

**Calibration of a surround panel used to measure
window U-values in a hot box apparatus as
specified in BS EN ISO 12567-1:2000**

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Abstract

The measurement procedures in BS EN ISO 12567-1:2000 require that the surround panel used to measure window U-values in a hot box apparatus must be calibrated by carrying out hot box measurements on two glazed calibration panels of different thickness, each at three different temperature conditions. This report describes measurements carried out with the NPL Wall Guarded Hot Box following these procedures, using the glazed calibration panels TT206 and TT207 mounted in the 150 mm thick expanded polystyrene surround panel number 10. The results are presented exactly as shown in the standard. Results are also given of a measurement carried out of a 1.48 m high x 1.23 m wide PVCu window system that had been previously measured using a different surround panel calibrated with different glazed calibration panels. The difference between the U-values measured using the CEN procedures and by using a more simple method (which is described) was 0.5% and between the two CEN measurements made with different surround panels calibrated with different glazed calibration panels was better than 3.5%.

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Approved on behalf of Managing Director, NPL
by John Redgrove Head of Thermophysics
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1 INTRODUCTION

The calibration procedures specified in BS EN ISO12567-1:Section 6.2 were used to calibrate a new expanded polystyrene surround panel (number 10) using two glazed calibration panels TT206 and TT207. The procedure requires measurements to be made on two different thickness of glazed calibration panels, each at three different temperature conditions. The calibration panels comprise a core of expanded polystyrene sandwiched between two sheets of 4 mm thick float glass. The method of manufacture was that specified in BS EN ISO 12567-1: Annex C1. The thermal conductivity of the expanded polystyrene was measured in the NPL standard guarded hot plate apparatus and the average thickness of the calibration panels was measured using a special device built for the purpose. From these data the thermal conductance of each calibration panel was determined.

From the data obtained from the hot box measurements on the calibration panels, three graphs were produced. These graphs are used to carry out the following:

- Calculate the density of heat flow rate through the holder panel, including any boundary loss around the reveal.
- Calculate the hot and cold environmental temperatures.
- Correct for the change in surface resistance that results from changing the heat flux density, from the value used to establish the air flow conditions that produced a total surface resistance of $0.17 \text{ (m}^2\cdot\text{K)/W}$ with the thin calibration panel, to the heat flux density used when measuring the window.

2 THE GLAZED CALIBRATION PANELS

The thermal conductivity values of the expanded polystyrene used in the calibration panels were taken from NPL Test Reports PP21/E01090142 and PP21/E01090090. The thermal conductance values are taken from NPL Test Report PP31/E02020284.

3 THE CALIBRATION MEASUREMENTS

The 21 mm thick glazed calibration panel was installed in surround panel 10, mounted 40 mm from the warm face of the holder panel as specified in BS EN ISO 12567-1. The thermal conductance of this panel was then measured with a warm air temperature of 23.4°C and a cold air temperature of 2.4°C . The air speed in the cold box was adjusted to give a total surface resistance of $0.17 \pm 0.01 \text{ m}^2\cdot\text{K/W}$. The cold box air speed was then kept at this setting for the rest of the calibration measurements and indeed for all subsequent window measurements. The measurement schedule as specified in BS EN ISO 12567-1 was then carried out on the 21 mm and the 58 mm thick glazed calibration panels. The summary results for these six measurements are shown in Tables 1 to 6. The calculation procedures specified in BS EN ISO 12567-1 were then used to produce the data shown in EN 12567-1: Tables D1, D2, D3 and D4. These are shown in Tables 7, 8, 9 and 10. The three graphs required by the standard are shown in Figure 1.

Table 1 21 mm panel warm air temperature 23.3 °C , cold air 2.4 °C

TT206A	Holder panel number	10
Glazed calibration panel 21 mm thick		

Data entered by.....

RGW

Service number...

Data entry checked by.....

Holder thermal conductivity data from 610 results

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Date & Time	Specimen area	Holder Th Cond.	Atm. pressure	Total power	Holder Hot temp	Holder Cold temp	Specimen Hot surface	Specimen Cold surface	Air temp Hot	Air temp Cold	Baffle Hot temp	Baffle Cold temp	Diviny Offset	boundary loss	Standard surface Res.	Thick effect	Thick edge
	(m²)	(W/m.K)	(mb)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(uV)	(%)	(m².K/W)	(m)	(m)
3 Mar 2002 08:15:27	1.820	0.0334	1020.4	72.618	22.432	2.762	18.331	4.300	23.357	2.431	22.063	2.481	-24.10	0.000			Line1
3 Mar 2002 06:15:28	1.820	0.0334	1019.6	72.615	22.417	2.715	18.319	4.255	23.345	2.390	22.048	2.446	-21.99	0.000			Line2
3 Mar 2002 04:15:06	1.820	0.0334	1018.7	72.657	22.421	2.762	18.317	4.293	23.345	2.428	22.052	2.479	-20.00	0.000			Line3
3 Mar 2002 02:15:24	1.820	0.0334	1018.6	72.543	22.427	2.795	18.325	4.332	23.345	2.446	22.054	2.506	-22.77	0.000			Line4
3 Mar 2002 00:15:23	1.820	0.0334	1018.3	72.625	22.422	2.719	18.312	4.270	23.334	2.390	22.041	2.441	-24.36	0.000			Line5
Averages	1.820	0.0334	1019.1	72.612	22.424	2.751	18.321	4.290	23.345	2.417	22.051	2.471	-22.64	0.000			

Date & Time	Total power	Surround	Surface	Power through Insert	Hot surface temp	Cold surface temp	Surface Temp diff	Air temperatures			Environmental temperatures			Baffle temperatures		Thermal Cond	Thermal Trans	Surface Resistance	
Correction - watts	0	Corfor	HFM Off	minus BL%				Hot	Cold	diff	Hot	Cold	diff	Hot	Cold	(W/m².K)	(W/m².K)	(m².K/W)	(m².K/W)
	(W)	(°C)	(°C)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)				
Area of specimen	1.820	m²		Thick @ edge		21.02	mm	B.L%Man		0.0			Mean temp		11.305	°C		Hr (c)	5.716
Area holder	2.002	m²		Holder thickness		0.14907	m						λ Holder		0.0334	W/m.K		Hr (h)	4.789
Efth	n/a	mm		Baffle Emis. Hot		0.94		Spec. Emis. Hot		0.9			Emissivity Factor Hot		0.8511			Tot Res	0.1745
				Baffle Emis Cold		0.94		Spec. Emis. Cold		0.9			Emissivity Factor Cold		0.8511				
3 Mar 2002 08:15:27	72.693	22.432	2.762	63.857	18.331	4.300	14.030	23.357	2.431	20.926	22.592	2.441	20.152	22.063	2.481	2.501	1.742	0.121	0.053
3 Mar 2002 06:15:28	72.683	22.417	2.715	63.833	18.319	4.255	14.064	23.345	2.390	20.955	22.578	2.401	20.178	22.048	2.446	2.494	1.739	0.121	0.053
3 Mar 2002 04:15:06	72.719	22.421	2.762	63.888	18.317	4.293	14.024	23.345	2.428	20.917	22.581	2.438	20.144	22.052	2.479	2.504	1.743	0.121	0.053
3 Mar 2002 02:15:24	72.614	22.427	2.795	63.796	18.325	4.332	13.993	23.345	2.446	20.898	22.582	2.458	20.124	22.054	2.506	2.506	1.742	0.121	0.053
3 Mar 2002 00:15:23	72.701	22.422	2.719	63.851	18.312	4.270	14.041	23.334	2.390	20.944	22.570	2.400	20.171	22.041	2.441	2.499	1.740	0.121	0.053
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Av.Values	72.682	22.424	2.751	63.845	18.321	4.290	14.031	23.345	2.417	20.928	22.581	2.427	20.154	22.051	2.471	2.501	1.741	0.12	0.05
Variation	0.14%	0.015	0.081	0.15%	0.019	0.077	0.50%	0.023	0.056	0.27%	0.022	0.058	0.27%	0.022	0.065	0.44%	0.26%	0.000	0.001
Surround temp difference		19.673	°C				Atmospheric pressure		1019.1	mb						2.443			
Surround mean temperature		12.587	°C													2.37			

Table 2 21 mm panel warm air temperature 23.7 °C - cold air 10.1 °C

TT206B	Holder panel number	10
Glazed calibration panel 21 mm thick		

Data entered by.....

RGW

Service number...

Data entry checked by.....

Holder thermal conductivity data from 610 results

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Date & Time	Specimen area	Holder Th Cond.	Atm. pressure	Total power	Holder Hot temp	Holder Cold temp	Specimen Hot surface	Specimen Cold surface	Air temp Hot	Air temp Cold	Baffle Hot temp	Baffle Cold temp	Diviny Offset	boundary loss	Standard Res.	Thick effect	Thick edge
	(m ²)	(W/m.K)	(mb)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(uV)	(%)	(m ² .K/W)	(m)	(m)
04/03/02 23:52	1.820	0.0339	1016.3	47.045	23.150	10.320	20.320	11.310	23.790	10.110	22.870	10.150	-21.20	0.000			Line1
05/03/02 01:52	1.820	0.0339	1015.4	46.972	23.140	10.310	20.330	11.310	23.780	10.110	22.870	10.140	-26.90	0.000			Line2
05/03/02 03:52	1.820	0.0339	1015.1	46.883	23.140	10.350	20.310	11.340	23.770	10.160	22.860	10.180	-21.80	0.000			Line3
05/02/02 05:52	1.820	0.0339	1014.9	46.935	23.160	10.360	20.340	11.350	23.800	10.160	22.890	10.190	-19.90	0.000			Line4
05/03/02 07:52	1.820	0.0339	1015.2	46.936	23.140	10.350	20.300	11.340	23.770	10.140	22.850	10.170	-23.30	0.000			Line5
Averages	1.820	0.0339	1015.4	46.954	23.146	10.338	20.320	11.330	23.782	10.136	22.868	10.166	-22.62	0.000			

Date & Time	Total power	Surround Hot	Surface Cold	Power through Insert	Hot surface temp	Cold surface temp	Surface Temp diff	Air temperatures			Environmental temperatures			Baffle temperatures		Thermal Cond	Thermal Trans	Surface Resistance Hot	Surface Resistance Cold
	Corfor HFM Off (W)	(°C)	(°C)	minus BL% (W)	(°C)	(°C)	(°C)	Hot (°C)	Cold (°C)	diff (°C)	Hot (°C)	Cold (°C)	diff (°C)	Hot (°C)	Cold (°C)	(W/m ² .K)	(W/m ² .K)	(m ² .K/W)	(m ² .K/W)
Area of specimen	1.820	m ²		Thick @ edge		21.02	mm	B.L%Man			0.0	Mean temp			15.825	°C		Hr (c)	5.799
Area holder	2.002	m ²		Holder thickness		0.1491	m					λ Holder			0.0339	W/m.K		Hr (h)	5.180
Efth	n/a	mm		Baffle Emis. Hot		0.94		Spec. Emis. Hot			0.9	Emissivity Factor Hot			0.8511			Tot Res	0.1800
				Baffle Emis. Cold		0.94		Spec. Emis. Cold			0.9	Emissivity Factor Cold			0.8511				
04/03/02 23:52	47.111	23.150	10.320	41.269	20.320	11.310	9.010	23.790	10.110	13.680	23.211	10.118	13.093	22.870	10.150	2.517	1.732	0.127	0.053
05/03/02 01:52	47.056	23.140	10.310	41.214	20.330	11.310	9.020	23.780	10.110	13.670	23.209	10.116	13.093	22.870	10.140	2.511	1.730	0.127	0.053
05/03/02 03:52	46.951	23.140	10.350	41.127	20.310	11.340	8.970	23.770	10.160	13.610	23.196	10.164	13.032	22.860	10.180	2.520	1.734	0.128	0.052
05/02/02 05:52	46.997	23.160	10.360	41.168	20.340	11.350	8.990	23.800	10.160	13.640	23.227	10.166	13.061	22.890	10.190	2.517	1.732	0.128	0.052
05/03/02 07:52	47.009	23.140	10.350	41.185	20.300	11.340	8.960	23.770	10.140	13.630	23.190	10.146	13.044	22.850	10.170	2.526	1.735	0.128	0.053
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Av.Values	47.025	23.146	10.338	41.192	20.320	11.330	8.990	23.782	10.136	13.646	23.207	10.142	13.065	22.868	10.166	2.518	1.733	0.128	0.052
Variation	0.34%	0.020	0.050	0.34%	0.040	0.040	0.67%	0.030	0.050	0.51%	0.037	0.050	0.46%	0.040	0.050	0.60%	0.30%	0.001	0.001
Surround temp difference		12.808	°C					Atmospheric pressure			1015.4	mb				2.443			
Surround mean temperature		16.742	°C													3.077			

TT206C	Holder panel number	10
Glazed calibration panel 21 mm thick		

RGW

Service number...

Data entry checked by.....

Holder thermal conductivity data from 610 results

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Date & Time	Specimen area	Holder Th Cond.	Atm. pressure	Total power	Holder Hot temp	Holder Cold temp	Specimen Hot surface	Specimen Cold surface	Air temp Hot	Air temp Cold	Baffle Hot temp	Baffle Cold temp	Diviny Offset	boundary loss	Standard surface Res.	Thick effect	Thick edge
	(m²)	(W/m.K)	(mb)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(uV)	(%)	(m².K/W)	(m)	(m)
07/03/02 00:13	1.820	0.0329	1009.0	103.789	22.060	-6.270	16.060	-4.060	22.830	-6.740	21.120	-6.650	-24.70	0.000			Line1
07/03/02 02:12	1.820	0.0329	1009.3	103.759	22.070	-6.280	16.080	-4.050	22.860	-6.750	21.140	-6.670	-20.10	0.000			Line2
07/03/02 04:13	1.820	0.0329	1011.5	103.795	22.070	-6.260	16.070	-4.060	22.870	-6.740	21.140	-6.660	-24.20	0.000			Line3
07/03/02 06:12	1.820	0.0329	1013.2	103.863	22.050	-6.240	16.060	-4.070	22.850	-6.690	21.130	-6.630	-19.90	0.000			Line4
07/03/02 08:12	1.820	0.0329	1016.3	103.900	22.070	-6.200	16.060	-4.030	22.860	-6.660	21.140	-6.600	-24.40	0.000			Line5
Averages	1.820	0.0329	1011.9	103.821	22.064	-6.250	16.066	-4.054	22.854	-6.716	21.134	-6.642	-22.66	0.000			

[illegible]

TT207A	Holder panel number	10
58 mm thick glazed calibration panel		

Service number...

Holder thermal conductivity data from 610 results

[illegible]

Table 5 58 mm panel warm air 24.1°C - cold air 12.3°C

TT207B	Holder panel number	10
58 mm glazed calibration panel		

Data entered by.....

RGW

Service number...

Data entry checked by.....

Holder thermal conductivity data from 610 results

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Date & Time	Specimen area	Holder Th Cond.	Atm. pressure	Total power	Holder Hot temp	Holder Cold temp	Specimen Hot surface	Specimen Cold surface	Air temp Hot	Air temp Cold	Baffle Hot temp	Baffle Cold temp	Diviny Offset	boundary loss	Standard surface Res.	Thick effect	Thick edge	
	(m ²)	(W/m.K)	(mb)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(uV)	(%)	(m ² .K/W)	(m)	(m)	
13/03/02 04:42	1.823	0.0341	1016.0	17.820	23.756	12.601	22.949	12.814	24.182	12.385	23.775	12.396	-19.92	0.000				Line1
13/03/02 02:42	1.823	0.0341	1015.6	17.868	23.745	12.526	22.933	12.745	24.173	12.322	23.763	12.347	-23.44	0.000				Line2
13/03/02 00:42	1.823	0.0341	1015.4	17.855	23.733	12.534	22.925	12.707	24.167	12.350	23.757	12.370	-20.28	0.000				Line3
12/03/02 22:42	1.823	0.0341	1015.0	17.898	23.714	12.538	22.913	12.720	24.150	12.356	23.741	12.373	-23.52	0.000				Line4
12/03/02 20:42	1.823	0.0341	1014.6	17.843	23.721	12.560	22.915	12.710	24.154	12.400	23.743	12.408	-21.79	0.000				Line5
Averages	1.823	0.0341	1015.3	17.857	23.734	12.552	22.927	12.739	24.165	12.363	23.756	12.379	-21.79	0.000				

Date & Time	Total power	Surround Hot	Surface Cold	Power through Insert	Hot surface temp	Cold surface temp	Surface Temp diff	Air temperatures			Environmental temperatures			Baffle temperatures		Thermal Cond	Thermal Trans	Surface Resistance	
Correction - watts	power	Hot	Cold	through Insert	surface temp	surface temp	Temp diff	Hot	Cold	diff	Hot	Cold	diff	Hot	Cold	(W/m ² .K)	(W/m ² .K)	(m ² .K/W)	(m ² .K/W)
0	Corfor			minus BL%															
	HFM Off																		
	(W)	(°C)	(°C)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(W/m ² .K)	(W/m ² .K)	(m ² .K/W)	(m ² .K/W)
Area of specimen	1.823	m ²		Thick @ edge		57.74	mm			B.L%Man	0.0			Mean temp	17.833	°C		Hr (c)	5.904
Area holder	1.999	m ²		Holder thickness		0.1491	m							λ Holder	0.0341	W/m.K		Hr (h)	5.284
Efth	n/a	mm		Baffle Emis. Hot		0.94				Spec. Emis. Hot	0.9			Emissivity Factor Hot		0.8511		Tot Res	0.1895
				Baffle Emis. Cold		0.94				Spec. Emis. Cold	0.9			Emissivity Factor Cold		0.8511			
13/03/02 04:42	17.882	23.756	12.601	12.777	22.949	12.814	10.136	24.182	12.385	11.797	23.903	12.387	11.516	23.775	12.396	0.692	0.609	0.136	0.061
13/03/02 02:42	17.941	23.745	12.526	12.807	22.933	12.745	10.188	24.173	12.322	11.851	23.892	12.327	11.565	23.763	12.347	0.690	0.608	0.136	0.059
13/03/02 00:42	17.919	23.733	12.534	12.794	22.925	12.707	10.218	24.167	12.350	11.817	23.885	12.353	11.532	23.757	12.370	0.687	0.609	0.137	0.050
12/03/02 22:42	17.972	23.714	12.538	12.857	22.913	12.720	10.193	24.150	12.356	11.794	23.871	12.359	11.512	23.741	12.373	0.692	0.613	0.136	0.051
12/03/02 20:42	17.911	23.721	12.560	12.804	22.915	12.710	10.205	24.154	12.400	11.755	23.872	12.401	11.471	23.743	12.408	0.688	0.612	0.136	0.044
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Av.Values	17.925	23.734	12.552	12.808	22.927	12.739	10.188	24.165	12.363	11.803	23.885	12.365	11.519	23.756	12.379	0.690	0.61	0.14	0.05
Variation	0.50%	0.042	0.076	0.62%	0.037	0.107	0.81%	0.032	0.078	0.81%	0.033	0.074	0.81%	0.034	0.061	0.74%	0.85%	0.001	0.017
Surround temp difference		11.182	°C					Atmospheric pressure	1015.3	mb						0.667			
Surround mean temperature		18.143	°C													3.403			

TT207D	Holder panel number	1
58 mm Glazed Calibration Panel		
IGU details -	4mm Pilk-k,16mm Air, 4mm glass	

Service number...

Holder thermal conductivity data from 610 results

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Date & Time	Specimen area	Holder Th Cond.	Atm. pressure	Total power	Holder Hot temp	Holder Cold temp	Specimen Hot surface	Specimen Cold surface	Air temp Hot	Air temp Cold	Baffle Hot temp	Baffle Cold temp	Diviny Offset	boundary loss	Standard surface Res.	Thick effect	Thick edge
	(m²)	(W/m.K)	(mb)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(uV)	(%)	(m².K/W)	(m)	(m)
20/03/02 05:53	1.8228	0.0330	1011.5	43.961	22.875	-4.418	21.130	-4.040	23.769	-4.886	22.905	-4.840	-27.96	0.000			Line1
20/03/02 03:53	1.8228	0.0330	1009.7	44.061	22.882	-4.453	21.134	-4.033	23.775	-4.930	22.912	-4.886	-15.31	0.000			Line2
20/03/02 01:54	1.8228	0.0330	1007.6	44.026	22.852	-4.398	21.110	-4.000	23.750	-4.871	22.886	-4.830	-22.23	0.000			Line3
19/03/02 23:53	1.8228	0.0330	1006.9	44.043	22.848	-4.460	21.111	-4.038	23.751	-4.912	22.885	-4.878	-23.14	0.000			Line4
19/03/02 21:53	1.8228	0.0330	1006.0	44.069	22.840	-4.421	21.096	-4.020	23.739	-4.886	22.873	-4.853	-23.13	0.000			Line5
Averages	1.8228	0.0330	1008.3	44.032	22.859	-4.430	21.116	-4.026	23.757	-4.897	22.892	-4.858	-22.36	0.000			

[illegible]

Table 7 - Measured values of TT206 and TT207 – as EN12567-1- Table D1

Measured values			Thin panel TT206			Thick panel TT207		
d	overall thickness	m	0.02102			0.05774		
A	area of panel	m ²	1.81956			1.8228		
S _{sur}	area of surround panel	m ²	2.00244			1.9992		
A _t	hot box metering area	m ²	3.822			3.822		
L	perimeter length	m	5.42			5.42		
Test number			2	1	3	5	4	6
Cold temperatures								
θ _{ce}	air	°C	10.14	2.42	-6.72	12.36	2.49	-4.90
θ _{se,b}	baffle	°C	10.17	2.47	-6.64	12.38	2.53	-4.86
θ _{se,cal}	calibration panel	°C	11.33	4.29	-4.05	12.74	3.15	-4.03
θ _{se,p}	reveal surface	°C	10.60	3.09	-5.82	12.65	2.91	-7.34
θ _{se,sur}	surround panel	°C	10.34	2.75	-6.25	12.55	2.85	-4.43
Warm temperatures								
θ _{ci}	air	°C	23.78	23.35	22.85	24.17	23.84	23.7568
θ _{si,b}	baffle	°C	22.87	22.05	21.13	23.76	23.16	22.8921
θ _{si,cal}	calibration panel	°C	20.32	18.32	16.07	22.93	21.78	21.1162
θ _{si,p}	reveal surface	°C	22.04	20.91	19.65	23.30	22.42	21.7462
θ _{si,sur}	surround panel	°C	23.15	22.42	22.06	23.73	23.14	22.8594
φ _{in}	input power	W	47.02	72.68	103.89	17.92	32.62	44.1016
v _i	air flow warm side (down)	m/s	0.1	0.1	1	0.1	1	1
v _e	air flow cold side (up)	m/s	1.6	1.6	1.5	1.6	1.5	1.5

Table 8 View factor calculations - As in EN 12567-1 Table D2

Values resulting from mounting instructions			Remarks	Thin panel TT206	Thick panel TT207
Total thickness of the calibration panel	mm		-	21.016	57.738
Total thickness of the surround panel	mm		-	149.07	149.07
Surround panel reveal depth - warm side	mm		-	40	40
Surround panel reveal depth - cold side	mm		-	88.05	51.33
Thermal conductivity of the surround panel	W/(m.K)		E0	0.0334	0.0334
Emissivity of the calibration panel				0.84	0.84
Emissivity of the reveal				0.92	0.92
Emissivity of the baffle				0.95	0.95
Ψ_{edge} for $\lambda = 0.0334$ (W/(m.K))	W/(m.K)		Table B.1	-	0.00646
Warm side	view factors	f_{cbi}	Table A.1	0.944	0.944
		f_{ppi}	Table A.1	0.0472	0.0472
		f_{cpi}	equation (A.11)	0.056	0.056
		f_{bpi}	equation (A.11)	0.056	0.056
	radiant factors	f_{pbi}	equation (A.12)	0.4764	0.4764
		α_{cbi}	equation (A.8)	0.7550	0.7550
		α_{cpi}	equation (A.9)	0.04548	0.04548
Cold side	view factors	f_{cbe}	Table A.1	0.8809	0.92832
		f_{ppe}	Table A.1	0.1043	0.06017
		f_{cpe}	equation (A.11)	0.1191	0.0717
		f_{bpe}	equation (A.11)	0.1191	0.0717
	radiant factors	f_{pbe}	equation (A.12)	0.4478	0.4699
		α_{cbe}	equation (A.8)	0.7064	0.7430
		α_{cpe}	equation (A.9)	0.09687	0.05823

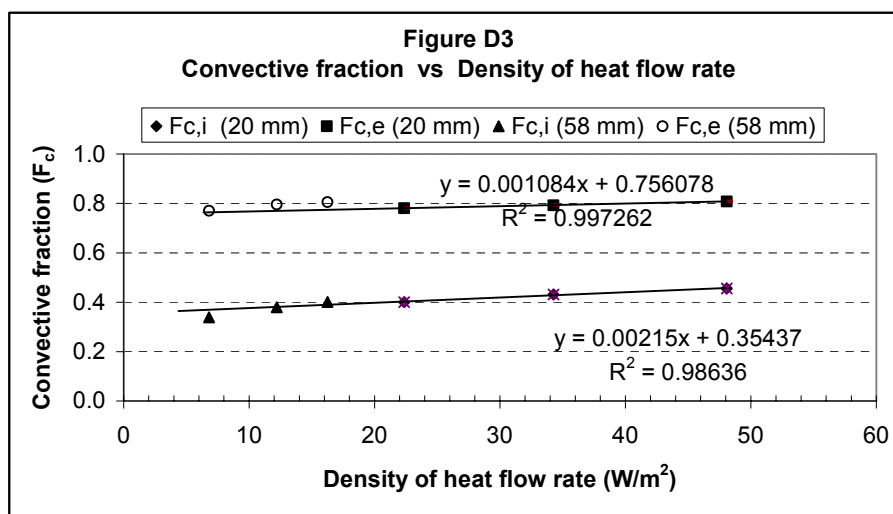
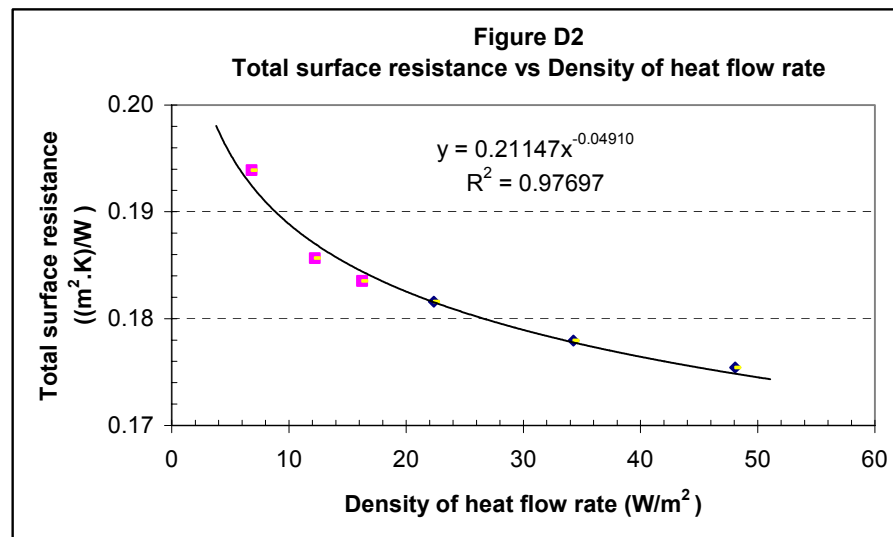
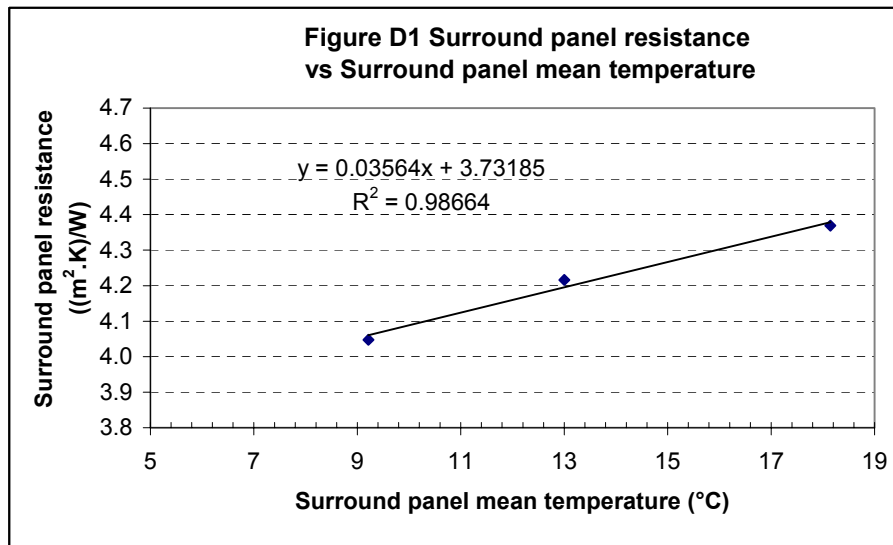
Table 9 Thermal resistance of surround panel – As in EN12567-1 Table D3

Data element			Remarks	Thick panel TT207		
Temperature difference air	$\Delta\theta_c$	K	-	11.8026	21.3549	28.6539
Temperature difference surface, surround	$\Delta\theta_{s,\text{sur}}$	K	-	11.182	20.2894	27.2896
Temperature mean surround	$\theta_{\text{me},\text{sur}}$	°C	-	18.14	13.00	9.21
Heat flow rate into the box	Φ_{in}	W	-	17.9248	32.6166	44.1016
Heat flow rate through the calibration panel	Φ_{cal}	W	equation 9	12.3953	22.2489	29.6205
Heat flow rate around perimeter	Φ_{edge}	W	equation 10	0.41325	0.7477	1.00326
Power through surround panel ($\Phi_{\text{in}} - \Phi_{\text{cal}} - \Phi_{\text{edge}}$)	Φ_{sur}	W	-	5.11629	9.61997	13.4778
Thermal resistance of the surround panel	R_{sur}	(m ² .K)/W	equation 8	4.36937	4.21649	4.04793
Optional check with thermal conductivity data						
Temperature mean surround	$\theta_{\text{me},\text{sur}}$	°C		18.14	13.00	9.21
thermal conductivity of surround @ $\theta_{\text{me},\text{sur}}$	λ_{sur}	W/(m.K)		0.03412	0.03349	0.03303
Thickness of the holder panel	d_{sur}	m		0.14907	0.14907	0.14907
Thermal resistance of the surround panel	$R_{\text{sur}(\text{check})}$	(m ² .K)/W		4.36881	4.45106	4.51358
Difference in resistance				-0.0128	5.27005	10.3167

Table 10 - Surface resistance and environmental temperatures – As in EN 12567-1 Table D4

Data element		Remarks	Thin panel TT206			Thick panel TT207		
Mean temperature cal panel	$\theta_{me,cal}$ °C		15.83	11.31	6.01	17.83	12.47	8.54
Surface temp diff cal panel	$\Delta\theta_{s,cal}$ K		8.99	14.03053	20.12	10.18788	18.6277	25.1424
Thermal resistance cal panel	R_{cal} m ² .K/W	equation 3	0.4019	0.4094	0.4185	1.4982	1.5261	1.5472
Density of heat flow rate thro' cal panel	q_{cal} W/m ²	equation 2	22.3667	34.2731	48.0820	6.8001	12.2059	16.2500
Warm blackbody radiant heat transfer coefficient baffle	$h_{cb,i}$ W/m ² .K	equation A.6	5.8075	5.7248	5.6326	5.9113	5.8594	5.8317
Cold blackbody radiant heat transfer coefficient baffle	$h_{cb,e}$ W/m ² .K	equation A.6	5.1896	4.7960	4.3561	5.2895	4.7678	4.4003
Warm blackbody radiant heat transfer coefficient reveal	$h_{cp,i}$ W/m ² .K	equation A.7	5.7830	5.6912	5.5894	5.8976	5.8374	5.7977
Cold blackbody radiant heat transfer coefficient reveal	$h_{cp,e}$ W/m ² .K	equation A.7	5.2014	4.8122	4.3760	5.2970	4.7778	4.3397
radiant heat transfer coefficient warm side	$h_{r,i}$ W/m ² .K	equation A.5	4.6477	4.5811	4.5069	4.7313	4.6895	4.6667
radiant heat transfer coefficient cold side	$h_{r,e}$ W/m ² .K	equation A.5	4.1696	3.8538	3.5008	4.2383	3.8205	3.5219
Mean radiant temperature warm side	$\theta_{r,i}$ °C	equation A.3	22.82	21.99	21.05	23.73	23.12	22.83
Mean radiant temperature cold side	$\theta_{r,e}$ °C	equation A.2	10.22	2.55	-6.54	12.40	2.55	-5.04
Warm side convective heat transfer coefficient	$h_{c,i}$ W/m ² .K	equation A.10	3.103	3.479	3.775	2.424	2.876	3.130
Cold side convective heat transfer coefficient	$h_{c,e}$ W/m ² .K	equation A.10	14.850	14.709	14.789	14.228	14.877	14.569
Warm side convective fraction	$F_{c,i}$ -	equation 6	0.4003	0.4316	0.4558	0.3388	0.3801	0.4015
Cold side convective fraction	$F_{c,e}$ -	equation 6	0.7808	0.7924	0.8086	0.7705	0.7957	0.8053
Warm side environmental temperature	$\theta_{ni,cal}$ °C	equation 7	23.21	22.57	21.87	23.88	23.40	23.20
Cold side environmental temperature	$\theta_{ne,cal}$ °C	equation 7	10.15	2.44	-6.68	12.37	2.50	-4.92
Environmental temperature difference	$\Delta\theta_{n,cal}$ K	-	13.05	20.13	28.55	11.51	20.89	28.12
Warm side surface resistance	$R_{s,i}$ (m ² .K)/W	equation 4	0.1290	0.1241	0.1208	0.1398	0.1322	0.1283
Cold side surface resistance	$R_{s,e}$ (m ² .K)/W	equation 5	0.0526	0.0539	0.0547	0.0542	0.0535	0.0553
Total surface resistance	$R_{s,t}$ (m ² .K)/W	equation 1	0.1816	0.1779	0.1754	0.1939	0.1857	0.1835

Figure 1 Surround panel resistance, Convective fractions and total surface resistance



4 DISCUSSION OF RESULTS

A comparison between the measured and calculated thermal conductance values for the two glazed calibration panels can be seen in Table 11. The comparison between the thermal resistance values of the surround panel calculated from thermal conductivity data (see NPL Test Report PP21/E02020240) and those calculated from these calibration measurements, can be seen in Table 9. The effects of the discrepancies between those figures can also be seen in Figure 1 – D1. The apparently large discrepancy between the thermal resistance values of the surround panel result from the hot box measurement uncertainty being “assigned” to heat transfer through the surround panel. This effectively magnifies the uncertainty, because a difference of 1% in the measurement of the thermal conductance of TT207 will produce an discrepancy 2.5% in the measured resistance of the surround panel. The measurement uncertainty of the NPL WGHB apparatus, under ideal conditions has been estimated to be $\pm 4.5\%$, which would produce a discrepancy of about 11.3 % in the thermal conductance of the holder panel. In fact the figures shown in Table 11 for five of the measurements show that the agreement between the measured and calculated thermal conductance values is significantly better than 4.5%.

Table 11 Comparison between measured and calculated thermal conductance values

Comparison with measured and calculation values of thermal conductance for the glazed calibration panels							
Measured values do include a boundary loss calculated using THERM							
Hot surf	Cold surf	Mean Temp	Temp	Conduct	Cond.	Ht flux	% Diff
°C	°C	°C	difference	calculated	measured	calc	Conductance
			°C	W/m2.K	W/m2.K	W/m2	(Ms-Clc)
20 mm panel					BL=3.7%		BL=3.7%
16.07	-4.05	6.01	20.12	2.390	2.391	48.082	0.1
18.32	4.29	11.31	14.03	2.443	2.396	34.273	-1.9
20.32	11.33	15.83	8.99	2.488	2.412	22.367	-3.1
60 mm panel					BL=2.2%		BL=2.2%
21.12	-4.03	8.54	25.14	0.646	0.677	16.250	4.8
21.78	3.15	12.47	18.63	0.655	0.671	12.206	2.4
22.93	12.74	17.83	10.19	0.667	0.668	6.800	0.1

Note BL = boundary loss calculated with THERM

5 CHECK MEASUREMENT CARRIED OUT ON A PVCU WINDOW

A 1.48 m x 1.23 m PVCu window previously measured using the surround panel number 1 and calibrated using calibration panels TT83 and TT84 (NPL Report QM115) was re-measured using the new surround panel number 10 and the calibration data shown in Figure 1. The results can be seen in Table 12, Table 13, Table 14 and Table 15. The results obtained using surround panel 1 and the previous calibration data obtained using glazed calibration panels TT83 and TT84 can be seen in Table 16 and Table 17. The results from the two sets of measurements are summarized in Table 18.

Table 12 Summary of measurement data for TT228 - check measurement

TT228	Holder panel number				10	Data entered by.....				RGW	Service number...				None/Repeat of TT226				
						Data entry checked by.....													
Holder thermal conductivity data from 610 results																			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
Date & Time	Specimen area	Holder Th Cond.	Atm. pressure	Total power	Holder Hot temp	Holder Cold temp	Specimen Hot surface	Specimen Cold surface	Air Hot temp	Air Cold temp	Baffle Hot temp	Baffle Cold temp	Diviny Offset	boundary loss	Standard Res. surface	Thick effect	Thick edge		
	(m²)	(W/m.K)	(mb)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(uV)	(%)	(m².K/W)	(m)	(m)		
25/03/02 06:52	1.817	0.0334	1030.5	86.572	22.578	1.841	16.737	3.297	23.214	1.501	21.685	1.559	-23.10	0.000				Line1	
25/03/02 04:53	1.817	0.0334	1030.2	86.636	22.569	1.840	16.733	3.308	23.215	1.495	21.687	1.559	-22.32	0.000				Line2	
25/03/02 02:52	1.817	0.0334	1030.6	86.674	22.588	1.777	16.750	3.252	23.221	1.465	21.694	1.517	-22.21	0.000				Line3	
25/03/02 00:52	1.817	0.0334	1031.3	86.715	22.584	1.784	16.747	3.258	23.224	1.457	21.695	1.518	-22.46	0.000				Line4	
24/03/02 22:52	1.817	0.0334	1031.6	86.737	22.565	1.721	16.732	3.211	23.205	1.392	21.675	1.453	-21.68	0.000				Line5	
Averages	1.817	0.0334	1030.8	86.667	22.577	1.793	16.740	3.265	23.216	1.462	21.687	1.521	-22.35	0.000					
Date & Time	Total power	Surround Hot	Surface Cold	Power through	Hot surface	Cold surface	Surface Temp	Air temperatures			Environmental temperatures			Baffle temperatures			Thermal Cond	Thermal Trans	Surface Resistance
	Corfor HFM Off			Insert	temp	temp	diff	Hot	Cold	diff	Hot	Cold	diff	Hot	Cold			Hot	Cold
	(W)	(°C)	(°C)	minus BL %	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(W/m².K)	(W/m².K)	(m².K/W)	(m².K/W)
Area of specimen	1.817	m²		Thick @ edge		60.00	mm		B.L% Man	0.0		Mean temp	10.003	°C			Hr (c)		5.659
Area holder	2.005	m²		Holder thickness		0.14907	m					λ Holder	0.0334	W/m.K			Hr (h)		4.739
Efth	n/a	mm		Baffle Emis.	Hot	0.94		Spec. Emis.	Hot	0.9		Emissivity Factor	Hot	0.8511			Tot Res		0.1718
				Baffle Emis	Cold	0.94		Spec. Emis.	Cold	0.9		Emissivity Factor	Cold	0.8511					
25/03/02 06:52	86.644	22.578	1.841	77.333	16.737	3.297	13.440	23.214	1.501	21.713	22.259	1.510	20.749	21.685	1.559	3.166	2.051	0.130	0.042
25/03/02 04:53	86.706	22.569	1.840	77.398	16.733	3.308	13.424	23.215	1.495	21.721	22.260	1.504	20.755	21.687	1.559	3.172	2.052	0.130	0.042
25/03/02 02:52	86.743	22.588	1.777	77.399	16.750	3.252	13.498	23.221	1.465	21.757	22.268	1.473	20.796	21.694	1.517	3.155	2.048	0.130	0.042
25/03/02 00:52	86.785	22.584	1.784	77.445	16.747	3.258	13.489	23.224	1.457	21.767	22.270	1.466	20.804	21.695	1.518	3.159	2.048	0.130	0.042
24/03/02 22:52	86.804	22.565	1.721	77.445	16.732	3.211	13.521	23.205	1.392	21.813	22.251	1.401	20.849	21.675	1.453	3.152	2.044	0.129	0.042
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Av.Values	86.736	22.577	1.793	77.404	16.740	3.265	13.474	23.216	1.462	21.754	22.261	1.471	20.791	21.687	1.521	3.161	2.049	0.13	0.04
Variation	0.19%	0.022	0.120	0.15%	0.018	0.097	0.72%	0.019	0.109	0.46%	0.019	0.109	0.48%	0.021	0.107	0.66%	0.39%	0.000	0.001
Surround temp difference		20.784	°C			Atmospheric pressure				1030.8	mb								
Surround mean temperature		12.185	°C																

Table 13 Tables D5 and D6 from EN 12567-1

Table D5 Window Data			
frame width	w	m	0.060
surround panel thickness	d _{sur}	m	0.14907
area of window	A _{sp}	m ²	1.8174
area of surround panel	A _{sur}	m ²	2.0046
perimeter length	L	m	5.42

Table D6 Window measurement results			
Cold temperatures			
θ_{ce}	air	°C	1.46
$\theta_{se,b}$	baffle	°C	1.52
$\theta_{se,p}$	reveal surface	°C	1.99
$\theta_{se,sur}$	surround panel	°C	1.79
Warm temperatures			
θ_{ci}	air	°C	23.22
$\theta_{si,b}$	baffle	°C	21.69
$\theta_{si,sur}$	surround panel	°C	22.58
ϕ_{in}	input power	W	86.74
v_i	air flow warm side (down)	m/s	0.1
v_e	air flow cold side (up)	m/s	1.6

Table 14 Table D7 EN 12567-1

Table D7 Calculation of the thermal transmittance of window			TT228	Remarks
Temperature mean surround panel	$\theta_{me,sur}$	$^{\circ}\text{C}$	12.185	-
Thermal resistance of the surround panel	R_{sur}	$(\text{m}^2.\text{K})/\text{W}$	4.1661	Figure D1 / regression
Thermal conductivity of surround @ $\theta_{me,sur}$	λ_{sur}	$\text{W}/(\text{m.K})$	0.0334	-
Ψ_{edge} for $w = 60 \text{ mm}$ and $d = 89.1 \text{ mm}$	Ψ_{edge}	$\text{W}/(\text{m.K})$	0.01455	Table B2
Temperature difference surface, surround	$\Delta\theta_{s,sur}$	K	20.784	-
Temperature difference air	$\Delta\theta_c$	K	21.754	
Input power to hot box	ϕ_{in}	W	86.736	
Power through surround panel	Φ_{sur}	W	10.001	equation 12
Edge zone heat flow	Φ_{edge}	W	1.7155	equation 10
Heat flow density through specimen	q_{sp}	W/m^2	41.2789	equation 11
Warm side convective fraction	$F_{c,i}$	-	0.4531	Figure D3 / regression
Cold side convective fraction	$F_{c,e}$	-	0.7606	Figure D3 / regression
Total surface resistance	$R_{s,t}$	$(\text{m}^2.\text{K})/\text{W}$	0.1762	Figure D2 / regression
Mean radiant temperature warm side	$\theta_{r,i}$	$^{\circ}\text{C}$	21.69	equation A.2
Mean radiant temperature cold side	$\theta_{r,e}$	$^{\circ}\text{C}$	1.52	equation A.2
Warm side environmental temperature	θ_{ni}	$^{\circ}\text{C}$	22.380	equation 7
Cold side environmental temperature	θ_{ne}	$^{\circ}\text{C}$	1.476	equation 7
Environmental temperature difference	$\Delta\theta_{n,cal}$	K	20.904	
Environmental temperature mean	$\theta_{n,cal}$	$^{\circ}\text{C}$	11.928	
U-value measured	U_m	$\text{W}/(\text{m}^2.\text{K})$	1.975	equation 13
Uncertainty	ΔU_m	$\text{W}/(\text{m}^2.\text{K})$	0.17	
Standard total surface resistance	$R_{s,t}$	$(\text{m}^2.\text{K})/\text{W}$	0.17	
Standardized U-value	U_{st}	$\text{W}/(\text{m}^2.\text{K})$	1.999	equation 14

EQUATION COEFFICIENTS FROM THE CALIBRATION MEASUREMENTS CARRIED OUT ON GLAZED CAL PANELS TT206 & TT207

See EXCEL WORKBOOK "WGHB CEN Cal Feb 02 Ex5.xls"

Warm side convective fraction	$F_{c,i} =$	0.00215	X	$q_{cal} +$	0.36437
Cold side convective fraction	$F_{c,e} =$	0.0001084	X	$q_{cal} +$	0.756078
Total surface resistance of cal panel at this q_{cal}	$R_{s,t} =$	0.21147	X	$q_{cal} ^{\wedge}$	-0.0491
Thermal resistance of surround panel	$R_{sur} =$	0.03564	X	$\theta_{me,sur} +$	3.73185

Table 15 Summary of measurement data for TT228 - holder panel 10 and new calibration

TT228	
Multichamber PVCu window	
4/16/4 Air filled units with Pilkington K	
Window dimensions	
Height	1.474 mm
Width	1.2273 mm
Thickness	0.060 mm
Percentage of the window area that is frame	32 %
Measured values	
Mean warm air temperature	23.22 °C
Mean warm baffle temperature	21.69 °C
	°C
Mean cold air temperature	1.46 °C
Mean cold baffle temperature	1.52 °C
Mean cold reveal temperature	1.99 °C
Power to hot box	86.736 W
Air flow rate in the cold box	1.6 m/s
Air flow rate in the hot box	<0.2 m/s
Calculated values	
Heat flux density through window*	41.279 W/m ²
Warm side convective fraction*	0.453
Cold side convective fraction*	0.761
Warm side environmental temperature*	22.38 °C
Cold side environmental temperature*	1.48 °C
Environmental temperature difference	20.90 °C
Environmental temperature mean	11.93 °C
Measured thermal transmittance (U)	1.97 W/m ² ·K
Total surface resistance *	0.176 m ² ·K/W
Thermal transmittance (U) standardised ^[2]	2.00 W/m²·K

{*} Values obtained using graphs produced from measurements on the calibration panels.

Table 16 Summary of the hot box measurement data for TT226 UPVC window

TT226		Holder panel number			1		Data entered by.....			JNC			Service number...				
IGU details -		4mm Pilk-k,16mm Air, 4mm glass			Data entry checked by.....												
Holder thermal conductivity data from 610 results																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Date & Time	Specimen area	Holder Th Cond.	Atm. pressure	Total power	Holder Hot temp	Holder Cold temp	Specimen Hot surface	Specimen Cold surface	Air temp Hot	Air temp Cold	Baffle Hot temp	Baffle Cold temp	Diviny Offset	boundary loss	Standard Res. surface	Thick effect	Thick edge
	(m²)	(W/m.K)	(mb)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(uV)	(%)	(m².K/W)	(m)	(m)
15/02/02 06:52	1.839	0.0411	1034.4	88.380	22.471	2.674	18.860	3.916	23.183	2.286	21.768	2.356	-23.51	0.000			Line1
15/02/02 04:52	1.839	0.0411	1033.6	88.326	22.469	2.664	18.854	3.888	23.181	2.305	21.765	2.369	-20.12	0.000			Line2
15/02/02 02:52	1.839	0.0411	1033.1	88.428	22.468	2.635	18.866	3.881	23.185	2.267	21.767	2.324	-25.88	0.000			Line3
15/02/02 00:52	1.839	0.0411	1033.1	88.371	22.465	2.630	18.862	3.866	23.192	2.272	21.772	2.334	-20.23	0.000			Line4
14/02/02 22:52	1.839	0.0411	1033.4	88.409	22.489	2.650	18.877	3.884	23.202	2.302	21.781	2.369	-22.27	0.000			Line5
Averages	1.839	0.0411	1033.5	88.383	22.472	2.651	18.864	3.887	23.189	2.286	21.771	2.350	-22.40	0.000			

Date & Time	Total power	Surround Hot	Surface Cold	Power through Insert	Hot surface temp	Cold surface temp	Surface Temp diff	Air temperatures		Environmental temperatures			Baffle temperatures		Thermal Cond	Thermal Trans	Surface Resistance		
	1.7155	Corfor						Hot	Cold	diff	Hot	Cold	diff	Hot	Cold		Hot	Cold	
	HFM Off			minus BL%				(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(W/m².K)	(W/m².K)	(m².K/W)	
	(W)	(°C)	(°C)	(W)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)				
Area of specimen	1.8388	m²		Thick @ edge		60.00	mm	B.L%Man		0.0		Mean temp		11.375	°C		Hr (c)	5.723	
Area holder	1.9832	m²		Holder thickness		0.1506	m					λ Holder		0.0411	W/m.K		Hr (h)	4.775	
Efth	n/a	mm		Baffle Emis. Hot		0.94		Spec. Emis. Hot		0.9		Emissivity Factor		Hot	0.8511		Tot Res	0.1282	
				Baffle Emis Cold		0.94		Spec. Emis. Cold		0.9		Emissivity Factor		Cold	0.8511				
15/02/02 06:52	86.738	22.471	2.674	76.020	18.860	3.916	14.944	23.183	2.286	20.897	22.565	2.296	20.270	21.768	2.356	2.766	2.040	0.090	0.039
15/02/02 04:52	86.673	22.469	2.664	75.951	18.854	3.888	14.965	23.181	2.305	20.876	22.562	2.314	20.248	21.765	2.369	2.760	2.040	0.090	0.038
15/02/02 02:52	86.793	22.468	2.635	76.056	18.866	3.881	14.986	23.185	2.267	20.918	22.567	2.274	20.293	21.767	2.324	2.760	2.038	0.089	0.039
15/02/02 00:52	86.719	22.465	2.630	75.981	18.862	3.866	14.996	23.192	2.272	20.920	22.571	2.281	20.290	21.772	2.334	2.755	2.036	0.090	0.038
14/02/02 22:52	86.763	22.489	2.650	76.023	18.877	3.884	14.993	23.202	2.302	20.900	22.581	2.311	20.271	21.781	2.369	2.758	2.040	0.090	0.038
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Av.Values	86.737	22.472	2.651	76.006	18.864	3.887	14.977	23.189	2.286	20.902	22.569	2.295	20.274	21.771	2.350	2.760	2.04	0.09	0.04
Variation	0.14%	0.024	0.043	0.14%	0.023	0.050	0.35%	0.020	0.038	0.21%	0.020	0.039	0.22%	0.016	0.046	0.40%	0.17%	0.000	0.001
Surround temp difference		19.822 °C		Atmospheric pressure				1033.5 mb											
Surround mean temperature		12.562 °C																	

Table 17 Summary data for TT226 (Holder panel 1, calibrated with panels TT83 and TT84)**Window description**

- Frame: 60 mm thick horizontally divided PVC-u frame - one fixed light, one opening light.
- Glazing: 24 mm thick sealed glazing units incorporating Pilkington **K Glass**TM.
(4 mm glass, air filled, 16 mm gap, 1 pane Pilkington **K Glass**TM)

Window dimensions

Height	=	1476	mm
Width	=	1228	mm
Thickness	=	60	mm
Percentage of the window area that is frame	=	32	%

Measured values

Warm side temperatures

Mean air temperature	=	23.19	°C
Mean baffle temperature	=	21.77	°C
Mean reveal temperature	=	21.02	°C

Cold side temperatures

Mean air temperature	=	2.29	°C
Mean baffle temperature	=	2.35	°C
Power to hot box	=	88.45	W

Air flow rate in the cold box

= 1.6 m/s (± 0.3 m/s)

Air flow rate in the hot box

= Natural convection

Calculated values

Heat flux density through window*	=	41.68	W/m ²
Warm side convective fraction*	=	0.4534	
Cold side convective fraction*	=	0.8581	
Warm side environmental temperature*	=	22.37	°C
Cold side environmental temperature*	=	2.30	°C
Environmental temperature difference	=	20.07	°C
Measured thermal transmittance (U)	=	2.08	W/(m ² ·K)
Total surface resistance	=	0.168	(m ² ·K)/W
Mean environmental temperature	=	12.34	°C
Thermal transmittance (U) standardised ^[2]	=	2.07 $\pm$ 0.18	W/(m ² ·K)

{*} Values obtained using graphs produced from measurements on the calibration panels.

The “simple measurement procedure” referred to in Table 18 is the method in which the heat transfer through the surround panel is calculated from the thermal conductivity of the expanded polystyrene used to make the holder panel and the “boundary loss” is calculated from the linear thermal transmittance value given in EN 12567-1 and the environmental temperatures calculated as specified in ISO 8990 using the air, baffle and surface temperatures.

Table 18 Comparison of U-values measured with the different procedures

Holder panel	Type of calculation	Calibration panels used	Measured U-value W/m ² .K
1	Simple	None	2.04
1	CEN	TT83 & TT84	2.07
10	Simple	None	2.01
10	CEN	TT206 & TT207	2.00

The difference between the simple measurement and the CEN measurement made with surround panel 1 is about 1.5% and between the simple measurement and the CEN measurement made with surround panel 10, is –0.5%. The differences between measurements made using surround panels 1 and 10 using the simple method is 1.5% and when using the using the CEN method is 3.5%.

So U-values measured using the different surround panels, calibrated with different glazed calibration panels were within 3.5% of each other. The repeatability of the NPL WGHB is, however, not better than 1%, so the agreement between the measurements carried out with different holder panels, calibrated with different calibration panels, is better than 3%.

6 CONCLUSIONS

The difference between U-values measured using holder panel 10 and the procedures specified in EN 12567-1, the “simple method”, was about 0.5%; and therefore the results are practically identical.

The equations derived from these calibration measurements that will be used in future window tests with surround panel 10 are as follows:

Warm side convective fraction

$$F_{c,i} = 0.00215 q_{cal} + 0.36437$$

Cold side convective fraction

$$F_{c,e} = 0.0001084 q_{cal} + 0.756078$$

Total surface resistance of cal panel at q_{cal}

$$R_{s,t} = 0.21147 q_{cal}^{-0.0491}$$

Thermal resistance of surround panel

$$R_{sur} = 0.03564 q_{me,sur} + 3.73185$$

ANNEX 1 FILE NAMES OF EXCEL SPREADSHEETS CONTAINING THIS HOT BOX AND CALIBRATION DATA

Data on original measurements on TT226

TT226, Summary, CEN calc, reveal 1.48 x 1.23 window-V2.xls

Data for re-measurement of TT226 as TT228

TT228 CEN Calc holder 10 repeat Ex5.xls

Data on calculation of thermal conductance TT206 and TT207 calibration panels and the hot box calibration data.

WGH B CEN Cal Feb 02 Ex5.xls