KARSTEN DUER

U-VALUE MEASUREMENTS ON ISO ROUND ROBIN WINDOW

REPORT

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DEPARTMENT OF BUILDINGS AND ENERGY

TECHNICAL UNIVERSITY OF DENMARK

TABLE OF CONTENT

1 INTRODUCTION

This report describes the results of the Danish part of the laboratory intercomparison of hot box measurements of a glazed window system using the procedures given in ISO/CD12567.

The following laboratories have participated in the round robin measurements:

National Physical Laboratory, UK.
Contact Ray Williams.

TNO Building and Construction Research, the Netherlands.
Contact Dick van Dijk.

EMPA, Switzerland.
Contact Thomas Frank or Thomas Nussbaumer.

Institut für Fenstertechnik e.V., Germany.
Contact Hans Hartmann.

Forschungsinstitut für Wärmeschutz e.V. München.
Contact J. Cammerer.

NRC-Institute for Research in Construction IRC.
Contact Hakim Elmahdy.

University of Massachusetts.
Contact Bill Goss

Swedish National Testing Institute.
Contact Bertil Jonsson.

Technical University of Denmark
Contact Svend Svenden or Karsten Duer.

2 DESCRIPTION OF THE WINDOW

The window is build from PVC-U-frames and measures 1480 mm high x 1230 mm wide. The glazings are 4-16-4 mm with one float glass pane outermost and one Pilkington K-glass pane innermost (low e-coating in position 3). The gap between the glass panes is airfilled and the spacer material is aluminium. The window has three glazing parts, one glazing is fixed, one is side hung and one is top hung.

3 CALIBRATION PANELS

Two calibration panels have been constructed in order to perform the hot box calibration procedure outlined in ISO/CD 12567. The panels measure 1480 high x 1230 wide as the round robin window and have a total thickness of 28 and 68 mm respectively.

The core material is blue extruded polystyrene which prior to the assembling has been ground plane in order to avoid or at least reduce variations in the material thickness. The core thickness is 20 and 60 mm respectively.

The glazings on both sides of the core are 4 mm float glass with normal emissivity.

The panels are assembled simply by means of heavy duty tape, no glue has been used in this process.

The thermal conductivity λ has been measured for the two sample thicknesses, 20 and 60 mm. The measurements were performed on the same material samples that were used in the calibration panels.
The thermal conductivity was determined at only one mean temperature of the polystyrene, 20°C, and the λ-values at the relevant temperatures were found by assuming a change in the thermal conductivity as a function of temperature of 0.4%/K, using the following expression:

$$\lambda_t = \lambda_{20} - \frac{(20 - t) \cdot 0.4 \cdot \lambda_{20}}{100}$$

where t is the actual temperature of the core material during calibrations.

The results of the two measurements are:

20 mm polystyrene: $\lambda_{20} = 0.033$ W/mK

60 mm polystyrene: $\lambda_{20} = 0.036$ W/mK

4 GUARDED HOT BOX

The hot box measurements were performed in a guarded hot box. Maximum sample size is 1500 x 1250 mm and the meetering box measures 1600 x 1350 mm inside. The guarded hot box is build and the measurements are performed in accordance to ISO 8990 and ISO/CD12567 with a few exceptions:

- No wind speed measurements are carried out during measurements but the windspeed on the cold side has previously been measured to ensure that the windspeed here is at least 2 m/s.

- Due to limitations in the cooling system it has not been possible to obtain a cold side temperature below -3.7°C during calibration with the 28 mm calibration panel and -4.1°C during calibration with the 68 mm panel.

- The thin calibration panel is >20 mm.

Prior to each calibration or U-value measurement the meetering box is tested for air tightness in order to assure that no air will be exchanged between hot and cold side.

5 CALIBRATION MEASUREMENTS

The two calibration panels were both tested at three different temperature levels on the cold side of the guarded hot box, ~-4°, ~0°C and ~10°C. The temperature on the warm side was kept constant at 20°C.

At the first calibration test the cold side temperature was 0°C and the wind speed on the cold side was regulated in order to obtain the standard total surface resistance coefficient of 0.17 m²K/W. After the first calibration the windspeed (or rather the voltage for the fan) was kept constant for the rest of the measurements.

From the known thermal resistance of the calibration panels the surface resistance as a function of heat flux density through the panel as well as the surround panel heat exchange coefficient as a function of surround panel mean temperature can be found. The results are shown in figure 1and 2
In table 1 on p. 6 is shown the key results from the calibrations.

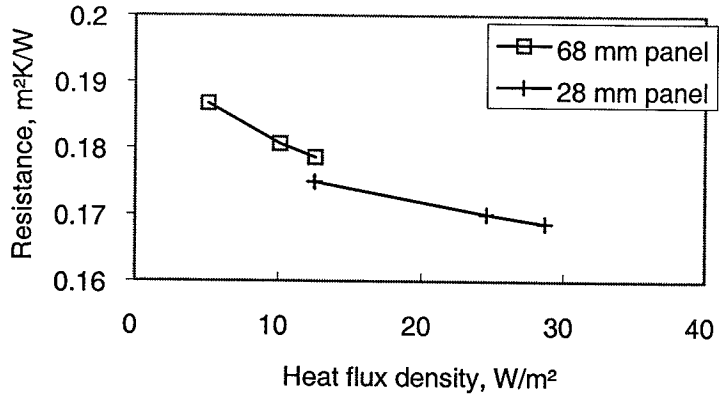

Figure 1 *Total surface resistance versus heat flux density. From calibrations*

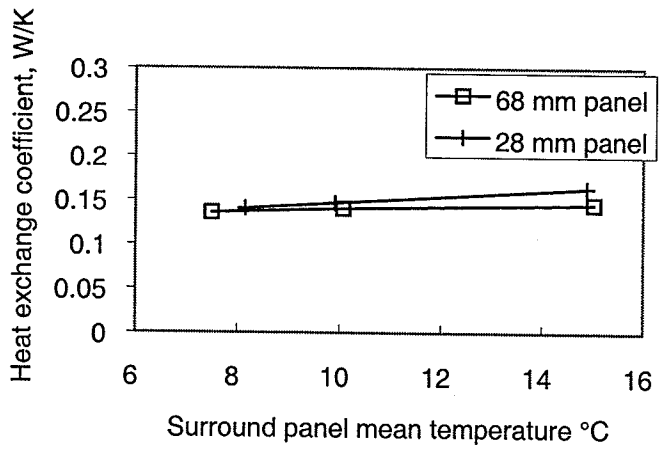

Figure 2 *Surround panel heat exchange coefficient. From calibrations.*

Table 1. Key results from calibrations

	28 mm	28 mm	28 mm	68 mm	68 mm	68 mm
Panel mean temp [°C]	7.20	9.07	14.40	7.10	9.72	14.82
Env. temp. diff [K]	23.42	19.94	10.08	24.58	19.59	9.76
Panel surface temp diff [K]	18.57	15.77	7.88	22.34	17.76	8.81
Heat flux q_{cal} [W/m²]	28.72	24.56	12.54	12.57	10.11	5.12
Surf. resist.[m²K/W]	0.169	0.170	0.175	0.179	0.181	0.187
Power to box [W]	55.47	47.55	24.43	26.11	21.05	10.68
Surround panel temp. diff [K]	22.70	19.33	9.75	23.79	18.92	9.41
Surround panel mean temp. [°C]	8.16	9.92	14.88	7.50	10.08	15.02
Surround panel heat exchange coef. [W/K]	0.140	0.147	0.164	0.136	0.140	0.146

6 U-VALUE MEASUREMENTS

6.1 Mounting of the window

The window was mounted in the hot box aperture with the frame face flush with the face of the cold side of the surround panel.
The interface between the surround panel and the window was taped on both warm and cold side to secure that no air could penetrate the interface. The parts of the window that can be opened were taped on the warm side only.

6.2 Sensor locations

Nine thermocouples were mounted on each side of the window measuring the surface temperature of the glazing parts of the window.

6.3 Results

The following results were obtained from the U-value measurement:

Warm side:	
Air temperature	20.00°C
Baffle temperature	19.57°C
Reveal temperature:	18.29°C
Glazing temperature:	15.50C
Cold side:	
Air temperature	0.08°C
Baffle temperature	0.28°C
$\Delta T_{surround\ panel}$	18.85°C
Glazing temperature:	1.97°C

Electrical input to warm side heater: 70.96 W

Heat flux through surround panel: 2.71 W

$q_c =$ 37.49 W/m²

$\Delta T_n =$ 19.57 K

U_m = 1.92 W/m².

ΔT_n has been calculated in accordance to ISO 12567 Annex A using the surface temperature of the center of the largest glazing in the window as the sample surface temperature. ΔT_n is not very dependant on the sample surface temperature. A parameter variation of the surface temperature on the warm and cold side shows that changing the surface temperature +/- 2°C on both sides results in a maximum change in ΔT_n of +/- 0.9%.

Due to the relatively large thickness of the smallest calibration panel the R_s curve in figure 1 does not cover the actual heat flux density from the U-value measurement. However the slope of the curve is decreasing with increasing heat flux density and from an extrapolation of the curve in figure 1 the total surface resistance coefficient during the U-value measurement is estimated to:

$R_{s,tot} = 0.1654$ m²K/W

Now the standard U-value can be found from the following expression:

$U_{st} = [1/U_m + 0.17 - R_{s,tot}]^{-1}$

U_{st} = 1.9 W/m²K