Dishwasher
Round Robin Test
2022/2023

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FINAL REPORT

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Dishwasher Round Robin Test 2022/2023

Table of contents

Index of figures VI
Index of tables IX
Index of equations XI
1. Introduction 1
2. Organization and test design 1
3. Objective 3
4. Actions 3
5. Participants and tiers 4
5.1 Participants 4
5.2 Tiers 4
6. Test procedure and general parameters 6
6.1 Appliances 6
6.2 Dishware and soil specification 6
6.3 Detergent 6
6.4 Pretests 6
7. Precision of testing (repeatability, reproducibility) and data display 7
7.1 Precision of testing (Repeatability and reproducibility) 7
7.2 Data consistency 8
7.3 Further statistical analyses 10
7.4 Data display 11
8. Pre-questionnaire results 12
8.1 Old reference machine data 12
8.2 Thermal cabinet and microwave oven 12
8.3 Specifications on porcelain, cutlery and glasses 13
8.4 Specifications on soil 15
8.4.1 Milk 15
8.4.2 Spinach 15
8.4.3 Tea 16

8.4.4 Oatflakes 16
8.5 Water supply and measurement 17
8.6 Detergent handing 19
8.6 Laboratory conditions 21
9. Data analysis and data consistency testing 24
9.1 Environmental conditions 24
9.1.1 Water hardness 24
9.1.2 Water temperature inlet 26
9.1.3 Water pressure 28
9.1.4 Relative humidity 30
9.1.5 Ambient temperature 32
9.2 Appliance parameters 35
9.2.1 Duration (cycle time) 35
9.2.2 Maximum temperature main wash 38
9.2.3 Maximum temperature rinsing 41
9.3 Consumption values 44
9.3.1 Water consumption 44
9.3.2 Energy consumption 47
9.4 Cleaning and drying performance 50
9.4.1 Cleaning performance 50
9.4.1.1 Overall cleaning score 50
9.4.1.2 Cleaning scores by dishware 53
9.4.1.3 Cleaning Index 57
9.4.2 Drying performance 59
9.4.2.1 Overall drying score 59
9.4.2.2 Drying score by dishware 61
9.4.2.3 Drying Index 64
9.5 Overall summary of consistency testing analysis 67
9.6 Further impact factor review 69
9.6.1 Overview on NR tiers 69
9.6.2 Overview on detergent E batches 75
10 Low Power Modes 79
10.1 LPM questionnaire results 79

10.1.1 General test set-up and measurement devices 79
10.1.2 Measurement procedure for off and standby mode 81
10.1.3 Measurement procedure for net-work standby 83
10.2 LPM consumption values 84
11 Result review additional appliances (“own appliances”) 88
11.1 Result overview cleaning 88
11.2 Result overview drying 90
11.3 Overall indices “own appliance” 91
12 Conclusions 97
12.1 Summary of important findings related to test procedures 97
12.2 Proposals for future improvements 97
APPENDIX 98

Index of figures

Figure 1: RRT tier set-up 5
Figure 2: Dotplot of reported time span since last calibration of the currently used reference machine 12
Figure 3: Dotplot of reported time span (in months) since last calibration of the currently used thermal cabinets 13
Figure 4: Dotplot of reported time span since last calibration of the currently used thermal cabinets..... 13
Figure 5: Dotplot of specified run cycles for porcelain and cutlery..... 14
Figure 6: Water preparation for tea: Water heating method and water preparation method 16
Figure 7: Specification on type of water applied (n=16), water preparation method (n=13), further monitored water parameters (n=16, multiple answers), trace minerals analysis (n=16)..... 18
Figure 8: Specification of temperature sensors for inlet water temperature measurement (n=16)..... 19
Figure 9: Specification of resolution (n=14) and accuracy (n=11) of water temperature inlet sensors..... 19
Figure 10: Specification of amount of water (volume in ml) between the circulation loop and the spur (n=15) 19
Figure 11: Specification of detergent storage (n=16), sample storage after preparation (n=16) and detergent sample preparation if no sample divider is used (n=8)..... 20
Figure 12: Reporting scheme of measured room temperature values (n=16) 21
Figure 13: Room temperature sensor resolution (n=13) and accuracy (n=11) 23
Figure 14: In-machine temperature sensor resolution (n=11) and accuracy (n=8)..... 23
Figure 15: Boxplot of water hardness by lab 25
Figure 16: Boxplot of water hardness by lab and machine 25
Figure 17: Aggregated boxplots of water hardness by machine and detergent..... 26
Figure 18: Boxplot of water inlet temperature by lab..... 27
Figure 19: Boxplot of water inlet temperature by lab and machine 27
Figure 20: Aggregated boxplot of water inlet temperature by machine and detergent 28
Figure 21: Boxplot of water pressure by lab..... 29
Figure 22: Boxplot of water pressure by lab and machine 29
Figure 23: Aggregated boxplot of water pressure by machine and detergent 30
Figure 24: Boxplot of relative humidity at cycle start by lab 31
Figure 25: Boxplot of relative humidity at cycle start by lab and machine 31
Figure 26: Aggregated boxplot of relative humidity by machine and detergent..... 32
Figure 27: Boxplot of ambient temperature by lab 33
Figure 28: Boxplot of ambient temperature by lab and machine..... 33
Figure 29: Aggregated boxplot of ambient temperature by detergent and machine..... 34
Figure 30: Aggregated mean values and SD of duration by machine and detergent 35
Figure 31: Mean values and SD of duration by lab and machine (detergent E only) 36
Figure 32: Aggregated mean values and SD of maximum temperature main wash by machine and detergent 38
Figure 33: Mean values and SD of maximum temperature main wash by lab and machine (detergent D+E) 39

Figure 34: Aggregated mean values and SD of maximum temperature rinsing by machine and detergent 41
Figure 35: Mean values and SD of maximum temperature rinsing by lab and machine (detergent D+E).. 42
Figure 36: Aggregated mean values and SD of water consumption by machine and detergent..... 45
Figure 37: Boxplots of water consumption of new reference machine, old reference machine and test appliance for detergent D and E by labs 46
Figure 38: Aggregated mean values and SD of energy consumption by machine and detergent..... 48
Figure 39: Boxplots of energy consumption of new reference machine, old reference machine and test appliance for detergent D and E by labs 49
Figure 40: Boxplot of overall cleaning score by lab and machine for **detergent E**, arranged by machine. 51
Figure 41: Boxplot of overall cleaning score by lab and machine for **detergent E**, arranged by lab..... 51
Figure 42: Boxplot of overall cleaning score by lab and machine for **detergent D**, arranged by machine 52
Figure 43: Boxplots of overall cleaning score by lab and machine for **detergent D**, arranged by lab..... 52
Figure 44: Boxplots of overall cleaning by machine, directly comparing detergent D and E values by lab 53
Figure 45: Boxplots of cleaning scores by machine and detergent for crockery, pots, glass, melamine and cutlery 55
Figure 46: Boxplot of cleaning index for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E, including all data) 58
Figure 47: Boxplot of cleaning index for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E) by lab (all data) 58
Figure 48: Boxplots of overall drying score by lab and machine for **detergent E**, arranged by machine .. 59
Figure 49: Boxplot of overall drying score by lab and machine for **detergent E**, arranged by lab 60
Figure 50: Boxplot of overall drying score by lab and machine for **detergent D**, arranged by machine 60
Figure 51: Boxplot of overall drying score by lab and machine for **detergent D**, arranged by lab 61
Figure 52: Boxplots of drying scores by machine and detergent for crockery, pots, glass, melamine and cutlery 62
Figure 53: Boxplots of drying indices for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E) calculated with fixed value (left) and measured value (right - data shown include all reported values) 65
Figure 54: Boxplots of drying indices for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E) calculated with fixed value by lab (data shown include all reported values) 66
Figure 55: Dotplots of key performance parameters (duration, water consumption, energy consumption, T max main wash and T max rinsing) by tier, detergent and lab..... 71
Figure 56: Boxplots of key performance parameters (duration, water consumption, energy consumption, T max main wash and T max rinsing) by tier..... 72
Figure 57: Cleaning score (average value and single run values) by tier and lab (detergent E only) 73
Figure 58: Cleaning score (average value and single run values) by tier, lab and detergent..... 73
Figure 59: Drying score (average value and single run values) by tier and lab (detergent E only) 74
Figure 60: Drying score (average value and single run values) by tier, lab and detergent..... 74
Figure 61: Cleaning score by tier (average value and single run values) detergent E batch, sorted by tier 75
Figure 62: Cleaning scores by detergent E batch (average value and single run values) and tier, sorted by detergent E batch 76

Figure 63: Cleaning scores by detergent E batch (average value and single run values) tier and lab, sorted by detergent E batch 76
Figure 64: Drying scores by tier (average value and single run values) detergent E batch, sorted by tier 77
Figure 65: Drying scores by detergent E batch (average value and single run values) and tier, sorted by detergent E batch 77
Figure 66: Drying scores by detergent E batch (average value and single run values) tier and lab, sorted by detergent E batch 78
Figure 67: Reported distance between the dishwasher and the router (in meters) 81
Figure 68: Reported measurement duration for LPM modes and specific modes 82
Figure 69: Dotplot of low power mode measurements by lab (n=15) 86
Figure 70: Dotplots of low power mode measurement “power off”, “standby”, “networked connection” and “delay start” and the text box by lab 87
Figure 71: Own appliances cleaning score by number of place settings and detergent 89
Figure 72: Own appliances cleaning score by appliance dimension and detergent 89
Figure 73: Own appliances drying score by number of place settings and detergent 90
Figure 74: Own appliances drying score by appliance dimension and detergent 91
Figure 75: Own appliances overall cleaning and drying indices for current, future and hybrid system 94
Figure 76: Own appliances overall drying indices for current, future and hybrid system based on reported values and fixed value (0,82) 95
Figure 77: Own appliances cleaning indices (CU = current system, FU= future system, HY = hybrid system) by number of place settings including the RRT test appliance (TA) 95
Figure 78: Own appliances drying indices (CU = current system, FU= future system, HY = hybrid system) by number of place settings including the RRT test appliance (TA) 96

Index of tables

Table 1: Test design Dishwasher RRT 2022/23 2
Table 2: Dishwasher RRT 2022/2023 schedule 3
Table 3: Participants of the Dishwasher RRT 2022/2023 4
Table 4: Used thermal cabinets model codes 12
Table 5: Used microwave ovens and model codes 13
Table 6: Porcelain supplier and brand name specification (n=16, multiple replies) 14
Table 7: Cutlery supplier and brand name specification (n=16, multiple replies) 14
Table 8: Summary on specified glass suppliers and brand names 14
Table 9: Milk brands used for milk soil preparation 15
Table 10: Mincer models, settings and preparation amounts / minute for spinach preparation 16
Table 11: Food processors, settings and cooking regimes applied in oatflake processing 17
Table 12: Sample divider usage specification (n=8) 21
Table 13: Room temperature sensor location (n=14) 22
Table 14: Specification of room temperature sensors (n=16) 22
Table 15: Specification of in-machine temperature sensors (n=16) 23
Table 16: Basic descriptive statistics of water hardness at cycle start (aggregated data and by machine / mmol/L)) 24
Table 17: Basic descriptive statistics of water temperature at cycle start (aggregated data and by machine / °C) 26
Table 18: Basic descriptive statistics of water pressure at cycle start (aggregated data and by machine / bar) 28
Table 19: Basic descriptive statistics of relative humidity at cycle start ((aggregated data and by machine (%) 30
Table 20: Basic descriptive statistics of ambient temperature (aggregated data and by machine / %) 32
Table 21: Basic descriptive statistics of duration (minutes) 35
Table 22: Basic descriptive statistics of duration including Mandel h / k-values (minutes) 37
Table 23: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for duration (min) 37
Table 24: Basic descriptive statistics of maximum temperature main wash (°C) 38
Table 25: Basic descriptive statistics of max. temperature main wash including Mandel h / k-values 40
Table 26: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for maximum temperature main wash (°C) 40
Table 27: Basic descriptive statistics of maximum temperature rinsing (°C) 41
Table 28: Basic descriptive statistics of max. temperature rinsing including Mandel h / k-values 43
Table 29: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for maximum temperature rinsing (°C) 43
Table 30: Basic descriptive statistics of water consumption (L) 44
Table 31: Basic descriptive statistics of water consumption values including Mandel h / k-values 46
Table 32: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for water consumption (L) 47

Table 33: Basic descriptive statistics of energy consumption (kWh) 47
Table 34: Basic descriptive statistics of energy consumption (kWh) including Manel h /k-values..... 49
Table 35: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for energy consumption 50
Table 36: Basic statistics of cleaning score by machine and detergent..... 51
Table 37: Basic statistics of cleaning scores by type of dishware, detergent and machine 54
Table 38: Cleaning score basic descriptive statistics including Mandel h / k-values 55
Table 39: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for cleaning performance (cleaning score) 56
Table 40: Basic statistics and expanded uncertainty E_{OR} % of the cleaning index for current, future and hybrid system 57
Table 41: Basic statistics of drying score by machine and detergent 59
Table 42: Basic statistics of drying scores by type of dishware, detergent and machine 61
Table 43: Drying score basic descriptive statistics including Mandel h / k-values 63
Table 44: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for cleaning performance (cleaning score) 64
Table 45: Basic statistics and expanded uncertainty E_{OR} % of the drying index for current, future and hybrid system based on calculation with measured values and fixed value 64
Table 46: Summary of repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for all key performance parameters 67
Table 47: Cleaning and drying performance ANOVA analysis for NR and detergent E batches 75
Table 48: Specified changes in measurement equipment for LPM measurement 79
Table 49: Set measuring range for the LPM measurement equipment 79
Table 50: Further specification on power supply stability, crest and distortion factor threshold, low power consumption value measurement procedure and measurement method to obtain the LPM value..... 80
Table 51: Further specification on the networked connected mode measurement 80
Table 52: Detail specification on the networked connected mode measurement set-up..... 81
Table 53: Interaction done with the appliance or the reaction recognized by the machine during first installation..... 82
Table 54: Door setting specification in LPM measurement..... 83
Table 55: Specifications on program runs and interactions prior to step 5 and 10 83
Table 56: Specification on program selection prior to step 15 and the duration set for delay-start in step 15 (n=15) 83
Table 57: Specification of connection process of the appliance to the network during measurement (n=12) 83
Table 58: Procedure with mobile device / App during the measurement (n=15) 84
Table 59: Basic statistics and expanded uncertainty E_{OR} % of the LPM measurement data (W) 85
Table 60: Cleaning score basic statistics of own appliances by number of place settings and detergent . 88
Table 61: Drying score basic statistics of own appliances by number of place settings and detergent 90
Table 62: Own appliances cleaning indices basic statistics (CU = current system, FU= future system, HY = hybrid system) by number of place settings including the RRT test appliance (TA),..... 92

Table 63: Own appliances drying indices basic statistics (CU = current system, FU= future system, HY = hybrid system) by number of place settings including the RRT test appliance (TA)..... 92
Table 64: Summary of cleaning indices and drying indices of own appliances (current system, future system, hybrid system (reported value and fixed value in drying)) by number of place settings and appliance width 93

Index of equations

Equation 1: Formula to calculate the repeatability standard deviation Sr 7
Equation 2: Formula to calculate the reproducibility standard deviation s_R 8
Equation 3: Formula to calculate the reproducibility standard deviation s_R 8
Equation 4: Formula to calculate the reproducibility standard deviation on the overall result 8
Equation 5: Formula to calculate the Mandel's h values 9
Equation 6: Formula to calculate the Mandel's k values 10

1. Introduction

APPLiA, the European Association of Domestic Appliance Manufacturers, is engaging itself in the reliability of the measurement standards and in finding qualified laboratories for the measurement of important parameters of appliances.

In order to learn about the repeatability and reproducibility of the EN 60436:2020 method in combination with the new upcoming reference system, APPLiA, in coordination with CENELEC TC59X WG2, initiated a Round Robin Test, that was performed from 09/2022 – 05/2023.

The RRT consisted of testing one household dishwasher (= test appliance, TA) and one new reference machine (NR) together with the participants own reference machine (OR) in each testing facility. In addition, each lab was welcomed to include „own“ additional dishwashers in the test series.

2. Organization and test design

Albstadt-Sigmaringen University (ASU), Faculty Life Sciences, Department for Performance & Hygiene, coordinated the Round Robin Test with technical support from the dishwasher development departments of Miele & Cie. KG (Bielefeld), supplying the new reference machine samples, and BSH Hausgeräte GmbH (Dillingen a.d. Donau), supplying the test appliance samples as well as an additional test box that was included in the Low Power Mode measurement.

All information concerning the RRT (general instruction, standard documents to be applied, test machine manuals, result data table), was posted on a MS Teams share folder, hosted by ASU. Access to documents on this site was restricted to RRT participants only. The data sheets for reporting were published in the share folder. Explanations on how to fill in data were provided with the file.

The appliances that were tested by the RRT participants were:

- “NR” - New reference machine (G 7332 SC, 5 samples)
- “OR” - Old reference machine (as used in labs)
- “TA” - Test appliance (SMV6ECX51E, 5 samples)
- “OA” - Manufacturer / lab own appliance, compliant with current EU (2019/2022) and EU(2019/2017) on a voluntary basis.

The test design (Table 1), consisted of a set of mandatory tests (detergent type E testing for the new & old reference appliance and test appliance for all performance tests as well as LPM test for the TA and an especially designed test box) and voluntary tests (additional detergent type D tests) and further voluntary tests of additional own appliances.

Even though the Detergent type D testing of the NR was neither defined as a mandatory nor as a voluntary test, 10 labs performed the test. 4 participants performed tests with additional own appliances. In total, results of 11 own appliances were contributed.

Table 1: Test design Dishwasher RRT 2022/23

	Test appliance	Old reference appliance	New reference appliance	Own appliance
Detergent type D	VOLUNTARY	VOLUNTARY	NN	VOLUNTARY
Detergent type E	MANDATORY	MANDATORY	MANDATORY	VOLUNTARY
Low Power Modes	MANDATORY	NN	NN	NN
Energy consumption	MANDATORY	MANDATORY	MANDATORY	VOLUNTARY
Drying efficiency	MANDATORY	MANDATORY	MANDATORY	VOLUNTARY
Cleaning efficiency	MANDATORY	MANDATORY	MANDATORY	VOLUNTARY
Water consumption	MANDATORY	MANDATORY	MANDATORY	VOLUNTARY

The following limitations came up during the test series:

- One lab was not able to finalize the test runs with the new reference machine (due to limited lab capacity),
- One lab did not perform LPM tests,
- It cannot be assured that all labs followed the standard specification on the ln W_c requirements, even though following all test procedures as specified in the standard was the pre-requisite for all test runs.

3. Objective

The overall targets of the Round Robin Test were to:

- Learn about the applicability and accuracy of the latest version of EN 60436:2020 with the inclusion of a new detergent type and a new reference machine;
- Check compliance to standard requirements;
- Calculate repeatability and reproducibility of the test procedure;
- Find fields of improvements;
- Train laboratories.

4. Actions

The following actions have been undertaken (in chronological order):

- Invitation of RRT participants
- Preparation of the round robin test documents (in alignment with appliance manufacturers), questionnaire and result-table set-up and set-up of a common MS Teams share folder
- Preparation and coding of the RRT appliances in alignment with the appliance manufacturers
- Grouping of the participants into tiers
- Coordination of testing and transports (pre-run verification, test-run support, final result table pre-check)
- Data evaluation and analysis
- Final evaluation and report release

The RRT schedule is summed up in Table 2.

Table 2: Dishwasher RRT 2022/2023 schedule

Task	Deadline / Timeline
Invitation letter	June 2022
Confirmation of participation	June 30th, 2022
Machines prepared, checked and sent out	from 08/2022
Tests runs	09/2022 – 05/2023
First data compilation (verification of provided data by all participants)	06/2023
Final data check by all participants	MS Teams Call: June 16th, 2023
Evaluation & Report	09/2023

5. Participants and tiers

5.1 Participants

17 laboratories (12 manufacturer test facilities, 5 test laboratories) took part in the RRT (Table 3). To guarantee the participants' anonymity, each lab was coded with three letters. All results are shown in alphabetic lab code order.

Table 3: Participants of the Dishwasher RRT 2022/2023

RRT Participant	Country
Applitest GmbH	Germany
Arcelik, R & D Lab Istanbul	Turkey
ASKO Appliances AB (Gorenje)	Sweden
Bonferraro spA	Italy
BRANDT FRANCE	France
BSH Home Appliances	Germany
Electrolux Italia S.p.A.	Italy
Electrolux Poland Sp. z o.o.	Poland
Foshan Shunde Midea Washing Appliances Mfg. Co. Ltd	China
Haier Germany GmbH	Germany
LG Electronics Deutschland GmbH	Germany
Miele & Cie. KG	Germany
Samsung Electronics GmbH	Germany
SLG Prüf- und Zertifizierungs GmbH	Germany
TÜV Rheinland LGA Products GmbH	Germany
UL International Italia	Italy
VDE Testing and Certification Institute	Germany

5.2 Tiers

To avoid delays in the schedule not all 17 labs were performing the tests after each other, but four/ five tiers with 1 - 5 labs each were run in parallel (Figure 1).

As the new reference machine of tier 3 showed a failure, caused by a transport damage, the tier was discontinued. In tier 2 only one lab was able to finish the test runs with all appliances, as the 2nd RRT participant within that tier could not perform the test runs with the NR, due to limited lab capacities in the set test time slot.

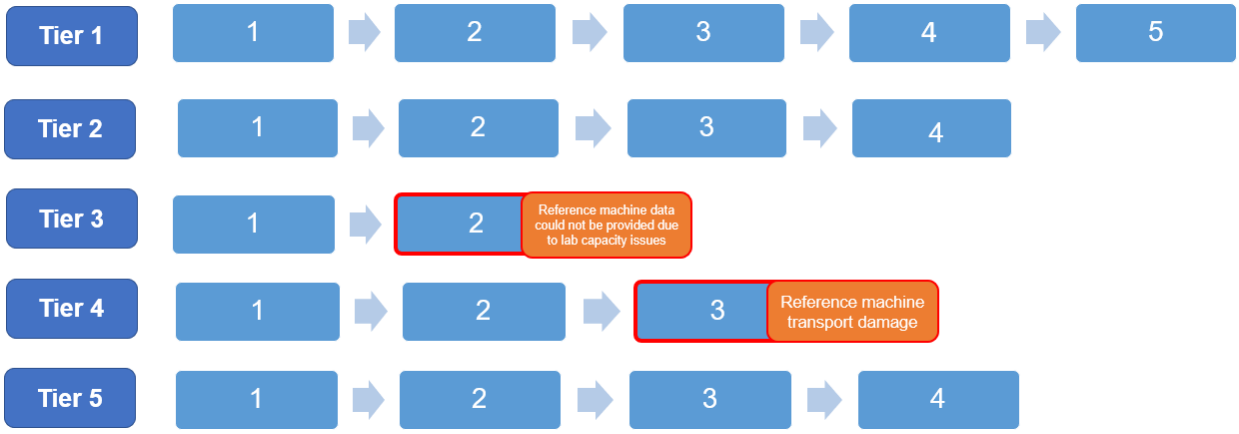

Figure 1: RRT tier set-up

6. Test procedure and general parameters

6.1 Appliances

The test series were carried out with a set of 5 NR appliances (G 7332 SC) and 5 TA (SMV6ECX51E), that were shipped to each participant directly by ASU.

All five appliances of each of the RRT models were tested in the respective manufacturer labs to ensure that nearly the same consumption values were provided for all machines in test. The mean values of those tests were handed out to ASU.

Next to the appliances a test box with a fixed resistance was sent along with the appliances for an additional LPM measurement.

6.2 Dishware and soil specification

The dishware and soil applied follow the specifications provided in EN 60436:2020:

Crockery	Type of soil	n
Soup plates	oat meal	6
Dinner plates	egg yolk	6
Dessert plates	spinach	6
Mugs	tea	6
Cups	tea	6
Saucers	tea	6
Oval platter	meat mixture	1
Total		**37**

Glass	Type of soil	n
Glass bowl	meat mixture	1
Dessert bowl	oat meal	6
Glasses	milk	6
Glasses	unsoiled	6
Total		**19**

Melamine	Type of soil	n
Melamine dessert plates	egg yolk	6
Melamine bowl	margarine	2
Total		**8**

Pots	Type of soil	n
Small pot (inner bottom)	spinach/margarine	1
Small pot (inner wall)	spinach/margarine	1
Small pot (outer surface)	unsoiled	1
Small pot (overall)	n/a	1
Oven pot (inner bottom)	meat mixture	1
Oven pot (inner wall)	meat mixture	1
Oven pot (outer surface)	unsoiled	1
Oven pot (overall)	n/a	1
Total		**8**

Cutlery	Type of soil	n
Soup spoons	oat meal	6
Soup spoons	unsoiled	6
Forks	egg yolk	12
Knives	unsoiled	12
Dessertspoons	unsoiled	12
Teaspoons	unsoiled	12
Serving cutlery	unsoiled	4
Total		**64**

6.3 Detergent

The new detergent type E was either directly supplied by Swissatest Testmaterialien AG on lab request or was directly supplied by ASU along with the appliances. 3 different batches of detergent type E were used: 2022/05, 2022/08, 2022/12.

For Detergent type D all labs used the detergent batches from their stock.

6.4 Pretests

To assure a proper test appliance operation, each lab had to perform three pretest runs with each NR and TA according to the standard, and provide the results of the 3rd run to ASU, to assure the proper function of the appliance and the test program.

If the values for water and energy consumption, max. temperature washing and rinsing were within the tolerances per appliance, the labs were allowed to continue with the test series. This procedure was followed to exclude the possibility that the appliances were damaged during transport, which could influence the results.

7. Precision of testing (repeatability, reproducibility) and data display

Data analysis is done with Minitab 21.4 and XLSTAT Premium 2023.

The data assessment is based on

- IEC 61923: TECHNICAL REPORT – TYPE 3: Household electrical appliances – Method of measuring performance – Assessment of repeatability and reproducibility
- CEN/CENELEC ECO - Coordination Group, Doc.number N 161: Revised guide to assess measurement uncertainties for products and services under the Ecodesign Directive 2009/125/EU

7.1 Precision of testing (Repeatability and reproducibility)

The data evaluation follows the "top down method". Repeatability standard deviation s_r, reproducibility standard deviation s_R and relative reproducibility standard deviation in % indicate the measurement uncertainty for the parameters.

Repeatability standard deviation (s_r)

The repeatability standard deviation is the standard deviation of test results which are obtained under repeatability conditions (independent test results obtained with: **same method, identical test items, same laboratory, same equipment, and short time interval**).

The repeatability standard deviation S_r of a test method is calculated from the following equations.

$$S_r = \sqrt{\frac{1}{p}\sum_{i=1}^{p} S_{L,i}^2} \quad \text{with} \quad s_{L,i} = \text{standard deviation in one lab}, \quad p = \text{number of participating labs}$$

Equation 1: Formula to calculate the repeatability standard deviation Sr

Reproducibility standard deviation (s_R)

The reproducibility standard deviation is estimated from **testing of the same appliance in different laboratories** using the same measurement method. Using the same appliance assures to eliminate inherent variations. It may be influenced by remaining differences (e.g. ambient test conditions, test equipment, operator).

The reproducibility standard deviation S_R of a test method is calculated from the following equations, where x_m is the arithmetic mean of the arithmetic mean values of the participating labs.

$$S_R = \sqrt{\frac{1}{p-1}\sum_{i=1}^{p}(\bar{x}_i - x_m)^2 + \frac{n-1}{n}s_r^2}$$

with
n = number of performed tests
x_m = average test result of one lab
p = number of participating labs
$\bar{x}_i$ = average test result of all labs

Equation 2: Formula to calculate the reproducibility standard deviation s_R

Expanded uncertainty calculation

The uncertainty of a measured result has two sources:

- The statistical uncertainty of what is measured (= repeatability standard deviation), showing the accuracy of the measurements within each laboratory participating;
- The uncertainty of the measuring method itself. This is expressed as expanded uncertainty where it is common to set the borders at a 95% confidence interval, which give the minimum and maximum value where the average measured result may be found when the measurement is re-done at any other laboratory. As basis for calculating the expanded uncertainty, the reproducibility standard deviation is used: It is calculated as twice the reproducibility standard deviation, always rounded up to the next one-digit number.

$$E\% = \frac{S_R}{m} \cdot 100\% \cdot 2$$

with
E% Expanded uncertainty
m arithmetic mean of the parameter for which E% is calculated.

Equation 3: Formula to calculate the reproducibility standard deviation s_R

For all data where just one result by lab is available, the expanded uncertainty on the overall result (E_{OR}) is calculated

$$E_{OR}\% = \frac{StDev}{m} \cdot 100\% \cdot 2$$

with
$E_{OR}\%$ expanded uncertainty of the overall result
StDev Standard deviation
m arithmetic mean of the parameter for which E% is calculated.

Equation 4: Formula to calculate the reproducibility standard deviation on the overall result

For the calculation of the expanded uncertainty of the cleaning and the drying indices, the cleaning and drying scores of each run are calculated per lab to derive the indices. The actual index is then the geometric mean of the five individual values.

7.2 Data consistency

To evaluate the **consistency between the laboratories** the **Mandel's h value** is calculated (equation 5), thus the Mandel h test is designed to identify labs whose results differ from those of

other labs. The closer the Mandel's h value is to zero the better is the conformity of one specific lab with the overall mean value.

To identify outlying or struggling values the h-values are compared with critical values, depending of the level of significance and the number of participating laboratories. The critical values for statistical outliers at a significance value of α = 0.01 are directly displayed in the result tables. The significance level, also denoted as α, is the probability of rejecting the null hypothesis when it is true. A significance level of 0,01 indicates a 1% risk of concluding that a difference exists when there is no actual difference (=confidence level 99%, as recommended in RRT-report technical standard IEC TR 63250).

An example of the Mandel h critical values related to specific N values is shown below. The specific critical values, based on the number of results included, is calculated and displayed in each result table.

The exemplary Mandel h critical values are:

Number of included labs (N)	Mandel h critical value
9	2,127
10	2,176
16	2,335
17	2,350

$$h_i = \frac{\bar{x}_i - x_m}{\sqrt{\frac{1}{p-1}\sum_{i=1}^{p}(\bar{x}_i - x_m)^2}}$$

with x_m = average of all test labs
$\bar{x}_i$ = average of one lab
p = number of participating labs

Equation 5: Formula to calculate the Mandel's h values

To evaluate the **consistency within one laboratory** the **Mandel's k value** is calculated (equation 6). The smaller the k-value the less differs the lab from the others in its variance, thus the repeatability is higher in this particular laboratory or measurements are more stable in this lab.

To identify outlying or struggling values the k-values get compared with critical values, depending on the level of significance and the number of tests and participating laboratories. The critical values for statistical outliers at α = 0.01 and for n = 4 runs are directly shown in the result tables. The significance level, also denoted as α, is the probability of rejecting the null hypothesis when it is true. A significance level of 0,01 indicates a 1% risk of concluding that a difference exists when there is no actual difference (=confidence level 99%, as recommended in RRT-report technical standard IEC TR 63250).

An example of the Mandel k critical values related to specific N values is shown below. The specific critical values, based on the number of results included, are specifically calculated and displayed in each result table.

The exemplary Mandel k critical values are:

Number of included labs (N)	Mandel k critical value
9	1,827
10	1,839
16	1,879
17	1,883

$$k_i = \frac{s_{L,i}}{s_r} \quad \text{with} \quad s_r = \sqrt{\frac{1}{p}\sum_{i=1}^{p} s_{L,i}^2}$$

$s_{L,i}$ = standard deviation in one lab

p = number of participating labs

Equation 6: Formula to calculate the Mandel's k values

Dealing with outliers

For all performance parameters all data sets are first shown including the data of all labs, highlighting Mandel h and Mandel k outliers per lab. For these data sets the repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty is calculated including all data.

Further on, an outlier test is performed, **excluding all Mandel h (reproducibility) OR Mandel k (repeatability) outliers.** For these outlier-corrected data sets the repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty is calculated as well.

For the outlier testing in LPM a Grubbs's test is performed, as just one data set per lab is available, based on the pre-defined test design.

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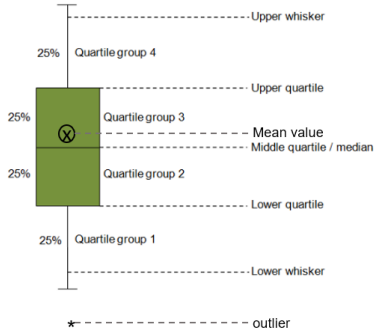
7.3 Further statistical analyses

For further analyses on significant differences t-tests are applied, with a significance level of α = 0.05 or an one-way ANOVA test design, an extension of the independent two-sample t-test, using Fisher's Least Significant Difference (LSD) test. ANOVA analysis of variance, is a critical analytical technique for evaluating differences between three or more sample means from test results. An ANOVA partitions out the variance in the response variable based on one or more explanatory factors.

7.4 Data display

Most data are displayed as box and whisker plots.

A box and whisker plot is a way of summarizing a set of data measured on an interval scale. It is used to show the shape of the distribution, its central value, and its variability. Box and whisker plots are ideal for comparing distributions because the center, spread and overall range are immediately apparent. In a box and whisker plot:



- The ends of the box are the upper and lower quartiles, so **the box spans the interquartile range, thus** the middle "box" represents the middle 50% of scores for the group.
- The **median is marked by a horizontal line** inside the box, that divides the box into two parts: The median (middle quartile) marks the mid-point of the data. Half the scores are greater than or equal to this value and half are less.
- The **whiskers** are the two lines outside the box that **extend to the highest and lowest observations:** The upper and lower whiskers represent scores outside the middle 50%.
- **Outliers** (marked as *): An outlier is a value that lies outside the overall distribution pattern and thus can affect the overall data series. The outliers shown in all figures with a detail insight on the results per refer to the data per lab and do not take into account the overall data of all labs.
- **All mean and median values shown INCLUDE outlier data.**

8. Pre-questionnaire results

The results section first shows the overall results of the pre-questionnaire. In the pre-questionnaire nine question-clusters had to be answered, covering input on the reference machine, appliances used to prepare the soiled dishes (thermal cabinet, microwave oven), further input on the soiling (with a special focus in milk, spinach, tea and oatflakes) as well as on tableware and cutlery and on the overall laboratory conditions, water supply and measurement and detergent handling. Further on general questions were focusing on some aspects of the general test procedure.

16 labs provided the filed pre-questionnaires. Not all questions were fully answered by all labs – missing data are shown as “not specified”.

8.1 Old reference machine data

All labs used the Miele G1222SC model as reference machine with last service or calibration dates ranging from 09/2021 to 06/2023. The following figure shows the last calibration dates in months reported by the labs at the start of their test series. All reference machines used in the test series were thus last calibrated at least 12 months prior to the RRT test series a minimum reports time span of less than 1 month and a mean of 4,9 months.

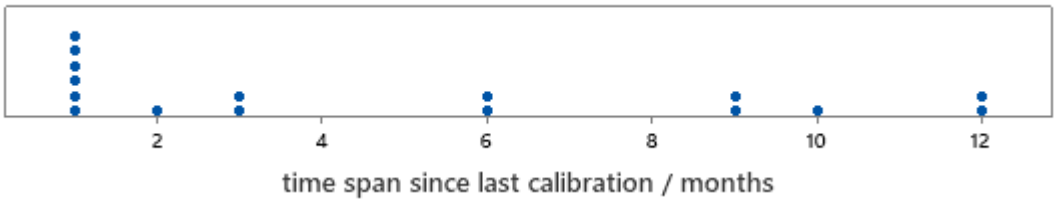


Figure 2: Dotplot of reported time span since last calibration of the currently used reference machine

8.2 Thermal cabinet and microwave oven

All RRT participants use thermal cabinets from the company Memmert. 43% use the model version UFP800DW and 31% use the model UFP800 (Table 4). Some labs also report to have 2 models running in parallel (see table below). All thermal cabinets used in the test series were last calibrated at least 12 months prior to the RRT test series, with a mean value of 6 months. Just one lab indicated a calibration period exceeding 4 years.

Table 4: Used thermal cabinets model codes

Memmert model code	n	%
ULM800	1	6,25%
UFP800DW	7	43,75%
UFP800	5	31,25%
ULP800 & UFP800	1	6,25%
UFP 800 & UFP 800DW	1	6,25%
ULM800 & UFP800DW	1	6,25%

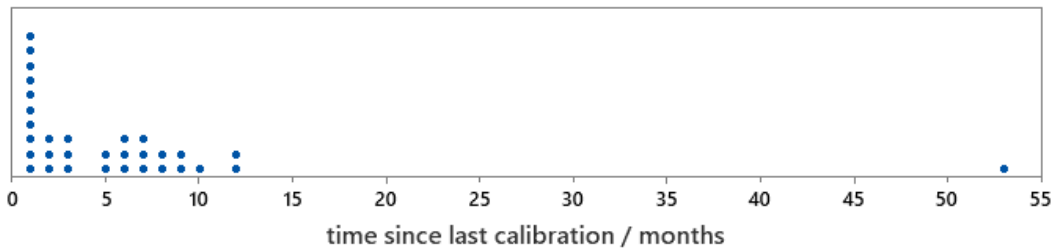


Figure 3: Dotplot of reported time span (in months) since last calibration of the currently used thermal cabinets

An overview of the microwaves used is given in table 5. Most labs use Bosch Model HMT75M421 or HMT743C, as specified in the standard. All microwave ovens used in the test series were last calibrated at least 12 months prior to the RRT test series, just one lab indicated a last calibration date exceeding 3,5 years. The mean of the last calibration date in months is 6,4 months.

Table 5: Used microwave ovens and model codes

Microwave brand	Model code	n	%
Franke	FMW242BG	1	6,25%
Bosch	HMT 752F	1	6,25%
Bosch	HMT 743C	5	31,25%
Bosch	AM 817ASW	1	6,25%
Bosch	HMT 75M421	3	18,75%
Bosch	HMT 742 C/02	1	6,25%
Bosch	HMT 743C, HMT75M421	1	6,25%
Bosch	HMT 743C & HMT 742C	2	12,50%

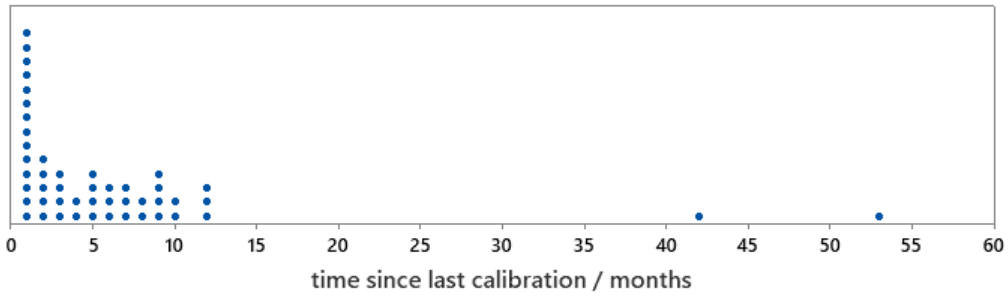


Figure 4: Dotplot of reported time span since last calibration of the currently used microwaves

8.3 Specifications on porcelain, cutlery and glasses

The following tables specify the suppliers and brand names of the used porcelain dishware and cutlery. For porcelain, 87,5% of the participants specify wfk as their supplier. The main brand is Arzberg (75%).

For cutlery 62,5% of the participants specify wfk as the main supplier. 81,25% further specify WMF as the brand name of their cutlery stock.

Table 6: Porcelain supplier and brand name specification (n=16, multiple replies)

Supplier	n	%	Brand name	n	%
Arzberg	3	18,75%	Arzberg	12	75,00%
Kahla	2	12,50%	Corelle	3	18,75%
Rosenthal	1	6,25%	Corning/Comcor	1	6,25%
Waca	1	6,25%	Kahla	6	37,50%
wfk	14	87,50%	wfk	1	6,25%
			WMF	1	6,25%

Table 7: Cutlery supplier and brand name specification (n=16, multiple replies)

Supplier	n	%	Brand name	n	%
Arzberg	2	12,50%	not specified	1	6,25%
Buhr Agenturer	1	6,25%	TTT tableware s.r.l	1	6,25%
TTT tableware s.r.l	1	6,25%	wfk	2	12,50%
wfk	10	62,50%	WMF	13	81,25%
WMF	2	12,50%			

The summarized answers related to the question on the run cycles of the tableware and cutlery used for the test ("How many cycles are approximately run with the set of tableware and cutlery you use for the test?) are shown in Figure 5: The specified porcelain and cutlery cycle runs result in the calculated mean of 117 runs, with a minimum of 13 and a maximum of 200 runs. One lab states not to keep track on the runs.

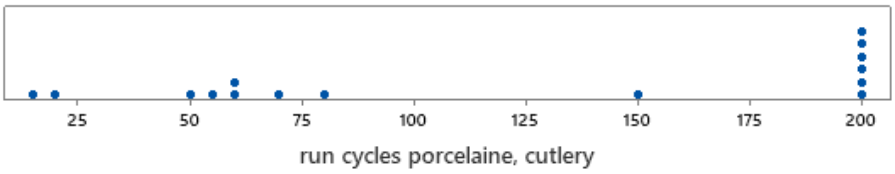


Figure 5: Dotplot of specified run cycles for porcelain and cutlery

Table 8 specifies the suppliers and brand names of the glasses used. 75% of the labs specify wfk as their supplier. For some labs the mixing of supplier / brand name specification is likely.

Table 8: Summary on specified glass suppliers and brand names

glass supplier	n	%		glass brand name	n	%
DWK Life Sciences GmbH	1	6,25%		as specified in standard	1	6,25%
Linegal Chemicals	1	6,25%		DWK Life Sciences GmbH	1	6,25%
Schott Duran	1	6,25%		Schott Duran	13	81,25%
TITOLCHIMICA (Rovigo)	1	6,25%		wfk	1	6,25%
wfk	12	75,00%				

8.4 Specifications on soil

81,25% (n=13) of the labs state to prepare and use the soil on one day (with the exemption of spinach in 2 labs, which is prepared on one day and used the next day). 3 labs specify to prepare the soil on one day and to apply it on the next day.

75% (n=12) labs report to have no separate rooms for the preparation of soil or dishes.

8.4.1 Milk

To not disclose the identity of the participants, the milk brands are not disclosed by lab (Table 9). 56,35% of the labs (n= 9) further specify to apply UHT milk versions of the specified brands.

Table 9: Milk brands used for milk soil preparation

Milk brand	n
Arla	1
Gut & Günstig	1
Ja!	2
Naarmann	1
Parmalat	1
SDT	1
SEK	1
Sterilgarda	1
Weihenstephan	5

Concerning the fat content, 13 participants (81,25%) specify to use milk with a fat content of 1,5%, 2 participants (16%) specify to use milk with a fat content of 1,6% and 1 participant uses milk with a fat content of 3%.

8.4.2 Spinach

Most labs (n=10, 62,5%) use frozen spinach. All labs apart from 1 lab is specifying IGLO spinach as the used brand, 1 lab specifies to use the EDEKA private label product. 4 labs (25%) apply freeze-dried spinach from Sta-De Testmaterialien, and 1 lab uses both, frozen as well as freeze-dried spinach.

Table 10 specifies the used mincer models of labs using frozen spinach, with setting specifications and preparation amounts / minute. The preparation amounts vary from 38g / minute to a maximum amount of 264 g / minute, 3 labs were not able to specify this value.

Table 10: Mincer models, settings and preparation amounts / minute for spinach preparation

Mincer Model	Mincer Setting	preperation amount g/min
Beko BKK2189	Blue light (mince meat mod)	230
BOSCH MUM 6010	Setting 2	not specified
Bosch MUM 6N21	2 mm hole diameter disk	250
Bosch MUM6N21	Level 2	190-250
Bosch universal plus 1000 W	Setting 1	not specified
Braun MultiQuick 3	2 mm hole diameter	38
BRAUN Power Plus 1300	Modified disk, no setting available	not specified
Gastroback 41409	350 Watt / 1,3 Nm	264
Gastroback 41409	position "ON "	235
Gastroback 41409	No particular settings	200-205
Gastroback Advanced model 41409	Setting is fixed - only 1 setting	205

8.4.3 Tea

All 16 labs specify to use Sir Winston Tea / “Broken Orange Pekoe” as the tea brand / type for the tea soil preparation. 15 labs further on specify to use the same lab water for the tea preparations as for the test machines.

75% of the labs use a kettle to heat the water for the tea preparation (Figure 6). 12 labs (75%) artificially prepare the water for the process, following EN 60735, Method B (31,25%, n=5) or IEC 60734, Method C (31,25%, n=5) or applying an own treatment method (12,5%, n= 2, Figure 6).

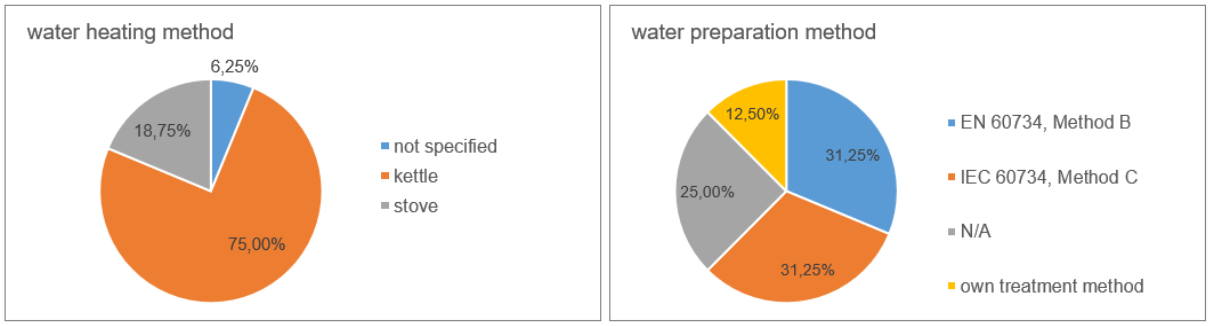


Figure 6: Water preparation for tea: Water heating method and water preparation method

8.4.4 Oatflakes

All 16 labs specify to use "Blütenzarte Köllnflocken" by Kölln. 15 labs confirm to use the same water for the preparation of oatflakes as for the machines under test. 11 labs do artificially prepare the water used in oatflake processing. 5 labs follow EN 60734 Method B, 4 labs follow IEC 60734 Method C and 2 labs follow an own regime.

12 labs (75%) state to use a food processor for the oatflake processing. Table 11 shows the food processors used, the respective settings and cooking regimes. 5 labs use the food processor

"Bosch cookit", 3 labs use the Kenwood processor KCC90. All other food processors mentioned are used by one lab each.

For all food processors specific settings are specified, also for labs using the same kitchen machines. The cooking regime analysis shows that all labs stick to a 10-minute boiling or simmering time after the overall heating-up phase. The heating regime, which shows variations within the labs, results in total heating and cooking times of 15 – 19 minutes.

Table 11: Food processors, settings and cooking regimes applied in oatflake processing

Fod processor	Food processor setting	Cooking regime
Bosch Cookit	own program	heating time (5:30 min) + 10 min boiling
	3D stirrer	heating time (7:00 min.) + 10 min boiling
	Boiling at 98°C, stirring Level 5 (continously); Simmering at 96°C + Level 5	boiling (7:00 min.) + 10 min simmering
	"manual cooking" programme, level 5, "3D-Stirrer"	heating time (7:00 min.) + 10 min boiling
	Level 5, clockwise rotation	heating time (7:00 min.) + 10 min boiling
Induction table SAUTER	Position 5	heating time + 10 min boiling
Kenwood KCC90	Step 1: Power 1000W, temperature 140 °C (till boiling point observed); Step 2: Power 1000 W, temperature 100 °C	heating time (9:00 min.) + 10 min boiling
	1200W 100°C Till boiling point and additional 10 minutes when boiling point is reached	17 minutes
	100 degrees	heating time (7:00 min.) + 10 min boiling
Krups Prep&Cook, Type HP503	105°C; Level 2 - 10sec stir / 10 sec pause cycle	16 min
Simfer electric oven	6th level until boiling, 10 minutes in 3rd level when it is boiling	heating time + 10 min boiling
Thermomix	1) 10 min with 110°C & left-run & 2 rotations 2) 10 min 105° & left-run & 0,5 rotations	Heating time (10;00 min) + 10 min. boiling

8.5 Water supply and measurement

13 (81%) of the participating labs indicate to apply an artificial pre-treatment to the water used (Figure 7). The main preparation method is following the standard method B (54%), followed by method C2 (23%).

13 labs (81%) state to further monitor water parameters (Figure 7). These parameters are mainly pH-value and conductivity (11 labs each). Trace minerals analysis is performed on a regular basis by 50% (n=8) of the participants, 13 % (n=2) state to run the analysis sporadically.

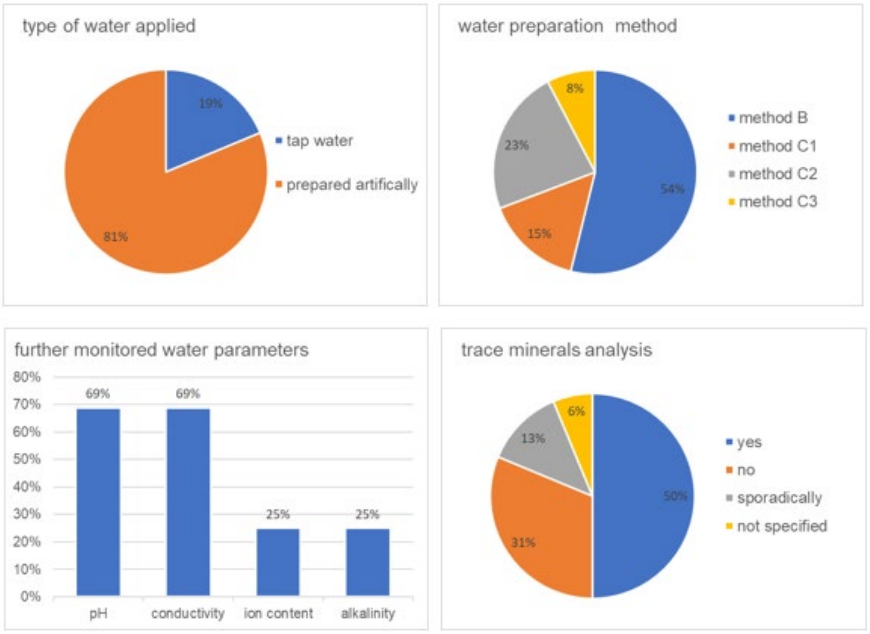


Figure 7: Specification on type of water applied (n=16), water preparation method (n=13), further monitored water parameters (n=16, multiple answers), trace minerals analysis (n=16)

The water inlet temperature sensor is placed next to the outlet by 5 participants (31,25%) and in the circulation line by 8 participants (50%). 2 (12,5%) labs specifies to have sensors at both locations without specifying which value is reported, and 1 lab does not further specify the location.

The further analysis of the impact of the temperature sensor location on the reported measurement values shows no significant difference (t-test analysis, p-value 0,999): The reported mean value and SD mean for temperature sensor location next to the outlet is 15,349°C ± 9,834 (MIN: 13,540°C, MAX: 16,800°C), the reported mean value and SD mean for temperature sensor location in the circulation line is 15,349°C ± 0,626 (MIN: 13,700, MAX: 17,000°C).

Information on the type of sensors used, as well as on sensor resolution and accuracy, is shown in figures 8 and 9. 44% of the labs indicate to apply thermocouples, without further specifying the type and 31% do not provide any specification. 50% of the labs specify a resolution of the sensors of 0,5 K, the other labs state resolution values <0,5 K, down to levels of 0,002 K. The accuracy of the water inlet temperature sensors ranges from 0,1 – 0,5 K (Figure 9).

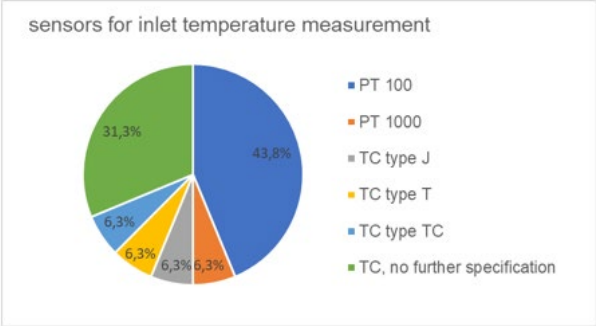


Figure 8: Specification of temperature sensors for inlet water temperature measurement (n=16)

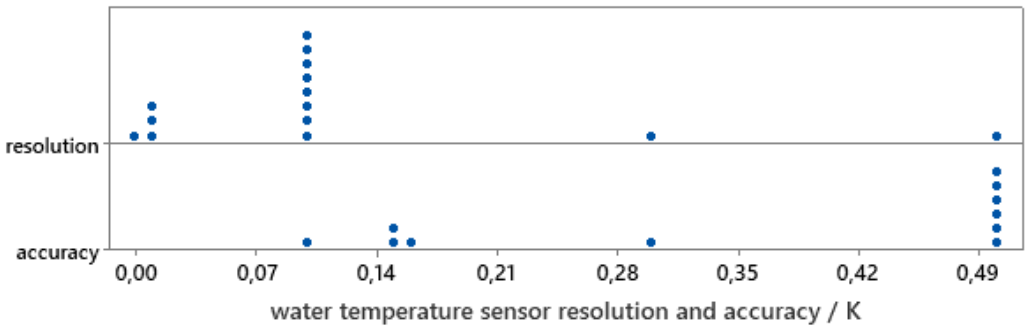


Figure 9: Specification of resolution (n=14) and accuracy (n=11) of water temperature inlet sensors

The amount of water (volume in ml) between the circulation loop and the spur, as specified by the labs, ranges from 50 ml to 500 ml, with a calculated overall mean of 203 ml (Figure 10). One lab does not specify the value.

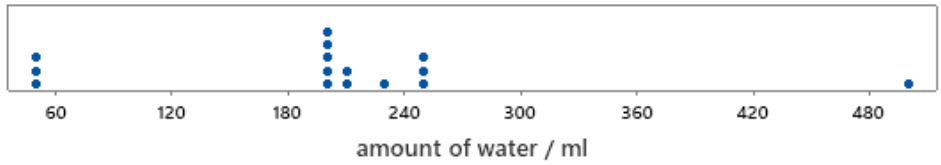


Figure 10: Specification of amount of water (volume in ml) between the circulation loop and the spur (n=15)

8.6 Detergent handing

The storage location of the detergent prior to usage is shown in Figure 11. 6 labs (27,5%) store the sample in the lab, 5 labs (31%) state to store the detergent in a refrigerator. The other 5 labs state to store the detergent in a cabinet or in the laboratory in dry and dark conditions.

Related to the sample storage directly after preparation, 6 labs (37,5%) state not to store the samples at all, but to use them directly. 5 labs (31%) store the samples in small containers in the

lab, 4 labs (25%) store the samples in small containers in the refrigerator and 1 lab keeps the samples in the divider container.

50% of the labs do not use a sample divider. These labs further state to shake the storage container prior to usage (50%, n=4), the other labs state to either mix the detergent with a spoon (25%, n=2) or weigh the required amount directly from the container (25%, n=2).

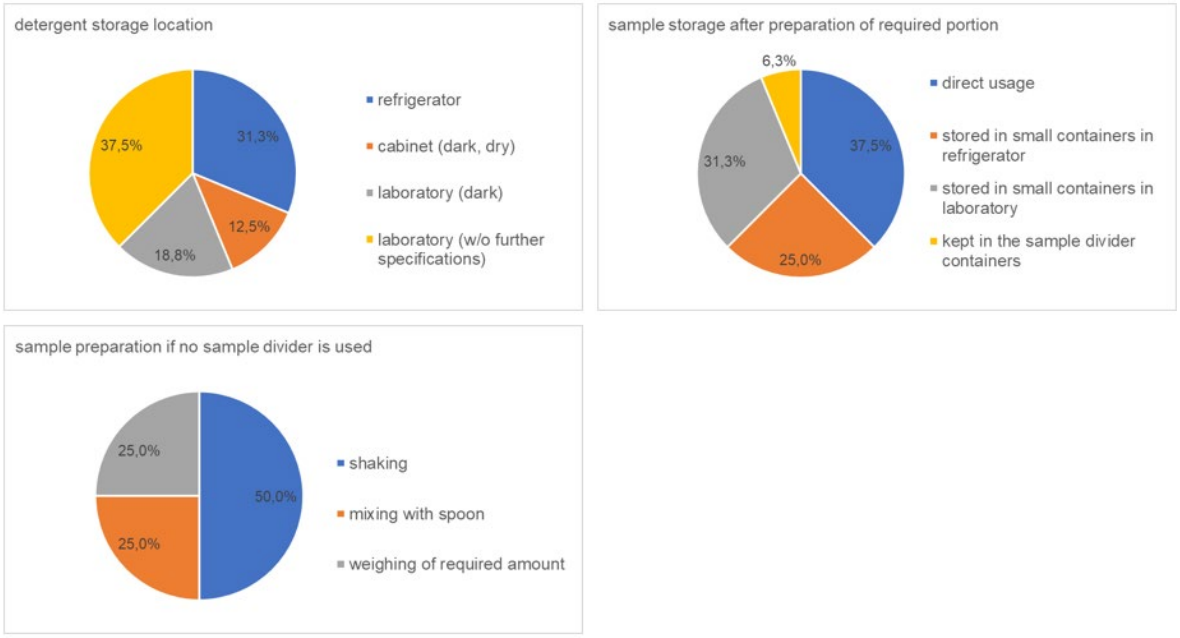


Figure 11: Specification of detergent storage (n=16), sample storage after preparation (n=16) and detergent sample preparation if no sample divider is used (n=8)

The labs using a sample divider (n=8) specify the divider usage as shown in the following table.

Table 12: Sample divider usage specification (n=8)

Sample divider usage specification as specified by RRT participants
– 2 kg into 10 * 200g than 200g into 10*20g (PT100 from Retsch)
– before preparing the detergent with a sample divider: pour through a sieve with a mesh size of 2 mm. – preparation the device with 8 sample glasses and set the settings: Amplitude initially 25, gradually increase up to 50 – Pour the detergent through the funnel in the sample divider 4) cleaning of detergent residues at sample divider
– 1 kg of detergent is placed on a sieve, large particles are removed, then detergent is split with 8-part-divider into 125 g portions – each 125 g portion split again into 8 portions with ~ 15 g each, for detergent Type E – For detergent type D, 250 g of detergent are split into 8 portions with ~31 g each.
– 1 kg detergent is divided into 6 equal portions with a Retsch DR 100.
– 1 kg of detergent is placed into a feeding hopper of sample divider with 10 glass containers and the device is turned on. Vibratory feeder settings: vibration speed is set to 40, funnel height kept on 30 mm. – Detergent is being divided into smaller portions, all of it goes through rotatory head, which takes approximately 5 minutes. – In past 1kg of detergent was divided into 100 portions, 10 g each, but due to problem with clumping, we divide now into 10 glass jars. – Prior to use for the test, glass jar is well shaken in order to ensure homogeneity of the detergent.
– 2 sample dividers are used. In one of them, the dosage of the pre-wash and in the other the main wash is weighed as net.
– 1 kg is divided in 8 parts, 2 of these 8 parts are put together and divided in 8 parts.
– 1kg in the detergent divider, 10 bottles to store detergent, speed 40 for 5 minutes

8.6 Laboratory conditions

8.6.1 Room temperature measurement

All labs report to measure the temperature continuously. 75% (n=12) further specify to report average values of the measured values (Figure 12). The other labs either report start / mid and end values (n=1), the temperature at the start of the test cycle (n=1) or the temperature range (MIN/ MAX-value, n=1). 1 lab states to visually check on a regular basis if the values are within the specified limit values.

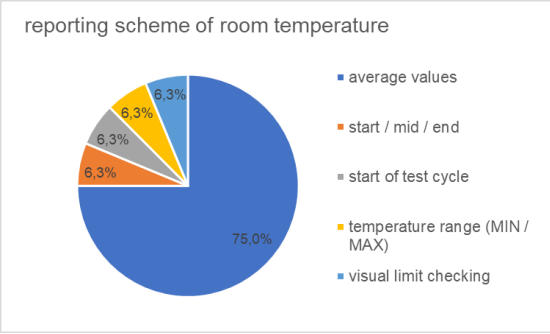


Figure 12: Reporting scheme of measured room temperature values (n=16)

14 labs further specify the location of the room temperature measurement system: 3 labs report to have the sensor element placed in the test room center, 4 labs report to have several sensor locations and 6 labs report sensor elements close to the test machines. The specific details are shown in Table 13. In a follow-up question a total of 9 labs (65,25%) report to have separate sensor elements close to the test appliances.

Table 13: Room temperature sensor location (n=14)

room temperature sensor location(s)	Further specification
Room center (n=3)	About in the center of the lab
	In the middle of the room, approximately 2 meters above the ground
	On the top middle of the room
Several locations (n=4)	In the middle of the lab and additional at each test station
	3 positions: above and beside the test appliances
	In the back of the machines and on top of the test racks
	General measurement for temperature, humidity and pressure by an electronic station and near the DWs for temperature by thermocouples
Close to the test machines (n=6)	Behind the machines, 0,7 meter above.
	Next to the testing machines
	From the middle of each station
	Above the testing position
	There is one sensor for combined measurement of room temperature and humidity hanging above each appliance to be tested and the reference machine.
	On the middle of the test machine in the middle of the test stations.

Table 14 further specifies the used temperature sensor elements, with 3 labs providing no further specification. The reported sensor element accuracy and resolution values are shown in Figure 13, with 2 labs not further specifying the accuracy.

Table 14: Specification of room temperature sensors (n=16)

Types of sensors used	n	%
not specified	3	18,8%
testo 174 T	1	6,3%
Testo Saveris	2	12,5%
Pt 100	4	25,0%
TFA KimaLogg Pro	2	12,5%
TC type K	1	6,3%
TC type TC	1	6,3%
TC type J	1	6,3%
AHLBORN FH A646	1	6,3%

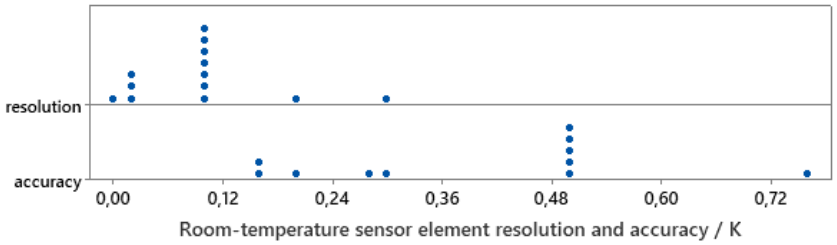


Figure 13: Room temperature sensor resolution (n=13) and accuracy (n=11)

8.6.2 Temperature measurement inside of the machines

Further laboratory condition questions referred to the temperature measurement near and inside the machine ("Do you have a separate temperature measurement sensor near the machine?" / "Do you have a separate temperature measurement sensor inside the machine?").

87,5% (n=14) of the labs specify to also use temperature sensors in the machine. Table 15 further specifies the used temperature sensor elements, with 3 labs providing no further specification. The reported sensor element accuracy and resolution values are shown in Figure 14, with 2 labs not further specifying the resolution and 5 labs not further specifying the accuracy.

Table 15: Specification of in-machine temperature sensors (n=16)

In-machine temperature sensor specification	n	%
not specified	3	18,8%
Thermocouple	4	25,0%
TC Type K	3	18,8%
TC Type T	1	6,3%
TC Type J	1	6,3%
PT 100	4	25,0%

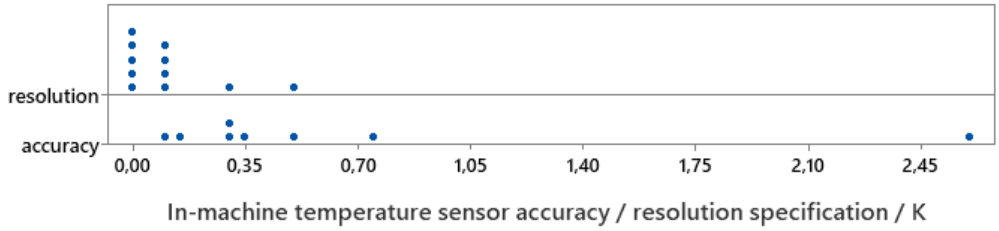


Figure 14: In-machine temperature sensor resolution (n=11) and accuracy (n=8)

9. Data analysis and data consistency testing

This chapter contains the data analysis of the environmental, the appliance parameters (duration, energy and water consumption and water temperature (maximum temperature main wash and rinsing), the performance results and low power mode consumption values.

For all analyses but the calculation of the cleaning and drying performance, regeneration runs are excluded. Thus the shown N refers to the number of reported runs by the labs, excluding regeneration runs, which mostly results in 4 runs (sometimes in 3 or 5 runs). In all data analyses, where a further splitting into batches is applied, all individual runs that were carried out with this batch are taken into account.

For all analysis parameters basic statistics and a graphical analysis is provided. For all performance parameters data consistency and outlier analysis is moreover included as well as the calculation of the repeatability standard deviation (s_r) and reproducibility standard deviation (s_R) and expanded uncertainty.

9.1 Environmental conditions

All environmental analysis data-sets are shown as boxplot figures, first showing the overall results by lab, then by lab and appliance and finally by machine and detergent. Theoretically the detergent does not have an impact on the environmental conditions, nevertheless a separate data display is shown, in order to detect difference that may arise from different test stations used within the labs.

9.1.1 Water hardness

Figures 15-17 show the boxplot-charts of the cold water hardness at cycle start for all appliances in the labs. The outliers shown per lab refer to the data per lab and thus are not related to the overall data of all labs. The water hardness limit values of 2.0 - 3.0 mmol/L are clearly within the tolerance range for all labs and appliances, with a minimum reported value of 2,05 mmol/L and a maximum value of 2,94 mmol/L. The values per lab show no deviation by appliance. The basic statistics of water hardness at cycle start is displayed in table 16.

Table 16: Basic descriptive statistics of water hardness at cycle start (aggregated data and by machine / mmol/L))

Machine	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
aggregated data	315	2,470	0,010	0,183	2,050	2,380	2,420	2,600	2,940
NR	104	2,457	0,018	0,184	2,050	2,379	2,412	2,518	2,940
OR	103	2,466	0,018	0,179	2,100	2,380	2,420	2,560	2,940
TA	108	2,485	0,018	0,186	2,100	2,380	2,495	2,670	2,900

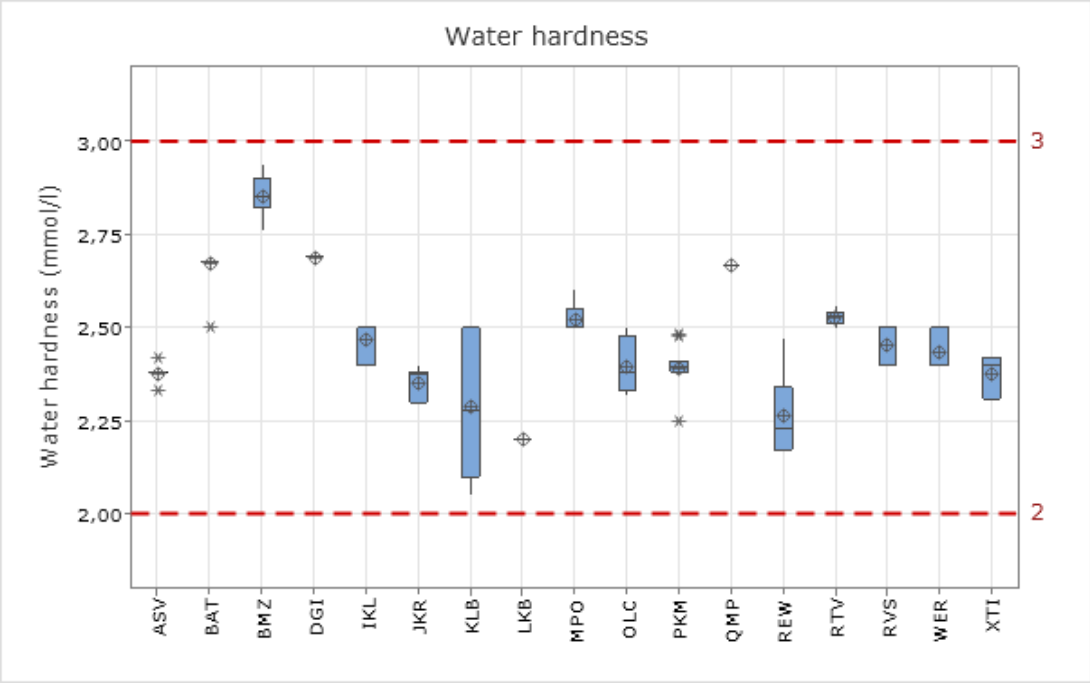


Figure 15: Boxplot of water hardness by lab

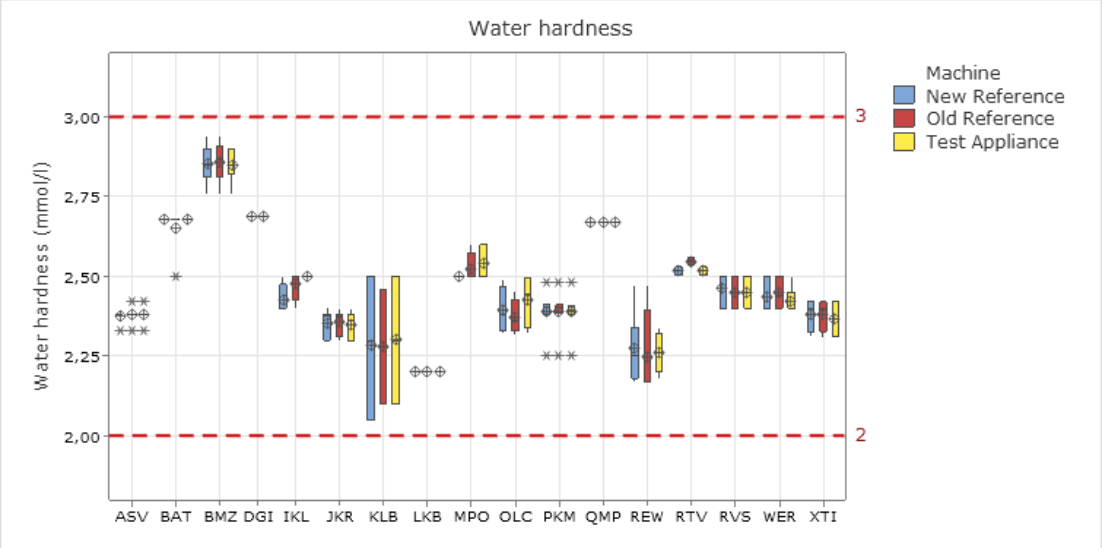


Figure 16: Boxplot of water hardness by lab and machine

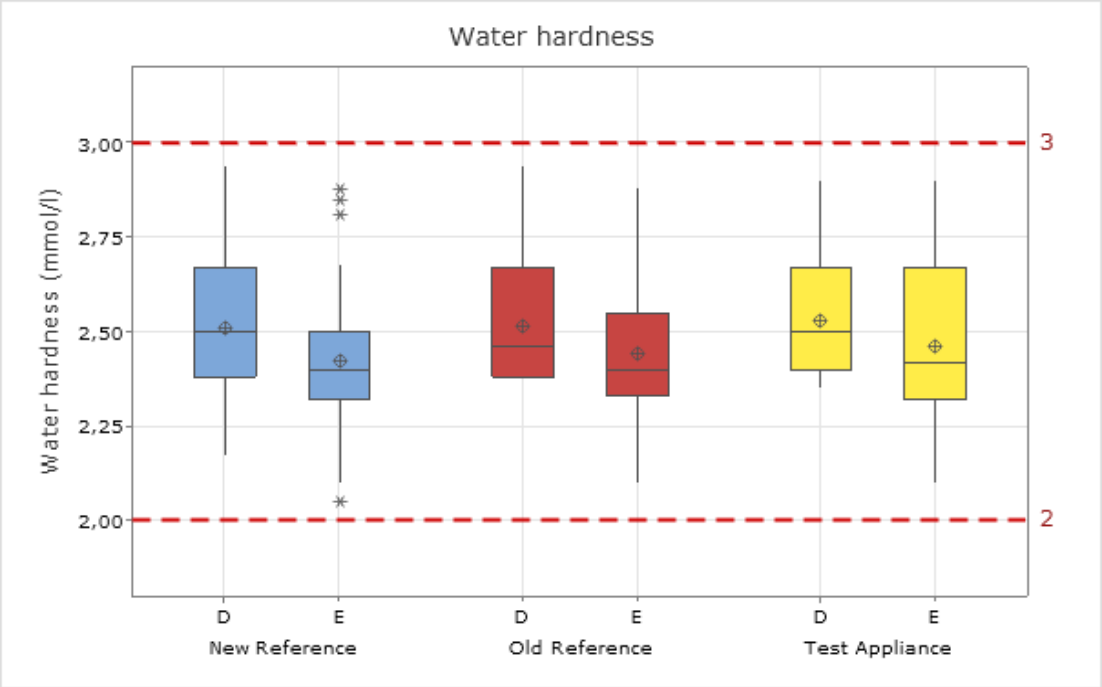


Figure 17: Aggregated boxplots of water hardness by machine and detergent

9.1.2 Water temperature inlet

Figures 18 - 20 show the water temperature at cycle start. The tolerance range of the water temperature inlet at cycle start lies between 13 and 17 °C and is met by all labs for all machines (Table 17). The reported values range from 13,5 °C to 17 °C. Most labs show a strong consistency for the tested appliances, whereas in some labs the inlet water temperature shows strong variations (DGI, MPO, QMP and XTI).

Table 17: Basic descriptive statistics of water temperature at cycle start (aggregated data and by machine / °C)

Machine	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
aggregated data	315	15,186	0,040	0,703	13,540	14,800	15,100	15,460	17,000
NR	104	15,216	0,061	0,618	14,000	14,877	15,215	15,500	16,900
OR	103	14,986	0,068	0,694	13,540	14,600	14,923	15,300	17,000
TA	108	15,346	0,072	0,746	14,000	14,897	15,200	15,907	16,900

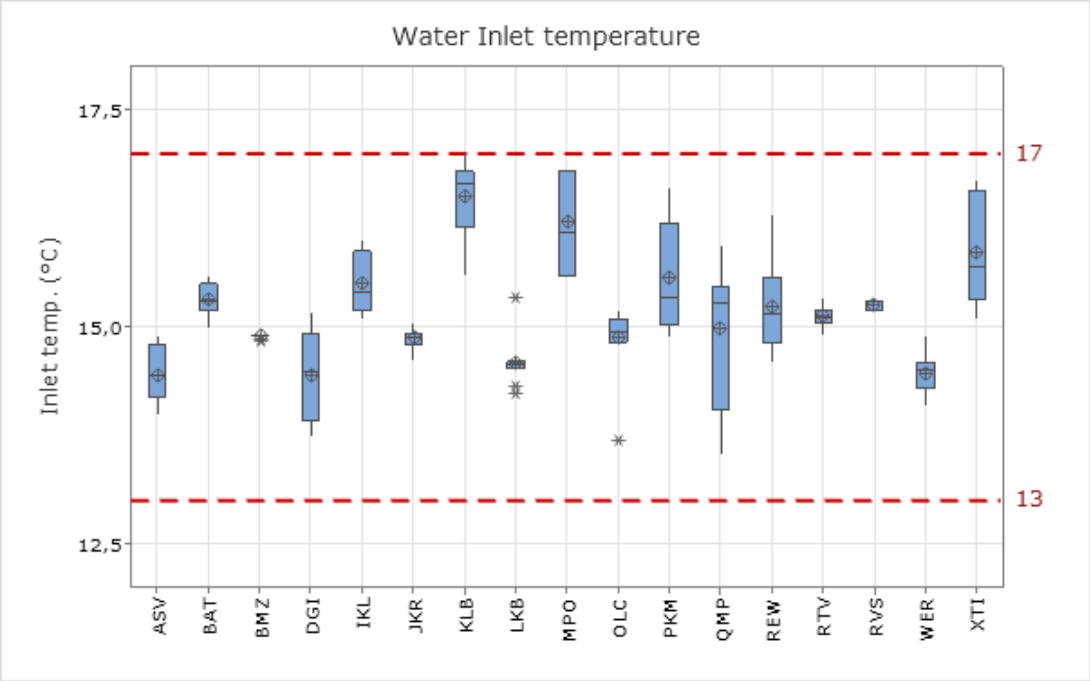


Figure 18: Boxplot of water inlet temperature by lab

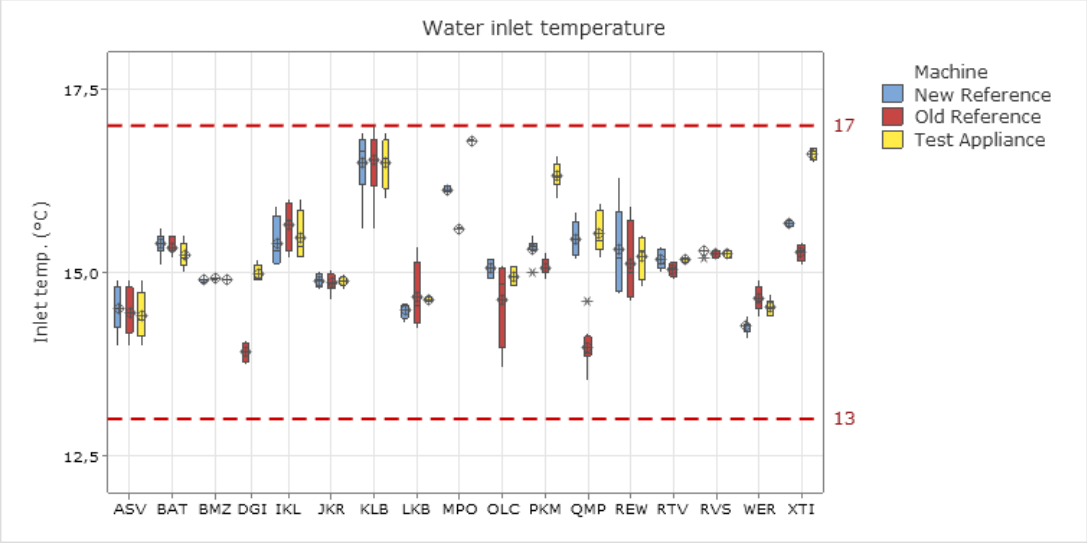


Figure 19: Boxplot of water inlet temperature by lab and machine

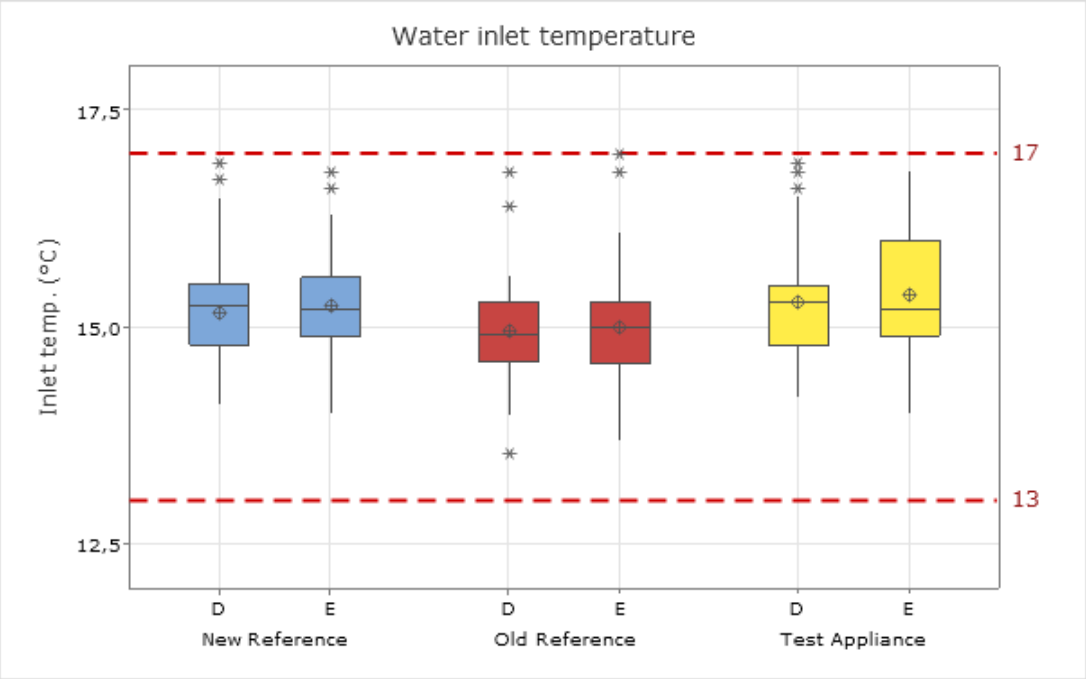


Figure 20: Aggregated boxplot of water inlet temperature by machine and detergent

9.1.3 Water pressure

Figures 21-23 show the water pressure at cycle start. The tolerance range acc. to the standard lies between 2,2 and 2,6 bar. The reported values range from 2,23 to 2,90 bar (Table 18). One lab (DGI) exceeds the values, showing a mean value of 2,7 bar. The too high water level pressure was confirmed by the lab – as no impact on the water consumption was shown in the results, the lab was not excluded for further data analysis.

Table 18: Basic descriptive statistics of water pressure at cycle start (aggregated data and by machine / bar)

Machine	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
aggregated data	315	2,436	0,005	0,087	2,230	2,400	2,400	2,470	2,900
NR	104	2,424	0,007	0,076	2,230	2,400	2,400	2,470	2,600
OR	103	2,437	0,009	0,087	2,290	2,400	2,400	2,480	2,800
TA	108	2,447	0,009	0,097	2,290	2,400	2,415	2,480	2,900

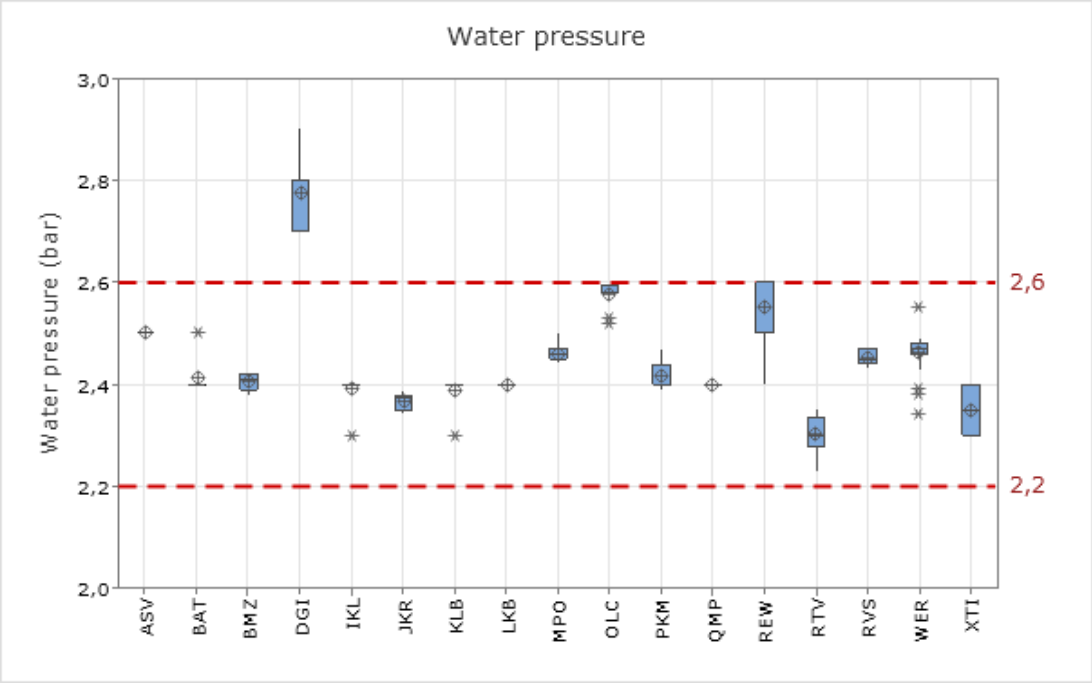


Figure 21: Boxplot of water pressure by lab

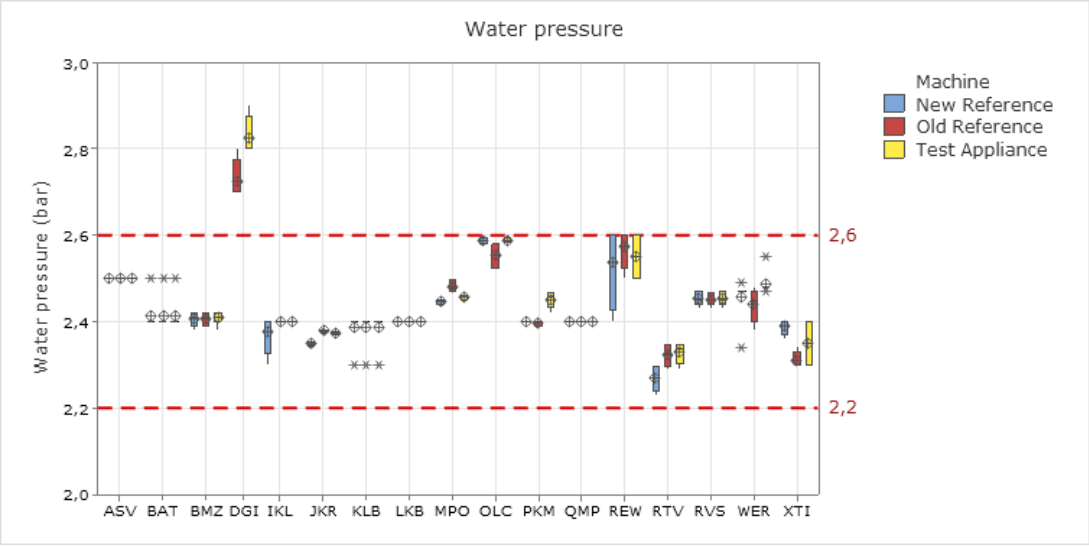


Figure 22: Boxplot of water pressure by lab and machine

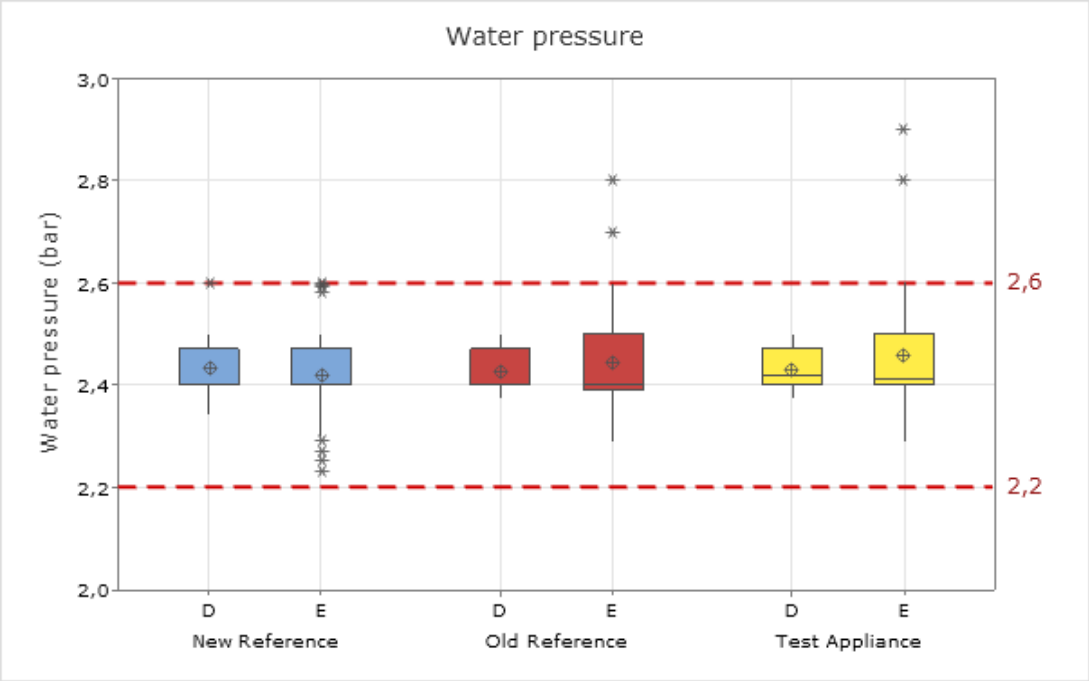


Figure 23: Aggregated boxplot of water pressure by machine and detergent

9.1.4 Relative humidity

The relative humidity at cycle start is shown in Figures 24-26. All labs reported values within the specified tolerances which are (55 ± 5) % relative humidity. The reported minimum value is 50,70% rH, the reported maximum value is 59,50%rH (Table 19).

Table 19: Basic descriptive statistics of relative humidity at cycle start ((aggregated data and by machine (%)

Machine	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
aggregated data	315	54,638	0,090	1,595	50,700	53,400	54,860	55,670	59,500
NR	104	54,551	0,150	1,534	51,000	53,125	54,600	55,400	58,500
OR	103	54,553	0,170	1,726	51,000	53,300	54,900	55,800	59,500
TA	108	54,802	0,147	1,523	50,700	54,000	55,000	55,992	58,500

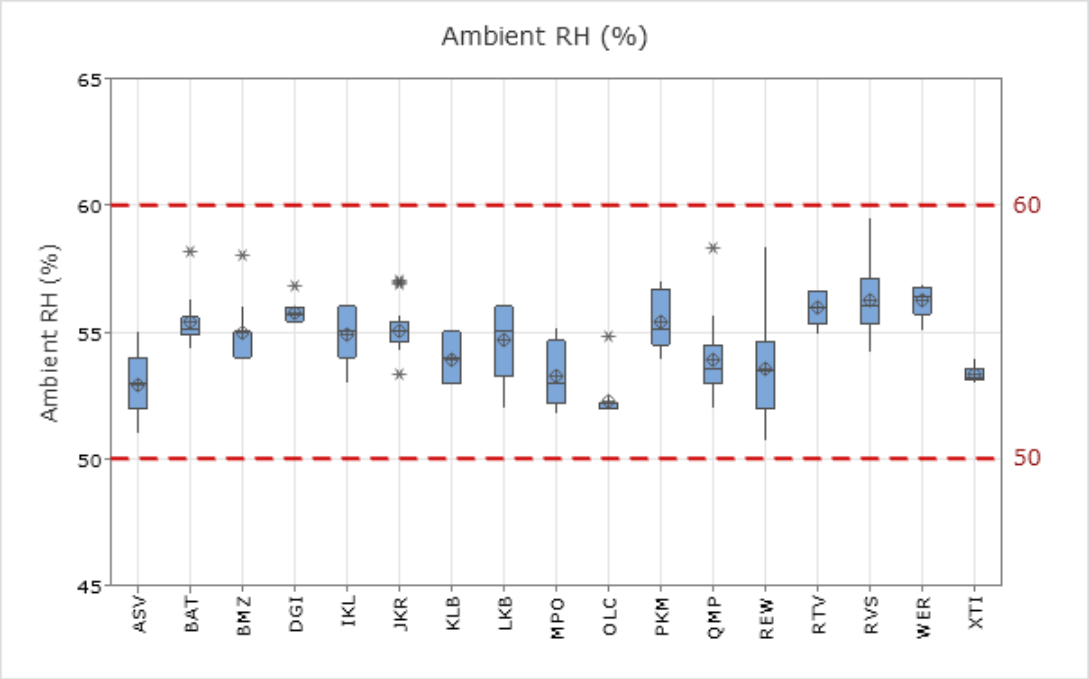


Figure 24: Boxplot of relative humidity at cycle start by lab

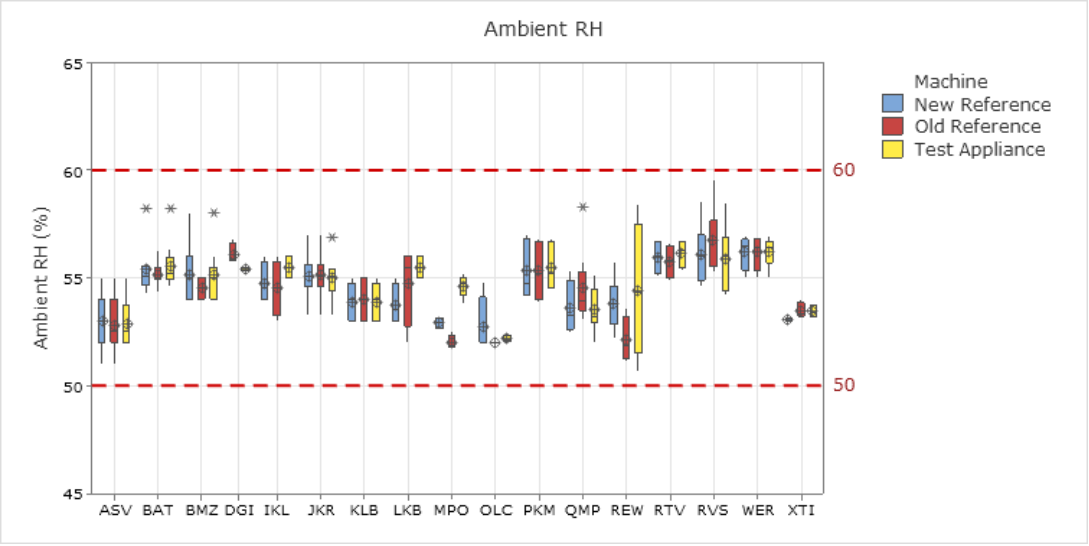


Figure 25: Boxplot of relative humidity at cycle start by lab and machine

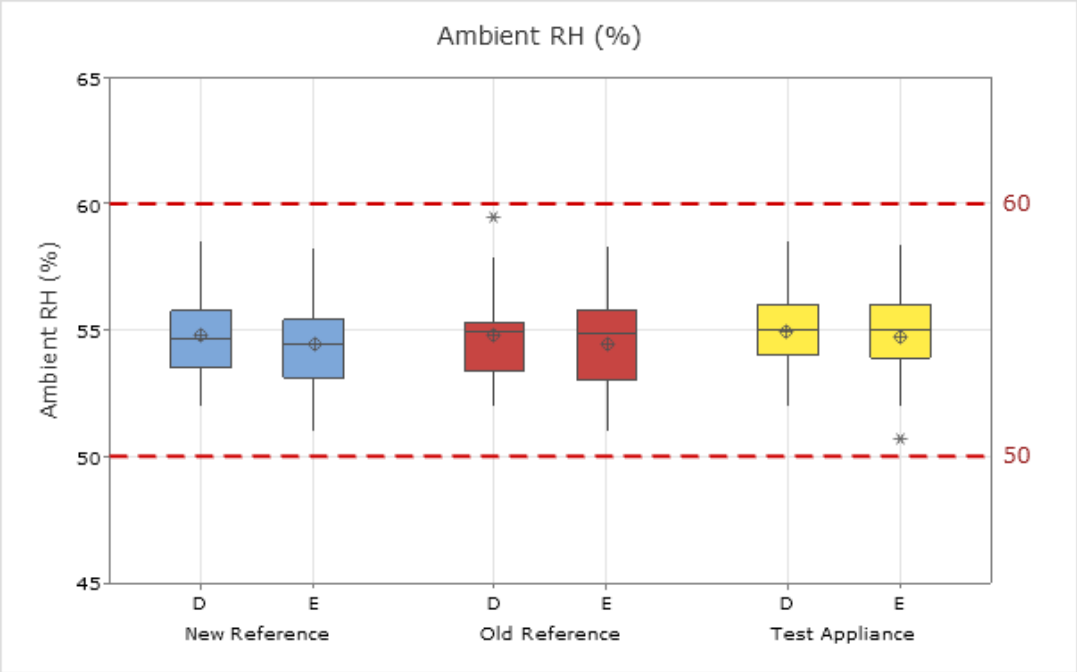


Figure 26: Aggregated boxplot of relative humidity by machine and detergent

9.1.5 Ambient temperature

Figures 27-29 depict the ambient temperature in the test series. The range for the ambient temperature lies between 21 and 25 °C. The reported minimum value is 20,9°C and maximum value 25,0°C (Table 20). Just 1 lab (ASV) reports the ambient temperature values that are slightly below the limit value of 21°C for some runs for the old and new reference machine. In all other labs the ambient temperature values are within the same range for the tested appliances, with some labs reporting larger temperature ranges (+/-1K – ASV, BAT, IKL) than others.

Table 20: Basic descriptive statistics of ambient temperature (aggregated data and by machine / %)

Machine	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
aggregated data	315	22,895	0,038	0,676	20,900	22,500	22,860	23,370	25,000
NR	104	22,938	0,065	0,659	21,100	22,525	22,900	23,400	25,000
OR	103	22,930	0,074	0,750	20,900	22,600	22,840	23,400	25,000
TA	108	22,820	0,059	0,614	20,900	22,500	22,800	23,197	24,200

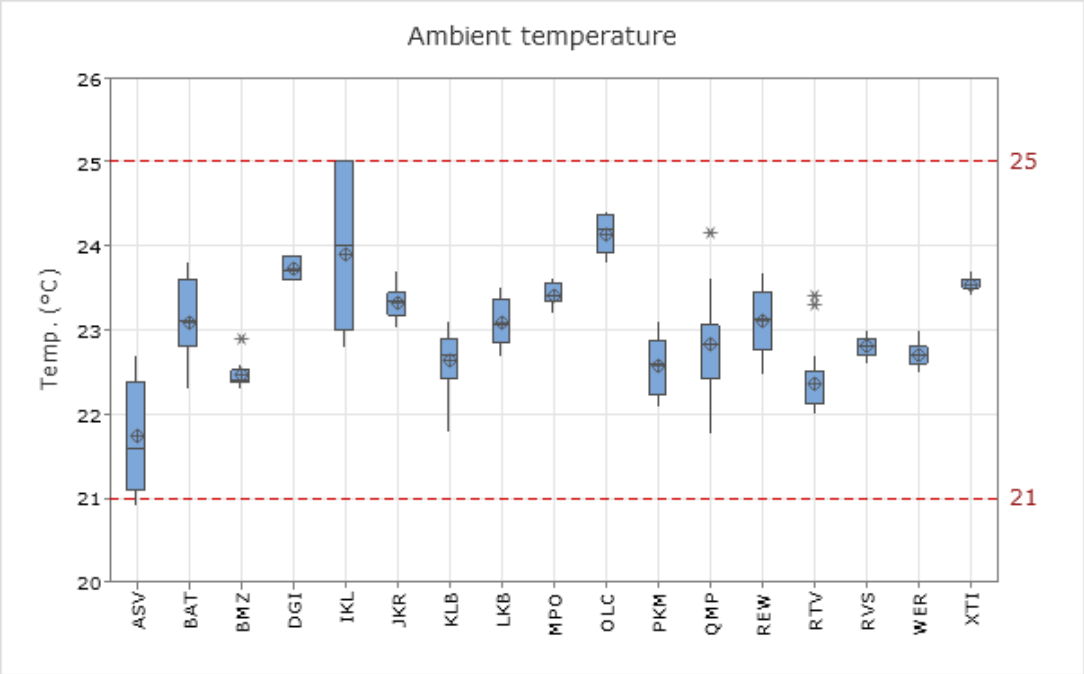


Figure 27: Boxplot of ambient temperature by lab

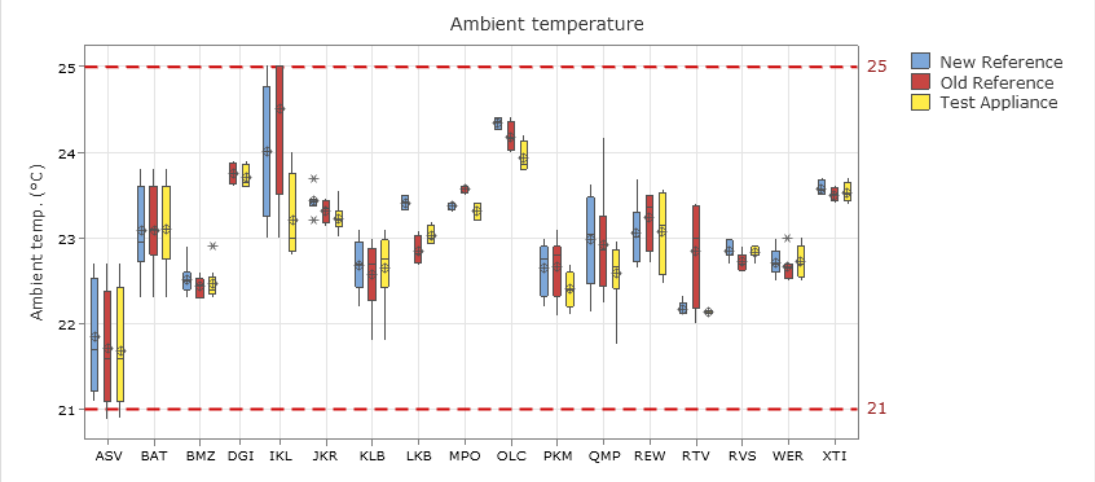


Figure 28: Boxplot of ambient temperature by lab and machine

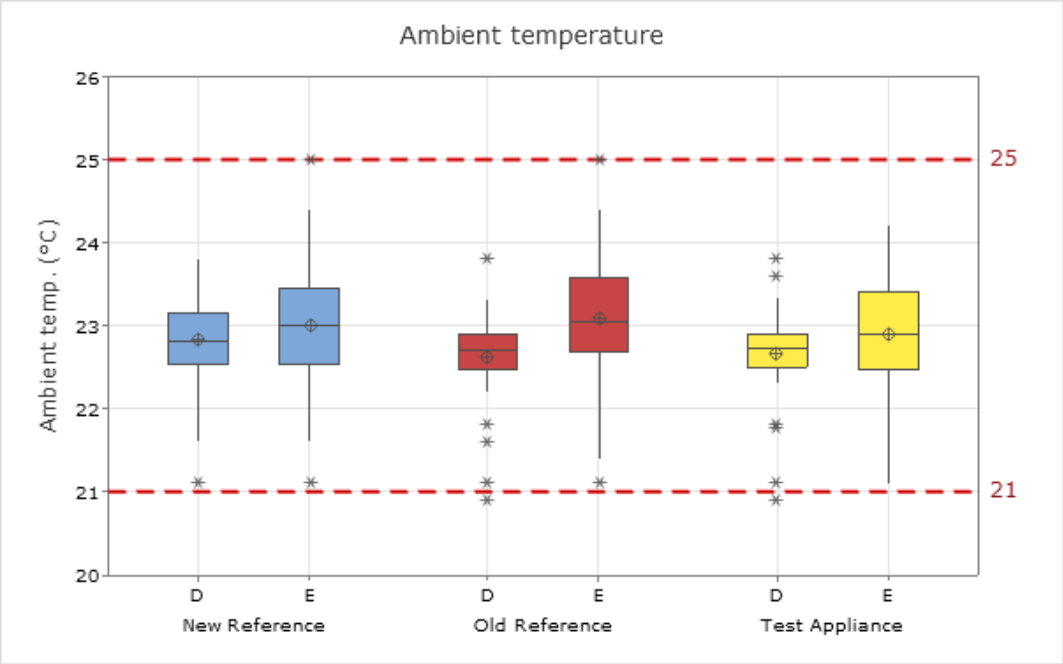


Figure 29: Aggregated boxplot of ambient temperature by detergent and machine

9.2 Appliance parameters

The appliance parameters shown in this chapter include water consumption, energy consumption and program duration. The dishwashing cycles where regeneration occurred were excluded for the calculation of the mean values.

9.2.1 Duration (cycle time)

Figure 30 shows the aggregated mean values of the duration by machine and detergent. The target value of 144 minutes for the new reference machine, 97 minutes for the old reference machine and 270 minutes for the test appliance is met in all runs (Table 21). For the reference machine the mean value is 143,84 ± 0,93 minutes, with minimum values of 142 minutes and maximum values of 148 minutes. For the old reference machine the mean value is 96,59 ± 2,18 minutes, with minimum values of 92 minutes and maximum values of 101,40 minutes. For the test appliance the mean value is 269,96 ± 1,72 minutes, with minimum values of 263 minutes and maximum values of 278 minutes.

Table 21: Basic descriptive statistics of duration (minutes)

Machine	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
NR	104	143,840	0,0914	0,932	142,000	143,000	144,000	144,000	148,000
OR	103	96,598	0,215	2,183	92,000	95,000	97,000	98,000	101,410
TA	108	269,960	0,165	1,720	263,000	269,000	270,000	270,000	278,000

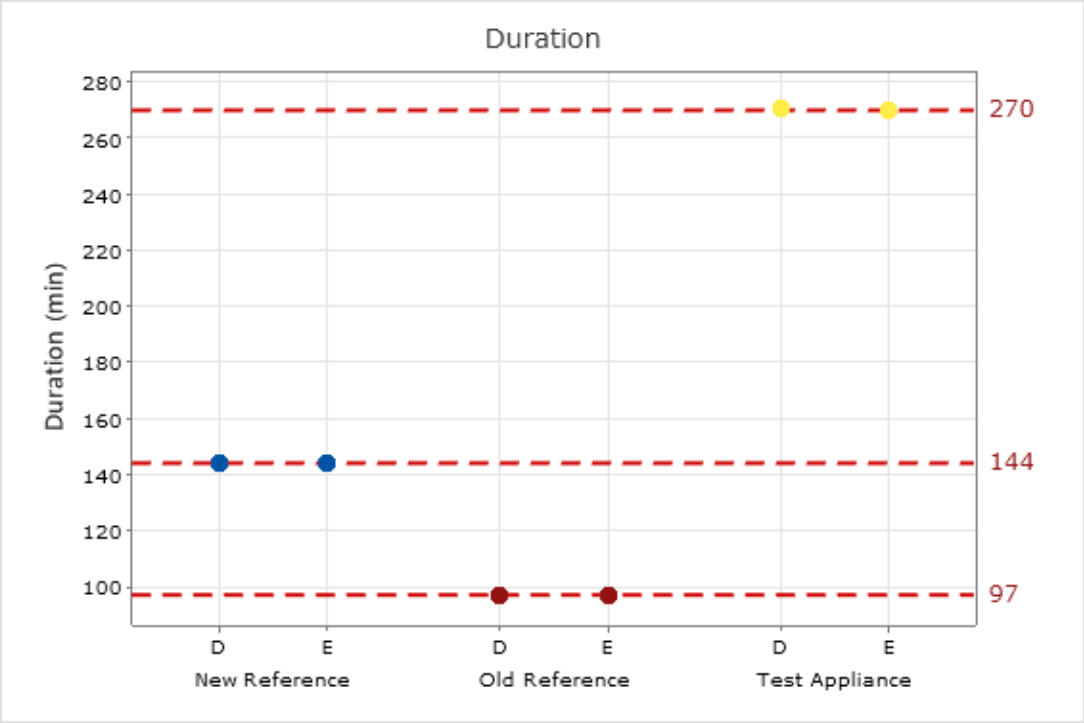


Figure 30: Aggregated mean values and SD of duration by machine and detergent

Figure 31 shows the mean values and SD of duration by lab and machine (detergent E only).

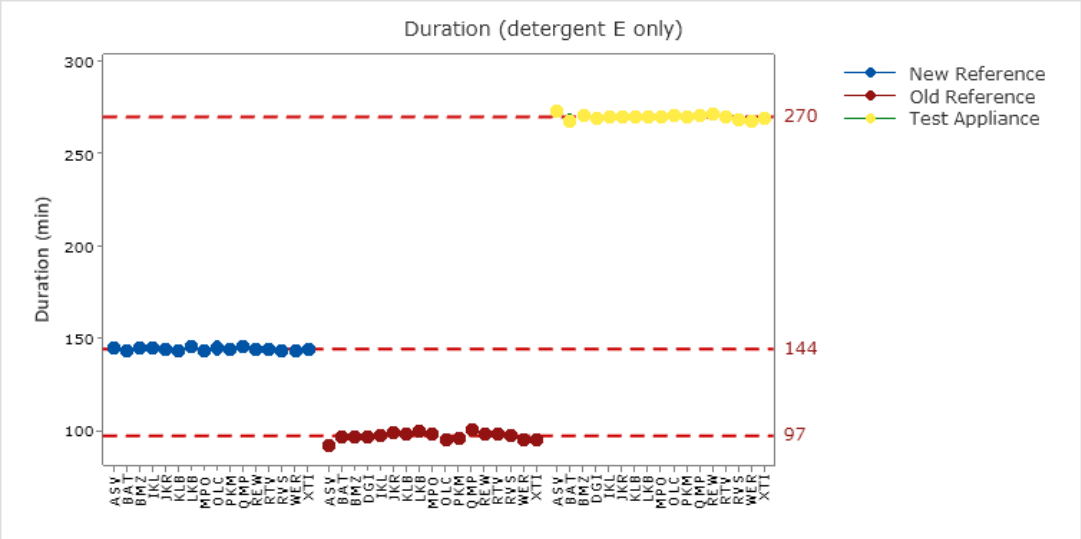


Figure 31: Mean values and SD of duration by lab and machine (detergent E only)

In table 22 the overall basic descriptive statistics of duration is shown by detergent and machine including the Mandel h and Mandel k values by lab. The Mandel h and Mandel k limit values are shown at the bottom lines, the outliers by are highlighted.

Outliers are shown for Mandel h for TA, det. E, lab ASV and for Mandel k for NE, det. E, lab OLC, TA, det. E, lab BAT, NR, det. D, lab ASV, OR, det D, lab KLB and TA, det. D, lab KLB.

Table 22: Basic descriptive statistics of duration including Mandel h / k-values (minutes)

NR E

Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	143,000	145,000	144,250	0,957	0,461	1,290
BAT	4	142,900	143,100	143,000	0,082	-1,149	0,110
BMZ	3	144,400	144,600	144,500	0,100	0,783	0,135
DGI							
IKL	4	144,000	145,000	144,750	0,500	1,105	0,673
JKR	4	143,000	144,000	143,750	0,500	-0,183	0,673
KLB	4	142,000	143,000	142,750	0,500	-1,471	0,673
LKB	4	144,900	145,100	145,000	0,082	1,428	0,110
MPO	4	143,000	144,000	143,250	0,500	-0,827	0,673
OLC	4	143,000	148,000	144,250	2,500	0,461	**3,367**
PKM	4	143,900	144,100	144,000	0,082	0,139	0,110
QMP	4	144,800	145,610	145,223	0,385	1,714	0,518
REW	4	143,900	144,100	144,000	0,082	0,139	0,110
RTV	5	143,000	144,100	143,800	0,453	-0,119	0,610
RVS	4	142,900	143,100	143,000	0,082	-1,149	0,110
WER	4	142,000	143,000	142,750	0,500	-1,471	0,673
XTI	4	143,900	144,100	144,000	0,082	0,139	0,110
h/k Crit (±)						2,335	1,879

OR E

N	MIN	MAX	AVG	SD	h(i)	k(i)
5	91,900	92,100	92,000	0,071	**-2,427**	0,099
4	96,000	97,000	96,250	0,500	-0,216	0,697
3	95,800	96,500	96,033	0,404	-0,329	0,564
4	95,900	96,100	96,000	0,082	-0,346	0,114
4	96,000	97,000	96,750	0,500	0,044	0,697
4	98,000	99,000	98,250	0,500	0,824	0,697
4	95,000	99,000	97,500	1,732	0,434	**2,415**
4	99,000	101,000	99,750	0,957	1,605	1,335
4	96,000	99,000	97,250	1,258	0,304	1,755
4	94,000	96,000	95,000	0,816	-0,866	1,138
4	95,000	96,000	95,750	0,500	-0,476	0,697
4	99,680	100,380	100,028	0,363	1,749	0,507
4	97,900	98,100	98,000	0,082	0,694	0,114
4	97,000	98,000	97,500	0,577	0,434	0,805
4	96,000	98,000	97,250	0,957	0,304	1,335
4	94,900	95,100	95,000	0,082	-0,866	0,114
4	94,900	95,100	95,000	0,082	-0,866	0,114
					2,350	1,883

TA E

N	MIN	MAX	AVG	SD	h(i)	k(i)
4	272,000	273,000	272,750	0,500	**2,442**	0,606
5	263,000	269,000	267,800	2,683	-1,667	**3,251**
5	270,000	271,000	270,400	0,418	0,491	0,507
4	268,000	270,000	269,000	0,816	-0,671	0,989
4	269,000	270,000	269,750	0,500	-0,048	0,606
4	269,900	270,100	270,000	0,082	0,159	0,099
4	269,900	270,100	270,000	0,082	0,159	0,099
4	269,900	270,100	270,000	0,082	0,159	0,099
5	269,000	270,000	269,800	0,447	-0,007	0,542
4	270,000	272,000	270,500	1,000	0,574	1,211
4	269,000	270,000	269,750	0,500	-0,048	0,606
4	270,060	271,410	270,740	0,556	0,774	0,673
4	270,000	272,000	271,000	0,816	0,989	0,989
4	269,900	270,100	270,000	0,082	0,159	0,099
4	268,000	269,000	268,500	0,577	-1,086	0,699
4	267,000	268,000	267,750	0,500	-1,709	0,606
4	268,900	269,100	269,000	0,082	-0,671	0,099
					2,350	1,860

NR D

Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	143,000	146,000	144,500	1,291	1,039	**2,377**
BAT	4	142,900	143,100	143,000	0,082	-1,074	0,150
BMZ	4	143,900	144,500	144,200	0,346	0,617	0,638
JKR	4	142,900	143,100	143,000	0,082	-1,074	0,150
KLB	4	143,000	144,000	143,250	0,500	-0,721	0,921
PKM	4	143,900	144,100	144,000	0,082	0,335	0,150
QMP	4	144,830	145,410	145,173	0,244	1,986	0,450
REW	4	143,000	144,000	143,500	0,577	-0,369	1,063
RVS	4	143,000	144,000	143,750	0,500	-0,017	0,921
WER	4	143,000	144,000	143,250	0,500	-0,721	0,921
h/k Crit (±)						2,176	1,883

OR D

N	MIN	MAX	AVG	SD	h(i)	k(i)
5	91,900	92,100	92,000	0,071	-2,053	0,103
3	96,900	97,100	97,000	0,100	0,125	0,146
3	95,800	96,600	96,300	0,436	-0,180	0,636
4	97,900	98,100	98,000	0,082	0,560	0,119
4	96,000	99,000	98,000	1,414	0,560	**2,063**
4	96,000	97,000	96,250	0,500	-0,202	0,729
4	99,000	101,410	99,873	1,127	1,376	1,643
4	98,000	99,000	98,250	0,500	0,669	0,729
4	94,000	95,000	94,750	0,500	-0,855	0,729
					2,127	1,841

TA D

N	MIN	MAX	AVG	SD	h(i)	k(i)
4	272,000	273,000	272,500	0,577	1,355	0,325
4	269,000	270,000	269,250	0,500	-0,707	0,281
4	269,500	270,900	270,275	0,685	-0,056	0,385
4	270,000	275,000	271,250	2,500	0,562	1,406
4	269,000	278,000	272,750	4,500	1,514	**2,530**
4	269,000	270,000	269,250	0,500	-0,707	0,281
4	270,000	271,000	270,500	0,577	0,086	0,325
4	269,000	270,000	269,500	0,577	-0,548	0,325
5	267,900	268,100	268,000	0,071	-1,499	0,040
					2,127	1,814

In table 23 the overall basic descriptive statistics of the program duration is shown by detergent and machine including standard deviations and the expanded uncertainty of the overall result (E_{OR}). The E_{OR} of the NR and TA is 2%, whereas the E_{OR} of the OR is 5%.

Table 23: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for duration (min)

Parameter	Machine	Detergent	N (labs)	Average	S_r	S_r %	S_R	S_R%	Expanded uncertainty / %
Duration (all data, including outliers)	NR	E	16	143,892	0,742	0,516	1,008	0,700	2
	OR	E	17	96,769	0,717	0,741	2,061	2,130	5
	TA	E	17	269,859	0,825	0,306	1,386	0,513	1
	NR	D	10	143,762	0,543	0,378	0,852	0,592	2
	OR	D	9	96,714	0,686	0,709	2,371	2,452	5
	TA	D	9	270,364	1,779	0,658	2,209	0,817	2
Duration (excluding outliers)	NR	E	15	143,868	0,414	0,288	0,874	0,608	2
	OR	E	15	96,921	0,619	0,638	1,684	1,737	4
	TA	E	15	269,746	0,525	0,195	0,978	0,363	1
	NR	D	9	143,680	0,378	0,263	0,774	0,538	2
	OR	D	8	96,553	0,528	0,547	2,443	2,530	6
	TA	D	8	270,066	1,014	0,375	1,644	0,609	2

9.2.2 Maximum temperature main wash

Figure 32 and table 24 show the aggregated mean values and SD of maximum temperature main wash by machine and detergent. The detergent has no impact on the max. temperature; nevertheless, a split data analysis is shown.

For the new reference machine, for which the target value is 45°C a mean max. temperature in the main wash of 45,57°C is reported for detergent D and 45,78°C for detergent E.

For the old reference machine, for which the target value is 52°C a mean max. temperature in the main wash of 50,45°C is reported for detergent D and 50,58°C for detergent E.

For the test appliance, for which the target value is 55°C a mean max. temperature in the main wash of 53,79°C is reported for detergent D and 54,33°C for detergent E.

Table 24: Basic descriptive statistics of maximum temperature main wash (°C)

Machine	Detergent	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
NR	D	40	45,571	0,146	0,923	43,100	45,400	45,750	46,100	47,100
NR	E	64	45,776	0,099	0,788	43,100	45,510	45,940	46,200	46,700
OR	D	35	50,449	0,077	0,456	49,700	50,000	50,400	50,800	51,400
OR	E	68	50,575	0,054	0,441	49,720	50,185	50,545	50,975	51,500
TA	D	37	53,794	0,324	1,969	48,900	53,350	54,100	55,100	57,200
TA	E	70	54,330	0,160	1,343	50,200	53,700	54,425	55,125	57,400

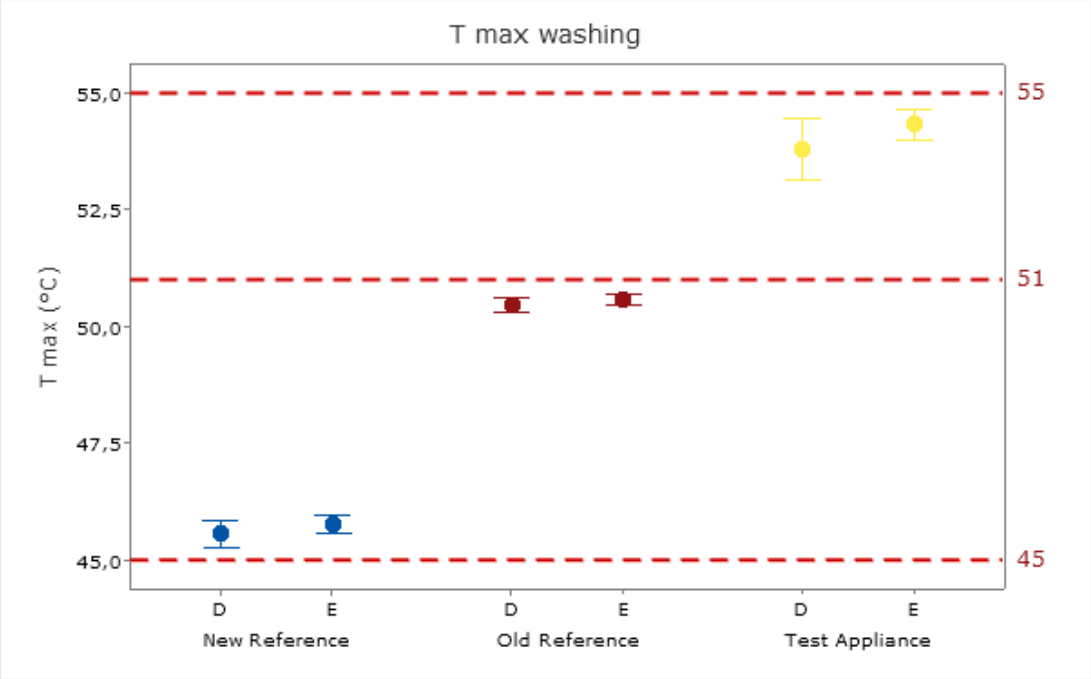


Figure 32: Aggregated mean values and SD of maximum temperature main wash by machine and detergent

Figure 33 shows the mean values and SD of maximum temperature main wash by lab and machine (detergent D+E).

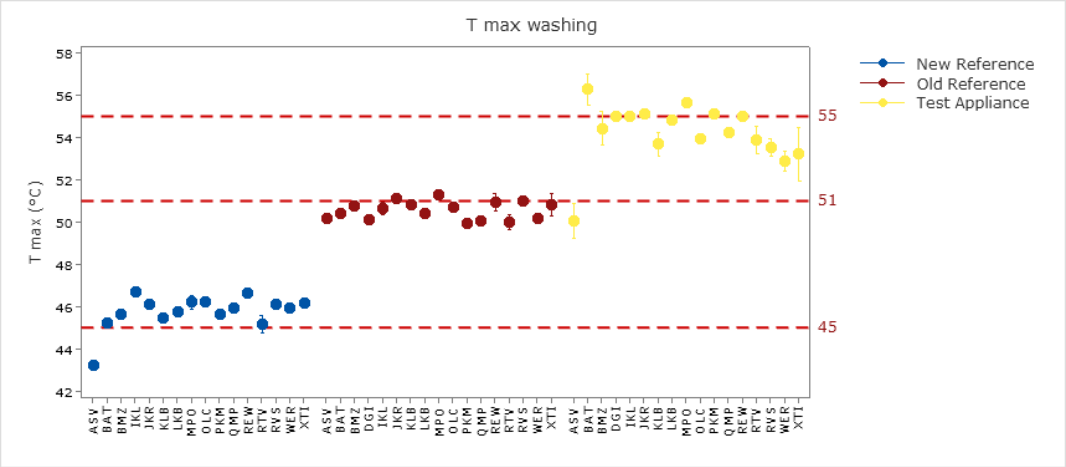


Figure 33: Mean values and SD of maximum temperature main wash by lab and machine (detergent D+E)

In table 25 the overall basic descriptive statistics of maximum temperature main wash is shown by detergent and machine including the Mandel h and Mandel k values by lab. The Mandel h and Mandel k limit values are shown at the bottom lines, the outliers by are highlighted.

Outliers are shown for the NR with det. D and E in Mandel h values for lab ASV and for NR, det. D in Mandel k for lab REW. Further on, one outlier is shown for OR, det. E in Mandel k value for lab XTI.

For the TA Mandel h value outliers are shown for lab ASV, for Mandel k for lab BAT in det. E runs and for lab BMZ in detergent D runs.

Table 25: Basic descriptive statistics of max. temperature main wash including Mandel h / k-values

NR E

Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	43,100	43,400	43,275	0,150	**-3,188**	0,850
BAT	4	45,200	45,400	45,300	0,115	-0,615	0,655
BMZ	3	45,400	45,800	45,667	0,231	-0,149	1,309
DGI							
IKL	4	46,600	46,700	46,675	0,050	1,132	0,283
JKR	4	46,000	46,100	46,075	0,050	0,370	0,283
KLB	4	45,400	45,700	45,525	0,126	-0,329	0,713
LKB	4	45,720	45,830	45,778	0,048	-0,008	0,271
MPO	4	46,000	46,500	46,200	0,216	0,528	1,225
OLC	4	46,100	46,400	46,223	0,132	0,557	0,747
PKM	4	45,800	45,900	45,825	0,050	0,052	0,283
QMP	4	45,620	46,180	45,890	0,272	0,134	1,542
REW	4	46,300	46,700	46,600	0,200	1,037	1,134
RTV	5	44,800	45,540	45,150	0,329	-0,806	1,867
RVS	4	45,900	46,500	46,175	0,250	0,497	1,417
WER	4	45,900	46,200	46,025	0,126	0,306	0,713
XTI	4	45,980	46,280	46,165	0,135	0,484	0,767
h/k Crit (±)						2,335	1,879

OR E

N	MIN	MAX	AVG	SD	h(i)	k(i)
5	50,000	50,400	50,180	0,179	-0,955	1,053
4	50,200	50,700	50,450	0,208	-0,317	1,225
3	50,700	50,900	50,800	0,100	0,510	0,589
4	50,000	50,300	50,125	0,126	-1,085	0,741
4	50,400	50,800	50,650	0,173	0,155	1,019
4	51,000	51,400	51,150	0,173	1,336	1,019
4	50,800	51,000	50,925	0,096	0,805	0,563
4	50,260	50,590	50,410	0,137	-0,412	0,808
4	51,200	51,500	51,325	0,126	1,750	0,741
4	50,500	50,800	50,700	0,141	0,273	0,832
4	49,930	50,140	50,063	0,097	-1,232	0,571
4	49,950	50,180	50,078	0,095	-1,197	0,559
4	50,700	51,300	50,950	0,252	0,864	1,481
4	49,720	50,250	49,998	0,229	-1,386	1,347
4	51,000	51,100	51,050	0,058	1,100	0,340
4	50,100	50,400	50,250	0,129	-0,790	0,760
4	50,500	51,200	50,830	0,334	0,580	**1,966**
					2,350	1,883

TA E

N	MIN	MAX	AVG	SD	h(i)	k(i)
4	50,200	51,500	50,875	0,556	**-2,637**	1,271
5	54,800	57,400	56,520	1,089	1,725	**2,491**
5	54,000	54,800	54,380	0,295	0,071	0,674
3	55,000	55,100	55,033	0,058	0,576	0,132
4	54,900	55,100	55,000	0,115	0,550	0,264
4	55,100	55,300	55,200	0,082	0,705	0,187
4	53,700	54,200	53,925	0,263	-0,280	0,601
4	54,630	54,930	54,825	0,133	0,415	0,305
5	55,600	55,800	55,660	0,089	1,060	0,205
4	53,800	54,000	53,925	0,096	-0,280	0,219
4	55,100	55,300	55,200	0,082	0,705	0,187
4	53,530	54,350	54,123	0,396	-0,128	0,905
4	54,900	55,200	55,000	0,141	0,550	0,323
4	53,340	54,270	53,898	0,411	-0,301	0,939
4	52,600	53,600	53,300	0,469	-0,763	1,073
4	52,100	53,500	52,800	0,577	-1,149	1,320
4	52,100	53,820	53,228	0,797	-0,819	1,823
					2,350	1,860

NR D

Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	43,100	43,300	43,175	0,096	**-2,527**	0,583
BAT	4	45,000	45,400	45,175	0,171	-0,418	1,040
BMZ	4	45,500	45,800	45,650	0,129	0,083	0,786
JKR	4	46,100	46,200	46,175	0,050	0,637	0,304
KLB	4	45,400	45,600	45,450	0,100	-0,128	0,609
PKM	4	45,326	45,625	45,483	0,152	-0,093	0,923
QMP	4	45,870	46,100	45,993	0,106	0,444	0,647
REW	4	46,300	47,100	46,725	0,330	1,216	**2,011**
RVS	4	45,700	46,200	46,038	0,236	0,492	1,436
WER	4	45,800	45,900	45,850	0,058	0,294	0,351
h/k Crit (±)						2,176	1,883

OR D

N	MIN	MAX	AVG	SD	h(i)	k(i)
5	50,000	50,500	50,200	0,235	-0,583	1,478
3	50,200	50,500	50,333	0,153	-0,285	0,963
3	50,600	50,800	50,733	0,115	0,610	0,728
4	50,900	51,400	51,125	0,206	1,486	1,299
4	50,600	50,800	50,750	0,100	0,647	0,630
4	49,700	49,900	49,850	0,100	-1,366	0,630
4	49,810	50,290	50,055	0,202	-0,908	1,273
4	50,900	51,100	50,975	0,096	1,151	0,603
4	49,900	50,200	50,125	0,150	-0,751	0,945
					2,127	1,841

TA D

N	MIN	MAX	AVG	SD	h(i)	k(i)
4	48,900	49,500	49,200	0,294	**-2,355**	0,389
4	55,300	57,200	55,975	0,854	1,101	1,129
4	53,500	57,000	54,525	1,664	0,361	**2,200**
4	54,830	55,230	55,063	0,170	0,636	0,225
4	52,100	54,000	53,450	0,904	-0,187	1,195
4	55,000	55,200	55,100	0,082	0,655	0,108
4	54,250	54,330	54,305	0,037	0,249	0,049
4	53,300	54,200	53,750	0,465	-0,034	0,616
5	52,000	53,800	52,980	0,701	-0,427	0,928
					2,127	1,814

Table 26 lists the repeatability (s_r) and reproducibility (s_R) results for max. temperature main wash by machine and detergent. Furthermore, the repeatability and the reproducibility are expressed as a percentage (s_r%, respectively s_R%) of the average values over the considered labs.

The table first shows the values including all values, and secondly the data sets excluding the outliers, highlighted in Table 24 (Mandel h: NR E: ASV, TA E: ASV, NR D: ASV, TA D: ASV; Mandel k: OR E: XTI, TA E: BAT, NR D: REW, TA D: BMZ).

Table 26: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for maximum temperature main wash (°C)

Parameter	Machine	Detergent	N (labs)	Average	S_r	S_r %	S_R	S_R%	Expanded uncertainty / %
Maximum temperature main wash (all data, including outliers)	NR	E	16	45,784	0,176	0,385	0,802	1,751	4
	OR	E	17	50,584	0,170	0,336	0,448	0,886	2
	TA	E	17	54,288	0,437	0,806	1,349	2,485	5
	NR	D	10	45,571	0,164	0,360	0,959	2,105	4
	OR	D	9	50,461	0,159	0,314	0,467	0,926	2
	TA	D	9	53,816	0,756	1,405	2,068	3,843	8
Maximum temperature main wash (excluding outliers)	NR	E	15	45,951	0,178	0,387	0,456	0,992	2
	OR	E	16	50,569	0,154	0,304	0,452	0,895	2
	TA	E	15	54,366	0,342	0,629	0,899	1,653	4
	NR	D	8	45,727	0,138	0,301	0,364	0,797	2
	OR	D	9	50,461	0,159	0,314	0,467	0,926	2
	TA	D	7	54,375	0,572	1,052	1,172	2,156	5

9.2.3 Maximum temperature rinsing

Figure 34 and table 27 show the aggregated mean values and SD of maximum temperature in the rinsing phase by machine and detergent. The detergent has no impact on the max. temperature, nevertheless a split data analysis is shown.

For the new reference machine, for which the target value is 62°C a mean max. temperature in the rinsing phase of 62,30°C is reported for detergent D and 62,49°C for detergent E.

For the old reference machine, for which the target value is 67°C a mean max. temperature in the rinsing phase of 67,54°C is reported for detergent D and 67,36°C for detergent E.

For the test appliance, for which the target value is 48°C a mean max. temperature in the rinsing phase of 47,44°C is reported for detergent D and 47,86°C for detergent E.

Table 27: Basic descriptive statistics of maximum temperature rinsing (°C)

Machine	Detergent	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
NR	D	40	62,305	0,255	1,615	57,500	62,500	62,880	63,142	63,500
NR	E	64	62,499	0,161	1,291	58,000	62,593	62,870	63,100	63,900
OR	D	35	67,535	0,109	0,648	66,100	66,980	67,500	67,900	68,520
OR	E	68	67,362	0,083	0,687	65,960	66,900	67,345	67,850	68,500
TA	D	37	47,444	0,250	1,518	43,700	46,600	47,800	48,480	50,100
TA	E	70	47,861	0,142	1,187	44,200	47,547	48,085	48,525	50,400

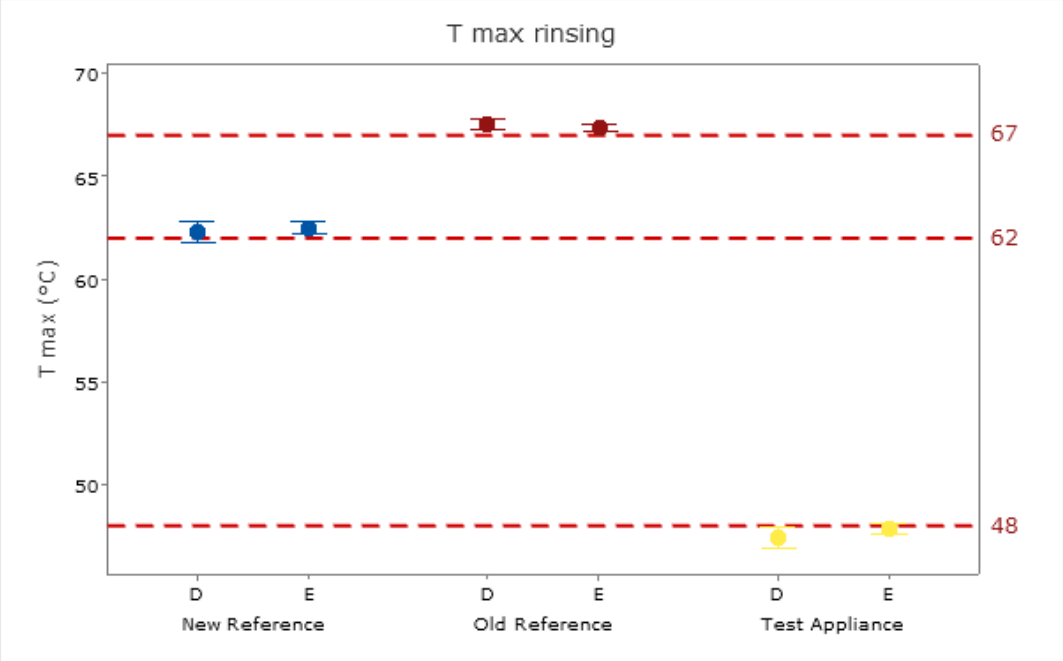


Figure 34: Aggregated mean values and SD of maximum temperature rinsing by machine and detergent

Figure 35 shows the mean values and SD of maximum temperature in the rinsing phase by lab and machine.

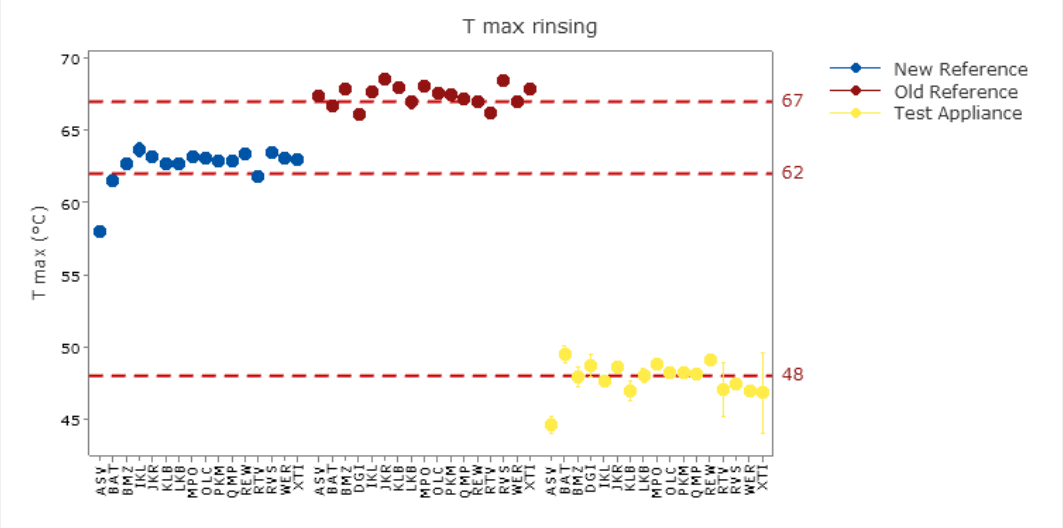


Figure 35: Mean values and SD of maximum temperature rinsing by lab and machine (detergent D+E)

In table 28 the overall basic descriptive statistics of maximum temperature rinsing is shown by detergent and machine including the Mandel h and Mandel k values by lab. The Mandel h and Mandel k limit values are shown at the bottom lines, the outliers by are highlighted.

Table 28: Basic descriptive statistics of max. temperature rinsing including Mandel h / k-values

NR E							
Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	58,000	58,100	58,050	0,058	**-3,405**	0,314
BAT	4	61,300	61,600	61,500	0,141	-0,771	0,768
BMZ	3	62,000	62,800	62,467	0,416	-0,033	**2,261**
DGI							
IKL	4	63,200	63,900	63,600	0,316	0,833	1,717
JKR	4	63,040	63,100	63,073	0,025	0,430	0,136
KLB	4	62,500	62,900	62,675	0,171	0,126	0,927
LKB	4	62,590	62,700	62,650	0,045	0,107	0,247
MPO	4	63,100	63,300	63,175	0,096	0,508	0,520
OLC	4	62,900	63,070	62,993	0,070	0,369	0,380
PKM	4	62,700	62,800	62,750	0,058	0,183	0,314
QMP	4	62,660	62,920	62,805	0,109	0,225	0,591
REW	4	63,200	63,400	63,275	0,096	0,584	0,520
RTV	5	61,310	62,130	61,754	0,347	-0,577	**1,887**
RVS	4	63,200	63,500	63,400	0,141	0,680	0,768
WER	4	63,000	63,200	63,100	0,082	0,451	0,443
XTI	4	62,730	63,050	62,890	0,168	0,290	0,914
h/k Crit (±)						2,335	1,879

OR E							
N	MIN	MAX	AVG	SD	h(i)	k(i)
5	66,800	67,500	67,160	0,251	-0,306	1,710
4	66,800	66,900	66,875	0,050	-0,718	0,341
3	67,700	68,100	67,867	0,208	0,713	1,418
4	66,000	66,100	66,025	0,050	-1,944	0,341
4	67,500	67,700	67,625	0,096	0,365	0,652
4	68,400	68,600	68,500	0,082	1,627	0,556
4	67,900	68,000	67,975	0,050	0,870	0,341
4	66,560	67,160	66,888	0,259	-0,700	1,764
4	67,700	68,200	67,975	0,222	0,870	1,511
4	67,500	67,600	67,558	0,051	0,267	0,345
4	67,250	67,460	67,343	0,090	-0,043	0,615
4	66,900	67,330	67,143	0,183	-0,332	1,247
4	66,800	67,000	66,950	0,100	-0,609	0,681
4	65,960	66,430	66,173	0,196	-1,731	1,338
4	68,300	68,500	68,400	0,082	1,483	0,556
4	66,900	67,200	67,075	0,126	-0,429	0,857
4	67,700	67,850	67,800	0,071	0,617	0,482
					2,350	1,883

TA E						
N	MIN	MAX	AVG	SD	h(i)	k(i)
4	44,600	45,700	45,150	0,493	**-2,515**	0,781
5	48,300	50,400	49,640	0,865	1,698	1,369
5	47,700	48,200	48,100	0,224	0,253	0,354
3	48,400	49,000	48,700	0,300	0,816	0,475
4	47,400	47,800	47,625	0,171	-0,193	0,270
4	48,500	48,700	48,575	0,096	0,699	0,152
4	45,800	47,600	47,000	0,849	-0,779	1,344
4	47,570	48,190	48,010	0,297	0,169	0,470
5	48,600	49,000	48,780	0,148	0,891	0,235
4	48,000	48,300	48,170	0,154	0,319	0,243
4	48,200	48,346	48,237	0,073	0,381	0,116
4	47,780	48,180	47,980	0,179	0,141	0,284
4	48,700	49,200	49,075	0,250	1,168	0,396
4	45,300	47,690	47,023	1,152	-0,758	1,823
4	46,800	47,900	47,350	0,532	-0,451	0,843
4	46,800	47,000	46,900	0,082	-0,873	0,129
4	44,200	47,870	46,800	1,744	-0,967	**2,761**
					2,350	1,860

NR D							
Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	57,500	58,000	57,775	0,222	**-2,702**	1,578
BAT	4	61,400	61,700	61,500	0,141	-0,480	1,007
BMZ	4	62,500	62,900	62,700	0,163	0,236	1,162
JKR	4	63,100	63,190	63,153	0,039	0,506	0,275
KLB	4	62,400	62,600	62,525	0,096	0,131	0,681
PKM	4	62,835	62,900	62,858	0,030	0,330	0,215
QMP	4	62,630	63,120	62,890	0,204	0,349	1,453
REW	4	63,200	63,400	63,275	0,096	0,579	0,681
RVS	4	63,100	63,500	63,350	0,173	0,623	1,233
WER	4	62,900	63,100	63,025	0,096	0,429	0,681
h/k Crit (±)						2,176	1,883

OR D							
N	MIN	MAX	AVG	SD	h(i)	k(i)
5	67,200	67,700	67,460	0,207	-0,079	1,415
3	66,100	66,700	66,433	0,306	-1,576	**2,084**
3	67,800	67,900	67,833	0,058	0,465	0,394
4	68,440	68,520	68,468	0,036	1,390	0,245
4	67,700	67,800	67,775	0,050	0,380	0,341
4	67,300	67,500	67,400	0,082	-0,167	0,557
4	66,900	67,300	67,060	0,173	-0,662	1,179
4	68,300	68,500	68,400	0,082	1,291	0,557
4	66,700	66,900	66,800	0,082	-1,041	0,557
					2,127	1,841

TA D						
N	MIN	MAX	AVG	SD	h(i)	k(i)
4	43,700	44,400	44,000	0,316	**-2,305**	0,507
4	48,600	50,100	49,200	0,638	1,161	1,022
4	46,300	49,300	47,700	1,324	0,161	**2,123**
4	48,500	48,700	48,575	0,096	0,744	0,153
4	45,900	47,800	46,825	0,964	-0,422	1,545
4	48,100	48,200	48,150	0,058	0,461	0,093
4	47,920	48,460	48,180	0,295	0,481	0,473
4	47,400	47,700	47,575	0,126	0,078	0,202
5	46,600	47,500	46,920	0,444	-0,359	0,712
					2,127	1,814

Table 29 lists the repeatability (s_r) and reproducibility (s_R) results for max. temperature rinsing by machine and detergent. Furthermore, the repeatability and the reproducibility are expressed as a percentage (s_r%, respectively s_R%) of the average values over the considered labs.

The table first shows the values including all values, and secondly the data sets excluding the outliers, highlighted in Table 27 (Mandel h: NR E: ASV, TA E: ASV, NR D: ASV, TA D: ASV; Mandel k: NR E: BMZ, RTV, TA E: XTI, TA D: BMZ).

Table 29: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for maximum temperature rinsing (°C)

Parameter	Machine	Detergent	N (labs)	Average	S_r	S_r %	S_R	S_R%	Expanded uncertainty / %
Maximum temperature rinsing (all data, including outliers)	NR	E	16	62,51	0,184	0,295	1,319	2,111	5
	OR	E	9	67,514	0,147	0,217	0,697	1,033	3
	TA	E	17	47,83	0,632	1,32	1,199	2,507	5
	NR	D	10	62,305	0,141	0,226	1,681	2,698	6
	OR	D	9	67,514	0,147	0,217	0,697	1,033	3
	TA	D	9	47,458	0,624	1,314	1,595	3,361	7
Maximum temperature rinsing (excluding outliers)	NR	E	13	62,914	0,137	0,218	0,525	0,834	2
	OR	E	17	67,372	0,147	0,218	0,704	1,046	3
	TA	E	15	48,078	0,483	1,004	0,906	1,884	4
	NR	D	9	62,808	0,128	0,204	0,569	0,906	2
	OR	D	8	67,649	0,112	0,165	0,599	0,886	2
	TA	D	7	47,918	0,485	1,013	0,964	2,012	5

9.3 Consumption values

9.3.1 Water consumption

Figure 36 and table 30 show the aggregated mean values and SD of water consumption by machine and detergent. The detergent has no impact on the water consumption, nevertheless a split data analysis is shown.

For the new reference machine, for which the target value is 8,9L a water consumption of 8,72L is reported for detergent D and 8,76L for detergent E.

For the old reference machine, for which the target value is 14,3L a water consumption of 14,32L is reported for detergent D and 14,39L for detergent E.

For the test appliance, for which the target value is 9,5 L a water consumption of 9,44L is reported for detergent D and 9,43L for detergent E.

Table 30: Basic descriptive statistics of water consumption (L)

Machine	Detergent	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
NR	D	40	8,716	0,016	0,099	8,500	8,673	8,703	8,800	8,900
NR	E	64	8,764	0,015	0,120	8,500	8,700	8,790	8,800	9,080
OR	D	35	14,321	0,021	0,121	14,000	14,280	14,330	14,400	14,500
OR	E	68	14,393	0,021	0,173	14,000	14,300	14,400	14,500	14,920
TA	D	37	9,444	0,020	0,123	9,200	9,392	9,490	9,540	9,600
TA	E	71	9,436	0,015	0,123	9,000	9,390	9,450	9,510	9,640

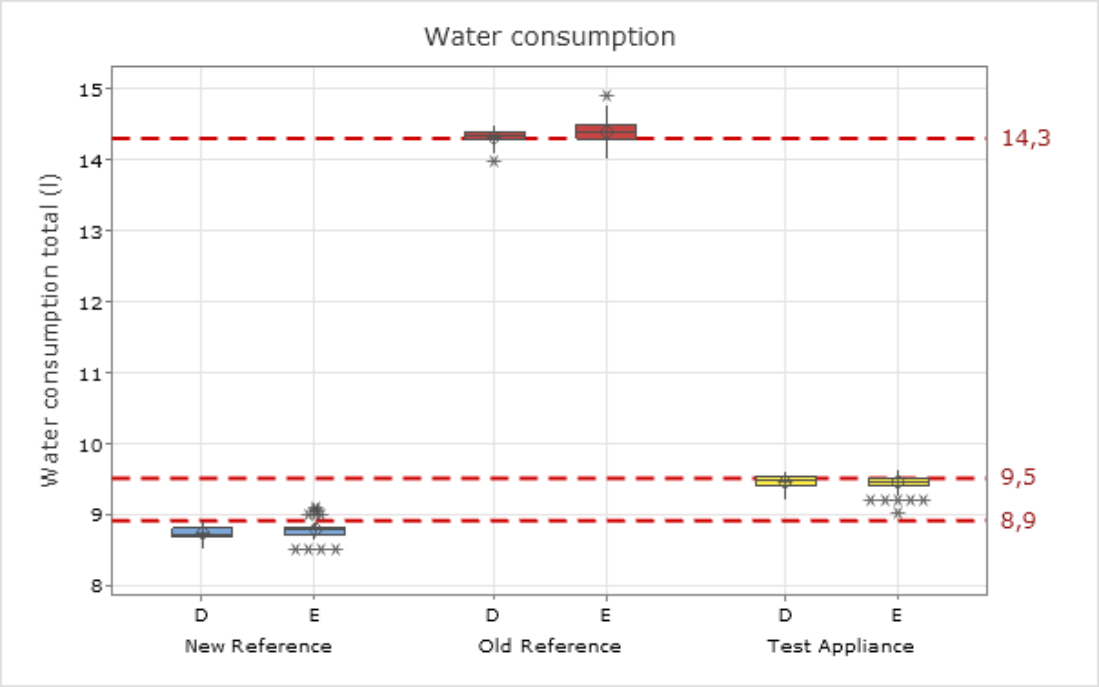
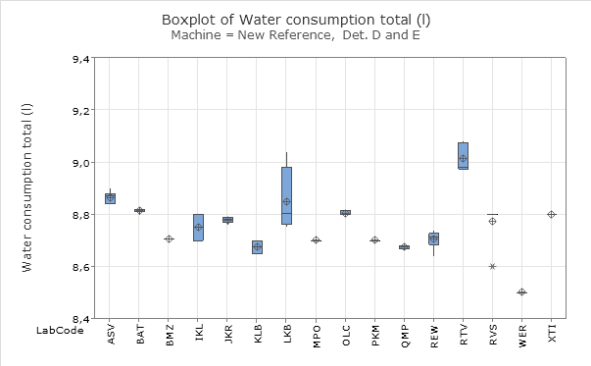
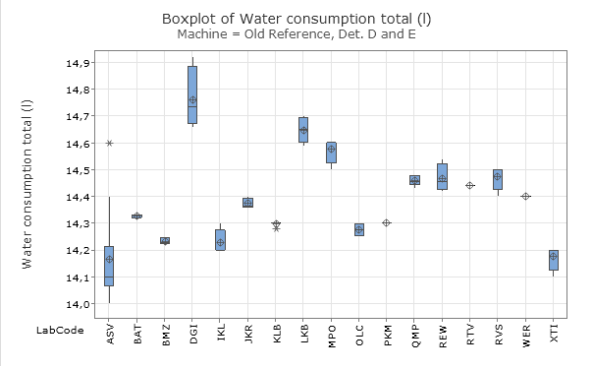


Figure 36: Aggregated mean values and SD of water consumption by machine and detergent

In the following tables and figures the reported values by machine, detergent and lab are shown, along with the consistency testing.





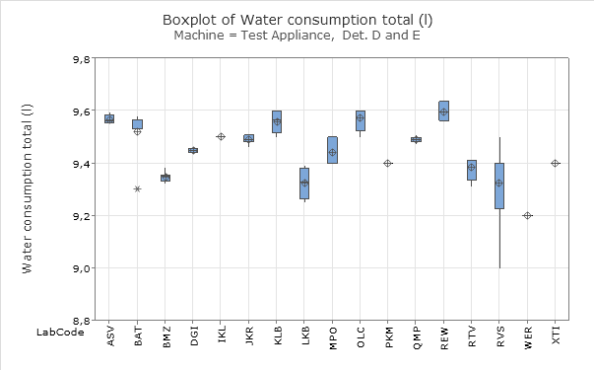


Figure 37: Boxplots of water consumption of new reference machine, old reference machine and test appliance for detergent D and E by labs

In table 31 the overall basic descriptive statistics of water consumption is shown by detergent and machine including the Mandel h and Mandel k values by lab. The Mandel h and Mandel k limit values are shown at the bottom lines, the outliers by are highlighted. Mandel k outliers are shown for NR, det. E (lab LKB) and D (lab RVS), OR det E (lab ASV) and det. D (labs ASV and RVS) and TA, det. D (lab RVS). Mandel h outliers are just shown for 1 lab in NR, det. D (lab WER).

Table 31: Basic descriptive statistics of water consumption values including Mandel h / k-values

NR E							
Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	8,840	8,880	8,865	0,019	0,933	0,493
BAT	4	8,800	8,830	8,818	0,013	0,512	0,324
BMZ	3	8,707	8,708	8,708	0,001	-0,460	0,015
DGI							
IKL	4	8,700	8,800	8,750	0,058	-0,085	1,486
JKR	4	8,780	8,790	8,788	0,005	0,247	0,129
KLB	4	8,640	8,660	8,650	0,008	-0,970	0,210
LKB	4	8,750	9,040	8,850	0,129	0,800	**3,329**
MPO	4	8,690	8,710	8,700	0,008	-0,527	0,210
OLC	4	8,800	8,820	8,805	0,010	0,402	0,257
PKM	4	8,690	8,710	8,700	0,008	-0,527	0,210
QMP	4	8,670	8,680	8,678	0,005	-0,727	0,129
REW	4	8,720	8,740	8,728	0,010	-0,284	0,246
RTV	5	8,970	9,080	9,016	0,054	2,269	1,393
RVS	4	8,790	8,810	8,800	0,008	0,357	0,210
WER	4	8,490	8,510	8,500	0,008	-2,297	0,210
XTI	4	8,790	8,810	8,800	0,008	0,357	0,210
h/k Crit (±)						2,335	1,879

OR E							
N	MIN	MAX	AVG	SD	h(i)	k(i)	
5	14,000	14,600	14,238	0,252	-0,958	**3,444**	
4	14,320	14,330	14,325	0,006	-0,421	0,079	
3	14,222	14,246	14,230	0,014	-1,006	0,185	
4	14,660	14,920	14,763	0,114	2,278	1,561	
4	14,200	14,300	14,225	0,050	-1,039	0,682	
4	14,360	14,400	14,370	0,020	-0,144	0,273	
4	14,290	14,310	14,300	0,008	-0,576	0,111	
4	14,590	14,700	14,648	0,048	1,569	0,653	
4	14,500	14,600	14,575	0,050	1,121	0,682	
4	14,250	14,300	14,275	0,024	-0,730	0,325	
4	14,290	14,310	14,300	0,008	-0,576	0,111	
4	14,430	14,480	14,455	0,021	0,381	0,284	
4	14,420	14,540	14,468	0,053	0,458	0,717	
4	14,430	14,450	14,440	0,008	0,288	0,111	
4	14,490	14,510	14,500	0,008	0,659	0,111	
4	14,390	14,410	14,400	0,008	0,041	0,111	
4	14,100	14,200	14,175	0,050	-1,347	0,682	
					2,350	1,883	

TA E						
N	MIN	MAX	AVG	SD	h(i)	k(i)
4	9,572	9,592	9,582	0,011	1,251	0,189
5	9,300	9,580	9,504	0,115	0,582	**1,988**
5	9,322	9,352	9,340	0,013	-0,833	0,222
4	9,440	9,460	9,450	0,008	0,116	0,141
4	9,490	9,510	9,500	0,008	0,548	0,141
4	9,460	9,510	9,488	0,021	0,440	0,355
4	9,500	9,530	9,518	0,015	0,699	0,258
4	9,250	9,390	9,325	0,062	-0,962	1,076
5	9,400	9,500	9,440	0,055	0,030	0,943
4	9,500	9,600	9,575	0,050	1,195	0,861
4	9,390	9,410	9,400	0,008	-0,315	0,141
4	9,480	9,510	9,493	0,013	0,483	0,217
4	9,560	9,640	9,598	0,039	1,389	0,665
4	9,310	9,410	9,385	0,050	-0,444	0,861
4	9,000	9,400	9,225	0,171	-1,825	**2,941**
4	9,190	9,210	9,200	0,008	-2,041	0,141
4	9,390	9,410	9,400	0,008	-0,315	0,141
					2,350	1,860

NR D							
Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	8,840	8,900	8,865	0,030	1,520	0,858
BAT	4	8,810	8,820	8,815	0,006	1,010	0,165
BMZ	4	8,706	8,708	8,707	0,001	-0,091	0,023
JKR	4	8,760	8,780	8,770	0,008	0,551	0,234
KLB	4	8,690	8,710	8,700	0,008	-0,163	0,234
PKM	4	8,690	8,710	8,700	0,008	-0,163	0,234
QMP	4	8,660	8,680	8,670	0,008	-0,469	0,234
REW	4	8,640	8,710	8,683	0,031	-0,341	0,885
RVS	4	8,600	8,800	8,750	0,100	0,347	**2,860**
WER	4	8,490	8,510	8,500	0,008	**-2,202**	0,234
h/k Crit (±)						2,176	1,883

OR D							
N	MIN	MAX	AVG	SD	h(i)	k(i)	
5	14,000	14,150	14,090	0,055	-2,034	**1,905**	
3	14,320	14,330	14,327	0,006	0,010	0,201	
3	14,223	14,246	14,233	0,012	-0,802	0,415	
4	14,360	14,400	14,375	0,017	0,428	0,602	
4	14,280	14,310	14,295	0,013	-0,263	0,449	
4	14,290	14,310	14,300	0,008	-0,220	0,284	
4	14,440	14,480	14,460	0,018	1,162	0,635	
4	14,400	14,500	14,450	0,058	1,075	**2,008**	
4	14,390	14,410	14,400	0,008	0,644	0,284	
					2,127	1,841	

TA D						
N	MIN	MAX	AVG	SD	h(i)	k(i)
4	9,550	9,552	9,552	0,001	0,828	0,048
4	9,530	9,570	9,540	0,020	0,734	0,960
4	9,330	9,384	9,357	0,022	-0,773	1,070
4	9,480	9,510	9,495	0,013	0,364	0,620
4	9,590	9,610	9,600	0,008	1,226	0,392
4	9,390	9,410	9,400	0,008	-0,415	0,392
4	9,470	9,500	9,488	0,013	0,303	0,604
4	9,400	9,500	9,425	0,050	-0,210	**2,400**
5	9,190	9,210	9,200	0,007	-2,057	0,339
					2,127	1,814

Table 32 lists the repeatability (s_r) and reproducibility (s_R) results for energy consumption by machine and detergent. Furthermore, the repeatability and the reproducibility are expressed as a percentage (s_r%, respectively s_R%) of the average values over the considered labs.

The table first shows the values including all values, and secondly the data sets excluding the outliers, highlighted in Table 30 (Mandel h: NR D: WER, Mandel k: OR E: ASV, TA E: BAT, RVS, NR D RVS, OR D: ASV, RVS, TA D: RVS).

Table 32: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for water consumption (L)

Parameter	Machine	Detergent	N (labs)	Average	S_r	S_r %	S_R	S_R%	Expanded uncertainty / %
Water consumption (all data, including outliers)	NR	E	16	8,760	0,039	0,444	0,118	1,346	3
	OR	E	17	14,393	0,073	0,509	0,174	1,209	3
	TA	E	17	9,437	0,058	0,615	0,126	1,340	3
	NR	D	10	8,716	0,035	0,401	0,103	1,178	3
	OR	D	9	14,325	0,029	0,201	0,118	0,827	2
	TA	D	9	9,451	0,021	0,220	0,123	1,303	3
Water consumption (excluding outliers)	NR	E	15	8,754	0,022	0,254	0,116	1,324	3
	OR	E	16	14,403	0,042	0,288	0,166	1,153	3
	TA	E	15	9,446	0,031	0,333	0,112	1,183	3
	NR	D	8	8,739	0,016	0,188	0,072	0,821	2
	OR	D	7	14,341	0,013	0,088	0,077	0,534	2
	TA	D	8	9,454	0,013	0,140	0,130	1,379	3

9.3.2 Energy consumption

Figure 38 and table 33 show the aggregated mean values and SD of energy consumption by machine and detergent. The detergent has no impact on energy consumption, nevertheless a split data analysis is shown.

For the new reference machine, for which the target value is 0,87 kWh, an energy consumption of 0,87 kWh is reported for detergent D and 0,88 kWh for detergent E.

For the old reference machine, for which the target value is 1,25 kWh, an energy consumption of 1,28 kWh is reported for detergent D and for detergent E.

For the test appliance, for which the target value is 0,71 kWh, an energy consumption of 0,71 kWh is reported for detergent D and E.

Table 33: Basic descriptive statistics of energy consumption (kWh)

Machine	Detergent	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
NR	D	40	0,876	0,003	0,016	0,852	0,862	0,870	0,891	0,903
NR	E	64	0,881	0,002	0,017	0,852	0,866	0,878	0,898	0,912
OR	D	35	1,279	0,006	0,034	1,224	1,238	1,287	1,304	1,340
OR	E	68	1,275	0,004	0,034	1,193	1,246	1,287	1,297	1,332
TA	D	37	0,708	0,004	0,024	0,665	0,700	0,706	0,716	0,788
TA	E	71	0,712	0,003	0,023	0,666	0,699	0,709	0,724	0,783

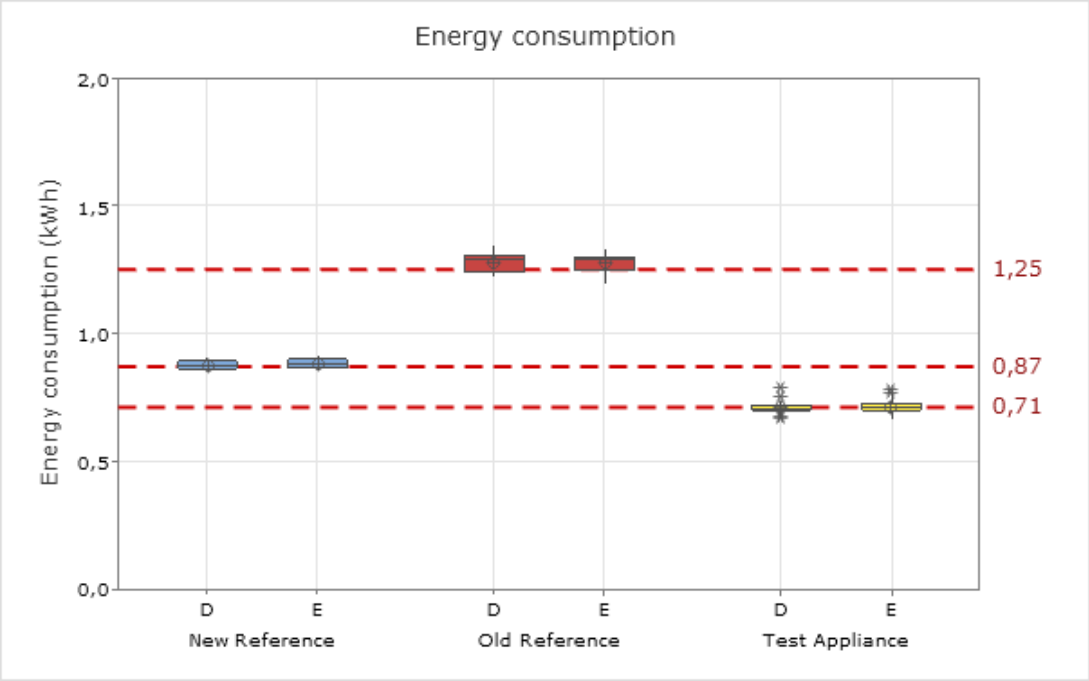
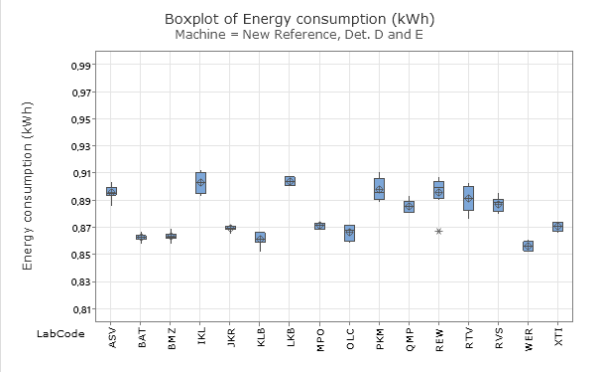
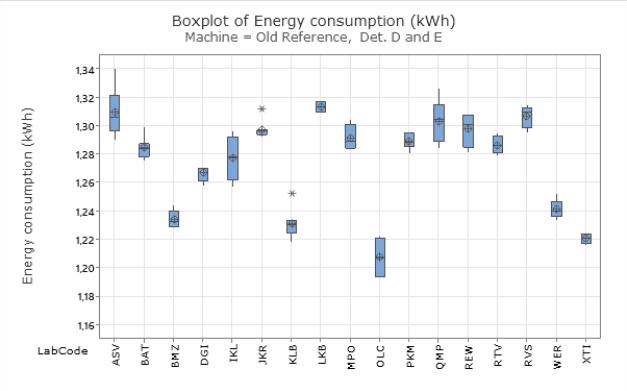


Figure 38: Aggregated mean values and SD of energy consumption by machine and detergent

Figure 39 shows the energy consumption values by appliance per lab for det. E.





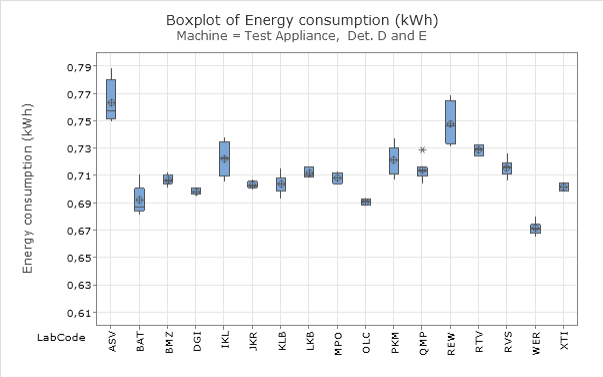


Figure 39: Boxplots of energy consumption of new reference machine, old reference machine and test appliance for detergent D and E by labs

In table 34 the overall basic descriptive statistics of energy consumption is shown by detergent and machine including the Mandel h and Mandel k values by lab. The Mandel h and Mandel k limit values are shown at the bottom lines, the outliers by are highlighted. For detergent E runs there is one outlier in the NR appliance (Mandel k, lab RTV) and in the TA (Lab ASV, Mandel h). For detergent D there is one outlier in the NR appliance (Mandel k, lab REW), two outliers in the OR (ASV and QMP, both Mandel k). Further on lab ASV shows outliers in Mandel h and k for TA, detergent D and is thus excluded for the further Sr and SR analysis for the TA.

Table 34: Basic descriptive statistics of energy consumption (kWh) including Manel h /k-values

NR E

Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	0,886	0,901	0,895	0,006	0,808	1,239
BAT	4	0,858	0,864	0,862	0,003	-1,127	0,554
BMZ	3	0,862	0,869	0,865	0,004	-0,956	0,731
DGI							
IKL	4	0,893	0,912	0,903	0,008	1,281	1,531
JKR	4	0,869	0,872	0,871	0,001	-0,599	0,243
KLB	4	0,859	0,867	0,863	0,003	-1,054	0,630
LKB	4	0,900	0,908	0,904	0,003	1,355	0,630
MPO	4	0,868	0,873	0,871	0,002	-0,584	0,417
OLC	4	0,858	0,872	0,866	0,006	-0,863	1,204
PKM	4	0,898	0,911	0,905	0,006	1,399	1,073
QMP	4	0,881	0,893	0,887	0,005	0,356	0,959
REW	4	0,895	0,907	0,901	0,005	1,193	1,026
RTV	5	0,876	0,903	0,891	0,010	0,603	**1,951**
RVS	4	0,880	0,890	0,884	0,004	0,165	0,869
WER	4	0,852	0,861	0,858	0,004	-1,362	0,778
XTI	4	0,866	0,874	0,871	0,004	-0,613	0,714
h/k Crit (±)						2,335	1,879

OR E

N	MIN	MAX	AVG	SD	h(i)	k(i)
5	1,297	1,332	1,310	0,015	1,083	1,532
4	1,275	1,287	1,280	0,005	0,188	0,531
3	1,230	1,244	1,236	0,007	-1,123	0,735
4	1,258	1,270	1,267	0,006	-0,207	0,621
4	1,257	1,296	1,277	0,016	0,091	1,664
4	1,292	1,312	1,298	0,009	0,718	0,975
4	1,218	1,252	1,233	0,014	-1,230	1,478
4	1,309	1,317	1,313	0,004	1,166	0,378
4	1,283	1,304	1,291	0,009	0,509	0,945
4	1,193	1,222	1,207	0,015	-1,992	1,539
4	1,289	1,295	1,293	0,003	0,577	0,297
4	1,293	1,311	1,303	0,008	0,875	0,786
4	1,281	1,308	1,298	0,012	0,703	1,284
4	1,279	1,294	1,286	0,006	0,368	0,641
4	1,295	1,312	1,302	0,008	0,823	0,786
4	1,236	1,252	1,242	0,008	-0,954	0,793
4	1,216	1,224	1,221	0,003	-1,596	0,354
					2,350	1,883

TA E

N	MIN	MAX	AVG	SD	h(i)	k(i)
4	0,753	0,783	0,767	0,013	**2,383**	1,734
5	0,681	0,687	0,685	0,003	-1,207	0,342
5	0,705	0,711	0,708	0,003	-0,200	0,355
4	0,696	0,701	0,698	0,002	-0,620	0,333
4	0,705	0,738	0,722	0,014	0,442	1,840
4	0,701	0,707	0,704	0,003	-0,368	0,436
4	0,698	0,715	0,707	0,007	-0,248	0,984
4	0,709	0,717	0,712	0,004	-0,018	0,514
5	0,703	0,713	0,708	0,004	-0,182	0,561
4	0,688	0,693	0,691	0,002	-0,938	0,302
4	0,725	0,737	0,730	0,005	0,792	0,697
4	0,709	0,729	0,716	0,009	0,168	1,252
4	0,731	0,769	0,748	0,016	1,569	**2,236**
4	0,724	0,732	0,729	0,004	0,715	0,561
4	0,706	0,719	0,712	0,005	-0,007	0,728
4	0,666	0,675	0,671	0,004	-1,813	0,548
4	0,698	0,705	0,702	0,004	-0,467	0,478
					2,350	1,860

NR D

Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	0,894	0,903	0,896	0,005	1,295	0,763
BAT	4	0,861	0,867	0,863	0,003	-0,803	0,472
BMZ	4	0,858	0,865	0,863	0,003	-0,850	0,511
JKR	4	0,865	0,870	0,868	0,002	-0,501	0,355
KLB	4	0,852	0,867	0,860	0,006	-1,041	1,009
PKM	4	0,888	0,893	0,891	0,002	0,946	0,365
QMP	4	0,881	0,889	0,884	0,004	0,516	0,630
REW	4	0,867	0,902	0,890	0,016	0,866	**2,606**
RVS	4	0,888	0,895	0,891	0,003	0,930	0,545
WER	4	0,852	0,858	0,855	0,003	-1,359	0,414
h/k Crit (±)						2,176	1,883

OR D

N	MIN	MAX	AVG	SD	h(i)	k(i)
5	1,290	1,340	1,309	0,020	0,928	**1,887**
3	1,284	1,299	1,290	0,008	0,380	0,747
3	1,228	1,238	1,232	0,006	-1,339	0,518
4	1,296	1,297	1,296	0,000	0,564	0,047
4	1,224	1,233	1,229	0,005	-1,432	0,438
4	1,280	1,287	1,285	0,003	0,225	0,311
4	1,284	1,326	1,303	0,021	0,770	**1,971**
4	1,309	1,314	1,311	0,002	0,998	0,231
4	1,233	1,247	1,240	0,007	-1,093	0,620
					2,127	1,841

TA D

N	MIN	MAX	AVG	SD	h(i)	k(i)
4	0,749	0,788	0,760	0,019	**2,186**	**2,282**
4	0,690	0,711	0,701	0,009	-0,377	1,134
4	0,701	0,712	0,706	0,005	-0,163	0,583
4	0,699	0,704	0,702	0,002	-0,323	0,270
4	0,693	0,706	0,701	0,006	-0,366	0,698
4	0,707	0,717	0,712	0,005	0,126	0,607
4	0,704	0,716	0,712	0,006	0,105	0,691
4	0,716	0,726	0,719	0,005	0,426	0,574
5	0,665	0,680	0,672	0,005	-1,614	0,658
					2,127	1,814

Table 35 lists the repeatability (s_r) and reproducibility (s_R) results for energy consumption by machine and detergent. Furthermore, the repeatability and the reproducibility are expressed as a percentage (s_r%, respectively s_R%) of the average values over the considered labs.

The table first shows the values including all values, and secondly the data sets excluding the outliers, highlighted in Table 33 (Mandel h: TA E: ASV, TA D: ASV; Mandel k: NR E: RTV, TA E REW, NR D: REW, OR D ASV, QMP, TA D: ASV).

Table 35: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for energy consumption

Parameter	Machine	Detergent	N (labs)	Average	S_r	S_r %	S_R	S_R%	Expanded uncertainty / %
Energy consumption (all data, including outliers)	NR	E	16	0,881	0,005	0,588	0,018	1,998	4
	OR	E	17	1,274	0,010	0,758	0,035	2,709	6
	TA	E	17	0,712	0,007	1,032	0,024	3,331	7
	NR	D	10	0,876	0,006	0,694	0,017	1,894	4
	OR	D	9	1,277	0,011	0,832	0,035	2,753	6
	TA	D	8	0,709	0,008	1,159	0,024	3,444	7
Energy consumption (excluding outliers)	NR	E	15	0,880	0,005	0,531	0,018	2,028	5
	OR	E	17	1,274	0,010	0,758	0,035	2,709	6
	TA	E	15	0,706	0,006	0,806	0,017	2,364	5
	NR	D	9	0,874	0,004	0,415	0,016	1,853	4
	OR	D	7	1,269	0,005	0,395	0,035	2,726	6
	TA	D	8	0,703	0,006	0,806	0,015	2,152	5

9.4 Cleaning and drying performance

9.4.1 Cleaning performance

9.4.1.1 Overall cleaning score

Figure 40- 43 and table 36 show the aggregated mean values and SD of the overall cleaning score by detergent, arranged by machine and by lab to allow for detail data analysis.

For the new reference machine an overall mean cleaning score of 3,824 is reported for detergent D and 3,884 for detergent E.

For the old reference machine an overall mean cleaning score of 3,508 is reported for detergent D and 3,674 for detergent E.

For the test appliance an overall mean cleaning score of 4,140 is reported for detergent D and 4,152 for detergent E.

Table 36: Basic statistics of cleaning score by machine and detergent

Machine	Detergent	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
NR	D	40	3,824	0,040	0,252	3,353	3,653	3,809	4,013	4,381
NR	E	64	3,884	0,034	0,271	3,331	3,726	3,846	4,097	4,375
OR	D	35	3,508	0,034	0,200	3,015	3,331	3,537	3,647	3,993
OR	E	68	3,674	0,022	0,180	3,284	3,563	3,658	3,785	4,052
TA	D	37	4,140	0,070	0,427	2,911	4,007	4,253	4,351	4,799
TA	E	71	4,152	0,032	0,272	3,404	3,993	4,212	4,329	4,719

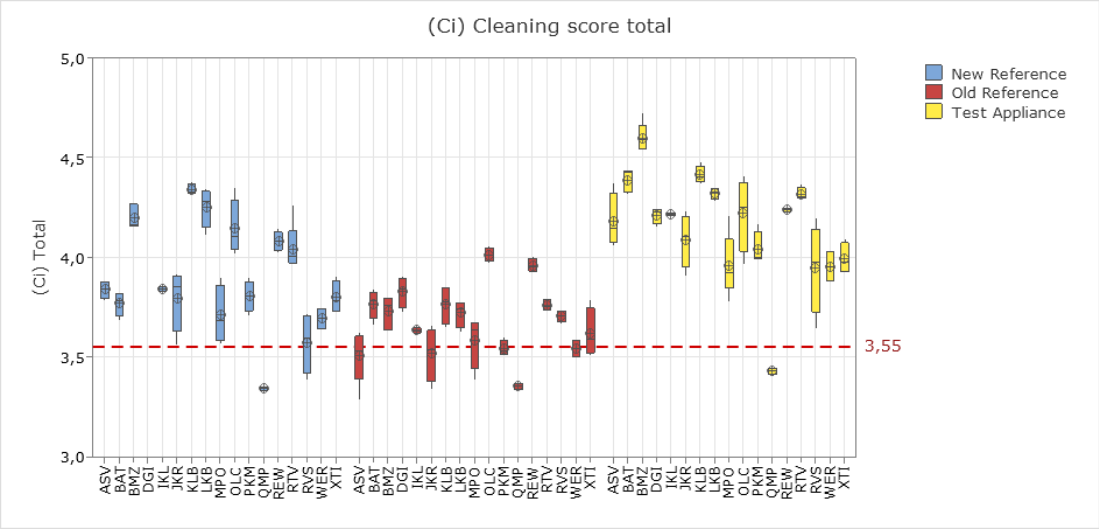


*Figure 40: Boxplot of overall cleaning score by lab and machine for **detergent E**, arranged by machine*

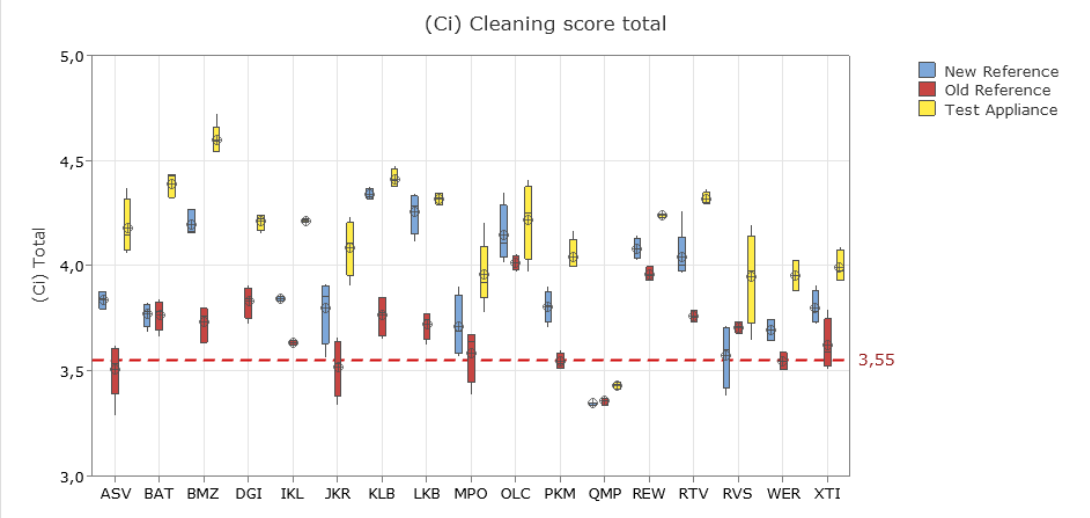


*Figure 41: Boxplot of overall cleaning score by lab and machine for **detergent E**, arranged by lab*

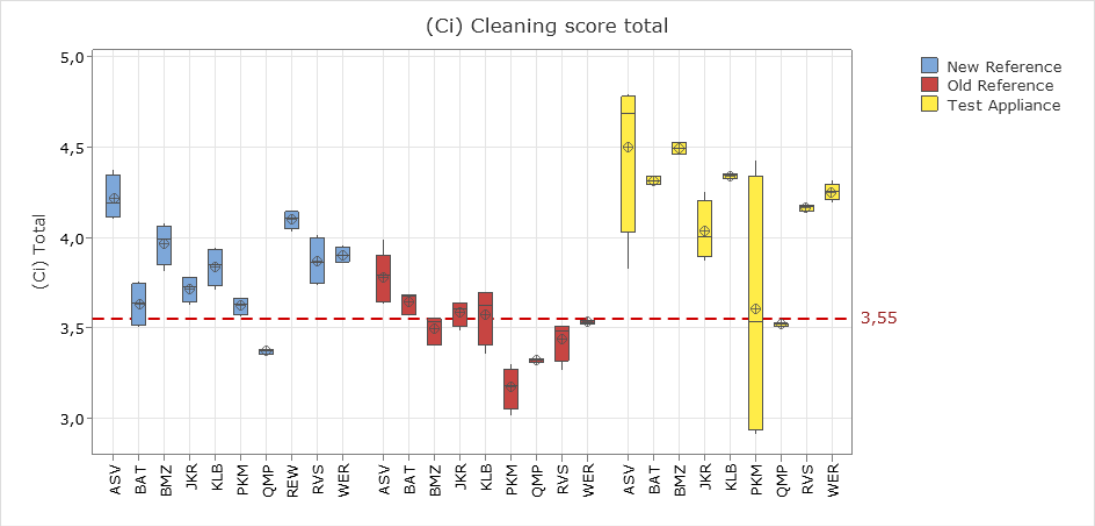


*Figure 42: Boxplot of overall cleaning score by lab and machine for **detergent D**, arranged by machine*

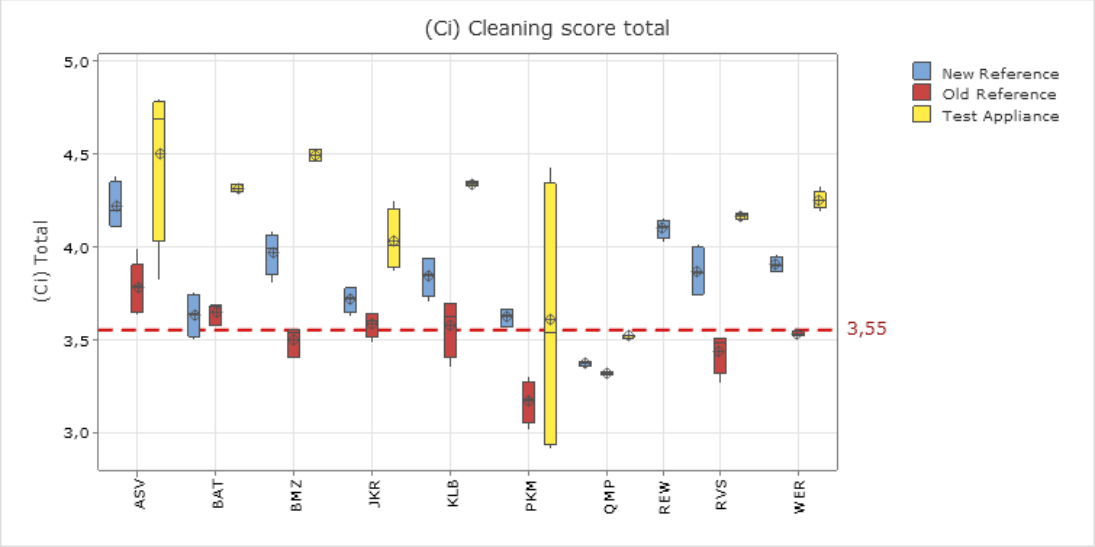


*Figure 43: Boxplots of overall cleaning score by lab and machine for **detergent D**, arranged by lab*

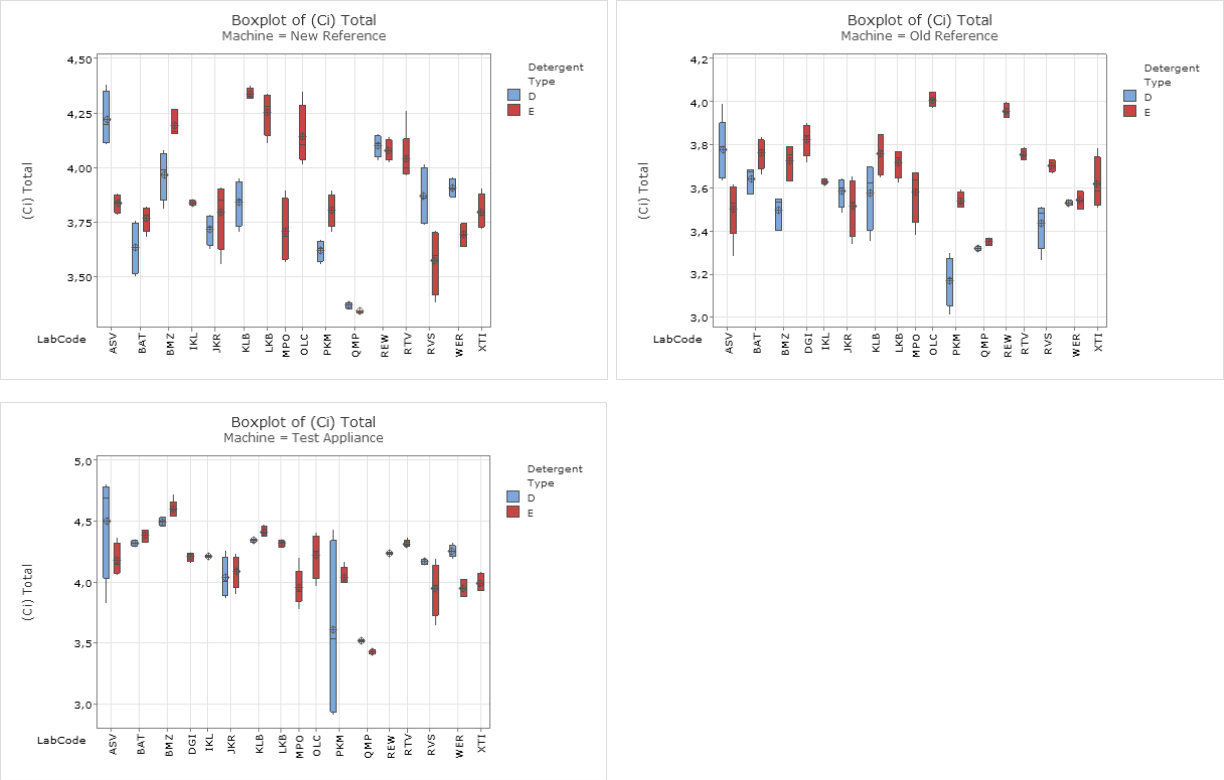


Figure 44: Boxplots of overall cleaning by machine, directly comparing detergent D and E values by lab

9.4.1.2 Cleaning scores by dishware

Table 37 and figure 45 display the overall cleaning scores by type of dishware, detergent and machine. The following dishware specification applies (c.f. 2.6): Crockery dishware includes soup plates, dinner plates, dessert plates, mugs, cups, saucers and oval platters. Pots include Small pot (inner bottom, inner wall, outer surface, overall), oven pot (inner bottom, inner wall, outer surface, overall). Glass includes glass bowls, dessert bowls, glasses. Melamine parts include melamine dessert plates and melamine bowls. Cutlery includes soup spoons, forks, knives, dessert spoons, tea spoons and serving cutlery.

For all dishware types and machines higher cleaning scores are reported for detergent E, apart from crockery: For crockery the NR and TA show lower cleaning scores for detergent E runs.

Table 37: Basic statistics of cleaning scores by type of dishware, detergent and machine

Dishware	Det.	Machine	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Crockery	D	NR	40	3,204	0,084	0,531	2,162	3,000	3,324	3,615	4,081
	E	NR	64	2,782	0,082	0,655	1,757	2,270	2,608	3,237	4,297
	D	OR	35	2,302	0,105	0,621	1,027	1,946	2,270	2,757	3,568
	E	OR	68	2,279	0,048	0,392	0,973	2,061	2,324	2,534	3,487
	D	TA	37	3,681	0,161	0,978	0,725	3,325	4,025	4,287	4,775
	E	TA	71	3,221	0,083	0,696	2,125	2,650	3,125	3,825	4,575
Cutlery	D	NR	40	4,714	0,031	0,194	4,328	4,547	4,719	4,906	5,000
	E	NR	64	4,752	0,024	0,189	4,250	4,586	4,766	4,902	5,000
	D	OR	35	4,595	0,032	0,188	4,219	4,469	4,594	4,781	4,875
	E	OR	68	4,677	0,021	0,172	4,328	4,516	4,703	4,828	4,969
	D	TA	37	4,671	0,035	0,212	4,044	4,558	4,681	4,819	5,000
	E	TA	71	4,746	0,023	0,194	4,087	4,623	4,812	4,913	5,000
Glass	D	NR	40	2,433	0,085	0,539	1,368	2,066	2,447	2,855	3,368
	E	NR	64	3,051	0,084	0,668	1,526	2,632	3,105	3,474	4,526
	D	OR	35	2,301	0,092	0,544	1,421	2,000	2,211	2,579	4,000
	E	OR	68	2,836	0,076	0,623	1,632	2,474	2,711	3,145	4,842
	D	TA	37	3,431	0,120	0,730	1,667	3,119	3,571	3,881	4,571
	E	TA	71	3,961	0,075	0,630	1,762	3,810	4,095	4,381	4,714
Melamine	D	NR	40	4,172	0,087	0,550	2,250	3,906	4,250	4,625	4,875
	E	NR	64	4,383	0,063	0,503	2,625	4,125	4,500	4,750	5,000
	D	OR	35	4,186	0,097	0,573	2,750	3,750	4,375	4,625	4,875
	E	OR	68	4,235	0,062	0,512	2,500	3,906	4,375	4,625	5,000
	D	TA	37	4,214	0,108	0,657	2,375	4,000	4,375	4,688	5,000
	E	TA	71	4,318	0,062	0,520	2,500	4,000	4,375	4,750	5,000
Pots	D	NR	40	2,502	0,126	0,799	1,000	1,875	2,625	3,250	3,625
	E	NR	64	3,510	0,089	0,714	1,125	3,031	3,354	4,094	5,000
	D	OR	35	2,553	0,114	0,677	1,250	2,000	2,750	3,167	3,500
	E	OR	68	3,540	0,080	0,657	1,750	3,125	3,500	4,000	4,750
	D	TA	37	3,624	0,145	0,884	1,375	3,250	3,625	4,292	4,750
	E	TA	71	4,032	0,074	0,627	2,750	3,625	4,125	4,500	5,000

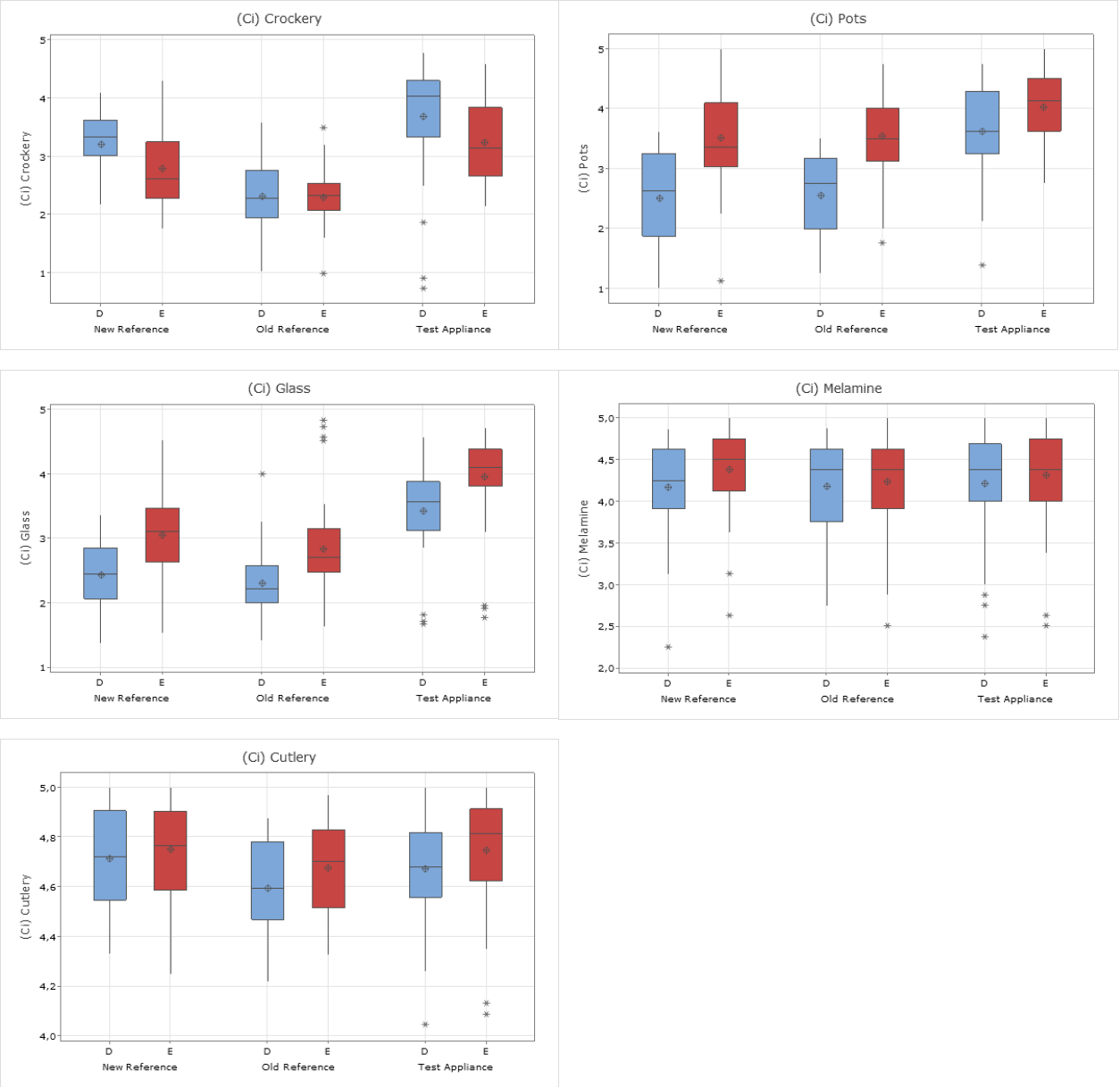


Figure 45: Boxplots of cleaning scores by machine and detergent for crockery, pots, glass, melamine and cutlery

In table 38 the overall basic descriptive statistics of the cleaning scores are shown by detergent and machine including the Mandel h and Mandel k values for each lab. The Mandel h and Mandel k limit values are shown at the bottom lines, the outliers are highlighted.

Outliers are shown for runs with the TA: TA detergent E runs show outliers for lab QMP (Mandel h) and RVS (Mandel k) and TA detergent D runs show one outlier for lab PKM (Mandel k).

Table 38: Cleaning score basic descriptive statistics including Mandel h / k-values

NR E							
Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	3,784	3,881	3,836	0,043	-0,191	0,450
BAT	4	3,684	3,824	3,767	0,059	-0,451	0,625
BMZ	3	4,154	4,265	4,194	0,062	1,152	0,650
DGI							
IKL	4	3,824	3,853	3,838	0,012	-0,181	0,127
JKR	4	3,559	3,912	3,794	0,160	-0,347	1,690
KLB	4	4,316	4,375	4,335	0,028	1,681	0,293
LKB	4	4,110	4,338	4,252	0,100	1,371	1,054
MPO	4	3,566	3,897	3,708	0,146	-0,671	1,539
OLC	4	4,015	4,346	4,142	0,142	0,957	1,499
PKM	4	3,706	3,897	3,803	0,078	-0,313	0,824
QMP	4	3,331	3,346	3,340	0,007	-2,051	0,074
REW	4	4,022	4,140	4,079	0,048	0,722	0,508
RTV	5	3,963	4,261	4,040	0,124	0,577	1,312
RVS	4	3,382	3,713	3,572	0,150	-1,182	1,585
WER	4	3,640	3,743	3,691	0,059	-0,733	0,627
XTI	4	3,721	3,904	3,796	0,081	-0,340	0,855
h/k Crit (±)						2,335	1,879

OR E							
N	MIN	MAX	AVG	SD	h(i)	k(i)	
5	3,284	3,619	3,503	0,132	-1,035	1,648	
4	3,662	3,838	3,765	0,074	0,521	0,922	
3	3,632	3,794	3,728	0,085	0,302	1,056	
4	3,721	3,904	3,827	0,077	0,892	0,965	
4	3,618	3,647	3,631	0,013	-0,277	0,156	
4	3,338	3,654	3,515	0,135	-0,965	1,680	
4	3,647	3,853	3,761	0,098	0,499	1,216	
4	3,625	3,772	3,719	0,068	0,248	0,844	
4	3,382	3,676	3,583	0,136	-0,561	1,691	
4	3,971	4,051	4,011	0,034	1,984	0,426	
4	3,507	3,596	3,540	0,039	-0,812	0,482	
4	3,331	3,368	3,351	0,016	-1,937	0,203	
4	3,926	4,000	3,958	0,034	1,668	0,425	
4	3,731	3,791	3,756	0,029	0,467	0,367	
4	3,669	3,735	3,704	0,028	0,160	0,346	
4	3,500	3,588	3,542	0,045	-0,801	0,561	
4	3,507	3,787	3,618	0,121	-0,353	1,512	
					2,350	1,883	

TA E						
N	MIN	MAX	AVG	SD	h(i)	k(i)
4	4,056	4,368	4,177	0,134	0,123	1,305
5	4,315	4,432	4,385	0,058	0,923	0,561
5	4,541	4,719	4,597	0,073	1,740	0,707
4	4,151	4,240	4,209	0,041	0,245	0,393
4	4,205	4,221	4,213	0,008	0,260	0,081
4	3,904	4,233	4,086	0,136	-0,229	1,318
4	4,370	4,473	4,411	0,044	1,023	0,424
4	4,281	4,342	4,317	0,028	0,660	0,273
5	3,776	4,204	3,956	0,156	-0,727	1,518
4	3,966	4,404	4,217	0,185	0,278	1,791
4	3,993	4,164	4,038	0,085	-0,414	0,821
4	3,404	3,445	3,428	0,017	**-2,760**	0,167
4	4,219	4,247	4,236	0,012	0,351	0,115
4	4,292	4,361	4,313	0,033	0,644	0,316
4	3,644	4,192	3,945	0,226	-0,770	**2,193**
4	3,877	4,027	3,950	0,081	-0,750	0,789
4	3,925	4,089	3,990	0,078	-0,598	0,753
					2,350	1,860

NR D							
Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	4,104	4,381	4,218	0,126	1,587	1,368
BAT	4	3,500	3,757	3,632	0,120	-0,770	1,299
BMZ	4	3,809	4,081	3,967	0,115	0,576	1,248
JKR	4	3,625	3,787	3,717	0,070	-0,429	0,756
KLB	4	3,706	3,949	3,840	0,106	0,066	1,156
PKM	4	3,559	3,669	3,621	0,048	-0,814	0,523
QMP	4	3,353	3,382	3,369	0,015	-1,827	0,165
REW	4	4,029	4,154	4,099	0,052	1,109	0,563
RVS	4	3,735	4,015	3,868	0,135	0,177	1,468
WER	4	3,860	3,956	3,904	0,042	0,325	0,456
h/k Crit (±)						2,176	1,883

OR D							
N	MIN	MAX	AVG	SD	h(i)	k(i)	
5	3,634	3,993	3,778	0,144	1,524	1,440	
3	3,574	3,684	3,645	0,062	0,783	0,617	
3	3,404	3,551	3,498	0,081	-0,037	0,811	
4	3,485	3,647	3,585	0,070	0,448	0,705	
4	3,353	3,699	3,575	0,162	0,397	1,617	
4	3,015	3,301	3,169	0,118	-1,868	1,182	
4	3,309	3,331	3,320	0,009	-1,027	0,095	
4	3,265	3,515	3,438	0,116	-0,372	1,163	
4	3,519	3,544	3,531	0,013	0,152	0,129	
					2,127	1,841	

TA D						
N	MIN	MAX	AVG	SD	h(i)	k(i)
4	3,826	4,799	4,500	0,453	1,016	1,505
4	4,295	4,342	4,317	0,023	0,504	0,075
4	4,459	4,527	4,495	0,038	1,001	0,125
4	3,870	4,253	4,034	0,164	-0,286	0,546
4	4,322	4,352	4,341	0,014	0,572	0,045
4	2,911	4,432	3,604	0,761	-1,487	**2,526**
4	3,507	3,527	3,519	0,009	-1,726	0,029
4	4,137	4,185	4,166	0,020	0,083	0,068
5	4,189	4,322	4,253	0,050	0,324	0,165
					2,127	1,814

Table 39 lists the repeatability (s_r) and reproducibility (s_R) results for the cleaning performance by machine and detergent. Furthermore, the repeatability and the reproducibility are expressed as a percentage (s_r%, respectively s_R%) of the average values over the considered labs.

The table first shows the values including all values, and secondly the data sets excluding the outliers, highlighted in Table 37 (Mandel h: TA E: QMP; Mandel k: TA E: RVS, TA D: PKM)

Table 39: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for cleaning performance (cleaning score)

Parameter	Machine	Detergent	N (labs)	Average	S_r	S_r %	S_R	S_R%	Expanded uncertainty / %
Cleaning performance (cleaning score - all data, including outliers)	NR	E	16	3,887	0,095	2,441	0,279	7,175	15
	OR	E	17	3,677	0,080	2,184	0,182	4,952	10
	TA	E	17	4,145	0,103	2,486	0,275	6,633	14
	NR	D	10	3,824	0,092	2,409	0,261	6,828	14
	OR	D	9	3,504	0,100	2,851	0,199	5,679	12
	TA	D	9	4,137	0,301	7,283	0,444	10,722	22
Cleaning performance (cleaning score - (excluding outliers)	NR	E	16	3,887	0,095	2,441	0,279	7,175	15
	OR	E	17	3,677	0,080	2,184	0,182	4,952	10
	TA	E	15	4,206	0,093	2,206	0,200	4,762	10
	NR	D	10	3,824	0,092	2,409	0,261	6,828	14
	OR	D	9	3,504	0,100	2,851	0,199	5,679	12
	TA	D	8	4,203	0,172	4,101	0,351	8,356	17

9.4.1.3 Cleaning Index

Table 40 and Figures 46 and 47 show the cleaning index values for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E). For the cleaning index calculation, the ln W_c calculation is not implemented.

All three cleaning indices significantly differ from each other.

In the overall data analysis (including all data) the following values are shown: For the current system the mean cleaning index value is 1,181, with reported minimum values of 1,060 and reported maximum values of 1,280.

For the future system the mean cleaning index value is 1,067, with reported minimum values of 1,015 and reported maximum values of 1,161. As compared to the current system the mean cleaning index for the future system is decreased by 9,4%.

For the hybrid system the mean cleaning index value is 1,129, with reported minimum values of 1,025 and reported maximum values of 1,230. As compared to the current system the mean cleaning index for the hybrid system is decreased by 4,3%.

Table 39 shows the basic statistics and expanded uncertainty E_{OR} % of the cleaning index for current, future and hybrid system for all data provided as well as the data sets excluding outliers.

Table 40: Basic statistics and expanded uncertainty E_{OR} % of the cleaning index for current, future and hybrid system

Parameter	Set up	n (labs)	mean	S_r	S_r %	S_R	S_R%	expanded uncertainty / %
Cleaning Index (all data, including outliers)	**Current**	9	1,181	0,095	8,009	0,103	8,729	18
	Future	16	1,067	0,03	2,821	0,047	4,405	9
	Hybrid	17	1,129	0,03	2,638	0,059	5,264	11
Cleaning Index (excluding outliers)	**Current**	8	1,183	0,056	4,756	0,08	6,795	14
	Future	15	1,061	0,031	2,921	0,041	3,875	8
	Hybrid	16	1,129	0,027	2,361	0,061	5,368	11

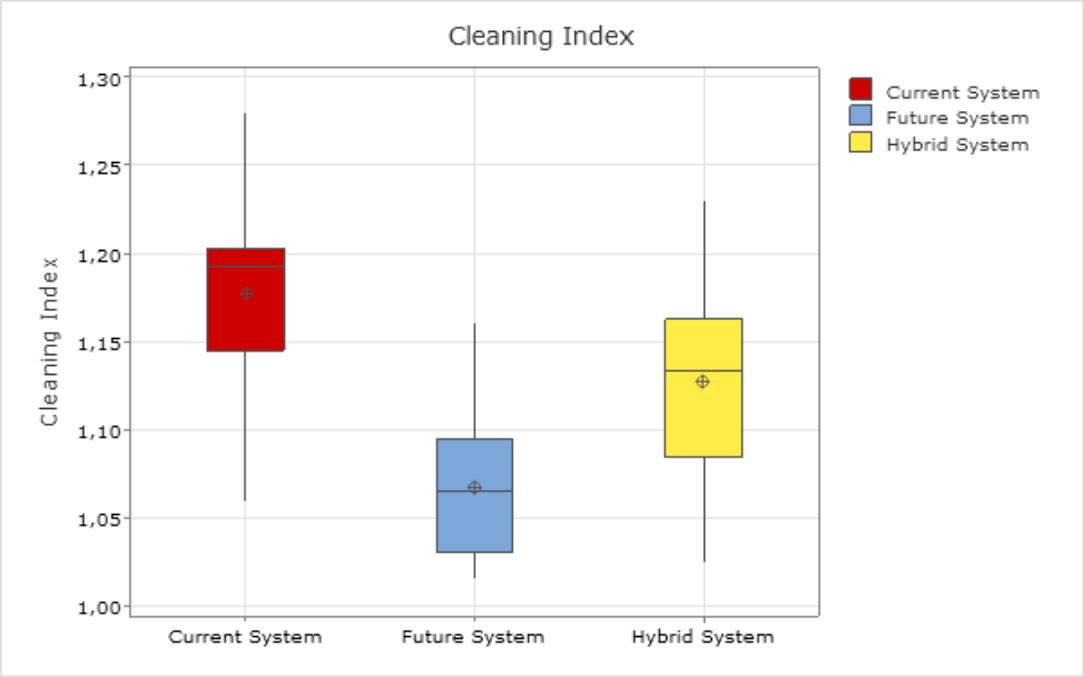


Figure 46: Boxplot of cleaning index for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E, including all data)

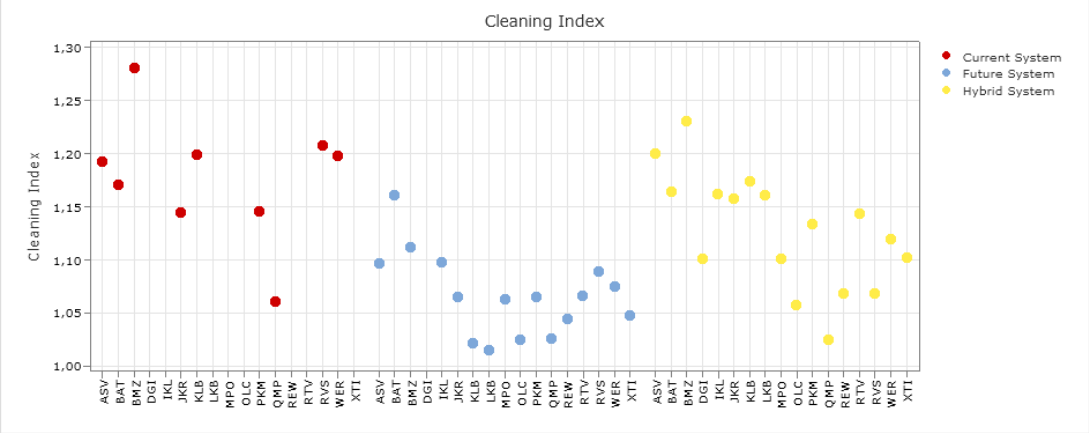


Figure 47: Boxplot of cleaning index for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E) by lab (all data)

9.4.2 Drying performance

9.4.2.1 Overall drying score

Figure 48 - 51 and table 41 show the aggregated mean values and SD of the overall drying score by detergent, arranged by machine and by lab to allow for detail data analysis.

For the new reference machine an overall drying score of 0,900 is reported for detergent D and 0,901 for detergent E.

For the old reference machine an overall drying score of 0,826 of is reported for detergent D and 0,834 for detergent E.

For the test appliance an overall drying score of 0,912 of is reported for detergent D and 0,920 for detergent E.

Table 41: Basic statistics of drying score by machine and detergent

Machine	Detergent	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
NR	D	40	0,900	0,004	0,025	0,838	0,883	0,901	0,918	0,967
NR	E	64	0,901	0,004	0,031	0,842	0,876	0,900	0,926	0,963
OR	D	35	0,826	0,004	0,026	0,761	0,805	0,831	0,846	0,864
OR	E	68	0,834	0,003	0,024	0,787	0,820	0,833	0,845	0,897
TA	D	37	0,912	0,003	0,018	0,880	0,901	0,911	0,926	0,944
TA	E	71	0,920	0,003	0,021	0,873	0,908	0,925	0,935	0,972

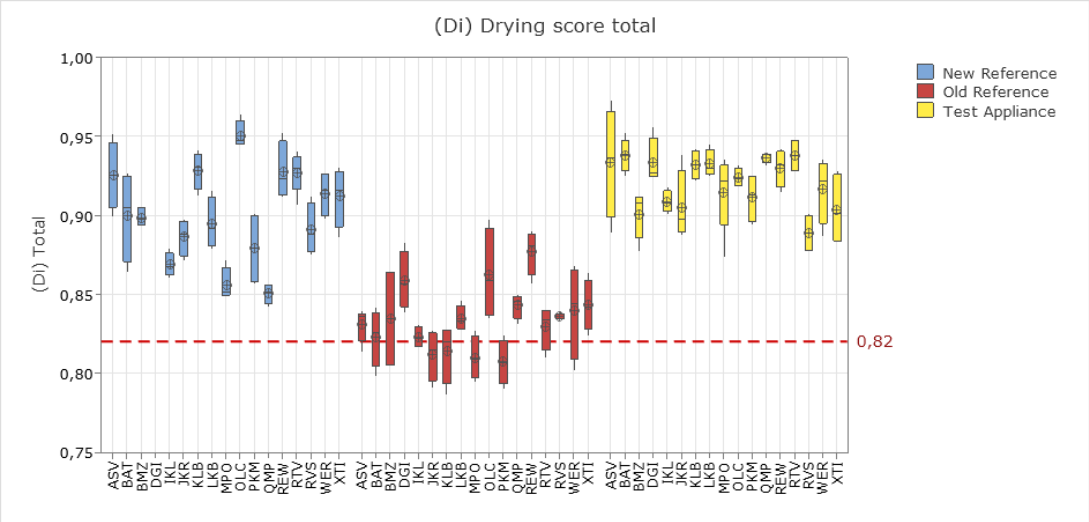


*Figure 48: Boxplots of overall drying score by lab and machine for **detergent E**, arranged by machine*

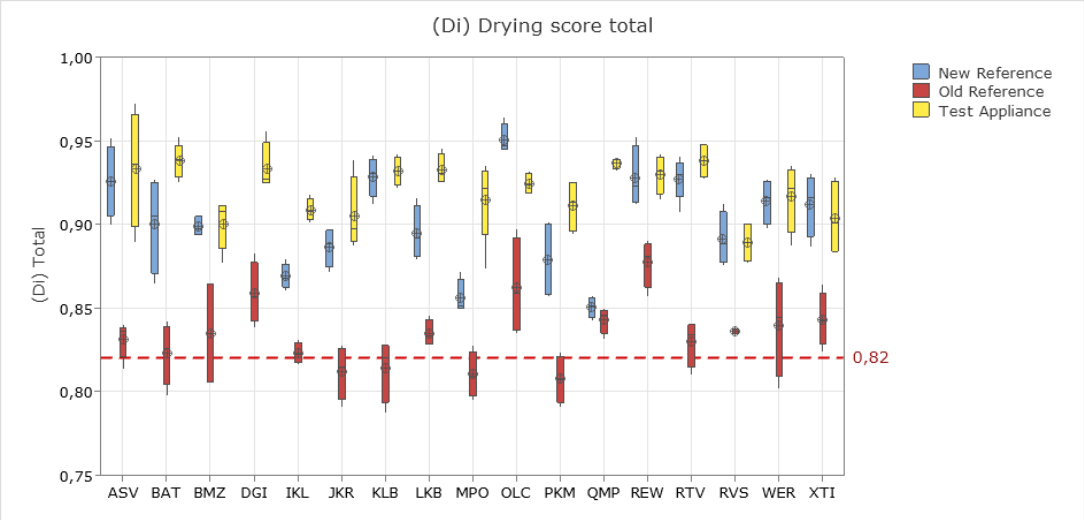


*Figure 49: Boxplot of overall drying score by lab and machine for **detergent E**, arranged by lab*

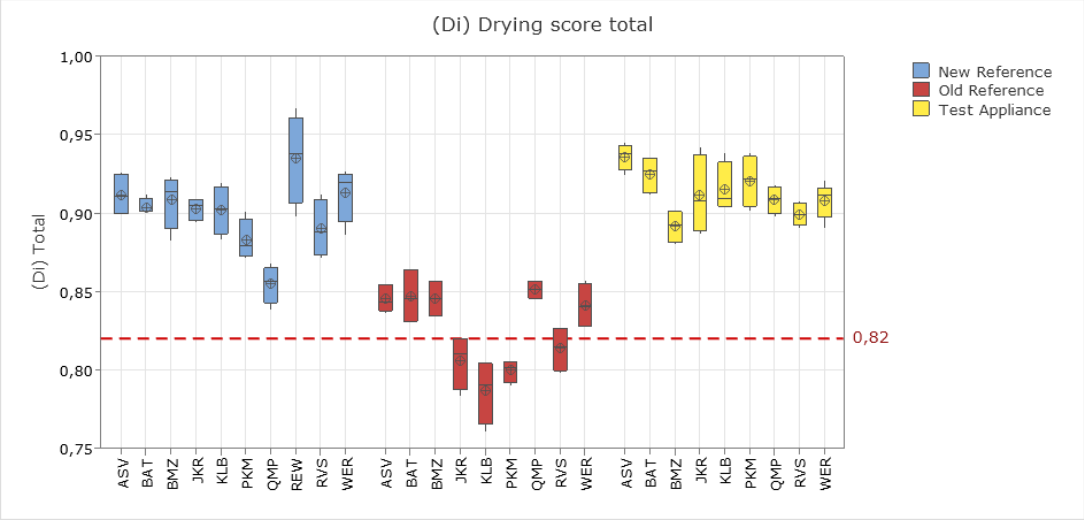


*Figure 50: Boxplot of overall drying score by lab and machine for **detergent D**, arranged by machine*

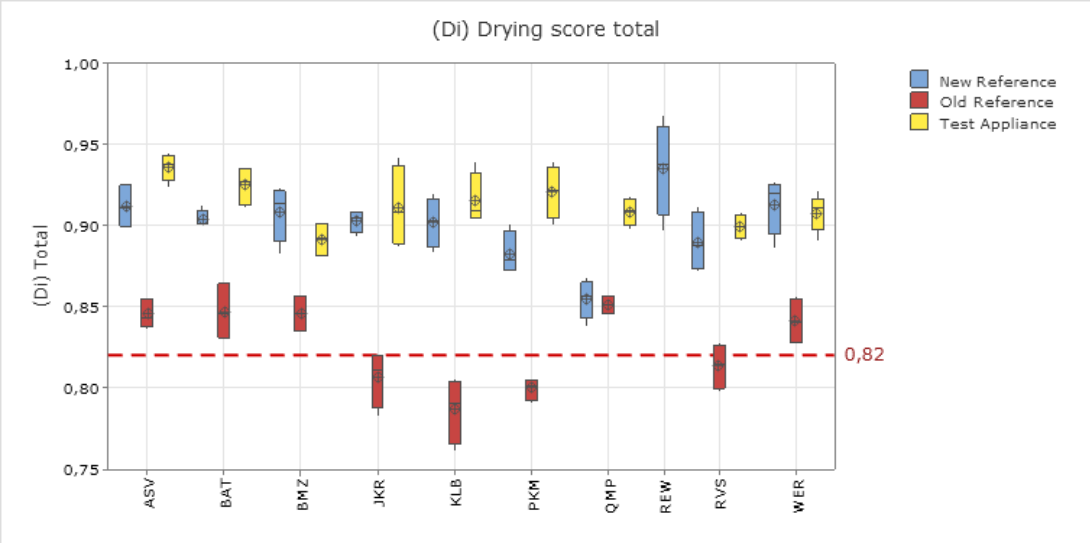


*Figure 51: Boxplot of overall drying score by lab and machine for **detergent D**, arranged by lab*

9.4.2.2 Drying score by dishware

Table 42 and figure 52 display the overall drying scores by type of dishware, detergent and machine. For all dishware types and machines comparable drying scores are reported for detergent D and E, apart from pots, where higher scores are reported in the TA. Higher scores are as well reported for melamine parts and glass in OR for detergent E.

Table 42: Basic statistics of drying scores by type of dishware, detergent and machine

Dishware	Detergent	machine	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Crockery	D	NR	40	0,832	0,006	0,039	0,757	0,805	0,845	0,865	0,892
	E	NR	64	0,826	0,007	0,059	0,649	0,784	0,851	0,865	0,919
	D	OR	35	0,666	0,011	0,065	0,487	0,635	0,676	0,689	0,797
	E	OR	68	0,687	0,007	0,061	0,541	0,649	0,682	0,730	0,838
	D	TA	37	0,785	0,006	0,037	0,700	0,763	0,788	0,813	0,850
	E	TA	71	0,796	0,005	0,044	0,700	0,763	0,800	0,825	0,950
Cutlery	D	NR	40	0,990	0,002	0,014	0,945	0,984	1,000	1,000	1,000
	E	NR	64	0,990	0,002	0,014	0,930	0,984	0,992	1,000	1,000
	D	OR	35	0,993	0,002	0,011	0,953	0,992	1,000	1,000	1,000
	E	OR	68	0,991	0,001	0,012	0,953	0,984	0,992	1,000	1,000
	D	TA	37	0,989	0,002	0,010	0,971	0,978	0,993	1,000	1,000
	E	TA	71	0,992	0,001	0,011	0,949	0,986	0,993	1,000	1,000
Glass	D	NR	40	0,902	0,012	0,074	0,579	0,875	0,921	0,947	1,000
	E	NR	64	0,910	0,008	0,061	0,711	0,868	0,921	0,947	1,000
	D	OR	35	0,879	0,010	0,061	0,763	0,842	0,868	0,921	1,000
	E	OR	68	0,891	0,007	0,058	0,711	0,849	0,895	0,947	0,974
	D	TA	37	0,932	0,011	0,065	0,762	0,893	0,952	0,988	1,000
	E	TA	71	0,946	0,006	0,049	0,762	0,929	0,952	0,976	1,000
Melamine	D	NR	40	0,755	0,026	0,167	0,375	0,641	0,781	0,875	1,000
	E	NR	64	0,756	0,022	0,173	0,188	0,625	0,750	0,875	1,000
	D	OR	35	0,466	0,023	0,137	0,188	0,375	0,438	0,563	0,750
	E	OR	68	0,504	0,021	0,173	0,188	0,375	0,500	0,625	1,000
	D	TA	37	0,985	0,006	0,034	0,875	1,000	1,000	1,000	1,000
	E	TA	71	0,985	0,005	0,040	0,813	1,000	1,000	1,000	1,000

Pots	D	NR	40	0,635	0,027	0,173	0,375	0,500	0,688	0,750	1,000
	E	NR	64	0,659	0,022	0,178	0,375	0,500	0,656	0,750	1,000
	D	OR	35	0,451	0,030	0,179	0,188	0,313	0,438	0,500	0,833
	E	OR	68	0,447	0,020	0,164	0,125	0,313	0,500	0,500	0,833
	D	TA	37	0,766	0,033	0,201	0,313	0,615	0,750	0,938	1,000
	E	TA	71	0,790	0,024	0,206	0,250	0,688	0,833	1,000	1,000

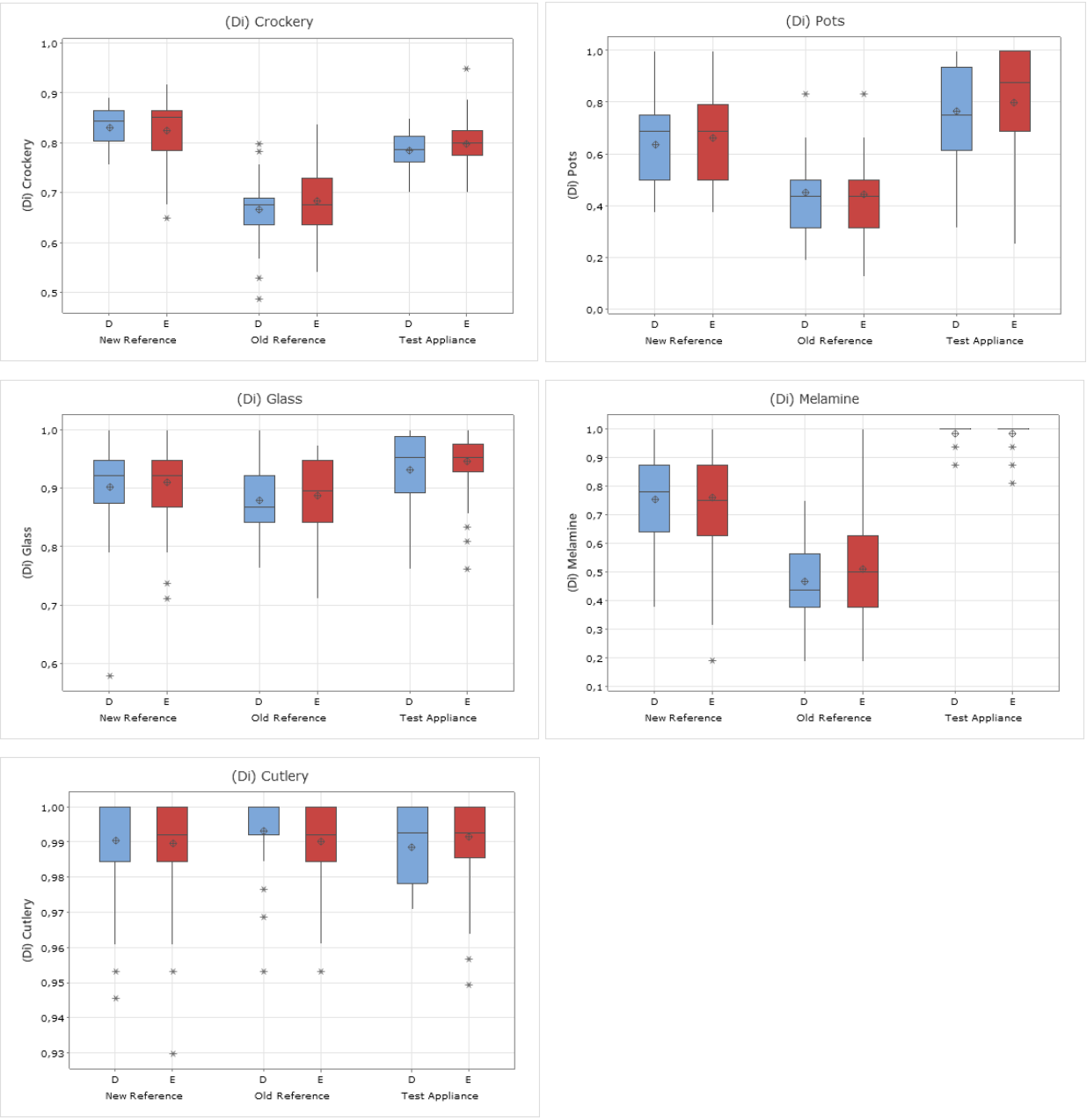


Figure 52: Boxplots of drying scores by machine and detergent for crockery, pots, glass, melamine and cutlery

In table 43 the overall basic descriptive statistic of the drying scores is shown by detergent and machine including the Mandel h and Mandel k values for each lab. The Mandel h and Mandel k limit values are shown at the bottom lines, the outliers by are highlighted.

One outlier is shown for the Mandel k value in the TA, detergent E run (lab ASV). Thus, no data is excluded for the follow-up analysis for S_r, S_R and expanded uncertainty.

Table 43: Drying score basic descriptive statistics including Mandel h / k-values

NR E

Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	0,899	0,951	0,925	0,022	0,885	1,366
BAT	4	0,864	0,926	0,900	0,029	-0,019	1,820
BMZ	3	0,893	0,904	0,898	0,006	-0,074	0,356
DGI							
IKL	4	0,860	0,879	0,869	0,008	-1,125	0,481
JKR	4	0,871	0,897	0,886	0,012	-0,507	0,737
KLB	4	0,912	0,941	0,928	0,012	0,989	0,773
LKB	4	0,879	0,915	0,894	0,016	-0,215	1,014
MPO	4	0,849	0,871	0,856	0,011	-1,580	0,670
OLC	4	0,945	0,963	0,950	0,009	1,769	0,555
PKM	4	0,857	0,901	0,879	0,023	-0,767	1,487
QMP	4	0,842	0,857	0,850	0,006	-1,776	0,398
REW	4	0,912	0,952	0,927	0,018	0,956	1,164
RTV	5	0,907	0,940	0,927	0,013	0,938	0,795
RVS	4	0,875	0,912	0,891	0,016	-0,345	1,014
WER	4	0,897	0,926	0,914	0,014	0,468	0,862
XTI	4	0,886	0,930	0,912	0,019	0,403	1,189
h/k Crit (±)						2,335	1,879

OR E

N	MIN	MAX	AVG	SD	h(i)	k(i)
5	0,813	0,840	0,831	0,010	-0,158	0,595
4	0,798	0,842	0,823	0,018	-0,581	1,047
3	0,805	0,864	0,835	0,029	0,052	1,678
4	0,838	0,882	0,858	0,018	1,316	1,049
4	0,816	0,831	0,823	0,006	-0,581	0,358
4	0,790	0,827	0,812	0,016	-1,164	0,913
4	0,787	0,827	0,813	0,019	-1,067	1,088
4	0,827	0,846	0,835	0,008	0,052	0,453
4	0,794	0,827	0,810	0,014	-1,261	0,792
4	0,835	0,897	0,862	0,029	1,510	1,665
4	0,790	0,824	0,807	0,014	-1,407	0,813
4	0,831	0,849	0,843	0,008	0,489	0,465
4	0,857	0,890	0,874	0,014	2,143	0,792
4	0,810	0,840	0,829	0,014	-0,227	0,804
4	0,835	0,838	0,835	0,002	0,100	0,105
4	0,801	0,868	0,839	0,029	0,295	1,682
4	0,824	0,864	0,843	0,017	0,489	0,944
					2,350	1,883

TA E

N	MIN	MAX	AVG	SD	h(i)	k(i)
4	0,889	0,972	0,933	0,035	0,848	**2,091**
5	0,925	0,952	0,938	0,010	1,142	0,623
5	0,877	0,911	0,900	0,015	-1,309	0,888
4	0,924	0,955	0,933	0,015	0,844	0,901
4	0,901	0,918	0,908	0,007	-0,763	0,423
4	0,887	0,938	0,905	0,023	-0,986	1,366
4	0,921	0,942	0,932	0,009	0,741	0,530
4	0,925	0,945	0,932	0,009	0,790	0,529
5	0,873	0,935	0,914	0,024	-0,373	1,452
4	0,918	0,932	0,924	0,006	0,239	0,351
4	0,894	0,925	0,911	0,016	-0,596	0,963
4	0,932	0,938	0,937	0,003	1,068	0,201
4	0,914	0,942	0,930	0,012	0,629	0,701
4	0,927	0,948	0,938	0,010	1,131	0,613
4	0,877	0,901	0,889	0,012	-2,045	0,721
4	0,887	0,935	0,916	0,021	-0,262	1,237
4	0,884	0,928	0,903	0,023	-1,098	1,386
					2,350	1,860

NR D

Lab Code	N	MIN	MAX	AVG	SD	h(i)	k(i)
ASV	4	0,899	0,925	0,911	0,014	0,529	0,866
BAT	4	0,901	0,912	0,903	0,006	0,157	0,339
BMZ	4	0,882	0,923	0,908	0,018	0,374	1,092
JKR	4	0,893	0,908	0,903	0,007	0,113	0,433
KLB	4	0,883	0,919	0,902	0,015	0,080	0,945
PKM	4	0,871	0,901	0,882	0,013	-0,840	0,805
QMP	4	0,838	0,868	0,855	0,012	-2,140	0,750
REW	4	0,897	0,967	0,935	0,029	1,630	1,775
RVS	4	0,871	0,912	0,890	0,018	-0,493	1,123
WER	4	0,886	0,926	0,913	0,018	0,590	1,114
h/k Crit (±)						2,176	1,883

OR D

N	MIN	MAX	AVG	SD	h(i)	k(i)
5	0,836	0,854	0,846	0,009	0,785	0,626
3	0,831	0,864	0,847	0,017	0,837	1,207
3	0,835	0,857	0,846	0,011	0,788	0,803
4	0,783	0,820	0,806	0,018	-0,819	1,282
4	0,761	0,805	0,787	0,021	-1,603	1,499
4	0,790	0,805	0,800	0,007	-1,080	0,513
4	0,846	0,857	0,851	0,006	1,012	0,464
4	0,798	0,827	0,813	0,014	-0,520	1,034
4	0,827	0,857	0,841	0,014	0,601	1,034
					2,127	1,841

TA D

N	MIN	MAX	AVG	SD	h(i)	k(i)
4	0,924	0,944	0,936	0,009	1,731	0,624
4	0,911	0,935	0,925	0,012	0,902	0,870
4	0,880	0,901	0,891	0,011	-1,589	0,783
4	0,887	0,942	0,911	0,025	-0,120	1,808
4	0,904	0,938	0,915	0,016	0,200	1,153
4	0,901	0,938	0,920	0,016	0,583	1,171
4	0,897	0,918	0,908	0,009	-0,311	0,611
4	0,890	0,908	0,899	0,007	-1,014	0,509
5	0,890	0,921	0,907	0,011	-0,383	0,799
					2,127	1,814

Table 44 lists the repeatability (s_r) and reproducibility (s_R) results for the drying performance by machine and detergent. Furthermore, the repeatability and the reproducibility are expressed as a percentage (s_r%, respectively s_R%) of the average values over the considered labs.

The table first shows the values including all values, and secondly the data sets excluding the outliers, highlighted in Table 42 (Mandel k: TA E: ASV)

Table 44: Repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for cleaning performance (cleaning score)

Parameter	Machine	Detergent	N (labs)	Average	S_r	S_r %	S_R	S_R%	Expanded uncertainty / %
Drying performance (drying score - all data, including outliers)	NR	E	16	0,900	0,016	1,752	0,031	3,486	7
	OR	E	17	0,834	0,018	2,102	0,024	2,908	6
	TA	E	17	0,920	0,017	1,813	0,021	2,300	5
	NR	D	10	0,900	0,016	1,806	0,025	2,828	6
	OR	D	9	0,826	0,014	1,662	0,027	3,305	7
	TA	D	9	0,913	0,014	1,535	0,018	1,985	4
Drying performance (drying score - excluding outliers)	NR	E	16	0,900	0,016	1,752	0,031	3,486	7
	OR	E	17	0,834	0,018	2,102	0,024	2,908	6
	TA	E	16	0,919	0,015	1,612	0,020	2,195	5
	NR	D	10	0,900	0,016	1,806	0,025	2,828	6
	OR	D	9	0,826	0,014	1,662	0,027	3,305	7
	TA	D	9	0,913	0,014	1,535	0,018	1,985	4

9.4.2.3 Drying Index

Table 45 and Figures 53 and 54 show the drying index values for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E), either calculated based on the reported values (as currently defined in the standard) or calculated based on a fixed value. The fixed value calculation is shown, even though it is not suitable for the hybrid and the future system, as it is assuming a target value, that is not available.

In Table 44 all values as well as the values excluding outliers are displayed.

Table 45: Basic statistics and expanded uncertainty E_{OR} % of the drying index for current, future and hybrid system based on calculation with measured values and fixed value

Parameter	Set up	n (labs)	mean	S_r	S_r %	S_R	S_R%	expanded uncertainty / %
Drying Index (all data, including outliers)	Current	9	1,106	0,020	1,801	0,046	4,189	9
	Future	16	1,022	0,024	2,375	0,039	3,857	8
	Hybrid	17	1,108	0,028	2,563	0,036	3,272	7
	Current (fixed value 0,82)	9	1,113	0,017	1,520	0,023	2,100	5
	Future (fixed value 0,82)	17	1,124	0,020	1,747	0,025	2,216	5
	Hybrid (fixed value 0,82)	17	1,124	0,020	1,747	0,025	2,216	5
Drying Index (excluding outliers)	Current	9	1,106	0,020	1,801	0,046	4,189	9
	Future	15	1,016	0,025	2,447	0,034	3,344	7
	Hybrid	17	1,108	0,028	2,563	0,036	3,272	7
	Current (fixed value 0,82)	9	1,113	0,017	1,520	0,023	2,100	5
	Future (fixed value 0,82)	16	1,122	0,018	1,605	0,025	2,207	5
	Hybrid (fixed value 0,82)	16	1,122	0,018	1,605	0,025	2,207	5

The data analysis including all reported data, results in the following data:

- For the current system the mean drying index, calculated with measured values is 1,106 and 1,113 calculated based on the fixed value.
- For the future system the mean drying index, calculated with measured values is 1,022 and 1,124 calculated based on the fixed value.
- For the hybrid system the mean drying index, calculated with measured values is 1,106 and 1,124 calculated based on the fixed value.
- For the drying indices applying all measured values for calculation, the future system results in significantly lower index values. As compared to the current system the mean drying index for the future system is decreased by 7,6%. As compared to the current system the mean drying index for the hybrid system shows no difference.
- For the drying indices applying the fixed value of 0,82 for calculation, there are no significant differences shown for the three systems. The future system as well as the hybrid system show a drying index increase in fixed value calculation (based on the mean values) of 0,9% (as the calculation is identical when the fixed value is applied).

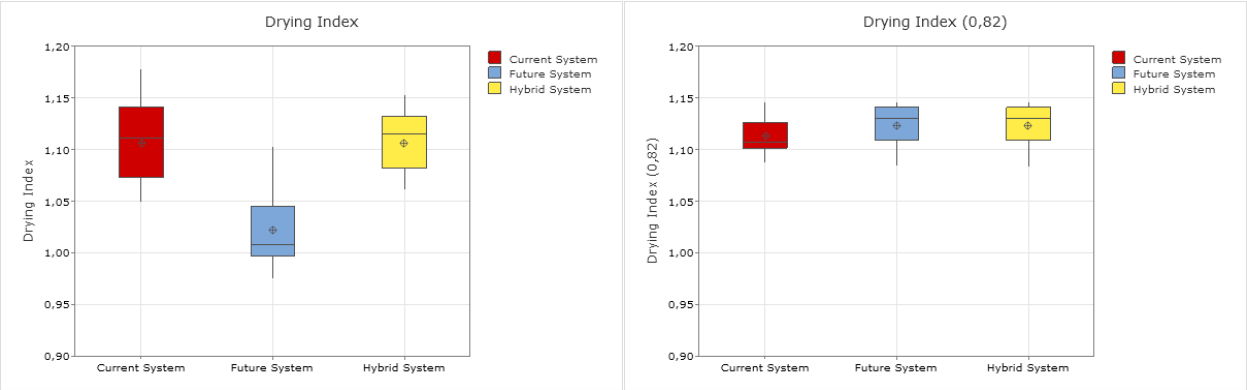


Figure 53: Boxplots of drying indices for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E) calculated with fixed value (left) and measured value (right - data shown include all reported values)

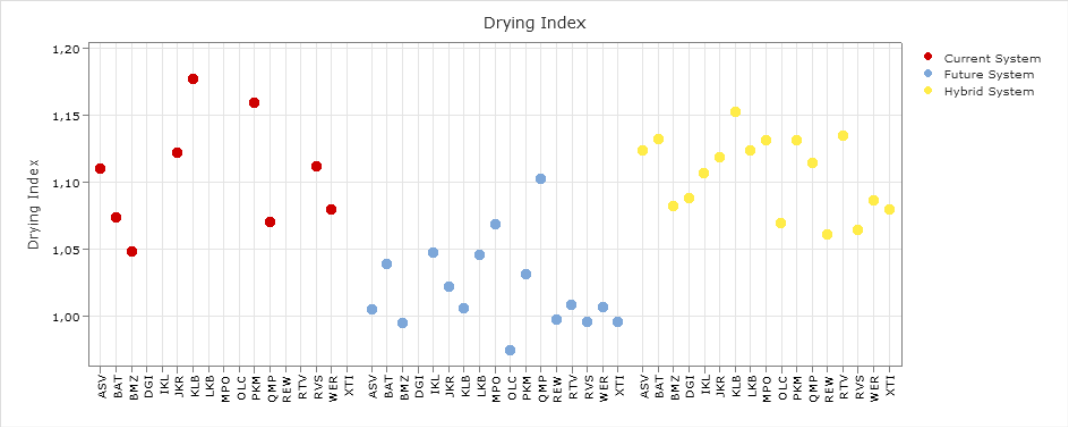


Figure 54: Boxplots of drying indices for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E) calculated with fixed value by lab (data shown include all reported values)

9.5 Overall summary of consistency testing analysis

The following table summarizes the repeatability (s_r) and reproducibility (s_R) results and expanded uncertainty for all key performance parameters by machine and detergent. Furthermore, the repeatability and the reproducibility are expressed as a percentage (s_r%, respectively s_R%) of the average values over all labs are displayed as well as the values excluding outliers.

Table 46: Summary of repeatability standard deviation (S_r), reproducibility standard deviation (S_R) and expanded uncertainty for all key performance parameters

Parameter	Machine	Detergent	n (labs)	average	S_r	S_r %	S_R	S_R%	expanded uncertainty / %
Duration (excluding outliers)	NR	E	15	143,868	0,414	0,288	0,874	0,608	2
	OR	E	15	96,921	0,619	0,638	1,684	1,737	4
	TA	E	15	269,746	0,525	0,195	0,978	0,363	1
	NR	D	9	143,68	0,378	0,263	0,774	0,538	2
	OR	D	8	96,553	0,528	0,547	2,443	2,53	6
	TA	D	8	270,066	1,014	0,375	1,644	0,609	2
T max cleaning (excluding outliers)	NR	E	15	45,951	0,178	0,387	0,456	0,992	2
	OR	E	16	50,569	0,154	0,304	0,452	0,895	2
	TA	E	15	54,366	0,342	0,629	0,899	1,653	4
	NR	D	8	45,727	0,138	0,301	0,364	0,797	2
	OR	D	9	50,461	0,159	0,314	0,467	0,926	2
	TA	D	7	54,375	0,572	1,052	1,172	2,156	5
T max rinsing (excluding outliers)	NR	E	13	62,914	0,137	0,218	0,525	0,834	2
	OR	E	17	67,372	0,147	0,218	0,704	1,046	3
	TA	E	15	48,078	0,483	1,004	0,906	1,884	4
	NR	D	9	62,808	0,128	0,204	0,569	0,906	2
	OR	D	8	67,649	0,112	0,165	0,599	0,886	2
	TA	D	7	47,918	0,485	1,013	0,964	2,012	5
Water consumption (excluding outliers)	NR	E	15	8,754	0,022	0,254	0,116	1,324	3
	OR	E	16	14,403	0,042	0,288	0,166	1,153	3
	TA	E	15	9,446	0,031	0,333	0,112	1,183	3
	NR	D	8	8,739	0,016	0,188	0,072	0,821	2
	OR	D	7	14,341	0,013	0,088	0,077	0,534	2
	TA	D	8	9,454	0,013	0,14	0,13	1,379	3
Energy consumption (excluding outliers)	NR	E	15	0,88	0,005	0,531	0,018	2,028	5
	OR	E	17	1,274	0,01	0,758	0,035	2,709	6
	TA	E	15	0,706	0,006	0,806	0,017	2,364	5
	NR	D	9	0,874	0,004	0,415	0,016	1,853	4
	OR	D	7	1,269	0,005	0,395	0,035	2,726	6
	TA	D	8	0,703	0,006	0,806	0,015	2,152	5

Parameter	Machine	Detergent	n (labs)	average	S_r	S_r %	S_R	S_R%	expanded uncertainty / %
Cleaning score (excluding outliers)	NR	E	16	3,887	0,095	2,441	0,279	7,175	15
	OR	E	17	3,677	0,08	2,184	0,182	4,952	10
	TA	E	15	4,206	0,093	2,206	0,2	4,762	10
	NR	D	10	3,824	0,092	2,409	0,261	6,828	14
	OR	D	9	3,504	0,1	2,851	0,199	5,679	12
	TA	D	8	4,203	0,172	4,101	0,351	8,356	17
Parameter	Set up		n (labs)	average	S_r	S_r %	S_R	S_R%	expanded uncertainty / %
Cleaning Index (excluding outliers)	Current		8	1,183	0,056	4,756	0,08	6,795	14
	Future		15	1,061	0,031	2,921	0,041	3,875	8
	Hybrid		16	1,129	0,027	2,361	0,061	5,368	11

Parameter	Machine	Detergent	n (labs)	average	S_r	S_r %	S_R	S_R%	expanded uncertainty / %
Drying score (excluding outliers)	NR	E	16	0,900	0,016	1,752	0,031	3,486	7
	OR	E	17	0,834	0,018	2,102	0,024	2,908	6
	TA	E	16	0,919	0,015	1,612	0,02	2,195	5
	NR	D	10	0,900	0,016	1,806	0,025	2,828	6
	OR	D	9	0,826	0,014	1,662	0,027	3,305	7
	TA	D	9	0,913	0,014	1,535	0,018	1,985	4
Parameter	Set up		n (labs)	average	S_r	S_r %	S_R	S_R%	expanded uncertainty / %
Drying Index (excluding outliers)	Current		9	1,106	0,02	1,801	0,046	4,189	9
	Future		15	1,016	0,025	2,447	0,034	3,344	7
	Hybrid		17	1,108	0,028	2,563	0,036	3,272	7
	Current (fixed value 0,82)		9	1,113	0,017	1,52	0,023	2,1	5
	Future (fixed value 0,82)		16	1,122	0,018	1,605	0,025	2,207	5
	Hybrid (fixed value 0,82)		16	1,122	0,018	1,605	0,025	2,207	5

	Measurement Mode	n (labs)	Minimum	Maximum	Average	Standard deviation		E_{OR}/%
Low Power Mode (W)	LPM Power off (W)	11	0,184	0,271	0,215	0,026		24
	LPM Standby (W)	15	0,184	0,252	0,208	0,018		18
	LPM Delay start (W)	16	2,6	3,05	2,848	0,096		7
	LPM networked (W)	16	1,41	2,023	1,638	0,189		24
	Test box (W)	16	0,8	0,84	0,812	0,012		3

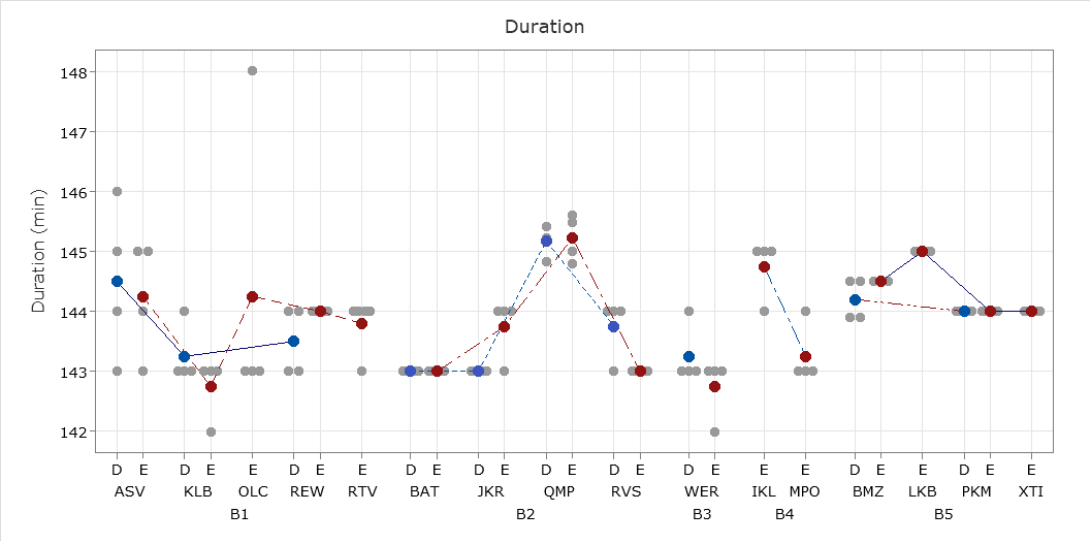
9.6 Further impact factor review

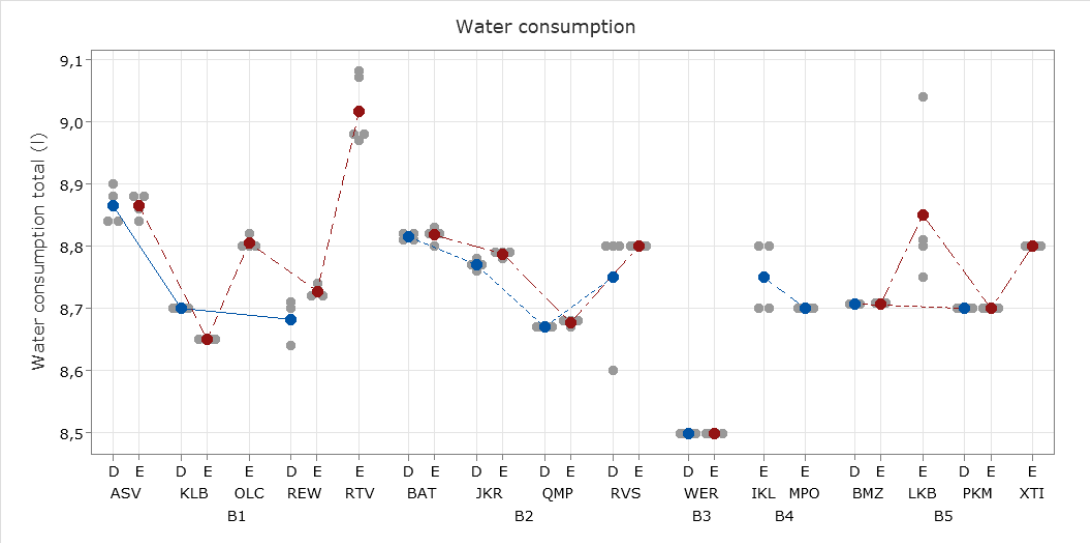
In the following the impact of the NR tier and detergent E batch is analyzed further to evaluate if tier / batch variations have to be taken into consideration in the overall result evaluation.

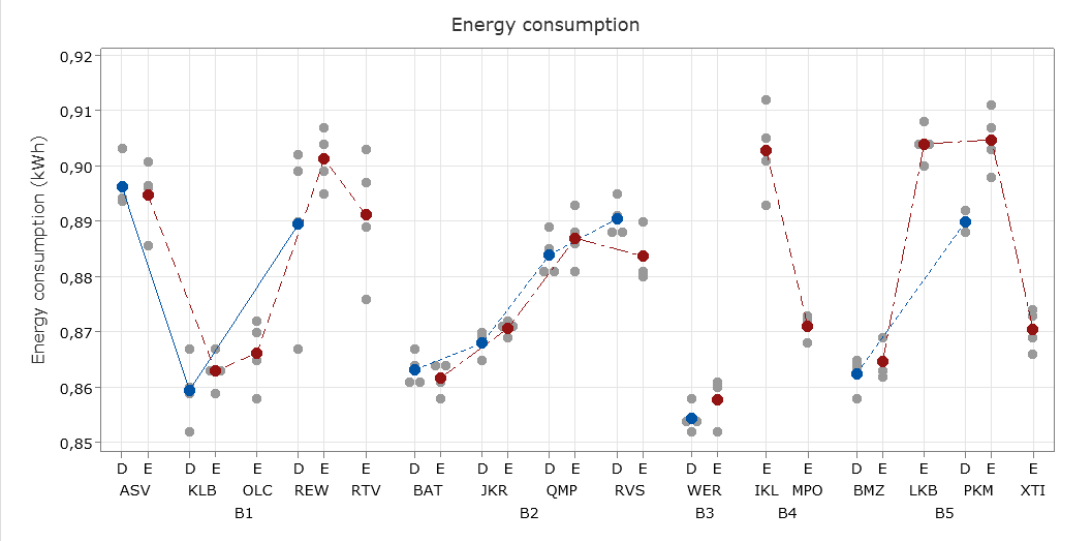
9.6.1 Overview on NR tiers

The following dotplot figures show the detail results of the key performance parameters (duration, water consumption, energy consumption, T max. main wash and T max. rinsing) by tier, detergent and lab. All labs on the x-axis are shown in alphabetic order. Shown are the single values per lab and detergent as well as the mean values (highlighted in color BLUE for detergent D and color RED for detergent E). Next to that an aggregated boxplot analysis is shown for these parameters. In the NR appliance no significant differences are shown for test runs with detergent D and E for any performance parameter, thus a joint analysis approach is possible.

For the overall analysis it has to be kept in mind, that tier B3 was just run by 1 lab thus the data sets provide no reliable data. Keeping that in mind there are no significant differences shown for the performance parameters duration, water consumption, energy consumption, T max main wash and T max rinsing.




Water consumption
Water consumption total (l)
9,1
9,0
8,9
8,8
8,7
8,6
8,5
D E
ASV
KLB
OLC
REW
RTV
BAT
JKR
QMP
RVS
WER
IKL
MPO
BMZ
LKB
PKM
XTI
B1
B2
B3
B4
B5


Energy consumption
Energy consumption (kWh)
0,92
0,91
0,90
0,89
0,88
0,87
0,86
0,85
D E
ASV
KLB
OLC
REW
RTV
BAT
JKR
QMP
RVS
WER
IKL
MPO
BMZ
LKB
PKM
XTI
B1
B2
B3
B4
B5

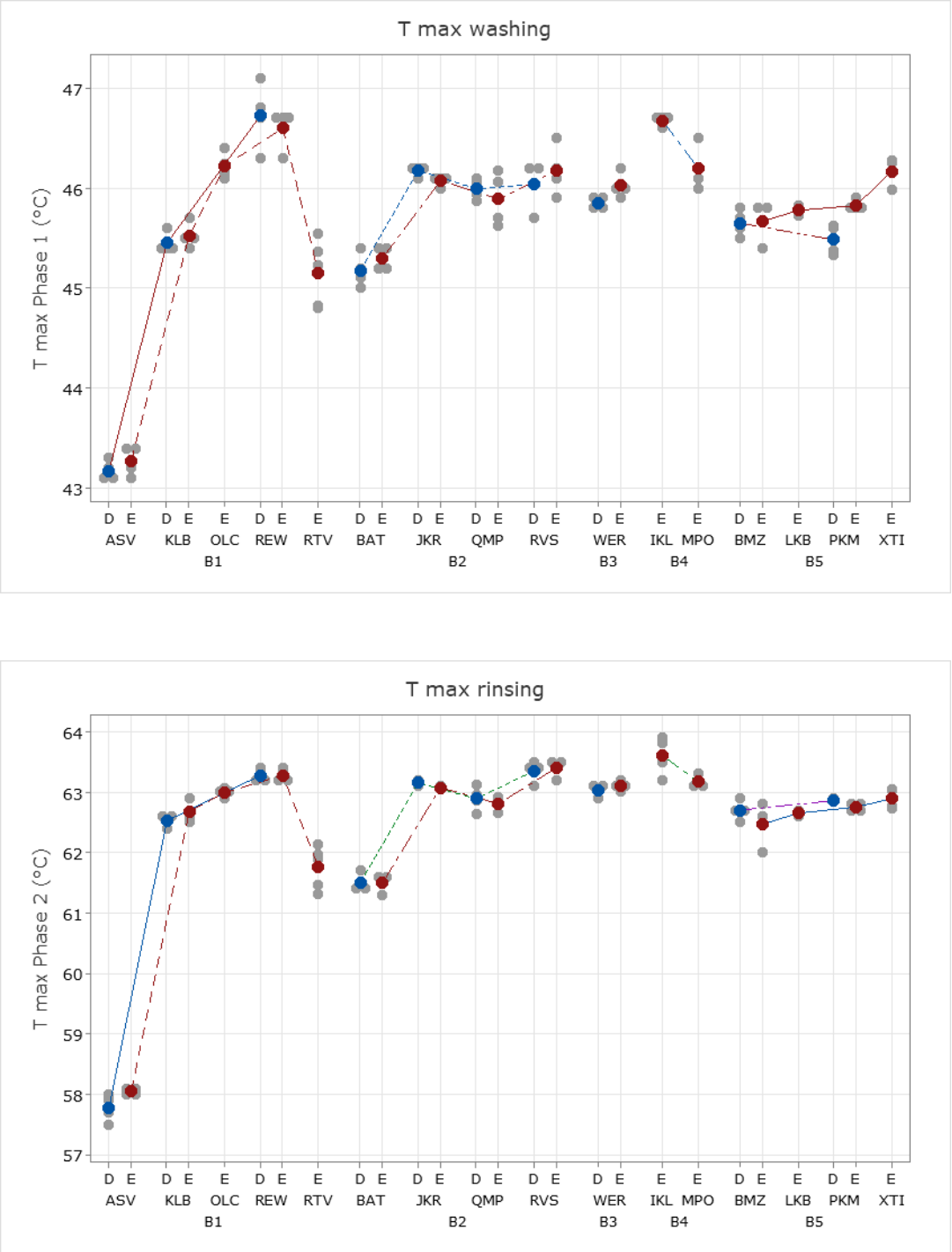


Figure 55: Dotplots of key performance parameters (duration, water consumption, energy consumption, T max main wash and T max rinsing) by tier, detergent and lab

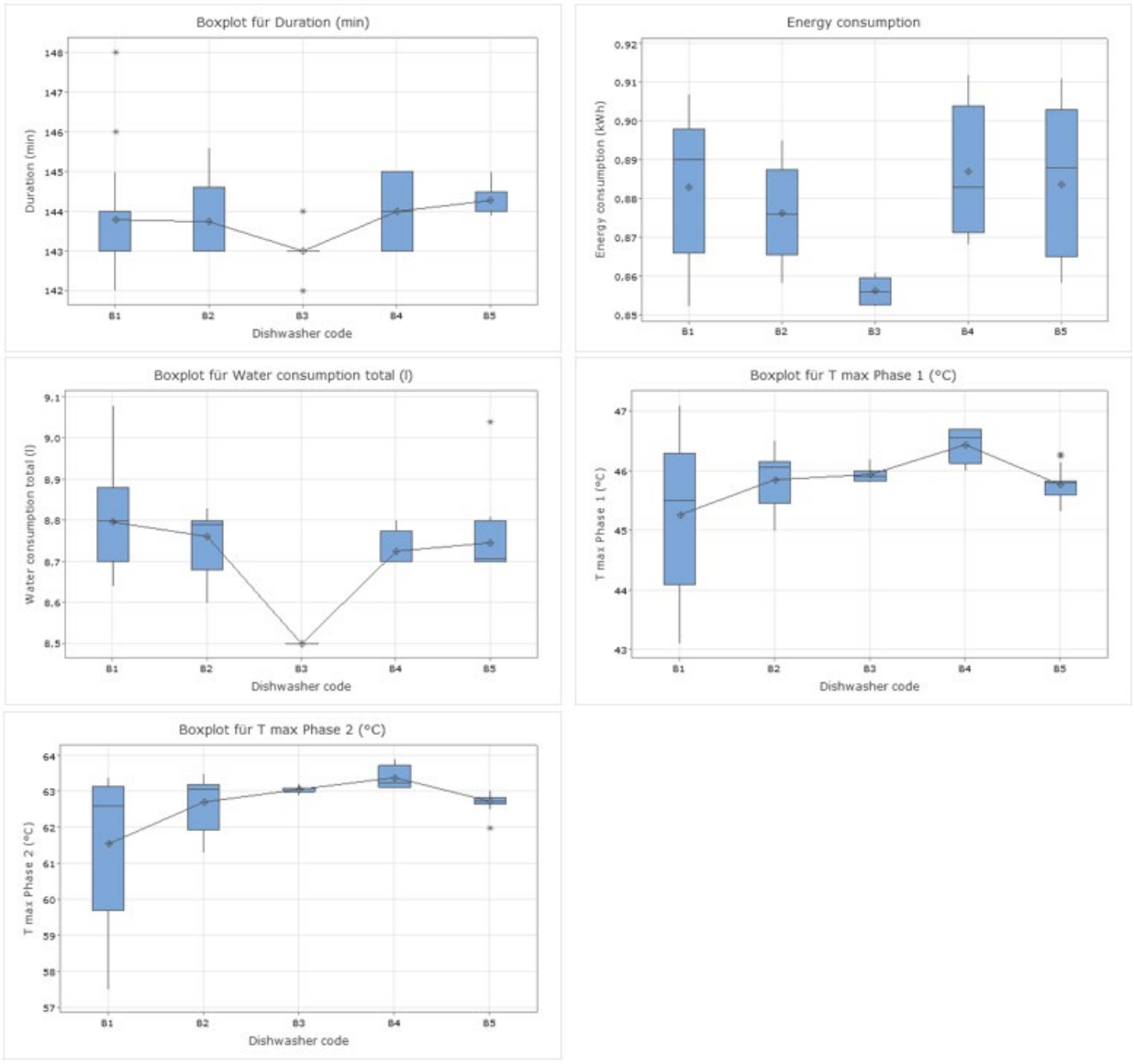


Figure 56: Boxplots of key performance parameters (duration, water consumption, energy consumption, T max main wash and T max rinsing) by tier

The cleaning and drying score results are shown from Figure 57 onwards. The detergent D and E runs show congruent results by lab – just Ci runs of the labs KLB and RVS show variations. For cleaning and drying scores differences are shown for nearly all tiers. Further elimination tier B3 and also B4 due to the limited number of labs performing runs with these appliances, differences are shown for tier B1 in Di. For Ci differences are shown for all labs.

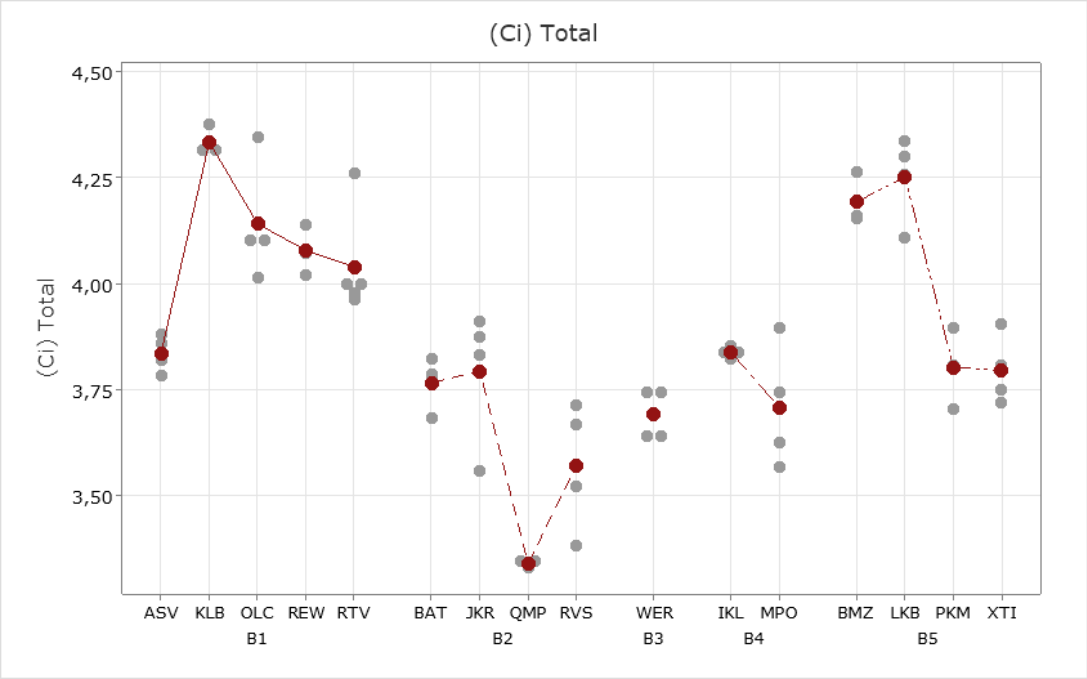


Figure 57: Cleaning score (average value and single run values) by tier and lab (detergent E only)

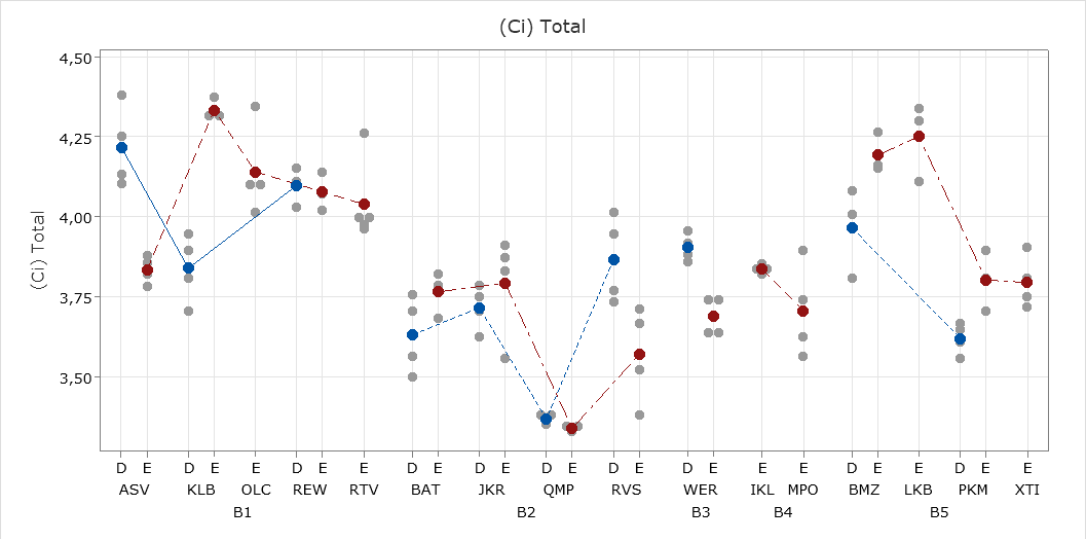


Figure 58: Cleaning score (average value and single run values) by tier, lab and detergent

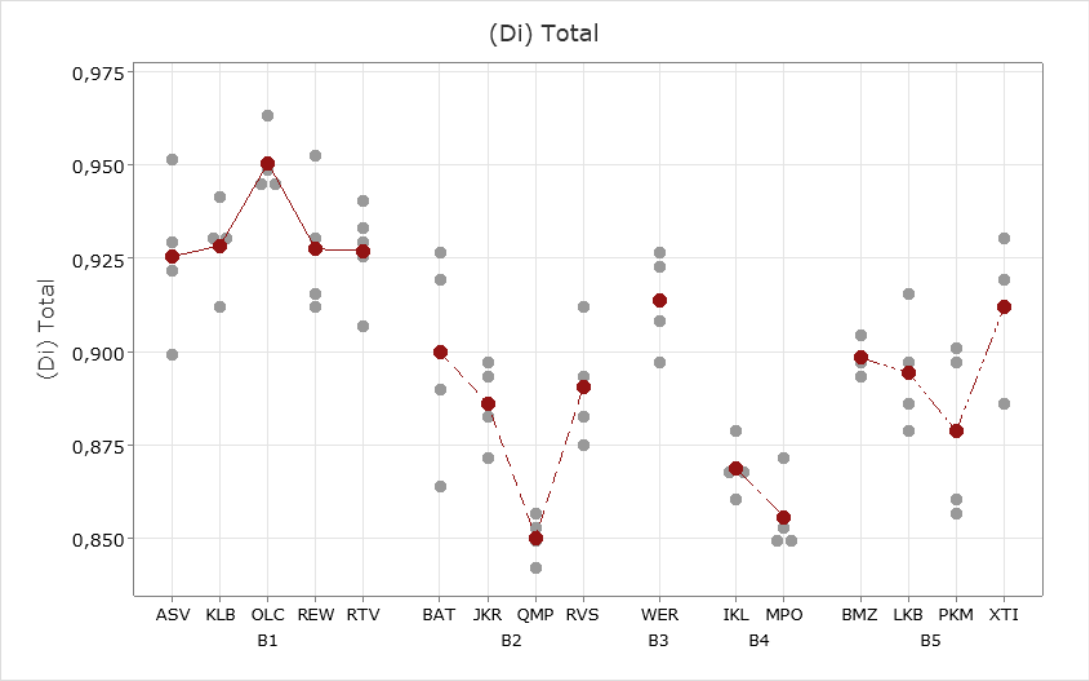


Figure 59: Drying score (average value and single run values) by tier and lab (detergent E only)

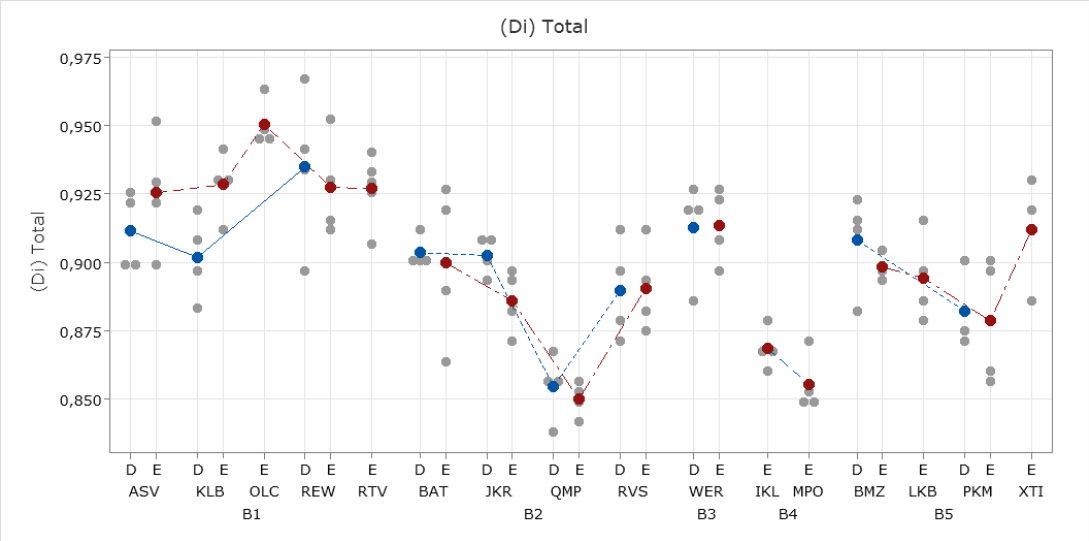


Figure 60: Drying score (average value and single run values) by tier, lab and detergent

9.6.2 Overview on detergent E batches

The following table summarizes the cleaning and drying performance ANOVA analysis for NR and the three detergent E batches 2022/05; 2022/08; 2022/12. The subsequent figures show the cleaning and drying scores by tier (average value (highlighted in color) and single run values (shown in grey color) and detergent E batch sorted by tier and by detergent E batch.

For drying scores no detergent batch effects are shown. For cleaning scores, the ANOVA shows significant differences for batch 2022/05. Due to the lower number of runs with this batch an overall effect cannot be ascertained. Net to that, the effect may also be traced back to the very low Ci scores of single labs in the other batches.

Table 47: Cleaning and drying performance ANOVA analysis for NR and detergent E batches

Parameter	Detergent E batch #	N	Mean	StDev	95% CI
Cleaning score	2022/05	13	4,069	0,217	(3,9253; 4,2121)
	2022/08	28	3,837	0,247	(3,7397; 3,9352)
	2022/12	23	3,837	0,291	(3,7291; 3,9447)
Drying score	2022/05	13	0,909	0,030	(0,89215; 0,92659)
	2022/08	28	0,895	0,026	(0,88362; 0,90709)
	2022/12	23	0,903	0,037	(0,88968; 0,91557)

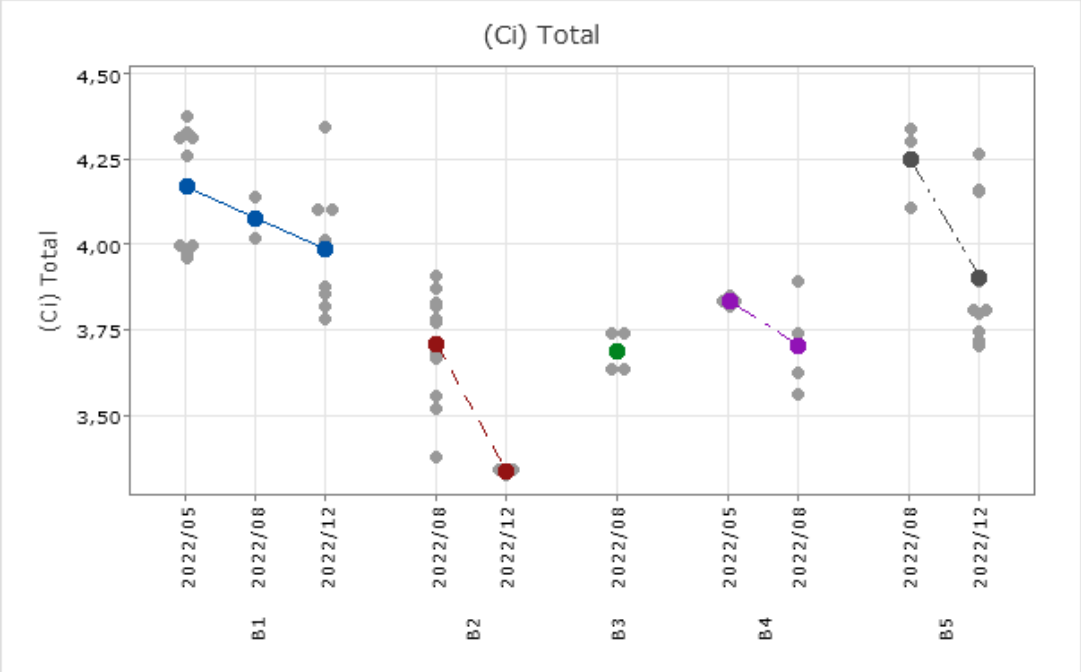


Figure 61: Cleaning score by tier (average value and single run values) detergent E batch, sorted by tier

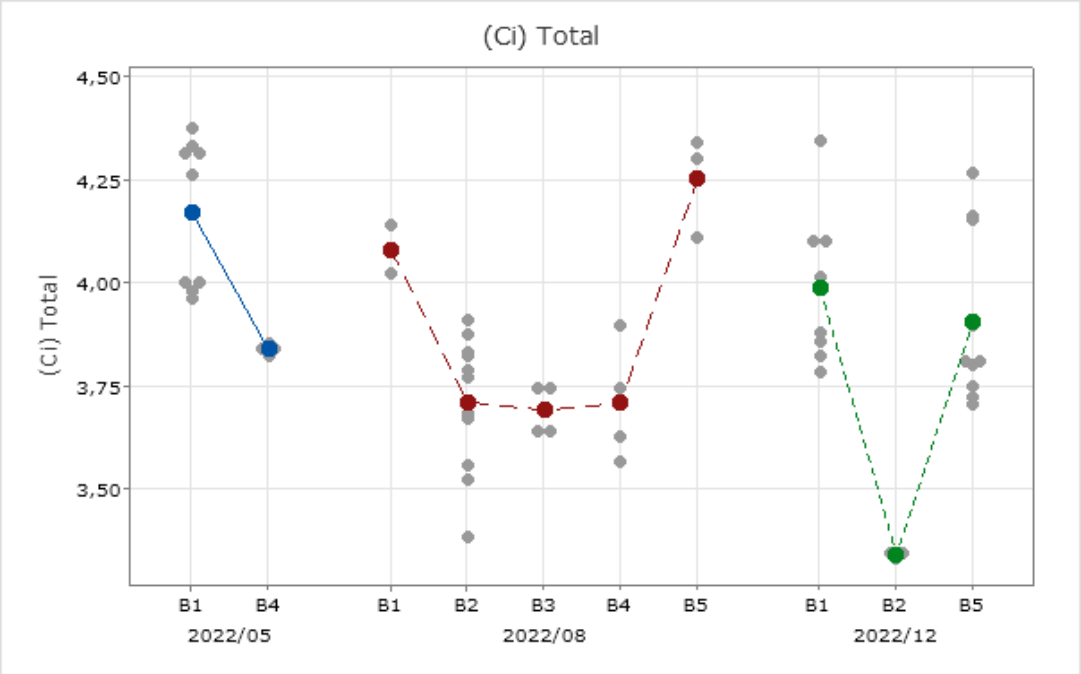


Figure 62: Cleaning scores by detergent E batch (average value and single run values) and tier, sorted by detergent E batch

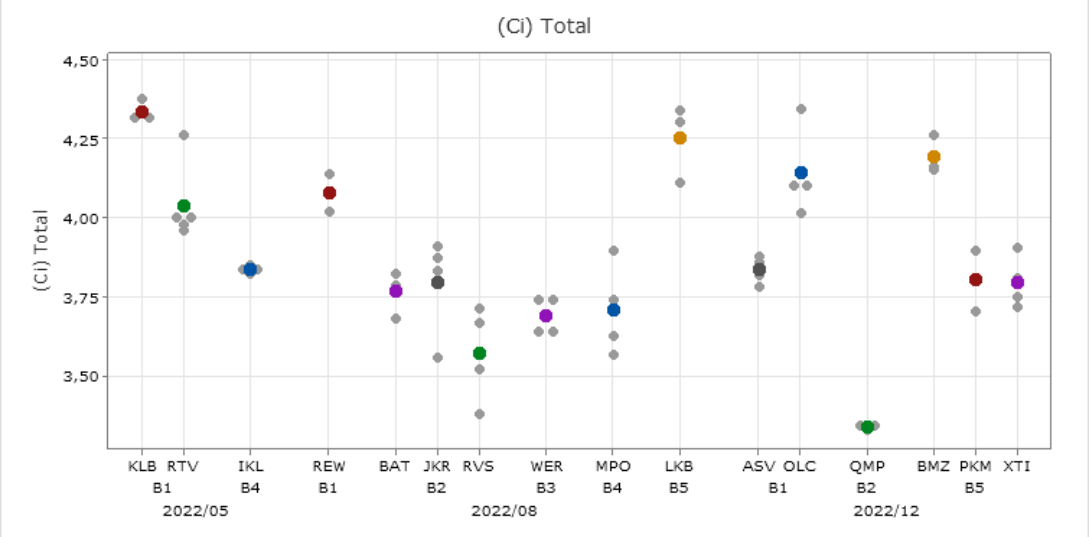


Figure 63: Cleaning scores by detergent E batch (average value and single run values) tier and lab, sorted by detergent E batch

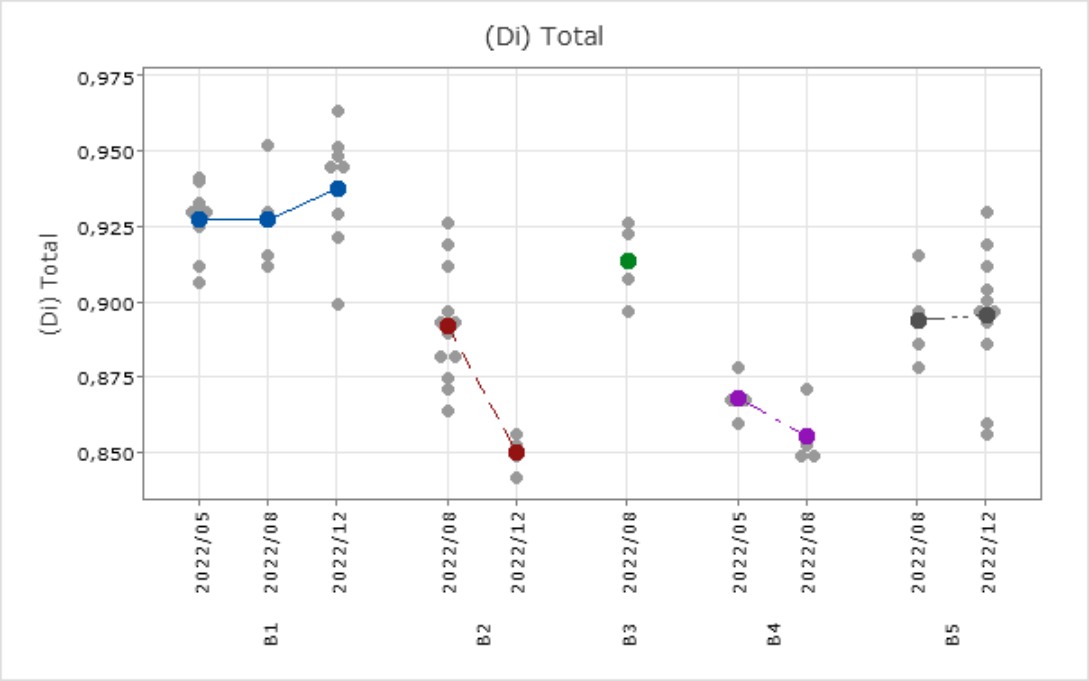


Figure 64: Drying scores by tier (average value and single run values) detergent E batch, sorted by tier

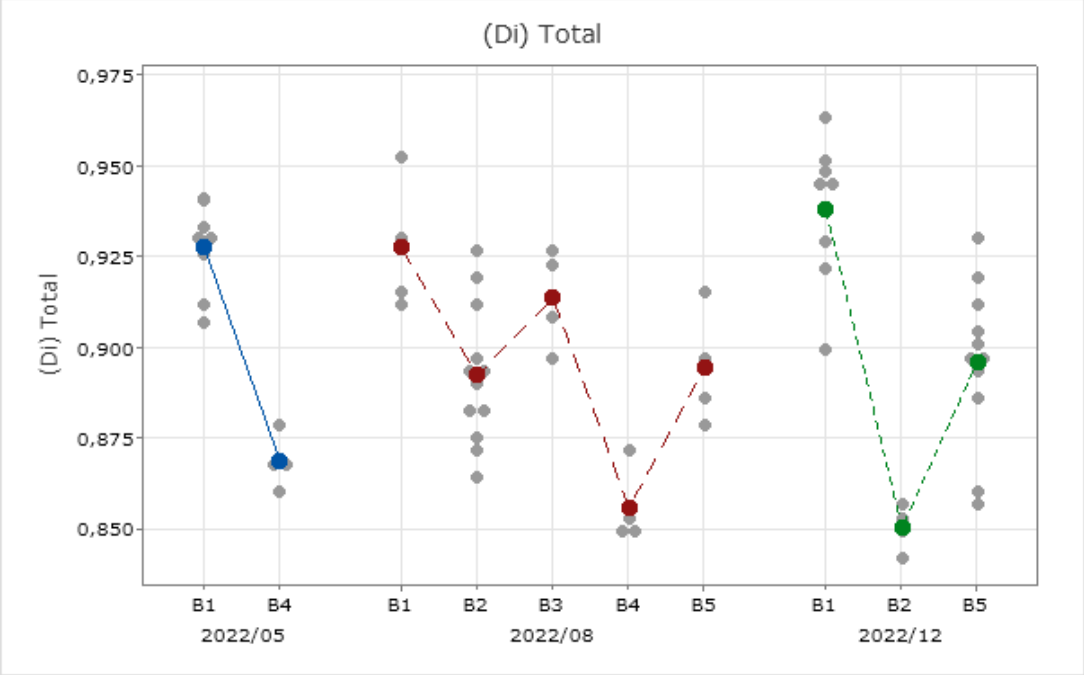


Figure 65: Drying scores by detergent E batch (average value and single run values) and tier, sorted by detergent E batch

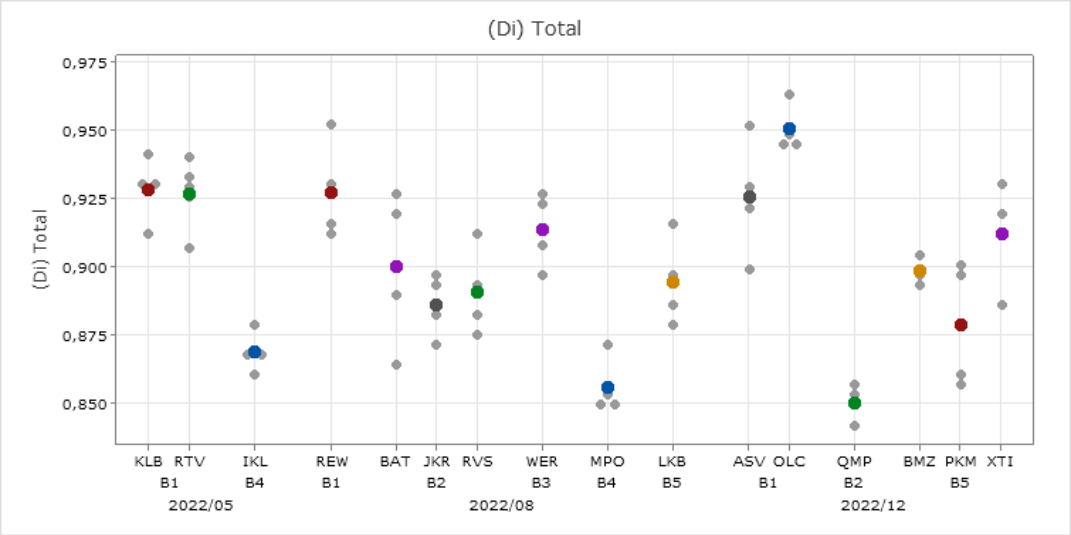


Figure 66: Drying scores by detergent E batch (average value and single run values) tier and lab, sorted by detergent E batch

10 Low Power Modes

In this chapter the summary of the LPM questionnaire is shown as well as the LPM measurement results, which were performed for the test appliance and the additionally provided test box. Due to the high variance in the answer categories the results as present in the tables are shown as absolute numbers by lab and not additionally in %. In total, 15 labs provided input on the LPM measurements.

10.1 LPM questionnaire results

The LPM questionnaire (see Annex) covered four reporting parts, which were the general test set-Up and input on measurement devices, the measurement procedure for off and standby mode, the measurement procedure on net-work standby and a data transfer of all measured data values by lab (not shown in the report to assure lab anonymity).

10.1.1 General test set-up and measurement devices

All 15 labs providing input on the LPM measurement confirm that the dishwasher is set back to factory settings prior to LPM measurement.

86% (n=13) of the participants state not to use the identical equipment and set-up for LPM and performance analyses.

Table 48: Specified changes in measurement equipment for LPM measurement

Reported changes in measurement equipment for LPM measurement	n
Different measurement device: Zimmer LMG 95	2
Different measurement device: Yokogawa powermeter	1
Different measurement device: Powermeter Yokogawa WT310. Connection to Yokogawa done with Gossen Metrawatt Power measuring adapter PMA16 Z228A	1
Different measurement device: Measurement device: Yokogawa WT310E Voltage stabilizer is connected to power supply, measurement device is connected to voltage stabilizer, appliance is connected to measurement device	1
Different measurement device: Energy meter: Christ CLM 1000 Professional+ / Yokogawa WT 210	1
Different measurement device: TS Claude Lyons voltage stabilizer for correct voltage + Power meter Yokogawa WT310E, measurement equipment.	1
Different measurement device: Digital Wattmeter Yokogawa WT210 + Measurem. SW PCMS (Power Consumption) Measuring System) + AC inverter Elettrotest CPSM	1
Current correct with a special adapter between dishwasher and measurement recording system	1
Instrumentation set-up and circuit used for LPM measurements	1
Not further specified	5

The reported set measurement range of the applied measurement equipment is shown in Table 49. Most labs (n=4) report to use the auto range-setting.

Table 49: Set measuring range for the LPM measurement equipment

set measuring range	n
auto range	4
individual setting	2
no detail specification	2

100mA/300V	1
200mA/300V	2
50/100mA; 300V	1
100-200mA / 300V	1
200mA	1
300V	1

Table 50 further specifies input on the low power consumption value measurement procedure and measurement method to obtain the LPM value, power supply stability, crest and distortion factor threshold. The majority of labs (67%, n=19) use the average reading method to obtain the LPM value and follow the step-by-step low power consumption value measurement procedure. 80% of the participants further confirm that the crest-factor and the distortion factor are within allowed thresholds.

Table 50: Further specification on power supply stability, crest and distortion factor threshold, low power consumption value measurement procedure and measurement method to obtain the LPM value

stability of the power supply	**n**	**crest-factor and the distortion factor within allowed threshold**	**n**	**low power consumption value measurement procedure**	**n**	**measurement method to obtain the LPM value**	**n**
Voltage stabilizer	6	yes	12	step by step	10	average reading method	10
Electronic power source	6	no	2	in a row	5	direct reading method	5
AC source	1	not specified	1				
No sufficient specification	2						

Further specification on the networked connected mode measurement is shown in Table 51. 8 labs report that the router provides 2,4 and 5 GHz frequency, 6 labs report that the router provides a 2,4 GHz frequency only. 67% (n=10) labs report to connect the dishwasher to the 2,4 GHz router frequency. 60% of the participants report that there is nothing in-between the router and the dishwasher.

Table 51: Further specification on the networked connected mode measurement

anything between the router and the dishwasher	**n**	**router frequency**	**n**	**to which router frequency is the dishwasher connected**	**n**
no	9	2,4 GHz	6	2,4 GHz	10
yes	6	5 GHz	0	5 GHz	3
		2,4 and 5 GHz	8	not specified	2
		not specified	1		

The reported distance between the dishwasher and the router is shown in figure 67, with a mean range of 1,95 m and a minimum of 1m and a maximum of 28 m. 1 lab did not further specify the distance and 1 lab stated that the distance to the router is 16 m and to the respective repeater 2 m.

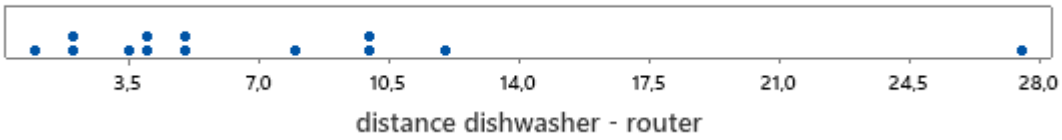
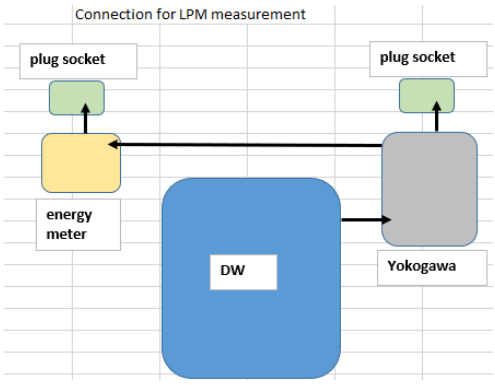


Figure 67: Reported distance between the dishwasher and the router (in meters)

The detail specification of measurement set-up of the connected mode as reported by the labs is summarized in Table 52. 3 labs do not further specify the set-up.

Table 52: Detail specification on the networked connected mode measurement set-up

Detail specification of measurement set-up	n
Equipment is between the source and the dishwasher	1
Current correct measurement	4
Yokogawa WT310 + Laptop	1
test stand for standard tests is used	1
Instrumentation set-up and circuit used for LPM measurements	1
PMA16 adapter connected to ENEL power supply, power line from adapter connected first to the Yokogawa current measurement connectors than back to the adapter, voltage measurement realized by Yokogawa connected to the Adapter power socket by designed Adapter outputs. Load connected straight to the adapter socket.	1
Measurement device: Yokogawa WT310E Voltage stabilizer is connected to power supply, measurement device is connected to voltage stabilizer, appliance is connected to measurement device	1
In the software : specification of type of measurement and which standard the measurement has to comply with. The software indicates automatically if some measurement parameters is out of range. The software measures according to standard and calculates all values automatically. After the measurement a report is created with all needed data.	1
EUT power supplied by controllable AC source (inverter) with Digital wattmeter in-between	1
Sketch on set-up  	1

10.1.2 Measurement procedure for off and standby mode

The questions related to the measurement procedure for off and standby mode had to be answered directly prior to the start of the test series or during the measurement.

Table 53 specifies the interactions done with the appliance or the reaction recognized by the machine during first installation as reported by participants.

Table 53: Interaction done with the appliance or the reaction recognized by the machine during first installation

Interaction done with the appliance or the reaction recognized by the machine during first installation	n
Not specified or not answered specifically	6
Factory setting	4
Switch on	1
Switch on/off, door open/close,	1
Turn on the appliance for the off mode, and change program (without starting it) for the stand-by mode	1
Machine is equipped with a power management system, which minimizes the power consumption	1
Appliance is connected to the stabilized power supply. It was switched on, but not used. The appliance switched off automatically (no display or LEDs active). 15 minutes after switching on the appliance, the measurement was started.	1

87% (n=13) of the labs state to start the recording 15 minutes after the last interaction, 1 lab reports 30 minutes and 1 lab provides no further specification.

The following figure further specifies the reported measurement duration for LPM modes and the specific modes, with 1 lab not specifying the duration for any mode. For the measurement duration for power-off mode 2 labs do not provide durations, stating that the mode is not applicable for the test appliance.

Most labs (n=10 / 67%) stick to a 10-minute measurement duration. The highest reported measurement duration for networked connection is 120 minutes.

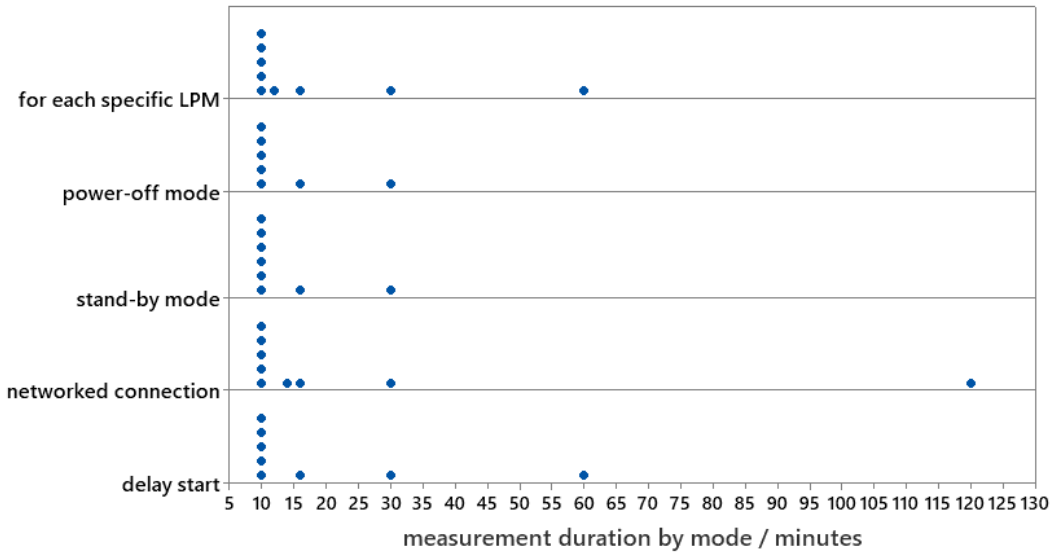


Figure 68: Reported measurement duration for LPM modes and specific modes

Table 54 specifies the door setting specification in LPM measurement. 9 labs state to perform the LPM measurement with open door, 4 with closed door. Further on 9 labs comments to choose different door settings for different modes.

Table 54: Door setting specification in LPM measurement

LPM measurement with open / closed door	n	same door settings followed for different modes?	n
not specified	2	not specified	0
open door	9	same setting	6
closed door	4	different settings	9

Table 55 specifies of program runs are done prior to step 5 and 10 and if interactions are done. Table 56 further specified the program selection prior to step 15 and the duration set for delay-start in step 15.

Table 55: Specifications on program runs and interactions prior to step 5 and 10

program run prior to step 5	n	Interaction in step 5	n	program run prior to step 10	n	Interaction prior to step 10	n
not specified	0	not specified	1	not specified	1	not specified	2
yes	4	yes	11	yes	3	yes	7
no	11	no	3	no	11	no	6

Table 56: Specification on program selection prior to step 15 and the duration set for delay-start in step 15 (n=15)

programme selection prior to step 15 and duration for delay start	n
not specified	2
short-Program, 3h	1
Eco50, 1,5h	1
Eco50, 3h	8
Eco50, 10,5h	1
Eco50, 21h	1
Auto, no duration specified	1

10.1.3 Measurement procedure for net-work standby

Table 57 specifies the connection process of the appliance to the network during measurement. 3 labs do not provide a specific answer.

Table 57: Specification of connection process of the appliance to the network during measurement (n=12)

Connection process of the appliance to the network during measurement
Connect the appliance, activate the network connection on the dishwasher and connect the BSH app with the dishwasher wait 15 min, measure the power consumption
Measure Standby-, Network-Standby- and Delay-Start-Mode in a row. Before the start of stand-by-mode the DW is connected. Then deactivate connection for standby-mode-measurement and activate it before starting the network-standby-measurement
The network connection was either switched on or off before each measurement as described in the measurement procedure. Not during.
Turn DW on and connect with WLAN router by the Home-Connect App
HomeConnect App is installed on a mobile device; Router with SIM-Card (not connected to WIFI of the building) is connected to power supply; WIFI-Function of the dishwasher is activated; mobile device is connected to the router, then a connection between

mobile device and dishwasher is established following the instructions of the manufacturer/HomeConnect App; via mobile device the access code for the router is transferred to the dw; finally the dw is connected to the router and can be controlled remotely
The appliance was connected to the stabilized power source. Then, it was connected to the "HomeConnect" app. The factory settings were restored, before the appliance was reconnected to the app. The "Remote" button was pressed at the appliance, and then the app was closed on the smartphone.
We have to record the machine to the app, via QR code, then connect it to the smartphone, via Bluetooth and same wifi connection. Activating the network connection we can then manage the machine by smartphone app.
Home Connect application was installed on the mobile phone, which was also used as a router. Test appliance was added to the app by QR code on the panel and network connection was made by pressing and holding the button. After the connection was made there was notification of updating the software on the application and the indication of ongoing process was visible on the display (the same as in case of resetting). After several minutes machine was ready to use. Machine was turned off and back on and left undisturbed for 15 minutes before starting the measurements of networked standby.
Enable Wifi on dishwasher, add the dishwasher to the Home Connect app, connect the dishwasher to the app and allow the dishwasher to access the home network.
For Bosch follow the instruction of LPM measurement.
The wireless network was activated in basic settings. The dishwasher was switched on and off with the app and then was the remote start activated.
The consumer App (Home Connect) was installed on a tablet. A smartphone was used as hot-spot (router)

All labs bot one, not providing an answer confirm to have activated the WIFI-functionality of the machine and to have connected the machine to the network and the specific app of the manufacturer. 14 labs further on confirm to have activated the remote start button for standby mode in networked condition and delay start, one lab has not done that and 1 lab does not specify the procedure.

Table 58 further specifies the procedure with mobile device / App during the net-work standby measurement.

Table 58: Procedure with mobile device / App during the measurement (n=15)

Handling of mobile device or the App during the measurement of network standby	**n**
Not specified	1
App is closed	2
App is still open	6
Mobile device is put away	3
App remains open until the power management of the mobile device shuts it off. After that the mobile device is periodically reactivated to confirm that the connection between app and dw remains active.	1
Measured in both conditions with similar result	1
Keep in active state, wiping over the screen from time to time	1

10.2 LPM consumption values

Table 59 and the following figures show the LPM measurement results. All labs but one performed LPM measurements.

For the LPM “delay start” the target value is 2,89 W. The mean value of the reported measurement data is 2,848 W, with a minimum of 2,600 W and a maximum of 3,050 W.

For the LPM “networked connection” the target value is 1,46 W. The mean value of the reported measurement data is 1,638 W, with a minimum of 1,410 W and a maximum of 2,023 W. The networked connection data show the highest variation for all reported LPM data, with a StDev of 0,189 W.

For the LPM “power off” and “stand-by” the target value is 0,20 W for both, as the mode “power off” does not exist for the TA. The mean value of the reported measurement data for power off, which was performed by 11 labs next to the standby measurement, is 0,215 W, with a minimum of 0,184 W and a maximum of 0,271 W. The mean value of the reported measurement data for standby is 0,212 W, with a minimum of 0,184 W and a maximum of 0,274 W.

For test box the target value is 0,81 W. The mean value of the reported measurement data is 0,812 W, with a minimum of 0,800 W and a maximum of 0,840 W.

The outlier test just shows one outlier for the labs providing LPM data for Standby (outlier: lab ASV).

Table 59: Basic statistics and expanded uncertainty E_{OR} % of the LPM measurement data (W)

LPM		N (labs)	Minimum	Maximum	Mean	Standard deviation	E_{OR}/%
all data	LPM Power off (W)	11	0,184	0,271	0,215	0,026	24
	LPM Standby (W)	16	0,184	0,274	0,212	0,024	23
	LPM Delay start (W)	16	2,600	3,050	2,848	0,096	7
	LPM networked (W)	16	1,410	2,023	1,638	0,189	24
	Test box (W)	16	0,800	0,840	0,812	0,012	3
data excluding outliers	LPM Power off (W)	11	0,184	0,271	0,215	0,026	24
	LPM Standby (W)	15	0,184	0,252	0,208	0,018	18
	LPM Delay start (W)	16	2,600	3,050	2,848	0,096	7
	LPM networked (W)	16	1,410	2,023	1,638	0,189	24
	Test box (W)	16	0,800	0,840	0,812	0,012	3

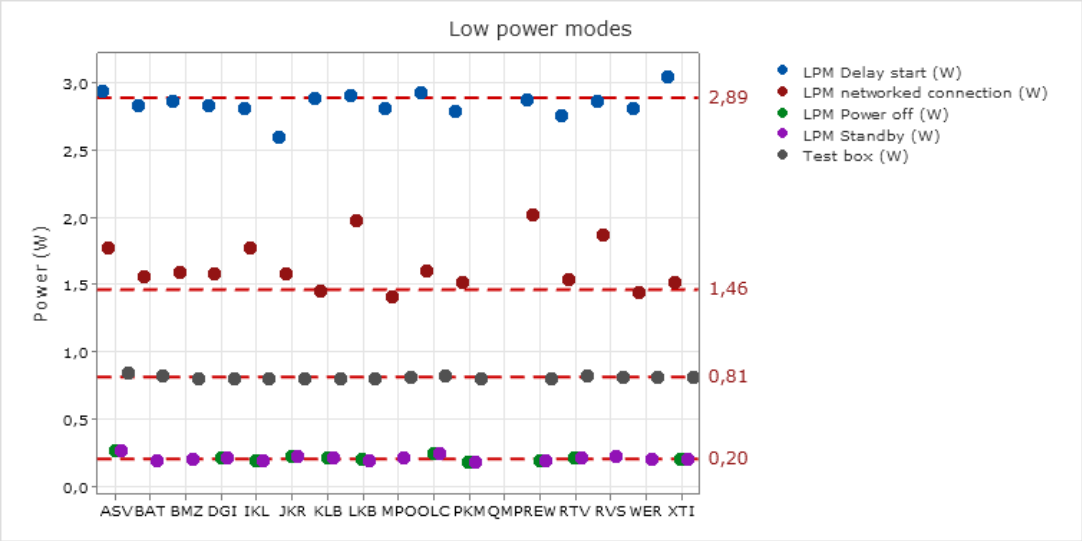
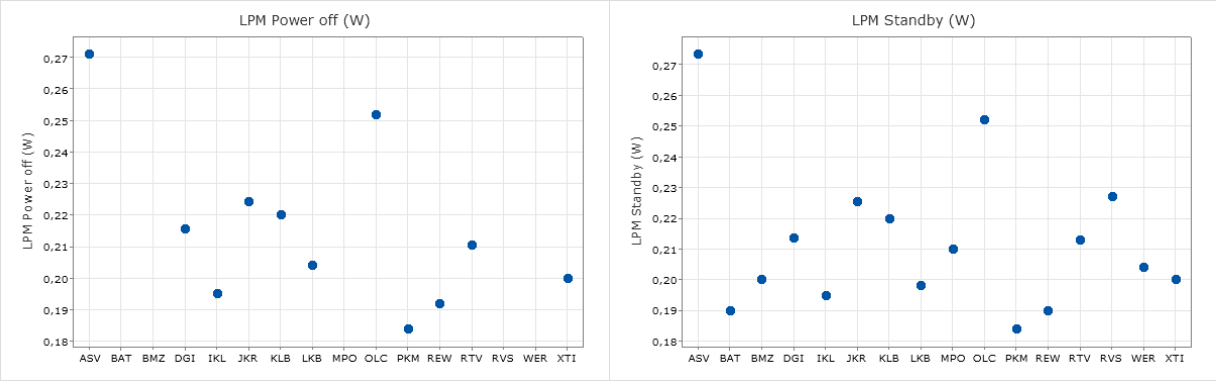
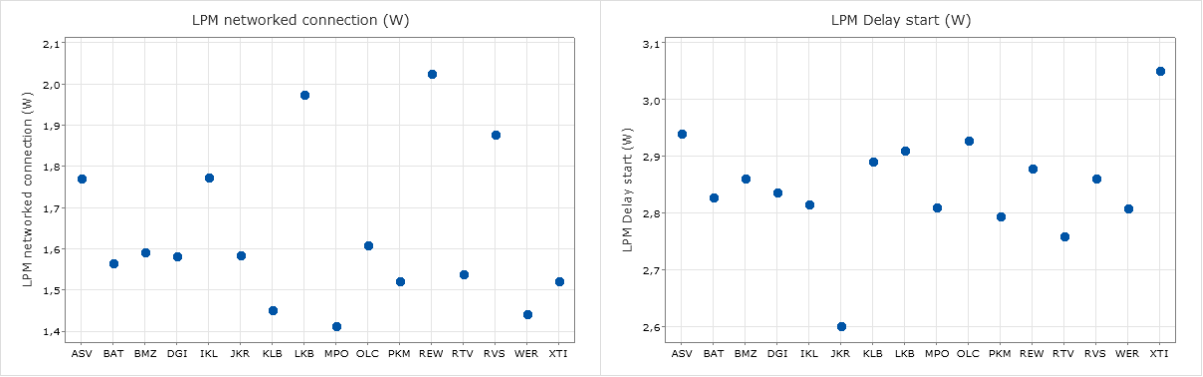


Figure 69: Dotplot of low power mode measurements by lab (n=15)





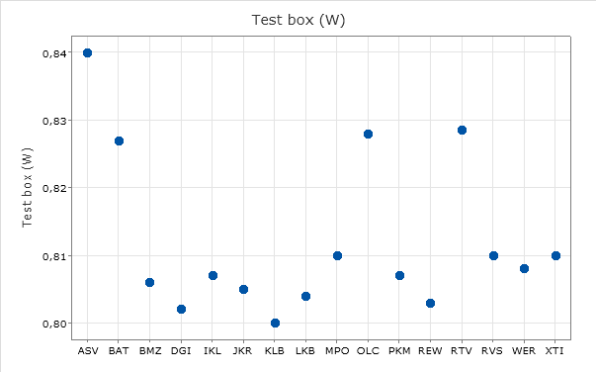


Figure 70: Dotplots of low power mode measurement "power off", "standby", "networked connection" and "delay start" and the text box by lab

11 Result review additional appliances (“own appliances”)

11.1 Result overview cleaning

All reported data on the 11 additionally tested own appliances are shown either ranked by the number of place settings (PS) or by appliance dimension (45 cm / 60 cm / other). The identity of the labs contributing the results per appliance is not disclosed – the tested appliances are coded with individual letters (A to K).

The following Table 60 and Figure 71 show the reported cleaning scores of the measured additional own appliances by number of place setting (PS) and detergent. A figure sorting the cleaning score by appliance dimension is shown in addition (Figure 72).

All appliances with 7 – 13 PS show similar cleaning score results with no significant differences. Significant differences are shown for the appliance with 17 PS and some of the appliances with 14 PS.

Table 60: Cleaning score basic statistics of own appliances by number of place settings and detergent

Numer of PS	Detergent	N	Mean	SE Mean	StDev	Min	Q1	Median	Q3	Max
7	D	5	4,360	0,038	0,085	4,288	4,288	4,338	4,444	4,488
7	E	5	4,440	0,043	0,095	4,325	4,338	4,488	4,519	4,525
10	D	9	4,458	0,038	0,113	4,216	4,387	4,478	4,545	4,577
10	E	8	4,472	0,042	0,120	4,252	4,392	4,482	4,568	4,631
13	D	12	4,396	0,049	0,169	4,103	4,281	4,387	4,510	4,740
13	E	12	4,558	0,048	0,167	4,288	4,373	4,634	4,690	4,740
14	D	19	4,116	0,042	0,181	3,699	3,981	4,083	4,295	4,397
14	E	18	4,244	0,056	0,237	3,814	4,051	4,311	4,402	4,571
17	D	4	3,508	0,068	0,135	3,409	3,414	3,460	3,651	3,704
17	E	4	3,473	0,097	0,194	3,344	3,347	3,395	3,677	3,758

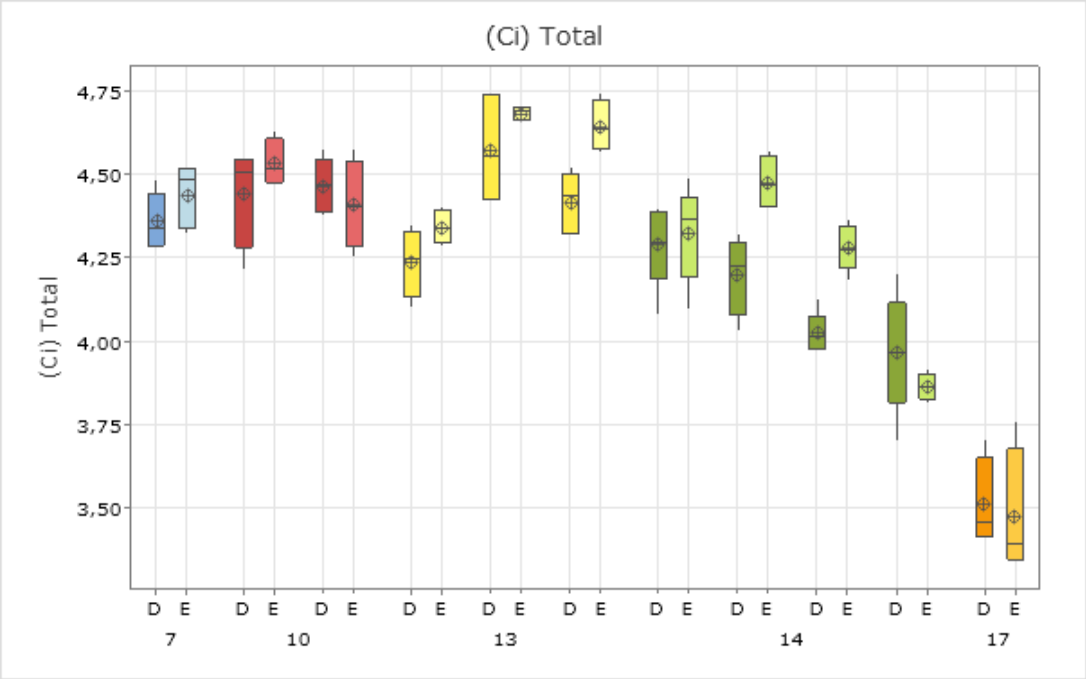


Figure 71: Own appliances cleaning score by number of place settings and detergent

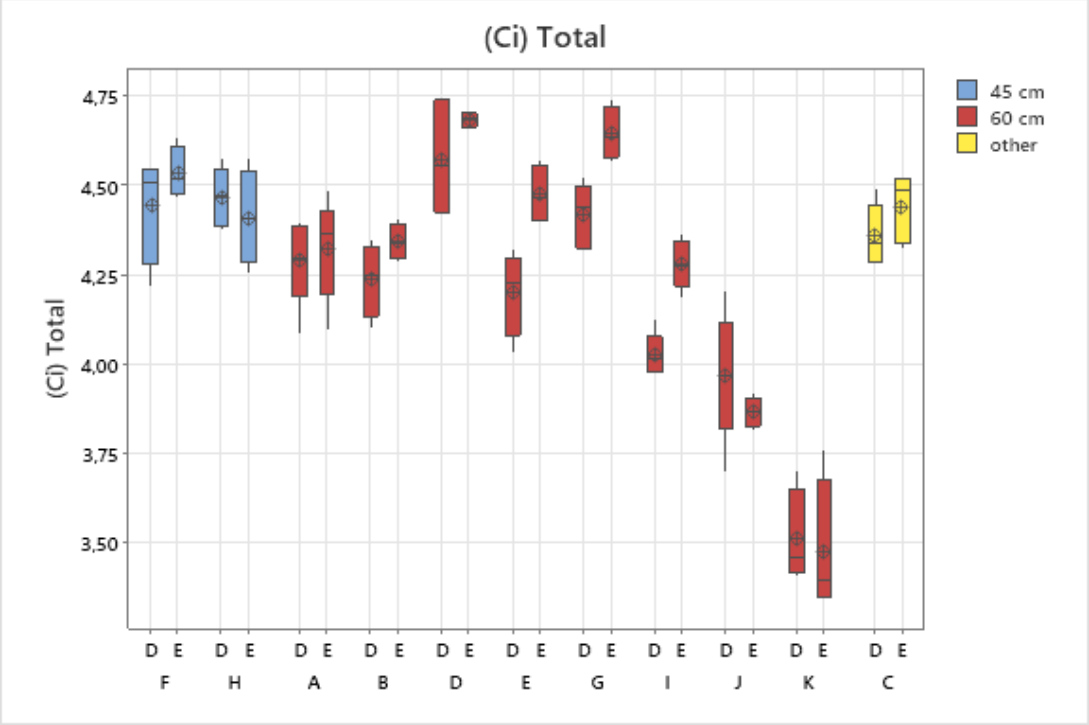


Figure 72: Own appliances cleaning score by appliance dimension and detergent

11.2 Result overview drying

The following Table 61 and Figure 73 show the reported drying scores of the measured additional own appliances by number of place setting (PS) and detergent. A figure sorting the drying score by appliance dimension is shown in addition.

The overall drying score analysis shows significant differences by place setting for all numbers of PS, but appliances with PS of 10 and 13 for the tested appliance range. Differences are especially shown the appliances with 7 PS (Figure 73).

Table 61: Drying score basic statistics of own appliances by number of place settings and detergent

Numer of PS	Detergent	N	Mean	SE Mean	StDev	Min	Q1	Median	Q3	Max
7	D	5	0,723	0,009	0,020	0,706	0,709	0,719	0,738	0,756
7	E	5	0,699	0,012	0,027	0,675	0,681	0,688	0,722	0,744
10	D	9	0,900	0,008	0,023	0,874	0,881	0,892	0,917	0,946
10	E	8	0,885	0,007	0,020	0,860	0,866	0,885	0,901	0,914
13	D	12	0,909	0,010	0,034	0,825	0,898	0,920	0,926	0,962
13	E	12	0,912	0,006	0,020	0,884	0,898	0,908	0,923	0,955
14	D	19	0,941	0,004	0,019	0,907	0,929	0,939	0,958	0,974
14	E	18	0,930	0,005	0,021	0,901	0,913	0,925	0,949	0,968
17	D	4	0,839	0,004	0,007	0,833	0,833	0,839	0,846	0,847
1	E	4	0,848	0,016	0,032	0,823	0,824	0,839	0,882	0,893

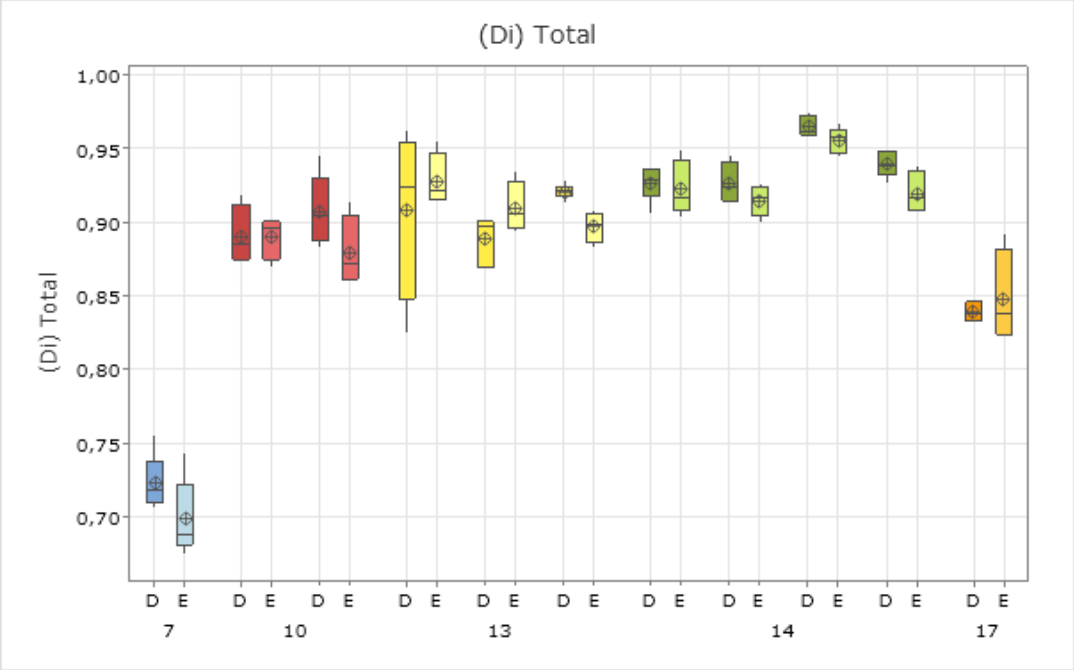


Figure 73: Own appliances drying score by number of place settings and detergent

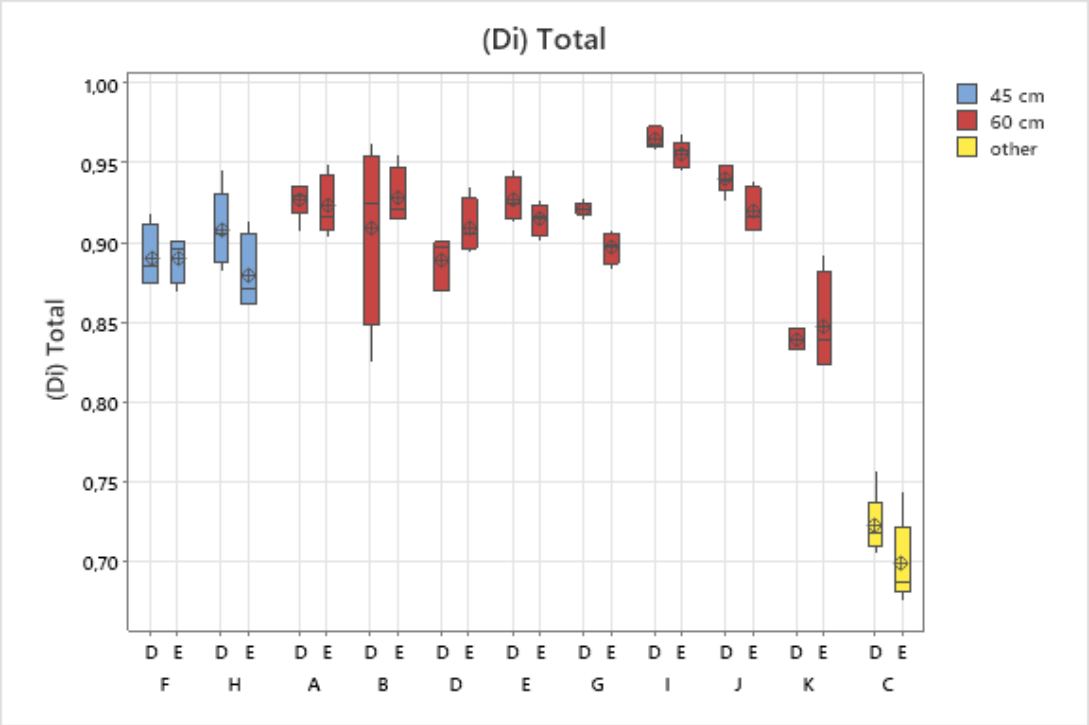


Figure 74: Own appliances drying score by appliance dimension and detergent

11.3 Overall indices "own appliance"

In the following the basic statistics and boxplot summary of the cleaning and drying indices of the current, future and hybrid set-up is shown. The dotplot figures further specify the results by PS and appliance.

Table 64 summarizes the overall cleaning and drying indices (Current / Future / Hybrid) of the own appliances by number of place settings. The drying indices are either calculated based on the reported values (as currently defined in the standard) or calculated based on a fixed value (Table 64). The fixed value calculation is shown, even though it is not suitable for the hybrid and the future system, as it is assuming a target value, that is not available.

For the cleaning index the future system shows significantly lower values over all PS than the current and the hybrid system, also if appliances with 7 and 17 PS are excluded in the analysis.

The drying index does not show significant differences in the system approaches. When appliances with 7 and 17 PS are excluded, the drying index is significantly lower for the future system.

Table 62: Own appliances cleaning indices basic statistics (CU = current system, FU= future system, HY = hybrid system) by number of place settings including the RRT test appliance (TA),

System	Number of PS	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
CURRENT	7	1	1,245	*	*	1,245	*	1,245	*	1,245
CURRENT	10	2	1,277	0,002	0,003	1,275	*	1,277	*	1,279
CURRENT	13	3	1,253	0,021	0,036	1,214	1,214	1,261	1,284	1,284
CURRENT	13 (TA)	1	1,180	*	*	1,180	*	1,180	*	1,180
CURRENT	14	4	1,196	0,030	0,059	1,112	1,134	1,213	1,241	1,247
CURRENT	17	1	1,032	*	*	1,032	*	1,032	*	1,032
FUTURE	7	1	1,074	*	*	1,074	*	1,074	*	1,074
FUTURE	10	2	1,084	0,016	0,022	1,068	*	1,084	*	1,099
FUTURE	13	3	1,101	0,027	0,047	1,047	1,047	1,125	1,132	1,132
FUTURE	13 (TA)	1	1,070	*	*	1,070	*	1,070	*	1,070
FUTURE	14	4	1,035	0,020	0,039	0,993	0,999	1,032	1,075	1,085
FUTURE	17	1	0,947	*	*	0,947	*	0,947	*	0,947
HYBRID	7	1	1,188	*	*	1,188	*	1,188	*	1,188
HYBRID	10	2	1,199	0,017	0,024	1,182	*	1,199	*	1,216
HYBRID	13	3	1,218	0,030	0,052	1,158	1,158	1,244	1,252	1,252
HYBRID	13 (TA)	1	1,130	*	*	1,130	*	1,130	*	1,130
HYBRID	14	4	1,146	0,024	0,048	1,085	1,099	1,149	1,189	1,200
HYBRID	17	1	0,929	*	*	0,929	*	0,929	*	0,929

Table 63: Own appliances drying indices basic statistics (CU = current system, FU= future system, HY = hybrid system) by number of place settings including the RRT test appliance (TA)

System	Number of PS	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
CURRENT	7	1	1	0,850	*	*	0,850	*	0,850	*
CURRENT	10	2	2	1,058	0,011	0,015	1,047	*	1,058	*
CURRENT	13	3	3	1,070	0,008	0,015	1,055	1,055	1,071	1,084
CURRENT	13 (TA)	1	1	1,110	*	*	1,110	*	1,110	*
CURRENT	14	4	4	1,150	0,036	0,071	1,091	1,092	1,136	1,223
CURRENT	17	1	1	1,053	*	*	1,053	*	1,053	*
FUTURE	7	1	1	0,773	*	*	0,773	*	0,773	*
FUTURE	10	2	2	0,981	0,006	0,008	0,975	*	0,981	*
FUTURE	13	3	3	1,010	0,008	0,014	0,998	0,998	1,007	1,025
FUTURE	13 (TA)	1	1	1,020	*	*	1,020	*	1,020	*
FUTURE	14	4	4	1,029	0,007	0,015	1,013	1,015	1,028	1,043
FUTURE	17	1	1	0,952	*	*	0,952	*	0,952	*
HYBRID	7	1	1	0,840	*	*	0,840	*	0,840	*
HYBRID	10	2	2	1,067	0,007	0,009	1,061	*	1,067	*
HYBRID	13	3	3	1,098	0,009	0,015	1,086	1,086	1,095	1,114
HYBRID	13 (TA)	1	1	1,110	*	*	1,110	*	1,110	*
HYBRID	14	4	4	1,136	0,019	0,038	1,102	1,104	1,129	1,175
HYBRID	17	1	1	1,017	*	*	1,017	*	1,017	*

Table 64: Summary of cleaning indices and drying indices of own appliances (current system, future system, hybrid system (reported value and fixed value in drying)) specifying number of place settings and appliance width

System	Place Settings	Width of appliance	Lab Code	Cleaning Index	Drying index (as defined in standard)	Drying index (fixed value 0,82)
Current System	14	60 cm	I	1,11	1,24	
Current System	14	60 cm	J	1,25	1,18	
Current System	17	60 cm	K	1,03	1,05	
Current System	14	60 cm	A	1,22	1,09	
Current System	13	60 cm	B	1,21	1,07	
Current System	7	Other	C	1,24	0,85	
Current System	13	60 cm	D	1,28	1,05	
Current System	14	60 cm	E	1,20	1,09	
Current System	10	45 cm	F	1,28	1,05	
Current System	13	60 cm	G	1,26	1,08	
Current System	10	45 cm	H	1,28	1,07	
Future System	14	60 cm	I	0,99	1,03	
Future System	14	60 cm	J	1,02	1,05	
Future System	17	60 cm	K	0,95	0,95	
Future System	14	60 cm	A	1,05	1,02	
Future System	13	60 cm	B	1,05	1,02	
Future System	7	Other	C	1,07	0,77	
Future System	13	60 cm	D	1,13	1,01	
Future System	14	60 cm	E	1,08	1,01	
Future System	10	45 cm	F	1,10	0,99	
Future System	13	60 cm	G	1,12	1,00	
Future System	10	45 cm	H	1,07	0,98	
Hybrid System	14	60 cm	I	1,14	1,18	1,17
Hybrid System	14	60 cm	J	1,08	1,15	1,13
Hybrid System	17	60 cm	K	0,93	1,02	1,04
Hybrid System	14	60 cm	A	1,16	1,11	1,13
Hybrid System	13	60 cm	B	1,16	1,11	1,13
Hybrid System	7	Other	C	1,19	0,84	0,85
Hybrid System	13	60 cm	D	1,25	1,09	1,11
Hybrid System	14	60 cm	E	1,20	1,10	1,12
Hybrid System	10	45 cm	F	1,22	1,07	1,09
Hybrid System	13	60 cm	G	1,24	1,09	1,10
Hybrid System	10	45 cm	H	1,18	1,06	1,08

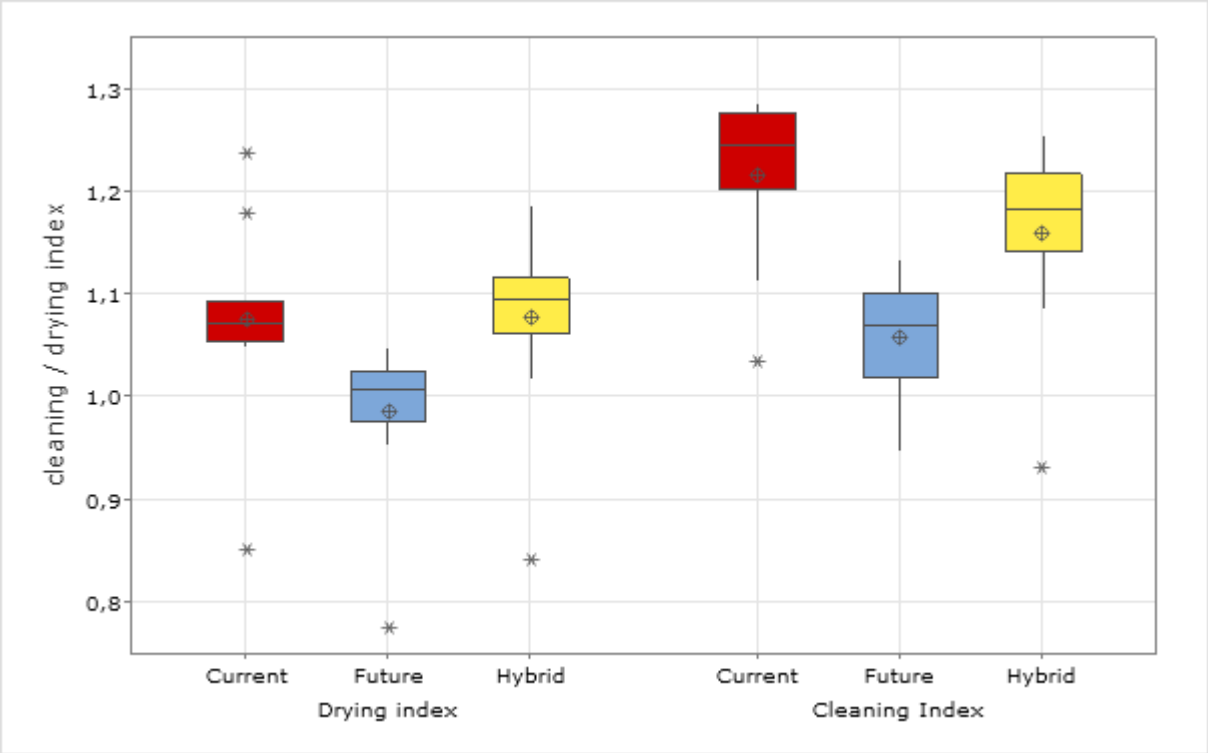


Figure 75: Own appliances overall cleaning and drying indices for current, future and hybrid system

Figure 76 additionally shows the drying index values for the current (OR-D /TA-D), future (NR-E/TA-E) and hybrid system (OR-E/TA-E) for the own appliances, either calculated based on the reported values (as currently defined in the standard) or calculated based on a fixed value

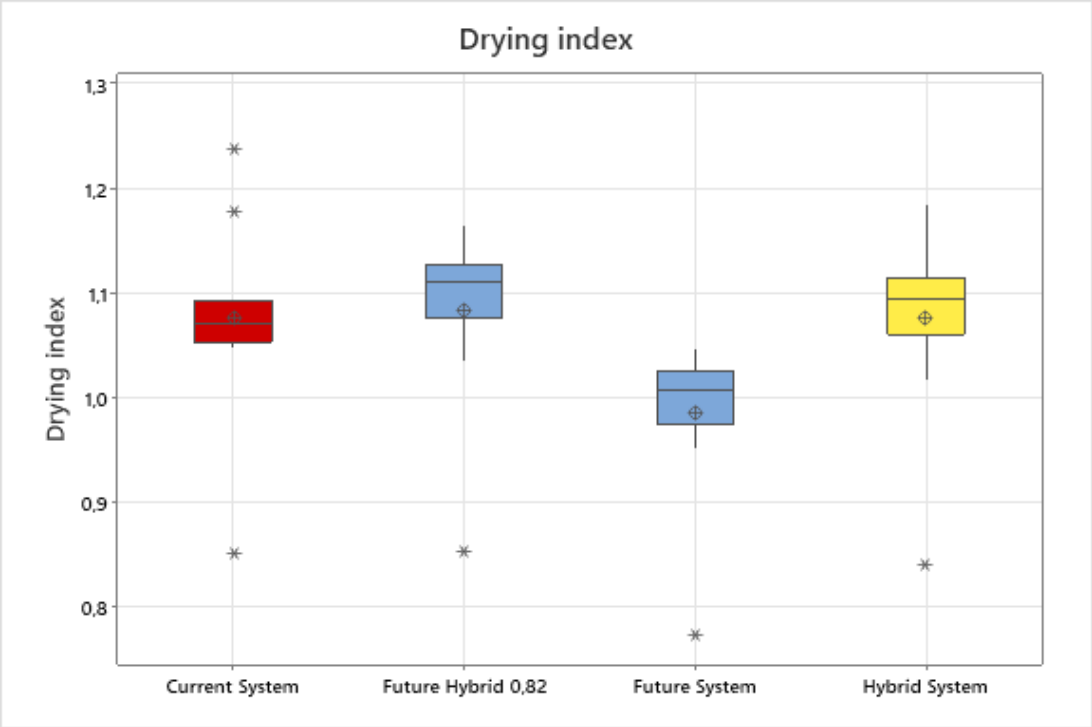


Figure 76: Own appliances overall drying indices for current, future and hybrid system based on reported values and fixed value (0,82)

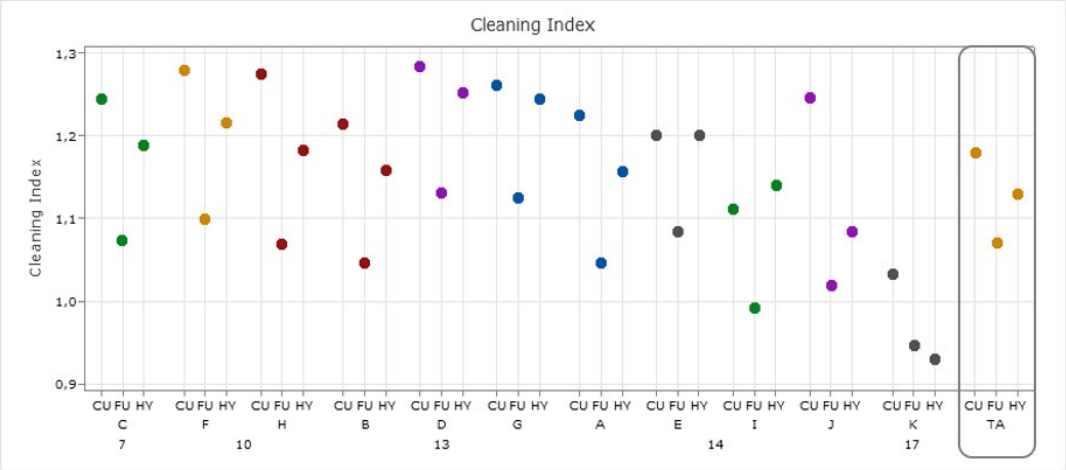


Figure 77: Own appliances cleaning indices (CU = current system, FU= future system, HY = hybrid system) by number of place settings including the RRT test appliance (TA)

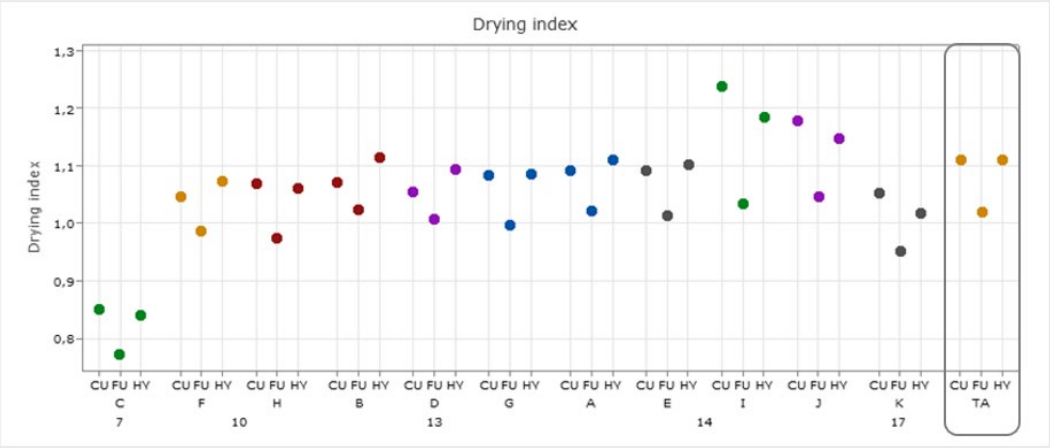


Figure 78: Own appliances drying indices (CU = current system, FU= future system, HY = hybrid system) by number of place settings including the RRT test appliance (TA)

12 Conclusions

12.1 Summary of important findings related to test procedures

Through the round robin test it was possible to gain a deeper insight into the laboratory practice and application of the upcoming future system with a new reference machine and the new detergent E.

The examination of the collected data on the one hand and the exchange with different labs, revealed good knowledge in applying the basic standard parameters like environmental conditions, consumption values and LPM, but also showed that further practice to handle the values of cleaning performance with the future reference system is required.

This test report examined the performance of a new reference system compared to the previous reference system, specifically a new reference detergent and a new reference machine. The main objective of the test was to determine if a correction factor is necessary to compensate for discrepancies between the measurements of the two systems and to improve the accuracy of the results. Among other things, the specific areas or measured variables for which the correction factor is required must be identified.

The data analysis of the own appliances, which were checked on a voluntary basis in this RRT, showed that a correction factor is actually necessary. The new reference system delivers different measurement results for the Cleaning Index and Drying Index compared to the previous reference system. This is particularly visible in devices with 14-17 place settings. This data can be used as comparative data.

A correction factor is typically used to adjust or equalize the results or measurements of the new system to the results of the previous reference system.

The exact calculation of the correction factor depends on the specifics of the reference system and the type of data being measured. Validation studies or comparative analysis between the new and the established reference system are often carried out to determine the correction factor. The data collection in this RRT can help.

It is important that the introduction of a correction factor is done carefully to ensure that the measurements and results from the new reference system are reliable and accurate.

12.2 Proposals for future improvements

In order to determine the correction factor, the following considerations should be made: Use a fitting function to calculate the correction factor. The correction factor can be represented as a multiplier or an adder to adjust the readings of the new system to those of the previous system. The validation of the calculated correction factor can be carried out by taking further measurements/data collection and comparing the results with the previous reference system. It should be ensured that the correction factor provides the desired adjustments. After adjustment with the correction factor, the measurement uncertainty should be recalculated in order to be able to assess the reliability of the adjustment

APPENDIX

Appendix A: General Procedure Manual Dishwasher RRT

Appendix B: Test appliance (SMV6ECX51E) key information

Appendix C: New reference machine key information

Appendix D: Pre-Questionnaire

Appendix E: LPM-Questionnaire

Appendix F: Detail results cleaning score by type of dishware

Appendix G: Detail results drying score by type of dishware