Type tests (ITT-tests) of *SEALE*CTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam

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Requested by: IsoGreen Industries Ab

VTT EXPERT SERVICES LTD

Requested by	IsoGreen Industries Ab BOX 3095 83103 Sweden
Order	E-mail on 21.1.2013 from Lena Kershaw
Contact person	**VTT Expert Services Oy** Research Engineer Hannu Hyttinen Kemistintie 3 P.O. Box 1001, FIN-02044 VTT Tel. + 358 20 722 4747 E-mail: hannu.hyttinen@vtt.fi

Task

Type tests (ITT-tests) of *SEALE*CTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam

Samples

The samples were sprayed in Sweden on 15.3.2013 by the manufacturer in the control of the representative of SP Technical Research Institute of Sweden. The third party control protocol is presented in the appendix 1.
In the control protocol is presented the Spray parameters and the used components.
The sample lot was received by SP to VTT Expert Services Oy.

The samples were received on 26.3.2013.

Performance of the task

The tests were performed according to the test procedure of CUAP /ETA request no. 12.01/21 "Soft foam insulation".
The tested characteristics, test specimens and test standards are presented in the table 1. The test specimens were cut from the sample lot at VTT Expert Services.

Table 1: Tested characteristics, test specimens, test methods and test standards.

Test/task	Test standard	Size of the test specimen [1)] (mm)	Number of test specimen
Thermal conductivity	EN 12667	600x600x50	10
Declared value of thermal conductivity	EN ISO 10456	-	*
Short term water absorption	EN 1609, method A	200x200x50	4
Water vapour permeability	EN 12086	Ø 150x50	6
Compression strength	EN 826	200x200x100	10
Tensile strength perpendicular to faces	EN 1607	200x200x100	10
Tensile strength parallel to faces	EN 1608	300x600x(100-50)	6
Density	EN 1602	600x600x50	10
Dimensional stability:			
-at laboratory conditions	EN 1603	500x500x50	3
- +70 °C/90 % R.H, 48 h	EN 1604	200x200x50	3
- -20 °C, 48 h	EN 1604	200x200x50	3
Compressibility	EN 12431	200x200x50	10
Corrosion developing capacity	CUAP Annex C	500x500x50	1*
Dynamic stiffness	EN 29052-1	200x200x50	3*
Resistance to mould fungi	CUAP Annex B	500x500x50	1*
Reaction to fire	EN ISO 11925-2	-	*

* See the separated test report.

Details of the test methods

Thermal conductivity

Test method

The tests were performed according to the standard EN 12667: "Building materials - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Products of high and medium thermal resistance".

The apparatus used are in accordance with the standard ISO 8301: "Determination of steady-state thermal resistance and related properties - Heat flow meter apparatus".

The identifications of apparatus used is: Fox600 L 4TC Sn 09101136.

The test method was one specimen symmetrical. During the tests specimen was in horizontal position and the heat flow was vertical.

The calibrations of the apparatus were done using Certified Reference Material IRMM-440 nr.19 (4.December 2001) as a reference material.

Density of the test specimens was measured according to the standard EN 1602.

The water vapour transmission properties

Test method

Water vapour transmission properties of the test specimens were determined according to the standard EN 12086, Set B: "Thermal insulating products for building applications-Determination of water vapour transmission properties" The water vapour transmission properties were measured using five test specimens. The sixth test specimen was so-called "blind" specimen according to test standard.

The test conditions were:

- +23 °C, 0 % R.H. / 85 % R.H.
- average barometric pressure was 102 hPa.

The water vapour permeance W (kg/(m^2·s·Pa)), the water vapour resistance Z ((m^2·s·Pa)/kg), the water vapour permeability δ (kg/(m·s·Pa)) and the water vapour diffusion factor μ of the test specimens are calculated using formulas 1-4:

$$W = G / (A \cdot \Delta p) \quad (1)$$

$$Z = 1 / W \quad (2)$$

$$\delta = W \cdot d \quad (3)$$

$$\mu = \delta_{air} / \delta$$

$$\delta_{air} = (0{,}083 / (R_D \times T) \times (p_o / p) \times (T / 273)^{1{,}81} \quad (4)$$

where:

G is water vapour flow rate through the specimen(kg/s)
A is area of the specimen (m^2)
Δp is water vapour pressure difference across the specimen (Pa)
d is thickness of the specimen (m)
R_D is gas constant for water vapour 462 x 10^{-6} Nm / (mg · K)
T is average thermodynamic temperature (K)
p is average barometric pressure (hPa)
p_o is standard barometric pressure (1013.25 hPa)

The test specimens were weighed to an accuracy of 10 mg at predetermined times.

Compressibility

Test method

The compressibility was done applying the standard EN 12431.

Deviating from the test standard as maximum load was used 10 kPa instead of 50 kPa. The final thickness d_B was measured after 300 s after removing the 8 kPa load.

Time of the measurements

The tests were performed during time period; 26.3.2013 – 27.5.2013.

Results The test results are presented in the tables 2-11.

Table 2. Thermal conductivity of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam (EN 12667).

Test specimen	Thickness of the test specimen b (mm)	Density ρ (kg/m^3)	Mean temperature T_m (°C)	Temperature difference ΔT (K)	Heat flow rate q (W/m^2)	Thermal resistance R (m^{2}K/W)	Thermal conductivity λ_{10} (W/(m·K))
1	58.4	9.2	10.84	18.82	12.24	1.538	0.0380
2	48.2	9.1	10.82	18.83	14.93	1.261	0.0382
3	35.9	9.0	10.82	18.81	19.55	0.962	0.0373
4	39.2	9.0	10.82	18.80	17.68	1.063	0.0369
5	40.2	9.5	10.84	18.77	17.22	1.090	0.0369
6	43.1	9.0	10.84	18.77	16.31	1.151	0.0375
7	38.5	9.6	10.84	18.74	17.89	1.047	0.0368
8	32.1	8.9	10.83	18.73	21.48	0.872	0.0368
9	55.7	9.2	10.86	18.76	12.63	1.486	0.0375
10	54.3	9.5	10.84	18.79	12.71	1.479	0.0367
Mean value	-	9.2	-	-	-	1.195	**0.0373**

The estimated uncertainty of the thermal conductivity measurements is ±3%.

Table 3. Compressive strength of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 826).

Sample	Test specimen	Length (mm)	Width (mm)	Thickness (mm) (250±10) Pa	Density ρ (kg/m³)	Force corresponding to a relative deformation of 10 % F_{10} (N)	Compressive strength at 10 % deformation σ_{10} (kPa)
1	1	200.5	200.0	101.0	10.9	442.5	11.0
	2	199.0	200.0	100.7	10.1	492.5	12.4
	3	197.5	200.0	100.8	11.6	398.8	10.1
	4	199.0	200.0	100.9	10.7	406.2	10.2
	5	199.5	201.0	100.8	11.3	437.7	10.9
Mean value	-	-	-	-	**10.9**	-	**10.9**
2	1	200.0	198.5	100.6	**10.9**	493.6	12.4
	2	200.0	200.0	100.8	**11.1**	497.2	12.4
	3	198.0	200.0	100.9	**11.7**	386.7	9.8
	4	197.5	202.5	100.7	**10.8**	494.5	12.4
	5	199.0	199.5	100.8	**11.1**	410.0	10.3
Mean value	-	-	-	-	**11.1**	-	**11.5**
Mean value of the product							**11.2**

Table 4. Tensile strength parallel to faces measurements of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 1608)

Test specimen	Dimensions of test specimen l x b x d (mm)	Maximum tensile force F_m (N)	Tensile strength σ_t (kPa)
1	600 x 182 x 97.4	163.1	9.2
2	600 x 182 x 97.3	278.4	15.7
3	600 x 183 x 97.9	191.9	10.7
4	600 x 182 x 98.1	220.3	12.3
5	600 x 182 x 52.6	64.5	6.7
6	600 x 182 x 97.5	229.9	13.0
Mean value	-	-	**11.3**

Table 5. Tensile strength perpendicular to faces measurements of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 1607).

Test specimen	Dimensions of test specimen l x b x d (mm)	Density ρ (kg/m^3)	Maximum tensile force F_m (N)	Tensile strength σ_{mt} (kPa)
1	200.0 x 201.0 x 100.6	11.3	753.3	18.7
2	202.0 x 195.0 x 100.4	11.1	640.3	16.2
3	200.0 x 200.0 x 100.5	11.2	247.8	6.2
4	200.0 x 201.0 x 100.6	12.1	237.0	5.9
5	201.0 x 196.0 x 100.6	12.5	410.8	10.4
Mean value	-	**11.6**	-	**11.5**

Table 6. Short term water absorption by partial immersion of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 1609, method A).

Test specimen	Dimensions of the test specimen (mm)	Density ρ (kg/m^3)	Short time water absorption by partial immersion W_p (kg/m^2)
1	200 x 201 x 50.5	9.6	2.63
2	201 x 198 x 50.5	9.8	2.23
3	200 x 200 x 50.5	9.4	3.14
4	200 x 200 x 50.5	9.7	2.55
Mean value	-	**9.6**	**2.64**

Table 7. Water vapour transmission properties of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 12086, +23 °C, 0 % R.H. / 85 % R.H).

Product		Test specimen / Thickness of test specimen, d (mm)					
Semi-rigid polyurethane foam		1	2	3	3	5	
Symbol*	Unit	50.6	50.9	50.9	50.3	50.0	Average
G	kg/s	2.705E-08	2.510E-08	2.378E-08	2.439E-08	2.254E-08	2.457E-08
g	kg/(m^{2}s)	1.606E-06	1.489E-06	1.411E-06	1.447E-06	1.338E-06	1.458E-06
W	kg/(m^{2}sPa)	6.963E-10	6.442E-10	6.094E-10	6.254E-10	5.767E-10	6.304E-10
Z=1/W	(m^{2}sPa)/kg	1.436E+09	1.552E+09	1.641E+09	1.599E+09	1.734E+09	1.592E+09
δ	kg/(msPa)	3.523E-11	3.279E-11	3.102E-11	3.146E-11	2.884E-11	3.187E-11
μ	-	5.503	5.913	6.251	6.163	6.724	6.111
sd	m	0.28	0.30	0.32	0.31	0.34	0.31

* G; moisture flow rate through the test specimen
g; density of water vapour flow rate
W; water vapour permeance
Z; water vapour resistance
δ; water vapour permeability
μ; water vapour resistance factor
sd; water vapour diffusion-equivalent air layer thickness

Table 8. Dimensional stability under constant normal laboratory conditions (23 °C/50 %) of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 1603 method A).

Test specimen	Direction	Initial value l_0 (mm)	Final value l (mm)	Chance of dimension Δl (mm)	Chance of dimension Δε (%-from l_0)
1	Length	508.0	508.1	+0.1	**0**
	Width	502.3	502.4	+0.1	**0**
2	Length	507.8	507.7	-0.1	**0**
	Width	507.9	507.5	-0.4	**-0.1**
3	Length	502.4	502.2	-0.2	**0**
	Width	509.0	509.0	0	**0**

No changes of flatness were found.

Table 9. Dimensional stability (48 h, (-20±3) °C) of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 1604).

Test specimen	Position	Initial value l_0 (mm)	Final value l (mm)	Change of dimension Δl (mm)	Change of dimension $\Delta\varepsilon$ (%-l_0)	Mean value of change $\Delta\varepsilon$ (%-l_0)
1	1. length	199.62	199.71	0.09	0.04	0.05
	2. length	200.16	200.30	0.14	0.07	
	3. length	200.30	200.37	0.07	0.04	
	1. width	200.86	200.79	-0.07	-0.04	0.02
	2. width	199.88	199.88	0.00	0.00	
	3. width	199.73	199.92	0.19	0.09	
	1. thickness	49.38	49.36	-0.02	-0.04	-0.06
	2. thickness	51.64	51.59	-0.05	-0.10	
	3. thickness	51.91	51.88	-0.03	-0.06	
	4. thickness	51.63	51.62	-0.01	-0.02	
	5. thickness	52.88	52.83	-0.05	-0.09	
2	1. length	200.09	200.13	0.04	0.02	0.02
	2. length	200.42	200.46	0.04	0.02	
	3. length	200.73	200.76	0.03	0.01	
	1. width	204.74	204.73	-0.01	0.00	0.00
	2. width	204.01	204.03	0.02	0.01	
	3. width	202.91	202.88	-0.03	-0.01	
	1. thickness	51.20	51.22	0.02	0.04	0.04
	2. thickness	52.23	52.27	0.04	0.08	
	3. thickness	50.71	50.73	0.02	0.04	
	4. thickness	51.52	51.50	-0.02	-0.04	
	5. thickness	52.52	52.56	0.04	0.08	
3	1. length	202.32	202.31	-0.01	0.00	0.00
	2. length	203.23	203.23	0.00	0.00	
	3. length	202.70	202.72	0.02	0.01	
	1. width	200.75	200.78	0.03	0.01	0.01
	2. width	201.37	201.39	0.02	0.01	
	3. width	201.13	201.16	0.03	0.01	
	1. thickness	51.50	51.48	-0.02	-0.04	0.00
	2. thickness	50.71	50.68	-0.03	-0.06	
	3. thickness	51.47	51.51	0.04	0.08	
	4. thickness	51.34	51.31	-0.03	-0.06	
	5. thickness	52.47	52.51	0.04	0.08	
$\Delta\varepsilon$ (%-l_0) Mean value of the product	Length: **-0.02**		Width: **-0.01**		Thickness: **-0.01**	

Table 1. Dimensional stability (48 h, (+70±2) °C/ (90±5) % R.H) of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 1604).

Test specimen	Position	Initial value l_0 (mm)	Final value l (mm)	Change of dimension Δl (mm)	Change of dimension $\Delta\varepsilon$ (%-l_0)	Mean value of change $\Delta\varepsilon$ (%-l_0)
1	1. length	201.18	201.64	0.46	0.23	0.47
	2. length	201.08	202.39	1.31	0.65	
	3. length	200.13	201.18	1.05	0.52	
	1. width	197.86	198.64	0.78	0.39	0.31
	2. width	200.59	201.28	0.69	0.34	
	3. width	202.01	202.43	0.42	0.21	
	1. thickness	52.20	53.27	1.07	2.05	1.73
	2. thickness	51.10	52.21	1.11	2.17	
	3. thickness	49.54	50.34	0.80	1.61	
	4. thickness	51.35	52.15	0.80	1.56	
	5. thickness	52.55	53.22	0.67	1.27	
2	1. length	201.89	202.50	0.61	0.30	0.23
	2. length	202.35	202.75	0.40	0.20	
	3. length	202.43	202.81	0.38	0.19	
	1. width	201.16	201.45	0.29	0.14	0.19
	2. width	202.51	202.96	0.45	0.22	
	3. width	202.80	203.19	0.39	0.19	
	1. thickness	52.07	52.41	0.34	0.65	0.61
	2. thickness	51.51	51.81	0.30	0.58	
	3. thickness	50.05	50.30	0.25	0.50	
	4. thickness	51.36	51.71	0.35	0.68	
	5. thickness	52.51	52.84	0.33	0.63	
3	1. length	199.33	199.50	0.17	0.09	0.10
	2. length	199.39	199.64	0.25	0.13	
	3. length	199.62	199.82	0.20	0.10	
	1. width	201.09	201.29	0.20	0.10	0.11
	2. width	201.73	201.98	0.25	0.12	
	3. width	203.04	203.27	0.23	0.11	
	1. thickness	50.81	51.08	0.27	0.53	0.57
	2. thickness	50.94	51.24	0.30	0.59	
	3. thickness	49.74	50.08	0.34	0.68	
	4. thickness	51.73	51.95	0.22	0.43	
	5. thickness	52.21	52.53	0.32	0.61	
$\Delta\varepsilon$ (%-l_0) Mean value of the product	Length: **+0.27**		Width: **+0.20**		Thickness: **+0.97**	

Table 11. *Compressibility of SEALECTION Agribalance® two component open cell, spray applied, semi-rigid polyurethane foam, (EN 12431).*

Test specimen	Density ρ (kg/m^3)	Thickness d_L (mm) under load 250 Pa (time 120 s)	Thickness d_F (mm) under load 2 kPa (time 240 s)	Thickness d_B (mm) after 300 s after removing load (120 s) 8 kPa, under load of 2 Pa, 300 s (total time 660 s)	Change of thickness * (%) $\frac{(d_L - d_B)}{d_L} x100$
1	12.3	52.90	51.75	**49.08**	7.2
2	12.7	51.63	50.55	**48.78**	5.5
3	11.4	52.56	50.87	**46.85**	10.9
4	10.8	52.28	50.68	**46.83**	10.4
5	12.4	52.54	51.25	**47.46**	9.7
6	11.3	52.12	50.64	**43.42**	16.7
7	12.7	52.00	50.97	**48.78**	6.2
8	12.6	52.08	51.09	**49.10**	5.7
9	12.6	52.06	51.00	**47.53**	8.7
10	10.8	52.63	50.85	**46.76**	11.2
Mean value	**12.0**	-	-	-	**9.2**

** Calculated as information, not necessary according to test standard.*

Espoo 27.5. 2013

Hannu Hyttinen
Research Engineer

Paulina Tiainen
Laboratory Technician

Appendix 1. Sampling Report

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Liisa Rautiainen / VTT Expert Services Oy Copy

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The test results relate only to the sample tested.

PROTOCOL

Contact person
Urban Häggström
Wood Technology
+46 10 516 62 46
Urban.Haggstrom@sp.se

Date 2013-03-15 Reference Page 1 (1)

IsoGreen Industries AB
Ronald Kershaw
Box 3095
831 03 Östersund

Spraying of Agribalance

This is a third party control protocol done by SP Wood Technology over sprayed open cell polyurethane foam. The production of foam is done according to companies an datasheets instruction and the foam were made by Ronald Kershaw and Jens Håkansson, IsoGreen Industries and supervised by Urban Häggström, SP. Test pieces were taken out according to VTT document VTT-O-140431-13.

Components:

Demilec Agribalance B800, Lot.nr. 20120634 #1, manufacture date 2012-10-23.

Demilec ISO PMDI, Lot.nr. 1I0401P403 #179, manufacture date 2012-10-09.

Spray parameters:

A ISO	49°C
B Agribalance	49°C
C Hose	49°C
Pressure	1300 PSI
Ambient temp	21°C
Substrate temp	21°C
Ambient Humidity	25% RH

The test pieces was marked with test standards name on it and sent to VTT Espoo Finland.

SP Technical Research Institute of Sweden
Wood Technology
Performed by

Urban Häggström

SP Technical Research Institute of Sweden

Postal address
SP
Skeria 2
SE-931 77
SKELLEFTEÅ
Sweden

Office location
Laboratorgränd 2
SE-931 62
SKELLEFTEÅ

Phone / Fax / E-mail
+46 10 516 50 00
+46 33 13 55 02
info@sp.se