TPSYS20

High-accuracy thermal conductivity measuring system

TPSYS20 is a user friendly system for the measurement of thermal conductivity using TP02 or TP08 thermal needle probes. The system is designed for high-accuracy measurements. It is particularly suitable for analysis of soils, thermal backfill materials, sediments, foodstuff, sludges, paints, glues and highly viscous fluids.

Figure 1 *application of the complete TPSYS20 measuring system in a laboratory environment using a CRC01 calibration reference cylinder*

Figure 2 *TPSYS20 is delivered with either a TP02 Non-Steady-State Probe or its smaller equivalent TP08*
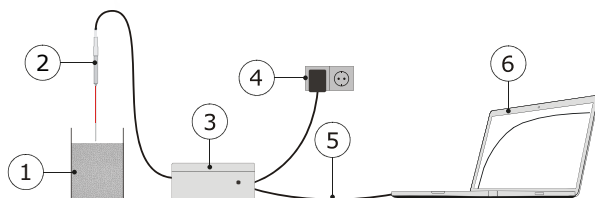

Figure 3 *TPSYS20 standard configuration: Sample (1), Needle model TP02 or TP08 (2), MCU Measurement and Control Unit (3), Adapter suitable for both 230 and 110 VAC (4), USB or ethernet connection (5), PC (not included) (6)*

Introduction

TPSYS20 is an accurate and user friendly system for measuring thermal conductivity. Its main components are the TP02 thermal needle probe (or its smaller equivalent, model TP08), the MCU Measurement and Control Unit and software. TP02 and TP08 are designed for measuring thermal conductivities in the range from 0.1 to 6.0 W/(m·K).

The measurement principle is the transient line source technique, in which the thermal conductivity of a specimen is determined from the step response of the specimen temperature to heat from a linear heater. For details on TP02 or TP08, see the separate brochures. The MCU takes care of the measurement and control process and provides a convenient graphical user interface in the form of a webpage.

TPSYS20 is particularly suitable for thermal conductivity measurements in a laboratory environment. If needed, TPSYS20 can be powered from a 12 V battery, so that it may be used in the field. TPSYS20 is operated in conjunction with a PC. An intuitive and easy-to-use graphical user interface allows the user to set measurement parameters, control measurements, view measurement progress and view and download measurement data.

TPSYS20 advantages

- **Connection via Ethernet or USB.** The MCU can be connected to a local area network (LAN) via ethernet or directly to a PC via USB.
- **Intuitive and easy-to-use graphical user interface**. The MCU acts as a server that provides a graphical user interface in the form of a webpage. The graphical user interface is accessible through a web browser. No software installation is required.
- **High-accuracy thermal conductivity measurements.** Thermal Needle Probes, also known as Non-Steady-State Probes (NSSPs) and line-source probes are designed for high-

accuracy measurements. The transient-line source method is sensitive to the specimens thermal conductivity only. It is insensitive to other specimen properties and there is no need to make assumptions about the specimen heat capacity or thermal diffusivity. This makes it an ideal method for measuring thermal conductivity.

- **Adjustable constant current source.** The current source in the MCU provides a stable heater current that can be adjusted such that a broad range of thermal conductivities can be measured.
- **Measurement and analysis of heating and cooling phase.** Users can choose to measure heating phase only or to measure heating and cooling phase. The latter reduces effect of specimen temperature drift on the measurement result.

Suggested use

NSSPs are particularly suitable for measuring the thermal conductivity of fine granular materials, powders, pastes, gels and highly viscous fluids in which a needle probe can be easily inserted. Harder materials such as rocks may also be measured provided that a hole can be drilled to insert the probe. Examples of typical specimen materials include soils, thermal backfill materials, sediments, foodstuff, sludges, paints and glues.

Areas of application include measurement of soils for thermal management of high-voltage electric cables, pipelines and ground heat exchangers; measurement of plastics for the optimisation of material processing; material characterisation. TPSYS20 can be used to measure thermal conductivities in the range from 0.1 to 6.0 W/(m·K). Recommended specimen dimensions are a diameter of 100 mm or more and a length of at least 160 mm for TP02 (specimen volume ~1.3 L) or 80 mm for TP08 (specimen volume ~ 0.65 L). Use of smaller specimen may be possible depending on the thermal properties of the specimen and the required accuracy.
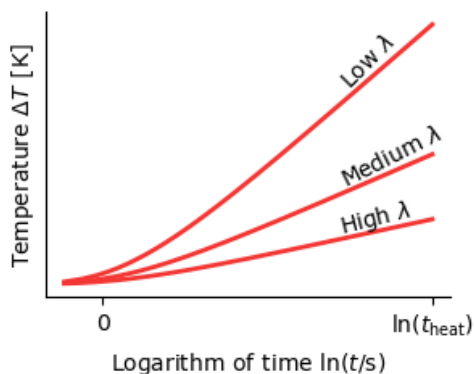
TPSYS20 specifications

Measurand	thermal conductivity
Rated measurement range	0.1 to 6 W/(m·K)
Measurement uncertainty (depends on material type)	± (3 % + 0.02 W/(m·K)) (k = 2)
Optional measurand	thermal resistivity
Measurement duration (typical)	3 to 10 minutes
Test methods	ASTM D5334 - 14; IEEE 442-2017; ASTM D5930 - 17
Probe supplied	TP02 or TP08
Heating cycle duration	200 s (typical)
Operating modes	• heating measurement only • heating and cooldown measurement

TP02 / TP08 specifications

Rated operating temperature range	-55 to + 180 °C
IP protection class	IP68 (needle and base) IP67 (entire probe)
Needle length TP02	150 mm
Needle length TP08	70 mm

MCU specifications

Connection	to local area network (LAN) via Ethernet or directly to PC via USB
Graphical user interface	web page via web browser
Supported web browsers	Chrome 10 Firefox 4 Internet Explorer 9 Opera 11 Safari 5 or later
Rated operating voltage MCU	10 to 16 VDC
Rated operating temperature range MCU	- 25 to +50 °C
IP protection class	IP54
Sampling rate	2 Hz

Power Supply Unit specifications

Input	100 to 240 VAC 50/60 Hz
Input plug	Type A/B (USA), Type C/F (EU), Type G (UK), Type I (AU)
Output	12 VDC 2.5 A
IP protection class	IP40

Figure 4 *the thermal conductivity is determined by measuring the temperature change in response to heating. The slope of the ΔT -vs- ln(t) graph is inversely proportional to the thermal conductivity.*
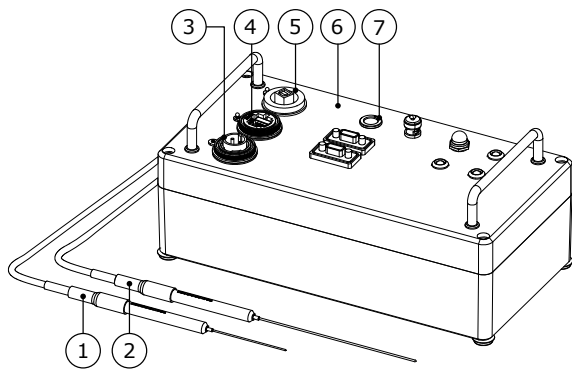
Figure 5 *overview of TPSYS20: the system includes needle model TP08 (1) or TP02 (2) and the MCU (6). The thermal needle probe must be connected to the MCU (7). The MCU is powered from a 12 VDC power source (3). Communication with the MCU can be done via Ethernet (4) or USB (5).*

TP02 or TP08 probe

TPSYS20 is either delivered with a TP02 or a TP08 probe.

TP02 is equipped with a reference temperature junction, located in the tip of the needle. This allows the temperature difference between the heated section of the needle and the reference junction to be measured. The use of a reference junction makes the thermal conductivity measurement much less sensitive to specimen temperature drift. For more details see the TP02 brochure.

TP08 is a shorter needle, which makes it an excellent alternative when only small amounts of sample material are available. TP08 does not have a reference temperature junction. For more details see the TP08 brochure.

Standards

The measurement with TPSYS20 complies with the IEEE Guide for Soil Thermal Resistivity Measurements (IEEE 442-2017) as well as with ASTM D5334 - 14 Standard Test Method for Determination of Thermal Conductivity of Soil and Soft Rock. TPSYS20 is suitable for use by ISO certified laboratories.

Alternative systems

TPSYS20 is primarily intended for laboratory use. For outdoor soil measurements Hukseflux recommends consulting the brochures of the more robust albeit less accurate FTN, MTN and TNS systems designed for outdoor use.

User interface: MCU as a web server

TPSYS20 is controlled via a PC. The TPSYS20 MCU can be connected to a local area network via ethernet or directly to a PC via USB. The graphical user interface is available through a webpage and can be opened in any of the supported web browsers. No installation of software is required. The graphical user interface allows the user to configure measurement parameters, control measurements, view measurement progress and to view and download measurement results.
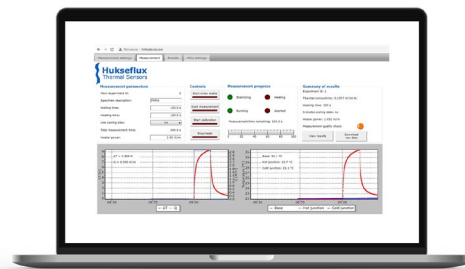

Figure 6 *TPSYS20 graphical user interface, accessible through a web browser*

Included items

- TPSYS20 measurement and control unit (MCU)
- TP02 or TP08 thermal needle probes
- Set of 5 GT02 or GT01 guiding tubes
- Power supply unit (PSU)
- USB-A to USB-B cable
- Carrying case

Figure 7 *TPSYS20 measuring system includes a TP02/TP08 probe, MCU and carrying case.*

Options
- **TPSYS20-02**, TPSYS20 with TP02 probe
- **TPSYS20-08**, TPSYS20 with TP08 probe

Accessories
For high-accuracy calibration, dedicated CRC01 Calibration Reference Cylinders are available. For insertion into hard material types or for casting into plastics, cement and backfill materials, GT Series Guiding tubes can be applied.

- **CRC01 –** calibration reference cylinder for TP02 and TP08
- **GT01** – a spare set of 5 guiding tubes for TP08
- **GT02** – a spare set of 5 guiding tubes for TP02
- **CR1000KD** – Campbell Scientific CR1000 keyboard display for controlling TPSYS20 MCU without a PC
- **TP02** – a spare thermal needle probe
- **TP08** – a spare thermal needle probe

Figure 8 *A CRC01 calibration reference cylinder containing a polymethylmethacrylate reference material for calibrating TP02 and TP08*

See also
- our range of sensors, systems and services for thermal conductivity measurement
- robust alternative systems: FTN02, MTN02

About Hukseflux
Hukseflux Thermal Sensors makes sensors and measuring systems. Our aim is to let our customers work with the best possible data. Many of our products are used in support of energy transition and efficient use of energy. We also provide services: calibration and material characterisation. Our main area of expertise is measurement of heat transfer and thermal quantities such as solar radiation, heat flux and thermal conductivity. Hukseflux is ISO 9001 certified. Hukseflux products and services are offered worldwide via our office in Delft, the Netherlands and local distributors.

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