



BSI Standards Publication

Specifications for industrial laundry machines - Definitions and testing of capacity and consumption characteristics

Part 3: Continuous tunnel washer

National foreword

This British Standard is the UK implementation of EN 17116-3:2019. It supersedes BS ISO 9398-3:2003, which is withdrawn.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Specifications for industrial laundry machines - Definitions
and testing of capacity and consumption characteristics -
Part 3: Continuous tunnel washer

Spécifications pour les machines de blanchisserie
industrielles - Définitions et contrôle des
caractéristiques de capacité et de consommation -
Partie 3: Tunnels de lavage

Festlegungen für Wäschereimaschinen - Definition und
Prüfung der Beladung und Verbrauchsmerkmale - Teil
3: Waschstraßen

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European foreword

This document (EN 17116-3:2019) has been prepared by Technical Committee CEN/TC 214 “Textile machinery and accessories”, the secretariat of which is held by SNV.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2020, and conflicting national standards shall be withdrawn at the latest by January 2020.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document is based on ISO 9398-3 extended by the application of the state of the art methodology to measure performance and has been prepared by the EUP Lot 24 Working Group of VDMA — ETCT European Textile Care Technology and CEN/TC 214 in collaboration with wfk-Cleaning Technology Institute, Germany.

The standard testing procedure for continuous tunnel washer is based on ISO 9398-3. It includes among others the references EN ISO 10472-1 and EN ISO 10472-3.

EN 17116-3:2019 enhances the second edition of ISO 9398-3, i.e. ISO 9398-3:2003, to comply with European Standard requirements.

ISO 9398-3:2003 is extended by state of the art methodology to measure performance. Significant technical differences from ISO 9398-3:2003 are:

- a) more detailed description of testing procedure;
- b) changed test conditions under practical *in situ* laundry conditions;
- c) introduction of a new type of test load;
- d) implementation of energy consumption of various heat sources;
- e) implementation of air compressor energy consumption;
- f) implementation of detergent consumption;
- g) implementation of washing performance, as stain/soil removal, secondary wash performance and rinse performance;
- h) comparison of wash performance with reference washing machine.

Contrary to washer extractors, dewatering of the load is carried out in separate machines, like presses or centrifuges. Therefore, these machines are not content of this standard.

A bilingual version of this publication may be issued at a later date.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria,

Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document defines the characteristics of continuous tunnel washer and gives the usual test methods for these characteristics with regard to machine capacity, power consumption and productivity. It is applicable for use as a reference in the drafting of purchasing orders for continuous tunnel washer. In addition it is recommended for determination of energy consumption and productivity according to Directive 2009/125 EC. This document excludes the energy consumption for dewatering of the load. Furthermore, the document describes standard methods for measuring principal performance characteristics of continuous tunnel washer. It does not cover safety requirements (see EN ISO 10472-3).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies

EN 676, *Automatic forced draught burners for gaseous fuels*

EN 1049-2, *Textiles — Woven fabrics — Construction — Methods of analysis — Part 2: Determination of number of threads per unit length (ISO 7211-2:1984 modified)*

EN 1773, *Textiles — Fabrics — Determination of width and length*

EN 12127, *Textiles — Fabrics — Determination of mass per unit area using small samples*

EN ISO 139, *Textiles — Standard atmospheres for conditioning and testing (ISO 139)*

EN ISO 2060, *Textiles — Yarn from packages — Determination of linear density (mass per unit length) by the skein method (ISO 2060)*

EN ISO 2061, *Textiles — Determination of twist in yarns — Direct counting method (ISO 2061)*

EN ISO 3759, *Textiles — Preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change (ISO 3759)*

EN ISO 13934-1, *Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method (ISO 13934-1)*

EN ISO 15797:2018, *Textiles — Industrial washing and finishing procedures for testing of workwear (ISO 15797:2017)*

ISO 2267, *Surface active agents — Evaluation of certain effects of laundering — Methods of preparation and use of unsoiled cotton control cloth*

ISO 4312, *Surface active agents — Evaluation of certain effects of laundering — Methods of analysis and test for unsoiled cotton control cloth*

ISO 9398-1, *Specifications for industrial laundry machines — Definitions and testing of capacity and consumption characteristics — Part 1: Flatwork ironing machines*

ISO 9398-3, *Specifications for industrial laundry machines — Definitions and testing of capacity and consumption characteristics — Part 3: Washing tunnels*

DIN 4754 (all parts), *Heat transfer installations working with organic heat transfer fluids*

DIN 38409-23, *German standard methods for the examination of water, waste water and sludge — Parameters characterizing effects and substances (group H) — Part 23: Determination of bismut active substances (H 23)*

DIN 61101-1, *Weaves; general terms, basic weaves*

RAL-GZ 992/1, RAL-Gütezeichen 992 für sachgemäße Wäschepflege „Objekt- und Haushaltswäsche“

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9398-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1.1

continuous tunnel washer

automatic washing system that processes laundry in continuous operation or in batches

3.1.2

compartment, cage

single unit in a continuous tunnel washer which contains the laundry batch

3.1.3

compartment, cage (basket) volume

net volume of the cage, expressed in cubic decimetres (litres), equivalent to the inside volume minus all the inwardly projecting volumes

3.1.4

zones of the continuous tunnel washer

one or more compartments used for different washing phases

3.1.5

pre-wash zone

one or more compartments of continuous tunnel washer zones used for pre-washing

3.1.6

main wash zone

one or more compartments of continuous tunnel washer used for main wash

3.1.7

rinsing zone

one or more compartments of continuous tunnel washer used for rinsing

3.1.8

conditioning/neutralization zone

one or more compartments of continuous tunnel washer used for conditioning which means neutralization and/or other final treatment like softening, starching

3.1.9

counter flow

continuous tunnel washer zone where the continuous water flow is opposite to the direction of laundry flow

3.1.10

bath exchange

part of the washing process in continuous tunnel washer where within one cycle water is drained out of a compartment and refilled with fresh or other recovered water

3.1.11

standing bath

compartment without water drainage and water inlet during cycle time and consequently no counter-current or concurrent water flow

3.1.12

water recovery tank

tank for collecting water from different zones of the continuous tunnel washer and/or from de-watering unit (e.g. press, extractor)

3.1.13

drum agitation

movement of drum during the cycle time, depending on kind of load transfer system in one direction or by oscillating

3.1.14

bottom transfer machine

continuous tunnel washer with load transfer into the next compartment via the bottom of drum, e.g. by the Archimedean transfer principle

3.1.15

centre transfer machine

continuous tunnel washer with load transfer into the next compartment through centre of drum by transport scoop which is integrated in the drum construction

3.1.16

top transfer machine

continuous tunnel washer with load transfer into the next compartment via the top part of the drum by transport scoop which is integrated in the drum construction

3.1.17

inner drum

moving drum which contains laundry/textiles and water

3.1.18

outer drum

fixed drum around inner drum, allows the supply of water, chemicals, energy and drainage as well as control applications

3.1.19

single drum machine

continuous tunnel washer with compartments consisting of only single moving drum

3.1.20**double drum machine**

continuous tunnel washer with compartments each consisting of an inner and an outer drum

3.1.21**combined single/double drum machine**

continuous tunnel washer with compartments consisting of both single drums and compartments with added double drums

3.1.22**reference washing machine**

specially constructed washer extractor of known washing performance level with high repeatability and reproducibility of results which is used to compare the primary washing performance (stain/soil removal of supplied test fabrics) of tested continuous tunnel washer as defined in this standard

Note 1 to entry: Refer to 5.2.

3.1.23**nominal load**

weight of normally soiled load in kg of cotton (100 %) textiles (including (9 ± 2) % residual moisture content, related to bone dry load) in the compartment of a continuous tunnel washer

Note 1 to entry: The value of nominal load is given on the manufacturer's rating plate of the machine.

3.1.24**nominal hourly production output**

nominal load multiplied by the number of unloads per hour

3.1.25**process time**

time, in minutes, for the batch of textiles to pass through the entire length of the tunnel without de-watering including loading and unloading

3.1.26**cycle time**

time between start of drum agitation movement and end of load transfer into the next compartment of the continuous tunnel washer

3.1.27**bone dry-conditioning**

bringing the test load (see 3.1.33) into a state without moisture content (bone dry) by multiple drying until a steady-state weight is achieved (identical weight for minimum three replicating drying cycles)

3.1.28**test run**

single performance assessment

3.1.29**test series**

number of test runs on a continuous tunnel washer which, collectively, are used to assess the performance of that machine

3.1.30

operation

performance of a function that occurs during the continuous tunnel washer process such as pre-wash, main wash, rinsing and conditioning

3.1.31

programme

series of operations which are pre-defined within the continuous tunnel washer and which are declared by the manufacturer as suitable for washing certain types of textiles

3.1.32

wash cycle

complete washing process, as defined by the selected programme, consisting of a series of operations but excluding dewatering

3.1.33

test load

mass of the nominal load plus stain and soil monitors, wash process control sheets and rinse performance fabrics (test fabrics)

3.1.34

rated voltage

constant voltage with an acceptable range of $\pm 10\%$ (EN 60038) assigned to the continuous tunnel washer by the manufacturer

3.1.35

rated steam pressure

min./max. steam pressure assigned to the continuous tunnel washer by the manufacturer

3.1.36

rated water pressure

min./max. water pressure assigned to the continuous tunnel washer by the manufacturer

3.1.37

rated compressed air pressure

min./max. compressed air pressure assigned to the continuous tunnel washer by the manufacturer

3.2 List of symbols

The symbols are listed in Table 1.

Table 1 — List of symbols

Symbol	Unit	Definition
C_{Yu}	—	sum of average reflectance values of all stain and soil fabrics before washing in test machine
$C_{Yu,ref}$	—	sum of average reflectance values of all stain and soil fabrics before washing in reference machine
C_{Yw}	—	sum of average reflectance values of all stain and soil fabrics after washing in the test machine
$C_{Yw,ref}$	—	sum of average reflectance values of all stain and soil fabrics after washing in the reference machine
E_A	kWh	measured energy for air compression for the test run
E_E	kWh	measured electric energy consumption for the test run
E_H	kWh	measured energy for heating for the test run
E_{HF}	kWh	calculated energy embedded/lacking in hot/cold fresh water
$E_{HF,dw}$	kWh/kg	calculated energy embedded/lacking in hot/cold fresh water per dry load
$E_{wt,tot,nt}$	kWh	sum of energy consumption for heating, electric energy for motors and air compression
$E_{wt,tot,nt,dw,M}$	kWh/kg	mean value of energy consumption of continuous tunnel washer (specific energy consumption) without hot water feeding
$E_{wt,tot,nt,dw}$	kWh/kg	sum of energy consumption for heating, electric energy for motors and air compression per treated mass of test load
$E_{wt,tot,nt,dw,i}$	kWh/kg	sum of energy consumption for heating, electric energy for motors and air compression per treated mass of test load and per test run
$E_{wt,tot,nt,dw,M}$	kWh/kg	mean value of sum of energy consumption for heating, electric energy for motors and air compression per treated mass of test load
$E_{wt, tot.}$	kWh	total energy consumption of continuous tunnel washer
$E_{wt,tot nt,spec}$	kWh/kg	total specific energy consumption per kg dry load without hot/cold water feed
$E_{wt, tot, spec}$	kWh/kg	total specific energy consumption; including energy embedded/lacking in hot/cold fresh water
FAZ	—	colour shift number
m		number of stain/soil types
mc_{sl}	%	moisture content of soiled test load under ambient conditions in the laundry
$m_{load/hour}$	kg/h	mass of washed load of normally soiled hotel cotton textiles during the 1 h
$m_{load/hour,i}$	kg/h	mass of washed load of normally soiled hotel cotton textiles during 1 h in one test run

Symbol	Unit	Definition
$m_{\text{load/hour,M}}$	kg/h	arithmetic mean of mass of washed load of normally soiled hotel cotton textiles during 1 h
$M_{\text{HF,dw}}$	kg/kg	mass of the specific fresh water per kg dry load
M_{li}	l	water consumption during the test run
$M_{\text{li,dw}}$	l/kg	water consumption per kg bone load (9 % residual moisture)
$M_{\text{li,dw,i}}$	l/kg	water consumption per kg bone load (9 % residual moisture) per test run
$M_{\text{li,dw,M}}$	l/kg	mean value of water consumption per kg load (9 % residual moisture) of single test runs
n		number of readings of tristimulus value per stain/soil
N		number of test runs
p		number of treated nominal loads (batches) during the test run
s		damage factor, chemical damage
$S_{\text{tot,nt,dw}}$	kWh/kg	standard deviation of sum of energy consumption for heating, electric energy for motors and air compression per treated mass of test load
$S_{\text{Mli,dw}}$	l/kg	standard deviation of water consumption per treated mass of test load
$S_{\text{M,D,total,dw}}$	mg/kg ml/kg	standard deviation of total detergent consumption per treated mass of test load
$S_{\text{M,load/hour}}$	kg/h	standard deviation of mass of washed load of normally soiled hotel cotton textiles during 1 h
t_{DP}	s	time to reach determined detergent volume
$t_{\text{D,total}}$	s	total dosing time per test run
t_{tr}	min	duration of the test run
R_{c}	—	cleaning index, ratio between difference of Y-values increase (washed-unwashed) in tested machine and reference machine
V_{DP}	ml	volume of detergent
$V_{\text{DP/t}}$	ml/s	flow rate of dosing pumps
W_{bd}	kg	mass of the bone dry test load
W_{bdi}	kg	mass of the bone dry (conditioned) items
W_{c}	kg	mass of the test load, related to ambient conditions 20 °C, 65 % r.h.
$W_{\text{D,total}}$	ml mg	total consumption of completely designed detergents, single detergent components and/or boosters added into the compartments of the continuous tunnel washer during cycle time

Symbol	Unit	Definition
$W_{D,total,dw}$	ml/kg mg/kg	total consumption of completely designed detergents, single detergent components and/or boosters added into the compartments of the continuous tunnel washer during cycle time in the test run per treated mass
$W_{D,total,dw,i}$	ml/kg mg/kg	total consumption of completely designed detergents, single detergent components and/or boosters added into the compartments of the continuous tunnel washer during the test run per treated mass
$W_{D,total,dw,M}$	ml/kg mg/kg	arithmetical mean of total consumption of completely designed detergents, single detergent components and/or boosters added into the compartments of the continuous tunnel washer per treated mass
$W_{D,total,i}$	ml mg	total consumption of completely designed detergents, single detergent components and/or boosters added into the compartments of the continuous tunnel washer during cycle time in the test run
W_i	kg	mass of the selected items under ambient conditions in the laundry
W_L	kg	treated mass load during the test run
W_{Lb}	kg	nominal load mass in one compartment
W_{sl}	kg	mass of the nominal load under ambient conditions in the laundry
Y	—	tristimulus reflectance value
$Y_{i,u}$	—	tristimulus reflectance value for certain stain/soil fabrics before washing
$Y_{i,w}$	—	tristimulus reflectance value for certain stain/soil fabrics after washing in the test machine
$Y_{i,w,ref}$	—	tristimulus reflectance value for certain stain/soil fabrics after washing in the reference machine
$Y_{i,u,ref}$	—	tristimulus reflectance value for certain stain/soil fabrics before washing in the reference machine
$Y_{m,u}$	—	average reflectance value before washing
$Y_{m,w}$	—	average reflectance value after washing in the test machine
$Y_{m,u,i}$	—	average reflectance value for each stain/soil type before washing
$Y_{m,u,ref}$	—	average reflectance value before washing in the reference machine
$Y_{m,w,i}$	—	average reflectance value for each stain/soil type after washing in the test machine
$Y_{m,w,ref}$	—	average reflectance value for each stain/soil type after washing in reference machine
$Y_{m,w,i,ref}$	—	average reflectance value for each stain/soil type after washing in the reference machine
$\Delta Y_{total,test}$	—	increase of Y-values of all types of stain/soil by washing compared to unwashed stain/soil fabrics in the test machine

Symbol	Unit	Definition
$\Delta Y_{\text{total,ref}}$	—	increase of Y-values of all types of stain/soil by washing compared to unwashed stain/soil fabrics in the reference machine
$\Delta Y_{\text{total,test-ref}}$	—	difference of increase of the Y-values of all types of stain/soil by washing compared to unwashed stain/soil fabrics between test machine and reference machine
δ_{HF}	°C	medium fresh water temperature during the test run

4 Requirements

4.1 General

This standard does not specify minimum performance requirements for continuous tunnel washers. This standard does however set methods for the measurement of following performance parameters:

- primary wash performance (stain and soil removal);
- secondary wash performance;
- rinse efficiency;
- water consumption;
- energy consumption;
- hourly production output.

It also includes the determination of:

- ambient air temperature;
- electrical energy consumption of the whole continuous tunnel washer (drive motor, control system);
- electrical energy consumption for generation of compressed air (e.g. via connected separate air compressor);
- steam energy consumption;
- detergent consumption (no bleach, disinfection agents, neutralization agents, textile softeners);
- fresh water temperature;
- temperature-time profile of the washing programme (wash liquor in continuous tunnel washer);
- alkalinity, pH-value and active oxygen content of the water in each compartment;
- running time (agitation), stand still time;
- load size per compartment;
- primary wash performance (stain and soil removal) of reference machine.

Any claims of performance referring to this standard for these parameters shall be measured in accordance with the requirements of this standard. Any claims of performance referring to this document at other than nominal loading shall be qualified with load type and amount used for the test (refer to 4.2 for details).

4.2 Nominal load (of a compartment)

The manufacturer shall declare the nominal load of a compartment for cotton items. The nominal load in kg of cotton (100 %) textile contains (9 ± 2) % residual moisture content, related to bone dry load

Where the manufacturer gives a range of values for the nominal load for cotton textiles (100 %), the maximum value shall be used.

For different textiles the nominal load of a continuous tunnel washer compartment may be different.

5 General test conditions

5.1 General

The determination of washing performance, consumption of energy, water and detergents and hourly production output is carried out under typical laundry conditions. This includes ambient conditions as well as the use of the test load and detergents.

The tolerances specified for parameters within this European Standard, using the symbol ' $\pm$ ', indicate the allowable limits of variation from the specified parameter.

5.2 Reference machine

Unless otherwise specified, the reference machine shall be a specific well proven test washer-extractor with respect to conditions, materials and equipment specified.

Specifications for the reference machine are given in Annex A.

5.3 Ambient conditions

5.3.1 Ambient temperature and humidity

The ambient air temperature during the test shall be (24 ± 6) °C and the relative humidity (50 ± 10) % throughout the continuous tunnel washer test. Ambient temperature and relative humidity shall be measured in the vicinity of the continuous tunnel washer being tested.

5.3.2 Water supply

5.3.2.1 General

The tests are carried out under typical laundry practise conditions (see 5.3).

In the Rinsing Process only the use of fresh water is accepted.

The measured total water hardness, water temperature and water pressure of the fresh water supplied to test continuous tunnel washers shall comply with the following requirements and shall be reported.

5.3.2.2 Water properties

Standard soft water with a total hardness of $(0,3 \pm 0,1)$ mmol/l shall be applied. All other water characteristics are given in Annex K.

Total water hardness is determined and expressed in mmol/l of CaCO_3 equivalent.

The total hardness of the water used shall be reported. In addition, the pH of the water used shall be reported.

Fresh water temperature:

The temperature of the fresh water used in the test shall be $(17 \pm 3) ^\circ\text{C}$. The measured water temperature shall be reported. For tropical countries, a temperature of $(25 \pm 5) ^\circ\text{C}$ is allowed.

If the fresh (e.g. rinse) water is heated up (e.g. by use of a heat exchanger), the heat exchanger shall be disconnected.

If the disconnection is impossible because of specific laundry conditions this test modification shall be mentioned in the report. In addition, heat energy consumption shall be related to the prescribed fresh water temperature of $17 ^\circ\text{C}$ by calculation (see 7.5).

Fresh water temperature and volume shall be recorded on a continuous basis during processing.

5.3.2.3 Water pressure

The static (gauge) pressure of the supply water at the inlet to the test continuous tunnel washer shall maintain at the pressure recommended by the machine manufacturer [e.g. $(240 \pm 50) \text{ kPa}$] throughout the test.

The water supply to the reference machines shall be in accordance with Annex A.

The water pressure (as applicable) shall be determined as close as practicable to the point of connection of the continuous tunnel washer to the water supply system. The measured pressure shall be rounded to the nearest whole 10 kPa compared with the allowed range.

5.3.3 Energy supply

Energy for the test shall be supplied by steam, gas, electricity or heat-transport fluid, as specified by the manufacturer.

5.3.4 Electricity supply

The supply voltage at the power outlet to the continuous tunnel washer shall be maintained at the rated voltage $\pm 10 \%$ throughout the test. If a voltage range is indicated, then the supply voltage shall be the nominal voltage of the country in which the appliance is intended to be used.

The supply frequency to the continuous tunnel washer shall be maintained at the rated frequency $\pm 1 \%$ throughout the test.

The measured voltage and frequency of the power supply used during testing shall be reported.

5.3.5 Compressed air supply

The compressed air supply at the continuous tunnel washer air inlet should be in the range of the machine manufacturers' recommendations. The pressure shall be maintained at the pressure recommended by the machine manufacturer [e.g. $(600 \pm 100) \text{ kPa}$] throughout the test.

5.3.6 Steam supply

The steam supply at the continuous tunnel washer shall meet the manufacturer specifications.

5.3.7 Condition of the machine

The continuous tunnel washer shall be installed in accordance with the manufacturer's instructions and shall be clean. Drain pipes shall have a sufficient large diameter and shall be clean for free-flowing.

5.4 Machine/test load

5.4.1 General

The test load consists of:

- nominal load,
- stain and soil monitors,
- multi-wash test fabrics/wash process control sheets,
- rinse performance fabrics.

5.4.2 Amount of load

The amount of the test load shall correspond to the nominal loading of the machine as defined in 4.2.

The amount of load is based on the nominal load in kg of cotton (100 %) textile containing (9 ± 2) % residual moisture content, related to bone dry load.

5.4.3 Number of test loads

The number of test loads for the determination of the different performance characteristics is as follows (Table 2).

Table 2 — Number of loads (test runs) with test fabrics

Performance characteristics	Number of loads (test runs) with test fabrics
Consumption of energy and water, hourly production output	Minimum 2 tests, with duration of one complete process (from loading to unloading of the continuous tunnel washer). The test shall start after reaching the thermal equilibrium. After the test has started no stops of the continuous tunnel washer are allowed.
Primary wash performance	5 test runs with each 10 test fabric sets in one compartment (parallel to determination of consumption values).
Secondary wash performance	25 test runs with 2 wash process control sheets in one compartment (first 5 runs parallel to determination of primary wash performance and the remaining 20 under supervision by the laundry management).
Rinse performance	5 test runs with each 2 rinse performance fabrics in one compartment (parallel to determination of primary wash performance).

5.4.4 Nature of nominal load

The test load consists of a mixture of normally soiled hotel textiles of 100 % cotton (bed sheets, bed covers, pillow cases) treated in the laundry.

The nominal load shall comprise

- Bed covers ($40 \% \pm 5 \%$) with a mass per unit area of (270 ± 15) g/m² and dimensions of (252 ± 10) cm $\times$ (204 ± 5) cm.
- Bed sheets ($40 \% \pm 5 \%$) with a mass per unit area of (200 ± 20) g/m² and dimensions of (300 ± 25) cm $\times$ (200 ± 5) cm.
- Pillow cases ($20 \% \pm 5 \%$) with a mass per unit area of (283 ± 15) g/m² and dimensions of (90 ± 5) cm $\times$ (64 ± 5) cm.

The age of the single textile items should represent the typical age of the hotel flatwork textiles treated in the laundry. The selected nominal load items should have been washed at least 5 times, but not more than 50 times.

The types of items, mass per unit area and dimensions as well as the age (number of treated wash cycles) of the textiles used during testing shall be reported.

5.4.5 Stain and soil monitors

Stain and soil monitors are attached to single larger items of the nominal load prior to testing to assess the primary washing performance of the tested continuous tunnel washer. Different stain and soil types are used in order to assess the following washing characteristics:

- the general detergency;
- the bleaching performance;
- the enzyme performance.

For determination of primary washing performance standard stains/soils (5×5) cm² are applied during five test runs using 10 sets of test fabrics for each wash cycle in combination with one nominal load. One set consists of the following stain/soil monitors, fixed on a tracer fabric:

- a) General Detergency:
 - 1) CO-pigment/wool fat;
 - 2) PES/CO-pigment/wool fat;
 - 3) CO-pigment/skin fat;
 - 4) PES/CO-pigment/skin fat;
 - 5) CO-motor oil/pigment;
 - 6) CO-pigment/oil/milk;
- b) Bleaching Performance:
 - 1) CO-red wine;
 - 2) CO-curry;
 - 3) CO-blood, fixed;
- c) Enzyme Performance:
 - 1) CO-egg/pigment;
 - 2) CO-starch/pigment;
 - 3) CO-cocoa, fixed.

Where an iron or ironing appliance is used to prepare stain/soil test strips after washing and prior to reflectance readings, it shall have a surface temperature between 130 °C and 150 °C.

The specifications of test pieces with standardized soiling for each soil type which are used on the tracer fabric are given in Annex B.

NOTE Information about the compliance of stains/soils used in stain/soil monitors with respect to importation regulations of particular countries can be obtained from the supplier.

5.4.6 Wash process control sheets

Two identical cotton wash process control sheets according to ISO 2267 are attached to one nominal load (preferable in the first wash cycle in the nominal load with stain/soil monitors) prior to testing to assess the secondary washing performance of the tested continuous tunnel washer.

For determination of accumulating wash effects, the two control sheets are washed and dewatered (no tumbler drying and ironing) for 25 wash cycles. The first two wash cycles are carried out parallel to energy consumption testing. The completion up to 25 wash cycles is done by the industrial laundry respective the machine manufacturer in the defined test programme conditions.

The following criteria of secondary washing performance are determined:

- chemical damage (damage factor s) according to ISO 4312,
- tensile strength loss according to EN ISO 13934-1,
- inorganic incrustation according to ISO 4312,
- whiteness according to Ganz/Griesser, colour shift number (FAZ) and basic degree of whiteness according to ISO 4312.

The specifications of the control sheet are given in Annex C.

NOTE Information about the fabric specification can be obtained from the supplier.

5.4.7 Rinse performance fabrics

Rinse performance of the continuous tunnel washer is characterized by the amount of surfactants left on applied rinse performance fabrics (two standard cotton fabrics respectively wash process control sheets according to ISO 4312 without any prewash).

Two fabrics (100 × 80) cm² are added to 5 nominal loads respectively batches, preferable in nominal loads with stain/soil monitors. The rinse performance fabrics are removed after the dewatering procedure. Afterwards the fabrics are dried by air and conditioned according to EN ISO 139 (20 °C, 65 % relative humidity). Then a sufficient amount of test material is removed from the rinse performance fabrics and reduced to (4 × 4) cm² large pieces and homogenized.

Subsequently, the amount of surfactants left on the test pieces (as specified in Annex D) is determined by extraction. The anionic and non-ionic surfactants are determined according to DIN 38409-23.

NOTE Information about the fabric specification can be obtained from the supplier.

5.4.8 Addition of the test fabrics

The test fabrics for performance testing are simultaneously added to the nominal load during loading into the first compartment of the continuous tunnel washer.

Table 3 demonstrates the number of test fabrics for performance characterization per batch (test load per compartment).

Table 3 — Number of added test fabrics

Type of test fabric	Number of fabrics per test load respectively batch
Primary wash performance	5 batches, each with 10 monitors
Secondary wash performance	one batch, each with 2 monitors
Rinse performance	5 batches, each with 2 monitors

5.5 Preparation for testing

5.5.1 General

This clause sets out the requirements for the preparation of the continuous tunnel washer and reference machine prior to testing. It also specifies the requirements for the preparation of test loads for tested continuous tunnel washer and the reference machine.

The measurements shall generally be carried out on a newly produced continuous tunnel washer that represents its production series.

5.5.2 Installation of the continuous tunnel washer

The test report shall clearly state the machine design and the wash programme by description and technical drawing (machine and wash zone design). The specification should demonstrate the following data of the machine design:

- loading system of continuous tunnel washer;
- kind of load transfer;
- compartments with single and double drum as well as bath exchange;
- number of compartments for each wash zone;
- water flow (amount and direction) in whole continuous tunnel washer, zones and compartments including connected water recovering tanks and dewatering system;
- compartments with heat energy input and with connected heat exchangers for heating up fresh respectively rinse water;
- compartments with dosage of detergent and wash additives;
- special machine design features with effect on water and energy consumption.

5.5.3 Washing programme

The washing programme including detergents (type, amount of dosage and time of dosage) is fixed in a way to reach sufficient wash performance in accordance with practise requirements respectively the launderer's requirements. For determination of wash performance effects in accordance to the general test conditions of Clause 5, a temperature of $(70 \pm 2) ^\circ\text{C}$ for at least 10 min in the main wash measured with a data logger (see Annex M) should be reached.

5.5.4 Preparation of the continuous tunnel washer for a test series

Before the test series is commenced the continuous tunnel washer shall be checked to confirm that it has no operating defects that may affect the operation of the machine.

If the test series are carried out before common use of the continuous tunnel washer, prior to the test series (not less than one day in advance but not more than two weeks in advance and without any other run before the test series is started) a cleaning run should be undertaken on a programme with the maximum wash temperature set and setting maximum main wash water level if applicable without load and without detergent.

During the tests in the laundry, the tested continuous tunnel washer is only used for washing the usual textiles from the hotel business, which are normally soiled. The performance test starts after reaching thermal equilibrium (minimum 30 min) in the continuous tunnel washer working under normal conditions (70 °C at washing phase in main wash zone).

The number of conditioning loads (number of loads used to fill the complete continuous tunnel washer) depends on the number of compartments and cycle time.

Prior to start of the test the continuous tunnel washer shall be operated under standard operating condition until it is full and has continued to operate for a further 30 min.

5.5.5 Preparation of the continuous tunnel washer for a test run

Before each test run the filters, heat exchangers and water pumps intended to be serviced by the user shall be cleaned according to the manufacturer's instructions. Furthermore, the heat exchanger (heat exchanger used for heating up of the fresh water by the drain water) shall be disconnected and the cooling water for the dewatering system shall not be used in the washing process.

The detergents and/or other chemical additives in washing tunnels are in general dissolved, diluted and/or transported into the washing tunnel with fresh water by feed lines/pipes. Before each test run, any detergent dosage including feeding lines shall be clean prior to the addition of detergent and chemical additives.

The continuous tunnel washer shall be at ambient temperature according to 5.3.1 at the beginning of each test run. This is fulfilled when the temperature sensor to determine the water temperature in the sump during the wash operation shows an adequate temperature.

5.6 Reference machine

The reference machine which is only used for determination of primary washing performance (stain/soil removal) shall be checked in accordance with the requirements of Annex A prior to a test series.

Lint blocking the drain valve shall be removed completely before starting a test series. The water filter of the supply valve shall be cleaned. The reference programme without load and detergent shall be run to remove residues.

Before each test run, the detergent dispenser shall be clean and dry prior to the addition of detergent.

At each test run it shall be checked that no detergent remains in the detergent dispenser. It shall be ensured that in the reference machine the detergent is totally dispensed during the water intake for the main wash. If detergent remains in the dispenser after the initial fill, then that test run shall not be valid.

5.7 Preparation of the nominal load

5.7.1 General

The tests are carried out with the nominal load which is a mixture of normally soiled hotel textiles of 100 % cotton (bed sheets, bed covers, pillow cases) respectively only hotel-like-soiled textiles from hospitals and retirement homes (see 5.4.4).

The test load mass is adjusted so that it corresponds to the nominal loading of the continuous tunnel washer to be tested (4.2).

The real load size of the batches (nominal loading) is determined by the laundry conditions. For determination of the mass of the load, the continuous tunnel washer/loading system shall be equipped with an automatic weighing system which allows the registration of the single batches during the test (loading monitoring at conveyer belt to loading chute or transport sack).

The nature of the nominal load (dimensions, area weight) is specified in 5.4.4.

5.7.2 Bone dry-conditioning

Bone dry-conditioning is the process of reduction of humidity from the laundry textiles by drying to the “bone-dry-status” in a tumble dryer or with a flatwork ironer (calendar) and for determination of the corrected weight of the load. The drying process is carried out without cool down.

Bone dry-conditioning is done to avoid the use of reduced load size batches respectively use of heavily wetted textiles.

The bone dry-conditioning for determination of the bone dry weight (W_{bd}) is done by continuous drying of washed test load according to 6.2 until constant weight is achieved (without any residual moisture, constant weight for at least three successive drying procedures).

The determination of the weight is carried out by weighing a sample of at least 20 % of the nominal load and which shall not be less than 10 kg. The sample shall consist of nominal load representative items. The determination of the bone dry weight shall be repeated at least once. If the moisture content between two samples differ by 5 % a third repetition shall be conducted. The mean value of all three measurements of the moisture content shall be taken as the average moisture content of the whole load.

The moisture content of the soiled test load (whole batch) shall be (9 ± 2) % related to bone dry weight.

The moisture content of the test load shall be recorded.

The determination of the corrected weight (W_c) of the load is given in 6.3.

5.8 Detergent

5.8.1 General

The test load is washed under common washing conditions with a conventional detergent system for normally soiled hotel textiles.

The detergent used for all test runs shall be as specified in 5.8.2.

Type and dosage of detergents for the reference machine are given in Annex E.

5.8.2 Specification of detergent system

The specification of the used detergent system (including wash additives like booster, bleach agent and neutralization agent) shall be given with respect to:

- type of detergent, including supplier and brand name;
- time of dosage and number of compartment;
- dosage per compartment (set point);
- dosage per wash cycle (set point) in ml/s;
- dosage (set point) per kg load (rated and actual capacity);
- amount of water for flushing in the detergents.