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Critical aspects in the determination of the surface in contact with foods for migration testing of kitchen utensils

Results from two investigations by interlaboratory comparisons organised by the European Reference Laboratory for food contact materials

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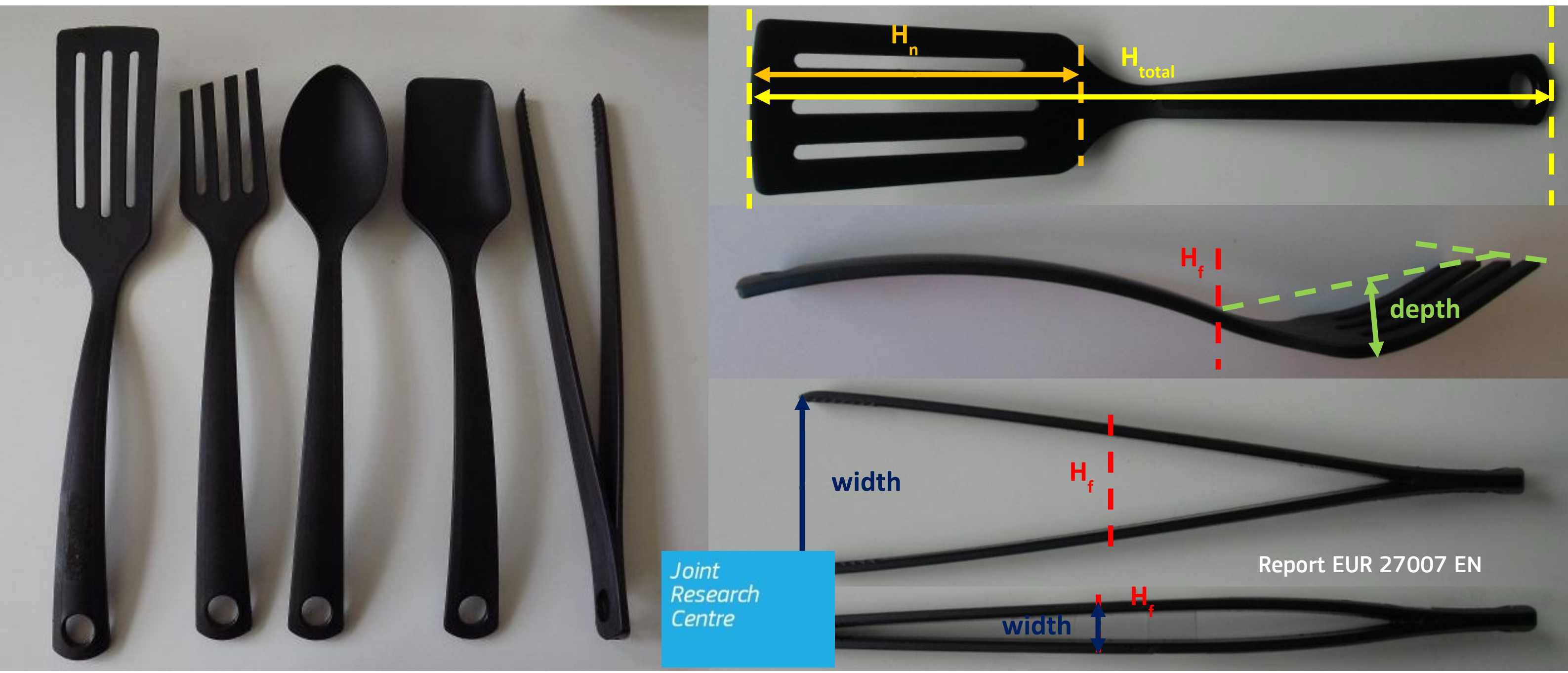

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Abstract

This report presents the results of investigations by ILCs and follow-up questionnaires which focused on the determination of the food contact surface area of kitchen utensils. The study also included a voluntary exercise on the determination of the envelope volume which constitutes a different technique to estimate contact with foods.
The objective of the study was to identify sources of error that appeared in a first ILC (ILC003 2013) previously reported (EUR 26477, 2013).A questionnaire was designed and all laboratories which had obtained a zU-score >2 or <-2 for any of the reported results in ILC003 2013 were kindly invited to reply. With the information gained from the questionnaire, some difficulties in the surface area measurement and the main issues in the determination of Hf and the envelope volume could be identified. Reasons why certain results reported during ILC003 2013 had been outside the tolerance limits could also be identified.

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1. Summary

The Institute for Health and Consumer Protection (IHCP) of the European Commission's Directorate-General Joint Research Centre hosts the EU Reference Laboratory for Food Contact Materials (EURL-FCM). One of its core tasks is to organise interlaboratory comparisons (ILCs) among appointed National Reference Laboratories (NRLs).This report presents the results of investigations which focused on the determination of the food contact surface area of kitchen utensils. The study included results from ILCs and of questionnaires that were developed as follow up. It also included a voluntary exercise on the determination of the envelope volume which constitutes a different technique to estimate contact with foods. The objective of the study was to identify sources of error that appeared in a first ILC (ILC003 2013) previously reported [1]. A questionnaire was designed and all laboratories which had obtained a z_U-score >2 or <-2 for any of the reported results in ILC003 2013 were kindly invited to reply. With the information gained from the questionnaire, some difficulties in the surface area measurement and the main issues in the determination of H_f and the envelope volume could be identified. Reasons why certain results reported during ILC003 2013 had been outside the tolerance limits could also be identified. Issues identified for the surface area measurement were related to whether one or both sides of an article needed to be considered in the surface area measurement and to samples that contained slots or holes. Several participants did not remove or subtract slotted parts when measuring the surface of articles. In general, the determination of the surface area of a test specimen should be done as accurately as possible. For those articles where slotted parts and/or side parts have a negligible contribution to the total surface of a sample, a convention could be developed that allows ignoring these sample parts. For the determination of the envelope volume, including the determination of H_f, the main issues were related to the measurement of the sample dimensions, meaning H_{total}, H_{handle}, H_n, as well as depth and width of each sample. In contrast to what was hypothetised upon completion of the ILC003 2013, the main difficulty was not related to whether dimensions were measured straight or along the curved shape of an article but rather to the sample part which was considered relevant for the measurement.

2. Introduction

ILC studies are an essential element of laboratory quality assurance and allow individual laboratories to check their analytical performance while providing them objective standards to perform against. It is one of the core duties of the EU Reference Laboratories to organise interlaboratory comparisons, as stated in Regulation (EC) No 882/2004 of the European Parliament and of the Council [2].This report presents results of investigations carried out in 2014 which focused on the determination of the food contact surface area of kitchen utensils. The work was a follow up of the outcome of the first investigation on surface area as ILC which took place in 2013. In the ILC003 2013 [1], the participants had been provided with five different kitchen utensils. The exercise foresaw to determine the sample height (H_f) up to which contact with food would be foreseeable for each sample and to measure the surface area of this sample part in contact with food (as defined by H_f). This could be done following four different test protocols representing four different approaches. An additional voluntary exercise aimed at the determination of the envelope volume of all five samples on a 2-cm-scale and on a 5-cm-scale, again following instructions provided by the EURL-FCM. The envelope volume refers to the volume of a rectangular solid which can be constructed around each sample and which serves as an estimate for the amount of food that will come into contact with the respective sample under normal, foreseeable conditions of use [3]. During the evaluation of the results submitted in ILC003 2013, it became obvious that the determination of the H_f value had been problematic. The same applied to results submitted for the surface area and the envelope volume where some laboratories had reported inexplicably high or low values. At the time of the evaluation of the data of the ILC003 2013 by the EURL-FCM, it was not possible yet to speculate on the reasons that caused the discrepancies. Therefore a further investigation was developed using questionnaires specifically designed in order to identify the potential critical parameters as cause for errors. All laboratories which had obtained a z_U-score >2 or <-2 in one of the exercises of ILC003 2013 were kindly invited to fill it in.

3. Scope

The objective of this study was to identify sources of error which had appeared in ILC003 2013. A specific questionnaire was designed, developed and distributed to all participants whose results in ILC003 2013 had been outside the tolerance limits. The information gained from this questionnaire aimed to help improving guidance or instructions for the measurement of surface area of food contact articles and to identify critical steps in novel approaches such as the determination of the envelope volume.

4. Instructions to participants and requested information

The questionnaire consisted of six parts. Part I covered general aspects, e.g. feedback on the instructions provided in ILC003 2013, occurrence of calculation mistakes and errors in reporting of values. Part II-VI contained specific questions for each of the five samples A-E. These questions were mostly related to the measurement of the sample dimensions (i.e. H_{total}, H_n, H_{handle}, depth and width) on which the calculation of H_f and the envelope volume in ILC003 2013 had been based (Annex 0). The laboratories were asked to fill in specific parts of the questionnaire, depending on which of their results in ILC003 2013 had been outside the tolerance limits (Annex 0).

5. Results and Conclusions

5.1. Participation

44 laboratories were asked to fill in the questionnaire, among them 19 NRLs and 25 official control laboratories. 33 of them submitted the filled questionnaire (18 NRLs, 15 OCLs). 16 of them had voluntarily answered the entire questionnaire, even though only the filling of certain parts had been requested to them.

5.2. Results

The information about measurement methods used to determine H_{total}, H_{handle}, H_n, depth and width of the samples is summarised in Annex 9.2 Table 10 to Table 14. The values reported for the different measured parameters are listed in Annex 9.6 Table 15 to Table 19.

5.2.1. *Sample height with foreseeable food contact (Hf)*

For the determination of H_f in ILC003 2013, participants had to measure the total height (H_{total}) of the sample, the height of the handle (H_{handle}) if a handle was clearly defined (otherwise by default it had to be assumed that 1/3 of H_{total} served as a handle) and the height of the functional part with necessary food contact (H_n). Based on the measured values, the calculation of H_f was done as shown in Figure 1.

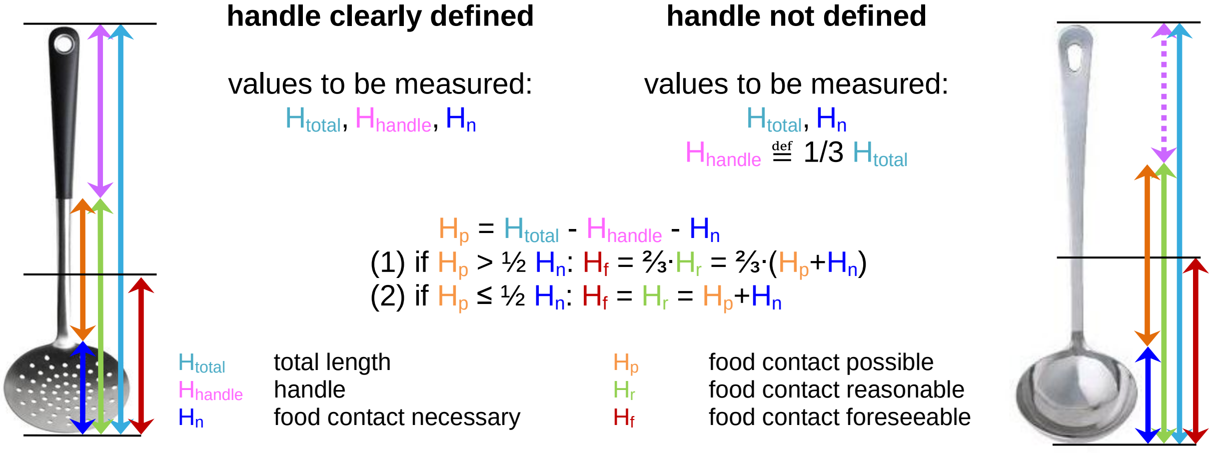

Figure 1 Scheme for the determination of H_f. Detailed instructions were given in [1]. (Photos from www.ikea.com)

The information received allowed in most cases to identify why participants obtained H_f values outside the tolerance limits in ILC 003 2013. The main reasons were mistakes in the calculation of H_f itself or in the calculation of the default value for H_{handle}. In addition, several participants assumed a value for H_{handle} that was different from the default value of 1/3 of H_{total}. The main difficulty for sample A, a flat kitchen spatula, was the definition of H_n. For sample C, a spoon, one of the participants had measured H_{total} along the curved shape of the elliptic spoon part. All identified reasons are listed in Table 1. For some laboratories, the reasons remained unclear. Figure 2 to Figure 6 in Annex 9.3 show the correlation between the measurement methods, the values obtained for H_{total}, H_{handle} and H_n and the results obtained for H_f. All graphics were prepared using R and the R package "ggplot2" ([7], [8]).

Table 1 Identified reasons why obtained H_f values were outside the tolerance limits for the respective sample

Reasons why obtained H_f values were outside tolerance limits	Number of affected laboratories				
	Sample A	Sample B	Sample C	Sample D	Sample E
mistake in calculation of:					
H_f itself	1	1	1	1	0
default value for H_{handle}	1	1	1	1	1
mistake likely but not confirmed	2*	3	2	2	3
determination of H_{total}, H_{handle} and H_n:					
way of measurement of H_{total}	0	0	1	0	0
part taken into consideration for H_{total}	0	0	0	0	1
part taken into consideration for H_{handle} (≠ default value (1/3 of H_{total}))	4	4	3	2	8
part taken into consideration for H_n	12	0	0	0	0
reason unclear**	0	0	0	0	0
no information available***	4	5	7	3	6

*NOTE: One of these laboratories reported values for H_{total}, H_{handle} and H_n in the study that were probably not those actually assumed in ILC003 2013. Therefore it cannot be clarified whether a calculation mistake took place.
** From the information gained in the follow-up, no reason could be identified why the respective participant obtained a H_f value outside the tolerance limits.

*** Respective laboratories had obtained results outside the tolerance limits in ILC003 2013 but did not participate in the study.

Calculation mistakes

Two laboratories declared to have made a mistake in calculation (marked with a red filling in Figure 2 to Figure 6, Annex 9.3). One of them had applied $H_f = H_r$ to all samples A-D, instead of $H_f = 2/3\ H_r$ as the rules would have required in their case (Figure 1 and instructions in [1]). The other laboratory had done a mistake in calculating the default value for H_{handle} for all samples. In the instructions, this value was set to 1/3 (i.e. 33.3%) of H_{total}. Instead, the laboratory concerned had assumed by mistake 30% of H_{total} as the default value for H_{handle}. For both laboratories, the obtained H_f values were outside the tolerance limits. For some other laboratories, it is likely that they made a mistake in the calculation of H_f as well. From the values reported for H_{total}, H_n and H_{handle} during the study, the EURL-FCM recalculated the respective H_f values and compared them to the value submitted by the respective laboratory in ILC003 2013. The H_f values obtained by the EURL-FCM are displayed in Annex 9.3 Figure 2 to Figure 6 by a green plus-symbol ("+"). Small deviations up to 0.2 cm between the reported and recalculated H_f values may be due to rounding of values by the participants. For two laboratories in case of sample A, C and D and three laboratories in case of sample B and E, the deviation is higher than 0.2 cm. In these cases, it is likely that the respective participant either had done a mistake in the calculation of H_f or the values for H_{total}, H_n and H_{handle} reported by them within the study were not those used in ILC003 2013. The latter may be the case for at least one of the laboratories where the value for H_{total} of sample A reported in the study is equal to the H_f value they had reported for the same sample in ILC003 2013 (Annex 9.3 Figure 2b). Consequently, the H_f value recalculated by the EURL-FCM is lower than the one initially reported by the laboratory in ILC003 2013.

Measurement of H_{total}, H_{handle} and H_n

For all five samples, the values obtained for H_{total} were very similar, irrespective of whether H_{total} was measured diagonal between the edges of a sample, as a projection or somehow along the curved shape of a sample (Annex 9.3 Figure 2 to Figure 6). Consequently, the way how the total height (H_{total}) was measured was of minor influence on the obtained H_f values. The only exception was for sample C, an elliptic spoon, where one of the participants had measured H_{total} along the curved shape of the elliptic spoon part. The obtained value for H_{total} was significantly higher and the resulting value for H_f was outside the tolerance limit. In general, it was more important which sample part was considered for the measurement of H_{total}, rather than the way its height was measured. For example, one of the laboratories obtained a much lower total height (H_{total}) for sample E, some kitchen tongs, and consequently also a lower value for H_f because they did not consider the upper, incompressible part of the tongs for their measurement of H_{total} (Annex 9.2 Table 14 and Annex 9.3 Figure 6b). Also for the determination of H_{handle}, i.e. the height of the handle, it was not so important how measurements were carried but it was important which sample part was considered for the measurement. All samples were integral and did not have a clearly separated handle. Therefore, most laboratories (sample A-D: 18-21, sample E: 15) assumed the default value for H_{handle}, i.e. 1/3 of H_{total} as described in the instructions in ILC003 2013 ([1] and Figure 1). As the values for H_{total} did not differ much, also the default values obtained for H_{handle} were all very similar but noticably different from those values where a different handle than the default one was assumed (Annex 9.3 Figure 2 to Figure 6). For sample A-D, two laboratories had assumed that H_{handle} was defined by a mark on the tool in the lower part of the handle (Table 2), whereas one laboratory had estimated H_{handle} for each tool from its practical use (Annex 9.2 Table 10 to Table 13). For sample E, five participants declared to have assumed that the handle was defined by a groove on the upper part of the tool and another three laboratories had assumed a handle independent from any marks on the tool but which would allow a proper handling of the tongs (Table 2 and Annex 9.2 Table 14). In all cases except one, the resulting H_f values were outside the tolerance limits (Annex 9.3 Figure 2 to Figure 6).

Table 2 Sample A-D with mark on the handle and Sample E with a groove on the handle

Sample	Mark on the lower part of the handle or groove on the upper part of the handle
A 	
B 	
C 	
D 	
E 	

The values reported for the sample height with necessary food contact (H_n), i.e. the functional part of each sample, were rather widespread for all samples and did not allow to detect a correlation between the way the measurement was done and the obtained value for H_n (Annex 9.3 Figure 2 to Figure 6). However, for sample B-E, the actual value obtained for H_n was only of minor importance for the obtained H_f value, so that most of the participants obtained similar H_f values even though they had assumed very different values for H_n. The calculation algorithm for the determination of H_f required checking whether $H_p \leq 1/2\ H_n$. H_p marked the sample part which probably comes into contact with food, meaning the sample part between the one that serves as a handle and the functional part with necessary food contact. If so, H_f had to be set to the value of H_p+H_n. Otherwise H_f had to be set to 2/3 of (H_p+H_n) (scheme in Figure 1 and detailed instructions in [1]). For samples B-E, H_p was much higher than ½ H_n and therefore H_f had to be set to 2/3 of (H_p+H_n) in any case. For sample A, a flat kitchen spatula, H_p was about ½ H_n as already explained in the report of ILC003 2013. Annex 9.3 Figure 2d shows that all laboratories which assumed a value for H_n > 13.5 cm (independently from the way of measurement) had to set H_f to H_p+H_n and consequently obtained a H_f value > 20 cm, which was outside the tolerance limits. In conclusion, the reason why the H_f values for sample A consisted of two subpopulations was not due to the measurement of H_{total} as assumed in the report of ILC003 2013 but due to the part of the sample which was taken into consideration for the measurement of H_n.

5.2.2. *Surface area*

The surface area measurement in ILC003 2013 had been based on empirical methods. Participants had determined the surface area of the samples using four different approaches, namely "calculation" where the surface area was calculated using mathematical formulas for regular geometric shapes, "wrapping in paper" and "wrapping in aluminium foil" where the food contact part of the samples was wrapped in paper or aluminium foil, excess wrapping material was removed and the remaining material weighed, and "drawing the shape" of the food contact part on paper, followed by cutting and weighing the paper afterwards ([1]). There were many different possible sources of error and it was difficult to trace back whether mistakes had occurred, especially as ILC003 2013 had been carried out in April/May 2013 and the follow-up started only about one year later in May 2014. Only in very few cases, the participants noticed an error in one of their calculations or other mistakes. In most cases, reasons why participants had obtained surface area values outside the tolerance limits were not obvious. All reasons that could be identified are listed in Table 3 to Table 7. Figure 7 to Figure 16 in Annex 9.4 show which of the results reported in ILC003 2013 were affected by calculation mistakes as declared by the participants during the study. For sample A and B, the graphics show also whether slotted sample parts were removed or subtracted during the determination of the surface area. Again all graphics were prepared using R and the R package "ggplot2" ([7], [8]).

Calculation mistakes
Four laboratories declared to have done mistakes in calculations in the determination of the surface area of at least one sample. One laboratory had measured the surface area only of one side of each test specimen and consequently had obtained very low surface area values for all five samples. One laboratory declared to have done a mistake in the weighing of paper when determining the surface area by "wrapping in paper" and three laboratories declared to have done a mistake in determining the surface area by "calculation". For example, one laboratory did a mistake in the use of the formula to calculate the surface area of an ellipsoid to calculate the surface area of sample C.

Other possible sources of error
As detailed in the final report of ILC003 2013, there was a correlation that higher values for the surface area were obtained when higher values for H_f were assumed. This was to be expected as H_f marked the food contact sample part for which the surface area had to be determined. The same applies if slotted sample parts as present in sample A and B were not removed or subtracted. Of the laboratories participating in the study, 4-6 declared to not have removed or subtracted the slotted parts in the determination of the surface area of sample A and B. One of them subtracted the slotted parts only when using "calculation" and "drawing the shape" but not when determining the surface area by "wrapping in paper" or "wrapping in aluminium foil". Although information is not available for all laboratories that participated in ILC003 2013, the data obtained in the follow-up at least show a tendency that higher values for the surface area were obtained when slotted sample parts were not removed or subtracted. As a consequence, if very low or very high values for H_f were assumed by a participant (in the latter case especially if in addition slotted sample parts were not subtracted), it was possible that the corresponding surface area value was outside the tolerance limits. For some laboratories, this may explain why their obtained results were above or below the limit of tolerance. However, for several laboratories, the reasons remain unclear (Table 3-Table 7).

General remark
It should also be noted that the limits of tolerance and the alarm limits obtained for the surface area of all samples A-E in ILC003 2013 were very broad and laboratories may have done a mistake in the determination of the surface area but may still have obtained a result within the tolerance limits. For example, of those 4-6 laboratories that did not subtract the slotted parts of sample A and B, in the end only one

laboratory obtained results which exceeded the upper tolerance limit. The same applies to one laboratory that declared to have done a mistake in the determination of the surface area of sample A and D by "wrapping in paper". Only for sample A, the obtained result was outside the tolerance limits (Annex 9.4 Figure 7 b). For sample D, the result was higher than the robust mean value but still within the range of tolerance (Annex 9.4 Figure 13 b). This shows that the performance criteria applied in ILC003 2013 did not allow identifying those laboratories that did "avoidable errors" in the determination of the surface area. In the ILC003 2013, the robust mean values and the robust standard deviations obtained from the results reported by all participants were used as assigned values for the surface areas of the different samples and as target standard deviations, respectively. Based on these values, tolerance and alarm limits were calculated in order to assess the performance of laboratories. As all reported results were included in these calculations, the obtained assigned values and target standard deviations may be affected by "avoidable errors", even though robust statistics were applied. Instead, assigned values could have been based on reference values (in case of surface area values e.g. obtained beforehand from a laser scanning). In addition, target standard deviations could have been defined beforehand, independently from laboratory performance.

Table 3 Identified reasons for surface area values outside the tolerance limits (sample A)

Identified reasons for surface area values outside tolerance limits	Number of affected laboratories (Sample A)			
	calculation	wrap paper	wrap Al foil	draw shape
calculation mistakes				
only 1 side of the sample considered	1	1	1	1
mistake in one of the calculations	0	-	-	-
mistake in weighing of wrapping material	-	1	0	-
H_f value outside tolerance limits	1	1	0	0
slotted parts not subtracted	0	1	1	1
reason unclear*	0	0	0	0
no information available**	1	3	1	2

* From the information gained in the follow-up, no reason could be identified why the respective participant obtained a surface area value outside the tolerance limits; ** Respective laboratories had obtained results outside the tolerance limits in ILC003 2013 but did not participate in the study.

Table 4 Identified reasons for surface area values outside the tolerance limits (sample B)

Identified reasons for surface area values outside tolerance limits	Number of affected laboratories (Sample B)			
	calculation	wrap paper	wrap Al foil	draw shape
calculation mistakes				
only 1 side of the sample considered	1	1	1	1
mistake in one of the calculations	0	-	-	-
mistake in weighing of wrapping material	-	0	0	-
H_f value outside tolerance limits	1	0	1	0
slotted parts not subtracted	0	0	1	0
reason unclear*	1	1	0	0
no information available**	0	3	2	2

* From the information gained in the follow-up, no reason could be identified why the respective participant obtained a surface area value outside the tolerance limits; ** Respective laboratories had obtained results outside the tolerance limits in ILC003 2013 but did not participate in the study.

Table 5 Identified reasons for surface area values outside the tolerance limits (sample C)

Identified reasons for surface area values outside tolerance limits	Number of affected laboratories (Sample C) calculation	wrap paper	wrap Al foil	draw shape
calculation mistakes				
only 1 side of the sample considered	1	1	1	1
mistake in one of the calculations	1	-	-	-
mistake in weighing of wrapping material	-	0	0	-
H_f value outside tolerance limits	1	2	0	0
reason unclear*	1	0	1	1
no information available**	4	2	1	2

* From the information gained in the follow-up, no reason could be identified why the respective participant obtained a surface area value outside the tolerance limits; ** Respective laboratories had obtained results outside the tolerance limits in ILC003 2013 but did not participate in the study.

Table 6 Identified reasons for surface area values outside the tolerance limits (sample D)

Identified reasons for surface area values outside tolerance limits	Number of affected laboratories (Sample D) calculation	wrap paper	wrap Al foil	draw shape
calculation mistakes				
only 1 side of the sample considered	1	1	1	1
mistake in one of the calculations	1	-	-	-
mistake in weighing of wrapping material	-	0	0	-
H_f value outside tolerance limits	1	1	1	0
reason unclear*	3	0	0	0
no information available**	1	3	2	2

* From the information gained in the follow-up, no reason could be identified why the respective participant obtained a surface area value outside the tolerance limits; ** Respective laboratories had obtained results outside the tolerance limits in ILC003 2013 but did not participate in the study.

Table 7 Identified reasons for surface area values outside the tolerance limits (sample E)

Identified reasons for surface area values outside tolerance limits	Number of affected laboratories (Sample E) calculation	wrap paper	wrap Al foil	draw shape
calculation mistakes				
only 1 side of the sample considered	1	1	1	1
mistake in one of the calculations	1	-	-	-
mistake in weighing of wrapping material	-	0	0	-
H_f value outside tolerance limits	4	5	3	3
reason unclear*	0	3	2	2
no information available**	3	5	4	3

* From the information gained in the follow-up, no reason could be identified why the respective participant obtained a surface area value outside the tolerance limits; ** Respective laboratories had obtained results outside the tolerance limits in ILC003 2013 but did not participate in the study.

5.2.3. *Envelope volume*

In Resolution CM/Res(2013)9 on "metals and alloys used in food contact materials" of the Council of Europe, the envelope volume refers to the volume of a rectangular solid which can be constructed around the food contact part of a kitchen utensil and which serves as an estimated value for the amount of food that will come into contact with the respective utensil [3]. The determination procedure requires the measurement of the actual width (x) and depth (y) of each sample. The z-coordinate is equal to the value of H_f, which is determined as described in section 5.2.1 Figure 1. To calculate the volume of the imaginary box, the values of x, y and z are rounded on a 5-cm-scale. For ILC003 2013, also a 2-cm-scale was used in addition. This way assigned values for x, y and z (x_{ass}, y_{ass} and z_{ass}) are obtained. In the end, the envelope volume results from the product of $x_{ass} \cdot y_{ass} \cdot z_{ass}$ ([3] and instructions in [1]). The main difficulties in the determination of the envelope volume were related to the determination of x, y and z. In some cases, participants may have done a calculation mistake. In one case, a mistake in recording the sample dimensions appeared. Table 8 and Table 9 list the sources of error that could be identified to have appeared in the determination of the envelope volume, apart from those related to the determination of H_f. The graphics in Annex 9.5 summarise the information reported by the participants in the study. If available, the correlation between the actual values obtained for H_f, the sample depth or the sample width, their way of measurement and the corresponding result for the envelope volume are displayed. Three participants did not report the actual value obtained for the sample depth and width but reported the assigned value on the 2- and/or 5-cm-scale instead. These values could not be included in the correlation plots. All graphics were prepared using R and the R package "ggplot2" ([7], [8]).

Determination of z

The main difficulties related to the determination of z were discussed in section 5.2.1, as the z-value was equal to H_f. One of the participants simply overlooked that the value of H_f had to be chosen for the z-value. Instead, they set $z = H_{total}$ for all five samples and consequently obtained a much higher result for the envelope volume, in all but one case also outside the tolerance limits. Another laboratory declared to have considered the entire sample surface for the determination of the envelope volume, but only for sample A. Especially for sample A, major difficulties in the determination of H_f appeared which were not related to unsatisfactory laboratory performances. There were three laboratories that did not have mistakes either in the determination of H_f, or in the measurement of the depth and width or in the calculation of the envelope volume. Yet the envelope volume values for sample A which they determined on the 2-cm-scale where outside the tolerance limits, simply because they had assumed a value for H_n of 14-15 cm and then obtained a H_f value of 20.3-20.6 cm (section 5.2.1).

Determination of x and y

For sample A-D, most laboratories obtained similar values for the sample width (Annex 9.5 Figure 17 to Figure 24). For these samples it was rather clear which part of the sample had to be considered as the widest one and how its width had to be measured. However, some laboratories reported much smaller values for the sample width. One plausible reason was that they did not measure the sample width at the widest part but probably at the very edge which is not necessarily the widest part. However, this is an hypothesis and cannot be demonstrated. In the study, participants reported only their measured values for the sample width of sample A-D but no further information was asked about how these values were obtained. When designing the questionnaire, the measurement of the sample width for sample A-D was not considered problematic. Therefore none of the questions aimed on the way of measurement of the sample width for these samples. In contrast to the measurement of the width for sample A-D, the measured values for the sample depth were rather wide spread. For sample A and B, most laboratories measured the depth correctly, meaning depending on the value of H_f as shown in Annex 9.2 Table 10 ("5a", "5b") and Table 11 ("5a"), but two and six laboratories, respectively, measured only the thickness of the plastic material. One laboratory misunderstood the meaning of depth in case of sample A and measured a value similar to H_n which was much higher than the actual depth of the sample and consequently the resulting envelope volume was outside the tolerance limits. For the envelope volume of sample B determined on the 2-cm-scale, two groups of values could be observed depending on the way the sample depth was measured (Annex 9.5 Figure 19 c). Almost all laboratories that measured just the material thickness, obtained much lower values for the envelope volume of 144 or 168 cm^3 compared to the assigned value of 336cm^3. For the 5-cm-scale instead, no matter how the depth was measured, all depth values obtained were lower than 5 cm and in all cases a value of 5 cm had to be assigned. Therefore, the measurement of the depth had no influence on the envelope volume of sample B determined on the 5-cm-scale. The two groups of values observed for the envelope volume of sample B on the 5-cm-scale in fact are due to different values that were assumed for the sample width. In the homogeneity studies carried out by the EURL-FCM, the widest part of the sample had a width of approx. 5.1 cm in average ([1]). Some laboratories assumed a width of 5 cm, or even less. They had to assign a value of 5 cm for the width and obtained (or would have obtained if they had done the calculations correctly) an envelope volume of 375 cm^3. On the contrary, all laboratories which measured a value 5.1 or 5.2 cm for the sample width had to run the calculations with an assigned value of 10 cm and obtained an envelope volume of 750 cm^3 (Annex 9.5 Figure 20 a, d). For sample C and D, the correct depth, i.e. related to the value of H_f, was almost the same as the depth of the elliptic or rectangular functional part of the spoons. Therefore, the majority of laboratories measured the depth of the latter sample part. No reasons could be identified that caused the presence of different subpopulations for the envelope volume of sample D when determined on a 2-cm-scale. Simply different values had to be assigned depending on the depth, width and height that the participants had obtained in their measurements. But no correlation could be identified between the way of measurement and the obtained values for the measured sample dimension. The widest part of sample D had a width of 6.1-6.2 cm according to the homogeneity studies carried out by the EURL-FCM ([1]) and would have required an assigned value of 8 cm. Some laboratories reported values for the width of 6.0 cm or less and consequently used 6 cm as assigned value. For the sample depth, the majority of laboratories participating in the follow-up had measured the maximum depth of the food contact part. In the homogeneity studies, the EURL-FCM determined the depth of this part to be approximately 2.1 cm in average, corresponding to an assigned value of 4 cm. However, several participants reported a value 2.0 cm or less for the same parameter and consequently worked with an assigned value of 2 cm. For sample E, the kitchen tongs, the results reported for its width were wide spread. It had been supposed already during the evaluation of the data of ILC003 2013 that some participants might have measured the sample width of the compressed item. Indeed, three participants declared to have measured the width of sample E in compressed mode (Annex 9.2 Table 14). Three other participants measured the thickness of the plastic material itself and considered this as the sample width (Annex 9.2 Table 14, method "others1" and "others2"). For all of them, the resulting envelope volume on the 2-cm-scale was much smaller than the assigned value and for two of them the result was even below the lower limit of tolerance. For the 5-cm-scale, the range of tolerance was much bigger and the corresponding envelope volumes were still within the tolerance limits. One laboratory assumed that the width of sample E was 0. For the calculation of the envelope volume they assigned the lowest value on the scale, i.e. 2 cm or 5 cm for the 2-cm-scale and the 5-cm-scale, respectively. In both cases, the resulting value for the envelope volume was below the lower limit of tolerance, because in addition they had assumed a very high value for H_{handle} and consequently had obtained a very low value for H_f. For the depth of sample E, most laboratories carried out the measurement correctly, i.e. depending on the value for H_f obtained before. Two laboratories measured the depth at the very edge of the sample, one of them at the very edge of the handle which was the point of the biggest depth in this case and one of them at the tip which was the point of the lowest depth. In the latter case, the value for the envelope volume determined on the 2-cm-scale was below the lower limit of tolerance.

Mistakes in calculation

From the actual values reported for x, y and z (or H_f), the EURL-FCM determined the appropriate assigned values (x_{ass}, y_{ass}, z_{ass}) for the 2- and 5-cm-scale and recalculated the corresponding envelope volumes. The values obtained thereby are marked in Figure 17 to Figure 26 (Annex 9.5) with a blue (+) and green (+) plus symbol, respectively. If the blue (+) and green (+) plus symbol do not overlap, the laboratory did not use H_f as z-value or reported a different z-value than the one actually used in ILC003 2013. The former is the case for one laboratory for all samples A-E as already described above. The latter may be the case for one laboratory with respect to the envelope volume of sample C. For several laboratories, the envelope volume reported in ILC003 2013 is not equal to the one obtained by the EURL-FCM after recalculations. This means either that the respective laboratory did a mistake in the calculation of the envelope volume (e.g. when assigning the proper values for x_{ass}, y_{ass} or z_{ass}) or that the values for x, y and z reported in the study were not those actually used in ILC003 2013.

Recording of values

In ILC003 2013, one laboratory had reported extremely high values of 2184 cm^3 and 3750 cm^3 for the envelope volume of sample C determined on the 2- and 5-cm-scale, respectively. They had done a mistake in recording of the depth measured before. Instead of 2.9 cm as actually measured they ran the calculations based on a depth of 29 cm. If the calculations are carried out with the correct value of 2.9 cm, a result equal to the assigned value is obtained.

Table 8 Sources of error that appeared in the determination of the envelope volume on a 2-cm-scale

Sources of error in determination of EV values on a 2-cm-scale	Number of affected laboratories*				
	Sample A	Sample B	Sample C	Sample D	Sample E
determination of z:					
$z = H_{total}$	2 (2)	1 (0)	1 (1)	1 (1)	1 (1)
H_f value outside tolerance limits	11 (7)	5 (1)	6 (1)	3 (0)	6 (2)
determination of x and y:					
width not measured at widest point	-	-	-	-	4 (3)
width measured for compressed article					3 (2)
depth measured incorrectly	3 (1)	6 (0)	9 (0)	9 (0)	3 (2)
calculation mistakes likely but not confirmed	3 (2)	2 (2)	4 (3)	3 (2)	3 (1)
recording of values	0	0	1 (1)	0	0
reason unclear**	(0)	(1)	(0)	(0)	(1)
no information available***	(2)	(1)	(1)	(1)	(7)

* Values in brackets refer to the number of laboratories whose results were outside the tolerance limits due to the identified reason (eventually in combination with other reasons); ** From the information gained in the follow-up, no reason could be identified why the respective participant obtained an EV-value outside the tolerance limits. *** Respective laboratories had obtained results outside the tolerance limits in ILC003 2013 but did not participate in the study.

Table 9 Sources of error that appeared in the determination of the envelope volume on a 5-cm-scale

Sources of error in determination of EV values on a 5-cm-scale	Number of affected laboratories*				
	Sample A	Sample B	Sample C	Sample D	Sample E
determination of z:					
$z = H_{total}$	2 (2)	1 (0)	1 (0)	1 (1)	1 (0)
H_f value outside tolerance limits	11 (5)	5 (0)	6 (1)	3 (0)	6 (1)
determination of x and y:					
width not measured at widest point	-	-	-	-	4 (1)
width measured for compressed article					3 (0)
depth measured incorrectly	3 (1)	6 (0)	9 (0)	9 (0)	3 (0)
calculation mistakes likely but not confirmed	3 (3)	2 (1)	3 (2)	2 (2)	2 (0)
recording of values	0	0	1 (1)	0	0
reason unclear**	(1)	(1)	(0)	(0)	(1)
no information available***	(1)	(0)	(0)	(1)	(0)

* Values in brackets refer to the number of laboratories whose results were outside the tolerance limits due to the identified reason (eventually in combination with other reasons). ** From the information gained in the follow-up, no reason could be identified why the respective participant obtained an EV-value outside the tolerance limits. *** Respective laboratories had obtained results outside the tolerance limits in ILC003 2013 but did not participate in the study.

5.2.4. *General remarks by the participants*

Issues related to the given instructions
Ten participants declared to have had issues in understanding some of the specific instructions during the ILC003 2013. Regarding the determination of H_f, four participants mentioned issues in understanding how to determine H_{total}. The given instructions mixed the terminology of "length" and "height" and caused confusion amongst participants. The "length" of an article is measured along its curved shape whereas the "height" of an article is measured straight, meaning parallel to the y-plane. Pictures would have been helpful to demonstrate how the measurements should have been carried out. In addition, one participant declared that it was difficult to define H_n and to decide which sample part should be considered for its measurement. The same applied to H_{handle}. One laboratory mentioned issues in the determination of H_{handle}, especially for sample E. Another laboratory declared that the instructions should explain better when a handle is considered to be clearly separated and when the default value for H_{handle} needs to be applied. They recommended adding pictures of all different types of kitchen utensils showing examples with and without clearly separated handles.

Regarding the determination of the envelope volume, two participants declared that it was not clear how to measure the depth and/or width of an article. For sure, it would have been helpful if the instructions provided in ILC003 2013 included examples which demonstrated how to measure the depth and width of the samples as it is done in the instructions provided in Res(2013)9. In there, several photos show in detail how measurements for depth and width should be carried out for different kind of kitchen utensils [3]. One participant wondered about the fact that the exercise did not allow to combine different approaches. It is true that in some cases a combination of several approaches could be best to measure the surface area of an item. For example, for flat spatulas like sample A the surface area of the flat, functional part could be easily determined by "drawing its outline on paper" whereas to determine the surface area of side parts of a sample or parts of the handle eventually included in a migration testing "calculation" may be better suited. For ILC003 2013, the use of combined approaches was not permitted because the exercise also aimed at a method validation and a comparison of different approaches. In ILC003 2013, participants had been asked to determine the surface area of all five samples applying each of the four approaches described in the instructions. In case of sample C and D, this required drawing the outline of a round-shaped article on paper and one laboratory mentioned that the instructions did not contain enough details to allow complex rounded items to be drawn.

Issues related to the approaches applied in the determination of the surface area
Two laboratories mentioned again that upon determination of the food contact surface area by wrapping in aluminium foil small folds and crinkles are formed which cause extra weight during weighing of the wrapping material. Thus the actual surface area will be overestimated, as discussed also in [1]. Therefore one of the participants recommended again redrawing the shape of the aluminium foil used for wrapping on a sheet of paper, followed by cutting and weighing the paper. This way, folds and crinkles in the aluminium foil will not affect the final weight of the wrapping material. In ILC003 2013, direct weighing of the aluminium foil was preferred to keep the approaches as simple as possible and to avoid additional sources of error. As regards to drawing the outline of articles on paper, one participant mentioned that the actual surface area is overestimated due to the thickness of the drawing tool tip (e.g. a pencil) and the thickness of the sample itself. In a test performed by the respective

laboratory, the outline of a piece with a surface area of 1 dm^2 was drawn on paper. Three replicates were done and a value of 1.042 dm^2 was obtained for the surface area, meaning the surface area was overestimated by about 4 %. To take this into consideration, they advise to apply a correction factor (in this case 96%). One laboratory also mentioned issues in selecting the correct mathematical formula which describes best the shape of the sample, e.g. whether a shape is closer to the shape of a rectangle or a trapezoid. It might be helpful if a future guidance contained examples showing which regular shapes can be used to describe the irregular shape of different types of kitchen utensils.

General comments
One laboratory emphasized to prefer the 2-cm-scale instead of the 5-cm-scale to calculate the envelope volume of a kitchen utensil. In their opinion, the 2-cm-scale specifies the worst case surface-to-volume ratio in real food contact use in a sufficient way. The EURL-FCM included the 2-cm-scale in ILC003 2013 in order to check whether this scale leading to smaller envelope volumes and thus being somewhat stricter would still be suitable for practical application. To decide whether the 2-cm-scale or the 5-cm-scale better reflect real food contact applications, additional investigations would be necessary that focus on the actual surface-to-volume ratio of kitchen utensils in real food contact use.

6. Conclusions

Some difficulties in the surface area measurement and the main issues in the determination of H_f and the envelope volume were identified during this study. In most cases, a reason could be identified why certain results reported during ILC003 2013 had been outside the tolerance limits. For the surface area measurement, one of the identified issues was whether one or both sides of an article need to be considered in the surface area measurement. This is a problem related to migration kinetics and will be addressed in an upcoming guideline on migration testing in the framework of Reuglation (EU) No 10/2011 on plastic food contact materials [9]. Depending on the thickness of the material, it has to be checked whether or not top <u>and</u> bottom side (or inside <u>and</u> outside) of the immersed sample part need to be considered for the surface area measurement to express overall or specific migration results. Another issue in the surface area measurement was related to samples that articles. In general, the determination of the surface area of a test specimen immersed in a migration testing should be done as accurately as possible. In case of slotted spoons, skimmers or other articles that contain slots or punched holes, the slotted/perforated parts would need to be subtracted from the entire surface while at the same time the additional inner surface resulting from a perforation would need to be taken into consideration. This may be very tedious and time-consuming. ISO 1186-1:2002 paragraph 9.3 [4] stated that the area of side parts (and inner side parts) of the sample part immersed in a migration testing did not need to be included in the surface area measurement when their total did not exceed 10% of the total surface area of the immersed sample part. Furthermore, the thickness of side parts did not need to be taken into account if their thickness did not exceed 2 mm, as declared in ISO 13130-1:2004 paragraph 10.3 [5]. A similar convention could be developed for the surface area measurement of kitchen utensils. Some laboratories noticed to have done calculation mistakes. Such errors can only be discovered if results are checked for their plausibility, e.g. by doing a rough estimate. Plausibility checks should become a routine in proofing of surface area and envelope volume results.

With regard to the results from this study on the non-harmonised but novel approach to determination of the envelope volume, including the determination of H_f, the main issues were related to the measurement of the sample dimensions, meaning H_{total}, H_{handle}, H_n, as well as depth and width of each sample. In contrast to hypotheses made within the reporting of ILC003 2013, the major issue was not related to whether dimension were measured straight or along the curved shape of an article but to the sample part which was considered relevant for the measurement. This could be solved by using more examples to demonstrate how measurements need to be carried out and especially which sample parts should be considered for the measurement of H_{total}, H_{handle} and H_n. Regarding H_{handle}, more guidance would be needed on when to consider a handle as clearly separated. Several examples on how to measure depth and width of different kitchen utensils have been given in Res(2013)9 [3]. One of the issues which is not addressed in the examples given in Res(2013)9 is the measurement of dimensions of compressible items, e.g. tongs. Here, clarification could still be needed. The same applies to the measurement of H_{total} and how to define H_n. It would be helpful if the instructions in Res(2013)9 also contained examples on how to measure these sample dimensions. It should be noted again that migration experiments for kitchen utensils made of plastic have to be carried out as described in Regulation (EU) 10/2011 [6]. The concept of the envelope volume is not part of this regulation. It refers only to kitchen utensils made of metal within the scope of Res(2013)9 [3]. According to Regulation (EU) 10/2011 Art. 12 (1) and Art 17 (2) b [6], overall and specific migration results of plastic utensils need to be expressed in mg/dm^2, applying a surface-to-volume ratio of 6 dm^2/kg to express specific migration in mg/kg food that comes into contact with the article. The determination of H_f is not a necessity in migration testing of plastics within the scope of Regulation (EU) 10/2011.

For materials and articles where migration is expected to be even over the entire surface (i.e. those that consist only of one type of material and are not covered with printings), it is not of such importance up to which height a test specimen is immersed during migration testing but it is absolutely essential to make sure that the surface area of the part which is/was immersed in the migration testing is measured correctly.

7. Acknowledgements

The NRLs and guests who participated in this exercise are kindly acknowledged.

8. References

[1] Report of an inter-laboratory comparison organised by the European Reference Laboratory for Food Contact Materials. ILC 003 2013 – Food Contact Surface Area of Kitchen Utensils. EUR 26477 EN, Luxembourg: Publications Office of the European Union, 2013

[2] Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules. Last amended by Regulation (EU) No 652/2014 of the European Parliament and of the Council of 15 May 2014. OJ L 189, 27.06.2014, p. 1

[3] Council of Europe. Resolution Res(2013)9 on Metals and Alloys used in food contact materials and articles, 1st edition, 2013

[4] European Standard EN 1186-1:2002. Materials and articles in contact with foodstuffs – Plastics. Part 1: Guide to the selection of conditions and test methods for overall migration

[5] European Standard EN 13130-1:2004. Materials and articles in contact with foodstuffs. Plastics substances subject to limitation. Part 1: Guide to test methods for the specific migration of substances from plastics to food and food simulants and the determination of substances in plastics and the selection of conditions of exposure to food simulants

[6] Commission Regulation (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food. OJ L 12, 15.1.2011, p. 1–89. Last amended by Commission Regulation (EU) No 202/2014 of 3 March 2014. OJ L 62, 04.03.2014, p. 13

[7] R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/

[8] H. Wickham (2009). ggplot2: elegant graphics for data analysis. Springer, New York

[9] Technical guidelines for compliance testing. In the framework of Regulation (EU No 10/2011 on plastic food contact materials. Luxembourg: Publications Office of the European Union, 2015 (in progress)

9. Annexes

9.1. Invitation letters and documents sent to the participants

Invitation letter

EUROPEAN COMMISSION
GENERAL DIRECTORATE JRC
JOINT RESEARCH CENTRE
Institute for Health and Consumer Protection – IHCP
Chemical Assessment and Testing Unit

Ispra, 23rd May 2014

Follow up to ILC003 2013 on the Determination of the Food Contact Surface Area of Kitchen Utensils

Dear Madam, Sir

On behalf of the EURL for Food Contact Materials, I invite you to participate in the follow-up exercise of ILC003 2013 on the "Determination of the Food Contact Surface Area of Kitchen Utensils".

ILC003 2013 involved the determination of the sample part with foreseeable food contact (indicated by H_f) and its surface area for five different kitchen utensils, using four different methods. In a voluntary exercise, the envelope volume of the same samples was determined. The results displayed some difficulties in the determination of H_f and/or the surface area as well as the envelope volume. The final report for ILC003 2013 with detailed discussions of all results is available online at http://publications.jrc.ec.europa.eu/repository/handle/111111111/30398.

The objective of this follow-up is to identify sources of error that appeared in ILC003 2013. Therefore, you are kindly asked to fill in the questionnaire (Annex 1) provided along with this letter. Annex 2 tables the questions that each laboratory is requested to answer, in order to enable us to understand the issues encountered and to arrive at a better guidance on the measurement of surface area of kitchen utensils.

Please send back the filled questionnaire **by 30th June 2014** to Anja Mieth (anja.mieth@ec.europa.eu).

If you have any questions, please contact Anja Mieth (anja.mieth@ec.europa.eu, phone: +39 0332 78 6478).

Sincerely yours,

Eddo Hoekstra

European Union Reference Laboratory for Food Contact Materials
European Commission, DG-Joint Research Centre
Institute for Health and Consumer Protection
Unit Chemical Assessment and Testing (T.P. 260)
Via E. Fermi 2749
I-21027 Ispra (VA)
Italy

PS. Due to other priorities in the work programme of the NRL-EURL network, a measuring exercise is not foreseen in 2014.

Cc: P. Aguar (JRC), D. Rembges (JRC), C. Simoneau (JRC)
B. Schupp (SANCO)

Annex 1 questionnaire follow up ILC003 2013.doc
Annex 2 questions to be answered

Questionnaire

EUROPEAN COMMISSION
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Institute for Health and Consumer Protection – IHCP
Chemical Assessment and Testing Unit

EURL European Union Reference Laboratory for Food Contact Materials

QUESTIONNAIRE

Follow up to ILC003 2013 on the Determination of the Food Contact Surface Area of Kitchen Utensils

PART I. GENERAL QUESTIONS

Feedback on the instructions

1) Did problems occur in understanding the delivered instructions? If yes, please specify where (meaning the chapter of the instructions, the method/parameter and the sample) and describe the problem that appeared. This will help us to improve the instructions.

( ) yes *(Please specify in the comments.)*
( ) no

Comments:

Sources of error identified within your internal review

2) Did you identify errors in reading values (ruler, tape measure, balance)? If yes, please specify the parameter and sample that were affected as well as the type of error.

( ) yes *(Please specify in the comments.)*
( ) no

Comments:

3) Did you identify mistakes in any of your calculations? If yes, please specify the parameter and sample that were affected.

( ) yes *(Please specify in the comments.)*
( ) no

Comments:

4) Did you identify typing errors in any of your reported values? If yes, please specify the parameter and sample that were affected.

( ) yes *(Please specify in the comments.)*
( ) no

Comments:

1

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5) Did you identify any other source of error? If yes, please specify the source of error and the parameter and sample that were affected.

( ) yes *(Please specify in the comments.)*
( ) no

Comments:

2

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PART II. SAMPLE A

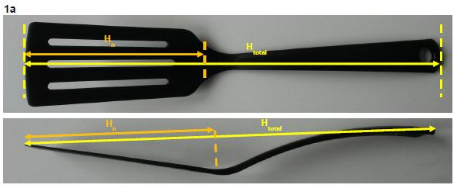
All terms and abbreviations hereafter refer to the instructions send to you in ILC003 2013.

Identifying reasons for deviations in reported H_f values

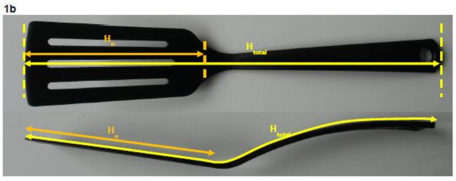
1) How did you measure H_{total} and H_n of sample A? Please, select one of the following answers. The options refer to those indicated in the figures.

H_{total}	H_n
( ) 1a	( ) 1a
( ) 1b	( ) 1b = 1c
( ) 1c	
( ) others *(Please specify in the comments and/or mark it in the figure below.)*	( ) others *(Please specify in the comments and/or mark it in the figure below.)*

1a



1b



3

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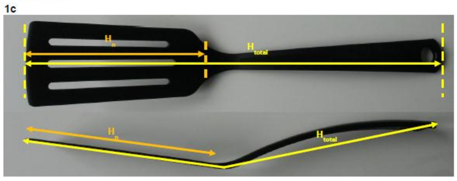
1c

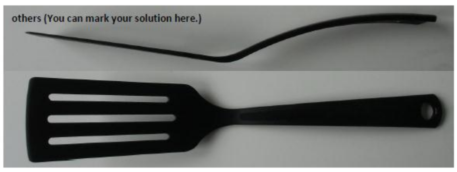


others (You can mark your solution here.)

Comments:

2) What did you assume as handle for sample A?

( ) default value (i.e. 1/3 of H_{total})
( ) others *(Please specify in the comments and/or mark it in the figure below.)*



4

Comments:

3) Which values did you finally obtain for H_{total}, H_n and H_{handle} of sample A?

	obtained values
H_{total} [cm]	
H_n [cm]	
H_{handle} [cm]	

Comments:

Identifying reasons for deviations in reported surface area values

4) Did you remove/subtract the slotted parts of sample A?

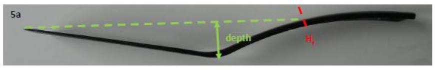
( ) yes
( ) no

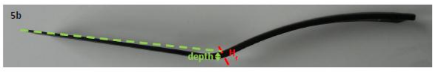
Comments:

Identifying reasons for deviations in reported envelope volume (EV) values

5) How did you measure the actual depth of sample A? Please, select one of the following answers. The options refer to those indicated in the figures depending on the H_f value that you determined before.

actual depth
( ) 5a
( ) 5b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*





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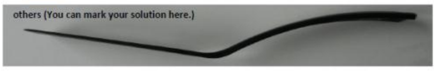
others (You can mark your solution here.)



Comments:

6) Which values did you finally obtain for the actual dimensions of sample A?

	obtained values
actual depth [cm]	
actual width [cm]	
actual height [cm]	

Comments:

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PART III. SAMPLE B

All terms and abbreviations hereafter refer to the instructions send to you in ILC003 2013.

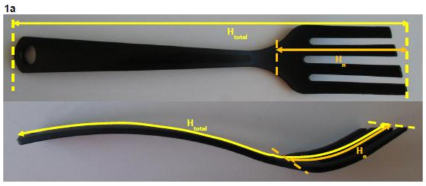
Identifying reasons for deviations in reported H_f values

1) How did you measure H_{total} and H_n of sample B? Please, select one of the following answers. The options refer to those indicated in the figures.

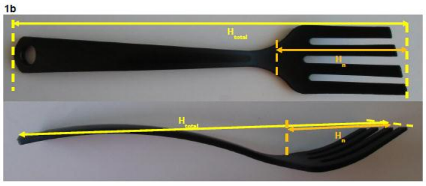
H_{total}
( ) 1a
( ) 1b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

H_n
( ) 1a
( ) 1b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

1a



1b



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others (You can mark your solution here.)

Comments:

2) What did you assume as handle for sample B?

( ) default value (i.e. 1/3 of H_{total})
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

others (You can mark your solution here.)

Comments:

3) Which values did you finally obtain for H_{total}, H_n and H_{handle} of sample B?

	obtained values
H_{total} [cm]	
H_n [cm]	
H_{handle} [cm]	

Comments:

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Identifying reasons for deviations in reported surface area values

4) Did you remove/subtract the slotted parts of sample B?

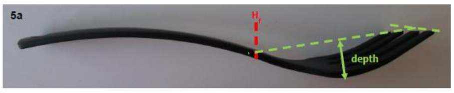
( ) yes
( ) no

Comments:

Identifying reasons for deviations in reported envelope volume (EV) values

5) How did you measure the actual depth of sample B? Please, select one of the following answers. The options refer to those indicated in the figures depending on the H_f value that you determined before.

actual depth
( ) 5a
( ) 5b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*



others (You can mark your solution here.)

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Comments:

6) Which values did you finally obtain for the actual dimensions of sample B?

	obtained values
actual depth [cm]	
actual width [cm]	
actual height [cm]	

Comments:

10

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PART IV. SAMPLE C

All terms and abbreviations hereafter refer to the instructions send to you in ILC003 2013.

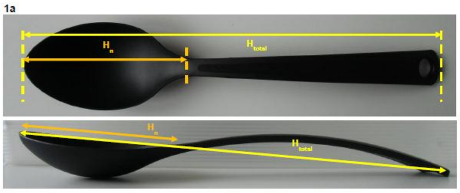
Identifying reasons for deviations in reported H_f values

1) How did you measure H_{total} and H_n of sample C? Please, select one of the following answers. The options refer to those indicated in the figures.

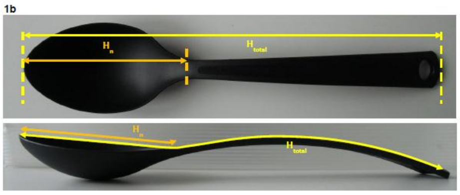
H_{total}
( ) 1a
( ) 1b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

H_n
( ) 1a
( ) 1b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

1a



1b



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others (You can mark your solution here.)

Comments:

2) What did you assume as handle for sample C?

( ) default value (i.e. 1/3 of H_{total})
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

others (You can mark your solution here.)

Comments:

3) Which values did you finally obtain for H_{total}, H_n and H_{handle} of sample C?

	obtained values
H_{total} [cm]	
H_n [cm]	
H_{handle} [cm]	

Comments:

12

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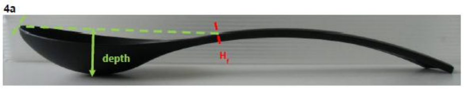
Identifying reasons for deviations in reported envelope volume (EV) values

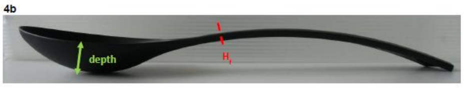
4) How did you measure the actual depth of sample C? Please, select one of the following answers. The options refer to those indicated in the figures depending on the H_f value that you determined before.

actual depth
( ) 4a
( ) 4b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

4a



4b



others (You can mark your solution here.)

Comments:

5) Which values did you finally obtain for the actual dimensions of sample C?

	obtained values
actual depth [cm]	
actual width [cm]	
actual height [cm]	

Comments:

13

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PART V. SAMPLE D

All terms and abbreviations hereafter refer to the instructions send to you in ILC003 2013.

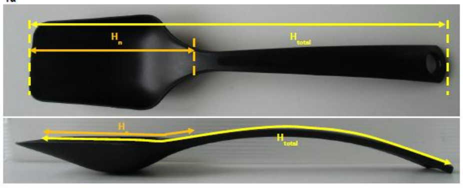
Identifying reasons for deviations in reported H_f values

1) How did you measure H_{total} and H_n of sample B? Please, select one of the following answers. The options refer to those indicated in the figures.

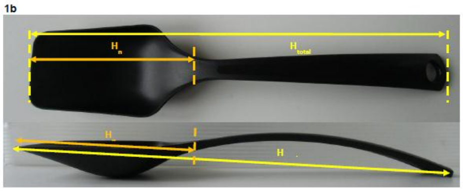
H_{total}
( ) 1a
( ) 1b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

H_n
( ) 1a
( ) 1b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

1a



1b



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others (You can mark your solution here.)

Comments:

2) What did you assume as handle for sample D?

( ) default value (i.e. 1/3 of H_{total})
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

others (You can mark your solution here.)

Comments:

3) Which values did you finally obtain for H_{total}, H_n and H_{handle} of sample D?

	obtained values
H_{total} [cm]	
H_n [cm]	
H_{handle} [cm]	

Comments:

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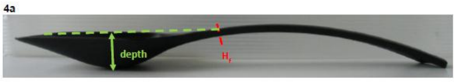
Identifying reasons for deviations in reported envelope volume (EV) values

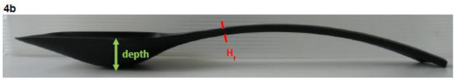
4) How did you measure the actual depth of sample D? Please, select one of the following answers. The options refer to those indicated in the figures depending on the H_f value that you determined before.

actual depth
( ) 4a
( ) 4b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

4a



4b



others (You can mark your solution here.)

Comments:

5) Which values did you finally obtain for the actual dimensions of sample D?

	obtained values
actual depth [cm]	
actual width [cm]	
actual height [cm]	

Comments:

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PART VI. SAMPLE E

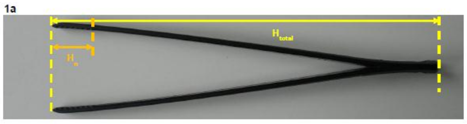
All terms and abbreviations hereafter refer to the instructions send to you in ILC003 2013.

Identifying reasons for deviations in reported H_f values

1) How did you measure H_{total} and H_n of sample E? Please, select one of the following answers. The options refer to those indicated in the figures.

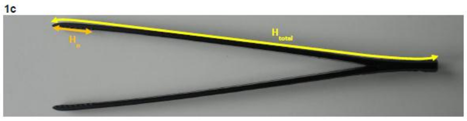
H_{total}	H_n
( ) 1a	( ) 1a
( ) 1b	( ) 1b
( ) 1c	
( ) others *(Please specify in the comments and/or mark it in the figure below.)*	( ) others *(Please specify in the comments and/or mark it in the figure below.)*

1a



1b

1c



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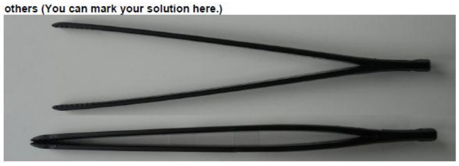
others (You can mark your solution here.)



Comments:

2) What did you assume as handle for sample E?

( ) default value (i.e. 1/3 of H_{total})
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

others (You can mark your solution here.)

Comments:

3) Which values did you finally obtain for H_{total}, H_n and H_{handle} of sample E?

	obtained values
H_{total} [cm]	
H_n [cm]	
H_{handle} [cm]	

Comments:

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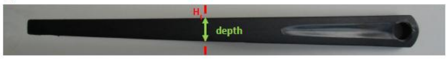
Identifying reasons for deviations in reported envelope volume (EV) values

4) How did you measure the actual depth of sample E? Please, select one of the following answers. The options refer to those indicated in the figures depending on the H_f value that you determined before.

actual depth
( ) 4a
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

4a



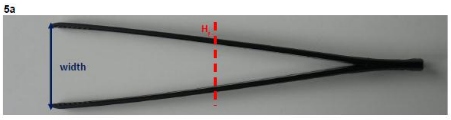
others (You can mark your solution here.)

Comments:

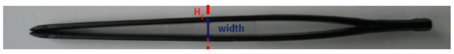
5) How did you measure the actual width of sample E? Please, select one of the following answers. The options refer to those indicated in the figures depending on the H_f value that you determined before.

actual width
( ) 5a
( ) 5b
( ) others *(Please specify in the comments and/or mark it in the figure below.)*

5a



5b



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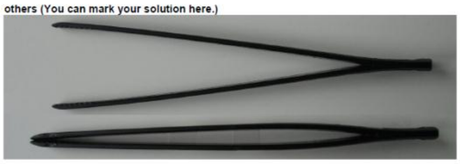
others (You can mark your solution here.)



Comments:

6) Which values did you finally obtain for the actual dimensions of sample E?

	obtained values
actual depth [cm]	
actual width [cm]	
actual height [cm]	

Comments:

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Follow up to ILC003 2013 on the Determination of the Food Contact Surface Area of Kitchen Utensils

Please answer those questions in the questionnaire that are requested for your laboratory as indicated in the table below. The lab codes refer to those of ILC003 2013.

	Questions to be answered in the questionnaire (indicated by "+")												
Lab code	part I (general)	part II (sample A)			part III (sample B)			part IV (sample C)		part V (sample D)		part VI (sample E)	
	1-5	1-3 (Hf)	4 (SA)	5-6 (EV)	1-3 (Hf)	4 (SA)	5-6 (EV)	1-3 (Hf)	4-5 (EV)	1-3 (Hf)	4-5 (EV)	1-3 (Hf)	4-6 (EV)
LC0002	+		+		+	+		+				+	
LC0003	+				+				+			+	
LC0004													
LC0005													
LC0006	+											+	
LC0007	+											+	
LC0008	+											+	
LC0009													
LC0010													
LC0011	+					+							
LC0012													
LC0013	+	+		+									
LC0014													
LC0015													
LC0016	+					+						+	
LC0017													
LC0018	+	+		+									
LC0019													
LC0020	+									+			
LC0021	+			+									
LC0022													
LC0023	+				+	+		+					
LC0024	+		+		+	+		+		+		+	
LC0025													
LC0026	+		+			+						+	
LC0027	+	+		+									
LC0028	+	+			+			+		+		+	
LC0029	+		+	+	+	+		+				+	+
LC0030													
LC0031	+												
LC0032	+							+					
LC0033	+	+			+			+					
LC0035	+							+					
LC0036													
LC0037	+										+		
LC0038	+			+			+		+		+		
LC0040													
LC0041	+	+	+	+			+				+		+
LC0042	+	+	+		+			+		+		+	
LC0044	+	+			+			+		+		+	
LC0045	+											+	
LC0046	+	+											
LC0047													
LC0048	+	+			+	+						+	+
LC0049													
LC0050	+	+	+			+		+					
LC0051	+	+	+	+	+	+	+	+	+	+	+		+
LC0052	+	+		+									
LC0053	+	+											
LC0054													
LC0055	+												
LC0056	+												
LC0057	+	+			+			+		+		+	
LC0058	+							+					
LC0059	+	+			+			+		+		+	
LC0060	+								+				
LC0061	+											+	
LC0062													
LC0063													
LC0064	+	+	+	+		+	+		+		+		+
LC0065	+	+		+									
LC0066	+	+	+			+							
LC0067	+	+			+	+		+		+		+	

9.2. Ways of measurement for H_{total}, H_{handle}, H_n, depth and width of sample A-E

Table 10 Ways of measurement applied for H_{total}, H_{handle}, H_n and depth of sample A. (Values in brackets refer to the number of laboratories that applied this measurement method.)

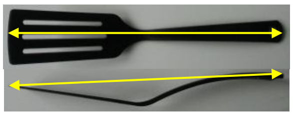
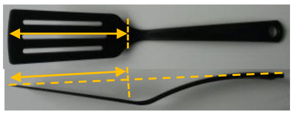
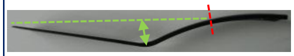
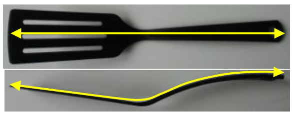
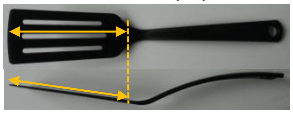
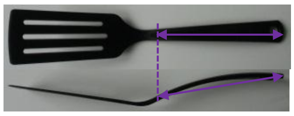
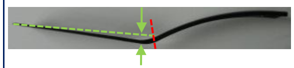
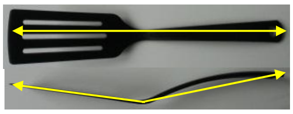
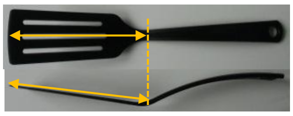
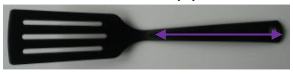
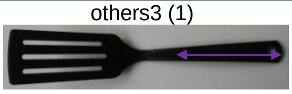
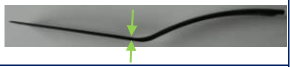
H_{total}	H_n	H_{handle}	depth
1a (18) 	1a (8) 	default (21) 1/3 of H_{total}	5a (9) 
1b (4) 	1b = 1c (14) 	others1 (1) 	5b (5) 
1c (2) 	others1 (2) 	others2 (1) 	others1 (1) 
		others3 (1) 	others2 (2) 
		others (not specified) (1)	

Table 11 Ways of measurement applied for H_{total}, H_{handle}, H_n and depth of sample B. (Values in brackets refer to the number of laboratories that applied this measurement method.)

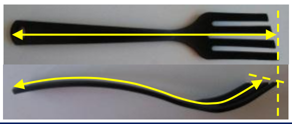
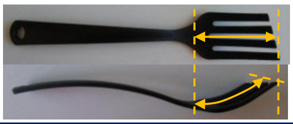
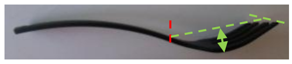
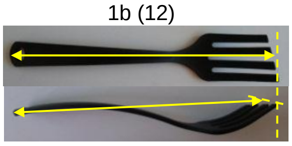
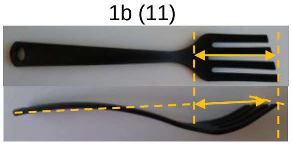
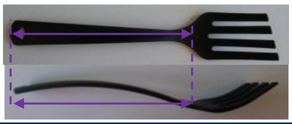
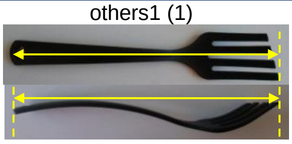
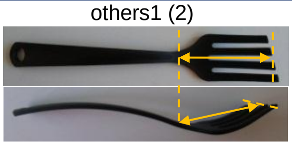
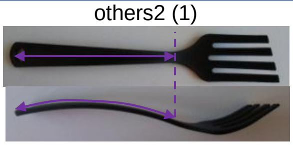
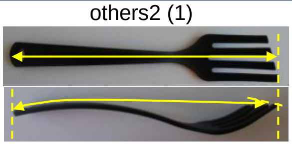
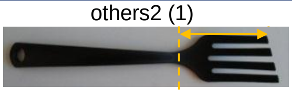
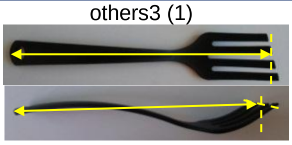
H_{total}	H_n	H_{handle}	depth
1a (6) 	1a (7) 	default (18) 1/3 of H_{total}	5a (7) 
1b (12) 	1b (11) 	others1 (1) 	5b (6) 
others1 (1) 	others1 (2) 	others2 (1) 	others1 (1) 
others2 (1) 	others2 (1) 	others3 (1) 	
others3 (1) 		others4 (1) 	

Table 12 Ways of measurement applied for H_{total}, H_{handle}, H_n and depth of sample C. (Values in brackets refer to the number of laboratories that applied this measurement method.)

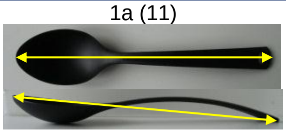
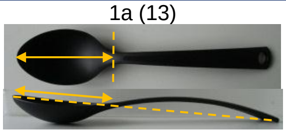
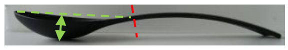
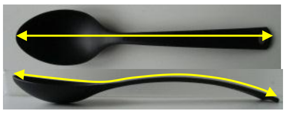
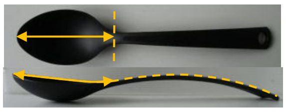
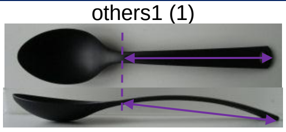
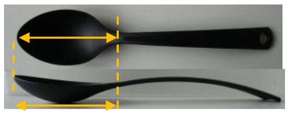
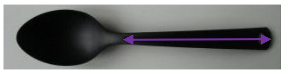
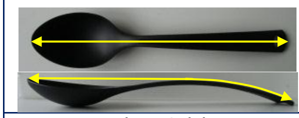
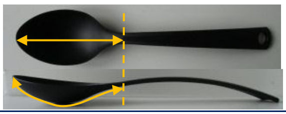
H_{total}	H_n	H_{handle}	depth
1a (11) 	1a (13) 	default (18) 1/3 of H_{total}	4a (5) 
1b (5) 	1b (5) 	others1 (1) 	4b (9) 
others1 (2) 	others1 (1) 	others2 (1) 	others (not specified) (1)
others2 (1) 	others2 (1) 	others3 (1) 	
others3 (1) 			

Table 13 Ways of measurement applied for H_{total}, H_{handle}, H_n and depth of sample D. (Values in brackets refer to the number of laboratories that applied this measurement method.)

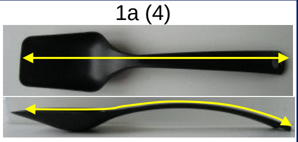
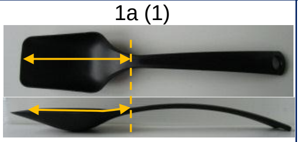
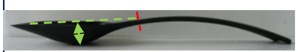
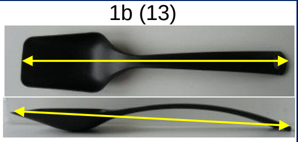
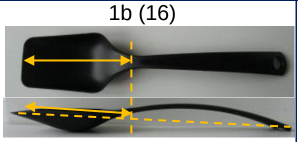
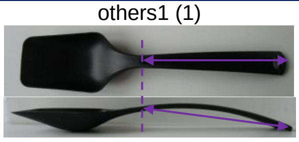
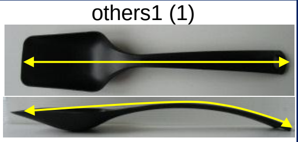
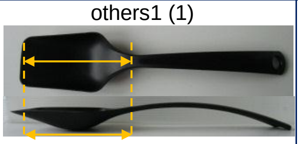
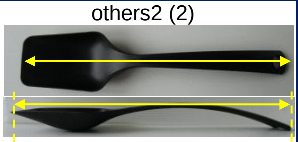
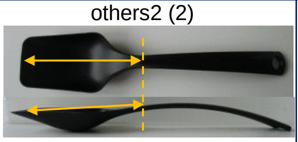
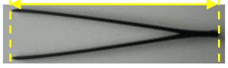
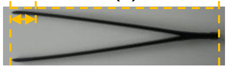
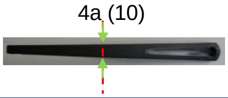
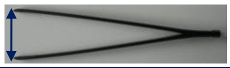
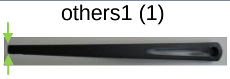
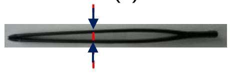
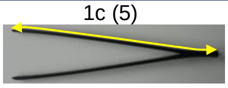
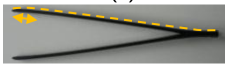
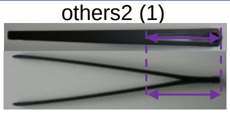
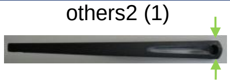
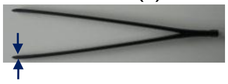
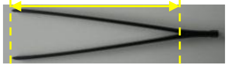
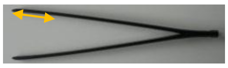
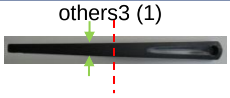
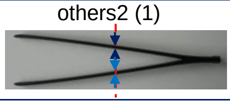
H_{total}	H_n	H_{handle}	depth
1a (4) 	1a (1) 	default (18) 1/3 of H_{total}	4a (4) 
1b (13) 	1b (16) 	others1 (1) 	4b (9) 
others1 (1) 	others1 (1) 	others2 (1) 	others (not specified) (1)
others2 (2) 	others2 (2) 	others3 (1) 	

Table 14 Ways of measurement applied for H_{total}, H_{handle}, H_n, depth and width of sample E. (Values in brackets refer to the number of laboratories that applied this measurement method.)

H_{total}	H_n	H_{handle}	depth	width
1a (9) 	1a (8) 	default (15) 1/3 of H_{total}	4a (10) 	5a (7) 
1b (7) 	1b (9) 	others1 (4) 	others1 (1) 	5b (3) 
1c (5) 	1c (4) 	others2 (1) 	others2 (1) 	others1 (2) 
others1 (1) 	others1 (1) 	others3 (1) 	others3 (1) 	others2 (1) 
		others4 (1) 	others (not specified) (1)	width = 0 (1)
		others5 (1) 		

9.3. Results for H_f

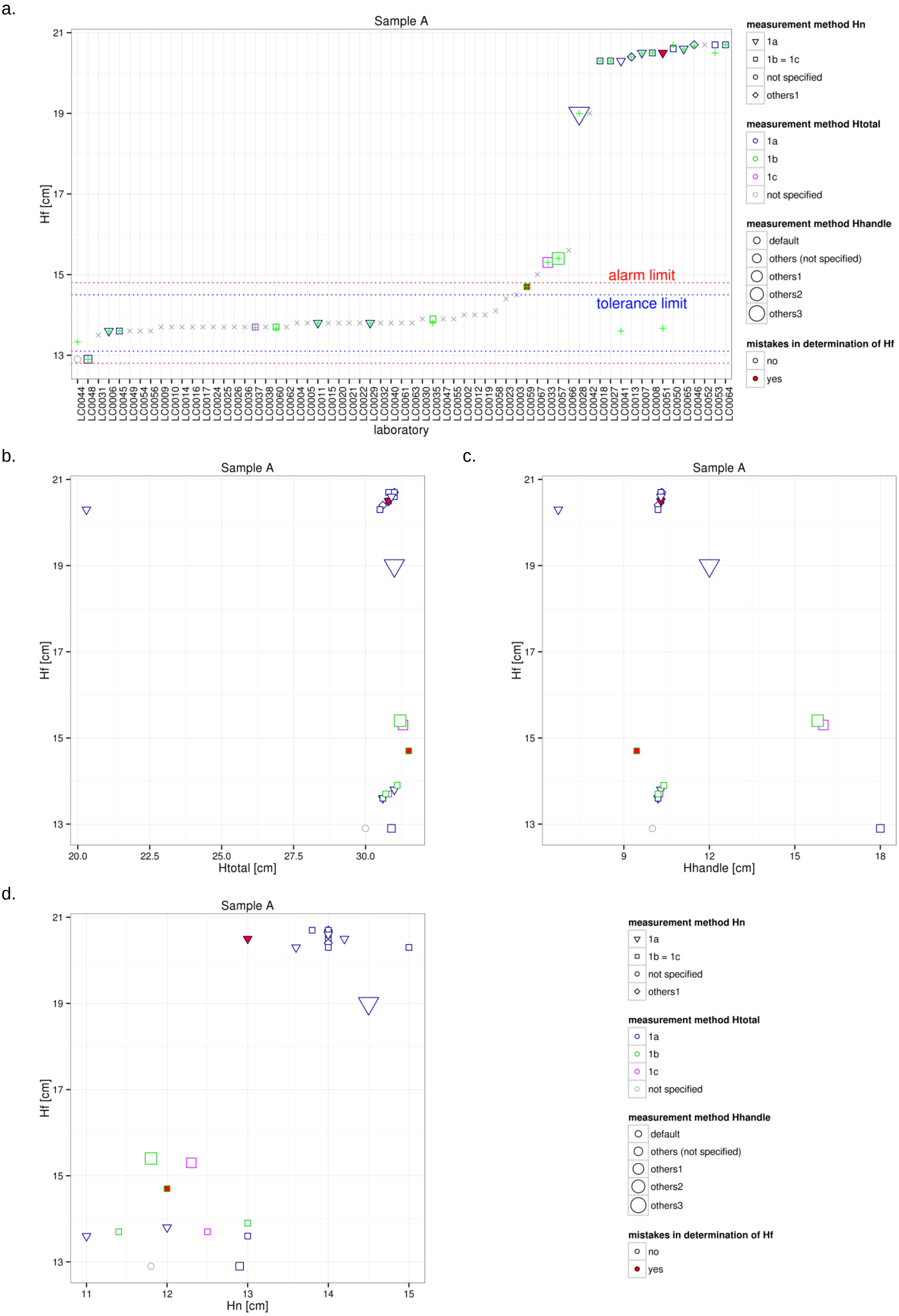


Figure 2 H_f values (a) and their correlation to H_{total} (b), H_{handle} (c) and H_n (d) reported for sample A. Categories in the legend refer to Table 10. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+ H_f calculated by EURL-FCM from respective values for H_{total}, H_{handle} and H_n reported by the laboratories during the study; × H_f reported in ILC 003 2013, no further information available)

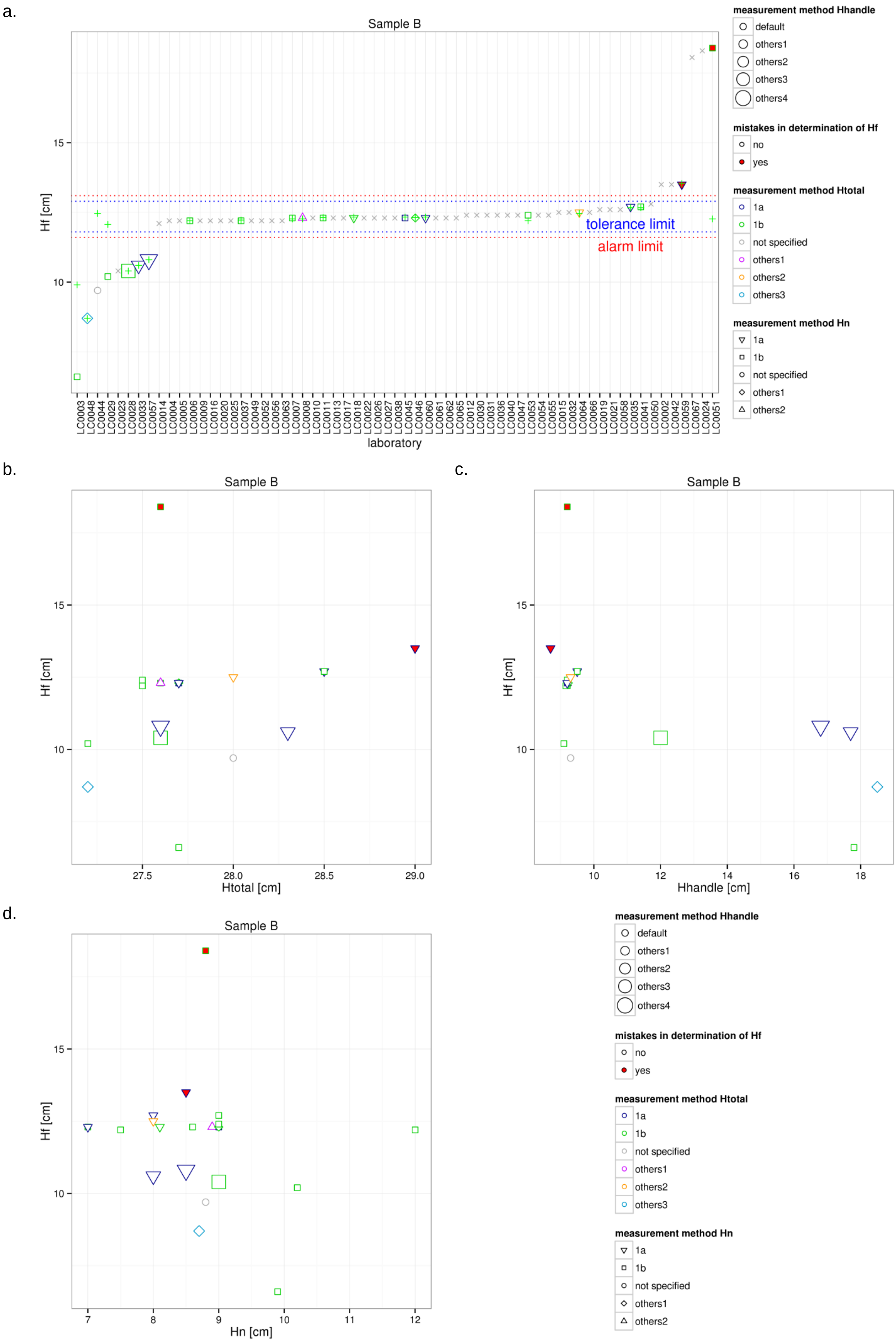


Figure 3 H_f values (a) and their correlation to H_{total} (b), H_{handle} (c) and H_n (d) reported for sample B. Categories in the legend refer to Table 11. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+ H_f calculated by EURL-FCM from respective values for H_{total}, H_{handle} and H_n reported by the laboratories during the study; × H_f reported in ILC 003 2013, no further information available)

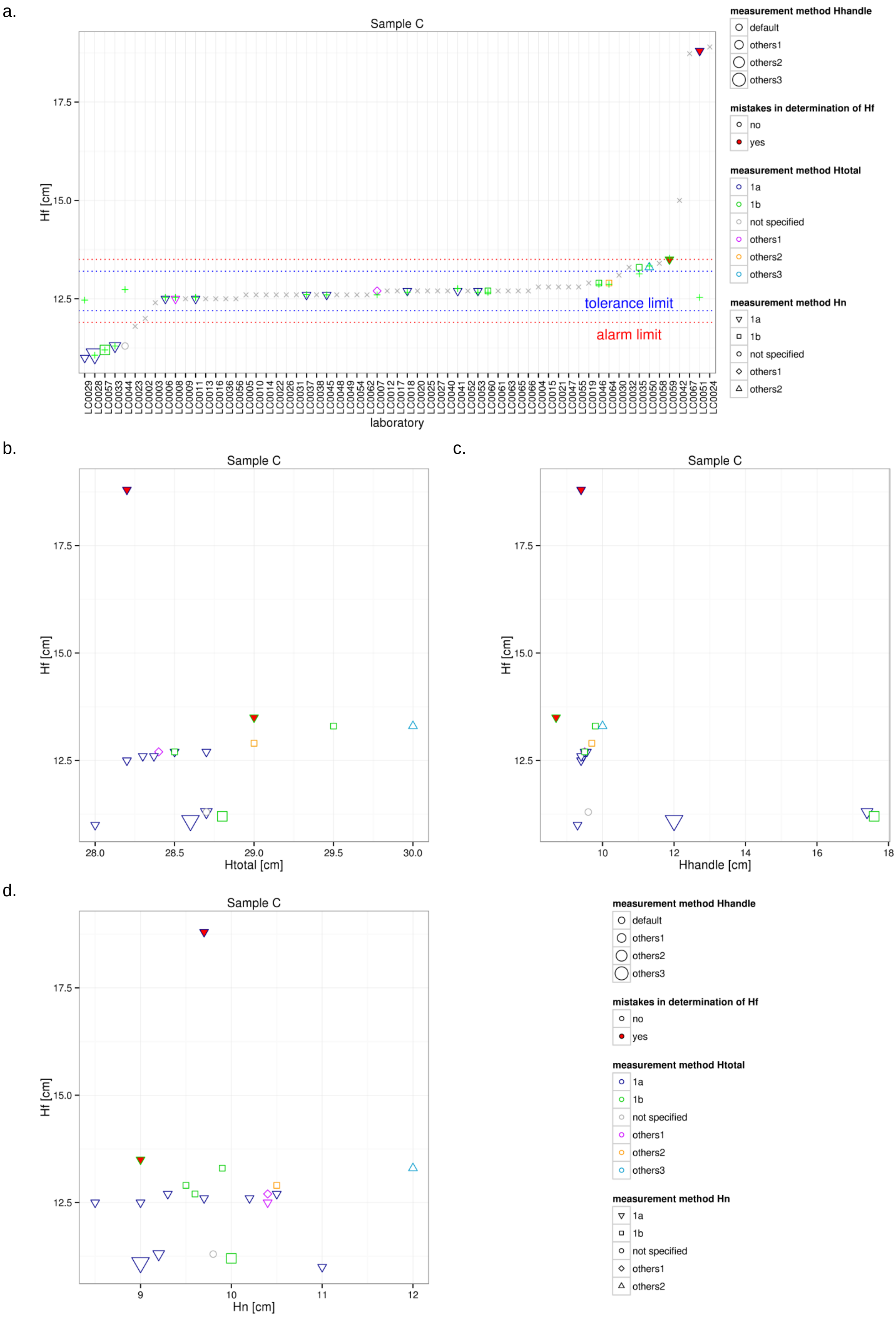


Figure 4 H_f values (a) and their correlation to H_{total} (b), H_{handle} (c) and H_n (d) reported for sample C. Categories in the legend refer to Table 12. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+ H_f calculated by EURL-FCM from respective values for H_{total}, H_{handle} and H_n reported by the laboratories during the study; × H_f reported in ILC 003 2013, no further information available)

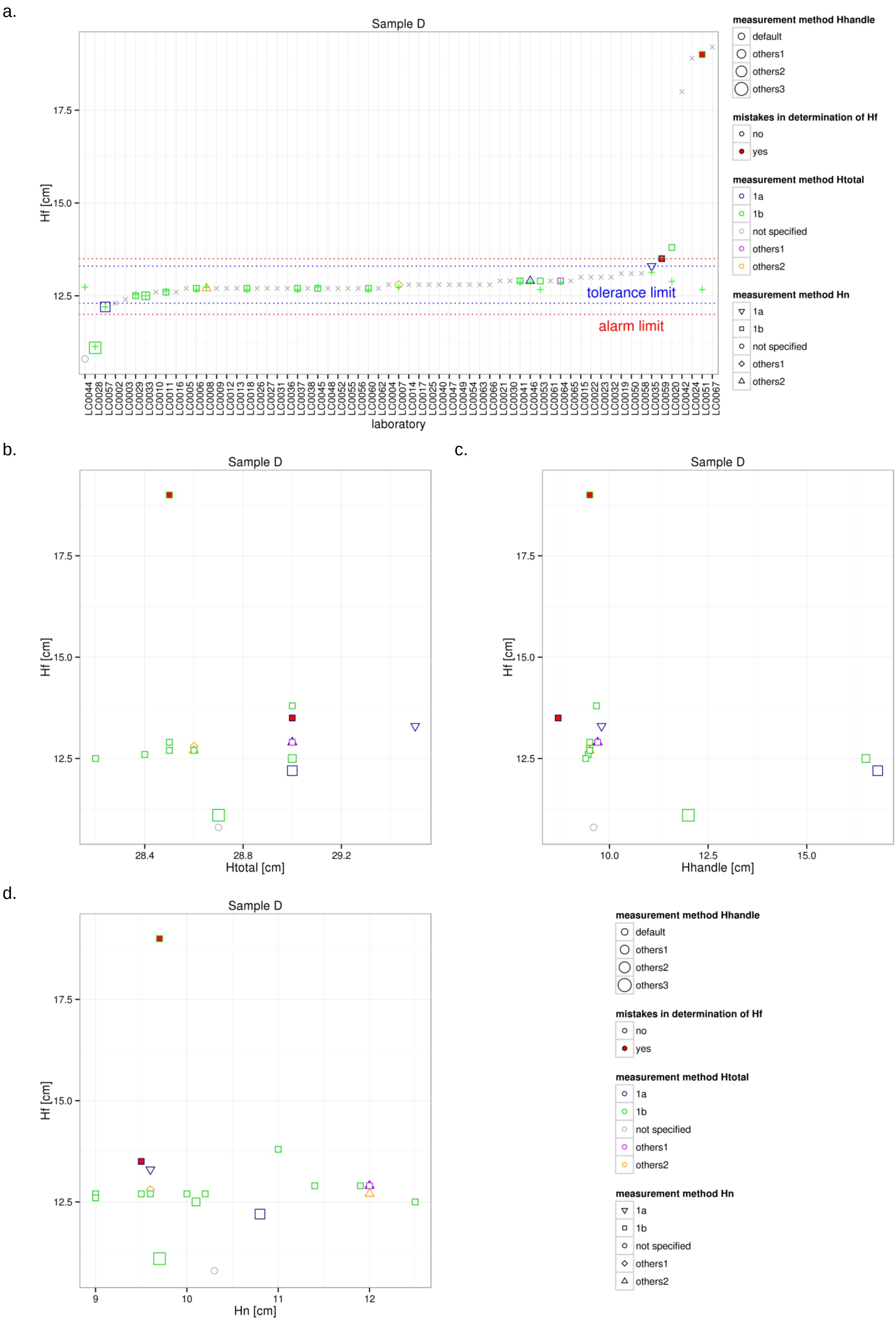


Figure 5 H_f values (a) and their correlation to H_{total} (b), H_{handle} (c) and H_n (d) reported for sample D. Categories in the legend refer to Table 13. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+ H_f calculated by EURL-FCM from respective values for H_{total}, H_{handle} and H_n reported by the laboratories during the study; × H_f reported in ILC 003 2013, no further information available)

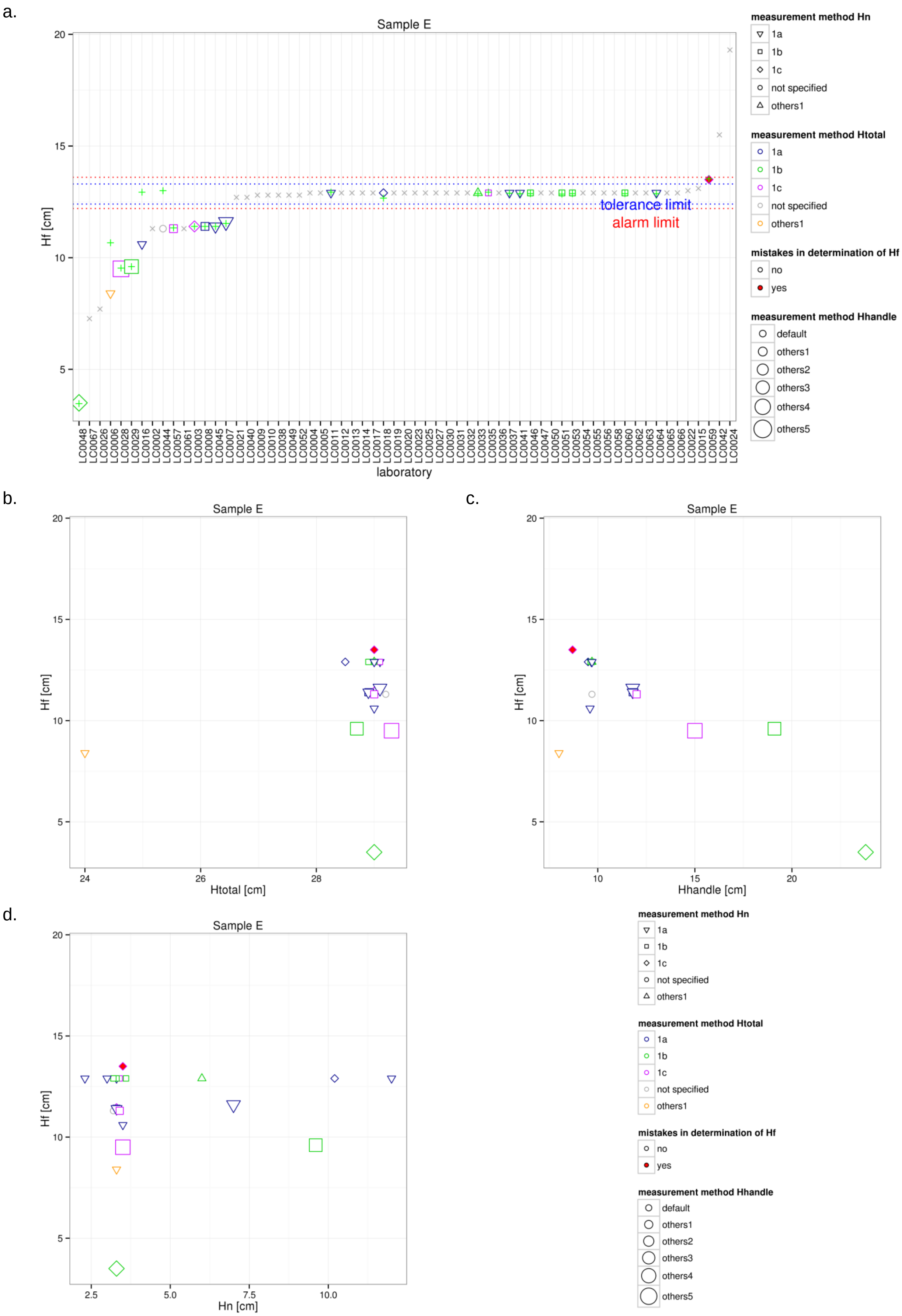


Figure 6 H_f values (a) and their correlation to H_{total} (b), H_{handle} (c) and H_n (d) reported for sample E. Categories in the legend refer to Table 14. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+ H_f calculated by EURL-FCM from respective values for H_{total}, H_{handle} and H_n reported by the laboratories during the study; × H_f reported in ILC 003 2013, no further information available)

9.4. Results for the surface area

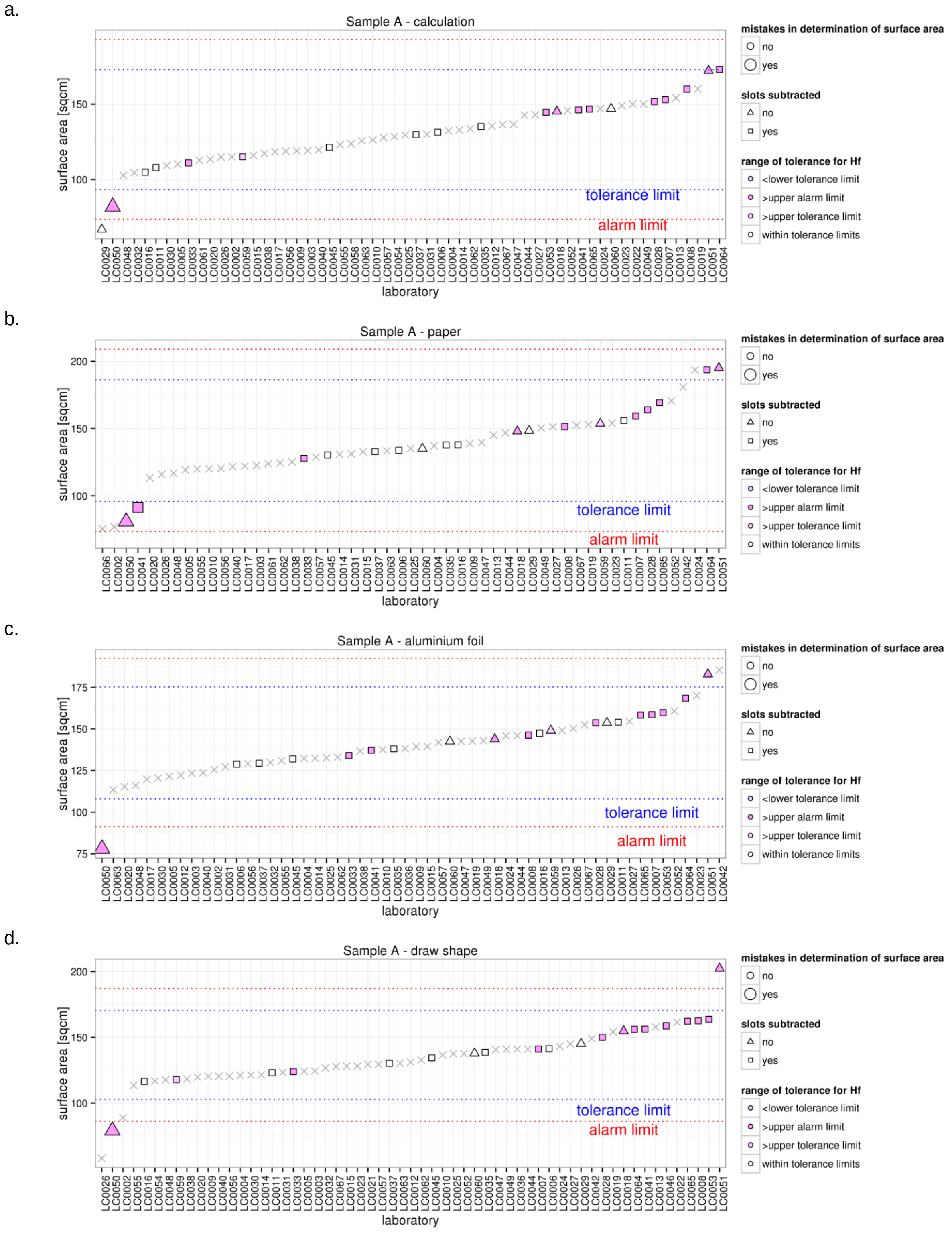
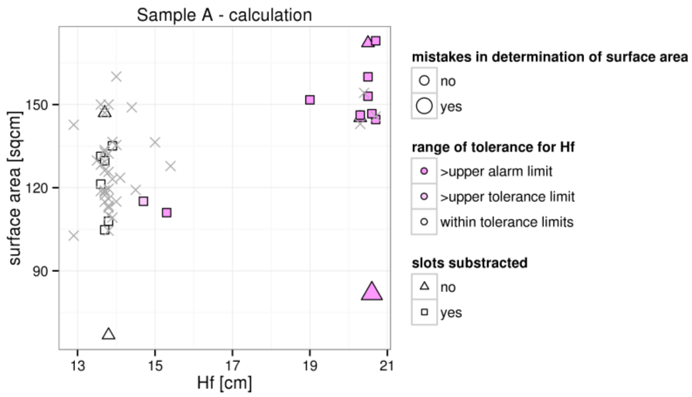
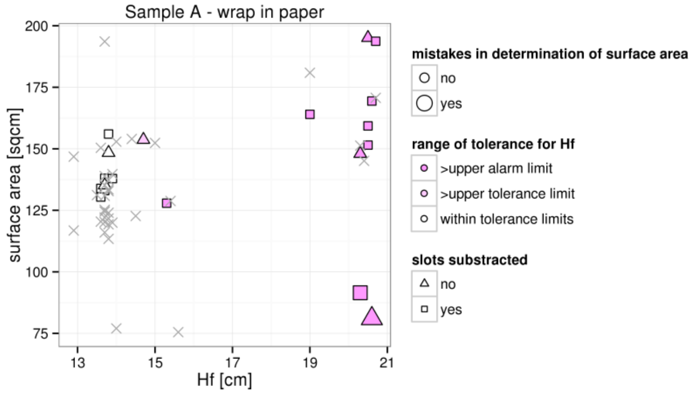


Figure 7 Surface area values reported for sample A determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d). Categories in the legend refer to Table 10. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (× surface area reported in ILC 003 2013, no further information available)

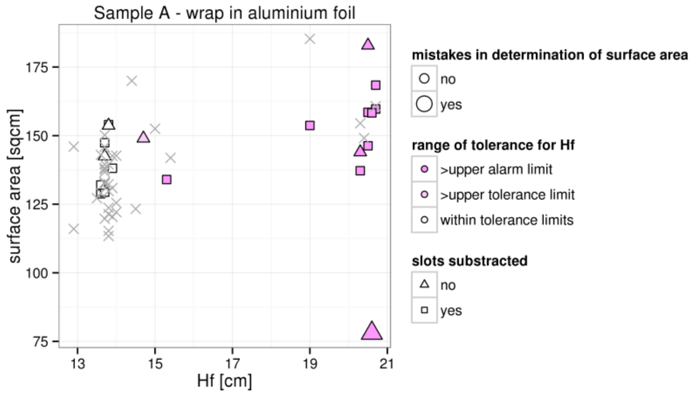
a.



b.



c.



d.

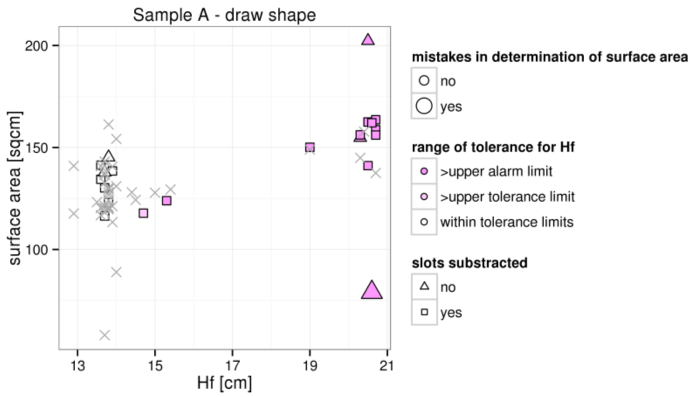


Figure 8 Correlation between surface area values reported for sample A determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d) and reported H_f values. Categories in the legend refer to Table 10. (× surface area reported in ILC 003 2013, no further information available)

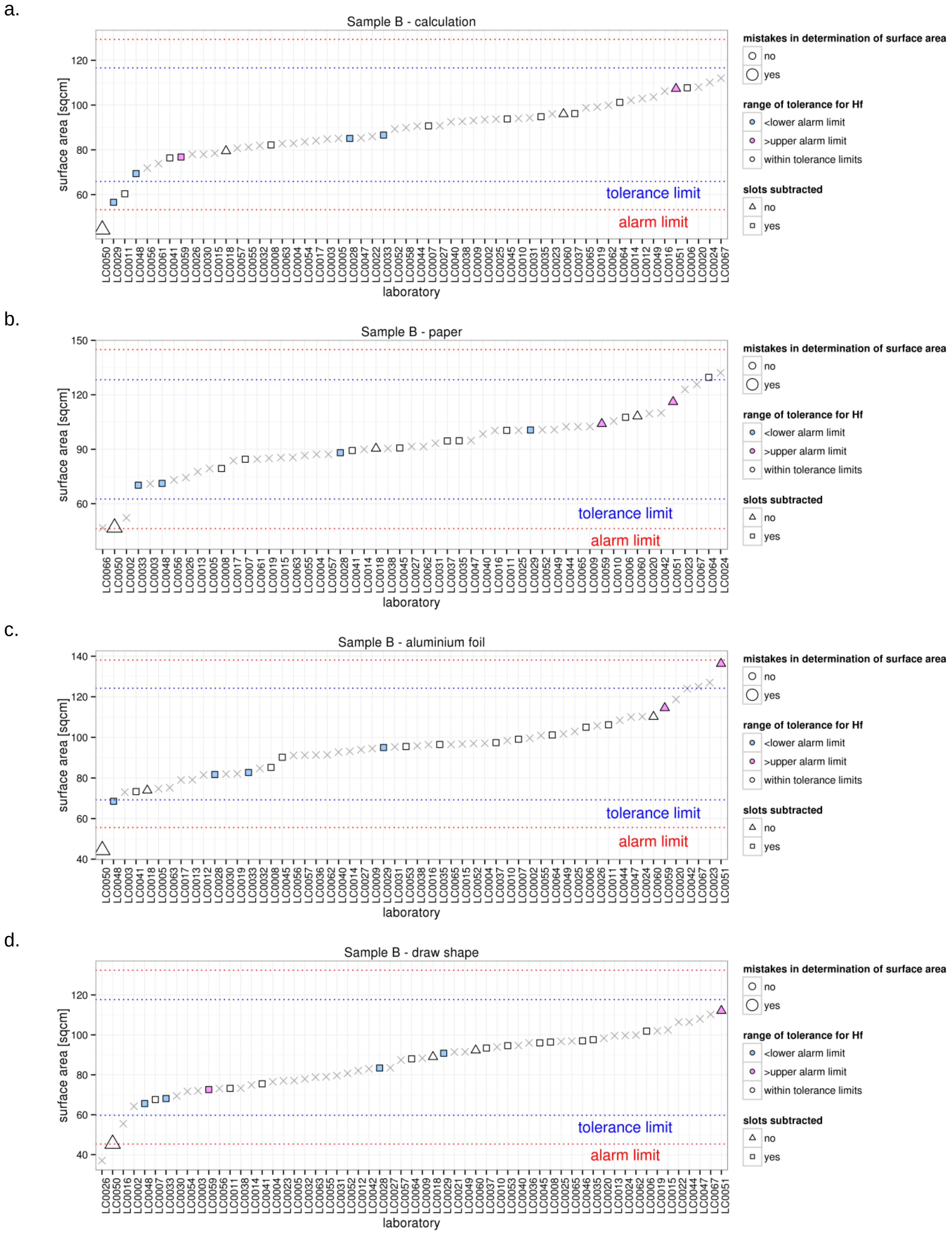
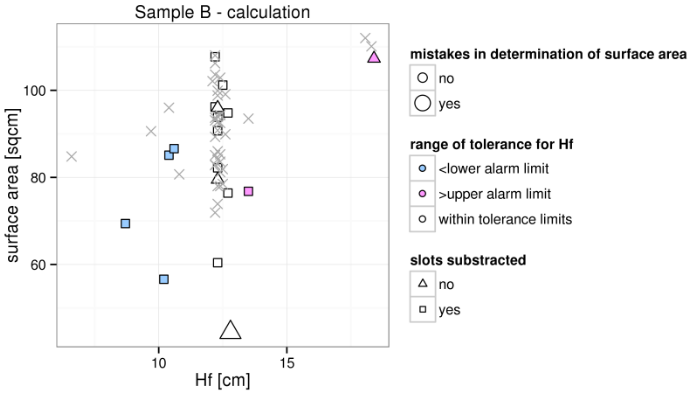
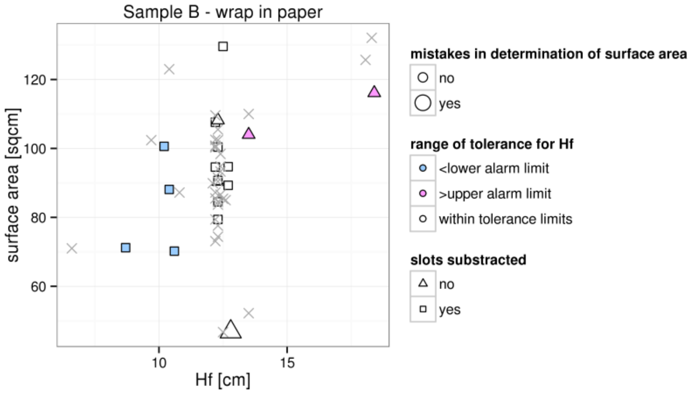


Figure 9 Surface area values reported for sample B determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d). Categories in the legend refer to Table 11. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (× surface area reported in ILC 003 2013, no further information available)

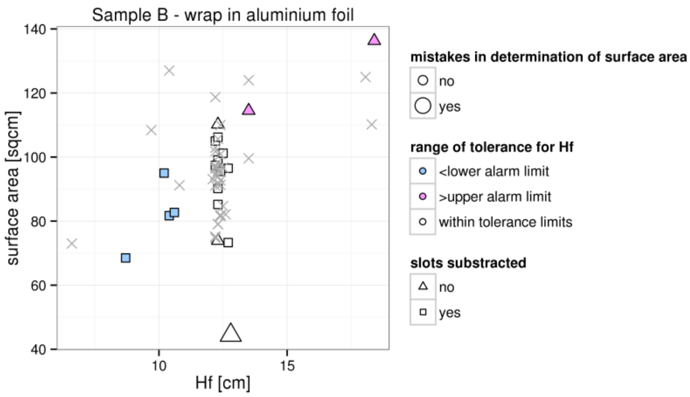
a.



b.



c.



d.

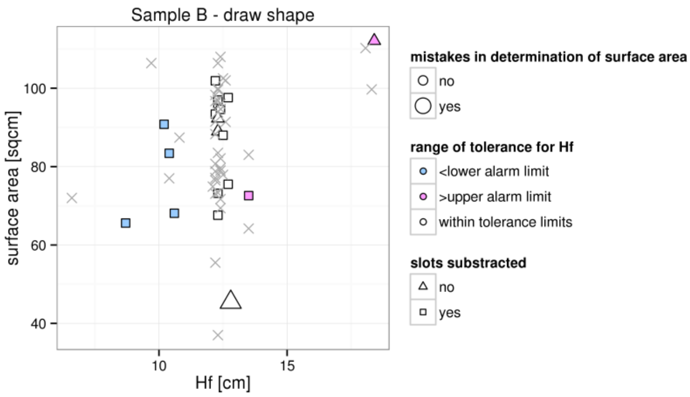


Figure 10 Correlation between surface area values reported for sample B determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d) and reported H_f values. Categories in the legend refer to Table 11. (× surface area reported in ILC 003 2013, no further information available)

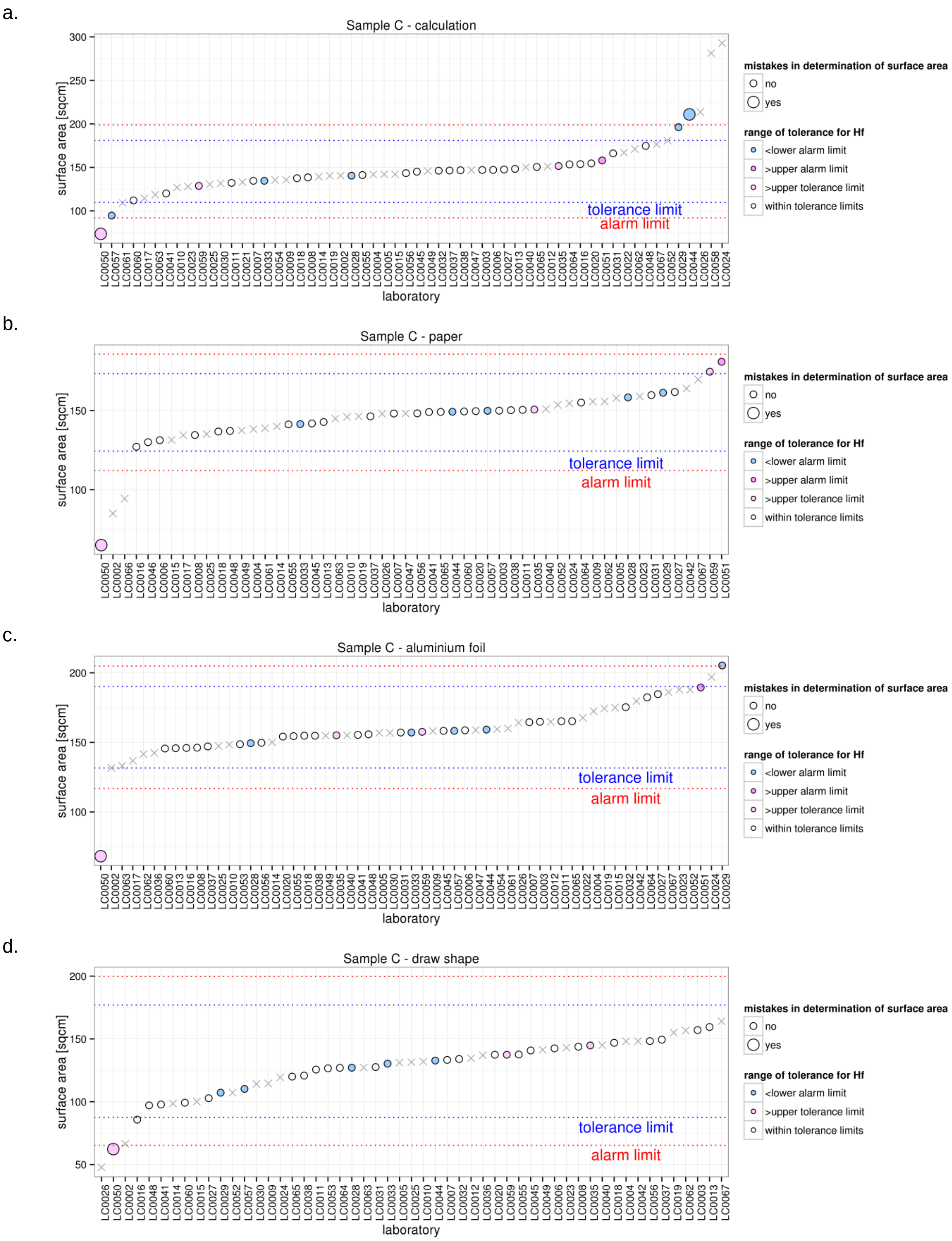
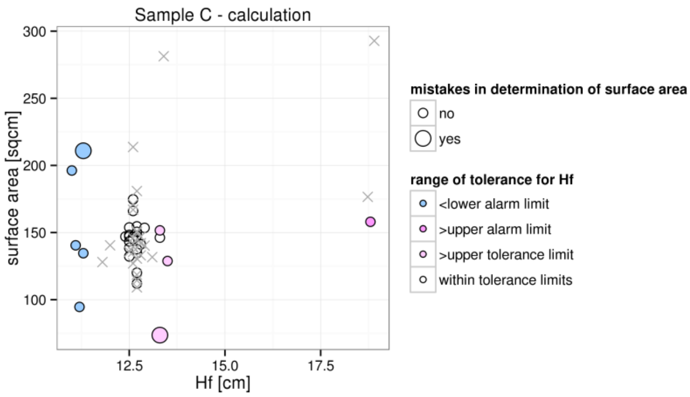
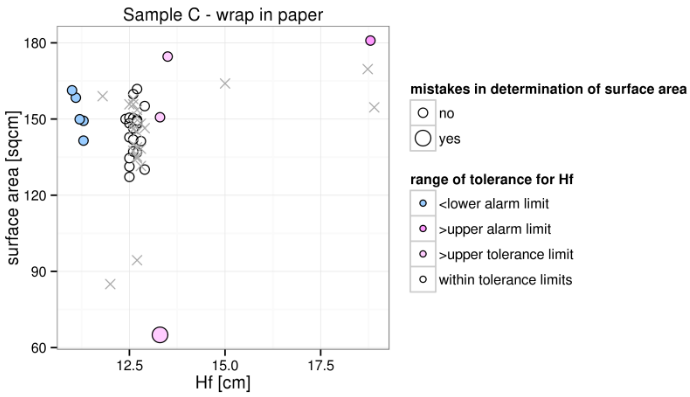


Figure 11 Surface area values reported for sample C determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d). Categories in the legend refer to Table 12. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (× surface area reported in ILC 003 2013, no further information available)

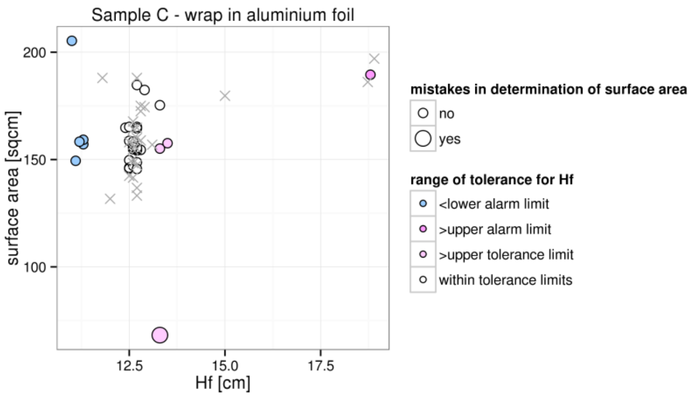
a.



b.



c.



d.

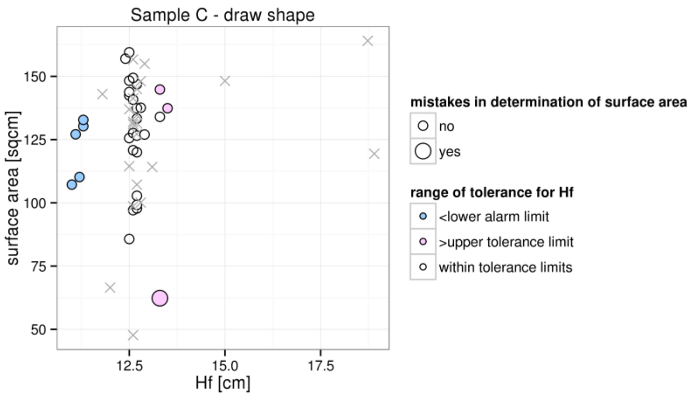


Figure 12 Correlation between surface area values reported for sample C determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d) and reported H_f values. Categories in the legend refer to Table 12. (× surface area reported in ILC 003 2013, no further information available)

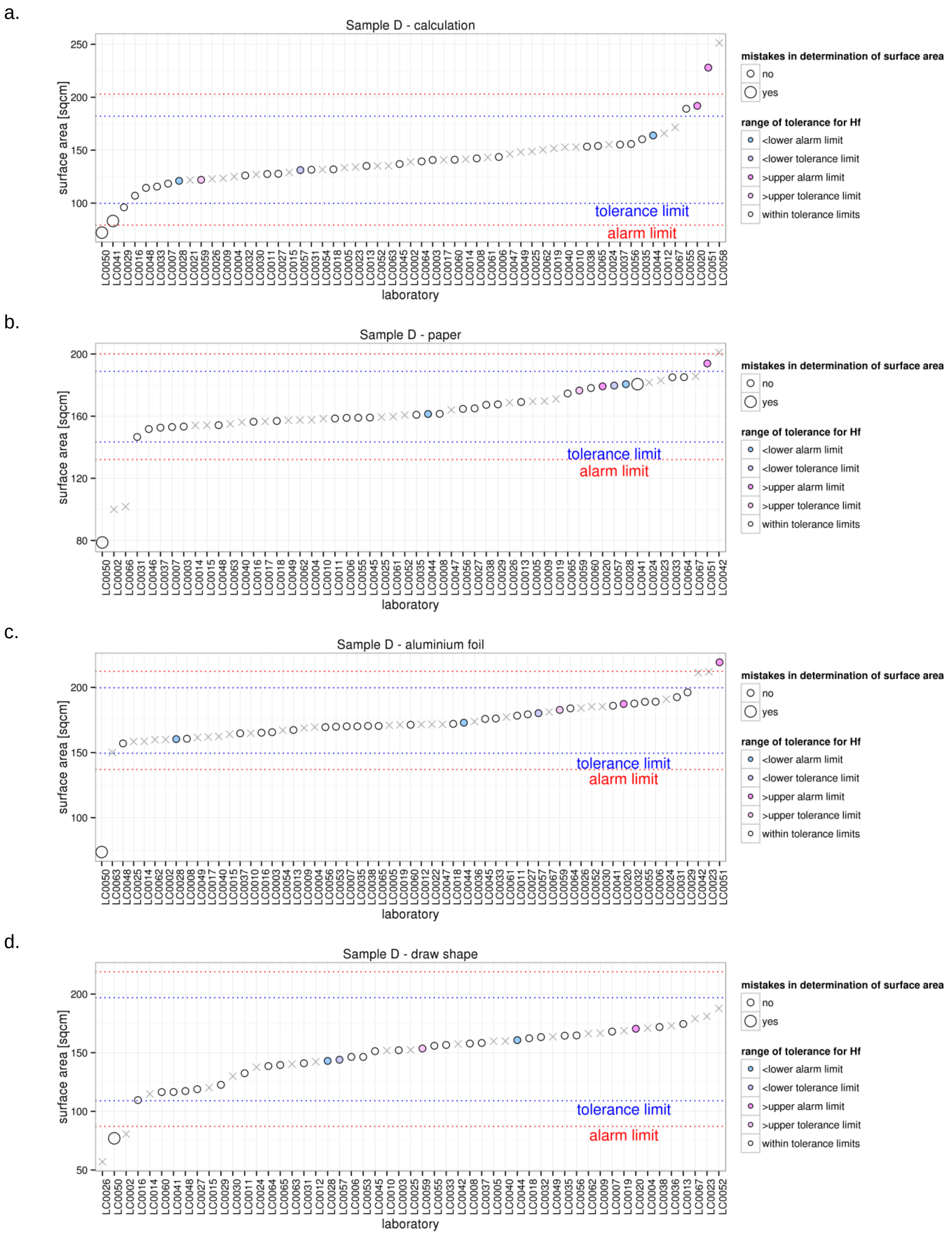


Figure 13 Surface area values reported for sample D determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d). Categories in the legend refer to Table 13. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (× surface area reported in ILC 003 2013, no further information available)

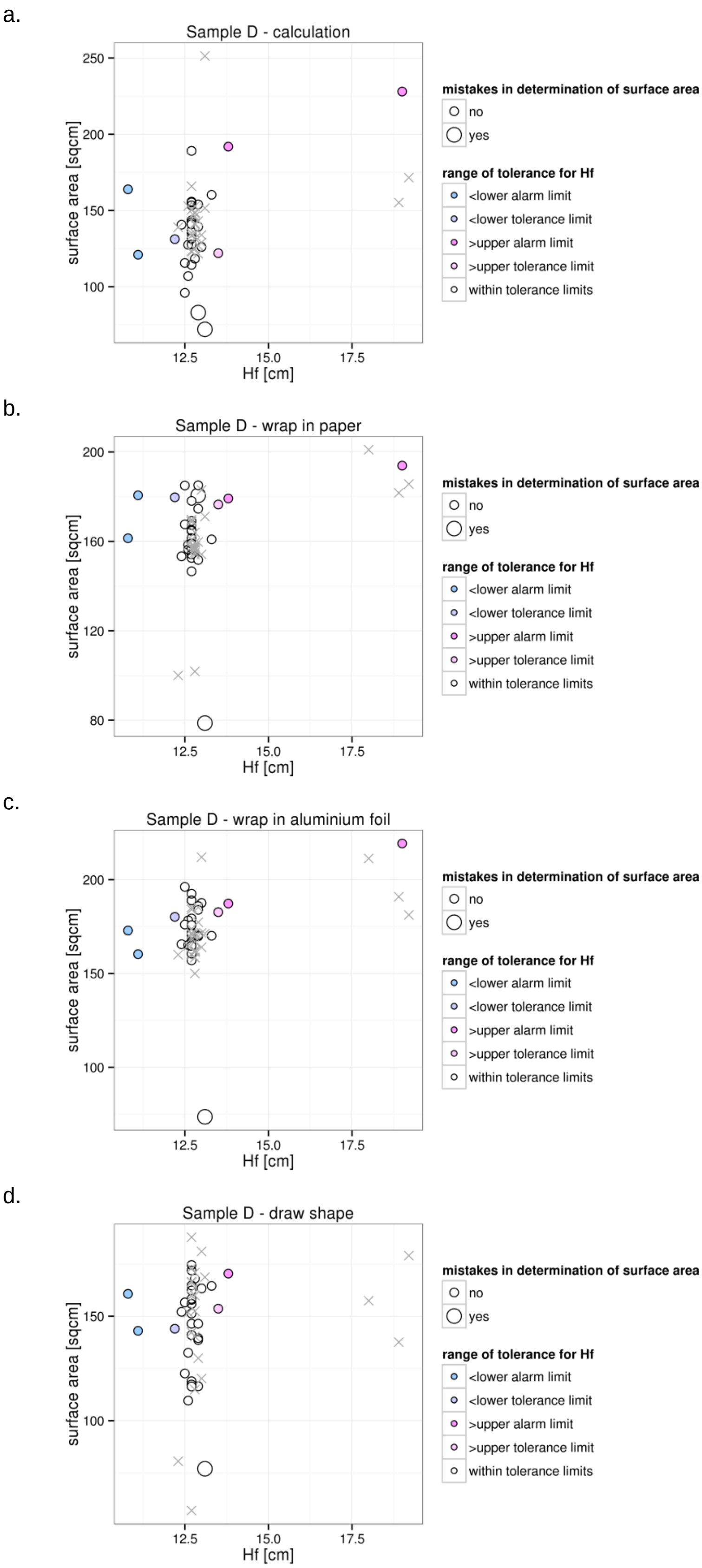


Figure 14 Correlation between surface area values reported for sample D determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d) and reported H_f values. Categories in the legend refer to Table 13. (× surface area reported in ILC 003 2013, no further information available)

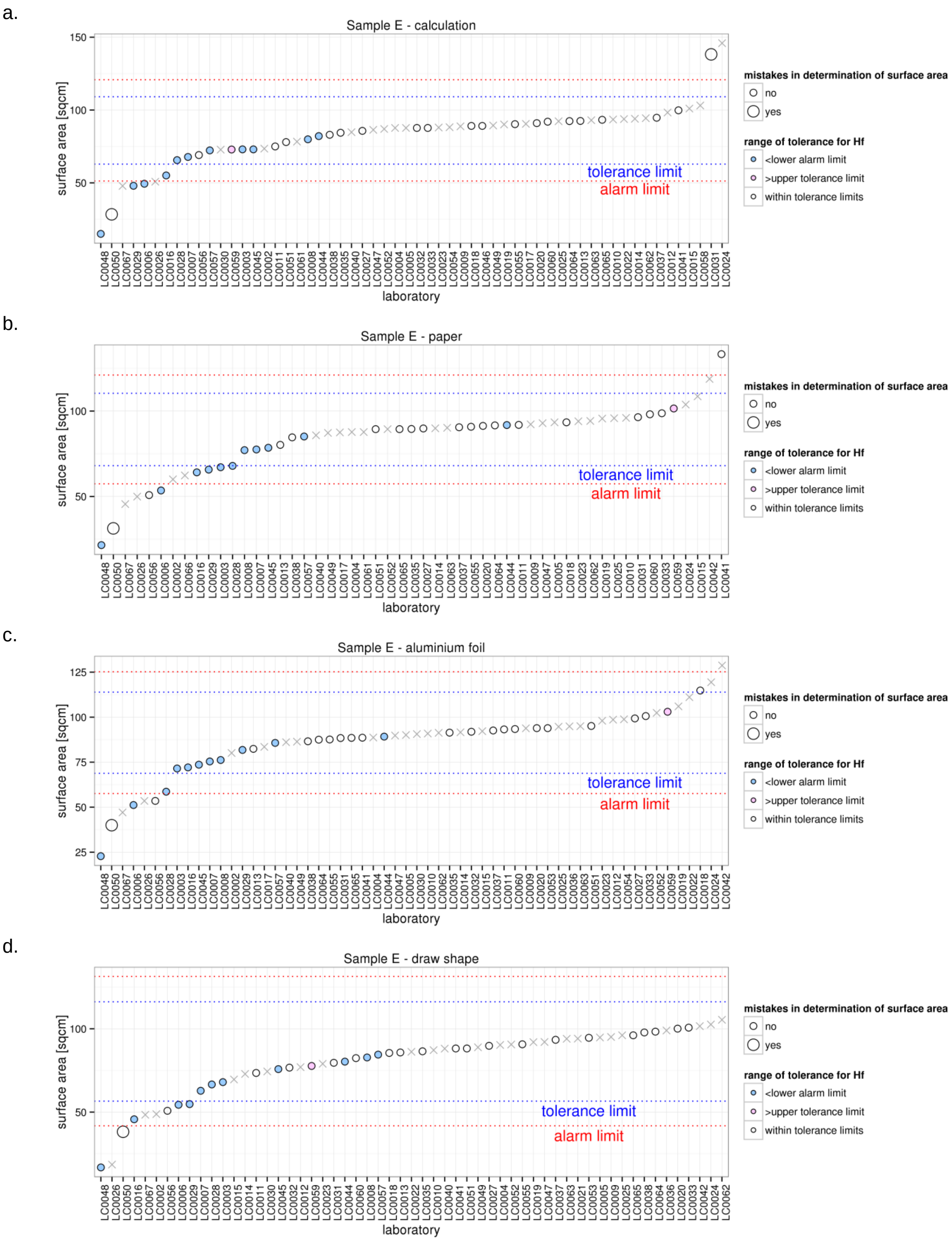
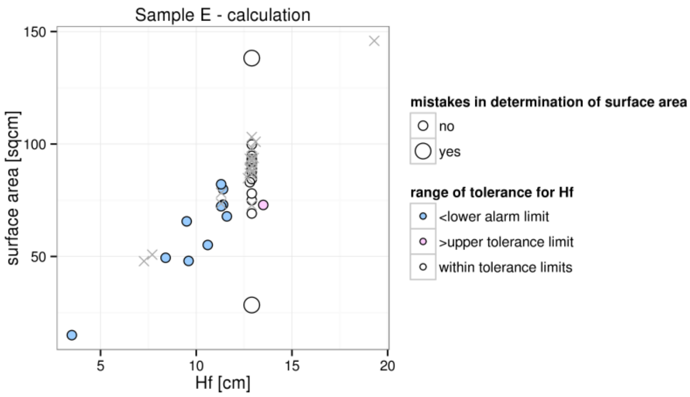
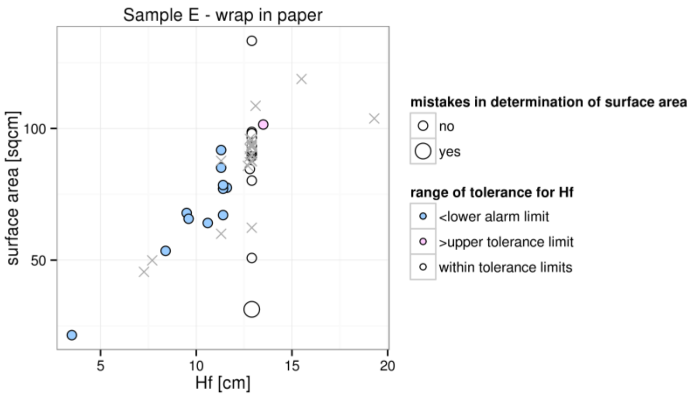


Figure 15 Surface area values reported for sample E determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d). Categories in the legend refer to Table 14. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (× surface area reported in ILC 003 2013, no further information available)

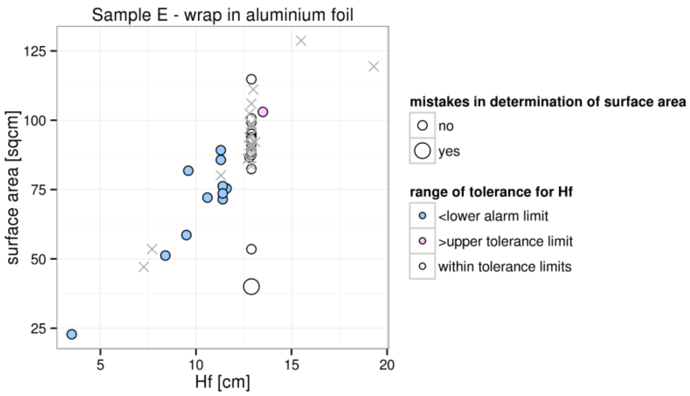
a.



b.



c.



d.

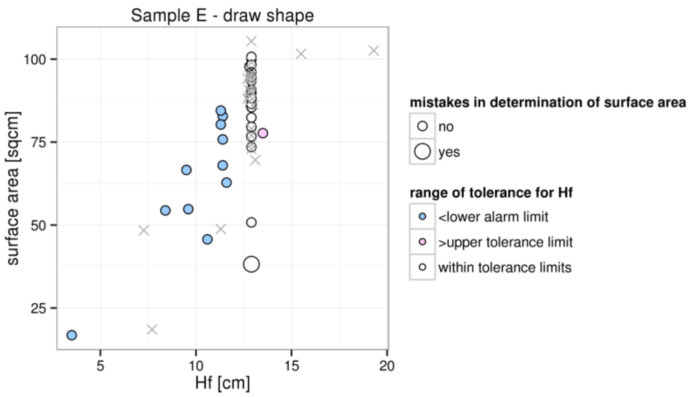
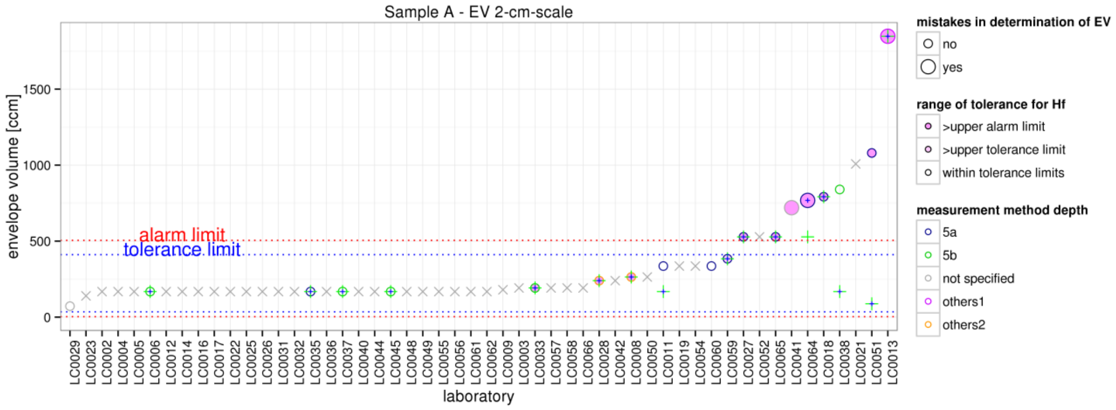


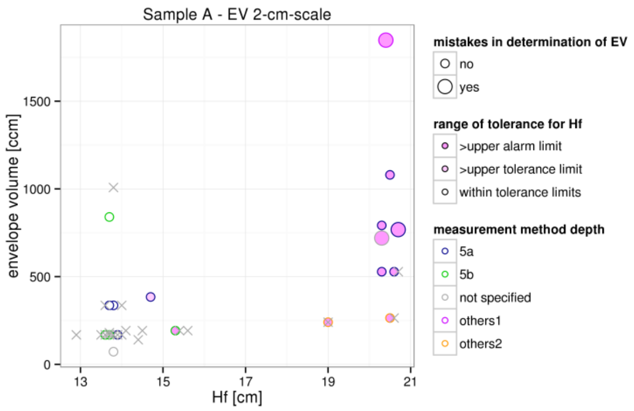
Figure 16 Correlation between surface area values reported for sample E determined by "calculation" (a), "wrapping in paper" (b), "wrapping in aluminium foil" (c) and "drawing the shape" (d) and reported H_f values. Categories in the legend refer to Table 14. (× surface area reported in ILC 003 2013, no further information available)

9.5. Results for the envelope volume

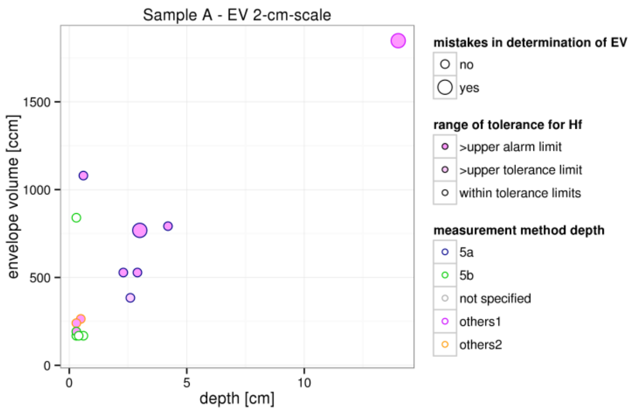
a.



b.



c.



d.

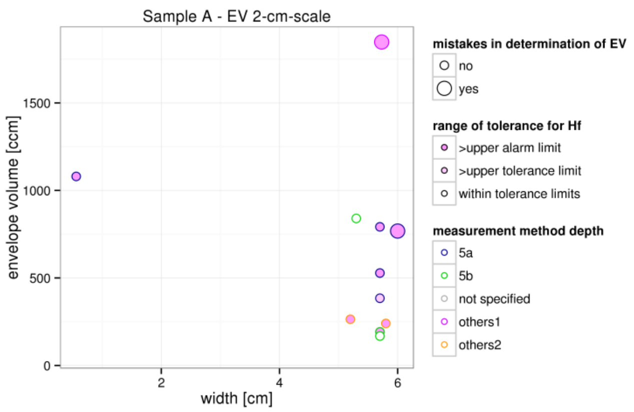


Figure 17 Results for the envelope volume determined on a 2-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample A. Categories in the legend refer to Table 10. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

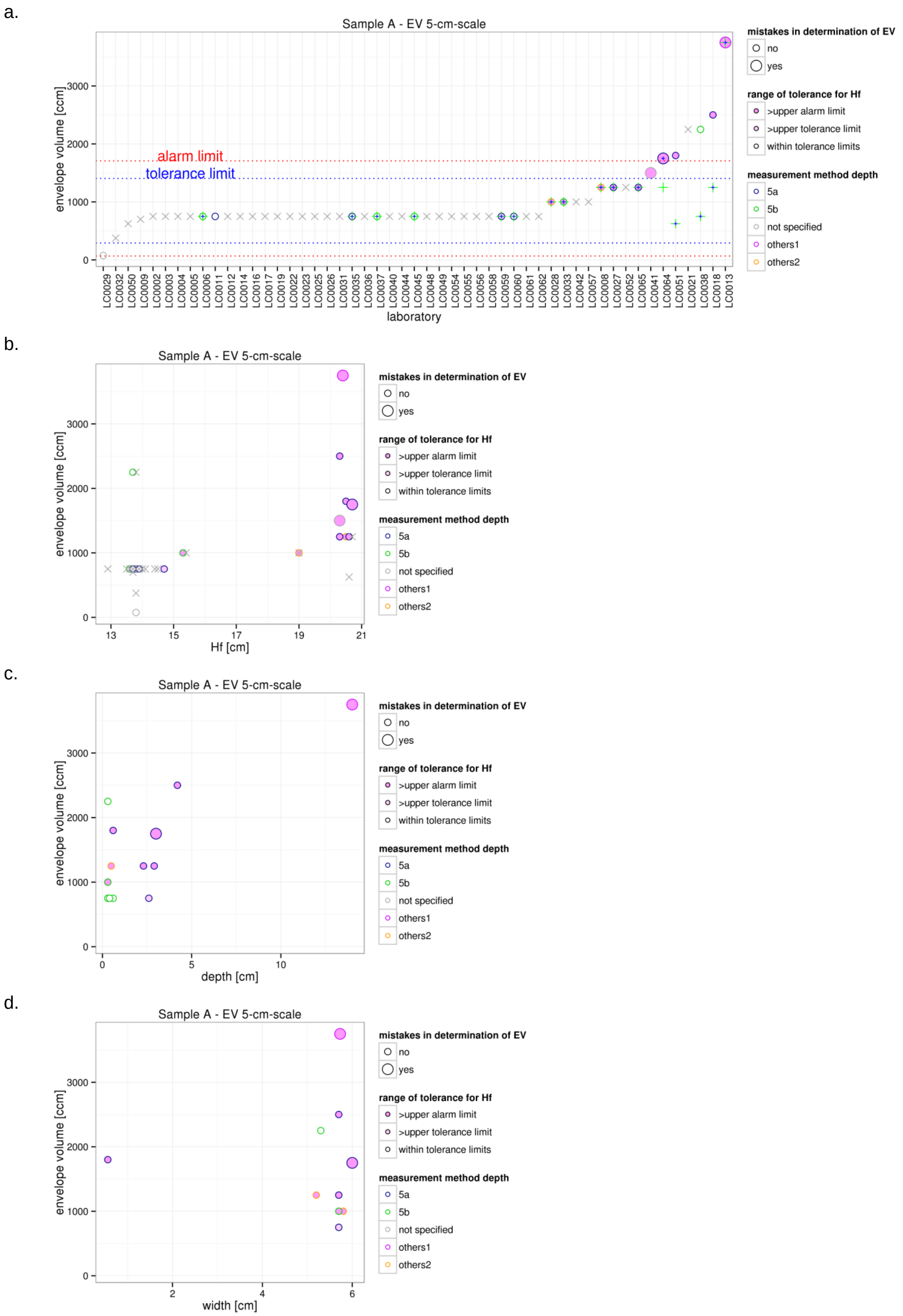
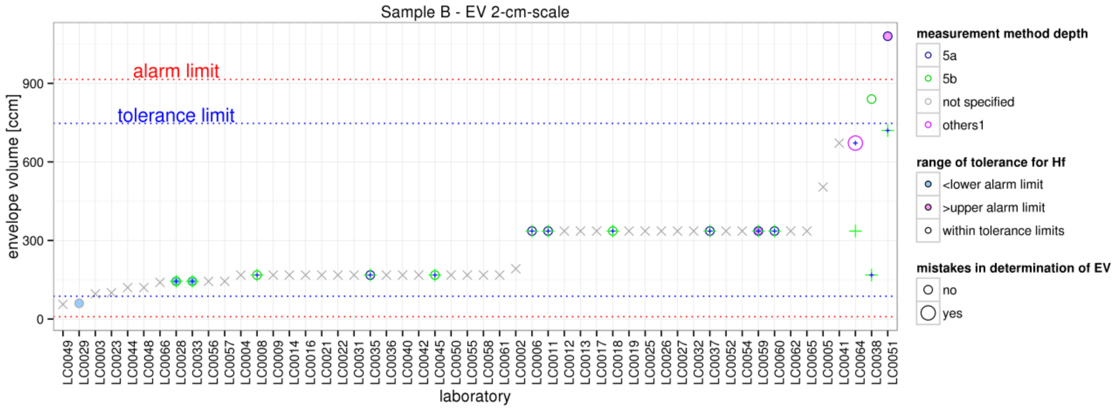
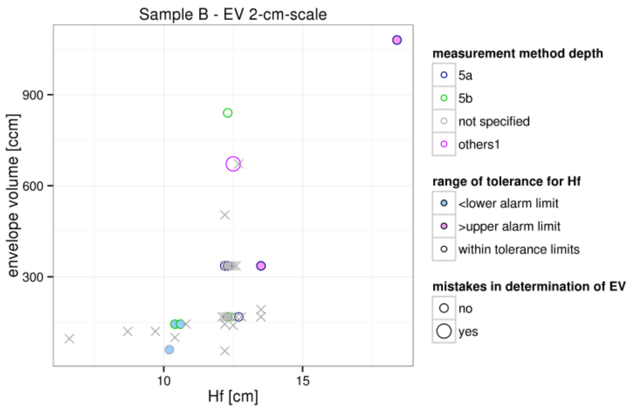


Figure 18 Results for the envelope volume determined on a 5-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample A. Categories in the legend refer to Table 10. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

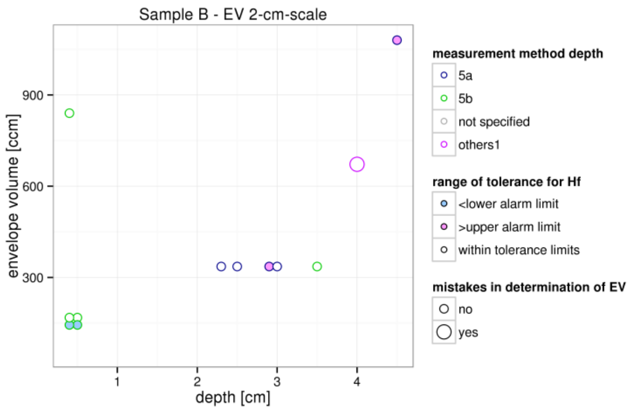
a.



b.



c.



d.

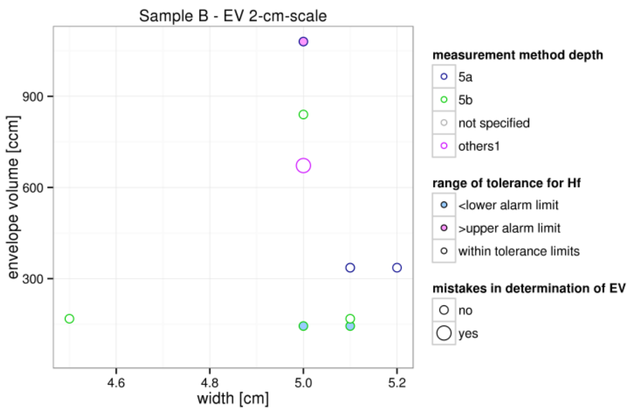


Figure 19 Results for the envelope volume determined on a 2-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample B. Categories in the legend refer to Table 11. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

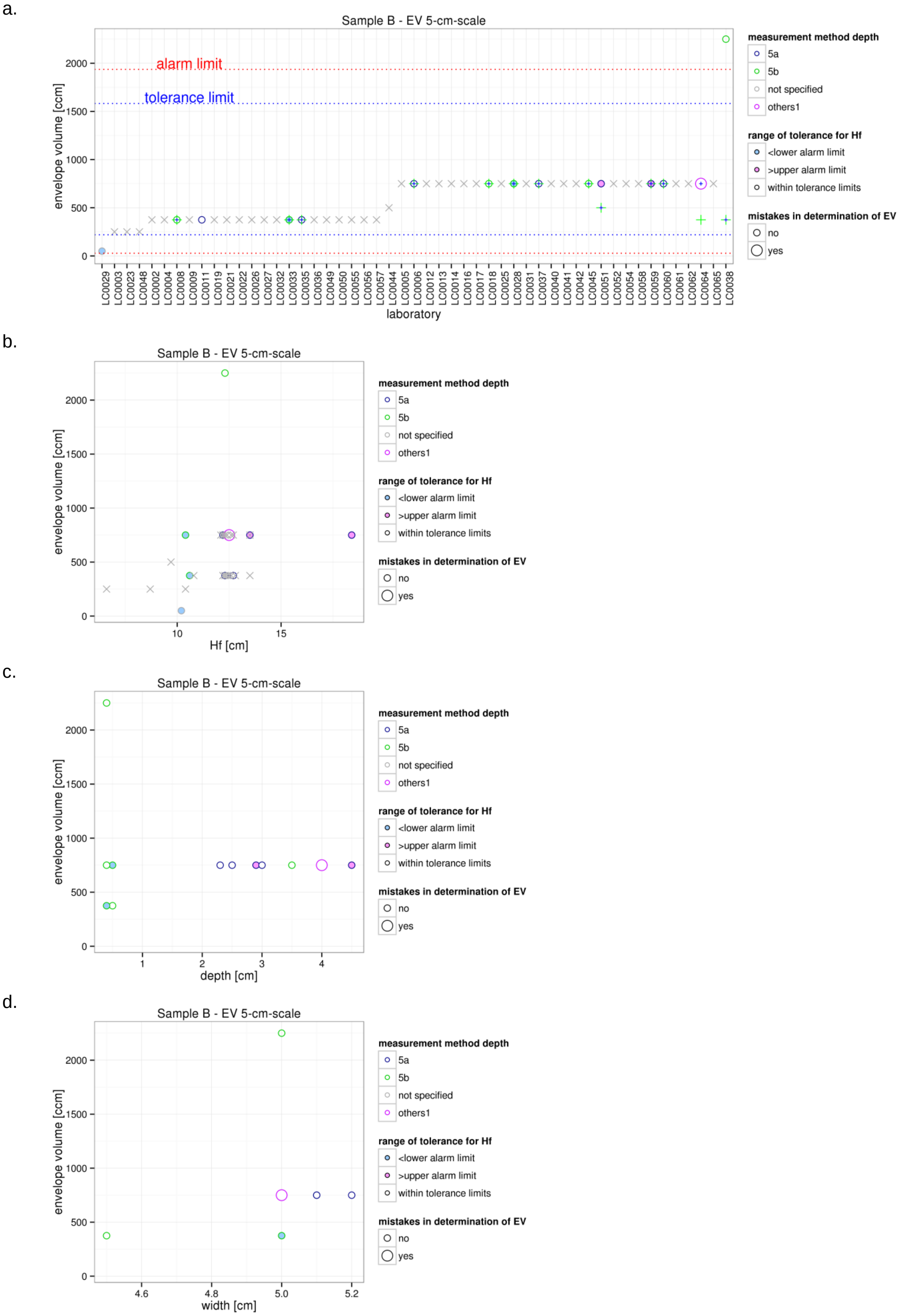


Figure 20 Results for the envelope volume determined on a 5-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample B. Categories in the legend refer to Table 11. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

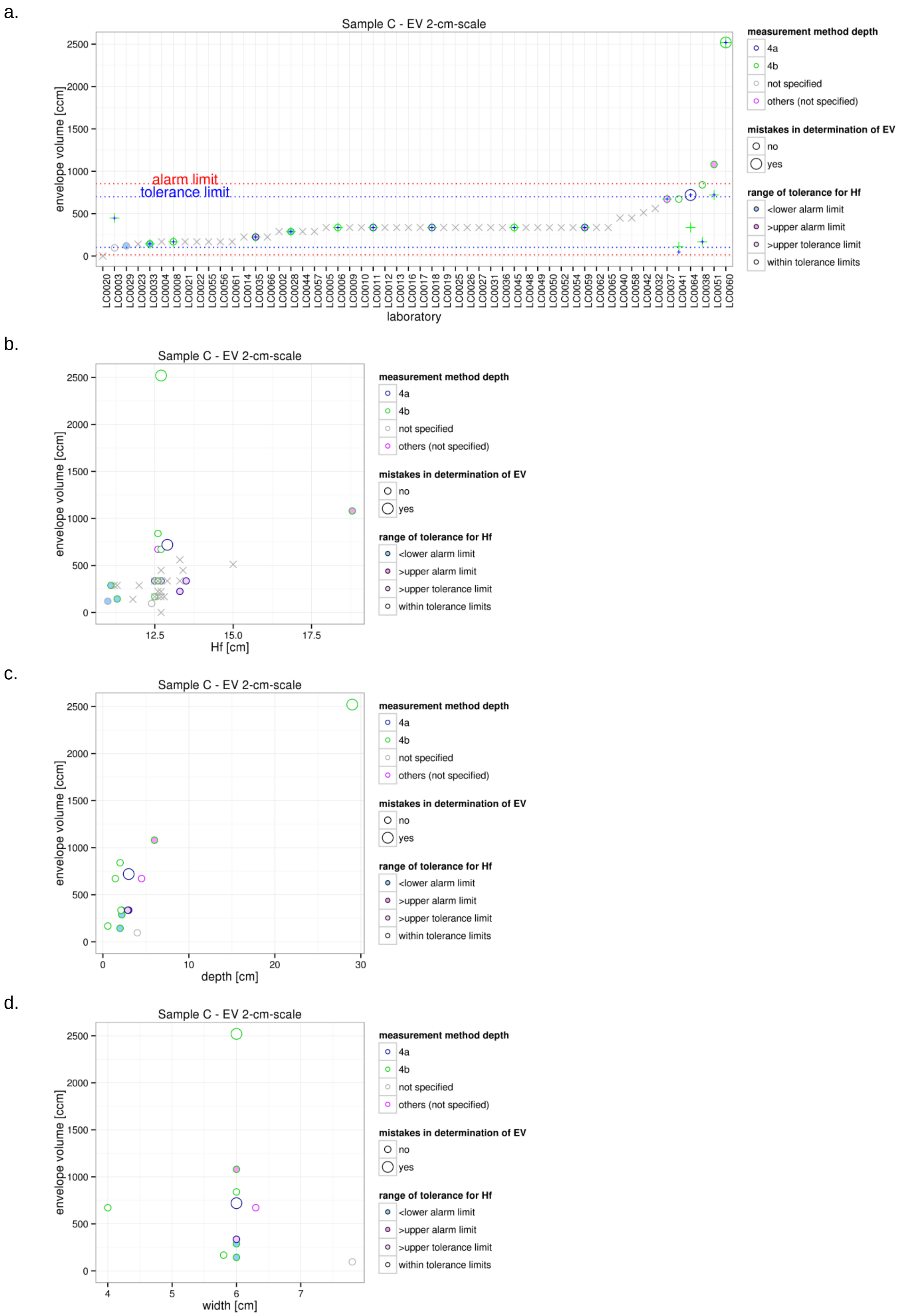


Figure 21 Results for the envelope volume determined on a 2-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample C. Categories in the legend refer to Table 12. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

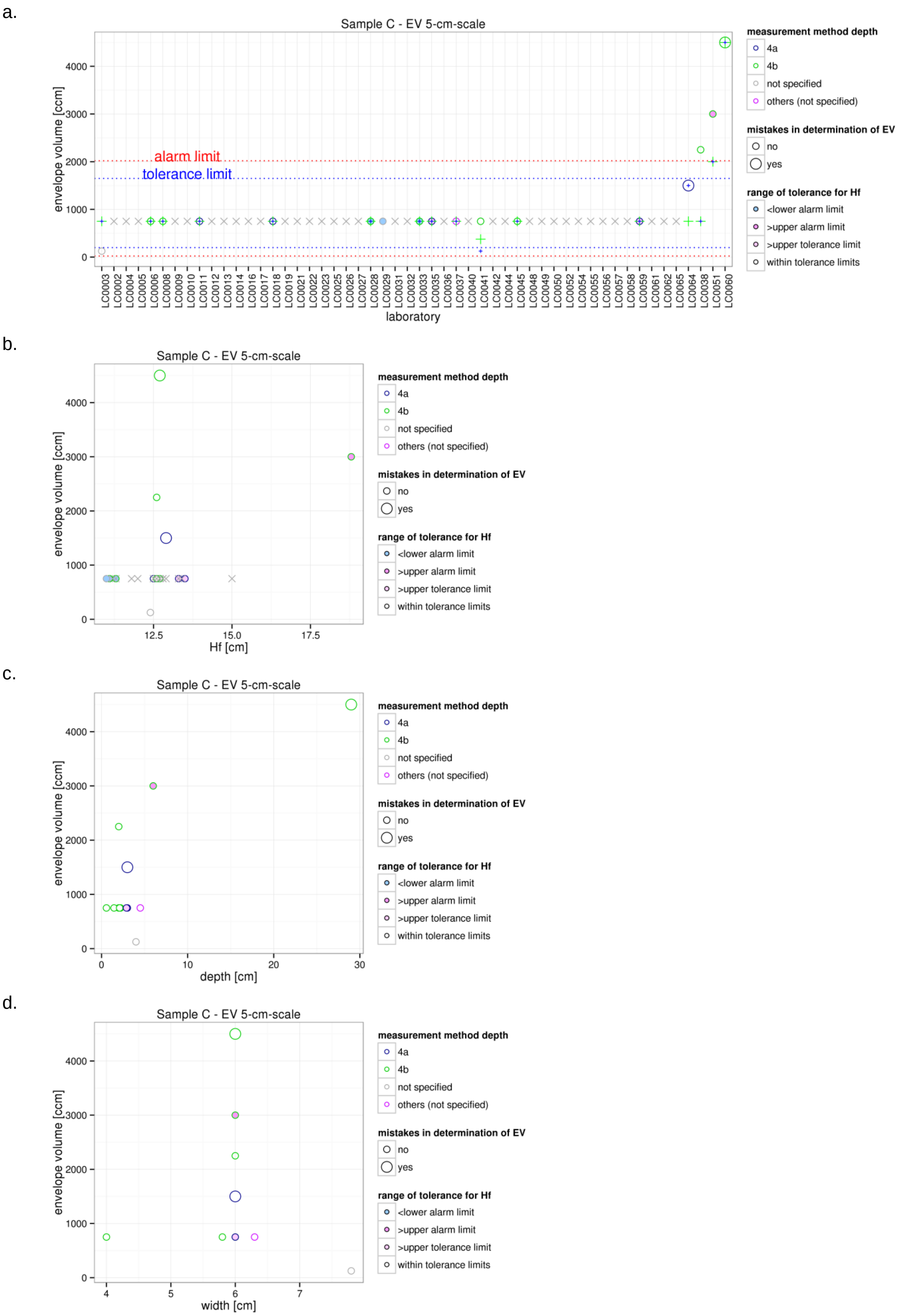
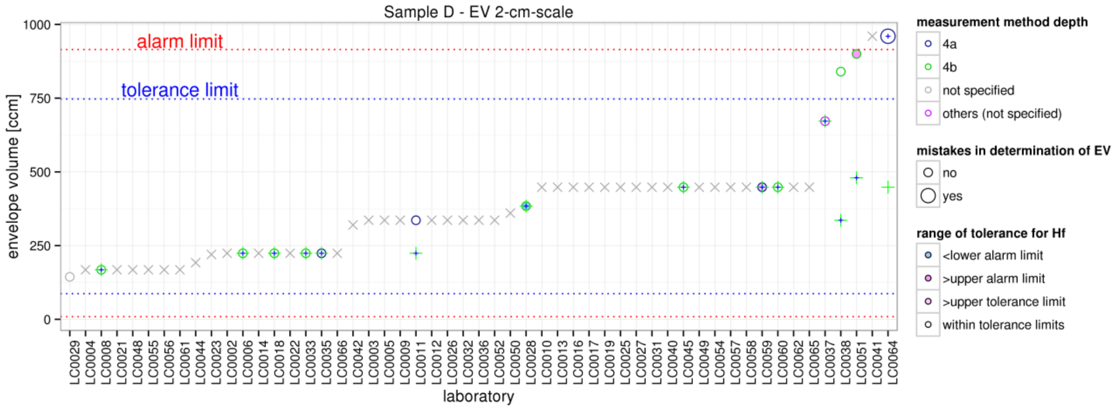
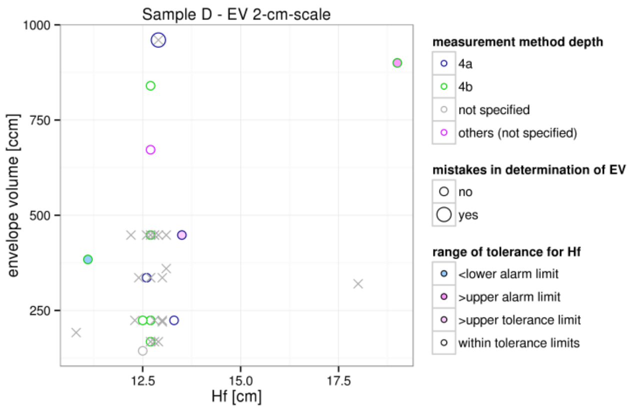


Figure 22 Results for the envelope volume determined on a 5-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample C. Categories in the legend refer to Table 12. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

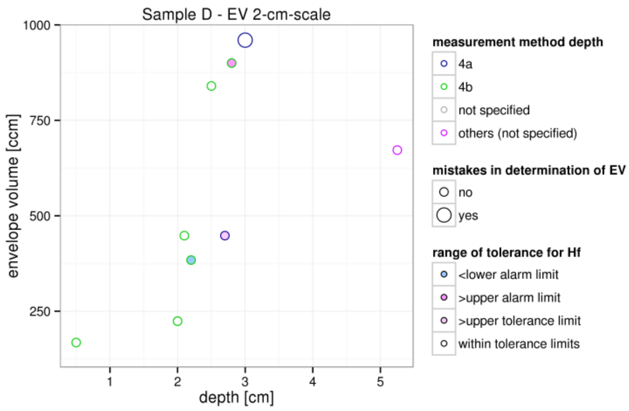
a.



b.



c.



d.

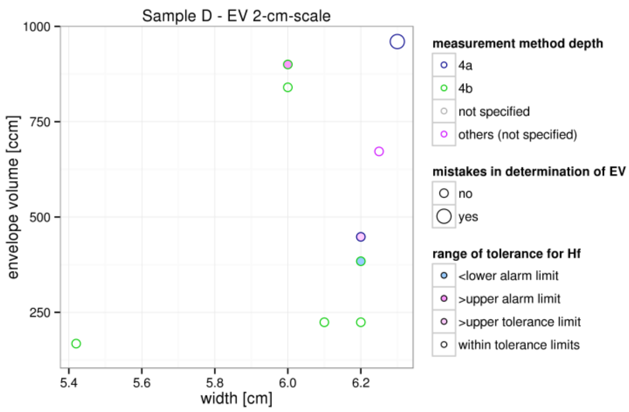


Figure 23 Results for the envelope volume determined on a 2-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample D. Categories in the legend refer to Table 13. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

a.

b.

c.

d.

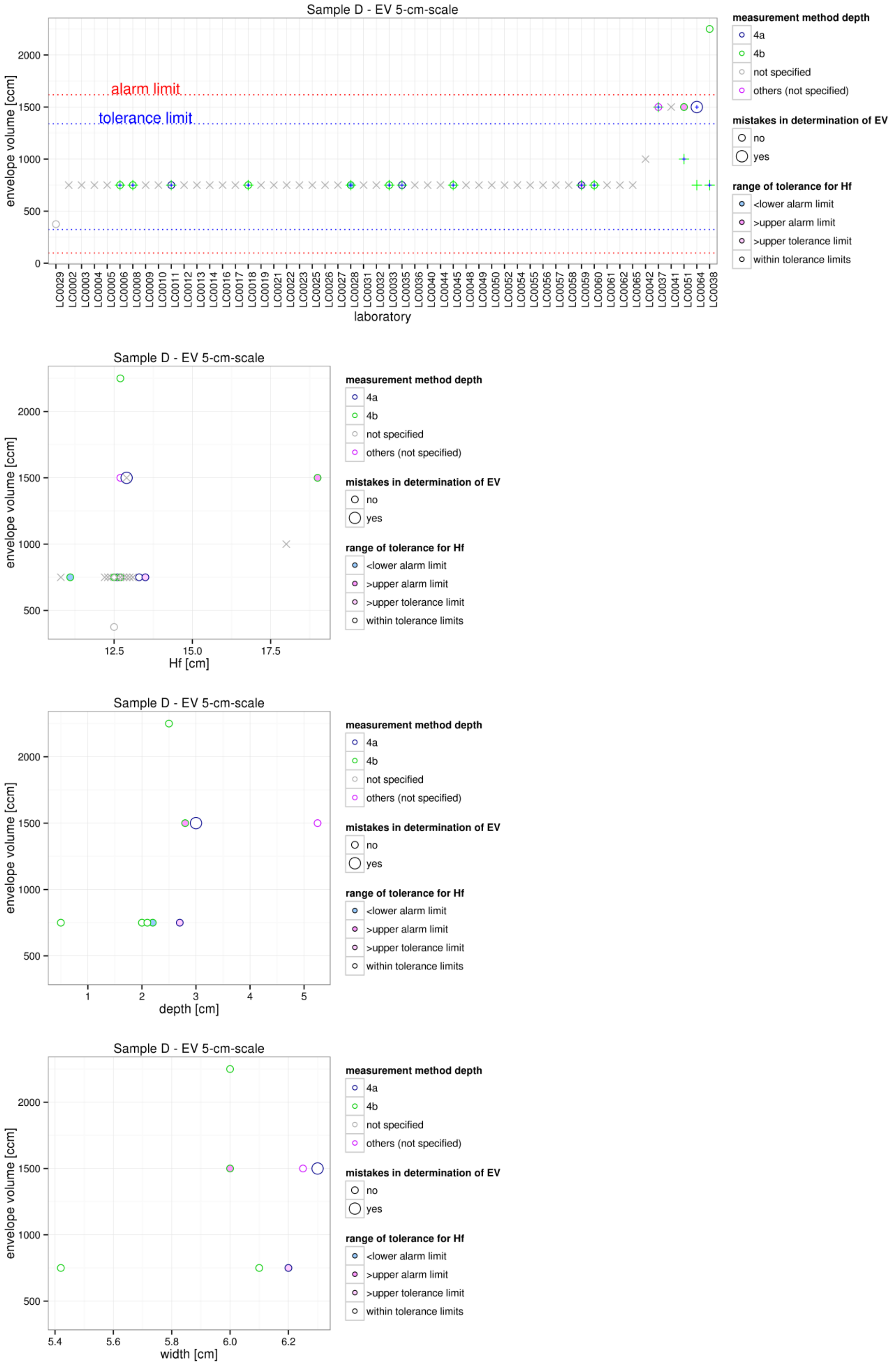


Figure 24 Results for the envelope volume determined on a 5-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample D. Categories in the legend refer to Table 13. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

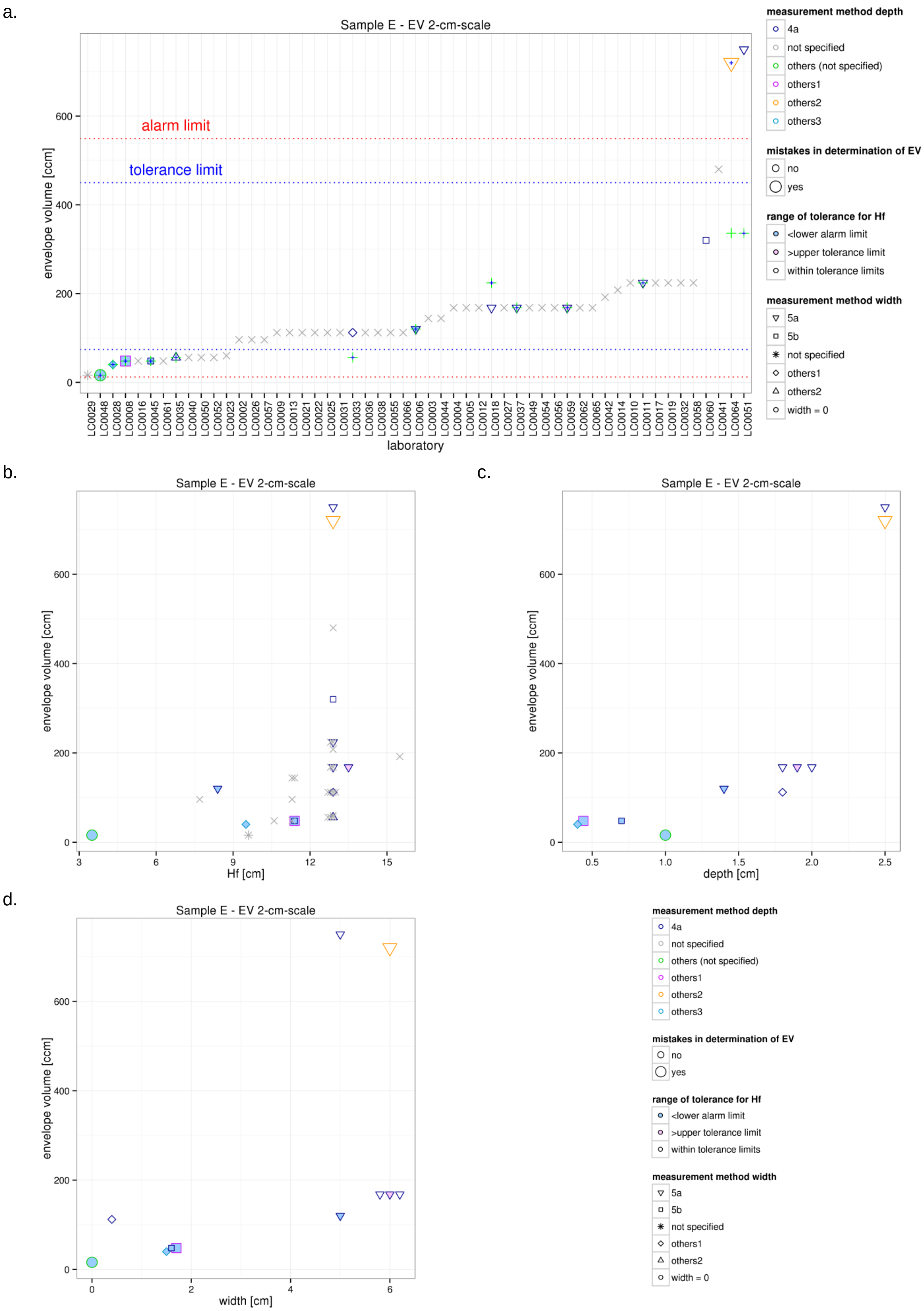


Figure 25 Results for the envelope volume determined on a 2-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample E. Categories in the legend refer to Table 14. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

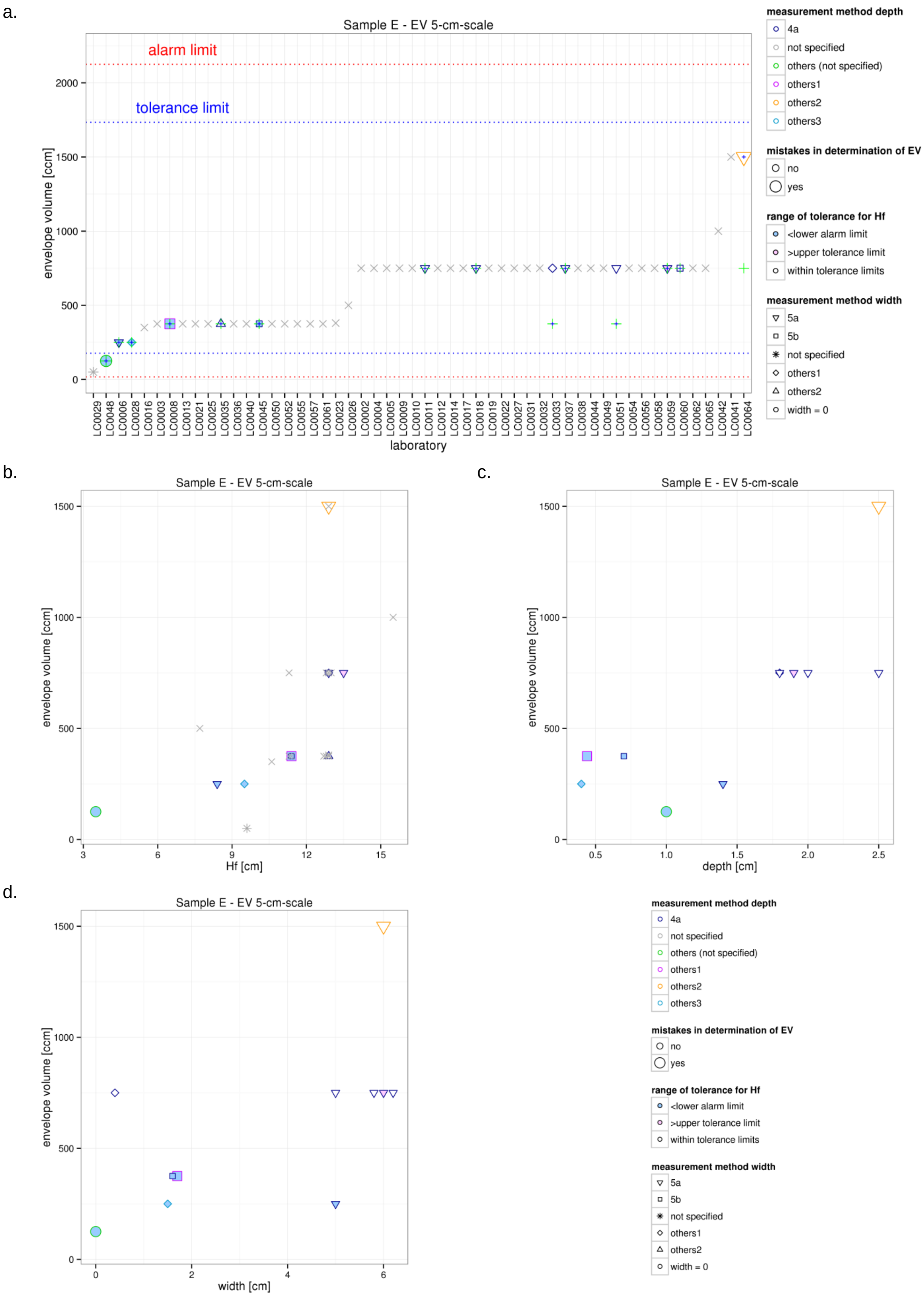


Figure 26 Results for the envelope volume determined on a 5-cm-scale (a) and their correlation to H_f (b), depth (c) and width (d) reported for sample E. Categories in the legend refer to Table 14. Tolerance limits and alarm limits refer to ILC003 2013 [1]. (+/+ envelope volume calculated by EURL-FCM from respective values for H_f (+) or z (+), depth and width (or the respective assigned values) reported by the laboratories during the study; × envelope volume reported in ILC 003 2013, no further information available)

9.6. Actual values obtained for measured sample dimensions

Table 15 Applied measurement methods and obtained values for dimensions of sample A

	measurement method				obtained values					
Lab code	H_{total}	H_n	handle	depth	H_{total} [cm]	H_n [cm]	H_{handle} [cm]	actual depth [cm]	actual width [cm]	actual height [cm]
LC0006	1a	1a	default	5b	30.6	11	10.2	0.3	5.7	13.6
LC0007	1a	1a	default		30.8	14.2	10.3			
LC0008	1a	1b = 1c	default	others2	30.8	14	10.3	0.49	5.2	20.5
LC0011	1a	1a	default	5a	31	12	10.3	2	6	14
LC0013	1a	others1	default	others1	30.6	14	10.2	14	5.73	20.4
LC0018	1a	1b = 1c	default	5a	30.5	15	20.3	4.2	5.7	20.3
LC0027	1a	1b = 1c	default	5a	30.5	14	10.2	2.9	5.7	20.3
LC0028	1a	1a	others3	others2	31	14.5	12	0.3	5.8	19
LC0029	1a	1a	default		31	12	10.3			
LC0033	1c	1b = 1c	others1	5b	31.3	12.3	16	0.3	5.7	15.3
LC0035	1b	1b = 1c	default	5a	31.1	13	10.4	2 (5)	6 (10)	14 (15)
LC0037	1c	1b = 1c	default	5b	30.8	12.5	10.27	0.6	5.7	13.7
LC0038				5b				0.3	5.3	13.7
LC0041	1a	1a	default		20.3	13.6	6.7			
LC0045	1a	1b = 1c	default	5b	30.6	13	10.2	0.4	5.7	13.6
LC0046	1a	others1	default	5a	31	14	10.33	2.25	5.7	21
LC0048	1a	1b = 1c	others (not specif.)		30.9	12.9	18			
LC0050	1a	1b = 1c	default		31	14	10.3			
LC0051	1a	1a	default	5a	30.8	13	10.3	0.6	0.56	20.53
LC0053	1a	1b = 1c	default		30.8	13.8	10.3			
LC0057	1b	1b = 1c	others2		31.2	11.8	15.8			
LC0059	1b	1b = 1c	default	5a	31.5	12	9.45	2.6	5.7	14.7
LC0060	1b	1b = 1c	default	5a	30.7	11.4	10.2	5	10	15
LC0064	1a	1b = 1c	default	5a	31	14	10.3	3	6	31
LC0065	1a	1a	default	5a	30.9	14	10.3	2.3	5.7	20.6

Table 16 Applied measurement methods and obtained values for dimensions of sample B

	measurement method				obtained values					
Lab code	H_{total}	H_n	handle	depth	H_{total} [cm]	H_n [cm]	H_{handle} [cm]	actual depth [cm]	actual width [cm]	actual height [cm]
LC0003	1b	1b	default		27.7	9.9	17.8			
LC0006	1b	1b	default	5a	27.5	7.5	9.2	2.5	5.1	12.2
LC0007	1b	1b	default		27.6	8.6	9.2			
LC0008	others1	others2	default	5b	27.6	8.9	9.2	0.5	4.5	12.3
LC0011	1b	1b	default	5a	27.7	7	9.23	4	6	14
LC0018	1b	1a	default	5b	27.7	8.1	12.3	3.5	5.1	12.3
LC0028	1b	1b	others4	5b	27.6	9	12	0.5	5.1	10.4
LC0029	1b	1b	default		27.2	10.2	9.1			
LC0033	1a	1a	others2	5b	28.3	8	17.7	0.4	5	10.6
LC0035	1a	1a	default	5a	28.5	8	9.5	2 (5)	6 (5)	14 (15)
LC0037	1b	1b	default	5a	27.5	12	9.16	2.3	5.2	12.22
LC0038				5b				0.4	5	12.3
LC0041	1b	1b	default		28.5	9	9.5			
LC0044			default		28	8.8	9.3			
LC0045	1a	1b	default	5b	27.7	9	9.2	0.4	5.1	12.3
LC0046	1b	others1	default	5a	27.7	9	9.23	2	5.1	12.8
LC0048	others3	others1	others1		27.2	8.7	18.5			
LC0051	1b	1b	default	5a	27.6	8.8	9.2	4.5	5	18.4
LC0053	1b	1b	default		27.5	9	9.2			
LC0057	1a	1a	others3		27.6	8.5	16.8			
LC0059	1a	1a	default	5a	29	8.5	8.7	2.9	5.1	13.53
LC0060	1a	1a	default	5a	27.7	7	9.2	3	5.1	12.3
LC0064	others2	1a	default	others1	28	8	9.3	4	5	28

Table 17 Applied measurement methods and obtained values for dimensions of sample C

	measurement method				obtained values					
Lab code	H_{total}	H_n	handle	depth	H_{total} [cm]	H_n [cm]	H_{handle} [cm]	actual depth [cm]	actual width [cm]	actual height [cm]
LC0003								4	7.8	12.4
LC0006	1a	1a	default	4b	28.2	8.5	9.4	2.2	6	12.5
LC0007	others1	others1	default		28.4	10.4	9.5			
LC0008	others1	1a	default	4b	28.2	10.4	9.4	0.57	5.8	12.5
LC0011	1a	1a	default	4a	28.2	9	9.4	4	6	14
LC0018	1a	1a	default	4a	28.5	9.3	12.7	3	6	12.7
LC0028	1a	1a	others3	4b	28.6	9	12	2.2	6	11.1
LC0029	1a	1a	default		28	11	9.3			
LC0033	1a	1a	others1	4b	28.7	9.2	17.4	2	6	11.3
LC0035	1b	1b	default	4a	29.5	9.9	9.8	2 (5)	8 (10)	14 (15)
LC0037	1a	1a	default	others (not specified)	28.37	10.2	9.46	4.5	6.3	12.6
LC0038				4b				2	6	13.6
LC0041	1a	1a	default	4b	28.7	10.5	9.56	1.45	4	4.65
LC0044			default		28.7	9.8	9.6			
LC0045	1a	1a	default	4b	28.3	9.7	9.4	2.1	6	12.6
LC0046	1b	1b	default	4a	29	9.5	9.7	2.8	6	12.8
LC0050	others3	others2	default		30	12	10			
LC0051	1a	1a	default	4b	28.2	9.7	9.4	6	6	18.8
LC0053	1a	1a	default		28.5	10.5	9.5			
LC0057	1b	1b	others2		28.8	10	17.6			
LC0059	1b	1a	default	4a	29	9	8.7	2.9	6	13.53
LC0060	1b	1b	default	4b	28.5	9.6	9.5	29	6	12.7
LC0064	others2	1b	default	4a	29	10.5	9.7	3	6	29

Table 18 Applied measurement methods and obtained values for dimensions of sample D

	measurement method				obtained values					
Lab code	H_{total}	H_n	handle	depth	H_{total} [cm]	H_n [cm]	H_{handle} [cm]	actual depth [cm]	actual width [cm]	actual height [cm]
LC0006	1b	1b	default	4b	28.5	9	9.5	2	6.1	12.7
LC0007	others2	others1	default		28.6	9.6	9.5			
LC0008	others2	others2	default	4b	28.6	12	9.5	0.5	5.42	12.7
LC0011	1b	1b	default	4a	28.4	9	9.46	2	8	14
LC0018	1b	1b	default	4b	28.5	10.2	12.7	2	6.2	12.7
LC0020	1b	1b	default		29	11	9.67			
LC0028	1b	1b	others3	4b	28.7	9.7	12	2.2	6.2	11.1
LC0029	1b	1b	default		28.2	12.5	9.4			
LC0033	1b	1b	others1	4b	29	10.1	16.5	2	6.1	12.5
LC0035	1a	1a	default	4a	29.5	9.6	9.8	2 (5)	8 (10)	14 (15)
LC0037	1b	1b	default	others (not specified)	28.5	9.5	9.5	5.25	6.25	12.68
LC0038				4b				2.5	6	12.7
LC0041	1b	1b	default		29	11.4	9.7			
LC0044			default		28.7	10.3	9.6			
LC0045	1b	1b	default	4b	28.6	10	9.5	2.1	6.2	12.7
LC0046	1a	others2	default	4a	29	12	9.7	2.2	6.2	12.8
LC0051	1b	1b	default	4b	28.5	9.7	9.5	2.8	6	19
LC0053	1b	1b	default		28.5	11.9	9.5			
LC0057	1a	1b	others2		29	10.8	16.8			
LC0059	1a	1b	default	4a	29	9.5	8.7	2.7	6.2	13.53
LC0060	1b	1b	default	4b	28.5	9.6	9.5	4	8	14
LC0064	others1	1b	default	4a	29	12	9.7	3	6.3	29

Table 19 Applied measurement methods and obtained values for dimensions of sample E

	measurement method					obtained values					
Lab code	H_{total}	H_n	handle	depth	width	H_{total} [cm]	H_n [cm]	H_{handle} [cm]	actual depth [cm]	actual width [cm]	actual height [cm]
LC0003	1c	1c	others1			29	3.3	11.9			
LC0006	others1	1a	default	4a	5a	24	3.3	8	1.4	5	8.4
LC0007	1a	1a	others2			29.1	7	11.8			
LC0008	1a	1b	others1	others1	5b	28.9	3.3	11.8	0.44	1.7	11.4
LC0011	1a	1a	default	4a	5a	29.1	3.3	9.7	2	8	14
LC0016	1a	1a	default			29	3.5	9.6			
LC0018	1a	1c	default	4a	5a	28.5	10.2	12.7	2	6.2	12.7
LC0028	1c	1b	others5	others3	others1	29.3	3.5	15	0.4	1.5	9.5
LC0029	1b	1b	others4			28.7	9.6	19.1			
LC0033	1b	others1	default	4a	others1	29	6	9.7	1.8	0.4	12.9
LC0035	1c	1b	default	4a	others2	29.1	3.4	9.7	2 (5)	2 (5)	14 (15)
LC0037	1a	1a	default	4a	5a	29	12	9.67	1.8	5.8	12.89
LC0041	1a	1a	default			29	2.3	9.7			
LC0044			default			29.2	3.2	9.7			
LC0045	1a	1a	others1	4a	5b	28.9	3.3	11.8	0.7	1.6	11.4
LC0046	1b	1b	default	4a	5b	29	3.2	9.7	1.78	2	16.1
LC0048	1b	1c	others3	others (not specif.)	width = 0	29	3.3	23.8	1	0	3.5
LC0051	1b	1b	default	4a	5a	28.9	3.3	9.63	2.5	5	12.85
LC0053	1b	1b	default			29	3.2	9.7			
LC0057	1c	1b	others1			29	3.4	12			
LC0059	1c	1c	default	4a	5a	29	3.5	8.7	1.9	6	13.53
LC0060	1b	1b	default	4a	5b	29	3.6	9.7	15	5	10
LC0064	1a	1a	default	others2	5a	29	3	9.7	2.5	6	29
LC0003	1c	1c	others1			29	3.3	11.9			
LC0006	others1	1a	default	4a	5a	24	3.3	8	1.4	5	8.4

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