Roll-off effect of automotive liquids on membrane surfaces, after driving dynamic tests

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EXTENDED ABSTRACT

The main objective of this work, carried out at W.L. Gore and Associates GmbH, in Putzbrunn, was the study of the roll-off effect of automotive liquids on membranes surfaces, after dynamic driving. For this purpose, five *Gore* oleophobic *PTFE membranes* were used: A, B, C, D and E. These membranes were chosen in order to better suit the properties of liquids in the automotive hydraulic applications.

These membranes were tested with different types of automotive liquids:

- Liquid 1: Surface Tension 24.9 [mN/m],
- Liquid 2: Surface Tension 30.8 [mN/m],
- Liquid 3: Surface Tension 36.3 [mN/m],
- Liquid 4: Surface Tension 44.8 [mN/m],
- Liquid 5: Surface Tension 72.6 [mN/m],
- Liquid 6: Surface Tension 74.7 [mN/m].

The volume, of the liquids, in the containers, was defined by the existing application containers volumes. The size of the containers was chosen according to the market demand in the automotive industry.

Each membrane was studied on several pre conditions:

- New – standard ware,
- Membrane Aging – in an oven at 150° C during 1000h,
- Fake aging – 1000h at room temperature for Liquid 2 and Liquid 6 and 1000h at 80°C for the rest of the liquids.

For each container the caps used had different sizes and according to the size of the caps also the membrane size change. These caps were submitted to a WEP test (Water Entry Pressure) at the pressure of 0.5 or 0.6* mbar during 60 seconds to check if they were in good condition for further testing.

After the WEP tests the airflow was measured at 12 and 50 mbar, in each sample. The airflow at 50 mbar was only measured in the beginning and end of each experiment while the airflow at 12 mbar was measured twice a day.

After the first airflow measurement the containers were placed inside a vehicle and driven in sequences of about 1500 km (two weeks) in order to be submitted to different road profiles and pressure conditions. Figure 1 shows an example of the interference, of the dynamic driving, in the pressure variation.

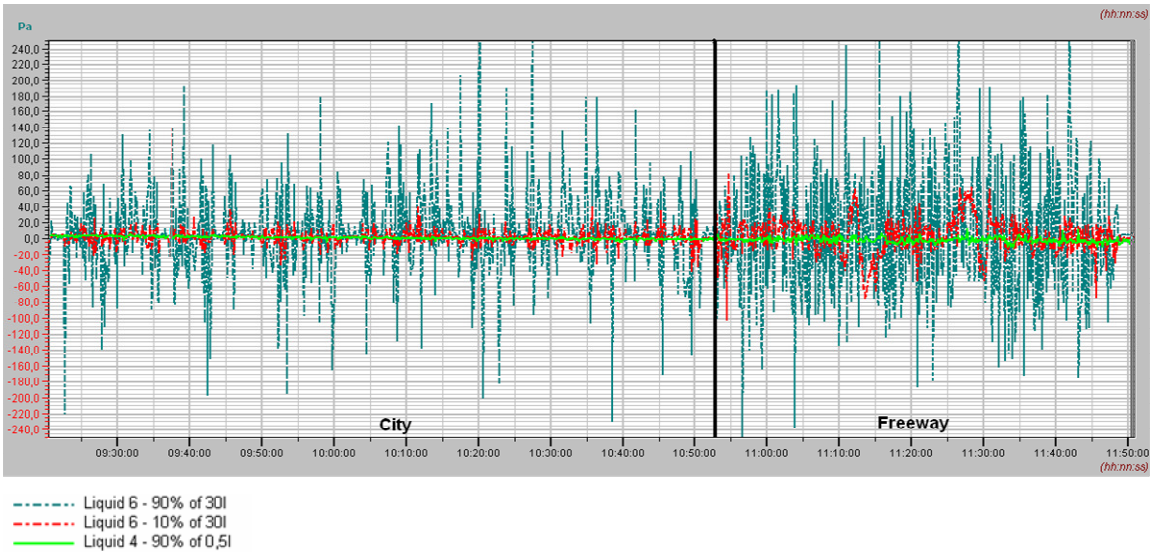

Figure 1 – – Pressure curves inside the containers filled with 90% and 10% Liquid 6, 90% Liquid 4, during a City and Freeway driving.

The behaviour of the membranes was analyzed daily, by the following measurements: airflow, temperature and pressure. In the end of each experiment, other analyses were made by using digital and Scanning Electron Microscopy observation, Water Entry Pressure (WEP) and study of characteristic superficial tension.

Figure 2 shows the airflow results of the membranes, during the experiment 2.1.Y, in the containers filled with 90% liquid. In these figure it can be seen that in some of these membranes there was a decreasing of the airflow because splashes were more intense, in these containers.

In figure 3 it can be seen some examples of the structure of the membranes, taken with SEM, before and the after a complete dynamic driving test (experiment).

*Membrane C – 0.5 mbar; Membrane A, B, D and E – 0.6 mbar

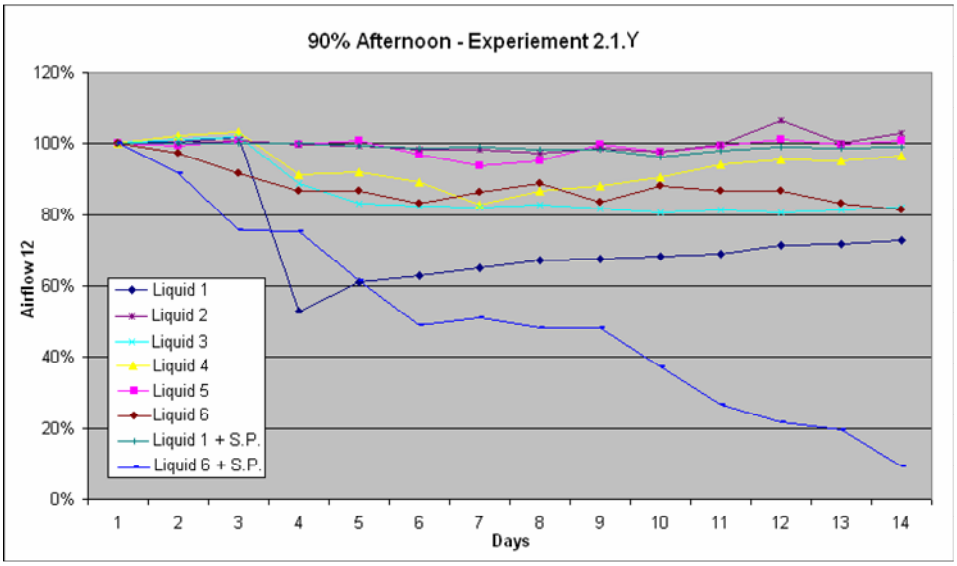

Figure 2 - Afternoon airflow measurements, of the membranes, in containers filled with 90% liquid (experiment 2.1.Y.)

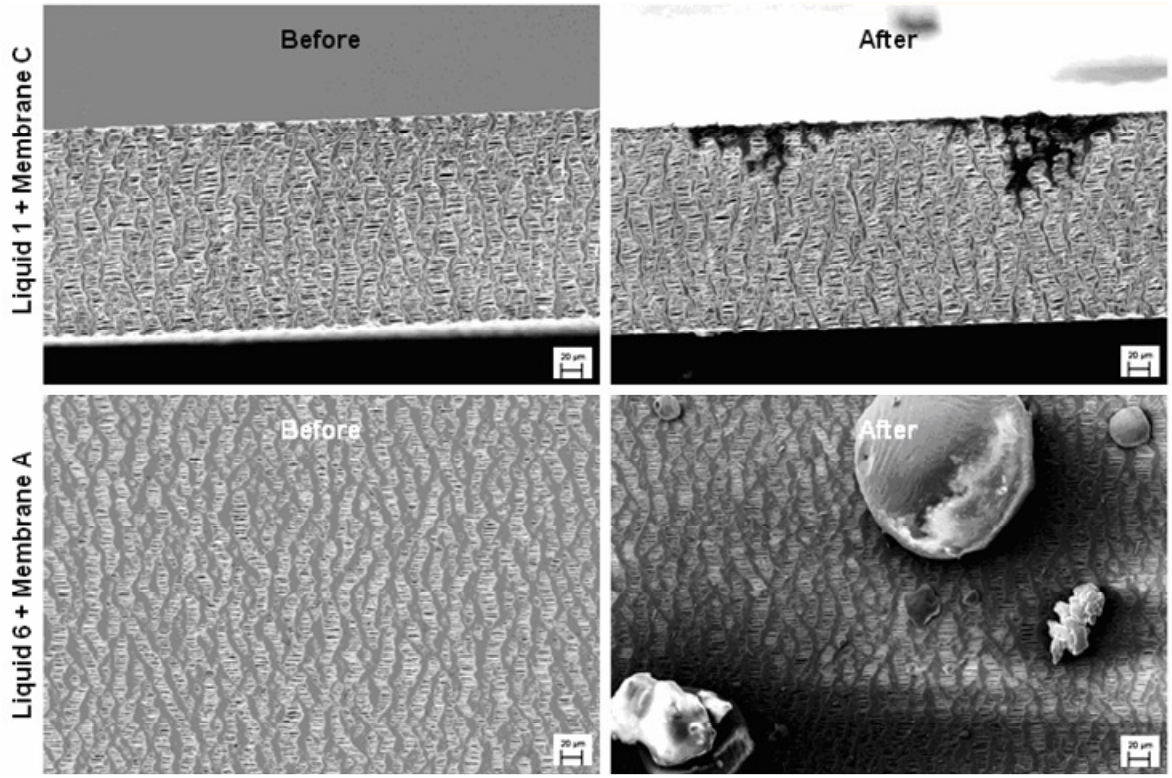

Figure 3 – SEM pictures of new membranes and after one experiment.

Additionally, within the framework of this project, eight splash protection prototypes were projected, created and reviewed to be tested.

The objective targets of the prototypes are: offer a good liquid roll-off effect, avoid liquid splashes on the membrane surface to offer breath ability of the system and be economically viable.

The developed prototypes were inserted in special caps and tested in containers of 0,5l and 30l with 90% filled with Liquid 6 and in 0.5l containers with 90% filled with Liquid 1. They were grouped in Liquid 1 +Splash Protection, Liquid 6 +Splash Protection, P1.Z and P2.Z. The first two splash protection prototypes were developed by W.L.Gore & Associates GmbH within the framework of another research and development project, while P1.Z and P2.Z were developed within this project. These prototypes where separated in P1.Z and P2.Z, according to their design and were tested in containers of 0.5l filled with 90% Liquid 6.

The P1.Z and P2.Z prototypes were tested during 4 weeks with the average of 3000km in dynamic driving. The airflow, at 12 mbar, was measured twice a day.

Conclusions

Based on the results obtained in this work it can be concluded that the different kind of preconditions, in the production membranes, had no influence on the membrane behaviour. However in Membrane D, after aging, the venting results are different from the other pre conditions (new and fake aging).

After testing and analyzing of the results the membrane/liquid combinations that can be recommended for serial use and commercialization are:

- Liquid 5 + Membrane A or Membrane D,
- Liquid 6 + Membrane A,
- Liquid 4 + Membrane D.

In all of these combinations there is no decrease of the membrane venting capacity. This property is the main objective of the use of these membranes in the automotive industry.

Out of this experiment the following conclusions, from prototypes testing, were drawn:

- Liquid 1 + Splash Protection → the splash protection design gives an opportunity to the membrane performance avoiding the splash on the membrane and a good roll off effect is possible,
- The prototypes 2.2, 2.3 and 2.4, with Liquid 6, avoid the splashing of the membrane and had a good roll off effect,
- The prototypes 1.1, 1.2 and 2.1, with Liquid 6, didn't have a good roll off effect,
- The size of a splash protection shouldn't be increased, i.e. for using in another application.