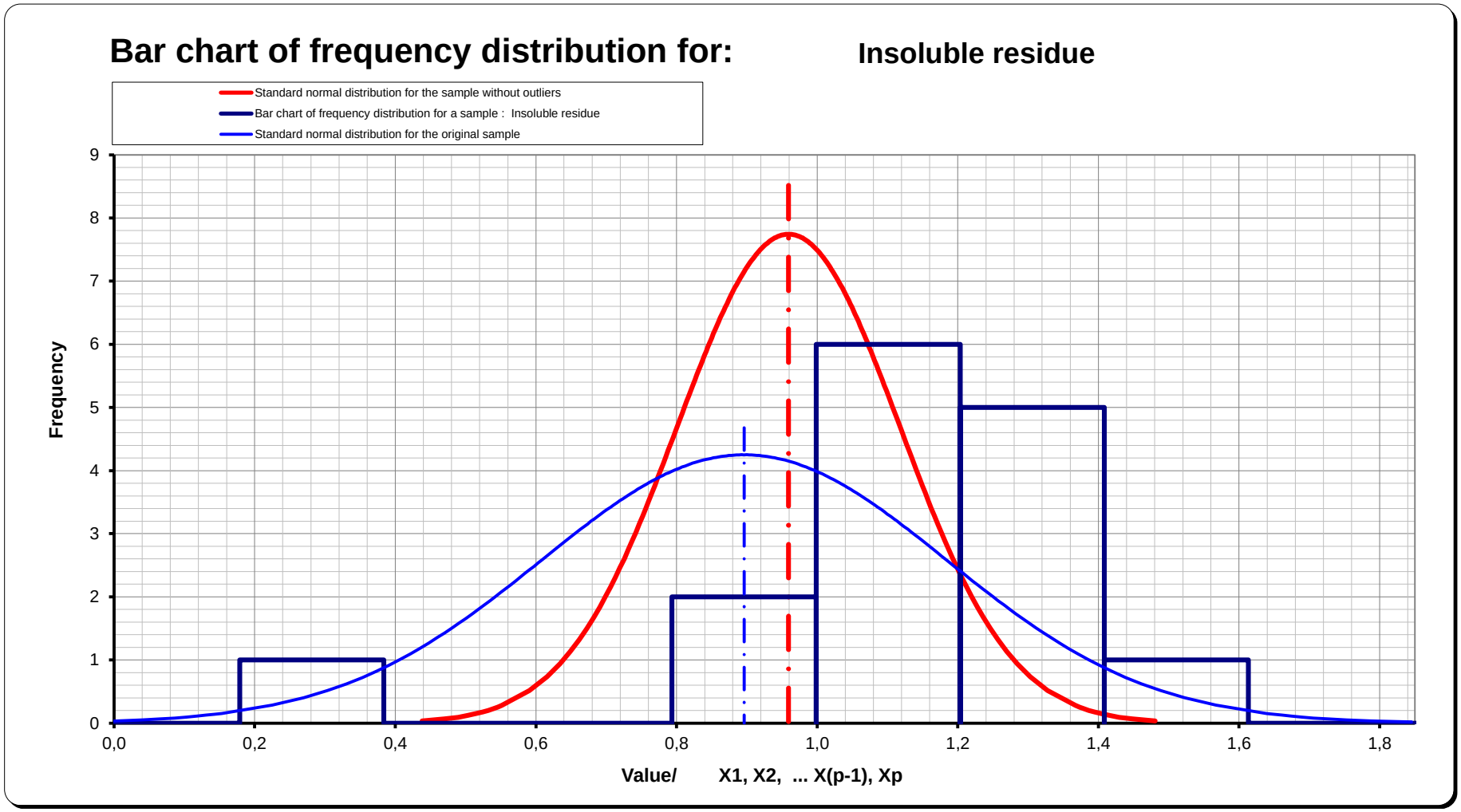
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 14 | 15 |
| Minimum value | $x_{min} = x_1$ | 3,375 | 3,80 | 3,83 | 3,38 | 3,38 | 3,80 |
| Maximum value | $x_{max} = x_p$ | 4,1 | 4,10 | 4,10 | 4,02 | 4,01 | 4,10 |
| Range of sample R = | $x_{max} - x_{min}$ | 0,725 | 0,31 | 0,27 | 0,65 | 0,64 | 0,31 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 0,6756 | | | | | 0,3544 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 3,4759 | | | | | 3,7058 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 3,5506 | | | | | 3,7455 |
| Lower Irwin confidence limit (for P=95%) | xminIw1-5% | 3,5897 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | xminG1-1% | 3,4364 | 3,6908 | | | | |
| Lower Grubbs confidence limit (for P=95%) | xminG1-5% | 3,4787 | 3,7369 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 3,8884 | 3,9227 | 3,9318 | 3,8743 | 3,8639 | 3,9227 |
| Precision of a measure of the mean (for P=95%) | ± ε | 0,0872 | 0,0908 | 0,0950 | 0,0908 | 0,0950 | 0,0474 |
| Upper Grubbs confidence limit (for P=99%) | xmaxGp-5% | 4,2981 | | | 4,2191 | | |
| Upper Grubbs confidence limit (for P=95%) | xmaxGp-1% | 4,3404 | | | 4,3045 | | |
| Upper Irwin confidence limit (for P=99%) | xmaxIw1-5% | 4,2253 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 4,2262 | | | | | 4,0999 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 4,3009 | | | | | 4,1396 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,15849 | 0,08263 | 0,07752 | 0,15331 | 0,1535 | 0,08263 |
| Standard deviation | $s_{x,0}$ | 0,15346 | 0,07983 | 0,0747 | 0,14811 | 0,14792 | 0,07983 |
| Coefficient of variation | v | 4,1% | 2,1% | 2,0% | 4,0% | 4,0% | 2,1% |
| Standard skewness | $Sk_{est}$ | -2,318 | 0,556 | 0,721 | -2,668 | -2,733 | 0,556 |
| Standard kurtosis (exces) | $\gamma_2$ | 7,708 | -0,009 | 0,069 | 8,829 | 8,965 | -0,009 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,160 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,650 | 2,625 |


Bar chart of frequency distribution for: Loss on Ignition
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Loss on Ignition
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
7
8
9
10
3,0
3,2
3,4
3,6
3,8
4,0
4,2
4,4
4,6
4,8
5,0
Value/ X1, X2, ... X(p-1), Xp

**A) Summary statistics for a sample :**

**Insoluble residue**

| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 15 | 14 | 13 | 14 | 13 | 14 |
| Minimum value | $x_{min} = x_1$ | 0,011 | 0,71 | 0,74 | 0,01 | 0,01 | 0,71 |
| Maximum value | $x_{max} = x_p$ | 1,24 | 1,24 | 1,24 | 1,14 | 1,14 | 1,24 |
| Range of sample R = | $x_{max} - x_{min}$ | 1,229 | 0,53 | 0,50 | 1,13 | 1,12 | 0,53 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 1,2376 | | | | | 0,6844 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 0,1389 | | | | | 0,5395 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 0,2773 | | | | | 0,6171 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | 0,3311 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | 0,0865 | 0,523 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | 0,2472 | 0,5622 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 0,8961 | 0,9593 | 0,9785 | 0,8715 | 0,8508 | 0,9593 |
| Precision of a measure of the mean (for P=95%) | ± ε | 0,1654 | 0,1729 | 0,1815 | 0,1729 | 0,1815 | 0,0949 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 1,545 | | | 1,5801 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 1,7057 | | | 1,6502 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 1,5189 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 1,5149 | | | | | 1,3015 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 1,6533 | | | | | 1,3791 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,28852 | 0,15838 | 0,14696 | 0,28266 | 0,28299 | 0,15838 |
| Standard deviation | $s_{x,0}$ | 0,27873 | 0,15262 | 0,1412 | 0,27238 | 0,27189 | 0,15262 |
| Coefficient of variation | v | 32,2% | 16,5% | 15,0% | 32,4% | 33,3% | 16,5% |
| Standard skewness | $Sk_{est}$ | -2,138 | 0,112 | 0,169 | -2,332 | -2,375 | 0,112 |
| Standard kurtosis (exces) | $\gamma_2$ | 6,355 | -0,837 | -0,796 | 6,951 | 7,039 | -0,837 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,145 | 2,160 | 2,179 | 2,160 | 2,179 | 2,160 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,625 | 2,650 | 2,681 | 2,650 | 2,681 | 2,650 |

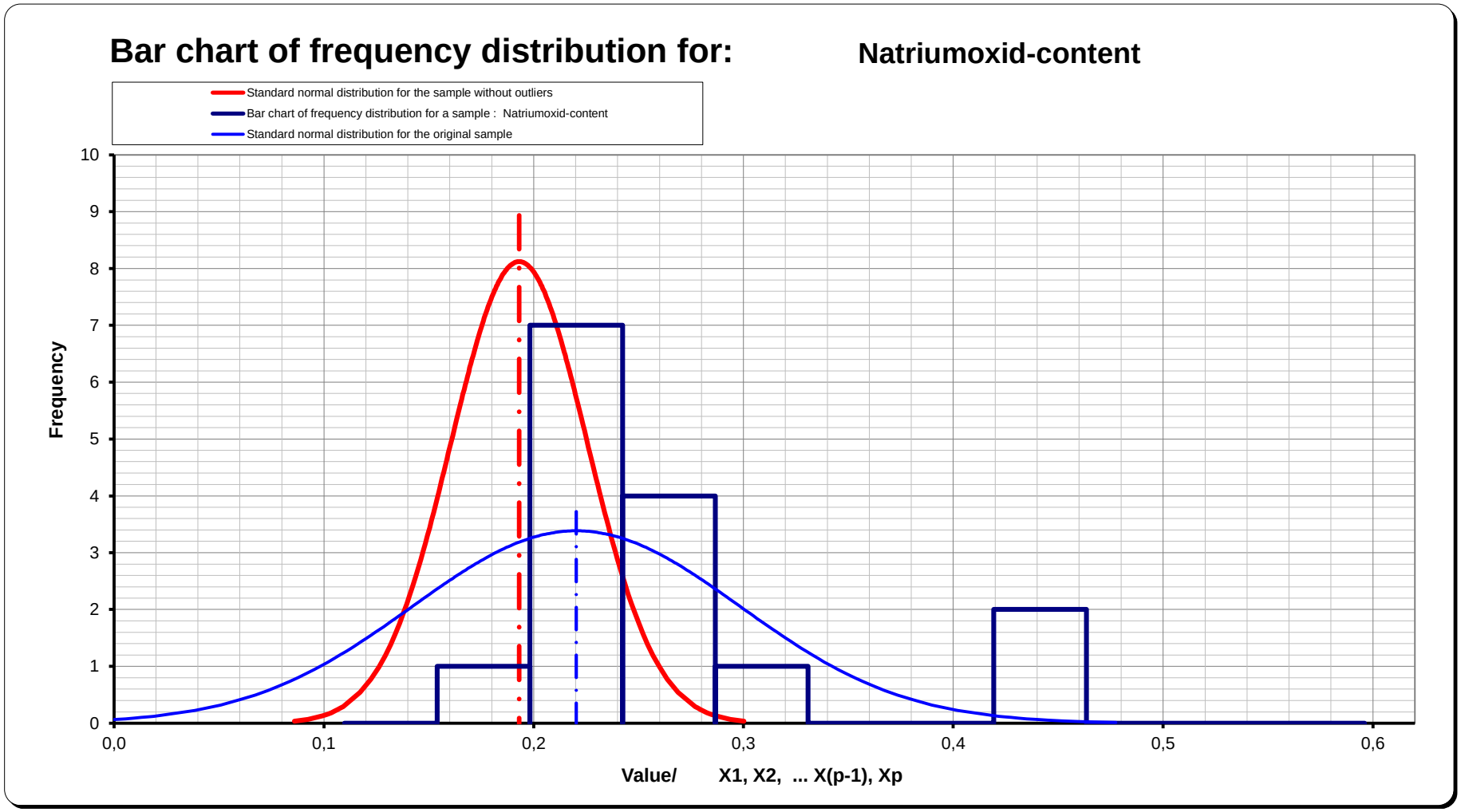

Bar chart of frequency distribution for: Insoluble residue
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Insoluble residue
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
7
8
9
0,0
0,2
0,4
0,6
0,8
1,0
1,2
1,4
1,6
1,8
Value/ X1, X2, ... X(p-1), Xp

TSÚS, Building Testing and Research Institute, Notified body 1301
967/3 Studená Str., Bratislava 821 04, Slovak Republic

## A) Summary statistics for a sample :

**Natriumoxid-content**

| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 15 | 14 | 13 | 14 | 13 | 13 |
| Minimum value | $x_{min} = x_1$ | 0,18 | 0,19 | 0,20 | 0,18 | 0,18 | 0,18 |
| Maximum value | $x_{max} = x_p$ | 0,445 | 0,45 | 0,45 | 0,42 | 0,31 | 0,31 |
| Range of sample R = | $x_{max} - x_{min}$ | 0,265 | 0,26 | 0,25 | 0,24 | 0,13 | 0,13 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 0,3352 | | | | | 0,142 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 0,0502 | | | | | 0,1408 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 0,0877 | | | | | 0,1571 |
| Lower Irwin confidence limit (for P=95%) | xminIw1-5% | 0,0874 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | xminG1-1% | 0,036 | 0,0454 | | | | |
| Lower Grubbs confidence limit (for P=95%) | xminG1-5% | 0,0796 | 0,0648 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 0,2553 | 0,2607 | 0,2662 | 0,2418 | 0,2281 | 0,2281 |
| Precision of a measure of the mean (for P=95%) | ± ε | 0,0448 | 0,0468 | 0,0491 | 0,0468 | 0,0491 | 0,0205 |
| Upper Grubbs confidence limit (for P=99%) | xmaxGp-5% | 0,431 | | | 0,3924 | | |
| Upper Grubbs confidence limit (for P=95%) | xmaxGp-1% | 0,4746 | | | 0,4073 | | |
| Upper Irwin confidence limit (for P=99%) | xmaxIw1-5% | 0,5226 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 0,4229 | | | | | 0,2991 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 0,4604 | | | | | 0,3154 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,07814 | 0,07815 | 0,07853 | 0,06008 | 0,03257 | 0,03257 |
| Standard deviation | $s_{x,0}$ | 0,07549 | 0,07531 | 0,07545 | 0,0579 | 0,03129 | 0,03129 |
| Coefficient of variation | v | 30,6% | 30,0% | 29,5% | 24,8% | 14,3% | 14,3% |
| Standard skewness | $Sk_{est}$ | 1,791 | 1,788 | 1,760 | 2,270 | 1,091 | 1,091 |
| Standard kurtosis (exces) | $\gamma_2$ | 2,437 | 2,244 | 1,974 | 6,078 | 2,659 | 2,659 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,145 | 2,160 | 2,179 | 2,160 | 2,179 | 2,179 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,625 | 2,650 | 2,681 | 2,650 | 2,681 | 2,681 |

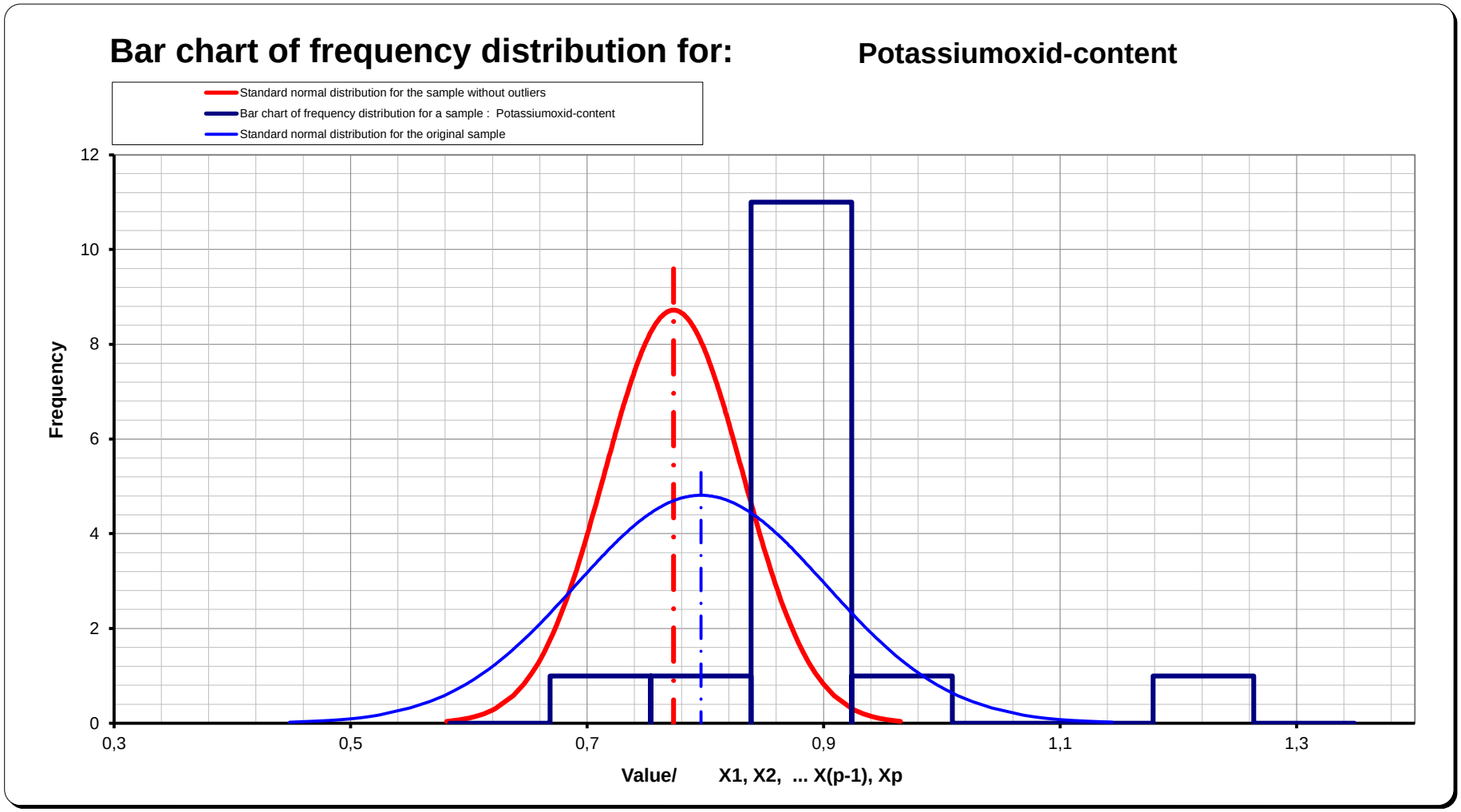

Bar chart of frequency distribution for: Natriumoxid-content
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Natriumoxid-content
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
7
8
9
10
0,0
0,1
0,2
0,3
0,4
0,5
0,6
Value/ X1, X2, ... X(p-1), Xp

TSÚS, Building Testing and Research Institute, Notified body 1301
967/3 Studená Str., Bratislava 821 04, Slovak Republic

## A) Summary statistics for a sample :

**Potassiumoxid-content**

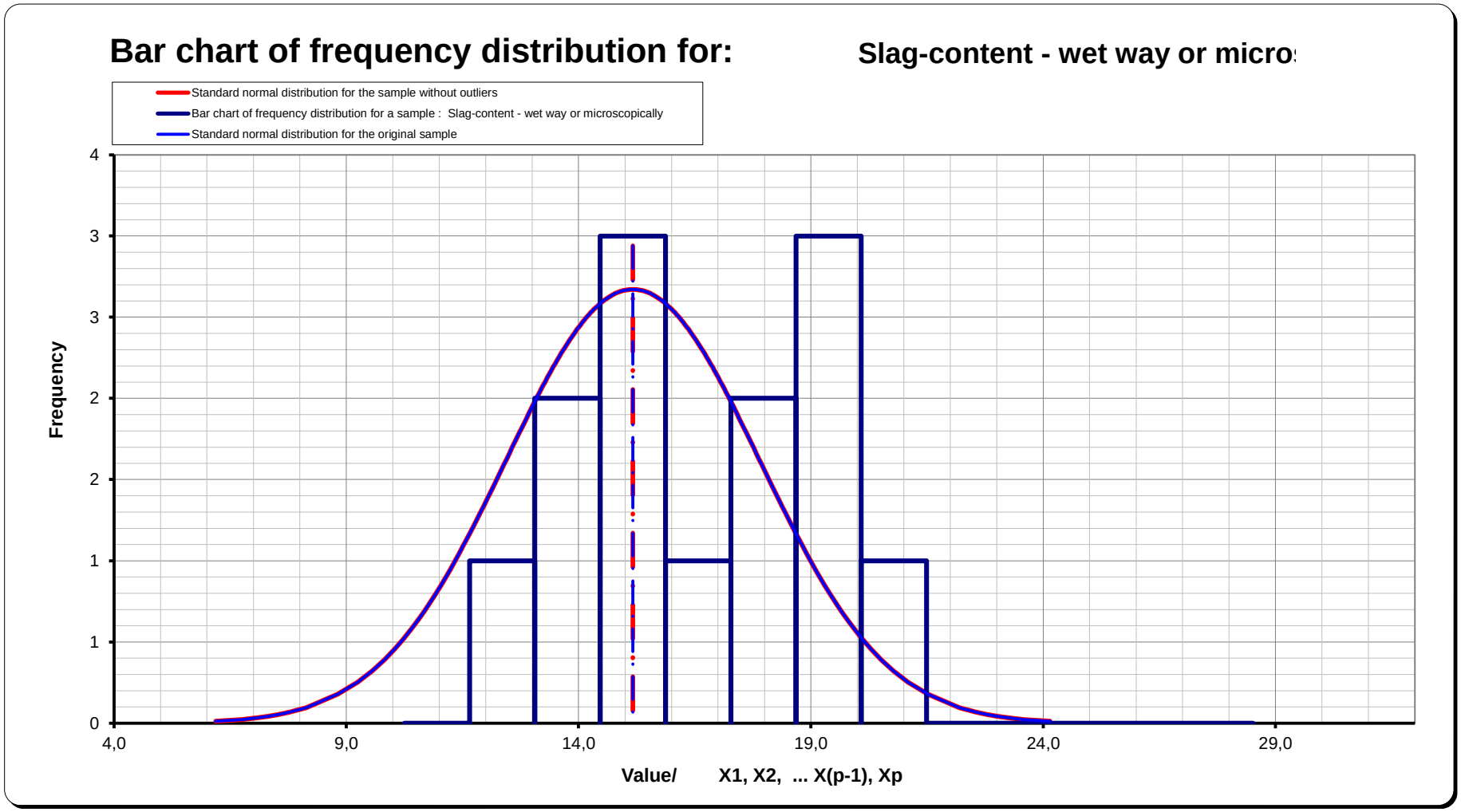
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 15 | 14 | 13 | 14 | 13 | 14 |
| Minimum value | $x_{min} = x_1$ | 0,56 | 0,67 | 0,71 | 0,56 | 0,56 | 0,56 |
| Maximum value | $x_{max} = x_p$ | 1,07 | 1,07 | 1,07 | 0,83 | 0,76 | 0,83 |
| Range of sample R = | $x_{max} - x_{min}$ | 0,51 | 0,41 | 0,36 | 0,27 | 0,20 | 0,27 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 0,4534 | | | | | 0,252 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 0,4688 | | | | | 0,5686 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 0,5196 | | | | | 0,5972 |
| Lower Irwin confidence limit (for P=95%) | xminIw1-5% | 0,5262 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | xminG1-1% | 0,4496 | 0,4957 | | | | |
| Lower Grubbs confidence limit (for P=95%) | xminG1-5% | 0,5085 | 0,5195 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 0,7463 | 0,7596 | 0,7669 | 0,7232 | 0,7154 | 0,7232 |
| Precision of a measure of the mean (for P=95%) | ± ε | 0,0606 | 0,0633 | 0,0665 | 0,0633 | 0,0665 | 0,0350 |
| Upper Grubbs confidence limit (for P=99%) | xmaxGp-5% | 0,9841 | | | 0,8694 | | |
| Upper Grubbs confidence limit (for P=95%) | xmaxGp-1% | 1,043 | | | 0,8839 | | |
| Upper Irwin confidence limit (for P=99%) | xmaxIw1-5% | 0,9638 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 0,9730 | | | | | 0,8492 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 1,0238 | | | | | 0,8778 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,10572 | 0,09579 | 0,09558 | 0,05833 | 0,0525 | 0,05833 |
| Standard deviation | $s_{x,0}$ | 0,10213 | 0,0923 | 0,09183 | 0,05621 | 0,05044 | 0,05621 |
| Coefficient of variation | v | 14,2% | 12,6% | 12,5% | 8,1% | 7,3% | 8,1% |
| Standard skewness | $Sk_{est}$ | 1,903 | 2,956 | 3,090 | -1,533 | -2,492 | -1,533 |
| Standard kurtosis (exces) | $\gamma_2$ | 7,021 | 9,812 | 10,080 | 4,951 | 6,917 | 4,951 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,145 | 2,160 | 2,179 | 2,160 | 2,179 | 2,160 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,625 | 2,650 | 2,681 | 2,650 | 2,681 | 2,650 |


Bar chart of frequency distribution for: Potassiumoxid-content
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Potassiumoxid-content
Standard normal distribution for the original sample
Frequency
0
2
4
6
8
10
12
0,3
0,5
0,7
0,9
1,1
1,3
Value/ X1, X2, ... X(p-1), Xp

**A) Summary statistics for a sample :**

**Slag-content - wet way or microscopically**

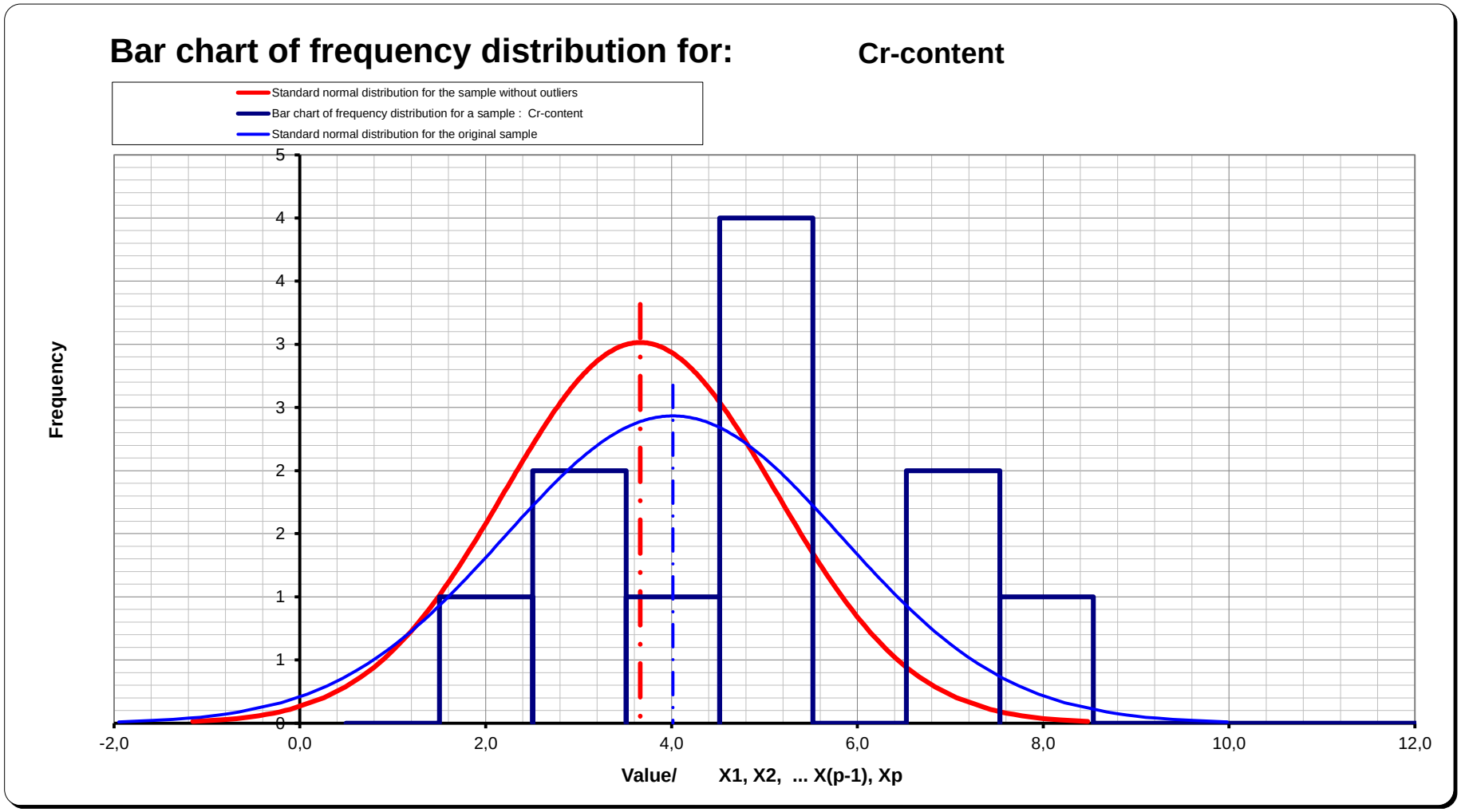
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 13 | 12 | 11 | 12 | 11 | 13 |
| Minimum value | $x_{min} = x_1$ | 10,57 | 12,60 | 13,05 | 10,57 | 10,57 | 10,57 |
| Maximum value | $x_{max} = x_p$ | 19 | 19,00 | 19,00 | 18,60 | 18,20 | 19,00 |
| Range of sample R = | $x_{max} - x_{min}$ | 8,43 | 6,40 | 5,95 | 8,03 | 7,63 | 8,43 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 11,888 | | | | | 11,888 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 7,853 | | | | | 7,853 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 9,223 | | | | | 9,223 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | 8,903 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | 7,804 | 9,073 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | 8,45 | 9,623 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 15,167 | 15,550 | 15,818 | 14,848 | 14,506 | 15,167 |
| Precision of a measure of the mean (for P=95%) | $\pm \varepsilon$ | 1,716 | 1,810 | 1,922 | 1,810 | 1,922 | 1,716 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 21,884 | | | 21,078 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 22,53 | | | 21,657 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 22,297 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 21,111 | | | | | 21,111 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 22,481 | | | | | 22,481 |
| Standard deviation of a sample | $s_{x,n-1}$ | 2,7281 | 2,4572 | 2,3858 | 2,583 | 2,4089 | 2,7281 |
| Standard deviation | $s_{x,0}$ | 2,621 | 2,3526 | 2,2748 | 2,473 | 2,2968 | 2,621 |
| Coefficient of variation | v | 18,0% | 15,8% | 15,1% | 17,4% | 16,6% | 18,0% |
| Standard skewness | $Sk_{est}$ | 0,009 | 0,162 | 0,015 | 0,103 | 0,203 | 0,009 |
| Standard kurtosis (exces) | $\gamma_2$ | -1,346 | -1,882 | -1,928 | -1,214 | -0,958 | -1,346 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,179 | 2,201 | 2,228 | 2,201 | 2,228 | 2,179 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,681 | 2,718 | 2,764 | 2,718 | 2,764 | 2,681 |


Bar chart of frequency distribution for:
Slag-content - wet way or micro
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Slag-content - wet way or microscopically
Standard normal distribution for the original sample
Frequency
0
1
1
2
2
3
3
4
4,0
9,0
14,0
19,0
24,0
29,0
Value/ X1, X2, ... X(p-1), Xp

TSÚS, Building Testing and Research Institute, Notified body 1301
967/3 Studená Str., Bratislava 821 04, Slovak Republic

**A) Summary statistics for a sample :**

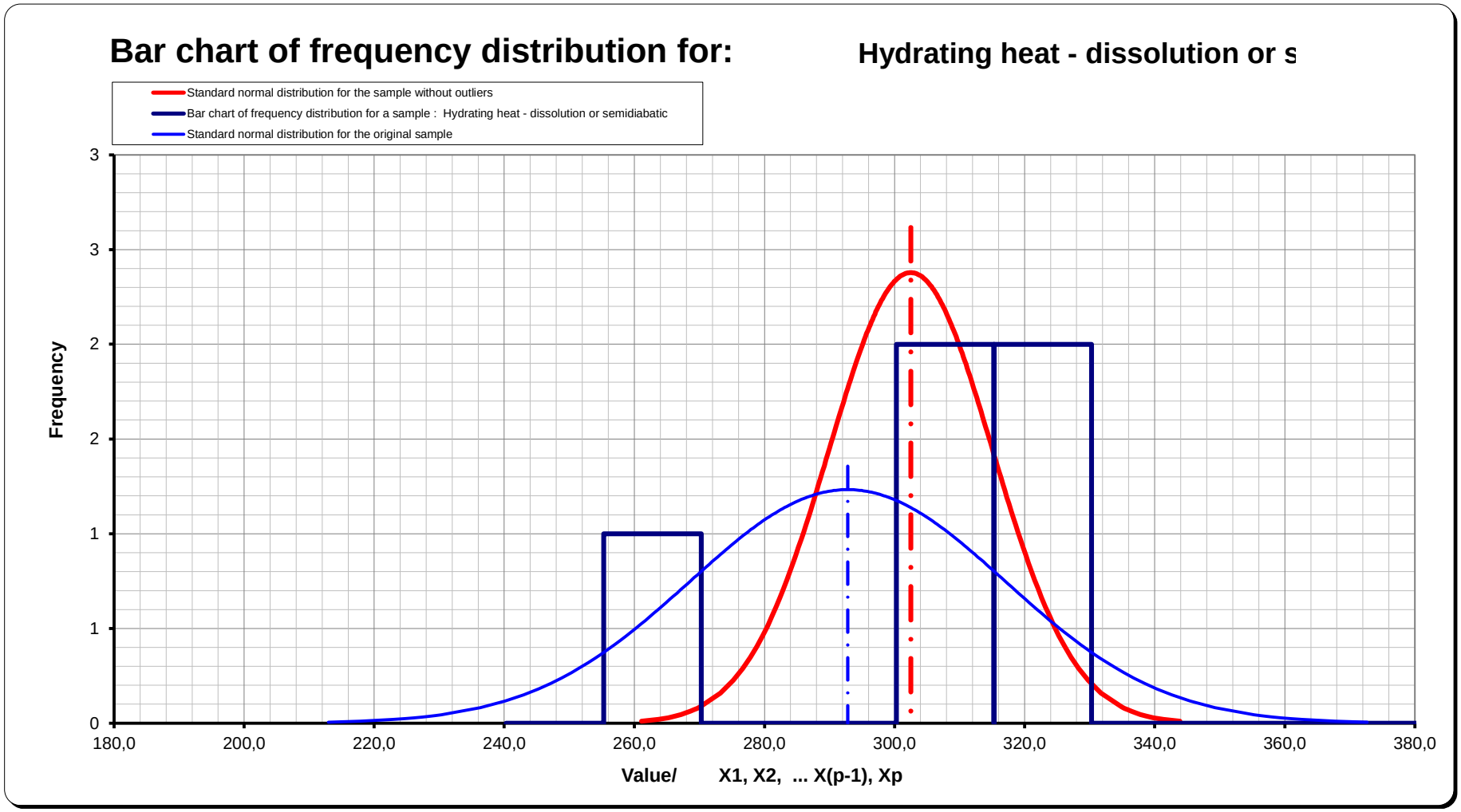
| | | Cr-content | | | | | |
|---|---|---|---|---|---|---|---|
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
| Count (Sample size) | n | 11 | 10 | 9 | 10 | 9 | 10 |
| Minimum value | $x_{min} = x_1$ | 1,5 | 2,30 | 2,44 | 1,50 | 1,50 | 1,50 |
| Maximum value | $x_{max} = x_p$ | 7,53 | 7,53 | 7,53 | 5,90 | 5,70 | 5,90 |
| Range of sample R = | $x_{max} - x_{min}$ | 6,03 | 5,23 | 5,09 | 4,40 | 4,20 | 4,40 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 8,078 | | | | | 6,62 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | -0,995 | | | | | -0,466 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | -0,024 | | | | | 0,353 |
| Lower Irwin confidence limit (for P=95%) | XminIw1-5% | -0,253 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | XminG1-1% | -0,633 | 0,055 | | | | |
| Lower Grubbs confidence limit (for P=95%) | XminG1-5% | -0,254 | 0,38 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 4,015 | 4,266 | 4,484 | 3,663 | 3,414 | 3,663 |
| Precision of a measure of the mean (for P=95%) | ± ε | 1,277 | 1,367 | 1,478 | 1,367 | 1,478 | 1,103 |
| Upper Grubbs confidence limit (for P=99%) | XmaxGp-5% | 8,284 | | | 7,014 | | |
| Upper Grubbs confidence limit (for P=95%) | XmaxGp-1% | 8,663 | | | 7,295 | | |
| Upper Irwin confidence limit (for P=99%) | XmaxIw1-5% | 8,453 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 8,054 | | | | | 6,973 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 9,025 | | | | | 7,792 |
| Standard deviation of a sample | $s_{x,n-1}$ | 1,8129 | 1,6968 | 1,6438 | 1,4633 | 1,3092 | 1,4633 |
| Standard deviation | $s_{x,0}$ | 1,7285 | 1,6097 | 1,5498 | 1,3882 | 1,2343 | 1,3882 |
| Coefficient of variation | v | 45,2% | 39,8% | 36,7% | 39,9% | 38,3% | 39,9% |
| Standard skewness | $Sk_{est}$ | 0,555 | 0,662 | 0,601 | 0,195 | 0,255 | 0,195 |
| Standard kurtosis (exces) | $\gamma_2$ | -0,219 | -0,144 | -0,034 | -0,932 | -0,471 | -0,932 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,228 | 2,262 | 2,306 | 2,262 | 2,306 | 2,262 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,764 | 2,821 | 2,897 | 2,821 | 2,897 | 2,821 |


Bar chart of frequency distribution for: Cr-content
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Cr-content
Standard normal distribution for the original sample
Frequency
5
4
4
3
3
2
2
1
1
0
-2,0
0,0
2,0
4,0
6,0
8,0
10,0
12,0
Value/ X1, X2, ... X(p-1), Xp

**A) Summary statistics for a sample :**

**Hydrating heat - dissolution or semidiabatic**

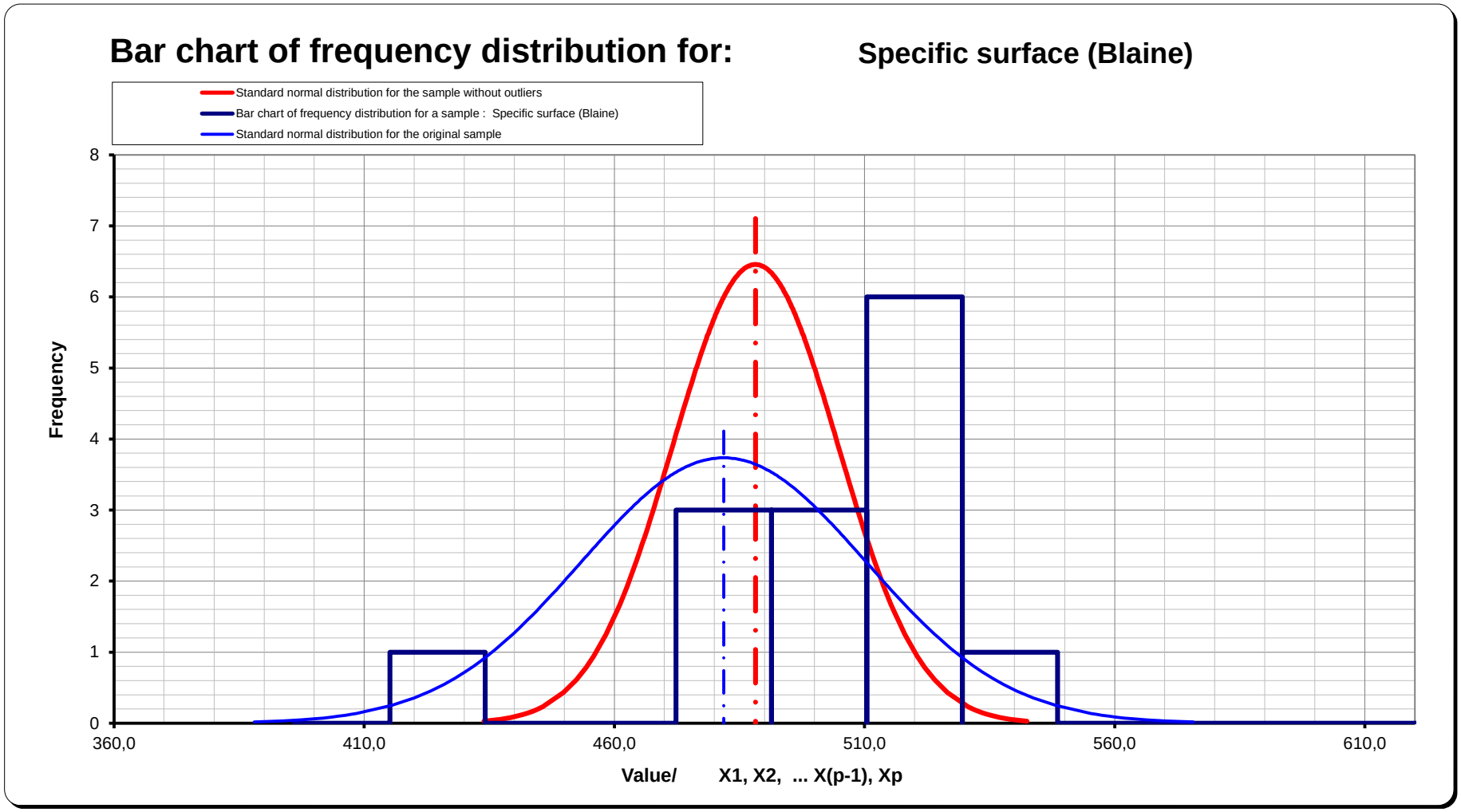
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 5 | 4 | 3 | 4 | 3 | 4 |
| Minimum value | $x_{min} = x_1$ | 254 | 288,00 | 296,00 | 254,00 | 254,00 | 288,00 |
| Maximum value | $x_{max} = x_p$ | 314 | 314,00 | 314,00 | 312,00 | 296,00 | 314,00 |
| Range of sample R = | $x_{max} - x_{min}$ | 60 | 26,00 | 18,00 | 58,00 | 42,00 | 26,00 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 134,8 | | | | | 80 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 201,9 | | | | | 245,4 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 225,4 | | | | | 262,5 |
| Lower Irwin confidence limit (for P=95%) | xminIw1-5% | 246,7 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | xminG1-1% | 250 | 283,7 | | | | |
| Lower Grubbs confidence limit (for P=95%) | xminG1-5% | 251,2 | 283,9 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 292,8 | 302,5 | 307,3 | 287,5 | 279,3 | 302,5 |
| Precision of a measure of the mean (for P=95%) | ± ε | 33,7 | 44,6 | #HODNOTA! | 44,6 | #HODNOTA! | 23,1 |
| Upper Grubbs confidence limit (for P=99%) | xmaxGp-5% | 334,4 | | | 323,7 | | |
| Upper Grubbs confidence limit (for P=95%) | xmaxGp-1% | 335,6 | | | 324,1 | | |
| Upper Irwin confidence limit (for P=99%) | xmaxIw1-5% | 353,3 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 360,2 | | | | | 342,5 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 383,7 | | | | | 359,6 |
| Standard deviation of a sample | $s_{x,n-1}$ | 24,27 | 12,58 | 9,87 | 24,46 | 22,3 | 12,58 |
| Standard deviation | $s_{x,0}$ | 21,71 | 10,9 | 8,06 | 21,18 | 18,21 | 10,9 |
| Coefficient of variation | v | 8,3% | 4,2% | 3,2% | 8,5% | 8,0% | 4,2% |
| Standard skewness | $Sk_{est}$ | -1,220 | -0,316 | 0,000 | -1,015 | -1,485 | -0,316 |
| Standard kurtosis (exces) | $\gamma_2$ | 1,379 | 0,000 | 0,000 | 0,000 | #DELENIENULOU! | 0,000 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,776 | 3,183 | #HODNOTA! | 3,183 | #HODNOTA! | 3,183 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 3,747 | 4,541 | #HODNOTA! | 4,541 | #HODNOTA! | 4,541 |


Bar chart of frequency distribution for:
Hydrating heat - dissolution or s
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Hydrating heat - dissolution or semidiabatic
Standard normal distribution for the original sample
Frequency
3
3
2
2
1
1
0
180,0
200,0
220,0
240,0
260,0
280,0
300,0
320,0
340,0
360,0
380,0
Value/ X1, X2, ... X(p-1), Xp

**A) Summary statistics for a sample :**

**Specific surface (Blaine)**

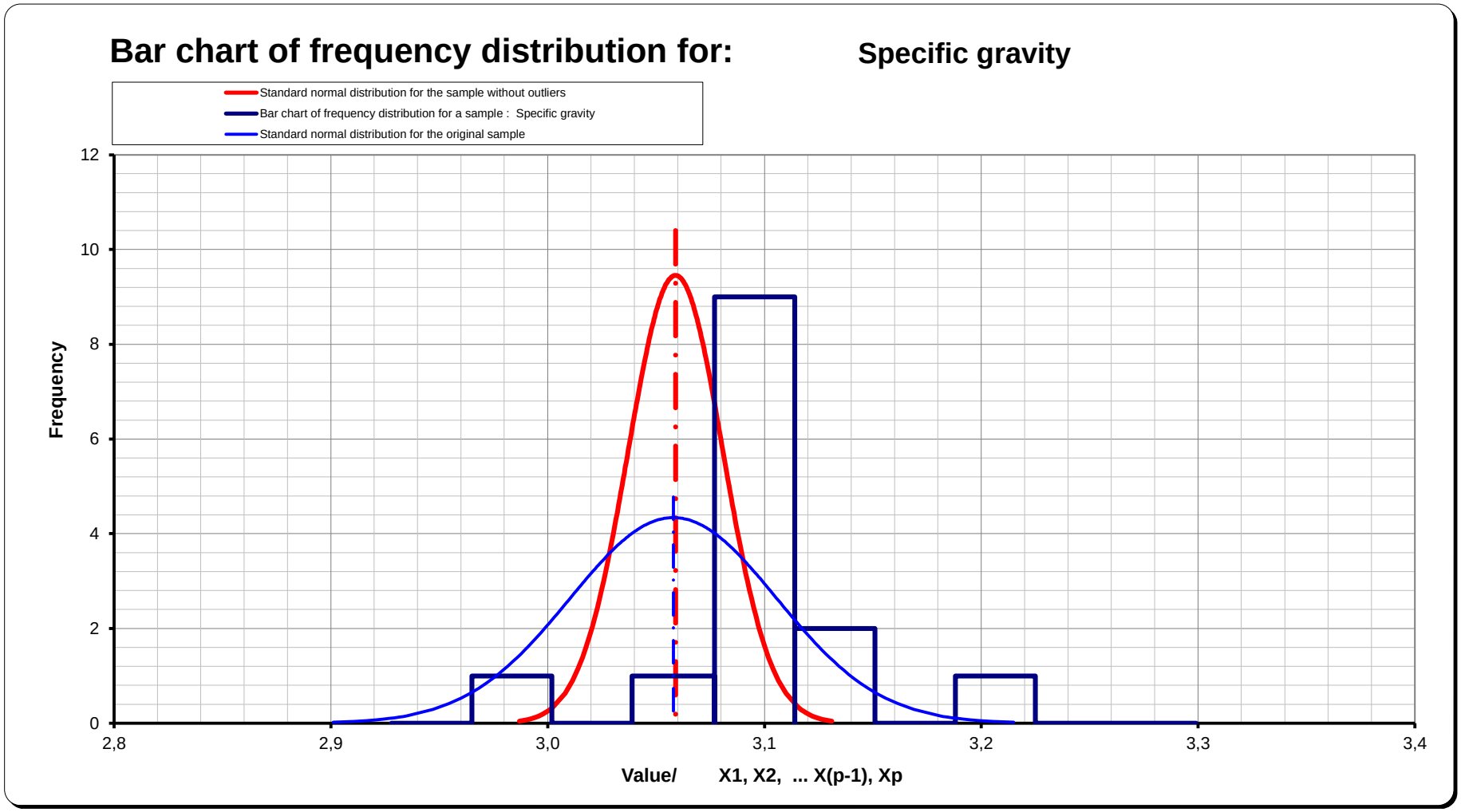
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 14 | 13 | 12 | 13 | 12 | 13 |
| Minimum value | $x_{min} = x_1$ | 399,5 | 463,30 | 464,10 | 399,50 | 399,50 | 463,30 |
| Maximum value | $x_{max} = x_p$ | 513,9 | 513,90 | 513,90 | 509,50 | 502,00 | 513,90 |
| Range of sample R = | $x_{max} - x_{min}$ | 114,4 | 50,60 | 49,80 | 110,00 | 102,50 | 50,60 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 123,22 | | | | | 71,88 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 406,28 | | | | | 443,97 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 420,25 | | | | | 452,26 |
| Lower Irwin confidence limit (for P=95%) | xminIw1-5% | 425,29 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | xminG1-1% | 403,3 | 443,67 | | | | |
| Lower Grubbs confidence limit (for P=95%) | xminG1-5% | 410,37 | 447,58 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 481,86 | 488,20 | 490,28 | 479,40 | 476,89 | 488,20 |
| Precision of a measure of the mean (for P=95%) | ± ε | 17,09 | 17,94 | 18,92 | 17,94 | 18,92 | 10,38 |
| Upper Grubbs confidence limit (for P=99%) | xmaxGp-5% | 553,35 | | | 548,55 | | |
| Upper Grubbs confidence limit (for P=95%) | xmaxGp-1% | 560,42 | | | 555,2 | | |
| Upper Irwin confidence limit (for P=99%) | xmaxIw1-5% | 547,51 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 543,47 | | | | | 524,14 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 557,44 | | | | | 532,43 |
| Standard deviation of a sample | $s_{x,n-1}$ | 28,516 | 16,497 | 15,356 | 28,086 | 27,773 | 16,497 |
| Standard deviation | $s_{x,0}$ | 27,479 | 15,849 | 14,703 | 26,985 | 26,59 | 15,849 |
| Coefficient of variation | v | 5,9% | 3,4% | 3,1% | 5,9% | 5,8% | 3,4% |
| Standard skewness | $Sk_{est}$ | -1,939 | -0,170 | -0,259 | -2,062 | -2,175 | -0,170 |
| Standard kurtosis (exces) | $\gamma_2$ | 5,084 | -0,961 | -0,596 | 5,435 | 5,721 | -0,961 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,160 | 2,179 | 2,201 | 2,179 | 2,201 | 2,179 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,650 | 2,681 | 2,718 | 2,681 | 2,718 | 2,681 |


Bar chart of frequency distribution for:
Specific surface (Blaine)
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Specific surface (Blaine)
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
7
8
360,0
410,0
460,0
510,0
560,0
610,0
Value/ X1, X2, ... X(p-1), Xp

## A) Summary statistics for a sample :

**Specific gravity**

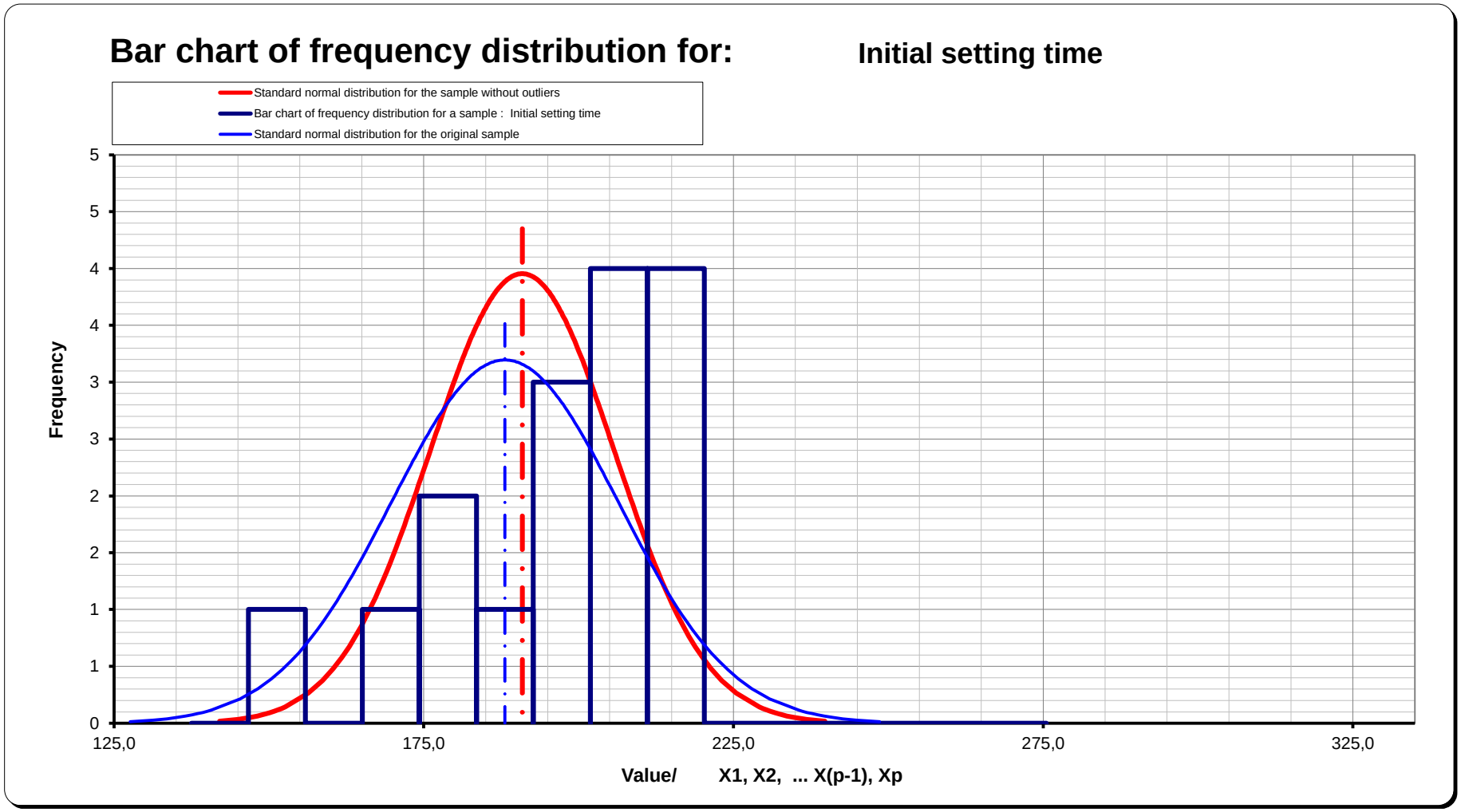
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 14 | 13 | 12 | 13 | 12 | 12 |
| Minimum value | $x_{min} = x_1$ | 2,94 | 3,01 | 3,04 | 2,94 | 2,94 | 3,01 |
| Maximum value | $x_{max} = x_p$ | 3,16 | 3,16 | 3,16 | 3,10 | 3,08 | 3,10 |
| Range of sample R = | $x_{max} - x_{min}$ | 0,22 | 0,15 | 0,12 | 0,16 | 0,14 | 0,09 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 0,206 | | | | | 0,096 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 2,932 | | | | | 2,999 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 2,955 | | | | | 3,011 |
| Lower Irwin confidence limit (for P=95%) | xminIw1-5% | 2,946 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | xminG1-1% | 2,927 | 2,973 | | | | |
| Lower Grubbs confidence limit (for P=95%) | xminG1-5% | 2,938 | 2,981 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 3,058 | 3,067 | 3,072 | 3,050 | 3,046 | 3,059 |
| Precision of a measure of the mean (for P=95%) | ± ε | 0,029 | 0,030 | 0,032 | 0,030 | 0,032 | 0,015 |
| Upper Grubbs confidence limit (for P=99%) | xmaxGp-5% | 3,178 | | | 3,147 | | |
| Upper Grubbs confidence limit (for P=95%) | xmaxGp-1% | 3,189 | | | 3,156 | | |
| Upper Irwin confidence limit (for P=99%) | xmaxIw1-5% | 3,164 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 3,161 | | | | | 3,107 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 3,184 | | | | | 3,119 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,0477 | 0,035 | 0,0319 | 0,0392 | 0,0378 | 0,0219 |
| Standard deviation | $s_{x,0}$ | 0,046 | 0,0336 | 0,0305 | 0,0376 | 0,0362 | 0,021 |
| Coefficient of variation | v | 1,6% | 1,1% | 1,0% | 1,3% | 1,2% | 0,7% |
| Standard skewness | $Sk_{est}$ | -0,493 | 1,450 | 2,206 | -2,008 | -2,332 | -0,494 |
| Standard kurtosis (exces) | $\gamma_2$ | 3,473 | 4,136 | 5,608 | 5,245 | 5,980 | 2,087 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,160 | 2,179 | 2,201 | 2,179 | 2,201 | 2,201 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,650 | 2,681 | 2,718 | 2,681 | 2,718 | 2,718 |


Bar chart of frequency distribution for: Specific gravity
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Specific gravity
Standard normal distribution for the original sample
Frequency
0
2
4
6
8
10
12
2,8
2,9
3,0
3,1
3,2
3,3
3,4
Value/ X1, X2, ... X(p-1), Xp

## A) Summary statistics for a sample :

**Initial setting time**

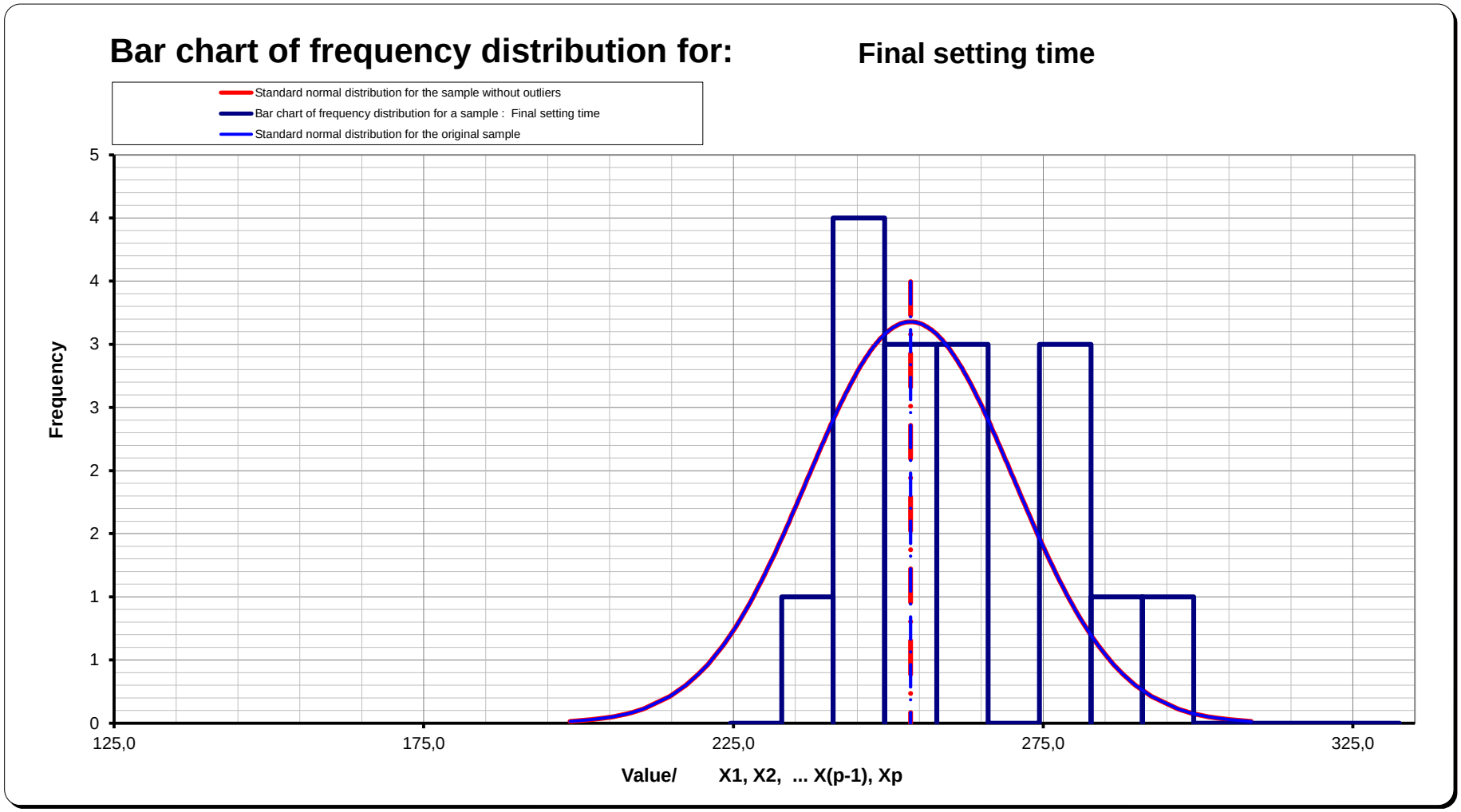
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 13 | 15 |
| Minimum value | $x_{min} = x_1$ | 145 | 163,00 | 169,00 | 145,00 | 145,00 | 163,00 |
| Maximum value | $x_{max} = x_p$ | 209 | 209,00 | 209,00 | 208,00 | 205,00 | 209,00 |
| Range of sample R = | $x_{max} - x_{min}$ | 64 | 46,00 | 40,00 | 63,00 | 60,00 | 46,00 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 78,4 | | | | | 63,8 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 140,3 | | | | | 151,9 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 148,9 | | | | | 159 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | 139,2 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | 135,7 | 149,2 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | 140,6 | 157,5 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 188,1 | 190,9 | 192,9 | 186,7 | 183,4 | 190,9 |
| Precision of a measure of the mean (for P=95%) | $\pm \varepsilon$ | 10,1 | 10,5 | 11,0 | 10,5 | 11,6 | 8,5 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 235,6 | | | 227,5 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 240,5 | | | 237,6 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 231,8 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 227,3 | | | | | 222,8 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 235,9 | | | | | 229,9 |
| Standard deviation of a sample | $s_{x,n-1}$ | 18,38 | 14,85 | 13,16 | 18,13 | 17,2 | 14,85 |
| Standard deviation | $s_{x,0}$ | 17,8 | 14,35 | 12,69 | 17,51 | 16,52 | 14,35 |
| Coefficient of variation | v | 9,8% | 7,8% | 6,8% | 9,7% | 9,4% | 7,8% |
| Standard skewness | $Sk_{est}$ | -0,939 | -0,594 | -0,606 | -0,919 | -0,976 | -0,594 |
| Standard kurtosis (exces) | $\gamma_2$ | 0,386 | -0,680 | -0,464 | 0,378 | 0,433 | -0,680 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,179 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,681 | 2,625 |


Bar chart of frequency distribution for: Initial setting time
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Initial setting time
Standard normal distribution for the original sample
Frequency
0
1
1
2
2
3
3
4
4
5
5
125,0
175,0
225,0
275,0
325,0
Value/ X1, X2, ... X(p-1), Xp

**A) Summary statistics for a sample :**

**Final setting time**

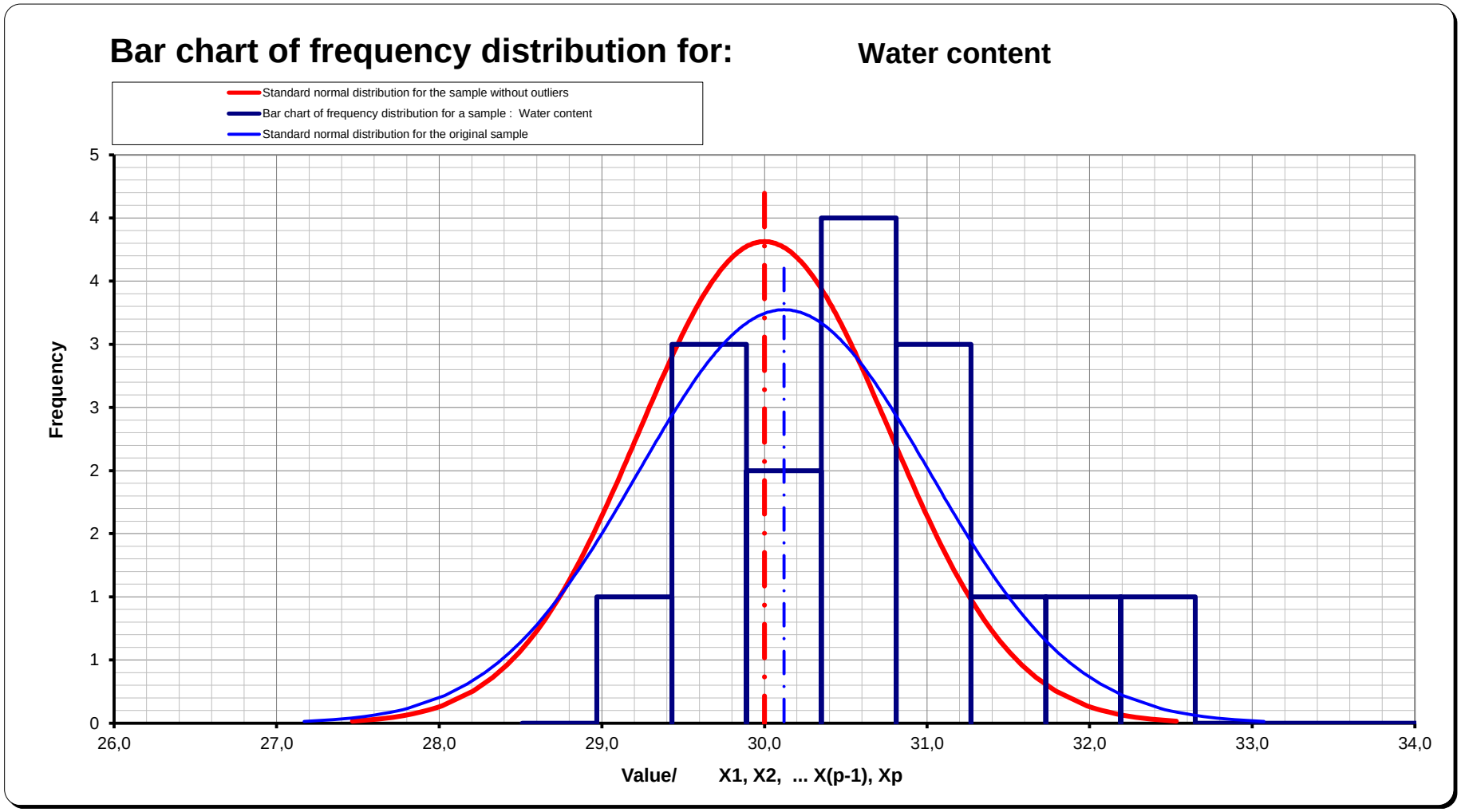
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 14 | 16 |
| Minimum value | $x_{min} = x_1$ | 227 | 235,00 | 240,00 | 227,00 | 227,00 | 227,00 |
| Maximum value | $x_{max} = x_p$ | 285 | 285,00 | 285,00 | 277,00 | 273,00 | 285,00 |
| Range of sample R = | $x_{max} - x_{min}$ | 58 | 50,00 | 45,00 | 50,00 | 46,00 | 58,00 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 71,2 | | | | | 71,2 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 210,1 | | | | | 210,1 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 218,0 | | | | | 218 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | 213,4 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | 205,9 | 211,5 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | 210,4 | 220,2 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 253,6 | 255,4 | 256,9 | 251,5 | 249,7 | 253,6 |
| Precision of a measure of the mean (for P=95%) | $\pm \varepsilon$ | 9,2 | 9,6 | 10,0 | 9,6 | 10,0 | 9,2 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 296,8 | | | 285,2 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 301,3 | | | 293,5 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 298,6 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 289,2 | | | | | 289,2 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 297,1 | | | | | 297,1 |
| Standard deviation of a sample | $s_{x,n-1}$ | 16,71 | 15,66 | 15,15 | 14,97 | 13,71 | 16,71 |
| Standard deviation | $s_{x,0}$ | 16,18 | 15,13 | 14,6 | 14,46 | 13,21 | 16,18 |
| Coefficient of variation | v | 6,6% | 6,1% | 5,9% | 6,0% | 5,5% | 6,6% |
| Standard skewness | $Sk_{est}$ | 0,389 | 0,523 | 0,509 | 0,313 | 0,336 | 0,389 |
| Standard kurtosis (exces) | $\gamma_2$ | -0,814 | -0,981 | -1,061 | -0,882 | -0,650 | -0,814 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,160 | 2,132 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,650 | 2,603 |


Bar chart of frequency distribution for: Final setting time
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Final setting time
Standard normal distribution for the original sample
Frequency
5
4
4
3
3
2
2
1
1
0
125,0
175,0
225,0
275,0
325,0
Value/ X1, X2, ... X(p-1), Xp

## A) Summary statistics for a sample :

**Water content**

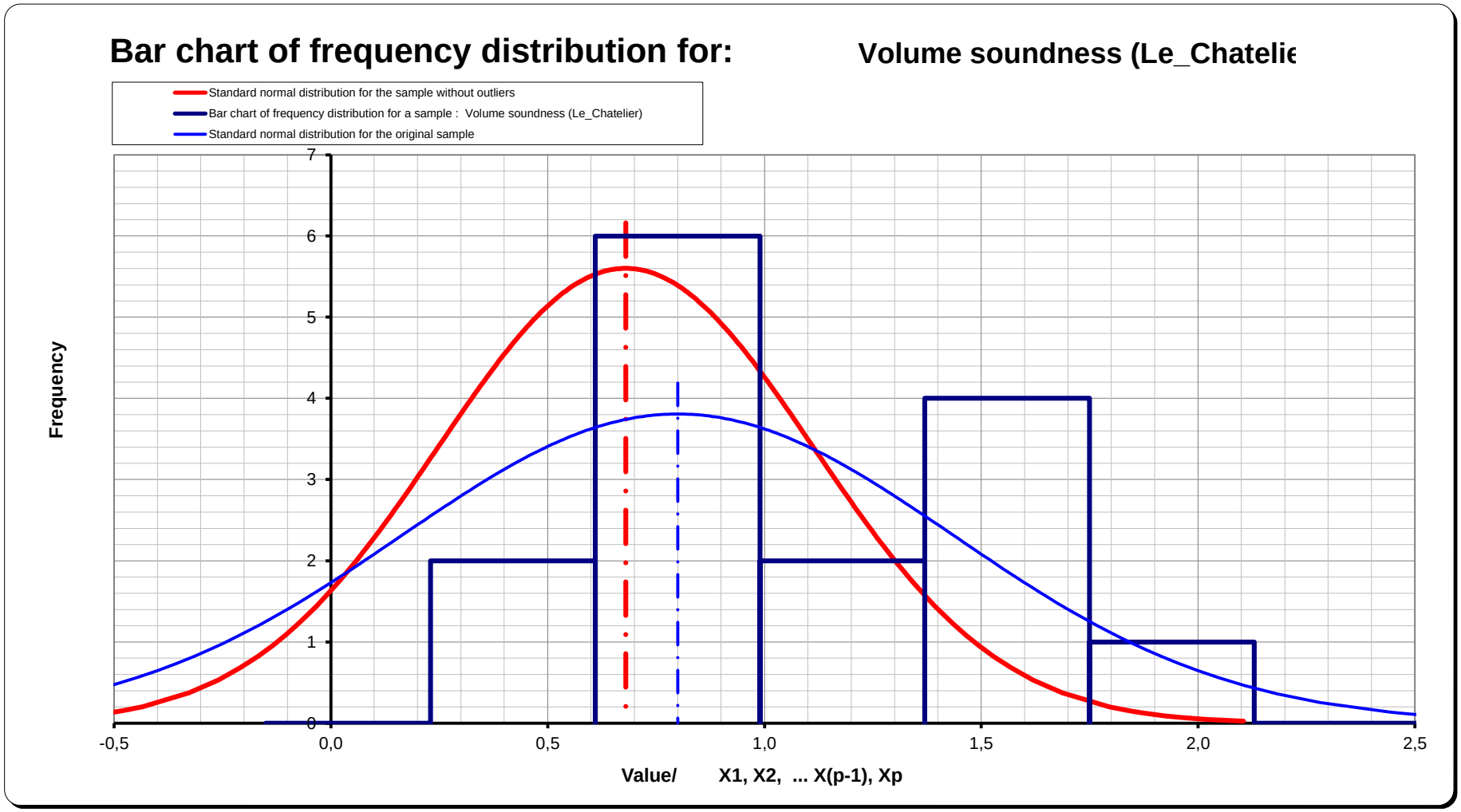
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 14 | 15 |
| Minimum value | $x_{min} = x_1$ | 28,8 | 29,00 | 29,20 | 28,80 | 28,80 | 28,80 |
| Maximum value | $x_{max} = x_p$ | 32 | 32,00 | 32,00 | 31,50 | 31,00 | 31,50 |
| Range of sample R = | $x_{max} - x_{min}$ | 3,2 | 3,00 | 2,80 | 2,70 | 2,20 | 2,70 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 3,82 | | | | | 3,3 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 27,79 | | | | | 27,98 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 28,21 | | | | | 28,35 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | 27,84 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | 27,56 | 27,81 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | 27,8 | 28,29 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 30,12 | 30,21 | 30,30 | 30,00 | 29,89 | 30,00 |
| Precision of a measure of the mean (for P=95%) | $\pm \varepsilon$ | 0,49 | 0,51 | 0,54 | 0,51 | 0,54 | 0,44 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 32,44 | | | 31,73 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 32,68 | | | 32,16 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 32,66 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 32,03 | | | | | 31,65 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 32,45 | | | | | 32,02 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,897 | 0,854 | 0,816 | 0,770 | 0,673 | 0,770 |
| Standard deviation | $s_{x,0}$ | 0,869 | 0,825 | 0,786 | 0,744 | 0,649 | 0,744 |
| Coefficient of variation | v | 3,0% | 2,8% | 2,7% | 2,6% | 2,3% | 2,6% |
| Standard skewness | $Sk_{est}$ | 0,558 | 0,646 | 0,728 | 0,326 | 0,095 | 0,326 |
| Standard kurtosis (exces) | $\gamma_2$ | -0,209 | -0,152 | -0,114 | -0,517 | -0,833 | -0,517 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,160 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,650 | 2,625 |


Bar chart of frequency distribution for: Water content
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Water content
Standard normal distribution for the original sample
Frequency
0
1
1
2
2
3
3
4
4
5
26,0
27,0
28,0
29,0
30,0
31,0
32,0
33,0
34,0
Value/ X1, X2, ... X(p-1), Xp

**A) Summary statistics for a sample :**

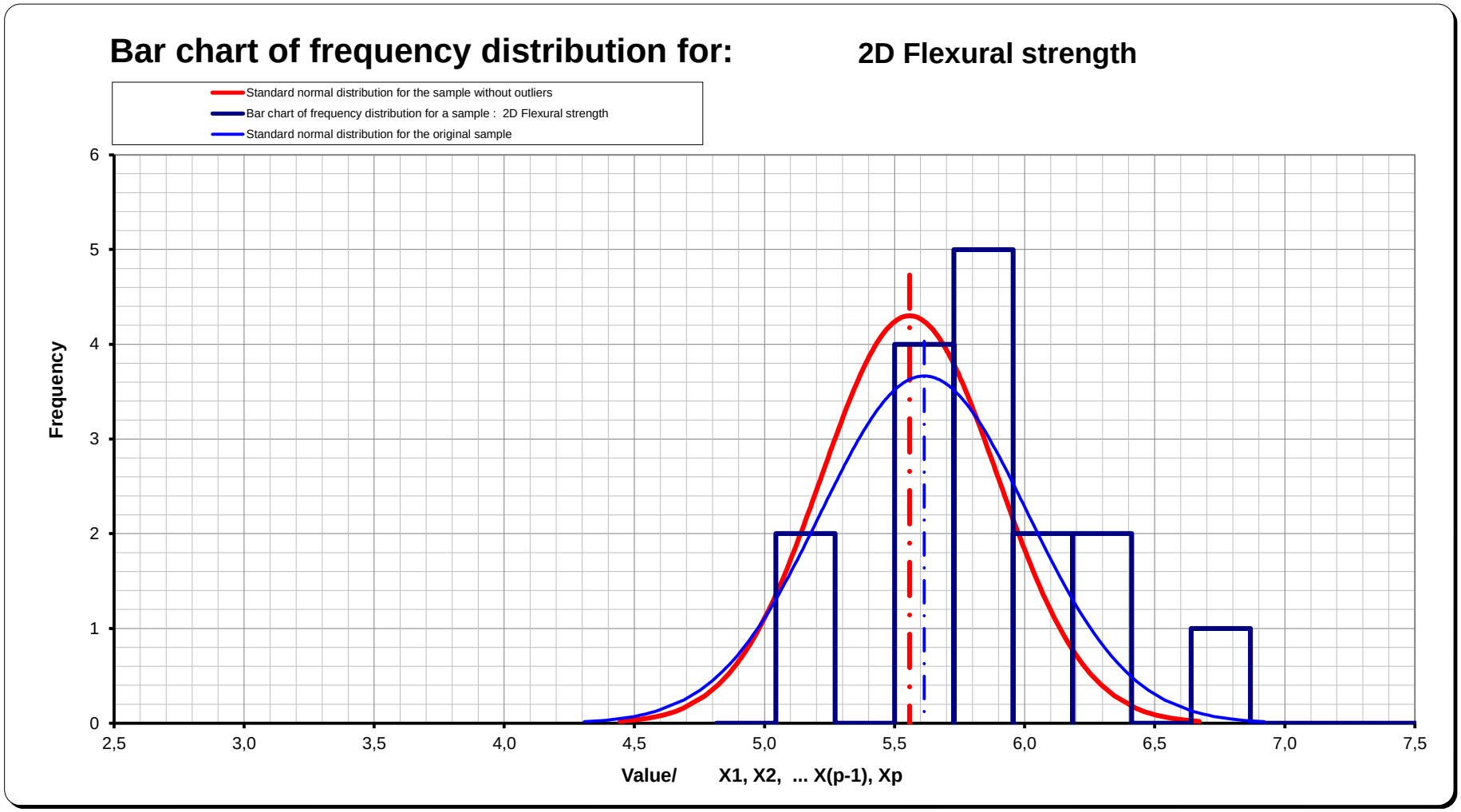
**Volume soundness (Le_Chatelier)**

| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 16 | 14 | 13 | 15 | 14 | 15 |
| Minimum value | $x_{min} = x_1$ | 0 | 0,30 | 0,50 | 0,00 | 0,00 | 0,00 |
| Maximum value | $x_{max} = x_p$ | 2,6 | 2,60 | 2,60 | 1,50 | 1,30 | 1,50 |
| Range of sample R = | $x_{max} - x_{min}$ | 2,6 | 2,30 | 2,10 | 1,50 | 1,30 | 1,50 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 2,72 | | | | | 1,86 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | -0,86 | | | | | -0,46 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | -0,56 | | | | | -0,25 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | -0,52 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | -1,02 | -0,73 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | -0,85 | -0,58 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 0,80 | 0,91 | 0,96 | 0,68 | 0,62 | 0,68 |
| Precision of a measure of the mean (for P=95%) | $\pm \varepsilon$ | 0,35 | 0,38 | 0,40 | 0,37 | 0,38 | 0,25 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 2,45 | | | 1,77 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 2,62 | | | 1,87 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 2,32 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 2,16 | | | | | 1,61 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 2,46 | | | | | 1,82 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,637 | 0,596 | 0,592 | 0,433 | 0,383 | 0,433 |
| Standard deviation | $s_{x,0}$ | 0,616 | 0,574 | 0,569 | 0,418 | 0,369 | 0,418 |
| Coefficient of variation | v | 79,6% | 65,5% | 61,7% | 63,7% | 61,8% | 63,7% |
| Standard skewness | $Sk_{est}$ | 1,488 | 1,891 | 1,940 | 0,181 | -0,057 | 0,181 |
| Standard kurtosis (exces) | $\gamma_2$ | 3,403 | 4,410 | 4,507 | -0,374 | -0,498 | -0,374 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,160 | 2,179 | 2,145 | 2,160 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,650 | 2,681 | 2,625 | 2,650 | 2,625 |


Bar chart of frequency distribution for: Volume soundness (Le_Chatelie
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : Volume soundness (Le_Chatelier)
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
7
-0,5
0,0
0,5
1,0
1,5
2,0
2,5
Value/ X1, X2, ... X(p-1), Xp

**A) Summary statistics for a sample :**

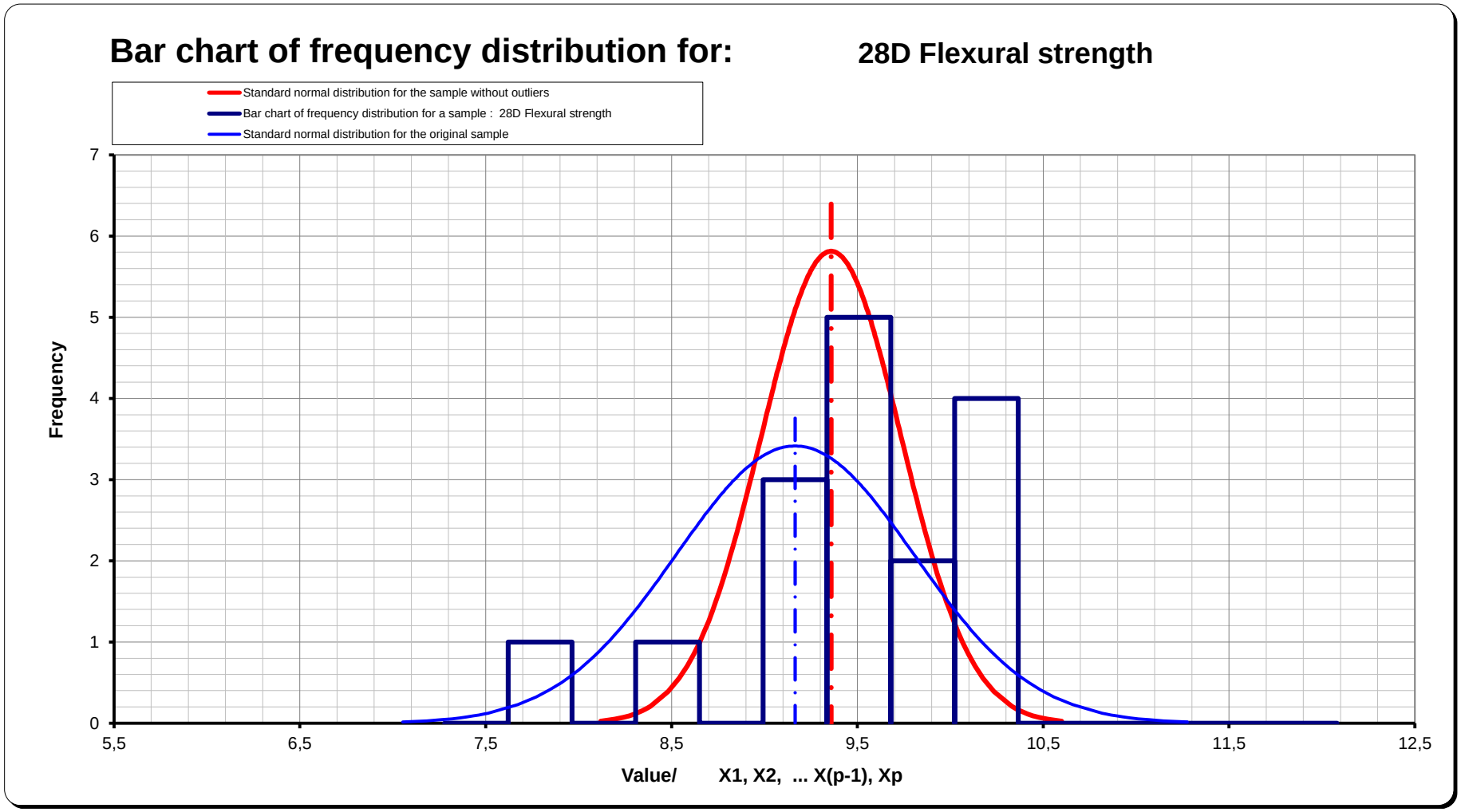
| | | 2D Flexural strength | | | | | |
|---|---|---|---|---|---|---|---|
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 14 | 15 |
| Minimum value | $x_{min} = x_1$ | 4,87 | 5,03 | 5,29 | 4,87 | 4,87 | 4,87 |
| Maximum value | $x_{max} = x_p$ | 6,46 | 6,46 | 6,46 | 6,12 | 6,03 | 6,12 |
| Range of sample R = | $x_{max} - x_{min}$ | 1,59 | 1,43 | 1,17 | 1,25 | 1,16 | 1,25 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 1,692 | | | | | 1,452 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 4,581 | | | | | 4,67 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 4,768 | | | | | 4,832 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | 4,516 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | 4,481 | 4,665 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | 4,587 | 4,863 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 5,614 | 5,664 | 5,709 | 5,558 | 5,518 | 5,558 |
| Precision of a measure of the mean (for P=95%) | $\pm \varepsilon$ | 0,219 | 0,228 | 0,238 | 0,228 | 0,238 | 0,194 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 6,641 | | | 6,319 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 6,747 | | | 6,508 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 6,634 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 6,460 | | | | | 6,284 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 6,647 | | | | | 6,446 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,3971 | 0,3560 | 0,3215 | 0,3384 | 0,3119 | 0,3384 |
| Standard deviation | $s_{x,0}$ | 0,3845 | 0,344 | 0,3098 | 0,3269 | 0,3005 | 0,3269 |
| Coefficient of variation | v | 7,1% | 6,3% | 5,6% | 6,1% | 5,7% | 6,1% |
| Standard skewness | $Sk_{est}$ | 0,206 | 0,577 | 1,044 | -0,344 | -0,550 | -0,344 |
| Standard kurtosis (exces) | $\gamma_2$ | 0,503 | 0,713 | 0,822 | 0,196 | 0,442 | 0,196 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,160 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,650 | 2,625 |


Bar chart of frequency distribution for: 2D Flexural strength
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : 2D Flexural strength
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
2,5
3,0
3,5
4,0
4,5
5,0
5,5
6,0
6,5
7,0
7,5
Value/ X1, X2, ... X(p-1), Xp

## A) Summary statistics for a sample :

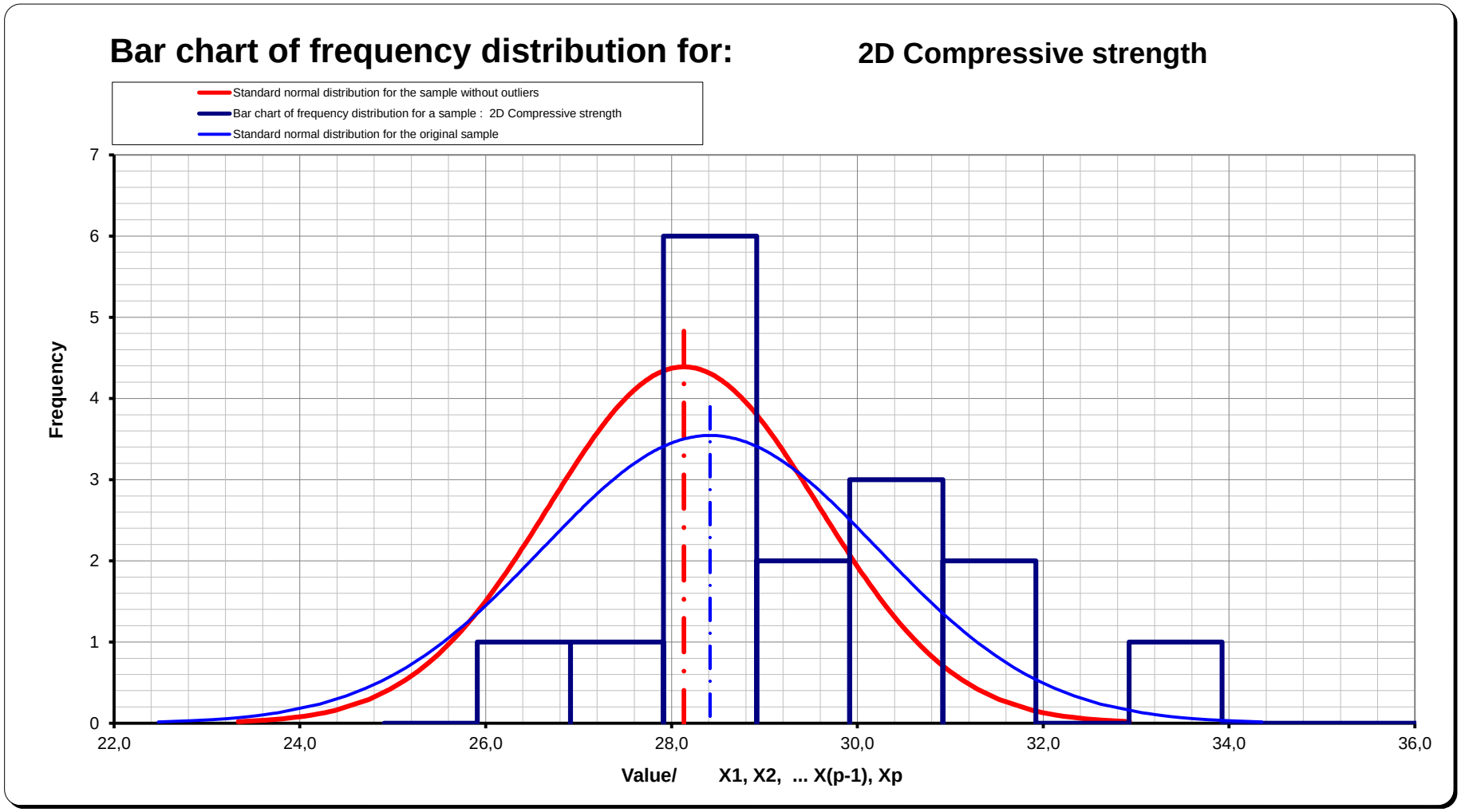
**28D Flexural strength**

| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
|---|---|---|---|---|---|---|---|
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 14 | 14 |
| Minimum value | $x_{min} = x_1$ | 7,58 | 8,03 | 8,75 | 7,58 | 7,58 | 8,75 |
| Maximum value | $x_{max} = x_p$ | 9,98 | 9,98 | 9,98 | 9,85 | 9,80 | 9,98 |
| Range of sample R = | $x_{max} - x_{min}$ | 2,4 | 1,95 | 1,23 | 2,27 | 2,22 | 1,23 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 2,736 | | | | | 1,628 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 7,495 | | | | | 8,36 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 7,797 | | | | | 8,545 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | 7,199 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | 7,335 | 7,869 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | 7,506 | 8,147 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 9,165 | 9,271 | 9,359 | 9,111 | 9,058 | 9,359 |
| Precision of a measure of the mean (for P=95%) | $\pm \varepsilon$ | 0,353 | 0,368 | 0,384 | 0,368 | 0,384 | 0,226 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 10,824 | | | 10,516 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 10,995 | | | 10,864 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 10,681 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 10,533 | | | | | 10,173 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 10,835 | | | | | 10,358 |
| Standard deviation of a sample | $s_{x,n-1}$ | 0,6416 | 0,4997 | 0,3769 | 0,6249 | 0,6128 | 0,3769 |
| Standard deviation | $s_{x,0}$ | 0,6213 | 0,4828 | 0,3632 | 0,6037 | 0,5905 | 0,3632 |
| Coefficient of variation | v | 7,0% | 5,4% | 4,0% | 6,9% | 6,8% | 4,0% |
| Standard skewness | $Sk_{est}$ | -1,198 | -0,858 | 0,185 | -1,284 | -1,338 | 0,185 |
| Standard kurtosis (exces) | $\gamma_2$ | 1,571 | 1,488 | -0,887 | 1,720 | 1,811 | -0,887 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,160 | 2,160 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,650 | 2,650 |


Bar chart of frequency distribution for: 28D Flexural strength
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : 28D Flexural strength
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
7
5,5
6,5
7,5
8,5
9,5
10,5
11,5
12,5
Value/ X1, X2, ... X(p-1), Xp

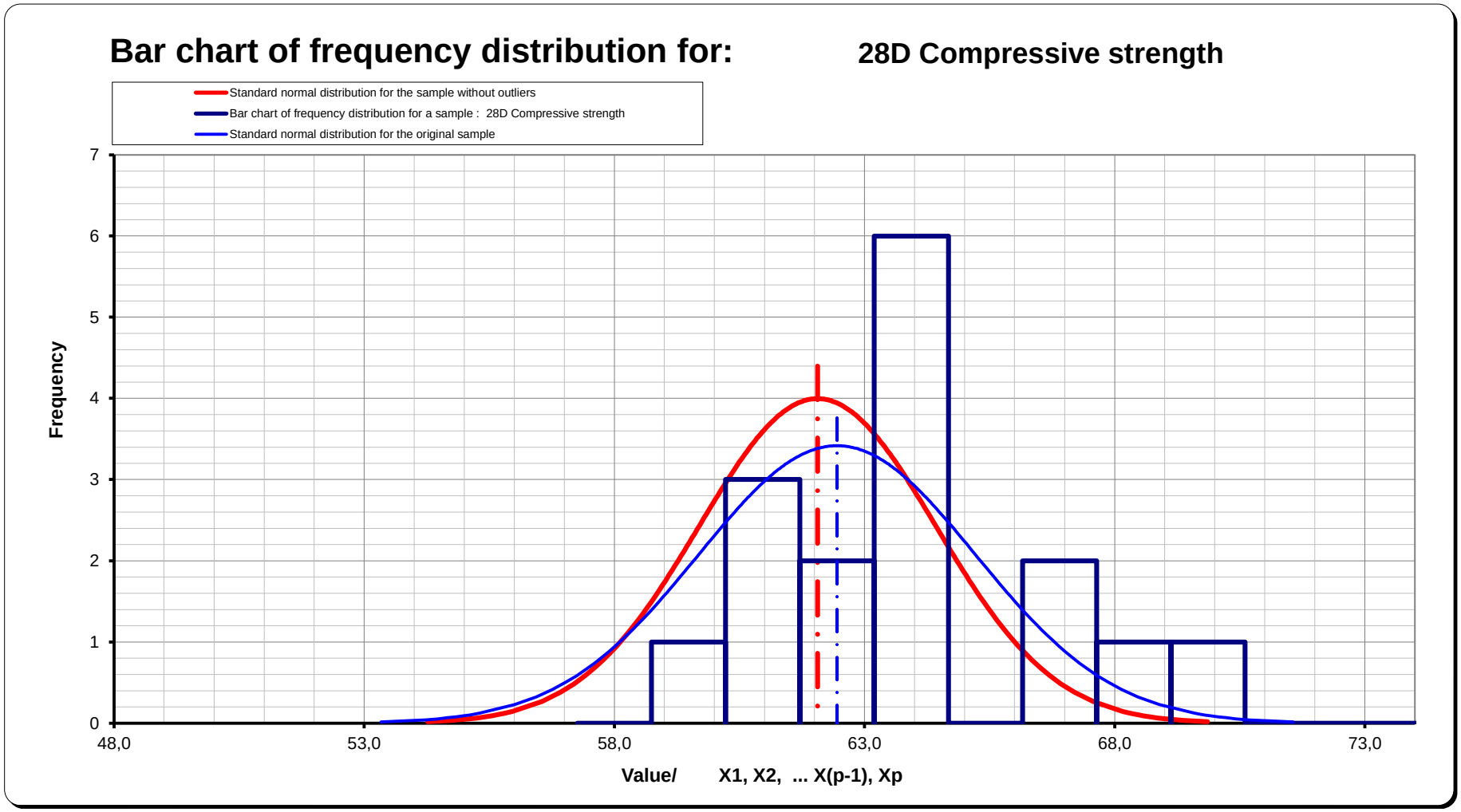
**A) Summary statistics for a sample :**

| | | 2D Compressive strength | | | | | |
|---|---|---|---|---|---|---|---|
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 14 | 15 |
| Minimum value | $x_{min} = x_1$ | 25,64 | 26,89 | 26,92 | 25,64 | 25,64 | 25,64 |
| Maximum value | $x_{max} = x_p$ | 32,65 | 32,65 | 32,65 | 30,51 | 30,50 | 30,51 |
| Range of sample R = | $x_{max} - x_{min}$ | 7,01 | 5,76 | 5,73 | 4,87 | 4,86 | 4,87 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 7,694 | | | | | 6,252 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 23,718 | | | | | 24,308 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 24,568 | | | | | 25,007 |
| Lower Irwin confidence limit (for P=95%) | $x_{minIw1-5\%}$ | 24,552 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | $x_{minG1-1\%}$ | 23,267 | 23,819 | | | | |
| Lower Grubbs confidence limit (for P=95%) | $x_{minG1-5\%}$ | 23,749 | 24,768 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 28,415 | 28,600 | 28,722 | 28,133 | 27,963 | 28,133 |
| Precision of a measure of the mean (for P=95%) | $\pm \varepsilon$ | 0,993 | 1,035 | 1,081 | 1,035 | 1,081 | 0,835 |
| Upper Grubbs confidence limit (for P=99%) | $x_{maxGp-5\%}$ | 33,081 | | | 31,411 | | |
| Upper Grubbs confidence limit (for P=95%) | $x_{maxGp-1\%}$ | 33,563 | | | 32,222 | | |
| Upper Irwin confidence limit (for P=99%) | $x_{maxIw1-5\%}$ | 32,848 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 32,262 | | | | | 31,259 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 33,112 | | | | | 31,958 |
| Standard deviation of a sample | $s_{x,n-1}$ | 1,8049 | 1,7040 | 1,6988 | 1,4574 | 1,3496 | 1,4574 |
| Standard deviation | $s_{x,0}$ | 1,7476 | 1,6462 | 1,637 | 1,408 | 1,3005 | 1,408 |
| Coefficient of variation | v | 6,4% | 6,0% | 5,9% | 5,2% | 4,8% | 5,2% |
| Standard skewness | $Sk_{est}$ | 0,775 | 0,974 | 0,910 | 0,249 | 0,294 | 0,249 |
| Standard kurtosis (exces) | $\gamma_2$ | 0,465 | 0,579 | 0,529 | -0,866 | -0,574 | -0,866 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,160 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,650 | 2,625 |


Bar chart of frequency distribution for: 2D Compressive strength
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : 2D Compressive strength
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
7
22,0
24,0
26,0
28,0
30,0
32,0
34,0
36,0
Value/ X1, X2, ... X(p-1), Xp

**A) Summary statistics for a sample :**

| | | 28D Compressive strength | | | | | |
|---|---|---|---|---|---|---|---|
| | | X1, X2, ... X(p-1), Xp | X2, X3, ... X(p-1), Xp | X3, X4... X(p-1), Xp | X1, X2, ... X(p-2), X(p-1) | X1, X2, ... X(p-3), X(p-2) | Sample without outliers |
| Count (Sample size) | n | 16 | 15 | 14 | 15 | 14 | 15 |
| Minimum value | $x_{min} = x_1$ | 57,93 | 59,39 | 59,78 | 57,93 | 57,93 | 57,93 |
| Maximum value | $x_{max} = x_p$ | 68,31 | 68,31 | 68,31 | 66,72 | 65,51 | 66,72 |
| Range of sample R = | $x_{max} - x_{min}$ | 10,38 | 8,92 | 8,53 | 8,79 | 7,58 | 8,79 |
| difference $L_{m95\%} - L_{M95\%}$ ..... | $\Delta L_{95\%}$ | 11,81 | | | | | 10,16 |
| Lower confidence limitsafterelimination of outliers (for P=98%) | $L_{m98\%}$ | 55,241 | | | | | 55,845 |
| Lower confidence limitsafterelimination of outliers (for P=95%) | $L_{m95\%}$ | 56,546 | | | | | 56,981 |
| Lower Irwin confidence limit (for P=95%) | XminIw1-5% | 55,802 | | | | | |
| Lower Grubbs confidence limit (for P=99%) | XminG1-1% | 54,55 | 55,508 | | | | |
| Lower Grubbs confidence limit (for P=95%) | XminG1-5% | 55,289 | 56,946 | | | | |
| Average (arithmetic mean) $\bar{x}$ = | $1/p\sum(x_i)$ = | 62,451 | 62,753 | 62,993 | 62,061 | 61,728 | 62,061 |
| Precision of a measure of the mean (for P=95%) | ± ε | 1,525 | 1,588 | 1,660 | 1,588 | 1,660 | 1,358 |
| Upper Grubbs confidence limit (for P=99%) | XmaxGp-5% | 69,613 | | | 67,387 | | |
| Upper Grubbs confidence limit (for P=95%) | XmaxGp-1% | 70,352 | | | 68,706 | | |
| Upper Irwin confidence limit (for P=99%) | XmaxIw1-5% | 70,308 | | | | | |
| Upper confidence limitsafterelimination of outliers (for P=95%) | $L_{M95\%}$ | 68,356 | | | | | 67,141 |
| Upper confidence limitsafterelimination of outliers (for P=98%) | $L_{M98\%}$ | 69,661 | | | | | 68,277 |
| Standard deviation of a sample | $S_{x,n-1}$ | 2,7705 | 2,5820 | 2,4995 | 2,3683 | 2,0618 | 2,3683 |
| Standard deviation | $S_{x,0}$ | 2,6826 | 2,4944 | 2,4086 | 2,288 | 1,9868 | 2,288 |
| Coefficient of variation | v | 4,4% | 4,1% | 4,0% | 3,8% | 3,3% | 3,8% |
| Standard skewness | $Sk_{est}$ | 0,579 | 0,811 | 0,854 | 0,332 | 0,083 | 0,332 |
| Standard kurtosis (exces) | $\gamma_2$ | 0,054 | 0,068 | 0,088 | -0,073 | -0,044 | -0,073 |
| t-value of the Student's distribution for P=95% | $t_{(n-1),\alpha=2,5\%}$ | 2,132 | 2,145 | 2,160 | 2,145 | 2,160 | 2,145 |
| t-value of the Student's distribution for P=98% | $t_{(n-1),\alpha=1,0\%}$ | 2,603 | 2,625 | 2,650 | 2,625 | 2,650 | 2,625 |


Bar chart of frequency distribution for: 28D Compressive strength
Standard normal distribution for the sample without outliers
Bar chart of frequency distribution for a sample : 28D Compressive strength
Standard normal distribution for the original sample
Frequency
0
1
2
3
4
5
6
7
48,0
53,0
58,0
63,0
68,0
73,0
Value/ X1, X2, ... X(p-1), Xp