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Xenon Arc Weathering Testing of Composite FRP Materials

Job No: C3804	**Client:** Mr J. Hunt	Dura Composites Ltd Unit 14, Telford Road Clacton On Sea Essex, CO15 4LP

1. Introduction

Dura Composites have undergone an artificial weathering testing regime on a number of components to EN ISO 4892-2:2006 for a 5000hr duration. This report details the results at completion.

2. Test Parameters

Test parameters are detailed below:

Machine Type	**Q Panel 'QSun' Xe-3**
Test standard	ISO 4892 part 2 cycle 1
Exposure Cycling	102 Minutes Dry, 18 Minutes water spray.
Narrowband Irradiance (w/(m^2 @ 340nm)	0.51 ± 0.02
Black Standard Temperature (°C)	65 ± 3
Chamber Temperature (°C)	38 ± 3
Relative Humidity (%)	50 ± 10
Test duration	5000hrs*

*note a number of samples started part way into the test and therefore did not receive the full 5000hr exposure period. Actual exposure periods for each sample are shown in the sample list.

3. Sample List

The table below lists the samples supplied. The actual exposure period is indicated in the table for each sample. Duplicates of many of the samples were supplied, this allowed removal of samples for comparative purposes at intervals during the test (typically 1000hrs), again this is also indicated in the table. Images for the samples are shown in the results section

	Description	Test Duration
J	MarinaDeck Mini, Gritted, RAL 1001 Sand	5000hrs
K	MarinaDeck Mini, Gritted, RAL 6010 Green	
L	DuraTread Standard, Gritted, RAL 7047 Light Grey	
M	DuraProfile Pultruded, RAL 1003 Yellow	
N	DuraSlab Pultruded, RAL 7047 Light Grey	

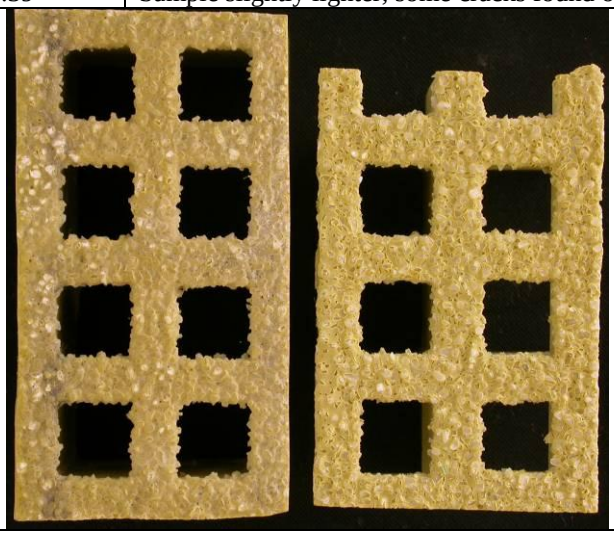
4. Results

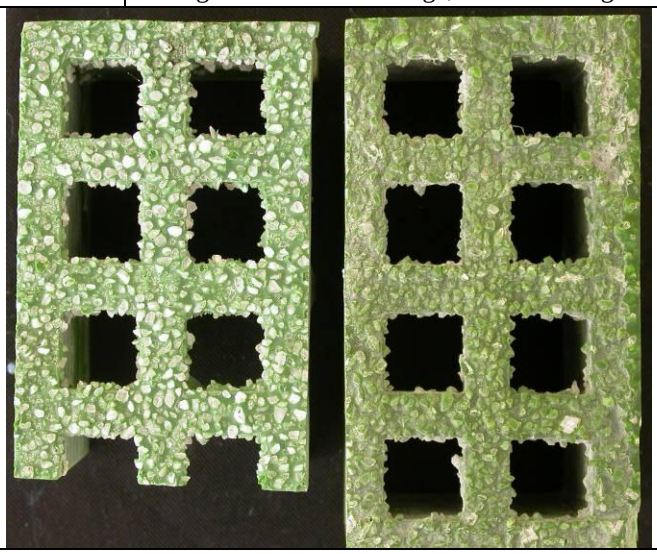
Results for each of the samples are tabulated below. Images in each case are shown for the virgin sample and the sample on completion of the test. Interim images have been shown in interim reports submitted during the test, but for conciseness have not been included in this report.

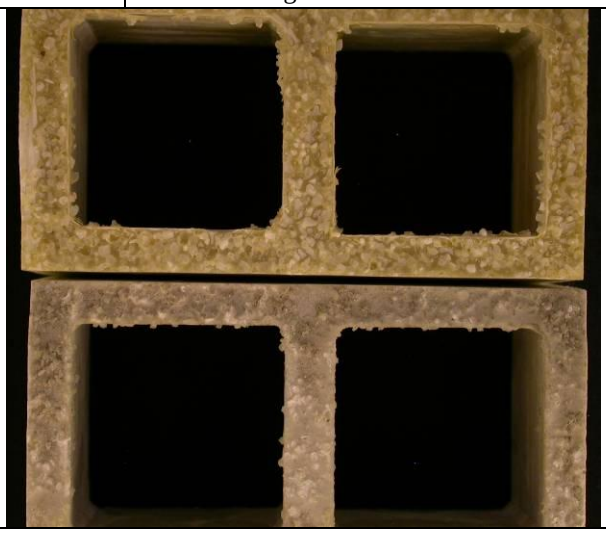
ΔE*ab values are quoted for each of the samples, in general a higher value indicates a greater colour change. A full explanation is given in the appendix.

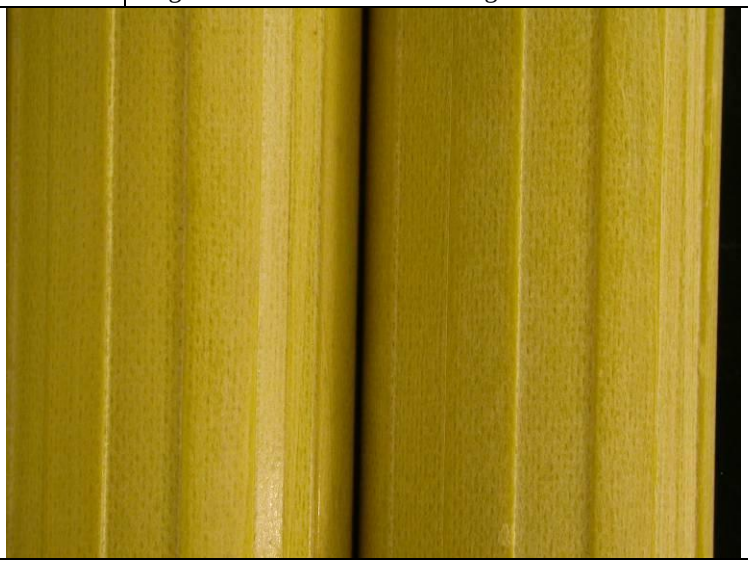
A number of the samples exhibited chalking during the course of the test. This is a phenomenon whereby the surface polymer is degraded and a powdery chalky deposit remains on the surface.

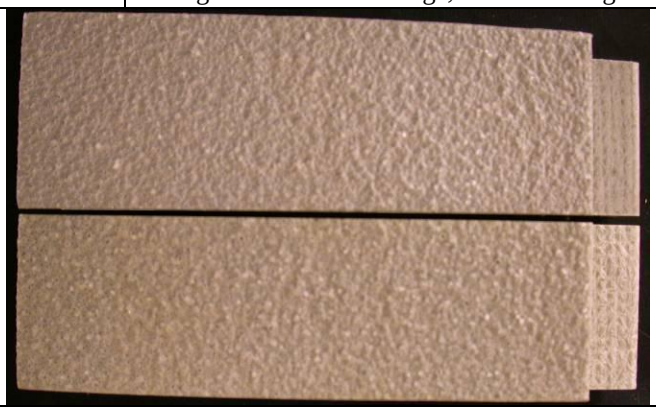
Due to the number of colour readings, it has not been practical to append them to this report and as a result they have been supplied separately as an Excel file.

	J – MarinaDeck Mini, Gritted, RAL 1001 Sand	
	ΔE*ab	**Observations**
500hrs	4.63	No significant change.
1000hrs	5.92	Sample has become slightly lighter, though the change is not major.
1500hrs	6.09	No major change over the 1000 hrs.
2000hrs	3.81	No major change over the 1000 hrs.
2500hrs	4.32	No major change over the 1000 hrs.
3000hrs	4.48	No major change over the 1000 hrs.
3500hrs	5.07	The sample shows some cracks on the non-exposed surface.
4000hrs	5.02	No major change from 3500hrs.
4500hrs	3.18	No major change from 3500hrs.
5000hrs	5.39	Sample slightly lighter, some cracks found on non-exposed side
Exposed on RHS		

	K - MarinaDeck Mini, Gritted, RAL 6010 Green 5000hrs	
	ΔE*ab	**Observations**
500hrs	3.11	No significant change.
1000hrs	2.36	No significant change.
1500hrs	2.91	No significant change.
2000hrs	2.76	No significant change.
2500hrs	4.72	No significant change.
3000hrs	3.61	No significant change.
3500hrs	6.46	Some cracks on the non-exposed surface.
4000hrs	5.65	No change from 3500h.
4500hrs	6.90	No change from 3500h.
5000hrs	5.13	No significant colour change, some loss of grit from top surface.
Exposed on LHS		

	L – DuraTread Standard, Gritted, RAL 7047 Light Grey	
	ΔE*ab	**Observations**
500hrs	5.80	No significant change.
1000hrs	6.91	No significant change.
1500hrs	5.28	No significant change.
2000hrs	8.98	No significant change.
2500hrs	3.94	No significant change.
3000hrs	7.40	No significant change.
3500hrs	4.27	The sample shows microscopic cracks on the surface.
4000hrs	2.54	No major change from 3500h.
4500hrs	6.68	No major change from 3500h.
5000hrs	11.90	Some loss of grit and discolouration observed.
Exposed sample below.		

	M – DuraProfile Pultruded, RAL 1003 Yellow	
	ΔE*ab	**Observations**
500hrs	7.08	No significant change.
1000hrs	5.57	No significant change.
1500hrs	9.83	No significant change.
2000hrs	11.78	Some further lightening.
2500hrs	13.11	Some further lightening.
3000hrs	14.45	Some further lightening.
3500hrs	12.34	Some further lightening.
4000hrs	15.79	Some further lightening.
4500hrs	14.56	Further lightening. Top surface has some chalking.
5000hrs	13.63	Slight loss of colour and chalking found.
Exposed sample on RHS.		

	N – DuraSlab Pultruded, RAL 7047 Light Grey	
	ΔE*ab	**Observations**
500hrs	4.66	No significant change.
1000hrs	4.37	No significant change.
1500hrs	5.50	No significant change.
2000hrs	5.67	No significant change.
2500hrs	5.41	No significant change.
3000hrs	6.57	No significant change.
3500hrs	5.70	The specimen shows an increment of cracks on the lateral surfaces. Fibres are also exposed.
4000hrs	5.45	No major change from 3500hrs.
4500hrs	5.67	No major change from 3500hrs.
5000hrs	5.73	No significant colour change, some cracking and exposed fibres.
Exposed sample above.		

Author:

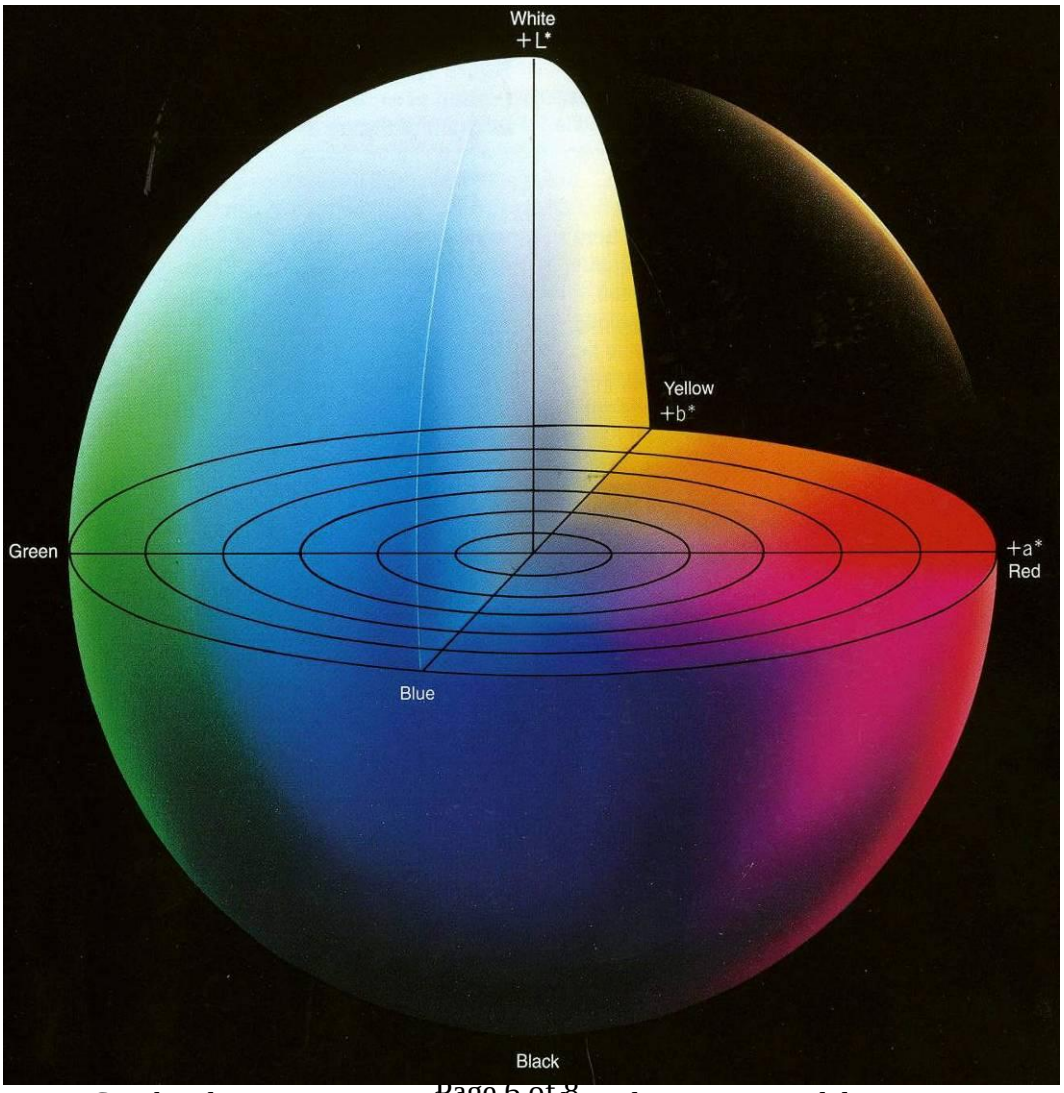
J.Bates (Director)

5. Appendix 1. Explanation of the L*A*B Colour space system

Colorimeter readings were taken using the Lab colour space system; this defines the colour of an object as 3 dimensional coordinate within a colour sphere. The L coordinate represents lightness and runs from 100 (complete lightness) to 0 (complete darkness), a is the red direction –a is the green direction, +b is the yellow direction and –b is the blue direction. A graphical representation of this is shown below. Lab readings taken are an average over a 2mm spot size in each case.

Three colour readings were taken on each sample in the tested and untested state, these were averaged to give a single L, a & b figure. The readings are appended to this report.

In quoting overall colour difference values it is common to produce a single value (ΔE*ab), this is produced using Pythagoras theorem and gives an absolute value for the size of the colour difference, but not the direction of change.



Graphical representation of the L*a*b* colour space model.

6. Appendix 2 Full colourimeter readings

	Pre Test			500 hours			1000 hours			1500 hours			2000 hours			2500 hours			3000 hours			3500 hours			4000 hours			4500 hours			5000 hours		
J – MarinaDeck Mini, Gritted, RAL 1001 Sand	62.34	2.27	19.29	62.34	2.32	24.62	63.86	1.68	24.63	62.61	1.74	24.52	62.41	1.85	23.17	61.87	1.86	22.57	64.91	2.10	25.01	64.62	2.16	23.47	66.27	2.01	25.10	60.53	2.01	20.05	64.50	2.15	23.40
	61.44	2.56	20.42	61.96	1.73	24.27	64.17	1.60	25.28	64.50	1.46	25.52	62.76	2.09	23.16	64.13	1.99	23.41	62.30	2.25	21.69	63.78	2.25	24.33	62.83	2.23	22.83	64.56	1.87	23.51	65.35	1.98	22.33
	60.64	1.80	19.32	59.47	2.31	24.02	64.48	1.09	24.75	64.29	2.09	25.82	62.82	2.28	23.56	66.35	2.23	23.28	63.98	1.88	23.93	64.63	2.21	23.76	63.02	1.95	24.03	63.56	2.03	24.00	67.40	1.36	23.07
	61.47	**2.21**	**19.68**	**61.26**	**2.12**	**24.30**	**64.17**	**1.46**	**24.89**	**63.80**	**1.76**	**25.29**	**62.66**	**2.07**	**23.30**	**64.12**	**2.03**	**23.09**	**63.73**	**2.08**	**23.54**	**64.34**	**2.21**	**23.85**	**64.04**	**2.06**	**23.99**	**62.88**	**1.97**	**22.52**	**65.75**	**1.83**	**22.93**
			ΔE*	**-0.21**	**-0.09**	**4.63**	**2.70**	**-0.75**	**5.21**	**2.33**	**-0.45**	**5.61**	**1.19**	**-0.14**	**3.62**	**2.65**	**-0.18**	**3.41**	**2.26**	**-0.13**	**3.87**	**2.87**	**0.00**	**4.18**	**2.57**	**-0.15**	**4.31**	**1.41**	**-0.24**	**2.84**	**4.28**	**-0.38**	**3.26**
			ΔE* ab	4.63			5.92			6.09			3.81			4.32			4.48			5.07			5.02			3.18			5.39		
K - MarinaDeck Mini, Gritted, RAL 6010 Green	35.93	-10.67	6.94	34.48	-11.58	6.66	38.52	-14.00	8.34	35.87	-15.10	8.77	40.07	-14.29	6.44	46.00	-10.65	5.94	39.54	-11.56	5.49	43.10	-9.72	3.97	40.94	-10.71	4.72	40.97	-12.44	5.83	42.68	-12.05	5.39
	41.10	-12.79	9.65	35.88	-13.17	7.89	38.53	-15.74	8.85	38.86	-14.25	7.36	44.75	-12.40	7.14	41.51	-11.39	5.88	33.81	-12.38	5.39	44.74	-12.67	6.47	44.65	-9.58	4.49	39.16	-11.53	5.68	39.67	-10.44	4.30
	39.09	-13.46	9.92	37.28	-13.04	8.17	37.51	-13.76	7.19	40.26	-16.13	9.18	36.00	-12.60	6.53	39.22	-12.26	5.68	41.94	-10.74	5.07	43.98	-10.99	5.24	41.34	-10.89	5.56	52.26	-9.48	2.66	44.32	-10.69	6.24
	38.71	**-12.31**	**8.84**	**35.88**	**-12.60**	**7.57**	**38.19**	**-14.50**	**8.13**	**38.33**	**-15.16**	**8.44**	**40.27**	**-13.10**	**6.70**	**42.24**	**-11.43**	**5.83**	**38.43**	**-11.56**	**5.32**	**43.94**	**-11.13**	**5.23**	**42.31**	**-10.39**	**4.92**	**44.13**	**-11.15**	**4.72**	**42.22**	**-11.06**	**5.31**
			ΔE*	**-2.83**	**-0.29**	**1.26**	**-0.52**	**-2.19**	**0.71**	**-0.38**	**-2.85**	**-0.40**	**1.56**	**-0.79**	**2.13**	**3.53**	**-0.87**	**3.00**	**0.28**	**-0.75**	**3.52**	**5.23**	**1.18**	**-3.61**	**3.60**	**-1.91**	**-3.91**	**5.42**	**-1.16**	**4.11**	**3.51**	**-1.25**	**3.53**
			ΔE* ab	3.11			2.36			2.91			2.76			4.72			3.61			6.46			5.65			6.90			5.13		
L – DuraTread Standard, Gritted, RAL 7047 Light Grey	59.02	0.67	4.47	70.10	-1.26	3.40	67.68	-2.29	5.68	63.68	-1.71	6.20	70.28	-1.59	6.56	66.38	-0.53	5.73	60.62	-0.87	8.22	53.50	-1.40	8.78	59.02	-0.37	6.78	60.56	-0.89	6.96	74.45	-0.99	6.79
	60.67	-0.06	6.05	61.34	-2.22	4.76	66.40	-2.22	5.45	66.93	-0.98	7.10	74.13	-1.07	6.86	61.26	-1.68	9.39	71.56	-1.57	7.05	55.31	-0.99	9.17	62.63	-1.48	7.25	63.64	-1.30	10.87	68.98	-1.19	9.58
	63.50	0.32	4.56	67.48	-2.05	3.37	68.18	-2.46	5.82	66.53	-1.41	7.37	64.89	-1.30	5.94	63.61	-0.93	7.59	71.13	-1.52	7.78	67.43	-1.90	6.57	64.17	-1.20	7.00	73.47	-1.29	10.39	74.12	-1.08	7.36
	61.06	**0.31**	**5.03**	**66.31**	**-1.84**	**3.84**	**67.42**	**-2.32**	**5.65**	**65.71**	**-1.37**	**6.89**	**69.77**	**-1.32**	**6.45**	**63.75**	**-1.05**	**7.57**	**67.77**	**-1.32**	**7.68**	**58.75**	**-1.43**	**8.17**	**61.94**	**-1.02**	**7.01**	**65.89**	**-1.16**	**9.41**	**72.52**	**-1.09**	**7.91**
			ΔE*	**5.25**	**-2.15**	**-1.18**	**6.36**	**-2.63**	**0.62**	**4.65**	**-1.68**	**1.86**	**8.71**	**-1.63**	**1.43**	**2.69**	**-1.36**	**2.54**	**6.71**	**-1.63**	**2.66**	**-2.31**	**-1.74**	**3.15**	**0.88**	**-1.33**	**1.98**	**4.83**	**-1.47**	**4.38**	**11.46**	**-1.40**	**2.88**
			ΔE* ab	5.80			6.91			5.28			8.98			3.94			7.40			4.27			2.54			6.68			11.90		
M – DuraProfile Pultruded, RAL 1003 Yellow	74.33	2.31	52.59	70.91	4.75	61.47	68.72	4.08	56.49	71.05	3.03	45.74	72.74	2.67	43.02	70.95	3.18	42.67	70.92	2.69	41.16	74.15	2.77	41.00	72.73	2.67	41.21	71.86	1.42	39.93	73.41	2.97	40.83
	73.70	3.27	52.40	70.46	4.69	60.83	70.14	4.07	52.24	72.45	3.48	46.36	72.70	3.25	42.83	73.66	3.01	43.99	73.67	2.56	41.89	73.34	2.83	44.07	73.76	1.78	39.49	72.98	1.83	41.01	72.06	2.42	42.46
	74.48	3.55	61.33	69.04	4.48	60.83	68.52	3.57	50.99	72.45	3.54	45.48	72.69	3.09	45.40	70.40	2.62	41.06	72.54	1.74	40.32	72.63	3.02	44.30	70.54	1.66	38.67	72.41	2.46	42.15	71.82	2.41	42.50
	74.17	**3.04**	**55.44**	**70.14**	**4.64**	**61.04**	**69.13**	**3.91**	**53.24**	**71.98**	**3.35**	**45.86**	**72.71**	**3.00**	**43.75**	**71.67**	**2.94**	**42.57**	**72.38**	**2.33**	**41.12**	**73.37**	**2.87**	**43.12**	**72.34**	**2.04**	**39.79**	**72.42**	**1.90**	**41.03**	**72.43**	**2.60**	**41.93**
			ΔE*	**-4.03**	**1.60**	**5.60**	**-5.04**	**0.86**	**-2.20**	**-2.19**	**0.31**	**-9.58**	**-1.46**	**0.04**	**11.69**	**-2.50**	**0.11**	**-12.87**	**-1.79**	**0.71**	**-14.32**	**-0.80**	**-0.17**	**-12.32**	**-1.83**	**-1.01**	**-15.65**	**-1.75**	**-1.14**	**-14.41**	**-1.74**	**0.44**	**-13.51**

			ΔE* ab	7.08			5.57			9.83			11.78			13.11			14.45			12.34			15.79			14.56			13.63		
N – DuraSlab Pultruded, RAL 7047 Light Grey	70.13	0.52	2.35	63.35	-0.25	1.30	62.76	-0.18	1.77	61.55	-0.28	2.53	60.52	-0.17	3.60	61.51	-0.30	4.05	60.46	-0.39	3.85	62.35	-0.33	4.30	60.96	-0.30	4.34	61.35	-0.08	4.06	62.62	0.00	4.51
	62.98	-0.17	2.10	61.97	-0.42	0.97	63.23	-0.25	1.95	61.44	-0.29	2.77	62.54	-0.58	3.56	62.66	-0.20	3.44	60.45	-0.30	3.70	61.55	-0.42	4.60	61.97	-0.39	4.49	62.20	-0.32	4.26	61.40	0.00	3.85
	67.81	-0.26	1.78	61.89	-0.34	1.49	61.85	-0.40	1.95	61.56	-0.19	2.90	61.38	-0.47	3.08	61.47	-0.28	4.14	61.01	-0.18	3.88	61.39	-0.09	4.21	63.19	0.04	4.34	61.54	0.11	4.15	61.16	0.17	4.80
	66.97	**0.03**	**2.08**	**62.40**	**-0.34**	**1.25**	**62.61**	**-0.28**	**1.89**	**61.52**	**-0.25**	**2.73**	**61.48**	**-0.41**	**3.41**	**61.88**	**-0.26**	**3.88**	**60.64**	**-0.29**	**3.81**	**61.76**	**-0.28**	**4.37**	**62.04**	**-0.22**	**4.39**	**61.70**	**-0.10**	**4.16**	**61.73**	**0.06**	**4.39**
			ΔE*	**-4.57**	**-0.37**	**-0.82**	**-4.36**	**-0.31**	**-0.19**	**-5.45**	**-0.28**	**0.66**	**-5.49**	**-0.44**	**1.34**	**-5.09**	**-0.29**	**1.80**	**-6.33**	**-0.32**	**1.73**	**-5.21**	**-0.31**	**2.29**	**-4.93**	**-0.25**	**2.31**	**-5.27**	**-0.13**	**2.08**	**-5.24**	**0.03**	**2.31**
			ΔE* ab	4.66			4.37			5.50			5.67			5.41			6.57			5.70			5.45			5.67			5.73		