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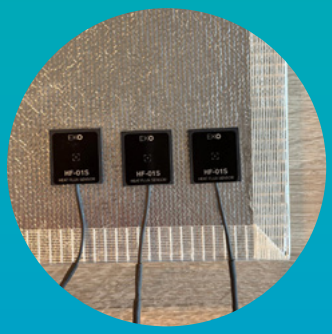
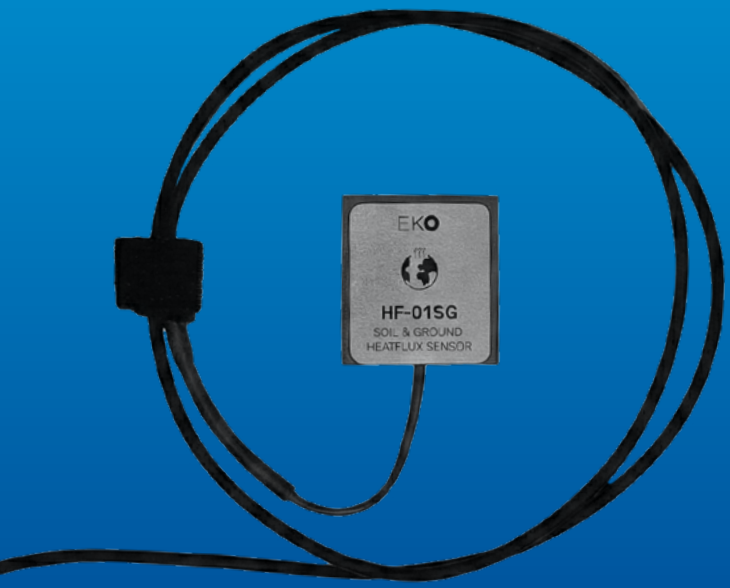
Heat Flux Sensors Application Guide





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HF-01S

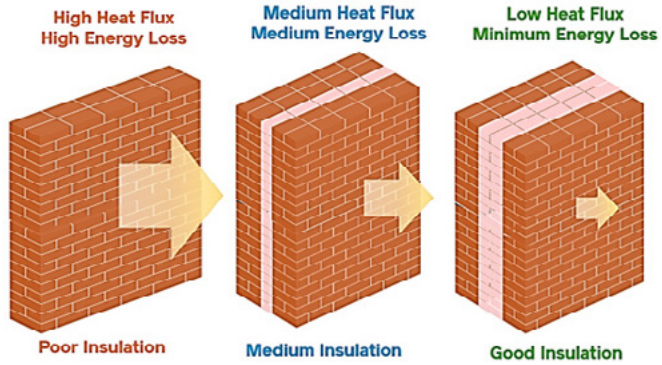
Building Physics

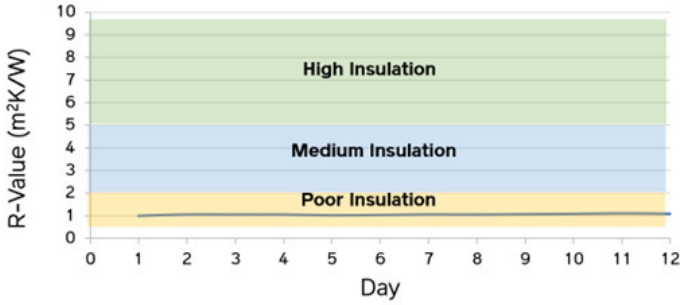
The rapid depletion of fossil fuels necessitates an enhanced focus on energy management in the field of built environment Consequently, energy efficiency measures are being actively implemented and continuously developed. Among the critical threats related to energy conservation is the high levels of heat loss in buildings, which can be effectively quantified using heat flux sensors. EKO HF-01S heat flux sensor is used to measure the heat flux from or towards a surface of interest. This helps evaluate the insulation performance. Install the sensor on specific points, such as building façades, floors, roofs, doors, windows and any surface where the heat transfer rate is to be determined.

By capturing real-world conditions, heat flux sensors provide insights into the actual thermal performance of building components, aiding in informed decisions regarding energy efficiency improvements, insulation upgrades, and overall building envelope design. A wall's insulation level, for instance, can be evaluated qualitatively by observing the heat flux data on the surface, measured by a heat flux sensor, HF01S, installed on the surface of the wall. Heat flux levels can be monitored over certain periods to evaluate the insulation condition of the wall or other building components.

By detecting high levels of heat flux on surfaces as a clear indication of inadequate insulation, one can promote attention from energy stakeholders. Below, an example data is shown from a HF-01S heat flux sensor that was installed on an office wall which is between indoor and outdoor with an average of 5K temperature gradient.

HF-01S also aids in the precise determination of in-situ thermal resistance R-Value and thermal transmittance U-Value, which are known to often depart from their nominal values. Using a single heat flux sensor in combination with two temperature sensors, one can determine these parameters following ISO 9869 standard (equivalent to ASTM C1045 and ASTM C1155). This method provides insights into the actual thermal performance of building components, facilitating informed decisions in terms of energy efficiency improvements, insulation upgrades, and overall building envelope design.

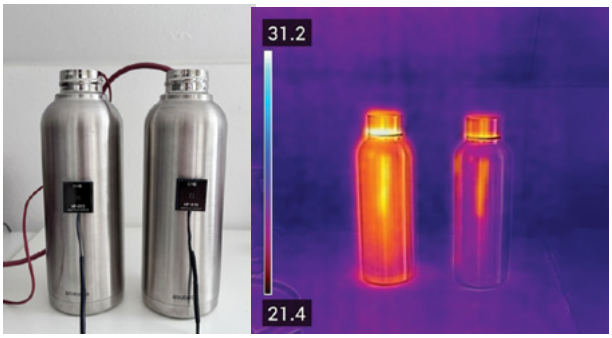




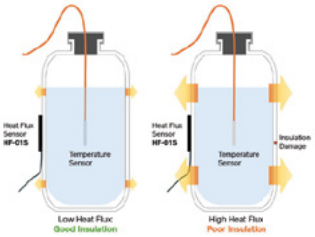
HF-01S

Insulation Evaluation

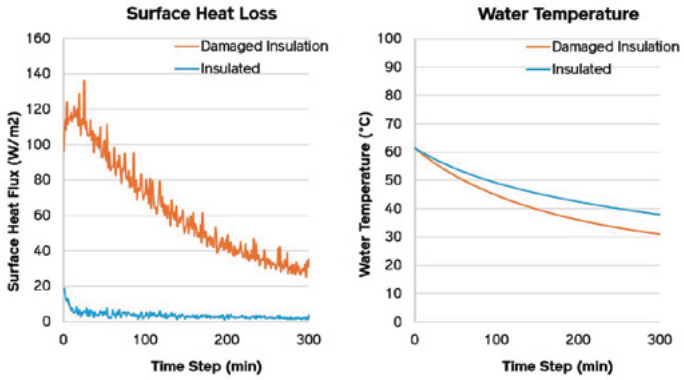
In the process of quality control, when ensuring the thermal efficiency of insulated containers, pinpointing the exact areas of heat loss is crucial. While traditional temperature sensorsand IR thermography barely provide basic insights, they oft en fall short in quantifying insulation problems accurately. EKOHF01S heat flux sensor, however, excels in this domain. It not only measures the rate of heat transfer but can also help one to identify specific areas where insulation is compromised.



In an experiment below, surface heat flux and inside liquid temperature (starting at 60 °C) are measured in two insulation containers (flask bottles), one with damaged insulation (leakage, right) and the oher one in good condition (left).

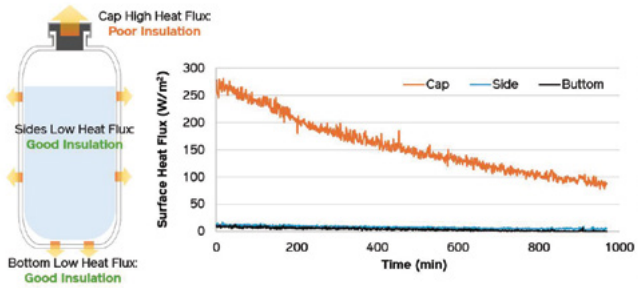


As seen in the data from heat flux and temperature for 300 minutes, measuring internal temperature will take significantly longer time to show small difference in data, leading to a long delay and difficulties in addressing the insulation problems. Heat flux data on the contrary, shows significant difference from the very beginning, aiding in qualifying the insulation condition and quantifying the heat loss level.



In an insulation container in good conditions, the heat loss level can still be investigated, when looking at different points of the body. In another measurement shown below, 3 heat flux sensors have been installed on different parts of a flask bottle: On the side (wall), Bottom, and on the cap. Heat flux level has been monitored to examine the difference on heat loss on these different points.

As seen in the measured data,heat flux values on the cap are significantly higher than the body. Such large deviations cannot be observed by IR camera or temperature sensors (See previous images and data) and therefore heat loss monitoring by heat flux sensor (In this case, HF-01S) is key to understanding the thermal performance of the product.



HF-01S

PV Panel Monitoring

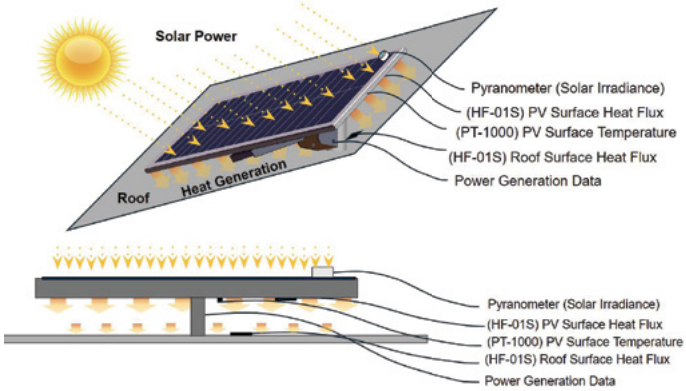
The promotion of energy conversion using renewable energy resources is essential for sustainability and environment. Photovoltaic (PV) panels are for instance, widely used to convert solar power into electricity. This process generates significant amount of heat, which transfers to the surfaces on which the panels are installed. When it comes to PV panel monitoring, heat flux sensors therefore offer substantial benefits by providing a deep understanding of the thermal dynamics at play and can be key to thermal management.

Pyranometer
(Solar Irradiance)

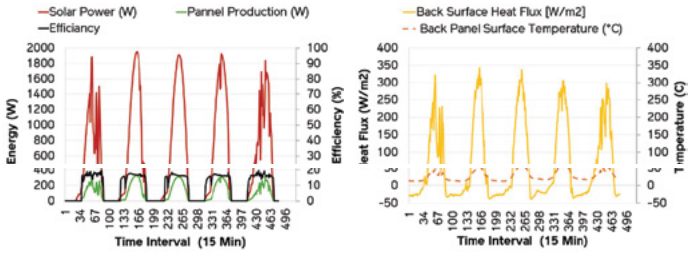
HF-01S (Heat Flux)
PT-1000 Sensor
(Surface Temperature)

HF-01S (Heat Flux)

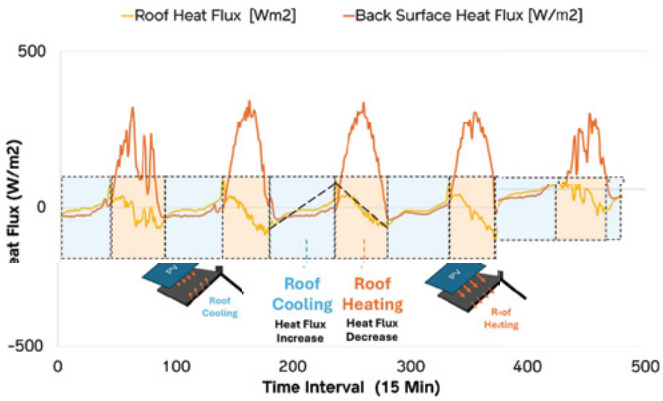
By Installing a combination of sensors (EKO HF-01S, PT-1000 Temperature sensor, and EKO ML-02 Pyranometer) on a PV panel, the thermal performance of the panel is depicted.



As shown in the previous image, the ML-02 Pyranometer measures solar irradiance. The HF-01S sensors measure heat flux towards the roof and the heat flux from the back of the solar panel. The PT-1000 temperature sensor measures the surface temperature of the PV panel's back. The data from the electricity generation is used to estimate the pannel's efficiency (nominal value is 21%).



As seen in the data, heat flux profile, besides being much more sensitive than the temperature, captures the thermal dynamaics and energy changes much better than the temperature profile. The data follows the same pattern as solar irradiance (and therefore the generation profile). Additionally, the roof heat flux is observed to have been highly influenced by the PV heat generation, as seen below. HF-01S has captured the heat balance between the two surfaces (the back of the PV panel and the surface of the roof) and can be used for optimal thermal management such as insulation application and PV cooling



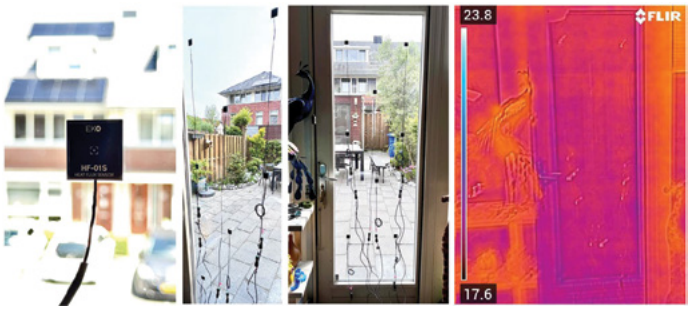
HF-01S

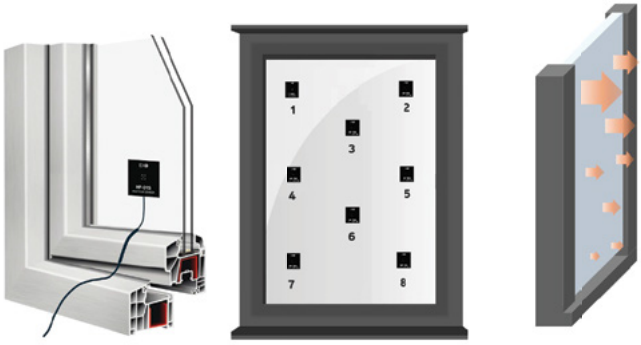
Thermal Analysis of Glazing and Windows

In the quest for energy efficiency, double glazing windows have globally become a popular choice for facade insulation. The performance of these windows however, can vary significantly due to factors such as thermal bridges, manufacturing defects, and installation quality decay. To optimize the insulation performance of windows, understanding the heat flux patterns across the window is crucial. EKO HF-01S is the perfect tool for performing full-scale measurements and understanding the pattern of heat flux on the surface of glazing.

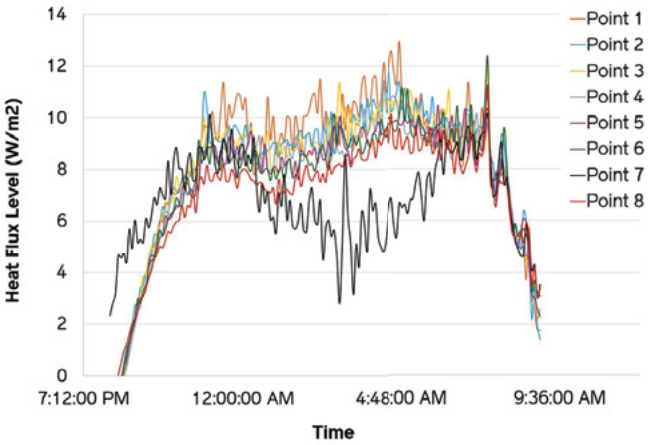
Traditional methods like temperature measurement and IR thermography provide surface temperature data though fall short in offering a complete picture as well as the rate of heat transfer, missing critical insights into insulation performance. On the contrary, heat flux measurements using heat flux sensors provide precise and quantitative data regarding the heat transfer rate, allowing for the identification of weak points in insulation that might not be apparent through temperature measurement alone. By placing these sensors at strategic points, such as the center and edges of the window, one can gather detailed information on heat transfer patterns. Identifying insulation weak points with in-situ data promotes cost savings by pinpointing energy loss. eko-instruments.com

In a measurement shown below, 8 heat flux sensors have been installed on the surface of a double glazed window. The measurements have been carried out during the night in order to avoid the effects of solar radiation. Where IR Thermography does not show any quantitative data, HF-01S sensors have provided the heat flux data, showing the pattern of heat flux on the surface of the window. The sensors have been installed on 8 points as shown in the second image:





As seen in the measured data,heat flux values vary in different points, by up to 8 W/m2, even in a window which seemed perfectly thermally homogeneous when observed with an IR camera.

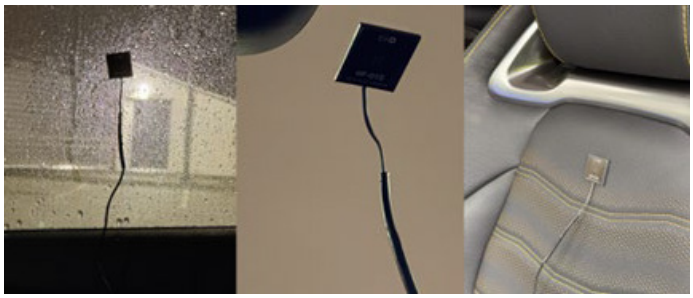


HF-01S is a suitable solution for Energy auditors, Quality Control (QC) teams and professionals, building maintenance teams, architects, builders, contractors, and anyone who is involved in the field of energy saving and energy efficiency.

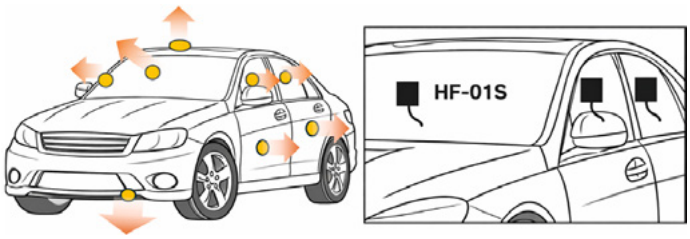
HF-01S

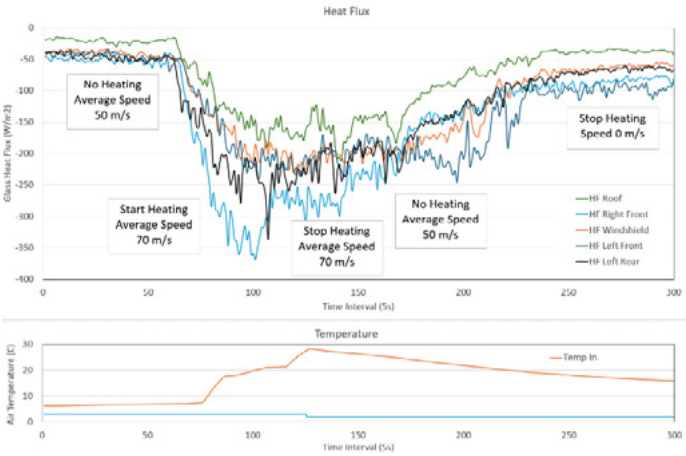
Cabin Heat Balance

HF-01S offers a simple and powerful way for automotive engineers to observe thermal balance situation in a car. This includes cabin heating and cooling conditions, cabin's thermal insulation situation, EV battery heat generation, and car seat heating analysis.



By mounting a number of sensors on key interior surfaces—such as the roof, windshield area, and side windows and doors, manufacturers can measure how heating, outside temperature, vehicle speed, and driver occupancy affect thermal losses in real time. This helps identify weak insulation zones, left-right cabin imbalances, and areas where HVAC energy is being wasted. This information translates to faster optimization of cabin comfort, more efficient heater and HVAC system tuning, reduced energy consumption, and better cold-weather performance. In a test shown below, HF-01S sensors were installed on the glass in the car while driving and heat loss is measured.



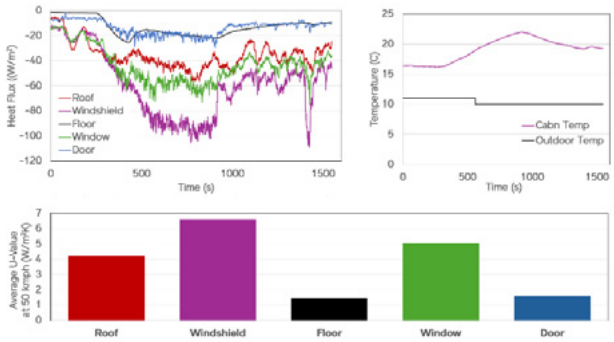


As seen in the data, all measured surfaces are losing heat to the outside throughout the test (winter night time). When cabin heating is switched on, the heat loss from the cabin becomes higher. The lowest losses appear at the panoramic roof, showing better insulation. When heating is reduced and vehicle speed changes, the heat flux gradually moves back towards lower levels, showing how both HVAC operation and driving conditions directly affect cabin thermal behavior.

This analysis can be extended to all components of the cabin. In an experiment below, the heat loss during a ride with average speed of 50 kmph is monitored with HF-01S on the side window, door, sunroof, windshield and floor.

The heat fluxes are measured in the absence of direct solar irradiance (UV Index=1) and the temperatures of the cabin is measured at the center of the cabin.

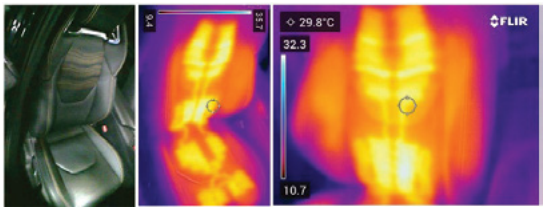
As seen in the data, windshield shows the highest level of heat flux during the movement. Using the temperature gradient between the cabin and the outdoor air, an average U-value can be estimated for each component, which can be used for comparison of each components' contribution to total heat loss of the cabin.



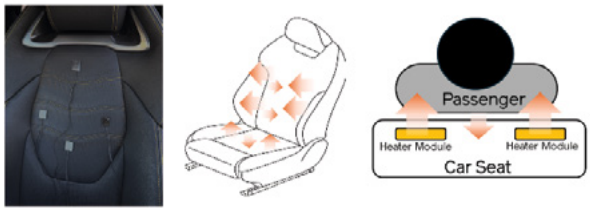
HF-01S

Heat Generation by Seat Heaters and EV Batteries

Cars are perfect examples of heat generation systems. Of the most interesting features of cars nowadays are the seat heaters. HF-01S is the perfect tool to study the heat generation by these systems and the ones alike. As the heating elements are not used in all seat locations, the thermal behavior of the seat/body is not easy to understand unless measured. For instance, opposite to common sense, the heat direction is not always towards the passenger while the heaters are on. Installing an array of sensors on the seats, engineers and designers can accurately determine how the heat behaves in each point of the system.

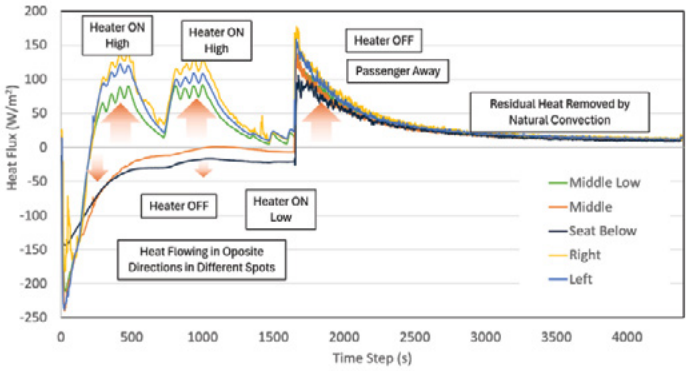


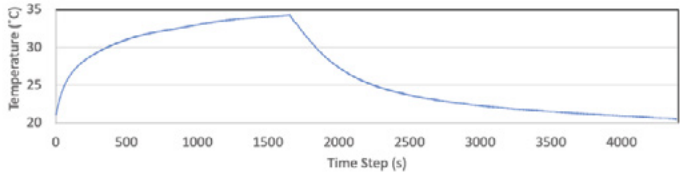
During an experiment, an array of 5 HF-01S sensors have been applied on the back of the seat (left, right, middle, bottom, seat below) and the heat flux data at each point is measured and compared to the temperature.



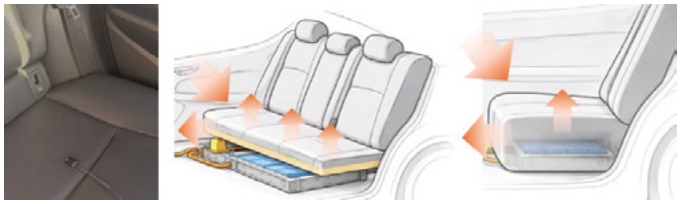
The heater has been switched on (high and low levels) and off during the occupancy and left off when unoccupied. In the measured heat mapping data, the heater ON/OFF events produce clear, immediate changes in heat transfer at multiple locations. The positive/negative data show theopposite heat transfer directions even on close points. After “heater off” and “passenger away,” the curves decay smoothly as residual heat is removed by natural convection, providing a clean signature of how the energy is transferred to the empty cabin. By comparison, the temperature trace in the bottom graph fails to illustrate any level of detailed information.

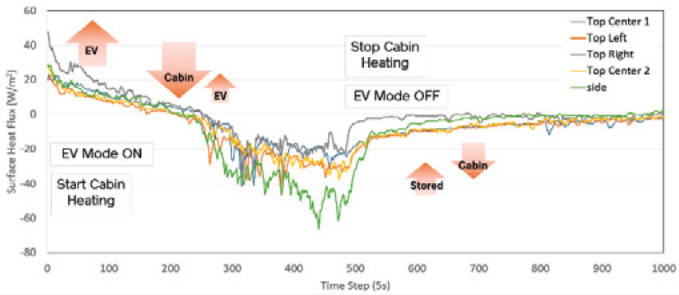
HF-01S also helps to illustrates the changing heat balance at the seat surface above the EV while both cabin heating and EV mode influence the thermal conditions. In an experiment below, heat transfer at multiple points are measured using HF-01S. Sensors are installed on the seat above the battery.





At the beginning of the test, heat flux is positive with a negative slope, due to the balance between EV generated heat and the cabin heating. With EV mode still on, the surface continues to draw heat, and the side location shows the strongest negative response, indicating the highest local heat absorption due to stronger thermal coupling to nearby structure. After cabin heating is stopped and EV mode is turned off, the heat flux at all points moves back toward zero, which means the seat surface is approaching thermal equilibrium again as the stored heat in the system and the remaining cabin warmth gradually dissipate.





HF-01S

Heat Flux Measurement of Vacuum Insulation Panels

Minimizing thermal energy loss through the use of thermal insulation materials is of the most straight-forward approaches towards reaching a decarbonized society. In the recent years, vacuum insulation panels (VIPs), have become increasingly popular, being widely used in various applications such as refrigeration, building materials, cold chain logistics, and apparatus insulation. A VIP is a composite heat insulator that is protected and maintains a high degree of vacuum by a multi-layered laminated film (Fig.1). In VIP, metal foil film and metallized film are used as barrier layers. It is often seen that the thermal performance of the center and edges are different, leading to problems in achieving thermal equilibrium, creating "Thermal Bridges". IR Thermography is often used to visualize this (Fig.2), but to quantify it, the heat flux at that point must be measured correctly.

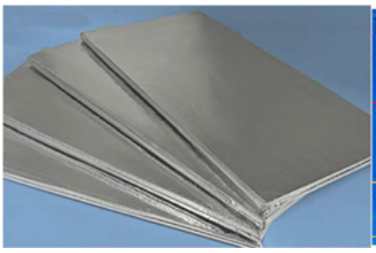


Fig 1. VIPs appearance [1]

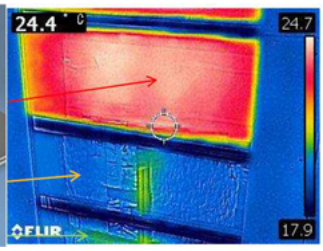


Fig 2. thermal edge effects [2]

Heat flux sensors quantify the energy change by capturing the flow of heat in and out of insulation surfaces. The results can be used to make performance decisions, including quantifying and improving energy efficiency and changing materials, and insulation edge construction. The HF-01S is a thin compact plate-type heat flux sensor. The combination of high nominal sensitivity of 50 μV/Wm^{-2}, small size, and low resistance, makes it an excellent choice for measuring heat flow from high-performance insulating materials, including VIPs. The stable and accurate output leads to an outstanding measurement experience, even at very small heat fluxes of about 1 W/m2. In this application sheet, two experiments are shown to demonstrate the advantage of using HF-01S in VIP evaluation.

Experiment 1: Thermal Bridge Measurement

HF-01S is attached to the VIPs as shown in Fig.3 and inserted into Heat Flow Meter Apparatus (FOX series) to measure heat flux at a specific temperature difference. In this case, the thermal bridge of a specific location can be obtained depending on the installation position of the HF-01S. Fig.4 shows an example of measuring the thermal bridge of a 30x30 cm2 VIP with Aluminum metallized film, claimed to have minimal heat edges. The measurement results on the contrary show that the heat flux is greater at a point 60 mm from the edge than at the center. This data can be used for the thermal design of the location where the VIPs will be installed.

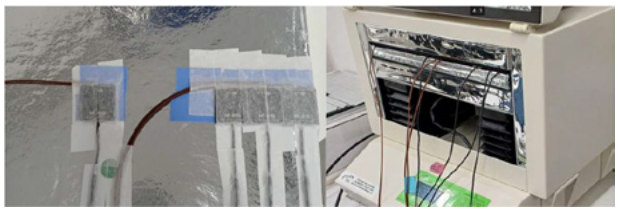


Fig.3: Installation of HF-01S on VIPs and placing in FOX314

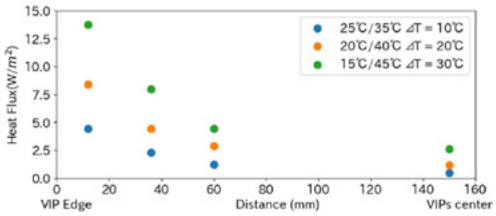


Fig 4: Heat flux at each measurement position of VIPs using HF-01S

Experiment 2: Heat Flux Measurement on site

The HF-01S is also an ideal solution for post-construction monitoring of VIPs at construction sites. By inserting this only-2mm-thin sensor into a gap between insulation materials, heat flux measurements can be taken in an environment where there is virtually no gap. As shown in Fig.6, it is possible to evaluate the effectiveness and energy eduction efficiency of insulation retrofits using VIPs by comparing them with existing insulation materials.

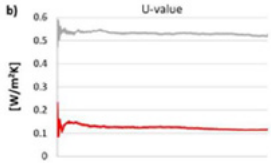


Fig 5. VIPs installed on the inside of the roof [3] (left)
Fig 6. Comparison of U-value calculated from heat flux (right)

References

[1] Appearance of vacuum insulation, https://www.ecotherm-insulations.com/
[2] H.Yamamoto, D.Ogura, Energy and Buildings Study of long-term performance of vacuum insulation panels containing getter materials in the building environment (2022)
[3] S. Fantucci, H.Yamamoto, D.Ogura, Long-term hygrothermal monitoring of glass fiber Vacuum Insulation Panels for roof application (2023)

HF-01SG

Soil Heat Flux and In-Situ Thermal Conductivity Evaluation

Soil and ground heat flux measurement is essential for understanding energy exchange between the surface, subsurface layers, and surrounding environment. In applications such as agriculture, geothermal studies, green roofs, bifacial PV systems, ground heat pumps, and construction foundation testing, heat transfer through soil directly influences thermal behavior, energy balance, and system performance. The **EKO HF-01SG Soil & Ground Heat Flux Sensor** is designed to measure this heat flow under real outdoor and buried conditions, providing reliable data for evaluating soil thermal dynamics.

By installing the **HF-01SG** at selected soil depths or directly on ground surface layers, users can monitor heat flux variations caused by solar radiation, weather changes, irrigation, vegetation, surface coverings, and subsurface thermal storage. Its thin, compact design minimizes disturbance to the natural heat flow, while the rugged IP67 weather-proof construction supports stable use in harsh soil and outdoor environments. The sensor's high sensitivity and fast response make it suitable for both short-term thermal behavior studies and long-term field monitoring.

When used together with temperature sensors placed above and below the heat flux plate, the **HF-01SG** enables in-situ thermal conductivity evaluation using Fourier's Law. This allows researchers and engineers to estimate how effectively heat is conducted through soil or ground materials under actual field conditions. The resulting data supports improved ground heat storage analysis, surface energy balance modeling, geothermal system design, agricultural thermal studies, and evaluation of insulation or ground-covering performance.

HF-01SG

Green House Climate Control

Energy optimisation
Identify when additional heating stops improving root temperature and becomes energy loss. Avoid unnecessary heating runtime.

Improved control response
Reduce unnecessary soil heat storage, enabling faster and more predictable temperature regulation.

Irrigation impact awareness
Quantify how soil moisture increases thermal conductivity and heating demand.

Uniformity between greenhouse zones
Detect uneven heat distribution caused by pipe depth, insulation gaps, or soil variability.

Commissioning and installation validation
Verify that heating design and pipe layout deliver the intended energy distribution.

Early detection of system drift
Monitor long-term changes caused by soil compaction, insulation degradation, or structural changes.

Data-driven troubleshooting
Distinguish between increased heating demand caused by crop factors versus thermal losses. Demonstrate measurable system performance to clients or investors.

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