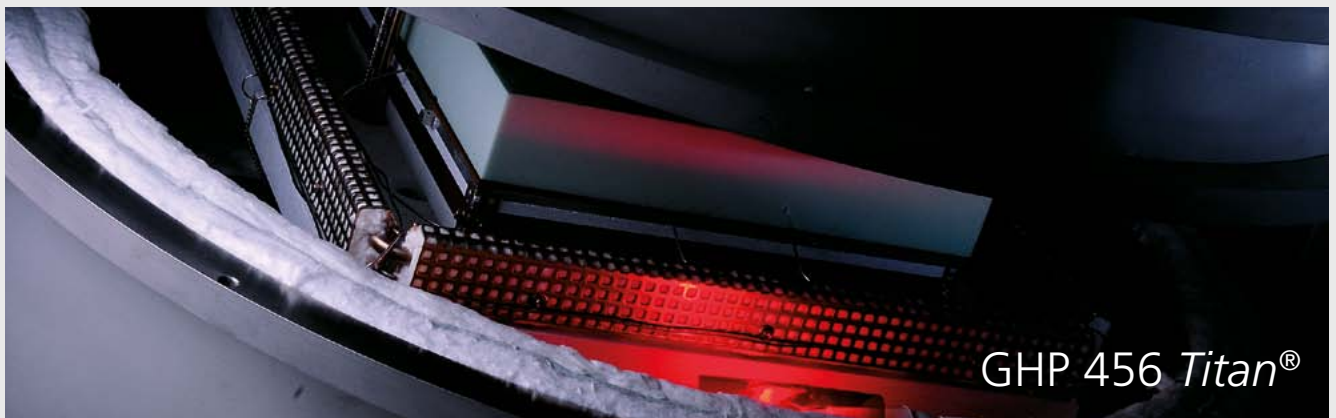


Guarded Hot Plate - GHP

Method, Instrumentation, Applications



GHP 456 Titan® - Guarded Hot Plate System

GHP 456 Titan® - Principle of Operation

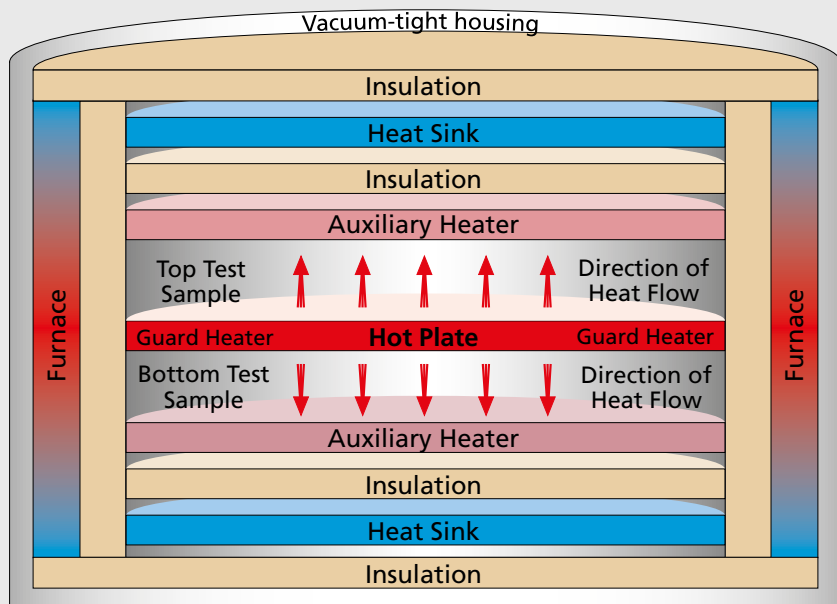
How is a particular insulation material performing? How can I insulate cryo tanks in the best possible way? What is the optimum insulation for furnaces operating at different temperature, gas or pressure conditions?

In order to answer questions like these, a versatile and reliable, easy-to-operate thermal conductivity tester for insulating materials is required. Plate-type instruments are generally used for such kinds of

applications. However, these are generally quite limited in temperature and difficult to handle up to now.

The new NETZSCH GHP 456 Titan® is the ideal tool for researchers and scientists in the field of insulation testing. Based on the well-known, standardized guarded hot plate technique (e.g. ISO 8302, ASTM C 177 or DIN EN 12667), the system features unrivaled performance over an unmatched temperature range.

The GHP principle is based on an absolute measurement method and therefore requires no calibration standards. It offers optimum accuracy regardless of the temperature range of interest. Combining cutting-edge technology with the highest quality standards, NETZSCH has designed a robust and easy-to-operate instrument, featuring unparalleled reliability and optimum accuracy over a wide temperature range.



The hot plate and the guard ring are sandwiched between two samples of the same material and approximately the same thickness (Δx). Auxiliary heaters (cold plates) are placed above and below the samples. The cold plates are heated such that a well-defined, userselectable temperature difference (ΔT) is

established between the hot and the cold plates (over the sample thickness). The power input in the hot plate with area A is then measured as soon as thermal equilibrium is reached. Using the measured sample thicknesses, temperatures and power inputs, the thermal conductivity can be

determined from the steady-state heat transfer equation:

$$\dot{Q} = -\lambda \cdot 2 \cdot A \cdot \frac{\Delta T}{\Delta x}$$

λ = thermal conductivity
 \dot{Q} = heat flow

GHP 456 *Titan*[®] - Technology

The NETZSCH GHP 456 *Titan*[®] combines the latest developments in material science and electronics with state-of-the-art design and technology. Innovative plate materials allow higher operating temperatures (250°C) without the risk of thermally induced

deformation. Various cooling options are available for the system; pressurized air can be used to cool the heat sinks to 50°C, while the LN2 system enables measurements down to -160°C (mean sample temperature). This makes it the ideal tool for researchers and quality

control engineers in a broad field of high-performance insulation materials. The vacuumtight design allows measurement under well-defined atmospheres such as inert and oxidizing as well as under vacuum.

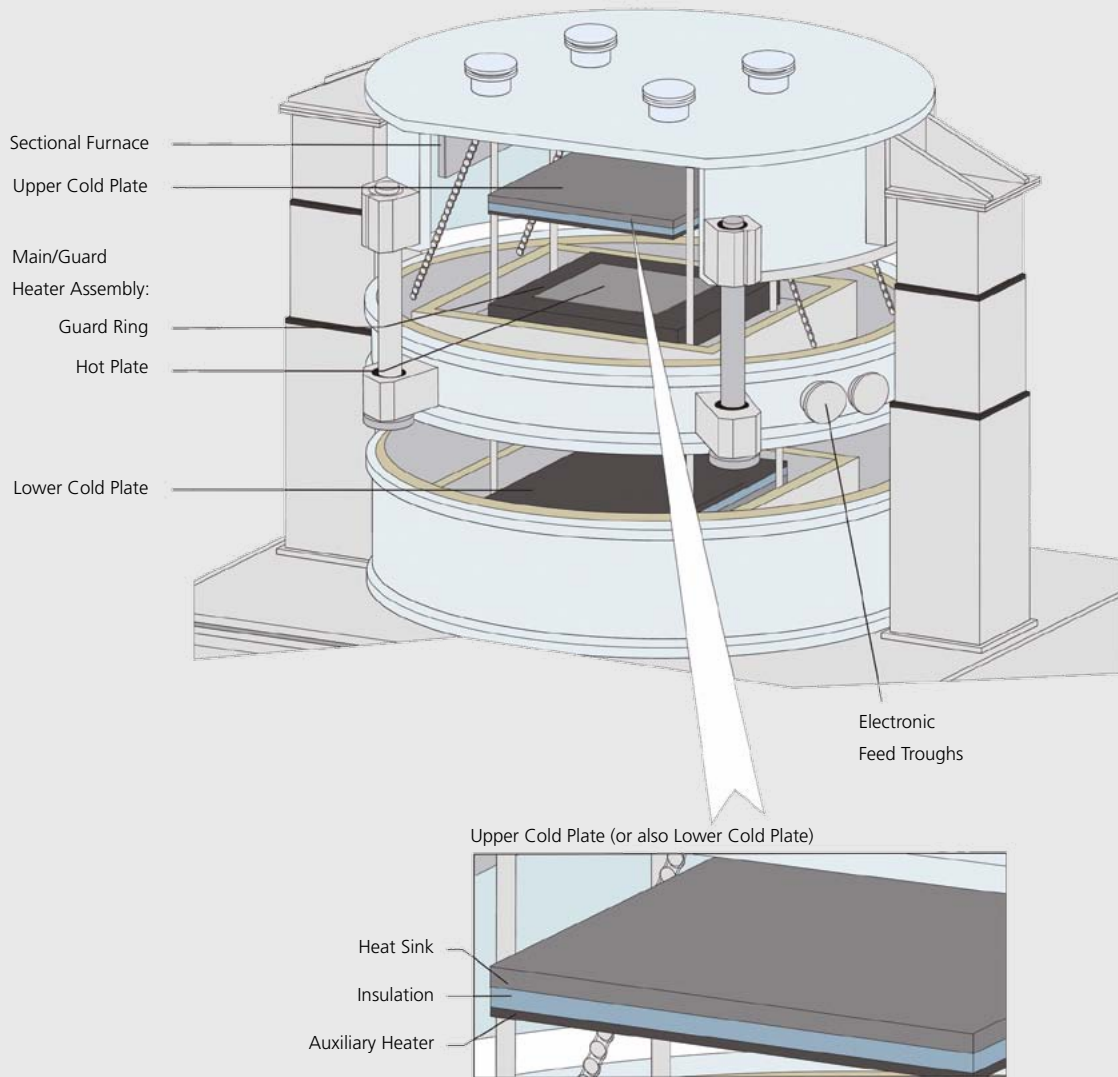


GHP 456 Titan[®] - Hardware

The NETZSCH GHP 456 Titan[®] was developed combining more than 25 years of university experience in guarded hot plate design with

innovative technologies in advanced materials, electronics and software. Aluminum alloy plates are used to cover a temperature range between -160°C

and 250°C. Cost-effective design and fast heating and cooling cycles are some of the features of this instrument.



Absolute measurement device

The system performs absolute thermal conductivity measurements. No system calibration or reference material is required to carry out accurate measurements. This is a basic principle of a guarded hot plate system.

Easy handling

A newly-developed motorized plate hoisting device is integrated into the GHP 456 *Titan*®. The system opens the vacuum housing and the plate stack with the simple press of a button. Changing samples is easy and can be done within a minute.

Symmetrical arrangement

The system is fully symmetrical and requires two samples for each test. According to the relevant standards, this arrangement ensures the maximum possible accuracy of better than 2% (for most materials and samples).

Innovative temperature control

Each plate, the guard ring and the furnace are connected to a separate control system and a stabilized power supply. The fully-digital five-stage PID control system ensures that plate temperatures are reached quickly and that perfect stability is achieved. This ensures that differences between programmed and actual plate temperatures are 0.01 K or better.

Temperature measurement

Temperature measurement at the plates, the guarded ring and the furnace as well as the gap temperature control is accomplished using 29 sheeted, individually calibrated PT100 temperature sensors. These sensors offer higher sensitivity and accuracy, lower noise and longer durability compared to thermocouples.

Artificial environment

The entire plate stack is surrounded by an artificial environment. This sectional furnace creates a temperature profile around the plate stack similar to what is generated by the plate stack itself. This almost completely eliminates radial heat losses. Furthermore, all wiring to the plates is connected to the artificial environment. Therefore, wire heat losses are fully eliminated.

Vacuum-tight design

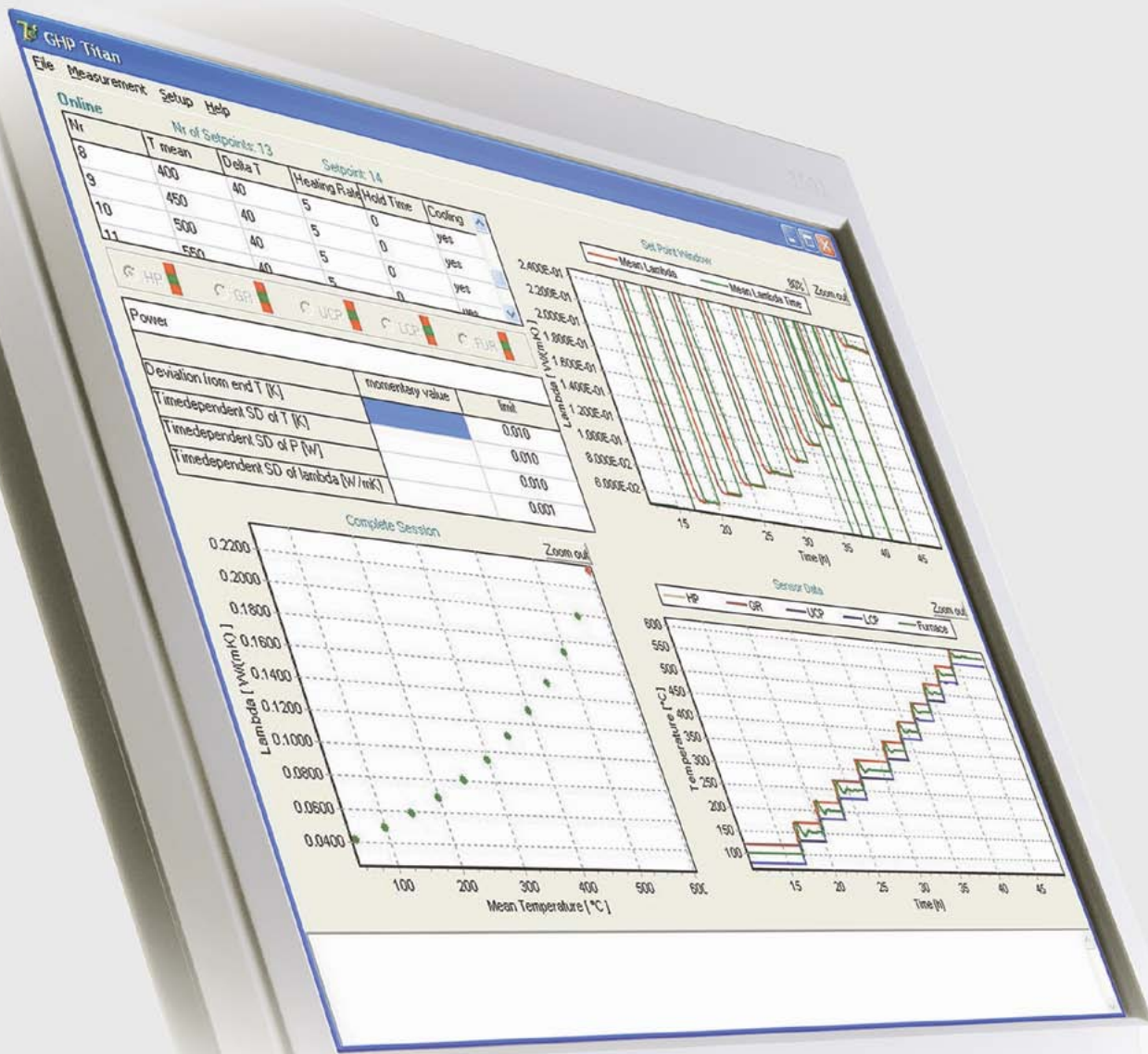
The plate stack is placed in a vacuum-tight housing. Depending on the pump employed (rotary or turbo pump systems) measurements can be carried out under vacuum down to 10^{-4} mbar (0.01 Pa). Furthermore, tests are possible under very pure atmospheres (oxidizing or inert) or defined pressure levels.

Unique safety systems

The system operation is fully automated. In case of any unexpected event, the three-stage safety control system prevents any damage to the system. Even in case of a complete computer software failure, the specially-designed watch-dog system stops the power supply to all plates and therefore any uncontrolled system behavior.

GHP 456 Titan[®] - Software

The NETZSCH GHP 456 Titan[®] comes with 32-bit Windows[®] software which combines easy operation and handling with complex control and evaluation algorithms. Multiple windows offer a fast, comprehensive overview of the instrument activity.

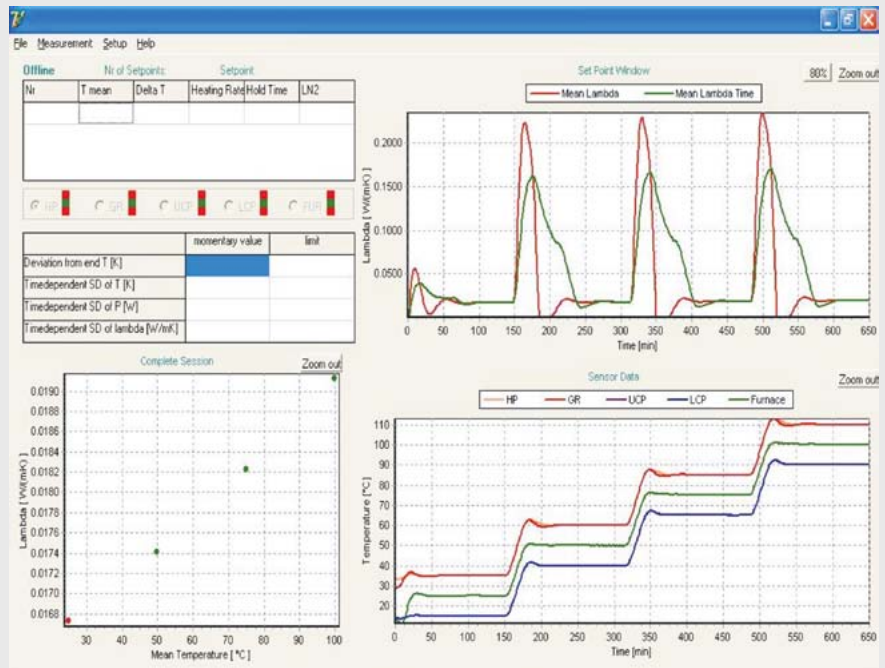


Easy temperature input

System programming is straightforward in a tabular form. Any test can be opened and repeated on a new sample by simply adjusting the necessary parameters.

Equilibrium parameters

Equilibration parameters can, of course, be adjusted any time. The system can therefore be optimized for high sample throughput and/or maximum possible accuracy.



Digital control system

The specially-developed integrated digital control system fully commands all instrument components automatically (hot plate, guard ring, upper and lower cold plate and surrounding furnace). This unique feature generally does not require adjustment or other user input regardless of the measurement temperature, atmosphere or thermal resistance of the sample. For one temperature point, system stability is often reached within a few hours. No user input is required during the measurement progress.

Temperature analysis

The individual temperature readings (29) can be analyzed in graphic or tabular form. Plate temperature inhomogeneity can be seen at every stage of the test. Standards conformation can therefore be proven for any time.

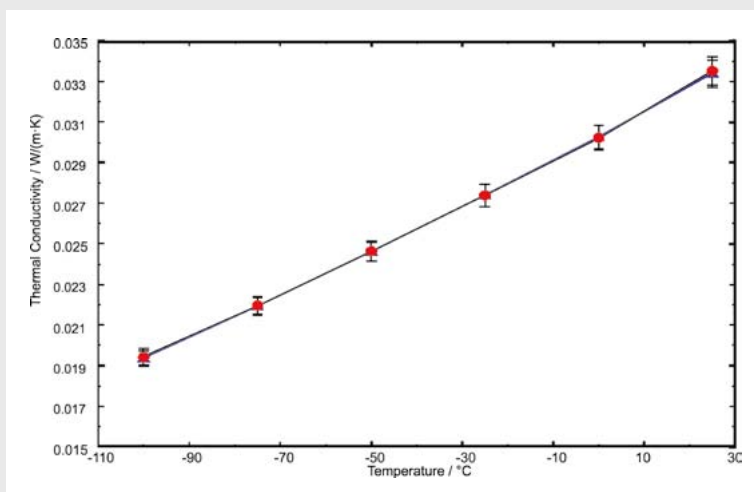
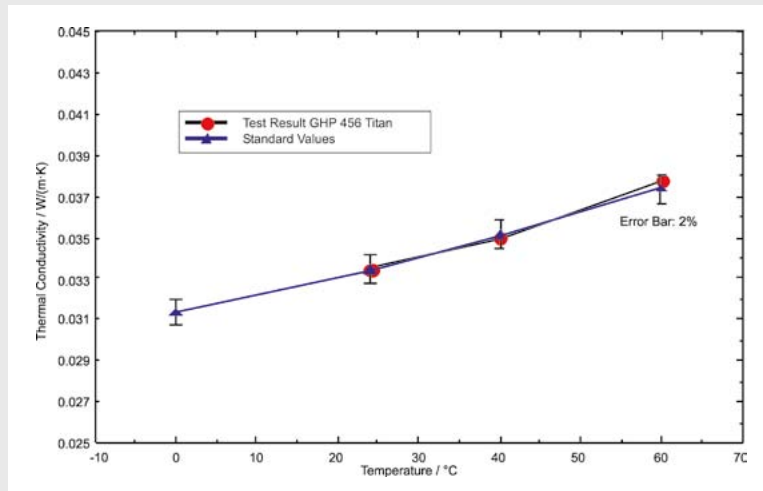
Data output

Results can be printed as graphs or tables or exported as ASCII files. Furthermore, all raw data readings are stored in an ASCII file and can be analyzed in detail if necessary.

GHP 456 *Titan*[®] - Performance and Applications

Accuracy: SRM 1450C glass-fiber board

A glass-fiber board (NIST-certified standard reference material 1450C) was measured over the certified temperature range (0°C to 60°C). The deviations between the literature values (taken from the NIST certificate) for the reference material and the measurement results are generally less than 1% and easily within the stated uncertainty of the reference material. This clearly reflects the outstanding performance of the GHP 456 *Titan*[®].

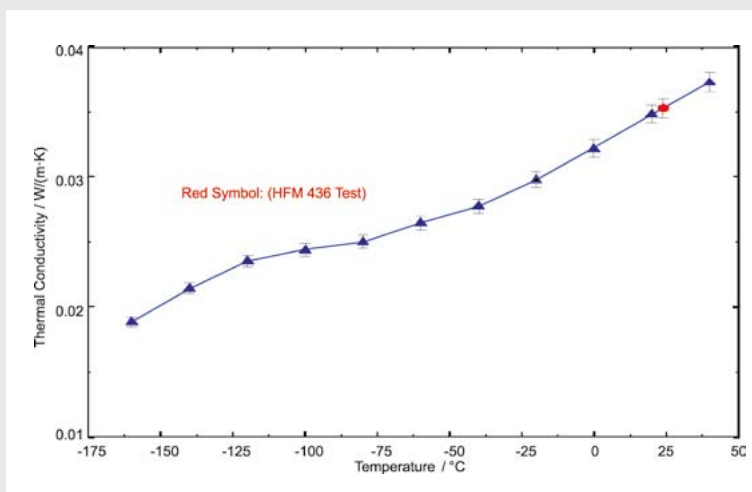
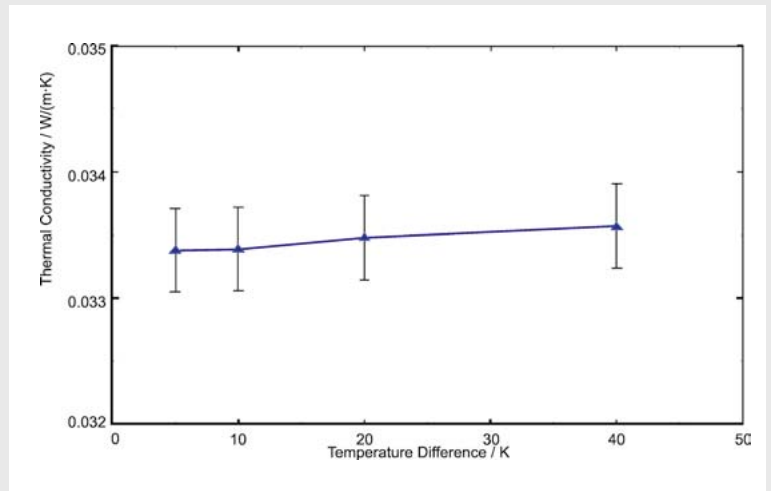


Repeatability: Styrodur

A 5 cm thick Styrodur C sample was measured twice between -100°C and 25°C in the GHP 456 *Titan*[®]. The samples were removed, turned and placed into the system between the runs. The maximum difference between the individual results was 0.4% indicating the excellent repeatability of the system.

Impact of temperature difference

In case of any imbalance in the system (inhomogeneities in the plate temperatures, imperfect gap control or relevant radial heat losses), different temperature differences cause deviations in the results. The GHP 456 *Titan*[®] does not show any impact of the temperature difference used for the tests and the resulting thermal conductivity. This is simple proof of the nearly perfect system design.



Application: PUR foam

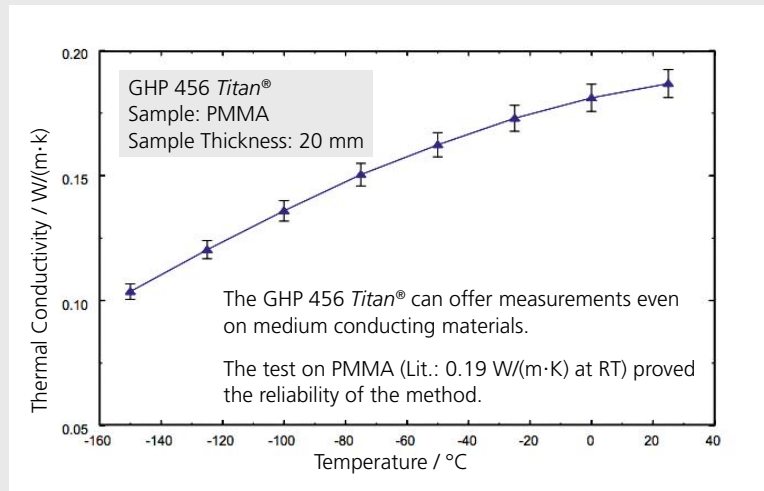
Insulation of modern house roofs, cryo-tanks or even ships requires materials featuring both low thermal conductivity and high mechanical stability. Polyurethane (PUR) foams offer these properties. Presented here is a comparison of a test with an HFM at room temperature and a GHP test down to -160°C. Both results agree perfectly. Additionally, the GHP result shows the impact of cell-gas condensation between -50°C and -125°C.

GHP 456 Titan[®] - Performance and Applications

Application: PMMA

Polymethylmethacrylate is a transparent thermoplastic material which was brought to the market in the early 1930th under the trademark Plexiglas. PMMA is often used as a lightweight or shatter-proof alternative to glass, e.g. for panes in architecture, for covers or lenses of automotive lighting or in medical engineering. In literature its thermal conductivity at room temperature is specified as 0.19 W/m·K.

The PMMA measurement shown here was carried out on a 20 mm thick sample in the temperature range between -150°C and 25°C. The results clearly demonstrate that the GHP instrument gives reliable data also for medium conducting materials. The error bars in the graphic represent an accuracy interval of about +/- 2%.



Advantages in GHP Testing

NETZSCH offers a full range of thermal characterization solutions for insulating materials over an unmatched temperature range (-260°C to 2800°C). For quality control applications, we provide a unique range of heat flow meters (HFMs). Based on the patented plate temperature control system, the HFMs offer fast and reliable thermal conductivity measurements on insulating materials around room temperature. Thermal expansion or softening points of foams can be accurately analyzed using the NETZSCH

dilatometer DIL 402 C or TMA systems. Glass transitions or melting points can be analyzed using the NETZSCH DSC 204/404 instruments.

The decomposition behavior can be measured using thermobalances or STA systems. Together with evolved gas analyzers such as quadrupole mass spectrometers (QMS), Fourier Transform Infrared Spectrometers (FTIR) or combination between a gas chromatograph and a mass spectrometer (GC-MS), TG or STA offers further

information regarding your insulating materials. Firing stability and/or gases released during a fire can be easily analyzed by employing such instrumentation. The wide range of different thermal instruments, the high performance, the excellent build-quality and unparalleled support makes NETZSCH the right partner for your R&D or quality control needs.

Contact us and find out how we can help you to be more efficient, more innovative and more competitive in your markets.

GHP 456 Titan® - Key Specifications:

- Symmetrical test configuration (2 samples)
- Temperature range: -160°C to 250°C
- Thermal conductivity range: 0 W/(m·K) to 2 W/(m·K)
- Vacuum-tight by design (down to 10⁻⁴ mbar)
- Inert, oxidizing atmospheres or vacuum
- High accuracy: better than 2%
- Sample thicknesses up to 100 mm
- Plate dimensions: 300 mm x 300 mm (standard version), 500 mm x 500 mm

GHP 456 Titan® - Unique Highlights:

- Motorized hoist for the vacuum housing and plates
- Artificial environment (sectional furnace) for reduced lateral heat loss
- Complete elimination of radial heat flow via wiring (sensors, power supply)
- High resolution temperature measurement (1 mK) using separately calibrated temperature sensors (29 individual units)
- Guaranteed mechanical stability of the plates even at minimum or maximum service temperature
- Newly-developed computerized temperature control system for increased test speed

The NETZSCH Group is an owner-managed, internationally operating technology company headquartered in Germany.

The three Business Units – Analyzing & Testing, Grinding & Dispersing and Pumps & Systems – provide tailored solutions for highest-level needs. Over 2,200 employees at 125 sales and production centers in 23 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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