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TP08

SMALL SIZE NON-STEADY-STATE PROBE FOR THERMAL CONDUCTIVITY MEASUREMENT

TP08 is a probe that offers the possibility to perform a practical and fast measurement of the thermal conductivity (or thermal resistivity) of the medium in which it is inserted at a high accuracy level. It works in compliance with the ASTM D 5334-00, D 5930-97 and IEEE 442-1981 standards. The TP08 is a small version of type TP02, made for situations where the length of TP02 poses a problem. The standard TP08 probe has proven suitability in soils, thermal backfill materials, sediments, foodstuff, powders, sludges, paints, glues and various other materials. The Non-Steady-State Probe (NSSP) measurement method (also known as transient line source, thermal needle, hot needle, heat pulse- and hot wire technique) has the fundamental advantages that it is fast and absolute while the sample size is not critical. Hukseflux is specialised in NSSP design. Special models have been developed for in-situ field experiments. For permanent installation in soils, a dedicated model, TP01, is available. TP08 has been designed and tested in collaboration with the Applied Physics Group of Wageningen University.

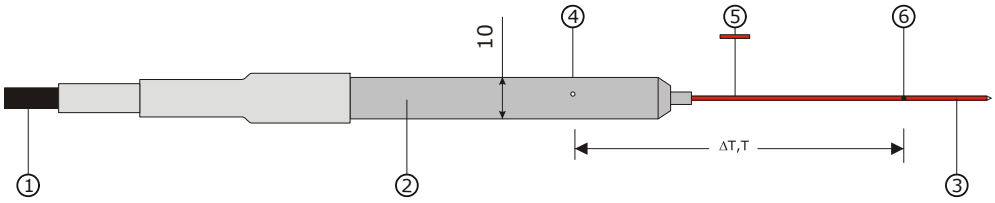

Figure 1 TP08 Small Size Non-Steady-State Probe: The probe consists of a needle (3) with a single thermocouple junction (6) and a heating wire, (5). It is inserted into the medium that is investigated. In the base, (2), a temperature sensor, (4), is mounted. All dimensions are in mm.

INTRODUCTION

The standards of the American Society for Testing and Materials (ASTM) and Institute of Electrical and Electronics Engineers (IEEE) describe proven methods for determining the thermal conductivity of materials.
ASTM D 5334-00 and D 5930-97 and IEEE Std 442-1981 " Standard Test Methods" specify the use of Non-Steady-State Probes (NSSP) in various applications. In general a NSSP consists of a heating wire, representing a perfect line source, and a temperature sensor capable of measuring the temperature at this source. The probe is inserted in the medium that is investigated. The NSSP principle relies on a unique property of a line source: after a short transient period the temperature rise, ΔT, only depends on heater power, Q, and medium thermal conductivity, λ:

$$\Delta T = (Q / 4 \pi \lambda) (\ln t + B)$$

With ΔT in K, Q in W/m, λ in W/mK, t the time in s and B a constant. By measuring the heater power, and tracing the temperature in time (for TP08 typically during 2 minutes), λ can be calculated. The sample size is not critical, as long as a 20 mm radius around the needle is covered.

The measurements of Q, t and ΔT are all direct measurements of power, time, and temperature respectively. These are done without need of reference materials. The measurement with TP08 is absolute.

TP08 can be obtained as a separate probe for incorporation in the user's measurement and control system. It is suitable for operation with the Campbell Scientific CR10X.

TP08 DESIGN

Hukseflux specialises in Non-Steady-State probe design. The primary model of the Hukseflux product range is the TP02. This model offers optimal measurement accuracy by a combination of its design features.
For some applications however the requirements regarding the sample size are such that the needle length and diameter of TP02 are too large. For this category of samples, TP08 has been designed.
Having a needle length of 70 mm, with the junction at around 17 mm from the tip, and a diameter of 1.2 mm, samples of around 80 ml can be analysed. (35 mm depth). In some cases samples can even be smaller (consult Hukseflux).

TP08 DESIGN (CONTINUED)

In TP08 the reference junction of the thermocouple is located in the base. A high quality measurement with TP08 requires that not only the sample but also the base are at a stable (preferably the same) temperature.
Usually this is achieved by clamping the base into the same material (metal) that holds the sample.

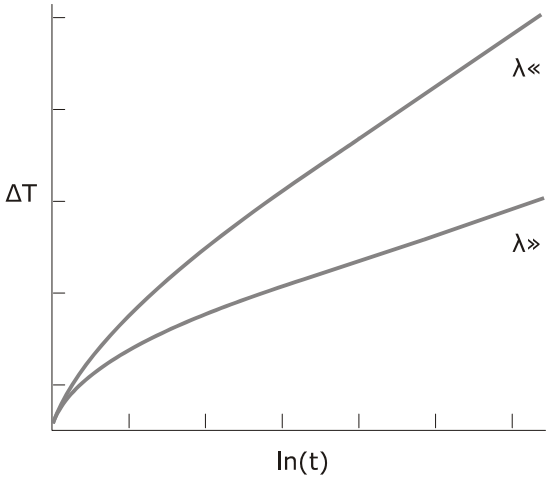

Figure 2 *The signal of TP08 as a function of the natural logarithm of time (ln(t)). After a transient period the graphs show linear behaviour. In this phase the slope of the graph is inversely proportional to the thermal conductivity λ.*

CALIBRATION / ISO 9000

Verification of the stability of the total probe can be done by repeated (yearly) testing in glycerol, preferably at several temperatures. Alternatively Calibration Reference Cylinders (CRC) traceable to NPL can be purchased at Hukseflux. TP08 is suitable for use by ISO certified labs.

SUGGESTED USE

- Studies of ocean sediments
- Studies of small samples
- Studies of high cost samples (uranium sludge)

OPTIONAL CONTAINER TP08

Because of the relative importance of the thermal equilibrium between base and sample, an optional container can be ordered with TP08.

MORE INFORMATION / OPTIONS

Standards: ASTM standards can be obtained from ASTM at http://www.astm.org.
Alternative designs: Hukseflux is specialised in NSSP design. Alternative models, for instance smaller, more robust or temperature resistant have been manufactured on request.
Permanent installation in soils: The dedicated model TP01 is specifically designed for long term monitoring. A separate brochure is available.
Solutions for measurement and control: See the TP08 manual or inquire at Hukseflux. A program for Campbell Scientific CR10X is available. Turn key systems are offered for sale: see TPSYS.
Manuals: The TP08 manual is available free of charge as a PDF file via e-mail.

NEW!

For high accuracy calibration CRC Calibration Reference Cylinders are available.
For insertion into hard soils GT Series Guiding tubes can be applied.

TP08 SPECIFICATIONS

Test method:	ASTM D 5334-00 and D 5930-97 IEEE Std 442-1981
Needle length:	70 mm
Traceability:	NPL
Range (λ):	0.1 to 6 W/m.K
Sensitivity (ΔT):	Thermocouple K, ANSI MC96.1-1982
Temperature range (total sensor including cable):	-55 to +180 °C
Accuracy (@ 20 °C):	+/- (3% + 0.02) W/mK
Temperature dependence of the Accuracy:	+/- 0.02 %/K (additional)
Measurement cycle duration:	200 s (typical)
Power requirements (switched) :	3 V, 1 Watt (max)
Medium / sample requirements:	Granular materials, powders, slurries, gels, pastes. Some samples require pre-drilling. Sample size: Min 20 mm radius. Min volume 80 ml. Smaller samples: consult Hukseflux. Caution: please consult the product manual for more details.
Protection needle and base:	IP 68
Protection total sensor:	IP 67