SCANDINAVIAN PULP, PAPER AND BOARD
TESTING COMMITTEE

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Paper and board

Beta-radiation-based grammage formation measurement — Point source method

0 Introduction

This SCAN-test Method describes the principles for measuring and characterising local grammage variations in paper and board.

Many different methods for assessing formation based on light-transmission are available on the market. These are not included here, since it is not possible to evaluate true local grammage variations using optical methods, due to local variations in the light-scattering coefficient and differences in the optical properties of the various components.

Initially, radiogram methods were included in the work on which this Method is based. The number of radiogram instruments are few and it was difficult to obtain sufficient results for the precision statement. Therefore, the initial radiogram methods for beta formation are not included here, but they are described in NSP Report 5.

This SCAN-test Method is based on beta ray absorption and it is therefore possible to measure the true local grammage of papers based on mixtures of components with different optical properties (different fibre types and fillers), as well as with local differences in light scattering due to calendering etc.

Note 1 – A method commonly available is the AMBERTEC method.

Note 2 – The definition of Formation number in this method differs from that in NSP Report 5.

1 Scope

This SCAN-test Method describes the principles for measuring and characterising local grammage variations in paper and board with a grammage of (30 - 350) g/m^2. All kinds of paper and board can be measured.

Note – Materials with a grammage less than 30 g/m^2 can be measured provided that the mechanical strength of the material allows it to be scanned, but this is outside the scope of this Method.

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 186	Paper and board - Sampling to determine average quality
ISO 187	Paper, board and pulps - Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples
ISO 536	Paper and board - Determination of grammage

3 Terms and definitions

For the purposes of this SCAN-test Method, the following definitions apply:

3.1 Formation

variation in local grammage in paper and board products limited to floc sizes smaller than 15 mm

3.2 Formation number, F_σ

standard deviation of the local grammage

$$F_\sigma = \sigma_w \qquad (1)$$

where

F_σ is the formation number in g/m^2;

σ_w is the standard deviation in g/m^2.

Note 1 - A similar method is normally used to describe the large-scale grammage variations recorded on-line at the dry end of a paper machine.

Note 2 – The definition of Formation number in this method differs from that in NSP Report 5.

3.3 Specific formation number, F_{1g}

formation number normalized with respect to the grammage. Since the formation number is statistically inversely proportional to the square root of the mean grammage, this means that

$$F_{1g} = F_\sigma / \sqrt{w} \qquad (2)$$

where

F_{1g} is the specific formation number in $\sqrt{g}/m$;

F_σ is the formation number in g/m^2.

w is the sample grammage in g/m^2;

4 Principle

The grammage variation is measured by exposing a test piece to a suitable beta ray source and recording the attenuation of radiation transmitted through the test piece with a suitable detector. Point source measurements are made in a matrix to cover a large area of the test piece. The resulting pulse count readings are transformed to actual grammage values through a calibration procedure. A software, specified by the supplier, performs the measurement as well as the formation analysis and presents the resulting formation number.

5 Apparatus

Point source Beta Formation Tester with:

5.1 Radiation source

A beta radiation source, Pm-147, of 185MBq collimated to a beam 1 mm in diameter.

Note - The amount of beta radiation transmitted depends on the mass, and not on the state of bonding or colour. The number of transmitted beta particles, T, follows the equation

$$T/T_0 = e^{-\mu w} \qquad (3)$$

where

T is the number of beta particles transmitted through the test piece;

T_0 is the number of i beta particles transmitted without any test piece;

μ is the absorption coefficient, in m^2/g;

w is the grammage in g/m^2.

In the point source method, Pm-147 is used as a radiation source, see Table 1.

Table 1. Promethium-147 Beta ray source

Energy maximum [keV]	225
Penetration maximum [g/m^2]	350
Half-life [years]	2,6

5.2 Measurement aperture

The aperture is 1 mm in diameter.

5.3 Scanning mechanism

A device to achieve xy-directional scanning of the test piece. The scanned area shall be

67,5 mm x 67,5 mm, and stepwise scanning shall be performed with a step length of 3,5 mm.

5.4 Radiation detector

Scintillation counter, suitable for detection of beta radiation from Pm-147.

5.5 Calibration samples

Seven traceable Mylar samples of known grammage within the grammage range (30 - 300) g/m^2.

Note 1 - Traceable Mylar samples can be traced to known ISO-calibrated grammage samples.

Note 2– Calibration of the point source tester is carried out according to the supplier's instructions.

5.6 Software

A computer with relevant software to analyse the results from the scanning, as specified by the supplier.

6 Sampling

If the tests are being made to evaluate a lot, the sample shall be selected in accordance with ISO 186. If the tests are made on another type of sample, make sure that the test pieces are representative of the sample received.

7 Conditioning

Condition the samples as specified in ISO 187. Keep them in the conditioning atmosphere throughout the test.

8 Preparation of test pieces

Cut A4 size test pieces or strips with a maximum width of 200 mm from the sample, avoiding all creases or folds, since such spots may yield too high (up to three times) local grammage values.

Prepare at least ten test pieces in order to be able to obtain a reliable value for the formation variability in the sample.

If the sample material consists of laboratory handsheets, the formation measurements shall be made on at least five test pieces.

Note 1 - It is possible to measure a continuous sample strip (long enough for at least ten parallel determinations), single sheets or sheets glued consecutively (with an overlap of about 20 mm) to make a consecutive test strip.

Weigh the test pieces and determine the grammage, w according to ISO 536.

Note 2 – The true grammage is required only for the calculation of the specific formation number (3.3). The calibration procedure ensures that the formation number, F_σ, (3.2), is correct even without the correct mean grammage value.

9 Procedure

Keep the test pieces in the conditioning atmosphere (see ISO 187) throughout the test.

To maintain a steady measurement geometry, press the test piece against the collimator with a suitable pressing cup during the measurement. Scan the sample stepwise (i.e. keep the sample stationary during pulse counting).

As a standard procedure, measure a coarse matrix of 20 x 20 (=400) points with a step length of 3,5 mm in both directions (x/y on the sheet). Such a measurement is carried out in about 3,5 minutes with a pulse counting time of 0,3 s/point. The area measured represents 67,5 x 67,5 mm^2 on the test piece.

Choose the pulse counting time per point according to the following guideline:

The average number of pulses per point measured should be greater than 4000 per point (yields a precision of better than 1,6 % for the grammage of a point).

This pulse count value can be achieved and maintained through selection of a suitable pulse counting time from the measuring parameter settings.

Note – Ways of achieving improved precision are described in Annex B.

10 Calculation

Transform the pulse counts recorded at the points measured to grammage values using the transformation function obtained from calibration (see Annex C). From the grammage values, calculate the formation number (3.2) for each test piece measured. If any value differs from the mean by more than four times the standard deviation (due for example to holes or particles that do not belong to the test piece), this value can be discarded before the formation number is calculated. Calculate the specific formation

numbers (3.3) for each test piece according to Equation 2.

10.1 The formation number for the sample

Calculate the formation number for the sample as the mean of the formation numbers of the individual test pieces.

Calculate the 95% confidence limits CL_F of the formation number

Report the formation number for a sample as $\overline{F}_\sigma \pm CL_F$ in g/m^2, to the first decimal place.

10.2 The specific formation number for the sample

Calculate the specific formation number (3.3) for the sample as the mean of the specific formation numbers of the test pieces:

Calculate the 95% confidence limits of the specific formation number

> *Note* – The confidence limits indicate the quality of the formation result as well as the internal variability of the formation within the sample.

Report the specific formation number for the sample as $\overline{F}_{1g} \pm CL_{F1}$ in $\sqrt{g}/m$, to the second decimal place.

11 Report

The test report should include the following particulars

(a) reference to this SCAN-test Method;
(b) date and place of testing;
(c) description or identification of the material tested;
(d) the formation number as indicated in 10.1;
(e) the specific formation number as indicated in 10.2;
(f) any departure from this procedure or any other circumstances that might have affected the results.

12 Bibliography

Komppa, A., Komppa, O.: Measurement of paper formation, 50th APPITA Annual General Conference 1996 Proceedings, Vol. 2, Paper 4B41, p 803-808, ISBN 0646 27925 4 (Vol. 2)

Kajanto, I., Komppa, A., Ritala, R.: How formation should be measured and characterized. Nordic Pulp Paper Research Journal 4(1989):3, 219-228

Komppa, A.: Measurement of formation, Paper and Timber 70(1988):3, 243, 245-250

Annex A
Precision
(informative)

A1 Repeatability

One laboratory tested two different grades. The repeatability of the specific formation numbers obtained is shown in Table A1.

Table A1: Repeatability of the point source method

	Mean [$\sqrt{g}$ / m]	**CoV*** **[%]**
Newsprint		
One set of test pieces measured 5 times	0.407±0.006	1.2
5 different sets of test pieces	0.410±0.006	1.1
Light weight liner		
One set of test pieces measured 5 times	0.549±0.004	0.5
5 different sets of test pieces	0.556±0.005	0.8

* Coefficient of variation.

A2 Reproducibility

Five laboratories tested four different grades. The laboratories performed measurements on different sets of test pieces for each grade. The reproducibility of the specific formation number obtained is shown in Table A2.

Table A2: Reproducibility of the point source method

Laboratory	**News** [$\sqrt{g}$ / m]	**SC paper** [$\sqrt{g}$ / m]	**Light weight Liner** [$\sqrt{g}$ / m]	**Kraft liner** [$\sqrt{g}$ / m]
1	0,41±0,01	0,343±0,004	0,55±0,02	0,87±0,02
2	0,44±0,01	0,36±0,01	0,57±0,02	0,91±0,02
3	0,43±0,01	0,34±0,01	0,57±0,01	0,88±0,02
4	0,41±0,01	0,33±0,01	0,56±0,02	0,90±0,02
5	0,42±0,01	0,33±0,01	0,56±0,02	0,91±0,02
Mean value	**0,422**	**0,341**	**0,562**	**0,894**
CoV* (%)	**3,1**	**3,0**	**1,6**	**1,8**

* Coefficient of variation

Annex B
Recommendations for achieving greater precision in measurements
(informative)

A greater precision may be desired in special situations, for example, when measuring very uneven paper. The first recommendation is then to increase the number of test pieces, provided that relevant sample material is available.

The precision may also be improved if the grammage of each test piece is used to calculate the specific formation number of that test piece. This eliminates the influence of differences in grammage between test pieces.

An increase in the number of pulses per measuring point from the prescribed 4000 (i.e., up to 10000) may also give some improvement in the precision.

Measurements using these modifications comply with this SCAN-test Method.

Annex C
Calibration
(informative)

Calibration is performed using samples with known grammages. A traceable calibration sample kit with seven grammage levels covering (30 – 300) g/m^2 is required in order to achieve both good repeatability of the results and a good comparability between different point source method testers.

Perform the calibration according to the manufacturer's instructions.

SCAN-test Methods are issued and recommended by FFIF, PFI and INNVENTIA for the pulp, paper and board industries in Finland, Norway and Sweden.
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