Inputs:

Region of Interest (ROI): A user-defined area in the thermal image. The size and location of the ROI depends on the objective of survey.

Exterior surface temperature (T_s): the average exterior surface temperature for the selected area, as measured by the IR camera from the outside of the building.

Emissivity (ε) : It is defined as the ratio of the energy radiated from a material's surface to that radiated from a perfect emitter (blackbody) at the same temperature and wavelength and under the same viewing conditions. It is a dimensionless number between 0 (for a perfect reflector) and 1 (for a perfect emitter). The emissivity of the exterior wall surface can be selected from a web pre-sets or a user-defined value.

Atmospheric Temperature (T_{out}): refers to the outdoor air temperature at the time of the test.

Indoor air temperature (T_{in}): refers to the average room air temperature at the time of the test.

Reflected temperature (T_{ref}): regarded as the apparent temperature of surrounding objects, which is determined based on the method suggested in **ASTM E1862**.

L*:* the height of the wall (m) measured from the exterior.

Instantaneous Field of View (IFOV): It is a spec of IR cameras which refers to the smallest detail within the field of view of camera that can be resolved. The unit is milliradians (mRad).

Wind Speed (v): the speed of air in the vicinity of the wall surface during the survey.

Relative Humidity (%): the amount of moisture in the air, compared to the maximum that the air can "hold", at the temperature measured at the time of the test.

Prandtl number (Pr): the ratio of the momentum and thermal diffusivities. (i.e., for air at 5-10 ºC, Pr=0.71 is used)

Thermal conductivity (k): a metric that describes the rate of heat conduction in a material (i.e., for air at 5-10 ºC, k is 0.024 W/m K).

Kinematic Viscosity (ϑ): a measure of a fluid's internal resistance to flow under gravitational forces.

Atmospheric transmittance (τ): refers to the capacity of the atmosphere to transmit electromagnetic energy. It is a dimensionless number between 0 (blocks all the radiation) and 1 (transmits all radiation). For a relatively short distance between the IR camera and the target (~6 meters), it is almost equal to 1.

Nusselt number (Nu): the ratio of convection heat transfer to pure conduction heat transfer.

Reynolds number (Re): the ratio of inertia to the viscous forces acting on a fluid.

$$Re = \frac{vL}{\vartheta}$$

Convective heat transfer coefficient (h_c): The rate of heat transfer between a solid surface and a fluid per unit surface area per unit temperature difference. In this tool, h_c is calculated based on the dimensionless method, as shown in the following Equation.

$$h_c = \frac{Nu\ k}{L}$$

For laminar flow over a wall surface, *Nu* is determined by using the following equation:

$$Nu = 0.664\ Re^{1/2} Pr^{1/3}$$

$Pr > 0.6$

Stefan-Boltzmann constant (σ): a physical constant expressing the relationship between radiation emitted by a black body and its absolute temperature. Its value is (5.67×10^{-8}).

Testing Tips:

How to measure reflected temperature? A crumpled and stretched aluminum foil is attached to a piece of cardboard and placed in front of the wall. The reflected temperature is equal to the average temperature of then foil by setting the emissivity (ε) to 1.0. While it is understandable that the aluminum emissivity is very small, an emissivity of 1 was selected to represent the surrounding environment. Since the orientations of walls in a building and their surrounding environment are different, it is recommended that the reflected temperature is measured for each wall separately (ASTM E1862).

How to measure emissivity? To measure the emissivity, a sample of vinyl black electrical tape with a known emissivity value (0.95±0.02) is attached to the object surface at least two hours before measurements, in order to allow time to reach thermal equilibrium with the object. The emissivity of target is then determined by adjusting the emissivity of images until the target temperature is equivalent to the temperature of the tape (ASTM E1933).

Web-tool Outputs:

Thermal Transmittance Coefficient (U-value): It refers to the ability of an element to transmit heat from a warm space to a cold space though a building element such as a wall, and vice versa. The lower the U-value, the better insulated the building element.

The U-value ($W/(m^2 K)$) in this tool is calculated using the following Equation :

$$U_{overall} = \frac{\varepsilon\sigma\left(T_s{}^4 - T_{out}{}^4\right) + h_c(T_s - T_{out})}{T_{in} - T_{out}}$$

(1)

The **Infrared Index (IRI)** is obtained based on the approximation of a steady-state condition where the rate of heat flux from the interior to the exterior is equal to the heat flux from the exterior surface to the outdoor air (assuming one-dimensional heat transfer). IRI is expressed as:

$$IRI = \frac{T_s - T_{out}}{T_{in} - T_{out}}$$

(2)

IRI can be appropriate for thermal performance ranking and/or relative comparison of two or more ROIs.