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Interim report SM&T Framework III project 3032 - Calibration Panels for Thermal Transmittance of Glazed Assemblies

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Abstract

This report describes the work carried out in Phase 1 of the above SM&T project. It describes the results of the thermal conductivity measurements made on the Expanded Polystyrene material selected as the core of the calibration panels. It gives the results of the limited intercomparison of these measurements and discusses some of the issues raised by that intercomparison exercise. The specification of the glazed calibration panels and the fabrication procedures to use are given. Finally, the proposed timetable is given for phase two of the project.

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Approved on behalf of Managing Director, NPL,
by Dr J R Gott, Director, Centre for Quantum Metrology.

1 BACKGROUND

1.1 Objectives of the project

The objective of the project is to produce a technical supplement to two new CEN standards[1]&[2], setting out a precise method for the construction, characterisation and application of glazed calibrated reference panels for hot-box use.

The project involves five laboratories (see section 8) fabricating reference panels and carrying out thermal measurements. Four of the laboratories are from different EU countries and one from a non-EU country. An additional participant is involved as an advisor to benefit from his specialist knowledge of the original standards.

The deliverables will be:-

- A report detailing the design specification for producing calibrated reference panels of known uncertainty (±7%)

- Report on comparison of hot-plate measurements.

- Report on comparison of measurements on the same calibrated reference panels from different laboratories and comparison of measurements of calibrated reference panels made by different laboratories to a common design.

- Four sets of well characterised, calibrated reference panels for use within the Community.

1.2 Summary of decisions taken at the 26th January meeting

At the first project meeting, held at the NPL (UK) on the 26th January 1995, the following issues were decided:

- the type of panel to fabricate
- the materials to be used in the calibration panels
- the fabrication method for the calibration panels
- the details of how to carry out the thermal conductivity measurements on the insulation material.

The first phase of the project was to purchase the expanded polystyrene (EPS) insulation material and the toughened glass. The thermal conductivity of the EPS then had to be measured over the temperature range required by the standards. Lastly, each laboratory was to send its 12 mm thick EPS thermal conductivity specimens to one laboratory and its 50 mm thick EPS thermal conductivity specimens to another. The details of those transfers are given below.

λ Intercomparison schedule for the 12 mm thick EPS specimens.

IFT (2 x 500 mm specimens) to	TNO (2 x 500 mm specimens)	
TNO (2 x 500 mm specimens) to	BBRI(2 x 600 mm specimens)	Note[2]

BBRI (2 x 600 mm specimens) to	NPL (2 x 305 mm specimens)	Note[3]
NPL (2 x 305 mm specimens) to	EMPA(2 x 500 mm specimens)	Note[2]
EMPA (2 x 500 mm specimens)	to IFT (2 x 500 mm specimens)	

λ Intercomparison schedule for the 50 mm thick EPS specimens.

IFT (2 x 500 mm specimens) to	EMPA (2 x 500 mm specimens)	
EMPA (2 x 500 mm specimens)	to NPL (2 x 610 mm specimens)	Note[2]
NPL (2 x 610 mm specimens) to	BBRI (2 x 600 mm specimens)	Note[3]
BBRI (2 x 600 mm specimens) to	TNO (2 x 500 mm specimens)	Note[2]
TNO (2 x 500 mm specimens)	to IFT (2 x 500 mm specimens)	

Note [2] A collar of similar material will have to be used in the guard area.

Note [3] Specimens will have to be cut down to fit the apparatus.

1.3 What is included in this report

This report contains the following:

- Results of all the thermal conductivity measurements
- A comparison of the different measurements made on the same specimens
- Issues raised by the measurement results
- The fabrication method chosen for the calibration panels
- A proposed timetable for phase two of the project.

2 DESCRIPTION OF THE VARIOUS HOT PLATE APPARATUSES USED

The apparatus used by the different laboratories to carry out the thermal conductivity measurements are described in detail in the individual test reports[3],[4],[5],[6],[7]. A summary is given below in Table 1.

Table 1 Apparatus used by the different laboratories

Laboratory	Type of apparatus and the associated measurement standard	Specimen size (m)	Central heater zone (m)	Number of specimens	Measurement uncertainty claimed (%)
NPL	Guarded Hot Plate BS 874: Part 2: Section 2.1	$(0.305)^2$ x 0.012 thick	$(0.2)^2$	2	± 3.5
NPL	Guarded Hot Plate BS 874: Part 2: Section 2.1	$(0.61)^2$ x 0.05 thick	$(0.305)^2$	1	± 2.0
TNO	Guarded Hot Plate NEN 2444	$(0.5)^2$	?	2	± ?
IFT	Guarded Hot plate DIN 52 619 part 2	$(0.5)^2$	?	2	± 3
BBRI	Guarded Hot Plate NBN B62-201	$(0.6)^2$	$(0.4)^2$	2	± 2
EMPA	Guarded Hot Plate SIA 279/5 03	$(0.5)^2$	$(0.25)^2$	2	± 2 ± 2

3 RESULTS OF THE λ MEASUREMENTS

3.1 The λ values measured by the different laboratories

Each laboratory has reported on its own thermal conductivity measurements[3],[4],[5],[6],[7] and the results are summarised in Tables 2, 3, 4 and 5.

Table 2 Summary of the λ measurements

Lab. & Specimen identifier	Spec density (kg/m^3)	Spec. thick. (mm)	Hot surface temp. (°C)	Cold surface temp. (°C)	Mean specimen temp. (°C)	Temp. diff. (°C)	Thermal cond. W/m.K	Diff. thick. O-I/O (%)	Diff. Th.Con. O-I/O (%)
NPL									
1a	26.7	11.57	11.7	-5.1	3.3	16.8	0.0303		
1b			18.5	2.1	10.3	16.4	0.0311		
1c			27.9	12.0	20.0	15.9	0.0321		
2a	26.10	59.15	13.0	-3.2	4.9	16.2	0.0337		
2b			19.7	3.8	11.7	15.9	0.0345		
2c			28.3	11.7	20.0	16.6	0.0356		
7dBBRI	37.9	11.84	14.3	-4.1	5.07	18.4	0.03036		
7e			19.1	0.9	9.99	18.2	0.03084		
7b*					9.90		0.03083	2.1	3.3
10dEMPA	25.73	49.67	13.3	-3.1	5.10	16.4	0.03414		
10e			23.0	6.8	14.92	16.2	0.03537		
10b*					9.0		0.03463	2.4	-1.9
TNO									
3a	22.1	14.2	15.4	5.3	10.3	10.1	0.0323		
3b									
3c									
4a	23.1	49	14.9	3.8	9.35	11.1	0.0338		
4b									
4c									
5c[IFT]	16.6	9.8	9.95	2.05	6.0	7.9	0.0319		
5e			15.8	8.0	11.9	7.8	0.0321		
5d			18.95	12.45	15.7	6.5	0.0324		
5a*					9.4		0.0321	0	11.6
8d[BBRI]	32.4	48.6	9.9	-1.5	5.7	11.4	0.0319		
8e		48.8	16.1	5.0	10.5	11.1	0.0316		
8f		48.6	21.0	9.8	15.4	11.2	0.0322		
8b*					10.4		0.0316	0.5	4.7
IFT									
5a	n/a	9.8	14.9	4.1	9.4	10.5	0.0363		
5b	n/a		23.6	13.2	18.6	10.4	0.0377		
6a	n/a	49.1	14.9	4.8	9.9	10.1	0.0353		
6b	n/a		22.7	12.7	17.7	10.0	0.0363		
6c									
11a[1]	21.8	8.8	13.7	3.1	8.4	10.6	0.0330		
11b[1]			23.6	13.0	18.3	10.6	0.0327		
12a[1]	31.6	49.5	14.9	3.8	9.3	11.0	0.0327		
12b[1]			24.7	13.7	19.2	11.0	0.0340		

9d^{EMPA}	28	12.0	14.2	4.4	9.3	9.8	0.0334		
9e			23.7	14.1	18.9	9.6	0.0338		
9b*					9.0		0.0334	4	-1.0
4d^{TNO}	22.94	48.5	14.0	3.8	8.9	10.2	0.0345		
4e	24.0		24.8	14.7	19.8	10.1	0.0348		
4a*					9.35		0.0345	1	-2.1

Table 3 Summary of the λ measurements (continued)

Lab ID & Spec. ID	Spec. density (kg/m^3)	Spec. thick. (mm)	Hot surface temp. (°C)	Cold surface temp. (°C)	Mean specimen temp. (°C)	Temp. diff. (°C)	Thermal cond. (W/m.K)	Diff. thick. O-I/O (%)	Diff. Th.Con. O-I/O (%)
BBRI									
7a	37.081	12.10	15.872	-5.347	5.262	21.219	0.031329		
7b			20.303	-0.498	9.903	20.800	0.031884		
7c			24.919	4.714	14.817	20.204	0.032411		
8a	32.230	48.853	16.332	-6.426	4.946	22.736	0.032628		
8b			21.602	-0.773	10.414	22.375	0.033146		
8c			26.611	4.153	15.382	22.458	0.033781		
3d^{TNO}	22.43	13.93	17.575	-5.366	6.105	22.94	0.03337		
3e			26.604	4.593	15.599	22.01	0.034643		
3a*					10.3		0.03393	-1.9	-5.0
2d^{NPL}	Not done								
2e									
2b*									
EMPA									
9a	27.2	12.5	6.0	-4.0	1.0	10.0	0.03206		
9b			14.0	4.0	9.0	10.0	0.03306		
9c			22.0	12.0	17.0	10.0	0.03402		
10a	25.9	50.90	6.0	-4.0	1.0	10.0	0.03296		
10b			14.0	4.0	9.0	10.0	0.03400		
10c			22.0	12.0	17.0	10.0	0.03480		
1d^{NPL}	25.8	12.08	6.0	-4.0	1.0	10.0	0.03138		
1e			14.0	4.0	9.0	10.0	0.03240		
1f			22.0	12.0	17.0	10.0	0.03334		
1b*					10.3		0.03252	-4.4	-4.7
6d^{IFT}	16.0	49.65	6.0	-4.0	1.0	10.0	0.03566		

6e			14.0	4.0	9.0	10.0	0.03680		
6f			22.0	12.0	17.0	10.0	0.03824		
6a*					9.9		0.03696	-1.1	-4.7

4 DISCUSSION OF THE λ MEASUREMENT RESULTS

4.1 Summary of the intercomparison measurements

The intercompared thermal conductivity measurements are summarised in Table 4. The measured thicknesses and thermal conductivities have been used to calculate thermal conductances and these are compared in Table 5. The "acceptable" differences between measured λ values has been calculated by adding the stated uncertainties of the two respective laboratories in quadrature and taking the square root.

Table 4 Summary of the intercomparison measurements - thermal conductivity

Lab ID Own/ Comp	Thickness (mm)	Difference thickness Own-Comp Own (%)	Mean temp. (°C)	Temperature difference (°C)	Thermal conductivity (W/m.K)	Difference Thermal conductivity Own-Comp Own (%)
NPL	11.57	-4.4	10.3	16.4	0.0311	-4.6
EMPA	12.08		10.3	10.0	0.03252	Accept ± 4.0
NPL	59.15		11.7	15.9	0.0345	
BBRI	not done					
TNO	14.2	-1.9	10.3	10.1	0.0323	-5.0
BBRI	13.93		10.3	22.42	0.03393	Accept ± 3.6
TNO	49	1.0	9.35	11.1	0.0338	-2.1
IFT	48.5		9.35	10.1	0.0345	Accept ± 4.2
IFT	9.8	0	9.4	10.5	0.0363	11.6 Accept ± 4.2

TNO	9.8		9.4	7.8	0.0321	
IFT	49.1	-1.1	9.9	10.1	0.0353	-4.7 Accept ± 3.6
EMPA	49.65		9.9	10.0	0.03696	
BBRI	12.10	2.1	9.9	20.8	0.0319	3.3 Accept ± 4.0
NPL	11.84		9.9	18.2	0.0308	
BBRI	48.85	0.5	10.4	22.4	0.03315	4.7 Accept ± 3.6
TNO	48.6		10.4	11.1	0.0316	
EMPA	12.5	4.0	9.0	10.0	0.0331	-1.0 Accept ± 3.6
IFT	12		9.0	9.8	0.0334	
EMPA	50.9	2.4	9.0	10.0	0.0340	-1.9 Accept ± 2.8
NPL	49.67		9.0	16.3	0.03463	

Table 5 Summary of the intercomparison measurements - thermal conductance

Lab ID Own/ Comp	Thickness (mm)	Thermal conductivity (W/m.K)	Thermal conductance (W/m^2.K)	Difference Thermal conductance Own-Comp Own (%)
NPL	11.57	0.0311	2.688	-0.2
EMPA	12.08	0.03252	2.695	
NPL	59.15	0.0345	0.5833	
BBRI	not done			
TNO	14.2	0.0323	2.275	-7.1
BBRI	13.93	0.03393	2.436	
TNO	49	0.0338	0.6899	-3.1
IFT	48.5	0.0345	0.7113	
IFT	9.8	0.0363	3.704	11.6
TNO	9.8	0.0321	3.276	
IFT	49.1	0.0353	0.7189	-3.4
EMPA	49.65	0.03696	0.7444	
BBRI	12.10	0.0319	2.636	1.3
NPL	11.84	0.0308	2.601	
BBRI	48.85	0.03315	0.6786	4.2
TNO	48.6	0.0316	0.6502	
EMPA	12.5	0.0331	2.648	-5.1
IFT	12	0.0334	2.783	
EMPA	50.9	0.0340	0.668	-4.4
NPL	49.67	0.03463	0.6972	

4.2 Areas of interest and concern in Phase 1.

4.2.1 Variation in the density of the EPS material

The density of the material selected by the five laboratories ranged from between 16 and 38 kg/m^3. After the meeting in January, IFT bought new higher density material from which they will make their calibration panels. The thermal conductivity values for this new material can be seen in Table 2 as specimens 11 and 12. The thermal conductivity of these materials will not be intercompared. The variation of thermal conductivity with density for the thin and thick materials can be seen in Graphs 1 and 2 respectively.

4.2.2 Variation of thickness of the EPS material

The thickness of the thin material ranges from between 8.8 mm and 13.9 mm and the thickness of the thick material ranged from between 48.5 mm and 59.15 mm.

4.2.3 Agreement between the thermal conductivity measurements

The level of agreement between the measured thermal conductivity values obtained by the different laboratories was rather mixed (See Table 4). The values obtained by the different laboratories for the thin and thick material are compared in Graphs 3 and 4 respectively.

In five cases the agreement is less than would be expected from the claimed uncertainty of the measurements.

The differences between NPL and EMPA with the 10 mm thick sample, seems to be explainable in terms of thickness. This can be seen in Table 5 which compares thermal conductances.

The agreement between the thickness measurements made to measure the thermal conductivity varied by up to 4.4%. If the thickness was measured in the apparatus then this may be due to the specimens being compressed to different amounts in the different apparatuses.

The λ values of the same material measured by different laboratories were all within ± 5%, except when TNO measured the IFT 10 mm thick material. The results from these two measurements have been re-examined but no mistakes were found. This material will be sent to NPL for an additional check measurement to be made before the project is completed.

The density of the IFT EPS material is 16.6 kg/m^3, which is quite low. Radiation heat transfer will be fairly high and so the difference between the two laboratories may be caused by different hot and cold plate emissivities. The TNO thermal value for the IFT material appears too low, as shown in Graph 1.

For a given density and mean temperature, the apparent thermal conductivity values of expanded polystyrene, measured in a guarded hot plate apparatus, will decrease with decreasing thickness. This is caused by the "thickness or plate effect" which is due to the radiant heat transfer in a thin layer of the EPS material adjacent to the hot and cold plates and the plates themselves. The thermal resistance of this layer is approximately proportional to the inverse of the total hemispherical emittance of the plates or surfaces in contact with the insulation[8]. It may be therefore be necessary to take the "thickness effect" into account when calculating the conductance of the glazed calibration panels as the glass may have a different emissivity to that of the hot and cold plates of the guarded hot plate apparatus used to make the thermal conductivity measurements.

The size of this "thickness or plate effect" increases with decreasing EPS density.
The relationship between the values measured for the thin and thick specimens by the different laboratories for their own EPS materials is shown in the Graph 5. It must be remembered that the density of the thick and thin materials are not identical and so the relationships shown in Figure 5 will have been influenced by the differences in the material densities as well as by the "thickness effect".

The graph shows that the thermal conductivity values measured by NPL, TNO, BBRI and EMPA for their thin material is lower than the values measured for their thick materials. This is expected. The thermal conductivity values measured by IFT for their thin material is, however, higher than the values measured for their thick materials. We should try to identify why this is so.

4.2.4 Thermal conductivity measurements remaining.

BBRI did not measure the NPL thick material because that would have required adding a "collar" of different EPS material around the central specimen to bring the sample up to the correct size. BBRI felt that this would have adversely affected their measurement accuracy. The NPL should have enough EPS material to send BBRI when they have made their glazed calibration panel.

4.3 Conclusions about the thermal conductivity measurements

The measurements show that five laboratories agree on the thermal conductivity of the EPS material to within an uncertainty of ± 3.6% (with the exception of the IFT thin material measured by TNO). This figure will be used as the uncertainty in the thermal conductivity values when the overall uncertainty of the calculated conductance of the glazed calibration panels are evaluated.

4.4 Conclusions about the thickness measurements

The measurement of thickness of the completed panel will need to be carried out as precisely as possible if the total uncertainty in the predicted conductance of the calibration panel is to be about ± 6%.

eg ± 2% of 20 mm is ± 0.4 mm total uncertainty

± 2% of 60 mm is ± 1.2 mm total uncertainty

5 FABRICATION DETAILS FOR THE GLAZED CALIBRATION PANELS

A note was sent to all participants describing in detail the outcome of the actions that were identified at the November 1995 meeting. A summary of the final fabrication specifications for the glazed calibration panels is given below.

Type of panel	• Both to be non-instrumented
Panel size	• Both panels:- (1198 ± 2 mm) x (1198 ± 2 mm)
Core material	• White EPS with a density of approximately 28 kg/m^3. The core of both panels to be made from the same sheets from which the thermal conductivity specimens were taken.
Core thickness	• Panel 1 approximately 12 mm thick EPS core • Panel 2 approximately 50 mm thick EPS core
Glazing material	• 4 mm thick toughened glass for both panels
Uncertainty of thermal conductivity measurements	• Not worse than ± 3.6%
Uncertainty of Panel thickness	• Not worse than ± 2%. Measure the average thickness of the EPS material and of the glazed calibration panel.

Construction details

- Toughened glass to be glued to EPS using Dow Corning 7091 compound in a 4 x 4 array of glue points (centres 70 / 353 / 353 / 353 / 70 mm).

- The adhesive to be approximately 35 mm final diameter

- Suggested method of applying the adhesive

  The method used at the NPL to produce an even adhesive "spot" is as follows. Metal "washers" with a 28 mm diameter hole and 0.5 mm thick are placed in the required array on the EPS surface. The holes are filled flush to the top surface with Dow Corning 7091 compound and then the washers are removed.

  The glass is put in position, ensuring that the edges are square to the EPS material. The joint is put under pressure by placing a 1.2 m x 1.2 m piece of 19 mm thick plywood on top of the glass and weighting with buckets filled with sand.

- **IT IS VERY IMPORTANT THAT THE GLASS IS THOROUGHLY CLEANED USING A SOLVENT SUCH AS ACETONE**

Edges Tape edges of panel to reduce the amount of moisture absorbed.

StorageAlways store and transport the panels in a dry environment.

Conductance If, for the purpose of calculating the conductance, the gap between the glass sheets is assumed to be only filled with EPS material, the error in the calculated conductance caused by the effect of the air gap, is given in Table 6. If the thickness of the EPS sheet and the glazed panel are both measured, then the effect of the air gap can be corrected for.

6 TRANSPORTATION OF THE PANELS BETWEEN LABORATORIES

This is a critically important issue. All panels MUST be transported in a box made from a frame of approximately 50 mm x 50 mm wood covered with stout plywood. The panel should be surrounded by EPS material, including the edges. The panel should be sealed in a plastic bag to ensure it stays dry.

The "crate" should be fitted with triangles of plywood at the bottom of each side to produce an "A" frame. This will ensure that the box will only stand upright. Suitable "fragile" and "This way up" labels will encourage people to keep the panels upright.

Every effort should be made to ensure that the panels are packaged soundly.

7 TIMETABLE AND INSTRUCTIONS FOR PHASE 2

22nd April 1996 Final panel fabrication specification to be sent to all participants by Ray Williams at NPL.

1st May 1996 All laboratories start to build the calibration panels

1st June 1996 Finish building calibration panels
Write brief report identifying any problems that might need solving before we proceed to the next step and circulate to all participants. Discuss by phone/fax.

1st July 1996 Start to measure our own calibration panels in the hot box as agreed. Details of the measurements required are given in Section 8.1 and details of the suggested method for mounting the thermocouples on the glass surface are given in Section 8.3.

1st September 1996 • Finish the hot box measurements on our own panels.

	• Finish report of these measurements and send to Ray Williams. • Buy the wooden boxes that are to be used in transporting the panels.
1st September 1996	Start to circulate the panels as specified at the 21st November 1995 meeting (see Section 9). Carry out the intercomparison measurements described in Section 8.2 as soon as a panel is received. Remember one panel will have to be sent to 4 laboratories. If we assume 2 weeks in transit and 2 weeks at each laboratory for measurements, the four months allowed will have been used up! **There is no margin for delay!**
1st January 1996	Finish the intercomparison measurements. Report of these measurements sent to Ray Williams.
15th February 1997	Draft final report written by Ray Williams sent to all participants.
12th March 1997	Final meeting to discuss draft final report and recommendations for the design and fabrication procedures to be included in a supplement to the CEN standards.
1st June 1997	Final report and design specification finished.

Table 6 Effect of air gap on the calculated conductance of the glazed calibration panels

For 1.2 m x 1.2 m glazed calibration panels

Estimates of the effect of assuming the air gap is full of EPS material.

Panel height	(m)	1.2	1.2	1.2	1.2	1.2	1.2
Panel width	(m)	1.2	1.2	1.2	1.2	1.2	1.2
Panel area	(m2)	1.44	1.44	1.44	1.44	1.44	1.44
Glass thickness	(m)	0.004	0.004	0.004	0.004	0.004	0.004
Glass thermal conductivity	(W/m.K)	1	1	1	1	1	1
Air gap thickness	(m)	0.0002	0.0005	0.0008	0.0002	0.0005	0.0008
Air thermal Conductivity	(W/m.K)	0.025	0.025	0.025	0.025	0.025	0.025
Area of air gap (less glue)	(m2)	1.4287	1.4287	1.4287	1.4287	1.4287	1.4287
EPS thickness	(m)	0.012	0.012	0.012	0.05	0.05	0.05
EPS thermal Conductivity	(W/m.K)	0.032	0.032	0.032	0.032	0.032	0.032
Glue thickness	(m)	0.0002	0.0005	0.0008	0.0002	0.0005	0.0008
Glue diameter	(m)	0.03	0.03	0.03	0.03	0.03	0.03
Glue area	(m2)	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071
Glue thermal Conductivity	(W/m.K)	0.2	0.2	0.2	0.2	0.2	0.2
Number of glue spots each side		16	16	16	16	16	16
Total area of glue	(m2)	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113
Resistance 2 off sheets glass	(K/W)	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
Resistance 1 side Air	(K/W)	0.0056	0.014	0.0224	0.0056	0.014	0.0224
Resistance 1 side glue	(K/W)	0.0884	0.221	0.3537	0.0884	0.221	0.3537
Total resistance air+glue 1 side	(K/W)	0.0053	0.0132	0.0211	0.0053	0.0132	0.0211
Total resistance air+glue 2 side	(K/W)	0.0105	0.0263	0.0421	0.0105	0.0263	0.0421
Resistance actual EPS	(K/W)	0.2604	0.2604	0.2604	1.0851	1.0851	1.0851

Resistance of EPS with gap as EPS	(K/W)	0.2691	0.2821	0.2951	1.0938	1.1068	1.1198
Res-actual EPS & air gap + glue	(m2.K/W)	0.3982	0.4209	0.4437	1.5857	1.6084	1.6312
res - ignore air gap	(m2.K/W)	0.3955	0.4143	0.433	1.583	1.6018	1.6205
% difference (Real-Assumed)/Real	(%)	0.67	1.58	2.4	0.17	0.41	0.65

8 DETAILS OF THE HOT BOX MEASUREMENTS TO BE MADE

8.1 On our own panels

The full CEN calibration measurement schedule should be carried out (that is each panel to be measured at three mean temperatures of 5, 10, and 15°C, keeping the hot box air temperature constant). Each laboratory should ensure that it has the latest version of prEN 1098 the standard relating to hot box measurements of glazing panels and and CEN TC 89 WG7 Document N216E rev.02.1995 (now prEN 12412) the standard relating to the hot box measurements of window systems. Care should be taken that the procedures described in these standards are followed exactly.

As the panels are 1.2 m x 1.2 m the requirements of the glazing standard prEN 1098 should be met. That includes using 50 mm beading to around the specimen edges on both the hot and cold sides.

8.2 On the panel(s) from other laboratories

This should be measured at a mean temperature of 10°C, with the hot air temperature at the same temperature as used for when measuring your own panels and with the same air flow. The surface of the specimen should be instrumented.

The thickness of this calibration panel should be measured using the technique you used with your own panel.

The results should be used to compare directly with those obtained using our own panel as well as to measure its U-value and conductance using the CEN technique.

8.3 Method of mounting surface thermocouples

- Thermocouples shall be made of wire with a maximum diameter of 0.25 mm

- The insulation shall be stripped back a minimum of 15 mm from the hot junction

- The thermocouple should be taped to the glass surface for a minimum of 100 mm.

- The tape should be of the paper "masking tape" type.

9 THE SCHEDULE FOR CIRCULATING THE CALIBRATION PANELS

For the 20 mm panel

TNO	to	BBRI
BBRI	to	IFT
IFT	to	EMPA
EMPA	to	NPL
NPL	to	TNO

For the 60 mm thick panel

IFT	to	NPL
NPL	to	BBRI
BBRI	to	EMPA
EMPA	to	TNO
TNO	to	IFT

- **An additional measurement was agreed.**

The thin panel made by EMPA or the thin panel made by NPL would continue around the circuit so that all the laboratories would have measured it. Which panel, will be decided nearer the time. This means that three of the laboratories will be making one additional measurement.

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