3.1 THE THERMAL PROPERTIES OF THE MATERIALS

The followings are the thermal properties of the materials that some of these properties can be applied and measure using the thermal properties equipments:

- Thermal conductivity
- Testing thermal performance on building
- Components by means of the Hotbox apparatus
- Measurement of dimensions
- Determination of apparent (Bulk) density
- Thermal (heat) stability
- Dimensional stability
- Water absorption
- Moisture adsorption
- Moisture content
- Measurement of water vapor transmission

3.2 THE EQUIPMENTS USED FOR TESTING THERMAL PROPERTIES

In order to achieve the required measurements for the thermal properties mentioned in above the followings equipments are needed:

- Water vapor permeability tester
- Ovens
- Thickness apparatus
- Dimensions apparatus
- Compression machine

- Heat flow meter apparatus
- Guarded hotbox apparatus
- Climatic Chamber
- Solar box apparatus
3.3 TYPES OF TESTING METHODS FOR THE EQUIPMENTS

1. Guarded Hot Plate Method (ASTM C 177 Test Method)

Widely used for measuring the thermal conductivity of insulations. Although the specimens are often rather large, this usually presents no difficulty. A flat, electrically heated metering section surrounded on all lateral sides by a guard heater section controlled through differential thermocouples, supplies the planar heat source introduced over the hot face of the specimens. The most common measurement configuration is the conventional, symmetrically arranged guarded hot plate where the heater assembly is sandwiched between two specimens (Figure below). In the single sided configuration, the heat flow is passing through one specimen and the back of the main heater acts as a guard plane creating an adiabatic environment.

This is an absolute method of measurement and its applicability requires:

(a) The establishment of steady-state conditions.
(b) The measurement of the unidirectional heat flux in the metered region, the temperatures of the hot and cold surfaces, the thickness of the specimens and other parameters which may affect the unidirectional heat flux through the metered area of the specimen.

Three different categories of measurement systems can be distinguished: apparatus working around room temperatures, apparatus working below room temperatures (down to about -180°C), and apparatus working at high temperature (600°C or above). A given apparatus is most often best adopted for measurement in one of these temperature ranges.

1. **Hot Wire Method (ASTM C1113 Test Method)**

Hot wire methods are most commonly used to measure the thermal conductivity of “refractories” such as insulating bricks and powder or fibrous materials. Because it is basically a transient radial flow technique, isotropic specimens are required.

The technique has been used in a more limited way to measure properties of liquids and plastics materials of relatively low thermal conductivity.

Relatively recent modification of this long-established technique is the “probe“ method. This configuration is particularly practical where the specimen conductivity is determined from the response of a “hypodermic needle” probe inserted in the test specimen. Thus the method is conveniently applied to low-conductivity materials in powder or other semi-rigid form. A probe device can be used to measure the thermal properties of soils in situ, but most commonly a closely controlled furnace is used to contain the sample and produce the base temperatures for the tests.

The probe contains a heater and a thermocouple attached to it. When a certain amount of current is passed through the heater for a short period of time, the temperature history of the heater’s surface will take on a characteristic form. In the initial phase, the temperature will rapidly rise, and as the heat begins to soak in, the rate of rise becomes constant. When the thermal front reaches the outer boundary of the sample, the rise will slow down or stop altogether due to losses into the environment.
From the straight portion of the rate curve (temperature vs. time) the thermal conductivity can be calculated.

2. GUARDED HEAT FLOW METER METHOD ASTM E1530
It is a measurement of thermal conductivity according to the ASTM E1530 guarded heat flow meter method. In this equipment, a small sample of the material to be tested is held under a compressive load between two polished metal surfaces, each controlled at a different temperature. The lower surface is part of a calibrated heat flux transducer. As heat flows from the upper surface through the sample to the lower surface, an axial temperature gradient is established in the stack. By measuring the temperature difference across the sample along with the output from the heat flux transducer, thermal conductivity of the sample can be determined when the thickness is known. A guard furnace surrounds the test stack to reduce the effect of heat transfer across the edges of the sample which would cause an error in the measurement. The tests at room temperature only and therefore do not require a guard furnace.

![Test Section Schematic](image)

A sample of the material is held under a uniform compressive load between two polished surfaces, each controlled at a different temperature. The lower surface is part of a calibrated heat flow transducer. The heat flows from the upper surface, through the sample, to the
lower surface, establishing an axial temperature gradient in the stack. After reaching thermal equilibrium, the temperature difference across the sample is measured along with the output from the heat flow transducer. These values and the sample thickness are then used to calculate the thermal conductivity. The temperature drop through the sample is measured with temperature sensors in the highly conductive metal surface layers on either side of the sample. Each instrument is factory calibrated using samples of known thermal resistance, spanning the particular range. The contact resistance is kept small by applying a reproducible, pneumatic load to the test stack, and if needed, a thermally conductive interface compound. A guard furnace surrounds the test stack to reduce the effect of heat transfer across the edges of the sample.

For testing at temperatures below ambient, the device is supplied with an airtight compartment, where the atmosphere can be kept relatively moisture free with dry air purge. Also, special containment cells are available for fluids, pastes, and powders. It typically takes from 45 to 60 minutes to complete a test at a temperature. A unique feature of this system is the automatically controlled heat sink thermal spacer on the computerized models. This allows uninterrupted testing over the entire temperature range of the instrument, a capability not available in competitive commercial devices. It is unavoidable to have a substantial temperature difference between the cold face of the sample and the heat sink. For this reason, a city water cooled heat sink allows operation with a lowest sample temperature of about 50°C. To fully utilize the range of the instrument, the optional chiller circulator is used, that can provide heat sink temperature to –10°C, or for the cryogenic model, to –60°C. The instrument is provided with one of three operating range modules. Each module covers a different thermal resistance region. The various modules are field exchangeable.

3. **Guarded Hot Box (ASTM C-236)**

This apparatus used to measure the thermal performance of the walls components. The measurements for the wall sample has dimensions of (2.25m X2.25m)

This apparatus consists of two chambers one is he hot chamber and the other is the cold chamber, there are also metering box in hot chamber
4. THERMAL PROPERTIES ANALYZER

It is a portable device for direct measurement of thermo physical properties of a wide range of materials. It is equipped with various types of optional probes: needle Probes for porous, fibrous or soft materials, surface probes for hard materials. It applies a dynamic measurement method which reduces the time of thermal conductivity measurements to 10-16 minutes. Built-in menu system on 4-line alphanumeric display enables effective interactive communication with the device and recalibration of measurement probes by means of reference materials. Calibration data in internal memory ensure interchangeability of probes without affecting the measurement accuracy. Measurement data can be stored into the internal memory. Content of the memory is accessible through the display.
3.4 THE SPECIFICATION OF THE EQUIPMENTS

- GUARDED HEAT FLOW METER
  THERMAL CONDUCTIVITY MEASURING SYSTEM ASTM E1530

used to measure thermal conductivity of a variety of materials. These include polymers, ceramics, composites, glasses, rubbers, most metals, and other materials of low to medium thermal conductivity.

Only a relatively small test sample is required. Non-solids, such as pastes or liquids, can be tested using special containers. Thin films can also be tested accurately using a multi-layer technique. The tests are in accordance with the ASTM E1530 Standard.

- SPECIFICATIONS
  Thermal Conductivity Range 0.1 to 40 W/mK
  Accuracy +3% to 8% depending on sample’s thermal resistance
  Reproducibility +1% to 2% depending on sample’s thermal resistance

- Temperature Range [T]
  [1] 20°C to 300°C [4]-60°C to 300°C
  Note: In ranges [1] and [2], the use of an appropriate chiller/circulator, or liquid nitrogen cooling module is mandatory. Circulator is not included in price of the range options. For ranges [4] and [6], liquid nitrogen cooling module is used and a liquid nitrogen source is required.
  (Standard LS 160 tank recommended.)
- **Operating Range** [R]
  - [1] Thermal resistance 0.0005 – 0.010 m²K/W
  - [2] Thermal resistance 0.002 – 0.020 m²K/W
  - [3] Thermal resistance 0.01 – 0.05 m²K/W

- **Sample Size** [S]
  - [a] 2” (50mm) round [c] 1” (25mm) square
  - [b] 1” (25mm) round [d] 1.41” (35.8 mm) square
  - Max. sample thickness: 1”

- **Power Options** [P]
  - [A] 115VAC-60Hz-1kVA [C] 100VAC-50/60Hz
  - [B] 220-230VAC-50/60Hz-1kVA

- **Instrumentation** [Z]
    (PC NOT included)

- **Guarded Hot Plate**
  **Thermal Conductivity Measuring System**

  Used to measure the thermal performance of insulations and other materials of high thermal resistance, the guarded hot plate is a primary measuring instrument that does not need to be calibrated with a known reference material. Because of the large sample size (maximum 300mm square by 75mm thick), the instrument is recommended for testing samples of inhomogeneous materials, including low density fibrous insulations, concrete, and entire thermal insulation systems consisting of different components, like roof sections and honeycomb panels.

- Can be used to test materials from –180°C to 550°C depending on the
Because of their complex design and labor intensive operation, guarded hot plate instrument are used mostly for R & D testing where having the flexibility to meet many different applications is often more important than the speed of testing.

- **Thermal Conductivity Range**
  
  \[ k = 0.1 \text{ to } 14 \text{ Btu in/ hr ft}^2 \text{ oF} \]

  \[ \lambda = 0.015 \text{ to } 2.5 \text{ W/mK} \]
  
  Accuracy +4%

  Reproducibility +2%

- **Temperature Range [Q]**
  
  [02] -180°C to 200°C
  
  [06] 50°C to 550°C
  
  [01] Ambient to 100°C

- **Sample Size [W]**
  
  Size Thickness

  [1] 12” square 0-3”

  305mm square 0-75mm

- **Power Options (Base Unit) [Y]**
  
  [A] 115V – 60Hz – 2kVA
  
  [B] 230V – 50Hz – 2kVA
  
  [C] 100V – 50/60 Hz – 2kVA

- **Size and Weight:**
  
  Size Weight
• Guarded Hot Plate Apparatus ASTM C177

Series of measuring instruments GHP 8302.xx is designed for testing steady-state heat transfer properties, thermal conductivity and thermal resistance, of flat slab specimens in accordance with international standards ISO 8302 and ASTM C177. Instruments GHP 8302.xx are designed for use in test laboratories, manufacturing processes and quality control procedures for a wide range of materials with low and intermediate thermal conductivity including minerals, ceramics, glasses, plastics, mineral and glass fibers, cellular polyurethane and polystyrene etc. Measurement method applying by models GHP 8302.x2 is primary (or absolute) method with two-specimen configuration, models GHP 8302.x1 have single specimen configuration. Motorized plate positioning in airtight test enclosure and fully automatic measurement system provide high degree of operating comfort and test reliability.

GHP 8302.xx have modular structure, which provides easy way for calibration of embedded instruments to ensure their metrological traceability to higher standards.

Specifications

<table>
<thead>
<tr>
<th>Measurement Method</th>
<th>ISO 8302 Guarded hot plate apparatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>-10°C to 70°C</td>
</tr>
</tbody>
</table>
| Specimen size      | GHP 8302.32: 0.3 m x 0.3 m  
                      | GHP 8302.31: 0.3 m x 0.3 m  
                      | GHP 8302.52: 0.5 m x 0.5 m  
<pre><code>                  | GHP 8302.51: 0.5 m x 0.5 m |
</code></pre>
<table>
<thead>
<tr>
<th>Thermal conductivity range</th>
<th>from 0.015 W/m.K to 1.0 W/m.K</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHP 8302.32 and GHP8302.52</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity range</td>
<td>from 0.015 W/m.K to 2.0 W/m.K</td>
</tr>
<tr>
<td>GHP 8302.31 and GHP8302.51</td>
<td></td>
</tr>
<tr>
<td>Surface temperature stability</td>
<td>±0.01°C</td>
</tr>
<tr>
<td>Reproducibility</td>
<td>0.5%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>2 %</td>
</tr>
</tbody>
</table>

**Prices**

- GHP8302.32: 35 500.- € (EUR)
- GHP8302.31: 38 000.- € (EUR)
- GHP8302.52: 39 500.- € (EUR)
- GHP8302.51: 42 000.- € (EUR)
• **Heat Flow Meter Apparatus (ASTM C518)**

Series of measuring instruments HFM 8301.xx is designed for testing steady-state heat transfer properties, thermal conductivity and thermal resistance, of flat slab specimens in accordance with international standards ISO 8301 and ASTM C518. Instruments HFM 8301.xx are designed for use in test laboratories, manufacturing processes and quality control procedures for a wide range of materials with low and intermediate thermal conductivity including plastics, mineral and glass fibers, cellular polyurethane and polystyrene etc. Measurement method applying by HFM 8301.xx is secondary method with single specimen configuration. Fully automatic measurement system provides high degree of operating comfort and test reliability.

HFM 8301.xx have modular structure, which provides easy way for calibration of embedded instruments to ensure their metrological traceability to higher standards.

**Specifications**

<table>
<thead>
<tr>
<th>Measurement Method</th>
<th>ISO 8301 Heat Flow Meter Apparatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>-10°C to 70°C</td>
</tr>
<tr>
<td>Specimen size</td>
<td>HFM 8301.30: 0.3 m x 0.3 m</td>
</tr>
<tr>
<td></td>
<td>HFM 8301.50: 0.5 m x 0.5 m</td>
</tr>
<tr>
<td>Thermal conductivity range</td>
<td>from 0.015 W/m.K to 0.60 W/m.K</td>
</tr>
<tr>
<td>Surface temperature stability</td>
<td>±0.02°C</td>
</tr>
<tr>
<td>Reproducibility</td>
<td>1.0%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>3 %</td>
</tr>
</tbody>
</table>

**Prices**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HFM8301.30:</td>
<td>28 500.- € (EUR)</td>
</tr>
<tr>
<td>HFM8301.50:</td>
<td>32 500.- € (EUR)</td>
</tr>
</tbody>
</table>
• **HFM 8301.x8 Heat Flow Meter Apparatus (ISO 8301)**

Heat flow meter apparatuses of series HFM 8301.x8 are measuring instruments for testing steady-state heat transfer properties, thermal conductivity and thermal resistance, of flat slab specimens in accordance with international standards ISO 8301 and ASTM C518. HFM 8301.x8 are designed for use in test laboratories, manufacturing processes and quality control procedures for a wide range of materials with low and intermediate thermal conductivity including minerals, ceramics, glasses, plastics, mineral and glass fibres, cellular polyurethane and polystyrene etc. Because of the large sample size, HFM 8301.x8 are also suitable for testing inhomogeneous materials.

HFM8301.x8 comprise temperature controlled test enclosure, measurement plates for single specimen symmetrical configuration with thermocouples and two heat flux transducers, remote controlled power supplies and measuring unit with controlling PC. Optional refrigerated circulator is provided to control cold surface specimen temperature. Hot surface temperature of the specimen is regulated by electrical heating system. Temperature controlled test enclosure maintains ambient temperature at the mean specimen temperature and prevents the ingress of moisture inside the tested specimen. High performance and fully automated switching and measuring system provide high degree of operating comfort, test reliability and measuring accuracy. Supplied measurement software evaluates measurements according to international standards ISO8301 and EN 1946 part 1. and 3., in addition full listing of measurement records is provided for detailed analysis. HFM 8301.x8 have modular structure, which provides easy way for calibration of embedded instruments to ensure their metrological traceability.

Three reference specimens supplied with the instrument enable periodical instrument performance checks and applying corrections.
Specifications

<table>
<thead>
<tr>
<th>Temperature range</th>
<th>Measurement Method</th>
<th>ISO 8301 Heat Flow Meter Apparatus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>for measurement range (0.015 - 2.0) W/m.K</td>
<td>from -10°C to 70°C</td>
</tr>
<tr>
<td></td>
<td>for measurement range (2.0 - 4.0) W/m.K</td>
<td>from 0°C to 70°C</td>
</tr>
<tr>
<td></td>
<td>for measurement range (4.0 - 8.0) W/m.K</td>
<td>from 15°C to 70°C</td>
</tr>
</tbody>
</table>

- Specimen size
  - HFM 8301.38: 0.25 m x 0.25 m
  - HFM 8301.58: 0.5 m x 0.5 m

- Thermal conductivity range
  - from 0.015 W/m.K to 8.0 W/m.K

- Surface temperature stability
  - ±0.02°C

- Reproducibility
  - 1.0 % for range (0.015 - 2.0) W/m.K
  - 2.0 % for range (2.0 - 8.0) W/m.K

- Accuracy:
  - 5 %
  - (3 % after corrections made by means of supplied reference specimens)

Delivery term: 6 months

- HFM8301.38 (without refrigerated circulator): 34 500.- € (EUR)
- HFM8301.58 (without refrigerated circulator): 38 500.- € (EUR)
- Refrigerated circulator: 4950.- € (EUR)

- **Portable measuring instrument**

ISOMET 2104 is a for direct measurement of thermo physical properties of a wide range of materials. It is equipped with optional measurement probes, needle probes are for porous, fibrous or soft materials, surface probes are suitable for hard materials. It applies
a dynamic measurement method which enables to reduce the period of thermal conductivity measurements to cca 10 -16 minutes. Built-in menu system on 4 line alphanumeric display enables effective interactive communication with the device and recalibration of measurement probes by means of reference materials. Calibration data in internal memory ensure interchangeability of probes without affecting the measurement accuracy. Measurement data can be stored into the internal memory. The content of the memory is any time accessible through the display or it can be transferred into a PC by serial interface RS 232.

MEASURED QUANTITIES

- $\lambda$ - Thermal conductivity  
  (W m$^{-1}$ K$^{-1}$)
- $a$ - Thermal diffusivity  
  (m$^2$ s$^{-1}$)
- $cp$ - Volume heat capacity  
  (J m$^{-3}$ K$^{-1}$)
- $T$ - Temperature  
  (°C)

APPLICATIONS

- Civil engineering
  - Measurement of thermal transfer properties of building materials and constructions,
  - Optimization of technology production of thermal insulating materials
  - Check of thermal isolation of buildings, pipelines, etc.
- Geological investigations
  - Indoor and outdoor measurement of thermal transfer properties of soils, sands, rocks, etc.
  - Soil homogeneity investigation
- Chemical industry
  - Measurement of thermo physical properties of chemical substances, agents, lubricant greases, plastics, suspensions, foam, rubbers, etc.
Woodworking industry
- Measurement of thermo physical properties of woods
- Moisture measurement and drying process optimization

Textile industry
- Optimization of textile thermal contact comfort
- Textile composition and surface adjustment
- Evaluation of floor plates and carpets

ISOMET 2104 - SPECIFICATIONS
Measurement Ranges:

<table>
<thead>
<tr>
<th>Probe Type</th>
<th>Thermal Conductivity</th>
<th>Volume Heat Capacity</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle Probe API 210402</td>
<td>0.015-0.20 W/m.K</td>
<td>4.0x10^4 - 1.5x10^6 Jm(^{-3})K(^{-1})</td>
<td>-20°C - +70°C</td>
</tr>
<tr>
<td>Needle Probe API 210403</td>
<td>0.20-1.0 W/m.K</td>
<td>1.5x10^5 - 4.0x10^6 Jm(^{-3})K(^{-1})</td>
<td>-20°C - +70°C</td>
</tr>
<tr>
<td>Needle Probe API 210404</td>
<td>1.0-2.0 W/m.K</td>
<td>1.5x10^6 - 4.0x10^6 Jm(^{-3})K(^{-1})</td>
<td>-20°C - +70°C</td>
</tr>
<tr>
<td>Surface Probe API 210411</td>
<td>0.030-0.30 W/m.K</td>
<td>4.0x10^4 - 1.5x10^6 Jm(^{-3})K(^{-1})</td>
<td>-15°C - +50°C</td>
</tr>
<tr>
<td>Surface Probe API 210412</td>
<td>0.30-2.0 W/m.K</td>
<td>1.5x10^6 - 4.0x10^6 Jm(^{-3})K(^{-1})</td>
<td>-15°C - +50°C</td>
</tr>
<tr>
<td>Surface Probe API 210413</td>
<td>2.0-6.0 W/m.K</td>
<td>1.5x10^6 - 4.0x10^6 Jm(^{-3})K(^{-1})</td>
<td>-15°C - +50°C</td>
</tr>
</tbody>
</table>

Accuracy:

<table>
<thead>
<tr>
<th>Measurement Range</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal 0.015-0.050 W/m.K</td>
<td>5 % of reading + 0.003 W m(^{-1})K(^{-1})</td>
</tr>
</tbody>
</table>
Conductivity: 0.050 – 0.70 W/m.K  5 % of reading + 0.001 W m⁻¹K⁻¹

0.70 - 6.0 W/m.K  10 % of reading

Volume Heat Capacity: 4.0x10⁴ - 4.0x10⁶ Jm⁻³K⁻¹  15 % of reading + 1x10³ Jm⁻³K⁻¹

Temperature: -20°C - +70°C  1°C

Measurement Reproducibility:

<table>
<thead>
<tr>
<th>Conductivity</th>
<th>3 % of reading + 0.001W m⁻¹K⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume Heat Capacity</td>
<td>3 % of reading + 1x10³ Jm⁻³K⁻¹</td>
</tr>
</tbody>
</table>

Operating Temperature Range
of Basic Device 0..40 °C

Internal Memory Capacity 1000 measurement records

Power Supply 12V DC or internal NiCd rechargeable batteries

Accumulator capacity cca 3.5 - 4 hours (depends on tested material)

Communications serial link RS 232

Dimensions 310 x 300 x 110 mm

Weight 4.5 kg
FOX50 HEAT FLOW METER
THERMAL CONDUCTIVITY INSTRUMENT

FOX50 is a microprocessor-based instrument for testing in accordance with ASTM C 518 and ISO 8301. It is designed for testing the thermal conductivity of materials in the conductivity range of 0.1W/mK to 10W/mK. The instrument is designed to test polymers, composite materials, low conductivity ceramics and glasses. The instrument tests up to 63 mm diameter specimens from 0 to 25 mm thick (2.5" diameter 0 to 1" thick), but can open to 26.27 mm (1.05”) for sample removal. The actual metering area is 25 mm (1”) square. Both instrument plates utilize solid state heating/cooling and can operate between 0°C and 110°C (32°F and 230°F). Higher temperature range Version will reach 190°C (374°F) plate temperature.

Specimens can be tested repeatedly at any one temperature within this range. Alternatively, up to nine temperatures can be entered for each specimen in which case the instrument will automatically advance to the next temperature once equilibrium conditions have been established. At the end of each test the results are displayed (or printed if an RS 232 printer is attached). A set of two pyrex standards of different thickness are provided in order to verify the Two Thickness procedure which eliminates air interface from results.

Cells for molten sample and liquid testing are available and a high temperature version (from 50°C to 300°C) is coming in the near future.

The specimen thickness is continuously monitored during the test by a sophisticated digital thickness readout system. Standard resolution of thickness readout is better than +/-0.0254mm (+/-0.001”). Constant pressure between the plates and the sample is provided through a pneumatic cylinder.

Both plates of the instrument are equipped with thin film high output heat flux transducers developed and manufactured by Laser Comp. The use of two heat flux transducers accelerates the tests and produces more accurate results.
FOX50 utilizes state of the art analog and digital electronics developed specifically for thermal conductivity testing instruments. The accuracy of the temperature control is +/-0.01°C. External thermocouples can be connected to outlets in back. The heat flux transducer readings are resolved down to 0.6 micro volts.

The FOX50 is also very simple to operate. Step by step instructions are displayed on a clear four line LCD display. The instrument can easily be operated by an operator with minimum training.

Each instrument is equipped with an RS232 port. The port is used to print results or to connect the instrument to a host computer.

Input power can be either 115V or 220V 50/60Hz user switchable at 400VA. Water at 18°C (65°F) or lower and air at up to 90 PSI (low consumption) are also required.

**Dimensions:** 10.5” (26.7 cm) D x 11” (28 cm) H x 6.5” (16.5 cm) W

**FOX50 INCLUDES**

Wintherm50 software operating under Microsoft WINDOWS allows for connection of the FOX50 to an IBM compatible computer through a standard RS 232 interface. All data entry and collection of results can be accomplished through customer's computer. The instrument can be configured by the user, e.g., temperature control parameters, equilibrium criteria. Up to two FOX50, instruments can be operated with this package simultaneously. The Two Thickness Test enables the elimination of the air interface from the calculation. The computer can be used for other purposes while operating the instruments as long as the user stays in the Windows environment.

**LIST PRICE** $24,310
• **Calibrated Hot Box Apparatus for Determination of Thermal Performance of Windows and Doors (ISO12567-1)**

CHB 2001 is a test apparatus for determination of thermal transmittance of doors and windows by calibrated hot box method according to EN ISO 8990, EN ISO12567-1. Apparatus is equipped with two surrounding panels for tested specimens (one for doors and one for windows). Warm and cold side of the apparatus move on metal tracks with electric drive.

Test process, data acquisition and evaluation of results are controlled by PC.

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range of the cold side</td>
<td>from -10 °C to +10 °C</td>
</tr>
<tr>
<td>Temperature range of the warm side</td>
<td>from +10 °C to +30 °C</td>
</tr>
<tr>
<td>Thermal transmittance measurement range</td>
<td>0.5 až 4 Wm⁻²K⁻¹</td>
</tr>
<tr>
<td>Accuracy of thermal transmittance measurement</td>
<td>7 %</td>
</tr>
<tr>
<td>Air flow measurement range on the cold side</td>
<td>0 až 10 ms⁻¹</td>
</tr>
<tr>
<td>Air flow measurement range on the warm side</td>
<td>0 až 5 ms⁻¹</td>
</tr>
<tr>
<td>Specimen sizes for windows (Table 3, ISO 12567-1)</td>
<td>1230 x 1480 mm</td>
</tr>
<tr>
<td>Specimen sizes for doors (Table 3, ISO 12567-1)</td>
<td>1000 x 2000 mm</td>
</tr>
<tr>
<td>Material of apparatus walls</td>
<td>PUR foam panels</td>
</tr>
<tr>
<td>Thickness of applied PUR foam panels</td>
<td>200 mm</td>
</tr>
<tr>
<td>Thermal transmittance of applied PUR foam insulation</td>
<td>0.10 Wm⁻²K⁻¹</td>
</tr>
</tbody>
</table>

**Calibration panels** for windows (2 pieces)
- a) thickness 20 mm
- b) thickness 60 mm

Number of temperature sensors on calibration panels 60 pieces (6x5 on each side)

**Calibration panels for doors** (2 pieces)
- a) thickness 20 mm
b) thickness 60 mm

Number of temperature sensors on calibration panels 64 pieces (4x8 on each side)

Apparatus sizes (width x depth x high) 6 x 2.5 x 3.3 m
Requirement for room sizes 6 x 4.5 x 3.3 m
Weight 1500 kg
Power supply, line frequency 3 x 400 V, 50 Hz
Power consumption max. 3.2 kW

Price (EXW Bratislava): 105 000.- €

- **Guarded Hot Box Apparatus Rk 02**

Rk 02 is a test apparatus for determination of thermal transmittance of different building products (e.g. walls, doors windows, panels etc.) according to EN ISO 8990 guarded hot box method. Apparatus is equipped with two surrounding panels for tested specimens. Cold box and warm box are moved on metal track with electric drive. Test process, data acquisition and evaluation of results are controlled by PC.

Specifications

<table>
<thead>
<tr>
<th>Measurement method</th>
<th>ISO 8990 (guarded hot box)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range of the cold side</td>
<td>from –18 °C to +5 °C</td>
</tr>
<tr>
<td>Temperature range of the warm side</td>
<td>from +5 °C to +40 °C</td>
</tr>
<tr>
<td>Thermal transmittance measurement range</td>
<td>0.1 až 4 Wm⁻²K⁻¹</td>
</tr>
<tr>
<td>Accuracy of thermal transmittance measurement</td>
<td>5 %</td>
</tr>
<tr>
<td>Air flow measurement range on the cold side</td>
<td>0 až 10 ms⁻¹</td>
</tr>
</tbody>
</table>
Air flow measurement range on the warm side 0 až 5 ms⁻¹
Specimen sizes 1500 x 1500 mm
Material of apparatus walls PUR foam panels
PUR foam insulation panel thickness 200 mm
Thermal transmittance of applied PUR foam insulation 0.10 Wm⁻²K⁻¹
Apparatus sizes (width x depth x high) 6 x 2.5 x 3.3 m

Requirement for room sizes 6 x 4.5 x 3.3 m

Weight 1700 kg
Power supply, line frequency 3 x 400 V, 50 Hz
max. 6 kW

Price: 135 000.- € (EUR)

THE CLIMATE CHAMBER

The climate chamber is an open topped cylinder made entirely of stainless steel. It is 800 mm across and 500 mm deep. The chamber can be used in two ways: A test specimen can be mounted to form the lid of the chamber, allowing investigation of the effects of a gradient in temperature and relative humidity on a porous structure. Alternatively the top can be sealed with a metal plate, so that the cylinder encloses the specimen under test in an airtight space. The temperature and relative humidity (RH) of the chamber can be controlled between about 30°C and 10°C and from about 40% to 95% RH. A unique facility is that the water moving into and out of the chamber, or into and out of specimens sealed within the chamber, can be measured: the humidity control unit within the chamber measures how much water it collects or releases.
Basically, water is evaporated from, or condensed into a weighed water tank whose temperature is controlled by heat pump.

The moisture diffusion through the specimen is either measured or defined by a device within the well which absorbs or emits water vapour at a controlled rate. The dew point and temperature are measured on both sides of the specimen and may also be measured at points within the specimen. In this way one can measure the water vapour flux through a specimen, and the resulting relative humidity at points within the specimen, under gradients of relative humidity and temperature.

The experiment is usually conducted with colder air in the well than in the enclosing room, so that convective air movement through the specimen is suppressed. This is an unnatural situation for a wall, but it simplifies interpretation. Processes involving streaming air, though a common cause of unexpected failures in building envelopes, are not so amenable to modeling.

The test chamber is a cylindrical well which contains the humidity control apparatus. The temperature in the well is controlled by a cooling coil in the outer annular chamber. The specimen is laid on a grid and enclosed by a thin wall continuing the line of the chamber wall. Outside this wall is a thermal guard ring of the same material.
The test specimen can be placed entirely within the chamber. It can be a vertical slab resting on the floor (maximum dimensions about 450 x 450 x 50 mm) or it can be suspended horizontally, resting on a grid which is supported by studs welded to the side of the chamber (max 790 mm dia. x 150 deep). The chamber has a second set of studs near the top, so that a specimen can be laid across the top of the cylinder, in place of the metal lid (790 mm x 1000 mm max. depth).
The previous specifications of the equipments are available in the following companies

APPLIED PRECISION Ltd.
TECHNICKA 5, BRATISLAVA
82104, SLOVAKIA
TEL:+421-2-43 337 340; FAX:
+421-2-43 426 628
e-mail: info@appliedp.sk

Anter Corporation
1700 Universal Road, Pittsburgh, PA 15235-3998 USA
Phone: (412) 795-6410 Fax: (412) 795-8225
E-mail: sales@anter.com Website: www.anter.com

LaserComp
20 Spring Street, Saugus, MA 01906, voice 781-233-1717, fax 781-941-2484
www.lasercomp.com E-mail: lasercomp@lasercomp.com
### 3.5 SUMMURY OF THE PRICING FOR THE EQUIPMENTS

#### NAME OF THE EQUIPMENTS & APPLICATIONS & PRICES

<table>
<thead>
<tr>
<th>Name of the equipment</th>
<th>Application</th>
<th>Supplier &amp; Trade Name of the equipments</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>THERMAL PROPERTIES ANALYZER</strong></td>
<td>It is a portable device for direct measurement of thermo physical properties of a wide range of materials. It is equipped with various types of optional probes: needle Probes for porous, fibrous or soft materials, surface probes for hard materials. – It used for measurement of thermal transfer properties of building materials and constructions, Optimization of technology production of thermal insulating materials. Check of thermal isolation of buildings</td>
<td>Applied Precision Ltd- ISOMET model 2104</td>
<td>6.000 $</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anter Corporation-Quikline 30</td>
<td>19.575 $</td>
</tr>
<tr>
<td>• <strong>THERMAL CONDUCTIVITY METER</strong></td>
<td>Used for Measurements of thermal conductivity of all types construction materials</td>
<td>Anter Corporation-Quikline 10</td>
<td>22.950 $</td>
</tr>
<tr>
<td></td>
<td></td>
<td>K2analytical Company – KEM</td>
<td>28.000 $</td>
</tr>
<tr>
<td>• <strong>HEAT FLOW METER</strong></td>
<td>Designed for testing steady-state heat transfer properties, thermal conductivity and thermal resistance</td>
<td>Applied Precision Ltd-HFM 8301X4</td>
<td>32.500 $</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anter Corporation</td>
<td>39.500 $</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FOX50</td>
<td>24.000$</td>
</tr>
</tbody>
</table>
### GUARDED HOT PLATE

- **Designed for testing steady-state heat transfer properties, thermal conductivity and thermal resistance**

Used to measure the thermal performance of insulations and other materials of high thermal resistance, the guarded hot plate is a primary measuring instrument that does not need to be calibrated with a known reference material. Because of the large sample size (maximum 300mm square by 75mm thick), the instrument is recommended for testing samples of inhomogeneous materials, including low density fibrous insulations, concrete, and entire thermal insulation systems consisting of different components, like roof sections and honeycomb panels.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Precision Ltd</td>
<td>GHP 8302</td>
<td>$42,000</td>
</tr>
<tr>
<td>Anter Corporation</td>
<td>Quikline 16</td>
<td>$46,500</td>
</tr>
</tbody>
</table>

### HOT BOX

- **Calibrated Hot Box Apparatus**
  
  Apparatus for determination of thermal transmittance of doors and windows

- **Guarded Hot Box Apparatus**
  
  A test apparatus for determination of thermal transmittance of different building products (e.g. walls, doors windows, panels etc.)

- **Guarded Hot Box Apparatus**
  
  A test apparatus for determination of thermal transmission properties of thermally homogenous and inhomogeneous building panels, construction assemblies including doors and windows

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Precision Ltd</td>
<td>Rk 02</td>
<td>$105,000</td>
</tr>
<tr>
<td>Applied Precision Ltd</td>
<td>Rk-04</td>
<td>$135,000</td>
</tr>
<tr>
<td>Applied Precision Ltd</td>
<td>Rk-04</td>
<td>$191,000</td>
</tr>
</tbody>
</table>
3.6 CONCLUSIONS

As our concern to have heat flow apparatus to test the K values of wide range of construction materials including (masonry, concrete, marbles, stone, insulations materials, ....etc). In this regard, the apparatus that fits the our requirements should have the thermal conductivity range to be from 0.015 W/m.k to 4 W/m.k in order to achieve our goal depending on PSI specification for the construction materials (PS 222-1999) where the thermal properties of different construction materials has been determined.

After reviewing many companies' catalogues and brochures in order to study the specifications that are suitable for our needs with allocated budget. The followings are three apparatus that belongs to Anter Corporation, APPLIED PRECISION and laser comp were reviewed in order to choose one of them

1. Thermal Conductivity Meter by Anter Corporation

2. Heat Flow meter Apparatus by APPLIED PRECISION

3. Heat Flow meter Apparatus (Thermal Conductivity Meter) by laser comp

After comparing the specifications of the three equipments, it concluded that Heat Flow meter Apparatus by APPLIED PRECISION are very close to achieve our needs and it is ideal for measure the K values of insulation materials as the range goes from 0.015 to 4.00 which most of the construction materials are included in this case

In the meantime, the Heat Flow meter Apparatus (THERMAL CONDUCTIVITY INSTRUMENT) by laser comp is ideal for testing K values of wide range of construction materials without insulations materials, as a result that the range of measurements for K between 0.1 to 10 without covering the insulations materials