



**International
Standard**

ISO 23742

**Test method for the evaluation of
permeability and filtration efficiency
distribution of bag filter medium**

*Méthode d'essai pour l'évaluation de la perméabilité et de la
distribution de l'efficacité de filtration d'un média filtrant à poches*

**First edition
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Foreword

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This document was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The main purpose of using dust collector systems is to separate dust particles from dirty gases. The dry type filtering dust collectors, bag filter systems are one of the most widely used industrial dust collectors such as municipal garbage incinerators, coal fired boilers, iron makings, cement factories, power plants, etc. They are also used to improve the local working environment where dust is emitted. For the bag filter systems, the operations to collect the dust particles at the surface of the filter for relatively long periods, and to remove the accumulated dust on the filter away instantaneously are conducted. Therefore, the dust particles are collected inside the filter immediately after the dust removal operation until the dust layer is completely formed on the filter and particle collection on the filter surface begins. Therefore, their most important performances, filtration efficiency and pressure drop depend upon the characteristics of the filter medium installed in them.

Such as non-woven filter medium for bag filter systems packs densely with relatively large fibres. Although fibre size and its orientation are different slightly in the entire filter medium, packing structure of the medium (packing density and area mass of fibres, thickness of the medium, etc.) can vary depending on the position of the filter medium due to the manufacturing method.

The non-uniformity (variation by the position) in the packing structure of the medium affects its pressure drop, gas permeability and filtration efficiency. As a result, the local values of the pressure drop, gas permeability and filtration efficiency in small domains in the medium are also distributed unevenly. However, the non-uniformity of these performances has been ignored. In many cases of commercial filters, their thickness, area mass, fibre packing density, and gas permeability are only indicated as the average specifications.

The non-uniformity of these properties of the filter medium can cause various troubles in operation and reducing the collection performance of the bag filter system. The part with relatively lower packing density of fibres in the filter medium allows higher gas flow rate, but the densely packed part provides lower gas flow rate. Thus, the gas and dust flows concentrate in areas with low packing density, causing clogging in those areas. Since the dust particles are collected inside the filter immediately after the cleaning operation of accumulated dust on the medium until the dust layer is completely formed on the filter (transition to the cake filtration process), the area with a relatively higher gas permeability can give the lower filtration efficiency, and the dust easily leak from there. These phenomena finally can accelerate the further deterioration of the filter medium.

Accordingly, in order to accurately evaluate the performance of the filter medium, it is preferable to measure not only the average value of each property but also its distribution based on globally consistent methods and standards.

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Test method for the evaluation of permeability and filtration efficiency distribution of bag filter medium

1 Scope

This document specifies a measuring method for the distribution of thickness, area mass, gas permeability and collection efficiency in the filter medium, and applies to both woven and non-woven filter medium.

This document provides a method for sampling specimen (position, size and number) from the filter medium required to obtain its performance distribution accurately.

The purpose of this document is to provide more accurate information about the morphology of the filter medium for users, and not to compare grade the performance of the filter medium.

2 Normative references

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

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

ISO 5084, *Textiles — Determination of thickness of textiles and textile products*

ISO 10012, *Measurement management systems — Requirements for measurement processes and measuring equipment*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1

lot

minimum unit for the manufacture of a product with the same specification

3.2

roll

minimum unit for filter shipping from the manufacturer

3.3

area mass

mass per unit area for a two-dimensional object

4 Determination of sampling

4.1 General

As explained in [Annex A](#), as the number of sample sheets increases, the accuracy of the non-uniformity measurement improves. The number of sample sheets corresponding to the required reliability shall be specified. Since the position of the sample sheets in the roll of the filter medium directly influences the obtained distribution for each measurement item, it shall be specified. As the specimen strip size for each measurement item decreases, the non-uniformity on smaller scales is measured. Hence, they shall be specified. Since reducing the sample sheet size also yields more localized distributions with finer resolution, it shall also be standardized.

4.2 Collection position, size and shape of representative sample sheets

[Figure 1](#) shows the position where sample sheets are cut from the filter medium roll. Sample sheets shall be taken from at least 20 cm inside the end and both sides of the roll of the filter medium, and avoid its selvedge. The lateral distance between the sample sheets shall be at least 50 cm equally spaced. The maximum number of sample sheets which are taken from a roll in the lateral direction is defined as 5. When the required number of sample sheets are not obtained from the row closest to the end of the filter roll (first row), the remaining sample sheets shall be taken in the same way from the next farther row, more than 20 cm apart. The size of the sample sheet shall be more than 30 cm square (30 cm × 30 cm). All the measurement items are tested sequentially on one specimen strip cut out from each taken sample sheet.

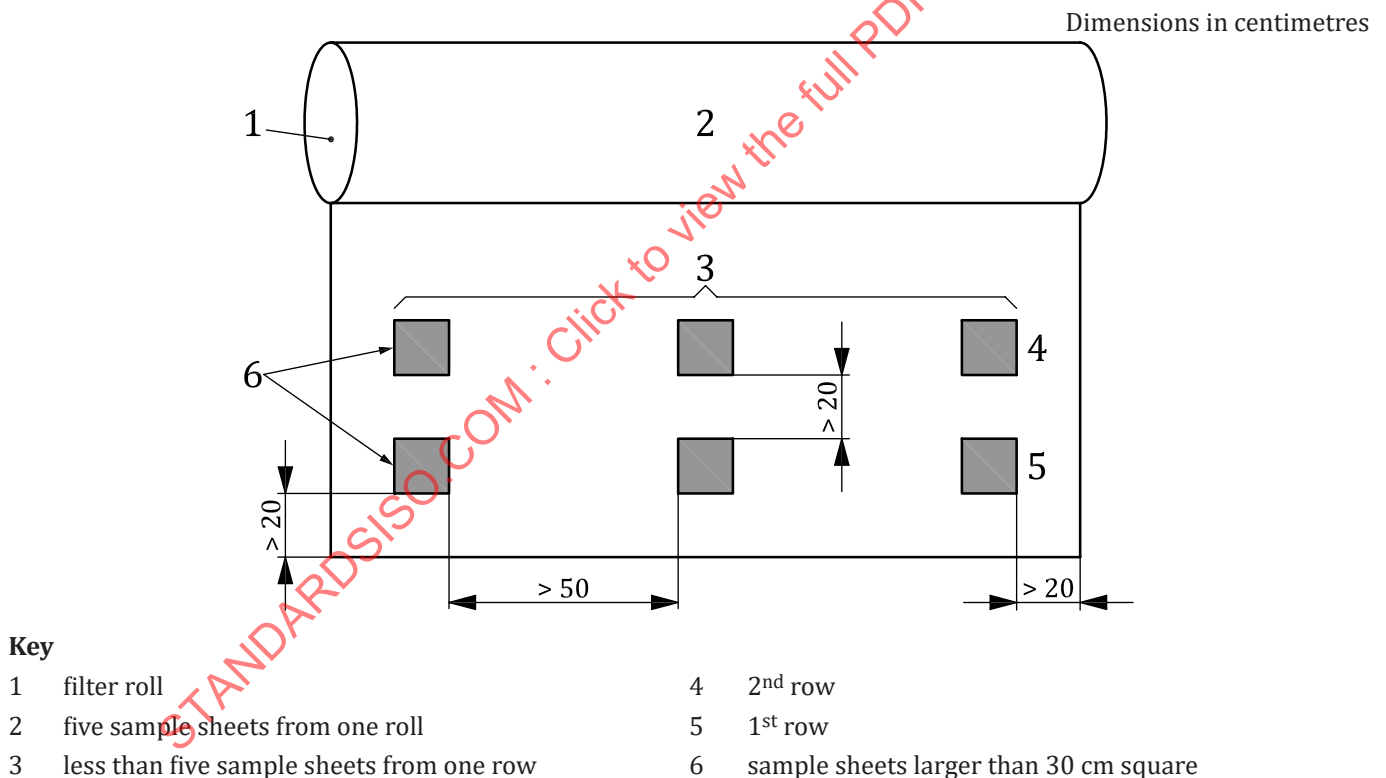


Figure 1 — Position to take sample sheets from the filter medium roll

4.3 Number of representative sample sheets

As the number of sample sheets increases, the reliability of the measured results increases, and the confidence interval decreases. Therefore, it is preferable to collect more sample sheets and evaluate each measurement item. However, as an increase in the number of sample sheets results in an increase in cost, the necessary and sufficient number of sample sheets shall be determined from the sample survey theory explained in [Annex A](#). Namely, at least 15 sample sheets shall be sampled per lot.

The selection of filter rolls to take sample sheets from one lot is shown in Figure 2. To evaluate the longitudinal variance, at least three rolls shall be selected evenly for each lot of the filter medium, and the number of sample sheets allowed to be taken from a roll is limited to five, respectively.

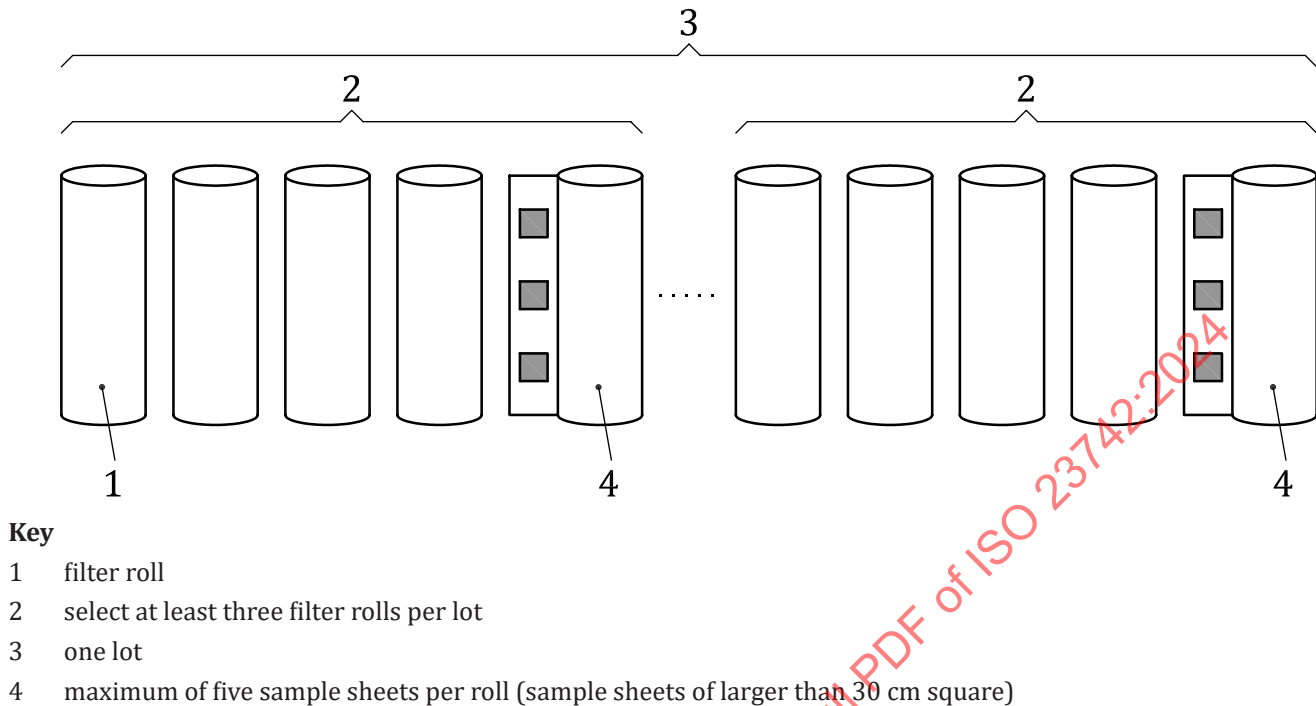


Figure 2 — Number of sample sheets to be acquired per lot of the filter medium

5 Preparation of specimen strips

5.1 General

A specimen strip to measure all three evaluation items (thickness, area mass, gas permeability) shall be cut out from each sample sheet taken.

5.2 Standard atmosphere for conditioning and testing

The atmosphere for conditioning and testing specimen strips shall be defined according to ISO 139. This atmosphere has a relative humidity of $(65 \pm 2) \%$ and a temperature of $(20 \pm 2) ^\circ\text{C}$. In tropical regions between the Tropic of Cancer ($23^\circ 26' 22'' \text{ N}$) and the Tropic of Capricorn ($23^\circ 26' 22'' \text{ S}$), centred on the equator, a temperature of $27 \pm 2 ^\circ\text{C}$ may be used, subject to the agreement of the interested parties.

5.3 Conditioning of specimen strips

Before measurement, specimen strips shall be brought into equilibrium with the standard atmosphere for testing by exposing them to this atmosphere in a tension-free condition. Equilibrium is considered to have been reached when the difference between successive weightings carried out at intervals of at least 2 h does not exceed 0,5 % of the final mass of the filter medium when conditioned in this atmosphere according to ISO 3801. The exposure time shall be a maximum of 8 h.

5.4 Size of specimen strips

A 30 cm square (30 cm $\times$ 30 cm) specimen strip shall be cut out from the centre of the taken sample sheet. In cases where 30 cm square is not appropriate for the measurement, an alternative length square of 15 cm to 40 cm or a circular specimen strip of 8 cm to 23 cm diameter may be chosen.

6 Measurement method - Thickness

6.1 General

Thickness of the filter medium is defined as the perpendicular distance between two reference plates exerting a certain pressure. The thickness of a specimen strip shall be measured as the distance between the reference plates on which the specimen rests and a parallel circular presser-foot that exerts a specified pressure on the area of the textile under test. A test specimen strip shall be placed between two reference plates which exert a known pressure on the specimen. The perpendicular distance between the reference plates is measured and recorded after a specified period.

6.2 Apparatus

Metrological confirmation of the test apparatus shall be carried out in accordance with ISO 10012.

6.2.1 Thickness tester

The necessary elements and recommended dimensions to be used with the thickness tester shall be in accordance with ISO 5084.

6.2.2 Thickness gauge

The thickness gauge shall be able to measure and register the distance between the two plates to an accuracy of 0,01 mm.

6.3 Procedure

The thickness at three points equally spaced on both diagonals of the specimen strip (total five points) shall be measured under exerting the specified pressure after the specified period and using the thickness tester and the thickness gauge. As shown in [Annex C](#), thickness can depend on the exerted pressure. Recommended period and exerting pressure are (30 ± 5) s and $(1 \pm 0,01)$ kPa, respectively. In cases where these specifications are not appropriate for the measurement, an alternative period of more than 10 s and exerting pressure of less than 15 kPa can be chosen. The arithmetic mean of the measured thicknesses in the accuracy of 0,01 mm shall be defined as the thickness of the specimen strip. Recommended specimen strip size for the thickness measurement is 30 cm square (30 cm $\times$ 30 cm), according to ISO 5084. In cases where this specification is not appropriate for the measurement, an alternative size of 10 cm to 30 cm square (10 cm to 30 cm $\times$ 10 cm to 30 cm) may be chosen.

7 Measurement method - Area mass

7.1 General

The area mass (mass per unit area) shall be determined by exposing the specimen strip taken from sampled filter medium. Specimens of known dimensions are then taken and weighed and the mass per unit area is calculated.

7.2 Apparatus

Metrological confirmation of the test apparatus shall be carried out in accordance with ISO 10012.

7.2.1 Precision balance

The precision balance shall be able to determine the mass of pieces with the accuracy of $\pm 0,2$ % of the determined mass. An accuracy of 0,001 g is required.

7.2.2 Calibrated rule

The calibrated rule shall be guaranteed even to the milli-meter order.

7.3 Procedure

The mass of the specimen strip shall be measured to an accuracy of $\pm 0,001$ g, ensuring that no loss of threads occurs. From the mass and the area of the specimen strip, the area mass (mass per unit area) of the filter medium shall be calculated to an accuracy of $\pm 0,01$ g. Recommended specimen strip size for the area mass measurement is 10 cm square (10 cm $\times$ 10 cm), according to ISO 3801. In cases where this speculation is not appropriate for the measurement, an alternative size of 10 cm to 30 cm square (10 cm to 30 cm $\times$ 10 cm to 30 cm) may be chosen.

8 Measurement method - Gas permeability

8.1 General

The rate of flow of air passing perpendicularly through a given area of fabric specimen is measured at a given pressure difference across the fabric test area over a given time period.

8.2 Apparatus

Metrological confirmation of the test apparatus shall be carried out in accordance with ISO 10012.

8.2.1 Circular specimen holder

The circular specimen holder shall have an orifice to carry out the measurement on the specified test area. The tolerance on the test area shall not exceed $\pm 0,5$ %.

8.2.2 Clamping device

The clamping device shall secure the specimen strip without distortion.

8.2.3 Guard ring device

The guard ring device may be used with the clamping device as an option to prevent leakage.

8.2.4 Pressure gauge or manometer

The pressure gauge or manometer shall be connected to the test head to indicate the pressure drop across the test area of the specimen strip with an accuracy better than 2 %.

8.2.5 Blower, fan or pump

The blower or pump shall draw the steady flow of air for adjusting the flowrate to produce a pressure drop across the specimen strip of between 50 Pa and 500 Pa at controlled temperature and humidity through the specimen holder.

8.2.6 Flowmeter, volumetric counter or measuring aperture

Flowmeter, volumetric counter or measuring aperture shall indicate the rate of air flow with an accuracy better than ± 2 %.

8.3 Procedure

The gas permeability at the centre of the specimen strip shall be measured. The specimen strip shall be mount in the circular specimen holder with sufficient tension to eliminate wrinkles, if any, taking care that

the fabric is not distorted in its own plane. The suction fan or other devices to force the air through the specimen strip shall be started and the flow rate of air shall be increased gradually adjusted till the specified pressure drop is achieved across the test area of the specimen strip. The air flow rate shall be recorded until steady conditions are achieved.

Recommended test surface area and pressure drop are 20 cm² and 200 Pa, respectively. In cases where these speculations are not appropriate for the measurement, an alternative test surface area of 5 cm², 37 cm², 50 cm² or 100 cm² and pressure drop of 50 Pa, 125 Pa or 500 Pa may be chosen.

9 Measurement method – Filtration efficiency (option)

Since the filtration efficiency of the filter medium is one of the most important evaluation indices of filter performance, it is recommended to measure it. However, its measurement requires long measurement time and complicated procedures. As the filtration efficiency is highly correlated with the thickness, area mass, and air permeability, these measurement results can provide an approximate filtration efficiency distribution. Therefore, the filtration efficiency measurement is optional item in this document. It is desirable to measure the filtration efficiency under the condition equal to the pressure drop used to measure the air permeability.

10 Order of measurement sequence

The measurement items that require a larger area of specimen strip shall be measured in order. That is, thickness, area mass, and gas permeability shall be measured in this order.

11 Expression of distribution of each measurement item

The mean, standard deviation and 95 % confidence interval of the mean for each measurement item of the whole filter medium is calculated based on this theory from the measurements of the sample sheets. The mean value of a measurement item for the whole filter medium $\bar{X}$ is equal to its mean value for the sample sheets $\bar{x}$. The standard deviation of a measurement item for the whole filter medium s is obtained as its unbiased standard deviation for the sample sheets as shown in [Formulae \(1\)](#) and [\(2\)](#),

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n x_i \quad (1)$$

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2 \quad (2)$$

where, n is the number of sample sheets, x_i is the measurement value of sample sheet i .

95 % confidence interval of the filter medium mean, which indicates the validity of the sample survey, is obtained from [Formula \(3\)](#):

$$\bar{x} - t_{95/2(n-1)} \sqrt{\frac{s^2}{n}} \leq \bar{X} \leq \bar{x} + t_{95/2(n-1)} \sqrt{\frac{s^2}{n}} \quad (3)$$

where, $t_{95/2(n-1)}$ is the value in the student's t distribution with “ $n-1$ degrees of freedom” at which the upper probability is equal to 95/2 (t value).

The theory of sample surveys based on a normal distribution should be referred to in [Annex A](#). As shown in [Annex B](#), the relationship between the number of specimen strips and the measurement error for each evaluation item of the various filter medium should be confirmed.

12 Test report

An example of a test report is shown in [Annex D](#), and an example of measurement results summarized in a test report is shown in [Annex E](#). The report shall include the following information.

- a) Facility: name of company, address, date of the test, name of a tester.
- b) Reference to this document, i.e. ISO 23742:2024.
- c) Material and properties of filter medium: name of product, type of fibre, web, scrim, fibre material and diameter, surface processing.
- d) Manufacturing conditions of filter medium: name of manufacturer, address, manufacturing date, length and width of one filter roll, and number of filter rolls per lot.
- e) Sampling conditions: lot no. selected for sampling, roll no. selected for sampling, number of filter rolls selected for sampling per lot, number of taken sample sheets from one filter roll, the total number of taken sample sheets from one lot, dimensions of sample sheet.
- f) Test conditions: ambient conditions for testing (temperature, humidity, pressure) for each measurement item, dimensions of specimen strip for each measurement item, waiting period and applied pressure for thickness measurement, test surface area and pressure drop for gas permeability measurement.
- g) Results of the test: normal distribution approximation of each measurement item for filter medium, mean and standard deviation of each measurement item for filter medium, 95 % confidence interval of the mean for filter medium, maximum and minimum values of each measurement item.
- h) Other comments: any deviations from the procedure, any unusual features observed.

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Annex A (normative)

Sampling survey theory based on normal distribution

When it is assumed that a certain variable of the statistical population is expressed by a normal distribution, a method of estimating the mean and variance of the statistical population using values obtained from the sample within a certain interval is called “interval estimation”. This interval is called a “confidence interval”.

The average value of the population (population mean) $\bar{X}$ is equal to the average value of the sample $\bar{x}$ as shown in [Formula \(A.1\)](#), and the variance of the population (population variance) is also equal to the unbiased variance of the sample s^2 calculated from [Formula \(A.2\)](#).

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n x_i \quad (\text{A.1})$$

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2 \quad (\text{A.2})$$

where, n is the number of samples, x_i is the variable of the sample i , respectively.

When the confidence coefficient is α , $100(1-\alpha)\%$ confidence interval CI of the population mean is obtained from [Formula \(A.3\)](#).

$$\bar{x} - t_{\alpha/2(n-1)} \sqrt{\frac{s^2}{n}} \leq \bar{X} \leq \bar{x} + t_{\alpha/2(n-1)} \sqrt{\frac{s^2}{n}} \quad (\text{A.3})$$

where, $t_{\alpha/2(n-1)}$ is the value in the student's t distribution with “ $n-1$ degrees of freedom” at which the upper probability is equal to $\alpha/2$ (t value) and is defined by [Formula \(A.4\)](#).

$$t = \frac{\bar{x} - \bar{X}}{\sqrt{\frac{s^2}{n}}} \quad (\text{A.4})$$

In general, more than 30 samples are necessary to conduct highly accurate specimen surveys.

When the number of populations is larger than the number of samples, the theoretical necessary number of samples nn is given by [Formula \(A.5\)](#):

$$nn \approx \left(\frac{2 k_j}{CI} \right)^2 s^2 \quad (\text{A.5})$$

where k_j is the critical value of the normal distribution at $j\%$ significant level ($k_5 = 1,96$, $k_1 = 2,58$).

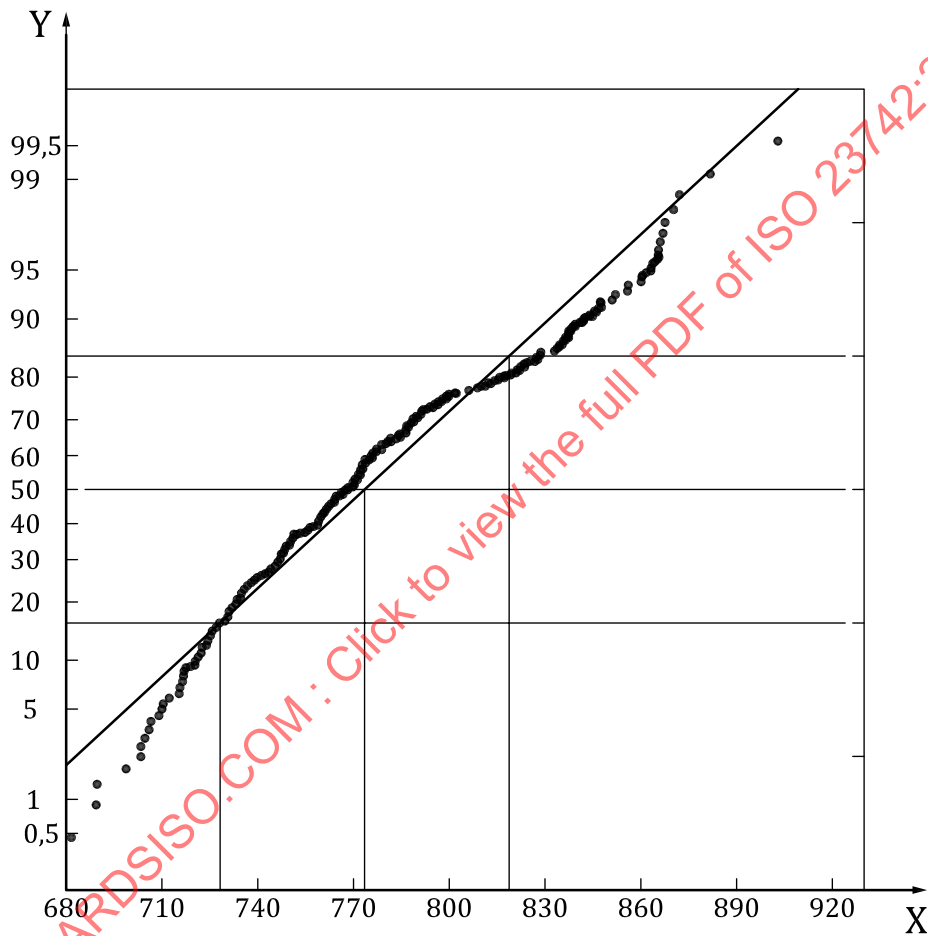
Annex B

(informative)

Analysis example of measurement results

B.1 Area mass

[Figure B.1](#) shows an area mass distribution and approximation by a normal distribution of a filter medium.



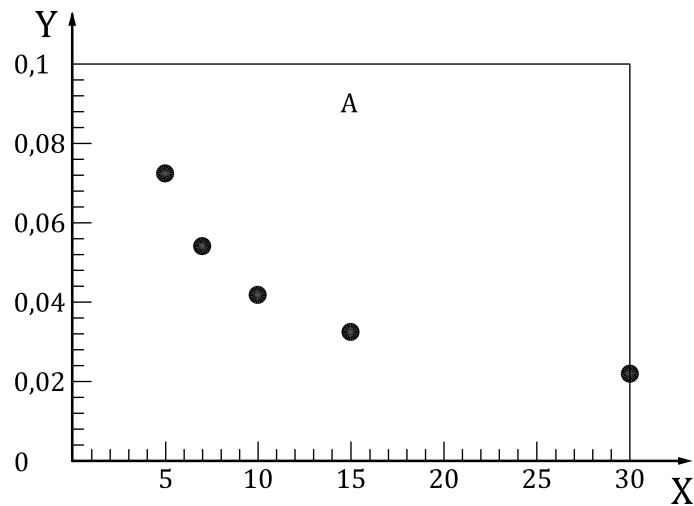
Key

X area mass (g/m^2)
Y fraction (%)

NOTE [Figure B.1](#) is prepared based on data from 220 sampled sheets, and the size of specimen strip is 7 cm square.

Figure B.1 — Area mass distribution and approximation by a normal distribution of a filter medium

[Figure B.2](#) shows relationship between number of sample sheets and measurement error of mean for area mass distribution obtained from the approximation by a normal distribution as shown in [Figure B.1](#).

**Key**

X number of samples [-]

Y CI/mean [-]

A mean of raw fabric = 773,6 g/m²

Figure B.2 — Relationship between number of sample sheets and measurement error of mean (CI/mean) for area mass distribution

The measurement and analysis results are the following:

Mean of the filter medium = 773,6 g/m²

Standard deviation of the filter medium = 45,14 g/m²

Maximum area mass = 903,6 g/m², minimum area mass = 681,6 g/m²

Theoretical necessary number of samples = 9,1

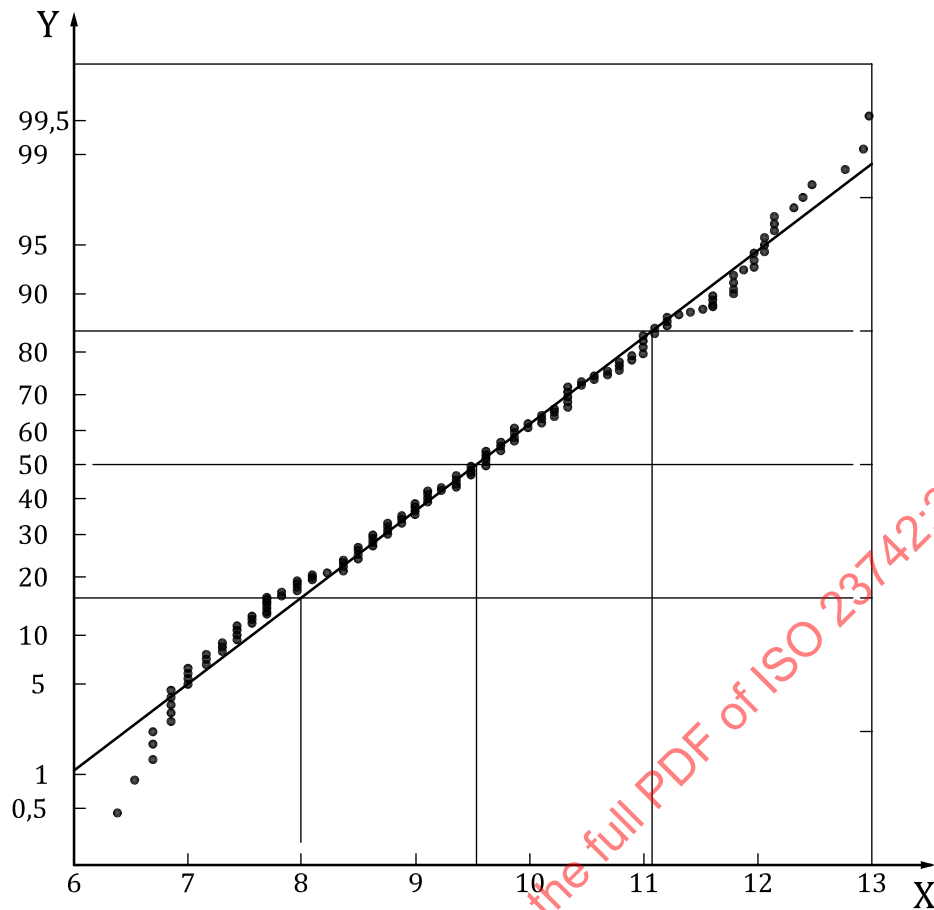
at measurement error (CI/mean) = ±5 %, significant level = 1 %

Theoretical necessary number of samples = 1,3

at measurement error (CI/mean) = ±10 %, significant level = 5 %

B.2 Gas permeability

[Figure B.3](#) shows a gas permeability distribution and approximation by a normal distribution of a filter medium.



Key

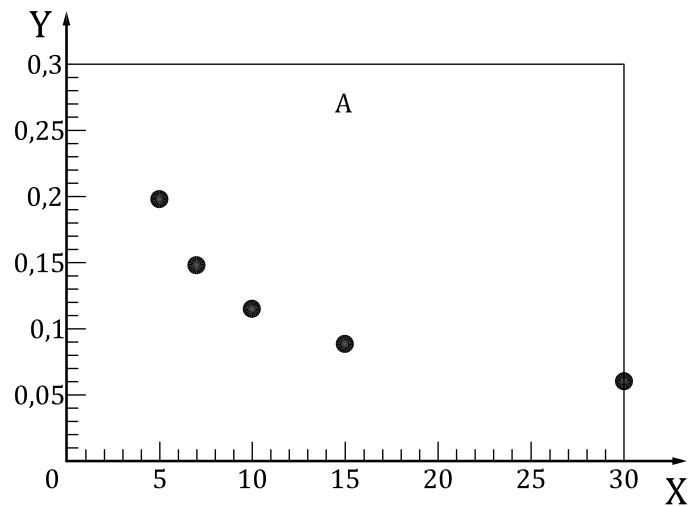
X gas permeability [cm/s]

Y fraction [%]

NOTE [Figure B.3](#) is prepared based on data from 220 sampled sheets, and the test surface area is 37 cm². The pressure drop was set to 125 Pa.

Figure B.3 — Gas permeability distribution and approximation by a normal distribution of a filter medium

[Figure B.4](#) shows relationship between number of sample sheets and measurement error of mean for gas permeability distribution obtained from the approximation by a normal distribution as shown in [Figure B.3](#).



Key

X number of samples [-]

Y CI/mean [-]

A mean of the raw fabric = 9,53 cm/s

Figure B.4 — Relationship between number of sample sheets and measurement error of mean (CI/mean) for gas permeability distribution

The measurement and analysis results are the following:

Mean of the filter medium = 9,53 cm/s

Standard deviation of the filter medium = 1,52 cm/s

Maximum gas permeability = 12,97 cm/s, minimum gas permeability = 6,38 cm/s

Theoretical necessary number of samples = 67,7

at measurement error (CI/mean) = ± 5 %, significant level = 1 %

Theoretical necessary number of samples = 9,8

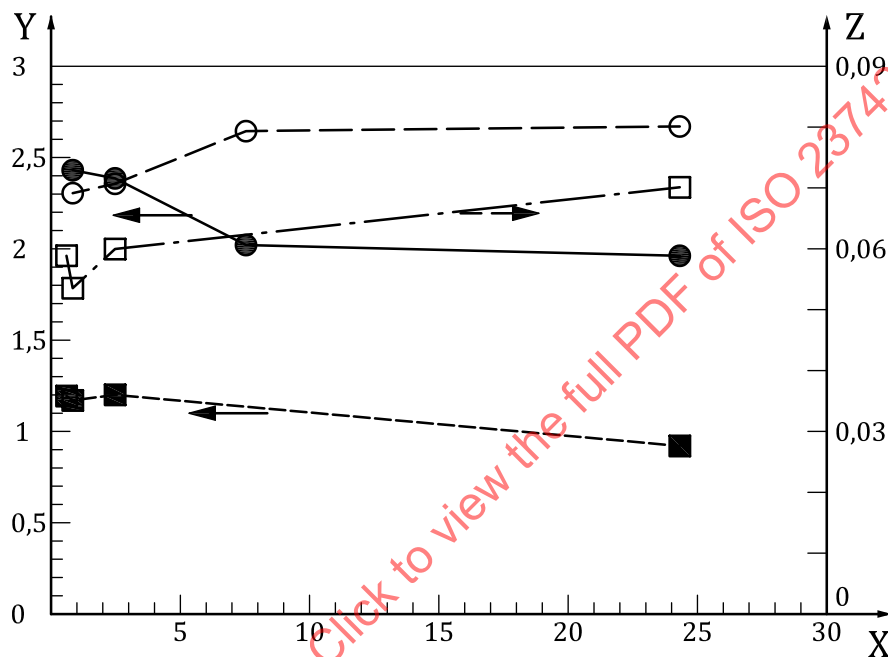
at measurement error (CI/mean) = ± 10 %, significant level = 5 %

Annex C

(informative)

Example of relationship between exerting pressure and thickness distribution

Figure C.1 shows relationship between exerting pressure and mean and standard deviation for thickness distribution. As the exerting pressure increases, the mean of the thickness decreases and its standard deviation increases. Above an exerting pressure of 10 kPa, little pressure dependence is observed.



Key

X exerting pressure [kPa]

Y average filter thickness [mm]

Z standard deviation of thickness [mm]

—●— average thickness of filter B

—○— standard deviation of thickness of filter B

—■— average thickness of filter C

—□— standard deviation of thickness of filter C

Figure C.1 — Relationship between exerting pressure and mean and standard deviation for thickness distribution

Annex D (informative)

Example of a test report

[Table D.1](#) shows an example of a test report.

Table D.1 — Example of a test report

1- Facility			
Name of company:		Date of test:	
Address:		Name of tester:	
2 - Material and properties of filter medium			
Name of product:		Surface processing:	
Type of fibre:			
Web front side		Scrim	
Fibre material:		Yarn material:	
Fibre diameter: [µm]		Yarn diameter: [µm]	
Web rear side			
Fibre material:			
Fibre diameter: [µm]			
3 - Manufacturing conditions of filter medium			
Name of manufacturer:		Manufacturing date:	
Address:			
Filter roll			
Length: [m]			
Width: [m]			
Number per lot:			
4 - Sampling conditions			
Lot no. for sampling:		Roll no. for sampling:	
Dimensions of sample: x [cm ²]			
Number of filter rolls used for sampling per lot:			
Number of taken samples from one filter roll:			
Total number of taken samples from one lot:			
5 - Test conditions			
Thickness measurement		Area mass measurement	
Ambient temperature:		Ambient temperature:	
Ambient humidity:		Ambient humidity:	
Ambient pressure:		Ambient pressure:	
Dimensions of specimen: x [cm ²]		Dimensions of specimen: x [mm ²]	
Waiting period:			
Applied pressure:			
Gas permeability measurement			