



**Title:** Physics and mechanical properties of Wood Polymer Composite decking Envirodeck™

**Report code:** 7.375

**Date:** December 5<sup>th</sup> 2007

SHR  
"Het Cambium"  
Nieuwe Kanaal 9b  
PO Box 497  
6700 AL Wageningen

Tel: + 31 317 467366  
Fax: + 31 317 467399

E-mail: b.tjeerdsma@shr.nl

This report has 17 numbered pages. It is the property of the principal, who has the right to publish the complete report. Partial publication, even by the principal, is only allowed after written approval of SHR..

Principal: Fiberplast B.V.  
Mr. W. Wieten  
Postbus 525  
9200 AM Drachten

Appendices: 2

Project number: 7.375

Authors:

A handwritten signature in blue ink, appearing to read 'B.F. Tjeerdsma', written in a cursive style.

Ir. B.F. Tjeerdsma  
Project manager

A handwritten signature in blue ink, appearing to read 'A. van Hunnik', written in a cursive style.

A. van Hunnik  
Technical assistant

Entries: Density, waterab sorption, bending strength, MOR, bending stiffness, MOE, linear thermal expansion

## Summary

Fiberplast BV has commissioned SHR to perform testing of two types of wood polymer composite (WPC) decking products, regarding the physics and mechanical properties. The testing has been performed from September 17<sup>th</sup>, 2007 to November 15<sup>th</sup>, 2007, with the exception of the testing of the samples which have been exposed in outdoor conditions for 1 year. These samples will be tested in October 2008.

The determined physical and mechanical properties of Envirodeck™ HB (cedar) and Envirodeck™ HA (coffee) are summarised in the table below.

Property				Test method/ standard
		Envirodeck™ HB (cedar)	Envirodeck™ HA (coffee)	ASTM standard EN standard
Density	kg/m <sup>3</sup>	1226	1301	ASTM D792-00
Water absorption 24 h 23°C	%	1.09	1.11	ASTM D570-00
Modulus of Rupture (MOR) at - 10 °C	N/mm <sup>2</sup>	18.7	20.6	ASTM D790-03 EN 408
Modulus of Elasticity (MOE) at - 10 °C	N/mm <sup>2</sup>	2252	2710	
Modulus of Rupture (MOR) at 20 °C	N/mm <sup>2</sup>	14.9	16.3	
Modulus of Elasticity (MOE) at 20 °C	N/mm <sup>2</sup>	1559	1857	
Modulus of Rupture (MOR) at 60 °C	N/mm <sup>2</sup>	9.2	10.4	
Modulus of Elasticity (MOE) at 60 °C	N/mm <sup>2</sup>	673	834	
Coefficient of linear thermal expansion (-20 to + 60 °C)	°C <sup>-1</sup>	5.34 x 10 <sup>-5</sup>	4.50 x 10 <sup>-5</sup>	ASTM D696-03

## Contents

Summary .....	3
Contents .....	4
1 Assignment .....	5
2 Execution of the test .....	5
2.1 Identification and description of the samples .....	5
2.2 Period of the test .....	5
2.3 Procedure .....	5
3 Results of the test .....	8
4 Conclusion .....	11
Appendix A Picture of the profile of the test sample .....	12
Appendix B Detailed results of the measurements .....	13

## 1 Assignment

Fiberplast BV has commissioned SHR to perform testing of two types of wood polymer composite (WPC) decking products, regarding the physics and mechanical properties. SHR is recognised by the European Union as a notified test laboratory under the number 1686. Detailed information can be found on the website <http://ec.europa.eu/enterprise/newapproach/nando/>.

## 2 Execution of the test

### 2.1 Identification and description of the samples

On September 17<sup>th</sup> 2007, two types of WPC decking boards have been delivered to SHR by Fiberplast BV. Of each type, Envirodeck™ HB (colour cedar) and Envirodeck™ HA (colour coffee brown), 20 boards of 2, 2 meter length have been delivered. The boards have a hollow profile and two types of profile on the sides (see appendix A). The sampling of the test material for the different tests has been performed by SHR.

### 2.2 Period of the test

The testing has been performed from September 17<sup>th</sup>, 2007 to November 15<sup>th</sup>, 2007, with the exception of the testing of the samples which have been exposed in outdoor conditions for 1 year. These samples will be tested in October 2008.

### 2.3 Procedure

In the table below the determined properties and the corresponding standards are listed.

Property	<i>Test conform</i>		
	Unit	ASTM standard	NEN standard
Density	kg/m <sup>3</sup>	ASTM D792-00	
Water absorption 24 h 23°C	%	ASTM D570-00	
Bending strength (MOR) at 20 °C	N/mm <sup>2</sup>	ASTM D790-03	EN 408
Bending stiffness (MOE) at 20 °C	N/mm <sup>2</sup>	ASTM D790-03	EN 408
MOR en MOE at 60 °	N/mm <sup>2</sup>	ASTM D790-03	EN 408
MOR en MOE at -10 °C	N/mm <sup>2</sup>	ASTM D790-03	EN 408
MOR en MOE after 1 year of outdoor exposure	N/mm <sup>2</sup>	ASTM D790-03	EN 408
Linear thermal expansion	°C <sup>-1</sup>	ASTM D696-03	BRL 1309

**Density**

The density has been determined on 5 independent samples by immersion in water and measuring the water displacement on an analytical balance. The density in kg/m<sup>3</sup> is calculated based on the weight of the sample and the weight of the displaced water with known volume.

**Water absorption**

The water absorption has been determined on 5 independent samples by immersion in water of 23 °C during 24 hours. The water absorption in % is calculated based on the (conditioned) weight before and after immersion.

**Bending strength (MOR) and bending stiffness (MOE)**

The MOR and MOE have determined on a bending machine in 3-point bending test. The used span (hart on hart) was 500 mm. The sample has been loaded in the middle until failure. The speed of the load increase by the machine has been adjusted resulting in failure of the samples within 60 seconds (± 30 seconds).

The MOE is calculated by the measured values in the 3-point bending test, according to the following formula:

$$E_m = \frac{l_1^3(F_2 - F_1)}{4bt^3(a_2 - a_1)}$$

In which:

- $E_m$  = Modulus of elasticity (MOE) in N/mm<sup>2</sup>
- $l_1$  = Span in mm
- $b$  = Width of the sample in mm
- $t$  = Thickness (height) of the sample in mm
- $F_2 - F_1$  = Difference of force in the elastic area (between 10% and 40 % of the failure load) in N
- $a_2 - a_1$  = Difference in deflection in mm corresponding to  $F_2 - F_1$ .

MOR has been calculated using the following formula:

$$f_m = \frac{3F_{\max}l_1}{2bt^2}$$

In which:

- $f_m$  = Bending strength (MOR) in N/mm<sup>2</sup>
- $F_{\max}$  = Maximum load at failure in N
- $l, b, t$  = As used in calculation of MOE

MOE and MOR are determined on the material after different conditionings:

- At a temperature of  $20 \pm 2$  °C and relative humidity of  $65\% \pm 5\%$
- After conditioning at  $-10$  °C
- After conditioning at  $+60$  °C
- After 1 year of outdoor exposure

For each condition 10 samples are tested.

### **Linear thermal expansion**

The linear thermal expansion has been determined on three independent samples with dimension: 300 mm x 20 mm x 25 mm (length x width x thickness). The changes in length of the samples conditioned in the different climates are measured with a specific Mitutoya measuring device (to the nearest 0,0001 mm).

### 3 Results of the test

#### Density

The mean results of the density measurements are demonstrated in the table below. Detailed results of all individual measurements can be found in appendix B.

	Property	Weight	Volume	Density
		[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]
<b>Type</b>				
Envirodeck™	Mean	63.22	51.55	1226
HB (cedar)	Stdev	1.23	0.66	15.3
-----	-----	-----	-----	-----
Envirodeck™	Mean	67.75	52.09	1301
HA (coffee)	Stdev	1.80	1.28	9.3

#### Water absorption

The mean results of the water absorption measurements are shown in the table below. Detailed results of all individual measurements can be found in appendix B.

	Property	Weight	Weight after 24 h. immersion	Water absorption
		[g]	[g]	[%]
<b>Type</b>				
Envirodeck™	Mean	63.22	63.91	1.09
HB (cedar)	Stdev	1.23	1.19	0.13
-----	-----	-----	-----	-----
Envirodeck™	Mean	67.75	68.50	1.11
HA (coffee)	Stdev	1.80	1.73	0.29

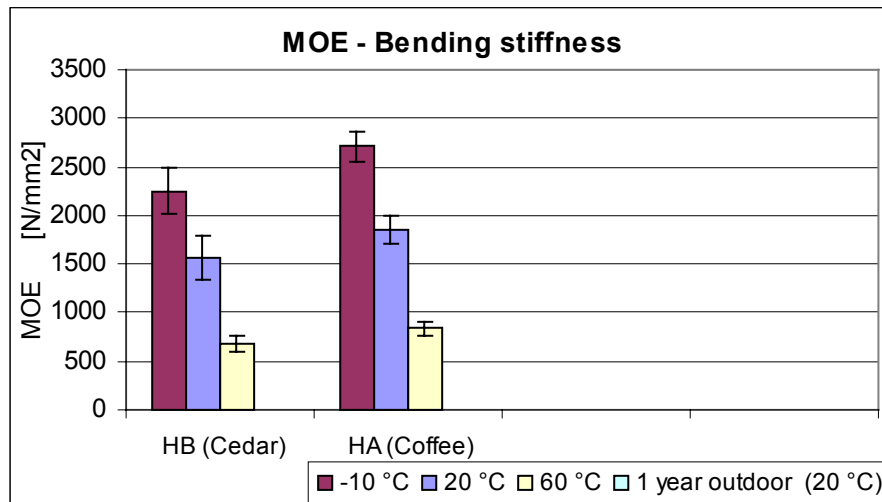
**Bending strength (MOR) and bending stiffness (MOE)**

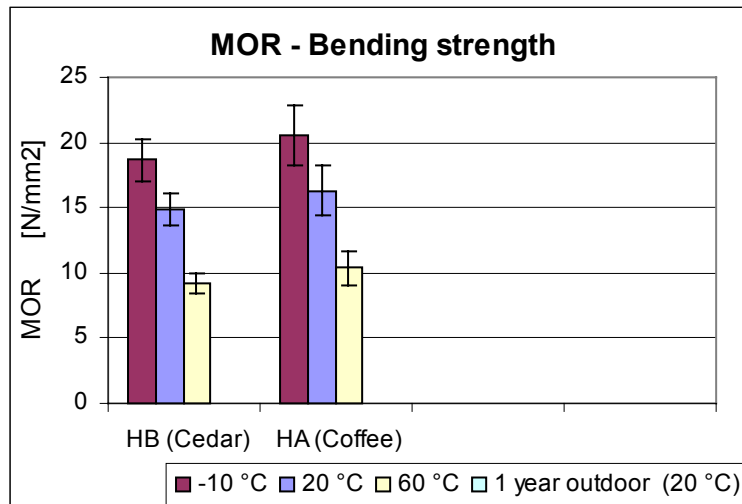
The mean results of the MOE and MOR measurements are demonstrated in the table below. Detailed results of all individual measurements can be found in appendix B

	Test condition	20 °C		-10 °C		60 °C		1 year outdoor exposure <sup>*)</sup>	
	Property	MOE	MOR	MOE	MOR	MOE	MOR	MOE	MOR
		[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]
<b>Type</b>									
Envirodeck™	Mean	1559	14.9	2252	18.7	673	9.2		
HB (cedar)	Stdev	230	1.2	234	1.6	85	0.7		
Envirodeck™	Mean	1857	16.3	2710	20.6	834	10.4		
HA (coffee)	Stdev	141	1.9	151	2.3	62	1.3		

\* Results available October 2008

The mean results of the MOE and MOR measurements are graphically in the figure below.





\* Results of year outdoor exposure available on October 2008

### Linear thermal expansion

The mean results of the linear thermal expansion measurements are demonstrated in the table below. Detailed results of all individual measurements can be found in appendix B.

	Test condition	Change of length* per temperature range			Coefficient of linear thermal expansion		
		20 to -20	-20 to 20	20 to 60	20 to -20	-20 to 20	20 to 60
	change of temperature	[mm]	[mm]	[mm]	[°C <sup>-1</sup> ]	[°C <sup>-1</sup> ]	[°C <sup>-1</sup> ]
<b>Type</b>							
Envirodeck™	Mean	-0.658	0.651	0.632	-5.48 x 10 <sup>-5</sup>	5.42 x 10 <sup>-5</sup>	5.27 x 10 <sup>-5</sup>
HB (cedar)	Stdev	0.041	0.041	0.050	3.45 x 10 <sup>-6</sup>	3.43 x 10 <sup>-6</sup>	7.17 x 10 <sup>-6</sup>
Envirodeck™	Mean	-0.608	0.607	0.472	-5.07 x 10 <sup>-5</sup>	5.06 x 10 <sup>-5</sup>	3.93 x 10 <sup>-5</sup>
HA (coffee)	Stdev	0.037	0.037	0.079	3.12 x 10 <sup>-6</sup>	3.08 x 10 <sup>-6</sup>	6.58 x 10 <sup>-6</sup>

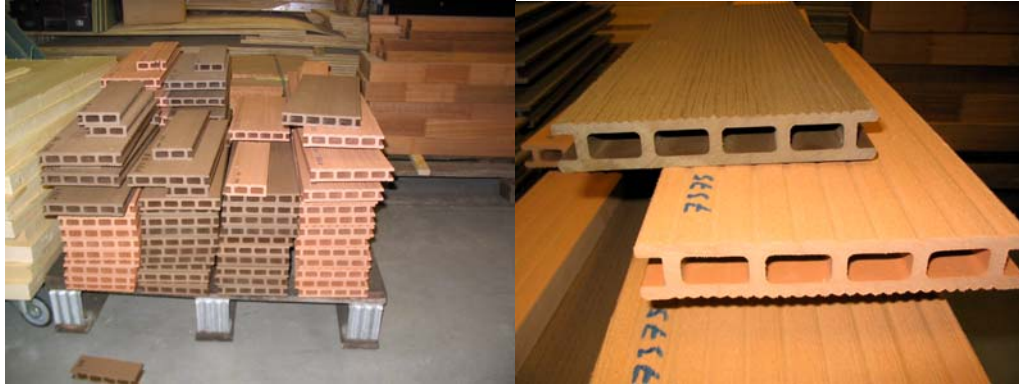
\* L<sub>0</sub> = 300 mm

## 4 Conclusion

The determined physical and mechanical properties of Envirodeck™ HB (cedar) and Envirodeck™ HA (coffee) are summarised in the table below.

Property				Test method/ standard
		Envirodeck™ HB (cedar)	Envirodeck™ HA (coffee)	ASTM standard EN standard
Density	kg/m <sup>3</sup>	1226	1301	ASTM D792-00
Water absorption 24 h 23°C	%	1.09	1.11	ASTM D570-00
Modulus of Rupture (MOR) at - 20 °C	N/mm <sup>2</sup>	18.7	20.6	ASTM D790-03 EN 408
Modulus of Elasticity (MOE) at - 20 °C	N/mm <sup>2</sup>	2252	2710	
Modulus of Rupture (MOR) at 20 °C	N/mm <sup>2</sup>	14.9	16.3	
Modulus of Elasticity (MOE) at 20 °C	N/mm <sup>2</sup>	1559	1857	
Modulus of Rupture (MOR) at 60 °C	N/mm <sup>2</sup>	9.2	10.4	
Modulus of Elasticity (MOE) at 60 °C	N/mm <sup>2</sup>	673	834	
Coefficient of linear thermal expansion (-20 to + 60 °C)	°C <sup>-1</sup>	5.34 x 10 <sup>-5</sup>	4.50 x 10 <sup>-5</sup>	ASTM D696-03

**Appendix A Picture of the profile of the test sample**



## Appendix B Detailed results of the measurements

### Density

	Property	Weight	Volume	Density
		[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]	[N/mm <sup>2</sup> ]
<i>Type</i>				
		64.37	52.42	1228
		63.87	52.00	1228
		61.36	50.77	1209
		62.60	51.40	1218
		63.91	51.14	1250
<b>Envirodeck™</b>	<b>Mean</b>	<b>63.22</b>	<b>51.55</b>	<b>1226</b>
<b>HB (cedar)</b>	<b>Stdev</b>	<b>1.23</b>	<b>0.66</b>	<b>15.3</b>
		67.47	52.37	1288
		70.12	53.87	1302
		68.99	52.52	1314
		65.76	50.72	1297
		66.40	50.96	1303
<b>Envirodeck™</b>	<b>Mean</b>	<b>67.75</b>	<b>52.09</b>	<b>1301</b>
<b>HA (coffee)</b>	<b>Stdev</b>	<b>1.80</b>	<b>1.28</b>	<b>9.3</b>

**Water absorption**

	Property	Weight	Weight 24 h. immersion	Waterabsorption
		[g]	[g]	[%]
<i>Type</i>				
Envirodeck™		64.37	64.99	0.96
HB (cedar)		63.87	64.60	1.14
		61.36	62.15	1.29
		62.60	63.24	1.02
		63.91	64.58	1.05
	<b>Mean</b>	<b>63.22</b>	<b>63.91</b>	<b>1.09</b>
	<b>Stdev</b>	<b>1.23</b>	<b>1.19</b>	<b>0.13</b>
<hr/>				
Envirodeck™		67.47	68.16	1.02
HA (coffee)		70.12	70.65	0.76
		68.99	69.91	1.33
		65.76	66.72	1.46
		66.40	67.04	0.96
	<b>Mean</b>	<b>67.75</b>	<b>68.50</b>	<b>1.11</b>
	<b>Stdev</b>	<b>1.80</b>	<b>1.73</b>	<b>0.29</b>

**Bending strength (MOR) and bending stiffness (MOE)**

Code	Fmax N	L1 mm	b mm	d mm	modulu N/mm <sup>2</sup>	fm N/mm <sup>2</sup>		MOE E mod. N/mm <sup>2</sup>	MOR fm N/mm <sup>2</sup>
<b>Envirodeck™ HB Cedar 20°</b>									
								<b>Major axis</b>	
HB-1	1790	500	149.4	24.2	1392	15.4	Mean	1559.1	14.9
HB-2	1993	500	148.7	24.8	1833	16.4	St.Dev.	230.3	1.2
HB-3	1837	500	149.6	24.8	1489	15.0	VC (%)	14.8	8.1
HB-4	1627	500	150.5	25.0	1466	13.0			
HB-5	1850	500	149.3	24.8	1351	15.1			
HB-6	1848	500	150.5	25.0	1462	14.8			
HB-7	1652	500	149.5	24.9	1279	13.4			
HB-8	1719	500	149.6	24.7	1604	14.1			
HB-9	2049	500	149.2	24.7	2015	16.9			
HB-10	1784	500	149.7	24.8	1702	14.5			
<b>Envirodeck™ HA Coffee 20°</b>									
								<b>Major axis</b>	
HA-1	2179	500	150.4	24.6	1976	18.0	Mean	1856.8	16.3
HA-2	2170	500	151.3	24.9	2019	17.4	St.Dev.	141.4	1.9
HA-3	2182	500	150.4	24.5	1990	18.1	VC (%)	7.6	11.5
HA-4	2058	500	151.5	24.9	1817	16.5			
HA-5	1870	500	150.5	23.8	1795	16.4			
HA-6	1513	500	151.5	23.5	1840	13.6			
HA-7	1736	500	150.6	24.0	1783	15.0			
HA-8	1549	500	151.2	23.6	1680	13.8			
HA-9	2338	500	150.8	24.7	2032	19.1			
HA-10	1905	500	150.3	25.0	1637	15.3			
<b>Envirodeck™ HB Cedar 60°</b>									
								<b>Major axis</b>	
HB-11	1178.08	500	150.5	24.7	775	9.6	Mean	673.1	9.2
HB-12	1160.84	500	150.0	25.0	620	9.3	St.Dev.	85.4	0.7
HB-13	1268.77	500	149.3	24.6	827	10.5	VC (%)	12.7	8.1
HB-14	1191.33	500	150.1	25.2	625	9.4			
HB-15	1035.19	500	150.8	25.0	617	8.2			
HB-16	1186.2	500	149.7	24.8	614	9.6			
HB-17	1144.08	500	150.7	25.0	637	9.1			
HB-18	975.96	500	150.3	25.0	655	7.8			
HB-19	1151.13	500	150.2	25.0	586	9.2			
HB-20	1129.8	500	150.1	24.8	776	9.2			
<b>Envirodeck™ HA Coffee 60°</b>									
								<b>Major axis</b>	
HA-11	1068.0	500	151.2	24.0	811	9.2	Mean	833.9	10.4
HA-12	1144.8	500	151.3	24.7	821	9.3	St.Dev.	61.5	1.3
HA-13	1026.3	500	151.5	24.0	727	8.8	VC (%)	7.4	12.4
HA-14	1493.0	500	151.0	24.9	868	12.0			
HA-15	1158.6	500	151.0	24.4	811	9.7			
HA-16	1538.2	500	151.0	24.8	876	12.4			
HA-17	1381.6	500	150.9	24.7	917	11.3			
HA-18	1202.7	500	150.7	24.9	797	9.7			
HA-19	1390.2	500	150.8	24.5	923	11.5			
HA-20	1235.6	500	150.7	25.0	787	9.9			

Code	Fmax	L1	b	d	modulu	fm		MOE	MOR
	N	mm	mm	mm	N/mm <sup>2</sup>	N/mm <sup>2</sup>		E mod.	fm
								N/mm <sup>2</sup>	N/mm <sup>2</sup>
<b>Envirodeck™ HB Cedar -10°</b>								<b>Major axis</b>	
HB-21	2236.4	500	149.9	24.8	2414	18.1	Mean	2252.4	18.7
HB-22	2306.9	500	149.2	24.9	2123	18.7	St.Dev.	233.6	1.6
HB-23	2620.6	500	149.7	24.9	2404	21.2	VC (%)	10.4	8.6
HB-24	2300.0	500	149.6	25.1	2182	18.3			
HB-25	2324.2	500	149.3	24.9	2037	18.9			
HB-26	2107.1	500	149.3	24.7	2348	17.3			
HB-27	2016.9	500	149.6	25.0	1983	16.2			
HB-28	2560.7	500	148.5	24.6	2667	21.5			
HB-29	2299.2	500	149.4	25.1	1947	18.4			
HB-30	2223.9	500	149.4	24.9	2417	18.0			
<b>Envirodeck™ HA Coffee -10°</b>								<b>Major axis</b>	
HA-21	2740.7	500	150.1	24.6	2869	22.7	Mean	2709.5	20.6
HA-22	2767.2	500	151.0	24.8	2947	22.4	St.Dev.	151.2	2.3
HA-23	2039.7	500	150.8	23.4	2762	18.5	VC (%)	5.6	11.0
HA-24	2064.9	500	150.3	24.6	2542	17.0			
HA-25	2821.9	500	150.3	24.8	2706	22.9			
HA-26	2639.0	500	150.0	24.4	2677	22.2			
HA-27	2805.1	500	150.2	24.6	2852	23.1			
HA-28	2137.3	500	150.5	23.5	2586	19.3			
HA-29	2253.9	500	150.2	24.2	2678	19.2			
HA-30	2071.6	500	150.4	23.4	2475	18.9			

**Linear Thermal expansion**

	Test condition	Change of length* per temperature range			Coefficient of linear thermal expansion		
		20 to -20	-20 to 20	20 to 60	20 to -20	-20 to 20	20 to 60
	change of temperature	[mm]	[mm]	[mm]	[°C <sup>-1</sup> ]	[°C <sup>-1</sup> ]	[°C <sup>-1</sup> ]
<b>Type</b>		-0.632	0.635	0.669	-0.0000527	0.0000529	0.0000558
Envirodeck™		-0.659	0.642	0.575	-0.0000549	0.0000535	0.0000479
HB (cedar)		-0.633	0.631	0.605	-0.0000528	0.0000526	0.0000504
		-0.722	0.721	0.628	-0.0000602	0.0000601	0.0000524
		-0.599	0.588	0.605	-0.0000499	0.0000490	0.0000504
		-0.677	0.668	0.658	-0.0000564	0.0000557	0.0000548
		-0.664	0.655	0.602	-0.0000553	0.0000546	0.0000502
		-0.711	0.702	0.697	-0.0000593	0.0000586	0.0000581
		-0.676	0.662	0.712	-0.0000563	0.0000552	0.0000593
		-0.604	0.601	0.568	-0.0000503	0.0000501	0.0000473
	Mean	<b>-0.658</b>	<b>0.651</b>	<b>0.632</b>	<b>-5.48 x 10<sup>-5</sup></b>	<b>5.42 x 10<sup>-5</sup></b>	<b>5.27 x 10<sup>-5</sup></b>
	Stdev	<b>0.041</b>	<b>0.041</b>	<b>0.050</b>	<b>3.45 x 10<sup>-6</sup></b>	<b>3.43 x 10<sup>-6</sup></b>	<b>7.17 x 10<sup>-6</sup></b>
Envirodeck™		-0.627	0.627	0.553	-0.0000522	0.0000522	0.0000461
HA (coffee)		-0.615	0.613	0.432	-0.0000514	0.0000513	0.0000361
		-0.547	0.541	0.534	-0.0000455	0.0000450	0.0000445
		-0.609	0.605	0.385	-0.0000508	0.0000504	0.0000321
		-0.622	0.627	0.507	-0.0000518	0.0000523	0.0000423
		-0.568	0.572	0.379	-0.0000473	0.0000476	0.0000316
		-0.686	0.68	0.587	-0.0000572	0.0000567	0.0000489
		-0.589	0.589	0.362	-0.0000491	0.0000491	0.0000302
		-0.604	0.603	0.509	-0.0000503	0.0000503	0.0000424
		-0.612	0.61	0.471	-0.0000511	0.0000509	0.0000393
	Mean	<b>-0.608</b>	<b>0.607</b>	<b>0.472</b>	<b>-5.07 x 10<sup>-5</sup></b>	<b>5.06 x 10<sup>-5</sup></b>	<b>3.93 x 10<sup>-5</sup></b>
	Stdev	<b>0.037</b>	<b>0.037</b>	<b>0.079</b>	<b>3.12 x 10<sup>-6</sup></b>	<b>3.08 x 10<sup>-6</sup></b>	<b>6.58 x 10<sup>-6</sup></b>

 \* L<sub>0</sub> = 300 mm