The Building Information Foundation RTS sr

# M1 Cleanliness Classification Testing Guideline for Ventilation Products

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# 1. M1 Cleanliness classification testing guideline for ventilation products

The cleanliness classification for ventilation products is part of a broader voluntary indoor climate classification system. The first indoor climate classification was published in 1995 and has been updated. The most recent valid version was published in 2018 by Finnish Society of Indoor Air and Climate (FiSIAQ) and Building Information Foundation RTS sr. The classification is intended for use in the design and construction of buildings where the goal is exceptionally healthy and comfortable indoor environments with excellent indoor air quality. Low-emitting and clean building materials and ventilation products play a significant role in indoor climate classification. Specific classification criteria and verification procedures have been developed for these products.

The cleanliness classification for ventilation products is owned by the Building Information Foundation RTS sr, and the classification activities are operated by Rakennustieto Oy, which is owned by the foundation. The classification activities are guided and developed by the Principal Committee Indoor Environment (PT 41), appointed by the Building Information Foundation RTS. The committee includes representatives from the building product industry, developers, designers, and research institutions.

This guideline is intended to supplement Section 3.2 (Cleanliness Classification of Ventilation Products) of the Classification of Indoor Environment 2018. It defines the testing procedures for ventilation products to determine whether they meet the cleanliness requirements of the classification. Other methods not defined in this document may also be used to demonstrate compliance, but their use must be agreed upon on a case-by-case basis, and the quality of such methods must be verified.

# 2. General criteria for cleanliness classification and the classification process

There is one cleanliness class for ventilation products: M1. A ventilation product is therefore either classified or not classified. A classified ventilation product must meet the following general requirements:

1. A classified product must not introduce impurities into the ventilation system or the supply air that are harmful to health or comfort.
2. A classified product must not produce odors or gaseous or particulate impurities that degrade the quality of the supply air.
3. Classified products must be properly protected so that their internal surfaces remain clean during transportation and storage.
4. A classified product must be easy to clean and must retain its properties when conventional cleaning methods are used.

The aforementioned requirements are considered fulfilled if the product meets the specific criteria set for its product category after manufacturing. Detailed product-specific requirements are presented in Classification of Indoor Environment 2018 for ducts, duct components, control and fire dampers, silencers, and filters. In general, the classification may be granted not only to the tested product but also to other similar ventilation products, such as ducts of different sizes made from the same material. This requires that the structure, materials, and manufacturing techniques of the products are sufficiently similar. The final decision is made by the impartial classification committee. Products may also be tested as combinations, in which case the classification applies to the specific combination and its components. For example, packaged air handling units can be tested as a single unit without the need to disassemble them for individual product testing.

The laboratory conducting classification-related tests must demonstrate to the classification body that its measurement methods are of sufficient quality. The classification body reviews the laboratory's quality and grants permission to perform measurements for each method before testing begins. Once permission is granted, the laboratory does not need to revalidate the method as long as it remains unchanged. The classification is valid for a fixed period, and its validity requires that no significant changes are made to the manufacturing process during that time. For example, if the lubricant used is replaced with another, the manufacturer is obligated to notify Rakennustieto Oy, and the related tests must be repeated as necessary.

Figure 2.1 presents a simplified overview of the cleanliness classification process for ventilation products. The issuance of the cleanliness classification is described in a separate guideline: M1 Cleanliness Classification Guideline for Ventilation Products.

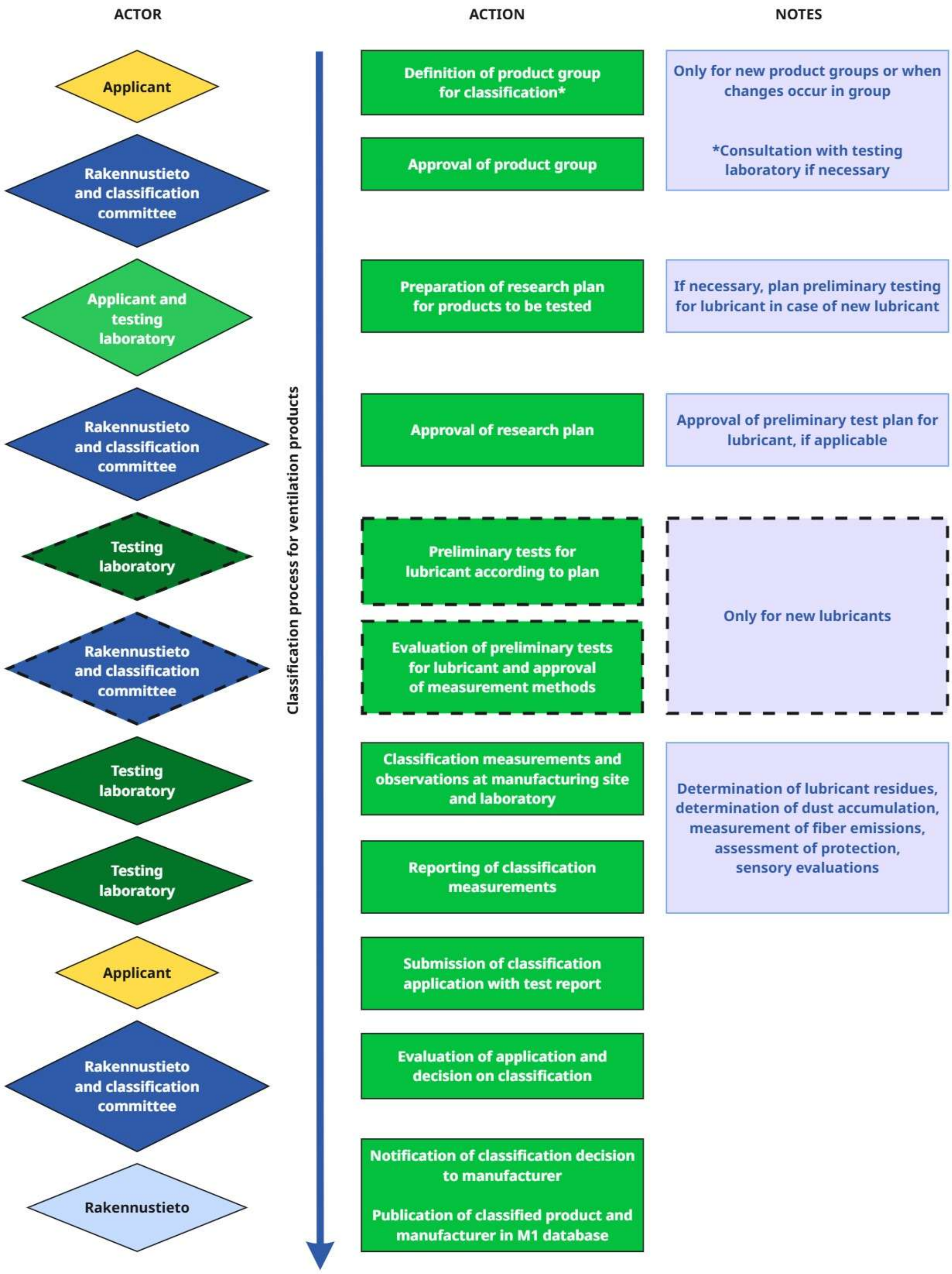


Figure 2.1. Simplified process of cleanliness classification for ventilation products.

# 3. Guidelines for product grouping and the selection of ventilation products for testing

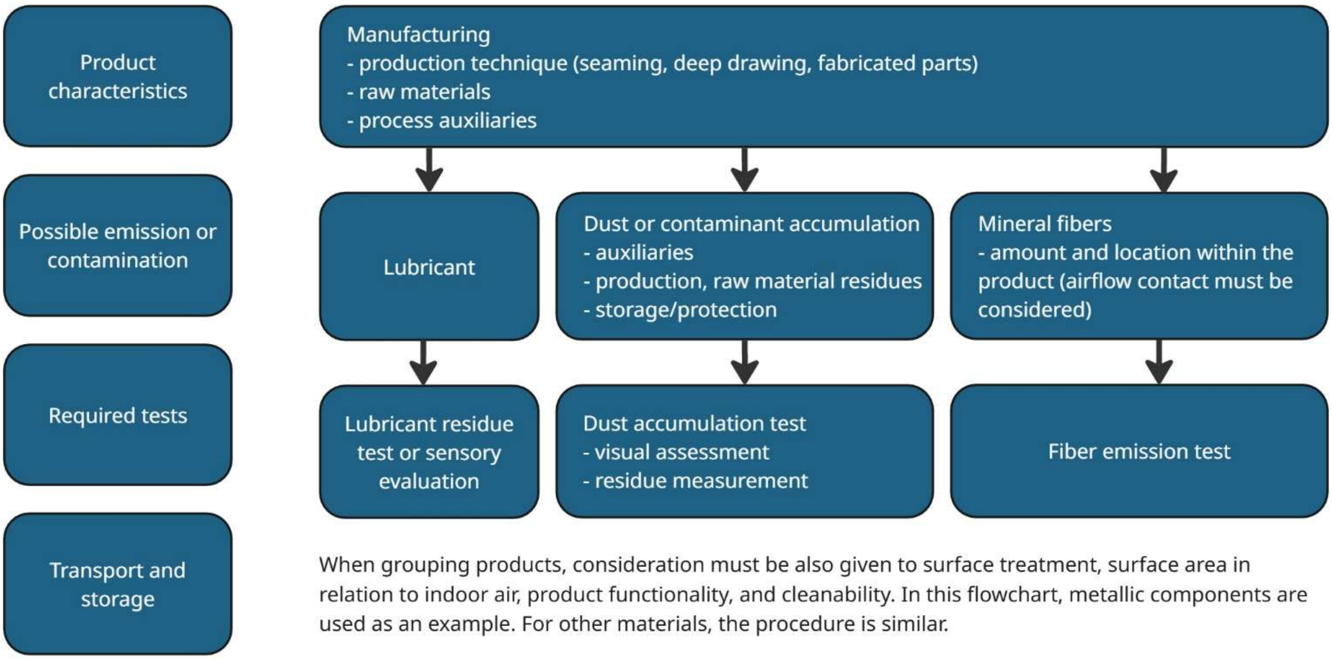
One of the objectives of the cleanliness classification for ventilation products is to provide a reliable system for quality assurance and labeling of clean ventilation products, in which approved products meet the requirements set by the Classification of Indoor Environment 2018. A quality assurance obligation has been established for the production and handling of classified products, allowing clients, developers, designers, and contractors to trust that ventilation products marked with the M1 label comply the cleanliness requirements.

The wide range of sizes and shapes of products intended for the construction of ventilation systems (e.g., ducts of various sizes and bends of different degrees) means that even a single manufacturer may have several hundred different individual products. For this reason, it is practical in the cleanliness classification to group products manufactured in the same way from the same raw material into a product group under a single classification label. Despite the quality assurance and cleanliness requirements, the system is designed to be flexible and adaptable to suit each manufacturer’s product family. This section describes the principles for forming product groups. The aim of the grouping is to ensure that each product undergoes the required and only the necessary classification tests regarding cleanliness and cleanability properties.

In practice, the manufacturer prepares the product grouping proposal and testing plan with the assistance of testing laboratories. For product grouping, a preliminary information form is provided in Appendix 1 of this guide, where product details can be recorded by product group. The form includes information such as materials used, production processes, manufacturing locations, and protection and storage procedures. The product grouping must be approved by the cleanliness classification committee for ventilation products.

## 3.1 Principles for forming product groups

Product grouping is based on products’ manufacturing techniques and materials used. Usage characteristics and the surface area of the product in contact with supply air also guide the formation of test groups. Impurities that may affect indoor air quality, such as dust accumulation, lubricant residues, the presence of mineral fibers in the product, and possible odour emissions, are the primary prioritization parameters for grouping. The raw materials, auxiliary substances, and surface treatment agents used in manufacturing also affect the grouping. For example, cleaning the product before coating it with a low-emission surface treatment agent (such as powder coating) reduces the number of parameters to be measured, whereas a product containing mineral fibers increases the need for fiber measurement in addition to possible lubricant residue or odour emission measurements. Products may also have specific features related to cleanability and functionality that must be considered when forming groups. Factors affecting product grouping are illustrated in Figure 3.1.



When grouping products, consideration must be also given to surface treatment, surface area in relation to indoor air, product functionality, and cleanability. In this flowchart, metallic components are used as an example. For other materials, the procedure is similar.

Figure 3.1. Factors affecting the grouping of products and testing methods.

Products manufactured in the same way from the same raw material and intended for similar use can be tested and classified as a single group. For example, bends produced using deep drawing techniques that require welding and sealing can be classified in the same group regardless of size or angle. The manufacturing technique requires the use of lubricant, therefore the amount of lubricant residue must be determined. If the product can be tested for lubricant residue, sensory evaluation is not needed. Dust and contaminant accumulation on the product must also be visually assessed (or measured). The product does not contain fibers, so fiber emission measurement is not necessary. This group differs from other bends intended for the same purpose that are manufactured using modular techniques without lubricants, which belong to a different group.

The following example presents the grouping of differently manufactured duct components from one factory's product family (Table 3.1).

Table 3.1. Example of grouping ventilation products for classification purposes.

| Group 1: Spiral ducts | | |
|---|---|---|
| **Sub-group** | **Required lubricant or storage residue tests** | **Required dust accumulation tests** |
| Spiral ducts made of 0.5 mm sheet metal | The average lubricant residue of the products in the subgroup is determined by randomly selecting three products. Four samples are taken from each duct. | The average dust accumulation of the products in the product group is determined by randomly selecting five products from the group. Two samples are taken from each duct. |
| Spiral ducts made of 0.7 mm sheet metal | | |
| Spiral ducts made of 0.9 mm sheet metal | | |
| Number of samples in the example | 12+12+12 = 36 lubricant residue samples | 10 dust accumulation samples |

### Group 2: Duct components manufactured without lubricants

| Sub-group | Required lubricant or storage residue tests | Required dust accumulation tests |
|---|---|---|
| Example: Bends, connector joints, end caps, control dampers, connector rings, take-off collars, transition pieces, access doors | One product is chosen from each sub-group. One sample is taken from each product. | The average dust accumulation of the products in the product group is determined by selecting five products with the highest potential dust accumulation risk. The dust accumulation of each product is determined based on a single sample. |
| End caps with handles | Residue from deep-drawn products is tested according to a separate measurement protocol; see group 5. | |
| Access doors | Manufactured by subcontractors, and the product may contain lubricant residues. A total of three samples are taken from three products. | |
| T-joints | Residue from deep-drawn products is tested according to a separate measurement protocol; see group 5. | |
| Insulated end caps | Residue from deep-drawn products is tested according to a separate measurement protocol; see group 5. | Mineral wool is not in contact with air, thus fiber measurements are not required. |
| Insulated access doors | Insulated access doors are manufactured from separate parts, unlike uninsulated doors. One sample is taken from a randomly selected product. | |
| Number of samples in the example | 10 + 3 = 13 lubricant or storage residue samples | 5 dust accumulation samples |

### Group 3: Silencers and other products containing mineral fibers

| Sub-group | Required lubricant or storage residue tests | Required dust accumulation tests |
|---|---|---|
| Silencers | Perforated sheet metal is used in manufacturing, and preliminary tests have indicated the presence of lubricant residues. Two residue samples are taken from three test products. | The average dust accumulation of the products in the product group is determined by selecting three products with the highest potential dust accumulation risk. The dust accumulation of each product is determined based on a single sample. Fiber emissions from silencers are also examined. |
| Number of samples in the example | 6 lubricant or storage residue samples | 3 dust accumulation samples |

### Group 4: Deep-drawn bends

| Sub-group | Required lubricant or storage residue tests | Required dust accumulation tests |
|---|---|---|
| Bends | Lubricant residue in bends is determined by testing the smallest and largest product sizes. Either 90° or 45° bends are tested. Three products are selected from the size group to be tested, and lubricant residue is measured based on one sample per product. Lubricant residues in 15°, 30°, and 60° bends are not tested separately, as they are manufactured from 45° and 90° bends. | The average dust accumulation of the products in the product group is determined by selecting three products with the highest potential dust accumulation risk. The dust accumulation of each product is determined based on a single sample. |
| Number of samples in the example | 6 lubricant or storage residue samples | 3 dust accumulation samples |

| Group 5: Other deep-drawn products | | |
|---|---|---|
| **Sub-group** | **Required lubricant or storage residue tests** | **Required dust accumulation tests** |
| Examples of products manufactured in a single deep-drawing process: take-off collars for rectangular ducts, take-off collars for spiral ducts, round connector joints, end caps | The smallest and largest product sizes from each subgroup are tested. One product is selected from the size group for testing, and its lubricant residue is measured based on a single sample. | The average dust accumulation of the products in the product group is determined by selecting five products with the highest potential dust accumulation risk. The dust accumulation of each product is determined based on a single sample. |
| Examples of products manufactured with two deep-drawing steps: transition pieces, take-off collars for spiral ducts | The smallest and largest product sizes from each subgroup are tested. Two products are selected from the size group for testing, and the lubricant residue is measured based on a single sample. | |
| Number of samples in the example | 16 lubricant or storage residue samples | 5 dust accumulation samples |
| **Totals** | **77 lubricant storage residue samples** | **26 dust accumulation samples** |

## 3.2 Research plan

When selecting products, the requirements set by testing must also be taken into account. For example, taking a lubricant sample from a duct smaller than Ø125 mm is difficult.

In some cases, sampling is not possible at all without damaging the product being tested, which must be considered when planning the testing. If a product is manufactured at multiple locations, samples should be taken separately from each manufacturing site or from products delivered from each site.

If auxiliary agents have been used in the products to reduce friction or prevent oxidation, and these agents cannot be tested using the solvent collection method with tetrachloroethylene (TCE), a series of preliminary tests may be conducted to identify a suitable collection and analysis method for the corresponding determination. If no suitable solvent can be found for collecting and analyzing the sample, odour assessment by a panel can always be used for the determination.

The research plan is submitted to the cleanliness classification committee for evaluation.

## 3.3 Selection, storage, and preparation of products

### 3.3.1 Selection of products for the determination of dust accumulation and lubricant residues

The selection of products to be tested is carried out by a person authorized by the research institute responsible for the testing. The products chosen for sampling are collected from the manufacturer's or wholesaler's warehouse, from original and unopened packages. For both dust and contaminant accumulation and lubricant residue determinations, a sample of 3–10 products are selected in accordance with the approved product grouping and research plan. This sample may include products of different sizes belonging to the same approved product group, which have undergone the same manufacturing process and are made from the same raw materials. For products manufactured specifically for testing, sizes are selected in cooperation with the supplier, where possible.

Ventilation products selected for lubricant residue sampling must have been manufactured less than two months prior. The products to be examined do not need to be transported, as samples can be taken from packages ready for delivery at the factory. Samples can also be taken from ventilation products sent from the factory to the laboratory, in which case the selection of products must be carried out under supervision at the factory. If products are sent to the laboratory, they must be protected from contamination during transport. Each product should be protected individually, for example, by sealing both ends of the product with a plastic cap or similar protection. Ventilation products selected for dust accumulation determination should typically be stored products. If the company's practice is to manufacture products based on customer orders, the products for testing can be manufactured separately at the request of the testing laboratory. The products to be tested must not be freshly manufactured, so that dust and contaminant accumulation occurring during storage at the factory and/or wholesale warehouse can also be assessed. During the assessment and/or measurement of dust accumulation, the methods of protection and storage of the products are also observed.

After the selection of products to be examined, the tests specified in the approved testing plan are carried out either at the manufacturing site or in the laboratory. If the products are transported to the laboratory for testing, they must be packaged so that their properties or dust or contaminant accumulation do not change during transport or storage. For example, individual products to be examined must be protected separately to prevent dust accumulation from transferring from other products to those being tested.

### 3.3.2 Selection of products for odour testing

In odour-based emission testing, usually only one piece of the product to be tested is required. Exceptions to this rule include ducts, duct components, and those products for which specific product instructions require otherwise.

For odour testing of ducts, the length of straight duct must be at least 15 meters. If duct components such as 90° bends are to be tested at the same time, there must be at least two of each type for every complete six meters. The ventilation product selected for testing must have been manufactured no more than 30 days earlier, as odour emissions typically decrease as the product ages. Products manufactured in small batches may be tested up to 60 days after production.

The selection of ventilation products for sensory testing is carried out as described in the previous section, from the manufacturer's or wholesaler's warehouse. After selection, the products chosen for testing must be protected, as the tests are usually performed in a testing laboratory. The protective packaging used for products selected for sensory emission tests must be as airtight and chemically neutral as possible, to prevent contamination of the ventilation product being tested. The products are stored indoors at the laboratory, either in their transport packaging or in an airtight and inert package prepared by laboratory staff. Filters packed in cardboard boxes must be tested immediately upon arrival or repackaged in an airtight manner. If products need to be stored for more than one month before testing, they must be packed in airtight packaging.

### 3.3.3 Multi-component products and product combinations

Testing combinations of different types of parts/products (for example, replaceable filter material and filter frame structure) or entire air handling units as a whole is possible. The components of an air handling unit could be tested one at a time with filtered air flowing through them, but if the entire unit is tested as a whole, all its components are tested at once. The result obtained in this way also applies to each component of the whole. The same procedure can be applied to products installed in ducts, of which there is typically only one in a standard system, such as a silencer.

Products of any size can be tested, provided that the previously stated requirements (e.g., for air velocity) are met. However, when testing components of a modular air handling unit, it is recommended to use a test apparatus with a cross-sectional area of 0.6 m × 0.6 m.

### 3.4 Product marking

The tested product must be marked so that it can be easily identified. The marking must include the name and identification of the manufacturer and/or importer, the product type and size designation, and other information necessary for product identification (e.g. manufacturing date). The markings should be made on the outer surface of the product or on the packaging.

## 4. Determination of the odour threshold of a lubricant

The odour concentrations of lubricants are determined from odour samples using a dynamic olfactometer, in accordance with the standard EN 13725:2022 – Air quality: Stationary source emissions – Determination of odour concentration by dynamic olfactometry and odour emission rate (CEN, 2022). The odour threshold of the lubricant used or intended to be used in the manufacture of ventilation products is compared to the odour threshold of the reference Solvac 1535 GD mineral oil. The lubricant used in the manufacture of an M1-classified ventilation product must have a higher odour threshold than the reference oil.

A dynamic olfactometer (for example, Olfasense T08) is a device that determines odour concentration in odour units per cubic meter (OuE/m³), which indicates the perceptibility of the odour relative to the human odour threshold. The olfactometer does not directly measure odour concentrations; instead, it dilutes the sample with clean air and produces highly accurate, repeatable dilutions for evaluation by a panel of assessors. The odour threshold is determined by diluting the sample until 50% of the panel members can no longer detect the odour. The odour unit [OuE/m³] is the reciprocal of the dilution factor and indicates how much the sample gas must be diluted before the odour is no longer perceptible.

Human olfactory sensitivity varies, and the standard defines criteria for panel work. Individuals must be able to consistently identify the odour threshold of n-butanol within the range of 62…246 µg/m³ in order to serve on the panel. This ensures that individuals with either too weak or too strong a sense of smell are excluded.

A screening parameter ΔZ (–5 ≤ ΔZ ≤ 5) is calculated for the panel according to the standard, further excluding results that deviate excessively from the mean. Incorrect detection of a blank sample also disqualifies the panelist's entire set of results.

Panel evaluations are conducted within the time recommended by the standard (30 hours) from sampling. For oil samples, the sampling time is considered to begin when the sample is transferred to the odor bag. The uncertainty of the panel evaluation is estimated at ±30%.

All materials used in sample handling must be food-grade and must not emit odors. Sample bags are made of materials suitable for the purpose and commonly used in odor analytics, meeting the criteria of the standard. For oil samples, an aluminum baking tray is placed inside the sample bag as a liquid container. (5 ml) of oil is added to the tray using a clean syringe, and the bag is sealed tightly around a Teflon tube. The bag is then filled with clean compressed air through the Teflon tube and sealed. Before evaluation, the samples are stored at room temperature for several hours to allow a saturated air mixture to form in the bag from the oil. The sample handling process is illustrated in Figures 4.1–4.7.

Figure 4.1. Sample preparation begins by cutting a suitable length of sample bag.

Figure 4.2. The bottom of the sample bag is sealed by “pleating” and taping the bag.

Figure 4.3. The seal of the sample bag is ensured by folding and tightening.

Figure 4.4. A food-grade aluminum tray is placed at the bottom of the sample bag.


Figure 4.5. 5 ml of the lubricant to be tested is added to the tray inside the sample bag using a clean syringe.


Figure 4.6. The sample bag is sealed around a Teflon tube, through which clean compressed air is introduced into the bag.


Figure 4.7. After filling with compressed air, the sample bags are sealed, and the odour unit [OuE/m³] is determined in accordance with standard EN 13725:2022.

# 5. Preliminary tests for lubricants used in the manufacturing of ventilation products

## 5.1 Initial assessment of the solvent and suitability for the analytical method

Before collecting lubricant samples, the main composition or raw material of the lubricant must be identified to select an appropriate sampling and analysis method. Prior to conducting lubricant residue tests on ventilation products, the yield and reliability of the sampling method must also be evaluated, and the detection limit for the lubricant must be determined. For most lubricants, tetrachloroethylene (TCE) is a suitable solvent, allowing the use of infrared spectroscopy for analysis. However, for some lubricants, TCE is not suitable as a solvent, and infrared spectroscopy cannot be used as the analytical method. If the lubricant does not dissolve in TCE, other suitable sampling and analysis methods must be used—if such methods are known. If no chemical analysis method is available, the products can be tested using odor assessment as the evaluation criterion, as described in Section 9 of this guideline.

The remainder of this section, along with Sections 6 and 7, deals with TCE-based analytics. Once it is confirmed that TCE can be used as the solvent and infrared spectroscopy as the analytical method, the wavelength range for lubricant analysis is determined. The analysis range must include the spectral peaks at 2960 and 2925 cm$^{-1}$ as completely as possible. However, the selected wavelength range must not contain other responses that could interfere with the analysis results. A typical suitable wavelength range for lubricants is 2900–3000 cm$^{-1}$.

## 5.2 Determination of extraction efficiency

After defining the analysis range, the extraction efficiency for the lubricant in question is determined. Extraction efficiency is assessed by preparing a comparison series of seven filter absorption samples from the lubricant (0–350 µg/ml, see Table 5.1), along with a solution standard series at the same concentrations. The filter absorption samples are processed according to Sections 6 and 7. Both the filter absorption samples and the solution samples are analyzed as described in Section 7.

Table 5.1. Example of preparation of comparison solutions and extraction efficiency samples.

| Sample | Concentration µg/ml | Standard dilution series used in the preparation of solution standards | |
|---|---|---|---|
| sdt 0 | 0 | 7 ml TCE | with sampler |
| std 1 | 9 | 0,5 ml ID + 7 ml TCE | with sampler |
| std 2 | 17 | 1 ml ID + 7 ml TCE | with sampler |
| std 3 | 34 | 2 ml ID + 7 ml TCE | with sampler |
| std 4 | 51 | 3 ml ID + 7 ml TCE | with sampler |
| std 5 | 171 | 1 ml SS + 7 ml TCE | with sampler |
| std 6 | 343 | 2 ml SS + 7 ml TCE | with sampler |
| ID | 120 | 1 ml SS + 9 ml TCE | without sampler |
| SS | 1300 | 12.0 mg lubricant + 10 ml TCE | without sampler |

*SS=stock solution, ID=intermediate dilution*

Extraction efficiency $T_{extraction}$ is calculated separately for each concentration using the Equation 5.1, where $C_{extract}$ is the concentration extracted from the sampling filter, N is the number of extracted samples, and $C_{stand}$ is the concentration of the comparison solution. To be suitable for analyzing lubricant samples, the extraction efficiency must exceed 70 %, and the relative standard error must be less than 2%. If the extraction efficiency is insufficient, this is accounted for by preparing lubricant standards using the same sampling material as in the extraction efficiency test.

$$T_{extraction} = \frac{\sum C_{extract}}{C_{stand} * N} * 100\ \% \qquad \text{(Equation 5.1.)}$$

## 5.3 Determination of extraction efficiency

The effectiveness and reliability of the sampling method for the specific product and lubricant are determined as follows:

1. Eleven plates (5 × 5 cm) made of galvanized chromated sheet metal are cleaned using the solvent intended for sampling. Each plate is placed on a separate clean glass dish.
2. A small drop of the lubricant to be tested is applied to each plate and spread evenly across the surface using lens paper.
3. A sample is taken from the plate using the tweezer method (see Section 6).
4. The collected sample is pretreated and analyzed (see Section 7).
5. The remaining lubricant on the plate is extracted by adding 5 ml of the solvent to the plate and collecting the rinse solution into a test tube.
6. The plate is removed from the dish, and the dish is rinsed with 2 ml of solvent.
7. The rinse is repeated, and the second rinse solution is also added to the same test tube.
8. The rinse solution is not evaporated but analyzed as-is, in the same manner as the actual sample (see Section 7).

From the analysis results, sampling efficiency $T_{sampling}$ is calculated using the Equation 5.2, where: $C_{samplei}$ is the concentration of a sample *i*, and $C_{rinsei}$ is the concentration of the rinse solution *i*. To be suitable for lubricant sampling, the sampling efficiency must exceed 80 %, and the relative standard error must be less than 2 %. Sampling efficiency is taken into account in the analysis of results by dividing the obtained lubricant concentration by the sampling efficiency.

$$T_{sampling} = \frac{\Sigma C_{samplei}}{\Sigma C_{rinsei} + \Sigma C_{samplei}} * 100\ \% \qquad \text{(Equation 5.2.)}$$

### 5.4 Determination of the detection limit for lubricants

The detection limit for the lubricant is calculated based on the standard deviation of ten filter blank samples. The concentrations of the filter blank samples are calculated using the calibration curve defined for the lubricant under investigation, after which the standard deviation of the results is determined. The detection limit is defined as a value that is six times the standard deviation of the blank samples (µg/ml). The detection limit for the lubricant must be lower than the classification threshold in order for the method to be suitable for classification measurements.

## 6. Sampling of lubricant residues from ventilation products using filter absorption and tetrachloroethylene

### 6.1 General description and applicability of the research method

This method guideline describes a filter absorption-based sampling technique for metal surfaces (Asikainen et al., 2003). The method determines the amount of non-volatile lubricant on the metal surface in unit of mg/m². The minimum detectable concentration using this method depends on the lubricant being tested and typically ranges between 8–50 mg/m² when using a filter with a surface area of 25 cm² as the sampler. The sample is collected by absorbing the lubricant from the surface onto a glass fiber filter moistened with solvent. The sample is then dried, extracted into solvent, and analyzed using infrared spectrophotometry. Before sampling, it is necessary to determine which lubricant has been used in the manufacturing of the ventilation product and, if needed, perform the preliminary tests described in Section 5. These preliminary tests identify a suitable solvent, analytical method, and sampling technique for the lubricant, and determine the sampling yield, extraction efficiency, and detection limit, as well as assess the reliability of the results.

## 6.2 Required equipment, reagents, and tools

Sampling is carried out using clean containers and equipment, as well as analytical-grade chemicals. Most importantly, the sampling equipment must not contain hydrocarbons or other substances that could dissolve in the solvents used. After washing and drying, glassware is baked at 300 °C for 1.5 hours. After baking, the containers must be stored protected from hydrocarbon and grease contamination. The purity of each batch of tetrachloroethylene used as a solvent is verified by IR analysis in accordance with Section 7. In addition, it is recommended to verify the purity before each sampling day. The verification is performed by IR analysis as described in Section 7.

## 6.3 Sampling of lubricant residues

### 6.3.1 Equipment required for sampling

The following equipment is needed for sampling lubricant residues:

- Glass fiber filters (e.g., MUNKTELL FILTER Quality MG 160, Art. No. 1409. Filter size: 50 mm × 50 mm, surface area 25 $cm^2$)
- Laboratory gloves that protect against skin exposure to tetrachloroethylene and prevent sample contamination
- Respiratory protection with a hydrocarbon-filtering respirator must be used if sampling is conducted outside a laboratory fume hood to avoid exposure to tetrachloroethylene
- Sampling table and protective paper for the table
- Tightly sealable waste container for waste containing tetrachloroethylene
- Cooler box with cold packs or an electrically cooled portable refrigerator
- Glass dishes with lids for storing sampling devices
- Pipette for measuring solvent volume (e.g., 1 ml volumetric pipette)
- Paper for cleaning sampling devices
- Pasteur pipettes for cleaning sampling devices
- Solvent (tetrachloroethylene, e.g., MERCK 100965 UVASOL) for cleaning sampling equipment between different samples
- Metal tweezers for pressing the filter and transferring the sample into a test tube
- Teflon film for sampling
- Test tubes for storing samples
- Solvent (tetrachloroethylene, e.g., MERCK 100965 UVASOL) for moistening the filters

### 6.3.2 Sampling

Samples are taken from the inner surface of the selected ventilation product according to the research plan, ensuring that the entire product or a representative part of it is covered. Depending on the size of the product, one to four parallel samples are taken. For example, in the case of a spiral-seamed duct, samples are taken longitudinally from the same section of the duct: from the bottom, both sides, and the top. Two samples are taken from the seam and two from non-seamed areas. To avoid contamination (e.g., from fingers), metal tweezers and gloves that are insoluble in the solvent must be used during sampling.

Lubricant sample collection procedure:

1. A clean filter is placed onto a Petri dish using tweezers, and the dish is closed.
2. Once the sampling point is selected, the Petri dish is opened and the filter is moistened by evenly adding 0.9 ml of solvent over the entire filter surface using a pipette.
3. The moistened filter is placed with tweezers onto the designated sampling point on the surface of the ventilation product.
4. Pressing the sampling filter through a Teflon film using tweezers (Figure 6.1):
    - The Teflon film is placed over the sample filter using tweezers.
    - The filter is pressed onto the sampling surface with tweezers so that it becomes fully moistened with the solvent. Pressing is done with small circular motions and repeated twice over the entire surface of the filter.
    - The Teflon film is removed from the top of the filter using tweezers.
5. The filter is carefully removed from the sampling surface using tweezers.
6. The sample filter is transferred into a test tube using tweezers, and the tube is sealed.
7. The sample is transported for analysis in a way that prevents damage or contamination during transport.
8. Before the next sample is taken, the sampling tools are cleaned using a disposable paper towel moistened with solvent and then dried with a clean paper towel.
9. Each test series must include at least one field blank sample, which is handled in the same way as actual samples but without taking a sample. If the series includes more than 15 samples, one field blank sample is analyzed for every 15 actual samples.
10. All disposable tools used during sampling (e.g., paper towels, pipettes) must be sealed in an airtight waste container after use.

Figure 6.1. Sampling of lubricant from a ventilation product using the filter absorption method. The sampling filter is pressed with tweezers.

## 6.4 Sample treatment and analysis

Samples are pretreated and analyzed as described in Section 7. The calculation of lubricant residue results is also described in Section 7.

## 6.5 Reporting of results

When reporting the results, the following information must be provided:

1. The exact identification of the tested product and a description of the sample, including the lubricant used in the manufacturing of the product or material, and a description of the manufacturing process.
2. Preliminary tests performed on the lubricant and their results.
3. Reference to this method guideline and the sample analysis instructions (Section 7).
4. A brief description of the sampling conditions.
5. Information on whether a calibration solvent other than the lubricant used in the product's manufacturing was used.
6. The result is reported as the average surface lubricant residue of the product type and its range of variation. If necessary, the lubricant residue of individual products or samples may also be reported. The maximum value of the average lubricant residue for the product type is calculated with a 95% confidence interval using the Equation 6.1 for one-sided error estimation:

$$C_{max(95\%)} = 1{,}65 * \frac{standard\ deviation}{\sqrt{number} of\ samples} \qquad \text{(Equation 6.1.)}$$

7. Results are reported in mg/m² with a precision of two significant figures.
8. Any other factors that may affect the results, such as information on sample composition, origin, storage, etc.

## 6.6 Safety instructions during sampling

When handling solvents, protective gloves must be worn to protect the skin and reduce solvent absorption through the skin. Dispensing of solvents must always be done using appropriate tools (e.g., volumetric pipettes) made from inert materials such as glass, steel or Teflon. All work steps should be carried out in a fume hood whenever possible. If some step cannot be performed in a fume hood, the worker must wear a respirator designed to protect against solvent vapors.

Solvent residues must not be poured down the drain. Solvent waste must be collected in containers and disposed of appropriately. Tools used for handling solvents (pipettes, paper towels, etc.) must be stored in a fume hood or in an airtight container until the solvent has fully evaporated. After evaporation, the tools should be rinsed with acetone and washed with regular laboratory dishware.

# 7. Analysis of lubricant residue samples by infrared spectrophotometry and determination of lubricant residue

## 7.1 General description and applicability of the method

This guideline is partially based on standard SFS 3010, which describes the determination of oil and grease in water using an infrared photometric method (SFS, 1980). The analytical method described here is suitable for determining oiliness and greasiness in air, water, or surface samples. It can be used, for example, to determine the amount of lubricant collected from the surfaces of ventilation products (see Section 6). A calibration series is prepared from the lubricant present in the sample, and the sample concentrations are compared against this series. Tetrachloroethylene is used as the solvent, and the samples are analyzed using an infrared spectrophotometer.

## 7.2 Required devices, reagents and equipment

All containers and tools used in sample analysis must be clean. Most importantly, they must be free of hydrocarbons and other substances that could dissolve in the solvent used. After washing and rinsing with water, the tools must be dried. They should be stored in a way that prevents contact with solvent vapors (e.g., acetone, ethanol) or air containing oil or grease. The lower the concentrations being measured, the more carefully the containers must be cleaned. If stoppers, caps, or taps are used in sample handling or analysis, they must never be lubricated with tap grease or similar substances.

The following equipment is needed for analyzing lubricant samples:

- Glass Pasteur pipettes for transferring samples from test tubes to measurement cuvettes
- Volumetric pipettes for preparing hydrocarbon mixtures, stock calibration solutions, and reference solutions
- Measurement cuvettes, either 10 mm or 50 mm quartz cuvettes, for sample analysis
- Infrared spectrophotometer (IR) or Fourier transform infrared spectrophotometer (FT-IR) capable of measuring absorbance in the range of 2940–4000 nm
- Tetrachloroethylene ($C_2Cl_4$) of analytical grade, with no significant infrared absorption in the 2940–4000 nm range

## 7.3 Verification of used equipment and method

Before collecting and analyzing lubricant samples, preliminary tests must be conducted on the lubricant (see Section 5). Both the sampling recovery and extraction efficiency determined for the lubricant must meet the criteria specified in Section 5 before the method can be applied to the lubricant under investigation.

## 7.4 Verification of tetrachloroethylene purity

The purity of each new batch of tetrachloroethylene must be verified. It is also recommended to check the purity before usage to ensure the solvent has not become contaminated. The inner and outer surfaces of the cuvettes are rinsed with tetrachloroethylene. The spectrum of the tetrachloroethylene is analyzed in the wavelength range of approximately 3030–3700 nm. If the absorbance peaks at 3380 nm and 3420 nm (wavenumbers 2960 and 2925 $cm^{-1}$) exceed 0.5 percentage points against an air background, the tetrachloroethylene must not be used for analysis and must be either purified or replaced.

## 7.5 Baseline determination (for conventional IR analyses)

Cuvettes that have been thoroughly cleaned inside and out with tetrachloroethylene are filled with tetrachloroethylene, and the baseline is determined in the range of 2940–3030 nm (wavenumbers 3400–2500 $cm^{-1}$). The baseline must be straight across the entire measurement range. Any absorbance peaks indicate contamination from the solvent or cuvette, in which case cleaning must continue until a straight baseline is achieved.

## 7.6 Quantification of samples

The amount of lubricant in the samples is quantified using a calibration series prepared from the same lubricant as in the sample.

### 7.6.1 Preparation of stock solution from lubricant

A stock solution is first prepared from the lubricant, from which a standard serie of reference solutions is made by dilution. The stock solution is prepared as follows:

1. Weigh approximately 10–30 mg of the lubricant using an analytical balance (accuracy at least 0.1 mg) into a 10 ml volumetric flask. Record the exact mass of the lubricant.
2. Fill the volumetric flask to the mark with room temperature tetrachloroethylene. After filling, mix the solution thoroughly.
3. The resulting stock solution concentration should be 1–3 mg/ml.

### 7.6.2 Preparation of reference solutions from the stock solution

Reference solutions are prepared from the stock solution into six test tubes, with the highest concentration being approximately 300 µg/ml and the lowest around 5 µg/ml. If necessary, an intermediate dilution can be made between the stock solution and the highest concentration standard. A dilution series should be planned in advance. An example of a dilution series and standard concentrations is provided in Table 5.1 (Section 5). Filter standards should be prepared using the same sampling material as used in actual sampling, to minimize errors caused by variation in extraction efficiency.

The reference solutions are prepared as follows:

1. If needed, prepare an intermediate dilution from the stock solution.
2. Pipette the appropriate volume of the standard solution (see Table 5.1, Section 5) onto the filter in the sample tube.
3. Evaporate the solvent from the standard using a nitrogen stream.
4. Extract the sampling device in 7 ml of TCE (tetrachloroethylene) in an ultrasonic bath for one hour.

5. Separate the solvent and sample from the sampling material into a centrifuge tube. Avoid transferring the sampling material into the sample solution as much as possible, while ensuring the sample solution is collected as completely as possible. Dry the filter by pressing it against the test tube wall with cleaned tweezers.
6. Centrifuge the sample solutions so that the sampling material remains at the bottom of the test tube. Centrifuge for 10 minutes at 3000 RPM at room temperature.

### 7.6.3 Calculation of the reference solution concentrations

The concentrations of the reference solutions in Table 5.1 (Section 5) are calculated as follows:
If the weighed amount of lubricant is 12.0 mg, the concentration of the prepared stock solution is 12.0 mg/10 ml = 1.2 mg/ml = 1200 µg/ml. For example, in the intermediate dilution shown in Table 5.1 (Section 5), 1 ml of the stock solution is mixed with 9 ml of TCE, resulting in a concentration of (1 ml × 1200 µg/ml)/10 ml = 120.0 µg/ml. The concentration of the standards and extraction efficiency samples/filter standards is calculated as follows. For example, if 3 ml of the intermediate dilution (120 µg/ml) is added to standard/extraction efficiency sample 4, the amount of lubricant added is 3 ml × 120 µg/ml = 360 µg. Since the solvent in the intermediate dilution is evaporated before extraction and the sample is extracted with 7 ml of TCE, the concentration of both the standard and the extraction efficiency sample/filter standard is 360 µg / 7 ml = 51.4 µg/ml.

### 7.6.4 Analysis of reference solutions

The concentrations of the reference solutions are determined using an infrared spectrophotometer as follows:
Clean the cuvettes with TCE, both inside and outside.

1. When using a conventional IR spectrophotometer, place TCE in the reference cuvette. When using FT-IR, first analyze the air background with an empty cuvette in the sample position. Then analyze the solvent against the air background to ensure the purity of the TCE.
2. Next, perform a background analysis with TCE, which will be used as the baseline for comparing standards and samples (see Section 7.6.6).
3. Add the standard solutions to the cuvette and analyze them with the IR spectrophotometer, starting from the most dilute (0) to the most concentrated.
4. Between analyses, rinse the cuvette first with TCE and then with the reference solution to be measured.
5. When using a conventional IR spectrophotometer, the standards are measured both before and after the actual sample runs, and the average of these absorbance values is used to determine the sample concentrations. When using FT-IR, the standards are measured once before the sample runs using a measurement program that records absorbance 20 times.
6. When using FT-IR, the standard curves can be saved in the device memory. In that case, it is not necessary to re-measure all standards in subsequent analyses, provided the same lubricant and solvent batch are used.
7. If the solvent batch changes, the standards must be prepared and analyzed again.

### 7.6.5 Determination of the calibration curve using a conventional IR spectrophotometer

When analyzing reference solutions and samples with a conventional infrared spectrophotometer, a calibration curve is created manually or using, for example, a spreadsheet program. The calibration curve is created as follows:

1. Draw a horizontal baseline from the absorbance minimum in the wavelength range of 2940–3030 nm.
2. From this baseline, measure the absorbance at wavelengths 3380 nm and 3420 nm (wavenumbers 2960 and 2925 $cm^{-1}$), and sum the two absorbance values. Typically, the baseline is at absorbance 0.00, but if it deviates from zero, both measured absorbance values must be corrected before summing.
3. The chart paper of infrared spectrophotometers often uses either a linear or logarithmic absorbance scale. The values can be read directly from the chart. If the device provides transmittance values, they must be converted to absorbance using a table, which is usually supplied with the instrument.
4. Using a spreadsheet program (e.g., Excel), draw a calibration curve using linear regression, where the corrected average absorbance (as described above) is plotted as a function of the actual concentration of the reference solutions. The calibration curve shown in Figure 7.1 is based on the measurement results presented in Table 7.1. The spreadsheet program provides the regression equation and the correlation coefficient. This equation is used to calculate the oil concentrations of the samples.

Table 7.1. Concentrations of reference solutions, measured absorbances, and corrected absorbance values.

| **Standard concentration (µg/ml)** | **Absorbance (measurement 1)** | **Absorbance (measurement 2)** | **Average absorbance** | **Corrected average absorbance** |
|---|---|---|---|---|
| 0 | 5 | 2 | 3.5 | 0 |
| 5.0 | 12 | 12 | 12 | 8.5 |
| 12.4 | 27 | 25 | 26 | 22.5 |
| 24.8 | 52 | 48 | 50 | 46.5 |
| 61.8 | 120 | 114 | 117 | 113.5 |
| 122.9 | 207 | 197 | 202 | 198.5 |

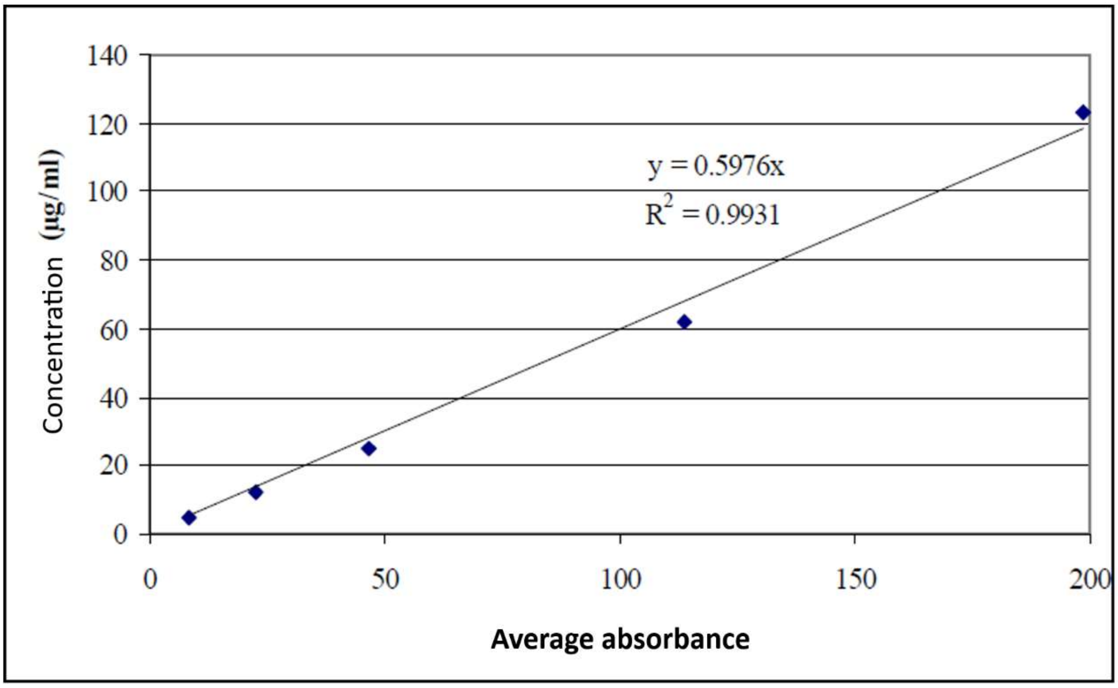


Figure 7.1. Calibration curve showing the corrected average absorbance of the reference solutions (after baseline correction) as a function of their actual concentration.

### 7.6.6 Determination of the calibration curve using FTIR

Before running samples with FT-IR, the instrument's energy spectrum must be measured to ensure proper functionality. After measuring the energy spectrum, the following background spectra are recorded: a) Air background (background spectrum without a cuvette), b) Air background against air background, c) Empty cuvette against air background, d) Cuvette background (background spectrum with cuvette), e) Cuvette filled with TCE against cuvette background, f) TCE background (background spectrum with cuvette filled with TCE)

All actual samples and standards are always analyzed against the TCE background. To determine the calibration curve, the instrument's Multipoint calibration feature is used, which allows the calibration curve to be generated from multiple reference solutions.

The calibration curve is determined as follows:

1. Open at least one of the previously measured standard files.
2. Open the calibration tool.
3. Locate the previously measured reference solution files and add them to the calibration table.
4. Enter the concentrations of the reference solutions.
5. Set the unit to µg/ml.
6. Select the analysis method based on peak area determination.
7. Choose linear regression as the fitting method for the calibration curve. Specify that the origin is not used as a calibration point.
8. Other settings: Enable automatic baseline correction during analysis.

9. Set the wavelength range used in the analysis, which depends on the lubricant being studied. The appropriate range is determined during preliminary testing (see Section 5) and must be used for all analyses of that specific lubricant. Once the measurement range is selected, save it for future analyses. Then return to the calibration table.
10. Calculate the calibration curve.
11. Save the calibration curve.
12. A report or graph of the calibration curve can be printed if needed.

## 7.7 Sample preparation

### 7.7.1 Solvent evaporation from samples

Solvent is evaporated from the samples in the laboratory. This is done because the exact amount of solvent in the sample is not known. During sampling, the solvent may have decreased due to evaporation, for example. The solvent is evaporated from the sample using a nitrogen stream. Drying takes approximately 15 minutes, depending on the amount of solvent in the sample. Evaporation is not performed for easily volatile lubricants, as it would significantly affect the results. The volatility of the lubricant is determined during the preliminary tests conducted for the lubricant.

### 7.7.2 Separation of samples from sampling material

After drying, 7 ml of tetrachloroethylene is added to the samples using a volumetric pipette. After adding the solvent, the samples are shaken in an ultrasonic bath for 120 minutes. During extraction, the lubricant dissolves from the sampling material. After extraction, the sample solutions are transferred quantitatively into centrifuge tubes by pressing the sampling filter against the wall of the test tube with clean tweezers. The sample solutions are then centrifuged, causing the used sampling material to settle at the bottom of the test tube. Centrifugation is performed for 10 minutes at 3000 RPM at room temperature.

## 7.8 Sample analysis

Between samples, the measurement cuvette is rinsed first with TCE and then with the sample to be analyzed. Samples are analyzed in the same way as reference samples (see Sections 7.6.4–7.6.6). This section only provides instructions for determining the lubricant concentration of the analyzed sample. The final calculation of the total lubricant amount collected in the sample is described separately in each method guideline. For example, surface lubricant residue is calculated in mg/m² according to Section 7.9.

### 7.8.1 Determination of lubricant concentration of samples using conventional IR

When analyzing samples, the absorbance of the actual samples is compared to the absorbance of pure TCE in the reference cuvette. Each sample is analyzed twice, and the average of the two absorbance values is used as the result. The obtained result is placed into the calibration curve equation as the value of *x*, yielding the result in µg/ml. For example, if the average of the summed absorbance values of the sample is 78, then the oil concentration of the sample, using a calibration curve like the one in Figure 7.1, is:

0.5976 µg/ml × 78 = 46.6 µg/ml

#### 7.8.2 Determination of lubricant concentration of samples using FT-IR

The sample concentration is calculated as follows:

1. Open the sample file.
2. Select the quantification tool in the analysis software.
3. Choose the desired calibration curve to compare the sample against.
4. The software displays the sample concentration (µg/ml).
5. If needed, a report or graph of the analysis can be printed.

### 7.9 Calculation of lubricant residue

The lubricant residue on the surface of the ventilation product (mg/m²) is calculated using Equation 7.1, where C is the lubricant concentration in the sample (mg/ml), V is the sample volume (7 ml), A is the sampling surface area (25 cm²), and T is the efficiency of the sampling method for the specific lubricant (%).

(Equation 7.1.)

$$M = \frac{C}{A} \times V \times T_{sampling} \ x\ 10000$$

### 7.10 Safety instructions

When handling solvents, protective gloves must be worn to protect the skin and reduce solvent absorption through the skin. Solvents must always be dispensed using tools made from inert materials (e.g., glass, steel, or Teflon), such as volumetric pipettes. All work steps should be performed in a fume hood whenever possible. If step cannot be performed in a fume hood, the worker must wear a respirator designed to protect against solvent vapors.

Solvent residues must not be poured down the drain. Solvent waste must be collected in containers and disposed properly. Tools used for handling solvents (pipettes, paper towels, etc.) must be stored in a fume hood or in an airtight container until the solvent has fully evaporated. After evaporation, the tools should be rinsed with acetone and washed with regular laboratory dishware.

## 8. Evaluation of dust accumulation in ventilation products

This guideline applies to new, uninstalled components of ventilation systems, and therefore the level of contamination should be minimal. The assessment of dust accumulation in ventilation products is primarily conducted visually, applying the evaluation guideline developed for new ventilation systems (Narvanne et al., 2002).

## 9. Determination of odor emissions

The odour emission of the tested ventilation products is assessed by determining the acceptability of the air in the test chamber or the air flowing through the product. The acceptability assessment is performed using an untrained odour panel, and the procedure follows the emission classification guideline for building materials (Building Information Foundation RTS, 2024). The current version of the guideline is available at: https://ymparisto.rakennustieto.fi/en/cleanliness-classification-of-ventilation-products/downloadable-materials

Before sensory testing of ventilation products, the products are ventilated with clean, filtered air at either the nominal airflow specified for the product or an estimated value based on its intended use. The ventilation conditions are as follows: a face velocity of 3.0 m/s for ventilation ducts, 2.5 m/s for ventilation unit components, and either the nominal airflow or a face velocity of 1.0 m/s measured from the connection duct for terminal devices and closely related components. The ventilation period begins when the product packaging is opened. Ventilation should continue for 3–5 days, and the temperature must remain between 20–25°C throughout this period. If test conditions (e.g., airflow rate) need to be changed during testing, the conditions must be allowed to stabilize for at least 30 minutes before continuing. The same procedure applies when the tested product is replaced.

The actual sensory testing is conducted using the sensory evaluation method for building materials, as described in the M1 classification testing protocol.

## 10. Testing of self-supporting mineral wool ducts for classification

Due to their structural differences, self-supporting mineral wool ducts differ from the more commonly used metal ducts in Finland and therefore require different testing methods. For self-supporting mineral wool ducts, the basis for granting a cleanliness classification for ventilation products is compliance with the requirements of ETA 20/0122. This is sufficient to meet the product group-specific requirements for ducts, which are presented on the Rakennustieto’s website.

## 11. Determination of the number concentration of airborne mineral fiber in non-self-supporting mineral wool ducts

Requirements for fiber emissions apply only to ventilation products made from materials containing mineral fibers that may come into contact with supply air. For fibers other than mineral fibers, the general requirements in Section 3.2.1.1 of the Classification of Indoor Environment 2018 apply. This guideline describes the test equipment, sampling, and analysis procedures for determining the number concentration of airborne industrial mineral fibers (glass and stone wool). The guideline is based on measurement results from the ILMI project (Kovanen et al., 2006).

### 11.1 Test equipment

The test equipment (Figure 11.1) includes, in sequence: an adjustable fan, a HEPA filter placed before the product under test, the product or duct being tested, and a polypropylene filter (F6–F8) for sample collection. The product is installed into the test setup, which is used to create the required conditions.

The test equipment must meet the following requirements:

- The air supplied to the system must be filtered through a HEPA filter

- The airflow must be adjustable according to the instructions below
- The system must be airtight to prevent uncontrolled leaks
- The number of released fibers must be reliably measurable

To meet the last requirement, the number of fibers in the duct airflow is not measured using a probe and pump, because despite isokinetic sampling, fibers do not reliably enter the probe. Instead, a polypropylene filter placed at the end of the test setup is used to collect all fibers present in the airflow.

During measurements, the air flowing through the tested product must be at a temperature of 20–25°C, and the relative humidity must be 20–65%. Products are generally tested at their nominal airflow rate. If the nominal airflow is not specified, it can be estimated based on the product’s intended use.

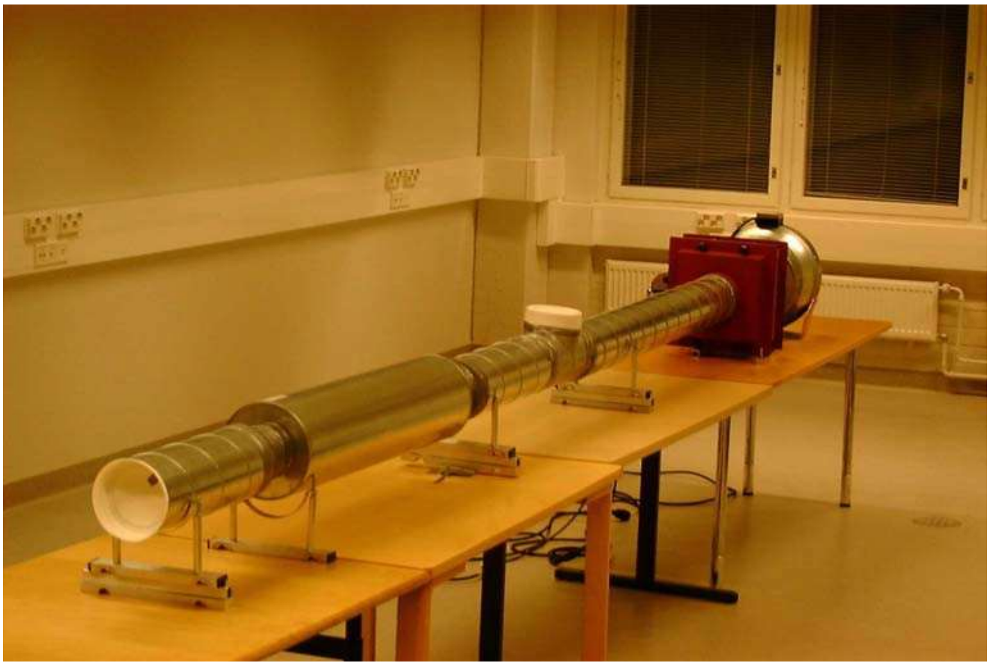


Figure 11.1. Schematic diagram of the test setup. The polypropylene filter is located on the left side of the image. The HEPA filter is inside the red frame visible on the right. The example test product is a duct silencer.

## 11.2 Test procedure

The classification of ventilation products is based on three different tests, in which fiber release is measured under the product’s nominal airflow, as well as during vibration and cleanability tests.

After installing the product into the test setup, the system is started and the product is flushed at its nominal airflow for 0.5 hours before the actual tests begin. During the flushing phase, mineral fibers and other impurities released from the product surface are collected on a polypropylene filter, which is not analyzed. This ensures that any fibers potentially accumulated on the product surface during manufacturing, transport, or storage do not affect the test results.

### 11.2.1 Fiber release at nominal air flow

After the initial flushing, the fan is turned off, the flushing filter is removed, and a new polypropylene filter intended for sampling is installed in the test setup. The fan is restarted and adjusted to produce the desired airflow velocity. After approximately one hour, the fan is turned off and the polypropylene filter is removed. A sample of the filter is cut from the center (e.g., 10 cm × 10 cm or Ø 37 mm) and placed in a protective bag for analysis. The filter must be handled carefully to prevent fiber loss. The airflow rate and sampling time are recorded.

After the one-hour test, a new polypropylene filter is installed in the test system. The test is then repeated with a sampling duration of approximately 24 hours. After sampling, the fan is turned off and the filter is sampled in the same way as in the one-hour test.

### 11.2.2 Vibration test

In the vibration test, the product is firmly mounted onto a vibration platform that induces oscillation at a frequency of approximately 25–35 Hz with an amplitude of about 0.5 cm (Figure 11.2). This vibration frequency is similar to that of a ventilation duct in operation. The tested product and the vibration platform are part of the test setup shown in Figure 11.1. Once the product is installed, a new polypropylene filter is placed in the test setup for sampling, and the sampling and handling are carried out as described in Section 11.2.1.

Figure 11.2. A test product mounted on a vibration platform using clamp fastening.

### 11.2.3 Cleanability test

Before starting the cleanability test, a new polypropylene filter is installed in the test system, and the fan is adjusted to produce the desired nominal airflow. A duct brush or a cleaning device specifically recommended by the product manufacturer is pushed back and forth through the tested product 10 times, as shown in Figure 11.3, simulating the cleaning of the product. The brush is rotated using, for example, a powerful drill (Figure 11.4) or equipment specified by the manufacturer. The cleaning process takes approximately 5 minutes. After the cleaning test, the fan is stopped and the filter used during cleaning is removed from the test system. A new sampling filter is then installed, and the fan is again adjusted to produce the desired nominal airflow. After 24 hours, the fan is stopped, and the polypropylene filter is removed from the test system. The sample is then handled as described in Section 11.2.1.

Figure 11.3. In the cleanability (brushing) test, a rotating brush is pushed into the duct and the tested product.

Figure 11.4. Cleaning brush and the drill used to rotate it.

## 11.3 Ducts and duct components

Ducts are tested according to the principles described above, but the length of the duct system under test must be at least 4 meters. Fittings are not included when determining the total length of the test duct system. If duct components such as 90° bends are to be tested at the same time, there must be at least 2 pieces of each type per every 6 meters of duct length.

## 11.4 Analysis and processing of results

The cut piece of the filter is analyzed by extracting or otherwise separating the industrial mineral fibers from the polypropylene filter. The result of the analysis is the number of fibers longer than 20 µm per unit area of the filter.

The number concentration of fibers in the duct airflow is calculated using Equation 11.1, where $C_V$ = fiber number concentration in the airflow [fibers/m³], $C_A$ = number of fibers per unit area of the polypropylene filter [fibers/cm²], A = cross-sectional area of the test duct at the location of the polypropylene filter [cm²], qV = volumetric airflow in the duct [dm³/s], and T = sampling time [s].

$$C_v = \frac{1000 * C_A * A}{q_V * T} \qquad \text{(Equation 11.1.)}$$

The test report must include the following information:

- Report identifier, date, and signatures in accordance with the quality system of the testing laboratory
- Precise identification and description of the sample
- Reference to this testing guideline

- Description of the test conditions
- Reported result: fiber number concentration $C_V$ and its estimated measurement uncertainty, using a 95% confidence level in accordance with the ISO standard (International Organisation for Standardisation, 1993)
- Results must be reported in fibers/m$^3$, rounded to two significant figures
- Any other factors that may have influenced the result, such as sensory assessment of the product's oiliness

## 12. Reporting guideline

Due to significant differences in testing and sampling procedures between different product groups of ventilation products, a standardized form for reporting results has not been created. Instead, information related to sampling, analysis, and result reporting is compiled into a free-form measurement report.

Appendix 2 provides a template for reporting classification measurements of ventilation products, specifically for the determination of lubricant residues, dirt accumulation, and fiber emissions.

For odour emissions, reporting must follow the emission classification guideline for building materials (Building Information Foundation RTS, 2024). The tested products and testing conditions must be reported in detail.

## 13. References

Asikainen, V., Pasanen, P. & Liesivuori, J. (2003). Assaying mineral oil residues on new HVAC-components: Development of a standardised measuring method. Building and Environment, 38, (8), 1057-1061

Building Information Foundation (2018). Classification of Indoor Environment 2018. Target Values, Design Guidance and Product Requirements. RT 07-11299 en

Building Information Foundation (2024). M1 emission classification of building materials: Protocol for chemical and sensory testing of building materials. Publication date: 18.6.2024. Available at: EN Emission Classification of Building Materials Downloadable Materials QA

CEN (2022). EN 13725:2022 Stationary source emissions - Determination of odour concentration by dynamic olfactometry and odour emission rate. The Finnish Society of Indoor Air and Climate (FiSIAQ) (2018).

International organisation for standardisation (1993). Guide to expression of uncertainty in measurement.

Jaarinen, S. & Niiranen, J. (2000). Laboratorion analyysitekniikka. Oy Edita Ab, Helsinki (in Finnish).

Kovanen, K., Heimonen, I., Laamanen, J., Riala, R., Harju, R., Tuovila, H., Kämppi, R., Säntti, J., Tuomi, T., Salo, S.-P., Voutilainen, R. & Tossavainen, A. (2006). Ilmanvaihtolaitteiden hiukkaspäästöt- Altistuminen, mittaaminen ja tuotetestaus. VTT tiedotteita 2360, Espoo (in Finnish).

Pasanen, P., Nevalainen, A., Ruuskanen, J. & Kalliokoski, P. (1992). The composition and location of dust settled in supply air ducts. Ventilation for energy efficiency and optimum indoor air quality 13th AIVC conference, Nice, France. p. 482-488

Sisäilmastoluokitus 2018: Sisäympäristön tavoitearvot, suunnitteluohjeet ja tuotevaatimukset (in Finnish).

Suomen standardisoimisliitto (1980). Standard SFS 3010: Veden öljyn ja rasvan määritys: Infrapunaspektrofotometrinen menetelmä. SFS (in Finnish)

## 14. Appendices

Appendix 1. Preliminary information form for product grouping (also available as an Excel file)
Appendix 2. Measurement report template
Appendix 3. Sampling protocol template (also available as an Excel file)

# Preliminary information form for product grouping

Appendix 1.

Preliminary information form on materials, production processes, manufacturing locations, protection, and storage procedures for a ventilation product or product group

| | |
|---|---|
| Manufacturer: | |
| Product or product group: | |
| Products included in the product group: | |
| Manufacturing location: | |

Possible subcontracted component manufacturers and manufacturing locations (attach a separate report on materials and production processes)

Materials used in product manufacturing (attach material certificates):

Description of manufacturing processes (in a separate attachment if necessary):

Description of protection and storage procedures (in a separate attachment if necessary):

# Measurement report template

Appendix 2.

Research facility

Researcher Alex Example

Research facility/laboratory

Address

Phone, fax, e-mail

**Measurement report**

Confidential

Date

Customer

Company (customer)

(Company contact person)

Address

---

**LUBRICATION RESIDUES, DUST ACCUMULATIONS, AND FIBER EMISSIONS OF VENTILATION PRODUCTS by DUCT Ltd.**

## 1. General

A general description of the content of the measurement report: what has been done, by whom (the laboratory), on whose behalf, and for what purpose the measurements are primarily applicable for.

*Example: This study was conducted based on an order placed by Company X on dd.mm.yyyy. The study investigated lubricant residues and dust accumulation in ventilation products, as well as determined the odour threshold of the lubricant used in the manufacturing process. The study was carried out in accordance with the cleanliness classification guideline for ventilation products, and its objective was to assess the classification eligibility of the product or product group.*

## 2. Tested products and sampling

A description is provided of the tested products and the types of samples taken from them (e.g., lubricant residue, dust accumulation, mineral fiber emissions). The selection of tested products is explained, including the selector, selection criteria (number of samples), and selection location. The manufacturing date of the tested products is indicated (manufacturer's batch code), as well as the sampling date. The storage location and protection of the tested products are described, if the product was not sampled directly from the production line. A table is used to clarify the information if multiple different products are involved (Table 1). The table should be modified as needed, for example, if both lubricant residue and dust accumulation samples are taken from the same products.

*Example: Five spiral ducts manufactured with external lubrication (lubricant type) using machine X at the production facility in location Y were selected for the determination of lubricant residues. The ducts were made of galvanized chromated sheet metal (type and quality details). The concentration of the lubricant used in manufacturing (name) was 4 %. The ducts were selected from a protected outdoor storage area, where they had been transferred to after manufacturing [insert manufacturing date].*

*Example: Lubricant samples were taken on [insert sampling date] using the filter absorption method, in accordance with section 6 of theM1 Cleanliness Classification Testing Guideline for Ventilation Products . The samples were collected at the factory. Four samples were taken from each duct, with both ends of the duct sampled to include areas with and without seams.*

*Example: Dust accumulation in the ducts was determined in accordance with section 8 of the M1 Cleanliness Classification Testing Guideline for Ventilation Products , by taking dust accumulation samples from both ends of five ducts.*

*Example: Researcher AE selected the products to be tested and collected the samples required for both lubricant residue and dust accumulation analysis.*

Table 1. Selected products for classification measurements and their properties (*blank sampling protocol template intended for editing, included as Appendix 3 of the testing guideline.*)

| | | | | | |
|---|---|---|---|---|---|
| ***Product information*** | | | | | |
| *Assessed product* | *product 1 e.g., duct d=160 mm and ID code, if available* | *product 2* | *product 3* | *product 4* | *product 5* |
| *Date of production* | X.C.XCVB | | | | |
| *Selection criteria* | random selection | | | | |
| *Storage* | outdoors, under a shelter | | | | |
| *Protection* | capped using plastic caps | | | | |
| ***Sample information*** | | | | | |
| *Sampling date* | C.V.BNMZ | | | | |
| *Types of samples* | lubricant residue and dust accumulation | | | | |
| *Sample identification details* | L1 and D1 | | | | |
| *Product selector* | Alex Example | | | | |
| *Sample collector* | Alex Example | | | | |

# 3. Measurement procedures

## Lubricant residue

Sample analysis method. Description of preliminary tests performed, or a reference if the lubricant has already been tested for odour and analyzability. In the latter case, the sampling and extraction yield must be indicated here. This section should include the results of odour and chemical analysis tests, as well as conclusions drawn from those results.

*Example: The samples were analyzed using FTIR spectrophotometry in accordance with the M1 Cleanliness Classification Testing Guideline for Ventilation Products (Sections 5–7). The odour threshold of the lubricant was determined using olfactometry and an untrained odour panel, as described in Section 4 of theM1 Cleanliness Classification Testing Guideline for Ventilation Products.*

### Results of preliminary tests performed on the lubricant used

Suitability of the lubricant for analysis

*Example: The following observations were made in the preliminary tests conducted on the lubricant used:*

1. *The lubricant dissolves in tetrachloroethylene, allowing its concentration to be determined using infrared spectrophotometry.*
2. *The extraction efficiency of the lubricant is relatively poor. Within the studied measurement range, the extraction efficiency is approximately [insert extraction efficiency].*
3. *When lubricant standards are prepared using the sampling material according to Section 5 of the testing guideline, the calibration curve is reliable [insert $R^2$ value].*
4. *The sampling yield of the lubricant using the tweezer pressing method is [insert mean value, %, and standard error of the mean, %].*
5. *The detection limit for the lubricant, calculated from the standard deviation of ten blank samples, was [insert detection limit, mg/m²].*

*Based on the preliminary tests, tetrachloroethylene was selected as the solvent and tweezer pressing as the sampling method. The samples were analyzed using the FTIR method.*

Odour threshold of the lubricant

*Example: The odour threshold of the lubricant used in the manufacturing of ventilation products was X odour units [OuE/m³]. The odour threshold of Solvac mineral oil used as a reference was Y odour units [OuE/m³]. The odour threshold value of the lubricant used in ventilation product manufacturing was slightly more than twice that of Solvac mineral oil, indicating that its odour threshold is higher.*

### Dust accumulation

The dust accumulation on products was determined using a filter sampling and weighing method.

*Example: Dust accumulation was determined from five spiral-seamed ducts typically stored outdoors and protected with end caps. Two samples were taken from each duct, one from each end, from the lower quarter of the duct surface. Filters were standardized and weighed before and after sampling in the laboratory, including the filter housing. The average of the dust accumulation results was calculated. The detection limit of the sampling method was 0.10 g/m$^2$. If the dust accumulation of an individual sample was below the detection limit, half the detection limit value was used in the average calculation.*

### Fiber emissions

Provide a description of the test equipment, test conditions, and how the testing was performed. Refer to Appendix / Section 11 of the *M1 Cleanliness Classification Testing Guideline forVentilation Products:* “Determination of the number concentration of airborne mineral fibers in non-self-supporting mineral wool ducts.” Mention if any subcontractors are involved.

## 4. Results

### Lubricant residue

Provide a brief written summary of the results. The actual results should be presented in a table, which must include a title and explanations for the columns and rows. Units must be indicated in the table.

*Example: No significant lubricant residues were found in ducts manufactured using external lubricant application. The average lubricant residue in ducts produced with external lubricant spraying was X mg/m$^2$, and the average maximum at a 95% confidence interval was Y mg/m$^2$. The thickness of the sheet metal used in manufacturing did not affect the lubricant residue levels in the ducts. A summary of lubricant residues in individual ducts is presented in Table 2.*

*Table 2. Lubricant residues in spiral-seamed ducts manufactured with external lubricant spraying.*

| | **Ventilation product** | **Average lubricant residue (mg/m$^2$)** | **Variance of lubricant residue (mg/m$^2$)** |
|---|---|---|---|
| **Metal sheet thickness 0.5 mm** | Duct 1 | s | <blod-y |
| | Duct 2 | t | <blod-t |
| | Duct 3 | r | r-u |
| | Duct 4 | h | b-k |
| | Duct 5 | g | l-o |
| **Average maximum lubricant residue at 95 % confidence interval** | | | u |

*Detection limit xx mg/m$^2$, blod = below limit of detection*

## Dust accumulation

Provide a brief written summary of the results. The actual results should be presented in a table, which must include a title and explanations for the columns and rows. Units must be indicated in the table.

*Example: No significant dust accumulation was found in the ducts. The average dust accumulation in the ducts was C g/m². Only one duct had a measurable dust accumulation of Z g/m²; the dust accumulation in the other ducts was below the detection limit. A summary of dust accumulation in individual ducts is presented in Table 3.*

*Table 3. Dust accumulation in tested spiral-seamed ducts.*

| **Ventilation product** | **Average dust accumulation (g/m²)** | **Variance of dust accumulation (g/m²)** |
|---|---|---|
| Duct 1 (200 mm duct) | s | <blod-y |
| Duct 2 (200 mm duct) | t | <blod-t |
| Duct 3 (250 mm duct) | r | r-u |
| Duct 4 (400 mm duct) | h | b-k |
| Duct 5 (500 mm duct) | g | l-o |
| **Average maximum dust accumulation at 95 % confidence interval** | | u |

*Detection limit xx g/m², blod = below limit of detection*

## Fiber emissions

Provide a brief written summary of the results. The actual results should be presented in a table, which must include a title and explanations for the columns and rows. Units must be indicated in the table. The result is reported as the number concentration of mineral fibers CV, in units of fibers/cm³, rounded to two significant figures.

*Example: No significant fiber emissions were observed in the silencers. The fiber emission at nominal airflow was C fibers/cm³ after 1 hour and C fibers/cm³ after 24 hours. The vibration test resulted in C fibers/cm³, and the cleanability test showed no change in fiber emissions, with the product emitting C fibers/cm³ after cleaning. Fiber emissions from the silencers were below the reference value.*

*Table 4. Fiber emissions from tested duct silencers.*

| **Ventilation product** | **Fiber emission at nominal airflow (fibers/cm³) after 1 hour** | **Fiber emission at nominal airflow (fibers/cm³) after 24 hours** | **Fiber emission in vibration test (fibers/cm³)** | **Fiber emission after cleaning (fibers/cm³)** |
|---|---|---|---|---|
| Silencer 1 | C | C | C | C |
| Silencer 2 | C | C | C | C |
| Silencer 3 | C | C | C | C |

## 5. Uncertainty assessment

This section includes a description of factors affecting uncertainty due to the representativeness of sampling and sources of error in analysis, as well as an evaluation of how successfully the tested product group was categorized.

The estimated measurement uncertainty is presented using a 95% confidence level.

Any factors that may have influenced the result must be reported.

*Example: Lubricant residue samples were taken from N samples across T different products. The majority (HJ%) of the results were below the specified guideline value of 50 mg/m², and the average lubricant residue for the component group was C mg/m² at a 95% confidence interval.*

*Example: Dust accumulation samples were taken from HJ samples across Y different products. The dust accumulation level of the product group was low, and only J results exceeded the detection limit. The average dust accumulation for the product group was 0.2 g/m², which is below the guideline value.*

## 6. Signatures

Place and date

| | |
|---|---|
| | |
| Researcher Alex Example | Research director Casey Cleverton |

## Sampling report template

Appendix 3.

M1 Cleanliness Classification Testing Guideline for Ventilation Products

| | | | | | |
|---|---|---|---|---|---|
| ***Product information*** | | | | | |
| *Assessed product* | *product 1 e.g., duct d=160 mm and ID code, if available* | *product 2* | *product 3* | *product 4* | *product 5* |
| *Date of production* | X.C.XCVB | | | | |
| *Selection criteria* | random selection | | | | |
| *Storage* | outdoors, under a shelter | | | | |
| *Protection* | capped using plastic caps | | | | |
| ***Sample information*** | | | | | |
| *Sampling date* | C.V.BNMZ | | | | |
| *Types of samples* | lubricant residue and dust accumulation | | | | |
| *Sample identification details* | L1 and D1 | | | | |
| *Product selector* | Alex Example | | | | |
| *Sample collector* | Alex Example | | | | |