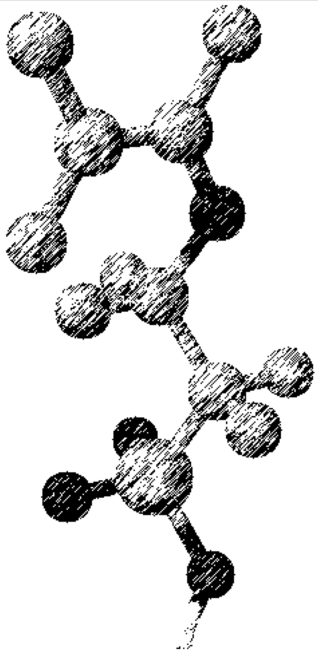
AQUIVION™ Technical Bulletin

Water Sorption and Permeation



AQUIVION™ is a family of products based on the proprietary Short Side Chain (SSC) perfluorosulfonic acid (PFSA) polymer produced by Solvay Solexis. These materials are copolymers of tetrafluoroethylene and a Sulfonyl Fluoride Vinyl Ether (SFVE) and feature lower equivalent weight and higher crystallinity than competitive perfluorosulfonic acid (PFSA) polymers.

AQUIVION™ membranes and tubing show improved mechanical properties, can be used under hotter conditions and show less degradation than ordinary products.

AQUIVION™ products' superior properties allow the design of simpler and more efficient humidification systems featuring:

- Higher operating temperature
- Remarkable performance and durability

WATER UPTAKE

Since AQUIVION™ is available in lower Equivalent Weights (EWs) than conventional PSFA polymers, it can absorb and retain water more easily allowing
better performance recovery after severe dehydration (see Figure 1).

MECHANICAL PROPERTIES

In a humidifier, membranes maybe subject to temperature, pressure and relative humidity variations which in turn develop hygro-thermal stresses that can lead to failures.

Because of the short side chain, AQUIVION™ features higher crystallinity also at low equivalent weights providing exceptional mechanical toughness and durability. In Figure 2 the tear resistance and the strength at break of AQUIVION™ and competitive extruded membranes are charted. Measurements were carried out in accordance with ASTM D1004 both in Machine Direction (MD) and in Transverse Direction (TD).

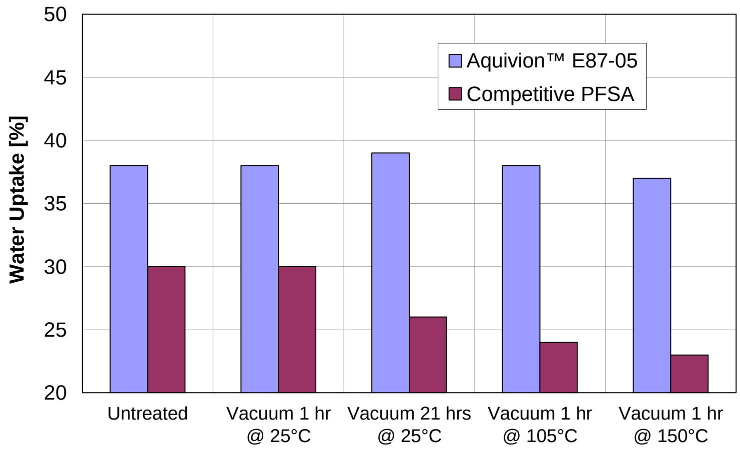


Figure 1 -AQUIVION™ Water Uptake at 80 °C Before and After Dehydration Treatments

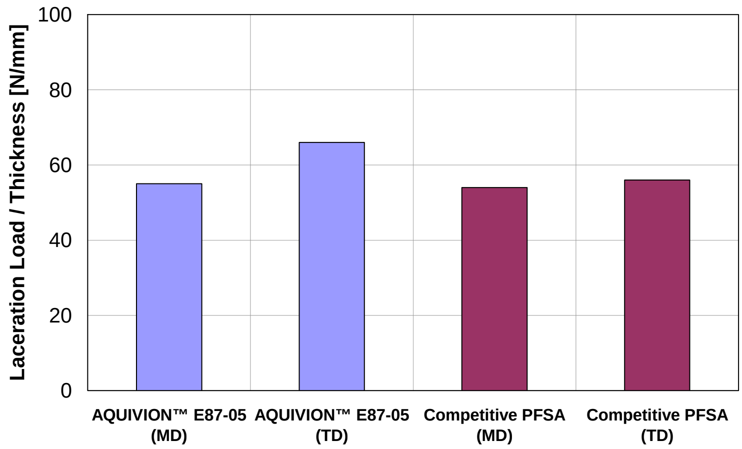


Figure 2 - AQUIVION™ Membranes Tear Resistance at 23°C, 50% RH

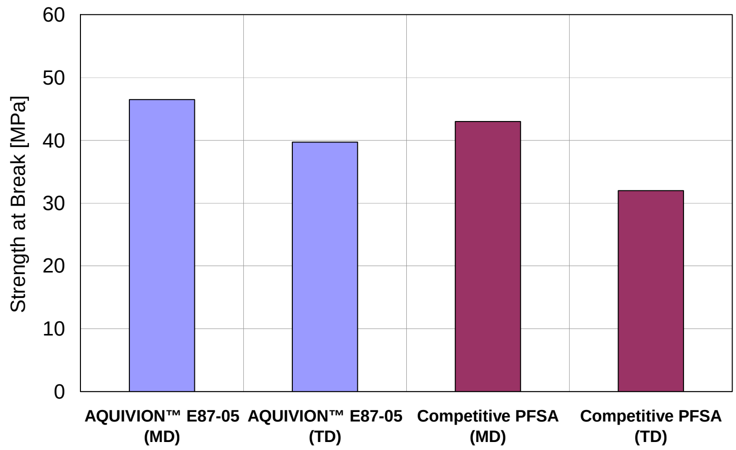


Figure 3 - AQUIVION™ Membranes Strength at Break at 23°C, 50% RH

PERMEABILITY

Permeability measurements were performed using the following test method. A PFSA membrane is placed in the cell C (see Fig. 4) which separates two vessels. After pulling the vacuum in the system, the valve V_2 is closed and the upstream vessel is filled with water vapor at a preset pressure through valve V_1. Valve V_2 is then opened exposing the membrane to the water vapor. Because of the membrane permeability, the pressure in the vessels will equalize and the permeability can be determined from the downstream pressure increase rate (Fig. 5).

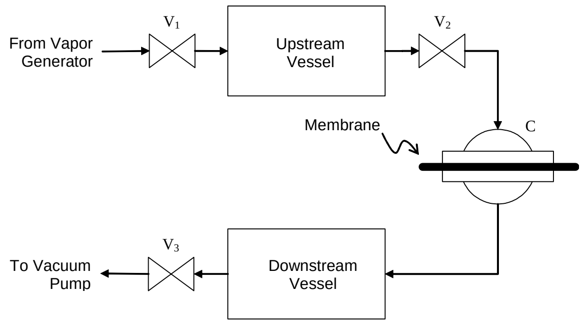


Figure 4 - Test Apparatus

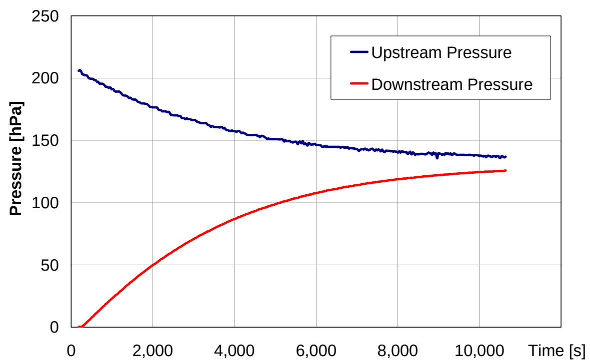


Figure 5 - Upstream (Blue Line) and Downstream (Red Line) Pressure

In Fig. 6 the AQUIVION™ permeability is plotted versus the upstream Relative Humidity (RH) at t=0. Prior to the measurements the AQUIVION™ membranes were vacuum dried for 1 hour at 105°C and then conditioned at the test temperature. At each temperature, the Relative Humidity was raised in three incremental steps.

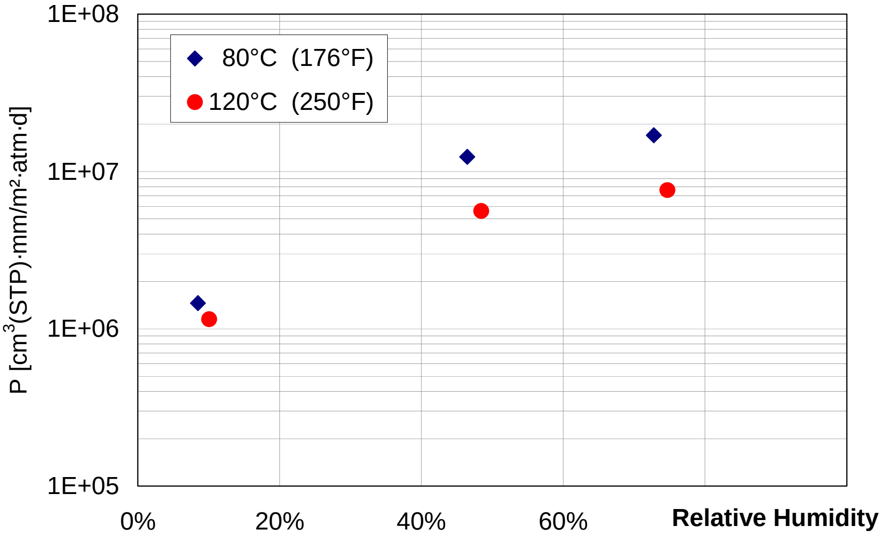


Figure 6 - AQUIVION™ Water Permeability vs. RH (Measured on 100 micron Thick Membranes)

It is worth emphasizing the importance of the thermal history on the permeability of ionomer membranes. As a general rule, specimens that undergo hydration/dehydration cycles at different temperatures exhibit a decrease in permeability.

Fig. 7 shows the water vapor permeability coefficients of a AQUIVION™ membrane tested at 80, 100 and 120°C (first cycle) and then again at 80, 100 and 120 (second cycle). The membranes also underwent a dehydration step at 105°C under vacuum for 1 hour before each temperature change.

The permeability coefficients measured in the second cycle are lower than in the first one.

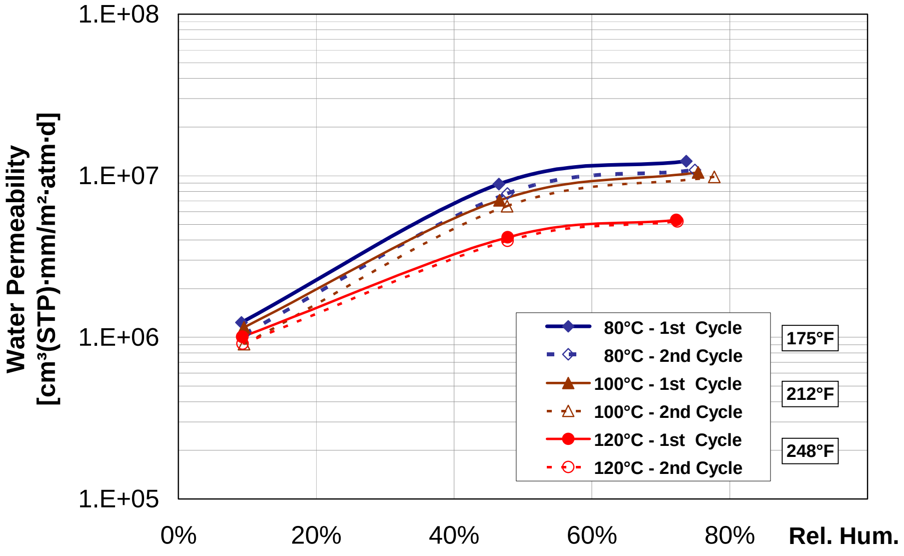


Figure 7 - AQUIVION™ Water Permeability vs. RH for different thermal histories (Measured on 100 µm membranes)

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