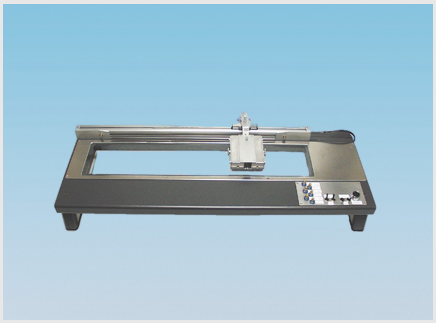
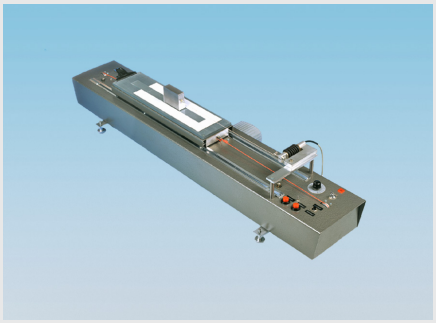
CLEAR CLEAN

Werk für Reintechnik GmbH

Test Methods

for HiTech Wipers and Papers Used in Clean Environments





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Test Methods

for Cleaning Wipers and Papers Used in Clean Technology

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Foreword

Since the advent of the first integrated circuits about 50 years ago, the resulting microchip industry has shown a rate of development and an impact that are unique in the world today. Parallel to the semiconductor industry itself, the supplier industry also has had to boost its development to meet the challenges of the changes caused by the increasing miniaturisation of semiconductor components.

The beginning of the global mass production of microchips led to the launch of many companies which saw a promising market as suppliers of the chip manufacturers in clean room technology. With the commissioning of the first large-scale clean rooms in Germany by the technology chip manufacturers IBM and Siemens in the mid 1980s, a special supplier industry, which already existed in the U.S. and Japan, also took root in Germany. In this early stage of development the company CLEAR & CLEAN GmbH was founded in 1979.

To a similar extent that the structural size of the semiconductors became smaller and smaller, efforts were intensified to identify and to eliminate sources of contamination in the clean rooms. Attention was focused on clean room consumables such as cleaning wipers, clean papers, gloves and overalls, which at that time were not consistently available in clean room-typical quality. Soon the users of clean room consumables demanded a clean technology-based standardisation of these products. The key parameter here is the use-related release of constituents from such materials into the production environment. However, the German Association of Engineers (VDI) only wanted to give general recommendations on this topic (VDI 2083 – Sheet 4) and did not want to formulate any test regulations of its own with specific implementation recommendations.

In the U.S., however, the Institute of Environmental Sciences and Technology (IEST) formulated a series of „recommended practices." Due to lack of experience, these American recommendations described by the IEST for the determination of the particle release of cleaning wipers were simple in concept and could be implemented with little instrumental effort, but they were flawed in their physical approach. (The currently valid version is IEST-RP-CC004.3 from August 2004.)
This meant that the recommended test method for the particle release of cleaning wipers did not even come close to simulating the wiping cleaning procedure used in practice. This leads to grossly erroneous assessments of the quality of the cleaning wipers for use in the techniques of clean work. One such faulty assumption is that cleaning wipers, which according to the test protocol were immersed in a water bath and there release great quantities of particles into the water, would also leave many particles on the cleaned surface during the cleaning procedure or would release them into the environment. The same misinterpretation applies to the extractable content of the cleaning wipers.

As one of the few manufacturers of cleanroom consumables in Europe, Clear & Clean GmbH is critical of the American testing practice. Clear & Clean demanded that the testing methods be more user oriented. As an example for the different technical approaches of the American standardisation bodies ASTM and IEST and the Clear & Clean Research Laboratory, the following key questions regarding the use of cleaning wipers for the techniques of clean work were formulated by Clear & Clean already in the late 1990s:

1. *By what measurable quantity did the surface cleanliness increase after a cleaning procedure with a specific cleaning wiper? (total increase in cleanliness)*

2. *How much time was needed for the cleaning procedure with a specific cleaning wiper? (increase in cleanliness per unit of time)*

This technical-economic test approach is exactly opposite the approach of the IEST, namely: „How ‚unclean' (i.e. contaminated) is a cleaning wiper?" This question disregards the surface cleanliness effected by the wiper, and the test is exclusively focused on the cleaning wiper as textile material. The user, however, does not want to know how contaminated the cleaning wiper is, but rather how much cleaner a surface is after the cleaning procedure. The formulation of application-oriented questions in the development both of testing methods and cleanroom consumables has since then become a hallmark of the work of Clear & Clean. Over the years a number of test methods have been developed in this way that not only address problems in the semiconductor industry, but also in the pharmaceutical, optical and aerospace industries. This brochure describes both the objectives and test sequence of the test methods listed here. This will enable lab technicians to perform the specified test steps and to place the test results in relation to the practical application of the products.

Clear & Clean Research Laboratory
Lübeck 2012

1. Tests of Material Properties

Test objective: With the material-specific characteristics, fundamental properties of a material are identified such as its thickness, breaking strength or mass per unit area. They can therefore be used in the sense of a goods receipt inspection to assess the quality of a material upon delivery. Deviations from the agreed upon quality of materials and/ or production parameters can often already be detected by the measurement of the characteristic data. For the quality control of flat textile structures, papers and gloves it is recommended to determine the following characteristics.

Test 1.1. **Thickness** in mm
- according to DIN EN ISO 5084

The thickness is measured by a gauge with digital display, which exposes the test sample to a defined pressure between two plane-parallel plates. The digital display shows the distance between the plates. To measure the thickness of non-flat-lying samples such as latex gloves, one of the test plates is replaced by a spherical point measuring head of 1 mm diameter, and the pressure is reduced.

Fig. 01 Electric thickness gauge. For fabrics and paper, Mitutoyo

Test 1.2. **Mass per unit area** in g/m²
- according to DIN EN 29073 (for nonwovens)
- according to DIN EN 1227 (for small samples)

The mass of a fabric or a paper is set in relation to a specified unit area. The check is made by weighing a 10 x 10 cm sample on a sufficiently sensitive scale.

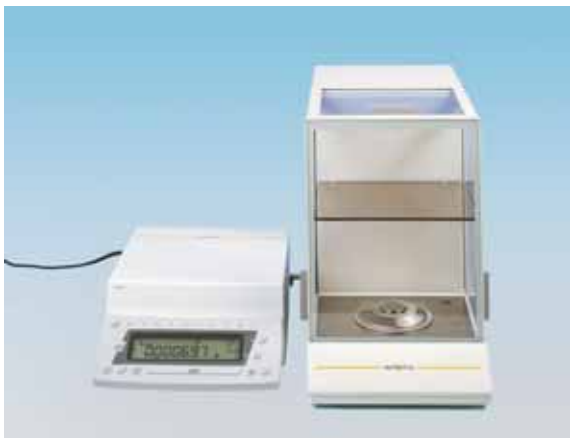


Fig. 02 Precision scale to measure the mass per unit area, Sartorius

Test 1.3. / 1.4. **Maximum tensile strength / Maximum possible expansion** in Newton
- according to DIN EN ISO 13934 T1

This is a reading of the force which must be exerted to rupture a test sample of 50 mm width and 100 mm length. A sample is considered torn if the tearing force applicable to it is below more than 50% of the maximum value achieved up to this point. As maximum possible expansion, the stretching of the material is defined as the maximum strain until the material ruptures. For tests on paper, plastic films and stretchable materials such as rubber, samples can be used in a width of 15 mm.
The maximum possible expansion can be given absolutely in millimetres or relatively in the percentage of the initial length of the sample.

Fig. 03 Maximum tensile strength / expansion gauge, Adamel

Parameter	Test of Material-Specific Properties
Test methods	**1.1. Measurement of thickness** **1.2. Measurement of mass per unit area** **1.3. Measurement of maximum tensile strength** **1.4. Maximum tensile strength – maximum possible expansion**
Instruments	Thickness gauge, maximum tensile strength / expansion gauge, microscale
Test steps for measuring the thickness	1. Insert test sample into the device. 2. Lower the measuring plate, read the displayed value and record it.
Value range	reading in mm
Test steps for mass per unit area	Cut square test sample of 10 x 10 cm edge length and determine its mass using appropriate scales.
Value range	reading in g/m²
Test steps 1.3. / 1.4.	1. Cut samples: nonwoven and knitted fabrics 50 mm x 150 mm, papers, films and gloves 15 mm 150 mm. Adjust the distance of the clamping devices to 100 mm. 2. Clamp the sample in the maximum tensile strength testing gauge and start the test process at 300 mm/min (paper at100 mm/min). 3. After the end of the test read the maximum values of tensile strength before breakage and the maximum possible expansion. Note the production running direction of the material. If possible, test the material both in the running direction and the traverse direction.
Value range maximum tensile strength	reading in N / sample width
Value range maximum tensile strength - maximum possible expansion	reading in mm (total) as a percentage of the initial length

Test 1.5. **Resistance against liquid chemicals**
- according to DIN EN ISO 13934-1

With this test it can be determined to what extent the maximum tensile strength of textile materials or other samples such as foil gloves is changed by contact with liquid chemicals.
Before performing the test, the samples are brought into contact with the chemicals they are exposed to during use. In the procedures of clean technology with regard to cleaning wipers these are mainly ultrapure water, isopropyl alcohol and acetone. If desired, other chemicals may be used in the tests such as disinfectants, acids, alkalis or cleaning naphtha. To determine the resistance of cleaning wipers or gloves against liquid chemicals, the difference in maximum tensile strength of the samples exposed and not exposed to chemicals is measured. For this purpose, the samples that were normally used in a dry state for the test of maximum tensile strength are immersed for 150 seconds in the particular chemical. Then they are subjected in a moist state to the test of maximum tensile strength – maximum possible expansion. The difference in comparison to the maximum tensile strength in the dry state is given in percent and with either minus or plus signs to indicate an increase or decrease.

Parameter	Test of Maximum Tensile Strength after Contact with Chemicals
Test methods	Resistance against liquid chemicals
Instruments	maximum tensile strength gauge, stopwatch, chemical resistant vessel
Test steps	1. Cut six samples with the longer side from the running direction of the material: width for cleaning wipers = 50 mm, for gloves and paper = 15 mm, length a minimum of 130 mm. The effective length between the jaws of the maximum tensile strength gauge is 100 mm. 2. Determine the breaking load/elongation at break on 3 dry samples. 3. Immerse another sample for 150 s in the predetermined chemical and then determine its maximum possible expansion within 15 seconds 4. Repeat the last process twice. 5. Determine the average values from the obtained data for the 3 dry and 3 dipped samples. Express these two average values in a percentage relationship.
Test media	Acetone, ultrapure water, isopropyl alcohol and/or other.
Value range	Reading of the difference for dry breaking force as a percentage of the same with pos. or negative sign

Test 1.6. **Surface roughness** (only paper)

The test of surface roughness is part of the quality control of clean room paper. Changes in surface roughness affect both the electrostatic and the transport properties of the paper in laser printers. During the test, it is necessary to measure both the upper and under side of the paper, both in the longitudinal and transverse direction of the fibres to determine the average roughness.
In the Clear & Clean Research Laboratory the surface roughness is measured with a device of the type Surftens manufactured by Mitutoyo GmbH. With the adjustable measuring modes in this device the mean roughness depth (Rz) is measured according to DIN EN ISO 4288. To perform the measurement, a measuring sensor with an integrated probe tip moves automatically along a defined path over the surface to be examined. The probe tip follows the topography of the surface and converts the information obtained about the heights into electrical signals, which are displayed as the average surface roughness in micrometres (µm).
With this method surfaces can also be measured which are used in the simulation of wiping cleaning procedures for the production of particle attrition.

Test methods	Measurement of Surface Roughness
Instruments	Mitutoyo Surftens
Test steps	1. Calibrate the gauge, put the probe on the surface and begin testing. 2. Repeat the test until a statistically relevant mean value has been obtained.
Test media	All flat surfaces of suitable dimensions
Value range	0,1 - 100 µm Rz

Fig. 04, 05 Surftens measuring device for surface roughness, left with calibration standard,

2. Tests of Cleaning Efficiency

2.1. Particle attrition
2.2. Liquid residue
2.3. Cleaning efficiency
2.4. Cleaning time

Test objectives

In hi-tech industries, precision cleaning wipers are indispensable tools of modern manufacturing culture. These wipers transfer undesirable materials from the surface to the inside of the wiper, where these materials remain and are ultimately disposed of together with the wipers. As for most industrially manufactured products, technical characteristics can be drawn up for the wipers with which the quality of the wipers for specific cleaning tasks can be determined, thus enabling a classification of the wipers. Such a parameter is the cleaning efficiency, which according to Labuda is measured in mass transfer / distance unit and in a further development of the measurement method is measured in mass transfer/time unit. An appropriate test method for cleaning performance on the basis of mass transfer per distance unit is described below. A test method per time unit is described in the reference literature. (Ref 1), but has not been sufficiently tested in practice. During use, cleaning wipers are subject to a dynamic, mechanical stress, which results from the friction between the surface of the wiper and the surface to be cleaned. This friction leads to attrition of the particles and fibre fragments from the wiper, which after the cleaning procedure remain on the cleaned surface. The number of residue particles increases with increasing surface roughness. It is also dependent on the properties of the cleaning wiper that is used. Because such particles may affect the functionality of the cleaned surfaces, it is useful to test precision cleaning wipers as to this specific quality. A corresponding test method is described below.
A special form of cleaning is the removal of unwanted fluids from surfaces. These usually are splashes, small puddles of liquids or liquid films that have to be removed from a surface. In this case, large amounts of liquid must be absorbed by the cleaning wipers, if possible without any residue. The test objective here is to elucidate the dynamic characteristics of liquid absorption during a defined wiping movement and liquid residue on the surface (in mass units). One such method is described below.

Test 2.1. Particle attrition

The test method simulates the particle / fibre attrition, which under the intended conditions of use of the cleaning wipers forms on surfaces with a roughness of > Rz 0.
Along with the test method described below, the Rotation Wiping Simulator Mark I was presented to the public by its designer Win Labuda. With this device it is possible to rotate the sample of textile material, of a foam or other suitable flat material in a stainless steel tray with given bottom roughness. The samples in a dry or controlled wet state are subjected to friction with constant stress values of pressure, rotation speed and rotation time. The resulting particle/fibre aattrition is then determined quantitatively. For this purpose, the tray is taken from the simulator and filled with ultrapure water. The water containing the abrader particles/fibres, is passed through a membrane filter with an average pore diameter of 0.2 µm. After the particle quantity on the filter surface has been counted microscopically, the particle/fibre release is converted to the unit k-Part/cm² of the tested textile material. Several trays with different bottom roughness can thus be used to obtain a graph of the attrition for ascending roughness values of the tray bottoms.

Notes

The test method Labuda Particle Attrition is contrary in its intellectual approach to the widespread method IEST-RP-CC004.3 of the U.S. Institute of Environmental Sciences and Technologies. This provides for the simulation of the release of particles/fibres of cleaning wipers in normal use. The samples are immersed in a tray with ultrapure water and then the released particles in the ultrapure water are counted.
The test results of the Labuda method and the IEST method show no correlation. This can also not be the case, because the IEST method neither takes into account the surface roughness of the test surface nor the attrition resistance of the textile material nor the particle adhesion effect of the cleaning wipers. This effect previously described by Labuda arises from the observation that in a wiping cleaning procedure, particles released from the wiper during movement to a high percentage do not remain on the surface, but are deposited again on the fibres or filaments of the cleaning wiper in close proximity to the place where they were released.
In summary, it must be noted that the method IEST-RP-CC004 para 6 and 7 contains serious physical errors in its intellectual approach.

It does not even come close to simulating the wiping cleaning procedure and therefore is unsuitable for the simulation of the particle release from cleaning wipers. Rather, through their use, misleading test results are

inevitable. (See also Ref 2) This also applies to all other test methods which do not take into account the particle attrition of cleaning wipers in cleaning procedures on surfaces with a roughness of > Rz 0.
An experiment by the Frenchman Frederic Laban et al. in 1990 (then at Motorola) could be confirmed, who showed in experiments that the particle attrition on a completely smooth surface (chip) is about the same for each cleaning wiper. In fact, the results of a standard nonwoven wiper in a controlled wiping movement on a polished surface differ only slightly from those of a high-class polyester knit. It thus follows that the significant factors that influence particle release in the cleaning by wiping procedure are the roughness of the surface to be cleaned and the attrition resistance of the textile material used.

References

Ref 2 – Essay by Textor, Bahners, Schollmeyer
Ref 3 – Essay by Laban, Garcin

Parameter	**Particle/Fibre Attrition of Cleaning Wipers during Wiping Motion on Different Rough Surfaces**
Test methods	Particle attrition according to Labuda
Instruments	Clean workbench, Labuda - Rotation – Wiping Simulator Mark I, membrane filter 0.2µm, filter holder, dark field - microscope 800x with eyepiece reticule, vacuum pump, Erlenmeyer – piston with suction supports, holding clip.
Test steps	1. Punch out samples and moisten if necessary. Affix them to the rotor block 4 by means of the clamping ring. 2. Set up the rotor aggregate 1-5 by tipping it on the previously cleaned tray bottom. 3. Start the simulator and after completion of the predetermined time, remove the rotor aggregate 1-5 from the tray again. 4. Take tray 6 out of the device, fill it with ultrapure water and filter the contents. 5. Analyse the filtrate microscopically. (All work shall be done under cleanroom conditions wearing cleanroom garments.)
Test media	Ultrapure water 18.2 M-ohm, 0.2µm – filtered
Value range	Readings in thousand particles per cm² rotation surface (kPart/cm²)

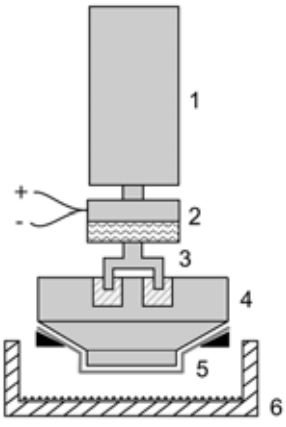


Fig. 06 Scheme of the Labuda Rotation Wiping Simulators, Mark I and II

1 rigidly suspended electric motor
2 torque transducer N/cm (in Mark II)
3 flexible coupling
4 rotor block
5 wiper – sample
6 tray with rough bottom

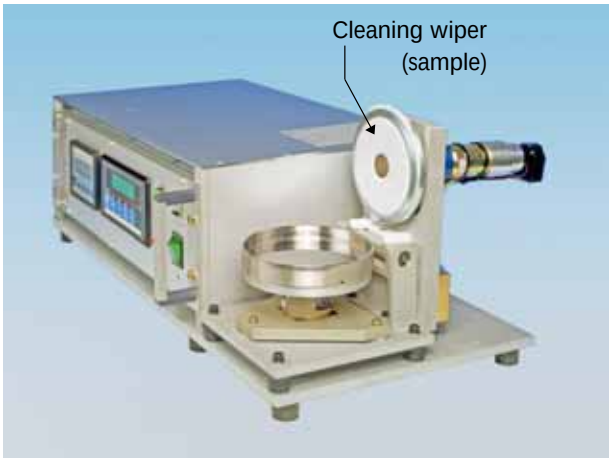


Fig. 07 Labuda Rotation Wiping Simulator Mark II for testing particle attrition (in opened state)

Fig. 08 ... and once again the Rotation Wiping Simulator in use

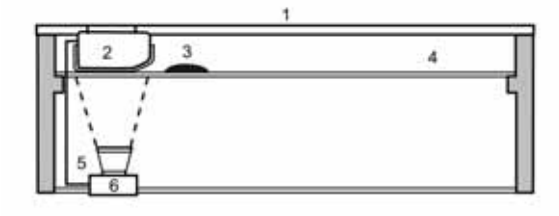
Test 2.2. Liquid residue

The test method simulates the dynamic liquid absorption of cleaning wipers during the removal through wiping of small liquid puddles and splashes on flat surfaces.
Along with the test method described below, a linear wiping simulator was presented to the general public by the designer Win Labuda. With this simulator, it is possible to determine the distribution of liquid contaminants into the moving cleaning wiper as to their mass and at the same time to document this in images. (Linear Wiping Simulator Mark II)
The sample (cleaning wiper) is fixed under a metal slide made of aluminum and is moved by a pneumatic actuator over a test plate. The device is designed for an effective wiping path of 45 cm in length and for three selectable wiping speeds. For the simulation, various exchangeable test plates with surfaces made of different kinds of materials can be used. Test plates of stainless steel with different surface roughnesses, Makrolon and glass are available. In principle, however, any other plate-shaped material can also be used. When using a transparent test plate (glass, Makrolon), a video camera can be mounted under it and in rigid connection with the sliding metal slide above the test plate, in order to document the distribution of the liquid into the cleaning wiper as a video film. A black test liquid should be used for this purpose.
To enable an exact gravimetric measurement of the liquid residue after one or more wiping procedures, the linear wiping simulator is designed so that it allows the application of sufficiently large quantities of liquid on the test plate to exclude any measurement errors due to evaporation effects.
Prior to the wiping simulation, the wiper is weighed, folded in four layers, and affixed to the metal slide that has a mass of 1000 g. The slide is then moved pneumatically with the set speed over the test surface on which a circular, 5 ml liquid puddle has been applied. After completion of the wiping procedure, the wiper is weighed again and the remaining amount of liquid is determined from the difference to the mass of the applied 5 ml liquid.

Note

By determining the liquid mass that is absorbed by the cleaning wiper in the simulated wiping procedure, the remaining liquid mass on the surface is also automatically given. This is particularly significant for the precision cleaning of surfaces.

Parameter	Dynamic Fluid Absorption of Cleaning Wipers
Test methods	Dynamic Fluid Absorption Test according to Labuda (Labuda Fluid Absorption Test)
Instruments	Analysis scale, Labuda Linear Wiping Simulator Mark II, pipette
Test steps	1. Set the wiping speed on the device. 2. Weigh the sample and attach it under the metal slide. 3. Using the pipette, apply a pool of liquid of known mass on the marked position on the test plate. 4. Start the device. 5. Move the sample over the liquid. 6. Remove the sample from the metal slide
Test media	All droplet forming liquids
Value range	0% - 100%



1 pneumatic linear motor (bidirectional)
2 standard weight with cleaning wiper sample
3 test liquid (possibly dyed)
4 interchangeable test plate (possibly transparent)
5 mechanical driver for camera
6 video camera on a slide system

Fig. 09 Scheme: Labuda Linear Wiping Simulator Mark II

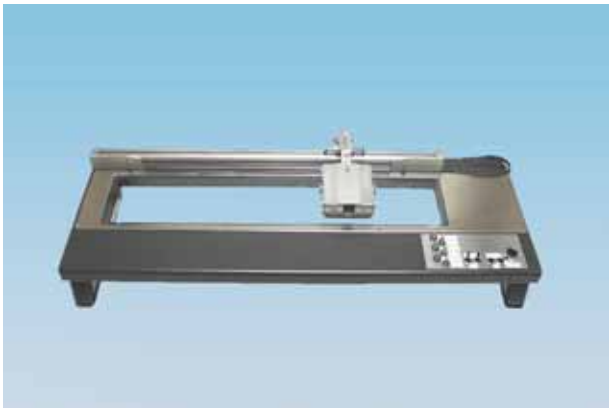


Fig. 10 Overall view: Labuda Linear Wiping Simulator Mark II

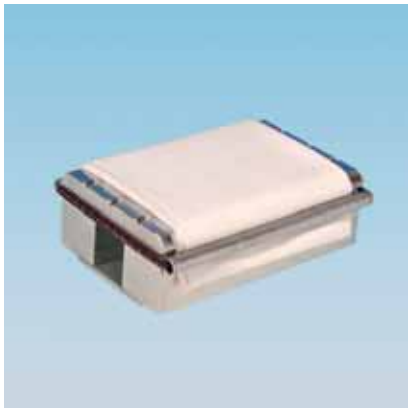


Fig. 11 Partial view: metal slide with clamped cleaning wiper

Test 2.3.Cleaning efficiency

The test method simulates the removal of thin-layered contaminants by a cleaning wiper as it is normally used. In 1998 Win Labuda presented a linear wiping simulator he designed along with this test method to carry out the tests described below. With this simulator it is possible to move a sample of a textile material under constant pressure and with a constant linear movement over a surface contaminated with a grease or oil film. This test method has the advantage that both the contaminant mass removed from the surface and the contaminant mass distributed on it can be determined. The efficiency of a cleaning wiper is characterised both by the mass taken up by the wiper as well as by the mass distributed on the surface. To simulate the wiping motion, a motor-driven carriage is used in the wiping simulator, which allows the application of a uniform, reproducible wiping speed.

Parameter	% Removal and Distribution of Thin-Layered Contaminants from a Substrate Using a Cleaning Wiper.
Test methods	Labuda Cleaning Efficiency Test
Instruments	Labuda - Linear Wiping Simulator Mark I four plates, microgram scale
Test steps	a low viscosity oil or a grease with a define viscosity
Test media	1. Weigh plates No. 4 and 5, homogeneously coat plate No. 4 with oil or grease, (possibly using a. spincoater) Determine the quantity of oil by differential weighing. 2. Insert all test plates into the holder, test block with the clamped sample (put a section of a cleaning wiper, 2 cm x 12 cm in size on the start plate, turn on the motor pulley. Turn off as soon as the test block rests on plate 6. 3. Weigh plates No. 4 and 5 and calculate the weight differences. 4. Calculate the percentage of the removed contaminants. The percentage of the grease/oil transferred from test plate No. 4 to test plate No. 5.
Value range	0% – 100% of the applied amount of oil

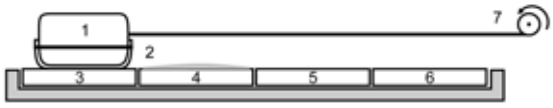


Fig. 12 Scheme: Labuda Linear Wiping Simulator Mark I

1 standard weight
2 cleaning wiper sample
4 support plate with defined contamination
5 support plate in a clean state
7 wind-up motor and pulley rope
3,6 resting plates in cleaned state

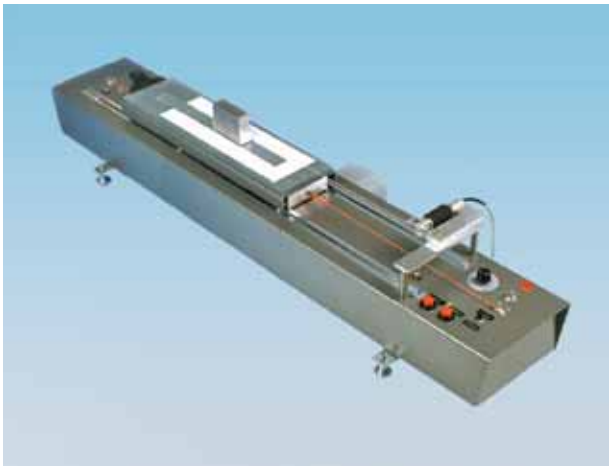


Fig. 13 Labuda Linear Wiping Simulator Mark I (full view)

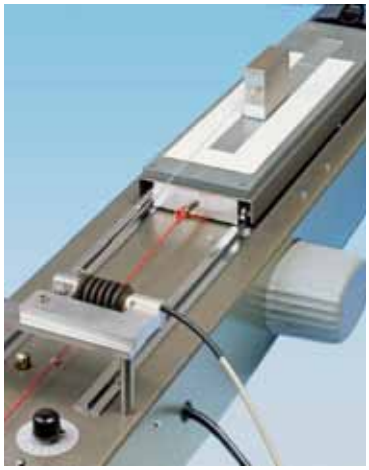


Fig. 14 Labuda Linear Wiping Simulator Mark I (partial view of the plate system)

A 20 x 80 mm textile sample weighted with a weight load of 500 g rests on a cleaned resting plate. 3. The sample is then pulled in accordance with the test with a speed of 0.875 cm/s across the test plates 4 and 5. The test plate 4 is homogeneously wetted with a known amount of lubricant or oil. Plates of the same thickness are used as rest plates before the start (3)and after completion of the test (6) to ensure that the cleaning wiper lies flat throughout the entire wiping process. During the wiping process the sample takes up part of the contamination from the first test plate and transfers part of the oil adhering to the wiper onto plate 5, which had previously been cleaned and weighed. Through differential weighing, the mass taken up by the cleaning wiper and also the mass of lubricant/oil transferred to plate 5 are determined. The cleaning efficiency is derived from the percentage of lubricant/oil which was taken up by the textile and was not transferred. The test plates may have different surface roughness.

Test 2.4. Cleaning time

An essential parameter of each cleaning procedure is the average time per used cleaning wiper (cleaning time). This is of high economic importance especially for big consumers of cleaning wipers. The Clear & Clean Research laboratory is therefore currently developing a method (as of September 2007), to quickly and easily measure the cleaning efficiency of precision cleaning wipers in a comparison via the time axis. Thus, the average cleaning time in the production process could be optimized and manufacturing costs could be reduced (Ref. 1). The designed test method is based on a principle, which is illustrated in Figure 15. Here, a standardized contaminant layer is applied onto a rotating steel roller; the thickness of this layer is measured continuously by means of laser fluorescence. A cleaning wiper is wrapped around the roller at an angle of 90 degrees, and the reduction of the contamination layer on the roller is continuously measured and recorded as a graph of the cleaning time.

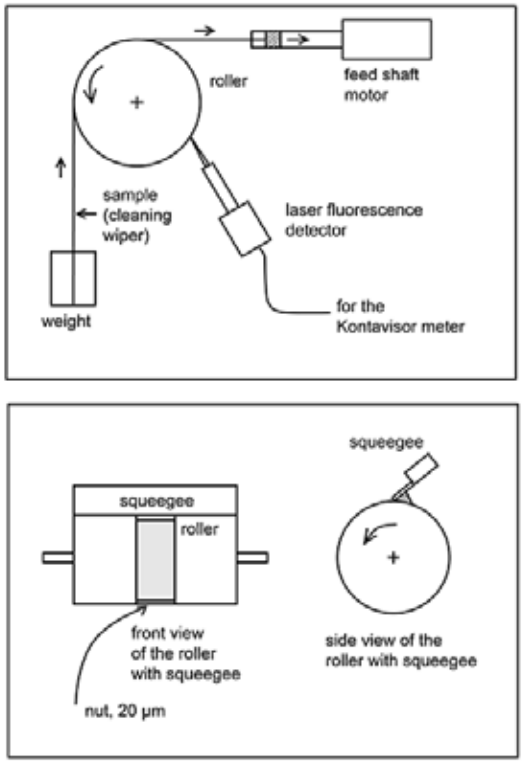


Fig. 15 Schematic diagram of the cleaning time meter TIMEPORT

3. Tests of Liquid Absorption

3.1. Total liquid absorption
3.2. Capillary liquid absorption
3.3. Drop penetration time

For most cleaning procedures, which are carried out by means of cleaning wipers, the wipers are in a solvent - soaked state. The reason for this is the substantial increase in cleaning performance due to the addition of a solvent in the cleaning-by-wiping procedure. The solvent may be, for example, DI water, DI water-alcohol mixture, butyl acetate, a DI water-surfactant mixture or acetone. Hence the wipers need to be particularly suitable for the absorption of such liquids. There are various methods for testing the liquid absorption of such textile fabrics, which may indicate both the maximum possible liquid absorption and retention after a liquid bath, the flooding a textile fabric with a liquid by means of capillary forces as well as the drop penetration speed of a drop of liquid on a surface. The methods described below to test the liquid absorption of precision cleaning wipers allow sufficient insight into the hydromechanics of the cleaning wipers to be tested.

Test 3.1. Total liquid absorption

This method tests both the maximum liquid absorption and the capability of a cleaning wiper to retain liquids. In the test, a section of the cleaning wiper, usually 10 x 10 cm, is immersed in a container with DI water and taken out again after 30 sec. The sample is allowed to drain for 10 seconds during which it is kept wrinkle-free by means of tweezers. Then, through differential weighing, the amount of liquid in the wiper is determined and the result is converted to g/m².

Test 3.2. Capillary liquid absorption

The test method shows the course of capillary liquid absorption of a porous fabric as mass / time diagram. Thus, it can be determined, which mass of a liquid is absorbed by a porous fabric within a selected period of time by the capillary forces against gravity. The result allows the assessment of the liquid absorption speed of cleaning wipers, which is an indication of their use quality.

For textile samples a 20 mm-wide strip with mechanically cut edges is hung up vertically, and by means of a spindle drive is lowered to a level that is at least 1 mm below the surface of a specific liquid. The container should contain a volume of liquid that is multiple times higher than the volume absorbed by the sample.
The liquid surface should be such that due to the volume of the liquid absorbed by the sample, the liquid level is not lowered to such a degree that the test sample loses contact with the surface of the liquid. During the test the container rests on an electronic scale, in which the measured value is recorded at a high as possible clock rate relative to time using an oscilloscope. If the sample comes into contact with the liquid surface, the liquid is sucked into the textile by the capillary forces, and the difference in weight with regard to time is recorded as a graph. With appropriate software, the resulting diagram is evaluated and the amount of liquids that were absorbed within 5 and also 60 seconds, are determined and recorded.

Parameter	**Capillary Liquid Absorption of Cleaning Wipers per Time Unit**
Test methods	Capillary Liquid Absorption
Instruments	Electronic scale with fast data output, oscilloscope with analysis software, immersion mechanism for tissue samples
Test steps	1. Cut out 3 samples from the machine direction and traverse direction of the material (20 mm x 15 cm). 2. Affix the samples to the immersion mechanism of the test instrument. 3. Activate the data acquisition of the oscilloscope and lower the test sample into the liquid. 4. Determine and record the liquid absorption from the resulting mass / time diagram at the PC.
Test media	All liquids, but ultrapure water is typical
Value range	Readings in absorbed mass per (g/5 s, g/60 s)

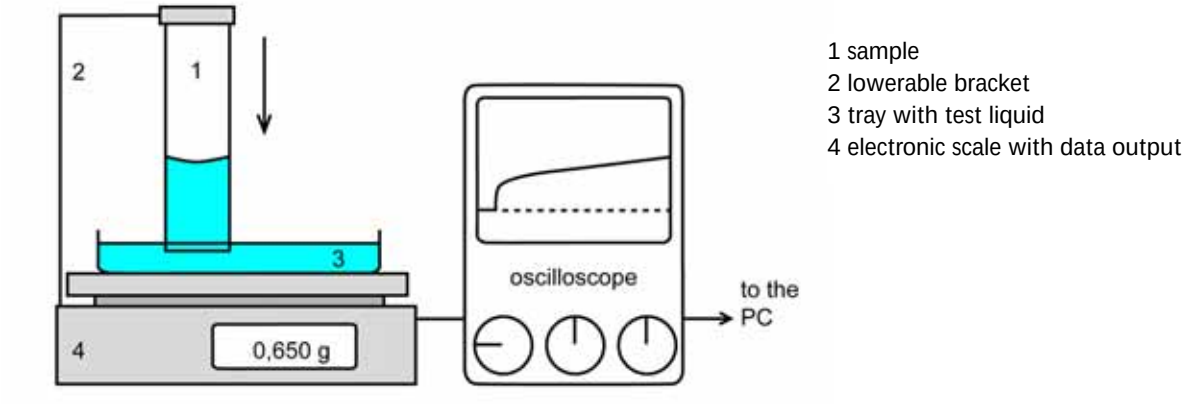


Fig. 16 Scheme: capillary liquid absorption of cleaning wipers

Test 3.3. Drop penetration time

This test method allows researchers to determine how long it takes for a cleaning wiper to completely absorb a drop of liquid. The result of this test makes it possible to gain insight, into the dynamics of the liquid absorption of a cleaning wiper. Especially in wipers made of hydrophobic synthetic fibres /filaments the effectiveness of the chemical hydrophilisation thereof can be evaluated and/or the equipment process can be steered to meet production requirements.
The measurement is performed by photographing the drop penetration process with a high-speed digital camera; the imaging sequences are stored in the computer. When saving each captured image is provided with an accurate time stamp (in 1/1000 s), making it possible to determine the time period between the contact of the drop with the textile surface and its complete submergence in the textile body. The drop is considered completely absorbed as soon as there is no longer any reflexion visible on the textile surface.
The test setup is fixed on an optical bench, which enables the sliding of individual parts - the camera, the sample holder and the milk glass screen - along the optical axis. The milk glass screen is illuminated from behind by a split ring light. If necessary, the sample surface can be additionally illuminated by a swan neck light conductor. To apply reproducible drops a motorised precision pipette is used. In the present configuration of the PC and the software, the camera can record aproximately 250 images / sec.

Parameter	**Liquid absorption of cleaning wipers per time unit**
Test methods	Measurement of the droplet penetration time
Instruments	Precision pipette, wiper holder, digital high-speed camera, lighting, image analysis software
Test steps	1. Fasten wiper, turn on camera, press pipette, after the penetration process stop the recording series. 2. Calculate and record the time between impact and complete penetration of the droplet.
Test media	All liquids which are suitable for the formation of droplets
Value range	0,05… 1000 s

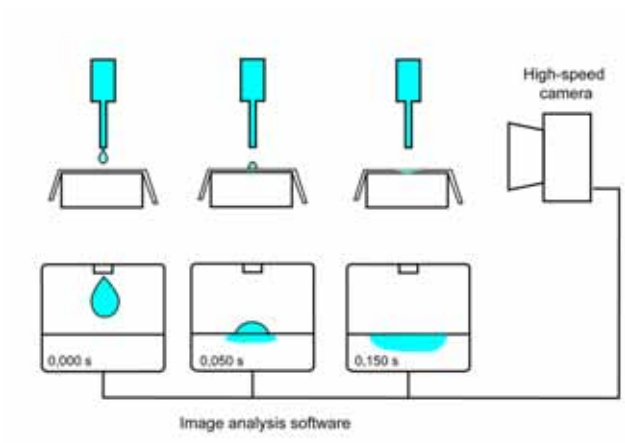


Fig. 17 Scheme: measure of the course of a drop during droplet penetration time

Fig. 18 Device to measure the droplet penetration time

4. Tests of Surface Cleanliness

4.1. Particulate cleanliness of paper surfaces
4.2. Extractable residues of cleaning wipers
4.3. Surfactant load of cleaning wipers
4.4. Surface cleanliness after cleaning procedures

The tests of surface cleanliness are tests that provide information about the surface properties of the raw material paper and raw knits in the state they are delivered. (Tests 4.1. to 4.3) The results of these tests do not yet say anything about the use quality of the final stage of the cleaning wipers and papers. However, they provide indications for changed production conditions at the raw material manufacturer's facility, which may lead to a reduction in quality of the finished product. On the other hand, within the scope of the test 4.4, conclusions can be drawn about the transfer of the slightest quantities of surfactant from the cleaning wiper onto the cleaned surfaces during the cleaning process, which may impair the quality of a precision cleaning wiper.

Test 4.1. Particulate cleanliness of paper surfaces

The test is used to assess the particulate cleanliness of papers, which are intended for use in a clean working environment. The particles are counted that are released during immersion of the sample in a test liquid. Ultrapure water with a resistivity of approximately 18.2 M Ohm is testified as test liquid. The quantity of particles contained in the test liquid can be counted through filtration and subsequent microscopic evaluation (according to DIN 50452-1: 1995-11) or through automatic counting with an electronic particle counter. The sample, a sheet of paper in A4 format is formed under a clean work bench into a tube with a length of about. 210 mm. the abutting edges of the narrow sides of the sheet are fixed to two strips of plastic film. The resulting tube is immersed three consecutive times for four seconds respectively in the beaker filled with ultrapure water up to its top.
After each immersion phase the sample is completely removed from the test liquid and allowed to drain for ten seconds. If the particle quantities resulting from the three dips are very low, possibly additional sheets must be immersed in order to obtain analysable quantities of particles in comparison to the particle basis value of the DI water.
After the immersion, the ultrapure water with its particle content is filtered through a black membrane filter with pores 0.2 µm in size and the particles > 0.5 µm are counted under the microscope of 800x magnification.
The residue may optionally be further investigated later by electron microscopy and X-ray analysis. The amount of particles per unit area is calculated from the number of particles in the test liquid and the paper surface in cm² wetted in the immersion.

Note

The above test does not simulate the particle release in the practical application of cleanroom paper. The particle quantities counted with this method are far above the quantities of particles released in practical use. The method can be used only for comparison of different batches of a specific cleanroom paper. In addition, the effect of the particle-binding coating can be measured.

Parameter	**Determination of the quantity of particles adhering to a paper surface; determination of the particles**
Test methods	Surface cleanliness of papers (immersion method)
Instruments	Ultrapure water system, particle counter of liquids or filtration system for a 0.2µm membrane filter
Test steps	1. All test steps must be performed at a clean workbench. Clean working gloves and gowns with covered cuffs. 2. Form the sample (a DIN-A4 paper sheet to a roll and fixate it), touching it as little as possible. (width: 210 mm length: 297 mm) 3. Immerse the sample 3 times for 4 s in 1000 ml ultrapure water. 4. Let the sample drain off for 10 s after each immersion. 5. Determine the particle concentration of the DI water before and after the 3 immersions. 6. Determine the difference in the quantity of particles. 7. Record the effective number of particles in relation to the wetted area.
Test media	Ultrapure water 18.2 M-ohm, 0.2µm – filtered
Value range	Amount of particles per unit area (m Part / cm² or mPart / sheet A4)

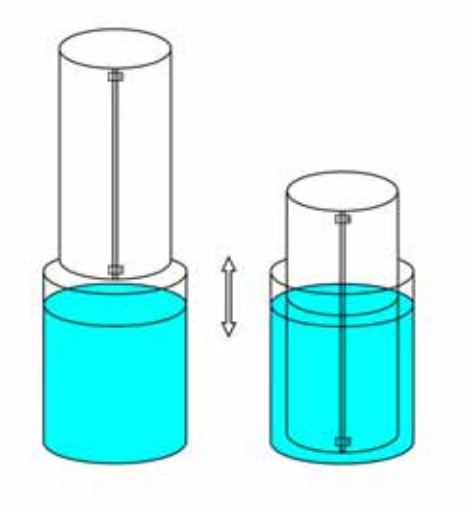


Fig. 19 Scheme: immersion of a shaped paper in a test liquid

Fig. 20 Immersion of a shaped paper in a test liquid

Test 4.2. Extractable residues of cleaning wipers

For the manufacture of precision cleaning wipers, filament yarns and knitted fabrics made from them are sometimes used. To ensure their process capability in the processing machines, these are equipped with avivages such as rinsing and needle oils which consist of a mixture of diverse chemical components. They are removed to a great extent in a decontamination process together with the particles that are always present in the textile body. To test the efficiency of the decontamination, the extractable residues contained in the cleaning wipers are determined before and after the decontamination.
In the Soxhlet method, the extraction takes place by continuous rinsing of a sample (e.g. a section of a cleaning wiper) of known initial mass with freshly distilled solvents. Then the released solvent components are concentrated and their mass is determined and correlated.
The Soxhlet apparatus consists of a heated receptacle containing an evaporable solvent. (water, methanol , petroleum ether, acetone, etc.). The solvent vaporizes when heated by electrical heating of the receptacle. The solvent vapor condenses on the vessel walls of a ball cooling system which is arranged so that it is located above a sample chamber in which the test sample is also stored.
The pure condensate flows into the sample chamber, so that the sample is always surrounded by the solvent. The extractable materials are extracted from the sample.
An overflow tube is connected to the sample chamber, so that after exceeding the solvent maximum level, this flows together with the soluble components of the test sample back to the receptacle in the sample chamber.
Clean, distilled solvent is constantly introduced into the sample chamber through this evaporation-condensation cycle while the extracted residues are concentrated in the receptacle. After a predetermined extraction time the solvent is distilled off from the receptacle and the residue in the flask is dried.
To determine the mass of soluble components, the receptacle (typically a round-bottom flask) is weighed before and after the extraction and the amount in percent of the sample weight is specified. Various polar and non-polar liquids can be used as solvents.

Note

The test result only refers to the amount of avivage (brightener) upon delivery of the material. This statement is not related to the expected surface cleanliness when performing a cleaning procedure with a cleaning wiper.

Parameter	Determination of the quantity of soluble constituents of a cleaning wiper
Test methods	Soxhlet extraction method
Instruments	Soxhlet extractor spherical condenser round-bottomed flask rotary evaporator analysis scale
Test steps	1. Weigh the sample. 2. Weigh the round-bottomed flask. 3. Fill the Soxhlet apparatus with the solvent and the sample. 4. Activate heating and cooling. 5. After completed extraction time distill off the solvent. 6. Dry and weigh the residue in the flask. 7. Calculate the residue quantity.
Test media	Polar or nonpolar solvent, coordinated with the substance to be extracted
Value range	Reading in mass – percentage of the amount of sample used

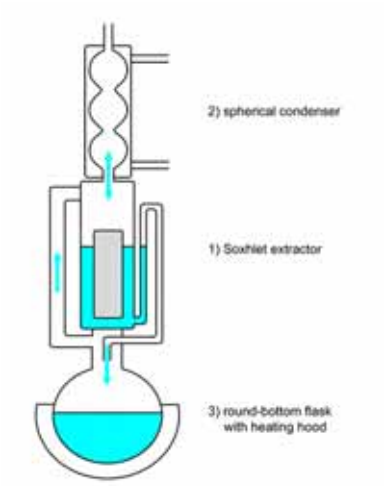


Fig. 21 Scheme: Soxhlet extractor

Fig. 22 Soxhlet extraction system

Test 4.3. **Surfactant load of cleaning wipers**
- based on DIN 53914

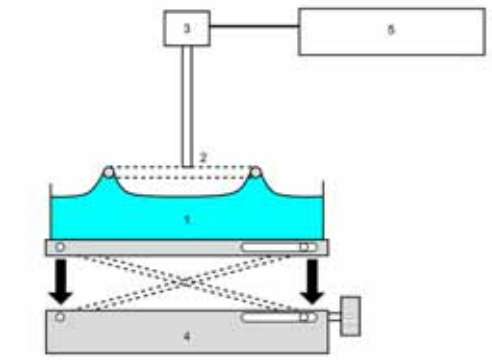
The tensiometric measurement of surface and interfacial tension according to DIN 53914 serves here to identify the surfactant mass which is contained in a cleaning wiper. This relates in particular to the monitoring of the washing and equipment process in the production of cleaning wipers made of hydrophobic filament yarns.

Cleaning wipers made of polyester or polypropylene are in a pure state, that is after all chemicals used in textile manufacturing have been washed out, and are therefore hydrophobic. In order to use them as intended, it is necessary to ensure their ability to absorb liquid.

This is generally carried out through the chemical finish of the textile with a surfactant. The amount of surfactant used for the hydrophilisation should be dosed as low as possible, to avoid a contamination of the cleaned surface due to surfactant residues when the cleaning wiper is used. In the development of washing and finishing processes it is important to create a balance between liquid absorption and surfactant release.
The surfactant release can be determined indirectly by the surface tension of the test liquid. If a textile immersed in ultrapure water releases surfactants, these cause a reduction in the surface tension of the water. With a

Parameter	Determination of the amount of rinsable surfactant residues
Test methods	Tensiometric comparative measurement
Instruments	Tensiometer (Labuda), ultrapure water 18.2 M Ohm
Test steps	1. Determine the surface tension of ultrapure water. 2. Immerse the sample 3 times for 4 s in 1000 ml ultrapure water. 3. Allow the sample to drain after each immersion for 10 s. 4. Determine the surface tension of the water again after the sample has been dipped three times. 5. Determine the difference in surface tension. 6. Compare the difference value with the calibration diagram of a know surfactant and determine the equivalent surfactant mass.
Test media	Ultrapure water 18.2 M-ohm, 0.2µm – filtered
Value range	Mass equivalent of the known surfactant in in mass per area of the cleaning wiper

tensiometer, the surface tension is measured before and after the rinsing of a sample.
This is done by measuring the force which is needed to overcome the surface tension during withdrawal of a defined test sample from the liquid surface. With ultrapure water of the quality 18.2 M Ohm, normally a constant value is achieved in this test. The more contaminants are released from the sample into the test liquid, the clearer this result falls short of the average value. Using a calibration graph that was produced for a known surfactant, a mass equivalent of the quantity of released surfactant can be specified.



1 test liquid
2 ring of Pt-Ir wire
3 sensor
4 level lowering
5 reading

Fig. 23 Scheme of tensiometric method of measuring surface tension after DuNouy

Test 4.4. Surface cleanliness following cleaning procedures

Measuring the contact angle of a sessile drop is recommended as one of the test measurements for surface cleanliness. This is suitable for the comparative determination of certain contaminants into the thickness range of monomolecular layers. This also applies to oil and grease layers prior to and following the cleaning with surfactant-hydrophilised cleaning wipers.
For the test, a drop of liquid is gently applied to the contaminated substrate surface. There it forms, seen in profile, a characteristic angle with the surface. This is dependent on the surface energy of the substrate under otherwise constant parameters. If this surface energy changes, e.g. through a cleaning procedure, the contact angle of the drop also changes. It increases with increasing surface cleanliness. The diverse drop profiles are captured using a digital camera and are analysed and documented by a specially developed software (company OEG).

Parameter	Detection of specific contaminants on surfaces
Test methods	Droplet contour analysis / angle measurement
Instruments	Digital camera, substrate holder, backlight, evaluation software (type "SurfTens" of OEG)
Test steps	1. Measure the droplet contact angle before and after the wiping simulation and determine the difference.
Test media	Ultrapure water 18.2 M Ohm, 0.2µm – filtered
Value range	Difference in percent with positive and negative signs for increase / decrease of the contact angle

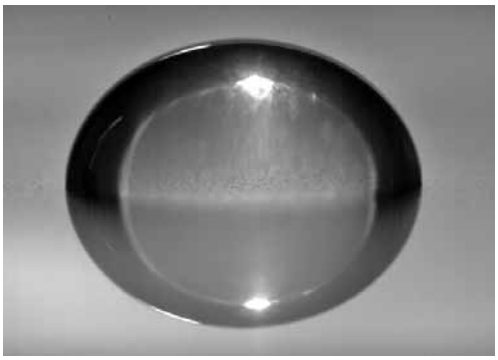


Fig. 24 liquid drops on a reflective surface

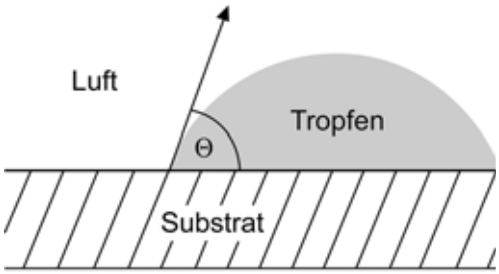


Fig. 25 Scheme: contact angle Θ of a drop as a measure of the surfactant content of the liquid

Tests of the Triboelectric Charge and Discharge

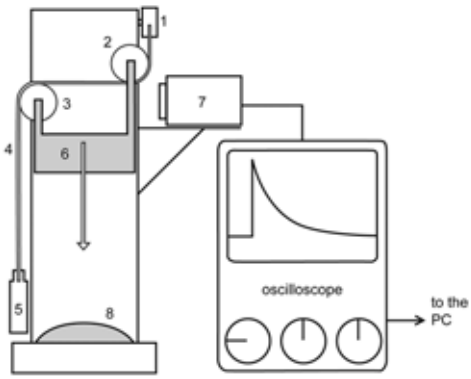
4.5. Triboelectricity, drop sledge after Ehrler
4.6. Triboelectricity in the paper feeder (paper)
4.7. Electric discharge behaviour after Chubb

Cleaning wipers are moved over surfaces under different pressures during their use. Clean papers are rubbed together when individual pages of a paper stack are automatically drawn into the printer. In both cases a triboelectric surface charge occurs (Ref.4). As a consequence of such charges, the charged surfaces attract airborne particles. Until the decay of the charge the particles adhere to the materials; then they lose their hold and are released into the environment. There they can be harmful to the process yield. The consumable materials in clean technology have different triboelectric chargeabilities. For the above reasons it is meaningful to know both the discharge behaviour of such materials after a specified surface charge as well as their triboelectric chargeability. The following test methods described below make it possible to obtain specific knowledge about these parameters for each fabric (or paper) used.

Test 4.5. Triboelectricity, drop sledge after Ehrler

The test method is used to determine the electrostatic chargeability of flat materials, such as textiles or films, by frictional processes and to measure the time until the resulting decay of the charge. A drop sledge developed by Dr. Peter Ehrler at the Denkendorf Textile Research Institute is used, which carries out a friction process. A sample 8 cm wide and at least 20 cm in length is fixed on the upper frame of the device and wrapped around two polystyrene rods that are mounted on a sledge transversely to the falling direction. After the sledge is triggered remotely, the sledge falls – guided on the side – vertically downwards. During the drop the polystyrene rods rub over the front and back side of the sample and charge it triboelectrically. With a measuring instrument constructed according to the principle of the field mill, the strength of the electric field created by the charge is measured, and the decay of the field is monitored over time.
The discharge curve is recorded with an oscilloscope and analysed on a computer. The test itself takes place in a climatic test chamber at +22 ° C and 45 % relative humidity on the samples stored in the test conditions. This conditioning is necessary to avoid erroneous test results due to environmental influences.

Parameter	Electrostatic chargeability of fabrics
Test methods	Triboelectricity after Ehrler
Instruments	Climatic test chamber Ehrler drop sledge field strength metre oscilloscope evaluation software
Test steps	1. Cut the samples and put them in the climatic test chamber. 2. Affix the samples to the halyard swivel. 3. Activate data collection on the oscilloscope. 4. Release the drop sledge. 5. Stop measurement after decay of the electric field. 6. Evaluate the charge / time diagram at the PC.
Test media	Electric field
Value range	Combined result of the maximum pulse height in kV and decay of the field in seconds.



1 clamping device
2 + 3 polystyrene rods
4 samples (8 cm x 25 cm)
5 clamp with weight
6 portable drop sledge
7 field strength meter

Fig. 26 Scheme: triboelectric drop sledge after Ehler

Fig. 27 Triboelectricity drop sledge after Ehrler and oscilloscope

Test 4.6. Triboelectricity in the paper feeder (paper)

During printing in laser or ink jet printers, the paper used for documentation purposes with the techniques of clean work should have the lowest possible triboelectric charge. Thus, the binding of airborne particles to the paper surface shall be reduced. The test method allows the comparison of different papers with respect to their triboelectric charge when feeding into a laser printer.
For the test, a commercial laser printer was used, and the paper feed was modified so that a device for measuring the electric field strength could be positioned directly above the paper input tray. The paper eject of the printer is positioned outside of the measurement environment and thus has no adverse effect on the measurement results. Another option would be to measure the triboelectric charge of the paper upon ejection from the printer. The field mill meter is fixed at a right angle to the stack of paper, at 10 mm distance to the paper surface of the top sheet. In the printer settings of the software (e.g. MS Word), a corresponding print mode with about 20 copies per minute is selected. To avoid undesirable environmental influences, the test is performed in a climatic test chamber at +22°C und 45% relative humidity.

Parameter	Comparison of the resulting triboelectric charges
Test methods	Triboelectricity of paper in the paper feeder
Instruments	Climatic test chamber, office printer with open paper tray (HP Laserjet 6L), field strength metre, oscilloscope with evaluation software
Test steps	1. Lay the DIN A4 paper that is to be tested in the printer. 2. Affix field strength meter at 10 mm distance from the paper. 3. Activate the recording of the measured values and the printing order (20 sheets/min). 4. Evaluate the resulting charge / time diagram at the PC.
Test media	Papers for documentation purposes in the cleanroom
Value range	When each sheet is drawn into the printer, a positive and negative charge is created. The difference between these two charges is measured and an average value is determined for the sheets fed into the printer.

An oscilloscope is connected to the output of the meter, which records a diagram of field strength with respect to time. This diagram serves the evaluation and documentation of the test. The difference in height from a positive pulse to the next negative pulse is measured, and the average peak voltage is defined as measure for the triboelectric charge of the paper during the transport process.

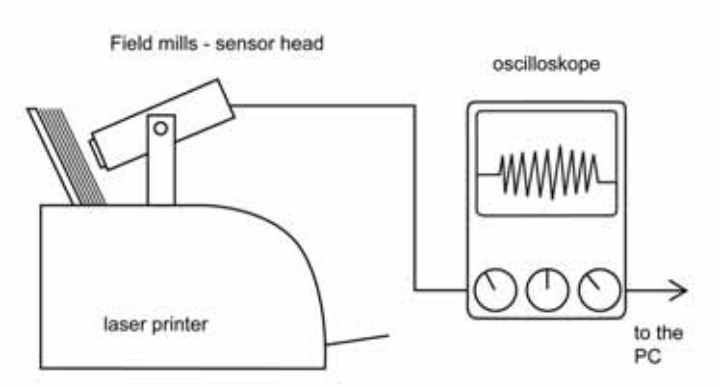


Fig. 28 Scheme: measurement of triboelectric charge of papers in laser printing

Test 4.7. Electric discharge behaviour after Chubb

With this test method, the charge and the decay behavior of electrically induced surface charges of fabrics, knitted fabrics, nonwovens, paper and films are investigated. The charge takes place by means of a Corona wire with defined electrical voltage that is moved a short distance in front of the surface of the sample. The test method allows researchers to measure and document changes in the surface modifications of a material by measuring changes in the material-specific decay behaviour. The measurement is performed by charging the surface to be tested and then measuring the charge state of the surface as opposed to time. The result is documented as a charge/time graph. The meter is placed on the surface to be tested. To measure thin, flexible sheet materials such as cleaning wipers or papers there is a sample holder, which holds this membrane-like sheet stretched under the meter.

Parameter	Investigation of the decay behaviour with Corona – induced electrical surface charge.
Test methods	Decay behavior after Chubb
Instruments	Climatic test chamber, measuring device JCI-155 of John Chubb Instrumentation Ltd, evaluation software JCI-Graph Vers. 2.1.3., PC
Test steps	1. Store the sample in the test climate for eight hours. 2. Automatic recording of the charge/time diagram 3. Evaluation.
Test media	All flat-lying surfaces
Value range	charge in volts; decay time in seconds

Due to the influences of temperature and humidity on the test results, electrostatic tests are carried out in a defined test climate, which the test surfaces are subjected to at least eight hours before the measurement. Based on conditions in clean rooms, the tests in the Clear & Clean Research laboratory are carried out at +22°C and at a relative humidity of 45% in climate test chamber.

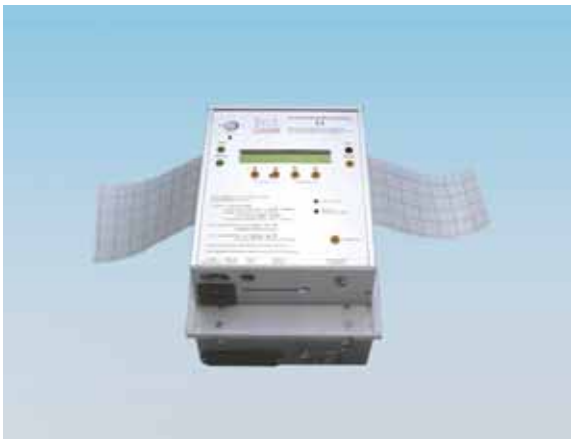


Fig. 29 Discharge measuring device after Chubb

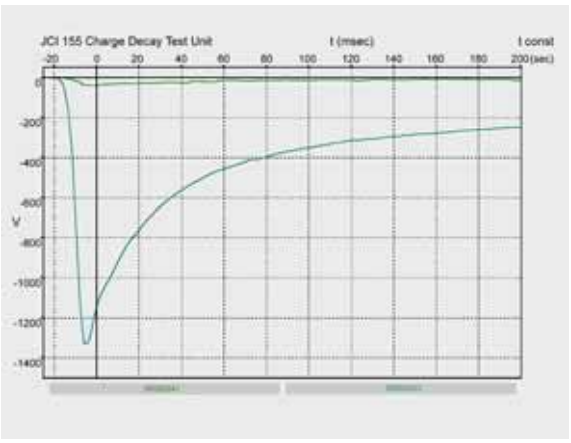


Fig. 30 Charge-time diagram of a textile sample after a measurement in the discharge measuring device after Chubb

5. Other Tests

The methods described in brief below primarily serve the study of the mechanisms of cleaning by wiping in the Clear & Clean Research Laboratory. In this sense they promote knowledge about the transfer of micro contaminants from the cleaning wiper back onto the surface. Observation of the morphology of the surface often gives an indication of a structure or an occurrence. In this respect the electron microscope is an important research tool with regard to surface contamination in the micro range. With the aid of this tool, nonwoven and knitted structures can be visualised in 3D, whereas in the light microscope they only appear blurred. The electron dispersive X-ray analysis EDX allows us to gain insight into the element spectrum of a surface and thus enables us to draw conclusions about the original states, identities or contaminations. Light microscopy allows us to count particles on the surface, in particular filter surfaces and thus also to detect the washed out state of our precision cleaning wipers after repeated decontamination in the DI water. In interference contrast it is thus possible to visualise in 3D the contamination of smooth surfaces and thus to show the greasy residues on the surfaces following a cleaning procedure in the most beautiful colours. With the aid of laser technology, the ellipsometric thickness

measurement provides insight into the nanometric contaminant residues on surfaces and their form factors. A new test method, laser fluorescence, provides information within seconds about the reduction of a contaminant layer on surfaces and gives us insight for the first time into the cleaning efficiency of wiping cleaning systems per unit of time. The measurement of kinetic and static friction of papers ensures that formatted cleanroom papers do not cause jams in laser printers. In all these tests, the imaging analysis systems for microscopes allow us to quantify the analogue structures digitally and thus to make a comparative evaluation. And lastly, ion chromatography, which we occasionally use to analyse the content of cleaning wipers and to ensure in this way that no harmful materials are contained the product that is to be cleaned.

Test 5.1. Scanning electron microscope (SEM), morphologies of surfaces, filaments, fibres and particles

To study the morphology of surfaces, filaments, fibres and particles, Clear & Clean Research Laboratory uses a scanning electron microscope of the type Leitz ISI 60 including an EDX system. The system can achieve magnifications of up to 100,000 times, record the images digitally and save them in a corresponding image analysis software.

Fig. 31 Scanning electron microscope Leitz ISI 60

Test 5.2. EDX – electron dispersive X-ray analysis, element analysis

Through the element analysis of the EDX system, the SEM can also be used to analyse ionic components or contaminations.

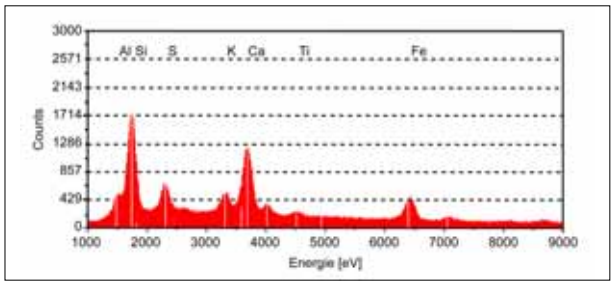


Fig. 32 Elements distribution in the EDX evaluation

Test 5.3. Light microscopy – reflected and transmitted light, dark field, interference contrast, fluorescence

The Leitz Orthoplan is mainly used in the evaluation of membrane filters (particle counting) in reflected light/dark field. With the connected camera, images of the microscope can be transferred to the PC and analysed and documented there using image analysis software. The image analysis software Image Pro plus also has an automatic particle counter. The microscope can also be converted for use as a fluorescence microscope to enable the counting of fluorescent-labelled particles on rough surfaces. Investigations in bright field and using transmitted light are also possible.

Fig. 33 Leitz Orthoplan fluorescence microscope

Zeiss Ultraphot 3
In addition to the light and dark field, this light microscope is equipped with an optic for investigations using the Nomarski interference contrast.

Test 5.4. Ellipsometry – measurement of thickness of ultrathin contamination layers

The measuring principle of laser ellipsometry is based on the change of an elliptically polarised laser beam in the reflexion on a coated surface. With this method, contaminant layers down to the sub-monolayer range (less than one molecule layer) can be detected (see DRE - Dr. Riss GmbH, Ratzeburg)

Fig. 34 Riss-Ellipsometer to measure the thickness of extremely thin, transparent contaminant layers in the nm range (examples Fig. 35, 36)

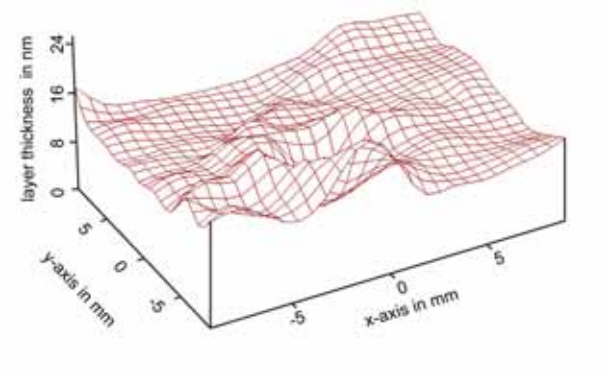


Fig. 35 Layer thickness prior to a cleaning procedure with a precision cleaning wiper

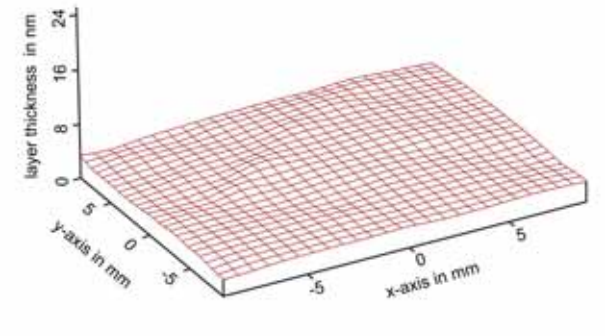


Fig. 36 Layer thickness after a cleaning procedure with a precision cleaning wiper

Test 5.5. Laser fluorescence – measurement of thickness of contamination layers

To measure contaminant layers in the micro- and nanometre range, the Kontavisor laser fluorescence measuring system is used, which evaluates the fluorescence behaviour of aliphatic hydrocarbons excited by laser light, such as in oil layers. This method enables statements to be made within seconds about the change of contaminant layers in cleaning-by-wiping procedures. This test method was introduced by Win labuda in 2009.

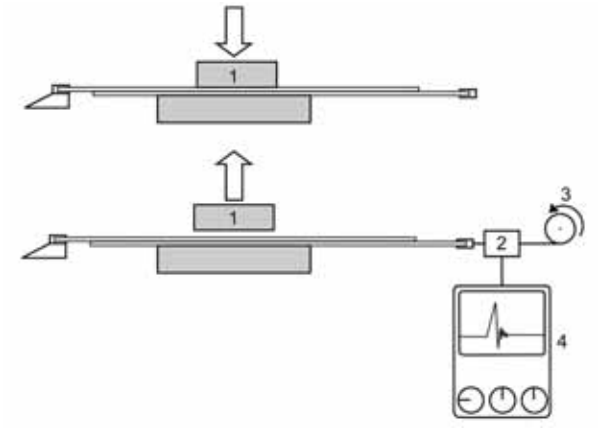
Fig. 37 Kontavisor, Kienzle Prozessanalytik GmbH, Flensburg Laser fluorescence thickness measurement of thin oil layers down to molecular structures

Test 5.6. Kinetic and static friction of papers

The test is used to compare different paper batches in terms of “sticking” effects, which can occur with latex-coated papers after being subjected to pressure. In the test 2 sheets of paper are placed on top of each other, pressurized and then pulled apart. The tensile force required for the separation is measured.
For the test a climate chamber, a knee lever press and a device to measure the pulling force in the range of 0-25 N is needed, preferably with a horizontal working direction. Sheets of paper cut in A5 format serve as samples which prior to the test have been stored in a test climate of + 22°C at 45% relative humidity. For the test, 2 sheets of paper with 2.5 cm margins are stacked on top of each other and placed in the press. Using a steel cylinder with a

Parameter	Measure of the force to separate glued papers
Test methods	Breakaway torque test
Instruments	Knee lever press, tensile testing device, oscilloscope with analysis software
Test steps	1. Cut samples and place on top of each other, apply pressure for two minutes. 2. Clamp in the samples and perform the tensile test. 3. Evaluate the time/force diagram on the PC.
Value range	Load in N

diameter of 40 mm the preset pressure is exerted on the paper for 2 minutes. Then the sheets are affixed in the tensile strength testing device. In doing so, care must be taken that no force is exerted on the sheets that would lead to a loosening or premature separation of the stuck-together papers. The measuring value is the maximum value in Newton that is necessary to separate the area that is stuck together.



1 Pressenstempel
2 Zugkraftmesser
3 Zugmotor
4 Oszilloskop

Fig. 38 Scheme: Measurement of the surface adhesion of latex-coated papers

Test 5.7. Image analysis - systems for microscopy

For analysis in imaging techniques such as microscopy or in high-speed video recordings, the Clear & Clean Research Laboratory has different imaging systems, which enable the following automated analyses:
- Counting of particles and sorting by size
- Measurement of surface content
- Time measurement in high-speed sequences
- Contact angle measurements for drop contour analysis

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