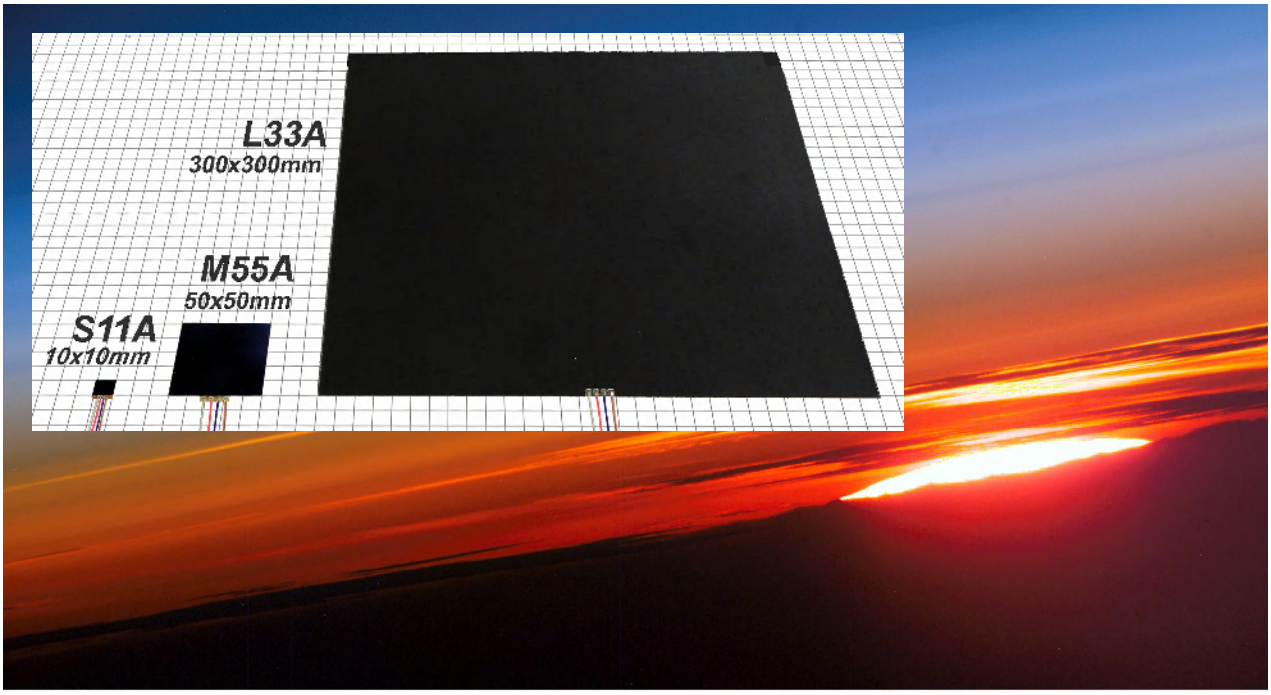


ISS015E10469 "Image courtesy of the Image Science & Analysis Laboratory, NASA Johnson Space Center."

General purpose
Heat Flux sensors

features

- High reliability
- High sensitivity
- Low thermal resistance

Preliminary Edition October 2011

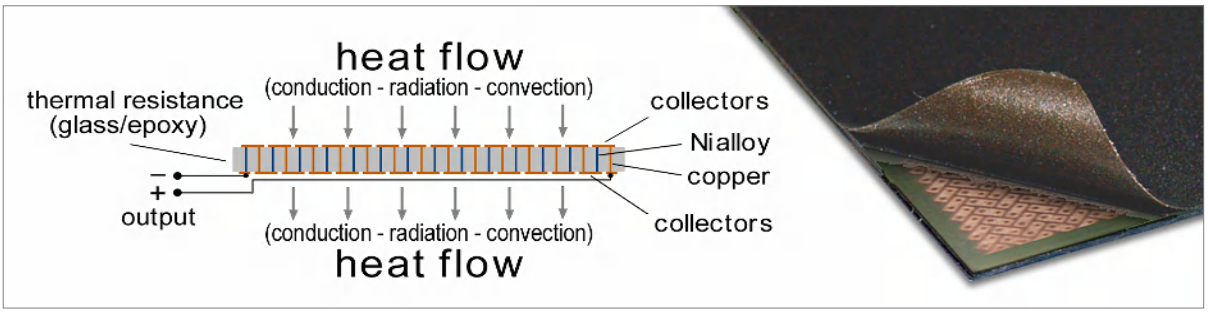
What is the general purpose Heat Flux sensor?

Heat travels in the forms of conduction, radiation and convection. Heat flow sensor measures amount of convective heat travelling through inside the sensor in a direction perpendicular to its surface.

When heat is applied to an object from outside, it increases temperature that raises internal thermal energy and causes transfer of heat: it is thermal energy and is recognized as heat. Conductive heat flow is identified as amount of heat (J) flowing through a unit area (m^2) in a unit time (s). The unit of heat flow density q – commonly called Heat Flux – is $q=J/s \cdot m^2=W/m^2$.

When there is a temperature difference (ΔT) between two sides of a board of a uniform thickness, thermal gradient ($\Delta T \cdot d^{-1}$) and the amplitude of heat flux bear in proportionate relationship. Coefficient of thermal conductivity is material specific, the value calculated by dividing heat flux by thermal gradient, and its inverse is thermal resistivity. In the heat flow sensor, heat flux is detected from temperature difference between two sides of thermal resistive element plate placed across flow of heat. Proportional relationship of the both is verified as an individual *sensitivity constant* of the sensor ($mV/W/m^2$), and representative heat flux (W/m^2) is shown as the product of output voltage (mV) and sensitivity constant. The value acquired in practical use is applicable when ambient heat flow is regarded constant without regard to the size of the sensor.

Eto's general purpose heat flow sensor is comprised of a thermopile is configured to which a number of thermocouples connected in series on the both sides of a thin plastic film. With this configuration, heat flow measurement has become possible even when temperature difference between the sides is as low as lower than 0.001℃ with higher accuracy comparing with conventional measuring system.



Structure and feature of general purpose Heat Flux sensors

As illustrated, heat resistive glass/epoxy board is laminated with a number of heat collectors of pure copper on both sides. Each collector is connected with pure copper and nickel alloy alternatively through the board. Algebraic sum of thermal electromotive force generated between nickel alloy on the thru hole and heat collector is output as temperature difference between two sides.

Pairs of thermocouples are placed evenly to normal direction throughout surface of the heat flow plate so that only perpendicular components of heat flow vector running through the heat flow sensor are correctly detected.

There are three models in series of Eto's heat flux sensors. Except for differences in dimension and thermocouple density according to its applications, their structure is basically identical. Area of applications may be extensive and the heat flow sensors may be used under different environment with different mounting arrangements. However the heat flow sensor is so designed and processed so that it meets conflicting requirements of low thermal resistance and high sensitivity. The sensor is equipped with a connecting terminal for the measurement when temperatures of sensor and the objects to be measured are nearly equal.

Eto Denki will be pleased to prepare the sensor designed to your requirement.

Applications

Heat flow sensor of this series is useful as a standard sensor in research laboratories, houses and buildings for such various purposes as evaluation of insulation efficiency and hot/cold temperature retention, and analysis of heat transfer. The sensors come in 10mm, 50mm and 300mm square.

Due to its inherent heat capacity of buildings and equipment, there is a time delay in the temperature change against thermal inflow and outflow, so value of thermal flow would be used as an advance indicator. Other applications under study include a parameter in automatic temperature control, energy saving in air-conditioning, and various uses in medical, garment or agricultural industries. Additional features like waterproofing, curved sensor or protective attachment will be available upon request.

Calibration

Each sensor is individually calibrated according to GHP (Guarded hot plate ISO 8302) using dedicated equipment based on absolute method. Upper side of the test piece (1) is covered with the source heater (2), upon which thin heat flow sensor (3), thin guard heater (4) and thermal insulator are placed in that order. Whole assembly of the same contour is placed on the heat sink of constant temperature. As the result that output of (3) is kept at zero by the effect of feedback circuit, energy of thermal flux passing through the test piece (1) is equal to supply power, thus accurate "sensitivity constant" is calibrated from the ratio between output power of the sensor and supply power.

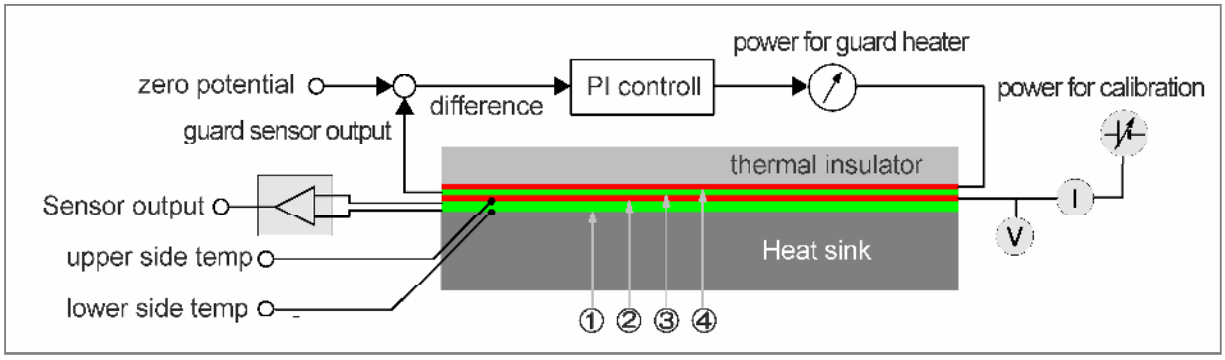


Table of rated values

Type	Dimension L.W.T (mm)	Sensitivity mV/W.m^{-2}	Thermal Resistance ℃/W.m^{-2}	Thermal Conductivity W/m.K	Water proof	Curved surface	Guard plate	Price Yen
L33A	300x300x0.8	0.1	2.7x10-3	0.36	Y	N	Y	84,000
M55A	50x50x0.7	0.01	2.5x10-3	0.4	Y	N	N	18,000
S11A	10x10x0.6	0.007	2.2x10-3	0.44	Y	Y	N	12,000

Important notes

When the sensor is applied as exposed on the surface of a subject, transfer of conductive, radiant and convective heats are measured as a thermal flux. Therefore, care must be taken for the best accuracy and ease of analysis to accord thermal conditions of surfaces of the sensor and surrounding area. Arrange the sensor in a direction perpendicular to thermal gradient as thermal flux comes up parallel with thermal gradient.

For surface mounting, smooth the surface and fix the sensor firmly using adhesive or double-sided tape. Be careful not to let air get in the bonded part as it may cause incorrect measuring. When embedding, avoid cavity and fill with the same material.

Note 1: Most sensors for measuring conductive heat employ the system to output the temperature difference among more than one temperature sensors. They are often called thermal flow sensor, thermal flux sensor, heat flow plate or heat flow meter. Heat flow is heat quantity flowing through a subject and is expressed in J=W・s. Thermal flow sensor is a device that measures and outputs amount of thermal energy that flows in a second per a square meter as heat flow density in $q=W/m^2$. Value of heat flow per a square meter is simply expressed as a product of output voltage and sensitivity constant.

Note 2: Where strict accuracy is necessary, resultant error caused by disturbed heat flow with insert of a sensor should be corrected. If the sensor is put inside the subject, difference in thermal conductivity of the subject and the sensor may cause disturbance of heat flow resulting in errors of resistance and deflection. Resistance error is corrected by calculation, while deflection error is alleviated by using guard plate of the same quality as that of the sensor around the sensor. In either case, the better in correction the lower the thermal resistance of the sensor. When the sensor is used by attaching to the surface of the subject, conductive thermal flow from the back side turns to radiation and convection flows. Difference in surface finishes of the sensor and the subject may cause errors depending on the difference.

Note 3: In this series of the heat flow sensor, thermal resistance is minimized while maintaining sensitivity by means of measures including raising density of thermocouples. When applied on the wall, output varies effected by changes in air current or by personal movement. Therefore, ingenious measures is recommended such as using cumulative average by shortening measuring intervals. Eto Data Logger is equipped with cumulative average features.

Note 4: Connection cable, water-proof design, curvy design and protective guard are optional.

ETO DENKI CO.
http://www.etodenki.co.jp/
1-10-16, Shinkawa, Mitaka-city, Tokyo181-0004, Japan
mail : info@etodenki.co.jp