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SCANDINAVIAN PULP, PAPER AND BOARD
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Chemical pulps

Floating tendency and swelling of pulp sheets

1 Scope

This SCAN-test Method describes a procedure for the determination of floating tendency, specific swelling volume, linear swelling and dynamic capillary rise. The Method is primarily applicable to rayon pulps.

> *Note* – These properties largely determine how the pulp will behave during steeping.

2 References

ISO 638 Pulps – Determination of dry matter content – Oven-drying method (EN 20638)

> *Note* – SCAN-test has withdrawn a number of test methods and refers instead to the corresponding ISO and/or EN Standards.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 *The floating tendency* – The maximum load that can be applied to one kilogram (calculated on an oven-dry basis) of the pulp floating in 18 % sodium hydroxide solution, without sinking it.

3.2 *The specific swelling volume* – The volume of one gram of oven-dry pulp in the swollen state. The linear swelling of a sheet of pulp is the ratio of the thickness of the swollen sheet to the thickness of the air-dry sheet.

3.3 *The dynamic capillary ris*e – The capillary rise that can be observed in a pulp sheet during immersion at a constant speed.

> *Note* – The result depends to some extent on the temperature of the lye, and the amount of hemicelluloses and other extractives in the lye. If the Method is to be used for determining the most suitable filling rate, it is preferable to use the same lye as that to be used for the actual steeping. If lye other than pure 18 % NaOH is used, the fact should be stated when reporting the results.

4 Principle

Test pieces of pulp, attached to a hydrometer, are lowered into a sodium hydroxide solution, and from readings on the loaded and unloaded hydrometer the floating tendency is calculated.

To determine the specific swelling volume, the test pieces are weighed before and after immersion in the sodium hydroxide solution.

5 Apparatus

5.1 *Ordinary hydrometer* for a density of 1,100 g/cm^3 to 1,200 g/cm^3 or a specially designed hydrometer with the following approximate dimensions:

Length, mm	315	Weight, g	38
Bulb length, mm	130	Bulb diameter, mm	18
Stem length, mm	185	Stem diameter, mm	3–5
Scale length, mm	110	Scale graduated	0–100

The hydrometer is provided with a loop at its top and has four stainless steel wire points on which two test pieces can be pressed. The scale is graduated from the top and the centre of the scale corresponds to a density of 1,2 g/cm^3, *Figure* 1.

5.2 *Glass cylinder* with a millimetre scale large enough to accommodate the hydrometer and the attached pulp.

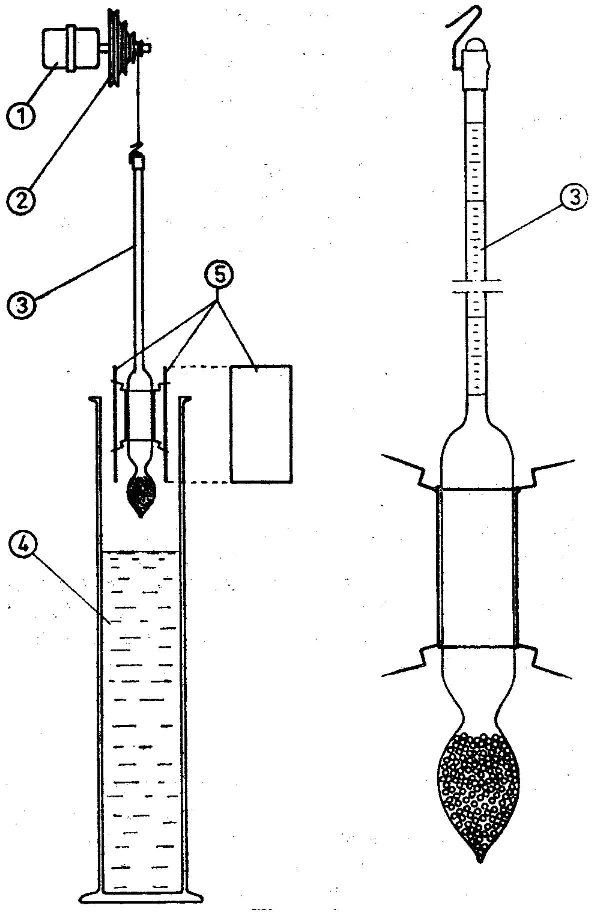

Figure 1. Equipment for the test
1. Motor
2. Pulleys
3. Hydrometer
4. Lye
5. Test pieces.

5.3 *Synchronous motor*, 1 rpm, equipped with pulleys of different diameters that give lowering rates from 1 cm/min to 20 cm/min, for example 2,5, 4, 6,5, 10, 15 and 20 cm/min.

5.4 *A thin wire* that can be attached to the pulleys by one end and has a hook in the other end for connecting the hydrometer.

5.5 *Wire screen* made of stainless steel.

6 Reagent

6.1 *Sodium hydroxide solution* (lye), 18,0 g ± 0,1 g of NaOH per 100 g of solution (see Note in Clause 3).

7 Calibration

Calculate the hydrometer constant from the formula:

$$k = \frac{1{,}20 \;\; 10 \;\; \pi \;\; d^2 \, l}{4} = 9{,}42 \;\; d^2 \;\; l \qquad [1]$$

where

d	is the diameter of the hydrometer stem, in cm;
l	is the length of 100 units of the hydrometer scale, in cm;
1,20	is the density of the lye, g/cm^3;
k	is the hydrometer constant.

The hydrometer constant can also be determined by taking readings with the unloaded hydrometer in two liquids of different known densities, e.g. 1,20 g/cm^3 and 1,17 g/cm^3. In this case calculate the hydrometer constant from the formula:

$$k = \frac{1{,}20 \;\; h}{f_2 - f_1} = \left[\frac{1}{\rho_1} - \frac{1}{\rho_2} \right] X \; 10^3 \qquad [2]$$

where

h	is the weight of the hydrometer, in g;
ρ_1 and ρ_2	is the density of the two liquids, g/cm^3;
f_1 and f_2	is the scale readings for the two liquids;
k	is the hydrometer constant.

8 Preparation of sample

From the air-dry pulp cut test pieces, 100 mm × 50 mm, either parallel or perpendicular to the machine direction, depending on how the sheet is to be placed in the steeping press. If this is not known, cut test pieces and carry out determinations for both directions.

9 Procedure

Measure the thickness of the pulp sheet with a micrometer screw gauge. If the pulp has a very rough surface, a number of determinations should be made so that a reasonably precise mean can be obtained. Note the thickness in centimetres, *e*. The thickness is measured for determining the linear swelling only.

At the same time weigh out a separate sample for determination of the dry matter content as described in ISO 638. Place the hydrometer in the lye so that it floats freely. Read the unloaded hydrometer and note the reading as a_o. Select a number of motor pulleys corresponding to, for example, immersion rates of 2,5, 4, 6,5, 10, 15 and 20 cm/min and proceed as follows for each rate.

Weigh two test pieces to the nearest 10 mg and fix them to the hydrometer. Suspend the hydrometer from the wire string and attach this to the motor pulley so that the hydrometer can be lowered into the lye at the selected rate. Lower the hydrometer by switching on the motor. As the test pieces are being immersed measure from the millimetre scale on the glass cylinder the distance between the level of the liquid in the test pieces and the level of the free meniscus. Note this distance when it has reached a constant value and report it as the dynamic capillary rise.

When the test pieces have been immersed completely in the lye, detach the hydrometer from the hook and read off 2 min after immersion is complete. Note the reading as a_n, *n* is the immersion rate selected. Remove the test pieces immediately from the hydrometer, place them on the wire screen and allow them to drain for 2 min. Weigh them together on a tarred glass plate and note the weight of the two pieces as *b* g. This weighing is for calculation of swelling only.

10 Calculation and report

For each property give the results in the form of a table or a graph.

> *Note* – The filling rate corresponding to minimum swelling is of particular interest. It often corresponds to a pronounced minimum in the floating tendency and it always coincides with zero dynamic capillary rise. It can be considered as the most suitable filling rate for the particular pulp being tested.

10.1 *Floating tendency*
The floating tendency is expressed as a force, gf, per kilogram of oven-dry pulp. Calculate as follows:

$$X_n = \frac{k\,(a_o - a_n)}{m} \qquad [3]$$

where
- X_n is the floating tendency (for sinking pulps this value will be negative), gf/kg of oven-dry pulp;
- a_o is the scale reading of the unloaded hydrometer;
- a_n is the scale reading of the loaded hydrometer;
- k is the hydrometer constant;
- m is the weight of the two test pieces, calculated on an oven-dry basis, g;
- n is the immersion rate, cm/min.

Report the results to the nearest whole number.

10.2 *Specific swelling volume*
Calculate as follows:

$$Y_n = \frac{b}{1{,}20\, m} \qquad [4]$$

where
- Y_n is the specific swelling volume, cm^3/g of oven-dry pulp;
- b is the weight of the two swollen test pieces, g;
- m is the weight of the two test pieces, calculated on an oven-dry basis, g;
- 1,20 is the density of the swollen pulp (assumed to be equal to the density of the lye), g/cm^3.

Report the result to the first decimal place. State if the test pieces where placed with the machine direction vertically or horizontally (see Clause 8).

10.3 *Linear swelling.* When immersed in lye the pulp swells only in the thickness direction; in the other direction it contracts. Calculate the linear swelling as follows:

$$Z_n = \frac{Y_n \quad m}{c \quad e} = \frac{b}{1{,}20 \quad c \quad e} \qquad [5]$$

where
- Z_n is the linear swelling, i.e. the ratio of the thickness of the swollen test piece to that of the air-dry test piece.
- b is the weight of the two swollen test pieces, in g.
- c is the area of the two swollen test pieces, in cm^2. For most pulps this is equal to 0,85 times the area of the air-dry test pieces, i.e. 85 cm^2.
- e is the thickness of the air-dry test piece, in cm.
- m is the weight of the test pieces, calculated on an oven-dry basis, in g.
- y is the specific swelling volume, corresponding to the immersion rate *n* cm/min.

10.4 *Dynamic capillary rise*
The results are obtained directly from the experiment and should be reported to the nearest millimetre.

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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