IKW-AK automatic dishwashing detergents*

Methods for ascertaining the cleaning performance of dishwasher detergents (part A)

Keywords: Test method, automatic dishwashing detergent, IKW (Association of German Detergent Manufactures e.V. / Industrieverband Körperpflege und Waschmittel e.V.)

1. Introduction

The market for dishwasher detergents is a growth market owing to the increasingly widespread use of dishwashers in the home. On the European level, the rate of growth is about 5 % per year. Closely linked to this, dishwasher detergents also benefit strongly from this growth. The market for these detergents was worth about 1.4 billion DM in Europe in 1997.
Mechanical dishwashing invariably involves a system of products. Three products are required overall: detergent, rinse aid and regeneration salt. Of crucial importance to mechanical dishwashing is the detergent. The most important tasks that it has to perform are:

- Releasing soil from the dishes
- Dispersing the soil in the wash solution
- Complexing residual water hardness and hardness ions from food residues
- Maximizing gentle treatment of the dishes.

Because of this complexity, dishwasher detergents are generally composed of up to five basic ingredients:

- Alkalinity carriers
- Complexing agents
- Bleaching components
- Bio-agents (enzymes)
- Wetting agents.

The product's overall performance may be supplemented by such additional components as silver protection agents, bleach catalysts, or the like.
Typical detergent compositions according to formulation type can be seen in **Table 1**.

Until 1990, all the detergents available on the market had similar compositions. They belonged to the group of conventional classical powders listed in **Table 1**. The interaction of the alkalinity carriers (metasilicate/sodium carbonate), the builder system (phosphate) and the bleach system (active chlorine carrier) yielded relatively similar wash results on the relevant types of soil, with little difference between the detergent types.
Not until the compact detergents were launched on the market in 1990/91 did significant differentiation of the wash profiles manifest themselves as a result of the greater scope for formulation design. With the test methods available at that time, e.g. with comparative consumers association tests, it was not always possible to adequately highlight these differences.
Until that time, the test methods employed had been developed by analogy with studies to assess the wash performance of dishwashers and subse-

Ingredients	Conventional detergents (powder / tablet) [Share in % by weight]		Compact detergents (powder / Tablet) [Share in % by weight]		
			Formula:	phosphate	non phosphate
Alkaline carriers	Metasilicate/-Disilicate	30 - 70	Sodium carbonate	0 - 40	0 - 40
	Sodium carbonae	0 - 10	Sodium bicarbonate	-	0 - 40
			Disilicates	0 - 40	0 - 40
Complexing agents + dispersing agents	Triphosphate	15 - 40	Phosphate	>30	-
	Polymeres	0 - 10	Citrat	-	>30
			Phosphonate	0 - 2	0 - 2
			Polycarboxylate	0 - 5	0 - 15
Bleaches + activator/-accelerator	Active chlorine carrier	0 - 2	Active oxygen carrier	3 - 20	3 - 20
			TAED	0 - 6	0 - 6
			Mn-Accellerator	-	<1
Wetting agents	Surfactants	0 - 2	Surfactants	0 - 4	0 - 4
Bio-agents		-	Enzymee	<6	<6
Auxiliaries	Paraffin oil	approx. 1	Perfumes	<0,5	<0,5
			Paraffin oil	<1	<1
			Silver protection agent	<1	<1
pH 1%		12 - 13		<11	>11

Table 1 Typical detergent compositions

Soil types	Practical examples
Colored, bleachable soil	• Tea (3, 4, 5, 6) • Ketchup • Carrot juice • Curry, saffron etc. • Lipstick
Persistent, burnt soil	• Burnt meat [13] • Burnt custard [13] • Burnt milk [13] • Burnt casseroles etc.
Dried, starchy soil (amylase-specific)	• Porridge (1, 10, 13) • Starchy sauces/gravies • Casseroles (pasta, rice, potatoes) • Remains of dough/batter, baked-on residues
Dried, proteinaceous soil (protease-specific)	• Egg yolk (7, 8, 9) • Casseroles (cheese, meat, egg)

Table 2 Classification of Food Soil

quently applied to the assessment of detergents. The most widespread methods are DIN 44990 (1) and IEC 436 (2). However, both methods were developed at a time when the new compact detergents containing enzymes had not yet become established on the market. Consequently, these methods are often incapable of adequately reflecting the wash profile of such detergents. It therefore became necessary to develop a system based on the existing methods for a more comprehensive assessment of the wash performance of dishwasher detergents.
In the middle of 1995, under the auspices of the German Industrial Association of the Manufacturers of Toiletries and Detergents (IKW), a work group of mechanical dishwashing experts was set up for this task and was joined by representatives of leading European test institutes and dishwasher manufacturers.

2. Goal

The goal of the work group was to select forms of soil from the field to enable the wash profile yielded by the composition of the detergent in question to be determined.
Food soil on domestic dishes can be roughly classified **(Table 2)**.

The test soil types also have to satisfy the following criteria.
- Simple (to produce, without complex apparatus)
- Relevant to practical washing experience
- Reproducible
- Discriminating
- Long storage life.

The methods chosen should be such that even powerful detergents are incapable of completely releasing the soil. This will allow the possibility of differentiating between powerful products at the top end of the scale.

Method	Current version	Product tested	Distribution
IEC 436 (2)	1981	Mechanical dishwasher	International
DIN 44990 (1)	1989	Mechanical dishwasher	D, A, I, E, F
prEN 50242 (10) (Cenelec TC 59 X)	in Arbeit	Mechanical dishwasher	EU
UTE 73-176 (11)	1968	Mechanical dishwasher	F, I
ANSI/AHAM DW-1-1982 (12)	1982	Mechanical dishwasher	USA
Altenschöpfer (13)	1971	Detergent	D
Novo (7,8)	1993	Enzymes	International
Genencor (9)	1994	Enzymes	International

Table 3 Existing Test Methods to Determine Cleaning Performance of Dishwashing Machines and Detergents

3. Review of existing methods

First of all, methods already known or discovered in literature searches were studied and assessed.
The overwhelming majority of the test methods were developed by organizations of dishwasher manufacturers in cooperation with various detergent manufacturers. These methods were designed to clearly define the efficiency of the dishwasher in terms of the action of the spraying arms and the filter system. A major aspect of this, namely the primary release of various food soil types from the surface of the dishes, is inadequately described by these methods. The majority of the soil types employed are not persistent enough for an assessment of detergent action.
In addition to these so-called dishwasher-specific methods, the more recent literature reports on enzyme-specific soils (7, 8, 9). These methods have been developed by enzyme manufacturers and supply information on amylase- and protease-specific soils. Nevertheless, no attempt at an integrated description that would permit an assessment of dishwasher detergents has been made.
The various test methods can be seen in **Table 3**.
An assessment of the various test methods described at that time is given by the work group in **Table 4**.

4. Methodology and proposed results

The task of the work group was, either to select such soiling methods from those already known, which enabled as high a differentiation as possible between different detergent formulations, or to adjust those methods accordingly. Hence, the soils should be so

	Effort	Practical relevance	Reproducibility	Discrimination	Storage life
IEC 436	-	+	?	-	-
DIN 44990	-	++/-	+	+/-	-
UTE 73-176	-	+	?	-	-
AHAM	Not so suitable in Europe in the opinion of dishwasher manufacturers				
Altenschöpfer	-	+	+	-	+
Novo	+	+	+	+	+
Genencor	+	-	+	+	+
+ = good	- = bad				

Table 4 Assessment by the Working Group of Various Test Methods Described

persistent, that even powerful test formulations combined with favourable washing conditions do not achieve 100 % cleaning efficiency.

Washing the soils in pure water should only result in a minor removal of soils, such that a wide range of differentiation is achieved. Since the known soils could not meet these criteria in every case, the working group also undertook new developments. Especially in the case of starch containing soils the developments have been built on the knowledge attained from the relevant literature (15-22).

Additionally, other described, but not certified, methods were included in the assessment (starch mixture according to IEC SC 59 A / WG II (14), milk in the microwave according to Cenelec TC 59 X (10).

For the selection of the soils to be included in the test method, a further requirement was that each of the soil classes described in **Table 2** (bleachable/coloured, persistent/burnt, dried starch containing as well as dried protein containing) should be represented by at least one single soil. The following 8 single soils in **Table 5** finally proved to be suitable to fulfil the required criteria.

The storage stability of the soils under laboratory conditions is at least 14 days. Moreover, the microbiological tests (23) did not show any significant increase of the germ counts over this period.

In order to achieve a better distinction between test products, in addition to the single soil, a ballast soil is added to the cleaning cycle of the dishwasher. This ballast soil, in form of a frozen lump, largely consists of fatty type ingredients as well as protein and starch containing food and as coloring components, tomato ketchup and mustard. In justified cases the addition of the ballast soil can be waived.

These chosen soils were evaluated using 2 test series in different participating test laboratories. During the tests the description of the test methods was optimized with the aim of preventing mistakes and avoiding deviations. The detailed description of the preparation of the soils and the conditions under which the comparative tests were carried out are presented in part B.

5. Experience with the methods to date

Since the conditions for soil preparation in the course of both test series with the products »R_1, R_2, R_3«, IEC A, and »R_3, P_3«, IEC A, **(Table 6)** as well as pure water for the base level were changed several times, individual results will not be presented, but the experience gained from the tests will be described.

5.1 Bleach specific stains

The hypochlorite containing products and the hypochlorite-free products of the type R_1-R_3 could be sufficiently differentiated using the tea method. No differences could be found between these three detergents which were based on the same bleach system, the same alkalinity, and the same builder system. In the 2nd comparative test, advantages were found under the compact detergents for the products containing phosphate, P_3. Using water alone, only minor removal of tea stains was observed.

Class	Soil	Origin	Evaluation
bleachable	Tea	new	visual/photo catalog
persistent / burnt	Minced meat on glass	Altenschöpfer (13) (modified)	visual/photo catalog
	Milk in the microwave	prEN 50242 (10) (modified)	visual/photo catalog
dried / starch containing	Starch mix	IEC SC 59A / WG 2(14)	gravimetric
	Oat flakes (porridge)	prEN 50242 (10)	visual (color reaction) / photo catalog
dried / protein containing	Egg yolk	Novo (7,8) (modified)	gravimetric
	Minced meat on porcelain	prEN 50242 (10) (modified)	visual (color reaction) / photo catalog
	Egg/milk	Novo (7,8) (modified)	gravimetric

Table 5 Suitable single soils meeting the required criteria

	R_1	R_2=P_2	R_3	P_3	IEC A
Cleaner type	compact	compact	compact	compact	klassical
Phosphate	-	-	-	+	+
Bleach system*)	AO	AO	AO	AO	ACL
% Amylase	1.0	2.0	3.0	1.0	-
% Protease	6.0	4.0	2.0	2.0	-
Alcalinity	10.5-11	10.5-11	10.5-11	10.5-11	12-12.5

*) *AO = active oxygen / ACl = activ chlor*

Table 6 Description of the experience gained

5.2 Persistent / burnt stains
Using the methods *»milk in the microwave«* and *»minced meat in glass vessels«*, detergent formulations with different alkalinity could be clearly differentiated.
While the results from *»milk in the microwave«* did not recognize the effect of protease activity, in the *»minced meat in glass vessels«* test the effect of increasing amounts of protease could be recognized. In practice, these methods offer the advantage of a significantly reduced hazard potential than before, where soils were burnt on oil baths

5.3 dried /protein containing soils
The method *»minced meat on porcelain plates«* delivered results that lead to the conclusion that both high alkalinity and increasing amounts of protease result in an increase in cleaning efficiency up to a plateau level. It was found to be advisable to spray the residues of meat protein with a solution of Ninhydrin in order to make them more visible. Altogether, this meat soil dried at 120 °C is harder to remove than the meat soil of EN 50242 (DIN 44990) dried at 80 °C.
The detergent formulations in the test could be differentiated significantly better with the methods *»egg yolk«* and *»egg/milk«* applied on steel plates. Here, the effects of protease could be recognized clearly, while the effect of alkalinity was relatively minor. In the first test series it was found that with the egg yolk soil even a protease free test detergent with high alkalinity - in comparison to the water value – a not insignificant cleaning result was achieved, albeit with widely fluctuating values. The reason for that was found to be due to too thick layers of egg yolk, which – due to the high alkalinity of the IEC reference detergent A - partly tended to flake off. Due to this fact, the WG decided to reduce the thickness of the applied egg yolk by half. The success was observed in the 2nd test series, where the effect of the protease could be recognized clearly from the results, while a high alkalinity had a smaller influence. Soil removal using the IEC reference detergent A was found to be of the same order of magnitude as the water value. The clear protease effect could also be observed in the results of the egg/milk soil, where the alkalinity seems to have no influence on the cleaning performance. The results of the egg/milk test also showed clearly the protease effect, whereas the alkalinity did not appear to effect the cleaning performance.

5.4 dried / starch containing stains
Originally it was assumed that the starch containing soils were exclusively specific to amylase. Using the *»porridge«* (oat flakes) method, which was adopted from the suggested method EN 50242 (DIN 44990), this does not always follow. The results of the test series showed that both the effect of the amylase and the effect of the alkalinity were perceptible. However, detergent formulations with minor amylase concentrations can clearly outperform the high alkaline detergent type A in terms of cleaning efficiency.
The working group also dealt for a short time with a gravimetric evaluation. Therefore, it should be mentioned, that even a detergent with a medium cleaning efficiency on starch, as e. g. IEC reference detergent type A, removes about 90 % of the starch. This high specific iodine/starch reaction can stain food residues so intensively, that the remaining 10 % can be clearly identified. Marks of 8-9 denote a cleaning efficiency well above 95 % (determined gravimetrically).
The method *»starch mix«* is indeed more time consuming, but offers a linear differentiating gravimetric evaluation. The test results clearly show the influence of the increasing amylase content and that the alkalinity only provides a minor contribution to the cleaning performance.

6. Evaluation

The working group's initial philosophy was to determine a selection of suitable single soils from the 4 different soil classes: bleachable, persistent/ burnt, dried/starch containing, and dried/protein containing. Over the course of the test series it became apparent that the cleaning performance on single soils can often not be characterized by just one single parameter. The influence of specific parameters is presented in **Table 7**.
For a simple presentation of the results, especially as evidence of cause and effect relationships in terms of the nature and amount of different ingredients, the results of the single soils

Soil class	bleachable	persistent/ burnt		dried / protein containing			dried / starch containing	
Soil	tea	milk	minced meat on glass	minced meat porcelain	egg yolk	egg/milk	porridge	starch mix
Bleach system	+							
Alkalinity		+	+	+	(+)		+	(+)
Protease		-	+	+	+	+		
Amylase							+	+
Other influence	phos-phate							

Table 7 Influence of the detergent composition on the cleaning efficiency of the single soils

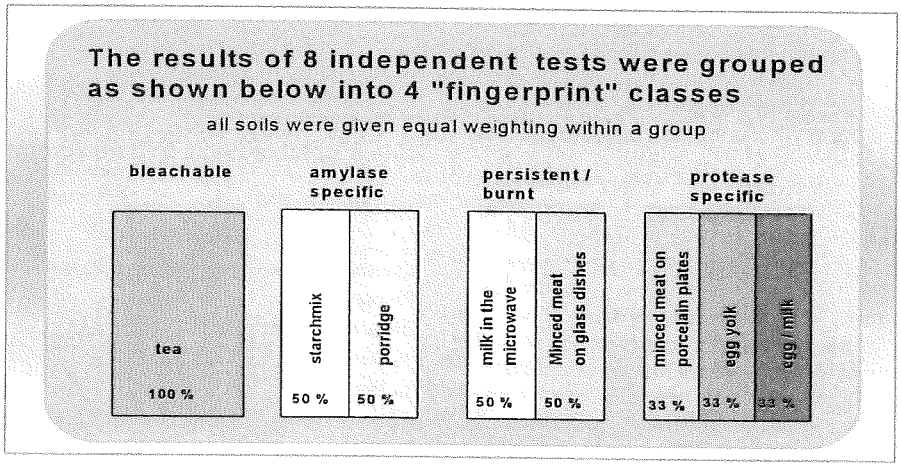


Fig. 1 Presentation of the general result

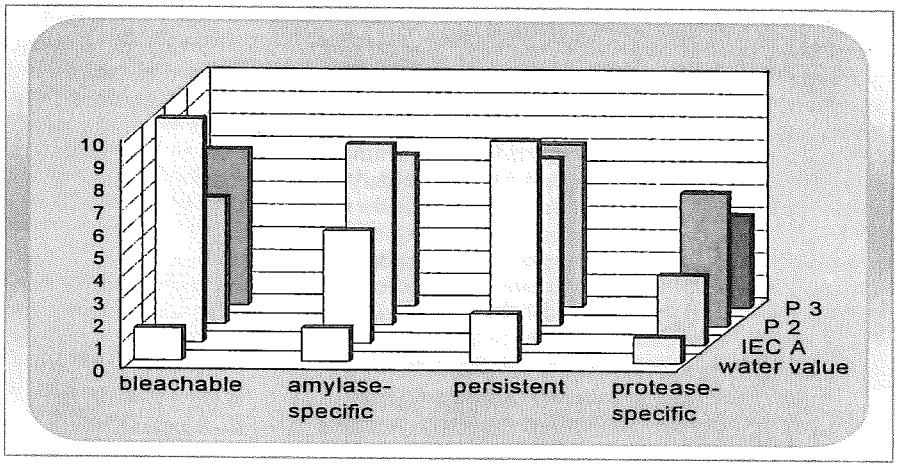


Fig. 2 Results of the 2nd test series

	Effort	Practical relevance	Reproducibility	Discrimination	Storage life
Tea	-	+	+	+	+
Minced meat on glass dishes	-	+/-	+	+	+
Milk in the microwave	+	+	+	+	+
Starch mix	-	-	+	+	+
Porridge	+	+	+	+	+
Egg yolk	-	+	+	+	+
Minced meat on porcelain plates	+	+/-	+/-*)	+	+
Egg/milk	-	+/-	+	+	+

+ = good - = bad

**) Fluctuating results with the classical detergent IEC A owing to its high alkalinity*

Table 8 Compliance of the demands on the single soils

IKW members	additional participants
☆ Benckiser Produktions GmbH	☆ Institut Fresenius Gruppe
☆ Chemolux s.a.r.l.	☆ Landesgewerbeanstalt Bayern
☆ fit Chemische Produkte GmbH	☆ Miele & Cie. GmbH & Co.
☆ Henkel KGaA	☆ Stiftung Warentest
☆ Luhns GmbH	☆ TNO Cleaning Techniques
☆ Procter & Gamble	☆ wfk Forschungsinstitut
☆ Seifenfabrik Budich	
☆ Lever	
☆ Werner & Mertz GmbH	

Table 9 Companies and test institutes which were involved in the development of the test methods within the framework of the IKW working group

can be combined into the 4 mentioned categories. For calculation, the cleaning results of the single soils are included proportionately as presented in principal in **Fig. 1**.
From this, a so called »fingerprint« of the specific detergent is being obtained, which illustrates the strengths and weaknesses in relation to the 4 soil classes.
As an example from the practice, the results of the 2nd test series are being presented in **Fig. 2**.
The different composition of the test detergents e.g. according to the bleach system as well as the content of protease and amylase can be recognized in the cleaning results. How the single soil described so far fulfil the mentioned criteria of **Table 4** is presented in **Table 8**.

7. Summary

In the opinion of the working group the new method is suitable to more comprehensively determine the performance profile of machine dishwasher detergents than previously known methods. This is, however, being achieved by a greater effort in the preparation of soils. On the other hand, the soils discussed here have the advantage that their storage life clearly surpasses that of all test soils known before. As a result mass production of the required quantity of soils is possible in advance, which leads to a significant reduction in preparation time. Using hitherto gained experience it is intended to further optimize and update the methods and where appropriate develop other soils. At a later review, further accumulated experiences can be incorporated into the test methods.

Literature

(1) DIN 44990, Teil 1, »Elektrische Geschirrspülmaschinen für den Hausgebrauch«, Deutsches Institut für Normung e.V., Berlin 1989.

(2) IEC 436, »Methods for measuring the performance of electric dish-washers«, Bureau Central de la Commission Electrotechnique Internationale, Genève 1981, and amendement 3, Genève 1994.

(3) *B. Ohler, D. Auerswald, C. Maluche, C. Walz,* »Methoden zur Bestimmung von Teerückständen in Porzellantassen«, SÖFW-Journal, 121. Jg., 6/95, S.439 ff.

(4) *M. Spiro, D. Jaganyi,* »What causes scum on tea ?«, Nature 364, 581 (1993).

(5) *R. Lemke,* »Die Haut auf dem Tee (2) oder: Tee mit Zitrone«, CLB 45, 193 (1994).

(6) DRV, »Die Haut auf dem Tee«, CLB 44, 592 (1993).

(7) *L. H. Dalgaard, K. Kochavi, M. Thellersen*, »Dishwashing-a new area for enzymes«, Inform AOCS 2 (1991), Nr. 6, S. 532 ff.

(8) *G. Jensen, M. Thellersen*, »Enzyme für Maschinengeschirrspülmittel«, SÖFW 119 (1993), Nr. 1, S. 37 ff.

(9) *D.H. Cater, M.J. Flynn, P.F. Plank*, »Use of enzymes in dishwashing detergents«, Inform AOCS 5 (1994), Nr. 10, S. 1095 ff.

(10) EN 50242 »Electric dishwashers for household use – Methods for measuring the performance«, CENELEC, European Committee for Electrotechnical standardization, Brussels, to be completed.

(11) UTE 73-176, »Machines à laver la vaiselle«, Editées par l'Union technique de l'Electricité (Paris 1968).

(12) ANSI/AHAM DW-1-1982, »An American National Standard: Household Electric Dishwashers«, ASSOCIATION OF HOME APPLIANCE MANUFACTURERS, North Wacker Drive, Chicago, Illinois 60606.

(13) *T. Altenschöpfer*, »Prüfung von Reinigern und Klarspülern für das maschinelle Geschirrspülen. 1. bzw. 2.«, SÖFW 98 (1972), S. 763 ff. und S. 801 ff.

(14) IEC SC 59A / WG 2, (method B1, starch mixture), »Report of the convenor, Mr. *Horowitz*, to SC 59 A«, (October 1994).

(15) *V. Lang, M. Linderer, G. Wildbrett, I. Stifter*, »Bewertung der Reinigungsleistung beim Geschirrspülen«, SÖFW 117 (1991), Nr. 3, S. 104 ff.

(16) *M. Rietz, K. Rubow, M. Teusch*, »Bewertung der Reinigungsleistung beim Geschirrspülen«, SÖFW 119 (1993), Nr. 6, S. 340 ff.

(17) *M. Linderer, G. Wildbrett*, »Untersuchungen zum maschinellen Geschirrspülen – Erarbeitung eines Prüfverfahrens«, SÖFW 119 (1993), Nr. 13, S. 822 ff.

(18) *M. Linderer, G. Wildbrett*, »Untersuchungen zum maschinellen Geschirrspülen – 2. Mitteilung: Einfluss der Verfahrensparameter auf die Stärkeentfernung«, SÖFW 120 (1994), Nr. 7, S. 405 ff.

(19) *M. Linderer, G. Wildbrett, G. Enderle*, »Untersuchungen zum maschinellen Geschirrspülen – 3. Mitteilung: Stärkeablösung mit verschiedenen Reinigertypen«, SÖFW 121 (1995), Nr. 3, S. 160 ff.

(20) *P. Weinberger, G. Wildbrett*, »2. Mitteilung: Entfernen von Stärkerückständen von Glasoberflächen«, Fette, Seifen, Anstrichmittel, 80. Jg./No. 2 (1978), S. 80 ff.

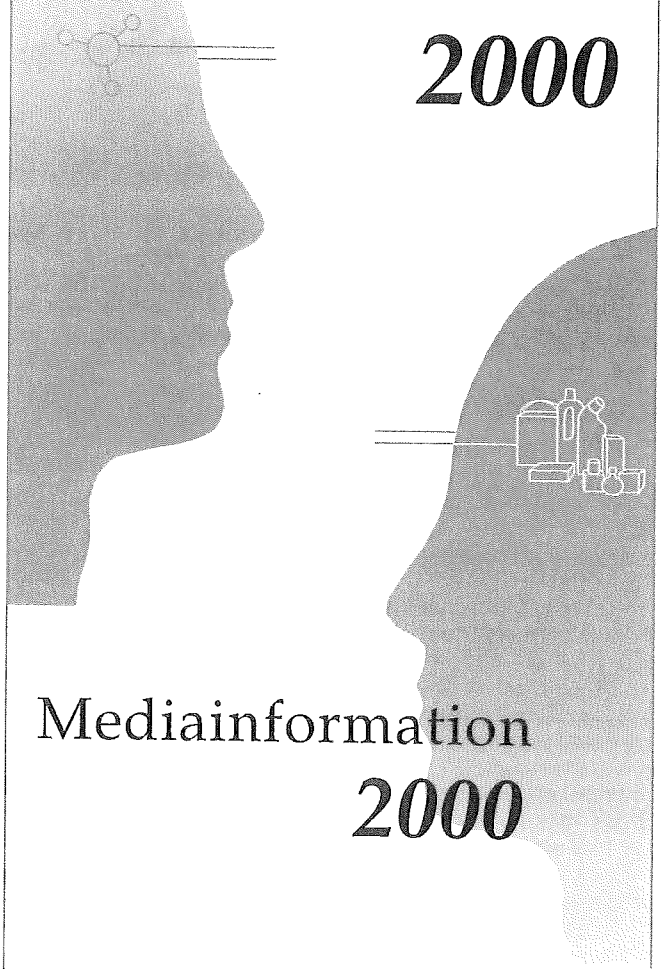
(21) *T. Altenschöpfer*, »Enzyme in Spülmitteln für Haushalt-Geschirrspülmaschinen? I«, Fette, Seifen, Anstrichmittel, 73. Jg./No. 7 (1971), S. 459 ff.

(22) *T. Altenschöpfer*, »Enzyme in Spülmitteln für Haushalt-Geschirrspülmaschinen? II«, Fette, Seifen, Anstrichmittel, 73. Jg./No. 9 (1971), S. 561 ff.

(23) Institut Fresenius »Bericht zur mikrobiologischen Stabilität der Testanschmutzungen«, 1997.

*Correspondence adress:
Dr. W. Buchmeier
c/o Henkel KGaA
WER/Maschinelle Spülmittel
D-40191 Düsseldorf

Mediainformation
2000



Mediainformation
2000

now available

Verlag für chemische Industrie
H. Ziolkowsky GmbH
Postfach 10 25 65
86015 Augsburg
Fax: (0821) 325 83-23
e-mail: engel@sofw.com

IKW working group automatic dishwashing detergents*

Methods for Ascertaining the Cleaning Performance of Dishwasher Detergents
(Part B, updated 2005)

Keywords: Test methods, dishwasher detergents,
German Industrial Association of the Manufacturers of Toiletries and Detergents (IKW)

Contents

Introduction

In 1995, under the auspices of the German Industrial Association of the Manufacturers of Toiletries and Detergents (IKW), a working group of mechanical dishwashing experts was set up, which was joined by representatives of leading European test institutes and dishwasher manufacturers. The goal of this working group was to choose appropriate methods of simulating routine soiling in order to determine the cleaning performance of automatic dishwashing detergents. Part A of the publication presents the approach adopted by the working group and how the group found the methodology. This part, Part B, describes in detail the procedures used to test the performance of an automatic dishwashing detergent.
The method was updated in 2005 by the working group. Viable alternatives are given for appliances, dishes or chemicals which are no longer available. Phloxin B is recommended for colouring the proteins instead of ninhydrin. As regards the starch mix method an increased quantity is advised in order to allow better differentiation in the upper performance range.

1. Preface

1.1 Selection of soil types

For the test, at least one of each of the four soil types is to be used (bleachable, stubborn/burnt-on, dried-on/amylase-specific and dried-on/protease-specific). Since, due to the influence of the alkalinity of dishwashing detergents, the minced meat on porcelain plates and porridge do not constitute purely enzyme-specific types of soil but can also be included to some extent in the »stubborn/burnt-on« category, at least one other enzyme-specific type of soil should be included when selecting these types of soil.
If only four types of soil are tested these should be tea, starch mix, egg yolk and milk in the microwave.
To produce the individual soil types, synthetic water should be used rather than tap water, with the hardness raised to 3.00 mmol (Ca+Mg) = 16.8 °d in accordance with DIN/EN 60734, method B - salt mixing technique (see Appendix 4).

1.2 Thorough washing of the crockery/utensils
Before the individual soil types can be applied, the various dishes must be thoroughly washed. This is essential as residues of certain persistent stains may still be present on the dishes from previous tests. New dishes should also be subjected to three thorough washes before being used for the first time in a test. The dishes are washed in a laboratory dishwasher at 95°C with a special, commercial dishwashing detergent of high alkalinity and containing active chlorine (e.g. »Perclin«, Ecolab). Dishes should be regularly inspected for surface changes and rejected if necessary. It is advisable to separate each plate with a clean paper towel to avoid damage.

1.3 Storage
The soil should be stored in controlled conditions of 20°C/40 - 60% relative humidity as weighing errors may occur, particularly with gravimetric soil types due to varying levels of water content on the surface of the crockery.
Storage life under the above conditions is at least 14 days.

1.4 Preparation of the detergent samples
The samples to be tested should be as representative as possible of the detergent formulation under examination and should ideally be taken from several different batches. It is therefore necessary to pass the contents of a test package of the detergent in question through a sample divider before taking samples for the detergent tests.

1.5 Procedure / Test conditions
The detergents are tested according to the following criteria:

Program:
50° / 55°C program

No. of test runs:
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 is identical. On appliances with heat exchangers, for example, several prewashes should be conducted so that the temperature is comparable at a 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 (2in1) - *as far as the highest water hardness stated on multi-purpose products.*

Detergent dosage:
The detergent dosage is as recommended by the manufacturer. If no dosage guidelines are given, the following dosages are recommended:

classic detergents
e.g. IEC type A **30 g**

compact detergents
e.g. IEC type B or IEC C **20 g**

or 1 tab.

No. of soiled items:
six of each kind

Additional ballast soil:
50g of ballast soil in the form a frozen lump in the main wash cycle.

The frozen soil consists of foodstuffs (see Appendix 3), especially food containing starch, protein and fat, and it also contains colourings, e.g. ketchup and mustard. This additional soil is intended to simulate the presence of easily removable food residues and provides an additional load for the cleaning solution.

Use of rinse aid:
It is left to the test laboratories' discretion whether to use a rinse aid.

Machine load:
For the dish loading plan, see Appendix 1 which uses the example of the Miele G 590 reference machine conforming to EN 50242. If another test machine is used, the loading should comply with the plan as closely as possible.

2. Tea

2.1 Apparatus
- Tea cups: The sides of the cups should be 6-8 mm thick (e.g. Fa. Bauscher, art. no. 6215/18 or 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. Teekanne or other company)
- Synthetic water (3.00 mmol Ca+Mg as per Appendix 4)
- Stock solution of ferric sulphate

2.3 Pre-treatment of cups
See preface (thorough washing)

2.4 Preparation (for approx. 20 cups)
Mix 2 litres of synthetic water with 0.1 ml of ferric sulphate solution and bring it to the boil. Pour boiling water onto 30 g of tea in an open container and leave to brew for 5 min. Then pour the tea through a strainer into another temperature-controlled vessel.

2.5 Test procedure
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 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.

2.6 Evaluation:
Visual with reference to the photographic catalogue (Appendix 6).

2.7 Important remarks:
- Initial temperature in the cup is 85 °C (temperature of the tea when poured is about 93 °C).

- Thickness of the tea cups determines the tea cooling rate
- Assam tea is particularly difficult to remove
- Thorough washing of tea cups: household dishwasher/65 °C/detergent IEC A or laboratory dishwasher/95 °C/commercial detergent
- 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 constant conditions (20 °C, 60% relative humidity).
- 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. For this reason it was decided to add ferric ions to the synthetic water to produce a darker tea stain.

  Production of the ferric sulphate stock solution:
  In a 1-litre beaker dissolve 5g $Fe_2(SO_4)_3$ (see chemical list) + 1 ml HCl (37%) in demineralised water and fill to 1 litre. Using an Eppendorff pipette, add 0.1ml of the solution to 2 litres of tea.

3. Minced meat on glass dishes

3.1 Apparatus:
- Drying oven (recirculating air) up to 300°C (e.g. Heraeus)
- Crystallising dishes (e.g. Duran/Schott, diameter 115 mm, height 65 mm)
- Mincer (hole diameter 3 mm)
- Rubber spatula
- Freezer cabinet
- Kitchen hand blender

3.2 Raw materials:
- A total of 225 g lean pork and beef (half and half)
- 75 g egg (white and yolk)
- 80 ml synthetic water prepared as per Appendix 4

3.3 Preparation:
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 of minced meat with 75 g of egg (white and yolk) and freeze (can be stored for 3 months at -18°C).
To soil the dishes, bring the mince-egg mixture (300 g) up to room temperature, mix it with 80 ml of synthetic water and then blend for 2 min. using a kitchen hand blender. Weigh 3 g ± 0.1 g of this mixture and place in each glass dish. Spread the mince evenly on the base with a rubber spatula. The weighed minced meat should not be allowed to stand for more than 30 minutes before the next part of the procedure

3.4 Baking conditions:
Preheat the drying oven to a temperature which yields 200 °C after inserting the glass dishes (experiment beforehand to determine this temperature). After loading, reset the temperature controller to 200 °C. Bake for 10 min at 200 °C.
After removing the crystallising dishes, do not put new samples in until the initial temperature has been reached again

3.5 Evaluation:
Visual with reference to the photographic catalogue (Appendix 6).

3.6 Important remarks
- If pork is not avilable beef can be used on its own
- Make sure that the temperature in the drying oven does not drop below 200 °C after inserting the glass dishes.

4. Milk in the microwave

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

4.2 Raw materials:
- Semi-skimmed UHT milk (1.5 % fat, ultra-heat treated, homogenised)

4.3 Preparation:
Set the microwave to an output of 450 W (see calibration instructions in Appendix 5).
To preheat the microwave, arrange six beakers containing 50 ml water symmetrically around the edge of the rotating plate and heat them for 10 min. Then pour 10 ml of milk at room temperature into each of the six glass beakers and arrange them in the same pattern as before on the rotating plate and heat them in the manner described below. Make sure that the exact heating time is observed in order to ensure that the results are consistent.
After heating, the milk soil is post-treated for 2 hours at 80 °C in the thermal cabinet.

4.4 Baking times:
The baking time is 10 min at 450 W.
Since the actual output of microwave ovens may deviate from the setting, it should be checked every three months, in accordance with the relevant instructions (conforming to EN 60705, see Appendix 5). Depending on the degree of deviation, the baking time should be adapted either with an independent time switch or, in the case of microwave ovens which can be set to the nearest second in the 10 minute range, by varying the oven's own time setting.

The exact baking time (in seconds) should be marked on the microwave together with its period of validity.

4.5 Evaluation:
Visual with reference to photographic catalogue (Appendix 6)

4.6 Important remarks
- Microwave without a safety cut-out
- Adhere precisely to the specified heating time down to the nearest second
- 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
- Electric laboratory stirrer - blade-type agitators
- Serial dispenser (e.g. Fortuna Optifix, Graf/Wertheim)
- Glass plate, arcoroc®, »Octime« series, Cristallerie d´Arques, black, octagonal, Ø 25 cm (from edge to edge), inner surface area 270 cm², individually numbered or arcoroc® Cosmos, flat 23 cm, no. 10980
- Rack for storing and pre-drying the soiled plates horizontally
- Thermal cabinet (recirculating air), e.g. Memmert or 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. no. 85650 Fluka Biochemica
- Maize starch: e.g. no. 85652 Fluka
- Rice starch: e.g. no. 85654 Fluka
- Wheat starch: e.g. no. 11685 Merck or no. 85649 Fluka
- Synthetic water as defined in Appendix 4

5.3 Preparation:
Make an adequate quantity of 0.65% starch suspension depending on the number of plates to be soiled. The quantity can also be multiplied, e.g. using a 1.3% or 2.6% starch suspension. The procedure described uses a 0.65% starch suspension.

Example for a 1000 g batch:
Weigh 993.5 g of cold synthetic water as defined in Appendix 4 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. Weigh 1.625 g of each of the four starch types (total weight 6.5 g) and pour into the second glass beaker.
Stirring continuously, transfer the starch mixture 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 10 min. Then remove the glass beaker from the water bath and, still stirring continuously, allow it to cool to room temperature. Add an appropriate quantity of water to compensate for any water evaporation loss (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 the nearest mg. The scale should be placed in a cabinet with a door to protect it from air movements.

Now set the dispenser so that about

$$29.5 \pm 0.1 \text{ g}$$

of the suspension is metered (this is a guide value; the exact setting must be determined experimentally beforehand).

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 horizontally on shelves and leave them there until they are visually dry (overnight).
Then stack the plates in plate racks and continue drying for 4 hours at 80°C in the thermal cabinet.
If the 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 should weigh between

0.189 und 0.216 g (0.75 ± 0.05 mg/cm²).

Plates deviating from this range cannot be used. If the plates are outside the approved range, the quantity of starch applied can be adapted by varying the quantity dispensed (in this case 29.5 ml).

After the wash test, place the plates in the thermal cabinet to dry at 80°C for at least 1 h.

After cooling, weigh within 30 minutes.

5.5 Evaluation

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

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 horizontal 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 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.
- Before applying the starch solution, the plates must be free of surface-ac-

tive soil as otherwise the plate surface will not be wetted.

- If no laboratory dishwasher is available for thorough washing, it is possible to use the heavy-duty cycle in a household dishwasher with a classic high-alkalinity detergent.
- 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 a static charge, particularly in conditions of low humidity, and this can lead to weighing errors. This can be prevented by placing the glass dishes on an anti-static surface prior to weighing.

6. Porridge (conforming to EN 50242)

6.1 Apparatus:

- Soup plates, diameter 23 cm, white, glazed porcelain (e.g. complying with EN standard, Arzberg tableware or similar)
- Magnetic stirrer with hotplate and magnetic stirring table
- Stainless steel saucepan
- Time switch
- Temperature sensor
- Thermal cabinet (recirculating air)
- Brush for application

6.2 Raw materials:

- 50 g porridge oats (e.g. Peter Kölln, Blütenzarte Köllnflocken)
- 250 ml milk, pasteurised (fat content: 1.5%)
- 750 ml cold water, synthetic, as defined in Appendix 4

6.3 Preparation

Stir the porridge oats into the water and milk, heat steadily and boil for 10 min, stirring continuously.
Using a brush, spread 3 g of hot porridge evently on the inner plate surface. Keep the rim of the plate free.

Quantity applied/area:

10.6 ± 0.5 mg/cm²

Dry the soiled plates for 2 h at 80°C in the thermal cabinet. When they have cooled to room temperature, the plates can be washed.

6.4 Evaluation

After washing, the performance is evaluated by visual inspection of the remains of the porridge with reference to the photographic catalogue (Appendix 6).

Immerse the plates in an iodine solution to make it easier to identify the residual soil from the porridge. Prepare the iodine solution in compliance with EN 50242.

Important information:
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.

7. Egg yolk

7.1 Apparatus:

- Stainless steel sheets (brushed on one side), 10 x 15 cm
- Flat brush (pure Chinese hog bristles), 2 1/2"
- Glass beaker
- If necessary, device for manually separating egg yolk from egg white Trennen von Eigelb und Eiweiß
- Fork
- Kitchen strainer (approx. 0.5 mm mesh)
- If necessary, holding device for immersing and drying (prupose-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, thoroughly wash the numbered sheets at 95°C in a laboratory dishwasher with a high-alkaline commercial detergent (cf. 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 1.0 ± 0.1 g of egg 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 (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 min at 80 °C. After this, weigh the cooled egg-coated sheets. After weighing, the sheets must be stored for at least 24 hours at room temperature before they can be used.

Approval requirement:
500 ± 100 mg/140 cm²
(egg yolk after denaturation).
After the wash test, dry again for 30 min at 80 °C in the thermal cabinet and weigh again after cooling.

7.4 Evaluation:

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

7.5 Important remarks

- To prevent injury, deburr the steel sheets before they are used for the first time.
- No water stains or fluff on the surface (visual inspection/repolish if necessary)
- Leave the freshly coated sheets horizontal to prevent the formation of droplets on the edges.

8. Minced meat on procelain plates

8.1 Apparatus:

- Tea plates (Arzberg, white, glazed porcelain) conforming to EN 50242, form 1495, no. 0219, diameter 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 Appendix 4
- Phloxin B, 0.01% in water

8.3 Preparation:

(Preparation as for minced meat in glass dishes as defined in section 3).
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 mince-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 min. Using a fork, spread 3 g of the minced meat/egg/water mixture on each white porcelain plate, leaving an unsoiled margin of 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 120 °C.

The soiled plates can be used as soon as they have cooled. Stack the plates with paper towels between them.

8.4 Evaluation:

After washing, immerse the plates in phloxin B solution (0.01% in water) for better identification of the minced meat residues.
After washing, the performance is evaluated by visual inspection of the colour reaction of the minced meat residues with reference to the photographic catalogue (Appendix 6).

8.5 Important remarks

- If pork is not available beef can be used on its own.
- The phloxin B solution should be stored in the dark.
- When working with phloxin B solution gloves should be worn to prevent staining on the hands.

9. Egg/milk

9.1 Apparatus:

- Bowl
- 50 ml measuring cylinder
- Egg whisk
- Flat brush
- Saucepan (at least 17.5 cm high)
- Hotplate
- If necessary a holding device for drying and immersing (purpose-built)
- Stainless steel sheets (brushed on one side), 10 x 15 cm
- Laboratory balance (accuracy 1 mg)
- Thermal cabinet (recirculating air)

9.2 Raw materials:

- 160 g egg (egg yolk and egg white, approx. 3 - 4 eggs)
- 50 ml semi-skimmed UHT milk (1.5% fat, ultra-heat treated, homogenised)

9.3 Preparation:

The stainless steel sheets for soiling must be clean and grease-free. To this end, thoroughly wash the numbered sheets in a laboratory dishwasher with a high-alkaline commercial dishwashing detergent (cf. 1.2) and polish dry with a cellulose cloth. Thereafter, the soiling surface of the cleaned sheets should not be touched. There should be no water stains or fluff on the surface.
Using the egg whisk, beat the raw egg (egg yolk and egg white, 160 g) in a bowl. Stir 50 ml milk and 160 g egg together without generating froth. Before soiling, treat the sheets in the thermal cabinet (30 min/80 °C), allow to cool, and then weigh. Using the brush, uniformly distribute 1.0 ± 0.1 g egg/milk mixture on the brushed side of the stainless steel sheets (use the balance to check), leaving an approx. 1.0 cm wide unsoiled margin along the short sides.
Dry the sheets horizontally (for at least 4 h and max. 24 h at room temperature). Then immerse the sheets in boiling demineralised water for 30 seconds. Dry the sheets in the thermal cabinet for 30 min at 80 °C. After cooling, weigh the egg/milk sheets. Leave the soiled sheets for 24 hours before reuse.

The quantity applied per sheet after denaturation is:

190 ± 10 mg

Sheets deviating from the specifications must not be used.

9.4 Evaluation:

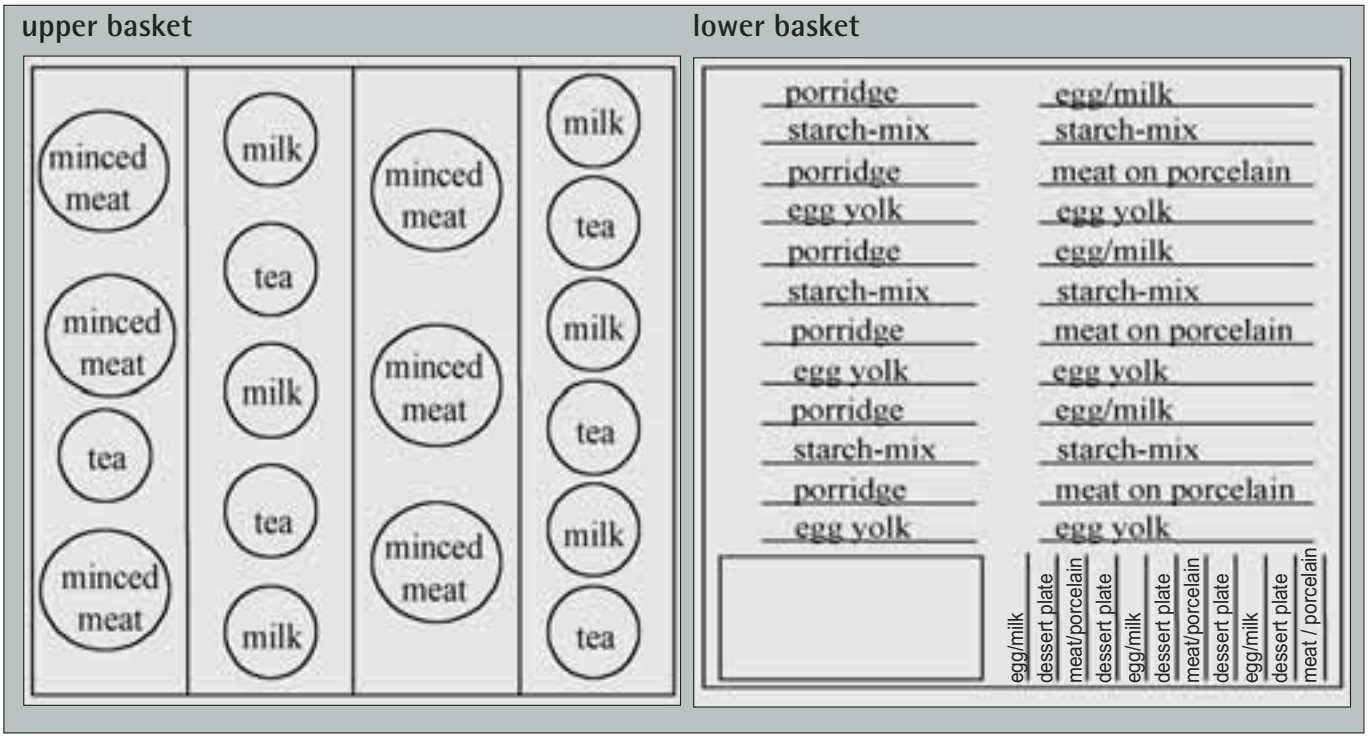
After washing, dry the sheets again for 30 min at 80°C, allow to cool, and weigh.

$$\%\ \text{cleaning performance} = \frac{\text{mg egg/milk released} \times 100}{\text{mg egg/milk applied (after denaturation)}}$$

9.5 Important remarks:

- No water stains of fluff on the surface (visual inspection/repolish if necessary)
- Keep the freshly coated sheets horizontal to prevent the formation of droplets on the edges.

Appendix 1 Loading plan taking the example of the Miele reference dishwasher



Appendix 2a Raw materials for test soils

Ballast soil:	see Apendix 3
Eggs:	Quality class A Weight class L
Minced meat:	Lean pork without sinew Lean beef without sinew
Porridge oats:	»Blütenzarte Köllnflocken« Full grain oat flakes Peter Kölln; D-25333 Elmshorn
Iodine:	0.05 mol I_2 volumetric solution
Milk:	semi-skimmed UHT milk 1.5 % Fat Ultra-heat treated homogenised
Pholoxin B	Phloxin B Merck no. 1.15926.0025
Starch mix:	Examples: **Wheat** starch for biochemical purposes E. Merck/Darmstadt; no. 11685.1000 E or no. 85649 Fluka **Maize** starch for biochemical purposes no. 85652 Fluka **Rice** starch for biochemical purposes no. 85654 Fluka Starch (native **potato starch)** for biochemical purposes no. 85650 Fluka
Tea:	Black tea Variety:. Assam, e.g. »Teekanne« Synthetic water (see below)
Water:	Ferric sulphate, dehydrated, pure (x H_2O) Synthetic water (3.00 mmol Ca+Mg as described in Appendix 4) Calcium Chloride Dihydrate for analysis Magnesium Sulphate Heptahydrate for analysis Sodium Hydrogencarbonate for analysis

Appendix 2 b Apparatus

Device	Example	Adress	Application
Drying oven up to 300°C	Heraeus	Heraeus W.C. Heraeus GmbH Produktbereich Elektrowärme Postfach 1553 63450 Hanau, Germany	Minced meat in glass vessels
Mincer	Perforated disk 8/3, Hole diameter 3 mm	Electric appliance stores	Minced meat in glass vessels Minced meat on porcelain plates
Freezer cabinet		Electric appliance stores	Minced meat in glass vessels Minced meat on porcelain plates
Kitchen hand blender	Braun	Electric appliance stores	Minced meat in glass vessels Minced meat on porcelain plates
Microwave oven with glass turntable	Bosch, Miele	Electric appliance stores	Milk in microwave oven
Serial dispenser	Fortuna Optifix Basic, 1.0 ml	Graf/Fortuna Am Bildacker 3-7 97877 Wertheim, Germany	Milk in microwave oven, Starch mix
Water bath	IKA Temperaturheizbad	Janke & Kunkel GmbH & Co.KG IKA Labortechnik Postfach 1263 79217 Staufen, Germany	Starch mix
Electric laboratory stirrer + blade type agitators + paddle agitator	IKA Eurostar	Janke & Kunkel GmbH & Co.KG Postfach 1263 79217 Staufen, Germany	Starch mix, porridge
Recirculation thermal cabinet	Memmert or Binder	Memmert GmbH & Co. KG Postfach 1520 91126 Schwabach Binder GmbH Postfach 102 78502 Tuttlingen, Germany	Starch mix, porridge, minced meat on porcelain plates, milk in microwave oven
Balance with range up to 1200 g, accuracy 1 mg	Sartorius	Sartorius AG Weender Landstr. 94-108 37070 Göttingen, Germany	Starch mix, egg/milk, egg yolk
Magnetic stirrer with hotplate	IKA RET basic	Janke & Kunkel GmbH & Co. KG Postfach 1263 79217 Staufen, Germany	Porridge, egg/milk

Appendix 2 c List of necessary items to be soiled

Soiling	Qty.	Item	Description and Manufacturer
Tea	6	Tea cups	e.g. Bauscher; no. 6215/18 or Schönwald; colour: white; form: 98L/0.19 Rehauerstr. 44-54, 95173 Schönwald, Germany
Minced meat, encrusted	6	Crystallisation dishes	e.g. Duran/Schott; ∅115 mm; h 65 mm No. 213114908; Schott Glaswerke Hattenbergstr. 10 55014 Mainz, Germany
Milk in the microwave	6	Glass beakers	e.g. Witeg; 150 ml short version, ∅ 55 mm, h 80 mm
Starch mix	6	Glas plates	arcoroc®, »Octime« series, black, octagonal, ∅ 25 cm (from edge to edge), inner surface area 270 cm^2; arcoroc®, Cosmos series, 23 cm flat, no 10980 ARC International Avenue du General de Gaulle 62510 Arques / France
Porridge	6	Soup plates	∅ 23 cm; e.g. Arzberg White glazed porcelain or equivalent DIN-compliant dishes Arzberg Ludwigsmühle 95000 Selb, Germany
Egg yolk	6	Stainless steel sheets	10 x 15 cm, brushed on one side; WMF AG Dr. Fehse 73309 Geislingen / Steige, Germany
Minced meat on porcelain plates	6	Dessert plates	Fa. Arzberg (see soup plates) White glazed porcelain conforming to EN 50242, form 1495, no. 0219; ∅ 19cm
Egg/milk	6	Stainless steel sheets	see egg yolk

Appendix 3 Production instructions for ballast soil

Raw material	% content	kg for 25 kg
Fat constituents		
Vegetable oil (e.g. Aro, Metro)	31.6	7.9
Margarine (e.g. Homann, Allgäu Margarine)	6.3	1.575
Lard (e.g. Laru, Langensiepen & Ruckebier)	6.3	1.575
Deep-frying fat (e.g. Aro, Metro, halbflüssig)	6.3	1.575
Protein constituents		
Full egg (e.g. Wiesenhof)	15.8	3.95
Cream (e.g. Debic, UHT cream, 32 % fat)	9.4	2.35
Whole milk, pasteurised, 3.5 % fat	6.3	1.575
Powdered constituents incl. starch		
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 % (chemicals supplier)	0.3	0.075
Other constituents		
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 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 ingredients and mix everything to a smooth paste.
6. Finally, put 50 g of the soil mix into each plastic beaker. Deep freeze them and keep them in the freezer until required.

Appendix 4 Instructions for the production of synthetic water

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 $MgSO_4 * 7 H_2O$ (38.0 g/l)
   - Solution 3: 446.1 mmol/l $CaCi_2 * 2H_2O$ (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 and fill with additional demineralised water up to 10 l. Before using the synthetic water, its pH value should be adjusted to 7.5 with HCl or NaOH.

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

Appendix 5 Calibration instructions for microwave oven

Instructions for checking the actual microwave output

The microwave output is calculated in accordance with EN 60705.

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 water's initial temperature should be 10 °C ± 0.1 °C. Measure it immediately before placing it 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, the microwave should be allowed to cool for at least half an hour. The test is to be repeated at least once.
Measure the water's final temperature after mixing it thoroughly.

The following equation is used to calculate the microwave's effective output:

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

P_{eff} = Microwave's effective output in W
T_2 = Final temperature in °C
T_1 = Initial temperature (10°C)
t = Time switched on in seconds
4187 = Water's specific heat capacity in J kg^{-1} K^{-1}

1.6 seconds should be deducted 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

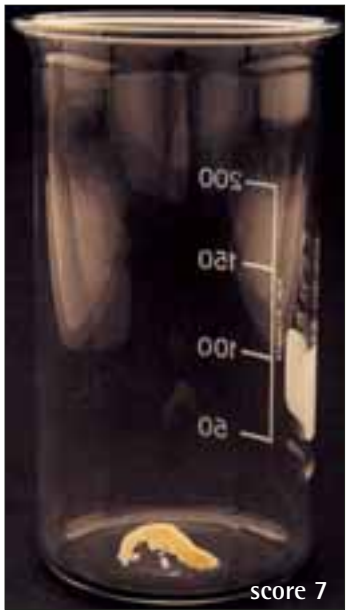
nominal output / calculated effective output (P_{set}/P_{eff}).

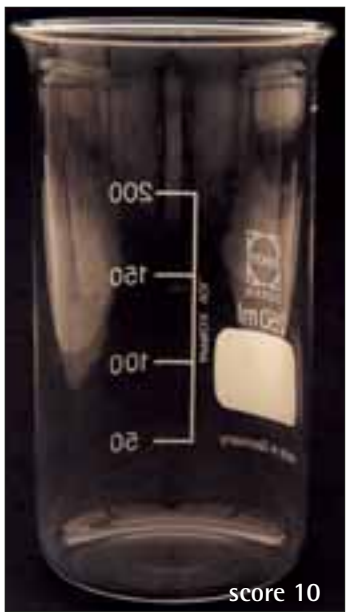
Extend or shorten the baking times by this factor. A time switch is recommended for this.

Appendix 6 Photo catalogue for visual evaluation

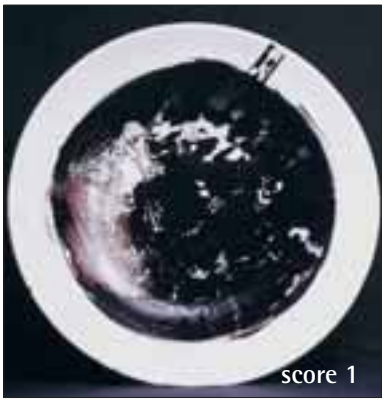
Bleachable stains: Tea

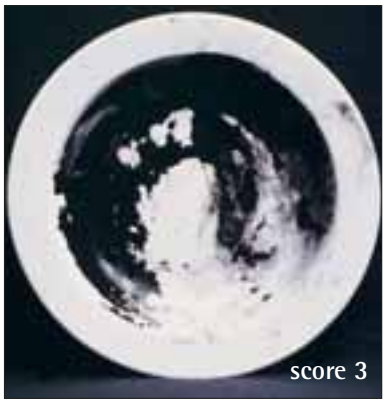
Persistent, burnt soil: milk in the microwave

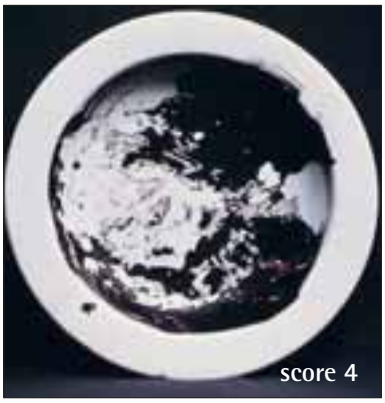




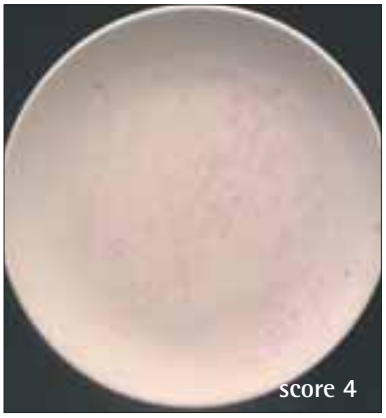
Amylase-specific soil: Porridge (in accordance with EN 50242)

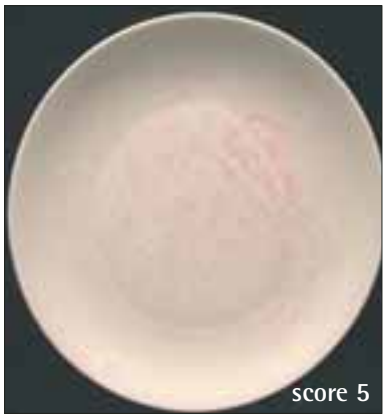


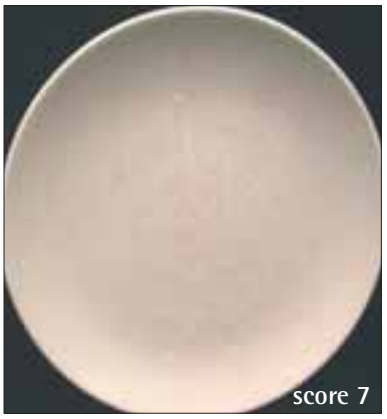


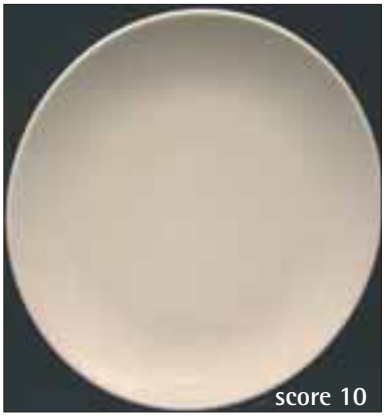


Protease-specific soil: Minced meat on porcelain plates (by analogy with EN 50242)

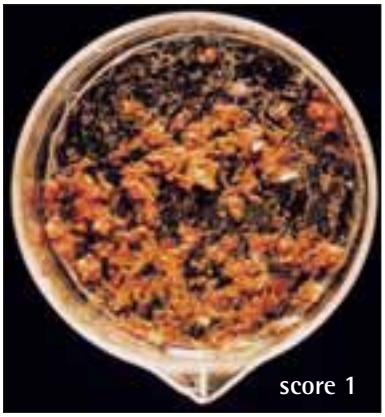


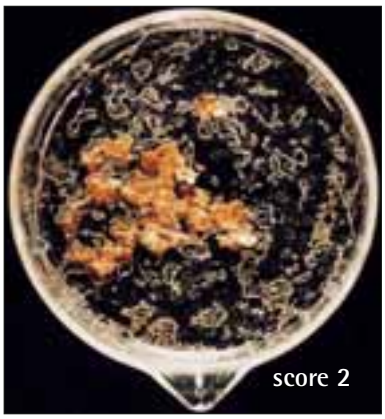


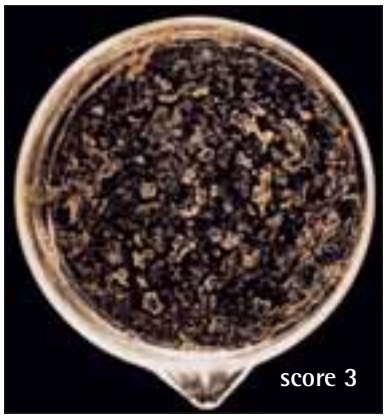


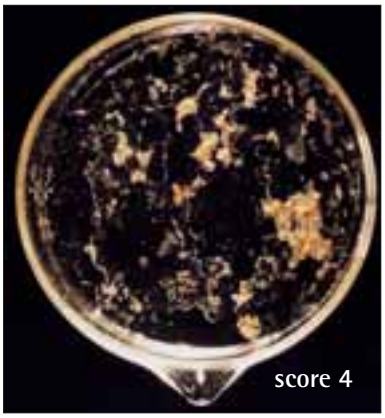


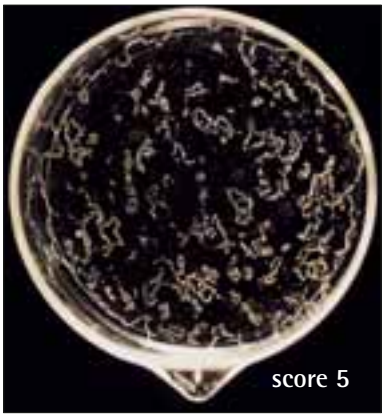
Persistent, burnt soil: Minced meat on glass dishes

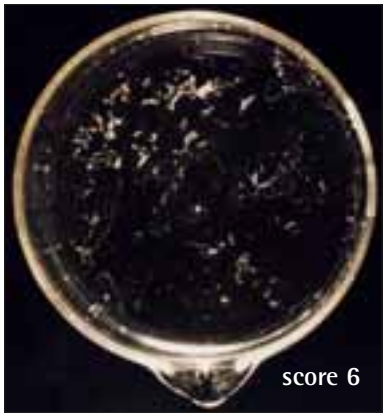


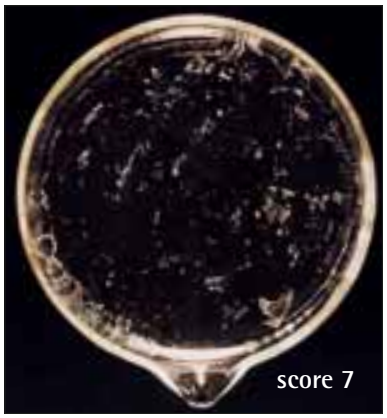


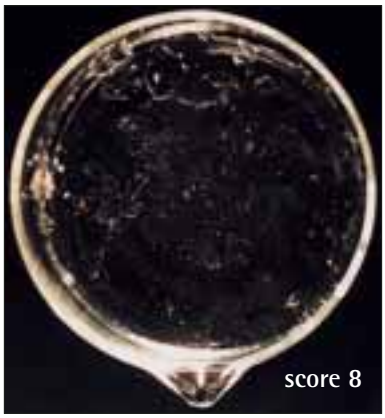


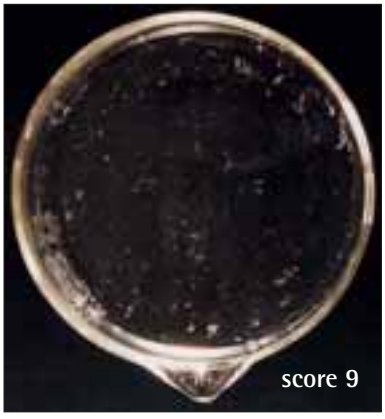












* *Corresponcence address:*
Industrieverband Körperpflege- und Waschmittel e.V. (IKW)
Karlstraße 21
60329 Frankfurt am Main
Germany
Email: info@ikw.org