P I T A G U I D E

to

Commonly used Test Methods for Paper and Board

prepared by

PITA RAW MATERIALS WORKING GROUP

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CONTENTS

SECTION 1

INTRODUCTION

There are many methods available for measuring the various characteristics and properties of pulp, paper, board and associated materials. The Background and status of these test methods varies enormously, ranging from full national or international standards prepared and published by the Relevant Standards organisations and widely recognised and accepted to the other end of the scale where a method may have been developed in-house to meet, say, a specific customer need. Many have been developed through the co-operation of interested parties working within a trade or technical body, to meet the needs of their particular section of industry. All these methods do have a part to play, but it can be confusing for the potential user of a test method to understand fully the status, applicability or acceptability of the method under consideration.

This Guide to Test Methods has been prepared by the PITA Raw Materials Working Group, with the aim of providing help to all practitioners working with paper and board and who have a need to measure its properties, or in a few cases those of its components (i.e pulp properties), by giving advice on the methods that are available and relevant to their needs. It is intended to be of assistance to a broad spectrum of users, including manufacturers, specifiers, purchasers and users of paper and board, researchers and students. It is neither the intent nor the function of the Working Group to design or develop test methods and furthermore it does not have the resource to do that. It is able, however, by virtue of the experience and expertise of its members, who represent a wide range of industry interests, to give advice on the wide range of test methods that are available, and to comment meaningfully on their application and usefulness.

The aim of this Guide is to describe those test methods, which are in common use across the industry. It is recognised that in addition to these there are many other test methods, which have been developed to meet the special needs of specific sectors.

In addition to the guidance on specific test methods, some background to the structure and operation of national and international standards organisations and how they interface and interact with each other is included, together with notes on the importance of sampling procedures and on the conditioning of samples when working with paper and board.

NOTE

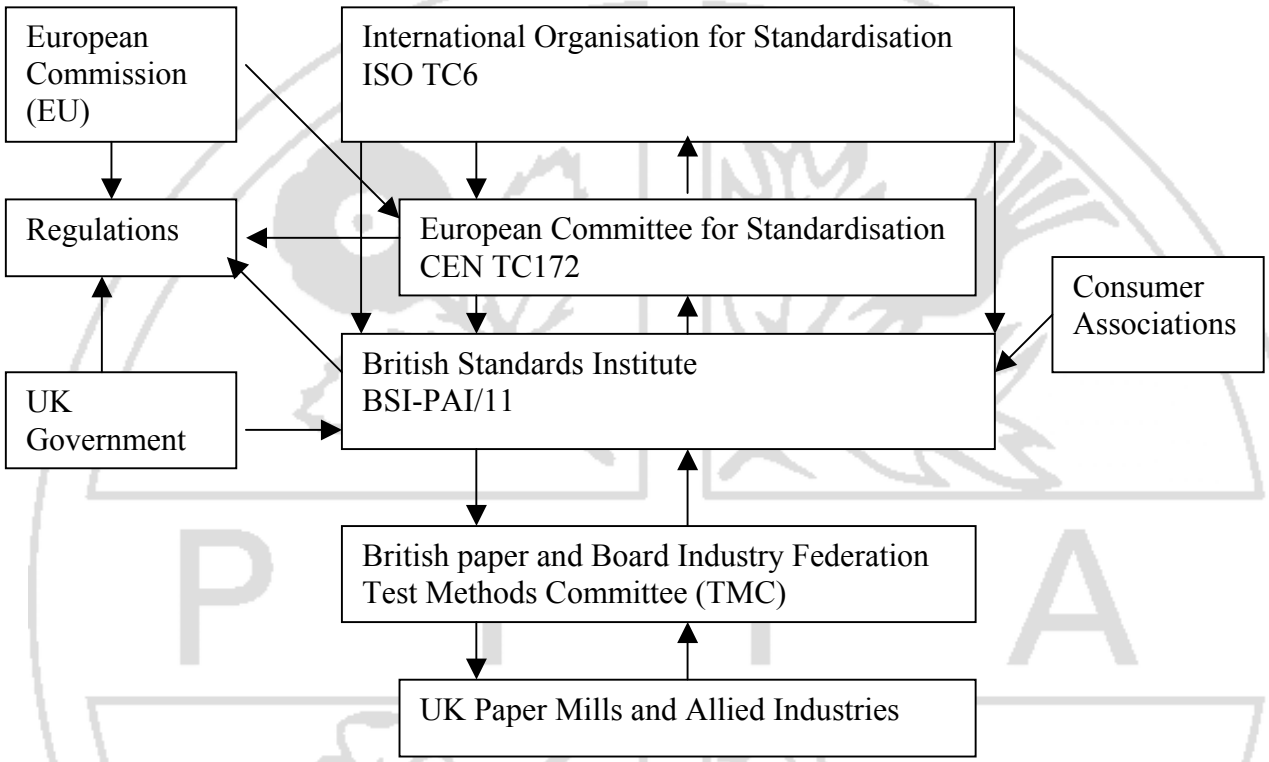
Standard numbers quoted in this document are correct at the time of issue. However, all Standard Organisations re-evaluate their list of Standards on a regular basis, which means that some standards may be declared obsolete or the Standard number may have been changed to accommodate a revised test method for the property in question.

SECTION 2

A GUIDE TO INDUSTRY, NATIONAL AND INTERNATIONAL STANDARDS

Standardisation of test methods and specifications in the paper industry can play an important role in helping the industry to remain competitive and in ensuring that the competition takes place on a level playing field. National and international standards have recognition in terms of their quality and trace-ability for ISO 9000 registrations.

For the paper industry the various national and international standard organisations are linked together with other interested parties as shown in the following diagram:



INDUSTRY STANDARDS

In the UK routine paper, board and pulp testing standards, known as Routine Test Methods ("RTM's") are developed and maintained by a committee of the Paper Federation, referred to as the Test Methods Committee ("TMC"). The membership of this committee is drawn, mainly, from technical staff from UK papermakers together with a few specialists and paper users representatives (Stationery Office).

The methods developed are relatively simple quality control techniques and do not have the legal standing as a British or International standard. Requests for a method development usually come from papermaking companies but sometimes methods being developed by the National Standard body (BSI) can be referred back to the Federation's members. Similarly routine methods developed by the TMC can be referred to BSI for national standardisation.

Another group of globally accepted industry standards are those developed and issued by the Technical Association of the Pulp and Paper Industry (TAPPI) in the USA. TAPPI have produced and maintain a large number of test methods and standards covering many aspects of pulp, paper and board production and use. TAPPI representatives serve on the USA's national standards committee and as such assist in the development of ISO standards.

NATIONAL STANDARDS

In the United Kingdom the British Standards Institution (BSI) has the responsibility for developing and publishing standards as the need arises. The call for a standard can come from government, government agencies or from commercial organisations, where it is usually a trade association or federation who initiates the work.

The committee in BSI with direct responsibility for development of paper, board and pulp testing standards and specifications is designated "PAI/11". Members of this committee represent Industry Organisations such as the Paper Federation or the Fibreboard Packaging Association, etc. Some of the members of the TMC serve as Paper Federation members on this committee. All work carried out by members for this committee is voluntary, excepting that of the BSI secretary.

Today almost all of PAI/11's work is a British Standard input into European (CEN) or international (ISO) Standards. Thus BSI as BS EN or as BS ISO publishes the European Standards and International Standards…

Any member of the BSI committee can propose a standard paper test method for consideration. There are two possible outcomes: either it is referred down to the Paper Federation if thought solely a UK issue, or it can be proposed at a CEN or ISO meeting for consideration as new work item for the corresponding European or international committees. It is very rare nowadays that the BSI committee will work on a purely British orientated standard.

The situation is similar in other European countries who each have their own national standards bodies. Possibly the most frequently encountered of European standards are those from the German standards organisation, DIN or the Scandinavian (SCAN) group of standards.

EUROPEAN STANDARDS (CEN)

The aim of European standardisation is to promote the "single market" by harmonization of standards on a Europe wide basis and to overcome the "non tariff" barriers to trade. The European standards organisation (CEN) is open to all EU countries. The members of its committees represent their National Standards Bodies (e.g. BSI, DIN, etc). Some members of the BSI PAI/11 committee are represented on the Pulp/Paper European Standards Committee, which is designated CEN TC172. Except for secretarial staff the time to develop standards by members of this committee is again voluntary.

The requirement of a European paper-testing standard can occur in two ways. One possibility is that a member country can propose it. A second route is that the CEN committee can be mandated by the European Commission to develop standards in conjunction with a Community Directive. One such example is that CEN standards were requested by the Commission for measuring heavy metal contents in packaging papers as part of the "Packaging Directive".

CEN Committee methodology is to develop standards initially through specialist working groups reporting to the CEN Committee TC172. Once a standard is approved it is published as an "EN" standard and normally will be subsequently adopted by each member country (e.g. BS EN…). One important aspect of EN standards is that no European country can have a national standard which conflicts on the same subject to an EN standard. Most CEN standards published to date are test methods but there are a few Product Standards (e.g. Office/Business Papers). The emphasis in this case is on fitness for purpose and end user functional requirements.

INTERNATIONAL STANDARDS (ISO)

ISO was formed in 1946 to promote standardisation development for orderly trade and for developing co-operation in scientific, technological and economic activities. As for CEN, members of ISO committees represent their National Standards Bodies. ISO has 73 participating countries on a worldwide basis and the input for standards development by the majority of its committee members is also voluntary.

The committee concerned with the Pulp and Paper Industry is Technical Committee 6 (TC6) and this is split into two sub-committees TC6/SC2-Paper and TC6/SC5-Pulp.

Proposals for new work items and the methodology for method development are similar to CEN, which is initially through working groups. Where possible early drafts are based on national standards. When published, BSI as BS ISO may adopt ISO standards… but unlike CEN standards, ISO standards are not mandatory and a BSI standard on the same subject can be used alongside an ISO standard.

When a completely new testing method is being considered the first possibility for its development is given to the ISO organisation. If ISO considers this is purely of European interest then the standard development may take place in the CEN organisation.

There is a technical co-operation agreement between CEN and ISO known as the "Vienna Agreement". This agreement allows for parallel voting to take place on a newly formed standard. One example of this is in the preparation of laboratory hand sheets (ISO 5270). In this case the standard was revised by ISO and voting on its acceptance took place simultaneously in CEN and ISO.

SECTION 3

THE RELEVANCE OF SAMPLING TECHNIQUES WHEN TESTING PAPER AND BOARD

Like many natural products paper produced from cellulose is an "extremely variable animal". Not only do most paper properties vary from one consignment to another but also there is also considerable variation within a consignment both through the making and across the machine deckle. Even within a single sheet there will be variations from place to place and this has relevance in the number of test specimens to be taken for a given sheet and test procedure. It can therefore be very difficult to obtain a representative sample for testing.

Sampling for testing purposes depends on the amount and form of the product to be tested, the intended purpose of the evaluation and the nature of the test. For example, if a large consignment of paper in reel or sheet form is required to be evaluated for compliance to a specification, the sampling of this consignment can be done according to the standard method, BS EN ISO 186 (TAPPI T400 is similar). There is a similar standard for sampling wood pulps, ISO 7213.

These sampling methods are based on statistical principles and are very time consuming. Generally they require up to five percent of the consignment to be taken for testing in sheet or reel form. The final material for testing will usually be in the form of sheets.

Most BS/ISO standard test methods for pulp or paper include a sampling clause. In the case of ISO standards the normal phrase in this clause is "sample according to ISO186", followed by instructions for preparing the appropriate number of test specimens for a given test procedure. However, on many occasions the sample to be tested consists of a few or only a single sheet. The practicalities of this situation has now been recognised and ISO186 has now been amended to accommodate this situation.

For some tests the rate at which the sample is taken is also defined. For example, in the determination of moisture content from wrapped reams there is a requirement for the samples to be taken quickly.

SECTION 4

THE RELEVANCE OF CONDITIONING WHEN TESTING PAPER AND BOARD

Paper produced from cellulose will gain and lose moisture depending on the moisture content in the atmosphere into which it is placed. The moisture content of the atmosphere in this case is referred to as the atmosphere's relative humidity, and is usually expressed as a percent (%R.H.). The rate of moisture gain or loss is dependent on many factors such as the paper furnish, presence of sizing agents, coating, etc.

The moisture content of the paper at the time of testing will affect many of the paper properties, in particular the strength properties. For example the folding endurance can change by up to 400% depending on the paper's moisture content at the time of testing.

Both temperature and relative humidity can independently affect the physical test results obtained. For example, a change of 1°C, at constant %R.H. can have the same effect on a property as a change of 2%R.H., at constant temperature.

In order to ensure that paper samples are tested in the same stable moisture condition it is recommended that the samples be "Conditioned" prior to testing at a standard atmospheric humidity and temperature. The standard atmospheric conditions are contained in BS EN 1S0 20187 and are 50 ± 2%R.H.; 23 ± 1°C.

It is recommended that most paper samples should be exposed to the standard atmosphere for a minimum of 4 hours (5-8 for heavier papers) and up to 48 hours for boards.

A further complication can arise, however, because the paper's natural moisture content may not be the same as the moisture content it will have after conditioning in the standard atmosphere. The test results obtained will depend on whether the natural moisture content was brought down to, or raised up to the moisture content after conditioning. This is known as a hysteresis effect. To minimise hysteresis effects, for the most accurate results, it is recommended that the samples are first pre-conditioned at a low R.H. (e.g. 10-35%) for 24 hours before exposing to the standard atmosphere conditions; the temperature in this case is not critical but should be around 20°C.

For quality control purposes in paper and board mills it is usually necessary to test a product immediately it comes from the machine, without adequate conditioning and frequently using a test method which has been modified to give results in the shortest possible time. The moisture content off machine is usually lower that the equilibrium value after conditioning and this affects the paper properties, especially strength and therefore off-machine testing only provides a guide to the values, which would be obtained after conditioning. It is however, acceptable to use off-machine testing provided that the shortcomings are recognised. Individual mills should ensure that they understand how the results from such tests correlate with those using standard methods and conditioned samples, so that meaningful interpretation of results can be achieved.

SECTION 5

HEALTH AND SAFETY

Readers should be aware of current Health and Safety requirements when carrying out sampling procedures or using test methods. There is a great deal of Health and Safety regulation, subject to continual change, and it is therefore not meaningful to include detail of any specific regulation in this document. However, the hazards, which commonly exist and need to be managed to ensure a safe working environment can be mentioned together with some of the management techniques used to control them.

The taking of samples of paper and board is frequently carried out in a factory or warehouse environment.

Typical hazards include:

- unstable stacks of reels, bales or pallets
- vehicle movements
- use of knives and other cutting instruments
- rolling reels
- sharp edges to paper and board samples
- sharp ends to cut strapping and wires

Persons entering such areas for sampling purposes should ensure that they are familiar with the local Health and Safety requirements. High visibility clothing, protective footwear and eye protection should be used as a minimum. Ear defenders may be necessary. A suitable location, with sufficient free space, should be identified for the opening and sampling of stock.

Test methods are usually used in a laboratory or control room, and indeed many require a conditioned atmosphere. Many use electrical or electronic instruments, and potential hazards include:

- lack of electrical integrity
- hot surfaces – ovens, hotplates
- cutting instruments – knifes and guillotines
- chemicals, including solvents

Persons using a test method should first read any instructions and note any safety recommendations. Electrical equipment should be subject to periodic check, and be certificated. The data sheets for any chemical used should be available, and the advice followed. The disposal of residual chemical may be subject to Special Waste regulation, and if in doubt advice should be sought from a competent person. When carrying out any new or modified procedure, or working in a new environment, it is good working practice as well as a legal requirement to carry out a risk assessment on the proposed task. If this is done with diligence, and with recognition of the potential consequences should an accident occur, the assessment will be successful in identifying the risks, which need to be controlled. The value of risk assessment cannot be over emphasised.

SECTION 6

TEST METHODS FOR PAPER AND BOARD - BASIC PROPERTIES

6.1 PROPERTY: GRAMMAGE

Background

Grammage is defined as the weight in grammes per unit area of paper or board. It is usually measured in the laboratory on an air-dry basis. Grammage, together with Thickness, are significant properties in the sale and use of the paper product. Many other physical properties are often expressed as a unit grammage.

In the USA the term "basis weight" is used and whilst the term grammage is now widely used and accepted, the previously used term "substance" is still occasionally encountered.

Description of Test Method (s)

In the laboratory the grammage is determined by weighing a known area of paper or board, after conditioning in a standard atmosphere for a set period of time. The results are expressed as $g/m^{2.}$

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Grammage of paper and board	BSENISO536	536	T410	ScanP6 DIN53104

General Comments/Points to Note

Instruments are available for the measurement of grammage on-line, both in the mill and in the laboratory.

In the USA the weight per ream is referred to as "basis weight". One illustration of this is for a printing paper of 75 g/m^2 to be reported as 50 pounds per 3300 ft^2 or 500 sheets 25" x 38". There are many different sizes and weights and this is only one illustration.

Typical Values

	g/m^2
Newsprint	40 - 50
Cigarette Tissue	22 - 25
Bond (printing/writing papers)	60 - 90
Office/Business Papers	80
Paperboard	120 - 300

1. Accepted trade tolerance ± 5%.

6.2 PROPERTY: THICKNESS, BULK AND DENSITY

Background

The measurement of paper thickness is a key characteristic in the assessment of a paper product quality.

The thickness of paper and board may be measured either on a single ply or multiple ply's; the decision as to the number of ply's to be tested is related to the purpose of the test.

When thickness measurements are related to grammage the ratio of these two parameters will give a value for apparent sheet bulk, or its reciprocal, apparent sheet density. Values for bulk are part of some product specifications, e.g. book papers. Sheet density directly influences many other paper properties such as strength and opacity when it is altered during forming and/or pressing. Changes in density during calendering have less effect on other properties.

Description of Test Method(s)

Paper thickness is measured with a micrometer, which can be digital or analogue. Most modern instruments have digital outputs reading in micrometers.

The paper or board thickness can be measured either as a single ply or multiple ply values (bulking thickness). The single thickness value is defined as the distance between the two parallel plates, determined under an applied static load. Bulking thickness is the thickness of a single sheet, calculated from the thickness of several sheets. As for grammage, it is usual for the test to be carried out on conditioned paper in a conditioned atmosphere.

For some papers (e.g. soft creped paper) the pressure between the two receiving plates of the micrometer has to be lower than for a normal paper micrometer. In this case micrometers conforming to other standards are available.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Thickness of paper and board	BS EN ISO20534	534	T411 T511	ScanP7 & P47 DIN53105
Thickness of soft tissue	7387 BS EN 12625-3	12625-3		

General Comments/Points to Note

1. The thickness of paper for a given grammage is dependent on such factors as, the furnish, fibre treatment and machine operating parameters.
2. Paper stiffness is proportional to the $(\text{Thickness})^3$
3. Variations in thickness are related to reel hardness and calendering performance.
4. Bulking thickness is a measure of softness in tissue papers and compressibility in printing papers
5. Apparent bulk is calculated from thickness μm (single sheet)/grammage g/m^2. The result is usually expressed in cm^3/g. Density is 1/bulk.
6. Apparent bulk is a measure of the air space in the paper.
7. Trade tolerance in thickness ± 10%

Typical Values

	Thickness μm
Office/Business Papers	105 - 110
Newsprint	60 – 80
Blotting paper (230 g/m^2)	540 – 590
Tracing paper (90 g/m^2)	78
Label paper (79 g/m^2)	63
Tissue (28 g/m^2)	125

N.B. Paper Density – a typical range is 0.5 – 0.8 g/cm^3 (500-800 kg/m^3)

6.3 PROPERTY: ASH CONTENT

Background

The amount of material remaining, calculated on the basis of oven dry weight of the original sample, after complete combustion of organic material at a specified temperature, represents the ash content. It is a measure of the inorganic filler or coating contents for papers containing such materials as calcium carbonate, china clay or titanium dioxide and is expressed as a percentage.

Description of Test Method(s)

Typically a weighed sample of paper or pulp (e.g. 1g) will be placed either in a crucible in a muffle furnace or directly in a dedicated incinerator at a standard temperature. After complete ignition of the cellulose the material will be removed, cooled and weighed.

One of two temperatures are normally used, i.e. 900 ± 25°C or 575 ± 25°C. The higher temperature is used where speed and only a measure of the residue is required. The lower temperature is used to determine the amount of filler material as carbonate or sulphate.

Whilst most inorganic fillers do not decompose below 900°C, calcium carbonate is an exception, losing carbon dioxide at temperatures above 525°C, the reaction starting possibly below this temperature (see over).

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Ash of pulp	BS ISO 2144 (900°C) Note – see also 4896	1762	T413 (900°C)	SCAN C6 (Pulp)
Ash of paper (Paper) and board	BS ISO 2144		T211 (525°C)	SCAN P5 SCAN C6

Notes: ISO 1762 This method has been renamed "Determination of residue (ash) on ignition at 525°C" It is applicable to pulp, paper and Board.

General Comments/Points to Note

1. Cellulose combustion starts to take place above 300°C.

2. If the ash is determined at two different temperatures (900°C and 525°C) it is possible to calculate the percentage of calcium carbonate and china clay in papers with a mixed carbonate/clay filler content (e.g. in recycled papers) The detail is shown below: -

$$Ash_{525} - Ash_{900} = CO_2 \text{ volatile proportion} \ldots\ldots 1$$

$$CaCo_3 \text{ content} = CO_2 \text{ volatile proportion} \times 100/44 \ldots\ldots\ldots 2$$

$$Ash_{clay} = Ash_{525} - CaCo_3 \text{ content} \ldots\ldots\ldots 3$$

$$\text{Clay content} = Ash_{clay} \times \times 1.13 \ldots\ldots\ldots\ldots 4$$

Method of Dr H J Putz

Typical Values

Pulp/Paper	Typical %
Commercial Wood pulp	0.3 – 0.5
Newsprint	0 - 12
LWC	30 - 50
Fine Papers	0 - 35

6.4 PROPERTY: MOISTURE CONTENT

Background

The moisture content of pulp, paper and board is important for both economic and end use purposes. For pulp the moisture content is required to be known for economic reasons as this product is sold on an "air dry" basis. In paper and board the moisture content effects such properties as dimensional stability, physical strength, paper runnability, calendering, embossing and in particular printability.

The moisture content is defined as the ratio of the loss of mass of a test piece when dried by a standard method, to its mass at the time of sampling. The result is normally expressed as a percentage.

Description of Test Methods(s)

In practice three techniques are used in the paper laboratory for determining the moisture of pulp, paper and board.

1. The most common method is to weigh a sample, place in a weighed, unsealed air-tight container, dry in an oven for a set period at 105 ± 2°C, cool in a desiccator, seal and re-weigh the container.

2. The method above will not totally remove all the water and is also unsuitable for a sample, which contains volatile substances. In this case boiling a weighed sample in Toluene and distilling off the water, which is condensed into a measuring tube, can determine the moisture content.

3. Many commercial instruments based on a variety of techniques, such as microwave, dielectric constant, infrared, are now available for the direct measure of moisture content. None of these methods fall under any recognised standards and all require some kind of calibration.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Paper and board (oven method)	BSEN20287	287	T 412;	SCAN P4 CPPA G3
Dry matter content of pulps	BSEN20638	638	T210;	SCAN C3
Moisture content of materials (Toluene method)			T208	

General Comments/Points to Note

1. Control of a paper's moisture content is critical for many grades of paper, in particular those grades which are intended for offset printing and Xerographic copying. Incorrect moisture levels in these grades can cause severe problems of curl, misregister, static and runnability.

2. Commercial equipment is available for measuring the equilibrium relative humidity of sheeted paper stacks, which can be related to the paper's moisture content.

3. Speed of sampling and correct handling of samples from wrapped reams or containers is critical.

Typical Values

Pulp/Paper	Typical %
Commercial Wood pulp	10
Printing Papers	6 - 7
Office/Business Papers	4 - 4.5
Tissue Paper	2 - 7
Newsprint	7.5 - 9.5

SECTION 7

TEST METHODS FOR PAPER AND BOARD - STRENGTH PROPERTIES

7.1 PROPERTY: TEARING RESISTANCE

Background

The tear strength of paper is the resistance of the material to the propagation of an initial flaw inserted in the edge of the paper. It is a particularly useful test for paper used as a wrapper to protect materials in transit or any paper subject to tearing strains in use.

Description of Test Method(s)

1. The most common test method is the "Elmendorf Tear Test". This method uses a pendulum instrument to measure the force required to continue tearing an initial slit in a sheet (or sheets) of paper or board. The results are expressed in mN force.

Normally an initial slit is pre-cut in four sheets simultaneously, but in some cases a smaller number may be used.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Elmendorf Tear	BS EN 21974	1974	T414	DIN 53128 SCAN P11

General Comments/Points to Note

1. The tearing strength of paper and board is generally dependent on fibre length over most of its refining range. The fibre strength, bonding degree between fibres and the fibre orientation in the sheet, also influences the tear strength.

2. The Elmendorf tear test measures an out of plane tear force, (i.e. Approximately perpendicular to the plane of the paper). Recent evidence suggests this is not the way which a "tear" will propagate and tests have been developed which can measure in-plane tear (also known as "Fracture Toughness" – SCAN P77). Fracture Toughness is currently being developed as an ISO test.

3. Modern Elmendorf instruments have electronic readouts.

Typical Values

Elmendorf Tear mN

Coating Base (80g/m²)	500-700
Bond (100 g/m²)	700 Approx
Office/Business Papers (80 g/m²)	500-600
Test Liner (186 g/m²)	1.80 N

7.2 PROPERTY: TENSILE STRENGTH

Background

The tensile strength of paper assesses the suitability of a product to withstand strain in end use. Typical applications for the tensile test are:

- for web printing papers – to assess the stresses imposed by the printing press draws on the paper
- for sack papers – to assess the paper's ability to resist shock loads.
- for tissue products – to assess the resistance to stress in both dry and wet states

In pulp evaluation the tensile test can assess the degree of refining a pulp requires to reach a certain strength level. The gain in tensile is related to creation of bonding sites on the fibre surfaces.

Description of Test Method(s)

Two test methods are available:

- Constant rate of loading – This is the older test method, based on a pendulum instrument and applies a constant rate of tensile force, which causes failure of the test piece. A test piece of paper or board of standard width, usually 15 or 25 mm, 180 mm in length, is clamped and a tensile force applied until the sample breaks. The tensile force is measured in Newton's per unit width (m) and the elongation at the point of rupture, which can also be obtained, is measured in percent.
- Constant rate of elongation – A test piece, as above, is stretched to rupture at a constant rate of elongation. Modern instruments incorporate sophisticated electronics, which will measure several parameters, including tensile strength (KN/m), elongation, (%) tensile energy absorption (J/m^2) and elastic modulus (GPa).
- For tissue products to be tested in the wet state, the sample strip is looped around a rod held by the bottom clamp of the instrument and both ends of the test strip are held by the top clamp. The rod is wetted so that part of the sample is completely soaked and the tensile test performed. In some cases the rod may itself be part of a custom piece of apparatus referred to as a "Finch Apparatus".

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Constant rate of loading	4415	1924/1	T404,	SCAN P16 & P38

(Note: Both BSI and ISO have declared the "Constant Rate of Loading Method" as obsolete as this equipment is no longer manufactured)

Constant rate of elongation	BS EN ISO 1924-2	1924/2 5270 (Pulp handsheets)	T494	DIN 53112
Wet tensile testing (tissues)	BS EN ISO 12625-5	12625-5		

General Comments/Points to Note

1. The two tensile methods may not give the same value for the same paper tested.

2. Instruments, which clamp the paper sample both vertically and horizontally, are now available. The latter tend to be quicker to use.

3. The standard length of the test strip is 180 mm. Shorter lengths may give slightly higher results, but this depends on the paper formation.

4. For tissue products the standard test width is usually 50 ± 0.5 mm, although tests have shown that widths between 25 and 50 mm produce no significant differences.

5. The modern commercial expression for tensile strength is "Tensile Index" (Nm/g), which is tensile force per unit width (m) divided by the sample grammage (g/m^2). Tensile strength can also be expressed as "Breaking Length", which is the length of a strip in metres that can be suspended before it would break under its own weight.

6. The tensile strength is mostly dependent on the degree of bonding between the fibres but the fibre strength (zero span strength) also influences the tensile.

7. The tensile strength is highly dependent on whether the sample is tested in the machine or cross direction and the results are sometimes expressed as a "tensile ratio" i.e. MD Tensile/CD Tensile, which can be used as a simple measure of the fibre orientation in a paper sheet.

Typical Values

Tensile Index Nm/g

Grade	g/m^2	MD	CD
Newsprint	40 – 49	45 – 60	-
Stationery	50 – 100	40 – 70	20 – 40
Tracing Paper	60 – 110	70	40
Test Liner	186 g/m²	175	80

7.3 PROPERTY: WET STRENGTH TENSILE

Background:

The wet strength tensile test is similar to the normal 'dry' tensile test – sample sizes are the same, as are load and extension rates. A paper is considered to have wet strength if the wet tensile strength is greater than 15% of the equivalent dry test (TAPPI). For wet strength tissue such as kitchen towel or facial tissue, wet tensile's can be as much as 40% of the dry test value. Some special papers have been reported with wet tensile's over 50% of the dry test value.

Description of Test Method:

The actual method used for the wet strength tensile tests depends on the arrangement of the equivalent dry test, and the established practices in individual mills. A typical example is given below for tissue: -

Sample Size: 180 mm x 25 mm
Number of plies: 10
Load Cell: 0.5 N
Elongation Rate: 300 mm/minute

Sample wetting

The way in which the sample is wetted can have a considerable effect on the result. This is where methods usually vary from mill to mill. The objective is to get a uniform and repeatable wet strip, usually a few millimetres thick, across the width of the sample. Using a fine brush or wash bottle can do this. Wetting is done once the sample is loaded in the measuring device and the test is started immediately after wetting.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
General for Paper & Board	2922-2	3781		
For Soft Tissues	BS EN 12625-5	12625-5		

Typical values

-Examples (vales calculated from 10 ply measurement):

Basis Weight (gsm)	**Plies**	**Tensile Strength (g)**	**Wet Tensile Strength (g)**
20 (Kitchen Towel)	2	650	200
13 (Facial Tissue)	2	115	35

7.4 PROPERTY: BURSTING STRENGTH

Background

Bursting strength ("burst") is one of the oldest tests developed for paper and board and is a general indicator of strength characteristics. This test is extensively used in the testing programmes for packaging papers and also in the evaluation of wood pulps.

The most attractive feature of this test is that it is very quick and easy to carry out and can be done directly on samples from the paper machine web, without any specific test specimen preparation.

Burst remains the major parameter in the specification and certification of corrugated containers for shipment by rail and truck in the USA (Rule 41 and Article 222). This is the main reason for retaining this archaic test in the corrugating industry.

Description of Test Method(s)

In the laboratory, the burst is determined by holding the paper sample between two small circular clamps. The sample is subjected to increasing pressure via a rubber diaphragm, expanded by hydraulic pressure, at a controlled rate, until the paper ruptures. The instrument used measures the peak pressure to rupture, usually in kilopascals.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Paper	3137	2758	T403	SCAN P24
	BS ISO 2758			DIN 53141
Board	3137	2759	T807	SCAN P25
				DIN 53141
Corrugated Board			T810	

General Comments/Points to Note

1. The most commonly used Burst Tester is the "Mullen" although other instruments such as the "Schopper" may be encountered.

2. The Burst test results are often expressed as a "Burst Index" which is Burst strength/Grammage (Kpa.m²/g). The results can also be expressed as "Bursting Energy Absorption" (J/m²), which is the work done per unit area of paper or board when stretched to rupture. The latter has applications in testing such products as sack kraft.

3. The burst strength is strongly related to tensile and elongation.

4. The burst strength is influenced by many factors in papermaking, such as the fibre type, degree of refining, presence of strength additives (e.g. Starch), sheet formation, and moisture content. On refining, burst strength increases as the fibre bonding increases, provided there is not too much fibre shortening.

Typical Values

	Kpa
Coated Paper (130 g/m^2)	200 - 300
Coated Paper (250 g/m^2)	300 – 650
Bond/Office/Business Papers (100 g/m^2)	250 – 300
Carbonless Base (50 – 60 g/m^2)	150 – 200
Bleached Kraft (60 g/m^2 Handsheets)	210 - 260
Test Liner (186 g/m²)	250 - 475

7.5 PROPERTY: STIFFNESS/RIGIDITY

Background

1. Stiffness is a measure of a paper's ability to support its own weight.

2. Rigidity is a measure of a paper's resistance to an applied force.

3. The stiffness of paper varies significantly with the type produced and is dependent on the fibres used, fibre treatment (refining), the paper grammage and its bulk. The paper stiffness in Office/Business Papers and printing papers is important for its performance on these imaging machines. This property is also important in the performance of paper and board in packaging machines.

Description of Test Method(s)

Several instruments are made in different parts of the world to measure this property. Generally they fall into three main groups.

1. Instruments which measure the bending moment of a paper sample of set dimensions through a given angle (typically 15° from the sample centre-line – example Taber instrument which is a two point bending stiffness method)

2. Instruments that measure the stiffness of a paper strip, whereby the free length is increased until it bends under its own weight (e.g. Clarke stiffness).

3. Instruments that vibrate a paper strip at a constant frequency and deduce the bending stiffness of the paper from the resonance length. A test strip is pulled slowly through a vibrating clamp. At a certain free length natural resonance occurs and the instrument measures this free length of the test strip. The original instrument for this purpose was designed by Lhomme and Argy, and is often known as Kodak stiffness.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Bending Resistance	3748	2493	T 495; T566	DIN 53 121; SCAN P29
Bending Stiffness	7424			
Stiffness (e.g. Clarke)			T451;	Paper Federation RTM27
Resonance length method		5629	T 535;	SCAN P64 DIN 53123

General Comments/Points to Note

1. The stiffness method (e.g. Clarke) is particularly suitable for finding the paper resistance to bending when handled, for example when testing newsprint or tissue.

2. Paper stiffness has been found to be proportional to the square root of the weighted average fibre length and also to the cube of the paper thickness for a given grammage.

Typical Values

Paper type	g/m^2	Bending moment stiffness mNm		Resonance length stiffness mNm	
		MD	CD	MD	CD
Coated Paper (matt finish)	135	65	45	1043	721
Office/Business Papers	80	39	17	493	160
Carbonless paper (calendered base)	46	7.5	3.3	76	34

7.6 PROPERTY: CONCORA MEDIUM TEST (CMT)

Background

The Concora Medium Test measures the crush resistance of a laboratory-fluted strip of corrugating medium. This test is one of a number of tests for crush resistance made on the components of corrugated board to gauge its contribution to the strength performance of the corrugated box produced from board. The load is applied in the lengthwise direction of the paper web; the maximum load applied to the test piece is recorded as the measure of the medium compression strength.

The compression strength of the corrugating medium is regarded as important because it indicates the flat crush resistance of the corrugated fibreboard.

Description of the Test Method(s)

The board is formed into a flute shape by passing it between heated rollers. Fixing a length of pressure sensitive tape onto the fluted tips retains the fluted shape. The corrugated board is then placed between two platens of the testing instrument. Application of the crushing force is perpendicular to the flutes so produced. The maximum force in Newton's sustained by the flutes before collapsing determines the crush resistance. The results are expressed in Newton's.

Relevant Standards

METHOD	BS	ISO	TAPPI	OTHER
Corrugating Medium – Determination of crush resistance after laboratory fluting	BS EN ISO 7263	7263	T809	Scan P27 DIN53143

General Comments/Points to Note

The test is carried out at a number of time lapses between forming the flutes and crushing the test piece, this time usually noted in minutes as follows:

CMT_0 crushed immediately
CMT_{30} crushed after 30 minutes
CMT_{60} crushed after 60 minutes

Typical Values

g/m^2	**Semi Chem Medium**	**Recycled Fibre Medium**
105	-	235
112	290	240
150	475	335
175	570	-

7.7 PROPERTY: RING CRUSH

Background

The Ring Crush Test measures the edge crush resistance of a piece of board formed into the shape of a cylinder. This compression strength measurement is across the paper web. Like the Concora test, it is used to assess the performance characteristics of the component of a corrugated box and has implications for the stacking strength of fibreboard containers in warehouses. Currently it does not have the recognition of an International standard.

Description of the Test Method(s)

A strip of the board is formed into a cylindrical shape and inserted into the groove of a ring in the sample holder. Half of the cylinder is within the sample holder grooves during the test. A compressive force at constant speed is applied to the top of the cylinder until the test piece fails. The ring crush value is the maximum load and the results are expressed in Newton's (N).

Modern instruments use two parallel platens, one fixed, the other driven at constant speed, the compressive force being measured electronically with a load cell. In older instruments one platen rests on a beam that deflects on loading. The force applied is derived by pre-calibration of the deflecting beam. The two types of instrument reflect the standard methods available.

Relevant Standards

METHOD	BS	ISO	TAPPI	OTHER
Ring Crush of paperboard (flexible beam)			T822	
Ring Crush of paperboard (parallel platens)			T818	Scan P34

General Comments/Points to Note

1. The Ring Crush test is unsuitable for very thin boards (less than 0.15mm), which will buckle during compression, or very thick boards (greater than 0.76mm) that will crack when formed into a cylinder. This test is now being superceded by the Short Span Compression Test (SCT).

Typical Values

Recycled Fluting Subst	**RCT**	**Testliner 2 g/m²**	**RCT**	**Testliner 3 g/m²**	**RCT**
105 gm²	125	125	160	117	130
112 gm²	130	140	200	140	180
150 gm²	220	186	300	180	280

7.8 PROPERTY: FOLDING ENDURANCE (DOUBLE FOLD)

Background:

The folding endurance of paper is the ability of a strip of paper to withstand breaking when folded continuously under a certain load.

It is an important test for papers that are to be handled, such as currency papers and certain types of wrapping papers. It is often used to estimate a paper's ageing characteristics, by testing the folding endurance before and after artificial ageing.

The test is very sensitive to testing conditions and gives extremely variable results. Folding endurance tests are often done in pulp evaluation routines as well as product testing.

Description of the Test Methods:

Over many years methods and instruments have been developed to measure the folding endurance of paper, from which four instruments have now been standardised. All four instruments are based on a similar principle of folding a paper strip under a standard load until the strip breaks. These instruments give different numerical results on the same product due to design differences such as the strip loading used, angle to which the paper is folded and the speed at which the paper is folded. The four standard instruments and differences are:

Instrument	Strip Loading Kg	Strip Folding Angle Degrees	Folding Speed Double Folds/Min
MIT	1.0	135	175
Schopper	1.0	180	115
Kohler Molin	0.8	156	200
Lhomargy	1.0	90	125

Folding endurance results can be expressed either as a number of double folds (folding strength) or as the Log 10 of the number or double folds (folding endurance).

Relevant Standards:

	BS	ISO	TAPPI	OTHER
MIT	BS 5626	5626	T 511	
Schopper	BS 5626	5626	T 423	
Kohler Molin	BS 5626	5626		Scan P17
Lhomargy	BS 5626	5626		

General Comments/Points of Interest:

1. The determination of folding strength can be a time consuming test because the strip may take a long time to break. This paper property is extremely variable and for a typical significance the means should differ by at least 20%.

2. Folding strength is related to the tensile strength, elasticity, stretch and the paper's formation and moisture content.

3. The property is affected by fibre length, coarseness and fibre type (very strong fibres such as staple cotton and hemp are often used to produce high fold strength).

4. On refining wood pulp the fold strength initially increases as the degree of fibre bonding increases, but the fold will then decrease if further refining reduces the fibre length.

5. Fibres such as staple cotton or bast fibres such as hemp tend to split on refining into more slender fibres. This assists in increasing the folding strength.

6. The folding strength is very sensitive to the test room relative humidity and is also affected by any increase in temperature at the folding head, if there is a prolonged testing time. Modern fold testing instruments have cooling systems to minimise this affect.

Typical Values:

		Double Folds	Log 10 Double Folds
Schopper Fold	Printing Papers (105-135g/m²)	281-1260	2.45-3.10
	Currency	1500-5000	3.17-3.70

7.9 PROPERTY: INTERNAL BOND STRENGTH

Background:

The Internal Bond Strength of paper or paperboard (also known as Ply Bond Strength or Z Directional Strength) is the ability of the product to resist splitting when a tensile load is applied through the paper's thickness i.e. in the Z direction of the sheet.

The internal bond strength is often determined on high tack coated Fine papers, offset papers and for multiply papers (e.g. top liner of carton board or abrasive paper used to form belts in grinding machines). One particular application is determining the ply bond strength of "Peelable" Wallpaper, where low peel strength is required between the paper and the backing.

Description of Test Methods:

Two standard methods have been developed for the determination of internal bond strength.

One method, usually referred to as the "Z Directional Tensile Test", consists of applying a double-sided pressure sensitive adhesive tape to both sides of a paper test specimen. This is then placed between two metal plates. The assemble is then placed in a tensile compression tester, which initially applies a compression load to ensure that the paper is firmly bonded to the metal plates. The instrument then applies a tension over the test area in a direction perpendicular to the plane of the sample to cause the paper sample to split. The splitting force can then be measured in lbs/sq. inch or in kPa.

The second method uses a custom built instrument, the most well known being the Scott Bond Tester. In this test the paper specimen is treated with double-sided adhesive tape as before. One side is in contact with a fixed metal plate while the other side is in contact with right-angled metal plate. The latter plate is struck with a pendulum, which causes the paper specimen to delaminate. The loss in kinetic energy of the pendulum after striking the right angle plate indicates the internal bond strength of the paper. The energy absorbed by the paper delaminating is measure in Millijoules.

Relevant Standards:

There are no British Standards or ISO Standards as yet available to determine the internal bond strength but an ISO standard is at a very early stage of development.

Internal Bond Strength (Z Directional tensile test)	Scan P80 and T541
Internal Bond Strength (Instrumental method)	T833

General Comments/ Points of Interest:

1. Internal bond strength is not necessarily linked to the paper's surface strength.
2. Other applications for determining internal bond strength include predication of paper blistering, paper converting faults and the evaluation of strength additives to papermaking wet end stock.

Typical Values:

Paper Quality	Scott Bond Instrument J/M2
Cover Paper	125-230
Offset	240-290
Xerographic	220-400
Coated Cover	200-315
Coated Text	240-380
42# Liner Board	200-365
69# Linder Board	190-305

Note:

All above data is from the USA.

SECTION 8

TEST METHODS FOR PAPER AND BOARD - OPTICAL AND SURFACE PROPERTIES

8.1 PROPERTY: BRIGHTNESS

Background

The brightness of market pulp is a property that specifies the class of pulp being purchased (e.g. bleached kraft compared to unbleached kraft). The brightness of paper is often linked to its aesthetic appeal.

Description of Test Method(s)

1. The ISO brightness of paper or pulp is defined as the ratio of the reflectance of an opaque pad of test sheets, using light with a wavelength of 457 nm compared to the reflectance of the perfect diffuser.

2. Two main types of instruments are used. These are the G.E. instrument (TAPPI Standard T452) and the Elrepho instrument. In the former the light is illuminated on the paper at a 45° angle and the reflected light at 0° is measured. The Elrepho instrument measures ISO brightness and in this instrument the light source is diffused and the reflected light at 0° is measured. Both GE and ISO Brightness values are expressed as percent.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
ISO Brightness				
Pulp, Paper and Board	BS ISO 2470	2470	T525	SCAN P3
G.E. Brightness				
Pulp & Paper			T452	

General Comments/Points to Note

1. The geometry of the instrument used for measuring ISO brightness is described in ISO 2469

2. There is no simple relationship between ISO and G.E. brightness

3. The brightness of a handsheet prepared specifically for brightness testing will usually be 0.5 – 1 unit higher than the brightness of a pulp sheet, made from the same pulp

4. Measurements may be carried out with or without a U.V. filter, as required

5. Brightness and whiteness should not be confused. Brightness is a measure of an intrinsic reflectance factor of the material surface. Whiteness is a colorimetric property.

6. Whereas brightness is used for writing and other printing grade papers luminance (or the Y value) is the industry standard for newsprint (IFRA Newshade 95). Luminance is measured in a similar way to brightness but at 557 nm. Typical luminance requirements for standard newsprint are around 63 to 64%.

Typical Values (without u.v.)	**%ISO**
Newsprint	62 – 65
Fully Bleached Pulp	90
Office/Business Papers	80-95
Bond	70-92
Coated Paper	85-90

8.2 PROPERTY: OPACITY

Background

The opacity of paper is the material's ability to obscure the content of printing matter on the opposite side of the same sheet, or on the same side of an underlying page. It is the result of light scattering due to the different refractive indices of fibre and fillers with air in the sheet.

It is an important property for all printing grades such as printing and writing qualities, envelopes and newsprint.

Description of Test Method(s)

The opacity of paper is determined as a ratio of reflectances and expressed as a percentage. It can be assessed in two ways:

* As the reflection from a single sheet of paper on a black background (<0.5% reflection) compared to the reflection from a pile of the same paper (often referred to as diffuse opacity or printing opacity).

* As the reflection from a single sheet of paper on a black background, compared to the reflection of a single sheet backed by a white body of known reflection value. This is usually referred to as "Contrast Ratio".

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Diffuse Opacity - Paper and Board	BSISO2471	2471	T519	DIN 53146 SCAN P8

General Comments/Points to Note

1. Groundwood fibres with a high proportion of fines produce high opacity papers as do short fibred hardwood chemical pulps (e.g. Eucalyptus)

2. The opacity of paper is influenced by fibre type, bleaching degree and the presence of dyes, coatings, or fillers (both white or black filler will increase opacity).

3. Opacity determinations by the Diffuse Opacity and contrast ratio methods are different and so the results are not comparable.

Typical Values

Grade	g/m^2	Diffuse Opacity %
Newsprint	40 – 49	90 – 94
Stationery	50 – 100	>88
Tracing paper	60 – 110	25 - 40

8.3 PROPERTY: SMOOTHNESS/ROUGHNESS

Background

The smoothness/roughness of a paper is a measure of the contour of the paper's surface. It relates to the shortness and slenderness of the fibres used and the degree of "filling in" of fibre on the surface. Smoothness and Roughness measurements are inversely related.

High smoothness or low roughness characteristics are important for all types of printing papers and photographic papers for clarity of the image. This property is important in writing paper, where it affects the ease of travel of a pen, and it is also important for laminating paper production. A controlled smoothness is required for sack kraft, so that the surface can be printed, but at the same time the paper is not too smooth otherwise the sacks will slide too easily.

Description of Test Method(s)

Several test methods are available for the measurement of paper smoothness. These include surface profiling instruments, optical contact area, photographic evaluation, ink coverage methods and lateral air flow measurement. Only the latter group are used for routine measurements and bear recognised standards.

Air flow measurement instruments are based on the principal that the volume of air voids between a paper and a plane surface is proportional to the roughness of the paper and that the rate of airflow between these surfaces is proportional to the volume of air voids.

In some instruments (e.g. Bekk) the air is drawn across the paper surface under reduced pressure and a test value is reported as time in seconds for a given air flow. This is referred to as"Bekk smoothness". Alternatively, in the Bendtsen and Parker Printsurf instruments air at a standard pressure is forced radially across the paper surface and this flow is measured on a flow tube. The main difference between the Bendtsen and the Parker Instruments is that the latter is specifically designed to measure roughness under conditions of different presses on the printing machine at different settings.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Bekk type instrument		5627	T479	DIN 53107
Bendtsen type instrument	4420	8791/2		DIN 53108 SCAN P21
Parker Print Surf Instrument	6563	8791/4	T555	SCAN P76
Sheffield Instrument		8791/3	T538	

General Comments/Points to Note

1. The paper smoothness is affected by the raw material selection, it's processing and by coating and finishing processes.

2. Paper smoothness may be related to the other properties such as gloss and coating absorption.

3. The Bendtsen, Parker and Sheffield instruments give instantaneous readings for smoothness.

4. The Parker Print Surf instrument can use either an air flow tube or an electronic impedance device to measure the air flow. This instrument converts the air flow into micrometers (μm) roughness. Bendtsen and Sheffield readings are expressed in mls/minute.

Typical Values

paper	g/m^2	Parker Print Surf micrometers	Bendtsen
Newsprint	40 – 49	2.6 – 4.5	80-140
Commercial printings	45 – 135	0.8 – 2.6	50-300
Test Liner	186		1750
Business Papers	80		100-300

8.4 PROPERTY: GLOSS

Background

Gloss of paper is a property linked to light reflection from its surface. It is an aesthetic feature whereby the surface appears to the eye as shiny or polished. High gloss is a characteristic of papers, which are cast coated, lacquered or plastic, or wax coated. A high gloss is also desirable for high quality prestigious printed images but gloss is generally unsuitable for textbooks.

The level of surface reflection (or degree of gloss) of paper can range from a "Matt" (no gloss), through a low level of gloss (sometimes called "Sheen") to very glossy surfaces. To accommodate these different levels two TAPPI methods are available which use different light incident angles. No International or European standards are currently available, although such standards are under development.

Description of Test Method(s)

Both TAPPI methods use similar instrumentation. A light source provides a converging beam of rays at one of two incident angles on to a flat test sample. A detector receives the reflected light at the same angle as the incident angle. For most papers an incident angle of 75 degrees is used but for papers with a very high gloss (e.g. wax coated papers or high gloss ink films) an angle of 20 degrees is preferred.

The instrument is calibrated using a highly polished black glass surface, of known refractive index, to provide a value of 100 gloss units. Ceramic tiles are then calibrated against the glass surface to provide standards for lower gloss levels. The results are reported as gloss units.

Relevant Standards

	ISO	TAPPI
Gloss at 75 degrees	8254-2 (In preparation)	T 480
Gloss at 20 degrees	8254-3 (In preparation)	T 653

General Comments/Points to Note

1. Surface gloss is influenced in papermaking by the formation of the sheet, calendering, moisture content and by various coatings.

2. TAPPI gloss instruments measure average gloss levels for a paper surface but sometimes the eye can detect variations in gloss on a given surface. An indication of this variation can be made using a "Goniphotometer" with varying angle geometry, although such equipment is non-standard.

3. Gloss measurements can be used in conjunction with ink density values to calculate ink amounts on paper. This is sometimes used to assess print quality.

Typical Values

Using the TAPPI 75 degree angle gloss meter, typical values would range from 10 to 80 gloss units. Using the 20 degree angle typical values would be expected to be in the range 5 to 30 gloss units.

	Gloss at 75°
Uncoated Printing Paper	4 – 6
Matt Coated	10 – 30
Silk Coated	25 – 50
Art coated	65 - 86

8.5 PROPERTY: WHITENESS

Background

Perceived whiteness in paper and board is a commercially important specification and visual assessment is still a frequently used method when comparing samples. This method is influenced by several factors, some physical such as the background colour, nature of the sample surface, type of illuminant and some aspects unique to the person doing the assessment such as personal preference and the capability of the eye.

A great deal of effort has therefore been devoted to the development of methods to allow simple instrumental measurement of whiteness to be made and the most widely used are those based on the work of the Commission Internationale de l'Eclariage (CIE).

Description of the Test Method(s)

The reflectance of the sample is measured and analysed using a spectrophotometer fitted with a suitable light source. The CIE L* a* b* co-ordinates are obtained from which it is possible to calculate the CIE whiteness value, although in most cases modern instruments are likely to be capable of performing the calculation and producing the figure directly. In contrast to the brightness measurement where the sample is illuminated by light having a narrow band or wavelengths centred around 457 nanometers (i.e. blue light), the illuminants for whiteness measurement cover the entire visible spectrum including UV as appropriate. In addition to the CIE whiteness value, which is expressed as a single figure an associated property, the CIE tint index can also be produced. For a perfect non fluorescent white, where the reflectance at all visible wavelengths is 100%, CIE whiteness would be 100 and the CIE tint index 0 and the instrument is standardised using reference standards having these characteristics.

Relevant Standards

METHOD	BS	ISO	TAPPI	OTHER
CIE Whiteness (Outdoor D65/10° Illumination)	BS ISO 11475	11475		
CIE Whiteness (Indoor C/2° Illumination)	BS ISO 11476	11476	T560 T562	SCAN P66

General Comments/Points to Note

1. The method is only suitable for materials that are essentially "white".

2. Considerable differences can exist between instruments and ideally measurements for comparative purposes should be made on the same instrument and at the same time.

3. Although a pure white reflector has a value of 100, it is possible for samples to have whiteness far in excess of 100, due to the presence of optical brighteners, i.e. compounds that fluoresce. When fluorescent samples are assessed, the equipment must be standardised using suitable reference standards, although care must be taken due to the relative instability of fluorescent standard materials.

4. Small amounts of "shading" dyes are often added to paper to enhance it's perceived whiteness. These are usually blues or violets, which counteract the natural yellowness of pulp, and although they reduce the measured lightness (L*) value, they can improve the CIE whiteness value.

5. A study reported in TAPPI Journal concluded that CIE whiteness and visual assessment in average indoor office environments did have a good degree of correlation provided that a suitable light source was used. ("The Whiteness of Paper-Colorimetry and Visual Ranking" B D Jordan and M A O'Neill, TAPPI Journal Vol 74 No 5, May 1991).

Typical Values %

	u.v. in	u.v. out
Uncoated Printings	130-140	80-95
Coated papers	100-130	70-90

8.6 PROPERTY: PICK RESISTANCE

Background

Printing methods require the paper's surface to have a resistance to the transverse pulling force, such as when the paper surface is pulled away from the printing blanket, otherwise the paper's surface may be ruptured and the print quality adversely affected. The paper's pick resistance is defined as the force required to resist fibres or coating material being picked out of the paper's surface during printing: a low value may signify printability problems.

A paper's pick resistance depends on the degree of adhesion of the fibres at the surface (relates to refining and surface strength additives) and its surface adsorption characteristics. It also depends on the internal adhesion characteristics of any coating applied, together with the bonding of such coatings to the paper surface.

Description of the Test Method(s)

Two methods are used to measure pick resistance. These are generally known as the "Dennison Wax" method and the "IGT" method.

For the Dimension Wax method a series of numbered hard resin wax sticks of different adhesive strength are applied to the surface by first melting the wax. Each stick is then pulled vertically from the surface and the number on the wax stick that just resists surface rupture is noted. This method has the disadvantage that it cannot be used if a paper to be tested has a synthetic binder in the coating.

In the IGT method a sample strip is printed with high viscosity tacky oil or high tack ink at an ever increasing print velocity. The printing speed just prior to picking measures the pick resistance. The results of this test are reported as picking velocity in mm/second.

Relevant Standards

METHOD	BS	ISO	TAPPI	OTHER
Dennison Wax method			T459	Paper Fed RTM30
IGT Pendulum method	6225-1	3782		
IGT Electrical method	6225-2	3783	T514	Scan P63

General Comments/Points to Note

1. All methods yield variable results.

2. Picking is closely associated with "Linting" (accumulation of fibre debris or dust from the paper surface onto the printing blanket).

3. In the IGT test a "wet pick test" can be done to establish if a coating, when moistened, has sufficient pick resistance. In this case the sample surface is wetted prior to the application of the tacky material.

4. IGT values can be affected by the paper's moisture content.

Typical Values

Dennison Wax method	Acceptable pick level for Uncoated papers => Wax No 6 Acceptable pick level for Gloss papers =>Wax No 11
IGT method	Acceptable pick level for Coated papers =>1.7m/s

8.7 PROPERTY: DIRT CONTENT

Background

The determination of the number of dirt specks or contraries in pulp, paper or board is a very common test and visual counting methods have existed for many years. These specks can be any unwanted foreign particle that is visible to the eye such as bark, undigested wood (shives), pitch, rust, plastic, slime etc. For pulp, paper and board the number or area covered by such specks on both surfaces and sometimes in the body of the material, can be estimated in either reflected or transmitted light.

Most test methods developed to date for dirt content are visual estimations, but recently instrumental methods, based on flat bed scanners, have started to emerge. The latter methods are particularly useful when the number of dirt particles is very high, such as in recycled papers or pulps.

Estimation of dirt content is important in mill control work and also for the development of specifications.

Description of the Test Method(s)

For International (ISO) or European (EN) standard methods the material is inspected in transmitted light on both sides of the sheet. Specks larger that 0.04mm2 are counted and classified according to area, using a transparent film with spots of known area but having differing shapes and size. The number of specks of each area are expressed either as mm2/Kg for pulp or mm2/m2 for paper.

For the USA TAPPI methods, the lower size limits and principal of the method is the same, but the expression of results is different. For TAPPI methods both the size (area) and the optical density of the specks are estimated and from these observations an "Equivalent Black Area" (EBA) is calculated. In this case dirt specks having a lower optical density, relative to its surrounds, are assigned a size smaller than its actual size, compared to those specks having a high optical density (egg very black specks on a white background). This allows for the lesser visual impact of a "duller" speck but the method does not give the true area of the dirt. For pulp or paper the results are usually expressed as mm2/m2 (ppm) EBA.

Relevant Standards

	BS	ISO	TAPPI	OTHER
Pulp – Estimation of dirt and shives	BS ISO 5350	5350-1,2,3	T213	DIN54362/1
Dirt in Paper and Paperboard	BS EN ISO15755	15755	T437	
Equivalent Black Area and count of visible dirt in pulp, paper and paperboard by image analysis			T563	
Dirt count in paper and paperboard (OCR)			T537	

General Comments/Points to Note

1. These subjective test methods for pulp and paper are very time consuming, can take up to 1.5 hours per determination and are often very variable.

2. In recent standards for chemical pulps, wetting of the pulp sheet prior to assessment is proposed to capture any dirt particles within the body of the sheet.

3. Dirt count is also determined using scanners and image analysis through PC software. A number of software packages are available. Both the spec size and area are reported.

4. Dirt particles in pulp may be on the surface or in the body of a pulp sheet and are regarded as unwanted contraries which may influence the appearance of the paper produced from that pulp. Since pulp is sold by weight, then it is usual to report the dirt content of pulp as mm^2 dirt area/kg weight of oven dry pulp. Dirt particles in paper however, are regarded as a distraction to the aesthetic appeal of the surface of the product. Since paper is sold by area, then it is usual to inspect a known area of the paper surface and report the dirt content as mm^2 dirt area/m^2 surface area of paper. (Or ppm dirt content)

Typical Values

Bleached pulp	Less than 7mm2/Kg
Newsprint from deinked pulp	100 to 300 ppm
Fine paper from deinked pulp	Less than 10 ppm

8.8 PROPERTY: COLOUR

Background

Papers and boards are coloured both for decorative and functional purposes and the matching of the colour of a product against a commercially agreed sample is a frequent requirement of the trade. Colour, however, is not a physical property but a perception by the observer and thus colour depends not only on the sample but also on the conditions under which it is viewed and on the observer. Nevertheless, a visual comparison may be meaningful given standard illumination of the sample, standard viewing conditions and a trained and experienced observer.

However, the need for a reliable instrumental method for colour measurement to remove the vagaries of the visual method has been long recognised and methods have been developed which are rapid and reliable, based on commercially available instruments.

Description of the Test Method(s)

The sample is placed in a colorimeter or spectrophotometer and the reflectance is measured in each case.

The colorimeter uses filters to select three discrete bands of the visible spectrum (red, green and blue), whilst the spectrophotometer makes measurements across the entire range of the visible spectrum. The reflectance values are converted into the tristimulus values, which in turn may be converted into specification values for colour using one of a number of colour space systems, the values uniquely describing the colour. Commonly used colour systems are the Hunter L, a, b system and the CIE L* a* b* or "CIELAB" system. Modern instruments have facilities for automatically computing all the derived values from the measurements and do so quickly.

The reflectance values from the spectrophotometer may be displayed graphically as a spectrophotometric curve.

Differences between samples may also be expressed in numerical terms.

Relevant Standards

	BS	ISO	TAPPI	OTHER
Visual			T515	RTM 23, 1996 (Paper Federation)
Instrumental – Diffuse reflection method	BS ISO 5631	5631	T 524	

Notes

1. Colour system values are calculated from tristimulus values and as such are independent of the equipment used to obtain the latter. Thus, for example, Hunter values do not necessarily need to be derived from values obtained on a Hunter instrument.

2. Two samples may appear to match under one set of lighting conditions but may not match under another. This phenomenon is known as metamerism and can be a major problem. It can be detected when using instrumental measurement by carrying out repeat measurements using different light sources.

3. In all cases, when using colour measuring instruments, manufacturers instructions should be followed.

Typical Values

Not relevant

SECTION 9

TEST METHODS FOR PAPER & BOARD - OTHER PROPERTIES

9.1 PROPERTY: AIR PERMEANCE

Background

Paper and board contain varying amounts of void volume, or porosity, within their fibrous structure. This allows the permeability of air and has major consequences in the manner in which the material behaves during many conversion and end use processes.

A measure of the porosity is made by measuring the rate of air that flows through the sheet under standard conditions and from this the air permeance may be calculated.

Description of Test Method(s)

1. By measuring the flow of air through a fixed area under specified conditions and pressure. This is the basis of the Bendtsen and Sheffield Methods.

2. By measuring the time for a given volume of air to flow through a given area under standard conditions. This is the basis of the Gurley method.

3. For very porous papers, e.g. filter papers, a fixed flow of air is passed through the sample and the pressure drop across the sample is measured.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Bendtsen	6538-2	5636-3		DIN 53120 SCAN P60
Gurley	6538-3	5636-5		DIN 53120 SCAN P19 & P53
			T460 and T536	
Sheffield		5636-4	T547	
Schopper		5636-2		

General Comments/Points to Note

1. Although air permeance is the preferred title for this property 'porosity' and 'air permeability' are often used.

2. The unit for Bendtsen permeance is μm/PaS, that is the mean flow (mls/min) under unit area in unit time at the operating pressure.

3. Both Bendtsen and Gurley are widely used with Gurley often considered a more robust measurement and is often used with less porous papers.

4. Porosity is affected by sheet consolidation. Both cross and machine direction variation in air permeance can be introduced during manufacture.

5. Other methods include Bekk (often used for less porous papers) and Coresta (used for Cigarette Tissue)

Typical Values

By Bendsten (mls/min)

Uncoated Paper	500-1500
Coated Paper	0-10
Test Liner 186 g/m²	25
Gaskets	1-5

By Gurley Air Resistance(s)

Blotting paper	1-2

9.2 PROPERTY: SIZING

Background

Cellulose fibre has a natural affinity for water and if untreated would produce paper unsuitable for the application of water based inks (e.g. writing inks, ink jet printing inks) or for use in offset printing. Difficulties would also arise when water based adhesives or coatings were applied. The term 'sizing' is given to the process of making the paper moisture resistant. In the mill 'sizing agents' can be added in several places but principally they are added at the wet end or at the size press.

Description of Test Method(s)

There are many variations of sizing tests but essentially they divide into four groups:

(a) Penetration of aqueous fluids through paper.

(b) Absorption of water on one surface (Cobb method)

(c) Surface wettability (contact angle)

(d) 'Feathering Tests', when the behaviour of aqueous inks applied to the surface is assessed visually.

Relevant Standards

	Method	BS	ISO	TAPPI	OTHER
1.	Penetration of aqueous fluids through paper				
1.1.	Hercules Method			T530	RTM 15
1.2.	Water resistance		5633	T433	(Paper Fed)
2.	Water Absorption				
2.1	Cobb method	BS EN ISO 20535	535	T441	SCAN P12
3.	Surface Wettability				
3.1	Contact Angle			T458 T558	SCAN P18 RTM16 (Paper Fed)
4.	'Feathering Tests'				

No established Standards

General Comments/Points to Note

1. The water penetration tests are usually employed to determine average level of sizing of paper or board. The principal is to allow water or aqueous based chemical to penetrate through the paper and measure the rate of penetration either colormetrically or by some instrumental means.

2. The Cobb sizing method involves determining the amount of water absorbed in a standard time on one surface. This test is again an average measure of paper sizing.

3. The contact angle measures the resistance to surface wetting. Initial contact angles are a guide to ruling qualities. The rate of change of the contact angles with time is a measure of writing quality and also a guide for the application of edge adhesives.

3. Featherings tests using Pen and are again a quick measure of sizing degree. A French method uses inks of differing aggressiveness. The water resistance is assessed against the ink type.

Typical Values

Cobb Method g/m²

Bond	24-30
Office/Business Papers	22-26
Carbonless Base	18-22
Test Liner (186 g/m²)	100
Unsized	50+

9.3 PROPERTY: DRAINAGE

Background

Drainage measurements are an assessment of the dewatering characteristics of papermaking stock on the machine wire. Two standard methods are available for the measurement of this property.

Canadian Standard Freeness (CSF) - used throughout North America and also in Europe for mechanical pulps.

Schopper Reigler (°SR) – used mostly in Europe

Canadian Standard Freeness is a measure of the readiness with which water drains from the pulp stock, whereas Schopper Reigler (often referred to as "stock wetness") is a measure of the extent to which water is held by pulp under free drainage conditions.

Both methods measure volumes of water but a "high CSF" equates to a "low °SR".

Description of Test Method(s)

Schopper Reigler method – A one litre sample of pulp stock at 0.2% consistency is passed through a machine wire into a funnel with bottom and side orifices. The discharge through the side orifice is collected in a measuring cylinder. The drainage is expressed as ° Schopper Reigler (°SR).

Canadian Standard Freeness method – A one litre sample of pulp stock at 0.3% consistency is passed through a perforated screen plate into a funnel with bottom and side orifices. The discharge through the side orifice is collected in a measuring cylinder. The drainage is expressed as mls Canadian Standard Freeness (CSF).

The immediate reading needs to be corrected for the actual weight of fibre in the sample and for temperature.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Schopper Reigler	BS EN ISO 5267-1	5267/1		SCAN C19 and SCAN M3, RTM 37 (Paper Fed)
Canadian Standard Freeness	6035/2	5267/2	T227	SCAN C21 and SCAN M4

General Comments/Points to Note

1. Schopper Reigler and CSF measurements are often used to assess drainage characteristics on the paper machine or the development rate of pulps when refined. The measurements are significantly influenced by the amount of fines (especially small fines or crill) in the stock.

2. Accurate measurements of Schopper Reigler are dependent on forming a discreet pad on the machine wire. The method is not recommended for very short fibre such as groundwoods or highly beaten hardwood fibres.

3. Both methods are affected by temperature, pH and by the presence of dissolved salts in the dilution water. For intercalibration checks deionised water should be used.

4. Stock left to stand for 30 minutes or more will change in drainage characteristics. It is recommended that such stocks should be re-disintegrated before testing.

4. A correlation between CSF and SR is available (e.g. TAPPI TIS 0809-01)

Typical Values

	SR(°SR)	CSF (mls)
Unrefined softwood kraft	14 – 15	700
Unrefined mechanical pulp	55 – 70	100 –200
Fine Papers Stock	25 – 45	250 – 450
Tracing Paper Stock	>80	<100

9.4 PROPERTY: DIMENSIONAL STABILITY

Background

Papermaking fibres from woodpulp and other natural sources interact with their environment by absorbing or desorbing moisture according to the prevailing conditions. As a result they will exhibit dimensional change. The rate at which this occurs depends on many factors, including the species of fibre, the pulping process and the treatment it receives in the papermill at virtually every stage of the process.

For papermakers this change in moisture content is often manifesting as a change in sheet dimensions in both the machine (x) and cross machine (y) direction. Knowledge of the response to moisture in this way is essential for accurate control of printing and similar processes. Dimensional instability of paper in this context is usually referred to as "Hygroexpansivity".

Description of Test Method(s)

Two ISO methods are available for the determination of Hygroexpansivity. Both methods measure the change in length of a strip of paper, cut either machine or cross direction, when the relative humidity of the environment in which the strip is placed is changed, either from 33%RH to 66%RH or 33%RH to 86%RH. The length change may be measured mechanically or electronically, and the strips are under a small load depending on the grammage of the paper.

A method is also available for determining the expansion of the paper sheet if the sample strips are totally immersed in water under no loading. This is referred to as hydroexpansion.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Paper and board-Hygroexpansivity up to a maximum relative humidity of 68%	6712-1	8226 Part 1		SCAN P28
Paper and board-Hygroexpansivity up to a maximum relative humidity of 86%	6712-2	8226 Part 2		
Paper-Measurement of dimensional change after immersion in water		5635		

General Comments/Points to Note

There is a complex interaction between drying conditions (including restraint during drying), degree of wet pressing and fibre anisotropy with the hygroexpansivity of paper. The dimensional instability of paper at any given point in time is also influenced by the past history of moisture changes to which the paper has been exposed.

Typical Values

Grade	Machine Direction %	Cross Direction %
Carbonless Paper	0.050 to 0.150	0.200 to 0.400
Bond Paper	0.100 to 0.200	0.200 to 0.400
Coated Art Paper (under 200 g/m2)	0.090 to 0.150	0.150 to 0.350
Gasket Paper	0.400 to 1.000	0.500 to 1.100

9.5 PROPERTY: PAPER CURL

Background

Paper curl can be defined as a systematic deviation of a sheet from a flat form. It results from the release of stresses that are introduced into the sheet during manufacture and subsequent use.

Paper curl has been a persistent quality issue and is increasingly important for paper grades being subjected to high speed printing, xerography and high precision converting processes.

There are three basic types of curl, mechanical curl, structural curl and moisture curl.

Mechanical curl develops when one side of the paper is stretched beyond its elastic limits. One example of this is the curl in the sheet which forms near the centre of a roll. Structural curl is caused by two-sidedness in the sheet, that is a difference in the level of fines, fillers, fibre area density or fibre orientation through the sheet thickness. Moisture curl can develop when the paper sheet is being offset printed. One side of the sheet may pick up more moisture than the other, the higher moisture side releases the built in drying strains and the paper will curl towards the drier printed side.

Description of Test Method(s)

Many curl testing methods have been developed often with consideration to the papers end use. These methods fall into three general groups.

Water or moisture is applied to one side of a sample sheet or strip of some given shape, which may be uncoated or coated with some material and its deviation from planarity is measured.

Heat is applied to one side of a paper sample and its deviation from planarity is measured. This is usually a quick quality control procedure for curl measurement.

A pack of samples (about 10 sheets) are drawn from a sealed ream or such samples are drawn after passing through a copier machine. These samples are placed over a visual curl measuring device which exhibits a number of arcs and the curl magnitude is measured as an angle of curvature.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Measurement of curl using single vertically suspended test pieces	BS ISO 11556	11556		
Measurement of curl in cut size office papers	BS ISO 14968			ASTM D4825
Curl or gummed flat paper			T 520	
Degree of curl and sizing of paper			T 466	
Degree of curl of board (Paper Federation)				RTM 2
Curl in paper and Board – Exposure to normal conditions				RTM 3
Curl in paper – Infrared method				RTM 32

General Comments/Points to Note

1. Curl in paper sheets often depends on the position in the paper web from which the sheets were cut, sheets cut from the edges will often exhibit a higher curl value.
2. For flat paper samples curl can be affected by gravity, especially for lighter weight papers; boards are generally unaffected. Technically it is preferred to measure paper curl with suspended samples, although the measurement is more difficult.
3. Several methods of expression of results for curl are used, from a simple measure of the average of uplifting corners in mm. to complex mathematical expressions of "twist". The normal units for curl are a calculation of the inverse radius of curvature expressed in metres^{-1}.
4. The actual curl shape observed in testing or in end use is rarely a simple cylindrical shape but varies depending on its cause. Non-regular shapes are often referred to as "twist".
5. Cockling is a curl related problem, since cockling is small scale out of plane deformations on the paper surface. No standard methods are yet developed although various methods are available.
5. Eight curl measurements carried out according to ISO 14968 on each of four reams of different qualities of cut-size office papers, in a single laboratory, produced results which ranged between ± 0.25m^{-1} and ± 0.35m^{-1} around the mean for each ream.

Typical values

Office/Business Papers (Infrared method)	0 – 5 mm
Carbonless Paper	5 – 30 mm (corner uplift)
Office/Business Papers (ISO 14968)	15 – 40 m^{-1}

9.6 PROPERTY: FORMATION

Background

A paper's formation is an aesthetic quality. It describes the uniformity of the sheet structure with respect to the fibre and filler distribution. An irregular fibre distribution is often described as a 'poor' or 'wild' formation. The sheet formation is best observed in transmitted light and this property is referred to as 'look-through'.

The formation of the paper is important in many paper grades including Fine papers (especially when watermarked). Laminating papers, Overlay papers and Photographic papers.

Currently there are no recognised National or International standard methods available for the quantitative measurement of formation. Some instrumental optical and ß transmission techniques (see below) have been suggested, which may eventually be adopted as standard methods.

Description of the test method(s)

Test methods for assessing formation fall into three main categories:

* Visual Assessments – A sample is held up in transmitted light and compared with a pre-determined sample or samples. The experience of the local operator then decides if such a formation is acceptable. As expected such methods can give rise to highly variable decisions between operators.

* Optical Scanners Measurements – In recent times flat bed optical scanners have been developed (egg by PIRA) that are quick and easy to use, have user friendly programmes and can be used anywhere in the paper mill. In the case of formation measurements the instrument detects variations in optical density across a given area. It provides a readout in optical density units. Such measurements are less reliable if the paper is made from heavily beaten stock, is coloured, highly calendered or printed.

* Beta Radiography Measurements – The use of Beta Radiation transmittance through a paper sample onto X-ray film to measure the mass density distribution (formation) of paper has been known for many years, but the method is too slow and complex to be used for routine testing. Unlike optical transmission methods, the Beta radiation method does have the advantage of being totally dependent on the variation in basis weight across a given area of the paper and can be used irrespective of the paper's make up and condition. Only one instrument produced in Finland "The AMBERTEC Beta Formation Tester", is known to be available to date, which gives a direct quantitative measurement of formation in a paper mill laboratory.

Relevant Standards

None identified

General Comments/Points to Note

1. The paper formation is affected by many factors, including the fibre type, stock preparation, wet end filler and chemical additions, wet end consistency and the design of the wet end forming section on the paper machine.

9.7 PROPERTY: RESIDUAL INK FROM DE-INKED STOCK

Background

De-inked pulp (DIP) prepared from recycled newsprint and magazines will contain levels of residual printing ink depending on the degree to which the pulp is deinked. Paper mills will specify the levels of residual ink that may be tolerated to produce the desired optical properties (namely brightness) of the finished sheet. Finally dispersed ink will tend to reduce sheet brightness, but improve the opacity, whereas large specs of ink will contribute to the dirt count. In either case a measure of the Effective Residual Ink Concentration (ERIC) may be used to control the levels in the finished pulp.

Description of Test Method(s)

ERIC is measured using a spectrophotometer with a light source that emits in the infrared region of the spectrum (950 nm). At this wavelength only ink (and not dyes, lignin or other pigments) absorbs light.

Currently the only laboratory instrument available to measure ERIC is the Technidyne spectrophotometer (which also measures other standard optical properties). ERIC is calculated from measurement of R_0 and R_{00} at 950 nm and using the Kubelka-Munk analysis.

Testing Machines Inc are launching an instrument with ERIC capability in mid 2002.

Relevant Standards

	TAPPI
ERIC Method	T567

General Comments/Points to Note

Expressed as ***ppm*** the value is a measure of the effect of the remaining ink and not the actual amount of ink. This is because the ink may either be agglomerated, in which case it will not absorb the maximum amount of light, or the same amount may be finely dispersed in which case the absorption will be far greater. A visual assessment of the samples should also agree with the ERIC value. A sheet with high ERIC (high ink dispersion) will appear less bright than a sheet with low ERIC (agglomerated ink particles).

Instruments to measure ERIC in-line are also available.

Typical values

	ERIC (ppm)
Pulped recycled fibre (70:30 old newsprint: magazines)	800 – 1200
Deinked pulp (depending on extent of ink removal)	<100 – 200+

9.8 PROPERTY: FRICTION

Background

Friction is the resisting force that occurs between two paper or board surfaces in contact when the surfaces are brought to slide against each other. This property is measured as a coefficient of friction, which is the ratio of the frictional force, to a force acting perpendicular to the two surfaces.

Two components of friction can be measured, these being static and kinetic friction. Static friction is the force resisting initial motion between the surfaces and kinetic friction is the force resisting motion of the two surfaces sliding against each other when already sliding at a constant speed.

Measurement of the coefficient of friction has applications in packaging where a high coefficient will indicate that containers such as sacks, bags and paperboard containers will resist sliding in unit loads or on packaging lines. This property is also important in printing papers, since a specific coefficient of friction is needed so that individual sheets will slide over each other, otherwise double press feeding may result.

Description of the Test Method(s)

Two methods are available for measuring the coefficient of friction. In both methods one test piece is fixed to a table, while a second test piece is fixed to the underside of a sled of known mass.

For the "Incline Plane" method, only the coefficient of static friction is measured. In this method the sled is placed on a horizontal table which is gradually inclined until the sled begins to move. The coefficient of static friction is calculated from the angle of inclination at the moment when sliding starts.

For the "Horizontal Plane" method, the sled is placed on a horizontal table and a pulling force is gradually applied to the sled until it begins to move. The force when the sled begins to slide provides the measure of static friction. The sled continues to be pulled along at a constant speed and the average force to achieve this motion provides the measure of the kinetic friction.

Relevant Standards

METHOD	BS	ISO	TAPPI	OTHER
Incline Plane method			T548 & T815	
Horizontal Plane method	BSISO15359	15359	T549 & T816	

General Comments/Points to Note

1. There is no direct correlation between friction and surface roughness, although the two properties are related.

2. Friction tests are sensitive to any material or specks of material which impart slip. Fillers, coatings, printing inks and many additives used in small amounts will affect friction properties. Care should be taken not to handle the surface of test pieces.

3. Several different values for a sample of paper may be obtained, depending on how the two test pieces are arranged against each other; that is top side/top side, topside/wireside, machine direction/cross direction etc.

4. Paper or board made from unbleached pulp will tend to have a higher coefficient of friction to that made from bleached pulp, due to the former having a higher lignin content, which tends to make the fibres more rigid.

5. The different test methods will rank different paper types in the same order, but the actual test values will not be the same.

6. For some papers e.g. photocopier paper, it is necessary to measure friction properties after multiple slides. Instruments conforming to ISO 15359 are fitted with mechanisms for replacing the sled in the same start position.

Typical values

PAPER GRADE	Horizontal Plane Method	
	Static Friction	Kinetic Friction
Office/Business Papers/Bond grades	0.50-0.65	0.35-0.50
Silk Coated grades	0.45-0.55	0.30-0.45
Gloss Coated grades	0.40-0.50	0.30-0.40

9.9 PROPERTY: PAPER SOFTNESS

Background

Paper softness, like formation, is an aesthetic quality and no simple definition is possible. For paper it is a general term that describes the presence or absence of a pleasant feel of the paper against the person's skin.

Softness of paper is an important property for tissue papers, especially for facial tissue, where a soft tactile quality is usually preferred or a "soft bulking" quality in the case of toilet tissue.

Currently there are no recognised National or International Standard methods available for the quantitative measurement of softness. All current methods are based on subjective panel assessments, usually developed in house at various mills. A softness test method was developed by TAPPI (see below), but this has now been withdrawn.

Description of the Test Method(s)

There are many variations in subjective softness testing methods. Usually a panel of experienced assessors evaluates this tactile property by comparing a "test sample" with a "control". The panel then decides if the "test sample" is at least as "Soft" as the "control" for acceptance.

Several attempts have been made to develop a quantitative test method. One such method, TAPPI T498 "Handle-O-Meter" was developed in 1960, but has now been recently withdrawn by TAPPI, because of difficulty of assessing current highly embossed products, although it is still used for nonwovens. Efforts are still being made to model human tactile response to toilet tissue using optical and mechanical characterisation of paper surfaces, but so far only in research projects.

Testing Machines Inc has two instruments for determining tissue softness in commercial production. These are the Lab Master Bulk Softness Tester and the Lab Master Surface Softness Tester. The latter instrument was developed in conjunction with a leading US tissue producer and has been shown to correlate well with test panel evaluations.

Relevant Standards

None identified.

General Comments/Points to Note

1. In the case of facial tissues, studies have shown that softness can be related to surface smoothness, friction and ease of compression for single sheets.

2. For toilet tissue, a softness impression can be related to the bulk compressibility for a number of plys.

9.10 PROPERTY: FIBRE LENGTH

Background

The determination of fibre length in a pulp sample provides useful information in the likely performance of that pulp quality and subsequent paper properties. Fibre length determinations often form part of a pulp evaluation exercise.

In a pulp mill producing softwood and hardwood pulps on the same drying line, fibre length determination is a key factor in deciding when one pulp type has cleared and the second type is dominant. In fluff pulp manufacture fibre length measurements are also used to optimise the defiberization process.

Description of the test method(s)

Several microscopical methods have been devised to measure fibre lengths, but all are very time consuming. On and off line instruments have now been devised which can very quickly determine fibre length and fibre length distributions, the most well known of the laboratory instruments is the "Kajaani FS200".

The principle of this instrument is to draw a suspension of fibres through a measuring cell in such a way that the fibres pass through the cell in "straight vertical lines" (that is practically no curved fibres). The measuring cell is viewed by a light source on one side and a photo sensor matrix on the other side detects the fibre images. In this particular method a crossed – polarizer set up on either side of the measuring cell is used to discriminate between fibres and other materials, such as air bubbles. The photo sensor matrix senses the length of the images of the fibres from the light that, due to bifrengence, is transmitted through the seconded polarizer; the length of the image is then automatically converted to fibre length.

Relevant Standards

Method	BS	ISO	TAPPI	OTHER
Pulps – Fibre Length by Automated optical analysis Part 1: Polarized light method		16065/1	T271	

General Comments/Points to Note

1. This test method is applicable to all kinds of pulp.
2. Particles less than 0.2mm are not regarded as fibres and are not included in the results.
3. This method is very fast, once the suspension of fibres is prepared it takes only 10 minutes to determine the fibre length on about 5000 fibres.
4. Fibre length values can be expressed in three ways:
   * As mean fibre length
   * As length weighted mean fibre length
   * As mass weighted mean fibre length

   The length weighted mean fibre length is usually preferred to the mean fibre length, since the latter can be distorted if there is an appreciable amount of short fibres present.
5. The fibre length distribution of a papermaking pulp furnish can significantly influence paper properties such as tear strength or the net work strength and bulk in fluff pulps.

Typical Values

	Fibre Length mm
Softwood Pulps	3-4
Hardwood Pulps	0.8-1.2
Straw Pulp	0.5-2.0
Cotton Fibre (Staple)	10-50
Esparto Fibre	0.5-2.5

SECTION 10

10. EMERGING METHODS

New methods are continually being developed and introduced. It takes several years for Standards to be established for such methods. Nevertheless such "Emerging" Methods can be of great value and several are reproduced in this section for general information.

10.1 TENSILE STIFFNESS ORIENTATION (TSO)

Background

This is an ultrasonic measurement of TSO and elastic properties of paper and board. The machine direction (MD) and cross direction (CD) tensile stiffness index are also reported. TSO angle is expressed as the deviation from the actual MD of the sheet and the measured maximum TSI value. The method is increasingly used for packaging paper but is also being applied to printing and writing grades.

The TSI/TSO measurements can be used to optimise machine settings to give the desired CD profiles or the TSI MD/CD ratio recommended for a particular product.

Description of Test Method

The ultrasonic multi-sensor head contains eight pairs of transmitters/receivers arranged in a circle and set 22.5 degrees apart. An ultrasonic signal is transmitted in the plane of the paper. The transmission time between the source and the sensor is measured and its velocity calculated. The velocity squared is equivalent to the elastic modulus (or tensile stiffness) of the paper.

$TSI = v^2 \times C$

Where:
v = propagated velocity of the ultrasonic signal (km/s)
C = Poisson's ratio (approximately 1 for paper)

The TSI can be used to calculate the anisotropy (TSI MD/CD ratio), compression strength, and bending stiffness.

Typical Values

Paper	Typical TSO (degrees)	Typical $TSI_{MD/CD}$ ratio
Copier and laser	±2-3	1.8-2.3
Offset	±3-5	2.2-2.7
Newsprint	±3-5	3.0-5.5
Liner and medium	±5	3.0-3.5
Boxboard	±2-3	2.0-2.5
Sack	±3-5	2.0-2.5

10.2 FRACTURE TOUGHNESS

Background

Fracture toughness is used to determine the propensity of paper to break on the paper machine or printing presses. It is related to the presence in the paper of crack like defects (such as edge tears or holes) which may propagate under an applied load.

Description of Test Method

The test is in two parts. Tensile tests are first carried out in both machine and cross directions at a constant but higher rate of elongation to that described in BS EN ISO 1924-2. Further Tensile Tests are then done in both directions in a similar manner but in this case the test pieces contain a manufactured sharp crack. Computerised software is available to analyse the data from the above tests to produce a "J-Integral" versus elongation curve from which the fracture toughness can be obtained.

10.3 DYNAMIC ABSORPTION TEST (DAT)

Background

The DAT is applied to test the water (or oil) absorbency of paper or board. The measurement reports the contact angle, volume and spread over time of a drop of liquid on the surface of the sheet. DAT can be used to determine the degree of sizing or water (or oil) hold out of paper with time.

Description of Test Method

A drop (typically 4µl) of liquid is automatically applied to the surface of the sheet by the DAT instrument. Immediately a camera is activated to take images at every 0.02 second intervals until the drop is completely absorbed. The image of the drop is analysed to calculate the contact angle, volume and spread. The properties can be reported at any given time or used to establish the absorbency characteristics of the sheet.

10.4 SURFACE SOFTNESS OF TISSUE

Background

Softness, a desired property for certain tissue grades, has been difficult to define and was confined to subjective assessments until the development of an objective test method. Properties such as compressibility, stiffness, roughness and drape have been traditionally used to give a composite measure of softness. Testing Machines Inc. (TMI) has recently introduced an instrument which determines this property giving a result that correlates with user-perceived softness of tissue.

Description of Test Method

The surface softness measurement principle relies of a friction sledge with an area, mass and surface topography that simulates tactile response of a human finger. The sledge is drawn over the test piece and the sensitive electronics track the minute variations in dynamic friction caused by roughness variation of the surface. The surface softness algorithm uses the average coefficient of friction and the roughness, averaged over the two sides and directions of the paper, to calculate softness value.

10.5 PAPER AGEING STANDARDS

Background

There are three standards in the course of preparation:

Ageing on exposure to elevated temperature
Ageing on exposure to pollutants
Ageing on exposure to light

ASTM Standards have been developed for each of these following an extensive study. The first two are being translated into ISO standards with no significant technical changes at this stage.

Description of Test Method(s)

Ageing due to exposure to elevated temperature – This standard seeks to rank papers for their sensitivity to prolonged exposure to elevated temperatures. A temperature of 100°C for 120 hours is employed to provide an acceleration of that deterioration. This procedure is believed to provide a good correlation with prolonged exposure at typical elevated temperatures. Properties measured include folding endurance and tear.

Ageing due to pollutants – This is similar to the standard for exposure to elevated temperature but includes both mechanical and optical properties. One gas only is used, nitrogen dioxide. Papers are again ranked for their resilience to pollutant gas exposure.

Ageing due to exposure to light – It is well known that papers can lose 'whiteness' and their mechanical properties can deteriorate with long term exposure to light. This standard is intended to determine the sensitivity of samples to exposure to light. An accelerated test will involve exposure of specimens for a number of days in a controlled atmosphere to high flux levels of light with a significant UV component. Research is being conducted in Canada to determine appropriate exposure conditions.

SECTION 11

11. USEFUL INFORMATION SOURCES

11.1 TECHNICAL INFORMATION AND DATA, BRITISH STANDARDS INSTITUTE

In 2003, BSI kindly carried out a full review of the standards printed in PITA Year Books and provided a comprehensive update covering many areas connected in some way with paper. The information provided at that time, was well beyond the space limitations of this publication and the Standards shown here are those specifically and directly related to paper production. Other areas covered were related to pulp purchase, core testing, packaging production and testing to mention only a few. Many British Standards now also have EN or ISO labelling and duplicate the standards shown here. Please view the BSI website for current information and up to date details on **www.bsi-global.com/bsonline**.
Alternatively, copies of Standards may be obtained from British Standards Institution, 389 Chiswick High Road, Chiswick, London W4 4AL. Tel: 020 8996 7111. Fax: 020 8996 7048. Where an identical international standard exists, this is shown in the top right hand corner of the record. The ≡ symbol represents items that are identically equivalent. International standards which are either technically equivalent or which contain technical references are not highlighted in this text. Please view the BSI website for more details. **www.bsi-global.com/bsonline**

BS 1000[676]:1984
Universal Decimal Classification. English full edition. Paper industry.

44 pages £40.00 (M), £44.00(NM). IDT/3

BS 1439:1992
Specification for single-ply wet-creped paper towelling

Minimum size and performance requirements for towelling designed primarily for the non-domestic market.
12 pages £14.00(M), £28.00(NM). PAI/10

BS 1467:1972
≡ ISO 623
Specification for folders and files

Definitions and sizes. Includes lever arch files, box files, transfer storage cases. Suspended filing pockets from BS 4438. Spacing and diameter of punched holes for filing.
12 pages £14.00(M), £28.00(NM). FW/3

BS 1521:1972
Specification for waterproof building papers

Quality, workmanship, dimensions, performance.
Class A for prevention of draughts or ingress of water into wall or pitched roof structures, Class B for temporary purposes such as protection of concrete during curing.
16 pages £13.00(M), £26.00(NM). B/546/5

BS 1808:1985
Specification for cut business forms and letterheads

Specifies the sizes of paper for cut business forms and letterheads up to and including ISO A4 size produced by flat sheet printing or rotary printing.
The location of the addressee panel and fold mark on such forms and letterheads intended for mailing in a DL window envelope is also specified.
8 pages £11.00(M), £22.00(NM). PAI/24

BS 1896:1972
Specification for sizes of repographic papers

Specifies types of sensitized paper, sizes of sheets and squareness, widths and lengths of paper in rolls, tolerances, and marking of packages.
8 pages £10.00(M), £20.00(NM). CPW/42

BS 2922-1:1985
≡ ISO 3689:1983
Strength of wet paper and board. Method for determination of the bursting strength of paper and board after immersion in water

Specifies a method for determining the wet bursting strength of paper and board.
6 pages £11.00(M), £22.00(NM). PAI/11

BS 2922-2:1984
≡ ISO 3781:1983
Strength of wet paper and board. Method for determination of the tensile strength of paper and board after immersion in water

Specifies three methods for determining the wet tensile strength of paper and board.
10 pages £11.00(M), £22.00(NM). PAI/11

BS 2924-1:1983
≡ ISO 6588:1981
Aqueous extracts of paper, board and pulp. Method for determination of pH

Provides methods of preparing cold or hot extracts for determination of pH.
8 pages £11.00(M), £22.00(NM). PAI/11

BS 2924-2:1992
≡ ISO 6587:1992
Aqueous extracts of paper, board and pulp. Determination of conductivity

Specifies a method for the determination of the conductivity of aqueous extracts of paper, board and pulp using extracts prepared by a hot or cold method.
8 pages £11.00(M), £22.00(NM). PAI/11

BS 2987:1958
Notes on the application of statistics to paper testing

Outlines elementary statistical concepts (i.e. mean, standard deviation, coefficient of variation, etc.); gives examples of calculations, and recommends computing procedure. Also includes a list of elementary formulae necessary for such calculations, a glossary of statistical terms and symbols, and a bibliography of general application.
36 pages £34.00(M), £68.00(NM). PAI/11

BS 3047:1988
Specification for sizes of posters

Specifies a range of sizes of posters for general display purposes. Also lists special sizes of posters such as those used by railways and bus companies and also common overseas sizes.
8 pages £11.00(M), £22.00(NM). PAI/23

BS 3177:1959
Method for determining the permeability to water vapour of flexible sheet materials used for packaging

Describes a method designed primarily for use with flexible packaging materials such as paper, plastics films and flexible laminates, but suitable also for certain other materials such as rubber sheeting
22 pages £25.00(M), £40.00(NM). PAI/11

BS 3137:1972
≡ ISO 2758 ISO 2759 ISO 3689
Methods for determining the bursting strength of paper and board

Describes the hydraulic methods for determining the bursting strength of paper in the range from 70 kN/m_2 to 1100 kN/m_2 and for board within the range 350 kN/m_2 to 5500 kN/m_2. The pneumatic method, sometimes needed for pulp handsheets and weak papers, is described in an appendix.
28 pages £34.00(M), £68.00(NM). PAI/11

BS 3203:1979
≡ ISO 4046:1978
Glossary of paper, board, pulp and related Terms

English text of terms and definitions accepted by ISO relating to paper, board, pulp, their properties and processes. 28 pages £34.00(M), £68.00(NM). PAI/12

BS 3748:1992
≡ ISO 2493:1992
Method for determination of resistance to bending of paper and board

Specifies a method, based on the beam principle.
8 pages £11.00(M), £22.00(NM). PAI/11

BS 4264:1987 □⇓ ISO 269
Specification for envelopes for commercial, official and professional use

Sizes and styles. Advice on storage is given in an appendix. Excludes envelopes for use with insertion machines and for the storage of X-ray films.
12 pages £14.00(M), £28.00(NM). PAI/33

BS 4415-1:1992
≡ ISO 1924-1:1992
Determination of the tensile properties of paper and board. Constant rate of loading method

Specifies a method of measuring strength using an instrument operating at a constant rate of application of tensile force. It also gives methods for calculating the breaking length and tensile index.
12 pages £14.00(M), £28.00(NM). PAI/11

BS 4420:1990
≡ ISO 8791-2:1990
Method for determination of the Bendtsen roughness of paper and board

16 pages £19.00(M), £38.00(NM). PAI/11

BS 4497:1969
Recommendations for the detection and estimation of nitrogenous treating agents in paper

Describes the problems involved and gives qualitative and quantitative methods for use with certain agents used in paper treatment; applies only to substances that have a strong affinity for acid dyes.
20 pages £26.00(M), £52.00(NM). PAI/11

BS 4574:1970
Recommendation for the determination of the ink absorbency of paper and board by use of K & N ink

Applies to paper and board to be printed by the lithographic, gravure or letterpress process.
10 pages £11.00(M), £22.00(NM). PAI/11

BS 4623:1989
≡ ISO 2784
Specification for folded continuous stationery for impact printers

Sprocket-holed stationery for use with impact printers associated with ADP machines.
12 pages £14.00(M), £28.00(NM). PAI/24

BS 4816:1972
≡ ISO 3036
Method for the determination of the puncture resistance of board

Specifies apparatus and procedure for determining puncture resistance of all types of heavy boards, including corrugated fibreboard, and especially those used in the manufacture of packing cases.
14 pages £11.00(M), £22.00(NM). PAI/11

BS 4817:1972
≡ ISO 3034
Method for the determination of the thickness of corrugated fibreboard

Specifies apparatus and procedures for measuring the thickness of corrugated fibreboard intended for use in manufacturing packaging cases, or used in packing cases. Is applicable to all types of corrugated fibreboard.
10 pages £11.00(M), £22.00(NM). PAI/11

BS 4818:1993
Method for determination of the creasing quality of carton board (Pira method)

Provides a numerical assessment of the creasing qualities of board materials that normally would be converted into cartons on cutting and creasing presses.
12 pages £14.00(M), £28.00(NM). PAI/11
BS 5477:1977
≡ ISO/R 1831
Method for visual assessment, by grid assay, of dirt in paper for character recognition

Measures the proportion of the surface area containing particles that are immediately obvious to the eye. Reports the number of grid squares per 6 m2 containing dirt.
2 pages £11.00(M), £22.00(NM). IST/12

BS 5626-1:1979 □⇓ IEC 60554-1:1977

Cellulosic papers for electrical purposes. Definitions and general requirements
Definitions and general requirements for cellulosic papers for electrical purposes, other than those papers containing modified cellulose.
8 pages £11.00(M), £22.00(NM). GEL/15

BS 5626-2:1979
≡ IEC 60554-2:1977
Cellulosic papers for electrical purposes. Methods of test

Test methods to be used in testing cellulosic papers for electrical purposes for compliance with the requirements of BS 5626-3.
36 pages £34.00(M), £68.00(NM). GEL/15

BS 5626-3.1:1981
≡ IEC 60554-3-1:1979
Cellulosic papers for electrical purposes. Specifications for individual materials. General purpose paper

Requirements for Class 1 general purpose electrical papers when tested by the procedures of BS 5626-2.
12 pages £14.00(M), £28.00(NM). GEL/15

BS 5626-3.2:1985
≡ IEC 60554-3-2:1983
Cellulosic papers for electrical purposes. Specification for individual materials. Capacitor paper

Specifies detailed requirements for kraft capacitor paper types 2.1, 2.2, 2.3 and 2.4 as defined in Part 1.
10 pages £19.00(M), £38.00(NM). GEL/15

BS 5626-3.3:1982
≡ IEC 60554-3-3:1980
Cellulosic papers for electrical purposes. Specification for individual materials. Crepe paper

Specifies detailed requirements for Type 3.1 (Hard) and Type 3.2 (Soft) creped kraft insulating papers as defined in Part 1.
8 pages £11.00(M), £22.00(NM). GEL/15

BS 5626-3.4:1980
≡ IEC 60554-3-4:1979
Cellulosic papers for electrical purposes. Specifications for individual materials. Electrolytic capacitor paper

Gives requirements for three types of paper described in Part 1: absorbent separator paper with long fibres, with short fibres and non-absorbent paper.
8 pages £11.00(M), £22.00(NM). GEL/15

BS 5626-3.5:1995
≡ IEC 60554-3-5:1984
Cellulosic papers for electrical purposes. Specification for individual materials. Special Papers

Requirements for special papers such as those used for cables, transformers and conductor wrapping in accordance with class 1 papers to BS 5626- 3.1:1981.
20 pages £26.00(M), £52.00(NM). GEL/15/3/9

BS 5879:1980

≡ ISO 5635:1978

Method for measurement of dimensional change of paper after immersion in water

Method applicable to most kinds of paper but may not be suitable for papers which become extremely fragile or curl excessively after soaking in water.
4 pages £11.00(M), £22.00(NM). PAI/11

BS 5880:1990

≡ ISO 5637:1989

Method for determination of water absorption of paper and board after immersion in water

A method for the determination of absorption after immersion in water for a specified time. Not applicable to very absorbent papers such as toilet tissue.
8 pages £11.00(M), £22.00(NM). PAI/11

BS 5881:1980

≡ ISO 5638

Method for determination of grammage of single layers of solid fibreboard

Method for determining the grammage of single layers of glued and laminated solid fibreboard. Applicable to all types of this fibreboard provided that the adhesive dissolves under the conditions specified for the test.
4 pages £11.00(M), £22.00(NM). PAI/11

BS 6225-2:1982

≡ ISO 3783:1980

Method for determining the resistance to picking of paper and board: accelerating speed method using the IGT tester. Electric model

Describes a method of operating the electric model of the IGT printability tester in order to provide a measure of the picking resistance of paper and board.
12 pages £19.00(M), £38.00(NM). PAI/11

BS 6388-1:1991

≡ ISO 5630-1:1991

Accelerated ageing of paper and board. Method for dry heat treatment at 105°C

8 pages £11.00(M), £22.00(NM). PAI/11

BS 6388-2:1987

≡ ISO 5630-4:1986

Accelerated ageing of paper and board. Method for dry heat treatment at 120°C or 150°C

Primarily intended for high purity papers such as are used in electrical equipment.
8 pages £11.00(M), £22.00(NM). PAI/11

BS 6388-3:1996

≡ ISO 5630-3:1996

Accelerated ageing of paper and board. Method for moist heat treatment at 80°C and 65% relative humidity

14 pages £26.00(M), £52.00(NM). PAI/11

BS 6410:1991

Methods of test for filter papers

Tests for general, structural, mechanical and functional properties of laboratory, high efficiency air, automotive and industrial filter papers and filter papers for diagnostic applications.
40 pages £41.00(M), £82.00(NM). PAI/13

BS 6504:1984

Method for determination of water absorption of paper and board (Klemm method)

Describes a method of determining the water absorption of paper and board using a closed vessel to provide a saturated atmosphere. The method provides better accuracy than the open vessel method in BS 2916.
6 pages £11.00(M), £22.00(NM). PAI/11

BS 6538-1:1985

≡ ISO 5636-1:1984

Air permeance of paper and board. Method for determination of air permeance: general aspects of testing

Specifies the basic requirements for apparatus and general operating procedures for determining the air permeance of paper and board in the medium air permeance range.
8 pages £11.00(M), £22.00(NM). PAI/11

BS 6538-2:1992

ISO 5636-3:1992

Air permeance of paper and board. Method for determination of air permeance using the Bendtsen apparatus

For use in the medium air permeance range.
16 pages £19.00(M), £38.00(NM). PAI/11

BS 6538-3:1987 □⇓ ISO 5636-5:1986

Air permeance of paper and board. Method for determination of air permeance using the Gurley apparatus

The method also permits the measurement of air resistance by the same apparatus.
10 pages £11.00(M), £22.00(NM). PAI/11

BS 6563:1985

Method for determination of the roughness of paper and board by the Parker Print-surf Apparatus

Provides a standard method of using three types of apparatus currently available and gives guidance on care and maintenance.
12 pages £14.00(M), £28.00(NM). PAI/11

BS 6616:1986

≡ ISO 1831

Specification for paper and print for optical character recognition (OCR)

Requirements for the optical properties of paper, print quality, and character positioning in printed matter for automatic optical character recognition using the character sets OCR-A, OCR-B and E13 B.
20 pages £26.00(M), £52.00(NM). IST/12

BS 6712-1:1995

≡ ISO 8226-1:1994

Measurement of hygroexpansivity of paper and board. Method for the measurement of hygroexpansivity up to a maximum relative humidity of 68%

14 pages £19.00(M), £38.00(NM). PAI/11

BS 6712-2:1991

≡ ISO 8226-2:1990

Measurement of hygroexpansivity of paper and board. Method for measurement of hygroexpansivity up to a maximum relative humidity of 86%

Method for the determination when subjected to change in the relative humidity with which it is in equilibrium from 33% to 86%.
10 pages £14.00(M), £28.00(NM). PAI/11

BS 6890:1987

≡ ISO 5634:1986

Method for determination of grease resistance of paper and board

Applies to creased or uncreased paper and board. It is primarily intended for foodboard, greaseproof, vegetable parchment and similar products.
10 pages £11.00(M), £22.00(NM). PAI/11

BS 6965-1:1988

Creasing properties of carton board. Method for determination of crease recovery (spring back) of 90° fold

Method of test for determining the decrease/increase in stiffness (spring back) after folding.
8 pages £11.00(M), £22.00(NM). PKW/2

BS 7325:1990

≡ ISO 9895:1989

Method for determination of the compressive strength of paper and board by the short span test

12 pages £14.00(M), £28.00(NM). PAI/11

BS 7406:1991

≡ ISO 9932:1990

Methods for determination of water vapour transmission rate of sheet materials (paper and board) by dynamic sweep and static gas methods

Can measure WVTR's as low as 0.05 g/(m_2d) and be used on materials up to 38 mm thick. 16 pages £19.00(M), £38.00(NM). PAI/11

BS 7424:1991

≡ ISO 5628:1990

Guide to general principles for determination of the bending stiffness of paper and board by static methods

Methods in which the mass of the test piece makes a negligible contribution to the line loading.
12 pages £14.00(M), £28.00(NM). PAI/11

BS 7427:1991

≡ ISO 5647:1990

Method for determination of titanium dioxide content of paper and board

Determination by either a spectrophotometric procedure or flame atomic absorption spectrophotometric procedure.
12 pages £14.00(M), £28.00(NM). PAI/11

BS 7463-1:1991

≡ ISO 9184-1:1990

Fibre furnish analysis of paper, board and pulps. General method

General method for the preparation of test slides for fibre furnish analysis.
12 pages £14.00(M), £28.00(NM). PAI/11

BS 7463-3:1991

≡ ISO 9184-3:1990

Fibre furnish analysis of paper, board and pulps. Method of test by Herzberg stain

To be read in conjunction with BS 7463-1.
8 pages £11.00(M), £22.00(NM). PAI/11

BS 7463-4:1991

≡ ISO 9184-4:1990

Fibre furnish analysis of paper, board and pulps. Method of test by Graff 'C' stain

To be read in conjunction with BS 7463-1.
12 pages £14.00(M), £28.00(NM). PAI/11

BS 7463-5:1991

≡ ISO 9184-5:1990

Fibre furnish analysis of paper, board and pulps. Method of test by Lofton-Merritt stain (Wisbar modification)

To be read in conjunction with BS 7463-1.
8 pages £11.00(M), £22.00(NM). PAI/11

BS 7463-6:1995

≡ ISO 9184-6:1994

Fibre furnish analysis of paper, board and pulps. Determination of fibre coarseness

Specifies a method for the determination of fibre coarseness, which is a fibre property used for characterizing pulp.

12 pages £14.00(M), £28.00(NM). PAI/11

BS 7463-7:1995

≡ ISO 9184-7:1994

Fibre furnish analysis of paper, board and pulps. Determination of weight factors

Specifies two methods for determining the weight factor of fibres.
12 pages £14.00(M), £28.00(NM). PAI/11

BS 7500:1995

Specification for marking of recycled paper board

12 pages £14.00(M), £28.00(NM). PAI/12

BS 7614:1992

≡ ISO 9961:1992

Specification for natural tracing paper

Specifies minimum requirements to be used as a draughting medium.

16 pages £19.00(M), £38.00(NM). PAI/20

BS EN 1104:1996

≡ EN 1104:1995

Paper and board intended to come into contact with foodstuffs. Determination of transfer of antimicrobic constituents

12 pages £19.00(M), £38.00(NM). CW/47/3

BS EN 1230-1:2001

≡ EN 1230-1:2001

Paper and board intended for contact with foodstuffs. Sensory analysis. Odour

12 pages £19.00(M), £38.00(NM). CW/47 CW/47/3

BS EN 1230-2:2001

≡ EN 1230-2:2001

Paper and board intended for contact with foodstuffs. Sensory analysis. Off-flavour (taint)

18 pages £26.00(M), £52.00(NM). CW/47 CW/47/3

BS EN 12625-3:1999

≡ EN 12625-3:1999

Tissue paper and tissue products. Determination of thickness, bulking thickness and apparent bulk density
8 pages £19.00(M), £38.00(NM). PAI/10

BS EN 12625-4:1999

≡ EN 12625-4:1999

Tissue paper and tissue products. Determination of tensile strength, stretch at break and tensile energy absorption
8 pages £19.00(M), £38.00(NM). PAI/10

BS EN 12625-5:1999

≡ EN 12625-5:1999

Tissue paper and tissue products. Determination of wet tensile strength

10 pages £19.00(M), £38.00(NM). PAI/10

BS EN 12625-6:1999

≡ EN 12625-6:1999

Tissue paper and tissue products. Determination of grammage

8 pages £19.00(M), £38.00(NM). PAI/10

BS EN 12625-7:2000

≡ EN 12625-7:2000

Tissue paper and tissue products. Determination of optical properties

14 pages £19.00(M), £38.00(NM). PAI/10

BS EN 12858:1999

≡ EN 12858:1999

Paper. Printing and business paper. Requirements for continuous stationery

8 pages £19.00(M), £38.00(NM). PAI/24

BS EN 12960:2001

≡ EN 12960:2001

Adhesives for paper and board, packaging and disposable sanitary products. Determination of shear resistance

10 pages £19.00(M), £38.00(NM). PRI/52

BS EN 13676:2001

≡ EN 13676:2001

Polymer coated paper and board intended for food contact. Detection of pinholes

8 pages £19.00(M), £38.00(NM). CW/47 CW/47/3

BS EN 1541:2001

≡ EN 1541:2001

Paper and board intended to come into contact with foodstuffs. Determination of formaldehyde in an aqueous extract

12 pages £19.00(M), £38.00(NM). CW/47 CW/47/3

BS EN 20187:1993

≡ EN 20187:1993 ISO 187:1990

Paper, board and pulps. Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples

16 pages £19.00(M), £38.00(NM). PAI/11

BS EN 20287:1994

≡ EN 20287:1994 ISO 287:1985

Paper and board. Determination of moisture content. Oven-drying method

Method for all paper and board, including corrugated and solid fibreboards, provided that there is not any substance present, other than water, that will escape at the temperature specified for the test.
8 pages £11.00(M), £22.00(NM). PAI/11

BS EN 20534:1993

≡ EN 20534:1993 ISO 534:1988

Method for determination of thickness and apparent bulk density or apparent sheet density of paper and board

Two methods of measuring the thickness and of calculating the density for the thickness determinations.
18 pages £14.00(M), £28.00(NM). PAI/11

BS EN 20535:1994

≡ EN 20535:1994 ISO 535:1991

Paper and board. Determination of water absorptiveness. Cobb method

Determination of surface water absorptiveness of most types of sized paper and board. Not suitable for newsprint, blotting paper or other absorbent papers.
12 pages £14.00(M), £28.00(NM). PAI/11

BS EN 21974:1994

≡ EN 21974:1994 ISO 1974:1990

Paper. Determination of tearing resistance (Elmendorf method)

A method using the single tear apparatus. Can also be applied to light boards if the tearing resistance is within the range of the instrument.
16 pages £19.00(M), £38.00(NM). PAI/11

BS EN 23035:1994

≡ EN 23035:1994 ISO 3035:1982

Single-faced and single-wall corrugated fibreboard. Determination of flat crush resistance

12 pages £14.00(M), £28.00(NM). PAI/11

BS EN 25264-2:1994
≡ EN 25264-2:1994 ISO 5264-2:1979
Pulps. Laboratory beating. PFI mill method

Applicable to all kinds of pulp and describes furnishing and beating of the stock, withdrawal and distribution of samples, and the beating equipment.
8 pages £11.00(M), £22.00(NM). PAI/11

BS EN 25264-3:1994
≡ EN 25264-3:1994 ISO 5264-3:1979
Pulps. Laboratory beating. Jokro mill method

16 pages £19.00(M), £38.00(NM). PAI/11

BS EN 25651:1993
≡ EN 25651:1993 ISO 5651:1989
Specification for units for expressing properties of paper, board and pulps

Excludes fibre building boards.
22 pages £26.00(M), £52.00(NM). PAI/11

BS EN 643:2002
≡ EN 643:2001
Paper and board. European list of standard grades of recovered paper and board

14 pages £19.00(M), £38.00(NM). PAI/11

BS EN 644:1999
≡ EN 644:1999
Paper. Untrimmed sizes. Primary range and supplementary range designation and tolerances, expression of direction of manufacture

8 pages £19.00(M), £38.00(NM). PAI/16

BS EN 645:1994
≡ EN 645:1993
Paper and board intended to come into contact with foodstuffs. Preparation of a cold water extract
10 pages £11.00(M), £22.00(NM). CW/47

BS EN 646:2001
≡ EN 646:2000
Paper and board intended to come into contact with foodstuffs. Determination of colour fastness of dyed paper and board

8 pages £19.00(M), £38.00(NM). CW/47 CW/47/3

BS EN 647:1994
≡ EN 647:1993
Paper and board intended to come into contact with foodstuffs. Preparation of a hot water extract

12 pages £11.00(M), £22.00(NM). CW/47

BS EN 648:1994
≡ EN 648:1993
Paper and board intended to come into contact with foodstuffs. Determination of the fastness of fluorescent whitened paper and board

12 pages £14.00(M), £28.00(NM). CW/47

BS EN 920:2001
≡ EN 920:2000
Paper and board intended to come into contact with foodstuffs. Determination of dry matter content in an aqueous extract

10 pages £19.00(M), £38.00(NM). CW/47 CW/47/3

BS EN ISO 15755:2000
≡ EN ISO 15755:1999 ISO 15755:1999
Paper and board. Estimation of contraries

14 pages £19.00(M), £38.00(NM). PAI/11

BS EN ISO 186:2002
≡ EN ISO 186:2002 ISO 186:2002
Paper and board. Sampling to determine average quality

18 pages £26.00(M), £52.00(NM). PAI/11

BS EN ISO 1924-2:1995
≡ EN ISO 1924-2:1995 ISO 1924-2:1994
Paper and board. Determination of tensile properties. Constant rate of elongation method

16 pages £19.00(M), £38.00(NM). PAI/11

BS EN ISO 216:2001
≡ EN ISO 216:2001 ISO 216:1975
Writing paper and certain classes of printed matter. Trimmed sizes. A and B series

Dimensions and tolerances.
14 pages £14.00(M), £28.00(NM). PAI/16

BS EN ISO 3037:1996
≡ EN ISO 3037:1996 ISO 3037:1994
Corrugated fibreboard. Determination of edgewise crush resistance (unwaxed edge method)

16 pages £26.00(M), £52.00(NM). PAI/11

BS EN ISO 536:1997
≡ EN ISO 536:1996 ISO 536:1995
Paper and board. Determination of grammage

14 pages £26.00(M), £52.00(NM). PAI/11

BS EN ISO 5457:1999
≡ EN ISO 5457:1999 ISO 5457:1999
Technical product documentation. Sizes and layout of drawing sheets

14 pages £19.00(M), £38.00(NM). TDW/4

BS EN ISO 7263:1995
≡ EN ISO 7263:1995 ISO 7263:1994
Corrugating medium. Determination of the flat crush resistance after laboratory fluting

16 pages £19.00(M), £38.00(NM). PAI/11

BS EN ISO 9706:2000
≡ EN ISO 9706:1998 ISO 9706:1994
Information and documentation. Paper for documents. Requirements for permanence

Specifies requirements for paper intended for documents which require to maintain their integrity for a long period of time.
18 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 10716:1994
≡ ISO 10716:1994
Paper and board. Determination of alkali reserve

For products that contain alkaline material added to improve the resistance to acid attack (degradation).
12 pages £14.00(M), £28.00(NM). PAI/11

BS ISO 10775:1995
≡ ISO 10775:1995
Paper, board and pulps. Determination of cadmium content. Atomic absorption spectrometric method

12 pages £14.00(M), £28.00(NM). PAI/11

BS ISO 11093-1:1994
≡ ISO 11093-1:1994
Paper and board. Testing of cores. Sampling

12 pages £14.00(M), £28.00(NM). PAI/19

BS ISO 11093-4:1997
≡ ISO 11093-4:1997
Paper and board. Testing of cores. Measurement of dimensions

16 pages £19.00(M), £38.00(NM). PAI/19

BS ISO 11093-5:1994
≡ ISO 11093-5:1994
Paper and board. Testing of cores. Determination of characteristics of concentric rotation

Specifies a method for determining the characteristics of concentric rotation of cylindrical board cores which meet certain specified dimensional criteria.
12 pages £14.00(M), £28.00(NM). PAI/19

BS ISO 11093-6:1996
≡ ISO 11093-6:1996
Paper and board. Testing of cores. Determination of bending strength by the threepoint method

10 pages £19.00(M), £38.00(NM). PAI/19

BS ISO 11093-7:1997
≡ ISO 11093-7:1997
Paper and board. Testing of cores. Determination of flexural modulus by the threepoint method

12 pages £19.00(M), £38.00(NM). PAI/19

BS ISO 11093-8:1997
≡ ISO 11093-8:1997
Paper and board. Testing of cores. Determination of natural frequency and flexural modulus by experimental modal analysis

10 pages £19.00(M), £38.00(NM). PAI/19

BS ISO 11093-9:1994 □⇓ ISO 11093-9:1994
Paper and board. Testing of cores. Determination of flat crush resistance

Specifies a method for determining the maximum flat crush resistance of wound paper and board cores.
12 pages £14.00(M), £28.00(NM). PAI/19

BS ISO 11108:1996 □⇓ ISO 11108:1996
Information and documentation. Archival paper. Requirements for permanence and durability

10 pages £19.00(M), £38.00(NM). PAI/11

BS ISO 11475:1999 □⇓ ISO 11475:1999
Paper and board. CIE whiteness, D65/10 degrees (outdoor daylight)

To be read in conjunction with BS 4432-1:1995.
16 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 11476:2000 □⇓ ISO 11476:2000
Paper and board. Determination of CIE whiteness, C/2° (indoor illumination conditions)

To be read in conjunction with BS 4432-1:1995. 20 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 11480:1997 □⇓ ISO 11480:1997
Pulp, paper and board. Determination of total chlorine and organically bound chlorine
12 pages £19.00(M), £38.00(NM). PAI/11

BS ISO 11556:1998 □⇓ ISO 11556:1998
Paper and board. Determination of curl using a single vertically suspended test piece

20 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 11605:1995
≡ ISO 11605:1995
Paper and board. Calibration of variable-area flowmeters

Specifies a method for the calibration of flowmeters as used in instruments for the determination of air permeance and roughness/smoothness of paper and board.

16 pages £19.00(M), £38.00(NM). PAI/11

BS ISO 13542:1995
≡ ISO 13542:1995
Paper and board. Specification for internal diameters of cores for reels

8 pages £11.00(M), £22.00(NM). PAI/19

BS ISO 13820:1996
≡ ISO 13820:1996
Paper, board and corrugated fibreboard. Description and calibration of compression testing equipment

16 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 14968:1999
≡ ISO 14968:1999
Paper and board. Cut-size office paper. Measurement of curl in a pack of sheets

16 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 15319:1999
≡ ISO 15319:1999
Recycled pulps. Estimation of visible contraries by instrumental means using reflected light

18 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 15360-1:2000
≡ ISO 15360-1:2000
Recycled pulps. Estimation of stickies and plastics. Visual method

18 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 2471:1998
≡ ISO 2471:1998
Paper and board. Determination of opacity (paper backing). Diffuse reflectance method

14 pages £19.00(M), £38.00(NM). PAI/11

BS ISO 2758:2001
≡ ISO 2758:2001
Paper. Determination of bursting strength

20 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 2759:2001
≡ ISO 2759:2001
Board. Determination of bursting strength

20 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 5626:1993
≡ ISO 5626:1993
Paper. Determination of folding endurance

Methods for determining the folding endurance of paper using the Kohler Molin, Lhomargy, MIT or Schopper testers.
20 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 5631:2000
≡ ISO 5631:2000
Paper and board. Determination of colour (C/2°D). Diffuse reflectance method

18 pages £26.00(M), £52.00(NM). PAI/11

BS ISO 777:2001
≡ ISO 777:2001
Paper, board and pulp. Determination of Calcium

14 pages £19.00(M), £38.00(NM). PAI/11

BS ISO 778:2001
≡ ISO 778:2001
Paper, board and pulp. Determination of copper 14 pages £19.00(M), £38.00(NM). PAI/11

BS ISO 779:2001
≡ ISO 779:2001
Paper, board and pulp. Determination of iron

14 pages £19.00(M), £38.00(NM). PAI/11

BS ISO 9198:2001
≡ ISO 9198:2001
Paper, board and pulp. Determination of atersoluble sulfates

12 pages £19.00(M), £38.00(NM). PAI/11

DD ENV 12281:1997
≡ ENV 12281:1996
Paper. Printing and business paper. Requirements for copy paper for dry toner imaging processes

24 pages £26.00(M), £52.00(NM). PAI/24

DD ENV 12282:1997
≡ ENV 12282:1996
Paper. Printing and business paper. Determination of edge dust
16 pages £14.00(M), £28.00(NM). PAI/24

DD ENV 12283:1997
≡ ENV 12283:1996
Paper. Printing and business paper. Determination of toner adhesion

14 pages £11.00(M), £22.00(NM). PAI/24

DD ENV 12448:1997
≡ ENV 12448:1996
Paper. Printing and business paper. Determination of the coefficient of static friction

14 pages £11.00(M), £22.00(NM). PAI/24

DD ENV 12497:1998
≡ ENV 12497:1998
Paper and board. Paper and board intended to come into contact with foodstuffs.
Determination of mercury in an aqueous extract

10 pages £11.00(M), £22.00(NM). CW/47

DD ENV 12498:1998
≡ ENV 12498:1997
Paper and board intended to come into contact with foodstuffs. Determination of cadmium, lead and chromium in an aqueous extract

10 pages £11.00(M), £22.00(NM). CW/47

DD ENV 12625-2:1999
≡ ENV 12625-2:1999
Tissue paper and tissue products. Procedures for sampling and conditioning

10 pages £11.00(M), £22.00(NM). PAI/10

DD ENV 12625-8:2001
≡ ENV 12625-8:2001
Tissue paper and tissue products. Water absorption time, water absorption capacity. Manual and automated test method

14 pages £11.00(M), £22.00(NM). PAI/11

PAS 29:1999
Disposable pulp products for use in healthcare

Specifies performance requirements, a water retention test and a maceration test.
10 pages £11.00(M), £22.00(NM). PAI/11

11.2 CONFEDERATION OF PAPER INDUSTRIES ROUTINE TEST METHODS

These are held by the Confederation of Paper Industries (CPI) who have the copyright.
The following is the complete list of available methods.

List of Test Methods

RTM1 1991 – Surface oil resistance test for paper and board (inclined plane method)
RTM2 1991 – Degree of curl of board
RTM3 1991 – Surface pH value: indicator smear technique
RTM4 1991 – Surface pH value: electrode technique
RTM5 1991 – Blue reflectance (brightness) EEL
RTM6 1991 – Opacity (paper backing) EEL: Printing opacity of paper
RTM7 1972 – (Withdrawn) – Determination of pentachlorophenyl laurate in paper and board. Declared obsolete 1990
RTM8 1972 – (Withdrawn) – Determination of glycerol in paper and board. Declared obsolete 1990.
RTM9 1991 – Laboratory beating – Lampen Ball Mill
RTM10 1991 – Dynamic tensile strength of paper – Van der Korput
RTM11 1992 – Added fluorescent substances in paper and board – detection by hot water leaching method
RTM12 1973 – (Withdrawn) – Contaminant odours in paper and board – rapid method. Withdrawn in 1998 as alternative standards being developed at international level
RTM13 1996 – Split second oil absorption of coated papers
RTM14 1973 – (Withdrawn) – Water resistance – hot water floatation method. Withdrawn in 1991 due to lack of use
RTM15 1992 – Water resistance – dry indicator method (cold water floatation)
RTM16 1992 – Water resistance – angle of contact method
RTM17 1992 – Water resistance – water drop absorption method
RTM18 1992 – Water resistance – edge wicking test
RTM19 1973 – (Withdrawn) – Water resistance – cold water penetration method (Variable head). Withdrawn in 1991 as equivalent to ISO 5633
RTM20 1975 – (Withdrawn) – Consistency of stock – rough check. Withdrawn in 1990 as covered by BS5878:1980
RTM21 1975 – (Withdrawn) – Added fluorescent substances in paper and board – detection by dioxane/water spot test. Declared obsolete 1993.
RTM22 1991 – Diffuse blue reflectance (Z brightness of fluorescent paper and board)
RTM23 1996 – Colour of paper and board – visual assessment
RTM24 1977 – (Withdrawn) – Instrumental measurement of colour. Declared obsolete 1993.
RTM25 1996 – Sampling for moisture content – Fourdrinier Wire Part
RTM26 1996 – Accelerated maturing of chemically wet-strengthened papers and boards
RTM27 1996 – "Droop Test" – determination of stiffness
RTM28 1981 – Determination of compression rigidity (ring crush and column crush resistance) of paper and board
RTM29 1982 – (Withdrawn) – Total absorptive capacity of paper – rapid method. Withdrawn in 1993 as method incorporated into BS 1439
RTM30 1989 – 1989 – Paper and board picking resistance by the Dennison Wax Method
RTM31 1989 – Curl in paper and board – exposure to normal conditions
RTM32 1989 – Curl in paper – infra-red method
RTM33 1992 – Pen and ink sizing test
RTM34 1996 – Fines content of pulp stock
RTM35 1996 – Fibre length index of chemical pulp stock
RTM36 1996 – Water retention value (WRV) of pulp stock
RTM37 1996 – Drainability or wetness of pulp stock, Schopper Reigler (SR) method
RTM38 1996 – Oleic acid absorption test
RTM39 1998 – Measurement of ply bond strength using the Scott-Bond method

Copies of these test methods are available from the CPI
Cost (Complete set): Members £25, Non-members £70.
Information originally provided by The Confederation of Paper Industries
Nigel Barnwell.
Tel: (01793) 889 629

GLOSSARY OF TERMS

See relevant fact sheet section.

11.4 BIBLIOGRAPHY

Title	Author	Published by
Pulp and Paper Testing	Jan Erik Levlin and Liva Soderhjelm	Fapet Oy
ISO Standards Handbook Paper, Board ad Pulps	ISO	ISO 1998
Properties of Paper: An introduction, Second Edition	W.E. Scott and J.C. Abbott In collaboration with S. Trosset	TAPPI Press 1995
Testing Guidebook	L.D. Hahn	TAPPI Press 1990
TAPPI Test Methods		TAPPI Press 1999

11.5 USEFUL CONTACTS

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F: 00-41-22-733-34-30

European Standards Organisation (CEN)
Rue de Stassart 36
B-150 Brussels
Belgium

T: 00-32-2-550-08-13
F: 00-32-2-550-09-66

11.6 EQUIPMENT SUPPLIERS

For a full list of suppliers visit www.pita.co.uk or refer to Paper Technology

Supplier (click on name for full information)	Products
Ambertech Oy	Formation Sensor (B-ray mass distribution)
Lloyd Instruments Ltd	Tensile strength & other testing equipment
Lorentzen & Wettre	A wide range of testing equipment including the Autoline testing station
Messmer Buchel TMI	A wide range of paper and board testing equipment
Metso Automation Ltd	The PaperLab testing station
PTS	DOMAS spec count and formation
Technidyne Corp.	Colour, Brightness and Residual Ink measurement equipment.
Tendring Pacific	A wide range of testing equipment
Zwick Roell	Paper & Packaging testing equipment