SCAN-P 20:95
Revised 1995

SCANDINAVIAN PULP, PAPER AND BOARD
TESTING COMMITTEE

Papers and boards

Wet tensile strength and wet tensile strength retention

Constant rate of elongation method

0 Introduction

This SCAN-test Method replaces SCAN-P 20:67, from which it differs in that the Finch soaking procedure has been deleted, the soaking procedure described has been modified so that the sample is now soaked to saturation and the blotting procedure has been excluded. This means that the testing is carried out at a lower dry matter content and that the wet tensile strength will therefore be lower than that given by the withdrawn SCAN-P 20:67, see Annex.

This revised Method also specifies the calculation of wet tensile strength retention, based on measurements of the tensile strength and the wet tensile strength using the same testing procedure (the same rate of elongation). The tensile strength and the wet tensile strength can be determined either according to ISO 1924-2 or ISO 1924-3.

Note 1 – If the wet tensile strength is determined according to ISO 1924-2 and the test pieces are saturated, the results obtained with this Method are equivalent to those obtained with ISO 3781 – *Paper and board – Determination of tensile strength after immersion in water*, clause 8.1, Normal procedure.

Note 2 – The wet tensile strength will, when the strength is determined according to ISO 1924-3, be somewhat higher than when the strength is determined according to ISO 1924-2, see clause 10 Precision.

Since paper and board are tested, the wet tensile strength is always tested on rewetted samples.

1 Scope

This Method specifies a procedure for determination of the wet tensile strength by measuring the tensile strength of the material after soaking in water.

The Method applies to papers and boards, such as papers for towels, bags, moist-food wraps etc, that are subjected to stress under wet conditions. It does not apply to low-density and highly absorbent papers, to which ISO 12625-5 is recommended.

2 References

ISO 187 Paper and board – Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples (EN 20287)

ISO 536	Paper and board – Determination of grammage
SCAN-P 9	Paper and board – Identification of machine and cross direction
ISO 1924-2	Paper and board – Determination of tensile properties – Part 2: Constant rate of elongation method (EN ISO 1924-2)
ISO 1924-3	Paper and board – Determination of tensile properties – Part 3: Constant rate of elongation method (100 mm/min)
ISO 14487	Pulps – Standard water for physical testing
SCAN-G 2	Statistical treatment of test results

Note – SCAN-test has withdrawn a number of test methods and refers instead to the corresponding ISO and/or EN Standards.

3 Definitions

For the purpose of this Method, the following definitions apply:

3.1 *Wet tensile strength,* $\sigma_T^b(rX)$ – The maximum tensile force per unit width that a test piece, after soaking in water, will stand before it breaks in a tensile strength test.

3.2 *Wet tensile index,* $\sigma_T^w(rX)$ – The wet tensile strength divided by grammage.

3.3 *Wet tensile strength retention,* R_T – The ratio of the tensile strength of the sample in the wet state to that of the same sample in the dry, conditioned state.

3.4 *Tensile strength,* σ_T^b – The maximum tensile force per unit width that a test piece will stand before it breaks in a tensile strength test.

4 Principle

Test pieces are soaked in water for a certain time. The test pieces are stretched to break, using a testing machine operating at a constant rate of elongation and recording the tensile force. The wet tensile strength is calculated.

The wet tensile strength retention is calculated by dividing the wet tensile strength by the tensile strength of the same sample measured in a dry conditioned state.

5 Apparatus and reagents

5.1 *Soaking equipment,* clean and carefully rinsed with the standard water (5.2).

5.2 *Standard water for physical testing,* as specified in ISO 14487, free from any wetting agent.

5.3 *Tensile strength testing equipment* as specified in ISO 1924-2 or in ISO 1924-3. The different test span lengths and rates of elongation are given in Annex B.

6 Sampling and preparation of test pieces

6.1 *Sampling.* The sampling procedure is not covered by this Method. Make sure that the test pieces taken are representative of the sample received.

6.2 *Conditioning.* Condition the sample as specified in ISO 187 before the determination of grammage and tensile strength (acc. to ISO 1924-2 or ISO 1924-3).

Conditioning is not necessary for the test pieces to be soaked, if the soaking time is 1 h or more.

6.3 *Preparation of test pieces.* Cut test pieces from undamaged samples avoiding watermarks, folds and wrinkles according to ISO 1924-2 or ISO 1924-3.

If the wet tensile index is to be calculated, determine the grammage in accordance with ISO 536.

7 Procedure

7.1 Rewetting

Soak the test pieces, using the soaking equipment (5.1) and the standard water (5.2) at (23 ± 1) °C for 1 h or for 24 h depending on the end use of the paper. The soaking time shall always be stated in the report. During the soaking, avoid close contact between the test pieces.

Note 1 – The soaking time may by agreement between the interested parties be selected to simulate particular conditions of use. This departure from the standard procedure shall be reported.

7.2 Wet tensile strength test

Remove a test piece from the soaking equipment and immediately, within 5 s, place it in the tensile strength testing equipment (5.3) and test it according to ISO 1924-2 or ISO 1924-3. Repeat this procedure until at least 10 approved test results are obtained in each testing direction.

Note 2 – The number of determinations required may be calculated as described in SCAN-G 2 or it may be governed by trade or other agreements.

Note 3 – In order to make it easier to handle the test piece or to prevent the testing equipment from damage, surplus water may be removed from the test piece before the wet tensile strength test. This can for instance be done by placing it for a few seconds on a wet laboratory blotter. Only surplus water shall be removed. If too much water is

removed, the wet tensile strength value will be too high, see Annex A.

7.3 Tensile strength test

If the wet tensile strength retention is to be calculated, determine the tensile strength of test pieces from the same sample in the dry, conditioned state, using the same tensile strength testing procedure as in the wet tensile strength test.

8 Calculation

Calculate and report the results separately in the machine and cross directions.

The following suffixes are recommended to identify the direction of the sample tested:

$\sigma^{b}_{T,MD}$ is the tensile strength in MD (machine direction);
$\sigma^{w}_{T,CD}$ is the tensile strength in CD (cross direction);
$\sigma^{b}_{T,GM}$ is the geometric mean value of the tensile strength in MD and CD.

The following suffixes are recommended to identify the conditions used during the test:

(rX) rewetted, is used to distinguish it from the initial wet condition;
*(r**X**)* represents the soaking time in hours, normally 1 h or 24 h.

An example of using the above mentioned suffixes

σ^{b}_{T}(**r24**) is a rewetted sample tested after 24 h soaking time.

8.1 Wet tensile strength

Evaluate the maximum wet tensile force in newtons for each test piece. Calculate the average maximum wet tensile force and then the wet tensile strength from the expression:

$$\sigma^{b}_{T}(rX) = \frac{1000\overline{F}_{T}(rX)}{b} \qquad [1]$$

where
$\sigma^{b}_{T}(rX)$ is the wet tensile strength, in newtons per metre;
$\overline{F_{T}}(rX)$ is the average maximum wet tensile force, in newtons;
b is the initial width (dry state) of the test piece, in millimetres.

Calculate and report the mean wet tensile strength to three significant figures.

8.2 Wet tensile index

Calculate the wet tensile index from the expression:

$$\sigma^{w}_{T}(rX) = \frac{\sigma^{b}_{T}(rX)}{w} \qquad [2]$$

where
$\sigma^{w}_{T}(rX)$ is the wet tensile index, in kilonewton-metres per kilogram;
w is the grammage, in grams per square metre.

Calculate and report the wet tensile index to three significant figures.

8.3 Tensile strength

If wet tensile strength retention is to be determined, calculate the tensile strength of the sample in the dry, conditioned state from the expression:

$$\sigma^{b}_{T} = \frac{1000\overline{F}_{T}}{b} \qquad [3]$$

where
σ^{b}_{T} is the tensile strength, in newtons per metre;
$\overline{F}_{T}$ is the mean value of the maximum tensile force, in newton.

8.4 Wet tensile strength retention

Provided that the same test span length and the same rate of elongation have been used when testing the wet test pieces and the dry, conditioned test pieces, calculate the wet tensile strength retention from the following expression:

$$R_{T}(rX) = \frac{100\,\sigma^{b}_{T}(rX)}{\sigma^{b}_{T}} \qquad [4]$$

where
$R_{T}(rX)$ is the wet tensile strength retention, as a percentage;
$\sigma^{b}_{T}(rX)$ is the wet tensile strength, in kilonewtons per metre;
σ^{b}_{T} is the tensile strength, in kilonewtons per metre for the dry , conditioned sample.

Calculate and report the wet tensile strength retention as a percentage to three significant figures.

9 Report

The test report shall include reference to this SCAN-test Method and the following particulars:

(a) date and place of testing;
(b) identification mark of the material tested;
(c) the soaking time, 1 h or 24 h;
(d) the tensile strength method (ISO 1924-2 or ISO 1924-3) used;
(e) the direction of the test;
(f) the test piece width and test span length;
(g) the test results as specified in clause 8;
(h) the standard deviation or the coefficient of variation of the results;
(i) any departure from the procedure described in this Method and any other circumstances that may have affected the test results.

10 Precision

In an interlaboratory test, ten laboratories used a soaking time of I h and seven laboratories a soaking time of 24 h. The repeatability and reproducibility results are shown in *Table 1*.

11 Literature

11.1 ISO 12625-5 Tissue paper and tissue products – Determination of wet tensile strength (EN ISO 12625-5)

11.2 Fellers Christer, Wellmark Per, Kolseth Petter "Unified symbols for expressing properties of paper – Part 1: Mechanical properties", STFI-report P 002 1995

Table 1. Repeatability and reproducibility of wet tensile strength in the interlaboratory study
The test piece width was 15 mm.

	ISO 1924-2 rate of elongation: 20 mm/min			**ISO 1924-3** rate of elongation: 100 mm/min			
	Wet tensile strength	Coeff. of variation			Wet tensile strength	Coeff. of variation	
		Within lab	Between labs			Within lab	Between labs
Sample type	N/m	%	%	Sample type	N/m	%	%
Soaking time 1 h:				*Soaking time 1 h:*			
Sack paper, 85 g/m²				Sack paper, 85 g/m²			
MD	723	6,8	10,7	MD	822	6,6	14,2
CD	559	7,2	13,0	CD	627	7,2	11,0
Liner, 175 g/m²				Liner, 175 g/m²			
MD	1870	4,7	5,8	MD	2220	4,3	9,5
CD	802	5,5	5,1	CD	937	5,7	7,8
Soaking time 24 h:				*Soaking time 24 h:*			
Sack paper, 90 g/m²				Sack paper, 90 g/m²			
MD	668	9,5	8,8	MD	793	5,8	5,2
CD	478	6,7	9,3	CD	577	7,3	6,1
Liner, 150 g/m²				Liner, 150 g/m²			
MD	1610	3,8	5,5	MD	1940	4,6	5,2
CD	609	6,2	10,4	CD	722	5,3	4,1

NB. The results for the two soaking times, 1 h and 24 h respectively, should not be compared to each other since different test material have been used.

Annex A – Influence on the wet tensile strength of dry matter content after rewetting

A.1 Introduction

During the revision of SCAN-P 20:67, the responsible working group has studied the influence on the measured wet tensile strength value of the dry matter content of the test piece after rewetting. The working group has sought to document the extent to which the present method may give results which differ from those obtained according to the withdrawn Method, SCAN-P 20:67.

A.2 The blotting procedures studied

Two different rollers were included in the blotting procedures studied:

- a light-weight roller with a width of 10 cm, diameter 24 mm and a weight of approx. 95 g;
- a Cobb-roller (solid brass-roller) with a width of 20 cm and a weight of 10 kg.

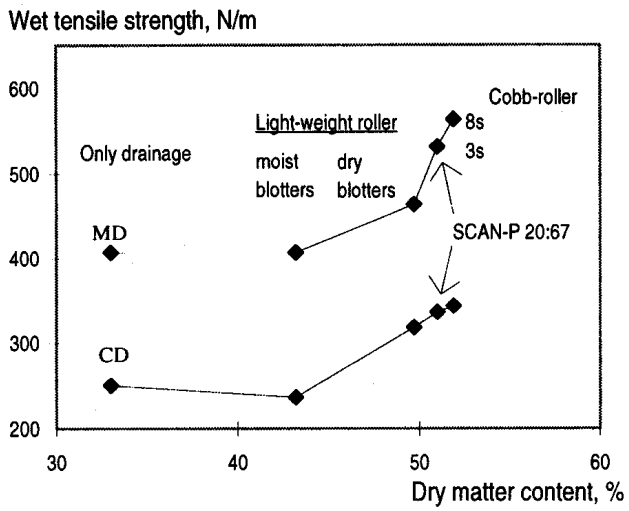
The following procedures were included in the study:

- no blotting, only drainage after rewetting;
- blotting between two moist blotters, with a light-weight roller;
- blotting between two dry blotters, with a light-weight roller;
- blotting between two dry blotters for 3 s, with a Cobb- roller (SCAN-P 20:67);
- blotting between two dry blotters for 8 s, with a Cobb- roller .

The time between blotting and the wet tensile strength test was 5 s.

A.3 Results achieved

The blotting procedures studied gave a dry matter content of the test pieces from the wet-sack paper from 33 % (no blotting) to approx. 53 % (Cobb-roller, 8 s). The differences in the wet tensile strength measured, caused by different dry matter content of the test pieces after blotting, are shown in the *Figure.*



Since the way of removing the surplus water has a considerable influence on the wet tensile strength value achieved (from 400 *N/m* to 580 *N/m* in MD for the paper grade here mentioned) SCAN-test has decided to specify the procedure in such way that a low dry matter content is achieved. The soaking and testing procedure described in clause 7 has thus been chosen so that the dry matter content of the test pieces shall be within the interval where the wet tensile strength does not change with small changes in dry matter content (the horizontal region of the relationship in the *Figure).*

Annex B –
Rate of elongation

Depending on the test span length and the tensile strength method used, the following rates of elongation applies:

SCAN-test Method + ISO standard used	Test span length, mm	Rate of elongation, mm/min
P 20 + ISO 1924-2	180	20
P 20 + ISO 1924-3	100	100

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