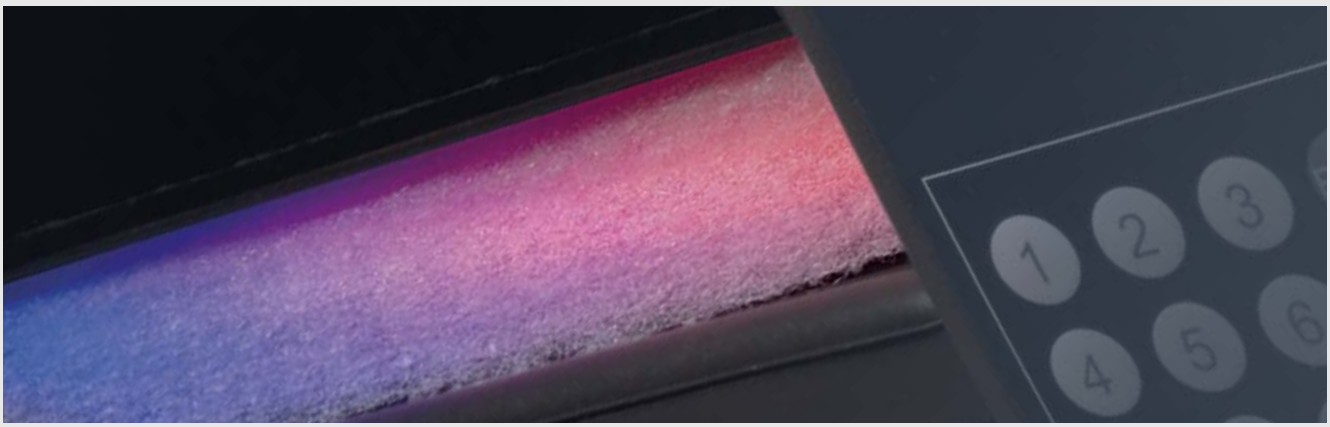
NETZSCH

Analyzing & Testing

Heat Flow Meter – HFM 436 *Lambda*

High Precision Instrument for Testing Insulating Materials
Compliant to ASTM C518, ISO 8301, JIS A1412 and DIN EN 12667



Leading Thermal Analysis

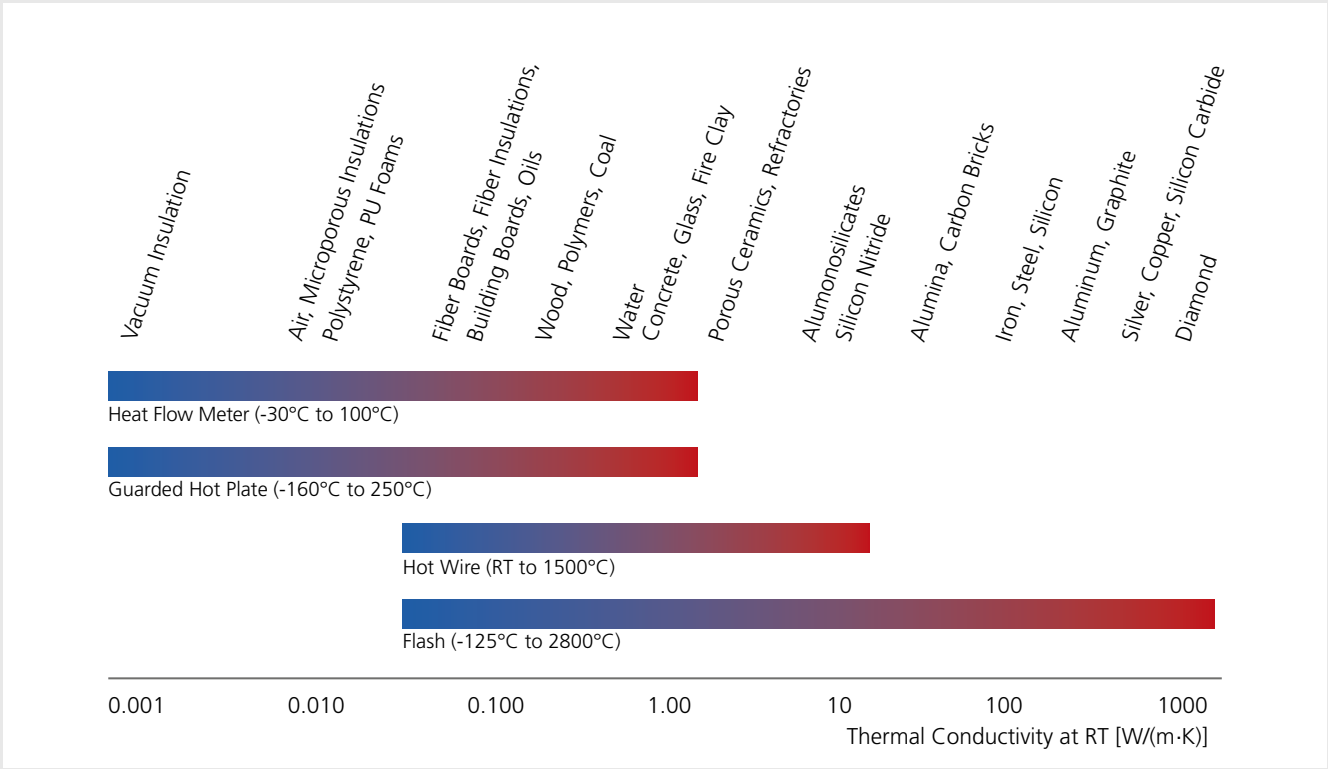
Thermal Conductivity: A Key Parameter for Improved Energy Efficiency

Overview of Methods

The Right Instrument for Every Application

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.



* plate temperature

NETZSCH also offers a complete family of flash diffusivity instruments for determining 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: The Solution for Measuring Thermal Conductivity

Instrument Characteristics

Heat Flow Meters (HFM) are exact, fast and easy-to-use instruments for measuring the thermal conductivity (λ) of low-conductivity materials such as insulations. The HFM is a calibrated instrument which performs tests according to ASTM C518, ISO 8301, JIS A1412 and DIN EN 12667. A specimen 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 owe its precision and speed of measurement to the patented temperature control and heat flux measurement technology. Test results are available within minutes, with outstanding accuracy and repeatability.

Excellent Stability

The instrument is stable within 0.10 to 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 also 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 sensor arrangement, conductivity values are consistently within 0.5% of the fully stabilized value in less than 15 minutes, and for many samples, repeatability of 15-minute tests is typically within a few tenths of a percent.

Complete Autonomy
Low Maintenance Cost

The HFM 436 *Lambda* can operate as a stand-alone instrument, without the assistance of a computer. The built-in printer produces a summary report, with a concise table of test results.
The state-of-the-art cooling technology works with a Peltier cooling system and requires no external chiller (except for the HFM 436/3/1/E and 436/6/1 models) or water supply, thereby improving reliability and avoiding maintenance cost and time.

Thickness Determination

The HFM 436 *Lambda* comes with an integrated µm-resolution transducer, allowing the measurement of the actual specimen's thickness within few seconds.

HFM 436 *Lambda* with the built-in printer

Instrumentation Kit

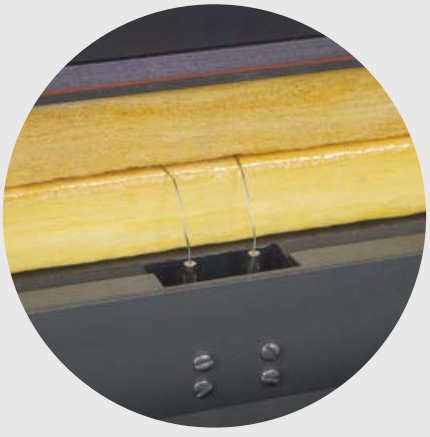
The HFM 436 *Lambda* can be equipped with an optional instrumentation kit that extends its range to higher thermal conductivity materials like concrete, wood products, brick. These materials are normally beyond the capability of the HFM, and often rigid, which can lead to a higher, non-uniform interface thermal resistance. The optional kit includes thin, compressible pads for use at both interfaces, and auxiliary thermocouples to be placed on the surfaces of the specimen.

Variable External Load

A new feature unique to the HFM 436 *Lambda* allows the operator to apply a precise load on the specimen, enabling control of the thickness, and thus density, of compressible materials. This optional feature also ensures that the plates make intimate contact with the specimen across the entire surface in order to produce a minimal and uniform contact resistance, two necessary requirements for obtaining reproducible thermal conductivity results.

Enhanced Capabilities

- Integrated printer
- Variable load
- Extendable to higher conductivity materials with the optional instrumentation kit



Optional instrumentation kit with the two additional, easy to install thermocouples

Quick and Easy Measurements in Compliance with International Standards

Principle of Operation

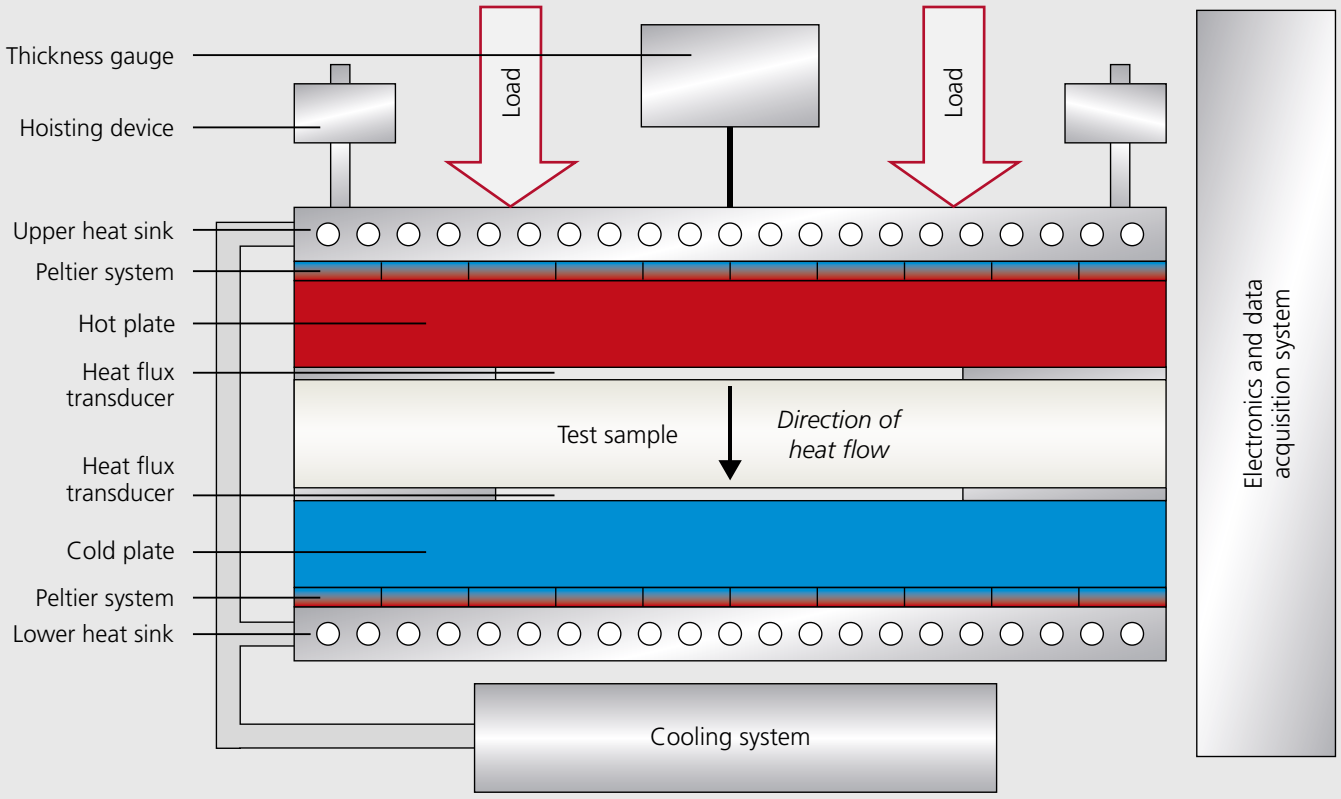
The user places the sample between two heated plates controlled to a user-defined mean sample temperature and temperature drop. The plate temperatures are controlled by bidirectional Heating/Cooling Peltier systems, coupled with a closed loop fluid flow with an integrated forced air heat exchanger. The extended range versions (HFM 436/3/1/E and 436/6/1 include an external chiller for reaching lower temperatures. Data are continuously acquired, processed and stored by the integrated electronics, and upon completing the test, all relevant results are printed out. The expected faster testing times (~15 min/sample) in a quality control environment are achieved with the two heat flux transducers configuration.

Features

- Precise, stable & accurate
- Fast and easy to use
- Automated operation
- Quick test setup and launch
- Fully self contained – no computer or external chiller required
- Printer output
- Variable load
- QC estimates in under 15 minutes
- Extendable to higher conductivity materials
- Patented plate temperature control system US-Patent No. 5,940,784

Thanks to a carefully designed test chamber, loading heavy and thick specimens is made easy.

The instrument is calibrated with a NIST-certified reference standard of known thermal conductivity. Other standard materials to be selected by the operator can also be used for calibratin. This establishes the precise correlation between the signal output of the transducers and the actual heat flow. Thermal conductivity is calculated once the user-defined equilibrium criteria are met. Of course, the operator is welcome to use any other standard material for calibrating the unit.



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

Additional Information

www.netzsch.com/n25823

The Q-Lab Software Makes Measurements Easy

Software Features

All HFM 436 *Lambda* heat flow meters operate on the internal Q-Test software package on an embedded micro-processor. Tests can be set up and run entirely from the front keypad, and a hard copy of the results will be produced by the integrated printer.

The external Q-Lab software runs under Windows® operating system, and allows enhanced flexibility in programming, instrument monitoring and data handling and storage. Input of temperature steps, 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.

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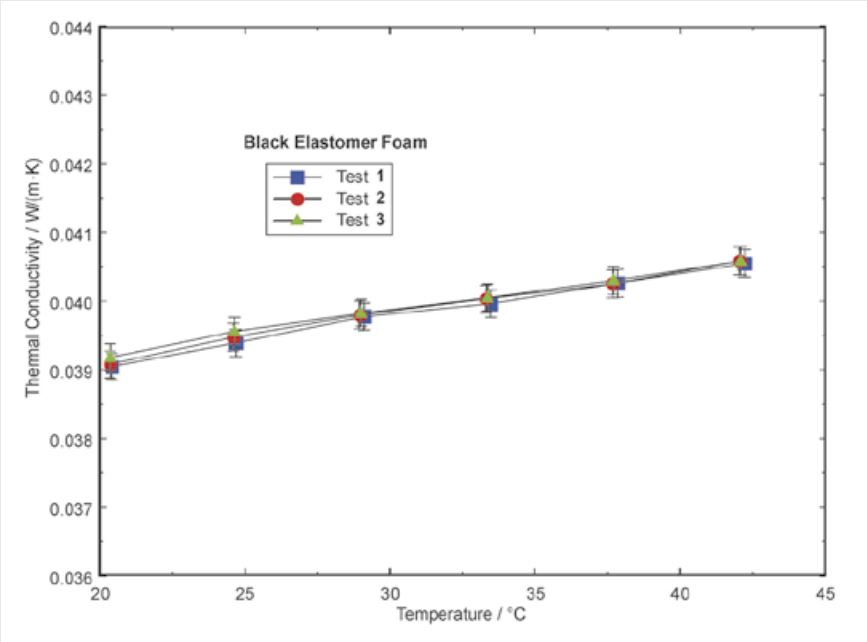
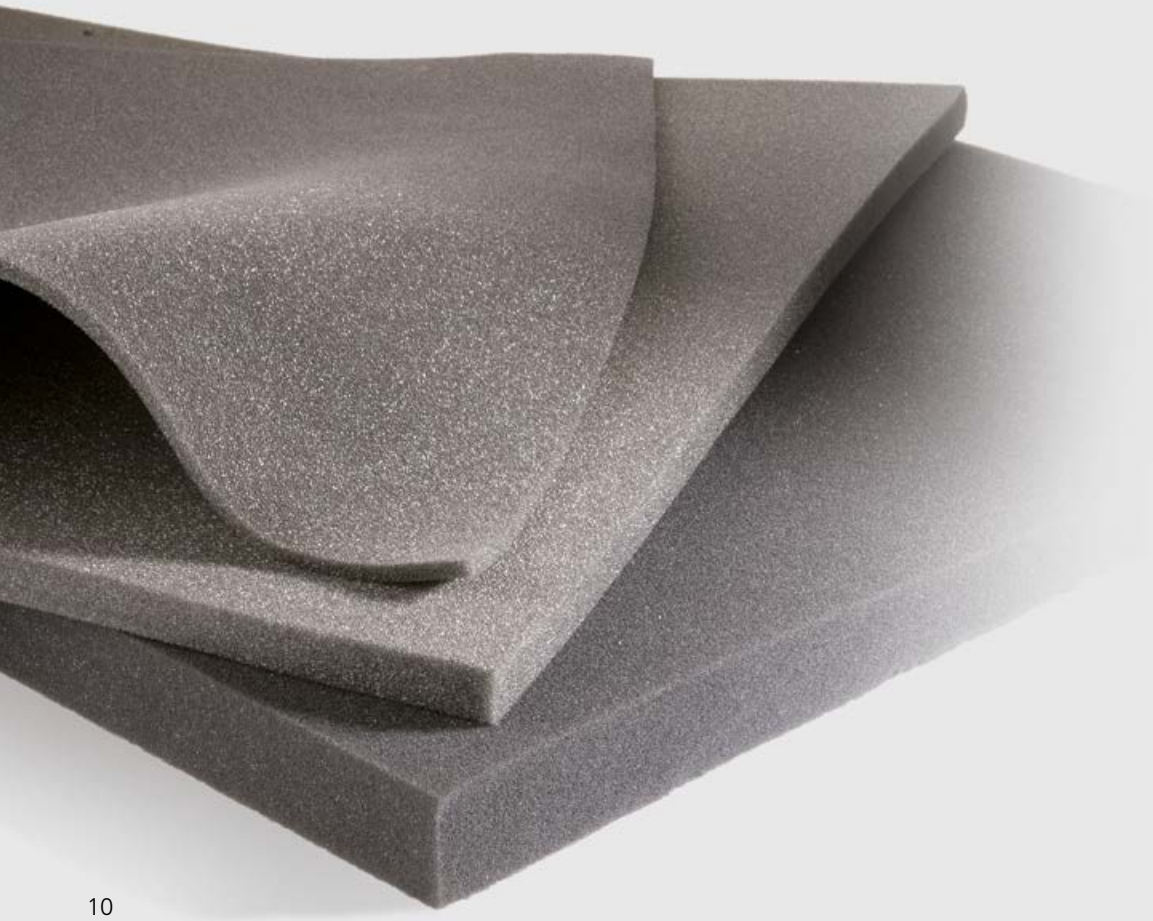
Proven Performance in R&D and QC

Reproducibility: Elastomer Foam

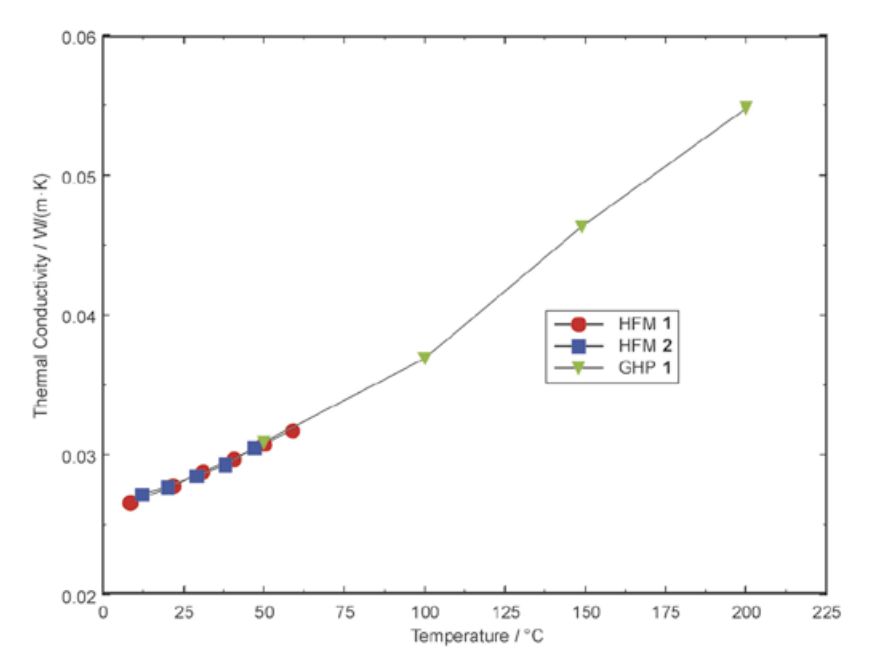
The HFM 436 series instruments carry out measurements with outstanding repeatability and reproducibility. Presented here are the results of three measurements on the same black elastomer foam. The sample was measured three times between 20°C and 42°C. After each test, the sample was removed from the 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.

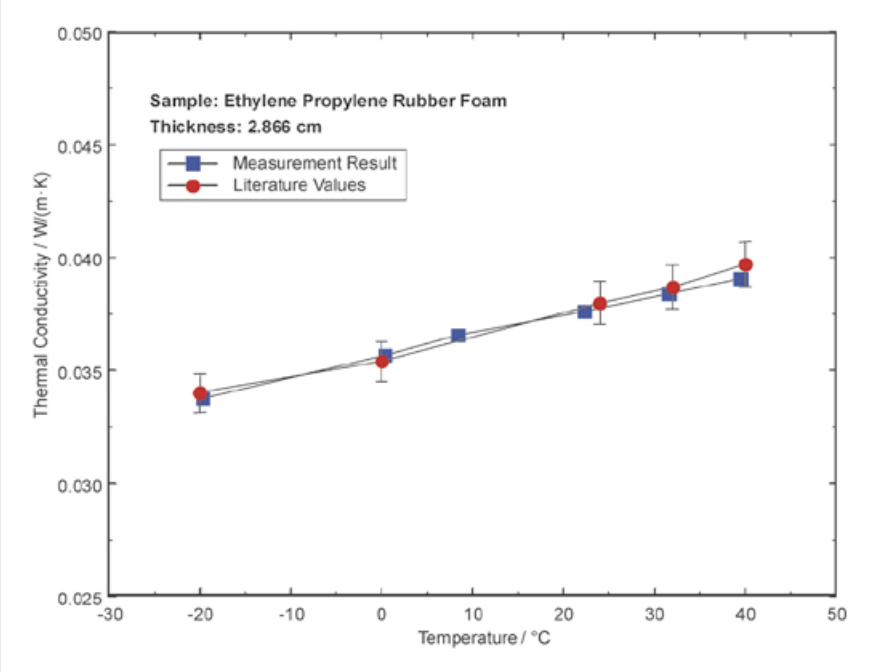




Accuracy: Nanoporous Insulation

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.

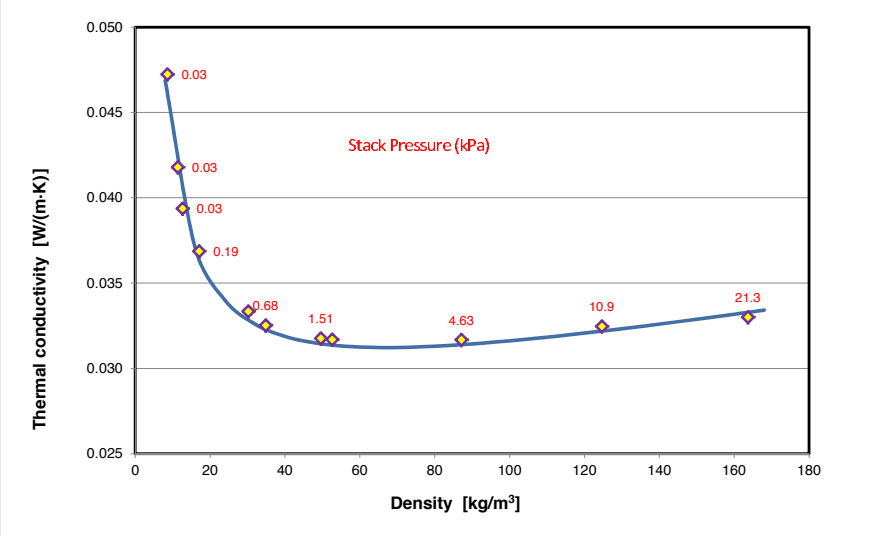




Accuracy: Ethylene Propylene Rubber Foam

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 at the sample.

Examples of Applications: Accurate and Reliable Results

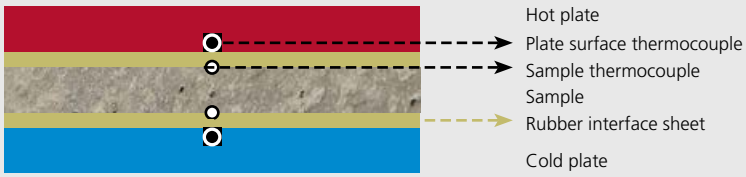


Variable Load

With the variable load feature, the density-conductivity correlation of compressible materials can be investigated. The case study presented here validates the expected multi-mode heat transfer within glass-fiber insulations. While the specimen is progressively compressed with an increasing load, here represented by the equivalent surface pressure, the combined conductivity first decreases due to a reduction in radiative heat transfer, and then increases as conductive heat transfer becomes more predominant.

High-Conductivity Materials

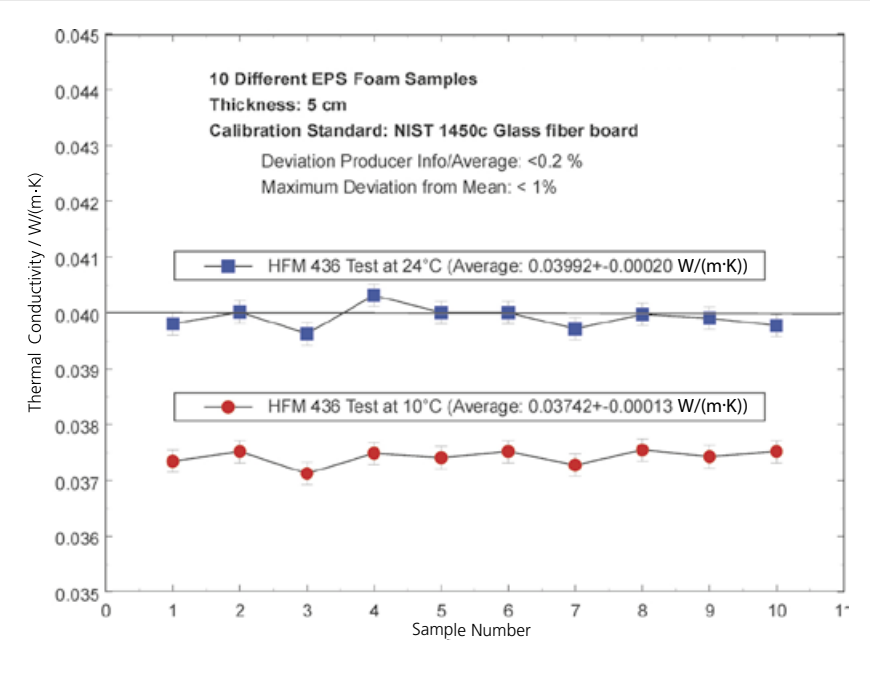
The use of the instrumentation kit is critical for high conductivity materials. Test results on three types of concrete specimen demonstrate excellent agreement with the well established Guarded Hot Plate method.
For thermal conductivity between 1.2 to 1.9 W/(m·K), the differences ranged from 2% to 4%.



Sample	Thickness (mm)	Density (kg/m³)	Mean temperature (°C)	Thermal conductivity (W/(m·K))	Thermal resistance (m·K/W)
A1, A2 (GHP)	51.4	2297	25.2	1.76	0.0292
A1 (HFM)	51.7	2298	23.4	1.92	0.0269
A2 (HFM)	51.1	2296	23.8	1.69	0.0303
A1, A2 (avg., HFM)	51.4	2297	23.6	1.80	0.0286
Variation				2.4%	

EPS Foam

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 polystyrene 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).



Technical Key Data

	HFM 436/3/0	HFM 436/3/1	HFM 436/3/1E	HFM 436/6/1
Plate Temperature Ranges	Fixed, 0°C to 40°C	Variable, 0°C to 100°C	Variable, -30°C to 90°C	Variable, -20°C to 70°C
Cooling System	Forced Air	Forced Air	External Chiller	External Chiller
Plate Temperature Control	Peltier System	Peltier System	Peltier System	Peltier System
Thermocouple Precision	± 0.01°C	± 0.01°C	± 0.01°C	± 0.01°C
Number of Programmable Temperatures	1	10	10	10
Specimen Size (L x W x H) mm	305 x 305 x 100	305 x 305 x 100	305 x 305 x 100	610 x 610 x 200
Thermal Resistance Range	0.05 to 8.0 m^2·K/W	0.05 to 8.0 m^2·K/W	0.05 to 8.0 m^2·K/W	0.1 to 8.0 m^2·K/W
Thermal Conductivity Range	0.002 to 2.0 W/(m·K)*	0.002 to 2.0 W/(m·K)*	0.002 to 2.0 W/(m·K)*	0.002 to 1.0 W/(m·K)
Repeatability	0.25%	0.25%	0.25%	0.25%
Accuracy	± 1 to 3%	± 1 to 3%	± 1 to 3%	± 1 to 3%
Dimensions (L x W x H) mm	480 x 630 x 510	480 x 630 x 510	480 x 630 x 510	800 x 950 x 800
Variable Load	Up to 21 kPa	Up to 21 kPa	Up to 21 kPa	No
Instrumentation Kit	Available	Available	Available	No

*with extension set

Our Expertise – Applications Laboratories

The NETZSCH Thermal Analysis applications laboratories are a proficient partner for nearly any Thermal Analysis issue. Our involvement in your projects begins with proper sample preparation and continues through meticulous examination and interpretation of the measurement results. Our diverse methods and over 30 different state-of-the-art measuring stations will provide ready-made solutions for all your thermal needs.

Within the realm of thermal analysis and the measurement of thermo-physical properties, we offer you a comprehensive line of the most diverse analysis techniques for materials characterization (solids, powders and liquids).

Measurements can be carried out on samples of the most varied of geometries and configurations. You will receive high-precision measurement results and valuable interpretations from us in the shortest possible time. This will enable you to precisely characterize new materials and components before actual deployment, minimize risks of failure, and gain decisive advantages over your competitors.

For production problems, we can work with you to analyze concerns and develop solutions. The minimal investment in our testing and services will reward you with reduced down time and reject rates, helping you optimize your processes across the board.

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The NETZSCH Group is a mid-sized, family-owned German company engaging in the manufacture of machinery and instrumentation with worldwide production, sales, and service branches.

The three Business Units – Analyzing & Testing, Grinding & Dispersing and Pumps & Systems – provide tailored solutions for highest-level needs. Over 3,000 employees at 163 sales and production centers in 28 countries across the globe guarantee that expert service is never far from our customers.

When it comes to Thermal Analysis, Adiabatic Reaction Calorimetry and the determination of Thermophysical Properties, NETZSCH has it covered. Our 50 years of applications experience, broad state-of-the-art product line and comprehensive service offerings ensure that our solutions will not only meet your every requirement but also exceed your every expectation.

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