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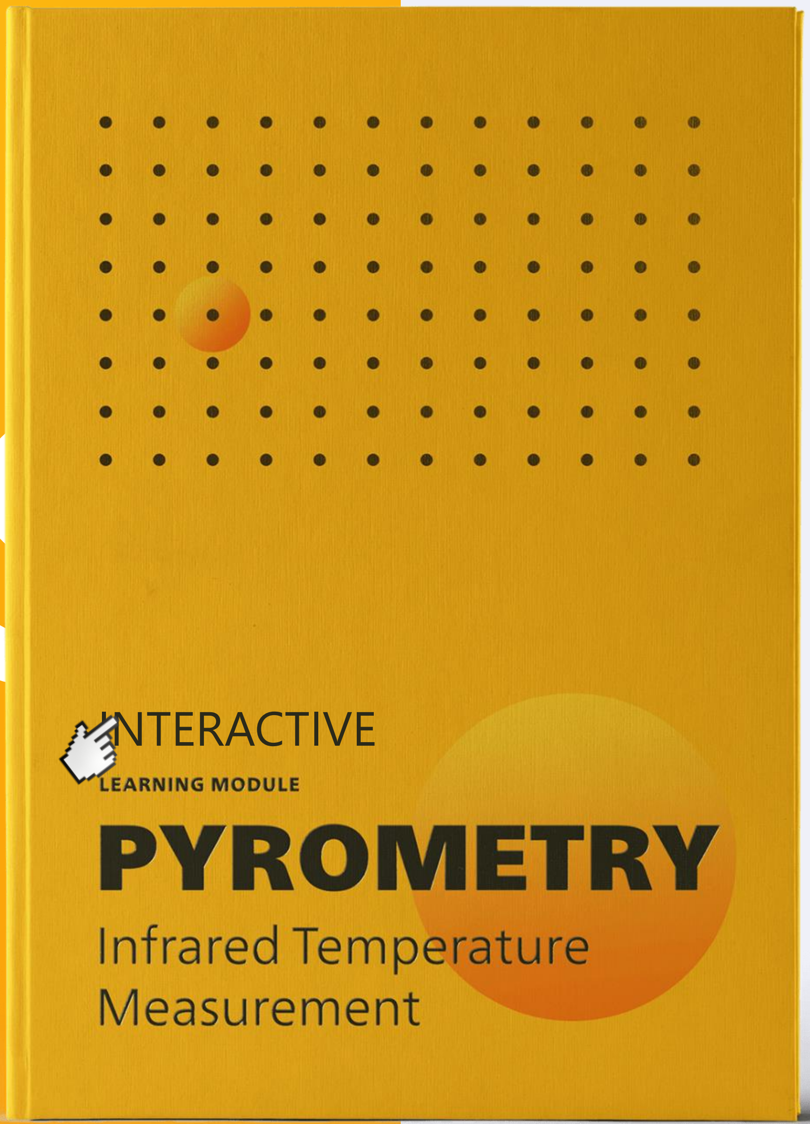
TECHNOLOGIES
An Advanced Energy Company

use this icon to navigate
direct to the emissivity tables

LEARNING
MODULE

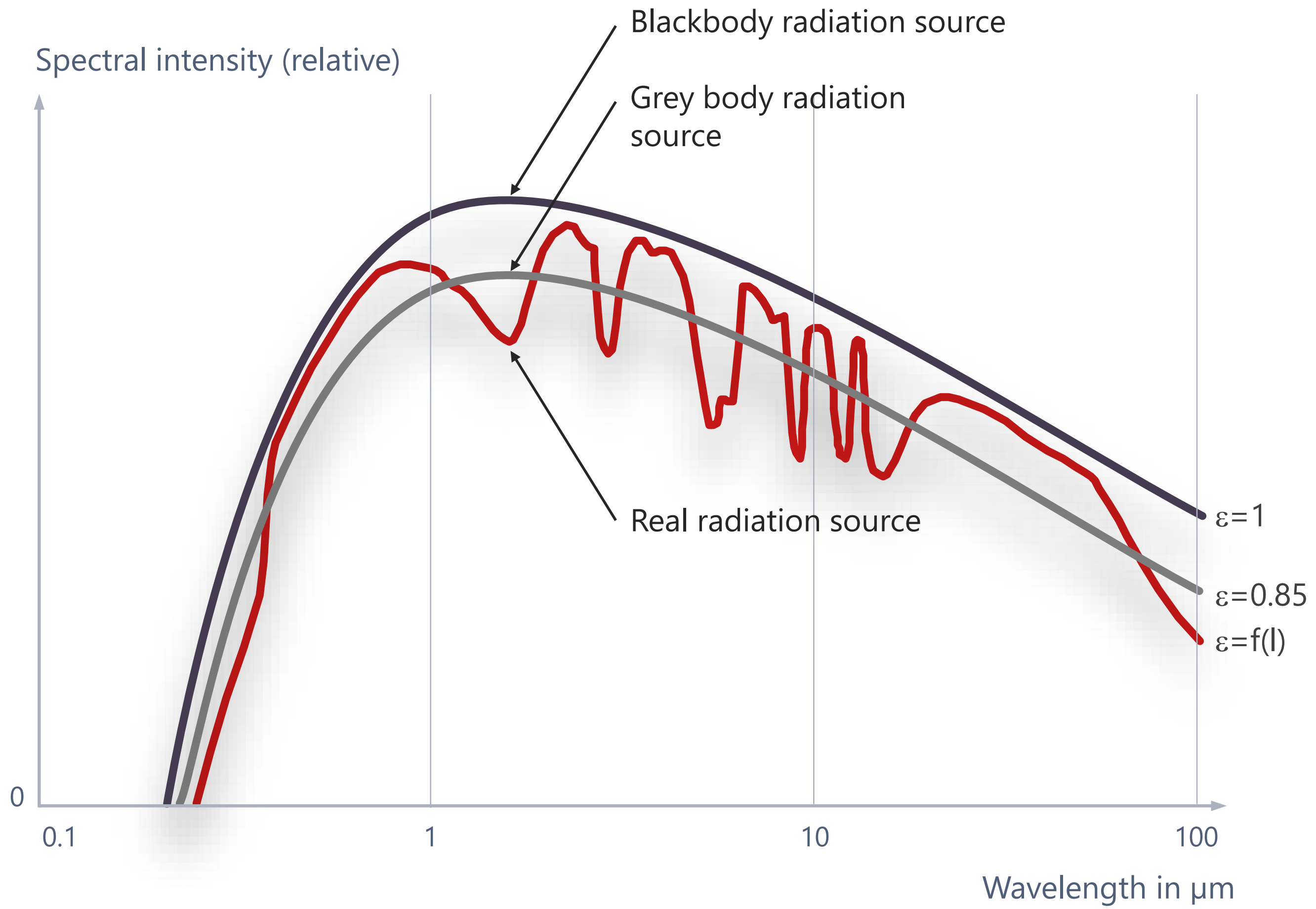
EMIS ITY



use these icons to navigate
back and forth

2. **Emissivity:**
Determination

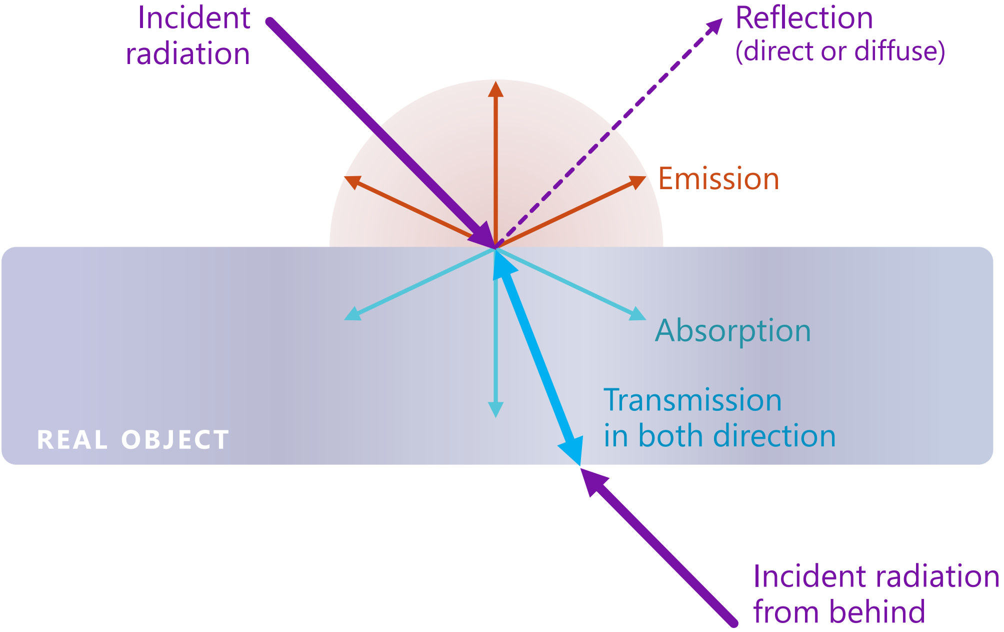
PROLOG



3. **Emissivity:** Determination

PROLOG

In thermal equilibrium, a body which absorbs well, emits well. This means that its absorption α coefficient equals its emission **ε** coefficient.



4. **Emissivity:** Determination

PROLOG

In thermal equilibrium, a body which absorbs well, emits well. This means that its absorption α coefficient equals its emission $\boldsymbol{\varepsilon}$ coefficient.

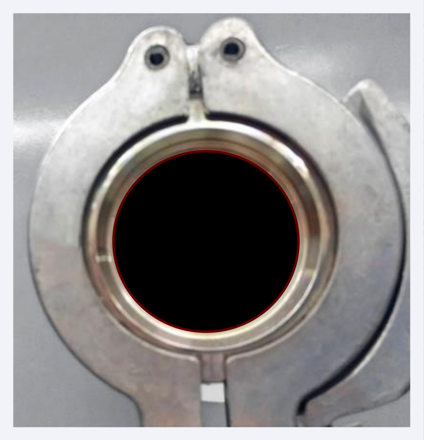
In the field of non-contact temperature measurement with a pyrometer or a thermography camera, the knowledge of this correlation is imperative, because it is needed as a reference to calculate the right temperature in the measuring system.

However, the emissivity is not constant.
Many factors influence it.

In the following, the individual factors are described, so that the determination of the "true" emissivity is simplified.

5. **Emissivity:** Determination

Influence factors - in order of relevance



Wavelength of the measuring system

The choice of the "right" wavelength of the measuring instrument is always the first step in determining the emissivity.

Materials have very different emission levels at different wavelengths.

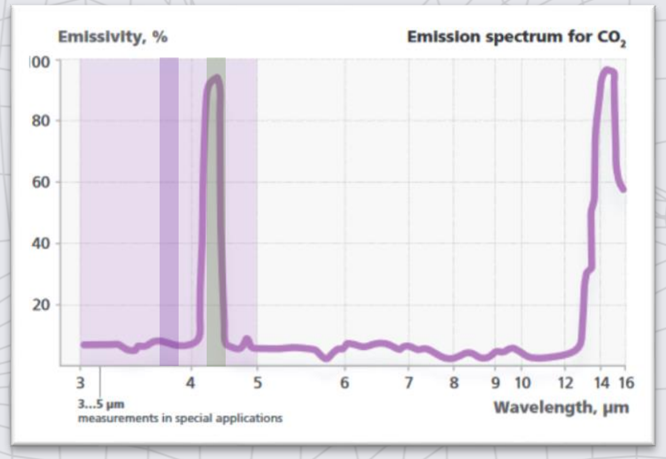
Depending on the measuring task, the transmission properties of the object must also be taken into account.

Example 01:
If you want to look through a sight glass into an oven, the wavelength dependent transmittance of the glass has to be considered. The objective should be able to “see” through the glass with as little signal loss as possible. In the long-wavelength measuring range (8-15µm) the transmission of the glass is so low, that the measuring system can only measure the surface of the glass and no longer look through it.

increasing wavelength ->

6. # **Emissivity:** Determination

Influence factors - in order of relevance



Wavelength of the measuring system

The choice of the "right" wavelength of the measuring instrument is always the first step in determining the emissivity.

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Depending on the measuring task, the transmission properties of the object must also be taken into account.

Example 02:

- If the temperature of a CO_2-containing flame has to be measured, a narrow-band filter at 4.5µm is used, because at this wavelength the emissivity of this gas is pretty high.
- On the other hand, is instead a filter with 3.9µm used, the absorption band of CO_2 and H_2O is avoided, which makes a measurement through the flames possible and so it's possible to measure the underlying furnace wall through the flame.

7. Emissivity: Determination

The measurement errors of five pyrometers having different spectral responses and where the emissivity setting was off by 10%.

- If you measure the temperature of an object heated to 1000 °C with a **long wavelength pyrometer** having a spectral response from 8 to 14 µm, a relative emissivity error of 10 % produces an overall error of 80 °C .
- But, if you use a **short wavelength pyrometer** with a spectral response from 0.7 to 1.1 µm, the measurement error is reduced to 11 °C in otherwise identical conditions.

The most important task is to choose a pyrometer that measures in the shortest possible wavelength range.

Influence factors - in order of relevance

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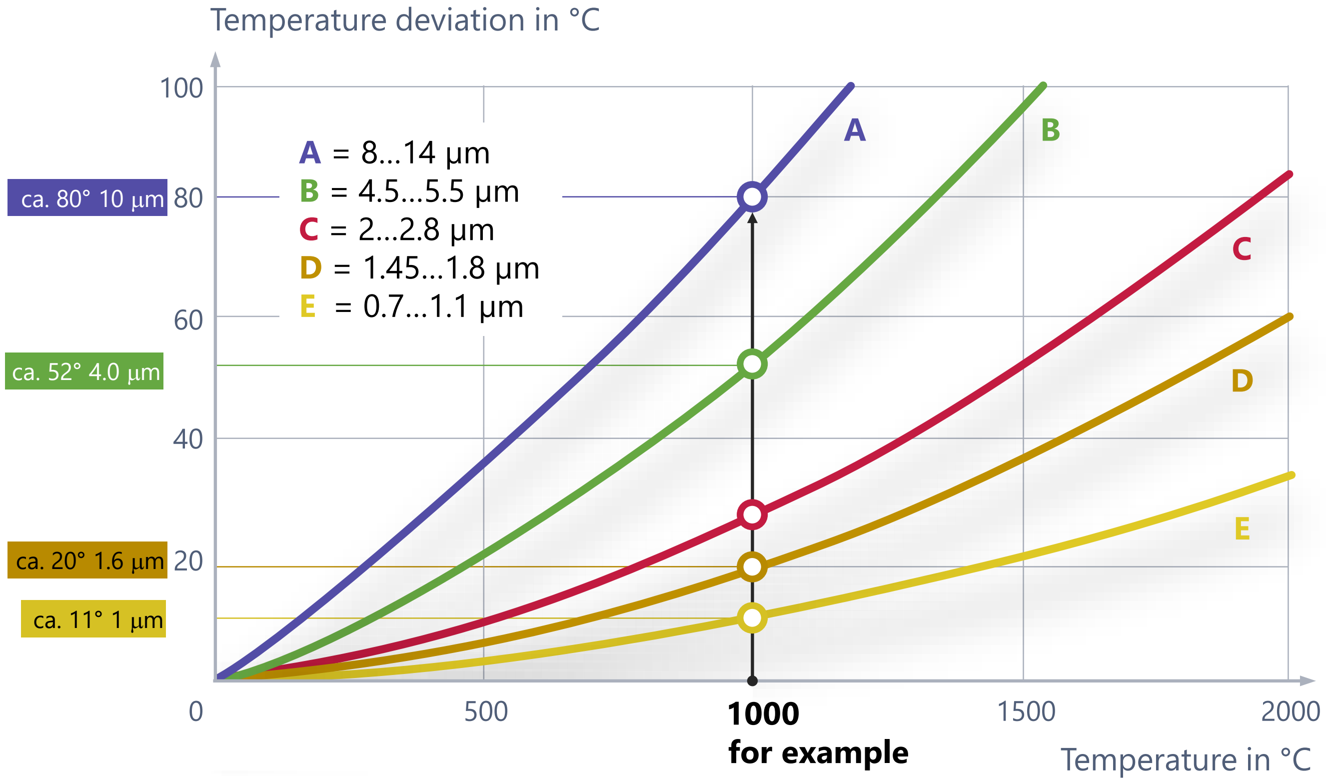
Wavelength of the measuring system

The choice of the "right" wavelength of the measuring instrument is always the first step in determining the emissivity.



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8. **Emissivity:** Determination

Influence factors - in order of relevance

Temperature of the measuring object

If the object temperature rises, in some cases - depending on the material - the emissivity changes even with the same surface textures. This behavior varies from material to material but must be taken into account.

Material and surface texture

Texture in the form of color, gloss level and roughness strongly influence the emission behavior of the object.

9. **Emissivity:** Determination

Influence factors - in order of relevance

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Environmental influences and measuring angles

Reflections on the surface due to external radiation like heat sources, cooling sources and ambiance light must be taken into account, as these also influence the emissivity behaviour. Even heat sources from behind of the object can effect the emissivity.

Example:

Certain ceramics become transparent in a short-wavelength measurement up to 1.100° C and so the underlying heat source becomes visible to the measuring instrument and influence the measurement.

10. # **Emissivity:** Tables

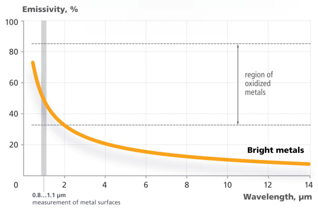
ε

The emissivity ε of an object is the most important factor for determining its temperature by means of a pyrometer.

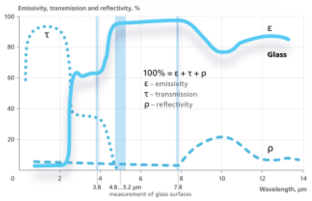
To measure the true surface temperature of an object by means of a pyrometer, you must know the emission coefficient, or emissivity, of the object and enter its value in the pyrometric measuring system.

EMISSIVITY MATERIAL GROUPS

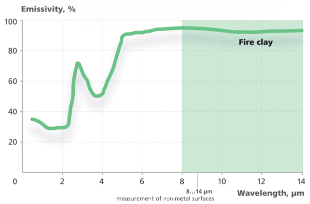
01. Metals



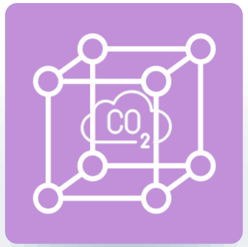
02. Glass

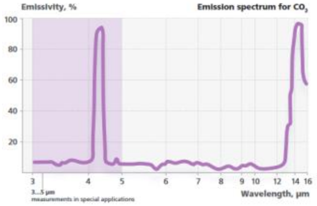


03. Un-/Organic Material



04. Fluids and Gases





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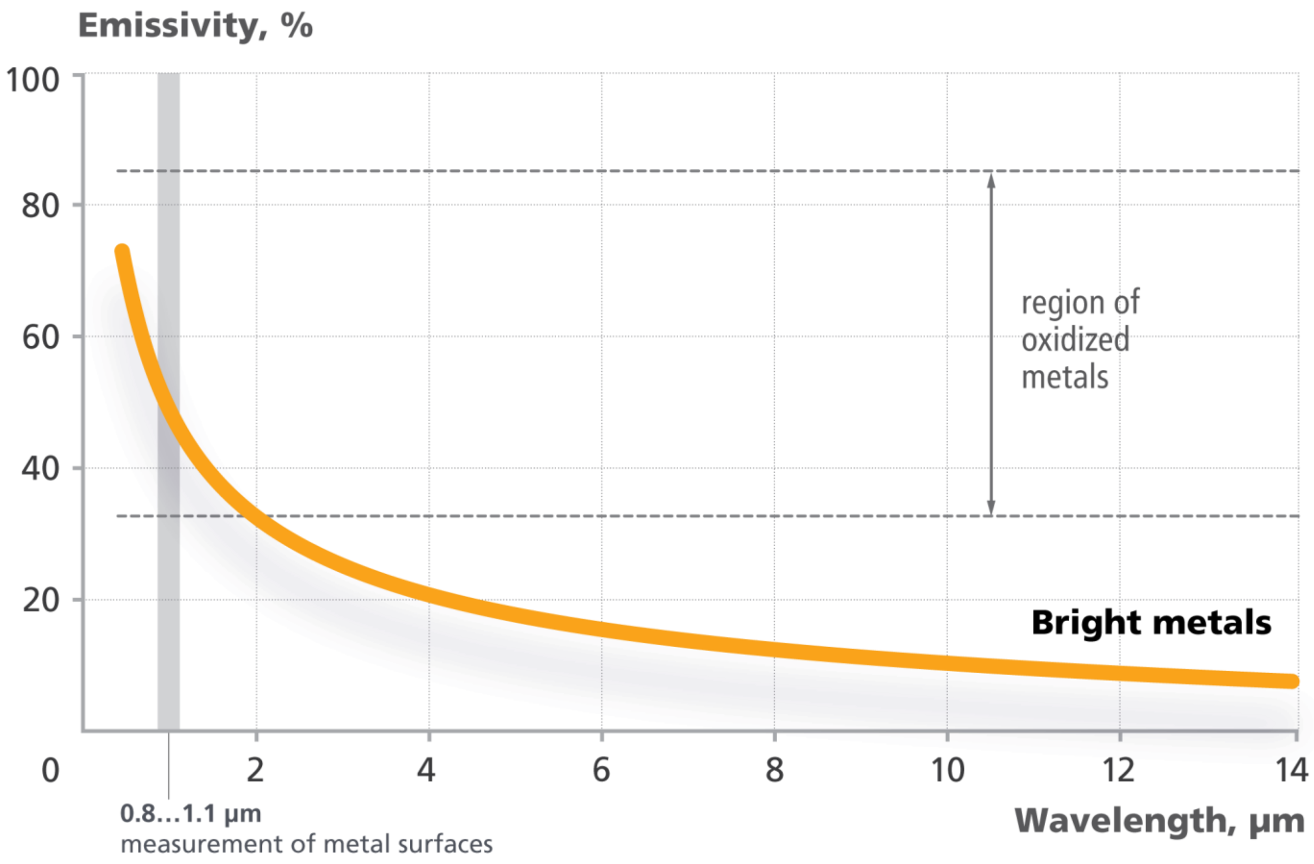
11. # **Emissivity:** Metals

The typical emissivity of bright metal surfaces is high at short wavelengths and decreases with lengthening wavelengths.

The emissivity of metals also changes with time due to wear and tear, oxidation, or soiling.

Shiny metal surfaces reflect light strongly, i.e. their reflection coefficient is high and their emission coefficient low.



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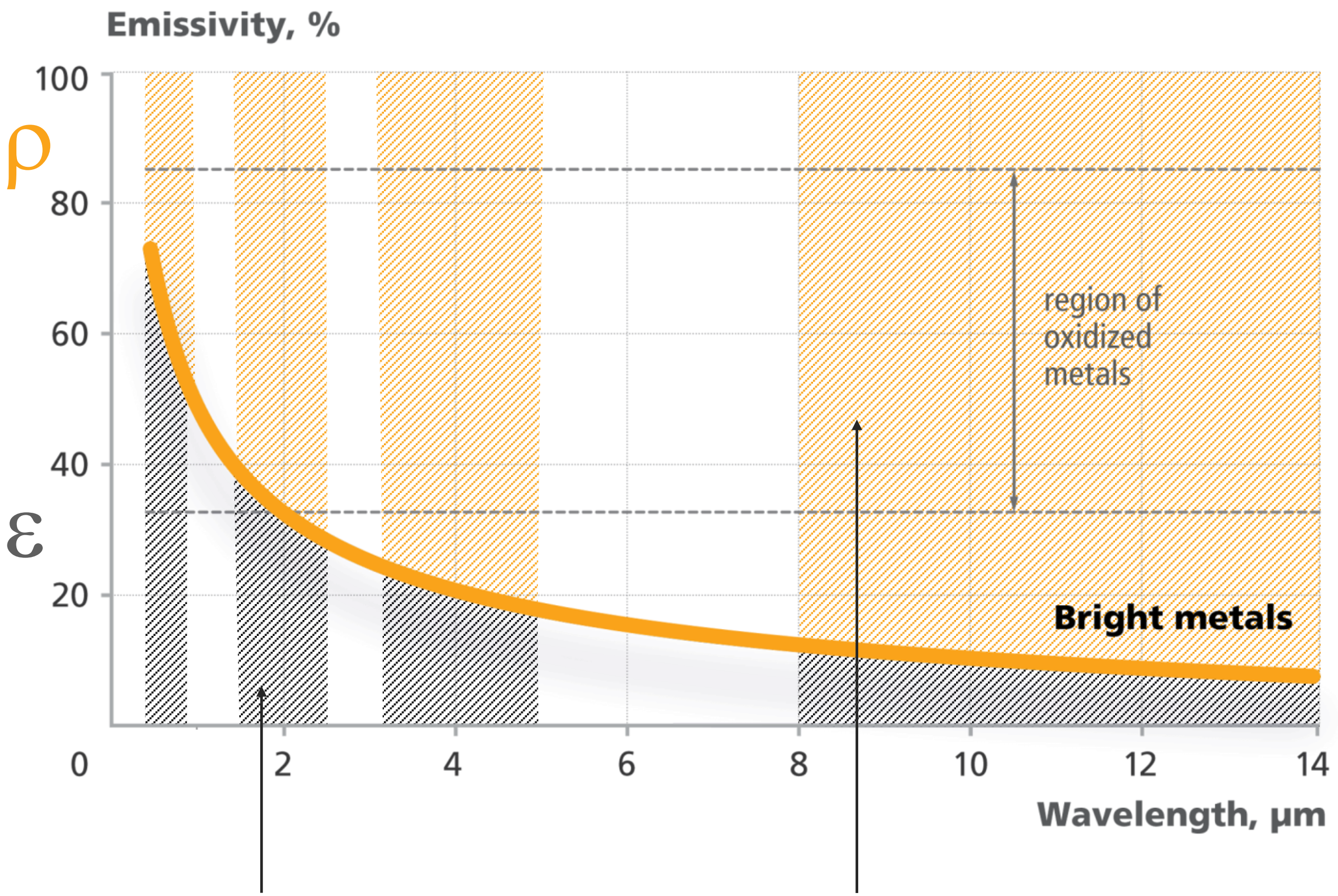
12. # **Emissivity:** Metals

TYPICAL METALS

- Ferrous (iron based) and non-ferrous metals (low-iron)
- Noble and Precious metals e.g. gold, silver, rhodium, tantalum, etc.

The shorter the wavelength the less reflectivity affects the reading on metallic surfaces



Object Signal: Integrated object signal for temp. determination based on emissivity

Disturbance: Spectral reflectivity adds signal uncertainty to the reading

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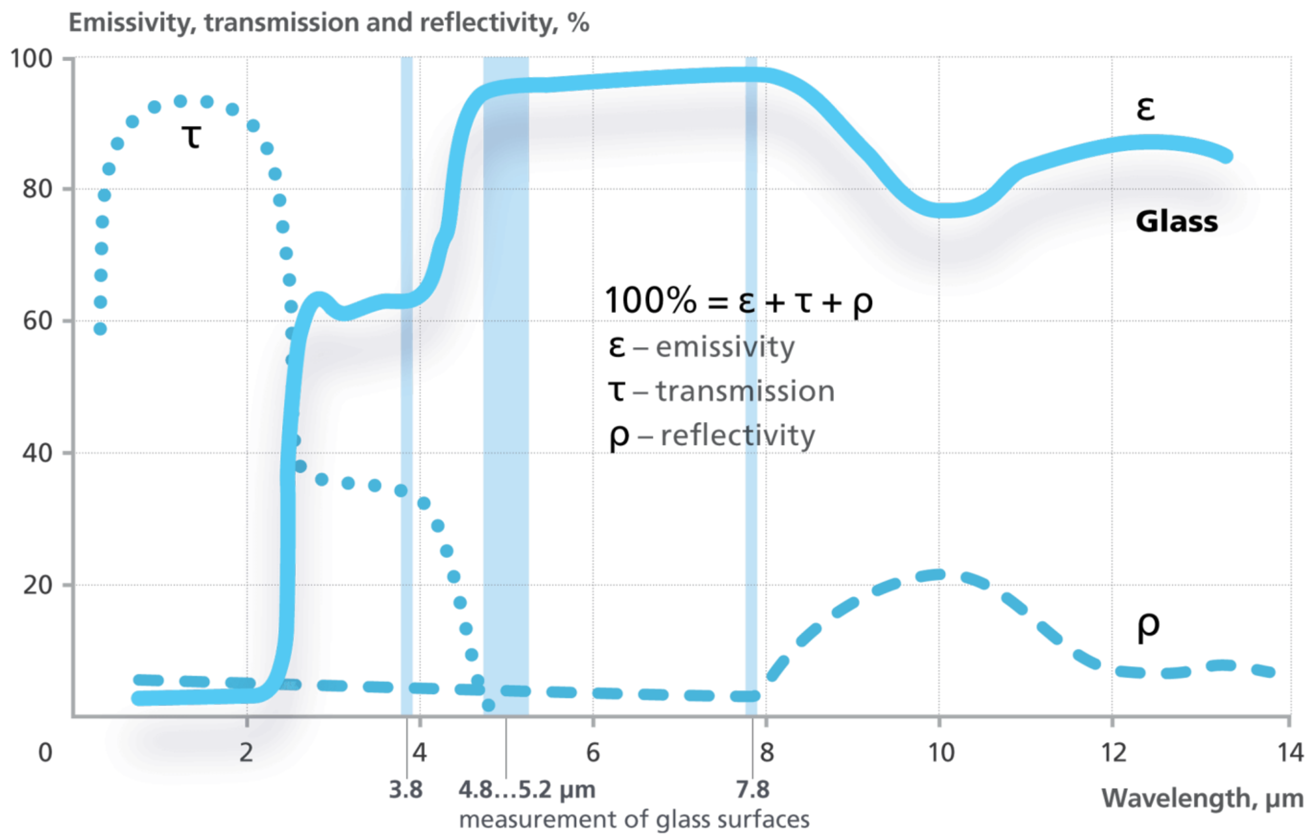
13. **Emissivity:** Glass

Transparent materials such as glass, quartz, water and plastic films, but also hot gases and flames, each have their own unique, emissivity.

The emissivity of glass, for example, is characterized by wavelength ranges where electromagnetic radiation largely passes through the glass material (transmission), and others in which it is absorbed almost completely (absorption)

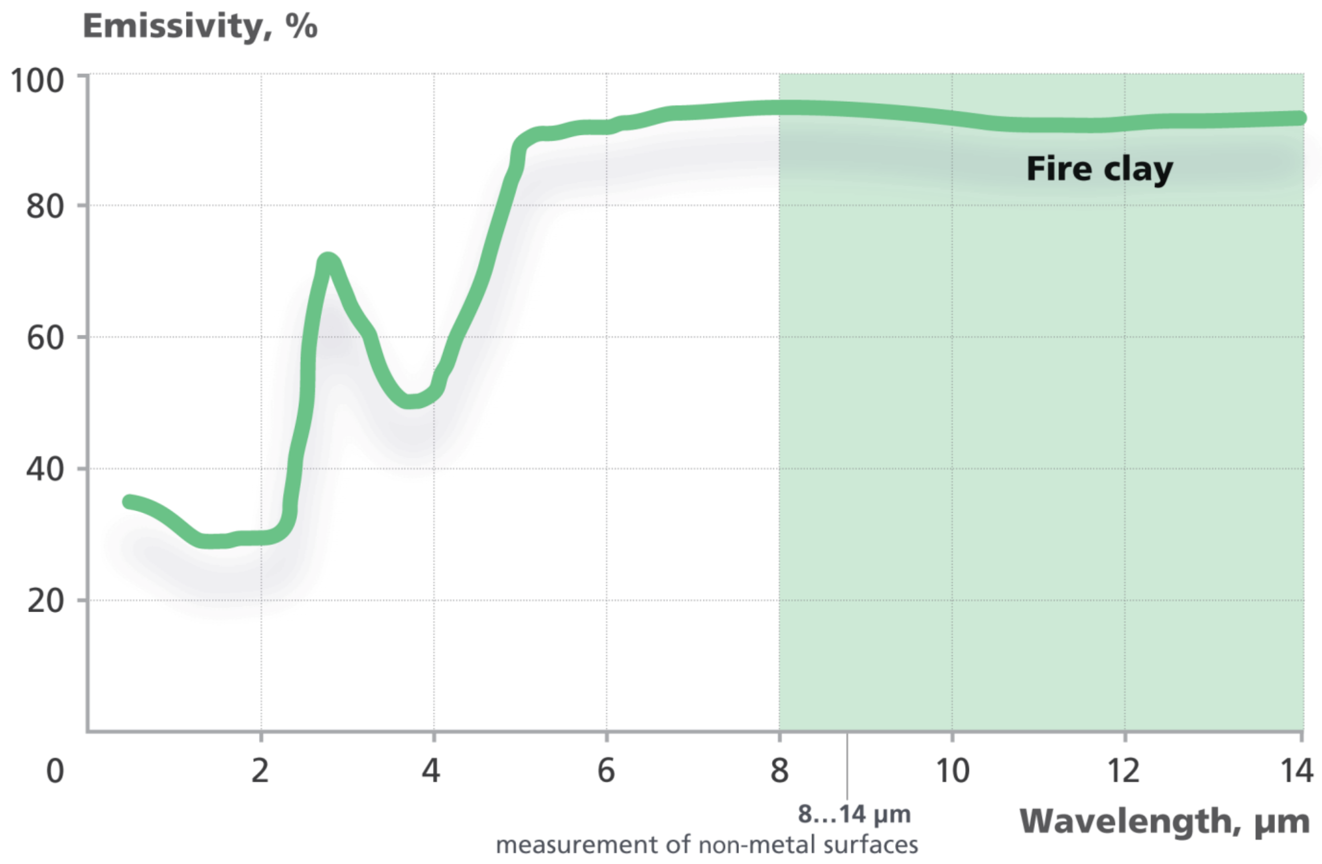


0.7…1.1 µm	Molten glass, immersive glass measurements, emissivity 95%
5.14 µm	General flat glass, emissivity 97%
7.8 µm	Very thin flat glass, emissivity 97% (Corning)
8…14 µm	Also possible, but emissivity only approximately 72%, reflections from hot surroundings.

Emissivity: Un-/organic materials

The group of un-/organic materials, such as foodstuffs, wood or paper, as well as inorganic materials such as carbon, ceramics or fire clay.

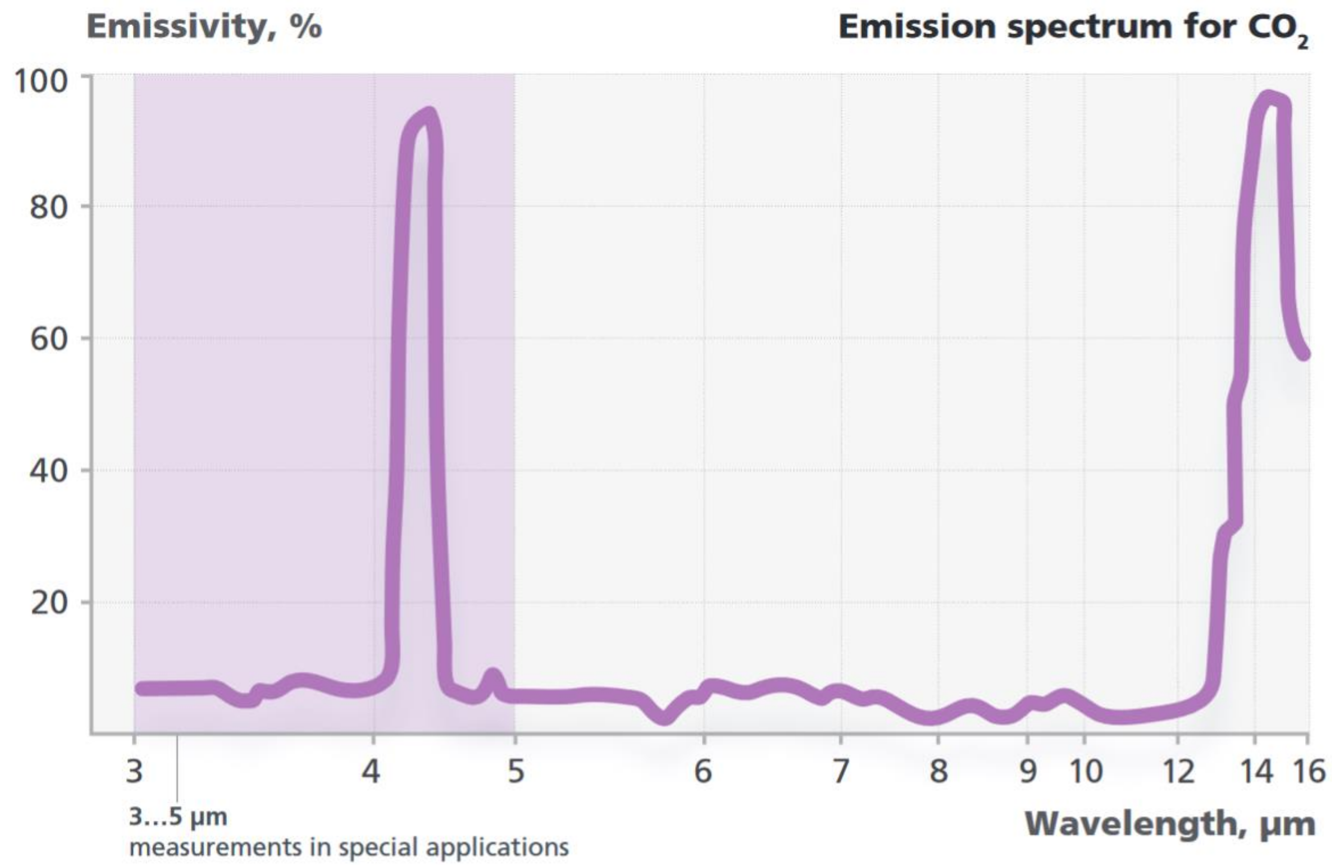
The emissivity of non-metals rises with increasing wavelength.



15. # **Emissivity:** Fluids and Gases

The group of fluids and gases includes liquids like water and also snow or ice, oil, sewage sludge as well as gases like CO_2, O_2, Sulfur or just water steam.

The emissivity of fluids and gases is very specific. To get advice from an expert is recommended.



Industrial: support tools

Pyrometry Overview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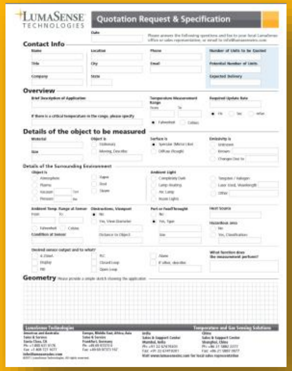
LUMASENSE IMPAC PYROMETERS
Product Overview
Highly Accurate Infrared Thermometers for Non-contact Temperature Measurements

Quotation and Application Tools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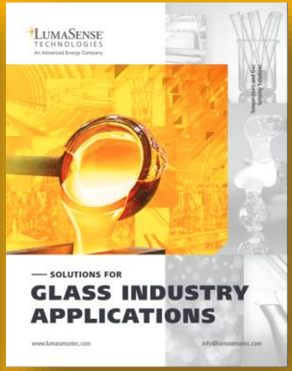
Quotation Request & Specification

Market / Material Solution Notes


LUMASENSE TECHNOLOGIES
SOLUTIONS FOR
STEEL APPLICATIONS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GLASS INDUSTRY APPLICATIONS