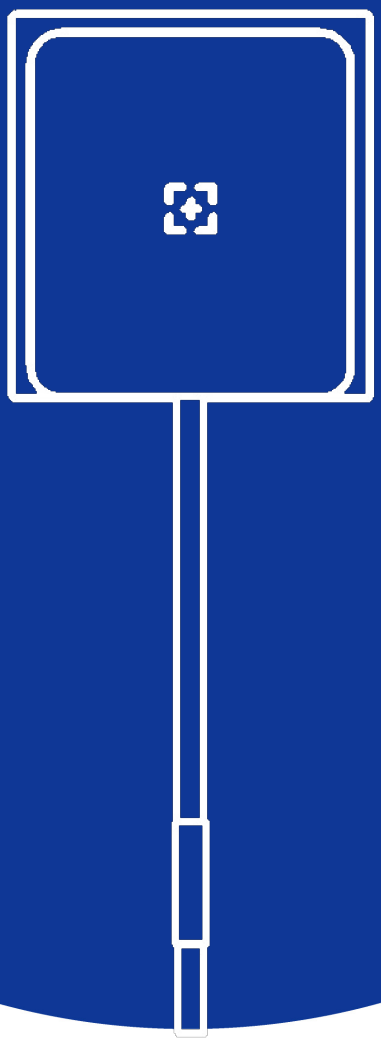
INSTRUCTION MANUAL

HF-01S

Standard Heat Flux Sensor



EKO

1. Index

2. Important User Information

Thank you for using EKO Products

Make sure to read this instruction manual thoroughly and to understand the contents before starting to operate the instrument. Keep this manual in a safe and handy place for whenever it is needed.
For any questions, please contact us at one of the EKO offices shown below:

2-1. Contact Information

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2-2. Warranty and Liability

For warranty terms and conditions, contact EKO or your distributor for further details.
EKO guarantees that the product delivered to customer has been verified, checked and tested to ensure that the product meets the appropriate specifications. The product warranty is valid only if the product has been installed and used according to the directives provided in this instruction manual.
In case of any manufacturing defect, the product will be repaired or replaced under warranty. However, the warranty does not apply if:

- Any modification or repair was done by any person or organization other than EKO service personnel.
- The damage or defect is caused by not respecting the instructions of use as given on the product brochure or the instruction manual.

2-3. About This Instruction Manual

This manual was issued: 2024/11/01

Version Number: 1

2-4. Environment

1. WEEE Directive (Waste Electrical and Electronic Equipment)

Although this product is not subject to the WEEE Directive 2002/96/EC, please make sure that it should not be disposed of in a landfill or with municipal or household waste. For proper processing, collection and recycling, please contact a specialist collection site or facility.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

2. RoHS Directive

EKO Instruments has completed a comprehensive evaluation of its product range to ensure compliance with RoHS Directive 2011/65/EU+(EU)2015/863 regarding maximum concentration values for substances. As a result, all products are manufactured using raw materials whose concentration levels are less than the hazardous substances specified in RoHS Directive 2011/65/EU+ (EU) 2015/863..

2-5. CE Declaration

EKO

IMPORTANT USER INFORMATION

CE

DECLARATION OF CONFORMITY

We: EKO INSTRUMENTS CO., LTD 1-21-8
Hatagaya Shibuya-ku, Tokyo 151-0072
JAPAN

Declare under our sole responsibility that the product:

Product Name : Heat Flux Sensor
Model No.: HF-01S

To which this declaration relates is in conformity with the following harmonized standards of other normative documents:

Harmonized standards:

EN IEC 63000：2018. [RoHS]

Date: November 26, 2024

Position of Authorized Signatory: Director of Quality Assurance

Name of Authorized Signatory: Taiji Yamashita

Signature of Authorized Signatory: Taiji Yamashita

3. Safety Information

EKO products are designed and manufactured under the consideration of the safety precautions. Please make sure to read and understand this instruction manual thoroughly in order to be able to operate the instrument safely and in the correct manner.

WARNING
CAUTION

Attention to the user; pay attention to the instructions given on the instruction manual with this sign.

3-1. WARNING/CAUTION

- Select an appropriate heat flux sensor for the application. If an indoor type heat flux sensor is used in an outdoor environment, water may leak into the heat flux sensor and cause disconnections and abnormal measurement values.
- Verify the upper and lower limit of operating temperature and heat flux and use the heat flux sensor within this temperature range. Using the heat flux sensors outside the operating range, may result in disconnections and permanent damage to the product.
- When using the Heat flux sensor for surface heat flux measurements, it is important to make perfect thermal contact and mask the sensor properly, to minimize measurement errors. Follow the installation instructions on this manual and the Quick Start Guide, or the installation video to make an accurate heat flux measurement.
- Never pull the cable of the sensor. Handle, install and uninstall the sensor with care.
- Do not drop or bump the heat flux sensor as it is sensitive to shocks.
- Do not use in environments with rapid temperature changes.

4. Introduction

Heat, as a fundamental form of energy, is vital for sustaining life and powering various essential processes. Understanding its flow and transfer mechanisms is crucial in comprehending how heat impacts the surroundings and influences numerous aspects of human life. There are numerous reasons to measure and monitor the heat flux. For instance, following the strong necessity for energy saving, obtaining accurate information about the heat flux levels from the thermal insulation of facilities such as buildings, offices, factories, and houses is essential. Evaluation of the performance of refrigeration units, insulations, thermal comfort, as well as the energy balance on the surface of the earth, are of other few examples of heat flux sensor applications. EKO Instruments, with over decades of history in thermal measurements, manufactures heat flux sensors to directly measure the heat transfer rate. The HF-01S is a durable standard plate type heat flux sensor. It comes with a built-in thermal guard and two facings, manufactured in compliance with ISO 9869 and ASTM 1046 Standards. The unique combination of low thickness, small dimensions, short response time, and high sensitivity gives this sensor the ability to seamlessly take measurements. These sensors can be used on flat surfaces such as walls (buildings, refrigeration systems, heating systems), floor/ground, or can be embedded inside materials.

To better understand the concepts and acquire sufficient knowledge before starting this practice, a brief overview of the physics and phenomena and the definitions are given here.

Heat Flux

Naturally, heat flows from a point with higher temperature towards one with lower temperature. The rate of heat transfer is called the heat flow. The amount of heat flow per unit area *A* is called heat flux ($\dot{q}$). Heat flux is a vector in the direction of temperature gradient which often is perpendicular to the surface:

$$\dot{q} = \frac{1}{A} dQ/dt$$

Where Q is heat and t is time. The heat flux can be estimated by engineering calculations for different heat transfer mechanisms. These include conduction, convection, advection, radiation, and accumulation. Heat flux can be measured on a surface, applying a heat flux sensor.

Heat Flux Sensor

A heat flux sensor is a transducer that measures the voltage in relation with the heat flux through the body of the sensor. This voltage can be converted into heat flux, using a parameter called “sensitivity” of the heat flux sensor. The sensitivity value is obtained through calibration of the sensor using an absolute measurement apparatus. For instance, Heat Flow Meter Apparatus (HFM) and Guarder Hot Plate (GHP), Thin film heater apparatus and hot box apparatus are used. Obtaining the sensitivity, the heat flux can be determined.

4-1. Main Functions

EKO HF-01S heat flux sensor provides highly accurate measurements of heat flux level. Thanks to the high sensitivity, these heat flux sensors perform excellently even in low heat flux conditions. The built-in guard and facings in accordance with ISO 9869, minimize the measurement uncertainties due to edge losses and surface thermal conductivity dependence. The small dimensions of the sensor make it possible to measure heat flux on small surfaces where larger sensors would not fit. The thin body and the high thermal conductivity ensures minimal thermal resistance, minimal edge losses, and very fast response time. The heat flux sensors are calibrated using HFM apparatus, following ASTM C1130-21 Standard Practice for Calibration of Thin Heat Flux Transducers.

4-2. Package Contents

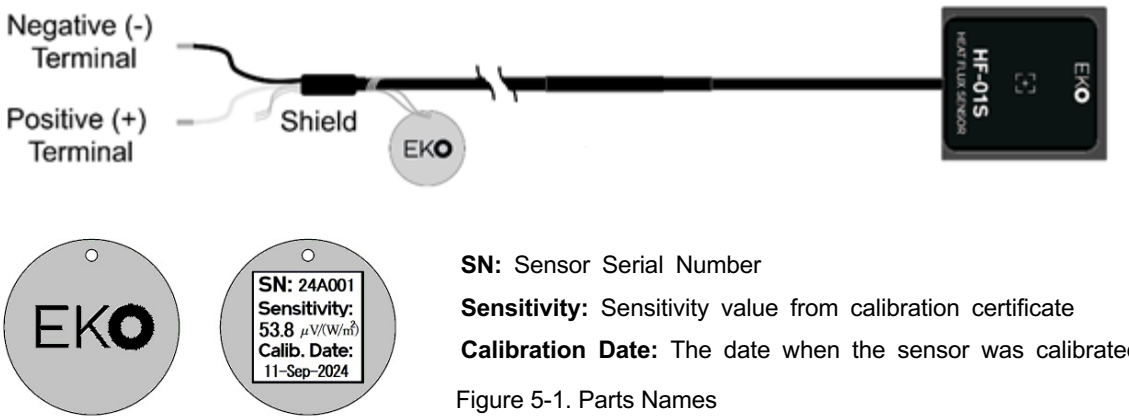
Check the package contents first; if any missing item or damage is noticed, please contact EKO immediately.

Table 4-1. Package Contents

Standard Items	Qty.	Remarks
Heat Flux Sensor	1pc	3m cable, Sensitivity Tag
Quick Start Guide	1	Instructions for quick set up
Calibration Certificate	1	Information about Calibration

5. Getting Started

5-1. Parts Name and Descriptions



SN: Sensor Serial Number
Sensitivity: Sensitivity value from calibration certificate
Calibration Date: The date when the sensor was calibrated

Figure 5-1. Parts Names

Heat Flow Direction: When heat flows towards the front side, voltage output is positive, vice versa.

5-2. Using the Sensor

Reliable data acquisition begins with careful installation of the sensor. Please follow the guidelines provided in this manual carefully to ensure accurate installation of HF-01S. Before installation, please carefully read the safety requirements stated in section [3-1. WARNING/CAUTION].

Before installing the sensor, heat flux direction and polarity of the sensor output must be verified (see [5-1. Parts Name and Descriptions]). A heat flow towards the surface on which the sensor is installed results in positive voltage and therefore positive heat flux reading. Always prepare the surface before installation. Clean the surface from any dust, dirt, moisture, or grease. If the surface is not even, try to smoothen it out. When the sensor is to be installed in the surface, emissivity will be important to take into account. Check the guidelines below for details.

1. Sensor Installation

1. Prepare the surface by making it smooth and even to ensure proper attachment between the surface and the sensor. Before installing, clean the surface from any dirt, dust, and oil.
2. Place the heat flux sensor on the installing surface and attach it with appropriate thermal contact material.
3. For temporary installation, use temporary or weak adhesive material such as thermal adhesive pads, carpet tape, thermal paste, thin film conductive liquid, etc. Avoid using strong adhesive materials.
4. For permanent installation, stronger adhesives (such as One Component RTV, deoxidation type, KE45W by Shin-Etsu Chemical Co.) can be used. The thermal conductivity of the adhesive should not be low and the thickness of the adhesive layer is best to keep at minimum necessary level. The sensor can also be embedded in the material using the same material as the rest of the body. Note that as this method uses permanent adhesive; once the heat flux sensor is adhered to the surface, the sensor meant not to be safely peeled off.
5. Avoid any air gaps between the heat flux sensor and the subjected surface.
6. To avoid effects from the surrounding radiation, cover/paint the surface with a thin layer of paint/masking

tape (e.g. paint masking paper) of same emissivity as the rest of the surface. This can be checked via an IR thermography camera if necessary.

2. Uninstallation

One has to be very careful not to damage the sensors and the finishing of the surface (e.g. wallpaper, paint). To perform a safe and clean uninstallation, slowly warm up the sensor using a heating device (e.g. hair dryer on low settings held from a distance not to overheat the sensor does not exceed 80℃). After a short time, the adhesive becomes loose and you can carefully remove the sensor. Remove and dispose the adhesive and clean the residues on the sensor.

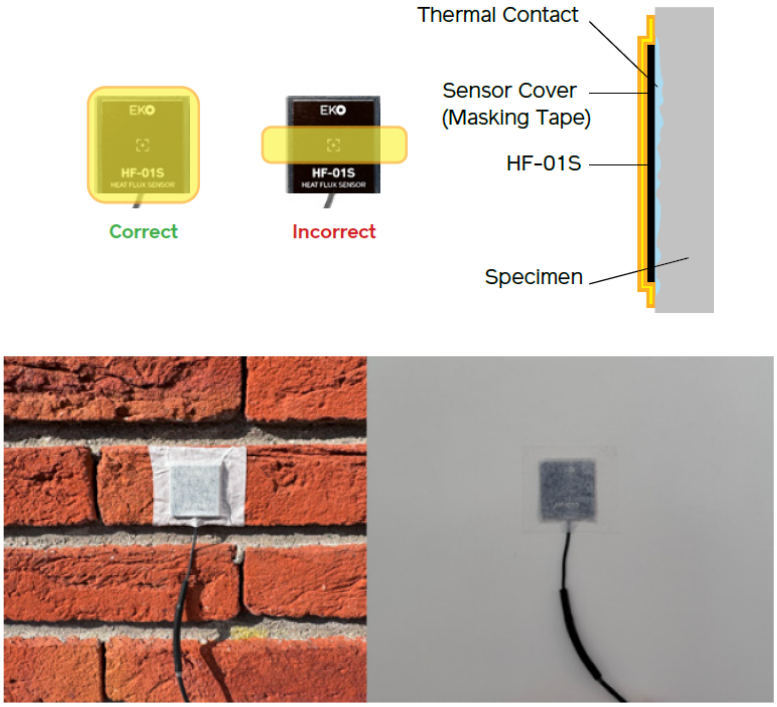


Figure 5-2.Installation of HF-01S sensor using thermal adhesive and covering it using masking tape to match the surface emissivity on indoor (right) and outdoor (left) surfaces.

5-3. Measurement

1. Data Collection

For a group of measurements such as insulation monitoring, the output of the heat flux sensor can be small. Therefore, selecting an appropriate measurement device, such as a high-resolution data logger is critical (in a typical indoor measurement, the heat flow is generally as low as below ten(s) W/m^2). It is therefore required to have μV resolution for the measuring device e.g. datalogger.

Although it depends on the installed location, there are large fluctuations in heat flux sensor output, thus an average or an integration value of a certain interval is used instead of using an instantaneous value.

It is important to select a measurement device which is suitable for the above purpose.

2. Heat Flux Measurement from Sensor Readings

As explained in Section 4, Introduction, the amount of heat flux $\dot{q}$ can be found using the following equation:

$$\dot{q} = V/S$$

Where S is the sensor's sensitivity (μV/(W/m^2)) and V is the output voltage, often in the order of μV. For instance, a measured voltage value of 0.37 mV is converted to heat flux of 7.4 W/m^2 using the sensitivity of the heat flux sensor (in this case S=50 μV / (W/m^2)) available from the calibration certificate.

3. Common Sources of Measurement Error:

Heat Flux measurement uncertainty begins by installing the sensor on the surface. As the sensor has a thermal resistance itself, the installation will change the local surface heat flux on the installation point. HF-01S is made with minimal thermal resistance to minimize this uncertainty. Nonetheless, to minimize the errors, as a rule of thumb, the thermal resistance of the object to be measured must be sufficiently larger than the Heat flux sensor.

Another source of error is the heat flux deflection and thermal conductivity dependence which is solved thanks to the thermal passive guard and the thermal facings (spreaders) integrated into the HF-01S following ISO 9869 standard.

The difference between the installation surfaces and the surface of the heat flux sensor also plays an important role in heat flux measurement accuracy. To ensure having similar IR radiation and heat convection on the surface of the sensor and the rest of the surface on which the measurement is taking place, use the right materials to mask or embed the sensor as explained in 5-2.

Avoid using the sensor in areas with a chance of high electrical noise. The sensor cable is shielded to minimize this risk.

6. Maintenance & Troubleshooting

6-1. Maintenance

To maintain accurate measurements, the following is recommended:

1. Check for any air space and/or skinning of the sensor at the time of installation.
2. Check for any damage on the sensor and lead wires.
3. Clean the sensor after using thermal contact gels and pastes.
4. It is recommended to recalibrate the sensor every 2 years.

6-2. Calibration Method and Traceability

The calibration of these heat flux sensors are performed at EKO according to the following procedure.

1) Set the calibrating heat flux sensor in between high temperature (40℃) and low temperature (20℃) plates and start the measurement (Approx. 100 W/m^2)
2) Achieve steady-state where the outputs become constant among the high temperature plate, low temperature plate and the calibrating heat flux sensor.
3) Measure the output voltage from the calibrating heat flux sensor, and calculate the sensitivity using following formula given in 5.3, Section 2 (Heat Flux Measurement from Sensor Readings)

For calibration of HF-01S, EKO Instruments follows ASTM C1130 and uses the HFM (Heat Flow Meter) Apparatus (ISO 8301, ASTM C518, JIS A 1412-2). The calibration apparatus is being periodically checked and recalibrated, using standard material boards.

6-3. Troubleshooting

Check the following items in case of trouble with the instrument. If any questions should remain, contact EKO for further technical support.

Table 6-1. Troubleshooting

Failure	Action
There is no output.	Check the electric impedance. Check the connection of the lead wires.
Output is very low.	Check the sensor contacting and adhesion conditions.
The polarity is not correct	Check if the sensor is not attached from the wrong side.
Output is too noisy	Check cable's physical condition and surrounding EM sources

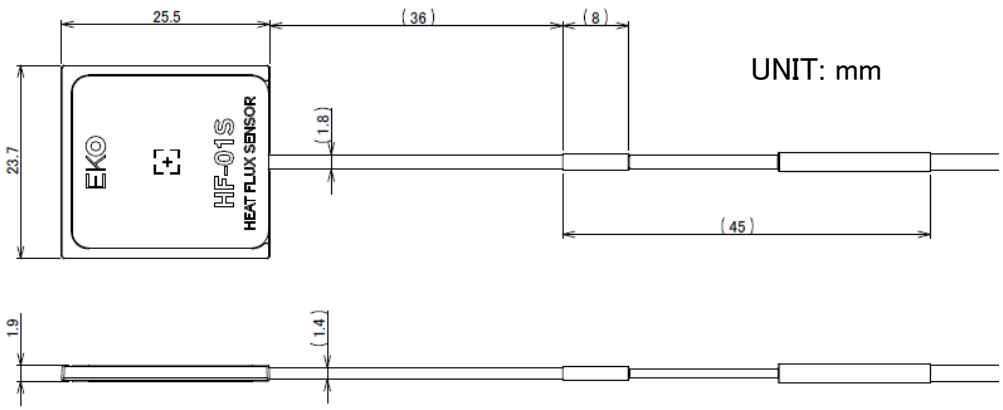
7. Specification and Dimensions

7-1. Sensor Specifications

Table 7-1. Sensor Specifications

Parameter	Description
Characteristics	Standard Type, Low Thermal Resistance High Sensitivity, Small size, For Indoor
Nominal Sensitivity	50 μV/(W/m^2)
Calibration Uncertainty	±3 % (K=2)
Time Constant (63%)	＜2 sec
Operation Temperature	Sensor: -30 ~ +80 °C , Cable: -20~+60 °C
Heat Flux Range	±10000 W/m²
Temperature Dependency	+0.2 %/°C
Electric Impedance	8 Ω - 12 Ω (10°C - 40°C)
Thermal Resistance	2.3 x10^{-3} m^2 K/W
Dimensions (L x W x H)	25.5 mm x 23.7 mm x 1.9 mm
Sensing Area	500 mm^2
Guard Width	Minimum 5x thickness of the active part (ISO 9869)
Ingress Protection	IP67
Cable Dimensions	3m (Diameter: 2.1 mm)
Weight	2.5g (Sensor Part)

7-2. Sensor Dimensions



APPENDIX

A-1. Applications

Table A-1. Applications

Category	Application Example
Building Physics	Heat transfer through the walls, windows, ceiling, floor, roof, doors of buildings, . Subways, plants, department store, glazing Analysis, hot spot identification, etc.
Insulation Monitoring	Performance evaluation of insulation materials, Insulation Containers and boxes
In-Situ U-Value and R-Value	Measurement of R-Value (Thermal Resistance) and U-Value (Thermal Transmittance) of components such as building walls, doors, roof, floor.
Greenhouse	Thermal environment measurement for greenhouse, conservatory, storage, Storing and Preservation of Agricultural Crops, etc.
Automotive	Heat transfer monitoring on the battery and other suitable surfaces in the engine, heated seats, thermal comfort.
PV monitoring	Monitoring of PV panels for performance analysis and efficiency assurance.
Research	Heat-transfer engineering research, education, calorimetry, chemistry, etc
Thermal Conductivity	Refrigerator, automobile, train cart, Calorie Meter, Heat Flow Meter

Figure A-1. Application examples of HF-01S – Explore HF-01S application brochures for more details

The HF-01S heat flux sensor is compatible with EKO Thermal Monitoring Kits, EKO QHT-10 and EKO QRU-100 .
For more information, please contact EKO sales offices.

QHT-10 Thermal Monitoring Kit

QRU-100 Thermal Monitoring Kit for Buildings

Figure A-2. Thermal Monitoring Kits QHT-10 and QRU-100, compatible with HF-01S

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