Every form of matter with a temperature (T) above absolute zero (-273.15°C / -459.8°F) or emits infrared radiation according to its temperature. This is called characteristic radiation. The cause of this is the internal mechanical movement of molecules. The intensity of this movement depends on the temperature of the object. Since the molecule movement represents charge displacement, electromagnetic radiation (photon particles) is emitted. These photons move at the speed of light and behave according to the known optical principles. They can be deflected, focused with a lens, or reflected by reflective surfaces. The spectrum of this radiation ranges from 0.7 to 1000 μm wavelength. For this reason, this radiation cannot normally be seen with the naked eye. This area lies within the red area of visible light and has therefore been called “infra”-red after the Latin, see Fig. 4.

Looking at Fig. 5, then, the goal should be to set up the IR thermometer for the widest range possible in order to gain the most energy (corresponding to the area below a curve) or signal from the target. There are, however, some instances in which this is not always advantageous. For instance, in Fig. 5, the intensity of radiation increases at 2 μm – much more when the temperature increases than at 10 μm. The greater the radiance difference per temperature difference, the more accurately the IR thermometer works. In accordance with the displacement of the radiation maximum to smaller wavelengths with increasing temperature (Wien’s Displacement Law), the wavelength range behaves in accordance with the measuring temperature range of the pyrometer. At low temperatures, an IR thermometer working at 2 μm would stop at temperatures below 600°C, seeing little to nothing since there is too little radiation energy. A further reason for having devices for different wavelength ranges is the emissivity pattern of some materials known as non-gray bodies (glass, metals, and plastic films). Fig. 5 shows the ideal— the so-called “blackbody”. Many bodies, however, emit less radiation at the same temperature. The relation between the real emissive power and that of a blackbody is known as emissivity ε (epsilon) and can be a maximum.
of 1 (body corresponds to the ideal blackbody) and a minimum of 0. Bodies with emissivity less than 1 are called gray bodies. Bodies where emissivity is also dependent on temperature and wavelength are called non-gray bodies. Furthermore, the sum of emission is composed of absorption (A), reflection (R) and transmission (T) and is equal to one. (See Equation 1 and Fig. 6)

\[
A + R + T = 1 \ (1)
\]

Solid bodies have no transmission in the infrared range (T = 0). In accordance with Kirchhoff's Law, it is assumed that all the radiation absorbed by a body, and which has led to an increase in temperature, is then also emitted by this body. The result, then, for absorption and emission is:

\[
A \iff E = 1 - R \ (2)
\]

There are various methods for determining the emissivity of an object. So you can find the emissivity of many frequently used materials in a table. Emissivity tables also help you find the right wavelength range for a given material, and, so, the right measuring device. Particularly in the case of metals, the values in such tables should only be used for orientation purposes since the condition of the surface (e.g. polished, oxidized or scaled) can influence emissivity more than the various materials themselves. It is also possible to determine the emissivity of a particular material yourself using different methods. To do so, you need a pyrometer with emissivity setting capability.

1. Heat up a sample of the material to a known temperature that you can determine very accurately using a contact thermometer (e.g. thermocouple). Then measure the target temperature with the IR thermometer. Change the emissivity until the temperature corresponds to that of the contact thermometer. Now keep this emissivity for all future measurements of targets on this material.

2. At a relatively low temperature (up to 260°C/500°F), attach a special plastic sticker with known emissivity to the target. Use the infrared measuring device to determine the temperature of the sticker and the corresponding emissivity. Then measure the surface temperature of the target without the sticker and re-set the emissivity until the correct temperature value is shown. Now, use the emissivity determined by this method for all measurements on targets of this material.

3. Create a blackbody using a sample body from the material to be measured. Bore a hole into the object. The depth of the borehole should be at least five times its diameter. The diameter must correspond to the size of the spot to be measured with your measuring device. If the emissivity of the inner walls is greater than 0.5, the emissivity of the cavity body is now around 1, and the temperature measured in the hole is the correct temperature of the target \(/4/\). If you now direct the IR thermometer to the surface of the target, change the emissivity until the temperature display corresponds with the value given previously from the blackbody. The emissivity found by this method can be used for all measurements on the same material.

4. If the target can be coated, coat it with a matte black paint (“3-M Black” from the company 3M or “Senotherm” from Weilburger Lackfabrik (Grebe Group)/2/, either which have an emissivity of around 0.95). Measure the temperature of this blackbody and set the emissivity as described previously.