SONOCO SUSTAINABILITY

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Big Steps to Increase Paper Container Recyclability

IN SUMMARY

Today 60-85% of paper products are recycled globally with 4evergreen reporting an 82% paper packaging recycling rate for Europe and a desire to increase that rate to 90% in the next few years. Consequently, it is crucial to recycle as many paper products, including packaging, as possible. Based on the 204.46 Billion USD paper and paperboard packaging market, Sonoco estimates that rigid paper containers (also called paper cans) comprise approximately 1.0% of the global paper packaging market. Rigid paper cans are a vital source of recycled content for paper products. When the paper cans are recycled, there is a significant reduction in climate impact or CO2 equivalent emissions.

An investigation into the recycling system shows that new and existing fibre sortation material recovery facilities (MRFs) in Europe and the US are very capable of enabling proper diversion of paper packaging away from residue and into fibre bales for recycling. Repulping and recycling paper products such as paper cans result in critical mass recovery of the fibrous materials and conversion into desired, high-quality paper products at standard and specialised mills.

The purpose of this white paper is to demonstrate the four key aspects of recyclability for paper cans: collection, sortation, processing (or technical recycling) and end markets. Successful sortation and processing of paper cans, paired with established end markets, will justify the inclusion of the high fibre paper cans on recycling collection lists across Europe, the US, and around the world. Certainly, more work and continued learning must be obtained from all geographical regions; thus, this white paper should serve as a source of information for reference by recycling associations, certifiers, and producer responsibility organizations as they evaluate the recyclability of paper cans.

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WHO NEEDS TO RECYCLE PAPER PACKAGING?

Many industry stakeholders, such as governmental agencies, legislators, Producer Responsibility Organizations (PROs), and fibre product recyclers, have an interest in increasing recycling rates for fibre-based materials. Government legislative bodies have increased mandates for consumer recycling of all materials. Subsequently, Extended Producer Responsibility (EPR) programs hold consumer goods brand owners accountable as they are the decision-makers for selecting recyclable and responsibly sourced packaging.

65%-85% CURRENT PAPER PRODUCT RECYCLING RATE

FUTURE STATE PAPER PRODUCT RECYCLING GOAL **90%**

For this reason, paper packaging recycling is important to the consumer goods industry. Currently, more than 53.5 million metric tons of paper packaging on the European market are used to transport and protect consumer and industrial products. Fortunately, paper packaging has an 82% recycling rate through municipal and kerbside collection recycling systems. Still, the paper packaging industry seeks to continually increase recycling rates through kerbside collection of household-like paper packaging.

Innovative Paper Container with Paper Bottom, Membrane, & Paper Lid

WHAT SHOULD YOU KNOW ABOUT RIGID PAPER CONTAINERS?

Based on the 204.46 Billion USD paper and paperboard packaging market, Sonoco estimates that rigid paper containers or cans comprise approximately 1.0% of the global paper packaging market. These paper cans play an important role in the consumer packaging industry as it is used to package snacks, spices, coffee and baked goods, and many other consumer foods and staples. Rigid paper cans provide superb physical protection of products throughout transportation and storage as well as extended product shelf life by using high moisture and oxygen barrier materials. These cans are comprised predominantly of paper but also consist of a heat sealable, foil or metalized film liner, a laminated or metal top closure, and a laminated paper bottom end. A paper or plastic lid may be included for reclose. Innovative and sustainable designs for the can previously included the replacement of metal and plastic components with paper-based structures for the top and bottom ends and lids. For these package designs, the top ends and lids are separated from the can by consumers upon opening and normally are discarded separately from the can for recycling.

RECYCLING PAPER IS A BETTER OPTION FOR THE ENVIRONMENT THAN LANDFILL
or incineration according to a meta analysis of life cycle assessments.

WHAT ARE THE ENVIRONMENTAL BENEFITS OF RECYCLING RIGID PAPER CONTAINERS?

Rigid paper cans are produced from high amounts of recycled fibre. These cans also generate high amounts of recyclable fibre content. If the paper containers tare landfilled instead of recycled, they decompose in anaerobic conditions, releasing harmful greenhouse gases into the atmosphere such as methane (CH_4) and carbon dioxide (CO_2). However, generally recycling paper is a better option than landfilling or incinerating paper waste, as concluded by a meta analysis of the life cycle assessments of paper waste. Additionally, A third-party verified streamlined Life Cycle Assessment found that the rigid paper cans have a reduced carbon footprint than comparably sized rigid packaging types (Figure 1). Paper containers with paper bottoms and steel bottoms result in more environmentally favorable outcomes.

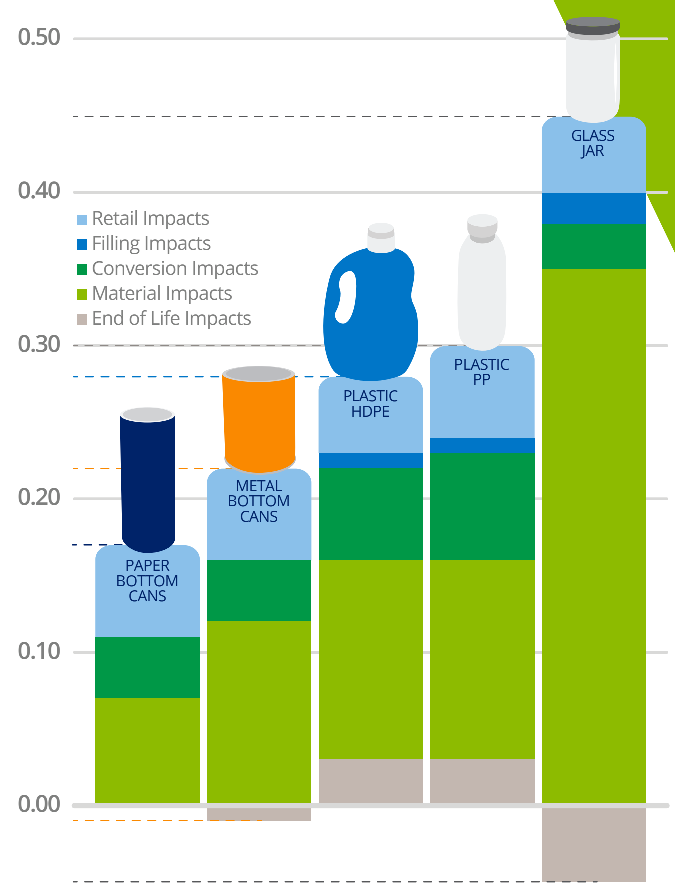


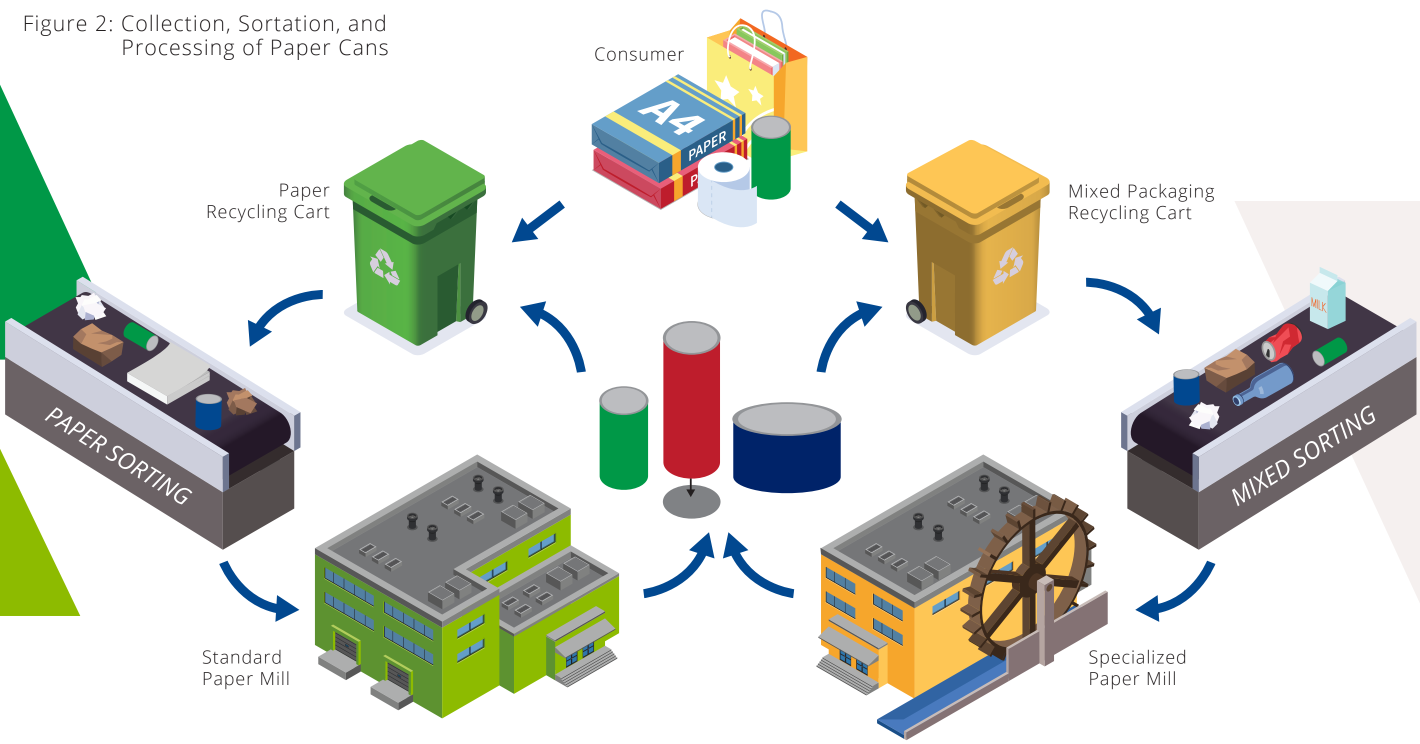
Figure 1: Reduced climate impact from paper cans compared to other rigid packaging formats.

Additionally, according to Planet Paper Box Group's life cycle analysis (LEO-SCS-002 framework), across the entire market of [writing, printing, and solid bleached sulphate] papers, coated papers produced from 100% recycled material have a significantly smaller environmental impact than virgin fibre production; including using 25% less water, avoiding the harvesting of 12,000 acres and creating less than 1% of the impact on climate change and ocean acidification.

HOW ARE RIGID PAPER CONTAINERS RECYCLED IN THE EXISTING INFRASTRUCTURE?

Advancing the recyclability of any package type depends on the viability of collecting, sorting, and processing the packages in the existing recycling infrastructure. There must also be a value to recycling and the existence of available end markets to receive the products to be recycled.

Figure 2: Collection, Sortation, and Processing of Paper Cans



KERBSIDE COLLECTION AND SORTATION

With 85-96% fibre content, paper cans with paper bottom and paper lid typically meet the minimum fibre content requirements for kerbside paper bin collection in most European residential programs. After collection, the packaging items are shipped to sortation facilities and then to paper mills for pulping and recycling.

Several sorting trials were conducted to determine the recovery rate of these containers into fibre streams using primarily three technologies. These trials in pilot facilities and sorting centres with Near Infrared (NIR) in combination with eddy current, AI/neural network robotics, and NIR-digital watermark reading technologies showed that the equipment can be adjusted or neural networks can be trained to recover more paper cans to increase sortation into the appropriate material bale. For instance, according to Figure 3, proof-of-concept trials showed a paper can recovery rate of only 33% by optical NIR sorters, but with increased learnings around can design and equipment detection settings, the recovery rate of 87% was achieved in a subsequent trial. Further optimization of the settings to decouple poly -coated paperboard detection from paper can detection resulted in 91% recovery of the paper container by the optical NIR sorter.

Figure 3: Paper Can with Paper Ends - Improvements in Sortation with Various Technologies

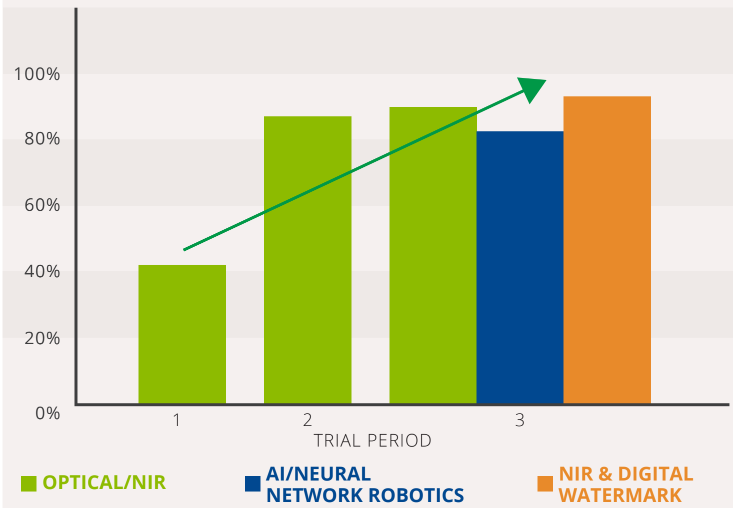


Table 1: Paper Containers with Paper Ends - Results of Various MRF Sortation Trials in Europe and USA

TRIAL PERIOD	EQUIPMENT TECHNOLOGY	EQUIPMENT BRAND-ORGANIZER	# OF CANS PLACED	PAPER / ALUMINIUM / RESIDUE
1	OPTICAL NIR	VARIOUS - INTERSEROH+	*30	
2	OPTICAL NIR	VARIOUS - CIRCPACK	793	
3	OPTICAL NIR	VARIOUS - CERTIFIER	2150	
3	AI/NEURAL NETWORK ROBOTS	AMP	**39	
3	NIR & DIGITAL WATERMARK	INNOVATION	360	

As proof-of-concept, *a small sample size was used for the first optical NIR (and eddy current) trial;
** a small sample size was used for the robotics trial.

Still more advancements in sorting have been shown to increase recovery of the rigid paper can. A series of sorting tests with AMP Robotics using high-speed cameras, neural networks and robotic arms were conducted to identify and retrieve items. The AMP Robotic software learns over time so that an object that has been seen before has a higher recognition and sort rate in subsequent runs. In the subsequent robotic equipment trials, the paper can recovery is 95% as recognition increased. In yet a third investigation, the use of the innovative NIR-digital watermarking technology resulted in a very acceptable and high recovery rate of 98% in a scaled trial performed by researchers. As this technology becomes more available to MRFs, the recovery rates of all materials will increase and the sortation will become more accurate.

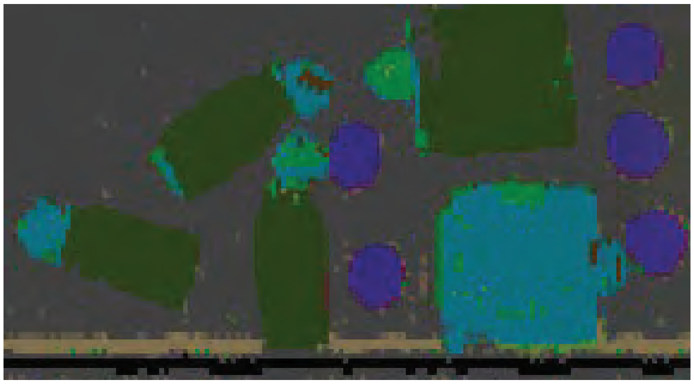
Rigid paper cans with paper ends are very likely to meet fibre requirements for acceptance in the paper bin. However, in very few European countries, these packages must be placed in the mixed packaging bin. Regardless of which collection bin the items are placed in, when paper cans are sent to the sorting centre, they are recovered into the fibre stream at varying sortation recovery rates. The highest recovery rates are achieved when the operator determines ideal NIR equipment settings, when neural networks have been trained to recognize the paper containers, and/or when new innovative technologies such as NIR-digital watermarking are leveraged. The results of sorting are determined by MRF sortation technologies, MRF design and equipment modulation, package material composition, and package size.

The use of innovative digital watermarking technology resulted in a high recovery rate of

98%

Of note, in Table 1 and Trial Period 1: the 67% of paper cans were recovered and sorted into the aluminium stream. It is important to show this atypical result as it re-emphasizes the importance of equipment settings on optimizing package recovery into the desired material bale. In this case, the aluminium recovery equipment settings were such that a significant amount of paper cans with even less than 3% aluminium were sorted into aluminium bales. Subsequent Trial Periods 2 and 3 prove that the proper settings can be established to more successfully recover paper cans into the fibre bales.

Picture 1: Near Infrared Material Identification (left) with Corresponding Paper Cans (right)



MORE ABOUT NIR SORTATION

Picture 1 shows the proper identification of the materials in the paper can. In this example, PP lids for reclose were included in the test. Purple colours show the appropriate determination of the lids; the green colours show the proper identification of paper or fibre in the cans. Finally, the blue colours show the PE sealant layer on the inside lamination sealed to the can or the inside of the heat-sealable barrier liner. Once the lid is identified as plastic and the can body as paper, the packaging components are properly sorted in the respective streams. Picture 2 shows paper cans on the conveyor to the NIR sorter (left circle) and in the process of ejection after the NIR scanner (right circle).

PAPER MILL RECYCLING

Picture 2:
Near Infrared (NIR) Sortation Equipment Showing Paper Can Sortation

As produced today, the paper can is made from approximately 40% virgin fibre and 60% recycled fibre content, making this can an ideal example of product circularity. When the paper can is diverted to existing paper mills, the fibre is recovered and converted into paperboard for new products, even for new paper cans. To validate the successful repulping of paper cans, seven distinct pulping trials were conducted in the European and US regions.

Understanding that there are a variety of paper mill operations, trials were conducted with different combinations of equipment and process setups. The trials were conducted at both standard and specialised paper mills. Generally, specialised mills use a higher consistency and pulp the incoming material for a long period compared to standard paper mills. The increased duration of pulping allows for specialized paper mills to accept a wider range of input material than standard paper mills. This could include packages that are poly-laminated on both sides or that use wet-strength additives in the fibre. The standard and specialised mills used for the pulping trials utilized either batch or continuous pulping with consistencies ranging from ~3% to ~10%. Some of the paper mills also used raggers in their paper recycling processes. Lastly, the paper mills had detrashing capabilities where scavenger systems, hydrapurges, or continuous detrashing systems were incorporated into the process. The different equipment types and combinations provided a broad and valid evaluation of the recyclability of the paper cans in varied paper mill processes used across the industry to produce paper today.

Paper cans were fed into the paper stream at a 5-15% ratio with other recycled paper products such as corrugated containers (OCC), mixed paper, and aseptic and gable top cartons. See Picture 3 below.

Picture 3: Paper cans on forklift (left) are fed into the pulping process and blended with other recycled paper products (right)

Adding the paper container material to the recycling feed stream had no negative impact on pulping, paper production, or quality. Optical uniformity and mechanical strength of the output paper material were consistent across all trials. Furthermore, no defects such as stickies or fibre tears were observed during the tests. Paper production continued at standard speed without any complications or need for adjustments. See Table 2 on the next page for trial settings information and common results across all paper mills.

Table 2: Results of Various Paper Recycling Trials in Europe and US

PAPER MILL OWNER	COUNTRY	EQUIPMENT	AMOUNT OF PAPER CONTAINERS	FEED RATIO	PAPER QUALITY	REJECT CHARACTERISTICS	PULPING EFFICIENCY
SONOCO	ITALY	STANDARD	4 TONNES	10%	NO IMPACT	<0.1% INCREASE	NO CHANGE
SONOCO	US	STANDARD	6.5 TONNES	5.5-7.5%			
3RD PARTY MILLS	BENELUX	STANDARD	<1 TONNE	N/A			
3RD PARTY MILLS	FRANCE	STANDARD	<1 TONNE	N/A			
SONOCO	UK	STANDARD	3.4 TONNES	10%			
SUSTANA	US	SPECIALIZED	1 TONNE	DID NOT MEASURE			
SONOCO	UK	SPECIALIZED	5.5 TONNES	100%			
SONOCO	UK	STANDARD	15 TONNES	10-15%			

Overall, the containers were processed with a fibre yield of around 85-95%, and the poly/foil laminate or non-fibre materials were separated from the pulp as large pieces with no adverse effect on the process or the effluent stream. It is concluded that the paper cans with either paper ends are easily pulpable in both existing standard and specialised paper recycling equipment. The successful results provide confidence that the results are obtainable independent of 1) which detrashing equipment the paper mill is using, 2) the consistency of the material in the pulper and 3) which system is utilized: batch and continuous at either a standard or specialised mill. Below are images showing the accepted fibre, the non-fibre materials ejected from the pulping process and the finished stacked high-quality paper boards produced from the recycling process with accepted fibers.

Picture 4: Ejected Scrap (left) and Recycled Paper Finished Product (right)

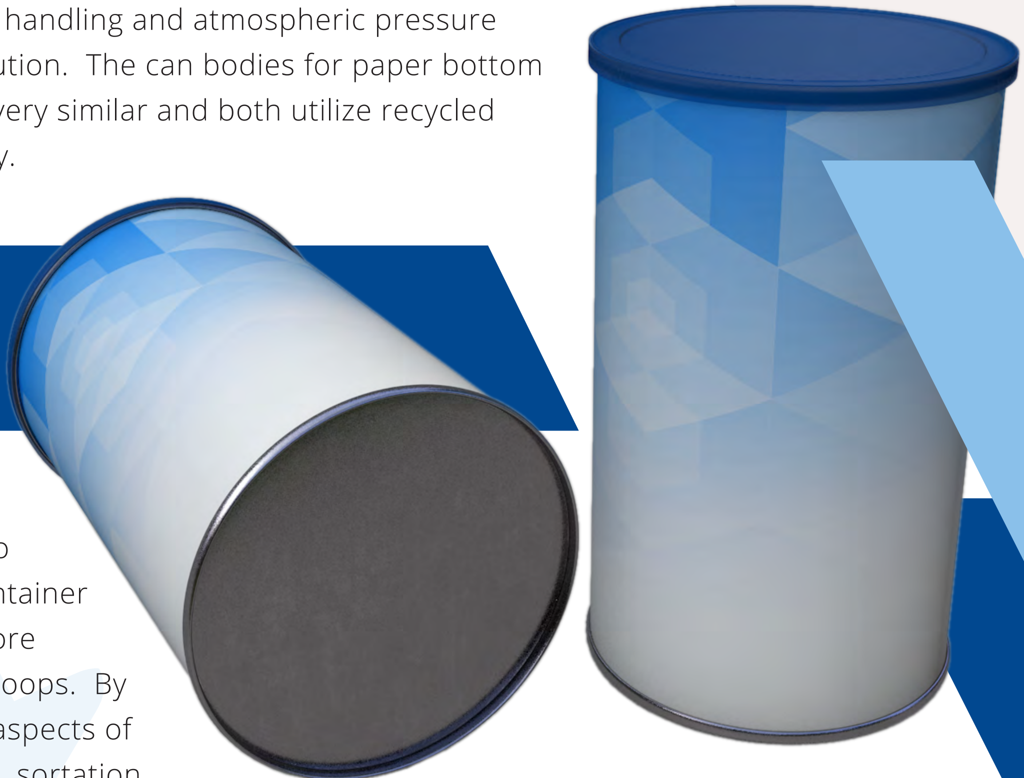
PAPER PULPING AND RECYCLING SIMULATIONS

Conducting paper mill trials is not always feasible, so comparing laboratory pulping and recycling test results to paper mill trial results is useful for ensuring confidence in future laboratory recyclability assessments. Paper cans have been tested by various external laboratories and certifiers in Germany, France, Belgium, Italy and the US. A typical testing protocol includes 1) sampling the packaging, 2) pulping of 80 - 100% sample material in water for 5, 10, 15 or 20 min, 3) screening with coarse and fine screens without a cleaning step, 4) production of hand sheets and 5) assessment of hand sheets for optical non-uniformity, defects and macro-stickies.

In these laboratory pulping simulations, paper cans show good disintegration in water (pulping), with barrier material mainly staying intact, which were removed through coarse or standard screens subsequently. Non-fibrous content which disintegrates into smaller particles was mainly removed by the fine screen. The average fibre recovery from these laboratory tests was 80-90%

METAL BOTTOM PAPER CONTAINERS

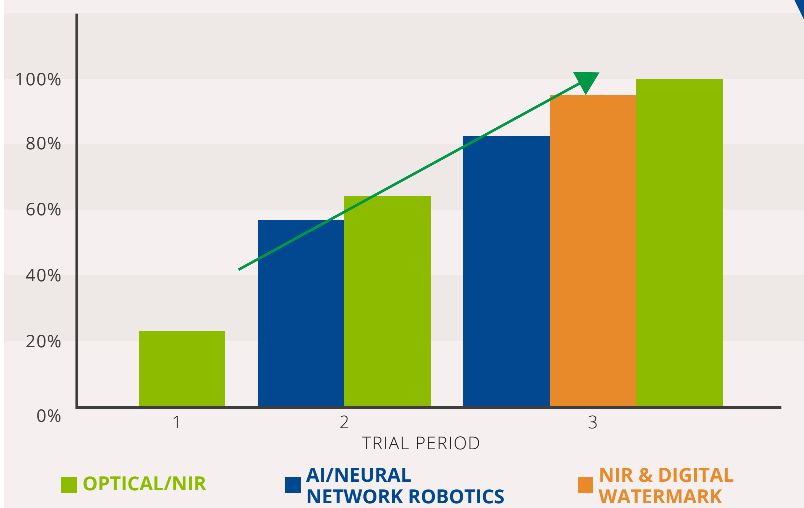
The forerunner to the paper container with paper bottom is, of course, the metal bottom paper can which is still found on the market today. Produced with double lock mechanical seams to attach the metal ends to the can, this package is used to package heavy products that require extra abuse resistance. The robustness of the metal end provides protection against package deformation and damages that can be caused by shipping, handling and atmospheric pressure changes during distribution. The can bodies for paper bottom and metal bottom are very similar and both utilize recycled content in the can body.



Identifying a pathway to recyclability for this container is critical to keeping more materials in circularity loops. By analysing the four key aspects of recyclability - collection, sortation, processing and end markets - a recyclability assessment of this package can be made. The paper can with metal end may not meet minimum fibre content requirements for kerbside paper bin collection, but it is sometimes collected in the mixed packaging bin in dual stream collection systems or collected in the single bin in single stream collection systems. Once collected, the steel bottomed paper cans are shipped to sorting centres for additional sortation. They pass through the various sorting equipment and subsequently can be sorted into bales of either steel or paper at various recovery rates depending on equipment settings and MRF equipment layouts. Depending on the dimensions of the paper can and the steel content, these packages may sort into the ferrous metal stream (Shown in Table 1 with Trial 1). However, when fibre sortation occurs before the ferrous sortation at the MRF, these paper cans will sort into the 2D or 3D fibre streams, with recovery rates increasing as MRF fibre sortation technologies are optimized.

Several sorting trials were conducted to determine the recovery rate of these containers into fibre streams using primarily three technologies. These sorting trials in pilot facilities and actual sorting centres with Near Infrared (NIR), AI/neural network robotics and NIR-digital watermark reading technologies show that the system recognises paper cans with metal ends and sorts them into the appropriate material bale. For instance, according to Figure 4, a proof-of-concept trial showed that paper cans with metal ends were recovered using NIR sorters at a rate of 24% for cans passing through the NIR equipment. With increased technological learnings, recovery rates of 65% were achieved for the same stream of cans. Further optimization of can material design to simulate general paperboard packaging resulted in 100% recovery of the paper can with metal end passing through the optical NIR sorter.

Figure 4: Paper Can with Metal Ends - Improvements in Sortation with Various Technologies



Likewise, robotics trials with machine learning software have proven that repeated exposure to paper containers leads to successful recognition and considerably higher recovery rates of the paper can at the MRF. Specifically, the recovery rate increases from 57% to 87% from Trial Periods 2-3 with the AMP robots and learning software. Finally, the innovative NIR-digital watermarking trial - where the system detects the package label to determine the material composition - revealed a 99% recovery of the paper can into the targeted bin. As this technology becomes more available to MRFs, the recovery rates of all materials will increase and the sortation will become more accurate.

Table 3: Paper Cans with Metal Ends - Results of Various MRF Sortation Trials in Europe and USA

TRIAL PERIOD	EQUIPMENT TECHNOLOGY	EQUIPMENT BRAND-ORGANIZER	# OF CANS PLACED	PAPER / FERROUS METAL / RESIDUE / LOST
1	OPTICAL NIR	VARIOUS - CIRCPACK	600	
2	AI/NEURAL NETWORK ROBOTS	AMP	*87	
2	OPTICAL NIR	TOMRA	*60	
3	AI/NEURAL NETWORK ROBOTS	AMP	*310	
3	NIR & DIGITAL WATERMARK	INNOVATION	271	
3	OPTICAL NIR	VARIOUS - CERTIFIER	100	

*For these tests/trials, there was no magnet available for ferrous metal recovery.

BRING BANK OR DROP-OFF COLLECTION

In addition to kerbside collection, there are privately run collection points or drop off collection bins for paper packaging with subsequent recycling in a specialised paper mill typically used for poly coated paper packaging. One example is the ACE UK Bring Bank collection system. In the UK, Sonoco has partnered with ACE UK to allow consumers to return paper cans with metal ends to the same bring banks where they return food and aseptic beverage cartons. The two packaging types are baled and shipped to a Sonoco specialised paper mill in Stainland, UK, where the materials are recycled into new paper products.

PROCESSING AND END MARKETS

As the metal bottom paper can consists primarily of paper and steel, several organizations have considered environmental benefits, sortation viability and end market value of recovering either or both the steel and the paper from the package. Recovering and recycling steel is attractive to the steel industry as 85% of steel products are produced from the recycled steel. The addition of steel to the steel recycling stream is appreciated. Using recycled steel versus virgin steel yields a 75% reduction in GHG emissions and energy. Similarly, 60-85% of paper packaging is recycled and converted to new materials. The paper industry depends on keeping paper products in circulation to minimize depletion of virgin paper resources.

Picture 7:

When metal bottom cans are recycled at paper mills, 90% of the available fiber is recovered and converted to new paper products. The non-fibrous content is ejected successfully without contaminating the pulping stream. See Picture 7 showing typical reject material from the paper recycling process for paper cans with steel bottoms. Only the poly-foil or poly metalised film and the steel bottom are ejected from the process. This picture shows how cleanly the fibre is separated from the rest of the paper can. Metal ends are separated from the pulp with already existing equipment for coarse reject like trommel or sandsep in both enhanced and standard mills.

SUMMARY

The collaborative work between Sonoco and others in the industry up to this point presents a strong foundation to educate consumers, MRFs, paper mills, recyclability associations, etc. on the suitability of paper cans for inclusion in the paper recycling stream. Through partnerships with Kelloggs, Circpack, ACE UK, TOMRA, Interseroh, MSS, AMP Robotics, Cyclos-HTP, and others the core elements of sortation, processing, and end use have been analysed and verified to have feasible solutions. Forming global industry partnerships is part of the ongoing work to increase paper container recycling to increase the amount of paper packaging that is recycled around the world. These partnerships support innovative solutions and technical learnings to dispel common assumptions that some types of paper packages (such as paper cans) are not recyclable. Equally important is understanding the need to balance:

1. Paper packaging that extends product shelf life and reduce food waste.

2. High fibre content in new paper packaging designs.

3. Incorporation of new infrastructure equipment and technologies to facilitate paper package recycling.

THANKS TO:

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AMP ROBOTICS

MSS

TOMRA

ace UK

HolyGrail 2.0 Intelligent Sorting

SUSTANA

certified by Institute cyclos-HTP recyclable

CIRCPACK by VEOLIA

interseroh Die Recycling-Allianz

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