Thermal insulation and CLTE

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1. Thermal insulation and U-value

The properties of thermal insulation of a moulded part are described by the commonly named “U-value”. The U-value is directly linked to the thermal conductivity (λ) of the material and to the thickness of the part (t). The lower the U-value, the better the part insulates during heat transfer in conduction.

$$U=\frac{\lambda}{t}$$

Increasing the thickness or using a material with a lower thermal conductivity will reduce the U-value, improving the thermal insulation property of the considered product. Thanks to its very low thermal conductivity, ARPRO is a material of choice for applications with stringent requirements in terms of thermal insulation.

The thermal conductivity represents the amount of heat transmitted per unit time and area through the thickness of a sample presenting a gradient of temperature of 1°C (or kelvin) per unit of length and is typically expressed in milliwatt per metre-kelvin ($mW.m^{-1}.K^{-1}$). The standard ISO 8301 describes the method as used for the determination of the thermal conductivity.

Test method: ISO 8301
The tested sample at dimensions 300 x 300 x 20mm is placed in between two heating plates. Both plates are kept at two different fixed temperatures so that a gradient of temperature of 20°C is created through the thickness of the sample. Thanks to a heat flow meter measuring the actual heat flow through the sample, the thermal conductivity at the mean temperature between both plates (here 10°C) is obtained by the following formula:

$$\lambda=-\frac{Q*t}{\Delta T}$$

Where:

- Q: heat flow through the sample
- t: sample thickness
- ΔT: temperature difference between plates

Tested densities: ARPRO Black from 20g/l to 200g/l, ARPRO White from 20g/l to 80g/l and ARPRO Grey between 40g/l and 60g/l

Note: Some additives, such as carbon black, can influence the thermal insulation. This is in particular the reason for which ARPRO Black presents a lower thermal conductivity than ARPRO White.

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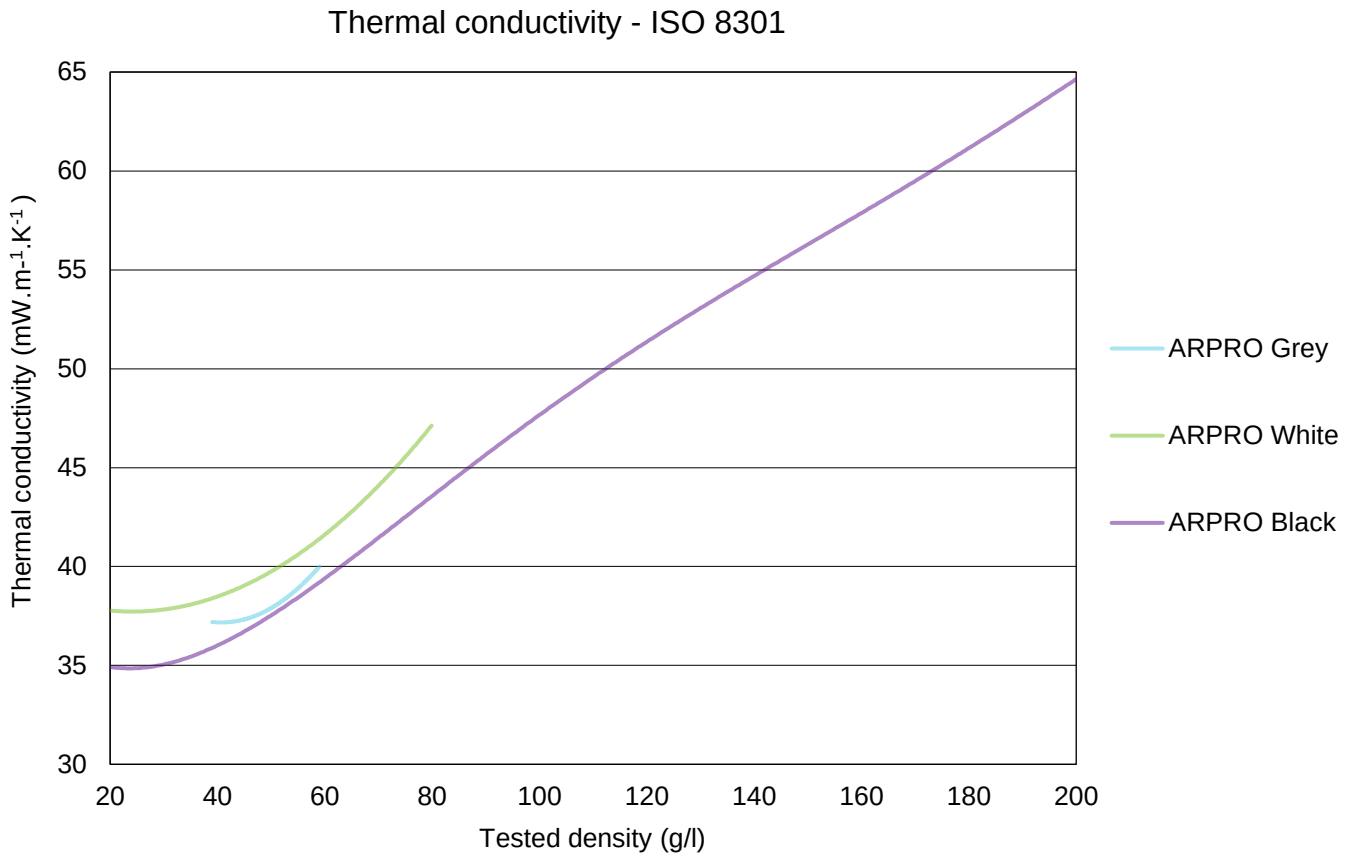

ARPRO grade	Unit	Test	Density (g/l)											
			20	30	40	50	60	80	100	120	140	160	180	200
λ - thermal conductivity														
• Black	mW.m^{-1}.K^{-1}	ISO 8301	35	35	36	37	39	44	47	51	54	58	61	65
• Grey		10°C	-	37	37	38	40	-	-	-	-	-	-	-
• White			38	38	38	40	42	47	-	-	-	-	-	-

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2. Dimensional stability / in use

The coefficient of linear thermal expansion (CLTE) of a material is its tendency to expand (or shrink) due to temperature variation.

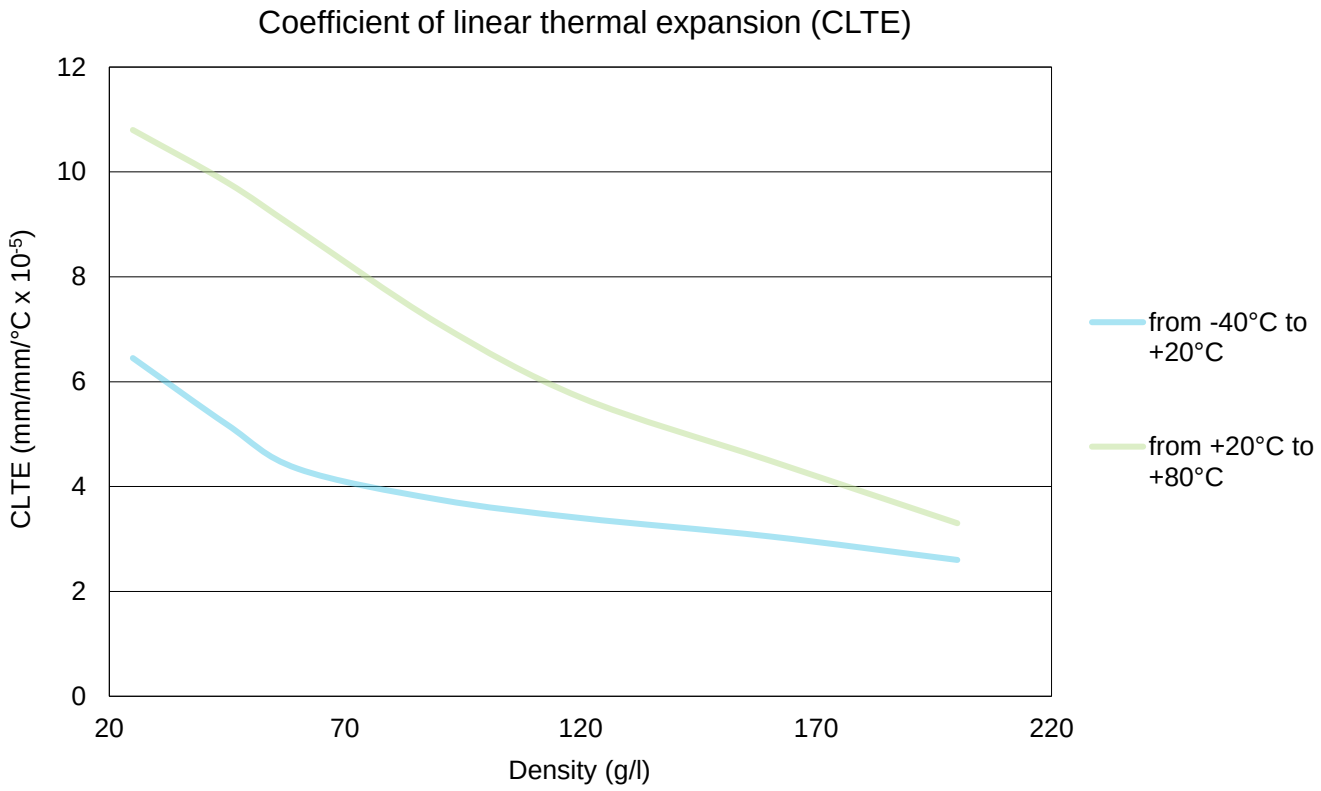
Test method: Gauge marks are placed at 25mm intervals lengthwise in the sample in a thermostatic chamber at an initial temperature for 24 hours. The gauge length is measured immediately after removing the specimens from the thermostatic chamber. Then, the sample is placed at a final temperature for 24 hours. The gauge length is measured once more, immediately after this temperature treatment.
The CLTE, expressed as K, is calculated by the equation:

$$K = \frac{L_1 - L_0}{\Delta T * L_0}$$

Where:

- L_1: sample length at final exposure temperature
- L_0: sample length at the initial exposure temperature
- ΔT: final temperature-initial temperature

Tested densities: ARPRO Black from 20g/l to 200g/l



Note: The final results might slightly vary according to the specific moulded part geometry.

Test result use: CLTE of ARPRO at 160g/l from +20°C to +80°C is $4.5*10^{-5}$mm/mm/°C. This means that if a 160g/l ARPRO part has an original length of 100mm; after 24 hours conditioning at +80°C the final length of the part will be:

$$L_1 = L_0 + K^* \Delta T^* L_0 = 100 + 4.5*10^{-5}*60*100 = 100.27\text{mm}$$

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