

FHF05SC series

Two self-calibrating foil heat flux sensors with thermal spreaders and heater

Next-level sensors from the world market leader in heat flux measurement; FHF05SC sensors are a combination of our standard models FHF05 heat flux sensors and a heater. The heater allows you to perform self-tests, verifying sensor functionality and stability during use, without having to remove the sensor. FHF05SC series is ideal for high-accuracy and long-term heat flux measurement, construction of calorimeters, (zero heat flux) core temperature measurement and thermal conductivity test equipment. Available in two models: standard model size 50X50 mm and a larger and more sensitive size of 85X85 mm.

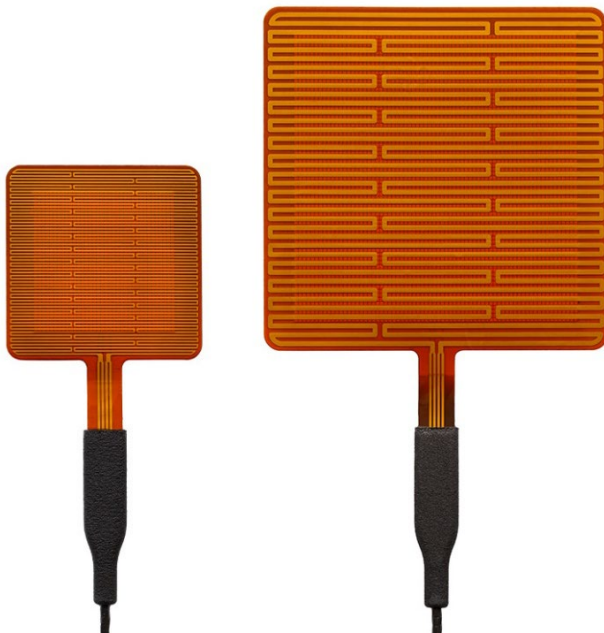


Figure 1 Model FHF05SC-50X50 and FHF05SC-85X85 self-calibrating heat flux sensor with heater: thin, flexible and versatile.



Figure 2 FHF05SC-50X50 being installed to measure heat flux on a curved surface.

Introduction

FHF05SC sensors are sensors for general-purpose heat flux measurement, combined with a heater. This combination is used when the highest level of quality assurance is required and for long-term heat flux measurements. FHF05SC sensors are thin, flexible and versatile. The heat flux sensor in FHF05SC measures heat flux through the object in which it is incorporated or on which it is mounted, in W/m^2 . The sensor within is a thermopile. This thermopile measures the temperature difference across FHF05SC's flexible body. A type T thermocouple is integrated as well to provide a temperature measurement. The thermopile and thermocouple 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 FHF05SC sensors is independent of their environment. Many competing sensors do not have thermal spreaders so their sensitivity cannot be relied upon; it depends on the material on which they are mounted. The passive guard area around the FHF05SC sensor reduces edge effects and is also used for mounting.

The unique feature of the FHF05SC sensors is an incorporated heater. This heater may be used for self-testing purposes. When activated, the heater does require power.

Looking only for heat flux and temperature measurement without the heater? See our **FHF05 series** heat flux sensors.

Unique features and benefits

- heater for self-test
- flexible (bending radius $\geq 15 \times 10^{-3}$ m)
- low thermal resistance
- wide temperature range
- fast response time
- integrated type T thermocouple
- robustness, including potted cable connection block, may be used as strain relief
- IP protection class: IP67 (essential for outdoor application and in humid environments)
- integrated thermal spreaders for low thermal conductivity dependence

Using an FHF05SC sensor is easy. For heat flux measurements, it can be connected directly to commonly used data logging systems. The heat flux in W/m^2 is calculated by dividing the sensor output, a small voltage, by the sensitivity. The sensitivity is provided with the sensor on its product certificate. When used under conditions that differ from the calibration reference conditions, the FHF05SC series sensitivity to heat flux may be different than stated on its certificate. See the user manual for suggested solutions. Make sure your data acquisition accepts type T thermocouples to perform temperature measurements.

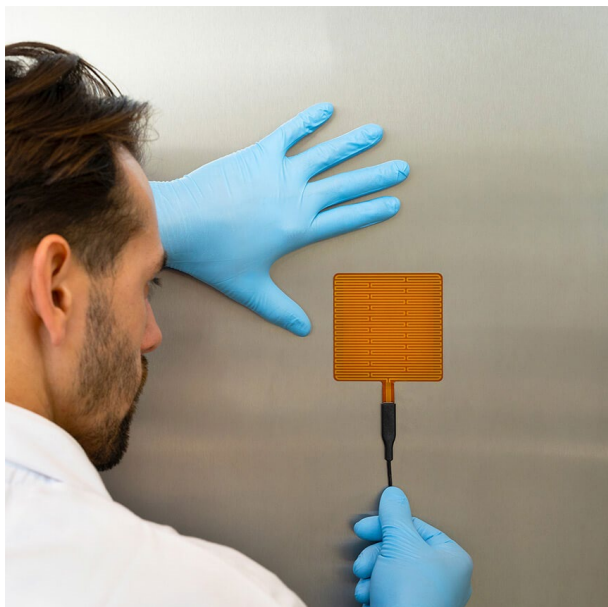


Figure 3 Working with FHF05SC-85X85 on a metal wall.

FHF05SC series specifications

Measurand	heat flux
Measurand	temperature
Temperature sensor	type T thermocouple, IEC 60584-1 class 2*
Thermal spreaders	included
On-line functionality testing	self-test including self-calibration
Rated bending radius	$\geq 15 \times 10^{-3}$ m
Rated load cable	≤ 1.6 kg
Outer dimensions foil with guard	$(50 \times 50) \times 10^{-3}$ m $(85 \times 85) \times 10^{-3}$ m
Sensor thermal resistance	24×10^{-4} K/(W/m ²)
Sensor thickness	0.7×10^{-3} m
Uncertainty of calibration	$\pm 5\%$ (k = 2)
Measurement range	$(-10$ to $+10) \times 10^3$ W/m ²
Sensitivity (nominal) per model	
50X50:	13×10^{-6} V/(W/m ²)
85X85	50×10^{-6} V/(W/m ²)
Rated temperature range	
continuous use:	-40 to +120 °C**
short intervals:	-160 to +150 °C**
IP protection class	IP67***
Standard wire length	2 m
Heater resistance per model	
50X50	120 Ω (nominal)
85X85	40 Ω (nominal)
Heater power supply	12 VDC
Options	5 or 10 m cable length without cable**** BLK black sticker GLD gold sticker

*temperature measurement uncertainty: ± 1 or $0.0075 \times T$ °C.

For details, see the user manual.

** when measuring at temperatures of -160 °C, contact Hukseflux.

*** see appendix on long-term use under condensing, wet and underwater conditions

**** sensor foil only (without cable and cable connection block) may be used in vacuum.

Self-testing

Measuring heat flux, users may wish to regularly check their sensor performance. During use, the film heater can be activated to perform a self-test. The heat flux sensor's response during self-test verifies its performance. Implicitly also, cable connection, data acquisition, thermal connection of the sensor to its environment and data processing are tested. Heat flux sensors are often installed for long periods of time. Using self-testing, the user no longer needs to take sensors to the laboratory to verify their stable performance. The heater has a well-characterised and traceable surface area and electrical resistance.

Suggested use

- high-accuracy scientific measurement of heat flux, with a high level of data quality assurance
- study of convective heat transfer mechanisms
- calorimeter prototyping
- (zero heat flux) non-invasive core temperature measurement
- thermal conductivity test equipment

Measurement and control

Requirements for data acquisition and control:

- for heat flux: one millivolt measurement
- for heater voltage: one voltage measurement
- optional, for heater current: one current measurement or voltage measurement over a resistor
- for switching the heater current on and off: one relay with 12 VDC nominal output

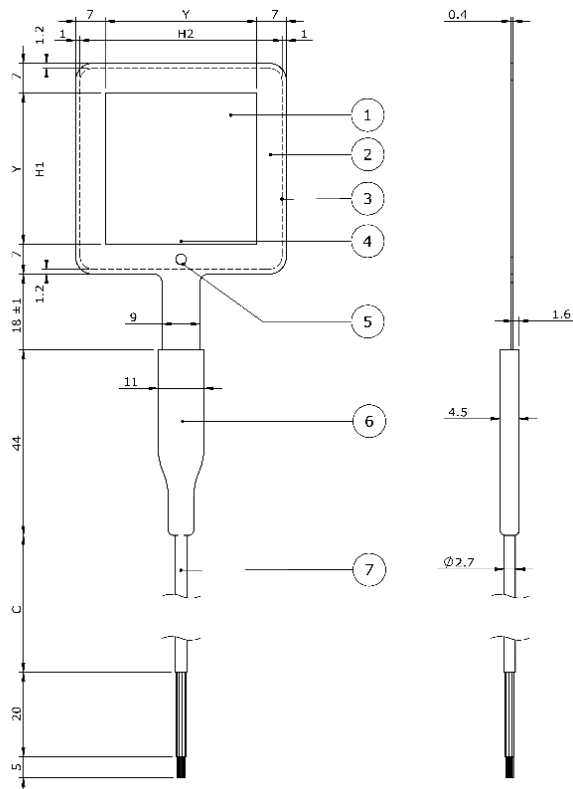


Figure 4 FHF05SC sensor models 50X50 and 85X85 heat flux sensor; $Y = 36$ or 70 , $H1 = 47.6$ or 82.6 and $H2 = 48$ or 83 . Dimensions in $\times 10^{-3}$ m. (1) sensing area with thermal spreaders, (2) passive guard, (3) contour of the heater area for self-test, (4) type T thermocouple, (5) dot indicating front side, (6) cable connection block for strain relief, (7) cable, standard length is $C = 2$ m.

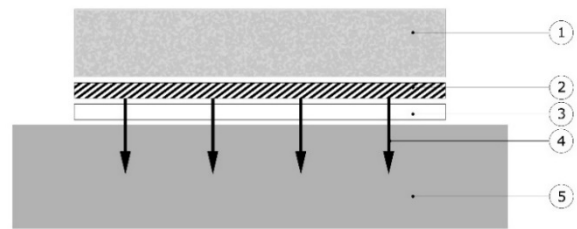


Figure 5 Calibration of FHF05SC series; a typical stack used for calibration consists of a block of metal (mass > 1 kg), for example aluminium (5), the heat flux sensor (3), with heater (2) and an insulation foam (1). Under these conditions, heat losses through the insulation are negligible. Heat flux (4) flows from hot to cold.

Robust and stable

Equipped with a potted cable connection block, that prevents moisture from entering and may also serve as strain relief, FHF05SC sensors have proven to be very robust and stable.

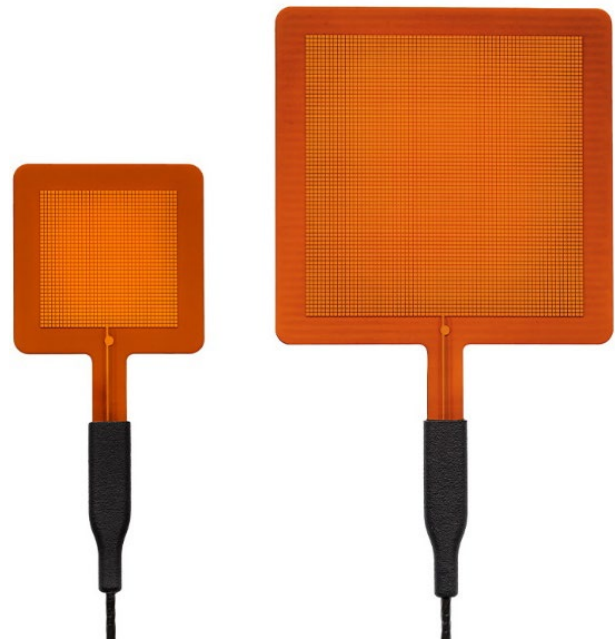


Figure 6 Model FHF05S0C-50X50 and FHF05SC-85X85 heat flux sensors' front side.

Application example

The FHF05SC heater can be used to check for stable performance of the sensor at regular intervals without the need to uninstall the sensor or interrupt operation. A typical stability check is based on the step response of the measured heat flux and sensor temperature to an applied heater. Upon installing the sensor, a reference measurement should be made. A time

trace of the heater voltage, the measured heat flux and the measured sensor temperature should be stored as reference measurement. Stable operation of the sensor can then be confirmed at any time by repeating the test and comparing heat flux and temperature signals to the reference measurement.

GLD and BLK sticker series

Would you like to study energy transport / heat flux in detail? Hukseflux helps taking your measurement to the next level: order FHF05SC 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. There are stickers for every sensor dimension. Optionally, they can be ordered pre-applied. See the BLK – GLD sticker series user manual and installation video for instructions.



Figure 7 FHF05SC heat flux sensor with BLK-5050 and GLD-5050 stickers.

Options

- with 5 or 10 metres cable length
- separate cable in 2, 5 or 10 metres length
- LI19 hand-held read-out unit / data logger
NOTE: LI19 measures heat flux only, not temperature, does not support the self-test functionality
- BLK black sticker (to measure radiative as well as convective heat flux)
- GLD gold sticker (to measure convective heat flux only)
- BLK - GLD sticker series can also be ordered pre-applied at the factory

See also

- FHF05 series, our standard sensor models for general-purpose heat flux measurement
- model HFP01 (used on walls and in soils as lower cost alternative to FHF05 85X85)
- heaters of the HTR02 series, a loose heater for verification of performance of FHF type sensors
- BLK - GLD sticker series to separate radiative and convective heat fluxes
- Hukseflux offers a complete product range of heat flux sensors with the highest quality for any budget

About Hukseflux

Hukseflux is the leading expert in measurement of energy transfer. We design and manufacture sensors and measuring systems that support the energy transition. We are market leaders in solar radiation- and heat flux measurement. Customers are served through our headquarters in the Netherlands, and locally owned representative sales offices in the USA, Brazil, India, China, Southeast Asia and Japan.

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