# HEAT FLOW SENSORS

MF-180

MF-180M

MF-190

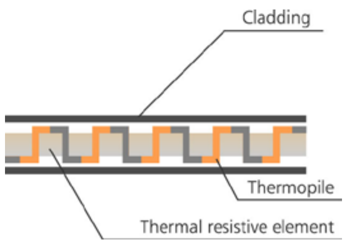
MF-200

# INSTRUCTION MANUAL

EKO Instruments Co., Ltd.

## 1. General outline

EKO Heat Flow Sensors are suitable for the direct heat flow measurement of materials, and for the measurement of radiant flow emitted by bodies such as refrigerators and containers.

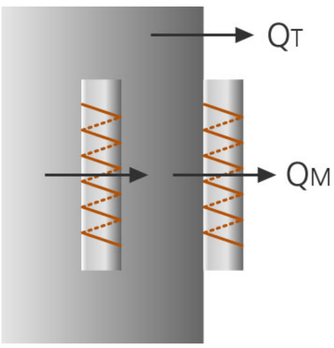



Thin construction and small heat capacity of those sensors achieved short response time and minimization of lateral heat loss.

The substrate, the thermal resistive element, is glass epoxy resin or Teflon that are thermally stable. The sensors are designed durable and non-corrosive.

## 2. Measuring principal

Heat transmission is caused by three modes, namely, thermal conductivity, radiation and convection. When a heat flow sensor is placed on the surface of a material, the sensor measures the total values of those three modes. When the sensor is placed inside of a material, it directly measures a heat transmission caused by thermal conductivity.




The heat flow "$Q_M$", which is passing through the sensor (placed on a surface or inside) and having thermal resistance "R", is expressed as

$$Q_M = 1 / R \cdot \Delta\theta$$

where $\Delta\theta$ is the temperature balance between both surfaces of the sensors.

By taking out the temperature balance with the thermopile, the passing heat flow can be measured directly. The constant 1/R is preliminary calibrated by the standard heat flow sensor, namely, $Q_M = k \cdot E$ where "k" is the calibration constant and "E" is the electromotive force equivalent to $\Delta\theta$. However, heat flow "$Q_T$" without setting a heat flow sensor is not generally the same as above "$Q_M$". EKO thin heat flow sensors determine that "$Q_T$", and it is practically the same as "$Q_M$".

## 3. Installation

3-1 Connect the output cable to the heat flow sensor and the data logging device such as data logger or recorder according to the wiring drawing.

3-2 Attach the sensor on the surface of the material

Attach the sensor to the material with no space between the sensor and the materials.
Install the heat flow sensor to the material according to the wiring drawing and the installation guide, which is shown at page 6 of this manual.
It is advisable to paint the sensor same color as the surface of the material.

Embed to the material

Set the sensor in the perpendicular direction of the feat flow.

## 4. Calculate the heat flow

By using the following equation, calculate the heat flow from the output voltage of the sensor.

$$Q = E / C$$

Where, Q : Heat flow flux [ $W \cdot m^{-2}$ ]
E : Output voltage from a sensor [ mV ]
C : Sensitivity of the sensor [ $mV / W \cdot m^{-2}$ at 20°C ]

Example :

E = 1 [ mV ]
C = 0.015 [ $mV / W \cdot m^{-2}$ at 20°C ]

Heat Flow Q = E / C
= 1 / 0.015
= 67 $W \cdot m^{-2}$

## Temperature compensation

The temperature coefficient of MF series heat flow sensors is very small and temperature compensation for measurement value is normally not required. This is the compensation method for your reference.

For example;

Model MF-180

Sensitivity C : 0.015 [ mV / W・$m^{-2}$ at 20°C ]

Temperature dependency Td : -0.03 [ % / °C ]

Temperature at a measurement Tm : +100 [ °C ]

Output voltage E : 1 [ mV ]

Heat flow Q = E / C x (1 + Td / 100 x (Tm - 20))
= 1 / 0.015 x (1 + (-0.03 / 100 x (100 - 20)))
= 67 x (1 + (-0.024))
= 68 W・$m^{-2}$

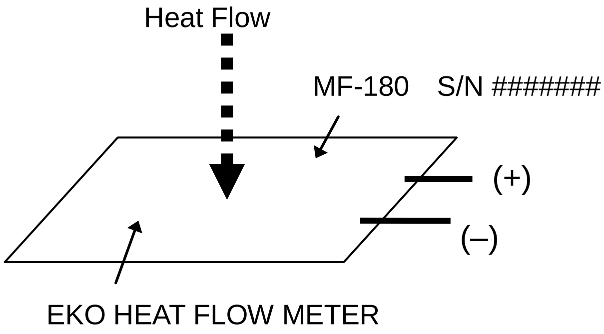
## Important Points of Measurement:

All of the Heat Flow Sensors are made of thermal resistive element; therefore, the heat resistance of the object to be measured must be sufficiently larger than the Heat Flow Sensor, or it will cause error. Below table shows the examples of wall materials and measurement errors. Also when the Heat Flow Sensor is attached on the surface, the convective flow and the radiation will affect on the measurement error.

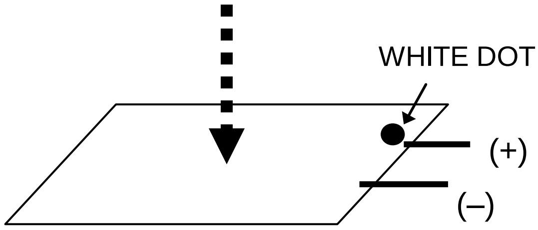
| Heat Radiation Wall | | | Sensor | | Measurement Value/True Value R/(R+Rs) |
|---|---|---|---|---|---|
| Material | Thickness (mm) | Thermal Resistance R ($m^2$・ K/W) | Model | Thermal Resistance Rs ($m^2$・ K/W) | |
| Wood | 50 | 0.31 | MF-180 | 0.014 | 0.96 |
| | | | MF-200/190 | 0.00304 | 0.99 |
| Cement | 100 | 0.1 | MF-180 | 0.014 | 0.88 |
| | | | MF-200/190 | 0.00304 | 0.97 |
| Steel | 5 | 0.001 | MF-180 | 0.014 | 0.07 |
| | | | MF-200/190 | 0.00304 | 0.25 |

## 5. Wiring

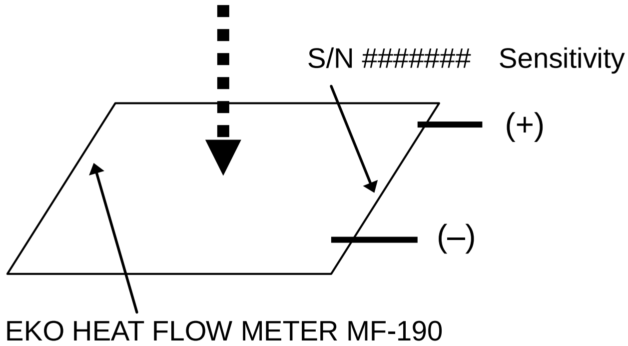
MF-180



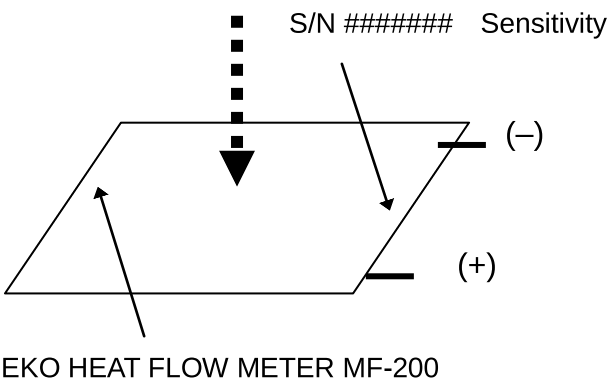

MF-180M




MF-190




MF-200




All of the sensors have 2-core shielded 10m long (standard) output cable. Plus (+) line has RED terminal, and Minus (-) line has BLUE terminal.

## 6. Installation guide

| Materials to be installed | Preparation | Installation |
|---|---|---|
| Metal | Smooth surface<br>Degrease by Organic Solvent<br>Rough surface<br>Make the surface smooth | Use Silicon adhesive<br><br>Use Silicon adhesive |
| Mat, Curtain | | Embed to the material<br>Use Silicon adhesive |
| Concrete, Mortar | Make the surface smooth | Embed to a material by Silicon adhesive or Mortar. |
| Glass wool board | Make the surface as smooth as possible | Embed to the material<br>Use Silicon adhesive |
| Wall mud, Tuff | Make the surface as smooth as possible | Embed to a material<br>Use Silicon adhesive |
| Wood | Record the direction of grain.<br>(Directional characteristic) | Use Silicon adhesive |
| Perlite board | Make the surface as smooth as possible | Use Silicon adhesive |
| Tile, Glass | Degrease by Organic Solvent | Use Silicon adhesive |
| urethane foam<br>Polyethylene foam | Make the surface as smooth as possible | Use Silicon adhesive |

## 7. Specifications

| Specifications | | MF-180 | MF-180M | MF-190 | MF-200 |
|---|---|---|---|---|---|
| Sensitivity ($mV/W \cdot m^{-2}$) at 20°C, Typ. | | 0.028 | 0.025 | 0.20 | 0.006 |
| Temperature range (°C) | Sensor | -30 to +120 | -30 to +120 | -20 to +120 | -20 to +120 |
| | Cable | -25 to +60 | -25 to +60 | -25 to +60 | -25 to +60 |
| Thermal resistance ($m^2 \cdot °C/W$) | | $1.4 \times 10^{-2}$ | $1.5 \times 10^{-2}$ | $3.04 \times 10^{-3}$ | $3.04 \times 10^{-3}$ |
| Temperature dependency (%/°C), Typ. | | -0.03 | -0.03 | < 0.05 | < 0.05 |
| Reproducibility (%) | | ±2 | ±2 | ±2 | ±2 |
| Internal resistance (Ω), Typ. | | 150~550 | 150~550 | 600~900 | 15~30 |
| Substrate | | Teflon | Teflon | Glass epoxy | Glass epoxy |
| Cladding | | Polyester | Carbon FRP | Polyester | Polyester |
| Size L x W x T (mm) | | 42 x 20 x 0.9 | 50 x 25 x 1.2 | 310 x 310 x 0.7 | 50 x 50 x 0.7 |
| Weight (g) | | 1.1 | 1.8 | 100 | 3.3 |

## 8. Contact Information

If you have any questions-feel free to call, fax or e-mail to EKO or your local distributor.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