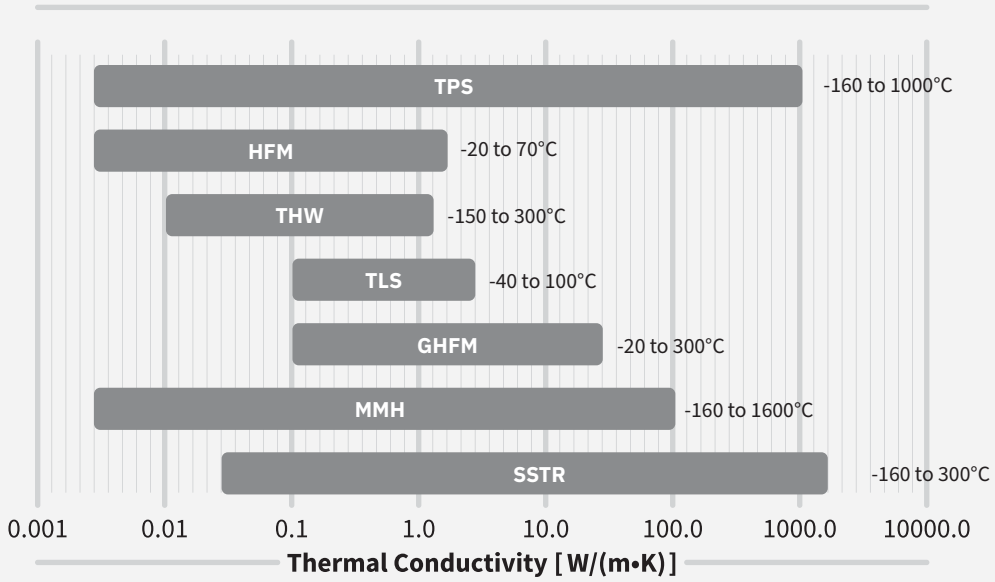
GHFM-01 Guarded Heat Flow Meter

Thermal Conductivity Meter for measurement of **metals, polymers, and composites**

Conforms to ASTM E1530-19

Thermtest™ INSTRUMENTS

Thermtest.com



Thermtest INSTRUMENTS

THERMAL CONDUCTIVITY:
HFM-100 (Heat Flow Meter)
THW-L1 (Transient Hot Wire)
GHFM-01 (Guarded Heat Flow Meter)
MMH-1600 (Monotonic Heating)
SSTR-F (Steady State Thermoreflectance)

Thermtest PORTABLE

TLS-100 (Transient Line Source)
THW-L2 (Transient Hot Wire)
TPS-EFF (Transient Plane Source)
GHFM-02 (Guarded Heat Flow Meter)
MP-2 (Measurement Platform)

Thermtest has been advancing the measurement of thermal conductivity, thermal diffusivity, and specific heat since 2005. With more than 2000 satisfied customers worldwide, our unique combination of advanced thermal conductivity instrumentation for the laboratory, portable meters for the field, and accessories enables us to provide ideal solutions to fit any material testing application and budget.

GHFM-01 **Guarded Heat Flow Meter**

The Guarded Heat Flow Meter (GHFM-01) follows ASTM E1530-19 for testing thermal resistance and thermal conductivity of solids, such as metals, polymers, composites and paste from -20 °C to 300 °C. The Thermtest proprietary testing stack, replaces the traditional pneumatic movement with advanced motor control, which allows automated control of testing sample thickness, force or pressure applied.

GHFM-01 **Features**

Robust Design

Stepper Motor

Optical Digital Encoder

Pressure Sensor

Safety Door Switch

Proprietary Gimbled Stack

Upper Test Plate

Lower Test Plate

Furnance Movement By Stepper Motor

Easy Swap Lower Flux Stack

Featured **GHFM-01 Capabilities**

The advanced GHFM-01 is a primary measurement of thermal resistance—thermal conductivity for solids, such as metals, polymers, composites and paste. Specifically, the calculation of thermal conductivity from measurement of thermal resistance is the most accurate method of testing the true thermal conductivity of heterogeneous materials. The steady-state measurement of thermal resistance represents the full sample thickness and mature heat transfer properties.

According to the method, the sample is subjected to a steady-state through-thickness temperature gradient. The thermal conductivity of the sample is obtained by measuring the temperature difference across it, and one additional temperature.

The testing stack is made up of a heater – upper plate, with integrated temperature sensor and heat sink—lower plate with integrated temperature sensor on each side of the sample. Additional temperature sensors are placed near the top and bottom surface of the sample.

The thermal resistance of the sample, R_s (m2•K/W), is the ratio between the thickness of the sample, d (m), and its thermal conductivity, λ (W/m•K). R_s can be obtained from temperatures experimentally measured:

$$R_S = F\left[\frac{T_U - T_L}{T_L - T_H}\right] - R_{int} \Rightarrow R_S = F\left[\frac{\Delta T_S}{\Delta T_B}\right] - R_{int}$$

The above equation is linear in form, and is the working equation of the instrument. Constants F (m^2•K/W) and R_{int} (m^2•K/W), can be obtained by calibration of the instrument. To this effect, calibration samples of known thermal conductivity and hence, thermal resistance, are employed. Calibrated results for thermal resistance and thermal conductivity are reported.

- **Basic and advanced functions are easy with GHFM-01 Windows Software.**
- **Full computer control of GHFM-01; mean temperature, sample thickness, force or pressure applied.**
- **Programmable mean temperatures from -20 °C to 300 °C.**
- **Multiple high resolution (0.01 °C) thermocouples for accurate measurement of thermal resistance and thermal conductivity.**
- **Thickness is measured to an accuracy of 0.0254 mm, with use of a digital optical encoder.**
- **Integrated force sensor with feedback loop for controlling stepper motor.**
- **High performance stepper motor enables plate clamping to be automated or set to a user defined thickness – ideal for compressible materials.**
- **Flux modules are easily changed, with no tools needed.**
- **Follows international standard; ASTM E1530-19.**

GHFM-01 **Specifications**

Following international standards, the GHFM-01 is designed for testing both homogeneous and heterogeneous materials.

Materials	Metals, Polymers, Composites, and Pastes
Type of Sensors	Thermocouples (x6)
Applications	General Testing
Direction	Through-Thickness
Thermal Conductivity Range	0.1 to 40 W/m•K
Measurement Time	40 to 60 min
Accuracy	± 3%
Repeatability	± 1 to 2%
Plate Temperature Range*	-20 to 310 °C
Pressure	Automated up to 379 kPa (55 psi)
Sample Diameter	50 to 50.8 mm
Sample Thickness	Up to 25 mm | Thin-films down to 0.1 mm with optional Software
Standard	ASTM E1530-19

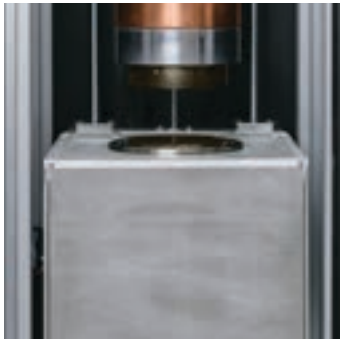
*chilled circulator included with each system

GHFM-01 **Highlights**

ACCURATE MEASUREMENTS

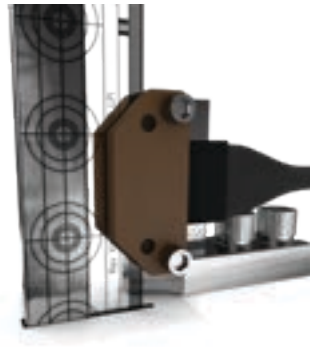
Flux Modules

TEMPERATURE CONTROL



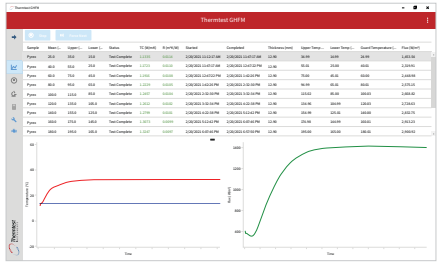
Resolution of 0.01 °C

THICKNESS MEASUREMENT



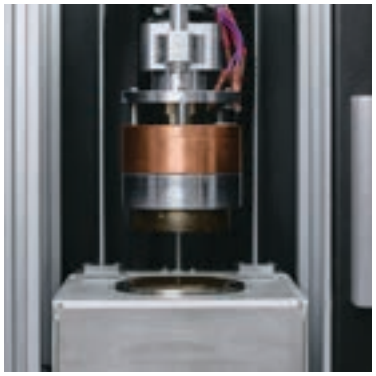
Accuracy of ± 0.0254 mm

OPERATION



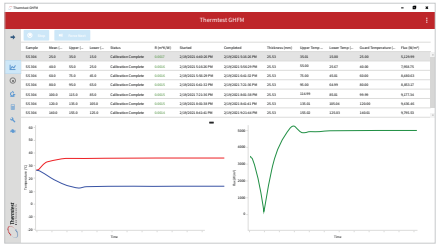
GHFM-01 Windows Software

CLAMPING CONTROL



Automated or Manual

CALIBRATION

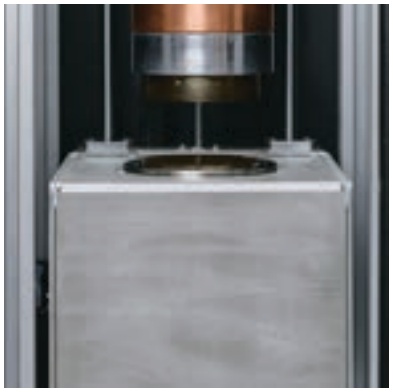


Automation

GHFM-01 **Characteristics**

Easy to Change Heat Flux Module

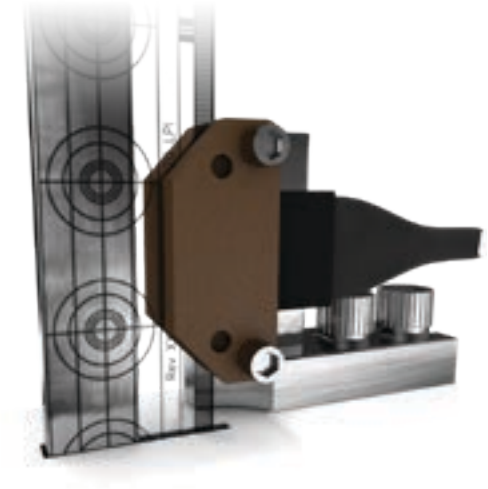
No tools are required to change the lower flux module, which forms a calibrated heat flux transducer. Housing multiple thermocouples to monitor temperature for confirmation of steady state condition of the temperature gradient across the sample is achieved.



Temperature Control

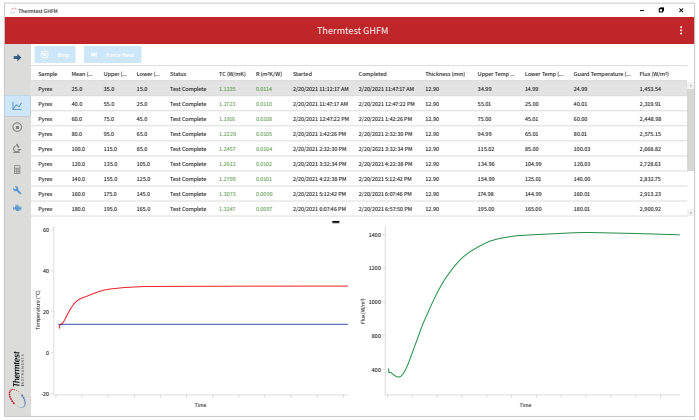
Optimally selected heaters cooled by heat exchangers matched with thermocouples, which have a resolution of 0.01 °C are positioned in the upper and lower stack are used to accurately control plate temperatures. Lateral heat loss across the sample thickness is minimized with the use of a guard oven. Upper and lower plate along with guard oven temperatures are fully controlled by the convenient GHFM-01 Software.

GHFM-01 **Characteristics**



Thickness Measurement

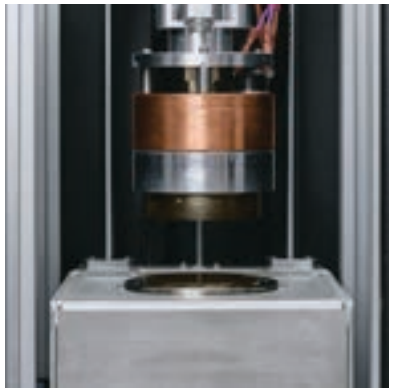
Accurate sample thickness is required for determining thermal conductivity of a material from the measurement of thermal resistance. The GHFM-01 features a proprietary gimble design, which has the advantage of either an automatic determination of sample thickness, for rigid materials, or a user defined sample thickness, force or pressure applied for compressible materials. Sample thickness is measured using digital optical encoder technology, ensuring the most accurate (± 0.025 mm) measurement of sample thickness.

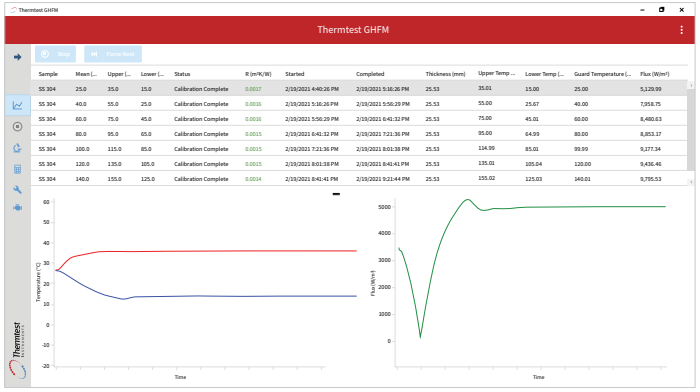


Operation

The GHFM-01 offers a feature packed Windows based software included with each system. The simple to use software offers unlimited automation steps of temperature along with thickness force or pressure settings. Basic testing and calibration steps are fully automated, as well as additional functions like saving, exporting, and printing of measurement results.

GHFM-01 **Characteristics**





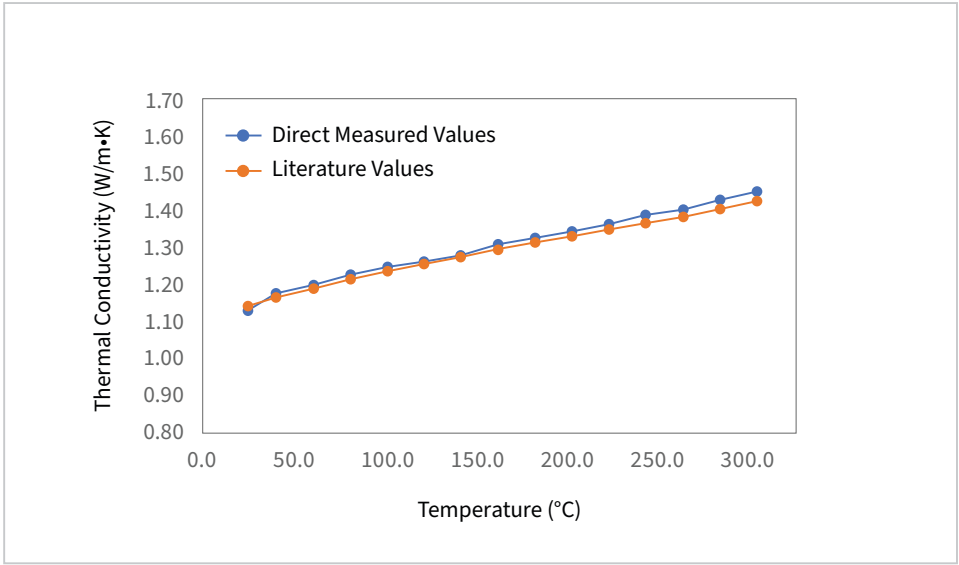
Clamping Control

For rigid materials, the GHFM-01 plates automatically clamp together for optimum sample contact. When testing compressible materials, the desired height, force or pressure (up to 80 kg, 379 kPa - 55 psi) applied may be set in the software and the plate will automatically stop once desired sample height or pressure is achieved.

Calibration

All conditions of calibration, such as management of reference materials, temperature steps and pressure are fully automated with the GHFM-01 software. Verification of calibration is performed through built in validation routines.

Accuracy



Pyrex(R) 7740 Thermal Conductivity

Demonstrating the performance of the GHFM-01, measurements on Pyrex 7740 were made up to 300 °C and compared to literature values. Accuracy of all results < 2%.

Thermal Conductivity (W/m•K)

Temperature (°C)	25	40	60	80	100	120	140	160	180	200	220	240	260	280	300
Direct Measured Values	1.134	1.172	1.192	1.223	1.246	1.261	1.280	1.307	1.325	1.343	1.361	1.386	1.401	1.426	1.451
Literature Values	1.143	1.164	1.190	1.214	1.236	1.257	1.276	1.295	1.313	1.330	1.348	1.366	1.385	1.404	1.426
Error (%)	0.80	0.71	0.11	0.71	0.75	0.33	0.27	0.96	0.92	0.99	0.98	1.44	1.19	1.54	1.78

Sample Measurement

Step 1

GHFM-01 samples should be 50 to 50.8 mm in diameter. The top and bottom surfaces should be flat and parallel. A thin layer of contact paste is added to the top and bottom of the sample surface.

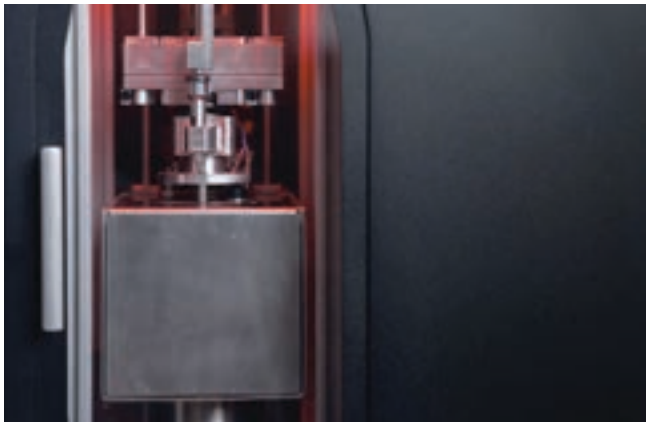
1 min.

Step 2

Sample then can be loaded into the testing stack. For rigid materials, upper stack will close to a default pressure. For soft materials, the user can define a specific pressure or required thickness. Pressure and thickness testing parameters can be controlled within the testing schedule.

1 min.

Advanced Automation



Step 3

Using the GHFM-01 Software, the user is able to schedule unlimited temperature steps up to 300C. Internal red backlight signals testing in progress.

40 to 60 min.

Step 4

Temperatures from upper and lower plates are monitored by the GHFM-01 software for temperature stability. Measured thermal resistance and calculated thermal conductivity results are tabulated and available for export to excel. Internal blue backlight signal testing is complete and stack safe to touch.

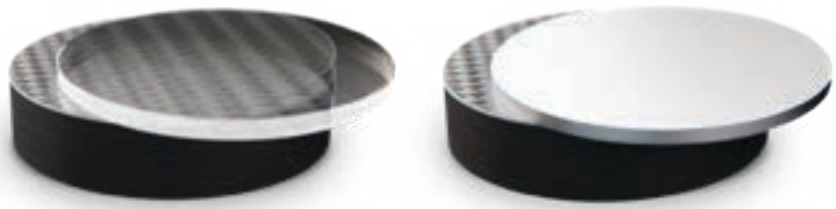
1 min.

GHFM-01 **Applications**

Anisotropic Carbon Fiber Composites

When testing anisotropic composites, the measurement of thermal resistance—thermal conductivity is ideal. Composites typically do not have repeating internal layers, making the measurement of full thickness by thermal resistance the only way to measure true thermal conductivity. A carbon fiber composite sample of 12.7 mm thickness was measured, and results summarized below.

Mean Temperature (°C)	Thermal Resistance (m^2K/W)	Thermal Conductivity (W/m•K)
40	0.0252	0.5153
60	0.0229	0.5671
80	0.0213	0.6103



Layered Carbon Fiber Composites

Measuring the thermal conductivity of a composite with added layers increases the measurement complexity. Transient methods designed to measure the thermal conductivity of well organized anisotropic materials, are not well suited for non-repeating layered structures.

Layers of pyrex and stainless steel were added to the anisotropic carbon fiber composite sample of 12.7 mm thickness. For the full thickness, thermal resistance and thermal conductivity were measured at a mean temperature of 40 °C, and results summarized below.

Added Layer to Carbon Fiber Composite	Thickness (mm)	Thermal Resistance (m^2K/W)	Thermal Conductivity (W/m•K)
Pyrex	3	0.0264	0.5680
Stainless Steel	2	0.0251	0.6340

GHFM-01 **Applications**

Heterogeneous

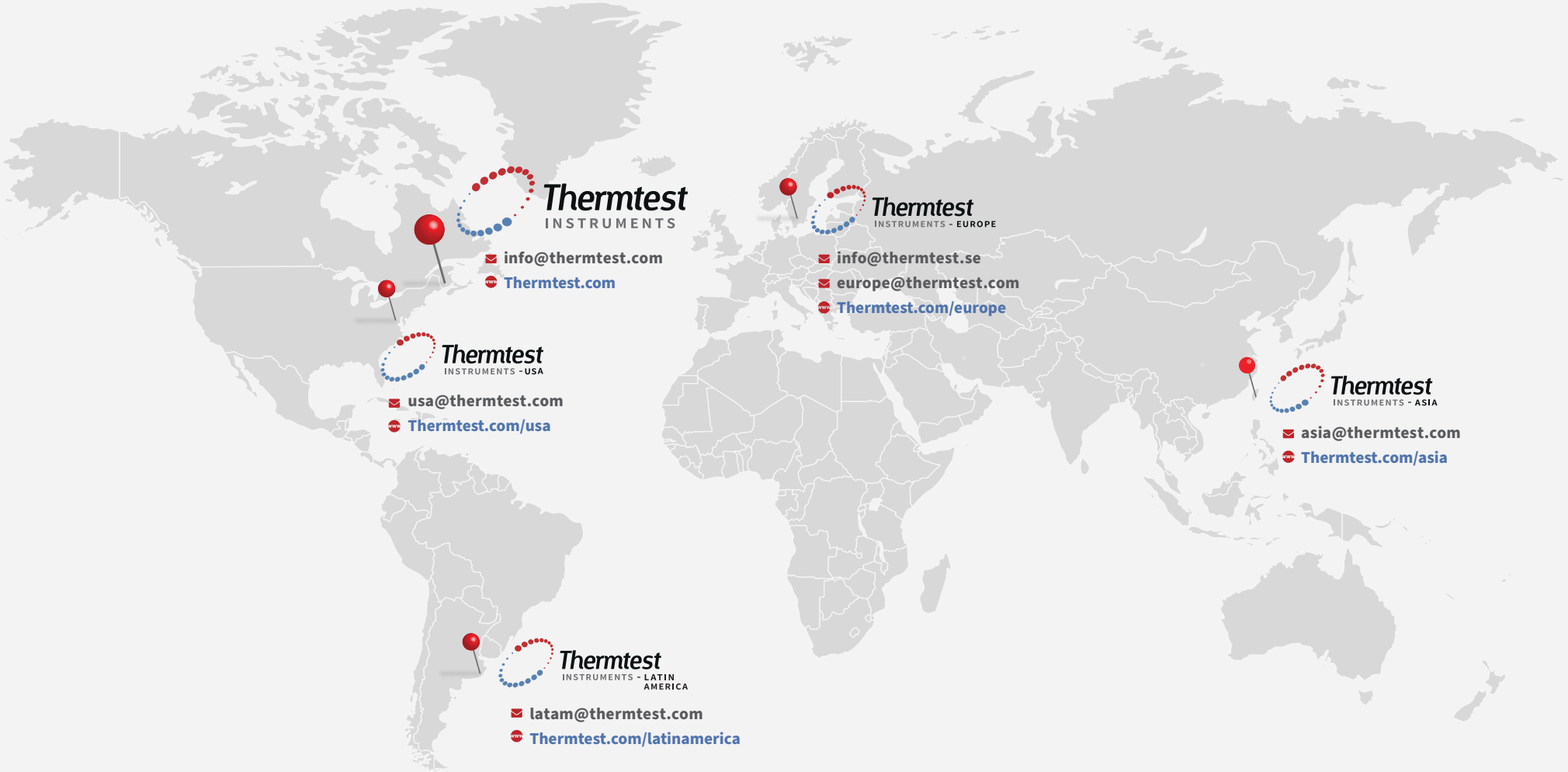
The GHFM-01 is well suited for the measurement of thermal resistance and thermal conductivity for a wide range of materials. As the GHFM method measures the thermal resistance of a sample size of 50 to 50.8 mm in diameter and thickness up to 25 mm thick, testing heterogeneous materials is possible.

Compressible

With the ability to schedule desired compression or pressure, the GHFM-01 is uniquely capable of testing compressible materials like rubber and gasket materials. Using the GHFM-01 software, any variation or combination of temperature, compression or pressure is possible.

Specialized Testing Cells

There are a wide variety of test cells available to extend the application range of the GHFM-01. These include paste, polymer – melt and powders cells.



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