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Recommendations for the Quality Assessment of the Cleaning Performance of Dishwasher Detergents (Part B, Update 2015)

German Cosmetic, Toiletry, Perfumery and Detergent Association (IKW)

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Instructions for Preparation – Test Soil Types – Test Procedures

German Cosmetic, Toiletry, Perfumery and Detergent Association (IKW) – Working Group Automatic Dishwashing Detergents*

abstract

Recommendations for determining the cleaning profile of cleaning products were first published in 1995. The goal of the Working Group was to find suitable soil types from practice. For this purpose, a working group of automatic dishwashing experts was set up inside the German Cosmetic, Toiletry, Perfumery and Detergent Association (IKW). Furthermore, representatives from reputable European test institutes and delegates from dishwasher manufacturers joined the Working Group. The WG updated the Recommendations in 2005. Since 2013 the WG has been working on another update. Following a round robin test, a dishwasher is recommended for comparative testing – as well as new or modified soil types. Testing no longer includes minced meat in glass dishes, egg/milk and oat flakes; new soil types to be tested are pasta and crème brûlée and optionally milk skin as an alternative to milk in a microwave oven. Egg yolk, starch mix and minced meat on porcelain plates have been modified.

1. General Preliminary Remarks

1.1 Selection of the Soil Types

The soil types are divided in the following soil classes: see **Tab. 1**. Corresponding to the composition of dishwashing detergents of bleach, alkali and various enzymes, at least one soil from each of the four soil classes (bleachable, persistent/alkaline-sensitive, starch-containing amylase-sensitive and protein-containing protease-sensitive) is to be used in testing. If only four soils are tested, these should be black tea, starch mix, egg yolk and milk.

The starch-containing soils stand for potatoes, noodles, rice or comparable foodstuffs. The protein-containing soils stand for eggs, dairy products or meat.

Assigning the soil types to the classes is not always straightforward. For example, in the removal of crème brûlée an amylase influence can be seen and in the removal of pasta and milk skin a protease influence. In the cleaning of the minced meat plates, the alkalinity of the detergent has a role too.

No tap water should be used in the production of the individual soils. This should be done with synthetic water, with hardness to be raised to 3.00 mmol (Ca+Mg) = 16.8°d conforming to DIN/EN 60734: 2012, method B – salt mixing technique (**Box 1**).

Soil classes and soil types			
Bleachable	**Persistent/ alkaline-sensitive**	**Starch-containing, amylase-sensitive**	**Protein-containing, protease-sensitive**
Black tea	Milk	Starch mix	Egg yolk
	Milk skin (optionally, as an alternative to milk in the microwave oven)	Pasta	Crème brûlée
			Minced meat

Tab. 1 Soil classes

1.2 Thorough Cleaning of the Tableware Items

Tableware items are cleaned thoroughly in a laboratory dishwasher connected to demineralised water, at 93°C with a special, high-alkaline/active-chlorine containing detergent (solid/liquid) for commercial dishwashing (e.g. "Perclin", Ecolab). Furthermore, an acid for neutralisation is added in the last wash cycle (e.g. citric acid).

Newly used tableware items need to undergo thorough cleaning three times before their first use in testing.

Tableware items used previously for testing need to undergo thorough cleaning once before the application of the various soils can start. Given the persistence of some soils, this is necessary in particular because residues from earlier tests might have remained on the tableware items. Tableware items should be inspected regularly for surface changes and rejected if

necessary. It is advisable to separate each plate with a clean paper towel to avoid mechanical damage.

1.3 Storage and Weighing

Storage of the soils and weighing should take place in controlled climate conditions at 20°C – 25 °C /40 – 60 % relative humidity as weighing errors might occur, particularly with gravimetric soil types due to varying levels of water content on the surface of the tableware items.
Storage life under the above conditions is at least 14 days.

1.4 Preparation of the detergent samples

The detergent samples to be tested should be as representative as possible of the formulation under examination. Where applicable, samples should be taken from several different batches. Before sampling, powder detergents for cleaning tests are passed through a sample divider.

1.5 Selection of the dishwasher

When the work on the publishing of methods for the testing of the cleaning performance of dishwasher detergents started in 1995, the rapid development for dishwashing machines – especially after the introduction of the energy label in 1995 – was not foreseeable.

Hardening the Water

1) Preparation of the Stock Solutions
- Solution 1: 800 mmol/l $NaHCO_3$ (67.2 g/l)
- Solution 2: 154.2 mmol/l $MgSO_4 \cdot 7\ H_2O$ (38.0 g/l)
- Solution 3: 446.1 mmol/l $CaCl_2 \cdot 2\ H_2O$ (65.6 g/l)

2) Preparation of Synthetic Water with 3.00 mmol Ca + Mg (16.8 °d)
Put 50 ml of each of the stock solutions 1, 2 and 3 in a vessel with 7 l of demineralised water according to DIN EN 60734: 2012, method B and fill with additional demineralised water up to 10 l. Before using the synthetic water, adjust its pH value to 7.5 with HCl or NaOH.

Box 1 Production instructions for synthetic water

Meanwhile, comparative testing has become difficult in domestic machines of standard market quality, because programmes are more and more controlled automatically.
In order to optimise, on the one hand, the consumption of water and energy and, on the other hand, the performance of the dishwasher, there are variations not only in automatic programmes but possibly also in other programmes (e.g. number of water changes, quantity of water intake, quantity of pumped off water, reuse of stored water, temperature control or other parameters). Therefore, even a precise knowledge of the individual machines cannot guarantee a comparable course of the respective programs.
In principle, the proposed methods can be applied in any dishwasher. Wishing to avoid that non-identified machine parameters influence comparative testing, the WG decided to recommend for such testing a special dishwasher that cannot be influenced by automatic control.
Suitable dishwashers are e.g. Miele GSL and Miele G 1223 SC GSL 2 (**Tab. 2**, cp. **Annex 2**).

Pre-wash	Cleaning temperature [°C]	Holding time after reaching the cleaning temperature [min]	Rinse temperature [°C]	Example of
No	40	8/20/55	55	Low-temperature programmes
No	45	3/8/55	55	Standard test programme
No	50	3/8/55	55	Normal programme
No	50	3/8/55	65	Normal programme
Yes	50	3/8/55	65	Normal programme
No	65	10/30/55	65	Intensive programme

Tab. 2 Programmes of Miele G 1223 SC GSL 2. The dishwasher offers the above mentioned programmes. Holding times can be selected at three levels in the main wash.

Prewash	Cleaning temperature [°C]	Holding time after reaching the cleaning temperature [min]	Rinse cycle temperature [°C]
No	45	8	55

Tab. 3 Parameters of the standard test programme

1.6 Test Implementation / Test Conditions

The following parameters were chosen for the comparative tests:

Standard Test Programme (cp. **Tab. 3**)
Miele GSL or Miele GSL 2:
No prewash
Temperature in main wash cycle: 45 °C
Holding time after reaching the main wash temperature: 8 minutes
Temperature in rinse cycle: 55 °C

Number of Wash Cycles
At least 3 tests are to be carried out.
When conducting a series of tests in the same machine, it is essential to ensure that the temperature profiles are identical. If an appliance with a heat exchanger is used instead of the Miele GSL 2, for example, several prewashes should be conducted so that the temperature is comparable at the start of each wash cycle.

Water Hardness
8–10 °d (1.4–1.8 mmol/l Ca + Mg) in the wash cycle for standard products and products with integrated rinse aid – as far as the highest water hardness stated on the sales packaging of multi-purpose products (usually 21 °d).

Water Temperature
A typical incoming water temperature is 15 °C or 20 °C. It must be ensured that the incoming water temperature is the same for comparative tests.

Detergent Dosage
The detergent dosage is as recommended by the manufacturer. If no dosage guidelines are given, the following dosages are recommended: classic high-alkaline detergents of type IEC A, 30 g and compact detergents of type IEC B or D, 20 g or 1 tab or one pouch.

Adding the Detergent
The detergent must be added by hand at the time when the dosage chamber opens, which can be noticed by an audible click. The Miele GSL 2 needs to be set "mit Dosierung" (with dosage).

Number of Soiled Items
6 of each type.

Additional Soil Burden
50 g of frozen ballast soil, added at the same time with the detergent.
The frozen ballast soil consists of foodstuffs (see **Tab. 4**), especially food containing starch, protein and fat. It also contains colourings, e.g. ketchup and mustard. This additional soil is intended to simulate the presence of easily removable food residues, providing an additional load for the cleaning solution. It is not necessary to adapt the quantity of ballast soil even if fewer tableware items are cleaned.

Use of Rinse Aid
It is left to the test laboratories' discretion whether to use a rinse aid with standard products. When using multi-purpose products with rinse aid function, no additional rinse aid must be applied. Note: If rinse aid is present in the Miele GSL 2 and the function "mit Dosierung"

Constituents	Raw material	% content	kg for 25 kg
Fat	Vegetable oil (e.g. Aro, Metro)	31.6	7.9
	Margarine (e.g. Homann, Allgäu-Margarine)	6.3	1.575
	Lard (e.g. Laru, Lagensiepen & Ruckebier)	6.3	1.575
	Deep-frying fat (e.g. Aro, Metro, semi-liquid)	6.3	1.575
Protein	Whole egg (e.g. Wiesenhof)	15.8	3.95
	Cream (e.g. Debic, UHT cream, 32 % fat)	9.4	2.35
	Whole milk, pasteurized, 3.5 % fat	6.3	1.575
Other powdered solid	Potato starch (e.g. Superior LXJ 72, Emsland)	2.2	0.55
	Gravy (e.g. Knorr)	1.7	0.425
	Wheat flour (e.g. Diamant-Mehl, type 405)	0.6	0.15
	Quark powder (e.g. Dr. Otto Suwelack, Billerbeck)	0.6	0.15
	Benzoic acid > 99.9 % (chemical supplier)	0.3	0.075
Other	Tomato ketchup (e.g. Kühne)	6.3	1.575
	Mustard (e.g. Löwensenf "Extrascharf")	6.3	1.575
Total amount		**100.00**	**25.00 kg**

1. Combine vegetable oil and whole egg and mix thoroughly (approx. 30 minutes).
2. Add ketchup and mustard, still stirring vigorously.
3. Melt the fats, allow to cool to approx. 40 °C, then add to the mixture and blend in well.
4. Stir in cream and milk.
5. Add the powdered solid constituents and mix everything to a smooth paste.
6. Finally, put 50 g of the soil mix into each plastic beaker (diameter 5 cm). Deep freeze them and keep them in the freezer until required.

Tab. 4 Production instructions for ballast soil

(with dosage) has been set, then the rinse aid is added. Therefore, it is recommended not to fill rinse aid in the reservoir but, if necessary, to add rinse aid with a pipette – in the clean rinse cycle when reaching 35 °C.

Machine Loading
For loading plan, see **Fig. 1** on the example of the Miele GSL 2. When using other test machines, loading should be as analogous as possible (**Fig. 2**).

Cleaning of the Filter System
After every rinse cycle.

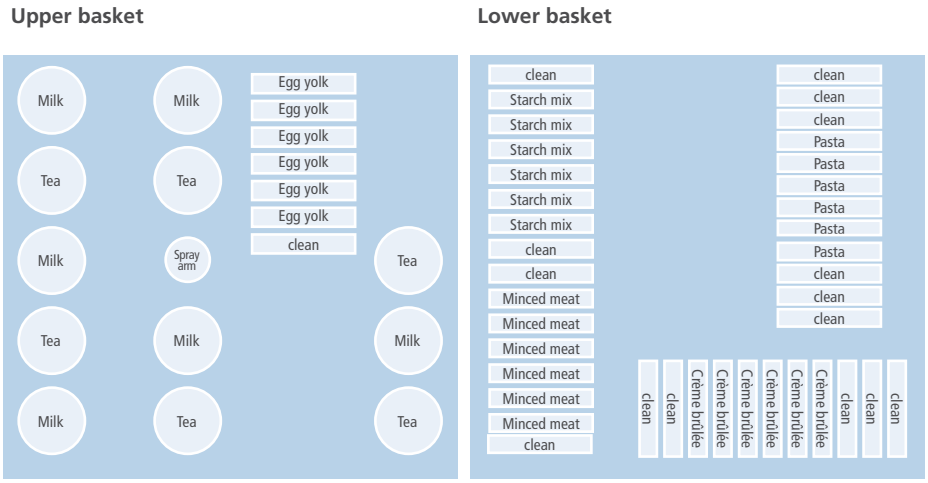

Fig. 1 Loading plan on the example of the Miele GSL 2

2. Black Tea

2.1 Apparatus

- Tea cups: The sides of the cups should be 6–8 mm thick (e.g. company Baucher, article no. 6215/18 or company Firma Schönwald (colour: white; form: 98L/0.19)
- Pipettes 100 ml, 20 ml or automatic metering pump
- Strainer, mesh width 0.5 mm
- Container for boiling/pouring out the tea
- Eppendorff pipette (0.1 ml)

2.2 Raw Materials

- Black tea, namely Assam (e.g. company Teekanne or other companies)
- Synthetic water (3.00 mmol Ca+Mg as per **Box 1**)
- Ferric sulphate stock solution

2.3 Pre-treatment of Cups

The cups to be soiled must be clean and grease-free. To this end, they undergo thorough cleaning in a laboratory dishwasher at 93 °C with a high-alkaline commercial detergent (cp. 1.2).

2.4 Preparation of the Tea (for ca. 20 Cups)

Mix 2 litres of synthetic water with 0.1 ml of the ferric sulphate stock solution and bring it to the boil. Pour boiling water on 30 g of tea in an open container and leave it to brew for 5 minutes. Then pour the tea through a strainer into another temperature-controlled vessel.

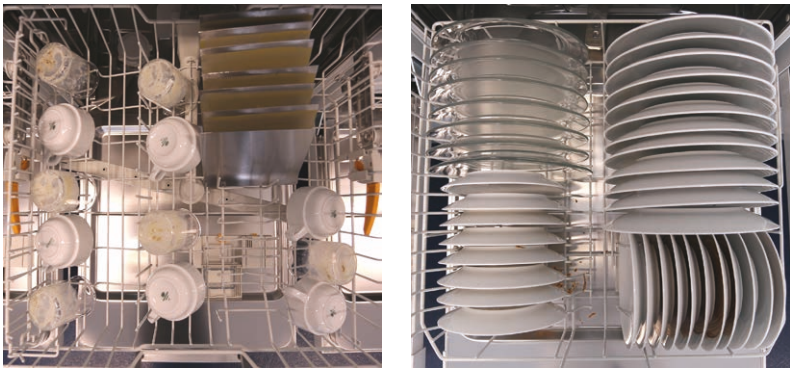

Fig. 2 Loading plan of a dishwasher

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2.5 Soiling of the Cups

The clean cups are filled with 100 ml of tea such that the temperature of the tea in the cups is 85 °C. The initial temperature of the poured tea is about 93 °C. Remove 20 ml of tea every 5 minutes with a pipette until all the cups are empty (5 times). This process is then repeated once more with freshly brewed tea.

Ferric sulphate stock solution (only for black tea)

In a 1-litre graduated measuring flask, dissolve 5g $Fe_2(SO_4)_3$ + 1 ml HCl (37 %) in demineralised water and fill with demineralised water up to 1 l.

In the handling of iron(III) sulphate solution the rules for the handling of dangerous substances must be followed.

Box 2 Production instructions for ferric sulphate stock solution

2.6 Evaluation

Visual with reference to the photographic catalogue (**Fig. 3**).

2.7 Important Remarks

- Initial temperature in the cup is 85 °C (temperature of the tea when poured is about 93 °C).
- The thickness of the tea cups determines the tea cooling rate.
- Assam tea is particularly difficult to remove.
- When drawing off the tea, make sure that the tip of the suction device penetrates the skin of the tea before starting to draw off the tea.
- Before washing, the soiled cups are stored for at least 3 days in a room with controlled climate conditions.
- It was evident that the tea cups were not sufficiently darkly stained when using synthetic water the hardness of which had only been supplemented with Ca and Mg ions. Therefore, ferric ions are added to the synthetic water to obtain tea soiling of a darker colour.
- Production of the ferric stock solution: see **Box 2**.

Fig. 3 Photo catalogue for visual evaluation: Black tea

3. Milk Skin (Optionally as an Alternative to Milk in the Microwave Oven)

3.1 Apparatus

- Microwave oven with a glass rotating plate, at least 750 W output (e.g. Bosch or Miele), without overload cut-out, glass beakers 250 ml, high form (ø 60 mm, height: 120 mm)
- Dispenser
- Thermal cabinet (recirculating air)

3.2 Raw Materials

- UHT milk, e.g. from Weihenstephan (3.5 % fat, ultra-heat treated, homogenised)
- The milk quality/brand influences the removability of the soil. If no difference can be observed between several dishwasher detergents, another milk quality/brand should be chosen.

3.3.1 Preheating Conditions

The preheating conditions are determined in a pretest. First of all, the microwave oven is preheated. For this purpose, arrange six beakers containing 100 ml water symmetrically around the edge of the rotating plate and heat them at output level 600 W for 6.5 minutes (alternative: output level 750 W for 5.3 minutes).

Then six beakers with 100 ml water are heated in the same way from room temperature at output level 600 W for 6.5 minutes (alternative: output level 750 W for 5.3 minutes). Now the water temperature should be 88 °C ± 2 °C. Depending on the degree of deviation in the water temperature, the preheating time needs to be adapted accordingly, either by means of an independent time switch or, in case of microwave ovens which can be set precisely to the second in the 10 minute range, directly by way of the owner's own temperature setting. As soon as the temperature of 88 °C ± 2 °C is reached in this procedure, the exact preheating time (in seconds) is noted down. This figure should be marked on the microwave oven (together with its validity period) and checked in three month intervals.

3.3.2 Preparation

The beakers to be soiled must be clean and grease-free. For this purpose, they are cleaned thoroughly in a laboratory dishwasher at 93 °C with a high-alkaline commercial detergent (cp. 1.2). To preheat the microwave oven, place 6 beakers with 100 ml water symmetrically around the edge of the rotating plate and heat them in the preheating conditions as determined in the pretest (see above).

Next, pour 100 ml of milk at room temperature in each of the six beakers and arrange them in the same pattern as before the beakers with water and heat them in the manner described above. It is important to exactly observe the preheating time, in order to ensure a reproducibility of results. After heating to 88 °C ± 2 °C, wait for the beakers filled with hot milk to cool down to 30 °C – 35 °C. Then pour off the milk carefully below the milk skin. It can be advantageous to detach in some places the milk skin from the glass wall of the beaker, using a spatula. After pouring off, the milk skin should settle as a whole on the glass wall.

Glasses without impeccable skin formation should be rejected. Glasses from which the milk was poured off are let to dry overnight. Then the milk soil is post-treated for 2 hours at 80 °C in the thermal cabinet (recirculating air).

3.4 Evaluation

Visual with reference to the photographic catalogue (**Fig. 4**).

3.5 Important Remarks

- Microwave oven without safety cut-out
- Adhere precisely to the specified heating time
- Glasses with milk skin soiling always need to be placed in the dishwasher facing the same direction

4. Milk in the Microwave Oven

4.1 Apparatus

- Microwave oven with a glass rotating plate, at least 750 W output (e.g. Bosch or Miele), without overload cut-out, calibrated
- 150 ml small beakers (ø 60 mm, height: 80 mm) (Caution: pictures in the photographic catalogue show 250 ml/tall form)
- Dispenser (e.g. serial dispenser Fortuna Optifix Basic 10 ml, company Graf, Wertheim)
- Thermal cabinet (recirculating air)

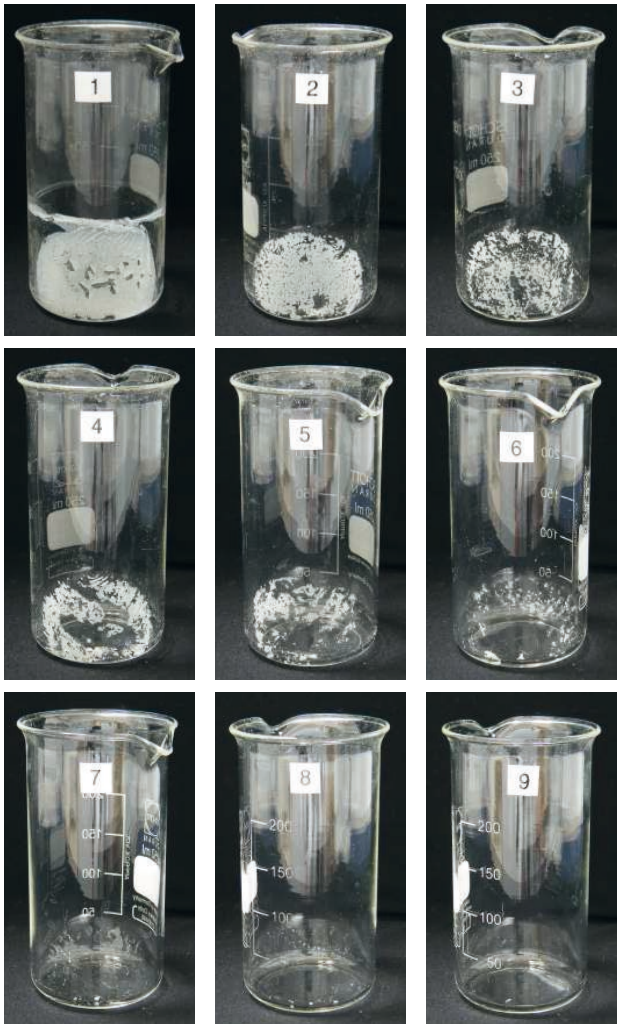

Fig. 4 Photo catalogue for visual evaluation: Milk skin

4.2 Raw Materials

• Low-fat UHT milk (1.5 % fat, ultra-heat treated, homogenised)

4.3 Preparation

The beakers to be soiled must be clean and grease-free. For this purpose, they are cleaned thoroughly in a laboratory dishwasher at 93 °C with a high-alkaline commercial detergent (cp. 1.2).
Set the microwave to an output of 450 W (see calibration instructions in **Box 3**).
To preheat the microwave, arrange six beakers containing 50 ml water symmetrically around the edge of the rotating plate and heat them for 10 minutes. Then pour 10 ml of milk at room temperature in each of the six beakers and arrange them in the same pattern as before the water glasses on the rotating plate and heat them in the manner described below.
It is important to exactly observe the baking time, in order to ensure a reproducibility of results.
After baking, the milk soil is post-treated for 2 hours at 80 °C in the thermal cabinet (recirculating air).

4.4 Baking Times

The baking time is 10 minutes at 450 W output.
Since the actual output of microwave ovens may deviate from the setting, it should be checked every three months (conforming to **Box 3**). Depending on the degree of deviation, the baking time should be adapted either with an independent time switch or, in case of microwave ovens which can be set precisely to the second in the 10 minute range, directly by way of the owner's own time setting.
The exact baking time (in seconds) should be marked on the microwave together with its period of validity.

Instructions for Checking the Actual Microwave Output

Fill a cylindrical vessel made of borosilicate (glass beaker, external diameter 100 mm, max. glass thickness 3 mm) with 1000 g ± 5 g drinking water.
The initial temperature of the water should be 10 °C ± 0.1 °C. Measure the temperature directly before placing the glass beaker in the microwave (using a calibrated thermometer). Place the glass beaker in the centre of the rotating plate and set the microwave to maximum output.
Now conduct several tests (using a calibrated stop watch) to determine the time it takes for water at a temperature of 10 °C ± 0.1 °C to be heated by 10 °C ± 0.1 °C.
After each test, allow the microwave to cool for at least half an hour. The test should be repeated at least once.
Measure the final temperature of the water after mixing it thoroughly.
The following equation is used to calculate the effective output of the microwave:

$$P_{eff} = \frac{4187 \cdot (T_2 - T_1)}{(t - 1.6\ s)}$$

P_{eff} = Effective output of the microwave in W
T_2 = Final temperature in °C
T_1 = Initial temperature (10 °C)
t = Time switched on in seconds (s)
4187 = Specific heat capacity of the water in $J \cdot kg^{-1} \cdot K^{-1}$

Deduct 1.6 seconds from the time switched on as the magnetron in the microwave takes this amount of time to preheat.
The correction factor is calculated from the ratio nominal output/calculated effective output (P_{set}/P_{eff})
Extend or shorten the baking times by this factor. A time switch is recommended for this.

Box 3 Calibration instructions for microwave oven

4.5 Evaluation

Visual with reference to the photographic catalogue (**Fig. 5**).

4.6 Important Remarks

- Microwave without safety cut-out
- Adhere to the second to the specific heating time
- Regular calibration of the microwave

5. Starch Mix

5.1 Apparatus

- Water bath (e.g. IKA TS 2)
- Glass beaker (depending on the quantity of the mixed starch)
- Glass beaker for weighing the starch
- Electrical laboratory stirrer + blade-type agitators
- Dispenser (e.g. serial dispenser Fortuna Optifix, company Graf/Wertheim)
- Glass plate, arcoroc®, "Octime" series, Cristallerie d'Arques, black, octagonal, ø 25 cm (from edge to edge), inner surface area 270 cm^2, individually numbered or arcorc® Cosmos flat 23 cm, no. 10980
- or duralex® "Lys" series, dinner plate, no. 3010A F06, transparent, round, ø 23.5 cm, inner surface 177 cm^2, individually numbered
- Rack for storing and pre-drying the soiled plates horizontally
- Thermal cabinet (recirculating air), e.g. companies Fa. Memmert or Fa. Binder
- Balance, weighing range up to 1200 g, weighing accuracy 1 mg

5.2 Raw Materials

The following types of starch are required:

- Potato starch: e.g. Superior from Emsland GmbH
- Maize starch: e.g. Standard from Roquette GmbH
- Rice starch: e.g. Remy DR from Beneo GmbH
- Wheat starch: e.g. SP from Roquette GmbH
- Synthetic water as defined in **Box 1**

Fig. 5 Photo catalogue for visual evaluation: Milk in the microwave

5.3 Preparation

The glass plates to be soiled must be clean and grease-free. To this end, they undergo thorough cleaning in a laboratory dishwasher at 93 °C with a high-alkaline commercial detergent (cp. 1.2).
Make an adequate quantity of 3.25 % starch suspension (0.8125 % of each type of starch), depending on the number of plates to be soiled. The application quantity might be increased. A careful formation of the starch film needs to be ensured (no peeling or flaking off).

Example for a 1000 g batch:
Weigh 967.5 g of cold synthetic water (as defined in **Box 1**) into a 2-litre glass beaker (deep version). Place the glass beaker in the water bath (which is still switched off) and position the stirrer as close as possible to the base.
Then weigh 8.125 g of each of the four starch types (total weight 32.5 g) and pour into the second glass beaker.
Stirring continuously, transfer the starch mixture quantitatively into the beaker of cold water.
Cover the glass beaker containing the starch mixture (e.g. with aluminium foil) and place in a simmering water bath, stirring continuously, until a temperature of 95 °C is reached. Continue stirring at this temperature for a further 30 minutes. Then remove the beaker glass from the water bath and, still stirring continuously, allow it to cool to ca. 35 °C. If necessary, add an appropriate quantity of water to compensate for any water evaporation loss through the stirring in the beaker glass (reweigh to check).
The starch should be stirred continuously but slowly, so that no sediment can form. It should not be stirred too vigorously, so that the suspension remains free of bubbles and the dispenser does not take any air in.

5.4 Starch Application / Weighing

After thorough washing, leave the plates to stand for at least 24 hours. Weigh the plates accurately to 1 mg. The scale should be placed in a cabinet with a door to protect it from air movements.
All of the following calculations refer to a plate surface of 177 cm^2.
Now set the dispenser so that

20.4 g ± 0.1 g

of the suspension is metered (this is a guide value; every laboratory needs to determine its exact setting experimentally beforehand, depending on its technical facilities).
Using the dispenser, measure the exact quantity of suspension onto the plates and distribute it evenly by swilling it over the inner surface.
Now place the plates with the starch solution on a suitable rack with horizontal shelves and leave them there until they are visually dry – at least for 48 hours. Here, it is important to have good drying conditions, e.g. by using a ventilator or a thermal cabinet (recirculating air).
Then, stack the plates in plate racks and continue drying for 4 hours at 80 °C in the thermal cabinet (recirculating air). If the applied amount is increased ensure that the starch film does not peel off.
After drying, leave the plates to cool for at least 1 hour. Then weigh them. The layer of starch on the plates is to weigh

between 619 mg and 708 mg (3.75 mg/cm^2 ± 0.25 mg/cm^2)

The target value is 664 mg per plate. Deviating plates cannot be used.
After the cleaning test, place the plates in the thermal cabinet (recirculating air) to dry at 80 °C for at least 1 hour. After cooling, weigh within 30 minutes.

5.5 Evaluation

$$\text{\% cleaning performance} = \frac{\text{mg starch released} \cdot 100}{\text{mg starch applied (dry)}}$$

5.6 Important Remarks

- The quantity dispensed must always be checked before the soiling process. The above-mentioned balance should be used to check the quantity dispensed. Make sure that the balance is always plumb to prevent weighing errors.
- It is advisable to calibrate the balance once a day with a suitable calibrating weight (obtained from the balance manufacturer), particularly if individual weighing is carried out on different days.
- Use a case to protect the balance from draughts.
- If the amount of space available dictates that the plates need to be stacked on top of each other, a clean paper towel should be laid between each plate.
- Gloves always to be worn when touching the glass plates, in order to avoid impurities.
- Before applying the starch solution, the plates must be free of surface-active soil, as otherwise the plate surface will not be wetted.
- Aluminium foil can be used to prevent evaporation losses, particularly during the boiling process.
- Do not use plates with irregular bases.

- Glass plates can attract static charge, particularly in conditions of low humidity, and this can lead to weighing errors. This can be prevented by briefly placing the glass plates on an anti-static surface prior to weighing.

- It must be ensured that the starch film does not peel off or tears open; otherwise the plates cannot be used.

6. Pasta

6.1 Apparatus

- Stainless steel saucepan
- Metal strainer
- Kitchen hand blender, e.g. Braun 600 W
- 3-litre plastic measuring cylinder
- Stop watch
- Dinner plates (company Arzberg, white, glazed porcelain) conforming with standard EN 50242, form 2000, no. 10225, ø 25 cm
- Thermal cabinet (recirculating air) 120 °C
- Silicon brush (width ca. 4 cm; bristle length ca. 1.5 cm; e.g. Brabantia)

6.2 Raw Materials

- 1 litre synthetic water as defined in **Box 1**
- 80 g spaghetti "Barilla" n. 5
- 200 ml fully demineralised water

6.3 Preparation

The dinner plates to be soiled must be clean and grease-free. To this end, they undergo thorough cleaning in a laboratory dishwasher at 93 °C with a high-alkaline commercial detergent (cp. 1.2).
Bring to the boil 1 litre of water in a large saucepan. Take 80 g spaghetti, break them through in the middle and put them in the boiling water; boil for 8 minutes (stop watch). After boiling, drain the noodles in a metal strainer and let them cool at room temperature (do not rinse with water).
Mix with the kitchen hand blender in a plastic measuring cylinder 150 g of the boiled spaghetti and 200 ml demineralised water (through up-and-down movements of the blender).
Using a short silicon brush, apply 3.0 g ± 0.1 g of the spaghetti mass onto the plates. Observe a distance of 2 cm to the edge of the plates.
The plates can be placed immediately in the non-preheated thermal cabinet. The drying time starts only after the drying temperature has been reached.
Drying for 2 hours at 120 °C.
After drying, stake the plates on top of each other and place them on the rack for cooling.

6.4 Evaluation

Evaluation by visual inspection of the pasta residues with reference to the photographic catalogue (**Fig. 6**).
For better identification of the residues of the pasta soiling, the plates are treated with an iodine solution.

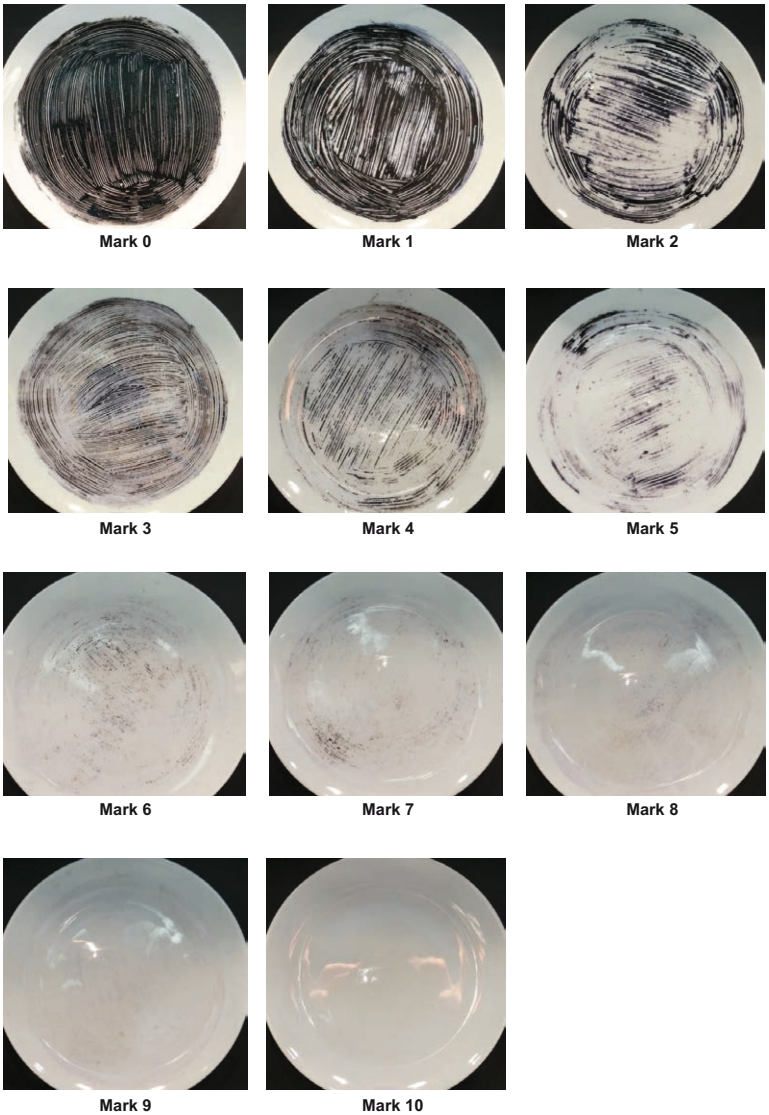

Fig. 6 Photo catalogue for visual evaluation: Pasta

6.5 Important Remarks

- The spaghetti used must be made of durum wheat semolina. Spaghetti products containing egg are unsuitable.
- In the handling of the iodine solution the rules for the handling of dangerous substances must be followed.

7. Egg Yolk

7.1 Apparatus

- Stainless steel sheets (brushed on one side), 10 cm x 15 cm
- Flat brush (pure Chinese hog bristles), 2 ½"
- Glass beaker
- If necessary, device for manually separating egg yolk from egg white
- Fork
- Kitchen strainer (approx. 0.5 mm mesh)
- If necessary, holding device for immersing and drying (purpose-built)
- If necessary, frame for holding device (purpose-built)
- Saucepan (round)
- Thermal cabinet (recirculating air)

7.2 Raw Materials

- 200 g egg yolk (approx. 10–11 eggs)

7.3 Preparation

The stainless steel sheets to be soiled must be clean and grease-free. To this end, the numbered sheets undergo thorough cleaning in a laboratory dishwasher at 93 °C with a high-alkaline commercial detergent (cp. 1.2). Dry the sheets before soiling (30 min/80 °C/thermal cabinet). The (brushed) surface of the cleaned sheets which is to be soiled should not be touched after this point.
Weigh the cooled sheets before soiling.
Separate the yolks of the raw eggs (using a special device if necessary), stir with a fork in a glass beaker to homogenise them and pass them through a strainer to remove the coarser particles and fragments of eggshell.
Using a brush, apply 1.5 g ± 0.1 g of egg yolk mass as uniformly as possible over an area of 140 cm² on the brushed side of each of the stainless steel sheets, leaving an approx. 1 cm wide unsoiled rim on the upper edge (use adhesive tape if necessary). Dry the soiled sheets horizontally at room temperature for four hours (max. 24 h).
For denaturation, immerse the sheets for 30 seconds in boiling, demineralised water (using a holding device if necessary). Then dry again for 30 minutes at 80 °C. After this, weigh the cooled egg-coated sheets. After weighing, the sheets must be stored for at least 24 h at room temperature before they can be used.
Approval requirement: (750 ± 100) mg/140 cm² (egg yolk mass after denaturation and drying)
After the wash test, dry again for 30 minutes at 80 °C in the thermal cabinet and weigh again after cooling.

7.4 Evaluation

$$\text{\% Cleaning performance} = \frac{\text{mg egg yolk released} \cdot 100}{\text{mg egg yolk applied (after denaturation)}}$$

7.5 Important remarks

- To prevent injury, deburr the steel sheets before they are used for the first time.
- Gloves always to be worn when touching the stainless steel sheets, in order to avoid impurities.
- No water stains or fluff on the surface (visual inspection/re-polish if necessary).
- Leave the freshly coated sheets horizontal to prevent the formation of droplets on the edges.
- Application quantities > 1.5 g are technically possible.

8. Minced Meat on Porcelain Plates

8.1 Apparatus

- Dessert plates (Arzberg, white, glazed porcelain) conforming with standard EN 50242, form 2000, no. 10219, ø 19 cm
- Fork
- Thermal cabinet (recirculating air)
- Freezer cabinet
- Mincer
- Kitchen hand blender

8.2 Raw Materials

- A total of 225 g lean pork and beef (half and half)
- 75 g egg (white and yolk)
- 80 ml synthetic water as defined in **Box 1**
- Phloxin B, 0.01% in water

8.3 Preparation

The tea plates to be soiled must be clean and grease-free. To this end, they undergo thorough cleaning in a laboratory dishwasher at 93 °C with a high-alkaline commercial detergent (cp. 1.2).
Put the finely chopped and cooled meat (50 % beef/50 % pork with visible fat removed) through the mincer twice. Avoid temperatures in excess of 35 °C.
Using a fork, mix 225 g minced meat with 75 g egg (white and yolk) and freeze (can be stored for 3 months at –18 °C).
To soil the plates, bring the minced meat-egg mixture (300 g) up to room temperature and mix with 80 ml synthetic water. Then homogenise it with a kitchen hand blender for 2 minutes. Using a fork, spread 3 g ± 0.1 g of the minced meat/egg/water mixture on each white porcelain plate, leaving an unsoiled margin of ca. thumb-width around the rim.
Quantity applied/area: (11.8 ± 0.5) mg/cm²
Place the plates in the preheated thermal cabinet.
Dry for 2 hours at 130 °C.
Minced meat on porcelain plates can used as soon as the plates have cooled. Stack the plates with paper towels between them.

8.4 Evaluation

For better identification of the minced meat residues, after washing the plates can be submerged in Phloxin B solution (0.01% in water) or swung with the solution.
After washing, evaluation by visual inspection of the colour reaction of the minced meat residues with reference to the photographic catalogue (**Fig. 7**).

8.5 Important Remarks

- As an alternative, only beef can be used if pork is not available.
- The Phloxin B solution should be stored in the dark.
- When working with the Phloxin B solution the rules for the handling of dangerous substances must be followed.

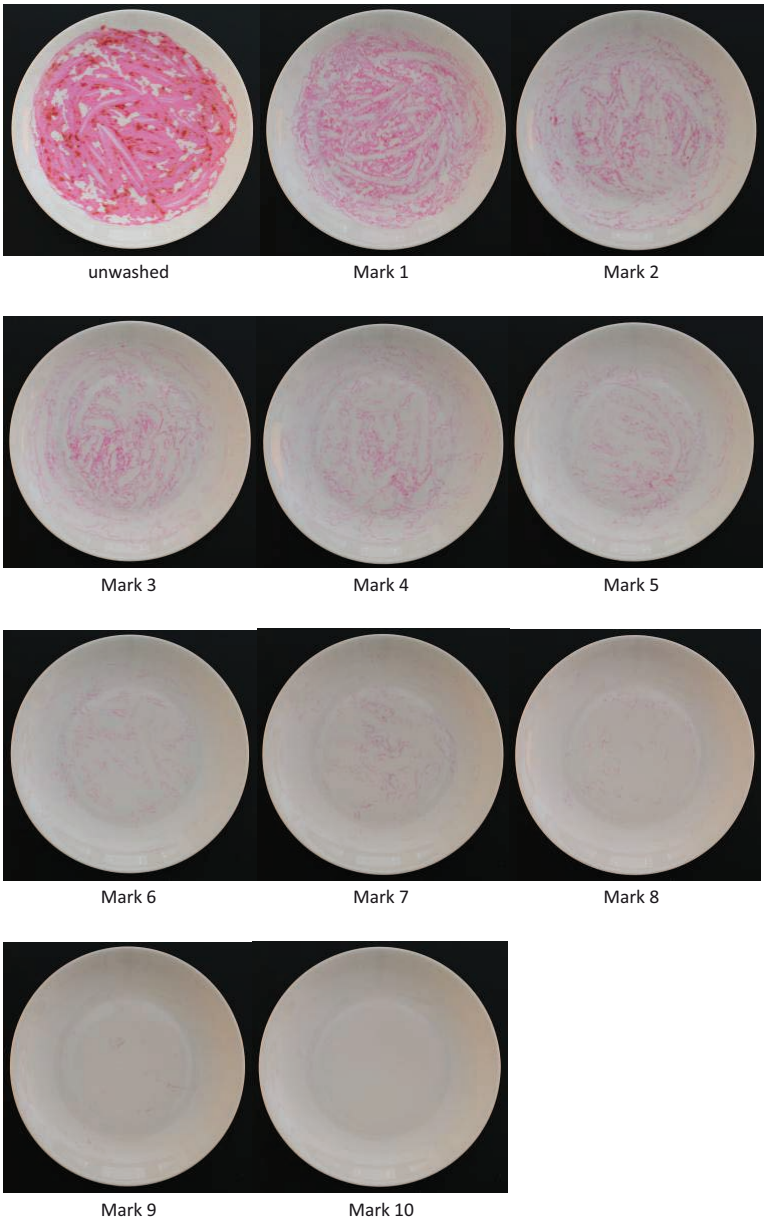

Fig. 7 Photo catalogue for visual evaluation: Minced meat

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9. Crème Brûlée

9.1 Apparatus

- Silicon brush (width ca. 4 cm; length 3.5 cm, 5 lines à 17 silicon threads, supply source wholesale trade, e.g. Metro)
- Dessert plates (e.g. Arzberg, white, glazed porcelain) conforming with standard EN 50242, form 2000, no. 10219, ø 19 cm
- Saucepan
- Cooking plate
- Thermometer
- Balance (weighing accuracy 0.1 g)
- Thermal cabinet (recirculating air), e.g. company Memmert or company Binder

9.2 Raw Materials

- Crème Brûlée (Debic)

9.3 Preparation

The dessert plates to be soiled must be clean and grease-free. To this end, they undergo thorough cleaning in a laboratory dishwasher at 93 °C with a high-alkaline commercial detergent (cp. 1.2).
Heat the ready-made mixture in a saucepan to 60 °C while stirring. Then let the crème cool to below 30 °C while stirring occasionally.
Next, apply the crème evenly on the dessert plates with an unsoiled rim of 2 cm.
Application per plate: 3.5 g ± 0.2 g (19.8 mg/cm² ± 1.1 mg/cm²)
After drying of the crème on the plates for 2 hours at room temperature, the crème is baked on the plates in the thermal cabinet without preheating the thermal cabinet. The baking time starts only after the baking temperature has been reached.
Baking for 2 hours at 140 °C.

9.4 Evaluation

Visual evaluation of the crème brûlée residues after washing, with reference to the photographic catalogue (**Fig. 8**).

9.5 Important remarks

- After opening the pack of the crème brûlée needs to be stored in a refrigerator and can be used for maximally one week.
- The plates can be used after cooling.

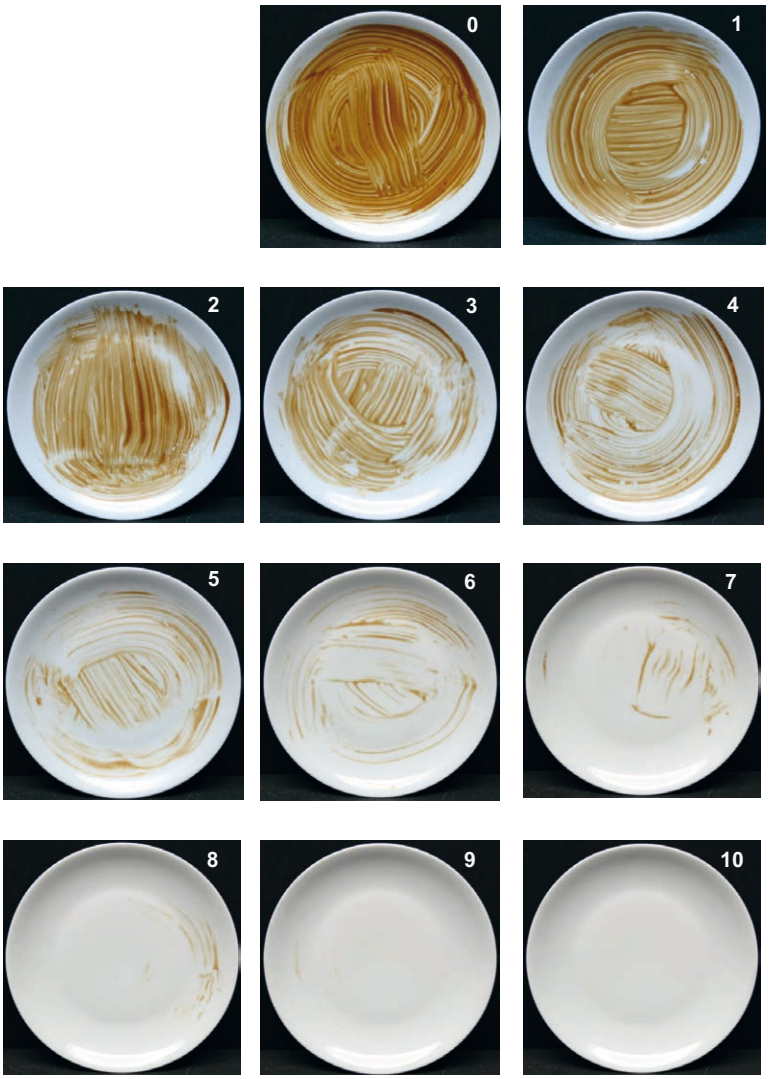

Fig. 8 Photo catalogue for visual evaluation: Crème brûlée

Annexes:

Ingredients	Material
Ballast soil	see **Tab. 4**
Crème Brûlée	Brand: Debic.com product Crème brûlée Manufacturer: FrieslandCampina Foodservice, PO Box 640, 3800 AP Amersfoort, The Netherlands Supply source: wholesale trade, e.g. Metro, Homepage: http://www.debic.com/de
Eggs	Quality class A Weight class L
Minced meat	Lean pork without sinew Lean beef without sinew
Iodine	0.05 ml I_2, volumetric solution (iodine-potassium solution, e.g. Fluka 318981)
Milk	UHT milk, 1.5 % fat (for milk in the microwave oven) or 3.5 % fat, e.g. from Weihenstephan (for milk skin) ultra-heat treated, homogenised
Pasta	Spaghetti from durum wheat semolina, e.g. Barilla n. 5
Phloxin B	Phloxin B Merck Millipore order no. 1159265000
Starch mix	Examples: Wheat starch SP from Roquette Maize starch Standard from Roquette Rice starch Remy DR from Beneo Potato starch Superior from Emsland
Tea	Black tea Variety: Assam, e.g. Teekanne Synthetic water (see below) Ferric sulphate, dehydrated, pure (x H_2O)
Water	Synthetic water (3.00 mmol Ca + Mg, as described in **Box 1**) Calcium chloride dehydrate for analysis Magnesium sulphate heptahydrate for analysis Sodium hydrogencarbonate for analysis

Annex 1 List of raw materials for test soils

Device	Example	Address	Application
Mincer	Perforated disk 8/3, hole diameter 3 mm	Electric appliance stores	Minced meat on porcelain plates
Freezer cabinet		Electric appliance stores	Minced meat on porcelain plates
Kitchen hand blender	Braun	Electric appliance stores	Minced meat on porcelain plates, pasta
Microwave oven with glass turntable	Bosch, Miele	Electric appliance stores	Milk microwave, milk skin
Serial dispenser	Fortuna Optifix Basic, 1.0 ml	Graf/Fortuna, Am Bildacker 3-7, 97877 Wertheim, Germany	Milk microwave, milk skin, starch mix
Water bath	IKA Temperaturheizbad	Janke & Kunkel GmbH & Co.KG IKA Labortechnik Postfach 1263, 79217 Staufen, Germany	Starch mix
Electric stirrer + blade type agitators	IKA Eurostar	Janke & Kunkel GmbH & Co.KG IKA Labortechnik Postfach 1263, 79217 Staufen, Germany	Starch mix
Recirculation thermal cabinet	Memmert or Binder	Memmert GmbH & Co.KG, Postfach 1520, 91126 Schwabach, Germany Binder GmbH, Postfach 102, 78502 Tuttlingen, Germany	Starch mix, pasta, minced meat on porcelain plates, milk microwave, milk skin, crème brûlée
Balance with range up to 1200 g, accuracy 1 mg and 10 mg respectively	Sartorius	Sartorius AG Weender Landstr. 94-108 37070 Göttingen, Germany	Starch mix, egg yolk, crème brûlée
Dishwasher G1223 SC (GSL 2)	Miele	**Technical enquiries:** **laboratory.machine@miele.de** **Quotes/price enquiries:** **sales.laboratory.machine@miele.de** **Service/local customer service:** **https://www.miele.com/service** *(updated 3 August 2022, IKW e.V.)*	

Annex 2 Apparatus list

Soiling	Quantity	Item	Description and Manufacturer
Black tea	6	Tea cups	e.g. Fa. Bauscher, article no. 6215/18 or Fa. Schönwald, colour: white; form: 98L/0.19 Rehauerstr. 44-45, 95173 Schönwald, Germany
Milk in the microwave **Milk skin (optional)**	6	Glass beakers	e.g. Fa. Witeg; 150 ml short version, ø 55 mm, height 80 mm (milk microwave), 250 ml tall version, ø 60 mm, height 120 mm (milk skin)
Starch mix	6	Glass plates	arcoroc®, "Octime" series, black, octagonal, ø 25 cm (from edge to edge), inner surface area 270 cm²; arcoroc®, "Cosmos" series, 23 cm flat, no. 10980 ARC International Avenue du Général de Gaulle, 62510 Arques, France duralex®, "Lys" series, dinner plates no. 3010A F06, transparent, round, ø 23.5 cm, inner surface area 177 cm²
Pasta	6	Dinner plates	Arzberg Porzellan GmbH Wittelsbacher Straße 41, 95100 SELB, Germany Dinner plates, white, glazed porcelain, form 2000, no. 10225, ø 25 cm
Egg yolk	6	Stainless steel sheets	10 x 15 cm, brushed on one side
Minced meat **on porcelain plates**	6	Dessert plates	Arzberg Porzellan GmbH (see dinner plates), white, glazed porcelain (conforming with standard EN 50242), form 2000, no. 10219, ø 19 cm
Crème brûlée	6	Dessert plates	see dessert plates for minced meat on porcelain plates

Annex 3 List of necessary items to be soiled

contact

***German Cosmetic, Toiletry, Perfumery and Detergent Association (IKW)**
Working Group Automatic Dishwashing Detergents
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60329 Frankfurt am Main | Germany
Email: info@ikw.org