NETZSCH

Heat Flow Meter

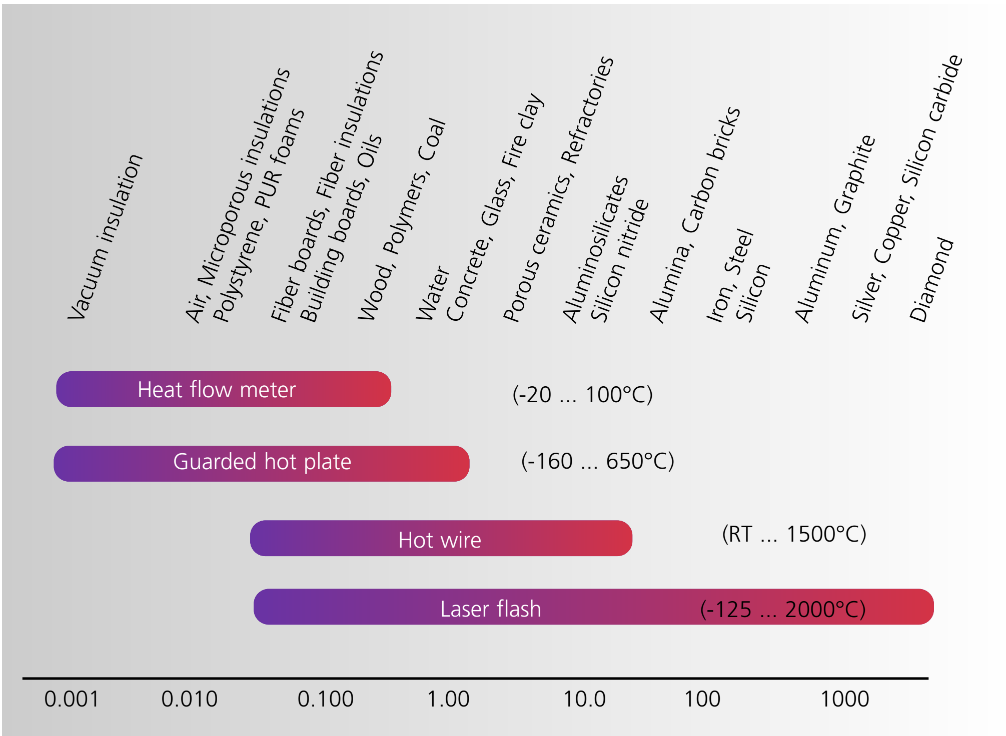
Leading Thermal Analysis.

HFM 436

Lambda™

Thermal Conductivity Testing

What is the heating/cooling load of a building? How does this change with the weather, and how can I improve it? How can I improve the heat transfer from an electronic component? How do I design a heat exchanger system to achieve the required efficiency, and what are the best materials to use? To answer questions like these, material properties such as thermal diffusivity and thermal conductivity must be known. Various testing methods can be employed to test the countless number of materials and possible configurations. To analyze a fiber insulation or a vacuum insulation panel, a heat flow meter or guarded hot plate is usually used. For highly conductive ceramics, metals or diamond composites, other methods such as laser flash give more accurate results. NETZSCH offers a broad range of thermal conductivity testing instruments covering nearly all possible applications and temperature ranges. For the analysis of lower-conductivity materials, NETZSCH offers various types of heat flow meters for diverse sample dimensions and temperature ranges.



Thermal Conductivity at RT in W/m·K

NETZSCH also offers a complete family of flash diffusivity instruments for measuring the thermal diffusivity and conductivity of small samples, multi-layer samples and highly conductive materials.
To measure refractory materials, the TCT 426 hot wire system can be used. High-temperature differential scanning calorimeters (DSC 404 F1/F3) to measure specific heat, and dilatometers (DIL 402 C series) to analyze density and length changes, are available as well.

Heat Flow Meters HFM 436 *Lambda*™ *Series*

Heat flow meters are accurate, fast and easy-to-operate instruments for measuring the thermal conductivity of low-conductivity materials such as insulations. The heat flow meter is a calibrated instrument which tests according to ASTM method C 518, ISO 8301, JIS A1412 and DIN EN 12667. A sample is placed between a hot and a cold plate and the heat flow created by the well-defined temperature difference is measured with a heat flux sensor. The HFM 436 *Lambda*™ series owes its speed of measurement and precision to the patented temperature control and heat flux measurement technology. Test results are available in minutes, with outstanding accuracy and repeatability.

Low maintenance costs

The Lambda's state-of-the-art cooling technology works with a Peltier cooling system and requires no external chillers (except for the HFM 436/6 and /1E models) and no CFC or water supply, thereby improving reliability and avoiding maintenance cost and time. The patented plate temperature control system and dual heat flux sensors quickly provide accurate data.

Excellent stability

The instrument is stable within 0.10 - 0.25% over the course of several days, providing excellent repeatability. This allows the use of quick tests as a reliable indicator of product variability during a production run. Over extended periods of time, this is valuable for conducting aging studies or examining the long-term consistency of a product.

Short testing times

Steady-state stability criteria can often be met in approx. 15 minutes, resulting in greater laboratory throughput and productivity gains. Due to the dual heat flux transducer arrangement, k-factors are consistently within 0.5% of the fully-stabilized value in less than 20 minutes, and for many samples, repeatability of 15-minute tests is typically within a few tenths of a percent.

Thickness determination

The HFM 436 *Lambda*™ comes with an integrated µm-resolution LVDT system, allowing automatic determination of the samples' actual thickness within a few seconds.

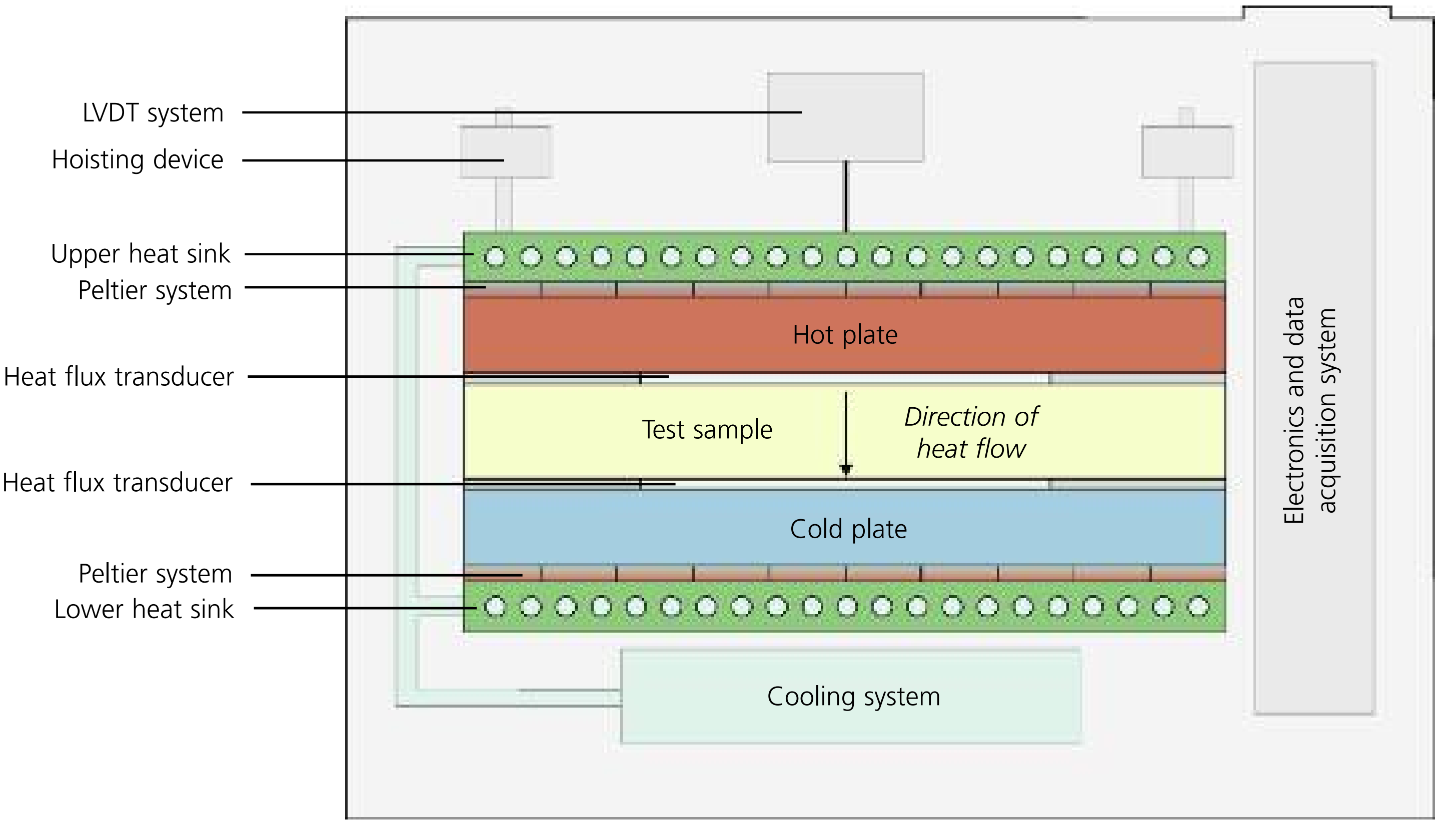
FEATURES

- Precise, stable & accurate
- Fast and easy to use
- Automated operation
- Quick test setup and launch
- Fully self contained – no chiller required
- QC estimates in under 15 minutes
- patented plate temperature control system US-patent No. 5,940,784 (1999)

Principle of Operation

The user places the sample between two heated plates controlled to a user-defined mean sample temperature and temperature drop. Thermocouples embedded in the plate surfaces measure the temperature drop across the sample. The temperatures of the plates are controlled by Peltier systems. Cooling/heating of the Peltier systems is done using an integrated fluid circle. The fluid is back-cooled by an integrated forced air cooling system. For very low temperatures, the forced air cooling system can be replaced by an external chiller (HFM 436/6/1 and /1E versions). Heat flux transducers mounted on each plate measure a voltage proportional to the heat flow through the sample. Steady thermocouple and transducer readings indicate thermal equilibrium. Readings are recorded and a test at a new temperature can begin. The use of two heat flux transducers improves the test speed (to ~ 15 min, per sample) for quality control.

The instrument is calibrated with an NIST-certified reference standard of known thermal conductivity. This establishes a relation between the voltage signal of the transducers and the heat flow through them. Thermal conductivity is calculated from the calibration data, the sample thickness and the temperature drop across the sample. Of course, the operator can use any other standard material for the calibration of the unit.



Schematic design of the NETZSCH HFM 436/3/1 *Lambda*™ (Plate temperatures between 0 and 100°C)

Standard Software Features:

All HFM 436 *Lambda*™ heat flow meters operate on the internal Q-Test software package on an embedded microprocessor. Tests can be set up and run entirely from the front keypad, and results can be printed directly from the instrument. Using the external 32-bit Windows® Q-Lab software allows enhanced flexibility in programming, instrument monitoring and data handling and storage. Input of a temperature program, data acquisition and analysis are, of course, standard features of the software.

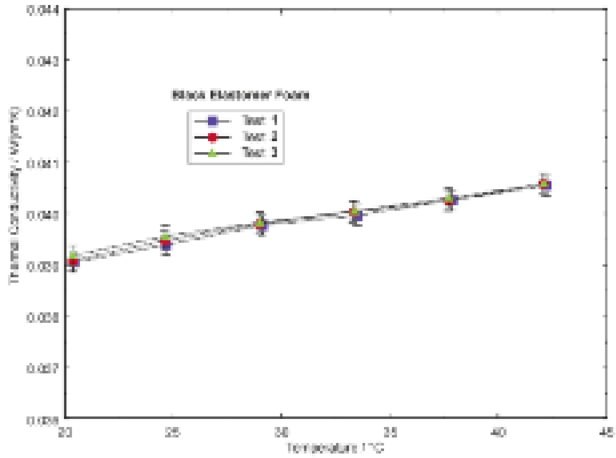
Standard software features:

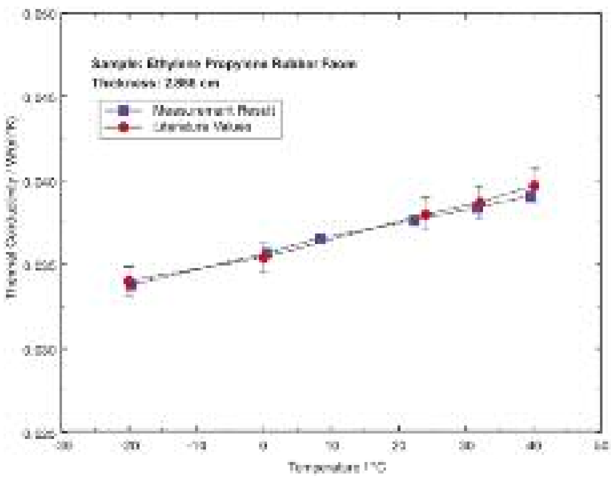
- easy input of test parameters
- storage and restoration of calibration files
- storage and restoration of measurement results
- monitoring of plate/mean temperatures, thermal conductivity results and heat flux transducer outputs.

	HFM 436/3/0 *Lambda*™	HFM 436/3/1 *Lambda*™	HFM 436/3/1E *Lambda*™	HFM 436/6/1 *Lambda*™
Plate Temperature Ranges:	Fixed, 0 to 40°C	Variable, 0 to 100°C	Variable, -30 to 90°C	Variable, -20 to 70°C
Cooling System:	Forced Air	Forced Air	External Chiller	External Chiller
Plate Temperature Control:	Peltier System	Peltier System	Peltier System	Peltier System
Programmable Data Points:	1	10	10	10
Specimen Size:	300 x 300 x 100 mm^3	300 x 300 x 100 mm^3	300 x 300 x 100 mm^3	600 x 600 x 200 mm^3
Thermal Resistance Range:	0.1 to 8.0 $m^2 \cdot K/W$	0.1 to 8.0 $m^2 \cdot K/W$	0.1 to 8.0 $m^2 \cdot K/W$	0.1 to 8.0 $m^2 \cdot K/W$
Thermal Conductivity Range:	0.005 to 0.50 W/m·K	0.005 to 0.50 W/m·K	0.005 to 0.50 W/m·K	0.005 to 0.50 W/m·K
Repeatability:	0.5 %	0.5 %	0.5 %	0.5 %
Accuracy:	± 1 to 3 %	± 1 to 3 %	± 1 to 3 %	± 1 to 3 %
Dimensions (LxWxH):	48 x 63 x 51 cm^3	48 x 63 x 51 cm^3	48 x 63 x 51 cm^3	80 x 95 x 80 cm^3

Performance - HFM 436 *Lambda*™ *Series*

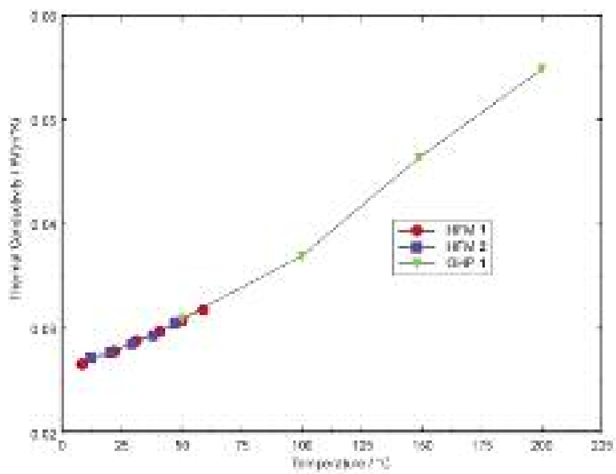
Reproducibility: Elastomer Foam
The HFM 436 Series instruments carry out measurements with outstanding repeatability and reproducibility. Presented here are the results of three measurements on the same black elastomer foam. The sample was measured three times between 20 and 42°C. After each test, the sample was removed from the instrument, turned over and measured a second time. All measurement results are in agreement within 0.5% (error bars), demonstrating the unsurpassed reproducibility of the HFM 436 heat flow meter system.





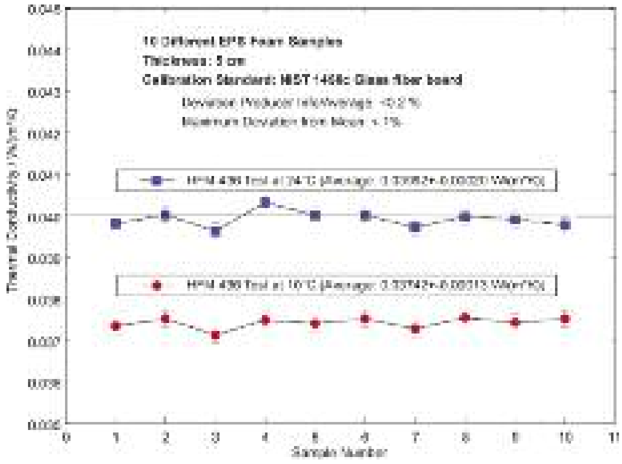
Accuracy: Ethylene Propylene Rubber Foam
Presented here are the measurement results on an ethylene propylene rubber foam, measured with an HFM 436/3/1E. Additionally shown are literature values for this material supplied by the customer. It can clearly be seen that the measurement results are in agreement with the corresponding literature data within 2.5%. Furthermore, it can be seen that the HFM 436/3, connected to an external chiller, can perform measurements even at temperatures of -20°C.

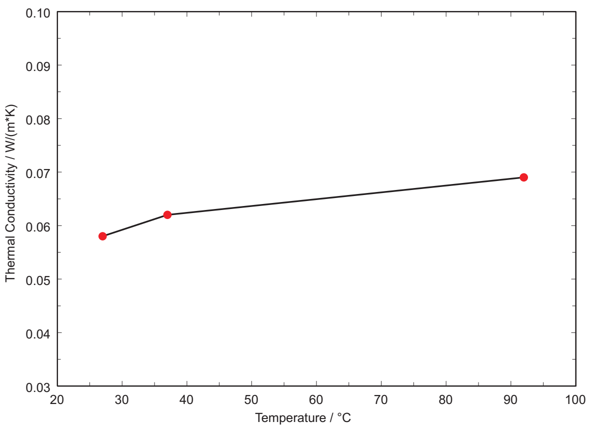
Accuracy: Nanoporous Insulation
How does a measurement in a heat flow meter compare to measurements with other standardized techniques such as guarded hot plate (GHP)? As part of a Round Robin Test, a nanoporous insulation board was measured with different NETZSCH heat flow meters as well as with a guarded hot plate system (absolute measurement technique). The results obtained by the different instruments are in agreement within 2.5% in the overlapping temperature range. Furthermore, the results show nearly the same temperature dependence. This clearly demonstrates the outstanding performance of the HFM 436 Series instruments.



Applications - HFM 436 *Lambda*™ *Series*

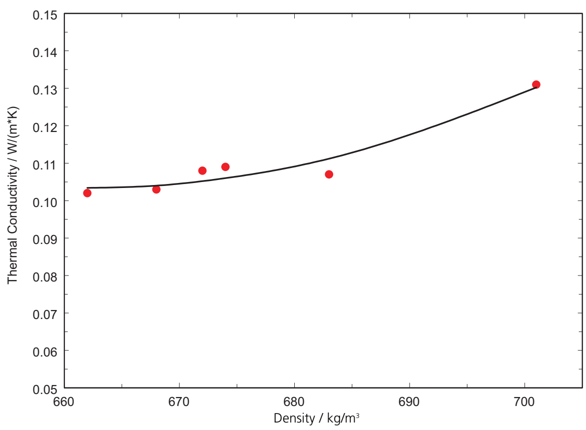
Expanded Polystyrene:
One of the most popular materials for the thermal insulation of buildings is expanded polystyrene. The example shows a quality control run on a commercially available expanded polystrene material (EPS 040). Ten samples of the same batch were tested at 24°C and, according to DIN EN 13163, at 10°C. It can clearly be seen that the deviation between the different samples is less than 1%. The determined λ90/90 value according to DIN EN 13163 was 0.03808 W/(m*K).





Cellular Glass:
The thermal conductivity of a cellular glass can be quickly and accurately analyzed using an HFM 436 *Lambda*™ heat flow meter system. The density of this sample was 144 kg/m³. As with bulk glass material, the thermal conductivity of the cellular glass sample increases with temperature. Of course, due to the high porosity of the material, the thermal conductivity is lower than that of a typical bulk glass by a factor of approximately 20.

Syntactic Foam:
Syntactic foams are used, among other applications, for the insulation of undersea pipelines. Here, insulating materials are important for keeping the oil at an elevated temperature to avoid thickening. The thermal conductivity of a syntactic foam was tested with the HFM 436 *Lambda*™. Samples were measured at different packing densities, showing that the thermal conductivity increases with density in a non-linear fashion. The scattering of the data can be explained by inhomogeneity in the material.



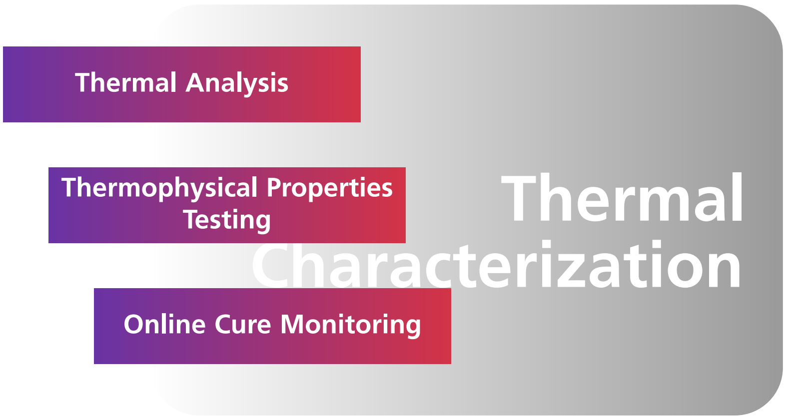
Testing Services

Are you interested in the thermal characterization of your material but reluctant to invest in an instrument? NETZSCH has the solution. NETZSCH Contract Testing Services offers an unrivaled range of instruments and methods for the analysis of your materials. We offer a wide range of thermal characterization services conducted by our experienced staff of scientists and engineers. You receive sound advice, accurate data, and real solutions for your thermal design problems from an unbiased, independent source. Contact us for further details.

State-of-the-Art Thermal Characterization with NETZSCH

Knowledge of the thermal characteristics of materials is critical to material development and design in every modern industry. Researchers who need reliable thermal analysis, thermophysical property or cure monitoring data turn to the state-of-the-art instruments and services offered by NETZSCH.

Our DSC, TG, STA, DIL, DMA, DEA and TMA instruments form the core of the NETZSCH Thermal Analysis instrument line, allowing measurement of dielectric properties, dimensional or mass changes and transformation energetics between -260 and 2800°C.
The DSC 404 F1/F3, DIL 402 C and the different LFA models, as well as the thermal conductivity instrument family, are well established components of the NETZSCH thermophysical properties world.



NGB · HFM 436 · E · 1000 · 0508 · MMM

NETZSCH

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb/Germany
Phone: +49 9287 881-0 · Fax: +49 9287 881-505
E-mail: at@netzsch.com

www.netzsch.com