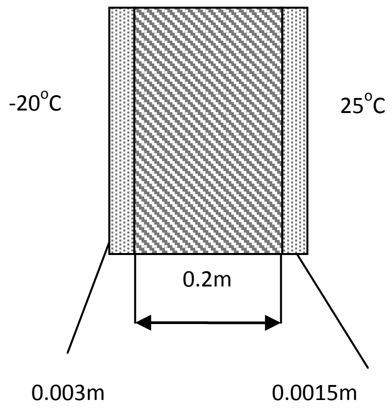
gSKIN®

Heat Flux Sensors

Insulation measurement of a refrigerator

Case description

An industrial freezer is designed to operate at an internal air temperature of -20° C, when the external air temperature is 25° C. The internal and external heat transfer coefficient are k_1= 11 W/m^2 and k_2 = 7 W/m^2. The walls of the freezer are comprising of a layer of plastic with λ_1=1W/mK and thickness d_1=3 mm, insulation material with λ_2=0.06 W/mK and thickness of d_2=200 mm and an outer layer of stainless steel with λ_3 = 16 W/mK and thickness of d_3=1.5mm. Below we describe the calculation and the measurement approach to derive the heat flux (Φ) to the inside of the refrigerator wall and the overall U-Value (U).



Calculation

Known parameters:

$$d_1 = 0.003m$$

$$\lambda_1 = 1\frac{W}{mK}$$

$$d_2 = 0.2m$$

$$\lambda_2 = 0.06\frac{W}{mK}$$

$$d_3 = 0.0015m$$

$$\lambda_3 = 16\frac{W}{mK}$$

$$k_1 = 11\frac{W}{m^2}$$

$$k_2 = 7\frac{W}{m^2}$$

$$T_{in} = -20^oC$$

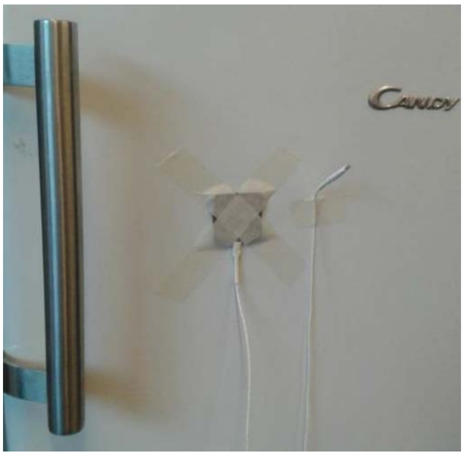
$$T_{out} = 25^oC$$

Measurement with gSKIN® U-Value KIT

Background knowledge for measurement approach:

No assumptions needed
No need for any known values beforehand (thickness, material, etc.)
No additional calculation needed

1. Mount the heat flux sensor and one temperature sensor on the outside of the refrigerator.



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Unknown:

Heat loss per m² of fridge surface:

$$\Phi = ? \left[\frac{\mathbf{W}}{\mathbf{m^2}}\right]$$

Heat transfer coefficient via the wall:

$$U = ? \left[\frac{\mathbf{W}}{\mathbf{m^{2\circ}K}}\right]$$

Assumptions needed for calculation:

1) Steady state conditions
2) One-dimensional conduction through the wall
3) Constant thermal conductivity

Formulas:

$$\Phi = U * (T_{in} - T_{out})$$

$$U = \frac{1}{\frac{1}{hk_1} + \frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \frac{d_3}{\lambda_3} + \frac{1}{k_2}}$$

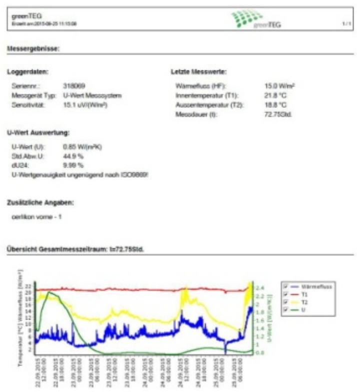
Results:

$$U = \frac{1}{\frac{1}{11} + \frac{0.003}{1} + \frac{0.2}{0.06} + \frac{0.0015}{16} + \frac{1}{7}} = 0.28 \frac{\mathbf{W}}{\mathbf{m^2K}}$$

$$\Phi = 0.28 * (25 - (-20)) = 12.6 \frac{\mathbf{W}}{\mathbf{m^2}}$$

Mount the second temperature sensor inside the refrigerator:

2. Connect all the sensors to the logging unit, start the measurement, evaluate the heat flux through the wall and the U-Value according to ISO 9869 and monitor it during the whole measurement time



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Messergebnisse:

Loggerdaten:

Seriennr.: 318069
Messgerät Typ: U-Wert Messsystem
Sensitivität: 15.1 uV/(W/m²)

Letzte Messwerte:

Wärmefluss (HF): 15.0 W/m²
Innentemperatur (T1): 21.8 °C
Aussentemperatur (T2): 18.8 °C
Messdauer (t): 72.75Std.

U-Wert Auswertung:

U-Wert (U): 0.85 W/(m²K)
Std.Abw.U: 44.9 %
dU24: 9.99 %
U-Wertgenauigkeit ungenügend nach ISO9869!

Zusätzliche Angaben:

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Übersicht Gesamtmesszeitraum: t=72.75Std.

Summary

Advantages of using gSKIN® U-Value KIT over calculation:

1) No need for additional parameters (i.e. heat transfer coefficients)
2) Real-time measurement
3) The measurement takes into account real conditions
4) gSKIN® Heat Flux Sensor detects all types of heat transfer

For more information go to: http://u-value.greenteg.com

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