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# Textiles — Test methods for nonwovens —

## Part 10: Lint and other particles generation in the dry state

*Textiles — Méthodes d'essai pour nontissés —*

*Partie 10: Relargage de peluches et autres particules à l'état sec*

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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9073-10 was prepared by Technical Committee ISO/TC 38, *Textiles*.

ISO 9073 consists of the following parts, under the general title *Textiles — Test methods for nonwovens*:

— *Part 1: Determination of mass per unit area*

— *Part 2: Determination of thickness*

— *Part 3: Determination of tensile strength and elongation*

— *Part 4: Determination of tear resistance*

— *Part 6: Absorption*

— *Part 7: Determination of bending length*

— *Part 8: Determination of liquid strike-through time (simulated urine)*

— *Part 9: Determination of drape coefficient*

— *Part 10: Lint and other particles generation in the dry state*

— *Part 11: Run-off*

— *Part 12: Demand absorbency*

# Textiles — Test methods for nonwovens —

## Part 10:
## Lint and other particles generation in the dry state

## 1 Scope

This part of ISO 9073 specifies a test method for measuring the linting of nonwovens in the dry state. It can also be applied to other textile materials.

## 2 Normative references

The following referenced documents are indispensable for the application 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 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 14644-1, *Cleanrooms and associated controlled environments — Part 1: Classification or air cleanliness*

## 3 Terms and definitions

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

**3.1**
**lint**
fibre fragments released during handling

**3.2**
**linting**
release of lint and other particles during handling

**3.3**
**coefficient of linting**
log of the particle count applied to all or to a part of the measurement channels

## 4 Principle

This procedure describes a modified Gelbo Flex method in which the sample is subjected to a combined twisting and compression action in a test chamber. During the flexing, air is withdrawn from the chamber and particulates in the air stream are counted and classified in a particle counter. Depending on the choice of counter, the size ranges can fall within the limits of 0,3 µm or 0,5 µm to 25 µm.

See Annex A for general information on reproducibilty.

## 5 Apparatus

**5.1 Lamina flow hood**, vertical, for use in a clean-air station to ensure a clean test environment.

NOTE A Class 5 clean room in accordance with ISO 14644-1 may be used as an alternative.

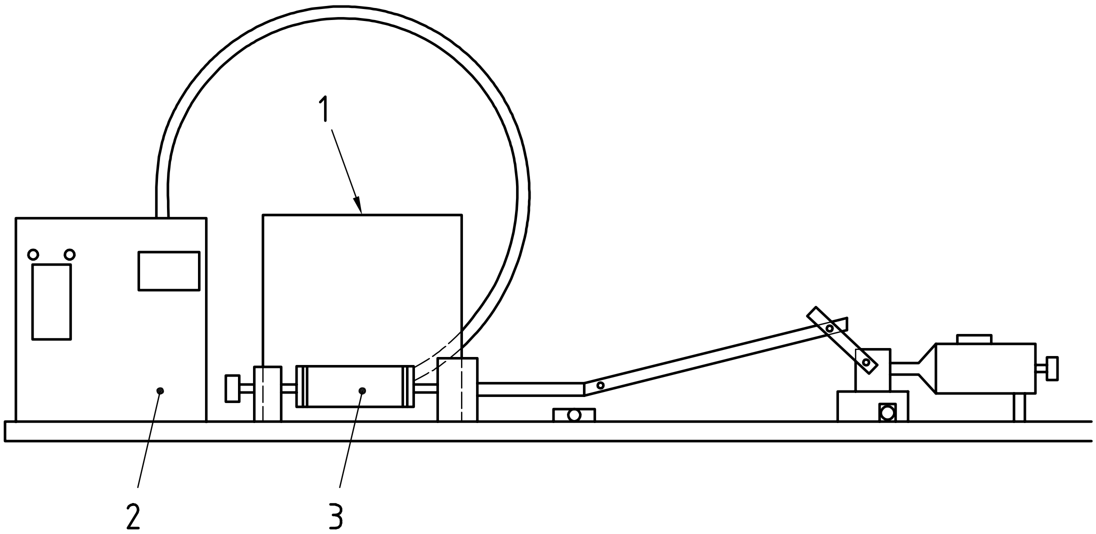
**5.2 Flexing unit (modified Gelbo Flex)**, consisting of two circular plates, of diameter 82,8 mm, one fixed and the other moveable, but located on a mechanism that allows it to move towards and away from the fixed plate at a frequency of 60 cycles/min whilst at the same time rotating clockwise and anti-clockwise through an angle of 180°, in synchronization with a to-and-fro movement. See Figure 1.

The plates have 8 holes (diameter 12,5 mm) located 10 mm from the outer edge and equally spaced.

The distance between the plates at the starting position is (188 ± 2) mm and the stroke of the linear motion is (120 ± 2) mm.

Clamping devices are used to fix the test piece, in a tubular form, to the circular plates.

**5.3 Flexing chamber and air collector**, in which the flexing unit is enclosed in an antistatic perspex box measuring (300 × 300 × 300) mm (see Figure 2). This chamber has removable front and back panels for cleaning and purging with filtered, clean air. The back and two sides each have two holes (diameter 10 mm) located 25 mm from the top of the chamber and spaced equally across the 300 mm of each panel.



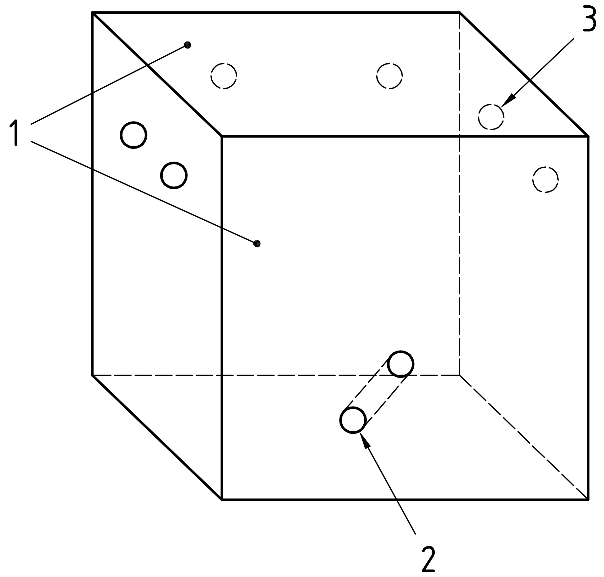

**Key**

1 test chamber

2 particle counter

3 test piece

**Figure 1 — Gelbo Flex dry particle generator**




**Key**

1 removable front and back panels
2 air collector
3 side holes (10 mm in diameter)

**Figure 2 — Flexing chamber and air collector**

The intake probe of the air collector is fixed to the centre of the base in the chamber, 2 cm above the base plate (see Figure 3).

The diameter of the intake probe end is (40 ± 5) mm.

The flexible duct connecting the air collector to the particle counter has the following characteristics.

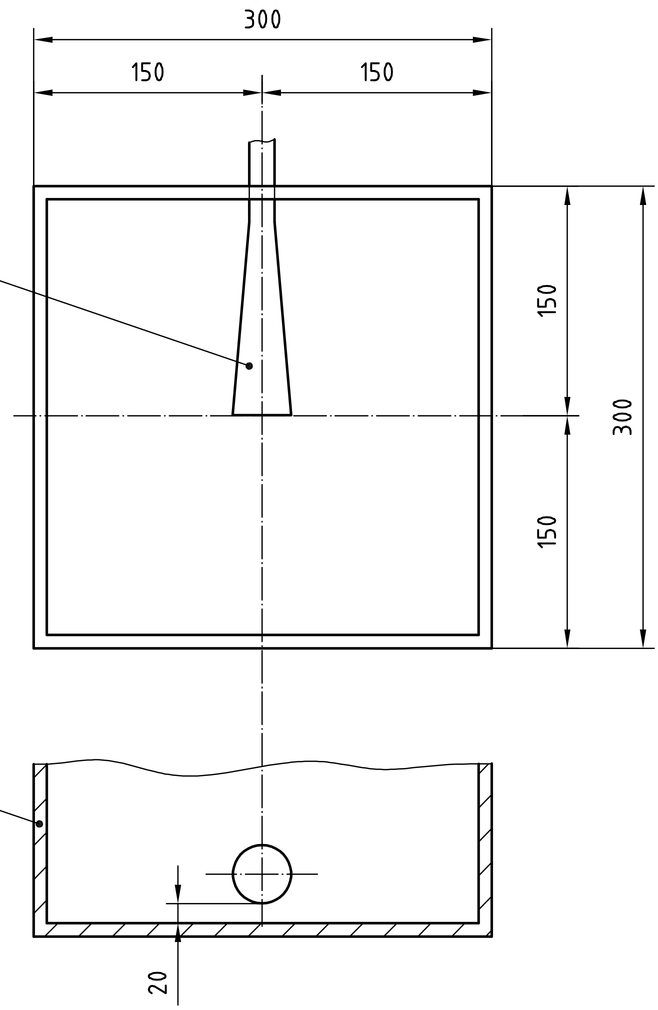
— polyurethane or polyester lined vinyl or similar;

— maximum length 1 500 mm;

— inner diameter (8,5 ± 1,5) mm;

— not kinked nor curved with a small curvature radius.

Dimensions in millimetres




**Key**

1 air collector intake probe

2 flexing chamber

**Figure 3 — Position of air collector intake probe**

**5.4 Particle counter**, with the following main characteristics:

— 8 measurement channels;

— overall size range: 0,3 µm or 0,5 µm to 25 µm;

— air flow: (28,3 ± 1,4) l/min;

— sampling time selectable between 1 s and 24 h.

**5.5 Glue**, for sealing the cylindrical test piece.

**5.6 Gloves**, for use in ISO class 5 clean room. See ISO 14644-1.

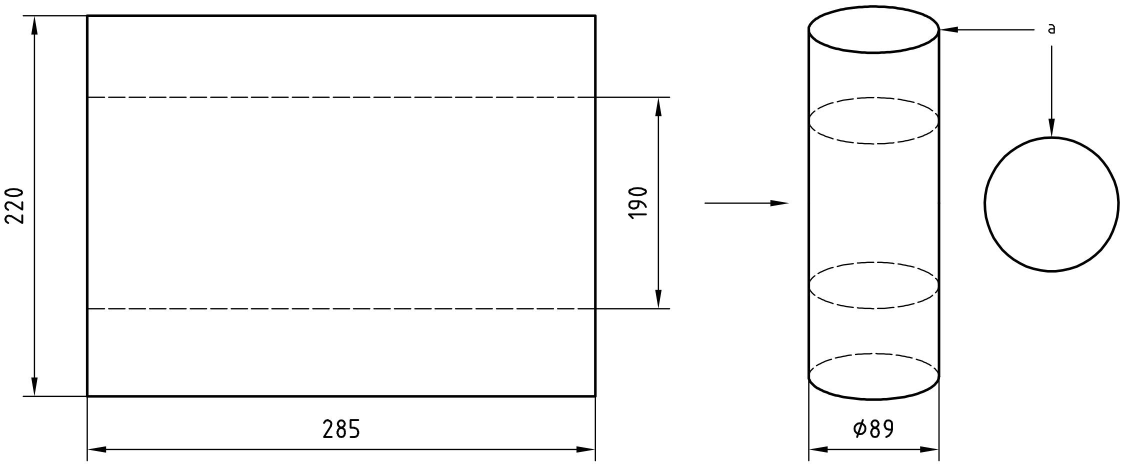
## 6 Procedure

**6.1** The operator shall wear gloves for handling test pieces.

**6.2** Preparation of the test pieces shall be made under clean room conditions (see 5.1) and observing the specifications given in ISO 554.

**6.3** Two sets of seven test pieces are cut (see Figure 4), (220 ± 1) mm × (285 ± 1) mm (larger dimension in the cross direction); one set is marked on one face as side A and the other set on the other face as side B. Only five test pieces are used in the test, the other two (top and bottom) test pieces are to protect those in use. The sets of test pieces shall be free from folds and wrinkles and be kept in a clean antistatic environment.

Dimensions in millimetres




a Glued

**Figure 4 — Test piece**

**6.4** The environment in which the tests are carried out shall be dust free (see 5.1). The flexing chamber shall be thoroughly cleaned between each measurement and the air quality in the chamber checked before each test is carried out.

a) With the back panel removed (to allow clean air to flow into the empty chamber) and the flexing unit turned off and with no sample in place, two measurements are carried out. The total count of particles ⩾ 0,5 µm in 30 s shall be less than 100. If not achieved, the procedure shall be repeated.

b) In order to obtain $C_0$ and take a particle count:

   1) the back panel of the chamber shall be closed;

   2) with the flexing unit operating but without a sample mounted, and after stabilization for ten 30 s counting periods, the results are recorded;

   3) the results are added to obtain $C_0$.

In order to report results for each size classification the particle count for each classification shall be recorded to give the $C_0$ value for each class.

**6.5** A tube is made from the test piece with the longer dimension corresponding to the circumference and the free edges glued on a 0,5 cm width using a suitable adhesive product for sealing the cylindrical test piece (see Figure 4).

**6.6** The circular plates are set in their starting position, (188 ± 2) mm apart.

**6.7** With minimum handling and care, the test piece tube is attached to the circular plates by means of appropriate clamping devices (e.g. rubber bands).

**6.8** The particle counter is set for a counting period of 30 s and a 1 s reset time (run mode).

**6.9** The flexing chamber is closed.

**6.10** The flexing unit and the particle counter are started concurrently and the flexing unit is run until 10 consecutive periods of 30 s have been completed.

**6.11** The flexing unit and the particle counter are stopped, the test piece is removed and the flexing chamber cleaned prior to the procedure being repeated on the next test piece.

NOTE Cleaning is carried out with wet clean room wipes followed by drying before each trial.

**6.12** The results for each size classification from the read-out device for the particle counter are recorded.

**6.13** The procedure shall be repeated for all ten test pieces, five from side A and five from side B.

# 7 Calculation

## 7.1 Background correction

**7.1.1** For each test piece, $C_0$ is subtracted from the total count for the ten periods to give the estimate of the particle count of the material. The result is termed linting.

**7.1.2** To obtain the total count, where the particle size classification is ignored, all the counts are added and from the sum obtained, $C_0$ for that class is subtracted.

To report only the counts in each particle size classification, the counts in that class are added and $C_0$ for that class used.

**7.1.3** See Annex B for a worked example.

## 7.2 Results

**7.2.1** The linting (separately for sides A and B) is calculated as the mean of the results from the 5 test pieces. The calculations shall be made either for each particle size class (linting) or the sum of all counts (total linting) or for any selected number of classes.

Linting and total linting can be calculated for side A and side B separately or for the material as the mean of side A and side B.

**7.2.2** Standard deviation and coefficient of variation shall be calculated for each of the results mentioned in 7.2.1. The coefficient of variation is the ratio standard deviation versus linting expressed as a percentage.

**7.2.3** If requested, the coefficient of linting ($C_L$) may be calculated as the log of the total linting (see 7.2.1), corresponding to all different classes or a selected number of classes, for each side and for all the material.

## 8 Test report

The test report shall include the following information:

a) type or designation of material tested;

b) type of particle counter used;

c) number of test pieces tested;

d) linting for each side separately (side A and side B), of each particle size classification, or for a selected number of classes as the mean result of the five test pieces;

e) if requested, for each side separately, the total linting, summing up all classes or a selected number of classes as the mean result from the five test pieces (see 7.2.1);

f) if requested, the linting or total linting of the material (see 7.2.1) for all classes or selected classes;

g) standard deviation and percent coefficient of variation (7.2.2) for each of the results reported in d) and e);

h) if requested, the coefficient of linting (7.2.3) as the log of the results reported in e) and f);

i) any deviation from the procedure described in this part of ISO 9073.

# Annex A
(informative)

## General information regarding reproducibility

The particles that are counted during the test may be airborne debris (dust) or fragments from fibres, binders or other process treatments. In using the test to assess the lint generating potential of nonwovens or composites the dust should be kept to a minimum. The test is particularly adapted for low linting nonwovens which are used mainly in medical, computer or similar environments.

It has been found that many types of nonwovens made from different materials have similar particle generation characteristics. Particles are released by the flexing and slowly diffuse to the particle counter inlet. Within the five minute total test time the diffusion reaches a maximum and then declines. Thus a five minute test time seems suitable for characterizing a material.

Generally, the flexing action causes only some of the available particles to be released and this can lead to variable results between test pieces from the same sample. However, multiple sampling and testing can give good relative measurements of products and processes and then linting potential.

Reproducibility is only moderate in absolute numbers but rankings are very reproducible.

To calculate the 95 % confidence interval for the coefficient of linting, it is necessary to first calculate the standard deviation of the original particle counts. This statistic is used to calculate the confidence interval, which is then reported as a logarithm.

# Annex B
(informative)

# Worked example — Total linting — Sample X

## B.1 First background count (chamber open)

Particles ⩾ 0,5 µm for 0 s to 30 s: 29
30 s to 60 s: 10

These counts are for checking system cleanliness and are not used in the calculation.

## B.2 Second background count (chamber closed)

Particles ⩾ 0,5 µm: for 10 times 30 s

**Table B.1**

| Period number [a] | 0,5 µm to 1 µm | 1 µm to 2 µm | 2 µm to 3 µm | 3 µm to 4 µm | 4 µm to 5 µm | 5 µm to 7 µm | 7 µm to 10 µm | > 10 µm | Σ > 0,5 µm |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 56 | 52 | 32 | 12 | 6 | 1 | 0 | 14 | **173** |
| 2 | 12 | 8 | 3 | 2 | 0 | 0 | 0 | 2 | **27** |
| 3 | 10 | 18 | 2 | 2 | 2 | 0 | 0 | 1 | **35** |
| 4 | 14 | 22 | 6 | 8 | 0 | 0 | 0 | 1 | **51** |
| 5 | 10 | 16 | 4 | 4 | 1 | 0 | 0 | 0 | **35** |
| 6 | 6 | 8 | 0 | 2 | 0 | 2 | 0 | 0 | **18** |
| 7 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | **6** |
| 8 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | **5** |
| 9 | 7 | 4 | 3 | 1 | 1 | 1 | 0 | 1 | **18** |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| $C_0$ ($X_1$) | **118** | **132** | **52** | **32** | **10** | **4** | **0** | **20** | **368** |

[a] Per consecutive 30 s period of time.

$C_0$ for particles ⩾ 0,5 µm of sample $X_1$ (side A) is the sum of the above ten counts.

## B.3 Test results for test piece $X_1$ (side A)

**Table B.2**

| Period number [a] | 0,5 µm to 1 µm | 1 µm to 2 µm | 2 µm to 3 µm | 3 µm to 4 µm | 4 µm to 5 µm | 5 µm to 7 µm | 7 µm to 10 µm | > 10 µm | Σ > 0,5 µm |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 19 197 | 18 280 | 4 132 | 4 988 | 3 406 | 2 200 | 3 000 | 6 791 | **61 994** |
| 2 | 8 612 | 9 988 | 2 539 | 3 208 | 2 283 | 1 414 | 1 860 | 3 349 | **33 253** |
| 3 | 6 580 | 7 896 | 2 239 | 2 769 | 1 804 | 1 239 | 1 658 | 2 723 | **26 908** |
| 4 | 4 886 | 6 315 | 1 853 | 2 281 | 1 456 | 1 091 | 1 358 | 1 952 | **21 192** |
| 5 | 3 871 | 5 336 | 1 487 | 2 010 | 1 325 | 932 | 1 235 | 1 688 | **17 884** |
| 6 | 3 882 | 5 162 | 1 465 | 1 833 | 1 260 | 878 | 1 100 | 1 657 | **17 237** |
| 7 | 3 812 | 4 979 | 1 411 | 1 951 | 1 345 | 949 | 1 111 | 1 842 | **17 400** |
| 8 | 2 502 | 3 445 | 1 045 | 1 365 | 896 | 612 | 838 | 1 141 | **11 844** |
| 9 | 2 076 | 3 168 | 962 | 1 292 | 851 | 543 | 737 | 1 037 | **10 666** |
| 10 | 1 378 | 2 470 | 700 | 946 | 664 | 411 | 553 | 699 | **7 821** |
| Total | 56 796 | 67 039 | 17 833 | 22 643 | 15 290 | 10 269 | 13 450 | 22 879 | **226 199** |
| **Total** − $C_0$ | **56 678** | **66 907** | **17 781** | **22 611** | **15 280** | **10 265** | **13 450** | **22 859** | **225 831** |

[a] Per consecutive 30 s period of time.

## B.4 Sample X (side A)

Table B.3 gives the mean test results from the five test pieces $X_1$ to $X_5$ (side A) for each particle size and period. In the last row of the table, the sum of the values corresponding to the 10 periods gives the linting per classes and the total linting of side A.

**Table B.3**

| Period number [a] | 0,5 µm to 1 µm | 1 µm to 2 µm | 2 µm to 3 µm | 3 µm to 4 µm | 4 µm to 5 µm | 5 µm to 7 µm | 7 µm to 10 µm | > 10 µm | Σ > 0,5 µm |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 10 832 | 11 809 | 2 812 | 3 538 | 2 358 | 1 561 | 2 077 | 3 883 | **38 871** |
| 2 | 4 525 | 5 965 | 1 633 | 2 132 | 1 445 | 947 | 1 259 | 1 938 | **19 846** |
| 3 | 3 228 | 4 480 | 1 290 | 1 680 | 1 111 | 765 | 991 | 1 405 | **14 950** |
| 4 | 3 151 | 4 336 | 1 231 | 1 602 | 1 032 | 738 | 950 | 1 332 | **14 372** |
| 5 | 2 357 | 3 558 | 1 004 | 1 363 | 894 | 629 | 797 | 1 089 | **11 690** |
| 6 | 1 902 | 2 995 | 886 | 1 159 | 794 | 547 | 706 | 919 | **9 909** |
| 7 | 1 713 | 2 634 | 756 | 1 034 | 746 | 477 | 603 | 850 | **8 813** |
| 8 | 1 361 | 2 137 | 644 | 896 | 577 | 389 | 508 | 644 | **7 156** |
| 9 | 1 172 | 1 968 | 604 | 809 | 541 | 355 | 468 | 613 | **6 530** |
| 10 | 931 | 1 690 | 510 | 678 | 456 | 298 | 386 | 473 | **5 422** |
| Total | 31 172 | 41 573 | 11 371 | 14 891 | 9 955 | 6 707 | 8 743 | 13 147 | **137 558** |
| **Total** − $C_0$ | **31 043** | **41 435** | **11 334** | **14 865** | **9 943** | **6 700** | **8 741** | **13 135** | **137 197** |

[a] Per consecutive 30 s period of time.

## B.5 The standard deviation

**Table B.4**

| 0,5 µm to 1 µm | 1 µm to 2 µm | 2 µm to 3 µm | 3 µm to 4 µm | 4 µm to 5 µm | 5 µm to 7 µm | 7 µm to 10 µm | > 10 µm | Σ > 0,5 µm |
|---|---|---|---|---|---|---|---|---|
| 11 202 | 11 102 | 2 813 | 3 402 | 2 341 | 1 542 | 1 977 | 4 277 | 38 545 |

## B.6 Coefficient of variation of the results

**Table B.5**

| 0,5 µm to 1 µm | 1 µm to 2 µm | 2 µm to 3 µm | 3 µm to 4 µm | 4 µm to 5 µm | 5 µm to 7 µm | 7 µm to 10 µm | > 10 µm | Σ > 0,5 µm |
|---|---|---|---|---|---|---|---|---|
| 36 | 27 | 25 | 23 | 24 | 23 | 23 | 33 | 28 |

## B.7 Test results for Sample X (side B)

The results of the tests carried out on side B of five test pieces $X_6$ to $X_{10}$, are reported in similar tables.

## B.8 Report — Total linting

### B.8.1 Sample X, side A

Total linting: 137 197

Standard deviation: 38 545

Coefficient of variation: 28 %

Coefficient of linting ($C_L$): 5,13

### B.8.2 Sample X, side B

Total linting: 88 151

Standard deviation: 34 637

Coefficient of variation: 39 %

Coefficient of linting ($C_L$): 4,94

### B.8.3 Sample X, material

Total linting: 112 674

Coefficient of linting ($C_L$): 5,05

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