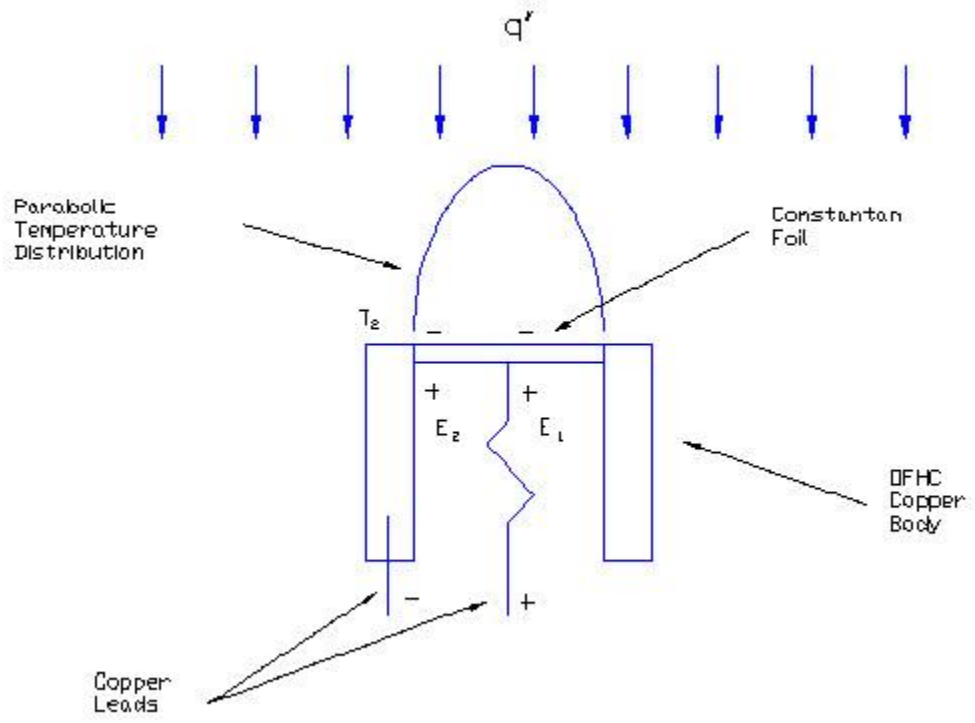
VATELL CORPORATION

Use of the Thermogage Circular Foil Heat Flux Gauge

When used properly, the Vatell Corporation Thermogage Circular Foil Heat Flux gauge will provide excellent heat flux measurement for a wide variety of applications. This document explains the use of the Thermogage products and important factors to consider while making measurements.

Operating Principles:

The transducer is a differential thermocouple that measures the temperature difference between the center and the circumference of a thin circular foil disk. The disk is bonded to a circular opening in a cylindrical heat sink. The foil and body are made of complimentary thermocouple alloys. These materials produce an output which is directly proportional to heat flux. The Thermogage products measures radiation and convective heat flux. The 9000 series radiometers only measure radiative heat transfer.



High convective heat transfers can skew measurements with a circular-foil gauge. If your application includes larger components of convective heat transfer your measurements may be shifted.

Installation:

Mounting conditions for water-cooled Thermogage products are not as critical as conduction-cooled Thermogage units. The water removes the absorbed heat continuously providing a good heat sink. Conduction-cooled units should be mounted so that the sensor is in good thermal contact with its surroundings. The heat sinking of the conduction-cooled unit should allow for heat to be removed from the unit for the duration of the test.

The normal 1000 and 2000 series Thermogage products have a 180° view. It is important to align the sensors so that the view of the sensor is appropriate for the measurements you intend to take. The 9000 series radiometers have a limited view angle. The 9000 series sensors should also be aligned so that the geometry of the view is appropriate for the measurements you wish to make.

Taking Measurements:

When the Thermogage transducer is exposed to heat flux, a voltage will be produced that is proportional to heat flux. Each unit is individually calibrated by Vatell and that information can be found on the calibration sheets included with the sensor. All Vatell calibrations are for absorbed heat flux, performed with radiative heat sources because they are the most consistently repeatable. To determine the measured heat flux, simply multiply the output voltage by the scale factor of the unit, which can be found on the calibration sheet.

Example: A sensor exposed to a halogen spot lamp generates a 6.2 mV output. The calibration sheet indicates that the scale factor is 1.961 W/cm²/mV. The heat flux, *q"*, is found as:

$$q'' = (6.2\ \text{mV}) \cdot (1.961\ \text{W/cm}^2/\text{mV}) = 12.16\ \text{W/cm}^2$$

There are 3 wires associated with standard Thermogage sensors. The red wire is (+) positive, the black is (-) negative and the silver wire (shield) is the ground. Vatell recommends connecting the Thermogage differentially with the shield grounded. If the application requires single-ended termination, connect the black wire to the common and connect the shield to the case ground or leave unconnected.

A range is specified when the Thermogage product is purchased. The top of the range is set for a 10 mV full scale output. Units may be over-driven to 15 mV without damage or loss of calibration. Outputs between 15 mV and 20 mV are not linear and the calibration information is not valid. Overdriving the units to 20 mV will damage the gauge.

Face Coating:

Thermogage sensors are coated with a high temperature black paint. The calibrated sensitivity of your transducer is dependent on the emissivity of the face of the sensor.

Colloidal graphite is used for higher heat flux levels. The calibrated sensitivity of your transducer is dependent on the emissivity of the face of the sensor. Depositing material or removing coating can change the emissivity of the face of your sensor, changing the calibrated sensitivity. It is important to try to maintain the original coating on the face of the sensor as much as possible. You should regularly inspect the face of your sensor for physical damage or build up of material.

Recalibration:

Vatell Corporation recommends recalibrating your sensor at least once a year. More frequent calibrations are recommended for applications in which the sensor is placed directly in a flame or those applications which are known to deposit onto or remove material from the face of the sensor.

Troubleshooting:

If you are having problems with your sensor, you should check the resistance of the instrument. The resistance should typically not be above 5 ohms for sensors with the standard 2 meter leads. Ohmmeters used to check resistance will not damage the sensing element. The face of the sensor should also be inspected. Any changes to the original coating that can be visually noted can affect the sensitivity.

Water-cooled Thermogage Units:

When using the 1000 or 9000 water-cooled series it is important to use clean water. Generally plain water is fine for cooling. Deionized water isn't necessary unless there is an issue with electrical isolation through the cooling lines. Ethylene glycol (EG) mixtures can be used if needed, with some caveats. First, the specific heat of a EG solution is lower than plain water (about 20% less for a 50/50 mix) so the flow rate needs to be higher to maintain adequate cooling. Second, the EG solution needs to be mixed properly. Mix the EG with distilled or deionized water because the chlorine added to tap water makes the EG solution corrosive. Don't use automotive antifreeze because it contains silicates which help protect the aluminum in cars but can cause fouling in copper. Third, EG will break down and generate organic acids, so it must be flushed and replaced regularly. Use of "inhibited" EG (that is, with anticorrosive additives) will extend the life of the solution.

The temperature of the cooling fluid does not affect the calibration of the sensor; the construction of a circular-foil sensor makes it temperature independent. The cooling fluid temperature should be above the dew point to prevent condensation from forming on the gauge, especially in applications where flames are involved. The condensation will not hurt the sensor, but it will affect the sensor readings. The cooling fluid should also stay well away from its boiling point; if the cooling fluid starts boiling the gauge will be damaged.