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TÜV Rheinland LGA Products GmbH

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on a comparative study of drying hands with paper towels and hand-drying with a high-speed air stream
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about the execution of a comparative study of drying hands with paper towels and hand-drying with a high-speed air stream

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1 ASSIGNMENT

On 14.4.2011, TÜV Rheinland LGA Products GmbH was commissioned by Verband Deutscher Papierfabriken e.V. (the German Pulp and Paper Manufacturing Association) in Bonn, represented by Dr Thomas Moldenhauer, to conduct a comparative study of hand-drying with paper towels and air dryers of the Dyson Airblade™ type.

The tasks of this study were

- To measure the noise that is generated by the Dyson Airblade™ hand dryer and to evaluate whether the noise that is generated during the operation of this device has effects on the health;
- To examine the change in the number of bacteria on the hands during a practical test with 135 test subjects, before hand-washing and after drying, where the objective was to examine changes in the number of bacteria that occur with the use of paper towels as compared to the Dyson Airblade™ hand dryer; and
- To examine possible bacterial contamination, of the ambient air, the surfaces of the device, and its immediate surroundings, in a washroom where Dyson Airblade™ hand dryers are in operation.

2 INTRODUCTION

Even in the 21st century, infectious diseases are responsible for the death of millions of people around the world each year.

In recent years, epidemics with previously unknown pathogens such as bird flu, swine flu, and norovirus infection have surfaced. The population of Germany were made to feel insecure earlier this year, when a number of people succumbed to *Escherichia coli* infections, the source of which could not be identified for quite some time.

So-called hospital-acquired infections, which are caused by bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA), *Pseudomonas*, and *Clostridium*, are also increasingly making headlines, requiring hospitals to implement higher standards of hygiene.

It has been scientifically proved that bacteria can be transferred to other people by direct hand contact with the patient or through staff. Efficient hand-cleaning methods are, therefore, essential for breaking the transmission chain.

Diverse equipment and materials for drying hands can be found in public sanitary facilities. These items include paper towels, textile towel rolls, and air dryers.

Recent years have seen increasing numbers of market launches of hand-drying devices that are claimed to dry the hands completely and hygienically in a very brief period of time, as compared to standard hot-air dryers, by using a high-speed stream of cold air. This is supposed to be achieved by holding dripping-wet hands in the device, where they are dried by an intense air stream.

During the drying process, the intense stream of air blows water droplets from the dripping hands into the surroundings. In cases of frequent use, this leads to visible pools of water in the vicinity of the devices.

Our studies in September 2005 (please refer to report 425-452 006, on the implementation of a study of hand-drying) have shown that comparatively high bacterial contamination still is found on wet hands after washing.

Dispersion of this contaminated water, which is blown into the vicinity by the air stream of the device, raises hygiene issues, which we examined in microbiological studies of bacterial contamination, conducted for ambient air and the surfaces of the devices, both during and after operation of the air dryer.

Further studies should permit a comparison of the bacterial contamination on hands before and after washing, and after drying both with a Dyson Airblade™ hand dryer, on one hand, and with paper towels, on the other.

During operation of the Dyson Airblade™ hand dryer, significant noise levels are particularly noticeable. Whether such noise pollution can result in a health hazard, and whether children, whose ears tend to be much closer to the device than those of adults and are therefore subjected to higher risk, was examined through our measurements of noise levels.

3 NOISE MEASUREMENTS

In the scope of the present investigation, noise measurements were conducted for three Dyson Airblade™ hand dryers. During the operation of a Dyson Airblade™ hand dryer, significant noise levels are particularly noticeable. The thought occurred in this regard that children, because of their height, could come much closer to the device than do adults and may therefore be subjected to higher noise levels.

Tests were carried out on the Dyson Airblade™ hand dryers with the serial numbers A01-EU-110215 J140A, J141A, and J150A.

The measurements are divided into three test packages, which are described in detail below.

3.1 Measurements in a real-life washroom by means of sound level analysis

3.1.1 Testing specifications

Modelled after Directive 2002/44/EC, on the protection of employees against noise hazards:

a) Measurement method

Individual measurements at a person's ear level (approx. 0.1 m from the ear, at an ear height of approx. 1.6 m above ground level) (see also the photos attached to this report).

b) Measurement location

A washroom with tiled walls and a suspended ceiling.

c) Measurement conditions

Three units attached to the wall, with the distance between each pair being about 0.4 m. The top of the device housings located approximately 1.05 m above the floor, in accordance with the manufacturer's specification for 'men'. Measurements for the devices were carried out in 'idling' and 'drying' mode.

d) Measuring equipment

Sound-level analyser: Brüel & Kjær, Type 2260.

Calibrator: Brüel & Kjær Type 4231.

The measurement system fulfils the requirements of DIN EN 61672 and was calibrated at the beginning of the measurements.

3.1.2 Measurement results

The results of the measurement procedure were registered at a minimum distance of 0.5 m between the source of the noise and the ear. At a distance of, for instance, 25 cm, which can be found when the dryer is used by children, a noise intensity of approx. 6 dB or higher can be expected under the laws of sound propagation.

The following A-weighted sound pressure levels were measured at the ear of the operator, standing at the middle unit of the three. The A-weighting takes into account the frequency-dependent hearing ability of different people. In this regard, the low and high frequencies especially are damped.

Table 1:

No.	Comment	Sound pressure level in dB(A)
1	Dyson Airblade* in the middle, idling	87
2	2nd Dyson Airblade*, idling	89
3	3rd Dyson Airblade*, idling	90
4	Dyson Airblade* in the middle, hand-drying mode	91
5	2nd Dyson Airblade*, hand-drying mode	92
6	3rd Dyson Airblade*, hand-drying mode	92

* Dyson Airblade™ hand dryer

Table 1 clearly shows that sound pressure levels in excess of 90 dB(A) can manifest themselves at users' ears, particularly during the drying process.

When the drying time of 10 seconds specified by the technical data for the device is taken into account, this level does not represent an impact that falls within the range wherein a risk of hearing loss occurs.

Comparison with the noise level of human conversation at about 65 dB(A) shows that human communication is nonetheless significantly disrupted during device operation.

VDI Guideline 2058's Sheet 3 makes the following provision in this respect:

> For low requirements (satisfactory intelligibility of speech: 80% monosyllable intelligibility, 97% sentence intelligibility; increased voice effort) and a distance of 1–2 m from the conversation partner, the A-weighted sound pressure of the background noise should not exceed 55–65 dB. This requirement is recommended for short conversations only.

In extreme situations, such as when a child exposes an ear directly to the drying area of the device, sound pressure levels of up to LAF = 110 dB(A) and peak levels LpCpeak = 129 dB(C) occur.

In the absence of a separate set of rules, we will refer to the requirements of other regulations as an alternative:

DIN EN 71-1, 'Safety of Toys', version of September 2008

This European standard applies to children's toys – i.e., for any products or materials designed or clearly intended to be used for playing by children under 14 years of age.

Section 4.20, 'Acoustic requirements', contains, amongst others, this provision:

> The requirements in 4.20 do not apply for mouth-operated toys, where the noise level is determined by the blowing strength (e.g., pipes and miniature musical instruments, such as trumpets or flutes).
>
> The C-weighted peak-emission sound pressure level (LpCpeak) generated by any other toy, with the exception of toys using percussion caps, must not exceed 115 dB.

Furthermore, Paragraph 7.14 states: 'Toys generating high-frequency sound levels must be furnished with the following warning on the toy itself or its packaging:

> WARNING! Do not use close to the ears!
> Misuse can lead to hearing damage!'

3.2 Description of the noise impact

In description of the effect of noise, the ‘annoyance’ factor is of particular importance. A clear and universal definition of the term ‘annoyance’ is currently not available. The problem of arriving at a clear definition stems from the fact that annoyance is a subjective measure that may differ in its perception, depending on the situation and the person involved.

In assessment of the level of annoyance of sounds, psycho-acoustic noise parameters such as loudness, sharpness, roughness, fluctuation strength, and tonality are used.

Other than sheer loudness, the greatest significance is given to sharpness and tonality in the present case. Besides the above-mentioned sound strengths, the characteristics of sharpness and tonality are examined below.

Sharpness

Sharpness can be perceived separately from other sensation variables. In this regard, the spectral envelopes of a sound are of fundamental importance in determination of perceived sharpness. High spectral components are responsible for a dominant, strong sharpness. In the range of 200 Hz to 10 kHz, sharpness increases by a factor of approximately 50.

Comparison of the measured spectra with the above criteria indicates that the noise emitted by a Dyson Airblade™ hand dryer reveals dominant spectral components in the frequency range of 200 Hz to 10 kHz and that the device can, consequently, be said to make a ‘sharp’ noise.

Tonality

An analysis in terms of tonality shows, both subjectively and on the basis of technical measurements, that the noise emitted by the Dyson Airblade™ hand dryer shows significant tonality.

This is especially evident in the spectral analysis, which indicates notable instances of individual frequencies in the 500–630 Hz range.

3.3 Measurements using a ‘dummy head’

The aim of noise analysis using a dummy head is distortion-free measurement, transmission, and reproduction of sound events at the eardrums.

For this purpose, a calibratable dummy-head-based measurement system made by HEAD acoustics GmbH was employed in this case.

This dummy-head measurement system consists of a faithful reproduction of the head and outer ear, which provides transmission properties that are similar to those of human hearing.

Equalisation is required, if we are to be able to analyse dummy-head signals in a manner compatible with conventional measurement techniques (microphone recordings outside the ear).

In the present case, so-called ID equalisation was used, a procedure based on sound fields that correspond neither to a diffuse field nor to an open field (here, a washroom of a toilet facility).

The results of measurements performed with applied equalisation are shown in an appendix in the form of one-third-octave-range spectra.

Evaluation of these spectra in terms of annoyance criteria, such as ‘sharpness’ and ‘tonality’, indicates that the annoyance effects already determined by means of ‘conventional’ measurement techniques are still clearer.

3.4 Measurements according to 2006/42/EC (the Machinery Directive)

According to the Machinery Directive, any instruction manual must contain the following information, at minimum:

- The A-weighted sound pressure level emitted in the workplace, insofar as 70 dB(A) is exceeded or, if the level is lower than or equal to 70 dB(A), a statement to that effect
- The maximum value of the C-weighted sound pressure level in the workplace, insofar as 63 Pa (130 dB referenced to 20 m) is exceeded
- The A-weighted sound power level of the device when the A-rated sound pressure level emitted in the workplace exceeds 80 dB(A)

These values must be determined either by measurement of the actual machine or by measurement of a technically comparable machine that is representative of the one planned for production.

If no harmonised standards are applied, the most appropriate method for determination of the noise emissions is to be determined. The degree of uncertainty must be indicated for any documented sound emission values. Both the operating conditions of the device during measurement and the measurement method are to be described.

The Dyson Airblade™ hand dryers come with a ‘Technical Data’ sheet. This information sheet indicates ‘noise level: 85 dB(A)’.

Additionally required information, such as the ‘A-weighted sound power level’, the ‘uncertainty’, and the ‘measuring method’, are not specified.

Acoustic measurement of the device under the Machinery Directive indicates a sound pressure level of LAeq = 87 dB(A), at a measurement distance of about 10 cm from the user's ear. With an uncertainty of 2 dB taken into account, the noise level indication on the information sheet is, therefore, confirmed.

The corresponding C-weighted sound pressure level is 102 dB(C).

The sound pressure level resulting from the measurements is approx. Lw = 91 dB(A).

This value can be used to derive the sound pressure levels for different measurement distances.

The noise values to be indicated under the Machinery Directive are not limiting values. Their purpose is to inform the consumer.

3.5 Evaluations of noise measurements

The noise measurements for Dyson Airblade™ hand dryers were carried out

- In a real washroom by means of sound level analysis;
- In a real washroom, by means of a ‘dummy head measurement system’; and
- In accordance with the Machinery Directive, 2006/42/EC.

The following results were noted during these tests:

- Sound pressure levels at users’ ears of up to 92 dB(A) were measured. Voice communication is significantly distorted at such sound pressure levels. Nonetheless, the impact does not fall within the scope of a hearing hazard.
- In extreme situations, such as when a child exposes an ear directly to the drying area of the device, sound pressure levels of up to LAF = 110 dB(A) and peak levels of LpCpeak = 129 dB(C) occur.

  If, in the absence of a specific set of rules, we fall back on DIN EN 71-1, ‘Safety of Toys’ (version of September 2008), the following provisions would apply:

  ‘The C-weighted peak-emission sound intensity level (LpCpeak) generated by any other toy, with the exception of toys using percussion caps, must not exceed 115 dB.’

‘Toys generating high-frequency sound levels must be furnished with the following warning on the toy itself or its packaging:

WARNING! Do not use close to the ears!
Misuse can lead to hearing damage!’

- In the scope of an evaluation of the noise impact, characteristics of ‘sharpness’ and ‘tonality’ were assigned to the sound of the Dyson Airblade™ hand dryer as annoyance criteria.
- Measurement results under the Machinery Directive confirm the noise specifications in the information sheet.

4 HYGIENE TESTS

4.1 Practical test

4.1.1 Implementation

To obtain comparable test results with respect to hygiene properties, the products in question (two types of paper towels and a Dyson Airblade™ hand dryer) were subjected to tests of their intended use in practice, in three series, by 45 test subjects. The participants were recruited exclusively from the workforce of TÜV Rheinland. Each subject was allowed to participate only once within a test series, so as to ensure adequate comparability.

4.1.1.1 Procedure for sampling in the microbiological laboratory examinations

An examination room was set up at TÜV Rheinland headquarters in Cologne for carrying out these practical tests. Paper-towel dispensers and Dyson Airblade™ hand dryers were installed in this room for that purpose. The practical tests of washing hands and drying them were carried out by the test subjects during the practical test in this examination room. An evaluation of the hygiene properties of the relevant microbiological samples was also carried out in this room.

Samples were first taken from the hands of the subjects, prior to washing. For this purpose, the finger surfaces were brought into contact with a culture medium for 10 seconds. The hands were washed in cold water and a mild liquid soap that is tolerated well by the skin. Another sample was taken after the subjects had dried their hands.

A non-selective culture medium was used for determining the total number of aerobic bacteria (see section 4.1.2.1).

An additional series of samples from a selective culture medium (see section 4.1.2.1) was taken from all participants, for the purpose of detecting specific species of bacteria. This permitted verification of the presence or absence of bacteria, such as *E. coli*, other coliforms, or *Staphylococcus*. This differentiation was carried out on the basis of use of selective culture media, for all three products and for 135 tests, in total.

The culture media were incubated at the microbiology laboratory of TÜV Rheinland LGA Products GmbH in Cologne. The bacteria colonies growing on the culture media were quantitatively evaluated and the number of bacteria noted.

4.1.2 Materials and equipment used

Practical test

The practical test used he following:

1. Paper towel Katrin Classic, One Stop L2, (two-ply)
2. Paper roll Tork Premium Soft, H1 Matic Systems, (two-ply)
3. Hand dryer Dyson Airblade™ brand, aluminium fascia, AB 01, serial numbers A01-EU-110215 J142A and J148A

Bacteria incubation

<u>Nutrient culture medium agar</u>

This culture medium agar was used for determination of the total number of bacteria. It is a non-selective growth medium that is used for determining the number of bacteria. It facilitates the growth of all non-fastidious aerobic bacteria.

Specific bacterial incubation

So as to obtain more information about the bacteria occurring, the following selective media were used to identify individual species of bacteria.

<u>CLED agar</u>

The cysteine lactose electrolyte-deficient culture medium agar has a selective effect and is used for the isolation of potentially pathogenic bacteria such as *Enterococcus*, *Staphylococcus*, *Streptococcus*, and *Escherichia coli* and other coliform bacteria.

<u>Mannitol salt agar (MSA)</u>

Mannitol salt agar is a selective culture medium that serves to isolate presumably pathogenic staphylococci. The growth of most other bacteria, except some halophilic, marine organisms, is inhibited by the high salt concentration. Coagulase-positive staphylococci produce colonies with a bright yellow zone, while other staphylococci form reddish zone colonies.

All culture media were purchased from the company Oxoid.

4.1.2.2 Environmental studies

Air sampler: RCS Biotest

Bacterial incubation

<u>CASO culture medium agar</u>

This culture agar contains a non-selective growth medium, which is used for determination of the number of bacteria. It facilitates the growth of all non-fastidious aerobic bacteria.

Peptone water

Also used is a buffered liquid medium that is rich in a nutritive salt for growing bacteria.

4.1.3 Results

4.1.3.1 Total number of bacteria

The results of analysis of the individual test series are presented in a table (Table 2) and graphically (in Figure 1), below. Nutrient culture media were used for investigation of the total bacterial count. Averages of the number of bacteria before washing (BW) and after washing and drying (AD) of the hands were combined for the various drying methods used (paper towels, rolls, and air drying) and indicated in colony-forming units (CFU). The values before washing were normalised to 100%.

Table 2: Number of bacteria before washing (BW) and after drying (AD)

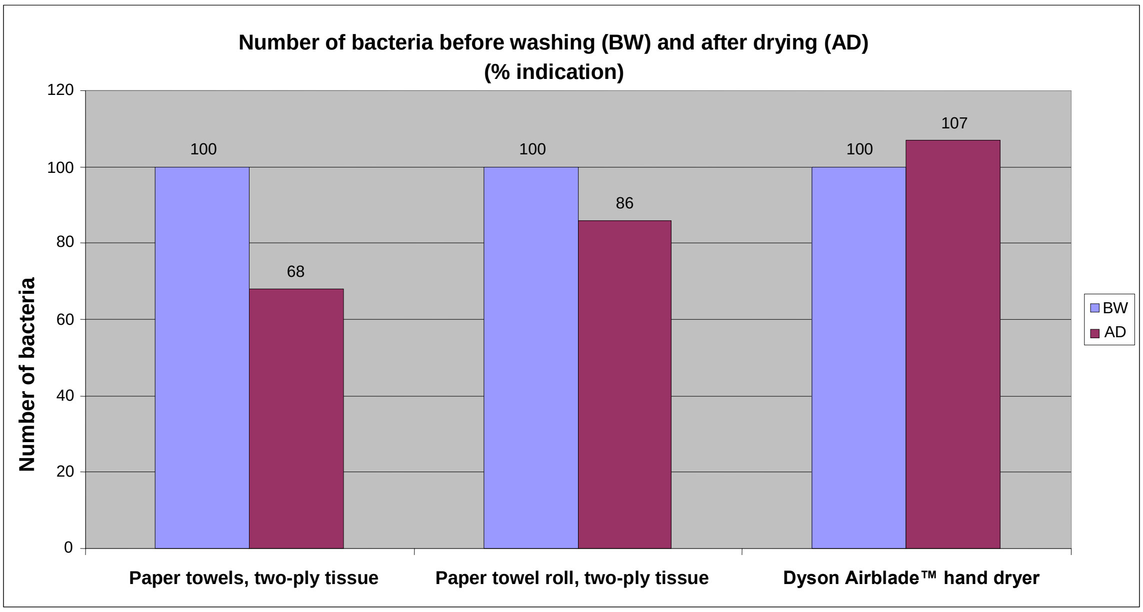
Series	**Before washing (BW) (CFU)**	**After drying (AD) (CFU)**
Paper towels, two-ply tissue	100	68
Paper towel roll, two-ply tissue	100	86
Dyson Airblade™ hand dryer	100	107

* 1 CFU = 1 colony-forming unit, corresponding to one bacterium from the sampled medium

The bacterial contamination of the hands prior to washing, and in comparison to the contamination after washing and drying, declined for both types of paper towels, while it increased when the Dyson Airblade™ hand dryer was used.

The averages of the change in the total number of bacteria (Table 2) on the hands before washing and after drying for the individual series are compared in Figure 1. The values before washing were normalised to 100%.

Figure 1



4.1.3.2 Specific bacteria

The following table summarises the results of the examination of three different growth media, indicating the changes in the number of bacteria and types, in percentages, prior to the washing and drying of hands via the various drying methods (paper and air dryer). In Table 3, the average values for paper towels and paper rolls are indicated in each line.

Table 3: Number of bacteria in CFU, before washing (BW) and after drying (AD)

Medium	Hand-drying method	Before washing (BW) (CFU)	After drying (AD) (CFU)	Change (%)
NA	Paper (towels and roll)	92	70	- 24
NA	Dyson Airblade*	82	88	+ 7
MAN	Paper (towels and roll)	73	64	- 12
MAN	Dyson Airblade*	77	90	+ 17
CLED	Paper (towels and roll)	75	65	- 13
CLED	Dyson Airblade*	65	75	+ 15

* Dyson Airblade™ hand dryer
** 1 CFU = 1 colony-forming unit, corresponding to one bacterium from the sampled medium

An analysis of the tests for bacteria on selective culture media confirms the results of a total bacterial contamination study that used non-selective media. After drying of the hands with paper towels, there were fewer bacteria than before washing. After drying of the hands with the Dyson Airblade™ unit, more bacteria were present on the hands than before washing.

Specific bacteria are enriched during the drying procedure with the Dyson Airblade™ hand dryer. The increase in total bacteria counts on non-selective culture media came to a mere 7%, while the growth of specific bacteria on selective media increased significantly, by 17% and 15%.

4.2 Environmental studies

During the drying process with the Dyson Airblade™ hand dryer, the strong stream of air may blow water droplets from the dripping hands into the surroundings. In the case of frequent use, this leads to visible pools of water in the vicinity of the devices.

Our studies in 2005 showed that comparatively high bacterial contamination remains on the wet hands after washing. Microbiological studies of both the ambient air and the surfaces of the devices were indicated for the operations of the Dyson Airblade™ hand dryer, since the situation is dubious from a hygiene point of view when contaminated water is blown into the vicinity by the air stream of the device.

To this end, examinations of the environment were conducted in an air-conditioned washroom in front of a heavily frequented toilet facility, on the one hand, where two Dyson Airblade™ hand dryers had been in operation for a period of three months, and in a separate examination room with window ventilation, on the other hand, as a supplement to the practical tests carried out as part of the hand-drying study.

In addition, the surfaces of the paper-dispensers and hand-drying devices were tested for contamination and evaluated on the basis of hygiene standards before and after the test series.

Furthermore, hand-drying with a Dyson Airblade™ hand dryer that had been in operation in the heavily frequented washroom for three months was simulated by introduction of culture media into the device.

4.2.1 Microbiological air analysis

4.2.1.1 Implementation

Measurements of the number of bacteria in the air were performed according to the mould guide [3] and as described in VDI 4300-10 [6]. This method permits determination of the number of viable – i.e., germinable – spores and bacteria. This is a semi-quantitative method for studying germ concentrations in the air.

The concentration measurements were performed separately, for determination of the concentration of bacteria in indoor and outdoor air. CASO agar was used as a culture medium for the quantitative detection of bacteria in both indoor and outdoor air. In both cases, an air volume (of 100–333 l) was drawn in. The contaminated culture media were returned to their respective storage containers on-site, sealed in an airtight manner with tape, and kept at ambient temperature in an isolated cooling box for further processing in the laboratory.

The culture media for growing the bacteria were then incubated at 30 ± 1 °C for two days. The colonies on the nutrient media were assessed daily, and their number was counted on the last day of incubation. The results are expressed in colony-forming units per cubic metre of air in the room (CFU/m³).

4.2.1.2 Results

a) Examination room

The indoor air measurements were carried out in the centre of the room, at a height of 1.5 m above the floor. Table 4 shows the results of microbiological testing for bacteria in the room and reference air and indicated in CFU/m³.

Table 4: Results of microbiological air examination in the examination room

Sampling point	Bacteria (CFU/cm²)
Before the start of the test series (Dyson Airblade* not in operation)	250
After completion of the test series (Dyson Airblade* not in operation)	520
Reference air**	243

* Dyson Airblade™ hand dryer
** Outdoor air was used as the reference air in the examination
*** 1 CFU/m^3 = 1 colony-forming unit per cubic metre, corresponding to one bacterium per cubic metre of indoor air

After completion of the test series (25 operating cycles of the Dyson Airblade™ unit), the bacterial contamination of the air in the examination room increased from 250 to 520 CFU/m³, having therefore more than doubled.

b) Washroom

The ambient air measurements were performed at 1.5 m height above the floor. Table 5 shows the results of microbiological testing of the room and reference air for bacteria, indicated in CFU/m³.

Table 5: Results of the microbiological air examinations in and in front of the washroom

Sampling point	Bacteria (CFU/cm²)
Reference air**	246
At the centre of the washroom (Dyson Airblade* not in operation)	450
In the washroom above the Dyson Airblade* (Dyson Airblade* in operation)	1,000

* Dyson Airblade™ hand dryer
** The rooms in this part of the building, including the washroom, are all air-conditioned; in order to compare 'normal indoor air' to ambient air in the washroom, air from the washroom was measured and used as a reference, instead of outside air
*** 1 CFU/m^3 = 1 colony-forming unit per cubic metre, corresponding to one bacterium per cubic metre of indoor air

In the washroom, the bacterial contamination in the air increased when the Dyson Airblade™ hand dryer was not in operation, however not to a significant degree for a frequently visited sanitary facility. When the Dyson Airblade™ hand dryer was in operation, the contamination above the device more than doubled.

4.2.1.3 Explanation and evaluation

Depending on the location, season, and day-to-day environmental conditions, the concentration of bacteria and fungi in the outdoor air varies between 100 and 1000 CFU/m³ (according to Tesseraux et al. (2004) [1] and Herr et al. (1999) [7]), although the figures may be higher in continuously hot and humid weather conditions.

The concentration of bacteria in the outdoor air is usually measured such that a comparison with, and evaluation of, the bacteria content of the indoor air can be made. With 243 bacteria per cubic metre, the contamination of the outdoor air was in the lower to medium range of the expected contamination.

The concentration of bacteria in the indoor air in the examination room before the practical test was recorded as 250 bacteria per cubic metre, and it showed similar levels to that in the outside air (243 CFU/m³). After use of the Dyson Airblade™ hand dryer by 25 test subjects, the concentration stood at 520 bacteria per cubic metre, which was higher than at the beginning of the practical test. However, in absolute terms, a value of 520 bacteria per cubic metre is not regarded as hazardous to the health.

This was followed by air testing in a heavily frequented washroom. This test was carried out in an air-conditioned room. The bacteria concentration in the washroom was measured at a height of 1.5 m, with the objective of also obtaining a reference value for ambient air in this room. Bacterial contamination of 246 CFU/m³ was measured in the room air. The measurement procedure was carried out in the middle of the washroom and at a height of 1.5 m, without operation of the Dyson Airblade™ hand dryer. Contamination of the indoor air was detected during this measurement procedure and amounted to 450 bacteria per cubic metre. Measurement was carried out also during operation of the Dyson Airblade™ hand dryer, at 1.5 m above the floor and above the device – that is, at mouth/nose height. The concentration detected during this measurement amounted to 1,000 CFU/m³ so was four times as high as the concentration in front of the washroom. This level of concentration is in the high range and can therefore be described as significant.

There are no legally defined threshold values for bacteria concentrations in buildings. The German workplace regulations [5] and the Workplace Directive [4] require that the quality of indoor air in enclosed workplaces not be below that of outdoor air. During our tests, this requirement was fulfilled both in the heavily frequented washroom and in the examination room.

Both during the tests in the examination room and during the measurements in the heavily frequented washroom, the results show that the bacteria concentration is approximately doubled through the use of the Dyson Airblade™ hand dryer. This leads to the concern that, at higher yet quite typical levels of initial germ contamination in sanitary facilities, the use of a Dyson Airblade™ hand dryer may result in levels of contamination that do entail health risks.

4.2.2 Surface examination

4.2.2.1 Contact samples

Microbiological examinations were conducted via semi-quantitative methods, such as adhesive-film tests or contact samples using culture media, so as to determine the surface contamination by bacteria. There is currently no generally accepted assessment standard for contact sample tests in the Federal Republic of Germany. The standard practice for the assessment of contamination of surfaces in ventilation facilities is the application of the evaluation scheme in VDI Guideline 6022's Sheet 2 [7]; see Table 3 there. This guideline refers to a bacterial contamination in excess of 100 CFU per contact sample test as an indication of bacterial contamination.

Table 6: Assessment of surface bacterial counts in accordance with VDI 6022, Sheet 2

Result (CFU / 25 cm²)	Assessment and measures
≤ 25	The hygiene-microbiological state of the investigated surface(s) is to be regarded as *not contaminated* (background contamination).
26 to 100	The hygiene-microbiological state of the investigated surface(s) is to be regarded as *borderline contaminated*.
> 100	The hygiene-microbiological state of the investigated surface(s) is to be regarded as *heavily contaminated*.

* 1 CFU / 25 cm^2 = 1 colony-forming unit per 25 m^2, corresponding to one bacterium per 25 cm^2 of sampled surface

Five-second contact samples were taken locally from the surfaces to be examined for assessment of the surface contamination in the examination room and in the washroom. The CASO culture media for growing bacteria were incubated for three days at 30 °C. Thereafter, the number of grown colonies was counted. The results are indicated in colony-forming units per 25 cm² (of surface in the adhesive-film test) (CFU / 25 cm²). The sampling was documented in accordance with internal regulation QMA 2.515.107.

a) Practical test in the examination room

Table 7: Results of the adhesive-film tests in the examination room for practical testing

	Sampling point	Bacteria (CFU/m²)** ***	Assessment of contamination with bacteria
Before the start of the test series	Paper towel holder, outside	13	Low microbial infestation
	Paper roll holder, outside	20	Low microbial infestation
	Dyson Airblade*, outside	4	Low microbial infestation
	Dyson Airblade*, inside	12	Low microbial infestation
After completion of the test series	Paper towel holder, outside	16	Low microbial infestation
	Paper roll holder, outside	18	Low microbial infestation
	Dyson Airblade*, outside	22	Low microbial infestation
	Dyson Airblade*, inside, top	45	Medium microbial infestation
	Dyson Airblade*, inside, bottom	**110**	**Heavy microbial infestation**

* Dyson Airblade™ hand dryer
* 1 CFU / 25 cm^2 = 1 colony-forming unit per 25 m^2, corresponding to one bacterium per 25 cm^2 of sampled surface
*** The indicated figures are averages

Brand-new paper-dispensers and other equipment were used for the examination of surface contamination. This equipment was in perfectly hygienic condition at the start of our test series. Only the normal level of background contamination could be detected.

After use (with 45 test subjects), the paper-dispenser remained in perfect hygienic condition. Sampling of the Dyson Airblade™ hand dryer, however, led to a different result. Moderate to severe contamination was detected on the inside of the unit – namely, in the compartment in which the hands are inserted during the drying process.

The inner space of the Dyson Airblade™ hand dryer will be referred to as the hand-drying compartment below.

b) Washroom

In a heavily frequented washroom, two Dyson Airblade™ hand dryers had been in operation for three months. Contact samples were taken from the surfaces of equipment for testing.

Table 8: Results of contact sample tests in the washroom

Sampling point	Bacteria (CFU / 25 cm²)** ***	Assessment of contamination with bacteria
Dyson Airblade*, outer housing	C.c.O.****	**Heavy microbial infestation**
Dyson Airblade*, inside, top	C.c.O.****	**Heavy microbial infestation**
Dyson Airblade*, inside, bottom	C.c.O.****	**Heavy microbial infestation**

* Dyson Airblade™ hand dryer
* 1 CFU / 25 cm^2 = 1 colony-forming unit per 25 m^2, corresponding to one bacterium per 25 cm^2 of sampled surface
*** The indicated figures are averages: C.c.O. = culture media completely overgrown (> 200 CFU)

The surfaces of the devices in use were in a critical hygiene state. Strong microbial infestation was detected at all locations examined, by which heavy microbial contamination was confirmed.

4.2.2.2 Swab samples

In the studies described above, the culture media were completely overgrown, thereby exceeding the upper limits of the measurement range for contact sample tests. An additional method was employed, which permitted more precise quantification and classification of the contamination of the Dyson Airblade™ hand dryer in the washroom. Samples were collected with the aid of swabs.

Before sampling, the sterile swabs were moistened with sterile peptone (see section 4.1.2.2). The sampling was carried out with a single horizontal swipe across an area of 1 cm² (0.4 cm x 2.5 cm) with a moistened swab. The contaminated swabs were then sealed in sterile containers and transported directly to the laboratory for further processing.

Each swab was placed in 1 ml of sterile peptone water (see section 4.1.2.2) and mechanically extracted (vortexed), and the eluate was diluted in phases. Then, 1 ml of each dilution phase was plated on agar (nutrient medium) and incubated for two days at 36 °C. Thereafter, the number of bacteria colonies was counted. Samples were taken at different times of day while the equipment was switched off.

Table 9: Results from the swab samples

Sampling point	Bacteria (CFU/cm²)**	Assessment of contamination with bacteria
Dyson Airblade*, bottom of hand-drying compartment	600–6,000	**Heavy microbial infestation**
Floor with water drops below the Dyson Airblade* unit	6,000–60,000	**Heavy microbial infestation**
Controls***	0	**No contamination**

* Dyson Airblade™ hand dryer
** 1 CFU/cm^2 = 1 colony-forming unit per 25 m^2, corresponding to one bacterium per 25 cm^2 of sampled surface
*** To validate the results, sterile swabs and peptone water were analysed for contamination in parallel as controls

By means of this method, we were able to verify a count of 600–6,000 bacteria per square centimetre in the lower hand-drying compartment of the equipment. Even higher contamination was measured in the water that had dripped onto the floor from the hand-drying compartment of the Dyson Airblade™ hand dryer. Here, surface contamination by bacteria had increased by a factor of 10, to a level of 6,000–60,000 bacteria per square centimetre.

Extrapolation of these values to the surface area of a contact sample (25 cm²) yields concentrations of 15,000–150,000 CFU / 25 cm² in the hand-drying compartment, and 150,000–1,500,000 CFU / 25 cm² in the water on the floor, in the near vicinity of the equipment.

The spectrum of bacteria ranged from normal environmental bacteria to possibly pathogenic bacteria such as *Staphylococcus*, *Pseudomonas*, *Escherichia coli*, *Klebsiella*, *Enterobacter*, and *Bacillus* species.

Bacteria from the hand-drying compartment of the Dyson Airblade™ hand dryer can therefore reach the hands through inadvertent contact or through the high-speed air streams that are generated during the drying procedure. Contamination that occurs in this way can be transmitted to other people on contact. Because of the high-speed air stream, bacteria can also be deposited on the clothing, in the mouth, and in the respiratory passages of the user, possibly causing illnesses. In special cases, these bacteria can be transmitted from person to person, thereby leading to dissemination of illnesses.

4.2.2.3 Simulation of the hand-drying procedure

To determine what happens from a hygiene point of view to hand surfaces during drying of the hands in the air stream of a Dyson Airblade™ unit, open culture-media plates (three different ones) were inserted vertically into the drying compartment instead of hands. The studies were carried out in a heavily frequented washroom with a Dyson Airblade™ hand dryer that had been in operation for three months.

The culture media plates were inserted in the hand-drying compartment of the Dyson Airblade™ hand dryer, removed after 10 seconds of operation, enclosed in a sterile container, and incubated in the laboratory.

After the simulated hand-drying procedure, 87 bacteria were detected, on average, on a plate of 64 cm². Since this area is equivalent to approximately a quarter of the hand surface, this means that roughly 700 bacteria are transported onto a pair of hands by the air stream. These are foreign bacteria, which are added by the air stream to those bacteria already present on the skin.

The air that is sucked into the Dyson Airblade™ hand dryer is cleaned via a HEPA filter. While it should, therefore, be free of germs, our study results lead to the conclusion that the air stream is once more contaminated with germs in the hand-drying compartment. In the case of heavily frequented Dyson Airblade™ hand dryers, one reason for this could be that water from wet hands drips into the hand-drying compartment. This water contains bacteria, which continue to propagate in that compartment and can be taken up by the passing air stream. The studies carried out show that in Dyson Airblade™ hand dryers, the air cleaned by the HEPA filter is contaminated with bacteria on the way from the HEPA filter to the hand surface.

In our examination of the bacteria detected, we were able to identify potentially pathogenic – that is, disease-causing – bacteria such as *Staphylococcus*, *Pseudomonas*, *Escherichia coli*, *Klebsiella*, *Enterobacter*, and *Bacillus* species in addition to those normally found on the skin. The skin, the intestines, faeces, floors, and washroom environments are indicated as typical sources of these bacteria. Comparison of the spectrum of bacteria identified for the Dyson Airblade™ hand dryer with that of hot-air dryers (TÜV Rheinland Study 2005) reveals significant similarities.

4.3 Summary assessment of the results of the hygiene study

The purpose of washing the hands is reduction in the presence of bacteria not normally present on the skin, thereby preventing pathogenic germs from entering the body or being transmitted to third parties.

In the 2005 TÜV Rheinland study, we demonstrated that levels of bacteria on the hands after drying with paper were reduced by 24%, and with the use of cloth towels they were reduced by 4%, while there was an increase of 117% in drying with hot air.

We were able to demonstrate a reduction of total bacteria counts on the hands that amounted to, on average, 24% when paper towels were used and an increase of 7% in the case of the Dyson Airblade™ hand dryers.

We used selective media for assessment of specific bacteria. Application of the selective medium CLED nutrient agar permits the isolation of potentially pathogenic bacteria, such as enterococci, staphylococci, and *Escherichia coli* and other coliform bacteria. With this approach, we noted a decrease in the presence of specific bacteria by 13% in washing and drying of the hands with paper. When the Dyson Airblade™ hand dryer, by contrast, was used, the presence of specific bacteria on the hands after washing and drying increased by 15%.

Mannitol salt agar was another selective medium used for the isolation of staphylococci. With this, we obtained values almost identical to those seen in the case of CLED nutrient agar: In drying with paper, there was a decrease of 12% in the levels of specific bacteria, while there was an increase of 17% in drying with the Dyson Airblade™ hand dryer. In our summary of results, we have not drawn a distinction between coagulase-positive and coagulase-negative staphylococci, which have different levels of pathogenicity; we have cited the total number of staphylococci.

During the drying process with the Dyson Airblade™ hand dryer, the strong stream of air may blow water droplets from dripping hands into the surroundings. In the case of frequent use, this leads to visible pools of water in the vicinity of the equipment. Our studies in 2005 showed that comparatively high bacterial contamination remains on the wet hands after washing. Since hygiene is highly dubious when such contaminated water is blown into the surroundings by the powerful air stream of the Dyson Airblade™ hand dryer, we considered it necessary to carry out microbiological studies to detect bacterial contamination during and after the operation of the dryer, both in ambient air and also on the surfaces of the equipment and in its vicinity.

For this purpose, an ambient air examination was carried out for bacteria in a washroom of a heavily frequented toilet facility where two Dyson Airblade™ hand dryers had been in operation for three months. The studies were carried out in addition to those in an examination room with window ventilation and as a supplement to the hand-drying test series. In this testing, measurements for bacteria were carried out for the air of the room, both before the start of each test series and at the end.

The ambient air studies in a heavily frequented washroom were carried out while a Dyson Airblade™ hand dryer was operating at a height of 1.5 m above floor level – i.e., the height of the mouth/nose. At 1,000 CFU/m³, the bacteria concentrations detected in the ambient air were at an elevated level. The contamination detected was four times greater than that in front of the washroom, and it was twice as high as the contamination before the Dyson Airblade™ hand dryer was brought into use.

The ambient air studies for bacteria in the examination room also showed that the original contamination, which amounted to 250 CFU/m^3 and therefore was equivalent to environmental contamination, had risen to 520 CFU/m^3 during operation of the Dyson Airblade™ unit, a considerably higher value.

Since the studies of ambient air in the examination room and also those in the heavily frequented washroom showed a doubling of the bacterial contamination, it is to be feared that such doubling of the bacterial contamination will also take place in room air during operation of a Dyson Airblade™ hand dryer.

In addition, the surfaces of the paper-dispensers and hand-drying devices were tested for contamination, which was evaluated on the basis of hygiene standards before and after the test series.

At the beginning of our test series, the surfaces of the new devices were in immaculate condition in terms of hygiene. After use (with 45 test subjects), the paper-dispensers retained their previous, immaculate hygiene; however, the interior space of the Dyson Airblade™ hand dryer (again, the area where the hands are located during the drying process) showed moderate to heavy contamination with bacteria.

The surfaces of the Dyson Airblade™ hand dryer in a highly frequented washroom were even more heavily contaminated with bacteria.

The water dripping from washed hands adds moisture to the hand-drying compartment of the Dyson Airblade™ hand dryer and the floor in the vicinity of the devices. This water contains bacteria, which then multiply in the hand-drying compartment or on the floor. The surfaces examined are contaminated to such an extent that contamination through, for instance, skin contact with these surfaces and health hazards cannot be ruled out.

Furthermore, hand-drying with a Dyson Airblade™ hand dryer, which was in operation in the heavily frequented washroom for three months, was simulated by introduction of culture media plates vertically into the drying compartment of the device. These culture media were subsequently incubated, and the CFU count was determined. Scaling of the number of bacteria detected on the surfaces of the culture medium to the average surface of a pair of hands shows that approximately 700 bacteria, including potentially pathogenic bacteria, are deposited on the hands during drying with the air stream. These bacteria can be transported by the stream and deposited on clothing and in the mouth and airways of users, possibly causing disease.

In washing with soap, dirt and bacteria are dissolved from the skin’s surface, wiped off with paper towels during drying, and therefore removed from the skin’s surface. With air drying, however, the depositing of bacteria on absorbent material is not possible.

Moreover, there is potential for cross-contamination to other users. Simply through contact of the hands with the device during the drying procedure, bacteria can be transferred from the Dyson Airblade™ unit’s hand-drying compartment and then transferred to other people.

This propagation path is not available to bacteria when paper towels are used for drying, which means that hand-drying with paper towels is the better solution from a hygiene standpoint.

5 OTHER CONSIDERATIONS WITH REGARD TO HAND-DRYING

For an evaluation of the time required, we have carried out time measurements with 45 test subjects. These measurements showed that the average duration of washing of the hands was 18 seconds. The subsequent drying with paper towels took 15 seconds. Hand-drying with the Dyson Airblade™ hand dryer took, on average, 20 seconds, which is clearly more.

Many studies by independent institutes confirm the safety of paper towels, since the quality of paper remains constant in comparison to that of cloth and since contact-free removal of paper from a paper-towel dispenser is possible (this way, the user comes into contact with the paper only once). Hygienic separation between fresh and used sanitary towels is thus ensured. Since paper-towel dispensers are designed for single-sheet removal, it is not possible to remove entire packs of towels.

Although the air sucked into a Dyson Airblade™ hand dryer is cleaned via a HEPA filter and should therefore be free of bacteria, our studies have shown that the air stream is already contaminated with bacteria again in the hand-drying compartment. In the case of heavily frequented Dyson Airblade™ hand dryers, one reason for this could be that water from wet hands drips into the hand-drying compartment. This water contains bacteria, which continue to propagate in the hand-drying compartment and can be taken up by the passing air stream. The studies that have been carried out show that in Dyson Airblade™ hand dryers, the air cleaned by the HEPA filter is once more contaminated with bacteria, on the way from the HEPA filter to the hand surface.

6 SUMMARY

The Dyson Airblade™ hand dryer was to be tested and evaluated with regard to noise emissions and hygiene factors during our study.

The noise levels measured during operation are an annoyance but cannot be said to be hazardous to adults. When assessing the impact on children, whose ears are probably closer to the device than those of adults, and in the absence of a specific set of rules, we have referred to alternative standards as an aid: DIN EN 71-1, 'Safety of Toys'. These guidelines state: 'Toys generating high-frequency sound levels must be furnished with the following warning on the toy itself or its packaging:

WARNING! Do not use close to the ears!
Misuse can lead to hearing damage!'

Previous TÜV Rheinland studies have shown that drying the hands with paper towels yields hygiene results that are superior to the use of air dryers. This result has been confirmed in the present study, also during the use of Dyson Airblade™ air dryers as a hand dryer. In comparison of the bacterial contamination of the hands before washing and after drying, there is significant reduction when paper towels are used, while use of the Dyson Airblade™ hand dryer actually increases contamination.

The operation of the Dyson Airblade™ hand dryer resulted in an increase in the bacterial contamination of the ambient air. In our studies, bacterial air contamination doubled during operation of the Dyson Airblade™ hand dryer from the initial values. Our studies, which were carried out in a washroom with increased initial contamination, the operation of the Dyson Airblade™ hand dryer resulted in values that can be described as striking. At an even higher level of initial contamination, which can be expected for washrooms, still greater contamination may occur during operation of the devices, which would create a health hazard.

The measured bacterial surface contamination of the Dyson Airblade™ hand-drying compartment – namely, in the area where the hands are located during the drying process – is so high that a health hazard cannot be ruled out. The same applies to surfaces in the vicinity of the Dyson Airblade™ hand dryers. Water dripping from the hands into the hand-drying compartment, which then trickles out of the device and onto the floor, shows extremely high contamination with bacteria that includes pathogens.

Even the simple use of the new Dyson Airblade™ hand dryers caused the bacterial contamination on the hands to increase by 7%. It can, therefore, be assumed that devices that have been in operation for a longer period of time are likely to be subject to significantly higher bacterial contamination.

Our studies show that operation of the Dyson Airblade™ hand dryer is associated with the following disadvantages:

Noise factors

- High noise levels during operation of the device

Hygiene factors

- High bacterial contamination of equipment surfaces
- High bacterial contamination in the vicinity of the equipment

The result is:

A risk of transmission of bacteria on contact (cross-contamination), and a risk of transmission of bacteria through the air during use of the equipment.

Evelyn Schwarz, Dipl.-Biologin
Expert

Dr Walter Dormagen
Technical Manager

7 LITERATURE

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(2) Mr C, Bittighofer PM, Bünger J, Eikmann T, Fischer AB, Grüner C, Idel H, zur Nieden A, Palmgren U, Seidel HJ. Hazardous Substances – Keeping Air Clean 59 (No. 6): 229–240 (June 1999).

(3) Guidelines for the prevention, investigation, assessment and remediation of indoor mould growth (Mould Guideline). Federal Environment Office Berlin, 2002.

(4) Workplace Directive 5, 'Ventilation' (ASR5). BArbBl. 10/1979, p. 103, 22 August 1979.

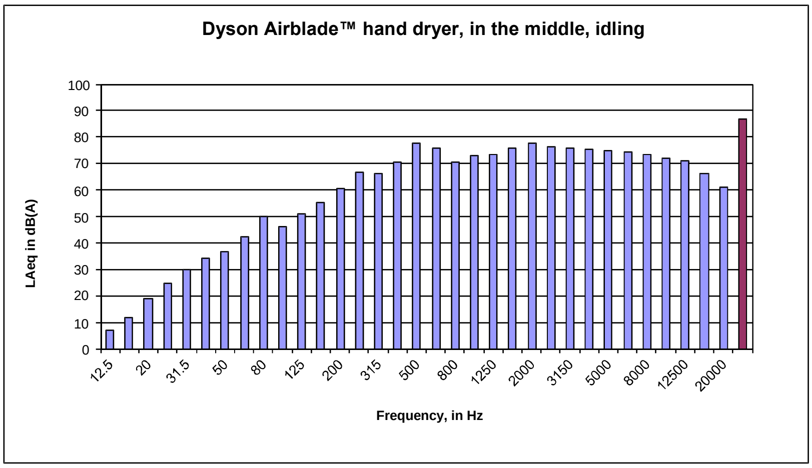
(5) Workplace Regulations (ArbStättV), version of 14 April 2002, Paragraph 5, 'Ventilation'.

(6) VDI 4300 Sheet 10: Measurement of indoor air contaminants. Measurement strategies in the study of fungi in interior spaces. Association of German Engineers (July 2008).

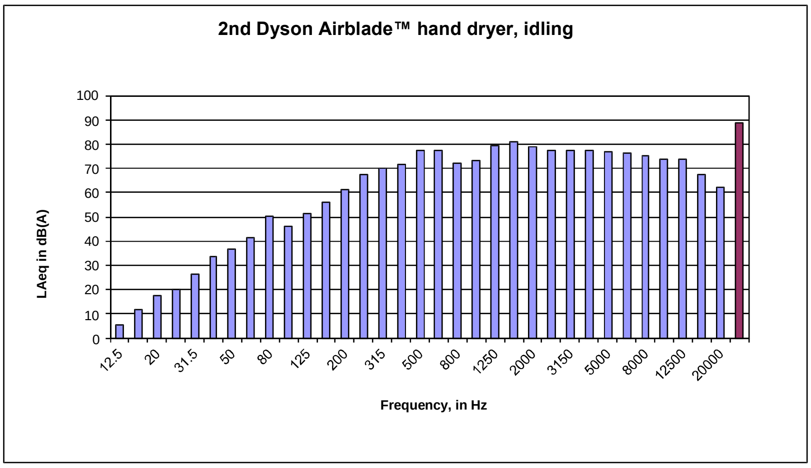
(7) VDI Guideline 6022, Sheet 1: Hygiene requirements for ventilation and airing facilities and devices (April 2006).

8 ANNEX

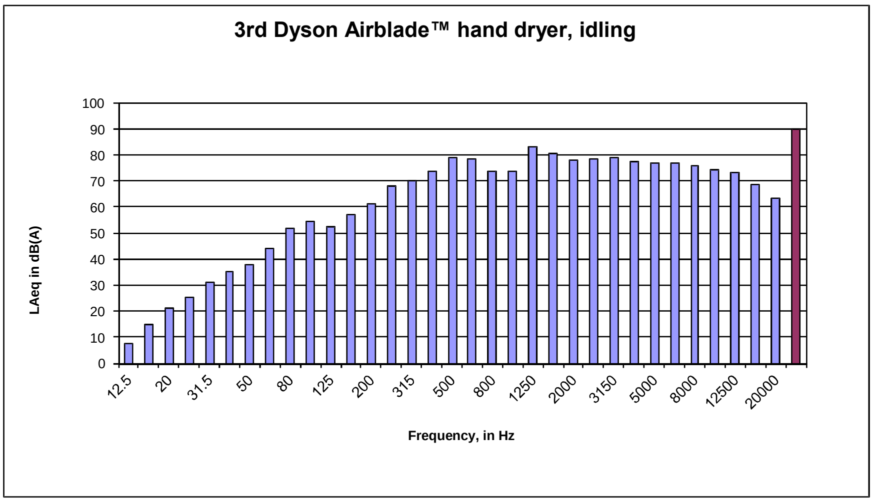
Annex 1: Noise measurements, third-octave spectra, noise-level recorder



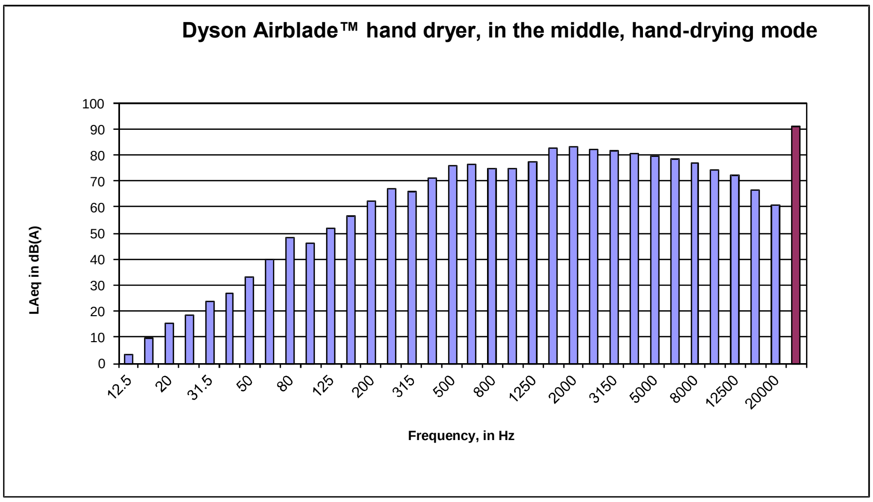
Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	7.1	11.8	18.8	24.8	29.8	34.3	36.5	42.3	49.8
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	46.0	51.0	55.1	60.7	66.5	66.2	70.7	77.9	75.8
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	70.8	72.9	73.5	75.7	77.6	76.2	75.9	75.5	74.8
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	74.4	73.4	72.2	70.9	66.3	61.1			
Overall level, in dB(A)	**87.0**								



Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	5.7	11.8	17.5	20.0	26.1	33.6	36.5	41.5	50.2
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	45.9	51.3	55.9	61.3	67.5	70.1	71.5	77.4	77.3
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	72.1	73.3	79.5	80.7	78.7	77.3	77.1	77.5	76.6
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	76.2	75.1	73.9	73.4	67.6	62.4			
Overall level, in dB(A)	**89.0**								

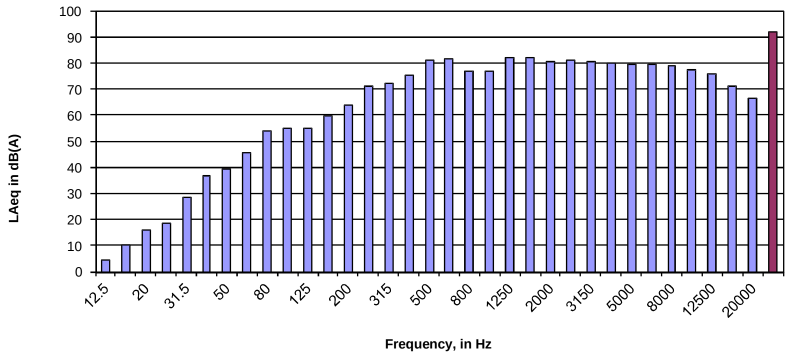


Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	7.5	14.9	21.0	25.2	31.1	35.2	37.5	44.2	52.0
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	54.4	52.1	56.8	61.2	67.9	69.9	73.5	78.7	78.2
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	73.7	73.6	83.0	80.7	78.0	78.4	78.9	77.4	76.8
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	76.7	75.8	74.5	73.0	68.5	63.5			
Overall level, in dB(A)		**90.0**							



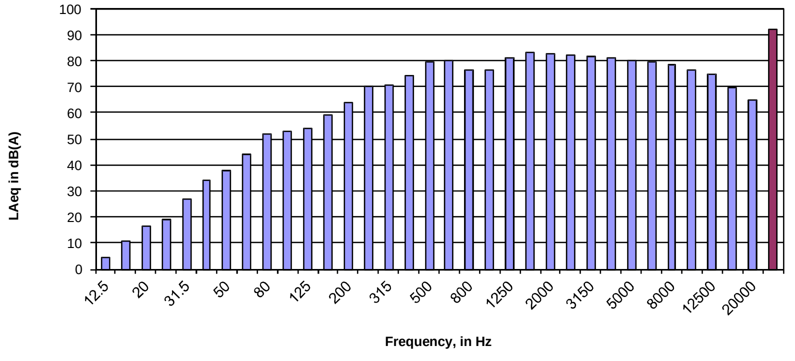
Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	3.5	9.8	15.5	18.7	23.8	27.1	33.3	40.1	48.2
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	46.0	51.8	56.6	62.3	67.0	66.1	71.3	75.9	76.2
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	74.5	74.7	77.3	82.4	82.9	82.1	81.6	80.6	79.6
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	78.2	76.6	74.3	72.0	66.3	60.8			
Overall level, in dB(A)		**91.0**							

2nd Dyson Airblade™ hand dryer, hand-drying mode

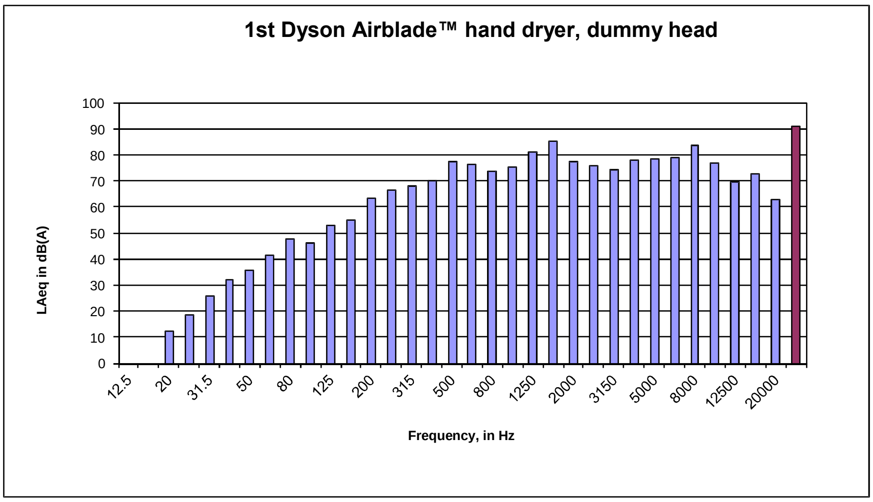


Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	4.3	10.1	16.0	18.4	28.5	36.5	39.6	45.7	53.7
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	54.9	55.0	59.9	63.8	71.0	72.1	75.3	81.0	81.4
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	76.9	77.0	82.2	82.3	80.6	81.1	80.5	80.1	79.5
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	79.4	78.7	77.2	75.8	71.2	66.2			
Overall level, in dB(A)		**92.0**							

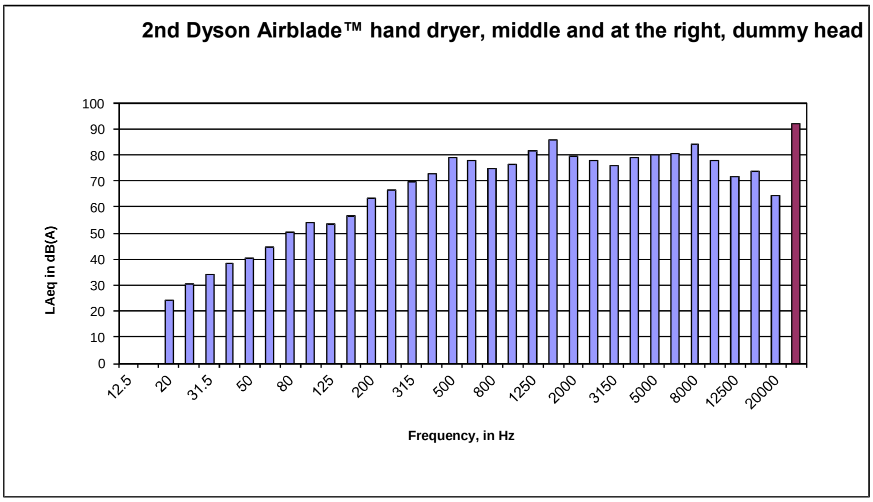
3rd Dyson Airblade™ hand dryer, hand-drying mode



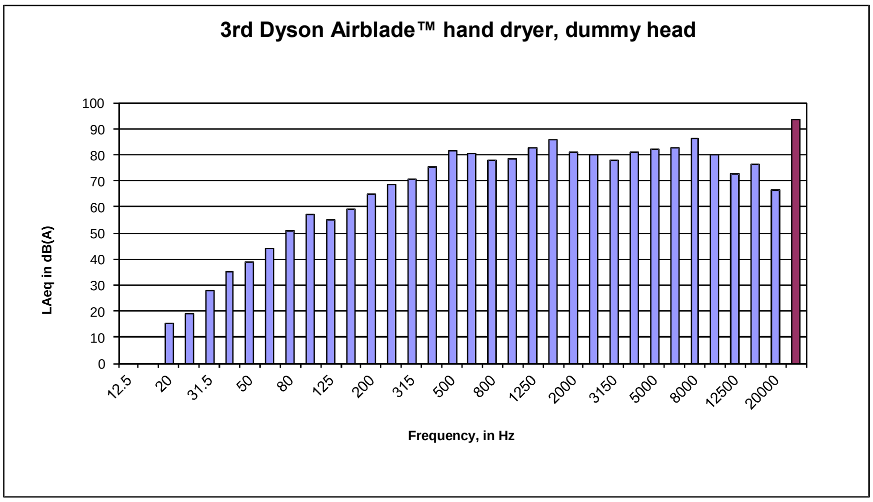
Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	4.4	10.4	16.3	19.1	27.1	34.1	37.8	44.0	52.1
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	52.6	54.1	58.9	63.6	69.8	70.4	74.1	79.5	79.9
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	76.3	76.4	80.8	82.8	82.5	82.2	81.6	80.9	80.1
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	79.3	78.2	76.4	74.6	69.8	64.6			
Overall level, in dB(A)		**92.0**							



Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	-63.6	-56.4	12.2	18.6	25.9	31.8	35.9	41.3	47.7
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	46.0	53.0	54.8	63.2	66.2	67.7	70.0	77.1	76.1
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	73.7	75.5	80.8	85.4	77.6	76.0	74.0	77.6	78.3
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	79.0	83.4	76.6	69.3	72.7	63.0			
Overall level, in dB(A)		**91.0**							



Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	-63.6	-56.4	24.4	30.3	34.1	38.4	40.5	44.7	50.4
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	53.9	53.6	56.7	63.5	66.4	69.7	72.9	78.9	77.7
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	74.9	76.5	81.5	85.4	79.5	77.9	75.6	79.1	79.8
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	80.3	84.4	77.7	71.6	73.9	64.3			
Overall level, in dB(A)		**92.0**							



Third-octave levels									
Frequency, in Hz	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**
LAeq, in dB(A)	-63.6	-56.4	15.3	19.2	27.7	35.4	38.6	44.0	50.8
Frequency, in Hz	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
LAeq, in dB(A)	56.8	55.2	59.0	64.6	68.5	70.7	75.2	81.4	80.3
Frequency, in Hz	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**
LAeq, in dB(A)	78.0	78.6	82.5	85.6	81.1	80.1	77.8	80.8	82.0
Frequency, in Hz	**6300**	**8000**	**10000**	**12500**	**16000**	**20000**			
LAeq, in dB(A)	82.4	86.2	79.7	72.8	76.2	66.4			
Overall level, in dB(A)	**93.6**								

Annex 2: Noise measurement, pictures