

# Testing Household Washing Machines acc. IEC 60456 Edition 4

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for

IEC 60456 Workshop  
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## IEC 60456 - Scope

**This International Standard deals with the methods for measuring the performance of clothes washing machines with or without heating devices and for cold and/or hot water supply, for household use. It also deals with appliances for water extraction by centrifugal force. It is also applicable to appliances for both washing and drying textiles (called washer-dryers) with respect to their washing performance.**

**The object is to state and define the principal performance characteristics of household electric washing machines and spin extractions and to describe the standard methods for measuring these characteristics.**

**This standard is not concerned with safety requirements.**



## IEC 60456 – Performance Tests

## Five key elements:

1. Washing performance

2. Rinsing performance

3. Spin extraction performance

4. Water and energy consumption and programme time

5. Wool Shrinkage

AT ONE TIME POSSIBLE





Soil  
 Laundry  
 Water  
 Detergent  
 Ambient Conditions

# IEC 60456

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## 1. Performance Test – Summary Washing Performance



Machine under test

**Soil (cloth)**

**Laundry**

**Water**

**Detergent**

**Ambient Conditions**



Reference machine

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**Soil**  
Laundry  
Water  
Detergent  
Ambient Conditions

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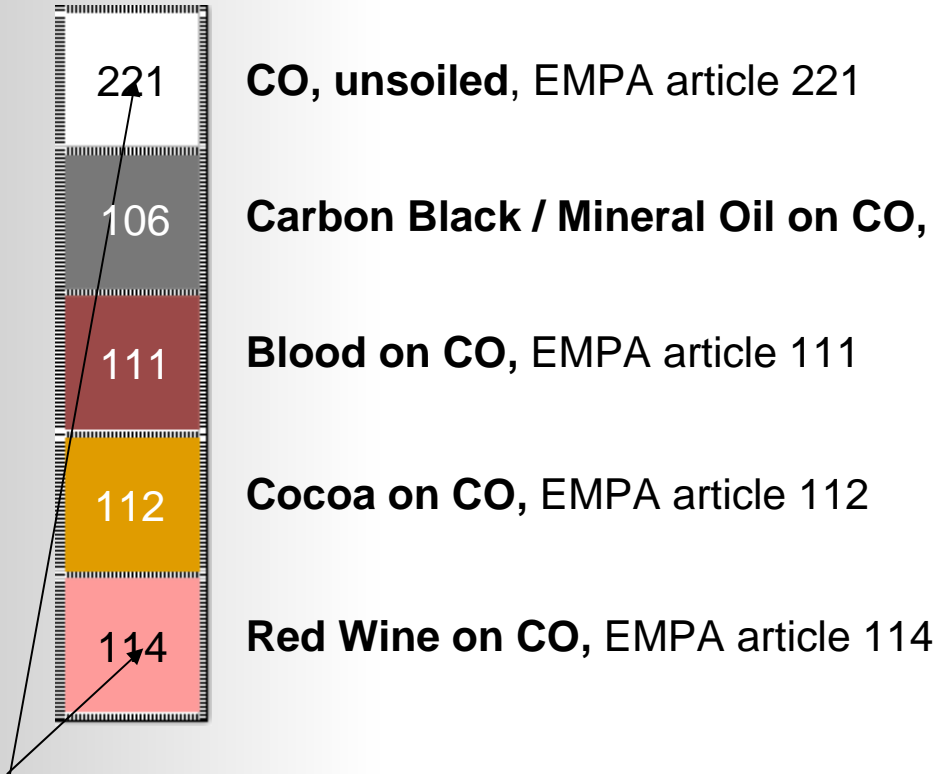
## 1. Performance Test – Test Conditions

### 1.1. Performance test – the “soil” strips

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## 1. Performance Test - Soil Strips



**EMPA Article 105**

Each sample is 15 x 15 cm





**Soil**  
 Laundry  
 Water  
 Detergent  
 Ambient Conditions

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## 1. Performance Test - Soil Strips

### Certification

221	<b>EMPA 105</b>	<b>Serial number:</b>	<b>233</b>
106	<b>Test strips according to IEC/EN 60456 ed.4</b>		
111	<b>Limit date for use:</b>	31. December 2007	
112	<b>Storing conditions:</b>	On receipt of a batch of test strips, the strips must be stored at once in a cool, dark place and kept well packed.	
114		Storage temperature: Between -20°C and +5°C.	
		<b>Packaging:</b>	vacuumed
	<b>Please note:</b>	Before opening a packet of test strips please allow packet to acclimatise to room temperature.	

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**Soil**  
 Laundry  
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## 1. Performance Test - Soil Strips

### Certification



Tristimulus values Y:

	soiled fabric	cotton 60°C ; 180 g	cotton 40°C ; 180 g	cotton 60°C ; 90 g	ratio 40°C/60°C	ratio 90 g/180 g	defined ratios and tolerances	
							40°C/60°C	90 g/180 g
Carbon blacks	25.5 0.3	43.1 0.4	38.3 0.6	41.0 0.5	0.89	0.95	0.88 ± 0.03	0.94 ± 0.03
Bloods	17.7 0.5	87.7 0.3	81.2 0.5	82.1 0.6	0.93	0.94	0.91 ± 0.04	0.92 ± 0.05
Cocoas	37.0 0.3	67.3 0.6	59.7 0.5	60.0 0.8	0.89	0.89	0.89 ± 0.04	0.88 ± 0.05
Red Wines	47.7 0.5	82.9 0.5	72.2 0.5	75.4 0.4	0.87	0.91	0.87 ± 0.03	0.92 ± 0.03
Sum	127.9 0.4	281.0 1.0	251.4 1.0	258.5 1.6	0.89	0.92	0.89 ± 0.02	0.92 ± 0.02

Washing Conditions:

According to IEC 60456, Fourth Edition  
 Washed with Wascator FOM 71 MP Lab  
 Number of cycles: 5  
 Detergent IEC-A\*. Batch: 215-853  
 Dosage: 180 g (60°C and 40°C) and 90 g (60°C)  
 Sodium Perborate Batch: SPB4. 175-426  
 TAED Batch: 004052  
 Load: 4/4; new loading scheme

Measuring conditions:

Instrument: Spectraflash 500 (Spectral photometer)  
 Illuminant / observer: D65 / 10°  
 Measuring geometry: d/8°  
 Wavelength range: 420 to 750nm  
 UV filter: UV barrier at 420nm  
 Measuring diameter: 26mm  
 Gloss: excluded





## 1. Performance Test - Soil Strips

### Detailed production specifications

### Detailed performance requirements

Soiling	Ratio Cotton 40 °C/ Cotton 60 °C	Cotton 60 °C, Ratio: 90 gr /180 gr
Carbon black/oil	0.88 +/- 0.03	0.94 +/- 0.03
Blood	0.91 +/- 0.04	0.92 +/- 0.05
Cocoa	0.89 +/- 0.04	0.88 +/- 0.05
Red wine	0.87 +/- 0.03	0.92 +/- 0.03
Sum	0.89 +/- 0.02	0.92 +/- 0.02

*Ratio requirements for reference machine results*

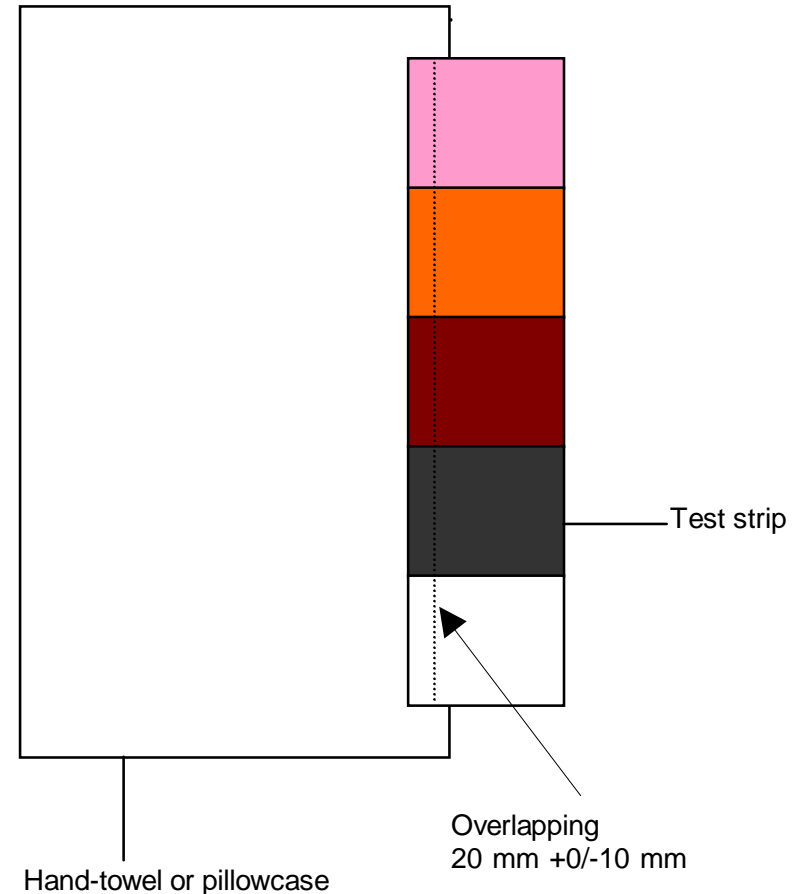


## 1. Performance Test - Soil Strips

### Attachment and number of pieces

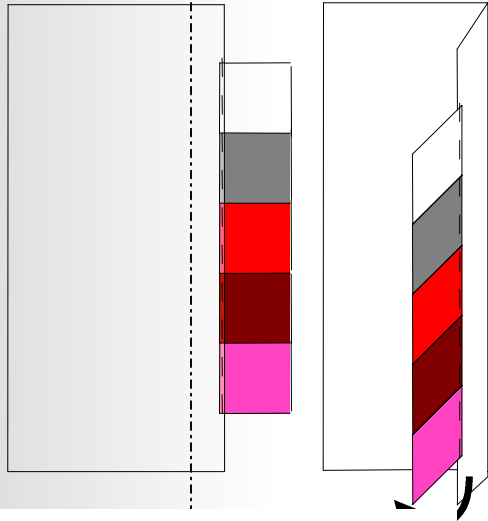
Rated capacity in kg	Number of test strips
up to 2,4	2
2,5 to 3,4	3
3,5 to 4,4	4
4,5 to 5,4	5
5,5 to 6,4	6
6,5 to 7,4	7
7,5 to 8,4	8
more than 8,5	9

***New strips used for each cycle***



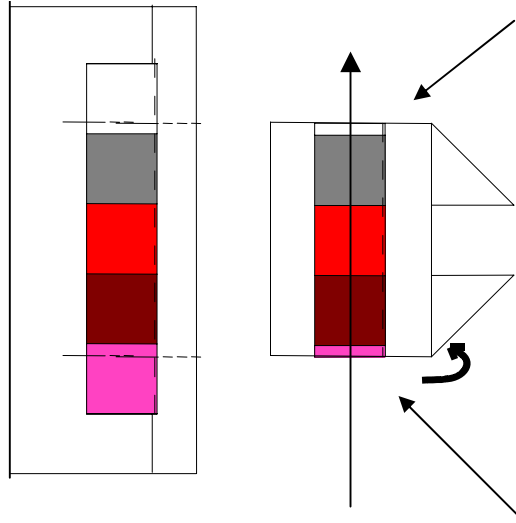
## 1. Performance Test - Soil Strips

### Towel + strip



Towel is folded once on the strip side so that the fixed strip lies in the middle of the towel.

supplier and serial number visible



Towel is folded twice again at the short side, so that the three stains remain at the upper side of the towel.

Upper Side

Long side of test strip perpendicular to drum axis

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Soil  
**Laundry**  
Water  
Detergent  
Ambient Conditions

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## 1. Performance Test – Test Conditions

### 1.2. Performance test – the load

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## 1. Performance Test - Load

### Base loads :

<b>Cotton :</b>	<b>Substrate :</b>	<b>100% cotton sheets / pillowcases / hand-towels</b>
	<b>(Test pieces :</b>	<b>Cotton soiled strips)</b>
<b>Easy care :</b>	<b>Substrate:</b>	<b>65% polyester and 35% cotton</b>
	<b>(Test pieces :</b>	<b>Cotton soiled strips)</b>
<b>Usage :</b>	<b>Cotton :</b>	<b>Average age : 30 till 50 cycles</b> <b>Max. number of test cycles : 80</b>
	<b>Easy care :</b>	<b>Average age : 20 till 60 cycles</b> <b>Max. number of test cycles : 80</b>





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## 1. Performance Test - Load

Cotton base load

Bed Sheets

Pillowcases

Towels

Criterion for conditioned new textiles	Bed sheets	Pillowcases	Huckaback hand towels
Substrate	Long Staple Pure Cotton		
Yarn	Ring Spun		
<b>Yarn Twist (T/m)</b>			
Warp	600 ± 20		610 ± 20
Weft	500 ± 15		490 ± 15
<b>Yarn Count (tex)</b>			
Warp	33 ± 1		36 ± 1
Weft	33 ± 1		97 ± 1
Weave	Plain Weave Linen 1/1		Huckaback
<b>Pick Count (pick/cm)</b>			
Warp	24 ± 1		20 ± 1
Weft	24 ± 1		12 ± 1
Mass per Unit Area (g/m <sup>2</sup> )	185 ± 10		220 ± 10
<b>Dimensions (mm)</b>			
Length	2400 ± 150	800 ± 50	1000 ± 50
Width	1600 ± 40	800 ± 20	500 ± 30
Weight per piece (g)	725 ± 15	240 ± 5	110 ± 3
Finish	Desizing, Boiling off, Singeing, Bleaching, no Filling or Stiffening Size		
<b>Criterion for washed textiles</b>			
Water uptake in %*	138 ± 10	138 ± 10	250 ± 15
<b>Shrinkage Warp in %</b>			
0 to 5 cycles	- 5 ± 1	- 7 ± 1	- 16,5 ± 1
> 5 to 25 cycles	- 3 ± 1	- 3 ± 1	- 3 ± 1
<b>Shrinkage Weft in %</b>			
0 to 5 cycles	- 5 ± 1	- 7 ± 1	- 11 ± 1
> 5 to 25 cycles	- 3 ± 1	- 3 ± 1	- 3 ± 1





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## 1. Performance Test - Load

### Cotton base load

- Number of pieces

Rated capacity kg	Number of sheets	Number of pillowcases	Number of hand-towels
2	1	2	Number required to make the test load <b>after the addition of the test strips 7.4 as close as possible to the rated capacity.</b>
2,5	1	3	
3	1	4	
3,5	2	3	
4	2	4	
4,5	2	6	
5	2	6	
5,5	2	8	
6	2	8	
6,5	2	10	
7	2	12	
7,5	3	12	
8	3	14	
8,5	3	16	
9	3	18	
9,5	3	20	
10	3	22	

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## 1. Performance Test - Load

**Preparation: 5 times wash with 15g/kg of A\* (three ingredients)**

**Normalization : After 5 wash cycles : 1 wash cycle 60°C in Wascator**

**Dry : Till a final moisture content of approximately 0%**

**Conditioning : To  $(20 \pm 2)$  °C and relative humidity  $(65 \pm 5)$  %  
At least 15 hours**







## 1. Performance Test – Load Preparation

### Cotton Base load:

For the test, a base load previously normalized and conditioned will be taken from a room with 20°C and a relative humidity 65%.

This base load consists of four parts with different ages :

- |                 |                               |
|-----------------|-------------------------------|
| <b>Part 1 :</b> | <b>01 till 20 Washcycles</b>  |
| <b>Part 2:</b>  | <b>21 till 40 Waschcycles</b> |
| <b>Part 3 :</b> | <b>41 till 60 Waschcycles</b> |
| <b>Part 4 :</b> | <b>61 till 80 Washcycles</b>  |



## 1. Performance Test – Load Preparation

**Exchange of base load items in order to achieve a weighted average age between 30 and 50 test cycles**

- 1 – 20 cycles**
- 21 – 40 cycles**
- 41 – 60 cycles**
- 61 – 80 cycles**

**At each change after 20 cycles, items are added which have been pre-treated for 5 cycles.**

**The old items that have been washed for 80 cycles must be removed.**



## 1. Performance Test - Load

### Easy-care base load

**The easy-care base load shall consist of an equal number of men's shirts and pillowcases (as defined in Annex B).**

**The men's shirts are made of :  $(65 \pm 3)$  % Polyester and  $(35 \pm 3)$  % Cotton**

**The pillowcases are made of :  $(65 \pm 3)$  % Polyester and  $(35 \pm 3)$  % Cotton**

**Final adjustment of the test load is made after adding the soiled test strips, by adding or subtracting one shirt or one pillowcase whichever adjusts the test load to be closest to the rated capacity.**

**If the manufacturer declares the easy-care textile load as a "number of shirts", the rated capacity (kg) shall be the number of shirts multiplied by 0.2!**





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**Laundry**  
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## 1. Performance Test - Loading

### 1.2.1. Performance test – loading

*(will be shown tomorrow in the practical part !)*

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Laundry  
**Water**  
Detergent  
Ambient Conditions

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## 1. Performance Test - Water

### 1.3. Performance test – the water

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## 1. Performance Test - Water

**Water hardness:**  $2,5 \pm 0,2$  mmol/l

**Water preparation:** If water hardness needs to be adjusted, it shall be prepared according to IEC 60734.

**Water temperature:**

<b>Cold water</b>	$15 \pm 2$ °C
<b>Hot water</b>	temperature indicated by the manufacturer $\pm 2$ °C, or $60 \pm 2$ °C, if a value is not given.





Soil  
Laundry  
Water  
**Detergent**  
Ambient Conditions

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## 1. Performance Test - Detergent

### 1.4. Performance test – the detergent

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## 1. Performance Test - Detergent

### Detergents

Detergent A\* is for Horizontal Drum washing machines

#### For Cotton :

Reference washing machine (5 kg) :	180g A* (three ingredients)
Test washing machine :	54g + 16g/kg <u>of rated capacity</u>

#### For Easy care :

Reference washing machine (2 kg) :	150g A* (three ingredients)
Test washing machine :	54g + 16g/kg <u>of rated capacity</u>

The proportions of ingredients of the ready detergent A\* are:

- a) 77% basic powder with enzyme and foam inhibitor
- b) 20% sodium perborate tetrahydrate
- c) 3% Bleach activator tetra-acethylethylenediamine







Soil  
Laundry  
Water  
**Detergent**  
Ambient Conditions

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## 1. Performance Test - Detergent

### Detergent: Type A\*, Composition

Ingredient	%	Tolerance ( ± )
Linear sodium alkyl benzene sulfonate	8,8	0,5
Ethoxylated fatty alcohol C <sub>12/14</sub> (7 EO)	4,7	0,3
Sodium soap (tallow soap)	3,2	0,2
Foam inhibitor concentrate (12 % silicon on inorganic carrier)	3,9	0,3
Sodium aluminium silicate zeolite 4 A (80 % active substance)	28,3	1,0
Sodium carbonate	11,6	1,0
Sodium salt of a copolymer from acrylic and maleic acid (granulate)	2,4	0,2
Sodium silicate (SiO <sub>2</sub> :Na <sub>2</sub> O = 3,3:1)	3,0	0,2
Carboxymethylcellulose	1,2	0,1
Phosphonate (DEQUEST 2066, 25 % active acid)	2,8	0,2
Optical whitener for cotton (stilbene type)	0,2	0,02
Sodium sulfate	6,5	0,5
Protease (Savinase 8.0)	0,4	0,04
Sodium perborate tetrahydrate (active oxygen 10,00 – 10,40 %)	20,0	
Tetra-acetythylenediamine (active content 90,0 – 94,0 %)	3,0	

**Dosage:**

**Machine under test:**

**54 g + 16 g/kg of rated capacity**

**Reference machine:**

**180 g**

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## 1. Performance Test - Detergent

### Detergent: Type C, Composition

Ingredient	%
Sodium dodesylbenzene sulfonate	13 ± 0,2
Sodium tripolyphosphate	30 ± 0,5
Alkaline sodium silicate (Na <sub>2</sub> O, 2SiO <sub>2</sub> )	10 ± 0,1
Sodium carboxymethylcellulose	0,8 ± 0,1
Sodium sulfate	36,2
Water	10

**Reference detergent C is for use in agitator and impeller washing machines.**

**Dosage: 19 g/kg of rated capacity for water hardness 0,5 mmol/l**





## 1. Performance Test – Reference Washing Machine

### 1.5. Performance test – the reference machine



## 1. Performance Test – Reference Machine

### HA Frontloader

Detailed 'generic' specification  
(normative Annex A)

Machine currently used:

Electrolux Wascator FOM 71MP/Lab,  
fully programmable,  
also specified in ISO textile standards

Future reference machine:

Electrolux Wascator FOM 71 CLS

IEC Programs: Cotton 40°C, 60°C, 85°C

Easy care 40°C, 60°C

Wool 40°C



FOM71MP/Lab

## 1. Performance Test - Rated Capacity of machine under test

<u>Rated capacity:</u>	<b>Declared (by the manufacturer)</b>	<b>Use the declared rated capacity</b>
<u>Rated capacity :</u>	<u><b>Not declared</b></u>	<b>Deduced from the volume of the drum :</b>

<b>Horizontal drum WM</b>	<b>1 kg / 13 l</b>
<b>Agitator WM</b>	<b>1 kg / 15 l</b>
<b>Impeller WM</b>	<b>1 kg / 20 l</b>
<b>Nutator WM</b>	<b>1 kg / 10 l</b>
<b>Spin extractor</b>	<b>1 kg / 4,6 l</b>

**For cotton load 100% of this rated capacity**  
**For easy care 40% of this rated capacity**  
**For Wool 20% of this rated capacity**





## 1. Performance Test - Measurement

### 1.7. Performance test – measurement

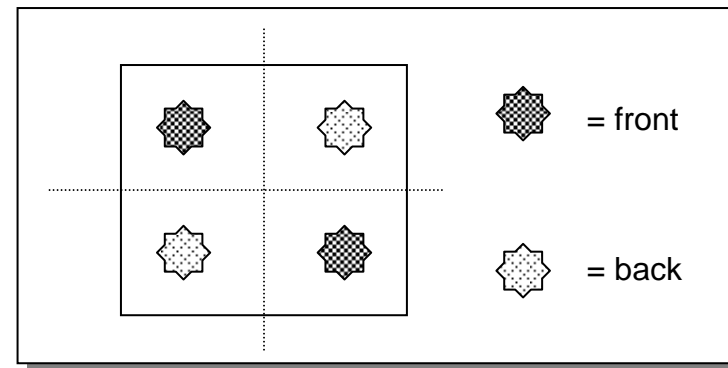
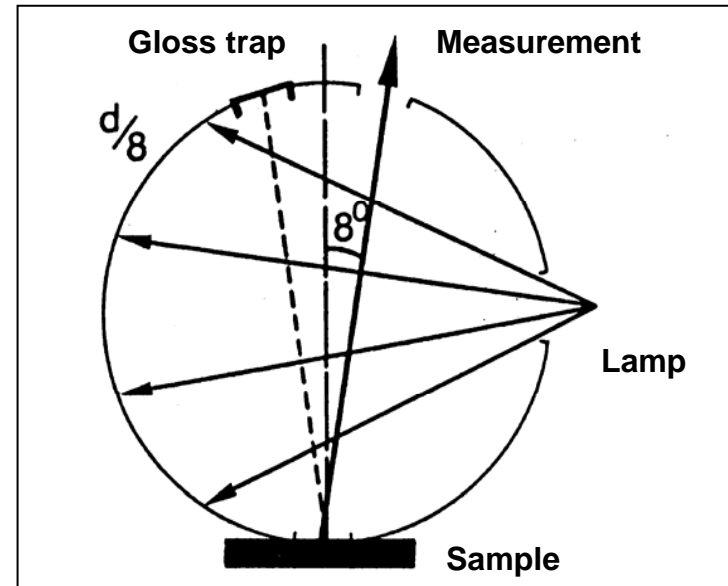


## 1. Performance Test - Measurement

### Reflectance measurement

<b>Device:</b>	<b>Spectral photometer</b>
<b>Measure:</b>	<b>Tristimulus Y (CIE 1984)</b>
<b>Illuminant / observer:</b>	<b>D65 / 10°</b>
<b>Measuring geometry:</b>	<b>d / 8°</b>
<b>UV barrier:</b>	<b>420 nm</b>
<b>Measuring diameter:</b>	<b>minimum 20 mm</b>
<b>Gloss:</b>	<b>excluded</b>
<b>Calibration white:</b>	<b>Barium sulphate or ceramic tile</b>
<b>Calibration black:</b>	<b>Black body or light trap</b>

**Strips have to be ironed!**  
**Every Swatch is measured twice each on front and rear side!**



# 1. Performance Test - Measurement

- Reflectance measurement of washed strips
- Evaluation of Tristimulus Y readings
- Calculation of normalised test result:

<p>1. Avg. reflectance / soil type:</p> $\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$	<p>2. Sum of soiling readings:</p> $C = \sum \bar{x}$	
<p>3. Avg. sum soil readings:</p> $\bar{C} = \frac{\sum_{i=1}^k C}{k}$	<p>4. Ratio machine under test/ reference machine:</p> $q = \frac{\bar{C}_{\text{test}}}{\bar{C}_{\text{ref}}}$	

*x<sub>i</sub>*: Average of the individual readings for each soiled test piece

*n*: Number of test strips in the wash

*k*: Number of cycles.





## 2. Rinsing performance

## 2. Rinsing performance



## 2. Rinsing performance - Summary

- **Evaluation of the textile rinse through residual alkalinity measurements**
- **Materials and test conditions as for washing performance test; no extra cycles necessary (5 cycles)**
- **Extraction of laundry after wash cycle in separate spin extractor (specification of drum diameter and spin speed)**
- **Evaluation:**
  - **Titration of alkalinity of tap water and extracted water**
  - **Only the last 4 cycles**



## 3. Spin Extraction Performance

# 3. Spin Extraction Performance



### 3. Spin Extraction Performance - Summary

- **Materials and test conditions as for washing performance test; no extra cycles necessary, reference machine run not needed (5 cycles)**
- **Determination of remaining moisture of base load as compared to the conditioned base load**
- **Expressed as the percentage, rounded to the nearest whole percent**
- **Equation used:**

$$\text{Remaining moisture} = \frac{M_r - M}{M}$$

**M:** Conditioned mass of the base load

**M<sub>r</sub>:** Mass of base load after extraction





## 4. Water and Energy Consumption / Programme Time

# 4. Water and Energy Consumption and Programme Time



## 4. Water and Energy Consumption and Programme Time

- **Calculation of environmental impact and cost of operation**
- **Materials and test conditions as for washing performance test; no extra cycles necessary (5 cycles)**
- **Evaluation:**
  - **Water:** expressed in litre and rounded to the nearest whole litre
  - **Time:** Programme is completed when the machine opens the door.
  - **Energy:** expressed in KWh rounded to the nearest whole KWh
  - **Cold water supply energy correction has to be made.**





## 5. Wool Shrinkage - Laundry

# 5. Wool Shrinkage - Laundry

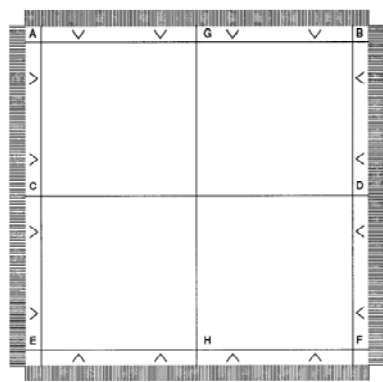


## 5. Wool Shrinkage - Procedure

### Wool shrinkage : Measurement of the shrinkage rate

Base loads : Substrate polyester different number (according to rated capacity)  
 Test pieces : three wool specimens (always only 3)  
 Preparation base loads : Not necessary

Preparation test pieces : a) 0.5 cm is frayed out round all four sides.



- b) Four “V” cuts into each side.
- c) Immerse 3 specimens in 1.5 l water at 40°C with 3g of detergent A\* for 1 hour.
- d) Water the 3 specimens, three times, in at least 1.5 l water at 15°C for 10 min without agitation.
- e) Immerse 3 specimens in water to a depth of 1 cm at 15°C for 15 min. Remove any air bubbles.
- f) The 3 specimens can be measured.

Loading the reference machine : No order of placing specified

EMPA order : 6 base / 1 wool. / 6 base / 1 wool /6 base / 1 wool /7 base.





## 5. Wool Shrinkage - Procedure

Programme reference machine :	<b><u>40°C</u> / 1x Main wash 26 l / 3x Rinse 26 l / 2x Spinning / Total water 104 l</b>
Programme test machine :	<b>Highest possible Temperature, all extra program parts</b>
Detergent :	<b>Reference machine : 70g (for 1 kg test load) Test machine : Formula = 54g + 16g/kg of rated capacity</b>
Reference and test machines :	<b>They are run in parallel (at the same time)</b>
Measurements test pieces :	<b>From second washing on</b>
Number of washings pro test :	<b>6 washings</b>
Number of tests per machine:	<b><u>Always 2</u></b>
Total number of washings per machine:	<b>12 washes (6 washes test 1 + 6 washes test 2)</b>
Total number of test pieces per machine :	<b>6 wool specimens (3 pieces test 1 + 3 pieces test 2)</b>



## 5. Wool Shrinkage - Procedure

### Evaluation :

- a) Average width and length after each test cycle (from second washing on)  
 The arithmetic mean of the individual readings for each set of three measurements (e.g. A-B, C-D, E-F and B-F, G-H, A-E) is calculated:

$$\bar{y} = \sum_{i=1}^3 \frac{y_i}{3}$$

- b) Linear felting shrinkage for width and length (from second washing on)

$$WS \text{ or } LS \% = \frac{W_{(k-1)} - W_k}{W_{(k-1)}} \times 100$$

where

**WS** is the percentage of the width shrinkage;

**LS** is the percentage of the length shrinkage;

**$W_{(k-1)}$ , and  $W_k$**  are the mean measurements (width or length) of the washed wool shrinkage specimens, after each wool programme test cycle



## 5. Wool Shrinkage - Procedure

### c) Area felting shrinkage (from second washing on)

The area felting shrinkage after each test cycle is calculated:

$$SR = WS + LS - \frac{WS \times LS}{100}$$

### d) Shrinkage rate index (only for test cycles 3, 4, 5 and 6)

The average of the percentage area felting shrinkage only for test cycles 3, 4, 5, and 6 of the two sets  $SR_{test}$  is calculated for the washing machine under test. The results of the first and second cycle shall not be used in the calculations. The corresponding value from the same batch of wool shrinkage specimens,  $SR_{ref}$  is also calculated for the reference washing machine. To calculate the shrinkage rate index the used  $SR_{ref}$  shall not be older than 3 months. The shrinkage rate index,  $SRI$ , for the washing machine is calculated as follows:

$$SRI = SR_{test} / SR_{ref}$$



## 5. Wool Shrinkage - Laundry

### Polyester base load:

- Knitted polyester textile
- Mass:  $35 \pm 3$  g
- Area weight:  $200 \pm 25$  g/m<sup>2</sup>
- Size:  $30 \pm 3$  cm x  $(30 \pm 3)$  cm,  
double layer sewn along all four edges.



## 5. Wool Shrinkage – Test Specimen

Wool quality

100 % wool fabric – plain weave

Mass per unit area

(150 ± 10) g/m<sup>2</sup> (ISO 3801)

Warp

(114 ± 10) ends per 10 cm (ISO 7211-2)

Weft

(118 ± 10) picks per 10 cm (ISO 7211-2)

Folded yarn twist

warp/weft 380 ± 20 T/m

Size of test pieces

(34 × 35) cm (approximately),  
with marker threads along the edges

— Frayed edges  
about 0,5 cm

∨-cuts, not more  
than 3 mm deep  
(the number adjusted  
to what is needed to  
avoid distortion)

- No soil added
- Water as in performance test
- use of detergent A\*

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## References

The following referenced documents are indispensable for the application of IEC 60456. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- IEC 60456:1998, *Clothes washing machines for household use - Methods for measuring the performance*
- IEC 60734: *Household electrical appliances – Performance – Hard water for testing*
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**THANK YOU VERY MUCH  
FOR YOUR ATTENTION !!**

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