How does a globe thermometer work?

QUESTION: To measure the temperature in our workshop the building services company uses both a radiation-shielded thermometer and a globe thermometer. Why? How does the globe thermometer work?

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ANSWER: The radiation-shielded thermometer only measures the air temperature. With a globe thermometer – see figure – you take into account both the air temperature and the radiation from hot or cold surfaces and objects in the workshop. In stationary conditions, the measured temperature is determined by the balance between the radiation from the globe to the surroundings and the convection from the air to the globe or vice versa. In a draught-free environment you are measuring a form of "operative temperature", which from a comfort perspective provides better information than the air temperature alone.

If, for example, we measure the temperature inside premises whose walls are colder than the air, the globe thermometer will display a temperature that is somewhat lower than the air temperature. If the readings are taken in premises containing hot furnaces, the globe thermometer will display a temperature that is higher than the air temperature.

A globe thermometer consists of a black, hollow, air-filled metal globe with an outer diameter of 50 –150 mm. The globe wall is thin and consists of a material, such as a copper alloy, with very high thermal conductivity. The globe is clamped to a stem which contains a temperature sensor that is positioned at the centre of the globe. See figure. Nowadays the sensor is either a thermocouple or a Pt100 sensor. If the temperatures of the air, walls, and objects in the globe's surroundings vary, the heat transfer via convection and radiation to various parts of the globe will also vary. In contrast, the temperature of the globe's surface will not vary very much because the globe wall's thermal conductivity is very high, which equalises the wall temperature. That is why we measure a mean temperature.

Questions should be of general interest and be about temperature measurement techniques and/or heat transfer.

QUESTIONS ANSWERS

The heat transfer from the globe's inner wall to the sensor occurs mainly via convection and radiation. The heat transfer between the wall and the sensor is not very efficient, which results in a long response time. If the globe wall's temperature is constant, after a while the sensor will measure the wall's temperature – the globe temperature. If the air temperature and the temperature of the surroundings vary over time, the globe thermometer will measure a mean value over time.

The velocity of the air in the room influences the heat transfer coefficient and thereby both the globe temperature and the response time. If the air velocity increases, both the response time and the difference between the air temperature and the globe temperature will decrease. The air velocity also influences how a person experiences the comfort level inside the premises, because the heat transfer from his/her body to the surroundings increases with the air velocity. [Ref 1]

The globe temperature only reveals the interaction between convection and radiation inside the premises. To make an even better assessment of the comfort level there, we can use the concept of "equivalent temperature". This takes into account such factors as how a person experiences the influence of the air temperature, radiation and air velocity. Additional influencing parameters are the air humidity plus the individual's activity and clothing.

If you have questions or comments, contact Dan Loyd, LiTH, dan.loyd@liu.se

An example of a globe thermometer (50 mm) here with a thermocouple inserted into the centre of the globe. The globe thermometer should be freely installed in the air.

[Ref 1] See further www.pentronic.se > News > Technical info > Examples of heat transfer > "Does a table fan reduce the room temperature?" (2010-4 p. 3)