

Section 1 - Pulp Evaluation Application Information

Introduction to Pulp Evaluation and Sheet Making

These test instruments have three main uses:

1. Evaluating slush pulps taken from production lines to ensure continuity in pulp quality.
2. Checking consistency of purchased pulp and evaluating alternative pulp sources to provide the required paper or board properties at the most economical cost.
3. Research and development to improve pulp quality, alter pulp characteristics to optimize paper and board product properties and optimize pulp blends and their treatment in stock preparations.

In the following pages instruments are presented in terms of their contribution to pulp evaluation including the principles of application, particular benefits and operational characteristics.

These instruments cover all aspects of pulp evaluation in terms of screening, beating and refining, freeness measurement, fiber classification and laboratory handsheet preparation.

Canadian Standard Freeness Tester

[Data Sheet](#)

Application

The Canadian Standard Freeness Tester (CSF), together with the alternative Schopper Riegler Tester, measures the degree of work done on the fibers during stock preparation, and is a basic tool in the evaluation of pulp characteristics.

When the stock or pulp under evaluation undergoes any treatment, including mixing and dispersion, work is done on the fibers changing their morphology (structure). The physical changes which occur are:

- fibrillation of the secondary walls of the fiber
- fiber shortening (occurs primarily during beating or refining)
- formation of cellulose debris (occurs primarily during beating or refining)

The measurement of pulp freeness (drainability) for this purpose was originally designed to give a test value for the control of groundwood pulp production. It is now used in all aspects of stock control and is the primary test used in determining property development during the evaluation of pulps.

It should be noted, however, that freeness values are subject to the influence of water quality since the presence of certain chemical ions can affect readings. The use of distilled or de-ionized water is recommended when comparative tests are being conducted.

Also, when freeness is measured for pulps that have a high percentage of fines or debris, their influence should be considered. Cloudiness in the backwater will indicate that debris has been drained from the pad, resulting in a higher freeness value.

The test is applicable to all types of pulp. However, values will not necessarily correlate with the drainage behavior of pulp material on a commercial paper machine. This is due to the effect of chemicals present in the stock and to the different conditions under which drainage occurs. It is nevertheless possible to set up correlation factors for specific conditions. The instrument conforms to the International and all relevant National Standards including ISO 5267/2, BS 6035/2 and TAPPI T-227.

Specification

The apparatus consists of a drainage chamber and rate measuring funnel on a bench-mounted support. The drainage chamber is fitted with a calibrated screenplate through which the water drains leaving a pad of pulp. The bottom is sealed with a quick release lid opened at the start of the test. The top is similarly sealed but the lid is fitted with a petcock, which is opened to release the vacuum created during drainage. The seals and screenplate all conform to ISO 5267 as well as all National Standards for the instrument.

The rate measuring funnel is a cylindrical top fitted over a conical lower section. At the base of the cone is a calibrated orifice which governs the rate of discharge from the cone. Excess water is led off through a side orifice, at a set critical distance above the orifice, into a measuring cylinder. The volume of water collected is the freeness value.

All critical dimensions and calibration procedures are according to ISO 5267 and BS 6035 to which the instrument conforms in every respect.

Operational Characteristics

The instrument is designed for ease of operation with top and bottom lids fitted with quick release knobs and adequate clearances for easy removal of the container. The instrument is constructed from corrosion resistant materials throughout providing ease of maintenance and calibration. The screenplate and orifice should be regularly cleaned and the calibration checked to ensure they are clear of adhering material.

Comparison with other Instruments

The two main drainability testers in use are the Canadian Standard Freeness Tester and the Schopper Riegler Tester. They are similar in principle with main differences in the Schopper Riegler having a lower pulp concentration in the test sample, a wire screen instead of calibrated screenplate and using a reverse scale for measurement of the water discharged.

The Schopper Riegler also has a conical seal in the drainage chamber which rises when released, thus mildly agitating the pulp sample with any given pulp type, correlation can be achieved between the two instruments but such correlations are not universal.

The values obtained from both instruments are largely governed by the variation in surface area of fibers in the test sample. This property is more accurately measured by classic permeability tests. However, no other instruments have been produced which are as rapid and convenient to operate.

Fiber Classifier

Data Sheet

Application

Fiber classification separates a given fiber sample into a number of groups, differing in range of fiber length, and determines the relative proportion (by weight) of fiber in each group.

Ideally, the separation should be due solely to fiber length but all methods based on the use of screens will be affected by variation in other properties, such as fiber flexibility.

The Messmer Fiber Classifier is based on the McNett design where the fiber is circulated at high uniform velocity across the face of the screen forcing the fibers to orient themselves parallel with the wire mesh. Water flows through the screen at a low velocity to avoid disturbing the fiber orientation. The system also prevents fibers from blocking the screen.

Weighted average fiber length is a fundamental property of the pulp and other factors remaining constant, has been shown to relate to the strength properties of paper.

The numerical average fiber length, on the other hand, is of less significance since it is influenced by the arbitrary lower limit of length chosen for which a particle is no longer considered a fiber.

For ideal results, a pulp should be classified into a very large number of fractions and the weighted average length of each obtained. In practice, however, satisfactory results may be obtained from values provided by five fractions, using a four-screen classifier.

The TMI instrument conforms in all respects to standards TAPPI T233 and SCAN M6. It is suitable for use with all pulp types.

Specification

The apparatus consists of a cascading series of screens, which divides the pulp into fractions according to the range of mesh sizes chosen. The units are modular so that the system may be easily extended.

Each unit consists of a smooth sided PVC tank (to prevent fiber adhesion) and a motor-driven cylindrical impeller to provide constant agitation speed. The drive is by toothed belt to minimize transmission noise.

Screens are held in place with four automatic hydraulic clamps, combining perfect sealing with ease of removal. A regulating valve ensures constant water pressure.

The water inlet is of stainless steel and provides a constant water flow of 10 liters per minute. Efficient fiber collectors are provided which are easy to install and remove.

A standard series of screens ASTM 30, 50, 100 and 200 is provided. Alternative series are available upon request.

Operational Characteristics

Tests carried out over the last 50 years have confirmed the excellent reproducibility provided by the McNett design of instrument, the most common source of error being the initial sampling of the pulp. Improvements to the current instrument described above are designed to further increase operator efficiency in respect of both speed and convenience of operation as well as accuracy. These improvements also reduce the time spent in maintenance.

PFI MILL

Data Sheet

Application

The PFI Mill processes (beats) pulp under laboratory conditions that simulate commercial refining processes. The PFI Mill produces standardized reference pulp in accordance with ISO 5264/2 and TAPPI T-248. Physical testing of handsheets formed from this pulp helps predict the pulp's performance when it is converted to paper.

The PFI Mill develops the fibrillation and bonding potential of paper and board making fibers.

The PFI Mill is suitable for use in evaluating all types of pulps in common use. It is not recommended for very long fibered materials such as hemp or for the defibration of semi-digested raw materials, as calibration will be difficult to maintain.

Operation

The PFI Mill consists of an internal roll with beating bars revolving inside a heavy bowl (bedplate). Both the roll and bedplate rotate, but at different speeds. As the roll is pressed against the bedplate it transfers energy to the fibers.

Pulp consistency is constant throughout the operation as roll and bedplate revolve at constant speed (both in the same direction but at differing speeds). The rate of pulp development is governed by the pressure between the roll and bedplate which can be adjusted to suit the pulp type under evaluation. The degree of beating is proportional to the beating time. Separate pulp samples are required for each point on the beating development curve.

Specification

Beating in the PFI Mill is carried out automatically once the pulp charge has been placed in the bowl. The beating elements consist of a stainless steel roll with 33 chiselled bars and a smooth sided circular bedplate. The bedplate is charged with pulp, forming an endless band around the circumference. As the roll rotates with a higher peripheral speed than the bedplate, the roll bars cut out sections of the pulp band, transporting them into the beating zone. The beating pressure is obtained from a load applied by means of a weight lever action via a cantilever mounted on the base of the supporting pillar that is rigidly attached to the frame. Brass weights are attached to the lever arm to vary the load.

In the standard operating procedure the load is applied directly to the pulp and the beating gap between roll and bedplate forms naturally. The PFI Mill also allows pulp to be beaten with a fixed gap set by means of a micrometer placed against the pillar adjusting the amount of swing made by the cantilevered arm. This practice is used also for grinding-in and calibration purposes.

The rotating speed of the roll is set to 1440 ± 30 r.p.m. and the bedplate to 720 ± 20 r.p.m., under no-load conditions. The roll and bedplate are driven by separate motors and both rotate clockwise (this direction is reversed for grinding-in).

The normal beating pressure with the fixed weight is 1.8 kgf/cm of bar height and with the additional weight 3.4 kgf/cm.

Maintenance

Maintenance is minimal. Every six months, remove the bottom sleeve and top cover and:

- Grease the shafts
- Inspect the drive belts and check the tension
- Inspect hardware and sensors for loose parts or wires

Comparison with other instruments

Sample reproducibility is better controlled compared with the Valley beater due to the fact that samples may be weighed out rather than being scooped from the tub at depths varying with the beating time.

The design of the beating elements is a good compromise between the non-barred laboratory beaters and the bar-to-bar Valley or laboratory refiners. This again gives rise to good reproducibility but with the advantage of the better correlation of fiber characteristics with mill beaten stock.

The PFI Mill is a precision instrument that is preferred by many laboratories because of its good calibration characteristics and ease of operation, both of which enhance the reproducibility of pulp evaluation.

The automation of the PFI Mill both reduces the risk of operator error and allows more free time for other tasks in the laboratory.

Somerville Screen

Data Sheet

Application

The Somerville Screen, developed in 1930 by J.L. Somerville was originally designed to determine shives (fiber bundles) in groundwood pulps. The device is also used for screening mechanical and chemical pulps. It is increasingly used to separate contraries (stickies) in recycled wastewater furnishes. It is used by pulp mills, recycled paper and board manufacturers and fiber processing equipment manufacturers. It is also used by chemical suppliers to evaluate the effectiveness of stickies dispersion agents.

The Somerville Screen has been designed to ensure, as far as possible, that no fiber useful for papermaking is included in the shive content and that no significant fiber bundles are present in the accepted stock. The contraries are collected on a screen for subsequent analysis. Since the selection is made by gravity, there is little room for operator error.

The Somerville Screen was fully investigated by the Technical Section of the British Paper Making Association, the results of which are given in the Second Report of the Pulp Evaluation Committee. Tests were carried out on a wide range of contemporary pulps which confirmed that the method removes all fiber bundles that would contribute to an obvious lack of uniformity in the sheet.

Specifications

The shives are separated from fiber using a 316 stainless steel screen plate with a 250 x 300mm working area with 6 rows of slits, 126 slits per row (756 slits total). The slits are 45 mm long and 150 micrometers wide. The width tolerance is +0.005mm, -0.010mm. A 100 micron slot is available for optimum detection of stickies and plastics.

The dimensional limits which differentiate acceptable and unacceptable fiber bundles for paper making purposes will vary with the desired paper quality and the method of shive determination.

Operation

A headbox above the screen plate is filled with water to a level determined by a weirbox attached to the side of the apparatus, and the water is delivered to the headbox at a rate of 8.6 litres/min. via a spray nozzle fitted with 12 calibrated, horizontally placed holes.

A 50g sample of pulp is introduced above the screen and kept in dispersion by the water flow.

When the motor is switched on, a vibrating diaphragm under the horizontal screen draws fiber through the slits, with fiber and shive being prevented from blocking the screen by the horizontal jets of water and the pulsations of the oscillator.

After 20 minutes of operation, the separated fibers have passed through the screenplate and out to waste via the weir, leaving the fiber bundles to be collected from the screen.

Since the amount of shive present in a pulp sample is generally very small, this method enables large pulp samples to be processed, thus providing accurate results.

Operational Notes

The Somerville Screen is designed to process batches up to 25g. To obtain a representative sample of contraries often requires screening at least 100 to 200g of fiber. Therefore the operator should process the sample in several batches to avoid overloading.

Set-up, Maintenance and Calibration

- The optional water flow control cabinet should be mounted away from water splashes
- Calibrate the water pressure gauge. Working pressure is 124 ± 5 kPa
- Check nozzle calibration. Should be 8.6 ± 0.2 l/min. Adjust by drilling out or replacement.
- Adjust weir to give a head of 102 ± 2 mm above screen plate
- Check speed and stroke of agitator. Should be 700 ± 10 rpm and 3.2 ± 0.1 mm amplitude
- Lubricate bearings and check integrity of water seals
- Inspect screen plate. Look for slits damaged by dropped objects, improper cleaning or worn oversize by use. Note that calibration of a plate to T275 requires complex measuring equipment and is not normally possible in the field

Note: Few standards exist for the Somerville and none of them specify the external shape, dimensions or thickness of the screen plate. For this reason screens are not normally interchangeable between manufacturers

The simple approach offered by this method lends itself to ease of operation and, apart from normal housekeeping requirements, very little maintenance.

Consistency Determination Apparatus

[Data Sheet](#)

Application

The Consistency Determination Apparatus forms an essential part of the laboratory pulp testing system, allowing determination of consistency of a pulp in suspension to be established at any stage of the procedure.

The instrument is suitable for use with all mill stocks and pulps prepared in the laboratory for evaluation purposes. It is frequently used for a number of other purposes involving the concentration of pulps including confirmation of the mass of pulp used in freeness

tests and, for example, is particularly useful in preparing pulp samples for laboratory beating in the PFI mill.

However, the instrument is not appropriate for preparing pads used in the determination of diffuse reflectance factor (ISO Brightness) since this requires the absence of contact with metal surfaces.

Specifications

The apparatus consists of a top container fitted with quick release clips, sealed to a wire screen by a soft rubber gasket. The screen is supported over a drainage cone to which a vacuum line is attached.

The wire screen is 60 mesh plain weave phosphor bronze wire gauze conforming to ISO 3310/1 and BS 410. It is supported by a frame fitted with a split metal ring which permits ease of replacement.

The volume of the receiving cone will comfortably contain 500 ml of water.

Operational Characteristics

The main characteristic is simplicity providing rapid and efficient operation. A hand held spreader is supplied to prevent recycled backwater disturbing the formed pad of fiber.

Comparison to other Instruments

The alternative to this apparatus is a slower and less efficient method that uses a Büchner funnel and filter paper.

Standard Sheet Former & Drainage System

[Data Sheet](#)

Application

With the disintegrator and Auto-press, the Standard Sheet Former forms part of the pulp evaluation apparatus researched and designed by the Pulp Evaluation Committee of the British Paper & Board Making Association. Due to the detailed standardisation of the instrument, the design has changed little over the years except where contemporary fittings have been employed in its manufacture. The major developments to standard sheet forming in terms of operation have resulted in the production of the automated version.

The standard sheet former is designed to produce laboratory handsheets for the purposes of carrying out physical tests to assess the quality of virgin pulps and mill stocks. It conforms in detail and operating characteristics with procedures laid down in the Second Report of the Pulp Evaluation Committee except in respect of the improvements outlined above. It also conforms in every respect to ISO 5269 Part I, TAPPI T205, SCAN C26, CPPA C4 and other appropriate National Standards.

It is therefore suitable for use with almost all kinds of pulp but is not recommended for long fibered pulps such as unshortened cotton, flax and similar materials.

It is used in conjunction with the standard disintegrator and auto-press. Drying may be carried out in the standard way using drying discs and rings or by accelerated means, such as drying cylinders and Speed Dryers.

Specification

The specification complies with the standards specifying a nominal 12 litre, 159-mm diameter cylindrical container set above a wire mesh gridplate fitted with an 80-mesh screen supporting a 120-mesh stainless steel gauze. Drainage is via a hand-operated valve into a vacuum leg 800 mm long ending in a siphon chamber. The drainage time with water only is calibrated to 4.0 ± 0.2 seconds.

The apparatus is delivered complete with all necessary ancillary items but excluding sheets of standardized blotter for use as couching felts.

Operational Characteristics

This method of producing handsheets for testing results from extensive early research and almost 70 years of trial without any major change in procedure. The operation, although operator intensive, is not onerous and, provided the standard procedure is rigorously complied with, provides good reproducibility. There is a tendency with some operators, however, to try speeding up the timed aspects of the procedure resulting in variability in results. The development of the semi-automatic version of the sheet former eliminates this source of error.

Semi-Automated Sheet Former & Drainage System

Data Sheet

Application

In all essential detail, the Semi-Automatic Sheet Former has the same construction as the Standard Sheet Former. It therefore conforms to the same ISO and National Standards as does that instrument. It differs in that the operator-sensitive parts of the procedure are all automated.

It is applicable to almost all kinds of pulp with the usual exclusion of pulps in conjunction with the Disintegrator for Dispersion of the pulp in water, the auto-press for compaction and initial drying of the formed handsheets and with drying rings and discs for air drying under tension to avoid shrinkage.

The instruments conform to the International and all relevant National Standards including ISO 5269/1, TAPPI T205, SCAN C26 and CPPA C4.

Specification

The Semi-automatic Sheet Former follows the same specification as the hand operated former in all main criteria. It differs in the method of stirring in the container and in the couching operation. These innovations have been shown by experiment under mill laboratory conditions to give identical mean values for handsheet properties, but with better reproducibility.

The apparatus is operated electrically, the pressure being supplied by compressed air. The operation is push button controlled with manual override available.

Water is fed to the container via a solenoid valve which is shut automatically when the correct level is reached. Stock is then added and the stirring action supplied by the timed release of compressed air from a series of peripheral holes. Drainage then takes place automatically after which the operator opens the container and sets the couching device in place. The timed application of compressed air to a diaphragm replaces the couch roll, after which the sheets are couched in the normal way.

Operational Characteristics

These are similar to the Standard Sheet Former except that the operation is very much simplified with time to spare for the operator to carry out other tasks.

In addition to this the automatic operation of error sensitive aspects of the procedure eliminates the possibility of operator error.

Digital Sheet Press

Data Sheet

Application

In conjunction with the Disintegrator and either of the Sheet Formers, the Digital press is intended to compact freshly prepared laboratory handsheets and to continue the dewatering process before drying.

The operating principle of this press was designed by the Pulp Evaluation Committee and as such conforms to ISO 5269, TAPPI T205, SCAN C26 and CPPA C4/

It is applicable to handsheets prepared from all kinds of pulp and for the preparation of sheets used to determine diffuse reflectance factors (ISO brightness).

Specification

The press accepts handsheets up to 159 mm in diameter and after hand closing, presses them automatically for the selected time at the standard pressure exerted on the sheets of 415 kPa.

The procedure is repeated for the second pressing, the timers automatically resetting at the termination of each cycle.

Operating Characteristics

The press is fitted with a light weight aluminum top which is closed in position with four quick action cock-nuts.

The ISO procedure is then followed with the press automatically raising and maintaining the correct pressure for the correct time. Provided suitable blotters are employed, this eliminates the source of most operator errors.

The press is easy to operate and maintenance is minimal.

Schopper Riegler Beating & Freeness Tester

Data Sheet

Application

The Schopper Riegler apparatus was the first drainability tester to be designed and the application is virtually identical with that of the Canadian Standard Freeness Tester. Although in principle, suitable for testing all kinds of pulp in aqueous suspension, the test only provides acceptable results if a sufficiently dense mat of fiber of the correct weight is deposited on the wire screen. Caution should therefore be exercised when pulps contain high percentages of debris or fines and when SR values are outside the range 10 to 90 SR.

In practice therefore, it is suitable for use with all pulps in common usage in the manufacture of paper and board products. The instrument conforms to the International and all relevant National Standards including ISO 5267/1 and BS 56035/1.

Specification

The instrument is basically similar in principle to the Canadian Standard Freeness Tester, consisting of a drainage chamber and rate measuring chamber. The drainage chamber is constructed of corrosion resistant material with the base consisting of a phosphor bronze wire screen. This is sealed with an internal cone which, when released, rises through the dilute pulp sample mixing the stock in the process.

The rate-measuring funnel is similar in design to that of the Canadian Standard Freeness Tester having a calibrated orifice to govern flow and sidearm for the discharge of excess water.

The SR value is the inverse of the volume of water collected divided by 10.

All critical dimensions and calibration are according to ISO 5267, BS 6035 and SCAN C19 to which the instrument conforms in every respect.

Operational Characteristics

The instrument is again designed for ease of operation and is easily taken apart for maintenance purposes.