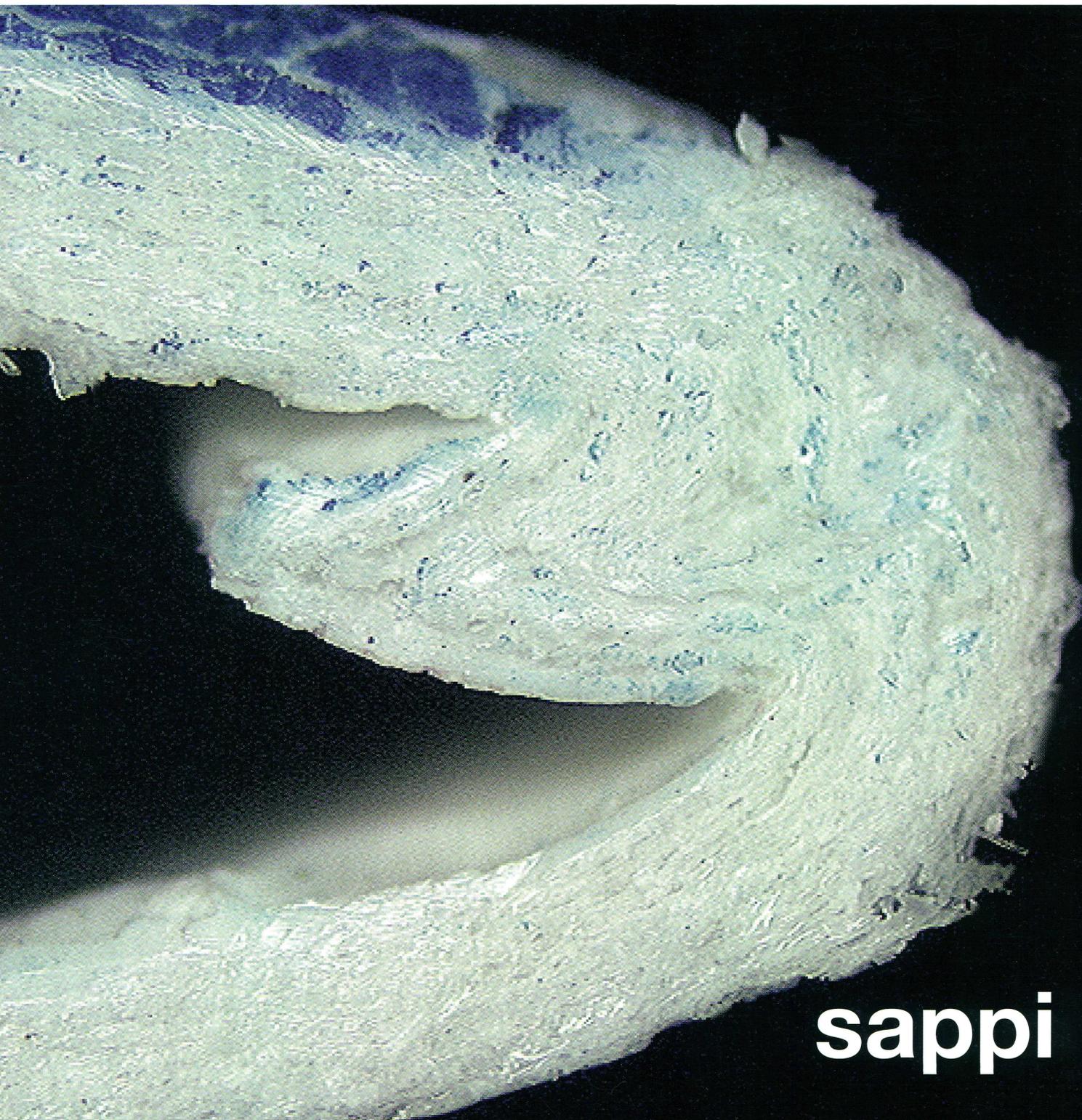


# Folding and Scoring

Finishing of Coated Papers after  
Sheet-Fed Offset Printing



**sappi**

# Folding and Scoring

## Finishing of Coated Papers after Sheet-Fed Offset Printing

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# I Introduction

## Description of the situation in the printing and paper industry

One of the aims of the printing industry sector is to reproduce copies in a quality as close as possible to that of the original. Achieving this demands fine screen densities and a wide range of colours corresponding to nature. The range of colours, which defines the number of reproducible colours in printing, is influenced by a diversity of factors.

In addition to the scanning and printing technique, the surface quality of the paper plays an important role in image reproduction in offset printing. Coated papers can reproduce a larger colour space, and therefore more colours, than uncoated paper. Fine screen densities can also be reproduced with a higher contrast on coated papers.

The paper industry has therefore always been faced with the challenge of producing papers with surfaces capable of meeting higher and higher standards. Application of a coating, either single or multiple, fulfils the requirement for an outstanding surface.

The trend towards more coating and further optimization of the paper surface will also continue in future.



Sappi Alfeld GmbH

As a global paper manufacturer Sappi holds a significant market share of coated papers in the Western world. Sappi Fine Paper Europe has 7 production sites for coated papers in Europe. Using state-of-the-art technology, these sites predominantly manufacture woodfree coated papers for the printing industry. A priority for Sappi is innovation and ongoing development of both the production processes and the papers themselves.

The world's largest and most modern paper machine for woodfree coated papers is located in the Gratkorn mill. In the year 1706, paper production began in the Alfeld works with the erection of a paper mill. The mill, with integrated pulp production, has continuously made its mark on the history of paper technology.

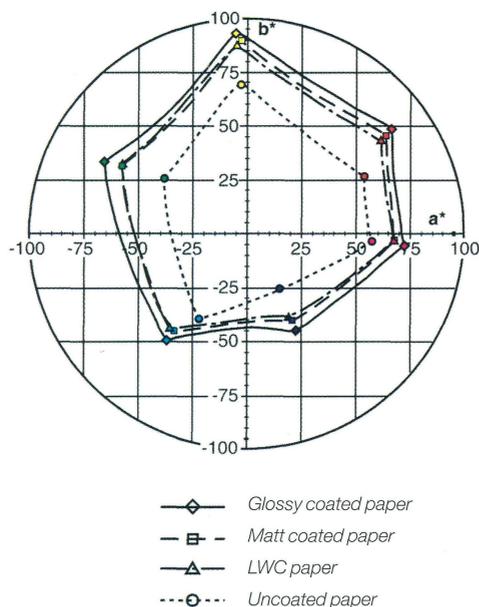


Fig. FOGRA colour space for sheet-fed offset printing

## Description of the situation in finishing

Finishing the printed sheets after printing is the final stage in the long production chain leading to a finished product. During folding, the printing carrier (paper/board) is subjected to considerable mechanical stresses.

Coloured areas or images are frequently printed over the fold. During subsequent finishing the coating layer or the fibre structure may split open. This splitting open is particularly obvious in places which have been printed.

Coated papers are more sensitive towards this kind of cracking during folding. The following information and tips show how fold cracking can be avoided, or at least reduced.

This brochure is intended to provide an explanation and help with the folding of coated papers. In addition, a simple overview of folding techniques is presented.

## Definition of terms

### **Folding**

Folding a printed sheet in a regular sequence in order to give it the required shape for finishing.

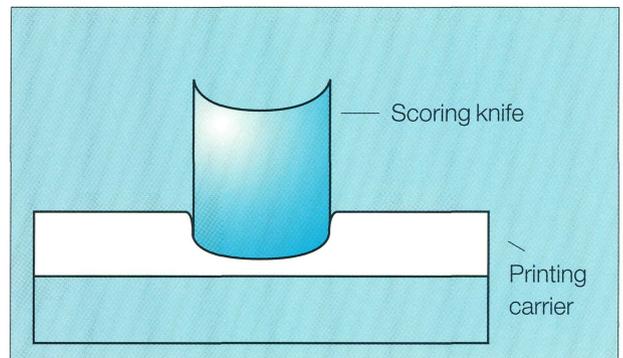
### **Grooving**

Cutting a chip out of the material to enable it to be bent or broken along the line of the groove.

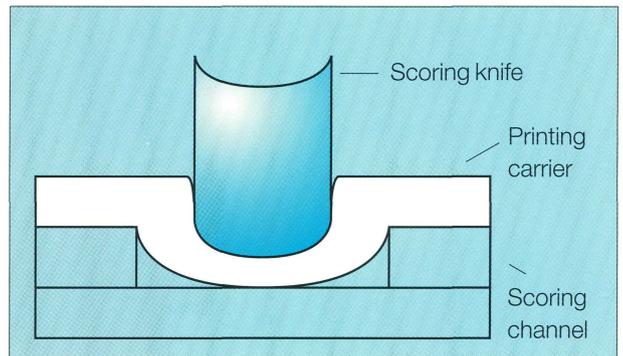
### **Scoring**

Producing a linear depression to enable the material to be bent or broken (folded) along the line of the score.

In the printing industry the term grooving is often used when scoring is meant. The brochure deals solely with the topic "scoring".



Full score



Hollow score

We distinguish between:

### **Full scoring**

The reduction of flexural stiffness through compressing the printing carrier.

### **Hollow scoring**

The reduction of flexural stiffness through forming of the printing carrier.

When processing coated papers, a hollow score with the corresponding scoring channel produces better results in comparison with a full score. This brochure therefore only covers finishing with the hollow score.

### **Coating cracking**

Cracks and signs of breakage through localized over-stretching of the paper texture along the folding seam.

### **Fold cracking**

Bursting open and tearing apart of the paper texture at the fold seam through loss of strength.

### **Fold breaks**

Fold breaks indicate the number of folds in a folded sheet.

In sheet-fed offset printing the main problem is coating cracking. In rotary offset printing and digital printing, on the other hand, the main problem is fold cracking as a result of heavy losses of moisture from the paper.

## II Types of folding

### Types of folding for the finishing of printed sheets

There are several different types of fold that can be produced mechanically. We differentiate between parallel folds and cross folds.

#### **Parallel fold**

The parallel folding techniques, e.g. spiral fold, zig-zag or Leporello fold, window fold or parallel centre fold, are mainly used for processing leaflets and printed advertising materials for a wide diversity of requirements. A parallel fold is always made parallel to the preceding fold.

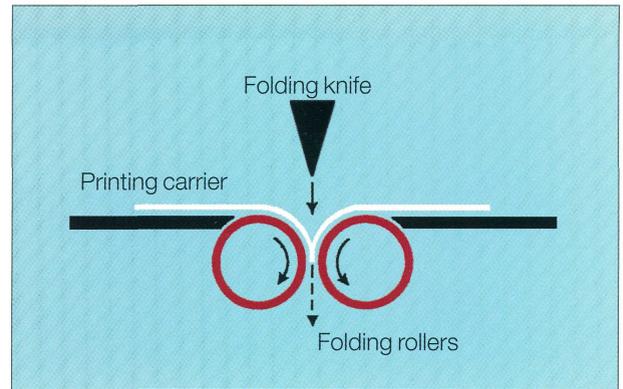
#### **Cross fold**

Cross folds are primarily used in book work. A cross fold is made at right angles to the previously made fold. In this way, for example, a 3-break cross fold generates 16 pages.

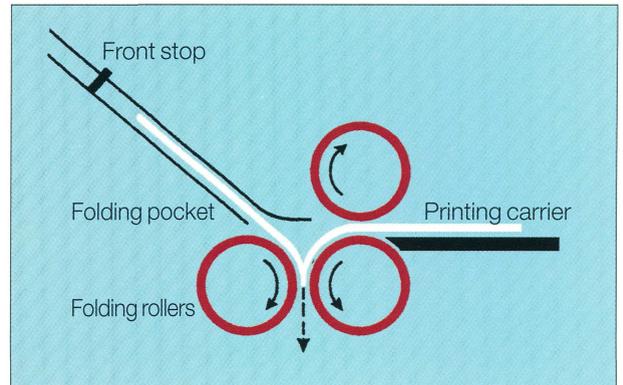
#### **Combined folding methods**

The two kinds of fold can be combined to meet special requirements. This is referred to as combination folding.

*An overview of the types of fold is presented on the 4th side of the cover.*



*Knife folder*



*Buckle folder*

## III Folding machines

### Folding machines for the finishing of printed sheets

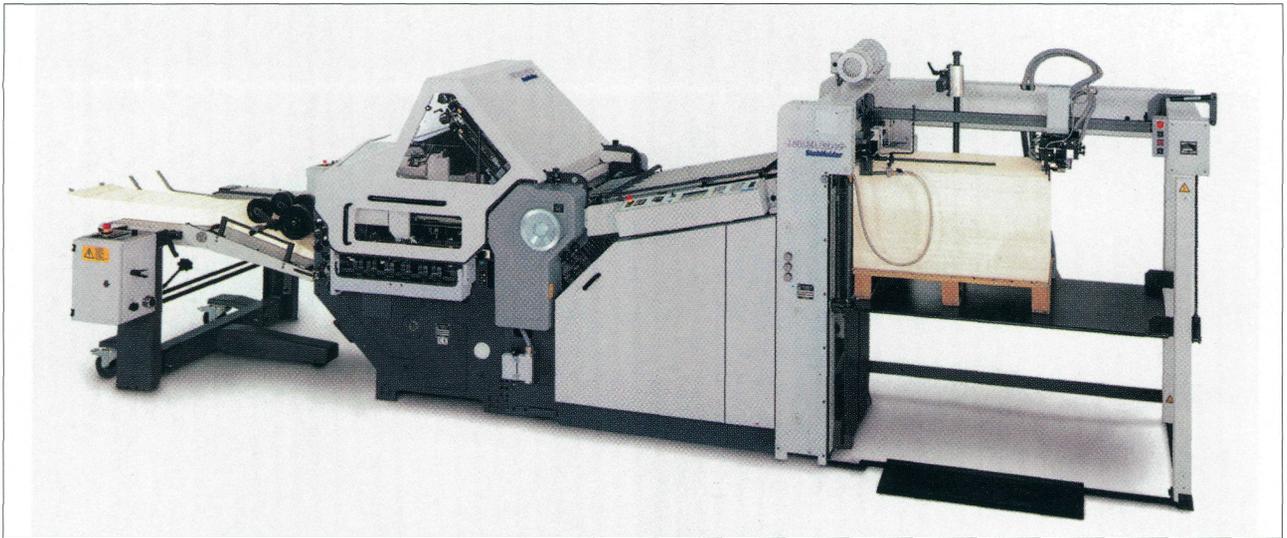
Depending on the folding principle, a distinction is made between three different folding machine systems for processing single sheets:

#### **Knife folder**

A folding knife presses the aligned and flat lying sheet between two rotating folding rollers. The folding rollers grip the sheet, fold it and carry it away. Higher basis weights can also be folded with a folding knife. In modern knife folders the arriving sheet triggers a pulse for the knife movement.

#### **Buckle folder**

A folding unit based on the buckle folding principle consists of three folding rollers and a folding pocket with an adjustable front stop. The sheet is fed into the folding pocket. When it meets the front stop, set according to the folding format, it is prevented from moving further. Since it cannot move any further inside the pocket it must do so downwards. There, it is gripped by the folding rollers, folded and carried away.



*Combination folder*

The buckle folder achieves a greater capacity compared with a knife folder since it is not subject to clock-pulse-control. It is very easy to adjust and can also process several copies produced from one sheet at the same time.

**Combination folder**

The combination folder is a combination of buckle folder and knife folder, which enables the advantages of both types of folding to be utilized in a single machine. Combined folding machines are very flexible and require little space. Modern folding machines are equipped with electronic setting up, production monitoring and production control. Different sheet feeders and delivery systems facilitate handling of the printed sheets and the folded sheets.

**Comparison of 7 grades**

The folding characteristics of the 7 most important silk papers with basis weights of 170 g/m<sup>2</sup> were examined in a folding test. The sheets were printed with a blue area and were then folded at right angles and parallel to the grain direction.

Result: All the papers show coating cracking. The base paper is visible at the burst open positions. If the fold is printed over, this becomes more obvious with inscoring contrast between the layer of ink and the white base paper. In this case the visual impression produced by the printed material is impaired and the customer complains about fold breaks or coating cracking.

**IV Folding**

**What happens during folding?**

The paper is subjected to high mechanical stress during folding. Excessive stretching or compression of the fibres can lead to cracks or bursting open of the outer coat (coating layer) of the paper texture. The coating consists predominantly of chalk and kaolin and is bound by a binder. The coating layer is not as strong as the base paper. The thicker the coating layer, the greater is the danger of coating cracking.



*Fold comparison of multiple coated papers available on the market*

## V Influence on coating cracking

### What should be considered during paper production?

Coating cracking is influenced by many factors. One important influence is the quality of the fibre composition for the base paper. High-strength fibres and a good bond between the base paper and the coating layers are decisive in preventing fold breaks.

The strength of the individual fibres is determined by the method used to produce the fibre material. During chemical fibre material production using the sulphite or sulphate process, digestion of the fibres must be optimally tuned to the types of wood used. The subsequent bleaching stage should be as gentle as possible in order to preserve the stability of the fibres.

During mechanical production of fibre materials the fibres should suffer as little damage as possible.

The use of mechanically treated fibre materials impairs the folding characteristics in comparison to chemically digested, woodfree pulps.

In the case of impregnation, care should be taken to minimise embrittlement of the paper surface.

With careful selection of short and long fibres, combined with optimal refining of these fibres, the paper maker can influence the fibre binding and thereby the folding characteristics. This is monitored during production by constantly measuring the strength in the laboratory.



Sappi laboratory

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Sappi laboratory

## What influence does the pressroom have?

Other influences arise during finishing in the pressroom or bookbinding.

### **Grain direction**

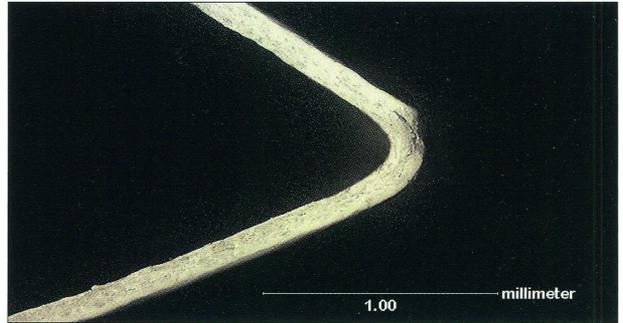
The grain of the paper exerts an important influence on the quality of the fold. The final fold should always be made parallel to the grain. This ensures that the larger part of the fibres in the base paper are not over-stretched.

If the fibre texture does burst open, the breakage points are considerably smaller than for a fold at right angles to the grain.

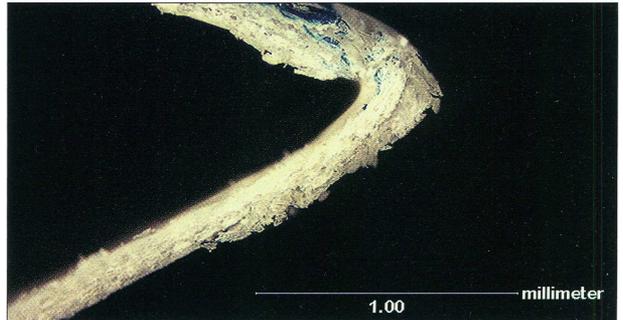
### **Printing across the fold**

In a folding test we have established that after printing the paper across the fold, the fold quality deteriorates and coating cracking becomes worse as a result. In an extensive laboratory investigation the strength of the paper was measured before and after printing. The laboratory results revealed that the paper becomes less flexible. The increase in stiffness depends on the binder in the printing ink. The greater the amount of binder which penetrates into the texture of the paper and makes it brittle, the greater the increase in coating cracking.

UV inks and UV varnishes are especially liable to cause increased brittleness of the paper, with considerable coating cracking as a result.



*Macro enlargement, unprinted*



*Macro enlargement, printed*

### **Residual moisture / climatic conditions**

A further influence is the residual moisture in the paper. The paper fibres try to adapt to the prevailing climatic conditions. The paper is delivered with a residual moisture content of approximately 50 %. In a humid climate the paper absorbs moisture; in a dry climate it emits it. The moisture content of the paper is also reduced as a result of heat, e.g. through an IR drying unit in the printing machine.



*Folding test in the laboratory*

This showed that the climatic conditions have an important influence on the quality of the fold. Printed sheets were placed in a climatic cabinet and acclimatized to different relative humidities from 55 % to 25 % at 21 °C. The sheets were then folded parallel and at right angles to the grain.

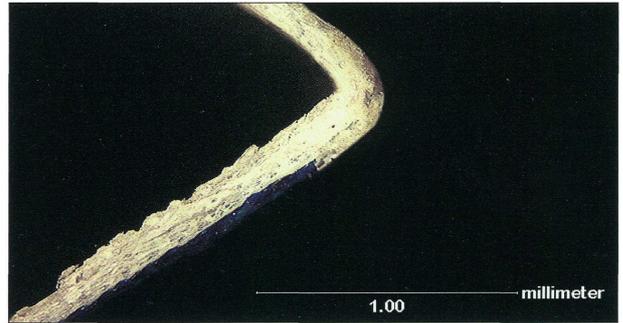
Result: The folded sheets were evaluated in terms of coating cracking. In this respect, folding quality deteriorated with descending relative humidity. The break positions became larger and the coating cracking could be seen more clearly. It may be concluded from these results that constant climatic conditions have an influence on fold quality in paper processing.

As a paper manufacturer, we notice that more complaints are made about coating cracking during the winter months. This period of the year is especially prone to very dry climatic conditions. For this reason, many printers have installed air humidifiers both in the printing shop and in the bookbinding in order to ensure constant climatic conditions.

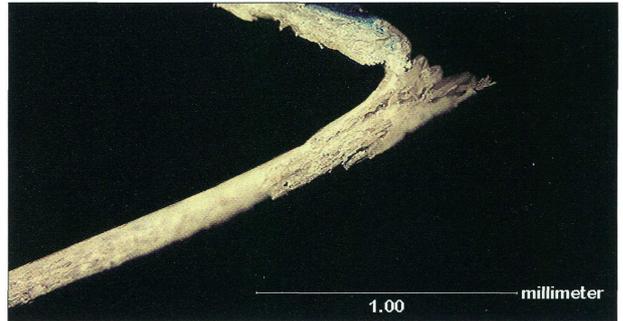
### Setting up the folding machine

Modern folding machines are very fast and quite accurate. A digitally controlled folding machine is set up through an automatic pre-set configuration provided by a folding program. Nonetheless, the exact adjustment of the folding rollers continues to exert an important influence on the fold quality. A sharp-edged fold has a greater tendency towards coating cracking. This is caused by too much pressure being exerted on the paper. The quality of the folding rollers is also important. Elastic rollers reduce the pressing force and improve the result of folding.

Today's soft PU rollers require the lowest pressing force and consequently produce the best result in terms of coating cracking. With the knife folding principle, the folded sheet is drawn into the folding mechanism by only 2 rollers. As a result, the stress on the folded sheet is somewhat lower than that generated through the buckle folding method with its 3 - 5 rollers. With higher basis weights, the knife folder can achieve a marginally better result than the buckle folder in respect of coating cracking.



Fold at 50 % relative air humidity



Fold at 25 % relative air humidity

## Recommendations for Folding

### How can the pressroom avoid coating cracking?

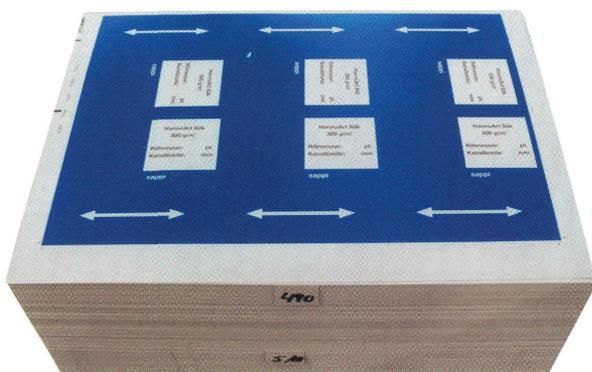
- Do not print dark areas or images over the fold.
- Always make the final fold parallel to the grain.
- Set the pressing force of the folding rollers exactly to the thickness of the folded product.
- The relative air humidity in the finishing and storage rooms should be about 50%.
- Avoid using UV varnish in the *folding area* if possible since this can make the paper more brittle.
- Thorough scoring should take place before printing across the fold in basis weights of 100# text and over.

## VI Scoring

### Practical scoring experiments in letterpress printing

As already mentioned while defining the terms, scoring produces a linear depression intended to enable the printing carrier to be folded or bent. We have performed extensive practical testing in order to study the creasability of our papers and to make recommendations for the scoring process.

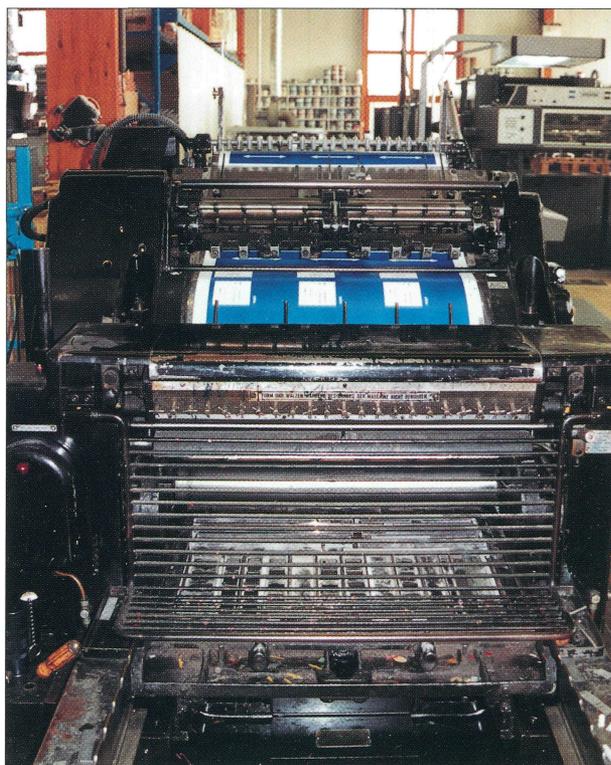
For the purposes of this experiment we prepared a test form with 6 copies produced from one sheet, in which every grade and every basis weight was labelled. This test form was printed in two colours with black and blue HKS 42 K, and with a printing varnish, in the format 50 x 70 cm.



Test form

All the combinations were then scored on a Heidelberg cylinder with the standard scoring knives and scoring channels. This practical experiment was performed in a printing shop at a relative humidity of 43 %.

The scoring process was performed once parallel and once at right angles to the grain for all the grades. The side of scoring was also changed so that the scoring bulge was directed once to the outside and once to the inside.



Heidelberg cylinder

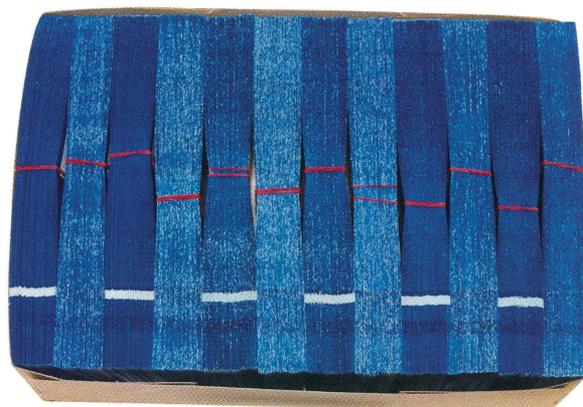
The copies were then labelled with the different scoring variants and cut individually.

From the resulting 324 combinations, 25 copies of each were folded and packed in boxes with the folded spines facing upwards.

### Evaluation of the practical experiments

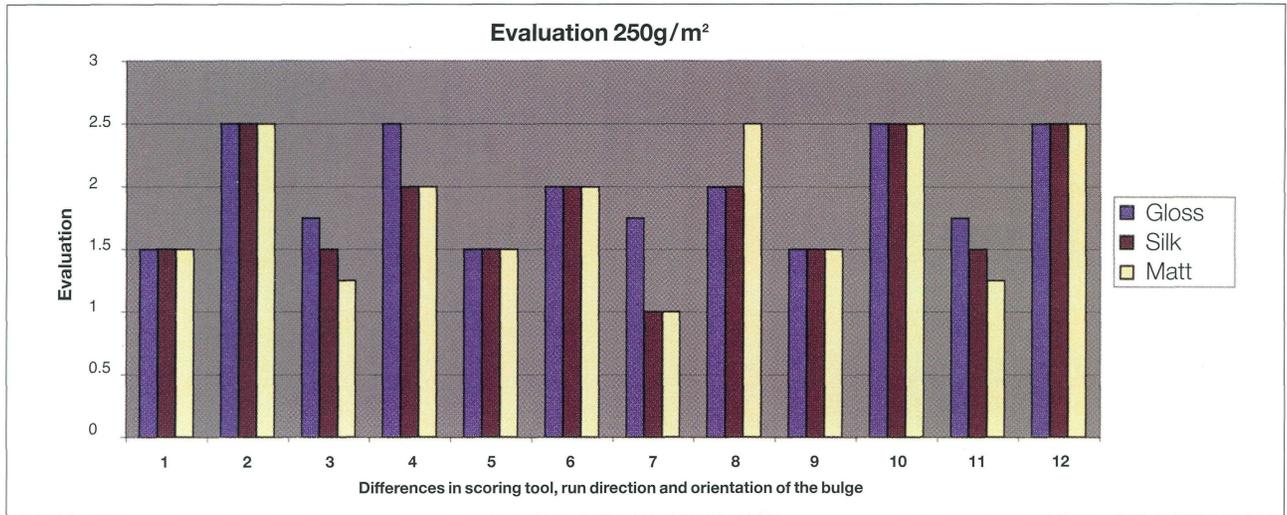
Considerable differences in folding results between the different paper qualities were already visible at first glance. For all the grades, very good and very poor results were obtained depending only on the different combination of the scoring tool, the side which was scored, and the grain direction.

The differences in coating cracking in the 324 combinations generated were assessed and evaluated in the laboratory according to the Sappi evaluation scale from 0 - 4.



Box with 12 combinations HannoArt Silk 250 g/m<sup>2</sup>

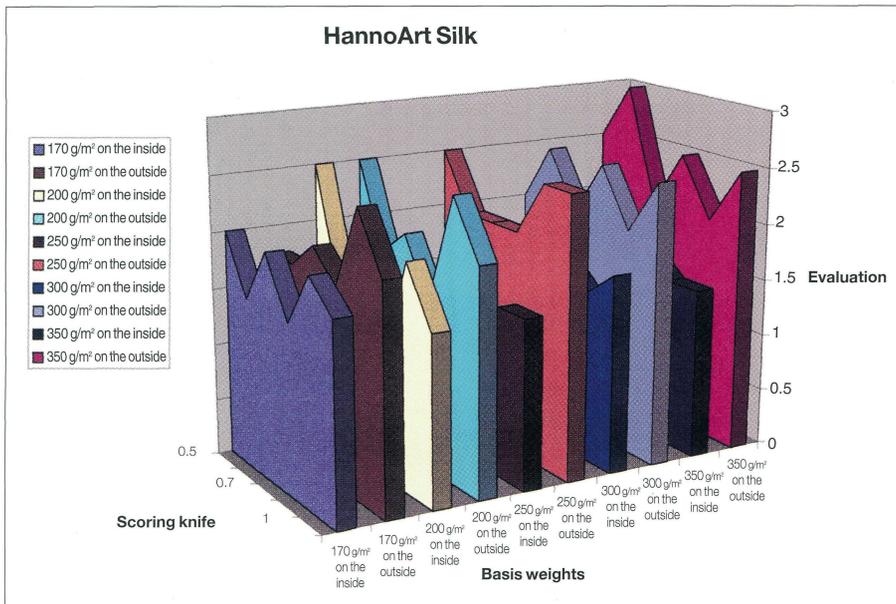
**Evaluation of 250 g/m<sup>2</sup> HannoArt Gloss, Silk und Matt**



The evaluation shows us that the results of scoring (and the corresponding fold quality) for the different paper surfaces

such as matt, silk or gloss, are comparable between the individual basis weights.

**Evaluation of all basis weights using HannoArt Silk as an example**



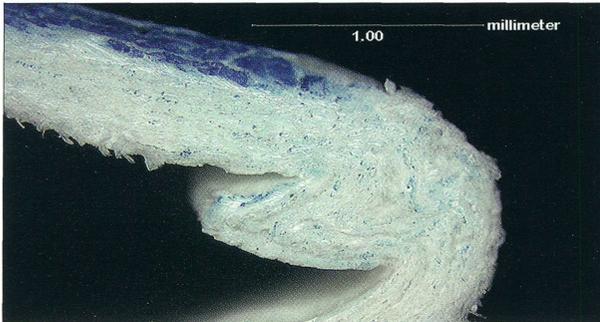
All grades and basis weights produced a better result if the scoring bulge of the folded product was on the inside. This means that the printed sheet is pressed into the scoring

channel by the scoring knife from the outside. A scoring knife with a thickness of 0.7 mm (2 pt) produced a good result for all basis weights.

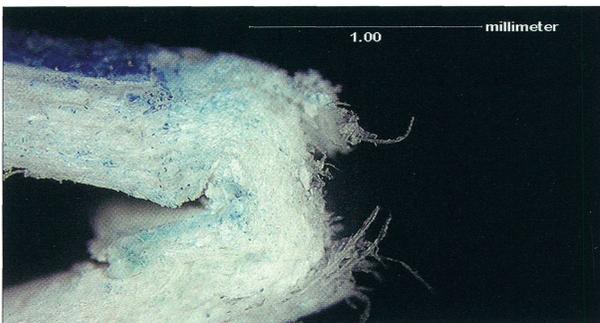
**Sappi Evaluation**

The Sappi evaluation scale is interpreted as follows:

- 0 – 0.75 Top
- 1 – 1.25 Upper standard
- 1.5 – 1.75 Standard
- 2 – 2.25 Lower standard
- 2.5 – 2.75 Critical
- 3 – 4 Unacceptable



Optimal scoring with hinging effect: scoring bulge on the inside, good line of the score



Bad scoring: scoring bulge on the outside, wrong line of the score

### Further evaluation of the practical test

It can also be stated that scoring against the grain produces better results in the large majority of cases, especially for basis weights of 100# text – 120# cover.

In many cases the grain direction is chosen depending on the later use of the product. At high basis weights > 120# cover scoring should take place parallel to the grain since, otherwise, the tendency of the folded product to open up becomes too great.

However, the influence of the grain direction on the result of folding after scoring is lower than had been assumed at the start of the experiment.

## Recommendations for scoring

Based on the results of the evaluation we can make the following recommendations for our papers when scoring in letterpress printing and at the scoring table.

Scoring knife in mm / pt	Scoring groove width in inches				
	100# Text	60-80# Cover	80-100# Cover	100-120# Cover	> 120# Cover
0.5 / 1.5	0.031	0.031-0.039	0.039	0.039	–
0.7 / 2	0.031-0.039	0.039	0.039	0.039-0.051	0.051
1.0 / 3	–	0.039-0.051	0.039-0.051	0.051	0.051-0.059

After selecting the scoring knife and scoring groove suitable for the material, the following instructions should also be followed:

- Far superior results are obtained if the scoring bulge faces inwards.
- For basis weights of 100# text–120# cover scoring across the grain leads to much better results.
- For basis weights over 120# cover the scoring should run parallel to the grain.
- The relative air humidity in the finishing and storage rooms should be about 50%.
- The scoring rule must be exactly centred on the scoring channel.
- The scores must be formed sufficiently strongly.
- Sharp-edged scoring tools must not be used.

A second copy of these recommendations is on Page 5 inside the cover. You can take out this copy and, for example, hang it in the printing shop or in the finishing department.

## VII Scoring at the gatherer-stitcher and the folding machine

In order to avoid an additional working step, scoring is often performed inline at the folding machine, the folder-feeder of the gatherer-stitcher or the cover feeder of the adhesive-binder.

We have also carried out practical tests on a Heidelberg Stichmaster ST 100 gatherer-stitcher and on the Heidelberg Stahlfolder KD 66 Topline folding machine.



Folder feeder in a gatherer-stitcher

### Scoring unit on the folder feeder

On the folder feeder all the basis weights from 170 g/cm<sup>2</sup> to 350 g/cm<sup>2</sup> were scored at right angles to the grain and parallel to the grain. The setting there can also be changed such that the scoring bulge faces outwards or inwards after folding. The pressure exerted by the scoring tool can be set very precisely. Different scoring channel widths are also available for scoring.

In this test we established that the information obtained during the scoring and folding tests in letterpress printing can also be applied in many respects to scoring on the folder feeder. An inwardly facing scoring bulge also produced better results here in most cases. This means that the scoring wheel presses the folded sheet into the scoring channel from the outside. It was not possible to achieve a satisfactory result for the basis weights greater than 300 g/m<sup>2</sup>. Before finishing at the gatherer-stitcher, these should be scored in the letterpress printing.

### Scoring devices on the folding machine

We distinguish between the following scoring devices at the folding machine:

#### **Conventional scoring**

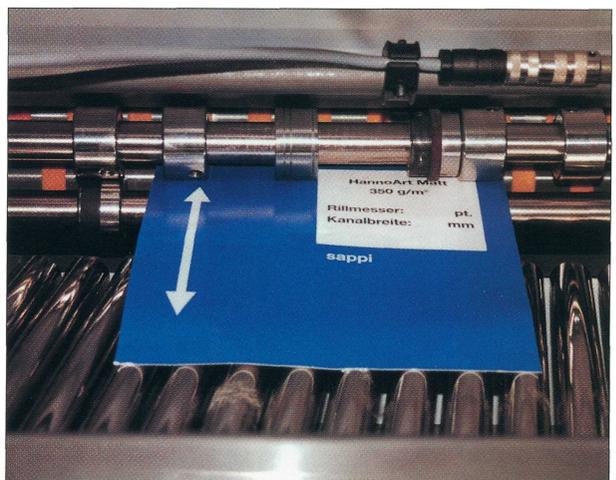
In conventional scoring a steel scoring knife is pressed against two counterknives with a sharp or rounded edge. The depth of the score is set by the separation between scoring knife and counterknives. Reducing the separation produces a stronger score. A score which is too strong and too sharp is associated with the risk of the paper being cut through. Fine adjustment is possible through repositioning the knife shafts.

#### **Scoring against PU (polyurethane)**

This scoring device consists of a steel scoring knife and a rubber scoring channel (polyurethane). A scoring knife with a small diameter produces less of a depression than a scoring knife with a large diameter. The diameter of the scoring knife must therefore be selected according to the weight of the paper. Here too, fine adjustment is possible through positioning the knife shafts. The risk of cutting through also exists if the pressure exerted is too great or the scoring is too strong.

#### **“Channel score“ scoring from Heidelberg finishing**

In this recently developed scoring device for Heidelberg folding machines a score is produced by pressing a soft scoring knife of natural rubber against a steel scoring channel.



“Channel score“ creasing device on the folding machine

By means of a scoring and folding test we have compared the quality of the scoring devices in respect of coating cracking. With higher basis weights the results of conventional scoring were not satisfactory.

The folding result could be improved by scoring against PU. In this case coating cracking was visible for the high basis weights.

Using the recently developed "channel score" scoring device we achieved an optimal result in the scoring and folding test, even with high basis weights such as a 350 g/m<sup>2</sup> HannoArt Silk. The quality of this scoring is comparable with that produced in letterpress printing and retrofitting to the folding machine incurs relatively low costs.

For every scoring device it was found that our papers produce a better folding result if the scoring bulge faces inwards. The scoring knife should therefore be applied from the outside towards the inside. Adjusting the knife shaft optimally and applying the minimum pressure to the folded sheet had a positive effect on the result of folding.

For other folding machine manufacturers the descriptions of the folding device differ to some extent from the scoring devices presented in this brochure. Most of the folding machines normally used in the printing industry are either already fitted with scoring devices, or can be retrofitted.

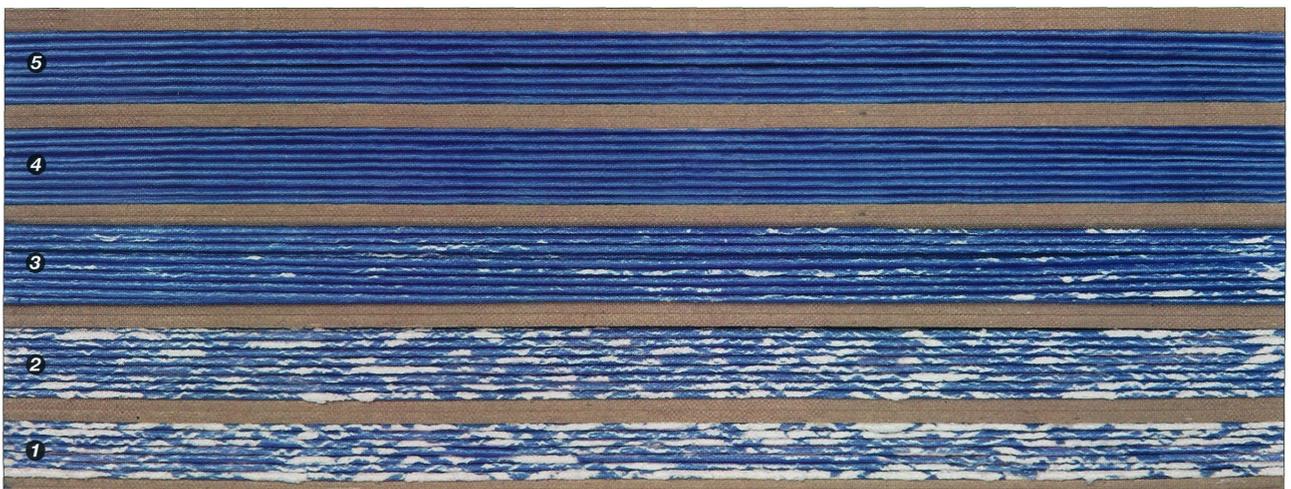


Comparison of "conventional scoring" ...



... and "channel score" scoring.

### Folding and scoring – 120# Cover HannoArt Silk



Comparison: ① Without scoring ② Conventional scoring ③ Scoring against rubber/PU ④ Channel score scoring ⑤ Scoring in letterpress printing

## VIII Concluding remarks

The contents of this brochure result from extensive research work closely linked with practice, and with practical experience.

We would like to take this opportunity to thank the following people for their support and assistance:

Druckerei Bakeberg und Löhner, Hildesheim,  
(Scoring and folding test in letterpress printing)

Druckerei Dobler, Alfeld,  
(Scoring test at the gatherer-stitcher and diverse folding tests)

FOGRA, Munich,  
(Figure "Colour space" and information)

Heidelberg Finishing GmbH, Ludwigsburg,  
(Folding and scoring tests and extensive information)

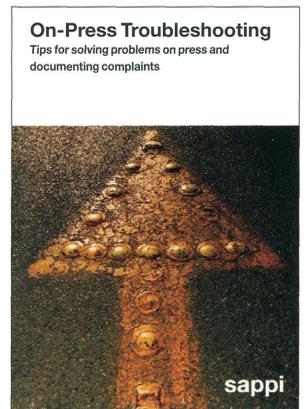
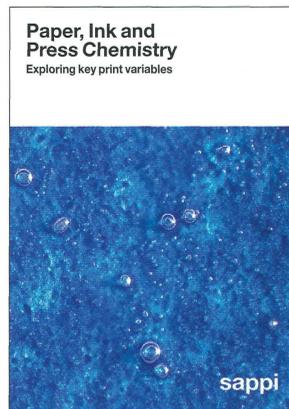
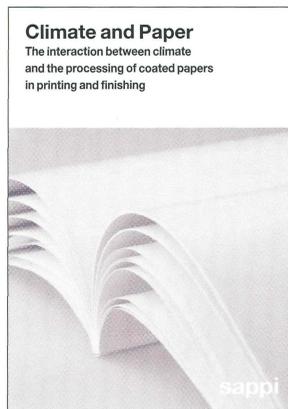
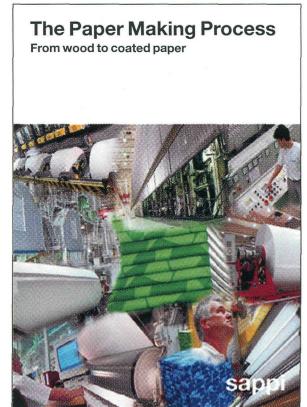
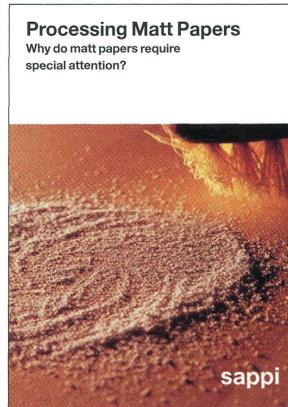
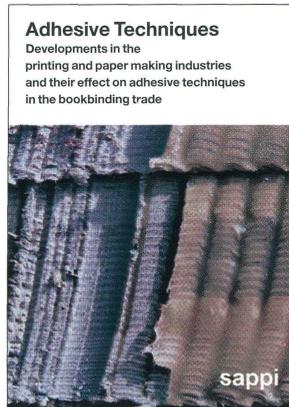
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The word for fine paper

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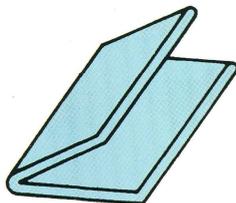
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# Overview: Types of Folding

## Cross folds

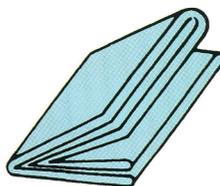
Cross fold: 2-break

4 Sheets  
8 Pages



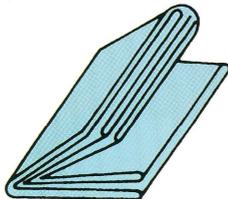
Cross fold: 3-break

8 Sheets  
16 Pages



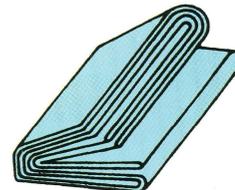
Cross fold: 4-break

12 Sheets  
24 Pages



Cross fold: 4-break

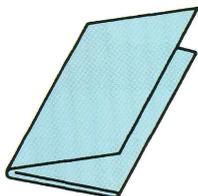
16 Sheets  
32 Pages



## Parallel folds

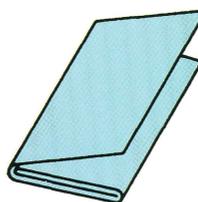
Spiral fold: 2-break

3 Sheets  
6 Pages



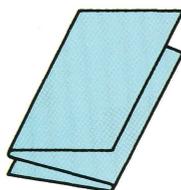
Spiral fold: 3-break

4 Sheets  
8 Pages



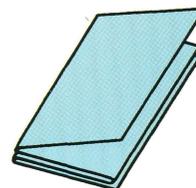
Zig-zag fold: 2-break

3 Sheets  
6 Pages



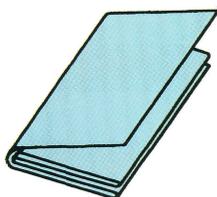
Zig-zag fold: 3-break

4 Sheets  
8 Pages



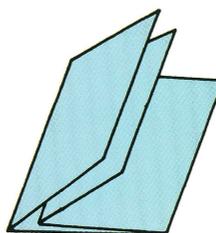
Combined zig-zag  
and spiral fold:

4-break  
5 Sheets  
10 Pages

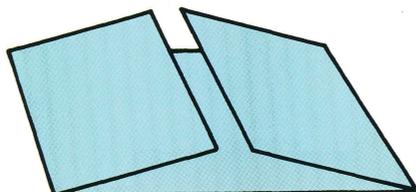


Parallel centre fold: 2-break

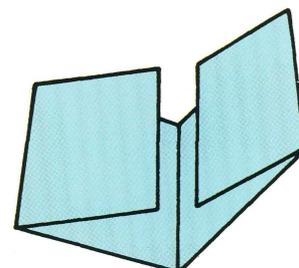
4 Sheets  
8 Pages



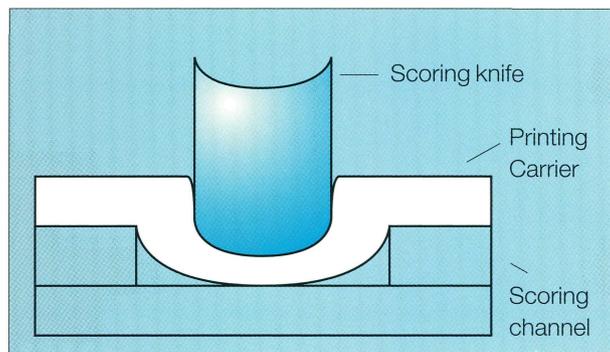
Window fold: 2-break



Double gate fold: 3-break



# Recommendations for Scoring



We recommend the following combination of scoring knife and scoring groove when scoring our grades in letterpress printing or at the scoring table.

Scoring knife in mm / pt	Scoring groove width in inches				
	100# Text	60–80# Cover	80–100# Cover	100–120# Cover	> 120# Cover
0.5 / 1.5	0.031	0.031–0.039	0.039	0.039	–
0.7 / 2	0.031–0.039	0.039	0.039	0.039–0.051	0.051
1.0 / 3	–	0.039–0.051	0.039–0.051	0.051	0.051–0.059

After selecting the scoring knife and scoring groove suitable for the material, the following instructions should also be followed:

- Far superior results are obtained if the scoring bulge faces inwards.**
- For basis weights of 100# text–120# cover scoring across the grain leads to much better results.**
- For basis weights over 120# cover the scoring should run parallel to the grain.**
- The relative air humidity in the finishing and storage rooms should be about 50%.**
- The scoring rule must be exactly centred on the scoring channel.**
- The scores must be formed sufficiently strongly.**
- Sharp-edged scoring tools must not be used.**

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