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# Assessment of Printed Product Recyclability

## Scorecard for the Removability of Adhesive Applications

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# 1 Introduction

The assessment of recyclability of printed paper products has several aspects. Two major ones are removability of adhesive applications and deinkability. The removability of adhesive applications of a printed product can be assessed by looking at its Removal Score, which can range from -20 to +100.

The sufficient removal of adhesive applications is one of the challenges for the paper manufacturers using recovered paper. In the recovered paper treatment process, adhesive applications disintegrate during pulping to “stickies”. Stickies is a broad term for all tacky components in recovered paper pulp. Depending on their size and their behaviour they are called macrostickies, microstickies or potential secondary stickies. Mechanical screening with slotted screens is the most efficient tool for sticky removal. High removal efficiency can only be achieved if adhesive applications disintegrate into particles of large size. The smaller the particles are, the lower their removal efficiency is. In addition, they can re-agglomerate later in the papermaking process and thus form secondary stickies which lead to major problems in paper production and/or converting processes.

In this regard, the removability depends not only on the composition of the adhesive but also on the type of application, such as the shape of the application and the thickness of the layer. The larger and thicker the layer of a given adhesive, the less disintegration into small particles occurs. In any case, the particle size of stickies has a certain distribution. The applied method for testing – INGEDE Method 12 – can detect particles of 100 µm size and larger.

Investigations have proven that macrostickies above a particle size of 2 000 µm are completely removed in state-of-the-art paper recycling processes. It is the objective to have a low total area of macrostickies which has to be expected after industrial screening. This area therefore can achieve up to 80 points in this assessment scheme. The higher the share of macrostickies below 2 000 µm, the higher the danger is of having many stickies below the detection limit of the method. Therefore the share of macrostickies below 2000µm has a threshold at 50%. Lower shares are rewarded with up to 20 points.

*Literature: see concluding remarks.*

## 2 Scope

This ERPC document provides an assessment of the removability of adhesive applications of a printed paper product as one aspect of its recyclability. The assessment is done by evaluating results of a laboratory test procedure. It is applicable to all kinds of printed paper products containing any adhesive applications.

## 3 Principle

This assessment scheme deals with the fragmentation of adhesive applications and their removability by a laboratory screening process. It serves as an evaluation for potential sticky problems at the paper machine and quality defects in the produced paper or board.

The assessment refers to complete printed products, disregarding which number and type of adhesive applications it contains. INGEDE Method 12 defines the details of the test procedure.

Results of macrosticky measurements achieved by means of INGEDE Method 12 are converted into Removal Scores. There is a threshold defined for the share of the macrostickies below 2 000  $\mu\text{m}$  (equivalent circle diameter). A share above this threshold results in a negative score and is assessed as “insufficiently removable”. The area below 2 000  $\mu\text{m}$  particle size has a scoring limit. By allocating removal efficiencies to the different sticky size classes in industrial screening the theoretical macrosticky content of the pulp after screening is calculated. If this value exceeds the scoring limit, the parameter macrosticky area receives 0 points. This happens also if the share of the macrosticky area fails to meet the threshold.

For both parameters – share and area – target values are defined. If the result meets the target value or is better, it scores the maximum points allocated to this parameter.

## 4 Determination of the Removal Score

In this chapter, particularly in the tables, abbreviations for the assessment parameters are used:

$A_t$	Theoretical macrosticky area in the pulp after industrial screening
$S_{2000}$	Share of macrosticky area below a particle size of 2 000 $\mu\text{m}$ (equivalent circle diameter)
$T_A$	Target value for the theoretical macrosticky area $A_t$
$T_S$	Target value for the share of macrosticky area $S_{2000}$

Rounding of the parameters:  $A_t$  to one decade,  $S_{2000}$  to whole numbers. The individual scores of both parameters are rounded to whole numbers as well. Method: financial rounding.

### 4.1 Source of the removability results

The test results have to be obtained according to INGEDE Method 12. For the image analysis, DOMAS or Simpatic are allowed.

### 4.2 Removal efficiency of the different size classes

One of the factors which defines the efficiency of industrial screening processes is the particle size distribution of macrostickies. The larger the macrostickies, the better their removal efficiency by screening is. Based on results of research projects and evaluation of industrial samples the screening efficiency can be determined as in [Table 1](#).

Size class of macrostickies (equivalent circle diameter)	Removal efficiency
< 600 $\mu\text{m}$	0 %
600 $\mu\text{m}$ to 1 000 $\mu\text{m}$	20 %
1 000 to 2 000 $\mu\text{m}$	80 %

Table 1: Removal efficiency as function of the macrosticky particle size

### 4.3 Weighting of the parameters

The assessment of removability consists of two parameters. It is beneficial for the paper recycling industry that the total amount of macrostickies is low. Therefore the amount receives a significantly higher score than the share.

Parameter	$S_{2000}$	$A_t$	Total
Maximum Score	20	80	100
Minimum Score	-20	0	-20

Table 2: Maximum score for each parameter

If printed products contain adhesive applications but no macrostickies can be detected, the reject of the laboratory screening has to be assessed. There are two extreme cases thinkable – either the adhesive is still attached to a medium (label, tape, etc.) or it is not detectable. In the first case the product will receive the full score for both parameters. In the second case it has to be assumed that all stickies are of low particle size. These products receive scores of -20 for  $S_{2000}$  and 0 for  $A_t$ .

### 4.4 Threshold value and scoring limit

Exceeding the upper threshold of  $S_{2000}$  results in a negative score for this parameter. Exceeding the scoring limit of  $A_t$  results in the score of 0 for this parameter.

Parameter	$S_{2000}$ [%]	$A_t$ [mm <sup>2</sup> /kg product]
Scoring limit	n/a	5 000
Upper Threshold	50	n/a

Table 3: Threshold value and scoring limit

## 4.5 Target values

Both parameters have target values.

Parameter	$T_s$ [%]	$T_A$ [mm <sup>2</sup> /kg product]
Target values	≤ 10	≤ 500

Table 4: Target values

### Special case: Labels

Normally, adhesive applications can only be assessed properly after their application on a printed product. Exceptions are labels which do not represent a final product but their application can be easily simulated. See INGEDE Method 12 for details. Since a label is usually not recycled as a pure material, this assessment defines a projection of the macrostickies content originating from label applications. In cases of sticker covers of magazines and of address labels on envelopes, the share of the complete labels (paper plus adhesive) is about 2,5 % of the complete product. Based on this, the amount of macrostickies in mm<sup>2</sup>/kg determined by the test according to INGEDE Method 12 has to be divided by 40.

This calculation tool should only be used if no real finished product is available.

## 4.6 Determination of the Removal Score

It is recommended to use spreadsheet software to calculate the score. The INGEDE Office can provide the formulae in Microsoft Excel<sup>®</sup> format.

### 4.6.1 Calculation of the score per parameter

Results of the individual parameters which meet or exceed the target values receive the maximum scores for these parameters (according to Table 2). “Exceeding the target values” means that the result has to be lower than the target value.

If this is not the case, the score has to be calculated by linear interpolation. For both parameters individually, the ratio of units better than the scoring limit respective threshold value, divided by the range between scoring limit respective threshold and target values, multiplied by the maximum score for this parameter, gives the Removal Score for this parameter. The individual scores are rounded to whole numbers by financial rounding.

### Calculation of the Removal Score for the share of macrostickies below 2 000 µm:

$$RS_S = \frac{(50 - S_{2000})}{(50 - T_S)} \times 20 \quad (\text{Formula 1})$$

Where

$RS_S$  is the Removal Score for the macrosticky share

$50$  is the threshold value of the share of macrostickies below 2 000 µm (equivalent circle diameter; according to Table 3)

$S_{2000}$  is the share of the macrosticky area below 2 000 µm (equivalent circle diameter)

$T_S$  is the target value of the share of macrostickies below 2 000 µm (equivalent circle diameter; according to Table 4)

$+20$  and  $-20$  are the maximum and minimums score of the share of macrostickies below 2 000 µm (according to Table 2)

### Calculation of the theoretical macrosticky area in pulp after screening:

*Note: The following calculations are only necessary if the score  $RS_S$  for the share of macrostickies is 0 or higher. If the score  $RS_S$  for the share of macrostickies is below 0, the score  $RS_A$  for the macrosticky area is set to 0.*

$$A_t = A_{600} + A_{1000} \times 0,8 + A_{2000} \times 0,2 \quad (\text{Formula 2})$$

Where

$A_t$  is the theoretical macrosticky area after industrial screening in mm<sup>2</sup>/kg printed product

$A_{600}$  is the macrosticky content in the size classes below 600 µm (equivalent circle diameter)

$A_{1000}$  is the macrosticky content in the size classes between 600 µm and 1 000 µm (equivalent circle diameter; 0,8 corresponds to a screening efficiency of 20 %)

$A_{2000}$  is the macrosticky content in the size classes between 1 000 µm and 2 000 µm (equivalent circle diameter; 0,2 corresponds to a screening efficiency of 80 %)

### Calculation of the Removal Score for the macrosticky area:

$$RS_A = \frac{(5000 - A_t)}{(5000 - T_A)} \times 80 \quad (\text{Formula 3})$$

Where

$RS_A$  is the Removal Score for the macrosticky area

$5000$  is the scoring limit of the macrosticky area (according to Table 3)

$A_t$  is the theoretical macrosticky area after screening in mm<sup>2</sup>/kg printed product

$T_A$  is the target value of the macrosticky area in mm<sup>2</sup>/kg printed product (according to Table 4)

$+80$  and  $0$  are the maximum and minimum scores for the macrosticky area (according to Table 2)

If the value  $A_t$  is higher than the scoring limit (5 000 mm<sup>2</sup>/kg), the score  $RS_A$  is set to 0.

The Removal Score is limited to the maximum score for each individual parameter, even if the calculation gives a higher result. In that case it is not possible to compensate a weak recyclability in one parameter with a very good recyclability in another parameter.

If the result is worse than the threshold, the score is negative for this parameter. In that case the absolute number is limited to the same value as the maximum score for this parameter.

#### 4.6.2 Calculation of the Removal Score

If the score  $RS_s$  for the macrosticky share is negative, the score  $RS_A$  for the macrosticky area is set to 0 and the assessment of the printed product is “insufficiently removable”. If the score  $RS_s$  for the macrosticky share is 0 or higher, both individual scores  $RS_s$  and  $RS_A$  are added.

## 5 Rating of the Results

In order to give the user an idea of the relevance of the Removal Scores, they should be assessed according to the following table:

Score	Evaluation of removability
71 to 100 Points	Good
51 to 70 Points	Fair
0 to 50 Points	Tolerable
Negative (failed to meet the threshold)	Insufficient

Table 5: Rating of the Removal Scores

In charts, coloured backgrounds as in the table above should be used whenever possible. In order to reflect the assessment above, the colours should be set as follows:

- Below 0 points: red
- 0 to 40 points: orange
- 40 to 50 points: transition orange to yellow
- 50 to 70 points: yellow
- 70 to 80 points: transition yellow to green
- 80 to 100 points: green

## 6 Report

The report should contain detailed data of the printed product, the process for applying the adhesives and the laboratory screening test:

- Identification of printed product as to name, publishing company, date of issue, product category, type of adhesive applications and paper quality.
- Technical data and settings of the adhesive application device.
- Name and exact identification of adhesives.
- Results of the recyclability test according to INGEDE Method 12.
- The laboratory equipment used for the recyclability test and deviations from INGEDE Method 12, if any.
- Removal Scores for both parameters and total (total only if both scores are 0 or higher). The results can be provided either numerical or as graphics. For a graphic presentation column stacked charts are recommended. If the score of the share of macrosticky points is negative, this product is rated as “insufficiently removable”, even if the score for the macrosticky area is positive.
- Assessment of the recyclability according to Table 5.
- Optional but desired: Any interpretation of the result which is possible with the help of the technical data.

## 7 Concluding remarks

This assessment was developed with results from INGEDE Project 129 09 PMV which was also supported by bvdM, FEICA and FINAT. The data collected was from books, brochures, catalogues and labels.

There are numerous literatures on stickies, their origin, their behaviour in the paper recycling process and their impact on runnability and quality. One example is: Putz, H.-J., Stickies in recycled fiber pulp, chapter 11 of: Göttsching, L. and Pakarinen, H. (editors), Recycled Fiber and Deinking, Fapet Oy 2000, ISBN 952-5216-07-1.

## 8 References

- INGEDE Method 12 – Assessment of the Recyclability of Printed Paper Products – Testing of the Fragmentation Behaviour of Adhesive Applications
- Terminology of Stickies, ZELLCHEMING Technical Leaflet RECO1, 1/2006

## Annex: Examples

### Characterisation of the examples:

- A. Book with protein, EVA and PVAc adhesives
- B. Telephone directory with EVA hotmelt adhesives
- C. PSA paper label with UV acrylic, non tackified adhesive
- D. Book with PVAc dispersion adhesive

Parameter / Sample	Example A	Example B	Example C*	Example D	Remarks
<b>Macrosticky area by size class [<math>\mu\text{m}</math>]</b>	mm <sup>2</sup> /kg	mm <sup>2</sup> /kg	mm <sup>2</sup> /kg	mm <sup>2</sup> /kg	
<b>100 - 200</b>	143	33	35	10	
<b>200 - 400</b>	340	59	23	11	
<b>400 - 600</b>	442	68	459	15	
<b>600 – 1 000</b>	1 000	208	4 315	16	
<b>1 000 – 2 000</b>	836	599	33 058	30	
<b>2 000 – 3 000</b>	127	388	30 162	0	
<b>3 000 – 10 000</b>	3 402	1423	15 419	0	
<b>10 000 – 20 000</b>	0	19 043	0	0	
<b>20 000 – 200 000</b>	0	13 244	0	0	

Table 6: Macrosticky size distribution (determined by INGEDE Method 12)

\* Example C: Results obtained by means of INGEDE Method 12 are already divided by 40 (see chapter 4.5)

### Size distribution of macrostickies (according to INGEDE Method 12)

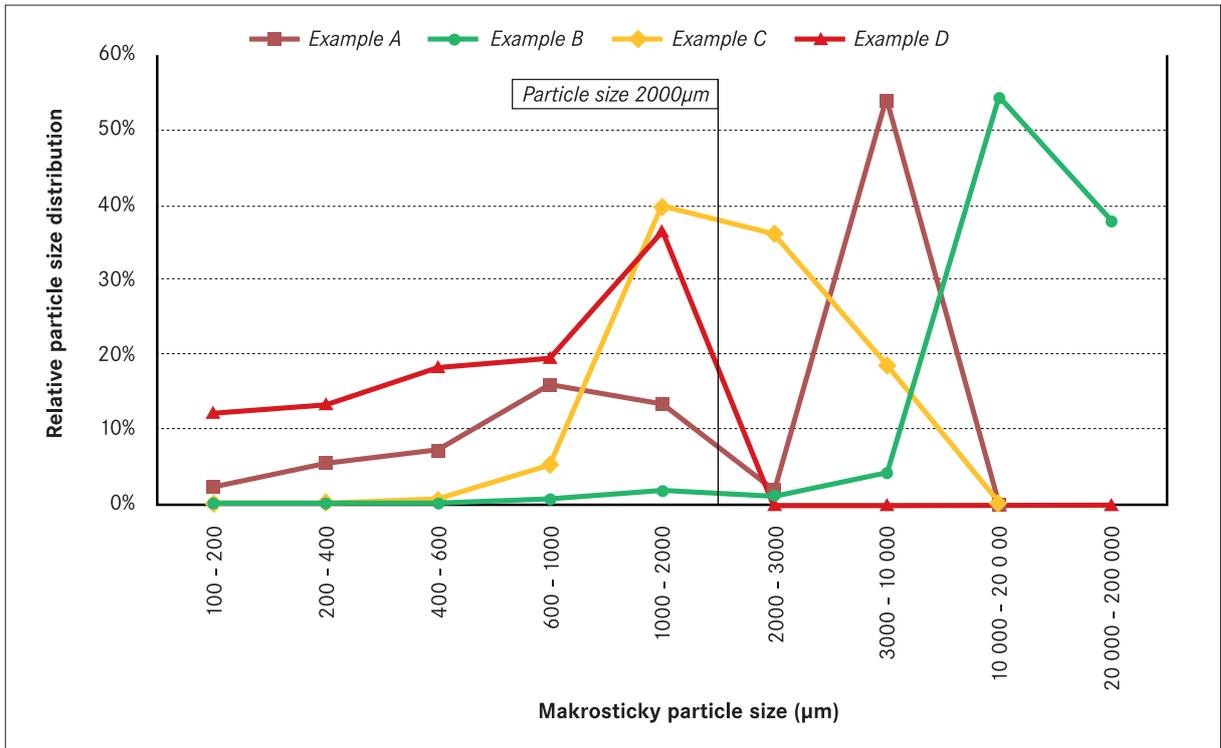


Figure 1: Macrostickie size distribution

Parameter / Sample	Example A	Example B	Example C	Example D	Remarks
<b>Macrostickie area by size class [µm]</b>	mm <sup>2</sup> /kg	mm <sup>2</sup> /kg	mm <sup>2</sup> /kg	mm <sup>2</sup> /kg	
<b>100 - 600</b>	925	160	517	36	<i>A<sub>600</sub></i>
<b>600 - 1 000</b>	1 000	208	4 315	16	<i>A<sub>1000</sub></i>
<b>1 000 - 2 000</b>	836	599	33 058	30	<i>A<sub>2000</sub></i>
<b>100 - 2 000</b>	2 761	967	37 890	82	<i>Subtotal 2000</i>
<b>100 - 200 000</b>	6 290	35 065	83 471	82	<i>Total</i>

Table 7: Subtotals and totals of Table 6

Parameter / Sample	Example A	Example B	Example C	Example D	Remarks
Share of macrosticky area below 2 000 $\mu\text{m}$ $S_{2000}$	44%	3%	45%	100%	Calculation: <i>Subtotal 2000</i> divided by <i>Total</i> (Table 7)
Theoretical macrosticky area after screening $A_t$ [ $\text{mm}^2/\text{kg}$ ]	1 892	446	10 581	55	See Formula 2

Table 8: Calculation of auxiliary parameters

Parameter / Sample	Example A	Example B	Example C	Example D	Remarks
Share					
Threshold for the share	50%	50%	50%	50%	
Target for the share $T_s$	10%	10%	10%	10%	
Maximum score for the share	20	20	20	20	According to Table 2
Score for the share $RS_s$	3	20	2	-20	See Formula 1
Area					
Scoring limit for the area	5000	5000	5000	5000	
Target for the area $T_A$	500	500	500	500	
Maximum score for the area	80	80	80	80	According to Table 2
Score for the area $RS_A$	55	80	0	0	
Total Score					
Removal Score	58	100	2	-20	$RS_s + RS_A$

Table 9: Score calculation

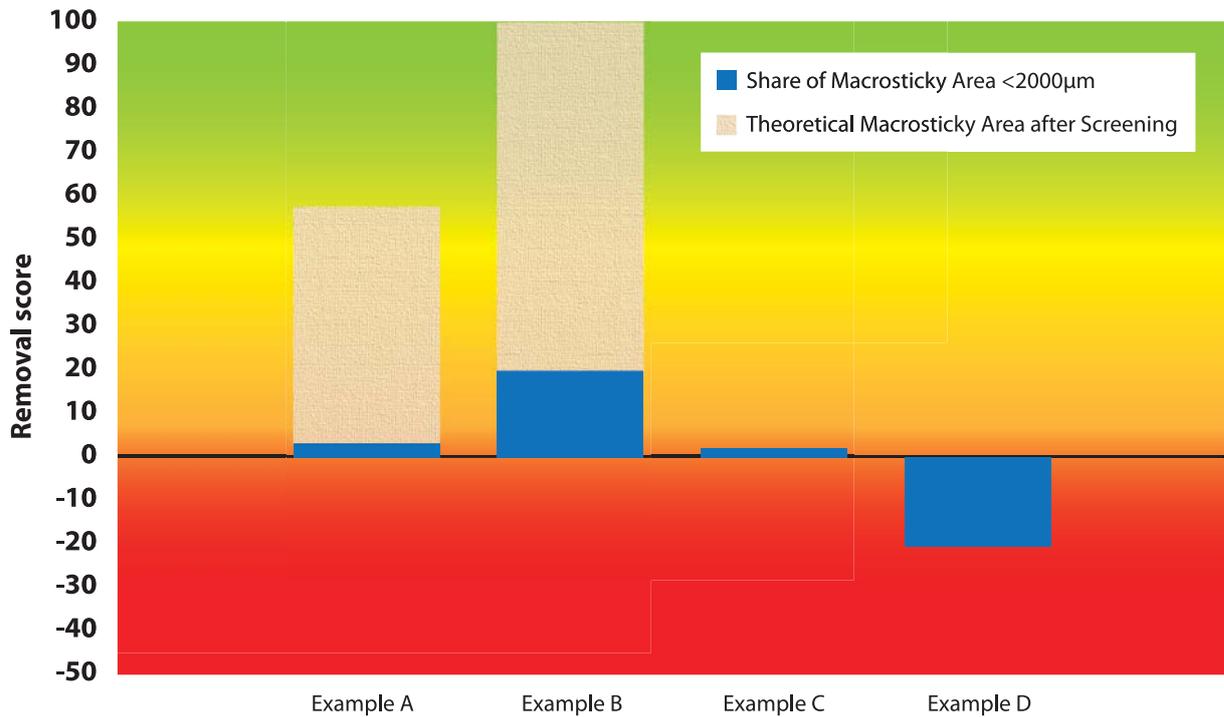


Figure 2: Removal Scores for Examples A to D

**Interpretation of the results of Examples A to D:**

- A. Share  $S_{2000}$  close to threshold and area  $A_t$  on average level results in an average Removal Score.
- B. Low share  $S_{2000}$  and low area  $A_t$  results in the maximum Removal Score.
- C. Share  $S_{2000}$  close to threshold and very high area  $A_t$  results in a low Removal Score.
- D. The very high share  $S_{2000}$  leads to the assessment “insufficiently removable” despite the very low area  $A_t$ .

## Contact

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