BILLERUD

Handbook

FOR SACK KRAFT PAPERS AND PAPER SACKS

Contents

THE PURPOSES OF THIS HANDBOOK

Billerud is a global leader in paper and packaging materials made from cellulose fibers, and we are passionately committed to sustainability, quality, and customer value. We serve customers in more than 100 countries through nine production units located in Sweden, the USA, and Finland. Our materials are used in a wide range of packaging applications, including one of the most demanding segments – paper sacks.

LET US GUIDE YOU

The purpose of this handbook is to help the packaging industry make the right choices according to each producer's demands and prerequisites for paper sacks. It is geared toward technicians and other specialists who are tasked with optimizing production, and enhancing the performance and quality of their products.

SHARING EXPERTISE

For almost a century, we have been gathering knowledge about paper sacks and we are delighted to share this extensive knowledge with customers all over the world.

Our close collaboration with equipment manufacturers and customers has provided us with deep insights into production and filling processes, enabling us to contribute to the optimization of conversion, filling, and packaging.

Finally, we work closely with research institutes to ensure that we are always at the forefront of innovation, industry standards, and legal issues.

CHAPTER 1

Sack kraft paper

Scandinavian sack kraft paper is the strongest paper known to man. The main reason is the high quality raw material, with fibres from trees, which have grown very slowly due to the harsh Scandinavian climate. This makes the fibres extremely long and strong.

The essential raw material

Sack paper is produced from chemical pulp and distinguished for its porosity and high strength. These properties make it optimal in the packaging of powdered goods such as construction materials, foodstuff, minerals and chemicals.

The paper acts as a natural filter during the aerated filling process, keeping the valuable contents inside the sack while efficiently letting the air out. [1, 2]

There are three main groups of sack kraft when the classification is made according to the stretch value in the machine direction:

- Flat kraft, with a stretch of 2-3%.
- Semi-extensible sack kraft, with a stretch of, 5-7%.
- Extensible sack kraft, with a stretch of, >8%.

Sack papers are also classified based on their air resistance as conventional or high porous:

- Conventional sack kraft, porosity over 7 Gurley seconds.
- High porous sack kraft, porosity under 7 Gurley seconds.

Some sack kraft paper grades are available with additional functions such as:

- Friction patterns.
- Improved wet strength.
- Clay coating.
- Moisture barrier.

COATED SACK KRAFT PAPER

Some sack kraft papers, typically flat kraft papers, are available with a clay coating on the print side. The clay coating improves the printability of the paper.

Semi-extensible sack kraft papers are also available with a barrier coating that provides the paper and the sack with a moisture barrier. The water vapor barrier in those sack kraft papers gives the sack the same moisture barrier as a slit or perforated free-film.

1) Paper Sacks – Design for Recyclability Guidelines, Prepared by RISE Bioeconomy & Health on behalf of CEPI-Eurokraft and Eurosac

2) High material efficiency (eurosac.org)

Paper properties and testing methods

Paper properties are measured in the machine direction (MD) and in the cross direction (CD), since there are significant differences in the properties, depending on the orientated fibre flow out of the headbox on the paper machine.

If the index of a certain property is needed, it should be calculated by dividing the actual value with the grammage for the paper in question. Please observe that the units of the property then will change.

PAPER TESTING CLIMATE (ISO 187)

The paper sample must be conditioned in the standard climate to reach equilibrium moisture before testing.

Standard climate for paper testing is 50% RH (relative humidity) and 23 °C.

The reason for conditioning is that the paper properties are strongly dependent of the paper moisture.

GRAMMAGE, g/m² (ISO 536)

The grammage, basis weight, is measured by weight and surface area. In on-line measurement the grammage is measured by beta radiation.

MOISTURE CONTENT, % (ISO 287)

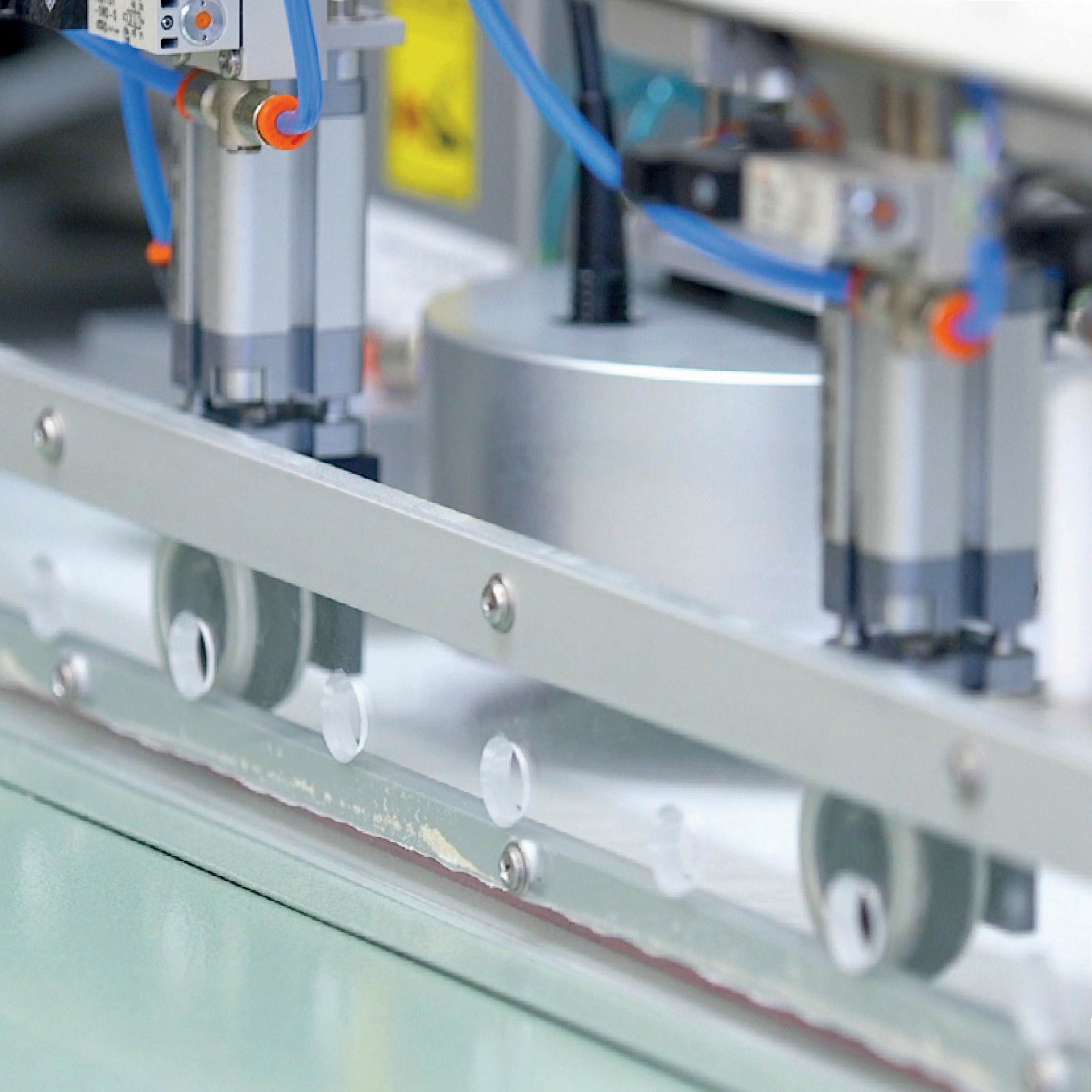
The moisture content is measured by weighing the sample before and after oven drying at 105 °C. The moisture content is dependent on the surrounding climate and influences most of the paper properties. The moisture content is measured on-line in the paper machine.

AIR RESISTANCE, Gurley, s (ISO 5636/5)

The air resistance is a measurement of the time for 100 ml of air to pass through a specified area of the paper sheet.

Short time means a highly porous paper. Note, that this can be described as high air permeance as well as low air resistance.

For valve sacks with powdered goods a highly porous paper gives higher filling speed, smaller sack volume and a cleaner filling process.

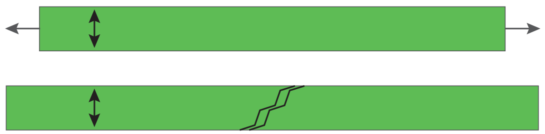


TENSILE STRENGTH, kN/m (ISO 1924/3)

The tensile strength is the maximum force that the paper will withstand before breaking.
In the test a strip of 15 mm width and 100 mm length is used with a constant rate of elongation.
The tensile strength is one parameter in the measurement of the TEA, the most important sack paper property. In the same test the tensile strength, the stretch and the TEA value are obtained.

STRETCH, % (ISO 1924/3)

Stretch is an important property for sack paper.
The stretch is a measurement of the elongation of the paper extended to rupture. Stretch is the other parameter in the measurement of the TEA.

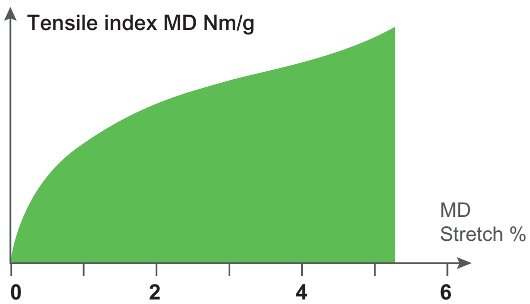


WET TENSILE STRENGTH MD, WET STRENGTH, KN/M (ISO 3781)

This test method is used for paper with wet strength resin added. Tensile strength in MD is tested on a test piece saturated with water.
The relative wet strength is the relation between the wet tensile strength (MD) and the dry tensile strength MD.The wet strength is important for root crop sacks.

TENSILE ENERGY ABSORPTION (TEA), J/m² (ISO 1924/3)

TEA is the main paper property for calculating the strength of the paper sack wall.
This is verified by the correlation between TEA and drop tests. By dropping a sack, the filling goods will move when reaching the floor. This movement means a strain on the sack wall.
To withstand this strain the TEA should be high, which means that a combination of high tensile strength and good stretch in the paper will then absorb the energy.



This diagram shows that TEA is the combination of tensile strength and stretch. The TEA is the coloured area under the curve.

WATER ABSORPTION, COBB60-TEST, G/M² (ISO 535)

The sizing of the paper is measured as a Cobb-value which is the amount of water absorbed by the paper surface in a specified time.
The most common test is Cobb60 where the time is 60 seconds.

TEAR STRENGTH, mN (ISO 1974)

The tearing force is the force required continuing the tearing from an initial cut in a paper sheet. The tear strength is important for e.g., sewn sacks where the needle holes can be a source of an initial cut. Perforations are also potential initial cuts.

SURFACE ROUGHNESS, Bendtsen, ml/min (ISO 8791/2)

The roughness of the paper surface will impact the printability of the paper, but it has no direct relation to friction.

Bendsten roughness test is an air leakage method, and a higher air flow means a rougher surface.

Other methods for measuring smoothness are Sheffield, Bekk, PPS etc.

BRIGHTNESS, % (ISO 2470)

High brightness gives a good general appearance to printing. The brightness is the amount of the incoming light that will be reflected by the paper surface. The measurement is made with blue light, wavelength 457 nm.

BURST STRENGTH, kPa (ISO 2758)

The burst strength is a measurement of the maximum pressure, which is possible to apply on the paper in a right angle to the surface.

A bulging circular elastic diaphragm applies the pressure.

FRICTION COEFFICIENT, (ISO 15359, Tappi T-815)

The paper friction is important for good palletizing properties of the filled sacks. Friction is, however highly influenced by printing and general handling of the sacks.

GLOSS, % (Tappi T480)

Gloss is the ability of the paper ability to reflect the incoming light in a specified angle. Paper gloss increases by clay coating and calendaring.

WATER VAPOUR TRANSMISSION RATE, WVTR, g/m², 24h (ISO 15106-2)

WVTR-test measure the transmission of water vapor through a paper at a specified time in specified conditions, typically 23°C and 50% RH.

In addition to the above tests your supplier can measure many other properties that are essential for specific applications. The most important testing methods and conversion factors listed on pages 45-59.


L&W DENSOMETER
003.0
LINE IND.
CC
100
50
150
25
200
300
GURLEY SEC.
SEC
ZERO
MAINS

Moisture influence

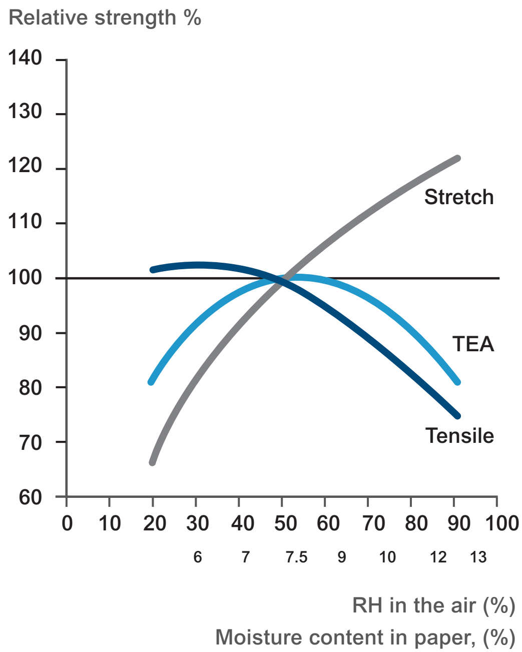
Paper is a hygroscopic material. This means that the moisture in the surrounding air influences the paper properties.

In a climate with high relative humidity the paper will have higher moisture content and opposite in a drier climate. Therefore, all paper testing should take place in a standardized climate of 50% RH and 23 °C.

The variations of TEA, tensile strength and stretch with relative humidity in the air, are shown in the figure.

- Stretch increases and tensile strength decreases with high moisture.
- TEA has an optimum at 7-10% moisture contents in the paper, which corresponding to 40-70% relative humidity.

However, a major part of TEA is left at very low paper moisture, for example after filling with hot cement of 90-100 °C.



Wrapping and storage

The reels are carefully wrapped with reel end covers and reel wrap to avoid damage or contamination during handling and storage.

The reel wrap and the outer reel end covers have a moisture barrier that keeps the moisture content of the material at a stable level, which is important for good runability during converting.

An optimized stock level should be held to ensure a fluent operation at the sack converter regarding raw material demand as well as to delivery fluctuations.

BASIC RULES

- Keep the reel wrapping in place on the reels as long as possible.
- Allow 24 hours storage time for the reels in machine/printing room for conditioning, with the wrapping on.
- Use a well-ventilated warehouse with controlled conditions: 10-30°C and 30-60% RH
- Avoid extreme atmosphere and temperature variations.
- Handle stored materials with care.
- Store reels on the end, and arrange reels so that their labels are clearly visible.
- Keep cleanness and order in the warehouse with good access to the stored material.
- Use clamp trucks for reel handling.
- Train the personnel in handling techniques.

Standard testing methods for sack paper

PROPERTY	Unit	ISO	Tappi
Grammage	g/m^2	536	410
Thickness	µm	534	411
Density	g/cm^3	534	411
Tensile strength	kN/m	1924/3	494
Stretch	%	1924/3	494
TEA (Tensile energy absorption)	J/m	1924/3	494
Tear strength	mN	1974	414
Burst strength	kPa	2758	403
Roughness Bendtsen	ml/min	8791/2	538
Brightness	%	2470	452
Gloss	%		480
Water absorption, Cobb 60s	g/m^2	535	441
Air resistance, Gurley	s	5636/5	460
Moisture	%	287	412
Friction, static coefficient of friction		15359	480
Wet tensile strength	kN/m	3781(mod)	456
Water vapor transmission rate	g/m^2 24h	15106-2	

Please note that the testing methods in the different standards might not always be identical. Therefore, it is very important to specify which standard and method is used. The SI-units are given for properties tested with ISO standards.

Conversion factors

	From US units	Conversion factor	To ISO units
Grammage	lbs/3000 ft^2 (lbs)	1.6275	g/m^2
Grammage	lbs/ream	1.6275	g/m^2
Grammage	lbs/1000 ft^2	4.8824	g/m^2
Caliper	1 in*10-3 (mils)	25.4	µm
Density	1 lb/ft^3	16.018	kg/m^3
Tensile strength	1 lbs/in	0.17513	kN/m
TEA	1 ft lb/ft^2	14.5939	J/m2
Tear strength	1 g	9.80665	mN
Burst strength	1 lb/in^2 (psi)	6.8950	kPa
Water Absorption, Cobb60	1 lbs/1000 ft^2	4.8824	g/m^2
Air resistance, Gurley	1 s/100 cc	1	s/100 ml
Weight	1 Short Ton	907.2	kg
Weight	1 Metric Ton	1000	kg
Weight	1 Pound (lbs)	0.45359	kg
Weight	1 Ounce (oz)	28.3495	g

	From ISO units	Conversion factor	To US units
Grammage	1 g/m^2	0.6146	lb/3000 ft^2
Grammage	1 g/m^2	0.6146	lb/ream
Grammage	1 g/m^2	0.2048	lb/1000 ft^2
Caliper	1 µm	0.0394	in*10^3 (mils)
Density	1 kg/m^3	0.0624	lb/ft^3
Tensile strength	1 kN/m	5.7100	lbs/in
Stretch	1 %	1	%
TEA	1 J/m^2	0.0685	ft lb/ft^2
Tear strength	1 mN	0.1020	g
Burst strength	1 kPa	0.1450	lb/int^2 (psi)
Water Absorption, Cobb60	1 g/m^2	0.2048	lb/1000 ft^2
Air resistance Gurley	1 s/100 ml	1	s/100 cc
Weight	1 kg	0.0011	Short Ton
Weight	1 kg	0.0010	Metric Ton
Weight	1 kg	2.2046	Pound (lbs)
Weight	1 g	0.0353	Ounce (oz)

CHAPTER

2

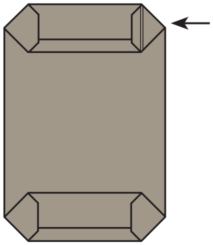
Paper sacks

The fact that the paper quality is the most important factor for sack quality and cost efficiency in the distribution system, is well known world-wide. The development of high-quality papers has made a major contribution in that respect. There are two principal types of paper sacks, open mouth sacks and valve sacks.
They can consist of one or more plies and may incorporate a barrier for specific applications.

Valve sacks

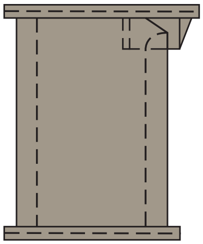
VALVED PASTED

Flat sacks from flush cut or stepped end tubes. The bottoms have a hexagonal shape. The flush cut tube is the simplest way to produce a sack with folded and pasted ends. The bottoms must be capped with a rectangular paper sheet to give them sufficient strength, to improve sift-proofing and to give a flat surface, which may be used for identification data, etc.


Valved Pasted

VALVED SEWN

Flat or gusseted sack from flush cut tubes only. The valve is inserted by a manual operation. The shape of the filled sack is not as good as the pasted type.


Valved Sewn

SINGLE PLY SACKS

The TEA-values of sack papers have been increased due to intensive development work during the years. The 2x70 g/m² sack is now used even for 50 kg sacks.

A further reduction of grammage may bring some disadvantages like unstable convertability in the sack production lines. An interesting alternative is then to make 1-ply sacks of 110 or 120 g/m² paper. Billerud has therefore developed suitable paper grades for this application; QuickFill® Single, which is available i both white and brown.

VALVE DESIGNS

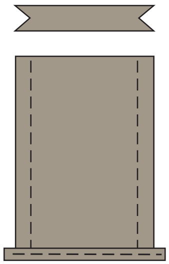
The valves that may be incorporated into sacks are many and varied, they may be internal or external. Different types of material can be used, for example paper, PE, non-woven and textile. Special coatings can be used to make the valve heat or ultra sonic sealable.

After filling external valves can be tucked by hand into the pocket formed by the fold. If necessary, some valves may be made narrower than the sack end.

Open mouth sacks

OPEN MOUTH SEWN

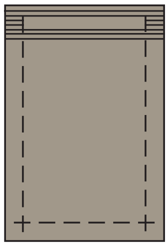
Flat or gusseted from a flush cut tube. This type of sack is easily filled using simple equipment. They are suitable for powdered, granular products, cereals and root crops.



Open Mouth Sewn

OPEN MOUTH PINCH CLOSED

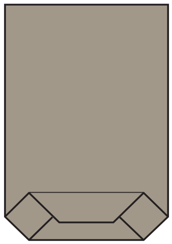
Flat or gusseted from a stepped end tube. This type of sack may be used as an alternative to a sewn sack. It may be preferred where a hermetically sealed package is required. If necessary the open end can be sealed by reactivating a pre-applied coating of hotmelt adhesive. The inside ply, if polymer coated, can be heat sealed to prevent ingress of moisture. This type of sack is particularly useful for packaging hygroscopic materials.



Open Mouth Pinch Closed
(Roll bottom, single closed)

OPEN MOUTH PASTED

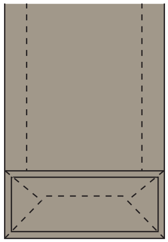
From a flat tube only, generally flush cut. The bottom has a hexagonal shape, but when filled the sacks have rectangular bottoms.



Open Mouth Pasted

OPEN MOUTH S.O.S.

The sack is always gusseted. This sack is produced on a specific machine combining a tuber and a bottomer. The bottom has a rectangular shape. S.O.S. means Self-Opening Satchel.



Open mouth S.O.S.

TOP CLOSURE OF OPEN MOUTH SACKS

All open mouth sacks may have their tops closed by sewing. However pinch sacks are generally closed by reactivation of a pre-applied hotmelt adhesive and this requires the use of special equipment.

CHAPTER 3

Sack manufacturing

Most paper sacks are printed before converted and then stored. This chapter will go through the whole process of sack manufacturing and highlight some areas from a paper perspective.

Printability and appearance

Most paper sacks are printed on the outer ply. The main reason for printing industrial sacks is to identify the content, but there is an increasing demand for more information and improved appearance. For consumer sacks a high-quality finish is an important commercial factor.

The dominant printing method in the sack industry is flexography. For simple 1-3 color prints, sack paper may be printed in-line in the tubers, or more often nowadays, in separate pre-printers. Print quality as well as productivity is improved with pre-printing.

The print quality depends on the right combination of the artwork, printing press, plates, anilox rollers, colors, and paper surface. Most industrial sacks are printed in 1-4 colors. Process per-print is commonly used for more demanding applications, such as consumer sacks.

FLEXOGRAPHIC PRINTING MACHINES

Flexography is the fastest growing printing method. For modern flexo presses the technology, efficiency and capacity is very much improved. For process printing the anilox rollers, color application system, web video control, and the cleaning and drying system are all very important. New presses may be equipped with 8-10 color stations. Older flexo presses can still give good print quality if the machines are well maintained and the anilox rollers regularly changed.

PRINTING INKS

Most flexo printers use water-based inks. In-house color blending systems and viscosity control are useful tools. The friction of a printed surface depends on the friction properties of the dried printing ink.

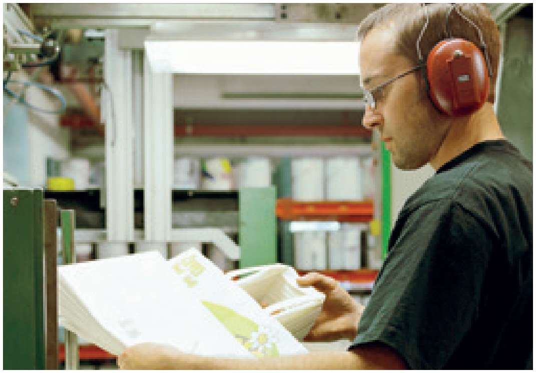
PRINTING PLATES

The trend is to move from photopolymer plates to photopolymer sleeves. Laser engraved rubber plates and sleeves are becoming more common. Plate manufacturers have materials with different thickness and hardness. For example, reduced thickness in high quality process printing and softer plates to improve print quality on rough substrates.

PAPER GRADES

Billerud has a wide range of sack kraft papers for various sack constructions as well as printing demands. For good printing results the paper grade selected should have the right appearance, formation and opacity, and a generally suitable print surface. Brown sack paper gives a good print quality, but white sack paper is recommended when lighter colors, half tone printing and improved total appearance is required.

Calendered or clay-coated papers are options for more demanding process printing.



Converting

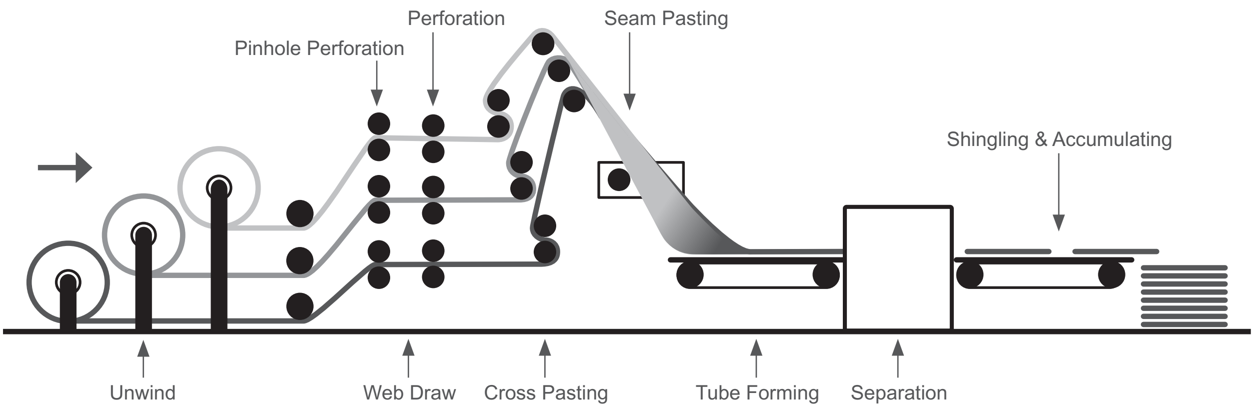
The production of paper sacks is an entirely automatic process.
It is divided into two main parts: tube forming and bottom folding.

TUBER

In the first step of tube forming, paper and film (if applied) could be vent-hole perforated to improve the air permeability, if high porous paper is not used.
They are combined by glue at the cross-pasting unit were after the longitudinal glue seam is applied at the edge of the layer.

In the next step, the layers are formed into a continuous tube.

Individual tubes are then separated and bundled at the shingling conveyer.
These bundles are transported from the tuber to the bottomer.

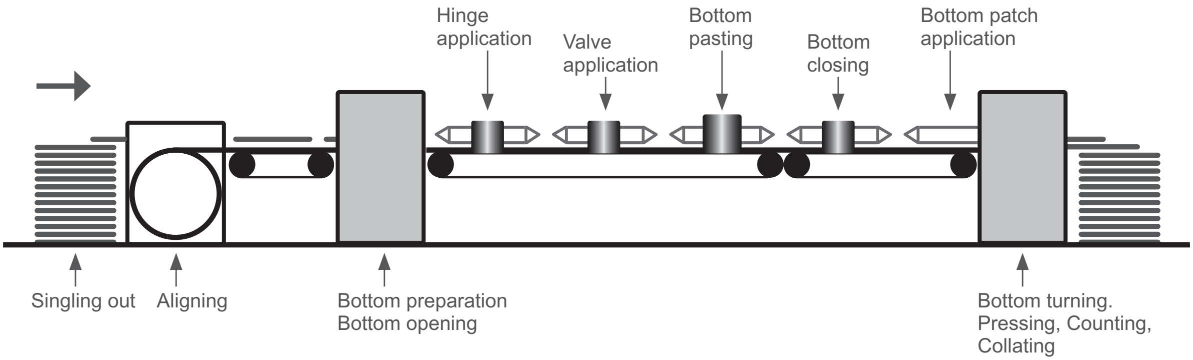


BOTTOMER

In the bottomer, the bottom is folded and pasted, and the top is either left open or folded with a valve depending on the type of paper sack being produced.
Afterwards, the sacks are transported via a press section, which ensures efficient paste distribution and adhesion, to a palletizing unit.

The production process is monitored by electronic inspection systems and machine operators.

All paper sacks are tailor-made and cater to the specific area of usage, product type and transportation needs.



Curing of paper sacks

Normally paper sacks are filled and handled without any issues, but if they fail, for example if they break on the side of the valve during filling, one likely root cause could be a too high moisture content.

During the sack manufacturing process glue, with a high water content, is used. This water is absorbed by the paper and results in the sack having an elevated moisture content for some time after production. Paper sacks must therefore be allowed to dry to the specified moisture content prior to being used. The drying time is dependent on sack construction, humidity, temperature, type and amount of glue.

Total sack moisture is a sum of the moisture in the paper and the moisture which is absorbed from the glue.

The paper´s moisture content depends on the environment and will be higher when exposed to high humidity climate as paper will absorb moisture from the atmosphere. When paper is produced it has normally 7-8% moisture, but in very humid climate it is not unusual that it can reach up to 10%.

This needs to be considered when curing sacks in for example tropical climate, where curing will need some extra time.

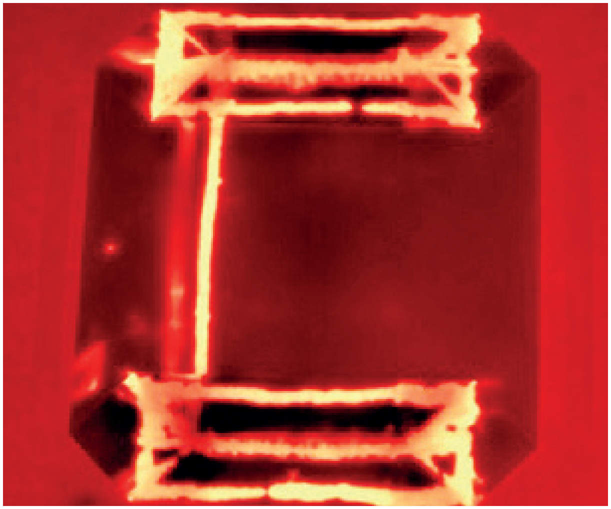
Glues normally contain circa 80% water. Directly after manufacture, it is not unusual that the average total sack moisture content reaches 16-18%, with levels greater than 20% measured in the valve area. This is disadvantageous since it is in the valve area that the sack is most stressed during the filling operation.

THE SACK DRIES, OR CURES, IN TWO PHASES

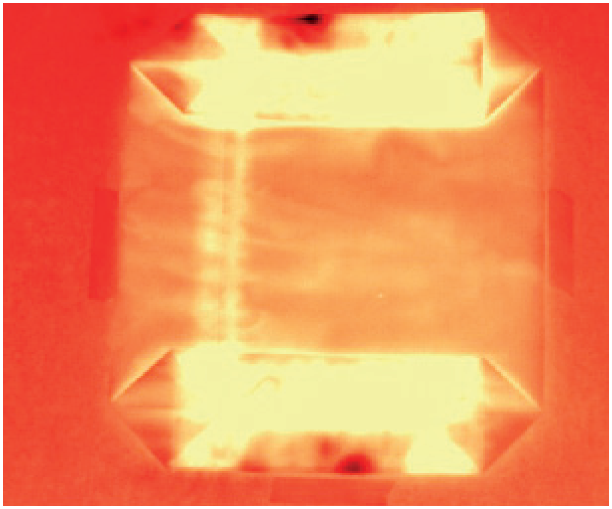
In the first phase the moisture moves within the paper as, due to high capillary forces, the paper absorbs the moisture until equilibrium is reached within the paper – this takes about 7-8 days.

After this, the second drying phase starts and the moisture starts evaporating to the atmosphere. Depending on the relative humidity of the atmosphere and the amount of water absorbed from the glue (this depends on the glue solids content), the sack will need another 1-2 weeks to cure completely. The drying procedure, especially in the second phase, can be accelerated by using various methods such as drying rooms and tunnels.

DRYING OF PAPER SACKS - COMPARISON



The sack directly after production



The sack after one week

Storage conditions for paper sacks

The storage area for paper sacks should be a weatherproof covered building having good ventilation. Sacks should be stored raised off the ground to allow air to circulate beneath them.

Storage areas should be free from contamination sources such as dust.
Dust may encourage mould growth and insect infestations, and corrosive vapours will damage the paper plies and reduce the strength of the sacks.

When automatic sack applicators are used, the supplier will deliver sacks packed as flat as possible and put a frame on the top of each pallet. Ensure that sacks are maintained in good condition by careful stacking, especially of partly used units. Always store sacks so that they may be used in rotation according to when they were delivered (first in, first out).

CHAPTER 4

Paper sack Performance

High-quality papers are vital for efficient sack production and distribution. Specifically, they are essential for pasted valve sacks, providing strength and proper deaeration during filling. Traditional sack papers require perforations for deaeration, weakening the sack and creating unfavorable working conditions. However, high-porous extensible papers eliminate the need for perforations, improving strength, reducing materials, and enhancing workplace safety. In summary, these papers are a game-changer for sack quality and cost efficiency in distribution systems.

Paper sack strength

For filling and handling systems in general we recommend geometric TEA-values according to the following table.

Sack strength is of course very much linked with paper strength and when calculating sack strength it is necessary to first calculate the total paper strength. TEA is the property that best describes paper strength, and it also correlates very well with drop testing.

A paper will have to be strong in both directions, that is both MD (Machine Direction) and CD (Cross Direction), and to consider both directions the geometrical TEA is calculated. This is done by using the following formula.

$$\text{Geometrical TEA} = \sqrt{(\text{TEA MD} \times \text{TEA CD})}$$

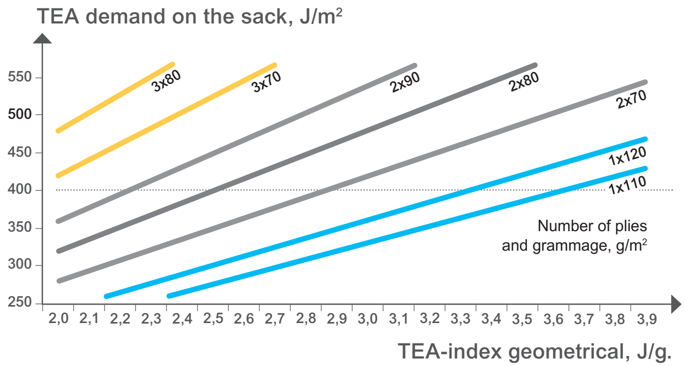
The total TEA in a sack is then calculated by adding the Geometrical TEA for each paper ply.

HANDLING CONDITIONS

	Normal	Tough
Geometric TEA in sack for 25 kg - sack J/m²	330-390	400-450
Geometric TEA in sack for 50 kg - sack J/m²	430-490	500-550

- Normal handling: Modern packing facility, palletization, and good transport infrastructure.
- Tough handling: Manual handling in packing and transportation.

THE IMPORTANCE OF TEA FOR THE SACK CONSTRUCTION. NONPERFORATED SACKS



From the diagram we can see the following:

- To reach 400 J/m² when a low-quality paper is used with a geometrical TEA-index of 2.25 J/g, the sack must be made of 2-ply of 90 g/m² each.
- High quality paper, with a geometrical TEA index of 2.9 J/g, makes it possible to use 2 plies of 70 g/m²-paper for the same total sack strength.
- A single-ply sack, for 25 kg goods, can be made of a 110 g/m² paper with a TEA-index of 3.65 J/g. The TEA-value will then be 400 J/m².

Billerud delivers sack paper grades with very high geometrical TEA index. This means there are great possibilities to reduce packaging material by use of Billerud papers.

Calculations for paper sacks

The sack strength and material reduction will be best calculated with the Billerud Sack Calculation Tool, which can be found on Billerud´s website.

Paper Quality	Total TEA needed in the sack	Geometrical TEA index of paper	Total grammage in sack	Grammage of each ply		Weight of each sack	Material reduction	Amount of paper needed
				2- ply	3- ply	at 1 m² sack surface		for 1 million sacks
	J/m²	J/g	g/m²	g/m²	g/m²	g	%	tons
Supplier 1, unperforated sacks	450	2.15	210		70	210	0	210
Supplier 1, perforated sacks *)	450	1.88	240		80	240	-14	240
QuickFill Brown SE	450	3.25	140	70		140	33	140

*) The perforation reduces the TEA-index by 13% in this example.

The reduction of packaging material also brings the following advantages:

- Less transport costs for the reels.
- Less paper per sack – better profitability.
- Less paper in stock per million sacks produced (less capital in store).
- Fewer reel changes in the tuber.
- More sacks per pallet – less transport costs.
- Faster filling thanks to better total porosity.
- Better tear strength of each ply – if fewer layers but higher grammage is used.

Billerud sack paper is among the strongest paper in the world. The main reason is a high-quality fibre raw material from trees which have grown slowly in a harsh Scandinavian climate.

Deaeration for valve sacks

The ability of sack paper to allow air to pass is specified as Gurley-value in seconds. The demand for high productivity and high filling speeds have further increased the need for high porous papers. When filling sacks with powdered goods like cement, gypsum or flour, the need for deaeration is very high as lots of air will have to pass through the sack wall.

ADVANTAGES OF HIGH POROUS PAPER

By using high porous paper the sack will be exposed to less strain during filling; therefore, a lower sack breakage could be expected. The air escapes quicker from the filled sacks and therefore the size of the sack can be reduced; experience shows that a reduction of 4-10% is possible. Perforation of the sack is no longer necessary, which then reduces dusting at filling and gives a better environment and cleaner sacks. Perforation of the sack reduces the TEA value by at least 10-20%.

BARRIERS AND DEAERATION

When a free-film, perforated or slitted, is incorporated in the sack construction will the total porosity of the sack be reduced. Extensive studies show that a combination of free-film and porous papers give an acceptable permeability of the sack, especially when the film has a rather open area.

There are solutions available regarding sack constructions that enables the sack to perform good in filling with a deaeration system that enables the air to escape out in various air channels instead of perforating sacks or usage of high porous paper. This is very useful especially when barrier papers are used, at Billerud we recommend a top-deaeration system that enables the air to escape in the top of the sack.

Material Protection

The sack must have a suitable deaeration for good performance in the filling process, a strength that withstand forces in the filling process and during storage and handling of the filled sacks.

In certain applications must the sack provide moisture protection against water vapor transmission from the surroundings.

MOISTURE BARRIER

Water vapor from higher relative humidity will transfer trough the sack into the filling goods during storage of filled sacks. How much moisture that will enter the sack is called water vapor transmission rate (WVTR). If the filling goods are sensitive to moisture must a protection against water vapor be incorporated into the sack. The moisture barrier is traditionally introduced in the sack with a free-film, but the deaeration demands during filling means that the free-film is normally slit or perforated. The WVTR increases with the open area of the free-film. Therefore, it will be a compromise between sack permeability and WVTR value. A somewhat less open free-film in combination with a high porous sack paper a may still result in a sack with sufficient porosity, and an acceptable protection from moisture.

For maximal protection against moisture can a free-film without perforations or slits be used. For these applications we recommend the top deaeration concept that provides enough deaeration in the sack for it to be filled in a normal way.

Today there are also alternative solutions available with a moisture barrier included in the paper, e.g., coated sack papers, which gives the needed moisture protection without a separate free-film.

The combination of a barrier paper and a sack construction with top deaeration ensures a sack with good filling performance and a good moisture protection without introducing a free-film into the sack construction.

CHAPTER 5

Paper Sack Testing

In order to ensure that you have the right solution for your specific situation factors such as strength, filling performance and shelf life could be essential to fulfil. There are a number of standards and sack tests that could be used to measure the sack´s performance.

Drop tests

Drop testing is the most effective way to test sack strength and correlates very well with the paper strength. In addition, drop testing immediately shows defects in the construction of the sack, regarding e.g. gluing, symmetry, design, folds, etc.

FLAT DROP TEST (ISO 7965/1)

Drop testing of filled sacks onto the main faces from a constant height, or regularly increasing height, will test the strength of the end closures as well as of the component plies.

The progressive height method will start from 0.85 m with an increment of 0.15 m after each drop until breakage, whereas the constant height method is made from 0.8 m or 1.2 m.

Depending on the size of the sack, the nature of the filling content (e.g. dangerous goods), and the actual conditions the sack is facing in its life cycle, the height can be selected to either 0.8 m or 1.2 m. For more challenging applications and dangerous goods the 120 cm drop height is recommended.

BUTT DROP TEST (ISO 7965/1)

Drop testing of filled sacks onto the top and/or the bottom of the sack from a constant height, or regularly increasing height, will test the strength of component plies of a sack but will not test the strength of the end closures. The progressive drop height method will start from 0,3 m with an increment of 0,05 m after each drop.


BILLERUD
QuickFill® Clean
zero
up to 10%
up to 99%
Faster filling = Higher productivity
Less paper = Better economics
Compact shape = Efficient handling
High strength = Less breakage and waste
Dust-free = Safer, healthier, less waste
billerud.com

Deaeration tests

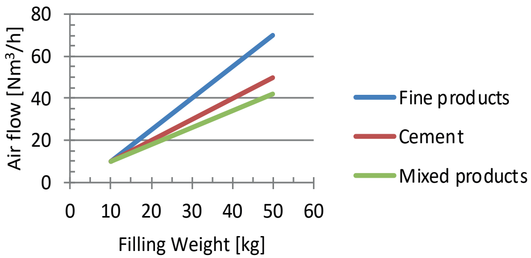
During the process of filling a paper sack with powdered goods, the air contained by the filled material needs to escape easily from within the sack. Therefore, deaeration or permeability of the paper sack is closely related to filling productivity and hence a high permeability will ensure a fast and effective filling process.

SACK DEAERATION TEST - MEGA GURLEY

Deaeration of manufactured valve sacks can be tested with the Haver Air Flow Tester, (Mega Gurley tester), which is shown in Figure 1. This instrument measures the permeability of the whole sack and includes all aspects of the sack construction such as the paper layers, glue seams and barrier layers. The valved sack is mounted on an expanding spout, which ensures no leakage of air and air is blown into the sack. The airflow is measured with rotameters at different pressure drops and this gives a very good indication on how the sack will perform during filling of powdered materials. See the Billerud and Haver&Boecker norm “Sack permeability” for more details.

SACK POROSITY TEST – BIG GURLEY

With a Big Gurley equipment it is possible to measure the interaction between packaging material and filling goods. This is done by simulating filling of a sack by pressurising a chamber filled with the filling goods that is sealed by the packaging material. The airflow through the packaging material is measured and can be done with air only or in interaction with the actual filling goods. This measurement will help to ensure the best possible construction of the paper sack can be made.



Filling tests

A filling test in a pilot filler helps you verify that your sack performs well in terms of filling speed, pressure and prevention from of product leakage during filling.

FILLING DEGREE

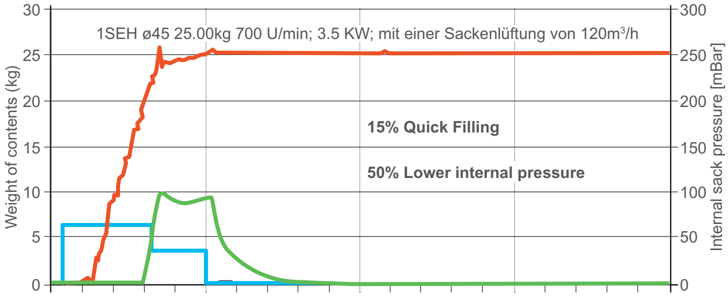
The filling degree of a sack is a matter of appearance but even more important, how the sack handles. A sack which is under filled will feel soft and collapse when carried. A sack which is over filled on the contrary, will feel rigid to carry but will be harder to grab due to rounder corners, as well as it will be more difficult to palletize and stack.

An incorrectly filled sack will also break more easily when dropped, why sack performance can be significantly influenced by the filling degree. See the Billerud and Haver&Boecker norm "Filling degree" for more details.

FIELD TRIALS

When paper sacks are being introduced into an entirely new market area, and particularly if multiple handling is involved, it is advisable to carry out at least a small initial field trial. Then all involved parties have the possibility to follow and evaluate the technical performance.

BILLERUD QUICKFILL® SACK – 2 PLY SEC



Gewicht [kg]	25.00
Max. Druck [mbar]	**99**
Füllzeit Grob [s]	3.39
Füllzeit Fein [s]	1.25
Füllzeit gesamt [s]	**4.64**
Sackformat	380x475x130
Sack	Billerud

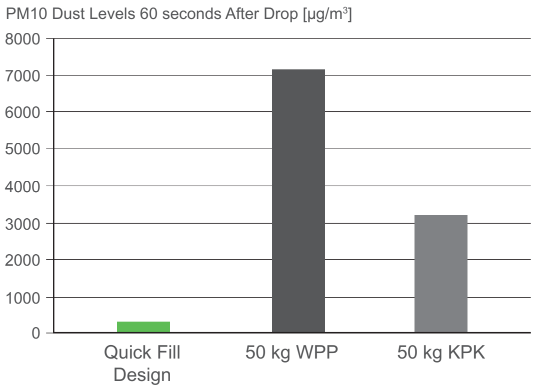

HAVER
PILOT FILLING MACHINE
HAVER
BILLERUD
QuickFill® Clean
close to
zero
product loss
up to
10%
productivity gain
up to
99%
dust reduction
Faster filling = Higher productivity
Less paper = Better economics
Compact shape = Efficient handling
High strength = Less breakage and waste
BILLERUD

Dust exposure analysis

When packaging powdered goods such as cement and chemicals, the aim must be to eliminate product dust along the whole value chain.

Using sacks that generates dust results in product loss and contamination of surroundings.
The consequences of this are:

- A negative impact on the health of people and nature
- Increased maintenance costs as the dust causes higher wear rates
- Reduced profits due to product loss



A Dust Exposure Analysis enables you to measure how effectively your sack packaging and process performs in terms of dust control and will assist in identifying areas of improvement. Such analysis also enables the testing of new concepts, leading to the implementation of an optimized sack packaging solution.

A high porous sack, such as a sack made of Billerud Quickfill papers, should not be perforated and thus will be significantly less dusty than regular non porous sacks. Our studies have showed that a paper sack can reduce the dust in the filling operation or during handling of the sacks by as much as 70%.

Gluing tests

THE TACK, OPEN AND SETTING TIME

There are a number of important glue characteristics to consider during sack converting. The major ones are:

- Tack of an adhesive refers to how sticky it is.
- Open time of an adhesive is the period which the product can form a satisfactory bond.
- Setting time is the period that is necessary for an adhesive to reach a satisfactory bond after application.

A setting time analysis, measures the time from application of the glue to the point where satisfactory bonding has occurred. This time is very important to prevent disturbances in the converting process of paper sacks.

SEAL STRENGTH

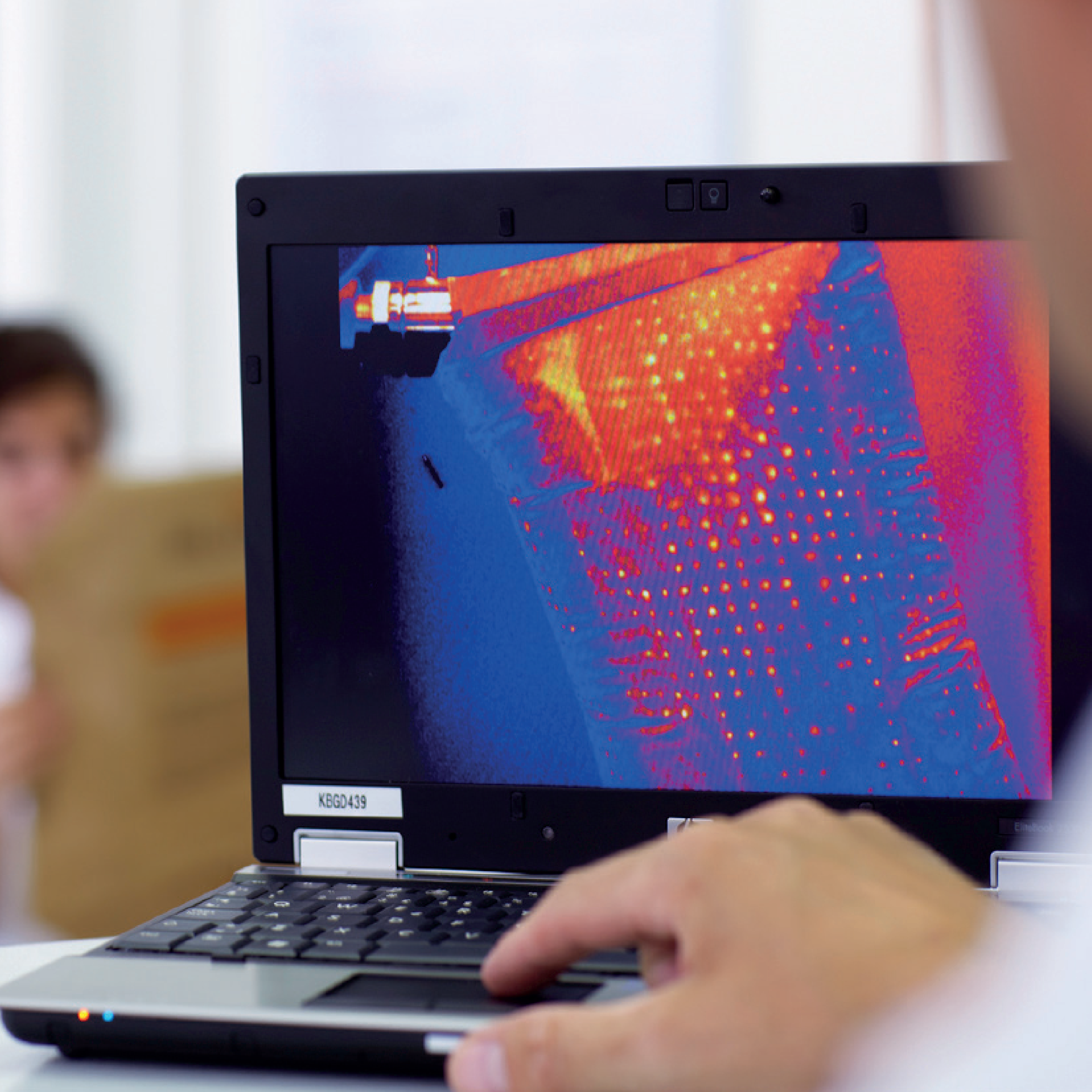
Seal strength is one of the most important sack strength characteristics and some minimum level is a necessary requirement to ensure sack integrity.

By measuring the glue seam in the tensile tester an adequate seal strength level can be determined.

Thermography analysis

WHAT THE EYES CANNOT SEE

The Billerud paper sack laboratory has a range of high-tech tools at its disposal. One is the high-speed thermography technology that enables deeper insights into sack performance. It can detect weak spots in a sack design and helps identify areas for improvement. The thermograph converts an object's infrared radiation to images, allowing a visualization of the differences in temperature. Thermal imaging also allows for non-contact testing of an object and is suitable in all performance tests, e.g., drop test, filling test or deaeration test.


KBGD439

Shelf life – Moisture barrier test

The are a lot of filling goods which are sensitive to moisture (Hygroscopic), and it is therefore very important to consider the water vapor transmission rate (WVTR) of the packaging. WVTR correlates to shelf life of the product and can therefore be used to assess the shelf life of a product, if the climate to which the packaging will be exposed, is known.

WVTR is a measure of how resistant the packaging is to water vapor in the surrounding air and is expressed as the weight of water vapor that passes through a unit area of the packaging wall per 24 hours (g/m2 day). The WVTR measurement is carried out according to one of 2 standards of measuring WVTR (ISO 2528 or ISO 15106-2).

THE CUP METHOD – ISO 2528

The Cup method according to ISO 2528 uses a cup filled with a dry desiccant. The sack wall material combination is fastened by means of a lid on the cup by pressing it against a rubber seal that is placed around the rim of the cup, see Figure 1. The cup is placed in a climate controlled chamber with the desired test climate normally either the normal climate 23°C/50% RH or the tropical climate 38°C/90% RH. Finally, the cups are weighed at specific time intervals in order to measure weight increase of the desiccant and hence the WVTR can be calculated.

MOCON

Another method of measuring WVTR is using ISO 15106-1 (Part 2) where an infrared measurement technique is used to establish WVTR performance. The Mocon method is used for packaging for more demanding applications with very high requirement on barriers. This test is more sophisticated and accurate for barriers in the low WVTR range than the Cup methodology.

Standard testing methods for paper sacks

There are several ISO standards for paper sacks that should be considered when manufacturing and using paper sacks.

PROPERTY	ISO	EN
Vocabulary and types - Paper	6590/1	
Description and measurements		26591-1
Part 1 : Empty paper	6591/1	
Paper sack volume	8281/1	
Dimensional tolerances for	8367/1	28367-1
Drop test for paper sacks	7965/1	27965-1
WVTR - Cup method	2528	
WVTR - Mocon	15106/1	

PACKAGING – SACKS – VOCABULARY AND TYPES – PART 1: PAPER SACKS (ISO 6590 –1)

This standard defines terms commonly used in paper sack manufacture.

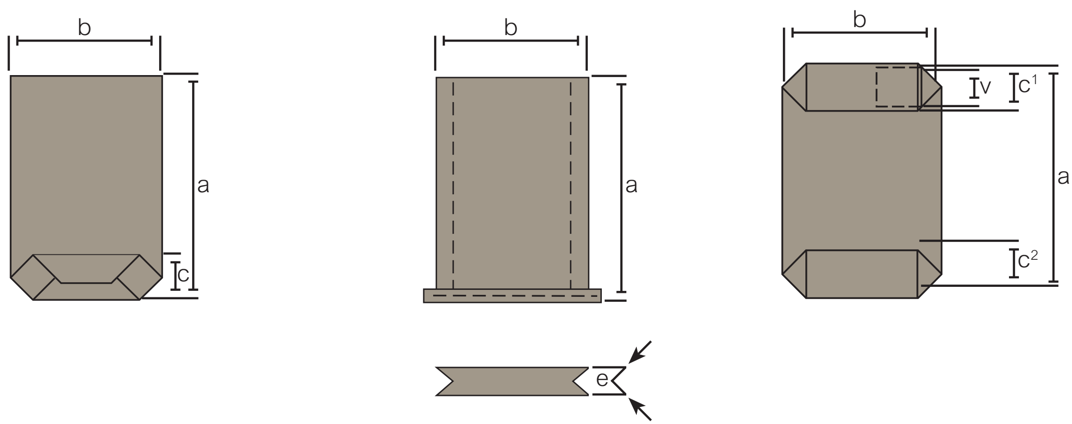
MEASUREMENT OF EMPTY SACKS (ISO 6591 –1)

This standard specifies the method of measuring the dimensions of empty paper sacks. All dimensions are external and will be expressed in millimetres.

Measurements will be made in the centre of the sack.

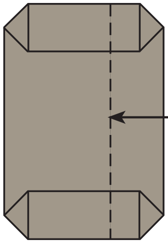
DEFINITIONS AND SYMBOLS:

- Length of sack (a): distance between the transverse edges of the flat sack.
- Width of sack (b): distance between the longitudinal edges of the flat sack.
- Width of gusset (e): distance between the external creases of th opened out gusset.
- Width of bottom (c): distance between the bottom edge folds.
- Width of the valve (v): internal dimension of the valve between the valve edge folds.



VALVE POSITION (EN 26591-1)

The following designation is applicable to both pasted and sewn valved sacks. With the longitudinal seam downward and displaced to the right of the sack, when viewed from above, the valve position shall be described as TOP or BOTTOM and as LEFT or RIGHT as shown in figure below.



SACK VOLUME CALCULATION (ISO TECHNICAL REPORT 8281/1)

The ISO Committee has developed a formula giving the possibility to calculate the volume and the size of a filled sack by using the dimensions of the empty sack. The symbols of the empty sack dimension are the same as those described in EN 26591-1.

Volume calculation for valved pasted sacks.
(V in litres, A, B, C in mm).

$$V = b^2 (0.2668\,a + 0.4047\,c - 0.1399\,b) \times 10^{-6}$$

Filled dimensions from flat dimensions (mm).

A (length of filled sack)
$= 1.025\,a + 1.02\,c - 0.0028\,c^2 - 80$

B (width of filled sack)
$= 0.920\,b - 0.0015\,c^2 - 35$

C (width of bottom of filled sack)
$= 0.095\,b + 0.0025\,c^2 + 58$

The choice of the filled sack dimensions is also dependent on the pallet pattern if sacks are palletised. The sack volume and other parameters could preferably be calculated with Billerud's sack calculation tool, a programme suitable for most computers.

DIMENSIONAL TOLERANCES FOR PAPER SACKS (EN 28367-1)

This norm specifies a set of tolerances applicable to the manufacture of paper sacks.

CHAPTER 6

Regulations and Sustainability

When it comes to producing paper sacks, sustainability and regulatory compliance are critical considerations. From the choice of materials to manufacturing processes and disposal methods, each step of the production process has implications for the environment and must adhere to the regulations.

Regulations to consider

This introduction provides a understanding of some of the key sustainability challenges and regulatory requirements that companies can encounter.

By addressing these factors effectively, the environmental performance can be enhanced while ensuring legal compliance in an increasingly eco-conscious market.

A wide range of products can be packed into paper sacks and for some products there are important regulations to be considered. For example when packing food it could be necessary to comply with the following regulations.

- FDA, Food and Drug Administration, USA.
- BfR, Bundesinstitut für Risikobewertung, Germany.

Some goods might also be transported world-wide by a number of different methods. It is necessary to be aware of any hazardous properties of products being packed and of relevant national or international regulations. One important document to consider is the "United Nations: The recommendation on the Transport of Dangerous Goods". The document, commonly called the “Orange Book”. cover the classification of dangerous goods, construction and approval of packaging and consignment procedures such as marking, labelling and documentation.

Sustainability

One of the most important aspects of packaging is sustainability. Paper sacks are the natural and sustainable choice as sack paper is made from a renewable source.

Billerud sack papers are sourced from sustainably managed forests, have low carbon footprint thanks to low emissions during the production.

Paper sacks are strong and protect its contents and allows light-weighting, and are safe to use for workers and consumers. After use a paper sack can easily be disposed of due to its high recyclability rate and is in most cases fully recyclable in a regular paper stream to standard recycling mills.

WOOD

One of the most important characteristics of sack paper is TEA and to get a high TEA but still be able to reach a high porosity you will need really good wood raw material. Strong sack paper is made from virgin fibres that stem from slowly growing soft wood species such as pine or spruce.

Wood is renewable as trees keep growing, which makes sack paper and consequently paper sacks really sustainable.

It is important to ensure that only certified and controlled wood from responsibly managed forests is used, where both biodiversity and social values are taken into account. Biodiversity in the forest is essential and based on respecting valuable natural environments and that all naturally occurring plants and animals are given good conditions for living in the forest landscape. Harvesting must be carried out in compliance with applicable national legislation. As transportation has an effect on sustainability it we strive to use local wood sources in the paper making process.

Billerud uses raw material from responsibly managed forests in a production process that is largely powered by biofuels and results in sustainable materials and packaging with low carbon footprint.

PEFC / FSC are specific certifications for wood management, issued by non profit international associations, which ensures that the forests are sustainable and responsibly managed and harvested.

Recycling

Sack papers made from virgin fibers are generally recyclable and have an important role in the recycling stream due to their long and strong fibers. However, the recyclability of paper sacks can be more complex and will depend on the sack construction and the filling goods.

The challenges are different in different parts of the world. The recycling of paper products like paper sacks depend on legislation, recommendations, certificates and standards, which seldom shares conformity throughout the world.

Different regions and countries have different ways of recycling, but some general guidelines can often be applied:

- Design the sack with materials that are easy to identify.
- Use paper (mono-material) wherever possible. An alternative can also be to have two different materials that can easily be separated.
- Design the sack to make it easy to empty and compress.
- Some wet strength agents can prove a difficulty, depending on wet strength level.
- Coating with latexes, and solvent-based and bio-based coatings are generally ok, if proven to be recyclable.
- Water-based adhesives are preferred over other adhesives or stitching to ensure recyclability of sacks.
- Printing with water-based flexo-press without mineral oils is preferred, otherwise there is a risk for contamination in the next recycling cycle.
- There should be a low amount of residues from the filled goods as contamination may compromise the recycling process.


BEAMIX
730
ZANDCEMENT
SABLE-CIMENT
BEAMIX
730
ZANDCEMENT
SABLE-CIMENT
BEAMIX
730
ZANDCEMENT
SABLE-CIMENT

There are a number of recycling tests where recyclability of the sack paper and/or the paper sack can be verifed.

Example recycling tests:

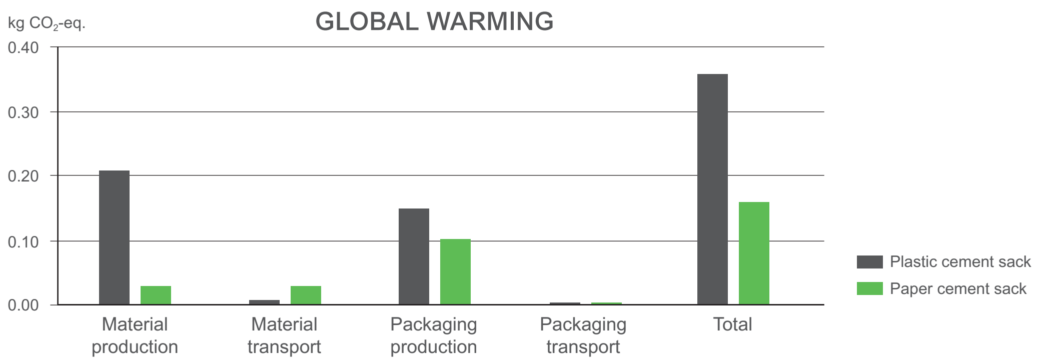
- PTS-RH 021:2012
- The Aticelca 501 Test
- Cepi Recyclability Test Method (Method 1 or 3)
- Interseroh – Made for recycling-seal
- Recyclability CTP Test Method CTP-REC21

Further there are papers that are designed to disintegrate in full during the process where the filling goods is used. Sacks made from such paper will thus be part of final product. It is important that the sack is fully disintegrated otherwise such fiber bundles can create disturbances in the process.

LCA

A Life Cycle Assessment (LCA) is an assessment of the potential environmental impacts of a product during their life cycle from raw material extraction through manufacturing, maintenance, distribution, use, end-of-life treatment, recycling, and final disposal.

An LCA study made by IVL (2015) showed that a paper sack is a better choice than plastic sacks from PP woven film. The study shows that production and packaging of paper sacks are significanlty better than using plastic sacks, whereas the transportation of empty plastic sacks have less impact mainly due to their lower weight.



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Widén & Co. 05-2025

Billerud makes high performance packaging materials for a low carbon society. We are a global leader in paper and packaging materials made from cellulose fibers, and we are passionately committed to sustainability, quality and customer value. We serve customers in more than 100 countries through nine production units in Sweden, USA, and Finland and around 5,800 employees in 19 countries. Billerud is listed on the Nasdaq Stockholm.

Billerud's sack papers and services

billerud.com

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