



*For wiping cleaning procedures it is an essential prerequisite that the wiper itself has the proper form with regard to the hand. At the beginning of the cleaning procedure, the user forms the wiper into a shape that is comfortable to hold in the hand and that cleans the contaminated surface effectively. For this purpose, four main handling variants have been developed, which are described below. This paper shall elucidate to what extent the handling of cleaning wipers during cleaning determines their effective surface area and thus also affects the working time.*

# Cleaning Wipers

## Handling Variants and Effective Surface during Cleaning Procedures

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### Wad form

To remove extensive and/or strongly adherent contaminants, the cleaning wiper is often formed into a "wad" that lies in the hand in such a way that it can be held firmly but still exposes the largest surface possible to absorb the contamination. With this wad form, the greatest possible pressure of all the different forms can be exerted on the surface that is to be cleaned.

### Tampon 1 form

Here, the cleaning wiper is crumpled, and the resulting tampon is positioned between the thumb, index, middle and ring fingers. This type of form is used for cleaning wipers with smaller dimensions or for the removal of minor contamination. This shape occurs when a too-large hand holds a too-small wiper. The disadvantage can be seen in the diagramme in Fig. 8.



**Fig. 1** Wad form



**Fig. 2** Tampon 1 form



**Fig. 3** Tampon 2 form



**Fig. 4** Layer form

### **Tampon 2 form**

In this type of shape the wiper is repeatedly folded without crumpling it to make a rather long roll with eight layers per wiper side that can be used to clean effectively. During the cleaning work, the top part of this wiper structure is grasped and clamped down between the thumb-thenar line on the one side and by the fingertips of the index, middle and ring finger. The advantage of this formation is the cleaning efficient use of up to 16 sub-areas due to the progressive folding system.

### **Layer form**

The layer form is often used to remove minor contamination. The cloth is folded twice in the middle, making four layers. The thus folded tissue is clamped at a corner between the

thumb and forefinger and is moved under the pressure of four fingers over the surface to be cleaned. This method for using cleanroom wipers is considered to be the most efficient in the cleanroom industry in particular. The following remarks refer to cleaning impurities on a small or medium surface area, depending on the degree of contamination up to 30 x 30 cm. This applies to wipers with an area of 15 x 15 up to 22 x 22 cm. For the removal of contaminants from grooves and cavities, specially shaped cloths are often needed that cannot be considered here. This also applies to the removal of large splashes of liquid. Depending on the handling variant selected for the cleaning, in practice the parts of the cloth effective for cleaning are of different sizes. With these experiments we wanted to gain the following insights:

**A** How large is the effective used area of a cleaning wiper, taking into account the four handling variants?

**B** Is there a handling variant that is conducive for cleanroom applications?

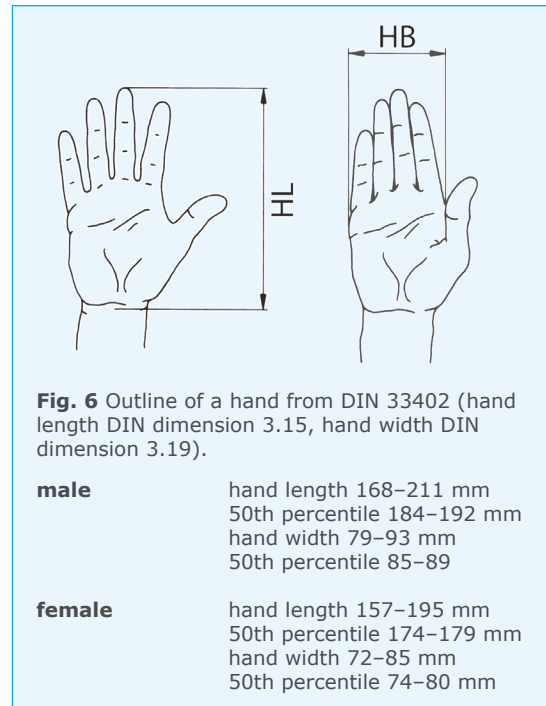
**C** Is there a cleaning wiper with optimal dimensions?

### Cleaning procedures with the wad shape

First, it was necessary to develop a method by which it is possible to properly determine the volume of a cleaning wiper in the crumpled wad shape. This became possible by using a transparent cylindrical hollow body in which we arranged a piston, which first had a weight of 1,200 g and alternatively was loaded additionally with 10,000 g. Based on the visible height of the piston above the bottom surface, the cloth volume could be calculated. Taking into account the five respective measurements, the variation coefficients were between 1.6 and 3.6 %. Based on these measurements, we found that, for example, the volumes of the cleaning wipers of the Clear / Clean Production programme have large variations. Table 5 shows the volumes of the individual cloths. A small cleaning cloth with low volume cannot be led optimally by a big hand during a cleaning procedure, especially when the wiper has the wad form. Therefore, after the compression volume, the next most important parameter to be determined was to calculate the volume of the hollow-shaped hand in which the cloth is embedded. This volume correlates naturally with the hand length (HL) and to some extent certainly also with the hand width. To achieve a first mathematical approximation, we assumed that the length of the hand from the carpal bone to the cup of the fingertip of the middle finger comprises half of

Wiper (type)	format in cm	cm <sup>3</sup> per wiper	CV
<b>Microweb 2</b>	22 x 22	45.4	1.6
<b>Sonit MD-A</b>	22 x 22	43.4	2.4
<b>Laboclear</b>	22 x 22	34.4	3.6
<b>Sonit HD-M</b>	22 x 22	26	1.8
<b>Microweb</b>	22 x 22	26	3.7
<b>Viscot</b>	22 x 22	24.4	1.6
<b>Sonit MD-M</b>	22 x 22	22.3	3.6
<b>Absormat</b>	22 x 22	18.8	3.0
<b>DryTech</b>	22 x 22	10.2	3.6

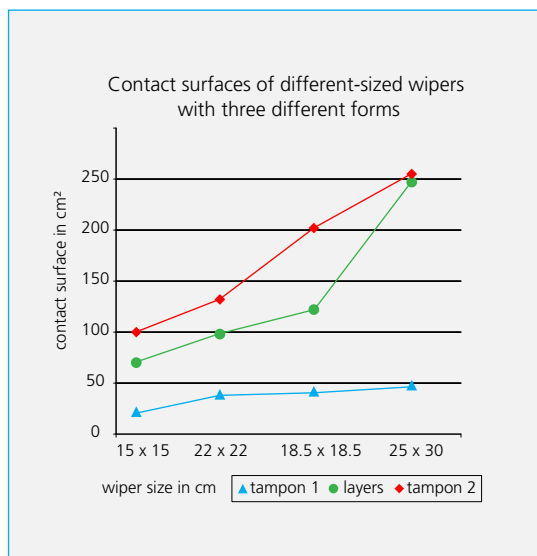
**Fig. 5** Measurements of the volume compression type,  $\bar{x}$  and CV. All data calculated for standard wiper sizes of 22 x 22 cm.



	1 wiper	2 wipers	3 wipers	4 wipers	5 wipers
<b>wiper surface in cm<sup>2</sup></b>	550	1100	1650	2200	2750
<b>contact surface in cm<sup>2</sup></b>	42.4	49.1	54	76	97.1
<b>CV</b>	16	16.3	12.9	10.9	8.1

**Fig. 7** Contact surface size when forming several wipers into a wad.

the optimal circumference of a crumpled cloth. According to this assumption, a cleaning cloth that is pre-formed as a wad has an optimal diameter of  $D_{opt} = 0.62 ((2HL): 3.14)$ . When a normally formed man's hand is calculated in its stretched length to be 19 cm (measured on the inside of the hand), this amounts to an empirically determined wad ball diameter of 7.25 cm. This results in a correction factor of 0.62. This correction factor may not be exactly the same for all hand shapes, but at present we do not have any better information available, so until further notice we will have to make do with the information we have. The introduction of a correction factor is necessary because the fat and tissue cushions of the hand during its bending form small convex regions, thereby changing the ratio of longitudinal line to semi-circular perimeter. In the specification DIN 33402 Part 2 of October 1986, the hand lengths and widths of male and female German individuals are specified as well as those for Italian, Yugoslavian and Turkish employees in Germany. From this the following physiological data can be derived for a group of persons aged 18–65 years. It can be said that cleaning wipers are used by people with a hand length between 15.7 and 21.1 cm and a hand width between 7.2 and 9.3 cm.



**Fig. 8** Contact surfaces of different-sized wipers which have different forms

From the above results there is a wide variation of wiper volumes that are necessary to fill a "cupped hand" sufficiently with a cloth. This is the essential problem of the wad form.

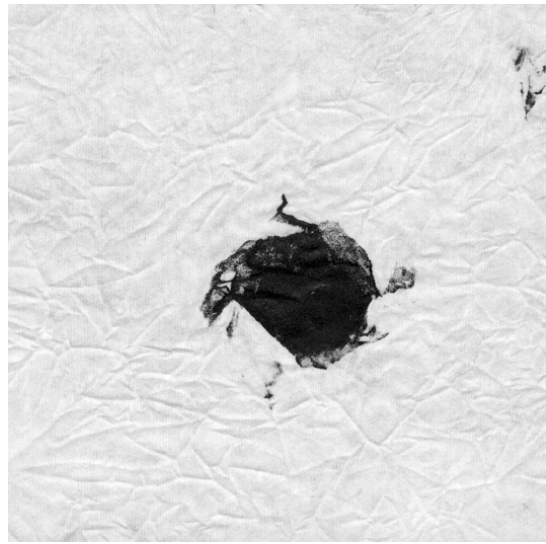
## Experiments

To determine the effective cleaning surface of a cleaning cloth, taking into consideration the different above-mentioned form variants, black oil dye was applied with a roller over a large area on a glass plate. The dye on the glass plate was removed by wiping, taking into account the three handling variants, initially without changing the manual holding position of the cloth, e.g. by refolding, in order to use a larger part of the total surface of the cloth in the cleaning procedure. Using a scanner and a suitable measurement program the blackened parts of the cleaning cloth were measured and added to the result as a total sum. The procedure was repeated four times respectively to ensure that even when taking standard deviation and the variation coefficient of the test series into account, the method was statistically sound. The results are shown in the tables below. For the wad shape, a ball was formed to fit into the hand. The first test consisted of one cloth and with each additional experiment the number of cloths forming the wad was increased by one. In the wad form, an increase in the used cloth surface of 500 % correlated to only 129 % of the effective cleaning surface. When considering the surface use in the wad form without refolding, there was merely a percentage of use of 7.7 % for one cloth in wad form and up to 3.5 % for five cloths in a wad. The wad form method only uses a small part of the cloth surface, and can therefore only be recommended for cleaning tasks in which the cleaning cloth can be refolded and used further. However, in cleanroom applications this is mostly excluded due to the invisibility of the impurities but also because of their possible transfer back from the cloth to the newly cleaned surfaces. The diagramme in Fig. 8 shows the results of the comparative measurements using tampon 1, tampon 2 and the layer form. For the wiping tests, one wiper with the respective dimensions and form was used. Since the wad form merely corresponds to a wiper with the tampon 1 form, it is not listed here.

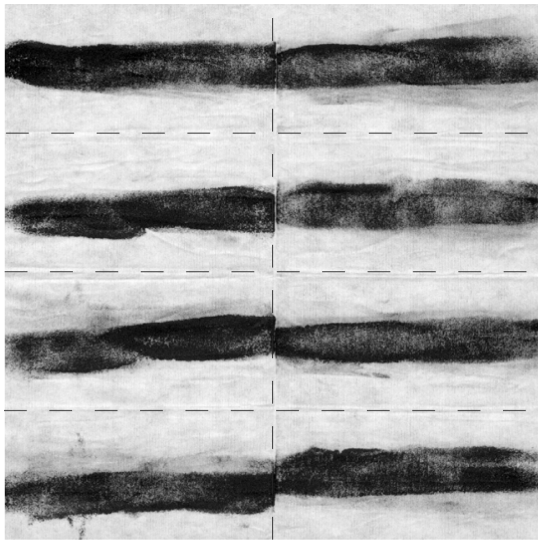




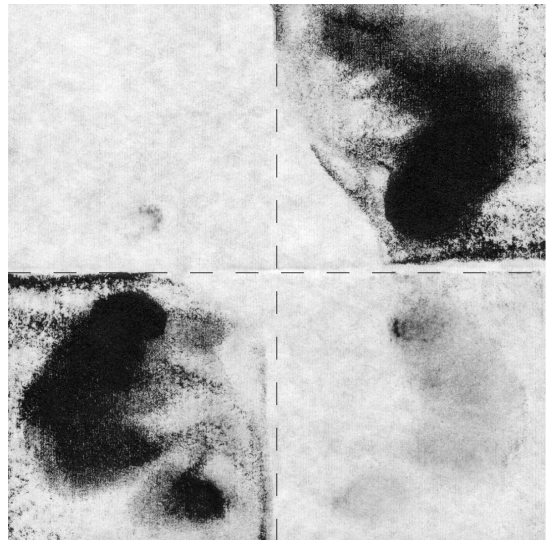
**Fig. 9** Trace image 1: wad form (with five wipers as wads)



**Fig. 10** Trace image 2: tampon 1 form



**Fig. 11** Trace image 3: tampon 2 form



**Fig. 12** Trace image 4: layer form

### Trace images of the different cleaning tests

In wiping cleaning procedures, the size of the contact area between the cleaning wiper and the surface is dependent on the hand size of the individual doing the cleaning. To prove this, the tests of the layer form were repeated by a test subject with a significantly smaller

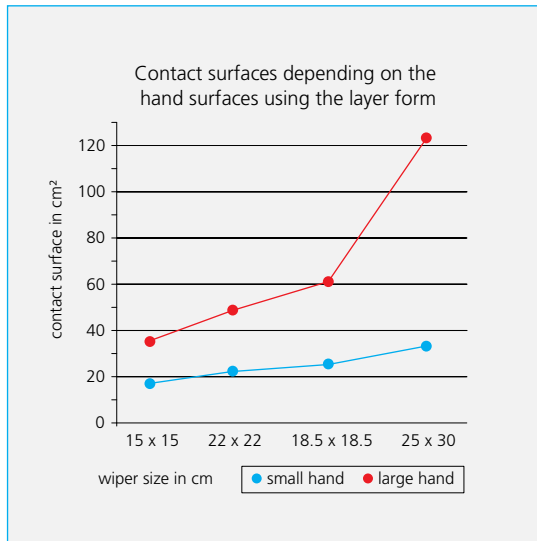
hand size. From the diagramme in Fig. 13 it can be seen that the wiper surface can be used less effectively by a smaller hand. An example for the effective use of surface in wiping cleaning procedures are the Gripfold wipers developed by Clear & Clean, in which the surface that is efficiently cleaned is significantly increased due to the hand-encompassing

form. The measurement of the utilised area of the glove cloth resulted in a use of about 49 % of the wiper surface while the use of the folded wipers amounted on average between 7 % and 25 % .

### Results

1. Regardless of the number of wipers that are used, the wad form is not an economical way to use cleaning wipers (see Fig. 7).
2. Especially in cleanroom settings, the tampon 1 form and the layer form are the most economical way to use cleaning wipers, and these two forms also minimise the risk of recontamination of the previously cleaned surfaces (see Fig. 8).

3. Especially for contaminations with a small surface area, the tampon form 2 can ensure a very good surface use of the cleaning wiper. However, for contaminations with a larger surface area , the layer form is recommended (see Fig. 13).
4. With the layer form, the hand size of the individual doing the cleaning has a significant impact on the effective contact area. (see Fig. 13).



**Fig. 13** Contact surfaces depending on the hand surfaces using the layer form