Hukseflux
Thermal Sensors

FHF04

Foil heat flux sensor with thermal spreaders, flexible, 50 x 50 mm, with temperature sensor

FHF04 is the latest standard model for general-purpose heat flux measurement. Significantly thinner and more flexible, FHF04 replaces earlier models FHF01 and FHF02. FHF04 is very versatile: it has an integrated temperature sensor and thermal spreaders to reduce thermal conductivity dependence. It is applicable over a temperature range from −70 to +120 °C. FHF04 measures heat flux from conduction, radiation and convection. Optionally, black BLK and gold GLD stickers are available to separately determine heat transport by radiation and convection.

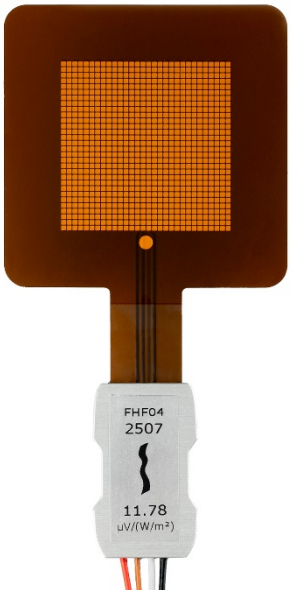

Figure 1 *FHF04 foil heat flux sensor with thermal spreaders: thin, flexible and versatile*

Figure 2 *FHF04 being installed to measure heat flux on a pipe*

Introduction

FHF04 is a sensor for general-purpose heat flux measurement. It is thin, flexible and versatile. FHF04 measures heat flux through the object in which it is incorporated or on which it is mounted, in W/m^2. The sensor in FHF04 is a thermopile. This thermopile measures the temperature difference across FHF04's flexible body. A type T thermocouple is integrated as well. The thermopile and thermocouple are passive sensors; they do not require power.

Multiple small thermal spreaders, which form a conductive layer covering the sensor, help reduce the thermal conductivity dependence of the measurement. With its incorporated spreaders, the sensitivity of FHF04 is independent of its environment. Many competing sensors do not have thermal spreaders. The passive guard area around the sensor reduces measurement errors due to edge effects and is also used for mounting.

Using FHF04 is easy. It can be connected directly to commonly used data logging systems. The heat flux in W/m^2 is calculated by dividing the FHF04 output, a small voltage, by the sensitivity. The sensitivity is provided with FHF04 on its certificate.

Unique features and benefits

- flexible (bending radius ≥ 7.5 x 10^{-3} m)
- low thermal resistance
- wide temperature range
- fast response time
- large guard area
- integrated type T thermocouple
- robustness, including wiring with strain relief block
- IP protection class: IP67 (essential for outdoor application)
- integrated thermal spreaders for low thermal conductivity dependence

Figure 3 *FHF04, thin and flexible, can be mounted on a curved surface*

Robust and stable

Equipped with a metal connection block, which may serve as strain relief, and with potted protective covers on both sides so that moisture does not penetrate, FHF04 has proven to be very robust and stable.

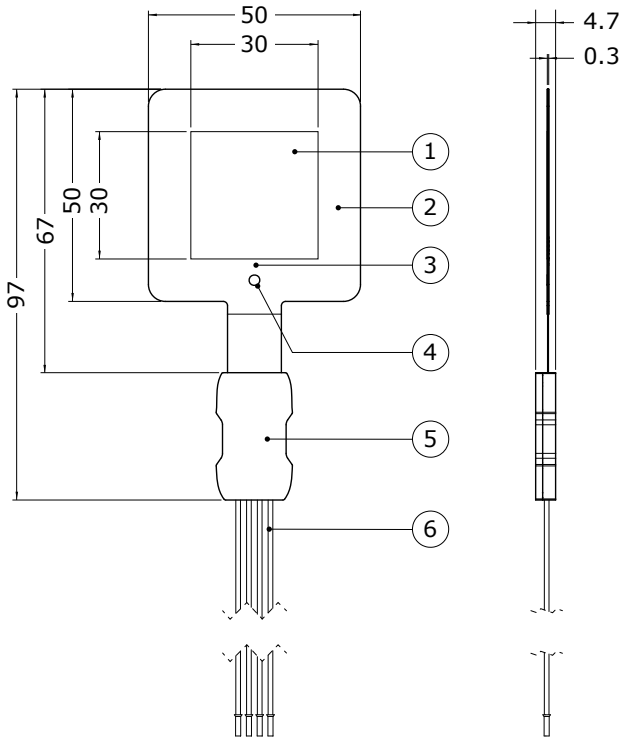

Figure 4 *FHF04 heat flux sensor: (1) sensing area with thermal spreaders, (2) passive guard, (3) type T thermocouple, (4) dot indicating front side, (5) metal connection block showing serial number and sensitivity, (6) wires, standard length is 2 m. Dimensions in x 10^{-3} m.*

FHF04 specifications

Measurand	heat flux
Measurand	temperature
Temperature sensor	type T thermocouple*
Thermal spreaders	included
Rated bending radius	≥ 7.5 x 10^{-3} m
Rated load on cable	≤ 1.6 kg
Outer dimensions foil with guard	(50 x 50) x 10^{-3} m
Sensor thermal resistance	30 x 10^{-4} K/(W/m^2)
Sensor thickness	0.4 x 10^{-3} m
Uncertainty of calibration	± 5 % (k = 2)
Measurement range	(-10 to +10) x 10^3 W/m^2
Sensitivity (nominal)	11 x 10^{-6} V/(W/m^2)
Rated temperature range - continuous use	-70 to +120 °C
Rated temperature range - short intervals	-160 to +150 °C**
IP protection class	IP67***
Standard wire length	2 m
Options	- with 5 m wire length - without wiring, without metal connection block - BLK-5050 black sticker - GLD-5050 gold sticker

* temperature measurement uncertainty: 2 % of value in °C. For details, refer to user manual.
** when measuring at temperatures of -160 °C , contact Hukseflux.
*** sensor is not suitable for continuous exposure to water.

BLK and GLD sticker series

Would you like to to study energy transport / heat flux in detail? Hukseflux helps taking your measurement to the next level: order FHF04 with radiation-absorbing black and radiation-reflecting gold stickers. You can then measure convective + radiative flux with one, and convective flux only with the other. Subtract the 2 measurements and you have radiative flux. BLK – GLD stickers can be applied by the user to the sensor. Optionally, they can be ordered pre-applied. See the BLK – GLD sticker series user manual and installation video for instructions.

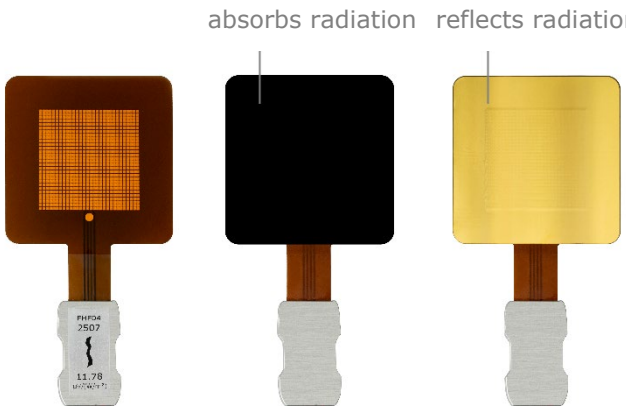

Figure 5 *FHF04 with BLK-5050 and GLD-5050 stickers*

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Suggested use

FHF04 is a sensor for general-purpose heat flux measurement, often applied as part of a larger test- or measuring system. FHF04SC is a self-calibrating version of the standard model FHF04, combined with a heater. FHF04SC is used when the highest level of quality assurance is required and for long-term heat flux measurement.

Calibration

FHF04 calibration is traceable to international standards. The factory calibration method follows the recommended practice of ASTM C1130 - 17.

Working with heat flux sensors

When used under conditions that differ from the calibration reference conditions, the FHF04 sensitivity to heat flux may be different than stated on its certificate. See the user manual for suggested solutions. See also our application note how to install a heat flux sensor.

Figure 6 *see also model FHF04SC, a self-calibrating version of FHF04 with a heater*

Options

- with 5 metres wire length
- without wiring, without metal connection block
- LI19 hand-held read-out unit / datalogger
  NOTE: LI19 measures heat flux only
- BLK-5050 black sticker (to measure radiative as well as convective heat flux)
- GLD-5050 gold sticker (to measure convective heat flux only)
- BLK - GLD sticker series can also be ordered pre-applied at the factory

See also

- model FHF04SC for a self-calibrating version of FHF04
- model FHF03, our most economical foil heat flux sensor
- model HFP01 for increased sensitivity (also consider putting two or more FHF04s in series)
- BLK - GLD sticker series to separate radiative and convective heat fluxes
- Hukseflux offers a complete range of heat flux sensors with the highest quality for any budget

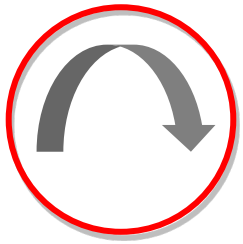
About Hukseflux

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.

Interested in this product?
E-mail us at: info@hukseflux.com

FHF series outperforms competing models: how?

FHF04 and FHF03 are Hukseflux' standard models for thin, flexible and versatile heat flux sensors. With its small footprint, FHF03 is the most economical one.

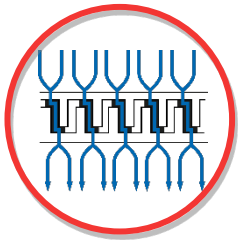


Flexible
FHF04 may be bent to a radius of 7.5 mm.
FHF03 may be bent to a radius of 50 mm.

Large-area
Larger is better: FHF04's sensitive area of 30 x 30 mm offers good averaging, leading to increased sensitivity. FHF04 has a thermal guard around the sensitive area. The guard can also be used for mounting the sensor without disturbing the sensitive area.

Sensitive area with thermal spreaders reducing thermal conductivity dependence

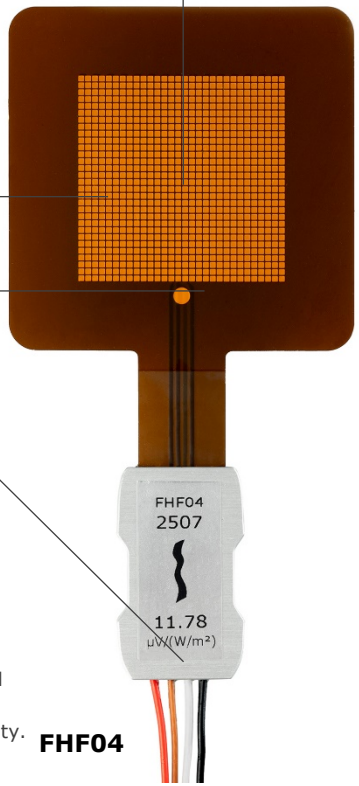
Sensitivity independent of environment: Thermal spreader included
Unlike many competing sensors, FHF series sensors have thermal spreaders, i.e. conductive layers covering the sensor. These layers help reduce the thermal conductivity dependence of the measurement. By employing spreaders, the sensitivity of FHF series becomes independent of its environment.



Corrosion-proof plastic cover protecting the thermal spreader

Thermocouple type T included

Durable waterproof wires with metal connection block, may be used as strain relief, temperature resistant up to 150 °C



FHF04

FHF03

Thermocouple type T included

Black and gold stickers matching FHF04 and FHF03 to measure radiative and convective heat flux separately

Durable waterproof shielded cable, temperature resistant up to 150 °C

Stable: waterproof (IP67), corrosion-proof
FHF series sensor connection is potted, and waterproof. Its protection class is IP67. Competing sensors often have wire connections with open contact to the environment. This is a large potential source of damage, as well as a starting point for measurement errors, corrosion, and sensor instability.

Best paperwork
Hukseflux has the paperwork covered; all FHF series sensors are provided with formally traceable calibration certificates. We calibrate in accordance with ASTM.