Hukseflux
Thermal Sensors

THISYS

APPARATUS FOR THERMAL CONDUCTIVITY MEASUREMENT OF THIN SAMPLES

THISYS offers an accurate, fast and uncomplicated measurement of the thermal conductivity of thin samples of high thermal conductivity materials. Typical samples are sheet materials of metals, alloys and high conductivity plastics with various filler materials. Metal samples are ideally in the thickness range of 0.1 mm and less, plastic samples typically in the thickness range of 6 mm, composites in between. THISYS is a combination of a Thin Sample Instrument (THI01) and a Measurement and Control Unit (MCU). The measurement essentially determines the temperature gradient across the sample when it is heated, in the plane of the sample itself. Employing a specially designed high accuracy thermopile sensor THI01 can handle thin sample materials (less than 0.01 to 6 mm) usually in the thermal conductivity range to 200 W/mK. Following this method, problems with contact resistance are avoided. The method is a good alternative when procedures according to ASTM D5470 are failing. Using a climate chamber a large temperature range can be covered, performing measurements at regular intervals. THISYS is fully PC controlled. For use with low thermal conductivity materials a different model, type THASYS, is available.

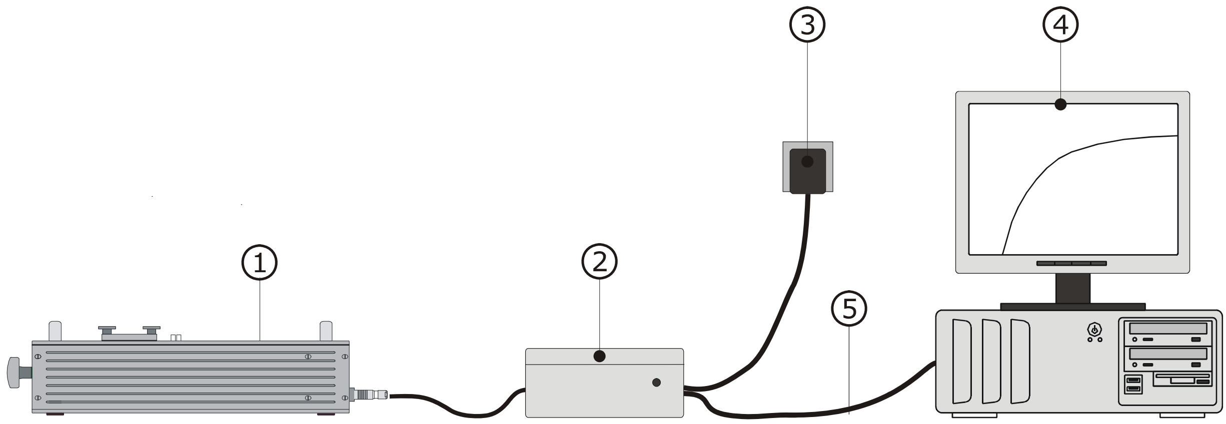

Figure 1 *THISYS consists of the Thin Sample Instrument (THI01), (1) and a Measurement and Control Unit (MCU), (2). It is PC controlled though RS232 (4, 5). The PC is not included. The measurement result appears on screen automatically. The THI01 housing contains two heat sinks in a bath of glycerol. It has a slot on top through which the sample is inserted. The sample is heated on two sides. One heater also contains the hot joints of the thermopile sensor. The sample plus heater are then pressed together with the heat sinks using a screw on the side, creating a perfectly symmetrical setup. The glycerol fluid eliminates the problem of contact resistance.*

INTRODUCTION

The measurement of thin materials with relatively high thermal conductivity is a classic problem. Commonly used methods like ASTM D 5470 – 01 (Standard Test Method for Thermal Transmission Properties of Thin Thermally Conductive Solid Electrical Insulation Materials) have shown to be highly sensitive to contact resistance, and not applicable with high conductivity materials. THISYS offers a solution to this problem.

THISYS essentially measures the temperature gradient from centre to side across the sample when mounted across a well insulated cavity, and heated with a known uniform flux.
By measuring the flux φ (derived from heater power), the differential temperature across the sample, ΔT_{amp}, and the sample thickness, H, it is straightforward to calculate the relative thermal conductivity λ_{rel}:

$$\lambda_{rel} \sim \varphi \;/\; H\, \Delta T_{amp}$$

The measurement is performed relative to a known reference material.

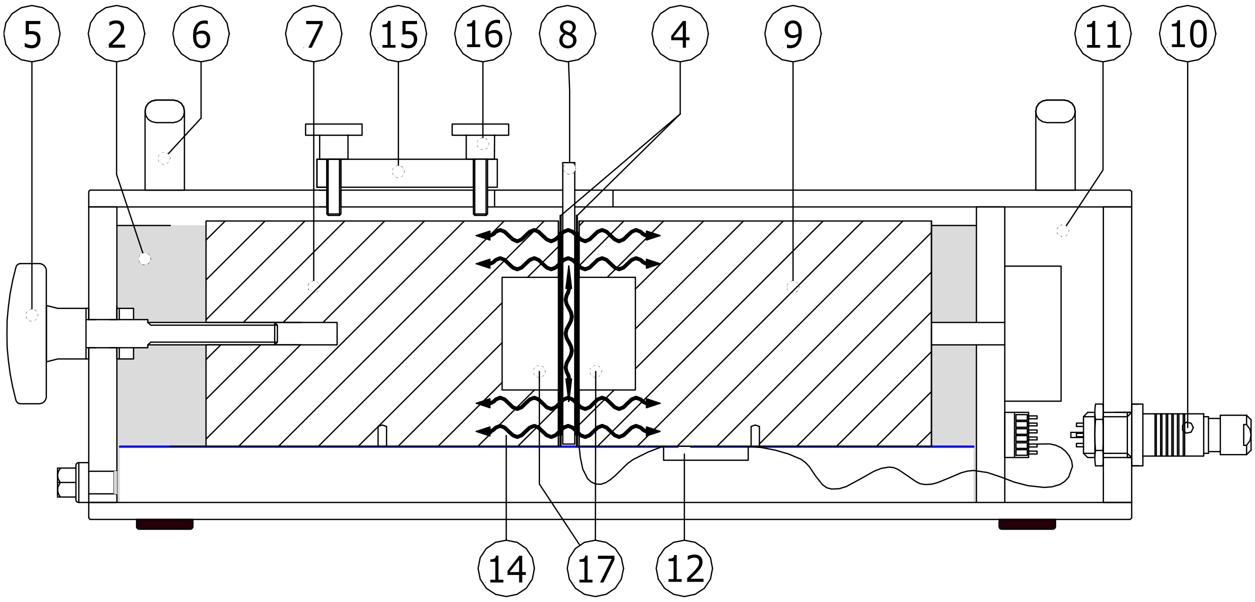

Figure 2 *THI01 geometry: heat sinks (7, 9). sample material (8), air filled cavities (17), heaters (4). Heat generated by the heaters first flows in the plane of the sample and only after that into the heatsinks (14).*

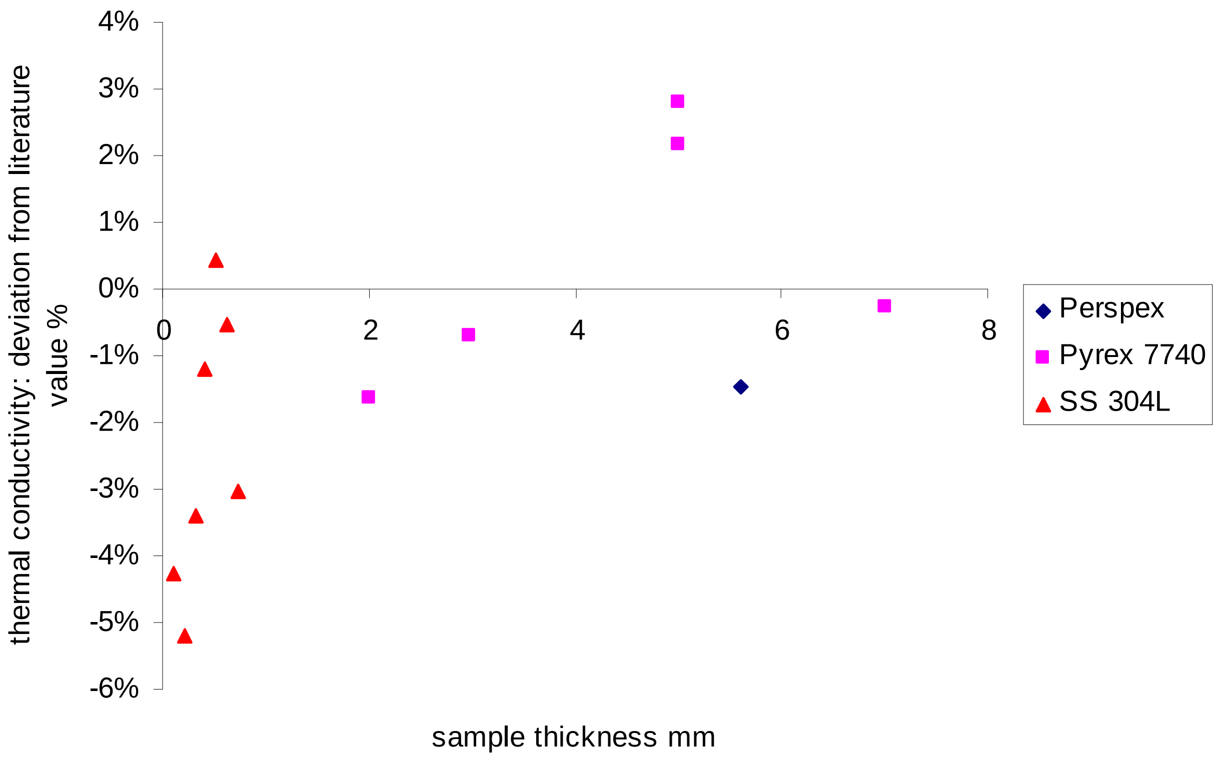

Figure 3 *Test results with THISYS: Measurements were performed with Pyrex 7740 (2 to 7 mm), Perspex reference standard from NPL (5.62 mm) and Stainless Steel type 304L (stacked from 0.1 to 0.7 mm). The test shows a remarkable accuracy level of +/- 6% relative to literature values (1.086, 0.188 and 14.34 W/mK respectively).*

THI01 DESIGN

The Hukseflux THI01 employs two aluminium "heat sinks". Each of these contains a heater that is mounted over an air-filled, insulating cavity. The sample is installed over the cavities.
The resulting temperature gradient (centre-edge) is measured. Apart from the new design, the technological novelties are a thin thermocouple thermopile (proprietary Hukseflux design) performing an accurate and ultra-sensitive differential ΔT measurement, and the fact that the measurement is performed in a bath of glycerol.

The THI01 can handle samples of less than 0.01 to 6 mm thickness. Samples typically are sheet materials with a size of 70 by 100 mm.
The reference material is 5 mm Pyrex 7740 material. The thermal conduction in the sheet plane, H x λ, is around 4 10^{-3} W/K. Samples ideally have values of H x λ close to that.

The measurement essentially is done at the temperature of the THI01. If necessary the temperature can be changed by putting the whole THI01 in a climate chamber, performing measurements while the instrument temperature changes across the required range. In a simplified description, the measurement consists of a heating cycle and a measurement to establish ΔT. The THI01 temperature is monitored by a Pt100 temperature sensor to correct for the temperature dependence of the thermopile sensitivity.

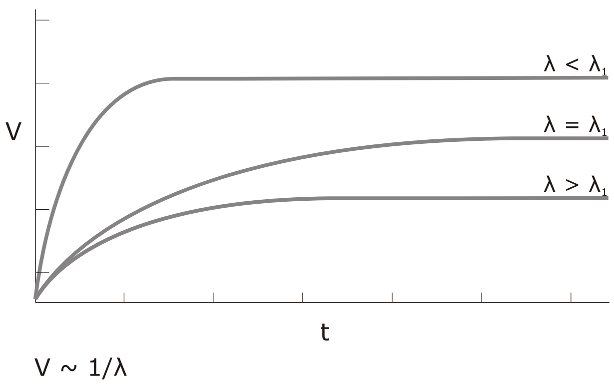

Figure 4 *Analysis of several samples of filled plastics using the THISYS. The graphs represent the signals when putting the heater on. The signal amplitude is inversely proportional to the thermal conductivity λ multiplied by the thickness H.*

MCU DESIGN

The MCU performs the functions of measurement and control as well as data storage. It is PC operated. Software in a Windows environment is part of the delivery. The parameters cycle time, sample thickness and heater area are entered and the experiment is started from the screen.

CALIBRATION

Depending on the samples to be analysed, various reference samples can be offered. Typically Pyrex 7740 is used. The Pyrex sample thermal conductivity is traceable to NPL. THISYS is suitable for use by ISO certified laboratories.

SUGGESTED USE

- High thermal conductivity sheet materials
- Metal alloys
- High thermal conductivity composite materials

MORE INFORMATION / OPTIONS

Please consult the manual for a full list of THI01 specifications. This manual is available free of charge as a PDF file via e-mail. For use with low thermal conductivity materials the model THASYS is available.

THI01 SPECIFICATIONS

Test method:	Thin sample analysis
Temperature range:	-30 to +120 °C
Accuracy (λ_{ref}) (depending on samples):	depending on reference, typically +/- 6% @ 20 °C with H x λ around 4 10^{-3} W/K
Repeatability (λ_{ref}):	+/- 2% @ 20 °C
Total measurement time:	3000 s (typical)
Power requirements (switched):	15 V, 0.8 Watt (typical)
Heater (resistance, diameter):	50 Ohm, 80mm
Sample requirements:	H = up to 6 mm, H x λ = 1 to 5 10^{-3} W/K
Sample surface A:	preferred: 70 x110 mm, always > 50 x 50 mm
Temperature sensing Pt100:	Class B, IEC 751:1983
Traceability:	NPL National Physical Laboratory UK

MCU SPECIFICATIONS

Differential temperature readout:	0.5 µV @ 0 - 30 °C
Pt100 readout:	+/- 0.2 °C @ 20 °C
Voltage input/output:	220-110 VAC / 15 VDC
Communication:	RS232