

# Packaging Review

# 4/2023

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## SAFETY FACTORS IN CORRUGATED PACKAGING FOR EXTREME ENVIRONMENTAL CONDITIONS



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 Phone: +48 22 828 14 00 / contact@packagingreview.eu  
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## EDITORIAL OFFICE'S ADDRESS / ADRES REDAKCJI:

Świętokrzyska 14A Str. / 00-050 Warsaw, Poland  
 www.packagingreview.eu / contact@packagingreview.eu

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## ADVERTISING AND MARKETING /

### / REKLAMA I MARKETING:

Phone: +48 22 828 14 00 / contact@packagingreview.eu

## DESKTOP PUBLISHING / SKŁAD I ŁAMANIE:

Alfa-Print Sp. z o.o. / Świętokrzyska 14A Str.  
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### Dear Readers!

On November 16th 2023 I had a pleasure of moderating 12. Edition of "Safe Packaging" conference. During the event 13 very interesting lectures were delivered and they represented a very high professional level. The subjects of the presentations were connected with a comprehensively understood safe packaging. Each of the lecturers had a different attitude to the mentioned problem; in connection with this fact, the lectures were much diversified but they were close to the basic topic. As being the person who had carried on all the so-far organised conferences I can say that the subjects presented during the event were interesting, exploratory and on a high professional level. Year by year, the level of the presented lectures and their modernity is increasing. The range of the safe packaging idea outlines also the higher and higher frames. This year, various digital technologies serving the production or protection a safe packaging, were dominating. I encourage you to read the coverage of the conference and participate in the next edition of the event!

**Stefan Jakucewicz, D.Sc, Ph.D, Prof. emeritus Warsaw University of Technology.** A graduate of Łódź University of Technology in the field of cellulose and paper technology, as well as Warsaw University of Technology in the field of printing. From 1974 he was a researcher at TU Warsaw. Since September 2018 he has been a pensioner. The editor of the sections in the periodicals: *Opakowania* (Packaging) and *Przegląd Papierniczy* (Paper Review). Research interests: printing materials science, paper technology and printing techniques of various substrates, with particular emphasis on plastics and the production of printed packaging, production of banknotes and postage stamps (security prints), certification of new base materials for both classic and digital printing techniques. Author or co-author of over 300 scientific articles published in Ukrainian, Slovak and German national journals, and 70 scientific and scientific-technical books published in Polish, German, Slovak and Ukrainian.

### Drodzy Czytelnicy!

16 listopada 2023 r. miałem przyjemność moderować 12. już edycję konferencji „Bezpieczne Opakowanie”. Podczas wydarzenia wygłoszono 13 bardzo interesujących, o wysokim poziomie merytorycznym, referatów. Tematyka wystąpień była związana z szeroko pojętym bezpiecznym opakowaniem. Każdy z prelegentów inaczej pojmował to zagadnienie, w związku z czym wystąpienia były bardzo różnorodne, ale nie odbiegały od tematu podstawowego. Jako osoba prowadząca wszystkie dotychczasowe konferencje mogę stwierdzić, że tematyka prezentowana obecnie była bardzo ciekawa, odkrywcza i na wysokim poziomie merytorycznym. Z roku na rok poziom prezentowanych wystąpień oraz ich nowoczesność rosną. Rozpiętość pojęciowa bezpiecznego opakowania zakreśla także coraz szersze ramy. W tym roku dominowały różne technologie cyfrowe służące do wytworzenia lub zabezpieczenia bezpiecznego opakowania. Zachęcam do zapoznania się z relacją z konferencji oraz udziału w kolejnej edycji wydarzenia!

**Dr hab. inż. Stefan Jakucewicz, em. prof. PW.** Absolwent Politechniki Łódzkiej w zakresie technologii celulozy i papieru oraz Politechniki Warszawskiej w zakresie poligrafii. Od 1974 roku pracownik naukowo-dydaktyczny Politechniki Warszawskiej, od września 2018 emeryt. Redaktor działowy w czasopismach „Opakowanie” i „Przegląd Papierniczy”. Zainteresowania naukowe: materiałoznawstwo poligraficzne, technologia papieru oraz techniki drukowania różnych podłoży ze szczególnym uwzględnieniem tworzyw sztucznych i produkcji opakowań drukowanych, produkcji banknotów oraz znaczków pocztowych (druki zabezpieczone), atestacja nowych materiałów podłożowych przeznaczonych tak do klasycznych, jak i cyfrowych technik drukowania. Autor lub współautor ponad 300 artykułów naukowych opublikowanych w czasopismach krajowych, ukraińskich, słowackich i niemieckich oraz 70 książek naukowych i naukowo-technicznych wydanych w językach polskim, niemieckim, słowackim i ukraińskim.

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POZNAN UNIVERSITY OF LIFE SCIENCES, FACULTY OF ENVIRONMENTAL AND MECHANICAL ENGINEERING

# EVALUATING SAFETY FACTORS IN CORRUGATED PACKAGING FOR EXTREME ENVIRONMENTAL CONDITIONS

## OCENA CZYNNIKÓW BEZPIECZEŃSTWA OPAKOWAŃ Z TEKTRY FALISTEJ W EKSTREMALNYCH WARUNKACH ŚRODOWISKOWYCH

**ABSTRACT:** This article presents an in-depth analysis of the critical safety factors necessary for corrugated packaging, particularly in the context of transportation and storage under extreme environmental conditions such as high humidity and low temperatures. The study begins with an overview of the fundamental properties and applications of corrugated packaging materials, emphasizing their significance in the global supply chain. It then delves into the specific safety factors that are crucial for maintaining the structural integrity of corrugated packaging, including compressive strength, burst strength, and edge crush test ratings. Special attention is given to the impact of extreme environmental conditions on these materials. The article highlights how factors like humidity and temperature fluctuations can significantly weaken corrugated packaging, necessitating adjustments in safety factors. Tables outlining suggested safety factor ranges for various conditions are provided to guide manufacturers and shippers in adapting their packaging strategies. Furthermore, the article reviews relevant ASTM and ISO standards, along with FEFCO guidelines, providing insights into industry best practices and compliance requirements. This comprehensive analysis aims to equip stakeholders in the packaging industry with the knowledge to ensure the durability and reliability of corrugated packaging, thereby safeguarding the quality and safety of goods in transit and storage.

**Key words:** safety factors, corrugated board, packaging strength

**STRESZCZENIE:** Artykuł ten przedstawia dogłębną analizę kluczowych czynników bezpieczeństwa niezbędnych dla opakowań z tektury falistej, szczególnie w kontekście transportu i przechowywania w ekstremalnych warunkach środowiskowych, takich jak wysoka wilgotność i niskie temperatury. Badanie rozpoczyna się od przeglądu podstawowych właściwości i zastosowań materiałów do opakowań transportowych, podkreślając ich znaczenie w globalnym łańcuchu dostaw. Następnie zagłębia się w konkretne czynniki bezpieczeństwa, które są kluczowe dla zachowania integralności strukturalnej opakowań falistych, w tym wytrzymałość na ściskanie, wytrzymałość na przebicie i odporność na zgniatanie krawędziowe. Szczególna uwaga poświęcona jest wpływowi ekstremalnych warunków środowiskowych na tekturę falistą. Artykuł podkreśla, jak czynniki takie jak wilgotność i wahania temperatury mogą znacząco osłabić opakowania z tektury falistej, wymagając dostosowania czynników bezpieczeństwa. Zapewnione są tabele z zalecanymi zakresami czynników bezpieczeństwa dla różnych warunków, aby pomóc producentom i nadawcom w dostosowaniu ich strategii opakowaniowych. Ponadto artykuł przegląda odpowiednie normy ASTM i ISO, wraz z wytycznymi FEFCO, dostarczając wglądu w najlepsze praktyki branżowe i wymagania zgodności. To wszechstronne badanie ma na celu wyposażenie interesariuszy branży opakowaniowej w wiedzę, która zapewni trwałość i niezawodność opakowań, chroniąc tym samym jakość i bezpieczeństwo towarów w transporcie i magazynowaniu.

**Słowa kluczowe:** współczynniki bezpieczeństwa, tektura falista, nośność opakowania

## 1. INTRODUCTION

In the rapidly evolving landscape of global trade and logistics, corrugated packaging plays a pivotal role in the protection and safe delivery of goods across diverse industries. As the backbone of modern packaging solutions, corrugated materials offer a unique blend of strength [22], flexibility, and sustainability [2, 24, 26], making them an ideal choice for a wide range of

applications. However, the performance of these materials is not immune to the challenges posed by environmental factors. Extreme temperature and humidity conditions [21], commonly encountered during transportation and storage [17, 25], can significantly impact the structural integrity and effectiveness of corrugated packaging.

Transportation and storage of goods involve a myriad of environmental challenges that can significantly affect the integrity and safety of products. Corrugated packaging commonly used for shipping and storing products faces various environmental stressors that necessitate careful consideration in its design and material selection [7, 12, 20]. One of the primary challenges in transportation and storage is temperature fluctuations. Products may be exposed to extreme heat or cold depending on the geographic location and time of year. These temperature variations can affect the physical properties of corrugated packaging materials making them either brittle in cold conditions or overly pliable in hot environments which can lead to structural failures.

Humidity is another critical factor particularly in regions with high moisture levels or during sea transport. Humidity can weaken the corrugated fiberboard reducing its strength and making it more susceptible to damage [3]. Moisture absorption can also lead to mold and mildew growth which not only compromises the structural integrity of the packaging but can also pose health hazards especially for food and pharmaceutical products. Mechanical stresses such as vibrations shocks and impacts during transportation are further challenges [17]. These can occur during handling loading and unloading as well as from the movement of the transportation vehicle itself. These mechanical forces can cause deformation crushing or even bursting of packaging especially if the material is not robust enough to withstand such stress.

Another challenge is exposure to chemicals or contaminants. This can occur during industrial shipments or due to environmental factors such as air pollution or exposure to saltwater during maritime shipping. Such exposure can degrade packaging materials leading to potential contamination of the contents. Overall managing these environmental challenges is crucial for ensuring the safe and effective transport and storage of goods. It requires a thorough understanding of the conditions that the packaging will be exposed to and the selection of appropriate materials and design features that can withstand these challenges. This not only ensures the safety and integrity of the products being transported but also enhances the efficiency and reliability of the supply chain operations.

In recent years the packaging industry has recognized the growing need for estimating the strength of corrugated boxes using simple analytical formulas and numerical methods [4, 8, 10, 13, 18, 2]. This approach is essential for optimizing design ensuring cost-effectiveness and maintaining product safety during transportation and storage. Cost and time efficiency are major factors driving this trend. Developing simple yet reliable analytical formulas for estimating box strength can significantly reduce the time and resources required for empirical testing [8]. This efficiency is crucial in a fast-paced production environment. Additionally design optimization is facilitated by numerical methods allowing for the simulation of various design scenarios helping manufacturers to optimize box design for specific loading conditions and distribution channels without the need for extensive physical prototyping [9, 19, 23].

Predictive analysis enabled by these methods allows for the prediction of box performance under different environmental conditions such as humidity and temperature fluctuations which are challenging to replicate in physical tests [3]. Furthermore these methods enable customization for specific packaging requirements considering factors like material properties flute size and wall construction which are critical for customizing packaging solutions to individual product needs [18, 19].

This article delves into the critical examination of safety factors essential for ensuring the resilience and reliability of corrugated packaging in the face of such environmental extremes. Understanding and appropriately adjusting these safety factors is not just a matter of maintaining the physical integrity of the packaging but also about safeguarding the quality and condition of the contents within [11]. This becomes particularly crucial in scenarios where the packaging is subjected to prolonged exposure to low temperatures, which can render corrugated materials brittle and less impact-resistant, or high humidity levels, known to weaken the tensile and compressive strength of these materials.

Given the diverse and often unpredictable nature of transportation and storage conditions, this report aims to provide a comprehensive overview of the safety considerations

necessary for corrugated packaging. It underscores the importance of adapting these factors to meet the challenges posed by extreme environmental conditions, thereby ensuring the continued efficacy of corrugated packaging as a key element in the global supply chain.

## 2. SAFETY FACTORS IN CORRUGATED PACKAGING

Compressive strength in corrugated packaging refers to the maximum load a packaging material can withstand before failing. This measure is crucial in determining how much weight a box can handle before collapsing ensuring that the packaging is suitable for stacking and transport. Burst strength measures the force required to rupture or puncture the wall of corrugated board. This strength is essential to determine how well packaging can hold up to rough handling pressure or stacking forces that might cause it to burst. The Edge Crush Test ECT on the other hand indicates the stacking strength of corrugated boxes. It measures the amount of force a piece of corrugated board can withstand before collapsing on its edge. ECT is key in evaluating the vertical stacking strength of a box critical for designing packaging that needs to support heavy loads or endure high stacking in storage facilities.

Understanding these factors is essential for creating packaging that protects contents effectively during shipping and storage. They are key in determining the overall strength and durability of packaging while balancing factors like cost and material efficiency. Compliance with these metrics ensures consistency and reliability in packaging performance across different applications and industries.

Material quality in corrugated packaging plays a crucial role in determining its strength and durability. Higher quality materials typically exhibit better bonding and consistency leading to improved compressive strength and higher resistance to bursting. The type of paper used the weight and the quality of the fibers whether virgin or recycled all contribute to the overall material quality [16]. Flute size and profile are also key factors in the structural integrity of corrugated packaging. Different flute profiles like A B C E and F offer various degrees of strength and cushioning. Larger flutes provide better stacking strength

suitable for heavier loads while smaller flutes offer better crush resistance and are ideal for packaging requiring high-quality printing. The choice of flute size and profile affects the overall performance of the packaging in terms of strength protection and printability.

Wall construction in corrugated packaging referring to the number of layers of corrugated material like single-faced single-wall double-wall or triple-wall significantly influences its strength and durability. Single-wall construction is common for most standard shipping boxes while double-wall or triple-wall constructions provide enhanced strength and cushioning for heavier or more fragile items. The wall construction determines the packaging's ability to withstand various stresses such as compression impacts and punctures.

These aspects, i.e. material quality, flute size and profile as well as wall construction together determine the key safety factors of corrugated packaging such as compressive strength burst strength and edge crush test ratings. The combination of these elements is essential for designing packaging that meets specific functional and safety requirements ensuring the safe transport and storage of goods.

## 3. IMPACT OF EXTREME CONDITIONS ON PACKAGING

Low temperatures and high humidity have significant impacts on corrugated packaging which need to be carefully considered for ensuring packaging integrity and performance.

In low temperatures, the fibers in corrugated cardboard become more brittle increasing the risk of cracking or breaking under impact or pressure. Adhesive performance is also impacted as the cold can reduce the effectiveness of adhesives leading to potential delamination and compromised structural integrity. Moving packaging from cold to warmer environments can cause condensation, weakening the cardboard and reducing its load-bearing capacity. Consequently, Edge Crush Test (ECT) and Box Compression Test (BCT) values may decrease as the material becomes less flexible and more prone to fracture under load.

High humidity presents different challenges for corrugated packaging as it weakens the cardboard by softening the fibers.

TABLE 1. SUGGESTED SAFETY FACTOR

Condition/Factor	Suggested Safety Factor Range	Notes/Considerations
Material Quality	1.1 - 1.3	Higher quality materials might need a lower safety factor.
Flute Size and Profile	1.2 - 1.4	Larger flutes provide more cushioning and strength.
Wall Construction	1.1 - 1.5	More layers typically mean higher strength.
Moisture and Humidity	1.3 - 1.6	High humidity weakens corrugated material.
Temperature Extremes	1.2 - 1.5	Extreme temperatures affect material strength.
Duration of Stress	1.2 - 1.6	Long-term storage under load requires a higher factor.
Transportation Vibrations	1.3 - 1.7	Transportation stress can weaken packaging.
Stacking Pattern and Height	1.2 - 1.5	Higher stacks require a higher safety factor.
Product Weight/Distribution	1.1 - 1.4	Heavier/unevenly distributed contents need higher factors.
End-use Environment	1.2 - 1.5	Packaging used in varying environments.
Low Temperature	1.2 - 1.5	Corrugated material can become brittle in cold.
High Humidity	1.5 - 2.0	Humidity can significantly weaken the material.

This results in a significant reduction in compressive and tensile strength. Glue and adhesive degradation is also a concern in humid conditions, potentially leading to structural failures, especially when the packaging is stacked. Moreover, prolonged exposure to high humidity can encourage mold and fungal growth, compromising both the structural integrity and hygiene of the packaging. Like low temperatures, high humidity also adversely affects ECT and BCT values due to the loss of rigidity and strength from moisture absorption.

When corrugated packaging is exposed to both low temperatures and high humidity, albeit not simultaneously, the material undergoes a range of stresses. While low temperatures make it brittle and more prone to cracking, high humidity weakens and softens it. This necessitates careful design considerations, such as using higher-grade materials, incorporating moisture barriers, or adding insulation. To maintain structural integrity under varying conditions, regular testing under simulated environmental conditions is crucial to ensure compliance with relevant standards and maintain the safety and integrity of the packaging.

Understanding and mitigating the effects of low temperatures and high humidity are essential for the safe and effective transportation and storage of goods in corrugated packaging. Table 1 summarizes the safety factors for corrugated packaging

under various conditions, along with their suggested value ranges.

Table 1 provides a general guideline and should be tailored based on specific requirements, testing outcomes, and industry standards.

#### **Discussion of the need for increased safety factors under these conditions.**

The need for increased safety factors in corrugated packaging under conditions of low temperature and high humidity is imperative for maintaining the structural integrity and performance of the packaging. Low temperatures can lead to increased brittleness in corrugated materials which means that they become more prone to breaking or cracking under stress or impact. This necessitates a higher safety factor to account for the reduced flexibility and increased fragility of the material. Similarly, the adhesives used in corrugated packaging can lose their effectiveness in cold temperatures leading to potential delamination and structural weakness. In such cases, a higher safety factor would help ensure that the packaging remains intact and functional despite the reduced adhesive strength. High humidity presents a different set of challenges as it weakens the corrugated material by softening the fibers leading to a reduction in both compressive and tensile strength. In environments with high humidity levels, corrugated

TABLE 2. SUGGESTED SAFETY FACTOR ADJUSTMENTS FOR LOW TEMPERATURES

Aspect of Corrugated Packaging	Standard Safety Factor	Adjusted Safety Factor for Low Temperatures	Notes/Considerations
Material Quality	1.1 - 1.3	1.2 - 1.5	Low temperatures can make materials brittle; higher quality materials may be more resistant.
Flute Size and Profile	1.2 - 1.4	1.3 - 1.6	Larger flutes may provide better insulation and structural integrity in cold environments.
Wall Construction	1.1 - 1.5	1.2 - 1.6	Multi-wall construction might offer better performance in low temperatures.
Moisture and Humidity	1.3 - 1.6	1.3 - 1.6	Although humidity is a separate factor, low temperatures can also lead to condensation issues.
Transportation Vibrations	1.3 - 1.7	1.4 - 1.8	Vibrations can have more impact on brittle materials at low temperatures.
Stacking Pattern and Height	1.2 - 1.5	1.3 - 1.6	The brittleness caused by low temperatures can affect stacking strength.
Product Weight/Distribution	1.1 - 1.4	1.2 - 1.5	Uneven weight distribution can be more problematic when material is brittle.

packaging can absorb moisture which significantly diminishes its load-bearing capacity. As a result, there is a need for a greater safety factor to compensate for this loss of strength and rigidity. Furthermore, high humidity can also cause the degradation of adhesives and glues used in corrugated packaging compromising its overall structural stability. Increasing the safety factor in such conditions is crucial to account for the potential weakening of bonding and the overall structure of the packaging.

In addition to these material-specific considerations, the cumulative effect of both low temperatures and high humidity on corrugated packaging necessitates a comprehensive approach to safety factor adjustments. While each condition independently affects the packaging material, their combined impact can be more severe and unpredictable. Therefore, understanding the specific challenges posed by these environmental conditions and adjusting the safety factors accordingly is essential for ensuring the safe transport and storage of goods in corrugated packaging. Regular testing and compliance with industry standards are also key in adapting these safety factors effectively.

#### 4. ADJUSTING SAFETY FACTORS FOR EXTREME CONDITIONS

Table 2 provides suggested safety factor adjustments for corrugated packaging in response to low temperatures.

These values are suggestive and should be tailored based on specific product requirements, material testing, and industry standards. The adjustments are made considering the increased brittleness and potential changes in material properties at low temperatures.

On the other hand, Table 3 illustrates suggested safety factor adjustments for corrugated packaging in high humidity conditions.

The safety factors are adjusted to account for the reduced strength and increased susceptibility to damage in high humidity conditions. These values should be further tailored based on the specific type of corrugated material, the anticipated level of humidity, and the product's sensitivity to moisture. Additional protective measures like moisture barriers or desiccants can also influence these factors.

TABLE 3. SUGGESTED SAFETY FACTOR ADJUSTMENTS FOR HIGH HUMIDITY

Aspect of Corrugated Packaging	Standard Safety Factor	Adjusted Safety Factor for High Humidity	Notes/Considerations
Material Quality	1.1 - 1.3	1.4 - 1.6	High humidity weakens materials; quality is more crucial.
Flute Size and Profile	1.2 - 1.4	1.5 - 1.7	Certain flute profiles may resist humidity better.
Wall Construction	1.1 - 1.5	1.4 - 1.8	Multi-wall construction can provide better resistance.
Moisture Resistance Treatment	1.3 - 1.6	1.5 - 1.8	Treatments for moisture resistance become vital.
Transportation Vibrations	1.3 - 1.7	1.5 - 1.9	Weakened material may respond poorly to vibrations.
Stacking Pattern and Height	1.2 - 1.5	1.5 - 1.8	Humidity can compromise stacking strength.
Product Weight/Distribution	1.1 - 1.4	1.4 - 1.7	Weight distribution is crucial in weaker structures.

## 5. INDUSTRY STANDARDS AND GUIDELINES

Relevant ASTM [1] and ISO [14, 15] standards play a crucial role in ensuring the quality and safety of corrugated packaging materials among these standards.

- ASTM D642-20 [1] stands out as a critical benchmark for determining the compressive resistance of shipping containers components and unit loads. This standard is essential for assessing how much load a corrugated box can bear before collapsing ensuring that the packaging is suitable for stacking and transport under various conditions.
- ISO 13820:2021 [14] focuses on the description and calibration of fixed platen compression-testing equipment used for testing paper board and corrugated fibreboard. This standard specifies the essential characteristics and principles of calibration for this equipment which is vital for accurate testing of the compressive strength of packaging materials.
- ISO 3037:2022 [15] provides a methodology for determining the edgewise crush resistance of corrugated fibreboard a key indicator of the material's stacking strength. This standard is instrumental in evaluating the vertical stacking capability of corrugated boxes particularly important for understanding how much weight these boxes can support during storage and transportation.
- The FEFCO Technical Specifications [5, 6] offer additional guidance specifically for the corrugated industry focusing on the converting equipment used in producing corrugated materials. These specifications are crucial for those involved

in selecting and operating converting machines ensuring that the finished corrugated products meet the required quality levels.

Additionally the FEFCO Good Manufacturing Practice (GMP) standard updated in 2020 [6] is developed for the manufacturing of packaging made of corrugated board. It supports companies in fulfilling legal requirements according to EU regulations for food contact materials and good manufacturing practices ensuring the safety hygiene and quality of corrugated boxes. Together these ASTM and ISO standards along with FEFCO guidelines provide a comprehensive framework for assessing and ensuring the structural integrity and quality of corrugated packaging materials. Compliance with these standards is essential for manufacturers and suppliers in the packaging industry ensuring that their products are safe reliable and suitable for a wide range of applications.

## 6. CASE STUDIES AND REAL-WORLD APPLICATIONS

Businesses in various industries have adapted their safety factors for corrugated packaging in response to extreme conditions to ensure the safety and integrity of their products during transport and storage [11]. In the food and beverage industry companies shipping perishable goods have increased safety factors for packaging in high humidity environments. This adjustment accounts for the potential weakening of corrugated boxes due to moisture absorption which is critical in preventing product damage and maintaining hygiene. Standards for burst strength and compressive resistance are

particularly emphasized to withstand the rigors of long-distance shipping and fluctuating humidity levels

In the electronics sector where products are sensitive to temperature fluctuations businesses have adjusted the safety factors of their packaging for low-temperature environments. This includes using higher-grade corrugated materials with enhanced cold resistance and incorporating insulating layers to protect against temperature-induced brittleness and cracking. These measures ensure that electronic goods remain protected from the impacts of cold during shipping especially in winter months.

The pharmaceutical industry also showcases significant adjustments in packaging safety factors for both high humidity and low-temperature conditions. Medicines and medical devices being highly sensitive to environmental conditions require packaging that can maintain its structural integrity under extreme conditions. This has led to the adoption of corrugated boxes with higher safety factors and specialized coatings to resist moisture and temperature changes ensuring that the products remain safe and effective throughout their journey.

Retail and e-commerce businesses dealing with a wide range of products have adopted a flexible approach to packaging safety factors. Tailoring the packaging based on the destination's climate and the product's sensitivity these businesses use variable safety factors to optimize protection and cost-efficiency. This approach involves rigorous testing of packaging materials under simulated environmental conditions and adhering to strict industry standards for material strength and durability.

In summary businesses across different sectors have recognized the importance of adjusting safety factors in corrugated packaging to address the challenges posed by extreme environmental conditions. These adjustments are key to ensuring product safety and quality during transportation and storage while also reflecting a commitment to customer satisfaction and regulatory compliance.

#### A PRACTICAL EXAMPLE

Let's assume a pharmaceutical company specializing in the transport of temperature-sensitive vaccines faces the challenge of shipping across regions with varying climates including areas

with low temperatures To address this the company adjusts the safety factors for their corrugated packaging to ensure the vaccines remain safe and effective during transportation. Standard safety factors such as compressive strength (BCT) at 1.3; burst strength (BST) at 1.2 and Edge Crush Test (ECT) at 1.5 are re-evaluated for low-temperature conditions

For low temperatures, the compressive strength is increased to 1.5 considering the risk of material brittleness in cold weather. Burst strength is adjusted to 1.4 to ensure the packaging can withstand rough handling which is more likely in cold conditions. ECT is raised to 1.7 to accommodate the increased risk of edge crushing when the material becomes brittle. Additional measures are incorporated into the packaging design including insulating layers to maintain a stable internal temperature and a moisture-resistant coating to protect against potential condensation issues when moving from cold to warmer areas. The company conducts a series of cold chamber tests to simulate the low-temperature conditions validating the adjusted safety factors. This rigorous testing ensures that the new safety factors and additional protective measures are effective. After successful validation, the company adopts these higher safety factors and additional measures for all vaccine shipments to cold regions.

This approach demonstrates a proactive and calculated response to the unique challenges posed by transporting sensitive products like vaccines. The increased safety factors and implementation of additional protective measures are key to maintaining product integrity in the face of environmental challenges ensuring that the vaccines remain safe and effective throughout their journey.

#### AN ILLUSTRATIVE EXAMPLE.

Let's consider a scenario where corrugated packaging is exposed to both high humidity and significant vibration during transportation. Here's how you might visualize the combined impact on safety factors:

1. **Baseline Safety Factor:** Assume a standard safety factor for corrugated packaging is 1.5 under normal conditions.
2. **Adjustment for High Humidity:** High humidity might require increasing the safety factor by 20%, taking it to 1.8.

TABLE 4. SAFETY FACTORS FOR VARIOUS ENVIRONMENTAL AND STORAGE CONDITIONS

Environmental Factors	Compression Loss	Multipliers
Storage time under load	10 days – 37 percent loss	1.37
	30 days – 40 percent loss	1.40
	90 days – 45 percent loss	1.45
	180 days – 50 percent loss	1.50
Relative humidity, under load (cyclical RH variation further increases compressive loss)	50 % RH – 0 percent loss	1.00
	60 % RH – 10 percent loss	1.10
	70 % RH – 20 percent loss	1.20
	80 % RH – 32 percent loss	1.32
	90 % RH – 52 percent loss	1.52
	100% RH – 85 Percent Loss	1.85

- Adjustment for Vibration:** Transportation vibration might add another 15%, increasing the factor to 2.07.
- Combined Safety Factor:** Instead of simply adding, we consider the compounded effect. The final safety factor might be estimated conservatively as 2.1 or higher, depending on the severity and duration of conditions.

This approach illustrates the need for a cautious and cumulative adjustment of safety factors when multiple stressors are present. The exact values would depend on specific conditions and material testing.

#### MORE SPECIFIC VALUES

If one is interested in more detailed values of safety factors that depend on storage time, palletization or relative humidity,

comprehensive information can be found in Tables 4 and 5 from Goodwin's work [13].

#### MEANS OF TRANSPORT

Assigning a specific safety factor for each transportation mode requires careful consideration of the unique stresses and risks associated with that mode. While there are no universally fixed values, one can assume some general guidelines or typical ranges for safety factors for each mode of transportation:

- **Road Transport:** Typical Safety Factor Range: 1.2 to 1.5.  
Considerations: Road transport often involves vibrations, impacts from rough roads, abrupt stops, and turns. The safety factor should account for these variables, especially for longer journeys or routes known to have poor road conditions.

TABLE 5. SAFETY FACTORS FOR VARIOUS PALLETIZATION PATTERNS

Pallet Patterns	Loss	Best Case	Worst Case
Columnar, Aligned	Up to 8 percent loss	1.00	1.08
Columnar, misaligned	10-15 percent loss	1.10	1.15
Interlocked	40-60 percent loss	1.40	1.60
Overhang	20-40 percent loss	1.20	1.40
Pallet deck board gap	10-25 percent loss	1.10	1.25
Excessive handling	10-40 percent loss	1.10	1.40

- **Rail Transport:** Typical Safety Factor Range: 1.3 to 1.6. Considerations: Rail transport is characterized by constant vibrations and potential for lateral and longitudinal shocks. The continuous nature of these stresses often necessitates a slightly higher safety factor.
- **Air Transport:** Typical Safety Factor Range: 1.4 to 1.8. Considerations: Air transport involves additional stresses like pressure changes, potential for greater impacts during loading and unloading, and less control over handling. The higher range of safety factor accounts for these increased risks.
- **Sea Transport:** Typical Safety Factor Range: 1.5 to 2.0. Considerations: Sea transport poses challenges like high humidity, saltwater exposure, long-duration vibrations, and heavy impacts during storms. The highest range of safety factor is often used due to these prolonged and varying conditions.

These ranges are general estimates. The specific safety factor for the packaging should be determined based on more detailed analysis of the product, packaging material, and specific transportation conditions. It's advisable to conduct rigorous testing, including simulated transportation conditions, and consult industry standards (like ISO or ASTM) for more precise safety factor determination. The fragility and value of the product being shipped can also influence the required safety factor. More delicate or valuable items may necessitate higher safety factors. The overall environmental conditions (e.g., extreme temperatures) and handling practices (e.g., manual vs. automated) during transportation should also be factored into the safety factor calculation. Ensure that your packaging meets any specific regulatory requirements for the regions and countries you are shipping to or through.

These safety factors are an additional margin of security over and above the expected maximum stresses to ensure that the packaging can withstand unexpected situations without failing.

## 7. CONCLUSION

The study of safety factors in corrugated packaging under extreme environmental conditions reveals key insights essential

for the packaging industry. Corrugated packaging must be designed to withstand challenges such as low temperatures and high humidity which can significantly impact material properties leading to reduced strength and integrity. Adjusting safety factors for compressive strength burst strength and edge crush test is crucial in these conditions. Material quality, flute size and wall construction play vital roles in determining these safety factors ensuring the packaging is robust enough to protect contents under varying environmental stresses.

The findings highlight the need for businesses to adopt a proactive approach in adjusting safety factors based on specific environmental challenges faced during transportation and storage. Rigorous testing and adherence to industry standards like ASTM and ISO are recommended to ensure packaging reliability and safety. This approach not only ensures the protection of goods but also enhances the efficiency and reliability of supply chain operations.

Recommendations for industry practices include regular material testing under simulated environmental conditions, careful selection of packaging materials based on product, transportation needs and continuous monitoring or reassessment of packaging performance in different environments. Companies should also stay updated with the latest developments in packaging technology and materials to continually improve their packaging solutions. In summary understanding and effectively responding to environmental challenges in packaging is key to maintaining product safety and quality while also meeting consumer and regulatory expectations.

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DR JOANNA KARWOWSKA / ORCID: 0000-0001-7328-193X / jkarwow@sgh.waw.pl

COLLEGIUM OF MANAGEMENT AND FINANCE, SGH WARSAW SCHOOL OF ECONOMICS IN WARSAW

# ENVIRONMENTAL PROTECTION IN CONTEMPORARY MARKETING – THEORETICAL BACKGROUND AND MARKET PRACTICE ON THE EXAMPLE OF PACKAGING – PART 1

OCHRONA ŚRODOWISKA WE WSPÓŁCZESNYM MARKETINGU

– PODSTAWY TEORETYCZNE A PRAKTYKA RYNKOWA NA PRZYKŁADZIE OPAKOWANIA – CZĘŚĆ 1.

**ABSTRACT:** This paper presents theoretical and practical aspects of packaging compliant with the environmental protection principles in marketing communication. There were indicated models valid from the perspective of technical knowledge, such as recyclability, biobased materials, biodegradability, compostability and upcycling. Focus was placed on the attitudes, level of knowledge and awareness of the buyer, which translate into the effectiveness of various ways of communicating about a product or brand.

**Key words:** environmental protection, effectiveness of marketing communication, buyers' attitude, purchasing decisions

**STRESZCZENIE:** Analiza prezentuje teoretyczne i praktyczne aspekty stosowania opakowania zgodnego z zasadami ochrony środowiska w komunikacji marketingowej przedsiębiorstwa. Wskazano uprawnione z perspektywy wiedzy technicznej modele takie jak przydatność do recyklingu, biopochodność, biodegradowalność, kompostowalność czy upcycling. Szczególnie skupiono się na postawach, poziomie wiedzy i świadomości nabywcy przekładających się na efektywność rozmaitych sposobów komunikacji dotyczącej produktu czy marki.

**Słowa kluczowe:** ochrona środowiska, efektywność komunikacji marketingowej, postawy nabywców, decyzje zakupowe

## INTRODUCTION

In the contemporary brand and product management, packaging plays a key role as an effective element of positioning, distinguishing and adding emotional values building customer loyalty. Compliance of packaging with the principles of environmental protection is an increasingly important aspect of packaging design due to the expectations of buyers, but also legal regulations: recycling rates and restrictions on the use of disposable products. The numerous limitations, but also

the level of awareness of the buyer, makes that effective marketing communication through environment compliant packaging is a complicated issue, requiring a synergic combination of promotional elements with technical knowledge. The modern market is aware of environmental conditions, the consumers have wider access to knowledge, and the phenomenon of prosumers (Toffler 1980) is becoming more and more common. Irresponsible (intentional or resulting from lack of knowledge) behavior of enterprises bearing the

hallmarks of the so-called greenwashing (Horiuchi et al. 2009) may undermine or even destroy the image of enterprises, brands, and products. Therefore, it becomes necessary to build modern environmental communication and registers of authorized solutions relating to scientific knowledge, which can be the basis not only for product design, but also for information strategies.

In this complicated situation, packaging becomes a medium for two types of marketing messages: general (a) and more precise, concerning both the product (b) and itself (c). The latter is a powerful communication tool, according to McLuhan, assuming that the choice of medium itself is the message (McLuhan 2004) (and the choice of packaging reflects the actual activities of the company, even if they are not communicated directly and convincingly):

- a. medium of general information about activities related to environmental protection or social responsibility, e.g., activities for communities or social groups. However, a noticeable problem is the low level of verifiability of the manufacturer's declaration. The lack of trust of the modern buyer is influenced, for example, by imprecise, unjustified, or deliberately misleading environmental declarations – practices of greenwashing,
- b. medium of information related to the product, e.g., manufacturer, composition, best-before date, suitability for vegans. This group of information elements also includes the so-called third-party labels for products such as EU Ecolabel, Krav or Nordic Swan,
- c. medium of information about the packaging itself, such as the environmental protection models used, e.g., various forms of messages regarding recyclability, compostability or the use of bioplastics. It is especially advisable to undergo codified assessment methods, e.g., certification of bio-origin or compostability, preceded by tests that authorize the use of appropriate signs on packaging (Karwowska 2021).

## 1. MODELS OF SHAPING PACKAGING ACCORDING TO ENVIRONMENTAL CRITERIA

Based on consumer research and the circular economy model principles: the Life Cycle Assessment and the eco-design

guidelines, it has been established a list of the most important criteria for environmental protection. It is also worth emphasizing the fact that the defined criteria are universal: they can be applied not only to the packaging, but also to the whole product. These features can be combined, bio-based and compostable, for example:

1. recyclability,
2. recycled content/material,
3. bio-biobased content/material,
4. biodegradability,
5. compostability,
6. suitability for upcycling (Karwowska 2021).

Recycling is a recovery method in which waste is reprocessed into products, materials, or substances for original or other purposes – products other than packaging. The term organic recycling can refer to the aerobic (including composting) or anaerobic treatment of biodegradable waste under controlled conditions using microorganisms. This process produces organic matter or methane. On the other hand, material recycling means the reprocessing of waste into products with utility value, usually for purposes other than the original one. This takes place in the so-called a cascade system in which products are less demanding at each subsequent stage. The last solution is chemical recycling, which consists in processing waste into materials with different physical and chemical properties by depolymerizing chains to monomers (Żakowska 2017), (Karwowska 2021).

Bioplastics are a group of biodegradable and/or bio-based polymers made of three types:

- non-biodegradable (not degradable to simple organic compounds under the influence of microorganisms) from renewable resources (reproducible in the same or shorter time than the time needed to use them),
- biodegradable from renewable raw materials,
- biodegradable, produced from conventional petroleum-derived raw materials.

Biodegradable packaging material undergoes biochemical decomposition of organic compounds into simple inorganic

compounds with the participation of microorganisms. On the other hand, biomaterial is produced from renewable sources, from natural resources other than crude oil (Żakowska 2017), (Karwowska 2021).

The term composting and compostable refers to one of the biological processes of processing organic substances. It is a natural method of waste disposal (recovery) and waste management, consisting in the decomposition of these substances by microorganisms (Ustawa z dnia 14 grudnia 2012 r. o odpadach), (Karwowska 2021).

Upcycling is a form of waste recycling that produces products with a higher value than the original value of the waste. It is worth noting that this type of practice is common in households, but in the recent years there has been an increasing interest in this solution among companies introducing products to the market. The solutions that favor reuse and thus extend the life cycle are considered part of packaging design.

Additional features of packaging related to environmental protection should also be reusable or monomateriality (using a combination of materials that do not limit or exclude recycling). It is worth noting, however, that the use of reusable packaging applies to a limited group of products, usually traditionally packaged in a specific way, and associated with an appropriate collection system – on the Polish market this applies primarily to beer. This feature of the packaging, although it complies with the eco-cutting guidelines, does not distinguish it from the group of competing products in terms of marketing (Karwowska 2021).

## 2. VISUAL ELEMENTS INFORMING ABOUT COMPLIANCE WITH ENVIRONMENTAL CRITERIA

The second key element of the analysis is to assess the effectiveness of visual elements that communicate compliance with environmental criteria available to the buyer at the time of purchasing the product. As such visual elements the following were defined:

- text information,
- slogans,
- symbols related to the certificates and attestations held,

- other occasional symbols not related to the certificates and attestations held, designed by the enterprises themselves,
- colors (Karwowska 2021).

It is crucial to determine which of the above-mentioned solutions are the most effective in conveying knowledge to the consumer about the environmental aspects of packaging, creating the right associations and convincing to make a purchasing decision, and whether there are noticeable differences in this respect between individual types of messages, and then types of packaging or packaged products. It is the perception of the consumer, his perception and proper interpretation of information on solutions for the protection of the natural environment that seems to be the key issue determining the success of the implementation of these solutions in business practice. Therefore, it is necessary to determine which visual signals are perceptible by the buyer and how they are interpreted and whether the interpretation of the average consumer (representative sample of the Polish market) is conducive to making decisions in accordance with the principles of environmental protection, or vice versa – it disturbs the mentioned process.

### 2.1. TEXT INFORMATION

It seems that relatively extensive communication of this type, although probably relatively less effective than the others, is effective in the case of so-called habitual (taken under the influence of habit) or impulsive (made from curiosity or price) purchase decisions and requiring fuller involvement, in the context of environment has the greatest value. A precise message, referring directly to the buyer's awareness, and not based on the subconscious perception of the product or loose associations, creates the least opportunities to promote the product and brand using greenwashing practices – understatements or syllogisms suggesting the environmental qualities of the packaging. Of course, the producer may act unethically also in this case, but his actions are easier to identify, it is also easier to verify the content of the message and, if necessary, apply sanctions related to the violation of consumer rights or competition law (Karwowska 2021).

From the perspective of the authors of the study, however, it was primarily important to determine whether longer, often complex, and technical knowledge-based messages are effective in the context of the level of perception of the buyer, and the knowledge conveyed in this way is a real source of information about the environmental qualities of the product. It was expected that the extended form may not be adequate to the situation of making a purchasing decision due to the excess of information creating a kind of information noise for a person with an average or lower level of technical knowledge – this initial thesis was largely confirmed by the study.

## 2.2. SLOGANS

It was assumed that next to the color of the packaging, it is the element that has the strongest impact on the consumer's subconscious. According to the so-called affect transfer model, the attitude towards the brand results directly from the attitude towards the advertisement concerning it. It seems, therefore, that the more emotion-based the message, the greater the buyer's, albeit not fully conscious, emotional relationship with the product and the greater the tendency to choose it. Promotional slogans, due to their specificity: metaphors, humor, paradox, are an example of reaching the consumer and attracting his attention directly through emotions. Therefore, it is an effective tool, which unfortunately often encourages producers to abuse it. Various slogans concerning the green values of products or brands are so general and difficult to verify that their unauthorized use in practice does not entail any image or even more legal consequences. In the study, apart from analyzing the issue of the promotional slogan itself, it was decided to compare the effectiveness of two models of its construction: a short slogan and a more complex one (Karwowska 2021).

## 2.3. SYMBOLS RELATED

### TO THE CERTIFICATES AND ATTESTATIONS

Due to the level of credibility, it is probably the most ethical promotion tool related to the environmental parameters, but it requires a high level of awareness from consumers, which may be a certain difficulty in reaching a mass customer and create

the phenomenon of the noise, information overload, especially in the making quick or routine purchasing decisions in which the buyer is unwilling or unable to invest significant resources of attention or time. However, this does not change the fact that in the case of more and more consumers who are aware and willing to use products compliant with the principles of environmental protection, this type of element may be an interesting solution to the issue of promotion, especially since the share of the so-called three parties, i.e. an authorized institution, may eliminate the potential lack of trust in the declarations of the manufacturer itself, which – as the study showed – is a significant problem on the Polish market affecting the effectiveness of communication. In addition, through a kind of exclusivity of participation in certification systems, as in the case of quality systems, such marks can undoubtedly place the product in a higher segment, reducing buyers' sensitivity to price (Karwowska 2021).

## 2.4. OTHER OCCASIONAL SYMBOLS

These types of visual solutions are a complex issue that requires careful analysis, also in the context of greenwashing and official certification symbols or third-party attestations. Awareness of the real meaning of individual symbols and the ability to distinguish those associated with specific features from those created freely by the manufacturer only for promotional purposes may be a problem for customers. Producers should, however, consider the fact that abuses in this area, although they may translate into an increase in demand or profit in the short term, can be quickly verified by the market and have an extremely negative, permanent impact on the image (Karwowska 2021).

## 2.5. COLORS

As an element that directly appeals to emotions, evoking a strong reaction, color is undoubtedly a key, effective element of marketing communication. Its role additionally increases with the development of concepts showing the buyer not only in behavioral terms as a consumer of goods, but as a personality, individuality with a wealth of emotional experiences. The color of the packaging in many cases affects not only the

perception or selection of the product, but also the creation and consolidation of a specific image of it. In the era of increasing importance of environmental protection, a trend called green marketing has become widespread. Shades of green, but also the so-called earth tones, as well as the gray of unbleached paper are supposed to evoke the environmental qualities of the product. The authors of the study initially assumed that it would show a high degree of effectiveness of color as an element of marketing communication but focused on the question of whether the buyer's impressions and attitudes clearly change with the modification of only this element (Karwowska 2021).

### 3. RESEARCH METHOD

The aim of this study was to determine the effectiveness of individual models of marketing communication based on packaging compliant with the principles of environmental protection. The analysis was carried out in an indirect way, tailored to the buyer's perception. A tool in the form of an online panel questionnaire was used (e-panel). The survey was conducted in November 2022 using a statistical survey method: the Ariadna Periodic Panel, specialized in quantitative consumer and social research. They were carried out on a quota-matched, statistically justified sample of adults living in Poland, used in the case of the panel study, reflecting the structure of the population in terms of demographic characteristics such as: gender, age, education, size of town. The sample size was 1066 respondents.

The respondents were selected in two stages: through pre-selection based on data in the user panel, and then through a series of filtering questions. Designed in this way, and then conducted once, the study made it possible to make the most of the opportunities offered by the study panel, such as: precise sample items, completeness, exceptionally high level of so-called feedback (the ratio of the number of the completed questionnaires to the number of questionnaires provided to respondents) and the speed of implementation. research while avoiding most of the limitations that may be associated with this method. The main limitations include the lack of

representativeness or the so-called wear of the panel, i.e., resignation from participation in subsequent stages (Babbie 2008).

...to be continued

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WYDAWNICTWO SIGMA-NOT 

HAVENKO SVITLANA / ORCID: 0000-0003-4973-5174 / svitlana.havenko@p.lod.pl

LODZ UNIVERSITY OF TECHNOLOGY

DOVHANYCH VALENTYNA / ORCID: 0009-0008-1975-1871 / dovghanich.valya@ukr.net

UKRAINIAN ACADEMY OF PRINTING

LABETSKA MARTA / ORCID: 0000-0003-2818-051X / martalabetska@gmail.com

UKRAINIAN ACADEMY OF PRINTING

# STUDY OF OPERATIONAL (CONSUMER) PROPERTIES OF PAPER NAPKINS

## BADANIE WŁAŚCIWOŚCI UŻYTKOWYCH (KONSUMENCKICH) SERWETEK PAPIEROWYCH

**ABSTRACT:** In the present article, the studies of the operational properties of paper napkins printed by the flexographic method have been discussed. The classification of napkins made of tissue paper according to consumer characteristics has been given. The physical and mechanical parameters of one-, two-, and three-layer napkins were studied, in particular: capillary absorption of water, aqueous solutions, and liquid food products, as well as the resistance to deformation during compression. Densitometric indicators were determined according to the printed test scale. It has been confirmed that the optical density is changed depending on the colour percentage of the print area. The conducted test for smearing of printed images showed a negative result, which ensures the satisfactory quality of the napkins when used.

**Key words:** issue products, paper napkins, consumer properties, flexographic printing, quality

**STRESZCZENIE:** Artykuł ten przedstawia badania właściwości użytkowych serwetek papierowych zadrukowanych metodą fleksograficzną. Podano klasyfikację serwetek wykonanych z papieru cिसowego według cech konsumenckich. Przeprowadzono badania parametrów fizyko-mechanicznych serwetek jedno-, dwu- i trójwarstwowych, w szczególności kapilarną absorpcję wody, roztworów wodnych i płynnych produktów spożywczych oraz odporność na odkształcenia podczas ściskania. Wskaźniki densytometryczne wyznaczane są według wydrukowanej skali testowej. Potwierdzono, że gęstość optyczna zmienia się w zależności od procentowego udziału koloru w obszarze zadruku. Przeprowadzony test usuwania farby z nadruków dał wynik negatywny, co zapewnia zadowalającą jakość serwetek podczas ich użytkowania.

**Słowa kluczowe:** produkty tissue, serwetki papierowe, właściwości konsumenckie, druk fleksograficzny, jakość

## INTRODUCTION

In today's world, it is impossible to imagine a person who would not use products made of tissue materials. Humanity uses various sanitary and hygienic products every day.

Depending on the scope of application, sanitary and hygienic products should be divided into two groups: personal (consumer tissue/ at home (AH)) and commercial use (tissue for bulk consumers/ away from home (AFH)). The first group includes toilet paper, paper towels, napkins, handkerchiefs, tablecloths, etc. The second one – is toilet paper and paper towels for offices, public catering enterprises, and schools. By

volume of use in the world, the tissue segment for personal consumption dominates (almost 82%) compared to the products for commercial use (18%) [1-4].

A napkin is a small indispensable thing that may be needed in various life situations. The very word "napkin" comes from the Latin "salve" – "be healthy". Ordinary paper napkins in the form we are used to seeing them appeared recently - a little more than 100 years ago when the English entrepreneur John Dickinson in 1887 constructed a machine that produces napkins from cellulose.



FIG. 1. GENERAL APPEARANCE OF NAPKINS; 1 – UNPRINTED WHITE, 2 – COLOURED, 3 – WITH PRINTING AND EMBOSSING

However, the interest in tissue products and the relevance of these products is dictated by the daily needs of people around the world. Moreover, July 9 is marked in the calendar as the World Paper Napkin Day [5].

With the growth of the market of paper napkins, the demand for them and consumer requirements for such products is steadily growing. As is well known, high-quality paper napkins are usually made from cellulose and wood fibres. The quality of raw materials, the manufacturing technology of tissue products and their purpose – all determine the structure of product consumption by price segments and are formed by the level of the population's welfare.

According to economic criteria, tissue products are divided into three main categories: "Economy", "Standard" and "De Luxe", or "Premium" (high-quality, expensive products):

- economy-class napkins, intended for inexpensive cafes, canteens, and fast-food establishments, usually of standard sizes – 24×24 cm or 25×25 cm;
- standard napkins used at home are single-layer paper napkins, stronger than their counterparts in the economy segment, made in white or multi-coloured;
- luxury napkins, which are the densest among all the napkins mentioned above. Their sizes are larger than usual – 33×33 cm or 41×41 cm. They are used for serving the festive table, in the work of expensive cafes and restaurants. Such napkins are used to create work in the decoupage technique, while the top layer with a pattern plays an important role. They are made of high-quality raw materials, and the full-colour images on them are bright and clear [2].

According to the number of paper layers, napkins are divided into single- and multi-layered. According to the availability of crepe, creped and non-creped napkins can also be classified according to absorbency (excellent, high, medium and low absorbency) into dry or wet. Today, there are many types of wet napkins on the market: universal, for personal hygiene, medical, household wipes, etc. Each group, in turn, is divided into categories according to its scope of application. On the world market, universal wet napkins are in the greatest demand – 45%. Baby wipes account for 29%, wipes for removing make-up and masks – 10%, wipes for intimate hygiene – 5% and deodorant wipes for 1%. Napkins are divided by colour – white/bleached, natural colour and dyed in different colours; according to the presence of flavourings – flavoured and unflavoured. According to the type of packaging, napkins should be divided into single and packed in several pieces. A special part of the market is napkins that are used in medical practice and belong to both the first (baby care napkins) and the second group (sterile obstetric and surgical, antiseptic, prophylactic, therapeutic, etc.). By raw material, products are classified into those made from primary raw material – cellulose, and from secondary raw material – waste paper [3].

All these classification features of napkins are expedient, meaningful and complete from a merchandising point of view [4].

However, their classification according to decoration technologies is also important: with printed images (single or multi-coloured), with embossing or without it (Fig. 1).

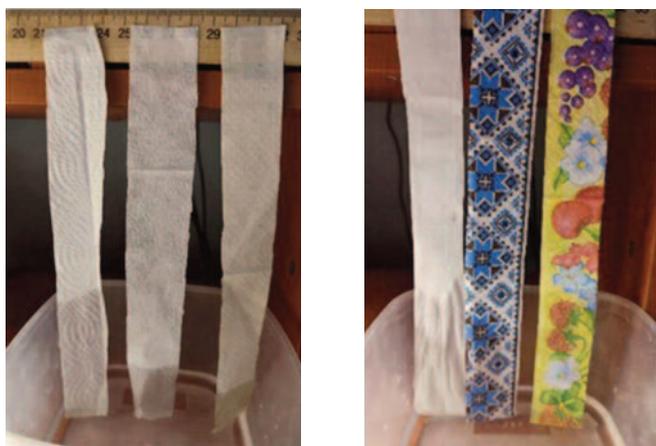
The quality of decoration and marking of napkins depends on their purpose and the selected printing technologies used for this purpose. In the recent years, printed advertising on napkins has become more and more widespread: logos, corporate symbols, slogans, and advertising images. The main requirements for all types of napkins are that they should not crumble into small pieces when wet, not dirty your hands and absorb moisture and fat well.

Therefore, the improvement of printing technology on tissue materials, the selection of ecological inks, technological regimes and finishing methods using the latest printing technologies is an urgent task [6-10].

## MATERIALS AND METHODS

The object of the research was one-, two-, and three-layer napkins with a size of 24×24 cm. The napkins had the following technical characteristics: degree of crepe – 12%, weight of 1m<sup>2</sup> – 37g. For the manufacture of napkins, paper from the cellulose fibre of the Huchtemeier Papier GmbH company was used, and printing was carried out with USOP01 NEO INK (AQUA FLEX plus – Ukraine) in full-colour printing on an OMET TV 503 Lecco flexographic printing machine.

The task of the research included determining the quality of printed images (densitometric and colorimetric indicators) and capillary absorption of water and fat, that is, the absorbent capacity of the napkin in two directions. Assessment of the



**FIG. 2. DETERMINATION OF CAPILLARY ABSORPTION OF LIQUIDS BY NAPKINS**

absorbent capacity of napkins was determined by the Klemm method based on capillary absorption (ISO 8787-86) (Fig. 2).

The value of the tensile strength was determined by the destructive force averaged in two directions in the dry and wet states of the napkins. To determine the destructive force in the wet state, three samples for testing single-layer products and one sample for testing multilayer products were cut out of ten randomly selected products in machine and transverse directions. The time of keeping the samples in water is (30±2) s. Three wet test samples of single-layer products are attached to the clamps of the tearing machine at the same time. For testing multilayer products, one wet test sample is attached to the clamps of the tearing machine. The arithmetic mean value of all determinations is taken as the result of the test.

To determine the deformation of the compression of napkins, a pressing device based on the UK25-1.6M unit was used.

The quality of the printed image and the absence of smearing of the colour image are important for the operational properties of printed napkins. The method of determining ink smearing involved the selection of 10 napkins. The samples are cut into pieces with a size of 10×10 mm with size deviations of no more than ±5 mm. The pieces are thoroughly mixed. From the obtained pieces, take a weight of about 2 grams, weighed with an error of no more than 0.01 grams. Next, the resulting sample is placed in a flask with a capacity of at least 200 cm<sup>3</sup>. The sample is poured with 100 ml of distilled water at a temperature of 15-25°C. The sample is left to stand for one hour, stirring every 10-15 minutes. Then the aqueous extract is poured into glasses made of chemical glass. The water extract should be colourless. Distilled water is used as a standard for comparison.

Optical density measurements of printed images were determined using a GRETAG SPM50 spectrophotometer.

## RESEARCH RESULTS

The absorbent capacity of napkins for water, water solutions and liquid food products (milk, oil, vinegar, etc.) is one of the main physical and mechanical indicators characterizing their properties. The absorbent capacity of the napkin depends both

TABLE 1. RESULTS OF STUDIES OF CAPILLARY AND SURFACE ABSORPTION OF LIQUIDS BY PAPER NAPKINS\*

Napkin samples	Composition component					
	Water		Water + glycerine		Oil	
	Absorption rate, min	Height, mm	Absorption rate, min	Height, mm	Absorption rate, min	Height, mm
1-layer	0.22	33	0.22	27	1.4	21
2-layer	0.25	38	0.34	29	2.2	23
3-layer	0.27	42	0.42	30	2.4	26

\* average values

on the viscosity of the liquid and on the properties of the tissue paper itself, in particular its micro and macrostructure. To achieve a high absorption capacity, the paper should have a loose structure and high porosity. This is achieved due to the use of fibrous semi-fibres, such as fine grinding, mechanical destruction of the structure of the paper web (creping, embossing), intensive drying and increasing the hydrophilicity of the fibres with the help of chemical additives.

Comparative studies of the structural characteristics of napkins made from cellulose and secondary raw materials were conducted. Napkins with different numbers of layers (one, two and three layers) were studied, six identical samples each. The absorption capacity was evaluated by measuring capillary absorption, which reflects a certain aspect of the paper's absorption capacity: capillary absorption – absorption rate, and also by surface absorption – the paper's wetting ability (Table 1).

The results of the research showed that the indicator of surface absorption of water and composition (water and glycerine) for all samples of paper napkins meets the standard requirements (more than 22 mm). The rate of capillary absorption of oil into the structure of single-layer napkins increases by 6 times, and in two- and three-layer napkins – by 8 times. The height of absorption of water solutions in 2-3 layers of napkins increases and is achieved by applying several layers of paper.

If the paper has high absorption, it is also important that it has the required mechanical strength. The conducted studies have determined that the tensile force indicators of napkins with printing and embossing by the Steel-t-Rubber method - in the machine direction are placed in a series:

Napkins: one layer → two layer → three layer

Resistance:

Machine direction: 3.2H → 3.8H → 4.3H

Transverse direction: 1.8H → 2.0H → 2.5H

Based on the experimental studies and their mathematical and statistical processing, a diagram of changes in the resistance of paper napkins to compression was constructed (Fig. 3).

Analysis of the diagrams showed that the maximum amount of napkin deformation characteristic of 3-layer samples with printing and embossing using the Steel-t-Rubber method is on average 15.8 kPa, and the sample without printing withstands a resistance of 14.6 kPa. Single-layer napkins have the lowest resistance - 10 kPa (without printing) and 10.7 kPa (printed and with embossing). An intermediate place is occupied by

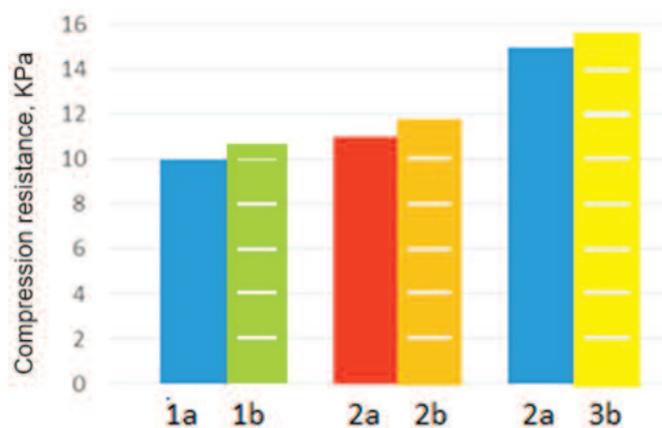


FIG. 3. RESISTANCE OF PAPER NAPKINS TO COMPRESSION:

1 – ONE-LAYER, 2 – TWO-LAYER, 3 – THREE-LAYER NAPKINS;

A – WITHOUT PRINTING; B – WITH PRINTING AND EMBOSSING

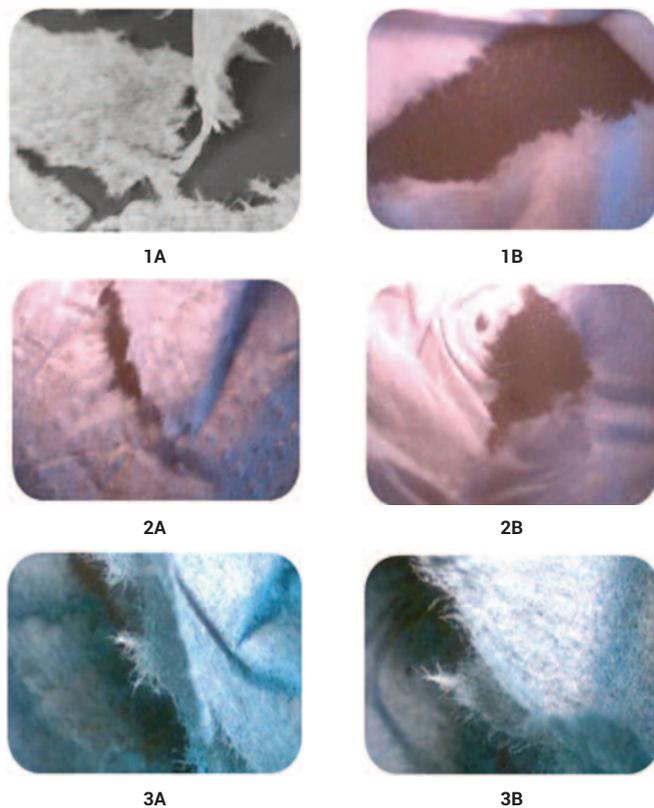


FIG. 4. MICROPHOTOGRAPHS OF NAPKINS IN PLACES OF COMPRESSION:

1 – ONE LAYER; 2 – TWO-LAYER; 3 – THREE-LAYER;

1 – WITHOUT PRINTING; 2 – WITH PRINTING AND EMBOSSEING

two-layer napkins. Fig. 4 shows microphotographs of napkins after compression.

The values of the optical densities of the printed test scales (Fig. 5) are presented in Table 2.

The analysis of tabular data showed that the values of the optical density of inks depend on the tonal transfer. A stable gradation colour rendering is observed in light areas. Colour rendering in light areas within the range of 0-5% gradually increases. In the halftone and dark areas from 30-70% and 80-

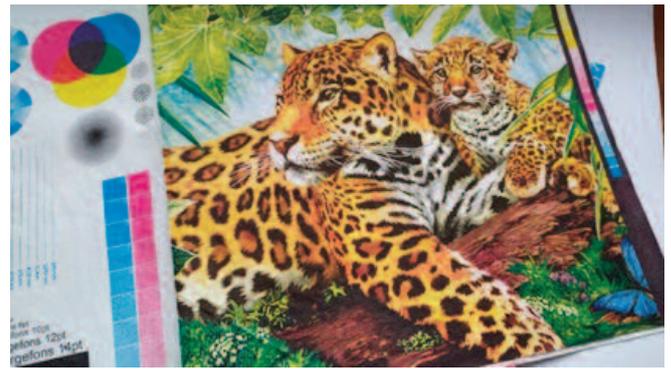


FIG. 5. TEST OBJECTS PRINTED ON A NAPKIN TO DETERMINE DENSITOMETRIC INDICATORS

100%, there is a significant increase and deviation of these colours among themselves, and it is especially noticeable when printing with black ink (contour). The analysis of the diagrams shows that the imprint changes depending on the colour of the image and its saturation. For CMYK inks, the optical density changes depending on the percentage filling with the colour of the imprint area. Thus, in the range from 2% to 100%, the optical density increases almost 7 times for Cyan, 5.6 times for Magenta, 3,7 times for yellow ink, and 6 times for black ink.

The aesthetic properties of paper napkins are determined by their appearance and are characterized by the quality of printed images.

As can be seen from the microphotographs (Fig. 6) of the napkin appearance with the printed image, the flexographic ink is evenly distributed on the surface of the fibres, which indicates a close relationship between the ink particles and the cellulose fibres.

The conducted test for smearing printed images on napkins showed a negative result, that is, the inks do not leave a mark on the consumer.

TABLE 2. THE RESULTS OF MEASURING THE VALUE OF THE OPTICAL DENSITY OF THE PRINTED TEST SCALES

The value of the optical density of the image															
%	0,4	0,8	1	2	5	10	50	75	80	85	90	95	98	99	100
C	0,22	0,24	0,27	0,27	0,34	0,36	0,58	0,92	1,03	1,05	1,1	1,14	1,18	1,19	1,6
M	0,22	0,25	0,25	0,3	0,43	0,48	0,73	1,09	1,13	1,18	1,18	1,21	1,2	1,22	1,24
Y	0,32	0,33	0,34	0,37	0,41	0,43	0,63	0,89	0,94	1,05	1,1	1,14	1,19	1,21	1,21
K	0,23	0,26	0,28	0,29	0,32	0,96	0,72	1,07	1,11	1,2	1,31	1,3	1,34	1,42	1,4

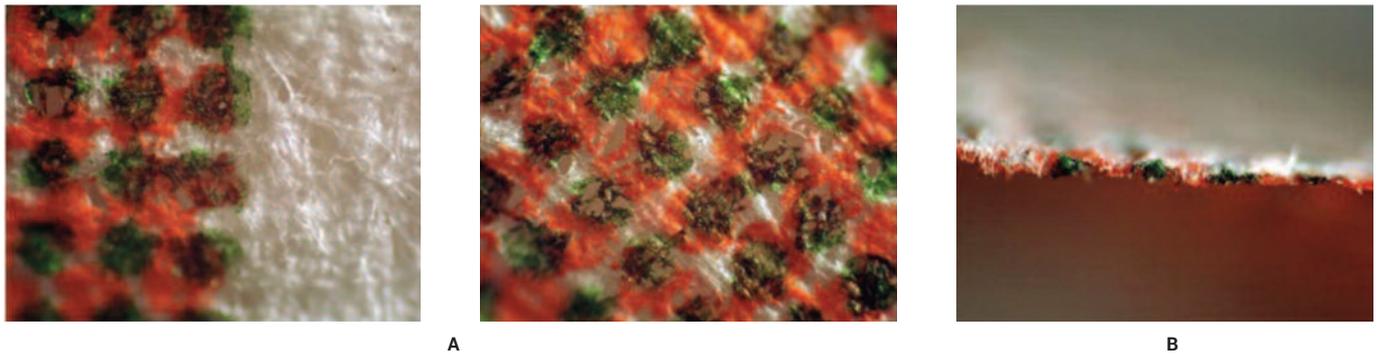


FIG. 6. MICROPHOTOGRAPH OF THE SURFACE (A) AND CROSS-SECTION (B) OF THE PRINTED IMAGE ON A NAPKIN (MAGNIFIED  $\times 200$  TIME)

## CONCLUSIONS

Despite the fact that the requirements for performance indicators of paper napkins are regulated by standards, consumers also put forward their own standards that ensure ease of use. Among them, such as softness (which is determined by the thickness, looseness, macrostructure of the paper web), looseness (which mainly depends on the degree of grinding of the paper mass: with an increase in the degree of grinding, the looseness of the paper increases), the degree of crepe (giving the paper a wrinkled structure, in order to increase elongation to break), absorption capacity, degree of embossing, number of layers, presence of perforations, presence of coloring and flavoring or impregnation with special solutions.

The conducted expert surveys made it possible to form consumer requirements for the appearance of napkins and provide the following list:

- absence of mechanical damage and stripes, folds, holes, stains, foreign inclusions;
- even cut of the edges of the napkin;
- the printed image on the products must be clear, without distortions and gaps. Traces of plucking fibres from the surface of the product and smearing of ink are not allowed;
- the colour tone and saturation of images should be uniform;
- the embossing relief should be even, clear, visible to the naked eye, without gaps;
- the layers of paper in multi-layer napkins must be fastened together, which ensures a tight fit over the entire area.

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# IN-PACK PRESENTS THE FUTURE OF THE EUROPEAN PACKAGING INDUSTRY

Traysealers, packing machines, cartoners, various packaging and labelling machines and many industry innovations will be presented at the premiere edition of IN-PACK Fair. Companies such as Mitsubishi, Maszyny Pablo and Polpack will show their products. Entrepreneurs can join the exhibitors at the event scheduled from February 13<sup>th</sup> to 15<sup>th</sup> at the Kielce Fair.

Kielce Fair will bring together leading entrepreneurs from the European packaging and logistics sector. Products will be presented by representatives of the following sectors: packaging for moving and storing goods, packaging techniques, labelling, printing, e-commerce, robotics, machinery and raw materials. Fair exhibitors include Verpalin, Turck, Etyland, Promark and ARDEKAS. Relopack, which has been operating

in the logistics services and industrial packaging industry since 2016, is the co-organizer of the fair, while the Creative Packaging Group Cluster is the event's partner.

## SHOWING INNOVATIONS

The organizers promise that with its numerous shows and thematic zones, IN-PACK will meet the expectations of even the most demanding visitors. One of the highlights of the fair will be the LET'S PACK IT! demonstration zone, where participants will be able to see the functions of the robotic arm, automatic packaging systems and its optimization processes.

## A DOSE OF PROFESSIONAL KNOWLEDGE

The rich offer of the fair also includes accompanying events. The IN-PACK EXPO will feature the second installment of the LogInPack International Congress for the logistics and

**THE EVENT IS COLLOCATED WITH THE 2ND INTERNATIONAL INTRALOGISTICS FAIR SCHEDULED FROM FEBRUARY 13<sup>TH</sup> TO 15<sup>TH</sup>, 2024.**

**[HTTPS://WWW.TARGIKIELCE.PL/IN-PACK](https://www.targikielce.pl/in-pack) / [HTTPS://WWW.LINKEDIN.COM/SHOWCASE/IN-PACK-EXPO](https://www.linkedin.com/showcase/in-pack-expo)**



packaging industry. During the event, experts will discuss the latest trends as well as innovations and challenges in logistics and packaging. Piotr Snopek - director of sales and marketing from Passport to Export - will address, among other topics, logistics in e-commerce. An industry lecture titled "From simulation model to digital twin" will be given by FlexSim Executive Vice President Dawid Dabal.

#### TOP COMPANIES WITH WIN-PACK AWARD

Those exhibitors who use innovative and creative solutions as well as process optimization tools will be able to submit their products in the competition for WIN-PACK. The best will be selected by experts and industry authorities. Awards and prizes presented at the gala event will be a good way to further promote the brand. Exhibitors will be awarded for, among other things, the most innovative solutions, process optimization tools, and the most creative solutions.

#### POLAND – A EUROPEAN POWERHOUSE

Poland, thanks to its market potential, is becoming an increasingly attractive country for foreign companies operating in the logistics sector. According to a report by Bank Pekao, one of Poland's largest banks, Poland has a chance to beat France in packaging exports in the European Union as early as 2023. The growing demand among Polish and foreign companies for packaging "made in Poland" is, among other things, the result of the diversification of the market, as well as the innovation of materials and a good price/quality ratio, the organizer of the IN-PACK Packaging Fair emphasizes. In addition, the success of Polish packaging and machinery manufacturers is due to Poland's geographical location.

The event is collocated with the 2<sup>nd</sup> International Intralogistics Fair scheduled from February 13<sup>th</sup> to 15<sup>th</sup>, 2024.

STEFAN JAKUCEWICZ

# 12 EDITION OF THE „SAFE PACKAGING” CONFERENCE FROM THE VIEWPOINT OF THE HOST

In November 16-17, 2023, the 12<sup>th</sup> Conference “Safe Packaging” was held in Warsaw; this time it had place in the Airport Okęcie Hotel. It was organized by the editorial offices of “Opakowanie” and “Poligrafika” magazines. During the Conference, 11 lectures were delivered, including two ‘double’ lectures which differed in subject and were submitted by the different authors but came from the same company. The discussed Conference lasted for two days – the second day was dedicated to the discussion panel of ML Polyolefins, entitled: “Recyclates in packaging – is it possible?”

The partners of the present edition of the Conference included the following companies: Bank Pekao SA, Bobst, Digiprint (representing the companies: HP Indigo and Scodix), eProductivity Software, Heidelberg, hubergroup, Mark Andy,



Metsä Board, ML Polyolefins, Mocon (together with its distributor Comef) and Wolff Printing, together with Clarifoil company. The first evening, a solemn dinner was organized in the Meeting Rooms of the Airport Okęcie Hotel.

During the discussed Conference, 11 or rather 13 very interesting lectures were delivered and they represented a very high professional level. The lectures were classified into 4 topic groups and after each of them the session of questions and answers was arranged. The subjects of the presentations were connected with a comprehensively understood safe packaging. Each of the lecturers had a different attitude to the mentioned problem; in connection with this fact, the lectures were much diversified but they were close to the basic topic. As being the person who had carried on all the so-far organised conferences, the author of the present paper may say that the subjects presented during the event were interesting, exploratory and on a high professional level. Year by year, the level of the presented lectures and their modernity is increasing. The range of the safe packaging idea outlines also the higher and higher frames. This year, various digital technologies serving the production or protection a safe packaging, were dominating.

**THE LEVEL OF THE PRESENTED SPEECHES**

**AND THEIR MODERNITY ARE INCREASING EVERY YEAR.**

**THE HOLISTIC CONCEPT OF SAFE PACKAGING ALSO SPANS**

**A BROADER FRAMEWORK**



Within the first group of the speeches, three lectures connected with the application of digital technologies for printing and betterment of packaging and their protection were delivered.

The first lecturer was **Łukasz Chruśliński** from **Mark Andy company**, who delivered the lecture **“The newest trends in printing of labels and of packaging”**. The submitted subject was connected with the possibility of employing machines and the equipment and technological solutions by Mark Andy company for the discussed purpose. Two types of labels, performed on Mark Andy machines were widely presented and discussed. They were the linerless labels and RFID labels with tags, made in a new technology (digested tags - not the printed ones). RFID labels, as produced in Mark Andy machines are generated and printed during one run of the printing machine. There was also submitted the application and utilization of RFID labels. The linerless labels as well as RFID labels are a specific protection of the labelled products; RFID label additionally enables identification and location of the packaging.

The successive lecture, entitled: **“Digital production of cardboard packaging – printing and refinement”** was submitted by **Szymon Symonowicz** from **Digiprint** company. In the mentioned speech, the possibilities of employing the protection on prints, serving for production of packaging, printed in digital HP Indigo machine or /and refined in digital Scodix printer, were presented. The cited title refers to folding boxes but the range of the lecture was considerably wider and covered most of paper packaging.

HP Indigo facilitates application of protecting inks (visible in IR or lighting in UV) and a series of drawing protection such as e.g. guilloche, QR codes, micro-codes, micro-text, anti-photocopying signs and printer water marks. All this may be reached during one passage through the printing machine. Wider possibilities occur at the application of Scodix digital machine, e.g. varnish of different thickness, preserved by UV radiation, foil seals, the laid-on graphics performed with the use of foil (the so-called patterns), Cast & Cure technology, etc. The combination of prints with the protection in HP Indigo and Scodix technologies enables protection of mark and protection against fraud. It ensures a wide spectrum of protections, and the only one limitation is creativeness and skilful utilization of the discussed technologies with the appropriate software.

The successive lecture: **“From ‘office’ to production. Maximum efficiency owing to automation and integration of eProductivity, Esko and HP software”** was developed by **Monika Nojszewska** from **eProductivity Software**. The ePS (eProductivity Software) company is the world leader in respect of the comprehensive technological solutions for packaging and printing. It promotes a dedicated offer of integrated and automated solutions, designed as to increase the profit, strengthen the diversification and improve the operating efficiency owing to the following factors: automation of service of the orders, intelligent pricing of manufacturing costs, dynamic planning and transparency of operating processes in the company. All obtained data, necessary for construction of automation process, are given in a real time.



ROBERT WICZOREK



PAWEŁ KOCIK



SZYMON OCHOCIŃSKI

Thanks to the automation, we may obtain higher efficiency which is reached via better transparency and visibility of the processes, improvement of productivity, lower waste amount, shorter time of implementation of the order, access to accurate data, improvement of the satisfaction of the customers and optimized cash flow. On the other hand, the two-direction integration is based upon the basic assumptions which include: finalization of production and downtime reporting, ensuring the complete traceability from a raw material to a final product, a precise monitoring of production and integration of digital operations.

Automation decreases a risk of human error incidence, gives an access to more precise data, and increases the retention of labourers and utilization of their knowledge and experience during the work with the mentioned system.



EDWIN PIOTROWSKI

After the session of questions and answers, the successive lecturers were the representatives of **Heidelberg Poland company**. They delivered the following lectures: the first one was submitted by **Edwin Piotrowski**, the sales manager of narrow-banded Gallus machines at Heidelberg Poland and the second speaker was **Robert Wiczorek**, the head of the product management department. In the first lecture, entitled: **"Safe production of packaging in digital inkjet technology"**, Edwin Piotrowski discussed the possibilities of the newest three inkjet machines for printing of labels: Gallus Labelmaster, Gallus Labelfire 340 and Gallus ONE. They are fully automated – the two first machines allow printing with eight colours (inks) – CMYK + OGV (O – orange, G – green, V – violet) + W (white) with the speed of up to 70 m/min. The discussed colours are the inks preserved with UV radiation, and are especially destined for printing of labels of cosmetics and food products (inks with a lower migration); they are universal for printing of labels on different materials. The second lecture, entitled: **"Efficient and safe printing of packaging in Speedmaster Drupa 2024 Technology"** was delivered by Robert Wiczorek. The lecturer submitted a new version of Speedmaster machine, equipped with the new solutions, protecting against committing the errors during printing. The discussed equipment contains the elements of AI which practically supervises the process of printing and is responsible for its failure-free run.

The successive two appearances were presented by the representatives of **BOBST company**. **Paweł Kocik**, in his lecture



PIOTR ORLIŃSKI



PIOTR PAZIK



ROBERT KUCZERA

“DMT (Digital Makeready Tool) – new tools for technology of hot gold plating”, discussed variants of DMT application in detail. The employment of the mentioned technology protects: the connection of preparation with production, design of digital arrangement of the sheet, easiness of service owing to a simple and ergonomic position of tools, minimization of downtime, optimization of time of work and its efficiency, a precise fitting of stamping and waste reduction what leads to the sustainable development. The second lecture entitled: “**BOBST Connect in Smart Factory – digital solutions increasing the productivity**” was submitted by **Szymon Ochociński** and contained the characterization of digital solutions, i.e. the so-called BOBST Connect Industry 4.0 in communication, digitalization and automation in the presently produced machines. BOBST Connect System combines a huge platform of data and intelligent services; it helps to organize the process of packaging production, facilitating the efficient flow of the data between machine and digital solutions, enriched with the advanced possibilities; it supports analytically the activities, connected with the preparation to printing, cutting out, optimization and supply. It also supports the above mentioned processes relating to the preparation to printing, cutting out, production, optimization, maintenance and supply.

The successive lecturer was **Robert Kuczera** from **hubergroup Poland**. His previous appearances concerned usually inks, but this time, he submitted more philosophical subject: “**Should new always mean better? Motivation or the necessity of changes?**”.

To illustrate his lecture, Robert Kuczera presented facts from life of humans and animals, connected with the necessity of motivating the changes. Summing up, he state as follows:

- the change is unavoidable and necessary in life as well as in business;
- it often results from external factors such as technological development or varying social trends;
- the change may be also a natural evolution which allows development and reaching the success;
- it is important to be flexible and ready to change and be not afraid of it because it may bring the new possibilities.

Final slides showed the changes which occurred in hubergroup Polaska and namely, a new seat of the company and transfer of production from Munich to Nowa Wieś Wroclawska (Poland).

After lunch the floor was taken by **Piotr Orliński** from **Metsä Board company**. He delivered the lecture entitled: “**The sustainable packaging on the grounds of fibres for the future based on circular economy**”. The aim of the sustainable development, promoted by Metsä Board up to 2030 is the effect on climate changes via the reduction of CO<sub>2</sub> emission and the reasonable utilization of raw materials owing to the reduction of the quantity of the produced waste. To this end, the strategic programmes, defined as premium supplier, effective innovativeness, safe and reasonable activity and organic development, are implemented. The discussed company is a leader in respect of the sustainable development and its employees are motivated to the mentioned activities.

All is commenced from the forests. The forests in Finland occupy 75% of the land area. The company protects their biodiversity by remaining the wood of the dead trees inside and the support of the tree species diversity as well as protection of the natural habitats of the endangered species. The successive goal includes giving up the fossil fuels, what causes reduction of carbon footprint and a circular production. Metsä Board consumes now 87% of energy coming not from fossils. By the end of 2030, the plants will not use fossil energy. Metsä Board employs the innovative modular technology. The application of primary fibres in production of cardboard by Metsä Board FBB results in a lower effect on climate and allows reduction of packaging weight and enables recycling of post-use packaging.

The successive lecture, entitled: **“Clarifoil films as alternative to plastics in design of packaging”** was delivered by **Piotr Pazik** from **Wolff Printing company**. Clarifoil is a British foil made from cellulose acetate, being known and applied in Poland until the seventies of the 20th century for lamination of covers and wrappers. It became eliminated by cheaper and more efficient film from BOPP. Due to its properties, the discussed foil, as being compostable (up to 100 µm), is suggested for production of window-containing paper packaging, wrappers and closures of containers by heat sealing. The lecturer anticipates that Clarifoil will displace the non-degradable PET and BOPP films. As it is informed by “Internet lexicon of plastic packaging”, Clarifoil films are used, first of all, for lamination of boxes and production of windows in packaging. They have

certificates DIN EN 13432 and ASTM D6400. The producer stresses that the discussed material was created on the basis of raw, natural material, from the disintegrated wood; owing to this fact, it meets the ecological requirements as well as quality standards. It is a barrier foil in the case of water and aromas but it transmits water vapour; it is not permeable for UV radiation and is medium permeable for oxygen; it is also well printable. The problem concerning its wide application consists in the necessity of organizing the selective waste collection and relative high costs. It cannot be processed with other non-degradable foils as it disturbs the process of recycling.

The successive lecture entitled: **“How the gas penetration tests may help in development of safe packaging”** was delivered by **Gabriele Benedetti** from Italian **Mocon** company. It was translated by **Grzegorz Przeliorz** from **Comef**. The submitted lecture was a practical instruction how to create a flexible multi-componential packaging with the assumed parameters. Gabriele Benedetti listed the instruments which should be employed in measurements of gas permeation and informed on which side of the tested material the measurements should be performed. He mentioned the factors affecting the penetration of gases which include: characteristics of polymer (its atomic structure, density, crystallinity, molecular weight, glass transition and cross-linking), technological factors (plasticizers, fillers, residues of solvents, orientation, polymer mixture, co-polymers and composite structures, surface and thickness), and environmental conditions (relative humidity, total pressure, difference of partial pressure, temperature and type of carrier gas) which affect the penetration of gases – which we are seldom aware of. In connection with it, the packaging which is correct in the northern Europe may be unsuitable (due to high oxygen permeability) in the South Korea and Vietnam.

Summing up, we should remember that penetration of gases, mainly of oxygen affects the time of the product's storage; the appropriate barrier is a partial solution, the integrity of the sealing has a key meaning. The testing of a final packaging is necessary, as well.



FROM LEFT: GRZEGORZ PRZELIORZ AND GABRIELE BENEDETTI



KRZYSZTOF MRÓWCZYŃSKI



KRZYSZTOF NOWOSIELSKI



PAWEŁ ANTONIK

After the break, dedicated to the session of questions and answers, the lecture was delivered by the manager for sector analyses in **Bank Pekao SA, Krzysztof Mrówczyński**. The title of his appearance was **“Sector of packaging in the period of lower demand. The current situation and the perspectives for the coming quarters of the year”**. In the lecture, financial situation of the packaging industry in Poland and in the EU, with a particular consideration of packaging from wood, paper, glass, plastics and metal was discussed. The situation in the whole packaging sector with the breakdown into their particular types was indicated. In the summary, the development of packaging industry up to July 2023 was presented. The analyses were carried out since 1, January 2021. The mentioned lecture contained several dozen diagrams and plots. It would be worthy that the decision-makers from the discussed sector could get familiarized with the elaboration of Bank Pekao SA.

To make it easy, the brochure containing the appearance of Krzysztof Mrówczyński was published. It counts 50 pages of A4 format and Pekao Bank is its publisher.

The last lecture delivered during the first day of the Conference was the appearance entitled: **“Situation at the plastics market”** was developed by **Krzysztof Nowosielski** from **ML Polyolefins Ltd.**, and **Paweł Antonik** from **Bank Pekao SA**. In the mentioned presentation, the prices of the raw materials necessary for production of plastic together with the prognosis up to the end of 2024, were submitted and discussed. It refers to petroleum Brent and gas. As far as the costs of petroleum is concerned, there are the discrepancies in this respect: it may become cheaper or become more expensive by 2 USD from the initial price of 90 dollars. The gas market is forecasted in another way: the increase of the quotations up to 49-50 EUR/MWh in

#### DURING THE GALA DINNER ML POLYOLEFINS AWARDED SUSTAINABLE PACKAGING COMPANIES WITH PACKAGING CIRCULAR ECONOMY CERTIFICATES



winter and a seasonal decline in summer up to 41 EUR/MWh in 2024 (at the initial price in the 1st quarter 2023 equal to 50 EUR/MWh). The prices of plastics: decline in summer 2023, increase of prices since 1.10. 2024. The European demand on recyclates for production of packaging amounts to 39% of plastics production, i.e. 21.06 million tonnes; in Poland 10.9 million tonnes. The processing capacities in the Central-Eastern Europe is equal to 1 875 thousand tonnes; in Poland – 600 thousand tonnes. As it can be seen, our processing possibilities are lower than the demand what does not guarantee the complete occupancy of the recyclates.

In the evening, during the solemn dinner, the awarding of the PCE (Packaging Circular Economy) certificates by ML Polyolefins company had place. This year, the following companies were distinguished: Amcor Flexibles, Amerplast, CDM, Drukpol Flexo, Florek-Plast, Foldruk, Grafix, Lorenz Bahlsen, Lotte Wedel Ltd., Mondi, Pak Ltd., Pałucka Prining Plant of Packaging (Polish: Pałucka Drukarnia Opakowań) and Vefi. There were also granted the additional awards – distinctions PCE for the companies, striving at implementation of the practices of circular economy in their activity. They were obtained by the following companies: A-Z Color Ltd., Mpak, ZPHU Pakfol and Pepsico.

**On 17, November (Friday), the discussion panel of ML Polyolefins: “Recyclates in packaging – is it possible?” had place.**

The mentioned panel was conducted by **Jacek Leszczyński**, the editor-in-chief of Plastech.pl portal and branch periodical:

“Plast Echo”. The basis of the discussion was the lecture of **Dr Edyta Wielgus-Barry**, Eng., from the Plastic Europe Polska Association; its title was: “Recycling of plastic packaging waste – the presence and the future”. Apart from the lecturer and the panel moderator, the discussion was attended by the following 5 persons: **Krzysztof Nowosielski**, the commercial director and the authorized representative (Polish: prokurent) of ML Polyolefins company; **Robert Przybylski**, the President of the Board of Plastoplan Poland; **Estera Jamrozek**, international sales manager at MAS Austria; **Małgorzata Rein**, commercial director of Pałucka Packaging Printing Plant (Polish: Pałucka Drukarnia Opakowań) and **Anna Naruszko**, editor-in-chief of periodicals: “Printing” (Polish: Poligrafika) and “Packaging”. As it can be seen, the group of the persons competent in the field of recycling of post-use plastic packaging. In the presentation of Dr Edyta Wielgus-Barry, Eng., there were submitted the levels of recyclates in plastic packaging, and the levels of selective collection in accordance with the EU guidelines. If we do not treat seriously and quickly the matters of recycling of the post-consumer plastic packaging, we will not reach the assume EU levels. All discussing persons have agreed that in respect of the recovery of plastics coming from the used packaging, the following factors are indispensable: education, logistics together with the legal regulations, tests of the contents of the recyclates (essentially, of their level) in the new packaging and the selective collection systems.

**ON 17, NOVEMBER (FRIDAY), THE DISCUSSION PANEL OF ML POLYOLEFINS: “RECYCLATES IN PACKAGING – IS IT POSSIBLE?” HAD PLACE**



# Packaging Review

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