APPLICATION**NOTE**

Heat Flow Meter (HFM) with Instrumentation Kit: Measurements on Pyrex® – in Good Agreement with the Laser Flash Analysis (LFA) and Literature

Fabia Neidhardt, Dr. Marc-Antoine Thermitus and Robert Campbell

1 HFM 436/3/1 *Lambda*

2 LFA 467 *HyperFlash*®

Introduction

The Heat Flow Meter (HFM) technique is a well-known and accepted method to determine the thermal conductivity of insulating materials like EPS, rock-wool or glass-fiber boards. Also building materials like concrete with higher thermal conductivity and stiff structure can be investigated with the HFM. The Instrumentation Kit extends the measurement range up to 2 W/(m·K). This application note describes the Instrumentation Kit in detail, and presents data obtained on Pyrex® with the HFM 436/3/1 (figure 1). Its effectiveness is demonstrated by correlating the data with the Laser Flash Analysis (LFA, figure 2) technique.

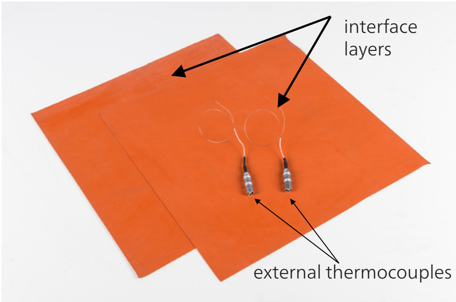
Instrumentation Kit

When testing insulating materials with the HFM technique, the interface thermal resistances between the specimen and the HFM plates are usually negligible, relative to the specimen´s thermal resistance. In case of high conductive and/or stiff samples, this assumption is no longer valid. Even if the specimen´s surfaces are very flat and plane-parallel, there always remain some small air gaps at the interface, leading to significant differences between the plates´ and the specimen´s surface temperatures, and an inhomogeneous heat flow through the sample. To avoid these shortcomings, the Instrumentation Kit is necessary. It

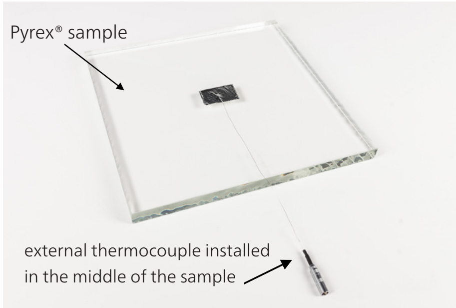
NGB · Application Note 084 · E · 03/15 · Technical specifications are subject to change.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com

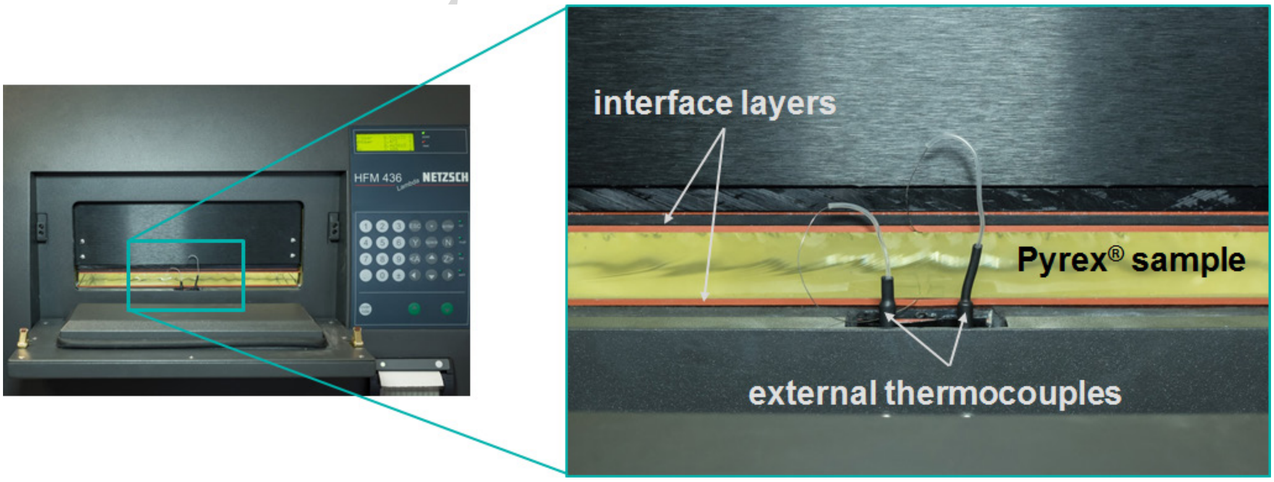
NETZSCH



3 Instrumentation Kit: Interface layers and external thermocouples



4 Pyrex® sample with installed external thermocouplce



5 Pyrex® sample with Instrumentation Kit inside the HFM

consists of two external thermocouples, and of two interface layers (figure 3). The interface layers improve the thermal contact between the plates and the specimen, while the external thermocouples are in direct contact to the specimen's surfaces (figure 4) and therefore measure the exact and "true" surface temperatures (figure 5).

Comparison of Measurement Data on Pyrex® Using the HFM with Instrumentation Kit and LFA Technique

The performance of the Instrumentation Kit is demonstrated with Pyrex®, a homogeneous, chemically stable and well-known thermal conductivity reference material since the 1960´s with a thermal conductivity of about 1.14 W/(m·K) at 23°C [1].

The reported data were carried out on specimens measuring 300 mm x 300 mm x 20 mm with and without Instrumentation Kit. The calibration of the heat flux sensors was achieved with a NIST certified glass-fiber board (1450D) without instrumentation kit, in accordance with ASTM C 518. Three different Pyrex samples (A, B, C) from the same batch were tested. Two samples (1, 2) with a diameter of 12.7 mm and a thickness of 2.5 mm were also prepared from the same batch for the LFA tests. The measurements were performed with the LFA467 *Hyperflash*®.

Table 1 shows the results at 23°C from different HFM and LFA tests. The small standard deviation (1.7%) of the HFM tests demonstrates the good reproducibility of the method. The mean thermal conductivity of 1.15 W/(m·K) shows a deviation of only 0.88% to the mean value from LFA and literature. This proves the accuracy of the HFM measurements with the Instrumentation Kit.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com

Tab. 1 Thermal conductivity of Pyrex® at 23°C using HFM and LFA

Method	Sample / Measurement	Thermal Conductivity W/(m·K)	Mean Thermal Conductivity W/(m·K)
HFM	Pyrex A	1.13	1.15
	Pyrex B	1.17	
	Pyrex C	1.14	
HFM	Pyrex **without** Instrumentation Kit	0.53	0.53
LFA	Pyrex – 1	1.14	1.14
	Pyrex – 2	1.14	

Without the Instrumentation Kit, the high thermal contact resistance and the unknown surface temperatures lead to a thermal conductivity of 0.53 W/(m·K), significantly lower than the expected value.

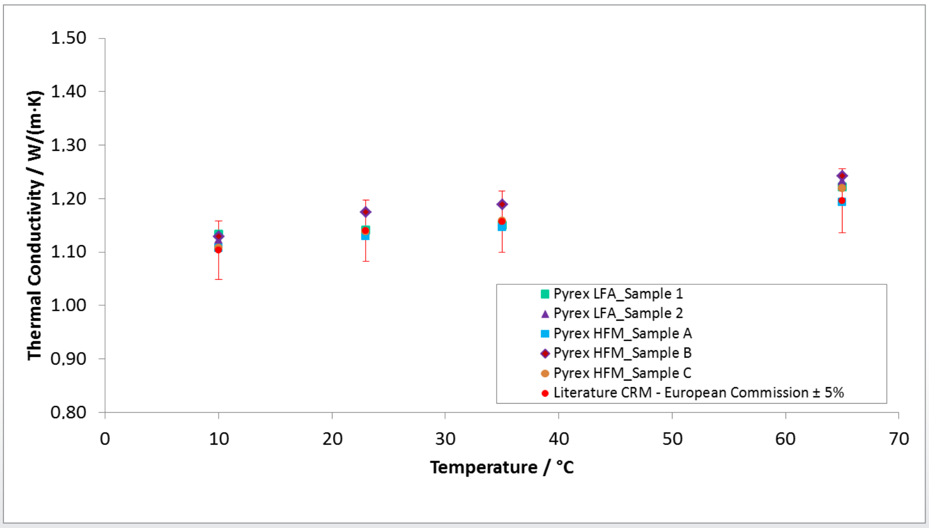
Figure 6 depicts results from 10°C to 65°C with the HFM, the LFA and literature values (error bars ± 5%). Over the whole temperature range, the HFM and LFA results are in good agreement with literature values (max. deviation 2.8% – LFA and 3.9% – HFM).

Summary

The thermal conductivity of stiff materials up to 2 W/(m·K) can be reliably investigated with the HFM, provided that the surface temperatures are accurately measured. This is achieved with the Instrumentation Kit, which ensures a homogeneous heat flow and true specimen´s surface temperatures. The data of the HFM measurements with the Instrumentation Kit are highly reproducible and in good agreement with the results from the LFA technique and literature. Furthermore, the long term stability qualifies Pyrex® as a material of choice for verifying the performance of the HFM with Instrumentation Kit prior to measuring unknown, high conductive samples.

Literature

[1] I. Williams, R. E. Shawyer: Certification report for a pyrex glass reference material for thermal conductivity between -75°C and 195°C; Commission of the European Communities; Luxembourg; 1991



6 Thermal Conductivity of Pyrex® from 10°C to 65°C measured with HFM and LFA compared to literature values

NGB · Application Note 084 · E · 03/15 · Technical specifications are subject to change.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com