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DEPARTMENT OF MATERIALS
Laboratory for Polymers

Ljubljana, 25 September 2018

TRANSLATION OF THE TEST REPORT
No. 1103/17–440–2

on the testing of the ES Kerrock boards

Orderer:	**KOLPA, proizvodnja in predelava plastičnih mas d.d., Rosalnice 5, 8330 Metlika, Slovenija**
Order/contract:	**1709163, dated 10. 11. 2017**
Responsible investigator:	**Gregor Strmljan, MSc.**
Head of laboratory:	**Assis. Prof. Andrijana Sever Škapin, PhD.**
Director:	**Assoc. Prof. Andraž Legat, PhD.**

ZAVOD ZA GRADBENIŠTVO SLOVENIJE – LJUBLJANA 16

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INTRODUCTION

Table 1: Data on the samples received for the testing.

Applicant	KOLPA, proizvodnja in predelava plastičnih mas d.d., Rosalnice 5, 8330 Metlika, Slovenija
Sample number. APPLICANT DESIGNATION (description) Quantity, dimensions	**1. KERROCK ES 112** 4 BOARDS: 86 cm x 76 cm x 12 mm
Manufacturer	KOLPA, proizvodnja in predelava plastičnih mas d.d., Rosalnice 5, 8330 Metlika, Slovenija
Internal (laboratory) sample designation	**D17-90-5** KERROCK ES 112
Date of sampling / mode of sampling	14. 11. 2017 / sampled and delivered by the applicant
Start of testing / end of testing:	
Density	29. 1. 2018 / 30. 1. 2018
Flexural properties (flexural strength and flexural modulus)	31. 1. 2018 / 6. 6. 2018
Tensile properties (tensile strength and elongation at break)	1. 2. 2018 / 6. 6. 2018
Charpy impact strength of unnotched specimens	5. 2. 2018 / 6. 6. 2018
Water absorption	23. 1. 2018 / 6. 7. 2018
Resistance to surface wear	26. 2. 2018 / 27. 2. 2018
Resistance to water vapour	8. 3. 2018 / 9. 3. 2018
Resistance to dry heat	5. 3. 2018 / 7. 3. 2018
Resistance to cigarette burns	14. 5. 2018 / 17. 5. 2018
Linear expansion coefficient	1. 2. 2018 / 9. 7. 2018
Barcol hardness	14. 3. 2018/ 14. 3. 2018
Mohs hardness	20. 4. 2018 / 26. 4. 2018
Compressive properties	13. 2. 2018 / 13. 2. 2018

In agreement with the applicant, the KERROCK boards were tested to determine the following properties:

1. DENSITY / *SIST EN ISO 1183-1: 2013*
2. FLEXURAL PROPERTIES (FLEXURAL STRENGTH AND FLEXURAL MODULUS) / *SIST EN ISO 178: 2011*
3. TENSILE PROPERTIES (TENSILE STRENGTH AND ELONGATION AT BREAK) / *SIST EN ISO 527-2: 2012*
4. CHARPY IMPACT STRENGTH OF UNNOTCHED SPECIMENS / *SIST EN ISO 179-1/1fU^{c}: 2010*
5. WATER ABSOPRTION / *SIST EN ISO 62: 2009*
6. RESISTANCE TO SURFACE WEAR / *SIST EN 438-2: 2016, §10*
7. RESISTANCE TO WATER VAPOUR / *SIST EN 438-2: 2016, § 14*
8. RESISTANCE TO DRY HEAT / *SIST EN 438-2: 2016, §16*
9. RESISTANCE TO CIGARETTE BURNS / *SIST EN 438-2:2005, § 30*
10. LINEAR EXPANSION COEFFICIENT
11. BARCOL HARDNESS / *SIST EN 59:2016*
12. MOHS HARDNESS / *DIN EN 101:1985*
13. COMPRESSIVE PROPERTIES / *SIST EN ISO 604: 2003*

Note: The test methods listed above may, in some cases, deviate from the standards which specify them. The differences were agreed with the applicant prior to the testing.

COURSE OF MEASUREMENTS AND TEST METHODS DESCRIPTION

1. DENSITY

Method A was used to determine density of the samples tested. During the testing density was calculated gravimetrically using the Archimedes' principle. The test specimens were weighed dry (in air) as well as submerged in liquid water. Knowing the difference in mass, taking into account the density of water at know temperature at the time of the measurement density was then calculated. At least 3 specimens were tested per product type.

2. FLEXURAL PROPERTIES (FLEXURAL STRENGTH AND FLEXURAL MODULUS)

At least 5 test specimens with the dimensions of (240 x 20 x 12) mm were prepared using a CNC milling machine. Flexural properties were measured on the ZWICK Z100 tensile testing machine at standard laboratory conditions (23 °C and 50 % relative humidity). The span between specimen supports was 192 mm (16 x height of the test specimen) and the flexural strain rate was 2 mm/min.

3. TENSILE PROPERTIES (TENSILE STRENGTH AND ELONGATION AT BREAK)

Boards that were received for testing were machined using a CNC milling machine to produce test specimens with the following dimensions (length x end width x thickness): (200 x 20 x 12) mm. Width in the central (narrowest) part of the test specimen was 10 mm. Note that the specimens were machined without regard of orientation since the product is uniform in structure.

5 test specimens were prepared for each product type tested and the tensile properties were measured in the ZWICK Z100 tensile testing machine at standard laboratory conditions

(23 °C and 50 % relative humidity). Hydraulic jaws with the pressure set at 80 bars were used to hold the test specimens in place and the tensile strain rate was 1 mm/min.

4. CHARPY IMPACT STRENGTH

Boards that were received for testing were machined using a CNC milling machine to produce test specimens with the following dimensions (length x width x thickness): (80 x 10 x 12) mm. The samples prepared were unnotched.
At least 10 test specimens per product type tested were prepared for testing in the ZWICK D-7900 tester. The testing was done at standard laboratory conditions (23 °C and 50 % relative humidity. 1 J hammer with a speed of 1 m/s was used and the span between specimen supports was 62 mm. The hammer was carefully selected prior to the testing to ensure the specimen broke at the first blow.

5. WATER ABSORPTION

Boards that were received for testing were machined using a CNC milling machine to produce test specimens with the following dimensions (length x width x thickness): (60 x 60 x 12) mm.
Three test specimens were prepared for each product type tested. Prior to the testing the test specimens were dried for 10 days at 50 °C. When testing the test specimens were first weighed dry and then submerged in purified (deionised) water. The mass of the specimens was inspected at regular time intervals (24 hours). Before the weighing the specimens were wiped with a dry cloth. The testing of water absorbed by the test specimens lasted for 192 hours..

6. RESISTANCE TO SURFACE WEAR

Boards that were received for testing were machined using a CNC milling machine to produce test specimens with the following dimensions (length x width x thickness): (100 x 100 x 12) mm.
Three test specimens were prepared for each product type tested. During the testing the test specimens were placed in the ABRASER – MODEL 503 tester. Calibrated sand paper was used and the load exerted to the test specimen was defined. The test specimens were exposed to 100 revolutions after which surface wear was calculated and expressed gravimetrically as the difference in mass between the initial mass of the test specimen and the mass of the test specimen after the abrasion procedure with the unit (mg/1000 revolutions).

7. RESISTANCE TO WATER VAPOUR

Boards that were received for testing were machined using a CNC milling machine to produce test specimens with the following dimensions (length x width x thickness): (100 x 100 x 12) mm.
One test specimen for each product type tested was prepared. During the testing procedure the test specimen was exposed to boiling water vapour for one hour after. After 24 hours the surface of the test specimen was carefully inspected with a scale from 1 to 5 where 1 means worst and 5 means best grade. The scale used to evaluate the results was as as follows:

Rating 5: No visible change.
Rating 4: Slight change of gloss and/or colour, only visible at certain viewing angles.
Rating 3: Moderate change of gloss and/or colour.
Rating 2: Marked change of gloss and/or colour.
Rating 1: Blistering and/or delamination.

8. RESISTANCE TO DRY HEAT

Boards that were received for testing were machined using a CNC milling machine to produce test specimens with the following dimensions (length x width x thickness): (400 x 400 x 12) mm.

One specimen for each product type tested was prepared. During the testing the test specimen was exposed to silicone oil that was preheated to 160 °C. After the testing the test specimen was left to rest for one hour when it was visually assessed for discoloration, change in gloss and colour, blistering, swelling, cracking and other parameters. The scale used to evaluate the results was as as follows:

Rating 5: No change. Test area indistinguishable from adjacent surrounding area.
Rating 4: Minor change. Test area distinguishable from adjacent surrounding area, only when the light source is mirrored on the test surface and is reflected towards the observers`s eye, e.g. discoloration, change in gloss and colour.
Rating 3: Moderate change. Test area distinguishable from adjacent surrounding area, visible in several viewing directions, e.g. discoloration, change in gloss and colour, no change in the surface structure e.g. cracking, blistering.
Rating 2: Significant change. Test area clearly distinguishable from adjacent surrounding area, visible in all viewing directions, e.g. discoloration, change in gloss and colour, and/or structure of the surface slightly changed, e.g. slight cracking, slight blistering.
Rating 1: Strong change. The structure of the surface being distinctly changed, e.g. strong cracking, strong blistering and/or discoloration, change in gloss and colour, and/or the surface material being totally or partially delaminated.

9. RESISTANCE TO CIGARETTE BURNS

The test was performed on test specimens with the dimension of (230 x 230) mm, cut out of the samples supplied to us by the applicant. One test specimen per material type was tested. Marlboro Red cigarettes were used for the testing where a burning cigarette was placed onto the test specimens and was allowed to burn for 20 mm of its length. After the exposure to the cigarette burn the surface was cleaned with a soft cloth moistened with ethanol and examined with the naked eye.

The scale used to evaluate the results was as as follows:

Rating 5: No visible change.
Rating 4: Slight change of gloss only visible at certain viewing angles and/or slight brown stain.
Rating 3: Moderate change of gloss and/or moderate brown stain.
Rating 2: Severe brown mark, but no destruction of the surface.
Rating 1: Blistering and/or cracks.

10. LINEAR EXTENSION COEFFICIENT

Boards received for testing were machined using a CNC milling machine to produce test specimens with the following dimensions (length x width x thickness): (500 x 100 x 12) mm.
One specimen for each product type was prepared. During the testing the test specimens were put into a climatic chamber with temperature-relative humidity control to expose them to the temperatures ranging from -20 °C to +70 °C. The specimens undergone 3 cycles during which the extension-contraction was measured using a SMARTEC SOFO measuring system on the basis of optical fibres.

11. BARCOL HARDNESS

Hardness was measured with an apparatus supplied by the applicant. The presser foot was type GYZJ 934-1 and had an indenter with a diameter of the flat tip measuring 0.157 mm. Each test specimen was measured 10 times at standard laboratoy conditions ((23 ± 2) °C and (50 ± 5) % relative humidity).

12. MOHS HARDNESS

Using a mineral of known hardness we tried to scratch and abrade the surface, the principle of the test being the material of a lesser hardness leaves no mark when scratching and the material of a higher hardness leaves marks when scratching. Minerals used to determine the hardness of the test specimens were as follows:

Hardness 1: Talc $Mg_3Si_4O_{10}(OH)_2$
Hardness 2: Gypsum $CaSO_4 \cdot 2H_2O$
Hardness 3: Calcite $CaCO_3$
Hardness 4: Fluorite CaF_2
Hardness 5: Apatite $Ca_5(PO_4)_3(OH\text{-},Cl\text{-},F\text{-})$
Hardness 6: Orthoclase feldspar $KAlSi_3O_8$
Hardness 7: Quartz SiO_2
Hardness 8: Topaz $Al_2SiO_4(OH\text{-},F\text{-})_2$
Hardness 9: Corundum Al_2O_3
Hardness 10: Diamond C

Because of the relative imprecision of the method the result of the test is expressed as the interval between the highest hardness of the mineral used to scratch the test specimens that left no visible marks and scratches on the surface and the hardness of the material used to scratch the test specimen that first left visible marks and scratches.

13. COMPRESSIVE PROPERTIES

Boards received for testing were machined using a CNC milling machine to produce test specimens of the dimensions (10 x 10 x 4) mm At least 5 test specimens were prepared for the testing.
Measurements were made in the ZWICK Z100 tensile testing machine where the compression speed was 5 mm/min. All measurements were made in controlled laboratory conditions at 23 °C and 50 % relative humidity. Brushed steel plates were used as tool to compress the test specimens.

RESULTS

of the testing are gathered in Table 2 on the following pages.

ZAVOD ZA GRADBENIŠTVO SLOVENIJE LJUBLJANA 18

Table 2: Results of the testing.

Property tested (unit) / *METHOD OF TESTING*		**Sample tested**
		ES 112
Density / *SIST EN ISO 1183-1:2013 METODA A*	**Individual values (kg/m^3)**	1552,7
		1551,5
		1552,9
		1552,3
	average value ± standard deviation	**1552,4** ± 0,6
Flexural properties – flexural strength, flexural modulus / *SIST EN ISO 178: 2011 METODA A*	**individual values (MPa)**	**flexural strength**
		82,7
		81,8
		73,8
		79,7
		73,1
	average value ± standard deviation	**78,2** ± 4,5
	individual values (MPa)	**flexural modulus**
		5550
		5990
		5590
		5650
		5490
	average value ± standard deviation	**5650** ± 200
Tensile properties – tensile strength, elongation at break / *SIST EN ISO 527-2: 2012*	**individual values (MPa)**	**tensile strength**
		51,4
		49,1
		49,7
		50,9
		49,5
	average value ± standard deviation	**50,1** ± 1,0
	individual values (%)	**elongation at break**
		1,4
		1,2
		1,2
		1,4
		1,2
	average value ± standard deviation	**1,3** ± 0,1
Charpy impact strength of unnotched specimens / *SIST EN ISO 179-1/1fUc: 2010*	**individual values (kJ/m^2)**	7,00 | 7,06
		6,98 | 7,12
		6,91 | 6,91
		6,95 | 6,99
		6,85 | 6,87
	average value ± standard deviation	**6,96** ± 0,08

Property tested (unit) / *METHOD OF TESTING*		**Sample tested**
		ES 112
Water absorption / *SIST EN ISO 62:2009*	**individual values (%)**	**water absorption after 24 h immersion**
		0,050
		0,047
		0,051
		0,042
	average value ± standard deviation	**0,047** ± 0,004
	individual values (%)	**water absorption at saturation c_s**
		0,576
		0,579
		0,580
		0,579
	average value ± standard deviation	**0,578** ± 0,002
	individual values (mm^2/s)	**diffusion coefficien D**
		$9,07 \times 10^{-7}$
		$9,07 \times 10^{-7}$
		$9,07 \times 10^{-7}$
		$8,17 \times 10^{-7}$
	average value ± standard deviation	**(8,85** ± 0,16) **x** 10^{-7}
Resistance to surface wear / *SIST EN 438-2: 2016, tč. 10*	**individual values (mg/1000 revolutions)**	939
		962
		986
	average value ± standard deviation	**962** ± 23
Resistance to water vapour / *SIST EN 438-2: 2016, tč. 14*	**result**	**Rating 5**
	description	No visible change.
Resistance to dry heat / *SIST EN 438-2: 2016, tč. 16*	**result**	**Rating 5**
	description	No change. Test area indistinguishable from adjacent surrounding area.
Resistance to cigarette burns / *SIST EN 438-2:2005, tč. 30*	**rezultat**	**Rating 3**
	description	Moderate change of gloss and/or moderate brown stain.

Property tested (unit) / *METHOD OF TESTING*		**Sample tested**
		ES 112
Linear coefficient of extension	**α (-20 °C do 0 °C)**	**(3,49 ± 0,02) x 10^{-5} K^{-1}**
	α (0 °C do 20 °C)	**(3,79 ± 0,06) x 10^{-5} K^{-1}**
	α (20 °C do 50 °C)	**(4,36 ± 0,49) x 10^{-5} K^{-1}**
	α (-20 °C do 50 °C)	**3,88 x 10^{-5} K^{-1}**
Barcol hardness / *SIST EN 59:2016*	**individual values (/)**	58 58
		58 59
		59 58
		58 58
		60 59
	average value ± standard deviation	**58** ± 1
Mohs hardness / *DIN EN 101:1985*	**result**	**2 - 3**
Compressive properties – compressive strength / *SIST EN ISO 604: 2003*	**individual values (MPa)**	123
		112
		143
		133
		140
	average value ± standard deviation	**130** ± 13

Test report prepared by:
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ZAVOD ZA GRADBENIŠTVO SLOVENIJE LJUBLJANA 16