Hukseflux – heat flux measurement at the next level

Hukseflux is the world market leader in heat flux measurement. This white paper briefly explains the fundamentals of measuring with heat flux sensors. It also offers general directions what to watch out for and some, perhaps surprising, applications of heat flux sensors. Would you like to get more information? Please contact Hukseflux.

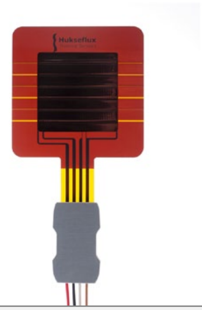
Heat flux sensors measure energy flux onto or through a surface in [W/m^2]. The source of the heat flux may be conduction, radiation or convection. Convective and conductive heat transfer are associated with a temperature difference. Heat always flows from a source to a sink, from a hot to a cold environment. Convective and conductive heat flux is measured by letting this heat flow through the sensor. Radiative flux is measured using heat flux sensors with black absorbers. The absorbers converts radiative to conductive energy. Hukseflux started in 1993 with sensors for measurement of heat flux in soils and on walls. In the course of the years, we have added specialised sensors and systems for many other applications.
Heat flux sensors manufactured by Hukseflux are optimised for the demands of different applications:

- rated temperature range
- rated heat flux range
- sensitivity
- response time
- chemical resistance, safety requirements
- size, shape and spectral properties

Hukseflux heat flux sensor typically employ thermopiles. Thermopiles generate a signal, as a result of the temperature diffence between the hot and cold side of the thermopile. The signal is proportional to the heat flux. Themopiles are passive sensors; they do not require power. The output usually is a small millivolt signal. Pictures show models SBG01 water-cooled heat flux sensor, IHF01 industrial heat flux sensor and FHF02 foil heat flux sensor.

Water-cooled heat flux sensor
for radiative flux

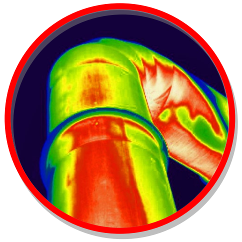
High-temperature all-metal heat flux
sensor (industrial)



Plastic flexible heat flux sensor
(general purpose)

Measurement with a heat flux sensor; what matters most?

On this page, the fundamentals of heat flux measurement are briefly explained. These are general considerations for measuring heat flux.

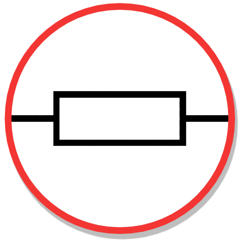


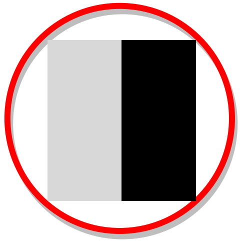
Representativeness in time and space; average!

A heat flux sensor measures at a certain location. Is this location representative of what you need to measure? If possible, use a relatively large sensor, rather than a small one, and consider use of multiple sensors. Thermal processes often have large time constants; instantaneous measurements may be misleading. Average to get the full picture.

Thermal contact sensor to heat sink

A small layer of air often forms a major contribution to the thermal resistance. Make sure that there is good thermal contact between sensor and environment or heat sink. Avoid air-gaps. Use double-sided tapes, welded connections, graphite sheets. Use Power strips to fill up gaps.



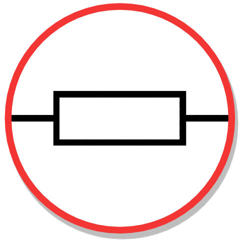


Optical properties

When heat flux sensors also measure radiation, pay attention to the surface colour. If needed paint the sensor surface. Please mind that shiny metallic surfaces reflect both infra-red and visible radiation. Paints may have different colours in the visible range, but are usually “black” absorbers in the far-infra-red.

Sensor thermal resistance

A heat flux sensor distorts the local heat flux. In order to minimise this effect, use the sensor with the lowest possible thermal resistance.

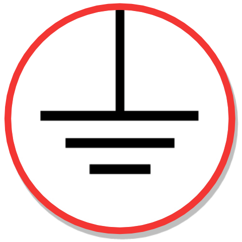


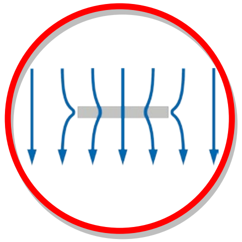
Absolute temperature

Sensors are calibrated at room temperature T CAL. Typical temperature dependence is in the order of 0.15 % / K. When working at high or low temperatures T, ask for the temperature dependence. Typically, this is a linear correction with (T – T CAL). Self-calibrating sensors compensate for temperature dependence.

Noise? Pay attention to signal ground

Signals from thermopiles are small DC voltages in the microvolt range. These are easily distorted. To guarantee immunity to external sources pay attention to grounding and shielding. A good starting point is to make sure that signal wires are well insulated from the environment (no possibility for ground loops) and are well protected against humidity ingress (possibly creating electrical contact)



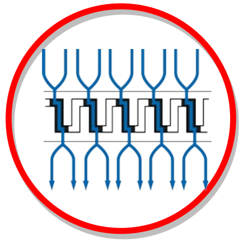


Edge effects

A heat flux sensor locally distorts the heat flow pattern, in particular around the edges of the sensor. A passive guard, i.e. a non-sensitive part around the sensor is essential to avoid errors due to edge effects.

Micro effects – thermal conductivity dependence

In case the thermopile sensor has direct exposure to the environment, there is a risk of so-called micro effects; on a micro scale (scale of the thermopile grid), the local heat flux gets distorted. The result is that sensor sensitivity changes as a function of the thermal conductivity of the environment. The calibration is no longer valid. A thermal spreader, for example using a metal cover, is a proven counter-measure.



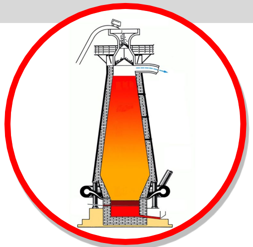
Heat flux sensors applications

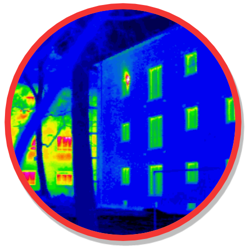
Hukseflux Thermal Sensors is the world market leader in heat flux measurement. Here are some examples of heat flux sensor application:

Catalytic cracker fouling measurement
Analysed with HF05 and a meteorological station

Clothing thermal performance
Analysed with FHF02

Blast furnace refractory performance
Analysed with NF01 in the shell

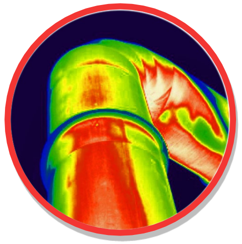




Building envelope thermal resistance
Measure it with HFP01 and TRSYS

Cone calorimeter calibration
With water-cooled SBG01

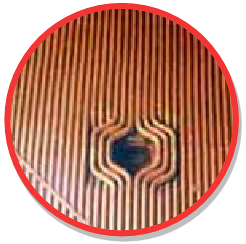
Industrial insulation performance
Analysed with FHF and IHF sensors



Solar concentrator boiler heat flux
With a special IHF01

Building block: thermal comfort measurement, thermal mannequin
Special equipment made with FHF02

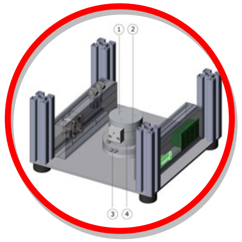
Boiler waterwall fouling
Heat flux sensors may be included on the steam tube surface of boiler tubes! From the trend in heat flux, users can analyse flame position and fouling of the surface; With adapted IHF01



Building block: heat flow reaction calorimeter
With adapted FHF01

Building block: LED thermal power calorimeter
Designed for the Zhagi consortium; TPL01

Ice rink thermal control
Improved with HFP01



Flare monitoring
With HF02

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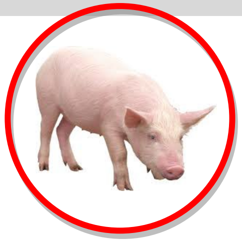
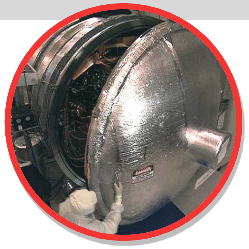


Human and animal metabolism studies
with HFP01 and FHF02

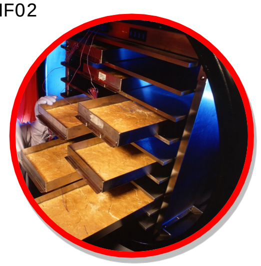


Aerospace engineering: thermal test in vacuum
Water-cooled SBG01 to measure heat flux of a solar simulator

Firefighter exposure measurement
With HF02 + LI19

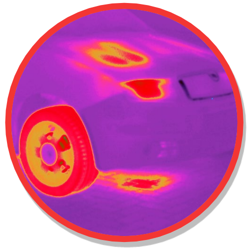
In situ study of airplane insulation
With HFP03

Monitoring and control of freeze dryers
With FHF02



Battery exothermic reaction calorimeters
Using FHF02

Insulation of car parts
Analysed with FHF02

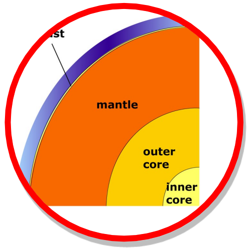


Eddy covariance / Bowen ratio
Soil heat flux with HFP01SC

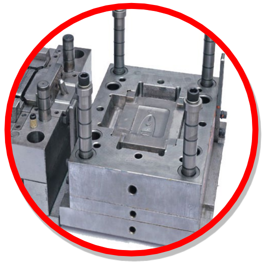
Plastics and composite process- and flow front monitoring
Process monitoring of the flow front and of the curing process in the mould with the sensitive NF02

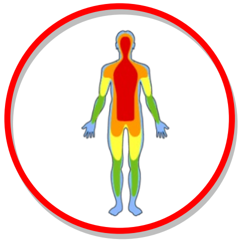
Body core temperature measurement (zero heat flux temperature measurement)
With FHF02 and FHF02SC

Determining human and equipment exposure to heat sources
With HF03 portable heat flux



Geothermal heat flux
With HFP03 or multiple HFP01's





Industrial (aluminium reduction cell) heat flux and temperature survey
With HF01 and ALUSYS