MP-1 Measurement Platform

Absolute thermal conductivity, thermal diffusivity, specific heat of **solids, liquids, pastes** and **powders**.

Testing Methods:

Transient Plane Source (TPS)
ISO 22007-2 (solids)

Transient Hot Wire (THW)
ASTM D7896 (liquids)

Solid

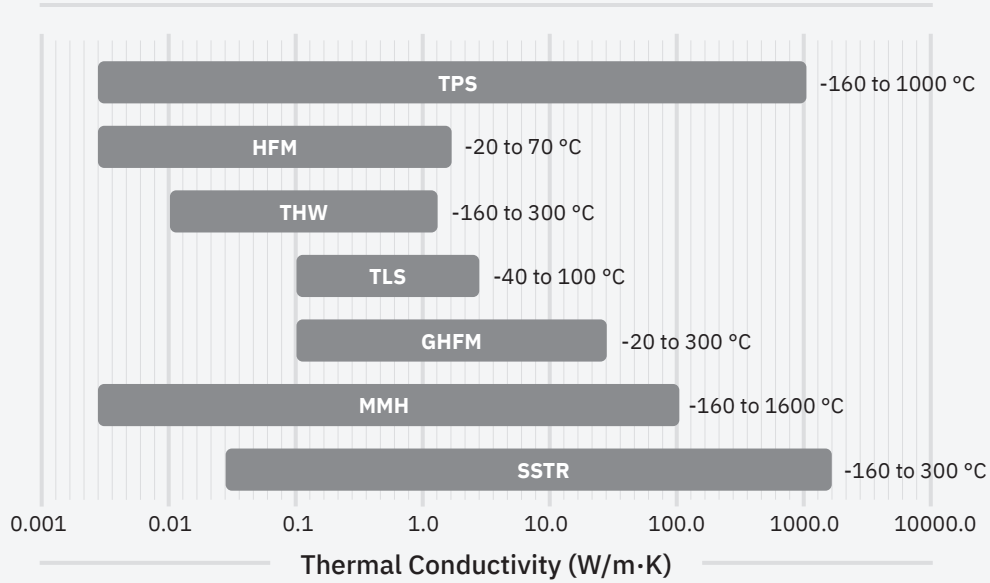
Liquid

Paste

Powder

Thermtest™ INSTRUMENTS

Thermtest.com



Thermtest™ INSTRUMENTS

MP-1 (Measurement Platform)
– MP-1: TPS (Transient Plane Source)
– MP-1: THW (Transient Hot Wire)
HFM-100 (Heat Flow Meter)
HFM-50 (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)
– MP-2: TPS (Transient Plane Source)
– MP-2: THW (Transient Hot Wire)
– MP-2: TLS (Transient Line Source)
HFM-25 (Heat Flow Meter)

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.

TPS/THW
Room Temperature

TPS
Temperature Platform

THW
Temperature Platform

TPS - **Solids**

THW - **Liquids**

TPS / THW - **Pastes**

TPS / THW - **Powders**

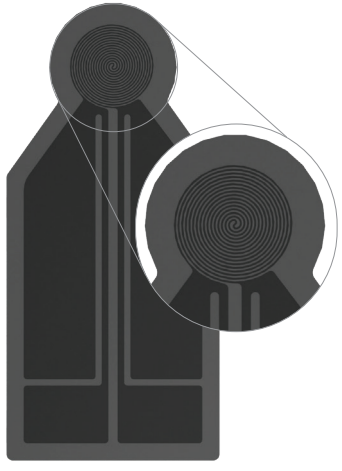
MP-1 **Measurement Platform**

The powerful combination of Transient Plane Source (**TPS**) for solids, and Transient Hot Wire (**THW**) for liquids, gives the Thermtest MP-1 a unique and versatile selection of testing methods for your sample type. The TPS and THW methods are widely used for accurate measurement of absolute thermal conductivity, thermal diffusivity, specific heat, and thermal effusivity. This versatility is greatly expanded with the addition of Thermtest's proprietary Temperature Platform (TP) which is appreciated by academic and commercial users alike.

Following ISO 22007-2 and ASTM 7896-19, the TPS and THW are primary measurement methods, trusted worldwide with 1000s of published papers.

MP-1 **Methods**

The Transient Plane Source (TPS) and Transient Hot Wire (THW) share similar theory, with differences that are specific to their primary design. The basic theory is that the sensor is electrically connected to a power supply and sensing circuit. A current passes through the sensor and creates an increase in temperature, which is recorded over time. The heat generated is then diffused into the sample at a rate dependent on the thermal transport characteristics of the material.



Transient Plane Source (TPS) Sensor

The TPS sensor designed for solids, pastes, and powders is comprised of a double-spiral of nickel encapsulated between layers of insulation. Standard operation of this sensor (Two-Sided) is sandwiched between two pieces of the same sample, with expanded use to Single-Sided sensor, which only requires one piece of sample (Single-Sided). The proprietary Thermtest TPS calculation model measures the contact resistance between sensor and sample, as well as the thermal conductivity, thermal diffusivity, volumetric specific heat and thermal effusivity of the sample.

Transient Hot Wire (THW) Sensor

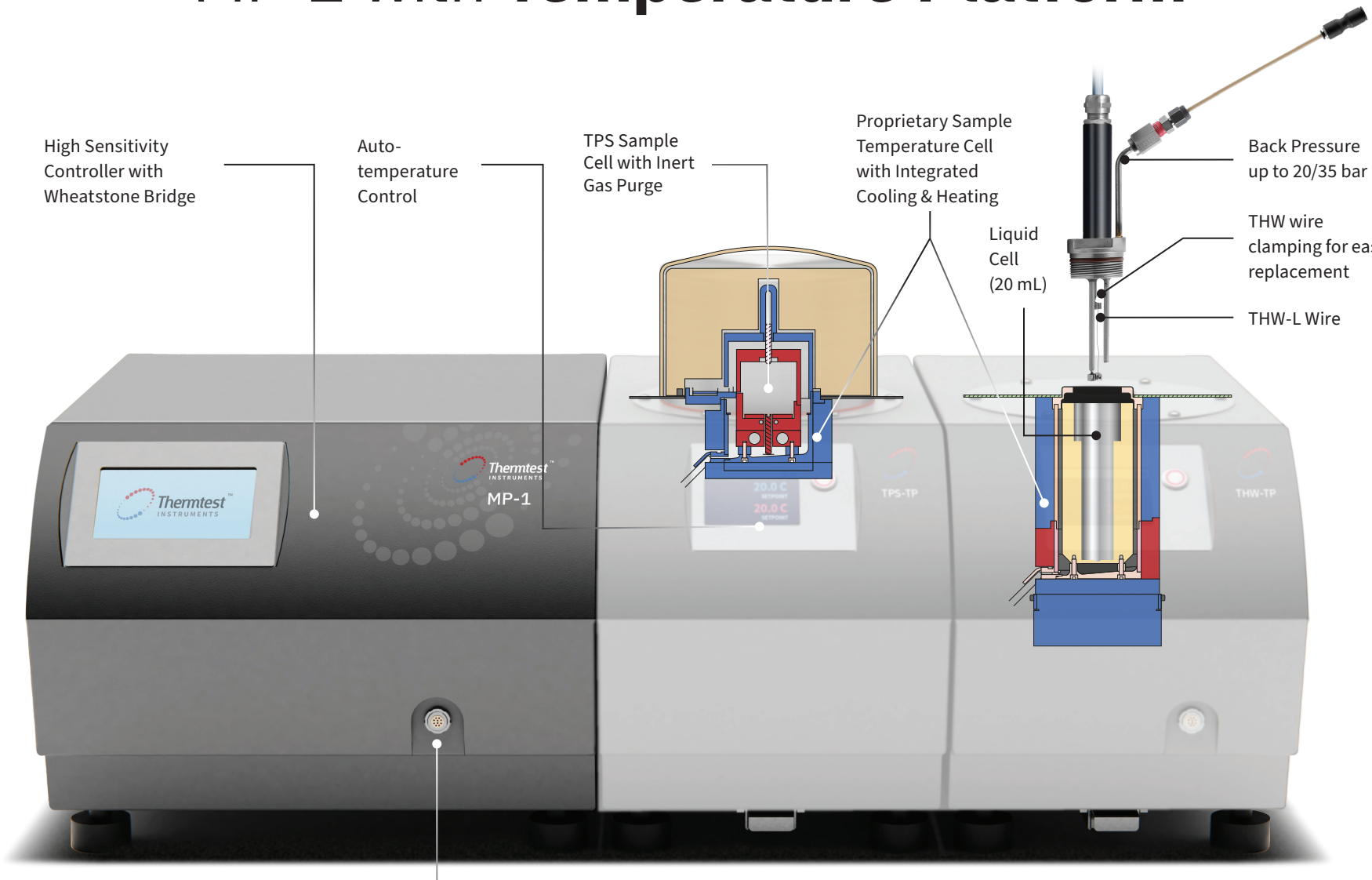
The THW sensor designed for liquids, as well as pastes and small particle powders consists of a replaceable thin heating wire (40 mm in length) secured to specially designed sensor and sample cell which allows back pressurizing liquids to measure thermal conductivity, thermal diffusivity and volumetric specific heat past boiling temperatures. Measurements are done at short test times (1 second) to limit convective effects on samples with a wide range of viscosities.

MP-1 **Specifications**

Methods	**Transient Plane Source (TPS)**	**Transient Hot Wire (THW)**
Materials	Solids, Pastes, and Powders	Liquids, Pastes, and Powders
Testing Modules	3D: Bulk, Anisotropic, Slab | 1D: Standard, Thin-films General: Specific Heat	Bulk
Thermal Conductivity (W/m•K)	0.005 to 1800 W/m·K	0.01 to 2 W/m·K
Sample Size*	5 x 5 mm to unlimited	20 mL
Sample Thickness*	0.01 mm to unlimited	N/A
Additional Properties	Thermal Diffusivity | Specific Heat |Thermal Effusivity	Thermal Diffusivity | Specific Heat
Sensor Contact Resistance (m^2K/W)	Measured	N/A
Temperature Platform (TP)	0 to 300 °C -160 °C | -50 °C | -20 °C | 0 to 300 °C	10 to 200 °C | -15/0 to 200 °C 0 to 300 °C | -45 to 300 °C | -160 to 300 °C
Extended Temperature Range	-160 to 1000 °C	N/A
Test Time (seconds)	0.25 to 1280	1
Data-Points (points/second)	Up to 600	400
Thermal Conductivity Accuracy	5%	2%
Repeatability	1%	1%
Sample Configuration	Symmetric (Two-Sided) | Asymmetric (Single-Sided)	N/A
Standard	ISO 22007-2:2015	ASTM D7896-19

*Based on testing module used.

MP-1 with **Temperature Platform**



TPS-Temperature Platform

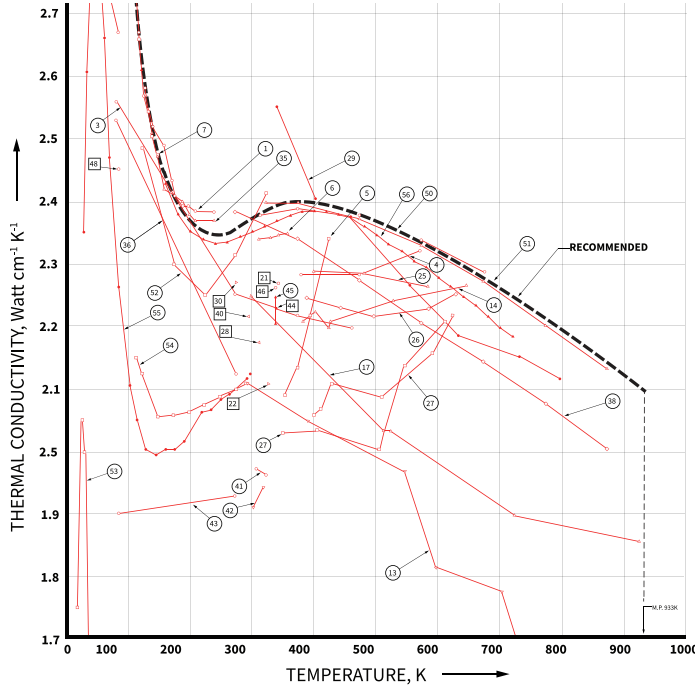
TPS-TP: **0 to 300 °C**
Expanded: **-160 °C | -50 °C | -20 °C | 0 to 300 °C**
Uniformity: **< 0.1 °C**

THW-Temperature Platform

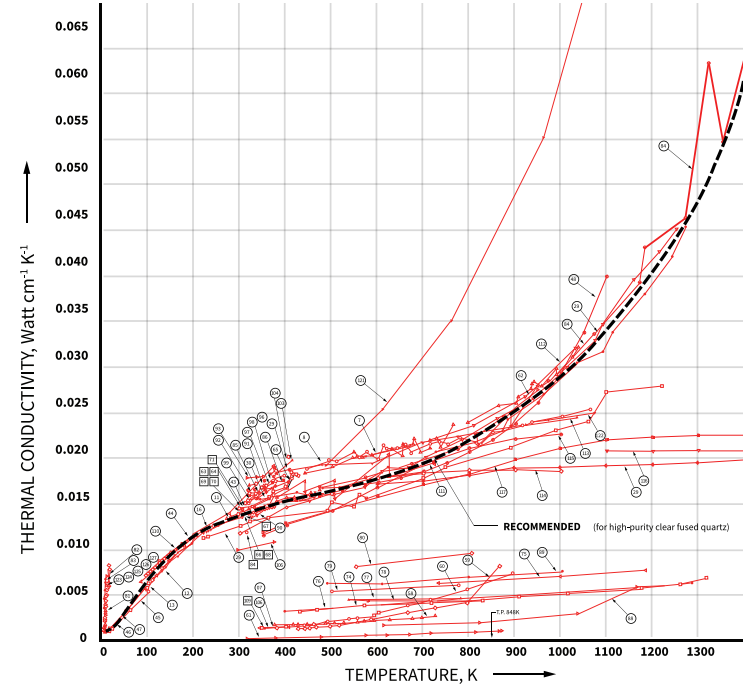
THW-TP: **10 to 200 °C**
Extended for 200 °C: **-15 °C | 0 to 200 °C**
Extended for 300 °C: **-160 °C | -45 °C | 0 to 300 °C**
Uniformity: **< 0.1 °C**

MP-1 **Fully Characterize Your Materials**

NIST - **Aluminum**



NIST - **Quartz**



THERMAL CONDUCTIVITY vs. TEMPERATURE

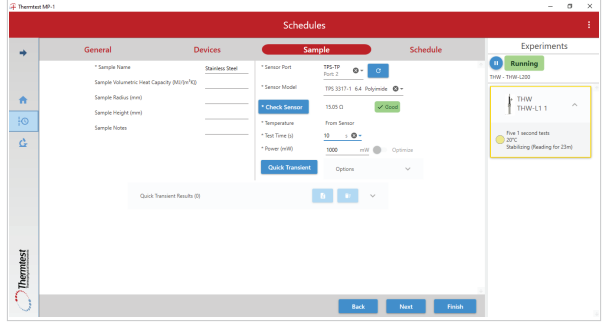
As materials are unique, the reliance on reference information to predict thermal conductivity or its relationship with temperature, can lead to the use of inaccurate data. Using NIST's "**Thermal Conductivity of Selected Materials**" reference for aluminum and quartz, we can see that there is a wide variance in thermal conductivity vs. temperature. Due to the dramatic variance in global material sources, it is critically important to fully characterize materials for thermophysical properties. Optional temperature capability can be added to the MP-1, allowing for full temperature characterization.

Citation: Powell, R.W., Ho, C.Y., and Liley, P.E. (1996). *Thermal Conductivity of Selected Materials*. Washington, U.S.: Dept. of Commerce, National Bureau of Standards; for sale by the Superintendent of Documents, U.S.. Govt. Printing Office. pp. 17, 99.

MP-1 **Data Acquisition Software**

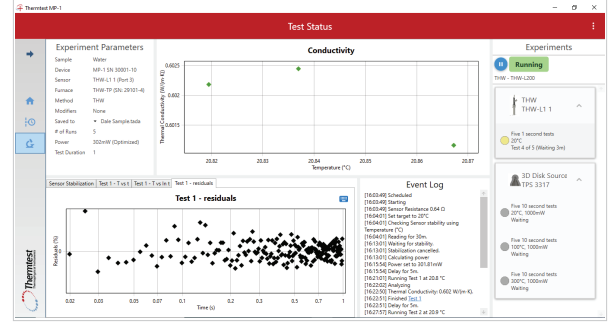
Designed from the ground up, the MP-1 Data Acquisition Software (DAQ) smartly controls all aspects of testing and scheduling. Testing methods and experimental parameters may be selected for automated scheduling.

A unique feature for the MP-1 is the integration of a four channel switch which is designed to allow automation of multiple devices and sensors to be controlled at the same time, greatly increasing testing capacity.



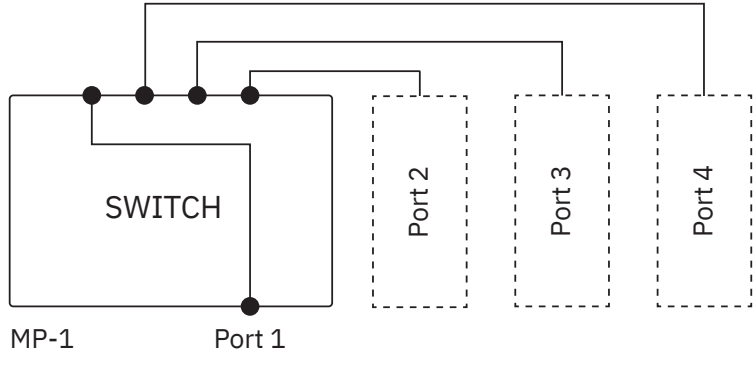
Methods & Parameters

Methods and testing modules can be selected & parameters optimized for solids, liquids, pastes, and powders.



Scheduling

Any combination of methods, devices and sensors can be scheduled to operate at a variety of conditions, such as temperature range.

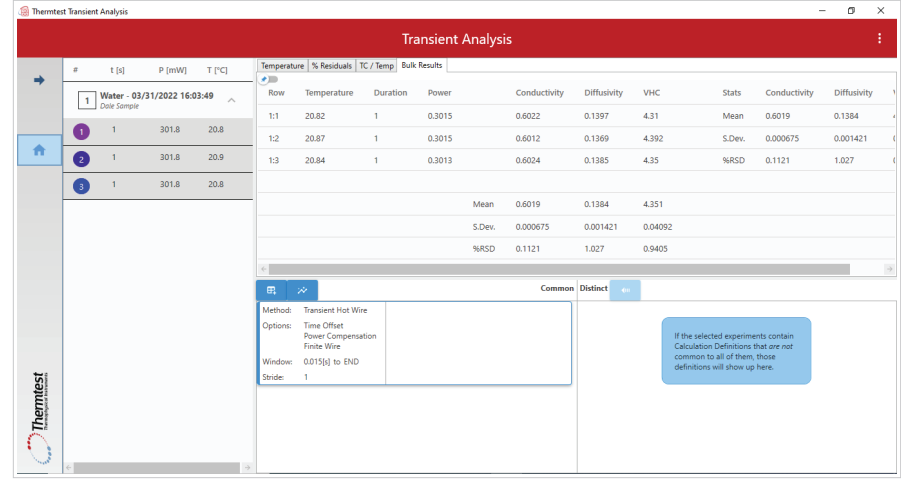


Switch

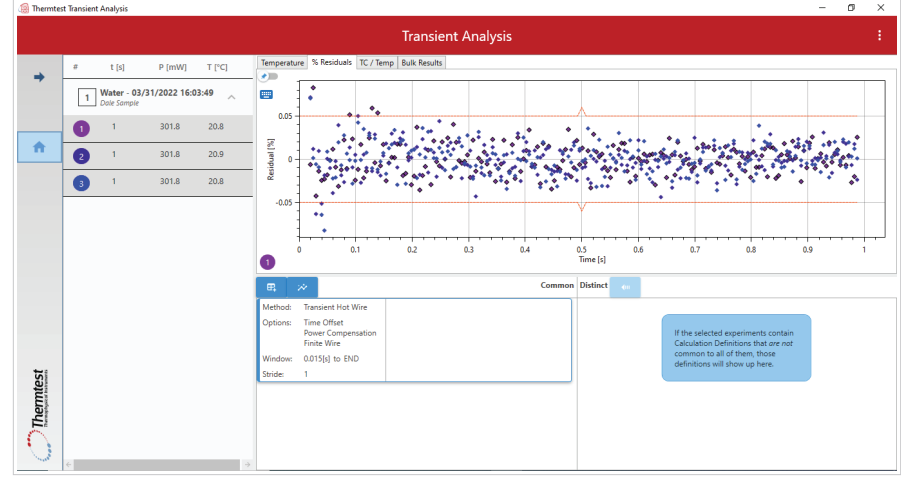
Integrated into each MP-1, the four port switch enables use of a number of optional devices, temperature platforms and sensors to maximize convenience and capacity.

MP-1 **Analysis Software**

Creating a better user experience, the Analysis Software (AS) was designed to operate independent of the DAQ. A wide range of analysis operations can be conveniently accomplished. Testing data is grouped together based on method used, making corresponding calculations easy to apply.



Variations in applied corrections are stored for easy comparison. In addition to summary of results, variations in applied corrections are stored for easy comparison and exporting.

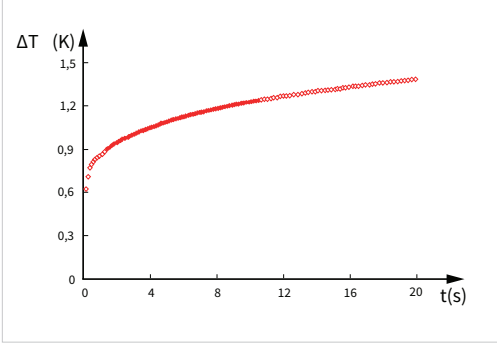


MP-1 **TPS Contact Analysis**

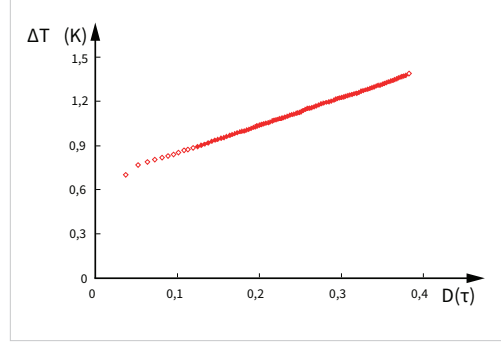
TPS theory states that the non-linear section of temperature rise vs time, known as contact resistance has to be removed, so the intrinsic thermophysical calculations are based on the linear region of transient. This can be done manually by iteratively removing start points till best fit is achieved. Although this is a suitable approach, it does take an experienced user to reduce errors and achieve required repeatability.

The contact resistance between the sensor and sample is dependent on the quality of the sample surface. When manually removing the contact resistance a small number of points (step 1) is removed and newly calculated for best fit analysis. If the resulting residual mean deviation can be improved, more points (step 2) can be removed and calculation steps repeated.

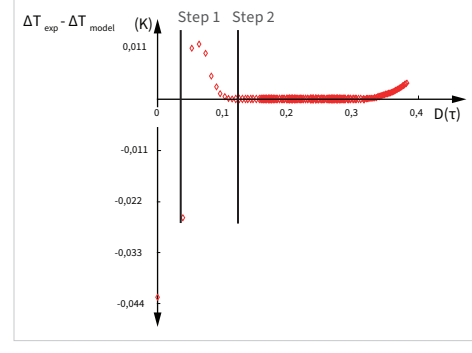
Raw Data



Calculation Data



Residual Data



MP-1 **TPS Contact Analysis**

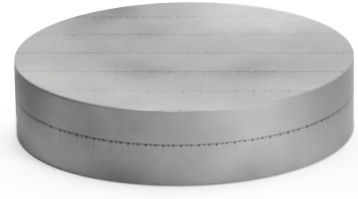
Alternatively, using our proprietary Contact Analysis (CA), the MP-1 is able to calculate the contact resistance (m^2K/W) between sensor and sample, automatically removing the corresponding start time. In addition to better understanding the effects of surface finish on your measurements, this greatly simplifies the analysis for the intrinsic thermophysical properties.

Demonstrating the application of the contact analysis measurement, four samples of stainless steel 316 with different surfaces were measured for thermophysical properties. As the MP-1 is able to measure contact resistance, selection of the calculation window is greatly simplified, maximizing repeatability of the intrinsic properties of the sample as the surface roughness increases, the measured contact resistance also increases.

Stainless Steel 316

Surface Finishes	Surface Roughness Ra (um)		Contact Resistance (m^2K/W)	Conductivity ($W/m{\cdot}K$)	Diffusivity (mm^2/s)	Volumetric Specific Heat (MJ/m^3K)	Effusivity ($W\sqrt{s}/m^2K$)
Polished	0.101	Mean	1.00E-04	13.80	3.73	3.70	7149
		%RSD	6	0.1	0.4	0.3	0.2
Machined	0.324	Mean	1.54E-04	13.93	3.75	3.71	7194
		%RSD	1	0.1	0.3	0.2	0.1
400 grit	0.516	Mean	1.32E-04	13.84	3.74	3.71	7163
		%RSD	2	0.1	0.3	0.3	0.1
80 grit	2.78	Mean	2.41E-04	13.85	3.73	3.71	7171
		%RSD	1	0.02	0.2	0.2	0.1

Polished

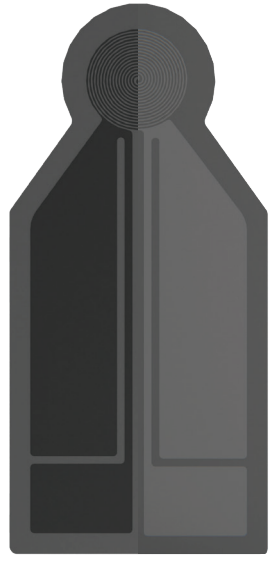


Machined

Sanded (400 grit)

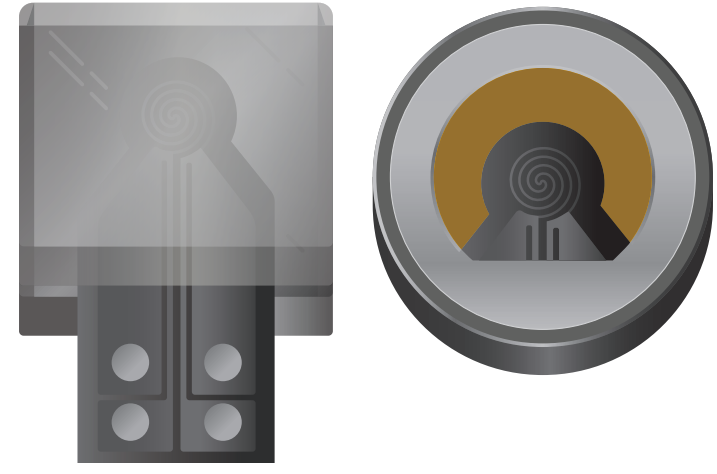
Sanded (80 grit)

MP-1 **TPS Sensors**



TPS (400 or 800/1000 °C)

Standard double-spiral nickel sensor patterns can be insulated in various insulation types for use at a wide range of temperatures.



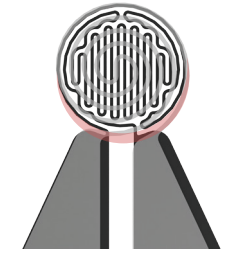
TPS Sensors

Sensors for testing solids, paste, and powders. Configurations of symmetric (Two-Sided) with one sample piece on top and bottom of sensor and asymmetric (Single-Sided) requiring only one piece of sample.

MP-1 **TPS Vertical Strip Sensors**

TPS Double Spiral
2 mm radius

TPS Vertical Strip
2 mm radius



Overlay of TPS Double Spiral and
TPS Vertical Strip 2 mm radius

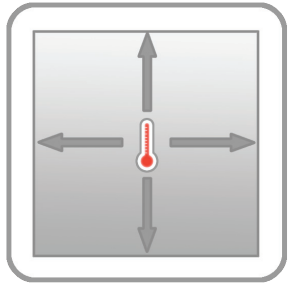
New proprietary sensor (TPS Vertical Strip) design is a near perfect circle, which better follows the ideal TPS theory. When testing with small sensor radii, this improved design reduces required corrections, while decreasing measurement uncertainty. When comparing the Corrected Radius between small diameter TPS sensors, the TPS Vertical Strip (2 mm, 1.30%) requires less correction when compared to TPS Double Spiral (2 mm, 5.75%) of the same radius. As the TPS sensor radius increases, this advantage is reduced.

	Radius (mm)	Corrected Radius (mm)	% Difference
TPS Vertical Strip Sensor	2	2.026	1.30
	3.2	3.201	0.03
	6.4	6.405	0.08
TPS Double Spiral Sensor	2	2.115	5.75
	3.2	3.28	2.50
	6.4	6.591	2.98
	9.9	10.11	2.12

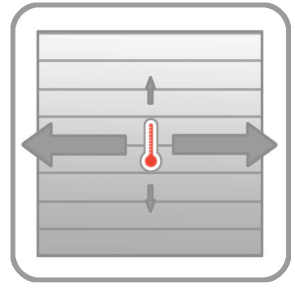
MP-1 **TPS Modules**

Thermtest offers a growing selection of testing modules which are grouped based on their testing theory.

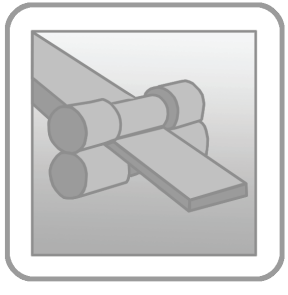
3-Dimensional



Standard
Bulk thermal conductivity, thermal diffusivity, specific heat and thermal effusivity



Anisotropic
In-plane and out-of-plane thermal conductivity and thermal diffusivity.

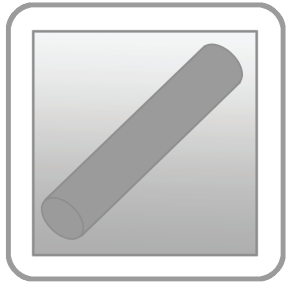


Slab
Isolated in-plane, for thermal conductivity, thermal diffusivity and volumetric specific heat for thin, conductive sheets.

MP-1 **TPS Modules**

Thermtest offers a growing selection of testing modules which are grouped based on their testing theory.

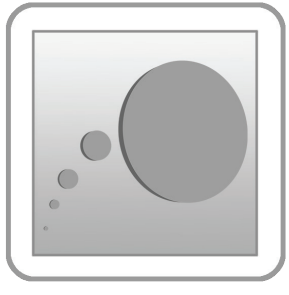
1-Dimensional



Standard
Isolated out-of-plane, for thermal conductivity, thermal diffusivity for elongated shapes, rods and bars

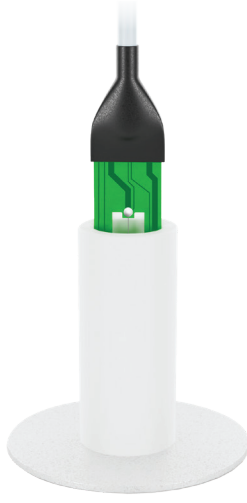
Thin-film
Thermal resistance and thermal conductivity of free-standing films and coatings

General



Specific Heat
High accuracy direct measurement of specific heat. Various cell dimensions available, for improved accuracy of heterogenous materials

MP-1 **THW Sensors**



THW-RT Sensor
(10 to 40 °C)

THW Sensor for liquids, pastes and small particle powders in composite for measurements at ambient pressure.

THW-L200 Sensor
(-50 to 200 °C) up to 20 bar

THW Sensor for liquids, pastes and small particle powders is stainless steel construction with sealed liquid cell for use of back pressure to test past boiling points.

THW-L300 Sensor
(-50 to 300 °C) up to 35 bar

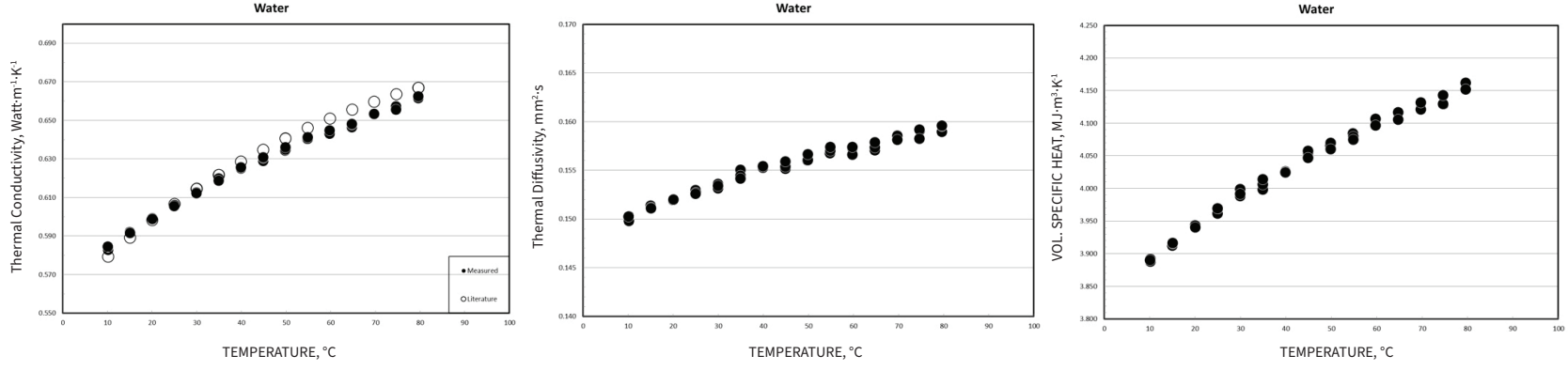
High-Temperature THW Sensor for liquids, pastes and small particle powders is stainless steel construction with sealed liquid cell for use of back pressure to test past boiling points.

THW-LT Sensor
(-160 to 200 °C) up to 35 bar

Low-Temperature THW Sensor for liquids, pastes, and small particle powders at cryogenic conditions.

MP-1 **THW Testing**

Demonstrating the accuracy of the transient hot wire method, below are thermophysical measurements of water and ethylene glycol. Low back pressure can be applied, to allow testing past boiling points.



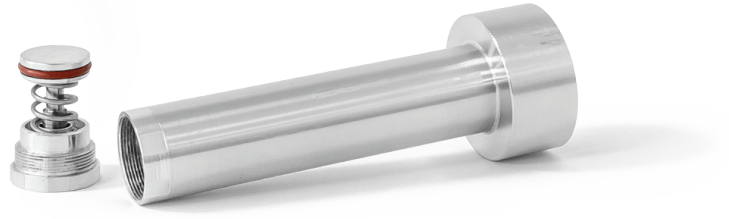
Citation: International Association for the Properties of Water and Steam, "Release on the IAPWS Formulation 2011 for the Thermal Conductivity of Ordinary Water Substance," Sept. 2011, Plzen, Czech Republic.

http://www.iapws.org/relguide/ThCond.html

MP-1 **THW Cells**

Paste and PCM Cell

Special Phase Change Materials (PCM) with easy to load access. Unique spring design allows sample expansion and contraction while ensuring sample is in constant contact with THW wire during measurement.

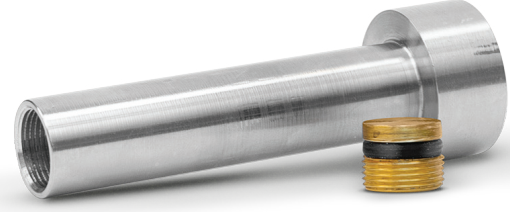


Observation Cell

THW observation sample cell is used for liquids, powder, and paste testing. The cell has convenient glass ports for observing what is happening with the sample. Typical applications are phase separation, boiling or particle settling.

Ambient Density Powder Cell

The THW Ambient Density Powder Cell is suitable for basic powder sample testing at ambient pressure.

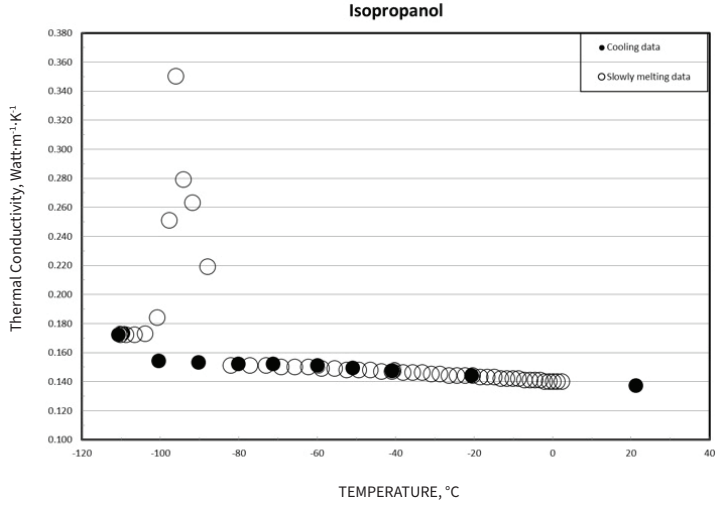


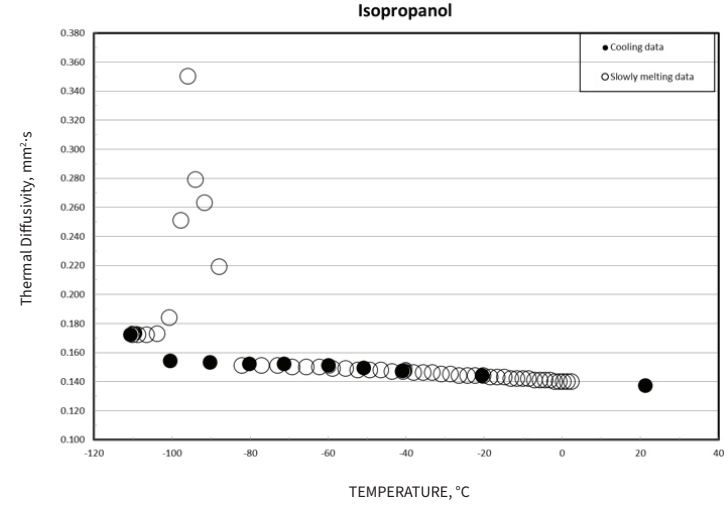
Variable Density Powder Cell

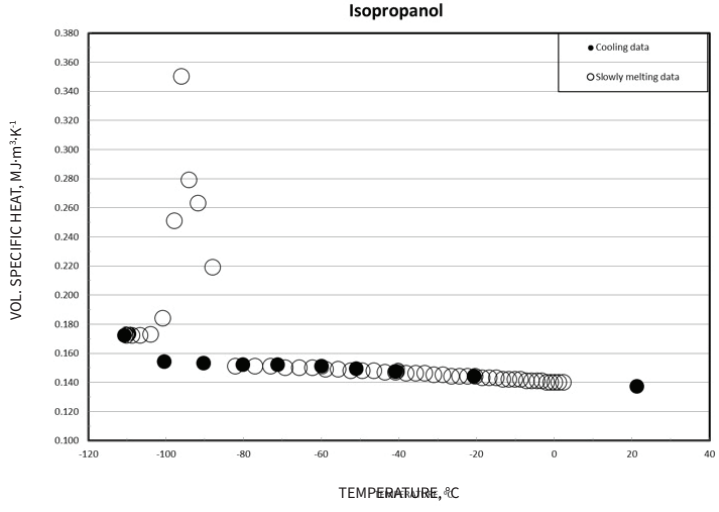
THW test cell with screw-type compression system for varying the density of powder samples can also be used to ensure powders stay in contact with THW wire.

MP-1 **PCM Tests**

Testing of phase change materials is possible with the use of the optional PCM cell. The unique spring design ensures the sample stays in contact with the sensing wire through phase changes. Isopropanol was measured for thermal conductivity, thermal diffusivity and specific heat from 20 °C to -110 °C . The sharp “anomalous” thermal conductivity rise during the phase transition is expected during the melting of the samples.







TPS **Accessories**

Muffle Furnace

- Large sample or multiple samples
- Size up to: 150 x 150 x 50 mm
- 750 °C in backfilled environment

Tube Furnace

- Option 1: 40 x 40 x 13 mm
- Option 2: 75 x 75 x 25 mm
- 1000 °C in backfilled environment

+

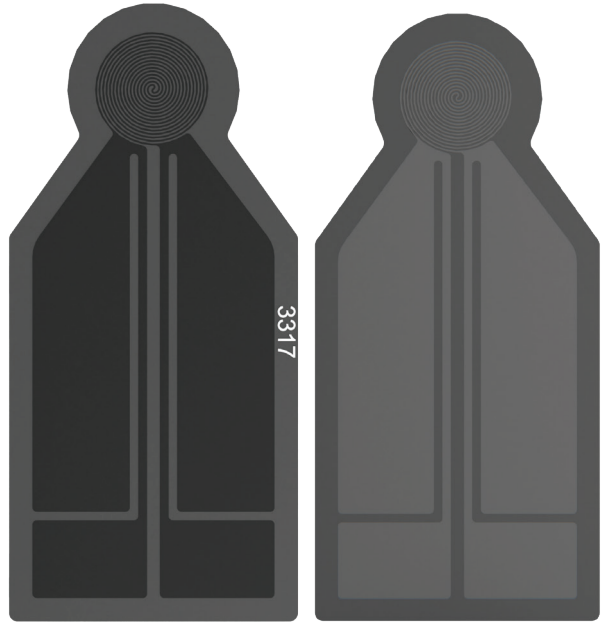
Fan Furnace

- Affordable, versatile, expandable
- Up to 4 samples
- Size up to: 75 x 75 x 50 mm
- 300 °C and 400 °C options

TPS Expanding Switch

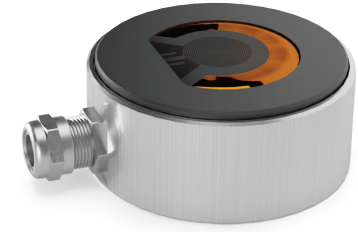
- Automate multi-sensor testing
- Channels: x2, x4, or x8

TPS **Accessories**



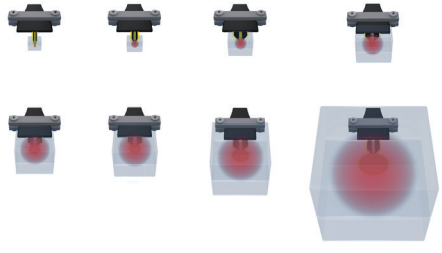
Two-Sided TPS Sensor

Two-Sided sensor for accurate lab testing



Single-Sided TPS Sensor

Spring-loaded sensor for testing large samples or one when only one piece of sample is available.



Extended TPS Sensors

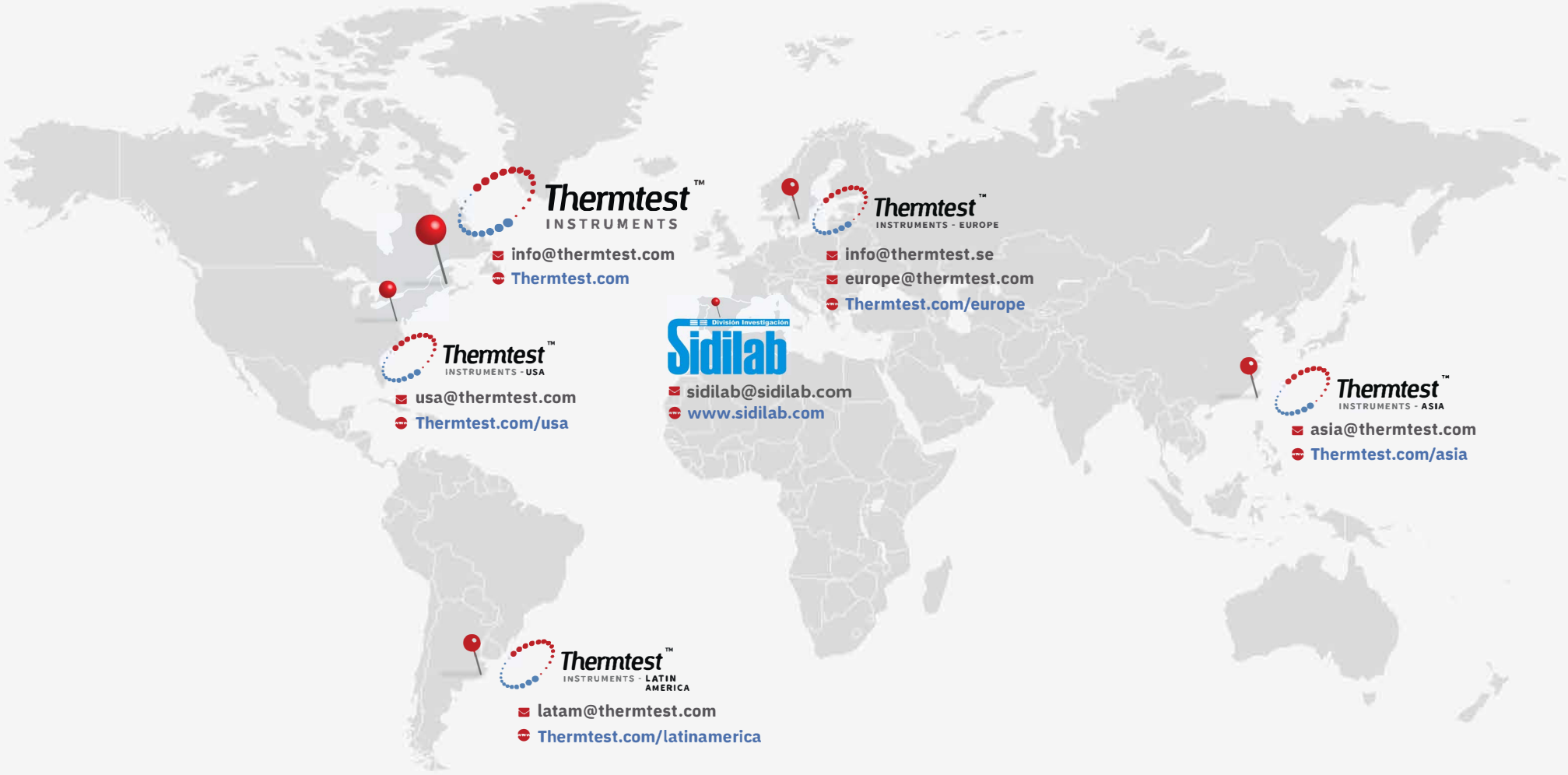
- Small sensors for samples as small as 5 mm
- Large sensors for heterogeneous samples or large particle powders

Testing Cells

- Powder Cell
- Liquid Cell
- Paste Cell
- Polymer Melt Cell

Compression Stand + Temperature

- For compressible materials
- Force gauge: 10 to 100 N
- Distance gauge
- Room temperature or -40 to 200 °C



HEADQUARTERS

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