

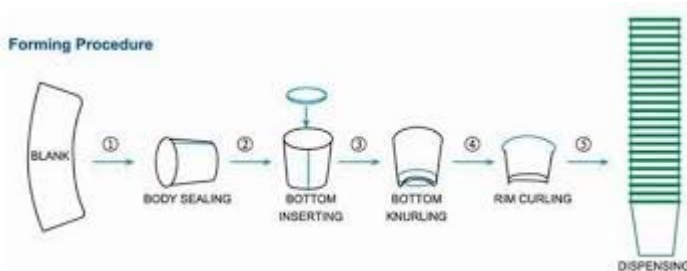
Carboset® GA Engineered Polymers

For Paper Cup Coatings Applications

Carboset® GA Engineered Polymers are specially designed for the manufacture of paper cups. They are part of a comprehensive line of products developed by Lubrizol for the packaging industry that includes different products designed to meet different needs of the industry.

Description

Paper cups are made as a two-piece structure using PE lined board with grammages that vary from 170 grs to 350 grs. This two-piece structure (wall and bottom) is sealed together in a high-speed machine which first forms the wall, sealing A to B (lined face to paper face), and then the pre-formed bottom structure is pulled in and sealed A-A (lined face to lined face). The cup production lines work at high speed so the sealing times are normally short and rarely exceed 0.5 sec. Pressure is normally low and most of the time not very well controlled.



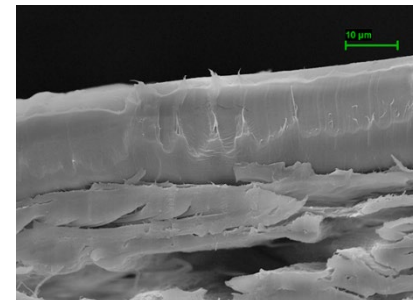
The function of the PE liner is twofold, first to provide heat sealability during the cup manufacturing process, and secondly to impart impermeability on the inside of the paper cup to prevent leaking. Lately PLA film has been introduced in the market; as PLA is compostable under certain conditions it is claimed to provide an advantage in terms of

sustainability.

Introducing a film layer (PE or PLA), either by laminating or extruding on the paper, causes the final product (paper cup) to be non-recyclable, since separating the film from the paper, especially if it is extruded on the board, is extremely difficult, and results in low quality fibres. Additionally, the significant quantities of PE or PLA lined paper scrap produced during cup manufacturing, or during extrusion or lamination, cannot be recycled internally or repulped because of the plastic film content.

Film thickness of PE or PLA coated boards varies between 18 microns and 22 microns depending on the source.

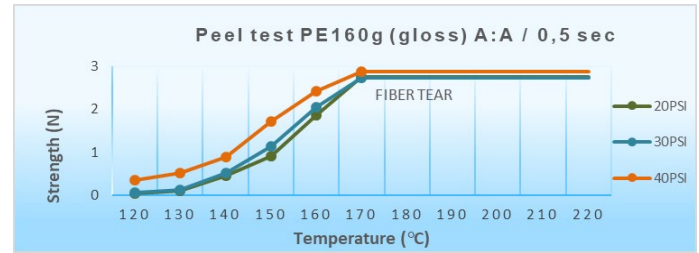
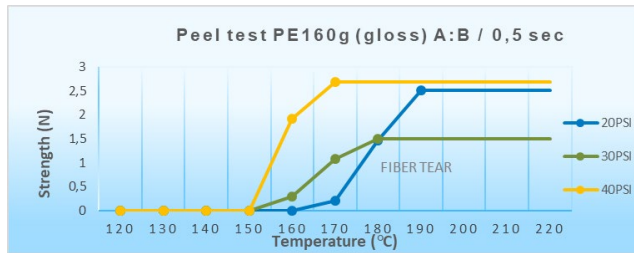
board	total t (um)	interior layer t (um)	exterior layer t (um)
gloss	19 (range 16-22)	9 (range 8-10)	10 (range 9-10)
matte	19 (range 17-22)	11 (range 8-13)	8 (range 7-9)



Background

Polycoated boards have been benchmarked for heat-sealability and water absorption (Cobb Testing) such that the performance of PE coated board can be targeted with emulsion-coated cupstock boards to provide the same or similar performance.

Heat seal testing was carried out on polycoated board supplied by Clearwater Paper Corp. (200 grs cupstock) both in A-A and A-B seals at different pressures in order to mimic different speeds in the cup



forming machines.

Heat sealing was carried out using a Brugger heat sealer sealing two 15mm strips varying the pressure applied and heating both jaws at the desired temperature, and then testing the sealing force using a Zwick Tensile tester. Temperature was increased until fiber tear resulted which is reached at the paper cohesive strength.

Cobb Levels were assessed following ISO 535:2014 standard for 1800 sec both at Room Temperature and using water at 90°C in order to simulate hot beverages.

Cobb 1800	Test at 23°C	Test at 90°C
PE 160g (gloss)	2,48gsm	1,59gsm
PE 196g (matt)	2,21gsm	1,16gsm

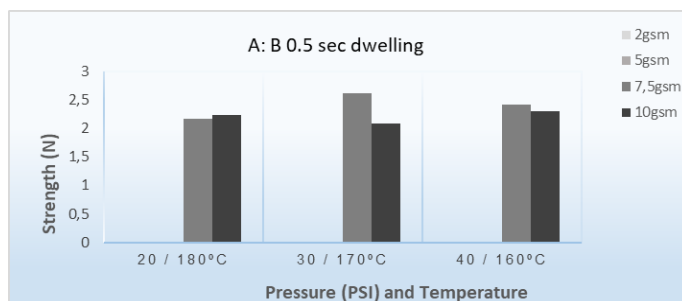
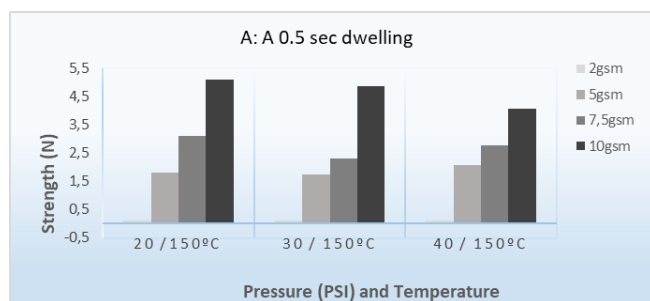
Technical Performance

Carboset® GA7513 has been designed in order to meet the technical targets for paper cup applications following a demanding testing regime. Carboset GA7513 has been selected as providing the best overall performance in the required properties for this application.

Carboset GA7513 has been successfully applied on paper cup stock using conventional coating systems such as gravure, flexo and curtain coating. The application system is key in order to ensure a smooth and uniform coating that will provide the properties needed in this end-use. Application systems that allow the coating to penetrate into the paper fibers do not generate a uniform and even surface that allows the coating to achieve the desired properties.

Heat sealability testing was measured on the product applied on Clearwater Paper Corp. paper stock commonly used in this application, at different temperatures and pressures. Initial testing for benchmarking purposes was carried out at different coating weights in order to identify the optimum application parameters to achieve the best technical performance.

Heat seal testing was measured both in A:A and A:B seals at 0.5 seconds dwell time. In all cases the results end up in paper tear, although the values are different in terms of peel strength. The optimal value in terms of coating weight was found at 10 gsm.



Cobb testing (ISO 535:2014 & TAPPI T441) has also been carried out at several coating thickness in order to benchmark and recommend optimum application levels. Cobb testing was measured using water at RT (23°C) and hot water (90°C) for 30 minutes

(1800 seconds). Paper board stock used was 200 grs Clearwater Paper Corp.

Again, the best results were found at 10 gsm application thickness, but it was also found that a double application of 5 gsm was even more suitable than single coat of 10 gsm.

In order to assess product suitability, different paper cupstock sourced from different

suppliers have been assessed for heat sealability and Cobb testing to evaluate the difference under this variable. Heat sealability and Cobb were tested using only 10 gsm application coating weight which was found previously to be the optimal coating thickness for this application. Results are summarized in the tables below:

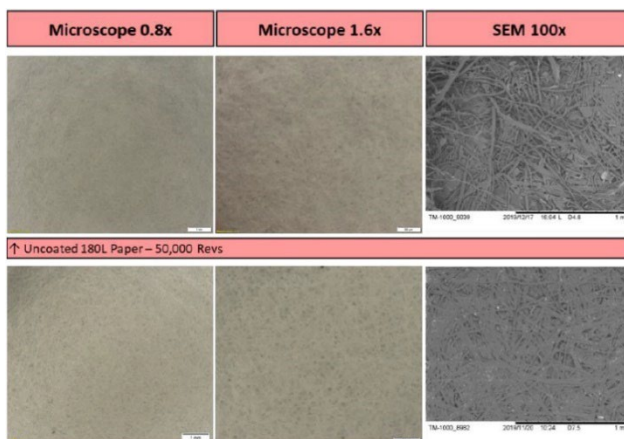
Cobb 1800	Test at 23°C	Test at 90°C
Carboset GA7513 (2gsm)	6,49gsm	15,43gsm
Carboset GA7513 (5gsm)	5,18gsm	9,51gsm
Carboset GA7513 (7,5gsm)	4,55gsm	7,10gsm
Carboset GA7513 (10gsm)	3,82gsm	4,42gsm
Carboset GA7513 (two layers of 5gsm)	3,31gsm	4,19gsm

Coob 1800	Standard
Lecta Board Carboset GA7513 (10 gsm)	4,74 grs
Clearwater 200 grs Carboset GA7513 (10 gsm)	3,91 grs
International Paper (1) Carboset GA7513 (10 gsm)	4,03 grs
International Paper (2) Carboset GA7513 (10 gsm)	4,75 grs
MetsäBoard 215 grs Carboset GA7513 (10 gsm)	3.79 grs
Georgia Pacific 221 grs Carboset GA7513 (10 gsm)	3.12 grs
Georgia Pacific 293 grs Carboset GA7513 (10 gsm)	2.35 grs

Paper and Polymer	Standard
Lecta Board Carboset GA7513 (4,9gsm)	1,72N ±0,08 (paper tear)
Clearwater board Carboset GA7513 (10gsm)	1,63N ±0,16 (paper tear)
International Paper (1) Carboset GA7513 (10gsm)	1,51N ±0,10 (paper tear)
International Paper (2) Carboset GA7513 (10gsm)	1,69N ±0,09 (paper tear)

Repulpability testing was conducted on Carboset GA7513 using different paper stocks and following the testing regime TAPPI Method T205 (British disintegrator). Paper stock selected were 200 grs board from Clearwater, Lecta, International Paper stock (2 versions).

Stock was disintegrated and sheets formed in accordance to the TAPPI T205 procedure. In this process, 24g of dry sample was torn into approx. 30 mm squares and soaked in 2000 mL deionised water for at least four hours at room temperature. This was then disintegrated using a TLS blender at 3000 rpm with either 30,000 or 50,000 revolutions as stated in the results table. The pulp was diluted to a total of 8000 mL by the addition of tap water, and 400 mL stock was used to form each sheet in a FORMAX Standard Sheet Mold with Actuated Valve. After removal of the sheet from the wire using two blotting papers and a standard couch roll, the sheets were dried on a hotplate at 90 °C for 3 minutes per side. They were then stored in a humidity cabinet at 23 °C and 50 % RH prior to weighing and testing.



Dry tensile strength was measured from 1.5 cm width sheets cut across the centre of the circular handsheets, using an Instron® 3366 tensile tester with a 25 mm/min extension. Flat jaws were used to clamp the sample at a testing distance of 100 mm.

Substrate Type & Coating → Physical Properties ↓	Uncoated 180L Paper	Rotary Coater 180L Paper with RDBCN099407N
Revolutions in Disintegration Step	50 000	50 000
Average Sheet Mass (gsm)	60.9 ± 3	59.3 ± 3
Dry Tensile Strength (N/15mm)	29.9 ± 0.9	30.1 ± 0.5
Dry Burst Strength (kPa)	150.3 ± 7.4	165.5 ± 5.9
Dry Stiffness (Taber units)	1.5 ± 0.1	1.39 ± 0.21
Air Permeability (mm/s)	5.0 ± 0.7	5.5 ± 0.5

Taber stiffness was tested in range 2 with a sample size of 3.75 x 3.75cm. Mullen burst measurements were performed on a Regmed BT-21 with a flow rate of 95 mL/min, a clamping pressure of 430 kPa and a rupture condition of 90%. A TEXTTEST instrument, Lab Air FX3300 IV, was used to measure the air permeability in mm/s at a test pressure of 100 Pa. A test head area of 20 cm² was used, following the standard EN ISO 9237.