



# Oxygen Permeability Using the Polarographic Method

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## Overview:

The oxygen permeability is a key characteristic for a contact lens material. This is since the cornea is avascular and derives its oxygen requirements from the atmosphere. Placing a contact lens on the eye will obviously restrict this process, so it is important that a lens material is able to transmit a sufficient level of oxygen to satisfy the requirements of the cornea. Hydrogel materials are able to transmit oxygen through the aqueous portion of the material since oxygen dissolves in water. Gas permeable materials on the other hand contain silicone and fluorine compounds which are inherently permeable to oxygen.

The oxygen permeability is measured using the procedure outlined in the following standard.

ISO 18369-4:2006 Ophthalmic Optics - Contact lenses - Part 4: Physiochemical properties of contact lens materials.

This corresponds to section 4.4 Oxygen Permeability and more specifically section 4.4.3 Polarographic method. Although this standard is directed towards contact lens materials, it is suitable for the evaluation of any material including both hydrogel and non-hydrogel materials.

The Polarographic method directly measures the number of oxygen molecules diffusing through a test material by electrochemically removing the molecules from the solution as soon as they pass through the material. As a molecule of oxygen emerges from the sample material, it contacts the centre electrode (cathode) of the oxygen sensor, placed against the back surface of the sample, and is instantaneously converted into hydroxyl ions. This production of ions constitutes the electric current which is quantified by the apparatus and is proportional to the number of molecules removed. The measured current is used to calculate the uncorrected oxygen transmissibility and then corrected for both the boundary layer and edge effects. This enables the corrected oxygen permeability of a material to be calculated.

## Procedure:

To determine oxygen permeability, measurements are made on lenses of four different thicknesses. If a material is not available at a different thickness, such as in the case of cast moulded contact lenses, samples have to be 'stacked' one above the other. However care must be taken when stacking the lenses that no air bubbles are trapped between the layers.

Before any measurements can be carried out, the environmental chamber must be stabilised at  $35^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$  with a maximum percentage of



humidity. The chamber has been designed to achieve humidity values of approximately 95%. Samples are placed into the chamber to equilibrate prior to measurements.

Once the chamber has reached equilibrium, the measurements can be performed. The lens is placed carefully on the cell ensuring that no air bubbles are trapped between the sample and the surface of the cell. The current is allowed to stabilise on the permeometer and then recorded ensuring that the temperature of the cell is between 34.5°C and 35.5°C.

When a result is recorded, the temperature and humidity within the chamber are recorded. The atmospheric pressure is also recorded as this has a significant effect on the calculation of the Dk value. The thickness of the sample is known and is then used in the Dk calculation. This process is repeated until results are obtained for the samples at 4 different thickness values. The oxygen permeability corrected for both the edge and boundary layer effects is then mathematically derived from these values.