Confidential Technical Report

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PROPOSAL NO: 99935EC
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MATERIAL PROPERTIES TESTING OF BROCK PERFORMANCE BASE F24

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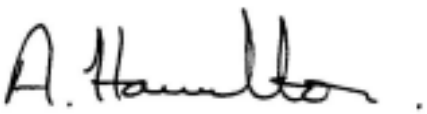

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1. INTRODUCTION.

Details of the samples received and the test requested are as follows:

1.1 Sample designations:

Brock Performance Base F24 from new production facility in the Netherlands
Sample dimensions;
5 off 50 x 20 x 24 mm
5 off 100 x 100 x 24 mm
2 off 300 x 300 x 24 mm
5 off 50 x 50 x 24 mm

1.2 Date received:

30th March 2009

1.3 Testing requested:

Co-efficient of linear thermal expansion to ISO 4897: 1995 Method B
Thermal Conductivity Testing to BS EN 12667: 2001
Compression Strength to BS ISO 844: 2007
Compression Set to BS EN ISO 1856: 2001 Method C

2. EXPERIMENTAL DETAILS.

2.1 Co-efficient of Linear Thermal Expansion

The Coefficient of Linear Thermal Expansion was determined using a calibrated Linseis dilatometer modified to operate in vertical mode with specially fabricated silica apparatus. Thermal expansion measurements were made over a temperature range of -20°C to +60°C using a ramp rate of 1°C/min, with results reported over this range. The test was performed in general accordance with ISO 4897 Method B.
Deviations away from the standard are as follows;

1. Conventional mechanical dilatometer of overall size in accordance with Method B, but with a 5 mm push-rod, and operating with electronic control of temperature and with electronic measurement of temperature and displacement.
2. Tests will be performed over the temperature range -20 to 60 °C at a slow ramp rate, heating and cooling over at least three thermal cycles to obtain the average effects, and to note any softening at the upper end of the temperature range.
3. Results to be corrected for the thermal expansion and baseline shift of the apparatus.
4. Only two samples were tested.

This test was subcontracted.

2.2 Thermal Conductivity

The sample was weighed (103.6gms) and then placed in the Fox 314 apparatus at an average T of 16°C and 60 %RH. The apparatus measures the mean thickness of the sample, and then makes the top plate 0.0°C and the lower one 20.0°C for a mean T of 10°C using Peltier heating and cooling to control these to typically ±0.05°C and with a matched pair of thermocouples in the 100 mm square heat flux transducers in the centre of each plate. After

every 256 seconds a "block mean average" is stored and then after equilibrium another hour or so is allowed until the values started to creep up again at which point the experiment was stopped.
This test was sub contracted.

2.3 Compression Strength
The compression strength testing was performed in accordance with BS ISO 844, with the exception that the samples were not 50 mm thick.
The length, width and thickness of the samples were each measured three times at five locations prior to test. They were tested at full thickness (24 mm) and were not plied up to increase the thickness. The load was applied using a crosshead speed of 2.4 mm/min (10% of the thickness per minute) until the thickness was reduced by more than 75%.
Compressive strength measurements were taken from the stress/strain curves at 25%, 50% and 75% strains.

2.4 Compression Set
The compression set testing was performed in accordance with BS EN ISO 1856 Method C.
The length, width and thickness of the samples were each measured three times at five locations prior to test.
The samples were compressed by 25% of their initial thickness and maintained in this condition at 23±2°C for 22 hours before being released. The thickness was then remeasured after 24 hours recovery and the percentage compression set calculated.

These tests were performed at Smithers Rapra Billingham.

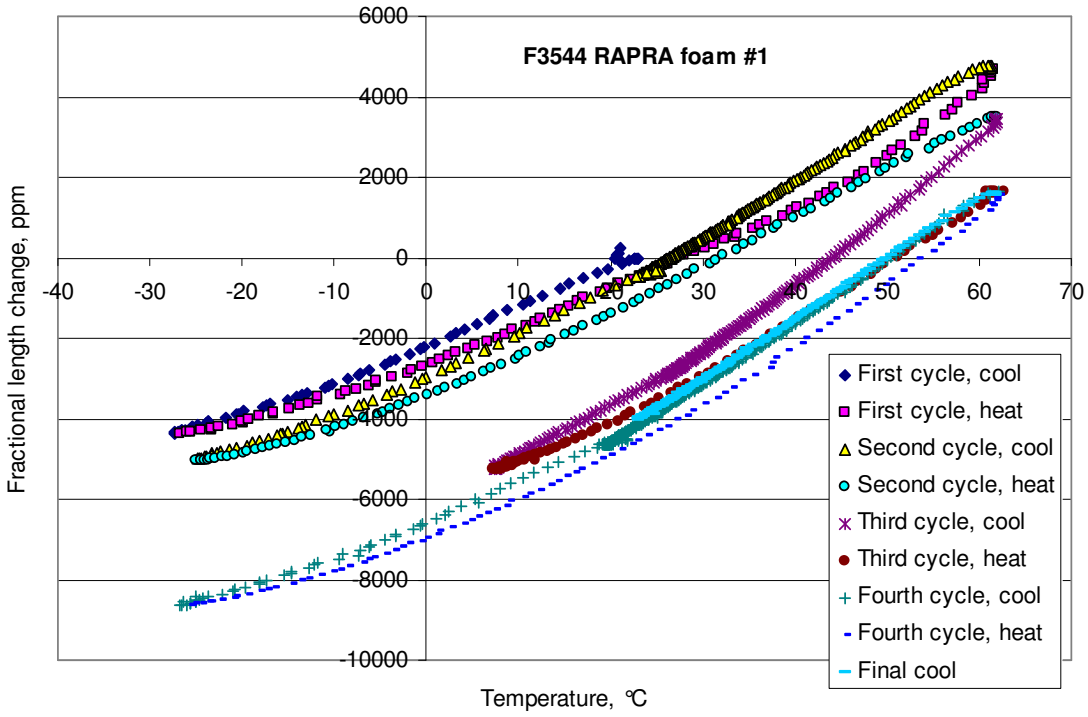
3. RESULTS.

3.1 Co-efficient of Linear Thermal Expansion

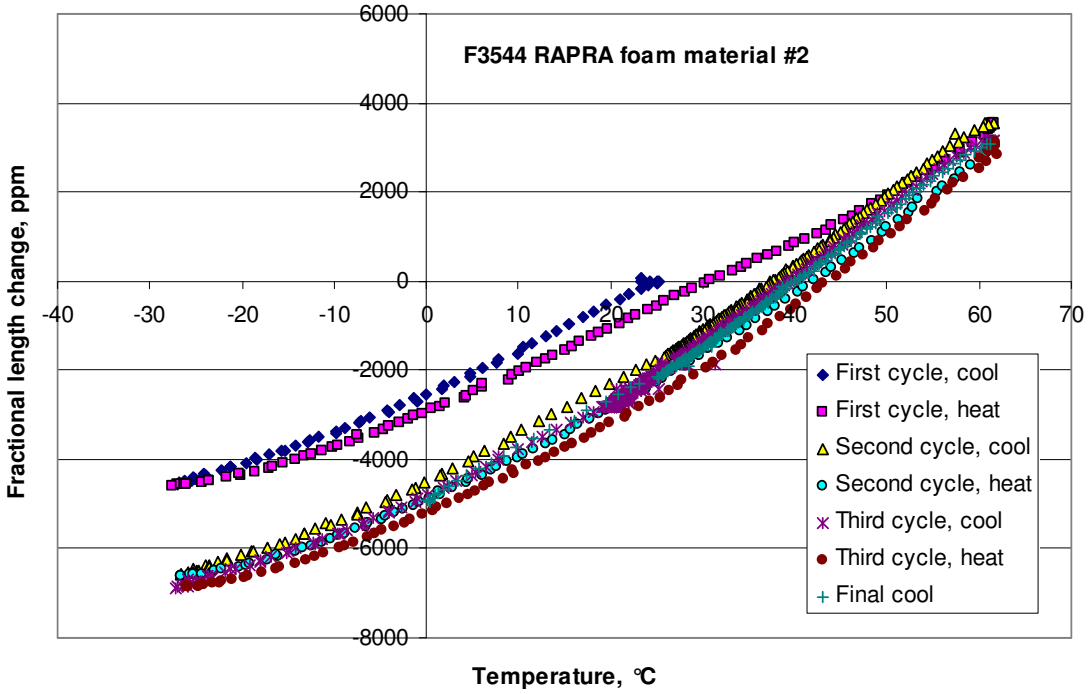
Temp. Range (°C)	Sample 1 Mean Co-efficient $10^{-6}°C^{-1}$		Sample 2 Mean Co-efficient $10^{-6}°C^{-1}$	
	Average	Std. Deviation	Average	Std. Deviation
-20 – 0	78.2	7.2	77.4	4.8
0 – 20	103.4	5.0	103.5	4.8
20 – 40	132.1	10.0	133.7	7.2
40 – 60	144.3	17.5	151.8	2.3
-20 - 60	114.8	8.2	116.6	2.9
Thermal Expansion, per 1°C change	0.11 mm/m		0.12 mm/m	
Thermal Expansion, per 30°C	3.4 mm/m		3.5 mm/m	

Traces showing fractional change in length with temperature change are shown below.

Sample 1



Sample 2



3.2 Thermal Conductivity

Thermal Conductivity (λ value) at mean of 10°C **0.0377 W/mK**
Sample thickness 24.02 mm

Accuracy: +/-2%. T accuracy ± 1°C. Repeatability better than 1%.

Thermal Resistivity = $\frac{\text{Sample thickness (m)}}{\text{Thermal Conductivity}} = \frac{t}{\lambda}$

Therefore for this sample of Brock Performance Base, the thermal resistivity (R) = $\frac{0.02402}{0.0377}$ =

= **0.64 Km^2/W**

3.3 Compression Strength

Sample	Compressive Strength (kPa)		
	@ 25%	@ 50%	@75%
1	250	350	750
2	280	380	840
3	220	320	690
4	290	390	870
5	240	340	710
Mean	260	360	770
σ_{n-1}	29	29	79

3.4 Compression Set

BROCK PERFORMANCE BASE F24		
Sample number	Compression set (%)	Median
1	9.5	9.5%
2	9.5	
3	10.3	